Comprehensive Design Guidance for Cycle Tracks

Requested by
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Executive Summary

Background

Caltrans is planning to improve and update its design standards for bicycle facilities to include guidance for cycle track design, among other changes. However, Caltrans does not currently have the detailed guidance necessary to develop these standards. To address this need, CTC & Associates gathered information and standards in place both in the United States and abroad about:

- Cycle track geometry.
- Signage.
- Pavement markings.
- Intersection treatments.
- Accessibility.
- Maintenance of cycle tracks.

CTC also explored the California Vehicle Code to determine how cycle tracks conform to the code.

Summary of Findings

Cycle Track Geometry

Width is one of the primary geometric features of a cycle track. It encompasses two elements: the width of the cycle track travel lane or lanes, and the width of the buffer zone between the cycle track and the motor vehicle travel or parking lanes. The typical minimum widths recommended are 1.5 to 2 meters per lane of cycle track plus a buffer of at least 0.5 meter. However, many jurisdictions require or recommend larger cycle tracks either under general circumstances or in specific conditions.

Delineation of cycle tracks is also a significant concern. Common options for protected cycle tracks include painted buffers, flexible bollards, planters, concrete curbs or medians.

When a raised cycle track is adjacent to the roadway, recommended vertical separation between the cycle track and the roadway ranges from 1 to 6 inches, while vertical separation between the cycle track and pedestrian facilities range from 0 to 5 inches.

While a low-height curb may be used to separate the cycle track from the road, many sources recommend a mountable curb to allow cyclists to use the roadway for passing.

Signage

There are two primary publicly available sources that provide details about signage on cycle tracks: the Ontario Traffic Manual (OTM) and the NACTO Urban Bikeway Design Guide. The OTM specifies signs to designate a Reserved Bicycle Lane as well as Turning Vehicles Yield to Bicycles and Bicycle Trail Crossing signs at intersections. The NACTO Urban Bikeway Design

Guide recommends signs at intersections as well as Bike Lane, One Way and Do Not Enter signs for the track itself.

The City of Los Angeles Draft Mobility Plan also includes signage recommendations for bikeways, but they are not specific to cycle tracks. These recommendations address specific conditions such as dips, narrow bridges or slippery-when-wet conditions that may be appropriate for use on cycle tracks.

Pavement Markings

Outside of intersections (which are described in **Intersection Treatments**), there is limited guidance for pavement markings on cycle tracks. Typical pavement marking recommendations include a white bicycle symbol, the words Bike Lane and/or arrows on the lane itself. Buffer zones typically are delineated with white lines, potentially with diagonal crosshatches to add emphasis. Two-lane cycle tracks typically require a yellow centerline. Several sources make allowances for colored pavement to define the cycle track or a color other than white for edge lines for branding purposes.

Intersection Treatments

Intersections are probably the most significant design concern for cycle tracks since the cycle track concept puts all potential conflict points between bicycles and motor vehicles at the intersection. Intersection design guidance for cycle tracks generally focuses on improving the visibility of cyclists, although there is no single recommendation to accomplish this. Instead, options include:

- Converting the cycle track to a traditional cycle lane at the intersection, which typically requires parking restrictions near the intersections.
- Pavement markings through the intersection, including bike stencils, chevrons, sharrows, guide lines or colored pavement.
- Bending a cycle track away from the intersection and reducing the corner radius, forcing drivers to turn slowly and giving them space to see crossing cyclists and wait for them to clear the intersection.
- Setback stop bars for vehicles.
- Bike boxes.
- Advance green signal phases or exclusive cycle phases for bicycles.

Accommodating cyclist left turns poses a particular challenge for cycle tracks. In Denmark, cyclists are prohibited from making left turns from a cycle track and are instead required to use two-stage left-turn queue boxes. Many other jurisdictions recommend this treatment, which typically prohibits motor vehicles on the cross street from turning right on red.

Accessibility

A major accessibility concern for cycle tracks is providing accessible parking adjacent to street-level protected cycle tracks. Widened buffers adjacent to accessible parking spaces can provide access. Accessible spaces may also be relocated; the U.S. Access Board's Public Rights of Way Accessibility Guidelines recommend at least one accessible space per 25 parking spaces

around a block's perimeter—not necessarily on a specific side of the block. Cycle tracks may also be chicaned to provide space for accessible parking or transit stops.

Additional accessibility concerns identified by sources include:

- Cross-slopes across the cycle track, which the NACTO Urban Bikeway Design Guide recommends should be limited to 2 percent.
- Steepness of cycle track slopes, which the County of Los Angeles limits to 5 percent except in short runs.
- Cycle track surface. The County of Los Angeles requires a "firm and stable" surface that will not be compressed by a wheelchair, while Quebec recommends that raised cycle tracks should have a surface with a different texture than the sidewalk that can be detected by visually impaired users.

Maintenance of Cycle Tracks

Street sweeping to keep cycle tracks free of debris as well as plowing and other winter maintenance to keep cycle tracks free of snow are the primary maintenance requirements for cycle tracks. The width of a cycle track has a significant impact on how easily these functions can be performed. The minimum width for snowplows and street sweepers is typically at 1.8 meters, although one source states that cycle tracks need to be at least 10 feet (3.3 meters) to be included in normal maintenance operations. Posts or bollards used to delineate cycle tracks may need to be removed to permit maintenance equipment access to the cycle track. On narrower cycle tracks, special equipment may be required for maintenance. Agreements with maintenance partners are also recommended as a possible solution.

Sources are mixed about the use of abrasives or deicers. An Alta Planning + Design white paper recommends anti-icing, plowing and deicing operations similar to general road maintenance. Ontario permits their use, but recommends they be used "judiciously." Cambridge, MA, recommends that salt not be used on permeable pavements because it can clog the pores that water seeps through. Quebec discourages the use of salt or sand, but recommends the use of 5-millimeter fine aggregate to improve traction.

Several sources recommend a transverse slope in the cycle track to facilitate drainage. Additionally, concrete curbs or medians used to delineate cycle tracks need to have breaks periodically to allow water to flow through. Drainage gates should either be located in an adjacent lane or have a design that will not catch bicycle tires.

Gaps in Findings

This research uncovered limited guidance for pavement markings and signage in cycle tracks outside of intersections. While these locations are likely to require relatively little signage or markings, the investigation of specific cycle track designs may provide details about what treatments other jurisdictions have used.

Significant guidance is forthcoming, particularly Federal Highway Administration's Separated Bike Lane Planning and Design Guide, which is anticipated this spring. That guide is likely to provide the most up-to-date guidance available for American jurisdictions.

Next Steps

Several pieces of guidance are not currently available but are anticipated in the near future:

- FHWA plans to release the Separated Bike Lane Planning and Design Guide this spring.
- According to the OTM, the TAC is currently developing guidelines and specifications for using bicycle signals. Currently Ontario doesn't have legal regulations or statutes for bicycle signals, but they are proposed future legislation items.
- According to Focus on Cycling: Copenhagen Guidelines for the Design of Road Projects, the Copenhagen Bicycle Programme is developing a new informational signage system for all cycle track routes.
- Nick Falbo of Alta Planning + Design is planning to release a white paper in the near future with detailed design drawings of the concepts he outlines in Protected Intersections for Bicyclists (http://www.protectedintersection.com).

These sources may provide useful information as Caltrans develops its standards.

Detailed Findings

Cycle Track Geometry

Width is one of the primary geometric features of a cycle track. It encompasses two elements: the width of the cycle track travel lane or lanes, and the width of the buffer zone between the cycle track and the motor vehicle travel or parking lanes. The following tables summarize recommended widths for protected one-way cycle tracks, protected two-way cycle tracks and raised cycle tracks. However, many factors, including barrier type and traffic level, affect width recommendations and the tables cannot capture this level of detail; see the individual sources below for detailed guidance.

One-Way Protected Cycle Track Widths

Jurisdiction	Width	Notes	Source
Ontario, Canada	1.5 m plus 0.5-m buffer	Minimum recommendation when cycle track is separated from automobile lanes by flexible bollards; minimum widths for other types of separation range from 1.5 m to 1.8 m, with a buffer from 0.5 m to 0.8 m; recommended widths range from 1.8 m to 2.0 m with a 1.2-m buffer.	OTM, Book 18
United States	5 ft plus 3-ft buffer	Minimum lane width: 7 ft in high-volume sections or in uphill sections to permit passing. When a parking-protected pavement marking buffer is in use, the buffer and parking lane should total at least 11 ft.	NACTO Urban Bikeway Design Guide
The Netherlands	2.0 m	More generous widths should be provided if there are higher cyclist volumes. The manual expects that cyclists should be able to ride at least two abreast.	CROW Design Manual for Bicycle Traffic, via Ottawa Segregated Bike Lane Pilot Project
Copenhagen, Denmark	2.5 m		Ottawa Segregated Bike Lane Pilot Project
New York City	1.5 m plus 1.0-m buffer	On major avenues, bike lanes are wider.	Ottawa Segregated Bike Lane Pilot Project

Jurisdiction	Width	Notes	Source
Portland, OR	2.1 m		Ottawa Segregated Bike Lane Pilot Project
Vancouver, BC	2.0 m		Ottawa Segregated Bike Lane Pilot Project
Ottawa, ON	1.8 m plus 0.3-m buffer	0.5-m buffer is preferred	Ottawa Segregated Bike Lane Pilot Project
Copenhagen, Denmark	2.0 m	A 2.2-m lane is recommended; accommodates 2,000 cyclists/ hour. An additional 1.0-m lane accommodates an extra 1,500 cyclists/hour.	Collection of Cycle Concepts
Copenhagen, Denmark	2.2 m	Cycle track width can be as low as 1.7 m. The city's PLUSnet high-capacity, three-lane cycle track network has a minimum width of 2.8 m. Standard widths are 2.5 m, 3.0 m on PLUSnet.	Focus on Cycling: Copenhagen Guidelines for the Design of Road Projects
County of Los Angeles	7 ft plus 2-ft buffer		County of Los Angeles Bicycle Master Plan
City of Los Angeles	5 ft plus 3-ft buffer		Complete Streets Manual, City of Los Angeles Mobility Plan
Cambridge, MA	5 ft plus 1-ft buffer	Preferred widths: 7 ft with a 3-ft buffer	Cycle Tracks: A Technical Review of Safety, Design, and Research
London	1.5 m	Guidance is for low-flow cycle tracks; tracks with higher traffic have recommended widths of 2.2 or 2.5 m.	London Cycling Design Standards
Quebec	1.5 m per lane plus 0.5-m clearance from parking lane, if adjacent.		Planning and Design for Pedestrians and Cyclists: A Technical Guide

Two-Way Protected Cycle Track Widths

Jurisdiction	Width	Notes	Source
Ontario, Canada	3.0 m plus 0.5-m buffer	Minimum recommendation when cycle track is separated from automobile lanes by a marked buffer or flexible bollards; recommended widths are greater.	OTM, Book 18
United States	12 ft plus 3-ft buffer	Minimum width in constrained locations: 8 ft	NACTO Urban Bikeway Design Guide
Montreal	3.0 m plus 0.5 m	Installed cycle tracks are two-way, although one-way tracks will be preferred in the future. Greater widths required when hills or light posts in medians.	Ottawa Segregated Bike Lane Pilot Project
County of Los Angeles	12 ft plus 2-ft buffer		County of Los Angeles Bicycle Master Plan
City of Los Angeles	8-12 ft plus 3-ft buffer		Complete Streets Manual, City of Los Angeles Mobility Plan
Cambridge, MA	8 ft plus 1-ft buffer	12 ft plus 3-ft buffer preferred	Cycle Tracks: A Technical Review of Safety, Design, and Research
Copenhagen, Denmark	2.5 m plus 1.0-m buffer	Two-way cycle tracks not standard in Denmark but permitted as an aid to cycling infrastructure coherence.	Focus on Cycling: Copenhagen Guidelines for the Design of Road Projects
London	2.0 m	Guidance is for low-flow tracks; on busier tracks, recommended widths: 3-4 m	London Cycling Design Standards

Raised Cycle Track Widths

Jurisdiction	Width	Notes	Source
Ontario, Canada	1.5 m	1.0-m clearance required when adjacent parking. Recommended width: 2.0 m. Double widths for two-way cycle tracks.	OTM, Book 18
United States	6.5 ft	Plus a 3-ft parking buffer when cycle track is protected by a parking lane. Minimum width at intersections or pinch points: 5 ft.	NACTO Urban Bikeway Design Guide
City of Los Angeles	5 ft plus 3-ft buffer	Preferred width: 6.5 ft	Complete Streets Manual, City of Los Angeles Mobility Plan
Quebec	1.0-1.5 m	0.5-m clearance required when adjacent to a parking lane or if street furniture is present.	Planning and Design for Pedestrians and Cyclists: A Technical Guide

Note that cycle track width has implications for maintenance costs since full-size street sweeping equipment and snowplows require a certain width in which to operate. See **Maintenance of Cycle Tracks** for more details.

Book 18—Cycling Facilities, Ontario Traffic Manual, Ministry of Transportation of Ontario, December 2013.
http://www.library.mto.gov.on.ca; search "Ontario Traffic Manual."
The OTM provides information and guidance for the design, application and operation of traffic control devices and systems. Book 18 addresses cycling facilities and provides design guidance for protected cycle tracks, described in the manual as separated bicycle lanes (Section 4.2.2), and for raised cycle tracks. (Section 4.3)

Width
Cycle track width described in the manual varies based on the type of cycle track, the number of lanes, the type of separation between the cycle track and the motor vehicle lanes or parking, the available right of way and the roadway characteristics. The manual includes both minimum and recommended widths. However, the manual instructs that "designers should implement the desired widths unless restricted by site constraints" (page 86). All widths are adapted from the AASHTO Guide for Planning, Design and Operation of Bicycle Facilities.

For one-way protected cycle tracks, the manual's suggested width is 1.8 meters plus a 1.2-meter buffer if the cycle track is separated from the road by a marked buffer or on-street parking; and 2.0 meters plus a 1.2-meter buffer if separation is provided by flexible bollards, planters, concrete curbs or medians. Suggested minimum widths are 1.5 meters plus a 0.5-meter buffer if the cycle track is separated by a marked buffer or flexible bollards; 1.8 meters plus a 0.5-meter buffer if separated by planters, a concrete curb or a median; and 1.5 meters plus a 0.8-meter buffer if separated by on-street parking (page 87).

Recommended widths for two-way cycle tracks are double the width of the one-way cycle track's bicycle lane, with the same buffer width as the one-way cycle track. In other words, two-way cycle tracks separated by marked buffers have a recommended width of 3.6 meters plus a 1.2-meter buffer, and a minimum width of 3.0 meters with a 0.5-meter buffer.

The manual includes special notes for designers to keep in mind:

- In cycle tracks delineated by flexible bollards, planters, concrete curbs or medians where high bicycle traffic levels are expected, the manual states that "[p]ractitioners should provide a minimum of 2.0 meters effective width between the curb and the physical component of the barrier where high volumes of cyclists are anticipated. This will reduce the risk of cyclists clipping the physical buffer or curb while overtaking other cyclists." (page 87)
- When the cycle track is delineated by on-street parking, "[p]ractitioners should provide the widest buffer possible to reduce the risk of a cyclist colliding with an opening car door, recognizing that the space available for avoiding debris or imperfections and overtaking is limited." (page 87)

For raised cycle tracks, the manual recommends a minimum width of 1.5 meters width per bicycle travel lane and a desired 2.0 meters per lane (page 106). When the cycle track is adjacent to on-street parking, there should be a minimum of 1.0-meter clearance between the cycle track and the face of the barrier curb to reduce the risk of collisions between bicycles and opening car doors or passengers exiting a vehicle.

<u>Delineation</u>
Raised cycle tracks require special consideration of the delineation between the cycle track and the sidewalk. From page 105 of the manual:

> Particular consideration should be given to persons with disabilities, especially those who are visually impaired.

See **Accessibility** for more details.
When a raised cycle track is adjacent to a sidewalk, delineation options include a boulevard strip or contrasting pavement material. Designers should particularly consider delineation in areas where sidewalks are frequented by children, dog walkers or other pedestrians who may stray beyond the sidewalk's edge.

Between a raised cycle track and the motor vehicle lane, designers may specify rolled curbs to allow cyclists to comfortably transition between the two. However, motorists might use rolled curbs to do the same; barrier curbs with a vertical face will prevent them from doing so. If vertical-faced barrier curbs are installed, the manual recommends using splash strips: a typically 1.0-meter-wide section that keeps bicyclists away from the drop-off of the curb face (and which can also store plowed snow).

In protected cycle tracks, designers should use sidewalk curbs and furnishings to discourage pedestrians from using the cycle track.

NACTO Urban Bikeway Design Guide, National Association of City Transportation Officials, March 2014.
http://nacto.org/cities-for-cycling/design-guide/
This guide offers design guidance for one-way protected cycle tracks, raised cycle tracks and two-way protected cycle tracks.

Width
The guide recommends a minimum desired width of 5 feet for one-way cycle tracks with a minimum desired width of 7 feet to allow for passing in uphill sections or sections with high cyclist volumes. As buffer zones, the guide recommends the following options:

- 3 feet between the cycle track and parking lanes.
- A minimum 3 feet painted buffer width for bollards, planters, signs or other protection if there is no raised median or curb.
- 11 feet for the parking lane and buffer when a parking-protected pavement marking buffer used.

If the gutter seam extends more than 12 inches from the curb, the guide recommends the cycle track be wider to allow bicycles room to go around it. The guide recommends widening the cycle track by the distance from the curb to the edge of the gutter seam minus 18 inches, if the value is positive.

Two-way cycle tracks should have a width of 12 feet (with a minimum of 8 feet in constrained locations), with a 3-foot buffer between the cycle track and parking lanes or a 3-foot painted buffer to be used for planters, bollards, signs or other forms of protection.

For raised cycle tracks, the guide recommends a desired width of 6.5 feet, with a minimum width of 5 feet at intersections and pinch points. When the cycle track is protected by a parking lane, it should have a 3-foot buffer to allow for passenger loading.

Delineation
The guide recommends that a one-way raised cycle track should have a mountable curb at least 1 foot wide when the cycle track is positioned adjacent to a motor vehicle travel lane. This curb is not considered part of the rideable cycle track width and it should have a 4-to-1 or flatter slope, with no seams or lips that could catch bicycle wheels. The width of the mountable curb should be increased to at least 3 feet if the curb is used as a buffer that holds lamp posts, bollards, street furniture, low vegetation or trees.

According to the guide, cycle tracks should be vertically separated from the roadway by 1 to 6 inches. Vertical separation between the cycle track and the sidewalk should be between 0 and 5 inches.

East-West Segregated Bike Lane Pilot Project Draft Report, City of Ottawa, January 25, 2011.
http://ottawa.ca/en/city-hall/public-consultations/transportation/background-reports

This report reviewed a pilot project to install a protected bike lane in 2011 in Ottawa, ON. In an email, Colin Simpson, senior project manager, Transportation–Strategic Planning Unit, City of Ottawa, said, “It was deemed a big success and city council made it permanent in July 2013.” The report includes an overview of design practices from other jurisdictions as well as details

about Ottawa's bike lane design. Both Section 3 and Appendix C describe design principles from other jurisdictions, while Section 8 describes the design the city implemented.

Width

Ottawa only considered a protected cycle track. Based on recommendations from research and staff from other cities that have segregated bicycle lanes, the city decided to only implement one-way cycle tracks. Minimum lane widths from other jurisdictions ranged from 1.5 to 2.5 meters. The TAC and New York City both require 1.5 meters, although New York City uses wider lanes on major avenues. The Netherlands and Vancouver, BC, both have a minimum width of 2.0 meters, although The Netherlands recommends wider widths to allow cyclists to ride two abreast. The minimum width in Portland, OR, is 2.1 meters, and Copenhagen requires a minimum 2.5-meter width.

Ottawa opted to use a minimum lane width of 1.8 meters (the minimum space to accommodate the city's maintenance vehicles), but the city's downtown area has space constraints.

The report identified buffer zones as small as 0.05 meter in other jurisdictions. Appendix C notes that New York City has a 1.0-meter minimum buffer. Ottawa opted for a minimum of 0.3 meter for the buffer zone with a preference for 0.5 meter.

As described in Appendix C, Montreal's installed cycle tracks are all two-way, although the city now prefers one-way cycle tracks. Minimum width for two-way cycle tracks is 3 meters total, with a minimum of 3.5 or 4.0 meters in sections that are at least 400 meters where the cycle track goes up a hill with a 6 percent grade or more to allow passing. Medians are a minimum of 0.5 meter if they do not have light posts, or 0.9 meter if they do house light posts.

Delineation

As described in Section 8 of the report, the cycle track used a combination of precast curbs and delineators to separate it from the rest of the road. At loading zones, the curb was removed and replaced with painted lines and delineators spaced 5 meters apart. As an aesthetic consideration, the cycle track includes planter boxes before and after on-street parking areas.

Cycle Tracks: Concept and Design Practices, Association of Pedestrian and Bicycle Professionals, February 17, 2010.
http://nctcog.org/trans/committees/bpac/CycleTracksPresentation_2.17.10.pdf

Width

In this webinar, Peter Furth, professor of civil engineering, Northeastern University, suggested that cycle track width should be about 3.75 feet per lane.

Cara Seiderman, transportation program manager, City of Cambridge, MA, shared one of the city's cycle track designs, which is 5 feet wide with a 3-foot buffer between the cycle track and the parking lane, and a 6-foot planting buffer between the cycle track and the sidewalk.

Rob Burchfield, city traffic engineer, Portland (OR) Bureau of Transportation, described the city's SW Broadway cycle track, which is 7 feet wide with a 3-foot buffer between the cycle track and the parking lane.

Hayes Lord, bicycle program director, New York City Department of Transportation, provided details about three of the city's cycle tracks:

- 9th Avenue features a 6-foot-wide cycle track with a 10-foot buffer between the cycle track and parking lane. The road has high collision rates and high vehicle speeds, with traffic levels of 1,700 vehicles per hour and 780 cyclists every 12 hours.
- Grand Street features a 5-foot-wide cycle track with a 3-foot-wide buffer between the cycle track and the parking lane. The road receives 647 bicyclists per hour. Lord described traffic on the road as "disorderly."
- On Kent Street, the city replaced unpainted curbside bike lanes (6 feet wide with a 3-foot buffer between the lane and the motor vehicle lane) with an 8-foot-wide, two-way cycle track with a 5-foot buffer between it and the parking lane in 2009. The city also converted the road from two-way for motor vehicles to one-way.

Collection of Cycle Concepts 2012, Troels Anderson, Frits Bredal, Marianne Weinreich, Niels Jensen, Morten Riisgaard-Dam and Malene Kofod Nielsen, Cycling Embassy of Denmark, 2012.
http://www.cycling-embassy.dk/wp-content/uploads/2013/12/Collection-of-Cycle-Concepts-2012.pdf
This guide "is not intended to be a summary of Danish road standards, but to provide inspiration and motivation for creating more and safer bicycle traffic." It updates a 2000 guide published by the Danish Road Directorate. Moreover, cycling design standards in Denmark are typically "guidelines" or "explanatory notes," meaning that local authorities have a lot of leeway to determine actual cycle track designs.

Width
Citing the City of Copenhagen's Danish-language cycling web site (http://www.kk.dk/da/borger/trafik/cyklernesby), the guide suggests that cycle tracks should be at least 2.0 meters wide, with 2.2 meters recommended. These widths are sufficient for two lanes and will have a capacity of 2,000 cyclists per hour. Additional lanes will each accommodate an extra 1,500 cyclists per hour, so a 3.0-meter cycle track has a capacity of 3,500 cyclists per hour. However, capacity is not the only consideration. Copenhagen promotes the idea of "conversation cycling"— that the cycle track is likely to be used by small groups of people who will want to ride two abreast with enough space for a third person to pass, which suggests that cycle tracks should have a minimum width of 3.0 meters on important routes.

Citing https://www.retsinformation.dk, a collection of Danish legal information, the guide noted that three-wheeled cargo bicycles, which may be as wide as 1.25 meters, are becoming more common. Planning for these bicycles, the guide suggests using cycle tracks with a minimum width of 2.5 meters, and up to 3.5 meters in locations with high cyclist volumes. Retsinformation states that the minimum one-way cycle track width is 1.7 meters with a recommended width of at least 2.2 meters.

A significantly earlier report (1983), Cycling and Moped Accidents in Rural Areas—Documentation Report*,* stated that when a cycle track is part of a shared-use path, the minimum width is 1.5 meters. Even this report noted that 2.2 meters is necessary for safe overtaking, and 2.8 meters (and preferably 3.0 meters) will permit three cyclists to ride abreast.

Delineation
Cycle tracks in high-speed (60 kilometers per hour and up) rural areas often use grass verges between the cycle track and the road. They eliminate the need for curbs or drainage facilities,

but they are not safe in areas with closely spaced intersections. These verges are typically 1.5 meters wide, with a recommended minimum of 0.6 meter. The verge should generally not contain solid objects like trees, although it appears they are permitted if the verge is wider than 2 meters.

Focus on Cycling: Copenhagen Guidelines for the Design of Road Projects, City of Copenhagen Technical and Environmental Administration/Traffic Department, The Bicycle Programme, December 2013.
http://kk.sites.itera.dk/apps/kk_pub2/pdf/1133_mLNsMM8tU6.pdf

Width
Widths of cycle tracks in Copenhagen have grown in recent years due to greater cycle volumes, more cargo bikes, and greater differences in cycling speeds. Standard widths are 3.0 meters on PLUSnet, the city's high-capacity, 3-lane cycle track network, and 2.5 meters for other cycle tracks. Minimum widths are 2.8 meters on PLUSnet, or 2.2 meters on other cycle tracks (which can be as low as 1.7 meters "in exceptional cases.")

Two-way cycle tracks are not standard, but they are used "as an aid to cycling infrastructure coherence." Their minimum width is 3.5 meters if part of PLUSnet, and 2.5 meters otherwise. A 1.0-meter verge (buffer) should also be installed, preferably a solid surface.

Normally there is no verge between one-way cycle tracks and parked cars because the priority is maximizing cycle track width. Buffers may be installed where tourist buses stop, at taxi stands, or where there are high pedestrian crossing volumes and between the cycle track and traffic lanes on very wide cycle tracks with high pedestrian crossing volumes.

Cycle tracks should not have sharp curves; the curve radius should be dimensioned to 30km/h.

Delineation
Bollards are rarely used to delineate cycle tracks, because they require an extra 0.3 meter of width and because drivers may come to expect them in all places where parking is forbidden.

Appendix F: Design Guidelines, County of Los Angeles Bicycle Master Plan, 2012.
http://dpw.lacounty.gov/pdd/bike/docs/bmp/Appendix%20F.pdf
This document describes cycle tracks as an "innovative treatment" that jurisdictions in California and other states are experimenting with. As a result, they are not approved for all agencies, but local agencies can undertake projects on a case-by-case basis as approved by the California Traffic Control Devices Committee and FHWA.

The plan provides only limited guidance for cycle tracks: a preferred width of 7 feet for one-way cycle tracks or 12 feet for two-way cycle tracks, with a 2-foot buffer that contains bollards, striping, colored pavement, curbs or medians, or a combination of those elements.

Raised bicycle lanes—the equivalent of cycle tracks—are described in the plan as an "innovative bicycle treatment" not currently present in state or federal design standards. The only design details the plan offers are that they should have a 1- to 2-foot buffer with a 4-to-1 or flatter slope and no lip that could catch bicycle tires.

Complete Streets Manual, Chapter Nine of the City of Los Angeles Mobility Plan (Draft), Los Angeles Department of City Planning, February 2014.
http://planning.lacity.org/Cwd/GnlPln/MobiltyElement/Text/CompStManual.pdf
Chapter 7 of this draft manual describes cycle tracks and bicycle lane designs.

Width
On arterial streets, desired widths are 5 feet with a 3-foot buffer for curbside one-way tracks, 8 to 12 feet with a 3-foot buffer for two-way cycle tracks and 6.5 feet (with a minimum of 5 feet) with a 3-foot buffer for raised cycle tracks. The manual does not provide standards for nonarterial streets.
The manual includes special conditions related to buffer widths:

- When there is a raised buffer with adjacent parking, the buffer must be 3 feet wide; 4 feet is preferred.
- When there is a raised buffer without adjacent parking, the buffer may be as narrow as 2 feet wide, but 4 feet is preferred.
- California's Manual on Uniform Traffic Control Devices (MUTCD) currently does not permit striped buffers between a cycle track and parking or travel lanes. However, they are expected to be added when the MUTCD is updated, permitting the implementation of this treatment as it has been done in other cities. The minimum width is expected to be 3 feet, with a preferred width of 4 feet.

When raised cycle tracks have a mountable curb, it should have a slope of 4-to-1 or flatter and no lip to catch bicycle tires.

Cycle Tracks: A Technical Review of Safety, Design, and Research, City of Cambridge, June 2014.
http://www.cambridgema.gov/~/media/Files/CDD/Transportation/Bike/Final_CycleTrackWhitePaper_20140722.ashx
This white paper sets a minimum width for one-way cycle tracks of 5 feet, with a preferred width of 7 feet. Two-way cycle tracks have a minimum width of 8 feet and a preferred width of 12 feet. Both types have a minimum buffer of 1 foot, with 3 feet or more preferred.

In an email message, Cara Seiderman, transportation program manager, City of Cambridge (MA), said that the city uses NACTO Urban Bikeway Design Guide, the Netherlands' CROW Design Manual for Bicycle Traffic, Danish guidelines and best engineering judgment to design its cycle tracks.

Cycle Tracks: Lessons Learned, Alta Planning + Design, February 4, 2009.
http://www.altaplanning.com/wp-content/uploads/Cycle-Track-Lessons-Learned-Study.pdf
This report, prepared for the City of Portland, OR, summarizes research gathered through a tour of Amsterdam and Copenhagen.

Width
In the Netherlands, one-way cycle tracks are typically 7 feet wide, and 8 feet is desirable for new construction; in high-demand situations, each lane can be up to 10 feet. The CROW Design Manual for Bicycle Traffic standardizes cycle track width based on usage: 6.5 feet if rush-hour traffic volume is less than 150 bikes per hour, 10 feet if traffic is 150 to 750 bikes per hour, and 13 feet if traffic is greater than 750 bikes per hour. The Alta guide recommends a

width of at least 6.5 feet to provide safe passing, although it can be narrowed to 5 feet at constrained intersections.

The CROW manual also describes buffer widths, which vary based on the type of barrier. The minimum buffer area should be 1.1 feet in built-up areas, but the guidelines are 2.3 feet if the buffer contains a fence, 3.2 feet if the buffer contains lamp posts, 3.6 feet if the buffer contains a physical barrier and 7.5 feet if the buffer contains vegetation.

If a road does not have enough space to accommodate a physical barrier, a narrow paved separation or an asphalt ridge or concrete curb may be used. These curbs or ridges should have a height of 4 to 5 inches from the travel lane, and 2 to 3 inches from the cycle track to avoid conflicting with pedals.

For cycle tracks in rural areas, the barrier width should depend on main road speed. A 40 mph road requires a barrier of 5 to 8 feet wide, while a 50 mph road requires a 15- to 20-foot-wide barrier.

According to the CROW manual, two-way cycle tracks should be 8 feet wide if total rush-hour traffic in both directions is less than 50 bikes per hour, 10 feet wide if traffic is 50 to 750 bikes per hour and 13 feet if traffic is over 750 bikes per hour. Two-way cycle tracks require a minimum buffer width of 3.2 feet.

London Cycling Design Standards, draft for consultation, Transport for London, 2014.
Available at https://www.tfl.gov.uk/corporate/publications-and-reports/cycling
This document updates the 2005 London Design Standards. Chapter 4 addresses cycle lanes and cycle tracks.

Width
Width guidance from Section 4.4.1 is as follows: 1.5 meters for a low-flow one-way cycle track, 2.2 meters for a medium-flow cycle track and 2.5 meters for a high-flow cycle track. For a two-way cycle track, recommended widths are 2.0 meters for low flow, 3.0 meters for medium flow and 4.0 meters for high flow.

Low flow is defined as less than 200 cyclists in the peak hour for a one-way cycle track or less than 300 cyclists for a two-way cycle track. Medium flow is 200 to 800 cyclists in the peak hour for a one-way track, or 300 to 1,000 cyclists for a two-way track. High flow is greater than 1,000 cyclists.

As described in Section 4.2.3, when islands segregate the cycle track from travel lanes, recommended widths are at least 0.5 meter. However, wider widths are recommended for several circumstances: 0.8 meter at the beginning of the cycle track to accommodate a 100-millimeter flexible post, 1.0 meter at the beginning of the track to accommodate a bollard, 1.0 meter when adjacent parking or loading bays are present or where plantings are included in the island, 1.2 meters at uncontrolled pedestrian crossings, 1.3 meters if a low-level signal pole is present, 1.5 meters if a standard traffic signal pole is present or 1.8 meters at controlled pedestrian crossings or if accessible parking is required.

Delineation
Other design suggestions for cycle tracks standards follow:

- When curbs are used to separate the cycle track from the roadway, limiting the height of the curb on the cyclist side to about 50 millimeters will lower the risk of cyclists catching their pedals on the curb. (Section 4.2.3)
- Signal poles or bollards provided in islands or segregating strips require at least 0.3 meter of space to provide safe clearance for moving vehicles. Guidance in Design Manual for Roads and Bridges suggests a 450-millimeter clearance on the motor traffic side; there is no requirement on the cyclist side, although at least 250 millimeters is recommended. (Section 4.2.3)
- The standards note that some international jurisdictions have implemented two-way cycle tracks in the center of the carriageway rather than at an edge. There are no standard design details available and no experience in the U.K., however. (Section 4.2.4)

Portland Bicycle Plan for 2030, Portland Bureau of Transportation, 2010.
http://www.portlandoregon.gov/transportation/article/289122
Appendix D, Bikeway Facility Design: Survey of Best Practices (http://www.portlandoregon.gov/transportation/article/334689), includes design best practices. It includes a limited amount of design guidance collected from other sources:

- Copenhagen Traffic Department requires a minimum width of 6.5 feet, while 7 feet is typical, 8 feet is desirable for new construction and up to 10 feet is provided when additional capacity is needed. A 2-foot buffer on the vehicle side is desirable and is required if cycle track width is less than 7 feet. A curb should separate bike and pedestrian facilities.
- In the Netherlands, the CROW manual sets 5.5 feet as the minimum width, while 6.5 feet to 13.1 feet is typical, depending on rush-hour bicycle traffic levels.
- Alta Planning and Design suggests that when there is on-street parking, the cycle track should be adjacent to the sidewalk with 2 feet of clear space to prevent “doorings.”

Planning and Design for Pedestrians and Cyclists: A Technical Guide, Marc Jolicoer, Vélo Québec, 2010. (Not available online)

Width
Chapter 5 of this design guide states that protected cycle tracks must be at least 1.5 meters wide per lane. When adjacent to a parking lane, there must be at least 0.5-meter additional clearance, although this space can be provided either by a buffer or by widening the bike lane.

For raised cycle tracks (described as sidewalk-level bike paths in the guide), a 15-centimeter curb is recommended, or if parking is prohibited adjacent to the track, a 7.5-centimeter mountable curb that allows cyclists to use the street to pass. The raised cycle track should be 1.0 to 1.5 meters wide, with at least 0.5-meter clearance if adjacent to a parking lane and 0.5-meter clearance from any street furniture.

Delineation

When delineators are used to set off the cycle track, they must be spaced no more than 20 meters apart. When the cycle track is separated from the road by a median or wall, this wall must have openings to allow water to flow to storm sewers.

According to Chapter 6 of the guide, delineators are 5 to 10 centimeters wide and at least 1.2 meters tall, with reflective stripes near the top. Stationary delineators are preferred over flexible ones because drivers view flexible delineators as less of a collision threat and may not heed them. Delineators are not permitted as separators if the speed limit is above 50 kilometers per hour.

Signage

Book 18—Cycling Facilities, Ontario Traffic Manual, Ministry of Transportation of Ontario, December 2013.
http://www.library.mto.gov.on.ca; search "Ontario Traffic Manual."
This manual offers significant guidance related to signage in cycle tracks. In general, it offers two signage options: designers can use signs from the OTM or the TAC Bikeway Traffic Control Guidelines for Canada.

The manual provides guidance for cycle track signage in Section 4.2.2.2 (protected cycle tracks) and Section 4.3.1.2 (raised cycle tracks).

Reserved Bicycle Lane

Both protected and raised cycle tracks must be designated with a Reserved Bicycle Lane sign. When the cycle track is adjacent to the curb, a ground-mounted version should be installed, either OTM sign Rb-84A or TAC sign RB-91. Otherwise, OTM sign Rb-84 or TAC sign RB-90 should be installed on a cantilever and centered above the cycle track.

If the OTM signs are used, a Reserved Lane Ends tab sign (Rb-85t) must be attached below the final Reserved Bicycle Lane sign, and a Begins tab sign (Rb-84t) may be attached below the first Reserved Bicycle Lane sign on the cycle track. If the TAC signs are used, the final Reserved Bicycle Lane sign should be replaced with a Reserved Bicycle Lane Ends sign (RB-92).

Reserved Bicycle Lane signs should be repeated after every intersection. Between intersections, sign frequency should be determined through engineering judgment, considering the speed of bicycles and other traffic, and the distance between intersections. The maximum permitted spacing, however, is 200 meters. (Note that page 109 of the OTM states that the maximum permitted spacing of this sign on raised cycle tracks is 20 meters; however, Tracey Difede, senior project manager, Operations, Ontario Ministry of Transportation, confirmed that this is a typo and maximum spacing is the same—200 meters—as it is in protected cycle tracks.)

Oversized versions of the reserved bicycle lane signs and tab signs are permitted at sites where conditions warrant greater visibility, such as complex environments where there are many signs and other visual stimuli competing for driver attention, or high-traffic locations where drivers need to concentrate more on driving.

Reserved Bicycle Lane Ahead
A Reserved Bicycle Lane Ahead sign (TAC sign WB-10) is an optional sign that may be placed adjacent to or above the curb lane ahead of a cycle track. It should be considered in locations where motorists are required to maneuver their vehicles to avoid the cycle track.

Turning Vehicles Yield to Bicycles
A Turning Vehicles Yield to Bicycles sign (TAC sign RB-37) is optional and should be considered at conflict zones where motorists turn to cross either a protected or a raised cycle track and are required to yield to cyclists. It should also be considered if a raised cycle track transitions to a conventional bicycle lane on the approach to an intersection, or at driveways where there is a significant number of right-turning vehicles crossing the cycle track and the vertical separation of the cycle track is reduced. The sign should include the type of bicycle facility markings or treatments in the conflict zone. Green surface treatment may be used in addition to or instead of this sign.

Bicycle Trail Crossing Side Street
A Bicycle Trail Crossing Side Street sign (TAC sign WC-44L or WC-44R, depending on which side of the street the cycle track is located) should be used on the approach to an intersection where a raised cycle track crosses the side street close to the through road. If the cycle track crosses that side street on the left-hand side of the through road, the sign should be installed on both sides of the road to ensure it is visible to left-turning traffic. A Trail Crossing tab (TAC sign WC-44T) may be attached below the Bicycle Trail Crossing Side Street sign to help convey its meaning.

NACTO Urban Bikeway Design Guide, National Association of City Transportation Officials, March 2014.
http://nacto.org/cities-for-cycling/design-guide/
The guide lists very few signs as required features for cycle tracks; however, it lists several signs as recommended or optional features.

Yield to Bikes
At conflict areas, the guide recommends Yield to Bikes signage in addition to color and yield lines for all types of cycle tracks to identify conflict areas and make clear that the cycle track has priority over entering and exiting traffic. Sign options include a variant of MUTCD R10-15 that includes a helmeted bicycle rider symbol, MUTCD R1-5 or 1-5a.

Bike Lane
On one-way cycle tracks, a Bike Lane sign (MUTCD R3-17) may be used to designate the bicycle lane. An additional No Cars sign may be added to this sign to clarify it.

One Way
If a two-way cycle track is located on a one-way street, a One Way sign (MUTCD R6-1 or R6-2) is required with an Except Bikes plaque. This sign should be located along the facility and at intersecting streets, alleys and driveways.

Do Not Enter
A Do Not Enter sign (MUTCD R5-1) with an Except Bikes plaque is required along two-way cycle tracks.

Complete Streets Manual, Chapter Nine of the City of Los Angeles Mobility Plan (Draft), Los Angeles Department of City Planning, February 2014.
http://planning.lacity.org/Cwd/GnlPln/MobiltyElement/Text/CompStManual.pdf
Chapter 15.2 of this draft manual describes signage for bikeways. All signs should be retroreflective, and mounting height and lateral placement should follow the guidelines in the California MUTCD, Part 2.

The manual offers guidance for bicycle facility signs. This guidance is not specific to cycle tracks; however, it provides an overview of guidance for signs that address specific conditions (dips, narrow bridges, slippery when wet) that may be appropriate for cycle tracks when those conditions are present.

Traffic Signs Policy Paper: Signing the Way, Department for Transport, London, October 2011.
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/4346/signing-the-way.pdf
This guidance document offers recommendations instead of regulations to simplify the traffic sign system. Section 5.44 addresses cycle track signage, suggesting that smaller-than-standard signs may be provided on cycle tracks where they are intended for bicycles only.

Pavement Markings

Outside of intersections (which are described in **Intersection Treatments**), there is limited guidance for pavement markings on cycle tracks. Typical pavement marking recommendations include a white bicycle symbol, the words “Bike Lane” and/or arrows on the lane itself. Buffer zones typically are delineated with white lines, potentially with diagonal crosshatches to add emphasis. Two-lane cycle tracks typically require a yellow centerline. Several sources make allowances for colored pavement to define the cycle track or a color other than white for edge lines for branding purposes.

Book 18—Cycling Facilities, Ontario Traffic Manual, Ministry of Transportation of Ontario, December 2013.
http://www.library.mto.gov.on.ca; search “Ontario Traffic Manual.”
The OTM describes pavement markings for protected cycle tracks (Section 4.2.2.3) and raised cycle tracks (Section 4.3.1.3). (Guidance for cycle track pavement markings at intersections is given in **Intersection Treatments**.)

According to the manual, both protected and raised cycle tracks should be marked by a white diamond and a white bicycle symbol. The diamond should be centered in the bicycle lane and have a stroke width of at least 75 millimeters. An optional directional arrow may be used where additional guidance is required.

When intersections are more than 400 meters apart, these bicycle symbols should have a minimum spacing of 200 meters. However, designers may place symbols more frequently if factors such as conflict zones require them to highlight presence of cyclists.

For protected cycle tracks, the buffer should be delineated by 100-millimeter solid white lines spaced at least 0.5 meter apart. The guide states that the line that defines the boundary between the buffer and the motor vehicle travel lane may be larger, from 100 to 200 millimeters wide. In addition, these edge lines may be a color other than white for branding purposes.

Diagonal hatched lines may be used between the buffer edge lines. If used, the guide recommends these lines be spaced 3 meters to 12 meters apart, depending on motor vehicle speeds: when motor vehicles travel faster the lines should be spaced more widely apart.

In conflict zones where vehicles may pass into a bicycle lane, the buffer should be discontinued and a dashed white bicycle lane should extend from the line that defines the boundary between buffer and travel lane. The dashed line is 100 to 200 millimeters wide and alternating 1-meter lines with 1-meter gaps.

Designers may apply a solid white edge line to raised cycle tracks that are intermittently flush with the roadway; other colors may be used for branding purposes.
Two-way cycle tracks should have a 100-millimeter yellow dividing line in the center to separate lanes. This line should be solid where there are reduced sightlines to discourage passing, and broken where passing is permitted.

NACTO Urban Bikeway Design Guide, National Association of City Transportation Officials, March 2014.
http://nacto.org/cities-for-cycling/design-guide/
According to the guide, Bicycle Lane word, symbol and/or arrow markings, as described in MUTCD Figure 9C-3, shall be placed at the beginning of all types of cycle tracks and at periodic intervals based on engineering judgment.

When pavement markings separate the cycle track from motor vehicle parking lanes, the buffer shall be delineated by solid white lane markings; diagonal crosshatch markings (as described in MUTCD Section 3B.24) may be added to the buffer area for special emphasis.

The guide recommends using color and yield lines in all types of cycle track to identify conflict areas.

A Bike Only word marking, as described in MUTCD Section 3D.01, is an optional feature that may be used to supplement Bicycle Lane word and symbol markings in one-way cycle tracks. Colored pavement is also an optional feature for defining the bicycle lane.

On two-way cycle tracks, a dashed yellow line should separate the lanes.

On raised cycle tracks, the guide recommends using color, pavement markings and textured surfaces to discourage pedestrian use of the cycle track if it is flush with the sidewalk. Landscaping and other furnishings can also be used to discourage pedestrians from using the cycle track. The guide also recommends supplemental shy distance striping at the entrance of a curb-protected cycle track to encourage cyclists to keep their distance from the curb.

Cycle Tracks: Concept and Design Practices, Association of Pedestrian and Bicycle Professionals, February 17, 2010.
http://nctcog.org/trans/committees/bpac/CycleTracksPresentation_2.17.10.pdf
In this webinar, Rob Burchfield, city traffic engineer, Portland (OR) Bureau of Transportation, described the city's SW Broadway cycle track. Pavement markings include a white bicycle logo and arrow at entrances to the cycle track, "Bike Lane" words in white at midblock, and a green bike box and bike lane within white dashed lines at intersections.

Cycle Tracks: Lessons Learned, Alta Planning + Design, February 4, 2009.
http://www.altaplanning.com/wp-content/uploads/Cycle-Track-Lessons-Learned-Study.pdf
According to this report, pavement markings in two-way cycle tracks should indicate lane direction, and tracks wider than 6.5 feet should have a 4-inch painted centerline, especially at bends.

Intersection Treatments

Book 18—Cycling Facilities, Ontario Traffic Manual, Ministry of Transportation of Ontario, December 2013.
http://www.library.mto.gov.on.ca; search "Ontario Traffic Manual."
The manual describes recommended treatments for cycle tracks at intersections in Sections 4.2.2.4 and 4.3.1.4. Protected cycle tracks should have an advanced stop bar at intersections to allow cyclists to position themselves ahead of motorists during a red signal. Designers should consider the characteristics of the site in determining if any treatment options should be applied through the intersection. Available options, in increasing order of visibility, are:

- No treatment.
- Bike stencils or chevrons spaced 1.5 to 10 meters apart (with optional directional arrows).
- Sharrows spaced 1.5 meters to 15 meters apart.
- Dashed guide lines (with optional bike stencils or chevrons—but not sharrows).
- Green surface treatment.
- Dashed guide lines (with optional bike stencils or chevrons, but not sharrows) in conjunction with green surface treatment.

The manual offers two possibilities for raised cycle tracks at intersections. The first, which is suitable only for one-way raised cycle tracks, is to transition it down a ramp into a conventional bicycle lane on the approach to an intersection, and then back up to a raised cycle track following the intersection. This option can improve visibility of cyclists in advance of the conflict point and may be appropriate if cyclists on the cycle track are obscured from motorists by on-street parking. In that situation, the manual recommends a triangular taper producing a 10- to 15-meter gap between the end of the parking lane and the point where the bike lane is adjacent to the motor vehicle lane. The offset from the end of the taper to the stop bar varies between sites based on the configuration of the approach to the intersection (particularly sight lines), driver and cyclist behavior, and the needs of cyclists who must merge with traffic to turn left.

The second option, which is suitable for one-way or two-way raised cycle tracks, is to continue the raised cycle track through the intersection as a crossride. In this option, the cycle track will bend away from the motor vehicle travel lane on the approach to the intersection and cross with a minimum offset of 4.0 meters to give turning motorists good visibility of crossing cyclists. This option may require the stop bar on the side road to be set back as well. Where the cycle track intersects a sidewalk, the cycle track should have a white stop bar 1 meter from the sidewalk, accompanied by a Cyclists Stop Here on Red Signal sign. This stop bar may be replaced by yield lines—a row of solid white isosceles triangles with a 30- to 60-centimeter-wide base spaced 5 to 30 centimeters apart, pointing toward approaching bicycle traffic—with a Yield to Pedestrians sign (TAC sign RB-39 or OTM sign Rb-73) to warn cyclists that they are entering a pedestrian zone. A Bicycle Crossing on Side Street sign may be installed to notify motorists

approaching the intersection of the potential of crossing bicyclists, and a SLOW Watch for Turning Vehicles sign may be installed to warn cyclists.

The manual recommends two-stage left turn queue boxes for both raised and protected cycle tracks to allow cyclists in a cycle track to safely make left turn movements in two stages. These queue boxes are square or rectangular boxes marked in 100-millimeter-wide solid white lines, surrounding a bicycle symbol oriented toward the direction from which bicyclists enter the intersection, and a turn arrow that points in the direction cyclists will leave it. The manual recommends using a green surface treatment to enhance the queue box's visibility.

Since cyclists in the queue box may block motor vehicles from turning right from the cross street, "designers should consider restricting this right turn on red." An alternative option places the queue box within the boulevard corner instead of the intersection, which does not impede right turns on red from the cross street. That option is not yet implemented and is not currently a recommended practice, but it may be considered if the context is appropriate.

Book 12—Traffic Signals, Ontario Traffic Manual, Ministry of Transportation of Ontario, March 2012.
http://www.library.mto.gov.on.ca; search "Ontario Traffic Manual."
Book 12 provides no specific guidance for cycle tracks. However, Section 2.5 notes that while bicycle-specific signal lenses (traffic signals with images of bicycles on their lenses) are in use in other parts of Canada, "the Province of Ontario currently has no legal regulations or statutes for bicycle signals." It adds that the TAC is currently formulating usage guidelines and specifications for using bicycle signals and that such signals are proposed future legislated items.

NACTO Urban Bikeway Design Guide, National Association of City Transportation Officials, March 2014.
http://nacto.org/cities-for-cycling/design-guide/
Additional detailed information about intersections is available at http://nacto.org/cities-for-cycling/design-guide/intersection-treatments/cycle-track-intersection-approach/.

The only requirement noted in the guide is that for two-way cycle tracks, intersections need to include traffic controls oriented toward bicycles on the cycle track traveling in the contra-flow direction.

However, it does make several recommendations for intersection treatments. The guide quotes the CROW Design Manual for Bicycle Traffic in recommending that cycle tracks be bent in (toward the motor vehicle lane) 20 to 30 meters before an intersection to improve cyclist visibility.

For parking-protected cycle tracks, it recommends at least a 30-foot no-parking area extending from each side of a driveway or minor street crossing to improve visibility. Design should accommodate a 20-foot sight triangle from the cycle track to minor street crossings and a 10-foot sight triangle from the cycle track to driveway crossings.

Intersection crossing markings with truncated cycle tracks should indicate the paths of bicyclists through the intersection. These markings must include dotted lines that define the bicycle crossing space as described in MUTCD Section 3B.08 that are the same color and at least the same width as the markings they extend. Adjacent to motor vehicle travel lanes, these stripes must be at least 6 inches wide. Dotted lines should be 2 feet long, spaced 2 to 6 feet apart.

Pavement markings should be white, skid-resistant and retroreflective. (See http://nacto.org/cities-for-cycling/design-guide/intersection-treatments/intersection-crossing-markings/.

Two-way cycle tracks should include either a yellow centerline or bicycle silhouettes and/or chevrons in opposite directions in the two lanes in the intersection to indicate that there is two-way traffic.

The guide gives several options for pavement markings to increase visibility, including:

- Chevrons, either in conflict areas or across entire intersections. These should be placed in the middle of lanes, close to crosswalks. Sharrows may also be used if the cycle track transitions to a shared bicycle lane through the intersection.
- Helmeted rider or bicycle symbol pavement markings in conflict areas or across entire intersections. Symbols may be rotated to face cross-traffic in the middle of the bicycle lane.
- Colored pavement or elephant's feet markings may also be used to increase visibility.
- A combination of strategies.

Yield lines—a row of solid white isosceles triangles pointing toward approaching vehicles—may be used to mark the edge of the bike lane at driveways and alleyways.

The guide recommends two-stage turn queue boxes to help cyclists make left turns safely.

At intersections where there is a large amount of right-turning traffic, a bike box or advanced stop bar may be provided to allow bicyclists to position themselves ahead of motorists.

When motor vehicles cross the cycle track, the guide recommends they be constrained or channelized to make their turns at sharp angles to reduce travel speed.

If the cycle track transitions to a bike lane at an intersection, the absolute minimum width is 4 feet, with a desirable minimum of 6 feet. At constrained intersections with right turn lanes, the guide recommends considering a combined bike lane/right turn lane.

If raised cycle tracks transition to a standard bike lane at an intersection, the slope should include tactile warnings or pavement markings that will slow bicyclist speed. The maximum slope should be 1:8 for this transition.

Exclusive bicycle signal phases may be used to segregate conflicting movements from bicyclists and motorists.

When there is a transit stop at a location, designers should consider wrapping the cycle track behind the transit stop to reduce conflicts; cyclists should be directed to yield to pedestrians in these areas.

Raised cycle tracks should maintain their elevation through the intersection, helping to serve as a speed hump for motor vehicles.

East-West Segregated Bike Lane Pilot Project Draft Report, City of Ottawa, January 25, 2011.
http://ottawa.ca/en/city-hall/public-consultations/transportation/background-reports
Based on observations of practices in Vancouver, Portland, OR, and European cities, Ottawa decided to implement two-stage left turn queue boxes at intersections. This treatment requires banning right turns on red for motor vehicles from the cross street.

The report identifies three approaches to reducing conflict between right-turning vehicles on the through street and bicycles on the cycle track:

- A separate bicycle green phase, which significantly reduces conflict risk but greatly increases delays.
- Merging right-turning traffic into a segregated cycling lane with pavement markings to mark the area as a shared zone. This reduces risk but may be intimidating to inexperienced cyclists, and the bicycle lane may become blocked if there are high volumes of turning vehicles.
- Signage to tell right-turning drivers that they must yield to cyclists continuing straight through the intersection. This clarifies right of way.

Ottawa opted to combine the first and third options. In addition to signage, the city offers a five-second advanced green arrow for cyclists to allow bicycles to clear the intersection and better create gaps for right-turning traffic.

Signage selected for intersections include a Bike Lane Designation sign and Right-Turning Vehicles Yield to Bikes signs. Pavement markings include advanced stop bars at all intersections 5 meters ahead of the motor vehicle traffic stop bar, and a blue bicycle lane painted through intersections.

At driveways and entrances, common treatments are colored pavement with bicycle symbols or raising the pavement. Ottawa selected colored pavement because the pilot project was a temporary facility and raising the pavement at all driveways and entrances was not feasible.

Cycle Tracks: Concept and Design Practices, Association of Pedestrian and Bicycle Professionals, February 17, 2010.
http://nctcog.org/trans/committees/bpac/CycleTracksPresentation_2.17.10.pdf
In this webinar, Peter Furth, professor of civil engineering, Northeastern University, suggested that bike silhouettes and color are options to improve safety at driveways and minor intersections by making it clear that the crossing is not a parking lane or a sidewalk. Raising the cycle track can also clarify that cycles have priority and have a speed bump effect.

At signalized intersections, Furth identified options including a protected left (left turn on green arrow only) and bicycle signal heads if the green periods for bicycles are different than those of cars. A leading “through” arrow can protect the first group of waiting bikes against motor vehicles crossing their path.

At the end of a cycle track, Furth warned about simply dumping wrong-way bike traffic into the street. Options to avoid this include jughandles to make it safer for bicycles to cross over to the proper lane and a corral where turning bikes can wait.

Rob Burchfield, city traffic engineer, Portland (OR) Bureau of Transportation, described the city's SW Broadway cycle track. Intersections include a green bike box, a green bike lane within white dashed lines and two-stage left-turn queue boxes.

Collection of Cycle Concepts 2012, Troels Anderson, Frits Bredal, Marianne Weinreich, Niels Jensen, Morten Riisgaard-Dam and Malene Kofod Nielsen, Cycling Embassy of Denmark, 2012.
http://www.cycling-embassy.dk/wp-content/uploads/2013/12/Collection-of-Cycle-Concepts-2012.pdf
Denmark has a "10-meter rule" that generally prohibits motor vehicles from parking within 10 meters of an intersection to improve visibility. However, when cycle tracks are present, this distance should be increased to 20 to 30 meters.

Bike boxes are not used in Denmark as bicycles are prohibited by law from making left turns from the vehicle lane. However, the stop line for cars is generally set back 5 meters from the cyclist stop line to improve visibility of cyclists and reduce conflicts at the start of the green phase.

Cycle tracks typically continue through the intersection as a blue thermoplastic cycle crossing or as "international cycle crossing designs" indicated by one or two 30-centimeter-wide dashed white lines and cycle symbols. The blue lane is considered more visible and safer than the international cycle crossing. However, more than one blue cycle crossing has been found to have a negative impact on road safety. Copenhagen permits up to two blue cycle crossings per intersection, but only after careful consideration of road safety issues at the specific intersection.

Separate cyclist signals are optional intersection treatments. These signals often provide a pre-green for cyclists before the motor vehicle green period as well as a shortened green phase for cyclists to help make the intersection more passable for motor vehicles. Cyclist signals with a countdown function have not been tested in Denmark.

Shunts, a right-turn lane for cyclists behind the traffic signal post that allows them to turn right on red, are popular among cyclists and permitted at intersections if there is enough space and they do not prevent adequate pedestrian facilities from being provided.

Complete Streets Manual, Chapter Nine of the City of Los Angeles Mobility Plan (Draft), Los Angeles Department of City Planning, February 2014.
http://planning.lacity.org/Cwd/GnlPln/MobiltyElement/Text/CompStManual.pdf
Options provided by this draft manual for intersections include protected cycle phases and advanced signal phases. When protected cycle phases are provided, bike boxes should be implemented if frequent cyclist left turns are anticipated.

Cycle Tracks: A Technical Review of Safety, Design, and Research, City of Cambridge, June 2014.
http://www.cambridgema.gov/~/media/Files/CDD/Transportation/Bike/Final_CycleTrackWhitePaper_20140722.ashx
Options for intersection treatments include continuing a protected cycle track to the intersection, creating a mixing zone where motor vehicles yield to cyclists and merge to make turns, maintaining a raised cycle track across the intersection, or transitioning the cycle track into a standard bike lane.

When a protected cycle track continues to the intersection, parking is restricted for some distance before the crosswalk to improve visibility. This distance is typically 20 feet but may be greater depending on travel speeds and stopping sight distances. Designing chicanes is also recommended for the cycle track to reduce bicyclist speed and improve visibility. This chicane is a reverse S-curve with approximate centerline radii of 22 feet, followed by 13 feet.
In mixing zones, cars should be angled into the mixing zone to reduce their speed. A Turning Vehicles Yield to Bicycles sign (Modified MUTCD sign R10-15) should be posted to clarify that bicycles have priority.

Transitioning to a standard bicycle lane is appropriate only in limited circumstances based on engineering judgment. The transition should occur prior to the intersection, and additional treatments such as bicycle boxes, turn queue boxes, green pavement, warning signs and/or separate signal phases should be considered.

Two-stage left-turn queue boxes are common practice in Europe and typically the easiest and most comfortable way for most cyclists to turn left from a cycle track.

Dedicated signalization for bicycles is an option for managing conflicts between different types of vehicles. The MUTCD allows standard signals to be designated for bicycle use by a regulatory sign. FHWA has also provided interim approval for the optional use of bicycle signal faces. Bicycle detection may be installed to reduce delay at bicycle signals. Push-button actuation is not recommended because it often poses a challenge for bicyclists, but loop detection, video detection and microwave detection are all viable detection technologies.

Treatments to facilitate access to two-way cycle tracks vary based on roadway conditions, but include pavement markings, colored pavement, signage, signalization or geometric features such as median islands.

Colored pavement can be used on cycle tracks to communicate upcoming intersections or driveways where reduced speeds and increased awareness are required.

A standard indicator (whether shared lane marking symbols, standard bicycle symbols, or oversized shared lane marking or bicycle symbols) should be selected for intersection crossings and maintained throughout the network for clarity, although the symbol may be supplemented with dashed lines.

Many communities use temporary educational signage to help users predict movements by different modes of travel.

Cycle Tracks: Lessons Learned, Alta Planning + Design, February 4, 2009.
http://www.altaplanning.com/wp-content/uploads/Cycle-Track-Lessons-Learned-Study.pdf
Options to show drivers that bicyclists in cycle tracks have right of way at driveways and side streets include bicycle pavement markings or a change of the cycle tracks marking, coloration or texture. The cycle track shouldn't change grade; instead, motorists should have to mount the curb to cross.

According to the CROW Design Manual for Bicycle Traffic, if the speed of the main street is 45 mph or less, the cycle track should turn inward (toward the main street) before the intersection to improve the visibility of cyclists to right-turning cars. At greater speeds, the cycle track should bend away from the main road so vehicles leaving the main road can stack up on a cross street. Signs should also warn motorists of the cycle track crossing.

At intersections with a cycle track in Amsterdam and Copenhagen, the stop line for motor vehicles is generally set back about 16 feet. The cycle track may be converted to a bicycle lane at this point; if so, the bike lane should be colored and lane markings can continue through the intersection at certain locations. According to the CROW manual, if colored pavement markings indicate a bicycle crossing, their width should be 8 feet.

Parking should be removed from intersections 16 feet ahead of the intersection to increase cyclist visibility. Reducing curb radii at a turn will also increase cyclist visibility by ensuring automobiles will cross in a smaller area.

Signal phase options in use include a completely separated bike phase or an advanced warning signal (which can be a two-second yellow warning, a pre-green interval or a bicycle countdown signal) that allows cyclists to prepare to cross the intersection.

When there are separate bike phases, a bicycle signal head is required. These can be distinguished from general traffic signals by using a bicycle emblem within the signal lens display, a bicycle emblem above the signal lenses and a smaller signal head and lenses (approximately 4 inches wide), or a Bicycle Signal sign adjacent to a conventional signal head. If low cycle traffic is expected, a demand-responsive signal actuated by a push button or embedded loop within the cycle track can reduce delay. When cyclists travel through the intersection on a protected phase, cars must not be permitted to make right turns on red.

At intersections where there are significant volumes of right-turning bike traffic, the cycle track should have a right-turn lane. A slip lane can be provided to allow cyclists to turn right on a red light into a cycle track.

Cyclists must make two-phase left turns and in many cases are physically prevented from turning left from a cycle track by the cycle track barrier.

Focus on Cycling: Copenhagen Guidelines for the Design of Road Projects, City of Copenhagen Technical and Environmental Administration/Traffic Department, The Bicycle Programme, December 2013.
http://kk.sites.itera.dk/apps/kk_pub2/pdf/1133_mLNsMM8tU6.pdf
These guidelines seek to ensure that bicycle traffic is factored into all Copenhagen road products. They include options for intersections, although not all are specific to cycle tracks and generally do not include detailed design information.

Intersection options include:

- Setback stop lines for cars, which is a standard treatment when a cycle track or bike lane continues to the pedestrian crossing. Stop lines are set back by 5 meters.
- Cyclist signals, typically placed on the main signal pole or positioned as a low signal near the main signal pole at a minimum height of 1.5 meters. When special cyclist signals are installed, cyclists are given a four-second pre-green signal cycle, and the setback stop line for cars is unnecessary. If buses traveling straight through the intersection are given a pre-green cycle, cyclists should be as well if a cycle track exists. Right-turning cars in this situation should be given a green at the end of the signal cycle rather than the beginning to avoid conflicts with cyclists at the corner.

- If an intersection has many right-turning cars, a pre-green for cyclists can be combined with a shortened green time for cyclists at the end of the phase, with a right-turn arrow for motorists at that time.
- A traffic island established between right-turn lane and the straight-ahead lane for motor vehicles could permit left-turning cyclists to turn from the lane beyond the island. (While the guide suggests this as an option for cycle tracks, it also notes that Copenhagen requires bicycles to make left turns in two-stage movements, which implies that this is not truly a permitted option.)
- Bike boxes should be long enough for all bicyclists to fit in but only installed in front of the inner traffic lane; extending it to the middle of an intersection may tempt cyclists to make a left turn from the middle of the intersection, which is illegal in Denmark. Two types have been tested: a blue box and a box marked with white lines.
- Blue cycle crossings (in which the cycle lane is painted blue across the intersection) are permitted but should be limited in number. One blue cycle crossing in an intersection has been found to have a positive safety impact, while more than that reduces safety. However, up to two blue cycle crossings per intersection are permitted after a thorough safety analysis.
- International cycle crossings, which are delineated by a broken white line and bicycle symbol, are standard at all legs of a signalized intersection where blue cycle crossings are not installed.
- Right or left turn lanes may make sense if there is a significant amount of turning cycle traffic in a wide cycle track.

It is standard to continue a cycle track at its full width to the intersection. However, it is acceptable if there is limited space to transition to a 1.5-meter cycle lane at the intersection.

After intersections, the cycle track should be widened for 20 to 30 meters if there are a large number of cyclists to allow them to merge after crossing. This has recently been implemented and is expected to become a mainstream practice.

At T intersections, cycle tracks may be exempted from signal control in the “T-bar”, but they must yield to pedestrians in uncontrolled crosswalks. Left-turn lanes may be installed to help cyclists position themselves appropriately. When this is present, the left-turn cycle lane through the intersection should be marked as a cycle crossing, preferably in blue, so left-turning drivers do not overlook the cyclists. Additionally, turning cyclists should be controlled by a cyclist traffic signal. Ramps from the cycle track to the street should be marked in white thermoplastic for visibility.

Protected Intersections for Bicyclists, Nick Falbo, Alta Planning + Design, 2014.
http://www.protectedintersection.com/
This proposal, based on Dutch intersection designs, was submitted for the Cameron Rian Hays Outside the Box Competition, a contest for actionable plans to solve current transportation or transportation policy problems at George Mason University.

The protected intersection includes:

- Corner refuge islands for bicyclists that separate them from cars while making right turns or waiting at a red signal.

- A forward stop bar for bicyclists (potentially 30 to 40 feet ahead of motor vehicle stop bars).
- A setback crossing which bends the cycle track away from the automobile lane to create at least one car length of space (6 meters) so that drivers turn 90 degrees and face the bike lane before crossing it to improve bicycle visibility.
- A small corner radius that encourages a slow turning speed of 5 to 10 mph.
- Bicycle-friendly signal phasing (which can take the form of a protected signal phase for bicyclists that uses red signals to prohibit car movements, a simultaneous green phase for all bicyclists in the intersection while all vehicles have a red phase to give bicyclists full rein of the intersection, or a two- to five-second leading bicycle interval).

Protected intersections are still unconventional and nonstandard, and the site describes the concept as "exploratory and experimental." In an email, Falbo said that he plans to release a white paper in the near future with detailed design drawings. He said that a few Canadian cities have constructed similar designs, but they have not been implemented in the United States (although Davis, CA; Austin, TX; Salt Lake City, UT; and Mountain View, CA, all have proposals in the works).

London Cycling Design Standards, draft for consultation, Transport for London, 2014. Available at https://www.tfl.gov.uk/corporate/publications-and-reports/cycling
This document updates the 2005 London Design Standards. Chapter 5 addresses cycle facilities at intersections.

At priority (uncontrolled) junctions, motor vehicle speed reduction through raised tables, entry treatments or a reduced corner radius is highly recommended. There are three methods to visually convey the cycle track's priority: continuing the cycle track through the junction without deviation, bending the cycle track in to convert it to a bike lane adjacent to the carriageway, or bending the cycle track away from the main road to produce space for motor vehicles to wait for cyclists. Colored pavement may reinforce visual priority but should not be relied upon as the only notification. (Section 5.3.4)

Traffic signals for cyclists are generally trial measures, but have the potential to become "important parts of the toolkit for cycling infrastructure in the U.K." Options include a red cycle aspect on a standard traffic signal head, low-level cycle signals or box signs. (Section 5.4.3)

Advance green phases for cyclists typically range from three to five seconds. (Section 5.4.4)

Cycle Track Crossings of Minor Roads, TRL Limited Report 462, A. Pedler and D.G. Davies, 2000. (Not available online)
This report was the result of a comparative study of safety at several intersections where cycle tracks are present. Based on the results, the report recommends that cycle tracks should be bent out at intersections where site conditions allow.

The project observed five sites: two with bent-out, humped crossings; two with straight and humped crossings; and one with a straight and flat marking. The sites with bent-out crossings had the fewest potentially hazardous interactions between cyclists and motor vehicles, pedestrians or other bicycles. Humped cycle track crossings were effective at slowing drivers and communicating the presence of a crossing, although they did not prevent drivers from obstructing a straight crossing.

Planning and Design for Pedestrians and Cyclists: A Technical Guide, Marc Jolicoer, Vélo Québec, 2010. (Not available online)
According to Chapter 5 of this guide, parking must be prohibited for at least 6 meters from the end of an intersection's curb radius if the cycle track is adjacent to a parking lane.

Accessibility

NACTO Urban Bikeway Design Guide, National Association of City Transportation Officials, March 2014.
http://nacto.org/cities-for-cycling/design-guide/
According to the guide, raised cycle tracks may function better for people with mobility disabilities than street-level cycle tracks. However, a widened buffer may be provided if accessible parking spaces are located adjacent to the raised cycle track to accommodate a side-mounted ramp or lift. The raised cycle track may be flush with the buffer and the adjacent sidewalk at these locations, and street furnishings should be placed to minimize conflict.

Ensuring accessibility of parking spaces near protected cycle tracks may require more considerations, including consideration of local parking regulations and the variables of the roadway context. Aspects that should be considered include the following:

- A widened buffer space may be provided to accommodate side-mounted vehicle ramps or lifts.
- Midblock curb ramps may be provided near accessible parking spaces—or at consistent intervals along the cycle track.
- Cross-slopes across the cycle track should not exceed 2 percent as greater slopes will create difficulty for some bicyclists and some disabled users.
- If there is significant taxi or paratransit service along the cycle track, designers should consider providing periodic loading zones to allow vehicles to pull out of the travel lane.
- Bollards placed in the buffer area should not impede access by disabled users. The guide recommends outreach and education to vision-impaired individuals to help them understand changes to the roadway. Design elements such as tactile surfaces may also help visually impaired users to orient themselves.
- Raised medians, bus bulbs or curb extensions may be configured in the buffer area to accommodate transit stops.

Two-way cycle tracks have similar accessibility concerns as one-way cycle tracks, but their greater overall width may make it easier to accommodate disabled users.

East-West Segregated Bike Lane Pilot Project Draft Report, City of Ottawa, January 25, 2011.
http://ottawa.ca/en/city-hall/public-consultations/transportation/background-reports
Ottawa's paratransit service makes regular stops along the location of the cycle track. Due to narrow roadway widths in some locations, the report recommends relocating one of the service's designated stopping areas to a nearby side street. At other stopping zones, the service was expected to use existing hotel zone, taxi zone or on-street parking spaces already provided. Paratransit vehicles are allowed to stop outside of designated stopping zones to load

passengers as well; in some places, however, there is not enough room for the vehicles to lower side-door ramps without blocking the cycle track. In those locations, the report recommends the buses use north-south cross streets or parallel adjacent streets instead.

The report identifies several options to address conflict zones between bus stops and cycle tracks:

- A pedestrian island for transit passengers, as recommended by the CROW Design Manual for Bicycle Traffic.
- Cyclist Yield to Pedestrian signage and a painted crosswalk in areas where bus passengers may need to cross bicycle lanes to reach the bus lane.
- Allowing transit vehicles to enter and block the bike lane to allow passengers to board.

Appendix F: Design Guidelines, County of Los Angeles Bicycle Master Plan, 2012.
http://dpw.lacounty.gov/pdd/bike/docs/bmp/Appendix%20F.pdf
This plan contains several accessibility requirements for bike paths that may also be applicable to cycle tracks. Among these requirements: Slopes should not exceed 5 percent, although there are limited conditions where steeper slopes are acceptable:

- 8.33 percent slopes are permitted for runs up to 200 feet.
- 10 percent slopes are permitted for runs up to 30 feet.
- 12.5 percent slopes are permitted for runs up to 10 feet.

The surface must be firm and stable, defined by the Forest Service Accessibility Guidelines as one not noticeably distorted or compressed by a device that simulates a person in a wheelchair. Passing spaces should be provided every 100 feet, and the cross slope should not exceed 5 percent. Signs should indicate the length of the accessible trail segment, and ramps should be provided at roadway crossings (with tactile warning strips and auditory crossing signals also recommended).

Related Resource:

Designing Sidewalks and Trails for Access, Federal Highway Administration, 2001.
http://www.fhwa.dot.gov/environment/sidewalk2/contents.htm
Chapter 7 of this best practices guide provides recommendations for curb ramps when trails intersect roads.

Cycle Tracks: A Technical Review of Safety, Design, and Research, City of Cambridge, June 2014.
http://www.cambridgema.gov/~/media/Files/CDD/Transportation/Bike/Final_CycleTrackWhitePaper_20140722.ashx
At intersections, high-visibility crosswalks across the cycle track and tactile warning strips on the sidewalk or medians can improve accessibility. Yield symbols on the pavement, transverse stop lines, chicanes and signage can slow bicyclists and alert them to yield to pedestrians.

Several options ensure transit stop accessibility: removing separation at the stop to allow curbside access, providing transit stop islands in the cycle track buffer space, raising the cycle track to allow pedestrian access across the cycle track from the sidewalk to the curb, or routing the cycle track behind the transit stop. Transit stops should include accessible pedestrian

landing zones for each bus stop door. Tactile warning strips, pavement markings, colored pavement and signage may also be used to alert bicyclists to yield to pedestrians.

Green Lane Project: Accessibility and Protected Lanes, Association of Pedestrian and Bicycle Professionals, July 2, 2014.
http://www.apbp.org/?page=PBL_webinars
This webinar, presented by Craig Williams of Alta Planning + Design and Nathan Wilkes of the City of Austin Transportation Department, reviewed accessibility of protected cycle tracks. In particular, Williams reviewed the U.S. Access Board's Public Rights of Way Accessibility Guidelines (PROWAG) as they relate to accessible parking and how they affect cycle tracks. PROWAG is considered to be "a step before" standards.

Under PROWAG, there must be at least one accessible parking space for every 25 spaces around a block perimeter. Ideally, Williams said, these spots can be located across the street or around the corner from a cycle track. The end of a block is the second choice, and midblock is third.

The loading zone adjacent to an accessible parking space must be at least 5 feet wide with no flex-post bollards or other obstructions. If located at the end of a block, the cycle track may be reduced in width to make space, but not to less than 4 feet overall. The space needs at least 8 feet of clearance behind it to allow access for rear wheelchair ramps. An optional flex-post bollard or raised concrete divider at the end of the block can provide protection for the space against turning vehicles and prevent confusion.

If the accessible space is located at midblock, chicaning the cycle track to provide space is the best option. Alternatively, the cycle track may simply be narrowed. Either way, the sidewalk should have a minimum 4-foot-wide parallel curb ramp with railing. Corduroy-patterned detectable warnings should be used instead of dot patterns. A high-visibility crosswalk should be installed as well as Bicycles Yield to Pedestrians signage in accordance with MUTCD R9-6. The space needs to be 20 feet long to ensure accessibility for rear-loading vehicles.

Traffic Signs Policy Paper: Signing the Way, Department for Transport, London, October 2011.
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/4346/signing-the-way.pdf
Section 5.35 of this policy paper addresses cycle tracks at intersections. Researchers note that cycle safety mirrors are being tested on traffic signal posts at signalized intersections to help heavy vehicle drivers see cyclists on their near side.

Planning and Design for Pedestrians and Cyclists: A Technical Guide, Marc Jolicoer, Vélo Québec, 2010. (Not available online)
The raised cycle track should also have a surface that has a different texture from the pedestrian space that can be detected by the visually impaired. The easiest solution is to use asphalt for the cycle track and concrete or paving stones for the pedestrian area.

Maintenance of Cycle Tracks

Book 18—Cycling Facilities, Ontario Traffic Manual, Ministry of Transportation of Ontario, December 2013.
http://www.library.mto.gov.on.ca; search "Ontario Traffic Manual."
Chapter 8 of Book 18 of the OTM describes maintenance strategies for bicycle facilities. These include sweeping debris from surfaces, performing surface repairs, managing vegetation to protect sight lines and prevent encroachment, maintaining signage and pavement markings, and cleaning drainage facilities.

During winter, the manual notes that simply installing No Winter Maintenance signs is not acceptable. The guide recommends using small, articulated tractors for cycle tracks and other physically separated bicycle lanes. Snowbanks should be removed or reduced if they restrict lane width or sight lines. Abrasives and deicers may be used but "should be used judiciously since they can damage bicycles, clothing and the environment." Abrasives should be swept at the earliest opportunity. Melting snow should drain away from the cycle track to prevent ice from forming during freeze-thaw cycles.

NACTO Urban Bikeway Design Guide, National Association of City Transportation Officials, March 2014.
http://nacto.org/cities-for-cycling/design-guide/
Recommended maintenance practices include keeping cycle tracks free of potholes, broken glass and debris. Street sweeping may be needed more frequently than on streets, particularly in autumn, because the profile of the cycle track and the lack of the sweeping effect of traffic tend to hold leaves.

Snow removal should minimize creation of banks in the buffer zone to avoid snow melting during the day, flowing across the cycle track and then freezing at night. Snow removal can be simplified if the cycle track is located at sidewalk level or if there is a raised median between the parking lane and the cycle track. Special equipment for snow removal and street sweeping may be needed if the cycle track width is too narrow for existing equipment.

To facilitate maintenance, parking restrictions at a regularly scheduled time should be considered, and bollards or flexible delineators may be removed to provide improved access.

The guide notes the importance of configuring gutter seams, drainage inlets and utility covers so as to not impede bicycle travel. It suggests that drainage should slope toward the street, with drainage grates located in the adjacent travel or parking lane.

East-West Segregated Bike Lane Pilot Project Draft Report, City of Ottawa, January 25, 2011.
http://ottawa.ca/en/city-hall/public-consultations/transportation/background-reports
Ottawa selected a minimum cycle track width of 1.8 meters to allow access to its snowplows and street-sweeping equipment.

The report notes that when cycle tracks are delineated by curbs, bollards or similar delineators, a regular repair program is needed to repair or replace delineators that are removed or damaged by maintenance vehicles.

Catch basins and maintenance holes were identified as a minor concern. The cycle track and buffer must be designed to allow maintenance vehicles to park in necessary locations; while the report said that was unlikely to cause design problems, it is a point that must be considered.

Catch basins may catch bicycle tires if their holes run parallel to the cycling lane. The report claims that most catch basins in Ottawa are bicycle-friendly, but that they should be reviewed to ensure their safety for cyclists.

When concrete curbs are used to delineate the cycle track, the curb should be discontinuous to allow water to flow to stormwater sewers.

Appendix F: Design Guidelines, County of Los Angeles Bicycle Master Plan, 2012.
http://dpw.lacounty.gov/pdd/bike/docs/bmp/Appendix%20F.pdf
The plan describes general bikeway maintenance guidelines that would likely apply to cycle tracks. Recommendations include a seasonal sweeping schedule that prioritizes roadways with major bicycle routes and provides extra sweeping in the fall to remove accumulating leaves; chip sealing with the smallest possible chip on bike lanes (and not chip sealing bike lanes when the road surface is chip-sealed if the bike lane condition is satisfactory); using sealants with the same color as the pavement to avoid sealing cracks in concrete segments with asphalt; maintaining a smooth bikeway surface; inspecting pavement two to four months after trenching construction activities to ensure that there has not been excess settlement; removing pavement markings before applying new markings; and using a maximum thermoplastic stencil thickness of 90 millimeters.

Road pavement overlays may improve conditions for cyclists. When an overlay project is undertaken, it should extend over the entire surface to avoid leaving an abrupt edge, although stopping at the shoulder or bike lane stripe may be appropriate if no ridge remains.

Signage should be included in a maintenance management plan and regularly checked and replaced as needed.

Complete Streets Manual, Chapter Nine of the City of Los Angeles Mobility Plan (Draft), Los Angeles Department of City Planning, February 2014.
http://planning.lacity.org/Cwd/GnlPln/MobiltyElement/Text/CompStManual.pdf
This draft manual provides limited maintenance guidance for raised cycle tracks. It states that the bike lane should drain toward the street, and drainage gates should be placed in motor vehicle lanes rather than on the cycle track.

Cycle Tracks: A Technical Review of Safety, Design, and Research, City of Cambridge, June 2014.
http://www.cambridgema.gov/~/media/Files/CDD/Transportation/Bike/Final_CycleTrackWhitePaper_20140722.ashx
Catch basin grates must be the city's standard cascade-type grates with cross bars to prevent them from catching bike tires.

Raised cycle tracks can be pitched either toward the road, to allow water to drain into existing infrastructure or a buffer zone (which may contain stormwater management facilities such as planters or rain gardens), or a central drain may be installed between the sidewalk and the cycle track. Cycle tracks can also be constructed with permeable pavement, which will allow water to drain through the pavement.

Cycle tracks more than 10 feet wide can be included in normal maintenance operations, although flexposts or bollards should be removable to facilitate the clearance of snow in winter. Narrower cycle tracks may require specialized maintenance equipment or agreements with maintenance partners to clean and plow the tracks.

Deicing strategies depend on the configuration of the cycle track and the type of pavement. In particular, salt and deicers are not recommended for use on permeable pavements because they can clog the void spaces of the pavement that water seeps through.

Focus on Cycling: Copenhagen Guidelines for the Design of Road Projects, City of Copenhagen Technical and Environmental Administration/Traffic Department, The Bicycle Programme, December 2013.
http://kk.sites.itera.dk/apps/kk_pub2/pdf/1133_mLNsMM8tU6.pdf
Cycle tracks should be sloped toward the pavement when the cycle track is installed along an existing road, but toward the traffic lane when the cycle track is installed on a new road to eliminate the need for drainage gates on the cycle track.

When installing new cycle tracks or renovating them, side inlet gullies should be installed for drainage rather than drainage grates. Troughs are permitted for cycle track drainage only as a last resort because they do not separate cyclists from pedestrians as well as a curb.

"Winter Bike Lane Maintenance: A Review of National and International Bike Practices," *Perspectives in Planning*, Vol. 2, No. 1, February 2014.
http://www.altaplanning.com/wp-content/uploads/winter-bike-riding-white-paper-alta.pdf
Many cities have specialized ATV-mounted snowplows that are primarily used for clearing sidewalks; these and bombardier snowplows can be used along cycle tracks too narrow for pickup truck-mounted plows. Chicago uses this approach.

Milling the area of pavement where thermoplastic pavement markings are applied by 3 millimeters deep can protect bike lane indicators from damage due to plows.

In Chicago and many other cities with protected cycle tracks, flexible-post bollards are installed along the buffer; they are bolted into the pavement and left up year-round and prevent large truck-mounted snowplows from fitting on cycle tracks.

Much as in general winter road maintenance, anti-icing operations are recommended two hours before a snow event, followed by plowing and deicing as needed after the snowfall. This can reduce the total use of deicing material.

Salt and sand tends to accumulate in bike lanes, which can cause discomfort and safety threats to bikers. Cities should develop a maintenance plan to remove debris once the threat of snow is past, prioritizing primary bike routes.

Heated paths and the use of heated wetted sand are innovative approaches to winter maintenance that have recently begun being tested in Europe.

Planning and Design for Pedestrians and Cyclists: A Technical Guide, Marc Jolicoer, Vélo Québec, 2010. (Not available online)
Chapter 8 of this guide explains that bikeways typically require weekly sweeping. Signs and markings should be inspected at least annually and replaced if damaged.

In winter, the guide recommends plowing and 5-millimeter fine aggregate to provide slip resistance. It claims that sand is ineffective after a few millimeters of snow, and salt is ineffective on snow more than a few centimeters thick or at temperatures below -10 degrees C.

Cycle Tracks in the California Vehicle Code

2015 Vehicle Code, Department of Motor Vehicles, State of California, January 2015. http://www.dmv.ca.gov/portal/wcm/connect/c3d57c91-d5e5-4af7-96d0-d9470b4262f3/veh_code.pdf?MOD=AJPERES
The California Vehicle Code has limited content that is applicable to cycle track design. Section 21456.2 notes that bicycles must obey traffic signals unless there are separate bicycle signals for them to obey instead. Section 21456.3 describes the various actions permitted by bicycles under various forms of signal control.

Section 21760 requires motor vehicles passing a bicycle to keep at least 3 feet between the vehicle and the bicycle. This may imply the necessity of a 3-foot buffer if a cycle track is adjacent to a travel lane.

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