Appendix C

City of Fort Collins

Recommended Bicycle Design Guidelines

This appendix provides general design considerations for implementation of bicycle facilities recommended in the 2014 Bicycle Master Plan (2014 Plan). The appendix begins with an overview of the national, state, and local guidelines and standards (baseline guidance) which form the basis for design in Fort Collins. In some cases the design guidance for a treatment will deviate or expand on the baseline guidance. Discussion is focused on treatments recommended (Chapter 4) for implementation by this 2014 Plan.

This document is not a design standard, and should not be used as such. Application of guidance provided in this document requires the use of engineering judgment. The detailed design considerations for each major treatment are intended to inform a future update to the City of Fort Collins Master Street Plan Classifications and Larimer County Urban Area Street Standards (LCUASS) as appropriate.

1 National Guidelines and Standards

AASHTO Guide for the Development of Bicycle Facilities (AASHTO Bicycle Guide).

The American Association of State Highway and Transportation Officials (AASHTO) is a not-for-profit, nonpartisan association representing state highway and transportation departments. It publishes a variety of planning and design guides, including the AASHTO Bicycle Guide.

The AASHTO Guide for the Development of Bicycle Facilities (2012) is not intended to set absolute standards, but rather to present sound guidelines that will be valuable in attaining good design sensitive to the needs of both bicyclists and other roadway users. The provisions in the Guide are consistent with and similar to normal roadway engineering practices. Signs, signals, and pavement markings for bicycle facilities should be used in conjunction with the MUTCD.

Key provisions in the AASHTO Bicycle Guide include:

- Bicycle planning, including types of planning processes, technical analysis tools, and integrating bicycle facilities with transit
- Bicycle operation and safety, including traffic principles for bicyclists and causes of bicycle crashes
- Design of on-road facilities
- Design of shared-use paths
- Bicycle parking facilities
- Maintenance and operations

Manual on Uniform Traffic Control Devices (MUTCD), 2009

The 2009 MUTCD is a document issued by the Federal Highway Administration (FHWA) of the U.S. Department of Transportation (USDOT) to specify the standards by which traffic signs, road surface markings, and signals are designed, installed, and used. These specifications include the shapes, colors, fonts, sizes, etc., used in road markings and signs. In the United States, all traffic control devices must generally conform to these standards. The manual is used by state and local agencies and private design and construction firms to ensure that the traffic control devices they use conform to the national standard.

The National Committee on Uniform Traffic Control Devices (NCUTCD) advises the FHWA on additions, revisions, and changes to the MUTCD. The committee also evaluates research reports for experimental traffic control treatments to determine the suitability or need for developing changes to the MUTCD.

Key provisions of the 2009 MUTCD related to bicycling include:

- Bicycle-related regulatory and warning signs
- Bicycle destination guide and route signs
- Pavement markings such as bicycle lane symbols and striping
- Shared-use path signs
- Shared-lane pavement markings

The FHWA recognizes new traffic control treatments may be required to provide for the safe use of the transportation system by all types of travelers. FHWA has established an experimentation process to study the operational and safety effects of new treatments which are not included in the MUTCD. This process is described in Chapter 1, section 1A.10 of the MUTCD. They also explain this process further on their webpage:

http://mutcd.fhwa.dot.gov/condexper.htm

FHWA maintains a webpage that provides frequent updates on the status of on-going bicycle facility treatments which are under experimentation and consideration for inclusion into the MUTCD. This can be viewed here:

http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/design_guidance/mutcd/

A major revision of the 2009 MUTCD is anticipated to be published in the federal register in May 2015. Public agencies and the general public will have approximately 6 months to provide comments. It is anticipated a revised draft of the MUTCD will be ready for final rulemaking in May or June of 2017.

Since the publishing of the 2009 MUTCD, the NCUTCD has approved draft language for the following items which are likely to be incorporated into the 2017 MUTCD:

- Green bicycle lanes (issued interim approval by FHWA April 2011, expanded guidance approved by NCUTCD June 2014)
- Bicycle signal faces (issued interim approval by FHWA for protected uses December 2014, expanded guidance approved by NCUTCD June 2014)
- Except Bicycles Regulatory Plaque (approved by NCUTCD June 2010)
- Except Bicycles Warning Plaque (approved by NCUTCD June 2014)
- Bicycle boxes (approved by NCUTCD June 2014)
- Buffered bicycle lanes (approved by NCUTCD June 2014)
- Contra-flow bicycle lanes (approved by NCUTCD June 2014)
- Two-stage turn queue box (Approved by NCUTCD June 2014)
- Turning vehicles yield to bicycles sign (modified R10-15, Approved by NCUTCD June 2014)
- Extension lines of bicycle lanes through intersections (Approved by NCUTCD June 2014)
- Barrier separated lanes/protected bicycle lanes (approved by BTC August 2014)

Additional information can be found here: http://www.ncutcdbtc.org/

National Association of City Transportation Officials (NACTO) Urban Street Design Guide and Urban Bikeway Design Guide

The National Association of City Transportation Officials (NACTO) has developed Urban Street and Bikeway design guidelines which are tailored to the unique constraints and needs of urban areas. The guidelines are a compendium of state-of-the practice techniques designed to result in high quality, multimodal communities. The guidelines are based on current research and applied experiential practice of urban design professionals from around North America. The guidelines are freely available and regularly updated through their respective websites:

Urban Street Design Guide:

http://nacto.org/usdg/

Urban Bikeway Design Guide:

http://nacto.org/cities-for-cycling/design-guide/

2 State Guidelines and Standards

The Colorado Department of Transportation (CDOT) establishes state guidelines and standards for the design of transportation facilities. These guidelines and standards must be followed on State Owned and maintained roadways. Local agencies may also adopt or follow CDOT standards where they do not have their own.

Bicycle & Pedestrian Project Development & Design Guidance

The CDOT Bicycle and Pedestrian Program manage and oversee bicycle, pedestrian, and safe routes to school efforts on behalf of the Department. The program seeks to integrate bicycle and pedestrian safety, mobility and accessibility into the overall transportation program through engineering, planning, education and training. CDOT updated the bicycle facility design guideline in 2013. Pertinent to this bicycle plan, the guide includes discussion of bicycle lanes, buffered bicycle lanes, shared lane markings, neighborhood greenways (bicycle boulevards), cycle tracks (protected bicycle lanes), and signal detection. The guide can be downloaded here:

http://www.coloradodot.info/programs/bikeped/documents/DesignGuide-Ch14/view

2011 Colorado Supplement to the 2009 MUTCD

State agencies are required by federal law to develop a State level MUTCD that substantially conforms to the federal MUTCD. Colorado supplement explains which provisions of the Federal MUTCD have been modified by Colorado statute.

http://www.coloradodot.info/library/traffic/traffic-manuals-guidelines/fed-state-co-traffic-manuals/mutcd/MUTCD_2003_Colorado_Supplement.pdf/view

CDOT Non-motorized Travel Policy

The CDOT adopted a policy in October 2009 supporting transportation mode choice through the enhancement of safety and mobility for pedestrian and bicycle travel. The policy directs the Department to consider and incorporate non-motorized modes of transportation when building new projects or making improvements to existing infrastructure as a routine activity for all planning, design, and operation projects and processes.

3 Local Guidelines and Standards

Larimer County Urban Area Street Standards (LUCASS)

Larimer County, City of Loveland, and City of Fort Collins have adopted the Larimer County Urban Area Street Standards. These Standards apply to the design and construction of new and reconstructed streets within the two cities and within the Growth Management Areas for Fort Collins and Loveland within Larimer County.

The Standards went into effect on March 1, 2001 and were revised October 1, 2002, April 1, 2007 and March 1, 2013[1]

http://www.larimer.org/engineering/gmardstds/urbanst.htm

4 Midblock Bicycle Facility Treatments

The 2014 Plan envisions an on-street network of buffered bicycle lanes, protected bicycle lanes, neighborhood greenways, and to a limited extent shared travel lanes to complement the off-street trail network. The following section describes key design criteria and considerations for recommendations which are currently not described in existing Fort Collins or LCUASS guidance for midblock scenarios with the exception of neighborhood greenways. Neighborhood greenways are described in their own section due to the fact they are essentially combinations of a wide variety of midblock and intersection treatments.

Buffered Bicycle Lanes

Buffered bicycle lanes are created by striping a buffer zone between a bicycle lane and the adjacent travel lane and/or parking lane. The buffer creates a more comfortable operating environment for bicyclists by creating additional space between bicyclists and passing traffic or parked vehicles. It typically creates sufficient space for bicyclists to operate side by side if desired or to pass slower moving bicyclists without having to encroach on adjacent travel lanes.

Additional Design Considerations

- Widths of buffered bicycle lanes are the same as those for bicycle lanes without buffers.
- The minimum width for the buffer area is 2 feet. There is no maximum.
- Buffer striping will require additional time and materials for installation and maintenance when compared to conventional bicycle lanes.
- Consider placing the buffer next to the parking lane where there is high parking turnover.
- Consider placing the buffer next to the travel lane where speeds are 35 mph or greater or when traffic volume exceeds 8,000 vehicles per day.
- The space between cross-hatching is flexible, but typically varies between 5 and 40 feet. Wider spacing is sufficient for locations with no on-street parking and higher speed roadways. More frequent spacing may be desired in areas with on-street parking.

[1] Text copied from http://www.larimer.org/engineering/gmardstds/GMARdStds.htm

Traffic Buffered Bike Lane	Parking Buffered Bike Lane
	

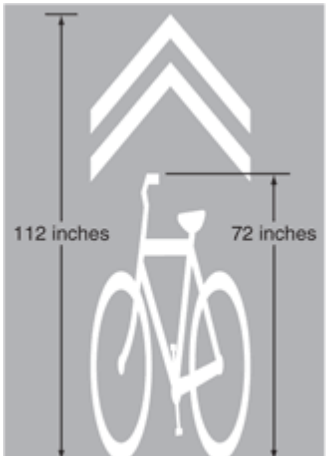
- *Buffer: minimum width 2'*
- *Buffered on travel lane side when speeds are 35 mph or higher and traffic volume exceeds 3,000 ADT*
- *Buffer on parking lane side when parking turnover is high*
- *Bike lane: minimum width 6'*
- *Cross-hatches typically spaced 5'-40' apart*

Shared Lane Markings

A Shared Lane Marking is a pavement symbol consisting of a bicycle with two chevron markings above it that is placed in the roadway lane indicating that motorists should expect to see and share the lane with bicycles, and indicating the legal and appropriate line of travel for a bicyclist. Unlike bicycle lanes, they do not designate a particular part of the roadway for the exclusive use of bicyclists.

Additional Design Considerations

The revised 2009 Edition of the MUTCD includes provisions for installing Shared Lane Markings. The following is taken directly from the 2009 Edition of the MUTCD.



Shared Lane Marking Source: 2009 MUTCD

The Shared Lane Marking may be used to:

- Assist bicyclists with lateral positioning in a shared lane with on-street parallel parking in order to reduce the chance of a bicyclist's impacting the open door of a parked vehicle,
- Assist bicyclists with lateral positioning in lanes that are too narrow for a motor vehicle and a bicycle to travel side by side within the same traffic lane,
- Alert road users of the lateral location bicyclists are likely to occupy within the traveled way,
- Encourage safe passing of bicyclists by motorists, and
- Reduce the incidence of wrong-way bicycling,
- Serve as wayfinding along bicycle routes,
- May be placed within roundabouts to provide guidance to bicyclists
- Shared lane markings should be placed a minimum of 11 feet from the curb, when a parking lane is present, and a minimum of 4 feet from the curb when on-street parking is not present.

Placement Where Travel Lanes Are Less than 13 Feet in Width

Shared lane markings should be placed in the center of the travel lane where travel lanes are less than 13 feet to encourage bicyclists to occupy the full lane and not ride too close to parked vehicles or the edge of the roadway. A BICYCLES MAY USE FULL LANE (R4-11) sign may be used to supplement the marking. Travel lanes of this dimension are too narrow for sharing side by side with vehicles.

Placement Where Travel Lanes Are Greater than or Equal to 13 Feet in Width

Where travel lanes are 13 feet or wider, motorists will generally be able to pass bicyclists within the same lane or will only need to slightly encroach on adjacent lanes to pass bicyclists. The Shared Lane Marking should generally be located in the right portion of the lane (per the MUTCD minimum requirements) with exceptions for locations adjacent to parking where it is desirable to encourage riding further from parked vehicles. A Share the Road sign (W11-1 AND W16-1P) may be used to supplement the marking.

Shared lane markings should generally be used on arterial and non-arterial roadways with motor vehicle speeds 35 mph or less. Research has shown placing the marking in the center of travel lanes wider than 13 feet will likely result in poor compliance by bicyclists who will travel in the right portion of the lane which may undermine the effectiveness of shared lane markings in narrower lanes.

Placement within Right Turn Lanes

In situations where a bicycle lane drops to accommodate a right turn lane, a Shared Lane Marking may be placed within the center or left hand edge of the right turn lane. A BICYCLES MAY USE FULL LANE (R4-11) sign may be used to supplement the marking. An EXCEPT BICYCLES plaque should be placed beneath any RIGHT TURN MUST TURN RIGHT regulator signs.

Considerations for Symbol Placement Frequency

Shared Lane Markings should be placed at the far side of an uncontrolled intersection, at both sides of an arterial intersection with traffic control, and at mid-block locations where block faces are more than 250 feet long.

When placing mid-block Shared Lane markings, they should be placed in such a manner that the first Shared Lane marking a bicyclist or motorist would come upon would be the Shared Lane marking in their direction of travel.

Where there are mid-block marked crosswalks, the tip of the chevron should be placed 25 feet beyond the far side of the marked crosswalk. Where markings are placed in close proximity to each other, the markings should be separated by at least 10 feet.

On streets with posted speed limits of 25 mph or lower:

The NACTO Design Guide suggests placement of the shared lane marking in the center of the travel lane to encourage bicyclists to use the full lane.

Where speed limits equal 35 mph or greater

The NACTO Design Guide indicates that on streets with posted speed limits of 35 mph or higher, or where vehicle volumes exceed 3,000 vehicles per day, shared lane markings are not the preferred treatment.

Priority Shared Lane Markings

A Priority Shared Lane Marking is and enhanced Shared Lane Marking. It is located within a rectangular green colored pavement box and spaced at 100 foot intervals to simulate the effect of a bicycle lane within a shared travel lane. A BIKES MAY USE FULL LANE (R4-11) sign should be used to supplement the marking.

Shared Lane Marking and Priority Shared Lane Marking Placement Examples:

Travel Lane <13' with BMUFL sign

Close Spacing of SLM

Priority Shared Lane Marking

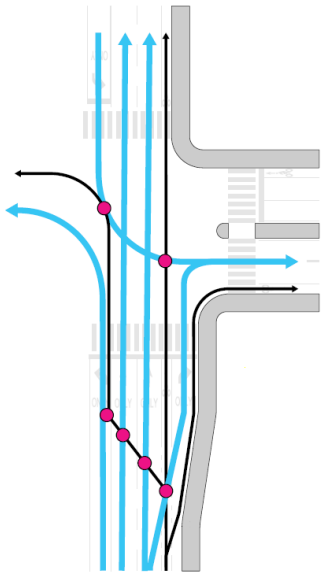
SLM Placed within Right Turn Lane

Protected Bicycle Lanes

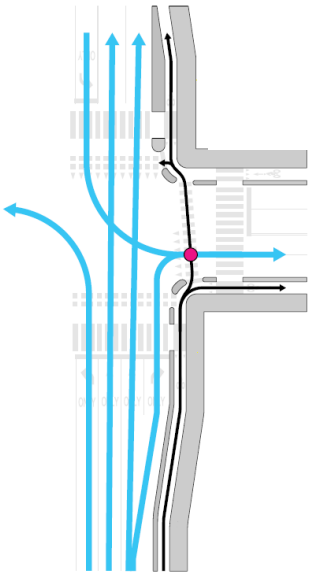
This plan calls for an extensive network of "protected bicycle lanes" which are physically separated from automobile and pedestrian traffic. Protected bicycle lanes are also frequently referred to as cycle tracks, separated bicycle lanes, or bicycle only sidepaths. Protected bike lanes improve comfort and reduce stress for bicyclists by physically separating them from automobile and pedestrian traffic. They may be located at street level or sidewalk level and the protection may be provided with flexible delineators, curbing, parking, or other physical treatments.

A key reason for providing separated bike lanes at intersections is to reduce the number of conflict points between bicyclists and motorists at intersections. On roadways with traditional bike lanes or shared lanes, bicyclists often must merge, weave and otherwise cross paths with motor vehicles that are traveling at a greater speed. These maneuvers are uncomfortable for most bicyclists due to the combination of the speed differential and bicyclists' vulnerability. In contrast, separated bike lanes at intersections reduce bicyclists' exposure by reducing multiple merging and crossing movements to a single predictable crossing point.

Conflict Points Diagram:



Shared Lane or Bike Lane



Protected Bike Lane

Protected Bike Lane Mid-block Design

Designs of protected bike lanes will generally fall into the following two categories:

Flexible Post Protected: This bike lane is street level, and provides physical separation from parallel vehicle travel lanes with vertical flexible delineators. This may be considered an interim treatment, as it is significantly cheaper, and easier to implement than a curb-protected bike lane. This design can lead to an increase in roadway debris within the protected bike lane as debris from the roadway can easily deposit within the buffer and bike lane area. The flexible delineators may require repair or replacement if struck by vehicles or if damaged during routine winter plowing. On streets with parking, parking will located between the bike lane and travel lane increasing the level of protection and comfort.

Curb Protected: This bike lane may be street level or sidewalk level. It provides physical separation from parallel vehicle travel lanes with vertical curbing. If the bike lane is street level, the barrier will form narrow medians between the vehicle travel lanes and the bike lane. The curbing can reduce the spread of debris from the roadway and offers a higher degree of protection than flexible delineators. On streets with parking, parking will be located between the bike lane and travel lane.

Protected Bike Lane Examples:

Flexible Post Protected

Curb Protected Street Level

Curb Protected Sidewalk Level

The cross section of a separated bike lanes includes three basic zones:

- Street Buffer Zone – separates bike lane from travel lanes or parking lanes
- Bike Lane Zone – dedicated travel lane for bicyclists
- Sidewalk Buffer Zone – separates bike lane from sidewalks or pedestrian zones

Street Buffer Zone Widths

Bike Lane Elevation Relative to Street	With On-Street Parking		Without On-Street Parking	
	Minimum	**Desirable**	**Minimum**	**Desirable**
Sidewalk level	3 feet	5 feet+	2 feet	Increased width as vehicle speeds increase
Street level, curb separated	3 feet[1]	5 feet	2 feet	
Street level, object separated	3 feet	5 feet	2 feet	

Protected Bike Lane Zone Widths

In corridors with higher volumes of pedestrians, it is recommended the bike lane be at a different elevation than the sidewalk, typically street level, to reduce the likelihood pedestrians will walk in the bike lane. If the bike lane must be sidewalk level, the bike lane should have a contrasting appearance to the sidewalk. The following provides guidance for determining one-way vs two-way bike lane widths:

One-Way			Two-Way		
Peak hour volume in one direction (bicycles/hour)	Minimum Width[1]	Desirable Width	Peak hour volume in two directions (bicycles/hour)	Minimum Width[2]	Desirable width
0-150	5 feet	8 feet	0-150	8 feet	10 feet
150-750	6.5 feet[3]	10 feet	>150	11 feet	14 feet
>750	10 feet	12 feet			

NOTES:

1. The minimum width should not be used for street level curb separated bike lanes. The minimum width for a separated bike lane between two curbs is six feet.
2. Passing may occur in the opposing lane.
3. The minimum width to accommodate a passing movement within the bike lane is 6.5 feet. If the width is constrained, designers should consider options that allow bicyclists to use buffer space for passing.

Sidewalk Buffer Zone Widths

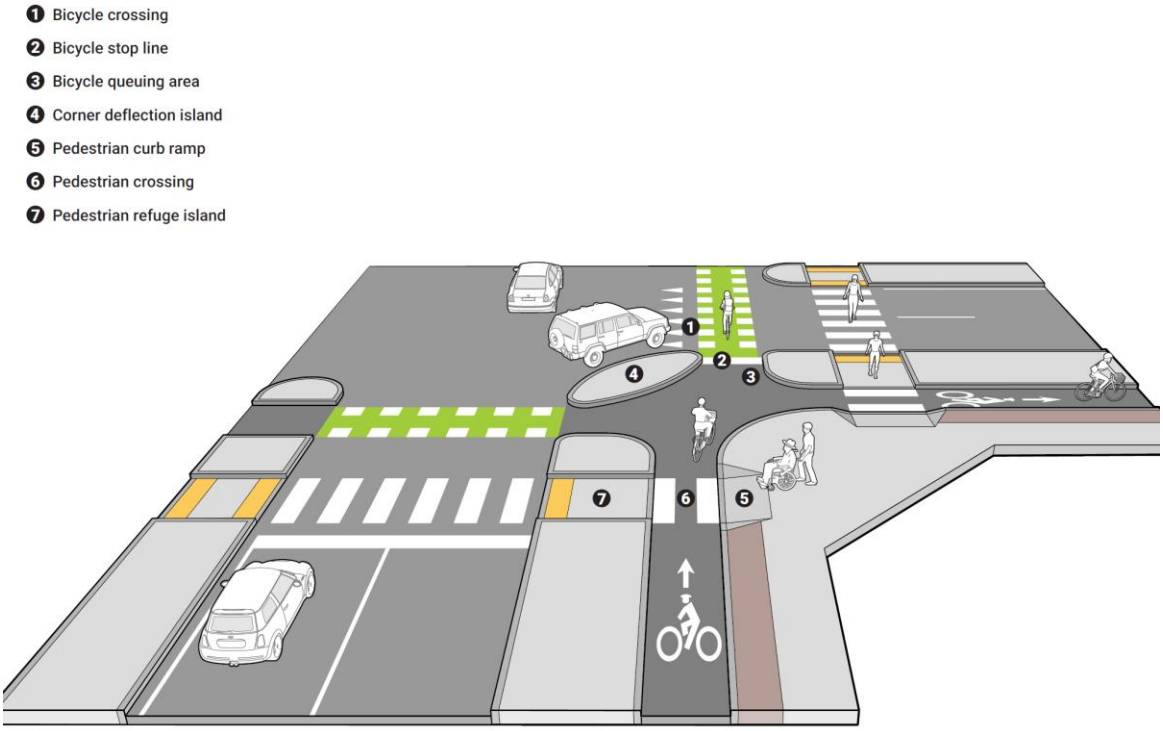
There is a wide range of potential treatments for the sidewalk buffer zone. The buffer zone should promote separation between pedestrians and bicyclists to improve comfort for both users. For sidewalk level bike lanes, it is desirable to provide vertical elements such as street furniture or vegetation to promote separation.

Protected Bike Lane Intersection Design

The design of intersections should ensure visibility between approaching and departing motorists, bicyclists and pedestrians. All users should be provided visual cues that clearly indicate right-of-way priority and expected yielding behavior. The following strategies can be used to accomplish this:

- **Clearly delineate crossings:** marked crossings should indicate the preferred crossing location for bicyclists and pedestrians across all potential conflict points.
- **Clearly indicate right-of-way priority**: signs and markings should reinforce correct yielding behaviors.
- **Provide yielding geometry:** intersection geometry should not require users to turn their head more than 90 degrees to see a potential conflict. The angle of conflict between through moving bicyclists and turning traffic should be between 60 and 90 degrees.
- **Reduce speeds:** Reducing motorist turning speeds improves the ability of motorists to appropriately yield to bicyclists, which is particularly important at intersections, driveways and alleys. Slower bicyclist approach speeds reduce the likelihood a turning motorist cannot see an approaching bicyclist and improves the ability of the motorist to yield to the through moving bicyclist. Reduced speeds at conflict points reduce conflicts between all users, reduce stopping sight distance requirements, and reduce severity of injuries in the event a crash occurs**.** Speed reduction is achieved primarily through horizontal and vertical deflection.
    - **Vertical deflection**: Raising the conflict point can slow motor vehicles and bicyclists on the approach.
    - **Horizontal deflection:** Reducing the turning radius where vehicles turn right across separated bike lanes can reduce speeds. Horizontal deflection can also be utilized to slow bicyclists on the approach to an intersection.

A typical protected bike lane intersection should have the following elements:



Elements of a Protected Bike Lane Intersection, Source: Toole Design Group

Additional Design Considerations

- Standard bicycle lanes symbols, signs, and markings should be utilized to designate protected bicycle lanes per the MUTCD, Chapter 9.
- Corner deflection islands should be provided at all corners to slow approaching bicyclists and to create queuing space for waiting bicyclists. It should deflect bicyclists the full width of the protected bike lane.

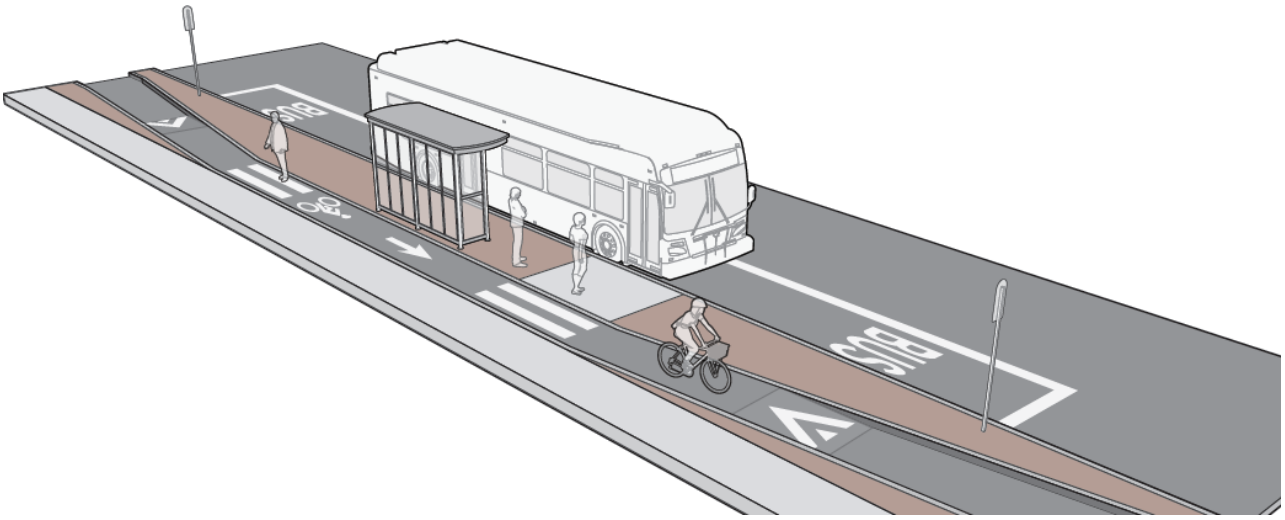
Corner Deflection Island

Pedestrian Crossings

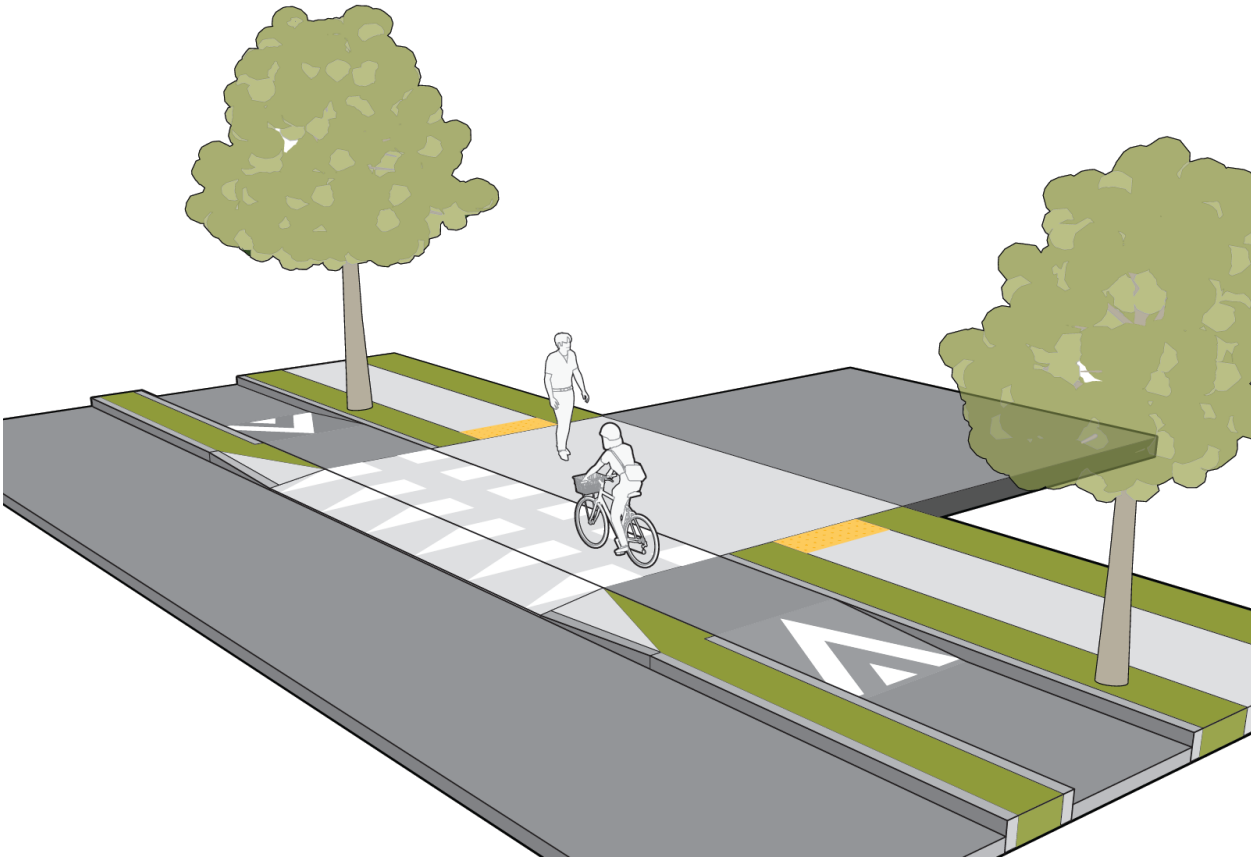
Queuing Area

- For street level bike lanes where corner deflection islands are not provided, two-stage turn queue boxes should be provided to assist bicyclists in making left turns from the protected bicycle lane facility.
- Leading or protected phasing should be considered at intersections with more than 150 vehicles turning in a peak hour across the bike lane
- Driveways and street crossings are a unique challenge to protected bicycle lane design. The following guidance may improve safety at crossings:
    - The bicycle crossing should be marked with bicycle lane extensions
    - The conflict area can be enhanced with green color.
    - A modified R10-15 sign which incorporates a bicycle symbol may be used to notify motorists of their requirement to yield to bicyclists while turning. These signs may be supplemented with yield lines
    - If the protected bicycle lane is parking-protected, vehicle parking should be prohibited near the intersection to improve visibility. The desirable no-parking area is a minimum of 30 feet from each side of the crossing.
    - Motor vehicle traffic crossing the protected bicycle lane should be constrained or channelized to make turns at sharp angles to reduce turning speeds to 10 mph or less at the crossing.
- At transit stops along protected bicycle lanes, special consideration should be given to manage bicyclist, pedestrian and transit operator interactions.
    - The bike lane should be located behind the transit stop.
    - A 6 foot minimum width median should be provided for pedestrians to access the transit vehicle.

Modified R10-15 sign



Example Transit Stop with Protected Bike Lane, Source: Toole Design Group



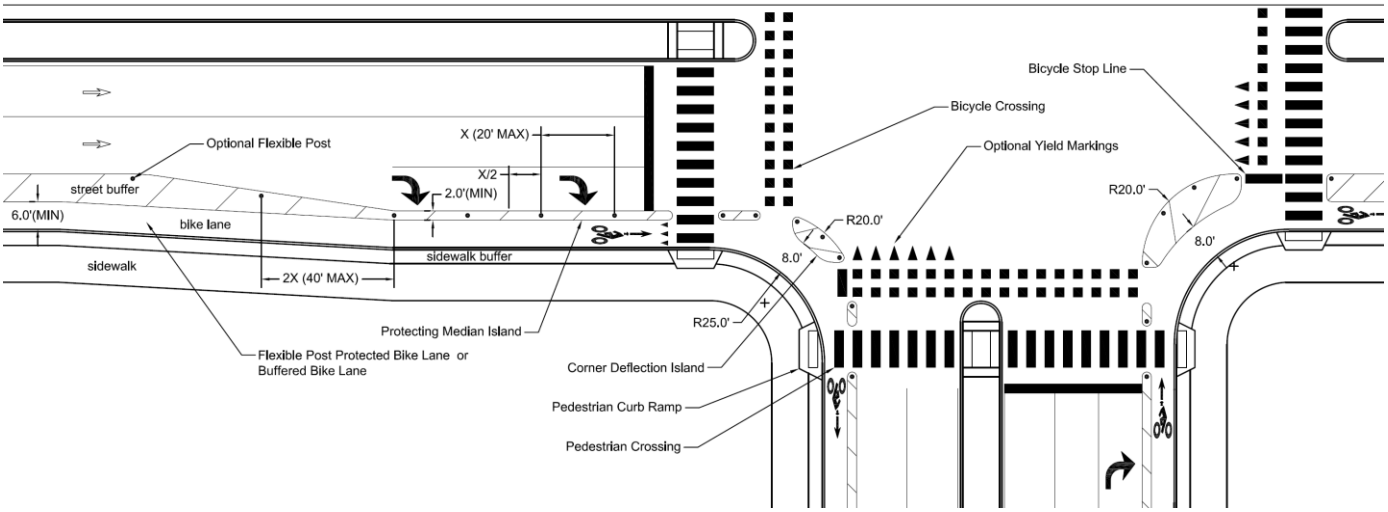
Example Driveway Design with Protected Bike Lane, Source: Toole Design Group

Examples of Protected Intersection Bike Lane Retrofits

The following examples depict two strategies for potential arterial protected intersection retrofits. They conform to typical Fort Collins intersection geometry for the intersection of two arterial streets with existing buffered bike lanes. Actual designs will vary from location to location based on street widths and travel lane allocation needs. It is likely pedestrian curb ramps and detection would require relocation from existing conditions.

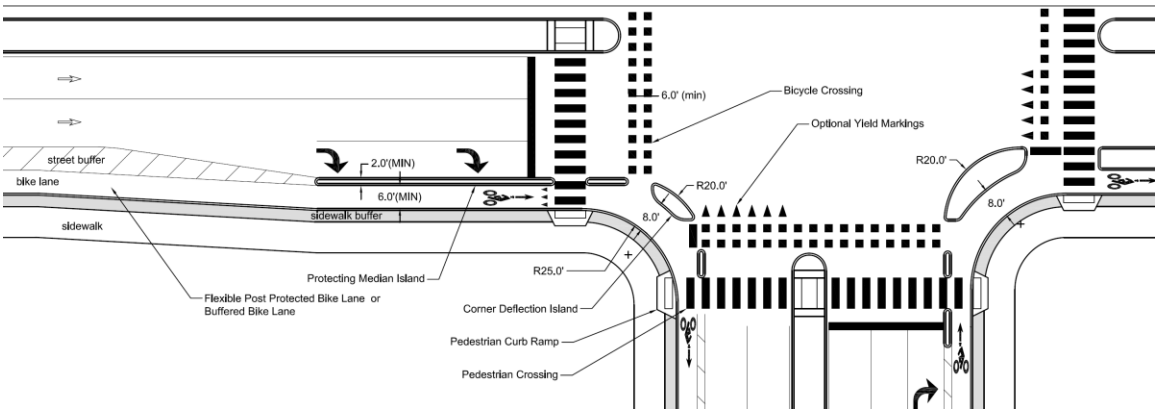
Arterial Intersection Retrofit Painted and Post Protecting Island Example

The following is an example arterial protected bike lane intersection retrofit. The midblock cross section could be a buffered bike lane or a flexible post protected bike lane. As the right turn lane develops, the flexible posts spacing can be reduced to simulate a protecting island. A corner deflection island can be created with closely spaced flexible posts and pavement markings to slow right turning vehicles and to deflect the approaching bicyclists. The bicycle and pedestrian crossings would be set back from the intersection to improve the sight line between the turning motorists and the approaching bicyclist and pedestrians.



Arterial Retrofit Painted and Curb Protecting Island Example

The following is an example arterial protected bike lane intersection retrofit. The midblock cross section could be a buffered bike lane or a flexible post protected bike lane. As the right turn lane develops, the street buffer would transition from flexible post protection to curbed median protection. A corner deflection island slows right turning vehicles and to deflect the approaching bicyclists. The bicycle and pedestrian crossings would be set back from the intersection to improve the sight line between the turning motorists and the approaching bicyclist and pedestrians.

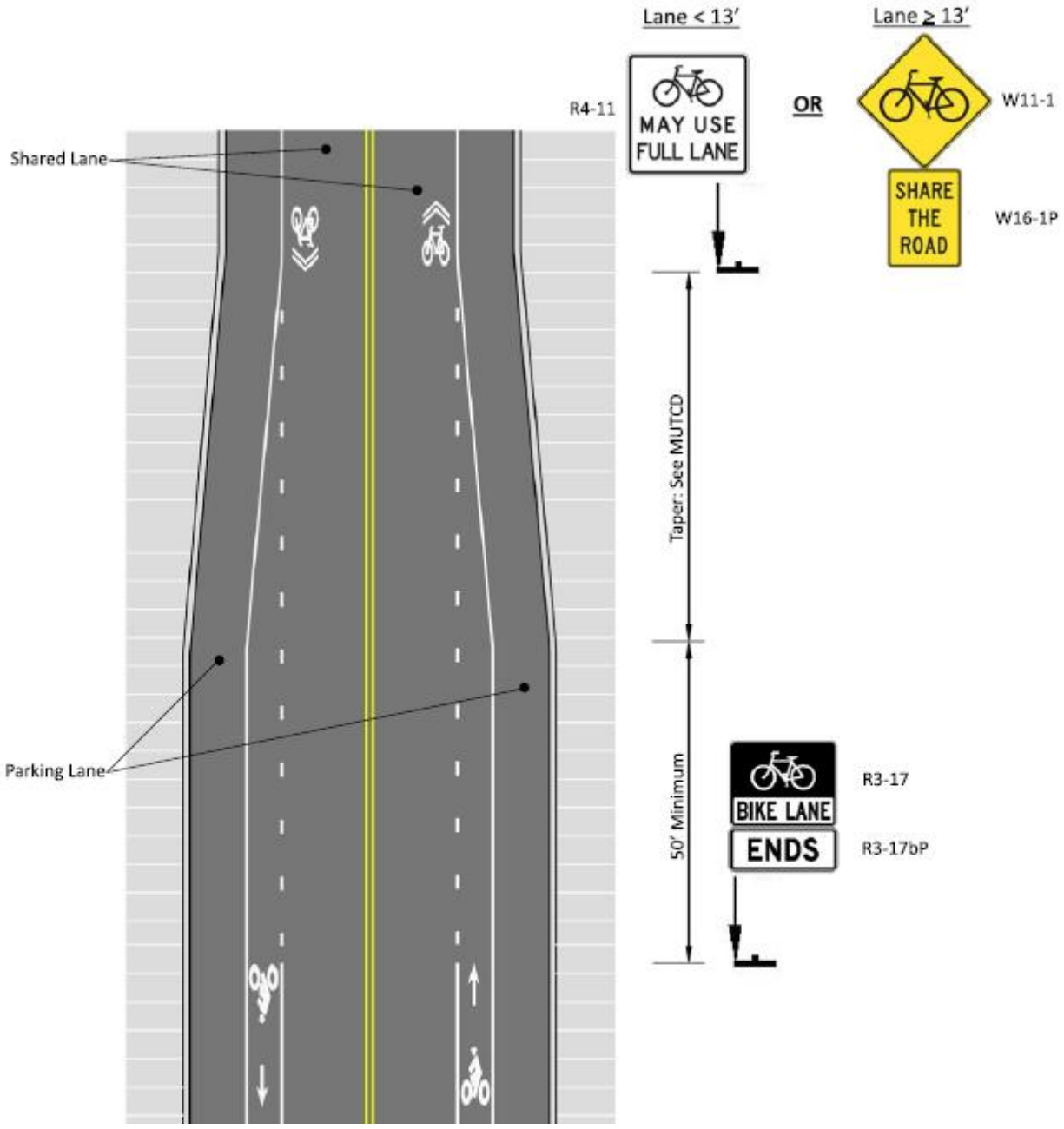


5 Transitions between Different Bicycle Facility Types

It is often necessary to use different bicycle facilities to provide bicycle access within the same roadway corridor due to existing roadway conditions, surrounding land uses, available right-of-way, and other characteristics. Where this condition occurs, it is important to provide transitions between different facilities. These transitions can be made safer and more understandable for bicyclists and motorists with appropriate and consistent treatments such as spot directional signs, warning signs, pavement markings, curb cuts, etc. Transitions should be provided as a part of the bicycle facility design process.

Transitions from Bike Lanes to Shared Lanes

At locations where bicycle lanes terminate to become shared lanes it may be desirable to provide a transition to a marked shared lane for a brief distance, even if it is not desirable to mark a continuous shared lane for the remainder of the roadway. The placement of the shared lane marking should conform to guidance provided previously. The taper terminating the bicycle lane should conform to the MUTCD.



Example Bike Lane to Shared Lane Transition, Source: Toole Design Group

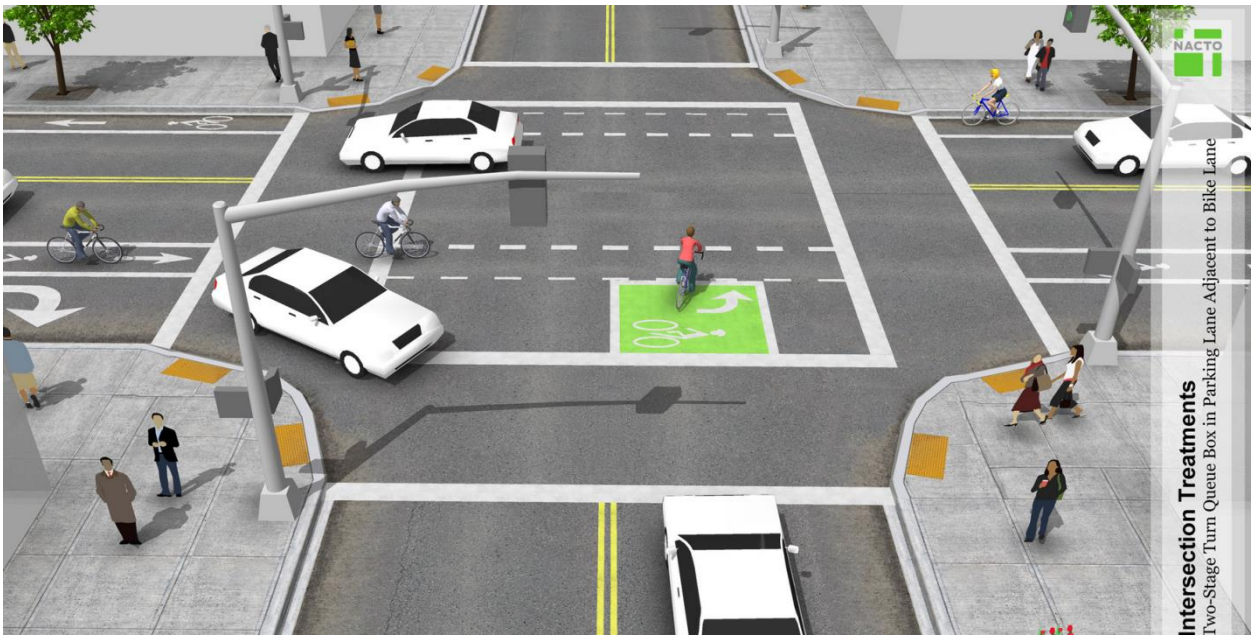
Transitions from Protected Bike Lanes to Bike Lanes

At locations where protected bicycle lanes terminate to become bike lanes the protected bike lane should generally terminate on the far side of the intersection. Where it is determined necessary to terminate the protection prior to the intersection, a mixing zone design which identifies a clear merging area should be used such as the following example.

Example Right Turn Mixing Zone with Protected Bike Lane, Source: NACTO

Two-Stage Left Turn Queue Box, Transitions from Protected Bike Lanes and Bike Lanes to Cross Streets

At locations where it is difficult for bicyclists to turn left across multiple travel lanes or at location where protected bicycle lanes channelize bicyclists to the right side of the roadway, two-stage left turn queue boxes should be used.



Example Right Turn Mixing Zone with Protected Bike Lane, Source: NACTO

Design Guidance:

- Right Turns on Red should be prohibited where there is potential for conflict between right turning motorists and waiting bicyclists.

- The box should be located outside the turning path of left turning vehicles.
- The box should have green coloring, a bicycle symbol, and a left turn arrow.
- The dimensions of the box may vary, but should be no less than 4 feet wide by 6 feet long to hold one bicyclist.

Trail System and the On-Street Bicycle Network Transition

Where a shared use path crosses or terminates at an existing road, it is important to transition the path into the system of on-street bicycle facilities and sidewalks. Care should be taken to properly design the terminus to transition the bicycle traffic into a safe merging of intersecting facilities. Appropriate signing is necessary to warn and direct both bicyclists and motorists regarding these transition areas. Each roadway crossing is also an access point, and should, therefore be designed to facilitate movements of path users who either enter the path from the road, or plan to exit the path and use the roadway. Where possible, provide additional space where trails intersect roadways, particularly at signalized locations where multiple trail users are likely to be waiting to cross the street. Curb ramps at trail crossings and other on-street access points should be assessed and widened where they are narrower than the trail width and/or where the volume of trail users is high.

6 Intersection and Street Crossing Treatments

Intersection improvements can enhance cyclist safety by eliminating or raising awareness of potential areas of conflict between motorists and bicyclists, and by reducing the delay bicyclists experience at intersections. Intersection design must also consider the positioning of bicyclists, particularly longer bicycles or bicycles with trailers, queueing of groups of bicyclists, and related crossing times to design a crossing that can get bicyclists across a busy roadway safely and comfortably. Improvements to the bicycling network are of limited utility if bicyclists cannot safely *and* comfortably cross streets.

Of particular challenge are intersections with collector and arterial streets, particularly during peak travel periods. While approaching an intersection along the arterial street, bicyclists are regularly exposed to high volumes of higher speed traffic merging across the bicyclists to turn right. Within the intersection bicyclists may exposed to right or left turning traffic across their path. Merging right turning traffic is uncomfortable and is a leading cause of sideswipe and right-hook crashes with bicyclists. Left turning motorists generally have poor visibility to approaching bicyclists contributing to left hook crashes.

The following sections describe types of treatments that are recommended to help bicyclists approach and cross intersections. The selection of the appropriate street crossing treatment depends on a number of factors which must be evaluated at each specific location to determine an appropriate treatment:

- Roadway width/number of lanes
- Presence and length of turning lanes
- Type of bicycle accommodation
- Land use and pedestrian activity
- Signal phasing
- Motor vehicle traffic volumes
- Motor vehicle operating speed
- Sight-distance
- On-street parking
- Presence of traffic signals at the intersection or at nearby intersections
- Satisfaction of necessary and relevant traffic warrants

Bike Lane Extensions through Crossings

Bicycle lane extensions delineate a safe and direct bicycle crossing through an intersection, or driveway, providing a clear boundary between the paths of through bicyclists and either through or crossing motor vehicles in the adjacent lane. Within intersections, these are often parallel with pedestrian crosswalks. At two-way protected bike lane crossings, a dashed centerline should be used within the crossing to separate the two directions of bicycle traffic.

They may include bicycle lane markings and be highlighted with green colored pavement. The use of contrasting green color is used primarily to highlight areas with a potential for bicycle-vehicle conflicts, such as bicycle lane extensions through crossings where a bicyclists is susceptible to conflicting left or right turning traffic or merge areas where right turning vehicles must cross a through bicycle movement to enter a right turn lane. If a pair of dotted lines is used to extend a bicycle lane across an intersection or driveway, or a ramp, green colored pavement should be installed in the same dotted pattern as the white edge lines.

Intersection Crossing

Approach Merging Area

Advanced Yield Markings

Advanced yield markings in conjunction with YIELD HERE TO PEDESTRIANS signs have proven to be effective at reducing multiple threat crashes at uncontrolled, marked crosswalk locations. A multiple threat crash results when a car in one lane stops to let the pedestrian cross, blocking the sight lines of the vehicle in the other lane of a multi-lane approach which advances through the crosswalk and hits the crossing pedestrian(s). The MUTCD (2009) requires the use of YIELD HERE TO PEDESTRIANS (R1-5, R1-5a) sign if yield lines (shark's teeth) are used in advance of a marked crosswalk that crosses an uncontrolled multi-lane approach. If yield lines and YIELD HERE TO PEDESTRIANS signs are used in advance of a crosswalk, they should be placed together and 20 to 50 feet before the nearest crosswalk line; parking should be prohibited in the area between the yield line and the crosswalk.

At trail crossings or locations with parallel bicycle and pedestrian crossings, the YIELD HERE TO PEDESTRIANS sign may be include a bicycle symbol. It is recommended to use the W11-15 warning sign in advance of the crossing. This application should be considered at all unsignalized crossings of multi-lane streets.

Example Crossing with Crossing Island and Advanced Stop Line, Source NACTO

Crossing Islands

Crossing islands facilitate crossings of multiple lane and/or high-volume arterials by providing space in the center of the roadway, allowing the pedestrian or bicyclist to focus on one direction of traffic at a time (two-stage crossing). Median islands (or crossing islands) are constructed at the center of a road to physically separate the directional flow of traffic, and to provide pedestrians and bicyclists with a place of refuge while reducing the crossing distance between safety points.

Arterial roadway intersections that have low demand for left-turn movements can be potential candidates for adding crossing islands. Crossing islands can be constructed on these roadways by using the available center turn lane area. On streets with on-street parking, they can be installed by removing parking from one side of the street and shifting the travel lanes creating chicane around the island.

The 2012 AASHTO Bicycle Guidelines outline design considerations for crossing islands:

- Minimum width for storage on the crossing island is 6 feet. Ten feet accommodates a bicycle with trailer
- Island should be large enough for multiple people to be on the island at once e.g. strollers, bicyclists, pedestrians etc.
- Angling the refuge area at approximately 45 degrees is recommended to direct those crossing to face towards on-coming traffic.

Curb Extensions

Curb extensions are a section of sidewalk extending into the roadway at an intersection or midblock crossing that reduces the crossing width for pedestrians and increases their visibility, and may help reduce traffic speeds. Curb extensions shorten bicyclist and pedestrian exposure time in traffic and increase the visibility of non-motorized users at roadway crossings. By narrowing the curb-to-curb width of a roadway, curb extensions may also help reduce motor vehicle speeds and improve bicyclist and pedestrian safety. Curb extensions are appropriate only for locations that have full time, on-street parking.

Design considerations:

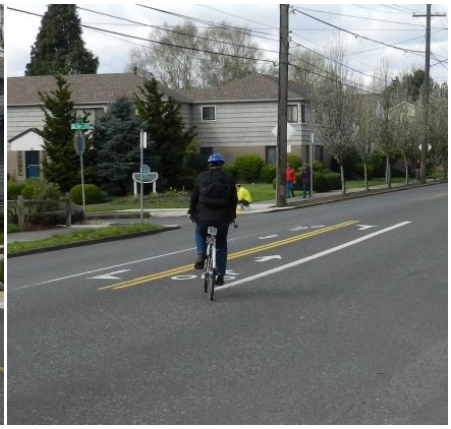
- No wider than parking lane e.g., 7 feet
- Curb radius can be tightened to slow right turning vehicles
- Curb bulbs can provide additional space for curb ramp construction if there is limited right-of-way

Crossings at Off-Set Intersections

Several designs have been developed to facilitate crossing of intersections with "legs" that do not line up directly across from one another. These include bicycle left-turn lanes that create a designated space for two-way left turns using pavement markings, left-turn with raised median that creates a single protected left turn using a raised curb median, and a sidepath. Left turn lanes should be a minimum six feet wide and 8 feet in length so that bicyclists can be completely separated from the travel lanes.

Median with Bicycle Left Turn Pocket

Sidepath Connecting Offset T- Intersections



Median Bicycle Left Turn Lanes

Greater detail on all of these design treatments can be found in the documents mentioned above, as well as other sources such as PedSafe and the National Association of City Transportation Officials (NACTO) website.

Right Turn Lane Design with Bicycle Lanes

Long right-turn lanes on high-speed, high-traffic arterials with existing bicycle lanes currently create the potential for conflicts between bicyclists and automobiles. These designs cause high stress for bicyclists due to the long length of exposure to higher speed merging traffic. Reconfigurations of right-turn lanes will have to consider potential impacts on intersection capacity and motorist safety in balance with bicyclist safety and comfort needs. Each intersection will require additional engineering study to determine the proper design treatment. The following design options to improve the comfort and safety of the approach for bicyclists include:

- *Remove right turn lane and convert to protected intersection*: Protection for the bicycle lane continues to the stop line eliminating exposure to merging or weaving traffic.
- *Reduced merge area for right turn lane*: Traffic entering this lane would have a limited zone where it may cross the protected bicycle lane. This would be demarcated with a conspicuous pavement treatment and potentially flexible delineators or curbing.

Traffic Signals Warrants

Signalized intersections allow bicyclists to cross arterial streets without needing to select a gap in moving traffic. Traffic signals make it easier to cross the street, though it is important to make improvements to reduce conflicts

between bicyclists and turning vehicles. It is important to note that bicyclists may be counted as pedestrians or vehicles when evaluating MUTCD warrants.

Additional Design Considerations

MUTCD warrants justifying installation of traffic signals may be hard to meet at arterial crossings which may be difficult for pedestrians and bicyclists to cross without a signal. For purposes of this plan, the warrant criteria can be waived by the City Traffic Engineer if it is determined a signal is the most suitable way to accommodate a non-motorized crossing identified in the 2020 Low-Stress Bicycle Network. This is essentially a Low-Stress Bicycle Network Warrant to ensure the Low-Stress Network is a viable alternative to parallel arterial roadways.

Bicycle Signal Faces

Bicycle signal faces provide clearer direction to bicyclists crossing signalized intersections that they may enter an intersection. At locations (typically trail crossings) where it is expected bicyclists should follow pedestrian signals, under present law and timing practices, bicyclists are only "legal" when they enter the crosswalk during the solid WALK portion of the signal which is significantly shorter than the provided walk plus clearance time. This frequently results in bicyclists disobeying the flashing don't walk portion of the cycle which can lead to them being caught in the intersection during the change interval. Providing bicycle signal faces allows for a longer display of green as compared to the walk, which significantly improves the compliance with the traffic control. Further, the MUTCD states explicitly that pedestrian signals are for the "exclusive use of pedestrians". Bicycle signal faces can be designed to call a green signal phase through the use of loop detectors (or other passive detection such as video or radar) or push button. Bicycle signal faces and a separate bicycle signal phase should be considered at intersections and trail crossings with very high volumes of bicyclists or locations where it is desirable to provide separate phasing for the bicyclists to improve their safety and reduce conflicts with turning motorists.

Rectangular Rapid Flashing Beacons

Rectangular rapid flashing beacons (RRFB) are installed at unsignalized street crossings or mid-block crossing to assist pedestrians and bicyclists in crossing the street. Rectangular rapid flashing beacons have proven to be effective devices at uncontrolled intersections for increasing motorist yielding rates and reducing pedestrian-vehicle crashes at crosswalk locations. The rapid flashing beacon device consists of a pair of rectangular, yellow LED beacons that employ a stutter-flash pattern similar to that used on emergency vehicles. The beacons are often mounted below a standard W11-15 crossing warning sign and above the arrow plaque. The beacons are pushbutton or passive detection activated and placed on both sides of the street. If a median exists at the crossing location across a multi-lane street, a third and fourth beacon may be placed in the median, which, studies show, significantly increases motorist yield rates. Advanced W11-15 warning signs can also be used with the rapid flashing beacon at locations with poor sight lines or high speed traffic.

Half Signal

This signal is intended to allow pedestrians and bicyclists to stop traffic to cross high volume arterial streets. The signal provides a completely protected crossing of the street. The signal may be used in lieu of a full signal that meets any of the 9 warrants in the MUTCD as well as at locations which do not meet traffic signal warrants where it is necessary to provide assistance to cross a high volume arterial. Pushbuttons should be relatively "hot" (stop traffic within 30 seconds), be placed in convenient locations for bicyclist actuation in addition to pedestrians, and abide by other ADA standards. Passive signal activation, such as video or infrared may also be considered. While this type of signal is intended for pedestrians, it would be beneficial to retrofit it as the City of Portland, Oregon has with bicycle detection and bicycle signal heads on major cycling networks to provide adequate guidance. Depending upon the detection design, the city may have the option to provide different clearance intervals for

bicyclists and pedestrians. The provision of bicycle signal heads would require permission to experiment from FHWA.

Pedestrian Hybrid Beacons (a.k.a: HAWK Signal - High Intensity Activated Crosswalk)

This signal is intended to allow pedestrians and bicyclists to stop traffic to cross high volume arterial streets. The signal allows traffic to stop and go while pedestrians and bicyclists may still be the street by flashing red (motorists must remain stopped if the pedestrian or bicyclist is on their half of the roadway). The signal may be used in lieu of a full signal that meets any of the 9 warrants in the MUTCD as well as at locations which do not meet traffic signal warrants where it is necessary to provide assistance to cross a high volume arterial. The MUTCD provides suggested minimum volumes of 20 pedestrians or bicyclists an hour for major arterial crossings (excess of 2,000 vehicles/hour). Pushbuttons should be relatively "hot" (stop traffic within 30 seconds), be placed in convenient locations for bicyclist actuation in addition to pedestrians, and abide by other ADA standards. Passive signal activation, such as video or infrared may also be considered. While this type of signal is intended for pedestrians, it would be beneficial to retrofit it as the City of Portland, Oregon has with bicycle detection and bicycle signal heads on major cycling networks to provide adequate guidance. Depending upon the detection design, the city may have the option to provide different clearance intervals for bicyclists and pedestrians. The provision of bicycle signal heads would require permission to experiment from FHWA.

Curbside Push Button for Cyclist

Bicycle and Pedestrian Signals

HAWK Signal across Arterial with Bicycle/Ped Crossing Warning Sign

7 Neighborhood Greenway Guidance

Neighborhood greenways are low-volume and low-speed streets that have been optimized for bicycle and pedestrian travel through treatments such as traffic calming and traffic reduction, signage and pavement markings, and intersection crossing treatments. Neighborhood greenways have been implemented in cities across the country, including Columbia (MD), Minneapolis, Berkeley, and Portland. Neighborhood greenways are garnering more attention as cities look to strategies for attracting more people that are “curious, but cautious” about riding their bicycles in an urban context. Neighborhood greenways allow bicyclists to avoid higher volume, higher speed roadways, offering a more comfortable and leisurely riding experience. For this reason, neighborhood greenways are more likely to attract families, and other more cautious or less confident bicyclists that are less likely to use bicycle facilities on roadways where interaction with higher vehicle volumes and speeds are likely. The primary characteristics of a neighborhood greenway are:

- low motor vehicle volumes (generally less than 3,000 vehicles/ day)
- low motor vehicle speeds (generally less than 25 mph)

- logical, direct, and continuous routes that are well marked and signed
- convenient access routes to desired destinations (typically parallel routes to higher speed, higher volume arterial or collector streets)
- minimal bicyclist delay
- comfortable and safe crossings for bicyclists at intersections

There are several resources available that provide a thorough introduction to the fundamentals of neighborhoods greenways, addressing the planning, design, and maintenance of these facilities. These resources include:

> *Fundamentals of Bicycle Boulevard Planning and Design*, Portland State University and Alta Planning+Design, 2009.
>
> *Bicycle Boulevard Design Tools and Guidelines*, City of Berkeley, 2000.
>
> *Traffic Calming State of the Practice*, ITE, 1999, http://www.ite.org/traffic/tcdevices.asp
>
> *Traffic Calming: Roadway Design to Reduce Traffic Speeds and Volumes*, Victoria Transport Policy Institute, updated 12/26/11, http://www.vtpi.org/tdm/tdm4.htm

Because these resources provide a good background on neighborhood greenways, this section will not focus on the fundamentals of neighborhood greenways, but rather, on key steps in the planning process, how neighborhood greenways might work in the City of Fort Collins context, and the specific design considerations that are most applicable to City of Fort Collins.

Bicycle Boulevards in City of Fort Collins

Neighborhood greenways have the potential to play an important role in City of Fort Collins's bicycle network. Fort Collins has an extensive trail network that forms the backbone of the City's bicycle network. A primary objective of the 2014 Plan is to extend that network by supplementing trails via a low-stress, on-street bicycling network. The types of riders that are attracted to trails will feel comfortable using neighborhood greenways that are properly designed.

There are several areas in the city where it is possible to connect trails by way of a neighborhood greenway, which could significantly expand the reach of the trail system. Additionally, there are numerous high volume, high speed arterial roadways in City of Fort Collins where retrofit of on-street bicycle lanes to protected lanes are not feasible due to right-of-way or funding constraints. Developing neighborhood greenway facilities parallel to these streets may be an ideal solution for expanding the bicycle network into these areas of the city.

Bicycle Boulevard Design Considerations

There are a number of design considerations that should be made before implementing a neighborhood greenway, including how best to manage the speed and volume of motor vehicles and establish bicycle priority, how to minimize impacts to nearby residential streets, how to maintain reasonable access for emergency and service vehicles, how to guide bicyclists along the route and get them safely across arterial streets. Streets with existing low volumes (less than 1,000 ADT) are good neighborhood greenway candidates as they typically require minimal or no traffic diversion treatments. These streets may only require traffic calming measures to get speeds down to 20-25 MPH and increase the comfort and safety of bicyclists. Where traffic volumes exceed 1,000 ADT, traffic reduction measures should be considered where reasonable alternative routes exist for motorists in addition to traffic calming measures. Lastly, creating arterial street crossings that are accessible, safe, comfortable, and provide quality level of service are essential to a successful neighborhood greenway route.

Prominent Markings Can Brand the Boulevard and Provide Wayfinding

Example Sign Branding the Bicycle Boulevard

Bicycle Priority/Advantage

Design elements that prioritize travel on the neighborhood greenway are intended to raise awareness of the route as a bicycle priority thoroughfare and create conditions that reduce unnecessary delay for bicyclists. Design treatments include pavement markings and wayfinding signage, adjustments to stop/yield control, and arterial crossing enhancements.

Employing distinctive symbols and/or colors to distinguish the neighborhood greenway from other roadway signs provides visual cues to motorists and bicyclists that this is a different type of roadway. Supplementing wayfinding signage with pavement markings helps to further establish bicycle priority, and also encourages proper positioning by bicyclists while sharing the lane with motor vehicles. Unique neighborhood greenway pavement markings such as “bicycle dots” or extra-large “bicycle blvd” lettering with bicycle symbol may be developed. Shared lane markings are being used more commonly in places like Portland and Seattle.

Because stop signs increase cycling time and energy expenditure due to frequent starting and stopping, they tend to result in non-compliance by bicyclists. Bicyclists should be able to travel continuously for the entire length of the neighborhood greenway with a minimum of stops. Assigning stop or yield signs to control cross traffic is one way to minimize stops for bicyclists. Mini traffic circles may be an alternative to stop and yield controlled intersections. Parking may need to be removed near the intersection to improve sight distance of bicyclists and motorists approaching the intersection. After stop or yield signs are reoriented to cross streets to provide bicycle priority, an increase in motor vehicle volume or speed along the route may occur – this should be mitigated using traffic calming treatments.

Traffic Calming Strategies on Local Streets and Collectors

There are numerous traffic calming treatments that may be integrated into a neighborhood greenway. Brief definitions are provided below for treatments which are likely to create the highest quality Bicycle Boulevards in City of Fort Collins – for more detailed information on each treatment, or to review additional treatments please refer to the resources cited below.

- **Mini traffic circles at 4-way intersections**- raised circular islands located in the center of intersections of local streets, intended to reduce speed of vehicles approaching the intersection while minimizing delay. Stop and yield signs may be eliminated when mini traffic circles are used. Signage indicating counter-clockwise circulation should be installed in advance and/or on the traffic circle.

- **Mini traffic circles with Neckdowns at T-Intersection**. T-intersections require the use of smaller circles, limited parking restrictions within the circle, and approach neckdowns to deflect the movement across the top of the tee which otherwise could not be deflected by the circle.

- **Chicanes** – raised curb features in the middle of the road (pedestrian refuge) or along the edge (chokers or curb extensions) that create horizontal shifting of travel lanes, which reduces vehicles speeds. Chicanes are typically used on long stretches of straight roadway and are ideal for approaches to signalized intersections where motorists may be inclined to accelerate towards the signal. A "chicaning" effect may also be achieved by alternating the location of on-street parking (on one side of the street) from one block to the next.

- **Speed tables or raised crosswalk** - long and broad, flat-topped sections of raised roadway (3-4 inches high and 22 feet wide) that slow traffic by requiring motorists to reduce their speed. Speed tables are more comfortable than speed humps for bicyclists to ride over without reducing their speed. A 22 foot table has a motor vehicle design speed of 25 miles per hour.

- **Speed cushions** – Similar in design to speed humps, speed cushions are rounded raised areas placed in the center of travel lanes to reduce vehicle speeds. They are generally 10 to 14 feet long (in the direction of travel) with. These are designed to allow free passage of larger chassis vehicles such as fire trucks through the flattened area.

- **Speed humps** – Speed humps are rounded raised areas placed across the roadway to reduce vehicle speeds. They are generally 10 to 14 feet long (in the direction of travel).
- **Speed humps with raised islands** are an effective combination on streets with low parking demand.

Traffic Reduction Strategies

Traffic reduction design elements are intended to maintain existing low volumes or reduce the overall volume of motor vehicle through trips on the neighborhood greenway, while allowing continuous through travel by bicyclists and other non-motorized users. Impacts on nearby local streets and emergency response should be analyzed before implementing traffic reduction elements.

- **Partial Diverters** - restrict motor vehicle access while allowing bicycle and pedestrian access, typically restricting through movements or left turns. This type of treatment is typically placed on minor streets at an intersection with an arterial street to manage motor vehicle volumes on the minor street.

- **Diagonal Diverters** – restrict through motor vehicle access completely at standard 4-way intersections while allowing bicycle and pedestrian access. This type of treatment is typically placed on minor streets at an intersection with an arterial street to manage motor vehicle volumes on the minor street.

- **Median Closures** – restrict through motor vehicle access completely at standard 4-way intersections while allowing bicycle and pedestrian access requiring right in and right out motor vehicle movements. This type of treatment is typically placed on minor streets at an intersection with an arterial street to manage motor vehicle volumes on the minor street. This treatment can be used to facilitate bicycles crossing the arterial or transitioning from the arterial to the neighborhood greenway.

The above traffic calming and traffic reduction design elements have been in use in several communities for many years. However, concerns regarding traffic calming and reduction that occur on the neighborhood greenway are likely to be similar to concerns that are raised when these improvements are implemented anywhere else in the community. Most commonly, residents and officials will raise concerns about four potential issues related to traffic reduction and calming:

- Access to property;
- Impact on traffic patterns;
- Enforcement issues with motorcycles and mopeds; and
- Emergency response.

These are all legitimate concerns that need to be addressed, and can be addressed through a combination of good design and enforcement, if needed. It is important to keep in mind that eliminating or modifying traffic diversion and calming design elements that are part of a larger system may reduce their effectiveness. Poorly designed traffic diversion and calming elements on so-called neighborhood greenways may create new traffic problems, such as attracting through motor-vehicle traffic to a neighborhood greenway with fewer stops. This reduces the comfort and safety of bicyclists, may negatively impact the neighborhood, and negatively influences opinions regarding the utility of neighborhood greenways in general.

To address each of these concerns it is important to involve stakeholders early. For residents living along a planned neighborhood greenway street, and concerned about accessing their property, presenting the design so that they can see how their access is affected is an important first step. Trial installations of design elements can alleviate resident concerns regarding access by allowing them to “try out” design features and allow any necessary modifications to be made before the city commits to a permanent installation. It is also very important during the initiation and conceptual planning phases to highlight the positive attributes of neighborhood greenways and the benefits residents can expect, including fewer cars on their street, fewer speeders, less noise, and generally, a more livable street.

When motor vehicle traffic is restricted or calmed on the neighborhood greenway it may induce an increase in motor vehicle traffic on adjacent streets. It is important to examine the impacts of traffic calming diversion elements both on the proposed neighborhood greenway and nearby streets, and include mitigation (e.g., additional traffic calming on adjacent streets) for any impact in their designs. Again, trial installations can allow residents to “try out” the design features and allow the city to evaluate and address impacts on traffic patterns.

Where traffic diversion is used, enforcing restrictions to motorcycles and mopeds may be needed. However, experiences in other communities have shown such violations to be seldom-it is likely that motorcyclists, like motorists, prefer to use the higher speed parallel streets when they are available nearby.

Traffic-calming elements can be a concern to fire and police personnel if the design substantially increases response times to properties along the neighborhood greenway. Having the support of the fire and police department is critical-without it development of a neighborhood greenway may be delayed or permanently deferred. Emergency services need to be engaged early in the planning process in order to identify acceptable design elements. Traffic reduction and calming design elements may be designed in such a way that allows a wide-chassis vehicle, such as a fire truck, to pass over, while preventing a similar movement of most passenger vehicles. Again, trial installations of street closures, medians, chicanes, or other design elements that may present an access concern to emergency services may be used to evaluate impacts on emergency responses.

8 Bicycle Parking

The *Association of Pedestrian and Bicycle Professionals (APBP) Bicycle Parking Guidelines, 2nd Edition* covers virtually everything related to bicycle parking, including recommended racks, site layout, security, aesthetics, weather protection, lighting maintenance etc. Model legislation for determining required parking for new developments is also provided.

The APBP guidelines are applicable in both urban and suburban contexts. The only significant difference will be scale. The number of bicycle parking racks needed at a particular location may be less in suburban and semi-rural areas. This difference in demand will immediately be captured if parking requirements are based on density and distance (addressed in APBP Guidelines). Lower densities and longer distances from population centers will generally result in lower demand for bicycle parking.

9 Maintenance

Maintaining bicycle facilities is important to bicycle safety. As vulnerable users, bicyclists are subject to additional discomfort when maintenance is not performed on dedicated bicycle facilities. Providing well maintained facilities can generate more interest and comfort in bicycling. The maintenance quality of roadways and trails in City of Fort Collins is high. As the bicycle network is expanded, protocols for bicycle facility maintenance should be developed. In many cases these protocols can be incorporated into existing maintenance protocols. Written maintenance protocols that are budgeted and funded are required in order to maintain a safe bicycle network. Bicycle facilities that were installed prior to development of this Plan should be assessed to determine if they require maintenance or upgrading based on their condition and according to updated standards and guidelines from AASHTO and MUTCD. Responsible entities should refer to this Plan to determine if existing facilities have any design deficiencies that should be addressed to improve safety and to ensure consistency with facilities that will be installed as part of the recommended bicycle network. For ongoing maintenance needs, establish a system for routine evaluation of bicycle facility maintenance needs, as well as a system for citizen reporting.

- Where inductive loops and push buttons have been installed for bicycle detection, they should be periodically tested to ensure that the signal can be actuated by bicyclists.
- Bicycle lanes and key roadways in the bicycle network that experience a large amount of debris should be given consideration for higher frequency sweeping. If adjacent travel lanes are swept mechanically, sweepers should reach as close to the curb as possible and make sure material is not deposited in the bicycle lanes. Perform spot sweeping if sand is left in bicycle lanes after a snow or ice event.
- Repave bicycle facilities as part of street repaving projects. Consider repaving streets with bicycle facilities more often and include bicycle facilities as a factor in determining the city repaving schedule.
- City of Fort Collins has a detailed snow removal plan which includes removal of snow from important regional trails. The plan should be updated to identify priority, on-street bicycle routes that serve as both connections between important regional trails and important on-street connections to employment centers. When streets with bicycle lanes are plowed, snow should be removed from the bicycle lane as well as motor vehicle travel lanes. As protected bicycle lanes are installed, consideration should be given to adding these to the priority snow removal routes to maintain their functionality.
- Replace missing or damaged warning, regulatory or wayfinding signs. Replace signs based on manufacturer recommendations related to reflectivity and readability (15-20 years).
- Replace faded or damaged pavement markings. Conduct annual replacement program to replace bicycle pavement markings based on a regular basis as needed. Replace bicycle pavement markings when roadways are repaved.

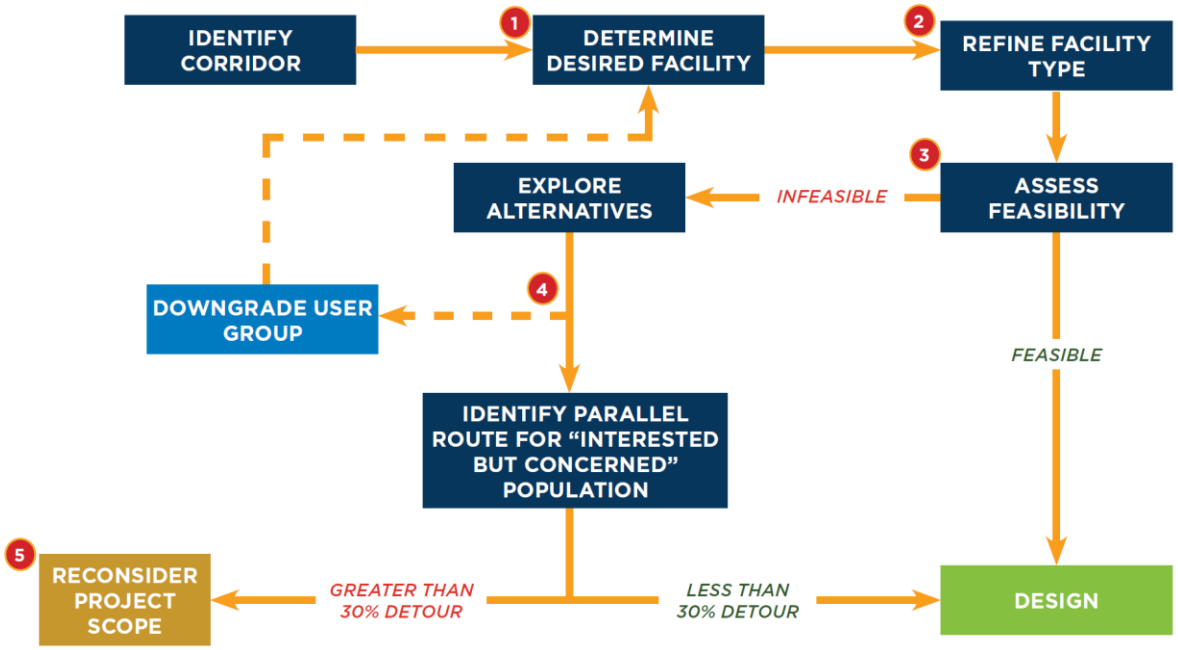
- Arterials with flexible post protected bike lanes will require special attention as snow piles within the buffer zones are not likely to be cleared. This snow is likely to melt and run across the bike lane where it may refreeze creating icy conditions. Porous bike lanes or pre-treatment strategies may be required to keep the protected bike lanes ice free. Smaller equipment and additional snow clearing passes will be required to remove snow.
- Protected bike lanes should be designed to accommodate street sweepers. Debris will collect in the buffer area between delineators thus debris will continually shed into the bike lane, causing hazards and flat tires if not kept clear. Increased street sweeping of the protected bike lanes may be necessary. Smaller equipment will be required to sweep protected bike lanes.

10 Approach to Facility Selection

The 2014 Plan recommends short-term and long-term bicycle facilities on a majority of roadways with the City of Fort Collins. In some circumstances, there may be a need to revisit the recommendation due to changes in land use, traffic volume, or limitations in funding. It may also be necessary to consider improvements on existing streets that do not have specific bicycle facility recommendations within the 2014 Plan or as new streets are constructed. For those situations, this guidance was developed to assist City staff in the preliminary selection of a preferred bike facility to accommodate the *Interested but Concerned* bicyclist. This guidance is based on the principles of the 2014 Plan to provide low-stress bicycle facilities comprehensively throughout the City.

Selecting the appropriate bicycle facility requires an understanding of the roadway characteristics, expected users and trip types. The following flow chart outlines a process for evaluating new corridors or for reassessing recommendations from the 2014 Plan. The use of the corridor evaluation flow chart in conjunction with the *Interested but Concerned* facility preference matrix will result in the identification of a preferred facility. If the preferred facility for the *Interested but Concerned* cannot be accomplished, this process recommends the identification of an alternative, parallel route.

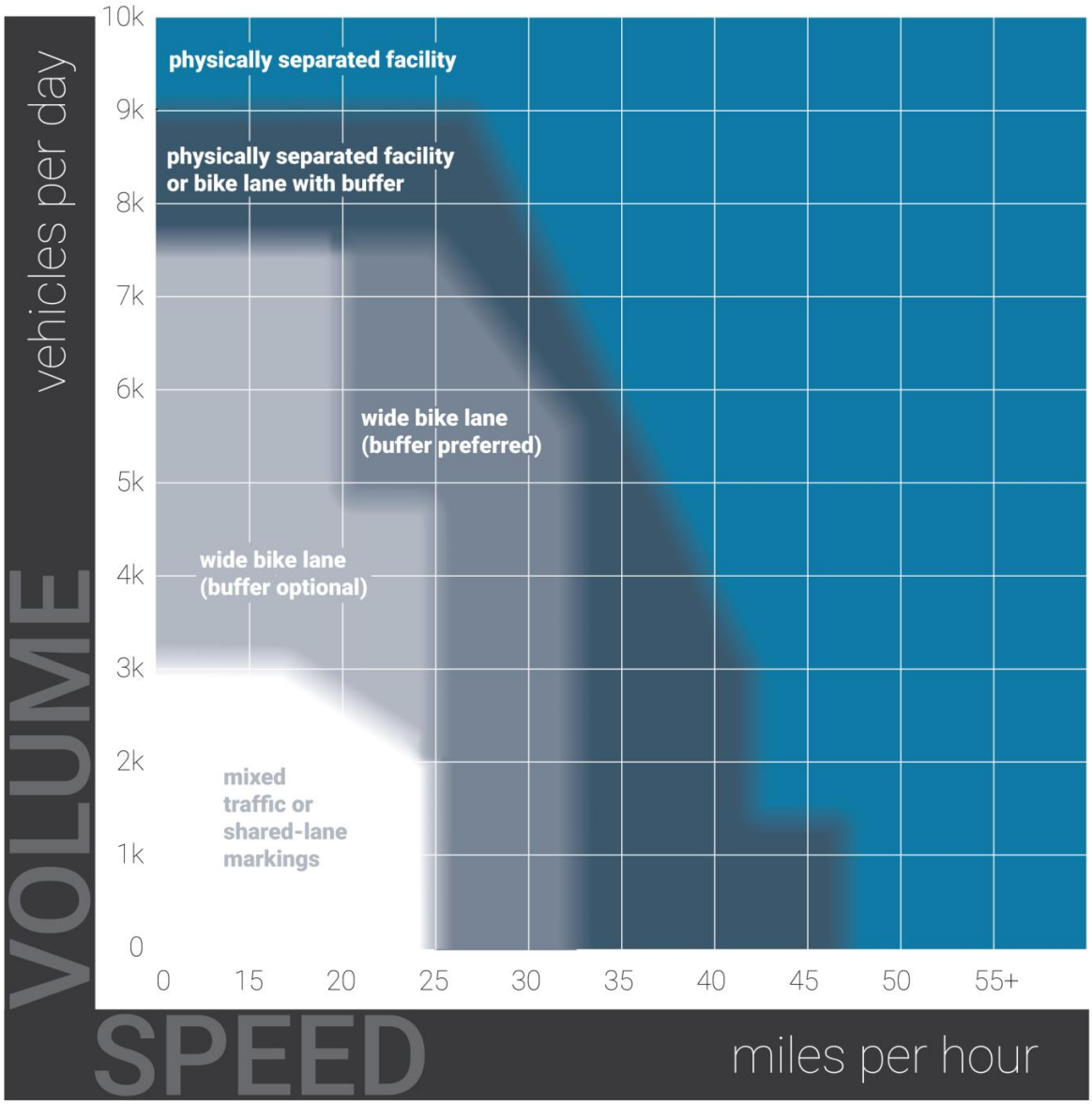
Corridor Evaluation Flow Chart



Flow Chart Notes:

1. Use the "Designing for *Interested but Concerned*" chart to pre-select bikeway facility type.
2. Use the "Level of Traffic Stress" methodology to refine the facility type.
3. Determine engineering and cost feasibility.
4. If the facility is not feasible, determine a secondary option for the *Interested but Concerned* population on a parallel corridor while continuing to evaluate the necessary facility for the *Enthused and Confident* population on the primary corridor.
5. The *Interested but Concerned* population is unlikely to be served if their trip length increases by more than 30 percent.

Designing for the *Interested but Concerned* Facility Selection Chart



Facility Selection Chart Notes:

1. A physically separated facility may be either a protected bicycle lane or a sidepath/shared-use path.
    a. Sidepaths/shared-use paths are only appropriate where pedestrian volumes or bicycle volumes are low
    b. Protected bicycle lanes should be at a different elevation than sidewalks where pedestrian volumes are high
    c. The use of the FHWA Shared Use Path Level of Service Calculator can be used to inform the selection of this facility type and to analyze the quality of service provided
2. A wide bicycle lane may include a buffer. The total minimum width should be seven feet.
3. Traffic volumes below 3,000 vehicles/day and speeds less than 25mph are ideal for neighborhood greenways