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MUNICIPAL RESOURCE GUIDE

FOR BIKEABILITY

MAY 2019

#MABIKEPLAN

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Letter from the Secretary



I am pleased to present the Massachusetts Department of Transportation's **Municipal Resource Guide for Bikeability**. In recognition of the important role the 351 cities and towns of Massachusetts play in encouraging bicycling, MassDOT developed the Guide – a companion document to the **2019 Bicycle Transportation Plan** – specifically to support municipalities in their efforts to increase and improve cycling. Because the vast majority of roadways (80 percent) and shared use paths are under local municipal ownership, municipal partners are critical to helping achieve the vision of the Commonwealth as a place where people of all ages and abilities have the option to bicycle safely for everyday trips.

In Massachusetts, 52% of all trips are three miles or fewer – a typical biking distance for many people (about 16 minutes) – and yet 80% of those trips are currently made in vehicles. This is a statistic that we need to start to change in order to meet our goals for reducing congestion and greenhouse gas emissions and improving public and community health.

MassDOT created this easy-to-follow Guide for municipalities to advance bikeability – a measure of how well an area encourages biking for everyday trip purposes. Whether people ride their own bicycles or make use of bikeshare services, bicycling plays an important role in our transportation system and can help to fill "first and last mile" gaps to and from public transit stations and stops.

I would like to thank all of stakeholders and MassDOT staff who contributed to this Guide, including municipal staff who provided valuable feedback on the challenges and opportunities of developing bicycling facilities at the local level. This Guide includes discussion of physical design elements essential to bikeability; best practices for planning and maintaining connected bicycle networks; and case studies on how municipalities have supported bike lanes, bikeshare, and bike parking. Additional tools highlighted within the Guide are helpful for collecting and evaluating bicycle-related data.

MassDOT has been working for years to make our transportation system more sustainable; to encourage walking, bicycling, and transit; and to ensure that roads are safe and comfortable for all people. This Guide—plus the **Bicycle Transportation Plan**—builds upon the work of the award-winning **Project Development & Design Guide** (2006), the **Healthy Transportation Policy Directive** (2013), and the internationally recognized **Separated Bike Lane Planning & Design Guide** (2015). The **Municipal Resource Guide for Bikeability** and **Municipal Resource Guide for Walkability** represent MassDOT's continued commitment to partnering with municipalities to build streets that are accessible, safe, and convenient for people of all ages and abilities.

Stephanie Pollack
Secretary of Transportation and Chief Executive Officer
Massachusetts Department of Transportation

Introduction

MassDOT has established the following DRAFT vision for biking in Massachusetts:

Biking in Massachusetts will be a safe, comfortable, and convenient option for everyday travel.

The Municipal Resource Guide for Bikeability ("the Guide") provides an introduction to the core concepts of bikeability and outlines additional resources available on each topic. The Guide is intended to provide municipalities—which own and maintain 80 percent of Massachusetts streets—with the tools and information needed to provide safe, comfortable, and convenient bike networks that appeal to the broadest base of people. The audience for this Guide is community practitioners: municipal staff, elected officials, volunteers, residents, and advocates.

The topics addressed in this Guide were selected based on input received during the Massachusetts Bicycle Transportation Plan's public outreach process. The Massachusetts Department of Transportation (MassDOT) and partner organizations identified and engaged target audiences with in-person events and supplemented these interactions with online tools. Between May and October 2017, MassDOT:

- Conducted nine **listening sessions** with the following audiences of people who bike (listed in chronological order and including location):
  - Children (Revere)
  - Rural and small town residents (North Adams)
  - Women (Somerville)
  - Low-income community residents (Lawrence)
  - Majority-minority community residents (Dorchester)
  - Non-English speakers (Boston)
  - People with disabilities (Hadley)
  - Families (Cambridge)
  - Seniors (Hyannis)
- Participated in four **open streets events** with activities and a separated bike lane demonstration (listed in chronological order):
  - Connecticut River Roll & Stroll (Holyoke, South Hadley)
  - 3rd Thursdays (Pittsfield)
  - SomerStreets (Somerville)
  - Downtown Ciclovía (Lawrence)
- Launched and maintained an **online survey** and **online interactive map**.

BICYCLIST



Throughout this Guide, and the 2019 Massachusetts Bicycle Transportation Plan, the terms "bicyclist" and "people biking" are used inclusively of people of all ages, abilities, and backgrounds. The terms "bicycle" and "bike" include standard two-wheeled bikes, recumbent bikes, adult-sized tricycles, two- and three-wheeled cargo bikes, and children's bikes. For detailed description of bicycle design vehicle types, see the most recent edition of the Guide for the Development of Bicycle Facilities by AASHTO. A bike may be pedal-powered or electric-assist.

The Massachusetts Bicycle and Pedestrian Advisory Board (MABPAB) serves as the Steering Committee for the Bicycle Transportation Plan. The MABPAB was established by law in 2004 and serves in an advisory role advancing bicycle and pedestrian transportation for MassDOT and other state agencies. Its members are appointed by the Governor of the Commonwealth.

Contents

This Guide is organized into seven chapters, each of which focuses on a specific topic related to the development and maintenance of bicycle infrastructure. Each chapter features key information, case studies, and links to additional resources.

» **Why Bikeability is Important** page 6
Presents the case for municipalities to make investments in biking.

» **Everyday Biking for All Ages and Abilities** page 11
Describes the potential for everyday biking in Massachusetts and introduces the principles of connected bike networks.

» **Planning for Bikeable Communities** page 15
Describes the process for developing a bike plan, envisioning a connected bike network, and supportive policies and programs.

» **Designing Connected Bike Networks** page 28
Provides design guidance for bikeways, intersection treatments, and bike parking.

» **Establishing Bikeshare** page 47
Introduces the need for bikeshare, available bikeshare technologies, and the essential elements for successful bikeshare systems.

» **Collecting and Evaluating Data** page 53
Summarizes the need for bicycle-related safety, volume data, and economic data and strategies to collect and evaluate these data.

» **Maintaining Year-Round Bikeways** page 60
Offers guidance on asset management, bikeway maintenance, and maintaining bicycle access during construction.

Why Bikeability is Important



Bikeable communities provide safe, comfortable, and convenient bikeways that attract bicyclists of all ages and abilities. Bikeable communities can be urban, suburban, and rural in character, as short trip opportunities exist everywhere in Massachusetts.

Bicycling is an efficient, healthy, low-cost, and fun way to travel for transportation and recreation. Massachusetts residents of all ages and bicycling abilities choose to ride a bike for routine, everyday trips like commuting, running errands, shopping, or visiting family and friends. Improving the "bikeability" of our roadways and communities with safe, comfortable, and convenient bikeways make it possible to convert more short trips to bicycling. When greater numbers of people bike, communities can experience mobility, safety, health, economic, environmental, and equity benefits. Municipalities that invest in programs and infrastructure projects to encourage biking can realize these benefits at the community level. MassDOT supports municipalities in becoming more bikeable as part of its effort to foster a sustainable and efficient transportation system for the Commonwealth.

Benefits of Biking

Mobility and Efficiency

Roadway congestion is a vexing problem in communities across Massachusetts. Bicycling provides residents and visitors an array of transportation options that serve a variety of trip purposes and distances. Bicycling can be part of a balanced transportation system that includes walking, transit, and driving. The following are ways that bicycling can increase mobility and connectivity:

- **Bicycles are an efficient use of roadway space,** and dedicated bikeways can move many more people in considerably less space than is needed to move the same number of single-occupancy motor vehicles.
- When communities build bikeways separated from car traffic (i.e., separated bike lanes) on key corridors, people use them. Newly built separated bike lanes across the U.S. have increased bicycling by **21–171 percent**, with many people increasing their bicycle usage as a direct result of the changes.[1]
- **Integrating bicycles with public transportation allows commuters to utilize a range of options for their daily travel,** changing as needed due to weather conditions or other demands.[2]

Safety

Increasing the safety and comfort of bicycling on our roadways can have a beneficial effect for all roadway users:

» **Streets with separated bike lanes are significantly safer for cyclists, pedestrians and drivers** compared to streets without such infrastructure, and are effective in reducing severe injuries.[3 4 5 6]

» Municipalities with higher bicycling rates show a **lower risk of fatal crashes for all road users**. This trend suggests that communities with more bicyclists on the streets have calmer traffic and a culture of slower and more conscientious driving.[7]

» There is a **"safety in numbers"** effect when more people regularly ride; fatality rates per trip and miles traveled decreases as biking rates increase.[8]

» Drivers value the **greater certainty** that comes when bicyclists have their own dedicated infrastructure.[9 10]

Health and Wellness

Bicycling can help individuals improve their own health and wellness and play a role in improving public health:

» Approximately **66 percent** of adults and **25 percent** of children in Massachusetts were categorized as overweight or obese.[11] Bicycling allows people to combine physical activity with everyday trips, which can **improve an individual's physical health and fitness.**



Busy streets that lack dedicated bikeways create uncomfortable conditions that limit biking's role as a transportation option for most people.

» Regular physical activity—like bicycling—is associated with **improved mental health, increased happiness, and well-being** across multiple age groups.[12]

» Moderate physical activity—such as walking and biking—prior to school can **improve childrens' focus and cognitive performance**.[13]

Economy and Cost Reduction

Investments in bicycling can increase individual access to economic opportunities, boost the local economy, incentivize investment, and reduce the financial burden of traffic crashes:

» Bicycle infrastructure and related services like bikeshare help workers make first- and last-mile connections to transit. **Bicycle infrastructure also allows travel to jobs that are not accessible using transit,** boosting wage-earning potential and increasing the size of employers' potential labor pool.[14]

» Shared use paths are an amenity that many homeowners and renters value. **Bicycle infrastructure can boost residential property values** by creating safer, more walkable, livable neighborhoods.[15 16 17]

» **Bicycle infrastructure can increase customer traffic** by providing safe, comfortable, and convenient ways to reach businesses by bike.[18 19]

» In addition to the human toll of traffic crashes, there is also significant economic loss. Nationwide, bicyclist fatalities and injuries resulting from traffic crashes cost more than **$4 billion** per year.[20 21] Investments in bikeways can reduce these costs by making streets safer.

» Investing in bicycle infrastructure is fiscally prudent. Capital and lifecycle costs are lower for bicycle infrastructure than that of vehicle infrastructure.

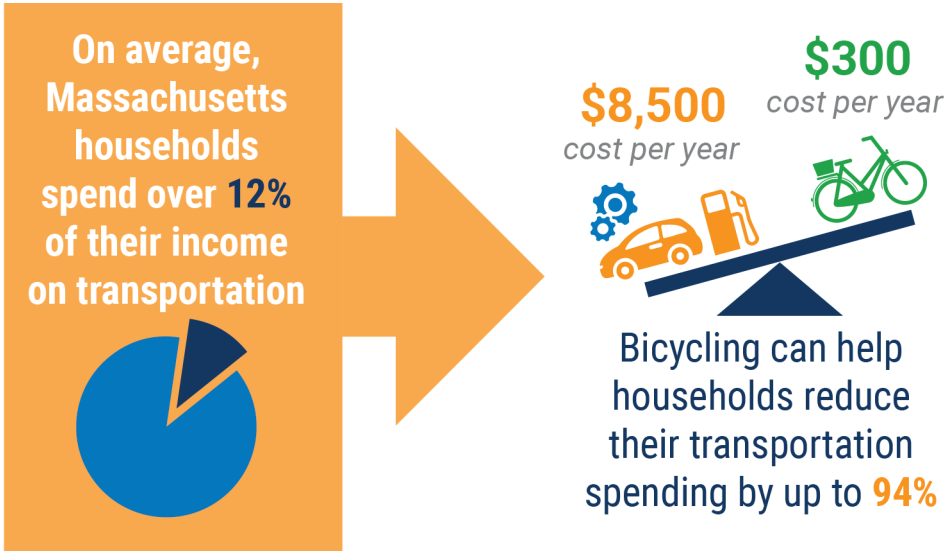
Environment

The transportation sector is the largest emitter of greenhouse gas (GHG) emissions in Massachusetts, and passenger vehicles are the primary source of transportation emissions.[22] Reducing GHG emissions and mitigating the effects of climate change are increasingly important priorities at all levels of government in Massachusetts. Bicycling can have the following environmental benefits:

» **Reducing motor-vehicle-miles traveled is a crucial component of efforts to address climate change.** When people replace driving trips with bicycling trips, it can reduce carbon dioxide emissions, the primary GHG contributing to climate change.

» **Local air quality can be improved by reductions in vehicle miles traveled,** leading to a reduction in air pollutants that are harmful to breathe such as carbon monoxide, nitrogen oxides, hydrocarbons, and particulate matter.

» Bikeable roadway designs often incorporate more space for trees, landscaping, and pervious surfaces, which **reduces stormwater run-off and buffer pedestrians and bicyclists from exhaust emissions.**



Equity

Improving bikeability can help achieve various equity objectives by providing infrastructure that all can use, regardless of age, ability, or income status:

» While people from across the income spectrum ride bicycles, **low-income people are more likely to bike for transportation.**[23]

» Bicycling to school is **more common** among children from low-income and minority households.[24]

» For older adults, children, and people with disabilities, access to safe and comfortable bicycle infrastructure allows for **greater independence and reduces reliance on cars**. Various adaptations are available to make bicycles usable for people with certain mobility impairments.

» The cost to own, operate, and maintain a vehicle is nearly **$8,500** per year, or about **94 percent** of the average household's annual transportation costs.[25] People who bike may be able to reduce or eliminate the use of motor vehicles, thereby reducing household expenditure.

Explore More Resources

» Pedestrian and Bicycle Information Center Library, Federal Highway Administration. http://www.pedbikeinfo.org/data/factsheet.cfm

References

1 Christopher Monsere, Nathan McNeil, and Jennifer Dill, "Multiuser Perspectives on Separated, On-Street Bicycle Infrastructure," Transportation Research Record: Journal of the Transportation Research Board 2314 (December 1, 2012): 28, doi:10.3141/2314-04;

2 Dill, Mohr, and Ma, "How Can Psychological Theory Help Cities Increase Walking and Bicycling?," 122.

3 Anne C. Lusk et al., "Risk of Injury for Bicycling on Cycle Tracks versus in the Street," Injury Prevention 17, no. 2 (April 1, 2011): 131–35, doi:10.1136/ip.2010.028696;

4 Anne C. Lusk et al., "Bicycle Guidelines and Crash Rates on Cycle Tracks in the United States," American Journal of Public Health 103, no. 7 (July 2013): 1244, doi:10.2105/AJPH.2012.301043;

5 New York City DOT, "Prospect Park West Bicycle Path," New York City DOT. Accessed December 10, 2014. http://www.nyc.gov/html/dot/html/bicyclists/prospectparkwest.shtml#documents.

6 Beth Thomas and Michelle DeRobertis, "The Safety of Urban Cycle Tracks: A Review of the Literature," Accident Analysis & Prevention 52 (2013): 233.

7 Wesley E. Marshall and Norman W. Garrick, "Evidence on Why Bike-Friendly Cities Are Safer for All Road Users," Environmental Practice 13, no. 01 (2011):

8 John Pucher and Ralph Buehler, "Making Cycling Irresistible: Lessons from The Netherlands, Denmark and Germany," Transport Reviews 28, no. 4 (July 2008): 508, doi:http://dx.doi.org.ezproxy.library.tufts.edu/10.1080/01441640701806612.

9 Sanders, R. (2013). Examining the Cycle: How Perceived and Actual Bicycling Risk Influence Cycling Frequency, Roadway Design Preferences, and Support for Cycling Among Bay Area Residents, University of California, Berkeley, Berkeley, CA.

10 Monsere, McNeil, and Dill, "Multiuser Perspectives on Separated, On-Street Bicycle Infrastructure," 28–9; Goodno et al., "Evaluation of Innovative Bicycle Facilities in Washington, D.C.," 147; Monsere et al., Lessons from the Green Lanes, 142.

11 Massachusetts Department of Public Health. Municipal Wellness and Leadership Program. Accessed October 15, 2018: http://www.mass.gov/eohhs/docs/dph/mass-in-motion/mim-community-overview.pdf

12 Exercise and well-being: a review of mental and physical health benefits associated with physical activity. Penedo, Frank Ja; Dahn, Jason R. Current Opinion in Psychiatry: March 2005 -Volume 18 https://journals.lww.com/co-psychiatry/Abstract/2005/03000/Exercise_and_well_being_a_review_of_mental_and.13.aspx

13 National Academies of Sciences, Engineering, and Medicine. 2013 Educating the Student Body: Taking Physical Activity and Physical Education to School. Accessed October 15, 2018. http://www.nationalacademies.org/hmd/Reports/2013/Educating-the-Student-Body-Taking-Physical-Activity-and-Physical-Education-to-School.aspx

14 Garrett-Peltier, Heidi. 2011. "Pedestrian and Bicycle Infrastructure: A National Study of Employment Impacts." Political Economy Research Institute, University of Massachusetts. Accessed October 15, 2018. https://www.peri.umass.edu/fileadmin/pdf/published_study/PERI_ABikes_October2011.pdf

15 Racca, David P. and Amardeep Dhanju. 2006. "Property Value/Desirability Effects of Bike Paths Adjacent to Residential Areas." College of Human Services, Education and Public Policy, University of Delaware.

16 Parent, Olivier and Rainer vom Hofe. 2012. "Understanding the Economic Benefits of Trails on Residential Property Values." Annals of Regional Science, 51 (2), 355-375. DOI 10.1007/s00168-012-0543-z

17 Della Penna, Craig. 2006. "Home Sales near Two Massachusetts Rail Trails." The Murphy's Realtors, Inc. Accessed October 15, 2018. http://brucefreemanrailtrail.org/wp-content/uploads/2016/01/1-25-2006-Report-to-MLSPIN-house-sales-near-to-rail-trails.pdf

18 Kelly J. Clifton et al., Examining Consumer Behavior and Travel Choices (Portland, OR: Oregon Transportation Research and Education Consortium, February 2013), http://trid.trb.org/view.aspx?id=1244464

19 Lee, Alison. 2008. "What is the Economic Contribution of Cyclists Compared to Car Drivers in Inner Suburban Melbourne's Shopping Strips?" University of Melbourne, Masters of Urban Planning. http://colabradio.mit.edu/wp-content/uploads/2010/12/Final_Thesis_Alison_Lee.pdf

20 Blincoe, L. J., Miller, T. R., Zaloshnja, E., & Lawrence, B. A. 2015. "The Economic and Societal Impact of Motor Vehicle Crashes, 2010. (Revised)" (Report No. DOT HS 812 013). Washington, DC: National Highway Traffic Safety Administration. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812013

21 Pedestrian and Bicycle Information Center. "Pedestrian and Bicyclist Crash Statistics" http://www.pedbikeinfo.org/data/factsheet_crash.cfm

22 2015 Update of the Clean Energy and Climate Plan for 2020. Accessed October 15, 2018. https://www.mass.gov/files/documents/2017/12/06/Clean%20Energy%20and%20Climate%20Plan%20for%202020.pdf

23 Pucher, J., Charles Komanoff, C., Schimek, P. 2011. Bicycling renaissance in North America? An update and re-appraisal of cycling trends and policies. Transportation Research A, 45

24 McDonald, N. 2008. Critical Factors for Active Transportation to School Among Low-Income and Minority Students: Evidence from the 2001 National Household Travel Survey. American Journal of Preventive Medicine, 34(4), 341-344.

25 Bureau of Transportation Statistics. "Chapter 6: Household Spending on Transportation." In Transportation Economic Trends, 69-75. https://www.bts.gov/content/transportation-economic-trends

Everyday Biking for All Ages and Abilities

Massachusetts communities have the potential for everyday biking. Our urban, suburban, and rural cities and towns have the basic ingredients needed to make short, bikeable trips a viable option: vibrant town centers, a mix and density of land uses, and the third highest population density in the U.S. The 2017 National Household Travel Survey confirms this high potential for short, bikeable trips: **52 percent** of all trips taken by Massachusetts residents are three miles or less,[1] a relatively short distance that can be accomplished by bike in about the same time as a motor vehicle trip.

Why Do People Bike for Everyday Trips?

While there are many factors that influence how people choose to travel, many bike because it is **convenient**. Biking can be quicker and cheaper than other travel options, especially where trip distances are relatively short. Others enjoy being outside and active or may not have access to an alternative mode due to age, income, or health reasons.

Regardless of whether they lived in a rural, suburban, or urban setting, MA Bike Plan public outreach respondents said they wanted to bike to work, shopping, and parks, as summarized below. For a complete summary of public outreach results, see the Massachusetts Bicycle Transportation Plan Public Engagement Results.

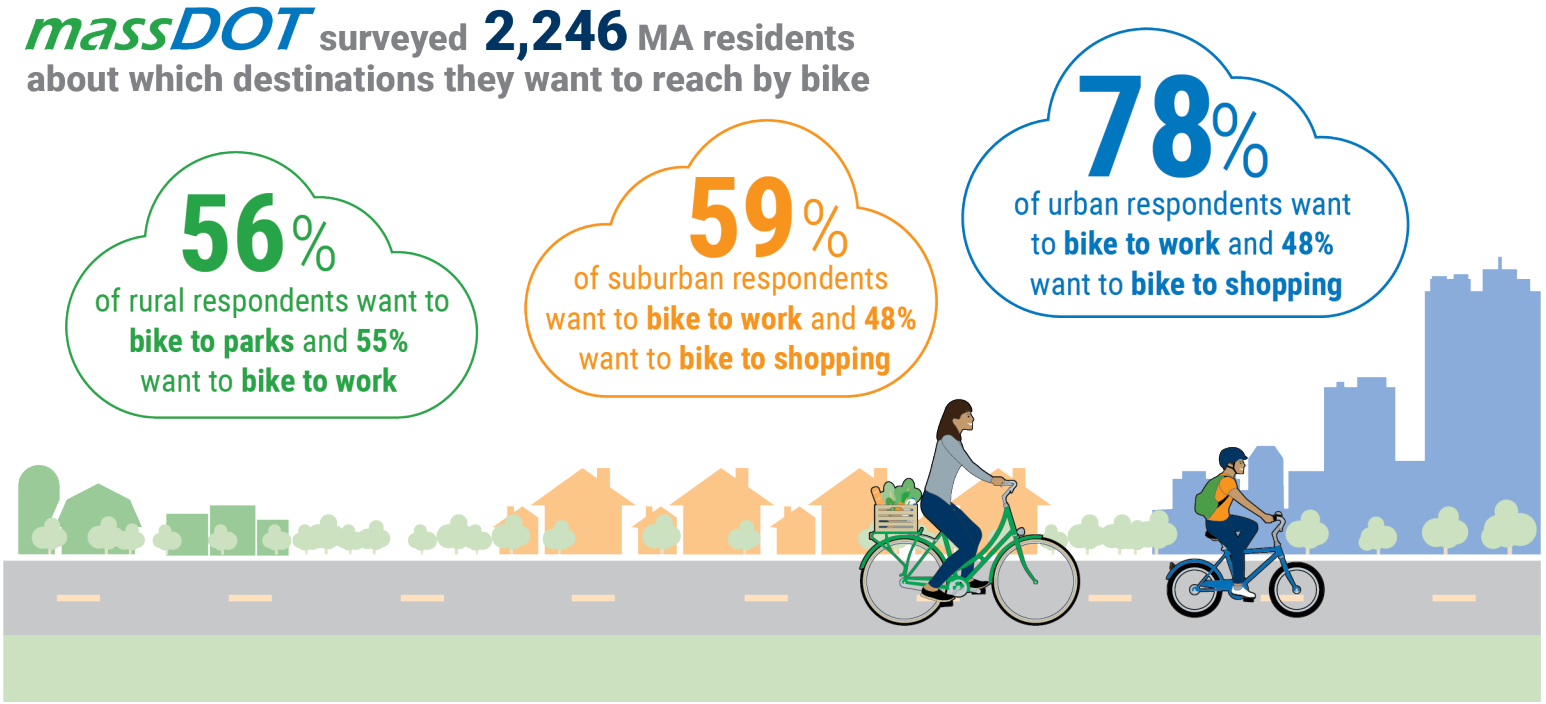


Figure 1. People throughout Massachusetts—regardless of living in urban, suburban, and rural communities—want the option to reach their everyday destinations by bike. People in rural communities favored bicycle access to parks above all other destinations.

Unrealized Potential

Approximately **2 percent** of trips for any purpose are made by bike in Massachusetts.[2] There is potential to increase this share by making it more **convenient**, **safe,** and **comfortable** to ride a bike for everyday, short trips.

People biking are vulnerable road users. They lack the benefit of physical protection provided to vehicle occupants, and are **four times likelier** to suffer a fatal or serious injury than a driver in the event of a crash.[3] As a result, bicyclists are sensitive to high motor vehicle speeds and volumes.

There is broad interest in biking for transportation across the general adult population, but stressful interactions with motor vehicles are the most significant deterrent.[4] These "interested but concerned" individuals vary by age and biking ability and account for **60% of the general population**. They include children, seniors, women, people of color, low-income riders, people with disabilities, and people riding bikeshare.[5] While some bicyclists are more willing to ride in mixed traffic, they account for a significantly smaller share of the population. Even fewer are willing to ride with friends or family in stressful roadway conditions.

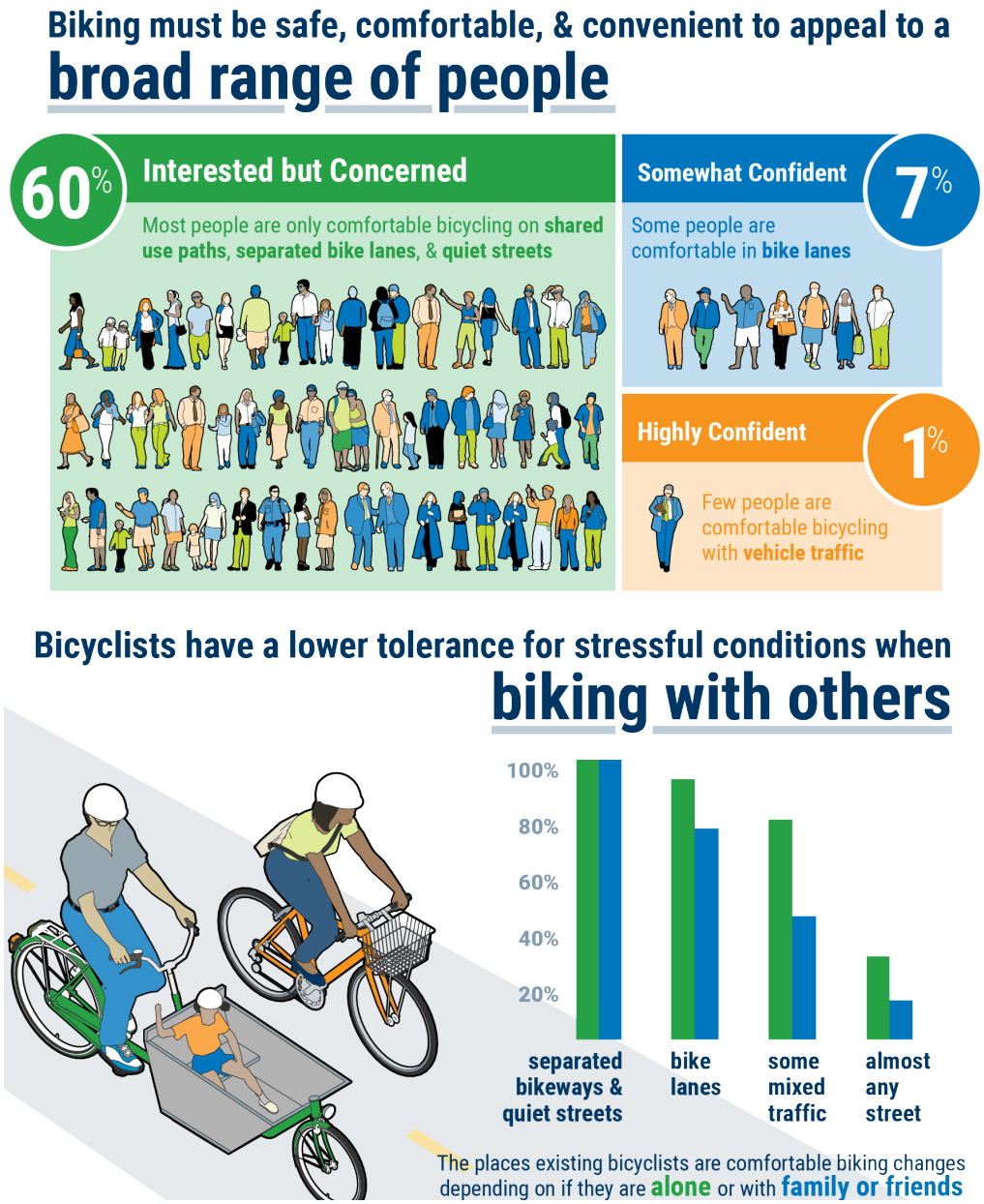


Figure 2. Biking becomes more appealing to a broader segment of the population as the stress of riding a bicycle decreases. **MA Bike Plan public outreach** revealed that existing bicyclists have a lower tolerance for stressful conditions when biking with others. Communities can only expect to attract a modest percentage of the general population without safe, comfortable, and convenient bikeways.

Attracting Riders of All Ages and Abilities

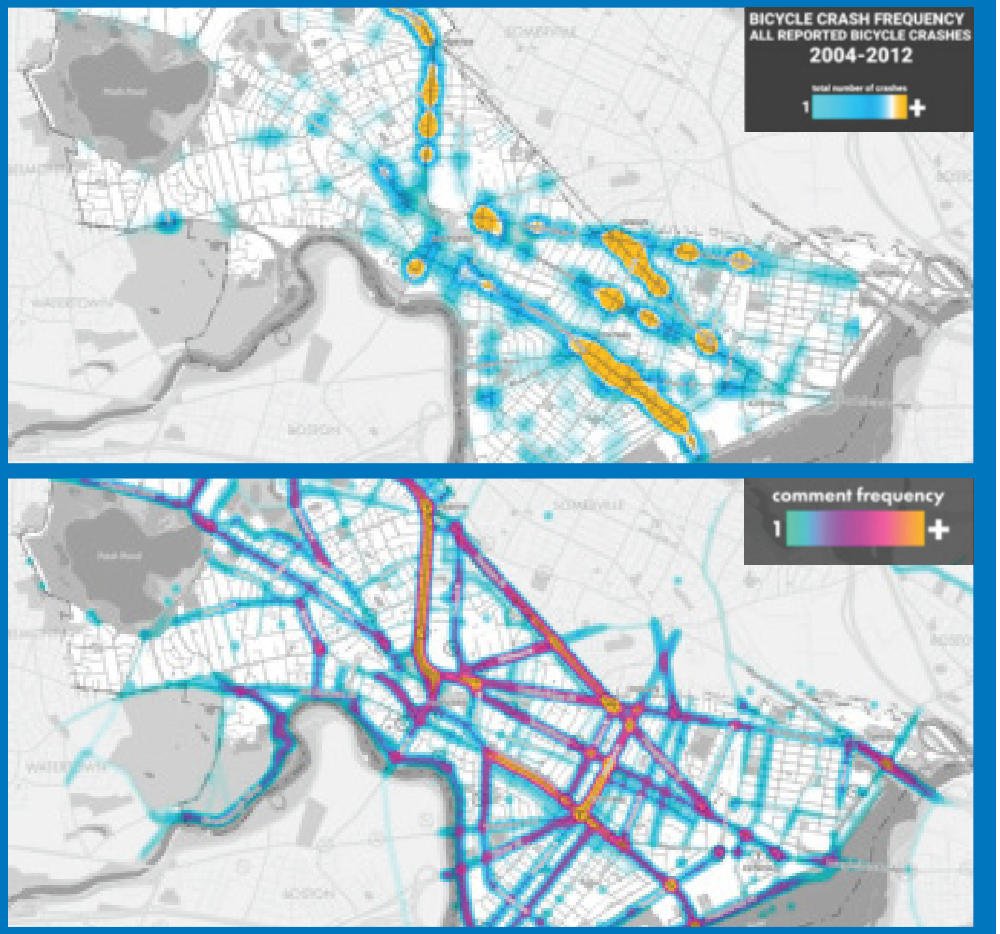
Realizing the potential for everyday biking in Massachusetts will require **connected networks** of safe, comfortable, and convenient bikeways that meet the needs of riders of all ages and abilities (see Planning a Connected Bike Network on page 15). Connected bike networks in any community should enable uninterrupted travel to destinations along high-comfort streets and bikeways. The Federal Highway Administration (FHWA) has identified six principles of connected networks based on its review of international best practices:[6]

- **Safety and Security**: the network provides routes that minimize risk of injury, danger, and crime.
- **Comfort**: the network appeals to a broad range of age and ability levels and consideration is given to user amenities.
- **Cohesion**: the network is connected in terms of its concentration of destinations and routes.
- **Directness**: the network provides direct and convenient access to destinations.
- **Access**: the network accommodates travel for all users, regardless of age, income level, or ability.
- **Alternatives**: there are numerous different route choices available within the network.

Connected network principles are embedded throughout the guidance provided in this Guide.

Case Study: Bicyclist Safety and Comfort

The City of Cambridge explored the relationship between bicyclist safety and comfort as part of its 2015 Cambridge Bicycle Plan. The plan revealed that bicycle safety (i.e., bicycle crash data) and comfort (i.e., bicycle survey results) within Cambridge are related but separate concepts. Crash data alone do not fully capture the everyday risks experienced by bicyclists, for example, near-misses and proximity to moving traffic. Ultimately, most people are attracted to bikeways that make them feel safe, so these uncomfortable interactions are likely preventing people from considering biking as a transportation option. The City uses these analysis results to inform planning, design, and prioritization of bikeway projects.



Frequency of reported bike crashes (top) shows known safety concerns, but the frequency of perceived safety concerns (bottom) shows where people feel uncomfortable. Credit: City of Cambridge.

Explore More Resources

» FHWA Bicycle Network Planning & Facility Design Approaches in the Netherlands and the United States: https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/network_planning_design/network_planning_design.pdf

» NACTO Designing for All Ages & Abilities: Contextual Guidance for High-Comfort Bicycle Facilities: https://nacto.org/wp-content/uploads/2017/12/NACTO_Designing-for-All-Ages-Abilities.pdf

References

1 Federal Highway Administration. 2017 National Household Travel Survey. Accessed October 15, 2018. https://nhts.ornl.gov/

2 Massachusetts Department of Transportation. Massachusetts Travel Survey (2011). Accessed October 15, 2018. http://www.massdot.state.ma.us/planning/Main/MapsDataandReports/Reports/TravelSurvey.aspx

3 Massachusetts Department of Transportation. 2010–2015 crash data retrieved from https://services.massdot.state.ma.us/crashportal/

4 Massachusetts Department of Transportation. Separated Bike Lane Planning & Design Guide. Chapter 1: Overview. Accessed October 15, 2018. https://www.mass.gov/lists/separated-bike-lane-planning-design-guide

5 National Association of City Transportation Officials. Designing for All Ages & Abilities: Contextual Guidance for High-Comfort Bicycle Facilities. Accessed October 15, 2018. https://nacto.org/wp-content/uploads/2017/12/NACTO_Designing-for-All-Ages-Abilities.pdf

6 Federal Highway Administration. Small Town and Rural Multimodal Networks. Accessed October 15, 2018. https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/small_towns/

Planning for Bikeable Communities



Main Street, Great Barrington, was reconstructed with bike lanes, bike parking, and an enhanced streetscape.

Municipal planning plays a significant role in encouraging and sustaining biking as an everyday mode of transportation. Effective municipal bike plans include both infrastructure and non-infrastructure components. Developing a connected bike network plan is an essential step to identify routes and prioritize investments to encourage more biking. Non-infrastructure elements of a bike plan include policies and programs that create a supportive framework for the development of a bikeable community. This chapter provides an overview of these bike plan elements as well as general planning processes.

Planning a Connected Bike Network

A connected bike network is comprised of segments (roads and paths) and nodes (intersections and crossings) designed to enable uninterrupted travel to destinations along high-comfort streets and bikeways. Effective bike network planning addresses the principles of **cohesion**, **access**, **directness**, and **alternatives** as described on. The principles **safety** and **comfort** are addressed by design, which is discussed in Designing Connected Bike Networks starting on page 28. The development of a connected bike network plan should happen in conjunction with and be informed by the processes and steps described in Bike Planning Processes starting on page 22.

Developing a connected bike network plan is an important part of the bike planning process and provides a vision for the community to work towards implementation. Municipal bike network plans should consider all roadways within the municipality where bicycles are allowed to legally operate, including those owned by MassDOT. While opportunities to implement bikeways will differ depending on jurisdiction, it is important to document and plan for future improvements.

Achieving a fully interconnected high-comfort bike network takes a sustained and concerted effort and typically evolves over many years. The initial lack of connection to other bikeways, therefore, should not preclude the consideration of bikeways during project planning. A new bikeway that sees lower levels of use in its early years could become a key link in the network as connections develop, land use changes, and mode shift occurs.

When consulting previously adopted plans, it is important to consider that bikeway design best practices have advanced significantly in recent years, especially with the increased implementation of separated bike lanes. While specific recommendations for separated bike lanes may not be included in existing plans, they should be considered along with other types of bikeways such as bike lanes and bike boulevards.

Network Cohesion and Access

Municipalities planning a connected bike network may weigh the benefits of covering a wide area (coverage) versus focusing on the areas with the highest concentration of activity (density). Municipalities seeking to increase bike usage may want to focus on developing a core connected bike network in areas with the highest potential demand before expanding outward. Research has found a relationship between higher bike network density and higher rates of bike commuting.[1] Network density refers to the mileage of bikeways within a certain area.

The Local Access Score is a tool developed by the Metropolitan Area Planning Council (MAPC) to help municipalities across Massachusetts identify and prioritize bike and pedestrian route improvements. Each road segment receives a score based on its usefullness for biking or walking under ideal conditions, regardless of current infrastructure. The score is calculated based on access to schools, shopping, transit, and parks. In order to prioritize cohesion and access, municipalities can choose to prioritize road segments that have high Local Access scores.

Network Directness and Alternatives

High-comfort bikeways on busy corridors are a necessary component of a cohesive network. Providing a high-comfort bikeway on busy corridors will help encourage everyday biking by allowing people to access important daily destinations, which are often

Case Study: Closing a Network Gap in Northampton

Northampton has an extensive network of shared use paths that connect it to other towns and cities throughout the Pioneer Valley region. These trails allow residents to make daily trips by bike and are a draw for bicycle tourism to the region. However, a gap in the network north of downtown Northampton had, until recently, required people to follow a lengthy detour route along high speed roads in order to avoid crossing an active rail line.

A recently-opened bicycle and pedestrian underpass now allows trail users to make a direct connection between the Northampton Bikeway, Norwottuck Rail Trail, and Manhan Rail Trail. The new underpass eases travel for trail users by providing a high-comfort route directly into downtown Northampton, significantly improving regional bicycle connectivity.

Completion of this project was brought about through effective interagency coordination between municipal leaders in Northampton, MassDOT, and the Department of Conservation and Recreation. The project cost $4.4 million and was funded through American Recovery and Reinvestment Act Knowledge Corridor Project.



located along busy corridors, by bicycle. When determining if a high-comfort bikeway should be included on a busy corridor, planners sometimes look for alternative routes on other parallel corridors. It is important to consider that bicyclists operate under their own power and are sensitive to routes that require out-of-direction travel. Most bicyclists are willing to lengthen their trip by up to 25 percent to avoid difficult traffic conditions in cases where they can access a high-comfort bikeway. Therefore, alternative routes that require significant out-of-direction travel route should not be considered a substitute for direct, high-comfort bikeways on busy corridors.

Connecting to Transit

Biking increases the utility of transit by closing the "first and last mile" gap. Safe, comfortable, and convenient routes to transit stations and stops significantly expands the number of households that can access transit (see Figure 3). Providing the option to bike to transit can encourage transit ridership growth while managing congestion and demand for additional car parking near transit stations. In other words, people who bike to transit keep additional cars off local roadways and require significantly less space to store their bicycles when compared to the space required for car parking. Municipalities should consult with their regional planning agency to identify opportunitites to program capital funding for transit access projects.

An effective strategy for increasing biking to transit includes the following key elements:

» **Safe, comfortable, and convenient routes to transit stations and stops.** High-comfort bikeways, reasonable delay at intersections, and effective wayfinding to reduce trip-planning effort are key elements of bike routes to transit. Bike network planning should include routes to transit and communities may consider ranking transit connectivity highly in their project prioritization formula.

» **Bike parking at stations and stops.** Secure bike parking enables people to bike for a portion of their trip, leave their bike at a station or stop, and continue their trip on transit. Bike parking is a critical piece of bicycle infrastructure and a relatively low-cost and easily-implemented component of the system (see Bike Parking on page 28).

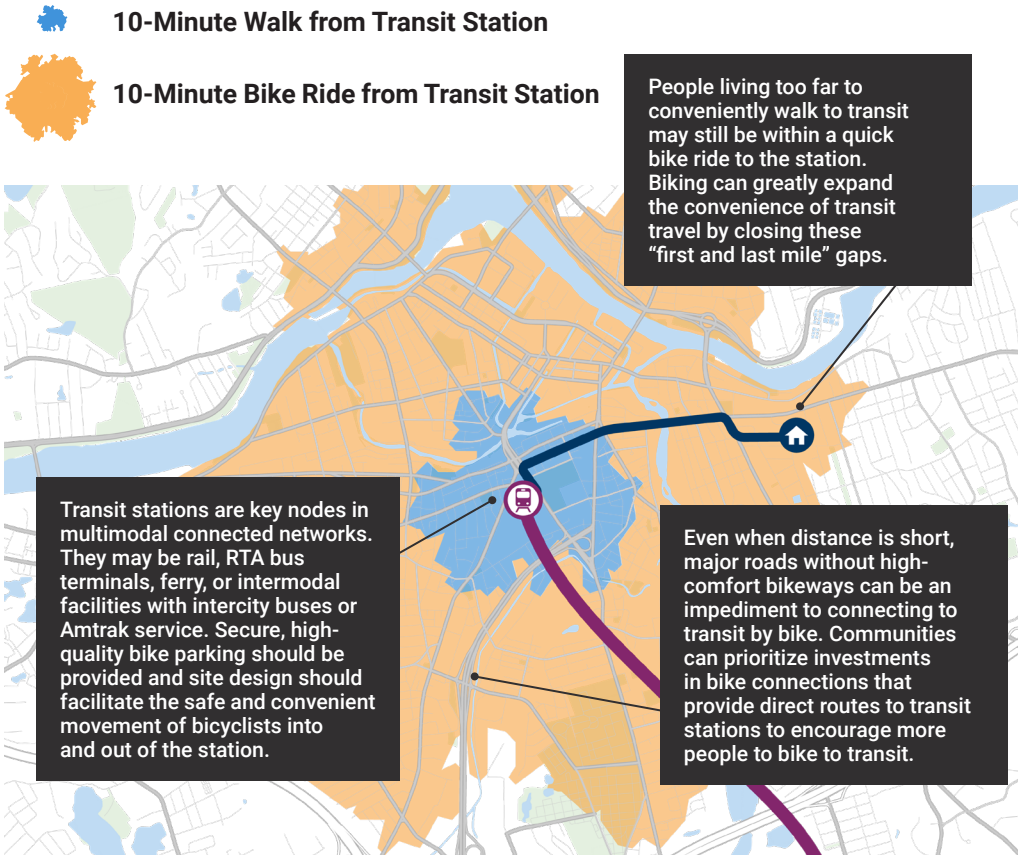


Figure 3. First and Last-Mile Transit Connections

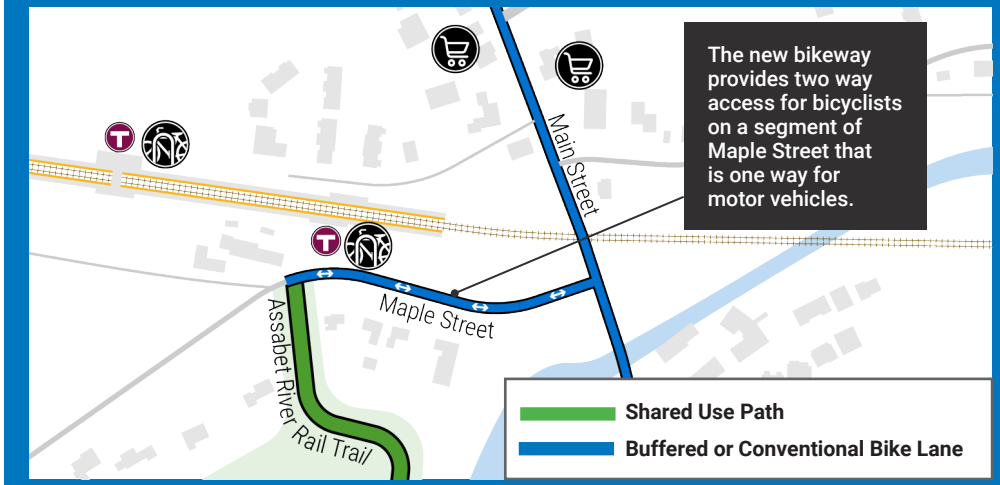
For more information, see:

» Achieving Multimodal Networks: Multimodal Access to Existing Transit Stations by FHWA

» Achieving Multimodal Networks: Multimodal Access to New Transit Stations by FHWA.

Case Study: Connections to Rail in Acton

South Acton is the busiest commuter rail station on the MBTA Fitchburg Line. Recognizing the need to improve access for the many commuters who bike to and from the station, in 2018 the Town of Acton and MassDOT partnered to construct a contra-flow buffered bike lane along Maple Street. The new bikeway also provides a critical link to and from the recently extended Assabet River Rail Trail.





Connected Bike Network Examples

While each community in Massachusetts has its own unique needs, it is useful to identify common bike network planning considerations based on typical land use and development patterns. Three typical scenarios are presented on the following pages that show how a connected bike network can be planned for rural, suburban, and urban areas (see Figure 4–Figure 6). Some Massachusetts municipalities have a variety of land use patterns and therefore multiple scenarios may apply. Each page contains a map illustrating an area bike network and a discussion of considerations for selecting and connecting proposed bikeways.

A definition of **connected bike networks** can be found in Attracting Riders of All Ages and Abilities on page 13. For detailed descriptions and considerations for the bikeway types presented in the scenarios on the following pages, see Designing Connected Bike Networks starting on page 28. The example areas depicted in the scenarios are not intended to represent specific locations in Massachusetts.

For more information, see Achieving Multimodal Networks: Network Connectivity by FHWA.

Connected Bike Networks in Rural Areas

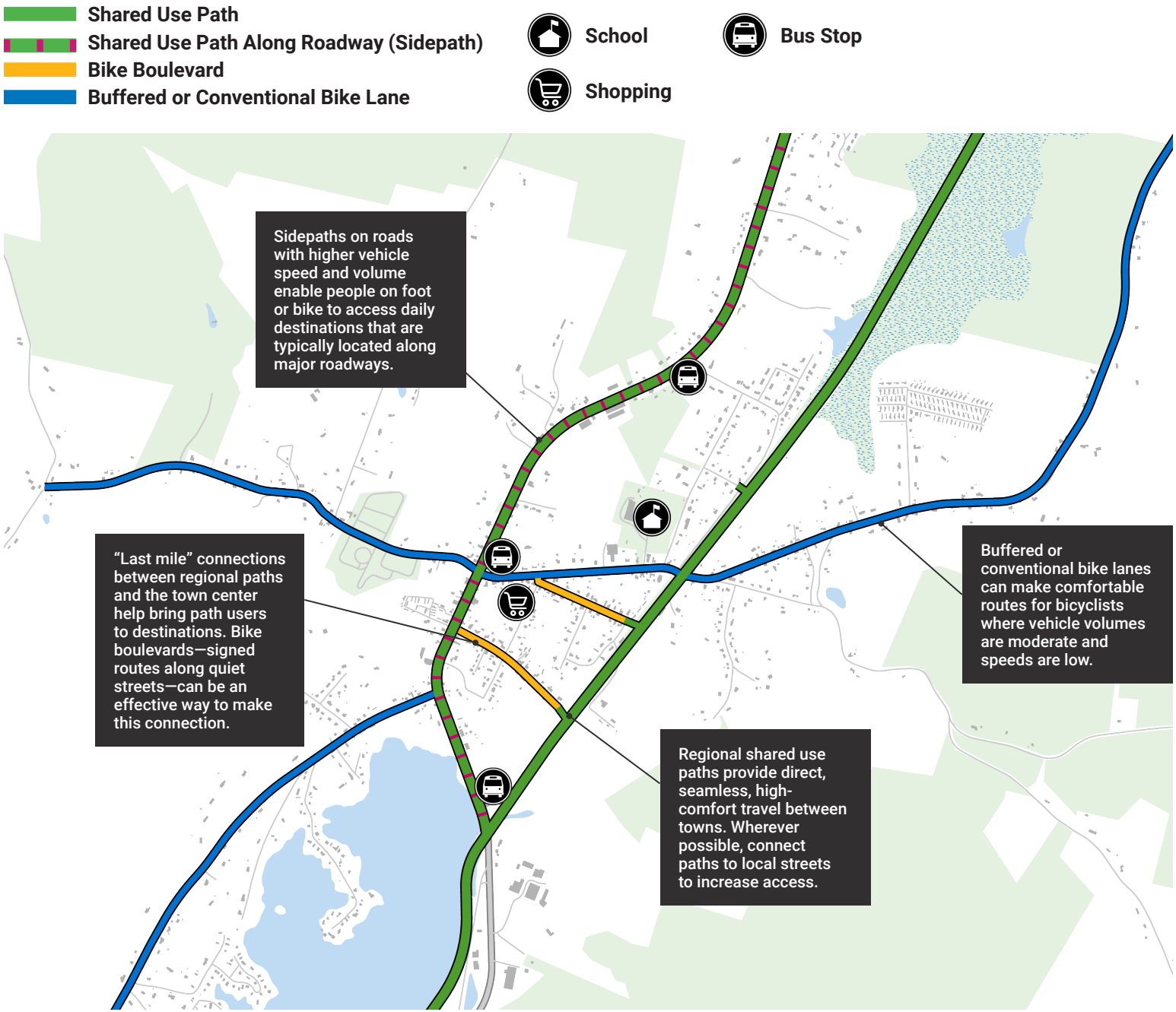


Figure 4. Connected Bike Networks in Rural Areas

Connected Bike Networks in Suburban Areas

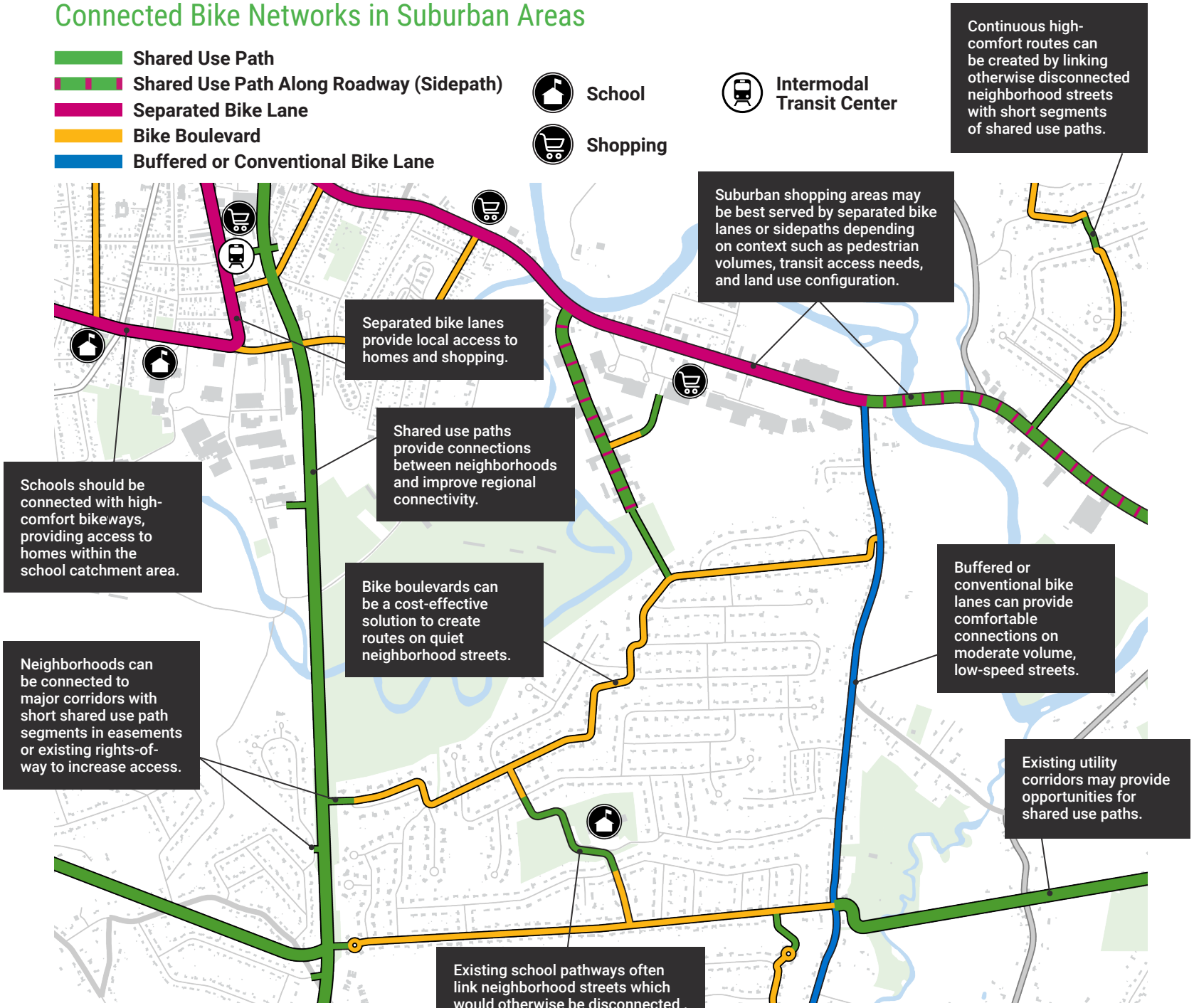


Figure 5. Connected Bike Networks in Suburban Areas

Connected Bike Networks in Urban Areas

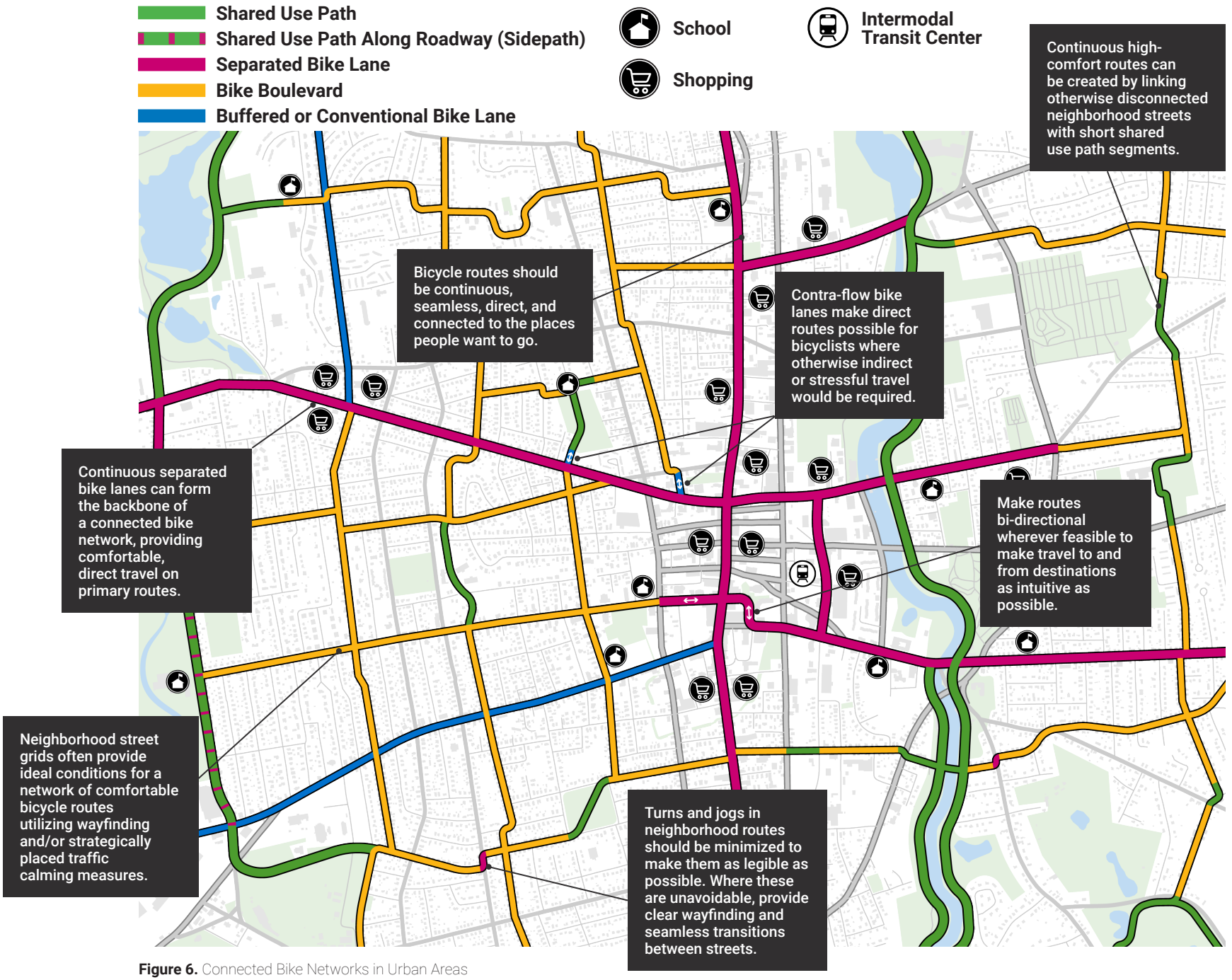


Figure 6. Connected Bike Networks in Urban Areas

Bike Planning Processes

This section describes processes and steps involved in bike planning that can be applied to developing a bike plan, corridor planning efforts, or bike elements within a larger transportation plan. Many of these processes, such as goal setting and stakeholder engagement, are carried out for many types of planning efforts.

Responsibility for Bike Planning

The responsibility for planning and implementing bike infrastructure and programs at the municipal level can vary widely across municipalities depending on their size or organizational structure. The responsibility may also be shared across several departments or disciplines based on the type of project, program, or stage of implementation. Bike planning may be carried out by one or all of the following roles depending upon the municipality:

- **Bicycle/active transportation coordinators:** Larger municipalities may have one or more full-time staff roles whose sole responsibility is to oversee the implementation of bike infrastructure and programs. They may also oversee pedestrian and transit planning. These roles are typically within the planning or transportation departments.
- **Planning staff:** Planners have oversight of development proposals and can help set priorities around changes to zoning codes, both of which can have an effect on biking. Within smaller municipalities, planning staff may have the responsibility of bike planning, which may include network planning, bike parking, non-infrastructure programs, prioritization, and implementation.
- **Engineering or public works staff:** In some municipalities, all road transportation responsibilities may be the purview of engineering or public works staff. In addition to the responsibilities of the planning staff, their tasks often include developing roadway engineering documents for construction and overseeing design consultants.
- **Bicycle advisory committee:** Many municipalities in Massachusetts have established an advisory committee for issues related to biking. Some municipalities have separate committees for walking, biking, and transit, while others combine these interests into one committee. The process for establishing a committee is pursuant to municipal bylaws.

In addition to municipal staff, metropolitan planning organizations (MPOs) and regional planning agencies (RPAs) can assist municipalities with many of the aspects of bicycle planning discussed in this chapter. For more information, see Regional Planning at Mass.gov.

Defining Goals and Performance Measures

Municipalities should consider how biking fits in with community goals related to economic development, sustainability, safety, equity, recreation, public heath, multimodal accessibility, and other focus areas. For the best outcome, goal setting should be a consensus- building process that includes municipal staff such as key decision makers from planning, public works, and public safety departments, as well as stakeholders such as a bicycle advisory committee, the private sector, and community groups.

Bike plans can include performance measures to help track progress toward meeting goals. Performance measures for a bike plan may include metrics such as eliminating fatal and serious injury crashes, miles of new high-comfort bikeways, increasing the supply of bike parking, an increase in the mode share of biking, or more bicycle usage along a corridor or within a specific area.

Establishing Existing Conditions

It is important to understand both the physical conditions of the transportation network as well as the policy environment and how both serve to encourage or discourage biking. An assessment of physical conditions should begin with a comprehensive review of the existing transportation network and its suitability for everyday biking. This assessment should include roadways and potentially shared use paths. There are several different approaches for analyzing existing conditions for biking and communities may choose which ones best suit their needs:

- **Network review:** Review a map of existing bikeways and supporting facilities that may have been proposed during a previous planning effort.

Consider where there are gaps in the network and how to connect them.

» **Bicycle Level of Traffic Stress:** Assess the entire roadway network to place a value on each segment for how stressful it is for bicyclists. For more information, see Low-Stress Bicycle Networks at Pedestrian and Bicycle Information Center.

» **Safety:** Use crash data to identify high crash locations, common crash types, and crash trends. See Safety Data on page 53 for more information.

» **Demand:** Measure the demand for biking by conducting manual counts, installing automatic counters, using geospatial analysis, or a combination of these methods. See Travel Data on page 55 for more information. Note that current usage may not reflect the actual potential for everyday biking once high-comfort bikeways are introduced.

Evaluating existing programs, policies, ordinances, bylaws, and municipal codes is an important part of the bike planning process, as these elements may create an environment that encourages or discourages biking. For example:

» Does the school system offer bike training for students and does it encourage children to walk and bike to school?

» Are there requirements for developers or employers to develop transportation demand management plans?

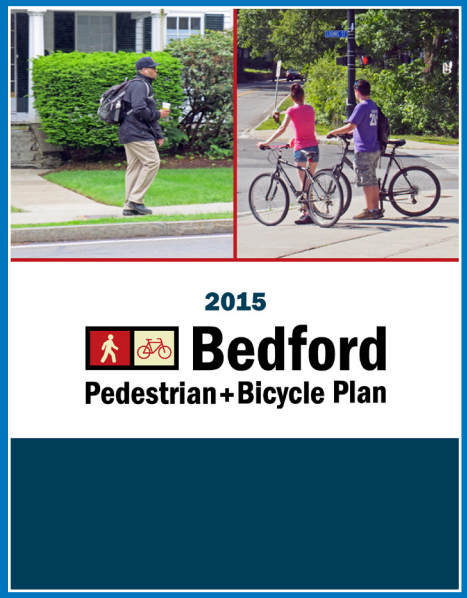
» Are bike parking and other end-of-trip facilities like showers required or encouraged in new development and new municipal buildings?

» Are there codes or incentives in place to encourage mixed-use development near transit?

» Does municipal code encourage compact, mixed-use development or single-use, suburban-style development?

Case Study: Bedford

In 2015, the Town of Bedford completed a bicycle and pedestrian plan that, with community input, identified and prioritized projects to make active transportation safer and more convenient. As a result of that plan, the Town now integrates bicycle improvements within its routine planning and design processes. The plan defined five priority corridors, each of which included specific recommendations and conceptual designs to close network gaps and remove barriers. The Great Road redesign is among the first corridor reconstruction efforts to result from the master plan. This project will include bicycle facilities as well as reconstructed sidewalks and enhanced crossing treatments.



Engaging Stakeholders

Stakeholder engagement is an essential part of the bike planning process that helps build the consensus needed for successful implementation. An effective engagement process includes the general public, internal stakeholders, partner agencies, and institutional and private sector entities. Internal stakeholders may include planning, public works, public health, law enforcement, emergency response, and other municipal departments. Partner agencies may include MassDOT, the Department of Conservation and Recreation, regional planning agencies, and other regional and state agencies. Private sector stakeholders may include, but are not limited, to community groups, business improvement districts, colleges and universities, large employers, and non-profit organizations.

Community engagement strategies should focus on equity. Because biking can be the most beneficial to people with limited or no access to automobiles such as lower-income earners, older adults, and children, attention should be paid to engaging and understanding the needs of these groups.

Each group may require their own tailored engagement strategy. The following are examples of municipal community engagement strategies with a focus on equity:

» **geoDOT Engage Gallery** by MassDOT

» **Community Engagement Plan: 2016 - 2019** by Boston Public Health Commission

» **Blueprint for Equitable Engagement** by the City of Minneapolis, MN

» **Public Engagement Plan** by Burlington, VT, Public Works

A primary purpose of community engagement is to understand opportunities and barriers for everyday biking among the public. Probing the reasons why people do or do not bike for routine travel can be illuminating and provide direction for the plan. For example, if many people report that they do not bike to work because their employer does not provide bike parking, strategies may need to be developed to expand bike parking at workplaces. Location-specific feedback is also essential. People may favor certain bike routes over others because of high traffic and/or a lack of comfortable bikeways. This engagement process can help identify and prioritize needed improvements along corridors and at intersections.

It is vital to look beyond the traditional public meeting when planning outreach strategies. Open streets, demonstration events, and focus groups are some ways that planners can target specific groups. For more information on demonstration projects, see Implementation on page 46. Online platforms are a common method for gathering feedback. Many bike plans make use of interactive mapping platforms where users can submit location-specific comments. However, electronic engagement should be complemented with in-person engagement to ensure that community members with limited access to or proficiency with technology can be part of the process. Finally, bicycle advisory committee members can assist with various aspects of public outreach, such as devising an outreach strategy and organizing events.



Hosting engagement activities alongside well-known community events can result in a broad spectrum of participants and viewpoints.

Prioritization

Prioritization is a process in which a community decides which factors are most important and uses those factors to rank projects in order of priority for implementation. This process involves assigning scores to proposed projects based on factors such as safety, connectivity, demand, equity, and public feedback. For more information, see **Pedestrian and Bicycle Transportation Along Existing Roads—ActiveTrans Priority Tool Guidebook** by the National Cooperative Highway Research Program

Implementation

The opportunity to add bikeways as part of repaving or capital projects can arise even in the absence of a municipal or neighborhood level bike plan. When this occurs, planners should utilize the same processes and principles of a connected network described in this chapter but apply it to the corridor or project level.

See the **Implementation** section in **Designing Connected Bike Networks** for more information on implementation phasing and funding opportunities to help with design and construction costs.

Key Policies and Programs

Policies and programs to support bikeability are an essential component of effective bike planning. Sometimes called "non-infrastructure" components, these help build the institutional framework that is needed to implement connected bike networks and encourage the growth of bikeable communities.

Complete Streets

Complete Streets describes an approach to transportation policy and infrastructure design that seeks to provide safe and comfortable facilities for all road users regardless of age or ability. In practice, planners and designers must consider the needs of and providing space for people walking, biking, taking transit, and driving. Complete Streets can improve safety, health, economic vitality, and quality of life in communities by providing residents with a range of transportation options for everyday travel.

MassDOT's **Complete Streets Funding Program** provides municipalities the resources to develop and adopt Complete Streets policies, develop prioritization plans, and apply for project funding. The program also provides training resources and design guidance. As of June 2018, 142 municipalities have adopted Complete Streets policies, 90 municipalities have developed prioritization plan, and 48 municipalities have received competitive capital construction funding.

Vision Zero

Vision Zero is a policy approach that aims to eliminate fatalities and serious injuries on all roadways. Vision Zero uses a proactive, systemic approach that involves data collection and analysis to identify the underlying causes of fatal and serious crashes, then implement countermeasures to reduce risk regardless of whether a crash has already occurred.

First implemented in Sweden in the 1990s, Vision Zero has proved successful across Europe and is now gaining momentum in major American cities. Several municipalities across Massachusetts, including **Boston**, **Cambridge**, and **Somerville**, have also adopted Vision Zero policies, with additional municipalities considering adoption. MassDOT supports municipal adoption of Vision Zero policies and works collaboratively to address identified safety issues on MassDOT-owned roadways within municipalities.

For more information, see:

» FHWA **Zero Deaths Vision**

» **Vision Zero Network**

» **Massachusetts Vision Zero Coalition**

Land Use, Development Codes, and Housing

Municipal-level zoning code has a large amount of influence over the shape that the built environment takes and, in turn, how people travel. Municipalities seeking to encourage bikeability may consider implementing complementary land use and development policies. Examples include:

» Creating a Smart Growth zoning district to encourage dense, mixed-use development in existing city and town centers, near transit stations, and other suitable locations. Proximity to transit and affordability can both be key considerations.

» Establishing a subdivision ordinance that requires developers to provide connectivity easements for shared use paths and/or to reserve right of way for proposed bikeways.

» Requiring biking and walking access investments as part of traffic mitigation for developments that exceed established thresholds. Development site plans can facilitate connections between separated bike lanes and other bikeways within the development as well as nearby.

» Encouraging or requiring bike parking and other end-of-trip facilities to be included in commercial and multi-family development or major renovations. Specific facilities may include both short- and long-term bike parking, as well as showers, lockers, and bike repair stations. As an additional step, developers can be allowed to exchange a certain number of car parking spaces for bike parking facilities, other facilities, or programs that encourage transit or non-motorized travel.

» Adopting a parking and transportation demand management (PTDM) ordinance that requires tiered mitigation measures based on size thresholds.



Separated bike lanes were installed on Bill Delahunt Parkway in Weymouth as part of the Union Point development project, providing direct access to the nearby South Weymouth MBTA Commuter Rail Station.

> Well-structured PTDM ordinances incentivize sustainable transportation modes and discourage the growth of motor vehicle trips. PTDM may also include education and encouragement programs conducted by municipal staff and private sector partners.

Municipalities can utilize existing state resources to realize housing and development goals that complement biking, walking, and transit. The **Housing Choice Initiative** aims to help Massachusetts achieve a goal of 135,000 new housing units by 2025. Communities that produce new housing units and adopt best practices in sustainable housing development and efficient land use are eligible for incentives, including new Housing Choice Capital Grants, and receive preferential treatment for state grant and capital funding programs, including the **Complete Streets Funding Program**, other MassDOT capital projects, and **MassWorks**. The Housing Choice Initiative supplements other state programs, such as the **Smart Growth Zoning Overlay District Act** and the **Transformative Development Initiative**, which encourage residential and mixed-use development in dense, walkable areas such as city and town centers, former industrial districts, and near transit stations.

Safe Routes to School

Promoting active lifestyles for children is instrumental in achieving long-term positive health outcomes and for normalizing biking and walking for everyday travel. **Safe Routes to School** is a national partnership program adopted by MassDOT to encourage elementary and middle school students to walk and bike to school through infrastructure improvement funding and non-infrastructure programs.

MassDOT encourages municipalities to participate in Safe Routes to School. To date, 804 elementary and middle schools across 206 Massachusetts communities have participated in the Safe Routes to School program, which has served over 389,000 students. During the 2017-2018 academic year, 171 pedestrian and bicyclist safety training events and 412 walk and bike to school events were held.

Education, Encouragement, and Enforcement

In addition to infrastructure improvements, communities should consider education, enforcement, and encouragement programs to increase safety, improve perceptions, and promote healthy travel behavior. For more information, see **Behavior Change** at FHWA's Pedestrian and Bicycle Information Center.

Education and encouragement programs can be an important part of promoting bicycle use for transportation. Municipalities should begin by assessing the specific needs in their communities and developing strategies to address identified gaps. Some common gaps in public awareness about bicycling

may include a lack of basic knowledge about how to choose an appropriate bicycle and maintain it, which safety equipment is required and recommended, and skills for operating a bicycle in mixed traffic. Municipalities can address these gaps in a variety of ways including, but not limited to, awareness raising campaigns, informational web pages and printed material, safety equipment giveaways, and hands-on bicycle skills training. Awareness campaigns and informational materials should strive to be inclusive and focus on lowering the barriers to entry for would-be bicyclists. Education and encouragement programming can be implemented in collaboration with public health departments, law enforcement, non-profit community organizations. Lastly, Demonstration Projects can be an excellent setting for education and encouragement programming. See page 46 for more information.

Effective law enforcement can help set expectations for how all road users behave in traffic and interact with one another. Before launching a targeted enforcement program, municipalities should assess their specific needs. A needs assessment should include determining the level of awareness of bicycle laws among law enforcement officers and identifying specific road user behaviors that may be addressed through enforcement. Enforcement programs should target the riskiest behaviors of all road users. For more information on bicycle laws in Massachusetts, see:

- Massachusetts law about bicycles
- Shifting Gears: Bicyclists & Public Safety
- Bicycling Rules of the Road

As a best practice, municipalities should coordinate enforcement activities with education and encouragement efforts. One approach to an enforcement program is to start by issuing warnings, which can serve to educate road users about specific risky behaviors, then move on to issuing tickets. For more information, see What Police Can Do to Enforce the Laws at FHWA's Pedestrian and Bicycle Information Center.

In addition, many municipalities in Massachusetts have bicycle police patrol units that support general policing activities and may have a specific focus on traffic safety.

Explore More Resources

- FHWA Achieving Multimodal Networks: Ch 13 Network Connectivity: https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/multimodal_networks/13_network_connectivity.pdf
- FHWA Bicycle Network Planning & Facility Design Approaches in the Netherlands and the United States: https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/network_planning_design/network_planning_design.pdf
- FHWA Bike Network Mapping Idea Book: https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/bikemap_book/
- FHWA Incorporating On-Road Bicycle Networks into Resurfacing Projects: https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/resurfacing/resurfacing_workbook.pdf
- FHWA Measuring Multimodal Network Connectivity: https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/multimodal_connectivity/fhwahep18032.pdf
- FHWA/PBIC ActiveTrans Priority Tool: http://www.pedbikeinfo.org/planning/tools_apt.cfm
- APBP Bicycle Parking Guidelines: http://www.apbp.org/?page=publications

References

1 Dill, Jennifer, and Kim Voros. 2007. Factors Affecting Bicycling Demand: Initial Survey Findings from the Portland, Oregon, Region. Transportation Research Record: Journal of the Transportation Research Board 2031: pp 9-17

Designing Connected Bike Networks

Connected bike networks support everyday biking when they provide safe, comfortable, and convenient access to destinations. Bikeways, intersection treatments, and bike parking are the key components of connected bike networks. This chapter introduces these components, provides links to detailed design guidance, and highlights opportunities to implement bicycle facilities in phases through the use of temporary materials.

The designs and selection criteria summarized in this chapter discuss best practices for designing high-comfort bikeways that appeal to people of all ages and abilities. This guidance is based on established state and national guidelines. It may not always be feasible to achieve high-comfort bikeways in all projects, particularly in retrofit and routine repaving projects. These projects represent important expansions of the bikeway network but may not necessarily appeal to the "interested but concerned" demographic and therefore may see lower levels of use. Bikeways that do not meet high-comfort standards should be considered interim facilities and municipalities should strive towards building high-comfort bikeways as part of new construction and reconstruction projects.

MassDOT recommends that planners and designers refer to the latest versions of the resources listed at the end of this chapter for detailed bikeway design guidance.

Bikeway Segments

Bikeway segments are the linear components of a bike network that are located within roadways, parallel to roadways, or within their own rights of way. The appropriate treatment should be selected based on roadway context.

The level of comfort that people experience when biking is closely linked to motor vehicle volumes and speeds. People prefer greater separation from traffic as vehicle volumes and speeds increase. Figure 7 provides a framework to guide the selection of bikeway type based on these factors.

This section defines, provides high level guidance, and lists additional resources for the following bikeway segment types:

- Shared use path
- Separated bike lane
- Buffered and conventional bike lane
- Contra-flow bike lane
- Bike boulevard
- Advisory bike lane
- Shared lane markings

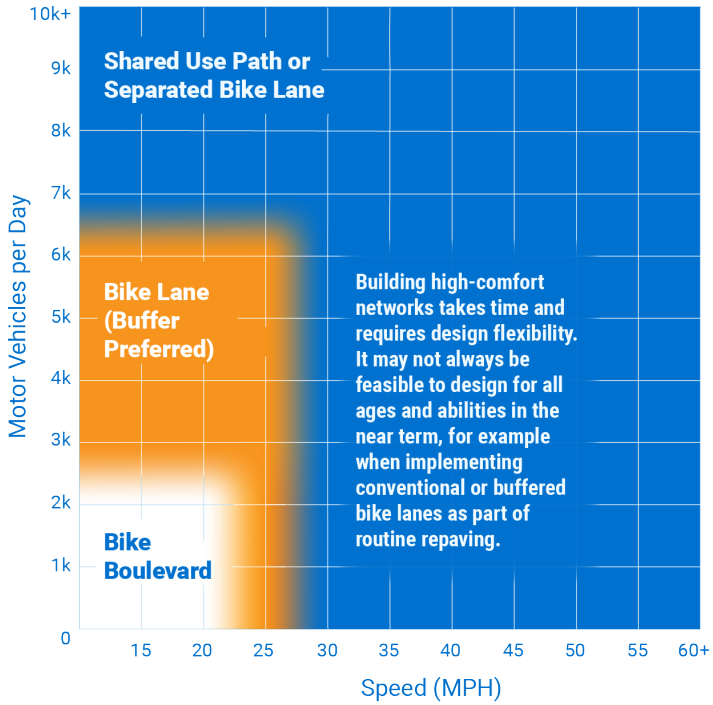


Figure 7. Recommended motor vehicle speed and volume thresholds for implementing high-comfort bike networks.

Notes:

This figure assumes that vehicle operating speeds are similar to posted speeds. If they differ, designers should use vehicle operating speed rather than posted speed.

Advisory bike lanes may be an option for streets for low-speed streets with less than 3,000 vehicles per day.

Separated bike lanes or shared use paths are recommended on any street with two or more travel lanes per direction.

Shared Use Path

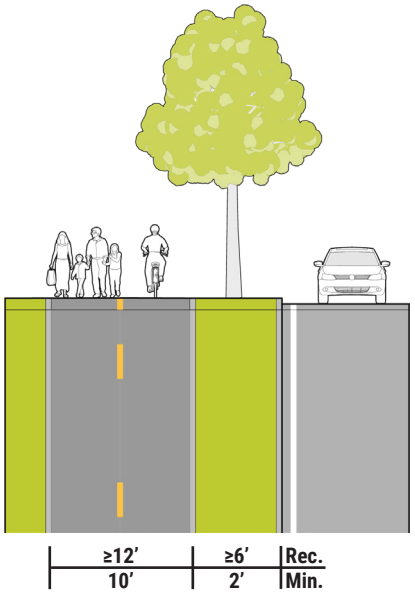
A shared use path (also called a trail, multi-use path, greenway, or bike path) is a two-way, off-road transportation and recreation facility that is physically separated from motorized vehicular traffic and designed for use by people of all ages and abilities. Shared use paths may be located along a street (i.e., sidepath) or through independent rights-of-way (e.g. abandoned railroad corridors). As pedestrian routes, shared use paths must comply with the latest accessibility requirements.

Consider the FHWA Shared Use Path Level of Service Calculator to help determine when to provide separate facilities for people walking and biking. MassDOT is currently developing a Shared Use Path Guide, parts of which have been released in 2019.

Where to Use Shared Use Paths

- Through parks, along waterways, or along active or abandoned railroads
- To connect disconnected streets or bikeways
- Along streets where pedestrian and bicycle demand is anticipated to remain low
- Along corridors with few or no turning conflicts

Shared Use Path in a "Sidepath" Configuration





Urban parkways and suburban and rural corridors are often excellent candidates for sidepaths.



Gateway treatments, such as bike parking, maintenance stations, and seating at this entrance to the Norwottuck Rail Trail in Northampton, increase the attractiveness of everyday biking.

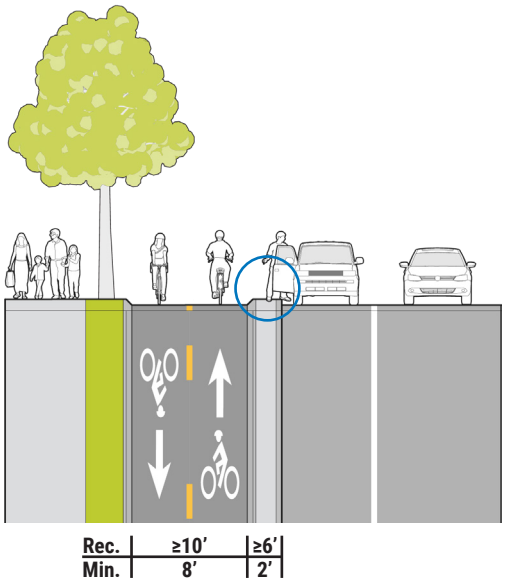
Separated Bike Lane

A separated bike lane is an exclusive space for bicyclists along or within a street that is physically separated from motor vehicles by vertical elements and from pedestrians by vertical and/or horizontal elements. They may be designed for one-way or two-way use and may be constructed at the street, sidewalk, or an intermediate level. Separated bike lanes are buffered from the street by a raised median or vertical elements such as flexible delineators or planters. Where space permits, a buffer zone with trees or other streetscape elements between the bike lane and sidewalk is recommended to reduce encroachment.

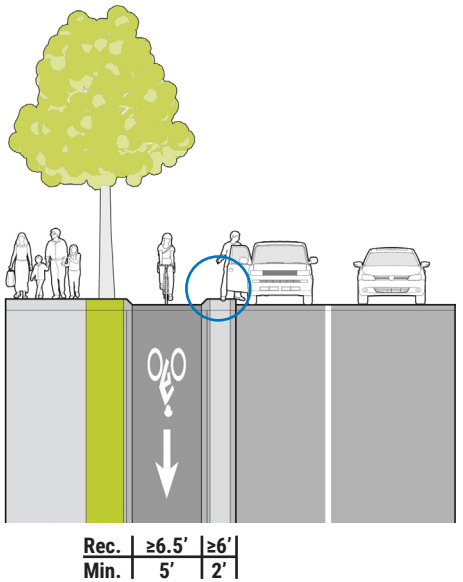
Where to Use Separated Bike Lanes

- Streets with ≥6,000 vehicles per day or ≥25 mph operating speeds
- Any street where shared operation with motor vehicles is stressful, including streets with high curbside activity, more than one lane per direction, higher percentage of large vehicles, concentration of children or seniors, or unusually high peak hour volumes.
- In constrained locations where physical separation of bicyclists is desired and the total available bike lane and buffer width is <7', a raised bike lane may be the preferred treatment. Raised bike lanes may be built at any level between the sidewalk and the street and are directly adjacent to motor vehicle travel lanes at locations where provision of a street buffer is not feasible. For more information, see Chapter 3 of the MassDOT Separated Bike Lane Planning & Design Guide.

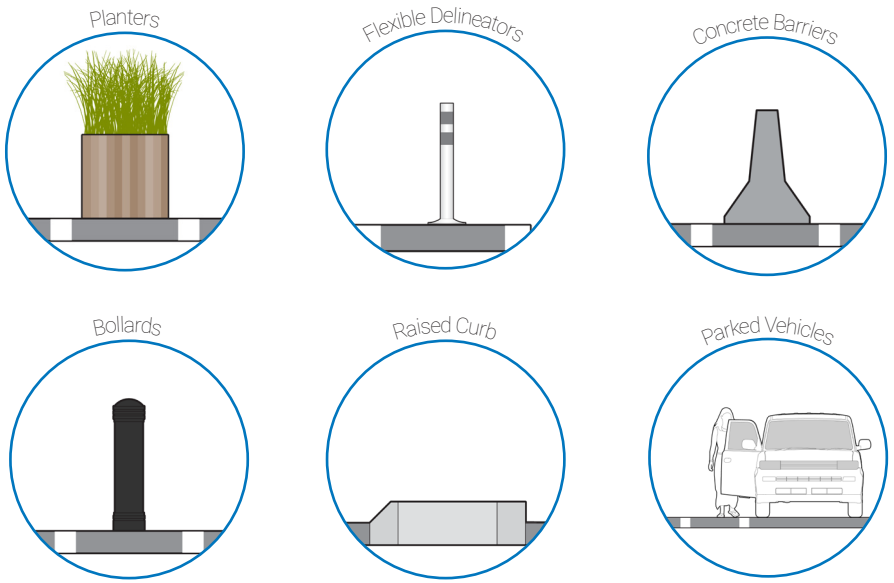
Two-way Separated Bike Lane



One-way Separated Bike Lane



Options for Vertical Objects in the Street Buffer Zone

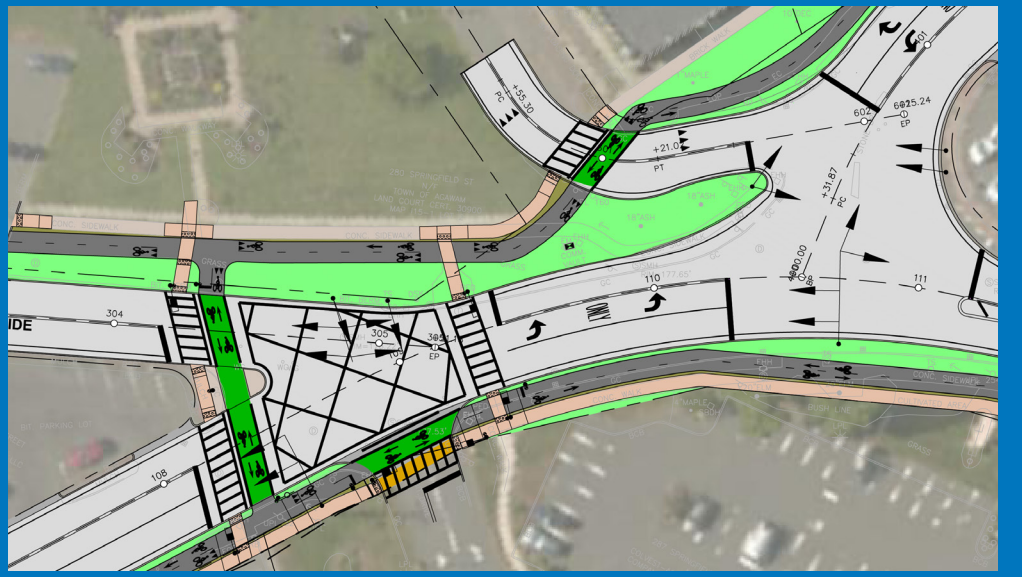




The City of Boston and National Park Service have constructed a two-way separated bike lane on several streets (Commercial Street/Atlantic Avenue shown) as part of Connect Historic Boston, a project to connect people walking and biking to historic downtown sites.

Case Study: Agawam

The Town of Agawam is working to reshape O'Brien's Corner, a civic and commercial node that lacks continuous biking and walking accommodations. With assistance from MassDOT's Complete Streets Funding Program, Agawam is reimagining the intersection with two-way separated bike lanes connected by dedicated bicycle crossings and supported with new signal phasing. The new design fully separates people walking, biking, and driving to improve the safety and comfort for everyone. This project was included in Agawam's Complete Streets Prioritization Plan.



O'Brien's Corner conceptual design. Credit: Town of Agawam

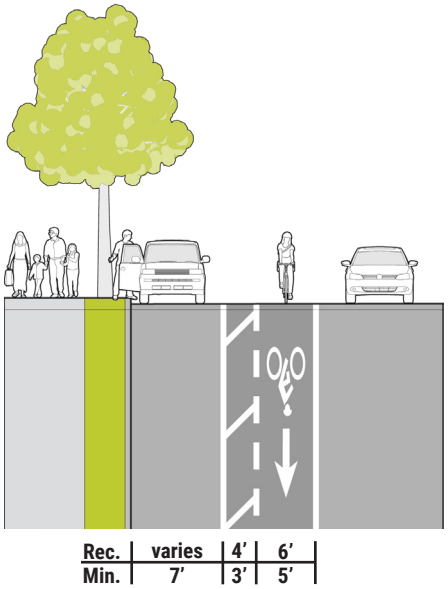
Buffered and Conventional Bike Lane

Buffered and conventional bike lanes are a type of on-street bikeway separated from an adjacent travel lane, on-street parking lane (if present), or both by pavement markings. Buffered bike lanes utilize buffer striping while conventional bike lanes are delineated with a single line. For buffered bike lanes, buffer placement should be determined based on the following factors. On segments with high turnover parking, the buffer should be placed on the parking side to mitigate dooring risk. On segments with low turnover parking or no parking, the buffer should be placed between the bike lane and vehicle lane to increase separation.

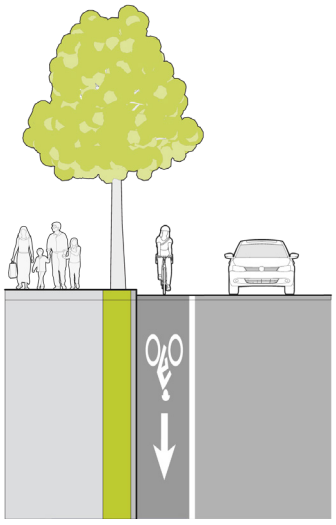
Where to Use Buffered or Conventional Bike Lanes

- Streets with 2,000—6,000 vehicles per day and ≤25 mph operating speeds
- Buffered bike lanes may be used on roadways with higher vehicular speeds and volumes, depending on the roadway context. However, buffered bike lanes in higher speed, higher volume contexts may not meet high-comfort criteria (see Figure 7).
- Any street with minimal curbside activity or congestion and a single lane in each direction or single lane one-way operation
- On streets with parking and the width available for a buffered bike lane, designers may instead consider Separated Bike Lanes to provide greater comfort for bicyclists and reduce encroachment from motor vehicles.

Buffered Bike Lane With Parking



Conventional Bike Lane Without Parking



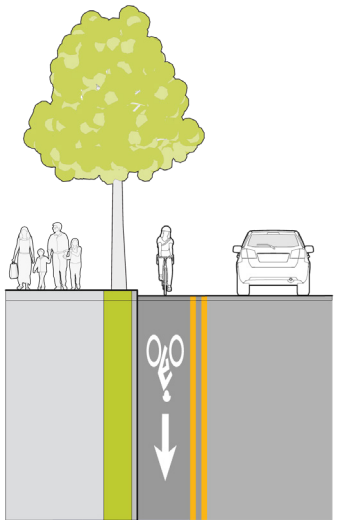
Contra-Flow Bike Lane

Contra-flow bike lanes are bike lanes on one-way streets that allow people on bikes to travel in the opposite direction of motor vehicle traffic. Contra-flow bike lanes can increase connectivity and reduce out-of-direction travel in areas with many one-way streets. Contra-flow bike lanes can be designated using pavement markings and signage or physically separated from opposing traffic.

Where to Contra-Flow Bike Lanes

- For speed and volume thresholds, refer to Buffered and Conventional Bike Lanes and Separated Bike Lanes depending on level of separation
- Streets where bicyclists are commonly observed riding the wrong way
- As part of a Bike Boulevard network

Contra-Flow Bike Lane



Bike Boulevard

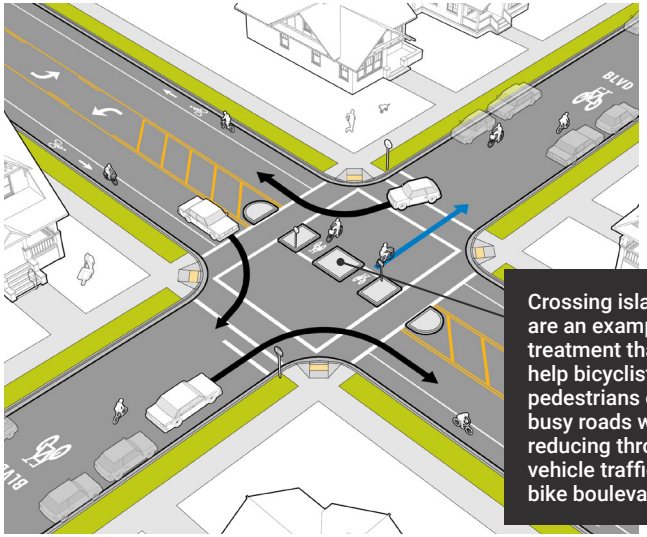
A bike boulevard—also known as a neighborhood greenway, neighborway, or bicycle priority street—is a low-volume, low-speed street that has been designed to prioritize bicycle travel with signs, pavement markings, wayfinding signage, and traffic calming measures. Bike boulevards should provide enhanced crossing treatments at intersections with arterial and collector streets to ensure continuous high-comfort biking for all ages and abilities. Where motor vehicle volumes exceed thresholds listed below, consider strategies that divert through motor vehicle traffic while maintaining local motor vehicle access and bicycle and pedestrian mobility.

Municipalities should consider designating bike boulevards as Safety Zones with a 20 mph speed limit. For more information, see MassDOT's **Procedures for Speed Zoning on State Highways and Municipal Roads**.

Where to Use Bike Boulevards

- Local streets with ≤2,000 vehicles per day and ≤20 mph operating speeds
- <75 vehicles per hour in the peak direction at peak hour

Bike Boulevard





Bike boulevards are characterized by the use of traffic calming measures to reinforce 20 mph or lower operating speeds.

Advisory Bike Lane

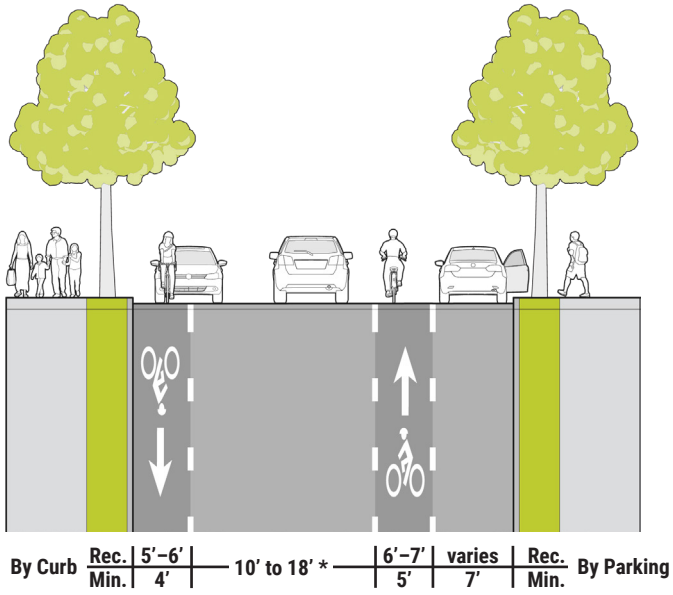
Advisory bike lanes (also known as dashed bike lanes) provide space for biking on low-volume, low-speed streets that are too narrow for conventional bike lanes. Marked with a continuous dashed line, vehicles may temporarily enter the advisory bike lanes when there are no bicyclists present to provide oncoming traffic space to safely pass. Where usable by pedestrians, they are called advisory shoulders and must meet accessibility standards.

Municipalities may consider designating streets with advisory bike lanes as Safety Zones with a 20 mph speed limit. For more information, see MassDOT's Procedures for Speed Zoning on State Highways and Municipal Roads.

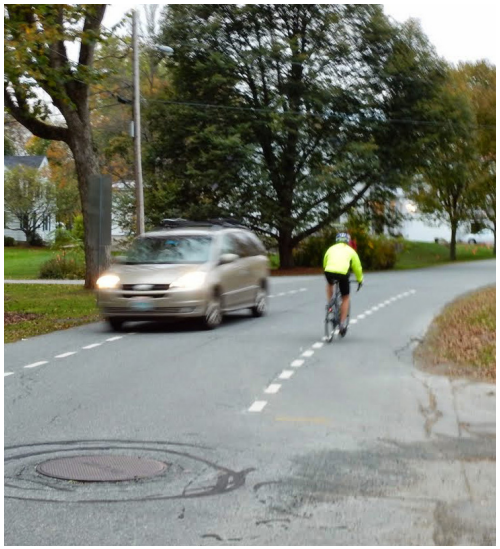
Where to Use Advisory Bike Lanes

- Streets with ≤3,000 vehicles per day, ≤25 mph operating speeds, and a single lane in each direction. Consider traffic calming to promote desired operating speeds, if necessary.
- Streets with adequate sight distance for safe passing and infrequent heavy vehicle traffic
- Advisory bike lanes are experimental traffic control treatments and municipalities must obtain interim approval from the FHWA to implement them. For more information on state of practice, see FHWA Bicycle Facilities and the Manual on Uniform Traffic Control Devices: Dashed Bicycle Lanes and Lessons Learned: Advisory Bike Lanes in North America.

Advisory Bike Lane With and Without Parking



*** Avoid 13.5'–16' central operating space, which may result in vehicle conflict**



Advisory shoulder for shared bicycle, pedestrian, and motor vehicle use in Hanover, NH. Credit: David Loutzenheiser, MAPC.



Advisory bike lane for shared bicycle and motor vehicle use in Cambridge, MA.

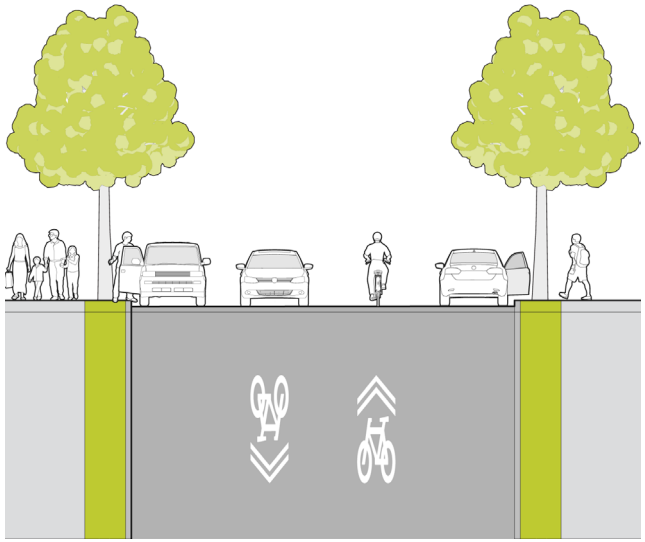
Shared Lane Markings

Shared lane markings or 'sharrows' may be installed in shared travel lanes to indicate to motorists and bicyclists where bicyclists are expected to travel. By themselves, shared lane markings are not a bikeway as they do not change the geometric or operational conditions of the roadway or improve comfort for bicyclists.

Where to Use Shared Lanes Markings

- Streets with ≤3,000 vehicles per day, and ≤25 mph operating speeds, such as a bicycle boulevard where bicycle operating priority needs to be indicated.
- In travel lanes adjacent to on-street parking, to indicate where bicyclists should position themselves to avoid being hit by suddenly opened car doors.
- To fill a temporary gap between two sections of roadway that have bike lanes or separated bike lanes
- In narrow lanes (< 14 ft in width) that are too narrow for a motor vehicle and a bicycle to travel side-by-side within the same travel lane, to encourage bicyclists to operate in the center of the travel lane (to control the lane), motorists to operate at reduced speeds behind bicyclists until there is a safe opportunity to pass, and motorists to change lanes to pass.
- In wide lanes (> 14 ft in width), to indicate appropriate bicyclist positioning away from the curb or the edge of the traveled way
- On a steep section of roadway where there is room for only one bike lane in one direction. In these situations, a climbing bike lane may be used on the uphill direction of travel due to the bicyclist's slower operating speed with a shared lane marking used on the downhill travel direction
- Within shared lanes at, or adjacent to, transit stops to provide visual cues to motorists, transit operators, and bicyclists where to expect bicyclists to travel
- Shared lane markings should not be used on roadways that have a speed limit above 35 mph, nor should they be located within bicycle lanes or shoulders.

Shared Lane Markings on a Bike Boulevard



Bikeway Intersections

Bikeway intersections are locations where bicyclists come into conflict with other road users, including vehicles, pedestrians, and transit vehicles. These locations include intersections, driveways, road crossings, and bus stops. Appropriate treatments should be selected based on context and the type of conflict being mitigated.

Intersection design has a large impact on the level of comfort a bicyclist experiences along a route. Even when a route features high-comfort facilities like shared use paths or separated bike lanes, the experience can be significantly degraded by intersections that are stressful to traverse, impose delay, or both.

This section defines, provides high level guidance, and lists additional resources for the following bikeway intersection treatments:

- Bike crossing
- Bike box
- Two-stage bicycle turn box
- Protected intersection
- Transition
- Floating bus stop
- Bike signal
- Signal phasing
- Pedestrian hybrid beacon



Bikeway intersections can include one or more treatments that separate people biking from those walking, taking transit, or driving. At Broadway and Hampshire Street in Cambridge, separated bike lanes and bike signal phasing work in tandem to channelize high volumes of bicyclists and eliminate conflicts with vehicles.

Bike Crossing

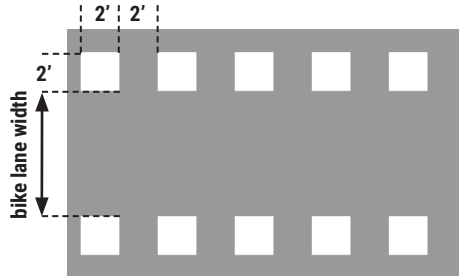
A bike crossing is a marking that designates a path for bicyclists through an intersection and indicates where bicyclists and vehicles may come into conflict. Bike crossings are characterized by dashed white pavement markings. All communities have the option to supplement these markings with green colored pavement, as MassDOT has received statewide interim approval through FHWA. If green pavement markings are used, materials should be selected to minimize the risk of bicyclists slipping under wet conditions.

Where to Use Bike Crossings

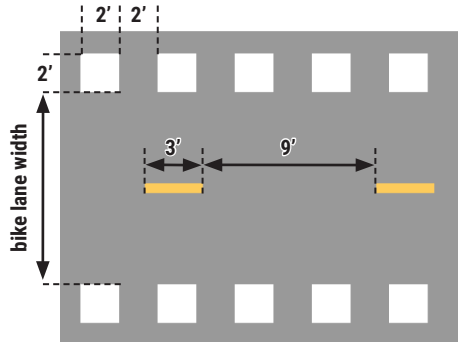
» Any intersection with another street

» Commercial driveways or any driveway with heavy use

One-way Bike Crossing



Two-way Bike Crossing





A one-way bike crossing in Brookline implemented as part of a successful travel lane removal (i.e., "road diet") on Beacon Street.



A two-way bike crossing under construction as part of the Casey Arborway project. This bike crossing features green colored pavement and is adjacent to a separate high-visibility pedestrian crossing.

Two-stage Bicycle Turn Box

A two-stage bicycle turn box is a marked location in an intersection where bicyclists may pull right or left to wait to make a left or right turn across vehicular traffic. This optional treatment provides a low stress alternative at intersections where making turns would otherwise require bicyclists to merge across one or more vehicle lanes. It is also useful for roads with separated bike lanes where bicyclists are not able to exit the separated bike lane upstream from an intersection.

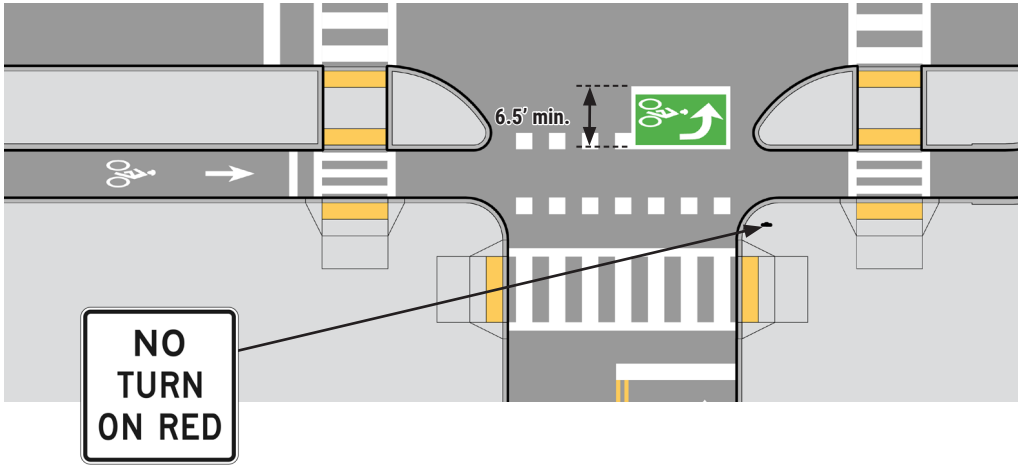
Two-stage bicycle turn boxes should be adjacent to the bike crossing and must be located outside of the turning or through vehicle paths. Depending upon the design of connecting bikeways, two-stage bicycle turn boxes may be on either side of the bike crossing. Two-stage bicycle turn boxes are subject to interim approval from FHWA. Municipalities seeking to use the treatment must inform FHWA through a simple form letter that indicates their intent and whether the treatment will be used at a single location or on a municipality-wide basis.

Where to Use Two-stage Turn Queue Boxes

- Signalized intersections where bicyclists would otherwise have to merge across high speed and/or high volume vehicle lanes to make a permissive turn onto an intersecting street or facility
- Signalized transitions between various bikeway types (e.g., from a one-way conventional bike lane into a two-way separated bike lane)



A two-stage turn queue box located between a pedestrian and bike crossing in Back Bay, Boston.



R10-11
Required where permissive turns on red would travel through the two-stage turn box, per FHWA interim approval

Bike Box

A bike box is a marked area between the vehicle stop bar and crosswalk where bicyclists can queue during a red signal phase. This optional treatment allows bicyclists to queue in an advanced location that is more visible to drivers, thereby mitigating conflicts with right-turning motorists. On corridors with a high volume of bicycle traffic, bike boxes provide additional space for bicyclists to queue at an intersection.

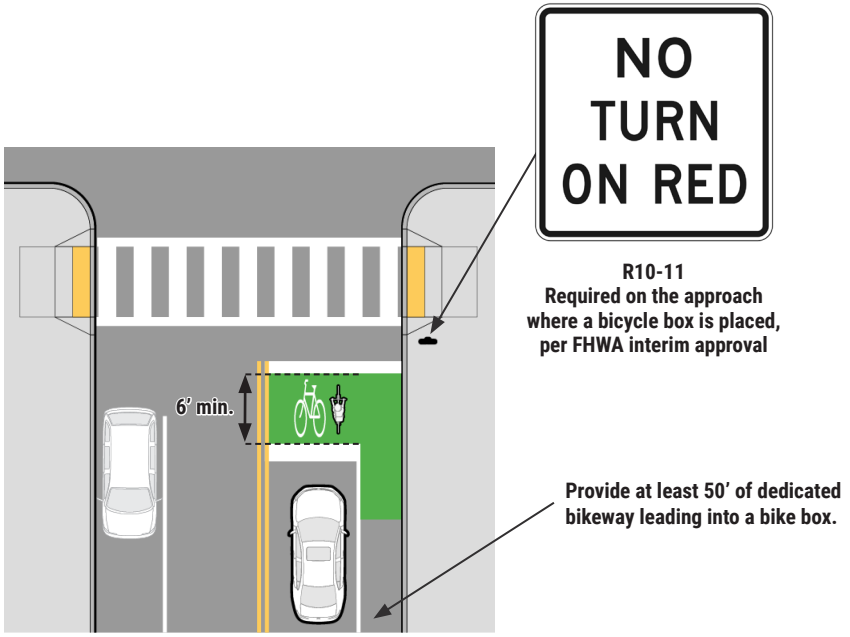
Bike boxes are not preferred across more than one travel lane and are not intended to facilitate left turns for bicyclists (see Two-stage Bicycle Turn Box). Bike boxes are subject to interim approval from FHWA. Municipalities seeking to use the treatment must inform FHWA through a simple form letter that indicates their intent and whether the treatment will be used at a single location or on a municipality-wide basis.

Where to Use Bike Boxes

» Signalized intersections



Bike boxes mitigate conflicts with right-turning motor vehicles by increasing drivers' visibility of people biking. On multi-lane streets, bike boxes should extend across one travel lane, as shown.



Protected Intersection

A protected intersection is a geometric design approach that increases safety for bicyclists and pedestrians by slowing turning vehicles, improving visibility, and minimizing the number of conflict points. This treatment eliminates merging and weaving movements inherent in conventional bike lane and shared lane designs. Protected intersections reduce conflicts to a single location where turning traffic crosses the bike lane and helps control motorist turning speeds.

Well-designed protected intersections are intuitive and comfortable, clearly indicate right-of-way assignment, and promote predictability of movement. They also clearly define pedestrian and bicyclist operating spaces within the intersection and minimize potential conflicts between all roadway users.

The corner refuge island is a key feature of protected intersection design. The island protects bicyclists from right-turning motor vehicle traffic and, depending on its size, creates space for a bicycle queuing area, provides space for vehicle queuing, and reduces bicycle and pedestrian crossing distances.

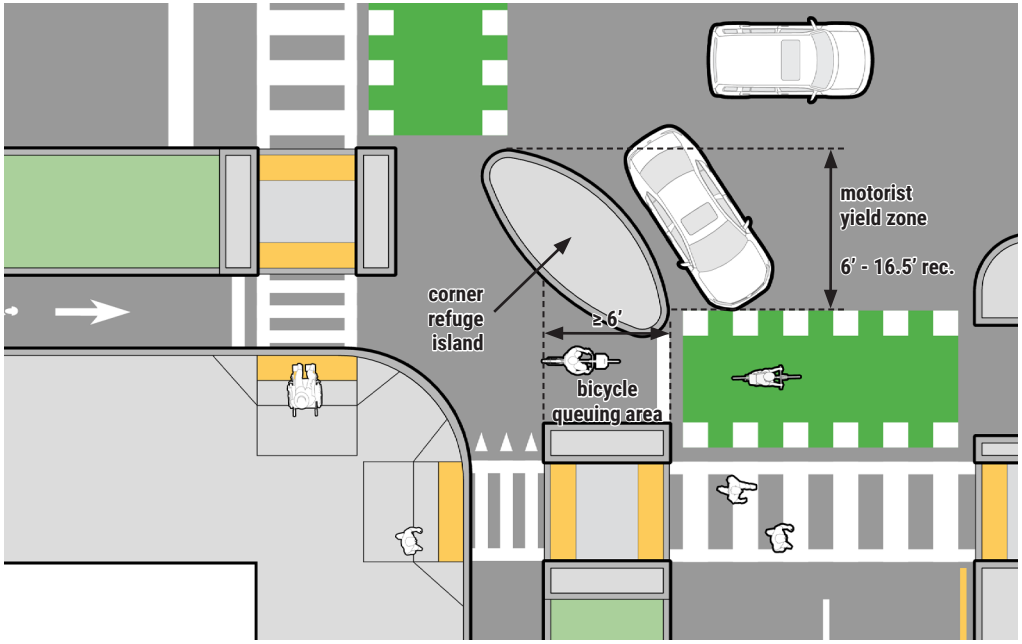
Where to Use Protected Intersections

» Signalized and non-signalized intersections on corridors with separated, buffered, or conventional bike lanes

» Signalized and non-signalized intersections where it is desirable to mitigate conflicts between through bicyclists and turning vehicles, for example due to crash history or turning vehicle volume



Incorporating protected intersection design principles does not always require the intersection of two separated bike lanes. For example, these under-construction corner islands where a separated bike lane intersects a side street will improve visibility for all modes and create crossing islands for people walking.

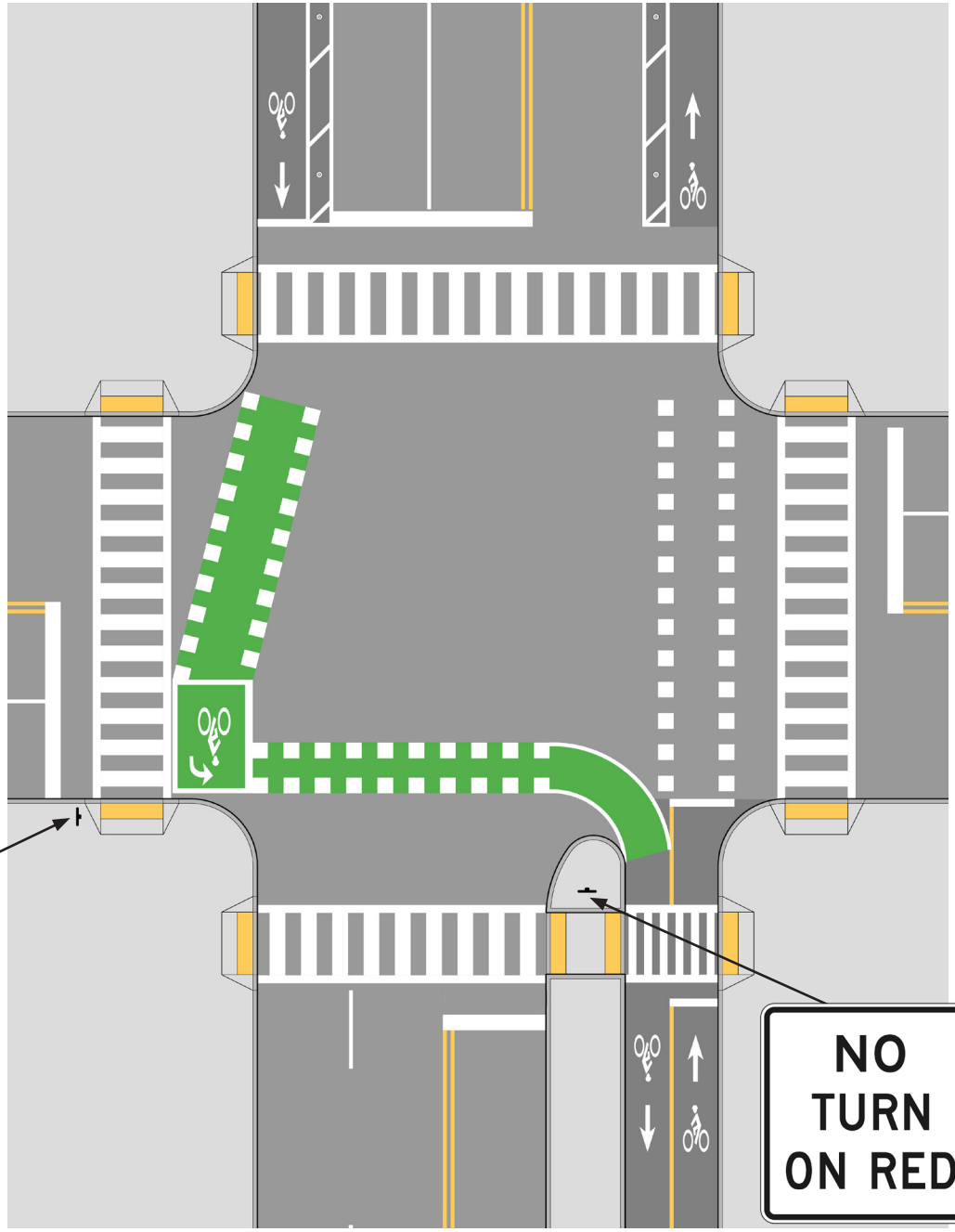


Transition

A transition is a location that has been designed to facilitate a safe, comfortable, and intuitive progression from one bikeway type to another or to provide access to a destination. Transitions vary greatly from location to location depending upon many contextual factors and may use a combination of intersection treatments including bike crossings, two-stage bicycle turn boxes, bike boxes, protected intersections, bike signals, and signal phasing in a manner that minimizes conflicts, minimizes delay, and is easily understood by all roadway users.

Where to Use Transitions

- Transition points between different bikeway types
- Locations where bicyclists must change sides of the street in order to continue along a bikeway
- At the beginning or end of bikeways



R10-11
Required where permissive turns on red would travel through the two-stage turn box, per FHWA interim approval

R10-11
Optional recommended placement

A transition between a two-way separated bike lane (or sidepath) and a pair of one-way separated bike lanes. Southbound bicyclists navigate to the other side of the street with a two-stage turn queue box and through signal phasing.

Floating Bus Stop

A floating bus stop is a short bikeway segment that routes bicycle traffic along the back side of a bus stop in order to eliminate bus-bike conflicts. This treatment creates a dedicated passenger platform between the motor vehicle lane and the bike lane that provides space for bus passenger amenities such as shelters, seating, and trash receptacles.

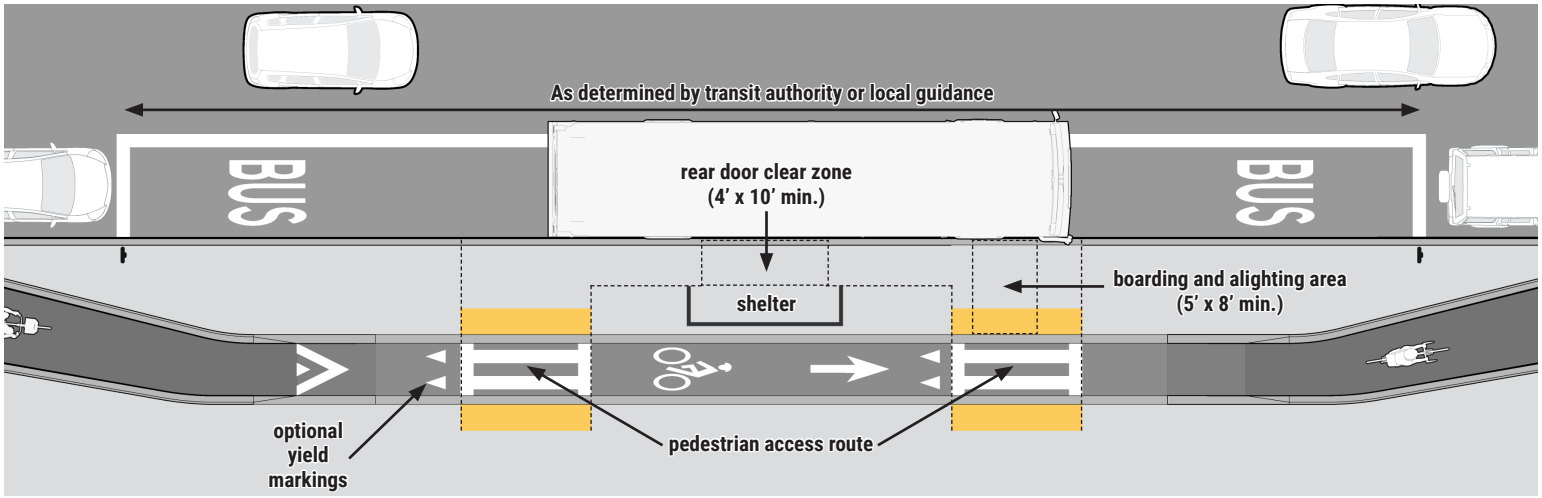
Floating bus stops must be accessible for people with disabilities with sufficient space for accessible pedestrian routes, a dedicated boarding and alighting area, and a rear door clear zone.

Where to Use Floating Bus Stops

» Any corridor with bus stops and a dedicated bikeway



A floating bus stop implemented on Western Avenue, Cambridge. A 12" offset between the separated bike lane and bus shelter is recommended to reduce the risk of handlebar strikes. The glass shelter and clutter-free design of this floating stop ensures that pedestrians crossing the bike lane are visible to bicyclists.

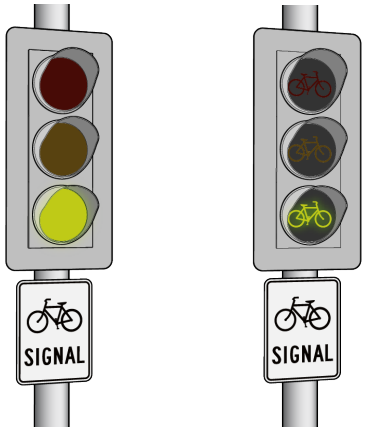


Bike Signal

Bike signals are dedicated signal heads used to control the movement of bicyclists through an intersection or crossing. Bike signals mitigate or eliminate conflicts and facilitate transitions between bikeway types. Bike signals are subject to interim approval from FHWA. Municipalities seeking to use the treatment must inform FHWA through a simple form letter that indicates their intent and whether the treatment will be used at a single location or on a municipality-wide basis.

Where to Use Bike Signals

- Intersections with leading or protected phases for bicyclists
- Intersections with bike movements that run counter to the direction of vehicular traffic (i.e. "contra-flow")
- Intersections where existing traffic signal heads are not visible to bicyclists
- At protected intersections



Sign Required | Sign Optional

Pedestrian Hybrid Beacon

A pedestrian hybrid beacon is a traffic control device that facilitates pedestrian and bicyclist crossings of high volume streets. The beacon is activated by pedestrians and bicyclists using a push button. Common applications for bikeways include locations where a shared use path or a bike boulevard crosses a high volume street.

The beacon may be used in locations that do not meet the warrant for a full traffic signal or at locations that meet any of the nine warrants for a full traffic signal as defined in the MUTCD.

Push buttons for pedestrian hybrid beacons should respond quickly when activated to encourage user compliance when activated and be placed in a convenient location for all users, including people biking, walking, and in wheelchairs.

Where to Use Pedestrian Hybrid Beacons

- Crossings with ≥20 pedestrian or bicyclists crossings in the peak hour and motor vehicle volumes >2,000 in the peak hour
- Crossings of streets with operating speeds of ≥40 mph and ≥12,000 motor vehicles per day
- Any crossing where other traffic control measures are inadequate to create safe crossings

Signal Phasing and Detection

Operating characteristics for bicyclists should be considered when developing a phasing plan whether or not the intersection has dedicated bike signals.

At intersections with standard signals, the minimum green time, extension time, and clearance intervals should reflect typical speeds and travel patterns for bicyclists, as well as motorists.

At intersections with bike signals, the following types of bicycle signal phasing may be considered:

- **Protected bike phases** may be used at intersections with a two-way or contra-flow bike movement, a high volume of bicycle traffic, or a high volume of conflicting motor vehicle turning movements.
- **Leading bicycle intervals** may be used at intersections with a high volume of conflicting vehicle turning movements and where protected bike phasing is not feasible or warranted.
- **Concurrent bicycle signals** may be used at simple intersections with a low volume of conflicting vehicle turning movements.

At signalized intersections with acuation, passive detection should be utilized to allow people riding bikes to trigger the green signal. Loop detectors are a common form of passive detection and should be calibrated to detect a bicyclist. Where pushbuttons are used, the location of the buttons should be placed where bicyclists can easily access them without having to dismount or divert from their path of travel.

Bike Parking

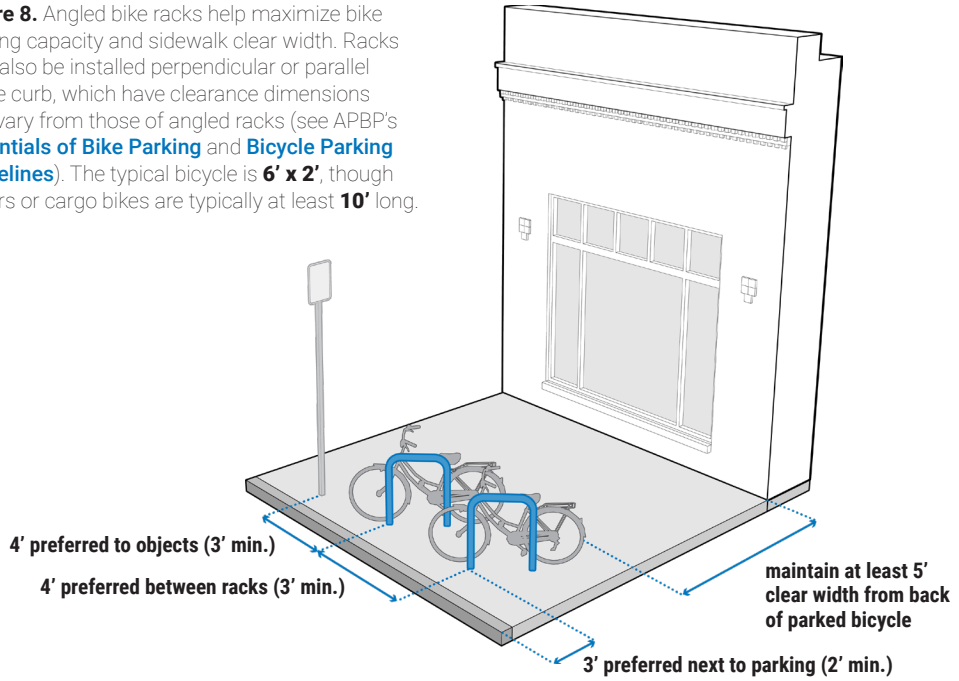
Bike parking is an essential element of connected bike networks. For everyday biking to be a feasible and attractive option, people need a place to park their bikes that is secure, easy to use, and convenient to employment, shops, restaurants, transit, schools, and other community destinations. Municipalities can implement bike parking with local, regional, and state partners through a variety of methods, including the project development process, as part of community improvement district enhancements, or through public and private developments.

MassDOT encourages communities to follow bike parking site planning, design, installation, and placement guidance established by the Association of Pedestrian and Bicycle Professionals (APBP):

- Bike parking should follow the **"inverted-U"** rack style. It is the most intuitive, provides two points of contact for stability, and accommodates the widest variety of bike styles.
- Bike parking should be visible, well-lit, and convenient to destinations, ideally **≤50'** to the entrance.
- Bike parking may be implemented on sidewalks or in a corral of **8–12** bike racks occupying one on-street parking space.

For more detail regarding short- and long-term parking considerations, including spacing requirements, refer to APBP's Essentials of Bike Parking and Bicycle Parking Guidelines.

Figure 8. Angled bike racks help maximize bike parking capacity and sidewalk clear width. Racks may also be installed perpendicular or parallel to the curb, which have clearance dimensions that vary from those of angled racks (see APBP's Essentials of Bike Parking and Bicycle Parking Guidelines). The typical bicycle is **6' x 2'**, though trailers or cargo bikes are typically at least **10'** long.



Case Study: Westfield

In 2017, the Pioneer Valley Transit Authority opened a multimodal transit center in downtown Westfield, the Olver Transit Pavilion. While primarily serving as a municipal bus terminal, the Olver Transit Pavilion includes covered bike parking, a vending machine with bike parts, and a self-service maintenance station. These amenities help connect the transit hub to the Columbia Greenway Rail Trail, which is a few blocks away and is currently being extended through downtown to connect with the Westfield River Esplanade. The transit hub was funded with state and federal sources, with some of the land provided by the City of Westfield.



Loop-style "inverted U" bike racks located in a covered area at the Olver Transit Pavilion in Westfield. Credit: Anand Patel, UMass Amherst

Drainage Grates

Drainage grates should be located outside of the bicyclist path of travel wherever feasible to maintain a safe and comfortable riding experience. When their placement in the bicycle path of travel cannot be avoided, drainage grates should be bicycle friendly (e.g., hook lock cascade grates as noted in MassDOT Engineering Design Directive E-09-003). Designers should consider eliminating grates in the bicycle path of travel in favor of curb inlets.

All existing slotted grates should be positioned with their slots perpendicular to the bicycle direction of travel. This will prevent crashes resulting from a bicycle tire becoming lodged in a parallel slot. Maintenance crews who may move drainage grates should be instructed to place and replace grates in the perpendicular direction to ensure road user safety.

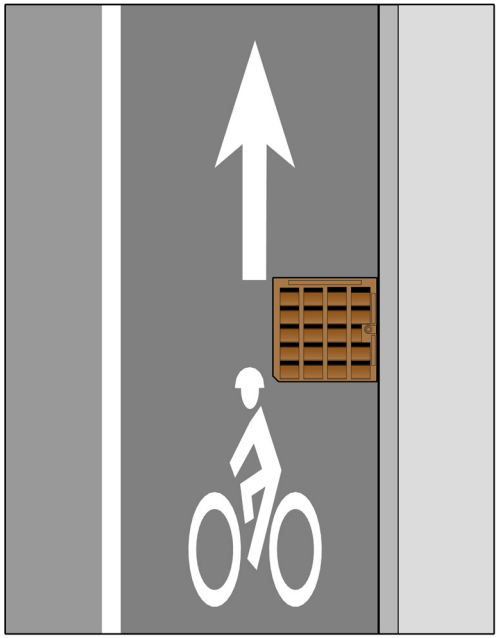
Pavement Quality

Clean, smooth pavement is essential to providing a safe and comfortable riding experience. What may be an adequate roadway surface for automobiles can cause difficulties for bicyclists. Debris from adjacent travel lanes often accumulates in the area where people bicycle and can damage the wheel of a bicycle, and broken glass can puncture bicycle tires. Uneven longitudinal cracks and joints can divert a bicycle wheel, causing a crash. Potholes can cause wheel rims to bend or tires to puncture, which also leads to crashes.

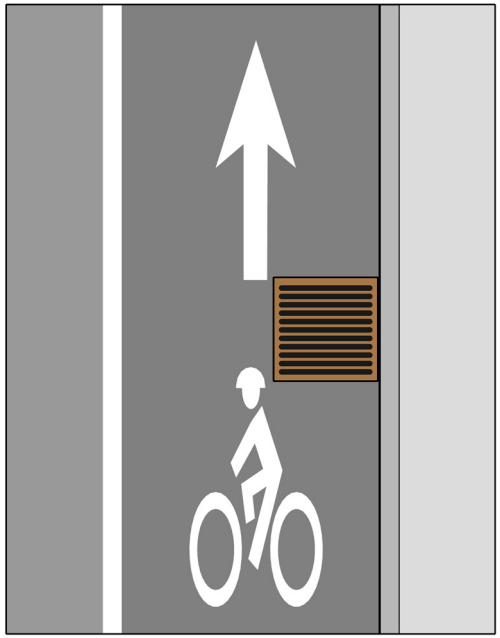
Because facilities that are not kept free of debris year-round may discourage bicyclists from using the facility, routine cleaning and clearing as well as more significant repairs and maintenance are necessary to keep bike facilities safe and comfortable in all seasons, year after year.

See Chapter 7: Year Round Bikeways of this Guide for more information

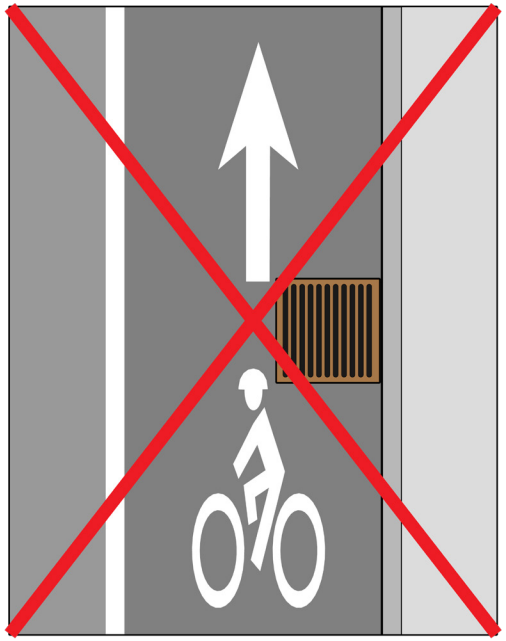
Bicycle-friendly Drainage Grate



Perpendicular Drainage Grate Placement (Bicycle-friendly)



Parallel Drainage Grate Placement (Unsafe for Bicyclists)



Implementation

Like all transportation projects, the process of planning, designing, and constructing connected bike networks takes time and funding. In response, many communities in the U.S. are using a flexible, phased approach to accelerate implementation timeline and reduce cost.

A phased approach can help communities quickly address immediate safety needs, demonstrate the benefits of high-comfort bikeways, and build public and stakeholder support for bicycle infrastructure investments. While this section summarizes each potential phase—demonstration, retrofit, repaving, and construction/ reconstruction—communities are not required to follow all three in sequence.

Demonstration Projects

Bikeways can be piloted as demonstration projects using inexpensive, temporary materials such as tape, traffic cones, paint, and chalk. Demonstration projects are a useful tool to introduce bikeways to the public, especially where bike infrastructure may be unfamiliar to residents and stakeholders.

Demonstrations are typically implemented as part of an "open streets" event or similar street festival, and are usually installed and removed over the course of a single day or weekend. Event staff and/or local traffic enforcement officials can be on site to supervise and provide information about the bikeway. Event planners should consider involving stakeholders, such as neighborhood groups or local advocacy organizations, in planning, promoting and staffing a demonstration project.

Communities can consider demonstration projects as an opportunity to test and refine projects and build public support. Collecting community feedback during the demonstration can inform design decisions in advance of full construction.

For more information, see the **Tactical Urbanist's Guide to Materials and Design**.

Retrofit Projects

Bikeways can be retrofitted into existing streets using low-cost, interim materials (e.g., pavement markings, signs, flexible delineator posts, planters, etc.) and with minor construction (e.g. repaving, signal re-timing, etc.). Retrofit projects help communities quickly implement safe and comfortable bikeways without significant expense, and provide an opportunity to test bikeway configurations in the near term

Case Study: Holyoke and South Hadley

The City of Holyoke, Town of South Hadley, and the Massachusetts Bicycle Coalition opened the Vietnam Veterans Memorial Bridge (Route 116) exclusively to walking and biking for the inaugural Connecticut River Roll & Stroll in 2017. MassDOT participated in this "open streets" event with a separated bike lane demonstration. Using low-cost materials, this one-day demonstration repurposed a roadway shoulder into a one-way separated bike lane, providing the public with an opportunity to test ride a high-comfort bikeway.



Demonstration of a one-way separated bike lane using chalk, tape, and planters

while planning for permanent redesign of the street in the long term. For more information, see **Quick Build for Better Streets: A New Project Delivery Model for U.S. Cities** by PeopleForBikes.

Routine Repaving Projects

Incorporating new bikeways within routine repaving projects is a relatively quick and cost-efficient implementation strategy. In Massachusetts, Chapter 90 funds are widely used by municipalities for routine roadway maintenance. The material cost of adding new bike lanes—such as new striping and signage—can be rolled into roadway repaving budgets. Design and public engagement may add additional cost to this process.

As a best practice, municipalities should establish a process to review annual repaving lists for corridors where bikeways can be added. This process can begin immediately even in lieu of or during the development of a bike network plan. For more information, see **Incorporating On-Road Bicycle Networks into Resurfacing Projects** by FHWA

New Construction and Reconstruction Projects

Some bikeway configurations may only be feasible with major construction or reconstruction work. Municipalities constructing new roads should strive to incorporate the highest comfort bikeway appropriate for the given context. Reconstruction provides the opportunity to achieve more complex designs that require adjustments to curb lines, utilities, drainage, stormwater, streetscape, or bus stops.

Funding

Municipalities have a variety of funding tools available to assist them with the design and construction of a bikeway project including the following:

- **Chapter 90**
- **MassDOT Complete Streets Funding Program**
- **Regional transportation improvement programs**
- **Recreational Trails Program**
- **MassWorks Infrastructure Program Grants**
- **USDOT BUILD Discretionary Grant Program**
- Development mitigation funds



MassDOT implemented buffered bike lanes along Route 20 in Brimfield as part of a routine resurfacing project.



Reconstruction of Commonwealth Avenue, Boston, with a floating bus stop and a one-way separated bike lane. Credit: Nathaniel Fink.

Explore More Resources

- AASHTO Guide for the Development of Bicycle Facilities: https://bookstore.transportation.org/collection_detail.aspx?ID=116
- APBP Bicycle Parking Guidelines: https://www.apbp.org/page/publications?
- FHWA Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts: https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/multimodal_networks/
- FHWA Interim Approvals: https://mutcd.fhwa.dot.gov/res-interim_approvals.htm
- FHWA Manual on Uniform Traffic Control Devices: https://mutcd.fhwa.dot.gov/
- FHWA Small Town and Rural Multimodal Networks: https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/small_towns/
- MassDOT Separated Bike Lane Planning & Design Guide: https://www.mass.gov/lists/separated-bike-lane-planning-design-guide
- MassDOT Project Development & Design Guide: https://www.mass.gov/files/documents/2018/08/08/pddg.pdf
- NACTO Urban Bikeway Design Guide: https://nacto.org/publication/urban-bikeway-design-guide/
- FHWA Bicycle Facilities and the Manual on Uniform Traffic Control Devices: https://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/mutcd/

	Bikeway Segments							Bikeway Intersections								
Guide	Shared Use Path	Separated Bike Lane	Buffered and Conventional Bike Lane	Bike Boulevard	Advisory Bike Lane	Contra-Flow Bike Lane	Shared Lane Markings	Bike Crossing	Two-stage Bicycle Turn Box	Bike Box	Protected Intersection	Transition	Floating Bus Stop	Bike Signal	Pedestrian Hybrid Beacon	Signal Phasing
MassDOT Separated Bike Lane Planning & Design Guide	√	√						√	√		√	√	√	√		√
AASHTO Guide for the Development of Bicycle Facilities (2012)	√	√	√			√	√	√								
NACTO Urban Bikeway Design Guide		√	√	√		√	√	√	√	√				√		
FHWA Achieving Multimodal Networks	√	√	√					√			√		√	√	√	√
FHWA Small Town and Rural Multimodal Networks	√	√	√	√	√		√	√				√			√	√

Figure 9. Lookup table for design guidance resources related to specific bicycle facilities.

Establishing Bikeshare

Bikeshare is a mobility service that allows people to access and use a network of bicycles for point-to-point trips. Like boarding a bus near home and exiting downtown, bikeshare allows users to pick up a bike in one location and leave it in another. Users may pay small one-time fees or, in some cases, purchase a daily, monthly, or annual pass. Bikeshare is typically implemented at the municipal level or for use within focused geographies such as office parks or university campuses. This chapter provides information on the different types of systems and equipment that are currently available and how they are applicable to different contexts.

Bikeshare has proven to be an effective, low-cost mode of public transportation for short trips. Most bikeshare trips in the U.S. are up to 1–3 miles and between 15–35 minutes long, with bikeshare users most commonly connecting to transit, commuting, or using it for social or recreation trips.

With only **54 percent** of MA households owning a bicycle, bikeshare expands the availability of bicycling to a wider range of people and increases awareness of bicycling as an everyday transportation option. Bikeshare provides first- and last-mile connections for transit trips, helps fill transit gaps, and expands the potential market for existing transit service. See Connecting to Transit on page 17 for more information on planning first and last mile connections to transit.

Bikeshare Technologies

Bikeshare can be implemented as a **"dock"** or **"dockless"** system. Dock systems require users to pick up and drop off bikes at dedicated stations or docks, whereas dockless systems allow users to pick up and drop off bikes in any location within a service area. Bikeshare technology and business models are evolving quickly. Communities may find that dock, dockless, or a combination of both systems are right for them. The capital and operating costs cited in this section are based on current estimates and are subject to change. The costs are intended for informational purposes only.

Smart Dock

Smart dock systems include a computerized terminal where transactions and information are processed to release and lock the bikes at a series of inter-connected stations. In these systems, the locking mechanism and technology are provided at the dock. Although some systems offer independent locks for mid-trip stops, to complete a trip, the user must return the bike to a station. Typical capital costs range from **$4,000–$6,000** per bike and operating costs between **$1,200–$2,700** per bike per year for smart dock systems.

Electric-Assist Smart Dock

Electric-assist ("e-assist") bicycles provide a boost while pedaling. E-assist bicycles can reduce some barriers to access and may be appealing where there are environmental barriers (e.g., steep terrain or hot weather) or to aging populations or those with health concerns. E-assist bicycles can extend the distance that someone can comfortably ride. Taken together, e-assist technology can attract a wider range of users. However, of all bikeshare technologies it is the most expensive.



Boston, Brookline, Cambridge, and Somerville are served by Blue Bikes, a smart dock system of 3,000 bikes and 300 stations. It is one of the largest bikeshare systems in the U.S.

Typical capital costs range from **$5,200–$6,100** per bike and operating costs between **$1,200–$2,700** per bike per year for electric assist smart dock systems.

Smart Bike

Smart bike systems are dock systems that provide a lock, a transaction terminal, and a GPS unit on each bicycle. This allows more flexibility as to where bicycles can be locked and users sign up and locate bicycles using mobile and web-based applications. Smart bike systems can be set-up with stations (often called "hubs") to look like smart dock systems. However, not all stations require transaction terminals, providing greater flexibility when siting stations. Given the greater flexibility in pick-up and drop-off locations, smart bike systems are less predictable for operators charged with rebalancing.

Typical capital costs range from **$2,500–$4,500** per bike and operating costs between **$1,200–$2,700** per bike per year for smart bike systems.

Lease-Option Smart Bike

Lease-option smart bike systems are a dock system similar to smart bike systems but are leased and not owned by the municipality, company, or university where they are located. This provides an affordable option for a bikeshare system where the large up-front capital may not be available. There are fewer vendor options associated with lease option smart bikes and, as a result, fewer aesthetic options available.



Amherst, Holyoke, Northampton, South Hadley, and Springfield launched ValleyBike Share with the University of Massachusetts and the Pioneer Valley Planning Commission. ValleyBike Share is the Commonwealth's first e-assist smart dock system, incorporating 500 bikes served by 50 stations. Credit: Bewegen



While there are no smart bike systems in Massachusetts, other communities are adopting this relatively new bike share technology. Portland, OR, launched Biketown in 2016 and expanded it to 1,000 bikes and 125 stations. Biketown includes adaptive bikes for people with disabilities that can be reserved in advance.

Lease-option smart bike systems typically have operating costs of approximately **$1,800** per bike per year but not capital costs for host communities.

Self-Locking Bike

Self-locking bike systems are the most recent bikeshare technology in the U.S. These dockless bikes include a wheel lock that locks the bike to itself but not to other objects like bike racks, parking meters, and sign posts. Rentals require the use of a smart phone app and a Quick Response (QR) code to unlock for use. Self-locking systems are typically owned and operated by a third-party for-profit company. As such, there is no capital or operating cost for host communities.

While these systems do not need docking stations they still rely on sidewalks and public spaces for bicycle storage. Communities considering dockless systems should establish a policy framework to ensure dockless bikeshare works with municipal objectives, advances local goals, and is safe to use. For more information, see the Institute for Transportation & Development Policy's **Optimizing Dockless Bikeshare for Cities.**

Essential Elements for Successful Bikeshare

Successful bikeshare systems are a product of a community's interest, capacity, physical environment, and funding. This section recommends strategies to address each of these elements.



Marlborough launched a two-year bikeshare pilot in 2017. This lease-option smart bike system includes 30 bikes served by 5 stations. Credit: Assabet River Rail Trail, Inc.



Communities served by self-locking bikeshare systems are experimenting with new sidewalk markings that encourage customers to leave bikes in designated areas outside of pedestrian access routes. Credit: Seattle Department of Transportation



The MAPC Regional Bikeshare system utilizes self-locking dockless bikes in 15 communities in the metro Boston area. In the example above, self-locking bikes are shown parked in a residential area in Chelsea.

Interest

Implementing and maintaining a successful system requires community and stakeholder support garnered through an inclusive planning process. This support should ultimately result in buy-in from decision makers.

- **Community Support:** Gauge community interest for bikeshare by launching a survey or online interactive map, and/or hosting a public meeting. Invite representatives from nearby communities with existing bikeshare systems, where available, to help answer questions or demonstrate a particular bikeshare technology. Incorporate bikeshare as part of the comprehensive plan update process, which can result in formal support via adopted bikeshare goals and actions.
- **Stakeholder Support:** Local stakeholders are instrumental in the bikeshare planning process as they understand local conditions and can identify challenges and opportunities, develop priorities and goals for the program, and build support for the program. Identify key community stakeholders (e.g., City department, community organizations, neighborhood groups, business association, hospital, large employers, etc.) and host group or one-on-one meetings to discuss bikeshare opportunities and build momentum. Some stakeholders may have interest sponsoring bikeshare.

Capacity

Community champions and partnerships, as well as determination of ownership and management, are required to start, maintain and grow a successful bikeshare system. Often these essential elements are identified during or soon after community and stakeholder outreach as part of a planning process.

- **Champion:** Local champions typically stem from the bottom up. Prior to the launch of bikeshare, this person is instrumental in the excitement, support, and coordination of key pieces to bring bikeshare off the ground. Champions are typically someone whose personal or professional goals are in line with those of bikeshare and who has the interest and capacity to help spearhead the program.
- **Partnerships:** Partners are often transit agencies, municipalities, universities, and community groups, among others. Typically partners begin as stakeholders in the planning process and their role evolves as it is identified as essential for the success of the program. For example, partners can become a key sponsor, a transit agency supporting the integration of transit and bikeshare fares, a bicycle co-op who manages the maintenance of the bikes, or a university located within a university town.
- **Ownership and Management.** One of the key decisions for any bikeshare program is to determine who will own and manage the program and who will operate it. Existing U.S. bikeshare programs operate under different governance models depending on the local funding

Case Study: Salem

The City of Salem launched their lease-option smart bike system in May 2017 and quickly expanded from three to six stations within two months. For the 2018 relaunch, Salem increased its system to 10 stations to cover a greater geographic area and provide multimodal connectivity to the MBTA commuter rail and the Salem Ferry. The City established a three-year, $35,000 per year contract with the bikeshare vendor, paid in part by Salem State University and a grant from Blue Cross Blue Shield of Massachusetts. The bikeshare vendor owns the equipment and the contract pays the vendor for day-to-day operations and management. This leased-option model reduces the need for up-front capital costs.



One of 10 lease-option smart bike stations in Salem (Washington Street at Front Street).

environment, institutional capacity, and local program needs. There are precedents throughout the country for a variety of organizations fitting these roles including government agencies, non-profit organizations, or a for-profit company specializing in bikeshare (e.g., dockless or lease-option systems).

Physical Environment

Bikeshare works best in already bikeable communities, though bikeshare can be a strategy to improve bikeability alongside the implementation of bicycling infrastructure. While there is no single recipe for making a community more bikeable, several traits of a community's physical environment greatly influence bikeshare suitability:

» **Potential Demand**: Estimate the potential demand for bikeshare with an identification of key destinations (e.g., town centers, transit stations, employment and shopping hubs, community institutions, etc.) and review of street layout and existing trip patterns. Geospatial techniques may be employed to estimate and map demand. Bike Sharing in the United States: State of the Practice and Guide to Implementation illustrates how this planning analysis is conducted.

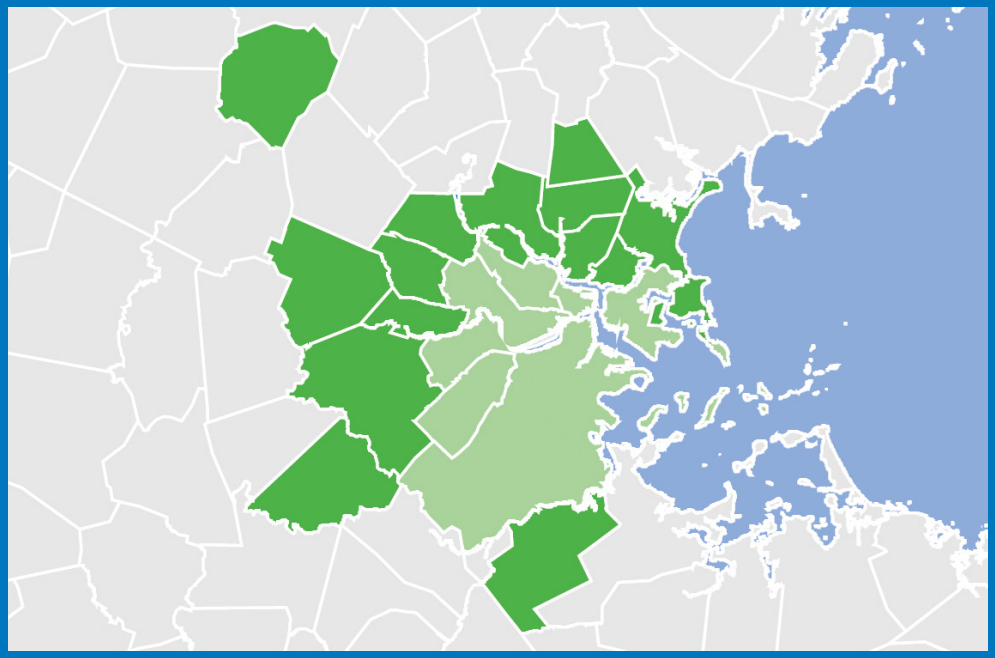
» **Topography and Climate:** Identify topographical or climate challenges that may influence bikeshare technology selection, station siting, or months of operation. Many cities with challenging topography and climates have launched successful bikeshare systems. Launching first in Baltimore, MD, and Birmingham, AL—and recently in Pioneer Valley—e-bikes are becoming a widespread bikeshare technology to address issues with hills and heat. In many cities with inclement winter weather, bikeshare service may be reduced during winter months as a result of costs associated with snow clearance and removal.

» **Bicycling Infrastructure:** If not yet completed, plan and adopt a connected bike network plan for your community (see Planning for Bikeable Communities on page 15). Implement bikeways as part of routine resurfacing to quickly introduce new bikeways, and integrate

Case Study: MAPC Regional Bikeshare

The Metropolitan Area Planning Council (MAPC) is helping bring dockless bikeshare service to 15 communities within the Boston region: Arlington, Bedford, Belmont, Chelsea, Everett, Malden, Medford, Melrose, Milton, Needham, Newton, Revere, Waltham, Watertown, and Winthrop.

MAPC launched an RFP process on behalf of these communities in 2017 to select vendors. In April 2018, two dockless bikeshare vendors were selected to provide more than 2,000 bikes at no cost to the host communities. Unique to dockless systems, users are able to pay with cash in addition to the standard smart phone payment systems.



Regional dockless bikeshare communities (shown in dark green) are adjacent to Blue Bikes communities (shown in light green). Dockless bike share is not permitted within the Blue Bikes service area.

Complete Streets principles into the street design process for longer-term projects. Dedicated bikeways are not required for bikeshare but will help attract riders of all ages and abilities if designed well. NACTO found that investments in bike infrastructure and bikeshare are complimentary and yield greater results.

Funding

While dockless bikeshare typically requires no funding support from the municipality, dock systems require some mix of capital and operational funding to purchase bikes and equipment and to pay for day-to-day operations and maintenance of those assets.

» **Capital and Operations:** Identify and pursue capital and operations funding mechanisms from a variety of sources, including federal, state, or local grants; sponsorships from large employers, hospitals, or key community establishments; or municipal budgets. MassDOT's Funding for Community Transportation website lists many resources for municipal funding, while the Congestion Mitigation and Air Quality Improvement (CMAQ) Program has been a source of capital funding for many systems throughout the U.S.

Equity

Bikeshare can be a valuable mobility option in lower income and historically under resourced communities. Increased access to mobility options like bikeshare can support broader equity-focused goals and initiatves. With the right focus on equity, municipalities can effectively reduce barriers to participation in bikeshare. These barriers can include high membership costs, required use of credit cards or smartphones, lack of non-English options, and absence of nearby docks (for docked bikeshare systems).[1] Bikeshare programs throughout the country are introducing equity-focused programs to address and mitigate these barriers, including:

» **Payment Options:** Offer flexible pricing and payment options, for example, allowing participants to pay with cash and pay a reduced-price membership or per-trip rate. Reduced-price programs can be implemented either as pilot projects or on a permanent basis. Nationally, bikeshare programs have successfully partnered with local foundations, hospitals, and housing authorities to help subsidize these efforts or fund additional stations.

» **Community Organizing:** Partner with community-based organizations to conduct in-person outreach to reach those who are traditionally underserved by bikeshare. As part of this effort, outreach ambassadors should communicate bikeshare benefits, demonstrate how to use the system, and promote flexible pricing and payment options.

Explore More Resources

» BBSP Resources: http://betterbikeshare.org/resource/

» FHWA Bike Sharing in the United States: State of the Practice and Guide to Implementation: http://www.pedbikeinfo.org/pdf/Programs_Promote_bikeshareintheus.pdf

» ITDP The Bike-Share Planning Guide: https://www.itdp.org/the-bike-share-planning-guide-2/

» NABSCA Dockless Bikeshare Regulation Preliminary Guidance: https://nabsa.net/wp-content/uploads/2017/09/Dockless-Regulation-Preliminary-Guidance-1.pdf

» NABSCA Resources: https://nabsa.net/resources/

» NACTO Bike Share Initiative: https://nacto.org/program/bike-share-initiative/

» NACTO Bike Share Intercept Survey Toolkit: https://nacto.org/interceptsurveytoolkit/

» NACTO Bike Share Station Siting Guide: https://nacto.org/wp-content/uploads/2016/04/NACTO-Bike-Share-Siting-Guide_FINAL.pdf

References

1 McNeil, N., Dill, J., MacArthur, J., Broach, J., and Howland, S. Breaking Barriers to Bike Share: Insights from Residents of Traditionally Underserved Neighborhoods. NITC-RR-884b. Portland, OR: Transportation Research and Education Center (TREC), 2017. https://doi.org/10.15760/trec.176

Collecting and Evaluating Data

Collecting and analyzing quality data helps communities identify needs, inform planning and design efforts, prioritize investments, evaluate project effectiveness, and communicate the benefits of completed investments. This chapter describes how data can be used to inform the planning, design, and evaluation of bikeways and connected bike networks, including:

» **Network data**, for example the location and type of bikeway

» **Safety data**, for example the number and severity of crashes, contributing factors to crashes, and user comfort

» **Travel data**, for example the number of bicyclists, their characteristics, and their travel patterns

» **Economic data**, for example how bikeway investments benefit the local economy

Municipalities can develop their own data collection program, utilize the existing resources described throughout this chapter, or use a combination of both approaches.

Network Data

Central to creating bikeable communities is maintaining a database of existing and planned bikeways. Accurate and updated bike network data are fundamental to the planning, design, preservation, and maintenance of connected bike networks as well as for personal wayfinding. Bike network data should contain attributes that describe:

» The location and type of bikeways

» Date of implementation and most recent maintenance work

» Basic physical characteristics such as bikeway width, surface material, and presence of adjacent on-street parking

Municipalities typically record and maintain geospatial network data via ArcGIS. MassDOT maintains a statewide database of local and state-owned bikeways through GeoDOT. Municipalities can also access geospatial data through the MassGIS website.

Safety Data

Collecting, maintaining, and analyzing safety data helps municipalities respond to safety concerns. Massachusetts crash data (2010–2015) show that bicyclists are **four times likelier** to suffer a fatal or serious injury than a motorist in the event of a crash.[1] MA Bike Plan public outreach confirmed that most people do not consider biking as an everyday travel option because they perceive it to be unsafe. Proximity to high motor vehicle volumes and speeds is uncomfortable for people biking. Therefore, both observed and perceived safety challenges should be reviewed to fully understand the safety needs of bicyclists.

Municipalities can collect and evaluate the following types of bicycle-related safety data:

» **Crash data**, including detailed narratives, to understand the frequency and severity of crashes, map high crash locations, and illuminate contributing factors

» **Risk and user comfort data**, including motor vehicle speeds, to understand location- or area-specific concerns that may not be reflected in crash data

MassDOT shares the FHWA Zero Deaths Vision of eliminating fatalities and serious injuries on all roadways. Several Massachusetts communities have also committed to Vision Zero, a proactive approach to eliminating fatal and serious injury crashes through implementing evidence-based countermeasures. As vulnerable road users, people bicycling are a focal point for these efforts.

Crash Data

Municipal and state police collect motor vehicle crash data, including crashes involving people biking. These data are compiled statewide by the Massachusetts Registry of Motor Vehicles (RMV), a division of MassDOT. In turn, MassDOT provides several options for communities to view and download aggregated crash data for bicycles and other travel modes:

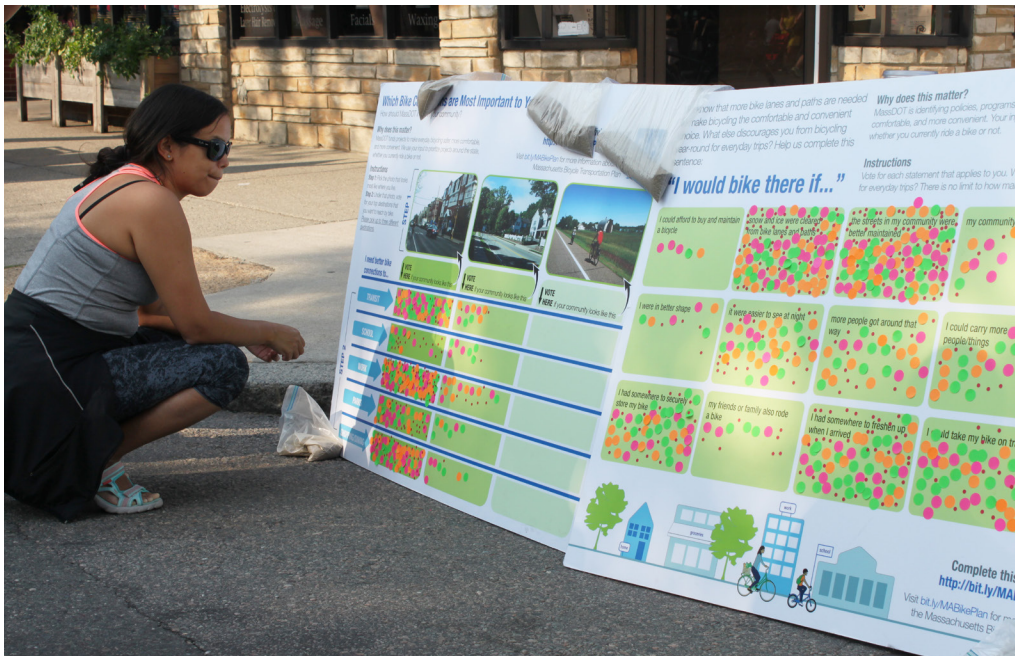
» Municipal crash listing files can be downloaded for any city or town. Crashes are listed individually in the municipal data files with information on date, time, location, severity, non-motorist type (e.g., bicyclist), and lighting conditions.

» The Crash Data Portal allows users to download municipal crash data or to create custom queries from the statewide crash database.

» The Interactive Crash Cluster Map and Top Crash Location Report highlight bicycle-motor vehicle crash cluster locations statewide. Crash clusters are identified with a severity-weighted methodology in compliance with the Highway Safety Improvement Program (HSIP). This methodology gives greater weight to fatal and injury crashes compared to property-damage-only crashes.

Crash Data Limitations

Statewide crash data are compiled based on crash reports submitted by state and local police. Some information in these reports may be incorrectly or incompletely reported, so data quality may vary by jurisdiction. In addition, the reporting levels of some communities have significantly changed with the switch to electronic reporting. Planners and designers should review MassDOT's Crash Data website for answers to frequently asked questions regarding these data. Municipalities can help improve the quality of the state's crash data by consistently and accurately reporting crashes. Research shows that crashes involving bicyclists tend to be underreported.[2]



In-person surveying can be an effective strategy to collect risk and user comfort data from people who are interested in biking but do not because of stressful interactions with motor vehicles.

Planners and designers should supplement crash data with fatal and serious injury data from local or regional emergency medical services, where available.

Risk and User Comfort Data

Crash data alone do not fully capture the everyday risks experienced by bicyclists or the barriers preventing others from riding (see Case Study: Bicyclist Safety and Comfort on page 13). These risks include near-misses with motor vehicles, proximity to moving traffic, and other stressful interactions on roadways.

Chief among these uncomfortable conditions, high motor vehicle operating speeds are a known barrier to everyday biking and a critical factor in reducing bicyclist injuries and fatalities. Consequently, motor vehicle speed is a critical factor when selecting bikeways (see Designing Connected Bike Networks on page 28). MassDOT recommends municipalities collect motor vehicle speed data with detection devices to inform the planning, design, and evaluation of bikeways as part of a connected bike network. For more information on vehicular speeds, see the **Safety** chapter in the Municipal Resources Guide for Walkability.

More broadly, communities can better understand barriers to everyday biking by collecting user comfort data via online or in-person surveying techniques:

» **In-person surveying** at public meetings and events or in the project area helps reach a wide variety of demographics, but can be time-consuming and costly for large projects or community plans.

» **Online surveying** via interactive maps and forms can reach many people more efficiently than in-person surveying, but can be biased toward those with time and ability to navigate through project websites. Online interactive maps result in geocoded data that simplifies geospatial analyses of perceived safety. The City of Boston's Vision Zero Safety Concerns Map is an example of an interactive mapping survey.

Bicycle Crash Evaluation

Bicycle crashes and perceived safety issues can be grouped into two categories and addressed through specific evidence-based countermeasures. FHWA's BIKESAFE Bicycle Safety Guide and Countermeasure Selection System identifies 13 crash types and 46 corresponding countermeasures that can be applied to improve bicycle safety. The tool includes matrices to help select countermeasures based on either crash type or performance measures.



MassDOT partners with community stakeholders to review known safety issues and identify opportunities for safety improvements as part of the Road Safety Audit process. Credit: Brendan Kearney, WalkBoston

Knowing the type of bicycle crashes and perceived safety issues that are occurring at a site, municipalities can use the BIKESAFE selection tool to identify applicable countermeasures specific to the site's circumstances. Designing Connected Bike Networks on page 28 discusses several of these countermeasures and recommends various applications to attract bicyclists of all ages and abilities.

Additional detail as to what comprises a crash type and the countermeasures, including planning-level cost estimates, is available on the BIKESAFE website.

Finally, a Road Safety Audit (RSA) is a process involving a multidisciplinary team of local and regional partners that identifies safety issues and possible countermeasures at crash cluster locations, including bicycle hot spots. An RSA is required for HSIP funding applications, and if all or part of a project is HSIP-eligible, an RSA is required for 25 percent design plans. For more information about requesting and conducting an RSA, visit MassDOT's RSA webpage.

Travel Data

Collecting and analyzing data on the number, percentage, routes, and characteristics of bicyclists within a community can serve many uses. Understanding trends in bicycle usage can allow communities to develop a measure of exposure against which to compare safety data (e.g. crashes per bicyclist), compare before-and-after project conditions, prioritize bikeway investments and municipal maintenance efforts, and monitor the equity of investments.

Communities can obtain bicycle count data to support such analyses via several methods:

» **Existing data sources** such as the U.S. Census Bureau, MassDOT, regional planning agencies and metropolitan planning organizations, app developers, or bikeshare vendors

» **Bicycle counting programs,** which can vary significantly by scope, technologies, and level of effort

» **Surveys**, including intercept surveys and broader options

Existing Data Sources

The U.S. Census Bureau publishes estimated **bicycle commute data** through the American Community Survey (ACS). The ACS provides journey-to-work data on a five-year rolling average basis for all transportation modes. Municipalities can download community- or region-specific estimates for various years at the American FactFinder. However, observing statistically significant changes over time can be difficult due to sample size limitations and the relatively small number of bike commuters in most communities.

More broadly, MassDOT provides **bicycle trip data by all purposes** (e.g., work, school, shopping, etc.) obtained through the Massachusetts Travel Survey, which was most recently conducted in 2011. These data are summarized at the regional and statewide levels only.

Regional Planning Agencies typically collect and provide bicycle count data. These count programs can vary in complexity (see Bicycle Counting Programs on page 56). More broadly, the Metropolitan Area Planning Council estimated the **usefulness of all Massachusetts streets for biking** through Local Access Score. These scores identify which streets would be most useful for bicyclists to get from point A to point B. As such, the Local Access Scores can be used as a tool in estimating where to anticipate bicycling usage if safe, comfortable, and convenient bikeways were available.

Bicyclist travel pattern data, which includes the number and routes of bicyclists, may be acquired from developers of route-tracking fitness apps or through data-sharing agreements with bikeshare vendors. These data typically do not represent a random sample of the population or of bicycle trips, but can help illustrate usage patterns for particular subsets of the bicycling population.

Bicycle Counting Programs

Communities can count bicyclists over a variety of time frames using one or more methods of data collection.

Basic bicycle count programs involve manually counting bicyclists on one or more days per year at one or more fixed locations. Manual counts have the lowest up-front cost and are typically completed by municipal staff, consultants, or on a volunteer basis with municipal bicycle committee members, interested citizens, advocates, or students. In addition to counting the number of bicyclists, basic bicycle count programs should consider capturing select bicyclist characteristics such as gender, helmet use, type of conveyance, and wrong-way riding.

To illuminate trends over time, count efforts should be repeated annually in the same locations, during the same time periods, and approximately at the same time of the year. MassDOT recommends weekday May and September counts, at a minimum, to record usage under favorable conditions and when schools are in session. An expanded program can cover other times of year to measure seasonal variations.

Project-based **before-and-after counts** can measure usage associated with new bikeway investments. In general, this process entails collecting counts at least once before project initiation and at least once after project completion, though additional counts could continue afterward for a longer time frame.

As a municipality expands its counting program, the need may arise for more advanced and sophisticated approaches. Municipalities may pursue a **comprehensive bicycle count program** that involves dedicated equipment to electronically record data and a combination of short and continuous counting time frames.

Short-duration counts (typically two-week-long periods) can be conducted with equipment that is moved from one place to another to extend the breadth of the counting program. Municipalities can also perform continuous counts with permanent equipment to "factor" or annualize short-duration counts by season, weather condition, geography, etc.

For permanent equipment, resource needs include identification and evaluation of

Case Study: Permanent Bicycle Count Equipment

The City of Cambridge conducts biennial counts of bicycles throughout the city, providing a glimpse at the trends in usage over time. One visible part of the counting program is an "Eco Totem" in Kendall Square, which counts bikes using in-ground detection technology and displays the daily count of bicyclists in real time. These data are available online for public viewing, and provide the ability to compare local impacts to levels of bicycling resulting from construction projects and detours, various weather conditions, and special events.



The Kendall Square Eco-Totem bicycle counter is permanently installed and counts bicyclists continuously throughout the year.

potential sites, installation and maintenance of equipment, and regular reviews of count data to make corrections. Routine oversight of counts is also needed, including monitoring data several times per week to ensure proper equipment performance.

Similarly, short-duration counter resource needs include installation, re-installation, and maintenance of equipment as well as routine oversight. The equipment needs for short-duration counts depend on the desired robustness of the comprehensive counting program and the turnover of equipment from one deployment site to another.

For more information on dedicated bicycle counting programs, see:

» Chapter 5 of NCHRP 797: Guidebook on Pedestrian and Bicycle Volume Data Collection for guidance on bicycle counting technologies including application, installation, level of effort, costs, accuracy, and strengths and limitations.

» Chapter 4 of the FHWA Traffic Monitoring Guide for guidance on both short-and long-term nonmotorized counting programs, including selecting locations, accounting for temporal variability, and selecting equipment

Surveys

Whereas counts can only capture the number of users and observable characteristics, surveys can help collect more detailed data on bicyclist trips and understand the attitudes and opinions of the general population.

Intercept surveys help efficiently collect **detailed bicyclist data** such as origins and destinations, trip purposes, area of residence, attitudes, and many other characteristics. Surveyors should be stationed at representative locations and times along a specific bikeway or street where bicyclists are known to travel. Advance warning, including local media publicity as well as signage near the bikeway itself, increases participation rates and helps people understand the importance of the survey. Incentives (e.g., gift cards, discount coupons, etc.) can also increase participation rates.

More broadly, surveys can be conducted to gauge **general population attitudes** towards bicycling and bicycle infrastructure. In addition to intercept survey methods, general population surveys can be conducted using mail-in, telephone, or internet methods, or some combination of these. Such surveys can be expensive, especially if efforts are made to obtain a representative sample of the population.

For more information on surveys, see:

» NACTO Bike Share Intercept Survey Toolkit

» Design for Health Pedestrian and Bicycling Survey Approach

Data Management

Data collected manually and electronically must be managed to ensure communities can track changes and establish trends over time. Data management has the following components: collection and cleanup, internal sharing, and public sharing.

Collection and cleanup. Manually collected data must be entered from tally sheets or spreadsheets, which takes time. Data collected with dedicated count equipment can be exported at the end of a collection period or transmitted daily for continuous counts.

Internal sharing. Data must be checked for errors and omissions. Raw data should be shared with planners and engineers to perform initial quality control, including identifying omissions, corrections, and cleaning the data. Sharing data early in the process with count program partners will help verify data accuracy.

Public sharing. Consider placing final data on a dedicated project or program website or as part of the broader municipal website. Continuously collected count data may be shared publicly in real time using a "totem" style counter similar to the one installed on Broadway in Kendall Square, Cambridge.

For more information on data processing and common problems and resolutions, see:

» Chapter 4 of the FHWA Traffic Monitoring Guide

» NCHRP 797 Guidebook on Pedestrian and Bicycle Volume Data Collection

Economic Data

Investments in on-street bikeways, shared-use paths, and Complete Streets can stimulate local economies by providing greater access to jobs and services, increasing tourism, and improving livability (see Economy and Cost Reduction on page 7). These projects in cities throughout the U.S. have measurably benefited local economies. Collection of

before-and-after data will help the cities and towns of the Commonwealth better understand and communicate the benefits of investments and what types of investments are most effective at stimulating growth.

Data Collection Plan

As part of project scoping or planning, communities can develop a data collection plan to ensure that high-quality before-and-after data is collected in the most appropriate locations.

The **study area** should be the area in which the benefits of the project are most likely to be observed, for example the street along which the project is implemented or, more broadly, nearby neighborhoods or an entire business district.

The **analysis time frame** should span within two years prior to the start of construction to within one to three years after project completion. This allows communities to establish a good baseline of data to serve as the foundation of the analysis. Any short-term disruptions due to construction activity should be considered separately from long-term benefits or impacts.

Data collection strategies should be selected based on the types of economic impacts under investigation (e.g., business activity, sales of private property, shopping frequency, etc.). Analysts should select the same data collection strategy throughout the life of the analysis time frame to ensure compatible data are being compared.

Case Study: Hudson

The Town of Hudson is experiencing a renaissance. A decade ago nearly two-thirds of Main Street storefronts were empty. Today, these buildings are fully occupied with thriving local restaurants, cafes, shops, and a brewery, transforming Main Street into a vibrant center of economic activity. Residents and business owners attribute much of this success to the 2005 opening of the Assabet River Rail Trail, a 5.8-mile shared use path running from the south side of downtown Hudson to Marlborough. The trail has become a defining feature for the community and efforts are underway to more closely stitch the two together. The Town's 2014 Master Plan calls for a downtown wayfinding program, additional connectivity between the trail and planned bikeways, and improved connectivity to former mills to increase their economic development potential.









Data Collection Strategies

Several data collection strategies are available to measure commercial or personal economic impacts in a project area. Communities can pursue more than one strategy for the same project to paint a more robust picture of economic benefits or to compare initial expectations to post-implementation reality.

- **Field surveys** involve walking the corridor and tabulating the number and type of businesses, as well as vacancies, in the project area. A before-and-after comparison can indicate the number of active businesses. Qualitative observations can also be made of property conditions to see if owners have undertaken any improvements.
- **Business owner surveys** may be administered online or in person to collect qualitative data pre- and post-implementation. These surveys should ask about the merchant's expectations of the project's impact on business traffic and sales prior to the project, as well as their actual experience as observed after project completion.
- **Customer intercept surveys** can be conducted within the project area to identify factors such as how customers arrive at the business, how much money is spent by people arriving by different modes, frequency of visits, and perceptions of the attractiveness of the district before and after project implementation.
- **Property value analysis** seeks to observe changes in property values as a result of project implementation. Because properties change owners relatively infrequently, a large geographic area and/or a long analysis period is usually needed to collect sufficient observations to measure a specific project impact. However, a qualitative assessment can also be made by reviewing real estate listings for language highlighting proximity to bike facilities and anecdotal evidence from real estate agents on consumer response to project-related amenities.
- **Sales tax data analysis** compares sales tax revenues for businesses before and after the project implementation to measure changes in sales activity. Changes over time can also be compared with changes in nearby areas.

Where feasible, a robust study should also look at other factors that may have influenced changes in bicycling activity to increase confidence that observations are related to the bikeway project rather than simple correlation. For example, broader changes to the local or regional economy may influence trends along the project corridor, independent of the project. This relationship can be examined through the use of "control" areas. Economic growth can be compared in demographically similar parts of the community not directly influenced by the bicycle project using the same methods as applied to the project study area.

Explore More Resources

- Rails-to-Trails Conservancy D&H Rail-Trail 2016-2017: User Survey and Economic Impact Analysis: https://www.railstotrails.org/resource-library/resources/dh-rail-trail-2016-2017-user-survey-and-economic-impact-analysis/?author=Rails-to-Trails+Conservancy

References

1 Massachusetts Department of Transportation. 2010–2015 crash data retrieved from https://services.massdot.state.ma.us/crashportal/

2 Lopez, D. S, D. B Sunjaya, S. Chan, S. Dobbins, and R.A. Dicker. Using Trauma Center Data to Identify Missed Bicycle Injuries and Their Associated Costs. Journal of Trauma and Acute Care Surgery, Vol. 73, No. 6, 2012. pp. 1602-1606.

Maintaining Year-Round Bikeways



Narrow maintenance vehicles help maintain separated bike lanes and shared use paths in all seasons.

This chapter describes approaches to maintaining safe, comfortable, and accessible bikeways year-round through asset management, seasonal maintenance, and construction zone access.

Communities generally maintain on-street bikeways as part of routine street maintenance. However, separated bike lanes and shared use paths require dedicated maintenance activities and, in some cases, equipment.

Asset Management

65 percent of all MA Bike Plan survey respondents indicated that street maintenance was a barrier to everyday biking. This highlights the importance of bikeway asset management.

Pavement

Ongoing pavement preservation and maintenance are important to maintain a smooth surface for bicyclists and prolong the life of bikeway pavement. Smooth surfaces are critical for comfortable and safe bicycling, as bicycles are particularly vulnerable to potholes, cracks, and debris compared to motor vehicles.

Maintenance treatments include crack sealing and roadway patching. Preservation treatments include micro-surfacing, replacement of friction courses, or other single lift resurfacing. On-street bikeway maintenance is typically performed as part of routine road maintenance activities. However, the presence of a high-priority bike route may be a consideration in prioritizing street maintenance.

Preservation and maintenance of shared use paths and separated lanes require dedicated activity. While not subject to heavy vehicle wear and tear, shared use paths and separated bike lanes still experience drainage issues, erosion, root heave, freeze-thaw cycles, and other aging and weathering processes. As with routine roadway maintenance, communities should establish schedules for preserving and maintaining off-street bikeways as well.

Many municipalities, as well as MassDOT, use pavement management systems to track the condition of roadways. These systems minimize life-cycle costs by helping communities prioritize maintenance and repair activities. Pavement management systems can store data specifically related to bikeways, including shoulders, separated bike lanes, and shared use paths. Data collection may need to be modified to capture the condition of the shoulder or bikeway.

MassDOT collects data on state-owned roadways and all facilities on the National Highway System owned by others every one to two years. MassDOT does not collect data on facilities that do not meet these criteria.

In addition to a proactive inspection program, agencies should have multiple means for members of the public to report sidewalk, crosswalk, and other pedestrian issues. Examples include See-Click-Fix and BOS:311.

Pavement Markings

Pavement markings are installed using latex paint, epoxy paint, thermoplastic, polyurea, or pre-formed tape. They deteriorate depending on the amount of vehicle traffic, snow plowing operations, pavement surface quality, material durability, and environmental conditions. Pavement markings need to be replaced at the end of their useful life.

For more information on the relative costs, lifespans, and retroreflectivity of different materials, see NCHRP Synthesis 306: Long-Term Pavement Marking Practices.

Signs and Signals

Bicycle regulatory and wayfinding signs and signals may be damaged, vandalized, worn, or lose retroreflectivity through natural aging and require repair or replacement.

Bicycle signs, signals, and push buttons should be maintained on the same schedule as motor vehicle signs and traffic signals. Signs should also be replaced on an as needed basis, which varies based on sign type, age, poor retroreflectivity, and/or deterioration, or instances of accidental damage. Regulatory signage requirements should be reviewed to ensure that necessary signs are in place and comply with Section 9B of the MUTCD and recommendations established in MassDOT Engineering Directive E-15-001.

To mitigate vandalism, signs can be treated with an anti-graffiti coating that makes it easier to remove common forms of graffiti such as spray paint and marker pens.

Seasonal Maintenance

People in Massachusetts ride bicycles all throughout the year for both transportation and recreation. Maintenance plans and operations must be tailored to seasonal considerations in order to ensure safe and comfortable conditions on a year-round basis. Accommodating and encouraging year-round bicycling is an important strategy in providing viable transportation choices in the Commonwealth and achieving our energy and environmental goals.

Bikeway Maintenance Equipment

Most bikeways and shared use paths can be swept and cleared of snow with typical maintenance vehicles. Generally, separated bike lane widths of **8'** or more are compatible with typical vehicles. However, narrow vehicles with operating widths between **4'–5'** may be required for one-way separated bike lanes. Narrow vehicles can also be used for sidewalk maintenance. Municipalities should procure vehicles that can serve year-round maintenance duties through a system of seasonal attachments, for example brooms, plow blades, and loaders. Some municipalities use snow throwers on shared use paths and sidewalks; with snow throwers, snow can be stored further off the path than with snow plows.

Sweeping and Debris Removal

Bikeways can accumulate debris during all seasons. Leaves, gravel, glass, sticks, and other debris create hazards for bicyclists, contribute to slippery surfaces, and increase the stopping distance of people biking.

Regular sweeping of bikeways—both on- and off-street—reduces the risk of falls and injuries due to debris in the bikeway. To simplify their maintenance, on-street bikeways should be incorporated into established street sweeping programs. More frequent sweeping is usually needed in the spring to remove accumulated winter debris and in the fall or after major storms to remove deposited organic matter.

Off-street bikeways such as shared use paths and separated bike lanes may require different sweeping schedules and additional debris removal. Many municipalities sweep off-street bikeways at a reduced frequency, for example at least once or twice per year, because they are not exposed to street debris. However, landscaped areas and separated bike lane street buffers can collect debris that should be routinely collected.

Bikeways constructed with permeable pavement should be vacuumed on a routine basis, as fine debris can settle into the surface and inhibit desired infiltration. Permeable pavement may need additional attention along areas where runoff routinely

carries sediment, and during winter months because of sand and salt accumulation.

Vegetation Management

Vegetation management includes the maintenance of grass, trees, tree roots, shrubs, bushes, and other organic material. Vegetation can encroach on the path of travel, reduce vertical clearance, limit visibility, or degrade the pavement surface.

Common vegetation management includes:

- Mowing along pathway edges to maintain visibility and keep a clear zone free of trees and shrubs.
- Trimming vegetation overhanging into the bicycle facility. Vegetation should be pruned to within **12"** from the outside of the bike lane and **100"** from above.
- Removing discarded vegetation building up on bikeways, including leaves and branches.
- Controlling erosion by revegetation and planting where necessary.
- Removing vegetation that is causing root heave.

Planning and Prioritizing Winter Maintenance

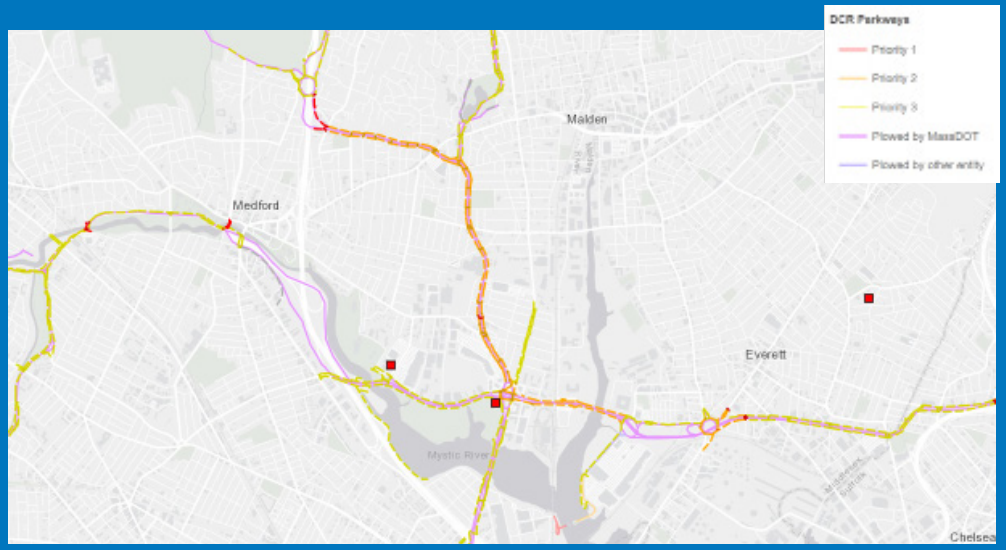
Municipalities that install bikeways should assume that people will use them during the winter and plan maintenance operations accordingly. **58 percent** of all MA Bike Plan survey respondents indicated that inconsistent snow and ice clearance was a barrier to everyday biking.

Snow and ice clearance for on-street bikeways is typically part of routine roadway clearance operations. However, different resources are needed for maintaining separated bike lanes and shared use paths, facilities that are often heavily favored by bicyclists but neglected for winter maintenance. Care is needed across all plowing operations to ensure that snow removed from one part of the road does not block access for other road or sidewalk users.

Municipalities can identify a winter bikeway network that receives plowing and snow removal priority shortly after a snowfall. The winter bikeway network ensures that critical route continuity is maintained following snow events and directs limited maintenance budgets to high-priority bikeways or areas with higher need. This prioritized approach is similar to the practice used by municipalities with a snow removal plan for sidewalks. A winter bikeway network should be identified with a planning process and monitored with performance targets to ensure bikeways are cleared quickly after a snow event.

Case Study: Prioritizing Winter Maintenance

The Massachusetts Department of Conservation & Recreation (DCR) follows a comprehensive storm management plan for the snow and ice season. The plan designates facilities according to three levels of snow removal priority. Level 1 (during storm event) and Level 2 (within 12 hours) include pathways accessing schools, foot bridges, and transit facilities, and other heavily traveled paths. Greater detail, including a map viewer, is available at https://www.mass.gov/service-details/dcr-winter-storm-plan-and-priority-map.



A close-up of DCR's winter priority map in Malden, Everett, Somerville, and Medford

Pre- and Post-Winter Storm Treatments

Treating bikeways with salt, salt brine, or sand can help reduce icy and slippery conditions. Where possible, environmentally friendly anti-icing and de-icing strategies should be deployed. Anti-icing materials should be applied prior to snow fall and de-icers applied again while clearing snow to help prevent ice formation. Excessive salt and large particles can cause slipping hazards for bicyclists.

Slippery conditions do not occur only after precipitation has fallen. Meltwater from snowbanks can spread across paths and lanes and refreeze, creating spots of black ice. Even a small patch of black ice can lead to a serious injury for a person biking. Black ice formation can be reduced by removing snow from buffer areas and by maintaining proper drainage.

Snow Clearance and Removal

Streets should be plowed to the fullest extent practical, including general travel lanes, bike lanes, parking lanes, and shoulders used for biking. Even if the bike lane is clear, failing to clear the parking lane often results in parked cars occupying and effectively eliminating the bike lane. In constrained situations, it may be necessary to move snow to an off-site location after large snow events.

Snow removal should occur in separated bike lanes in a similar manner as the adjacent roadway. Separated bike lanes are advantageous during winter because their sidewalk and street buffers may be used for snow storage. The width of the separated bike lane can be constrained during a snow event provided that a minimum **4'** clearance per direction is maintained (i.e., **8'** minimum for two-way separated bike lanes). Snow from the separated bike lane should not be placed in the clear width of the sidewalk or vice versa.

Shared use paths often form the backbone of connected bike networks so it is important to provide year-round usability. More jurisdictions are choosing to plow shared use paths in winter given how important they are for everyday travel. Plowing ensures that the paths remain accessible to both pedestrians and bicyclists. Unplowed paths quickly become trampled with hard-pack snow and ice that can take days or weeks to fully melt.

Access During Construction

Construction zones, whether for utility work, roadway reconstruction, or development of adjacent parcels, can create particular hazards for bicyclists because they may create width constraints, surface irregularities, surface debris, detours, or transitions between bicycle accommodations. These conditions may be in place for long periods of time or may abruptly change. Additionally, increased truck traffic and unfamiliar patterns of motor vehicle operation are of particular concern for bicyclists where operating space must be shared.

When a road work project or closure is planned, designers should provide the same level of consideration for bicyclists as for motorists. Bikeway closures should have advance notification, signage, and detours. Permits for work impacting bicycle facilities should include provisions for specific bikeway accommodations such as detours or traffic control.



Bicyclists are sensitive to detours. Where feasible, provide a bike route through construction zones, even if access is restricted for motor vehicles, as shown.

A Temporary Traffic Control Plan (TTCP) can provide detailed guidance to proactively address bicyclists' safety and operational needs in accordance with the Work Zone Management discussion in the MassDOT Project Development and Design Guide. **MassDOT Standard Details and Drawings for the Development of Temporary Traffic Control Plans** provide examples of work zone bicycle accommodations. Accommodations should strive to meet the following objectives:

- Avoid requiring bicyclists to dismount.
- Avoid placing signs or equipment in the bikeway.
- Provide smooth vertical and horizontal transitions that can be traversed safely by bicyclists.
- Maintain separation of bicyclists from pedestrians and motor vehicles where possible. Where not feasible, clearly delineate a preferred route through the construction zone. Where detours are necessary, limit out-of-direction travel for bicyclists.
- Minimize redirection of bicyclists to the opposite side of the roadway.
- Consider snow removal for bike routes through construction zones.

Explore More Resources

- Indiana LTAP Ohio and Ohio River Greenway Development Commission Best Practices in Trail Maintenance: **https://docs.lib.purdue.edu/inltappubs/8/**
- MassDOT Separated Bike Lane Planning & Design Guide: **https://www.mass.gov/lists/separated-bike-lane-planning-design-guide**
- Minneapolis Pedestrian and Bicycle Winter Maintenance Study: **https://lims.minneapolismn.gov/Download/File/1110/Winter%20Maintenance%20Study_Final.pdf**
- National Cooperative Highway Research Program Synthesis 306, Long-Term Pavement Marking Practices: **http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_306_1-14.pdf**