Denver Regional
Council of Governments

Bicycle+ Program Guide

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active transportation plan
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DENVER REGIONAL COUNCIL OF GOVERNMENTS

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Introduction

Over the past two decades, the Denver region has positioned itself as a national leader in promoting bicycling and micromobility for transportation. Since 2019, the adoption of DRCOG's previous Active Transportation Plan, the region's total bicycle facility mileage has grown nearly 700 miles—a 27 percent expansion of the region's dedicated bicycle network. During that same period, local jurisdictions have made policies and regulations to expand access to bike share and scooter share programs, resulting in one of the most productive shared micromobility markets in North America. Transportation partners throughout the region have stood up programs to expand access to e-bikes. Local partners including transportation management associations, community-based organizations, and bike shops have opened bike libraries and implemented commuter encouragement programs. Together, these actions are expanding access to active transportation for all people living and working in the region.

This guide, Building a Better Bicycle+ Program, provides a framework for local agencies and their partners across the Denver region to expand high-quality bicycle and micromobility infrastructure, and overcome the emerging challenges of rapid growth in active transportation.

This guide is not just a synthesis of national best practices—it is rooted in the lived experiences and on-the-ground realities of communities across the Denver region. To ensure the guide is practical, relevant and responsive to local needs, DRCOG staff undertook a two-pronged outreach approach in late 2024 and early 2025:

- **Micromobility Survey of Member Jurisdictions**: DRCOG surveyed nine member jurisdictions to better understand how communities are adapting their infrastructure, maintenance operations and regulatory frameworks to support emerging micromobility needs. The survey collected detailed information on infrastructure design practices, operational challenges, maintenance practices and the integration of electric and shared mobility devices.
- **Active Transportation Advisory Group (ATAG) Meeting**: DRCOG convened the ATAG in January 2025 to discuss the themes emerging from the survey. Representatives from member jurisdictions provided feedback on shared challenges—including regulatory enforcement, interjurisdictional coordination and equitable infrastructure design—and outlined critical support needs for future planning.

These insights shaped both the structure and content of this guide. In particular, the report highlighted:

- A strong desire for **regional consistency** in bikeway design, micromobility regulations and wayfinding across jurisdictions.
- The need to manage **growing speed differentials** between users, particularly as faster and heavier devices like e-bikes and delivery trikes become more prevalent.
- The need for **practical maintenance guidance**, especially in winter conditions, given limited resources and equipment.
- Widespread challenges with **conflict management at intersections** and **infrastructure retrofits** on constrained corridors, such as arterials.

Where applicable, these themes are reflected throughout the guide in the design considerations, facility recommendations and implementation strategies.

What is 'Bicycle+'?

For the purpose of this guide, "Bicycle+" refers to small, lightweight, low-speed human- and electric-powered vehicles, typically operating between 8 and 28 miles per hour and legally permitted to use bicycle transportation facilities including shared-use paths, on-street bicycle lanes, separated bicycle lanes, and in mixed traffic.

In this guide, "Bicycle+" or "micromobility" excludes wheelchairs (manually-powered or motorized), which operate more commonly akin to pedestrian than bicyclists. This does not preclude wheelchair users from using bicycle facilities (and many wheelchair users may prefer to operate in bikeways), but does acknowledge operational differences between bicyclists, scooter riders, and people using wheelchairs.

Bicycle+ vehicles may be privately owned personal vehicles, or may be part of a "shared micromobility" fleet available to the public for short-term rental.

"Bicycle+" may be used interchangeably with "micromobility," and may include the following vehicle types:

Bicycles

- Traditional (pedal) bicycles.
- Electric-assist bicycles, or e-bikes (Class I, II or III).
- Adaptive cycles, including recumbent bicycles, hand-cycles and tricycles.
- Cargo bicycles and tricycles.

Scooters

- Kick scooters.
- Standing electric scooters, or e-scooters.
- Seated e-scooters.

Other

- Motorized and non-motorized skateboards and longboards.
- Electric unicycles, or one-wheels.
- Hoverboards.
- Segways.

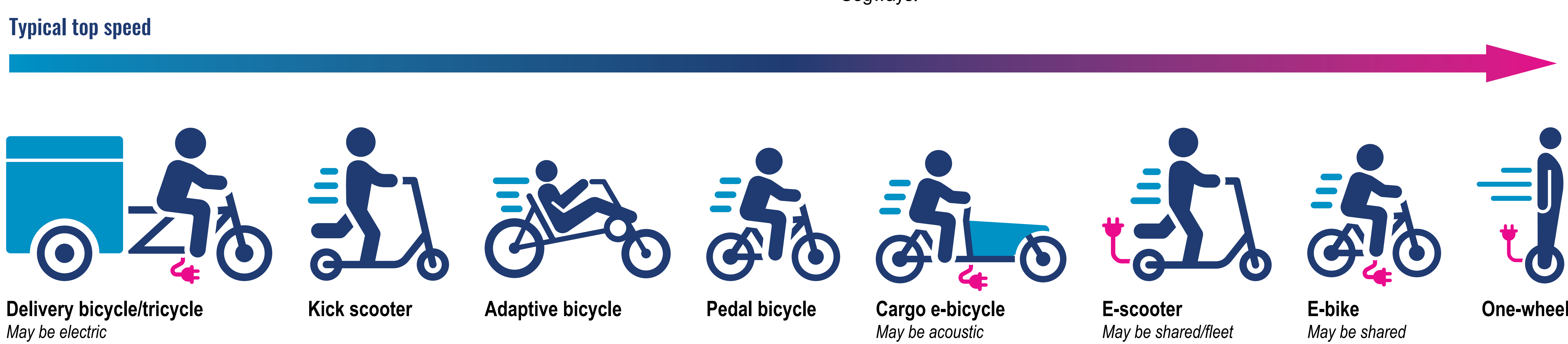


Figure 1 Types of "Bicycle+" vehicles and common operational characteristics

Using the Bicycle+ Program Guide

This resource is a supplement to DRCOG's 2025 Active Transportation Plan, providing guidance to local jurisdictions and partners in the Denver region for building and enhancing infrastructure and programs to support active transportation. As lightweight, low-speed vehicles like e-bikes, scooters and cargo bikes become more prevalent—both as shared vehicles and privately owned devices—the information in this guide can help local jurisdictions respond with infrastructure and programs that promote safety, comfort and access for all users.

This document builds on the vision and themes established in the Active Transportation Plan and reflects the region's growing emphasis on connected, multimodal networks that serve people of all ages, abilities and capabilities. By fostering a shared understanding of high-quality infrastructure, this guide strengthens regional collaboration and can be used as a roadmap for jurisdictions seeking to expand local support for bicycling and micromobility, and seek funding or resources to build their local bicycle+ networks.

The guide is organized into seven chapters:

Chapter 1: Emerging Mobility Trends explores the rapid growth and diversification of bicycle+ options—particularly the rise of privately-owned e-bikes and scooters—and their increasing role in personal and commute travel. This chapter sets the context for why infrastructure must adapt to meet evolving needs and behaviors, with regional and national data on mobility trends.

Chapter 2: How This Fits with National and Local Guidance summarizes the existing landscape of design guidance from federal, state, and regional sources, including the Manual on Uniform Traffic Control Devices (MUTCD), as well as guidance from the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO) and the National Association of City Transportation Officials (NACTO). It explains how this guide complements and localizes these resources.

Chapter 3: Design Controls for Emerging Modes introduces key physical and operational characteristics of emerging Bicycle+ vehicles. The chapter defines user profiles, speed differentials, and spatial needs that influence the selection and design of safe, comfortable facilities across a range of settings.

Chapter 4: Context-Sensitive Bikeway Design Considerations provides a structured framework for selecting appropriate bikeway types based on roadway classification, land use, and stress tolerance. It introduces street typologies, an All Ages and Abilities selection matrix, and a bicycle+ street design matrix tailored to the Denver region.

Chapter 5: A Focus on Regional Connector Streets addresses the challenges and opportunities of designing bikeways along Regional Connector Streets (arterials) that are often essential for regional access but difficult to retrofit. The chapter includes tailored strategies for rural, suburban, and urban contexts, along with treatments for intersection transitions and connectivity gaps.

Chapter 6: Design Strategies for shared-use path comfort, safety and usability focuses on shared-use paths, offering design guidance to enhance comfort and minimize conflict among users. Topics include signage, transitions, user separation, and the application of the Federal Highway Administration's (FHWA) Shared-Use Path Level of Service (SUPLOS) framework to evaluate shared-use path performance and support future investments.

Chapter 7: Bicycle Facility Maintenance outlines best practices for maintaining bicycle+ facilities throughout the year. The chapter details routine maintenance tasks, snow and debris removal strategies, equipment considerations, and coordination between agencies to ensure consistent safety and functionality over time.

Together, these chapters form a comprehensive, regionally tailored resource to support high-quality, multimodal infrastructure that works for both present and future, travel needs.

1

Emerging mobility trends

Over the past 15 years, the emergence of new types of small human-powered vehicles has reshaped how people travel, offering flexible and customizable access to Bicycle+ modes such as e-bikes, scooters, cargo bikes, one-wheels and adaptive cycles.

Shared micromobility also helped to lay the groundwork for a broader mobility shift. As people became familiar with riding e-bikes and scooters through public systems, many opted to purchase their own. This consumer adoption has led to a significant increase in both privately owned and fleet-operated bicycle+ devices on streets, shared-use paths and sidewalks across the country. What began as a shared economy experiment has evolved into a mainstream mode of personal travel.

This guide examines how jurisdictions can plan for and respond to the growing presence of bicycle+ devices. While shared micromobility continues to influence urban and suburban mobility, the growing number of users presents new challenges and opportunities for local infrastructure, policy and safety planning.

This chapter provides context for that evolution. It outlines trends in both personal and shared micromobility usage and activities, as well as the policies and programs that have helped accelerate the transformation of regional mobility. Understanding this trajectory is essential for designing infrastructure that safely and effectively support a reality where bicycles and micromobility are a regular part of everyday travel.

Privately-owned bicycle+ vehicles

In addition to a **pandemic-era boom in traditional pedal bicycle sales** across North America, **sales of both e-scooters and e-bikes** have increased significantly in recent years. E-scooters have the advantage of being lightweight, compact and relatively affordable, effectively serving efficient short trips and linked intermodal transfers. E-bikes, which offer greater speed and range, have experienced explosive growth. In 2022, the U.S. Department of Energy estimated that over **1.1 million e-bikes were sold**—four times more than in 2019. The rapid growth in bicycle+ sales may indicate a fundamental change in how people get around, while also surfacing new challenges and opportunities for managing change, promoting safety and planning for a more active and efficient future.

Supporting adoption through subsidies

To accelerate the adoption of micromobility as a viable mode of transportation, governments at all levels have introduced financial incentives—especially for e-bikes. There have been a variety of different incentive models including subsidies in the form of point-of-sale vouchers, tax credits and rebate programs. **Research shows these programs are effective in encouraging adoption**, replacing car trips and helping new riders become regular bicyclists. Another **study** found that rebate programs can encourage people to become regular bicyclists. Lastly, **multiple studies** found that e-bikes typically replace traditional bike usage, particularly among **middle-aged, full-time working individuals**.

Colorado has had several incentive programs over the past few years to encourage e-bike adoption. The City and County of Denver launched an **e-bike rebate program** in 2022 where residents could receive a $400 instant rebate on an e-bike. Income-qualified residents could receive a $1,200 instant rebate. The city estimates that nearly **8,000 e-bikes have been purchased through the program** since it first launched. The State of Colorado administered its own e-bike rebate program between 2023 and 2025, resulting in over 5,600 new e-bike purchases. The cities of **Boulder**, **Longmont** and **Lafayette** are among other local agencies that have offered e-bike incentive programs.

Expansion onto shared-use paths

As e-bike popularity continues to surge, their usage is expanding beyond urban areas. More riders are taking e-bikes out on shared-use paths, introducing conflicts among path users. The speed differential between e-bikes and pedestrians is a key safety concern. Agencies have implemented regulations to address the issue.

In the Denver region, local agencies are developing and implementing their own path and trail access policies to reflect regional needs and bikeway contexts. For instance:

- The **City of Arvada** permits Class I and II e-bikes on City trails so long as they obey the 15 mile per hour speed limit. Class III e-bikes are prohibited on city trails and paths.
- **Boulder County** permits class I and II e-bikes on most regional shared-use paths, including the LoBo Trail and parts of the Boulder Creek Path, but restricts them from soft-surface trails in the foothills and mountain parks to minimize conflicts with hikers and equestrians.
- The **Town of Castle Rock** does not have a specific ordinance, but permits via State law that e-bikes that reach 20 miles per hour or less (Class I or II) are permitted to operate on bicycle, pedestrian or multi-use paths.
- **Denver Parks and Recreation** allows Class I and II e-bikes on all paved trails and shared-use paths under a 15 mph speed limit, with signage encouraging safe and courteous riding.
- **Jefferson County Open Space** allows Class I and II e-bikes on paved shared-use paths; Class II e-bikes are prohibited on natural surface trails unless otherwise posted.
- Finally, Class I e-bikes are classified by the State of Colorado as traditional bicycles and are allowed in Colorado State Parks wherever bicycles are permitted. While these are typically not used as functional transportation facilities, riders may still want to connect to state park paths.

Commercial use of cargo e-bikes

Delivery companies have begun introducing cargo e-bikes to their fleets to meet carbon emission goals and make deliveries more efficient in dense urban areas. Over the past few years, **FedEx, Amazon and UPS** have rolled out their own cargo e-bikes in New York City and the **Department of Transportation** has responded by implementing regulations specific to these vehicles to make deliveries safer. Cargo e-bikes are allowed to use bike lines but are limited to 15 miles per hour, may be no more than 48 inches wide and have up to four wheels. They also established a “Commercial Bicycle Loading Only” zone.

There have also been efforts to boost cargo e-bike usage for local deliveries in Denver. In 2022, the Denver Streets Partnership received a grant from the City and County of Denver’s Climate Action, Sustainability & Resiliency Office to provide e-bikes to small businesses for deliveries.

Shared Micromobility in the Denver Region

The Denver region has been the epicenter for modern shared micromobility in North America. The continent's first modern bike share programs began in 2008 and were station-based or docked systems. The concept took off in Denver during the 2008 Democratic National Convention (DNC), when organizers launched the "Freewheelin" pilot, 1,000 bikes were made available to convention-goers and the public. This initiative laid the foundation for Denver B-cycle, which officially became the first large-scale, smart bike-share system in the U.S. in April 2010. While Denver BCycle has since been retired, the region has expanded access to shared micromobility each year, with active systems in five jurisdictions and an average of more than 8,000 active shared micromobility vehicles on streets each day.

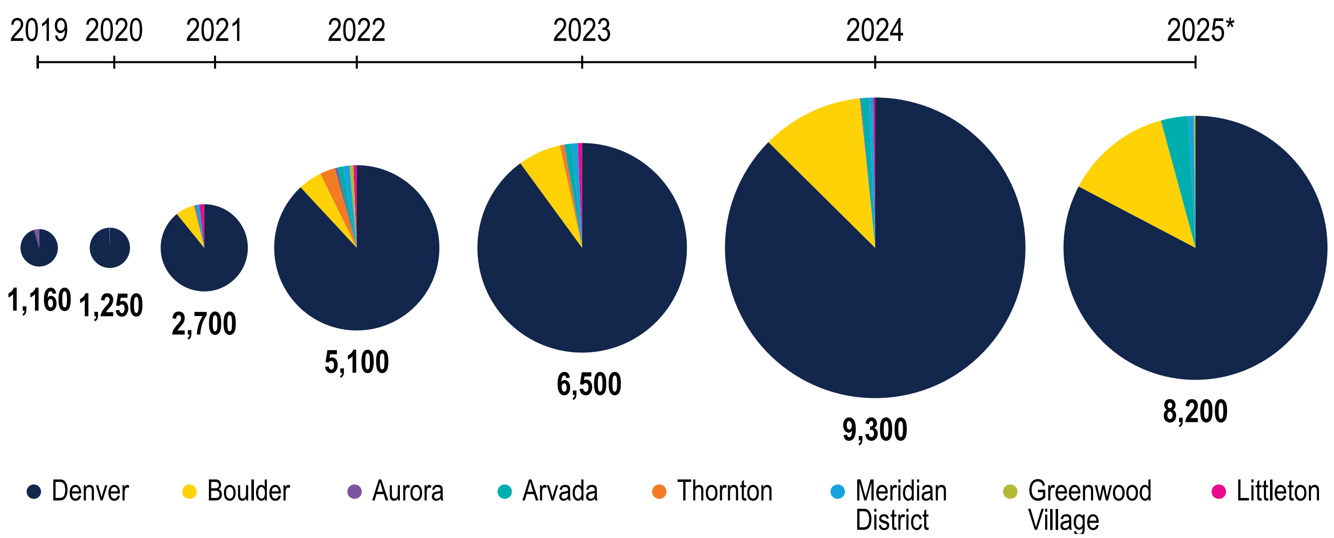
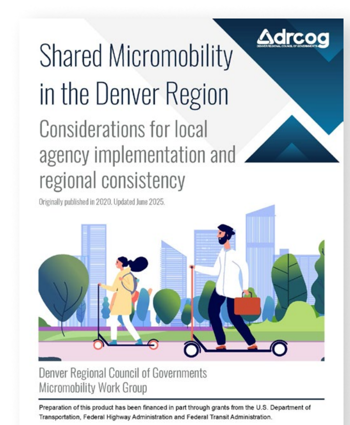


Figure 2 Average daily active vehicles, Denver region, 2019 - 2025 (partial year)

Today, the City of Boulder's BCycle program is the only docked program in the region. All other programs provide either dockless e-bike and e-scooters or both. For all existing programs and pilots, the systems are privately operated and local jurisdictions manage regulating the programs.

First published in 2020 and most recently updated in 2025, DRCOG's **Shared Micromobility in the Denver Region** is a comprehensive report detailing the state of usage, local programs, regulation, administration and operations of shared micromobility systems on the Front Range. While this section summarizes key details informing this guide, readers are encouraged to explore the full report to understand the state of shared micromobility in the region.



Trending electric, and mostly e-scooters

The shared micromobility ecosystem in the Denver region has evolved rapidly each year as new technologies, operators and regulatory approaches have emerged and responded to shifting needs and preferences. From an initial deploy-and-react period in 2017 and 2018 to an increasingly mature set of permits and operating agreements between local governments and private operators today, the industry is constantly transforming.

As of 2025, four operators administer a mix of e-bikes, e-scooters and seated scooters across the five active service areas (Denver, Boulder, Arvada, Greenwood Village and the Meridian Metropolitan District). All but one system is dockless, and throughout 2025 roughly 75% of active vehicles were e-scooters (compared to 20% e-bikes and 5% seated scooters). There are only a few traditional bicycles active in the region through bike libraries.

User mode choice has generally followed vehicle availability—while in 2019 and 2020 nearly all shared micromobility trips were made by e-scooter, the share of trips by e-bike has grown steadily, currently making up 19% of regionwide trips. E-scooters have constituted 75% of trips in 2025, while the newly deployed seated scooters comprise 5% of trips.

Shared Micromobility in the Denver Region details the status of current operations and vehicles, as well as a number of pending studies and pilot efforts to evaluate potential station-based systems and integration with mobility hubs and microtransit.

Ridership continues to grow

Since 2019, over 33 million trips have been taken by shared micromobility across the Denver region. Of those, roughly 27 million trips have been taken by e-scooter (86%) and 4 million by e-bike (13%), with the remainder by traditional bicycle or seated scooter.

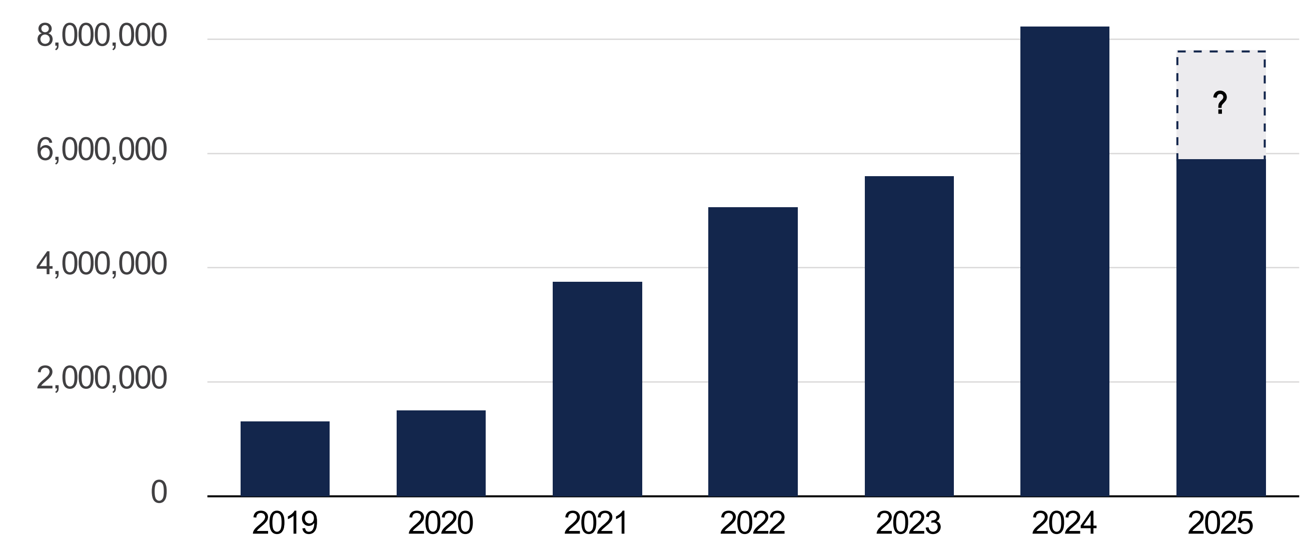


Figure 3 Annual shared micromobility trips, January 2019 - September 2025, Denver region

Year over year, shared micromobility trips have increased as operators have deployed more vehicles, with regionwide productivity between three and four trips per vehicle per day. The Denver area remains once of the **most productive regions nationally** for shared micromobility usage, leading the U.S. for e-scooter system productivity and coming in third for e-bike utilization.

Jurisdiction boundaries matter

Shared micromobility operations are managed at the local level, with each jurisdiction permitting operators to serve defined boundaries (either city/town-wide or within a specified district). While DRCOG works closely with local governments to advance coordination, users may still not be aware of system boundaries prior to using a shared micromobility vehicle. Figure 4 features the current active (dark magenta) and jurisdiction with either lapsed or planned shared micromobility programs (light pink):

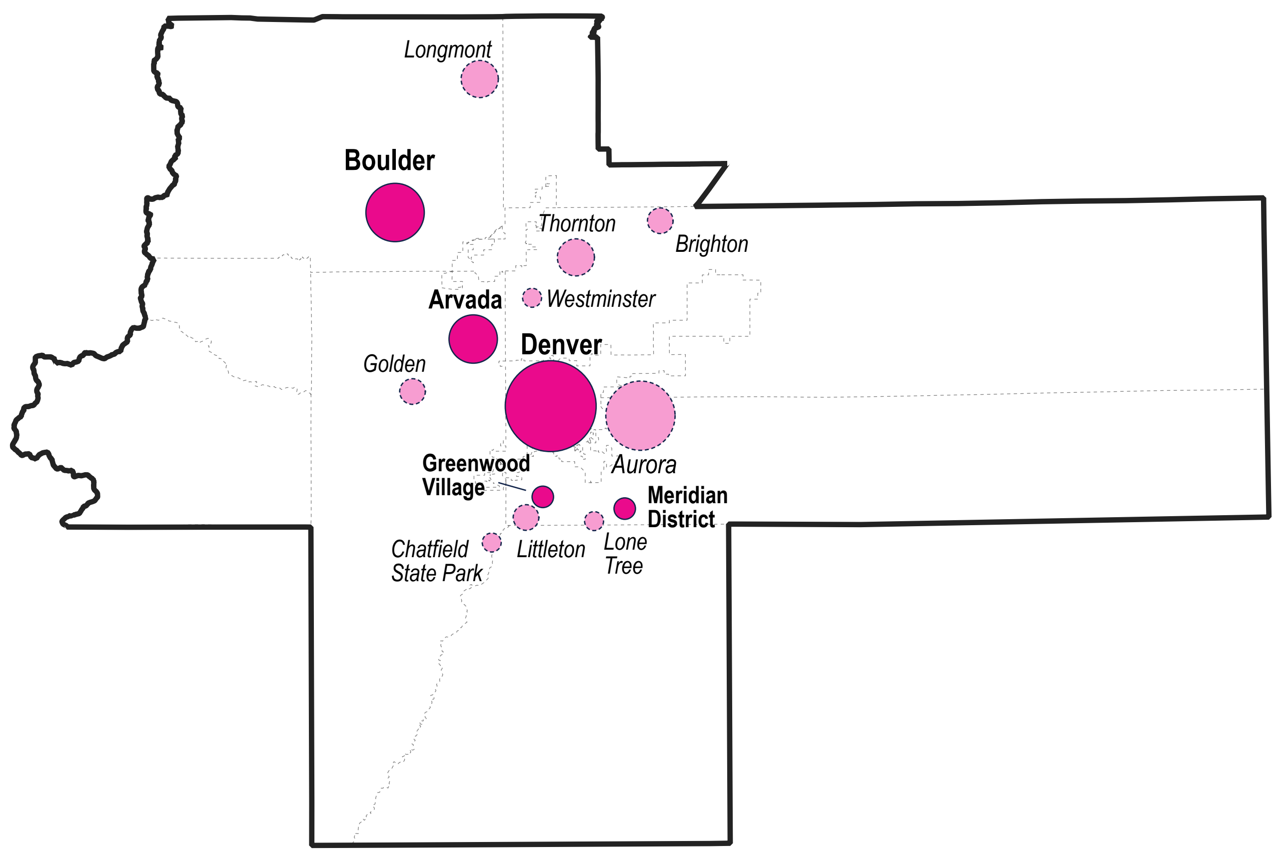


Figure 4 DRCOG planning boundary with past, present and future shared micromobility systems

While most users may already be operating within a single jurisdiction regardless, integration across jurisdictional lines may be a challenge for others. Dockless systems in the region are geofenced to preclude users from riding or parking in locations where they are unpermitted.

Unlocking short trips

Riders tend to use shared micromobility to complete very short trips—across the region in 2024, 51% of shared micromobility trips were one mile or less, and 81% of trips were under two miles long. 59% of all trips were 10 minutes of shorter.

A **national scan of user surveys** from the North American Bike Share Association (NABSA) suggests that riders primarily use shared micromobility to shift short trips from other modes, rather than taking new trips they would not have otherwise made. 35% of shared micromobility trips substituted for walking, while 25% replaced motor vehicle trips. A further 10% of shared micromobility replaced hailed rides (taxi or app-based ride-hail companies).

Surveys within the Denver region have found similar results: within Denver, 51% of shared micromobility users reported that their trips replaced driving or ride-hail, while 34% of riders in Arvada replaced driving or shared vehicles with shared micromobility. 47% of those surveyed in Boulder replaced driving or hailed rides.

Managing the right-of-way remains a challenge

Finally, a prominent and frequently cited challenge for local communities and operators alike is the management of micromobility vehicles in the right-of-way, especially ensuring that e-bikes and e-scooters are operating where permitted, at safe and comfortable speeds, and that they are parked in locations that do not impede access or create clutter.

Local governments have responded to these challenges and concerns primarily through permitting and regulatory requirement as well as infrastructure adjustments. For instance, some have used paint, markings and delineators to create on-street parking corrals for shared e-bikes and e-scooters. In some cases, they have even partnered with operators to install formal parking racks or add murals and artwork to beautify the streetscape. Signage indicating permitted and encouraged parking areas can support more orderly storage of shared vehicles.

Equally as important is expansion of high-comfort bicycle+ networks, including separated bicycle lanes and neighborhood bikeways where shared micromobility users can comfortably operate. Because of the speed differential, e-bikes and e-scooters are typically prohibited from riding on sidewalks, so safe on-street bikeways encourage safer riding and reduce conflicts.

Finally local jurisdictions use constituent complaints or reports to direct operators to collect improperly parked or damaged vehicles.

Private operators generally rely on technology tools and operations staff to manage right-of-way issues, using geofencing, computer vision, and compulsory parking photos to alert riders when they are riding or parking improperly and encourage safe behaviors. Geofencing can be used to enforce "slow zones," prohibted riding and parking zones and sidewalk riding.

Licensing agreements also require private operators to manage and rebalance their fleets, ensuring that staff are responding to complaints in a timely manner and maintaining sufficient vehicle coverage in priority districts.

2

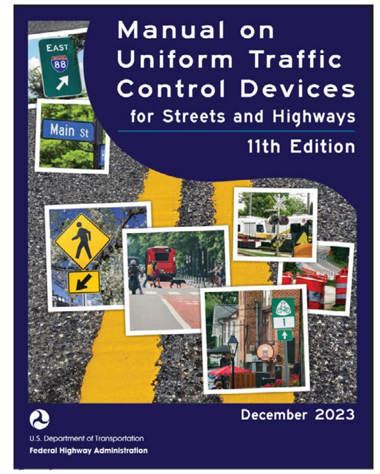
How this fits with national and local guidance

Designing for today's transportation realities requires a thoughtful integration of national best practices, evolving federal guidance and region-specific priorities.

This chapter provides a curated summary of design standards and policy references that inform the Denver Regional Council of Governments (DRCOG) approach to bicycle+ infrastructure. While many existing guidelines have historically focused on traditional bicycle facilities, this guide expands their application to better reflect the growing presence of diverse and electrified bicycle+ devices.

National design guidance

Manual on Uniform Traffic Control Devices for Streets and Highways, 11th Edition, FHWA (2023)

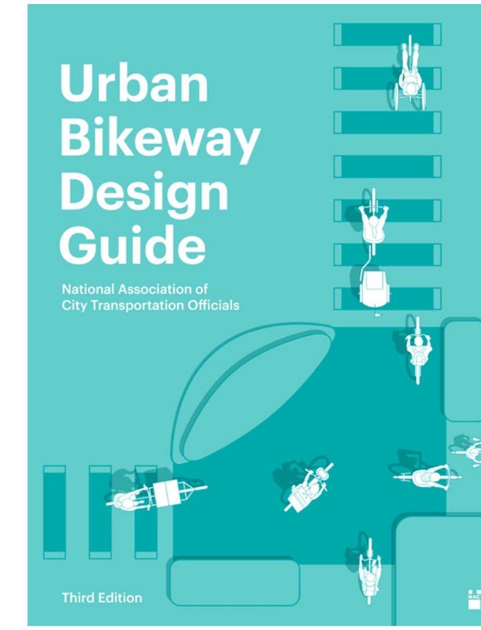


The Manual on Uniform Traffic Control Devices (MUTCD) is a publication of the Federal Highway Administration that outlines the standards by which roadway infrastructure such as traffic signs, road surface markings and signals are to be designed, installed and used. **Part 9** of the manual describes bicycle facilities and includes designs and considerations for signs, pavement markings and other traffic control devices related to bicycle operations.

Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way Guidelines (PROWAG)

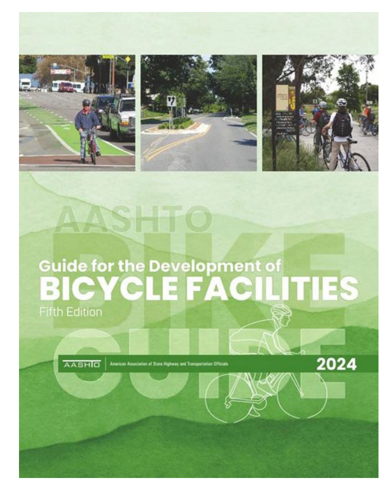
These **federal guidelines** from the Architectural and Transportation Barriers Compliance Board establish minimum standards for pedestrian facilities located in the public right-of-way to ensure that facilities used by pedestrians are readily accessible to and usable by pedestrians with disabilities. PROWAG is discussed in detail in the accompanying Sidewalk Delivery Guide, as much of its content is directly concerned with pedestrian facilities. However, especially where bicycle+ vehicles interact with pedestrians (such as intersections, sidepaths and shared-use paths, transit stops and boarding islands), PROWAG provides detailed standards and guidance for accessible facilities. Practitioners in the Denver region are strongly encouraged to consult PROWAG on all street projects to ensure compliance with federal accessibility requirements, and to provide safe and inclusive infrastructure for all active users.

Urban Bikeway Design Guide, NACTO (2025)



The National Association of City Transportation Officials publishes the **Urban Bikeway Design Guide** to establish guidance that city officials can use for designing streets with all ages and abilities bicycle facilities. Practitioners across the region are encouraged to consult NACTO guidance for peer-driven best practices in bikeway design, while keeping in mind that many of the examples and case studies are urban-focused.

Guide for the Development of Bicycle Facilities, AASHTO (2024)



The American Association of State Highway and Transportation Officials published this guide in 2024 to describe the physical infrastructure that supports bicycling and provide suggested minimum facility dimensions. The AASHTO Bike Guide covers a comprehensive range of facilities and contexts, from paths and trails to on-street separated and mixed-traffic bikeways. The guide encourages practitioners to use engineering judgment, be sensitive to the local context and consult with local bicycle coordinators and other publications.

FHWA Bikeway Selection Guide (2019)

The FHWA Bikeway Selection Guide serves as a guide for trade-offs and factors that influence selecting different types of biking facilities. The FHWA **Bikeway Selection Guide** serves as a guide for trade-offs and factors that influence selecting bicycle facility types based on roadway context. Figure 5 provides guidance for selecting the appropriate bikeway type in urban, suburban, and rural town center contexts where the target user is an "Interested but Concerned" type of cyclist. Figure 6 provides paved shoulder width guidance for rural roadways where the design user is a recreational cyclist who is typically more experienced and comfortable riding adjacent to vehicle traffic. Practitioners in the Denver region should consult this guidance when developing transportation projects where bicycle facilities are appropriate, especially on streets and roads that are part of the regional active transportation network.

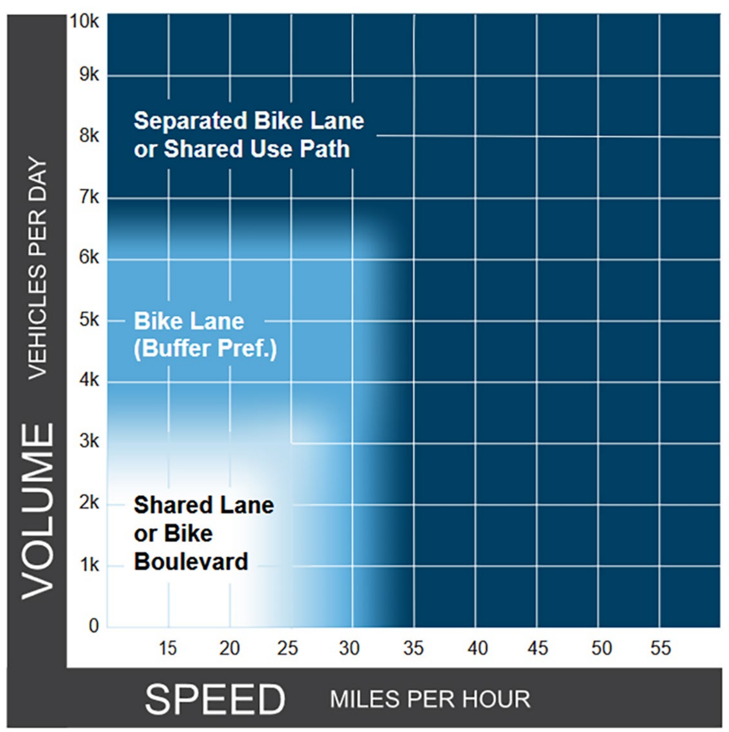


Figure 5 Facility selection guidance for urban core and suburban streets, FHWA 2019.

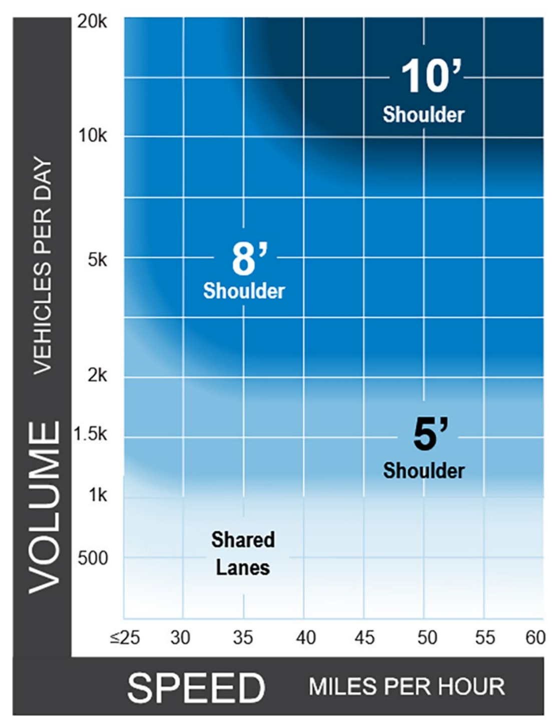


Figure 6 Preferred shoulder widths for rural roadways, FHWA 2019.

Shared Micromobility in the Denver Region, DRCOG (2025)

Denver Regional Council of Governments published a **document** in 2020 (and updated in 2025) that outlines what shared micromobility is and how local agencies can collaborate across the region while they are implementing shared micromobility systems. Local jurisdictions can use this document to understand best practices and get a step-by-step understanding of how a shared micromobility system may unfold.

Guidelines for Regulating Shared Micromobility, NACTO (2019)

NACTO's **guidelines for regulating shared micromobility** outline best practices for cities and public entities to regulate their micromobility fleets, especially for formal management of public-use mobility options that are not managed through procurement processes.

3

Design controls for emerging models

Bicycle+ devices are increasingly common on the region's streets. Micromobility devices come in various shapes, sizes and functionalities, ranging from traditional bicycles to pedal-assist e-bikes and throttle-powered scooters. These “small things with wheels” move at a wide range of speeds, handle turns and surfaces differently and attract people with varying degrees of skill and expertise.

Emerging vehicles and evolving riders

As new micromobility vehicles have entered and expanded the marketplace, the kinds of riders cycling and rolling in the region has expanded too. For instance, in the first year of the **City and County of Denver's e-bike rebate program**, 29% of those surveyed after using the rebate to purchase and e-bike were new bike riders. Where a traditional pedal bicycle may have primarily served the "Enthused and Confident" type of bicyclist, shared e-bikes and e-scooters can help occassional riders shift short trips efficiently. E-scooters, seated scooters, and e-bikes can be powerful mobility aids to people with mobility impairments, or even to folks who just want to avoid that big hill on the way home. Cargo bicycles and e-bikes can unlock bicycling for families and people running errands. And large cargo bicycles or tricycles can even create new opportunities for freight and delivery, especially in downtowns and urban centers where large delivery vehicles face congestion and parking or loading problems throughout the day. The growing universe of bicycle+ vehicles is breaking down barriers, serving more riders in more places for more trips.

Understanding the characteristics of these vehicles and their use cases is critical for planners and designers as they create safe, connected and inclusive networks that accommodate people of all ages and abilities. The combination of more varied and faster speeds, a wider variety of device sizes and more riders overall requires adapting street and bikeway design. The broader range of speeds created by the increase in electric and electric-assist devices means that planners and engineers are reconsidering design criteria for bikeway widths to accommodate comfortable riding and passing. Rapid growth in cargo bikes and tricycles for deliveries and family transportation means that many devices in a bikeway are wider, longer and have larger turning radii than typical bikes. E-scooters have smaller wheels than bicycles and handle surfaces, bumps, grates and gradients differently than devices with larger tires. To safely accommodate and encourage these new uses and modes, planners and engineers are revisiting bikeway design practices, including passing widths, queueing lengths, turn radii, grade changes and surface materials. This section explores these topics and other design considerations.

Attributes of small vehicles

As the popularity of bicycle+ transportation continues to rise, so does the need for bikeway designs that reflect the real-world diversity of small, wheeled devices now using our streets and shared-use paths. Riders today use everything from electric scooters and cargo bikes to adaptive cycles and delivery trikes—each with distinct dimensions, speeds and operational needs. Designing safe and accessible facilities requires an understanding of these varying characteristics.

The following section summarizes the major categories of small vehicles commonly found in urban bikeways. The next section provides a framework for considering width, stability, turning radius and surface needs during the planning and design process.

Table 1, adapted from **NACTO guidance**, illustrates the four primary types of devices frequently seen in bikeways and shared-use paths. These groupings are intended to help planners visualize the range of users and ensure that infrastructure design reflects the evolving mix of bicycle+ vehicle types.

A detailed table of attributes and vehicle types can be found in Appendix A. Emerging Small Vehicle Design Considerations.

Table 1 Common Devices in Urban Bikeways (NACTO Urban Bikeway Design Guide, 3rd edition)

Mini Devices	People riding electric and human-powered scooters, skateboards, rollerblades and other devices are typically riding or rolling upright on small wheels. Many people who use wheelchairs and personal mobility devices also use bikeways. In communities with shared e-scooters systems, people on e-scooters may be one of the most prevalent bikeway users.
Typical Bikes	People riding electric and human-powered upright bikes and trikes as well as recumbent bikes, hand cycles and any wheeled devices up to 2.5 feet (0.7 meters) wide. People riding typical bikes are common bikeway users and the typical bike is the conventional design vehicle for bikeways.
Cargo Bikes	People riding cargo bikes with or without a trailer as well as any wheeled device 2.5-3 feet (0.8-1 meter) wide are often carrying goods or passengers, commonly children.
Extra Large Bikes	People riding large freight tricycles, pedicabs and other devices wider than 3 feet (1 meter) and typically up to 4.5 feet (1.4 meters) may also use urban bikeways.

Strategies for designing for all ages, abilities and bicycle+ options

As the variety of bicycle+ devices grows—from traditional bicycles and e-bikes to scooters, cargo trikes and other small electrified vehicles—so does the diversity of people using them. Riders span all ages, abilities and experience levels and each device brings unique characteristics in terms of speed, size and maneuverability. To ensure a safe and comfortable experience for everyone, bikeway design must evolve to reflect this new landscape.

While bike lanes remain the safest and most intuitive place for people riding bicycle+ devices, they must be designed with a broader range of users and vehicles in mind. Creating inclusive infrastructure means accommodating not just the average cyclist, but also children, older adults, delivery workers on cargo bikes and individuals using adaptive devices. This requires updating longstanding design assumptions to address wider devices, faster speeds and increasingly complex interactions between users.

The following five focus areas, adapted from guidance by the NACTO, outline key design strategies to support an **All Ages & Abilities** approach for today's—and tomorrow's—bicycle+ users.

Lane widths

Wider and more diverse bicycle+ devices require wider bikeway facilities. As more people ride cargo bikes, trikes, e-bikes and other non-traditional devices, the space needed to operate safely—and to pass comfortably—has expanded. Bikeway widths must consider not only the physical dimensions of these larger vehicles but also the functional space needed for side-by-side travel, overtaking and maintaining rider comfort.

In constrained environments, minimum widths may still be acceptable. However, where space allows, planners and designers should prioritize preferred widths to better accommodate the growing volume and variety of users. Wider lanes are especially important in two-way facilities, where conflicting movements are more likely and the ability to maneuver safely is critical.

Table 2 outlines minimum and preferred rideable widths based on the type of bicycle+ device and whether the bikeway is one-way or two-way. These recommendations, adapted from NACTO guidance, support the creation of safe, inclusive bikeways that reflect real-world user needs.

Table 2 Minimum and preferred rideable widths for bicycle+ devices

Device type	Minimum Recommended Single-File	Preferred Single-File	Minimum Recommended Bidirectional	Preferred Bidirectional
Mini Device	6 ft	7 – 8 ft	8 – 10 ft	11 – 13 ft
Typical Bike	6 ft	7 – 8 ft	8 – 10 ft	11 – 13 ft
Cargo Bike	6.5 ft	8 – 9 ft	9 – 11 ft	12 – 14 ft
Extra Large Bike	7 ft	11.5 – 12.5 ft	12 – 14 ft	15-17 ft

Managing speed differentials

The electrification of bicycle+ devices has introduced a wider range of speeds into shared-use facilities. For example, a manual scooter may travel at 6 mph while an e-bike can reach speeds of 20 mph or more. This increased speed variance can lead to conflicts and reduced comfort, particularly for slower users like children, older adults, or people using non-motorized devices. Design strategies to manage this differential include grade separation, designated slow zones, lane striping within bikeways and signage or pavement markings that signal appropriate behavior. In some contexts, separate spaces for higher-speed bicycle+ devices may be appropriate.

Surfaces and gradients

Bicycle+ devices, particularly those with small wheels like scooters or skateboards, are sensitive to surface conditions. Uneven pavement, cracks, grates and steep inclines can pose serious safety hazards. Surface materials should be smooth, continuous and free of debris, with consistent maintenance practices in place. Gradients should be designed to minimize rapid elevation changes where possible or provide alternative routing for users who may struggle with steep slopes. Special attention should also be given to transitions at intersections, driveways and bridge joints, where gaps or sudden changes can destabilize riders.

Parking and network legibility

Well-designed networks should include clearly defined, convenient and abundant parking zones for scooters, bikes and other micromobility devices. Parking should be located near destinations, out of pedestrian paths and easily discoverable by riders. Network legibility also plays a role in comfort and safety. Wayfinding elements—such as signs, pavement markings and maps—should help users understand where to ride, how to navigate complex areas and where to park. High legibility also supports compliance with geofenced slow or no-ride zones, particularly for shared system users unfamiliar with the local area.

Intersections

Intersections remain the most dangerous locations in the transportation system—for all road users. For micromobility, the stakes are particularly high due to visibility challenges, turning conflicts with motor vehicles and the variability in rider behavior. Design elements like protected intersections, bike-specific signal phases, clear pavement markings and setback crossings help reduce conflicts and provide a more intuitive experience. Intersection designs should account for the turning radii and visibility needs of longer and wider micromobility devices, such as cargo bikes. Raised crossings, curb extensions and daylighting can further enhance safety by slowing motor vehicles and increasing the visibility of bicycle+ users.

4

Context-sensitive bicycle+ design considerations

Designing safe and comfortable infrastructure for bicycle+ devices across the Denver region requires more than just fitting facilities into available roadway space. It demands a context-sensitive approach—one that responds to diverse land uses, evolving transportation behaviors and the needs of people using a growing variety of personal mobility devices, including bikes, e-bikes, scooters and cargo bikes.

This chapter introduces a practical framework to help DRCOG member jurisdictions select infrastructure that aligns with street function, land use patterns and user comfort. It is grounded in a typology-based approach that expands on the DRCOG Complete Streets Toolkit and responds to gaps in traditional roadway classification systems, which are often centered around motor vehicle volume and speed. Instead, this guide emphasizes a broader view—designing streets for all users, including the most vulnerable.

At the heart of this chapter is a set of tools that support infrastructure decision-making in a wide range of real-world scenarios:

- The **Street Typology Framework** provides a consistent way to classify streets not only by motor vehicle function, but also by how well they can support bicycle+ travel. It adds nuance to the ten classifications from the DRCOG Complete Streets Toolkit by introducing two additional categories—Local Neighborhood Streets and Off-Street Bikeways—critical for a safe and complete regional network.
- **All Ages and Abilities Bikeway Selection** (Table 3) links bikeway facility types to key operational conditions like motor vehicle speeds and volumes taken from the NACTO Urban Bikeway Design Guide and FHWA Bikeway Selection Guide. This table helps identify which bikeway designs will provide the safety, comfort and accessibility required for users of all skill levels and device types.
- The **Bicycle+ Street Design Elements Matrix** (Figure 8) matches bikeway treatments with each street type to show which designs are most compatible. The matrix helps practitioners assess the relative appropriateness of different facilities—such as protected bike lanes, sidepaths, bike boulevards and shared-use paths—based on land use context and modal priorities. The full matrix can be found in **Appendix B**.

These tools are intended as a **decision-support resource** to inform:

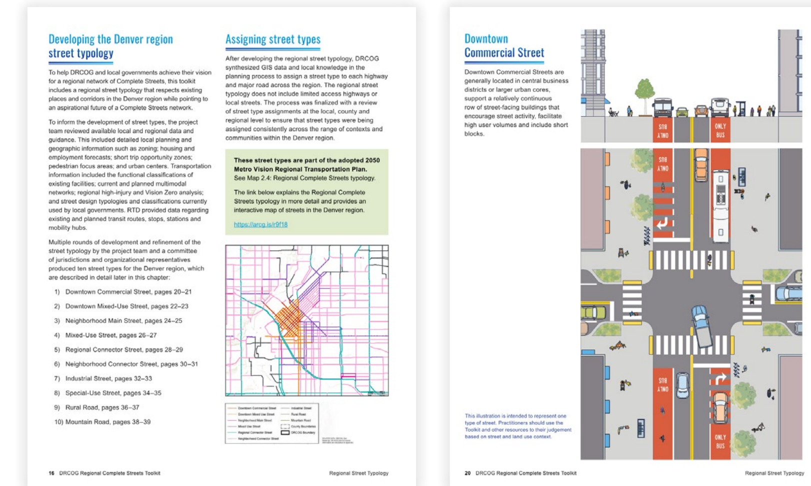
- Corridor-level planning
- Project scoping and feasibility analysis
- Grant applications (including TIP)
- Prioritization of capital investments

They are not prescriptive. Practitioners must apply engineering judgment, community input and local knowledge to refine recommendations to fit each corridor's unique needs.

This guide does **not**:

1. Address all issues that may arise in roadway design
2. Supersede established design manuals or guidance
3. Override engineering judgment or neighborhood preferences
4. Prescribe a one-size-fits-all solution for all street types or land use contexts

This chapter includes a section focused on **Regional Connector Streets**, which often serve long-distance travel needs but present challenges for bicycle+ infrastructure due to their high vehicle volumes and diverse settings. Through engagement with DRCOG member jurisdictions, these streets emerged as the most difficult to retrofit for safe, comfortable multimodal use—making them a key focus of this guide.



Importantly, this guide is not prescriptive. Rather, it provides a structured decision-support approach for planning, project scoping and capital investment prioritization. Users are encouraged to apply engineering judgment, local data and community feedback to refine these recommendations for their specific context.

Street classifications in the Denver region

The DRCOG Regional Complete Streets Toolkit established ten street classifications to guide the development of a multimodal network that serves people walking, rolling, biking, driving, using transit and moving freight. These classifications reflect a street's function within the broader transportation system and help identify where and how different modes should be prioritized.

While the Complete Streets Toolkit aimed to ensure streets work for all users, this guide goes a step further—by evaluating the compatibility of each street classification with bikeways and micromobility infrastructure. In doing so, it also introduces one additional classification critical to understanding the full range of bicycle+ contexts:

- **Local Neighborhood Streets**, where low speeds and volumes create inherently bike-friendly environments.

Street Classifications and Bikeway Compatibility

1. Downtown Commercial Street (High)
2. Downtown Mixed-Use Street (High)
3. Neighborhood Main Street (Medium/High)
4. Mixed-Use Street (Medium/High)
5. Regional Connector Street (Medium)
6. Neighborhood Connector Street (Medium/High)
7. Industrial Street (Medium/Low)
8. Special-Use Street (Medium/High)
9. Rural Road (Medium)
10. Mountain Road (Medium)
11. **Local Neighborhood Streets (High)**
12. **Off-Road Bikeways (High)**

Bicycle+ trips often span multiple types of facilities, each with different conditions and modal priorities. Selecting the most appropriate bikeway facility depends on many factors, but motor vehicle speed and volume are among the most important. Higher-speed, higher-volume streets typically require greater separation between motor vehicles and people biking or scooting to maintain safety and comfort.

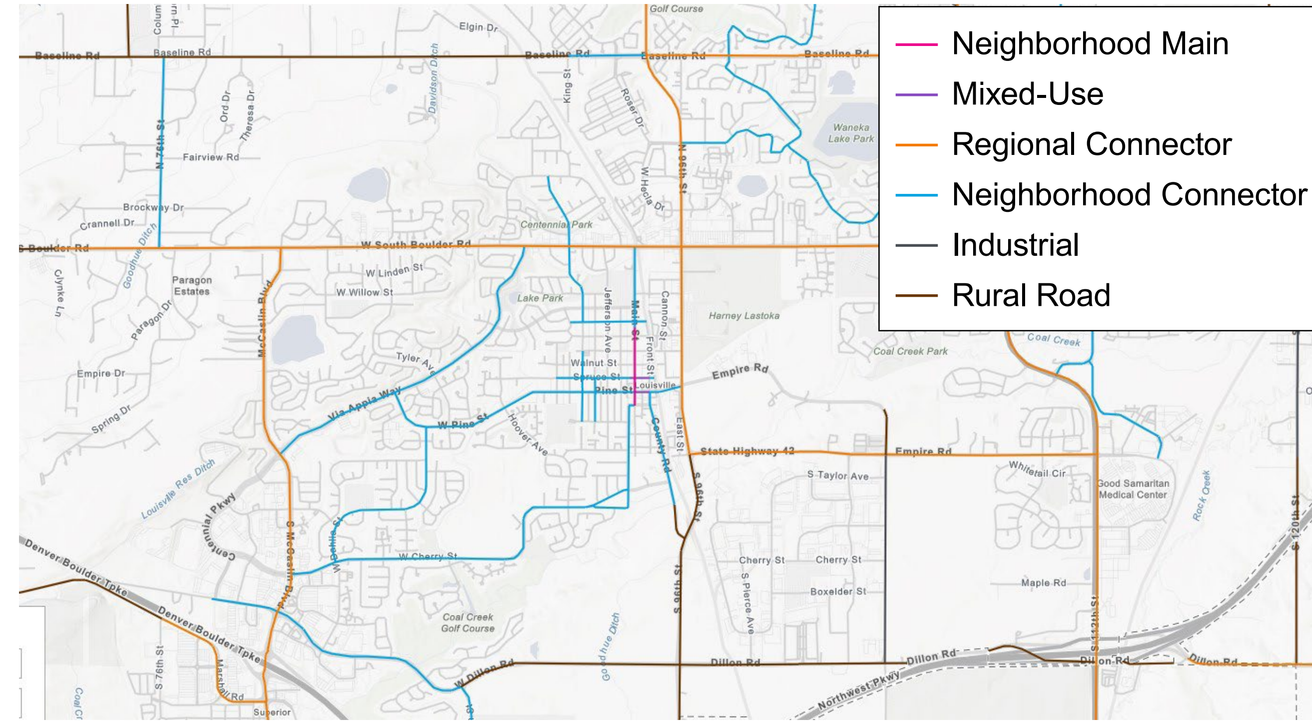


Figure 7 There are 10 street types in the Denver Region as defined by the Regional Complete Streets Toolkit, shown in the map above. (Source: DRCOG Regional Complete Streets Toolkit)

Guidance for selecting all ages and abilities bikeways

Not all bikeways are created equal—especially when it comes to serving people of all ages and abilities. The comfort, safety and usability of a bicycle+ facility are heavily influenced by the speed and volume of adjacent motor vehicle traffic. As speeds and traffic volumes increase, so too must the level of separation and protection provided for people riding bikes, e-bikes, or scooters.

Table 3 provides practical guidance for selecting appropriate bikeway types based on target motor vehicle speeds and volumes, drawing from the NACTO Urban Bikeway Design Guide and FHWA's Bikeway Facility Selection Guide. These guides helps practitioners match facility types to roadway conditions, ensuring infrastructure is not only technically feasible, but also inviting and safe for the broadest range of users—including children, older adults and less experienced riders.

These resources serve as foundational tools when evaluating or designing bikeways across different street types. While they does not prescribe specific treatments, each offers clear thresholds for understanding when greater separation or shared space may be appropriate—especially useful when working with constrained rights-of-way or retrofitting existing corridors.

Table 3 Minimum criteria for selecting a high-comfort on-street bicycle+ facility based on motor vehicle context; comparing both NACTO and FHWA guidance. For Separated Bicycle Lanes and Sidepaths, note that there is no lower bound for motor vehicle context where they are inappropriate; rather, as vehicle speed and volume increase, further separation is indicated, but separated bikeways on low-speed/low-volume streets suit all users.

	NACTO Urban Bikeway Design Guide (3rd Edition)				FHWA Bikeway Selection Guide	
Bikeway Type	Target motor vehicle speed	Motor vehicle lanes per direction	Motor vehicle volume per day	*Motor vehicle volume per peak hour, peak direction*	Target motor vehicle speed	Motor vehicle volume per day
Shared Street (with pedestrians)	≤ 10 MPH	No centerline	≤ 1,000	*≤ 60*	-	-
Bike Boulevard / Neighborhood Bikeway	≤ 20 MPH	Single lane	≤ 500 - 2,000	*≤ 50 - 150*	< 25 MPH	≤ 2,500
Constrained Bicycle Lane	≤ 20 MPH	Single lane	≤ 1,500 - 3,000	*≤ 300*	< 30 MPH	≤ 6,000
Buffered Bicycle Lane	≤ 25 MPH	Single lane	≤ 6,000	*≤ 600*	< 30 MPH	≤ 6,000
Separated Bicycle Lane*	Any	Any	Any	*Any*	> 30 MPH	> 6,000
Sidepath*	Any	Any	Any	*Any*	> 30 MPH	> 6,000

Bicycle+ street design matrix

Table 4 and Table 5 (on page 22) present each of the bikeway facility types and design elements included in the Complete Streets Toolkit and their compatibility with each of the twelve street types. For any given street type, a design element with high compatibility should be included by project staff in the street design if possible, while a design element with low compatibility may be omitted unless local conditions suggest otherwise. When developing street designs, practitioners should consider the assigned street type, its modal priorities, compatible design elements, adjacent land uses, existing and anticipated travel conditions and local plans and projects.

Table 4 Bicycle+ facility applications by regional complete street type

Bikeway Type	DOWNTOWN COMMERCIAL STREET	DOWNTOWN MIXED-USE STREET	NEIGHBORHOOD MAIN STREET	MIXED-USE STREET	REGIONAL CONNECTOR STREET	NEIGHBORHOOD CONNECTOR STREET	NEW: NEIGHBORHOOD LOCAL STREET	INDUSTRIAL STREET	SPECIAL-USE STREET	RURAL ROAD	MOUNTAIN ROAD
BICYCLE MODAL PRIORITY	**High**	**High**	**Medium**	**Medium**	**Medium**	**Medium**	**High**	**Low**	**Medium**	**Medium**	**Medium**
SIDEPATH OR SHARED-USE PATH	Low	Medium	Low	Medium	Medium	Medium	Low	Medium	Low	High	High
SEPARATED BICYCLE LANE	High	High	High	High	High	High	Low	Medium	Low	Medium	Medium
CONSTRAINED BICYCLE LANE	Medium	Medium	Medium	High	Medium	High	Medium	Low	Low	Medium	Medium
BIKE BOULEVARD/ NEIGHBORHOOD BIKEWAY	Low	Low	High	High	Low	Medium	High	Low	High	Low	Low
SHARED STREETS	Low	Low	Medium	Medium	Low	Low	Medium	Low	High	Low	Low

Table 5 Bicycle+ element applications by regional complete street type

Bicycle+ Design Elements	DOWNTOWN COMMERCIAL STREET	DOWNTOWN MIXED-USE STREET	NEIGHBORHOOD MAIN STREET	MIXED-USE STREET	REGIONAL CONNECTOR STREET	NEIGHBORHOOD CONNECTOR STREET	NEW: NEIGHBORHOOD LOCAL STREET	INDUSTRIAL STREET	SPECIAL-USE STREET	RURAL ROAD	MOUNTAIN ROAD	NEW: OFF-STREET BIKEWAYS
TRAFFIC CALMING ELEMENTS												
CURB EXTENSION	High	High	High	High	Low	Medium	High	Low	High	Low	Low	N/a
CORNER ISLAND/ PROTECTED CORNER	High	High	High	High	High	High	Low	High	Low	Low	Low	N/a
MEDIAN REFUGE ISLAND	High	High	High	High	High	High	Low	Medium	Low	Low	Low	N/A
HARDENED CENTER LINE	High	High	High	High	High	High	Low	Medium	Low	Medium	Low	N/a
SPEED HUMPS/ CUSHIONS	Low	Low	Low	Low	Low	Medium	High	Low	Medium	Low	Low	N/a
RAISED CROSSING	Low	Low	Medium	Low	Low	Medium	High	Low	Medium	Low	Low	N/a
RAISED INTERSECTION	Low	Low	High	Low	Low	Medium	High	Low	High	Low	Low	N/a
DIVERTER	Low	Medium	Medium	Low	Low	Medium	High	Low	High	Low	Low	N/a

Bicycle+ Design Elements	DOWNTOWN COMMERCIAL STREET	DOWNTOWN MIXED-USE STREET	NEIGHBORHOOD MAIN STREET	MIXED-USE STREET	REGIONAL CONNECTOR STREET	NEIGHBORHOOD CONNECTOR STREET	NEW: NEIGHBORHOOD LOCAL STREET	INDUSTRIAL STREET	SPECIAL-USE STREET	RURAL ROAD	MOUNTAIN ROAD	NEW: OFF-STREET BIKEWAYS
CONTROLLED CROSSINGS (design element refers to serving the street with the bicycle facility, not the cross-street)												
Bicycle Signals	High	High	Low	Medium	High	Medium	Low	Medium	Low	Low	Low	High
Half Signals	Low	Low	Medium	Medium	High	Medium	Low	Low	Low	Low	Low	High
Midblock Signals	Low	Low	Medium	Medium	Medium	Medium	Low	Low	Low	Low	Low	High
Hybrid Beacons	Low	Low	Low	Medium	High	Medium	Low	Low	Low	Low	Low	High
Rectangular Rapid-Flashing Beacons	Low	Low	Medium	Medium	Medium	High	Low	Medium	Low	Medium	Medium	High
Forward Queuing Area	High	High	Medium	High	High	High	High	Medium	Low	Low	Low	N/a
Separated Bicycle Lane Approach/ Departure	Medium	Medium	Low	Medium	High	High	High	Medium	Low	Low	Low	N/a
Bicycle Box	Low	Low	High	Medium	Medium	High	High	Medium	Low	Low	Low	N/a
CURBSIDE ACCESS												
Transit Boarding Island	High	High	High	High	High	Medium	Low	Low	Low	Low	Low	N/a
Shared Transit Boarding Area	Low	Low	Medium	Low	Medium	Medium	Low	Low	Low	Low	Low	N/a
Curbside Transit Stop (merge with bicycle lane)	Low	Low	Medium	Medium	Low	Medium	Low	Low	Low	Low	Low	N/a
Accessible Parking Stall	High	High	High	High	Low	Medium	Medium	Low	Low	Low	Low	N/a
Passenger and Commercial Loading	High	High	High	Medium	Low	Low	Low	High	Low	Low	Low	N/a
SUPPORTIVE INFRASTRUCTURE												
WAYFINDING	High	High	High	Medium	Medium	Medium	Low	Low	Low	Low	High	High
MOBILITY HUBS	High	High	High	Medium	Medium	Low	Low	Low	High	Low	Low	Medium
BICYCLE+ PARKING	High	High	High	High	Low	Low	Low	Low	High	Low	Low	Medium

5

A focus on regional connector streets

In the Denver region, Regional Connector Streets (as defined by DRCOG's Complete Streets Toolkit) span areas with varying population and employment densities. Regional Connector Streets are large arterials that connect everything from rural roads to downtown commercial streets.

DRCOG staff received feedback from jurisdictions during the planning process that these streets were the most difficult to tackle in terms of selecting appropriate facility types. Regional Connector Streets serve commercial land uses, feature buildings with large setbacks and off-street parking and facilitate long-distance trips for transit and driving. According to DRCOG's Complete Streets Toolkit, bicycle+ users have a medium modal priority on these corridors.

Although Regional Connector Streets are not designated as the highest priority for bicycles and micromobility, the geographic distribution of these large arterials causes them to frequently bisect neighborhoods and local bikeway networks, creating potential barriers to bicycle+ travel. Overcoming these barriers will be essential to maintaining regional bicycle+ network continuity, especially in suburban and exurban contexts.

Not all Regional Connector Streets will include dedicated bikeways in the future, but many are still commonly used by people biking, especially because they often serve as direct routes to commercial centers, services, and other local destinations. Some corridors may include bikeways along their full length, while others may only accommodate them in select segments. Many of these roadways are vital corridors for planned enhancements to the regional bus network, including bus rapid transit or more frequent service. Additionally, because many of these corridors have important destinations and active trip generators, local access needs and conflicts are important considerations. Future bicycle+ facilities on these corridors must be safe and comfortable for people of all ages and abilities because they will enable longer-distance trips and seamless connections to local networks and destinations.

Bicycle facility selection is primarily determined by the target motor vehicle speed and volumes for a given roadway. However, many Regional Connector Streets will exceed 25 MPH with 6,000 average daily traffic or 600 vehicles per hour in the peak direction, meaning the most appropriate bicycle facility for Regional Connector Streets will be separated bicycle facilities. Mixed facilities or facilities with minimal separation between people biking and people driving are unlikely to be compatible with these streets and meet the region's safety goals and criteria for high-comfort bicycle facilities. However, the diversity of land use contexts that Regional Connector Streets cross means that it is unlikely for a single typical cross-section to work for all of them. This chapter adds nuance to selecting the right separated bicycle facility for various Regional Connector Streets.

Rural regional connector streets

Regional Connector Streets on the suburban fringe may have fewer right-of-way constraints than roadways in the urban core. The exurban, semi-rural land use is often characterized by longer trip lengths and higher vehicle speeds. The grid of Regional Connector Streets accompanying suburban residential developments often results in long bock sizes (distances between cross streets and driveways) and more signalized intersections. Bicycle+ facilities in these contexts may not need to navigate as many turning-movement conflicts with motor vehicles, but the places they do intersect can often be at higher speeds and with greater bicyclist exposure due to longer crossing distances. Due to lower population densities, there are likely lower bicycle+ volumes on these Regional Connector Streets and destinations for people on bikes and micromobility are typically further away and may be concentrated to one side of the roadway.

The following roads in the 2025 Regional Active Transportation Plan network are examples of rural regional connector streets:

- CO-7, Adams County/Brighton
- Arapahoe Road, Boulder County
- US-36, Boulder County (Boulder to Lyons)
- CO-119, Boulder County
- 56th Avenue, Aurora

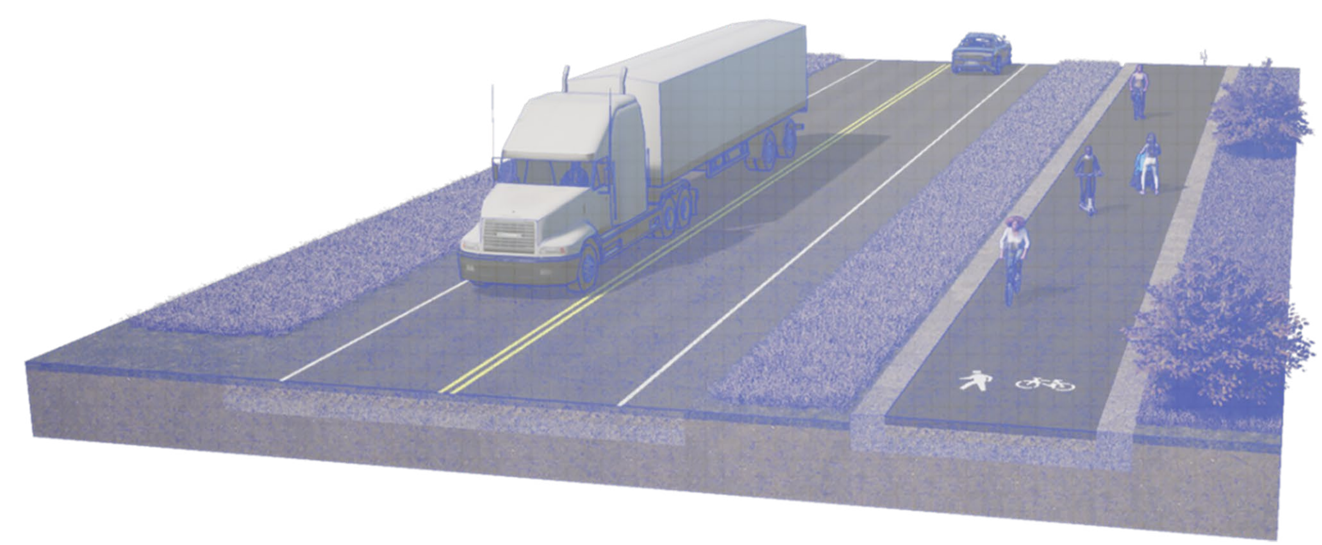


Figure 8 Rural regional connector streets design illustration

High-comfort bicycle+ facility

Sidepaths are particularly appropriate for longer distance travel in between activity centers. This is most likely between and approaching urban or suburban areas where there are fewer intersections or driveway conflicts. For these reasons, a sidepath may be a compatible facility for more rural Regional Connector Streets.

Dimensions: 11-foot preferred minimum/8-foot constrained minimum; if 50 bikers are present in the peak hour, up to 16 feet may be appropriate (see Figure 15 on page 34), with a 2-foot shoulder preferred.

Rural considerations

- **Bicycle+ charging and rest stations**: Given longer trip distances between activity centers, consider adding bicycle+ charging or battery-swapping stations at strategic intervals along sidepaths, encouraging usage of electric bikes and scooters. Stations can also provide shaded rest areas, benches and water refill opportunities, improving comfort and convenience for users.
- **Connectivity to local destinations**: While rural contexts may have fewer destinations overall, ensure sidepaths seamlessly connect to key local destinations such as schools, parks, commercial clusters, or transit stops. Consider enhanced connections (ramps, curb cuts, widened sidewalks) at entry points to these destinations.
- **Transit-oriented wayfinding**: Due to the dispersed nature of rural and semi-rural land uses, integrating wayfinding that clearly directs bicycle+ users toward transit facilities (such as bus stops or regional transit hubs) can significantly enhance multimodal connectivity. Signs should indicate travel times and distances to transit stops, including schedules or QR codes for real-time transit information. This improves accessibility for users completing first- and last-mile connections in areas where transit may be less frequent and stops less visible or intuitive to find.
- **Invest in areas where the facility typology transitions**: Advisory, regulatory, and/or wayfinding signage should be considered at transition points. Physical treatments to alert and guide shared-use path users include traffic calming measures such as vertical and horizontal deflection.
- **Consider sight distances**: Appropriate sight distances provide an unrestricted view of upcoming potential conflict points (such as intersections or pathway crossings) in order for users to slow and come to a stop based on the speed of travel and distance to nearby crossings, mixing zones, or other path transitions. They are typically calculated according to the fastest design vehicles, (e.g., electric bicycles) and take into account grades and curves.
- **Avoid constraining the facility width due to obstructions**: Relocate utility poles, signs, vegetation and trees to not obstruct the sidepath. If these elements are not relocated, the sidepath may deviate around these obstructions – but consider the swept path and turning radius needs for large micromobility devices.

Suburban regional connector streets

As Regional Connector Streets enter more suburban areas, volumes for all modes are likely higher, increasing the potential for modal conflict. Block sizes remain long. Bicycle+ facilities to a corridor are more likely to contend with right-of-way constraints imposed by existing structures or utilities. Sidewalks may already exist, connecting residential areas to activity centers on one or both sides of the roadway.

The following roads in the Regional Active Transportation Corridors network are examples of suburban regional connector streets:

- Broadway, Boulder
- 92nd Avenue/Thornton Parkway, Westminster/Northglenn/Thornton
- Colorado Blvd, Thornton
- Simms Street, Westminster
- Indiana Street, Arvada
- Founders Parkway, Castle Rock
- 104th Avenue, Commerce City

Figure 9 Suburban regional connector streets design illustration

High-comfort bicycle+ facility

Sidepaths and sidewalk-adjacent separated bicycle lanes help to separate pedestrians from bicycle+. By combining facilities on one side the bikeway can connect to existing shared-use paths and destinations on one side and minimize the number of conflict locations at intersections. For these reasons, sidepaths may be most appropriate for suburban Regional Connector Streets.

Dimensions: 12-14ft minimum (15-17ft preferred) tactile warning strip separating 6ft sidewalk

Suburban considerations

- **Bicycle+ parking and storage:** Implement clearly marked and conveniently located parking zones for bicycles and shared micromobility devices near suburban destinations such as shopping centers, schools, parks and transit stations. Covered or secured storage facilities can encourage increased use and minimize clutter or obstruction of sidewalks.
- **Access and intersection conflict management:** As suburban areas typically have higher volumes and increased turning movements at intersections and driveways, consider treatments such as medians and median tips, turn prohibitions, protected intersections, bicycle signals with protected phasing and clearly marked conflict zones to manage interactions between bicycle+ users and motor vehicles effectively.
- **Mid-block crossings:** Due to typically long suburban blocks, consider introducing mid-block crossing points or refuge islands at strategic locations. These crossings enhance directness and convenience for bicycle+ users accessing destinations situated between major intersections.
- **Extra width in busy areas:** Along a two-way bikeway, faster riders can pass slower riders by changing lanes during a gap in the opposing flow. However, on busy two-way bikeways, gaps in the opposing flow may be infrequent enough that faster riders choose to overtake slower riders while bikes are passing in both directions. Designate an additional 3 feet to accommodate passing along busy bikeways and create space for side-by-side riding.
- **Separate bicycle+ users from pedestrians where volumes are high:** To separate riders from pedestrians, create a detectable edge that contrasts visually with the surface treatment of the path. Separation can be achieved with a tactile warning delineator, curb, raised median, or planted area.
- **Mitigate conflict areas:** Advanced warning can be accomplished with advisory signage, pavement markings and the use of contrasting surface treatments (e.g. pavers/inlays with contrasting tones/textures, striping, or a combination of these treatments). These design elements help to guide shared-use path users safely through the mixing zone by alerting users to the change in conditions and thus reducing the speed differential.

Urban regional connector streets

As Regional Connector Streets cross denser land use contexts, they often feature commercial areas with large building setbacks and off-street parking areas. Sidewalks may already exist and there may be higher demand for bicycle+ facilities due to the increased density of destinations on both sides of the roadway. The greater prevalence of driveways in these locations increases turning movement conflicts with people riding bikes and micromobility. Right-of-way in these areas is often more constrained and transit stops may be more frequent.

The following roads in the Regional Active Transportation Corridors network are examples of urban regional connector streets:

- Speer Blvd, Denver
- Broadway, Denver/Englewood/Littleton
- Ford St & Jackson St, Golden
- Main Street, Longmont

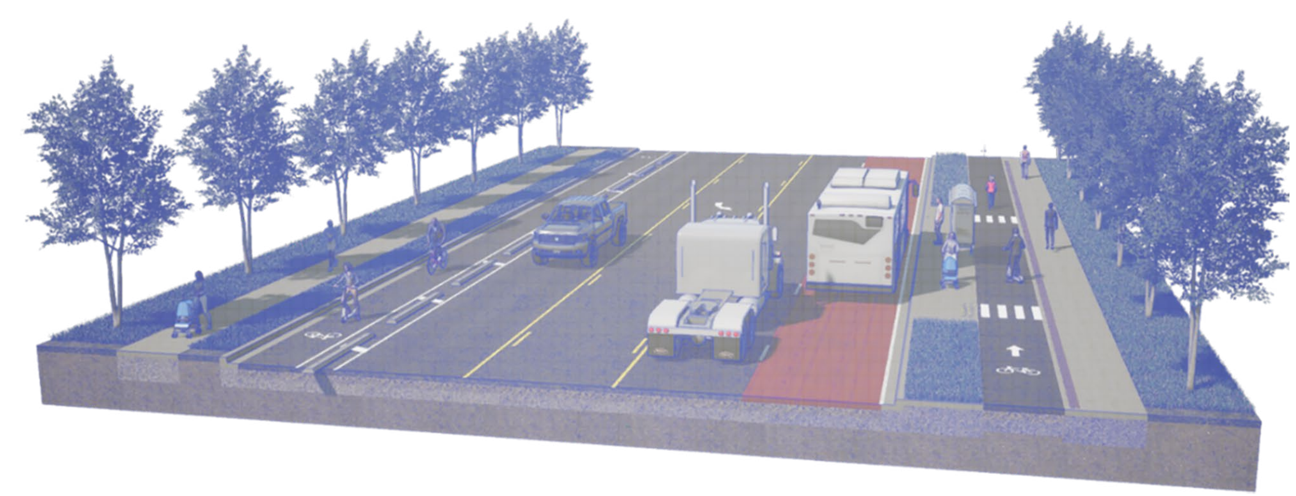


Figure 10 Urban regional connector streets design illustration

High-comfort bicycle+ facility

An on-street or raised separated bike lane may be more easily accommodated in a constrained right-of-way scenario. A one-way facility will reduce the number of potential conflicts in an area with many turns in and out of driveways. Having a bike facility on both sides of the roadway makes the destinations more accessible to people riding bikes and micromobility devices.

Dimensions: 7 feet minimum (8-12.5 feet preferred) with 3 feet or more street buffer

Urban considerations

- **Driveway conflict mitigation**: Due to increased driveway frequency in commercial areas, implement clear pavement markings, driveway aprons, colored conflict zones and signage alerting drivers to expect bicycle+ users. Raised crossings or distinct textured pavement can help reduce vehicle speeds and increase awareness at driveway crossings.
- **Handle driveways by prioritizing vulnerable users first**: Continuous raised facilities may be considered for minor intersections and driveways that intersect the Regional Connector Street. The vertical deflection raises bicycles and micromobility in the modal hierarchy and alerts drivers to changing contexts. Note that drainage needs to be planned at the earliest design stage for this kind of facility.
- **Help small vehicles through intersections**: At intersections, use green high-friction cross-bike markings. These can be recessed into the underlying surface to reduce the damage from winter snowplows.
- **Bicycle+ friendly signalization and timing**: Incorporate signal timing strategies sensitive to bicycle+ users, such as adequate crossing intervals, dedicated signals and signal detection specifically designed for bikes and scooters to ensure efficient and safe movement through busy intersections.
- **Reduce turning speeds**: Reduce the turning radii from the vehicle lanes to reduce vehicle turning speeds.
- **Pedestrian interaction management**: Clearly separate bicycle+ from pedestrian zones using vertical and horizontal separation methods (such as raised curbs, differentiated pavement, or planted barriers). This minimizes conflicts in busy commercial environments with heavy pedestrian foot traffic.
- **Avoid seams**: Treat longitudinal seams to provide a smooth surface for narrow and small wheels.
- **Ramp up and around bus stops**: On-street separated facilities can be raised to sidewalk level and wrap around bus stops to the right side. Reduce the lip and grade of these ramps to better accommodate bicyclists.

Connecting bikeways at regional connector street intersections

Intersections along Regional Connector Streets are among the most challenging environments for people riding bikes and using micromobility devices. Intersections along Regional Connector Streetsare typically designed to prioritize vehicle flow, with wide lanes and generous turning radii that encourage high-speed vehicle movements, conditions that heighten the risk for vulnerable users. The complexity of these intersections, often compounded by high volumes of turning traffic, limited signal time for non-motorized modes and long crossing distances, demands thoughtful, user-centered design. Where bikeways cross or connect at these intersections, jurisdictions must treat the intersection as an integral part of the bikeway, not a gap in it and invest in design strategies that provide continuity, visibility and protection for people of all ages and abilities.

Intersection Design Objectives for Regional Connector Streets

Achieving a safe, comfortable and intuitive intersection requires attention to detail and prioritization of safety over throughput. National guidance products from AASHTO and NACTO provide great foundations and detailed design tools and strategies for envisioning and implementing bicycle-supportive intersections.

First, NACTO's Urban Bikeway Design Guide organizes safe intersection design around four main objectives:

- **Reassess and reorganize the intersection.** Each project provides an opportunity to assess and address conflicts and challenges. The guidance emphasizes selection of the appropriate design vehicle for the context so that corner radii are not overbuilt; reducing intersection complexity by managing and restricting turns, eliminating skewed angles, and removing slip lanes that incentivize turning at speed.
- **Don't give up at the intersection.** Historically in the U.S., bicycle facilties have dropped at intersections where conflicts are most concentrated, in part because national standards and guidance have struggled to keep up with design innovation. Providing dedicated approaches, legible paths of travel, and clearly marked crossbikes are each core strategies for carrying the bikeway through the crossing.
- **Slow turns are safe turns.** Slower vehicle speeds are more forgiving to conflicts, giving everyone time to react and respond to dynamic conditions. Minimizing effective turning radii and hardening centerlines or lane lines are the key strategies for slow and safe turns.
- **Improve visibility at turn conflicts.** Finally, maximizing visibility at the intersection improves interactions between users. Providing advance visibility zones and establishing queuing spaces for bicycle+ users can improve visibility, while creating setback distances allows for better view angles from turning vehicles.

AASHTO's Guide for the Development of Bicycle Facilities similarly organizes intersection design guidance around six main objectives:

- **Minimize exposure to conflicts.** The guidance notes that exposure increases with motor vehicle speed and volume, and that practitioners should seek to limit width of multilane crossings, time spent between moving vehicle lanes, queuing time exposed to moving traffic, and vehicle turns across the bicycle travel path.
- **Reduce speeds at conflict points.** Where conflict points cannot be eliminated, reduce speed differential between bicycle+ and motor vehicles as much as possible to promote safe interactions.
- **Communicate right-of-way priority.** Where through-moving and turning users interact, it is critical to communicate through design which user has the right-of-way and which is expected to yield.
- **Provide adequate sight distance.** Similar to NACTO's guidance, AASHTO recommends strategies to maximize visibility and sight triangles at interaction points.
- **Transition between facility types.** Crossings often require transitions between types of bikeways, so make these transitions as intuitive and legible as possible.
- **Accommodate persons with disabilities**. Provide multi-sensory cues to guide all users, but especially those with disabilities that impact mobility, through conflicts and crossings.

For Regional Connector Streets, applying these principles can shift by context, but generally designers should seek to separate bicycle+ users in space and time; provide legible and intuitive visual and non-visual navigation cues; minimize effective radii and maximize view angle; and minimize speed differentials with safe vehicle operating speeds.

Figure 11 Illustration of a fully protected intersection. (Source: City of Fremont, CA Public Works)

Figure 12 A street-level view of a protected, sidewalk-level bikeway in Fremont, CA.

Figure 13 Street-level illustration of a protected intersection in Fremont, CA.

6

Design strategies for shared-use path comfort, safety and usability

Designing high-quality shared-use paths and bikeways involves more than selecting the appropriate facility type, it requires attention to the many real-world conditions that affect how people experience and navigate these spaces. As the Denver region sees increased use of e-bikes, scooters and other small-wheeled devices, ensuring that facilities are intuitive, safe and comfortable for all users has become a top priority.

This chapter provides a set of strategies that complement foundational infrastructure design and address operational considerations that influence user experience. These strategies focus on the critical but often overlooked details, such as managing speed differentials between users, clearly signaling transitions, ensuring adequate sight distances and providing secure, accessible parking.

The chapter also introduces tools for planning long-term functionality, including the Shard-Use Path Level of Service (SUPLOS) framework developed by FHWA. This tool helps agencies evaluate and design pathways to meet current and future demand, particularly in high-use corridors where shared-use path width, user separation and comfort are key to performance.

While many of the strategies presented here may seem minor compared to full facility reconstruction, they play a significant role in creating a predictable, user-friendly network. When applied consistently, these elements support a shared-use path system that works for people of all ages, abilities and device types—and is resilient to future growth.

Together, these design strategies help jurisdictions:

- Reduce conflicts in shared or constrained spaces.
- Enhance comfort and safety in high-traffic areas.
- Improve the clarity and legibility of off-street bikeway networks.
- Promote appropriate behavior through signage and striping.
- Build shared-use path segments that can grow with changing demand.

By pairing these strategies with context-sensitive facility design, communities across the region can deliver a seamless and inclusive experience for all path users.

Managing speed differentials

As the popularity of e-bikes and e-scooters are becoming more widespread, it is important to consider the varying operating speeds of these devices being used on bikeways across the Denver region. The acceleration characteristics and sustained operating speeds for an e-bike or e-scooter are typically faster than what most people can attain with a non-electric bicycle. In locations with anticipated high bicycle and e-scooter ridership, such as parks, downtown areas, or on Denver's Core Network, wider bikeways should be considered to increase bicyclist and scooter operators' levels of comfort when passing one another (for additional discussion and guidance, review the **Denver Bikeway Design Manual**). Managing speed differentials becomes even more important on shared-use paths where pedestrians mix with bicycles and micromobility devices. The following strategies can help mitigate conflicts between these modes.

Clearly define bicycle and pedestrian mixing zones

Active transportation mixing zones are necessary where physical space constraints do not allow for separated modes, or at locations along the shared-use path where a high level of cross-traffic is expected. Active transportation mixing zones need to provide clear indication to all users that a transition is occurring in advance of the change, so that path users can adjust their speeds and awareness appropriately to proceed carefully into the mixing zone.

Advanced warning can be accomplished with advisory signage, pavement markings and the use of contrasting surface treatments like pavers or inlays with contrasting tones or textures, striping, or a combination of these treatments.. Thoughtful design elements help to guide shared-use path users safely through the mixing zone by alerting users to the change in conditions and thus reducing the speed differential.

Visual and physical cues at transition zones

Advisory, regulatory, and/or wayfinding signage should be considered at transition points. Physical treatments to alert and guide shared-use path users include traffic calming measures such as vertical and horizontal deflection.

Design elements that alert path users to changing typologies could include pavement markings such as optical speed bars, zebra stripe crosswalks with yield/stop markings and "LOOK" legends and arrows. Other visual indications include bike and pedestrian directional markings, center lane striping and colored pavement to visually narrow or indicate a change in environment.

Tactile indications include speed humps, tactile speed bars and the use of multiple surface types, such as concrete, asphalt and pavers.

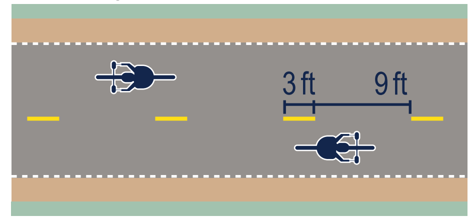
Lighting should be considered along shared-use paths in areas where the typology transitions, where vertical and horizontal deflections are used and in constrained places where people walking and biking are likely to share space or mix.

Use Pavement Striping on Paths

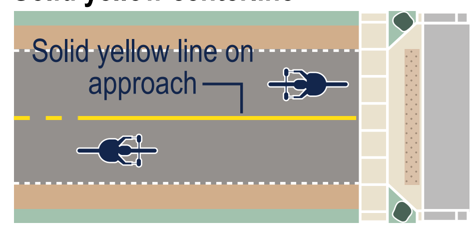
Striping and markings are ground treatments that can be used to help delineate pathways and directions of travel, to alert bicyclists and pedestrians of potential conflict zones and to warn vehicles of crossing pathway users. Striping and markings should defer to local and MUTCD standards. Maintenance is a large consideration, as pavement markings will wear and fade over time. Pathway striping can be used to delineate lanes of travel and pathway obstructions and should be 4" wide. Striping patterns used on pathways can include:

- Dashed yellow lines to separate directions of travel where sight lines allow safe passing.
- Solid yellow lines to separate directions of travel and indicate no passing due to limited sight lines or upcoming conflict points like astreet crossing, pathway junction, tunnel or bridge,).
- Solid yellow lines to inform pathway users of obstructions within the pathway.
- Solid white lines to inform pathway users of obstructions on the edge of the pathway.
- Solid white lines to separate users traveling in the same directions.

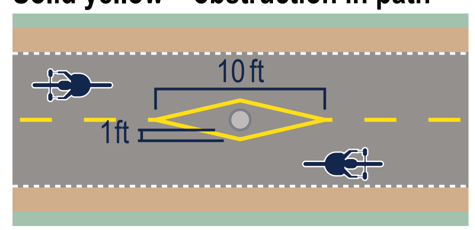
Dashed yellow centerline



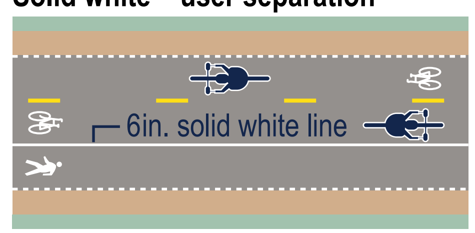
Solid yellow centerline



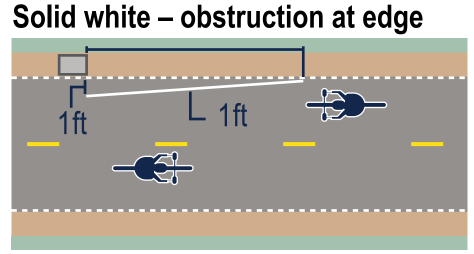
Solid yellow – obstruction in path



Solid white – user separation



Solid white – obstruction at edge



Factor in sight distances

Appropriate sight distances provide an unrestricted view of upcoming potential conflict points (such as intersections or pathway crossings) in order for users to slow and come to a stop based on the speed of travel and distance to nearby crossings, mixing zones, or other path transitions. Sight distances are typically calculated according to the fastest design vehicles, (e.g., electric bicycles) and take into account grades and curves.

The distance needed to bring a pathways user to a complete stop is a function of the user's perception and braking reaction time, their initial speed, friction between the wheels and the pavement, the braking ability of the mobility device and the grade of the pathway. Because of the difference in user capabilities and their mobility device, stopping sight distances will vary for different people, but AASHTO recommends that multi-use pathways provide a minimum sight distance of 150 feet.

Wayfinding and etiquette signage

Etiquette signs are informal signs intended to promote courtesy and educate pathway users on how to perform passing and other maneuvers safely. Potential signs may include 'Pass on Left, 'Slow Down', 'Yield to Pedestrians', 'Use Voice or Bell to Pass'.

Etiquette signage may be located at trailheads, crossings and in response to areas with known issues or conflicts. In general, use of etiquette signs should be limited to strategic placement, to avoid over-signing the pathway and cluttering fundamental wayfinding and regulatory signage. Etiquette signage should be designed to match other wayfinding and interpretive signage to reflect a recognizable, cohesive off-street network identity.

Adding mile sign posts is useful for wayfinding and exercise; however, mileposts also function as a safety feature for emergency response, helping path users more easily identify their location.

Parking

Bicycle+ parking is a simple yet essential support for these transportation modes—but only if done right. Poor placement or installation can render racks unusable and keeping walkways clear of small things with wheels requires thoughtful curb management and policy. With the growing diversity of bike sizes and attachments, well-designed parking is essential for integrating these modes into the transportation system.

The Essentials of Bike Parking (2015)

The Association of Pedestrian and Bicycle Professionals (APBP) prepared this guide for people planning to purchase or install bike parking fixtures on a limited scale. It is a brief overview of APBP's comprehensive Bicycle Parking Guidelines handbook, available at APBP's website. This guide ditvides bike parking into short-term and long-term installations. These two kinds of parking serve different needs and the starting point for most bike parking projects is recognizing whether the installation should serve short-term users, long-term users, or both. If users are typically parking for two hours or longer, they are likely to value security and shelter above the convenience and ease that should characterize short-term parking. For more detailed guidance on bicycle parking, see the guide directly.

Next generation bikeways: shared-use path level of service

As off-street bicycle networks evolve to serve a wider variety of users—including bicyclists, e-bike riders, pedestrians and other micromobility users—ensuring comfort and performance across facilities becomes increasingly important. One valuable planning tool for assessing shared-use path functionality is the Level of Service (LOS) framework, traditionally used to evaluate roadways based on travel time, speed, maneuverability and user experience.

To adapt this framework for shared-use paths, the FHWA developed the SUPLOS Calculator. This tool helps determine appropriate pathway widths and the potential need for separating different user types based on actual or projected volumes and mode splits. Figure 17 illustrates the various infrastructure types required depending on volume.

How SUPLOS works

The SUPLOS Calculator rates pathways on a scale from **A (excellent) to F (poor)**, based on operational performance.

- **Grades A through C** are considered acceptable, with **LOS B** offering a "good" level of service that accommodates future growth.
- **Grades D through F** are considered degraded and may result in poor user comfort, congestion, or safety risks—especially as volumes increase.

While useful, SUPLOS does not account for all the factors that influence user experience. As FHWA notes, the tool **does not incorporate** qualitative or environmental elements such as:

- Perceived safety and personal security.
- Scenic quality or natural setting.
- Proximity to vehicle traffic.
- Steep grades or frequent curves.
- Surface material and condition.

Despite these limitations, SUPLOS remains a valuable resource for evaluating **existing pathway performance** and **planning new facilities** that can meet expected demand while providing a high-quality user experience.

Applying LOS to design

Figures 16 and 17 illustrate recommended pathway widths in order to achieve LOS B and LOS C, depending on bicyclist and pedestrian volumes.

The following design principles are recommended when using LOS to guide path development:

- **Maintain a minimum of 10 feet** for shared-use bicycle paths and 6 feet for pedestrian lanes when separated facilities are provided.
- **Use the LOS B and LOS C targets** as general design thresholds—LOS B is preferred to accommodate future growth, while LOS C may be sufficient for current demand in constrained areas.
- For **new facilities where count data is not yet available**, use land use context and anticipated user types to estimate volumes and plan accordingly.

By applying the LOS framework, agencies can make better-informed decisions about **bikeway widths, separation strategies and long-term capacity needs**, ultimately supporting a higher-functioning regional off-street bicycle network.

Figures 16 and 17 show the required widths for LOS B and C depending on bicycle and pedestrian volumes (users per hour). These tables should be used when evaluating the LOS of existing pathways to determine the pathway width needed to achieve the desired LOS. If a separate lane is provided for pedestrians, pedestrian volumes do not need to be factored into the calculation for pathway width. However, a minimum of six feet for pedestrian lanes and 10 feet for bicycle pathways should be maintained in order to accommodate two-way travel.

When looking at pathway LOS, LOS B is considered “Good” and retains significant room to absorb more users while still providing a high-quality user experience. A pathway with LOS C is considered “Fair” and meets current demands, but an increase in users will begin to diminish the user experience.

For new pathways where count data is not available, pathway width should be determined by surrounding context and anticipated demand.

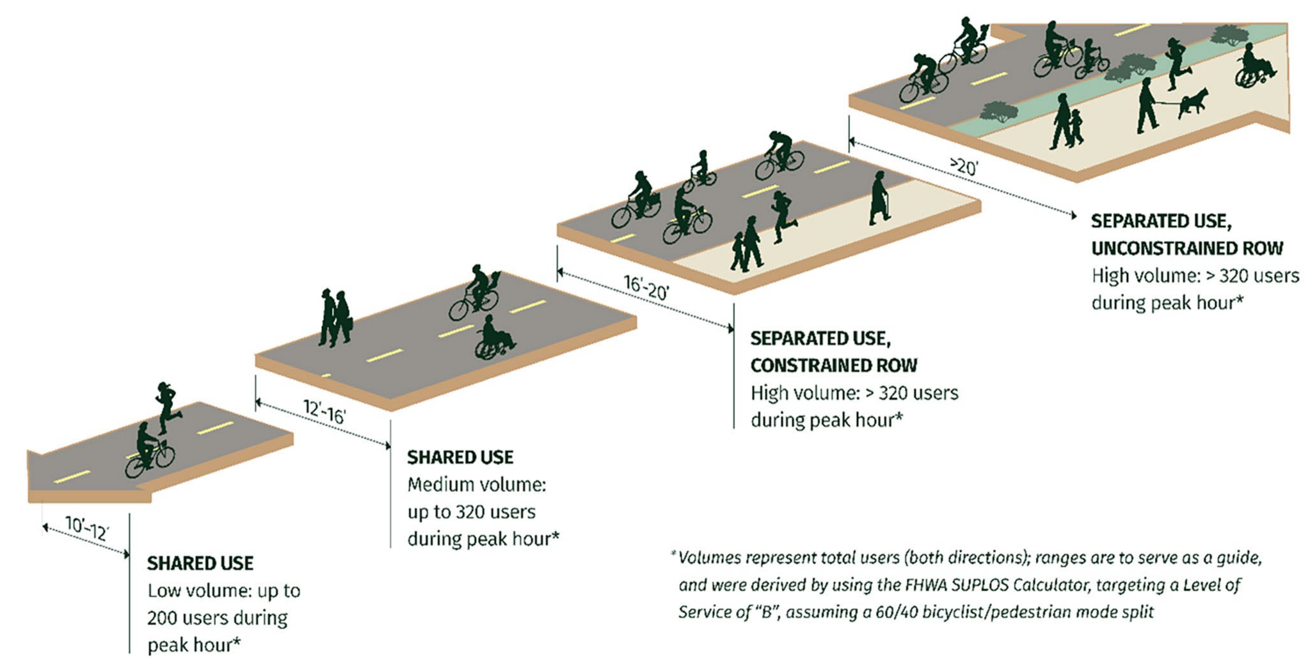


Figure 14 Example of different widths and facility types required depending on volume.

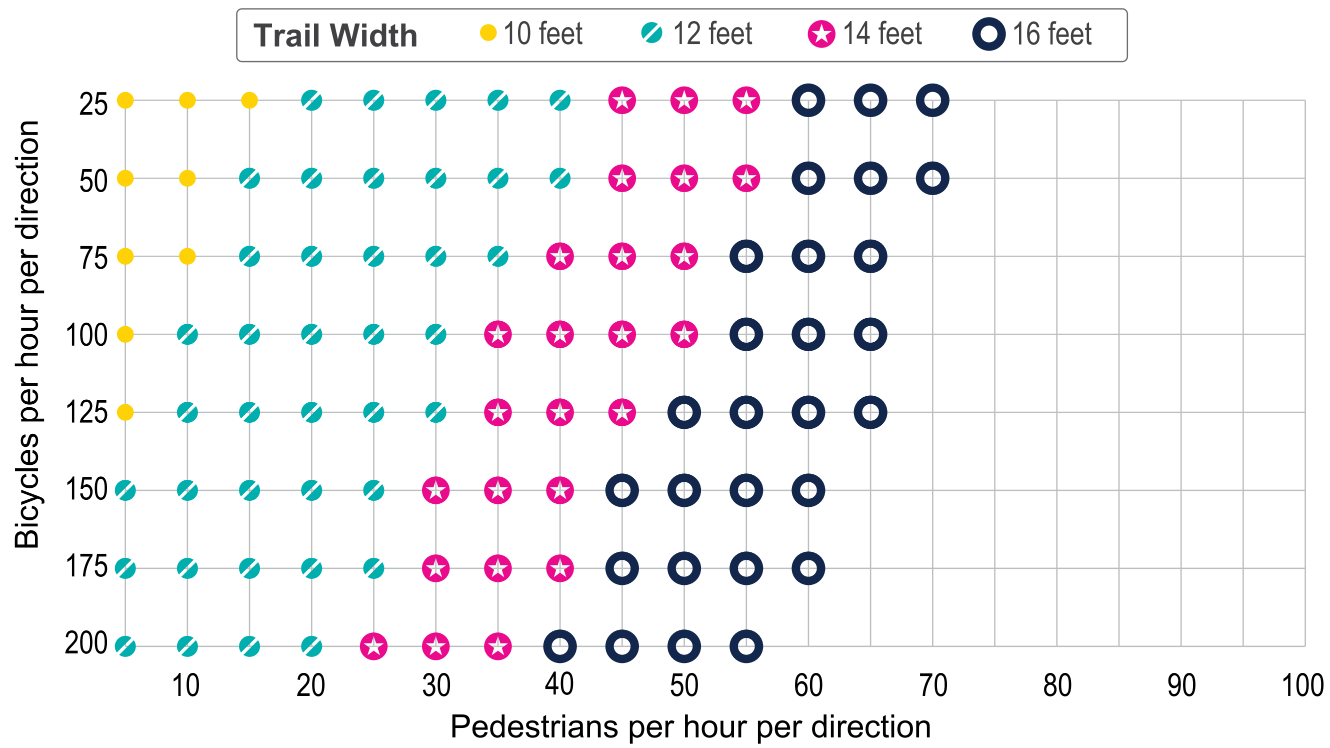


Figure 15 Necessary shared-use path widths by volume for Level of Service B.

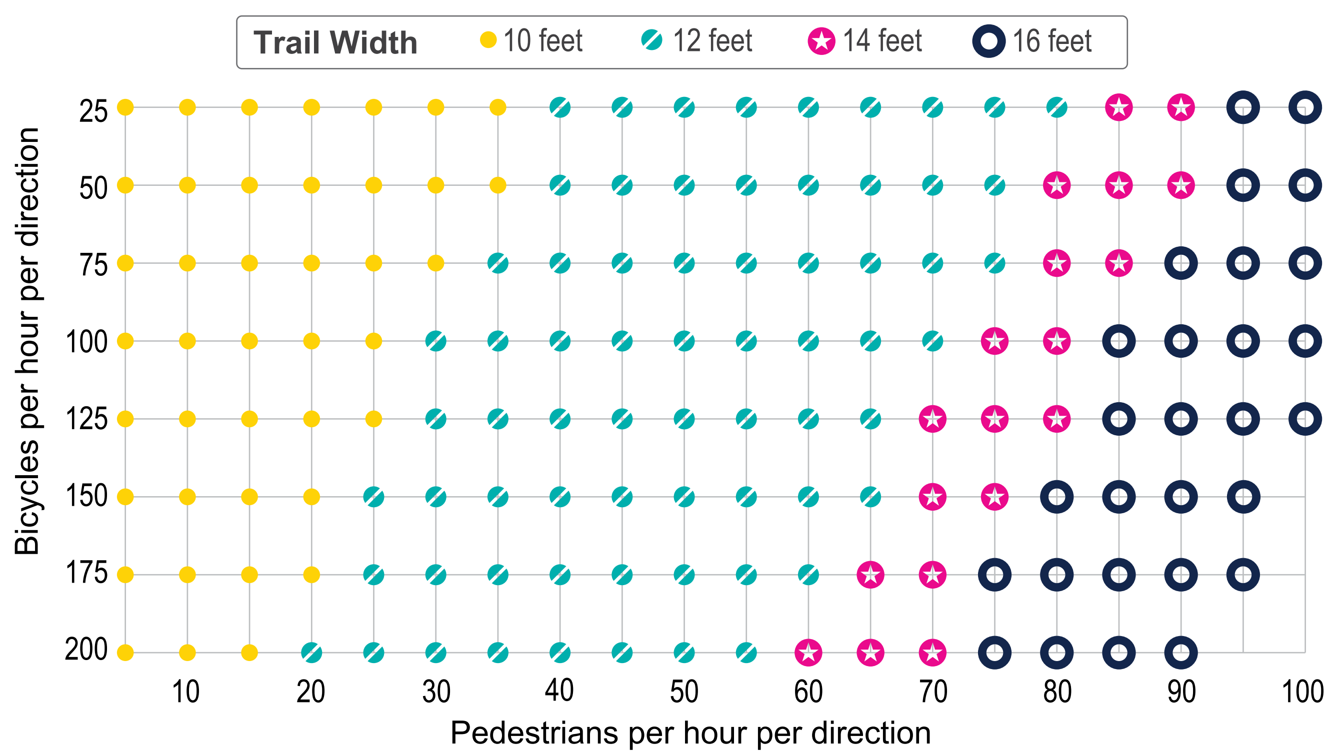


Figure 16 Necessary shared-use path widths by volume for Level of Service C.

7

Bicycle facility maintenance

Maintenance of bicycle+ facilities includes inspection, preservation, repair and restoration of facilities so that they are safe and accessible for users.

A survey conducted by DRCOG of its member jurisdictions revealed concerns about the maintenance of bicycle+ facilities. While maintenance concerns are real and important, they are not a reason to stop a bikeway project or diminish a design that facilitates the travel of riders of all ages and abilities. It is possible to prioritize maintenance and build high-quality bicycle+ facilities across the region. To do this, communities should have strategic and intentional conversations beginning at the planning and design stages to identify options that are feasible and sustainable. Below are some steps that local jurisdictions can take to address maintenance concerns:

- **Be willing to iterate**. It will take time and interdepartmental collaboration for agencies to determine the best equipment for the local context, set the correct service levels and solve coordination issues.
- **Combine bicycle+ facility maintenance with other maintenance plans**. By combining bikeway maintenance with sidewalk maintenance, communities may find efficiencies and buy-in from people who don't necessarily bike.
- **Establish fair maintenance agreements early**. Building a bikeway network that spans multiple jurisdictions requires a shared understanding of community needs and capacity in terms of cost participation policies. For example, when applying for grants with the Colorado Department of Transportation, jurisdictions should establish a context-based need early in the grant application phase so that undue burdens are not placed on communities with limited maintenance budgets.
- **Consider the need for new maintenance vehicles**. When designing new separated or protected biking and walking facilities, jurisdictions should consider the maintenance vehicles they currently own or are willing to purchase to inform the width of the facilities (for sweeping out debris or snowplowing).
- **Pilot projects first to build buy-in**. Local communities can undertake pilot projects to test the feasibility and effectiveness of an improvement. This not only helps identify ongoing maintenance costs, but successful projects can also help present the case for full-scale implementation and maintenance through regional, state, or federal funding.

Bicycle+ maintenance activities

Bikes and micromobility devices – especially those with small or narrow tires and wheels – are more susceptible to debris, ice, potholes, large cracks and other surface imperfections. Regular bicycle facility maintenance includes striping, sweeping, repairing barriers, snow removal and plowing, trimming encroaching vegetation and installing bicycle-friendly grates. Pavement overlays are a good opportunity to improve the smoothness of bicycle+ facilities as they transition surfaces like grates, longitudinal joints, railroads and bridge decks. The following is a summary of common maintenance activities from NACTO's Urban Bikeway Design Guide (2025):

Markings

- To the extent possible, pavement markings and green-colored areas should be placed out of the vehicle path of travel to minimize wear. In general, striping, pavement markings and

Figure 17 Example of clearing snow in a protected bike lane. (Source: Vancouver BC, Canada)

green colored areas should be well maintained especially areas in the path of vehicle travel and where high-turning movements occur.

- Bikeway markings should be refreshed on a regular basis, especially at intersections and where markings play a critical role in safe operations. Using durable surfacing treatments such as glass aggregate in a resin binder or pigmented asphalt will reduce the frequency of maintenance, as will recessing pavement markings to minimize damage from snowplows.

Constructed medians, durable barriers, flexible delineators and other modular materials

- Infrastructure that separates bikeways from motor vehicles will be damaged over time. For constructed medians, the addition of vertical elements such as signs or reflectors can improve their visibility and reduce the number of vehicle strikes. Durable barriers are less permanent than constructed medians in that they can readily be installed or removed with crews and specialized equipment. Communities should consider using a consistent barrier type throughout the jurisdiction with the same anchoring mechanisms to reduce maintenance costs. Flexible delineators will need to be replaced annually if not more frequently.

Sweeping

- Design protected bike lanes wide enough to accommodate sweeping equipment. Sharp curves may be difficult to sweep with a machine. Raised bikeways may collect less debris than on-street bikeways but still accumulate debris from tree leaves and litter.

Managing vegetation

- Regularly trim back vegetation to prevent encroachment into the bikeway. Avoid planting trees that produce nuts, fruits and large seeds that can drop into the bikeway, such as oak, spruce, sweetgum and pear trees.

Patching, repaving and utility grates

- Ensure pavement inspections occur after trenching activities are completed and if excessive settlement has occurred to require mitigation prior to the expiration of the project's warranty period.
- Repaired patches of trenches and cuts into bikeways should span the entire width of the bikeway.
- Apply non-skid surfacing to metal plates which should be recessed and secured to the pavement surface. For non-recessed plates, ramp up with a berm of 2ft with asphalt in the traveled direction and 1ft in the non-traveled direction.
- Ensure smooth surfaces for the interim and final surfaces of a repaired section. If the cut or plate transverses the bikeway, such lips must be no more than 0.5in. Final repairs must be rectangular in shape. When preparing the final surface, apply a tack coat on all surfaces, including vertical surfaces.
- Orient stormwater grates perpendicular to the path of travel or use grid pattern grates to prevent the grate from catching wheels of bicycle+ devices.

Railway tracks

- Minimize lips and gaps between tracks and bikeways.
- Prioritize seamless material transitions and durable surfaces, preferably concrete, around tracks that cross bikeways. Asphalt installed over the track bed is not sufficiently durable.
- Use flangeway gap fillers in urban contexts where rail vehicles will not be traveling fast.
- Design bikeways to cross tracks at 90 degrees. Where the bikeway and rail tracks cross at an angle less than 90 degrees, use a "bend-out" design to redirect the bikeway out and then across the rails at a safer angle. Do not angle bikeways across rails at anything under a 60-degree angle. To avoid the risk of slipping on the rails, the bikeway must be fully straightened out at least 6ft ahead of the rails. Avoid forcing people on bicycle+ devices to dismount or enter a shared travel lane.

Bridge decks

- Open metal decking on bridges can be slippery and hazardous, especially for people using bicycle+ devices with small and narrow wheels. Lightweight fiberglass plates for people on bikes and micromobility devices can provide a non-skid surface while minimizing the additional weight load on a bridge.

Winter maintenance

Maintaining bikeways in the winter can be grouped into three major activities:

- De-icing: spreading salt or liquid melter to prevent ice and snow accumulation.
- Snow clearing: pushing, blowing, or sweeping snow off the bikeway onto another part of the street.
- Snow removal: loading excess snow into a dump truck for transportation to a snow disposal site.

Winter bikeway maintenance best practices

Many considerations factor into how to provide safe, ridable bikeway surface conditions and sight lines in the winter. These factors are the bicycle facility type and the presence and type of vertical protection or separation along a bikeway.

Plan roadways with sufficient right-of-way

On new roadways or in roadway re-engineering projects that include bike lanes (or may include them in the future), design the street to provide space within the right-of-way for snow storage space. Ensure that the snow storage space is of adequate width to accommodate typical snowfall accumulations, which allows plows to clear the roadway and bike lane of snow and allows sidewalks to also be kept clear of snow storage.

The best practice for bike lanes or buffered bike lanes is to plow snow onto the parking strip/snow storage strip, as this practice most closely matches that of typical snow plowing operations. In the design phase, it may be important for communities with high snowfall to determine a minimum strip width (between the sidewalk and curb) based on snow storage requirements.

Use the Wide Bike Lane Buffer

When right of way is restricted to such an extent that only curb-tight sidewalk without snow storage space is available, local agencies should consider using the buffer space for snow storage. By providing a wide, painted bike lane buffer, snowplow operations may be able to store snow in the buffer between motor vehicle lane and the bike lane. This requires the roadway plow to plow snow to the right and the bike lane plow to plow snow to the left. This method may be useful where there is insufficient snow storage area between the bike lane and the sidewalk.

Figure 18 Illustration of using the bike lane buffer to store snow. (Source: Salt Lake City, UT. Photo Credit: Travis Jensen)

Considerations for this method include snow melt, which is especially relevant to front range communities that receive snowfall that melts and refreezes over the course of a day. Too often, stored snow can melt and sheet flow across the bike lane, resulting in a very icy bikeway surface condition. This needs to be countered with a deicing operation.

Recessed thermoplastic pavement markings

Milling the area of pavement 3mm in depth where thermoplastic pavement markings are applied has shown to be effective in reducing damage as a result of snowplows in a **2010 study**. Minneapolis, MN, mills the area of pavement where thermoplastic bike lane indicators are placed to help reduce damage as a result of snowplows. While this method increases the cost of installation, it may save in long-term maintenance costs (and help preserve safety conditions along the roadway).

Edge-of-roadway visual cues

Pavement markings, striping, sidewalk curbs and other types of travel delineators installed at ground level serve as good indicators of the bicycle travel path when the ground is clear, but after a snow event, these lose their utility and, in some cases, can become hazards, making the travel path difficult to navigate. For this reason, it is important to provide other visual cues to indicate the bikeway for both people riding bikes and snow plow vehicles. Possible locations for snow storage include the buffer area of protected bikeways, in the place of parked cars in parking-protected bike lanes and along the furnishing zone of the sidewalk. Piling snow in these locations all help to visually define the path of travel and help snowplows operators identify curblines. Being able to identify curblines becomes especially critical when the bike facility bends in or out around curb extensions, median islands or other transitions.

Figure 19 Recessed thermoplastic bike lane indicators in Denver, CO.

Figure 20 Vertical delineators help inform snow plow drivers of obstacles such as cycletracks, raised medians and bulb-outs in Bozeman, MT.

Small snowplow vehicles

When typical snowplows are too wide to fit, the community can consider using smaller, more specialized vehicles. These specialized small snowplows are becoming particularly important for bikeways that have widths smaller than a typical travel lane, such as separated bike lanes and shared-use paths.

Many communities that experience harsh winter climates maintain a fleet of these specialized small snowplows, which are sometimes referred to as 'downsized street maintenance vehicles' since they can be repurposed for other uses throughout the year. Where used, communities have found that smaller vehicles are effective for cleaning and plowing protected bike lanes, sidewalks and multiuse paths. The smaller vehicles can also supplement maintenance activities on other public facilities, such as narrow streets, parking lots, garages, basketball courts and pedestrian malls.

In addition to making the transportation network more accessible during the winter, **cities report operating cost savings and reduced emissions** stemming from the greater fuel efficiency of smaller vehicles. Some agencies in the Denver region have even tested battery-electric mini plow vehicles, which can further reduce emissions but require careful consideration of battery range and access to charging infrastructure. On the other hand, utilizing existing maintenance vehicles such as pickup trucks with mounted snow blades may prove to be much more cost-effective and time-efficient than purchasing smaller vehicles which operate at slower speeds and have smaller plow blades. Regardless, the design of shared-use paths and bicycle facilities will need to consider how the snow removal vehicles will access the facility.

Small snow plow vehicle classes

Due to their wide-ranging application, downsized street maintenance vehicles come in many different shapes and sizes. Many small utility vehicles such as pick-up trucks, tractors, ATVs, mini-loaders, bombardiers, skid-steers and even lawn mowers can be equipped with snow removal devices.

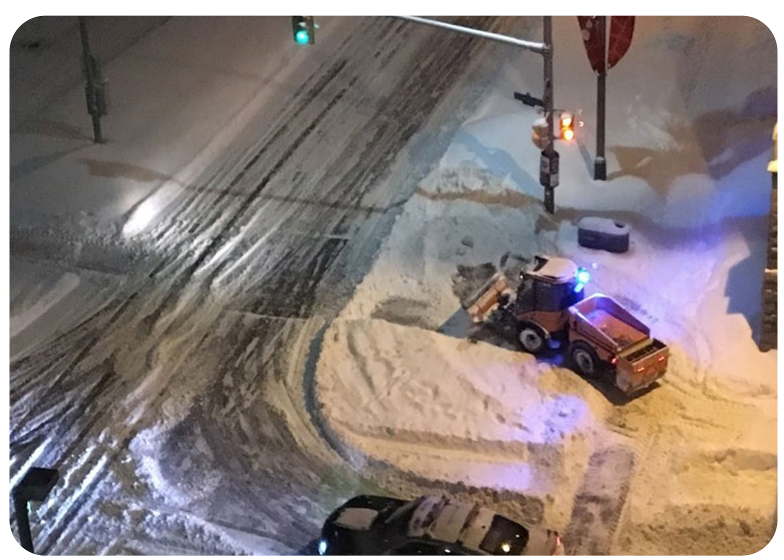


Figure 21 A small snowplow vehicle clears sidewalks in Salt Lake City, UT.

Typically, these small vehicles are either equipped with snow plows, snow brushes (effective for removing light snow) or snow blowers (effective for heavy snow). Many small snow removal vehicles can also be equipped with de-icing applicators as well, such as briners and drop spreader salters. Even more specialized attachments can include rotary sweepers and power washers, which extend the vehicle's utility year-round.

The combination of vehicle and attachment will change the clearance width and turning radius of the unit, affecting where it can be used. Among the options currently available on the market, clearance widths range from 4 feet - 12 feet with many vehicles being approximately 5 - 5.5 feet. **NACTO reports** a good rule of thumb for estimating the right size plow for a bike lane: the biggest one that isn't too big.

Fleet size and composition

The downsized street maintenance vehicle fleet size and composition differ for every jurisdiction and depend on climate, use cases and existing (and planned) active transportation network size. Boston, for example, owns 21 compact sweeping and plowing vehicles from six different vendors (each providing unique functions and utility) - largely because of the number of pedestrian plazas in the city combined with its bike network. Salt Lake City, however, needs only one sweeper for its protected bike lanes (3 miles) and 2 compact plows for the rest of its bike network. The City of Waterloo in Canada (population of approximately 120,000) maintains its network of sidewalks, paths and raised separated bicycle lanes with eight trackless compact plows (in addition to other larger vehicles).

Recommendations

When procuring downsized street maintenance vehicles, jurisdictions in the Denver region should consider the following factors.

Test

- A "try before you buy" strategy is recommended to make sure the vehicles meet particular needs, including size, maneuverability, traction, capacity, reliability and attachment customization and modification.
- Before the acquisition process begins, it is important that maintenance staff demo the equipment personally to familiarize themselves with the new vehicles and gain an understanding of the benefits of compact equipment. Peer communities report that staff buy-in is particularly important to smooth deployment of a winter maintenance program.

Comfort

- Public agencies should consider features that make using the vehicles safer and more comfortable, such as heated cabs, windshield wipers and larger cab interiors to accommodate larger drivers. This will help staff complete longer shifts.

Timing

- Public agencies should time the purchase and delivery of the vehicles (which may take a significant amount of time) to be used immediately in the upcoming winter to maximize their value (i.e., avoid a springtime delivery).

Training

- Public agencies should provide annual vehicle training for operators and work to share the vehicles with other departments to maximize their utility. This will require sustained and robust coordination as some departments struggle to handle an increased volume of clearing work without a corresponding increase in resources.

Typical snowplow vehicle class examples

There are many snowplow vehicle classes and names vary among vendors. The actual models and names may differ depending on the manufacturer. The table below loosely organizes the many types of snowplows from smallest to largest clearance widths.

Table 6 Typical snowplow vehicle class

Category	Approximate clearance width	Generic name
Small	1 – 3 ft	Manual snow blower
Small	4 ft	Small ATV
Small	4 ft	Miniature tractor/converted mower
Small	3 – 4.5 ft	Mini-loader
Medium	4.5 – 5.5 ft	Tracked snow removal vehicle
Medium	5 – 6 ft	Trackless tractor/vehicle
Medium	5 – 6 ft	Skid steer loader
Large	5 – 6 ft	Large ATV/utility vehicle
Large	7 – 8.5 ft	Pick-up truck
Large	8 – 12 ft	Tractor

Winter maintenance programming

A good winter maintenance program requires a maintenance plan that prioritizes facilities, establishes a maintenance schedule for frequent clearing and sets operational standards for maintenance relating to facility design, equipment and materials.

Figure 22 Snow storage spills out onto a separated bike lane reducing the path of travel along this block in Cambridge, MA.

Prioritization and scheduling is a key component of a successful winter bikeway program. For most jurisdictions, keeping all bikeways completely clear during or immediately after a heavy snow event is infeasible. Clearing major bikeways as soon as possible provides the best access to the greatest number of people possible following a heavy storm event.

The major bikeway network and winter maintenance program should focus on major local destinations. If roadway clearing and de-icing begins first thing in the morning, primary routes leading to schools, commercial corridors and business districts and other major destinations should be cleared first.

Coordination between agencies and departments responsible for on-street bikeways and shared-use paths is necessary to ensure the major bikeway networks are plowed in an organized, complete and timely matter.

In Järvenpää, Finland, Class A routes, the main bikeway routes from residential areas to the city center and through the city center, are cleared first. This is followed by Class B routes, bikeways along other major roads and Class C routes, those along residential streets and through parks.

- Class A routes are plowed within four hours of three cm of snow accumulation and de-icing treatments are applied before 7 a.m. Plowing is done before 7 a.m. when snowing at night.
- Class B routes are plowed within four hours of five cm of snow accumulation and de-icing treatments are applied as needed. Plowing is done before 7 a.m. when snowing at night.
- Class C routes are plowed after class B routes and plowing is done before 10 a.m.
- Sand and road grit is cleared from Class A, B and C bikeways in Järvenpää every year before the 1st of May.

The Wisconsin Department of Transportation also offers guidance on the prioritization of snow removal from shared-use paths (Wisconsin Bicycle Facility Design Handbook, 2009 p. A-4, A-5):

- Winter use varies according to local conditions. In some communities (e.g. Eau Claire, Madison), shared-use paths are plowed regularly and are used frequently by people walking and bicycling. Heavily-used paths that serve key destinations should be considered first for plowing. Even paths that serve only occasional use should be considered for snow removal if the path is the only means of making a key connection (e.g., crossing a bridge). Lower priority may be given to isolated trails that serve recreational users who must travel long distances to use them. In these cases, managers may want to allow use by cross country skiers or snowmobile operators as long as all applicable laws are followed.
- To ensure that winter use is properly accommodated, agencies must clearly understand who will maintain what bikeway. For shared-use paths along state highways, a municipality will have the responsibility for maintenance. Winter use and snow removal frequency will be determined by the municipality after considering the following expected use by bicyclists and pedestrians and parallel options for bicyclists and pedestrians if the shared-use path is not passable.

The City of Boulder recently added four segments of the on-street bike network to the city's Snow and Ice Response plan as pilot routes for winter 2024-2025. These segments were highly requested for snow clearing during community engagement for our recent Snow and Ice Response Review.

- The goal of the Winter Response Pilot Program is to better connect the network of lower-stress on-street biking options that are accessible during the winter. Due to staffing limitations, these segments will be cleared at the end of snow response operations for medium (three to eight inches of snow) and large (over eight inches of snow) storms.

A good winter maintenance program requires a maintenance plan that prioritizes facilities, establishes a maintenance schedule for frequent clearing and sets operational standards for winter maintenance relating to facility design, equipment and materials.

Case Study: Lessons learned from summer and winter servicing of Toronto's cycling network

Winter service levels

The City of Toronto, Ontario, is a city where, despite regular snowfall, bicycle volumes remain at 20-30% of the peak summer volumes even in the winter. Recently, the city changed its winter service levels and now has a standard of 60% bare pavement for snow clearance.

Before 2025, raised separated bicycle lanes received separate servicing from painted bike lanes, which would be serviced on the same schedule as the roadway classification it was on. However, this method of servicing bike lanes was found to be mismatched to the needs of the bikeway. The method was inadequate on roadways like arterials, where a large plow would clear the roadway of snow but, due to its size and other factors, would often fail to adequately clear the bike lane, especially if there were parked cars or other obstacles. The city has now elevated the service levels of bike lanes at the request of its Council. While the city relies on contractors to clear on-street facilities, it has moved all its shared-use paths servicing in-house.

Figure 23 Presentation from the City of Toronto. (Source: City of Toronto)

Key finding: Servicing on-street bike lanes may require a separate schedule to the servicing of other travel lanes, because bikeways can sometimes require special considerations and attention to remain viable paths of travel.

Replacing parts

Prior to 2025, the City of Toronto relied on 311 service requests and in-house patrollers utilizing city vehicles to identify maintenance issues on their bicycling network. However, staff found that this method was limited in its ability to identify issues. Starting in the spring of 2025, staff will be relying on in-house patrollers using e-bikes to assess bikeway conditions. The patrollers will still utilize the 311 codes for recording issues, the most common of which are damaged bike lane barriers (flex post bollards). For scale, the city reported fixing 3,417 bollards between 2023 and 2025 and only 10 pre-cast curbs (though this figure doesn't include realigning pre-cast curbs, which is a regular need).

The City of Toronto found that it was struggling to maintain its network via contractor agreements. Minor fixes to bikeways weren't worth the effort; thus, the city moved these activities in-house for faster service times. The city has also invested in small sweepers to sweep its protected bikeways twice a month, with special attention during the fall.

> **Key finding**: The City of Toronto finds that raised separated bicycle lanes and poured-in-place materials are the simplest to maintain, although they are more expensive and complex to design and build. The city reports that as quick-build networks expand, maintenance needs also increase, so upgrading quick-build bikeways is critical to reducing long-term maintenance burden .

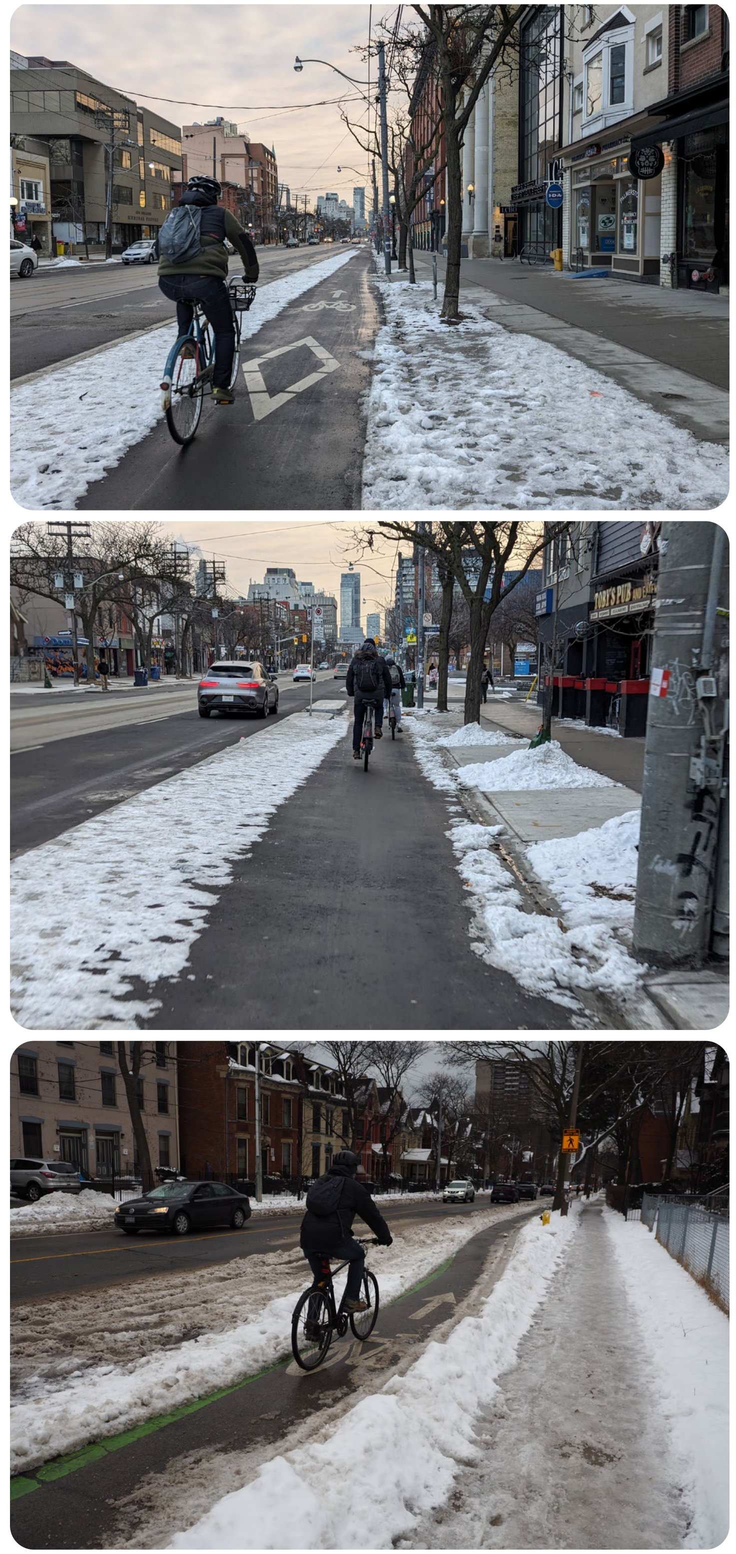


Figure 24 Example of 60% bare pavement (Source: City of Toronto)

Toronto's experience highlights the importance of adapting maintenance and servicing practices to meet the unique needs of an evolving cycling network. As the city's bikeway infrastructure has expanded, particularly through quick-build approaches, it has become clear that maintenance strategies must evolve in tandem. Whether by adjusting winter service standards, transitioning work in-house for greater efficiency, or deploying patrollers on e-bikes to better monitor conditions, Toronto demonstrates that proactive, bike-specific solutions are key to supporting year-round ridership.

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