



BICYCLE FACILITY

DESIGN MANUAL

ACKNOWLEDGMENTS

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PROJECT TEAM

MnDOT Project Managers and Staff

Melissa Barnes, MnDOT Metro District North Area Manager

Sonja Piper, MnDOT Office of Traffic Engineering

Hannah Pritchard, MnDOT Office of Transit and Active Transportation

Angela Rehbein, MnDOT Office of Communications

Liz Walton, MnDOT Office of Transit and Active Transportation

Project Advisory Committee

Simon Blenski, City of Minneapolis Public Works

Sara Buermann, Wright County Traffic Engineer

Amber Dallman, MnDOT Office of Transit and Active Transportation

Todd Grugel, MnDOT ADA Design and Construction

Andrea Hendrickson, MnDOT Hydraulics

Paul Johns, MnDOT Construction

Nick Mason, Bicycle Alliance of Minnesota

Michelle Moser, MnDOT Design Standards

Mike Kempinger, MnDOT Design – District 6

Jordan Kocak, Hennepin County Bicycle and Pedestrian Coordinator

Jon Mason, MnDOT Planning – District 3

Sara Pflaum, MnDOT State Aid

Dan Prather, MnDOT Bridge Office

Philip Schaffner, MnDOT Office of Transportation System Management

Kent Skaar, Minnesota Department of Natural Resources, Trails and Waterways

Will Stein, Federal Highway Administration

Mackenzie Turner Borgen, MnDOT Metro District Pedestrian & Bicycle Coordinator

Bob Vasek, MnDOT Maintenance Office

Jim Weatherhead, MnDOT Rail

Technical Advisory Committee

Melissa Barnes, MnDOT Metro North Area Engineer

Kristie Billiar, MnDOT ADA Program and Policy Coordinator

Bruce Holdhusen, MnDOT Design Flexibility Unit

Jamal Love, MnDOT Geometric Design Support Unit

Jim Rosenow, MnDOT Design Flexibility Unit

Consultant Team

Alta Planning and Design: Colin Harris, Joe Gilpin, Maria Wardoku, Kent Laughlin

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City of Minneapolis

Hennepin County

DISCLAIMER

The manual was developed based on national design standards and accepted industry practices, in particular the American Association of Highway Transportation Officials *Guide for the Development of Bicycle Facilities* (2012 edition and 2020 draft). The manual should be used in conjunction with the current versions of the MnDOT *Road Design Manual* and the *Minnesota Manual on Uniform Traffic Control Devices*. The manual is not intended as a legal standard, and all design guidance should be considered with engineering judgment.

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INTRODUCTION



Introduction

The Minnesota Department of Transportation is dedicated to supporting a multimodal transportation system that maximizes the health of Minnesota's people, the environment and economy. Bicycling is an important part of that system and MnDOT is committed to supporting bicycling as a form of transportation.

The Bicycle Facility Design Manual is organized to help designers make decisions from the earliest project planning phases through to maintaining facilities. It encourages design flexibility based on land use context and provides design guidance that is to be applied consistently to improve the safety and mobility of all roadway users— people walking, bicycling and driving.

Through the development of the [Statewide Bicycle System Plan](#) and extensive public outreach, MnDOT learned that the majority of people prefer bicycling on low-stress facilities separated from motor vehicle traffic.¹ This manual provides designers information to create projects and a complete transportation system that are:

- Usable
- Balanced
- Flexible
- Maintainable

Purpose of this Manual

This document is intended to be a resource for MnDOT planners and designers to plan for and implement context-appropriate bicycle facilities within MnDOT right-of-way. The Bicycle Facility Design Manual was developed for use by MnDOT staff. However, the design guidance within may also be a resource for planners and designers working on the broader network of streets, paths and trails within the state, subject to the judgment of individual localities as well as to other local governing criteria. Other agencies and advocates for bicycling may find the manual a useful reference.

***MnDOT's vision
for bicycle
transportation:
"bicycling is safe,
comfortable and
convenient for all
people."***

The Bicycle Facility Design Manual reflects and helps fulfill MnDOT's vision, mission and core values to plan, build, operate and maintain a safe, accessible, efficient and reliable multimodal transportation system that maximizes the health of people, the environment and our economy by connecting people to destinations and markets throughout the state, regionally and locally (EXHIBIT 1-1: MnDOT's Vision, Mission and Core Values).

This manual also helps MnDOT advance its statewide bicycle vision and goals and provide facilities the public values. As stated in MnDOT's Statewide Bicycle System Plan, bicycling contributes to the quality of life for people in Minnesota by connecting them to daily activities and creating access to the state's amenities.

MnDOT's vision for bicycle transportation is that "bicycling is safe, comfortable and convenient for all people." In order to achieve this vision, MnDOT staff should design for the majority bicyclist type, identified as Interested but Concerned, who prefer a low-stress facility with clear separation from motor vehicles (see Chapter 3).

This manual provides information on how to design Minnesota's transportation system to support bicycling. Though some of the information in this manual will apply to pedestrian design, the document focus is bicycle design. Providing connected networks of comfortable and safe bicycle facilities is an important factor to support and increase the use of bicycling for transportation.



DESIGN FLEXIBILITY

This manual is intended to provide clear guidance; however, in cases where there is limited research for clear guidance, this manual includes information for decision-making through design flexibility. Design flexibility encourages engineering judgement based on factors within the broad context of the roadway's motor vehicle traffic volumes and speeds. This method is not highly prescriptive; therefore, arriving at answers to design questions may be more difficult and involve more conversations, thoughtfulness, consideration and collaboration. Documenting the considerations and collaboration that go into such designs reduces liability and should result in a successful project that contributes to MnDOT's overall transportation goals and a more complete network.



VISION

Minnesota's multimodal transportation system maximizes the health of people, the environment and our economy.



MISSION

Plan, build, operate and maintain a safe, accessible, efficient and reliable multimodal transportation system that connects people to destinations and markets throughout the state, regionally and around the world.



CORE VALUES

Safety
Excellence
Service
Integrity
Accountability
Diversity and Inclusion

EXHIBIT 1-1: MnDOT's Vision, Mission and Core Values

Scope and Context of this Manual

This 2020 Minnesota Bicycle Facility Design Manual supersedes the 2007 Minnesota Bikeway Facility Design Manual. This manual provides the information necessary to develop safe, consistent and predictable bicycle facilities along MnDOT's trunk highway system.

Design balance is critical to establishing a cost effective and contextually appropriate multimodal transportation network within the existing space on Minnesota's roadways. This manual promotes flexibility and innovation in planning, designing, constructing and maintaining bicycle facilities. Designers should:

- **Use these guidelines to the maximum extent possible and in concert with other state and national policies and resources.**
- **Always employ professional engineering judgment when applying these guidelines to any particular situation.**
- **Never use the guidelines to justify planning or building to a lesser standard or denying accommodation.**

The MnDOT Bicycle Facility Design Manual should be used in conjunction with current versions of the [MnDOT Road Design Manual](#)² and the [Minnesota Manual on Uniform Traffic Control Devices](#).³ The design guidance in this manual is largely adapted from current national bicycle design guidance and accepted industry practices, including the American Association of Highway Transportation Officials Guide for the Development of Bicycle Facilities (2012 and 2020 draft)⁴, [Federal Highway Administration Separated Bikeway Planning and Design Guide](#)⁵ and [FHWA Bikeway Selection Guide](#).⁶

This manual is not intended as a legal standard. Rather, it presents vital engineering information typically required to design a new or retrofitted facility. This design guidance should be integrated with engineering judgment and balanced with social, economic and environmental factors in association with state and local plans to yield appropriate designs suitable for unique circumstances.

While this manual is intended for use by MnDOT designers, local agencies may choose to use it as a reference. Local agencies using state and/or federal funding for their projects should follow [Minnesota Rules Chapter 8820](#).⁷ Local agencies should consult their District State Aid Engineer to understand how this guidance relates to those rules.



Using This Manual

Information in the manual is organized in chapters as follows:

- 1 **Laws, policies and plans** (Chapter 1). The federal and state context for bicycle facility planning and design guides the recommendations in this manual. Content includes: federal laws and policies, state laws and MnDOT policies and plans.
- 2 **Scoping, planning and project coordination** (Chapter 2). Successful bicycle facilities depend on early and comprehensive planning decisions. Content includes: design flexibility, project planning, scoping and development, bicycle network planning, public and stakeholder engagement and equity.
- 3 **Facility selection** (Chapter 3). Appropriate facility selection is critical in achieving MnDOT's goal to provide a safe, accessible, efficient and reliable multimodal transportation system where bicycling is safe, comfortable and convenient for all people. Content includes: types of bicyclists, level of traffic stress, bicycle facility selection and demonstration projects.
- 4 **Operational characteristics and elements of design** (Chapter 4). Though people bicycling have similar access and mobility needs as other users of the transportation system, some needs differ. Content includes: bicyclist characteristics, corridor transitions, signals, signs and pavement markings and general intersection design principles.
- 5 **Bicycle facilities** (Chapter 5). The six bicycle facility types are organized from most separated from motor vehicle traffic to least separated. Content includes: shared use path, sidepath, separated bike lane, bike lane, paved shoulder, and shared roadway.
- 6 **Maintenance** (Chapter 6). A well-maintained bicycle facility requires early discussions to ensure it is safe, comfortable and appropriately prioritized to ensure functional, year round access. Content includes: facility selection and its effect on maintenance needs, design, construction and operation considerations.
- 7 **Additional design elements** (Chapter 7). Some projects require additional design decisions to ensure safe and convenient network connections and crossings. Content includes: medians, roundabout, railroad crossings, interchanges, bridges, tunnels and underpasses and bike parking.
- 8 **Appendices** (Chapter 8). Content includes supplementary information such as endnotes, acronyms and abbreviations and definitions.

Federal Law, Policy, and Guidance

Federal laws and policies encourage MnDOT to support bicycling as part of Minnesota's transportation system. MnDOT designers and planners should become familiar with federal legislation and FHWA guidance that exist to serve, protect and enhance bicycle transportation.

FIXING AMERICA'S SURFACE TRANSPORTATION ACT

The [2015 Fixing America's Surface Transportation Act](#)⁸ is the current guiding federal law that requires states to plan for and build connected networks for bicycles and pedestrians and provide federal funds for some highway programs. In September 2019, the FHWA updated their guidance to reflect small changes made by the FAST Act and includes new planning and design resources developed since 2015.

FAST Act highlights include:

- "Bicyclists and pedestrians shall be given due consideration in the comprehensive transportation plans developed by each metropolitan planning organization and State..." (23 U.S.C. 217(g)(1))
- "Bicycle transportation facilities and pedestrian walkways shall be considered, where appropriate, in conjunction with all new construction and reconstruction of transportation facilities, except where bicycle and pedestrian use are not permitted." (23 U.S.C. 217(g)(1))
- "Transportation plans and projects shall provide due consideration for safety and contiguous routes for bicyclists and pedestrians." (23 U.S.C. 217(g)(2))
- "In any case where a highway bridge deck being replaced or rehabilitated with Federal financial participation is located on a highway on which bicycles are permitted to operate at each end of such bridge, and the Secretary determines that the safe accommodation of bicycles can be provided at reasonable cost as part of such replacement or rehabilitation, the such bridge shall be so replaced or rehabilitated as to provide such safe accommodations." (23 U.S.C. 217(e)).

- The Highway Safety Improvement Program is established in the FAST Act. HSIP requires MnDOT to provide regular updates to FHWA regarding "motor vehicle crashes that include fatalities or serious injuries to pedestrians and bicyclists." (23 U.S.C. 148(d)(1)(B)) HSIP funds may be spent on highway safety improvement projects on "any public highway or publicly owned bicycle or pedestrian pathway or trail." (23 U.S.C. 148(e)).

AMERICANS WITH DISABILITIES ACT

The [Americans with Disabilities Act](#)⁹, enacted on July 26, 1990, is a civil rights law prohibiting discrimination against individuals on the basis of disability. Title II of the Americans with Disabilities Act guarantees the rights of individuals with disabilities to equal access to the services, programs, and activities of public entities. As a provider of public transportation services and programs, MnDOT must comply with this section of the Act as it specifically applies to state public service agencies and state transportation agencies. Title II of ADA provides that, "...no qualified individual with a disability shall, by reason of such disability, be excluded from participation in or be denied the benefits of the services, programs, or activities of a public entity, or be subjected to discrimination by any such entity."⁹

US DOT POLICY STATEMENT ON BICYCLE AND PEDESTRIAN ACCOMMODATION REGULATIONS AND RECOMMENDATIONS

“The DOT policy is to incorporate safe and convenient walking and bicycling facilities into transportation projects. Every transportation agency, including DOT, has the responsibility to improve conditions and opportunities for walking and bicycling and to integrate walking and bicycling into their transportation systems. Because of the numerous individual and community benefits that walking and bicycling provide — including health, safety, environmental, transportation, and quality of life — transportation agencies are encouraged to go beyond minimum standards to provide safe and convenient facilities for these modes.”

AASHTO POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS (THE GREEN BOOK)

By federal law, FHWA must adopt geometric standards for the National Highway System. State transportation departments work with FHWA through AASHTO to develop these design standards, which are often applied to non-NHS roads.

The seventh edition of the Green Book presents a framework for geometric design that is more flexible, multimodal, and performance-based than in the past.¹⁰ In its [adoption](#) of the 2018 Green Book, FHWA “encourages the use of flexibility and a context-sensitive approach to consider a full range of project and user needs and the impacts to the community and natural and human environment.”



State Laws and Statutes

In addition to federal laws and policies, state laws encourage MnDOT to support bicycling as part of Minnesota's complete and multimodal transportation system. For MnDOT to achieve its vision, mission and core values, MnDOT designers and planners should become familiar with state legislation that exists to define, serve, protect and enhance bicycle transportation. The three chapters of the Minnesota Statutes that are most applicable to bicycling are:

- Chapter 160 – Roads, General Provisions
- Chapter 169 – Traffic Regulation
- Chapter 174 – Department of Transportation

Some of the relevant statutes as of 2019 are described below. The full text of the statutes is available online from the [Office of the Revisor of Statutes](#).¹¹

MNDOT'S AUTHORITY AND RESPONSIBILITY TO PROVIDE FOR SAFE BICYCLING

Planning and Building Bikeways:

174.01 CREATION; POLICY.

Subdivision 1: Creates the Department of Transportation to "provide an integrated transportation system of aeronautics, highways... including facilities for walking and bicycling."

Subdivision 2: Transportation Goals

Identifies goals for the state transportation system which include:

- **Subd. 2(2)** "to provide multimodal and intermodal transportation facilities and services to increase access for all persons and businesses and to ensure economic well-being and quality of life without undue burden placed on any community;"
- **Subd. 2(14)** "to promote and increase bicycling and walking as a percentage of all trips as energy-efficient, nonpolluting, and healthy forms of transportation;"

160.262 BIKEWAYS.

- **Subd. 1(a)** Authorizes MnDOT to "...plan, design, establish, and maintain bikeways on the right-of-way of any trunk highway must consider the development of bikeways during the planning, design, construction, reconstruction, or improvement of any trunk highway, or allow the establishment of such bikeways within trunk highway right-of-way."
- **Subd. 1(b)** "The commissioner must maintain bikeway design guidelines consistent with the state transportation goals in section 174.01."

Maintaining and Replacing Bikeways:

160.262 BIKEWAYS.

- **Subd. 1(d)** MnDOT must "...maintain bikeways within the limits of trunk highway right-of-way unless a written agreement or limited use permit provides otherwise..."

160.264 REPLACING BIKEWAYS AND PEDESTRIAN WAYS

"Whenever an existing bikeway, pedestrian way, or roadway used by bicycles or pedestrians or the sole access to such is destroyed by any new, reconstructed, or relocated federal, state, or local highway, the road authority responsible shall replace the destroyed facility or access with a comparable facility or access. Replacement is not required where it would be contrary to public safety or when sparsity of population, other available ways or other factors indicate an absence of need for such facility or access."

BICYCLE, ELECTRIC-ASSIST BICYCLES, AND SCOOTERS

169.011 DEFINITIONS.

- **Subd. 4(a) and 4(b) Bicycle** Defines bicycle "... Bicycle includes an electric-assisted bicycle... and ..." Bicycle does not include scooters, motorized foot scooters, or similar devices..."
- **Subd. 27 Electric-assisted bicycle** defines electric-assisted bicycle.

169.222 OPERATION OF BICYCLE.

Subd. 4(g) Riding Rules "... A person may operate an electric-assisted bicycle on the shoulder of a roadway, on a bikeway, or on a bicycle trail if not otherwise prohibited..."

PLACES TO BIKE

Definition of a Bikeway:

160.02 Subd. 1a. and 169.011 Subd. 9

Definition of a Bicycle Lane, Path, Route, or Trail:

169.011 Subd. 5, 169.011 Subd. 6, 169.011 Subd. 7, and 169.011 Subd. 8 respectively

State Bicycle Routes:

160.266 State Bicycle Routes defines state bike route, the process to create one, and funding eligibility

RIGHTS AND RESPONSIBILITIES OF BICYCLISTS

Biking on Roads and Shoulders:

169.222 OPERATION OF BICYCLE.

- **Subd 1. Traffic laws apply** "Every person operating a bicycle shall have all of the rights and duties applicable to the driver of any other vehicle..."

- **Subd 4(b) Riding Rules** "If a bicycle is traveling on a shoulder of a roadway, the bicycle shall travel in the same direction as adjacent vehicular traffic..."

169.305 CONTROLLED-ACCESS RULES AND PENALTIES.

- **Subd. 1(c) and 1(d)** – MnDOT may "...prohibit or regulate the use of any such highway by pedestrians, bicycles, or other nonmotorized traffic, or by motorized bicycles..." and "...shall erect and maintain official signs on the controlled-access highway on which such rules are applicable..."

Biking on Sidewalks:

169.222 OPERATION OF BICYCLE.

Subd. 4(d) Riding Rules – "No person shall ride a bicycle upon a sidewalk within a business district unless permitted by local authorities. Local authorities may prohibit the operation of bicycles on any sidewalk or crosswalk under their jurisdiction."

169.011 DEFINITIONS.

Subd. 13.Business District 'Business district' means the territory contiguous to and including a highway when 50 percent or more of the frontage thereon for a distance of 300 feet or more is occupied by buildings in use for business."

Using Crosswalks:

169.222 OPERATION OF BICYCLE.

Subd. 4(f) Riding Rules "A person lawfully operating a bicycle on a sidewalk, or across a roadway or shoulder on a crosswalk, shall have all the rights and duties applicable to a pedestrian under the same circumstances."

Yielding to Pedestrians:

169.222 OPERATION OF BICYCLE.

Subd. 4(d) Riding Rules "A person operating a bicycle upon a sidewalk, or across a roadway or shoulder on a crosswalk, shall yield the right-of-way to any pedestrian and shall give an audible signal when necessary before overtaking and passing any pedestrian..."

RIGHTS AND RESPONSIBILITIES OF DRIVERS

Overtaking Bicyclists

169.18 DRIVING RULES.

- **Subd. 3(3) Passing** “...The operator of a motor vehicle overtaking a bicycle or individual proceeding in the same direction on the roadway shall leave a safe distance, but in no case less than three feet clearance, when passing the bicycle or individual and shall maintain clearance until safely past the overtaken bicycle or individual.”
- **Subd. 5(c) Driving left of roadway center; exception** “... a motor vehicle may be driven to the left side of the roadway to safely overtake a bicycle” under certain circumstances.”

Driving in the Bike Lane

169.18 DRIVING RULES.

- **Subd.4(4) Passing on the right** “In no event shall such movement [passing on the right] be made by driving in a bicycle lane or onto the shoulder, whether paved or unpaved, or off the pavement or main-traveled portion of the roadway.”
- **Subd.7(4) Laned highway** “...Whenever a bicycle lane has been established on a roadway, any person operating a motor vehicle on the roadway shall not drive in the bicycle lane except to perform parking maneuvers..., to enter or leave the highway, to prepare for a turn...or to stop a school bus...”

Parking in the Bike Lane

169.34 PROHIBITIONS; STOPPING, PARKING

- **Subd.1(a)(14)** “No person shall stop, stand, or park a vehicle, except when necessary to avoid conflict with other traffic or in compliance with the directions of a police officer or traffic-control device, in any of the following places:...within a bicycle lane, except when posted signs permit parking.”



MnDOT Policy & Plans

MnDOT plans for the ways people and goods move throughout Minnesota — individually for each mode and together as a multimodal system. It has developed a [“family of plans”](#) under Minnesota GO.¹² MnDOT has many policies and plans, those noted below particularly relate to enhancing Minnesota’s bicycle network.

MINNESOTA GO

[Minnesota GO](#)¹² is MnDOT’s 50-year vision to better align Minnesota’s transportation system with what Minnesotans expect to support their quality of life, economy and natural environment. It recognizes that infrastructure is only one of many elements necessary to achieving a high quality of life, a competitive economy and a healthy environment. Minnesota GO describes the preferred future for transportation. It asks “what are we trying to achieve?” It does not answer “how will we do it?” This is addressed in MnDOT’s statewide and modal plans, as well as through tribal, regional and local planning efforts.

STATEWIDE MULTIMODAL TRANSPORTATION PLAN

The [SMTP](#) is Minnesota’s highest level transportation policy plan and is used to ensure Minnesota’s transportation system maximizes the health of people, the environment and the economy and that it is accessible and safe for users of all abilities and incomes.¹³

The plan focuses on [five objectives](#), which are listed below.¹⁴ To help ensure MnDOT makes progress in the coming years, each objective includes related strategies for MnDOT and transportation partners including a list of related performance measures. Taken together, each supports Minnesota’s bicycle transportation vision and helps address changes affecting Minnesota. See Chapter 5 of the SMTP for a complete list of the objectives, strategies and performance measures.

1. Open decision-making: Make transportation system decisions through processes that are inclusive, engaging and supported by data and analysis. Provide for and support coordination, collaboration and innovation. Ensure efficient and effective use of resources.

2. Transportation safety: Safeguard transportation users as well as the communities the systems travel through. Apply proven strategies to reduce fatalities and serious injuries for all modes. Foster a culture of transportation safety in Minnesota.

3. Critical connections: Maintain and improve multimodal transportation connections essential for Minnesotans’ prosperity and quality of life.

4. System stewardship: Strategically build, manage and operate all transportation assets. Rely on system data and analysis, performance measures and targets, agency and partners’ needs and public expectations to inform decisions. Use technology and innovation to get the most out of investments and maintain system performance. Increase the resiliency of the transportation system and adapt to changing needs.

5. Healthy communities: Make fiscally-responsible decisions that respect the cultural, social and economic context. Integrate land uses and transportation systems to leverage public and private investments.

MnDOT updates this twenty-year plan every five years to account for shifts and changes in the state’s demographics, technology, environment, economy and travel behavior. The SMTP notes that “data suggest that more investment in transit, bicycling and walking infrastructure would encourage people to use these modes more often.” Anticipating trends in transportation behavior will help MnDOT meet the needs of road users and move people and goods safely and efficiently.

STATEWIDE BICYCLE SYSTEM PLAN

The [Statewide Bicycle System Plan](#)¹ presents MnDOT's vision and goals for bicycle transportation, implementation strategies, and performance measures to evaluate progress toward achieving the SBSP vision and goals. During the SBSP's public engagement process, MnDOT found that the public values state bicycle routes, but values opportunities to enhance local and regional bicycle connections even more. People also indicated that they prefer to ride on facilities that provide clear separation from motor vehicles.

The SBSP identifies four goals.

- **Safety and comfort:** build and maintain safe and comfortable bicycling facilities for people of all ages and abilities
- **Local bicycle network connections:** support regional and local bicycling needs
- **State bicycle routes:** develop a connected network of state bicycle routes with partners
- **Ridership:** increase ridership of people who already bicycle and people who don't

Local and regional bicycle networks support trips within and around communities. To support the public's desire for local connections, MnDOT committed in the SBSP to focus efforts to improve the safety and comfort of local bicycle facilities by investing in infrastructure along or across state trunk highways – even if not part of a designated state bicycle route or a district bicycle plan. When people bicycling feel safe and comfortable, have convenient, available facilities, Minnesota will see an increase in the number of people bicycling.

The SBSP identifies strategies to support local bicycle networks, such as:

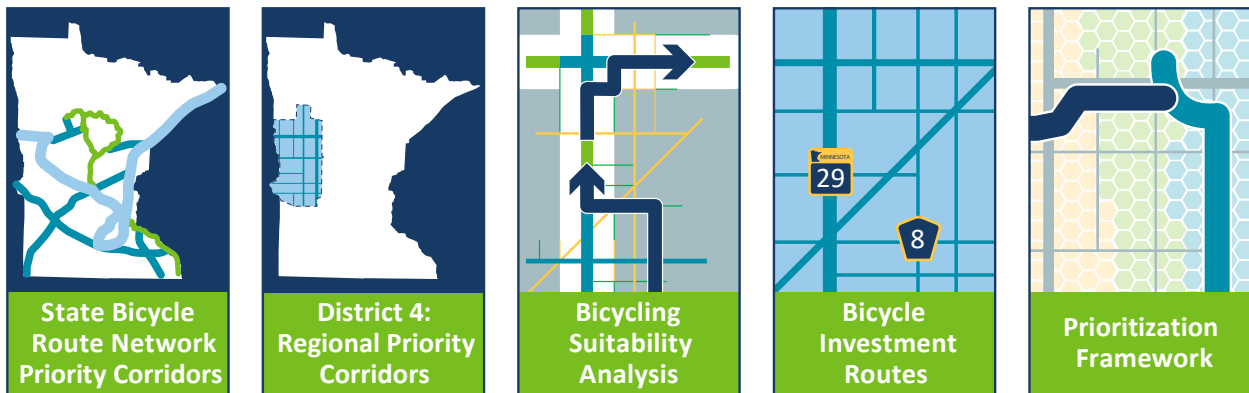
- Establishing a local bicycle planning technical assistance program to advance collaboration toward a bicycle system that conveniently connects people to important destinations by bicycle.
- Coordinate and consider regional and local partner participation in MnDOT plans and projects to efficiently respond to critical local and regional bicycle connections.

- Continue supporting efforts to allow local jurisdictions flexibility in choosing road designs that support bicycle travel.
- Build bicycle facilities that have the appropriate amount of separation from motor vehicles based on the local context.
- Develop a process to annually track bicycle infrastructure investments by MnDOT district and statewide.
- Formally include bicycling infrastructure as an asset in the Transportation Asset Management Plan.
- Continue bi-annual data collection to update bicycle-related information available for state, county and local roadways.
- Develop a bicycle safety plan using a data-driven, interdisciplinary approach that targets areas for improvement and employs proven countermeasures to enhance bicycling safety.

State trunk highways often create barriers or gaps in local bicycling networks. These barriers or gaps frequently inhibit access to destinations often deemed a reasonable bicycling distance, such as grocery stores, transit stops, parks, schools and similar day-to-day locations located adjacent to or across state trunk highways. MnDOT is committed to supporting safe and comfortable bicycle travel for people of all ages and abilities. This includes closing gaps in large infrastructure, such as bridges, overpasses and interchanges, which often last more than 50 years before reconstruction.

MnDOT is committed to improving the safety and comfort of local bicycle facilities by investing in infrastructure along or across state trunk highways – even if not part of a designated state bicycle route or a district bicycle plan.

EXHIBIT 1 -2: District Bicycle Plan Elements



DISTRICT BICYCLE PLANS

[MnDOT's District Bicycle Plans](#) are a key step toward realizing the vision of the SBSP.¹⁵ They are an investment guide jointly developed by MnDOT and local partners to provide a framework for bicycle investments in each of MnDOT's eight districts.

The purpose of each plan is to support local bicycle networks, prioritize MnDOT bicycle investments in each district and identify actions district staff can take to implement the SBSP strategies and achieve the SBSP goals and vision. Designers should consult the plan in the earliest project phases to ensure plan elements are factored into project scoping, planning and design. District planners led efforts to develop the district bicycle plans; therefore, they are familiar with the plans and can help designers with project scoping, public and stakeholder engagement and working through potential challenges that may come up during project development.

Each district formed a Technical Advisory Committee to help develop its plan. The TACs helped to identify investment routes, prioritized investment criteria. They now meet annually to share updates on bicycle projects in the region.

Greater Minnesota district plans include:

- State and regional bicycle route network priority corridors. These are corridors for future investment on the State Bicycle Network and may be designated as state bicycle routes or to enhance local and regional connections.

- Bicycle Investment Routes. Bicycle Investment Routes will guide future investments in bicycle facilities across each district. Routes were identified by district planning staff and with significant input from the TAC members. Some routes are located on MnDOT state trunk highways; others are located on local or regional roadways or shared use paths, and some follow future trail corridors.
- A framework to help MnDOT prioritize bicycle investments. MnDOT has a limited amount of funding available for bicycle infrastructure. The framework aggregated data of key characteristics to help each district identify and prioritize state trunk highway projects that have the greatest need for bicycle facility investment. The framework may also be used to estimate existing or potential demand for bicycle facilities in an area.
- Implementation strategies. Each plan provides strategies and actions to plan, program and maintain MnDOT's existing and planned bicycle facility network in a state of good repair. Each strategy is supported by a set of actions.

In Metro District, the district bike plan does not include specific investment routes. Rather, the plan provides planners and designers with information about local and regional routes and priorities that may apply to a particular trunk highway.

COMPLETE STREETS POLICY

MnDOT incorporates a Complete Streets approach to every project it delivers. Complete Streets is an approach to road planning and design that considers and balances the needs of transportation users of all ages and abilities. A Complete Streets approach helps maximize the use of public roadways and right-of-way to provide a comprehensive and connected multimodal transportation system. Complete Streets is one of several interrelated concepts, all existing under the over-arching philosophy of [Context Sensitive Solutions](#).¹⁶ CSS is the art of creating public works projects that meet the needs of users, neighboring communities and the environment.

MnDOT's Complete Streets policy statement says MnDOT "must follow a complete streets approach in all phases of planning, project development, operation and maintenance activities." One of the four policy goals is to "increase bicycling and walking as a percentage of all trips."¹⁷

The policy assigns responsibilities to MnDOT staff by discipline. In particular, traffic engineers and designers are to:

- Include all affected users in project safety reviews, road safety audits, traffic modeling, and intersection control evaluations
- Address the safety needs and ease of use of vulnerable users, especially in lower-speed environments and at intersections

MnDOT's Complete Streets policy states "districts should give higher priority to opportunities to address identified user needs on projects that meet the following criteria:

- Affected population includes a high proportion of individuals covered by [Title VI of the Civil Rights Act](#)¹⁸ and [Environmental Justice](#)¹⁹
- Have a higher probability of increasing the number of people biking, walking or taking transit, consistent with Minnesota Statutes §174.01
- Addresses a significant safety issue for vulnerable users
- Addresses a gap or barrier created by prior transportation investments
- Are identified in a local or regional plan

CONTEXT SENSITIVE SOLUTIONS

Context Sensitive Solutions is a collaborative, interdisciplinary approach that integrates projects into the context or setting in a sensitive manner through careful planning, considers different perspectives and tailors designs to particular project circumstances. It's an over-arching philosophy toward road design that leads to preserving and enhancing scenic, aesthetic, historic, community and environmental resources, while improving or maintaining safety, mobility and infrastructure conditions.



PERFORMANCE BASED PRACTICAL DESIGN

[Performance-Based Practical Design MnDOT Policy OP012](#), is a flexible approach to road and street engineering that “right sizes” projects to achieve the best transportation system MnDOT can afford.²⁰ Wider ranges of standard practice and greater acceptance of unconventional design decisions are essential in building facilities that are a good fit to user needs and community contexts. PBPD relies on using a flexible design approach and professional judgment to choose appropriate dimensions and parameters within, and sometimes outside, the ranges of standard nominal values.

PBPD is one of several interrelated concepts, all existing under the over-arching philosophy of CSS. MnDOT’s Performance Based Practical Design Guide recommends design flexibility using a data-driven approach and outcome-based way of thinking in an effort to consistently do more with less.

As noted in the PBPDG, building good projects means including context sensitivity, the mobility and safety of all users, environmental stewardship and more. The concepts of PBPD and design flexibility have been borne out of two primary recognitions:

1. The road building industry should do business in a more financially sustainable, results-oriented and context sensitive way.
2. A more flexible and data-driven design approach is necessary to realize this objective.

MnDOT planners and designers should follow PBPD procedures by consulting known PBPD resources during project development, exercising professional judgment and documenting design decisions. Every scoping and design decision should be based on whether the proposed feature will address the project’s stated outcomes as well as whether it represents a pragmatic use of funds. This approach is necessary for the development of a complete and functional transportation system in the long term.



A sampling of PBPDG language that relates to bicycle design includes:

- With the advent of CSS and complete streets, the spectrum of purpose, problem and goal has expanded to include factors related to livability as well as a broader definition of transportation need. Using PBPD, fundamental questions to be considered on every project are:
 - Whom are we serving?
 - What are we trying to achieve?
- Determining who we are serving is a precursor to identifying needs and problems, as that step will be incomplete without a full inventory of stakeholders and users.
- Consider Level of Service as a performance metric when evaluating design alternatives rather than a design parameter or criterion. Do not base design decisions solely on LOS, but as one of a number of factors to take into consideration in fashioning a practical, multimodal and context sensitive solution.
- Do not overemphasize control vehicle movements, which can degrade the safety and ease of use for the vast majority of users
- The nature of urban and suburban areas is a constantly-changing context. For that reason, downward revisions to design speed as part of corridor reconstructions are often appropriate to reflect changes in land use, density and modal usage since original construction. On urban streets, base design speed selection on context, practicality, driveway access frequency and the presence of nonmotorized users.
- Use a 10-foot travel lane width as the starting point when designing streets up to a design speed of 35 miles per hour.

As stated in the PBPDG, “projects that do not incorporate [these] principles steal from concurrent needs elsewhere on the system, as well as from other needs and projects in the future.”

TECHNICAL MEMORANDA

MnDOT issues technical memoranda to implement design practices and procedures immediately. Over time, each memo is incorporated into pertinent design documents and manuals. For a comprehensive list of active Technical Memoranda visit [MnDOT’s Tech Memo website](#).²¹

TOWARDS ZERO DEATHS INITIATIVE

[Toward Zero Deaths](#) is Minnesota’s cornerstone safety program, employing an interdisciplinary approach to reducing crashes, injuries and deaths on Minnesota roads.²² TZD uses a data-driven approach that targets areas for improvement and employs proven countermeasures, integrating and applying [education](#), [enforcement](#), [engineering](#) and [emergency medical and trauma services](#).²³ TZD is a partnership program between MnDOT, the Minnesota Department of Health, and the Minnesota Department of Public Safety and is based on the belief that even one traffic-related death on our roads is unacceptable. This “zero deaths” idea is a core objective in MnDOT’s Strategic Highway Safety Plans.

LOCAL PLANS

MnDOT learned from recent bicycle planning and engagement efforts that the public values opportunities to enhance local and regional bicycle connections. People also indicated that they are most comfortable bicycling on low-stress facilities that provide clear separation from motor vehicles. To ensure MnDOT efforts enhance and establish local connections, MnDOT planners and designers should consult and coordinate with local transportation authorities. Local plans identify key transportation issues at the city, township and regional level. Consult with district planners and/or appropriate MnDOT specialty offices, such as the Office of Transit and Active Transportation, for coordination assistance.

As part of thorough public engagement and project planning, in addition to district bicycle plans, designers should review:

- Comprehensive plans – at the city, township and county level
- Bicycle plans – often available at the county level; sometimes at the city level
- Other local policies that may be applicable such as Complete Streets or Vision Zero

Consult with local agencies early in the project development process to discuss how the project can support local plans. As necessary, consult with district planners for coordination assistance.

PEDESTRIAN AND BICYCLIST DATA PROGRAM

The statewide [Pedestrian and Bicyclist Data Program](#) started in 2013, when four automated bicycle counters were installed in the Twin Cities.²⁴ Since then, the program has expanded to include 29 continuous people counters at 22 reference sites in Minnesota, and a [counter loaning program](#) consisting of 16 portable devices that MnDOT district staff and local partners can borrow for their own data collection needs.

The purpose of this program is to generate walking and bicycling information that can be used to inform state, regional, and local planning and engineering initiatives and to assess important transportation policies and programs such as Complete Streets and Toward Zero Deaths.

Products of these collaborative efforts include:

- [Minnesota Bicycle and Pedestrian Data Collection Manual](#) for local jurisdictions and consultants designing manual and automated non-motorized traffic monitoring programs,
- Annual reports of walking and bicycling data,
- A statewide pedestrian and bicyclists data taskforce to coordinate, standardize, streamline and share pedestrian and bicyclist data to support the advancement of active transportation in Minnesota, and
- A strategic plan for maintaining and expanding the pedestrian and bicycle data collection in Minnesota

CONNECTED AND AUTOMATED VEHICLE PROGRAM

MnDOT is planning and preparing for emerging transportation technologies that impact the safety and mobility of people who bike, including connected and automated vehicle technologies, shared mobility and micro-mobility. The Connected and Automated Vehicles Office (CAV-X) is actively engaging transportation engineers, planners, bicyclists and communities to understand how these future technologies could impact bicyclist safety.

For example, the [MnDOT CAV Strategic Plan](#)²⁵ recommends developing a statewide traffic signal priority policy to address pedestrian, bicyclist and CAV safety and conducting pedestrian and bicyclist outreach to identify pilot projects using mobile and other applications to safely test emerging transportation technologies. CAV-X is researching ways to pilot mobile pedestrian and bicyclist warning applications and other technologies that alert passenger and transit vehicles when pedestrians and bicyclists are in intersections to avoid collisions.

MnDOT is also working with the Minnesota Design Center and the University of Minnesota's Humphrey School of Public Policy on their research into innovative design and policy solutions to improve mobility for bicyclists as trends in emerging technologies develop, such as protected bikeways to improve bicyclist and pedestrian safety.

While the future of these emerging technologies is unknown, governments, researchers and private industry will have to dramatically shift the way roads are constructed and transportation is envisioned to keep up at the rapid pace the technology is advancing. For more information, visit MnDOT's [CAV website](#).²⁶

2

**SCOPING,
PLANNING
AND PROJECT
COORDINATION**

Introduction

Comprehensive and timely planning helps MnDOT understand, identify and adequately fund bicycle facility needs to establish a complete and connected multimodal transportation network, from design through maintenance. Planners and designers have several tools available to them to help identify the need for bicycle facilities and incorporate them into a project early in its development.

This chapter describes:

- Design flexibility
- MnDOT's planning and project development tools;
- Steps to develop a bicycle network; and
- Equity

Design Flexibility

Stakeholders and partners are more likely to embrace projects when design standards are flexible enough to respond to community values. Roadway design flexibility is being developed on a national level consistent with the national efforts to plan for and include all modes of transportation. The seventh edition of the AASHTO Policy on Geometric Design of Highways and Streets, also known as the Green Book,¹⁰ presents a more flexible framework for geometric design that is multimodal and performance based.

Design criteria in the Green Book have always included a great deal of flexibility; the latest version now more clearly emphasizes design flexibility, encourages designers to take advantage of that flexibility and notes that designers should exercise flexibility to better meet specific project goals or to work within defined constraints. This change is evident in the title of the first chapter: New Framework for Geometric Design.

The Green Book also expands roadway “contextual” classifications such as rural, rural town, suburban, urban and urban core in an effort to help provide geometric recommendations that fit the space and context of the surrounding land.

The Green Book focuses on flexible, performance based design and now emphasizes moving people instead of moving motor vehicles. It acknowledges that achieving the appropriate design for any project is not an easy process because designers are expected to balance many competing needs. In order to address the traveling public’s expectations, a community’s needs, and the limitations of available funding, the context of a project needs to be considered when applying geometric design criteria.

This New Framework for Geometric Design, along with [MnDOT’s Performance-Based Practical Design](#) approach will influence revisions to MnDOT’s other guiding documents, such as the [Road Design Manual](#).^{20,2} These guidance changes underscore the shift in the agency’s culture and the importance of considering all modes of transportation, beyond just motor vehicles.



Planning & Project Development

Planners and designers can leverage various tools to ensure that bicycle facilities are considered comprehensively in a timely manner, and are included and well-designed within projects. These include:

- Previous project file notes
- District bicycle plans and Bicycle Investment Routes
- Local bicycle plans
- Crash reports, traffic studies and safety audits
- [MnDOT bicycle and pedestrian traffic counts](#)²⁷
- MnDOT policies and plans discussed in Chapter 1

As can be seen in the following schedule, the best opportunity to plan for nonmotorized transportation elements is in Year 5 or earlier in a project life cycle. Properly scoping projects is a key element to successfully delivering a project on-time and on-budget.

PROJECT DEVELOPMENT & SCOPING

There are three key documents that guide MnDOT work from planning to construction.

1. [MnSHIP](#): the State Highway Investment Plan.²⁸ MnSHIP is MnDOT's vehicle for deciding and communicating capital investment priorities for the majority of state transportation system for the next 20 years.
2. [CHIP](#): the Capital Highway Investment Plan.²⁹ The CHIP lists programmed and planned capital highway projects on the state highway network over a 10 year horizon. It is a check to ensure MnDOT is meeting the investment levels and performance outcomes identified in MnSHIP and explains any investment changes or outcomes. The CHIP is adjusted annually to remove projects that are currently being constructed, adjust timing of existing planned projects and add new planned projects.
3. [STIP](#): the State Transportation Improvement Program.³⁰ The STIP identifies Minnesota's four-year transportation project schedule and funding (by state fiscal year: July 1 through June 30) and includes state and local transportation projects. The STIP is MnDOT's committed construction program and is updated annually.

TYPICAL PROJECT SCHEDULE

Year 10 – Identify Projects: Districts, MnDOT Central Office and other specialty offices identify large project investments through the CHIP. Over a ten-year period, these projects move toward construction, which is in Year 1.

Years 6-9 – Refine Project Concepts: Districts work with Area Transportation Partnerships, MPOs and other key partners to recommend project adjustments, needs and timing. Districts may make changes based on additional studies, MnDOT planning and policy recommendations, new condition information, MPO policy direction, or new legislative special funding programs.

Year 5 – Initial Project Scoping: Districts identify project needs related to areas such as nonmotorized transportation, safety, or roadside infrastructure conditions. The goal is to enter projects into the STIP the following year. By Year 4, projects become part of the STIP and MnDOT has committed to construction. A project may be held in Year 5 for a few years before being listed in the STIP if funding is unavailable.

Years 2-4 – Select Projects for Funding; Commit to Delivering Projects: Districts update a project's scope, schedule and cost estimate annually based on project design and engineering progress. This period represents MnDOT's commitment to deliver a project. If necessary, MnDOT works to complete any studies and identifies any impacts a project may have on the surrounding environment.

Year 1 – Annual Construction Program: When a project reaches its final year, it becomes part of MnDOT's annual construction program and construction begins.

NONMOTORIZED SCOPING

Consistent with the previously mentioned policy, plans and scoping recommendations, MnDOT typically reviews nonmotorized scoping needs on each project in year five of the 10-year CHIP. During the review, Project Managers analyze the area population, existing infrastructure and project safety needs. Nonmotorized scoping also includes evaluating potential origins and destinations (housing, schools, shops, etc.), active living and/or comprehensive and bicycle plans and conducting a nonmotorized project audit.

Similar to other modes of transportation, people bicycling require safe, direct and reasonably convenient routes to preferred destinations. Designers and project managers should strive to design projects that account for bicycle safety, comfort and connectivity in coordination with regional efforts throughout the area. People bicycling choose routes based on the quality and the perception of safety. Quality may be in the level of separation from motor vehicles or an appropriately-sized radius to control turning motor vehicle speeds at intersections. The perception of safety for a person bicycling is an important factor in the quality of the bicycling experience and plays a key role in whether MnDOT can achieve its bicycling goals.

In order to align with the national and state goals of increasing the number of people walking and bicycling, the State of Minnesota needs to make progress in planning and implementing well designed and spaced bicycle networks. The easiest way to do this is to include bicycle facilities as MnDOT restripes trunk highways throughout the state. That effort begins with scoping. MnDOT scoping documents and considerations of note include:

- **Functional Group Scoping Worksheets:** Completed by functional groups responsible for focus areas; includes bicycling.
- **Scoping Report:** Includes a clearly defined purpose and need. Needs or justifications relevant to bicycling include, but are not limited to:
 - Bike facility connections: Is the proposed project a “connecting link to a shared use path or bike lane?” How does it fit within the local or regional bicycle facility network?

- Safely serves people bicycling: does the proposed project improve intersection crossings or address problem crash areas, near misses, or public concerns?
- Barriers to bicycling mobility: does the proposed project serve the preferred bicycle user type? Does it remove a bicycling barrier (improves access across a freeway or river bridge, etc.)?
- Links with other modes: How will the proposed facility connect with public transit, trains, or an airport?
- Driver and bicyclist behavior: how will the proposed project help MnDOT meet its vision to make bicycling safe, comfortable and convenient for all people? Or help meet its goal to increase the number of people bicycling? How will the project encourage lawful actions for all modes?

In general, all roadways should be safe and accessible for people bicycling, except where bicycle travel is specifically prohibited by law. There are many factors to consider when deciding how and where bicycle facilities will be included or improvements made on MnDOT trunk highways and in turn scoped, including:

- **User Need:** Identify the bicyclist design user profile and consider current and future bicyclists’ range of needs
- **Connection to Land Use:** Provide access to key destinations; land use factors (land use type, density, destinations, etc.) affect the types and volumes of likely bicycle network users
- **Traffic Volumes, Vehicle Mix and Speeds:** Consider motor vehicle traffic volumes, vehicle mix, speeds, road width and driveway access
- **Safety:** Evaluate crash data, crash reports and common location characteristics that may cause crashes
- **Latent Demand:** Assess the amount of bicycling that would occur if safe and comfortable facilities existed; consider trip attractors or destinations. The statewide Pedestrian and Bicyclist Data Program and prioritization tool developed in the District Bicycle Plans may also help to identify latent demand.
- **Overcoming Barriers:** Prioritize crossing barriers such as freeway, river, or railroad crossings
- **Gaps:** Similar to barriers, seek to close network gaps, which break up otherwise safe and comfortable connections



- **Equity and Environmental Justice:** Meet the needs of all community members, particularly those typically underserved (people with low motor vehicle ownership, communities of color, etc.)
- **Directness of Route:** Ensure a bicycle facility connects to desirable destinations via few detours and without complicated turns
- **Personal Security:** Provide features such as lighting and emergency call boxes for facilities that are isolated or with limited visibility from roads and neighboring buildings
- **Intersections:** Provide as few stops along a bicycle facility as possible and carefully plan and manage crossings to reduce crashes and improve operations for all users and modes. Stopping and starting on a bicycle requires more energy than uninterrupted forward motion.
- **Logical Route:** Bicycle networks should be intuitive to users
- **Green Space:** Consider scenery and views along a bicycle facility, particularly for facilities that primarily serve people bicycling for recreation. When space allows, consider trees, which can provide summer shade, act as a windbreak and contribute to a pleasant setting.
- **Bicycle Facility Spacing or Bicycle Facility Density:** Plan bicycle networks for maximum use and comfort and based on density relative to local conditions.

Some communities have set bicycle facility proximity goals; consult local plans for such information.

- **Overall Feasibility:** Avoid allowing constraints to result in poorly designed or constructed facilities. Constraint examples include: funding limitations and physical or right-of-way constraints. Seek to maximize the cost/benefit ratio; employ design flexibility, PBPD and other such principles to balance modal needs.

Additionally, designers should research and evaluate existing roadside facilities that will be integrated with a bicycle facility. As early as possible during project planning, scoping and design stages, designers should consider the following information when selecting a bicycle facility type.

- **Land Uses:** Evaluate current and future adjacent land use and potential relationships to the bicycle facility. For more information, see the MnDOT Land Use Contexts: Types, Identification and Use technical memorandum ([18-07-TS-05](#)).³¹
- **Proposed Development:** Review any proposed development plans to understand potential impacts from new traffic generators, especially for large commercial developments and civic facilities such as schools, libraries, parks, or other attractions.

- **Existing Speed Zones:** Analyze existing posted speeds and understand potential geometric impacts on the proposed bicycle facility (for example, the need for separation).
- **Traffic Data:** Consider impacts from traffic volumes, composition and capacity; turning movement volumes; and projected data on bicycle facility safety and selection.
- **Crash Data:** Evaluate any recorded crash history along the corridor.
- **In-Place Signals:** Evaluate existing signal locations and how the signals impact and may impact, safety and flow for all modes within the proposed design.
- **In-Place Widths:** Examine the geometry of turn lanes, shoulders, raised medians, streets, lanes and entrance widths and their relationship to the intended bicycle facility.
- **Access Management:** Every driveway and cross street creates a potential conflict point along a trunk highway; review the current alignment to verify the need for current or proposed access points.
- **Freight Traffic:** Coordinate with the Office of Freight and Commercial Vehicle Operations on whether the roadway or adjacent routes are used for regular truck, railway traffic, or Oversize-Overweight operations. Consult the Commercial Vehicle Permits Supervisor for information on freight movements.

PLANNING AND DESIGN CHECKLISTS

Example planning and design checklists for bicycle facilities are in Appendix E and available to guide project managers, planners and designers to plan and design bicycle and pedestrian facilities on MnDOT projects. Use the checklists as a starting point to evaluate assumptions and identify issues and opportunities regarding bicycle and pedestrian needs within a proposed MnDOT project. The checklists promote efficient and comprehensive project development and verify project purpose and need and can be used to supplement the bicycle section of the scoping worksheets.

Like any type of roadway design, bicycle facility design requires designers to consider the impact to other aspects within and adjacent to the roadways right-of-way, including: typical section widths, profiles, drainage, lighting, landscaping, barriers, striping, utility relocation, snow storage, maintenance responsibilities, interagency coordination and planning, municipal approval, funding, cost participation and others. Therefore, it is important to consider the needs of people bicycling early in the scoping, planning and design phases. Bicycle facility design should not be considered an “add-on” or “after-thought”.



Bicycle Network Planning

Having a bicycle network plan is critical to making good planning, scoping and design decisions related to bicycle routes and facilities. A great bicycle facility alone may not be used if people can't safely and comfortably reach it; it is only with a connected network that people can actually get where they need and want to go. By creating effective bicycle networks with routes that are efficient, seamless and easy to use, MnDOT can encourage more people to bicycle. This section includes key network planning items from the [FHWA Bikeway Selection Guide](#), which presents interrelated factors and considerations associated with transportation planning and bicycle facility selection.⁶

MnDOT's bicycle planning efforts consist of individual, but interconnected, District Bicycle Plans that advance the vision of the Statewide Bicycle System Plan. Each District Bicycle Plan identifies Bicycle Investment Routes that guide district staff to create a comprehensive bicycle facility based on prioritized corridors and locations. Review the District Bicycle Plan in early project phases to understand how a project fits within the statewide network and should be accordingly scoped. As necessary, consult district planners; MnDOT planners developed the District Bicycle Plans and are familiar with plan content and area stakeholders.

A bicycle network is a seamless interconnected system of bikeways. Networks should be thoughtfully planned to provide necessary and desired connections and access. The most successful bicycle networks enable people of all ages and abilities to safely and conveniently get where they want to go. The bicycle network informs bikeway type selection by showing where higher quality facilities are needed the most.

The FHWA Bikeway Selection Guide lists seven principles of bicycle network design. The first three: safety, comfort and connectivity, have particular importance in guiding bicycle facility selection.

TRANSIT ACCESS

A key determinant for whether people will bicycle is trip distance. In fact, research shows that excessive distance is often noted as a powerful deterrent to bicycling.³² Connections to transit stops, known as first- and last-mile connections, help people overcome physical barriers and travel longer distances. In many cases, people will walk or bicycle to transit if it is easy to do so. A combined bicycle and public transit trip may make travel between an origin and destination with incomplete infrastructure, or unsafe roadway crossings less difficult or possible. Many transit agencies nationwide have realized the connection between high-quality pedestrian and bicycle connections to their systems and the resulting impact on increased ridership for both modes. The proximity to transit should be a key consideration in project scoping and bicycle facility selection. MnDOT transit planners and local transit agencies can advise.



The District Bicycle Plans were developed based on the principles below. Cities, counties and others developing network plans may choose to use similar principles.

Bicycle Network Principles:

- 1. Safety:** The network minimizes the frequency and severity of crashes and limits roadway user conflicts
- 2. Comfort:** Network bicycling conditions do not deter use due to level of stress, anxiety, or safety concerns. Note: comfort and safety are closely related but not the same.
- 3. Connectivity:** The network provides gap-free access to all destinations and with no missing links.
- 4. Directness:** The network minimizes distances between origins and destinations; it also minimizes trip times.
- 5. Cohesion:** The network provides for minimal distances between parallel and intersecting bicycle routes.
- 6. Attractiveness:** The network prioritizes directing people bicycling through lively areas, areas of interest and where people feel safe.
- 7. Unbroken flow:** The network limits stops, such as long waits at traffic lights and provides consistent and adequate street lighting.

For additional network planning information, see the FHWA Bikeway Selection Guide. For additional District Bicycle Plan information, see the District Bicycle Plan section in Chapter 1 or the [MnDOT District Bicycle Plans website](#).¹⁵ For bicycle facility selection on MnDOT trunk highways, see Chapter 3.

PLANNING FOR VULNERABLE USERS

Vulnerable users are defined in [MnDOT's Complete Streets](#)¹⁷ policy as "Road users who are most at risk for serious injury or death when involved in a motor-vehicle related collision, including but not limited to people bicycling and pedestrians of all ages, types and abilities." This typically applies to people walking and bicycling, but also applies to people on motorcycles and those using other types of wheeled mobility devices (motorized and nonmotorized). As MnDOT notes in the Complete Streets policy:

- **Procedures - Design:** "The design process must include attention to speed outcomes, especially in urban, suburban and recreational environments where vulnerable users are common. Operating speed is a key factor in the severity of crashes involving both motorized and nonmotorized traffic. Consider design speed a target speed rather than a maximum safe speed."
- **Responsibilities - Traffic Engineers and Designers:**
 - "Address the safety needs and ease of use of vulnerable users, especially in lower-speed environments and at intersections."
 - "Include attention to speed outcomes, especially in urban, suburban and recreational environments where vulnerable users are common. Consider design speed a target speed rather than a maximum safe speed."

Facilities with low traffic volumes and speeds, or those with substantial separation from higher volumes and speeds have been correlated with a lower perception of "traffic stress", which serves vulnerable users well. EXHIBIT 2-1: Operating Speed and Crash Severity shows why vulnerable users find high speed roads more stressful. The concept of traffic stress is discussed in Chapter 3.

FUNDING FOR BICYCLE TRANSPORTATION

FHWA guidance on [Bicycle and Pedestrian Planning, Program, and Project Development states](#) “Almost every transportation improvement is an opportunity to enhance the safety and convenience of walking and bicycling...In the planning, design and operation of transportation facilities, bicyclists, pedestrians and persons with disabilities should be included as a matter of routine and the decision to not accommodate them should be the exception rather than the rule.”⁸ Many bicycle facilities can be routinely and cost-effectively included in a greater roadway or corridor project if scoped at the appropriate time and level. When seeking funding for walking or bicycling facilities within a greater roadway project or for a standalone bicycle facility project, see the [FHWA’s Pedestrian and Bicycle Funding Opportunities table](#) for funding options.³³ See additional bicycle transportation funding information in Appendix D. The table lists:

- Potential eligibility for pedestrian and bicycle projects under U.S. Department of Transportation surface transportation funding programs.
- Basic program guidance and detailed requirements.
- That agencies, such as MnDOT:
 - Should fully integrate nonmotorized accommodation into surface transportation projects.

- Are [required on federally funded projects](#) on the National Highway System to consider access for other modes of transportation and provide greater design flexibility to do so.³⁴

Federal funding sources listed in the FHWA Pedestrian and Bicycle Funding Opportunities table that are available specifically to State Aid eligible communities (or those with eligible sponsors) include:

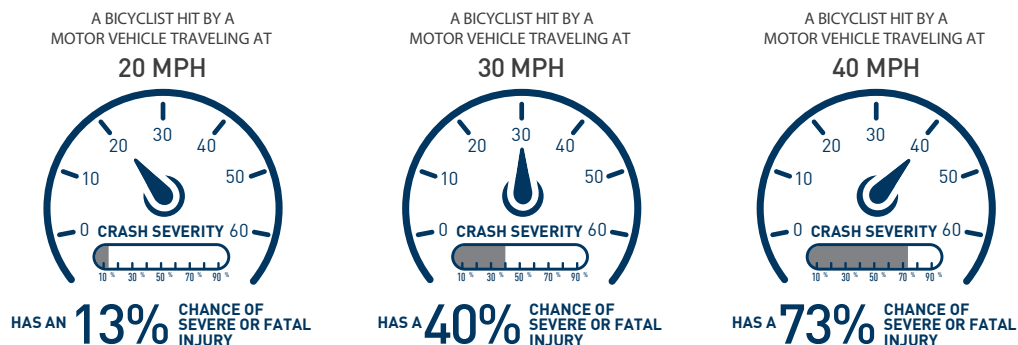
- Surface Transportation Block Grant Program
- Transportation Alternatives programs through the Greater Minnesota Area Transportation Partnerships

MnDOT’s Highway Safety Improvement Program which is administered by MnDOT’s Office of Traffic Engineering is another potential funding source. The purpose of HSIP is to achieve a significant reduction in fatalities and serious injuries on public roads. HSIP funds are used for safety projects consistent with Minnesota’s Strategic Highway Safety Plan—to improve hazardous road area or address a highway safety problem. Designers should confirm if a project that improves bicycling safety ranks high enough to receive funding. In addition, some counties have specific bicycle facility funding, as do some park implementing agencies. When identifying funding sources, consult with MnDOT’s district planners; they may be able to advise on options. ATPs and MPOs’ regional solicitation processes are another potential funding source. This competitive award process distributes federal transportation funds to projects that meet regional transportation needs.

EXHIBIT 2-1: Operating Speed and Crash Severity

SLOWER SPEEDS REDUCE CRASH SEVERITY

Especially for vulnerable roadway users, such as bicyclists and pedestrians



Source: Brian C. Tefft. 2013. AAA Foundation for Traffic Safety. Impact speed and a pedestrian’s risk of severe injury or death.

Public & Stakeholder Engagement

Public engagement can help designers better understand how transportation systems, services and decision-making processes help or hinder the lives of people living in close proximity to the project, particularly underserved and underrepresented communities in Minnesota. Not only does comprehensive public engagement inform project decision making, but it is one of the steps MnDOT identifies in its [Advancing Transportation Equity initiative](#).³⁵

For projects including bicycle facilities, public engagement may include working with local and regional transportation organizations and government entities, coordinating with local or regional bicycle plans, or conducting public meetings to exchange information about a project. For bicycle facility projects, planners and designers may need to specifically develop a standalone project public engagement plan. [MnDOT's Public Engagement Policy](#) and [Public Engagement and Constituent Services Office](#) provide guidance, resources and contacts for planners and designers.^{36 37}

PUBLIC ENGAGEMENT AT MNDOT

Public engagement at MnDOT refers to the agency's commitment to listen first and ultimately inform, consult, involve, collaborate and/or empower stakeholders and the public in transportation decision-making. Early and continuous public and stakeholder engagement is an essential part of project planning and project development. MnDOT uses the International Association for Public Participation Spectrum of Participation to help:

- Provide a clear and universal language for public engagement to be used by MnDOT employees
- Manage expectations for key stakeholders and partners about how much influence the community has over planning or decision-making.

DEVELOPING A PUBLIC ENGAGEMENT PLAN

Developing a written public engagement plan is an important early step in project development. Since public engagement may occur throughout project development and through to construction, reevaluate the plan periodically and revise as needed. A public engagement plan typically includes the following elements:

- Project history and background
- Goals, objectives and expected public engagement outcomes
- Identifies stakeholders, participants and audiences
- Public engagement strategies and techniques
- Budget, schedule and responsibilities for implementing public engagement.

To develop a public engagement plan, consult [MnDOT's Strategic Framework for Public Engagement Planning](#), which assists project managers by asking:³⁸

- What is the purpose of engagement?
- What are we trying to achieve?
- How will our decisions affect stakeholders and communities?
- What level of engagement are we promising the public?
- What is the reach of the engagement initiative?
- How will we track, measure, evaluate and follow through?

PUBLIC ENGAGEMENT ROLES AND RESPONSIBILITIES

To ensure adequate project pre-scoping and scoping, it is important to learn about the local community and local priorities, allow the community to weigh in on project-related issues and opportunities, and identify neighborhood and business preferences for mitigating construction impacts.

To ensure public engagement for a bicycle facility project is coordinated, timely and effective, in pre-scoping and scoping phases, tasks for project managers and public engagement staff include:

Project Managers:

- Lead and manage project-level public engagement activities, including plans, budgets and results.
- Consult with public engagement staff on planning, documenting and measuring public engagement efforts.
- Link project scope, schedule and budget performance to public engagement.
- Meet with local partners regarding active participation and decision-making for public engagement activities.

Public Engagement staff:

- Develop and document standard district approaches in identifying stakeholders, develop public engagement plans and assist with public engagement.
- Coordinate with district planners, project managers and public affairs staff to support their efforts to increase public and stakeholder engagement, mitigate construction impacts and resolve conflicts.
- Identify stakeholder groups and review communities in terms of social justice and underrepresentation.
- Develop and maintain a District Public Engagement and Outreach Plan to help guide in developing, updating and communicating District transportation plans, programs and studies.
- Conduct ongoing engagement and relationship-building with the public and various customer and stakeholder groups and individuals to earn trust, two-way feedback and an understanding of transportation-related affairs.

Because there may be several overlapping jurisdictions within a plan or project area, it is important to understand the unique needs, perspectives and responsibilities of the different levels of government. Stakeholders may include any or all of the following:

- Residents
- Local businesses
- Bicycle advisory committees
- Schools
- Bicycle advocates
- Special interest groups such as environmental or sporting groups
- Service organizations
- Transit providers
- Local government
- Regulatory agencies
- Area Transportation Partnerships
- Regional Development Commissions
- Metropolitan Planning Organizations
- Department of Natural Resources
- Department of Health
- MnDOT
- Federal agencies



Equity

Transportation contributes to many broad societal outcomes, such as employment, wealth and health. However, there are disparities and inequities in Minnesotans' ability to reach destinations. MnDOT, through its [Advancing Transportation Equity](#)³⁵ initiative, is seeking to better understand how transportation systems, services and decision-making processes help or hinder the lives of underserved and underrepresented communities in Minnesota. Underserved and underrepresented communities in Minnesota include low-income communities, communities of color, indigenous communities, older adults, people with disabilities, women and youth, rural residents and people with limited motor vehicle access.

When envisioning transportation equity, MnDOT considers:

- Transportation systems that support multimodal options that are affordable, sustainable, reliable, efficient, safe and easy to use;
- High quality transportation services that are accessible to all populations for reaching destinations independently if needed; and
- Transportation decision-making processes that incorporate inclusive public engagement to reduce the long-standing socioeconomic disparities experienced by underserved and underrepresented communities.

Bicycle facilities can be an important strategy to address transportation equity challenges in Minnesota communities for many reasons such as:

- Bicycles provide a mobility option for people too young to drive a motor vehicle, people who cannot drive a motor vehicle, people who are without the financial resources to own and maintain a motor vehicle and people who choose not to drive.
- Bicycle facilities support and supplement transit networks, as bicycles can effectively expand the network by connecting people via what's known as the "first and last mile,"
- Bicycling contributes to improved public health outcomes; it provides an opportunity for exercise regardless of trip purpose and improves environmental quality where motor vehicle trips are replaced by bicycle trips.

As MnDOT moves to better understand how different strategies can meaningfully impact advancing transportation equity, project managers should contact [MnDOT's Planning Program Coordinator](#) to learn more how individual project work can contribute to and enhance transportation equity.³⁹



3

**FACILITY
SELECTION**

Introduction

This chapter provides guidance for selecting the type of bicycle facility for a project. This guidance is based on the needs of the largest bicycle user group, Interested but Concerned bicyclists. Key factors to consider include land use context, the type of project, traffic volumes and roadway operating speed. This chapter also provides guidance to evaluate the feasibility of the preferred facility type, and refine options, if necessary.

Much of the facility selection information in this chapter is based on information in the [FHWA Bikeway Selection Guide](#), which draws upon available research and emphasizes using engineering judgment, design flexibility, documentation and experimentation. The following information will help designers understand the many elements that factor into selecting a bicycle facility that serves Interested but Concerned bicyclists.⁶

Types of Bicyclists

Not all people bicycling are alike. Adult bicyclists fall into three primary categories:

- 1. Interested but Concerned**
- 2. Somewhat Confident**
- 3. Highly Confident**

EXHIBIT 3-2: Bicyclist User Profiles provides examples of bicyclists in these three categories. Developed by planners in Portland, OR and supported by research, this framework identifies distinct types of bicyclists based on their comfort and willingness to bicycle, as well as their percentage of the population. The research also found that between $\frac{1}{4}$ and $\frac{1}{3}$ of the population had no interest in bicycling, regardless of the comfort level of a given facility. The Interested but Concerned group represents the largest portion of the population, and is therefore the typical user profile that MnDOT designs for whenever possible. In addition, designs that are comfortable and convenient for Interested but Concerned bicyclists will also provide benefit to Somewhat Confident and Highly Confident bicyclists.⁴⁰

It is important to note that people may not fit into a single user profile and a bicyclist's profile may change in a single day. For example, a person who is comfortable bicycling in a bike lane when traveling alone as part of their commute may prefer to ride on a sidepath or shared use path when traveling with children.

The current AASHTO Guide for the Development of Bicycle Facilities encourages designers to identify their bicyclist design user profile based on the level of comfort and skill of the person bicycling.⁴ MnDOT's [Statewide Bicycle System Plan](#) and [District Bicycle Plans](#) both identify designing for the Interested but Concerned bicyclists as a necessary step in increasing the number of people bicycling across the state.^{1,5}

SAFETY AND COMFORT FOR INTERESTED BUT CONCERNED BICYCLISTS

People walking and bicycling are our most vulnerable roadway users and most at risk for serious injury or death when involved in motor vehicle-related crashes. Objective safety benefits are derived using nominal design standards; however, perceived safety also needs to be considered when planning and designing for bicycle facilities. Perceived safety is defined as how safe a person feels traveling in the transportation system and can have significant impacts on how or if they use provided facilities.

Some facilities may be comfortable but unsafe, while other designs may be safe but not comfortable. Land use, terrain, traffic profile, separation and intersection/driveway treatments all have an impact on these variables and should be carefully considered during the design process. Designers are encouraged to consider both of these variables in roadway and bikeway design with caution.

For example, a bike lane alongside high turnover parking may feel safe to some people bicycling, but present a risk of collision with a motor vehicle door being opened. Similarly, a shared lane environment with low to moderate speed may be safe, but not comfortable to a substantial percentage of bicyclists.

Assessing perceived safety will vary between observers but is increasingly measurable by comfort rating tools such as Level of Traffic Stress. Designing for the Interested but Concerned bicyclist means addressing both objective and perceived safety when selecting a bicycle facility.

LEVEL OF TRAFFIC STRESS

A variety of bicycle compatibility criteria have been developed since the early 1990s to quantify how a roadway contributes to safe and efficient bicycle travel. MnDOT has chosen [Level of Traffic Stress](#)⁴¹ as the preferred measure to identify how well a roadway serves people on bicycles—particularly how well it serves the Interested but Concerned bicyclist. While a small fraction of the population will tolerate sharing a road with heavy or fast-moving motor vehicles, a large majority is “traffic-intolerant,” willing to tolerate only a small degree of traffic stress.

LTS is a method of classifying road segments and bicycle facility networks based on how comfortable people with different confidence levels are when bicycling and interacting with people in a motor vehicle. It was created to address deficiencies in the previously recognized method, Bicycle Level of Service, which is described in the Highway Capacity Manual. EXHIBIT 3-1: LTS and

Bicyclist User Profiles describes the four levels of traffic stress that correspond directly to the three types of bicyclist profiles in EXHIBIT 3-2.

Typical measurement factors in LTS include: number of lanes, motor vehicle speeds, road functional class, bicycle facility type and if traffic signals at major road crossings are present.

- Roads considered low(er) stress have few lanes, low speeds, a low functional class, bicycle facilities with horizontal separation and comfortable accommodations for people bicycling at busy intersections.
- Roads considered high(er) stress have more lanes, higher speeds, a higher functional class, no bicycle facility and lack of comfortable accommodations for people bicycling at busy intersections.

The guidance in EXHIBIT 3-3 and EXHIBIT 3-4 is based on the concept of LTS.

LTS LEVEL	DESCRIPTION	HIGHLY CONFIDENT BICYCLISTS WILL RIDE	SOMEWHAT CONFIDENT BICYCLISTS WILL RIDE	INTERESTED BUT CONCERNED BICYCLISTS WILL RIDE
LTS 1	Presents the lowest level of traffic stress; demands less attention from people riding bicycles, and attractive enough for a relaxing bicycle ride. Suitable for almost all people riding bicycles, including children trained to ride in the street and to safely cross intersections.	YES	YES	YES
LTS 2	Presents little traffic stress and therefore suitable to most adults riding bicycles, but demands more attention than might be expected from children.	YES	YES	SOMETIMES
LTS 3	More traffic stress than LTS 2, yet significantly less than the stress of integrating with multilane motor vehicle traffic.	YES	SOMETIMES	NO
LTS 4	Includes roadways that have no dedicated bicycle facilities and moderate to higher motor vehicle speeds and volumes OR high speed and high volume roadways WITH an exclusive bike lane where there is a significant speed differential between motor vehicles and bicyclists.	YES	NO	NO

EXHIBIT 3-1: LTS and Bicyclist User Profiles



Interested but Concerned

This is the bicyclist user profile that MnDOT typically considers when selecting a bicycle facility type. This group is more cautious and has some inclination towards bicycling, but is held back by concern over sharing the road with motor vehicles. They have the lowest tolerance for traffic stress and are uncomfortable on major streets, even with a striped bike lane. They avoid bicycling except where they have access to bicycle facilities that are separated from motor vehicles or low traffic neighborhood streets with safe roadway crossings. Many people in this group tend to bicycle for recreation. To maximize the potential for more people to bicycle for transportation, it is important to design bicycle facilities that meet their needs.

Examples of the Interested but Concerned type of bicyclist include:

A parent and child in suburban Woodbury who enjoy Saturday rides to the library along the shared use path that runs near their house. Concern over crossing a busy road prevents them from riding together to elementary school during the week.

A 45-year-old parent of two from Grand Marais who was just diagnosed with pre-diabetes. Their doctor has encouraged a more active lifestyle, yet they have little time to go to the gym. They feel uncomfortable passing people on bicycles when driving a motor vehicle and has a similar comfort concern as a bicyclist sharing the road with motor vehicles.

A Saint Paul resident who just moved to the US. They have used a bike-share bicycle a few times to ride home from the train station and enjoy riding as long as they are on quiet streets or the sidewalk. They'd like to be able to ride to the grocery store, but are uncomfortable crossing busy roads and intersections along the way.



**LOWER STRESS
TOLERANCE**

EXHIBIT 3-2: Bicyclist User Profiles

Somewhat Confident

This group of bicyclists are willing to ride in most roadway situations but prefer to have a designated facility. They are comfortable bicycling on major streets with striped or separated bike lanes, on low-volume residential streets and are willing to tolerate moderate levels of stress for short distance to complete trips or avoid out-of-direction travel.

Examples of the Somewhat Confident type of bicyclist include:

A person from Duluth who rides their bike downtown every morning to their job at the hospital. They prefer to ride on neighborhood streets, but don't mind riding the last few blocks on a busy street since there's a bike lane and that is the most direct route.

A lower-income Sauk Centre resident who rides a bicycle to save money for other household expenses. They are comfortable riding on Main Street without a conventional bike lane because it is a two-lane road and drivers usually don't pass them.



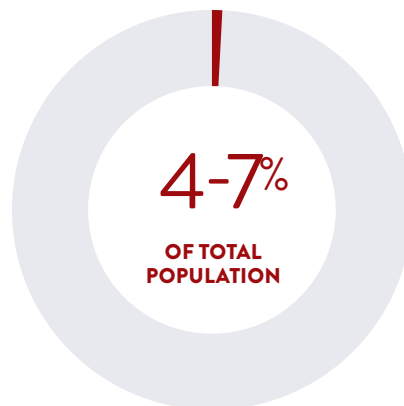
Examples of the Highly Confident type of bicyclist include:

A recent college graduate in Winona who can't wait to hit the road this weekend for a 100-mile ride on their brand new road bike. They helped pay their way through college as a bike messenger and they love the rush from riding in traffic.

A middle-aged professional in Minnetonka who has taken a bicycling skills class and understands the safest way to ride in mixed traffic and is now confident in virtually any situation.

Highly Confident

This group is willing to ride a bicycle on any roadway regardless of traffic conditions. They are comfortable taking the lane and riding in a vehicular manner on major streets without designated bicycle facilities. Many enjoy bicycle facilities separated from traffic, however; they have a higher tolerance for traffic stress compared to other bicyclist types. They also have the ability to bicycle at high speeds and typically prefer to bicycle on direct routes. Similarly, they may avoid bicycle facilities they perceive to be too crowded with people walking or bicycling slowly, or require deviation from their preferred route.



**HIGHER STRESS
TOLERANCE**

Bicycle Facility Types

Well-designed bicycle facilities encourage people to bicycle more often and help them to consistently and effectively operate in a legal and expected manner. This manual provides design guidance and information for six bicycle facility types, summarized below. See Chapter 5 for a detailed discussion of design considerations for each facility type, including how they best serve each bicyclist.

- **Shared use paths** are two-way bicycle facilities that are physically separated from motor vehicle traffic. They may be within parkland, natural areas or adjacent to roadways. They are used by people walking and bicycling.
- **Sidepaths** are two-way shared use paths located immediately adjacent and parallel to a roadway. They are physically separated from motor vehicle traffic by an open space or barrier. They are used by people walking and bicycling. This type of bicycle facility is very commonly installed on MnDOT projects.
- **Separated bike lanes** are bike lanes with some form of both horizontal and vertical separation from motor vehicle traffic. They are separated from pedestrian spaces and can be for one-way or two-way travel.
- **Bike lanes** are a portion of the roadway designated for one-way bicycle use. Buffered bike lanes are bike lanes with a painted buffer area that does not have any vertical separation from motor vehicle traffic.
- **Paved shoulders** encompass additional pavement that is wide enough for bicycle use outside the travel lane - separated from motor vehicles by the roadway's edgeline. This type of one-way bicycle facility is very commonly installed on MnDOT projects.
- **Shared roadways** exist in all contexts where a person bicycling can legally operate, such as local neighborhood streets, urban streets and suburban and rural highways. Shared roadways provide people bicycling little to no physical separation from motor vehicles and are most appropriate on low volume, low speed roads. Shared roadways are the foundation for many bicycle boulevards, but serve as a bicycle facility only when they are designed to favor bicycles over motor vehicle traffic.

Constrained Right-of-Way

One of MnDOT's statewide goals is to increase the number of people bicycling. Using minimum dimensions for all cross-sectional items within a roadway right-of-way may create conditions that are uncomfortable for some people bicycling, particularly for on-street facilities. This may result in fewer people choosing to bicycle. To find balanced and appropriate solutions in constrained right-of-way, consult the [Performance-Based Practical Design Guide](#).²⁰



Selecting a Bicycle Facility

Bicycle facility selection is a context-sensitive decision that involves a planning- and engineering-based process. Steps to selecting the appropriate facility type are:

1. Apply motor vehicle speed and volume to EXHIBIT 3-3: Preferred Bicycle Facility Type for Urban, Urban Core, Suburban and Rural Town Contexts and EXHIBIT 3-4: Preferred Bikeable Shoulder Widths for Rural Roadways.
2. Select a type of bicycle facility.
3. Review bicycle facility information in Chapter 5 to understand facility requirements, opportunities, and limitations.
4. Refine the facility selection if necessary.

As motor vehicle speeds and volumes increase, more separation between bicyclists and motor vehicle traffic is necessary. The quality of the bicycle facility selected will impact the level of comfort and, by extension, the amount of people in the community who will benefit from it and use it.

FHWA BIKEWAY SELECTION GUIDE

Much of the bicycle facility selection information in this section is based on information in the [FHWA Bikeway Selection Guide](#).⁶ The Guide refers to existing national resources and outlines a process for balancing trade-offs by identifying the preferred bicycle facility type, assessing and refining potential options and evaluating feasibility. The guide is “intended to accelerate the delivery of high-quality multimodal projects that improve safety for everyone and meet the transportation needs of people of all ages and abilities.”



LAND USE CONTEXTS

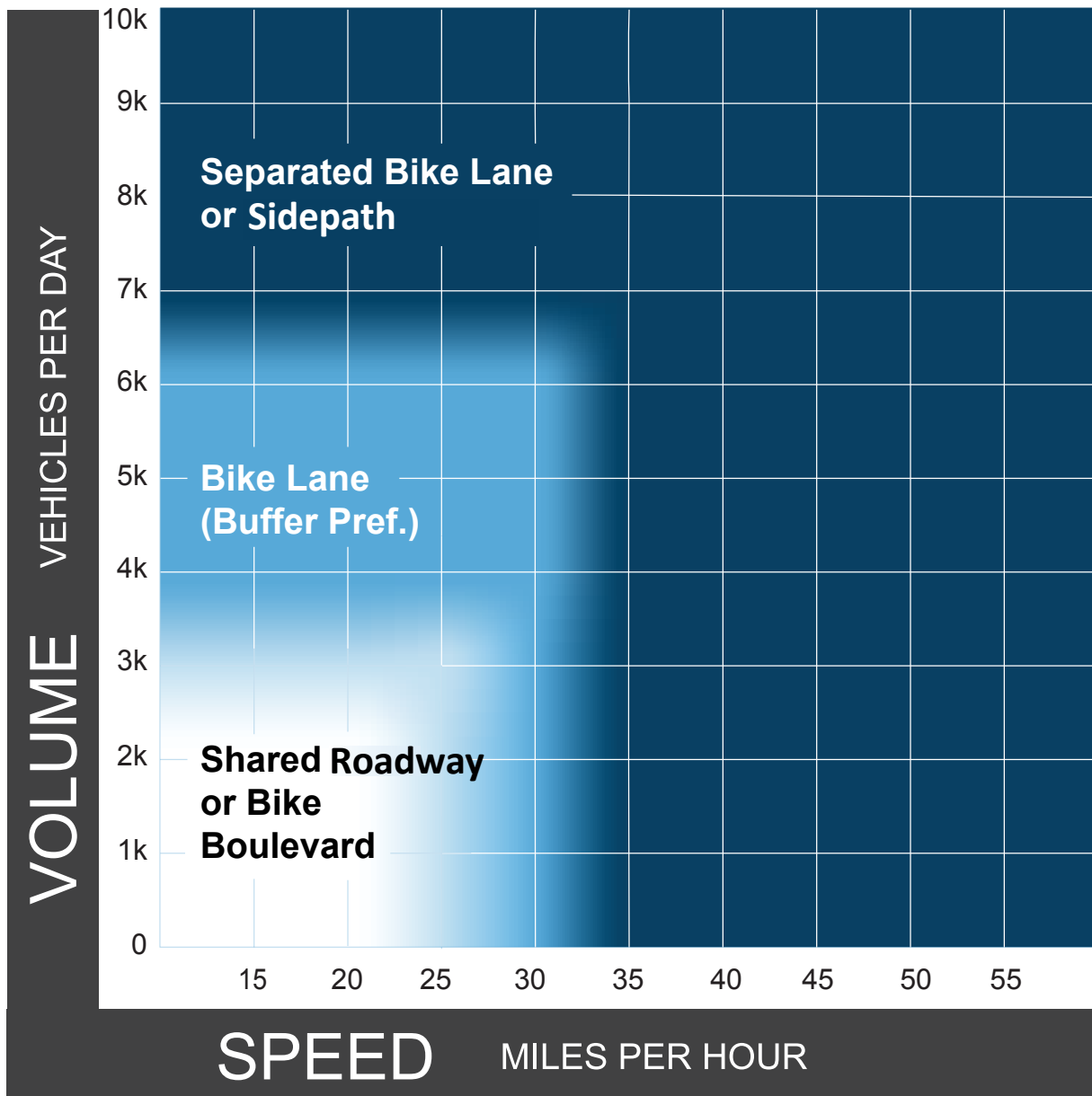
Land Use Contexts are discussed in detail on page 3-13. EXHIBIT 3-3 applies to the following land use contexts:

- Rural Crossroad
- Industrial – Warehouse - Port
- Suburban Residential
- Suburban Commercial
- Urban Residential
- Urban Commercial
- Urban Core

In these land use contexts, MnDOT’s typical bicyclist user profile is Interested but Concerned.

EXHIBIT 3-4 typically applies to natural and rural land use contexts. In these areas, designing for Interested but Concerned bicyclists may not be feasible. Due to long distances between land uses, bicycle commuting or utilitarian trips are also less likely. Bicyclists in these areas tend to fall into the Highly Confident or Somewhat Confident user profiles.

URBAN/SUBURBAN



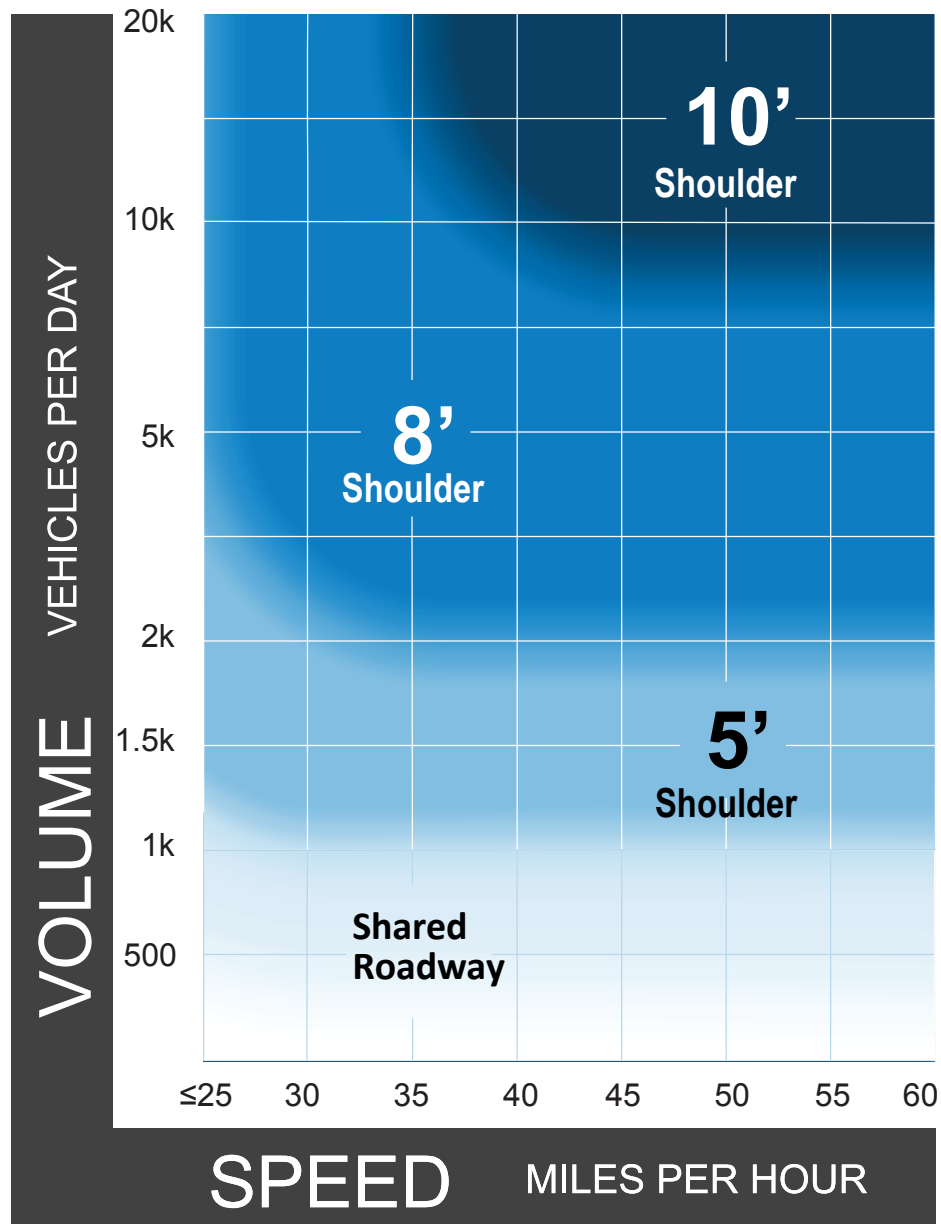
Source: FHWA Bikeway Selection Guide

Notes

- 1 Chart assumes operating speeds are similar to posted speeds. If they differ, use operating speed rather than posted speed.
- 2 Advisory bike lanes may be an option where traffic volume is <3K ADT.
- 3 See "Next-Best Bicycle Facilities" on page 3-12 for a discussion of alternatives if the preferred bicycle facility type is not feasible.

EXHIBIT 3-3: Preferred Bicycle Facility Type for Urban, Urban Core, Suburban and Rural Town Contexts

RURAL



Notes

Source: FHWA Bikeway Selection Guide

- 1 A separated shared use pathway is a suitable alternative to providing paved shoulders.
- 2 Chart assumes operating speeds are similar to posted speeds. If they differ, use operating speed rather than posted speed.
- 3 If the percentage of heavy motor vehicles is greater than 5%, consider providing a wider shoulder or a separated pathway.

EXHIBIT 3-4: Preferred Bikeable Shoulder Widths for Rural Roadways

ONE-WAY VERSUS TWO-WAY OPERATION

When motor vehicle traffic speeds and volumes are over a certain threshold, either a separated bike lanes or a sidepath are recommended to provide people bicycling separation from motor vehicle traffic (EXHIBIT 3-3). Selecting the appropriate type of separated facility depends on factors such as connectivity, access, available right-of-way, curbside uses, driveway locations and transitions at either end of the facility.

Whenever possible, separated bike lanes should be designed to operate as one-way in the same direction as motor vehicle traffic. Drivers are more likely to expect and notice people bicycling on a one-way separated bike lane operating in the same direction as motor vehicle traffic.⁶ In addition, one-way facilities provide intuitive, direct connections to the surrounding bicycle network and shared lanes.

An assessment of the surrounding bicycle network and land use context may provide insight into whether a one-way or two-way facility is most appropriate. If a roadway does not have convenient crossing locations at regular intervals, people bicycling may be more likely to ride contraflow on one side of the roadway. Consider the location of key origins and destinations when determining the side of the road for a two-way facility. In areas with origins and destinations on both sides of the road, consider providing a two-way sidepath on both sides of the road.

Two-way operation may be unavoidable in some situations. Because they are shared with pedestrians, shared use paths and sidepaths are typically two-way facilities.

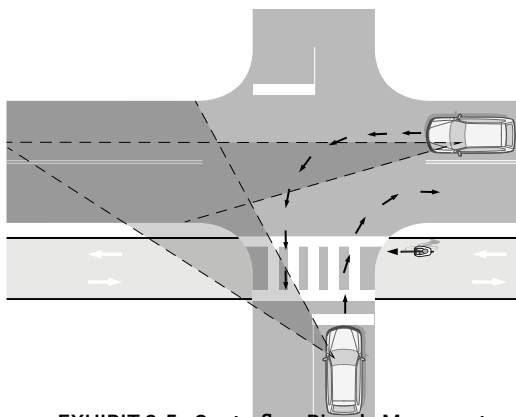


EXHIBIT 3-5: Contraflow Bicycle Movement

In addition, two-way shared use paths require less space than one-way, separated facilities, so right-of-way limitations may result in the selection of a two-way sidepath. Two-way bicycle facilities introduce a contraflow bicycle movement that drivers turning across the bicycle facility may not expect (EXHIBIT 3-5: Contraflow Bicycle Movement). For example, in EXHIBIT 3-5, the right turning driver may be looking for traffic on the left while the left turning driver may be looking for traffic ahead. In both cases, a contraflow bicyclist is not in the drivers' main field of vision.

When a two-way bicycle facility is built, additional design features that slow drivers' turning movements and give drivers more time to see oncoming bicyclists will improve safety (see Chapter 5 for more information on how to design sidepath intersections).

FEASIBILITY EVALUATION

The feasibility of the preferred type of bicycle facility may depend on the type of project – full reconstruction typically allows more flexibility than a roadway alteration project. When evaluating the feasibility of the preferred bicycle facility type, it is important to understand how it fits into the planned bicycle network and connects to land uses. Check District Bike Plans to understand if a project includes a Bicycle Investment Route; these routes have been identified as key connections in the statewide bicycle network. As necessary, consult with district planners or the Office of Transit and Active Transportation to discuss options.

Designers should make decisions using all design flexibility allowed, balancing project purpose, need and MnDOT's Statewide Bicycle System Plan goals to increase:

- **Safety and comfort:** Build and maintain safe and comfortable bicycling facilities for people of all ages.
- **Local bicycle network connections:** Support regional and local bicycling needs.
- **State bicycle routes:** Develop a connected route network.
- **Ridership:** Increase riding frequency for people who already bicycle and those who don't.

NEXT BEST BICYCLE FACILITIES

If the preferred facility type is not feasible, despite employing design flexibility in all roadway cross-section elements (narrowing lanes, road diet, etc.), consider the next best facility type. For example, if a separated bike lane is preferred to serve the Interested but Concerned bicyclist, but is not feasible, consider a buffered bike lane, which still provides some level of separation. Always consider the impacts on ridership, comfort, safety and overall network connectivity when evaluating bicycle facility alternatives or parallel routes to ensure the project will still meet the needs of people bicycling. A next best facility type selection should be based on context and specific project constraints. Ideally, a next best facility is a short-term measure and can be improved in a future project.

The level to which the preferred bicycle facility type should be compromised, if compromise is necessary, should be informed by the relative importance of the segment within the larger network and the availability of alternative routes. For example, if the form of the bike network is a grid, a compromise on one segment may be acceptable given that a parallel route may be available. In contrast, if there is only one roadway that provides access for people bicycling, for example across a river, compromising on the bicycle facility will have a greater impact on overall ridership.

Selecting the next best bicycle facility may mean that gaps in the network are not sufficiently filled. The selected facility may have a comfort level that doesn't meet the needs of people of all ages and abilities.

“The decision to modify the bikeway design should consider allowable design flexibility and trade-offs. If the preferred facility type is not feasible, the next best facility should be considered. Only after balancing roadway cross-sectional elements within the right-of-way based on context and after exhausting a variety of design configurations should designers consider implementing the next best bicycle facility type.”

From FHWA Bikeway Selection Guide

ACHIEVING THE PREFERRED TYPE OF BICYCLE FACILITY

High-quality bicycle facilities are substantially easier to implement if identified and planned for accordingly during project scoping. Planning for bicycle facilities at the outset of a project allows improved project delivery and efficient expenditure of project funding by ensuring adequate right-of-way is acquired and funding is sufficient for construction. See Chapter 2 for project scoping guidance.

Land Use Context

Planning and design guidance varies depending on the land use contexts. [Technical Memorandum No. 18-07-TS-05 MnDOT Land Use Contexts: Types, Identification and Use](#), provides guidance to identify the various land use contexts and how that dovetails with Performance-Based Practical Design to allow for greater design flexibility.³¹

Selecting a preferred bicycle facility type requires balancing community priorities based on relevant project constraints, data analysis, and engineering judgment. Land use context is an important consideration when determining facility type and the need for separation between modes. Land use context also influences right-of-way availability, the mix of roadway users, property access, traffic operating speeds, road operations and safety performance and community goals—all of which will drive trade-offs and decisions.



EXHIBIT 3-6: Land Use Context Types, is a summary of land use context types described in Tech Memo 18-07-TS-05. This information can help designers balance user needs and safety. Consider variations within land uses and transitions between land uses in the project area. Note there is not a ‘small town’ or ‘small city’ land use context. A small town typically includes many of the land use context types described below, but may be of a smaller scale or length along a roadway corridor compared to those in a larger developed area.

In addition to overall land use context, the presence of specific types of land uses should be considered in establishing the context of the project. The list below, developed as part of [Minnesota Walks](#), are typical destinations that all people visit – and should be factored into selecting a bicycle facility.⁴²

Destinations that influence bicycle facility selection include:

- Food (shops, markets, local restaurants, etc.)
- Bus/transit (including trains)
- Schools
- Parks



CONTEXT TYPE	DESCRIPTION	USERS AND FACILITIES
Natural	Sparsely settled, low intensity uses in a natural condition. Places less suited for development (wetlands, unique forests, meadows, prairies), lakes, waterways, steep slopes, historic areas. Destinations may be moderately to widely spaced.	All users, especially tourist, recreation. Shared roadways, shoulders, some shared use paths, few sidewalks. Some on-demand transit, little fixed route service. Mainly surface parking lots and some on-shoulder parking.
Rural	Sparsely settled, low intensity uses. Destinations may be moderately to widely spaced.	All users. Shared roadways, shoulders, some shared use paths, few sidewalks. Some on-demand transit; few transit stops. Mainly surface parking lots and some on-shoulder parking.
Rural Crossroad	Small scale, low to medium intensity use areas. Destinations may be closely to moderately spaced. A more intensely developed area may function as a Main Street or commercial node.	All users. Shared roadways, shoulders, occasional sidewalk or shared use path, some on-demand transit; few transit stops. Mainly surface parking lots and some on-street and on-shoulder parking.
Industrial – Warehouse - Port	Medium to large scale, medium intensity uses. May be in an isolated location within a rural area, or located within or adjacent to suburban and urban settings. Destinations are typically moderately spaced.	All users, especially medium and large truck/freight users. Shared roadways, shoulders, occasional sidewalks/sidepaths, bus stops often on adjacent edge/main roads. On-street parking, large internal surface parking lots and occasional structure parking.
Suburban Residential	Medium to large scale, low to medium intensity uses. Destinations are typically closely to moderately spaced.	All users, especially children. Shared roadways, shoulders, occasional paths, bus stops usually on adjacent-edge roads. Internal street, path connections to edge/main roads often limited, moderately spaced. Parking on-driveway, on-street.
Suburban Commercial	Medium to large scale, low to medium intensity uses. Destinations are typically moderately spaced.	All users. Multimodal roads, shoulders, occasional sidewalk or shared use path, some transit stops at major destinations, park and ride lots for commuters. Large surface parking lots, occasional on-street and structure parking.
Urban Residential	Medium to large scale, medium to high intensity uses. Destinations are typically closely spaced.	All users. Shared roadways, shoulders, alleys, sidewalks, street trees, transit stops, some bike lanes. On-street, alley-rear parking.
Urban Commercial	Small to large scale, medium to high intensity uses. Destinations are typically closely spaced and may be stacked vertically.	All users. Shared roadways, shoulders, alleys, sidewalks, street trees, bike lanes and separated bike lanes, transit stops/stations. On-street, surface parking lots and some structure parking; includes bicycle parking.
Urban Core	Compact area of varied scale, high intensity. Destinations are typically very closely spaced and stacked vertically.	All users. Shared roadways, shoulders, alleys, sidewalks, some street trees, skyways, bike lanes and separated bike lanes, transit stops-stations-centers. Mostly structure parking, some on-street parking; includes bicycle parking.

EXHIBIT 3-6: Land Use Context Types

Project Type

The type of construction project can often influence the type of bicycle facility that can be implemented. For example, if the project is a mill and overlay, designers are required to work within the constraints of the existing road section. If the project is a full reconstruction, then designers have more flexibility to make changes to the road section including moving curb lines. Designers are faced with complex challenges depending on the extent of the reconstruction and should consider flexible design options. MnDOT projects fall into six general categories. Each offers a different opportunity for selecting and implementing an appropriate bicycle facility type.

- **Reconstruction:** A roadway project constructed on a new alignment or full depth pavement reconstruction on the existing alignment. This project type usually has the fewest constraints and greatest design flexibility.
- **Bridges:** Bridge projects may be coordinated with a larger roadway project or as a standalone project based on bridge condition. Because bridges are expensive, there are significant width constraints. However, because they are such long term investments, including the appropriate bicycle facilities in bridge projects is critical.
- **Design/Build:** Large reconstruction/bridge projects may be contracted as a Design/Build project. While the type of work being done is the same, the process for developing the roadway designs is different. If a project will be contracted using the Design/Build method, consult with Office of Transit and Active Transportation staff when writing the RFP to ensure the design outcomes balance user needs within the corridor and consider the surrounding land use context.
- **Alteration or Mill and Overlay:** A roadway project that retains the existing roadway alignment (except for minor changes); the basic roadway type does not change. This project type is sometimes called a resurfacing or rehabilitation project. Projects in this category typically require curb improvements and sidewalk improvements as identified by the ADA Unit.

CORRIDOR-WIDE DESIGN

Sometimes corridor projects are designed and constructed in successive annual stages. When designing a project, always consider the effect adjacent projects and elements have on your project and vice versa.

Consider how a project connects to adjacent networks and corridors. This allows designers to capitalize on opportunities and avoid future complications. For example: ensure bicycle facilities don't end abruptly and they tie safely and predictably into adjacent segments; factored utility placement into the bicycle facility types and locations; and grades smoothly match adjacent and future segments.

When sidewalk improvements impact the curb line there may be additional opportunity to provide bicycle facilities and alignments within project constraints. This project type typically involves right-of-way constraints that should be taken into consideration.

- **Preventative maintenance:** This type of project typically enhances pavement performance and extend pavement longevity. This project type involves the most constraints but may provide an opportunity to include a bike lane or widen a shoulder. It is important to note that repair quality can affect bicycling comfort and facility use. For example, sealing or filing cracks with a smooth transition to the adjacent pavement allows bicyclists to concentrate on the surroundings rather than be distracted by surface conditions. Preventative maintenance can include fog sealing, chip sealing, slurry sealing and microsurfacing. Preventative maintenance may include restriping, which could provide an opportunity to include a bike lane or widen a shoulder.
- **Routine Maintenance:** Typical roadway maintenance operations include roadway surface repairs for cracks, potholes, bumps and other surface defects. Repairs can include bituminous patching (temporary and permanent), crack sealing and crack filling.

DESIGN FLEXIBILITY OPTIONS

Bicycle and/or pedestrian facilities are easiest to add during reconstruction or new construction projects; however, these opportunities may take decades to realize. New construction corridors should be designed for multimodal use from the beginning minimum dimensions for bicycle and pedestrian facilities can usually be avoided. When reconstruction is not an option, altering existing roadways is the most common scenario that designers encounter. For alterations, there are three common methods of finding space for bicycle facilities within the existing curb-to-curb space: roadway reconfiguration or road diet, narrowing lane widths, and removing parking.

RESURFACING

Installing bicycle facilities during roadway resurfacing projects is an efficient and cost-effective way for communities to create connected networks of bicycle facilities. See the [FHWA's Incorporating Bicycle Networks in Resurfacing Projects](#) for more information, which provides recommendations for how roadway agencies can integrate bicycle facilities into their resurfacing program, as well as methods for fitting bicycle facilities onto existing roadways, cost considerations and case studies.⁴³

Roadway Reconfiguration

Often, existing roadways are capable of handling substantially more motor vehicle traffic than they experience throughout the day. Roads are typically designed based on a forecast of future traffic volumes, but there are cases where the traffic forecast may have been incorrect or circumstances have changed, resulting in fewer motor vehicles than expected in an original roadway design. This often leads to roads with excess capacity that encourage people to drive at fast speeds, which creates low-comfort, high-stress conditions for people walking, bicycling and taking transit.

Road diets or roadway reconfigurations are one of the FHWA's proven safety countermeasures and have safety benefits for all modes. Four-lane to three-lane conversions are the most common roadway change. There are various examples of four-lane to three-lane conversions with 20,000 motor vehicles per day or less and some where converted roads carry over 20,000 motor vehicles/day. Through traffic analysis, it is often possible to remove and repurpose lanes to improve the safety performance of a roadway segment. Typical conversion outcomes are:

- Reduced travel speeds
- Space for bicycle facilities
- Safer street crossings and turn lanes
- New or enhanced streetscapes, wider sidewalks and other purposes

See the [FHWA Road Diet: Informational Guide](#) and the [NACTO Urban Street Design Guide](#) for more information.^{44,45}



Narrow Lane Widths

In many cases, space can be created for bicycle facilities by narrowing existing travel and turn lanes. Contrary to expectations, narrower lane widths do not reduce roadway capacity and can increase roadway safety.⁴⁶ People naturally drive slower when lanes are narrow, which can have a positive impact on crash severity. The AASHTO Green Book notes 10-foot travel lanes as within the acceptable range on urban arterial and collector roadways. In urban contexts, lanes as narrow as 10 feet typically result in no change to crash rates, severity or roadway capacity. MnDOT's Performance-Based Practical Design Guide highlights the tolerances and guidance for narrowing lanes when appropriate.²⁰

Finally, The PBPDG states that given, "the obvious economic and environmental advantages of narrower cross sections, designers should favor narrower lane dimensions unless wider dimensions can be justified on the basis of expected performance. Consideration should originate at 10 feet for design speeds of 20 to 35 mph and 11 feet for 40 mph design speeds and greater, with flexibility either wider or narrower depending on circumstances."

Remove or Relocate Parking

On-street parking serves more than one function. It may serve residents or businesses; provide a buffer for people walking, improving their comfort and safety; and it may reduce motor vehicle traffic speeds. At the same time, on-street parking introduces potential conflicts for people bicycling and driving a motor vehicle; it uses road width that might otherwise be used as a travel lane or to create a more separated bicycle facility. If removing, reconfiguring, or narrowing existing lanes does not provide sufficient space for bicycle facilities, consider removing on-street parking.

Removing parking is often a controversial proposal with both advantages and disadvantages. For example, removing parking allows space to be reallocated for new uses. Frequently, roads with on-street parking have higher crash rates than those that don't. On-street parking adds friction to the roadway which helps to reduce driving speeds.

Removing parking should involve careful evaluation and negotiation with any affected residents and businesses. Consider the number and type of businesses on each side of the street when considering parking removal on only one side. Some strategies to reduce the impact of parking removal are:

- If considering removing parking from only one side, look for streets with less than 50 percent parking occupancy.
- For roads with steep grades, consider removing parking on the downhill side as this may help minimize conflicts between faster downhill-moving bicyclists and parked motor vehicles.
- Parking can vary along a corridor. Consider alternating parking from one side of the road to the other which provides a traffic calming benefit.
- Include adjacent side street parking occupancy in parking studies. Often parking can be removed from the trunk highway corridor and adequate parking provided on the side streets.
- Look for ways to consolidate parking in newly created parking bays or in shared (off-street) surface parking lots or structures.
- Many communities are more actively managing on-street parking by implementing parking regulations or pricing strategies to promote more efficient use of existing on-street parking spaces to increase their short term parking supply, shift long-term parking activities to different locations and ensure curbside loading is available near businesses.

If parking is modified, accessible parking spaces for people with disabilities may still be required. A parking utilization study is often useful to help determine feasible solutions.

PILOT AND DEMONSTRATION PROJECTS

Demonstration projects are short term, low-cost, temporary roadway projects used to pilot long-term design solutions to improve walking/bicycling and public spaces. Projects may include, but are not limited to, bike lanes, crosswalk markings, curb extensions and median safety islands.

Demonstration project benefits could include:

- Test aspects of project design before making large political or financial investments
- Inspire action and build support for project implementation
- Expedite project implementation
- Widen public engagement by inviting stakeholders to try active transportation improvements
- Deepen understanding of active transportation needs in the community
- Encourage people to work together in new ways and strengthen relationships between government agencies, non-profit organizations, local businesses and residents
- Gather data from real-world use of streets and public spaces

See the [Demonstration Project Implementation Guide](#) for more information.⁴⁷



4

**OPERATIONAL
CHARACTERISTICS
& ELEMENTS OF
DESIGN**

Introduction

People bicycling have similar access and mobility needs as other users of the transportation system and legally may ride on any road that is not explicitly restricted through signs. People bicycling may use roads as their primary means of access to jobs, services and for recreational activities. To some extent, basic geometric design elements for motorized vehicles, such as stopping sight distance, horizontal and vertical alignment, grade and cross-slope will meet or exceed the minimum design standards for on-street bicycling. Other users, such as children, may have design characteristics that are different than adult bicyclists; designers should consider these differences for projects near locations children frequent.

This chapter provides guidance for the many design elements common to a wide range of bicycle facility types. Some design elements are critical to safe travel for bicyclists and bicycle facility design but are not affected by design controls. These include drainage, surface conditions and detection at signals. Common elements are discussed in this chapter and in later chapters pertaining to specific facility types. Where these same elements relate specifically to the facility types in Chapter 5, there is also information there.

Bicyclist Characteristics

A bicyclist's vision, balance, reaction time and perception of risk influences their ability to ride a bicycle and their operating characteristics. It is important to design facilities to meet the needs of all users, including children, those with disabilities and aging adults. For the purposes of the calculations shown in this guide, the design bicyclist is assumed to be an adult between the ages of 24 and 65. Compared to children and aging adults, adults can generally start and stop their bicycles more quickly, are more visible to drivers and have greater awareness of the rules of the road and potential conflicts. Children's brains are still developing, and their perception of gaps in traffic is different than that of an adult. For example, older children may choose the same size gap as an adult, but they take longer to get started and cross the roadway.⁴⁸

If children or aging adults are expected in numbers greater than average, designers may wish to deviate from the noted adult values and use lower travel speeds and longer reaction times. By understanding the unique characteristics and needs of people bicycling, a designer can provide appropriate facilities that attract users of all types and abilities while minimizing user risk.

Almost all bicyclists require space to accommodate side-to-side movement. This is why the minimum operating and preferred operating widths for bicyclists are greater than the physical operating width dimensions (EXHIBIT 4-1: Bicyclist Typical Dimensions). The preferred operating width of five feet should be provided in almost every instance. For short distances under constrained conditions (i.e. under an overpass), the minimum operating width can be used to prevent a gap in a bicycle facility. In addition to the minimum operating width, provide shy distances to obstacles such as curbs, bollards, gutter seams and parking. Motorized emergency and maintenance vehicles may periodically need to gain access to bicycle facilities, resulting in additional width requirements. See Chapter 5 for more details for designing specific bicycle facility types.

Bicyclist - Typical Dimensions

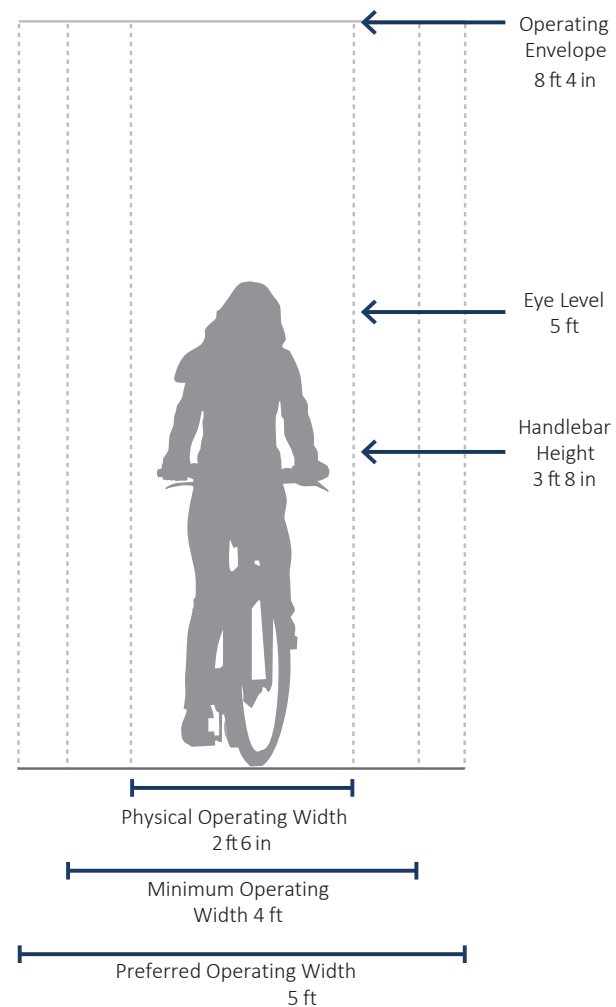


EXHIBIT 4-1: Bicyclist Typical Dimensions

Similar to motor vehicles, bicycles come in a variety of sizes and configurations. When designing a bicycle facility, use the dimensions of a typical adult upright bicyclist. In addition to the design dimensions of a typical bicycle, EXHIBIT 4-2: Bicycle Dimensions shows other commonly used pedal-driven or electric-assisted devices and accessories to consider when planning and designing bicycle facilities.

Bicycle Design Vehicle - Typical Dimensions

A: Adult Typical Bicycle

B: Adult Tandem Bicycle

C: Adult Recumbent Bicycle

D: Child Trailer Length

E: Child Trailer Width

F: Trailer Bike Length

G: Adult Tricycle Length

H: Adult Tricycle Width

I: Adult Longtail Cargo Bike Length

J: Adult Box Bike Length

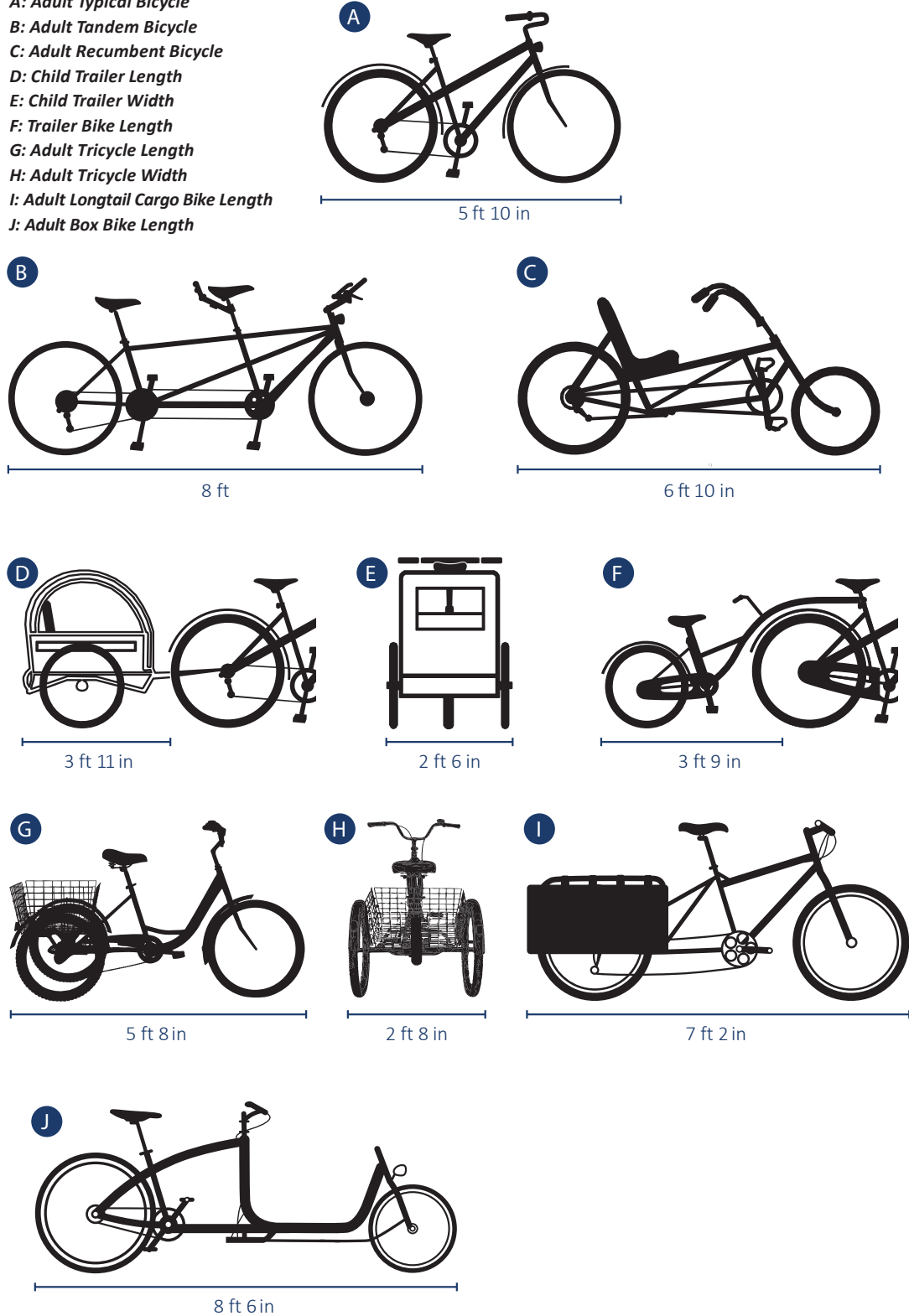


EXHIBIT 4-2: Bicycle Dimensions

A summary of the performance characteristics of a typical adult bicyclist that are important to bikeway design is shown in EXHIBIT 4-3: Typical Bicyclist Performance Characteristics. A bicyclist's speed can vary depending on trip purpose, type of facility, grade, cargo weight and riding companions. While some adults are able to maintain speeds of 20 mph or more, the typical adult bicyclist averages between 8 and 15 mph.

Bicyclist reaction times, acceleration rates and deceleration rates are used to calculate things such as stopping sight distance, and traffic signal timings.

EXHIBIT 4-3: Typical Bicyclist Performance Characteristics

FEATURE	RANGE*	RECOMMENDED VALUE*	USES
Travel speed on level terrain**	8-15 mph	15 mph	Sight triangles, intersection sight distance, horizontal sight line offset
Intersection travel speeds on level terrain**	8-11 mph	Crossing – 8 mph Approaching – 11 mph	Intersection signal timing
Reaction Time	1.0-2.5 seconds	1.5 seconds - expected stop 2.5 seconds - unexpected stop	Stopping sight distance, intersection signal timing
Acceleration Rate	2.0-5.0 ft/sec ²	2.5 ft/sec ²	Intersection signal timing
Deceleration Rate, (wet pavement)***	2.0-5.0 ft/sec ²	5.0 ft/sec ²	Intersection signal timing
Coefficient of friction (wet pavement)***	0.16	0.16	Stopping sight distance

*Based on adult, upright bicyclist

**To account for grade, increase the design speed by 0.5 mph for every 1 percent increase in downhill grade and decrease by 1 mph for every 1 percent increase in uphill grade.

***Rates for dry pavement are higher, but designers should plan for wet conditions

ELECTRIC-ASSISTED DEVICES

Electric-assisted bicycles and scooters are becoming increasingly popular and people operating them typically travel side-by-side in the same spaces as human-powered bicycles. Equipment, policies and laws are evolving to allow safe, coexistent use. Though there are operational differences, designers should consider these modes in a similar manner to human-powered bicycles; for example, using appropriately designed curves to slow people as they approach an intersection. Minnesota Statute 169.011 includes some parameters for electric-assisted bicycles, including a maximum assisted speed of 20 miles per hour.

Stopping Sight Distance

People bicycling need time to see and react to both expected and unexpected conditions. Stopping sight distance is a function of a user's perception and reaction time, initial speed, friction coefficient, equipment and grade. Consider all users when computing stopping sight distance, including children, people on in-line skates, people on adaptive bicycles, etc.

EXHIBIT 4-4 and EXHIBIT 4-5 show the minimum stopping sight distance for various design speeds and grades based on perception and brake reaction times of 1.5 and 2.5 seconds, respectively. Use 1.5 seconds where bicyclists will typically expect conflicts, such as intersections on urban roadways. Use 2.5 seconds where the potential conflict is unexpected, such as reduced path widths or blind curves.

Minimum stopping sight distance can also be calculated using the equation shown in EXHIBIT 4-6: Minimum Stopping Sight Distance Equation (U.S). On steep hills, the stopping sight distance required in the descending direction (G is negative) may be significantly longer than that for the uphill direction. Typical coefficients of friction vary from 0.20 for inline skaters to 0.30 for recumbent bicyclists. A coefficient of friction for a typical bicyclist is 0.32 for dry conditions and 0.16 for wet conditions.⁴

EXHIBIT 4-4: Stopping Sight Distance (ft) Based on Speed and Grade for a 1.5 Second Perception-Reaction Time

Speed (mph)	Grade (Positive indicated ascending)										
	-0.1	-0.08	-0.06	-0.04	-0.02	0	0.02	0.04	0.06	0.08	0.1
10				50	46	43	41	39	37	36	35
12				66	61	56	53	50	48	46	45
15			108	96	87	80	75	71	67	64	62
18	220	175	148	130	117	107	100	94	89	85	81
20	267	211	178	155	139	128	118	111	105	100	
25	403	316	264	229	204	185	171	159	150		
30	567	442	367	317	281	254	233	216			

EXHIBIT 4-5: Stopping Sight Distance (ft) Based on Speed and Grade for a 2.5 Second Perception-Reaction Time

Speed (mph)	Grade (Positive indicated ascending)										
	-0.1	-0.08	-0.06	-0.04	-0.02	0	0.02	0.04	0.06	0.08	0.1
10				65	61	58	55	53	52	51	50
12				84	78	74	71	68	66	64	62
15			130	118	109	102	97	93	89	86	84
18	246	201	174	156	143	134	126	120	115	111	108
20	296	240	207	185	169	157	148	140	134	129	
25	440	353	300	266	241	222	208	196	187		
30	611	486	411	361	298	298	277	260			

EXHIBIT 4-6: Minimum Stopping Sight Distance Equation (U.S)

$$S = \frac{V^2}{30(f \pm G)} + 1.47 Vt$$

VARIABLE	MEANING
S	stopping sight distance (feet)
V	velocity (miles per hour)
f	coefficient of friction (use 0.16 for a typical bike in wet conditions)
G	absolute value of grade (feet/feet) (rise/run)
t	perception/reaction time (1.5 seconds for expected stops, 2.5 seconds for unexpected stops)

Note: +/- = negative traveling downhill, positive uphill

Facility Transitions

People bicycling choose their routes based on a balance of route comfort and directness. A route may encompass multiple bicycle facility types and changes in direction. To design with a network-wide approach, create transitions between facility types that are functional, intuitive and accessible. Transitions between facility types, particularly along the length of a corridor, may happen for many reasons:

- The limits of a given project may not be long enough to complete network connections
- A project may be in multiple jurisdictions, each with different opinions on what to provide
- Available right-of-way and land use characteristics may change along the corridor

Most transitions occur at intersections, though they sometimes also occur mid-block. More information about bicycle facilities transitions at intersections can be found on page 4-25 in this chapter and in Chapter 5. If the bicycle facility type changes along a roadway, designers should create a logical transition and provide sufficient warning so that the transition is not abrupt for the bicyclist or the driver.



ONE-WAY SHOULDER OR BIKE LANE TO TWO-WAY SIDEPATH

The transition between one-way bike facilities on each side of the road to a two-way sidepath on one side of the road should be carefully considered. People walking and bicycling on one side of the road will be required to cross the roadway to travel on the sidepath. Adding sidepaths to both sides of the road eliminates a bicyclist's need to cross travel lanes and is always the preferred option. If including only one sidepath in a project, transitions to/from the opposite direction shoulder or bike lane to the sidepath should be well defined. The transition may occur at an intersection or a midblock location and may require pavement markings, signs, or other crossing treatments. Not including this transition may result in bicyclists riding against motor vehicle traffic on the shoulder or in the bike lane.

If the sidepath is less than ½ mile long, some bicyclists will decide not to cross travel lanes to use the sidepath-only to quickly cross back again. In these locations, on-street bike lanes may be a more appropriate facility choice. This guidance applies to any scenario where there is a transition from a one-way to two-way facility. See Chapter 7 for transitions from shoulders to sidepaths in roundabouts.

BIKE LANE TO SHARED LANE

At the end of a bike lane, BIKE LANE (R3-17) sign with an ENDS plaque (R3-17bP) should be installed in advance of the transition, along with dashed bike lane lines.

Depending on the context, a shared lane marking may be used to direct bicyclists into the correct position in the shared lane and confirm for users that the facility is now shared. In addition to pavement markings, signs may be used to draw attention to the transition. A BIKES MAY USE FULL LANE (R4-11) sign or a Bicycle Warning sign (W11-1) with a SHARE THE ROAD plaque (W16-1P) may be used, although the BIKES MAY USE FULL LANE (R4-11) sign is preferred. See Chapter 5 for details on markings and signs for shared lanes.

SHOULDER TO SHARED LANE

The transition between a shoulder and a shared lane may need to be signed and marked to help inform drivers and bicyclists of the change. SHOULDER ENDS (W8-25) signs, shared lane markings, BIKES MAY USE FULL LANE (R4-11) signs or a Bicycle Warning sign (W11-1) with a SHARE THE ROAD plaque (W16-1P) may be used to confirm that drivers should expect people bicycling in the shared lane. See Chapter 5 for details on markings and signs for shared lanes.

A shoulder-to-shared-lane transition is particularly applicable in rural crossroad contexts where a road with a paved shoulder enters a developed area with curb and gutter and bicycle traffic is likely. If there is a transition from a shoulder to shared lane condition in natural or rural areas, this type of transition may not need to be marked; it will depend on the context and existing or anticipated bicycling volumes.

Pavement Markings, Signs & Signals

Traffic control for bicyclists includes traditional traffic control devices such as pavement markings, signs and

signals, which can be deployed area-wide and are not just for a specific application, street, or intersection. The [Minnesota Manual on Uniform Traffic Control Devices Section 9](#)³ describes traffic control devices for bicycle facilities.

PAVEMENT MARKINGS

The following guidance is universal for all bicycle facility pavement markings. For information on pavement marking treatments that apply to each specific bicycle facility type, see Chapter 5. See Chapter 6 for information on pavement marking maintenance.

Pavement markings on bicycle facilities should be retroreflective, smooth, stable and slip-resistant. The markings themselves should not rise more than 0.16 inches above the pavement. Chapter 7 of the [Traffic Engineering Manual](#)⁴⁹ states that recessing pavement marking materials below the pavement surface can significantly increase the life expectancy of the marking. When recessing longitudinal lines, wet reflective elements are required.

Consider the quantity of markings to be used and whether safety and traffic control objectives can be met with fewer markings or through geometry. Bicyclists are one of the most vulnerable roadway users; be careful not to eliminate markings or traffic control devices that enhance a bicyclist's comfort or safety.

REQUESTS TO EXPERIMENT

All devices and applications shown in this manual are either in the MN MUTCD or have been approved for interim use by FHWA.

There may be a case where a new traffic control device or different application of an existing device could improve bicyclist safety or operations. For devices and applications that are not included in the MN MUTCD or do not yet have Interim Approval, consider a Federal Request to Experiment. See [MN MUTCD Section 1A.10.2](#)³ and contact the MnDOT Standards Engineer at 651-234-7388 for more information on the Request to Experiment process.

INTERIM APPROVALS

Many new or evolving bicycle pavement markings, signs and signals are allowed under FHWA interim approval until incorporated into the next federal MUTCD. MnDOT has received statewide approval for many of these treatments in all Minnesota jurisdictions. If considering one of these treatments, read the interim approval document carefully to understand the installation requirement. Provide the location of any installed treatment to the MnDOT Traffic Standards Engineer at 651-234-7388. See [MN MUTCD Section 1A.104](#) for more information on using devices with interim approvals and Appendix F for a list of all interim approvals referenced in this manual.³

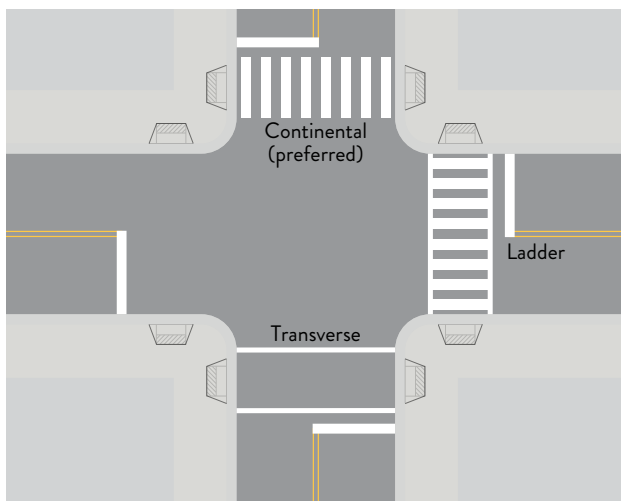


EXHIBIT 4-7: Crosswalk Marking Styles



GREEN COLORED PAVEMENT INTERIM APPROVAL

In April 2011, FHWA issued [Interim Approval 14](#) for green colored pavement in bike lanes, behind standard word and symbol markings, and in conflict areas.⁵⁰ In May 2012, MnDOT received a statewide approval from FHWA, allowing the use of green colored pavement in all Minnesota jurisdictions. In order to meet the requirements of this statewide approval, MnDOT must maintain a list of locations using the green colored pavement. If installing green colored pavement, please provide the location to the MnDOT Traffic Standards Engineer at 651-234-7388.

Marked Crosswalks

Crosswalk markings can enhance the awareness of yielding responsibilities at intersection locations and are necessary to establish a pedestrian crossing at mid-block locations. Under Minnesota State Statute 169.222 Subd 4(f), “A person lawfully operating a bicycle...across a roadway or shoulder on a crosswalk, shall have all the rights and duties applicable to a pedestrian under the same circumstances.”

Mark crosswalks using high visibility markings, such as ladder or continental patterns. MnDOT typically uses continental style crosswalk markings. EXHIBIT 4-7 shows different crosswalk marking styles. Install crosswalk markings according to [Section 3B.18 of the MN MUTCD](#)³ and Chapters 7 and 13 of the MnDOT [Traffic Engineering Manual](#).⁴⁹

Green Colored Pavement

Green colored pavement is an optional treatment that can enhance the conspicuity and comfort of bicycle facilities, particularly at conflict points. Colored pavement refers to differently colored paving materials, paint, or marking materials (MN MUTCD Section 3G.01). Green colored pavement is considered a traffic control device. Use green colored pavement to increase the conspicuity of a bike lane, bike lane extension, bicycle crossing, bike box, or two-stage turn queue box. See Chapter 5 for information on bike lanes, bike boxes and two-stage turn queue boxes.

In research, motorists reported a favorable impression of green colored pavement as a traffic control device, citing an increased awareness that people bicycling might be present and where they might be positioned.

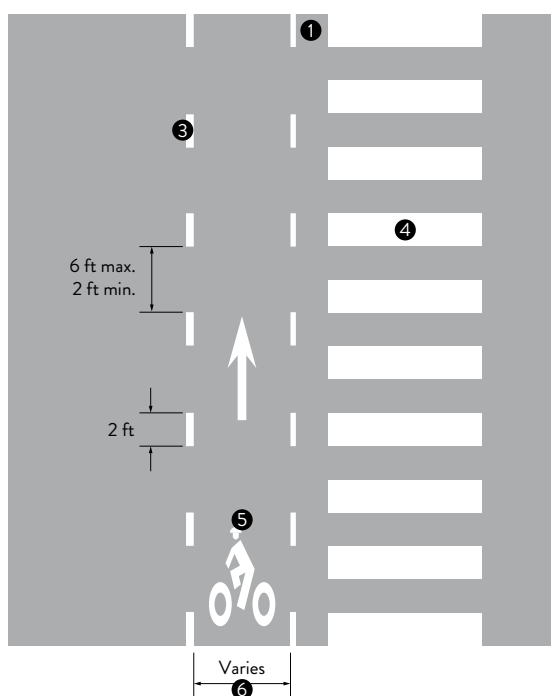
Maintenance responsibilities and agreements should be in place between MnDOT and local agencies, if relevant, before installing green colored pavement. General considerations include:

- Keep pavement markings out of the wheel track whenever possible to increase the marking’s life expectancy.
- Green colored pavement can be retroreflective, but retroreflectivity is not required.
- Green colored pavement can supplement, but should not replace, white dotted lines as defined by the MN MUTCD.
- Use durable, skid-resistant markings for longer-lasting effects and to reduce the risk of falls for bicyclists and pedestrians.

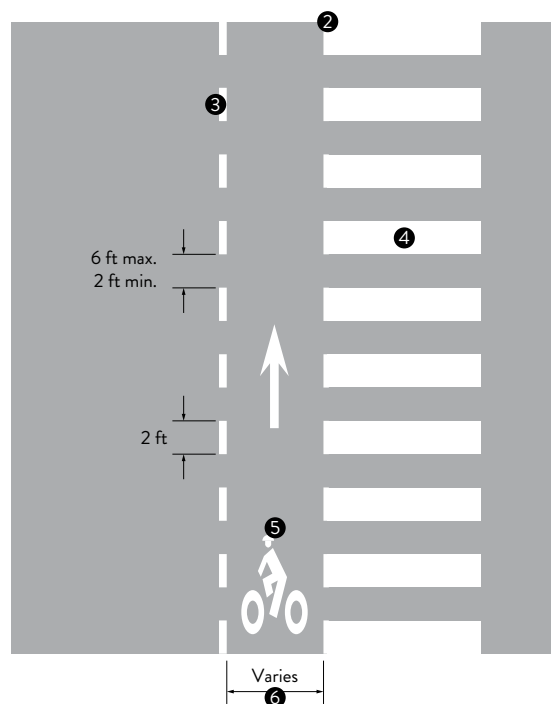
Bicycle Crossing Markings

Bicycle crossing markings clarify the intended path of bicyclists approaching intersections and at conflict points within intersections. The markings guide bicyclists through intersections by delineating between a bicyclist's path and the path of adjacent moving or crossing motor vehicles (EXHIBIT 4-8). Bicycle crossing markings are not required, but can improve intersection safety by:

- Raising awareness of conflict areas
- Reinforcing priority of through-moving bicyclists over turning drivers
- Guiding bicyclists on a direct path
- Reducing stress when crossing an intersection
- Increasing predictability

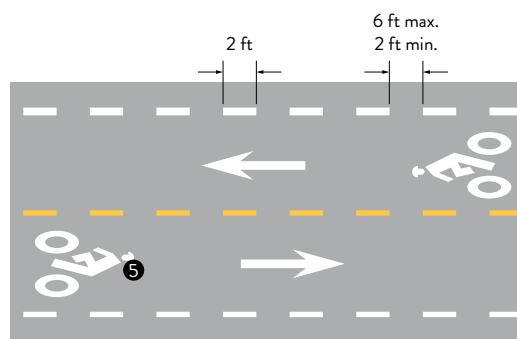


ONE-WAY BICYCLE CROSSING
WITH 1 FOOT MIN. OFFSET FROM CROSSWALK



ONE-WAY BICYCLE CROSSING
WITH NO OFFSET FROM CROSSWALK

- ① 1 foot minimum offset
- ② No offset
- ③ 6 inch white dotted line
- ④ Crosswalk
- ⑤ Optional bicycle symbol
- ⑥ Match bike lane width

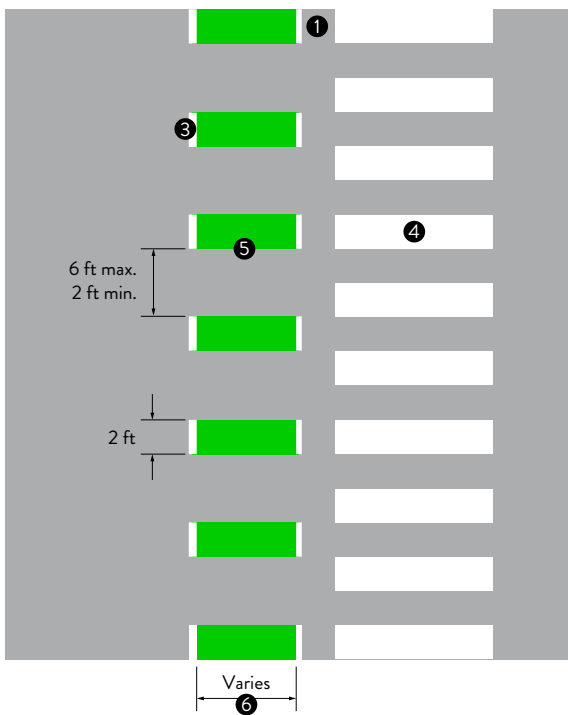


TWO-WAY BICYCLE CROSSING

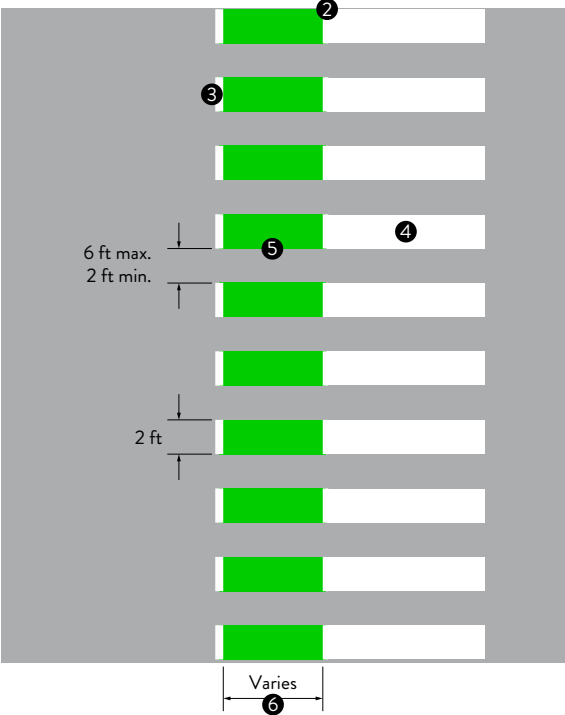
EXHIBIT 4-8: Bicycle Crossing Marking

When people walking and bicycling are not sharing the same facility (i.e. not a sidepath) bicycle crossing markings can be used at side-street, driveway and ramp crossings to distinguish the bicycle crossing from the pedestrian crossing. Where multiple agencies' roads and bicycle facilities meet along a corridor, coordinate bicycle crossing treatments for consistency and predictability.

Bicycle crossing markings should include dotted white edge line extension of the approaching bike lane. This dotted line indicates that conflicting vehicle movements may cross the bike lane. The crossing width should match the width of the approaching bike lane. Bicycle crossing markings should be offset from a crosswalk by a minimum of one foot.

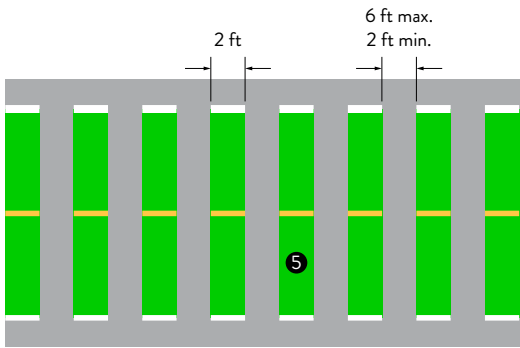


ONE-WAY BICYCLE CROSSING
WITH 1 FOOT MIN. OFFSET FROM CROSSWALK



ONE-WAY BICYCLE CROSSING
WITH NO OFFSET FROM CROSSWALK

- ❶ 1 foot minimum offset
- ❷ No offset
- ❸ 6 inch white dotted line
- ❹ Crosswalk
- ❺ Optional green colored pavement
- ❻ Match bike lane width

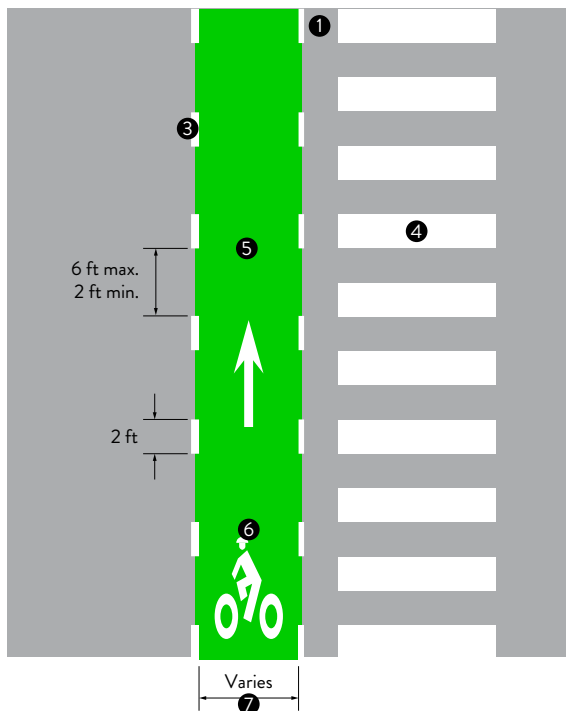


TWO-WAY BICYCLE CROSSING

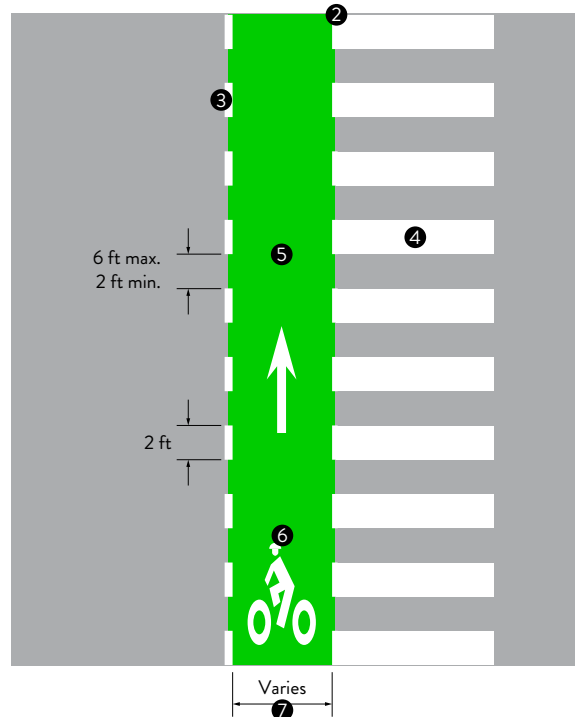
EXHIBIT 4-9: Broken Green Bicycle Crossing Marking (Preferred)

If a one-foot offset cannot be achieved, the crossing should be immediately adjacent to crosswalk markings, and only the outside edge line should be marked.

Green colored pavement may be used to supplement dotted white edge lines to add further conspicuity to the crossing (EXHIBIT 4-9). Green colored pavement should match the pattern of the dotted white edge line, but may be solid if additional emphasis is required (EXHIBIT 4-10). Bicycle crossings that serve two-way traffic should include a dotted yellow center line to distinguish between directions of travel.

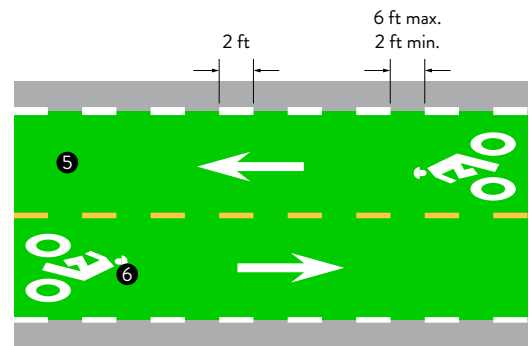


ONE-WAY BICYCLE CROSSING
WITH 1 FOOT MIN. OFFSET FROM CROSSWALK



ONE-WAY BICYCLE CROSSING
WITH NO OFFSET FROM CROSSWALK

- ① 1 foot minimum offset
- ② No offset
- ③ 6 inch white dotted line
- ④ Crosswalk
- ⑤ Optional green colored pavement
- ⑥ Optional bicycle symbol
- ⑦ Match bike lane width



TWO-WAY BICYCLE CROSSING

EXHIBIT 4-10: Solid Green Bicycle Crossing Marking (Optional)

SIGNS

There are three types of roadway signs: regulatory, warning, and guide signs. Signs for bicycle facilities should follow requirements in [Chapter 9 of the MN MUTCD](#).³ For clarity, sign descriptions in this manual include their MN MUTCD sign code. General provisions for signing include:

- Signs should be retroreflective.
- Signs should be placed at least two feet away from the edge of a shared use path or sidepath.
- Signs that apply to both bicyclist and drivers should be sized for the roadway. See MN MUTCD Part 2.
- Any signs intended specifically for bicyclists can be reduced in size and should be placed so as not to confuse road users. See MN MUTCD Table 9B-1 for bicycle sign sizes.
- Install regulatory signs at or near the regulated area.
- Install warning signs in locations where unexpected conditions will occur, such as a short length of reduced path width. Warning signs should be used sparingly, yet uniformly.
- Place signs along a bicycle facility to allow adequate response time. Base sign locations on the stopping sight distance of the anticipated fastest user. In some cases the fastest user may differ depending on the season. For example, a facility may serve people bicycling in the summer, but serve people snowmobiling in the winter. See guidance on shared use paths for additional discussion on design speed.
- Use guide signs and wayfinding signs to inform path users of intersecting routes and destinations. Consider placing mileage distances to popular destinations on wayfinding signs.



Warning Signs

Warning signs warn roadway users of approaching features on a particular section of road, such as curves, narrow bridges, pedestrian crossings or stop signs. They are black lettering on a yellow background. See MN MUTCD Part 9 for the full complement of applicable warning signs for bicycle facilities. EXHIBIT 4-11 depicts the standard bicycle warning sign which can be used to warn drivers of people bicycling on a road and to warn of a crossing when combined with the W16-7P (arrow). The sign depicted in EXHIBIT 4-12 is typically used at trail crossings or crossings where pedestrians and bicyclists will be present. See chapter 5 for information on warning beacons such as Rectangular Rapid Flashing Beacons.

Warning signs may be yellow or a fluorescent yellow-green when applied at crossings and in school zones. MnDOT typically uses fluorescent yellow-green for warning signs.



EXHIBIT 4-11: W11-1 Sign



EXHIBIT 4-12: W11-15 Sign

Regulatory Signs

Regulatory signs alert roadway users of rules they need to follow by law or regulation, such as the speed limit, stop, do not enter, parking restrictions and turning movements. They can have white lettering on either red or black backgrounds or black, red or green lettering on a white background. Notable regulatory signs for use with bicycle facilities are:

- Begin Right Turn Lane Yield To Bikes (EXHIBIT 4-13: R4-4)
- Bicycles May Use Full Lane (EXHIBIT 4-14: R4-11)
- No Parking Bike Lane (EXHIBIT 4-15: R7-9a)

When drivers are entering a right turn lane that is to the right of a bicycle lane, they must cross the bicycle lane. In this case, as the through vehicle, the bicyclist has the right of way. An R4-4 sign placed at this weaving location can inform both drivers and bicyclists of this conflict. Bicycles May Use Full Lane (R4-11) may be used anywhere that there are no bike lanes or usable shoulders or where the travel lanes are too narrow for drivers and bicyclists to operate side-by-side. No Parking Bike Lane signs can be useful when a new bike lane is added in a location where on-street parking was previously allowed.

CONSTRUCTION SIGNS

Construction signs can be warning signs or guide signs, and all have black lettering on an orange background. They alert users to construction related activities such as road construction ahead; non-standard features during construction, such as a closed bike lane or shoulder or a detour. Just like drivers, bicyclists need temporary traffic control through construction zones.

Construction signs with information for drivers should not be placed in an active bike lane. If a bike lane needs to be closed for construction activity, provide bicyclists with sufficient information about the closure and where they are required to merge with motor vehicle traffic. Bicyclists are especially sensitive to detours, since a detour may significantly increase their trip length. Place bicycle detour signs well in advance of a closure, and use other forms of communication to inform users of the change.



EXHIBIT 4-13: R4-4



EXHIBIT 4-14: R4-11



EXHIBIT 4-15: R7-9a



Guide Signs

Guide signs provide guidance and information along a shared use path or other bicycle facilities. They should give information to help bicyclists along their way in the most simple, direct manner possible. Guide signs are used to:

- Identify bike routes with either a generic or specific bike route sign
- Provide wayfinding guidance and connectivity between bike facilities
- Provide location-specific guidance such as:
 - Access to a bridge crossing
 - Navigation through complex roadway networks
 - Where a bicycle route diverges from a motor vehicle route

Guide signs should be placed so that they are visible to people bicycling. The spacing of the signs along a route should allow bicyclist time to read and comprehend the message on the sign, allow time to react to the message and make a decision before seeing another sign or coming to a decision point on the bike route.

[MN MUTCD Chapter 9³](#) has standards for application, placement and design of bicycle signs. This includes requirements for color, mounting height and lateral placement. Signs for the exclusive use of bicyclists should be located so that other road users are not confused by them. It is recommended that signs exclusively for bicyclists should be installed on their own sign structure. Guide signs and regulatory signs should not be installed on the same structure.

BIKE ROUTE SIGNS

Bike route signs identify designated bike routes. Bike routes should be designated on roads and shared use paths with favorable conditions for bicycling. A bike route, in and of itself is not a bicycle facility. Rather, it provides bicyclists information on where to find bicycle facilities such as sidepaths, on-street bike lanes, low-volume/low-speed shared roadways or paved shoulders.

Bike route signs should be placed at intervals frequent enough to keep bicyclists informed of changes in route direction and to remind motorists of the presence of bicyclists.

The generic BIKE ROUTE Sign EXHIBIT 4-16 can be used on either a roadway or shared use path. When installed with an arrow, the sign can be used to indicate bike route direction changes, for example at intersections, where the route turns from one road or shared use path onto another road or shared use path. The words BIKE ROUTE on the generic bike route sign may be replaced with a destination or route name on the D11-1c sign, which may provide bicyclists with more useful information.

A unique bicycle route sign can be used to identify a specific bike route, such as a US Bike Route or a local, named bike route (EXHIBIT 4-26 and EXHIBIT 4-27). Similar to generic bike route signs, these signs can be installed with an arrow at an intersection or decision point and as a confirmation sign after a turn.

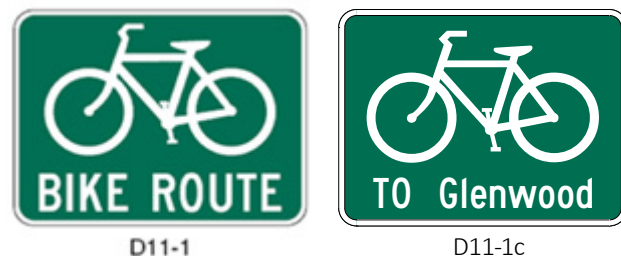


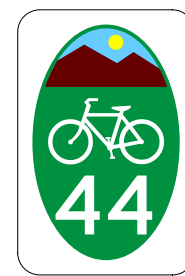
EXHIBIT 4-16: D11 Series Signs



M1-9



M1-8



M1-8a

EXHIBIT 4-17: Bike Route Signs

ADVANCE GUIDE SIGNS

Advance guide signs help bicyclists take the appropriate action at decision points and find their destination, whether it be a nearby city, a park or a key attraction within the area. These white on green signs are typically part of a wayfinding system. They usually are placed on designated bike routes.

Similar to advance guide signs for vehicles, advance guide signs for bicyclists are placed prior to intersections or decision points. These signs could include the name of the intersecting street(s), indicate turns needed to continue on a designated bike route, or provide direction to destinations found along the cross-street.

The design of advance guide signs for bicyclists is typically limited to three pieces of information, for example, three destinations. The signs may include the bike pictograph as part of the legend EXHIBIT 4-19 or as a single larger image at the top of the sign EXHIBIT 4-18. When installed on a shared use path that is only for non-motorized use, the pictograph is not needed. Distances may also be included on advance guide signs displaying destination or city names.

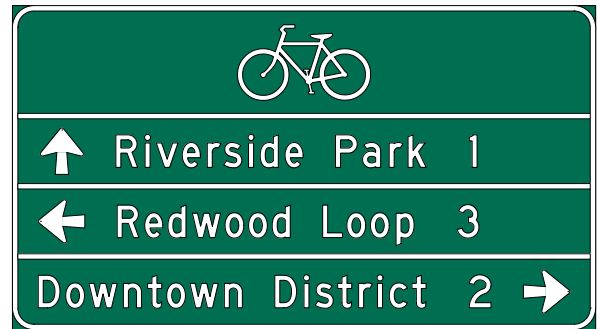


EXHIBIT 4-18: Custom Advanced Guide Sign

WAYFINDING SYSTEMS

A wayfinding system is a coordinated and continuous system of guide signs that direct bicyclists to key civic, cultural, visitor, and recreational attractions within an area, usually within a city or town. A wayfinding system should be simple and consistent. An area-wide bicycle wayfinding plan identifying destinations and routes is critical to developing clear and concise messages for advance guide signs.



EXHIBIT 4-19: Advanced Guide Signs for Bicyclists

TRAFFIC SIGNALS

Traffic signals manage traffic flow by allocating time and separating conflicting movements through intersections. In urban and suburban areas, bicycle facilities are likely to pass through signalized intersections. Where this occurs, consider bicyclists’ unique operating characteristics in traffic signal design and timing.

Signal Timing for Bicyclists

Bicyclists’ speed and behavior are important considerations at both motor vehicle traffic signals and bicycle-specific traffic signals. Parameters to modify depending on bicyclist characteristics are:

- Minimum Green – clears motor vehicles from stopped position. Bicyclists require a longer time than motor vehicles.
- Yellow Change Interval – warns approaching bicyclists or drivers of the end of their right-of-way and provides sufficient time to stop based on approach speeds.
- Red Clearance Interval – provides time for motor vehicles entering the intersection at the end of yellow to pass to the far side of an intersection.

MINIMUM GREEN CALCULATION

Typically, a vehicle-based minimum green is between 4 and 15 seconds. Depending on a bicyclist’s reaction time, acceleration rate and the intersection width, bicyclists may need additional time to enter and cross the intersection before the onset of yellow. Because bicyclists accelerate at a much slower rate than motor vehicles, a minimum green time that allows them to fully traverse the intersection may not be feasible. According to the AASHTO Guide for the Development of Bicycle Facilities,⁴ best practice is to calculate a minimum green time based on a bicyclist reaching a preferred location within the intersection, rather than clearing it completely. Typically a minimum green that allows a bicyclist to reach the middle of an intersection will result in a total phase length (green + yellow + red) long enough for the bicyclist to fully clear the intersection. For large, complex intersections, the calculation may need to be based on a distance up to the full width of the intersection; use engineering judgement based on land use context, bicyclist user volumes and other pertinent factors.

EXHIBIT 4-20: Bicycle Minimum Green Time Equation provides the equation used to determine the minimum green for a bicyclist starting from a stop, gaining speed

EXHIBIT 4-20: Bicycle Minimum Green Time Equation

$$G_{min} = t + \frac{1.47V}{2a} + \frac{d + L}{1.47V}$$

VARIABLE	MEANING
G _{min}	bicycle minimum green time (seconds)
V	attained bicycle crossing speed (assumed 8 miles per hour)
t	perception reaction time (assumed 1.5 seconds)
a	bicyclist acceleration rate (assumed 2.5 feet/second ²)
d	distance from stop bar to preferred location at the end of green (assumed middle of the intersection)
L	length of bicycle (assumed 6 feet)

and reaching the preferred location in the intersection. EXHIBIT 4-21: Bicycle Minimum Green Time provides a look up table based on assumed values. Note that grade may impact acceleration rate; manual calculations using an acceleration rate of 1.5 or 2.0 ft/sec² for uphill approaches may be necessary. In addition, young bicyclists need more time, so a higher perception reaction time and lower acceleration rate may be used to increase minimum green times near schools or where there are many young bicyclists.

Depending on the intersection width, yellow change and red clearance interval may not be sufficient to allow bicyclists to cross to the middle of the intersection during the minimum green time. Use the equation in EXHIBIT 4-22: Total Phase Length Equation to confirm that the total phase time is equal to or greater than the time needed to cross the entire intersection.

YELLOW CHANGE INTERVAL

The length of the yellow change interval is typically calculated based on motor vehicle approach speeds and deceleration rates. Because motor vehicles have

higher speeds and lower deceleration rates than bicycles, a yellow change interval calculation based on motor vehicles will be sufficient for bicyclists. If bicycle movements are controlled by a vehicle signal or a bicycle signal that runs concurrently with a vehicle signal, the vehicle yellow change interval should be used.

If a bicycle signal is used exclusively for a bicycle movement, a 3-second yellow change interval should be used. This provides significant reaction and stopping time for a bicyclist traveling up to 15 mph and matches the MN MUTCD minimum vehicle yellow change interval.

EXHIBIT 4-21: Bicycle Minimum Green Time

DISTANCE FROM STOP BAR TO PREFERRED LOCATION AT END OF GREEN (FEET)	BICYCLE MINIMUM GREEN TIME (SECONDS)
25	6.5
30	6.9
35	7.3
40	7.8
45	8.2
50	8.6
55	9.0
60	9.5
65	9.9
70	10.3
75	10.7
80	11.2
85	11.6
90	12.0
95	12.4
100	12.9
105	13.3
110	13.7
115	14.1
120	14.6
125	15.0
130	15.4
135	15.8
140	16.3
145	16.7
150	17.1

RED CLEARANCE INTERVAL

The red clearance interval provides a buffer for drivers entering an intersection at the end of yellow to clear the intersection before the start of green for conflicting traffic. Red clearance is calculated based on the speed of the approaching motor vehicle and the width of the intersection. Because bicyclists are traveling at slower speeds than drivers, a red clearance interval based on motor vehicle speeds will typically not be sufficient for a bicyclist entering at the end of yellow to completely clear an intersection.

Designers should consider the geometry of an intersection and where a bicyclist entering the intersection at the end of yellow will be at the beginning of green for conflicting traffic. A red clearance time that is long enough for a bicyclist entering the intersection at the end of the yellow change interval to be visible to drivers in conflicting motor vehicles and establish their right-of-way may be sufficient.

For very large or complex intersections or areas with sight distance issues, designers may consider implementing a red extension for bicyclists. A red extension requires detection. If a bicyclist is detected entering the intersection at the end of the yellow change interval, the red clearance time is extended to provide the bicyclist sufficient time to become visible to drivers.

EXHIBIT 4-22: Total Phase Length Equation

$$G_{min} + Y + R_{clear} \geq t + \frac{1.47V}{2a} + \frac{W+L}{1.47V}$$

VARIABLE	MEANING
G_{min}	bicycle minimum green time (seconds)
Y	yellow change interval (seconds)
R_{clear}	red clearance interval (seconds)
V	attained bicycle crossing speed (assumed 8 miles per hour)
t	perception reaction time (assumed 1.5 seconds)
a	bicyclist acceleration rate (assumed 2.5 feet/second ²)
W	intersection width (feet)
L	length of bicycle (assumed 6 feet)

Signal Design for Bicyclists

Bicycle movements at traffic signals can be controlled by any of the following types of signals:

- Vehicular signal heads that also control motor vehicle traffic
- Standard traffic signal heads designated for bicycle use
- Pedestrian signal heads
- Signal heads with bicycle signal faces designated for bicycle use



BICYCLE SIGNAL FACES INTERIM APPROVAL

In December 2013, FHWA issued [Interim Approval 16](#) for bicycle signal faces to control bicycle movements at traffic signals.⁵¹ In September 2014, MnDOT received a statewide approval from FHWA allowing the use of bicycle signal faces in all Minnesota jurisdictions. In order to meet the requirements of this statewide approval, MnDOT must maintain a list of locations using the bicycle signal faces. If installing bicycle signal faces, please provide the location to the MnDOT Traffic Standards Engineer at 651-234-7388.

Bicyclists in shared lanes and on-street bike lanes typically follow vehicular signal heads already in place. A standard traffic signal designated for bicycle use should include the "BICYCLE SIGNAL" sign (R10-10b) to indicate that it specifically applies to bicycles. Bicyclists on sidewalks or sidepaths have the same rights and responsibilities within a crosswalk as pedestrians. In these cases, they may follow the pedestrian signal. Use the "BIKES USE PED SIGNAL" sign (R9-5) in cases where bicyclists in an on-street bike lane should follow the pedestrian signal.

The use of one bicycle signal head (with or without a bicycle signal face) is typically sufficient, since bicyclists are rarely the primary movement at an intersection. A supplemental signal may be necessary for intersections with complex movements or protected bicycle phases. The primary bicycle signal head should be 8 or 12 inches in diameter.



Bicycle signal heads can address one or more of the following situations:

- Bicyclist non-compliance with the existing traffic control.
- Provide bicyclists with different information than the vehicular or pedestrian signals.
- Continue the bike lane on the right side of one or more exclusive right-turn lanes that would otherwise be in non-compliance with Paragraph 6 of MN MUTCD Section 9C.4 (Markings for Bicycle Lanes).
- Augment the design of a separated contra flow bicycle facility.
- Provide an increased level of control by facilitating unusual or unexpected arrangements of the bicycle movement through complex intersections and conflict areas.

BICYCLE DETECTION

Actuated signals should passively detect bicycles. If passive detection isn't available, a curb-side push button should be provided to allow bicyclists to manually activate the signal. If a signal is not pre-timed, bicycle detection, or lack thereof, has a significant impact on bicyclist comfort and mobility. For example, without pre-timing or detection, bicyclists may need to wait for a driver to trigger the detection or leave the road to push the pedestrian push button to actuate a signal. In cases where a bicyclist is shown a red indication for "an unreasonable time" because they have not been detected, Minnesota Statute 169.06, Subd. 9 allows for a bicyclist to enter or cross an intersection on red. However, interested but concerned bicyclists may not feel comfortable entering an intersection on a red indication, so this situation should be avoided.

When considering whether or not to provide bicycle-specific detection at a signal, take into account:

- Bicycle facilities present
- Number of lanes to cross
- Motor vehicle speeds and volumes on the street to be crossed
- Motor vehicle volumes in adjacent lanes
- Length of motor vehicle clearance interval
- Traffic signal equipment and operations
- Maintenance of detection equipment

Location

Passive bicycle detection at the stop line should be located:

- Across the entire bicycle path or within easy reach of a stopped bicyclist.
- In any two-stage turn queue box or bike box.
- Adjacent to a curb or another type of footrest, when available.

The MN MUTCD includes bicycle detector pavement marking that can be used to identify the best place for a bicyclist to stand to activate the signal. (EXHIBIT 4-23: Bicycle Detection Pavement Marking Dimensions) The pavement marking can be supplemented with a Bicycle Signal Actuation sign (R10-22) (EXHIBIT 4-24: R10-22 Sign). These markings and signs can be used with any type of detection.

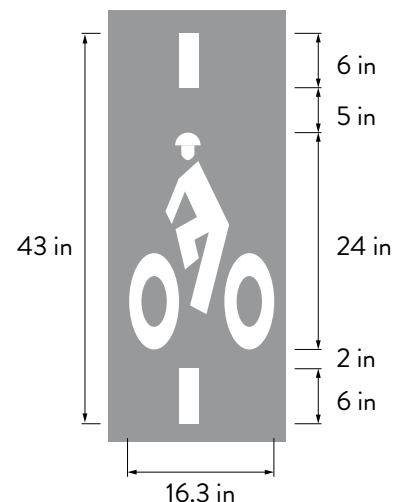


EXHIBIT 4-23: Bicycle Detection Pavement Marking Dimensions



EXHIBIT 4-24: R10-22 Sign

Effectiveness

Because bicycles are smaller and harder to detect than motor vehicles, detection equipment does not always reliably detect bicyclists. Any bicycle detector installation should be tested under a variety of lighting and weather scenarios to confirm its effectiveness. When using passive detection, such as video or inductive loop detectors, consider installing a confirmation light so that a bicyclist knows they have been detected.



Detection Technology

The following types of detectors are often used to detect bicyclists at traffic signals. New products and improved versions of existing bicycle detection products are being released regularly.

Inductive loop detectors (passive)

Inductive loop detectors are the most common type of passive vehicle detection on MnDOT's system. Most motor vehicle loop detectors cannot distinguish between a motor vehicle and a bicycle, and loop detectors calibrated for motor vehicles may have trouble detecting bicycles made from carbon fiber or other non-metallic materials.

Diagonal quadrupole or a 6-foot by 6-foot skewed loop are the most suitable for detecting bicycles in an on-street bike lane. Skewed loop detectors can also be used on shared use paths or in general travel lanes and are effective at detecting only the vehicles within that lane.

Bicycle-specific inductive loops can be used in bike lanes, separated bike lanes, on sidepaths, or on shared use paths at roadway intersections. However, bicyclists turning left may not be detected by a bicycle-specific inductive loop detector in the bike lane. If there is a large volume of left-turning bicyclists, consider video detection or some other form of detection that can differentiate between bicycles and motor vehicles. If an inductive loop detector can reliably distinguish between bicycles and motor vehicles, consider providing the minimum bike green on detection as opposed to the minimum motor vehicle green.

Video detection (passive)

Video detection is also common on MnDOT's system and can be used to detect moving and stationary objects. Signal controller software that analyzes images within set zones can differentiate between types of users with acceptable accuracy. Video detection can be easy to install, and there is flexibility in where detection zones are located.

Video detection can be ineffective in poor lighting or bad weather, and should be tested under a variety of conditions. Place video detection zones in well-lit areas. Video detection cameras may need periodic cleaning to remove road salt and other dirt.

Infrared detection (passive)

A thermal (infrared) camera can be used to detect changes in temperature caused by the presence of a bicyclist. Infrared detection is based on similar software as video detection, but the camera is more expensive. Infrared can be detected through fog, snow and other environmental constraints that impair video detection.

Microwave/radar (passive)

Microwave detectors analyze reflections from a radar transmitter and receiver to detect moving and stationary objects, as well as their direction of travel. Microwave detection cannot distinguish between types of user.

Push buttons (active)

Passive bicycle detection is preferred whenever possible. If bicycle-specific push buttons are used, they should be placed near the roadway where on-street bicyclists can reach them without dismounting.

For shared use facilities, such as sidepaths, an accessible pedestrian signal must be provided to share signal information with visually impaired pedestrians. However, passive bicycle detection can still be used in conjunction with an APS button. For guidance on ADA compliance and the placement of APS buttons, see [MnDOT Tech Memo 18-04-OP-01](#)⁵² or contact the ADA Unit.



Pavement Design

High quality pavement design and construction that minimizes maintenance needs benefits everyone and reduces ADA liability. Concrete and bituminous pavements differ in materials cost, time before repairs are needed and maintenance/major rehabilitation costs. Selecting the correct pavement for a particular project will help balance these factors. It is also important to address pavement structure, design/ specifications/ typical sections, base prep and smoothness; particularly for standalone bicycle facility pavement to ensure pavement longevity. This manual no longer provides specific information about paving materials or installation. Consult the [Pavement Design Manual](#).⁵³ As necessary, consult MnDOT's Materials Lab for material recommendations, particularly on standalone bicycle facility projects.

ON-STREET FACILITIES

Regardless of the bike lane width chosen (see Chapter 5), include at least three feet of smooth pavement outside of the gutter seam. This transition area between the gutter and roadway pavement poses a potential crash threat to people bicycling. Consider incorporating the bike lane into a widened, concrete gutter pan if the three feet of smooth pavement cannot be provided.

The vertical transition from the gutter to adjacent pavement should be no more than ¼ inch, regardless of where the seam is located in the bike lane. Inspect this transition area during and after construction.

SHARED-USE PATHS AND SIDEPATHS

For shared use paths or sidepaths, the structural design of the pavement can have substantial financial consequences. Inadequate base preparation or pavement thickness can result in surfaces that deteriorate quickly from maintenance vehicles, frost heave and intruding vegetation. Consider the type of maintenance vehicle to be used when selecting a pavement thickness.

Designing with trees in mind can prevent pavement heaving. Compacted soils cause shallow-rooted trees to move toward the pavement surface toward air and water. This results in heaved sections of pavement. Consult with MnDOT's Office of Environmental Stewardship for current best practices.

On concrete paths, use joints that accommodate expansion and serve people walking and bicycling on the shared use path. Use saw-cut expansion joints over troweled joints to create a smoother surface and to create a greater likelihood of meeting the ¼ inch maximum ADA horizontal gap requirement.

On shared use paths that are not adjacent to a roadway, natural surface paths provide a more rural or natural feel and tend to be preferred by runners, but may require expensive maintenance, may not meet ADA requirements and are difficult to effectively plow.

PERMEABLE PAVEMENTS

Permeable pavements reduce the amount of stormwater runoff from a bicycle facility and provide additional space for water retention, especially in constrained areas. Sidepaths, shared use paths, or separated bike lanes can be good candidates for permeable pavements. The [Pavement Design Manual](#)⁵³ indicates that non-highway pavements, such as sidewalks, driveways, and parking lots may be designed to allow infiltration under their structure. In addition, the Minnesota Stormwater Manual, produced by the Minnesota Pollution Control Agency also provides guidance on the design of permeable pavements. Contact the MnDOT Pavement Design Engineer if considering permeable pavements as part of a bicycle facility project.

Drainage

Drainage grates and utility covers can be hazards to people bicycling, especially when placed in their path. Grates in bike lanes should be bicycle compatible, which means they have appropriately sized and oriented openings to prevent a bicyclist from catching their wheel in the gap (EXHIBIT 4-25: Bicycle-Compatible Drainage Grates).

When a bicycle-incompatible grate is present in a location that will be converted to a bicycle facility, replace the grate with one that is bicycle safe or install a new frame/ grate casting assembly. Bicycle compatible grates may be less hydraulically efficient; consult early with the Hydraulics Unit for the best design outcome. Consider maintenance equipment and snow removal in the selection of drainage grates for a bicycle facility.

If installing a barrier between a road and bicycle facility, the barrier should be installed so as not to create damming.

Ideally, pavement overlays should raise grates or utility covers to within $\frac{1}{4}$ " of the new surface. If this is not possible, the inlet should be tapered so there is no abrupt edge. A smooth transition to the adjacent pavement allows bicyclists to concentrate on the surroundings rather than be distracted by surface conditions.

ADA-compliant shared use paths should have flush surfaces and good drainage to ensure debris, water or ice do not accumulate in the pedestrian access route. To achieve this, work closely with the Hydraulics Unit to meet ADA and drainage requirements.

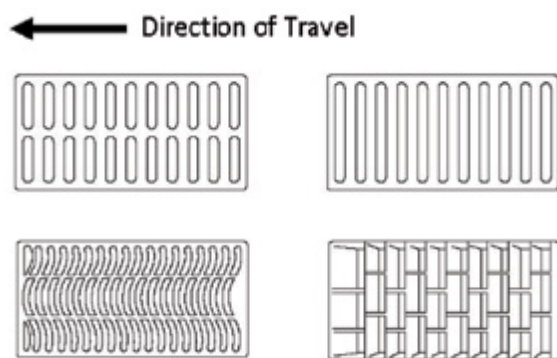


EXHIBIT 4-25: Bicycle-Compatible Drainage Grates

Lighting

The purpose of roadway lighting is to attain a level of visibility so users can see quickly, distinctly and with certainty all significant roadway details, such as the roadway alignment and surroundings and any obstacles on or near the roadway. As the [MnDOT Roadway Lighting Design Manual](#)⁵⁴ states, “Nearly all aspects of traffic safety involve visibility.” Fixed-source lighting can improve visibility along bicycle facilities at night or under other dark conditions. Lighting can also greatly improve a bicyclist’s ability to notice surface irregularities under such dark conditions, even if their bicycle is equipped with headlights. Pedestrian scale lighting is preferred for bicycle facilities. Provide appropriate and adequate lighting for all users, especially when night-time use is expected—particularly at the following locations:

- On bicycle facilities that provide convenient connections to typical popular destinations, such as transit stops and stations, schools, universities, shopping and employment areas
- Under vehicular bridges, underpasses, tunnels, or locations with limited visibility
- Along bridges (unless bicycling and walking are access-controlled)
- Along high-use bicycle facility locations that lead to areas with frequent evening events
- Where a bicycle facility intersects with roadways or driveways and crossing is required
- At major shared use path or sidepath entrances

To ensure adequate lighting, consult the Roadway Lighting Design Manual for guidance. Place lighting out of harms way by setting it back from the roadway in the buffer area. Plan for the maintenance of any lighting included in a bicycle facility project.

General Intersection Design Principles

Because intersections are where bicyclists and drivers interact the most, many bicycle-motor vehicle conflicts and crashes occur at intersections. EXHIBIT 4-26: Reducing Conflict Through Intersection Design, illustrates all the potential conflict points between a motor vehicle and a bicyclist in a conventional bike lane at a four-way intersection. Intersection design should provide good awareness between motor vehicle operators, pedestrians and bicyclists, isolate conflicts and clearly assign priority between modes. For specific intersection guidance related to each bicycle facility type, see Chapter 5.

Intersection design has a considerable impact on each intersection user's comfort, safety and mobility and should factor in how bicyclists and other users navigate the intersection approach, departure and crossing. Intersection geometric design features should complement traffic control devices to promote compliance with laws and the devices, as well as improve safety and comfort for users expected to yield the right-of-way. Intersection design should strive to reduce both conflicts and the risk of injury for all users in the event of a crash. This includes:

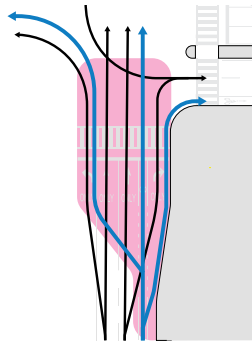
- Designing to minimize exposure to conflicts
- Reducing speed at conflict points
- Communicating right-of-way priority
- Providing adequate sight distance
- Creating clear, direct transitions to other facilities
- Accommodating people with disabilities

The following intersection design principles apply to all bicycle facilities:

- Avoid free-flowing motor vehicle turning movements.
- Provide adequate lighting.
- Enable direct, logical paths for bicyclists through intersections.
- Time signals so they do not cause excessively long wait times and design actuated signals to detect bicycles (See also "Pavement Markings, Signs & Signals" on page 4-8).
- If there is no pedestrian signal on recall, program minimum green and clearance intervals at traffic signals to sufficiently allow bicyclists to reach the far side of an intersection.
- Bike lane extensions and symbols can continue through intersections to define space and enhance pathways.
- Compact, right-angle intersections create better sightlines for drivers to see bicyclists. Acute angles create a narrower cone of vision, making bicyclists less visible.
- To treat acute angle intersections:
 - Realign approaches.
 - Reconfigure intersections with more than 4 legs.
 - Install dotted bike lane extensions.
 - Consider converting to a roundabout.
 - Consider protected intersection geometry in scoping and project development (See Chapter 5)
- Access management can be used to remove conflict points for all roadway users.

For specific intersection guidance related to each bicycle facility type, see Chapter 5.

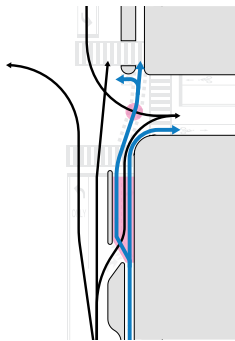
The diagrams on this page provide a comparison of the levels of exposure associated with various types of intersection designs.



Exposure Level: **High**

CONVENTIONAL BIKE LANES AND SHARED LANES

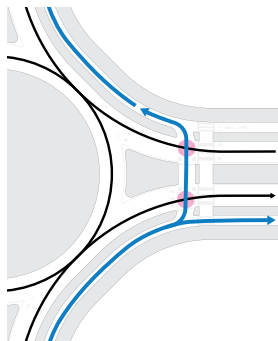
Bike lanes and shared lanes require bicyclists to share and negotiate space with motor vehicles as they move through intersections. Drivers have a large advantage in this negotiation as they are driving a vehicle with significantly more mass and are usually operating at a higher speed than bicyclists. This creates a stressful environment for bicyclists, particularly as the speed differential between bicyclists and drivers increases. For these reasons, it is preferable to provide separation through the intersection.



Exposure Level: **High to Medium**

SEPARATED BIKE LANES WITH MIXING ZONES

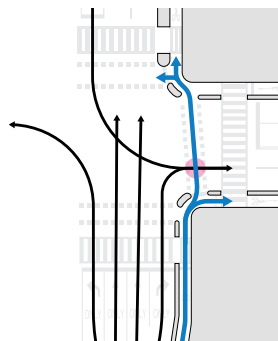
One strategy that has been used in the U.S. at constrained intersections on streets with separated bike lanes is to reintroduce the bicyclist into motor vehicle travel lanes (and turn lanes) at intersections, removing the separation between the two modes of travel. This design is less preferable to providing a protected intersection for the same reasons as discussed under conventional bike lanes and shared lanes. Where provided, mixing zones should be designed to reduce motor vehicle speeds and minimize the area of exposure for bicyclists.



Exposure Level: **Medium to Low**

SEPARATED BIKE LANES THROUGH ROUNDABOUTS




Separated bike lanes can be continued through roundabouts, with crossings that are similar to, and typically adjacent to, pedestrian crosswalks. Drivers approach the bicycle crossings at a perpendicular angle, maximizing visibility of approaching bicyclists. Bicyclists must travel a most circuitous route if turning left must cross four separate motor vehicle path approaches.



Exposure Level: **Low**

PROTECTED INTERSECTIONS

A protected intersection maintains the physical separation through the intersection, thereby eliminating the merging and weaving movements inherent in conventional bike lane and share lane designs. This reduces the conflicts to a single location where turning traffic crosses the bike lanes. The single conflict point can be eliminated by providing a separated signal phase for turning traffic.

Legend
 bicycle travel path
 driver travel path
 potential conflict

Source: MassDOT Separated Bike Lane Planning & Design Guide

EXHIBIT 4-26: Reducing Conflict Through Intersection Design

BICYCLE FACILITIES

5

Introduction

The six types of bicycle facilities in this chapter range from the most separated from motor vehicle traffic to least separated, beginning with shared use paths, sidepaths and separated bike lanes, which provide physical separation between people bicycling and motor vehicles. Next are bicycle lanes and paved shoulders, which are designated spaces for bicycling with no separation; they are immediately adjacent to the travel lane. Finally, shared roadways are spaces where people bicycling have no designated space and share the road with motorized vehicles. More separation better serves the Interested but Concerned bicyclist.

Community priorities, land use context and potential users are key considerations when making bicycle facility design decisions. Designing for accessibility is always necessary and critical. Where appropriate throughout this chapter, relevant ADA requirements and considerations are noted.

As discussed in Chapter 3, if a preferred facility type is not possible, it is still important to include the next-best solution in the short-term rather than nothing. In other words, don't let the ideal be the enemy of the good.

Finally, as discussed in Chapter 4, designs and best practices for bicycle facilities are changing and evolving quickly. Several of the elements described in this chapter, as well as Chapter 7 are new ideas for MnDOT. Designers are encouraged to remain open to new designs and treatments and carefully consider the opportunities and constraints for any of these concepts.

Shared Use Path



DESIGN OVERVIEW

Shared use paths are bicycle facilities physically separated from motor vehicle traffic by an open space or barrier. Most shared use paths are designed for two-way travel and can serve a variety of nonmotorized users. They may be located within roadway right-of-way or an independent right-of-way. Shared use paths are sometimes referred to as trails and greenways. In Minnesota, trails are facilities that may adhere to a variety of surface materials, widths and other standards. So, while a shared use path might be called a trail, not all trails are shared use paths.

The DNR is the state agency responsible for trails. In this document, the term trail is not interchangeable with shared use paths and follows different design guidelines. Sidepath is another common term used nationwide. Sidepaths are shared use paths located immediately adjacent and parallel to a roadway, and are covered in the following section.

PATH WIDTH

Walking and bicycling are inherently social activities. Designers should expect that people bicycling on shared use paths will ride side-by-side. Choosing an appropriate shared use path width depends on the mix of users, expected volumes, and land use context (See Chapter 3). Consider the following when determining a shared use path width:

- User types (e.g. adult bicyclists, child bicyclists, runners, dog walkers)
- User volumes, by type
- Nearby land use context
- Scenery
- Distractions
- Obstructions
- Right-of-way availability
- Maintenance vehicle access

Typical shared use path widths range from 10 to 15 feet. The minimum paved, operational width for a two-way shared use path is 10 feet, not including clearance distances, which may or may not be paved. This allows for a bicyclist traveling single file to pass someone coming from the opposite direction without a conflict, or for two bicyclists to ride comfortably side-by-side, effectively a “two-lane” path.

A 12-foot shared use path allows one single file bicyclist to pass two bicyclists riding side-by-side in the opposite direction without conflict, effectively a “three-lane” path. A 15-foot shared use path allows for the separation of bicyclists and pedestrians, effectively a 10-foot bicycle path and five-foot walkway. (EXHIBIT 5-1: Two Way Shared Use Path Dimensions and EXHIBIT 5-2: Shared Use Path Widths).

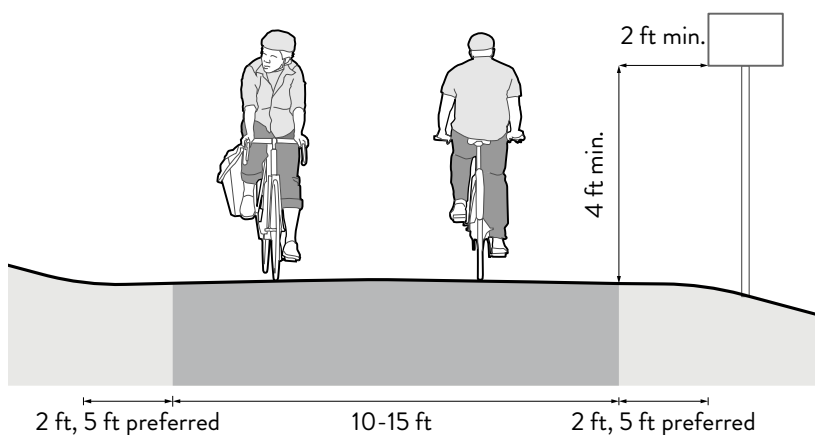


EXHIBIT 5-1: Two Way Shared Use Path Dimensions

EXHIBIT 5-2: Shared Use Path Widths

	TYPICAL TWO-WAY SHARED USE PATH	HIGH-VOLUME SHARED USE PATH**
Preferred width	10-12	12-15
Minimum	10	12
Constrained minimum*	8	11

*Constrained minimum should only be applied for short distances with physical constraints

**Either a high volume of bicycle traffic or a high percentage of pedestrian traffic

Wider paths may be necessary where there are either large numbers of people bicycling or large percentages of other nonmotorized users that create frequent and inconsistent passing and meeting events. Crowded paths can result in delay, frustration and collisions. User types to consider include: pedestrians, in-line skaters, roller skiers, children and people with disabilities.

Geometric characteristics that may merit a wider shared use path include: maintenance vehicle size, steep grades, curves and stationary activities (such as fishing or sightseeing).

In physically constrained conditions, for very short distances, an eight-foot shared use path may be used. Side-by-side riding is possible, but less comfortable on an eight-foot shared use path. These scenarios could include areas with wetland impacts, rock outcroppings, bridge abutments or piers, or utility structures. Consider using warning signs such as the W5-4a PATH NARROWS approaching the narrow section. For information on balancing sidepath widths with other roadway elements within a roadway cross-section, see the sidepath section. For information on shared use paths and sidepaths on vehicle bridges, see Chapter 7.



SEPARATING BICYCLISTS FROM PEDESTRIANS

This section is specific to shared use paths, which are in independent rights of way. For guidance on separating people walking and biking on a sidepath, see Separated Bike Lanes. Separating people walking from people biking may have benefits under the following conditions:

- Where conflicts between bicyclists and pedestrians during peak periods present safety concerns.
- Where peak daily pedestrian and bicyclist volume is greater than 2,000 individuals per day.

- Where peak hour bicycle traffic is greater than 100 per hour.
- When there is a wide range of speeds between path users.

Shared use path users typically keep right except to pass. On 10- to 14-foot shared use paths, a centerline stripe may help clarify the direction of travel and organize traffic. On shared use paths that are 15 feet or wider, separate two-way bicyclists with directional lanes and separate pedestrians from bicyclists with a bi-directional pedestrian lane on one side or in a separate alignment. Use this solution only when 10 feet can be allocated to two-way bicyclists and five feet allocated for two-way pedestrians.

Optimally, the pedestrian and bicycle facilities are separated by a detectable surface such as grass or a small curb (resulting in a total width of more than 15 feet). Striping or different materials can also be used to distinguish between bicycle and pedestrian spaces, but with caution. Careful consideration is necessary to ensure the separation is detectable and meets ADA requirements.

SHARED USE PATH LEVEL OF SERVICE

FHWA's Shared Use Path Level of Service Calculator can be used to determine if a shared use path may require additional width to function at an acceptable level of service. The calculator is based on traffic flow theory for shared use paths and extensive operational review of shared use paths around the country. There is not a single threshold for a "high-volume" shared use. Rather the calculation is based on four inputs: peak hour volumes, mode splits, shared use path width, and presence of a centerline

HORIZONTAL AND VERTICAL CLEARANCE

Fixed objects should not protrude within the vertical or horizontal clearance of a shared use path (EXHIBIT 5-3: Horizontal Clearances for Shared Use Paths and EXHIBIT 5-4: Vertical Clearances for Shared Use Paths). Ideally, a five-foot graded shoulder with a maximum cross-slope of 1V:6H should be provided on both sides of a shared use path. The shoulder should be a rideable surface, such as grass, packed aggregate, or pavement. In addition to providing recovery space for bicyclists who may inadvertently leave the paved path, this area provides space for signs, utilities and amenities such as benches or bicycle repair stations.

The minimum horizontal clearance of one to two feet is based on a bicyclist's inclination to shy away from the edge of a curb, obstruction, or continuous feature. If this clearance distance is not provided, the operating width of the shared use path is effectively reduced by one to two feet on the side where the clearance is not provided. For example, a shared use path with a total path width of 10 feet between a curb and a retaining wall is effectively only six to eight feet wide.

The recommended vertical clearance to obstructions is 10 feet. In constrained areas, the recommended minimum vertical clearance is eight feet. In some situations, vertical clearance greater than 10 feet may be needed to permit maintenance and emergency motor vehicles to pass. See Chapter 7 for more information on grade separated crossings.

EXHIBIT 5-3: Horizontal Clearances for Shared Use Paths

	RECOMMENDED	MINIMUM	NOTES*
Signs	2 ft	2 ft	See MN MUTCD Chapter 9
Obstructions such as guard rail posts, poles, bridge piers, rock outcroppings, shrubs, etc	3-5 ft	2 ft	Use warning signs, white edge lines, or object markers as needed
Steep slope (1V:3H or greater), or body of water	5 ft	5 ft	If less than 5 feet is available, a fence should be used, see EXHIBIT 5-5 for details
Continuous features such as railings or fences	2 ft	1 ft	Use warning signs or object markers

*All clearance areas should have a maximum slope of 1V:6H

EXHIBIT 5-4: Vertical Clearances for Shared Use Paths

	RECOMMENDED	MINIMUM	NOTES
Underpasses, obstructions, signs and trees	10 ft	8 ft	Clearance greater than 10 feet may be needed for maintenance or emergency vehicles. See Chapter 4.

Where a bicycle facility is adjacent to a potentially hazardous condition, such as a parallel body of water or steep downward slope, the recommended shy distance is five feet. For greater comfort, if available, consider a wider separation from the edge of the bicycle facility to the hazard. Depending on the nature of the adjacent hazard, a physical barrier, such as a fence or dense shrubbery may be needed. Apply engineering judgement in such cases, comparing the risk for a bicyclist who runs off the facility to the risk posed by the physical barrier. For steep slopes where the horizontal clearance between the facility and the

top of the slope is less than five feet, physical barriers or rails are recommended (EXHIBIT 5-5: Fence or Barrier Adjacent to Slopes).

See [MnDOT Standard Plate 9322K](#)⁵⁵ for fence detail. Begin the barrier or fence prior to and extending beyond the area of need. The barrier or fence lateral offset should be at least one foot from the edge of the path. Flare the barrier or fence ends away from the path edge and mark barrier or fence ends that remain within the two feet clear area with object markers. Install the fence with the line posts behind the chain link to reduce the risk of bicycle handlebars snagging the posts.

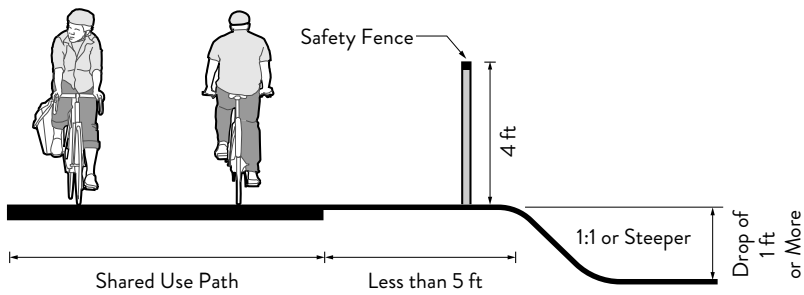
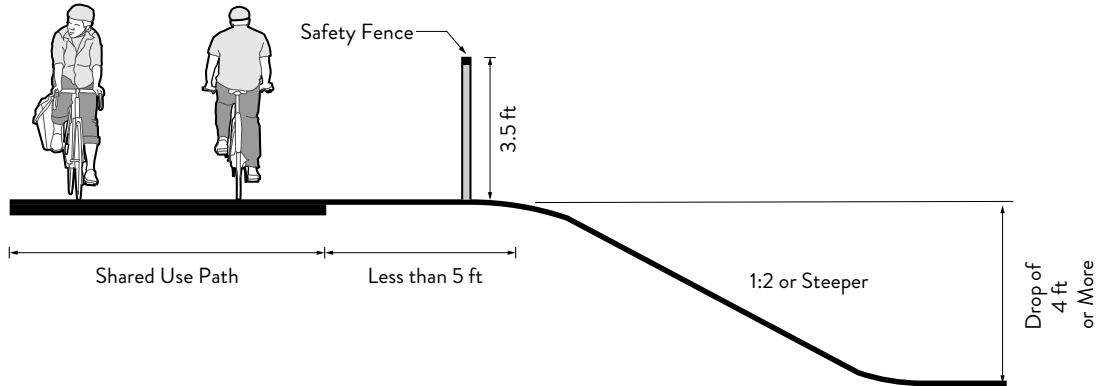
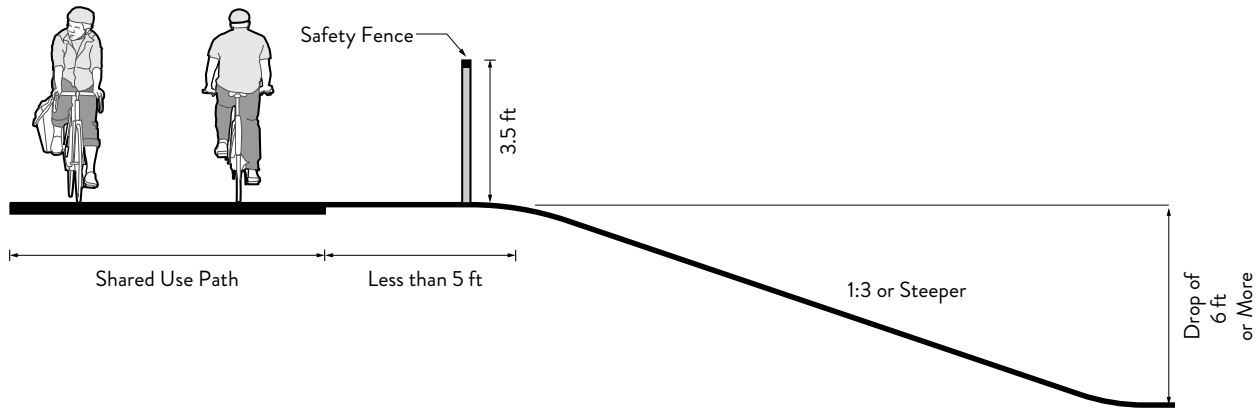


EXHIBIT 5-5: Fence or Barrier Adjacent to Slopes

CROSS SLOPE

Shared use path cross slopes should be accessible to people with disabilities and meet ADA requirements. Path cross slopes should meet the following design criteria for the full path widths:

- For ADA, the cross slope for a shared use path should be designed at 1.5 percent or less to allow for a 0.5 percent construction tolerance.
- For drainage, the cross slope for a shared use path should be designed at one percent or more, unless the longitudinal slope exceeds five percent. In that case a cross slope of 0.5 percent can be used.
- Superelevation is not recommended.
- Cross slope transitions should be a minimum of 5 feet for each 1 percent change.

If cross slope and design speed cannot be met, confer with MnDOT's ADA Unit to determine an appropriate design.

- Adding width for passing
- Installing hill warning signs (W7-5)
- Exceeding minimum horizontal clearances to keep objects and barriers farther from the path.
- Providing “resting” pull-offs.

A slope mitigation example is to install benches and side landings along continuously graded paths, providing a place for people to stop and rest. Use engineering judgment when placing landings, considering factors such as grade length, exposure to sun and other factors. Rails and landings can complicate path maintenance; which should be factored into discussions and final design decisions. For more information, see [Designing Sidewalks and Trails for Access Part 2](#).⁵⁶

GRADE

Like cross slope, shared use path running grades should be accessible to people with disabilities and meet ADA requirements. Paths should meet the following design criteria:

- The maximum grade should not exceed five percent, although the grade can match that of an existing parallel roadway.
- To ensure water drains, the minimum grade should not fall below 0.5 percent.
- Provide handrails when the grade exceeds five percent ([see MnDOT Road Design Manual, Section 11-3](#)).² When designing landings and handrails, consider context and user type.
- On a bridge, use a four percent grade break as a threshold for including a vertical curve. If less than four percent, add a note for the contractor to smooth out in the field during construction.
- Excessive grades can be mitigated by:
 - Using higher design speeds for geometrics to lengthen curves and provide additional maneuvering width.

PAVEMENT MARKINGS

Most low-volume shared use paths will not need pavement markings for the majority of their length. However, there are some cases where pavement markings can help provide guidance and information for path users.

A single yellow center line stripe may be to separate opposite directions of travel in locations where there are high volumes, on curves with limited sight distance, or approaching hazards such as roadway intersections or center obstructions (e.g. bollards).

A white edge line may be used to separate bicyclists and pedestrians on paths that are 15 feet wide or more. Edge lines may also be appropriate at roadway intersection approaches or where a shared use path width changes significantly over a short distance.

Where an obstruction in a shared use path cannot be avoided, obstruction markings should be used to guide bicyclist around the obstruction. Use white for edge obstructions and yellow for center obstructions.

Pavement markings should be retroreflective and slip resistant.

DESIGN SPEED

There is no single recommended design speed for shared use paths. Shared use path design speeds generally range from 12 to 30 miles per hour. Design speed should take into account bicyclist type, type of bicycle, terrain, surface type and general context. Design speed primarily influences horizontal and vertical alignment decisions. Bicyclist speeds approaching and through intersections are discussed in Chapter 4.

- 18 miles per hour is an acceptable design speed in most flat areas (grades less than two percent), due to mixed interaction with pedestrians.
- If the primary purpose of the shared use path is to provide high-speed bicycling connections between destinations and pedestrian volumes are expected to be low, a design speed up to 30 mph may be appropriate.
- For steep grades (five percent or greater), select a design speed based on the anticipated downhill travel speeds, which may be up to 30 miles per hour.

There may be areas where the preferred design speed may be less than 12 mph, such as near intersections, on switchbacks, or at the end of bridges. It is important to give people bicycling adequate warning they are approaching a lower speed area. Options include installing warning signs to encourage lower speeds however, using geometric designs to calm bike traffic through horizontal curvature and traffic control devices can be more effective than speed limit signs.

EXHIBIT 5-6: Minimum Radius of Curvature Based on Lean Angle

$$R = \frac{0.067V^2}{\tan\theta}$$

VARIABLE	MEANING
R	minimum radius of curvature (ft)
V	design speed (mph)
θ	lean angle from the vertical (degrees)

HORIZONTAL ALIGNMENT

Bicyclists lean while cornering to prevent falling outward due to forces associated with turning movements.

Twenty degrees is the typical maximum lean angle for most bicyclists. Assuming an operator who sits upright in the seat, EXHIBIT 5-6: Minimum Radius of Curvature Based on Lean Angle shows equations used to determine the minimum radius of curvature for any given lean angle and design speed. The curve radius should be based upon a design speed between 12 and 30 miles per hour and a desirable maximum lean angle of 20 degrees. EXHIBIT 5-6 shows the equation for curve radius and EXHIBIT 5-7: Minimum Radii for Horizontal Curves on Paved, Shared Use Paths at 20-Degree Lean Angles shows some common curve radii based on a 20-degree lean angle. Cargo or other three and four wheeled bikes will be unable to lean and will require slower travel or wider radii to negotiate the same corner as compared to a conventional bicycle.

Just like drivers, people bicycling need a clear line of sight around a horizontal curve. EXHIBIT 5-8: Lateral Clearance at Horizontal Curves illustrates the variable included in the calculation of horizontal sight line offset and EXHIBIT 5-9 indicates the minimum clearances for horizontal curve line-of-sight obstructions based on curve radius and stopping sight distance. These values can be calculated based on the equations in EXHIBIT 5-8. If keeping this line of sight clear is not practical, consider widening the path through the curve, installing a yellow center line stripe, installing turn or curve warning signs (W1 series) in accordance with the Minnesota Manual on Uniform Traffic Control Devices, or a combination of these alternatives.

EXHIBIT 5-7: Minimum Radii for Horizontal Curves on Paved, Shared Use Paths at 20-Degree Lean Angle

DESIGN SPEED (MPH)	MINIMUM RADIUS (FT)
12	27
14	36
16	47
18	60
20	74
25	115
30	166

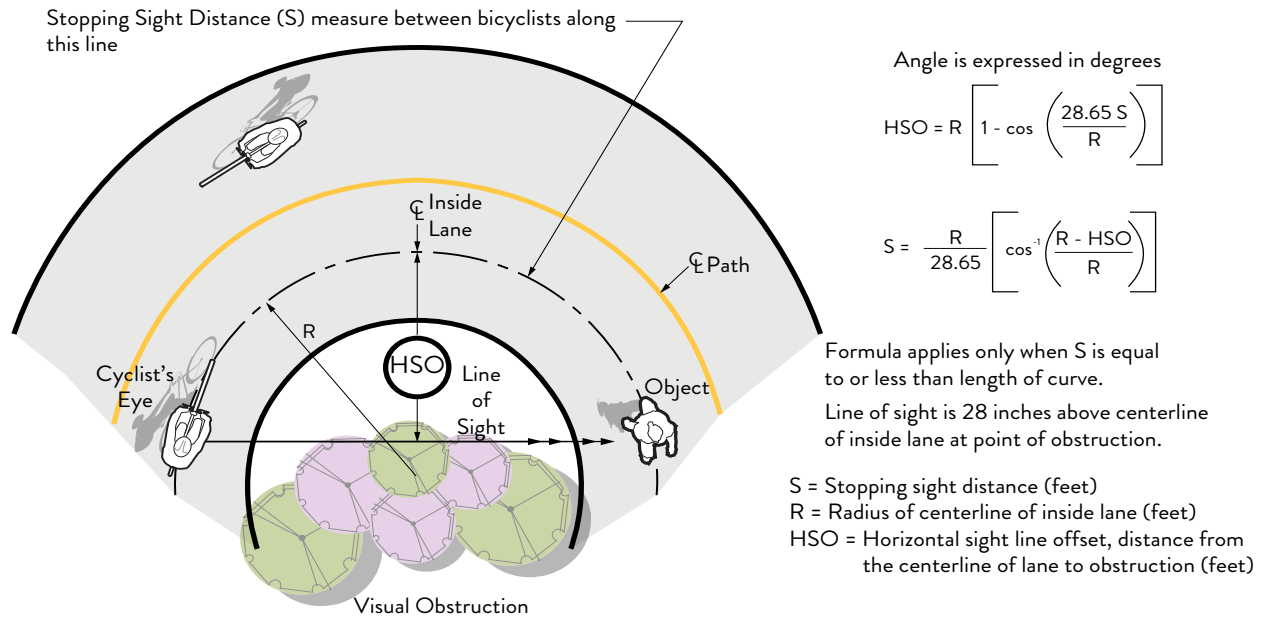


EXHIBIT 5-8: Lateral Clearance at Horizontal Curves

Radius (ft)	S=Stopping Sight Distance (ft)														
	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300
25	2.0	7.6	15.9												
50	1.0	3.9	8.7	15.2	23.0	31.9	41.5								
75	0.7	2.7	5.9	10.4	16.1	22.8	30.4	38.8	47.8	57.4	67.2				
95	0.5	2.1	4.7	8.3	12.9	18.3	24.7	31.8	39.5	48.0	56.9	66.3	75.9	85.8	
125	0.4	1.6	3.6	6.3	9.9	14.1	19.1	24.7	31.0	37.9	45.4	53.3	61.7	70.6	79.7
155	0.3	1.3	2.9	5.1	8.0	11.5	15.5	20.2	25.4	31.2	37.4	44.2	51.4	59.1	67.1
175	0.3	1.1	2.6	4.6	7.1	10.2	13.8	18.0	22.6	27.8	33.5	39.6	46.1	53.1	60.5
200	0.3	1.0	2.2	4.0	6.2	8.9	12.1	15.8	19.9	24.5	29.5	34.9	40.8	47.0	53.7
225	0.2	0.9	2.0	3.5	5.5	8.0	10.8	14.1	17.8	21.9	26.4	31.3	36.5	42.2	48.2
250	0.2	0.8	1.8	3.2	5.0	7.2	9.7	12.7	16.0	19.7	23.8	28.3	33.1	38.2	43.7
275	0.2	0.7	1.6	2.9	4.5	6.5	8.9	11.6	14.6	18.0	21.7	25.8	30.2	34.9	39.9
300	0.2	0.7	1.5	2.7	4.2	6.0	8.1	10.6	13.4	16.5	19.9	23.7	27.7	32.1	36.7
350	0.1	0.6	1.3	2.3	3.6	5.1	7.0	9.1	11.5	14.2	17.1	20.4	23.9	27.6	31.7
390	0.1	0.5	1.2	2.1	3.2	4.6	6.3	8.2	10.3	12.8	15.4	18.3	21.5	24.9	28.5
500	0.1	0.4	0.9	1.6	2.5	3.6	4.9	6.4	8.1	10.0	12.1	14.3	16.8	19.5	22.3
565		0.4	0.8	1.4	2.2	3.2	4.3	5.7	7.2	8.8	10.7	12.7	14.9	17.3	19.8
600		0.3	0.8	1.3	2.1	3.0	4.1	5.3	6.7	8.3	10.1	12.0	14.0	16.3	18.7
700		0.3	0.6	1.1	1.8	2.6	3.5	4.6	5.8	7.1	8.6	10.3	12.0	14.0	16.0
800		0.3	0.6	1.0	1.6	2.2	3.1	4.0	5.1	6.2	7.6	9.0	10.5	12.2	14.0
900		0.2	0.5	0.9	1.4	2.0	2.7	3.6	4.5	5.6	6.7	8.0	9.4	10.9	12.5
1000		0.2	0.5	0.8	1.3	1.8	2.4	3.2	4.0	5.0	6.0	7.2	8.4	9.8	11.2

EXHIBIT 5-9: Minimum Horizontal Sight line Offset (HSO) for Horizontal Curves

VERTICAL ALIGNMENT

Use EXHIBIT 5-10: Minimum Length of Crest Vertical Curve (L) Based on Stopping Sight Distance to select the minimum vertical curve length needed to provide minimum stopping sight distance at various speeds on crest vertical curves. For a bicyclist to recognize hazards on the path:

- Assume the eye height of a typical recumbent bicyclist, which is 3.83 feet.

- Assume the object height is zero inches, recognizing that impediments to bicycle travel exist at pavement level.
- The minimum length of vertical curve can also be calculated using the equation shown in EXHIBIT 5-10.
- Children may still have limited sight distance over crest vertical curves due to their low eye position. However most child bicyclists travel slower than typical adult bicyclists so the values in EXHIBIT 5-10 are sufficient.

A (%)	S = Stopping Distance (ft)													
	40	60	80	100	120	140	160	180	200	220	240	260	280	300
2									17	57	97	137	177	217
3						25	65	105	145	185	225	265	307	352
4				9	49	89	129	169	209	253	301	353	409	470
5			7	47	87	127	167	211	261	316	376	441	512	587
6			32	72	112	154	201	254	313	379	451	530	614	705
7		11	51	91	132	179	234	296	366	442	526	618	716	822
8		24	64	104	150	205	267	338	418	505	602	706	819	940
9		35	75	117	169	230	301	381	470	569	677	794	921	1057
10	3	43	84	131	188	256	334	423	522	632	752	883	1023	1175
11	10	50	92	144	207	281	368	465	574	695	827	971	1126	1292
12	16	56	100	157	226	307	401	508	627	758	902	1059	1228	1410
13	21	61	109	170	244	333	434	550	679	821	978	1147	1331	1527
14	25	66	117	183	263	358	468	592	731	885	1053	1236	1433	1645
15	29	70	125	196	282	384	501	634	783	948	1128	1324	1535	1762
16	32	75	134	209	301	409	535	677	836	1011	1203	1412	1638	1880
17	35	80	142	222	320	435	568	719	888	1074	1278	1500	1740	1997
18	37	85	150	235	338	461	602	761	940	1137	1354	1589	1842	2115
19	40	89	159	248	357	486	635	804	992	1201	1429	1677	1945	2232
20	42	94	167	261	376	512	668	846	1044	1264	1504	1765	2047	2350

when $S > L$ $L = 2S - 766/A$

Shaded area represents $S < L$

when $S < L$ $L = AS^2/766$

L = Minimum Length of Vertical Curve (ft)

A = Algebraic Grade Difference (%)

S = Stopping Sight Difference (ft)

Height of cyclist eye - 3.83 ft

Height of object - 0 ft

Minimum Length of Vertical Curve = 5 ft

EXHIBIT 5-10: Minimum Length of Crest Vertical Curve (L) Based on Stopping Sight Distance

DRAINAGE

Design paths to meet all stormwater management regulations, to prevent erosion, improve water quality and manage runoff quantity. Keep the following in mind when designing shared use paths for drainage:

- Where possible, avoid crowning.
- Slope in the direction of existing terrain, when possible.
- Design slopes to avoid erosion.
- Avoid or minimize drainage grates within a path surface.

If grates are located within a shared use path, it is important to ensure they do not create a hazard, or change flow. Specify in plans that any grates should be flush with the adjacent pavement. Designers should verify constructability with MnDOT's Construction staff.

SURFACES

Because shared use paths need to meet accessibility requirements, best practice is to use hard, all weather surfaces. Unpaved surfaces such as crushed aggregate or stabilized earth may be appropriate on rural paths where the intended use is primarily recreation, however they should be constructed of materials that are firm and stable.

Where a shared use path crosses an unpaved road or driveway, pave the road or driveway a minimum of 20 feet on each side of the crossing to reduce motor vehicles scattering gravel onto or along the path.

For information on pavement structure for shared use paths, see [Chapter 6 of the MnDOT Pavement Design Manual](#).⁵³

LIGHTING & PERSONAL SAFETY

Fixed-source lighting can improve visibility along paths and at intersections at night or under other dark conditions. Recent advances in solar technology have made installing lighting cheaper in some scenarios.

Lighting improves a bicyclist's ability to detect surface irregularities. Lighting also mitigates the impact of headlight glare from oncoming bikes and motor vehicles, especially on the outside of curves and where the bicycle facility is slightly below the road surface elevation. Pedestrian scale lighting is preferable to highway lighting. Where not providing lighting, or providing lighting only during specific hours, consider installing reflective edge lines along the edge of the shared use path. For more information see the [MnDOT Roadway Lighting Design Manual](#).⁵⁴

Call boxes can provide value in tunnels, in isolated areas and in areas with poor cellular reception. Any decision to include call boxes should be thoroughly vetted with proper inter-governmental coordination for maintenance and response expectations. If installed, call boxes should meet ADA requirements.



CONTROLLING MOTOR VEHICLE ACCESS

Controlling motor vehicle access can be accomplished through signs such as the R5-3 NO MOTOR VEHICLES sign, splitting the path directionally, landscaping, chicanes, bollards, gates and barriers (EXHIBIT 5-11: Motor Vehicle Access Control for Shared Use Path Crossing Roadway). Regardless of the method, the shared use path width and the curb ramp width should remain wide enough to serve all path users.

Avoid installing bollards whenever possible; bollards create a collision hazard for people bicycling. In addition, bollards and barriers may block snowmobiles and maintenance vehicles and require atypical maintenance. Install bollards and barriers only where there is a documented problem of controlling non-authorized access. If used, bollards should be removable or collapsible; the minimum recommended spacing between bollards is five feet. Instead of bollards,



consider gates. Gates should be placed to allow maintenance and emergency vehicle access, while still providing adequate openings for path users.

Gates may be easier to maintain in Minnesota's climate than removable bollards. If using bollards or gates, ensure they are visible to all path users using retroreflective markings or other treatments. Place any bollards or gates so bicyclists can pass without dismounting while still accommodating cargo bikes, trikes, trailers, adaptive bicycles and other permitted users.

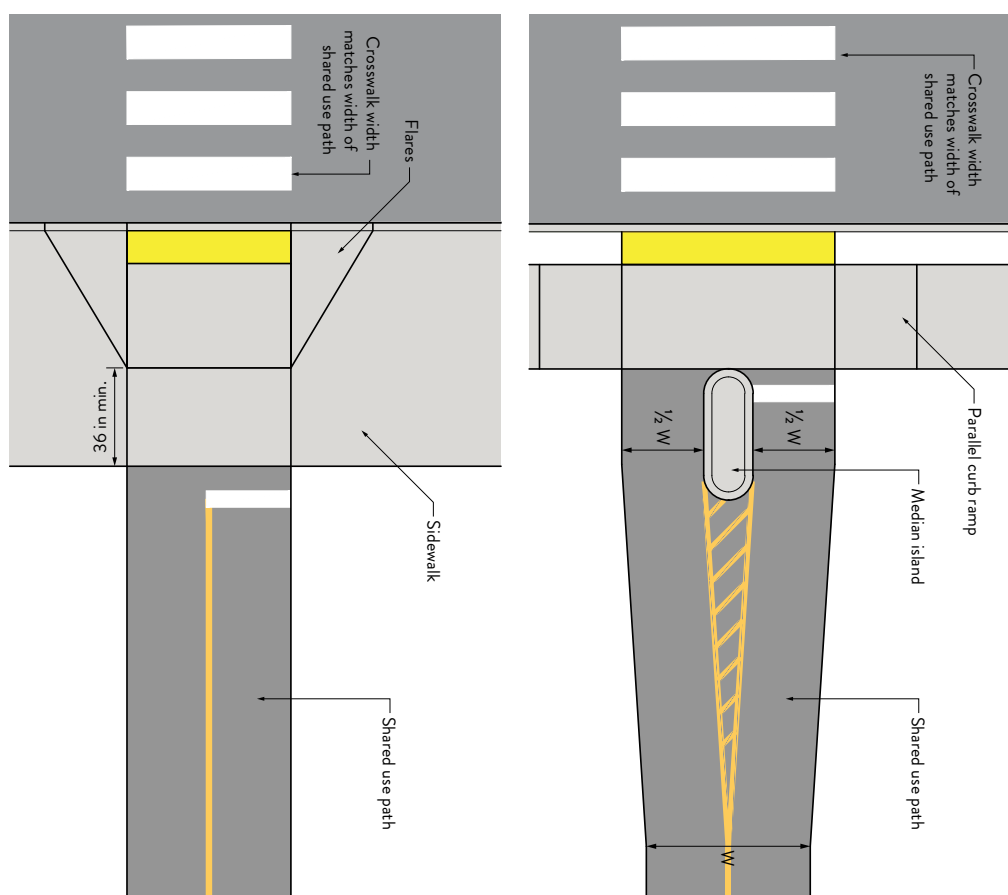


EXHIBIT 5-11: Motor Vehicle Access Control for Shared Use Path Crossing Roadway



ADA CONSIDERATIONS

Any shared use path funded by MnDOT, or within MnDOT right-of-way, serves a pedestrian transportation purpose and is required to be accessible year-round. There are many considerations related to ADA (EXHIBIT 5-12: ADA Requirements). Ramps and detectable warnings should be installed at every shared use path intersection with a roadway. Ramp width should match the shared use path width. When a shared use path ends, it needs to be accessible to and from a roadway or shoulder (See MnDOT TEM section 13-2.01).

Refer to [MnDOT's ADA standards](#)⁵⁷ and consult with the ADA Unit early in any project to clarify all requirements. MnDOT's ADA standards are based on information from the [Americans with Disabilities Act](#), [U.S. Access Board](#), and the [Public Right-of-Way Accessibility Guidelines](#).^{9,58,59} PROWAG relates specifically to transportation and has a roadway focus. The Minnesota DNR publishes its own [design guidelines for trails](#).⁶⁰ The U.S. Access Board resource that pertains to trails and recreation areas is the [Outdoor Developed Areas](#).⁶¹

EXHIBIT 5-12: ADA Requirements

TOPIC	REQUIREMENTS
Pedestrian Access Route	5 feet recommended PAR; 4 feet minimum PAR (need passing zones every 200 feet)
Cross slope	1 percent recommended (with 1.5 percent design maximum to account for construction tolerances); 2 percent maximum
Grade	5 percent maximum without landing areas; Grades on shared use paths may exceed 5 percent, but should be less than or equal to the roadway grade.
Detectable warnings at intersections	See ADA/PROWAG for requirements

SHARED USE PATH/ROADWAY INTERSECTIONS

There are two types of intersections between shared use paths and roadways: mid-block and roadway junctions (EXHIBIT 5-13: Functional Area of Intersection). Sidepath intersections, where the path is parallel to the roadway, are discussed in the sidepath section of this chapter. Midblock intersections are discussed in this shared use path section.

Pavement markings are required at mid-block locations to establish the location as a crosswalk and legal right of way for people walking and biking. Additional crosswalk treatments may be required depending on roadway width, volume, speed and available sight distance. To determine the most appropriate crossing treatment at a midblock intersection, consult the [MN MUTCD Part 3](#),³ [Traffic Engineering Manual Chapter 13](#),⁴⁹ and [At Grade Trail Crossing Guide](#).⁶² Intersection sight distance is fundamental in establishing priority and selecting an appropriate method of control for the roadway and the shared use path. Sight distance should be calculated using EXHIBIT 4-6.

Midblock crossings should include the following aspects:

- Crossing is conspicuous to all modes
- Sight lines are maintained for all users
- Approach grades are relatively flat, when possible
- Roads and shared use paths intersect close to a right angle
- Legal right-of-way and responsibility to stop/yield is clear
- Use least restrictive traffic control for non-motorized users that is effective

In some situations traffic calming may be appropriate for bicyclists, such as chicanes, directional splits, or other horizontal geometry to slow bicyclists' approach speeds at intersections. End chicanes before the intersection so bicyclists can first focus on the curves, then the intersection. Best-practice calls for a solid centerline stripe to reduce bicyclists "cutting corners" on the curve. Avoid design speeds below 8 miles per hour.

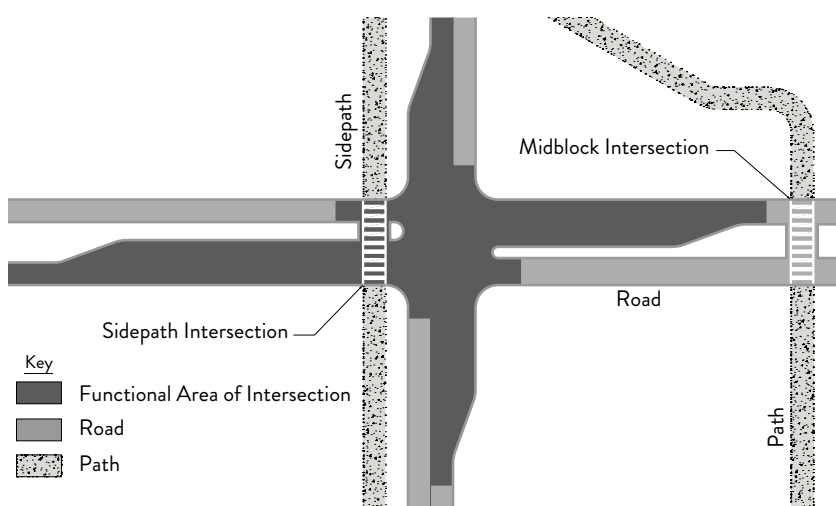


EXHIBIT 5-13: Functional Area of Intersection

Sight Triangles

Intersection sight triangles should be evaluated to provide appropriate control at midblock path-roadway intersections. When using yield-control for either the path approach or the roadway approach, the available sight distance should be adequate for a person on the yield-controlled approach to slow and stop to avoid contact with a person on the other approach. The sight triangle is based on a bicyclist's or driver's ability to see conflict and execute a stop before entering the intersection (EXHIBIT 5-14: Yield Sight Triangles). Roadway and path approaches to an intersection should provide sufficient stopping sight distance so that drivers and people bicycling can avoid conflict at the intersection.

Shared use path approach sight distance should be calculated using the fastest path user. Bicyclists are often the fastest path user, but horses, ATVs and snowmobiles may need to be considered as well. Where approach sight triangles

BICYCLISTS IN CROSSWALKS

MN Statute 169.222, Subd. 4 (f) states "A person lawfully operating a bicycle on a sidewalk, or across a roadway or shoulder on a crosswalk, shall have all the rights and duties applicable to a pedestrian under the same circumstances." Bicyclists are legally considered pedestrians when operating within a crosswalk.

cannot be achieved, consider a more restrictive form of control at the intersection. Sight distances along a shared use path and roadway based on common speeds are shown in EXHIBIT 5-15: Sight Distance Based on Roadway Speed and Bike Speed.

Assigning Priority

In conventional intersection design, priority is typically assigned to the higher volume and/or speed approach. At shared use path/roadway intersections, yield or stop control is typically applied to the shared use path. On high volume shared use paths, it may be reasonable to assign priority to the shared use path and yield or stop control to the roadway. An all-way stop condition may be applicable in cases where the shared use path and roadway have similar volumes.

In locations where the roadway has priority and sight distances are sufficient, yield signs for the shared use path may be appropriate. At very low volume locations where interactions between drivers and people bicycling are unlikely, the intersection may be left unsigned. If sight triangles cannot be achieved, stop signs for the shared use path may be necessary.

Midblock Intersection Control Treatments

Shared use path/roadway intersection treatments include signs and pavement markings. Additional enhancements such as Rectangular Rapid Flashing Beacons and Pedestrian Hybrid Beacons may also be considered.

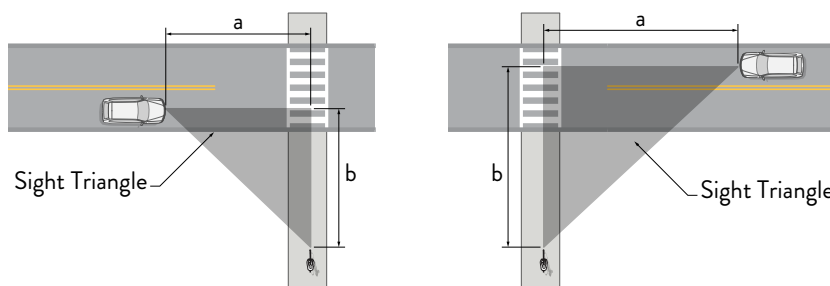


EXHIBIT 5-14: Yield Sight Triangles

EXHIBIT 5-15: Sight Distance Based on Roadway Speed and Bike Speed

Bike Speed (mph)	Roadway Speed (mph)					
	15	20	25	30	35	40
10	96 / 58	128 / 59	160 / 63	192 / 68	224 / 74	255 / 81
12	98 / 70	131 / 70	164 / 75	197 / 82	230 / 89	262 / 97
15	105 / 87	140 / 88	174 / 94	209 / 102	244 / 111	279 / 122
18	112 / 105	150 / 106	187 / 113	225 / 122	262 / 134	300 / 146
20	118 / 116	157 / 117	197 / 125	236 / 136	275 / 149	315 / 162
25	133 / 145	178 / 147	222 / 156	266 / 170	311 / 186	355 / 203
30	149 / 174	199 / 176	249 / 188	298 / 204	348 / 223	398 / 244

a = driver sight distance (ft.) along roadway
 b = bicyclist sight distance (ft.) along path

Assumptions: Bicycle reaction time = 1.5 sec
 Width of path = 10 ft. to 11 ft.
 Width of road lane = 11 ft. to 12 ft.
 Length of bicycle = 6 ft.
 Length of motor vehicle = 18 ft.
 Grade = -2% to 0%

SELECTING A TYPE OF CONTROL

The MN MUTCD indicates that engineering judgment should be used to establish intersection control. Bicyclists expend additional energy stopping and starting compared to drivers. They also have the benefit of a wider field of vision

than drivers and require a shorter stopping distance. Uncontrolled or yield controlled shared use path approaches may be preferable in locations where there is adequate sight distance and conflicting motor vehicle volumes are low.

SIGNS AND PAVEMENT MARKINGS

EXHIBIT 5-16: Example Midblock Path–Roadway Intersection—Path is Yield Controlled for Bicyclists and EXHIBIT 5-17: Example of Midblock Path - Roadway Intersection - Stop Controlled for Bicyclists illustrate unsignalized midblock pavement markings and sign installations. These diagrams are illustrative and not intended to represent every context or application of

signs and markings that may be necessary at validated locations. See Chapter 4 for general guidance on signs.

Shared use path crossing warning sign placement for roadway users should follow these general criteria (see the [MN MUTCD section 2C.5³](#) for full design criteria):

- Use either a W11-15 combination bicycle/pedestrian warning sign (EXHIBIT 4-12) or a W11-1 bike warning sign (EXHIBIT 4-11).

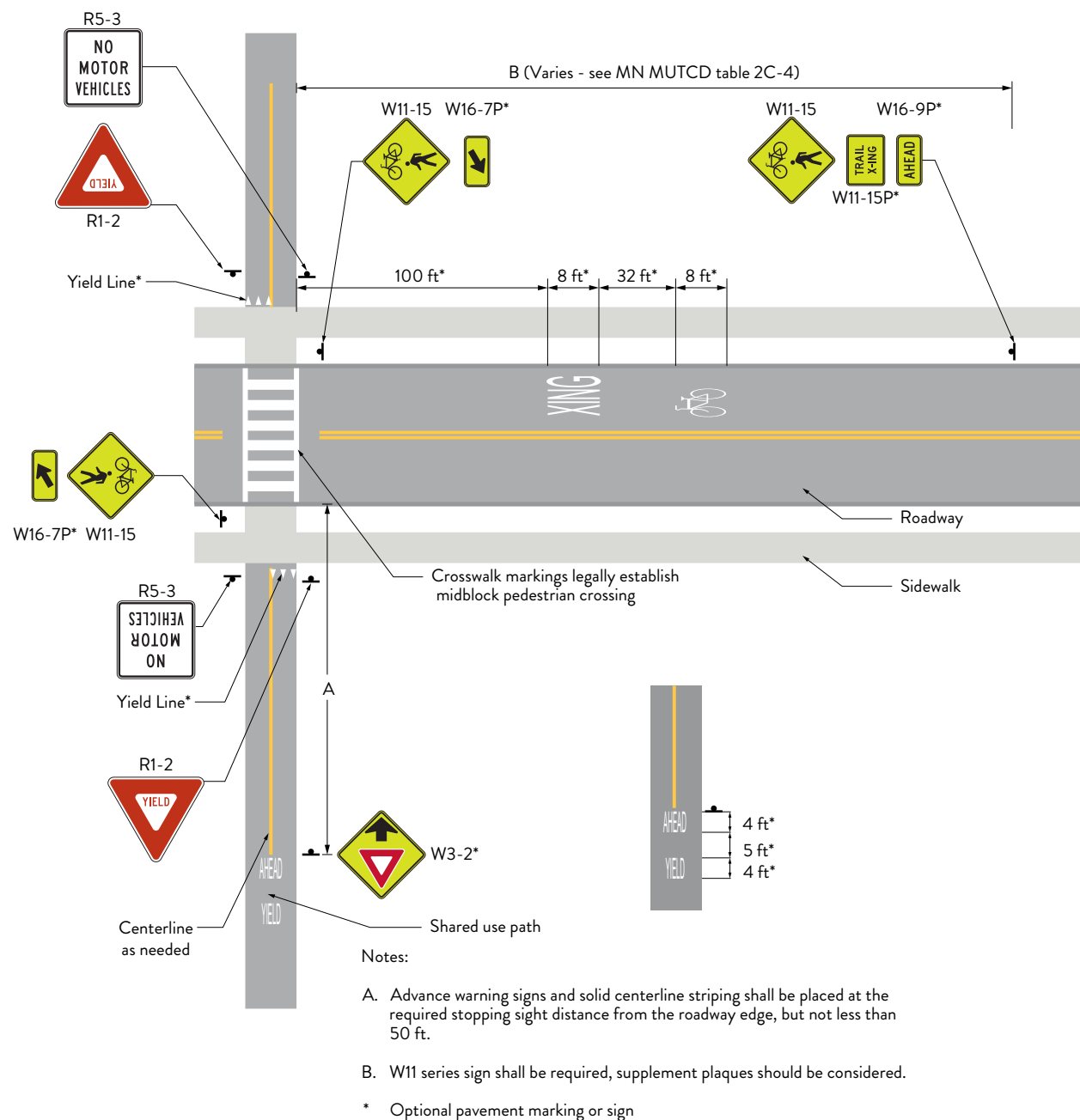


EXHIBIT 5-16: Example Midblock Path–Roadway Intersection—Path is Yield Controlled for Bicyclists

- Warning signs may be installed on one or both sides of the roadway depending on visibility and roadway width.
- Do not use W11-1 or W11-15 signs in advance locations where vehicle movements are stop, yield, or signal controlled.
- Warning signs may be supplemented with “AHEAD” (W16-9P), “TRAIL X-ING” (W11- 15P) or “XX Ft” (W16-2P).
- Advance traffic control warning signs should be used when the intersection is not visible within stopping sight distance.
- On shared use paths, place advance warning signs based on the stopping sight distance of the fastest path user in advance of where sign applies.
- Never install advanced warning signs less than 50 feet in advance of traffic control.

For intersection and advance traffic control warning signs on shared use paths, see the MN MUTCD and these guidelines:

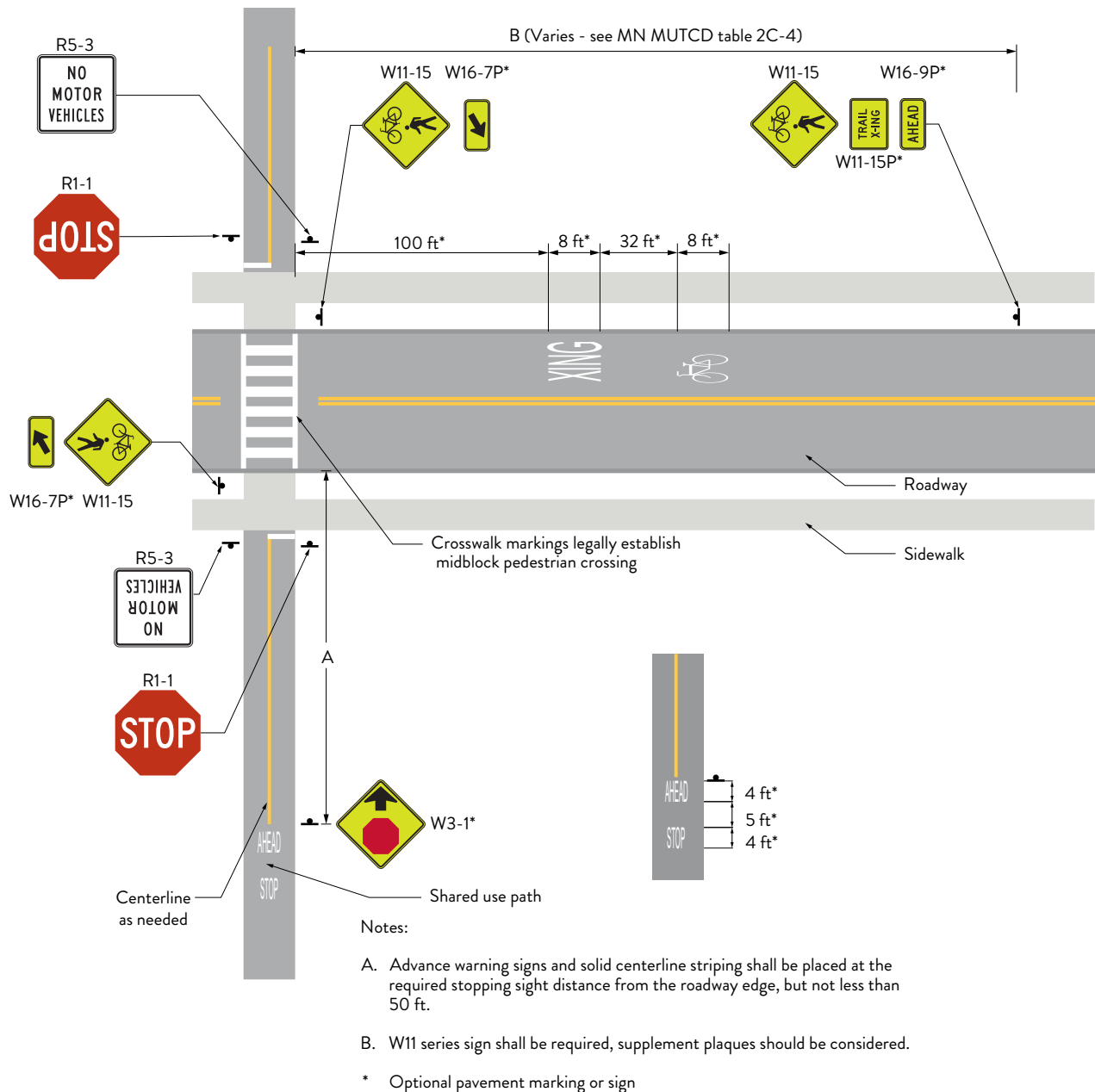


EXHIBIT 5-17: Example of Midblock Path - Roadway Intersection - Stop Controlled for Bicyclists



RECTANGULAR RAPID FLASHING BEACON INTERIM APPROVAL

In March 2018, FHWA issued [Interim Approval 21](#)⁶⁴ for pedestrian-actuated rectangular rapid-flashing beacons at uncontrolled marked crosswalks. In April 2018, MnDOT received a statewide approval from FHWA for the use of these pavement markings in all Minnesota jurisdictions. In order to meet the requirements of this statewide approval, MnDOT must maintain a list of locations with RRFBs. If installing an RRFB, please provide the location to the MnDOT Traffic Standards Engineer at 651-234-7388.



BEACONS

Beacons increase the conspicuity of bicycle and pedestrian crossings and have been shown to improve safety, and are especially applicable at marked mid-block crossing locations. FHWA recommends both Rectangular Rapid Flashing Beacons and Pedestrian Hybrid Beacons in the [Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations](#).⁶³ Both devices are user-actuated, either through push buttons or passive detection. Passive detection, as discussed in Chapter 4, does not require bicyclists to dismount in order to activate the beacon. RRFBs and PHBs need to include ADA compliant push buttons and audible warnings.

Rectangular Rapid Flashing Beacons

Rectangular Rapid Flashing Beacons are user-activated warning devices with rectangular-shaped high-intensity LEDs that flash in an alternating stutter flash pattern. RRFBs draw attention to the pedestrian or bicyclists crossing, but the user must start crossing in order to assert their right of way (See MN Statutes in Chapter 2).

RRFBs have been shown to be more effective at increasing driver yielding rates at uncontrolled crossings than traditional warning beacons. RRFB's are particularly effective at improving the visibility of pedestrians and bicyclists when crossing multi-lane roadways. They can be placed overhead and are often used in combination with advanced stop bars. Use the W11-15 warning sign when bikes are expected to use the RRFB. See Interim Approval 21 for guidance on RRFB installation.

Pedestrian Hybrid Beacons

A Pedestrian Hybrid Beacon, also known as a HAWK signal, is a traffic control device designed to help pedestrians and bicyclists safely cross roadways at midblock crossings and uncontrolled intersections where a full traffic signal isn't warranted. PHBs have lower thresholds for warrants than traffic signals and can be used where automobile delay from a signal is a concern because they can be coordinated with nearby traffic signals. When showing the CIRCULAR RED signal indication, a PHB is the same as a red traffic signal, and drivers are required to stop, regardless of where the pedestrian or bicyclist is. See Section 4F of the MN MUTCD for guidance on PHB warrants and installation.

SHARED USE PATH/WALKWAY INTERSECTIONS

At the intersection of a stop controlled or yield controlled shared use path and a sidewalk, a clear sight triangle extending 15 feet along the walkway from the edge of the shared use path and 25 feet along the shared use path from the walkway should be provided (EXHIBIT 5-18).

At the intersection of a shared use path and a walkway that is not adjacent to a roadway, the length of the clear sight triangle along the shared use path should be based on the stopping sight distance for the fastest user of the shared use path (typically a bicyclist). If the crossing is marked such that shared use path users would expect it, determine stopping sight distance based on EXHIBIT 4-4. If the crossing is unmarked or unexpected use EXHIBIT 4-5, which identifies a slower perception-reaction stopping sight distance. For pedestrian sight distance crossing the path, provide a clear sight triangle extending 15 feet along the walkway from the edge of the shared use path. This allows people walking to judge gaps in approaching bicycle traffic and for bicyclists to notice pedestrians in the crossing and slow or stop as necessary (EXHIBIT 5-19: Uncontrolled Shared Use Path Crossing Independent Walkway).

In high volume areas, such as transit stops, shared use path pedestrian crossings should be marked with crosswalks. Stop bars, STOP HERE FOR PEDESTRIANS (R1-5b) signs and stop ahead pavement markings may also be necessary.

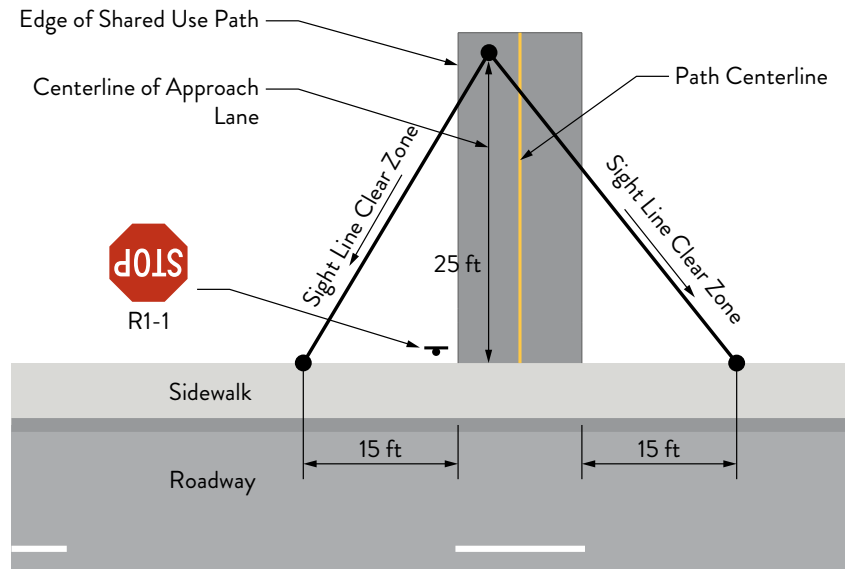


EXHIBIT 5-18: Minimum Path-Walkway Sight Triangle

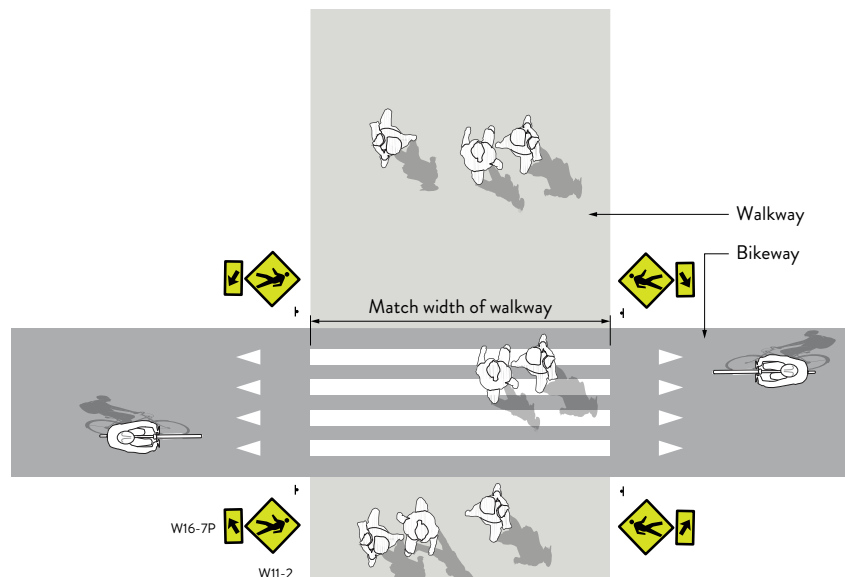


EXHIBIT 5-19: Uncontrolled Shared Use Path Crossing Independent Walkway

INTERSECTION OF TWO SHARED USE PATHS

At the intersection of two shared use paths, sight triangles should be calculated for a yield-condition based on a path-roadway intersection calculation. Use the bicycle sight distance along the path in EXHIBIT 5-15 for both legs to calculate the sight triangle.

Provide warning signs in advance of the intersection, similar to those provided for roadway intersections. Include wayfinding information in advance of the intersection so that shared use path users know where to turn to reach their destination. This avoids confusion and sudden stops.

Sidepath



DESIGN OVERVIEW

A sidepath is a type of shared use path that is parallel to a roadway but is physically separated from motor vehicle traffic. Increased separation from motor vehicle traffic increases bicyclist comfort, and in many circumstances a sidepath is more likely to attract MnDOT's chosen bicyclist comfort profile, Interested but Concerned bicyclists, than an on-street bicycle facility, such as a bike lane.

Most sidepaths are designed for two-way travel and can serve a variety of nonmotorized users. Providing a two-way sidepath along a roadway introduces a contraflow movement by bicyclists. Sidepath challenges can be mitigated through specific design treatments. To increase sidepath safety:

- Reduce conflict points.
- Reduce motor vehicle speeds at conflict points.
- Increase the predictability of sidepath and roadway user behavior.
- Increase the sidepath separation from the roadway at conflict points

People bicycling may legally ride on a road even if a sidepath is present and may choose to do so for a variety of reasons. In some cases, providing on-street bike lanes in addition to a sidepath is appropriate.

MANAGING CROSS-SECTION WIDTHS

The preferred sidepath design requires 18 feet of right-of-way. From the face of curb or edge of roadway pavement, the typical preferred design consists of a six-foot buffer, 10-foot sidepath and two feet of clearance from the back of right-of-way (EXHIBIT 5-20: Preferred Sidepath Dimensions). However, this amount of space is not always available. The following sections describe each of these features and how they interact with one another. Designers should consider how the total space allocated for a sidepath will impact its function for bicyclists. If compromises are necessary, clearly document project decisions regarding sidepath, buffer and clearance widths, and Chapter 7 for guidance on sidepaths on bridges.

Sidepath Width

Similar to shared use paths, sidepath width should be based on expected use and nearby land use context. The minimum paved, operational width for a two-way sidepath is 10 feet. This does not include clearance distances, which may or may not be paved. In physically constrained conditions, for short distances, an eight-foot sidepath may be used. These scenarios could include areas with wetland impacts, rock outcroppings, bridge abutments or piers, or utility structures. See the Shared Use Path section for more information on selecting a sidepath width.

Buffer Width

The preferred minimum separation between a sidepath and a roadway is six feet, with two feet as an absolute minimum in constrained areas. The separation distance, or buffer, is measured from the face of curb or the edge of roadway pavement when there is no curb (EXHIBIT 5-21: Sidepath Separation from Roadway, Urban Section and EXHIBIT 5-22: Sidepath Separation from Roadway, Rural Section). A paved shoulder should not be considered part of the buffer area, but an aggregate shoulder may be. The minimum width of two feet is based on a bicyclist's inclination to shy away from the edge of a curb, obstruction, or continuous feature (EXHIBIT 5-3). If this minimum clearance distance is not provided, the operating width of the sidepath is effectively reduced by two feet on the side where the clearance is not provided. Paved shoulders, bike lanes and parking lanes do not count as part of the buffer width sidepath.

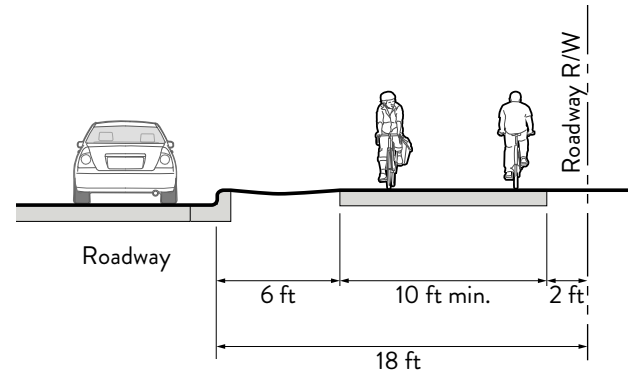


EXHIBIT 5-20: Preferred Sidepath Dimensions

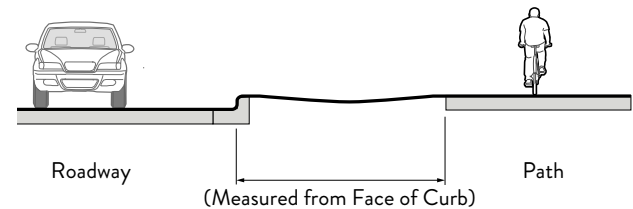


EXHIBIT 5-21: Sidepath Separation from Roadway, Urban Section

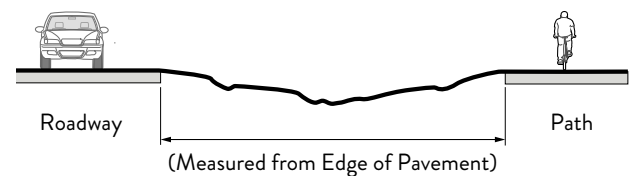


EXHIBIT 5-22: Sidepath Separation from Roadway, Rural Section

In addition to improving bicyclist comfort on the sidepath, buffers serve an important function for roadway operation. Buffers are used for signs, storm water infiltration, shade trees and roadside vegetation and snow storage. If space allows, a buffer width greater than six feet is desirable. Increasing separation beyond six feet will increase the amount of snow that can be stored, reducing the need for snow hauling. On a high-speed roadway (45 mph or greater) with a rural section, the ditch area may serve as an even wider buffer of 20 feet or more.

Under constrained conditions, buffer widths between two and six feet can be considered. Depending on expected sidepath use and traffic volumes/speeds on the adjacent roadway, a wider buffer and narrower sidepath may be preferred. For example, if expected bicycle volumes are low, an eight-foot sidepath with a four-foot buffer may be preferable to a 10-foot sidepath with a two-foot buffer.

Buffers made of grass or landscaping are preferred because they clearly define the shared use path and provide a detectable edge for cane users. Buffers of five feet or greater can support trees, which provide shade to sidepath users, process storm water and absorb carbon emissions. Buffers that are 3 feet wide or less should be paved, as grass or other vegetation may struggle to thrive, though land use context and other factors should determine the surface choice. In narrow spaces, consult with expert offices staff in the Landscape Architecture Unit or Office of Environmental Stewardship to determine options.

When pavement is the choice, consider using a different paving material for the buffer area, such as pavers or colored concrete, which helps provide bicyclists with a visual separation. An edge line between the sidepath and paved buffer may also be appropriate, especially if there are frequent obstructions such as signs or utility poles in the buffer area.



Clearance from Edge of Right-of-Way

The minimum clearance between the edge of a sidepath and the edge of the right-of-way is two feet. This minimum is based on a bicyclist's inclination to shy away from the edge of a curb, obstruction, or continuous feature (EXHIBIT 5-3). Sidepaths are also used by pedestrians, so this clearance distance can be important for meeting ADA requirements as well.

The value of this clearance distance depends on the adjacent land use. If the adjacent land use includes a continuous feature such as a building, fence, or retaining wall, bicyclists will shy away from the edge of the sidepath. This behavior effectively reduces the operating width of the sidepath. Adequate clearance also reduces the risk that routine sidepath maintenance will impact an adjacent property, so a clearance of less than 1 foot is not recommended. If bicyclists are unlikely to shy away from the adjacent land use (e.g. farm field, land uses with large setbacks), designers may consider reducing the clearance distance to one foot.

If the edge of the right-of-way includes a steep slope, see the Shared Use Path section for recommendations on slope clearance distances and the potential need for fences.

The clearance area can be paved or landscaped, depending on the context of the adjacent property. In natural and rural contexts, grass or aggregate may be appropriate. If the adjacent land use is paved or has continuous features, a paved clearance area may be more feasible. Similar to buffers, consider a different paving material such as pavers or colored concrete for the clearance area.

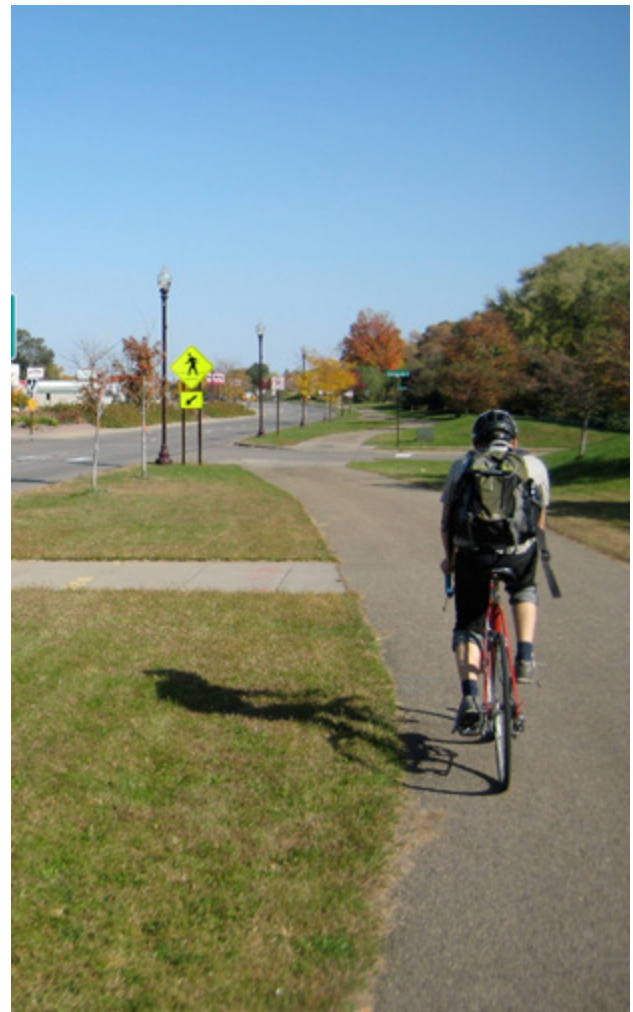
BARRIERS AND PERSONAL SAFETY

When designing barriers for sidepaths, keep personal safety in mind. Avoid sidepaths with barriers or fences on both sides that run for long distances. Users can feel trapped on these narrow corridors, and limited access may impede emergency response.

BARRIERS

A barrier, in the form of a concrete barrier or guard rail, should be used when engineering judgment indicates that an at-grade buffer separating the sidepath from the road does not adequately protect path users from errant motor vehicle traffic entering the sidepath, such as at horizontal or vertical curves on high speed roadways.

Barriers may require a total cross-section width of five to six feet. Barriers are considered a continuous feature and a two-foot recommended, one-foot minimum clearance should be provided between the sidepath and the barrier. In addition, the barrier itself is approximately two feet wide and roadway design standards typically require a two-foot shy distance from barriers for drivers. As a result, barriers may not be a space saving feature compared to the typical at-grade buffer.



SIGNS AND MARKINGS

Signs for roadway users may not be visible for contraflow sidepath users. Provide signs and wayfinding in both directions along a sidepath. Similar to shared use paths, sidepath users typically keep right except to pass. A centerline stripe may help clarify the direction of travel and organize traffic, but is not required.

Crosswalk markings can enhance drivers' awareness of yielding responsibilities at intersections. See Chapter 4 for discussion of crosswalk markings. There are currently no MUTCD-compliant signs or sign assemblies that clearly warn drivers of two-way bicycle traffic, although several jurisdictions are using experimental signs. Adding stop bars and STOP HERE FOR PEDESTRIANS (R1-5b) signs for motor vehicles approaching the parallel roadway and TURNING VEHICLES STOP FOR PEDS (R10-15a) for motor vehicles turning off the parallel roadway, can help improve yielding at the sidepath intersection (EXHIBIT 5-23: R1-5b (left) and R10-15a (right) Signs).



EXHIBIT 5-23: R1-5b (left) and R10-15a (right) Signs

SELECTING A SIDE OF THE ROADWAY

As discussed in Chapter 3, drivers are more likely to expect and perceive people bicycling that are traveling in the same direction as motor vehicle traffic. Sidepaths are two-way facilities, but their location within the roadway cross-section can help discourage contraflow bicycling. To help identify the best location for a sidepath:

- Evaluate if a sidepath on both sides of a road is appropriate in areas with origins and destinations on both sides of the road.
- If a sidepath on one side is the solution, assess the surrounding bicycle network and adjacent land uses for insight into which side is most appropriate.
- Provide convenient crossing locations at regular intervals to deter bicyclists from riding contraflow on one side of the roadway.



ADA CONSIDERATIONS

Sidepaths are shared use paths and therefore need to meet ADA requirements. Any shared use path funded by MnDOT, or in MnDOT right-of-way, is considered to serve a transportation purpose and is required to be accessible year-round. There are many considerations related to ADA. Ramps and detectable warnings should be installed at every shared use path intersection with a roadway. Ramp width should match the shared use path width. When a sidepath ends, it needs to be accessible to and from a roadway or shoulder ([See MnDOT TEM section 13-2.01](#)).⁴⁹ Refer to MnDOT's ADA standards and consult with the ADA Unit early in the project to clarify requirements.

MnDOT's ADA standards are based on information from the [Americans with Disabilities Act](#), [U.S. Access Board](#), and the [Public Right-of-Way Accessibility Guidelines](#).^{9,58,59} PROWAG relates specifically to transportation and has a roadway focus.

If a guardrail is used as a barrier, consider how a person with limited or low vision would detect it. Guardrail posts are not continuous. If possible, the space between the guardrail and sidepath should be grass, landscaping, or other detectable surface. If the clearance space between the sidepath and guardrail is a continuous surface, consider adding a detectable edge to the guardrail. Address any crashworthiness or liability concerns when attaching items to guardrails.



INTERSECTION DESIGN

As discussed in Chapter 4, intersection design should provide good awareness between all users, isolate conflicts and clearly assign priority between modes. At sidepath intersections, addressing conflicts between motor vehicles and two-way bicycle travel is the primary concern. As discussed in Chapter 3, contraflow bicycle movements present a challenge for drivers at intersections, since they may not be looking for people bicycling coming from both directions. Signs, pavement markings, traffic control devices, adequate sight triangle and education campaigns can all be used to help drivers notice contraflow bicyclists.^{65,66} Also, if right-of-way is available, increasing the offset distance between the sidepath and the roadway can help position motor vehicles so drivers can see bicyclists. This section discusses offset geometry, as well as potential intersection treatments at driveways, unsignalized intersections and signalized intersections.

Offset Geometry

With offset geometry, also known as “bend out” design, a driver turning from the parallel roadway more directly faces a bicyclist in the crossing, rather than conventional designs that position a bicyclist closer to the travel lanes and in the driver’s blind spot. This offset distance improves bicyclist visibility, motorist reaction time and creates space for a right-turning driver to yield and wait for a through-moving bicyclist. Larger offsets also provide space for a driver entering the parallel roadway to cross the sidepath and enter the roadway as two separate decision-making steps (EXHIBIT 5-24: Bend Out Shared Use Path Operational Improvements).

Offset geometry may not always be feasible. If it is used, the recommended minimum and maximum offsets are shown in EXHIBIT 5-25: Roadway Speed and Crossing Offset Distance. If a six-foot buffer is included in the corridor design, the minimum offset distance has already been met. However, increasing the separation between the roadway and the sidepath results in a driver turning off the parallel roadway approaching the sidepath at a better angle.

EXHIBIT 5-24: Bend Out Shared Use Path Operational Improvements

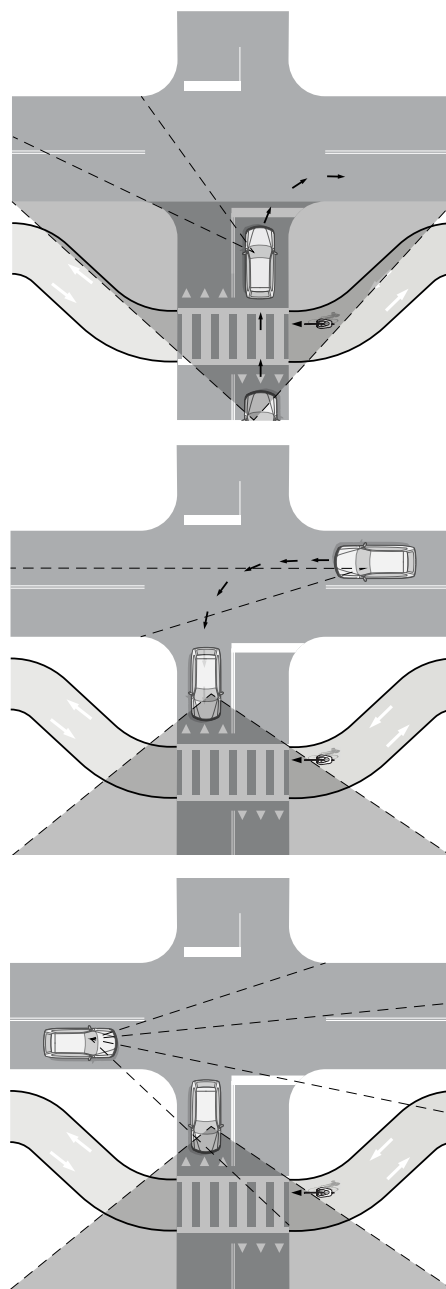


EXHIBIT 5-25: Roadway Speed and Crossing Offset Distance

ROADWAY SPEED	PREFERRED OFFSET DISTANCE	MINIMUM OFFSET DISTANCE
50 mph or less	16.5 feet	6 feet
55 mph or more	24 feet	6 feet

Driveway Intersections

Requiring people bicycling to stop at each driveway crossing is ineffective and inconsistent with Minnesota motor vehicle code. Through-moving vehicles having priority over turning vehicles, so turning motor vehicles should yield to through sidepath users. Bicyclists have the same rights as pedestrians in a crosswalk and drivers should yield to them once they have entered the crosswalk. Sidepaths should have traffic priority at low- and medium-volume intersections and driveways. Consider measures that make sidepath users aware of the conflict rather than requiring them to stop or yield.

Driveways can be classified into three categories based on motor vehicle volumes. At low- and medium-volume driveways the risk of an interaction between sidepath users and drivers is lower. The motor vehicular volume thresholds for low-, medium- and high-volume driveways are presented in EXHIBIT 5-26: Driveway Classification. A low-volume driveway may represent a single family home or commercial driveway. Medium-volume driveways could represent a small subdivision or strip mall. High-volume driveways should be treated the same

EXHIBIT 5-26: Driveway Classification

DRIVEWAY USAGE CLASSIFICATION	MOTOR VEHICLES PER HOUR CROSSING TWO-WAY SIDEPATH
Low	<10
Medium	10-50
High	>50

as unsignalized intersections as described below. Sight distance for bicyclists and drivers at driveways will also influence the level of treatment necessary.

LOW-VOLUME DRIVEWAYS

At low-volume driveways, signs and pavement markings may not be necessary to indicate that sidepath users have priority. If there is a history of conflicts at a low-volume driveway location, consider treatments that indicate to drivers that sidepath users have priority (EXHIBIT 5-27: Low-Volume Driveway). Offset geometry, raised crosswalks and reduced curb radii can be considered but may not be cost effective.

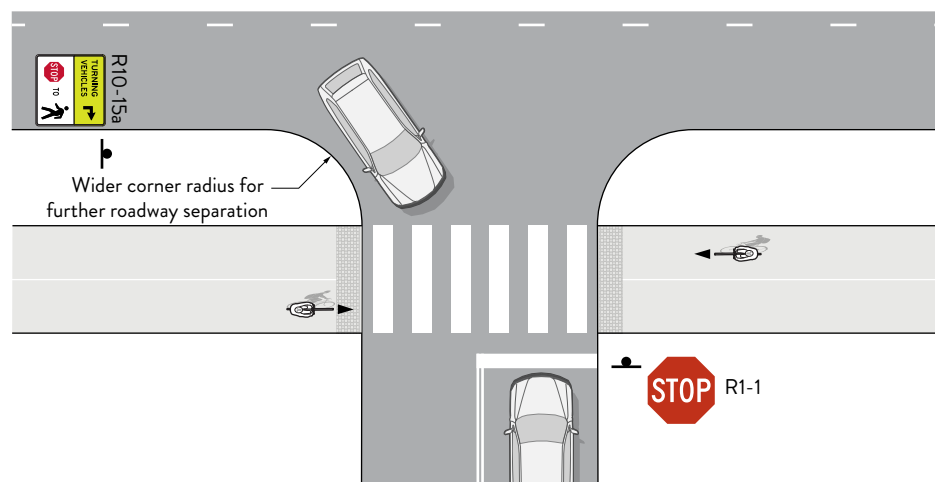


EXHIBIT 5-27: Low-Volume Driveway

MEDIUM-VOLUME DRIVEWAYS

At medium-volume driveways, the need for pavement markings and signs that indicate to drivers that sidepath users have priority may be greater. In addition, consider raised crosswalks and reduced curb radii. Raised crosswalks and reduced curb radii may slow motor vehicle speeds, calm traffic and can improve overall safety (EXHIBIT 5-28: Medium-Volume Driveway). For more information on raised crosswalks, see Chapter 7.

Lower turning speeds are proven to improve yielding compliance by drivers to crosswalk users. Consult with maintenance staff when designing traffic calming elements so that they minimize disruption to snow removal and other operations.

Sidepath users are most likely to encounter turning motor vehicles at high-volume driveways and unsignalized intersections. In these locations, pavement markings and signs are necessary, and geometric changes such as offset geometry and raised crossings are recommended.

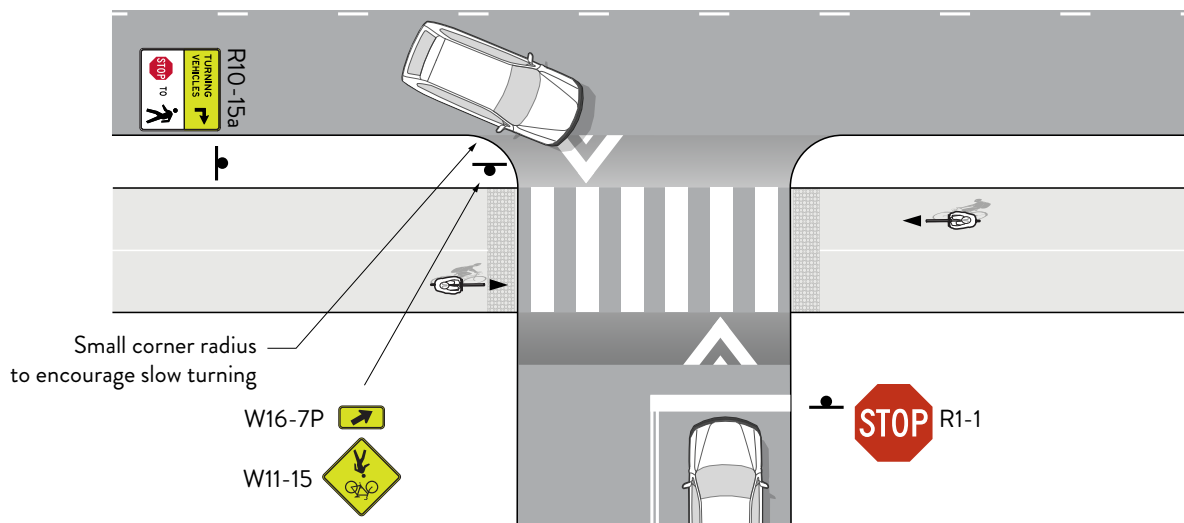


EXHIBIT 5-28: Medium-Volume Driveway

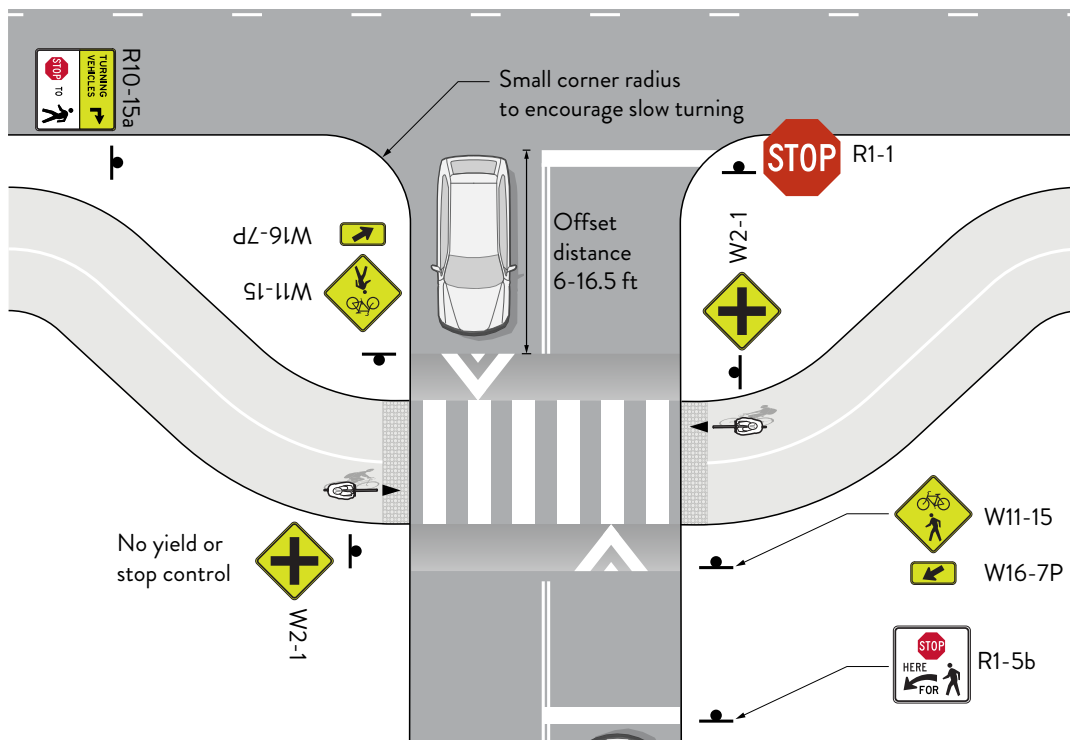


EXHIBIT 5-29: Unsignalized Intersections and High-Volume Driveways

UNSIGNALIZED INTERSECTIONS AND HIGH-VOLUME DRIVEWAYS

The need for signs, markings and geometric changes is higher at unsignalized intersections and high-volume driveways (EXHIBIT 5-29: Unsignalized Intersections and High-Volume Driveways).

Signalized Intersections

At signalized intersections, offset geometry and signs alerting drivers to the presence of sidepath users are especially applicable. A raised crossing may be appropriate, depending on motor vehicle speeds and the number of heavy motor vehicles on the roadway crossing the sidepath. For more information on raised crosswalks, see Chapter 7.

In addition, consider prioritizing sidepath users by providing an exclusive sidepath signal phase or a leading interval. Volume thresholds for providing a separated sidepath phase or leading interval at a signalized intersection are provided in EXHIBIT 5-30.

These thresholds, based on the [Massachusetts DOT Separated Bike Lane Planning and Design Guide](#),⁶⁷ should be considered when evaluating the need for a separate bicycle phase at a signalized intersection. A separate sidepath phase could be provided using a pedestrian signal or bicycle signal face. See Chapter 4 for bicycle facility signalization options.

Other signalization options include protected-only left and right-turn phases and prohibiting right run on red.

On a sidepath, maintain a minimum eight foot access route for travel between signal poles and push button poles. This allows bicyclists to pass one another and to provide maintenance motor vehicle access. Where large numbers of people bicycling are expected at a signalized intersection, provide adequate queuing space to store and quickly cross users, minimizing the duration of potential conflicts. This increases queuing space and crossing capacity and reduces path entrance/exit conflicts.

EXHIBIT 5-30: Sidepath Protected Signalization Volume Thresholds

SIDEPATH PROTECTED SIGNALIZATION THRESHOLDS	MOTOR VEHICLES PER HOUR CROSSING TWO-WAY SIDEPATH
Right-turn	100
Left-turn across one lane	50
Left-turn across two lanes	0



Separated Bike Lane



DESIGN OVERVIEW

Separated bike lanes, also known as cycle tracks and protected bike lanes, are exclusive facilities for bicycling that are located within or directly adjacent to a roadway. They are physically separated from motor vehicle traffic by a vertical element such as flexible post delineators, raised medians, landscaping, or another physical object. This vertical element is what differentiates separated bike lanes from conventional and buffered bike lanes. Unlike sidepaths, separated bike lanes are bike-only facilities. Corridors with separated bike lanes also have sidewalks on both sides for pedestrian use.

Separated bike lanes can be:

- one- or two-way facilities
- on the left or right-hand side of a street
- at road grade, at sidewalk grade, or at an intermediate grade between the roadway and sidewalk

MnDOT has adopted the FHWA's Separated Bike Lane Planning and Design Guide as its guidance for separated bike lane design. Therefore this section includes only general guidance on some key separated bike lane features. [See the FHWA Separated Bike Lane Planning and Design Guide⁵](#) for detailed, overall guidance, noting the following MnDOT-specific exceptions, additions and clarifications:

- The FHWA Guide identifies signs in the Federal MUTCD. Use the MN MUTCD to verify the correct Minnesota-specific signs to use.
- Consider drainage impacts when selecting a type of vertical separation. Raised medians may need to include gaps for stormwater drainage.
- Carefully plan how to maintain snow and debris in separated bike lanes. Snow removal can be challenging and may need specialized equipment. Refer to MnDOT's Maintenance Manual for its snow removal policy and consult early with Maintenance Office staff to discuss issues and responsibilities.
- If a separated bike lane is at sidewalk level, design any driveway and minor crossings so the bicycle facility continues at grade and motor vehicles change grade to cross the bike lane.
- Consider freight movements and delivery locations when designing separated bike lanes.
- Designers may consider temporary materials for bicycle facilities being implemented as a trial or demonstration project. For permanent projects, durable materials and barriers are recommended.

As discussed in Chapter 3, drivers are more likely to expect and perceive bicyclists that are traveling in the same direction as motor vehicle traffic. On two-way roadways, one-way separated bike lanes on each side of the roadway are typically preferred over a two-way separated bike lane on one side of the roadway. One-way separated bike lanes in the direction of motorized travel are typically the easiest option to integrate into existing roadway operations.



SEPARATED BIKE LANES AND STATE AID RULES

- Use Chapter 8820 off-street rules for intermediate or sidewalk level separated bike lanes
- Use Chapter 8820 on-street rules for street level grade separated bike lanes

LANE WIDTH

EXHIBIT 5-31 and EXHIBIT 5-32 show the preferred and minimum bike lane operating widths for one-way and two-way separated bike lanes based on expected bicycle volumes.

EXHIBIT 5-31: One-Way Separated Bike Lane Widths Based on Existing or Anticipated Volumes*

PEAK HOUR DIRECTIONAL BICYCLIST VOLUME	PREFERABLE BIKE LANE WIDTH (FT)	MINIMUM BIKE LANE WIDTH (FT)**
<150	6.5	5
150-750	8	6.5
>750	10	8

*Operating widths do not include horizontal clearance distances from obstructions.

**Constrained width may be as low as 4 feet for short distances.

Note: One-way bike lane widths of 7 feet or more allow for side-by-side riding.

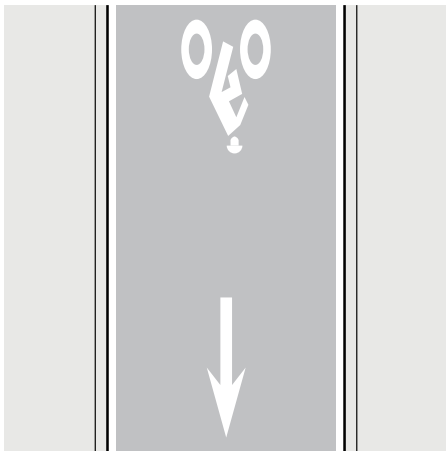
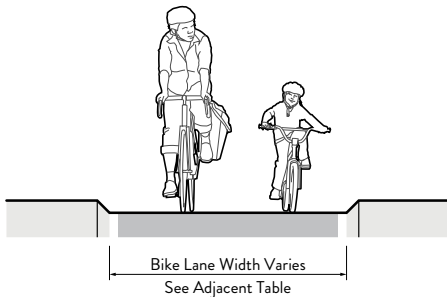


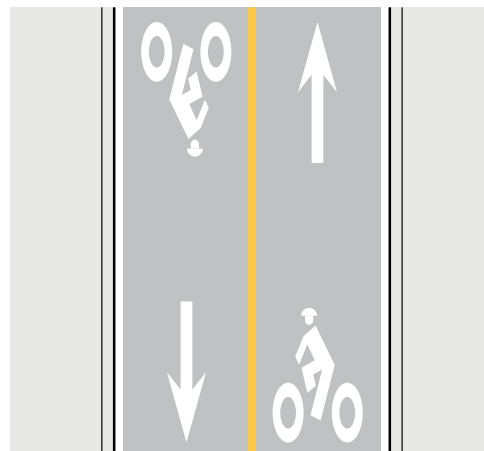
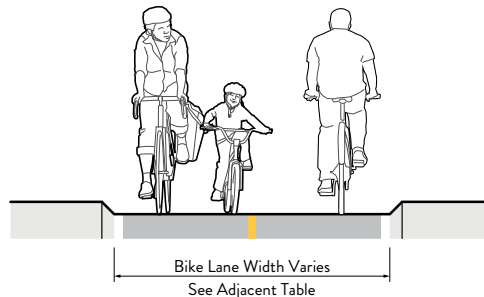
EXHIBIT 5-32: Two-Way Separated Bike Lane Widths Based on Existing or Anticipated Volumes*

PEAK HOUR BIDIRECTIONAL BICYCLIST VOLUME	PREFERABLE BIKE LANE WIDTH (FT)	MINIMUM BIKE LANE WIDTH (FT)**
<150	11	10
150-350	12	11
>350	16	14

*Operating widths do not include horizontal clearance distances from obstructions.

**Constrained width may be as low as 8 feet for short distances.

Note: Two-way bike lane widths of 12 feet or more allow for side-by-side riding in one direction.



HORIZONTAL AND VERTICAL CLEARANCES

Separated bike lanes are physically separated from motor vehicle traffic by a vertical element, such as flexible post delineators, raised medians, planters and landscaping, or other physical object. Any vertical barrier or hazard that is tall enough that handlebars may catch on it or may create pedal-strike should have a clearance of two feet (minimum one foot). Vertical curbs, if tall enough to catch a pedal: at least a nine-inch clearance from the bicycle operating space. Sloped or mountable curbs, or vertical curbs shorter than two inches do not require a clearance distance (EXHIBIT 5-33: Separated Bike Lane Clearances to Vertical Elements or Curbs and EXHIBIT 5-34: Pedal Compatible Curbs to Maximize Effective Operating Space).

If a gutter pan is present, it is not included as part of the bike lane width unless the gutter is incorporated into the width of the bike lane and results in no longitudinal joints or seams parallel to a bicyclist's line of travel. If there are no joints or seams, the nine inches of gutter pan adjacent to the curb can be considered clearance to the vertical curb.

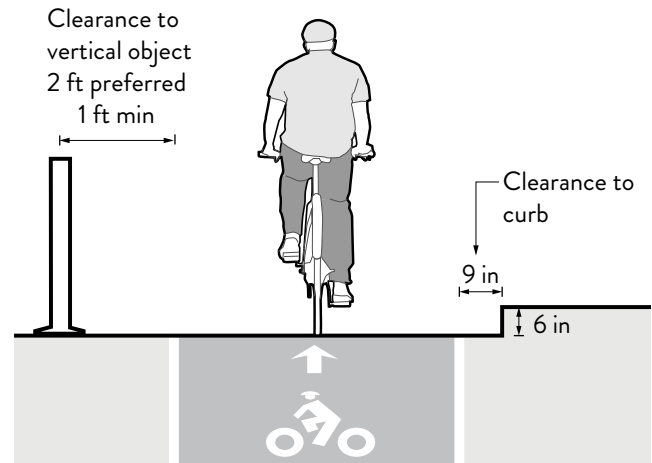


EXHIBIT 5-33: Separated Bike Lane Clearances to Vertical Elements or Curbs

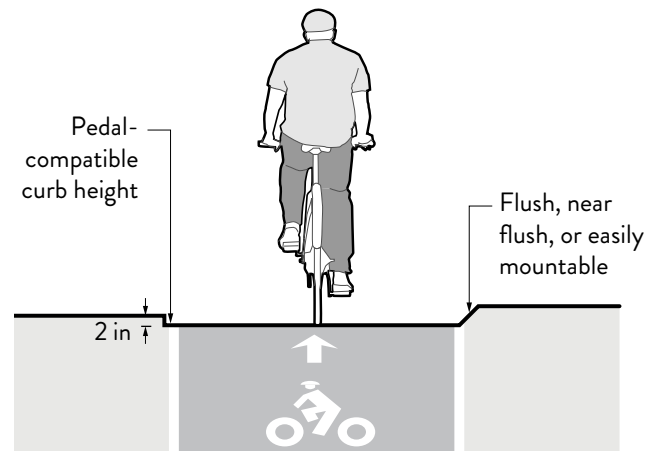


EXHIBIT 5-34: Pedal Compatible Curbs to Maximize Effective Operating Space

BUFFER SPACES

Buffers and vertical elements are critical parts of separated bike lanes. Designers should provide a buffer between the bicycle facility and the roadway and sidewalk. The buffer between the bicycle facility and the roadway is known as a street buffer; the buffer between the facility and sidewalk, is known as a sidewalk buffer. Each has different width requirements and different types of vertical elements.

Street Buffer

The preferred buffer width between a separated bike lane and a roadway, also known as the street buffer, is 6 feet. The buffer should be at least three feet wide, which allows for a horizontal clearance between the bike lane and the vertical element of one to two feet and horizontal clearance between the vertical element and the roadway of one to two feet. Flexible delineators and channelizing curbs, the narrowest vertical elements, are typically eight inches wide.

The type of vertical element between the bicycle facility and the roadway should be selected based on motor vehicle speed, land use context, the presence of on-street parking (particularly for people with disabilities using lifts), buffer area width, bike lane elevation, transit access and maintenance requirements. Types of vertical elements include flexible delineator posts, channelizing curb, rigid bollards, concrete barriers, raised medians, parking stops, parked motor vehicles and planters. For retrofit projects, non-continuous vertical elements are preferred, since they typically facilitate drainage into existing catch basins. For a sidewalk level or intermediate level separated bike lane the curb is considered a vertical element.



At sidewalk level, if the buffer between the separated bike lane and the roadway is more than three feet, landscaping such as grass, flower beds and low shrubs can serve as the vertical element. Buffers of five feet or more can support trees. At sidewalk level, elements such as roadway signs, utility poles and parking meters can be placed in the street buffer.

Sidewalk Buffer

The sidewalk buffer separates the bike lane from the pedestrian space and is critical keeping the two modes separated. The sidewalk buffer is also where street furniture and amenities such as trash cans and pedestrian scale lighting are placed.



The preferred buffer between a separated bike lane and the sidewalk is at least three feet. A buffer of three feet or more can be landscaped, and a continuously landscaped bed can provide a detectable edge for people with low vision. If a detectable directional indicator is provided, the sidewalk buffer can be as small as one foot. If using a sidewalk buffer of less than three feet, contact MnDOT's Office of Transit and Active Transportation and ADA Unit for assistance to design an appropriate detectable buffer.



SIGNS AND MARKINGS

Because one-way separated bike lanes with painted buffers may be wider than conventional bike lanes, they may attract wrong way riding. BICYCLE WRONG WAY (R5-1b) sign and RIDE WITH TRAFFIC (R9-3cP) plaque may be used to discourage wrong-way riding on one-way separated bike lanes.

Buffers for separated bike lanes often include pavement markings similar to those used for buffered bike lanes. See the bike lane section for guidance on marking these areas.

Green colored pavement is often used at separated bike lane crossings, especially for two-way separated bike lanes. See Chapter 4 for guidance on the use of green colored pavement.

ADA CONSIDERATIONS

Accessible design is a key element of any bicycle facility project, and separated bike lanes present some specific ADA challenges. Because separated bike lane design is new and still evolving, these challenges are still being evaluated by the US Access Board and separated bike lane design experts around the country. The ADA Unit is available to review and comment when considering separated bike lane designs; contact staff early to ensure appropriate, best-practice solutions.

Crossings and Detectable Edges

Designers should work closely with the disability community to identify design options to maintain access and use for people with disabilities to and between sidewalks, roads and properties. Just like drivers, people bicycling should yield to people walking across their path. Consider crosswalk markings and yield or stop bars to alert bicyclists to the presence of a crossing.

Pedestrian crossings at separated bike lanes need truncated domes to clearly define the crossing. Sidewalk level separated bike lanes should have a detectable division between the separated bike lane and the sidewalk. This could be either a vertical edge, a landscape or furnishings area or a grooved strip. At signalized intersections, accessible pedestrian signals and ADA design guidance related to pedestrian push button placement applies.

Cross Slopes

Separated bike lanes have no cross-slope requirements; however, for users of adaptive cycles and other devices, excessive cross slopes may present difficulty. Limit cross slopes along the bike lane where feasible.

The cross slope for the separated bicycle lane needs to meet ADA sidewalk standards where people are expected to be crossing. Consider people walking in the buffer areas as well. If people may walk in the buffer area (e.g. to enter/exit on-street parking), these areas should also meet ADA cross slope standards.

When designing a separated bike lane, keep in mind that bicycles are motor vehicles; treat them as such. Operations and ADA compliance are important aspects to consider at all separated bike lane crossings with pedestrians or motor vehicles.

Parking-Protected Separated Bike Lanes

Parking-protected separated bicycle lanes should be designed carefully to meet ADA needs. In Minnesota every paid parking spot is theoretically an accessible space, and a separated bicycle facility is considered an active travel lane. Therefore, adding a separated bicycle facility between the parking lane and the curb can be considered to be creating a barrier. For this reason, parking protected lanes are currently discouraged on trunk highways. If used, they should include the following:

- Designated ADA parking spaces that meet 2010 ADA standards. The location of accessible parking should be related to the context of the area and consider directness of access to services and points of interest on the block.
- Designated ADA vehicle ramp lift spaces.
- An 8-foot access aisle from designated ADA accessible parking spaces to the sidewalk, including necessary curb ramps.
- In situations where dedicated accessible parking is not provided and the separated bike lane functions as the accessible route to access the sidewalk the separated bike lane should have a cross slope of 2% or less.

In communities with para-transit and dial-a-ride operations designers and providers will need to consider impacts to pick-up and drop-off procedures. As an example, para transit drivers are tasked with seeing their passenger enter their destination, so drivers need to be able to drop off their customers very near a building door. Work with the ADA Unit to determine options.



PROTECTED INTERSECTIONS

Protected intersections separate pedestrians, bicyclists and motor vehicles using a variety of design elements. Protected intersections can be implemented at signalized or stop-controlled intersections to create safe, comfortable conditions for people bicycling. Protected intersections are most commonly used with separated bike lanes, but can be used with conventional bike lanes, shoulders, or shared lanes.

The [FHWA Separated Bike Lane Planning and Design Guide](#),⁵ released in 2015, does not include guidance on protected intersections. The general overview of protected intersections presented here is based, instead, on guidance from the [MassDOT Guide](#).⁶⁷ For detailed guidance about designing a protected intersection, contact MnDOT's Office of Transit and Active Transportation.

Consider access and legibility for pedestrians when designing a protected intersection. Align pedestrian refuge medians and crosswalks directly the extension of the PAR. Refuge medians that are 6-feet wide or more should have detectable warnings. Consider placement of APS buttons when designing the intersection. Wider medians and buffer areas make it easier to place required pedestrian elements.

Protected intersections may require additional right-of-way at intersection corners if parking lanes are not present. Similar to separated bike lanes, they may also require specialized snow removal equipment.

Benefits

A protected intersection improves upon conventional intersection design by:

- Providing clear right-of-way assignment between modes
- Maintaining physical separation between bicyclists and motor vehicles through an intersection
- Placing queued bicyclists in front of and in clear view of drivers
- Improving visibility of bicyclists by drivers of turning motor vehicles
- Clearly defining pedestrian and bicycle operating spaces
- Reducing pedestrian crossing distance
- Reducing motor vehicle turning speed

Elements of Design

The design of a protected intersection includes the elements found in EXHIBIT 5-35: Elements of a Protected Intersection. Key features include a corner island, forward bicycle queueing area, driver yield zone and pedestrian refuge median.

Corner Island: allows the bike lane to be physically separated from motor vehicle traffic up to the edge of the intersection and reduces motor vehicle turning speeds.

Forward Bicycle Queueing Area: provides a waiting area for bicyclists that is fully within view of drivers waiting behind the pedestrian crosswalk.

Driver Yield Zone: creates a space for turning drivers to yield to bicyclists and pedestrians by setting the bicycle and pedestrian crossings back from the intersection, similar to the offset geometry recommended for sidepath crossings. If pedestrian and/or bicyclist movements are to be protected by signal phasing, the size of the driver yield zone is not as critical.

Pedestrian Refuge Median: enables pedestrians to cross bicycle and motor vehicle traffic separately. If this area is more than six-feet wide and has detectable warning surfaces, it can function as a waiting area, thus reducing the pedestrian crossing distance. Medians less than six feet wide should not be considered refuges, and do not need detectable warning surfaces.

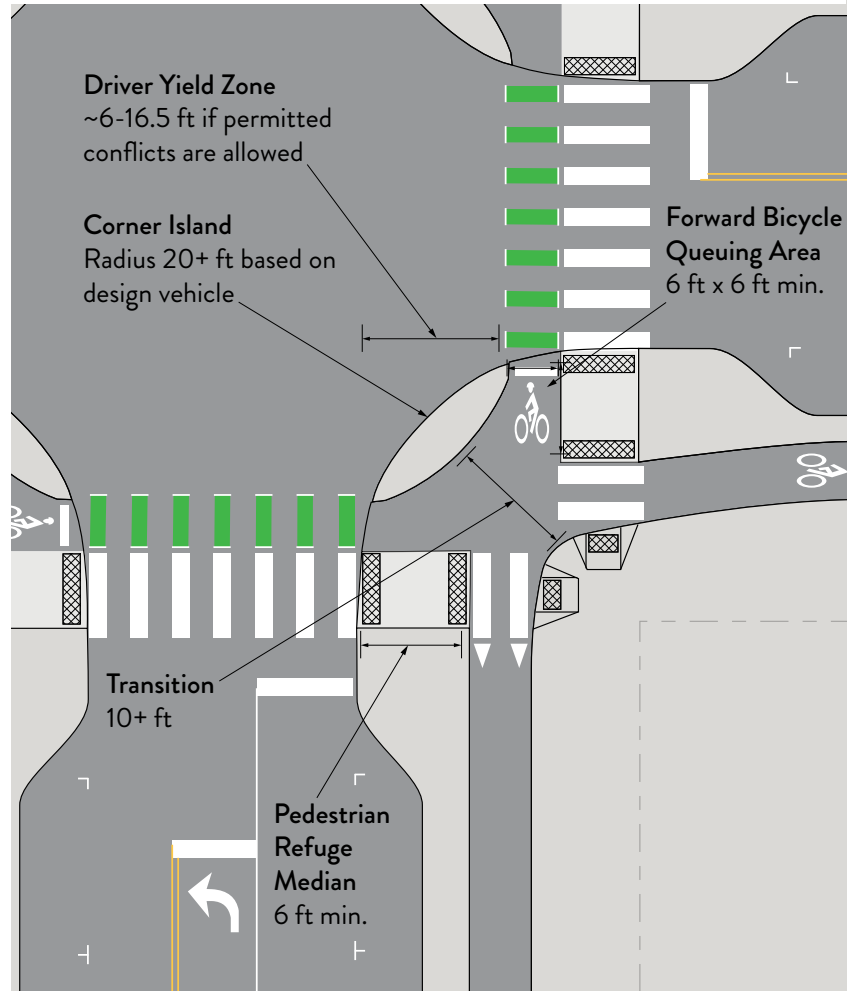


EXHIBIT 5-35: Elements of a Protected Intersection

Design Vehicle

Designing a protected intersection to serve the largest possible motor vehicle will result in significant compromises that will reduce the effectiveness and safety of the design. In particular, large design vehicles require large turning radii, reducing the size and effectiveness of a corner island. Design for frequent “design vehicles” rather than a large “control vehicle” that infrequently uses the intersection. To serve larger motor vehicles, consider including a truck apron (Chapter 7). If large motor vehicles

are very infrequent, consider allowing turning movements that involve drivers to “swing out” to use the full intersection when turning. Based on land use context and the roadway network, truck turning movements could be restricted at certain intersections and accommodated at others.

Bike Lane



DESIGN OVERVIEW

On-street bike lanes designate a preferential space for bicyclists through the use of pavement markings and signs. Bike lanes are for one-way travel and are normally provided in both directions on two-way streets and/or on one side of a one-way street. On roadways with motor vehicle speeds of 35 mph or less, bike lanes can be an appropriate way to serve Interested but Concerned bicyclists (EXHIBIT 3-4 on page 3-9). In areas where on-street parking or a large percentage of heavy vehicles are expected, a buffered bike lane may be preferable. For two-way bicycle travel on one side of the roadway in urban conditions, see Separated Bike Lanes. For two-way bicycle travel on one side of the roadway in rural or natural conditions, see Sidepaths.

BIKE LANE DIMENSIONS

Preferred and minimum bike lane widths are shown in EXHIBIT 5-36: Bike Lane Dimensions. Bike lane widths are measured from the center of the bike lane line(s) toward the curb. Bicyclists require a nine-inch horizontal clearance from a vertical curb.

If a gutter pan is present, it is not included as part of the bike lane width unless the gutter is incorporated into the width of the bike lane and results in no longitudinal joint or seams parallel to a bicyclist's line of travel. If there are no joints or seams, the nine inches of the gutter pan adjacent to the curb can be considered clearance to the vertical curb. If there is no gutter pan, such as in cases where a roadway has been overlaid to its full width, a nine-inch clearance from the vertical curb is necessary.

Start with preferred widths, as this offers the greatest likelihood of attracting the Interested but Concerned bicyclist. Use minimum dimensions only in constrained situations. When adjacent to parking, wider bike lanes are recommended, as a portion of the bike lane will be within the door zone (EXHIBIT 5-37: Bike Lane Dimensions). Where higher motor vehicle speeds and volumes exist, choose a width at the high end of the ranges noted. Seven feet allows people bicycling to ride side-by-side and pass within the bike lane.

EXHIBIT 5-36: Bike Lane Dimensions

BIKE LANE	PREFERRED WIDTH (FT)	MINIMUM WIDTH (FT)
Adjacent to edge of pavement or gutter pan	5-7*	4
Between travel lanes or buffers	5-7	4
Adjacent to parking (without buffer)	6-7*	5

* if more than 7 feet are available, consider a buffered bike lane. Drivers may confuse overly wide bike lanes without a buffer or separation as a parking or travel lane.

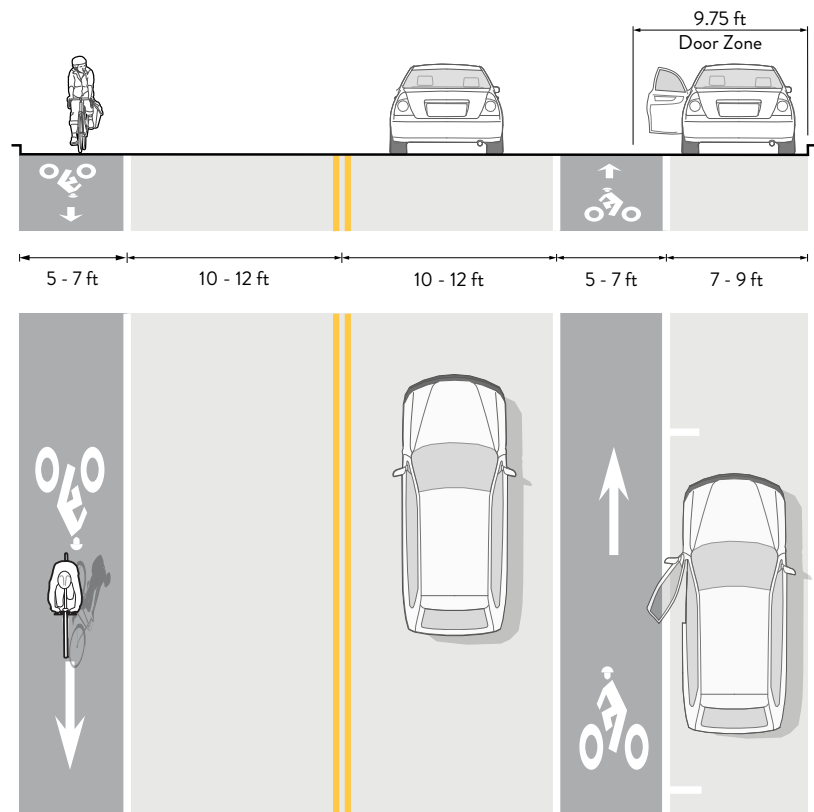


EXHIBIT 5-37: Bike Lane Dimensions

ROADWAY SURFACE INCONSISTENCIES

Manholes, drainage grates, or other obstacles should be set flush with the paved roadway. Roadway surface inconsistencies pose a threat to safe riding conditions for bicyclists. Manholes, access panels or other drainage elements should be constructed with no variation in the surface. The maximum allowable tolerance in vertical roadway surface is a quarter of an inch.

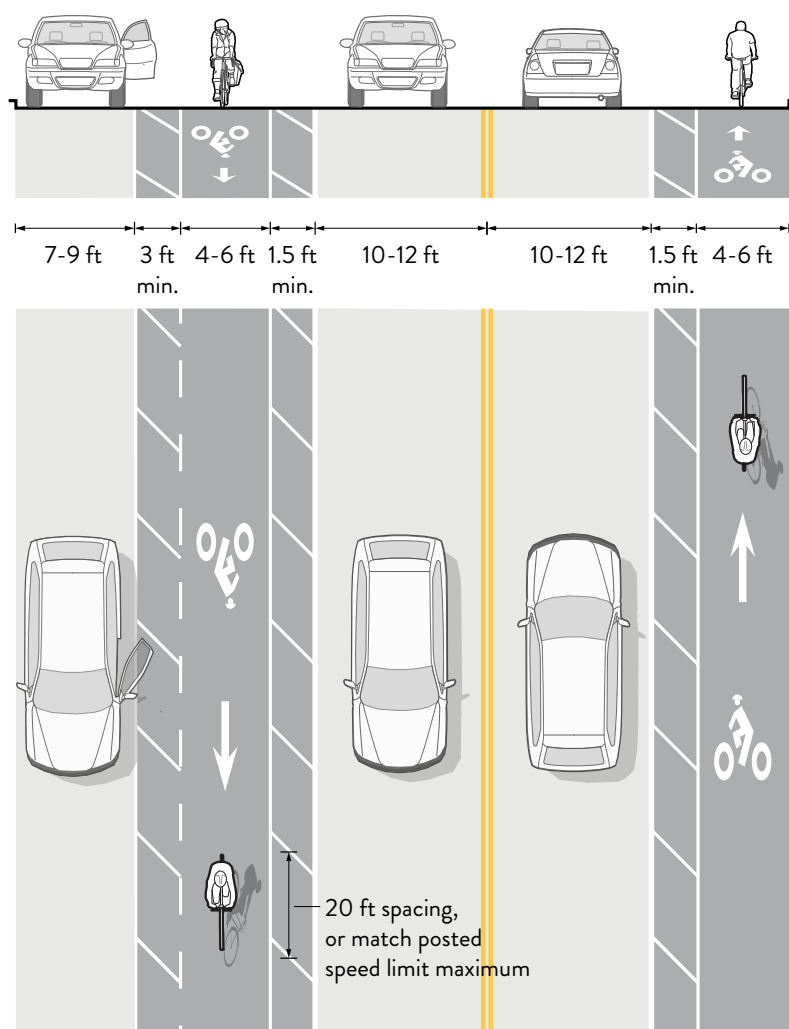


EXHIBIT 5-38: Buffered Bike Lanes

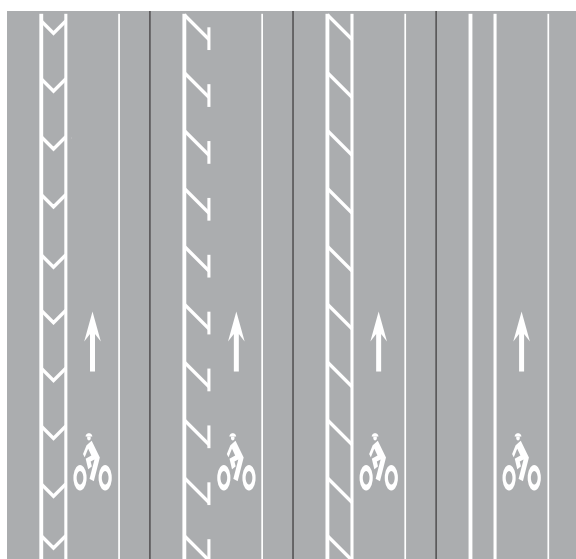


EXHIBIT 5-39: Buffer Types

BUFFERED BIKE LANES

Buffered bike lanes allow for increased horizontal separation between modes, and therefore increased comfort for bicyclists and drivers. Buffers provide a greater space for bicycling without making the bike lane appear overly wide; overly wide space may attract unintended motor vehicle use for driving or parking. Buffered bike lanes provide the highest value on streets with high speeds and/or volumes, though can be considered on any street where a standard bike lane is recommended. The buffer space can be placed between driving lanes and the bike lane, between the bike lane and parked motor vehicles, or both. A buffer between a bike lane and on-street parking has more value if the parking has high turnover.

Buffers should be at least two feet wide. Because they do not contain vertical elements or obstructions, buffers can be considered part of the total bike lane width. For example, a seven-foot space can be divided into a three-foot buffer and a four-foot bike lane, or a two-foot buffer and a five-foot bike lane. The portion designated for bicycle travel should not be less than 4 feet (EXHIBIT 5-38: Buffered Bike Lanes).

Signs and Markings

EXHIBIT 5-39: Buffer Types shows the different types of markings for buffered bike lanes. Generally, buffers should be marked with two solid white lines. If a buffer is three feet wide or wider, the buffer should also have white diagonal cross hatching or chevron markings.

Diagonal cross hatching or chevron markings should be spaced every 20 feet, or at a distance equal to the posted speed limit on the roadway.

If adjacent to a parking lane, the buffer may have one solid line white line and one dashed white line to indicate that drivers can cross the buffered bike lane to access on-street parking.

In one-way buffered bike lanes, consider installing a BICYCLE WRONG WAY (R5-1b) sign and RIDE WITH TRAFFIC (R9-3cP) plaque to discourage wrong-way riding.



BIKE LANES AND ON-STREET PARKING

When a bike lane is next to parallel parking, a collision arising from dooring, a sudden door opening in front of the bicyclist's path of travel, is a serious concern. Dooring concerns can lead to bicyclists not using a bike lane, particularly in places where there is high parking turnover. To reduce the risk of dooring, consider adding a buffer next to the parked motor vehicles (EXHIBIT 5-38). In conventional bike lanes, the bicycle symbol can be offset to be outside of the door zone.

The preferred minimum bike lane width adjacent to on-street parking is six feet. This allows people bicycling additional rideable space beyond minimum operating width that is outside the door zone. If parking and travel lane widths are at their minimums, the bike lane width should not also be at the minimum.

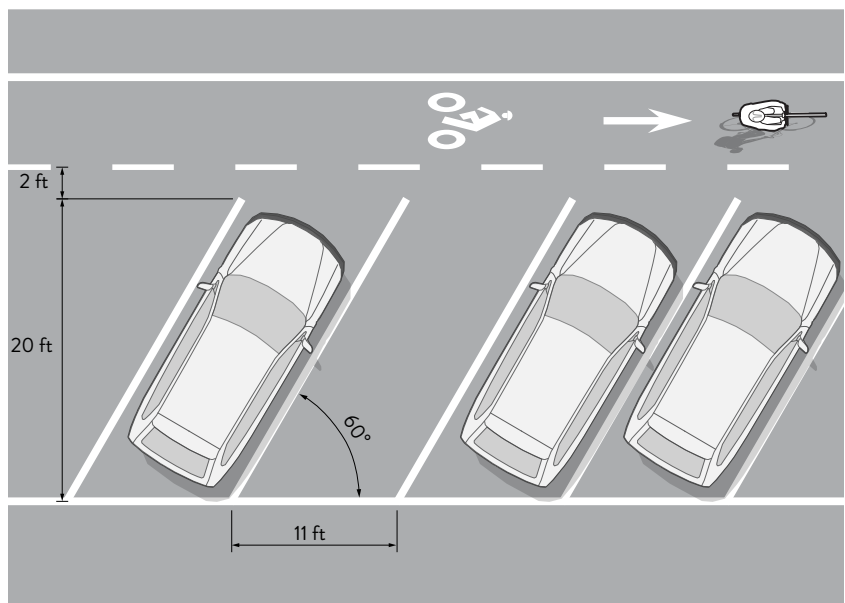


EXHIBIT 5-40: Typical Back-In Angle Parking Dimensions

Front-in angled parking is not recommended on roads with bike lanes because of a driver's limited ability to see the bike lane. Instead, back-in angled parking is the best practice (EXHIBIT 5-40: Typical Back-In Angle Parking Dimensions). Back-in angled parking should serve design vehicles of various lengths and requires additional right-of-way versus parallel parking. The benefits

of back-in angled parking include:

- Improved sight distance between exiting drivers and other traffic
- Eliminates dooring conflicts
- Passengers channeled to the curb when motor vehicle doors open
- Trunk access occurs at the curb
- Increased number of parking spots vs. parallel parking

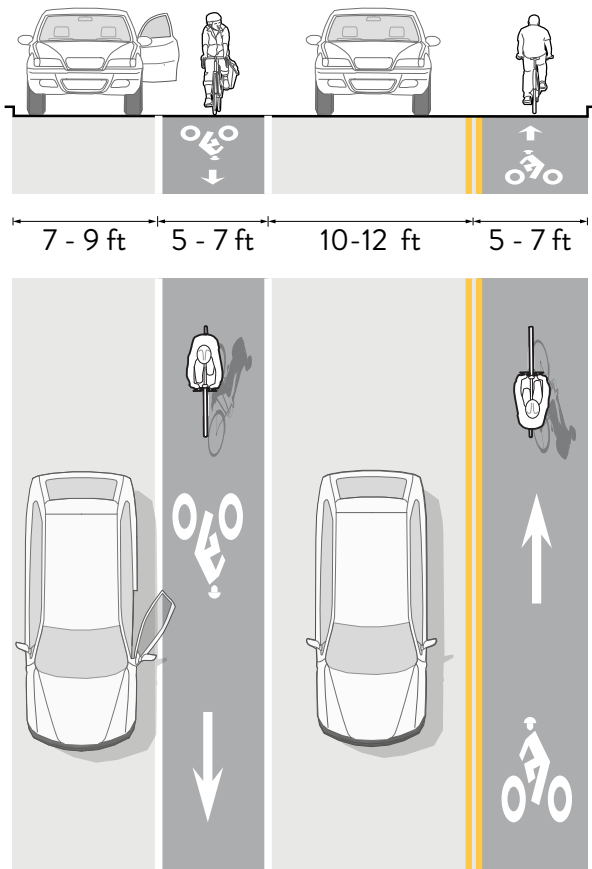


EXHIBIT 5-41: Contraflow Bike Lane

BIKE LANES ON ONE-WAY STREETS

Bike lanes on one-way streets are normally provided on the right side of the roadway unless destinations, motor vehicle turning patterns, or transit activity indicate a safer or more convenient installation would be on the left side (EXHIBIT 5-42: Left Side Bike Lane). Lanes should be installed on both streets in a one-way pair whenever possible. .

Contraflow Bike Lanes

On some one-way streets, it may be desirable to provide two-way bicycle access. For example, consider contraflow bike lanes (EXHIBIT 5-41: Contraflow Bike Lane) on a one-way street with direct access to a high-use destination. This can provide substantial time savings compared to another route and may deter bicyclists from riding on the sidewalk or the wrong way on the street.

Contraflow bike lanes should always be placed on the right-hand side of the road, with opposing traffic on the bicyclists left. Contraflow lanes are best where there are few intersecting conflict points (driveways, alleys, etc.) and where bicyclists can effectively make transitions to and from the facility. A buffer may increase comfort, or medians can provide separation and reduce turns across the contraflow bike lane.

Always pair contraflow lanes with a bike lane for bicyclists traveling in the same direction as motor vehicle traffic. If space is constrained and a bike lane in the direction of motor vehicle traffic cannot be included, install frequent shared lane markings in the travel lane.

Traffic control considerations for contraflow bike lanes include:

- Use bike lane symbols on approach and departure from each intersection to remind bicyclists and drivers of travel direction.
- Use a double solid yellow line for contraflow lane delineation and a broken double yellow line for contraflow lanes next to on-street parking.
- Add an EXCEPT BIKES plaque at ends and turns with regulatory signs such as ONE-WAY or DO NOT ENTER.
- Contraflow bike lanes may require signal upgrades to control contraflow bicycle movement.

Left Side Bike Lanes

Left-side bike lanes are conventional bike lanes placed on the left side of one-way streets or two-way median divided streets (EXHIBIT 5-42).

Left-side bike lanes offer advantages on one-way streets with heavy delivery or transit use, frequent parking turnover on the right side, a significant number of left-turning bicyclists, or other potential conflicts that could be associated with right-side bike lanes. Bicyclists in left-side bike lanes are less likely to experience interactions with motor vehicle door openings, as passenger-side motor vehicle doors are less frequently opened. Bicyclists riding in left-side bike lanes may be more visible to drivers, as they are on the driver's side.

A left-side bike lane may need to be more visible and conspicuous to drivers, as drivers may not be accustomed to encountering a bicycle facility on the left side of the roadway. Considerations for left side bike lanes include:

- Signs should accompany left-side bike lanes to clarify proper use by bicyclists to reduce wrong-way riding.
- Bicycle through lanes should be provided to the right of motor vehicle left-turn pockets to reduce conflicts at intersections, similar to right turn treatments for right-side bike lanes.
- Intersection treatments such as two-stage turn boxes and bike signals should be considered to assist in the transition from left-side bike lanes to right-side bike lanes.
- Green colored pavement may be used to draw attention to the left-side bike lane, or to highlight conflict areas and increase bicyclists' visibility

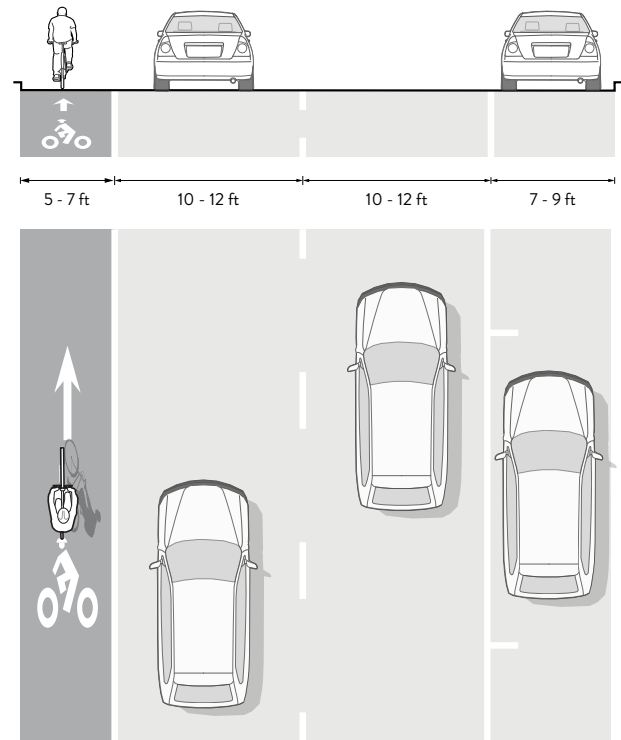


EXHIBIT 5-42: Left Side Bike Lane



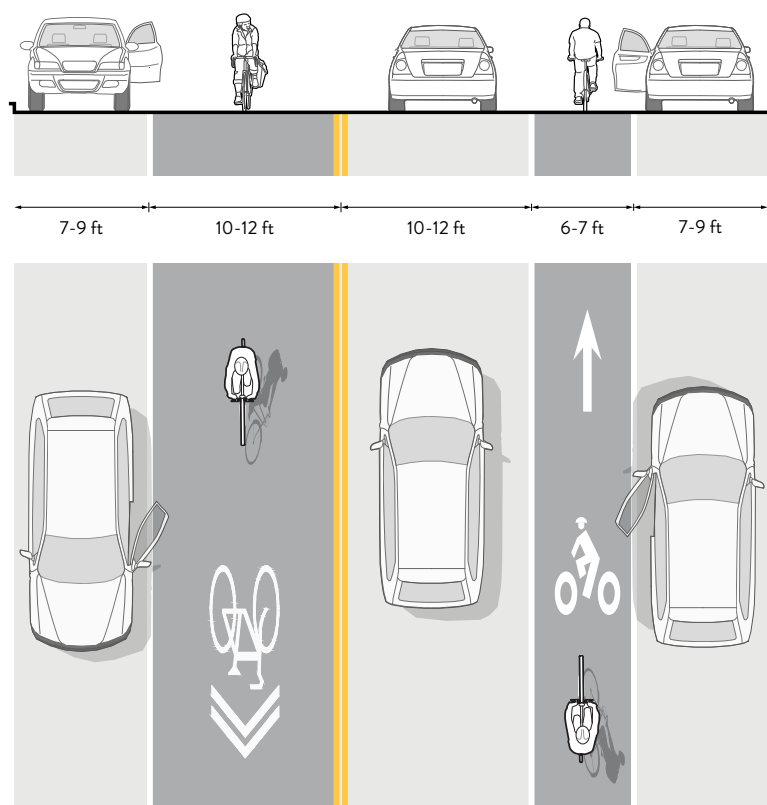


EXHIBIT 5-43: Uphill Bike Lane



CONSTRAINED CORRIDORS

When preferred bike lane widths are not possible, explore other treatments and pursue the flexibility allowed within the overall roadway cross-section as a next step. A less than desirable facility offers less usable space and reduced separation from motor vehicles, leading to a less comfortable facility, unpredictable behavior and reduced ridership. However, the following treatments may still provide some improvement to bicyclists comfort in constrained conditions.

Uphill Bike Lane

On two-way streets bike lanes should be provided on both sides of the street; providing lanes on only one side can encourage wrong-way riding. However, where roadway width is limited, it can be advantageous to provide a bike lane in the uphill direction, but just shared-lane markings in the downhill direction (EXHIBIT 5-43: Uphill Bike Lane). Uphill travelling bicyclists will move slower than average speeds and therefore benefit from a defined lane while bicyclists travelling downhill will travel much closer to motor vehicle speeds. The Shared Roadways section in this chapter provides additional guidance on appropriate roadway context for shared lanes.

Advisory Bike Lanes

Advisory bike lanes are considered an experimental treatment that is not currently in the MN MUTCD. As discussed in Chapter 4, new and experimental treatments should be implemented through the Request to Experiment process. If considering advisory bike lanes, please contact the MnDOT Traffic Standards Engineer to discuss the RTE process.

Advisory bike lanes are bicycle priority areas delineated by dotted white lines on the sides of a single center lane that serves two-way motor vehicle travel. Dotted lines indicate that drivers can enter the bike lane as needed, although they may only do so when bicyclists are not present. Drivers should overtake people bicycling with caution due to potential oncoming motor vehicle traffic (EXHIBIT 5-44: Advisory Bike Lanes).

Advisory bike lanes are most appropriate on streets where motor vehicle traffic volumes are low-to-moderate (1,500-4,500 vpd) and sightlines are good. Parking lanes (if present) should be high-turnover, or consider curb extensions to separate the parking lane from the advisory bike lane. There should be no centerline on the roadway and the two-way travel area should not exceed 20 feet.

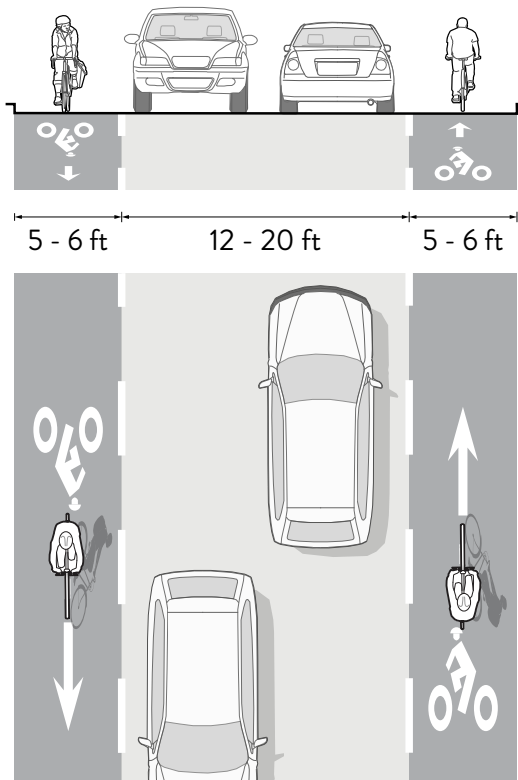


EXHIBIT 5-44: Advisory Bike Lanes

Combination Bus/Bike Lanes

Where a dedicated bicycle facility cannot be provided on a bus corridor, shared bus-bike lanes have been used in some locations nationally and internationally. Shared bus-bike lanes do not provide a high level of comfort for people bicycling and are not recommended on MnDOT roadways.

Consider shared bus-bike lanes only in situations with low bus volumes and a very constrained roadway width. Application should generally be limited to bus lanes with operating speeds of 20 miles per hour or less and transit frequency greater than 10 minutes. Refer to the [NACTO Transit Street Design Guide](#)⁶⁸ or contact MnDOT's Office of Transit and Active Transportation for more information on co-locating bus and bicycle operations.

ADA CONSIDERATIONS

There are no specific ADA requirements for bike lanes and most two-wheeled bicyclists are not affected by cross-slopes. However, for the comfort of people using bicycles with more than two wheels, such as cargo bikes or adaptive bicycles, strive for a cross-slope that does not exceed two-percent.

In addition, consider that, in reality, bike lanes may function as pedestrian facilities for wheelchair users accessing a curb ramp from a parked motor vehicle or inaccessible transit stop. Bike lanes should have a smooth, stable and slip resistant surface.



BIKE LANES AT INTERSECTIONS

Intersections are where conflicting movements come together and bicyclist comfort and safety are impacted by how well potential conflicts with motor vehicles are managed. Designs should require drivers to yield to bicyclists in appropriate locations and a bicyclist's path through an intersection should be continuous, direct and legible to all users.

As a bike lane approaches an intersection, solid bike lane markings can be continued, or they can be replaced with dotted lines. Dotted lines reinforce that motor vehicles will merge into the bike lane prior to turning. Dotted lines are important where there are frequent right turn movements or a high percentage of trucks. Dotted lines should begin 50 to 200 feet prior to crosswalk or the edge of the intersection. Solid lines may be used where there are few conflicts. Consider factors such as right-turning motor vehicle volume, bus stops, speed, motor vehicle types and land use context.

Shared Through/Right-Turn Lanes

At an intersection without right-turn only lanes, drivers may turn right or continue straight on the approach creating the potential for conflict with bicyclists traveling in a bike lane to their right.

Green colored pavement can be used to raise driver awareness of the presence of bicyclists and turning conflicts at intersections. Green colored pavement assists bicyclists in correctly positioning themselves at intersections. Green colored pavement can be continued through an entire bike lane, or started 50 to 200 feet prior to an intersection.

Right-Turn Only Lanes

Right-turn only lanes are typically used to improve motor vehicle traffic operations when there is a high volume of right-turning traffic. Through bike lanes should be located to the left of a right-turn only lane. (EXHIBIT 5-45: Right-Turn Only Lane Added without Parking Lane and EXHIBIT 5-46: Right-Turn Only Lane Added with Parking Lane). Benefits of correct placement include:

- Reduces conflicts between bicycles and motor vehicles.
- Encourages bicyclists to follow the rules of the road.
- Clearly defines merging movements in advance of an intersection.

People bicycling should not be required to ride between a turn lane and a travel lane with moving motor vehicle traffic for more than 200 feet and motor vehicle speeds at conflict points should be reduced by as much as possible. If a corridor has right-turn lanes that are significantly longer than 200 feet, consider a separated bike lane or sidepath instead of an on-street bike lane.

RIGHT-TURN ONLY LANE ADDED

EXHIBIT 5-45 and EXHIBIT 5-46 illustrate an added right-turn only lane to the right of an approaching bike lane with and without on-street parking. When a right-turn only lane is added on the approach to an intersection, drivers must yield to bicyclists when entering it. Consider using BEGIN RIGHT-TURN LANE YIELD TO BIKES (R4-4) signs to remind drivers of yielding obligations. Dotted lines or conflict markings are recommended.

BIKE LANE DROPPED TO ADD RIGHT-TURN ONLY LANE

If there is insufficient space for a bike lane and a right-turn lane, assess the risk to both users. Bike lanes may be dropped 50 to 200 feet prior to the crosswalk or edge of the intersection. Bicyclists may opt to continue straight in the right-turn only lane, or shift over to the through lane. Treatments such as shared lane markings in the right-turn only lane or BICYCLES MAY USE FULL LANE (R4-11) signs should be considered. An EXCEPT BICYCLES plaque may be added to any RIGHT-TURN ONLY (R3-5R) or RIGHT LANE MUST TURN RIGHT (R3-7R) sign.

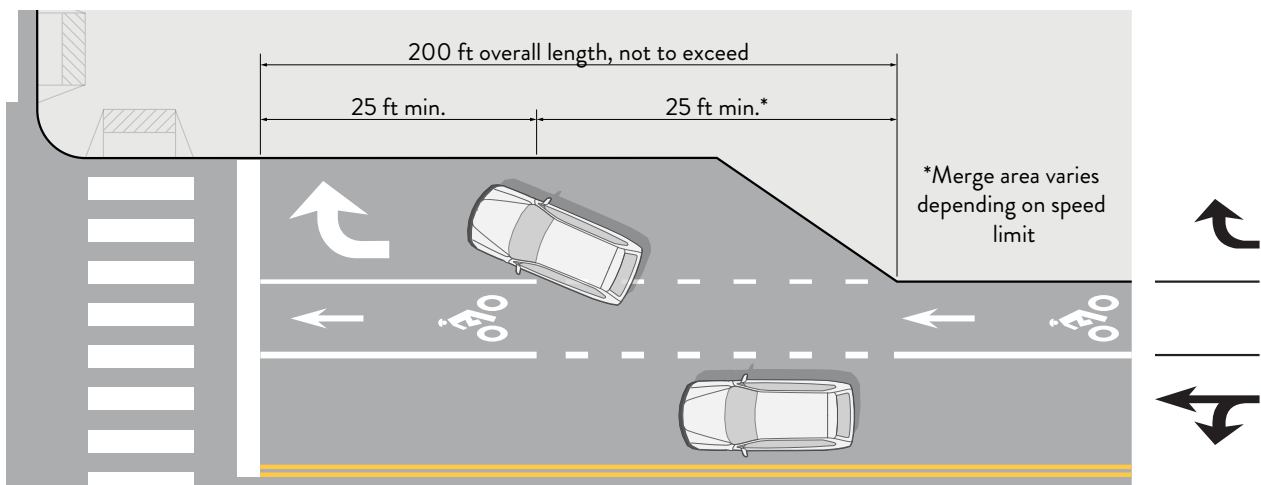


EXHIBIT 5-45: Right-Turn Only Lane Added without Parking Lane

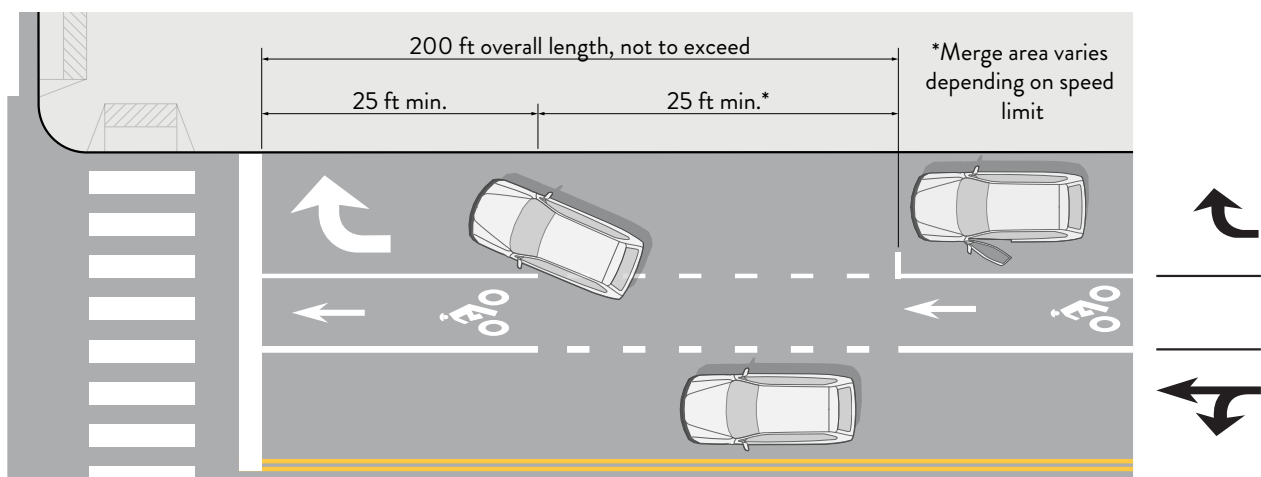


EXHIBIT 5-46: Right-Turn Only Lane Added with Parking Lane

THROUGH LANE TRANSITIONS TO RIGHT-TURN ONLY LANE

Where a through lane to the left of a bike lane becomes a right-turn only lane there are two primary options.

- EXHIBIT 5-47: Bike Lane Dropped and Introduced on Left Side of Right-Turn Only Lane shows the bike lane being dropped and reintroduced on the left side of the right-turn only lane. In this case, bicyclists would change lanes and yield to motor vehicle traffic. Shared lane markings may be used to provide additional guidance (not shown). In this case, bicyclists should yield to drivers and a BEGIN RIGHT TURN YIELD TO BIKES (R4-4) should not be used.
- EXHIBIT 5-48: Exclusive Bicycle Signal Phase shows a bicycle signal being used to create an exclusive bicycle phase. See Chapter 4 for more information on bicycle signals.

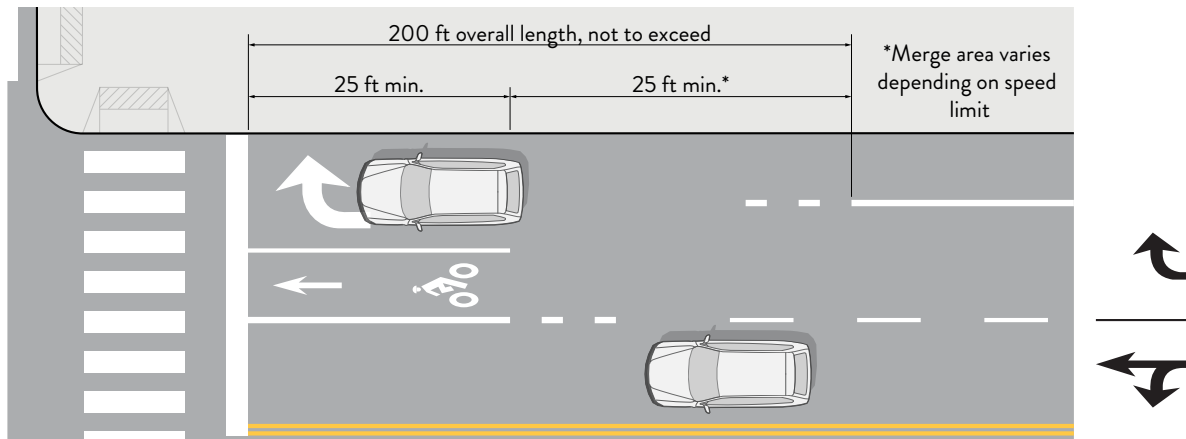


EXHIBIT 5-47: Bike Lane Dropped and Introduced on Left Side of Right-Turn Only Lane

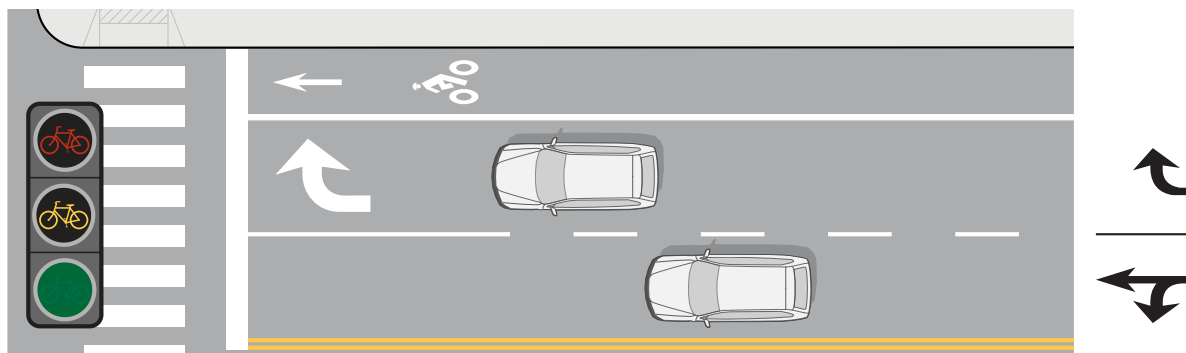


EXHIBIT 5-48: Exclusive Bicycle Signal Phase

DUAL ~~RIGHT~~ TURN ONLY LANES

Avoid installing dual right turns on streets with bike lanes. If they are unavoidable, consider using an exclusive bicycle signal phase or placing the bike lane to the left side of both right-turn lanes. On one-way streets consider placing the bike lane on the left side of the road to reduce conflicts.

OPTIONAL RIGHT-TURN LANE AND RIGHT-TURN ONLY LANE

Where an optional right turn lane exists next to a right turn only lane, consider reassigning the combined through/right turn lane to a through only lane. This change to lane assignment helps clarify user priority and more clearly indicates where a merging bicyclist should be positioned. It is also impossible to create a through bike lane in this condition. Solutions could include two right turn only lanes or signal timing changes. If the lane cannot be reassigned or eliminated, consider placing shared lane markings in the center of the through/right turn lane to guide bicyclists. A separated bike lane, sidepath and/or an exclusive bicycle signal phase should also be considered.

Do not stripe a bike lane diagonally across motor vehicle travel lanes with solid or dotted lines. This creates ambiguity for which user has priority (EXHIBIT 5-49: Bike Lane Striped Diagonally Across Travel Lanes (Not Recommended)).

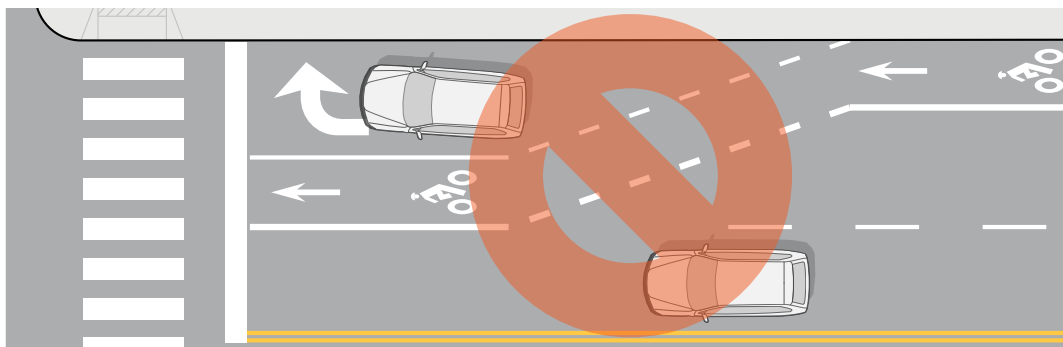


EXHIBIT 5-49: Bike Lane Striped Diagonally Across Travel Lanes (Not Recommended)

Bicyclist Left-Turn Considerations

Bicyclists make left turns in different ways depending on traffic volumes and personal comfort levels. Provide either a two-stage turn queue box or bicycle left-turn lane if bicycle left-turn movements are expected. Two-stage turn boxes are preferred on roadways with operating speeds of 35 mph or more.

TWO-STAGE TURN BOX

A two-stage turn queue box designates an area at an intersection for bicyclists to wait for traffic to clear before turning. It allows bicyclists to traverse an intersection within a bike lane, stop within the turn box, reorient themselves to cross the road and wait until the cross-street signal changes to cross (EXHIBIT 5-50: Two-Stage Left-Turn Queue Box Placement). A two-stage turn queue box may be used for left or right turns. Two-stage turn queue boxes eliminate the need for turning bicyclists to change lanes through moving traffic, although some bicyclists may still choose to do so.

Locate two-stage turn queue boxes outside the path of parallel through and turning motor vehicle traffic. They should be located adjacent to the bicyclist's direct path of travel and downstream of a crosswalk and of a stop line.

Dimensions of a two-stage turn queue box will vary based on available space and presence of a parking lane.

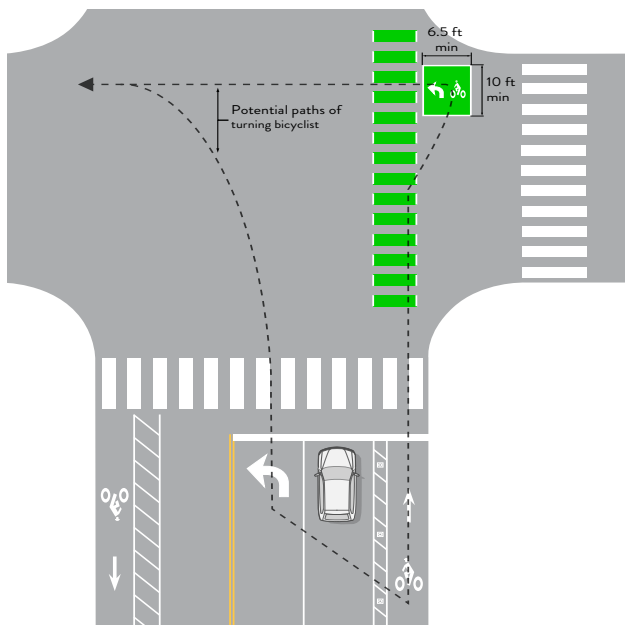


EXHIBIT 5-50: Two-Stage Left-Turn Queue Box Placement

BIKE LEFT-TURN ONLY LANE

On roadways with operating speeds of 30 mph or less, a bike left-turn lane can be used to reduce exposure for left-turning bicyclists, as well as reducing delay for bicyclists and drivers.

A bike left-turn only lane may also be appropriate at intersections where bicyclists are allowed to turn left, but drivers are not, such as an intersection with a bicycle boulevard. Green-colored pavement can help distinguish the bike left-turn only lane from the motor vehicle lanes.

In July 2017, FHWA issued [Interim Approval 20](#)⁶⁹ for two-stage bicycle turn boxes. In July 2017, MnDOT received a statewide approval from FHWA for the use of these pavement markings in all Minnesota jurisdictions. In order to meet the requirements of this statewide approval, MnDOT must maintain a list of locations with two-stage bicycle turn boxes. If installing a two-stage bicycle turn boxes, please provide the location to the MnDOT Traffic Standards Engineer at 651-234-7388.



Photo credit: Bruce Buckley

Intersection Bicycle Boxes

An intersection bicycle box is a designated area at the approach to a signalized intersection consisting of an advanced stop line and bicycle symbols (EXHIBIT 5-51: Intersection Bicycle Box). Bike boxes are used primarily to facilitate queuing a larger number of bicyclists at the head of the traffic queue to reduce conflicts between drivers and bicyclists at the beginning of the green signal phase

They can also be used to mitigate conflicts between through bicyclists and right-turning drivers. In limited situations, use a bike box to facilitate bicyclist left turns where there is an unusually high bicycle turning volume, such as near a popular shared use path. This implementation works best on minor streets with actuated approaches. The preferred treatment to assist left turns is the two-stage left turn queue box (EXHIBIT 5-50).

Bicycle box benefits:

- Improve bicyclists' visibility to drivers
- Reduces conflicts at the onset of green
- Allows bicyclists to cross intersections in groups, which increases traffic capacity at high-bicycle volume intersections

Placement/recommendations:

- Signalized intersections only
- Generally, do not install across more than one through travel lane.

INTERSECTION BICYCLE BOXES INTERIM APPROVAL

In October 2016, [FHWA issued Interim Approval 18](#)⁷⁰ for intersection bicycle boxes. In November 2016, MnDOT received a statewide approval from FHWA for the use of these pavement markings in all Minnesota jurisdictions. In order to meet the requirements of this statewide approval, MnDOT must maintain a list of locations with intersection bicycle boxes. If installing an intersection bicycle box, please provide the location to the MnDOT Traffic Standards Engineer at 651-234-7388.

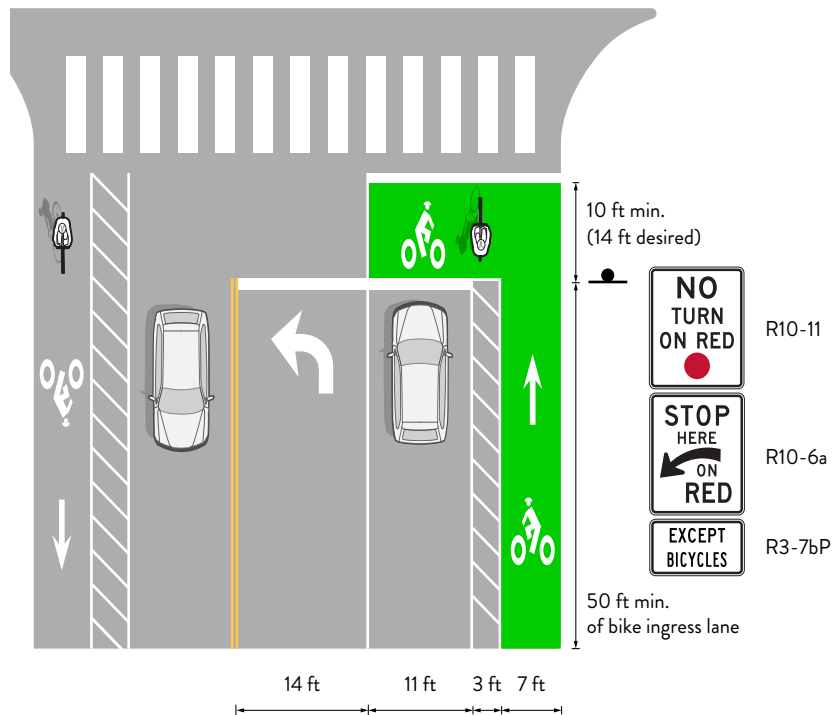


EXHIBIT 5-51: Intersection Bicycle Box

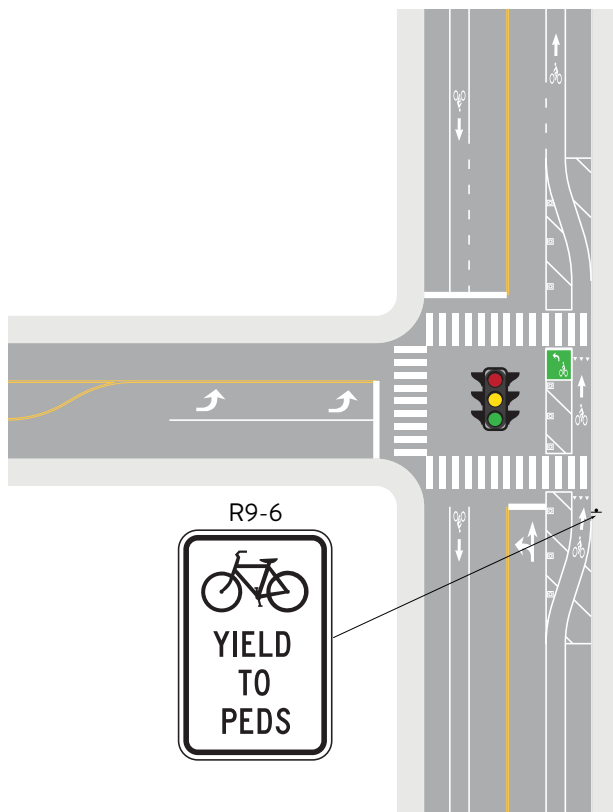


EXHIBIT 5-52: T-Intersection with Buffered Bike Lane and Turn Box

BIKE LANE CONTINUATION AT T-INTERSECTIONS

Preserving momentum is critical for people bicycling. Momentum lost when stopping for a traffic signal or stop sign has to be regained, requiring additional travel time and energy consumption. At T-intersections, where the bike lane is across the “top” of the T, motor vehicle movements typically do not cross the bikeway. Consider providing additional separation so that through moving bicyclists can continue through the intersection without stopping.

The continuing side should exhibit the following characteristics if the continuing bike lane stays in-street (EXHIBIT 5-52: T-Intersection with Buffered Bike Lane and Turn Box):

- Physical barrier, or curb separation so that left-turning motor vehicles do not conflict with through moving bicyclists
- Yield to pedestrians condition if intersecting pedestrian signals exist. A bicycle signal may provide added safety if the pedestrian crossings are actuated and called for half or more of the signal cycles.

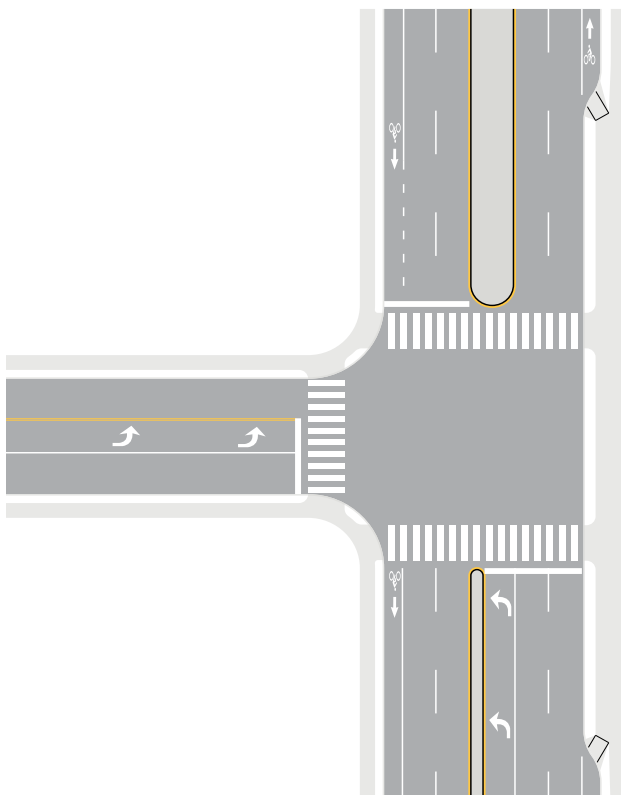


EXHIBIT 5-53: T-Intersection with Curb-Separated Bike Lane

The following characteristic should be exhibited if the continuing bike lane transitions to a sidepath behind the curb (EXHIBIT 5-53: T-Intersection with Curb-Separated Bike Lane):

- Bicycle slip ramps to terminate and reestablish the bike lane.
- Widened sidewalk to meet sidepath design guidance.

Other design features may assist the intersection usability. Considerations include:

- Formal way to allow bicyclist left turns from the continuing bike lane. These could include using the pedestrian crossing or a two-stage turn queue box.
- Ability for bicyclists originating from the cross-street to enter the continuing bike lane from the intersection.

Paved Shoulder



DESIGN OVERVIEW

Paved shoulders, which are most often used on rural roadways, serve as nonmotorized space where no other bicycle facilities are present. They allow bicycles, a lower-speed motor vehicle, to separate from higher-speed motor vehicles in lieu of sharing the travel lane. Adding or improving paved shoulders can greatly improve comfort for people walking or bicycling on roads with higher speeds and/or traffic volumes. Paved shoulders perform various other functions, such as reducing pavement edge deterioration, parking, motor vehicle safety and staging for maintenance activities.

Paved shoulders and bike lanes are different types of facilities and should be clearly distinguished. Shoulders can be used for motor vehicle parking, unless prohibited by local or area restrictions. Bike lanes cannot be used for motor vehicle parking. Shoulders are not considered a travel lane, although bicyclists are allowed to travel there. Pedestrians are allowed to walk on shoulders but not in bike lanes.

SHOULDER WIDTH AND HORIZONTAL CLEARANCE

EXHIBIT 3-5 on page 3-10 shows recommended shoulder widths based on motor vehicle volume and speed. A minimum five-foot paved shoulder is recommended for roads with motor vehicle volumes over 1,000 VPD, and a 10-foot shoulder may be necessary for high speed, high volume roads. On roads with high speeds and particularly heavy commercial motor vehicles, a wide shoulder reduces the amount bicyclists are buffeted by motor vehicle generated wind; this creates not only more comfortable conditions, but allows the bicyclists to maintain better control of their bicycle.

Horizontal clearance distances from physical obstructions apply on shoulders. If bridge abutments, guard rails, or retaining walls are placed immediately outside the shoulder a one- to two-foot clearance should be provided behind the edge of the minimum five-foot shoulder.

As discussed in Chapter 4, the typical upright, adult bicycle is 2.5 feet wide, and a bicyclist's minimum operating width is four feet. In order for a shoulder to be considered a bicycle facility, it should be at least four feet wide. If a roadway has a shoulder that is less than four feet wide, it should be assumed that bicyclists will ride in the travel lane.



SIGNS AND MARKINGS

Paved shoulders do not require any particular signs or markings to be used as bicycle facilities. In fact, marking a shoulder with a bike lane marking or shared lane marking, changes its designation to a bike lane. In that case, motor vehicle parking and pedestrian use are no longer allowed. A shoulder that has historically been used for motor vehicle parking that is being converted to a bike lane should include NO PARKING (R8-3) signs and an education campaign to inform drivers that it is no longer available for motor vehicle parking. A replacement pedestrian facility, such as a sidewalk should also be provided.

Warning and regulatory signs that may apply to bicycle use on shoulders include:

- W11-1 BICYCLE WARNING sign with SHARE THE ROAD plaque (W16-1P) – alerts drivers to the presence of bicyclists on the road or shoulder
- W8-25 – SHOULDER ENDS – alerts bicyclists that they should expect to merge into the travel lane
- R4-4 – RIGHT TURN LANE YIELD TO BIKES – when a shoulder is to the right of a right-turn lane, it may be necessary to alert drivers to the need to yield to bicyclists when turning.

SHOULDERS IN VERY CONSTRAINED CONDITIONS

If a paved shoulder of four feet or more cannot be achieved, a paved shoulder of less than four feet can still improve comfort for people bicycling on narrow roadways. This narrow shoulder allows bicyclists to move further to the right when being passed by motor vehicles. It also reduces pavement edge deterioration, which may affect bicyclists more than drivers because of their positioning in the right side of the lane.

Ideally, shoulders should be provided on both sides of two-way roads. Providing a shoulder on only one side of the roadway may encourage wrong-way riding. If the width is constrained there are certain situations where a shoulder on only one side may be appropriate:

- In an uphill direction to provide space for slow-moving bicyclists
- Where vertical curves limit sight distance, particularly over crests
- Where horizontal curves limit sight distance, such as on the inside of horizontal curves (EXHIBIT 5-54).

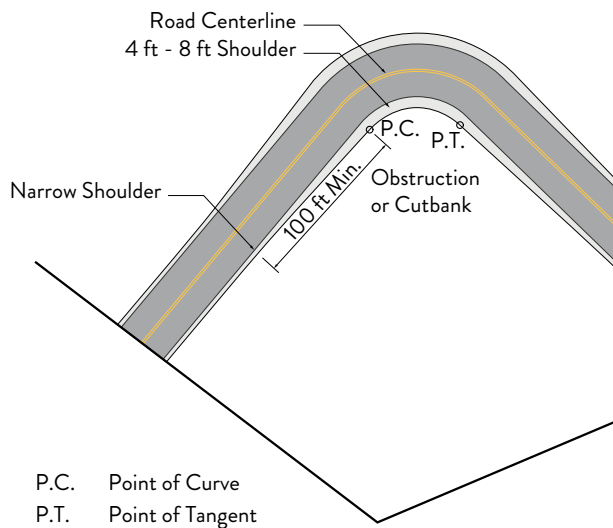


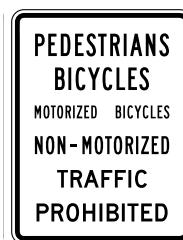
EXHIBIT 5-54: 4.80 Shoulder Bikeway on a Curve

SHOULDERS ON CONTROLLED-ACCESS FACILITIES

Bicycle travel on freeways and controlled-access facilities is typically prohibited in Minnesota but can be authorized where no alternate route is available. Controlled-access facilities are defined as having three or more interchanges in a row with no at-grade access between these interchanges. Signs should be posted prior to the limited-access portion of a roadway informing bicyclists of the legal requirement to exit. Signs should be posted far enough in advance of the controlled-access portion that bicyclists have an opportunity to exit and are not required to back track. In addition to the NO PEDESTRIANS, BICYCLES, MOTOR DRIVEN CYCLES (R5-10a) word message sign, consider using the NO PEDESTRIANS (R9-3) and NO BICYCLES (R5-9) signs for clarity (EXHIBIT 5-55: Pedestrian and Bicycle Exclusion Signs).

If bicycle access through a limited-access corridor is desired and right-of-way is available, a two-way sidepath with a buffer or barrier may be a more comfortable facility for bicyclists. However, in some cases, shoulder use may be necessary. When determining the suitability of allowing bicycle travel on the shoulder of controlled-access facilities, consider the following:

- Shoulder width: EXHIBIT 3-4 on page 3-10 illustrates the preferred shoulder width for bicycle use based on motor vehicle traffic volumes and speeds. Shoulders on controlled-access facilities should meet or exceed these values.
- Entrance/exit ramp volume and design: two-lane ramps, fly-overs and left-side ramps can be challenging for bicyclists. Avoid bicyclists merging across through lanes to reach exits (see "Interchanges" in Chapter 7).



R5-10d



R9-3



R5-6

EXHIBIT 5-55: Pedestrian and Bicycle Exclusion Signs

RUMBLE STRIPS

Rumble strips are an effective tool to prevent lane departure crashes, such as run-off-the-road and head-on crashes. However, edgeline or shoulder rumble strips can be difficult for bicyclists to traverse and impact the use of a paved shoulder as a bicycle facility. See [Tech Memo 17-08-T-02](#)⁷¹ for information on the different types of rumble strips and their uses.

Rumble strips should be placed in such a way as to provide at least a four-foot wide smooth, bikeable path along the shoulder (EXHIBIT 5-56: Rumble Strip Dimensions).

- On roadways with shoulder widths of five feet or more, this four-foot minimum width can be maintained by placing the rumble strip adjacent to or on the edgeline.
- On roadways with shoulder widths between four and five feet, the four-foot minimum width can be maintained by placing the rumble strip on the edgeline, also known as a rumble stripe.
- On roadways with shoulder widths less than four feet, assume bicyclists will ride in the travel lane because the width is narrower than their four-foot minimum operating width. When shoulders are narrower than four feet, placing the rumble strip at the edge of the shoulder pavement (away from the edge line) creates the most usable shoulder space for bicyclists.

Bicyclists will move between the shoulder and travel lane to turn left and to avoid obstructions, debris, or deteriorating pavement. For this reason, regardless of lateral placement, shoulder rumble strips/strips should be placed in an intermittent pattern, which includes a 12-foot gap in each 60-foot cycle of rumble installation. Consider an increased gap length in downhill sections. These frequent gaps in the rumble strips/strips allows bicyclists to more easily enter/exit the shoulder without traversing the jarring rumble strip.

Mumble Strips

MnDOT now uses rumble strip design that reduces exterior noise compared to the conventional, rectangular corrugated design. Sinusoidal rumble strips, or mumble strips, are also less jarring for bicyclists to traverse. Tech Memo 17-08-T-02 suggests that mumble strips may be considered on shoulders with a paved width of less than five feet. Mumble strips require the same intermittent pattern with gaps as conventional rumble strips.

Centerline Rumble Strips

Centerline rumble strips are intended to discourage drivers from crossing the centerline, reducing head-on and sideswipe crashes. However, they also discourage drivers from crossing the centerline to pass bicyclists. MN Statute 169.18 requires drivers to leave at least three feet between their motor vehicle and a bicycle when passing. In locations where centerline rumble strips are being used, a minimum five-foot paved shoulder is strongly recommended to allow drivers to pass bicyclists without crossing the centerline. If a five-foot paved shoulder is cannot be achieved, a paved shoulder of any width allows bicyclists some latitude to move to the right for their comfort and control when passed.

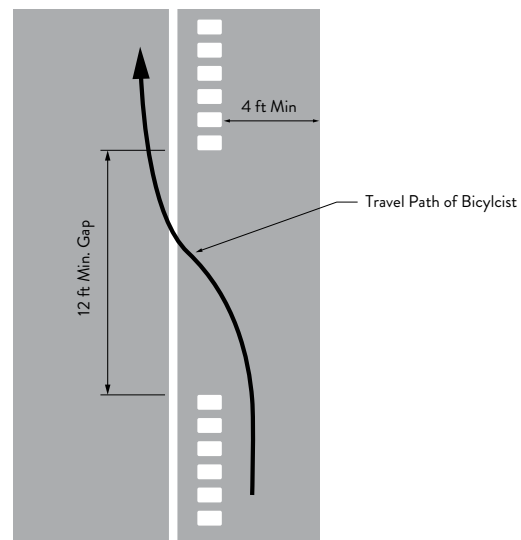


EXHIBIT 5-56: Rumble Strip Dimensions

ADA CONSIDERATIONS

Paved shoulders generally do not need to meet ADA requirements. In some cases, depending on land use context, nearby destinations and expected pedestrian activity they may provide pedestrian access to a degree that meeting ADA requirements becomes necessary. For more information, contact the ADA Unit.

INTERSECTIONS

Because paved shoulders typically serve as a bicycle facility in natural and rural land use contexts, intersections are often few and far between. Designers should consider three intersection contexts – unpaved cross-streets, right-turn lanes and shoulder bypass lanes.

Unpaved Cross-Streets

Where unpaved roads or driveways meet a paved shoulder where bicyclists are expected, pave a portion of the unpaved road to prevent debris tracking onto the shoulder. Ten feet of pavement beyond the edge of the shoulder is reasonable on low-volume driveways, while 30 feet (or to the right-of-way line) is appropriate for roads and high-volume driveways.

Right-Turn Lanes

At intersections, shoulders are typically to the right of the right-turn lane, or in low-volume areas the shoulder terminates into a right-turn lane. If the shoulder terminates into a right-turn lane, treatments at intersections may include:

- Install shared lane markings in the right-turn only lane.
- Add a bike lane to the left of a right-turn lane approaching and through the intersection.
- Add a short sidepath with a buffer approaching the intersection and use offset geometry to guide motor vehicle movements at the crossing.

These additional treatments should be considered based on the volume of right-turning motor vehicles, vehicle speeds and sight distances.

Shoulder Bypass Lanes

At T-intersections, shoulder bypass lanes that allow through drivers to pass drivers who are waiting to turn left are common. Because the shoulder terminates into the bypass lane, they can pose unexpected conflicts for bicyclists and drivers.

If motor vehicle volume is more than 1,000 Vehicles Per Day, consider providing a bikeable shoulder to the right of a bypass lane. Bicycle count data from [MnDOT's Pedestrian and Bicyclist Counting Program](#),²⁷ or District or local bicycle plans can be used to establish expected bicycle use. The paved shoulder should be the same width as the approaching shoulder and a minimum of four feet wide (EXHIBIT 5-57: Shoulder Bypass Lane).

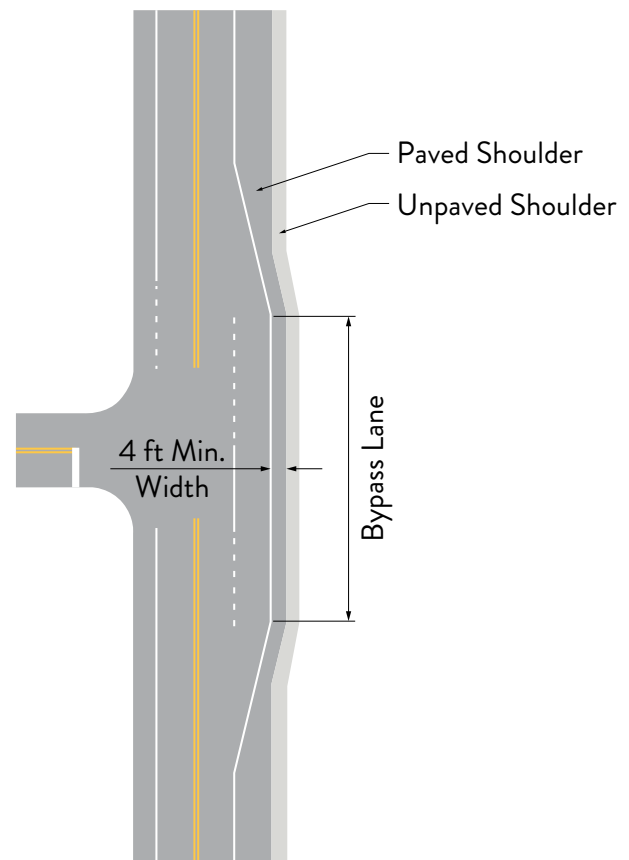


EXHIBIT 5-57: Shoulder Bypass Lane

Shared Roadway



DESIGN OVERVIEW

According to MN Statute 169.222, bicycles are considered vehicles, and therefore may be operated on all streets except where expressly prohibited (i.e., limited access roadways). There are two types of shared roadways – bicycle boulevards that have been designed specifically to favor bicycle travel and shared lanes on motor vehicle-oriented roadways. In low speed, low volume residential contexts shared roadways can be quite comfortable and acceptable for most users (See facility selection chart, EXHIBIT 3-3 on page 3-9).

Several geometric and operational factors affect the comfort of people bicycling on shared roadways. As speeds, volumes and/or context of the roadway changes a shared roadway will become less comfortable for MnDOT's chosen bicycle user profile, the Interested but Concerned bicyclist.

While many shared lanes and roadways may be comfortable for bicycling due to their low traffic volume and low operating speeds, do not consider them bicycle facilities unless they are designed specifically to favor bicycle travel.



INCREASING COMFORT ON SHARED LANES

Features to make bicycling more comfortable on shared lanes include:

- Low traffic speeds (traffic calming may lower speeds)
- Low traffic volume (traffic diversion may lower volumes)
- Signs, pavement markings and intersection crossing treatments
- Adequate sight distances
- Good pavement quality

SHARED TRAVEL LANE WIDTH

On shared roadways, the bicycle operating space should be a smooth, rideable surface that is clear of obstructions. On roadways with gutters, the gutter pan should not be included in the width of the shared travel lane.

Previous editions of this manual recommended wide outside lanes of a minimum width of 14 feet as a way to serve bicyclists on shared roadways. This is no longer the case. There is not a recommended width for a shared travel lane. Instead, consider how the width of a shared travel lane will impact driver and bicyclist behavior.

Travel lane widths less than 14 feet are too narrow for a bicyclist and driver to travel side-by-side in the same shared lane. Travel lanes less than 14 feet wide require drivers to encroach into the adjacent lane in order to follow Minnesota's three-foot passing law (Statute 169.18 Subd 3), or to remain behind and slow to the bicyclist's speed.

Travel lane widths of 14 feet or more technically allow drivers to pass bicyclists without encroaching into the adjacent lane. However, research has shown that drivers do not recognize that the additional width is intended for bicyclists and typically increase their speeds in wider travel lanes.⁷²

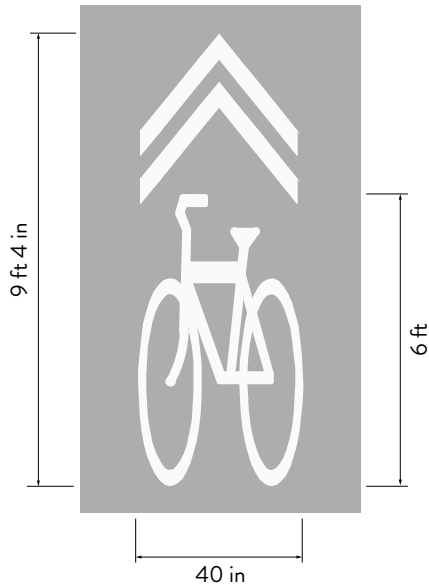


EXHIBIT 5-58: Shared Lane Marking Dimensions

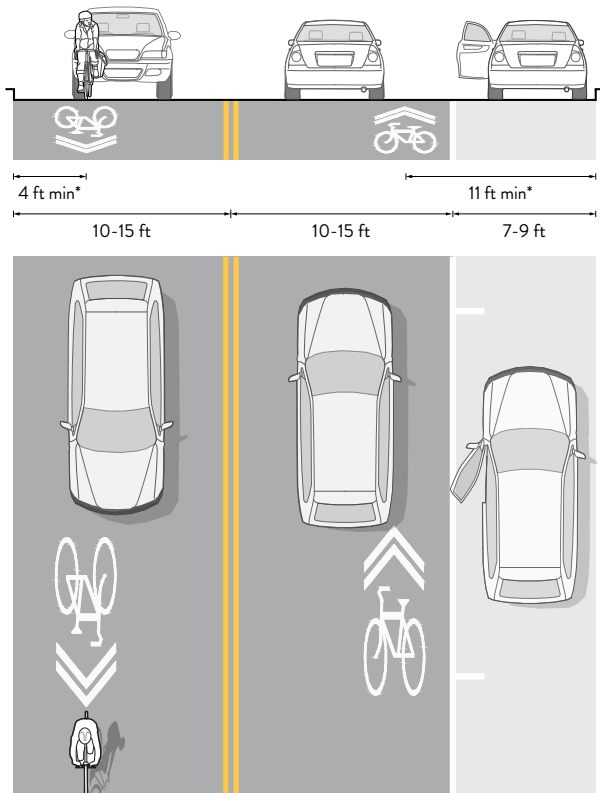


EXHIBIT 5-59: Shared Lane Marking Placement

SIGNS AND MARKINGS

Signs and markings can be used on shared roadways to confirm to drivers and bicyclists that bicycling on the roadway is appropriate. Signs and pavement markings on shared roadways should be limited to locations where bicyclists and drivers need specific instructions, or on bicycle boulevards to indicate that the shared roadway has been designed specifically to favor bicycle travel.

Shared Lane Markings

Shared lane markings, also known as sharrows, are a pavement marking that indicate to bicyclists and drivers where bicyclists should ride within a lane (EXHIBIT 5-58: Shared Lane Marking Dimensions). Shared lane markings can promote safer motor vehicle passing practices, good lateral positioning by bicyclists, reduce the risk of dooring and can reduce the risk of wrong-way bicycling.

By themselves, shared lane markings do not create a bicycle facility because they do not change the roadway geometric or operational conditions to improve comfort and safety for people bicycling. On higher speed and higher volume roadways, if sufficient width exists, a bike lane or other dedicated facility is preferred. There is shared lane markings guidance in the [MN MUTCD Chapter 9](#).³

Shared lane markings are not appropriate for use on paved shoulders or within bicycle lanes. Shared lane markings on roadways with speed limits of 40 mph or more should be limited to situations where there is no opportunity for separation. Shared lane markings can be considered under the following circumstances:

TO INDICATE BICYCLIST POSITIONING

On a roadway section or complex intersections where there may be confusion between bicyclists and drivers, or where insufficient width is available to provide a bike lane through an intersection, the shared lane markings can help identify bicyclists' proper positioning.

On a one-way street or a street where the bicycle route turns, a shared lane marking may be appropriate in the left turn lane.

Shared lane markings can be used in shared lanes adjacent to on-street parking to reduce the risk of dooring (EXHIBIT 5-59: Shared Lane Marking Placement). On roadways with parking and lane widths of 14 feet or less, shared lane markings should be placed in the middle of the lane. On roadways with parking and lane widths of 14 feet or more, shared lane markings should be placed 13 to 14 feet from the curb. The MN MUTCD recommends placing a shared lane marking at least 11 feet from the face of the curb. However, motor vehicle doors may open as far as 10.5 feet away from the curb, so it may be necessary to exceed the MN MUTCD standard.

TO ADDRESS GAPS IN A BICYCLE NETWORK

In some cases, a corridor may have a short, constrained section where a bike lane cannot be included. A shared lane marking along with either a BIKES MAY USE FULL LANE (R4-11) sign or a BICYCLE WARNING (W11-1) sign with SHARE THE ROAD (W16-1p) plaque, can help fill this gap and warn drivers that bicyclists will transition to using the travel lane for a short period.

Shared lane markings can also be used at the end of bicycle lanes or separated bicycle lanes to direct bicyclists into the travel lane. At complex, non-protected intersections, shared lane markings can be used to indicate the most desirable position for a bicyclist through the intersection.

AS PART OF A BICYCLE BOULEVARD

Shared lane markings on bicycle boulevards should be placed in the center of the travel lane to emphasize the presence of people bicycling on the roadway. Oversized shared lane markings may be used. In this context, shared lane markings can also provide wayfinding guidance and improve network legibility.

SHARED LANE MARKING PLACEMENT

Shared lane markings should be placed on the alignment that represents the practical path of a bicyclist's travel under typical conditions.

- Place shared lane markings immediately after intersections and at intervals not greater than 250 feet thereafter.
- On streets without on-street parallel parking, shared lane markings should be placed at least 4 feet from the face of curb or edge of traveled way where no curb exists (EXHIBIT 5-59).
- Shared lane markings may be placed further into the lane than the minimum distance where appropriate (such as where the lane is too narrow for side-by-side bicycle and motor vehicle operation). The MN MUTCD Section 9C.7 contains further guidance on shared lane markings.
- To prolong marking life, avoid placing the shared lane marking within wheel paths.

FIELD REVIEW

Shared lane markings need careful consideration for placement. A site visit and bike ride may be needed to determine correct positioning. Consider having the designer mark the location for placement in the field to ensure correct installation.





Signs for Shared Roadways

Signs are another way to reinforce that drivers should expect people bicycling on shared roadways. Signed shared roadways should not be considered a bike facility, unless designed specifically to favor bicycle travel. Shared roadway signs do not indicate a bike route, see Chapter 4 for information on wayfinding signs.

Sign use on shared roadways should be limited. Most roadways are shared roadways, unless bicycle use is specifically prohibited. Signs alone are not always effective at addressing conflicts between drivers and bicyclists. Shared roadway signs are appropriate at the terminus of bicycle lanes and sidepaths, within work zones, or other locations with short gaps (less than 1 mile) between bicycle facilities. These gaps may also be marked with shared lane markings.

Shared roadways can be signed with a BICYCLE WARNING (W11-1) sign with a SHARE THE ROAD plaque (W16-1p) or BIKES MAY USE FULL LANE (R4-11) sign. Both signs are included in the MN MUTCD, although MnDOT prefers using the BIKES MAY USE FULL LANE (R4-11) sign in lower speed urban contexts as they more clearly articulate to drivers to expect people bicycling in the roadway.

BIKES MAY USE FULL LANE (R4-11) signs may be used anywhere there are no bike lanes or usable shoulders or where the travel lanes are too narrow for drivers and bicyclists to operate side-by-side. BIKES MAY USE FULL LANE (R4-11) signs may be more applicable in urban areas.

A BIKES ON ROADWAY sign assembly consisting of a W11-1 sign and a supplemental plaque reading ON ROADWAY (EXHIBIT 5-60: BIKES ON ROADWAY Sign) may also be suitable in higher speed, non-urban contexts.



EXHIBIT 5-60: BIKES ON ROADWAY Sign

ADA CONSIDERATIONS

Shared roadways need to meet all the ADA requirements of any roadway. In particular, consider cross slopes at pedestrian crossing locations.

BICYCLE BOULEVARDS

Bicycle boulevards are a particular type of shared roadway. They are low-volume, low-speed streets modified to enhance bicyclist safety and comfort by using treatments such as signs, pavement markings, reduced motor vehicle speed and/or traffic volume reduction and intersection modifications. Designers may wish to employ traffic calming techniques such as those described in Chapter 7 in order to create a bicycle boulevard. Bicycle boulevards:

- Discourage through motor vehicle traffic but still maintain local access.
- Maintain low-stress bicycle access at busy cross streets.
- Typically allow bicyclists to share the lane with motor vehicle traffic.
- May incorporate shared use paths or other facilities to overcome discontinuous streets such as connecting cul-de-sacs and dead end streets.

Bicycle boulevards may incorporate design elements such as:

- Traffic diverters at key intersections which reduce motor vehicle traffic but permit bicycle passage (EXHIBIT 5-61: Traffic diverter)
- Bicycle traffic priority along the bicycle boulevard, limiting the times bicyclists are required to stop
- Neighborhood traffic circles and mini-roundabouts used at minor intersections (EXHIBIT 5-62: Traffic circle)
- Wayfinding signs
- Shared lane markings, or other bicycle boulevard specific pavement markings
- Crossing improvements, including traffic signals or beacons with bicycle detector/bicycle push buttons, median refuges and curb extensions

Bicycle boulevard features that restrict motor vehicle access to local streets can be combined with bicycle boulevards to improve bicyclist's access to destinations overall. For example:

- Stop signs have a negative effect on bicyclist travel time and energy expenditure. Bicyclists want to maintain momentum and are reluctant to come to a complete stop if unnecessary. Only use stop signs where completely necessary; consider other forms of traffic control such as yield signs or mini-roundabouts in lieu of stop signs.



EXHIBIT 5-61: Traffic diverter



EXHIBIT 5-62: Traffic circle

- One-way chokers have a positive effect on bicyclists as long as exemptions for bicyclists are allowed. Use "EXCEPT BICYCLES" on signs restricting motor vehicle traffic.
- Diverters and cul-de-sacs can improve neighborhood bicycling access if connections are created. Diverters and cul-de-sacs should be used cautiously in order to not contradict with other transportation goals, such as a grid network. If used, a well-designed and maintained cut-through will benefit bicyclists by improving access to and within neighborhood networks.



MAINTENANCE

6

Introduction

A well-maintained bicycle facility is safe and comfortable for people of all ages and abilities. For a facility to be accessible year-round it needs to be free of debris, snow and cracks or other obstacles, allowing people bicycling the maximum width of a street, bike lane, or shared use path. Maintenance goals include the following:

- Prevent falls and crashes.
- Provide clearly defined, year-round facilities.
- Encourage facility use, leading to increased bicycling and high return on investment.
- Prolong useful life of valuable infrastructure investments.

Winter maintenance for bicycle and pedestrian facilities is increasingly being discussed and over time will be incorporated into [MnDOT's Maintenance Manual](#)⁷³ under Snow and Ice Clean-Up Priorities.

Well maintained networks are the result of flexibility, interagency coordination and balancing resources. Inter-agency cooperation and agreements are a crucial ingredient. This chapter discusses facility selection, design, construction, operations and communication, with regards to maintenance.

KEY CONSIDERATIONS

Poorly maintained facilities may discourage people from bicycling and may contribute to crashes. Key considerations include:

- Provide redundancy in the network to allow bicyclists options.
- Avoid minimum widths throughout the roadway cross-section: minimum widths increase the difficulty of maintaining bicycle facilities.
- If there's a need for a barrier, gates may be a better solution than bollards since they enable access for maintenance equipment.
- Collaborate between departments and staff during project scoping and design to understand and prepare for all opportunities and constraints; this will help ensure once built, that the outcome is well maintained facilities.
- Establish maintenance responsibilities along bicycle facilities under all network jurisdictions.
- Develop local maintenance agreements and cost participation decisions among responsible agencies.

- Report annually on maintenance operations and progress toward maintenance goals.
- Consider current equipment and capabilities for maintenance when designing bicycle facilities. Narrow separated bicycle facilities may necessitate procuring additional equipment to maintain.



WORK ZONES

Provide for continuous bicycle and/or pedestrian travel through a work zone. MnDOT maintains a [website devoted to work zones](#) including a Work Zone Safety and Mobility Policy.⁷⁴ Refer to the [MN MUTCD](#)³ for design details. Basic principles of work zone applications for bicyclists and pedestrians include:

- Traffic control devices (temporary signs) should not protrude into the temporary bicycling and/or walking paths of travel.
- Bicyclists may be detoured onto another street when a parallel street exists and that street's bicycle facilities meet or exceed the level of stress on the existing route. If a designated bicycle route is closed, provide a signed alternate route.
- Four feet is the minimum width for alternate bicycle facilities
- Attempt to maintain the width of any connecting bicycle facility, sidewalk or shared use path. For bi-directional facilities, consider reduced motor vehicle speed limits and use more frequent/ substantial barriers to channelize drivers.
- Bikes may be detoured onto the sidewalk, a temporary bike lane, or served within a shared lane with mixed traffic under the following conditions:
 - Shared sidewalk conflicts have been discussed and minimized
 - The existing facility has a posted construction speed limit of 25 miles per hour or less
 - Signs and/or shared lane markings are provided to raise driver awareness
- In rare cases, shuttle vehicles may be required to transport bicyclists and/or pedestrians through a work zone if appropriate accommodations cannot be provided.
- Temporary Traffic Control plans are typically submitted with any project. These plans should include TTC for bicycle and pedestrian access.

TYPES OF MAINTENANCE ACTIVITIES

Necessary maintenance activities vary significantly between jurisdictions and by the type of facility surface material. Maintenance activities can generally be categorized into one of two types: 'routine maintenance' which is performed annually or more frequently, and 'major' or 'capital maintenance' which involves more intensive activity at a less than annual frequency.

A robust routine maintenance program may include any of the activities described in EXHIBIT 6-1: Routine Maintenance. However, it should be noted that every segment of a facility will have different needs and levels of expenditure. It is estimated that for routine maintenance approximately \$1,000 to \$2,500 should be budgeted annually per mile of facility.

Major or capital maintenance activities typically involve more intensive maintenance repairs such as pavement seal coating, pavement overlays, pavement reconstruction or other structural rehabilitations. Any paved surface will deteriorate over time with bituminous surface quality dropping rapidly after 10 years. Pavement Condition Index and other measures such as the Ride Quality Index provide quantitative pavement condition assessments. These methods can be used as a system preservation performance measure and can be used to trigger targeted preservation efforts. Preservation efforts such as seal coating extend the life of bituminous efficiently and at a lower cost than waiting for the surface to fail requiring expensive reconstruction. Concrete shared use path surfacing does not suffer from the rapid decay in surface quality and may only need minor spot repairs over a much longer period of time.

EXHIBIT 6-1: Routine Maintenance

ROUTINE MAINTENANCE	FUNCTION	FREQUENCY
Sweeping shared use paths	Keep paved surfaces debris free.	Spring, after snow melt and as needed. Fall during leaf drop.
Litter and trash removal	Keep bicycle facility clean and of consistent quality.	Annually, or as needed.
Mowing shared use path shoulders	Increases the operating width of the shared use path if bordered by grasses. Also helps limit weed encroachment.	As needed during the growing season.
Tree/ brush trimming	Eliminate encroachments into bicycle facility to open up sight lines.	Annually, or as needed.
Weed abatement	Manage existence and/or spread of noxious weeds, if present.	Annually
Snow removal	Keep bicycle facility clear and usable year round.	As needed
Sign, pavement marking and other amenity inspections	Identify and replace damaged infrastructure	Annually
Crack sealing and surface repair	Seal cracks in bituminous surfacing to reduce long-term damage	Annually
Vacuuming permeable pavements	Removes debris and keeps pavement permeable	Depending on surrounding vegetation or presence of sand.

Pavement Condition

Surface condition and pavement smoothness are important to bicyclist control and comfort. Gravel roads, loose material, cracks, bumps and potholes on a paved roadway can create an impediment for people bicycling and will have an impact on which routes a bicyclist will choose. Poor pavement quality on sidepaths may lead bicyclists to ride in the roadway or on the shoulder, rather than on the sidepath. This may be confusing or frustrating for drivers. Proper maintenance can extend high quality pavement condition along bicycle facilities and improve bicycling safety and comfort.

Thoughtful maintenance operations and policy decisions can yield higher quality pavement for longer periods of time.

- Include trails and bicycle facilities in regular maintenance schedule and budget.
- Make pothole repair a higher priority and meet a similar pavement quality standard for motor vehicles or higher.
- Create standards for utility work and other projects so that cuts are back-filled in a manner that returns the roadway to the original pavement condition. Do not leave ridges, cracks, or other deformities. Similarly, trenching projects involving bike lanes should trench the entire bike lane to avoid condition issues or joints.
- Examine transitions for every roadway project, not just those that include dedicated bicycle facilities.
- Consider maintenance timing and the quality differences between cold patch (winter) and hot mix (summer).
- Consider drainage structures and keep them cleaned out for proper functioning.



When possible, schedule bike facility implementation to coincide with resurfacing. This results in new bicycle facilities with high quality pavement condition. The [FHWA Guide to Incorporating On-Road Bicycle Networks into Resurfacing Projects](#)⁴³ provides many strategies. Successful maintenance include timely collaboration between active transportation, design, maintenance and construction departments and staff. Include staff whose work focuses on active transportation within resurfacing and pavement quality discussions. Review resurfacing candidate projects for bike facility feasibility.

PAVEMENT QUALITY DATA

For years, road authorities have tracked pavement quality data for motor vehicle use, yet only recently has it become a likelihood to track pavement conditions for bicycling. Though still evolving, MnDOT and others are actively pursuing methods to record bicycle facility pavement quality using a bicycle and components. For example, the Parks & Trails Council of Minnesota has developed a trail pavement data collection “[research bike](#)”.⁷⁵ The “research bike” includes:

- Phone and app to collect accelerometer data to assess pavement roughness
- 360 degree camera mounted on a monopod to gather panoramic street view data that will be uploaded into Google Maps)
- Camera to snap photos of pavement condition (can assist with verifying accelerometer data and assessing shoulder widths)
- Electric-assist bicycle, which ensures consistent data collection. An electric assist bicycle can travel easily at a steady speed and limits handlebar wobble when climbing uphill



BICYCLE CONSIDERATIONS IN PAVEMENT PRESERVATION PROJECTS

Chip-sealed surfaces can pose particular difficulties for bicycles. Existing and anticipated bicycle use should be reviewed when making decisions for pavement preservation. Where practical, avoiding chip-sealed surfaces in favor of smoother alternatives such as slurry seals or fog seals will encourage bicycle use. The impacts of chip seals on bicyclists can be reduced by using a fine mix (1/4" minus) and covering with a fog or slurry seal. Refer to the [MnDOT Pavement Preservation Manual](#)⁷⁶ for more information.

- Sweep bike lanes or shoulders in the weeks after chip seal projects.
- Respond quickly to remove gravel piles following chip seal projects. Install appropriate signs and consider using detour signs to guide people bicycling to other routes.
- Fill or grind down ridges / cracks to avoid bicycle wheels becoming caught in a pavement irregularity. Ridges or cracks that run parallel to bicycle travel are especially important to repair.
- Repair edge drop-off on shoulders, especially in locations with high bicycle ridership.



Debris and Obstructions

FACILITY SELECTION

Consider maintenance obligations dependent on local conditions. For example, some bicycle facilities that run between vertical curbs will collect leaves and other debris. Similarly, some bike lanes will be kept clear through vehicle wind blast.

DESIGN

Design should reinforce bicycle facility characteristics that reduce maintenance needs. Debris frequently builds up in areas with poor drainage. The FHWA notes that for areas prone to an abundance of debris, “Eliminating the source of the problem by providing better drainage is ultimately a more cost-effective solution than increased sweeping.” Other design considerations include:

All facilities:

- Plan for at least a 2-foot clearance between the edge of the pavement and the vegetation.
- If necessary, consider options ranging from additional staff to purchasing additional right-of-way.

Physically separated bike lanes and shared use paths:

- Use widths appropriate for street sweeping equipment.

Structures:

- Underpass design should encourage natural daylight or other methods of lighting the structure. People bicycling often have difficulty seeing pavement quality issues when traveling through underpasses because of the abrupt change in light.



OPERATIONS

Routine maintenance results in bicycle facilities that provide consistent, clear travel. To achieve this:

- Regularly sweep bike facilities for glass, sand and gravel. Sweeping for leaves is especially important in fall and spring; leaves hide surface problems and can be slippery. Do not sweep any materials onto the sidewalk; collect and dispose of appropriately, as necessary.
- Ensure that street sweeping crews are instructed to sweep close to the right edge of the roadway.
- Painted buffers may need more frequent sweeping.
- Pay attention to areas that fill with debris. These may be the same areas that fill with snow and ice in winter.
- Use vacuum trucks if street sweeping equipment is not adequate to remove debris if pervious pavement is used.

COMMUNICATION

Internal communication:

- Standardized employee training and standard sweeping procedures help reduce variation in the sweeping quality.

Communicating with the public:

- Restricting parking helps clean streets at regularly scheduled days and times. To be effective, this needs to be adequately communicated.

Winter Maintenance

Good winter maintenance is crucial to meeting MnDOT's goals of year-round accessibility for bicycling and walking. For further insights and context beyond the information listed below, see the [City of Minneapolis' 2018 Pedestrian and Bicycle Winter Maintenance Study](#).⁷⁷

WATER POOLING AND ICE

Design

Design considerations for water pooling and ice are similar to strategies related to accumulating debris, such as leaves and gravel. Design for adequate drainage to prevent pooling and ice formation. On shared use paths or on-street bike lanes, a cross-slope between one percent and two percent allows for good drainage. However, ice on excessive cross slopes can present a crash risk. Frequent inlets or stormwater management treatments can reduce pooling concerns.

Using permeable pavement on shared use paths or separated bike lanes outside of the roadway envelope can reduce the amount of de-icing material needed and improve drainage. See Chapter 4 for more information on permeable pavements.

Operations

Black ice, and ice in general, poses a serious threat to all modes, even for short stretches. Apply anti-icing treatments before frost or light snow events in accordance with roadway guidelines. Apply de-icing treatment, as needed, while clearing snow from bicycle facilities; use environmentally friendly materials to the extent possible.



FACILITY SELECTION

Consider trade-offs when designing grade separated bicycle facilities. Plan carefully, particularly at underpasses, to minimize pooling water and ice formation; this in turn, minimizes maintenance needs.



SNOW

Design

Designing facilities with maintenance in mind improves maintenance operations during snow events.

- Snow may accumulate on the edges of a sidepath or on-street bike lane over the course of several storm events, effectively reducing the operating width. Consider snow storage when selecting a bicycle facility width to ensure that a minimum of four feet can be maintained through the winter.
- Mountable curbs increase comfort but may be difficult for plows to detect and properly clear snow adjacent to this curb type.
- Provide snow storage space, such as a buffer between the street and sidewalk. Width needs will vary; identify needs in a timely manner.
- Consider structural pavement design, and if the facility can support the weight of maintenance equipment.
- Surfaces with a tapering edge, such as speed bumps and humps, can be difficult to clear.

Separated bike lanes:

- Bike lane and snow storage widths are important to ensure separated bike lanes are well-maintained during snow events. Allow space between physical barriers for snow removal.
- Most snow maintenance equipment have a plow width of 13-14 feet. Specialized snow removal equipment that fits between the curb and barrier may be needed.
- Sidewalk-level separated bike lanes or at-grade separated bike lanes with raised medians, may simplify snow removal.

Operations

The amount of time between the snow fall and snow clearance is important for bicycle travel, especially for less confident bicyclists. Consider the following:

- Set clear policies related to the timing of snow removal on bicycle facilities after snow events.
- Snow and ice removal has historically been accomplished via agreement with local agencies, who are able to respond to snow events on bicycle facilities faster due to their proximity to the facility.

- Local agencies generally have the equipment for operations in bicycle facilities. As different facility types have come about, such as separated bike lanes, equipment needs may require new considerations, priorities, partnerships and agreements.
- ADA requires shared use paths remain clear and usable year-round. MnDOT districts maintain a list of priority pedestrian routes that are cleared during Priority A operations; as appropriate, MnDOT communicates these priorities locally.

Snow removal priorities:

Neighborhood streets typically do not have dedicated bicycle facilities, but are an important component of a low stress bicycle network. A possible conflict exists because these streets are likely lower priority for snow removal. MnDOT and local agencies should work to set priorities and responsibilities to ensure robust, functioning winter bicycle networks.

Removing snow from mountable aprons:

Clear snow from mountable aprons on curb extensions or median islands by first clearing the truck apron, then clearing the travel lane outside the apron and finally clearing curb ramps and bicycle and pedestrian spaces.

Communication

Internally, standardized employee training and snow removal procedures helps reduce variation in snow clearance quality. Train staff on how to remove snow from a new type of facility.

Externally, changes to roadway uses such as restricting parking helps achieve prompt snow removal. These changes need to be adequately communicated. Plowing operations can be hazardous to people bicycling. For example, clearing snow in an active contraflow lane requires a plan to address and promote safe practices.

Pavement Markings and Signs

DESIGN

Pavement markings and signs deteriorate over time and may become hard to see, especially when dark. While signs intended exclusively for bicycles or pedestrians are exempt from federal retro-reflectivity standards, it is best practice to design to this threshold, particularly for regulatory and warning signs. Signs and pavement markings should be maintained in a condition that serves their intended function.

Various pavement marking materials are available for bicycle facilities, each with different costs, lifespans and retro-reflectivity properties; see Chapter 7 of the Traffic Engineering Manual for more information.

In high-traffic areas, or areas where snow plowing will occur, recessed pavement markings increase pavement marking life spans. Recessed pavement markings are installed below the pavement surface. The recess helps prevent damage from snow plows. This is particularly beneficial for thermoplastic or preformed tape markings, which otherwise may protrude above the pavement surface.

CONSTRUCTION

Bicycle markings should be placed to minimize wear from motor vehicle tires. When placing markings that will be driven on, such as shared lane markings or conflict markings, consider where motor vehicle wheel paths will be. Consider high-durability materials if the markings will be in a wheel path. [MnDOT's Provisions for Pavement Marking Operations \(TM 19-05-T-02\)](#)⁷⁸ provides guidance for the optimal type of markings based on roadway context.



OPERATIONS

- Plan to renew bicycle-specific markings at the same time as other pavement markings. Certain markings may require more frequent replacement due to turning movement wear or the durability of the material used.⁷⁹
- Replace bollards and other physical delineators, as needed. If in-street delineators are used year-round, plan to replace those damaged during snow removal in the spring
- Establish a schedule for regularly checking signs and maintain bicycle-specific signs in the same manner as other signs.



SPECIAL DESIGN ELEMENTS

Introduction

This chapter offers guidance on several elements that designers may encounter when including a bicycle facility in a roadway project. Chapter 4 provided some overall characteristics of bicyclists, bicycle facilities and design features. This chapter provides guidance on specific elements such as bridges, underpasses, interchanges, roundabouts, railroad crossings and bike parking. These elements are all things that, if not considered carefully, can create a gap in a bicycle network, particularly for the Interested but Concerned bicyclist. As necessary, consult with functional office experts to ensure that bicyclists are considered in all types of roadways and intersections.

Vehicle Bridges

Vehicle bridges without adequate bicycle facilities become barriers to bicycling. Consider bicyclists' and pedestrians' needs early when planning and scoping for bridge construction or reconstruction; this ensures projects complete and enhance Minnesota's bicycle network in accordance with district bicycle plans.

Bridges can function for over 100 years, so planning for all modal needs is vital to completing the statewide bicycle network. Bridges are also expensive, so providing balancing bridge widths for all users with safety, mobility and expense in mind are central to the success of any project. If no nearby alternative crossing is available, bicycle and pedestrian access should be allowed on controlled-access bridges. These connections are often the only way to overcome significant barriers such as rivers or long distances between river, rail, or roadway crossings. As necessary, consult with the Office of Transit and Active Transportation to determine bicyclist needs.

As noted in the [Performance-based Practical Design Guide](#),²⁰ for complex bridges, major river crossings, bridges with a single span greater than 200 feet, or bridges exceeding 250 feet in overall length, a risk assessment of non-standard width options to weigh the various modal, cost and performance factors should be conducted. See Article 2.1.2 of the [MnDOT Load and Resistance Factor Design Bridge Design Manual](#)⁸⁰ for guidance on bridge widths and bicycle facilities. See the current [Bridge Preservation and Improvement Guidelines](#)⁸¹ for information about bridge project selection and scoping.



Selecting a Cross-Section for Bridges

On bridges, it is important to balance the needs of all users and create a right-sized, fiscally smart design. Bridge width requirements are typically a function of:

- Lane and shoulder widths of the approaching roadway
- Pedestrian and bicyclist needs
- User safety requirements
- Drainage requirements
- Construction staging requirements
- Other project specific considerations such as maintenance equipment, snow storage and emergency vehicle access

Determining appropriate widths for a bridge project depends on the project's specific purpose and need. Thoughtful consideration of the surrounding land use context and project constraints are key in deciding cross-sectional widths for all roadway users. Consider:

- Structure length; the longer the bridge, the more cost becomes a substantial factor.
- Separating all users and providing pedestrians and bicyclists their own designated space in areas with dense land-uses, where high volumes of pedestrians and bicyclists are expected or when noted in district bicycle plans.

- A greater than minimum recommended separation between bicyclists and motor vehicles in areas with a large percentage of trucks, high winds, snow plow operations or high speeds. Separation examples include a wider shoulder or buffer for a sidepath.
- A consistent sidepath or shoulder width along the length of the bridge.
- A sidepath or shoulder on a bridge that is at least as wide as a bicycle facility at the bridge ends.
- Connections and access to and from a bridge to adjacent and intersecting bicycle facilities—both present or planned. For example, there are often shared use paths along a river; it is important to connect the river path to the bridge across the river.
- Access for maintenance vehicles to clear snow and to clean the roadway, shoulder and sidepath. It is important to consider maintenance during early design phases.

Retrofitting Bridges

Because bridges have such long lifespans, bicycle facilities are often added as a retrofit to an existing structure. Where bicycle facilities are desired and none currently exist, consider:

- Narrowing travel lane widths
- Reducing the number of lanes
- Eliminating medians
- Reducing shoulder widths, shifting the width to an off-road facility by widening a sidewalk to a sidepath.

Cantilevering a structure may also be an option, provided additional weight is compatible with the structure. See Chapter 5 for appropriate widths for different types of bicycle facilities on a bridge. If network connections have not yet been completed and a sidepath exists only on the bridge, do not leave a network gap; provide an on-street bike lane with a ramp to/from either roadway end to the bridge. As necessary, consult with the Office of Transit and Active Transportation for options.



Bridge Sidepath Widths

Structures within MnDOT right-of-way are designed using the AASHTO LRFD Bridge Design Specifications. The MnDOT Bridge Office should be consulted early in the design process to ensure compliance with best practices for bicyclists and pedestrians, in balance with MnDOT standards and practices.

Chapter 5 provides guidance on buffer widths for sidepaths along roadways, which includes one to two feet of horizontal clearance. Because bicyclists will shy away from the edge of a sidepath, they will not use the space immediately behind a curb or adjacent to a vertical element, such as a bridge railing. If no horizontal clearance is provided, the operating width of the sidepath is reduced.

Because of their cost, vehicle bridges are considered very constrained conditions. MnDOT's LRFD Bridge Design Manual Article 2.1.2 recommends matching the measured width of the approaching sidepath, plus two feet. For a typical, 10-foot sidepath, this results in a total width of 12 feet for a sidepath.

If there is not an approaching sidepath, the MnDOT BDM suggests an absolute minimum bridge sidepath width of 10 feet – effectively an 8-foot path with 1-foot minimum horizontal clearance on either side. See [Article 2.1.2 of the MnDOT LRFD Bridge Design Manual](#)⁸⁰ for more information on sidepath widths and horizontal clearances on bridges. Exhibit 5-4 indicates that a 1-foot minimum horizontal clearance is acceptable in very constrained conditions.

A total width greater than 12 feet should only be used in situations where the need for additional width has been identified. If the approaching sidepath has an operating width of greater than 10 feet, this could be an indication that additional width is needed on the bridge. In such cases, consult with the Office of Transit and Active Transportation, the state or local authority and/or the appropriate trail authority to determine the most appropriate width.

A shared use path level of service calculation could serve as basis for additional width. When shared use path LOS is at D or below, consider additional width and/or separating pedestrians and bicyclists. If the proposed sidepath approaching the bridge is new construction, consider future growth by reviewing an existing facility with similar land uses to estimate LOS.

Bridge Railing Design

For bicyclist comfort and safety, place a railing on the outside edge of any bridges where bicycle traffic is expected. Railings should extend beyond the area of need and taper away from the edge of the bicycle facility.

Where bicycles will be operating close to railings, whether on a sidepath or a shoulder, MnDOT specifies a minimum pedestrian/bicycle rail height of 54 inches on structures. See Chapter 13 in the MnDOT BDM for more information on minimum railing heights over water, roadways and rail lines.

AASHTO recommends a minimum pedestrian/bicycle rail height of 42 inches. Where high bicycle speeds may occur, such as on a downgrade, or where bicyclists may contact a railing at a 25 degree angle or greater, such as on a curve, AASHTO recommends a 48-inch minimum railing height. If considering a lower railing height, contact the Bridge Office to discuss.



For pedestrian/bicycle railings on a bridge that consist of a metal railing mounted on a concrete curb or parapet, the face of the metal rail must be offset a minimum of 4.5 inches from the face of curb/parapet. Openings between horizontal or vertical members on the metal railings must be small enough that a four-inch sphere cannot pass through the lower 27 inches and a six-inch sphere cannot pass through any openings above 27 inches.

MnDOT BDM Article 13.2.5 states that bridges with sidewalks crossing over roadways or railroads require protective screening (fencing or ornamental railing) to discourage people from dropping or throwing objects from the bridge. MnDOT prefers 8-foot high side screening under these conditions.

Bicycle railings and barriers may impact sight lines; provide clear sightlines between pedestrians, bicycles and motor vehicles. Consider how railings may impact views from historic bridges and at overlooks. Add pedestrian viewing areas that extend from the structure to avoid conflicts between bicyclists and pedestrians at viewpoints.

Barrier between the Bicycle Facility and Roadway on Bridges

Barriers provide crashworthy protection between motor vehicles and sidepath users. According to MnDOT BDM Article 2.1.2 a barrier between the roadway and sidewalk or sidepath is required if the bridge design speed is 50 mph or higher (EXHIBIT 7-1). Barriers should be a minimum of 36 inches high measured from the roadway. Consideration of a barrier for a 45 mph design speed depends on land use context.

Take criteria such as the following into account:

- User experience
- Sidepath width and expected sidepath volume
- Volume of motor vehicles, particularly trucks
- High-risk horizontal curves

For design speeds of 40 mph or less, separation with a concrete barrier is not required (EXHIBIT 7-2).

Barriers can create maintenance issues, impact sight lines and contribute to a closed-in feeling for users. Provide adequate lighting to ensure visibility.

Shared Lanes on Bridges

Where bicyclists will share the lane with motor vehicles, but have not shared the lane before the bridge, consider installing warning or regulatory signs to alert drivers about the change. These may include:

- BIKES MAY USE FULL LANE (R4-11)
- BICYCLE WARNING (W11-1) sign with user actuated (passive or active detection) beacons
- Shared Lane Markings

Provide adequate lighting to improve bicyclist visibility both in the travel lane and at the edge of the lane. Consider reducing posted motor vehicle speeds on bridges where bicyclists are expected to share the travel lane.

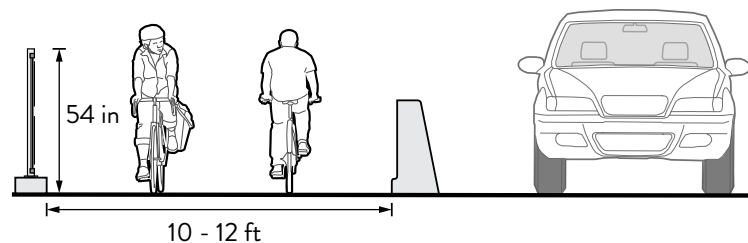


EXHIBIT 7-1: Typical Sidepath Bridge Cross Section (50 mph or more)

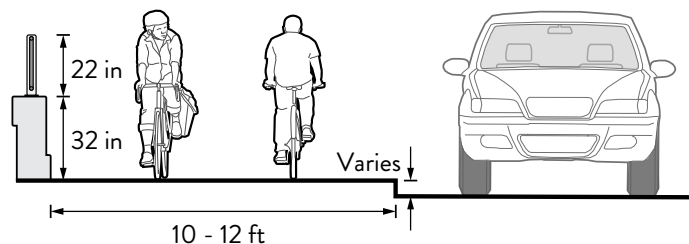


EXHIBIT 7-2: Typical Sidepath Bridge Cross Section (40 mph or less)

Vehicle Underpasses

Similar to bridges, vehicle underpasses can provide bicycle and pedestrian access across a barrier. The following guidance for underpasses can also apply to tunnels, since these structures are functionally the same from a bicyclist's perspective. Shoulder and sidepath width considerations for bridges also apply to underpasses. Design underpasses to ensure users have enough horizontal and vertical space to comfortably navigate and can experience a feeling of safety (EXHIBIT 7-3: Bicycle Facility Under an Existing Bridge Structure). Consider the width of the approaching facilities, mix of users and shared use path LOS when selecting a sidepath or shoulder width. Vertical clearance requirements for underpasses are:

- 10-foot clearance recommended; this dimension serves bicyclists, emergency vehicles and most maintenance vehicles
- Eight-foot clearance minimum; only if constrained. This dimension does not allow access for typical emergency or maintenance vehicles.
- 12- to 14-foot clearance may be necessary for shared use paths that accommodate snow-grooming equipment or horses.

Underpasses should be adequately lit for visibility and to provide a feeling of safety. For the purposes of determining tunnel lighting needs, consider underpasses greater than 80 feet long as tunnels. For bicycle facility tunnel design it is important to understand that the human eye progressively transitions from exterior lighting to tunnel interior lighting and vice versa. For example, a bicyclist entering a dark tunnel on a sunny day typically has difficulty seeing what's ahead until their eyes adjust for the light level.

Design the tunnel so as to flood light into the bicycle facility as well as the motorized roadway; provide sufficient ambient light to illuminate side walls and other fixed objects in the tunnel; and that the light fixtures are high enough that the cones of light completely envelope the bicyclists as well as the path surface they are riding on. Note that adequate lighting also helps minimize vandalism.

The longer or more enclosed an underpass is, the more necessary good lighting and higher vertical clearances become. In areas where personal safety concerns have been identified or where anticipated, consider installing call boxes. People who do not feel safe at underpasses will not use the facility.

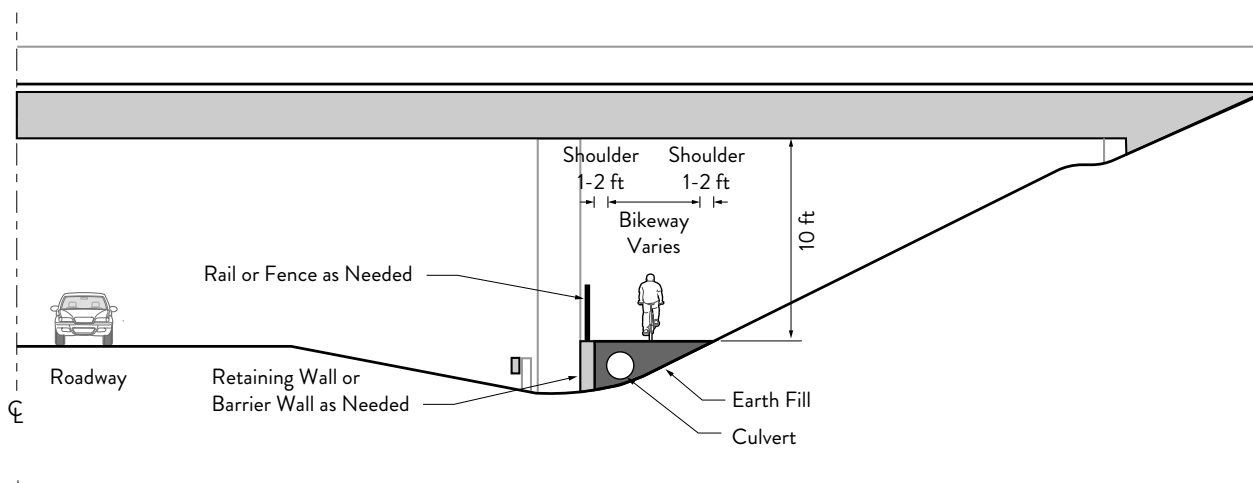


EXHIBIT 7-3: Bicycle Facility Under an Existing Bridge Structure

Pedestrian and Bicycle Bridges and Underpasses

Creating a grade-separated facility for nonmotorized users should be carefully considered. At locations with especially complex intersections, or high motor vehicle speeds and volumes, grade separation may be desirable. These structures are for shared use by bicyclists and pedestrians and therefore ADA guidelines should be followed. Bicyclists and pedestrians may choose not to use a grade-separated crossing if doing so greatly increases their travel distance or access to the crossing seems inconvenient. Instead, expect bicyclists to continue to cross at-grade, eliminating any crossing safety benefits. A first choice should always be to consider at-grade improvements, which are typically less costly than a bridge or underpass.

DECIDING BETWEEN A BRIDGE AND UNDERPASS

Bridges or overpasses typically have good visibility from surrounding areas, providing a greater sense of user safety. Ambient and natural light can reduce the need for significant lighting components. Bridges also offer the opportunity to add visual interest to a community's public space, which may even attract new users. When over a road, a significant elevation change is often required to provide motor vehicle clearance under the overpass.

Underpasses typically require less elevation change than an overpass, since the vertical clearance required is typically 10 feet. However, their enclosed feeling, the inability to sometimes see through to the end and lack of visibility from surrounding areas may result in a sense of insecurity for users. Flooding and collected debris can sometimes make the underpass seasonably unusable; proper drainage design is a key element to prevent wet conditions that may become a hazard. Underpasses are typically less noticeable than overpasses and are not likely to attract new users.



BRIDGES/OVERPASSES

Exclusive pedestrian/bicycle bridges are to be designed to the standards of the AASHTO LRFD Guide Specifications for the Design of Pedestrian Bridges. They should be designed to support pedestrian live loading and loading from any expected maintenance or emergency vehicles.

On exclusive pedestrian/bicycle bridges, maintain consistent bicycle facility/shared use path widths the length of the bridge; they should be at least as wide as the approaching facility. Similar to vehicle bridges, exclusive pedestrian/bicycle bridges have a long expected life span, so planning for future use is critical.

When MnDOT builds a specific bridge to serve only people walking and bicycling, it is because there is a high volume of use or a known safety concern. The recommended minimum width for an exclusive pedestrian/bicycle bridge is 14 feet. This allows for a 10-foot, two-way shared use path and two-foot clearances on either side.

A shared use path level of service calculation could serve as basis to confirm or justify a wider or narrower bridge. When shared use path LOS is at D or below, consider additional width and separating pedestrians and bicyclists. Future growth should also be considered in the calculation. Railing design for exclusive pedestrian/bicycle bridges should follow guidance provided in the previous Railings on Bridges section. Refer to [Article 2.1.2 of the MnDOT LRFD Bridge Design Manual](#)⁸⁰ for guidance on pedestrian/bicycle bridges.

Do not reduce bicycle facility/shared use path widths to prevent motor vehicles from entering the bridge. Instead, use alternate means of information and control, such as signs, bollards, gates, or mazes (see the Controlling Motor Vehicle Access section in Chapter 5 for more information).

Consider how the bicycle facility will approach the exclusive pedestrian/bicycle bridge. If the approach grade results in steep slopes, the recommended shy distance from the edge of the shared use path to the top of the slope may need to be increased. For steep slopes where the horizontal clearance between the facility and the top of the slope is less than five feet, physical barriers or fences are recommended (EXHIBIT 5-5: Fence or Barrier Adjacent to Slopes).

UNDERPASSES/TUNNELS

Exclusive pedestrian/bicycle underpasses should follow all the standards for sidepath vertical clearance described in the Vehicle Underpasses section. Tunnel bicycle facility dimensions should meet the same basic width requirements for bridges. The recommended minimum width for an exclusive pedestrian/bicycle underpass is 14 feet. This allows for a 10-foot, two-way shared use path and two-foot clearances on either side (EXHIBIT 7-4: Exclusive Pedestrian/Bicycle Underpass).

Because of the expense and the feelings of constraint and isolation often associated with tunnels, strive to design them as short as possible. Short lengths offer a greater likelihood of allowing daylight to enter the tunnel and to be seen from both ends.

The approaches to an underpass should be designed with safety and comfort in mind. To prevent bicyclists from running into the edge of the tunnel entrance, consider designing the tunnel entrance wider than bicycle facility. If the tunnel entrance is same width as the bicycle facility, consider installing conspicuous reflective markers on the tunnel entrance sidewall along with pavement markings to guide bicyclists away from the tunnel walls.

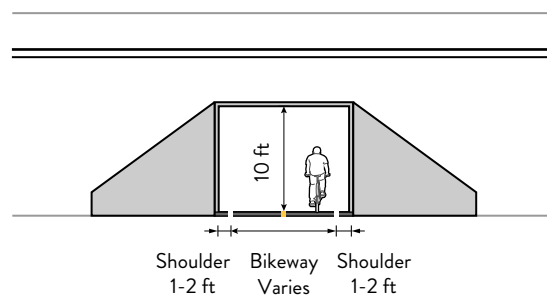


EXHIBIT 7-4: Exclusive Pedestrian/Bicycle Underpass

Interchanges

Interchanges involve high volumes of free-flowing motor vehicle traffic, multiple turn lanes, complex phasing and unexpected motor vehicle paths. Interchanges can be significant obstacles for bicyclists, especially Interested but Concerned bicyclists.

Consider the following design principles when designing for bicyclists through interchanges:

- Consider bicyclist access to destinations, shortest path, exposure to traffic and crash potential.
- Create a route for the bicyclist that is obvious, logical and convenient.
- Minimize and highlight conflict areas so all modes are aware of merging and crossing locations.
- Provide buffers or increased width where intersection configuration may increase stress for bicyclists.
- Reduce motor vehicle speeds at conflict points.
- Use signals and signs to control motor vehicle turns across the bicycle facility.

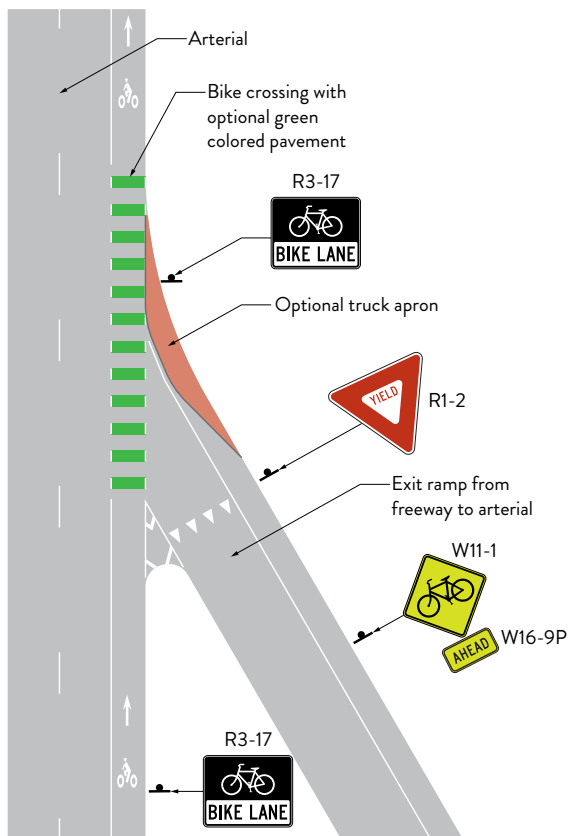


EXHIBIT 7-5: Bike Lane Carried Across Merge Ramp

MERGE RAMPS

Exit ramps from a freeway onto an arterial, also known as merge ramps, are difficult for bicyclists to traverse because of the undefined area created by the right lane merge movements and the acute approach angle that reduces visibility. Speed differentials are often high because of merging motor vehicle acceleration. If bike lanes are present consider:

- Allowing bicyclists to choose whether they merge, weave, or cross. If the merge is short and lower speed it may be appropriate to continue dotted lines of bike lanes through a merge area (EXHIBIT 7-5: Bike Lane Carried Across Merge Ramp).
- Where merges are longer and motor vehicle traffic volumes are higher consider guiding bicyclists across the ramp at a right angle. This shortens the crossing distance and improves sight lines between bicyclists and motor vehicle drivers. Bicyclists must yield to ramp traffic and may increase their delay. Place the bicycle crossing parallel to the pedestrian crossing (if present) and use a W11-15 to mark both crossings simultaneously. The bicycle crossing should have dotted white edge lines, and green-colored pavement can be used to draw attention to the area of conflict. (EXHIBIT 7-6: Bike Lane Perpendicular to Merge Ramp).

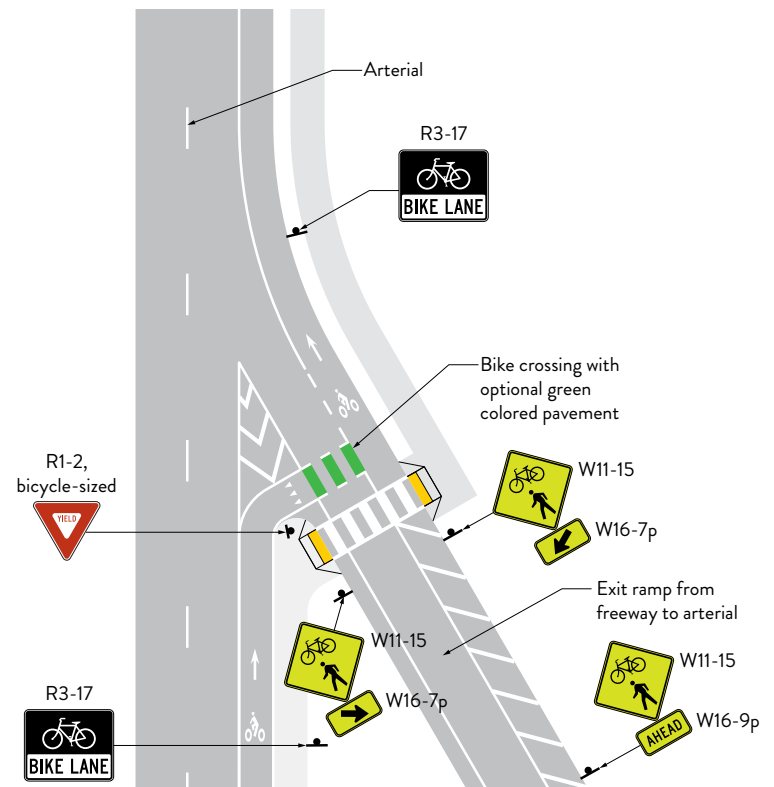


EXHIBIT 7-6: Bike Lane Perpendicular to Merge Ramp

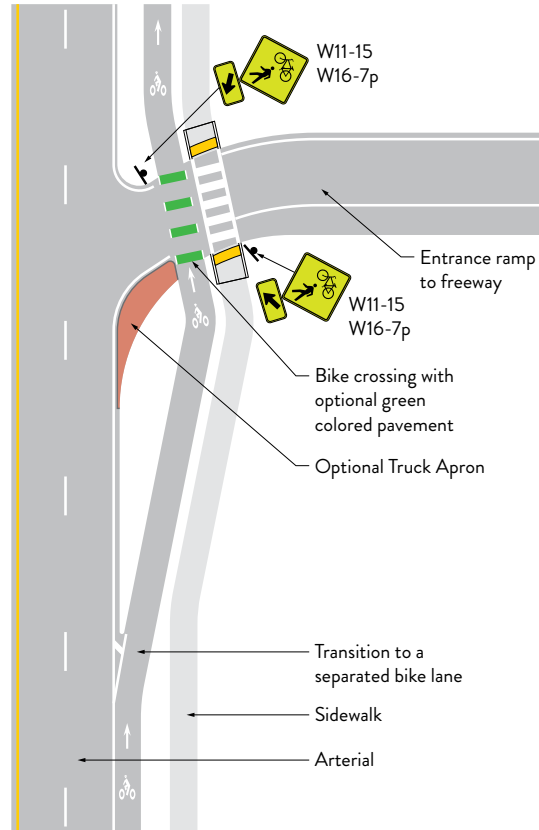


EXHIBIT 7-7: Entrance Ramp with Separated Bike Lane

DIVERGE RAMPS

Entrance ramps onto a freeway from an arterial, also known as diverge ramps, have similar issues to merge ramps. Drivers expect to exit the road with little speed reduction and sometimes fail to signal. They may not yield before crossing a through-bicyclist's path. Bicyclists may misjudge the intent of an overtaking driver's failure to signal. There are three bicycle facility/diverge ramp configurations:

- On-street bike lane converted to separated bike lane (EXHIBIT 7-7)
- On-street bike lane with right turn lane (EXHIBIT 7-8)
- On-street bike lane with no right turn lane (EXHIBIT 7-9)

At complex intersections, such as diverge ramps, providing physical separation between bicyclists and motor vehicles can help reduce the level of traffic stress for bicyclists, and clearly define conflict points.

Diverge Ramp with Short Separated Bike Lane

This is the preferred treatment, and can be used with or without an exclusive right turn lane. Transition the on-street bike lane to a short, one-way, separated bike lane that crosses the entrance ramp at a 90-degree angle. Place the bicycle crossing parallel to the pedestrian crossing and use a W11-15 to mark both crossings simultaneously. The bicycle crossing should have dotted white edge lines, and green-colored pavement can be used to draw attention to the area of conflict. Consider incorporating a mountable truck apron to reduce the turning speed of motor vehicle traffic through the conflict area. (EXHIBIT 7-7: Entrance Ramp with Separated Bike Lane)

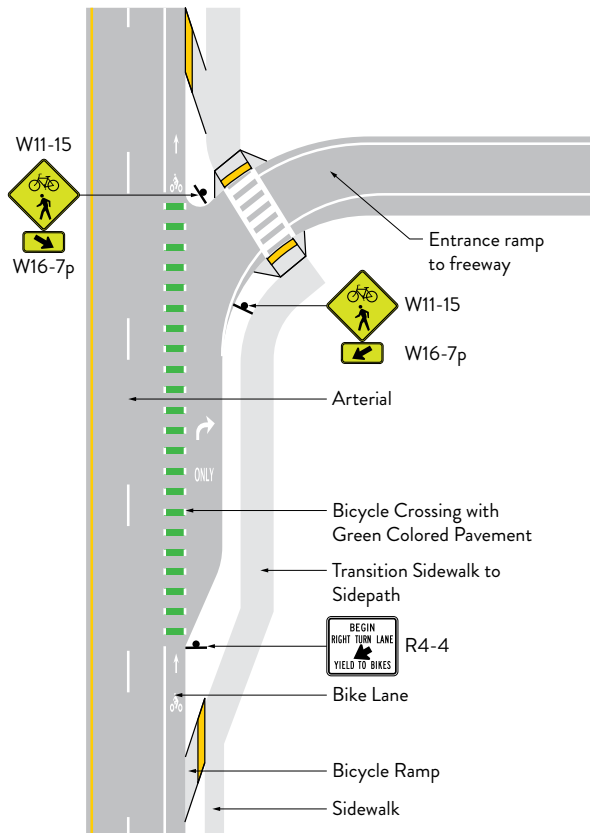


EXHIBIT 7-8: Entrance Ramp with Right Turn

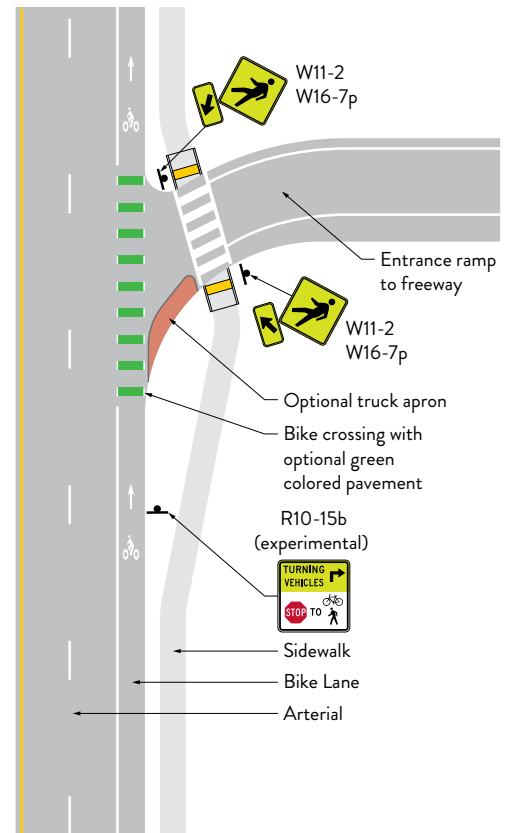


EXHIBIT 7-9: Entrance Ramp with Bike Lane

Diverge Ramp with Right Turn Lane

Consider providing a bicycle slip ramp to allow access to a parallel sidewalk and improving it to act as a short section of sidepath that crosses the entrance ramp at a 90-degree angle. Consider sidewalk width and pedestrian and bicycle volumes prior to implementing this treatment. In this case, only a crosswalk is marked, since the two modes are combined. Use a W11-15 warning sign to indicate to drivers that both modes are present.

If a bicycle slip ramp is not provided, the on-street bike lane should be maintained across the right turn lane. Through movements have right-of-way over turning movements. Place a BEGIN RIGHT TURN LANE YIELD TO BIKES (R4-4) sign at the diverge point. The bike lane should have dotted white edge lines across the diverge area, and green-colored pavement can be used to draw attention to the area of conflict. (EXHIBIT 7-8: Entrance Ramp with Right Turn)

There may be circumstances where both treatments are appropriate and the on-street bike lane is maintained while a bicycle slip ramp is also provided.

Diverge Ramp with No Right Turn Lane

Similar to the diverge ramp with right turn lane, consider providing a bicycle slip ramp to allow access to a parallel sidewalk and improving it to act as a short section of sidepath that crosses the entrance ramp at a 90-degree angle.

If a bicycle slip ramp is not provided, the on-street bike lane should be maintained across the ramp. Through movements have right-of-way over turning movements. Place a TURNING VEHICLES STOP FOR BIKES/PEDS (R10-15b) sign in advance of the conflict point. The R10-15b as shown in EXHIBIT 7-9: Entrance Ramp with Bike Lane is an experimental sign. Contact the MnDOT Standards Engineer prior to any application. Use a W11-2 warning sign at the location of the pedestrian crosswalk since the crossings are not combined. The bike lane should have dotted white edge lines across the diverge area, and green-colored pavement can be used to draw attention to the area of conflict. Consider incorporating a mountable truck apron to reduce the turning speed of motor vehicle traffic through the conflict area.

Roundabouts

Modern roundabouts are designed to make intersections safer and more efficient for drivers, pedestrians and bicyclists. Roundabouts generally create lower speed conditions as compared to traditional intersection. These slower speeds benefit bicyclists traversing the roundabout both as a vehicle and as a pedestrian. They also can increase the capacity of an intersection compared to a traditional stop sign or signal-controlled intersections.

Generally, there are two types of roundabouts: single-lane and multi-lane roundabouts. Single lane roundabouts are simpler and safer for all nonmotorized users.⁸² Bicyclists are often less visible and more vulnerable when changing lanes through a multi-lane roundabout. The various lane configurations and complexity of motor vehicle interactions can often leave bicyclists feeling vulnerable. Designers should be cognizant of bicycle traffic when designing roundabouts and constrain the design speeds to those compatible with typical bicycle speeds to promote bicyclist safety and comfort.

If long-term traffic projections suggest the need for a multi-lane roundabout, but the need isn't likely for several years, the roundabout can be constructed as a single-lane roundabout and designed for additional lanes to be constructed in the future when, and if, traffic volumes warrant the need for expansion.

Apply design principles that lead to slow motor vehicle entry and exit and contribute to pedestrian and bicyclist safety and comfort. Proper deflection angles design create slow speeds at all entries and exits and are critical to reducing motor vehicle speeds through the intersection at bicycle and pedestrian conflict points. Additional design details can be found in [Chapter 12 of MnDOT's Road Design Manual](#)² and [NCHRP Report 672 - Roundabouts: An Informational Guide](#).⁸²

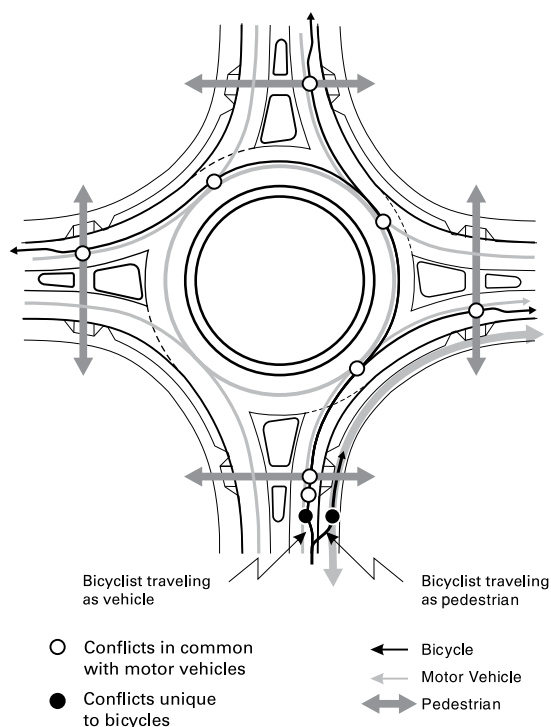


Image source: FHWA Roundabouts: An Informational Guide

NAVIGATING A ROUNDABOUT ON A BICYCLE

Bicyclists have the option to ride through the circulatory roadway of the roundabout with traffic or use the sidepaths and pedestrian crosswalks. Bicyclists riding through the circulatory roadway should obey the rules of the roundabout in the same manner as drivers. Roundabouts should include sidepaths for bicyclist and pedestrian use on all four quadrants, unless land use suggests that non-motorized travel to that quadrant will not occur. Bicycle lanes should not be installed on the circulatory roadway of a roundabout.

EXHIBIT 7-10: Bicycle Conflicts at Roundabouts shows the conflict points bicyclists experience when navigating a roundabout as a vehicle and as a pedestrian. The primary conflict point for bicyclists in the roadway is when merging into the motor vehicle traffic stream. The primary conflict point for bicyclists exiting the roadway to use a sidepath is conflicts with pedestrians when they join the sidepath.

EXHIBIT 7-10: Bicycle Conflicts at Roundabouts

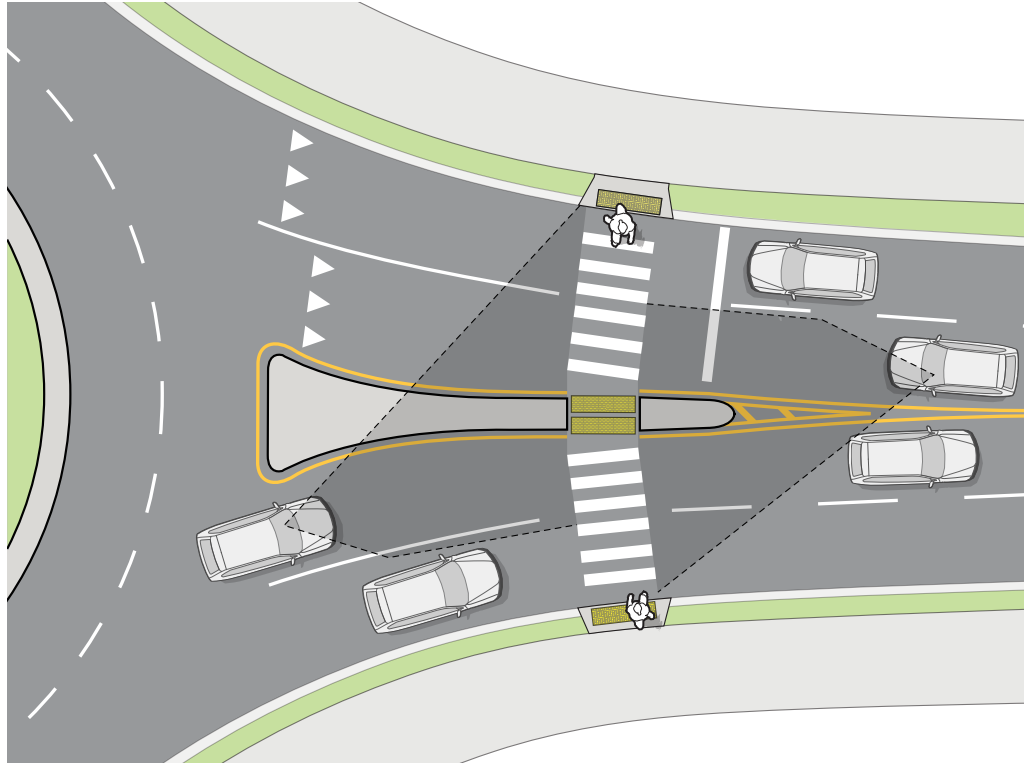


EXHIBIT 7-11: Double Threat to Pedestrians and Bicyclists on Dual Lane Roundabout Exit and Entry

Single lane roundabouts are strongly preferred over multi-lane roundabouts. At multi-lane roundabout exits, bicyclists are continuing through the roundabout may conflict with motor vehicles that are exiting. Bicyclists on a sidepath face a double threat as they cross multiple travel lanes (EXHIBIT 7-11: Double Threat to Pedestrians and Bicyclists on Dual Lane Roundabout Exit and Entry).

DESIGNING FOR BICYCLES THROUGH A ROUNDABOUT

Providing bicyclists the choice to navigate the roundabout as a motor vehicle or pedestrian is critical to serving the Interested but Concerned bicyclist, MnDOT's bicyclist design user. Roundabouts should include sidepaths for bicyclist and pedestrian use on all four quadrants, unless land use suggests that non-motorized travel to that quadrant will not occur. See Chapter 5 for sidepath design. Providing bicyclists with a route adjacent to the intersection allows the bicyclists an option to avoid on-street travel through the roundabout.

Bicycle lanes should not be installed within the circulatory roadway of a roundabout according to [Chapter 9 of the Minnesota Manual on Uniform Traffic Control Devices](#).³ If on-street bike lanes are present they should be terminated a minimum of 100 feet prior to the roundabout to allow adequate distance for a bicyclists to merge into the general travel lanes or exit onto a sidepath. On-street bike lanes should be terminated a minimum of 50 feet before the crosswalk to maintain the shortest possible pedestrian crossing distance.

An appropriate taper should be provided when terminating the bike lane and when shifting bicyclists to the sidepath. A taper rate between 1:5 and 1:7 is appropriate. Bicycle ramps should be placed at a 35- to 45-degree angle to the roadway and sidepath to slow bicyclists that are entering the sidepath.

As illustrated by EXHIBIT 7-12: Bicycle Accommodations Through Roundabout, the bike lane line should be dotted for 50 feet to 200 feet in advance of the taper to provide guidance to bicyclists merging into the travel lane. Shared lane markings may be used after the bicycle lane ends and within the circulating roadway to help position bicyclists. A BIKE LANE (R3-17) sign with an ENDS (R3-17B) may be used to notify bicyclists of the need to merge with vehicle traffic or use the slip ramp to access the sidepath.

When roundabouts are designed to encourage bicyclists to traverse them as a pedestrian, designers should ensure slip ramps are provided as required. Sidewalks should be upgraded through the roundabout to provide the extra space needed to mix bicyclists and pedestrians appropriately a minimum of 10 ft. The wider shared use path should completely surround the roundabout and be a consistent width at crossings with the roadway.

If a sidepath is not included in the initial design, consider at least grading the area for the slip ramps and future sidepath so they can be easily installed when needed.

The channelizing islands should be wide enough to store a bicycle (6 feet minimum) and preferably wide enough to accommodate a child's trailer (10 feet minimum). Designers should consider supplemental yield lines for crossings at roundabout exits to reinforce driver yielding.

BICYCLE SLIP RAMPS

For bicyclists that are uncomfortable taking a lane and traversing a roundabout using the same path provided for a motor vehicle, a slip ramp can provide them a way to transition to the sidepath around the roundabout.

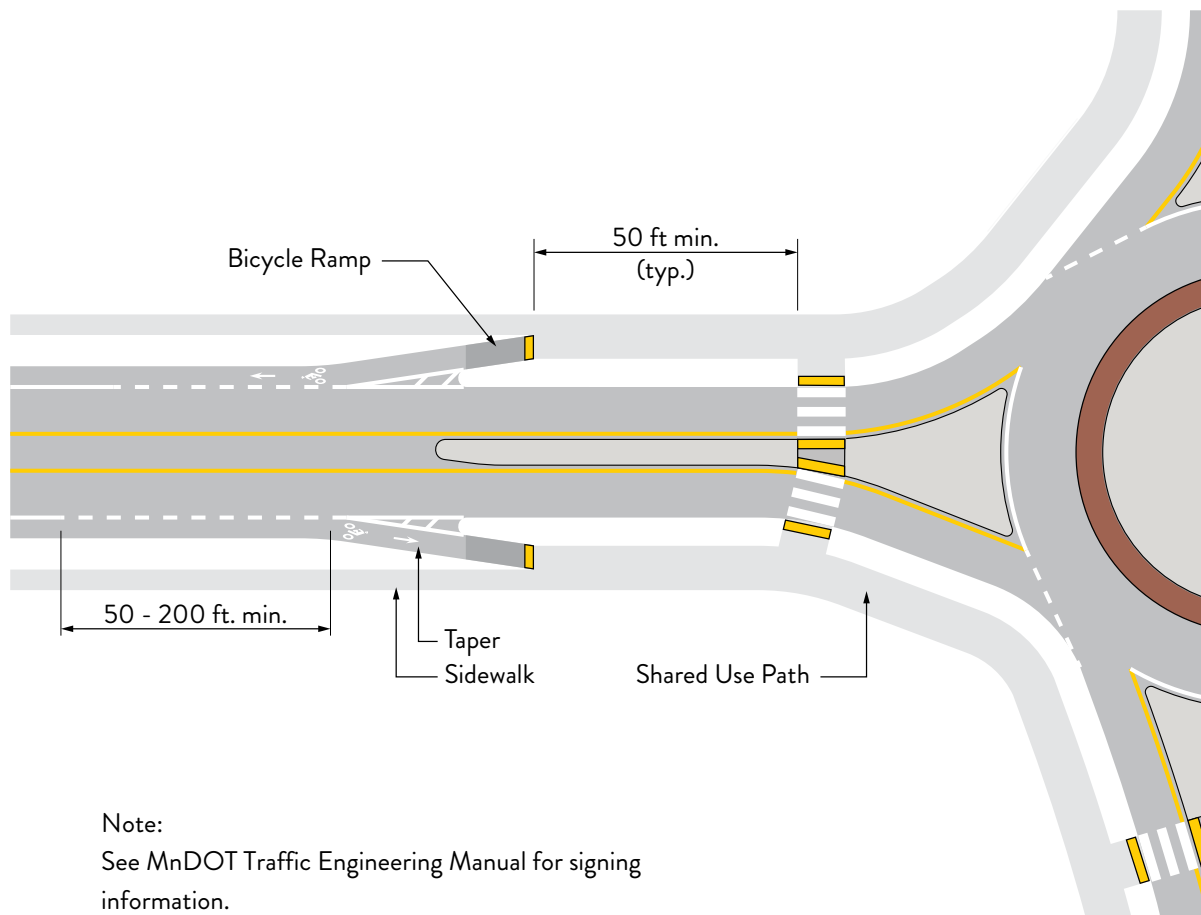


EXHIBIT 7-12: Bicycle Accommodations Through Roundabout

Slip ramps are the transition area from the end of a bike lane or from the roadway onto the sidewalk or sidepath. They are typically designed at an acute angle between the curb line and the approaching or exiting lane of the roundabout. The width of the slip ramp should match the width of the sidepath around the roundabout. Bicycle slip ramp installation is highly dependent on context.

In rural cross-sections, bicycle facilities are sometimes just a paved shoulder, which typically disappears at a roundabout, and nonmotorized users lose their operating space. Bicycle slip ramps can provide an opportunity for nonmotorized users to exit the roadway to an off-road sidepath while traveling through the roundabout. Always consider land use context when considering whether to install slip ramps.

Generally Install Slip Ramps:

- At all multi-lane roundabouts
- On legs with free-flow right turn lanes
- At roundabouts with bikeable shoulders on the approaches
- In areas with a high percentage of vulnerable users and no shared use path
- Where bike lane or shared lane markings lead up to the roundabout

Generally Do Not Install Slip Ramps:

- Where there is a low-use driveway or intersection within the preferred slip ramp placement area
- Where nonmotorized users are not allowed



Alternative and Innovative Intersections

Alternative and innovative intersections found on MnDOT's system include:

- Diverging Diamond Interchanges
([Tech Memo 16-07-TS-03](#))⁸³
- Restricted Crossing U-Turns (RCUTs)
([Tech Memo 17-03-TS-01](#))⁸⁴
- Median U-Turn
- Single Point Urban Interchanges (SPUIs)

When designing an alternative intersection, every effort should be made to include some type of bicycle facility that provides a dedicated and safe space for bicyclists. Due to motor vehicle traffic volumes, separated bike lanes or sidepaths will be most appropriate for most alternative intersections (EXHIBIT 3-4 on page <?>). Similar to conventional interchanges, bicyclists should be provided an obvious, logical and convenient path through an alternative intersection.

Give careful consideration to signal timing at intersections with very large footprints. Minimum green times may need to be increased to allow bicyclists to get to a visible location where drivers of conflicting motor vehicles can see them before the start of the yellow interval (see Chapter 4). Consider including detection and extending the red clearance interval when bicyclists are present.

Median Refuge Islands

Regardless of whether a bicycle facility crosses a roadway at an existing intersection or at a mid-block location, the design principles that apply to pedestrians at crossings (controlled and uncontrolled) are typically applicable to bicycle crossings since pedestrians and bicyclists are both vulnerable road users.

Median refuge islands are an [FHWA proven safety countermeasure](#)⁸⁵ and are associated with lower pedestrian crash rates at multi-lane crossings. Median refuge islands provide the greatest benefit when one or more of the following apply:

- Higher volumes of roadway traffic and/or speeds create difficult crossing conditions for bikes or pedestrians.
- Roadway width is excessive given the available crossing time.
- The roadway cross-section requires a bicyclist to cross more than two total through lanes.
- There is a need to minimize conflicts between turning vehicles and crossing bicyclists and pedestrians.

Median refuge islands reduce crossing exposure and allow a two-stage crossing. Two-stage crossings may be beneficial where gaps in traffic are produced by an adjacent traffic signal or where natural gaps in traffic allow a person to cross one half of the roadway at a time.

DIMENSIONS

The size of the bicycle and pedestrian area in the refuge island should take into account the potential demand, size of platoons of users, including groups of pedestrians and/or bicyclists, tandem bicycles, wheelchairs and people with strollers.

The pedestrian area in a median islands should be at least 6 feet wide to be considered a refuge space under ADA guidelines (EXHIBIT 7-13: Shared Use Path Roadway Crossing with Median Refuge Island). If designing for bicycle use, the median should be designed to be wide enough to serve the longest user. Ten feet provides

the space required for bicyclists with trailers, groups of bicyclists, etc. The width of the median refuge island will dictate whether the bicycle and pedestrian area should be at street level or sidewalk level. A narrow median refuge island does not have the space to include a proper ADA curb ramp, so median refuge islands less than 16 feet wide will typically have a street level bicycle and pedestrian area.

The perpendicular width of the median refuge openings and crosswalks should be at least the same size as the connecting facility. For example, a 10-foot wide shared use path would have at least a 10-foot wide opening and crosswalk.

The median refuge island should extend at least 6 feet on either side of the bicycle and pedestrian area (EXHIBIT 7-13). There is no maximum length for a refuge island, although the spacing of median refuge islands and left turn lanes for motor vehicles along a corridor may limit their length.

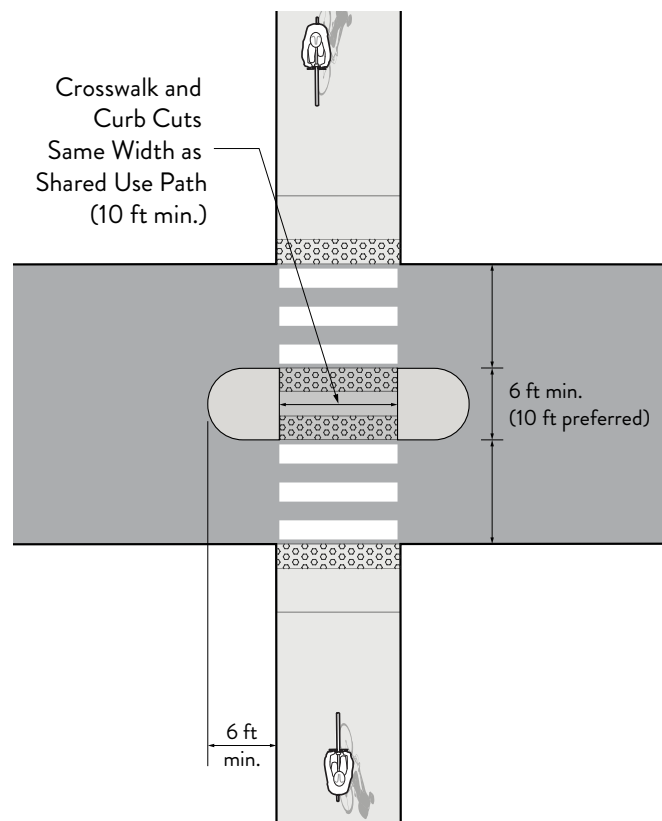


EXHIBIT 7-13: Shared Use Path Roadway Crossing with Median Refuge Island

SIGNS AND MARKINGS

All signs and striping and pavement markings associated with refuge islands should conform to the MN MUTCD. EXHIBIT 7-14: Median Refuge Island Signs shows the placement of bicycle and pedestrian crossing signs associated with refuge islands. Guidance to make drivers aware of the median refuge island may be necessary, especially for islands that are less than 30 feet long. Type 1 Object Markers (OM1-1, OM1-2, or OM1-3) or yellow, retroreflective flexible delineators can help draw attention to the median refuge island.

If a median refuge island is being included in a center left turn lane, on the crosswalk marking is necessary. If travel lanes are being shifted or narrowed to create space for a median island, appropriate tapers should be marked.

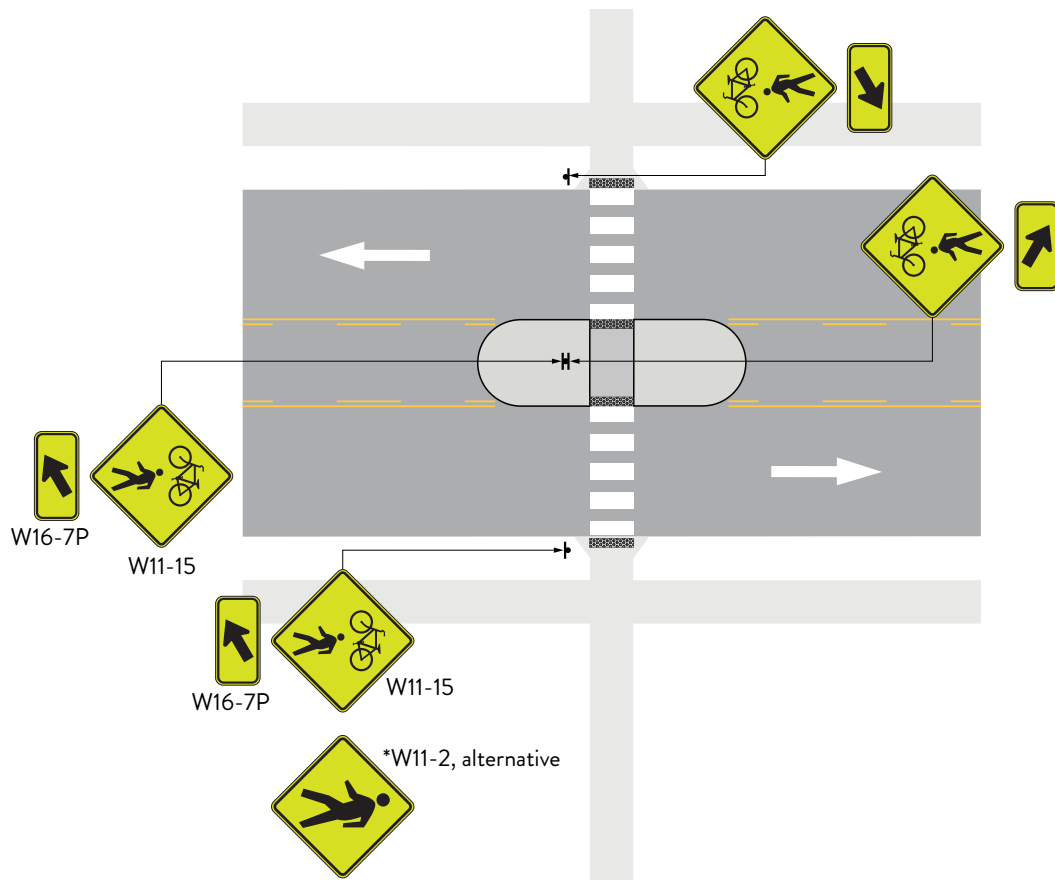


EXHIBIT 7-14: Median Refuge Island Signs

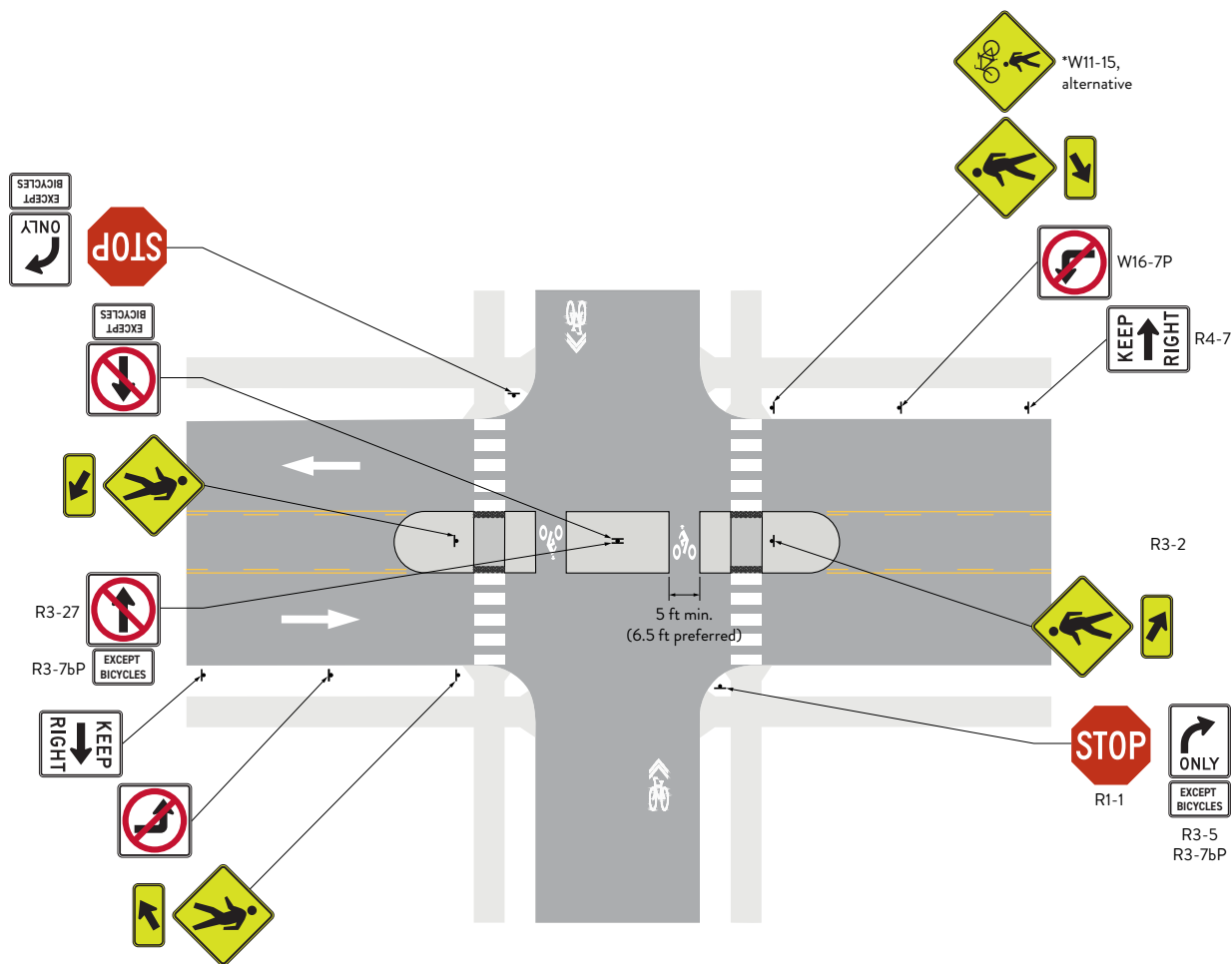


EXHIBIT 7-15: Median Refuge Island with Diverter

VARIATIONS

Median refuge islands may also be extended into an intersection to limit motor vehicle traffic along a bicycle boulevard (EXHIBIT 7-15: Median Refuge Island with Diverter). See Chapter 5 for more information on bicycle boulevards.

Median refuge islands may also be temporary or seasonal when installed using flexible delineators or breakaway channelizing devices. Depending on the duration of the installation, consider painting the pavement in the interior of the temporary median refuge island to distinguish it from the travel lanes.

Continuous Raised Medians

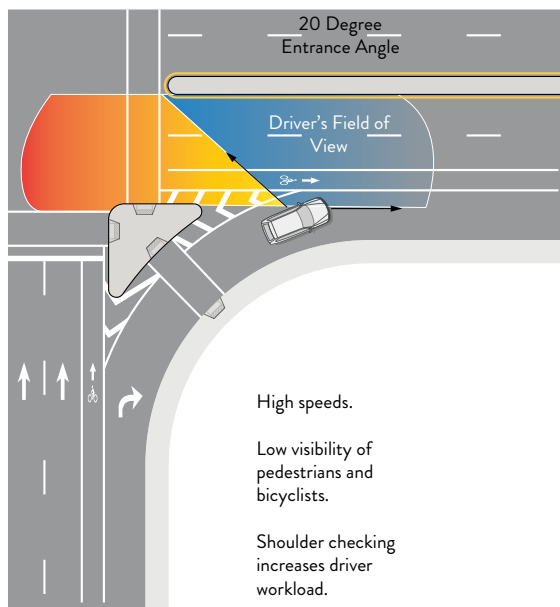
Assuming they are 6 feet wide or more, continuous raised medians provide the same refuge space for bicyclists and pedestrians that median refuge islands do. Wider medians can also serve an aesthetic purpose as green space, and if populated with trees, can have a traffic calming effect by creating a sense of enclosure.

More importantly, continuous raised medians limit motor vehicle left turns across a bike lane, separated bike lane, or sidepath. Left turn movements are either concentrated at signalized intersections or executed as a u-turn that results in drivers turning right across the bicycle facility.

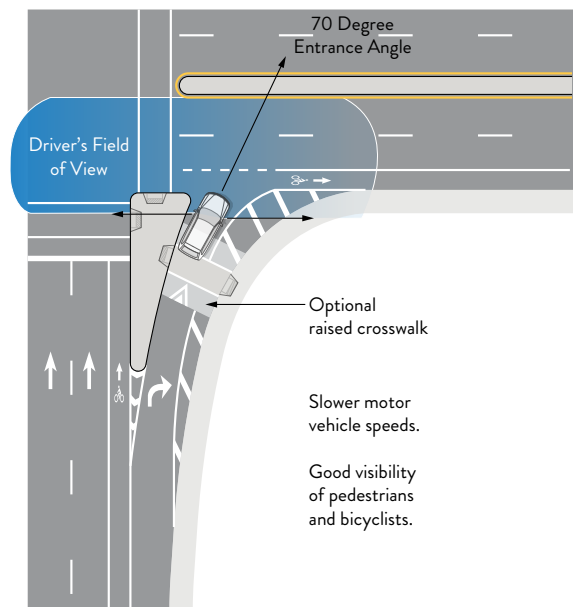
Channelized Right Turn Islands

Channelized right turn lanes have small islands, also called pork chops, which can break up crossings at large intersections into multiple stages. Channelized right turns need to be carefully designed to be a benefit to nonmotorized users.

- Pork chop islands should be large enough to serve expected path users, such as bicyclists with trailers and be large enough to store groups of bicyclists. Bicycle and pedestrian space should be at least 6 feet long, ideally 10 feet long.
- Pork chop islands should be large enough to accommodate any Accessible Pedestrian Signal push button placement necessary.
- Channelized right turn lanes should be designed to minimize driver speed and maximize the visibility of the pedestrian crossing. Consider Pedestrian “Smart Channel” geometry anywhere bicyclists and pedestrians are expected (EXHIBIT 7-16: Conventional Right-Turn Channel Compared with Pedestrian Smart Channel).
- Consider adding a raised crossing between the pork chop island and the edge of the roadway to improve visibility of bicyclists and pedestrians crossing and slow motor vehicle traffic.



Conventional Right-Turn Channel



Pedestrian Smart Channel

EXHIBIT 7-16: Conventional Right-Turn Channel Compared with Pedestrian Smart Channel

Curb Extensions

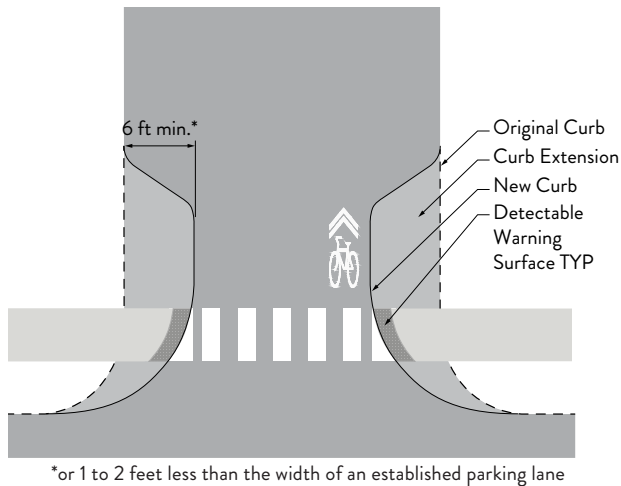


EXHIBIT 7-17: Curb Extensions

Curb extensions reduce crossing distances for pedestrians and bicyclists, which can improve safety. (EXHIBIT 7-17: Curb Extensions) Parked vehicles are further from the intersection, which improve visibility between drivers and those waiting to cross and reduce turning speeds. Curb extensions can also serve as a gateway/ transition from a rural to urban area by visually narrowing the roadway, and encouraging drivers to slow down.

Curb extensions provide additional space to install directional curb ramps. They also provide space for amenities like plantings, bike racks, or public art. In an area with a shoulder that is being used as a bicycle facility consider the tradeoffs between adding a curb extension to help crossing bicyclists/pedestrians and obstructing the path of through bicyclists. In these areas, a curb extension that extends only partway into the shoulder, or that has a gap for bicyclists to pass through it could be effective.



Speed Tables, Raised Crossings and Raised Intersections

Speed tables are traffic calming devices that raise the entire wheelbase of a motor vehicle. This type of vertical deflections can have a positive effect for bicyclists as they reduce motor vehicle speeds. Speed tables are typically between 3 and 6 inches high and between 10 and 25 feet long. Slopes on the approach to a speed table should be between 1:10 and 1:25. Section 3B.25 of the MN MUTCD provides guidance on marking speed tables and raised crossings.

A raised crossing is a crosswalk or bicycle crossing that is combined with a speed table. In addition to slowing motor vehicle traffic, raised crosswalks can also improve visibility between drivers, bicyclists and pedestrians at crossing locations. They eliminate the need for ADA curb ramps, although tactile warnings are still necessary. Raised crosswalks also make a good gateway treatment at the

Designers should consider drainage needs for all raised treatments to ensure the roadway still drains properly.

entrance to a bicycle boulevard or a downtown area. Raised crosswalks are a proven pedestrian safety countermeasure. [The FHWA Safe Transportation for Every Pedestrian](#)⁶³ guide suggests raised crosswalks as a candidate treatment for unsignalized intersections on roads with posted speeds of 30 mph or less and AADT of 9,000 vehicles per day or less.

Similarly, a raised intersection applies the speed table concept to an entire intersection - the intersection is elevated to sidewalk level. Raised intersections may be a better treatment on high volume roadways where a raised crossing is not appropriate.

Speed humps, also known as speed bumps, are not recommended as traffic calming treatments on roadways where bicyclists are expected. The short length of speed bumps often allows motor vehicles to pass over them at high speed with only mild disturbance to the wheels and suspension. However, they can be a hazard to bicyclists or motorcyclists. If used, speed humps should have sinusoidal profiles as they are less jarring for bicyclists at normal speeds.



Mountable Truck Aprons

Mountable truck aprons encourage smaller motor vehicles to make tighter turns while allowing larger motor vehicles, such as trucks to track over an apron. MnDOT frequently uses truck aprons on the center island of roundabouts for this purpose.

At intersections, wide crossings and high speed motor vehicle turns negatively impact pedestrian and bicyclist safety. Reducing corner radii slows motor vehicle turning speeds. However, implementation the smallest corner radii can pose challenges to some motor vehicles, specifically trucks. When corner radii is too small for trucks to navigate, bicyclists and pedestrians are also at risk from the rear wheels of a large vehicle over tracking the curb ramps.

Mountable truck aprons can help to strike a balance between slowing passenger cars and accommodating expected truck traffic with larger turning radii. They can be especially effective at skewed intersections where the truck turning radius is significantly larger than that of a passenger car or where truck traffic is very infrequent.

For legibility for all users, the mountable surface should be visually distinct from the adjacent travel lane, sidewalk and bike facility. Mountable truck aprons are part of the traveled way and should be designed to discourage pedestrians or bicyclists from using them as a safe queuing area. Bicycle stop bars, detectable warning surfaces, traffic signal equipment and other intersection features should be located behind the mountable surface area. Consider using vertical delineators to separate pedestrian and bicycle spaces from mountable truck apron and provide guidance to maintenance vehicles when snow accumulation hides curb. If considering a truck apron on a project, contact the Geometric Design Support Unit for specific design guidance.



Rails & Railroad Grade Crossings

Railroad tracks intersecting with bicycle facilities can be hazardous for bicyclists, people in wheel chairs and other small wheeled transportation devices. Adequate sight lines are critical for people approaching rail crossing by bicycle to see approaching trains. Pavement surfaces, rails and gaps may be uneven, causing additional obstacles for bicyclists. Additionally, metal rails can be slippery when wet. To successfully navigate a rail crossing, a bicyclist needs to cross nearly perpendicular to the rails to maintain control. Railroad tracks can cause steering difficulties, wheel damage, or loss of control of the bicycle.

There are four common materials used at railroad crossings: concrete, rubber, asphalt and timber. Concrete surfaces are best as they provide the smoothest ride, particularly under wet conditions while the metal rails are the most slippery.

FLANGEWAYS & FLANGEWAY FILLERS

The flangeway opening between the rail and the pavement surface can catch a wheel and cause the bicyclist to fall. Minimizing the flangeway width is beneficial to bicycle-rail intersections. Flangeway opening widths may vary based on the type of rail facility.

- Light rail flangeway widths are typically 2.5 inches
- Heavy rail flangeway widths are typically 3 inches.

Flangeway filler products are rubber fillers that are depressed by the rail wheels as they travel over the filler; the filler rises again after the train has passed to keep the flangeway opening limited. Flangeway fillers are more likely to be used on low speed, low volume rail spurs. They may not be appropriate on heavily used, high speed freight routes to limit the potential for a derailment. Coordinate with the MnDOT Rail Safety and Coordination Office for flangeway designs and traffic control for bicycle facilities.

RAIL CROSSING REVIEW

All projects that cross a railroad track should have a diagnostic review performed by the MnDOT Rail Safety and Coordination Office as early as possible to vet design issues and determine the appropriate level of warning required for the bicycle facility. Under Minnesota Statutes 219.26 and per Minnesota Administrative Rules, Chapter 8830, the Commissioner of Transportation has jurisdiction of all public at-grade crossings in Minnesota.



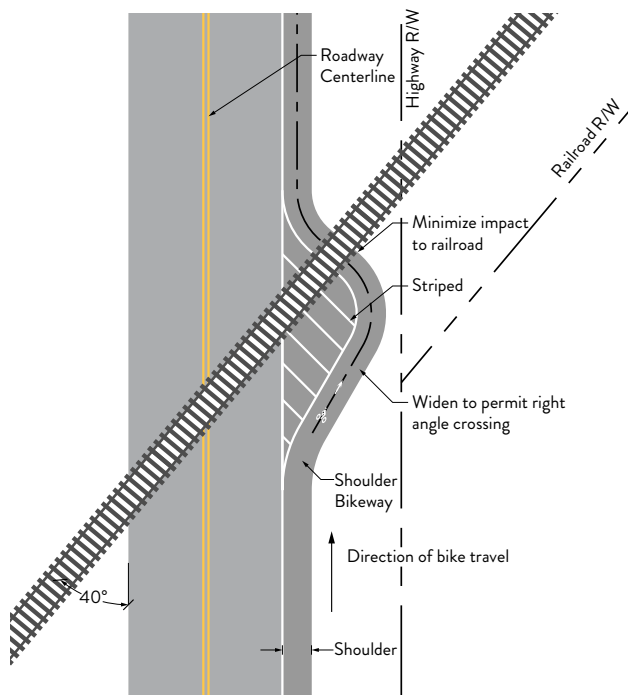


EXHIBIT 7-18: Correction for Skewed Railroad Grade Crossing - Widened Shoulder

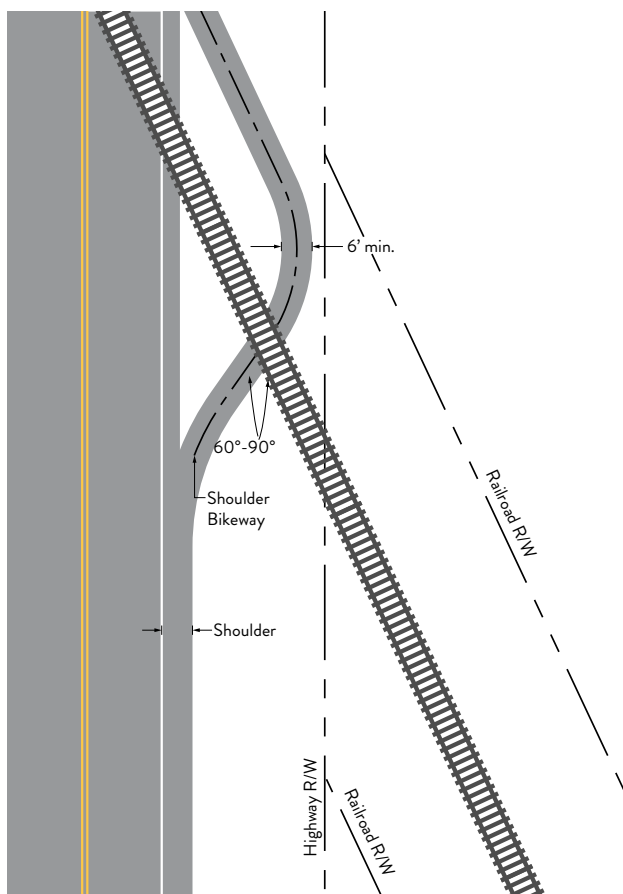


EXHIBIT 7-19: Correction for Skewed Railroad Grade Crossing - Separate Pathway

CROSSING ANGLE

Crossing angles should be designed as close to 90 degrees as possible, but at least 60 degrees. The angle is important to reduce the likelihood of bicycle wheels getting stuck in the flangeway causing bicycle crashes. Where a 60 degree angle cannot reasonably be achieved, the angle may be reduced to as low as 30 degrees though some crashes may occur. Angles below 30 degrees can expect bicycle crashes will occur regularly. Pavement markings can be added to guide a bicyclist through the fastest path through an angle greater than 30 degrees which reduces crash risk.

EXHIBIT 7-18: Correction for Skewed Railroad Grade Crossing - Widened Shoulder and EXHIBIT 7-19: Correction for Skewed Railroad Grade Crossing - Separate Pathway show how a bicycle path can be shifted through the use of short, independent alignments that continue the bike lanes immediately adjacent at either end. Pavement markings, a green colored high friction surface treatment and signs to help guide people bicycling to cross at the correct angle. Raised islands may also be effective at forcing preferred crossing angles.

Approach angle designs should avoid reverse curves when possible as reverse curves require bicycles to cross the tracks when leaning. It is easier for cyclists to avoid falling when crossing tracks while remaining upright. It may be necessary to widen the road, shoulder, or bike lane to achieve a crossing at a 90 degree angle.

BICYCLE CROSSINGS OUTSIDE EXISTING ROADWAY ALIGNMENT

Rail crossings are covered in [Minnesota Administrative Rule 8830.2700 – Establishing, Relocating, Changing Grade Crossings](#).⁸⁶ If a pathway crossing cannot be established on the existing roadway alignment over the tracks the road authority will need to negotiate with the railroad company to secure rights to establish a crossings. The application by the road authority for approval will need to be made to the Commissioner of the Department of Transportation.

OTHER DESIGN CONSIDERATIONS

Warning signs or markings should be used to inform bicyclists of upcoming intersection or other rail crossing. The grade crossing advance warning (W10-1) sign (EXHIBIT 7-19) and STOP (R1-1) or YIELD (R1-2) are required at railroad crossings that are not equipped with train activated flashing lights. Other signs to consider include the LOOK sign (R15-8), NO TRAIN HORN (W10-9), or skewed crossing symbol (W10-12). For more information on signing and pavement markings related to rail crossings, refer to Part 8 of the MN MUTCD.

Most railroads require a minimum 25-foot clearance for any fixed object, such as a shared use path, from the edge of the rail. Some may require distances greater than 25 feet. Contact the MnDOT Rail Safety and Coordination Office for information about rail clearances.

GATES, ARMS & MAZES

Gates and mazes are design treatments that can raise awareness of a crossing beyond the typical signs and warning beacons. They are sometimes required as a result of the joint grade crossing diagnostic review involving MnDOT, the railroad company and other stakeholders. Gates and mazes present maintenance challenges, and should only be used if a specific need is identified. These may be locations such as crossings with a high volume of pedestrian traffic, frequent and/or high speed trains, extremely wide crossings, complex rail crossings, school zones, and/or inadequate sight distance.

If a crossing treatment is deemed necessary, gates are generally preferred over mazes. They have a top and bottom detectable edge and the turning radius of the bicycle or wheelchair using the gate is not a factor in design. Bicyclists are typically required to dismount their bicycle in order to operate the gate, which helps focus their attention on the crossing. Mazes should be designed in a zig-zag orientation that aligns bicyclists to look towards approaching train before crossing.

With both gates and mazes, designers should provide sufficient space for maintenance equipment and all types of bicycles to maneuver such as bicycles with trailers. Railroads may have other specific design requirements for these elements.

Active traffic control devices for grade crossings include arm counterweights that typically extend beyond the center of the signal mast when the arm is extended. The edge of a sidepath or sidewalk should be at least two feet away from the end of the extended counterweight. Alternatively, the sidepath or sidewalk may be placed on the roadway side of the active traffic control device, allowing the arm to control all modes of traffic when extended. The sidepath or sidewalk should still have two feet of clearance from the signal mast. Finally, a smaller, secondary active control device can be used to stop pedestrians and bicyclists along a sidewalk or sidepath.

Regardless of the crossing treatment selected, ADA requires detectable warnings at railroad crossings. See [MnDOT Standard Plan 5-297.250](#) for railroad detectable warning design guidance.





Bike Parking

Short and long-term bike parking facilities are essential to supporting convenient access to destinations. All bike parking facilities should meet the following criteria:

- Bike can be stored upright with frame supported.
- Rack serves a variety of bicycle types.
- Frame and at least one wheel can be locked to rack with a U-shaped lock.
- Rack provides security and longevity features appropriate for the intended location.
- Rack design allows for intuitive operation without the need for written instructions.

For more information on rack placement, materials, styles, installation and site planning, refer to the [Association of Pedestrian and Bicycle Professional's Essentials of Bike Parking](#).⁸⁸



SHORT TERM BIKE PARKING

Short-term bike parking facilities are designed to serve people visiting businesses and institutions for up to a few hours at a time. These facilities should be:

- Visible to the public
- Close to the destination (preferably located within 50 feet of the entrance and visible from within the destination)
- Sheltered from weather whenever possible
- Well-lit at night



LONG TERM BIKE PARKING

Long-term bike parking is designed for regular use by people who leave their bicycles unattended for long periods of time. Bicyclists may store their bike at work, overnight at home, or at a transit station, for example. These facilities should be secure and protected from weather.



ADA CONSIDERATIONS

Chapter 4 includes dimensions of typical bicycles and their attachments. When placing bike parking, consider the space required for bicycles and ensure that a parked bicycle does not obstruct the pedestrian access route along the sidewalk.





APPENDICES

8

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- Appendix A – Acronyms and Abbreviations
- Appendix B – Definitions
- Appendix C – References
- Appendix D – Funding for Bicycle Transportation
- Appendix E – Bicycle Scoping Guide
- Appendix F – List of Interim Approvals Referenced

Appendix A: Acronyms & Abbreviations

ACRONYM	FULL NAME
AASHTO	American Association of Highway Transportation Officials
ADA	Americans with Disabilities Act
AADT	Average Annual Daily Traffic
APS	Accessible Pedestrian Signal
BLOS	Bicycle Level of Service
CAV	Connected and Automated Vehicle
CHIP	Capital Highway Investment Plan
CSS	Context Sensitive Solutions
DNR	Minnesota Department of Natural Resources
FAST	Fixing America's Surface Transportation Act
FHWA	Federal Highway Administration
HAWK	High-Intensity Activated Crosswalk
HSIP	Highway Safety Improvement Program
HSO	Horizontal Sightline Offset
IAP2	International Association for Public Participation
LOS	Level of Service
LRFD	Load and Resistance Factor Design
LTS	Level of Traffic Stress
MassDOT Guide	Massachusetts Department of Transportation Separated Bike Lane Planning and Design Guide
MN MUTCD	Minnesota Manual on Uniform Traffic Control Devices
MnDOT	Minnesota Department of Transportation

ACRONYM	FULL NAME
MnSHIP	Minnesota State Highway Investment Plan
MPO	Metropolitan Planning Organization
NACTO	National Association of City Transportation Officials
PAR	Pedestrian Access Route
PBPD	Performance-Based Practical Design
PBPDG	Performance-Based Practical Design Guide
PCI	Pavement Condition Index
PHB	Pedestrian Hybrid Beacon
PROWAG	Public Right-of-Way Accessibility Guidelines
RDC	Regional Development Commission
RQI	Ride Quality Index
RRFB	Rectangular Rapid Flashing Beacons
SBSP	Statewide Bicycle System Plan
SMTP	Statewide Multimodal Transportation Plan
STBGP	Surface Transportation Block Grant Program
STIP	State Transportation Improvement Program
TA	Transportation Alternatives
TAC	Technical Advisory Committee
TEM	Traffic Engineering Manual
TTC	Temporary Traffic Control
TZD	Toward Zero Deaths
VPD	Vehicles Per Day

Appendix B: Definitions

TERM	DEFINITION
AASHTO	American Association of State Highway and Transportation Officials.
Accessible	A facility that provides access to people with disabilities using the design requirements of the ADA.
ADA	The Americans with Disabilities Act (ADA); Civil rights legislation passed in 1990 and effective July 1992. The ADA requires public entities, such as state and local governments, to provide facilities and operate services, programs and activities that, when viewed in their entirety, are readily accessible to and usable by individuals with disabilities.
ADT/AADT	Average Daily Traffic or Annual Average Daily Traffic. The average number of motor vehicles passing a certain point each day on a highway, road or street.
Advisory Bike Lane	Continuously dashed bike lanes on narrow, low volume roadways with no center line, which allows drivers to temporarily enter the bike lane when no bicyclists are present, to provide oncoming traffic sufficient space to safely pass
Alternative Intersection	Intersection design that offers the potential to improve safety and reduce delay at a lower cost and with fewer impacts than traditional solutions, such as constructing additional lanes or converting an intersection from at-grade to grade separated. Safety should include provisions for walking and bicycling, with pedestrian and bicycle needs shaping the overall design accordingly. Types of alternative intersections include DDI, RCUT and others.
Bicycle	Every device capable of being propelled solely by human power upon which any person may ride, having two tandem wheels, except scooters and similar devices and including any device generally recognized as a bicycle though equipped with tow front or rear wheels. Bicycle includes an electric-assisted bicycle (as defined in subdivision 27). Bicycle” does not include scooters, motorized foot scooters, or similar devices. (MN Statute 169.011 Subd. 4).
Bicycle Boulevard	A roadway designed to prioritize bicycle traffic by minimizing motor vehicle traffic volumes and operating speeds.
Bicycle Box (Bike Box)	A designated area on the approach to a signalized intersection, between an advance motor vehicle stop line and the crosswalk or intersection, intended to provide bicyclists a visible place to wait in front of stopped drivers during a red signal phase
Bicycle Facilities	A general term denoting provisions to accommodate or encourage bicycling, including bicycle boulevards, parking facilities, bikeways, bikeway maps and shared roadways not specifically designated for bicycle use.
Bicycle Investment Routes	Prioritized bicycle routes that guide future MnDOT investments in bicycle facilities across the state.
Bicycle Level of Service (BLOS)	An equation used to estimate bicyclists’ average perception of comfort or stress between two roadway intersections. The equation reflects factors such as roadway width, bike lane widths and striping combinations, traffic volume, pavement surface conditions, motor vehicles speed and type, and on-street parking.
Bicycle Network	A continuous system of bicycle facilities and roadways in a region or municipality comprised of a range of facility types (e.g. bike lanes, separated bike lanes, shared use paths, etc.), linked together to facilitate short trips to and from destinations and long linear connections across a city or region.
Bicycle Route	A roadway or shoulder signed to encourage bicycle use (MN Statute 169.011 Subd. 7)

TERM	DEFINITION
Bicycle Trail (Bike Trail)	Bicycle route or bicycle path developed by the commissioner of natural resources under section 85.016. (MN Statute 169.011 Subd 8)
Bicycle Signal (Bike Signal)	A standard traffic signal designated for bicycle use including either the “Bicycle Signal” sign (R10-10b) or a bicycle signal face.
Bicycle Signal Face	The bicycle signal face is a new traffic control device that is being used to provide for separate control of bicycle movements. Using a bicycle signal face is optional. The FHWA has allowed MnDOT interim approval to install bicycle signal heads throughout the state.
Bicyclist User Profile	A generalized profile of different types of bicyclists based on their comfort when bicycling with motor traffic. Also considers their bicycling skills and experience. Profiles range from the Highly Confident to Somewhat Confident to Interested but Concerned.
Bike Lane (Bicycle Lane)	A portion of a roadway or shoulder designed for exclusive or preferential use by persons using bicycles. Bicycle lanes are to be distinguished from the portion of the roadway or shoulder used for motor vehicle traffic by physical barrier, striping, marking, or other similar device. (MN Statute 169.011 Subd. 5)
Bollard	A short post used to divert traffic from an area or road.
Buffer	Refers to the distance between the edge of the bicycle facility to the edge of the travel path for another mode. This may be a motor vehicle travel lane, a railroad line or a pedestrian facility. Buffers can be painted, landscaped, raised, and may have a variety of objects or barriers within them.
Buffered Bike Lane	A bicycle lane that is separated from the adjacent travel lane or parking lane by a buffer area, which may include chevron or diagonal markings.
Chicane	Curb extensions that alternate from side to side to create a serpentine motor vehicle path to reduce speeds.
Control Vehicle	An infrequent large motor vehicle on a roadway. For example, tractor-trailers and large emergency vehicles are generally considered control vehicles.
Contraflow Bicycle Lane	A bicycle lane designed to allow bicyclists to travel in the opposite direction of motor vehicle traffic.
Controlled Access Highway	A roadway where the commissioner of transportation, by order, can prohibit or regulate highway use by pedestrians, bicycles, or other nonmotorized traffic, or by motorized bicycles, or by any class or kind of traffic which is found to be incompatible with the normal and safe flow of traffic (MN Statute 169.305).
Crosswalk	That portion of a roadway ordinarily included with the prolongation or connection of the lateral lines of sidewalks at intersections; any portion of a roadway distinctly indicated for pedestrian crossing by lines or other markings on the surface. (MN Statute 169.011 Subd 20)
Curb Extension	Extending the sidewalk or curb line into the parking lane, which visually and physically reduces the effective roadway width and increases the overall visibility of/for pedestrians by aligning them with the parking lane and reducing the crossing distance. Also known as bump-out.
Curb Ramp	A short ramp cutting through a curb or built up to it, which provides an accessible route that people with disabilities can use to safely transition from a roadway to a curbed sidewalk and vice versa.
Cycletrack	See separated bike lane.
Diverging Diamond Interchange (DDI)	A type of alternative intersection

TERM	DEFINITION
Design Speed	A selected speed used to determine the various geometric design features of a roadway or bicycle facility.
Design Vehicle	A frequent user of a facility.
Detectable Warning (Detectable Edge)	See truncated domes.
Driver	Every person who drives or is in actual physical control of a motor vehicle. (MN Statute 169.011 Subd 24)
Edge Line Markings	Lines that outline and separate the outside edge of the travel lane from the shoulder.
Electric-Assisted Bicycle	Also known as e-bikes. A bicycle or tricycle with a saddle and fully operable pedals for human propulsion; has an electric motor with a power output of no more than 1,000 watts; is incapable of speeds greater than 20 miles per hour; and disengages or ceases to function when the vehicle's brakes are applied. Electric-assisted bicycle does not include a motorized bicycle, as defined in 169.223.
Grade Separated	The vertical separation of conflicting travel-ways with a structure, such as an interchange, overpass or underpass
HAWK	High Intensity Activated Crosswalk; see pedestrian hybrid beacon.
High Speed Road	A road in which a permanent speed limit of greater than 45 mph applies.
Highly Confident Bicyclists	A general term denoting bicyclists who have the most tolerance for traffic stress and are generally comfortable operating in mixed-composition traffic, regardless of traffic conditions. They are comfortable taking the lane and riding in a vehicular manner on major streets without designated bicycle facilities. This group represents 4-7 percent of the general population.
Highway	The entire width between boundary lines of any way or place when any part thereof is open to the use of the public, as a matter of right, for the purposes of vehicular traffic (MN Statute 169.011 Subd. 81). A general term denoting a public way for purposes of vehicular travel.
Interested but Concerned Bicyclists	A general term denoting bicyclists who have the lowest tolerance for traffic stress and prefer physical separation from motor vehicle traffic or bicycling on low-volume, low-speed roadways. This group represents 51-56 percent of the general population.
Intersection	The crossing of two or more highways or bicycle facilities at the same grade. (MN Statute 169.011 Subd 36)
Island	See median refuge island.
Land Use Context	Areas of land with a unique combination of characteristics that reflect the place and activities that occur there. MnDOT defines nine land use contexts in Technical Memorandum No. 18-07-TS-05 (MnDOT Land Use Contexts: Types, Identification and Use)
Leading Pedestrian Interval (LPI)	An advance WALKING PERSON (symbolizing WALK) indication displayed for a crosswalk while red indications continue to be displayed to parallel through and/or turning traffic. Gives pedestrians the opportunity to enter an intersection before motor vehicles are given a green indication so pedestrians can better establish their presence in the crosswalk before motor vehicles.
Level of Service	The vehicular intersection delay rating established in the Highway Capacity Manual.
Level of Traffic Stress (LTS)	A method of classifying road segments and bicycle facility networks based on how comfortable people with different confidence levels are when bicycling and interacting with people in a motor vehicle.

TERM	DEFINITION
Low Speed Road	A road in which a permanent speed limit of 45 mph or less applies, but not being a speed limit which applies only because of a temporary reason such as roadwork or a roadway event.
Median Refuge Island	A raised area located between opposing traffic lanes at an intersection or midblock location, which separates crossing pedestrians and bicyclists from motor vehicles. Also known as an island or raised median.
MN MUTCD	Similar to the “Manual on Uniform Traffic Control Devices,” this document contains the standards, as adopted by the Minnesota Commissioner of Transportation, for traffic control devices that regulate, warn and guide roadway users along all roadways within the State of Minnesota.
Motor Vehicle	Every vehicle which is self-propelled and every vehicle which is propelled by electric power obtained from overhead trolley wires. Motor vehicle does not include an electric personal assistive mobility device or a vehicle moved solely by human power. (MN Statute 169.011 Subd 42)
Mumble Strips	See rumble strips.
MUTCD	The “Manual on Uniform Traffic Control Devices,” approved by the Federal Highway Administration as a national standard for placement and selection of all traffic control devices on or adjacent to all highways open to public travel.
Nonmotorized	Pedestrian, bicycle and other types of traffic propelled by human power.
Path	See shared use path
Paved Shoulder	A portion of shoulder with concrete or bituminous surfacing that can support motor vehicle loading, among other functions, provides space for pedestrian and bicycle travel.
Pedestrian	Any person afoot or in a wheelchair. (MN Statute 169.011 Subd. 53)
Pedestrian Hybrid Beacon (PHB)	A traffic control device to consider at locations that do not meet traffic control signal warrants or for locations where it might be undesirable to provide a traffic control signal. This device should only be installed in conjunction with marked crosswalks and pedestrian countdown signals. Also known as a HAWK (High Intensity Activated Crosswalk).
Protected Intersection	An at-grade road junction where bicyclists and pedestrians are set back and separated from motor vehicles. Protected intersections use a variety of design elements to create safe, comfortable conditions for bicyclists and pedestrians, such as corner safety islands, corner/truck aprons to accommodate the wheel tracking of heavy motor vehicles, pedestrian crossing islands and more.
Restricted Crossing U-Turn intersection. (RCUT)	A type of alternative intersection under the category of reduced conflict intersections.
Recumbent Bicycle	A bicycle with pedals at roughly the same level as the seat where the operator is seated in a reclined position with their back supported.
Reduced Conflict Intersection	Intersections that decrease fatalities and injuries caused by broadside crashes on four-lane divided highways. Drivers approaching divided highways from a side street are not allowed to make left turns or cross traffic; instead, they are required to turn right onto the highway, then make a U-turn at a designated median opening. An RCUT is a type of RCI.
Right-of-Way	A general term denoting land, property, or interest therein, usually in a strip, acquired for or devoted to transportation purposes. “Right-of-way” also may mean the privilege of the immediate use of the highway. (MN Statute 169.011 Subd. 66)

TERM	DEFINITION
Road Diet	A method to reallocate travel lanes and use the space for other uses and travel modes. The most common type of road diet reduces the number of through lanes from four to two and adds a center two-way left turn lane (TWLTL). A road diet is an FHWA proven safety countermeasure.
Roadway	That portion of highway improved, designed, or ordinarily used for vehicular travel, exclusive of the sidewalk or shoulder. In the event a highway includes two or more separate roadways, the term “roadway” as used herein shall refer to any such roadway separately but not to all such roadways collectively. (MN Statute 169.011 Subd. 68)
Roundabout	A circular intersection that generally provides yield control to all entering motor vehicles and features channelized approaches and geometry to encourage reduced travel speeds through the circular roadway.
RRFB	Rectangular Rapid Flashing Beacon.
Rumble Strips	A countermeasure for reducing roadway departure crashes, exhibited by strips that produce noise and vibration through a motor vehicle to alert an inattentive driver when they leave the travel lane. There are various types, including: rumble stripes: a rumble strip that contains a pavement marking stripe and shoulder rumble strips: rumble strips outside the edgeline.
Rural Section (Rural Cross-Section)	A highway design that has wide rights-of-way, open ditches for drainage and a clearway of usually 30 ft from the edge of the outside line. The terminology refers only to the typical roadway cross-section, regardless of its location, and does not pertain to land use adjacent to the roadway.
Separated Bike Lane (Separated Bicycle Lane)	A bicycle lane that is physically separated from motor vehicle traffic by vertical elements and a horizontal separation from motor vehicle traffic. Also known as protected bike lanes or cycle tracks.
Shared Lane	A lane where motor vehicles and bicycles share operating space.
Shared Use Path	A bicycle facility that is physically separated from motor vehicle traffic by an open space or barrier, located within either the highway right-of-way or an independent right-of-way and available for use by other nonmotorized users. (MN Statute 160.02 Subd 27a). Also known as trail or path; MnDOT uses only the term shared use path. A sidepath is a type of shared use path.
Shoulder	Part of a highway which is contiguous to the regularly traveled portion of the highway and is on the same level as the highway. The shoulder may be pavement, gravel, or earth. (MN Statute 169.011 Subd. 74)
Shoulder Bike Lane	See bike lane.
Sidepath	A shared use path located adjacent and parallel to (alongside) a roadway.
Sidewalk	Portion of a street between the curb lines, or the lateral lines of a roadway and the adjacent property lines intended for the use of pedestrians. (MN Statute 169.01 Subd. 75)
Sidewalk Buffer	Distance between the edge of the sidewalk and the roadway. This space is typically landscaped, however may be hard surfaced or include a variety of objects and/or barriers.
Sight Distance	On a vertical curve, the distance at which an object zero feet above the pavement surface can be seen from a point 3.83 feet above the pavement

TERM	DEFINITION
Somewhat Confident Bicyclists	A general term denoting bicyclists who are comfortable on most types of bicycle facilities, but have a lower tolerance for traffic stress than the Highly Confident Bicyclist. They generally prefer bicycling on striped or separated bike lanes on major streets and on low-volume residential streets, but are typically tolerant of higher levels of traffic stress for short distances when bicycling for transportation. They may prefer lower traffic stress conditions when bicycling for recreation. This group represents 5-9 percent of the general population.
Single Point Urban Interchange (SPUI)	A type of alternative intersection.
State Bicycle Route	A connected network of prioritized bicycle routes within Minnesota that connect communities and destinations. The routes function as a guide for prioritizing infrastructure investments and formal route designation.
Statewide Bicycle System Plan	MnDOT's vision and goals for bicycle transportation, implementation strategies and performance measures to evaluate progress toward achieving the Statewide Bicycle System Plan vision and goals.
Street	The entire width between boundary lines of any way or place when any part thereof is open to the use of the public, as a matter of right, for the purposes of vehicular traffic. (MN Statute 169.011 Subd. 81)
Street Buffer	See buffer.
Traffic	Pedestrians, ridden or herded animals, motor vehicles, streetcars and other conveyances, either singly or together, while using any highway for purposes of travel. (MN Statute 169.011 Subd 84)
Traffic Calming	Measures that support the livability and vitality of residential and commercial areas through improvements in non-driver safety, mobility and comfort. This LOS is typically achieved by reducing motor vehicle speeds or volumes on a single roadway or a roadway network. Measures consist of horizontal, vertical, lane narrowing, roadside and other features that use self-enforcing physical or psycho-perception means to produce preferred effects.
Traffic-Control Signal	Any device, whether manually, electrically or mechanically operated, by which traffic is alternately directed to stop and permitted to proceed. (MN Statute 169.011 Subd 85)
Trail	See bicycle trail
Traveled Way	The portion of the roadway intended for the movement of motor vehicles, exclusive of shoulders and any bike lane immediately inside of the shoulder.
Travel Lane	A lane for the movement of motor vehicles traveling from one destination to another, not including shoulders.
Truncated Domes	A feature built in or applied to a walking surface to indicate an upcoming change from pedestrian to vehicular way. Also known as detectable warnings.
Trunk Highways	All roads established or to be established under the provisions of the Constitution of the State of Minnesota. (MN Statute 160.02 Subd. 29)
Two-Stage Turn Box (Turn Box)	A designated area at an intersection to provide bicyclists a place to wait to complete a two-stage turn from a separated bike lane or bike lane outside of the path of moving traffic
Under-served and Underrepresented Communities	Includes low-income communities, communities of color, indigenous communities, older adults, people with disabilities, women and youth, rural residents and people with limited motor vehicle access.
Urban Section (Urban Cross-Section)	A roadway design that includes curbs and gutters; refers only to the typical roadway cross-section, regardless of its location and does not pertain to land use adjacent to the roadway.

TERM	DEFINITION
U.S. Bicycle Route System	A national network of numbered bicycle routes designated by State Departments of Transportation composed of multiple types of bicycle facilities, including off-road paths, bike lanes and low-traffic roads.
Vehicle	Every device in, upon, or by which any person or property is or may be transported or drawn upon a highway, excepting devices used exclusively upon stationary rails or tracks. (MN Statute 169.011 Subd. 92)
Vulnerable User	Road users who are most at risk for serious injury or death when they are involved in a motor vehicle related collision. This includes pedestrians, bicyclists and motorcyclists of all ages, types and abilities, particularly older pedestrians and people with disabilities.
Wayfinding	Directional signs at strategic points that guide people along a bicycle route or to destinations.
Wide Outside Lane	Right-most through traffic lanes that are wider than 3.6 m (12 ft). Also called a wide curb lane in some cases. Not considered a bicycle facility type.
Work Zone	A zone where workers, flaggers and surveyors are present in bright yellow-green or orange vests; an area marked with orange cones or barrels, concrete barriers, traffic control devices or moving motor vehicles with flashers. Operations can occur day and night .

Appendix C: References

- 1 Statewide Bicycle System Plan <http://www.dot.state.mn.us/bike/documents/planning-research/statewide-bicycle-system-plan.pdf>
- 2 MnDOT Road Design Manual <https://roaddesign.dot.state.mn.us/>
- 3 Minnesota Manual on Uniform Traffic Control Devices <https://www.dot.state.mn.us/trafficeng/publ/mutcd/>
- 4 AASHTO Guide for the Development of Bicycle Facilities (2012). *AASHTO Task Force on Geometric Design*. American Association of State Highway and Transportation Officials, Washington, DC: 2012
- 5 FHWA Separated Bike Lane Planning and Design Guide https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/separated_bikelane_pdg/page00.cfm
- 6 FHWA Bikeway Selection Guide https://safety.fhwa.dot.gov/ped_bike/tools_solve/docs/fhwasa18077.pdf
- 7 Minnesota Rules Chapter 8820 <https://www.dot.state.mn.us/stateaid/programlibrary/stateaidrules.pdf>
- 8 Federal Highway Administration Bicycle and Pedestrian Planning, Program, and Project Development https://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/guidance_2019.cfm
- 9 United States Department of Transportation Policy Statement on Bicycle and Pedestrian Accommodation Regulations and Recommendations https://www.ada.gov/2010_regs.htm
- 10 A Policy on Geometric Design of Highways and Streets, 7th Edition. *AASHTO Task Force on Geometric Design*. American Association of State Highway and Transportation Officials, Washington, DC: 2018.
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- 15 MnDOT District Bicycle Plans <http://www.dot.state.mn.us/bike/district-bicycle-plans.html>
- 16 Context Sensitive Solutions <https://www.dot.state.mn.us/context-sensitive-solutions/about.html>
- 17 MnDOT Policies: Complete Streets <http://www.dot.state.mn.us/policy/operations/op004.html>
- 18 Title VI of the Civil Rights Act of 1964 <https://www.justice.gov/crt/fcs/TitleVI-Overview>
- 19 Environmental Justice at MnDOT <http://www.dot.state.mn.us/environmentaljustice/>
- 20 MnDOT Policies: Performance-Based Practical Design <http://www.dot.state.mn.us/pbpd/>
- 21 MnDOT Tech Memos <https://techmemos.dot.state.mn.us/>
- 22 What is TZD? <http://www.minnesotatzd.org/whatistzd/>
- 23 The Four Es and More <http://www.minnesotatzd.org/whatistzd/foures/>
- 24 MnDOT Pedestrian and Bicycle Data Program <http://www.dot.state.mn.us/bike/bicycle-pedestrian-traffic-counts.html>
- 25 MNDOT CAV Strategic Plan <http://www.dot.state.mn.us/automated/docs/cav-strategic-plan.pdf>
- 26 Connected and Automated Vehicles <http://www.dot.state.mn.us/automated/>
- 27 Bicycle and Pedestrian Traffic Counts <http://www.dot.state.mn.us/bike/bicycle-pedestrian-traffic-counts.html>

- 28 About Minnesota State Highway Investment Plan (MnSHIP) <https://www.dot.state.mn.us/planning/mnship/>
- 29 MnDOT's 10-Year Capital Highway Investment Plan (CHIP) <http://www.dot.state.mn.us/planning/10yearplan/index.html>
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- 37 Public Engagement at MnDOT <http://www.dot.state.mn.us/publicengagement/index.html>
- 38 Strategic Framework for Public Engagement Planning <http://www.dot.state.mn.us/publicengagement/plans-templates-tools.html>
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- 74 MnDOT Work Zones - Temporary Traffic Control Manuals and Guidelines <http://www.dot.state.mn.us/trafficeng/workzone/wzmanual.html>
- 75 Parks and Trails Council Research Bike <https://www.parksandtrails.org/news/researchbike-adventure-underway/>

- 76 MnDOT Pavement Preservation Manual <https://www.dot.state.mn.us/materials/pavementpreservation/manualsandguides/documents/MnDOT%20Pavement%20Preservation%20Manual%207.19.18.pdf>
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- 79 WisDOT Bicycle Facility Design Manual Appendix A: Maintenance and Operations. <https://wisconsindot.gov/Documents/projects/multimodal/bike/facility-app.pdf>
- 80 MnDOT LRFD Bridge Design Manual <http://www.dot.state.mn.us/bridge/lrfd/section02-update08-2018-10-30.pdf>
- 81 Fiscal Year 2016 through 2020 Bridge Preservation and Improvement Guidelines <http://www.dot.state.mn.us/bridge/pdf/bridge-preservation-and-improvement-guidelines-2016-2020.pdf>
- 82 NCHRP Report 672 - Roundabouts: An Informational Guide <https://nacto.org/docs/usdg/nchrprpt672.pdf>
- 83 Diverging Diamond Interchange Design and Implementation Guidance <http://dotapp7.dot.state.mn.us/edms/download?docId=1786834>
- 84 Restricted Crossing U-Turn (RCUT) Design and Implementation Guidance <http://dotapp7.dot.state.mn.us/edms/download?docId=1783214>
- 85 FHWA Proven Safety Countermeasure https://safety.fhwa.dot.gov/provencountermeasures/ped_medians/
- 86 MN Administrative Rules Establishing Grade Crossings <https://www.revisor.mn.gov/rules/8830.2700/>
- 87 MNDOT Curb Ramp Standard Plan <https://www.dot.state.mn.us/ada/pdf/5-297-250.pdf>
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Appendix D: Funding for Bicycle Transportation

EXHIBIT 8-1: Funding sources for bicycle facility planning, design and construction

FUNDING TYPE	LEVEL OF GOVT	FUNDING SOURCE	ELIGIBLE USES	WEBSITE
Infrastructure	Federal	Bicycle and Pedestrian Facilities: Federal Transportation Funding allocated through the Regional Solicitation process	Multiuse trails and bicycle facilities, Pedestrian facilities and Safe Routes to School Infrastructure Projects.	https://metro council.org/Transportation/Planning-2/Transportation-Funding/Regional-Solicitation.aspx
Infrastructure	Federal	Roadways including Multimodal Elements: Federal Transportation Funding allocated through the Regional Solicitation process	Integrating bicycle and pedestrian infrastructure into roadway expansion, Roadway reconstruction, Bridge rehabilitation/replacement projects. Traffic management technologies: Passive detectors for bicyclists and pedestrians, bicycle and pedestrian signal improvements as part of traffic signal projects.	https://metro council.org/Transportation/Planning-2/Transportation-Funding/Regional-Solicitation.aspx
Infrastructure	Federal	Travel Demand Management: Federal Transportation Funding allocated through the Regional Solicitation process	Programs and infrastructure to provide residents and commuters with greater transportation choices and options. Bikeshare is listed as an example project.	https://metro council.org/Transportation/Planning-2/Transportation-Funding/Regional-Solicitation.aspx
Planning	Federal	National Park Service: Rivers, Trails and Conservation Assistance Program (RTCA)	Technical assistance via direct NPS staff involvement to establish and restore greenways, rivers, trails, watersheds and open space	https://www.nps.gov/orgs/rtca/index.htm
Infrastructure	Federal	National Park Service: Federal Lands Access (FLAP)	The FLAP was established to improve transportation facilities that provide access to, are adjacent to, or are located within Federal lands. The Access Program supplements state and local resources for public streets, transit systems and other transportation facilities, with an emphasis on high-use recreation sites and economic generators. Funds capital improvements, enhancements, surface preservation, transit, planning, safety and research.	https://flh.fhwa.dot.gov/programs/flap/mn/

FUNDING TYPE	LEVEL OF GOVT	FUNDING SOURCE	ELIGIBLE USES	WEBSITE
Infrastructure	Federal	U.S. Department of Transportation: TIGER Discretionary Grants	Fund capital investments in surface transportation infrastructure and are awarded on a competitive basis.	https://www.transportation.gov/tiger
Infrastructure	Private	The Conservation Fund	Provides loans for land acquisition to support the creation of bicycle and pedestrian facilities that also support environmental conservation. Their loan program offers flexible financing and sustained and expert technical assistance to organizations aiming to protect key properties in their communities.	https://www.conservationfund.org/our-work/urban-conservation
Programs	Private	Blue Cross Blue Shield Center for Prevention	Programming that focuses on health equity, active living, tobacco and healthy eating.	https://www.centerforpreventionmn.com/
Infrastructure and Programs	State	State Funds for Safe Routes to School (SRTS)	Provides funding and resources to community and school groups to support students walking and biking to school. The state continues to invest in infrastructure projects as well as non-infrastructure programs through competitive grants.	http://www.dot.state.mn.us/saferoutes/grants-funding.html
Programs	State	MnDOT SRTS Planning Assistance Program	Grants to schools and communities to develop SRTS travel plans. Plans are completed by RDCs or a statewide SRTS consultant.	http://www.dot.state.mn.us/saferoutes/planning-grants.html
Infrastructure	State	DNR Local Trail Connections Program	Grants to local units of government to promote relatively short trail connections between where people live and public resources (e.g. historical areas, open space, parks and/or other trails).	http://files.dnr.state.mn.us/assistance/grants/recreation/local_trails_connection/ltc_manual.pdf
Infrastructure and Programs	State	MN Department of Health Statewide Health Improvement Partnership (SHIP)	Awards funding to Community Health Boards for coordinating and implementing evidence-based strategies targeted at reducing the percentage of Minnesotans who are obese or overweight and reducing the use of and exposure to tobacco.	https://www.health.state.mn.us/communities/ship/quickfacts.html
Infrastructure	State	State Bonding	Capital projects that are approved by the legislature	http://www.house.leg.state.mn.us/hrd/pubs/stbonding.pdf

Appendix E: Bicycle Scoping Guide

PURPOSE

The purpose of the bicycle scoping guide is to supplement the scoping and subject guidance for bikeway development in MnDOT's existing [Highway Project Development Process](#). This guide is designed to help District staff determine if bicycle facilities should be included on any given roadway and if crossing improvements are needed, generally during the scoping phase of project development.

SCOPING CHECKLIST

EXISTING CONDITIONS	
Are bicyclists legally prohibited from using the roadway (is there signage prohibiting bicycles)? (If yes, skip to Projected Demand section)	<input type="checkbox"/> Yes <input type="checkbox"/> No
Is there currently a dedicated facility for bicyclists? This may include: shared use path, bicycle lane (separated or not), and/or a wide paved shoulder	<input type="checkbox"/> Yes <input type="checkbox"/> No
PROJECTED DEMAND	
Is the project located directly on or travel across an existing or planned bikeway? (i.e. Transportation Plan, Bicycle Plan, MnDNR, County Plan)	<input type="checkbox"/> Yes <input type="checkbox"/> No
Is the project within a half mile of a school, and if so, is there a Safe Routes to School Plan that identifies a need for improvements?	<input type="checkbox"/> Yes <input type="checkbox"/> No
IMPROVEMENT OPPORTUNITIES ACROSS THE ROADWAY	
How does the project area score on the District Bicycle Plans route prioritization analysis?	<input type="checkbox"/> Tier 1 <input type="checkbox"/> Tier 2 <input type="checkbox"/> Tier 3 <input type="checkbox"/> Tier 4 <input type="checkbox"/> Tier 5
Are there other crossings that may warrant improvement due to a local plan? This may include: Safe Route to School Plan, MnDNR Trail Master Plan, City Comprehensive Plan, or any similar document that suggests there may be a future demand for an improved crossing.	<input type="checkbox"/> Yes <input type="checkbox"/> No
Who would maintain the crossings?	<input type="checkbox"/> MnDOT <input type="checkbox"/> Local partner has agreed to maintain <input type="checkbox"/> Local partner would be responsible, but maintenance agreement has not been discussed

IMPROVEMENT OPPORTUNITIES ALONG THE ROADWAY	
Is the project identified in a District Bicycle Plan? If so, what priority level does the Plan identify?	<input type="checkbox"/> High Priority <input type="checkbox"/> Medium Priority <input type="checkbox"/> Low Priority <input type="checkbox"/> Not identified
If the project is not identified as a Bicycle Investment Route in a District Bicycle Plan, how does the project score on the District Bicycle Plans route prioritization analysis? (Estimate the average priority level of the hexagons that the project traverses.)	<input type="checkbox"/> Tier 1 <input type="checkbox"/> Tier 2 <input type="checkbox"/> Tier 3 <input type="checkbox"/> Tier 4 <input type="checkbox"/> Tier 5
Who would maintain the facility?	<input type="checkbox"/> MnDOT <input type="checkbox"/> Local partner has agreed to maintain <input type="checkbox"/> Local partner would be responsible, but maintenance agreement has not been discussed
PROJECT BUDGET CONSIDERATIONS	
Are improvements consistent with MnDOT's Complete Streets policy, MnSHIP and other applicable funding guidance? If yes, summarize below:	<input type="checkbox"/> Yes <input type="checkbox"/> No
Should other funding be pursued for the project? (TAP , others?)	<input type="checkbox"/> Yes <input type="checkbox"/> No
Does a local partner have a cost participation requirement?	<input type="checkbox"/> No <input type="checkbox"/> Yes, and local partner has agreed to participate in costs <input type="checkbox"/> Yes, but cost participation has not been discussed
IMPROVEMENT OPPORTUNITIES ACROSS THE ROADWAY	
How does the project area score on the District Bicycle Plans route prioritization analysis?	<input type="checkbox"/> Tier 1 <input type="checkbox"/> Tier 2 <input type="checkbox"/> Tier 3 <input type="checkbox"/> Tier 4 <input type="checkbox"/> Tier 5
Are there other crossings that may warrant improvement due to a local plan? This may include: Safe Route to School Plan, MnDNR Trail Master Plan, City Comprehensive Plan, or any similar document that suggests there may be a future demand for an improved crossing.	<input type="checkbox"/> Yes <input type="checkbox"/> No
Who would maintain the crossings?	<input type="checkbox"/> MnDOT <input type="checkbox"/> Local partner has agreed to maintain <input type="checkbox"/> Local partner would be responsible, but maintenance agreement has not been discussed

DECISION MAKING GUIDANCE

The decision on when to incorporate bicycle accommodations on a project depends on many different factors. The scoping checklist is intended to help decision makers determine when it is appropriate to incorporate bicycle improvements.

Examples:

EXAMPLE 1

Is the project identified in a District Bicycle Plan? If so, what priority level does the Plan identify?

- ☒ High Priority
- ☐ Medium Priority
- ☐ Low Priority
- ☐ Not identified

Projects on high priority bicycle routes should be strongly considered for a bicycle facility. If existing bicycle facilities are adequate, these facilities should generally be improved with the project (barring inability to agree with local partners on maintenance responsibilities). When determining the appropriate facility type or project design, consider future bicycle and pedestrian volumes (which may increase following installation).

EXAMPLE 2

How does the project area location score on the District Bicycle Plans route prioritization analysis?

- ☐ Tier 1
- ☐ Tier 2
- ☐ Tier 3
- ☐ Tier 4
- ☐ Tier 5



Consider a hypothetical project on TH 210 between Underwood and Fergus Falls which does not cross any Bicycle Investment Routes (green lines). In this situation, improvements should be considered for key crossings in areas that scored higher in the route prioritization analysis. This is likely limited to areas within Fergus Falls and Underwood with dark blue hexagons. The decision to improve any given crossing for bicycles will be a location-specific decision and should be funded from the project budget.

Appendix F: Interim Approvals

IA NUMBER	TITLE	FHWA ISSUED	STATEWIDE APPROVAL FOR ALL MN JURISDICTIONS	BIKE MANUAL PAGE REFERENCE
14	Green Colored Pavement for Bike Lanes	April, 2011	May, 2012	4-9
16	Bicycle Signal Faces	December, 2013	September, 2014	4-21
18	Intersection Bicycle Boxes	October, 2016	November, 2016	5-52
20	Two-Stage Bicycle Turn Boxes	July, 2017	July, 2017	5-49
21	Pedestrian-Actuated Rectangular Rapid-Flashing Beacons at Uncontrolled Marked Crosswalks	March, 2018	April, 2018	5-19

In order to comply with the FHWA requirements for Statewide Interim Approvals, please report the location of all devices using a Statewide Interim Approval to MnDOT's Office of Traffic Engineering through the [Statewide Interim Approvals](#) website.