Complete Streets Manual

CITY OF BEND

May 2023

Accommodation Information for People with Disabilities
To obtain this information in an alternate format such as Braille, large print, or electronic formats, please contact streetspublic@bendoregon.gov, 541.317.3000 ext. 3. Relay Users Dial 7-1-1

Complete Streets Checklist

Creating a community-wide network of safe, comfortable streets that provide travel options for people of all ages and abilities requires a purposefully built complete street transportation network from the front doors of residences and businesses all the way to destinations. Planners, designers, and builders are encouraged to review this outline and checklist during every project phase It is not a comprehensive tool, but rather a list of key or often missed elements. It is intended to promote complete streets designs meeting or exceeding the minimum requirements in the Development Code and Standards.

Planning and Design Resources

The following documents provide information on the different elements of the complete street network:

- **Comprehensive Plan, Bend Development Code, and Building Code**: Outlines requirements for complete streets for the city-wide network, within developments, and to access buildings. (https://www.bendoregon.gov/government/city-codes)
- **Arterial and Collector Street locations:** TSP Figure 4-3 Functional Classification Map (https://www.bendoregon.gov/city-projects/transportation-system-plan)
- **Local Street Locations:** No map, layout developed per Bend Development Code and Engineering Standards
- **Bicycle Low Stress Network:** TSP Figure 5-1 Low Stress Bicycle Network (includes TSP Figure 5-3b Key Walking and Bicycling Routes) and standard cross-sections (https://www.bendoregon.gov/city-projects/transportation-system-plan)
- **Pedestrian Low Stress Network:** No map, sidewalks/paths required on all streets and as specified by the Bend Development Code and Standards including part VI Appendix C - Connector Routes and Crossings Map
- **Transit:** TSP Figure 5-2 Primary Transit Corridors and Mobility Hub Locations and the CET Transit Master Plan (https://cascadeseasttransit.com/about/2040-transit-master-plan/)
- **Trails:** TSP Figure 5-1 and the Bend Park and Recreation District (BPRD) Comprehensive Plan Map 4-Trail Map (https://www.bendparksandrec.org/about/planning-and-development/comprehensive-plan/)

The City's online GIS maps (https://www.bendoregon.gov/services/resources/mapping-services) show a variety of data layers related to complete streets including much of the above information.

Key Elements

- **Build Facilities for All Ages and Abilities:** Recognize that people walking, biking, and using transit include a diverse group of user types with different abilities. Incorporate Universal Design principals to serve more people across a wider range of abilities.
- **Include Safety in all Aspects**: Incorporate a Safe Systems Design approach to reduce risk of crashes and injuries and to reduce consequences if a crash does occur.
- **Prioritize Travel Options:** Emphasize design of facilities for walking, biking, transit, micromobility as applicable for the context of each street so that travel options other than just the single occupant automobile are just as easy to access and use.
- **Integrate Transit and Micromobility:** Locate transit and micromobility facilities so they are easily accessed enroute to/ from residences and destinations with comfortable, weather protected waiting and storage areas.
- **Design a Comfortable and Connected Network:** Build walking, biking, and transit routes that are connected, continuous, and separated. Where feasible separate people walking, biking, and driving.
- **Slow Speeds:** Create the street infrastructure and layout to encourage the target speed by design.
- **Openly Evaluate Trade Offs in Constrained Design:** There are tradeoffs when retrofitting complete streets in existing right-of-way. Develop options that serve the streets priorities and include a frank evaluation of the benefits and impacts to different modes for the segment and the network to facilitate the tradeoff choice.
- **Consider Maintenance:** Build infrastructure that is easily and efficiently maintained in all seasons.
- **Incorporate Placemaking:** Include streetscape features to build environmentally supportive and attractive places that encourage people to connect and interact.
- **Provide Wayfinding:** Use strategic signing to make it easy for people walking, biking, and driving to navigate from within private sites to and along public routes to access destinations.

Checklist

Site Design

- ☐ The land use and internal circulation system is oriented to directly connect schools, parks, and major destinations to the low stress network. The routes are easy to navigate for people walking, biking, and using transit.

- Where the project is near but not along a low stress route, the project includes sidewalks, paths, and bikeways to connect the site to the nearby low stress route including offsite infrastructure as feasible.
- Facilities for people walking and biking are designed to be separated from vehicle traffic. As appropriate spaces for walking and biking are separated and wide enough to allow for passing.
- The speed limit fits the context, as permitted by the Oregon Speed Zone law
- The street layout is designed to support connectivity and slower speeds while discouraging faster, uninterrupted travel.

Sidewalks and Shared Use Paths

- Sidewalks/paths connect to facilities on the adjacent block, or if there is no adjacent facility then the sidewalk/shared use path ends in a logical, safe spot providing the users an accessible way to get back to the street.
- The sidewalk layout provides a connected, continuous route to designated low - stress routes and enhanced/ marked crossings of arterial and collector streets.
- Within parking lots, a clearly identified and separated sidewalk/shared use path is provided for people parking to access the building outside of the drive aisles.
- Shared Use Paths cross arterial and collector streets at enhanced crossings located to connect the low stress network to major destinations, approximately ¼ mile spacing.

Bikeways

- Bikeways connect to the adjacent blocks, or if there is no adjacent facility then the bicycle facility ends at a safe and logical spot for people riding to continue their journey or turn around. Wayfinding and signing are installed as applicable to guide people through the transition.
- At intersections are the curb ramps are designed (width and location) to accommodate people biking in addition to mobility devices or walking.
- Pedestrian push buttons are located so that people biking can access them.
- Construction traffic control is designed and operated so that people riding bicycles can move safely through and around the work zone. On streets above 25 miles per hour explore options other than “Bikes on Road” sign that does not provide a comfortable route or adequate merge time.

Parking

- Parking is designed with curbside management providing flex spaces for shuttles, car share, deliveries, carpools, etc. to provide travel options and maximize parking use today or in the future.

- EV charging stations are in convenient, easily identified locations based on the land use and charging needs.
- Bicycle and micromobility parking are in a convenient location that is all-weather and secure.

Transit and Micromobility

- Transit and micromobility stops are in direct and convenient alignment to the building's main doors or the site's main walking and biking routes.
- Transit stops are along or directly connected by sidewalks/shared use paths to the Bicycle Low Stress Network and enhanced crosswalk locations.
- An all weather, secure shelter is provided to improve the safety and comfort of people waiting for transit. This may include such things as stops integrated into building design, or a covered shelter with bench and street lighting.
- Busier transit stops are integrated with other services to create mobility hubs or points.

Streetscape Elements

- Streets and public spaces are designed to encourage gathering and community with placemaking elements such as seating, art, information kiosks, bike repair stations, trash cans, and other amenities
- Waterwise landscaping and green infrastructure are used to support environmental stewardship and conserve resources.
- In business districts and other areas where people gather dark sky compliant pedestrian scale lighting is added.
- Above ground utilities are designed in locations that do not impact travel or visibility

Contents

Definitions

Access Corridor – Term used in the Bend Development Code referring to a separate or shared travel way for people walking and biking including paths, trails, bike lanes, shoulder bikeways, and shared roadways.

BPRD Trails – A walking and biking facility managed by the Bend Parks and Recreation District (BPRD). Some BPRD trails are outside of City rights-of-way and others overlap the city's facilities. BPRD trails are shown on the Trail Plan in the BPRD Comprehensive Plan and referenced in the city's Transportation Systems Plan (TSP). Not all the BPRD trail alignments were adopted on TSP Figure 5-1 Bicycle Low Stress Network map. Refer to the BPRD Comprehensive Plan for the complete extent of planned future BPRD trails.

Bicycle low stress network - A technical term used to describe the mapped system of connected bikeways identified in the Transportation Systems Plan as the minimum network planned to serve bicyclists of all ages and abilities. See Transportation System Plan Figure 5-1, Bicycle Low Stress Network for identified routes. The network includes both the route and the street crossing.

Bicycle low stress route – A bicycle route with specific infrastructure to achieve a Level of Traffic Stress 1 or 2 bicycling facility (as defined in the City of Bend Standards and Specifications) to accommodate people of all ages and abilities. The route may include, but is not limited to, a neighborhood greenway, multi-use path, buffered or separated bike lanes, trail or access corridor alignments.

Bicyclist – A person riding a bicycle or using other devices (scooter, one-wheel, skateboard, etc.) that operate at a bicycle speed and scale.

Bike Lane – A portion of a roadway for the exclusive use of people riding bicycles (includes striped and separated bike lanes).

Bikeway - Any road, path or way that is open to people riding bicycles regardless of whether such facilities are designated for the exclusive use of bicycles or are shared with other transportation modes. It includes:

- Sidewalks – except where prohibited by City Code (the downtown district)
- Bicycle facilities including bike lanes, shared use paths, and shared use trails
- Shared Roadways including shared lane streets, greenways, and plaza streets/ woonerfs
- Roadways- travel lanes where bicycles are permitted that are not specifically designed for people riding bicycles

Buffered Bike Lane – A bike lane offset from the vehicle travel lane by a double bike lane stripe. It provides a spatial offset from vehicles but not physical separation.

Complete Street – A street that includes bicycle facilities, walking facilities, and facilities for vehicles (including transit) is a complete street. It is designed to serve people of all ages and abilities traveling safely using a variety of modes. A complete street is planned, designed, operated, and maintained to enable safe, comfortable, connected, and reliable travel options across the variety of travel modes. Complete streets may include supporting infrastructure of parking and curbside management, streetscape (street amenities, landscaping, lighting, etc.), utilities, environmentally supportive design, transit facilities, and wayfinding.

Connector Routes and Crossings Map - A map in the Standards (Appendix C) that shows identified missing walking and biking facilities and enhanced arterial and collector street crossings for people walking to schools and parks. The development code includes requirements for completing the missing facilities.

Greenway/Neighborhood Greenway – A certain type of bikeway on the Bicycle Low Stress Network that is a shared lane local street with signs, pavement markings, and 20 mph speed limits. Greenways may have additional traffic calming to foster slower speeds or modal filters to discourage higher vehicle volumes. If the street lacks sidewalks on one or both sides the shared lanes may also serve as a pedestrian facility.

Key Walking and Biking Routes/ Key Route – Specific segments of the Bicycle Low Stress Network that are identified on TSP Figure 5-3b to prioritize project funding for low stress walking and biking routes.

Level of Traffic Stress – A rating for the level of comfort a facility provides for people biking or walking that ranges from LTS 1 (low stress) to LTS 4 (high stress).

Bicycle level of traffic stress – the rating for people riding bicycles

Pedestrian level of traffic stress - the rating for people walking.

Low Stress Network – A general technical term for the planned system of more comfortable walking and biking facilities designed to Level of Traffic Stress 1 or 2. See also pedestrian low stress network and bicycle low stress network.

Mobility Hub - A physical center that co-locates multiple transportation modes, such as transit, walking, bicycling and shared mobility services along with travel information and related amenities.

Micromobility - Micromobility a term used for an evolving category of individual travel vehicles that includes powered bicycles, powered standing scooters, powered seated scooters, powered self-balancing boards (e.g., One-wheel), powered non-self-balancing

boards (e.g., skateboards), and powered skates. These devices are smaller, lighter, and equipped with less power than vehicles and travel at 24 miles per hour or less.

Pedestrian – A person walking, using mobility devices, or other devices that operate at a pedestrian speed and scale.

Pedestrian Low Stress Network – A system of connected low stress routes for people walking. All streets are planned to have sidewalks or shared use paths that create a pedestrian low stress network. The standard street cross-sections require sidewalks or shared use paths on both sides of all streets. The pedestrian network also includes primary trails, connector trails, and Key Routes, requirements for which are defined in the Development Code. Because all streets and additional trails are planned as the pedestrian network, there is no specific pedestrian low stress network map like there is for the Bicycle Low Stress Network.

Protected bike lane – not used; see separated bike lane.

Separated bike lane – A bike lane physically separated from the roadway or vehicle travel lane; includes parking separated, delineator separated, or traffic separator (other vertical elements) separated as well as grade separated or raised bike lanes. Separated bike lanes are sometimes also referred to as protected bike lanes. They differ from buffered bike lanes by providing some type of physical offset from the vehicle travel lane such as a raised curb with delineator or a parked car.

Safe Routes to School Plan – A map that shows the primary low stress walking and biking routes and crossings between a school and adjacent residential area.

Sidewalk – A six-foot wide paved travel way designed for people walking that is separated from motor vehicle traffic. Sidewalks may also be used by people riding bicycles unless prohibited (e.g., City Code 6.35.000B prohibits riding bicycles on Downtown District sidewalks). Sidewalks that are offset from the curb/travel lane are separated sidewalks. The separation may be via a paved or landscaped surface. There are some existing sidewalks that are four or five feet in width, narrower than the current standard six-foot width.

Shared Use Path, also called a multi-use path in the Development Code – A paved travel way eight feet wide or more that is shared by people walking and riding bicycles. It is separated from motor vehicle traffic. Standard shared use path widths are shown on the standard cross-sections and vary from eight to ten feet.

Shared Use Trail, also called a multi-use trail in the Development Code – A type of shared-use path that is typically all or mostly outside of the street right of way. It is owned and managed by the Bend Park and Recreation District or others, not the city. It is paved when along a street and serving as the sidewalk/shared use path, otherwise may be paved or another surface.

Striped Bike Lane - A bike lane that includes striping only. The two types of striped bike lanes are a buffered bike lane and a lane-only bike lane. Neither type provides physical separation from the vehicle travel lane. The buffered bike lane provides spatial separation from the vehicle travel lane.

Woonerf, also called a Plaza street- A street designed to prioritize walking and biking along and across the street. It also allows lower volume and slower speed vehicles to share the travelway with people walking and biking.

General

Complete Streets Vision

The policies adopted in the City of Bend Transportation System Plan (TSP) and implemented through the Development Code and Standards identify the City's transportation network as a complete street system that provides travel options for people of all ages and abilities across all travel modes (walking, biking, driving, and transit). The vision is a network of complete streets that are planned, designed, operated, and maintained to enable safe, comfortable, connected, and reliable travel. Complete streets provide:

Safety and Comfort

- Designs that work to eliminate fatal and serious injuries across modes
- Infrastructure options for people that serve a range of ages, abilities, and comfort levels
- Street design and speed limits that fit the context including streets that prioritize low stress walking and biking

Connection

- Streets, trails, and shared use paths that link homes, schools, parks, businesses, and services
- A system that is easy to navigate between travel modes
- Reliable and predictable travel options for all including the most vulnerable members of our community such as children, people living with disabilities, older adults, or people who cannot afford, choose not to own/use, or do not have access to a car

Community

- Opportunities for neighborhoods that provide goods and services within a walkable, bikeable, or short drive radius
- Support economic vitality and providing inviting public spaces
- Safe streets that encourage use by everyone regardless of age, ability, ethnicity, income, or chosen travel

Sustainability

- Provide more travel options that can reduce vehicle trips and reduce fossil fuel use
- Lessen environmental impact through green infrastructure and right sized infrastructure

The complete street approach is a philosophy change from a higher speed; vehicle centric design based on highway design principles. It shifts to a more human centered design that focuses on the slower speed urban context with comfortable and safe facilities for people walking, biking, and driving. Every street is designed to serve all modes (driving, walking, biking, and transit as applicable). The priority and range of modes served will vary by street classification, context, location, and other factors. Some streets may be more oriented toward the pedestrian with slower and fewer vehicles. Other streets may be more oriented toward bicycle and vehicle movements with limited driveway access, enhanced bike lanes, and shared use paths. Trucks, buses, parking, and emergency vehicles are accommodated in different ways depending on the context and need.

Different Travel Modes

Complete Streets allow the City of Bend to meet its transportation goals by providing safe and efficient spaces for different travel modes. As transportation technology evolves there is an increase in people choosing to use a wider variety of human, electric, and other powered devices to travel. It can be challenging to categorize the various nuances of each of the travel options and incorporate them into designs for today while providing infrastructure resiliency for the future. The city identifies the following three user modes to represent the different travel options:

Drivers - people driving or riding in motor vehicles, electric cars, automated vehicles, delivery vehicles, trucks, emergency vehicles, and other vehicles operating at a motor vehicle speed and scale

Pedestrians – people walking, using mobility devices, or using other devices that operate at a pedestrian speed and scale

Bicyclists – people riding bicycles or using other devices (scooter, one-wheel, skateboard, etc.) that operate at a bicycle speed and scale

Bicyclists include people riding human powered bicycles or electric assisted bicycles. An electric assist bicycle, or ebike, in Oregon is a bike with operational pedals and an electric motor of no more than 1,000 watts and speeds up to 20 miles per hour (mph) Commonly ebikes are divided into three classes based on the speed and type of assistance:

- Class 1 – electric motor can assist when pedaling up to 20 mph. (The city's bike share Bird Bikes are Class 1 bikes that have the pedal assist speed limited to 15 mph)
- Class 2 – electric motor can assist with or without pedaling (via a throttle) up to 20 mph
- Class 3 - electric motor can assist with or without pedaling (via a throttle) up to 28 mph; Class 3 ebikes are considered motor vehicles and not bicycles in Oregon

Transit and micromobility are not considered separate user modes in this manual because people using transit travel as one or more of the three modes (drivers, pedestrians, and/or bicyclists). The different micromobility options are also represented by one of the three travel mode definitions depending on the type of device and speed of travel. This manual classifies the different categories for planning, design, and construction purposes. Reference federal, state, and local laws for operating requirements.

Purpose of This Manual

This manual provides information on the different complete streets elements to supplement the Bend Development Code and Standards for use by people designing, building, and operating the City of Bend transportation system. This manual:

- Meets the City Council goals to improve equity, safety, public health, and work toward a climate friendly community,
- Provides more information on complete street elements and including elements the city is exploring as pilot projects but has not yet adopted as standard,
- Promotes complete streets practices beyond the minimum requirement, and
- Introduces equity, universal design, and safe systems design approaches.

This manual is a supplement to the TSP, Bend Development Code, and Standards. It is not intended to contradict or override the requirements of the Bend Development Code or Standards; those documents take precedence. Below is a summary of the intent of these different documents:

Transportation Systems Plan	The planning document that creates the City transportation infrastructure policies and investment priorities
Comprehensive Plan and Development Code	The overall rules for designing and building the transportation system.
Design Standards & Specifications	Specific details on how to evaluate, design, and build the transportation system.
Design Guides and Manuals	Supplemental information with more details on implementing certain design elements ad includes: • Complete Streets Guide (this document) • Roundabout Design Manual • Signing and Striping Manual • Connector Routes and Crossings Map

When Are Complete Streets Built?

Complete streets are built when a new street is installed or when an existing street is reconstructed. Projects are encouraged to exceed the minimum standards, as feasible, to provide comfortable, connected, and separated facilities for walking, biking, and driving. Projects that do not include new or reconstructed streets are required to build applicable complete street elements for the scope of the project. This may include restriping for wider bike lanes, connecting sidewalk gaps, or building enhanced crosswalks. Complete streets are built with:

- **City Capital Improvement Projects**- City capital projects that include street reconstruction will build complete streets. Other projects will accommodate complete street elements as feasible within the project scope and funding. Many of the City's GO Bond projects specifically target improving facilities for walking, biking, and transit. A list of the current City Capital projects is on the Engineering Infrastructure and Planning Department website.
- **Development Projects** – New complete streets and upgraded complete street elements are built with projects as required by the Development Code.
- **City Maintenance Projects** – Pavement preservation and utility capital projects where the existing pavement is replaced or modified, will make minor complete street upgrades as feasible within the existing pavement width such as installing accessible curb ramps, marking crosswalks, or

modifying bike lane striping. Other complete street improvements such as pavement widening, adding missing sidewalks, separating bike lanes, and adding enhanced crossings are not part of maintenance project funding. Construction of these elements may be included as synergy projects along with a maintenance project when there is a budgeted capital improvement project that coincides.

Climate Friendly and Equitable Communities Rule

The State of Oregon passed the Climate Friendly Equitable Communities Rule in Summer 2022. The City is working on updates to policies and programs that incorporate the requirements of the rule that will be included in a future update of this manual.

Complete Street Approach

Equity

The City of Bend is committed to investing and building our work and focus on diversity, equity, inclusion, and accessibility (DEIA). We are committed to creating an inclusive community where everyone thrives. The use of equity best practices is encouraged across all city services and private development projects to increase diversity in the development, design, construction, and use of the transportation network. Examples of increasing equity in planning, designing, and building complete streets are:

Planning

- *Collaborative Governance*: Invite public input and feedback via multiple channels, including via email, phone, and in-person at the location in question, libraries, etc. Take meetings to the public during hours that encourage high attendance.

- *Expanded Outreach*: Extend project outreach beyond just standard groups who routinely participate; seek diverse panel of input from those impacted by planning.
- *Meaningful Participation*: Gather public input during the concept phase instead of the design phase to gather meaningful feedback and assess assumptions about location-specific needs.

Designing

- *Universal Design*: Incorporate tenants of universal design into all sites to benefit everyone, including persons with disabilities, children, seniors, and those utilizing mobility devices.
- *Barrier Reduction:* Reduce barriers of higher speed, higher volume streets that bisect residential neighborhoods or separate neighborhoods from services.
- *Socioeconomic Transit Equity*: Increase access to walking, biking, transit, and micromobility in areas where data indicates that income and car ownership percentages are lower.
- *Solicit Meaningful Input*: Involve people who will use the facility in a design advisory group.

Building

- *Local Support*: Connect with local building resources to support local businesses.
- *Continued Training*: Develop on-the-job training to expand diversity in the workforce.
- *Supplier Diversity Programs*: Expand contracting and subcontracting opportunities for diversly owned businesses via BIPOC (Black, Indigenous and People of Color) and women-owned businesses.

Planning Complete Streets

Building a complete street network starts with planning both the individual complete streets and a connected network of travel ways for each mode of travel. The planning requirements for the network layout and street system components are provided in the Transportation Systems Plan (TSP), Comprehensive Plan, and the Bend Development Code (BDC). Overall design requirements for complete street and intersection design are in the Standards). The following documents provide information on the framework for the network:

- **Comprehensive Plan, Bend Development Code, and Building Code**: Outlines requirements for complete streets for the city-wide network,

within developments, and to access buildings. (https://www.bendoregon.gov/government/city-codes)

- **Arterial and Collector Street locations:** TSP Figure 4-3 Functional Classification Map (https://www.bendoregon.gov/city-projects/transportation-system-plan)
- **Local Street Locations:** No map, layout developed per Bend Development Code and Engineering Standards
- **Bicycle Low Stress Network:** TSP Figure 5-1 Low Stress Bicycle Network (includes TSP Figure 5-3b Key Walking and Bicycling Routes) and standard cross-sections (https://www.bendoregon.gov/city-projects/transportation-system-plan)
- **Pedestrian Low Stress Network:** No map, sidewalks/paths required on all streets and as specified by Bend Development Code and Standards including part VI Appendix C - Connector Routes and Crossings Map
- **Transit:** TSP Figure 5-2 Primary Transit Corridors and Mobility Hub Locations and the CET Transit Master Plan (https://cascadeseasttransit.com/about/2040-transit-master-plan/)
- **Trails:** TSP Figure 5-1 and the Bend Park and Recreation District (BPRD) Comprehensive Plan Map 4-Trail Map (https://www.bendparksandrec.org/about/planning-and-development/comprehensive-plan/)

The City's online GIS maps (https://www.bendoregon.gov/services/resources/mapping-services) show a variety of data layers related to complete streets including much of the above information.

When new areas that are beyond the extents of the documents listed above are planned and designed, the Bend Development Code requires that the same principles be applied to extend the vehicle, bicycle, pedestrian, transit, and trail networks along the general alignments to and through the new areas.

Designing Complete Streets

The design requirements for City of Bend complete streets are provided in the Standards. The standards include complete street cross-sections for each street classification showing the level of traffic stress, a measure that identifies how comfortable a street is for people walking and biking. The Standards are the minimum acceptable complete street design. They include wider sidewalk/path widths as the street classifications increase, following the same principles that guide wider streets where the size increases to serve more users on busier types of streets. Both a wide sidewalk/shared-use path and a buffered or separated bike lane on both sides of the street are standard requirements on arterial and collector streets to serve different cyclist speeds, abilities, and needs.

Designs may vary from the standards to further enhance the minimum pedestrian, bicycle, transit, and safety elements such as moving the shared-use path farther away from the street, separating bike lanes, adding curb extensions, enhancing cross walks, providing truck aprons or enhanced truck maneuverability, creating pedestrian plazas/woonerfs, and more. Additional enhancements are encouraged on all streets and the Key Route bicycle facilities (TSP Figure 5-3b) are required to be as separated as feasible.

The following sections encourage consideration of Universal Design, Safe Systems, acknowledging constraints in design choices, multi-modal traffic control, and other multi-modal design resources.

Universal Design

The complete street approach emphasizes that people traveling have different skills and abilities. Designers are encouraged to apply the Universal Design Principles to find opportunities that remove potential barriers and facilitate more accessible streets for a wider range of people. Universal street design is the design and composition of street elements so they can be accessed, understood, and used to the greatest extent possible by all people regardless of ages, size, or ability. Applying Universal Design Principles (Figure 1) can help expand travel options and provide a higher quality of life for more individuals whose different abilities can make standard designs challenging.

To incorporate Universal Design, use the following seven principles to identify where there may be opportunities to adjust the complete street for a wider range of users:

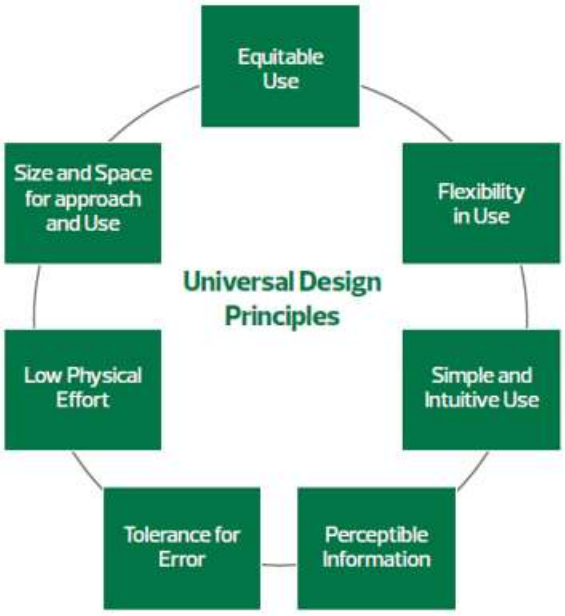


Figure 1 Principles of Universal Design, NC State University, The Center for Universal Design 1997

Equitable Use – the design is usable to people who experience disabilities, such as a rollover curb or ramp versus a vertical curb or step. The Standards accessibility requirements include compliance with the Public Right of Way Accessibility Guidelines (PROWAG) which the city has adopted.

Flexibility in Use – the design accommodates a wide range of individual preferences and abilities, such as providing an on-street bike lane and an off-street shared-use path or holding public meetings for transit planning at the bus stops.

Simple and Intuitive Use – the design is easy to understand regardless of the user's experience, knowledge, and language skills, such as a pedestrian push button that is raised and has an arrow pointing in the direction of travel.

Perceptible Information - the design communicates the necessary information effectively to the user regardless of ambient conditions of the user's sensory abilities, such as providing additional tactile or visual cues to distinguish a bicycle ramp from a sidewalk ramp at a roundabout by using greater separation, different grades, different angles out of the walking path.

Tolerance for Error – the design minimizes hazards and adverse consequences of accidental or unintended actions, such as moving street light poles from the inside curb at roundabouts to the back of the sidewalk.

Low Physical Effort – the design can be used efficiently and comfortably with minimum fatigue, such as a shorter route to connect a transit stop to a building.

Appropriate Size and Space for Approach and Use – appropriate size and space is allotted for approach, reach, and manipulation regardless of physical characteristics, size, or mobility (e.g., adding pedestrian signal poles and extending support arms, accommodating adult tricycles (Figure 2) approach and maneuvers into bicycle parking areas).

The City of Bend Accessibility Advisory Committee (COBAAC) helps the city operate as an accessible and welcoming community, represents the voice of people experiencing disabilities in local government, and assists and advises the city on making programs, services, activities, and facilities accessible to all of Bend' community members. COBAAC's primary roles are to:

- Identify and elevate accessibility issues
- Act as an advisory body to the city on issues related to accessibility
- Advise the Accessibility and Equity Manager and help prioritize accessibility projects
- Meet the Bend 2030 vision action item to establish an accessibility advisory committee
- Help the city meet obligations under Title II of the Americans with Disabilities Act

A hand cycle is a bicycle adaptation for people that use their arms rather than legs to pedal. The tricycle is wider and lower than a standard bicycle. One application of Universal Design would account for the wider width in bicycle parking areas and for the lower sight lines when selecting vegetation near intersections.

Figure 2 - Person Using a Hand Cycle

While designers are responsible for knowing PROWAG and other accessibility requirements, the city's Accessibility and Equity Manager or COBAAC (through the Accessibility and Equity Manager) are available to provide accessibility support or guidance.

Safe Systems

The City of Bend has set a goal to continually improve safety working toward zero serious injuries and fatal crashes. Taking a more comprehensive approach to reduce the risk of crashes happening and minimizing the harm caused when they do occur will help the city meet this goal. The Safe Systems Approach (Figure 3) is a tool developed to improve the safety of the transportation system by improving vehicle safety and operations, applying context-based speeds, designing safe streets, enhancing post-crash care, and encouraging safe travel and prioritizing safety.

The two components of the Safe Systems Approach that can be affected by complete streets design and operations are:

- **Safe Speeds** - Promote safer speeds through a combination of thoughtful, equitable, context-appropriate roadway design and appropriate speed-limit setting. Include targeted education, outreach campaigns, and enforcement.

- **Safe Roads** -Consider driver behavior when designing roads. Design roadway environments to reduce opportunities for mistakes and mitigate impacts. Separate users in space and time, the most vulnerable users.

Figure 3 - Safe Systems Approach Components

The Standards and Bend Development Code require a safety evaluation as part of the traffic impact analysis. Designers are encouraged to expand that basic evaluation to apply the more comprehensive Safe Systems approach. This requires a more holistic review of the interaction between the people traveling, the infrastructure, the context, the speed, and volumes. Examples of incorporating a Safe Systems approach are:

- Design the street and setting the speed limit based on the context (and per the ODOT speed rule)
- Review the number of conflict points in proposed preliminary design and evaluate options to reduce the number or severity of conflict
    - Example: Designing offset intersections for stop-controlled side-streets instead of full movement crossings reduces the number of conflict points from 32 to 18 (9 for each t intersection) and facilitates enhanced crosswalks with median islands.
- Reduce the severity of conflict points
    - Example: using a roundabout instead of an all way stop; reducing the potential for more severe head-on or right-angle crashes. Figure 4 shows the conflict points of different intersections.

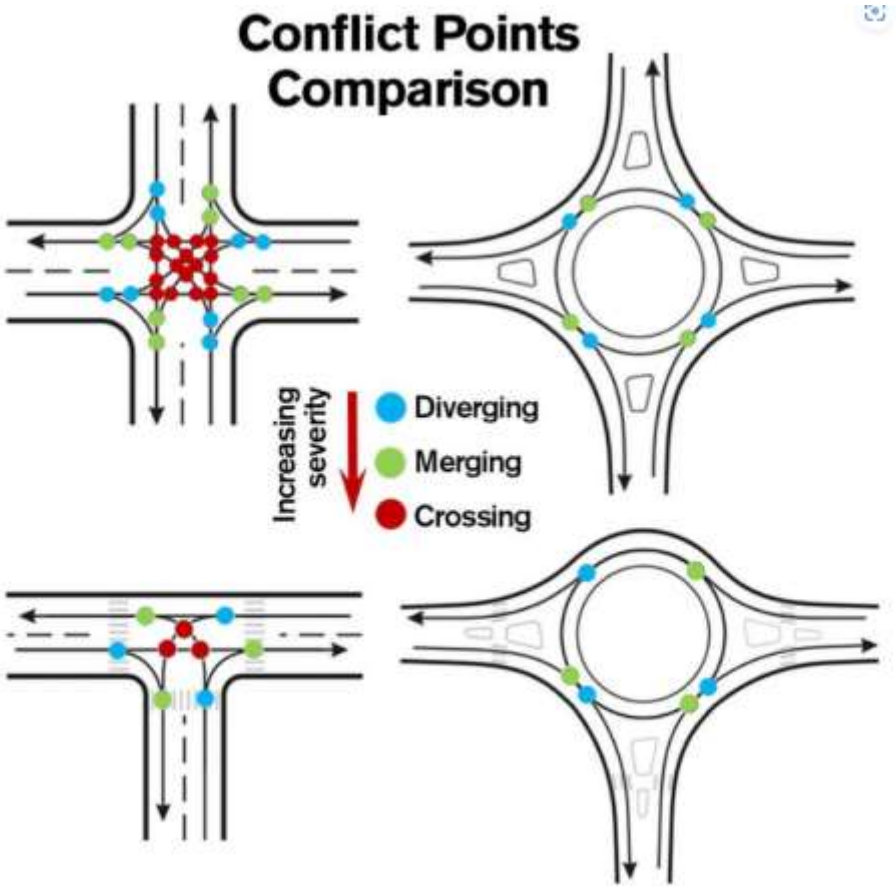
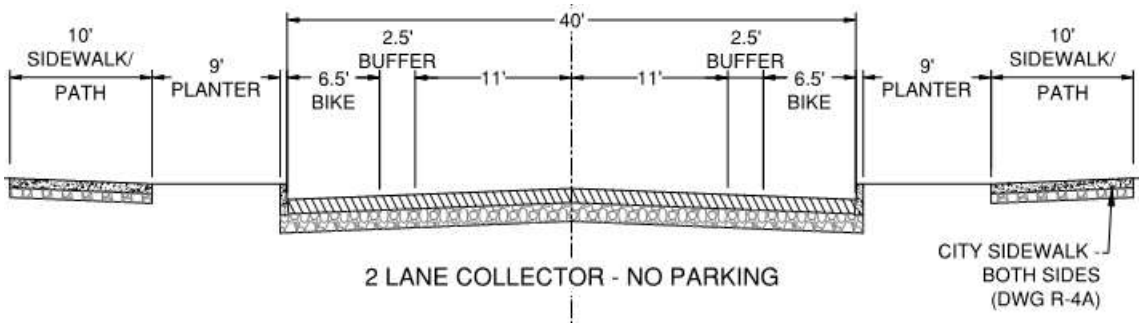


Figure 4 - Conflict Point Comparison, ASU News June 2017, Dr. Mamlouk

- Separate decision points
    - Example: moving the bicycle ramp farther away from the pedestrian ramp in at a roundabout entrance to allow people driving time to react to people on bicycles exiting or merging, people crossing, and circulating traffic at separate points
- Limit the number of simultaneous or closely timed distractions, decisions, and choices
    - Example: locating the first parking lot drive aisle in a major commercial center away from the street intersection and pedestrian crossing to separate the intersection entering maneuver from the turning maneuver into the parking lot.
- Separate vehicles, pedestrians, and bicyclists

- Example: Using a city standard cross-section (Figure 5) with buffered or separated bicycle lanes, or shared use paths separated from vehicle lanes by planter strips to provide different facilities for each



user

Figure 5 - Example City Standard Street Cross-Section

The Federal Highway Administration's Crash Modification Factor Clearing House is a national database that provides a list of different safety mitigation measures and the estimated reduction in risk. This safety countermeasures resource is online at http://www.cmfclearinghouse.org

Designing in Constrained Situations

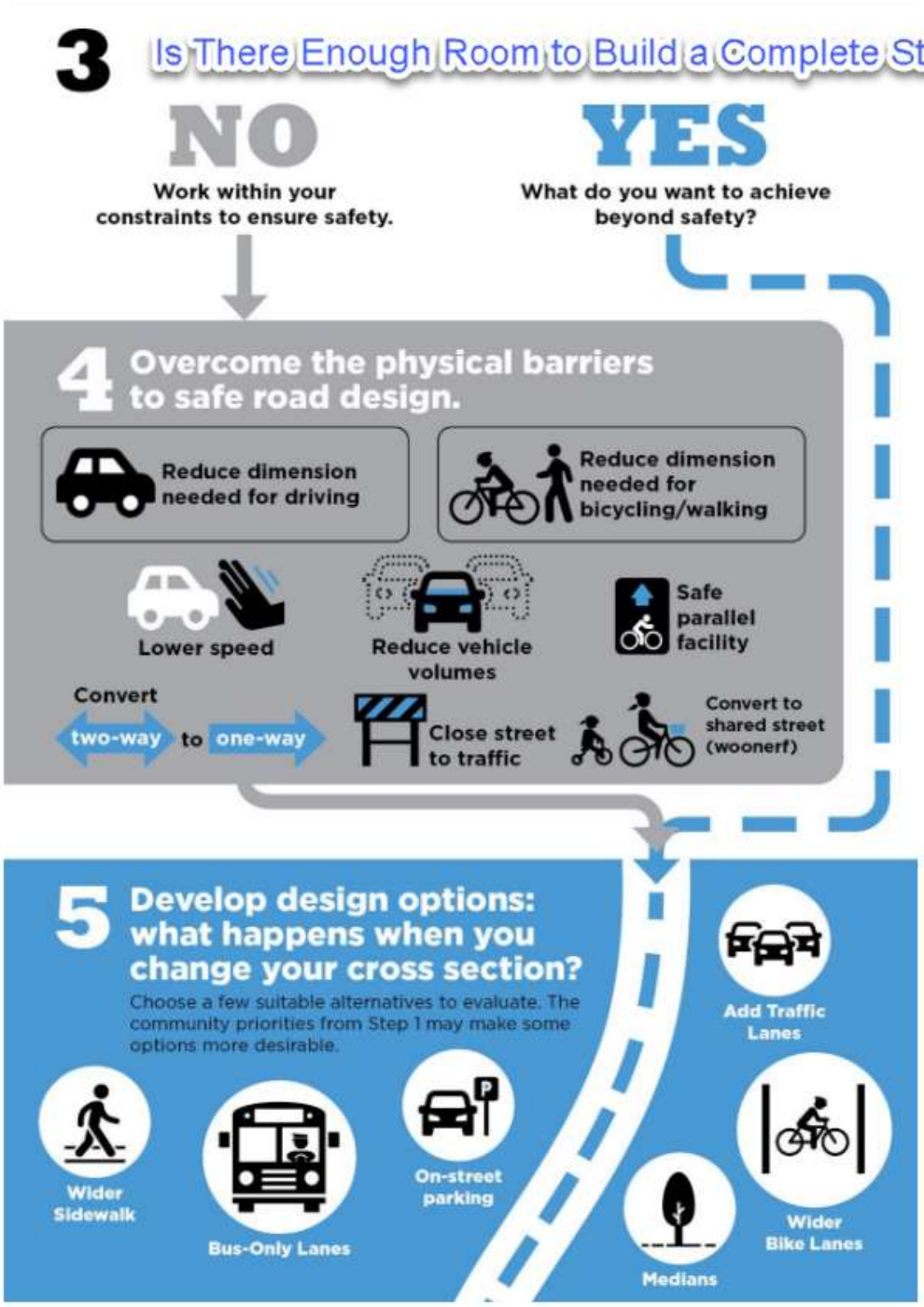
Where existing streets are redesigned or retrofit, there are often challenges to accommodate all the complete street elements at their target widths and desired separation. Designs can be limited by insufficient right-of-way widths and an inability to attain additional right-of-way. They can also be limited by existing buildings, mature trees, utilities, retaining walls, rock outcroppings, topography, existing street infrastructure on either side of a project frontage, or other constraints. The variation in existing street widths can pose additional challenges in developing cross-sections that align the centerline along the corridor. In these cases, the design of complete streets must evaluate trade-offs to determine how to best serve the different modes and different user abilities within the street context and available right-of way.

In constrained situations it is recommended that the project design concepts, the Transportation Facilities Report, and/or the Traffic Impact Analysis include an evaluation of what it would take to provide the target cross-section, alternatives considered, and documentation of the selection decision.

The Roadway Cross Section Reallocation: A Guide (2022) by the National Academies of Sciences provides a safety-based guide to help tie objective evaluations of design element trade-offs to community priorities. A process to develop and review alternatives

for choosing what can be built in a constrained right-of-way based on this guide is shown in Figure 6.

Figure 6 - Roadway Cross-Section Reallocation: A Guide (2022) by National Academies of Sciences


3 Is There Enough Room to Build a Complete Street?
NO
Work within your constraints to ensure safety.
YES
What do you want to achieve beyond safety?
4 Overcome the physical barriers to safe road design.
Reduce dimension needed for driving
Reduce dimension needed for bicycling/walking
Lower speed
Reduce vehicle volumes
Safe parallel facility
Convert
two-way to one-way
Close street to traffic
Convert to shared street (woonerf)
5 Develop design options: what happens when you change your cross section?
Choose a few suitable alternatives to evaluate. The community priorities from Step 1 may make some options more desirable.
Add Traffic Lanes
Wider Sidewalk
Bus-Only Lanes
On-street parking
Wider Bike Lanes
Medians

The matrix in the guide (Figure 7) provides example evaluation categories and notes the importance of developing project and corridor specific categories. Other City of Bend specific evaluation categories may include serves all ages and abilities (PLTS and BLTS), connectivity to the low stress network, supportive of affordable housing, and safety and risk to each mode (walking, biking, driving).

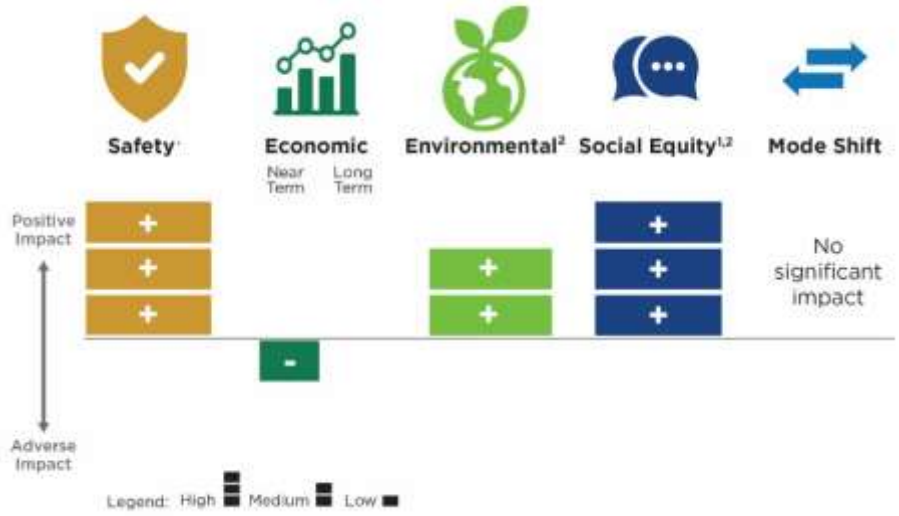


Figure 7 - Example Evaluation Matrix from Figure 55 of the Roadway Cross Section Reallocation: A Guide (2022) National Academies of SEM

Examples of mitigation measures when developing alternatives include:

- Adjust supplemental features such as landscaping, on-street parking, and then move to fundamental features like lane widths, number of lanes, and turn lanes.

    - Remove or add parking on one or both sides
    - Reduce the widths of landscape strips, accommodating impacts to stormwater, utilities, and planting requirements
    - Remove or add medians and traffic separators
    - Remove, resize, or add turn lanes to match the demand and considering design vehicle, turn warrants, and crash modification factors (Example: Locations with a center turn lane with no driveways or very few low volume driveways that could be restriped).
        - Remove right turn lanes
        - Does not include removing left turn lanes at signalized intersections or roundabout approaches
- Reduce the needed width or ways to expand available width
    - Obtain additional right-of way or a public access easement for the sidewalk or shared-use path
    - Reduce the travel lane widths where widths are greater than current standards
    - Move street trees outside of and adjacent to the right of way to narrow the landscape strip, if permitted by the Development Code, or install street tree grates; may require innovative stormwater designs
    - Relocate above ground utilities to public utility easements within private property adjacent to the right of way
- Adjust the design parameters
    - Reduce the speed limit (in compliance with Oregon speed law)
        - On arterial and collector streets, depending on the existing and proposed future conditions such as the context, continuity of adjacent speed zones, speeds on similar streets, and existing speed limits, it may be possible to reduce the speed limit to improve the level of traffic stress. Speed changes are dependent on the State of Oregon speed setting process and can take over a year, so coordination of Oregon Department of Transportation (ODOT) approval needs to be accommodated if this option is used.
    - Provide a connection and wayfinding for vehicles, bicyclists, or pedestrians to be served by nearby alternate routes that are or can be enhanced as low stress.
    - Provide a wider shared use path on one side of the street for short segments with additional enhanced crossings to connect the network
    - Build the facility that serves the lowest skill bicycle riders (e.g., widen/add a sidewalk/shared use path instead of widening standard bike lane to a buffered bike lane)

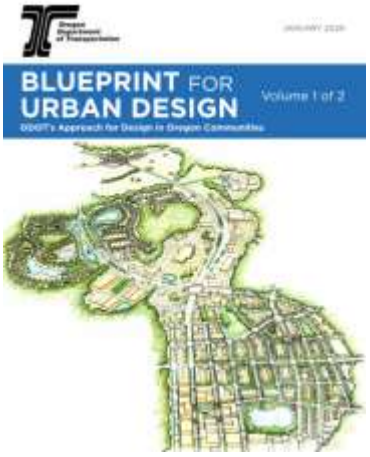
Multi-Modal Temporary Traffic Control

The city's traffic control rules require temporary traffic control in construction zones to account for the safety of people driving, walking, and biking. The following are additional items to consider minimizing construction impacts on people walking and biking:

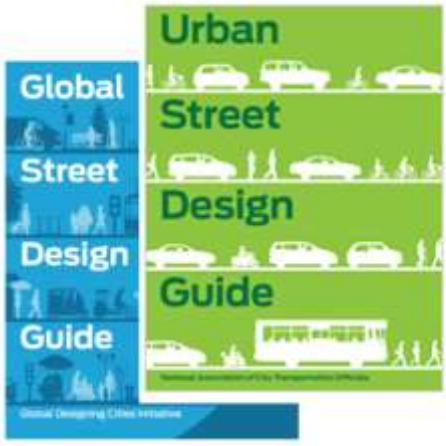
- Provide a temporary asphalt transition over steel trench covers in place for more than one week where bicycles must ride over the cover; the 1–2-inch lip can be a hazard when unexpected or unavoidable by a person riding a bicycle.
- Use steel plates with traction surfaces, the typical steel plates can be slippery for people walking or riding bicycles.
- Accommodate safe, direct routes for pedestrians and bicyclists through the construction zone or if necessary, via a short detour.
    - The routes should provide the same level of stress where feasible.
    - The routes should include wayfinding as needed for people walking and biking to navigate through the detour on the appropriate facility.
    - Recognize the larger impact for people walking and biking to detour around a construction site and work to accommodate a safe way through or near the site.
- Provide routine maintenance to keep debris from walking and biking surfaces.
- Watch the placement of signs so that they do not restrict the width of bike lanes or sidewalks/shared use paths.
- Where existing crosswalk intersection lighting is removed during construction, utilize temporary lighting.
- Provide additional wayfinding signs if the detour route is not direct and easily identified.
- Provide smooth transitions when paving in phases, not abrupt edges.
- Do not use of "Bikes on Road" in locations that require people riding bicycles to merge on streets with posted speeds over 30 mph. As an alternate, provide access to sidewalks/shared use paths, alternate routes, or using temporary slower speed limits that create LTS 1 or 2 with shared lanes.

Additional Design Resources

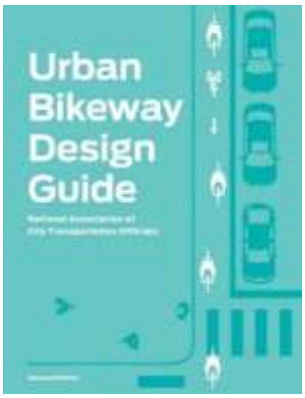
The City of Bend values innovation to create a safer and lower stress complete streets network. Appendix A lists additional resources that provide more information on complete street designs and adopted city plans that are related to street design. A few of the key resources are highlighted below:



The ODOT Blueprint for Urban Design and the ODOT Highway Design Manual provide context sensitive design criteria and discusses opportunities and trade-offs with different designs on State highways.



The NACTO Urban Street Design Guide (2013) is a collection of nationally recognized street design standards that offers guidance on applying different street and intersection designs for multi-modal use. The NACTO Global Street Design Guide (2016) provides world-wide complete street examples.



The Urban Bikeway Design Guide, 2nd Edition by the National Association of City Transportation Officials provides state-of-the-practice solutions to create complete streets that are safe and enjoyable for people biking. The NACTO supplemental guides of Don't Give Up at the Intersection and Designing for All Ages and Abilities provide additional solutions

The Separated Bike Lane Planning and Design Guide (2015) by the Federal Highway Administration shares different practices across the country for separated bike lane design.


Summary:
Designing safer roads for everyone

A new approach to allocating roadway space

In street design, tradeoffs are inevitable.

NCHRP Research Report 1036 Roadway Cros Section Reallocation: A Guide, National Academies of Sciences, Engineering, and Medicine 2022, The National Academies Press suggests steps that help support decisions on selecting and modifying cross-section elements when building in constrained conditions.

Maintenance

Complete Street Maintenance

Complete streets provide reliable transportation alternatives for people walking, biking, and driving only if they are consistently maintained. When pavement conditions are poor, the ability for the local streets to serve as bicycle low stress routes is impacted. Smooth pavement maintains travel time and ride comfort benefiting people driving, walking, and biking. Signing and marking must be routinely replaced to maintain visibility and retro reflectivity. Bridges, roundabouts, and traffic signals need routine maintenance and scheduled replacement. Maintenance includes both keeping the infrastructure in good repair and performing surface maintenance through the different seasons (sweeping, plowing, and debris removal).

The new complete street designs are adding more complex infrastructure to maintain such as roundabout splitter islands, separated bike lanes, median islands, and traffic separators. The amount and complexity of striping and pavement marking is increasing. This requires increased staff, increased manual work, and specialized equipment scaled for the different size facilities. Without dedicated funding for enhanced year-round maintenance, maintenance is limited. This impacts the ability of people to use the facilities, especially people walking and biking. Facilities may not be usable during inclement weather, and after storm events (wind, snow, heavy rain, etc.).

The TSP identifies the importance to develop funding to expand the maintenance programs so travel options are available for driving, walking, biking, and taking transit during all seasons. The current programs and potential expanded services include:

- **Pavement Preservation and Minor Repair Program** – The pavement management program identifies an efficient and economical plan for repaving roads, performing minor street repair, and patching potholes. This includes upgrading the concrete ADA ramps to meet current PROWAG standards in conjunction with street preservation projects. Pavement preservation includes minor striping complete street updates. Opportunities to expand the program include identifying funding for additional complete streets gap connection of sidewalks/paths and bike facilities in conjunction with pavement preservation.

- **Winter Street Maintenance Program** –

  
  Figure 8 - Truck Plowing Snow

  The priority-based program includes plowing (Figure 8), sanding, and preemptive de-icing of arterial streets, collector streets, and designated greenways during storm events. Snow is cleared on sidewalks/paths on roundabouts and bridges by seasonal staffing. Winter maintenance is provided on local streets only during major storm events. Per city code the maintenance of other sidewalks/ paths is the responsibility of the adjacent property owner. On-street buffered bike lanes are plowed as part of the routine winter maintenance program. Opportunities to expand the program include:
    - Fund equipment and staff to provide winter maintenance on separated bike lanes. The city is exploring options for the pilot separated bike lane project on the Wilson Avenue corridor.

- Fund equipment and staff to provide winter maintenance on sidewalks/paths on key routes and the expanding network of greenways.
- Increase education and compliance to encourage more timely and consistent property owner maintenance of sidewalks/paths.
- Implement a snow angel program to match volunteers with people who need assistance with shoveling their residential sidewalks/paths.

- **Landscape Maintenance Program.** City crews maintain the landscaping and irrigation system providing routine maintenance, repairs, and small reconstruction projects. This program also includes storm response to remove fallen trees and debris from storm events. The City Code requires adjacent property owners to keep vegetation trimmed along and over sidewalks/paths. Opportunities to expand the program include:
  - Convert existing and installing new water-wise, low maintenance vegetation in the rights of way.
  - Increase education and compliance to encourage more timely and consistent property owner maintenance of vegetation along and over sidewalks/paths.

- **Signing and Marking Program** – This program provides annual maintenance of street signs and marking. Street striping and high traffic marking locations are worn by vehicles and lose reflectivity in six to twelve months, in those locations re-striping and marking is targeted every year. Markings that are in lower traffic areas require less frequent maintenance. Opportunities to expand the program include:
  - Fund materials and equipment for enhanced bike markings such as green paint.
  - Fund materials and staff for education, mapping, and implementation for a wayfinding program.

- **Sweeping Program** – The sweeping program clears sediment and debris from the streets and bike lanes to reduce travel hazards and remove sediment in support of the stormwater quality program. Sweeping is conducted on arterial and collector streets (including the buffered bike lanes) multiple times per year and local streets at least once per year. Options to expand the program include funding staff and equipment for a separated bike lanes maintenance plan. The city is current working on a pilot program as part of the Wilson corridor project.

- **Sidewalk/Shared Use Path Repair Compliance Program** – City code requires property owners to maintain their sidewalks in good condition. On a complaint basis, staff works with adjacent landowners to repair damaged sidewalks/paths. In most cases repairs are made, or citations may be issued. Options to expand the program include funding staff and repair assistance to pro-actively coordinating

with property owners to improve the condition of sidewalks, particularly along the low stress routes.

Design and Build with Maintenance in Mind

Many maintenance friendly design elements are included in the Standards. The following are additional ways that infrastructure can be designed for lower cost, easier maintenance:

- Coordinate the design of separated bicycle facilities with Streets and Operations so there is an identified and funded maintenance plan before the facility is constructed. Maintenance friendly separated bicycle facilities may include additional stormwater facilities, snow storage, wider cross-sections, adjusted curb radii, etc.
- Include a staging area for maintenance vehicles to park in a larger landscaped roundabout median island such as a level 25 x 20 area.
- Locate signs, trees, and poles to reduce the areas that need a weed trimmer and increase the areas mowers can be used.
- Where curbs curve for parking, curb extensions, or width reductions use curve radii that support sweeper operations. Design consistent curb lines that do not jut out unexpectedly and radii that support the sweeping equipment.
- Use tapered end median islands that accommodate larger vehicle turning radius while still slowing traffic, providing a pedestrian buffer, and reducing impact from plow blades.
- Include delineators on the upstream end of curb extensions and islands (Figure 9).
- Select trees with canopies that do not require frequent trimming to reduce visibility and impact hazards
- Size and locate landscaping so it does not block clear vision requirements or visibility of signs and street users
- Build utility valve covers, utility access holes, grates, etc. flush with the street or inset ¼ inch and outside of the bicycle, wheel path, and walking path as feasible.
- Maximize exposure to sunshine (preferring shared use paths on north and west sides where paths built on one-side only).

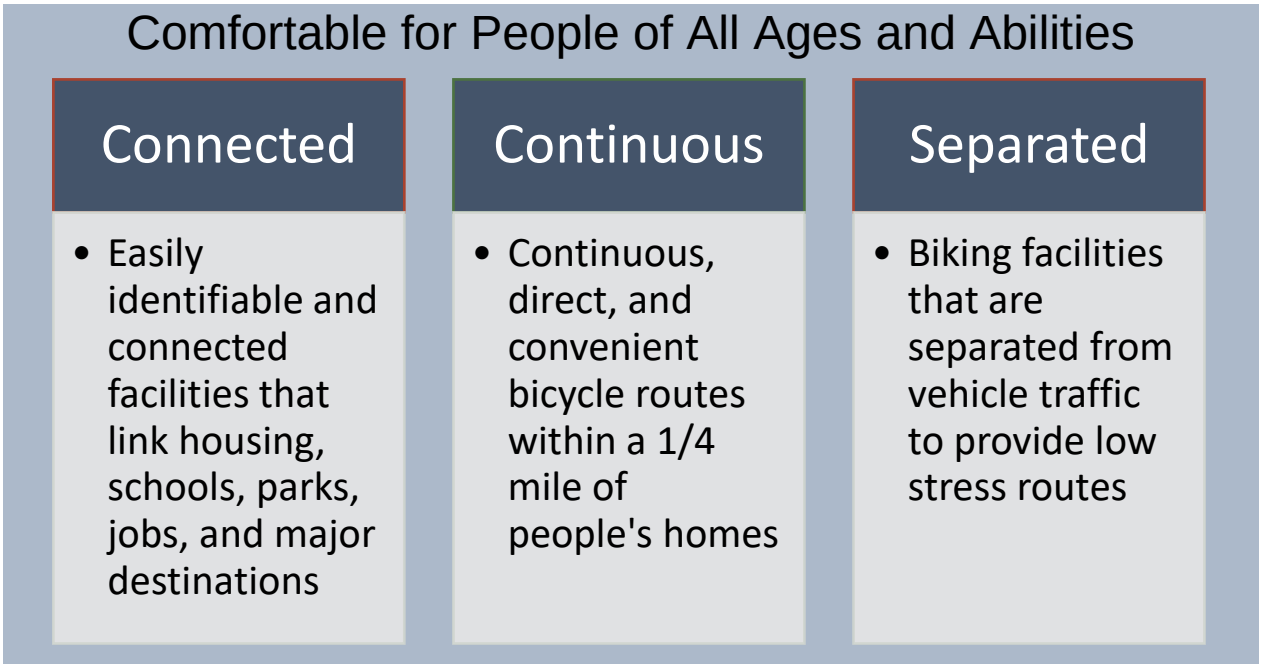
Figure 9: Vertical delineators used to inform drivers and plow operators of obstacles, and gap in curb extension design that requires additional maintenance.

- Include places for snow storage.
- Use recessed pavement markings.

People Biking

General

The City of Bend prioritizes building a connected, separated, and easy to navigate, bicycle network to give people a reliable travel alternative to driving. The aim is to encourage new riders and encourage more bicycle trips by all riders. Bicycle facilities are designed to accommodate people of all ages and abilities with a connected, continuous, and separated system.



Bend's bicycle ridership for trips to and from work was just over two percent in 2009 and nearly four percent in 2016[1] . This percentage is still relatively low considering the generally flatter topography, mixed-use neighborhoods, compact size, and milder weather for much of the year. As a comparison the City of Portland's bike to work trips

[1] American Community Survey – Census Bureau

are 7.2% and the City of Boulder, Colorado sees 10.7%[2]. With the extensive existing network, planned capital projects (including the GO Bond), and new developments building complete streets, Bend has an increasingly good opportunity to increase the number of people riding bicycles. Conditions that support more people riding bicycles in bend include:

A three to twelve mile trip is a comfortable biking distance.

- Bend is just seven miles wide and nine miles long.
- Half of all trips in the city of Bend are three miles or less.
- Major destinations, parks, and schools are close to where people live.

People prefer to ride bikes in nice weather and flat terrain.

- Bend has 263 sunny or mostly sunny days.
- Much of Bend is flat or rolling.
- The availability of electric assistance and wider tires can extend the range and season.

There are more than 67 miles of existing low stress facilities.

- There are 7 miles of existing neighborhood greenways.
- The existing network offers 25 miles of urban commuter trails, 18 miles of shared use paths, over 300 miles of low volume streets, and 140 miles of striped bike lanes (17 miles of these are buffered bike lanes).
- More improvements and lower stress routes to better serve all ages and abilities are coming in the next ten years with the voter approved GO Bond projects.

Understanding Bicycle User Types

People have different skill levels and comfort levels when it comes to riding a bicycle that can vary by age, ability, type of facility, and facility condition. Researchers in Portland, Oregon[3] developed a rider comfort level and level of traffic stress classification to explain these different types of riding bicycles for transportation. The system, adopted at the

---

[2] Portland State University Transportation Research Center. “Lessons from the Green Lanes: Evaluating Protected Bike Lanes in the US”, Chris Monsere

[3] Roger Geller, City of Portland Bureau of Transportation, Four Types of Cyclists. http://www.portlandonline.com/transportation/index.cfm?&a=237507. 2009

national level, by the Oregon Department of Transportation, and by the City of Bend classifies people riding bicycles in four comfort level groups (Figure 10):

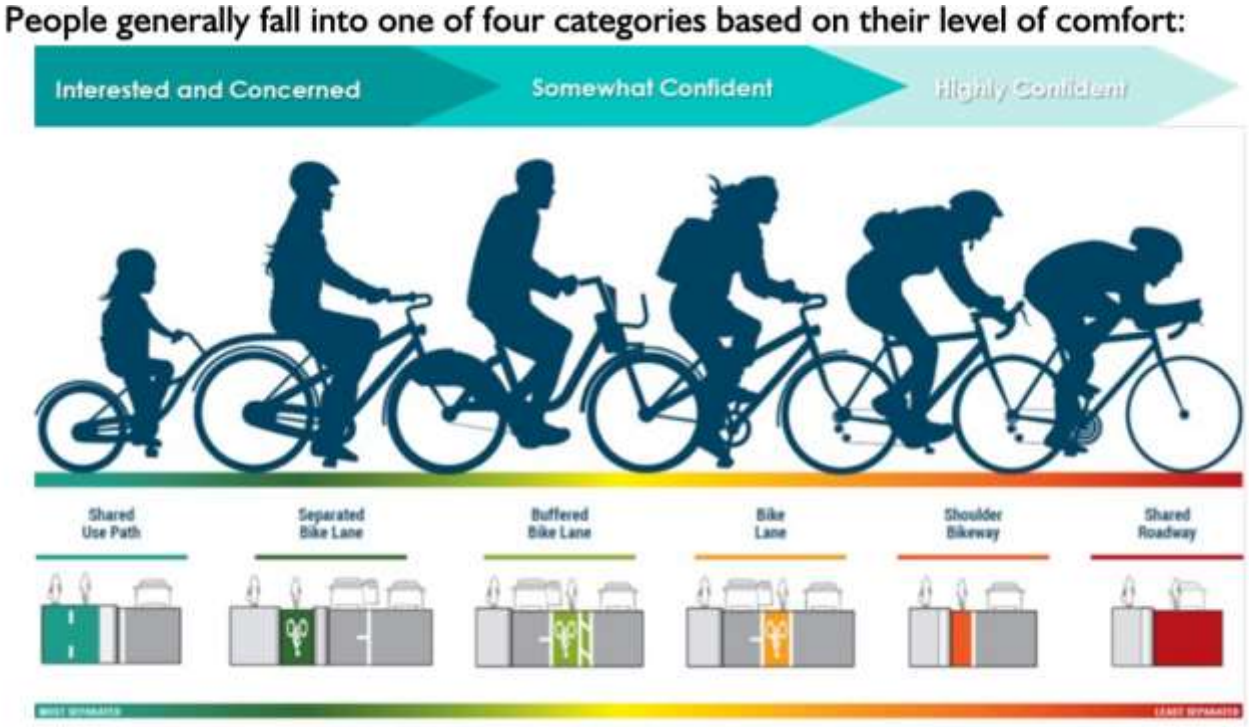


Figure 10 Classifications of People Riding Bikes by Comfort Level

- **Interested and Concerned** – People in this group of riders are typically not very comfortable in a lane only bike lane and are more apt to ride on sidewalks/shared use paths (separate from traffic) or on their own neighborhood local street where there are less vehicles. These riders are concerned when they are near frequent vehicles traveling at higher speeds. This is the largest segment of people riding bicycles and can comprise up to sixty percent of a community. Most new riders or people returning to cycling after years not riding start out as Interested and Concerned riders Providing a separated and comfortable bikeway network that serves the interested and concerned riders encourages riders, helps to grow their skills and confidence, and will leave them much more likely to choose to travel by bicycle more often and on different routes.

- **Somewhat Confident (also described as Enthused & Confident)** – This group represents intermediate cyclists that are comfortable with bike lanes on lower speed streets yet still prefer separated bikeways on higher volume and higher

speed streets. A small and growing category of riders, this group may be around ten percent of the community.

- **Highly Confident (also described as Strong and Fearless)** – This group is the advanced riders that are comfortable on most urban streets regardless of the bikeway type. Feedback from some Bend cyclists in this group indicates that while they have the skills to ride anywhere, they also prefer separated facilities due to increased potential for distracted driving and conflicts with people walking. While they have the skills to navigate most facilities, they are still concerned about safety and at a minimum look for controlled or enhanced crossings and safer lane transitions. This group may be as small as one percent of the population.

- **Not Interested** – This group is not shown in the graph above. These are people that are not interested in riding a bicycle. This can be for many reasons such as not having a bicycle, not physically able, or just do not want to. An estimated that thirty percent or more of the community falls in this category.

The different user types provide a behavioral context for use during design to evaluate how selected facilities on a corridor serve the full range of user types. People are not always the same user type. They change user types by their age, skill, the type of trip, type of facility, or a variety of other factors. Building a system designed for the largest category and lowest skill riders, the Interested and Concerned group, serves the whole range of people riding bicycles.

Level of Traffic Stress for People Bicycling

The safer and more comfortable facility is typically the one that provides the most separation between the person riding and the vehicle travel lane. There are four levels of traffic stress (LTS) for bicycles ranging from LTS 1(low stress, comfortable for all riders) to LTS 4 (high stress tolerated by the higher confident riders) shown in Figure 11.

Figure 11 Graphic Showing the Levels of Traffic Stress by Different Street Cross-Sections

Using the levels of traffic stress is a way to quantify how different facility types serve the different bicyclist comfort levels. For example, Interested and Concerned riders, the largest percentage of the community, are supported by lower stress bicycle facilities that provide greater separation from traffic. This is why the TSP policy targets LTS 1 adjacent

to and within 1/4 mile of schools, parks, and mobility hubs and LTS 2 elsewhere on the Bicycle Low Stress Network.

The LTS ranking of 1 through 4 is based on roadway characteristics and conditions including vehicle speeds, the number of travel lanes, turn lane configurations, separation from vehicles, width of bicycle facilities, and enhanced crossing treatment types. The City of Bend uses the methods provided in the Oregon Department of Transportation Analysis and Procedures Manual Chapter 14 Multi-modal Analysis to calculate the LTS. Table 1 describes the various bicycle levels of traffic stress.

Table 1 - Bicycle Level of Traffic Stress

BLTS 1	(The lowest, or most comfortable) Represents little traffic stress and requires less attention so it is suitable for all cyclists including children around 10 years of age traveling alone and trained to cross intersections or younger children with supervising parents. An example of a BLTS 1 facility is a shared use path physically separated from the street by a landscape strip, or a raised bike lane.
BLTS 2	Represents low traffic stress but requires more attention than most younger children would be expected to deal with, so is more suitable for teens and adults with moderate biking skills. An example of a BLTS 2 facility is a buffered bike lane or a greenway
BLTS 3	Represents moderate stress and serves most observant, adult cyclists that may feel uncomfortable but safe using. An example of a BLTS3 facility is a striped on-street bike lane that is not buffered.
BLTS 4	(The highest stress, or most uncomfortable) Represents high traffic stress and serves experienced and skilled cyclists. A BLTS 4 facility example is a striped bike lane with no buffer on a multi lane, higher speed street.

The standard complete street cross-sections provide LTS 1 or 2 bicycle facilities. These standards require both a buffered or separated bike lane and the shared-use path on arterial and collector streets. This is to serve the full range of cyclists such as more skilled commuters that elect to ride in the bike lane and younger people heading to school or less comfortable riders that prefer the separation of the shared use path. These are not redundant systems, but different systems that serve different user types.

Bicycle Low Stress Network

The City of Bend planned bicycle Low Stress Network is identified on TSP Figure 5-1. The routes generally provide bicycle facilities on approximately the half mile spacing so people can access the routes within that convenient ¼ mile range of where they live, work, and play. The network provides for both north-south and east-west routes near higher density developments, schools, parks, and destination/activity centers. The city developed the map in conjunction with the Bend La Pine School District, the Bend Park and Recreation District, and the Cascade East Transit authority. In addition to the low-stress network on TSP Figure 5-1, the Bend Development Code, Standards, and standard street cross-sections require low stress pedestrian and bicycle facilities on other streets and blocks to further enhance mobility. While the initial focus is on the base network shown on TSP Figure 5-1 now, ultimately the goal is for all streets to provide low stress bicycle facilities. The bicycle Low Stress Network aims to:

- Close bicycle facility gaps to allow people to ride at their comfort level right from their home continuously to the destination.
- Separate people biking from moving traffic or use shared lane facilities only in slow speed environments.
- Enhance intersections to provide lower stress crossings.
- Provides bicycle ramps to foster access for all ages and abilities.

Low stress bicycle route alignments target direct, easy to navigate routes that minimize the nubmer of street crossings and directly connect to other bikeways in the system.. Where feasible, routes along open space and parks that are farther away from vehicle travel lanes are preferred. Master Plan developments are encouraged to design the land use with a system of off-street routes through the development. The presence of a bicycle low stress route in the vicinity does not preclude or reduce the need for additional facilities to connect people to places.

Key Bicycle Routes

The Key Bicycle routes are certain segments of the Bicycle Low Stress Network that were designated on TSP Figure 5-3b to prioritize funding and construction timing. There are twelve Key Routes identified to provide cross-town connections and link other low stress routes for people riding bicycles and walking.

The Key Routes include street segments that already have low stress biking and walking facilities, segments that have funded improvement projects (bond or capital projects), and segments that do not yet have funded low stress improvement projects. Check the Engineering Infrastructure and Planning Department website for the list of funded and scheduled capital projects.

The Key Routes fall under the same general design requirements as the overall Low Stress Network targeting LTS 1 and 2 with additional requirement to maximize separation of the bicycle facilities from vehicle traffic.

Selecting a Facility Type for the Bicycle Low Stress Network

Understanding the different rider types helps to inform a bicycle system design that is inviting to a wider range of people. The more a route is separated from moving traffic, the more comfortable it is for people riding bicycles. Like the vehicle travel lane system, as bicycle routes move from local to collector to arterial streets, they serve more people and need to be wider. Bicycle facilities that serve two-way traffic require more width than those that serve one-way traffic. This section provides guidance on confirming the routes, selecting facilities, and connecting to the routes.

Confirming the Low Stress Routes

- **Use TSP Figure 5-1 to determine if a designated low stress route is within or adjacent to the project.** Also refer to the Bend Development Code that may require an extension of the network beyond the routes shown on the map. Bicycle low stress facilities are required on all arterial and collector streets per the standard cross-sections even if not shown on TSP Figure 5-1.

- **Confirm the route alignment.** Review the low stress route to see if the project changes conditions such that an adjacent street or path in the development provides a better low stress route than the one identified on the planning map (TSP Figure 5-1). Examples may be adding a major destination (commercial center, park, school, or higher density

development) or reconstructing a street to provide a low stress route now when there is no identified plan to upgrade the planned route along a built-out corridor. (See section on Modifying the Low Stress Network if the route changes.)

- **Check if the bicycle low stress route is also a Key Route.** TSP Figure 5-3b shows the key walking and biking routes. If the route is also a key route, then design the route to provide as separated bicycle facilities as feasible. Also check with the Engineering & Infrastructure Planning department to see if there is a scheduled and funded project to build the key route (Some segments are part of the GO Bond improvements.)

Selecting the Low Stress Facility Type

- **Check the planned facility type.** There are different types of facilities that serve as the bicycle low stress route. There is no prescriptive choice for the type of facility to use as the selection depends on the context, connectivity, speeds, and vehicle volume. For initial reference, the GIS Bend Data Viewer map has a Transportation & Mobility layer called "TSP Low Stress Network" that shows they type of facility identified during the TSP planning process. Click on any route or segment to open a dialog box that shows the suggested "Bicycle Facility Type" (Figure 12). This is the type that appeared to be the most feasible at the time of the TSP. Use the low stress ranking criteria in ODOT Analysis and Procedures manual and the City Signing and Striping Manual to design the appropriate facility based on the speeds, number of lanes, on-street parking, adjacent facilities, and other conditions. The different options for the low stress facility types include:

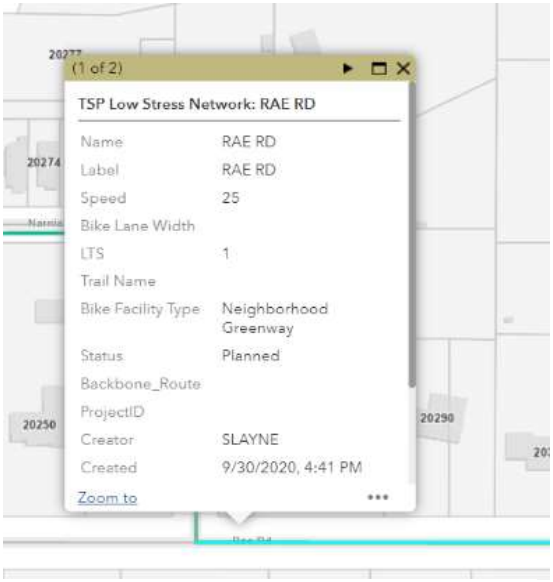


Figure 12 Bicycle LSN Facility Type from Bend Data Viewer Map

  - **Construct the standard street cross-section (Standard Drawing R1 series)**. The standard cross-sections for arterial and collector streets include both on-street and off-street facilities that generally meet requirement for bicycle low stress facilities.

- Confirm that the standard cross-section does meet requirements. Where the existing speed limit is over 35 mph, the on-street bike lane may not meet the target LTS 1or 2.
- If standard cross-section does not meet the target LTS, provide additional mitigation measures to achieve the target LTS. Examples may include providing additional bike lane buffer width, physical separation, or other design modifications to support a speed reduction.

- **Construct an enhanced street cross-section.** The city may consider modifications to the standard cross-sections that include enhanced features such as meandering shared use paths, physically separated bike lanes (on or off street), separated two-way shared use paths, and other innovative designs that improve the comfort level and safety of all road users.

- **Construct a greenway:** On a local street low-stress route, a greenway may be used where the following greenway criteria are met:
  - The street is on the low stress route map (TPS Figure 5-1).
  - The street is in a residential district.
  - Traffic volumes are less than 2,000 vehicles per day, targeting 1,200 vehicles per day or less.
  - The 85th percentile speeds are less than 30 mph.
  - There is signing and or marking indicting the presence of people walking or biking.
  - If volume and speed criteria not met, alternate options include:
    - Construct an eight-foot minimum shared use path on one side of a local street. A six-foot sidewalk is still required on the other side of the street. Preferred sides for the shared use path are the north and west sides for better sun exposure.
    - Implement modal filters to reduce vehicle volumes.
    - Implement traffic calming to reduce speeds.

- **Construct an off-street shared use paved trail (Standard Drawing R-48 primary trail).** Developers are encouraged to design a low stress route through a master planned area that is a paved primary off-street trail. In new areas there is tremendous opportunity to create a great amenity for the neighborhood that also serves the community at large. Integrated off-street primary trails meandering along open space and parks, are highly encouraged because a trail away from the vehicle travel lane the most low-stress and appealing facility to encourage increased biking and walking. Provide logical connection points that provide access between the off-street and street right-of-way routes. Public access easements are required to establish public access to the off-street trail system since it is outside of the right-of-way.

    - **Combination.** The design can be a combination of the above if it is easily identifiable, direct, and continuous, changes at logical points, and is easy to follow.

- **Construct an Enhanced Crossing, if required.** Creating the low stress route also includes designing and building low stress crossings where the route crosses arterial and collector streets. See the crosswalk marking section in the Signing and Marking Manual and the Connector Routes and Crossings Map for additional information on marked crossing requirements and planned crossing locations. Crossings are located to connect to other low stress routes, schools, parks, and major destinations.

- **Connect the Project to the Low Stress Route.** Design the project sidewalks and bike facilities provide a direct, easy to navigate connection to the low stress route.

Modifying the Bicycle Low Stress Network

The Bicycle Low Stress Network generally provides routes at ½ mile spacing in the east-west and north-south directions across town so that facilities are accessible within ¼ mile of homes and destinations. Routes are established to provide the most direct, continuous path of travel to access target destinations (schools, parks, transit facilities, commercial districts, and major activity centers). There may be limited cases where alternate routes are identified during site planning or development that provide a lower stress route, a better connection to target destinations, access higher density residential area, or serve a new target destination not identified during the TSP map development. The Bend Comprehensive Plan Figure 7-2 Key Walking and Bicycling Route note indicates that routes may be updated administratively by staff upon the adoption of a master plan and/or construction/completion of that route. For changes not associated with a master plan, consult with City legal staff to determine if a TSP map amendment is required.

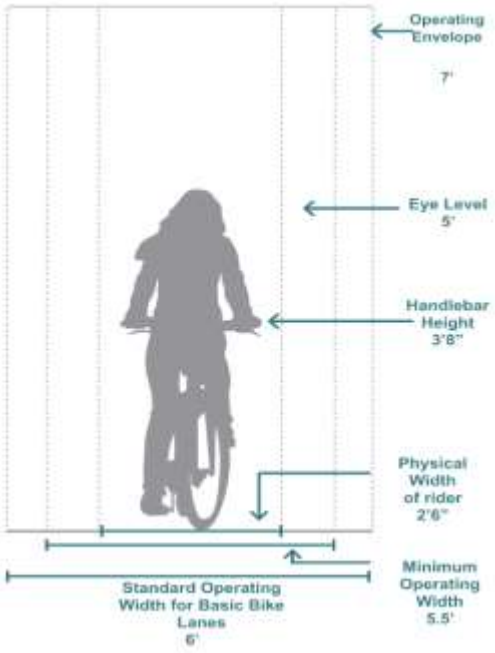
Dimensions of People Riding Bicycles

Bicycles (and the people riding them) come in a variety of sizes and configurations. To serve people of all ages and abilities for a variety of travel purposes, consider designs that accommodate a wider range of bicycle types than the standard bicycle. This may include such things as providing wider refuge islands for cargo and trailer bicycles, varying sight lines for recumbent bicycles, increasing shared us path turning radii, building wider curves, widening for three-wheel bicycles, and providing bicycle parking that accommodates three-wheel bicycles and other handicapped accessible bicycle sizes/dimensions.

The basic bicycle and rider design envelope is shown in Figure 13. Examples of different bicycle styles are shown in Figure 14 and include a recumbent, tricycle, cargo bicycle and child carrying bicycle that have widths up to five feet and lengths up to eight feet. A six-foot width or more provides for greater maneuverability of different bicycle types and for passing within the bike lane.

Bicycle facilities built for all ages and abilities expand that minimum envelope to provide a width that allows people to ride next to each other. This allows a parent to ride next to a child or two people to ride together and converse which makes cycling more enjoyable and encourages more people to ride. Additional width also allows faster riders to pass slower riders. The minimum typical width for two people riding side-by-side or passing is eight feet. The standard low stress median crossing targets nine to ten-foot widths that accommodate the length of the longer bicycle types. This allows people to stage in the island and cross one travel direction at a time. The minimum six-foot width required to comply with PROWAG guidelines serves only the basic bicycle length.

Figure 13 - Dimensions of Person Riding a Bicycle



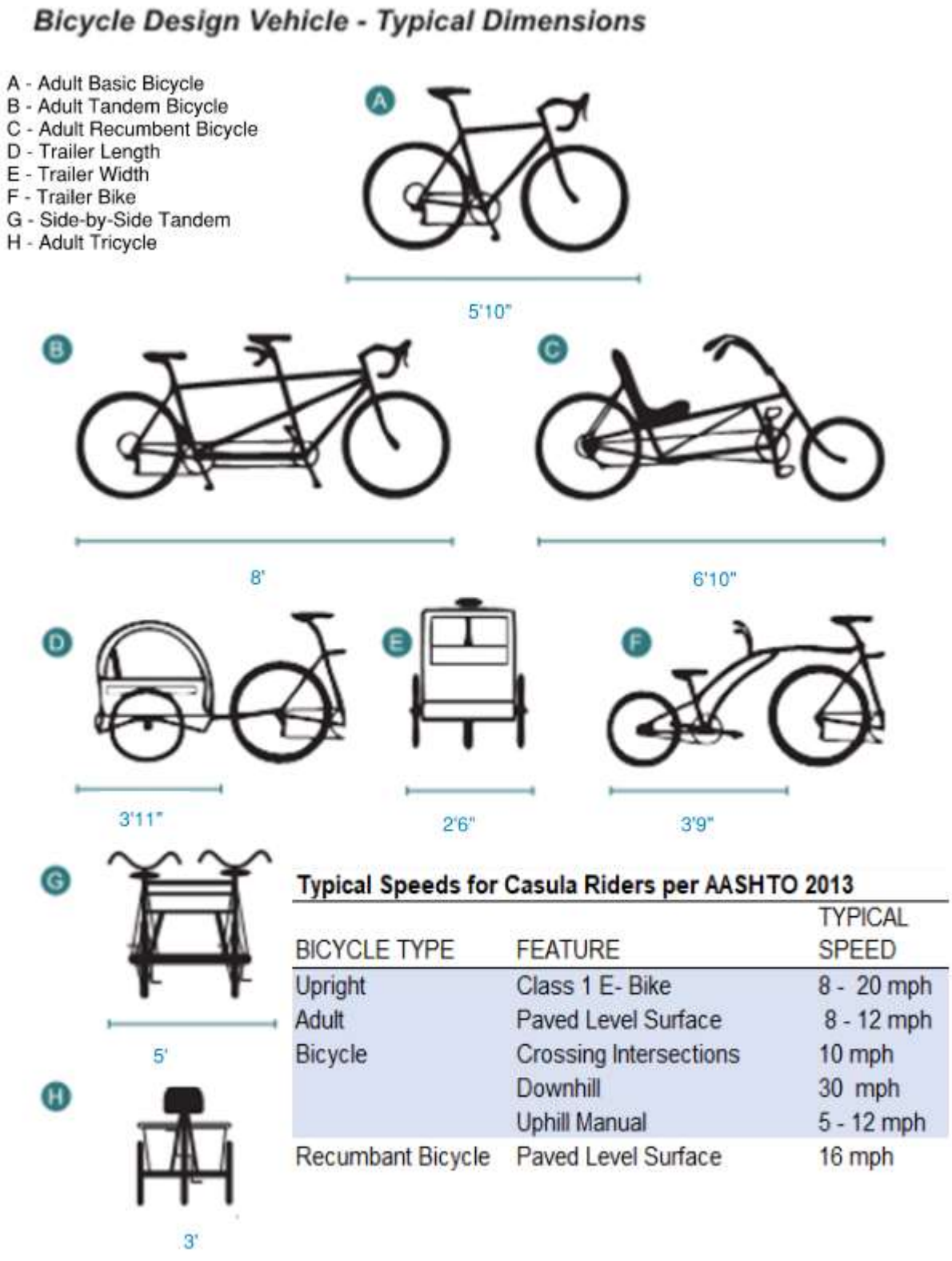


Figure 14 Example dimensions for different types of bicycles.

Where designing shares use paths that meander a typical design speed is 14 to 16 mph. Slower speeds of 10 mph are recommended for intersection approaches street crossings. Design radii to match the target speeds using Table 2:

Table 2 - Suggested minimum turning radius for shared use paths from AASTHO Guide for the Development of Bicycle Facilities, 4th Edition, 2012

Design Speed (mph)	Minimum Radius (feet)
12	27
14	36
16	47
18	60
20	74

People Walking

General

Sidewalks or shared use paths are required on every street to provide a connected pedestrian network through town. Additionally, connector trails are provided to connect between developments and there is an extensive network of off-street trails managed by the Bend Parks and Recreation District or other entities. An easy-to-use system provides a site design with a convenient walkway from the public street sidewalks/shared use paths through and between developments to access the buildings and facilities.

A pedestrian network encourages more people to walk when it is connected, separated, and continuous. One-half mile to a mile is typically considered a reasonable walking distance. This coincides with the Bend La Pine one mile walking radius and the Bend Parks and Recreation plan for a park within one half mile of most homes. The city's low stress bicycle network generally includes facilities for pedestrians too and plans for routes and crossings at approximately half mile spacing.

Connected	Continuous	Separated
• Easily identifiable and connected facilities that link housing, jobs schools, parks, and major destinations	• Continuous, direct, and convenient sidewalks starting right from the front door	• Walking facilities that are separated from vehicle traffic to provide low stress routes

Level of Traffic Stress for People Walking

Like the Bicycle Level of Traffic Stress, the level of pedestrian traffic stress (PLTS) is based on the strain or discomfort experienced by people walking. The PLTS ranges from 1 (most comfortable) to 4 (least comfortable) based on characteristics including: sidewalk/shared use path surface condition, buffer type, distance from moving vehicles, lighting, and the number of travel lanes and speeds. The PLTS is quantified using the Oregon Department of Transportation Analysis and Procedures Manual Chapter 14 Multi-modal Analysis and is summarized in Table 3.

Table 3 - Pedestrian Level of Traffic Stress

PLTS 1	(The lowest, or most comfortable) Represents little traffic stress and requires less attention so it is suitable for all users including children around 10 years of age traveling alone and trained to cross intersections or younger children with supervising parents. PLTS 1 facilities for walking are most often shared use paths separated from the street by a buffer. The sidewalks/shared use paths are in very good condition.
PLTS 2	Represents low traffic stress but requires more attention than most younger children would be expected to deal with, so is more suitable for teens and adults. PLTS2 facilities may be attached sidewalks next to a bike lane. The sidewalks/shared use paths are in good condition though may have some areas of fair condition.
PLTS 3	Represents moderate stress and serves most observant, adults that may feel uncomfortable but safe using the walkway. This may be a sidewalk with a small buffer on a higher speed street. Sidewalks/ shared use paths may have more areas in less than good condition.
PLTS 4	(The highest stress, or most uncomfortable) Represents high traffic stress and serves able bodied adults. A PLTS 4 facility may be a five-foot sidewalk adjacent to a high-speed ravel lane or a higher speed street with no sidewalk. Sidewalks/ shared use paths have extended areas of gaps and/or poor condition.

The analysis includes ratings for both the type of walking facility and the condition of the facility. The lowest LTS rating is the one used. Sidewalks/paths adjacent to fast, busy streets can be uncomfortable while sidewalks separated from the street by trees or landscaping or away from the street completely are less stressful to use. Condition is also a factor in the pedestrian network comfort as even a separated sidewalk, if in poor condition with root heaves, cracks, or gaps can be difficult to navigate or even create a barrier for people with disabilities. As an example, an off-street trail may be PLTS 1 for facility type, but if it is in poor condition and disconnected, it is a PLTS4 for condition and thus a PLTS4 overall.

Pedestrian Low Stress Network

The pedestrian low stress network is planned to include every street, so the standard street cross-sections provide for low stress sidewalks or shared use paths on all streets. The network also includes primary and connector trails between and through developments, and The Key Routes (TSP Figure 5-3b) that provide cross-town bicycle and pedestrian cross-town routes. Since every street is planned as part of the pedestrian low stress, there is no adopted network map like there is for the bicycle low stress facilities. The low stress-pedestrian network:

- Closes sidewalk gaps to allow people to walk right from their home continuously to their destination
- Separates people walking from moving traffic and higher speed bicycles
- Enhances intersections to provide lower stress crossings
- Includes ADA compliant curb ramps to foster access for all ages and abilities

The low stress pedestrian facility is achieved for development by:

- building the standard street cross-section (all standard cross-sections achieve LTS 1 except for wide, higher speed arterial and collector streets that achieve LTS 2),
- connecting to adjacent sidewalks and paths
- adding additional connections required based on the Bend Development Code (e.g., to meet block length and perimeter standards),
- modifying existing or new streets as needed to achieve the target LTS,
- reconstructing sidewalks in poor condition,
- completing existing gaps, and
- building any required low stress crossings of arterial and collector streets as identified on TPS Figure 5-1 Low Stress Bicycle Network or the Connector Routes and Crossings Map in the Standards and Specifications.

Guidance: Additional considerations for design of the pedestrian network include:

- Design the end of a sidewalk (i.e., at a property line where there is no existing adjacent sidewalk) at a logical, safe terminus that allows continued travel:
    - Construct an ADA compliant asphalt or concrete taper from the detached sidewalk back to the street or as otherwise permitted in the standards, or

    - Extend the sidewalk to the nearest intersection, including ADA ramps
- Locate above ground utilities in easements or outside of the minimum sidewalk/shared use path width as required by the Standards.

Dimensions of People Walking

People walking includes those running, using canes, using wheelchairs, pushing strollers, pushing bicycles, and various other forms of low-speed movement (skateboards, scooters). This means that the operating space for pedestrians can vary. Complete street designs consider wider operating space for a variety of pedestrians to travel side by side and to pass each other. The standard sidewalk/ shared use path widths of six feet on local streets allows people to walk side by side. The wider widths of eight to ten feet on arterial and collector streets support groups of people walking and people passing each other. A range of dimensions for people with mobility devices is shown in Figure 15.

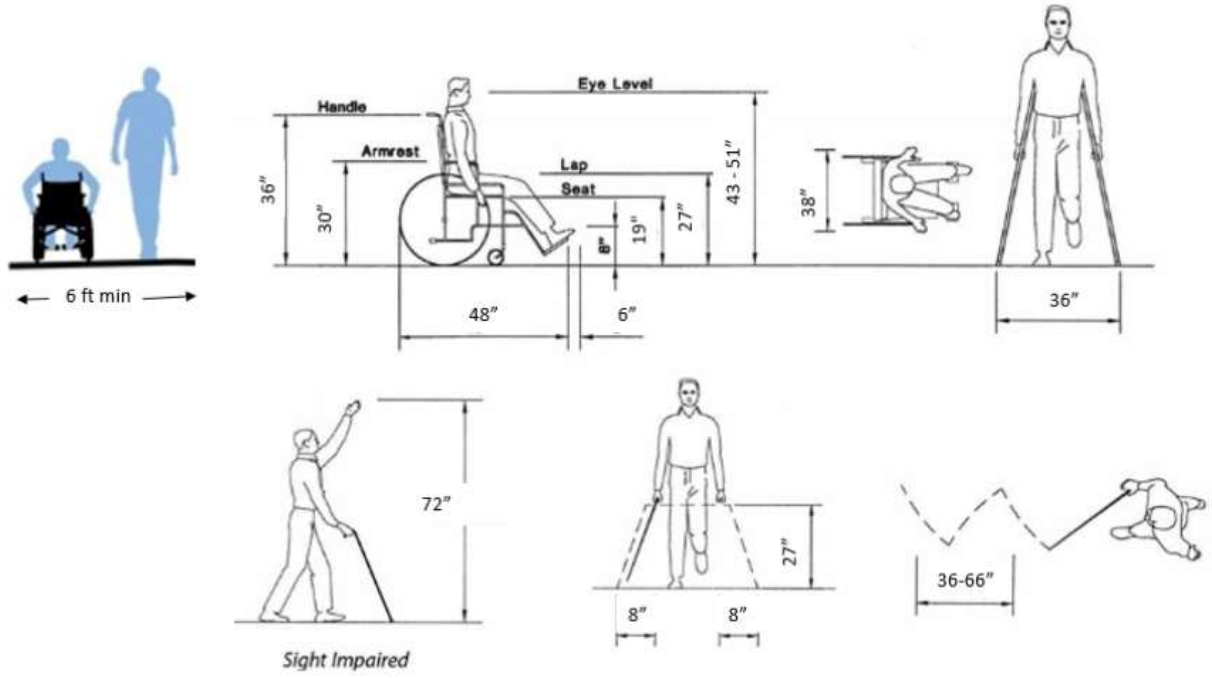


Figure 15 - Spatial needs for people using mobility aids from the FHWA and walking side by side.

Facilities for People Biking and Walking

The City of Bend aims to provide a walking and biking system for people of all ages and abilities. Separating people who are biking and walking from vehicle traffic increases comfort and safety for all street users. Providing different spaces for higher speed cyclists from lower speed cyclists and people walking can further encourage people to walk and bike. The low-stress network was identified as a first step to creating a system for providing low stress bicycle facilities. The ultimate achievement is for all streets to provide low stress walking and biking routes, and for those routes to directly connect to the system of off-street trails and internal walkways at destinations. The different facility types for people walking and biking in order from the most to least separated from traffic are shown on Figure 16 and described in the following sections.

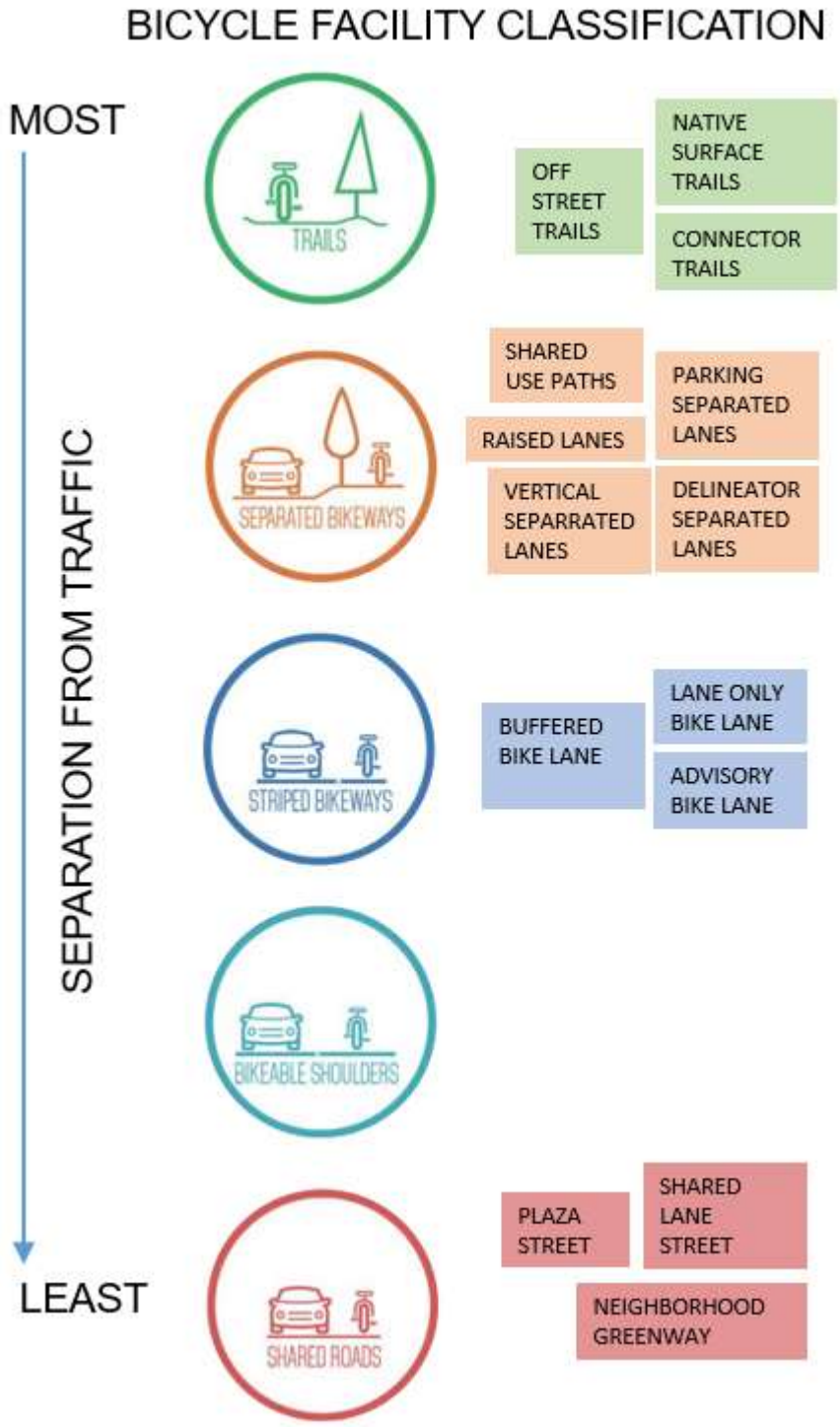


Figure 16 Bicycle Facility Classification by Level of Separation from Vehicle Traffic (Adapted from Bicycle Facility Design Toolkit, Montgomery County Planning Department, July 2017)

Native and Soft Surface Trails

Native and soft surface trails serve both people biking and people walking. Native surface trails are constructed trails composed of native soil and rock. Soft surface trails are constructed trails composed of compacted material as specified by the Standards. Soft surface trails and native surface trails may not meet public accessibility requirements and are not used in place of the standard multi-use path or sidewalk in the right-of-way.

Typical Application: Native surface trails and soft surface are used as part of the ancillary or informal bicycling and walking network. They may be used within parks or private developments and to provide supplemental connections to the public paved and accessible walking and biking routes. While they provide important secondary or tertiary connections, they are not part of the formal city network. This is due to the limitations in meeting all-ability and accessibility requirements.

Off-Street Trails

Off-Street trails are paved shared use trails located outside of the right of way (in a public access easement) that provide two-way travel for people walking and biking. Off-street trails are separated from motor vehicle traffic by an open space or by the location within a development instead of along the street. Off-street trails are distinguished from shared use paths in that the off-street trails are facilities managed privately or by other agencies. Examples are the Larkspur Trail (BPRD managed), Discovery Trail (privately managed), and Bridges trail (privately managed). The off-street trail is the premier type of shared use path because it is definitively separated from vehicle traffic, typically provides for less interruptions with streets and driveways, and provides the lowest stress (most comfortable) experience for users. The existing off-street trails are used for both transportation and recreation and they see some of our highest walking and biking usage. Off street trails require low stress crossings where they intersect streets and major driveways.

There are two types of off-street trails: primary trail and connector trail:

Primary Trail – (See Standard Drawings for cross-section.) A primary trail (Figure 17) is a paved trail that connects extended areas within and across the city. They may also connect to trails beyond the city limits. While the standard trail width is ten feet, increased widths of 12 – 14 feet may be used to serve higher volumes of people walking and biking in both directions

Figure 17 - Example of a Primary Trail

Figure 18 - Example of a Connector Trail

Connector Trail – (See Standard Drawings for cross-section.) A connector trail (Figure 18) is a paved trail that provides for shorter connections between other walking and biking facilities such as from a cul-de-sac sidewalk to a primary trail. Ranges from six to ten or more feet depending on the volume of people walking or biking and the sizes of the facilities they connect.

Typical Application: TSP Figure 5-1 the Low Stress Bicycle Network shows the general plan for off-street trails but may not include all alignments. Primary shared use path alignments are also identified on the Bend Park and Recreation District Trail Map, may be identified along railway or utility corridors, may be built in right of way for planned but unbuilt streets, and include trails through public land.

Connector trails are typically identified during development and may be required by the Bend Development Code to meet block length and perimeter connectivity.

Guidance:

- Off street trails are desirable low stress facilities. New developments, especially those in expansion areas, are encouraged to identify opportunities to create off-street trails that expand the north-south and east-west low stress system. Coordination with and approval from BPRD is required where they are to maintain the facility instead of the private development. The city does not maintain off-street trails.

- Design off-street trails to fit contours targeting grades of five percent or less and 1 percent or more.
- Use-of activated pedestrian scale illumination may be considered in locations with high nighttime use
- Centerline striping may be used in limited locations at curves or major intersection approaches to minimize conflicts between riders traveling in different directions
- On sections with longer, steeper grades, provide periodic sections with flat grades to make it easier for users to stop or rest.
- Off-street trails are not used instead of bike lanes, they are used in addition to bike lanes as they serve different user and trip types.
- The standard drawing shows a ten-foot typical width, twelve to fourteen-foot widths will also be considered to provide additional space for two-way traffic and directional passing
- Trails that are not part of the City's sidewalk/shared use path system such as trails within parks or private developments may have an option to be soft surface providing accessibility requirements are met.

Shared Use Paths

A shared use path is a paved path eight feet or more in width that provides two-way travel for people walking and biking and is typically within the right-of way. This facility is sometimes referred to as a side path as it is alongside a street. It is different than the off-street trail that is typically farther offset from the street and may not follow the alignment of the street. Shared use paths (Figure 19) are separated from the street by a planter strip except where standard allow curb -tight adjacent to a parking lane.

Figure 19 – Empire Avenue Shared Use Paths (and buffered bike lanes)

Typical Application: Shared use paths are required on both sides of arterial and collector streets and may be used on certain local streets to meet low stress route requirements. (See Standard Drawings)

Guidance:

- The width of the standard cross-section shared use path varies from eight to ten feet due to right-of-way width limitations; wider paths twelve to fourteen feet will be considered with the dedication of additional right of way or easements.
- Centerline striping may be used in limited locations at curves or major intersection approaches to minimize conflicts between riders traveling in different directions or along the length of busier paths.
- Shared-use paths are not used instead of bike lanes, they are used in addition to bike lanes as they serve different user and trip types.
- Design landscaping to minimize vegetation growth conflict with path users and minimize the need for trimming and sweeping.
- The standards require property-tight paths to provide separation from the travel lane; an additional easement increasing the separation of the path to meander farther from the street may be considered.
- Provide additional easements to maintain the standard path widths where the landscape buffer is not adequate to fit above ground utilities (versus narrowing the path).
- Provide a protective/railing fence at 42 – 54 inches high if the path is adjacent to a steep slope or drop off more than thirty”

Separated bike lanes

Separated bike lanes, also called cycle tracks, use offset or vertical design elements to physically separate the bikeway from adjacent travel lanes, and are distinct from the sidewalk. Separated bike lane designs significantly reduce the ability of people driving to encroach in the bike lane and thereby increase the comfort level of the people riding. While the shared use paths may serve the less experienced “interested but concerned riders,” the separated bike lanes can serve the growing number of “somewhat confident” riders as they gain skills. Even highly confident riders have expressed interest in facilities with greater separation from traffic. Separated bicycle facilities also provide greater comfort to pedestrians by separating them from the faster-moving bicyclists. The methods for separation may include parking, delineator, traffic separator or raised bike lane.

Parking Separated Bike Lane

In a parking separated bike lane the parking lane is between the travel lane and the bike lane so that parked cars physically separate people riding bicycles from the motor vehicle lane. A minimum two-and-a-half-foot car door buffer is provided between the parked vehicle and the bike lane. Using the parking lane as a buffer is the lowest cost, easiest to maintain separated lane to implement (Figure 20). This design works in areas of high parking demand where vehicles are typically present. In areas of low parking demand, the infrequent presence of vehicles provides less physical separation, but still provides a

space buffer to moving traffic. This option could also include delineators placed in the buffer spaced to allow opening doors.

Figure 20 - Parking Separated Bike Lane

Delineator Bike Lane

The delineator bike lane provides a vertical separation between the bicycle lane and the vehicle travel lane by using a series of delineators in the buffer space. They may be located just near intersections, continuously along a corridor, or intermittently.

Traffic Separator Bike Lane

Figure 21 - Traffic Separator Bike Lane

In the traffic separator bike lane vertical elements such as raised curb, modular separators, or modular bike rail are used in the buffer to physically separate people riding bicycles from the motor vehicle travel lane (Figure 21). Raised planter boxes are another type of traffic separator but are not included because they are typically too wide for the standard two-and a half foot buffer and generally do not meet the requirements for low maintenance and waterwise design. Traffic separators may be continuous, intermittent, or just at intersections. The devices are located to provide a minimum of one-foot separation from the nearest edge of the bike lane line to the center of the separator or a minimum of one foot offset whichever provides larger separation from the travel lane line.

Raised Bike Lane

Raised bike lanes are bike lanes that are elevated above the vehicle travel lane to separate people riding by the grade difference and a curb (Figure 22). They are typically at the same level as the adjacent sidewalk, though they may be lower. The different curb types provide different degrees of a barrier to vehicle encroachment in the bike lane. Rollover curbs provide a minimal barrier while vertical curbs provide a greater barrier.

Figure 22 - Raised Bike Lane

Two-Way Separated Bike Lanes

Two-way separated bikeways (Figure 23) are separated bike lanes that allow bicycle movement in both directions on one side of the street. They share most of the same design characteristics of one-way separated bicycle lanes but require additional design considerations at driveway and street intersections.

Typical Application of Separated Bike Lanes:

- Streets with posted speed limits 30 mph or higher and average daily traffic volumes of 8,000 vehicles or greater
- Streets with access control or use of driveway aprons for local streets and driveways for fewer conflicts
- Higher density areas, adjacent to commercial and mixed-use development, and near major transit stations and mobility hubs
- Key Routes (TSP Figure 5-3b)
- On existing streets where there is not a shared use path and construction of a shared use path is infeasible, separated bike lanes can provide a lower stress route.

Figure 23 - Two Way Separated Bike Lane

Guidance:

- Key routes are built with separated bike facilities (shared use paths and/or separated bike lanes) as feasible
- Parking Separated

    - Where on-street parking is next to a bike lane in areas of high parking demand, parking separated bike lanes are preferred due to the higher level of protection, lower maintenance, and lower cost.
    - Provide a 2.5-foot car door buffer where parking is adjacent to bike lane.
    - Consider speeds, travel lane width, and volumes (gaps for people to get out of cars)
- Evaluate the placement of parking space buffer and devices to allow for appropriate sight lines at intersections and driveways for both bicycles and vehicles
- Raised bike lanes adjacent to a sidewalk/shared use path require design treatments that address detectable separation for accessible ways per the Public Rights of Way Accessibility Guidelines (PROWAG)
- Two way separated bike lanes require a 12-foot minimum width, ten foot may be acceptable in short segments within constrained areas.
- Separated bike lanes, particularly two-way lanes, require additional design evaluation at intersection crossings and traffic signals to facilitate safe movements for people riding, walking, and driving
- In retrofits when there is insufficient room to provide a buffer to both the travel lane and the parking lane, use a six-foot minimum bike lane and place the minimum two-and-a-half-foot buffer on the travel lane side.
- Use of any device separated bike lane requires confirmation of a funded plan for winter and summer street maintenance
- Coordinate separated bike lanes with other curbside uses such as mail delivery, garbage/ recycling, service deliveries to provide alternate locations or mitigation for those uses.
- Conflict zone marking (BLEG on Standard Drawing R44A) may be utilized along separated bike lanes at high volume commercial driveways. It is not used at every driveway.

Contra-flow bike lanes


Contraflow bike lane. *Photo by Toole Design Group*

Figure 24 Contra-flow bike lane image from FHWA Bicycle Safety Guide and Countermeasure System

Contra-flow bike lanes are one-way on-street bike lanes designed to allow a bicyclist to ride in the opposite direction as vehicles on a vehicle one-way street by striping a yellow center lane stripe and bike lane symbols. The contra flow lane is typically a separated lane but may be a striped lane (Figure 24). The minimum bicycle lane is 6.5 feet wide.

Typical Application:

- On a one-way street in a location with higher volume bicycle travel the opposite direction.
- Where a one-way street provides a direct connection to common travel routes and popular destinations (versus an alternate route with long out-of-direction travel)

Contra-flow bike lanes may be striped on streets with speeds of 25 mph or less and lower traffic volumes. At higher speeds and volumes separation is required."

Striped bike lanes

Striped bike lanes use pavement markings to designate bicycle lanes. Striped bike lanes include buffered bike lane, lane only bike lane, and advisory bike lane.

Buffered Bike Lane

A buffered bike lane provides a double striped area of pavement to spatially separate people riding bicycles from vehicle traffic in the travel lane or from door opening in the parking lane. The buffered bike lane is the minimum standard for arterial and collector streets. A target bike lane width is 6 to 6.5-feet with a minimum 2.5-foot buffer. The minimum buffer width is 2.5 feet, the minimum dimension that could allow for a future installation of separated devices (Figure 25).

Figure 25 - Person Riding in a Buffered Bike Lane

Lane-Only Bike Lane

A lane only bike lane (Figure 26) uses a single stripe to delineate the portion of the street for the use of people riding bicycles. While this is found on some existing streets, they are not used on new or reconstructed streets, except for limited cases with constrained right-of-way. Buffered bicycle lanes are the standard, not lane-only bike lanes.

Figure 26 - Lane Only Bike Lane

Typical Application:

- Buffered bike lane is the standard minimum bike lane configuration on arterial and collector streets (except on key routes where separated facilities are the minimum configuration)
- Streets with existing lane only bike lanes that have sufficient pavement width to accommodate buffered bike lanes will be restriped as buffered bike lanes with pavement maintenance, capital projects, or development projects.

Guidance:

- Where existing built out streets are too narrow to fit the standard bike lane and buffer (6.5/2.5) with an eleven-foot travel lane, a reduced buffered lane with 5/2 or 5/2.5 may be used. Where there is less than seven feet, a lane only bike lane, not a buffered lane is used.
- There may be short segments, such as adjacent to a traffic separator in constrained existing conditions, where lane widths may be reduced to ten feet to accommodate a bike lane or buffered bike lane.
- The standard buffered bike lane design includes a buffer between both the vehicle travel lane and the parking lane where parking is provided.

Bikeable Shoulder

Bikeable shoulders are the part of the street marked with an edge line that is at least four feet but less than five feet wide, where people on bicycles may ride and share the space with stopped or parked vehicles and pedestrians where sidewalks are not present. (Less than four feet is considered a shoulder and not a bike facility)

Typical Application: This is not used for any new facilities. It may remain an existing condition until a street is reconstructed to meet complete street standards or otherwise improve the shoulder to minimum bike facility widths.

Guidance:

- Extended shoulders of five feet or more are restriped as bike lanes.
- When adding new striping or restriping arterial or collector streets with insufficient widths for bike lanes, aim to get as wide a shoulder as feasible. Where bikeable shoulders do not fit in both directions, prioritize the uphill direction on hilly streets, the inside of a horizontal curve, and the downgrade of a vertical curve

Shared Use Street

A shared use street is a street where people driving, riding bicycles, and maybe even walking share the same lane. The shared street prioritizes people biking and walking by slowing vehicle speeds and communicating through design features that people driving must yield to people walking and biking. A shared use street is a purposefully built street with design features to support interactive use. Shared use streets include a plaza street, a neighborhood greenway, and advisory bike lane, and a shared lane street.

Plaza Street/ Woonerf

A plaza street, also called a woonerf, is a street that is designed to focus on access and social space for people walking and biking rather than through vehicle movement (Figure 27). It gives priority to people walking and biking along and crossing at any point on the street while also allowing for slow through vehicle movement. The plaza street often does not have a clear division of space for users, though some may have separate sidewalk areas for pedestrians. Plaza streets have a defined entrance at each end and traffic calming to slow speeds.

Figure 27 - Plaza Street

Typical Application:

- Used on low-volume local streets (less than four hundred vehicles per day or 100 vehicles per hour) designed to meet Oregon Revised Statute statutory requirements for a fifteen mile per hour alley speed limit.
- Gateway treatments are used to create a defined entrance to the shared lane street to inform drivers that they are entering space where people walking, and biking have priority. Treatments include a driveway apron (Standard Drawing R5) instead of a standard intersection approach and may include colored pavement or alternate materials.
- Street furniture such as bollards, benches, planters, and bicycle parking help to enhance and delineate the shared space and limit where vehicles can travel.
- Traffic calming and curving vehicle routes are used to create a slower through driving path.
- Where a plaza street is on the bicycle low stress route, the plaza street provides a clear, easy to identify route from the adjacent Bicycle Low Stress Network to and along the plaza street.
- Plaza streets are privately maintained under a maintenance agreement with the city.

Guidance:

- Plaza streets typically allow for two-way travel but may be one-way
- Where Oregon Revised Statute requirements for a 15 mph alley speed limit are not met, then they are designed to meet the 20 mph business district speed limit.
- Plaza streets may consider green stormwater treatment and valley gutters, bioswales or other infrastructure than vertical curbs with traditional inlets. (Typically, there is no vertical curb).
- Parking is generally not provided along plaza streets. If parking spaces are used, they are clustered parallel spaces or back in angled spaces limited to four space bays. Perpendicular or angled spaces are not used as they have limited visibility to through bicyclists and pedestrians. Areas where parking is permitted are indicated by physical elements (such as bollards) and/or different paving material.
- May be designed to close to vehicle traffic intermittently for festivals, farmers markets, and events.
- Typically, are designed within a network that provides alternate access for emergency vehicles. Where used by emergency vehicles, additional requirements may apply to meet fire code.

Neighborhood Greenway

A neighborhood greenway is a specific type of shared lane local street with signs, pavement markings, and often additional traffic calming to foster slower speeds. If the street lacks sidewalks on one or both sides people walking may also share the street with people riding and driving. Greenways provide a route that is more comfortable for users than nearby busier, faster streets. Enhancing a local street as a greenway is one option to create a low stress bicycle facility on a local street (Figures 28 and 29).

Figure 28 - People riding over a speed hump on a Greenway.

Figure 29 - Image from NACTO Urban Street Guide that shows a neighborhood greenway with traffic calming.

Typical Application:

- Local streets can be designed as greenways where the average volumes (existing or proposed) are 2,000 vpd or less and the eighty-fifth percentile speeds are less than 30 mph
- The shared lane pavement markings, also called sharrows, serve as one type of wayfinding on designated bicycle low stress routes.
- Where volumes and speeds are higher, mitigation is required to reduce speeds to target 20 mph and volumes to 1500 vpd or lower.
- Greenways are posted with neighborhood greenway signs (Figure 30), pedestrian and bicyclist traffic control devices (signing and or striping), and 20 mph speed limits.
- Greenways on new streets require the standard cross-section with sidewalks on both sides.

Figure 30 - Neighborhood Greenway Sign

Guidance: Neighborhood greenways are the foundation of Bend's low stress bicycle network since many of the low stress routes are along the local street alignments. The local street routes were chosen to connect the community because they provide a continuous route on lower volume and speed streets. Using the local street system provides an economical way to retrofit existing streets and a low-cost build for new streets. Greenway considerations include:

- Provide straightforward routes that avoid zig zagging or circuitous routing compared to the shortest path along the target corridor.
- On new streets the routes should be direct and not circuitous. The challenge is providing a direct route but not a long uninterrupted street that fosters higher speeds.
- Target streets that have average daily volumes of 1,500 vpd or less and traffic calming/ diversion or a shared use path is recommended for volumes of 1,500 to 2,000 vpd.
- Traffic calming options (curb extensions, center islands, chicanes, diverters, etc.) are provided in the Standards with supplemental information provided in this manual. Coordinate traffic calming with emergency services.
- Use local street routes with lower traffic volumes that parallel major streets and provide convenient access to nearby commercial and key destinations
- Use streets that have alternative routes available for motor vehicle traffic to minimize the challenge of keeping volumes and speeds low on the neighborhood greenway
- Coordinate with City staff prior to design approval to confirm the state required 20-mph speed criteria are met. If criteria are met, a council ordinance is required to post the reduced speed limit.
- Provide wayfinding to let people know where to find and continue along the lower stress greenway routes with
    - Shared lane markings
    - Neighborhood Greenway signs (a supplemental plaque to the greenway 20 mph speed limit)
- Where there is no sidewalk on a retrofit greenway, design traffic calming or other design mitigations to accommodate accessible routes in the street.

Advisory Lane

An advisory lane uses a dashed stripe on each side of the street to provide priority, although not exclusive space, for people riding bicycles. Vehicle traffic travels in a single, bi-directional center traffic lane that is typically too narrow (16 feet or less) to serve two-way traffic. When two cars approach, they are permitted to enter the advisory bike lane after yielding to cyclists (Figure 31). Advisory bike lanes are also called edge lanes.

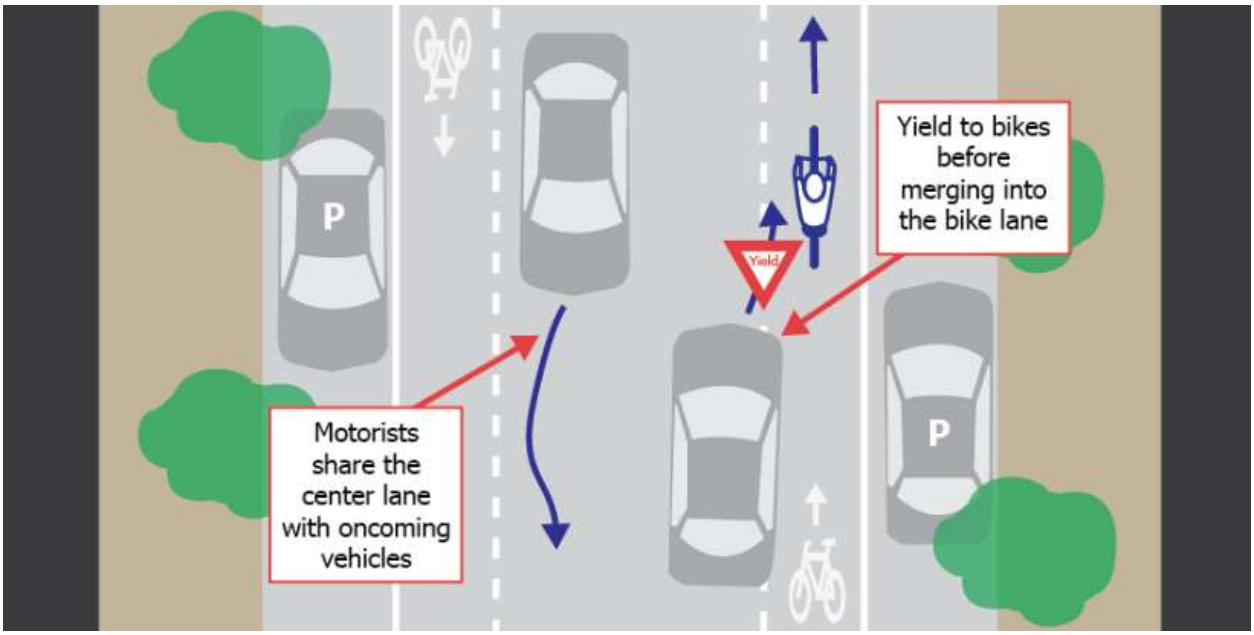


Figure 31 How to Use and Advisory Bike Lane (City of Minneapolis, www. Minneapolismn.gov/bicycles/advisory-bike-lane))

Advisory bike lanes may be an interim tool where the street segment is a gap in an otherwise established bicycle route and the street/right of way is not wide enough to accommodate bike lanes or a shared use path on one side. The use of an advisory bike lane requires City Engineer approval. Factors to consider in approving include review of a traffic study characterizing the applicability (slow speeds, low volumes, visibility not limited by horizontal or vertical curves, no bus route, low volumes of truck traffic, and six-foot minimum bike lanes and twelve to eighteen feet for the vehicle lane. Additionally, the study must show compliance with the FHWA conditions for permission to experiment including a width of at least six feet for each bike lane and between twelve and eighteen feet for the vehicle lane.

Shared Lane Street

The shared lane street uses shared lane pavement markings, or sharrows to remind people driving that people riding bicycles share the same directional travel lane. Shared lane streets have sidewalks for pedestrians. The shared lane street differs from a Greenway in that speeds and volumes are above the greenway threshold or it is not a local street. The city is generally not creating any new shared lane streets as they do not provide a comfortable bicycle facility that is LTS 1 or 2.

Typical Application:

- Not used for new routes on arterial or collector streets, and not used on local streets with more than 2,000 vehicles per day or posted speeds over 25 mph.
- Not to be used as a substitute for providing low stress bicycle facilities per the standard but may be considered to temporarily connect facilities until reconstruction.
- May be used in short segments
- When used with on-street parking, the standards identify offset distances for sharrow placement to guides people to ride in a location away from where the car doors open.
- Sharrows have been approved in the Bend Development Code on certain streets in the Bend Central District
- Sharrows may be considered where a generally continuous bike lane ends and has only a short (approximately 1800 feet or three to four block) gap on a street with a speed of 25 mph or less, shared lane markings may be used to continue the bicycle route along the same street if interim measures to connect are not feasible.

Safe Routes to Schools Plan

Safe routes to school refers to efforts that build infrastructure, educate, or encourage children to safely walk or bike to school. A safe route to school plan is a map that shows designated routes that provide more comfortable, lower stress routes to schools from a certain development or residential area. The Bend Development Code Chapter 4.7 Transportation Analysis requires an evaluation of pedestrian and bicycle facilities to provide access to schools. This section provides more details on developing a Safe Routes to School plan to meet those requirements. A Safe Routes to School plan is a map that identifies the low stress (target LTS 1) walking and biking routes and crossings between a school and adjacent residential areas. The alignment of the safe routes to school typically follows the bicycle low stress routes on TSP Figure 5-1, but revised or additional routes may also be required if the designated low stress route does not sufficiently serve the homes or schools.

For development projects that include housing for school aged children that are not required to complete a transportation facilities report, completing a Safe Routes to School plan is highly recommended to help encourage walking and biking to school. The plans are an important tool for parents and students to find the most suitable route for their skill and comfort level. Developing the Safe Routes to School plan helps identify where there may be gaps and needed improvements for children to access schools or where alternate routes can be used for a lower stress route (Figure 32).

Figure 32 - Children and Parents Using an Enhanced Crosswalk with a Crossing Guard.

Where the gaps and improvements are outside of the nexus for the school or development, the identification as part of the evaluation will help the city and school district to plan and prioritize future projects to complete the network.

Generally, the Bend La Pine School District does not provide bus service for residences within one mile of an elementary school or one and a half miles of other schools, so those are the minimum evaluation distances set in the Bend Development Code for a safe route to school evaluation.

A Safe Routes to School plan at a minimum is a map that identifies the following using existing facilities and facilities built with the development:

- Low stress crossings of arterial and collector streets between the development and the school
- A raised local street crossing between the development and the primary school entrance for students
- School speed zones (both at the school and any off-site arterial and collector school crossings serving the development), and
- Low stress (target LTS 1) walking and biking routes from the development to the school (Figure 33)
- May include supplemental information on walking or biking school bus routes. (A walking or biking school bus is a supervised group of children walking or biking to school along a set route with the group stopping to pick up or drop off passengers along the way.)

Figure 33 - Walking School Bus Route Map (from Commute Options)

Examples of maps for each Bend La Pine elementary school focused on walking that were created by Commute Options as part of a Safe Routes to School Grant can be found online at https://www.commuteoptions.org/walking-school-bus/. Safe routes to school plans for residential developments and for school sites are slightly different.

Residential Development

For residential site developments, evaluate the route from the development to the public elementary, middle, and high school that serves the development as identified by the Bend La Pine school district attendance area maps. Evaluation of private schools is not required. The Safe Routes to School evaluation includes:

1. **Confirm the site is served by a low stress route.** Review TSP Figure 5-1 Low Stress Bicycle Network map. Does the low stress route for biking and walking connect from walking and biking facilities throughout all portions of the site and to the school?
    a. Yes – build the segment related to the development and identify any gaps that are outside of the development's improvements.

b. No - amend the low stress routes to access the school or add a new route or internal connections to provide a low stress route to the school. Build the segment related to the development and identify any gaps that are outside of the development's improvements.
c. Guidance on Routes: Routes are as direct as possible along a path that provides safe, visible crossings that are at locations that are controlled locations where feasible or can be enhanced to create a low stress crossing. LTS 1 is required for elementary schools, and LTS 1 is the target, but LTS 2 is permissible for other schools. See the Low stress route section of this document for more information on creating low stress routes.
d. Coordinate with the city staff to determine if there is any funding/ opportunity to complete the identified gaps outside of the development's improvements in conjunction with the development construction so a complete route can be provided.

2. **Confirm arterial and collector low stress crossings are provided if required**. Does the low stress route from the development to the school cross an arterial or collector street? If yes, then check
    a. Is the low stress route served by an existing low stress crossing meeting the target LTS 1?
        i. Yes, no action
        ii. No, enhance an existing crossing or where none exists build a new low stress crossing to achieve the target LTS 1; LTS 2 may be accepted for retrofits of existing streets at middle or high schools and in limited cases at elementary schools.
    b. Guidance on Crossings. Locate arterial/ collector crossings to provide low stress school access in locations that meets the target ¼ to ½ mile crossing route spacing to serve not just the development, but also any nearby transit stops, low stress routes, and adjacent developments (i.e., provides a network connection rather than an isolated crossing location). The Connector Routes and Crossings Map (Standards Appendix C) identifies planned network crossing locations.
    c. Coordinate with city staff to determine if there is any funding/ opportunity to complete any identified low stress crossings outside of the development's improvements in conjunction with the development construction so a complete route can be provided.

3. **Provide an enhanced local street crossing if required.** Does the main student access to the school's student entrance(s) cross a local street? If yes, then typically a raised concrete crosswalk with signs and marking will be required. Additional traffic calming such as curb extensions may also be required.

4. **Create a Safe Routes to School Plan.** Create a map (Figure 34) that shows the low stress routes identified between the development and the different schools with existing and proposed sidewalks, existing and proposed bicycle low stress routes and type (bike lanes, greenways, shared use paths, etc.), traffic control, school speed zones, and low stress crossings including crossing guard locations. The map will include local low stress connections that are used to access the school that are extensions to but not part of the formal low stress routes shown on TSP Figure 5-1. Where the walking and biking routes are different, distinguish that on the map. An example map where walking and biking routes are the same follows:

Figure 34 - Example Safe Routes to School Plan. Modified from Clark County School. Zone Traffic Control Policy, Clark County, December 2016

School Site

School site developments follow the same methodology and develop a Safe Routes to School plan for the entire attendance area. The evaluation covers all residential areas with school aged children within one mile of an elementary school, and within one and a half miles of all other schools. Trade schools, colleges, and universities with older and/or more independent students attract students from larger areas. The City Engineer will confirm the extent of the study area for higher education schools as part of the traffic

analysis, but it will at a minimum include a one-and-a-half-mile radius. At higher education schools, pedestrian crossings are used instead of school crossings, and school speed zones are not applied.

Schools at a minimum should build the low stress facilities and crossings adjacent to the school and should complete any low stress crossings of arterial and collector streets within the attendance area. The development process will identify the full scope of required improvements. The school district is strongly encouraged to create attendance area boundaries that minimize the need for arterial and collector crossings where feasible.

Schools are encouraged to post a downloadable and printable safe route to school map on their website, incorporate them into any related lesson planning, and include them in parent/student introduction and supplemental information to help students and parents learn which streets provide lower stress routes and crossings access to their school.

Intersection and Crossing Designs

An essential aspect of the low-stress network is safe and comfortable crossings at street intersections and highway interchanges. A well-connected network includes clear and direct paths of travel through intersections, predictable movements at conflict points, clear right-of way priority, and straight forward decision making for all users. This section presents techniques for low stress intersections and crossings. Information on designs for people walking and biking at roundabouts is provided in the Roundabout Design Manual.

Enhanced Crosswalks

In Oregon, every intersection is a crosswalk whether marked or unmarked (ORS 801.220). People riding bicycles are required to approach a crosswalk at walking speed (ORS 814.410), and vehicles are required to stop for people on bicycles in a crosswalk as they are considered in the definition of pedestrians in crosswalks (811.028(4)). The requirement for people riding bicycles to slow to ordinary walking speed helps to provide people driving adequate time to perceive the intention to use the crossing and bring their vehicle to a stop for the crosswalk user. Refuge medians or islands reduce exposure of

people to vehicle traffic by reducing crossing distances and minimize delays for vehicles by shortening the crossing times. The islands also increase the number of gaps in traffic for people to cross by allowing them to navigate one direction of traffic at a time.

The Signing and Marking Manual provides the requirements for marking and enhancing low stress crosswalks.

Figure 36- Median Island with pavement marking and signing.

Figure 35 - Enhanced Crossing with Rectangular Rapid Flashing beacon

Based on a comparison of crash rates on arterial streets with 3 to 8 lanes and over 15,000 ADT, safety islands were found to reduce crosswalk collisions by 46% at marked crosswalks.

The types of enhanced crosswalks in the Signing and Marking manual include:

- Signed and marked crosswalks
- Signed and marked crosswalks with a traffic separator (used only in existing constrained conditions)
- Signed and marked crosswalks with a median or island refuge (Figure 36)
- Signed and marked crosswalks with/without a median island and a Rectangular Rapid Flashing Beacon (RRFB) (Figure 35)
- Cross bike (a green bike cross walk) – may be used on designated low stress routes or major trail (Deschutes River

Figure 37- Image shows a bike crossing marked with green paint and white crosswalk markings

Trail, COHC Trail, and Haul Trail) routes, at protected intersections, and at enhanced low-stress crossings of arterial and high volume/ major collector streets. (Figure 37)
- Raised crosswalks
- Pedestrian Hybrid Beacon

Guidance:

- Evaluate median and island landscaping. Where the enhanced crossing extends through an existing or proposed landscape median or island, re-evaluate the vegetation to eliminate or convert to low growing (less than 24 inches) within the area that provides sight distance for people driving oncoming vehicles and people in the crosswalk.
- Traffic separators provide traffic calming (people driving slow down) and additional visibility of the crosswalk with the in-street crossing sign. However, they are too narrow to provide a refuge for people waiting in the middle of the road for a break in traffic. Therefore, for higher volume and speed streets they do not provide a low stress crossing.
- Raised crosswalks are used at the main access where students who arrive by walking and biking access the school. Most schools just have one primary walking/ biking student access location; however, if a school has another primary school walking/ biking access to the building on other adjacent local streets, a raised crossing would also be used at that location. Raised crosswalks are only used adjacent to the school and only on local streets.
- While included in the list of options, the Pedestrian Hybrid Beacon is used at very high-volume pedestrian crossings of high volume and speed streets with four or more travel lanes to cross. Use of the beacon requires a traffic study to demonstrate why other options for enhanced crossings cannot be accommodated, that a roundabout (the preferred intersection choice) is neither feasible nor appropriate for the location, and that MUTCD criteria are met. The city also considers the NACTO criteria. Use of a pedestrian hybrid beacon will require considerable education to teach road users on how they operate, and a formal community education plan is required.
- Consider a left turn lane conversion. Where the best alignment for a low-stress network crosses a 3-lane roadway where existing traffic patterns can logically be shifted to adjacent streets in a grid network, consider closing one or both left turn lanes to install a median refuge island. The local street connection can then be converted to right in and right-out movements. These can also act to reduce traffic volume on the local street for shared lane and neighborhood greenways. A traffic study is required to evaluate how vehicle access and the modified traffic pattern can be accommodated by adjacent intersections and the network.

- Where angled parking is provided, design a sufficient curb extension so that the backing maneuver (with limited visibility) does not require backing over the crosswalk (Figure 38).

Figure 38 image shows a backing vehicle maneuver encroaching on a crosswalk

Modified Alignment at Channelized Right Turn Lanes

Where existing channelized right turn lanes are reconstructed or new islands are built, design the approach, curb radius, and crossing to maximize visibility of people walking and biking to right turning motorists; and increase driver yielding at the crosswalk and at the cross-street. This includes marking the crosswalks and signing (right turn stop for pedestrian), designing the shared use path to provide an approach perpendicular to the road with an offset to the mainline path of sufficient distance (6 – 10 feet) that allows a person riding a bicycle to stage without being in the through path, and providing a bicycle ramp for low stress users to access the shared use path. A raised crossing is encouraged across the right turn lane with a refuge island. Figure 39 shows different configurations for reducing the through bicycle/right turning traffic conflict.

Figure 39 - Examples of Bicycle Treatments at Right Turn Lanes

Raised Driveways

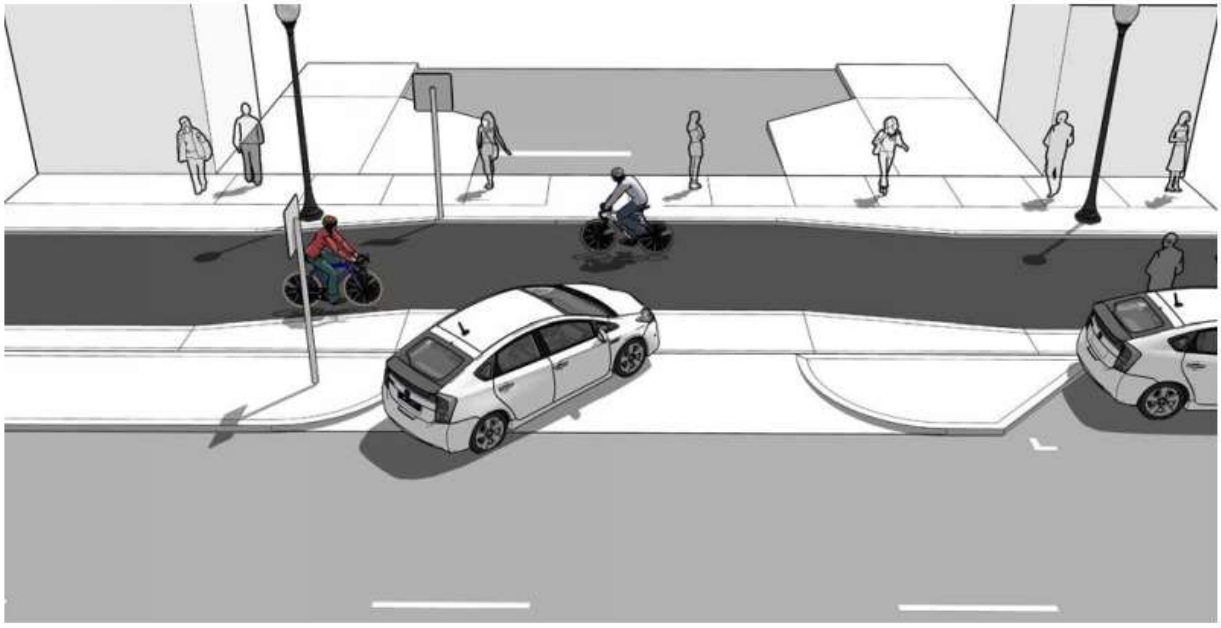


Figure 40 - Shared Use Path Crossing a Raised Driveway

Raised driveways (Figure 40) are a tool that when used in conjunction with a separated and raised bicycle lane or shared use path, provide an additional indicator to people driving to watch for both people walking and people bicycling as they turn. This configuration may be considered for local residential and commercial streets intersections with arterial and collector streets along low stress routes to improve the safety and comfort of bicycle lanes and/or shared use paths.

Bicycle Markings at intersections

The standard bicycle marking at an intersection is to stop the bike lanes before the crosswalk. There may be additional factors where additional marking can improve safety by increasing awareness of the bicycle facility, increase visibility of the people riding, isolate conflicts, or achieve a lower LTS. Some bicycle marking configurations in addition to those included in the standard drawings are shown on Figure 41.

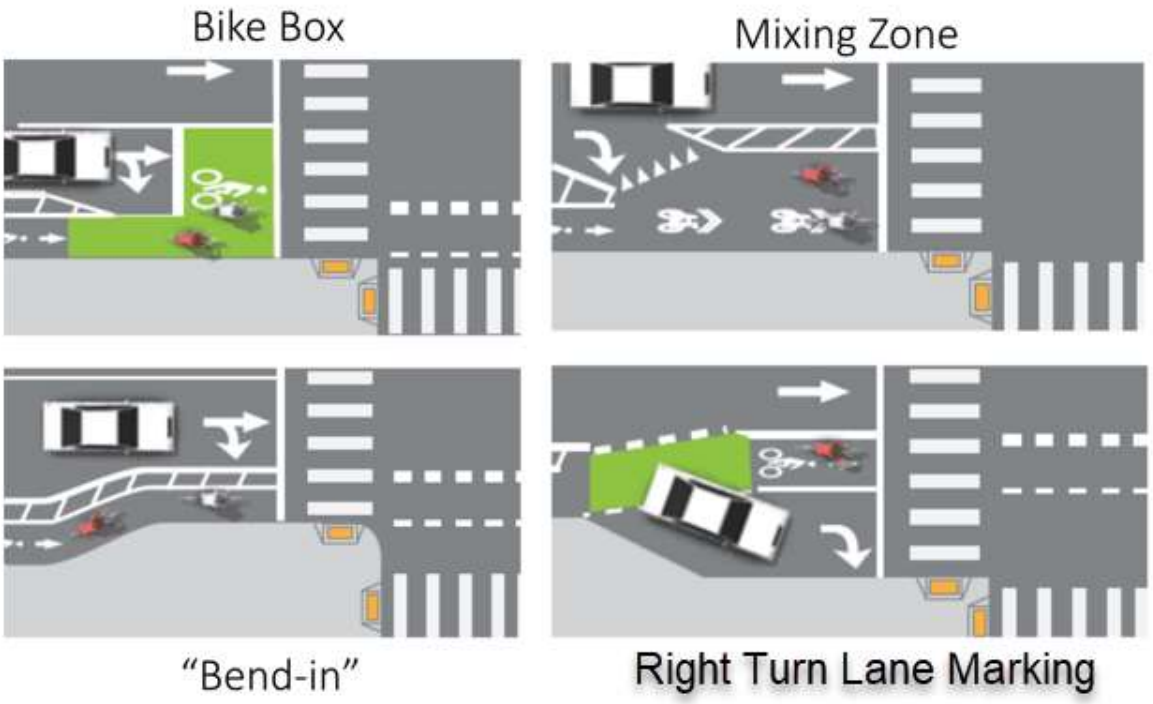


Figure 41 - Examples of Bike Treatments at Intersections

Bike Boxes

A bike box is a green pavement marking installed on a signalized intersection approach to reduce conflicts between people bicycling and driving. The boxes provide a space for people riding bicycles to stage in front of vehicles at a traffic signal. There is a standard bike box and a two-stage bike box (Figure 42). The two-stage bike box adds a second box on the downstream side of the intersection. Instead of weaving across the travel lane into a left turn lane, the two-stage bike box provides a way for people to go straight, wait in the second box, and then use the crosswalk signal to make the left turn movement.

Figure 42 A bike box on the near side and a two-stage left turn box on the far side of the intersection.

Typical Application: Bike boxes may be considered on a case-by-case basis by the Engineer. The bike box is not a preferred treatment. While it provides a space for through

bicycle riders to be more visible on a red light and clear the intersection more quickly as a group, it does not fully reduce the potential conflict between people driving and turning right and people riding straight through like other intersection treatments.

Figure 43 - Person Using a Bike Box

Where bike boxes are used, people driving cannot make a right turn on a red signal (Figure 43). Bike boxes are built to the Oregon's blanket use approval (ODOT TR17-02(B)) of the FHWA Interim bike box approval requirements (FHWA IA-18). A traffic analysis is required to evaluate the benefits and impacts of the bike box on all users, and to evaluate alternative options that provide a lower stress and more separated intersection treatment.

Guidance:

- The bike box should be long enough that people riding bicycles have an easily maneuvered path of travel into the box.
- Bike boxes are tools used on routes with higher volumes of experienced bicycle riders.

Two Stage Left Turn Boxes

Two-stage left-turn boxes make left turns safer and more comfortable for everyone. They prevent riders from needing to cross through traffic lanes to position themselves in a left turn lane, and from needing to share the left turn lane with drivers. The two-stage left-turn box provides people bicycling with a separate path of travel with fewer conflicts. The person bicycling can cross the intersection on green and remain to the right of traffic. They position themselves at the far-right side and proceed to cross the road on the next green phase.

Guidance:

- The two-stage left turn box may be considered as an interim tool to reduce the level of traffic stress in advance of a planned and funded protected intersection project.
- Place the two-stage turn box in a separated area such as in the shadow of a bike lane buffer or a downstream parking lane.
- The restricted size of the bike box or two-stage bike box may limit the number of riders that can use the area.

Mixed Zones- Bend in

Along routes where the bicycle lane is separated from vehicle traffic by parking, the parking lane ends and the bike lane alignment changes to bring the people on bicycles closer to the people driving so they are more visible (Figure 44). This can be improved by including a stop bar for motor vehicle traffic and bicycle traffic that are positioned to have the bicycle stop bar ahead of the car stop bar. Provide 20 – 40 feet of length to shift the bikeway closer to travel lanes (A) by prohibiting parking at the start of the transition (B) and extending the curb.

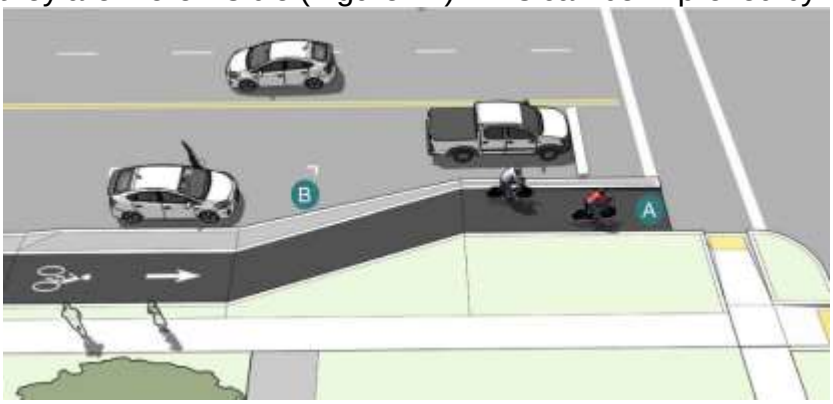


Figure 44 - A lateral shift or "Bend-in" bike lane

Right-Turn Lane Marking

Signing and marking is used at intersections with right-turn lanes to notify people driving where they cross the bike lane. Where there is a separate right turn lane at an intersection, the through bicycle and turning vehicle must cross paths. The use of green supplemental bicycle lane marking can help increase awareness of the potential conflict and provide direction to people at the intersection. Standard Drawing R 44-a provides for a green supplemented bicycle lane across an added right turn lane taper or at a dropped right turn lane. These markings may be required at low stress route approaches to 3rd Street and 27th Street where there are four or more travel lanes and right turn lanes. They may be considered at other arterial and collector street low stress crossings where there are a high number of conflicts.

At existing intersections where there is insufficient space for a separated bike lane, a shared bike and right turn lane may be marked, by extending the bike lane markings through the turn lane (Figure 45).

Figure 45 - Shared right turn and bike lane

For all these right turn scenarios the level of traffic stress is higher for both the person riding and driving due to the limited visibility, speeds, and bicycle positioned between vehicles. To provide a low traffic stress option, a bicycle ramp to a shared use path is recommended and may be required on low stress routes in addition to the conflict markings.

Guidance:

- The Standards limit the use of right turn lanes. While right turn lanes can provide operational benefits in some cases, they increase the conflict points for people walking and biking. Evaluate intersection operations to determine if the right turn lane can be removed and the bike lane extended prior to striping the shared lane.
- This configuration is a temporary measure for existing constrained street widths until the street can be widened or reconfigured for a separate bike lane. It is not an option for new streets. Evaluate options and intersection impacts to adjust the length of the right turn lane adjacent to the bike lane to 150 feet long or less where LTS 2 is targeted and 75 feet long where LTS 1 is targeted.
- Design the curb radius to support slower speed (15 mph) turns.
- The conflict zone markings run for the length of the taper or a minimum of 50 feet whichever is greater. Where the right lane is a drop lane, the conflict zone markings are split into two twenty-five-foot sections per the Standard Drawings.

Bike Lane Terminations

Where bike lanes end, clear transitions provide people riding direction on how to continue their trip. They also give notice to people driving of where a person riding could be expected to travel. Where the bicycle facility ends:

- Design bike lane striping to end at a logical transition point.
- Provide an interim, temporary connection to continue the route along the same street where feasible.
- Provide wayfinding to direct riders to an adjacent facility where there is a bicycle route or alternate bicycle facility within a block or two of the bike lane ending.
- Provide dashed striping and bike lane ends sign to advise both the person riding in the bike lane and drivers that the lane ends and the bicyclist will be merging into traffic. (Standard drawing R-44b).
- Where a continuous bike lane ends and has only a short (approximately 1800 feet or 3-4 block) gap on a street with a speed of 25 mph or less, shared lane markings may be used to continue the bicycle route along the same street if interim measures to connect are not feasible.

Low Noise Rumble strips

Safety and comfort for the low-stress route is reduced when motor vehicles encroaching in the bike lanes. This risk can be higher at curves. Low noise producing rumble strips (Figure 46) are a tool that may be piloted on curves at locations with standard bike lanes or narrower buffers that have higher incidences of vehicle encroachment to see if they deter vehicles from drifting into the bike lane. A rumble strip within the buffer provides visual cues to keep bicycle riders off the rumble to maintain control, though it does limit the use of the buffer by people biking to pass or avoid debris. ODOT research “Quantifying the Performance of Low-Noise Rumble Strips Final Report Project SPR 800” provides details on rumble strip dimensions. The report indicates that a sinusoidal rumble strip provides effective interval vehicle alerts while suppressing external noise output and is therefore a tool for urban use.

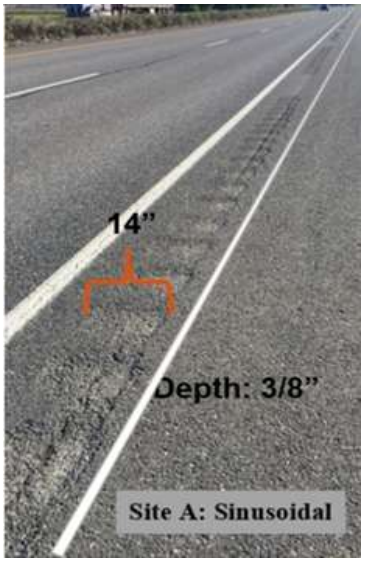
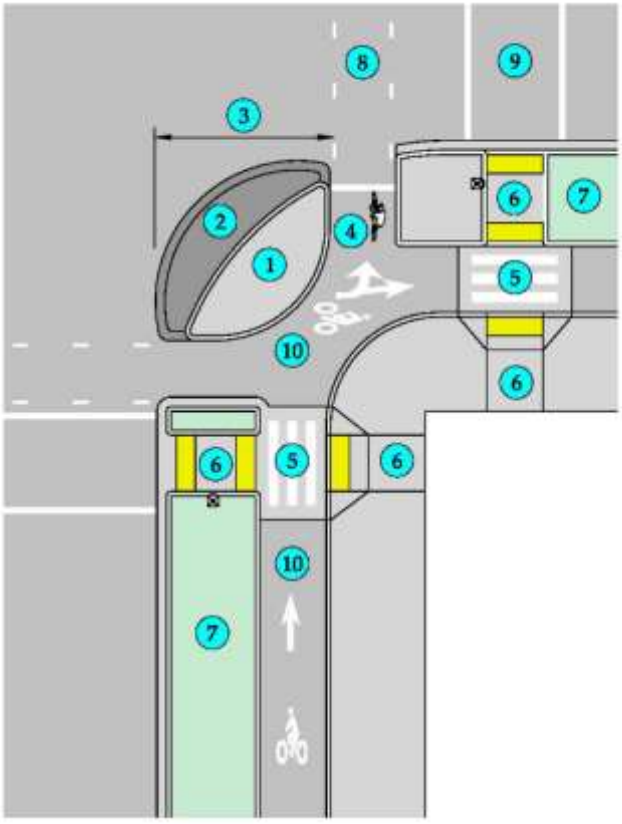


Figure 46 - Image shows a low-noise rumble strip placed within the bike lane's buffer striping.

Separated Bike Lanes at Intersections

In a separated intersection the bike lane physically separated from vehicle travel lanes on the approach corners. This configuration relocates the through bicycle movement so people riding bicycles are more visible to people in vehicles turning right. The setback bikeway crossing design slows turning vehicle speeds, promotes yielding to through bicycle riders, and provides lower stress for riders waiting at a red signal. There are separated designs for both signalized intersections and roundabouts. Figures 47 – 50 illustrate examples and elements of protected intersections.



1. Corner Island
2. Truck Apron
3. Motorist Yield Zone
4. Advance Bicycle Stop Line with Queuing Area
5. Crosswalk in Bike Lane
6. Curb Ramps on each side of the Bike Lane
7. Street Buffer
8. Extension of Bike Lane in Street Crossing
9. Crosswalk
10. Bicycle Path Horizontal Curvature

Figure 47 - Separated Intersection Design Elements from ODOT Highway Design Manual figure 900

Figure 48 - Concept for Protected Intersection (Montgomery County Division or Transportation Engineering)

Figure 49 – Aerial View of Protected Roundabout at 9th and Wilson Avenue

Guidance:

- Design the corner island and setback to provide a turning approach where the driver can see the bicyclist and target adequate storage for stopped bicycle riders and stopped cars (typically at least one car length and one bicycle length for each storage position, like the crosswalks setback at roundabouts).
- Examples of dimensions for protected intersection elements are provided in Figure 50 from the Alta document Evolution of the protected Intersection. (https://altago.com/wp-content/uploads/Evolution-of-the-Protected-Intersection_ALTA-2015.pdf)

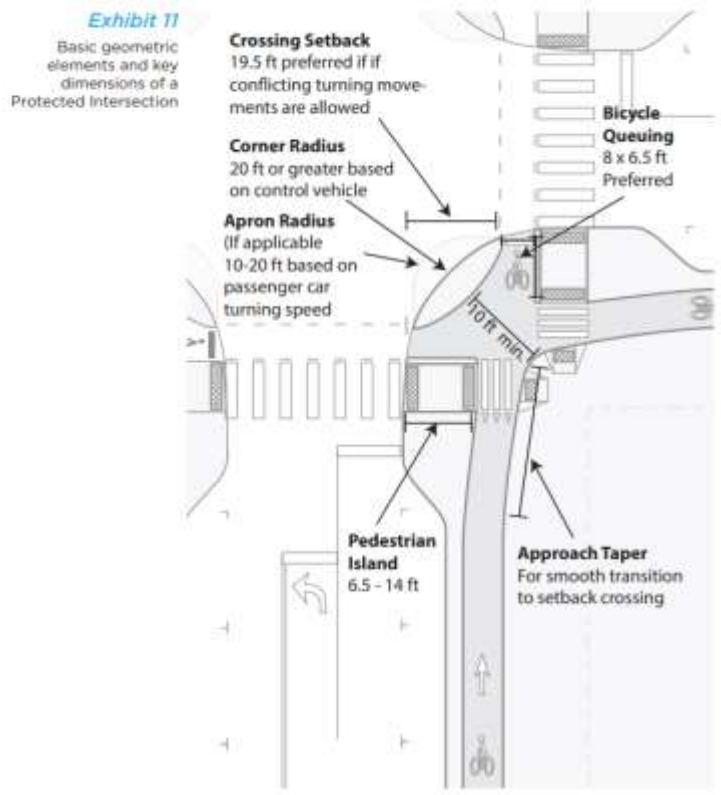


Figure 50 Alta Design Guide for Protected Intersections.

Grade Separated Crossings

Strategic higher volume walking/biking corridors benefit from an over or under crossing that eliminates conflict by completely separating the facilities for people walking and biking from vehicle travel ways. As future street extensions are built and grading provides favorable conditions, underpasses are recommended for the primary trail system, other high-volume shared use path crossings, and where feasible for low stress crossings of major arterial streets (Figure 51). Where feasible existing crossings with multiple traffic lanes and higher speeds should also be targeted for grade separation.

Figure 51 - Image trail under crossings that eliminate the conflicts of at-grade crossings to improve safety and travel time for all users

Guidance:

- A centerline stripe is recommended for both the under and over crossing and may be required where visibility of the exit or entry is limited or where there is a curved approach or exit.
- A twelve-foot width is recommended as the minimum width for the over or undercrossing, even if the path is 10 feet or less to allow additional maneuvering in the constrained space. Widths up to 20 feet may be required depending on the anticipated user volume and need for maintenance equipment and emergency services.
- Illumination is required for walking and biking grade separated crossings.
- Provide a minimum vertical clearance of ten feet. Additional height may be required to accommodate maintenance equipment and emergency services. Where utilities access is needed the minimum height is twelve foot and eight inches for the vactor truck plus six inches of clearance.

- Minimize switchbacks and multiple curves in the approach that are difficult to navigate with a bicycle and consider the longer bicycles with cargo trailers in the turning radii.

Enhanced Traffic Signals

Efficient multi-modal operation of traffic signals can improve travel time and safety for all users. The Standards include complete street design requirements for traffic signals. Additional tools that support complete streets include

- Transit Priority – The City and CET have identified the potential for a joint project to construct transit priority treatments (e.g., transit signal priority and queue jump lanes) that allow buses or trains to bypass traffic. These treatments can reduce the transit travel time delay caused by traffic congestion and improve the reliability of transit schedules. Transit priority treatments are a fundamental component for making transit service time-competitive with competing modes.
- Bicycle Detection or push-button location – design the pedestrian push buttons so in addition to accessibility requirements people riding bicycles have easy access to reach the push button. A supplementary push button may an option where bicycle detection is not available, and the pedestrian push button configuration is inaccessible.
- Radar detection –Upgrading the corridors with higher numbers of people riding bikes to radar detection can improve reliability of bicycles being detected. All new and reconstructed traffic signals require radar detection.
- Separate Bicycle Signal phasing – A separate bicycle signal phase provides a signal indicator (Figure 52) to people riding bicycles that allows them to cross in a separate signal phase free from conflicting motor vehicle or pedestrian movements or get an earlier start across the intersection. Applications for bicycle priority movements may include:
    - Contra-flow bike lanes - serves two-way bike lane flow where the contra flow lane would not otherwise have a signal phase
    - Leading bike intervals (LBI)- where high volumes of through bicycle traffic conflict with high volumes of right turning vehicle on multi-lane arterial streets. The LBI allows the through bicycle movement to start before the through, left, or right turn vehicle movement starts so the bicyclists queued on the red signal have time to move out of the conflict zone and have better visibility to people driving.

Figure 52 - Bicycle Signal

- Separate bike phase – allows high volume bicycle movements to be separated in time from a conflicting vehicle movement
- Clarifies crossing for bicycles – Since people riding bicycles travel faster than people walking, use of the pedestrian signal indicator can limit bicyclists crossing. Installation of a bicycle signal allows the bicycle to cross during a portion of the flashing “don’t walk” interval and times their crossing signal to their higher speed.

People Driving

General

Historically street design has been based on guidelines for the highway system that focused on higher speeds and facilities centered around the vehicle. A complete street design approach re-evaluates the more highway-oriented design parameters to consider the slower speeds and multi-modal travel associated with urban and suburban areas. Many urban design elements have already been incorporated into the Standards such as smaller corner radii, narrower travel lanes, and slower design speeds. The standards allow for right-sizing streets to accommodate infrequently used larger design vehicles (trucks, vehicles with trailers, etc.) with aprons and rollover curbs instead of larger radii and street widths. Additional complete street design elements related to vehicles include designing the local street network to discourage cut thru traffic, designing all streets with multi-mode supportive speeds, and providing traffic calming on local streets to influence slower speeds.

Multi-mode Supportive Speeds

The complete streets and safe systems design methodologies set travel speeds for the context and with consideration of all road users. Slower speeds better support safety for all street users, particularly those most at risk of crashes such as people walking and biking. At lower speeds, the field of vision for people driving is much greater, increasing detection and reaction time. Additionally, with lower speeds should a crash happen, the chance of injury to a person walking is much lower at 20 mph than it is at 40 mph (Figure 53).

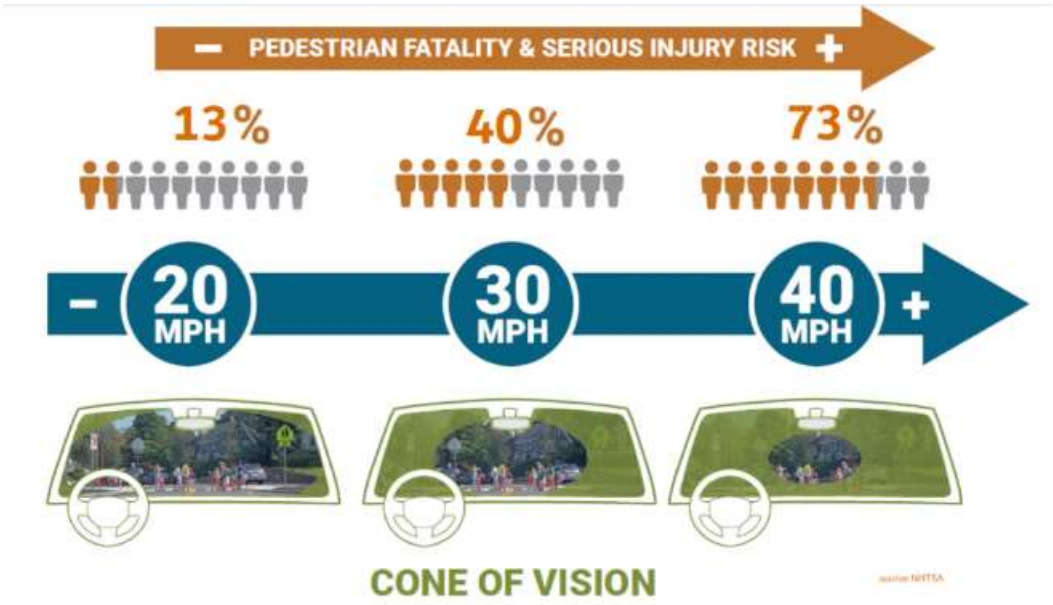


Figure 53 - Pedestrian Visibility and Injury Risk. Safe speeds, Mass.gov

The design of streets can have a significant impact on driving speed since people tend to drive at speeds that feel comfortable. The Standards identify the upper limit in the range of design speeds for the various road classifications. Speeds in the lower range of 30 - 35 mph on arterial streets are encouraged to support crossings and parallel pedestrian and bicycle facilities. Lower speeds of 25 mph may be considered on arterial or collector streets within pedestrian oriented commercial corridors. Speeds of 20 mph may be approved within the high density, pedestrian intensive urban core areas such as downtown where the state law for business districts is met. Designated neighborhood greenways are designed and posted with 20 mph speeds. As noted in the Standards, speeds are set by ODOT following the state law and the ODOT speed design manual.

Traffic Calming

Traffic calming is the implementation of designs or devices to reduce travel speeds to the posted speed or slower and/or reduce traffic volumes. The Bend Development Code includes standards to establish a local street grid network that by design does not encourage higher speeds or volumes on local streets. The block spacing and connectivity standards create an interconnected grid that avoids long uninterrupted local streets and provides multiple routes to spread out traffic volumes. The standard street cross-sections include narrower widths and on-street parking to encourage slower speed travel. The Standards provide details on the use of traffic calming including:

- Curb extensions
- Driveway aprons where the local street meets the arterial or collector

- On-street parking modifications
- Vertical elements such as trees or other landscaping to narrow the field of vision
- Narrowing wider travel lanes to standard widths
- Centerline treatments (islands, medians, traffic circles, roundabouts) (Figure 54)
- Chicanes
- Speed humps (Figure 55)
- Alternating parking
- Raised crosswalk

Figure 55 - Traffic Circle

Figure 54 - Speed Hump

Additional Considerations:

Where bus routes are provided on local streets with proposed traffic calming, coordinate the design of traffic calming (such as curb extensions and raised elements) to adjust the design or routes so traffic calming does not adversely impact bus operations or travel times.

The following devices are not included in the Standards but may be considered with a design traffic study to support the construction of a low stress route:

Temporary Traffic Calming Devices –Installation of temporary traffic calming devices may be considered as a quick build installation until permanent devices can be installed. While some may have quicker installation times and less impact on temporary traffic control, they are often not much less expensive than the permanent concrete solutions. These may include flexible bollards, temporary curbing, planters, etc. See Quick Build Burlington for additional options that may be considered.

Modal Filters – A modal filter or diverter is a device restricts the movement of people driving and allows the movement of people walking or biking. This tool can help reduce traffic volumes on local streets that are designated as neighborhood greenways when the streets have higher traffic volumes and shared use paths, or other alternate low stress routes are not feasible. Modal filters are located to keep people driving on arterial and collector

routes instead of allowing the option to shorten a through trip or avoid queues by cutting through an area using a local street. Modal filters may be considered in areas where there is alternate vehicle access and volumes on a designated neighborhood greenway street are above 2,000 vehicles per day or the target of 1,200 vehicles per day. Modal filter designs must be approved by the City Engineer and require a traffic study to evaluate the impacts and any mitigation for traffic pattern shifts including emergency vehicle access. Modal filters may be achieved by delineators, medians, curb extensions, or other approved barriers. They can divert all or some traffic onto a low stress route such as the examples in Figure 56.

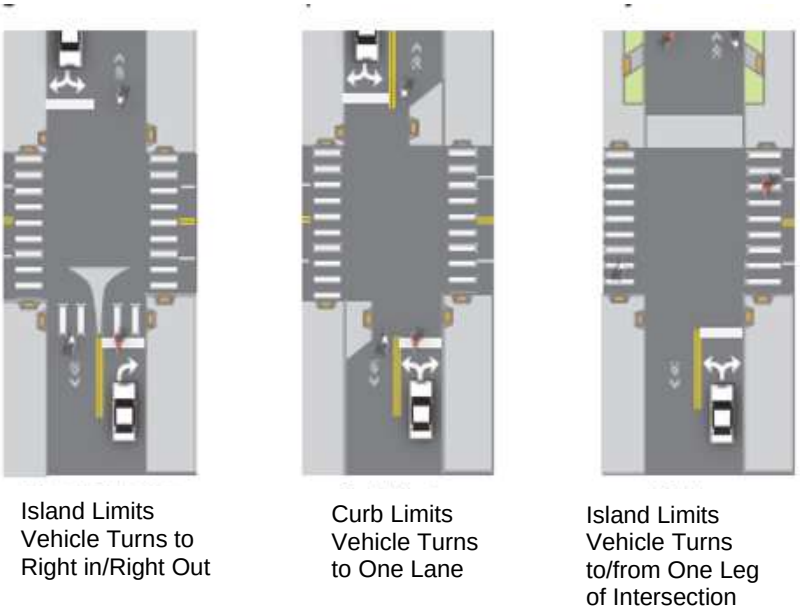


Figure 56 - Modal Filters (Diagonal Example from National Association of City Transportation Officials (NACTO) Global Street Design Guide, 2016 and median example from NACTO Urban Bikeway Design Guide, 2014)

Discourage Fast, Cut-Through Traffic

The Bend Development Code and Standards provide requirements to layout Bend's Street network in a grid pattern with a hierarchy of arterial streets on approximately the mile spacing, collector streets on the approximate half mile spacing, and interconnected local streets in between. Local streets are designed so they provide connectivity but are not long, straight uninterrupted segments more than three to four blocks long to discourage speeding and use of the local street network for trips without a trip end within the neighborhood (or cut thru trips). Street design can discourage local street cut through traffic from adjacent arterial streets by using an offset grid layout with t- intersections, curb extensions, traffic circles, and other traffic calming tools. Designing the network with this complete street philosophy upfront can encourage lower volumes and speeds preventing the need for traffic calming and mitigation in the future.

People Using Transit and Micromobility

Transit Services

Cascades East Transit provides fixed route transit services, community connector routes between Bend and surrounding areas, Dial-a-Ride, and recreation-oriented shuttles. The CET transit plan identifies a multi-centric transit system supported by mobility hubs throughout town. TSP Figure 5-2 shows the primary transit corridors and recommended mobility hub locations. (See CET at https://cascadeseasttransit.com/for current route information.)

In addition to CET there are other service providers to consider when developing transit and micromobility facilities such as the following providers as reported in the 2020 CET transit plan:

Table 4 - List of Transit Service Providers

Connecting Service	Service Description	Connecting Service Stops within ¼ Mile	Connecting Service Stops within ½ Mile
Amtrak Thruway (Operated by Pacific Crest Buslines)	Intercity bus service connecting Redmond Airport, Bend, Sunriver, La Pine, and Chemult Amtrak Station	Hawthorne Station (Bend) Riverhouse Resort (Bend)	Hawthorne Station (Bend) Riverhouse Resort (Bend) Shell (La Pine)
Central Oregon Breeze	Intercity bus service between Central Oregon communities and Portland-area destinations	Circle K & Chevron (Bend) Circle K (Madras)	Circle K & Chevron (Bend) Circle K (Madras)
Cog Wild Shuttles	Shuttle service supporting mountain bike tours	Cog Wild (Bend) Angeline's Bakery (Sisters)	Cog Wild (Bend) Angeline's Bakery (Sisters)
Eastern POINT	Intercity bus service connecting Bend to Ontario with 9 stops in between	Hawthorne Station (Bend)	Hawthorne Station (Bend)
Shuttle Oregon	Shuttle service connecting Bend, Redmond, and Sisters to Salem and Portland-area destinations	Hawthorne Station (Bend) Ski Inn (Sisters)	Hawthorne Station (Bend) Ski Inn (Sisters)
Pacific Crest Lines	Intercity bus service between Bend and the Greyhound and Amtrak stations in Eugene	Hawthorne Station (Bend) Ski Inn (Sisters)	Hawthorne Station (Bend) Ski Inn (Sisters)
People Mover (Grant County)	Bus service connecting Bend, Redmond, and Prineville to Prairie City, John Day, Mount Vernon, Dayville, and Mitchell	Hawthorne Station (Bend) McDonalds (Prineville)	Hawthorne Station (Bend) McDonalds (Prineville)

Complete street designs incorporate space for transit and micro mobility, so they are easily accessible from residences and businesses. This may be through mobility hubs, neighborhood mobility points, transit stops, or park and ride facilities. The ODOT Highway Design Manual and the CET provide guidance for transit facilities including park and ride sites.

Micromobility Vehicles

Micromobility is an evolving category of travel vehicles that is still developing more standardized terms. Six category groups have been developed including powered bicycles, powered standing scooters, powered seated scooters, powered self-balancing boards (e.g., One-wheel), powered non-self-balancing boards (e.g., skateboards), and powered skates. These devices are smaller, lighter, and equipped with less power than vehicles and travel at 24 mph or less. The variety of micromobility vehicles can add to the challenge of designing complete streets for all users and abilities. Many of the complete streets design strategies for people riding bicycles also serve micromobility users. Design considerations for micromobility vehicles include:

- Dedicated parking zones
- Geofencing and speed restrictions on shared micromobility devices

- Different skills and abilities addressed through low stress facilities
- Signs and education where not permitted on sidewalks

Mobility Hubs

Mobility hubs are places that provide connections between several types of transportation options such as transit, walking, biking, and shared mobility services (bikeshare, rideshare, etc.). They are expanded transit centers designed to encourage easy transition between modes and may even provide travel supportive services. Bend Development Code Section 3.6.300 (D) lists the requirements of a mobility hub that includes at a minimum:

- A transit stop and/or transfer station
- Flex mobility spaces, 250 sf (an area designated for shared use by a combination of transit, micromobility, transportation network company vehicles, or electric vehicle infrastructure)
- Secured bicycle parking for a minimum of 10 bicycles
- Garbage and recycling cans
- Benches
- Travel Information kiosks, signage to clearly identify how to access the different travel options, and wayfinding Additional facilities that may be provided could include but are not limited to:
- Customer service/operations center.
- Fare purchase kiosks.
- Electric vehicle charging stations.
- Electrification to support real-time information displays and EV charging.
- Electric conduit installed for future electrification purposes.
- Passenger pick-up and drop-off areas are designed to protect pedestrians and bicyclists from vehicle conflicts. Queue areas must provide adequate capacity to prevent vehicles from blocking streets and access corridors.
- Covered shelters
- Restroom and shower facility.
- Bicycle/gear lockers.
- Car and/or bike share services.
- Car sharing parking spaces.
- Shuttle services.
- Pedestrian lighting.
- Accommodation of other micromobility services and parking.
- Other facilities and services to support the mobility hub

TSP Figure 5-2 illustrates the primary transit corridors and areas targeted for mobility hub locations. The map is a guide for mobility hub locations, and the exact sites may vary

depending on where higher density and transit oriented and supportive land uses are built and how the transit routes and other services are integrated. An example mobility hub layout that integrates services to create a community amenity is shown in Figure 57.

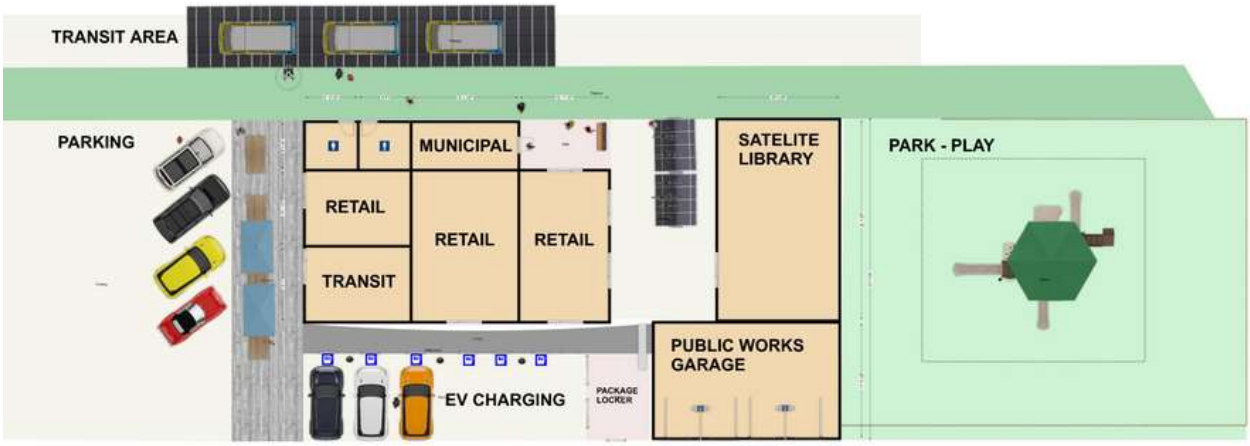


Figure 57 - Example Mobility Hub Layout

Neighborhood Mobility Points

A neighborhood mobility point is a smaller scale mobility hub that provides connections between a few transportation options and may offer more limited services. These facilities are smaller, and strategically located near places that facilitate short, one or two-way trips for commuting, high density residential areas, colleges/universities, shopping, running errands, social outings, exercise, or sight-seeing. When located at a transit stop, they can extend the reach of transit.

The City's mobility point program provides micromobility to rent for point-to-point travel. Bike share is particularly suited for Bend given the popularity of bicycle riding and the favorable climate for most of the year. The demand for micromobility services is expected to grow as the low stress network expands and as vehicle congestion and density increases.

Transit Stops

A transit stop is a signed location where transit vehicles stop, and people can get on and off a transit vehicle. Transit stops are located to make riding easy, comfortable, equitable, and safe. They may include amenities and information about how to ride readily available to residents, employees, and visitors. Providing real-time arrival displays/ information, route maps, and covered waiting areas at higher volume stops makes it easier for people

to use transit. The standards and CET provide information on selecting and designing transit facilities for both CET and other transit service providers (Figure 58).

Figure 58 - Example of parking spaces converted to transit stop near shared use path and commercial district.

Guidance:

- Complete street transit facility design locates transit stops so people can use the enhanced crossings on the low stress network.
- Place shelter to allow unobstructed access from the stop to transit with a minimum sidewalk width to meet ADA compliance.
- Minimize blocking sight lines at intersections and crosswalks (e.g., the stopped bus must be out of the clear vision zone)
- Evaluate the interaction of the bike lanes and transit stops and add enhancements as needed for safety, clear transition zones, and continuous bicycle flow where feasible.
- Floating transit stops, stops that are separated from the sidewalk by a raised bike lane and boarding island, may be a tool to improve user safety and access on five-lane arterial streets
- Consider boarding bulbs – a longer curb extension at a transit stop that allows the bus to stop in the travel lane and brings the passengers to the bus. It also provides more space for a waiting area and shelter outside of the sidewalk/ shared-use path travel way. Curb extensions require designs that address conflicts with the bike facility.

Parking and Curbside Management

Vehicle Parking

The Bend Development Code and Standards identify vehicle parking requirements. The complete street design for vehicle parking also considers the following:

- Use parallel parked vehicles next to a bike lane to separate people riding bicycles from the travel lane
- Allocate the first space on a block with a crosswalk in higher parking density areas to low profile parking such as for motorcycles, scooters, or bicycles to support increased visibility at intersections.
- Use curb extensions to define parking and maintain crosswalk visibility and designing them to accommodate the bike facility.
- Add on-street parking bays on higher volume collector and lower speed arterial streets to provide increased separation for people walking and biking.
- Restrict parking at intersections and driveways to provide a clear zone for visibility of people walking, biking, and driving.

Bicycle Parking

Bicycle parking is an important service at the end of a trip to provide a secure location for people to park and lock their bicycles. Convenient bicycle parking can encourage travel by bicycle, especially in areas where it is difficult to find unoccupied vehicle parking spaces. To be effective, bicycle parking must be in a convenient location near the route and destination access. Bicycle racks are the typical installation for day trip use while bicycle lockers or other secure, all-weather parking is the preferred parking facility for

overnight or multi-day parking. Target locations for bicycle lockers include high density residential areas, larger businesses, and mobility hubs (Figure 59).

Figure 59 - On-street Bike Parking in Commercial District

Bicycle rack designs vary and are designed to serve a variety of bicycle styles and tire sizes. The standard rack is an inverted u style or post & ring.

Application: The Bend Development Code requires bicycle parking and identifies design requirements (inverted “U”style racks or similar design) (Figure 60). Bike parking is allowed in the right-of-way or on an individual lot to enhance the streetscape and facilitate bicycle travel in the increased density area.

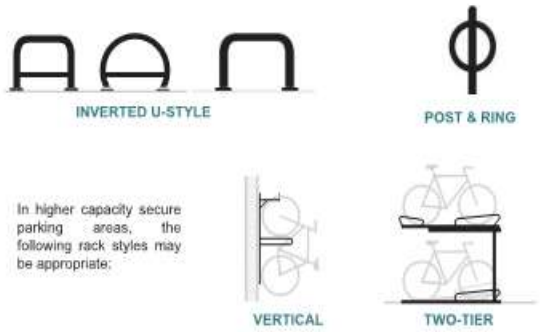


Figure 60 - City Approved Bike Rack Types

Guidance:

- The area within a curb extension that is not used for the sidewalk/ shared use path could be considered for bicycle parking when designed in a manner that people parking their bicycles do not need to step into the street or sidewalk/ path and it does not block a clear vision area (Figure 61).
- The first parking space next to a curb extension where if used for parking, the vehicle would back into the crosswalk is a suitable candidate for conversion into a bicycle parking space.
- Locate bicycle parking in a convenient location near the doors to destination buildings or access points for parks, schools, and transit facilities.
- Design an easy connection between the bikeway and the bicycle parking for people to transition their bicycle from riding it to the parking space
- Bicycle parking may be combined with other elements in a mobility point (Standard Drawing R-50A and B).

Figure 61 - Curb Extension Area for Bike Parking

Curbside Management

Curbside Management allocated curb space to different users and creates a program for the different uses. It can be a formal program or a block-by-block application to manage the curb space. Curbside management helps outline how to effectively optimize curb space considering the economic goals, public travel and service needs, and public policy. Curbside management may include items such as those shown in Figure 62. The city is piloting projects for curbside management including dynamic management:

- Parking (including bicycle parking) and loading time restrictions and limits
- Software application for vendors and services to reserve loading spaces
- Special event curbside and parking management

New developments, particularly in commercial areas are encouraged to work with the city Parking Manager to develop curbside management programs to coordinate mobility, delivery, and service functions of the curb zone.

Figure 62 Curbside Management Uses

Streetscape

Placemaking

Complete streets include elements that support placemaking such as – parklets, plazas, seating, and ped scale illumination. Placemaking is a process and philosophy that incorporates the ideas of people who use public spaces, the infrastructure assets, and community character to promote people's health, happiness, and wellbeing by creating spaces that people want to live, work, and play in not just travel through. Placemaking elements help streets and public right of way be more inviting to people, especially those walking and biking and taking transit. While moving through the city walking or biking, people share space, interact, and build community. Placemaking elements provide spaces to take a break, meet for business, or transition to a different travel mode. Figure 63 shows a variety of public space amenities including hanging baskets, bike racks, curb extensions, and streetlights.

Figure 63 - Street Created as a Place with Amenities

Street Furniture and Amenities

Amenities within the street right-of-way or adjacent areas include pedestrian lighting, landscaping, art, bicycle racks, bicycle tool/service stations, benches, trash and recycling receptacles, dog bag stations, and micromobility parking. These items are along the sidewalk/shared-use path or the parking lane and must be collocated to not impede the minimum travel path required for people walking or biking or the vehicle travel lanes. Private amenities may require a revocable permit.

Landscaping and Green Infrastructure

Complete streets including landscape and stormwater design that supports semi-arid, waterwise planting and minimal maintenance green stormwater infrastructure. Green street features may include vegetated curb extensions, sidewalk planters, vegetated swales, permeable paving, and street trees. Stormwater conveyance is designed to flow to stormwater structures or infiltration devices and not to accumulate at curb ramps, bicycle ramps, and bikeway transitions.

Street and Pedestrian Lighting

Complete streets illumination is designed to enhance nighttime visibility for all travel modes while being mindful of night-time lighting impacts. It may include pedestrian scale lighting in business districts or along shared use trails.

Utilities

Utilities designed for complete streets are underground or consider the least intrusive locations above ground that do not restrict sidewalks and shared use path widths. They may require easements where right-of-way is limited or near intersections where it is important to have the full width of shared use paths for bi-directional travel by people walking and biking. Underground utilities are required (Bend Development Code 3.4.600.A.) and any above ground equipment shall not obstruct clear vision areas, safe intersection sight distance. Additionally, any surface utilities such as utility access holes and valve box covers need to be flush and textured to not create slipping or tripping hazards.

Environmentally Supportive Streets

Complete streets support the City of Bend Community Climate Action Plan by providing travel alternatives to the automobile that reduce greenhouse gases and fossil fuels. The city's Climate Action Plan shows that transportation contributes to thirty-six percent of our greenhouse gas emissions (Figure 64). Complete streets help meet the plans goals of:

- Increasing bicycle and pedestrian trips
- Increasing transit ridership
- Promoting ride sharing
- Street trees and other landscaping elements help reduce the heat effect from buildings and pavement.

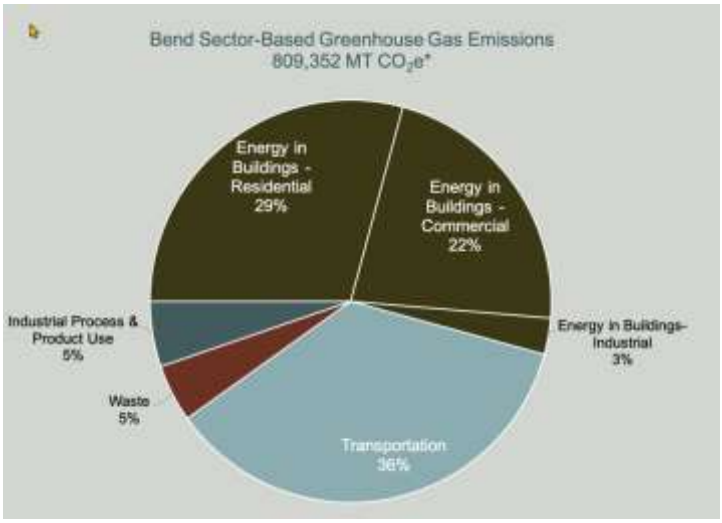


Figure 64 - Chart of City Greenhouse Gas Emissions

Bicycle Route Wayfinding

General

Wayfinding guides people along routes and to destinations. It can help people choose a route that matches their skills and abilities, such as a bicycle low stress route. An extensive wayfinding system encourages people that are less familiar with bicycling routes, new to town, or new to an area to travel by biking or walking because they are shown the distance and route. An integrated wayfinding system connects people to different travel options (transit, bikeways, walkways, shuttles, micromobility, etc.).

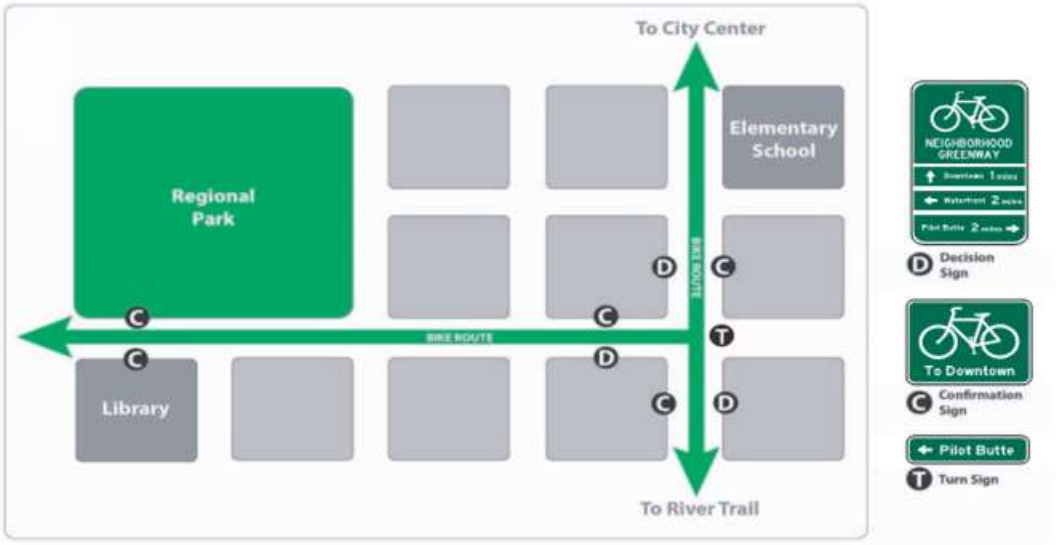
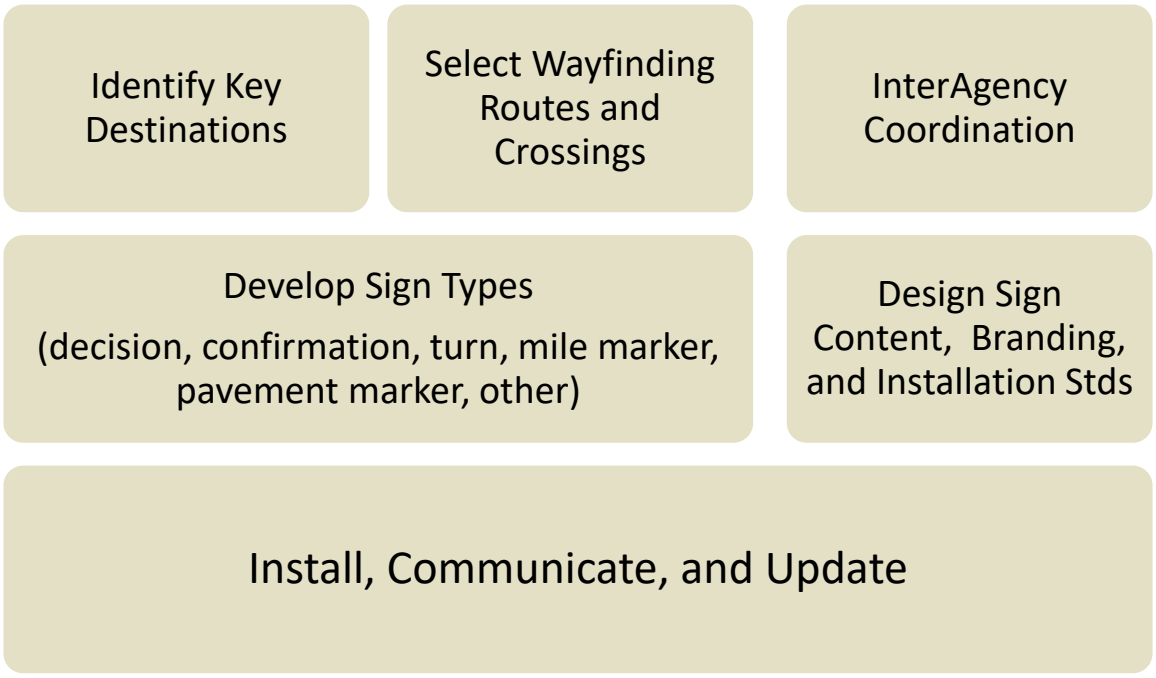


Figure 65 Example of Wayfinding

Wayfinding uses simple and consistent information presented in a predictable frequency to connect places and promote active travel. It can increase the comfort level of people traveling by providing an indication that they are still on the designated route. Wayfinding programs use elements such as signs, markings, kiosks, maps, and apps to relay travel information. A regional wayfinding system connects bicycle routes in the city to ODOT, County, and BPRD facilities. A simple example of different wayfinding signs along a route is shown on Figure 65.

Key Components of Bicycle Wayfinding

The key components of a wayfinding program include:



Identify Key Destinations

Identify recognizable and high demand primary destinations along the low stress bicyle routes such as transit stations, mobility hubs, business districts, the library, and regional parks and trails. Selected locations should be well known or a targeted destination and useful as a navigational reference. Secondary destinations such as schools and local parks often have their own on-site sign and are not included.

Select Wayfinding Routes and Crossings

Determine which routes will be included in the program and develop a system that can expand as the system grows. . Some of the routes may be more intuitive and need little or no wayfinding. Target routes where there is a less visible lower stress route choice (such as an overpass versus staying on the street) or direction to a nearby low stress crossing location.The system may include different types of facilities (bike lanes, greenways, shared use paths, ODOT facilities, and BPRD facilities).

Inter-Agency Coordination

As the various central Oregon agencies expand their biking systems, a regional wayfinding system will help people navigate across the interconnected agency systems. In particular, the city, BPRD, and ODOT are encouraged to plan wayfinding to create a seamless directional system for people riding bicycles. Coordination with CET, Deschutes County, USFS, and adjacent cities as the systems connect will further extend travel options for both transportation and recreation.

Develop Sign Types

A wayfinding program includes a family of signs (Figure 66) used for providing different types of bicycle wayfinding information including but not limited to decision signs, turn signs, confirmation signs, pavement markers, and mile markers. The sign family uses standard, readily available, cost-effective signposts and materials. To serve people of all abilities consider sign types that incorporate universal design including tactile, auditory, braille, and wheelchair accessible features.

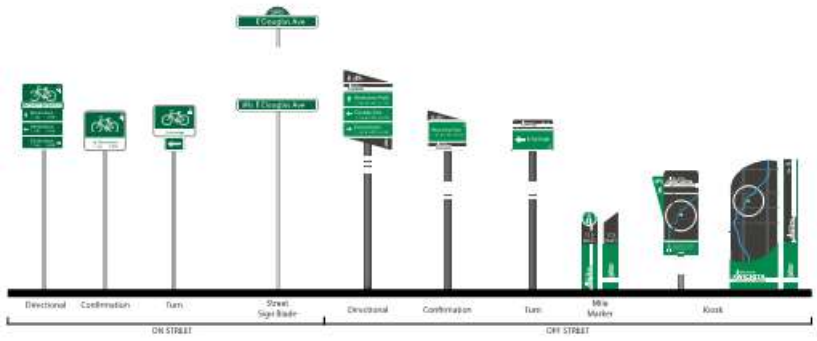


Figure 66 Example Sign Family Example Wayfinding Sign Family from Wichita Wayfinding Plan

Design Sign Content, Branding, and Installation Standards

Create a system for presenting information to convey a clear and concise message with the fewest words and graphics possible so people can quickly understand the information. Develop the sign content, graphics, and branding compliant with the Manual on Uniform Traffic Control Devices. Content may include space for icons of the different agencies (Figure 67).

Figure 67 Examples of Different Sign Content and Types

Install, Communicate, and Update

Install the wayfinding signs in logical phases that connect routes and destinations. Locate signs in locations where routes change, routes are not obvious, or at critical decision points. Develop a communications plan to educate people on how to navigate the system. The plan may include group rides, online apps and navigation tools, media releases, or other activities that encourage people to explore traveling the routes. Update the signing and any mapping as the system expands.

Appendix A - Complete Streets Related References

City Documents Related to Complete Streets

Area Refinement Plans (2021 Southeast Area Plan, 2020 Core Area Project (includes 2014 Bend Central District Plan), 2017-8 Bend Parking Study), and 2105 Central Westside Plan Phase 1)
Bend Comprehensive Plan
Bend Development Code
Bend Design Standards and Specifications (includes Standard Drawings, Connector Routes and Crossings Map, and Signing and Marking Manual)
Bend Pedestrian Network Implementation Plan
Deschutes County Intelligent Transportation Systems Plan
Transportation Systems Plan (TSP) 2020
Transportation Safety Action Plan (TSAP), September 30, 2019

Local Agency Documents Related to Complete Streets

Bend Park and Recreation District Comprehensive Plan
Cascades East Transit Master Plan 2020
Cascades East Bend Mobility Hub Feasibility Study
ODOT Highway Design Manual
ODOT Blueprint for Design
ODOT Speed Zone Manual

National Documents Related to Complete Streets

FHWA Crash Modification Factors Clearinghouse – provides safety mitigation measures and
FHWA Separated Bike Lane Planning and Design Guide, 2015
ITE Micromobility Facility Design Guide 2021
NACTO Urban Bikeway Design Guide 2012 – provides a toolbox of complete streets practices that are safe and enjoyable for bicyclists
NACTO Don't Give Up at the Intersection, May 2019

Roadway Cross Section Reallocation: A Guide (2022). National Academies of Sciences, Engineering, and Medicine. 2022. https://doi.org/10.17226/26788

Other Agency Example Documents

Quick Build Design and Materials Standards, Burlington Public Works
Portland Protected Bicycle Lane Planning and Design Guide, PBOT
Mass DOT Separated Bike Lane Planning and Design Guide
Rethinking Streets for Bikes, Schlossberg, Lindgren, Amos, Roswell, 2019 – provides 25 example projects of street retrofits to add enhanced bicycle facilities.
Protected Intersection Design Guide, 2021, Ottawa

99