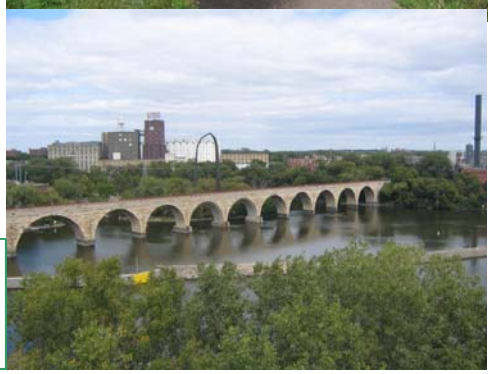
Bicycle Facility Types

Grade Separated Crossings - Physical barriers discourage bicycling. Physical barriers are typically major highways or freeways, rivers, railroad corridors, and steep hills. To remove these barriers it may be appropriate to construct an exclusive bicycle and pedestrian crossing. A crossing can be a bridge or tunnel.

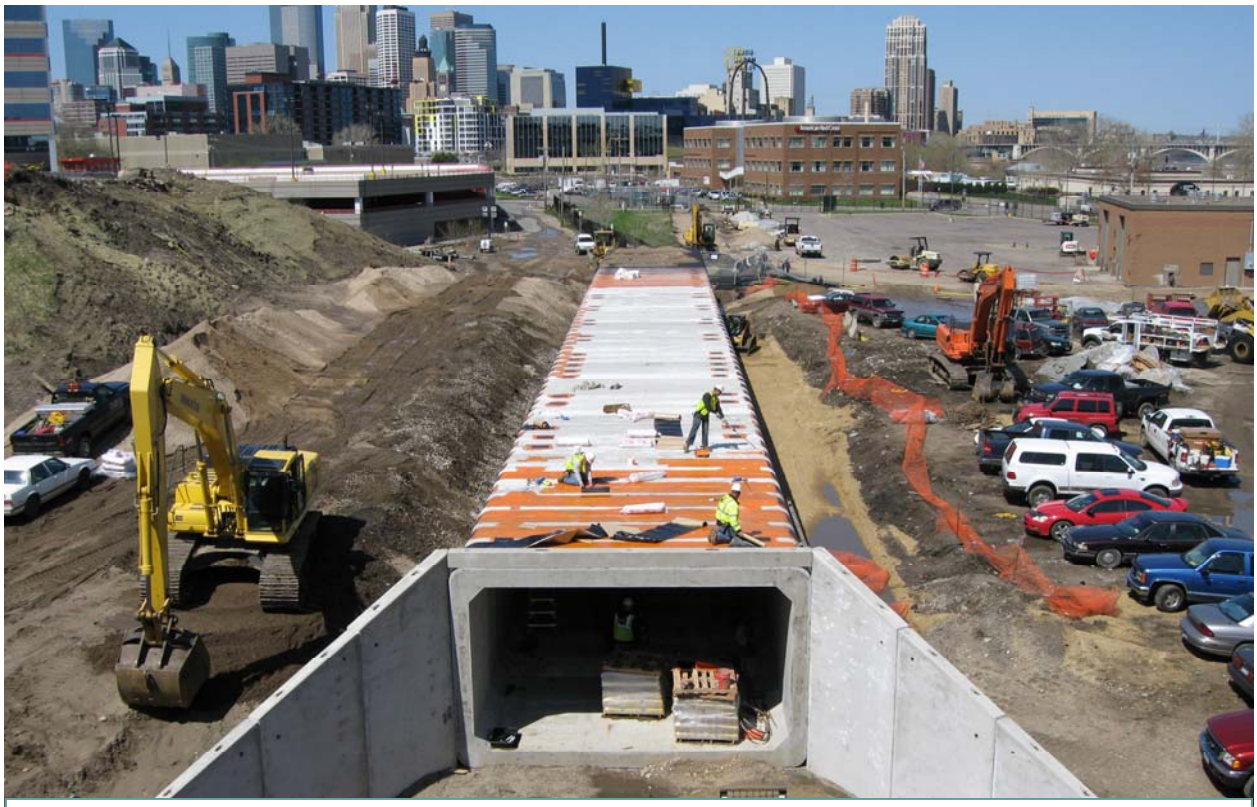
Although cost effectiveness is important, safety is the most important factor when determining the need for a new bicycle/pedestrian crossing. Not providing a safe and direct route may result in bicyclists taking unnecessary risks and may result in crashes and injuries. Because of the expense of a bicycle and pedestrian crossing the following criteria should be considered to minimize the number of crossings constructed across the city:

- The crossing needs to be constructed in a spot that will maximize pedestrian and bicycle use. The most direct route should be pursued if possible. An origin destination study may be helpful in placing a crossing.
- The number of barrier crossings per mile should be evaluated. Several alignment alternatives should be explored before it is concluded that a crossing is needed. There may be a nearby at-grade crossing that could be improved to accommodate bicyclists and pedestrians.
- Existing underutilized or abandoned crossings should be repaired or retrofitted if practical to accommodate bicycles and pedestrians.
- Employment and population density near the proposed crossing needs to be considered to help justify the investment.
- Community input should be gathered to determine need and to minimize neighborhood visual impact. In some cases a signature bridge or tunnel may help enhance the character of the neighborhood.
- Crossings should be constructed to accommodate both bicycles and pedestrians.



Right (From Top to Bottom): Martin Sabo Bridge, Loring Bikeway, Dinkytown Bikeway Connection (Bridge 9), I-394 Pedestrian/Bicycle Bridge/Ramp, Stone Arch Bridge

Grade Separated Crossings - Crossings must consider safety and security, must be lit, and should be wide enough to make users feel comfortable. All crossings must be at least 12 feet wide and have at least 10 feet of vertical clearance to allow for emergency and maintenance vehicles. When an approaching trail is wider than 12 feet the crossing width should match.



Above: I-35W tunnel under construction.

Above: Narrow Tunnel in Lino Lakes, MN.

Above: Big Rivers Trail, in Mendota Heights, MN.

Above: Narrow tunnel along SW LRT Trail.

Bicycle Facility Types

Grade Separated Crossings - Tunnels and underpasses may present a number of trade-offs that need to be examined. Personal safety and security is an extremely important factor in determining whether or not a tunnel is the right type of grade separation. Engineers must also consider soil strength in addition to bedrock and groundwater elevation. A community may want to look at other routes/ options before installing expensive tunnels.

Above: This trail underpass in Davis, California is an excellent example of a wide and safe grade separated crossing.

Above: This grade separated underpass in Victoria, BC along the Galloping Goose Trail is a great example of how to use public art to prevent graffiti.

Above: This tunnel was recently constructed along a trail in Deventer, Netherlands. The trail passes underneath a busy roadway with truck traffic.

Above: This trail underpass in Adelaide, Australia is very narrow and trail users must make an abrupt turn at the end of the tunnel. Often called cattle passes, this type of design is not recommended. Box culverts may be used if they are at least 12 feet wide, 10 feet tall, and well lit.

Above: This trail in Wroclaw, Poland has an excellent access ramp with crosswalk markings to denote the pedestrian and bicycle conflict zone. The dark and graffiti filled underpass however, does not look as inviting. Tunnel design must address personal safety/ security concerns such as lighting and sight lines.

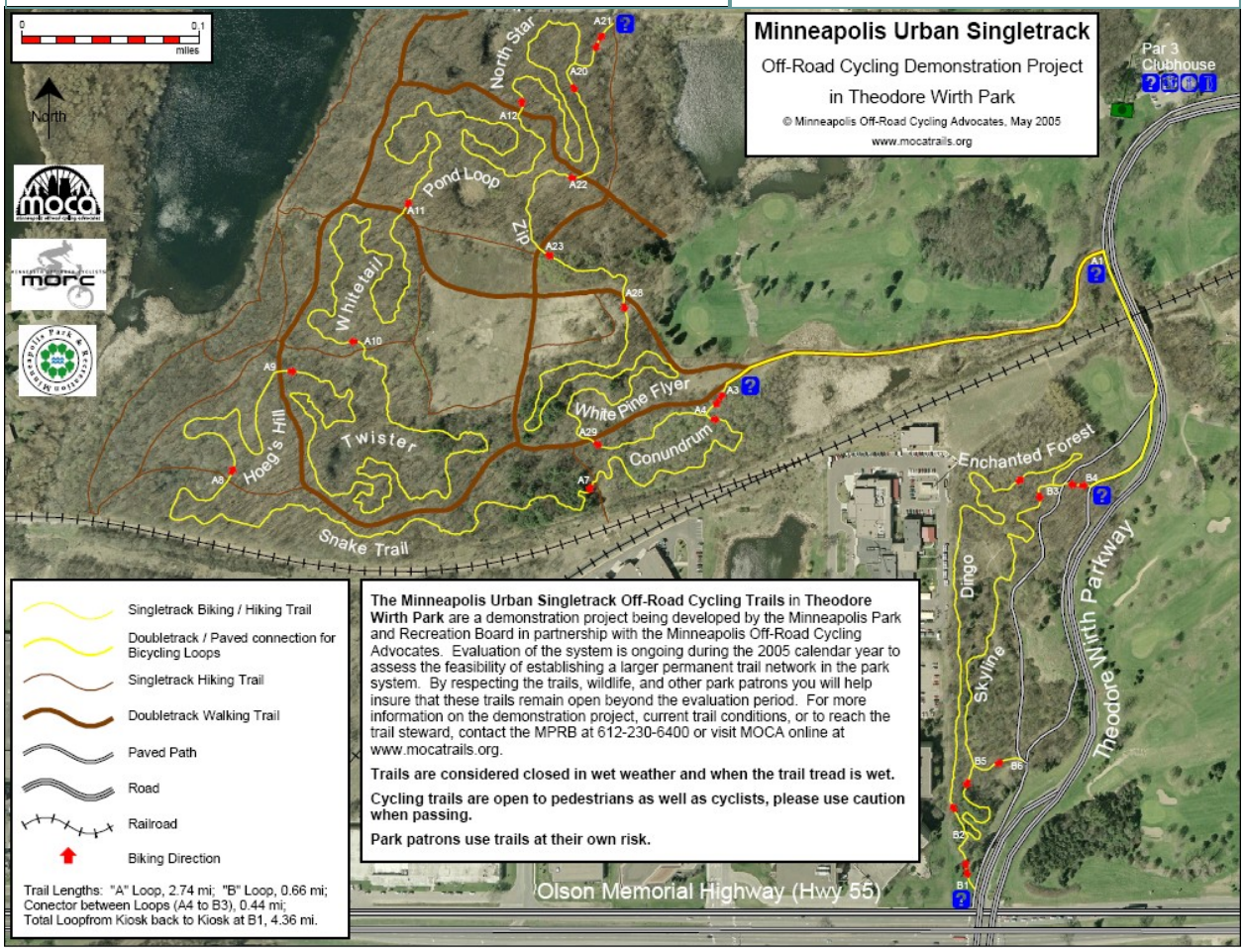
Bicycle Facility Design Guidelines
Chapter 3—Off-Street Facilities

Bicycle Facility Types

Mountain Biking Trails—Mountain biking is a popular recreational activity that requires special design consideration. Mountain biking trails are typically unpaved and include different courses for different skill levels. Natural and unpaved surface trail design guidelines can be found in the Minnesota Department of Natural Resources Trail Planning, Design, and Development Guidelines. Care must be taken when designing and maintaining mountain biking trails to prevent erosion and to maintain the natural vegetation and habitat adjacent to the trail.

Above: Off-road signage.

Below: The Minneapolis Park and Recreation Board in combination with the Minnesota Off-Road Cycling Advocates (MOCA) have created designated mountain biking trails in Theodore Wirth Park.



Bicycle Facility Design Guidelines
Chapter 3—Off-Street Facilities

Bicycle Facility Types

Multi-Use Trail— Multi-use trails effectively maximize available right-of-way by combining uses. Multi-use trails are designed to accommodate several types of non-motorized users including bikers, pedestrians, joggers, roller bladers, and wheelchairs. Some multi-use trails are striped with a centerline to delineate direction. All multi-use trails must be at least 10 feet in width in accordance with AASHTO standards. Wider trails are preferred on busier trails. In most cases, multi-use trails are developed along river corridors in railroad corridors, and along roadways. A typical multi-use trail cross section can be found below.

Above: Fridley Water Trail

Above: From left to right, LRT Trail, Humboldt Greenway, and SW LRT Trail

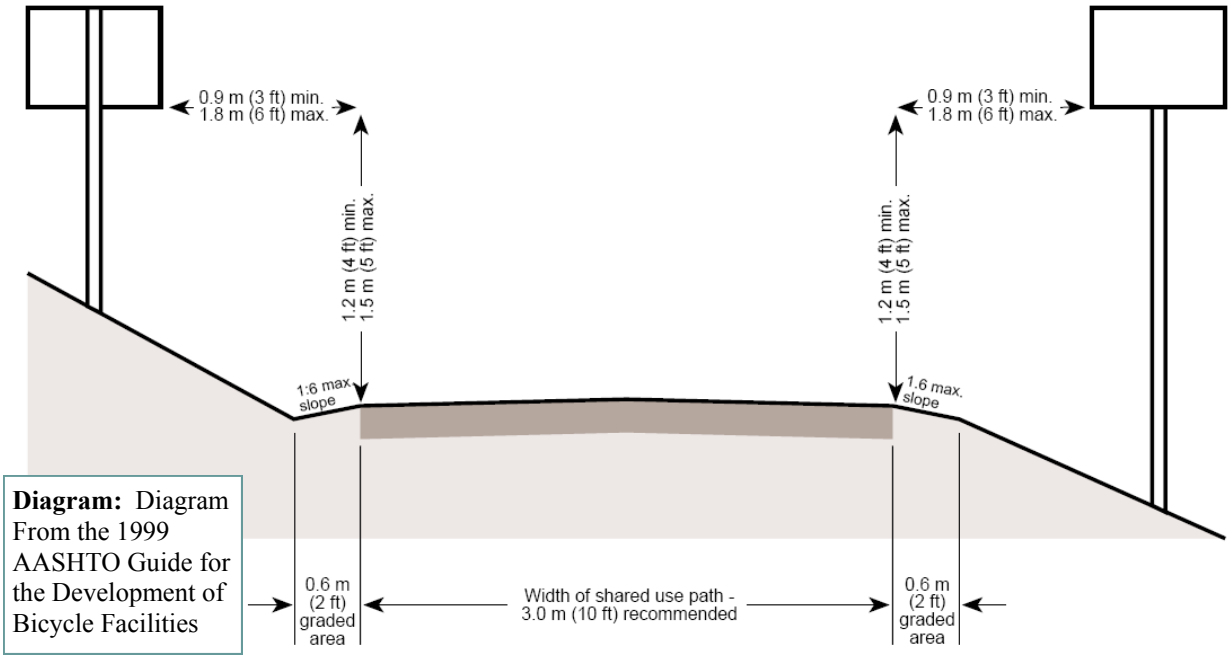


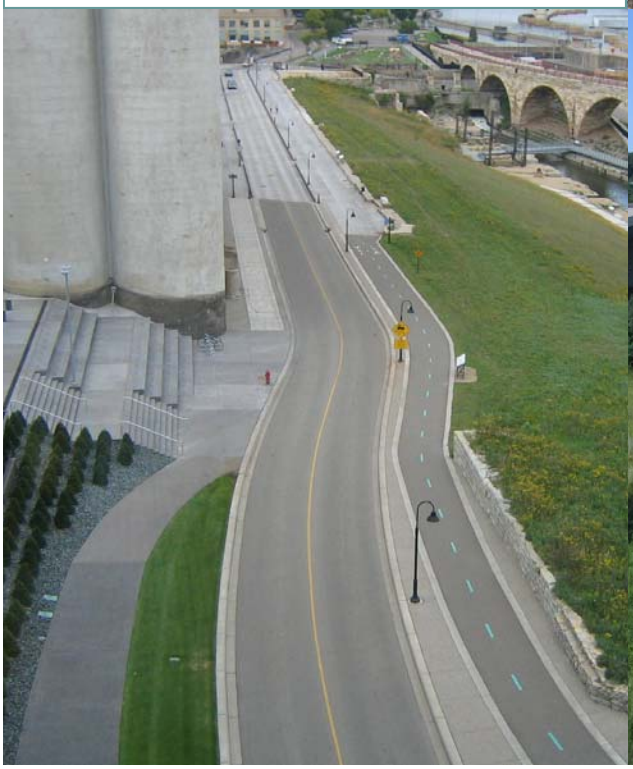
Diagram: Diagram From the 1999 AASHTO Guide for the Development of Bicycle Facilities

Bicycle Facility Design Guidelines
Chapter 3—Off-Street Facilities

Bicycle Facility Types

Separated Trail—A separated trail has dedicated space for bicyclists and pedestrians. The Minneapolis Park and Recreation Board began separating trail facilities in the 1970's and now the majority of the Minneapolis trail system is comprised of separated trail facilities. Separated trails allow for less conflict between faster bicyclists and slower pedestrians. Separated trails must have at least 5 feet in each direction for bicycles and a 6-foot walkway for pedestrians (16-foot minimum). The terms "path" and "trail" are used interchangeably in this document.

Right/Below: The top right photo is along the Victory Memorial Parkway Trail where the trail users are separated with pavement markings. The photo on the right is a one-way separated trail facility along Lake Calhoun. The bottom left photo shows a separated trail with an asphalt trail on one side and a concrete walkway on the other. The photo on the bottom right shows the Cedar Lake Trail with grass separating the 8-foot walking trail from the 7-foot directional bikeways.



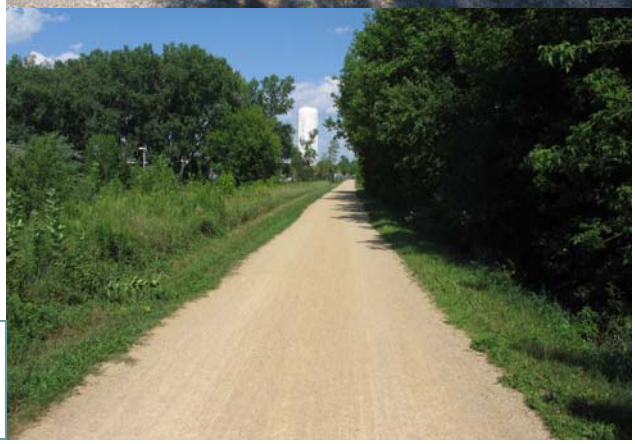
Bicycle Facility Design Guidelines
Chapter 3—Off-Street Facilities

Bicycle Facility Types

Unpaved Trails—Unpaved trails are common throughout the state and are cheaper to construct than paved trails. In many communities unpaved trails serve equestrians and snowmobilers in addition to bicyclists and pedestrians. Unpaved trails are generally made of compacted crushed rock or class 5 aggregate and are maintained with a motor grader or with smaller trail grooming implements. Trails within the City of Minneapolis are primarily paved, however there are some exceptions along Nicollet Island and Boom Island. The SW LRT Trails are also unpaved west of Hopkins and have a rural appearance.

Unpaved trails are more difficult to traverse when wet, (especially with road bikes) and can be dusty when dry. Unpaved trails are ideal for mountain bikes and require slower riding.

It is recommended that a 10-12-foot wide aggregate surface be maintained wherever possible and that vegetation within 2 feet of each side of the trail be mowed or trimmed as needed. A common unpaved trail would be constructed with at least 6 inches of aggregate base and would be crowned to allow for proper drainage. A 3:1 inside ditch slope is preferred. As trail use increases, unpaved trails within the city limits should be considered for inclusion into the City of Minneapolis 5-yr CIP to be paved to meet MnDOT Standards. Specifications for the construction of unpaved trails can be found in the Minnesota Department of Natural Resources (DNR) Trail Planning, Design, and Development Guidelines.



Right: From top to bottom; Nicollet Island, SW LRT Trail at Shady Oak Lake, Boom Island, and SW LRT Trail in Hopkins.

Trail Support Facilities

Trail Enhancements— Trail enhancements are not critical to the movement of people but do enhance the experience. Trail enhancements may include kiosks, public art, trees, plantings, benches, gateways, drinking fountains, public toilets, decorative fencing, memorials, pavers, trash receptacles, and air pumps. Trail enhancements may be funded as part of a trail project but may also be funded with private dollars. Bike racks and identification/wayfinding signage are especially important enhancements that should be considered with all bicycle projects.

Trail Support Facilities

Trailheads— Trailheads are public places to enter and exit a trail facility. Trailheads often include informational kiosks with trail maps, identification and wayfinding signage, trash receptacles, and bicycle parking. Some trailheads offer parking for visitors and include treatments to keep motor vehicles from entering the trail. In Minneapolis most trails are police patrolled so physical devices like bollards or curbs are not used at trailheads. All Minneapolis trail entries include "No Motor Vehicle" signage and violators are issued tickets by law enforcement officers. Trailheads should be spaced to reflect the density of land use and should contain consistent design elements throughout the system.

Above: Trailhead identification signage at a Tampa area trailhead.

Above: Bollards and curb treatments were used at this trailhead to prevent motorists from entering the trail.

Above: Trailheads are popular gathering places and are ideal locations to count trail users.

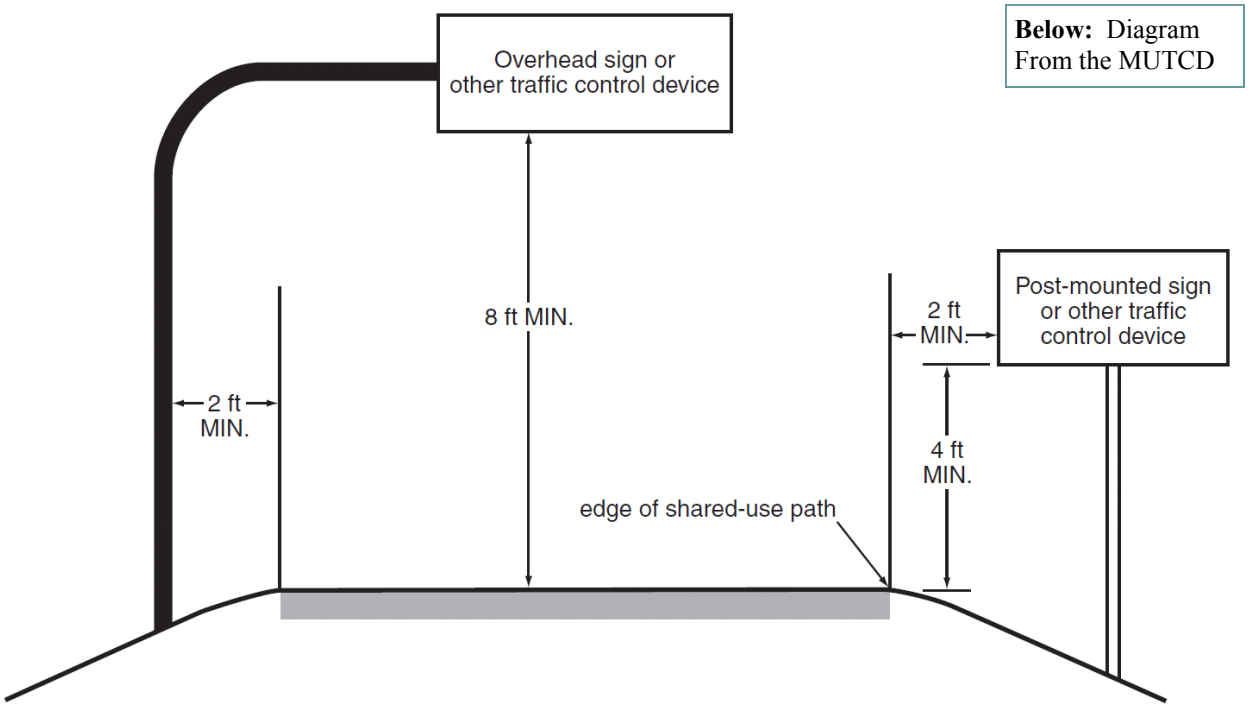
Above: This park and bike facility is full. Kiosks and bicycle parking are important trailhead amenities.

Above: Trailheads provide an opportunity to show the public trail rules and regulations.

Geometric Design Considerations

Horizontal Clear Zones—A minimum 2-foot horizontal clear zone must be maintained next to an off-street trail. The MnDOT Bikeway Facility Design Manual recommends a 3-foot clear zone next to trees, poles, walls, fences, and other lateral obstructions. A graded clear zone shall not exceed a 2:1 slope.

Below: Diagram From the MUTCD



Vertical Clear Zones — Overhead signs should not be less than 8 feet from the trail crown per MMUTCD standards. A minimum 10-foot vertical clear zone must be maintained when a trail passes underneath a bridge overpass or other structure to allow for emergency vehicles to pass through.

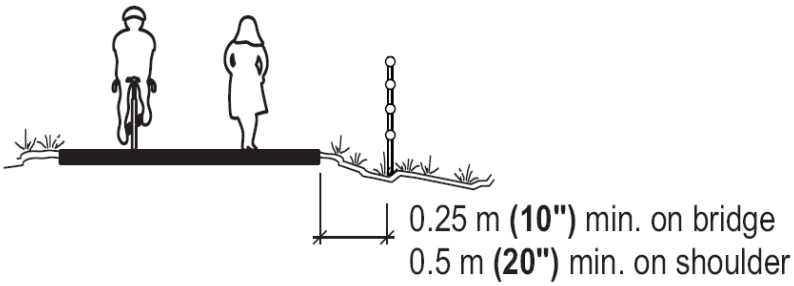
Above/Left — The photo on the left shows a sub-standard vertical clear zone located at the Spring Lake Park Trail access to the Cedar Lake Regional Trail. The photo above shows horizontal clear zones along the Midtown Greenway.

Geometric Design Considerations

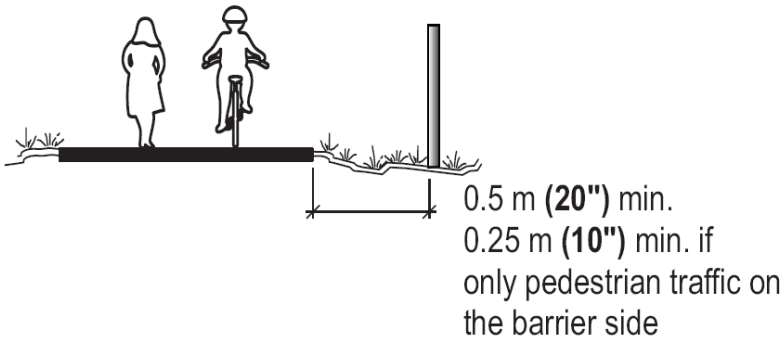
Clear Zones—Minimum requirements for trail clear zones differ from place to place. Although minimum clear zones are shown, it is important to consider bicycle/pedestrian volumes, types of users, and trail speed before selecting a barrier or railing treatment and selecting an appropriate setback.

Above: A minimum 8.5-foot clear zone is required for all railroad corridors.

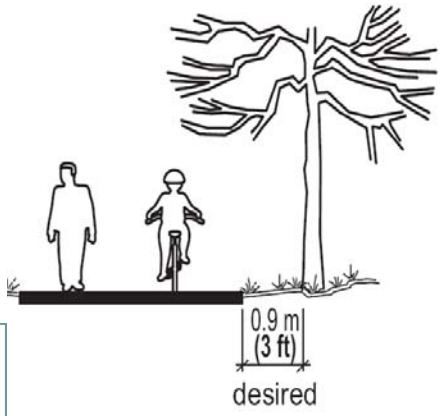
Clearance to railing: The MnDOT Bicycle Facility Design Manual recommends a minimum 20 inches of space between a shared use trail and a railing. 10 inches is recommended on bridge structures.



Clearance to retaining wall or concrete traffic barrier: The MnDOT Bicycle Facility Design Manual recommends a minimum 20 inches of space between a shared use trail and a barrier. 10 inches is recommended when the pedestrian section of a separated trail is placed next to the barrier.



Clearance to lamp post, signal post, tree trunk, or other fixed barrier: The MnDOT Bicycle Facility Manual recommends a minimum 3-foot clear zone between a trail and an obstruction. A minimum 2-foot clear zone is required by for safety purposes.



Right: The photo on the right shows a trail along 6th Ave SE where there is insufficient space between the trail and the light pole.

Geometric Design Considerations

Design Speed—Design speed is defined as the maximum safe speed that can be maintained over a section of trail. The design speed should be logical with regard to topography, trail use, and adjacent land use. Design speed should be slightly higher than the posted speed.

According to the MnDOT Bikeway Facility Design Manual the major geometric features that affect the speed at which a bicyclists can travel safely and comfortably are curvature, superelevation, gradient, and width of the traveled way. In addition, factors such as traffic, intersections, type of bicycle, physical condition of the rider, wind, and surface condition also affect the bicyclist's speed.

For all arterial trails a 20 mph design speed should be used. Federally funded trails require that State Aid Standards be used to design a facility. State Aid Standards require a design speed of 20 mph along a typical trail, except a design speed of 30 mph shall be used for descending grades longer than 500 feet and steeper than 4%. Unpaved paths may use a 15 mph design speed since bicyclists tend to move slower. Design speed is an important factor when designing horizontal and vertical curves, when evaluating grades, and determining stopping sight distances. Trails with faster design speeds may require wider pavement surfaces and greater separation between bikes and pedestrians to allow for safe passing.

Above: Chicago's Lakefront Trail was constructed to a 20-mph design speed.

Above: Van White Memorial Parkway Trail has been constructed to a 20-mph design speed.

Above: Godfrey Parkway was not constructed to a 20-mph design speed. Note the tight curves to avoid the trees.

Geometric Design Considerations

Drainage—A number of drainage factors should be considered in the design process. A straight 0.02 ft per ft cross slope is required on tangent trail sections and superelevated curves should be at least 2%. This allows water to drain off the trail and keeps water from ponding on the trail surface.

Stormwater Management: In some watersheds the amount of impervious surface a trail creates must be calculated and mitigated. Some projects may choose to pond stormwater on site, while other projects have the ability to channel stormwater into catch basins and into the underground stormwater piping system. It is important to properly judge the trail width to minimize stormwater runoff; however, projected trail volumes shall govern how wide a trail should be constructed so that trail safety is not compromised. Guidance on trail widths can be found in the Pavement Width section. Pervious pavement is not recommended for most trail surfaces due to higher maintenance costs and safety concerns relating to small loose particles.

Erosion Management: It is recommended that grass or native vegetation be planted on the edges of trails to reduce erosion and to encourage stormwater infiltration. During trail construction an erosion control method is required along slopes to prevent erosion. It is especially important to keep debris such as silt and rocks from washing onto a trail surface. Small rip-rap (rocks) should be avoided near trails. In some cases it may be appropriate to install concrete spillways or retaining walls to prevent erosion. Runoff from private property onto trails is not permitted unless mitigated.

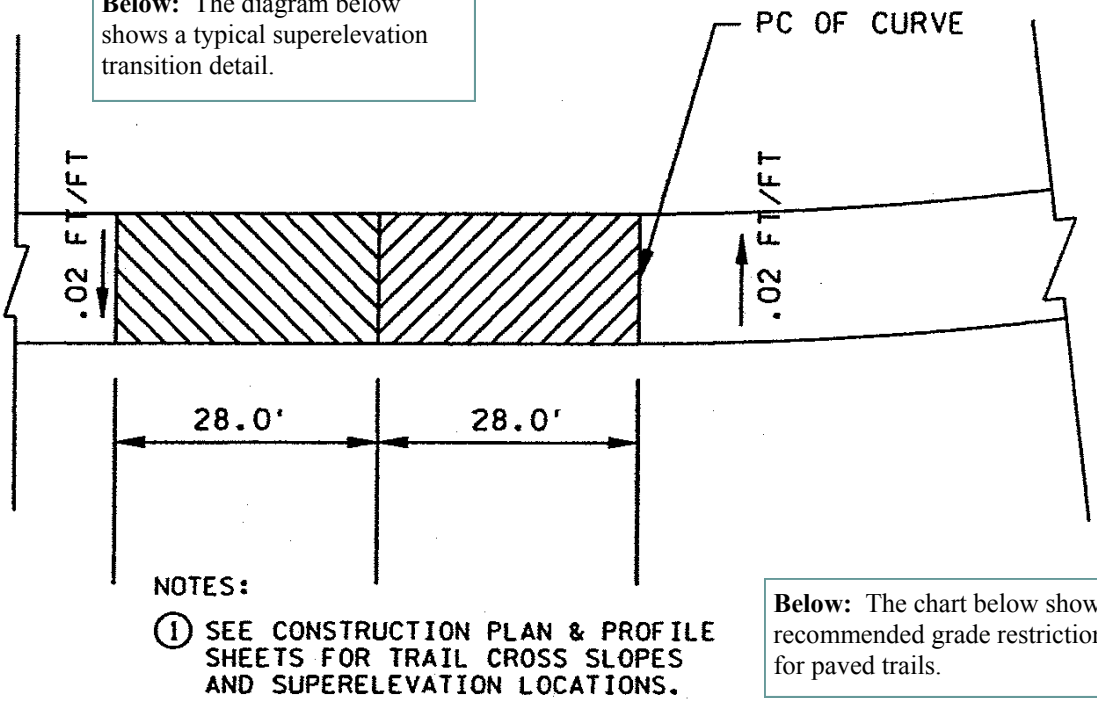
Geometric Design Considerations

Grades — Trails or access ramps should not exceed a 5% slope, however up to an 8.3% slope may be permitted for ramps in special circumstances. A straight 0.02 ft per ft cross slope is required on tangent trail sections.

Superelevated curves on separated bicycle facilities should be at least 2% and should not exceed 5% slopes. Mulit-use trails should not exceed a slope of 2% to meet ADA requirements. The MnDOT Bikeway Facility Design Manual should be used to determine horizontal and vertical curves based on appropriate design speeds and safe stopping sight distance. An example of a superelevation transition can be found below:

Above: The photo above shows the Midtown Greenway at Nicollet Avenue. The trail was elevated at this location to minimize the ramp slope.

Below: The diagram below shows a typical superelevation transition detail.



Below: The chart below shows recommended grade restrictions for paved trails.

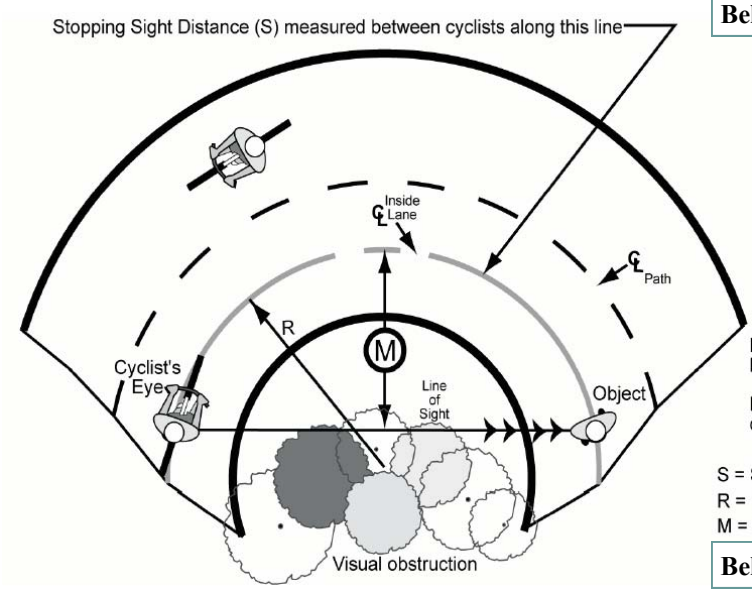
Grade Value (%)	Maximum Length of Grade Segment
5-6	240 m **(800 ft)**
7	120 m **(400 ft)**
8	90 m **(300 ft)**
9	60 m **(200 ft)**

Geometric Design Considerations

Below: Trail near Minnehaha Park showing a 10-mph speed limit and a tight horizontal curve.

Horizontal Curves—Horizontal Curves are commonly found on trails, especially those that parallel a water body or a parkway. The amount of lateral clearance required on the inside of a horizontal curve is a function of the design speed, the radius of curvature, and the grade. The centerline of the inside lane is used when measuring the length of the bicyclist's field of vision. According to the MnDOT Bikeway Facility Design Manual, lateral clearances should be calculated based on the sum of the stopping sight distances for bicyclists traveling in opposite directions around the curve. When this sight distance cannot be provided, the path should be widened or a continuous centerline should be striped between the lanes along the entire length of the curve and extending 30 feet beyond the curve at both ends.

Below: Lateral Clearance at Horizontal Curves



Angle is expressed in degrees

$$M = R\left[1 - \cos\left(\frac{28.65\,S}{R}\right)\right]$$

$$S = \frac{R}{28.65}\left[\cos^{-1}\left(\frac{R - M}{R}\right)\right]$$

Formula applies only when S is equal to or less than length of curve.

Line of sight is 700 mm (**28 in**) above centerline of inside lane at point of obstruction.

S = Stopping Sight Distance (m) (**ft**)
R = Radius of centerline of inside lane (m) (**ft**)
M = Distance from centerline of inside lane to obstruction (m) (**ft**)

Below: Trail Pavement Width vs. Curve Radius

Curve Radius	Recommended Minimum Two-Way Path Width
0 - 8 m **(0 - 25 ft)**	3.6 m **(12 ft)**
8.1 - 15 m **(26 - 50 ft)**	3.5 m **(11.5 ft)**
15.1 - 25 m **(50 - 80 ft)**	3.2 m **(10.5 ft)**

Horizontal Curves—According to the MnDOT Bikeway Facility Design Manual, superelevation (transverse sloping of the trail toward the inside of the curve) of 2 percent to 3 percent should be provided on most curves. For most conditions, the minimum superelevation rate of 2 percent will be adequate. The Public Right-of-Way Accessibility Guidelines (PROWAG) document allows a maximum superelevation rate of 2 percent for accessibility. When transitioning a 3 percent superelevation, a minimum 25 foot transition tangent distance should be provided between the end and beginning of consecutive and reversing horizontal curves. A cross slope of 1 to 2 percent is recommended for drainage on tangent (straight) sections of a shared-use path.

For English Units:

$$\theta = \mathrm{Tan}^{-1}\left(\frac{0.067\,V^2}{R}\right)$$

Where:
R = Radius of curvature (ft)
V = Design speed (mph)
θ = Lean angle from the vertical (degrees)

Above: Equation used to calculate radius given lean angle and design speed.

Right: Pictured is the North Mississippi Regional Trail.

Below: Chart showing radius length based on design speed.

The minimum radius of horizontal curvature depends on design speed, rate of superelevation, coefficient of friction, and the allowable lean angle of the bicyclist. By ignoring the coefficient of friction (assuming dry conditions) and the superelevation rate, the equation shown in the figure below can be used to find the approximate bicyclist lean angle for a given curve radius and bicyclist speed. The desirable minimum radius of horizontal curvature for varied design speeds, based on a 15 degree lean angle is provided below.

Desirable Minimum Radius of Horizontal Curvature for Paved Shared-Use Paths (Based on 15-degree lean angle)

Design Speed (mph)	Radius (ft)
12	36
15	56
20	100
25	156
30	225

Horizontal Curves—According to the MnDOT Bikeway Facility Design Manual, a lean angle of 20 degrees is considered maximum for average bicyclists, and the pedal may strike the ground at a lean angle of approximately 25 degrees, When the lean angle approaches 20 degrees, the minimum radius of curvature negotiable by a bicycle is a function of the superelevation rate, the coefficient of friction between the bicycle tires and the path surface, and the speed of the bicycle. For this situation, the minimum design radius of curvature can be determined from the equation shown below.

For English Units:

$$R = \frac{V^2}{15\left(\frac{e}{100} + f\right)}$$

Where:
R = Minimum radius of curvature (ft)
V = Design speed (mph)
f = Coefficient of friction
e = Superelevation rate (%)

Coefficient of friction factors used for design should be selected based upon the point at which centrifugal force causes the bicyclist to recognize a feelings of discomfort and instinctively act to avoid higher speed. The coefficient of friction depends on speed, surface type roughness and condition of pavement, tire type and condition, an whether the surface is wet or dry. Although no data exists for unpaved surfaces, it is suggested that friction factors be reduced by 50 percent to allow a sufficient margin of safety.

The minimum radius of horizontal curvature, based on a 2 percent superelevation rate and a 20 percent lean angle, is shown in table below. Extra paved width should be provided for curves designed for a 20 degree lean angle, because the bicyclists will require more space while leaning on the curve. When a curve radius smaller than shown in the table below is used (because of limited right-of-way or other considerations) standard curve warning signs and supplemental pavement markings may be needed. The negative effects of a sharper curve can also be partially offset by widening the pavement through the curve.

Minimum Radius for Paved Shared-Use Paths (Based on 2 Percent Superelevation and 20 Degree Lean Angle)

Design Speed (v) (mph)	Coefficient Friction (f)	Minimum Radius (R) ft
12	0.31	30
15	0.29	48
20	0.28	90
25	0.25	155
30	0.21	260

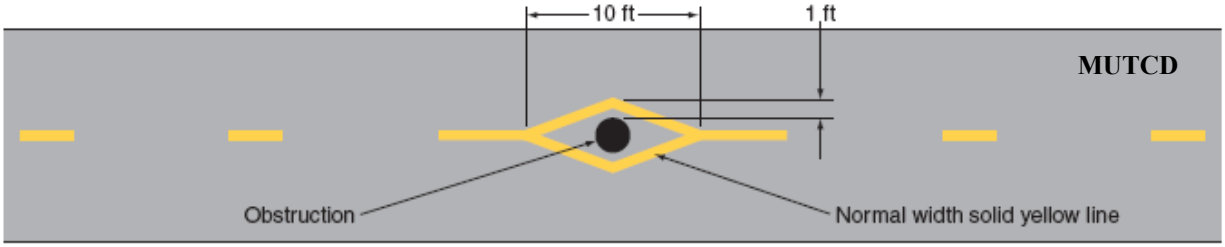
Bicycle Facility Design Guidelines
Chapter 3—Off-Street Facilities

Geometric Design Considerations

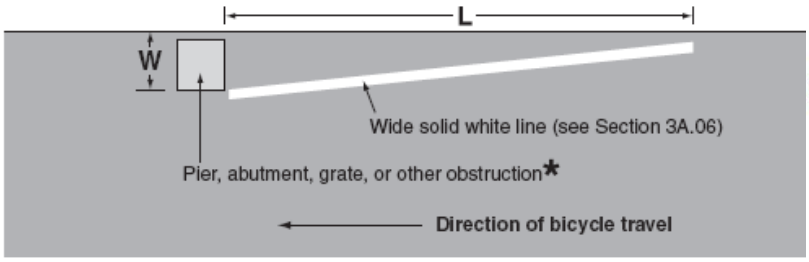
Obstructions—The AASHTO Design for Bicycle Facilities provides guidance with regard to trail obstructions. The diagram below states that a striped marking is required in approach of the object. Bicycle design speed for most trails should be 20 mph (S = 20mph). Obstruction signage should supplement pavement markings.

Right: 49th Avenue North obstruction striping.

Below: The diagrams below are taken from the MUTCD and show how pavement markings are used to mark obstructions within a path and at the edge of a path or roadway.



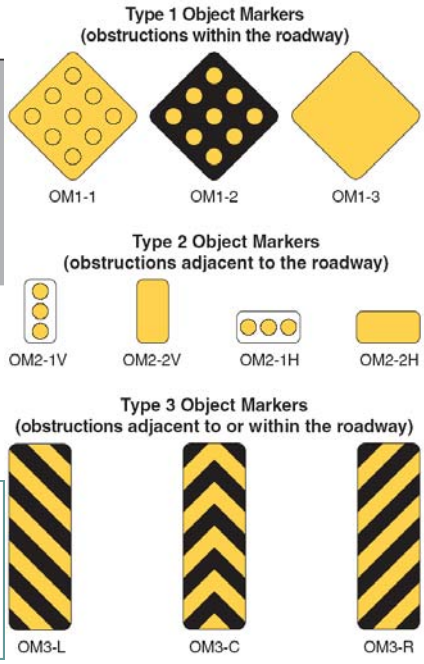
A - Obstruction within the path



B - Obstruction at edge of path or roadway

L = WS, where W is the offset in feet and S is bicycle approach speed in mph

* Provide an additional foot of offset for a raised obstruction and use the formula L = (W+1) S for the taper length



Right: The diagram on the right shows the types of signs used to mark an object. According to the MUTCD, all object markings shall be retro-reflective. On Type 3 markers, the alternating black and retro-reflective yellow stripes shall be sloped down at an angle of 45 degrees toward the side on which traffic is to pass the obstruction.

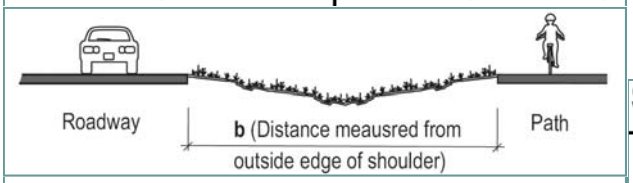
Bicycle Facility Design Guidelines
Chapter 3—Off-Street Facilities

Geometric Design Considerations

Path Separation Between Roadways and Trails—See categories below:

Path Separation from Roadway With No Curb: There are relatively few locations throughout the City of Minneapolis that apply to this category, however there are some exceptions. Clearly the faster the speed limit, the more distant the trail should be located away from the roadway. In some cases barriers are placed between the roadway and trail to improve safety.

Speed Limit - mph	Separation (b)
40 mph or less	20 ft (desirable) 10 ft (minimum)
45 mph or greater	24 ft - 35 ft
Freeway	50 ft (minimum)



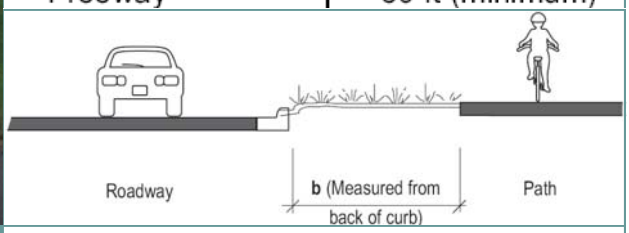
Above: Diagram/Chart is from the MnDOT Bicycle Facility Design Manual.

Above: Trail located along Cedar Avenue in Lakeville, MN. The path is separated from a 55 mph roadway.

Above: Minnehaha Parkway Trail

Path Separation from Roadway With Curb: Most roadways in the City of Minneapolis have a speed limit of 30 mph. Trails that parallel a 30 mph roadway or a 25 mph parkway must be separated by at least 3 feet if parking is allowed, and by 5 feet if parking is prohibited. A 3-foot clear zone is recommended and a 2-foot clear zone is required from the edge of the trail surface. Additional separation may be required if there are obstructions such as street lights or traffic signs between the roadway and trail.

Speed Limit - mph	Separation (b)
30 or less	5 ft (minimum) 3 ft (minimum, if parking allowed)
35 - 40	5 ft (minimum)
45 or greater	10 ft (desirable) 5 ft (minimum)
Freeway	50 ft (minimum)



Above: Diagram/Chart is from the MnDOT Bicycle Facility Design Manual.

Geometric Design Considerations

Pavement Widths—See guidance below:

Minneapolis Trail Widths: Below are typical trail widths for Minneapolis trails:

- Cedar Lake Trail: Separated trail with 7 feet in each direction for bicycles in addition to an 8-foot walkway (22 feet total).
- Kenilworth Trail: Separated trail with 7 feet in each direction for bicycles in addition to a 6-foot walkway (20 feet total).
- Midtown Greenway (Phases 1 and 2): Separated trail with 7 feet in each direction for bicycles in addition to a 6-foot walkway (20 feet total).
- Midtown Greenway (Phase 3): Separated trail with 5 feet in each direction for bicycles in addition to a 6-foot walkway (16 feet total).
- Minneapolis NE Diagonal Trail: Separated trail with 5 feet in each direction for bicycles in addition to a 6-foot walkway (16 feet total).
- LRT Trail (11th Ave to 28th St): 12-foot multi-use trail.

	Bicycle and Pedestrian Traffic Composition	Recommended Pavement Width
Two-Way Travel	Two-way bicycle travel with light pedestrian use	3.0 m **(10 ft)** (Standard width)
	Two-way bicycle travel with heavy pedestrian use, for short segments where right-of-way is restricted	
	Heavy two-way bicycle travel, with pedestrians on a separate path	
	Two-way bicycle travel, with pedestrians on a separate path	2.4 m **(8 ft)**
	Two-way bicycle travel where pedestrian use is likely to be infrequent	
	Two-way bicycle travel with light pedestrian use, for short segments where right-of-way is restricted	
	Two-way bicycle travel, with frequent pedestrian use	3.6 m **(12 ft)**
	Heavy bicycle travel, with light pedestrian use	
	Heavy bicycle travel, with light pedestrian use	
	Use by maintenance vehicles or emergency vehicles	
	Heavy bicycle and pedestrian travel	4.2 m **(14 ft)** or greater
	Path segments where queuing occurs, such as a road crossing	
	Minimum width for two-way pedestrian path, with light pedestrian use and bicycles prohibited (bicycle travel on a separate path)	1.5 m **(5 ft)**
	Recommended width for two-way pedestrian path with heavy pedestrian use or inline skating and bicycles prohibited (bicycle travel on a separate path)	2.0 m **(6.5 ft)**
One-Way Travel	Minimum width for one-way bicycle travel, with light pedestrian use	1.5 m **(5 ft)**
	One-way bicycle travel, where bicycles must frequently pass pedestrians	2.0 m **(6.5 ft)**
	Adjacent to curb, one-way bicycle travel, where bicycles must frequently pass pedestrians	2.4 m **(8 ft)**

Recommended Trail Widths: The chart on the left is guidance from the MnDOT Bikeway Facility Design Manual regarding trail widths. Since Minneapolis has over 25% of all bicyclists in the state, widths of arterial trails may need to exceed 14 feet in order to maintain free-flow conditions.

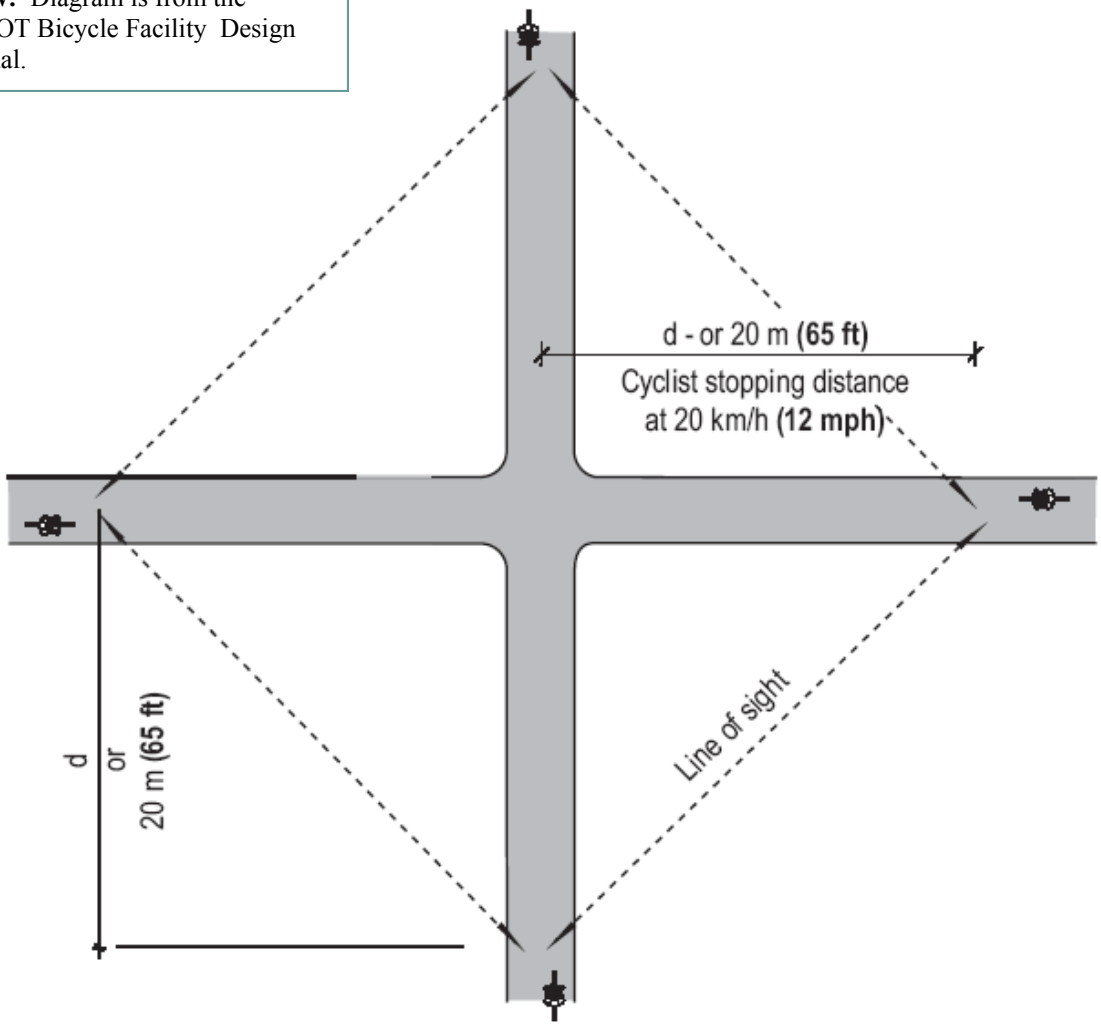
Supplemental Guidance:

- A multi-use trail must be at least 10 ft wide, but 12 ft wide is preferred when projected volumes exceed 500 users per day
- A 14-foot mulit-use trail is recommended when projected trail volumes exceed 1,000 users per day.
- The minimum bikeway width on an arterial trail with over 1,500 users per day should be a separated trail with at least 5 feet in each direction for bicyclists.
- The minimum bikeway width on an arterial trail with over 2,000 users per day should be a separated trail with at least 7 feet in each direction for bicyclists.
- When trail volumes exceed 5,000 users per day it is appropriate to design a trail with two 7-foot moving lanes in each direction with a separated 5-foot walkway in each direction.

When another agency or a developer constructs a trail to be maintained by the city, preferred widths must be constructed to allow for proper maintenance.

Sight Distances and Stopping Sight Distance—Similar to roadway design, a bicyclist must have enough time to react and stop to avoid a hazard or collision. A bicyclist must have a sight distance that is at least equivalent to the total stopping distance required at the recommended design speed. Since bicyclists tend to slow in approach of an intersection, a typical design speed for a trail intersection is 12 mph. No obstructions greater than 3 feet in height (except for necessary signage) should be placed within 65 feet of the intersection in the zone outlined below. In some situations a 50-foot stopping distance is adequate, however caution must be exercised on downhill slopes. When topography or other existing barriers prevent a 50-foot stopping distance, a 33-foot stopping distance may be used, however advance warning signage must be used to inform the bicyclist of the crossing. In some cases, better clear zones can be achieved at the time of construction through grading or vegetation removal.

Below: Diagram is from the MnDOT Bicycle Facility Design Manual.



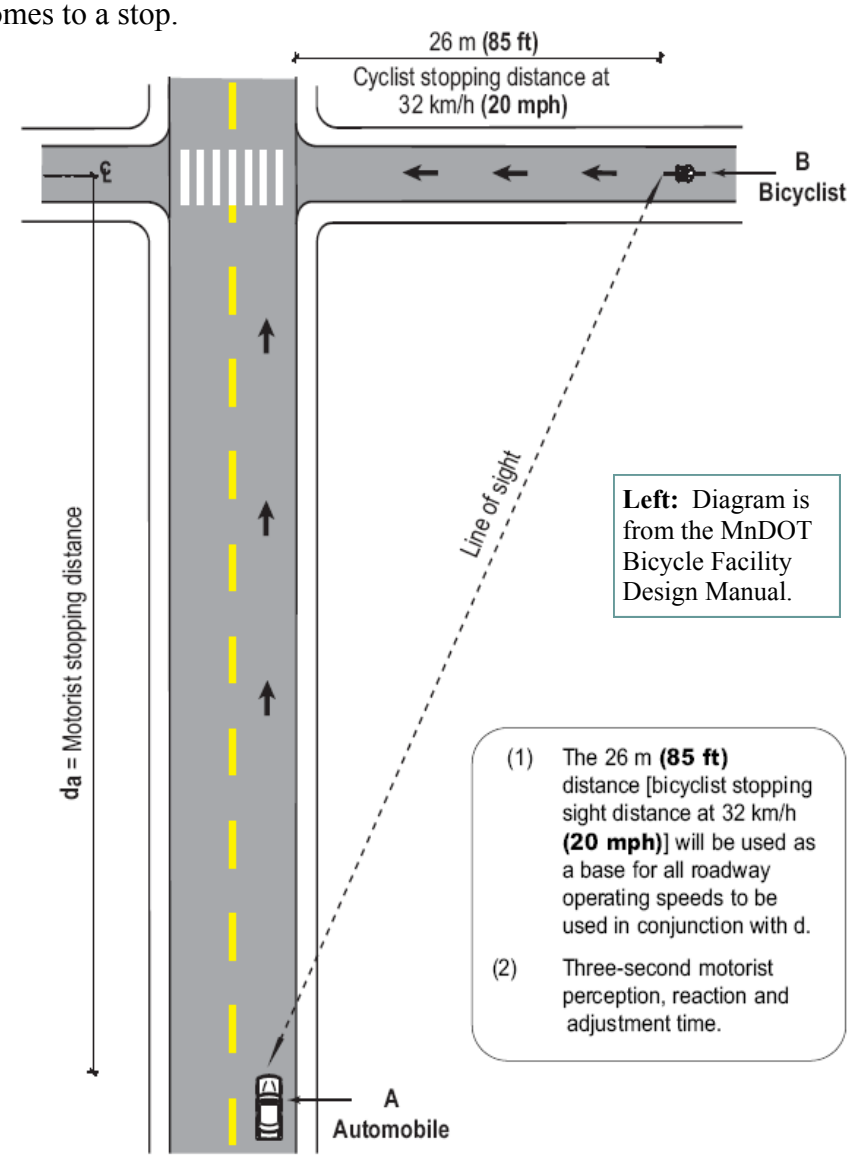
(a) FOUR-WAY PATH INTERSECTION

Sight Distances and Stopping Sight Distance — The standard reaction time recognized by AASHTO is 2.5 seconds. MnDOT recommends a reaction time of 3 seconds.

Vehicular Speed	30 mph	40 mph	45 mph	50 mph	55 mph	60 mph	70 mph
Distance	132 ft	176 ft	198 ft	220 ft	242 ft	264 ft	308 ft

Left: The chart on the left show distances travelled in 3 seconds.

Midblock Trail Crossings: An 85-foot cyclist stopping distance is needed for a bicyclist to stop assuming a 20 mph speed. The total distance to bring a motorist to a stop is a function of the grade, speed, and reaction time. Other factors such as roadway surface, weather, and tire quality can also affect stopping distances. The sum of the distance travelled during the reaction period and the distance travelled while braking determines stopping sight distance or the total distance from when an object has been identified by the driver to the point where the vehicle comes to a stop.



Left: Diagram is from the MnDOT Bicycle Facility Design Manual.

Assuming normal conditions the approximate distance to recognize an object and to come to a complete stop varies by speed:
d = 275 feet (25 mph)
d = 350 feet (30 mph)
d = 425 feet (35 mph)
d = 500 feet (40 mph)
d = 600 feet (45 mph)
d = 700 feet (50 mph)
d = 800 feet (55 mph)
An obstruction free window should be maintained from the line of sight to the intersection based on the cyclists stopping distance and the vehicle stopping sight distance. Advance warning signage is recommended along the roadway when the line of sight is obstructed by vegetation or topography. An engineering analysis should determine the appropriate traffic control devices for each midblock trail crossing.

Geometric Design Considerations

Vertical Curves— The steeper the top of a hill (or crest) the harder it is for a bicyclist to see objects in the distance. The AASHTO graph below can be used to determine the length of a crest vertical curve based on the formulas below. The chart below is for a crest vertical curve.

Above: West River Parkway Trail at Ford Parkway.

A	S = Stopping Sight Distance (ft)														
(%)	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300
2												30	70	110	150
3								20	60	100	140	180	220	260	300
4						15	55	95	135	175	215	256	300	348	400
5					20	60	100	140	180	222	269	320	376	436	500
6				10	50	90	130	171	216	267	323	384	451	523	600
7				31	71	111	152	199	252	311	376	448	526	610	700
8			8	48	88	128	174	228	288	356	430	512	601	697	800
9			20	60	100	144	196	256	324	400	484	576	676	784	900
10			30	70	111	160	218	284	360	444	538	640	751	871	1000
11			38	78	122	176	240	313	396	489	592	704	826	958	1100
12		5	45	85	133	192	261	341	432	533	645	768	901	1045	1200
13		11	51	92	144	208	283	370	468	578	699	832	976	1132	1300
14		16	56	100	156	224	305	398	504	622	753	896	1052	1220	1400
15		20	60	107	167	240	327	427	540	667	807	960	1127	1307	1500
16		24	64	114	178	256	348	455	576	711	860	1024	1202	1394	1600
17		27	68	121	189	272	370	484	612	756	914	1088	1277	1481	1700
18		30	72	128	200	288	392	512	648	800	968	1152	1352	1568	1800
19		33	76	135	211	304	414	540	684	844	1022	1216	1427	1655	1900
20		35	80	142	222	320	436	569	720	889	1076	1280	1502	1742	2000
21		37	84	149	233	336	457	597	756	933	1129	1344	1577	1829	2100
22		39	88	156	244	352	479	626	792	978	1183	1408	1652	1916	2200
23		41	92	164	256	368	501	654	828	1022	1237	1472	1728	2004	2300
24	3	43	96	171	267	384	523	683	864	1067	1291	1536	1803	2091	2400
25	4	44	100	177	278	400	544	711	900	1111	1344	1600	1878	2178	2500

when S > L $L = 2S - \frac{900}{A}$

when S < L $L = \frac{AS^2}{900}$

Height of cyclist's eye – 4.5 ft
Height of object – 0 ft

Shaded area represents S = L

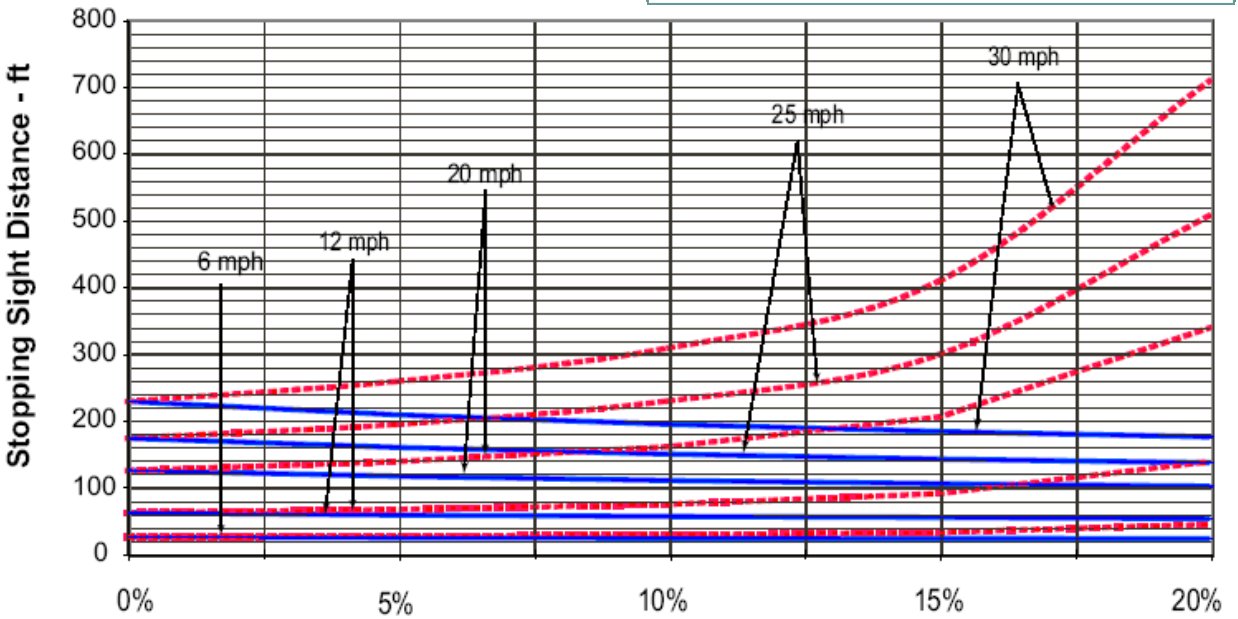
L = Minimum Length of Vertical Curve (ft)
A = Algebraic Grade Difference (%)
S = Stopping Sight Distance (ft)

Minimum Length of Vertical Curve = 3 ft.

Geometric Design Considerations

Vertical Curves—Stopping sight distances for a sag curve (the bottom of a hill) can be calculated using the formulas below. As speeds and grades increase it takes considerably longer for a descending bicyclist to stop. The calculations below are for a sag vertical curve.

Above: Minnehaha Parkway near Bryant Avenue.



MnDOT Bikeway Facility Design Manual

For English Units:

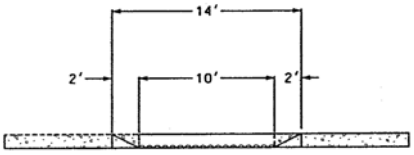
$$S = \frac{V^2}{30\,(f \pm G)} + 3.67\,V$$

S = Stopping distance (ft)
V = Velocity (mph)
f = Coefficient of friction (use 0.25)
G = Grade (ft/ft) (rise/run)

Ascend
Descend

Below: Stopping Sight Distances for Downgrades

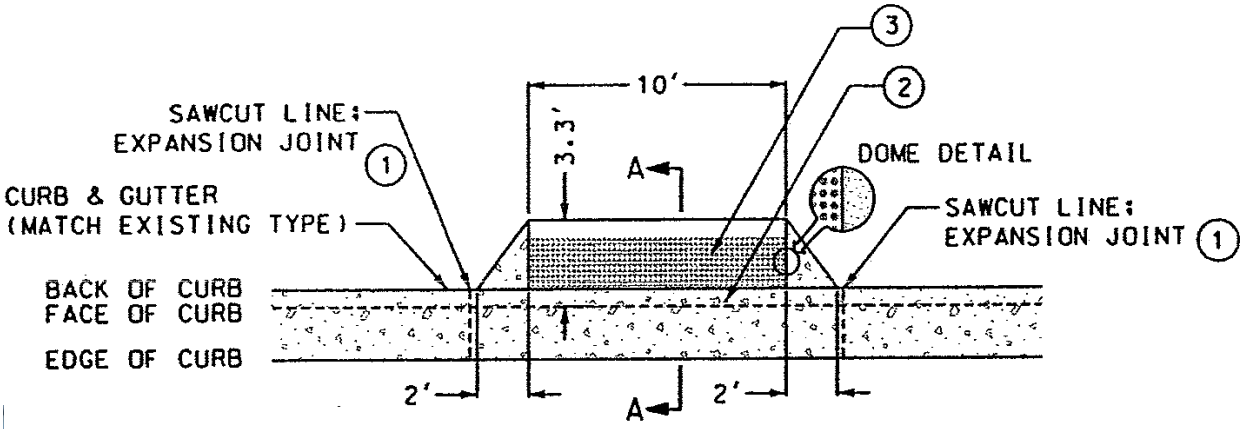
Design Speed	Stopping Sight Distance		
	0 % Grade	5 % Grade	10 % Grade
15 km/h **(10 mph)**	14 m **(50 ft)**	15 m **(53 ft)**	17 m **(59 ft)**
(12 mph)	**(63 ft)**	**(68 ft)**	**(76 ft)**
20 km/h **(15 mph)**	21 m **(85 ft)**	22 m **(93 ft)**	25 m **(105 ft)**
30 km/h **(20 mph)**	36 m **(127 ft)**	39 m **(140 ft)**	45 m **(162 ft)**
40 km/h **(25 mph)**	54 m **(175 ft)**	60 m **(196 ft)**	71 m **(231 ft)**
50 km/h **(30 mph)**	75 m **(230 ft)**	85 m **(260 ft)**	101 m **(310 ft)**



ELEVATION VIEW OF RAMP

Intersections

Curb Cuts at Intersections —Curb cuts at trail intersections should be installed with a curb cut the full width of the trail. Truncated domes are only required for the pedestrian section of a separated trail apron, but must traverse the entire section of a multi-use trail apron. Below is a detail for a standard multi-use trail apron a separated crossing photo:



PLAN VIEW OF RAMP

Above: Midtown Greenway trail crossing.

Intersections

Midblock Trail Crossings —Midblock trail crossings are common and require various degrees of traffic control. Trail volumes, traffic speed, roadway volumes, sightlines, topography, roadway functional classification, crash history, bikeway function, and distance to the nearest intersection are factors to consider when designing a trail crossing.

The information provided is based on federal and state guidance. For more detailed information see the City of Minneapolis Trail Crossing Policy.

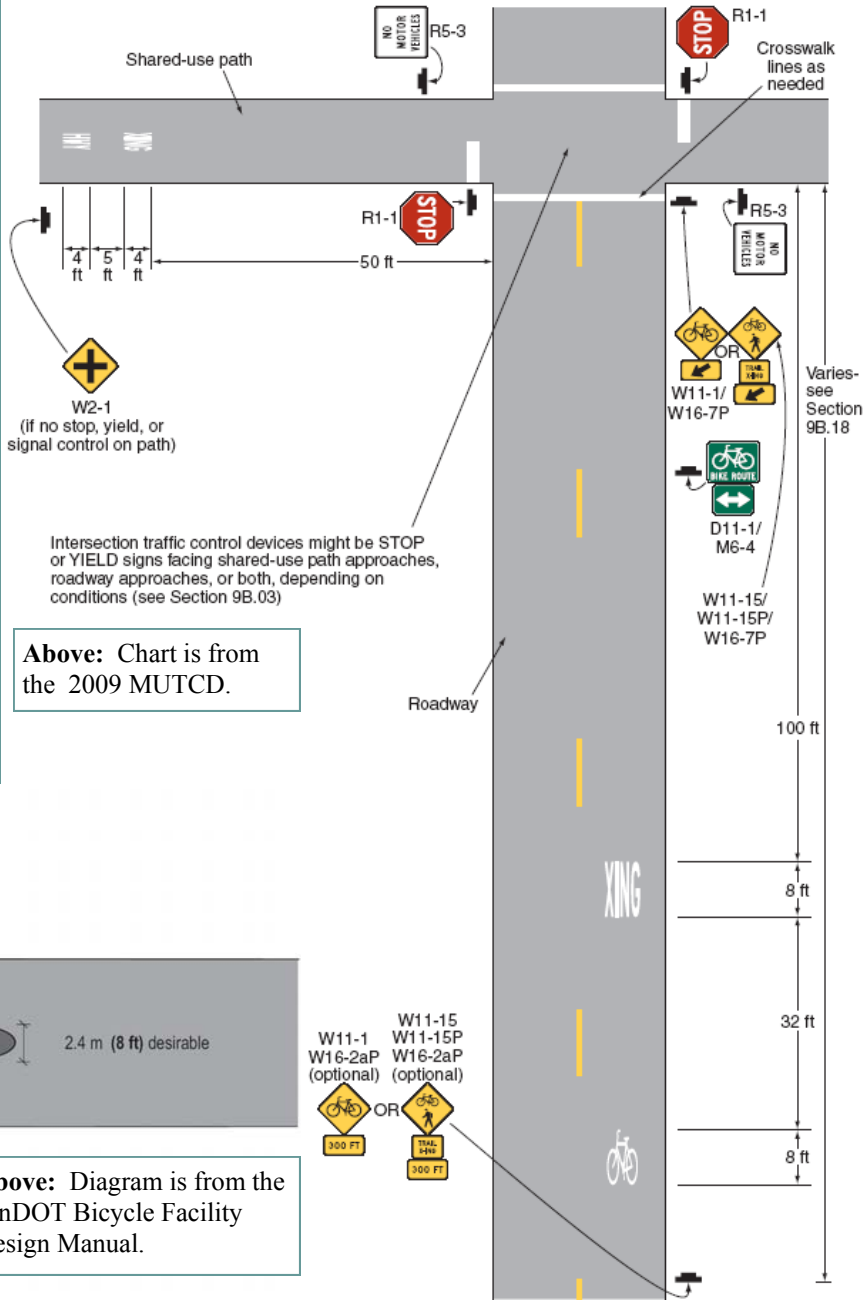
Above: Midblock trail crossing along the Kenilworth Trail at Cedar Lake Parkway.

Above: This crossing includes crosswalk markings in addition to a pedestrian actuated flashing signs to help pedestrians safely cross.

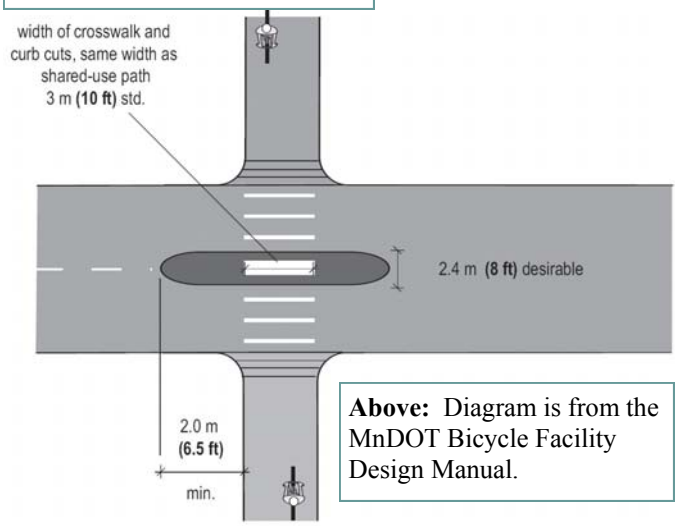
Below: The photo below shows a pedestrian actuated flasher and crosswalk at a midblock crosswalk located along the Midtown Greenway at Minnehaha Avenue.

Midblock Trail Crossings— Midblock Trail Crossings are commonly found throughout the region and must be properly signed and marked to ensure safety. Medians located at midblock trail crossings can improve safety by reducing the distance required to cross and by having trail users cross one direction of traffic at a time. An 8-foot median is needed to accommodate the length of a bicycle, however wider medians may be required to accommodate trailers. The number of moving lanes, available right-of-way, types of trail user, crashes, and speed should be considered. Consult the Minneapolis Trail Crossing Policy for additional guidance.

Right: The Minnesota Manual on Uniform Traffic Control Devices (MMUTCD) provides guidance for mid-block trail crossings. The diagram below shows how a typical midblock crossing should be signed and striped. Many of the trails in Minneapolis are constructed in existing and former rail corridors resulting in midblock crossings. It is important that all midblock crossings be designed to be uniform and consistent. When a trail crosses a major street it is customary to stop trail traffic, however when a trail crosses a local street where trail volumes exceed roadway volumes it is appropriate to stop the local street. All midblock crossings should be constructed with good visibility by minimizing obstructions and optimizing grades.

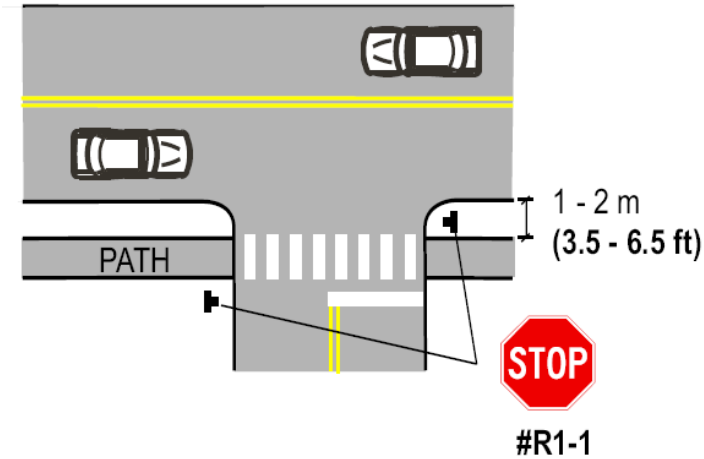


Above: Chart is from the 2009 MUTCD.



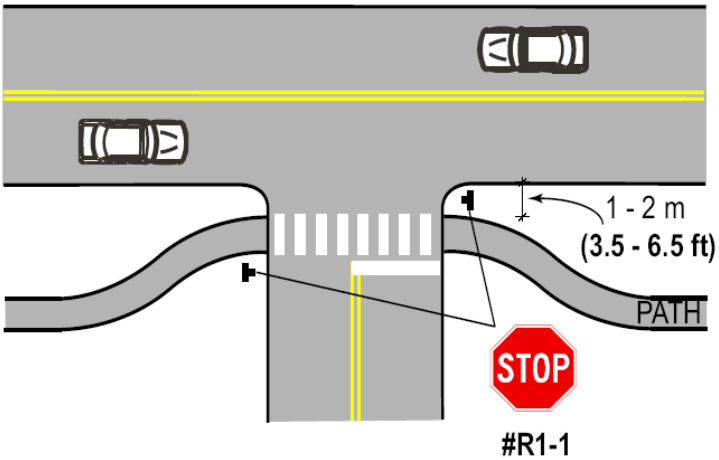
Above: Diagram is from the MnDOT Bicycle Facility Design Manual.

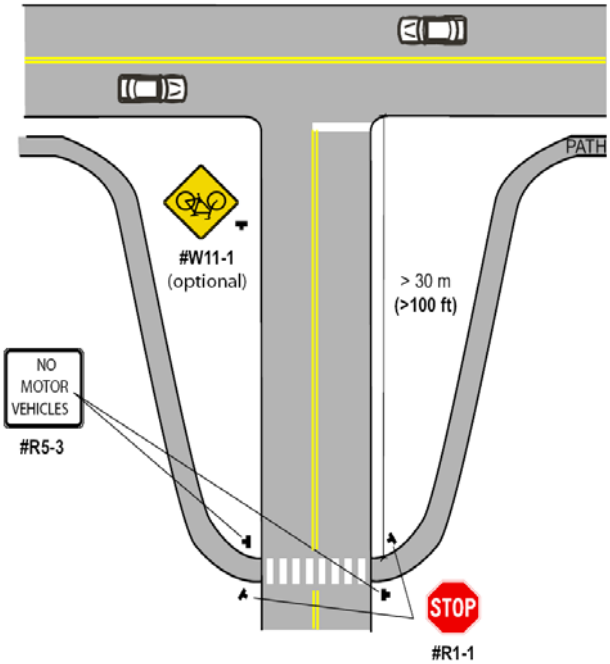
Intersections



Trail Crossings at Intersections— An off-street trail that parallels a major roadway should cross a perpendicular roadway at a 90 degree angle and a crosswalk should be clearly marked. Trail crossings should also be placed between 3.5 feet and 6.5 feet from the roadway. No pavement markings or signs are required at driveway crossings, however the number of these crossings should be minimized since bicyclists are not as easily seen on side paths.

When a trail is located further than 6.5 feet from the roadway, the trail may need to be moved closer to the intersection to facilitate a safer crossing. The roadway stop bar should still be located behind the crosswalk and the trail should be stopped at major roadways. The trail curve approaching the intersection should be designed to a minimum 12 mph design speed with clear sightlines and no obstructions. Side paths do not need to be stopped at driveways.





In some situations it is best to move the at-grade trail crossing away from a controlled intersection with the trail crossing at a mid-block location. It is important to provide at least 100 feet of space from the intersection to the crossing to allow for vehicle storage and ample stopping distance. This layout is ideal when there is a free right condition at the intersection or when topography or sight lines do not allow for a safe crossing. Within the City of Minneapolis it is preferred that mid-block crossings are avoided and that adjustments to the intersection are made to facilitate a crossing at the intersection. Mid-block trail crossings must conform to the City of Minneapolis Midblock Trail Crossing Policy to ensure uniformity.

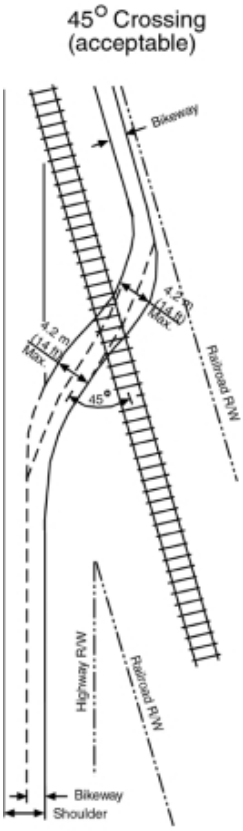
Bicycle Facility Design Guidelines
Chapter 3—Off-Street Facilities

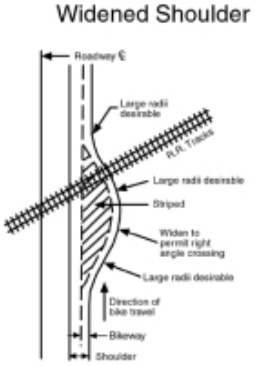
Intersections

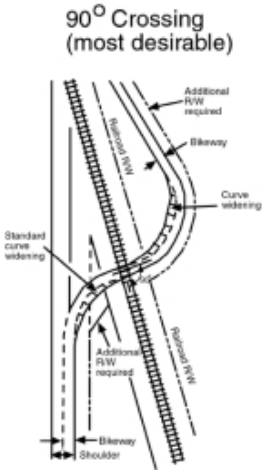
Railroad Crossings—Trail crossings at railroads require special consideration. There are five basic treatments that are recommended for use based on engineering judgment; factors including train speed, train frequency, trail volumes, and visibility.

Above: Hiawatha LRT at 24th Street.

Train Speed	Train Frequency	Type of Treatment	Trail Volumes	Visibility
Low	Low	At-Grade Crossing With a Crossbuck and a Yield Sign	Low	High
		At-Grade Crossing With Stop Sign		
		Signalized Crossing With Stop Sign		
		Signalized Crossing With Gate Arms		
High	High	Grade Separated Crossing	High	Low







NOTE:
Additional width to 4.2 m (14 ft) to be provided at railroad crossing to allow cyclists to choose their own crossing routes.

Above: Diagram is from AASHTO

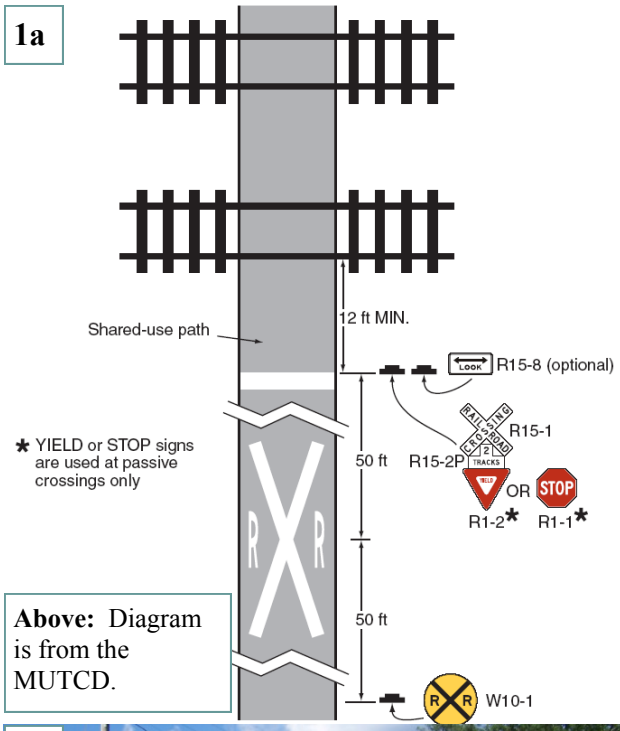
Railroad Crossing Criteria: Trails must cross railroads at a 45° angle or greater with a 90° angle desired (AASHTO Guide for the Development of Bicycle Facilities)

Intersections

Railroad Crossings—There are four primary railroad/trail intersection treatments:

1) At-Grade Crossing with Crossbuck with Yield OR At-Grade Crossing with Stop
2) Signalized Crossing With Stop Sign
3) Signalized Crossing With Gate Arm
4) Grade Separated Crossing

1a



Above: Diagram is from the MUTCD.

1b

Above: Trail of the Coeur d'Alenes, Idaho.

2a

Above: Madison, Wisconsin signalized crossing.

2b

Above: 24th St/LRT Trail crossing in Minneapolis.

3

Above: Signalized crossing with gate arm, Germany.

4

Above: Bridge Over BNSF RR, Minneapolis.

Trail Specifications

Barriers—Barriers are physical devices or objects that are used to protect bicyclists from danger. Barriers often protect bicyclists from steep slopes, from sharp obstructions, and from faster moving motor vehicles. Barriers can be steel, concrete, or natural (trees, flower pots, large rocks, etc.). Parked vehicles can also be effective barriers.

Above: A barrier along the Merriam Street Bridge.

Above: A barrier separates an expressway from a heavily used trail across the Golden Gate Bridge. Barriers help mitigate the severity of a crash and protect bicyclists and pedestrian from moving traffic.

Above: Jersey barriers or concrete barriers may be used between a trail and roadway to protect bicyclists, especially in corridors where there is limited space and where traffic speeds exceed 30 mph. Often called J-Barriers, Jersey barriers are heavy enough to buffer a crash and can easily be assembled with the proper equipment. Jersey barriers are often used in construction projects throughout the state. The photo on the left is a two way bicycle facility in New York City separated by barriers and a striping buffer. The photo on the right was taken on the 10th Avenue Bridge while the adjacent I-35W bridge was being reconstructed. Due to maintenance concerns, barriers are intended to be a temporary treatment and are not recommended for use longer than one year.

Trail Specifications

Bollards—Bollards are a vertical pole placed at a trail entrance or a diverter to prevent motor vehicles from entering but allow a narrower trail user to get through. A 5-foot distance between bollards is required to allow wheelchairs and bicycles with trailers to proceed. A bollard must be clearly visible to motorists using a bright yellow color or reflectorized material. Bollards are not widely used along City of Minneapolis trails to encourage regular police patrol and maintenance. Breakaway bollards have been used along some trails, which allows emergency vehicles the ability to access a trail. Bollards are not required at trail entrances where trails are regularly patrolled and where no motor vehicle signs exist.

Photos: The photo above is a series of bollards used at a traffic diverter at the intersection of Elm Street SE and 18th Ave SE. that was constructed as part of the NE Diagonal trail project. The bollards allow non-motorized users to pass while keeping drivers from entering. Police officers still need to monitor these types of crossings to prevent motorcyclists from using the cut-through. The photo below is a Minnesota River crossing near TH 169 featuring a breakaway bollard. In general bollards should be avoided if possible due to the potential for bicycle crashes.

Bridge Railings —Bridge railings must be at least 48 inches tall to allow a bikeway next to the edge of a bridge. Heights less than 48 inches may result in a bicyclist being thrown over the fence or railing. Railing edges must be smooth and footings must not protrude into the trail.

Below: The photos below are good examples of high quality bridge railings throughout the city.

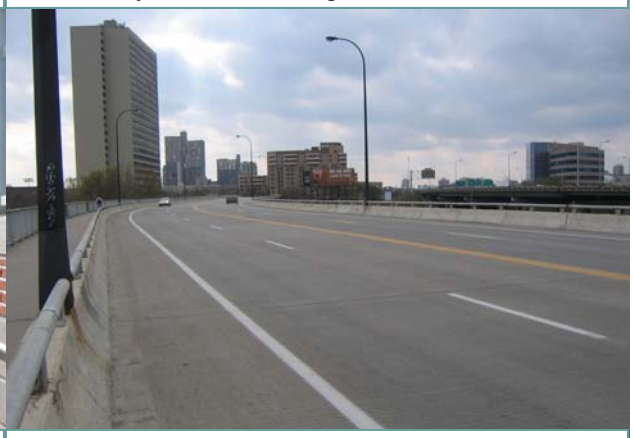
Above: Midtown Greenway barrier.

Above: Loring Bike Bridge barrier.

Above: Ford Bridge barrier.

Below: The photos below show locations where improvements to bridge railings are needed.

Above: Bryant Avenue Bridge barrier.



Above: 10th Avenue Bridge barrier.

Above: Camden Bridge barrier.

Trail Specifications

Detours — It is often necessary to close bicycle facilities for long periods to allow for construction activities. It is important to accommodate bicyclists needs with a safe and convenient way to either go through or around a construction site with minimal lost time. The same principles that apply to roadway closures should apply to bikeway closures. Although there are MMUTCD signs approved for bicycle route detours there is currently very little guidance on how to implement bikeway detours. Bikeway detours are mandatory when any existing trail, bike lane, or signed route has been closed.

Trail Bypass: In some cases it is possible to provide a bypass to safely accommodate trail users with minimal impact. This is the preferred solution, especially in arterial trail corridors such as the Midtown Greenway. Bridges over trails that must be reconstructed require a trail to be completely closed during demolition and when beams are placed. In these situations an alternate detour route must be created. There are 28 bridges over the Midtown Greenway; many of these bridges will need to be reconstructed in the next 20 yrs.

Trail Specifications

Above: Cedar Lake Trail detour signage.

Above: Midtown Greenway detour signage.

Above: Midtown Greenway detour signage.

Detours — When a trail or bike lane is closed an on-street detour may be the best available temporary solution for accommodating bicyclists. It is important to consider all of the types of users on a particular facility to ensure the detour treatment will accommodate all users.

Signage is a critical element to any detour route. A trail closed or bike lane closed sign must be supplemented by a bicycle detour sign and arrow sign. Detour signage should be placed at all turns along the route and at an appropriate interval spacing. Trails should have advisory signs placed at each end of the project two weeks prior stating that there will be a disruption to the corridor and when.

Bicycle lanes should not end abruptly at midblock locations without a delineated transition zone and advisory signage at the block ends. The bicycle functional classification chart should be used to determine if a share the road condition is best for a given route or if a detour route should be established. If the bikeway disruption is greater than one block a detour route should be established.

Considerations in determining temporary bicycle route treatments include traffic volumes, bikeway volumes, crash history, on-street parking, pedestrian needs, traffic capacity, and proximity of alternate routes.

Bikeway disruptions should consider the use of advance warning and guidance signs, lighting, retro-reflective pavement markings, barricades, and channelization to accommodate bicycles in the construction zone. It is also important to maintain a smooth riding surface free of gravel and debris. A bike lane should merge with a traffic lane and should not negatively impact pedestrians.

Trail Specifications

Fencing —A fence may be required to provide a physical barrier between a trail and a railroad corridor, private property, a slope, a river, or other obstruction. Wood or chain link fence should be between 5 and 6 feet high. Split rail fence or artistic fence may be used where appropriate.

Above: LRT Trail fencing.

Chain Link Fencing: Chain link fence is a common and cost effective fencing treatment. The standard for chain link fence along trail corridors should be 6-foot high with a bottom and top bar for support. In some areas where soils are poor or other conditions exist, the footings should be poured in concrete. Fencing is also required at the top of retaining walls and where slopes exceed 3:1 next to the trail. Black vinyl coated chain link fence has a more transparent look. Cable fencing may also be used where sightlines must be clear.

Above: Midtown Greenway fencing.

Wood Fencing: Split rail fencing may be used as an alternative to chain link fence. Split rail fence has a more natural appearance than chain link fence, however it can be easily climbed over. In most cases, railroads require chain link fence to separate trails from active railroads, however there are some exceptions. The Kenilworth Trail is fenced using split rail. Solid wood privacy fence (placed on property lines) may be used on projects where a trail user has easy access to private property or when trail users can see into windows.

Above: LRT Trail fencing.

Steel and Wrought Iron Fencing: Steel fencing can be given a contemporary or industrial look to fit into the surrounding neighborhood. All fence must be over 48 inches high and must be supported to buffer a bicycle crash. Wrought iron fencing can also be used, but because of expense, cost sharing arrangements are usually pursued. The Loring Bikeway features an artistic fence that is part of the city's art in public places portfolio. All steel or iron fencing must not have sharp edges and should be rust-proofed.

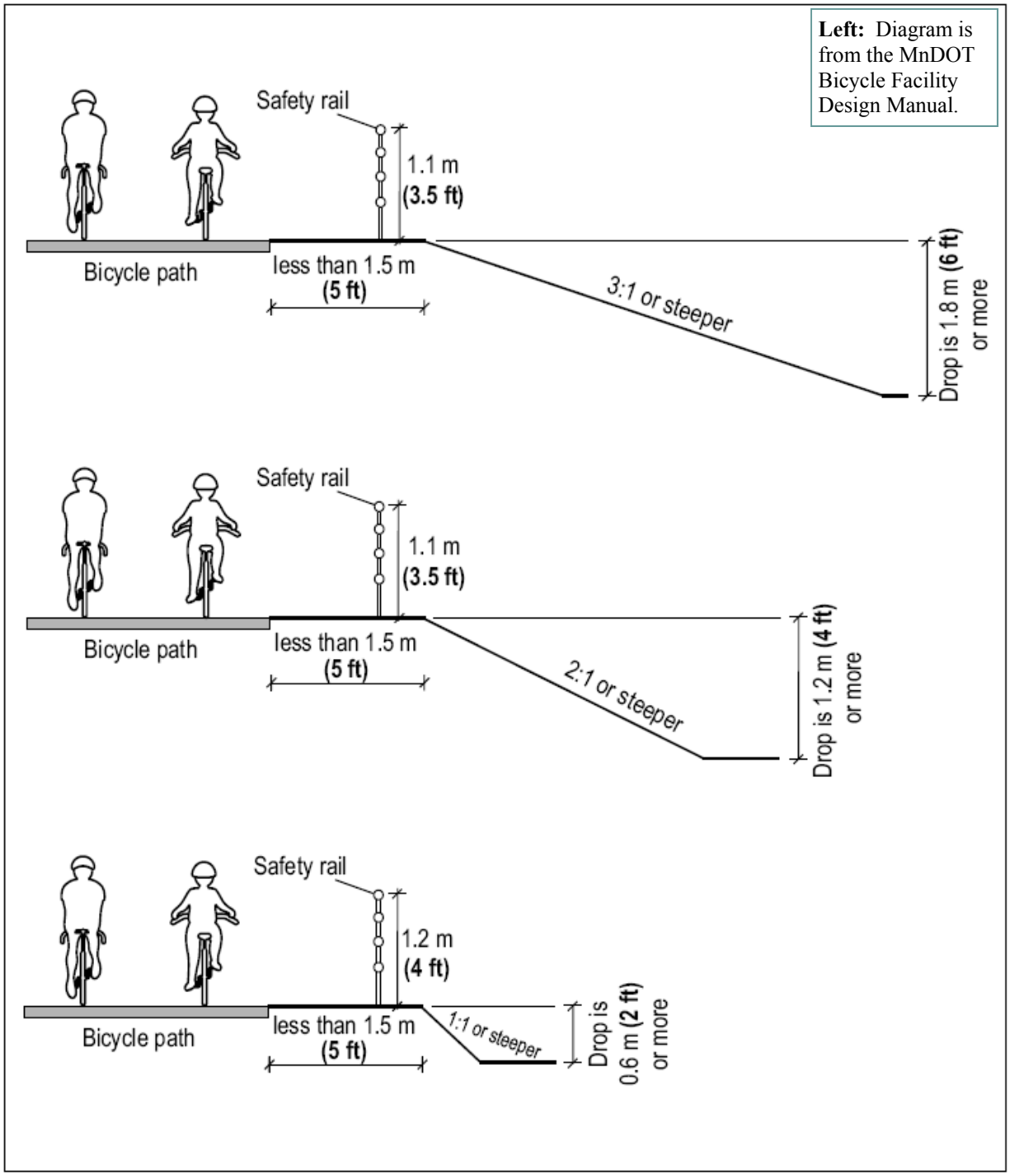
Above: Loring Bikeway fencing.

Trail Specifications

Fencing— The MnDOT Bikeway Facility Design Manual provides the following guidance for safety rail between a trail and a slope:

Above: Columbia Parkway Trail fencing.

Left: Diagram is from the MnDOT Bicycle Facility Design Manual.



Trail Specifications

Information and Wayfinding Signage—See guidance below:
Information Signage: Informational signage tells a biker where they are located or which facility or corridor they are using. Information Signage includes two types of sign treatments:

- Bicycle Route Sign (M1-8a) with the Minneapolis logo—Shown on left, this sign will be used at regular intervals and decision points along the city's designated on-street bicycle routes. The Bicycle Route Sign (M1-8a) is a modification of the MMUTCD sign using place names instead of a number.
- Modified Street Signs—When street name signs along designated off-street and on-street bike routes are replaced during routine maintenance cycles, the City will install new street name signs that will include a bicycle symbol, which will help users understand the bicycle system and to confirm bicycle routing.

Wayfinding Signage: Wayfinding Signage (top right photo) provides destination information at decision points along city bike routes, both on-street and off-street. Also known as Bicycle Route and Destination Signs, the primary purpose of this signage is to provide enough information for a bicyclist to complete their trip by route or to a facility destination point. Wayfinding Signage is intended to be coupled with kiosks and a citywide bicycle map for user convenience. To minimize sign clutter and significant maintenance costs, wayfinding signage must be prioritized and only used at key decision points along bike routes. A full description of these standards and treatments may be found in the Appendix. More information can also be found in Chapter 9 of the Minnesota Manual on Uniform Traffic

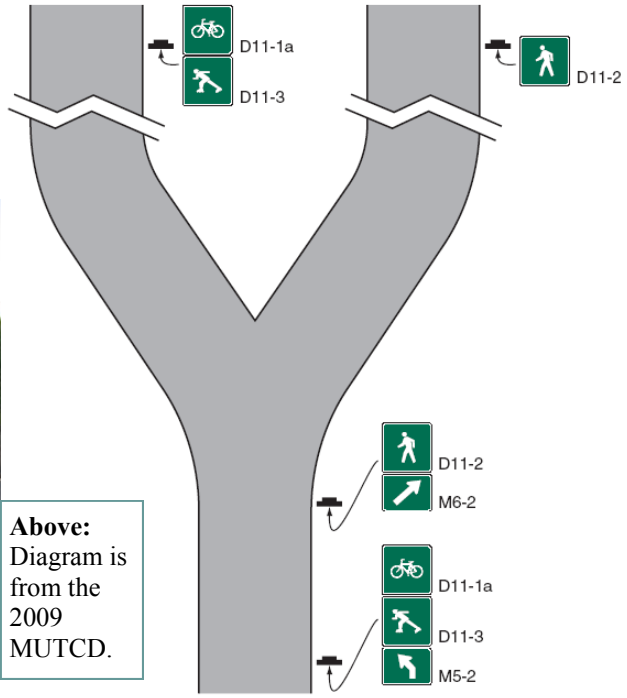
Bicycle Route and Destination Sign Criteria:

- Bicycle Route and Destination Signs are only to be installed on designated bicycle routes.
- Signs strategically placed at key decision points.
- Limit of 3 signs per location.
- All locations approved by Minneapolis Public Works.
- Signed destinations must be other bicycle routes or a facility destination point (in miles or tenths).
- Maintenance of signs to be same as other street signs to reduce cost.

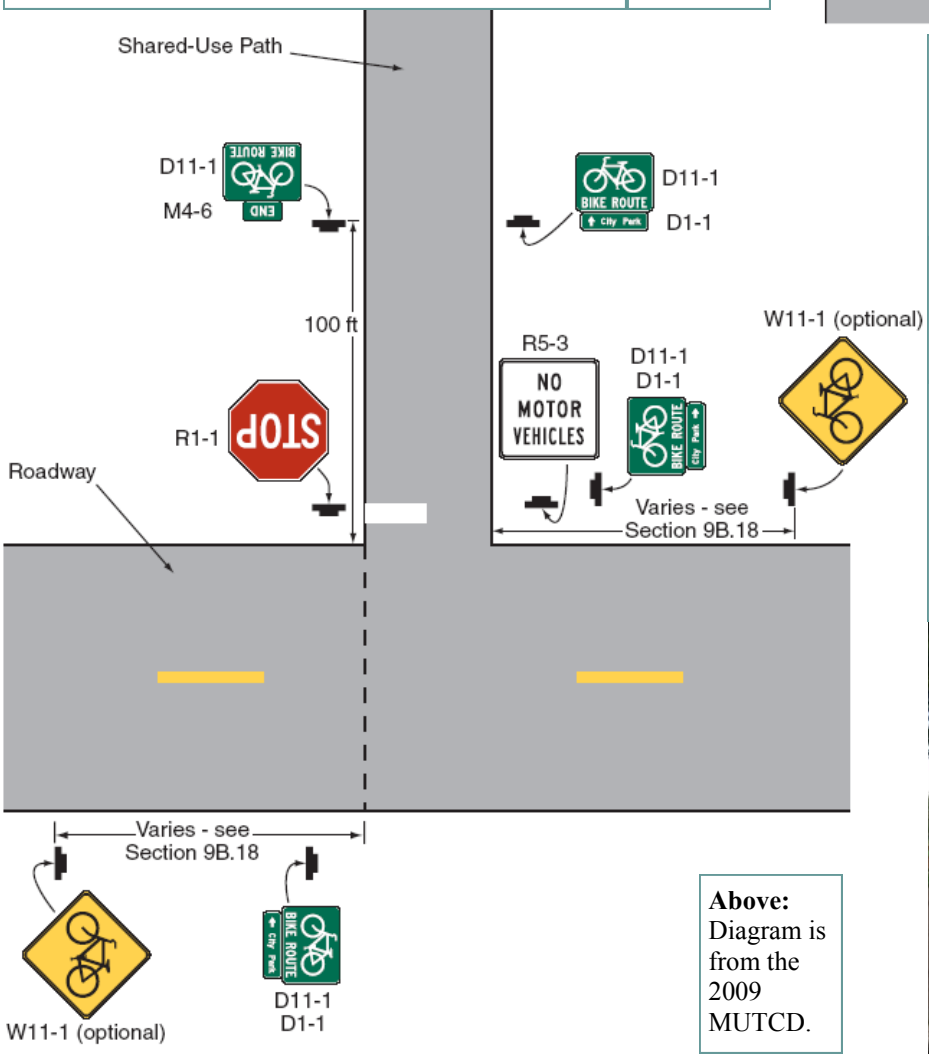
Trail Specifications

Guide Signage—See guidance below:

Above—The photo above shows how guide signage has been used along the Midtown Greenway.



Above: Diagram is from the 2009 MUTCD.



Above: Mode signage for separated trails is common throughout Minneapolis. The MUTCD suggests the signage configuration above.

Left: This diagram shows how guide signage is used at a trail entry from a roadway.

Below: Guide signs help trail users get around. The guide signs shown above are approved for trail use. The modified sign below is approved for use in the City of Minneapolis.

Above: Diagram is from the 2009 MUTCD.

Trail Specifications

Lighting — Trail lighting must comply with the City of Minneapolis Lighting Policy. All fixtures must be approved by Minneapolis Public Works. Standard styles for low level lighting fixtures include the acorn, lantern, and the shoebox.

Light fixtures should be spaced along trails to meet light levels judged safe based on the adjacent land use.

The following considerations should be examined to determine the need for low level lighting along trails:

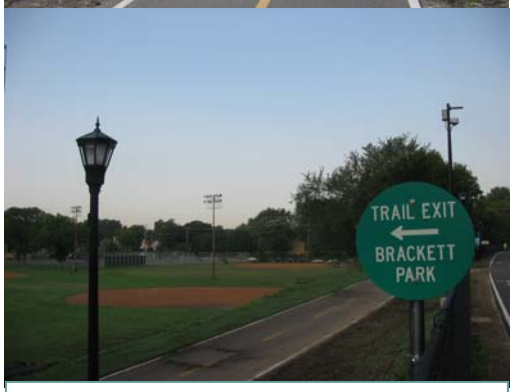
- Adjacent land uses
- Neighborhood input
- Land use impact
- Trail safety
- Horizontal and vertical curves
- Sightlines at intersections
- Nocturnal wildlife considerations
- Capital and operating costs
- Historical impacts
- Available right-of-way

All trails in confined area such as bridge underpasses and tunnels must be lit. All bridges with bicycle and pedestrian accomodations should be lit as well. Trail lighting on bridges and overpasses should be budgeted as part of all capital bridge and roadway projects.

Light fixtures should be placed just outside the trail clear zone to maximize lighting on the trail.

Trail lighting shall not be assessed to ajacent landowners in dedicated trail corridors. Petitions are also not required along dedicated trail corridors. Trails adjacent to roadways must follow the City of Minneapolis Lighting Policy.

Banners on trail light poles need to be permitted by the City of Minneapolis. Requests for maintenance will be given the same priority as street lights.



Above: The City of Minneapolis has three standard fixtures that may be used on trails; including the shoebox fixture (top two photos), the acorn fixture (second from top), and the lantern fixture (bottom two photos).

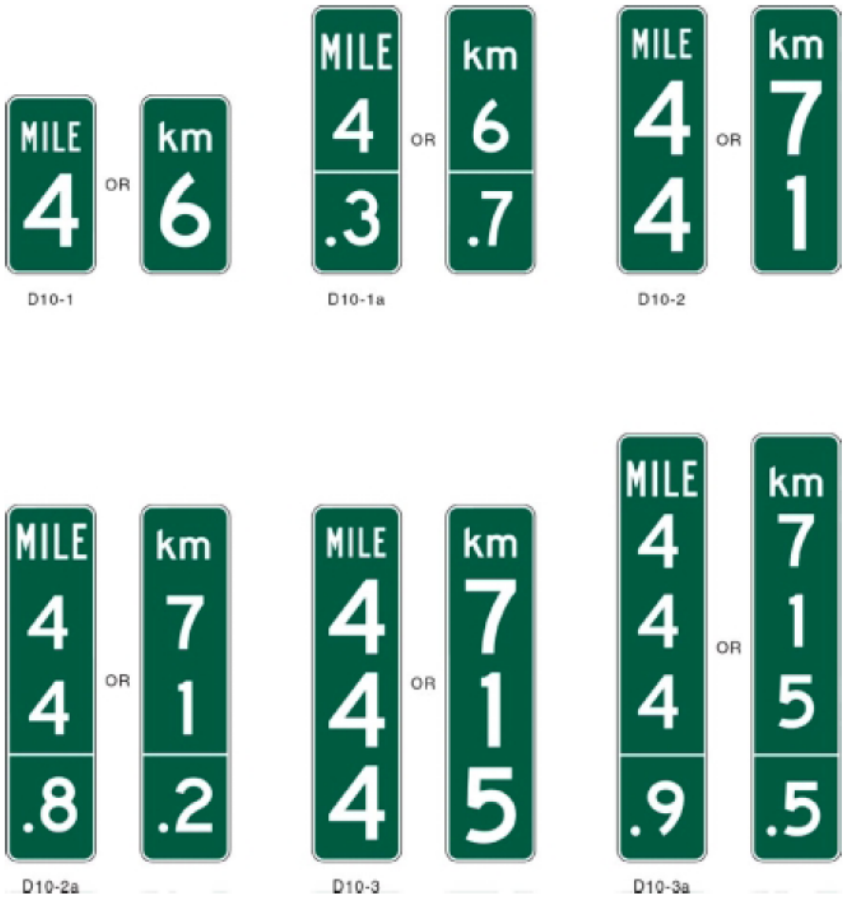
Mile Marker Signage—Mile Marker Signage is used to tell a bicyclist, pedestrian, or jogger where they are located and how far they have travelled from the start of the facility. This type of signage is also useful in identifying the location of emergency incidents including crashes and crimes and also aids in the maintenance of a trail.

MUTCD Mile Marker Signage Criteria:

- When Intermediate Reference Location (D10-1a to D10-3a) signs are used to augment the reference location sign system, the reference location sign at the integer (mile) point shall display a decimal point and a zero numeral.
- Reference location signs shall have a minimum mounting height of 2 feet to the bottom of the sign, and shall not be governed by the mounting height requirement prescribed in Section 9B.01 of the MMUTCD.
- Reference location signs may be installed on one side of the shared-use path only and may be installed back-to-back..
- If a reference location sign cannot be installed in the correct location, it may be moved in either direction as much as 50 feet.
- If a reference location sign cannot be placed within 50 feet of the correct location, it should be omitted.

Minneapolis Mile Marker Signage Criteria:

- Mile Marker Signs are only to be installed on arterial trails.
- Signs may be placed at 1/10-mile intervals, 1/4-mile intervals, or at 1/2-mile intervals depending on sensitivity to sign clutter.
- Signs should be in standard units (miles not km).
- All locations must be approved by Minneapolis Public Works.
- Mile markings may be used to improve emergency vehicle response times by providing a landmark for a caller to report from.



Trail Specifications

MPRB Signage—The Minneapolis Park and Recreation Board (MPRB) has its own signage standards throughout the Minneapolis Trail system. This type of signage is used on all Park Board owned and operated trails including the Minneapolis Grand Rounds. The various elements that can be consistently found throughout the MPRB system include blue blade signage, kiosks, identification signage, and directional signage.

Above: Grand Rounds signage with location and destination information.

Above: The MPRB uses blue blade signage to show bicyclists where to ride.

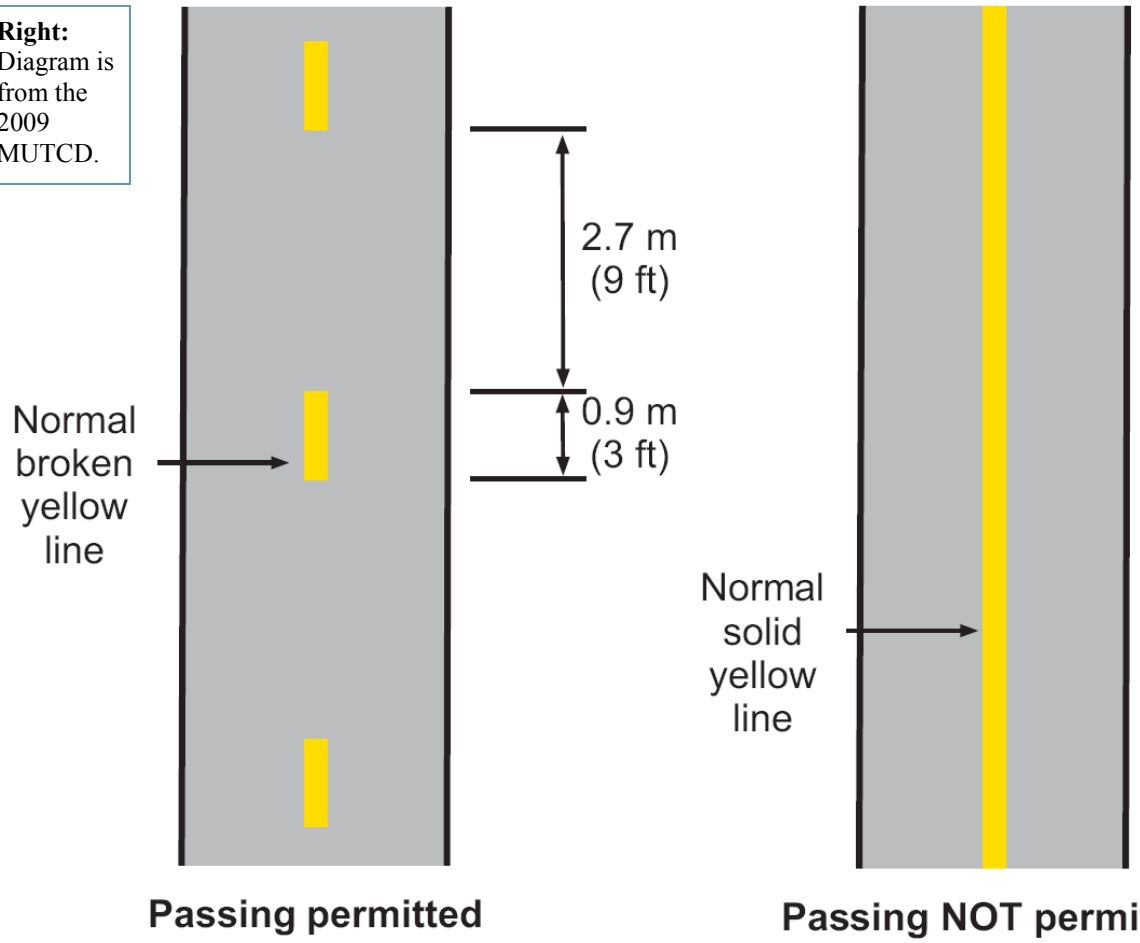
Above: A typical MPRB Kiosk providing route information, maps, and trail contact information.

Above: Although most MPRB trails are now separated, multi-use trails use combined path signage.

Above: The blue blades above denote which pavement surface bicyclists and pedestrians should use.

Passing Zones— Passing Zones along trails are denoted with a 4-inch wide yellow skip-dash centerline. A solid 4-inch wide yellow line denotes no passing along trail. Passing zones are typically located on long flat tangent sections of a trail where visibility is good..

Right: Diagram is from the 2009 MUTCD.



Above: Kenilworth Trail striping.

Above: Loring Bikeway striping.

Trail Specifications

Path Transitions—Path transitions are defined as changes in trail width, character, or function. In many situations trails must be narrowed, trails may need to go around obstructions, or trails must transition from a separated system to a multi-use or a shared-use facility or vice/versa. In some cases trails may be designed to transition into bike lanes and vice versa. In all cases, trail transitions require appropriate signage and pavement markings in addition to geometric design considerations.

Above: Transition from a sidewalk to a bike lane in Portland, Oregon.

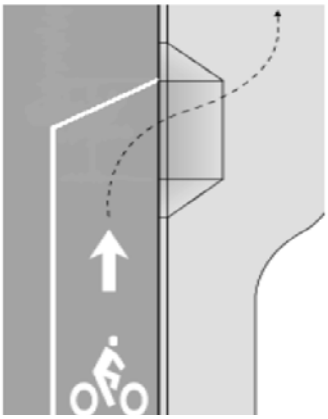
Right: Transition from a bike lane to a sidewalk in Northfield, Minnesota

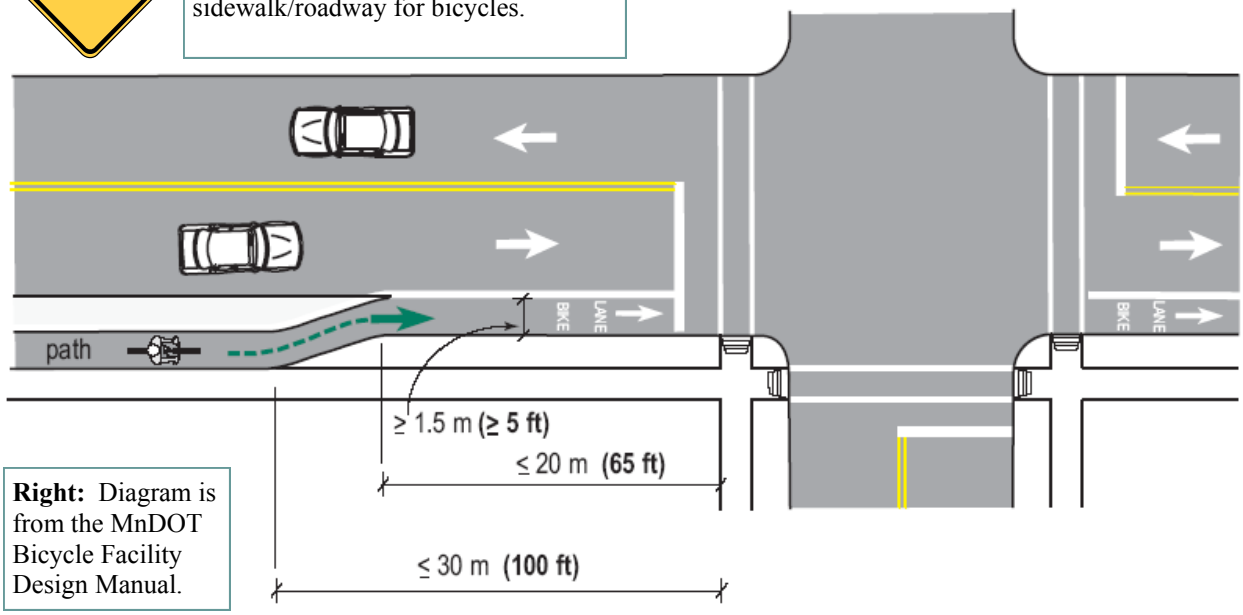
Left: Warning signage used along trails to inform users of changing trail conditions. Sign dimensions should be 18”x18” on all trails.

Right/Below: Off-street trails may be designed to transition to on-street bike lanes and vice versa. It is important to design the transitions to minimize vertical and horizontal grade changes so that bicycle spills are avoided. The diagram below presents recommended dimensions for a trail/bike lane transition. The diagram on the right is useful when retrofitting an existing sidewalk/roadway for bicycles.

Right: Example of transition from bicycle lane to shared use pedestrian/ bike lane.

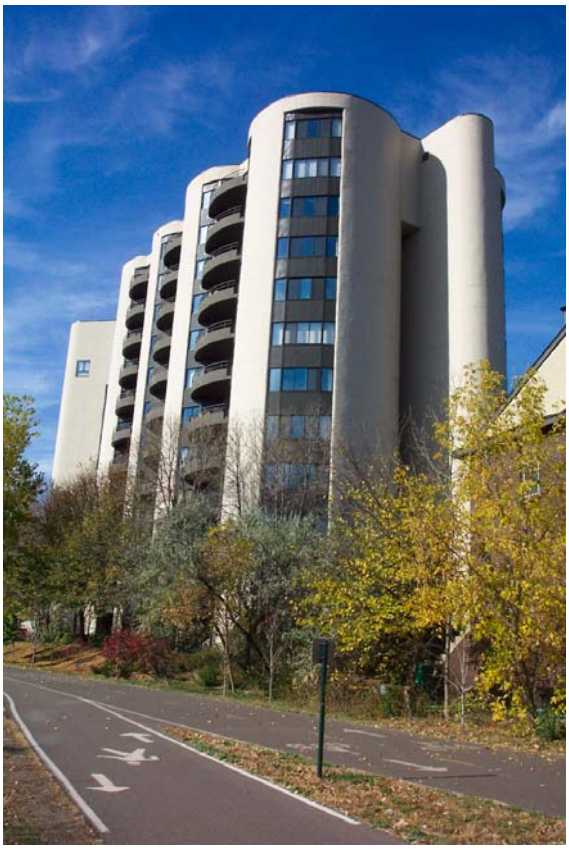
Source: Modified from Oregon Bicycle and Pedestrian Plan (Oregon DOT, 1995)





Right: Diagram is from the MnDOT Bicycle Facility Design Manual.

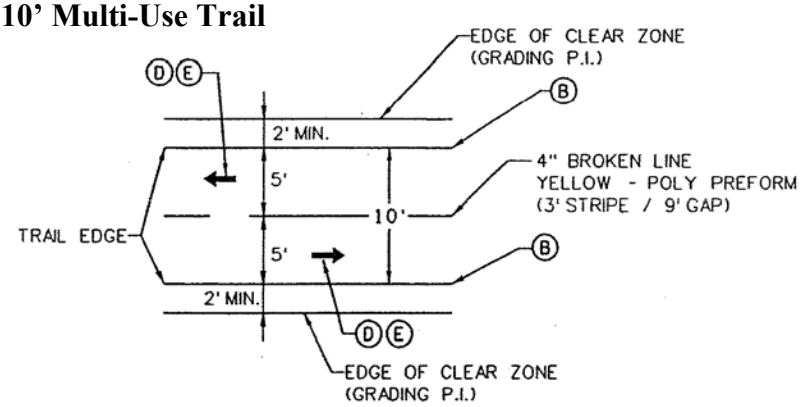
Trail Specifications



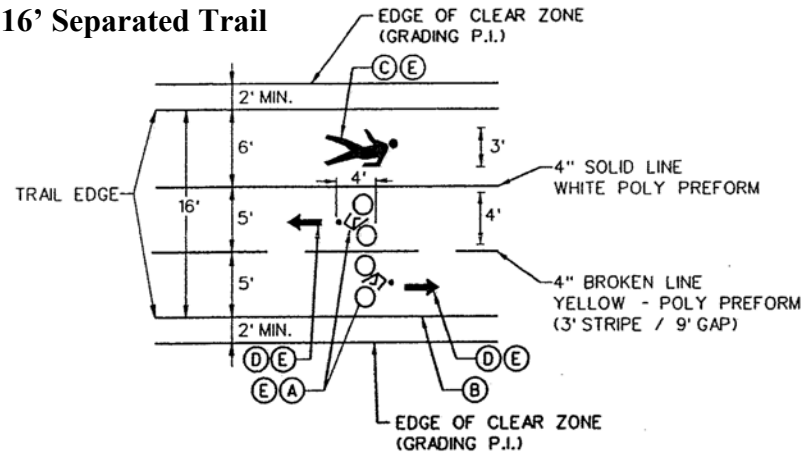
Pavement Markings—Trail pavement markings are important traffic control devices that help bicyclists understand where they should ride, especially along separated trails. All linear edge-line markings shall be 4-inch wide solid white and the centerline markings shall be 4-inch wide solid or broken yellow. All arrows, bicycle markings, and pedestrian markings shall be white in color and must conform to the latest Minnesota Manual of Uniform Traffic Control Device dimensions. The diagrams below show examples of how to mark a multi-use trail and how to mark a separated trail. Pavement markings should be placed near intersections and at decision points along a trail. Special pavement markings provide advance warning of railroad crossings, trail crossings, and obstructions.

Durable Markings: Trail pavement markings shall conform with MMUTCD standards. When possible durable pavement markings should be used to increase marking longevity and visibility. Durable pavement markings should be rolled into new pavement or a groove cut into the surface to prevent snow plow damage.

10' Multi-Use Trail



16' Separated Trail



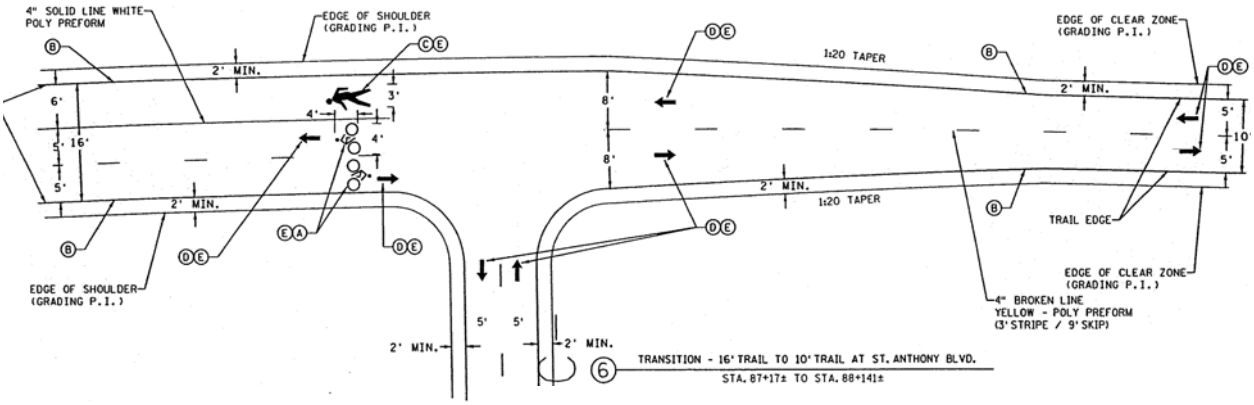
Trail Specifications

Pavement Markings—Pavement Markings often supplement and enhance the messages of other traffic control devices such as traffic signs and signals. In many cases pavement markings are the primary means of conveying a message to a trail user. The Minnesota Manual on Uniform Traffic Control Devices (MMUTCD) governs pavement marking colors, patterns, widths, symbols, and words, providing placement guidance so that there is national uniformity and easy recognition.

Above: Good pavement markings at the Sabo Bridge. Durable pavement markings were specified as part of this project and the linear striping was rolled into the pavement before it cooled. This technique prolongs the life of the markings by protecting it from snow plows.

Above: Faded Pavement Markings on the Stone Arch Bridge. Pavement markings on trails should be refreshed approximately every 5 years.

Above: A multi-use trail in Chaska, MN with no pavement markings. Most shared use trails do not require pavement markings.

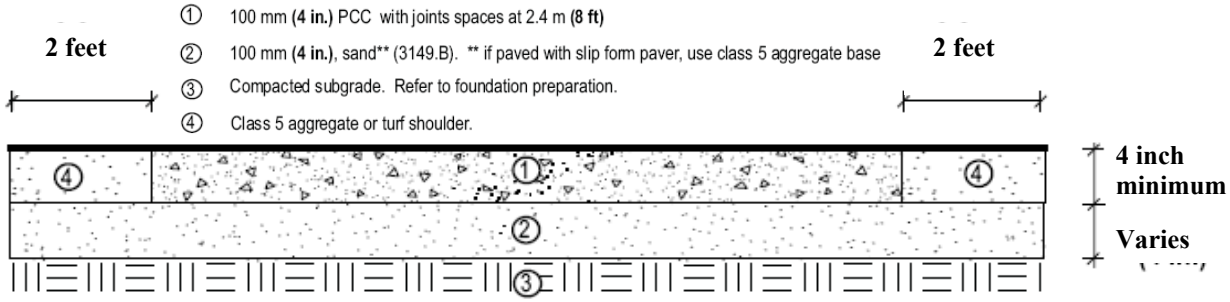


Above: Below is an example of how to stripe a transition from a multi-use trail to a separated trail (trail narrows).

Trail Specifications

Above: 12' concrete trail along Hiawatha Ave.

Pavement Types—Concrete is a common construction material that provides a long lasting pavement surface. Often called Portland cement concrete, the surface is poured into place, smoothed, and joints created before the surface hardens.



Concrete Pavement Recommendations for Shared-Use Paths

Materials:

1. Concrete mix Mn/DOT 3A32 per Mn/DOT Std. Spec. 2461.3 or as otherwise determined by the engineer (Mn/DOT Std. Spec. 2521)

2. Class 5 Aggregate base (Mn/DOT Technical Memorandum 04-19-MAT-02)
   a. 3 inches (min.) of compacted Class 5 base on granular subgrade
   b. 5 inches (min.) of compacted Class 5 base on non-granular subgrade
   c. Subgrade soil correction, if deemed necessary by engineer

Installation:

1. Machine-installed concrete for consistent pavement smoothness (desirable). (If manually installed, ensure excess material during screeding to avoid "bird bath" sags in panel centers)

2. Install concrete in accordance with Mn/DOT Std. Spec. 2301 or 2521, with the following recommended special provisions:
   a. Broom finish
   b. No longitudinal joints
   c. Transverse joints spaced at approximately 10 - 15 foot intervals
   d. Contraction joints installed by saw-cut for pavement smoothness
   e. Expansion joint installation:
      i. Vertical mis-alignment of adjacent panels; 3/16 inch (maximum)
      ii. Approximately 500-foot interval (maximum spacing)
      iii. Install expansion joints at all construction joints
      iv. Where new pavement will join existing pavement, saw cut existing pavement to create smooth vertical surface, use preformed expansion joint filler

Concrete Pavement Specifications: The MnDOT Bicycle Facility Design Manual provides guidance on concrete specifications for shared use trails. It is important to consider both the concrete mix and the thickness of concrete when designing a trail. A thicker paving section should be installed where vehicles (especially heavy vehicles) cross a trail. The trail should also be designed to accommodate emergency and maintenance vehicles (good subgrade is key). It is recommended that trail joints be saw cut to minimize bumps in the trail surface. Tree roots, poor foundation soils, and heavy vehicles are often the cause of pavement damage and should be considered in the design process.

Above/Left: The figure and chart shown is from the MnDOT Bicycle Facility Design Manual. The figure and chart prescribe concrete specifications for shared use trails.

Trail Specifications

Pavement Types—Class 5 aggregate or limestone are often used on state or regional trails, however they are not common in urban areas like Minneapolis. As a general policy all new trails within the city should be paved. Asphalt is typically preferred over concrete since asphalt is a smoother surface for trail users and pavement markings show up better on asphalt.

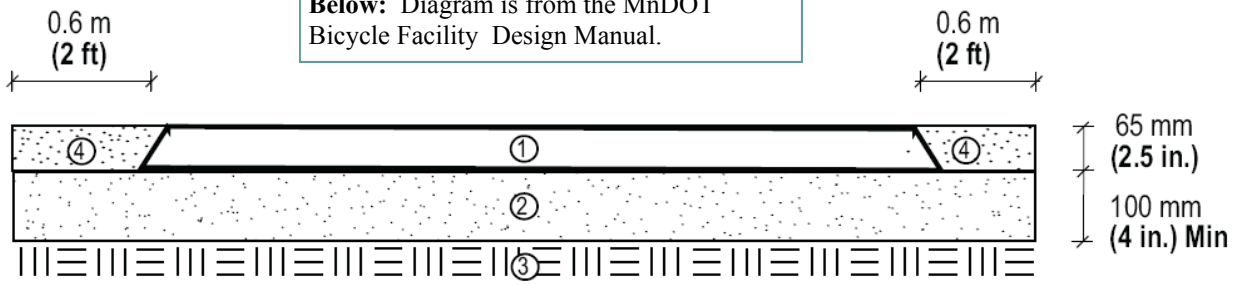
Asphalt Pavement: Asphalt (or bituminous pavement) is a popular construction material that provides a smooth pavement surface. Asphalt mix is prepared at a plant and transported to the site by trucks that dump hot asphalt into paving machines. The warm pavement is then rolled smooth. After the asphalt cools the process is often repeated with a different asphalt mix called a wear course. The diagram below shows the minimum required widths for asphalt trails funded with state or federal dollars. In Minneapolis the specifications are more stringent for asphalt trails to enable a 7-ton per axle standard. This allows for emergency and maintenance vehicles to use the trail without damage. Engineers may adjust sub-grade and pavement thickness to achieve the 7-ton standard.

Aggregate Sub-Base for Concrete and Asphalt Trails: According to the MnDOT Bicycle Facility Design Manual the following criteria must be met for all Class 5 aggregate trail bases:

- All vegetation topsoil, silty soil, and other soils that are considered unsuitable must be removed. Tree roots must also be removed in the sub-grade area.
- Organic solis should be removed and re-used for turf establishment.
- Soils should be scarified to a depth of 8 inches. If the trail is on a railroad embankment a 1-foot subcut is recommended.
- A trail must be constructed at least one foot higher than the 100-year high-water level.
- Geotextile fabric may be used on unstable soils and should be covered with at least 1 foot of select granular borrow.
- Aggregate may be incorportated into the upper portion of the trail sub-base to achieve adequate surface stability.

The Minnesota DNR Trail Planning, Design, and Development Guidelines provides a significant amount of information with regard to aggregate trail surfaces and trail sub-grades.

Below: Diagram is from the MnDOT Bicycle Facility Design Manual.



① 65 mm **(2.5 in.)** Type LV4 wearing course mixture (LVWE 45030), edges tamped at 45 degrees

② 100 mm **(4 in.)** Min., Class 5 aggregate base.

③ Compacted subgrade. Refer to foundation preparation.

④ Class 5 aggregate, turf shoulder or concrete shoulder

Above: Shown in an example of a typical trail cross section. 3" of asphalt over 6" of Class 5 aggregate sub-base is another popular cross section.

Trail Specifications

Ramps—Many arterial trails including the Midtown Greenway, Cedar Lake Trail, and NE Diagonal Trail are located in grade separated corridors that require ramps to access the trail. Ramps should be a minimum of 10 feet wide with grades not to exceed 8.33%. It is preferred that ramps not exceed a 5% slope. Ramps should be constructed to meet ADA standards with a flat landing at the top and bottom of the ramp (not to exceed a 2% cross slope). Switchback ramps may be constructed to meet ADA standards, however switchback ramps are more difficult to accommodate emergency vehicles. A larger ramp radius may be used where right-of-way exists, however not all existing trail ramps accommodate all types of emergency vehicles. Efforts should be made to ensure that all trail facilities have emergency vehicle access at reasonable intervals. All ramps must be constructed to a 7-ton standard and should be designed to at least a 12 mph design speed. Ramp intersections should have flanged pavement to minimize erosion, however intersections should be signed and striped so that trail users stop at the trail at a 90° angle.

Right: The photos on the right show three Midtown Greenway ramps (from top to bottom); Dean Parkway Ramp, 18th Ave S Ramp, and the 13th Ave S Ramp.

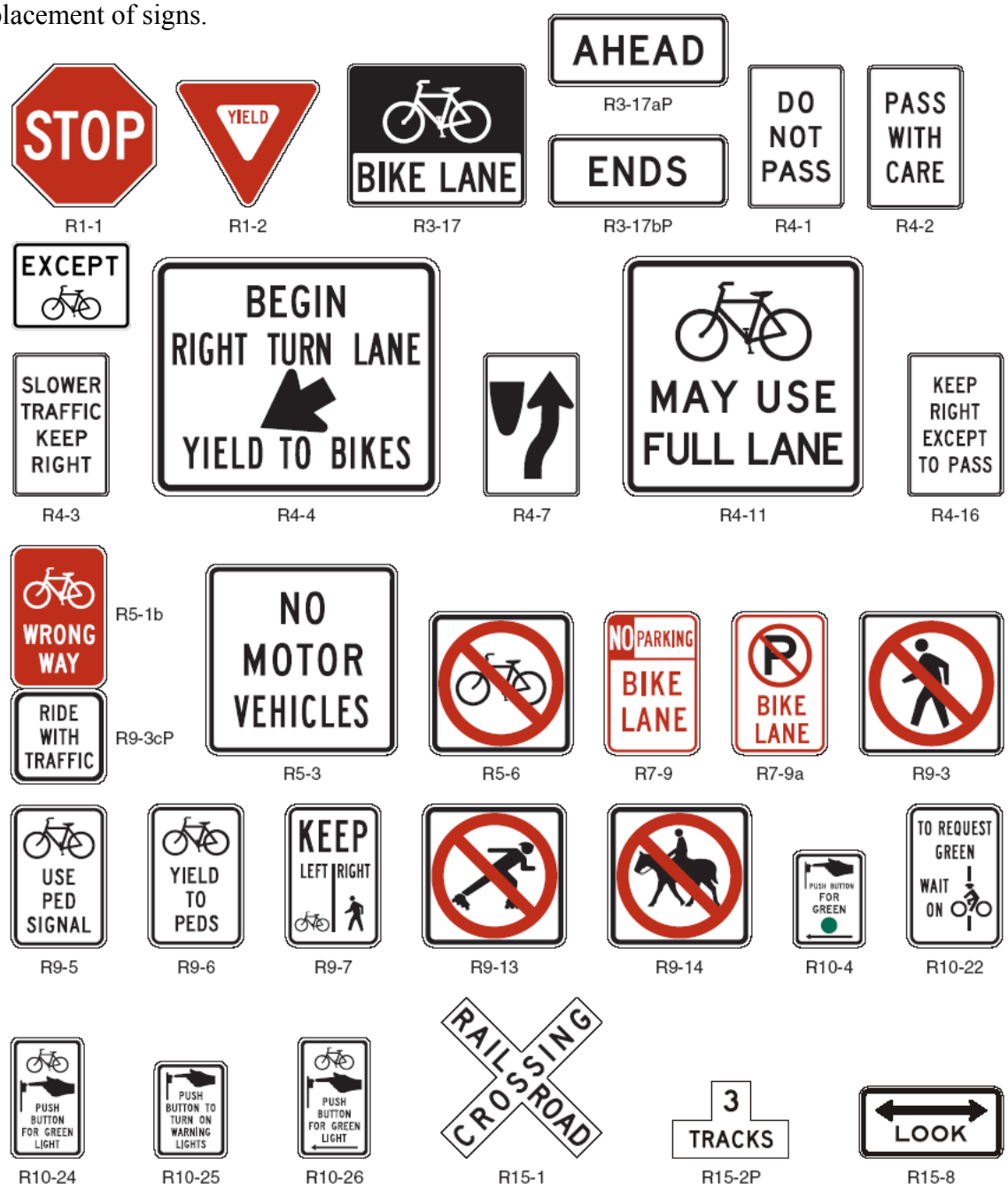
Below: Bicycling on freeways is prohibited by state statute in Minnesota. Some states permit bicycling on freeways and have details for bike lanes along freeways and at entrance/exit ramps.

Bicycle Facility Design Guidelines
Chapter 3—Off-Street Facilities

Trail Specifications

Regulatory Signage—Trail signage shall conform with MnDOT and MMUTCD standards. Signs should be appropriately sized and placed and are retro reflective to enhance visibility. Trail signs should also include a graffiti proof treatment to minimize replacement of signs.

Regulatory Signage—*"Regulatory signs shall be used to inform road users of selected traffic laws or regulations and indicate the applicability of the legal requirements. Regulatory signs shall be installed at or near where the regulations apply. The signs shall clearly indicate the requirements imposed by the regulations and shall be designed and installed to provide adequate visibility and legibility in order to obtain compliance."*



Trail Specifications

Regulatory Signage—The photos shown are examples of regulatory signs used along trails and at trail crossings throughout the region. Trail signage is smaller than roadway signage.

Above: Crossbuck and stop sign at night.

Above: Signage at West River Parkway.

Above: Signage along Kenilworth Trail.

Above: No Motor Vehicle signage.

Above: Signage near the Martin Sabo Bridge.

Above: Signage along the Cedar Lake Trail.

Above: Signage near the U of M.

Retaining Walls—Retaining walls are an important functional and aesthetic design element. There are several types of retaining walls including modular block, gabion walls, sheet pile walls, and cast-in-place concrete. Sheet pile walls are often used to anchor modular block walls using tieback systems. Small modular block can be used when short walls (under 10 feet) need to be constructed, however cast-in-place walls are recommended for taller walls. Modular block walls are slightly tapered and most walls can be treated to repel graffiti. An engineering analysis should be done to determine the appropriate type of wall for a particular location.

Modular Block: Modular blocks are a common type of retaining wall that have been used on a number of trail projects throughout the city including the Midtown Greenway and Cedar Lake Trail. Modular blocks are popular because they are easy to assemble and provide a landscaped look to a corridor. Modular blocks may be cheaper than poured cast-in-place concrete, but may require expensive tie-back systems or geotextile fabric. Soils behind modular blocks must be compacted properly to prevent failure.

Above: Small modular block along the Midtown Greenway

Above: Large modular block along the Midtown Greenway.

Trail Specifications

Retaining Walls—See guidance below:

Sheet Piling: Sheet piling is commonly used on construction projects to retain soils. Sheet piling is often cheaper than modular block or cast in place walls and can be installed relatively quickly. In some areas sheet piling is not recommended for aesthetic reasons or because the bedrock is located near the soil surface. Sheet piling also requires hydraulic hammering, which results in noise and vibration. In some cases sheet piling has been used as a tieback for modular block. The photo on the right is taken at the eastern end of the Midtown Greenway near West River Parkway. At this location a concrete cap was placed on the top of the wall for aesthetics.

Above: Sheet Piling along the Midtown Greenway.

Above: Gabion Wall at I-35W Tunnel.

Gabion Walls: Gabion walls consist of piled rocks that are contained by wire mesh. The wire mesh keep rocks from falling and prevents erosion of the slopes. Gabion walls also allow for vegetation to grow, providing for a much more natural look. Gabion walls were used as part of the I-35W bridge approaches (shown in the photo on the left) where a future bicycle/pedestrian tunnel was constructed. Gabion walls are typically cheaper per square foot than modular block or cast-in-place walls.

Cast In Place: Cast-In-Place walls are commonly installed throughout Minneapolis and are easy to install and maintain. Cast-in-place walls are concrete walls that have been poured and cured in-place. Although they are relatively quick to install, this treatment can be costly and may require sheet piling behind the forms to prevent failure or to increase the factor of safety. Cast-in-place walls are commonly used to mark graffiti and it is recommended that a special coating be applied. Shown is a photo of the Loring Bike Bridge.

Above: Cast-in-place Wall at Loring Bikeway.

Trail Specifications

Right-of-Way (ROW) Needs—All trails require a minimum 2-foot clear zone on both sides in addition to a 2-foot signage window on both sides. When these values are added, the minimum amount of right-of-way required for a linear 10-foot multi-use trail is 18 feet. A 12-foot trail requires 20 feet and so on. In some cases where projected trail volumes warrant wider trails, right-of-way needs may be higher. It is recommended that a 30-foot easement be obtained for a 20-foot separated trail.

When preserving or acquiring right-of-way it is recommended that at least 25 feet of dedicated space be preserved for trail use. This also allows for snow storage, easier maintenance, and space to widen the trail if use projections are higher than expected. When a trail easement needs to be preserved as part of a vacation request, a minimum of 25 feet should be preserved. Property should not be preserved for a trail project unless it has been identified in the Minneapolis Bicycle Master Plan and the project has been added to the 5-year capital budget. In some cases public land may be land-banked if a long term maintenance plan has been established.

Obtaining private property for the purpose of a public trail should be minimized and avoided if possible. Property acquisition requires a registered survey, an appraisal, and in accordance with State Statute must be negotiated before eminent domain is exercised. Efforts should be made when selecting new routes in the bicycle planning process to utilize existing public right-of-way for new bike routes whenever possible.

Above/Below: The map below shows a layout of the 18th Ave NE Trail. This is a good example of a project that has preserved public ROW through the vacation process. The project also requires easements from private property owners including the railroad. The photo above shows a public trail easement that was preserved when a development project along the 18th Ave NE corridor required a vacation.

Trail Specifications

Surveillance—Cameras and Code Blue phones may be required along specific trails but are expensive to install and maintain. To determine the need to install surveillance and emergency phones, capital cost, operating cost, crime rates, adjacent land uses, and neighborhood input should be considered.

Photos: The Midtown Greenway and Lake Harriet Parkway Trails provide code Blue Towers for emergency use. Trail users push a button for help and talk directly to a 911 dispatcher. The Midtown Greenway has 29 code blue towers along with 29 security cameras along the corridor. Security cameras images are fed to both the 3rd Precinct and the 5th Precinct.

Trail Specifications

Trail Thickness—All City of Minneapolis trails should be paved with asphalt unless unique circumstances warrant. The standard pavement thickness must be designed to achieve a 7-ton per axle standard. Class II material or grass may be used for trail shoulders. Concrete trails should be saw cut at the joints to provide a smooth ride.

Above: Loring Bikeway paving in 2007.

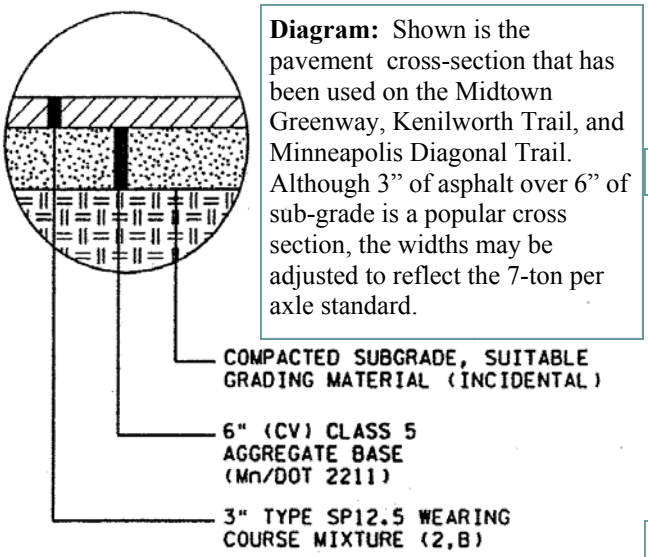


Diagram: Shown is the pavement cross-section that has been used on the Midtown Greenway, Kenilworth Trail, and Minneapolis Diagonal Trail. Although 3" of asphalt over 6" of sub-grade is a popular cross section, the widths may be adjusted to reflect the 7-ton per axle standard.

Above: Midtown Greenway paving in 2000.

Above: Midtown Greenway paving in 2004.

Warning Signage—The warning signs on this page are permitted for use along a bike route, trail, or path. Specific guidance for their use can be found in the Minnesota Manual on Uniform Traffic Control Devices (MMUTCD). Warning signs for bicycle facilities are typically smaller in size and many of the sign messages may be installed in a right or left orientation.

* A fluorescent yellow-green background color may be used for this sign or plaque. The background color of the plaque should match the color of the warning sign that it supplements.

Warning Signage—The photos shown are examples of warning signs used along trails and at trail crossings throughout the region. Warning signage is intended to send a message to trail users in advance of a condition to prepare or warn a user. Trail signage is smaller than roadway signage since trail users are slower than roadway users. Most standard warning signs have a yellow background with black markings. Trail crossing signage may also be fluorescent green.

Above: 24th Street Bridge signage.

Above: Midtown Greenway signage.

Above: Midtown Greenway signage.

Above: Kenilworth Trail signage.

Above: Kenilworth Trail signage.

Above: Midtown Greenway signage.