Shared Use Paths and Greenways

11.1 Introduction

This chapter describes the design considerations for shared use ***paths and greenways.*** Paths and greenways are found in a variety of settings throughout the Commonwealth including: trails in agricultural or wilderness areas; paths along active or abandoned railroad corridors; paths following highway corridors; paths and promenades along waterfront areas; paths following utility corridors; and paths and trails through neighborhood open-space networks and parkland.

Shared use paths are facilities for non-motorized users that are independently aligned and not necessarily associated with parallel roadways. Shared use paths are designed to accommodate a variety of users, including walkers, bicyclists, joggers, people with disabilities, skaters, pets and sometimes equestrians. These users can be on the facility for a variety of purposes including recreation, commuting, and local travel. A shared use path can accommodate various users in one or more treadways. A ***treadway*** is defined as a portion of the pathway designated for a particular user or set of users.

In contrast to shared use paths, the discussion of ***greenways*** in this chapter focuses on recreational facilities through backcountry or other remote areas. These facilities are generally unpaved trails and can serve hikers, mountain bikers, equestrians, or other off-road users. This chapter does not discuss other types of trails such as all-terrain vehicle trails, dirt bike trails, or snowmobile trails. The common distinctions between shared use paths and greenways is illustrated in Exhibit 11-1.

Exhibit 11-1
Distinction between Shared Use Path and Greenway

Similarly, this chapter does not discuss the design of sidewalks and on-road bicycle facilities. These design features are integrated into the roadway cross-section and are described in Chapter 5. This chapter provides general guidance on the design of shared use paths and greenways. The designer should refer to AASHTO's 2004 *Guide for the Planning, Design, and Operation of Pedestrian Facilities* and 1999 *Guide for the Development of Bicycle Facilities* for more detailed design guidance for these facilities. The *Manual on Uniform Traffic Control Devices (MUTCD)* 2000 edition also provides information on signing and pavement markings for bicycle facilities.

11.1.1 Design Considerations

In the design of any type of path or trail, care should be taken to design elements that are compatible within the context of the project. Path materials, barrier-types, landscaping, signage, walls and fencing should be properly selected to complement the character of the area in which the path is built.

11.2 Path Networks and Greenway Systems

The diversity of paths and trails provides transportation and recreation designers with a wide variety of facility types to satisfy the needs and wants of users. However, shared use paths and trails are not a substitute for adequate on-street facilities. Shared use paths and trails are a complementary, non-motorized extension to the street network and should not preclude shared use of streets either by regulation or design. Where pedestrian or bicycle use is prohibited or difficult to

accommodate on a roadway, alternative access for pedestrians and bicyclists via convenient paths to all linkages and destinations served by the roadway is a possible solution. A well-planned and designed network of shared use paths and trails can achieve the following objectives:

- Provide shortcuts between generators of pedestrian and bicycle activity;
- Provide pedestrian and bicycle access to areas served only by highways on which pedestrian and bicycle travel is prohibited;
- Provide pedestrian and bicycle access to areas not well-served by roads;
- Provide a training ground or alternative experience for bicyclists who are not comfortable with on-road cycling; and,
- Provide an integrated recreation facility that is in itself a destination for users and a valued community resource.

11.2.1 Path Networks

Shared use paths can be of any length from short connections between streets to long corridors following features like rivers or railroad corridors. A path network should be integrated with other pedestrian and bicycle facilities and connected to popular destinations including parks, schools, colleges, employment centers, and commercial centers. Connections with the street system should be carefully designed and signed to indicate street names and path destinations. Path networks should also be accessible from parking lots and transit services for those who are using one of these other modes as a component of their trip on the path. Where possible, paths should be integrated with nearby transit stations. A path network should be designed to:

- Achieve a context-sensitive facility that fits the environment through which it passes and achieves a high level of aesthetics;
- Include uniform design elements to present a consistent, safe facility for the user;
- Provide separation from motor vehicle traffic;
- Provide convenient access points and connections matching the origins and destinations of path users;
- Provide a high level of safety and security;

- Highlight the natural, scenic, historic, and cultural qualities of the area through which it passes;
- Minimize the number of street and driveway crossings to the extent possible; and,
- Provide safe crossings of streets and driveways where they are needed.

11.2.2 Greenway Systems

Greenway systems are usually less developed than shared use paths. In most cases, a greenway or trail system is associated with a particular resource area, such as a park or forest. Nonetheless, opportunities for connection to the pedestrian and bicycle facilities on surrounding roads and access to parking lots or transit stops are important considerations in the development of a greenway or recreational trail system.

11.3 Accessibility of Shared Use Paths and Greenways

Shared use paths and trails provide important transportation options and outdoor recreational opportunities. Shared use paths should be designed to meet the needs of the widest possible range of users, including people with disabilities. In this light, most pathways that serve as transportation facilities for pedestrians and bicyclists must meet accessibility requirements. The accessibility of a shared use path depends not only on the design of the path itself, but also on the design of associated facilities, including:

- Parking areas,
- Path entrances,
- Path destinations, and
- Resting and other wayside facilities.

All designs must comply with 521 CMR, *The Rules and Regulations of the Massachusetts Architectural Access Board,* which has jurisdiction over:

- Walkways: *An interior or exterior pathway with a prepared surface intended for pedestrian use, including but not limited to general pedestrian areas such as plazas, courts and crosswalks. Walkways include but are not limited to all walks, sidewalks, overpasses, bridges, tunnels, underpasses, plazas, courts and other pedestrian pathways,* …(521 CMR 22.1).

The requirements of 521 CMR include specification for width, grade, level changes, surface, drainage, gradings, and intersections.

A significant issue that designers face is that walkways outside a public right of way must conform with the slope limitation requirements for walkways (maximum 5%) and ramps (maximum 8.33%, with level landings every 30 feet and continuous handrails). In addition, the pathway material must be 'firm, stable, and slip resistant." These requirements may be difficult to meet in some settings. FHWA's *Designing Sidewalks and Trails for Access, Part II: Best Practice Design Guide* provides design details and alternative treatments for making paths accessible to all users. Where 521 CMR cannot be met, designers should recommend a variance request in consultation with MassHighway as well as the local disability commission(s) and the regional independent living center. The Massachusetts Architectural Access Board is authorized by law to grant variances when full compliance is "*impracticable," i.e. is…technologically unfeasible, or… would result in excessive and unreasonable costs without any substantial benefit to persons with disabilities.* (521 CMR 5.44).

11.4 Shared Use Path Design

A shared use path is physically separated from motorized vehicle traffic by open space or a barrier. Shared use paths are typically developed on a continuous right-of-way and experience minimal cross flow by motor vehicles. Users of these facilities may include bicyclists, inline skaters, roller skaters, wheelchair users (both non-motorized and motorized), and pedestrians, among others. It is important to identify the intended users of a path early in the design process to the extent possible, to provide appropriate accommodation and address potential conflicts.

A mix of users on a shared use path is not always a desirable situation because the potential for conflicts is high. For example, commuting bicyclists are slowed by users on recreational strolls. The safety and enjoyment of a path can decline when conflicts among users occur. For these reasons, the designer should avoid creating situations in which sidewalks are used as shared use paths. Conflicts between users stem from many sources including:

- Personal expectations;
- Overcrowding;

- Clashes between different users;
- Various levels of ability and experience; and
- Differences in speed.

The most effective way to address these potential conflicts is to accommodate different types of users through design, coupled with user courtesy and education. When paths are intended to be shared by a number of different users, their design should ensure that adequate visibility and sight-distance are provided. Design treatments to improve paths so that they are safer for everyone include:

- Horizontal and vertical alignment to ensure clear lines of sight for pedestrians and bicyclists, especially around horizontal curves;
- Shoulders at least 2-feet wide to provide stopping and resting areas off the path, allow for snow storage, help to prevent root damage, and to allow passing and widening at curves;
- Avoidance of view obstructions such as signs, poles, benches, landscaping, etc., at the edge of the trail;
- Use of a bicycle design speed suitable to the path setting and providing guidance for appropriate speeds; and
- Signing and marking, such as a centerline stripe or keep right signs, as described in the *Manual on Uniform Traffic Control Devices*.

Major design elements of a shared use path are discussed in the following sections.

11.4.1 Path Width, Side Clearance and Vertical Clearance

MassHighway and FHWA require that bike paths designed or constructed with state or federal funds follow the design standards of AASHTO. There are, however, situations where flexibility in design may be needed such as where there are environmental and/or geographic constraints. But the guidelines set forth in AASHTO and summarized below should be used as a starting point for the design, with the individual conditions of the project examined to determine any potential need for deviations from these standards. Public input should also be considered as the design is developed.

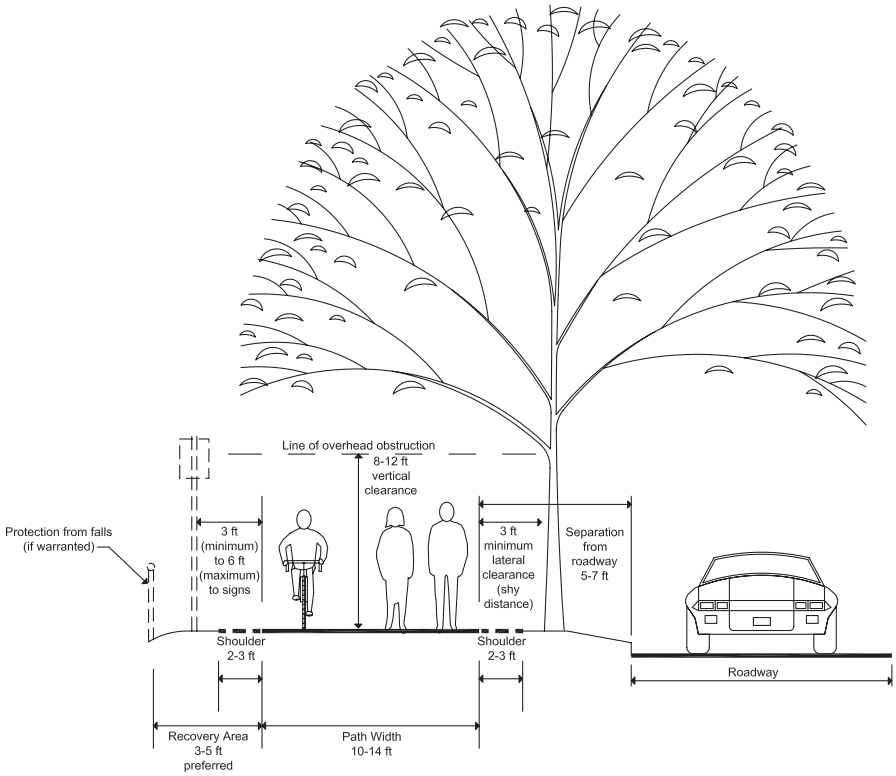
11.4.1.1 Path Width

Shared use paths are most commonly designed for two-way travel. In most cases, the users are accommodated in a single treadway, although multiple treadways with separation are possible as described below. As illustrated in Exhibit 11-2, under most conditions, the minimum width for a two-directional shared use path is 10 feet. Under most conditions it is desirable to increase the width of a shared use path to 12 feet, or even 14 feet to accommodate substantial use by bicycles, joggers, skaters, and pedestrians, and to provide access for maintenance vehicles. In certain instances, a reduced width of 8 feet may be acceptable where there are severe environmental, historical, and/or structural constraints.

11.4.1.2 Shoulders and Side Clearance

A minimum 2-foot wide graded shoulder should be maintained adjacent to both sides of the path. The graded area can be either paved or unpaved. Non paved surfaces could be constructed using grass, stone dust, or other stabilized materials. A minimum 3-foot clearance should be maintained from the edge of the path to signs, trees, poles, walls, fences, guardrails, or other obstructions. Where the path is adjacent to canals, ditches, or slopes steeper than 1 vertical :3 horizontal (1:3), a wider separation should be considered. A 5-foot separation from the edge of the path to the top of slope is desirable under these circumstances. Where a slope of 1:2 or greater exists within 5 feet of a path and the fill is greater than 10 feet, a physical barrier such as dense shrubbery, railing, or chain link fence should be provided along the top of slope. Other situations may also dictate the need for a physical barrier, such as the height of the embankment or an unsafe condition at the bottom of slope.

Exhibit 11-2
Shared Use Path Dimensions



Source: Adapted from the VTrans Pedestrian and Bicycle Facility Planning and Design Manual

Separation Between Shared Use Paths and Roadways

Shared use paths are not a substitute for street improvements, even if there is sufficient space to locate the path adjacent to the roadway. Some operational problems with paths adjacent to roads are:

- Bicyclists will be riding against the normal flow of traffic, contrary to the rules of the road. When a path ends, bicyclists riding against traffic may continue riding on the wrong side of the street.
- At intersections, motorists entering or crossing the roadway often do not notice bicyclists approaching from the right, as they are not expecting any traffic from that direction.
- Barriers used to separate motor vehicle traffic from path users can obstruct sight lines along both facilities and can reduce access to and across the path.
- Snow plowed from the adjacent roadway can obstruct the path.

When two-way shared use paths are located adjacent to a roadway, wide separation between a shared use path and the adjacent highway is desirable. This demonstrates to both the bicyclist and the motorist that the path functions as an independent facility for bicyclists and others. This separation area also acts as a "recovery zone" for path users. A 7-foot separation between the edge of the shoulder and the shared use path is recommended with the minimum being 5 feet. When this is not possible, a suitable physical barrier (considered to be one that does not obstruct sight lines, as identified in Section 11.4.3) is recommended. Such barriers serve both to prevent path users from making unwanted movements between the path and the highway shoulder and to reinforce the concept that the path is an independent facility.

Future signs, mailboxes, and other side obstructions should be considered when designing separation between the shared use path and roadway. Care should also be taken in providing adequate clearance along and between the path and adjacent parcels for future expansion and necessary buffers to adjacent land uses.

11.4.1.3 Vertical Clearance

The vertical clearance to obstructions should be a minimum of 8 feet, which meets the requirements of 521 CMR and ADAAG. In some instances, vertical clearance may need to be greater to permit passage of maintenance and emergency vehicles. In underpasses and tunnels, 10 feet is desirable for adequate vertical shy distance (the vertical clearance at which a bicyclist would feel comfortably separated from an obstruction) and passage by maintenance vehicles. Where equestrian users are expected, clearance of at least 12-feet should be provided. See Section 11.4.10.2 for a discussion of vertical clearances for underpasses.

11.4.2 One-Way Paths/Multiple Treadways

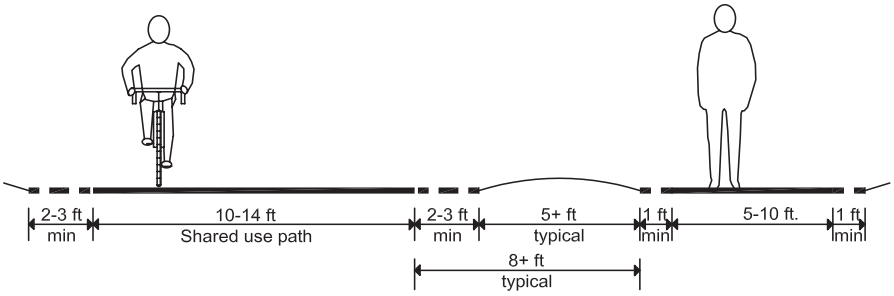
If a one-way shared use path is necessary to make a key connection, the minimum width should be 6 feet. A one-way path would rarely be designed and only in a special situation, such as to circumvent mature trees or connect to parallel paths. It should be recognized that one-way paths often will be used as two-way facilities unless effective measures are taken to assure one-way operation. Without such enforcement, it should be assumed that shared use paths would be used as two-way facilities by both pedestrians and bicyclists and designed accordingly.

In some cases it may be desirable to provide multiple treadways as part of a shared use path to separate user types to reduce potential conflicts,

as illustrated in Exhibit 11-3. Multiple treadways can be a successful design approach for heavily used corridors. In most applications of multiple treadways, a sidewalk or path suitable for pedestrians is provided separately from a path for bicyclists. Generally, the minimum width for the sidewalk is 5 feet and the minimum width for the bikeway is 10 feet.

Wider treadways are possible, and sometimes desirable, for both uses.

Exhibit 11-3
Cross-Section of Shared Use Path with Multiple Treadways



Source: Adapted from the VTrans Pedestrian and Bicycle Facility Planning and Design Manual

The designer should take measures to ensure, however, that the purpose of each is clear to the users. This approach is also suitable where equestrian users are expected.

11.4.3 Barrier Height and Placement

The placement of physical barriers adjacent to a shared use path serves many purposes including safety and security, protection from falls, screening for adjacent land uses and separation of paths from other transportation facilities. The design of barriers is dependent upon their intended function, safety, proximity to the path, and aesthetics. The designer should determine the need to provide protection along a shared use path on a case-by-case basis after evaluating the following factors:

- If adequate recovery area is provided, then the need for a barrier is lessened.
- The greater the height of the drop-off, the greater the need for protection. A protective barrier may be required when a vertical

drop from the path surface to the base of the slope is greater than 4 feet.

- 521 CMR requires *ramps and landings with drop-offs shall have edge curbs, walls, railings, or projecting surfaces that prevent people from slipping off the ramp. Edge curbs shall be a minimum of two inches high.*
- Where the side slopes are greater than 1:3, the need for a barrier is increased, unless the slope material is forgiving, or a recovery area is provided.
- If the material used on the side slope is grass, shrubbery, or another non-abrasive material, then the need for a barrier is lessened. If the material is likely to result in increased injury severity then the need for a barrier is increased.

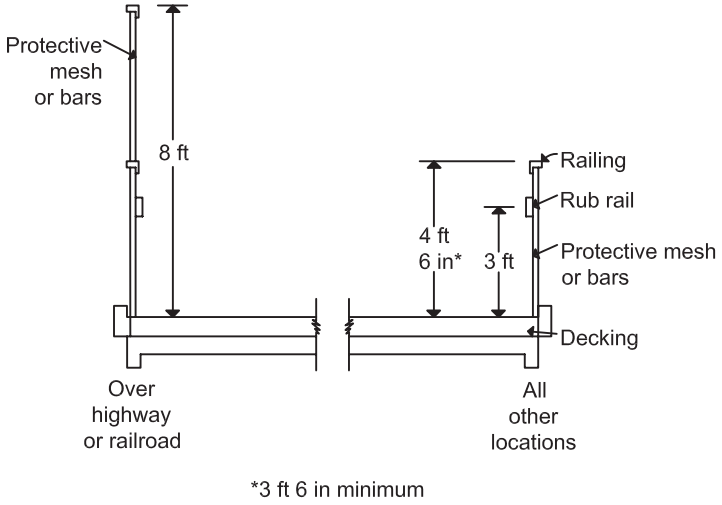
Where used, the *AASHTO Guide for the Development of Bicycle Facilities* recommends that the barrier should be a minimum of 3.5 feet high to prevent bicyclists from toppling over it. A barrier between a shared use path and adjacent highway should not impair sight distance at intersections and should be designed to not be a hazard to motorists or bicyclists. A variety of barrier types are possible including:

- Fences – a variety of types.
- Walls – retaining walls.
- Vegetation – cushioning vegetation (such as shrubs, pine trees, etc.) capable of stopping a fall, spaced at most 6 feet on-center within 10 feet of the grade drop. This barrier type will require maintenance to ensure that the vegetation does not eventually encroach on the path.
- Guardrail/Concrete Barrier – placement of a rail on the top may be necessary to reach the required height. These barriers should meet the requirements of NCHRP Report 350 if separating a path from a roadway.

Rub-rails to prevent snagging of handlebars are recommended at a height of approximately 3-feet from grade, as illustrated in Exhibit 11-4. Other types of fencing with rub rails might be more architecturally appropriate, including split or round rail fencing. Additionally, the barrier systems should be smooth and free of protruding objects such as bolts. One method for reducing these hazards is to countersink

washers and nuts into support posts, or mount a wood rail along the back side of the barrier. It is also important to flare the ends of the barrier where possible so the blunt ends do not pose a hazard. Another common mistake is to end the barrier too abruptly once past the hazard area. Consideration should be given to the possibility of a cyclist going off the path and behind the barrier toward the hazard.

Exhibit 11-4
Barrier Elements



Source: Adapted from VTrans Pedestrian and Bicycle Facility Planning and Design Manual

11.4.4 Design Speed

Shared use paths should be designed for a selected speed that is at least as high as the preferred speed of the faster bicyclists. In general, a minimum 20 mph design speed should be used. When a downgrade exceeds 4 percent or where strong prevailing tailwinds exist, a design speed of 30 mph or more is advisable. Lower design speeds, in the range of 10 to 15 mph, are appropriate for shared use paths through parks or other settings where the interactions between bicyclists and other users are frequent and unpredictable.

11.4.5 Cross-Slopes and Superelevation

Shared use pathways must meet the requirements of 521 CMR, *The Rules and Regulations of the Massachusetts Architectural Access Board* and the *Americans with Disabilities Act Guidelines* (ADAAG). Both of these standards require that cross slopes on pedestrian pathways and sidewalks not exceed 2 percent to avoid the dangers that greater cross slopes can create for people using wheelchairs, walkers, canes, etc. Thus, for most shared use paths, the maximum superelevation rate will be 2% in the

built condition (1.5% in design). When transitioning a 2% superelevation, a minimum 25-foot transition distance should be provided between the end and beginning of consecutive and reversing horizontal curves.

11.4.6 Horizontal Curvature

The curvature of a path is dependent upon the design speed, lean angle and cross-slope of the path. Exhibit 11-5 summarizes the resulting curve radii for a range of design speeds using a 15-degree lean angle.

Exhibit 11-5
Minimum Curve Radii

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

Source: Guide for the Development of Bicycle Facilities, AASHTO, 1999.

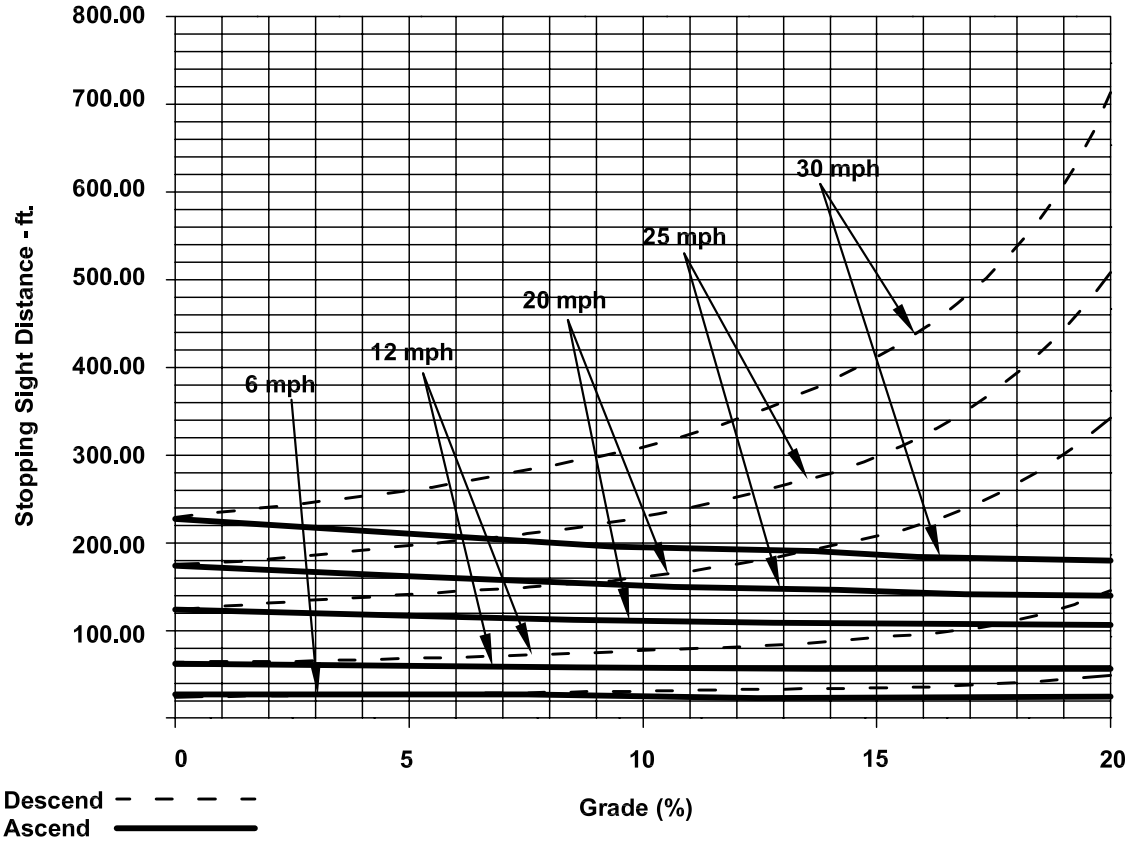
It should be noted that 521 CMR does not allow curved ramps.

11.4.7 Sight Distance

To provide bicyclists with an opportunity to see and react to the unexpected, a shared use path should be designed with adequate stopping sight distances. Minimum stopping sight distance for various design speeds, vertical and horizontal curves, and grades need to be considered to ensure safe breaking distance on a shared use path. The 1999 *AASHTO Guide for the Development of Bicycle Facilities* provides methodologies, tables and graphs of stopping sight distance for various combinations of grade and design speed. Similar tables are provided for calculating the minimum length of crest curves to provide adequate stopping sight distance. This information is presented in Exhibit 11-6.

Bicyclists frequently ride side-by-side on shared use paths, and on narrow paths bicyclists have a tendency to ride near the middle of the path. For these reasons, and because of the higher potential for head-on bicycle crashes, lateral clearances on horizontal curves should be calculated based on the sum of the stopping sight distances for bicyclists traveling in opposite directions around the curve.

Exhibit 11-6
Minimum Stopping Sight Distance



Source: Guide for the Development of Bicycle Facilities, AASHTO, 1999.

Exhibit 11-6
Minimum Stopping Sight Distance (Continued)

A	English Units. Minimum Length of Crest Vertical Curve (L) Based on Stopping Sight Distance 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	110	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	288	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	868	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 $S < L$, $L = \frac{AS^2}{900}$

Shaded area represents S = L

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

Height of cyclist's eye – 4-1/2 ft
Height of object – 0 ft

Minimum Length of Vertical Curve = 3 ft.

Source: Guide for the Development of Bicycle Facilities, AASHTO, 1999.

Where it is not possible or feasible to provide significant sight distance, consideration should be given to widening the path through the curve, installing a yellow center line stripe, installing a "Curve Ahead" warning sign in accordance with the MUTCD, or some combination of these alternatives. The designer can also consider clearing obstructions along the inside of the curve of the path to increase the

available sight distance. AASHTO provides guidance on the appropriate clearance areas.

11.4.8 Grade

Where a bicycle path follows the existing terrain, Exhibit 11-7 offers guidance on the maximum grade lengths. Grades greater than 5 percent are undesirable because the ascents are difficult for many bicyclists and the descents cause some bicyclists to exceed the speeds at which they are competent or comfortable. Steep grades also do not meet pedestrian accessibility requirements.

Exhibit 11-7
Maximum Grade Lengths for Bicycles

Grade (%)	Maximum Length (ft)
5 to 6	800
7	400
8	300
9	200
10	100
11+	50

Source: Guide for the Development of Bicycle Facilities, AASHTO, 1999.

Grades for pathways used by pedestrians cannot exceed 5% unless treated as a ramp, with a maximum slope of 8.33% in the built condition. Even when shared with bicyclists, these pedestrian pathway slopes must be met, or a variance from 521 CMR granted from the Massachusetts Architectural Access Board. Variances should only be recommended with support from MassHighway, the local disability commission(s), and the regional Independent Living Center.

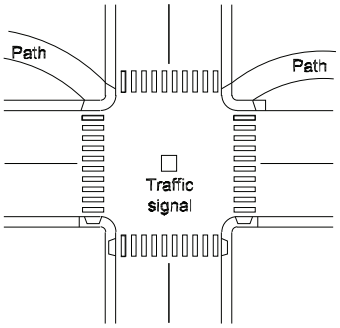
11.4.9 Path-Roadway Intersections

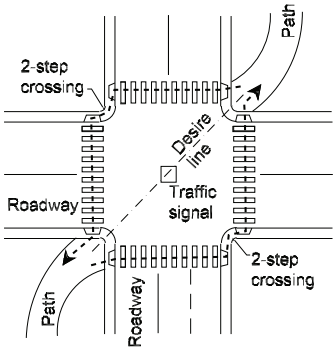
Intersections between paths and roadways are often the most critical issue in shared use path design. Good intersection design provides clear indication to those approaching the intersection what path they should follow and who has the right of way, including pedestrians and bicyclists, whose movements are constricted by their lesser speed and visibility. Typical arrangements of path crossings at intersections are shown in Exhibit 11-8. Some basic principles to be followed when designing intersections are:

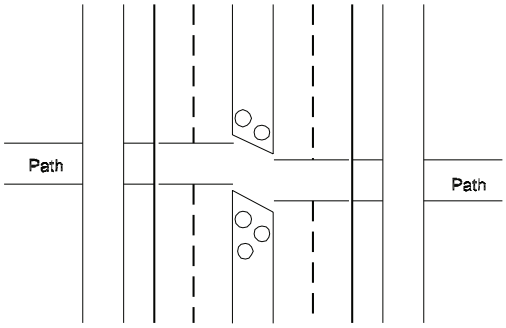
- Unusual conflicts should be avoided;

- Intersection design should create a path for bicyclists that is direct, logical and as close to the path of motor vehicle traffic as possible.
- Bicyclists following the intended trajectory should be visible and their movements should be predictable.
- Potential safety problems associated with the difference between auto and bicycle speeds should be minimized.

Exhibit 11-8
Path Crossings at Intersections







Source: Adapted from VTrans Pedestrian and Bicycle Facility Planning and Design Manual

Shared use paths should cross roadways as close to an intersecting road as practical. This allows for good sight distances for both motor vehicle operators and bicyclists.

Refer to 521 CMR when designing bicycle pathways.

As the path approaches the crossing it should be aligned with the destination of the crossing on the other side of the road. The crossing should also be as perpendicular as possible to the road being crossed. Curb cut ramps that comply with 521 CMR should be appropriately aligned and be the same width as the path (at least 36" plus the side flares). Stopping Sight Distance and Intersection Sight Distance should be evaluated and sound engineering judgment must be used in locating crossings. See Section 11.4.7 and Section 3.7 in Chapter 3 for appropriate guidance on sight distances.

Midblock crossings of paths with curb cut ramps and detectable warnings are also possible where adequate spacing from adjacent intersections is present. In many cases, it is desirable to provide a crossing island in the middle of a roadway when higher speeds or traffic volumes are present. These islands can increase the visibility of the crossing, slow motor vehicle speeds on the cross-street, and to provide a refuge for crossing path users. The islands should include curb cut ramps or cut-throughs with detectable warnings.

11.4.9.1 Traffic Control at Path Crossings

Traffic control at path-roadway crossings should be treated so that the intersection looks and functions like a regular road intersection. Path crossings can occur as signalized or unsignalized intersections, depending on the particular attributes of the location. Warrants for signalization are discussed in the MUTCD and Warrant #4 should be used as guidance for path crossings as bicycles are considered pedestrians under these circumstances. Additional guidance developed for the Florida Department of Transportation suggests that traffic signals be considered where paths cross roadways with volumes greater than 10,000 vehicles per day. The same research suggests that either traffic signalization or grade separation be considered when a path crosses a roadway with greater than 20,000 vehicles per day (see Section 11.4.9.2 below). Motor vehicle speeds along the crossing corridor are also an important factor in this analysis.

Where signals are provided, the path should be provided with adequate "green time" to allow pedestrians and cyclists to cross the

street. At locations with push-buttons, the signals should respond quickly to activation so that the likelihood of signal adherence is increased and a higher level of service is provided to the path. The 2002 federal Access Board's *Draft ADA Accessibility Guidelines for Public Rights of Way* require audible signals where pedestrian signals are provided.

At unsignalized locations, adequate sight distance should be provided along the roadway approaches to the path and the path approaches to the roadway. In most cases, advance warning signs indicating that a bicycle path is crossing the roadway should be provided along the road in accordance with the MUTCD. In most cases, STOP signs are provided on the path approaches to the intersection and STOP AHEAD signs along the path may be appropriate if visibility to the crossing along the path is limited. STOP bars and centerlines should be provided on the path approaches to the crossing. The path crossing of the street should be marked as a crosswalk since it carries a mix of non-motorized users. Removable bollards or other appurtenances may be placed on the path just prior to roadway intersections to discourage path use by motorized vehicles and to act as a visual alert to path users that a crossing is imminent.

Due to the potential conflicts at these junctions, careful design is of paramount importance to the safety of path users and motorists. Each intersection is unique and will require sound engineering judgment on the part of the designer as to the appropriate solution. The AASHTO *Guide for the Development of Bicycle Facilities* provides examples and guidelines for various intersection treatments. Path crossings of roadways are also discussed further in Chapter 6.

11.4.9.2 Grade Separation of Path Crossings

There is often a desire to grade separate the crossings of highly-utilized paths and busy roads. In these cases, both underpasses and overpasses are options. The topography of the surrounding area usually will govern which type of grade separation is selected. In level terrain, an underpass usually requires shorter ramp sections since the path clearance under a road ranges between 8 and 12 feet. Road or railroad clearance under a path, on the other hand, can range from 17 to 23 feet. If the path is designed with a maximum five-percent slope, then the transitions for an overpass can be twice as long as those for an underpass (as much as 500 feet in each direction). On the other hand, overpasses are generally open and have fewer security concerns.

While there are no clear "warrants" for grade separation of path crossings of roadways. The designer should consider a number of factors including:

- The suitability of the existing topography for grade separation;
- The effectiveness of signage or traffic signal control as an alternative for the crossing given the context of the location;
- Any changes in alignment that may be necessary to achieve the grade separation;
- The opportunities or limitations placed on path connectivity to the surrounding area by the grade separation;
- The context in which the path is set, in consideration of safety and security issues;
- The volume, mix of vehicles, and speed of cross-traffic on the roadway; and
- The volume and mix of path users.

If the grade separation adds out-of-direction travel to the path alignment or inconvenience, users will likely cross the roadway at grade, potentially eliminating the safety benefit of the grade separation. Furthermore, for shared use paths, pedestrians generally prefer at-grade treatments, so adequate provisions may be necessary for these crossings even if grade separation is provided.

11.4.10 Bridges, Overpasses, and Underpasses

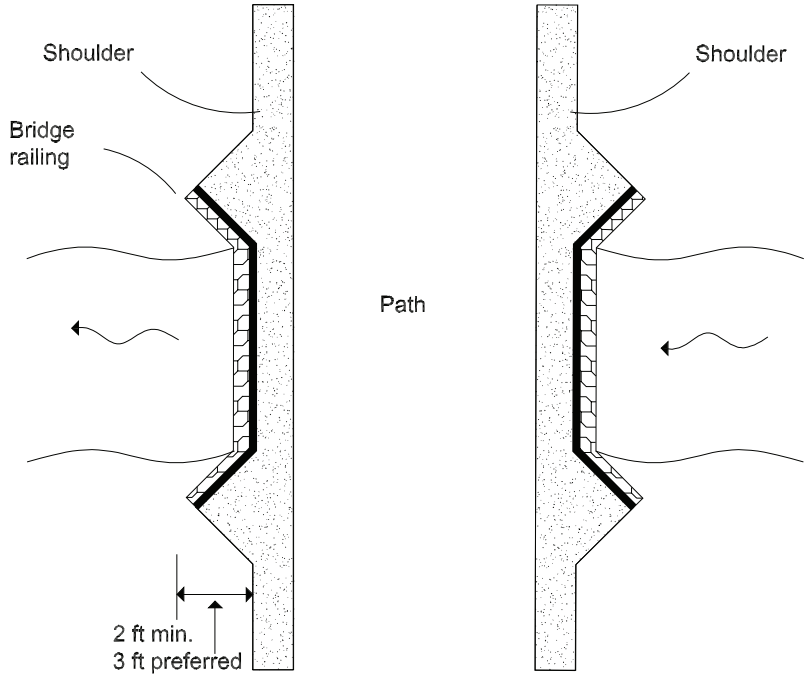
A shared use path may also cross a natural feature, such as a stream or river on a bridge. Design elements of these structures are described below.

11.4.10.1 Bridges and Overpasses

On crossing structures, the minimum clear width should be the same as the shared use path approach plus a minimum 2-foot wide clear shoulder on both sides of the path. The bridge railings should also be flared with an apron to direct path users onto the structure, as illustrated in Exhibit 11-9. Vertical transitions to and from the bridge should follow the grade guidelines discussed earlier in this chapter. The maximum slope and cross slope standards in 521 CMR apply to bridges and overpasses. Therefore any slope greater than 5% must be

treated as a ramp, with handrails and level landings; and any slope greater than 8.33% is not allowed without a variance from the Massachusetts Architectural Access Board.

Exhibit 11-9
Bridge Treatments for a Path



Source: Adapted from VTrans Pedestrian and Bicycle Facility Planning and Design Manual

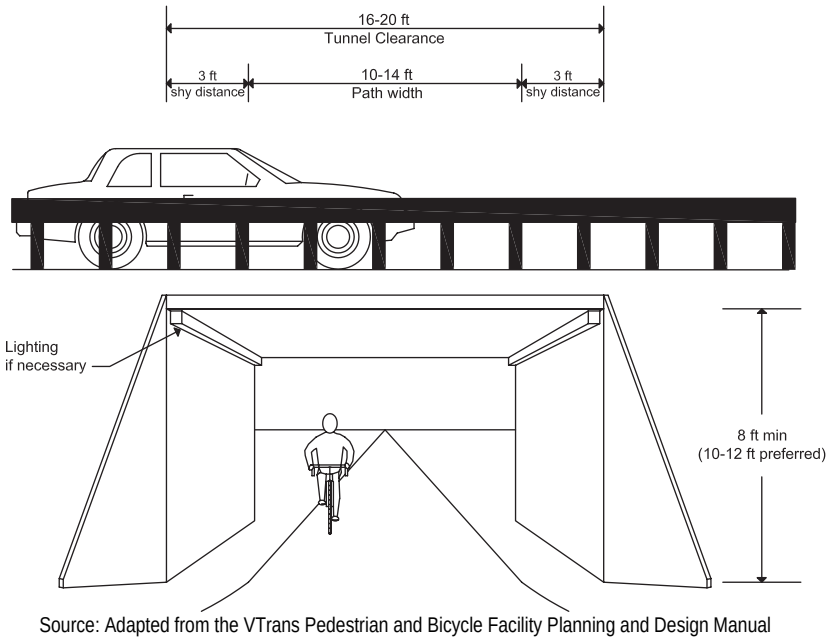
The *AASHTO Guide for the Development of Bicycle Facilities* recommends that railings, fences, or barriers on both sides of a path on a structure should be a minimum of 42 inches (3.5 feet) high. In situations where the structure crosses a high speed or high volume road or objects are subject to being thrown off the structure, it is recommended that the path be enclosed with fencing. Enclosing a path may also be desirable in other areas such as a waterway crossing. However, to the extent feasible, clear views along the path crossing should be preserved to retain the aesthetics of the path's environment.

11.4.10.2 Underpasses and Vertical Clearance

Much like for bridges and overpasses, 2-foot wide clear shoulder should be provided on both sides of the path. Vertical clearance of at least 8 to 12 feet should be provided, depending upon the anticipated users of the path, as described earlier in this Chapter. A typical arrangement of a path

underpass is illustrated in Exhibit 11-10. See also Section 11.4.1.3 for a discussion of vertical clearances for obstructions.

Exhibit 11-10
Path Underpass



Source: Adapted from the VTrans Pedestrian and Bicycle Facility Planning and Design Manual

11.4.11 Signing and Marking

Adequate signing and marking are essential on shared use paths, especially to alert bicyclists to potential conflicts and to convey regulatory messages to both bicyclists and motorists at highway intersections. Both advanced crossing and crossing warning signs are needed on roadways to provide appropriate warning to the motorists of the upcoming path intersection. In addition, guide signing on a path, such as to indicate directions, destinations, distances, route numbers, mile markers (to aid in emergency response), and names of crossing streets, should be used in the same manner as they are used on highways. Where the Massachusetts Architectural Access Board has granted variances for steeper slopes on walkways, it is useful to provide signage indicating the length and difficulty of the trail. This will allow people with disabilities or limited stamina to decide how much time do they need, which route they want to take, and what assistance might be needed to experience the sites of the trail.

Occasional signs with maps of the entire path route and indicating important destinations should be placed at major entry points to the path.

In general, uniform application of traffic control devices, as described in the MUTCD, provides minimum traffic control measures that should be applied. Warning signs, directional signs, and other devices along the path should also meet the MUTCD guidelines. The application of traffic control at path/roadway crossings is described in Section 11.4.9.

11.4.12 Surfacing

When selecting paving and surfacing materials, long-term durability, safety, availability, cost and maintenance are important selection criteria. All paths need to provide a firm, stable, slip-resistant surface in a wide variety of use and weather conditions. In general, surfacing materials for paths in urban areas should be paved or consist of other "hard-surface" materials. Paved pathways function best in areas with high use and those that will be cleared of snow in the winter. "Stone dust" and other unpaved paths may be suitable in areas with lower levels of use, where the mix of users is more suitable for an unpaved path, or where aesthetic or contextual factors suggest that an unpaved treatment is appropriate. Unpaved paths are best located in natural and historic surroundings where they fit well with the character of their environment. Unpaved materials are not suitable for inline skaters or bicyclists who travel at higher speeds.

Where pedestrians are intended pathway users, accessibility of the surface is a key factor. Both 521 CMR and ADAAG require that the surface be:

- Firm, stable, and slip-resistant.
- Without slopes and cross slopes greater than the maximum allowed. The Massachusetts Architectural Access Board measures compliance of slopes in 24 inch increments using a digital level. This can be a difficult standard to meet at first construction and over the life of the pathway.
- Without level changes of greater than ¼". Rippled asphalt and tree roots protruding through pathway surfaces create dangerous conditions for people with disabilities.

- Without low-hanging branches or other obstacles that protrude into the accessible route between the heights of 27" – 80". These are dangerous conditions for people with disabilities.

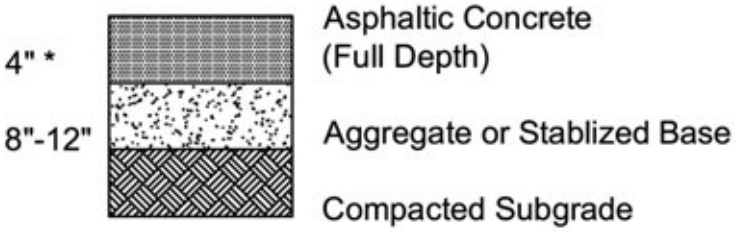
For paved paths, a subbase of compacted aggregate or structurally-suitable soil is important to ensure the long-term durability of the pavement. Exhibit 11-11 illustrates a typical pavement design for a path. In most cases, a 4-inch bituminous concrete riding surface placed over an 8 to 12-inch aggregate base is recommended, especially if the path needs to support occasional maintenance or emergency vehicles. The designer must consider the site-specific soil, environmental, and use characteristics of the path when determining the appropriate pavement design.

Some surface treatments may be appropriate to introduce a particular theme or gain a certain aesthetic quality for a shared use path. Both the Massachusetts Architectural Access Board and the ADAAG require that accessible elements be maintained. For example, if stone dust is used as an accessible surface and rain washes a section of it out, the AAB and ADAAG require maintenance to repair the section to meet their minimum accessible design standards. Finally, where a paved path intersects gravel roadways and driveways, 10-foot paved aprons on the roadway or driveway approaches are recommended to keep debris off the path and minimize pavement damage.

Where landscaping or natural vegetation is located near a path, root barriers can reduce root intrusion and resulting pavement buckling or other surface irregularities, as illustrated in Exhibit 11-12. Prevention of intrusion from tree roots and other vegetation should be given high priority during the design phase to prevent surface distortion that can be become a dangerous condition for people with disabilities and bicyclists and a deterrent to future path usage.

Path shoulders should also provide a smooth area that resists erosion, root intrusion, debris spreading and other undesirable effects. Grassed shoulders are very common along shared-use paths, but require mowing and other regular maintenance. Stone dust shoulders are another option that the designer may consider.

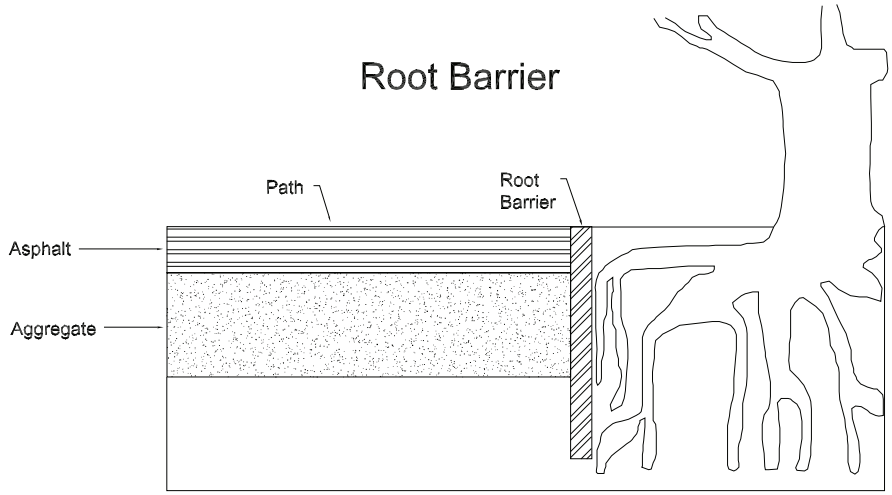
Exhibit 11-11
Typical Path Pavement Design



* The thickness of the asphalt layer can be increased at locations where heavy vehicle access (maintenance and emergency vehicles) are expected to be on or crossing the pathway.

Source: Adapted from WSDOT Pedestrian Facility Guidebook

Exhibit 11-12
Root Barriers



Source: Adapted from WSDOT Pedestrian Facility Guidebook

11.4.13 Landscape Selection and Maintenance

Selecting appropriate landscaping vegetation and then maintaining the landscaped vegetation that is chosen and installed are important aspects of path and trail design. Refer to Chapter 13 for more discussion of landscaping.

11.4.14 Drainage

The maximum allowable pavement cross slope of 2 percent adequately provides for drainage. However, lower design cross-slopes may be needed to ensure compliance with 521 CMR and AADAG regulations in the built condition. Sloping in one direction instead of crowning is preferred and usually simplifies the drainage and surface construction. A smooth surface is essential to prevent water ponding and ice formation. On unpaved paths, particular attention should be paid to drainage to avoid erosion. Where the path is constructed on a hillside, ditches of suitable dimensions to contain the flow of water from the uphill side of the path should be constructed. To prevent erosion, paved waterways should be provided at low points and berm should be provided on the edge of steep slopes along the shoulder and resulting drop-off. In areas with underground drainage systems, catch basins should be located outside of the path and flush with its surface. Bicycle-safe, wheelchair-safe, and crutch-safe drainage grates should be used exclusively.

11.4.15 Lighting

Lighting for shared use paths is important and should be considered where night usage is expected, such as paths serving college students or commuters, and at highway intersections. Lighting should also be considered through underpasses or tunnels and when nighttime security could be an issue.

11.4.16 Restriction of Motor Vehicle Traffic

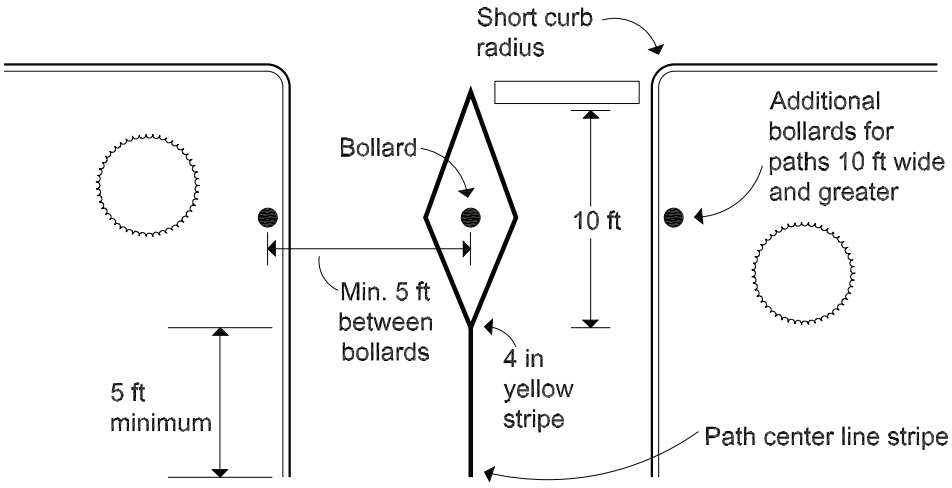
Shared use paths may need some form of physical barrier at highway intersections to prevent unauthorized motor vehicles from using the facilities. Provisions can be made for a lockable, removable (or reclining) barrier post to only permit entrance by authorized vehicles.

Bollards are the most common type of barrier used to control motor vehicle access to a path. These bollards should be marked with reflective materials to ensure their visibility at night. The recommended minimum height for bollards is 30 inches. Bollards need to be adequately spaced to allow easy passage by bicyclists, bicycle trailers, pedestrians and wheelchair users (to meet AAB and ADAAG standards, a minimum width of 36 inches must be provided) Typically, one bollard located in the center of the path is sufficient to control motor vehicle access to the path. As illustrated in Exhibit 11-13, if more than one bollard is needed, the additional bollards should be

placed at the path's edges. A minimum of 36" clear width should be maintained.

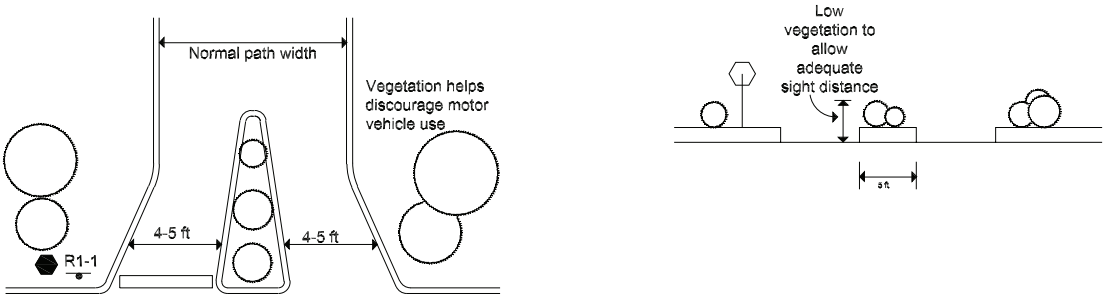
Other entrance treatments can be designed to discourage motor vehicle access, maintain emergency access, and act as an entrance treatment to a shared use facility. One example of an alternative treatment is a short splitter island with low landscaping that can be traversed by an emergency vehicle and does not obstruct sight lines, as illustrated in Exhibit 11-14. Gates and other devices also serve as ways to control vehicular access to paths. Regardless of the type of physical barrier used, it should be maintained to ensure that it does not become a safety issue.

Exhibit 11-13
Bollard Placement



Note: Bollards are removable for maintenance and emergency access.
Source: Adapted from VTrans Pedestrian and Bicycle Facility Planning and Design Manual

Exhibit 11-14
Splitter Island Treatment



Source: Adapted from VTrans Pedestrian and Bicycle Facility Planning and Design Manual

11.4.17 Bicycle Parking

Bicycle racks are an integral part of accommodating bicycle transportation. Bicycle racks should be located where they are convenient to the users and where they will not interfere with pedestrian and vehicular traffic. Providing bicycle racks helps discourage users from locking bikes to railings, street trees, and other furnishings. General guidelines are presented below:

- The appropriate number of spaces needed should be assessed with respect to the associated building or land use.
- Typical inverted "U" systems are preferred, but any similar rack that meets the following criteria may be used:
  - Rack must enable the frame and one or both wheels to be secured, preventing the bike from tipping over
  - The rack should be anchored so that it cannot be stolen with bikes attached
  - Two locking points available for theft-protection

For parallel storage, arrange rack elements 30 inches on center to allow space for two bicycles to be secured to each rack element.

11.5 Greenways

Design guidelines for hiking and other recreational trails are not as well established as those for shared use paths. Trails in parks and other open spaces are commonly designed to provide experiences for differing levels of accessibility. The levels of accessibility served may depend on the setting. For example, in urban parks, a full range of accessible recreation opportunities, including paths and trails, is typically expected by the public. However, in rural and remote areas, full accessibility is not generally expected, and trails and pathways that serve varying levels of accessibility are commonly provided. Some paths may serve as accessible routes of travel, while others may have steeper gradients and unpaved surfaces. Individuals can then choose a path or trail that provides the recreation experience and degree of challenge they desire.

The federal Access Board is in the process of developing specific standards for accessibility for recreational trails, and these are expected to reflect user expectations for greater accessibility as well as preservation of natural terrain and wilderness experiences. In the meanwhile, 521 CMR, *The Rules and Regulations of the Massachusetts Architectural Access Board*, applies to any pathway constructed for pedestrian use. Where there is a conflict between 521 CMR and the intended use of the trail, the designer should recommend that a variance be requested from the Board, and include input from people with disabilities in the design area, as well as the local independent living center.

Universal Access to Outdoor Recreation, *A Design Guide*, developed by the USDA Forest Service, provides extensive design guidance related to outdoor recreation trails. It includes a trail rating system and suggests that trails be signed to indicate the level of accessibility, as shown in Exhibit 11-15. Additional information and guidance can be found in the federal Access Board's 1999 Regulatory Negotiation Committee on Accessibility Guidelines for Outdoor Developed Areas: Final Report.

General guidelines for the development of recreational trails, adapted from the Forest Service guidelines are presented in Exhibit 11-16. Where these do not meet current 521 CMR requirements, a variance should be requested from the Massachusetts Architectural Access Board before proceeding. As with all variances requested from this Board, the designer should have input from people with disabilities, including people from the local commission(s) on disability and the regional independent living center.

Exhibit 11-15
USDA Forest Service Accessibility Guide Signs

Source: WSDOT Pedestrian Facility Guidebook

Exhibit 11-16
Recreational Trail Guidelines

	Level of Difficulty		
Design Element	Easy	Moderate	Difficult
Surfacing	Paved	Compacted	Varies
Clear Width	4 feet	3 feet	2.5 feet
Sustained Slope	5 percent	8.33 percent	12.5 percent
Maximum Grade and Distance	8.33 percent/30 feet	14 percent/50 feet	20 percent/50 feet
Maximum Cross-Slope	2 percent	3 percent	5 percent
Passing Interval Spacing	200 feet	300 feet	400 feet
Rest Area Intervals	400 feet	900 feet	1,200 feet
Maximum Surface Irregularity	0.5 inch	1 inch	3 inches

Adapted from US Forest *Service Universal Access to Outdoor Recreation, A Design Guide*
Source: WSDOT Pedestrian Facilities Guidebook

11.6 Rail Trails

Railroads developed a vast network of transportation corridors throughout the region. Many of these corridors no longer serve railroad activities and many still do. Regardless of the actual presence of railroad activity in a corridor, railroad rights-of-way (ROW) are often seen as opportunities for the development of shared use paths. The design elements of shared use paths described earlier in this chapter are applicable to rail trails. Although not discussed in detail below, rail trails can also be developed as more primitive trails, or for use by motorized vehicles such as snowmobiles.

11.6.1 Inactive ROW

Inactive ROW serve as ideal candidates for the development of formalized shared use paths and for informal use by other users such as snowmobiles and cross-country skiers. The railroad ROW is generally suitable for reuse as a shared use path because the geometric features of the railroad, such as grades, alignment, clearances, etc. are also favorable for use by pedestrians, bicyclists, and others. The key differences between developing a shared use path on an inactive railroad ROW versus a new alignment include:

- Property issues are sometimes complicated along railroad rights-of-way, especially those that have been long-abandoned by the railroad.
- Existing structures, road crossings, and other features may be suitable for re-use.
- The ROW may provide access to new recreational or other resources, not well served by the roadway network.
- The ROW may be highly separated from the surrounding urban or natural environment, facilitating through movement, but complicating connections to surrounding attractions and destinations.
- There is a reasonable expectation of hazardous material contamination, especially in former railroad yard areas.
- Redevelopment of the ROW may pose a real opportunity for economic growth and revitalization of adjacent properties.

11.6.2 Rails with Trails

The development of shared use paths adjacent to active railroads is often more controversial than the reuse of inactive ROW. Railroad companies may not enthusiastically embrace the concept of a shared use path adjacent to their facility. Railroad corridors are usually private property and are viewed as frequented by trespassers, who are often responsible for

vandalism or accidents. There is often a concern that development of a path will increase the amount of this undesirable activity. With this in mind, it is understandable that railroad owners and operators may be hesitant to support path development near their facilities, however, introducing formal trail use within the ROW can actually lead to a reduction in undesirable activities as well as a reduction in illegal dumping by abutters or outsiders.

With these concerns in mind, there is often width within a railroad ROW that is not being actively used for railroad purposes. These corridors can be opportunities for path development. The key considerations in the development of paths within active railroad corridors are the ability to provide adequate separation between the railroad activity and the shared use path as discussed below.

11.6.2.1 Separation from Railroad Operations

According to the FHWA's *Rails-with-Trails: Best Practice Report*, the minimum setback between the path and the railroad should take into consideration the speed and frequency of trains in the corridor, maintenance activities, separation techniques, existing problem areas, and good judgment. In areas where recommended setbacks cannot be achieved, additional right-of-way should be acquired, or additional separation measures should be established to improve security and ensure safety.

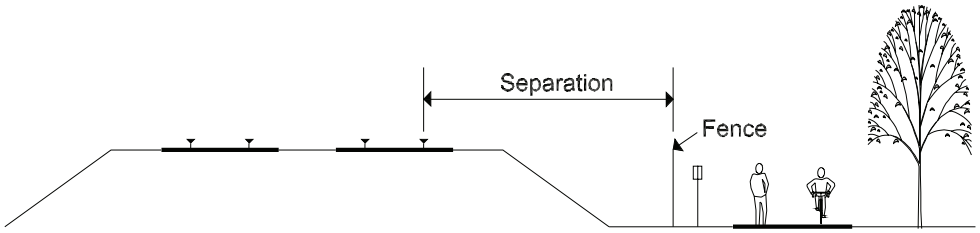
As an absolute minimum, the path cannot fall within the train's envelope of operation, which is the space required for the train and its cargo to overhang due to any combination of loading, lateral motion, or suspension failure. Separation between the track and the path is illustrated in Exhibit 11-17. Recommended values are presented in Exhibit 11-18. Exceptions to these recommendations are possible on a negotiated, case-by-case basis with the track owner/operator.

Methods to provide additional width for path development within a constrained existing railroad ROW are possible through selection of the path location or modification of the ROW cross-section. These methods are illustrated in Exhibit 11-19 and include:

- Locate the path at the bottom of the slope;
- Locate the path in an adjacent utility corridor;
- Widen the embankment;
- Excavate and retain the side-slopes;

- Cantilever the path at rail trail bridge crossing, or provide a separate crossing independent of the rail bridge; or
- Use a low retaining wall.

Exhibit 11-17
Separation Between Track and Path



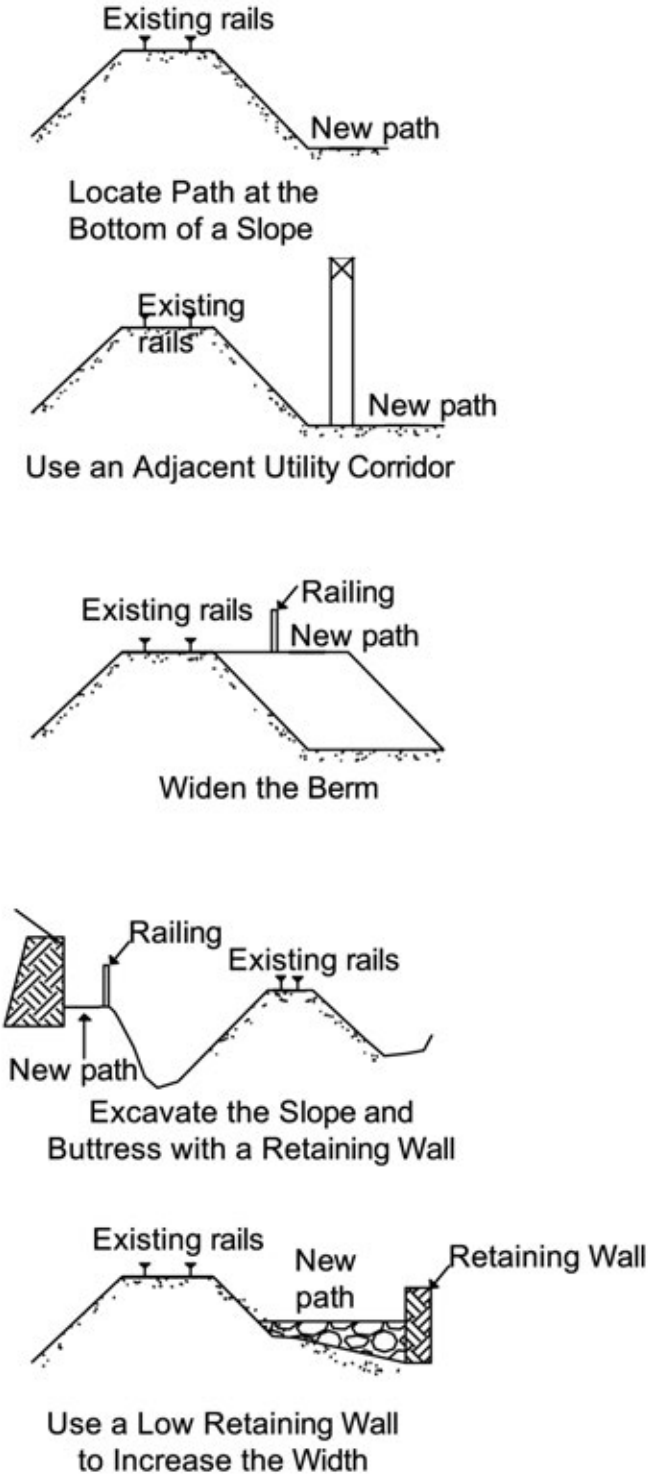
Source: Adapted from the VTrans Pedestrian and Bicycle Facility Planning and Design Manual

Exhibit 11-18
Recommended Separation between Active Rail Lines and Paths

Type of Rail Operation	Setting Characteristics	Recommended Minimum Separation
High Volume/ High Speed		
11 trains or more per day	Typical Conditions	25 feet with fence,
Max speed over 45 mph		15 feet with a solid barrier
	Constrained Areas (cut/fill, bridges, etc.)	15 feet with fence or other physical barrier
	Vertical Separation of at least 10 feet	20 feet
Medium Volume/ Medium Speed		
Fewer than 11 trains per day	Typical Conditions	25 feet
Max speed 45 mph		15 feet with a physical barrier
	Constrained Areas	11 feet with a physical barrier
	High Trespassing Areas	11 feet with a physical barrier
Low Volume/ Low Speed		
Fewer than 1 train per day	Typical Conditions	25 feet desired
Max speed 35 mph		11 feet minimum
	Constrained Areas	11 feet with a physical barrier

Adapted from FHWA Rails with Trails: Lessons Learned
Source: VTrans Pedestrian and Bicycle Facility Planning and Design Manual

Exhibit 11-19
Methods to Provide Additional Width for Path Development



Source: Adapted from the VTrans Pedestrian and Bicycle Facility Planning and Design Manual

11.7 Maintenance

Maintenance is an important consideration for all transportation facilities including on-road bicycle facilities and shared use paths. Good maintenance practices, such as periodic sweeping, surface repairs, tree pruning, mowing, trash removal, litter pick-up, new pavement markings, etc., are important elements of a routine maintenance schedule. In addition, both the Massachusetts Architectural Access Board and the Americans with Disabilities Act require that accessible elements be maintained to meet their minimum standards.

Path maintenance operations are often undertaken by the locality or governing agency and their importance and the associated costs should be considered during the planning stages of the project. The entity who is to take on these responsibilities should be established early in the process. In some instances, nonprofit groups, civic groups, and private organizations (i.e. bike clubs) partner with the locality by assisting in the smaller maintenance tasks. Key maintenance activities are discussed below.

11.7.1 Sweeping and Debris Removal

Sand and gravel accumulation on a path can pose a serious hazard to cyclists and skaters. Paths should be periodically swept to avoid accumulation of debris. The sweeping schedule should be established based on the path conditions and needs. At a minimum, it is recommended that a path be swept six times per year.

11.7.2 Pavement Quality and Striping

Path users are particularly sensitive to pavement irregularities and paths should be regularly maintained to ensure that cracks, potholes and other pavement defects are corrected. Additionally, most paths require periodic restriping to ensure the visibility and effectiveness of pavement markings. Missing and damaged signs should also be replaced.

11.7.3 Snow Removal

Snow removal is required if a path will be used in the winter months. Many paths are used for walking, jogging, and cycling year-round. To accommodate these uses, snow should be placed well beyond the path (or marked shoulder lane) edge to avoid ice formation and other hazards. Fences and barriers should be sufficiently set-back to allow effective snow removal.

In some cases, snow may not be removed to allow use of the path for cross-country skiing. A management decision should be made in

consultation with the local entity and user groups to determine the preferred winter time use.

11.8 For Further Information

For further information on the design of paths and trails consult the following publications:

- *A Policy on Geometric Design of Highways and Streets*, AASHTO, 2004.
- *Guide for the Development of Bicycle Facilities*, AASHTO, 1999.
- *Guide for the Planning and Design of Pedestrian Facilities,* AASHTO, 2004.
- *Manual on Uniform Traffic Control Devices*, Federal Highway Administration, 2003.
- *Virginia Bicycle Facility Resource Guide*, Virginia DOT, 2002.
- *Vermont Pedestrian and Bicycle Facility Planning and Design Manual*, Vermont Agency of Transportation, 2002.
- *Pedestrian Facilities Guidebook: Incorporating Pedestrians into Washington's Transportation System*, Washington State Department of Transportation, Puget Sound Regional Council, County Road Administration Board, Washington Association of Cities, 1997.
- *Design Manual*, Washington State Department of Transportation, 2004.
- *Rails with Trails, Lessons Learned*, Federal Highway Administration, 2002.
- *Trail Intersection Guidelines*, prepared for Florida Department of Transportation, University of North Carolina Highway Safety Research Center, 1996.
- Universal *Access to Outdoor Recreation: A Design Guide*, United States Department of Agriculture – US Forest Service (Draft) 2005.
- Accessible Rights of Way: A Design Guide, Architectural and Transportation Barriers Compliance Board, (Draft) 1999.
- ADA Accessibility Guidelines for Buildings and Facilities (ADAAG).

- MassHighway Policy Directive P-98-003 Bicycle Route and Share the Road Signing Policy
- MassHighway Specifications for Installation, Signing, and Surface Markings for Bicycle Sensitive Detectors at Traffic Signals.