VTrans Vermont Agency of Transportation

Shared Use Path Fencing Usage

FINAL REPORT

May 1st, 2007

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16. Abstract

The Vermont Agency of Transportation (VTrans) commissioned the University of Massachusetts at Dartmouth (UMassD) to review available guidelines and specifications relating to the design of shared use paths, with emphasis on the protective edges and scenarios of fencing usage. The objective of this research was to develop a design guideline based upon research of existing design guidance and use of barriers on existing paths. UMassD conducted field studies of 11 shared use paths across Vermont, interviewed 51 path users, and conducted an Internet-based survey of State Departments of Transportation.

The reasons to use a barrier adjacent to a shared use path were determined to be: access control, aesthetics/decoration, noise abatement, property separation/delineation, safety, screening, and wind abatement. In terms of safety, barriers are primarily used to protect path users from hazardous conditions.

Finally, a barrier selection guideline was formulated to identify when a barrier is required based on the combinational effects of the width of available clear zone (recovery area), embankment slope adjacent to the path, any vertical drop adjacent to the path, any hazardous condition (waterways, ravines, etc.) at the base of the slope adjacent to the path, and the material present on the side slope.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimetres	mm
ft	feet	0.305	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km
		AREA		
in^2	square inches	645.2	millimetres squared	mm^2
ft^2	square feet	0.093	metres squared	m^2
yd^2	square yards	0.836	metres squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometres squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	mililitres	mL
gal	gallons	3.785	Litres	L
ft^3	cubic feet	0.028	metres cubed	m^3
yd^3	cubic yards	0.765	metres cubed	m^3

NOTE: Volumes greater than 1000 L shall be shown in m^3

		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9	Celcius temperature	°C

* SI is the symbol for the International System of Measurement

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
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m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi
		AREA		
mm^2	millimetres squared	0.0016	square inches	in^2
m^2	metres squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometres squared	0.386	square miles	mi^2
		VOLUME		
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L	litres	0.264	gallons	gal
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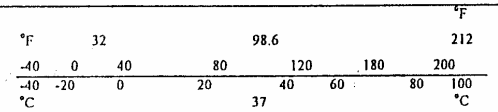
m^3	metres cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C+32	Fahrenheit temperature	°F



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1.0 Introduction

The University of Massachusetts at Dartmouth (UMassD) was commissioned by The Vermont Agency of Transportation (VTrans) to research the relevant design parameters as well as the issues for fencing usage on shared use paths. Per the VTrans Pedestrian and Bicycle Facility Planning and Design Manual (*1*), a shared-use path is "A path physically separated from motorized vehicular traffic by an open space or a barrier and either within the highway right-of-way or within an independent right-of-way. Shared use paths typically permit more than one type of user, such as pedestrians, joggers, people in wheelchairs, skaters, bicyclists, cross-country skiers, equestrians and snowmobilers. An equestrian-only or pedestrian-only trail is not a shared use path."

The goal of this research was to explore the relevant design parameters and the issues for fencing usage (barrier usage) on these shared use paths. As designers work on plans for shared use paths, they often come upon situations where the question is asked, *"Should we have a fence or barrier here?"* There is little or no technical guidance to designers of shared use paths regarding the specific situations that warrant the use of fencing or barrier along a path. Without such guidance, there is a tendency to err on the side of caution which likely results in the excessive use of barriers. This is costly to all sources of path funding. The intent of this proposed research was to develop more specific guidance about when barrier is needed so that its use is minimized to only those critical areas.

For the purposes of this research shared use paths on an independent right-of-way, and not subject to vehicular traffic in close proximity, are examined. Examples of such paths are rail/trail facilities, dedicated recreational facilities, and parks. Barrier usage along a shared use path associated with adjacent roadways and bridge sections was not included as part of this research.

1.1 Research Process Overview

To develop a guide for fencing on shared use paths, a comprehensive study of existing design guidelines and the use of barriers on existing paths was conducted in the following manner:

- A literature search was conducted to quantify shared use path design practices in the United States as well as other countries. Documents published by American Association of State Highway and Transportation Officials (AASHTO), Institute of Transportation Engineers (ITE), Federal Highway Administration (FHWA), Rails to Trails Conservancy, National Park Service, other State Departments Of Transportation (DOTs) and regional design guidance were reviewed. Additional existing guidance from organizations like trails and greenways groups was also included.

- A web-based survey of path managers, local, regional, state and national path designers, barrier designers and each state's Bicycle and Pedestrian Coordinators was conducted. The goal of this survey was to determine the extent of barrier use as well as the selection methodology on respective facilities.

- Field inspections of 11 existing installations and interviews with 51 path users were conducted to determine the conditions at which the threshold for the placement of a barrier was deemed necessary.

1.2 Definitions

In actual practice, the term "shared use path" is known by many interchangeable terms such as: bikeways, bike paths, paths, trails, rail-trails, bike-hike trails, bike/pedestrian ways, multiuse paths, or greenways. *(2)* Many agencies suggest their own varying definition for each of these terms. In an effort to clarify any confusion between terms, a more formal definition of different shared use path terminology is provided below:

Bikeway

"A generic term for any road, street, path or way which is designated for bicycle travel, regardless of whether such facilities are designated for the exclusive use of bicycles or are to be shared with other transportation modes." *(1)*

Pathways or Path

"An unpaved walkway, sidewalk, or shared use path (whether paved or unpaved)." *(1)*

Rail-Trails

"A shared use path, either paved or unpaved, built within the right-of-way of an abandoned former railroad." *(1)* An example of a rail-trail is shown in Figure 1.

Figure 1: Rail-Trail (*3*)

Rails-with-Trails

"A shared use path, either paved or unpaved, built within the right-of-way of an active railroad." *(1)* An example of a rail-with-trail is shown in Figure 2.

Figure 2: Rail-with-Trail (*3*)

Shared Use Paths on New Alignments

"A path that follows a stream or river, a property line, a sewer line, or crosses open fields is a path on a new alignment." *(2)* An example of a shared use path on a new alignment is shown in Figure 3.

Figure 3: Shared Use Path on New Alignment (*3*)

Side Paths

Side paths are built parallel to roadways in the usual location for sidewalks, but differ from sidewalks in that they are 10 ft wide, designed for shared use, and include a 5 ft or greater separation from the roadway or a barrier if less separation is provided. *(2)* An example of a side path is shown in Figure 4.

Figure 4: Side Path (*3*)

Trails

"Shared-use paths are sometimes referred to as trails; however, in many states the term *trail* means an unimproved recreational facility."*(3)*

2.0 Literature Review

A comprehensive literature review was conducted in order to determine the current state of practice regarding fencing usage for shared use paths. (Please note from this point forward fencing usage will be referred to as barrier usage). An attempt was made to review any available guideline or specification relating to the design of shared use paths, with an emphasis placed on those that described the protective edge and barrier usage scenarios. The ultimate goal of the literature review was to determine the critical design parameters and the issues for barrier usage on a shared use path.

2.1 Reasons for Barrier Use

From the literature review, many reasons for using barriers were identified. Vermont identifies that barriers are used for many purposes including: "…safety and security, protection from falls, screening of adjacent uses, separation of adjacent roadway or conflicting uses (i.e., active rail line), vertical or grade separation, enhanced aesthetics (via berms, landscaping and plantings)."(*1*)

A majority of the available literature identified that barriers are used for safety purposes to protection of path users from hazardous conditions adjacent to the actual path. These potentially hazardous conditions are outlined further in Section 2.1.1. Other functional uses of barriers were (*1,4,5,6,7*):

Function	Description
Access Control	Barrier used to control motorized vehicle and unauthorized users access on and off path.
Aesthetics/Decoration	Barrier used entirely to enhance visual appearance of a selected setting.
Property Separation (Delineation)	Barrier used as a physical separator between property lines.
Screening	Barrier used as a visual separator between path and adjacent property.
Noise Abatement	Barrier used to mitigate noise to residents near path.
Wind Abatement	Barrier used to mitigate wind to path users and residents near path.

Please note that the use of barriers for noise and wind abatement is not very frequent, especially in the experience of VTrans.

It is the responsibility of the designer to properly identify a situation where a barrier is required and what purpose it serves. Barriers may fulfill one or more of the functions noted based on their placement location and design.

2.1.1 Protection from Potential Hazard Conditions (Safety)

The main purpose of placing a barrier, as noted in the literature review, was to protect path users from potentially hazardous conditions. These conditions are mainly physical (i.e. the proximity of the pathway to ravines or drop-offs). As a result, paths must be designed to address these issues effectively. *(8)*

The most commonly identified hazard conditions for shared use path users (pedestrians, walkers, hikers, bicyclists, etc.) were: insufficient recovery area, insufficient clear distance to fixed objects, drop-offs and steep embankment slopes, insufficient path width, sharp curves, and path surface condition. Each of these is described in more detail in the following sections.

2.1.1.1 Recovery Area (Clear Zones)

Recovery areas, also referred to as clear zones, are discussed by many shared use path professionals. These areas provide room for bicyclists or other path users to 'recover' and rejoin the path in the event they accidentally veer from the defined path. The recovery areas are normally identified as a measured fixed distance outward from each edge of the path. This recovery area should not be confused with the path shoulder width. Shoulder widths are smaller graded areas used primarily for path users to pull-off, rest or pass. (*1*)

Vermont has comprehensive guidelines regarding recovery areas and corresponding barrier usage. As shown in Table 1 below, VTrans specifies that recovery areas are graded areas (with a maximum slope of 1:6) of varying widths based on the path surface (paved or unpaved).(*1*)

Table 1: Vermont Suggested Recovery Area Widths and Corresponding Barrier Recommendations

	Unpaved Surface		*Paved Surface*		
Slope	**Minimum**	**Preferred**	**Minimum**	**Preferred**	**Barrier Recommendations**
1:4 or Flatter	0	0.6 m (2ft)	0	0.9 m (3ft)	Generally no barrier necessary
1:3	0.6 m (2ft)	0.9 m (3ft)	0.9 m (3ft)	1.2 m (4ft)	If vertical drop 1.5 m (5ft) or greater, consider use of barrier unless preferred recovery area provided
1:2	0.9 m (3ft)	1.5 m (5ft)	1.2 m (4ft)	1.5 m (5ft)	If vertical drop 1.2 m (4ft) or greater, consider use of barrier unless preferred recovery area provided
Steeper than 1:2	1.5 m (5ft)	>1.5 m (5ft)	1.5 m (5ft)	>1.5 m (5ft)	If minimum recovery area not provided, barrier is necessary

Not all agencies have the same approach as Vermont has presented. Many other agencies take a more general approach as outlined in the following:

A good majority of reviewed literature simply follow the recommendations of the American Association of State Highway and Transportation Officials (AASHTO) in their 1999 "Guide for the Development of Bicycle Facilities" (*9*). In this guide, AASHTO recommends maintaining a minimum 2 ft (0.6 m) wide graded area adjacent to both sides of the path. In addition, where the path is adjacent to canals, ditches or slopes steeper than 1:3 (vertical: horizontal), a wider separation should be considered. Ideally, a minimum 5 ft (1.5 m) separation from the edge of the path to the top of the slope should be provided. (*9*)

As shown in Figure 5, Wisconsin recommends a minimum of 5 ft (1.5m) clear separation distance between the edge of the path pavement and the top of any slope. Although, they do note that depending on the height of the adjacent embankment and the conditions at the bottom of the embankment, a barrier may be required at the top of the slope. (*10*)

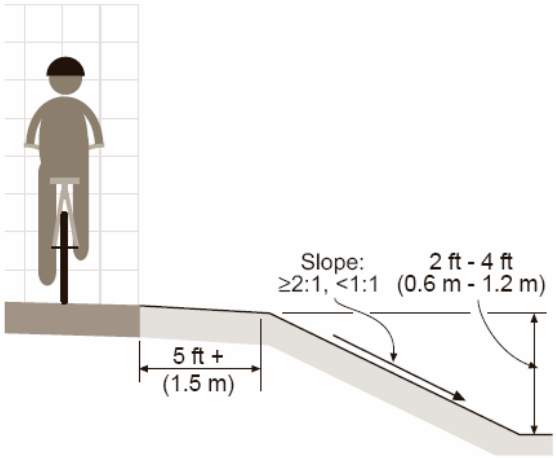

Figure 5: Wisconsin Recommendations for Clear Zone (*10*)

Similar to Wisconsin, Connecticut states "A wide separation between a multi-use path and canals, ditches, or other significant depressions is essential for safety. If a minimum 5ft (1.5m) separation from the edge of the bike path pavement is not possible, a physical barrier such as dense shrubbery or a chain link fence should be provided." (*5*)

Massachusetts suggests in locations where the path is adjacent to canals, ditches, or slopes steeper than 1:3, a 5 ft (1.5m) clear zone is preferred from the path edge to the top of the slope. (*6*)

Florida recommends a 6 ft (1.8 m) clear zone between the path edge and any embankment that "…would create difficulties for bicyclists (greater than or equal to a 3:1 slope)." If this is not met, Florida ***recommends*** the use of a safety barrier. For areas where the path intersects canals or ditches, Florida requires a minimum 6 ft (1.8 m) clear zone between the edge of the path and top of the slope. If this is requirement not met, Florida ***requires*** the use of a safety barrier such as dense shrubbery or chain link fence. (*11*)

Oregon states that where there is a fill or cut slope adjacent to the path, the area should be unpaved and graded the same slope as the path to allow for recovery from errant bicyclists. (*4*)

Thus, the horizontal distances to hazards are of high importance to this research study. Specifically, in terms of barrier usage, it is important to know when a path user comes too close to a hazardous condition due to insufficient horizontal clearance distance. The data presented in Table 2 suggest distances ranging from 2.0 ft (0.6 m) to 6 ft (1.8 m).

Table 2: Suggested Horizontal Clearances Zones.

Reference	Horizontal Distance to Hazard
AASHTO [9]	5 ft (1.5m)
Arizona [12]	2 ft - 4 ft (0.6 m -1.2 m)
Florida [11]	6 ft (1.8 m)
Georgia [13]	5 ft (1.5m)
Idaho [14]	5 ft (1.5m)
Iowa [15]	5 ft (1.5m)
Massachusetts [6]	5 ft (1.5m)
Minnesota [16]	5 ft (1.5m)
New York [17]	5 ft (1.5m)
Vermont [1]	See Table 1

[#] = Reference Number

2.1.1.2 Clearance (Shy) Distance to Fixed Objects

Many agencies specify a separate horizontal clearance distance to fixed objects (abutments, trees, posts, walls, fences, guardrails, horizontal obstructions, etc.). These objects may pose a collision threat to path users. Wisconsin explains that shy distances are required for two reasons. They state, "The first is to provide adequate clearances from trees, abutments, piers, poles, box culverts, guardrails, or other potential hazards. The second reason is to make maintenance (e.g mowing) easier." (*10*)

Again a good majority of reviewed literature simply follows the recommendations of the AASHTO 1999 "Guide for the Development of Bicycle Facilities." As shown in Figure 6, they recommend maintaining a minimum 2 ft (0.61 m) wide graded area adjacent to both sides of the path. Additionally, a minimum 3 ft (0.91 m) clearance should be maintained from the edge of the path to accommodate signs, trees, walls, fences, guardrails, or other horizontal obstructions. (*9*) Similarly, Connecticut DOT and MassHighway recommend that a clear distance of 3 ft (0.9m) is desirable from the edge of the path to all horizontal obstructions. (*5,6*)

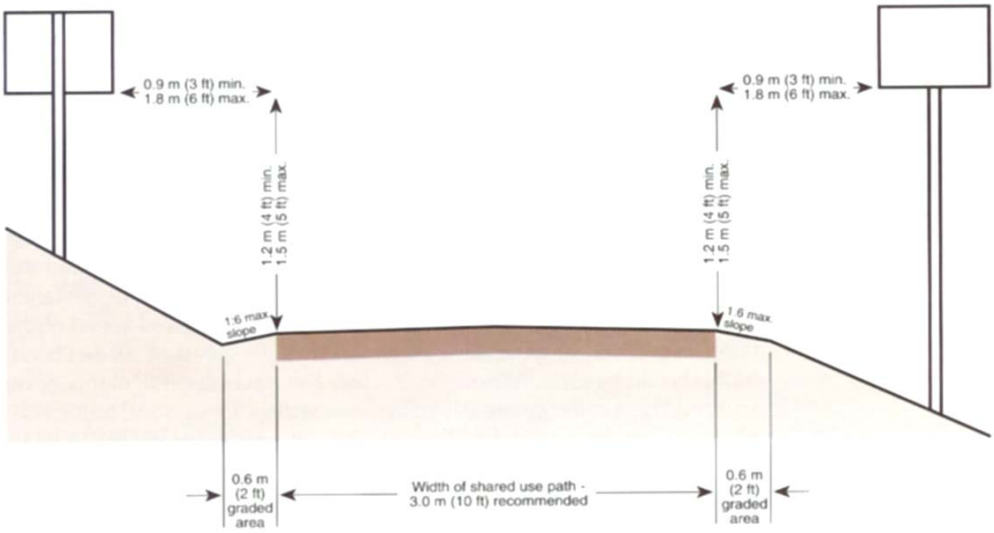

Figure 6: AASHTO Recommendations for Clear Distance (*9*)

Florida and Dane County Wisconsin recommend a minimum clear distance of 4 ft (1.2m) from all horizontal obstructions. (*11*,*18*) Wisconsin specifies a minimum clear distance of 3 ft (0.9m) on each side of the path, but also allows for a less stringent 1 to 2 ft (0.9 m -1.8 m) clearance for continuous obstructions like long section of wall, a railing, or fence. (*10*) Oregon suggests a minimum clear distance of 2 ft (0.6m), but a 3 ft (1.0m) or greater distance is preferred on both sides of the path. (*4*)

Georgia recommends a less stringent clear distance requirement. They define it as the horizontal distance on each side of the path beyond the path shoulders. They require 1 ft (0.3m) minimum, 2 ft (0.6m) preferred, clear distance from all obstructions. (*13*)

Iowa makes recommendations on clear distance based on intended path users. Hiking/walking and pedestrian trails do not require a clear distance since the path users are moving at slow speeds. For bicycle trails, a minimum 2 ft (0.6m) graded shoulder should be provided, and an additional 1 ft (0.3m) clear distance should be provided from the edge of the graded area to any fixed object. For mountain biking trails, only shrubbery vegetation should be removed within 3 ft (0.9m) on each side of the trail. For equestrian and snowmobile use trails, a clear zone of a minimum of 2 ft (0.6m) should be provided from the tread width. (*19*)

Australia has also recognized that the adoption of suitable clearances to obstacles adjacent to paths is important to enhance safety. They recommend a horizontal clearance of 3.3 ft (1.0 m) minimum between the edge of the path and any obstacle. A lesser clearance of 0.98 ft (0.3 m) minimum is acceptable for fences or walls provided they are “smooth,” are aligned parallel to the path, and have tapered end treatments set back at least 3.3 ft (1.0 m) from the edge of the path. (*20*)

Finally worth noting, Hamilton Ontario, Canada states that any curb with a height greater than 0.5 ft (0.15 m) is considered a horizontal obstruction.

Table 3 outlines the recommended horizontal clear distances to fixed objects for other agencies.

Table 3: Suggested Horizontal Clear (Shy) Distances to Fixed Objects.

Reference	"Shy" Clearance Distances
AASHTO [9]	3 ft (0.9 m)
Arizona [12]	3 ft (0.9 m)
Connecticut [5]	2 ft (0.6 m) min. 3 ft (0.9 m) preferred
Florida [11]	4 ft (1.2 m)
Georgia [13]	1 ft (0.3 m) min. 2 ft (0.6 m) preferred
Hawaii [21]	3 ft (0.9m)
Idaho [14]	2 ft (0.6m)
Iowa [15]	3 ft (0.9m)
Iowa [19]	Based on path users.
New York [17]	2 ft (0.6 m) min. 3 ft (0.9 m) preferred
Ohio[2]	3 ft (0.9 m)
Oregon [4]	2 ft (0.6 m) min. 3 ft (0.9 m) preferred
Virginia [22]	2 ft (0.6m)
Washington [7]	2 ft (0.6m)
Wisconsin [10]	3 ft (0.9 m)
Vermont [1]	2 ft (0.6 m) min. 3 ft (0.9 m) preferred
Australia[20]	3.3 ft (1.0 m) min.
Hamilton, Ontario Canada[8]	1.6 ft (0.5 m) min.

[#] = Reference Number

2.1.1.3 Drop-Off & Steep Embankment Grades

Drop-off hazards are defined as steep or abrupt downward slopes that can be perilous to path users. The path should be designed to consider shielding any drop-off determined to be a hazard. Generally, pedestrians and bicyclists will be adequately protected from a drop-off hazard if a barrier has been installed between the path and the drop-off. (*23*)

The AASHTO 1999 "Guide for the Development of Bicycle Facilities" suggests a barrier be considered if there is less than a 5 ft (1.5 m) separation from the path edge to ditches or slopes with down grades steeper than 1:3. They further state, "Depending on the height of the embankment and condition at the bottom, a physical barrier, such as dense shrubbery, railing or chain link fence, may need to be provided."(*9*) Wisconsin DOT follows AASHTO's recommendation as shown in Figure 7. (*10*) Similarly, Washington state and Dane County Wisconsin provide the same recommendation as AASHTO. (*7,18*)

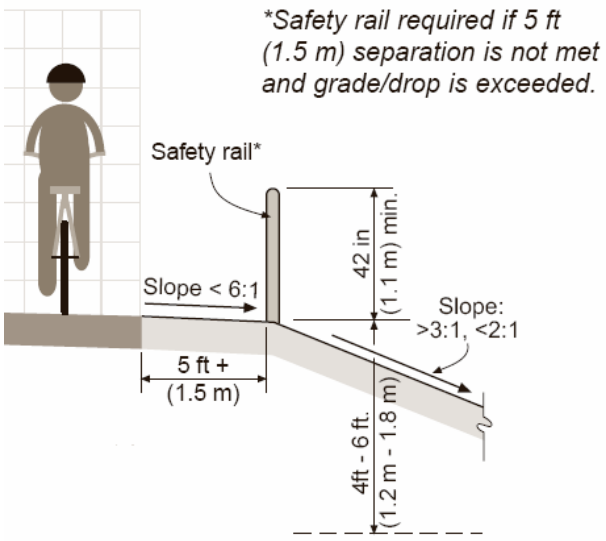

Figure 7: Wisconsin Identification of Drop-Off Hazards (*10*)

Georgia presents another explanation for when a barrier, in their case railings, is required to protect path users (bicyclists) from a drop-off hazard condition. Georgia states, "When a grade drops severely from the shoulder of a pedestrian or bike travel way, railings are required by most jurisdictions. When a vertical drop is more than 30 inches, exceeds a down slope grade of 1:2, and is located less than 4 feet from the edge of the trail, walkway, or sidewalk, railing needs to be installed along the extent of the grade drop." (*13*) These scenarios are further outlined in Figures 8 and 9.

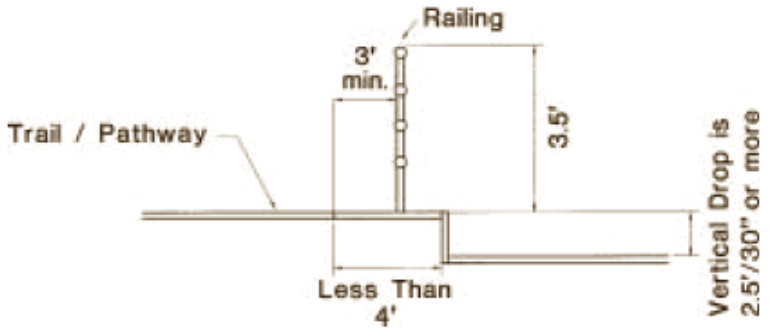

Figure 8: Georgia Identification of Drop-Off Hazards (*13*)

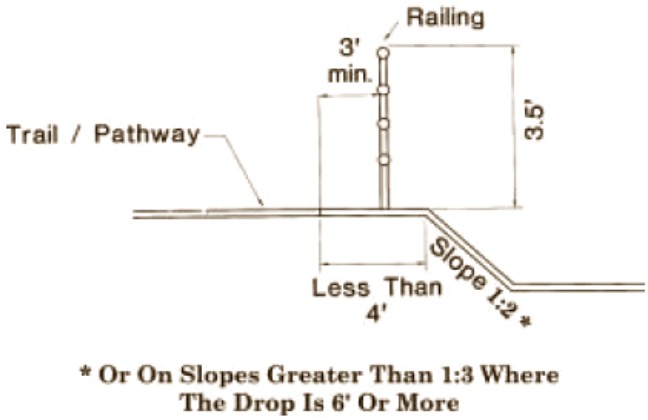

Figure 9: Georgia Identification of Steep Slope Hazard (*13*)

Massachusetts has a more general approach to drop-off identification. They state, " 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 the slope. Other situations may also dictate the need for a physical barrier, such as the height of embankment or an unsafe condition at the bottom of the slope." (*6*)

Connecticut provides guidance for barrier usage based on drop-off and steep side slopes as depicted in Figure 10.

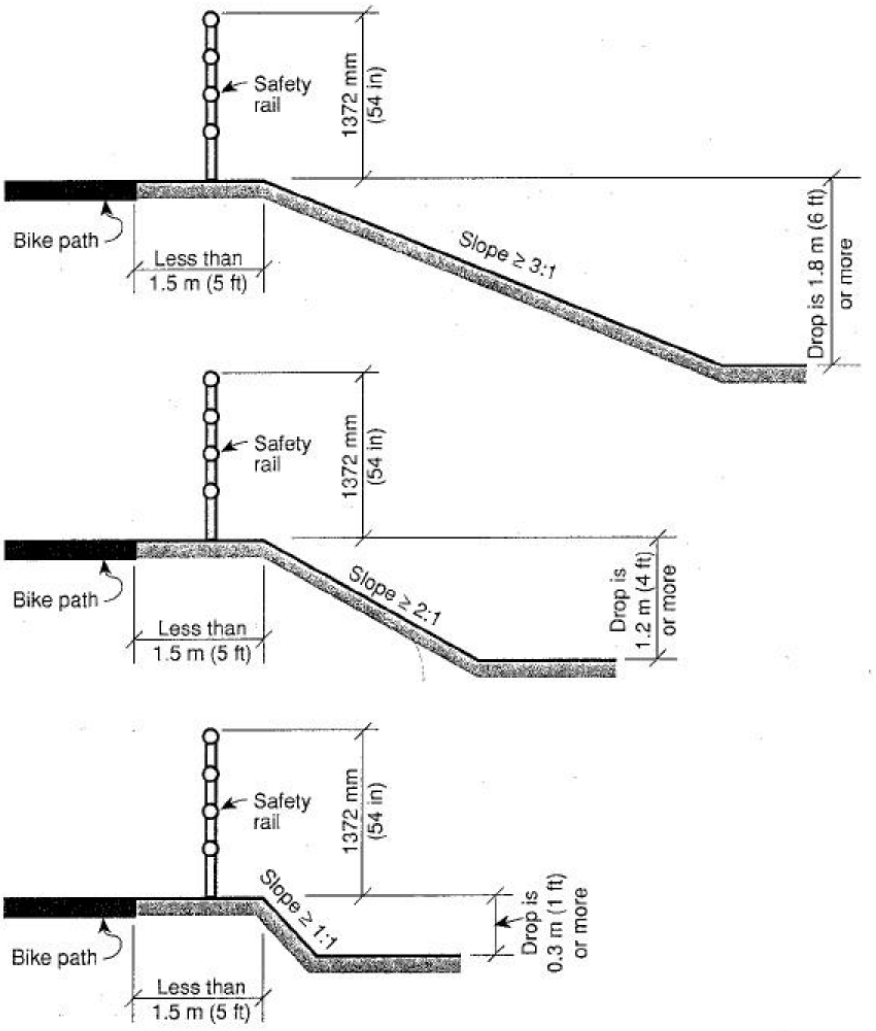

Figure 10: Connecticut Identification of Drop-Off Hazards (*5*)
Original Source: AZ Bicycle Facilities Planning & Design Guidelines; AZDOT, 1988.

In Florida, they define two cases for identification of a drop-off hazard for pedestrians and bicyclists. Case I, shown if Figure 11, identifies drop-off hazards based on total height drop within 2 feet of the path edge. Case II, shown in Figure 12, identifies drop-offs based on steep slope grades starting within 2 feet of the path edge and also the total height of drop from top to bottom of slope.

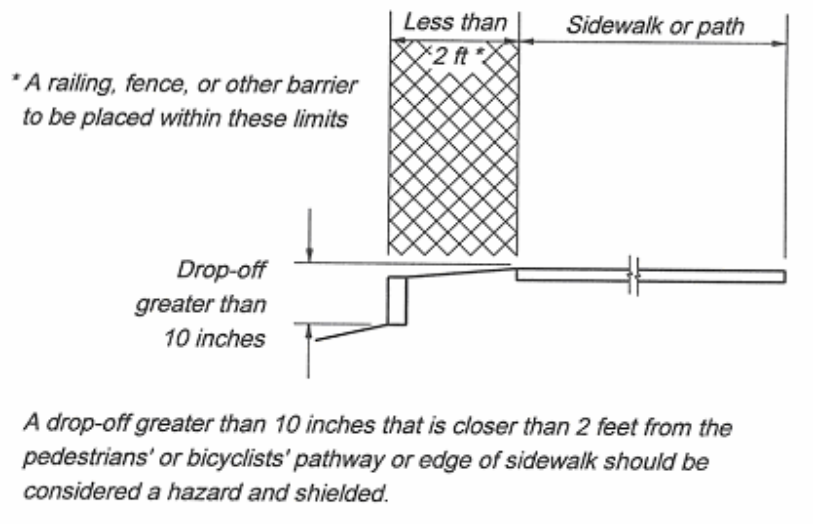

Figure 11: Florida Identification of Drop-Off Hazard – Case I (*24*)

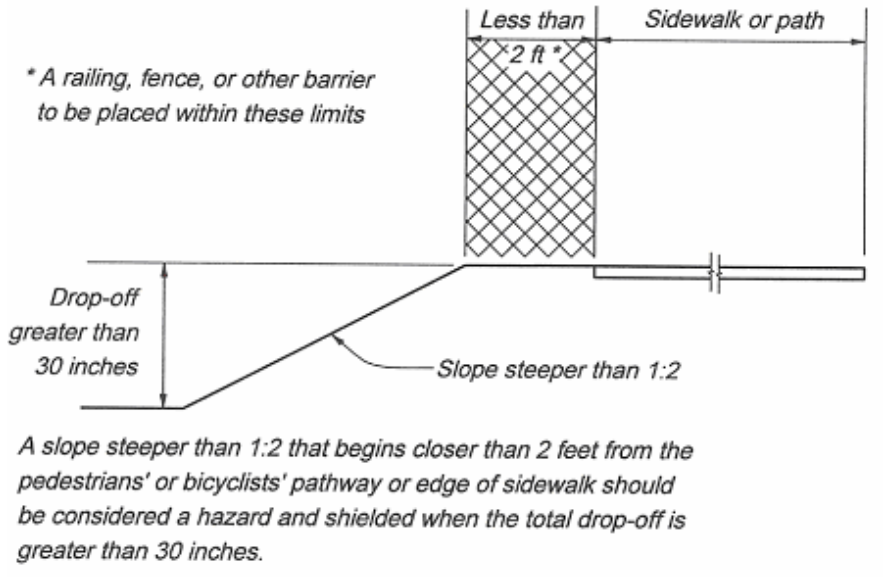

Figure 12: Florida Identification of Drop-Off Hazard – Case II (*24*)

The other literature reviewed suggests that most organizations recommend barriers in scenarios where there is an embankment slope next to a path that may pose a safety threat to path users. For example, Hamilton Ontario, Canada states generally that barriers are needed with the path is adjacent to a waterway with steep banks or near a ravine or steep slope (30% or more). (*8, 25*) Minnesota identifies rough and steep slopes for bicyclists as any slope greater than 1:4. (*16*)

2.1.1.4 Sharp Curves

Sharp curves on a shared use path may increase the potential for the bicyclists or other path users to veer from the path and potentially subject themselves to injury. Barriers around sharp curves may inflict injury upon path users, but protect them from even more potentially dangerous conditions like a drop-off and steep side slopes adjacent to the curve. The selection and purpose of barrier use around a sharp curve must be thoroughly understood and examined.

Some older paths were built with what can be subjectively considered sharp curves and steep slopes that are difficult to navigate on a bicycle. Bicyclists travel a good deal faster than the design speeds of these facilities; even average bicyclists can reach 30 mph on a downhill. *(26)* At high rates of speed, a bicyclist would probably be unable to remain on the path if entering a sharp curve from a steep slope.

Through the literature review, no firm criterion was presented to truly define a "sharp" curve. Currently most agencies follow the AASHTO 1999 "Guide for the Development of Bicycle Facilities" in regards to minimum radii for shared use path based on design speed, superelevation, and lean angle of a bicyclist as shown in Tables 5 and 6.

Table 5: AASHTO Desirable Minimum Radii for Paved Shared Use Paths Based on 15° Lean Angle

Design Speed (V)		Minimum Radius (R)	
km/h	(mph)	m	(ft)
20	(12)	12	(36)
30	(20)	27	(100)
40	(25)	47	(156)
50	(30)	74	(225)

Table 6: AASHTO Minimum Radii for Paved Shared Use Paths Based on 2% Superelevation Rates and 20° Lean Angle

Design Speed (V)		Friction Factor (f) (paved surface)	Minimum Radius (R)	
km/h	(mph)		m	(ft)
20	(12)	0.31	10	(30)
30	(20)	0.28	24	(90)
40	(25)	0.25	47	(155)
50	(30)	0.21	86	(260)

Virginia DOT further elaborates, "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 20 mph design speed should be used. When a downgrade exceeds 4 percent or where strong prevailing tailwinds exists, a design speed of 30 mph or more is advisable." (*22*)

The designer will ultimately need to calculate the acceptable curve radius in order to determine what curve is too sharp. With these engineering criteria, barrier selection or geometric path redesign may be suitable to protect users from these scenarios.

2.1.1.5 Path Width

Without adequate path width, path users could be exposed to other hazardous conditions like drop-offs or steep slopes during their passing maneuvers. Vermont suggests a variety of minimum and preferred path widths based on the shared use path type as outlined in Table 7 *(1)*.

Table 7: Vermont Suggested Minimum and Preferred Shared Use Path Widths.

Path Type	Minimum Path Width	Preferred Path Width
Paved Shared Use Path	2.4 m (8 ft)	3.0 to 4.3 m (10 to 14 ft)
Unpaved Shared Use Path	2.4 m (8 ft)	2.4 to 3.0 m (8 to 10 ft)
One-way Shared Use (rare)*	1.5 m (5 ft)	1.8 m (6 ft)
Paved Pedestrian-only	1.5 m (5 ft)	1.8 m (6 ft)

**These types of path are not recommended.*

Many other agencies specify minimum and preferred shared use path widths as outlined in Table 8.

Table 8: Typical Shared Use Path Widths.

Reference	Two-Way Path Width	Use or Recommendation
AASHTO [9]	10 ft (3.0m)	Recommended
Arizona [12]	10 ft (3.0m) 12 ft (3.6m)	Standard Width High Volume Path
Connecticut [5]	10 ft (3.0m) 12 ft (3.6m)	Minimum Desirable
Florida [11]	12 ft (3.6m)	Minimum
Georgia [13]	10 ft (3.0m) 12 ft (3.6m) 14 ft (4.3m)	Minimum Desirable Optimum
Hawaii [21]	10 ft (3.0m) 12 ft - 14 ft (3.6m - 4.3m)	Recommended High Volume Path
Idaho [14]	8 ft (2.4 m) 10 ft (3.0m) 12 ft (3.6m)	Not Recommended Standard Width High Volume Path
Iowa [15]	8 ft (2.4 m) 10 ft (3.0m) 12 ft (3.6m)	Minimum Desirable High Volume Path
Massachusetts [6]	10 ft (3.0m) 12 ft - 14 ft (3.6m - 4.3m)	Recommended High Volume Path
New York [17]	8 ft (2.4 m) 10 ft (3.0m) 12 ft (3.6m)	Minimum Desirable High Volume Path
North Carolina [27]	10 ft (3.0m)	Minimum
Ohio [2]	10 ft (3.0m)	Minimum
Oregon [4]	8 ft (2.4 m) 10 ft (3.0m)	Minimum Standard
Virginia [22]	10 ft (3.0m)	Recommended
Washington [7]	10 ft (3.0m) 12 ft (3.6m)	Minimum Desirable
Wisconsin [10]	10 ft (3.0m) 12 ft - 14 ft (3.6m - 4.3m)	Recommended High Volume Path
Vermont [1]	See Table 7	See Table 7
Australia [20]	6.6 ft (2.0m) 10 ft (3.0m) 13.1 ft (4.0m)	Low Volume Path Minimum High Volume Path
Hamilton,Ontario Canada [8]	10 ft (3.0m)	Minimum

[#] = Reference Number

2.1.1.6 Material Placed on Slopes Adjacent to the Path

Even the materials placed in the clear zone on slopes adjacent to the path can be hazardous to path users who impact it in the event of a fall. Vermont states, "The surface material of the slope has an impact on path user safety. Grassed or vegetated slopes are preferred versus crushed stone or rock (rip-rap) slopes."(*1*) None of the other literature reviewed addressed this important path user safety item.

2.1.1.7 Other Considerations

Any geometric design item (grade, cross slope, design speed, stopping sight distance, etc.) not properly considered and engineered in the design phase for a shared use path may have the potential to create safety issues for path users. Many resources, including AASHTO design guides (*9*), are available to properly design a shared use path for these design parameters. Additionally, all shared use path designs should consider all types of users including those with disabilities. The American with Disabilities Act (ADA) has comprehensive design guidelines to properly design path facilities to accommodate users with disabilities.

2.2 Barrier Need Determination

Some of the literature reviewed provided some general factors that should be considered in the determination of the need for a barrier for a shared use path.

Vermont states, "The design and selection of barriers adjacent to shared use paths is dependent on several factors including their intended function (i.e. protection from falls, separation of adjacent uses, delineation of property boundaries or screening), safety, proximity to the path, aesthetics and overall continuity of barrier type(s) within a path corridor." (*1*)

Furthermore Vermont elaborates, "Determine the need to include protection along a shared use path on a case-by-case basis after evaluating the following factors:" (*1*)

1. "**Amount of recovery area available**. If an adequate recovery area is provided, the need for a protective barrier is lessened." (*1*)

2. "**Height.** The greater the height of a 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 more than 1.2 m (4 ft) in height." (*1*)

3. "**Steepness of the slope.** Where the side slope is 1:3 or greater, the need for a protective barrier may be increased, unless the side slope material is forgiving (see #4) or a suitable recovery area is provided." (*1*)

4. "**Side-slope material.** If the material used on a side slope is grass, the need for protection is lessened. Shrubbery may also lessen the need for a physical barrier. Riprap is considered a harmful material where the need for a protective barrier is increased." (*1*)

5. "**Nature of hazard on or at the base of the slope.** If the consequences of colliding with a protective barrier would be less than the consequences of a crash at the bottom of a drop-off, a protective barrier should be strongly considered. Where protection is required, provide it along the full extent of the grade drop." (*1*)

Massachusetts' specification closely follows the recommendations made by Vermont. (*6*) Oregon further warns, "Fences, railings or barriers can become obstructions and should only be used where they are needed for safety reasons; for example, in an area where a pedestrian or

bicyclist could fall into a river, a high-speed roadway or canyon. They should be placed as far away from the path as possible." (*4*)

All these items should be thoroughly examined in the barrier placement and selection process for a shared use path.

2.3 Barrier Types

2.3.1 General Barrier Classifications

The Federal Highway Administration (FHWA) documented that barriers included fencing (34%), vegetation (21%), vertical grade (16%), and drainage ditches (12%). The fencing style varied considerably from chain-link to wire, wrought iron, vinyl, and wooden rail. *(28)* Generally, most literature identified barrier types in general terms like walls, fences, barriers, or vegetation. Moreover, barriers can be classified in general terms as outlined in Table 9.

Table 9: General Barrier Classifications

Type	Examples
Hard	Fences (metal, wood, picket, pipe railing, wrought iron, chain-link, etc.) (*1*) Walls (rock, cement, brick, etc.) Guardrails Concrete "Jersey" Barriers Railings
Live	Vegetation, Trees, Shrubs, Bushes, Plants
Terrain	Naturally occurring boundaries like rock walls, grade separations, etc.

2.3.2 Hard Barriers - Fences & Railings

Vermont discusses fences as the most common type of barrier used on a shared use path. Vermont further states, "When using fencing as a barrier any number of fencing types that meet the minimum requirements for height are acceptable including, wooden, picket fence, pipe railing, wrought iron decorative fencing or vinyl-coated chain link." (*1*)

Connecticut identified some specific types of fencing (hard and live barriers) as, "…solid walls, solid board, semitransparent panels, transparent panels, post and rail, picket, and vegetative hedges." (*5*) Some other types noted by Connecticut are depicted in Figure 13.

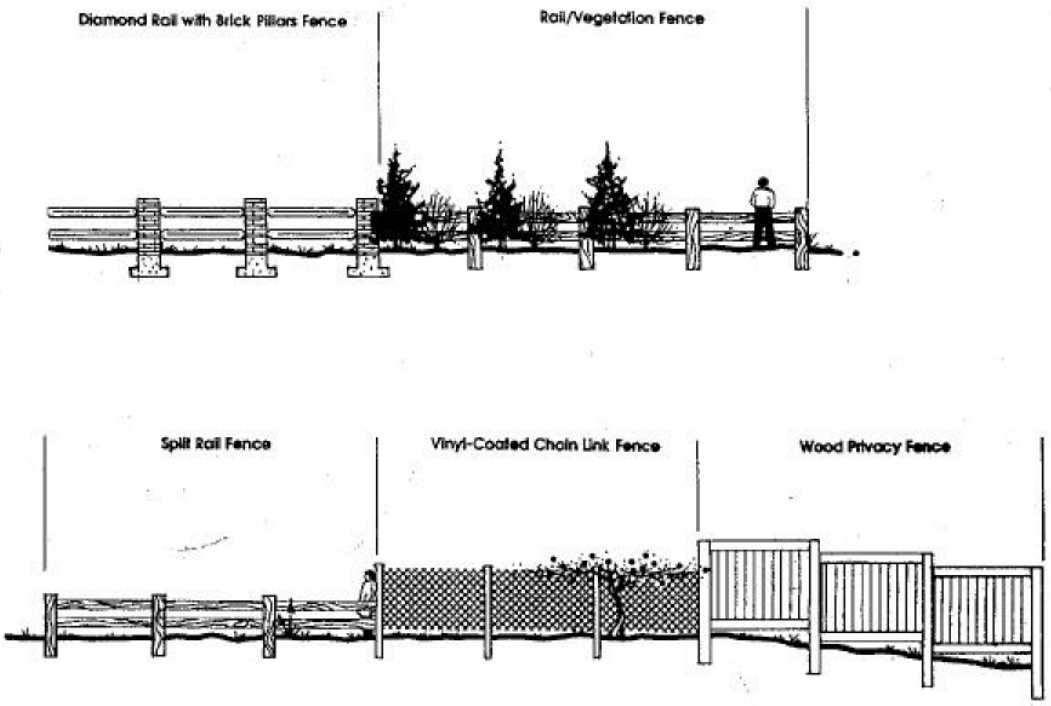

Figure 13 Types of Fencing (Barriers) noted by Connecticut
Original Source: Greenways - A Guide to Planning, Design and Development, 1988.

Arkansas refers specifically to fencing and safety rails. Fencing types include "…post and rail, chain link, post and cable, and lumber privacy fences…" Safety railings are usually "pipe railings or lumber rails." (*29*)

Specific types of fences and railings are shown in Figures 14 through 21.

Figure 14: Wood-Cable Fence

Figure 15: Wooden Rail Fence

Figure 15: Wood Split Rails Fence

Figure 16: Wood Safety Railing

Figure 17: Wood Privacy Fence/Wall

Figure 18: Plain Chain Link Fence

Figure 19: Vinyl Coated Chain Link Fence

Figure 20: Decorative Metal Fence

Figure 21: Metal Pipe Fence

2.3.3 Hard Barriers - Walls

Vermont specifically discusses walls as barriers. They state, “Retaining walls should not be placed closer than 0.6 m (2 ft) from the edge of the path. High walls should be terraced back from the edge of the path shoulder since they may be out of scale with creating a pedestrian friendly environment. Blank walls may be screened with landscaping or designed with an attractive face or artwork. Wall materials may also vary from cast in place concrete or precast concrete, masonry or laid up stonewalls.” (*1*) Examples of walls are shown in Figures 22 and 23.

Figure 22: High Concrete Wall with Chain Link Fence

Figure 23: Low Concrete Wall with Chain Link Fence

2.3.4 Hard Barriers - Concrete Barriers & Guardrails

Vermont specifically discusses guardrails and concrete barriers. They state, "Where concrete 'Jersey' type barriers or guardrail are used as protective barriers (i.e., between a roadway and an adjacent path or sidewalk) placement of a railing or fencing on top of the barrier may be necessary to achieve the required minimum barrier height of 1.05 m (3 ft 6 in). When used in this scenario the barrier must also meet the applicable NCHRP crash test requirements for the adjacent roadway." An example of a guardrail is shown in Figure 24.

Figure 24: Metal Guardrail

2.3.5 Live Barriers - Vegetation

Little information exists on the proper selection and design of buffering vegetation for use as a barrier for shared use paths. Most of the sources reviewed in the literature review did not elaborate on the use of vegetation as a barrier.

Vermont specifically discusses vegetation use as a barrier. They state, "Trees, bushes or other sturdy vegetation capable of stopping a fall may be used as a barrier if new or existing individual plants are continuously spaced no greater than 1.8 m (6 ft) on center within 3.0 m (10 ft) of the path along the full extent of the grade drop. The density and species of plants in a vegetative barrier determine how effective the barrier can be in deterring access and protection from falls. Planted barriers typically take a few years before they become effective barriers and may need to be augmented with other temporary barriers. Where existing natural vegetation exists every effort should be made to avoid damaging the natural vegetation during the construction phase of a project. Vegetation also provides a visual barrier that helps channelize path users to the main path surface. When any of these barrier types are used for purposes other than protection (such as right of way delineation, screening or others) and they are located outside the recovery area of the path, the required barrier heights do not apply." (*1*)

Arizona recommends that vegetation for a shared use path be low-water use native vegetation that requires minimal maintenance from falling debris. Also they recommend placing trees 3 to 5 feet from the path to prevent root intrusion on the path surface. (*12*)

Oregon states that buffering vegetation can be very expensive to install and maintain, especially if it requires irrigation. Most trail projects utilize buffering vegetation in specific areas along the corridor and often use native, drought resistant species that do not require irrigation, require little pruning, and are low growing (under 3 ft or 0.91 m at mature height). And of course, the location and placement of these materials should not promote growth over or onto the path surface. Finally, buffering vegetation should not interfere with visibility of trail users. (*4*)

An example of a vegetation as a barrier is shown in Figure 25.

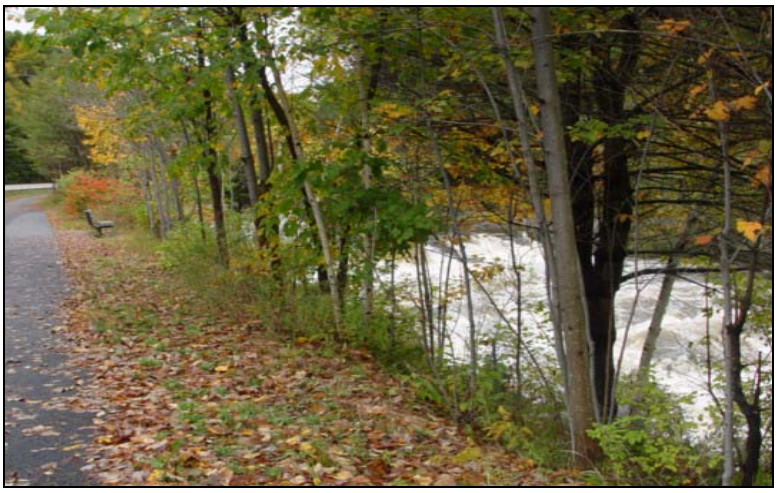

Figure 25: Vegetation as a Barrier

2.3.6 Terrain Barriers

Terrain barriers are naturally occurring boundaries like rock walls and grade separations. There was no information presented in the literature review that specified particular types of terrain barriers. An example of a natural rock wall as a terrain barrier is shown in Figure 27.

Figure 26: Natural Rock Wall as Terrain Barrier

2.4 Barrier Heights

2.4.1 Safety Railings

In terms of using a barrier for safety consideration, protection of path users from hazardous conditions, there is much discussion of the proper height of the barrier. As shown in Table 10, the height barrier was more universally understood to be either 3.5 ft (1.1m) or 4.6 ft (1.4m) with the majority specifying the former. The justification for these two heights is related to the majority of literature review sources following the various AASHTO specifications for bicycle facilities.

Table 10: Suggested Safety Barrier Heights.

References	Barrier Height
AASHTO [9]	3.5 ft (1.1m)
Connecticut [5]	4.5 ft (1.4m)
Florida [11]	3.5 ft (1.1m)
Georgia [13]	3.5 ft (1.1m)
Idaho [14]	4.5 ft (1.4m)
Iowa [15]	3.5 ft (1.1m)
Massachusetts [6]	3.5 ft (1.1m)
New York [17]	3.5 ft (1.1m)
Ohio [2]	3.5 ft (1.1m)
Oregon [4]	4.5 ft (1.4m)
Virginia [22]	3.5 ft (1.1m)
Washington [7]	3.5 ft (1.1m)
Wisconsin [10]	3.5 ft (1.1m)
Vermont [1]	3.5 ft (1.05m)
Quebec [25]	4.3 ft (1.3m)

A survey by Clough, Harbour and Associates LLP found that some states do not adhere to the AASHTO guidelines requirement for a 4.5 ft (1.4 m) high bicycle railing. Of the 28 states that responded to the survey, 68% (19 states) indicated that they use a 4.6 ft (1.4 m) bicycle railing height on bridges, while 18% (5 states) use a 3.6 ft (1.1 m) bicycle railing height. Four states (14%) indicated that their selection varies depending on project conditions. (*30*)

2.4.2 Others

There was little information of the selection of barrier heights for barriers used for purposes other than safety. Vermont suggests that when barriers are used "… for purposes other than protection (such as right of way delineation, screening or others) and they are located outside the recovery area of the path, the required barrier heights do not apply." (*1*)

Moreover, Vermont addressed barriers used as delineation of shared use paths and adjacent properties. They state, "In some cases, a section of a shared use path may be located immediately adjacent to a driveway, parking lot or other improved surface. In these cases, it can be hard to determine where the path ends and the adjacent facility begins. One way to delineate the two facilities from each other is through the installation of a physical feature, such as guardrail, fence or low landscaping. When a guardrail or fence is used for this purpose (i.e., not as a barrier to protect from hazards or falls), it does not need to meet the minimum height requirements for fencing as long as it is located with adequate lateral clearance from the path. When delineating the right-of-way with fencing it is recommended that woven wire mesh or traditional chain link fencing be used." (*1*)

Methods for determining appropriate barriers heights for other uses (access control, aesthetics, noise abatement, screening, wind abatement) were not discussed in any of the literature. It is assumed that these barriers heights must be evaluated on a case-by-case basis.

2.5 Barrier Maintenance

Barriers require regular maintenance in order to ensure that they do not impact path safety. In fact, according to the FHWA, improperly maintained fencing is a higher liability risk than no fencing at all. (*28*) Live barriers such as trees or vegetation, which may result in broken branches, downed trees (possibly after a storm), or even encroaching brush or grass, must be tended to and maintained regularly for path user safety. Illinois recommends keeping vegetation cleared to provide a minimum 3 ft (0.91m) horizontal clearance. Furthermore, they suggest selectively removing underbrush and pruning lower tree branches to improve sight distances through curves or in any areas where personal safety or security is a concern. (*31*)

Hard barriers, such as fencing or railings, must also be checked regularly to ensure they are intact. For example, it may be necessary to check if they are in any way damaged (possibly by a storm) or even vandalized. This routine maintenance will ensure that all barriers constructively fulfill their function and do not in anyway negatively impact usability of the trail. (*32*)

Finally, Hawaii recommends the following maintenance schedule for their Off-Road Bikeways, as shown in Table 11. (*21*)

Table 11: Hawaii Recommended Maintenance Schedule for Off-Road Bikeways

Routine inspection and identification of needed repairs	2 times per year
Sweep paved bikeways	2 times per year
Path repairs	As needed
Repair or replace signs and pavement markings	As needed
Vegetation control	As needed
Path resurfacing	10-12 years

2.6 Barrier Aesthetics

The design of a barrier should also be considered in terms of not only function but also in terms of aesthetics.

Fayetteville, Arkansas advocates careful consideration of aesthetics when determining a type of fencing or railing. They go one step further to indicate that the materials used should blend in with those used in the surrounding areas and the overall trail system. They also indicate that many different types of fences may be used depending on the specific site needs. (*29)*

In one county in California, they are quite explicit in their recommendations regarding fence placement so that it is unobtrusive. They indicate that where it is desirable to preserve the views through fencing, the fence should be as transparent as possible. So, it is important to set the fence back from the trail where possible, to reduce visual intrusion. In fact, locating the fence down slope from a trail is ideal as it reduces the perceived height of the fence while preserving views. Furthermore, planting should be used to reduce the visual impact of a fence where preservation of the view through the fence is not an issue. (*33*)

2.7 Barrier Porosity

Barrier porosity referees to the "openness" between the physical parts of the barrier itself. Concrete barriers and walls typically have no porosity since they are usually a continuous solid structure. However, fencing and railings are designed with vertical members that are spaced within the frame of the structure. Thus, barriers with higher porosity may unintentionally expose path users (potentially bicyclists and pedestrians) to hazardous conditions.

Oregon recommends openings in safety railings less than 6 in. (0.15 m) in width. Where cyclists handlebars may come into contact with a fence or barrier, it is recommended that a flat rail - or rub rail - be installed at the height of 3 ft (1 m). *(4)* Various experts indicate that a vertically-oriented flat rail - or rub rail - is the preferred type of handrail as bicycle handlebars do not get caught up in flat rails as easily as in standard round handrails with exposed supporting brackets. As a result, flat rails reduce the shy distance required. (*15*) It is unclear if Oregon and others suggest these rub rail requirements for path sections, bridge sections, or both. Vermont discusses rub rails specifically on bridge sections only. (*1*)

New York recommends replacing horizontal rail systems with balusters where concentrations of small children are anticipated. The recommended standard spacing of balusters on protective rails is:

1. On the portion of any protective railing up to a height of 2.2 ft (0.68 m) measured from the path surface, the baluster spacing must be no more than 3.9 in. (0.1 m apart).

2. On the portion of any protective railing that extends above a height of 2.2 ft (0.68 m) measured from the path surface, the baluster spacing must be no more than 5.9 in. (0.15 m) apart.

In addition, a 3.9 in. (0.1 m) sphere should not be able to pass through the space between the walkway surface and the bottom rail. (*17)*

2.8 Barrier Cost

No specific barrier cost considerations were discovered during the research for this project. However one author noted that relative to the overall cost of a shared-use path, the added cost of railings can be significant. A cost estimate of a 10 ft (3 m) wide asphalt paved shared-use path through a wooded area with an average existing cross slope of 10% from a cost per linear meter standpoint is approximately $150, which is about the same cost as a three rail metal railing. The addition of a two rail metal railing with a height of 3.6 ft (1.1 m) to one side of a shared-use path may increase the cost approximately 70% to $255 per linear meter. (*30*)

If the railing is increased to a three rail metal railing that is 4.6 ft (1.4 m) high, the linear cost of the shared-use path may increase by 95% to approximately $295 per linear meter. The difference in cost between the two height railings is approximately $40 per linear meter or approximately 15% of the cost of a shared-use path with a 3.6 ft (1.1 m) high railing. (*30*)

3.0 Field Inspections

An integral part of this study was conducting field inspections of existing installations coupled with interviews of path users. By traveling to, and photographing select segments of paths, UMassD had an opportunity to:

- Study the conditions upon which rail/fencing or other barriers were present or absent.
- Monitor the relative number of path users at the time of observation.
- Collect extensive photo documentation.
- Track existing parameters such as shoulder widths, path widths, embankment slopes, porosity of fencing, etc.

Table 12 outlines the specific field inspection locations for this study.

The field inspections of the 11 paths selected by Vermont were mostly conducted in early September 2005, with a few being completed in early October 2005. The time of the inspections ranged from early morning to late afternoon. As far as the types of barriers used, UMassD noted a lot of diversity. The most common barrier was a chain link fence. But other types of barriers used included wooden posts and beams, wire mesh fences, pipe fences, metal fences, concrete blocks, rocks, and vegetation.

Table 12: Vermont Field Inspection Paths and Locations.

Path Name	Location	City or Town	Type of Project
Burlington Northern Connector	Parallel to Route 127, connecting the north end of Burlington to the Ethan Allen Homestead	Burlington	AOT Project
Burlington Waterfront Path	Along the shore of Lake Champlain on old rail bed	Burlington	City of Burlington Project
South Burlington Path	Portion identified that was funded locally	South Burlington	City of South Burlington Project
Williston Recreation Path	Near Williston Federated church by intersection of Rte 2 and North Williston Road	Williston	AOT Project
Colchester Causeway	Old railroad causeway in Lake Champlain	Colchester	Town of Colchester
Missisquoi Valley Rail Trail	Segment in the vicinity of Enosburg Village	Enosburg Village	AOT Project
Cross Vermont Trail	Newbury underpass under I-91 and approaches	Newbury	AOT Project
Barre City Path	From Barre City Elementary school paralleling Vermont Route 14	Barre City	AOT Project
Montpelier Winooski West Path	From Montpelier High School west to recreation fields paralleling the Winooski River	Montpelier	AOT Project
Wilder (Hartford) Path	From Wilder village to Dothan Brook Elementary School	Wilder	AOT Project
Toonerville Trail	Portion of path from Paddock Road (west end) to Robert Jones Industrial Building	Springfield	AOT Project

3.1 Clear Zones, Shy Distance, and Path Width

In general, the paths were two-way ranging in width from 7.5 ft (2.3 m) on parts of the Burlington Waterfront path to 13 ft (4.0 m) on parts of the Cross Vermont Trail. Most paths were somewhere between 9.2 ft (2.8 m) and 10.4 ft (3.2 m) in width. The clear widths adjacent to the path width was also equally variable, ranging from as little as 0 ft as witnessed in parts of Burlington Waterfront path to as much as 20.8 ft (6.4 m) as witnessed on parts of Montpelier Winooski.

The horizontal clear zone and/or shy distance from the path edge to a fixed object or potentially hazardous condition ranged from as little as 0 ft, as witnessed at various ravines on the South Burlington path, to 5 ft (1.5 m) at the ballpark on the Williston Recreation path. Figure 27 demonstrates a path where there was almost no clear distance between the path and the lake.

Figure 27: Burlington Waterfront - No Clear Zone to Potentially Hazardous Water Body

3.2 Barrier Height

Barrier heights were fairly variable, ranging from 2 ft (0.61 m) concrete blocks on the Burlington Waterfront path to 6.25 ft (1.9 m) chain link fences on the Cross Vermont Trail. However it should be noted that not all barriers inventoried were placed for safety. Larger height chain link fences like those on the Cross Vermont Trails were likely for property separation or another intended use.

3.3 Barrier Usage

There was definitely an inconsistency when barriers were used as well as the type of barrier versus the hazard in question. For example, gabion walls were used frequently at Burlington North, which created a cattle chute effect. Furthermore, it obstructed views (unlike locations where chain link fences were used). Figure 28 demonstrate the cattle chute effect created on some paths.

Figure 28: Missisquoi - Cattle Chute Effect from Chain Link Barriers on Each Side of Path

Wilder had similar problems with the frequent use of walls. However, since the walls there abut residences, they provide privacy to residents. Figure 29 demonstrates the use of walls in a residential setting to maximize residents' privacy, and the transition to chain link fences to maximize path user views and visibility once residences come to an end.

Figure 29: Wilder - Walls for Screening Purposes (Privacy) at Residences

Another example of selective barrier use is exhibited in Figure 30, which demonstrates the use of a terrain barrier (ditch) instead of a fence in a setting where the latter would be obtrusive to the park setting of the path. Based on the actual side slope from the path to the ditch, this terrain barrier may require a hard barrier to be installed to protect path users from a steep slope condition.

Figure 30: Williston -Terrain Barrier (Ditch)

3.4 Potential Hazard Conditions

As far as the types of potentially hazardous conditions noted, these were also fairly diverse across the trails ranging from a waterfall at Toonerville to railroad tracks at Montpelier Winooski West. Overall, UMassD encountered many potentially hazardous conditions across the eleven paths, including:

Boulders/Big Rocks

These were witnessed at the side of paths at both Colchester Causeway and Burlington Waterfront. Figures 31 through 33 demonstrate the large rocks encountered the paths that may pose a risk to path users since many were within or very near the fixed object clear zone of 2 ft (0.6 m) minimum [3 ft (0.9 m) preferred]. It was unclear if these boulders were set there to be a barrier or were just a natural feature. If they were set as a barrier they were not effective in preventing path users from entering the water bodies, since the boulders do not have the appropriate minimum safety height and are not continuous along the hazard.

Figure 31: Colchester Causeway - Boulders at Water Body

Figure 32: Colchester Causeway - Boulders at Water Body

Figure 33: Burlington Waterfront - Boulders at Water Body

Obstructions on Path

Some unique circumstances, likes benches on paths were also noted. The problem was that in some cases they were hidden by shrubbery as in the case of some benches on Burlington Waterfront path. This could be hazardous for people on the benches who may get up to step onto the path as well as path users who may not see the bench because of the blind corners caused by vegetation. Once again, UMassD noted the lack of signs warning path users of the upcoming bench as witnessed at Toonerville. Figure 34 demonstrates the potentially hazardous condition posed by benches.

Figure 34: Burlington Waterfront - Bench on Path

Vegetation

Vegetation was noted that could cause a number of problems. For example, it was noted as overgrown on paths such as Burlington Waterfront and South Burlington, which created blind corners. Figures 35 and 36 demonstrate the types of vegetation overgrowth witnessed on the paths that may decrease visibility and therefore path user safety.

Figure 35: South Burlington - Potential Vegetation Overgrowth

Figure 36: Burlington Waterfront - Potential Overgrowth onto Path

Vegetation also created hazards when tree limbs landed on paths, just as a matter of course on Burlington Waterfront, where a disabled person in a wheel chair indicated problems getting around on more than one occasion because of them. Figures 37 through 39 demonstrate the range of debris witnessed on the paths. (Debris could be anything from fallen leaves, which can create slippery conditions when there is rain, to fallen trees.)

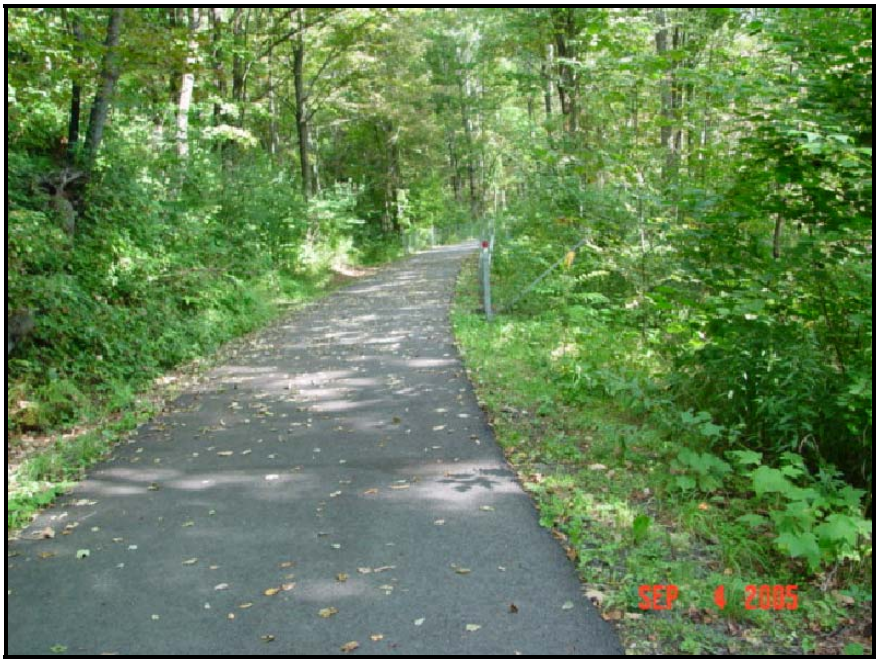

Figure 37: Barre -Vegetation Debris

Figure 38: Wilder - Vegetation Debris

Figure 39: Colchester Causeway - Vegetation Debris

3.5 Barrier Types

UMassD noticed the following types of barriers during field inspections: chain link fence, wooden post and beams, wooden stiles, wire mesh fences, cable fences, pipe fences, metal fences, concrete blocks, rocks, and vegetation.

The porosity of the fencing was also noted and was fairly broad ranging from none on the gabion walls at Burlington North to 8.3 ft wide by 1.25 ft high (2.54 m x 0.38 m) on the pipe fences at Burlington Waterfront. Figures 40 and 41 demonstrate some examples of the fencing porosity encountered during the field inspections.

Figure 40: Burlington - Cable Fencing

Figure 41: Burlington Waterfront - Wooden Railing Fence

By contrast, Figures 42 through 48 demonstrates the use of various types of fencing, all with sufficient porosity to facilitate safety without hampering visibility in various settings. Figures 47 and 48 demonstrate common deterioration of fences noted in the field inspections.

Figure 42: Barre - Chain Link Fence

Figure 43: Cross Vermont Trail - Safety Railing

Figure 44: Williston - Chain Link Fencing at Curve

Figure 45: Wilder - Fencing at Curve

Figure 46: Montpelier Winooski - Fencing at Curve

.

Figure 47: Barre - Deteriorated Wire Mesh fencing

Figure 48: Burlington Waterfront - Deteriorating Pipe Fence

3.6 Inconsistent Barrier Usage

Inconsistent barrier usage was a recurring problem across most of the paths surveyed. For example, in terms of the embankment slope, Montpelier Winooski was the most consistently fenced near steep drops (embankment slope ranged from 1:6 to 1:2) and where there were small clear zones. Furthermore, in general the path had generous shoulders where there were no fences.

On the other hand, Toonerville was the least consistently fenced near steep drops and where there were smaller shoulders. For example, at one location on the river where there was no barrier and the shoulder width was 3.3 ft (1.0 m), the embankment slope was 1:1. Yet nearby, at another location on the river where the shoulder width was slightly smaller at 2.9 ft (0.9 m) and the embankment slope was 1:1, there was a barrier. In both these cases the path width was the same. Figures 49 through 57 demonstrate this trend.

Figure 49: South Burlington - Inconsistent Use of Fencing

Figure 50: South Burlington - Inconsistent Use of Fencing

Figure 51: Montpelier Winooski - Inconsistent Use of Fencing

Figure 52: South Burlington - Inconsistent Use of Fencing

Figure 53: Montpelier Winooski - Inconsistent Use of Fencing

Figure 54: South Burlington - Inconsistent Use of Fencing

Figure 55: Toonerville - Inconsistent Use of Fencing

Figure 56: Toonerville - Inconsistent Use of Fencing

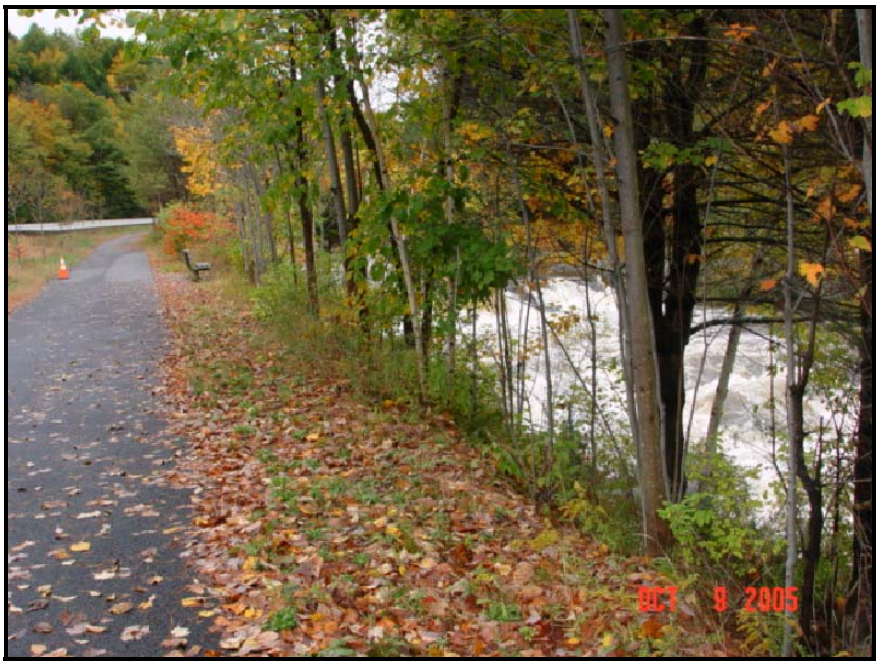

Figure 57: Toonerville Waterfall- Inconsistent Use of Fencing

The other paths, in general, were fairly inconsistent in their barrier placement when it came to the embankment slope:

- At Barre, there was one location near the main road where the embankment slope was 1:2 and no barrier was used. Yet nearby, where the embankment slope was also 1:2, a barrier was used.

- At Burlington Waterfront, there is a drop to the lake behind the cemetery where the grade is 1:2 and there is a fence. Yet, nearby where the grade is 1:2 there is no barrier.

- At Burlington South, on a downhill portion of the path, there is fencing on the part of the path where the embankment slope is 1:2. Yet nearby, where the grade is 1:2 (and in addition to the downhill aspect of the path there is also a curve in the path) there is no fence.

- At Wilder, some extreme variations in embankment slope were noted. In one area the embankment slope was 1:27 (near the residences) versus where it was nearly a straight vertical drop above the stream.

4.0 Path User Survey Results

Based on this research and interviews of 51 path users at the 11 paths recommended by Vermont, bicycling (51%) and walking (30%) were the predominant two overall path uses. Furthermore, the top two reasons users liked their respective paths were scenic views (21%) and convenience (19%). In terms of the presence of hazardous areas on the paths, in most cases (57%) respondents indicated that this was in fact an issue. The most evident examples of these were on paths such as:

- Burlington Waterfront - Broken fencing in parts coupled with the porosity of the fencing, could be easy for path users to fall through

- Toonerville - Lack of fencing in dangerous locations such as by the waterfall increase exposure to hazards

On a positive note, the majority of respondents across all paths felt that fencing height was "just right" (74%), "aesthetically appropriate" (69%) and fences were "located where most necessary" (73%). And while most (72%) could not think of areas on the paths for additional barriers, there was a consistent disparity between people with children and those without when it came to recommending more fencing. Of course, due to inclement weather, no respondents were encountered on two paths (Cross Vermont and Wilder).

The full results of the path users' survey are located in Appendix A.

5.0 Internet Survey Results

An online survey was created to help quantify the existing state of practice of fencing usage on shared use paths. A copy of this survey is located in Appendix B. The survey was sent to local, regional, state and national path managers, path designer, barriers designers and each state's Bicycle and Pedestrian Coordinator in New England

Only eleven responses to the internet survey were received. Therefore, because of the sample size, the results while very informative, may not be statistically significant. The results are presented for general informational purposes only.

The survey suggests that bicycle facility experts feel that the shared path users were fairly heterogeneous ranging from pedestrians (16%) and joggers (16%) to bicycles (16%) and in-line skates (14%).

Most bicycle facility experts avoid one way directional paths in favor of the safer, bi-directional paths including both paved (71%) and unpaved (29%) ones.

Hard barriers were the most frequently specified (35%), followed by live barriers (25%) and finally terrain barriers (20%). (These general barrier types are described in Section 2.3) Other miscellaneous types of barriers were also common in 20% of the cases.

Most bicycle facility experts feel AASHTO does not offer a lot of direction in terms of specifications or guidelines for shared path barrier usage and design. So, some states like Florida have developed their own. Other states, such as Colorado, use AASHTO standards in conjunction with their own locally designed standards. Overall, the majority of respondents (64%) followed a particular specification or guideline in regards to shared path barrier usage and design.

Aesthetics was the number one factor considered when selecting the type of barrier with 29% of respondents concerned with blending in with the environment. Practical concerns such as cost (20%) and space (20%) were also factored into the decision. Transparency, which is correlated with porosity and therefore safety, was a lower priority (11%).

There was some flexibility in terms of factors considered when determining the height of shared use path barriers. The purpose of the barrier was the primary concern (35%), followed by its location (28%). The third factor considered was equally split between fence type (17%) and adjoining properties (17%). Very few respondents considered the type of users (3%).

As far as the type of fencing used as a barrier, respondents indicated their states used a wide range of options. The most common fences used were the decorative metal picket fence (18%) and wooden three-rail fence (18%) followed by chain link fences (14%), and low walls with railing (14%). Live barriers such as natural features (11%) and dense vegetation (7%) were less common.

Respondents were evenly split between the use of wider separations (45%) and physical barriers (44%) to protect against hazards. In terms of the types of hazard conditions present that mandate the use of barriers to protect path users, 27% of respondents indicated vertical drop hazards were their biggest challenge. Roadways (19%) and rivers/lakes/creeks/other bodies of water (19%) tied for the second most common hazard. Unsafe crossings (13%) and impaired visibility (6%) were also challenges that designers have to contend with.

In the majority of the cases (46%) a path's horizontal and vertical alignment did not relate in anyway to barrier selection policies. However, in the majority of cases (56%) a path's shoulder width did impact decisions to use barriers. Most states (55%) do not provide guidelines for additional shy distance to barriers such as fences. However, in addition to shy distance, some do provide a clear zone on each side of the path (29%) and/or a wider separation (21%) when the path is adjacent to canals, ditches or slopes steeper than 1V:3H.

In 42% of the cases, the width of paths impacted respondents' decisions to use barriers under various circumstances. Interestingly, in only 14% of the cases, the width of paths impacted decisions to use barriers on sharp curves. And in only 7% of the cases, the width of paths impacted decisions to use barriers on steep grades.

The definition of a hazardous side slope varied among respondents. 1V:3H (34%) and 1V:6H (33%) were closely tied for first place followed by 1V:2H (17%).

The type of shrubbery, bushes and groundcover used in the states was fairly diverse (56%), but low growing plants were also fairly common (31%). By contrast, non-deciduous plants were not widely used (13%). The purpose of placing the vegetation also varied greatly (46%), but common reasons were to disallow growth over the path (23%) as well as to disallow interference with visibility of trail user (23%).

One area where there was overwhelming consensus was with respect to the type of embankment material used to impact path user safety. 62% of respondents use grass or vegetated slopes. 15% use a combination of grass or vegetation slopes coupled with rock and crushed stone. And another 15% use other techniques. Interestingly, respondent's choice of embankment material was not contingent upon its availability and/or its proximity to barriers in the majority of the cases (64%).

Finally 91% of respondents follow AASHTO specifications and guidelines when designing and specifying a barrier for a shared-use path even though AASHTO does not offer much guidance in this area.

The full results of the Internet survey are presented in Appendix B.

6.0 Barrier Usage Guideline Development

This section outlines the development of the *"Shared Use Path Barrier Usage Guideline"* located in Appendix C. This guideline was developed by primarily synthesizing the information compiled in the literature review. Limited information from the field inspections, path user interviews, and bicycle facility specialist survey were also used. Whenever possible, a conservative value approach was used in specifying exact values. The users of this guideline should recognize that these values are suggestions only, and that specific site details may supersede the use of this guideline. Best engineering practices and sound engineering judgment should be used at all times to protect the shared path users since safety is of the utmost importance. This guideline is not intended to replace or supersede any AASHTO, DOT, or other specification.

The first portion of the guideline outlines the need to identify the purpose of a barrier. From the literature review, Section 2.1, the main functions of barriers were determined to be: access control, aesthetics/decoration, noise abatement, property separation/delineation, safety, screening, and wind abatement. Barriers for these purposes, except safety, lacked any true design criteria as determined in the literature review. Since the literature review did not uncover any firm engineering criteria, the guideline was scripted to state that barrier designs and location decisions for these purposes will need to be subjectively made on a case-by-case basis using good engineering judgment.

Next, some general considerations, as they apply to all barriers, were presented. Specifically, as documented in the literature review and survey portions of this research, the following was added:

1. Barrier selection should be made based on user safety first and then aesthetics. With the wide variety of materials and fencing barrier types, the designer should be able to find a compromise in aesthetics without giving up safety.

2. Barriers themselves can be a safety hazard since they are a pathside obstruction. However, sometimes the placement of a barrier is required to protect path users from a more hazardous condition.

3. Caution should be used when curbing is part of a feature adjacent to a path. In some cases, curbed islands have been used to separate paths from adjacent roadways. However curbs should not be used as barriers from these hazards because they can cause hazardous conditions of their own and might restrict users with disabilities.

4. Barriers should be transitioned away from the path at the leading and trailing end, if possible. The ends of the barriers themselves can be hazardous to path users, thus a gradual transition of the barrier away from the path edge is recommended.

5. Live forms of barriers require much more maintenance and can produce their own hazards. Branches, leaves, and other vegetation can line the path surface, thus creating a possible hazardous condition for path users. Also, vegetation can easily overgrow the

path if it is not maintained consistently. Hard barriers will still require maintenance, but careful selection of materials and construction should permit that these go longer periods of time without regular maintenance.

Next, the guideline addresses barriers for safety purposes. These are barriers designed to protect path users from hazardous conditions where injury may result. Based on the literature review, the main factors in selection of a barrier for safety purposes were: width of available clear zone/recovery area (Section 2.1.1.1), embankment slope adjacent to the path (Section 2.1.1.3), any vertical drop adjacent to the path (Section 2.1.1.3), any hazardous condition (waterways, ravines, etc.) at the base of the slope adjacent to the path (Section 2.2), and the material present on the side slope (Section 2.1.1.6). Based on these items and the barrier need determination factors (Section 2.2), a design selection guide was formulated. Most of the currently available design suggestions address two or three of the main barrier selection factors for safety, however, this guide incorporates all five of the main safety selection factors.

The tabular design guide was created to address not only a single safety factor but the combined effects of many safety factors at the same time. In terms of clear zone (recovery area) widths, Vermont presented the most thorough design guidance. Their design guide not only addresses paved and unpaved trails, but also embankment slope and vertical drop-off hazards. Using Vermont's guide as a starting point, the values stated were compared with the others sources noted in the literature review and the most conservative values were selected. The final results of this analysis are outlined in the following tables. The first table is for paved surface shared use paths, and the second is for unpaved shared use paths. The description of the geometric parameters (recovery area, embankment slope, and vertical drop heights) required for the barrier usage guideline tables are outlined in Figure 58.

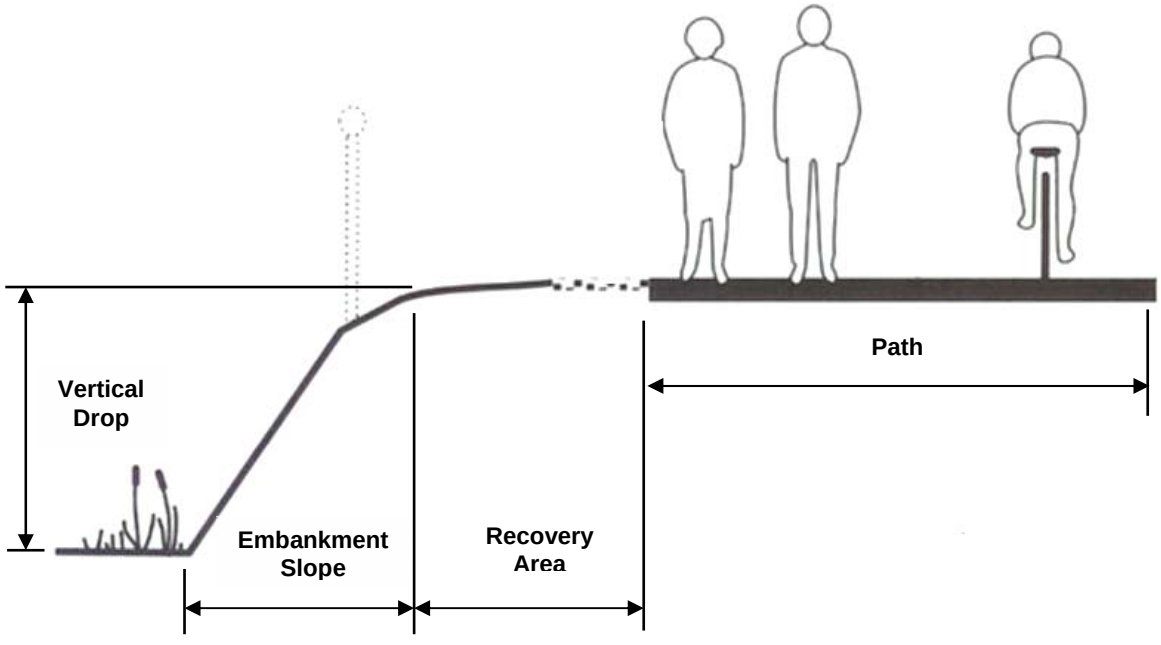

Figure 58: Description of Geometric Parameters Required for Barrier Usage Guideline
Adapted from: Vermont Pedestrian and Bicycle Facility Planning and Design Manual. December 2002.

Instructions for using the tables were also included as well as two specific step-by-step examples. To use these tables, the user must know the values the relative values for clear zone (recovery area), embankment slope, and vertical drop heights for their situation. Also, the user must know what the final side slope material will be as well as if there is, or will be, a hazard condition at the bottom of the side slope. Then, starting on the left of the table, the user enters the table at the value of the available recovery area. Next the user must examine each scenario presented for that value of recovery area and determine if any are a match for their particular case. The scenarios shown indicate when a barrier should be used adjacent to a shared use path. Some scenarios require the user to subjectively assess the hazards and side slope material.

Paved Shared Use Path Trail Surface														
		Embankment Slope				Vertical Drop				Hazard** at Bottom of Slope		Side Slope Material***		
Recovery Area	**Scenario**	1: 4 or Flatter	1:3	1:2	Steeper than 1:2*	10" - 2 ft (0.25 - 0.6m)	3 ft (0.9m)	4 ft (1.2m)	5 ft (1.5m) or Greater	Yes	No	Soft	Hard	**Remarks**
<3 ft (0.9 m)	1	X				Any Vertical Drop				Either		Either		See Notes 1-3
	2		X			Any Vertical Drop				Either		Either		
	3			X		Any Vertical Drop				Either		Either		
	4				X	Any Vertical Drop				Either		Either		
3 ft - <4 ft (0.9 -1.2m)	1		X						X	Either		Either		
	2		X			Selected Vertical Drops				X				Note 2
	3		X			Selected Vertical Drops					X		X	Note 3
	4			X		Any Vertical Drop				Either		Either		
	5				X	Any Vertical Drop				Either		Either		
4 ft - <5 ft (1.2 -1.5m)	1		X			Any Vertical Drop				X				Note 2
	2		X			Any Vertical Drop					X		X	Note 3
	3			X				Selected Vertical Drops						
	4			X		Selected Vertical Drops				X				Note 2
	5			X		Selected Vertical Drops					X		X	Note 3
	6				X	Any Vertical Drop				Either		Either		
>5 ft (1.5 m)	1	Any Embankment Slope				Any Vertical Drop				X				Note 2
	2	Any Embankment Slope				Any Vertical Drop					X		X	Note 3

* Includes vertical drop-offs next to path.

** Possible hazards include waterways, water bodies, ravines, active roadways, active railways, etc. A hazard can be any item that can comprise the safety of a path user if they encounter it.

*** Example of "Soft" materials is grass. "Hard" materials include rip-rap, rocks, boulders, etc.

Note 1: Generally no barrier necessary for 1:4 or flatter slopes. Evaluate on a case-by-case basis.

Note 2: Barrier use dependent on severity of hazard condition at bottom of slope. Evaluate on a case-by-case basis.

Note 3: Barrier use dependent on possible injury that could result from crash into side slope material. Evaluate on a case-by-case basis.

Unpaved Shared Use Path Trail Surface														
		Embankment Slope				Vertical Drop				Hazard** at Bottom of Slope		Side Slope Material***		
Recovery Area	**Scenario**	1: 4 or Flatter	1:3	1:2	Steeper than 1:2*	10” - 2 ft (0.25 - 0.6m)	3 ft (0.9m)	4 ft (1.2m)	5 ft (1.5m) or Greater	Yes	No	Soft	Hard	**Remarks**
<2 ft (0.6 m)	1	X				Any Vertical Drop				Either		Either		See Notes 1-3
	2		X			Any Vertical Drop				Either		Either		
	3			X		Any Vertical Drop				Either		Either		
	4				X	Any Vertical Drop				Either		Either		
2 ft - <3 ft (0.6 - 0.9m)	1		X						X	Either		Either		
	2		X			Selected Vertical Drops				X				Note 2
	3		X			Selected Vertical Drops					X		X	Note 3
	4			X		Any Vertical Drop				Either		Either		
	5				X	Any Vertical Drop				Either		Either		
3 ft - <5 ft (0.9 -1.5 m)	1		X			Any Vertical Drop				X				Note 2
	2		X			Any Vertical Drop					X		X	Note 3
	3			X				Selected Vertical Drops						
	4			X		Selected Vertical Drops				X				Note 2
	5			X		Selected Vertical Drops					X		X	Note 3
	6				X	Any Vertical Drop				Either		Either		
>5 ft (1.5 m)	1	Any Embankment Slope				Any Vertical Drop				X				Note 2
	2	Any Embankment Slope				Any Vertical Drop					X		X	Note 3

* Includes vertical drop-offs next to path.

** Possible hazards include waterways, water bodies, ravines, active roadways, active railways, etc. A hazard can be any item that can comprise the safety of a path user if they encounter it.

*** Example of “Soft” materials is grass. “Hard” materials include rip-rap, rocks, boulders, etc.

Note 1: Generally no barrier necessary for 1:4 or flatter slopes. Evaluate on a case-by-case basis.

Note 2: Barrier use dependent on severity of hazard condition at bottom of slope. Evaluate on a case-by-case basis.

Note 3: Barrier use dependent on possible injury that could result from crash into side slope material. Evaluate on a case-by-case basis.

In addition to the barrier selection tables, a note was added to address other important factors in the barrier determination process. As outlined in the literature review, these include clear distance to fixed objects (Section 2.1.1.2), sharp curves (Section 2.1.1.4), path width (Section 2.1.1.5), and other geometric considerations (Section 2.1.1.7), should be taken into account when designing for safety. These items are considered in the design of a safe shared use path, however, their engineering criteria is specific and generally consistent from agency to agency.

7.0 Conclusions

The research conducted for this project was used to formulate a design guideline that identifies situations where barriers should be used adjacent to a shared use path based on clear zone width, embankment slope, vertical drop, hazards at bottom of the slope, and side slope material. Moreover, the research determined the following:

Limited research has been conducted regarding guidelines and specifications relating to barrier usage and placement adjacent to shared use paths across. Through the use of Transportation Research Board's Transportation Research Information System (TRIS) access and other sources, existing guidance on design of shared use paths and any information related to fencing/barriers was compiled.

The reasons to use a barrier adjacent to a shared use path were determined to be: access control, aesthetics/decoration, noise abatement, property separation/delineation, safety, screening, and wind abatement. Little engineering criteria existed for the design and placement of barriers for all of these functions, except safety. In terms of safety, barriers are primarily used to protect path users from hazardous conditions. The most common hazardous conditions identified in the literature review were: insufficient recovery area, insufficient clear distance to fixed objects, vertical drop-offs and steep embankment slopes, insufficient path width, sharp curves, and path surface condition.

Based on the literature review many sources were consistent in terms of following AASHTO standards in a variety of shared use path related criteria. This was further reinforced by the results of the Internet survey where 91% of respondents indicated adherence to AASHTO standards. But it was also evident that when it comes to barrier usage, AASHTO offers very little guidance.

Barrier types were classified into the general classification of hard, live and terrain. Hard barriers included fences, walls, guardrails, concrete barriers, and safety railings. Live barrier included vegetation, trees, shrubs, and bushes. Terrain barriers included any natural occurring features like rock walls and grade separations.

A series of field investigations across eleven shared use paths in Vermont was also performed. The goal was to aid in determining conditions where barriers become necessary. Aside from the potential hazards identified in the literature review, new potential hazards encountered included a range of issues from big boulders/rocks, obstructions on the path, overgrown vegetation and path surface condition. Most of these potential hazards are not addressed specifically by AASHTO. It was also noted during the field investigations that horizontal distance to the potential hazard was critical.

Another observation was fencing usage in terms of height as well as frequency. While the former was fairly variable, the latter was rather inconsistent. For example, on more than one occasion and on more than one path similar circumstances where fencing was employed in one place but not in the other were encountered.

As a part of the field investigations, 51 path users were interviewed regarding their perceptions of safety, aesthetics and path use. In general, 74% of path users felt that the height of the barriers on the paths were just right and 69% felt fences were aesthetically appropriate for their respective setting. In addition, 73% felt that fences were placed where they were most necessary and 67% felt fences were maintained well enough to prevent additional hazards. And finally while 92% did not feel barriers were being set up unnecessarily, 72% did not see the need for additional barriers. Of course, the biggest discrepancy in this case was between people with children and those without.

The third step in the research involved preparing an Internet survey and sending it to various DOTs in the United States to study the available guidelines and specifications relating to the design of shared use paths, with emphasis on protective edges and scenarios of fencing usage. The response to this survey was limited and the results were presented in the report for informational purposes only.

Finally, the specification was formulated primarily based on the literature review. The field inspections and the interviews with path users were also utilized. This specification was constructed to identify when a barrier is required based on the combinational effects of the width of available clear zone (recovery area), embankment slope adjacent to the path, any vertical drop adjacent to the path, any hazardous condition (waterways, ravines, etc.) at the base of the slope adjacent to the path, and the material present on the side slope.

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Appendix

Appendix A

Path User Interviews

Path User Interview Questions

Date: _____
Time: _____
Initials: _____
Path Location/ID: _____
Type of Barrier Located Nearby: _____

1. How do you usually use this path?
   - Bicycle
   - Walking
   - Jogging
   - Rollerblading
   - Wheelchair
   - Handcycle
   - Other:

2. What do you like most about this path?
   - Convenience/proximity to home
   - Rural setting
   - Path network
   - Low volume of use
   - High volume of use
   - Condition of path
   - Views
   - Grade
   - Accommodations for the disabled
   - Other:

3. Do you think there are any hazardous areas along this path? If so, where?

_____

4. What do you think about the height of the barriers on this path?
   - Too high
   - Too low
   - Just right
   - Varies (Please elaborate)

5. What do you think about the type of barriers used on this path?
   - Aesthetically appropriate for this setting
   - Not aesthetically appropriate for this setting
   - Obstruct views
   - Creates too many hazards (e.g. fallen leaves)
   - Varies (Please elaborate)

6. Do you feel barriers on this path are located where they are most necessary (eg at hazards)?
   - Yes, always
   - Sometimes (please elaborate)
   - No (please elaborate)

7. Are there any areas on this path that you feel additional barriers would be beneficial?

_____

8. Are there any areas on this path that you feel barriers are used unnecessarily?

_____

9. Do you feel the barriers on this path are maintained adequately to prevent additional hazards?

_____

10. Is there anything else about the barriers on this path you would like to share?

_____

11. May we contact you if we have any follow up questions regarding your feedback?

_____

Path User Interview Questions

COMMENTS

1. How do you usually use this path?
    - Stroller
    - Snow shoeing
    - Fishing

2. What do you like most about this path?
    - I like its proximity to shops and buses
    - It's in good condition only in the paved parts of the path
    - Needs paving so people can roller blade
    - Cars do not have access to it

3. Do you think there are any hazardous areas along this path? If so, where?
    - Needs improvement by the school. One spot is especially bad where cars cross the path. It's also bad by the playground.
    - There are problems every spring when part of the path gets washed out by the water. There are also problems with broken branches being on the path as well as broken glass.
    - It is kind of narrow
    - 3 things: the bikers are disrespectful of the walkers, the holes in the pavement and unleashed dogs
    - The biggest issue is people who don't know the rules and walk on the left instead of the right. Maybe add signs to apprise them of the rules. And mandate use of dark leashes (that can be seen) on dogs.
    - It's easy to slide on the gravel because it is so thick
    - The non paved parts of the path
    - Just the old copper wires
    - Needs rest spots and garbage barrels
    - Where it crosses 105 is an accident waiting to happen. Also in one crossing south of Berkshire there is a terrible blind spot. Plus state cops use the path to back into for speed traps. And finally, the path is next to a four-wheeler bike shop and they get on here too.
    - The crossings with 105 and the motor vehicles
    - The septic truck keeps pulling onto the path
    - There are a few areas where the path comes up
    - Yes, people are the hazards
    - Please light the path so we can use it at night.
    - Please plough path so we can use it during winter time
    - Please clean up tree limbs left by beavers on the path more regularly
    - Need fence by the waterfall; need better fences for the kids
    - Not if you stay on the path

4. What do you think about the height of the barriers on this path?
    - Vegetation obstructs views around corners
    - I did not know they were there
    - In some areas the barriers are too low for children
    - I prefer if there were no barriers at all
    - I don't notice them
    - They could be higher
    - I prefer none – they are distracting
    - No opinion
    - Never thought about it
    - Never noticed them
    - If they were any higher, you could not see the river and if they were any lower it would be dangerous for the kids.

5. What do you think about the type of barriers used on this path?
    - Bridge gets really slippery at Callahan park, right after the restrooms
    - Attractive near Burlington, but it's not so nice further south
    - Shanty at railroad tracks is not covered - creates a hazard
    - The less fences the better
    - I don't think about it
    - Hardly ever notice them

6. Do you feel barriers on this path are located where they are most necessary?
    - Needs trim work
    - Needs bollards
    - They are inconsistent. Hard to tell why they are in one place, but not in another
    - Never noticed them

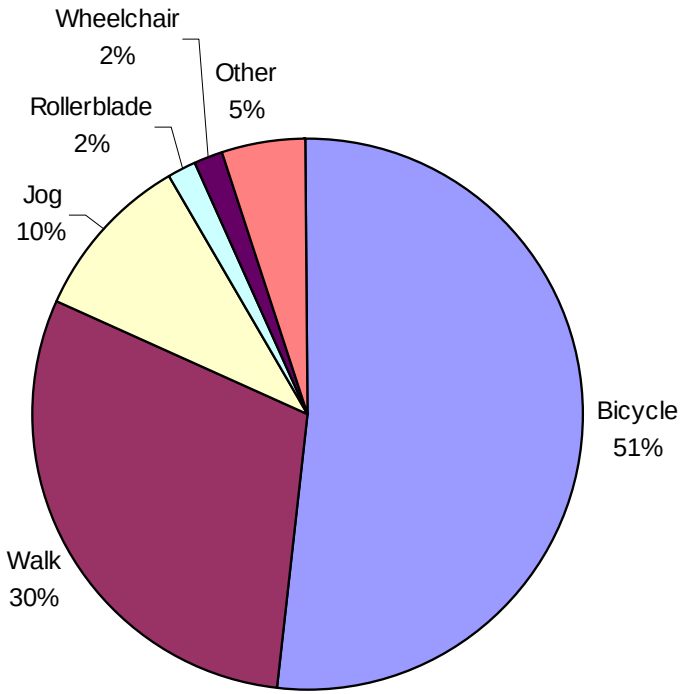
7. Are there any areas on this path that you feel additional barriers would be beneficial?
    - Yes, near the water. But I prefer it unfenced
    - Spot down past water treatment plant next to Blodgits
    - Please add restrooms
    - Yes, in some cases like around Texaco beach where there are paths off the path and kids can just take off
    - Yes, the area where the path is close to the water
    - Where there are steep drops
    - Limit high speed on areas that cross 105, add bridges or signs or culverts
    - Bollards are needed
    - Under the under pass and along the deep drop south of Grandview
    - By the road on the hill
    - Yes, by the waterfall
    - No, they obstruct views
    - Just maintain paths better by getting rid of tree limbs

8. Are there any areas on this path that you feel barriers are used unnecessarily?
    - ❖ I don’t notice the barriers

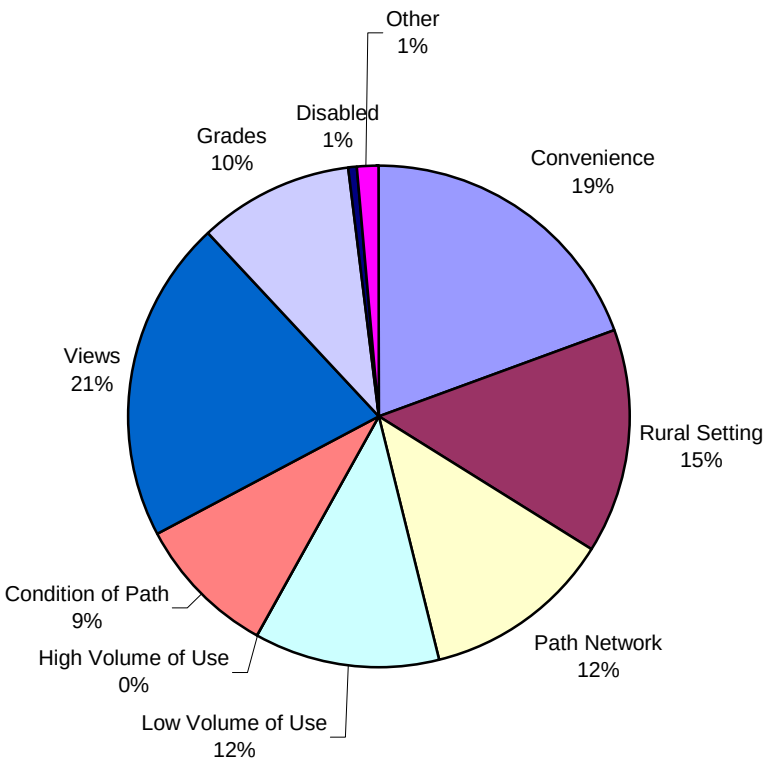
9. Do you feel the barriers on this path are maintained adequately to prevent additional hazards?
    - ❖ Kids keep tearing down the fences
    - ❖ Trees keep falling down on to the path
    - ❖ There are areas of overgrowth of vegetation
    - ❖ Please plough in the winter time
    - ❖ Can’t get on it in the winter time
    - ❖ Not down by lakeside weeds
    - ❖ Issue remains with speed of cars on 105
    - ❖ I don’t even look at that stuff
    - ❖ Need more maintenance on branches

10. Is there anything else about the barriers on this path you would like to share?
    - ❖ There are a lot of new cyclists in North Beach. Need signs in both French and English to apprise them of the rules and regulations here.
    - ❖ School kids damage fences so need new ones
    - ❖ Path should be extended
    - ❖ We live where we live because of this path
    - ❖ Too low in areas, making it easy for kids to (as an example) jump into the water
    - ❖ Don't block views with high barriers
    - ❖ I don't believe in every conceivable danger being addressed
    - ❖ Don't put anything along water. Knee high highway barriers don't bother me as much as chain link fences, which would not stop kids anyway.
    - ❖ They are not noticeable
    - ❖ I like the rocks and trees
    - ❖ Dangerous approaching Kennedy Drive, where asphalt turns to concrete
    - ❖ Need to set up cones or something to warn people when vehicle is on path to clear/cut back vegetation
    - ❖ If we had small kids, we’d care more
    - ❖ Just need more barriers
    - ❖ Beavers keep damaging the trees and littering the path with tree limbs
    - ❖ I never thought about them.

Composite Of All Paths
How Do You Usually Use This Path?

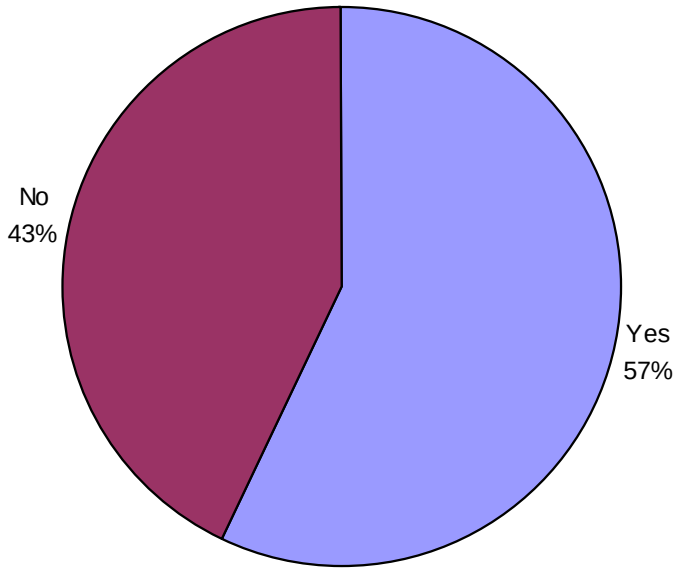


Composite Of All Paths
What Do You Like Most About This Path?



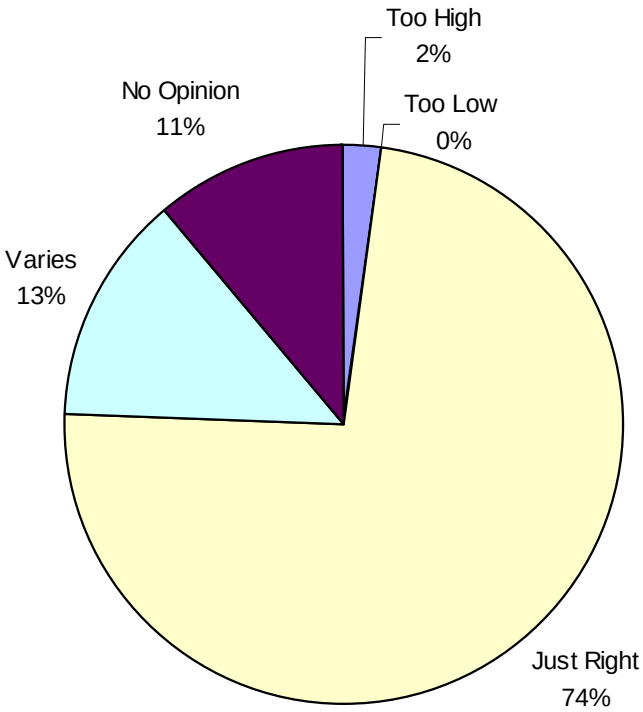
Composite Of All Paths

Do You Think There Are Any Hazardous Areas Along This Path?



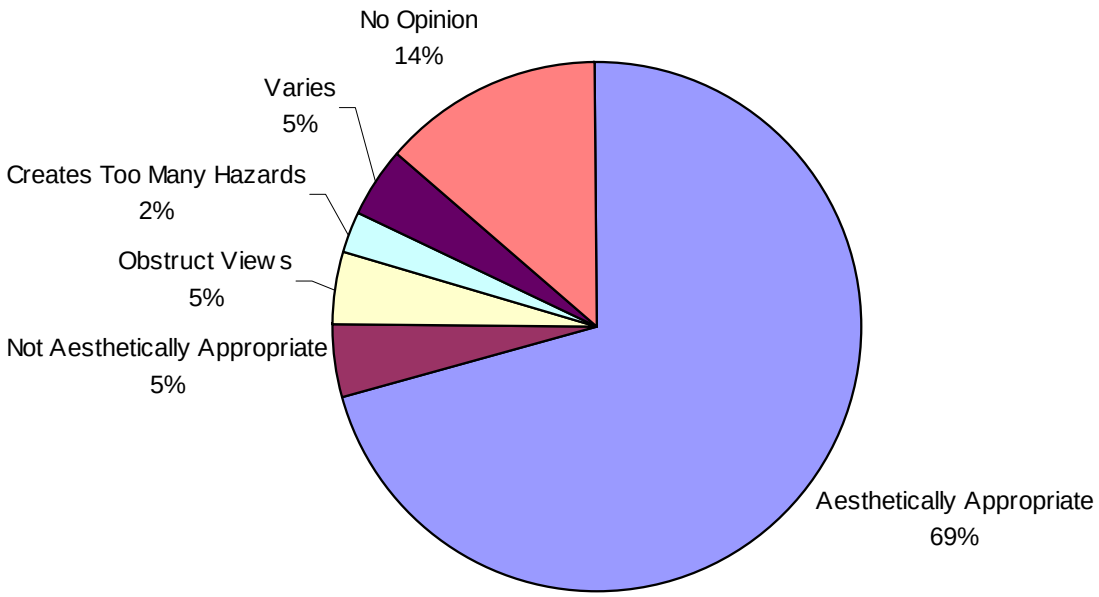
Composite Of All Paths

What Do You Think About The Height Of The Barriers Used On This Path?



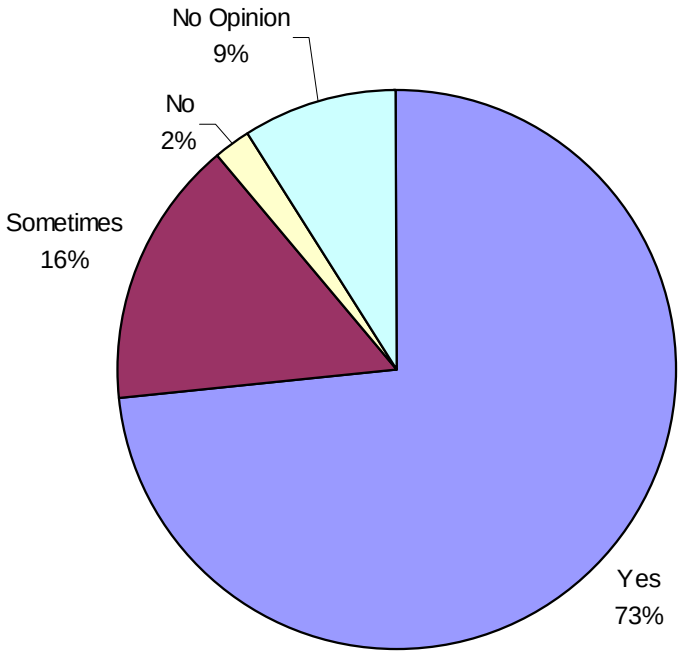
Composite Of All Paths

What Do You Think About The Type Of Barriers Used On This Path?



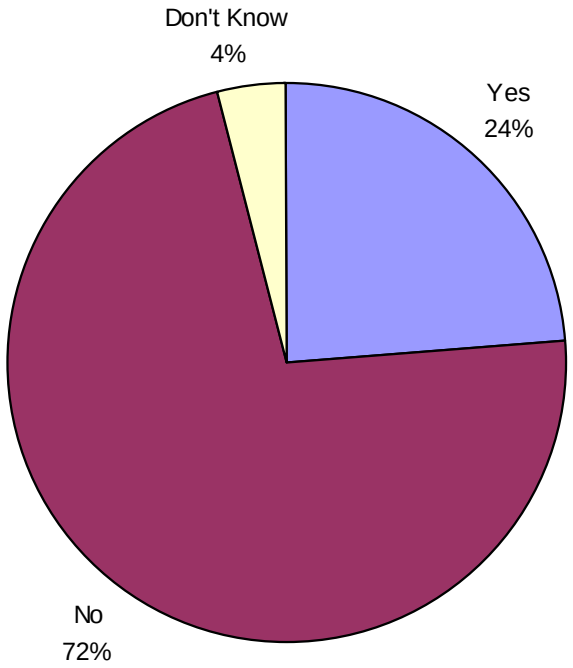
Composite Of All Paths

Do You Feel Barriers On This Path Are Located Where They Are Most Necessary?



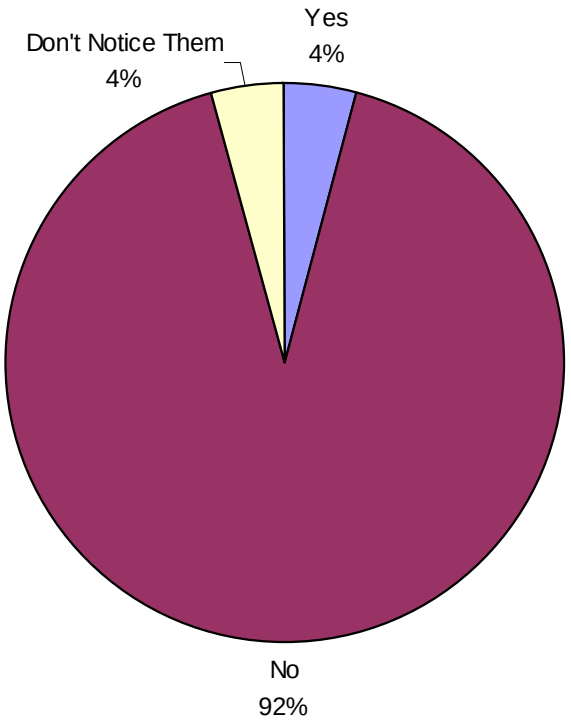
Composite Of All Paths

Are There Any Areas On This Path That You Feel Additional Barriers Would Be Beneficial?

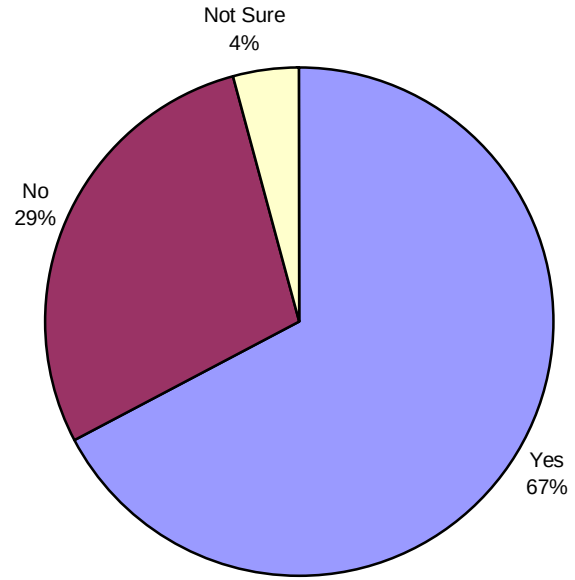


Composite Of All Paths

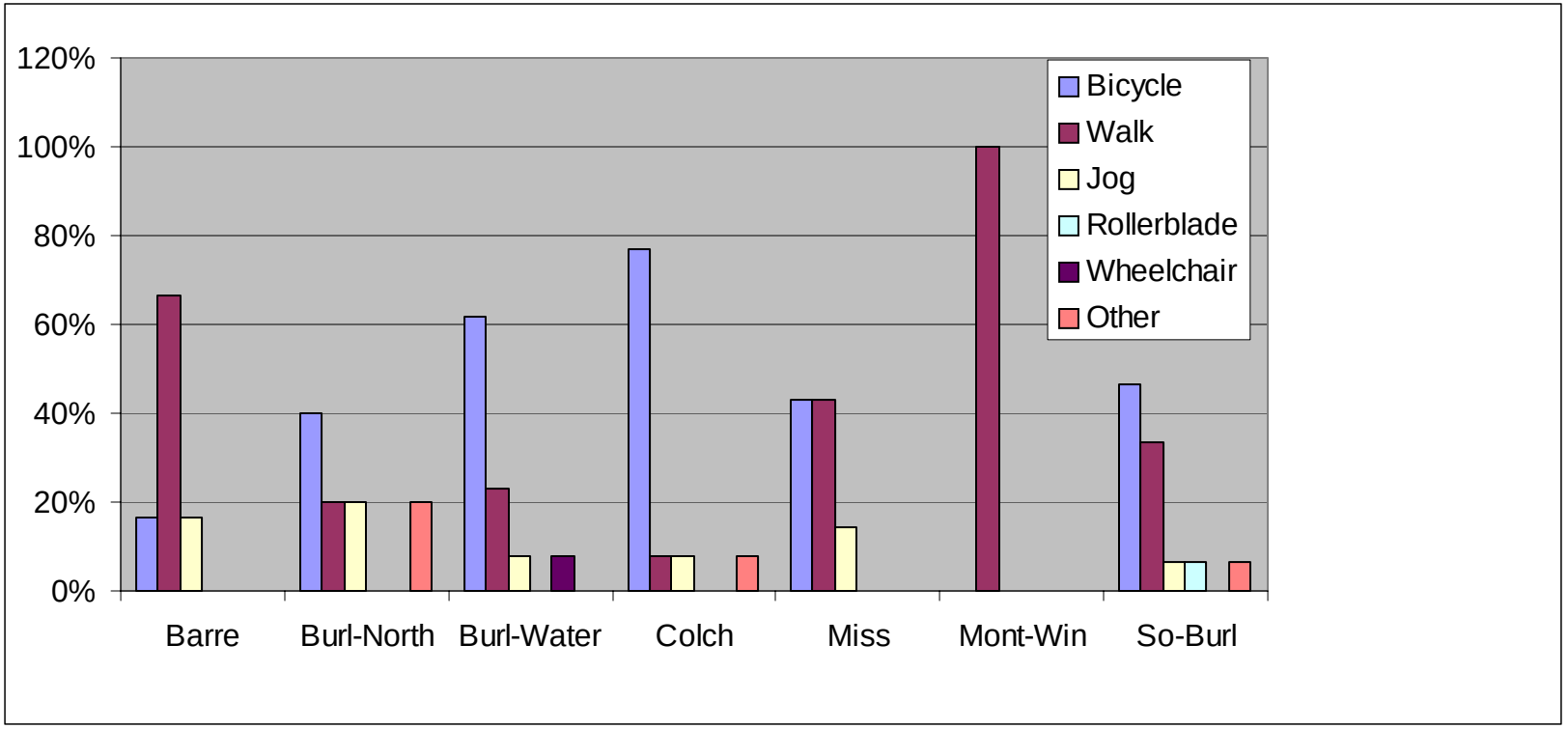
Are There Any Areas On This Path That You Feel Barriers Are Used Unnecessarily?



Composite Of All Paths
Do You Feel That Barriers On This Path Are Maintained Adequately To Prevent Additional Hazards?

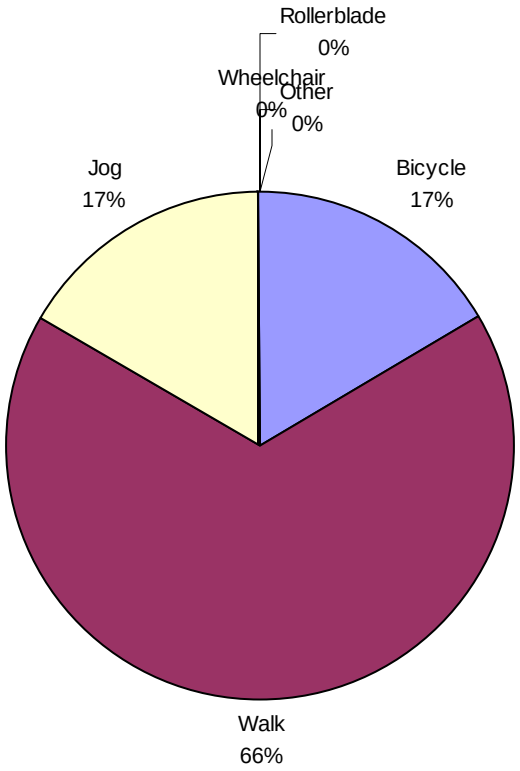


Q1: How do you usually use this path?

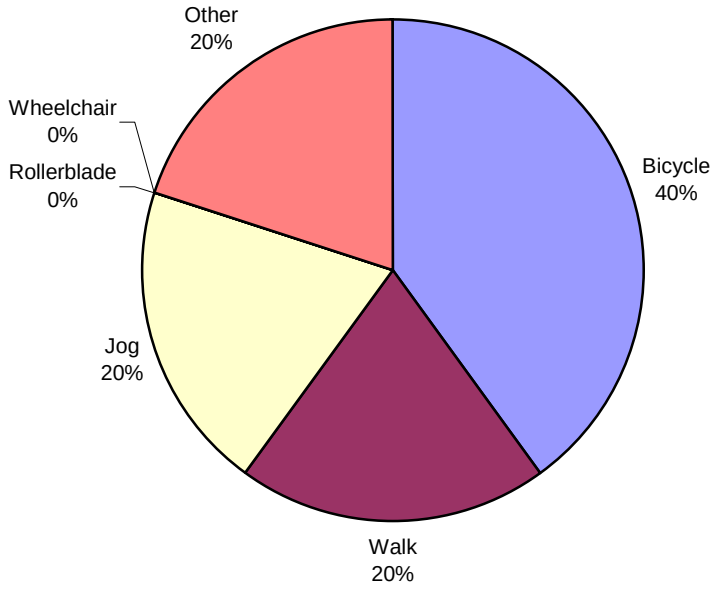


Q1: How do you usually use this path?

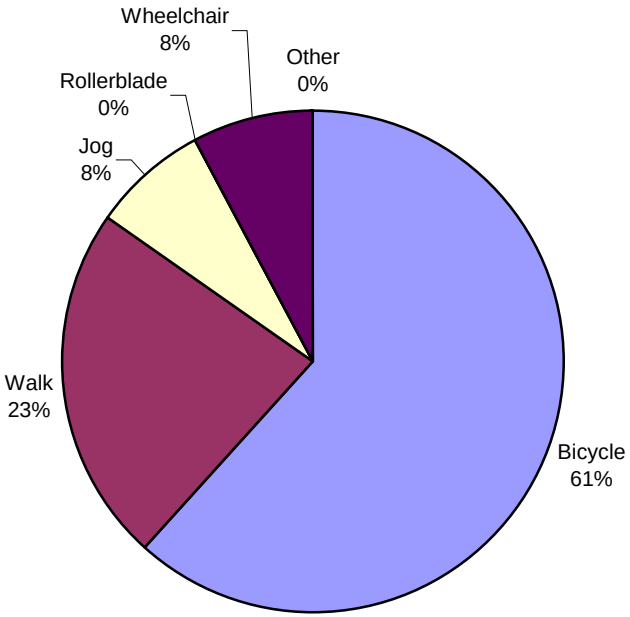
Barre



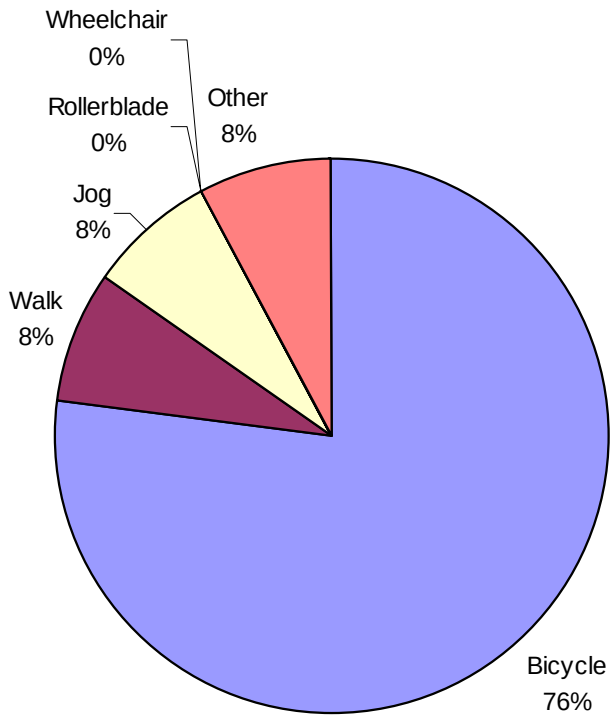
Q1: How do you usually use this path?
Burlington North



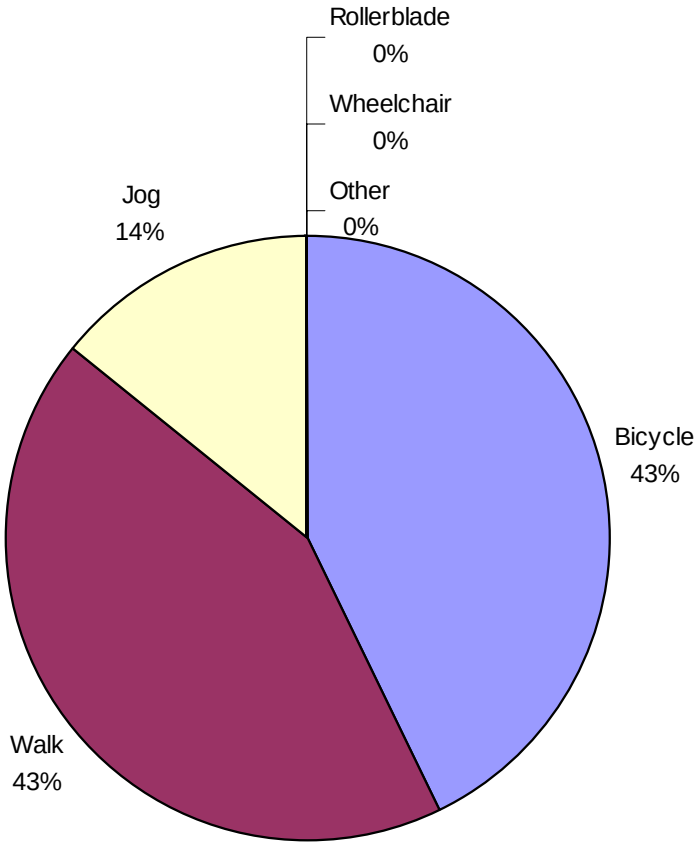
Q1: How do you usually use this path?
Burlington Water



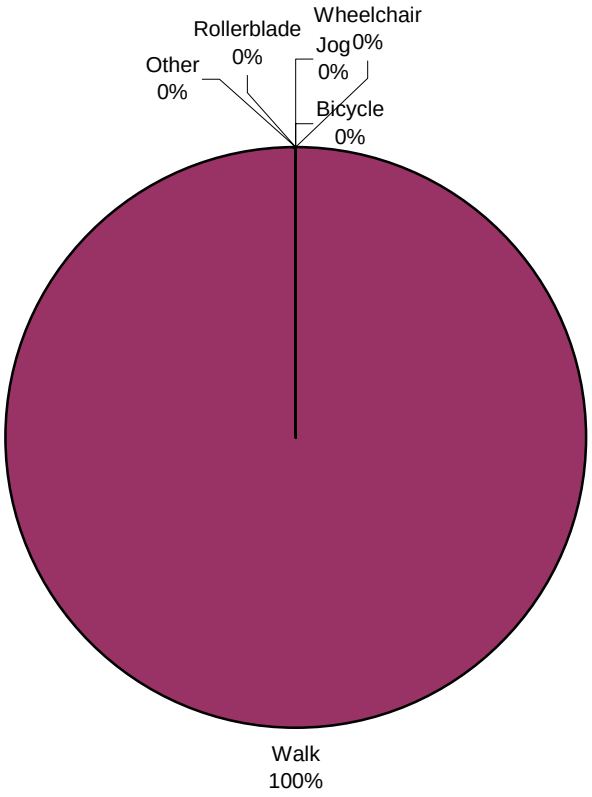
Q1: How do you usually use this path?
Colchester



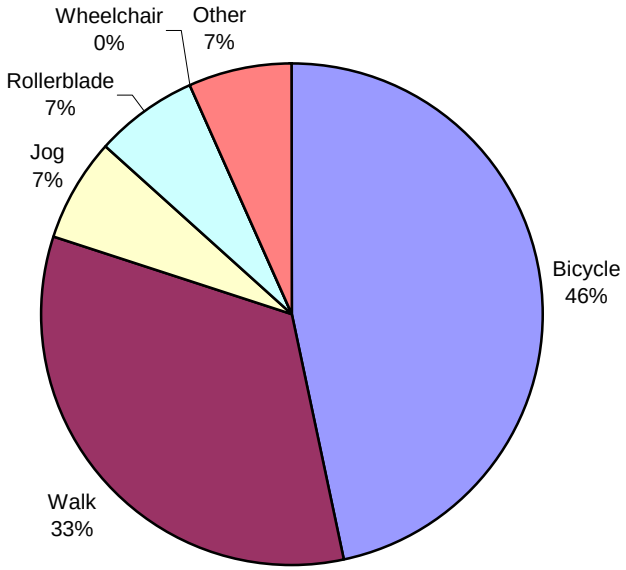
Q1: How do you usually use this path?
Missisquoi

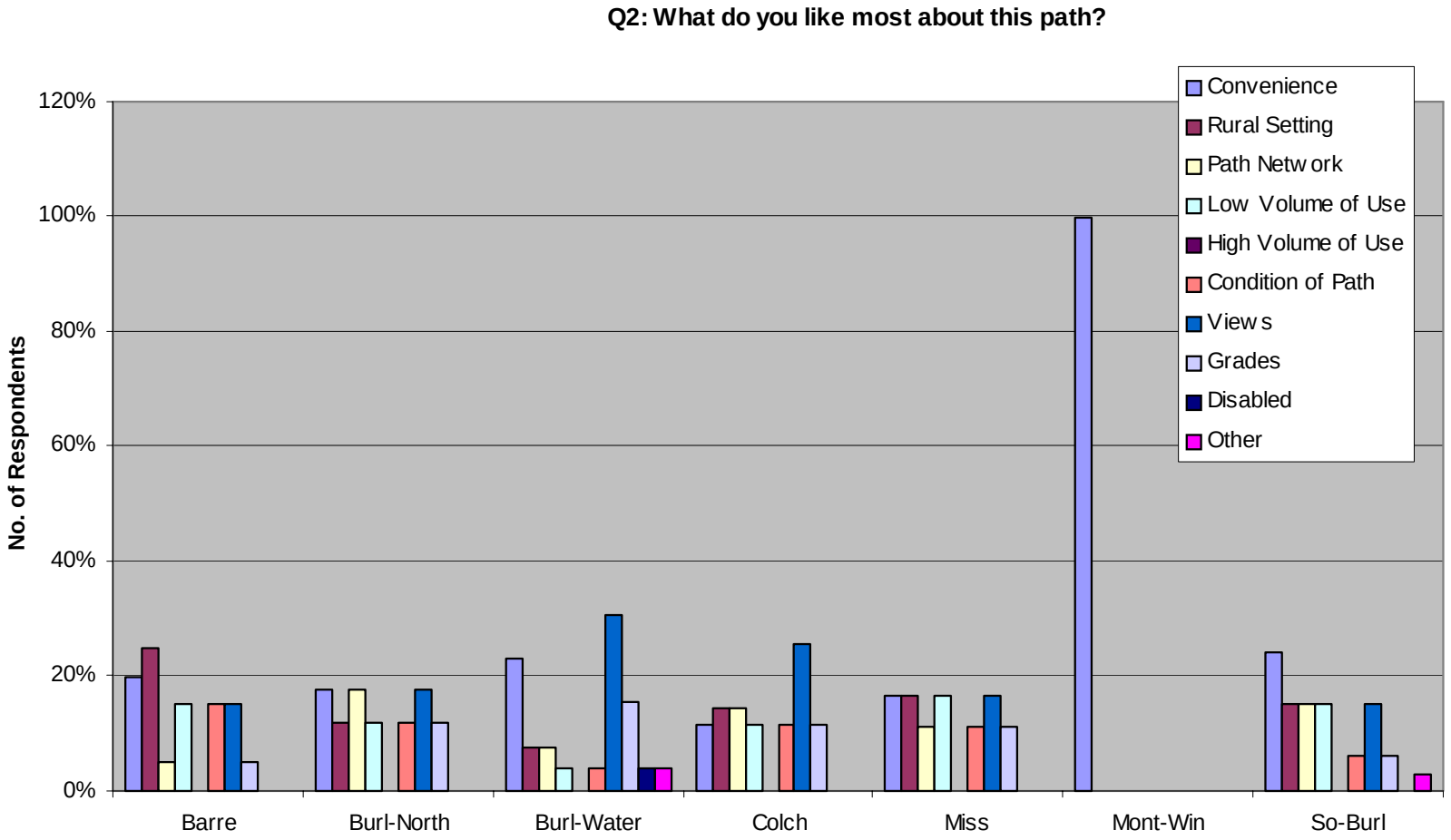


Q1: How do you usually use this path?
Montpelier-Winooski

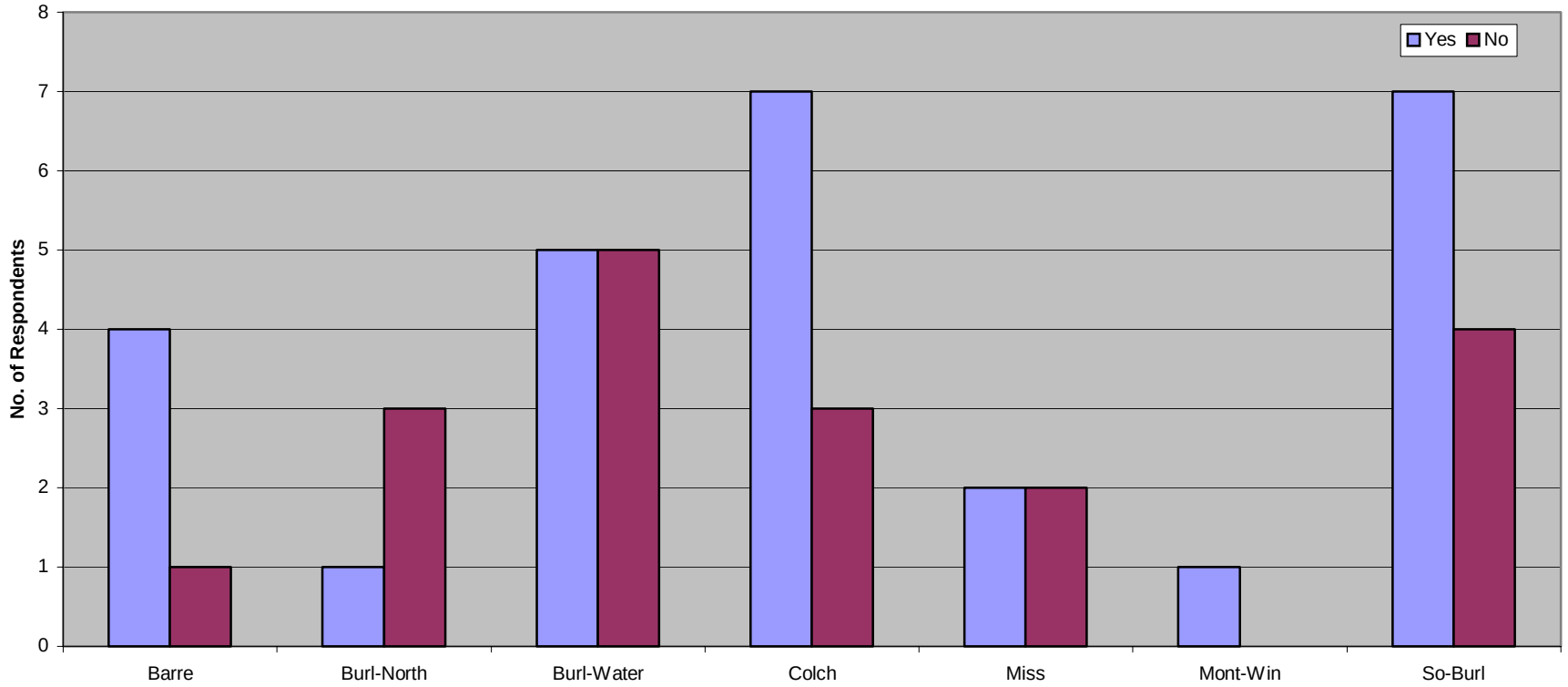


Q1: How do you usually use this path?
South Burlington

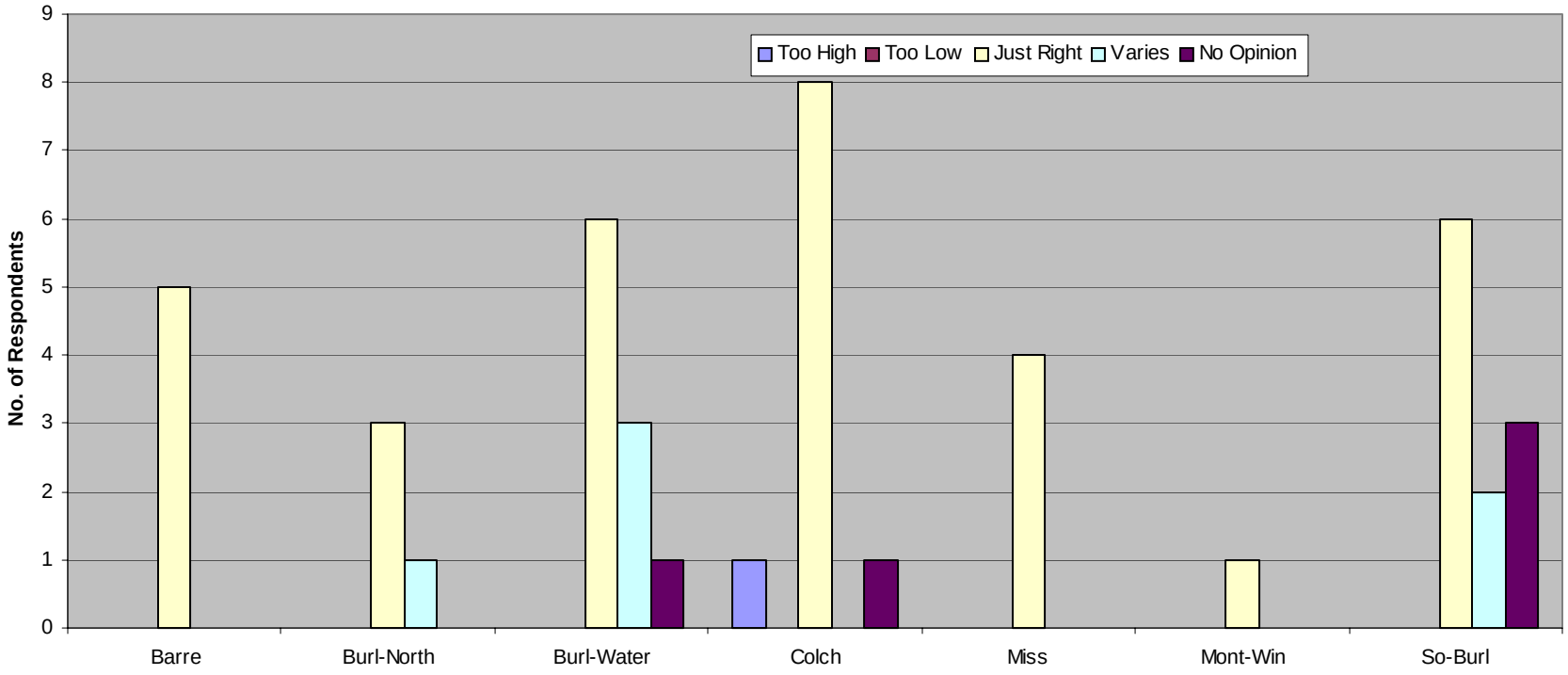



Q2: What do you like most about this path?
No. of Respondents
120%
100%
80%
60%
40%
20%
0%
Barre
Burl-North
Burl-Water
Colch
Miss
Mont-Win
So-Burl
Convenience
Rural Setting
Path Network
Low Volume of Use
High Volume of Use
Condition of Path
Views
Grades
Disabled
Other

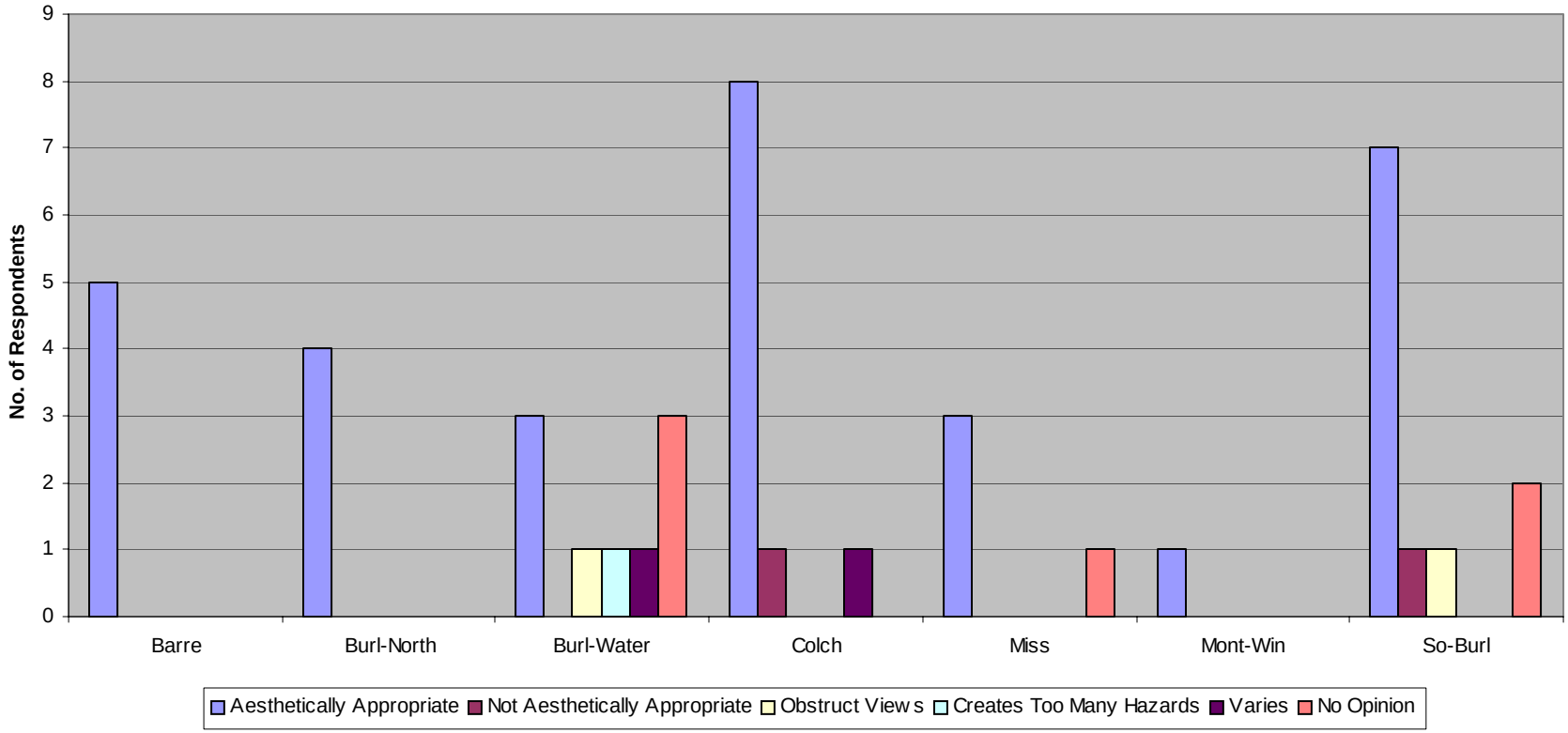
Q3: Do you think there are hazardous areas along this path?



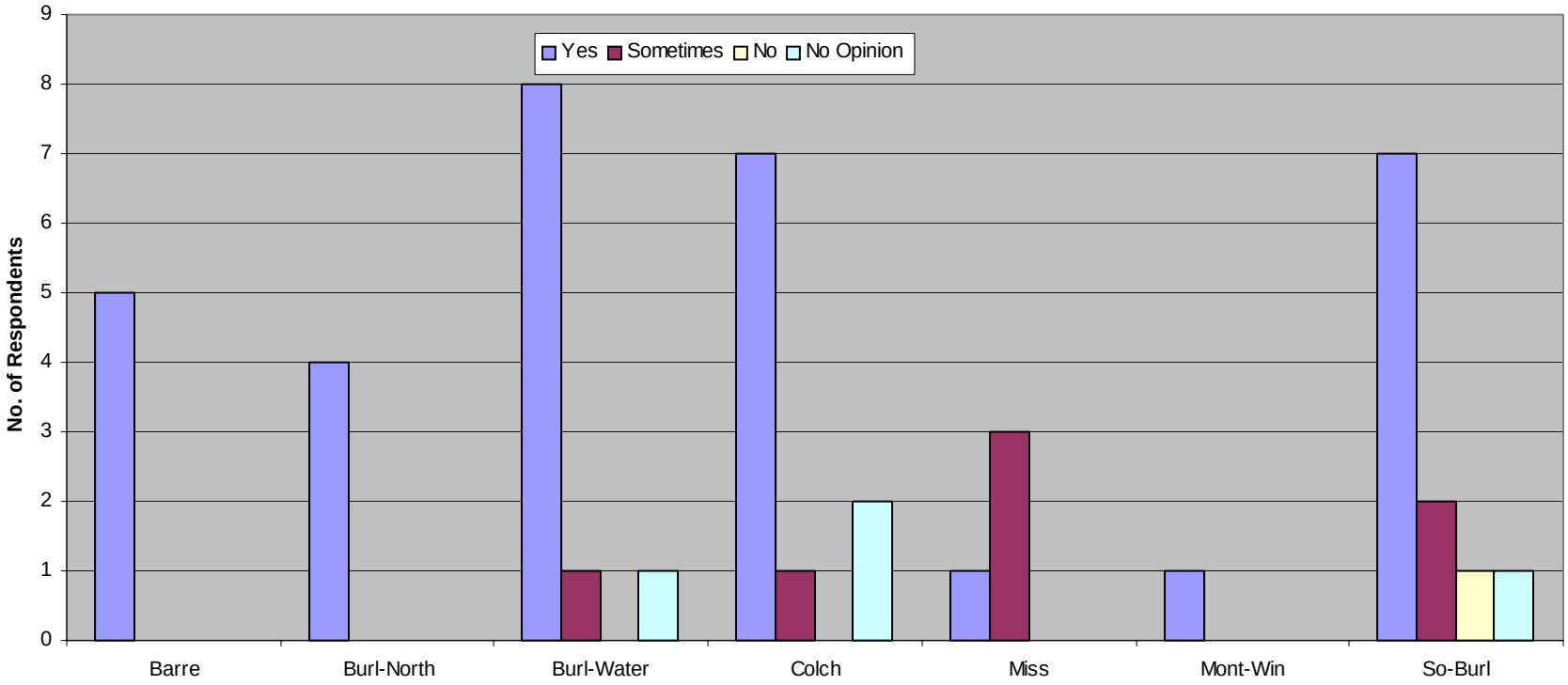
Q4: What do you think about the height of the barriers on this path?

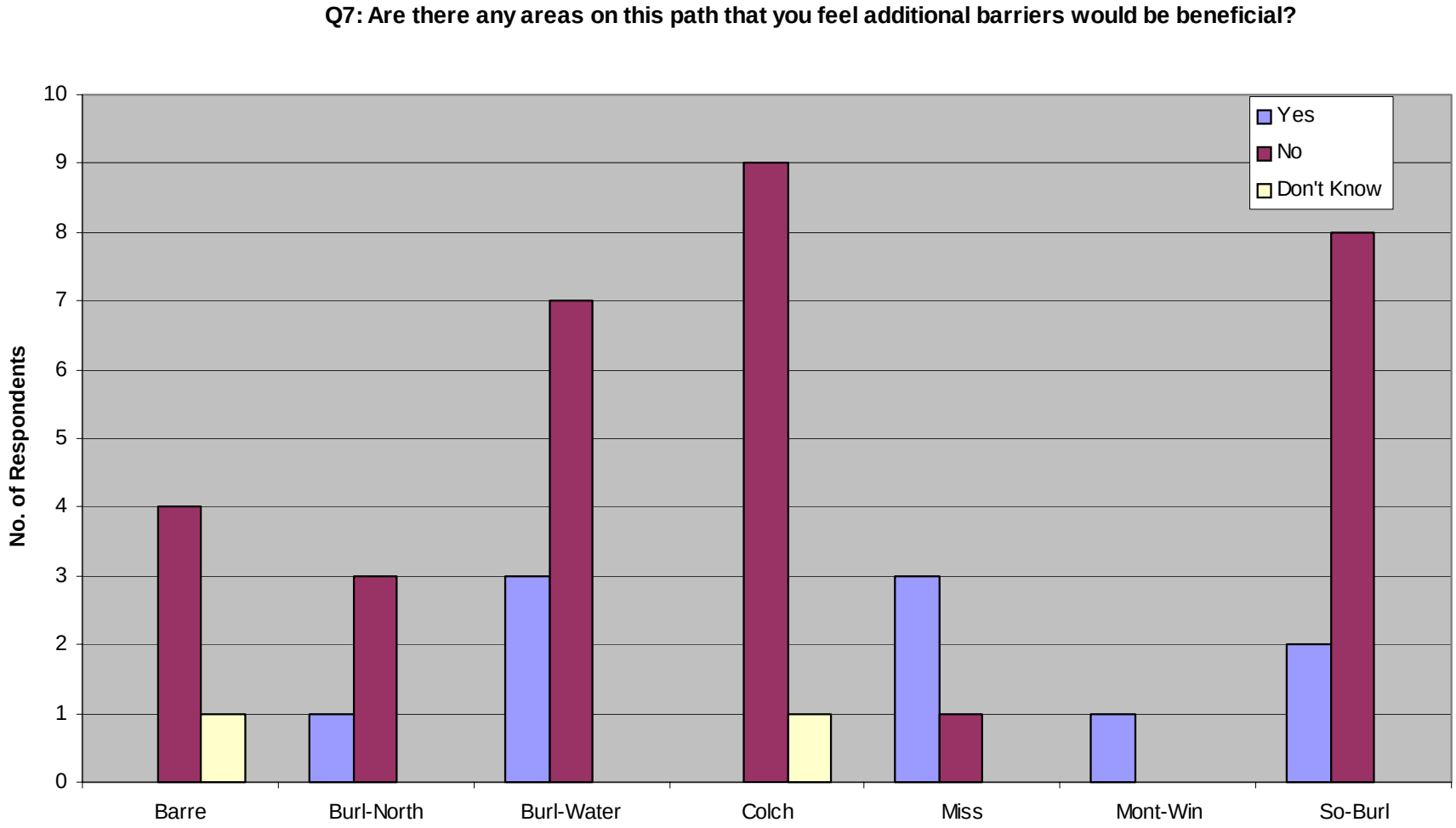


Q5: What do you think about the types of barriers used on this path?

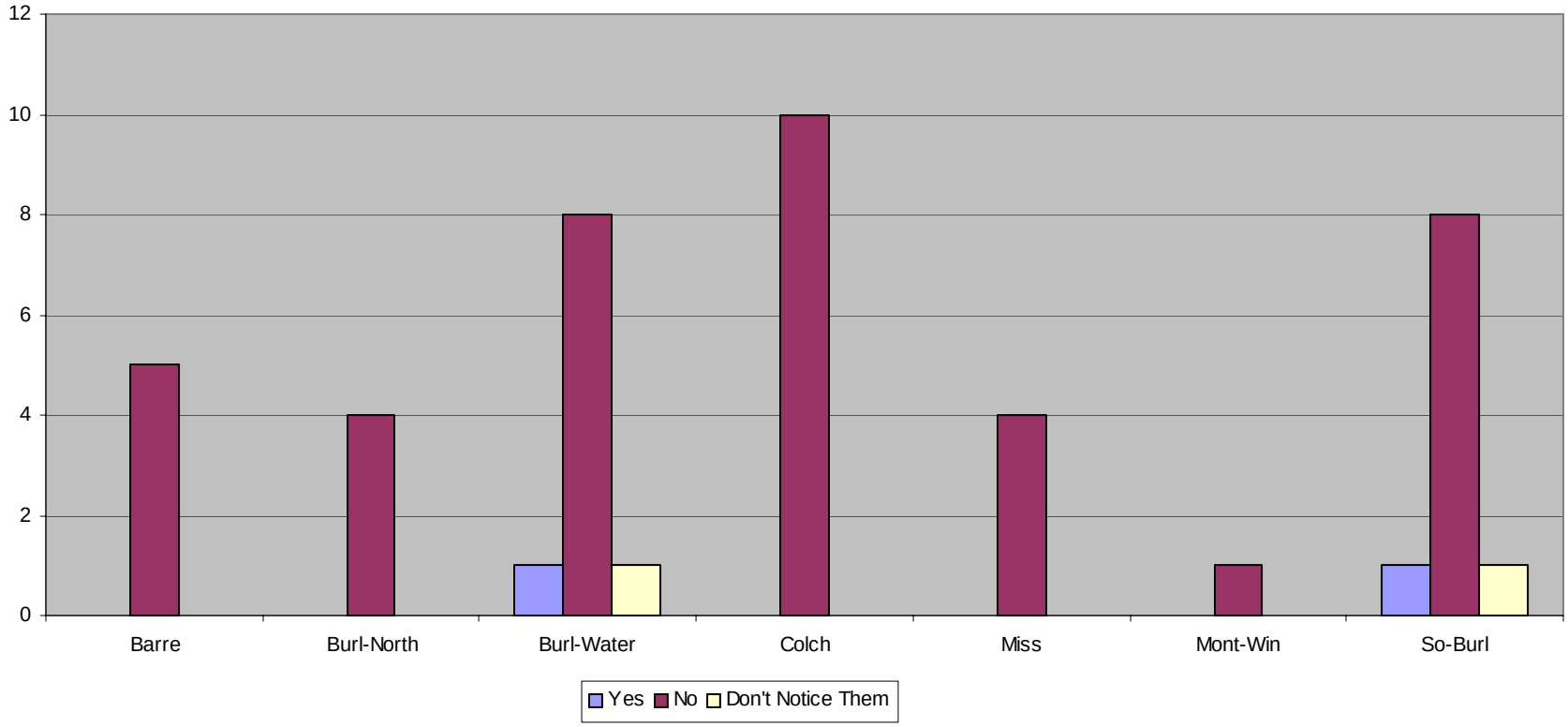


Q6: Do you feel the barriers on this path are located where they are most necessary?

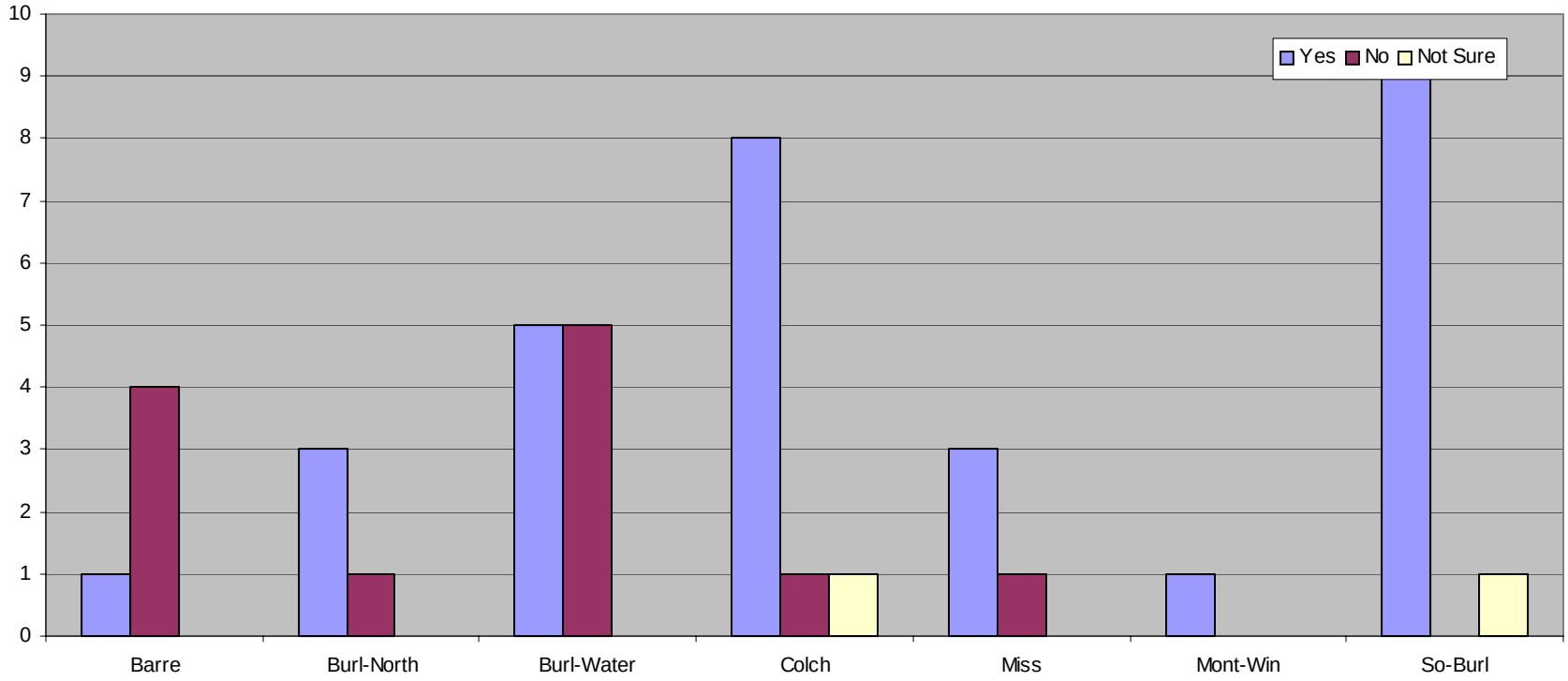



Q7: Are there any areas on this path that you feel additional barriers would be beneficial?
No. of Respondents
10
9
8
7
6
5
4
3
2
1
0
Yes
No
Don't Know
Barre
Burl-North
Burl-Water
Colch
Miss
Mont-Win
So-Burl

Q8: Are there any areas on this path that you feel barriers are used unnecessarily?



Q9: Do you feel barriers on this path are maintained adequately to prevent additional hazards?



Appendix B

Internet Survey

<u>Please Note:</u>
Only eleven responses to the internet survey were received. Therefore, because of the sample size, the results while very informative may not be statistically significant. The results are presented here for general informational purposes only.

Introduction

Dear Path Professional,

The University of Massachusetts Dartmouth (UMassD) was recently commissioned by the Vermont Agency of Transportation (VTrans) to research the available guidelines and specifications relating to the design of shared use paths, with emphasis on protective edges and scenarios of barrier/fencing usage. For the purposes of this research, shared use paths are defined as recreational trails dedicated for outdoor activities and are not subject to vehicular traffic in close proximity. Please note that bridge barriers along shared use paths are not included in this research.

Below find a brief survey designed to ascertain current practices in this area. Please complete this survey at your earliest convenience. In return for your valued contribution, UMassD will forward you a copy of the final survey results.

If you are aware of someone else within your organization who is qualified to fill out this survey, please forward a copy to them or contact me and I will send them a copy.

If you have any further questions regarding this study, please don't hesitate to contact me. I look forward to hearing from you.

Thank you in advance for your time.

Sincerely,

Dr. Walaa S. Mogawer, P.E.
Professor of Civil and Environmental Engineering
University of Massachusetts Dartmouth
wmogawer@umassd.edu

Take the survey

VTrans Vermont Agency of Transportation

Shared Use Path Survey

Below is a brief survey designed to collect data on the current use and design of shared use path facilities in your state, especially in terms of barrier usage to protect path users from a hazard condition. All barriers should be considered when answering, except those occurring at path bridges.

Your Contact Information:

Please enter your contact information below. Your name, title and organization are required; your phone and email are optional.

Name:
Title:
Organization:
Email:
Phone Number:

1. Which of the following users are the shared use paths in your state designed to accommodate?

- ☐ a. Pedestrians
- ☐ b. Joggers
- ☐ c. In-line Skates
- ☐ d. Skateboards
- ☐ e. Bicycles
- ☐ f. Recumbent Bicycles
- ☐ g. Adult Tricycles
- ☐ h. Wheelchairs
- ☐ i. Strollers
- ☐ j. Snowmobiles
- ☐ k. Cross-country Skiers
- ☐ l. Horses
- ☐ m. Other:

2. Are the shared use paths in your state typically?

- ☐ a. One-directional paved paths
- ☐ b. One-directional unpaved paths
- ☐ c. Bi-directional paved paths
- ☐ d. Bi-directional unpaved paths
- ☐ e. Other:

3. What types of barriers do you typically use on shared use paths?

- ☐ a. Live (planted)
- ☐ b. Hard (fences)
- ☐ c. Terrain barriers (channels, berms, depressions, and retaining walls)
- ☐ d. Other:

4. Does your state follow any particular specification or guideline in regards to shared path barrier usage and design?

- ○ a. Yes: _____
- ○ b. No

5. What factors do you consider when selecting the type of barrier to use?

- ☐ a. Cost
- ☐ b. Space
- ☐ c. Transparency
- ☐ d. Minimizing unwanted snow deposition
- ☐ e. Blending in with the environment
- ☐ f. Other: _____

6. How is the appropriate height for a shared use path barrier determined in your state?

- ☐ a. Location
- ☐ b. Purpose
- ☐ c. Fence type
- ☐ d. Adjoining properties (e.g. golf courses)
- ☐ e. Types of users

7. What is the typical porosity of the barrier? Why?

8. What maintenance considerations are weighed when deciding the type of barrier to install?

9. With regards to fences and railings used as a barrier, which of the following does your state usually specify? Are there any reasons for specifying a particular type?

- ☐ a. Decorative metal picket fence
- ☐ b. Low wall with railing
- ☐ c. Chain link fence
- ☐ d. Low wall, topped by fence
- ☐ e. Wooden three-rail fence
- ☐ f. Stacked split rail fence
- ☐ g. Flat rail or rub rail
- ☐ h. Bollards
- ☐ i. Dense vegetation
- ☐ j. Other natural features (large stones and boulders)
- ☐ Other:

Reasons for Specifying:

10. What types of hazard conditions are present in your state that warrant the use of a barrier to protect path users?

- ☐ a. Roadways
- ☐ b. Rivers, lakes, creeks or other bodies of water
- ☐ c. Vertical drop off hazards (such as steep embankments)
- ☐ d. Unsafe crossings
- ☐ e. Impaired visibility
- ☐ f. Other:

11. How does your state protect against these hazard conditions?

- ☐ a. Ensure wide separations between shared use paths and adjacent highways
- ☐ b. Use physical barriers (fences, posts and beams, vegetation)
- ☐ c. Other:

12. Have these protection measures been effective? If not, please explain why.

- ○ Yes
- ○ No:

13. What, if any, are your horizontal distance standards to the following hazards?

- a. Roadways
- b. Rivers, lakes, creeks or other bodies of water
- c. Vertical drop off hazards (such as steep embankments)
- d. Unsafe crossings
- e. Impaired visibility
- f. Other:

14. Does a path's horizontal and vertical alignment relate in anyway to your barrier selection policies? (Please elaborate.)

- ○ a. Yes
- ○ b. Sometimes
- ○ c. No

15. Does a path's shoulder width impact your decision to use barriers? (Please elaborate.)

- ○ a. Yes
- ○ b. Sometimes
- ○ c. No

16. How would you characterize the shoulder widths on paths in your state?

a. They are typically wider on: Choose One: (Please specify size below)

b. They are typically narrower on: Choose One: (Please specify size below)

c. It depends (Please elaborate):

Please specify/elaborate:

17. Does your state provide guidelines for additional shy distance to barriers such as fences?

- ○ a. Yes (Please indicate typical amount):
- ○ b. No
- ○ c. Sometimes (Please specify under what circumstances):

18. In addition to shy distance, do you provide any of the following?

- ☐ a. A clear zone on each side of the path for clearance from lateral obstructions such as trees
- ☐ b. A wider separation when the path is adjacent to canals, ditches, or slopes steeper than 1:3 (Vertical: Horizontal)
- ☐ c. Other situations:
- ☐ d. Not usually

19. Do the widths of paths impact your decision to use barriers under any circumstances?

- ☐ a. Yes, on steep grades
- ☐ b. Yes, on sharp curves
- ☐ c. Yes, in places where bicyclists will be likely to ride two abreast
- ☐ d. Yes, other (please elaborate):
- ☐ e. No

20. Which of the following is considered a hazardous side slope in your state?

- ☐ a. 1:2 (Vertical: Horizontal)
- ☐ b. 1:3 (Vertical: Horizontal)
- ☐ c. 1:4 (Vertical: Horizontal)
- ☐ d. 1:6 (Vertical: Horizontal)
- ☐ e. Other:

21. How does your state promote vegetation control?

- ☐ a. By placing a non selective herbicide under the path
- ☐ b. By placing a tightly woven geotextile or landscape fabric between the sub-grade and base course
- ☐ c. By requiring selective vegetation removal or path realignment
- ☐ d. Other:

22. What type of shrubbery, bushes, and ground cover is used in your state?

- ☐ a. Low growing (under 3 ft) to facilitate enhanced visibility
- ☐ b. Non deciduous trees that do not create slippery hazards (e.g. voluminous leaf piles every fall)
- ☐ c. Other (please elaborate):

23. In your state, what is the purpose of placing this vegetation?

- ☐ a. So it does not promote growth over or onto the path
- ☐ b. So it does not interfere with visibility of trail users, especially at crossings
- ☐ c. To protect against hazards such as steep embankments
- ☐ d. Other:

24. What type of embankment material does your state use to impact path user safety?

- ☐ a. Grass or vegetated slopes
- ☐ b. Crushed stone
- ☐ c. Rock
- ☐ d. Some combination of the above
- ☐ e. Other:

25. Is the choice of material in #24 contingent upon its availability and/or its proximity to barriers? (Please elaborate:)

- ○ a. Yes:
- ○ b. No

26. Does your state design and specify shared use path barriers to be in compliance with the Americans with Disabilities Act (ADA)? If yes, what exact parameters are specified?

- ○ a. Yes:
- ○ b. No

27. Does your state follow the AASHTO specification and guidelines when designing or specifying a barrier for a shared use path?

- ○ a. Yes
- ○ b. No

28. Please use the space provided below to share any additional comments regarding your shared use paths that you feel are relevant to this study. (Optional)

29. May we contact you if we have any follow up questions regarding your shared use path policies?

- ○ a. Yes
- ○ b. No

Submit Your Answers

INTERNET SURVEY COMMENTS

1. What type of users are the shared use paths in your state designed to accommodate?
   - Dog walking
   - Snow mobiles for rural inter-city trails, but not for urban or suburban trails that are paved

2. Are the shared use paths in your state one directional (paved or unpaved) or bi-directional (paved or unpaved)?
   - For urban and suburban trails they are almost always black topped

3. What types of barriers do you typically use on shared use paths?
   - Bollards. We use signage to transmit excluded activity as opposed to barriers in many cases.
   - None typically
   - Don't usually design a barrier – it's something that already exists in the environment. For example, we would not build a canal to provide a barrier but many trails do have canals near them.
   - Occasional railing or fence on rail-trails. We try to retain the existing bushes and trees. Seldom do additional plantings for the purpose of barrier enhancement.

4. Does your state follow any particular specifications or guidelines in regards to shared path barrier usage and design?
   - AASHTO barrier
   - We reference AASHTO – Trails For the 21st Century
   - Clear zone – try not to put barriers in clear zones
   - Florida DOT typically uses its Standard Pedestrian and Cycling Railing Designs
   - Fence when slope off is over a certain grade percentage
   - AASHTO Guide for Development of Bicycle Facilities and local street standards
   - Try to design maximum allowable side slopes consistent with AASHTO

5. What factors do you consider when selecting the type of barrier to use?
   - What is being addressed with the barrier
   - Safety
   - Don't know. I would guess all of the above enter into it as appropriate. Snow doesn't seem to be a major consideration (trails are considered unusable when snow covered).
   - Nature of adjoining property
   - Snow removal

6. How is the appropriate height for a shared use path barrier determined in your state?
   - Don't know

- ❖ We don't really consider varying the height based on specific conditions. We recommend 4.5' - but will allow 3.5' in most situations.

7. What is the typical porosity of the barrier?
    - ❖ Open wire or gating with bars so as not to inhibit sight through the bar
    - ❖ Bollards spaced at 6' intervals to prevent vehicle ingress/egress. Also lockable gates with 3' opening for non motorized ingress/egress on some sections closed to snowmobiling
    - ❖ Try to have shade created - but that a law enforcement person /public driving by can see any users or problems
    - ❖ Typical (for FDOT picket railing): reject 2" sphere under bottom railing - reject 4" sphere between pickets
    - ❖ These are rail trails in urban areas. The majority of the fences are installed and maintained by the property owners. Some go for maximum height barriers, others for the rustic split rail look. Where the community gets to build the fence, it is always built for visibility - to make the trail part of the community and to keep things visible - open and safe.
    - ❖ We typically want the barriers to look attractive while also being effective. We avoid chain link and usually use a western style post/rail fence with 'horse fabric', which is thin wire mesh at the bottom. In more urban areas, we go with a decorative railing painted to match the surrounding streetscape.
    - ❖ Railings and fences are used. There is typically no strong recommendation to use one over the other. Railings are typically very porous with only 1 or 2 railings in addition to the top rail. Fences or railings spaced no more than 6" apart would be used where there is an immediate hazard on the other side of the barrier and a need to protect a child from squeezing through an opening. This is rarely the case - usually just a bridge issue.

8. What maintenance considerations are weighed when deciding the type of barrier to install?
    - ❖ Low maintenance
    - ❖ Durability and location for potential vandalism
    - ❖ Typical for barrier
    - ❖ Easy to maintain
    - ❖ Minimal maintenance designs preferred
    - ❖ Low or no maintenance is preferred:
        - o Will litter and junk pile up against fence?
        - o Will snow removal destroy the barrier?
    - ❖ Durability and vandal-resistant materials
    - ❖ None that I am aware of
    - ❖ Maintenance is performed by municipalities; Minimum maintenance is desired

9. With regards to fence and railings used as a barrier, are there any reasons for selecting a particular type?
    - ❖ Low maintenance, cost

- Only want to control unauthorized activity in areas that have significant and/or recurring problems. Normal use serves to reduce or remove non-acceptable uses in many cases.
- None, most barriers are chosen for specific locations and needs
- Guardrail - ADA clear zone
- I have seen all of the above checked on rail trails in MA
- FDOT picket railing has the advantage that people cannot sit on it and rest their feet on a lower railing, which could be hazardous (e.g. at a drop off) Chain link fence is typically used for access control - not protection from hazard.
- Location and nature of adjoining property
- In almost all cases fencing is meant to delineate not restrict. Visibility over the barrier - and through the barrier is the prime concern. In an urban area places with poor visibility feel unsafe - and get abused in various ways (e.g. trash, public urination, etc.) Bollards are used to designate a non motor vehicle route.
- Need to balance cost, functionality, visual appearance
- We encourage complying with the side slope requirements to avoid using barriers. Or have a 5' flat area on both sides of the path. Barrier would be last resort if either condition above cannot be met.
- Aesthetics, site conditions, cost and maintenance

10. What types of hazard conditions are present in your state that warrant the use of a barrier to protect path users?
    - Roadways - but this is unusual
    - Adjoining properties e.g. golf course, lumber yard
    - None, these are urban areas
    - Active freight railroad tracks
    - Rail grades built on fill sections

11. How does your state protect against these conditions?
    - We realign crossing with tight angles. In a couple of cases we have added barrier/guard rails to the crossing to direct snowmobiles through the realignment rather than following the old sharper angle alignment
    - Standard crossing markings. In urban area trail users know how to deal with traffic

12. Have these protection measures been effective?
    - No accidents - not even in the shared parking lot/trail segment of our major spine.
    - To my knowledge we have very few run of the path crashes and we have about 2000 miles of trails.

13. What, if any, are your horizontal distance standards to the following hazards?
    - On high-speed highways we like to keep the paths outside of the clear zone. If we cannot maintain at least a 5' separation (much more on high speed highways) we will place a barrier in-between the highway and path
    - None

14. Does a path's horizontal and vertical alignment relate in anyway to your barrier selection policies?
    - We do not have barrier selection policies. Barriers are used as a last resort to manage use. Barriers for trail user safety are carefully chosen for the situation
    - Left to the designer
    - Don't know

15. Does a path's shoulder width impact your decision to use barriers?
    - Usually not a factor; decision based on separation distance from hazard
    - No it does not

16. How would you characterize the shoulder widths on paths in your state?
    - 2' wide
    - We follow AASHTO
    - ROW limitations
    - No difference
    - I haven't noticed any pattern relative to shoulder width and incline/decline side of the two way path
    - We have no choice – it's what the railroad gave us
    - Depends on space available and level of usage of trail
    - We try to have standard 2' shoulder on all paths
    - Varies by row width and site conditions

17. Does your state provide guidelines for additional shy distance to barriers such as fences?
    - We follow AASHTO guidelines
    - 2' on each side of path to fence
    - Clear zone should provide shy distance
    - Minimum 2' shy distance required
    - Don't know

18. In addition to shy distance, what do you provide?
    - We follow AASHTO
    - Don't know
    - Follow AASHTO Bike Design Guidelines
    - Vast majority of rail-trail mileage I have ridden in Massachusetts is very comfortable in terms of space on sides
    - The wider separation referred to earlier is 5'

19. Do the widths of paths impact your decision to use barriers under any circumstances?
    - We follow AASHTO - our shared use paths are 99.9% rail trails
    - ROW Limitations
    - Significant drop offs, headwalls, underpasses
    - Don't know
    - No policy - but not ruled out. Steep grades rare
    - On sharp curves where there is an obvious hazard or steep slopes

20. What is considered a hazardous side slope in your state?
    - Depends on the situation
    - >2:1
    - A side slope greater than 1:3 if the total vertical drop is greater than 5'

21. How does your state promote vegetation control?
    - We have used herbicide like Accord and we have tried vertical barriers in-trenched adjacent to the trail
    - I would say that vegetation control in MA isn't particularly effective; mowing gets done
    - No policy.
    - Depends on available resources

22. What type of shrubbery, bushes and groundcover are used in your state?
    - So far we have not installed vegetation close to our trails
    - Native landscaping
    - High to created clear window under tree canopy
    - Mostly grass adjacent to the trail
    - Deciduous trees that let the sun in through the winter - dropping huge quantities of leaves
    - Depends on location of project
    - Native species set back from path

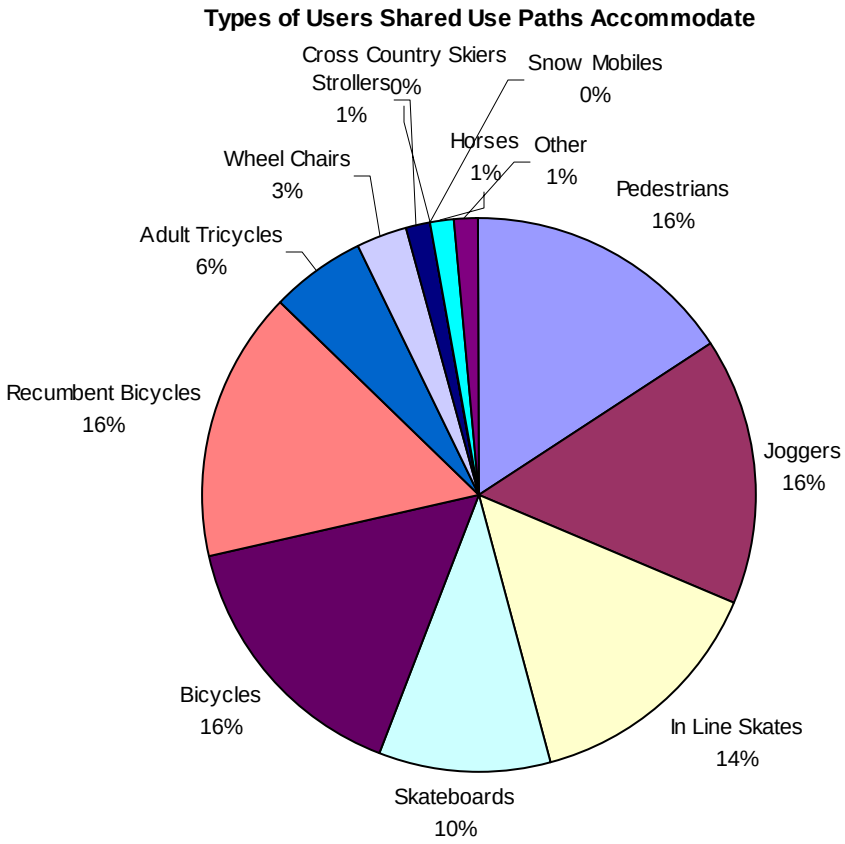
23. In your state, what is the purpose of placing this vegetation?
    - We don’t place vegetation
    - Erosion control; beautification
    - So it looks nice
    - Aesthetics – environmental restoration and enhancements

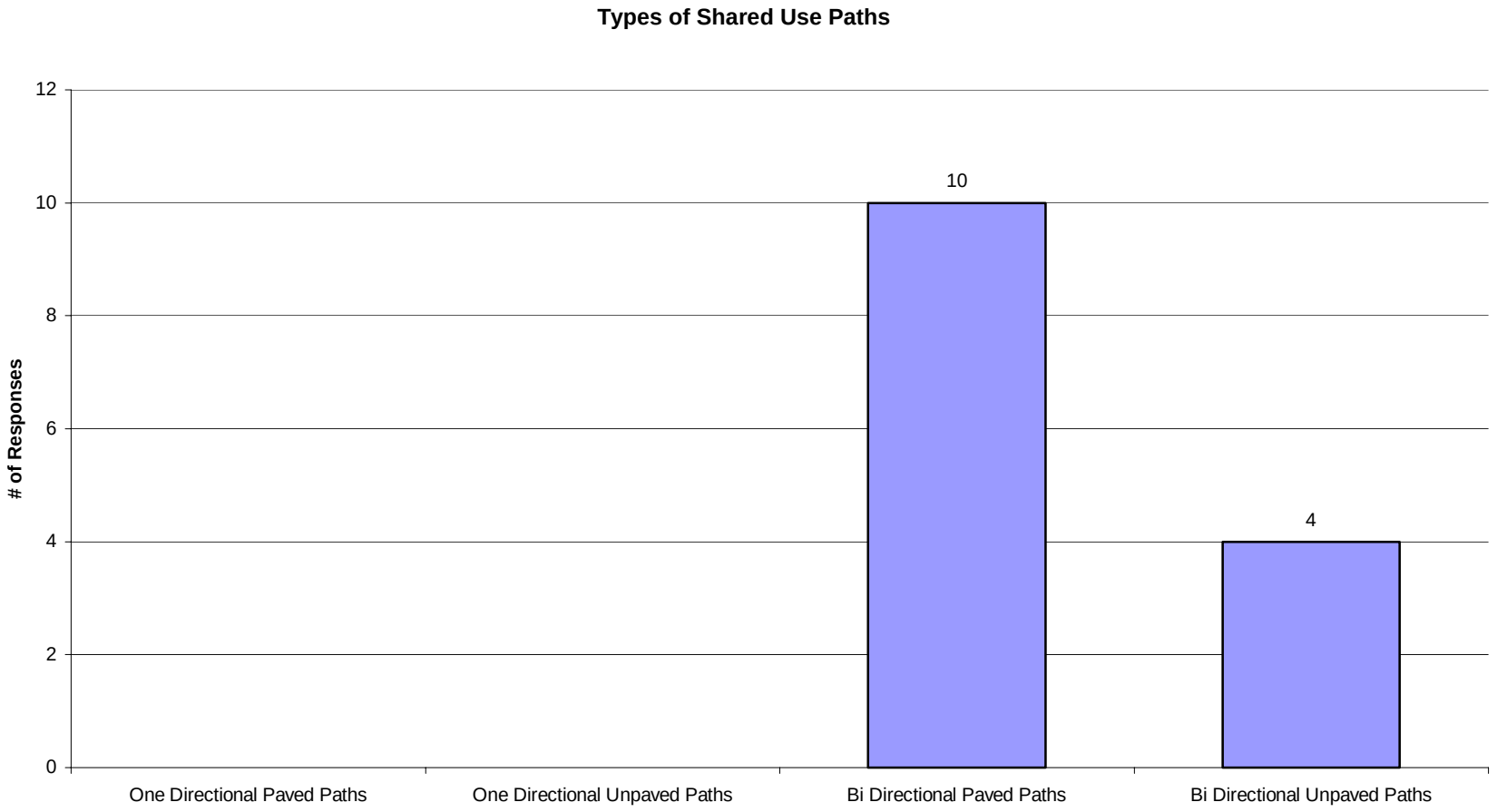
24. Is your choice of embankment material contingent upon its availability and/or its proximity to barriers?
    - Use of materials constrained in sensitive areas
    - Depends on location of project
    - Always available

25. Does your state design and specify shared use path barriers to be in compliance with ADA?
    - 1990 UFAS

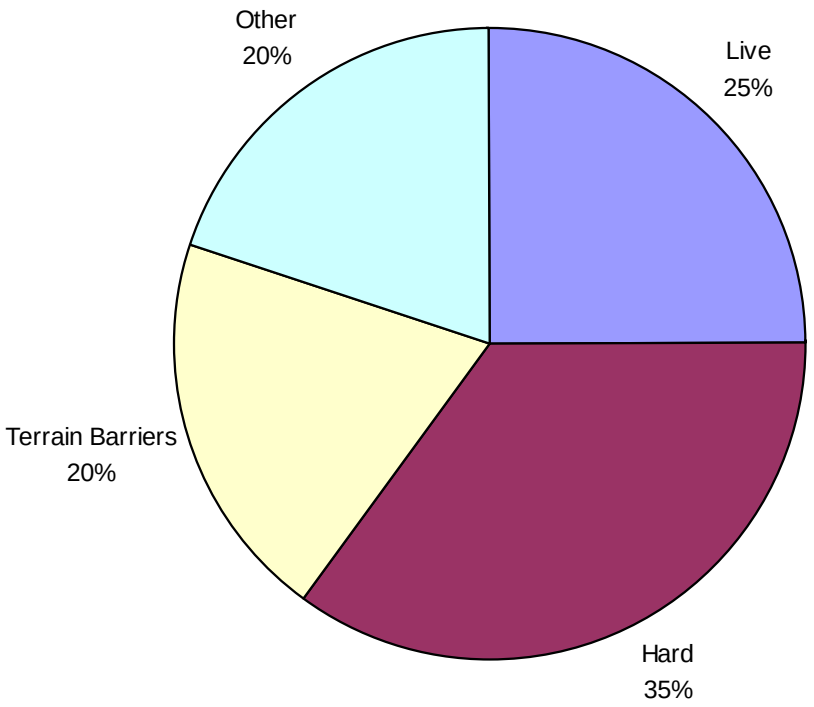
- Clearance
- ADAAG
- Picket style if drop off exceeds 30
- ADA is not a question – it is a requirement
- To the extent possible
- No obstructions; railings are required

26. Does your state follow AASHTO specification and guidelines when designing and specifying a barrier for shared use paths?
    - AASHTO offers very little

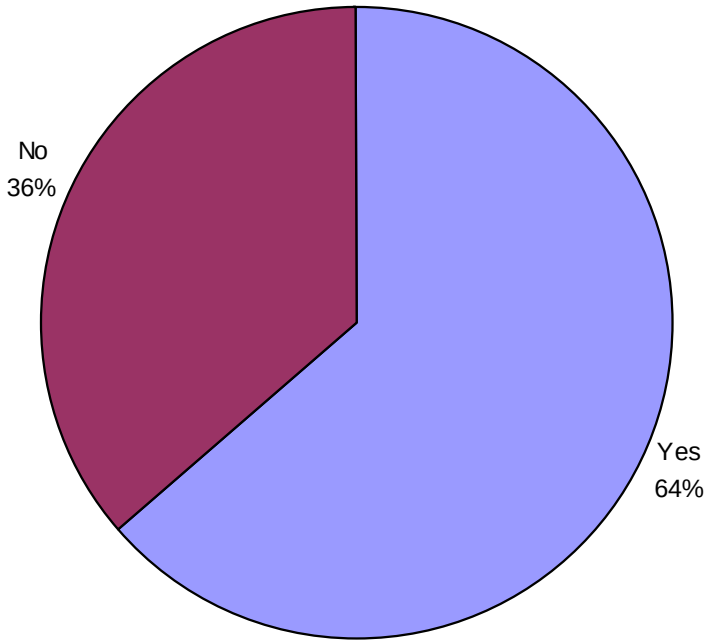

Types of Users Shared Use Paths Accommodate
Cross Country Skiers 0%
Snow Mobiles 0%
Strollers 1%
Horses 1%
Other 1%
Wheel Chairs 3%
Pedestrians 16%
Adult Tricycles 6%
Recumbent Bicycles 16%
Joggers 16%
Bicycles 16%
In Line Skates 14%
Skateboards 10%


Types of Shared Use Paths
# of Responses
12
10
8
6
4
2
0
10
4
One Directional Paved Paths
One Directional Unpaved Paths
Bi Directional Paved Paths
Bi Directional Unpaved Paths

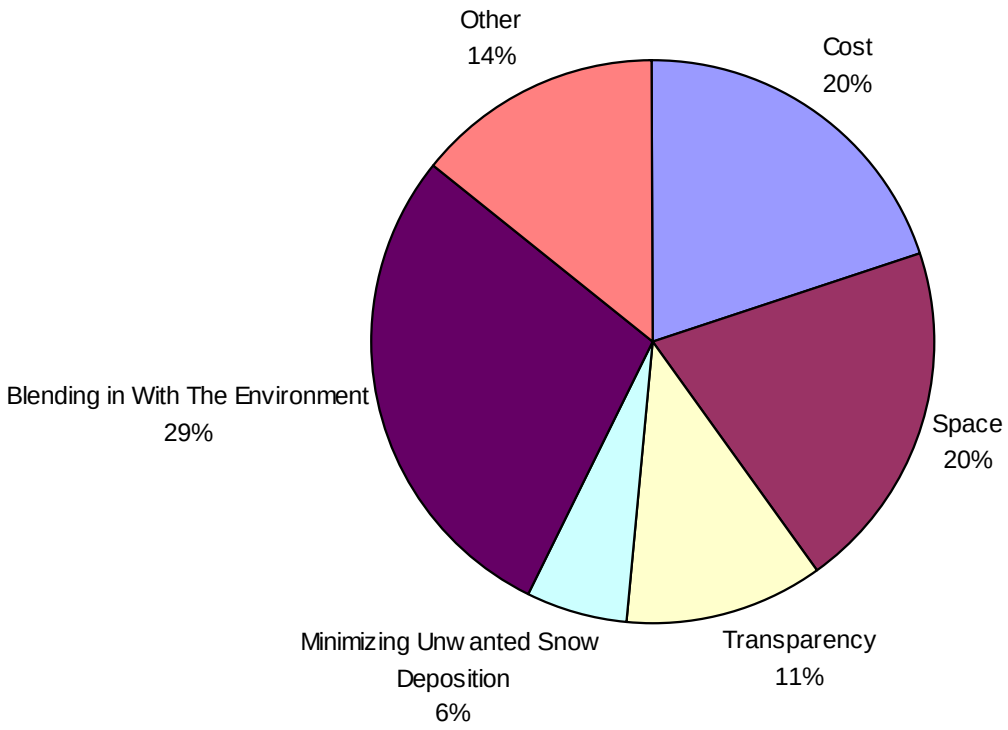
What Types of Barriers Do You Typically Use On Shared Use Paths?



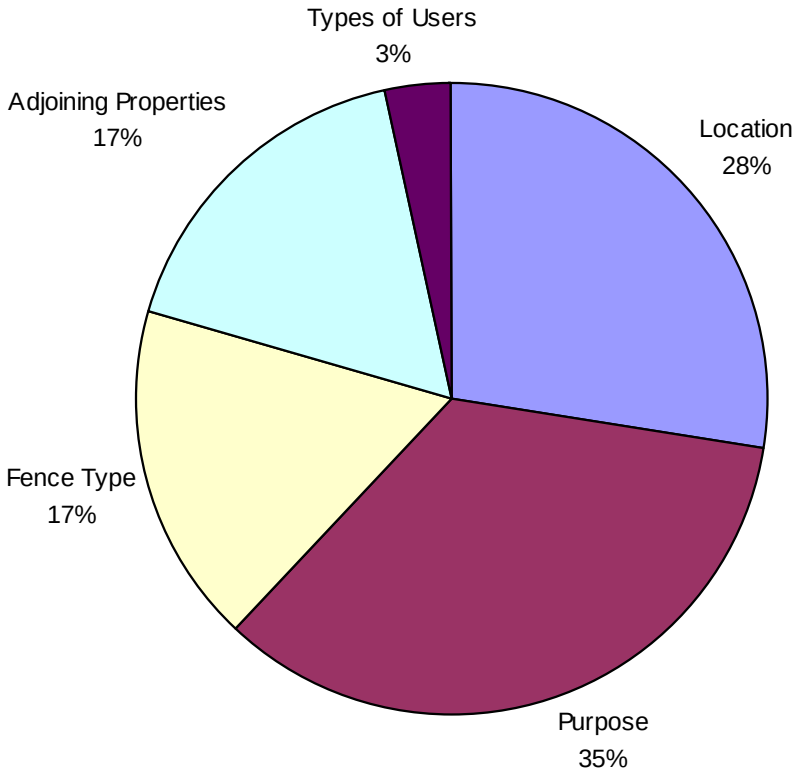
Does Your State Follow Any Particular Specification Or Guidelines In Regards To Shared Path Barrier Usage And Design?



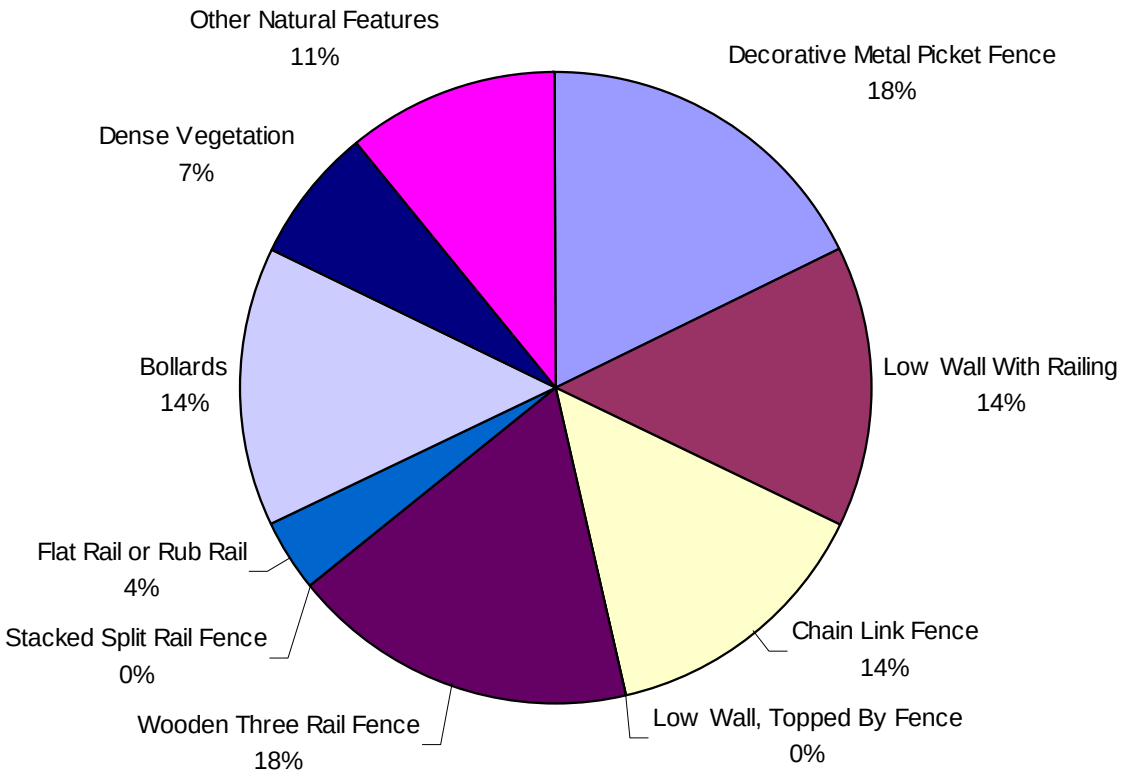
What Factors Do You Consider When Selecting The Type of Barrier To Use?



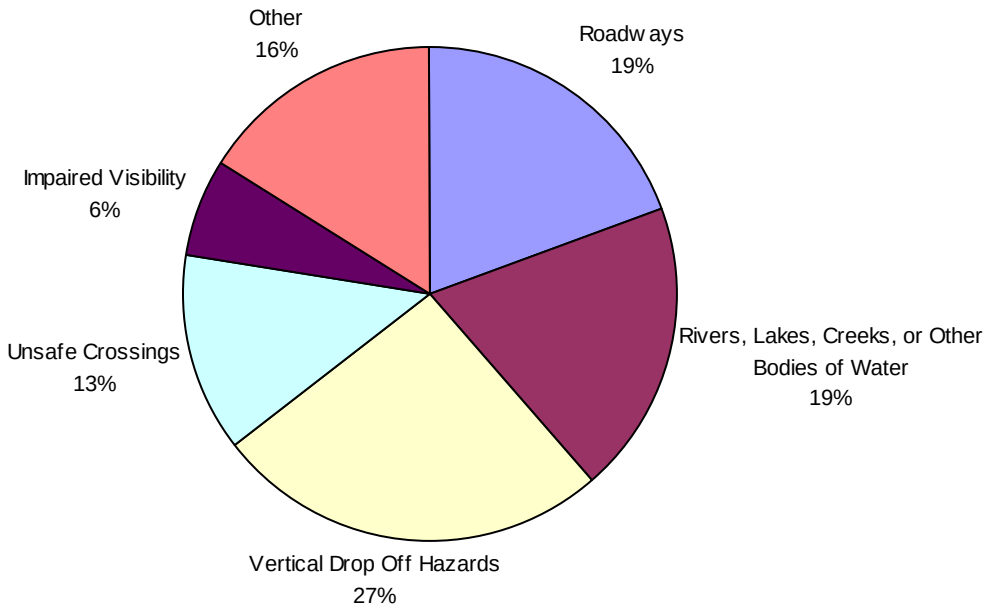
How Is The Appropriate Height For A Shared Use Path Barrier Determined In Your State?



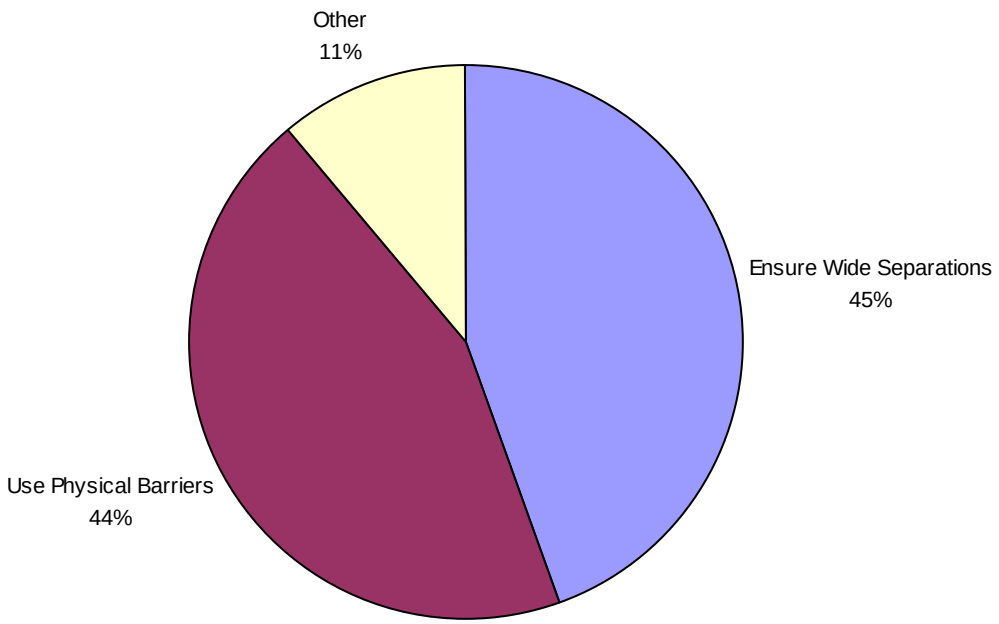
With Regards To Fence And Railings Used As A Barrier, Which Of The Following Does Your State Usually Specify?



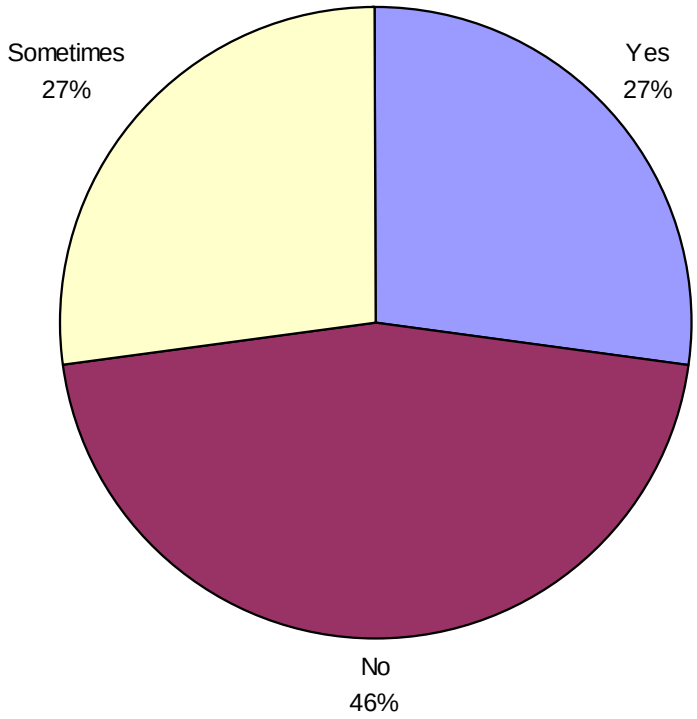
What Types Of Hazard Conditions Are Present In Your State That Warrant The Use Of A Barrier To Protect Path Users?



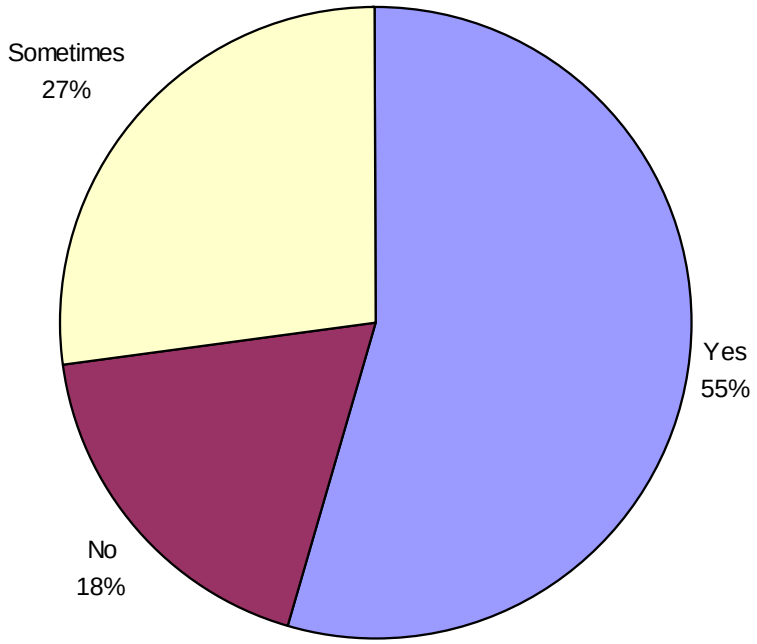
How Does Your State Protect Against These Hazard Conditions?



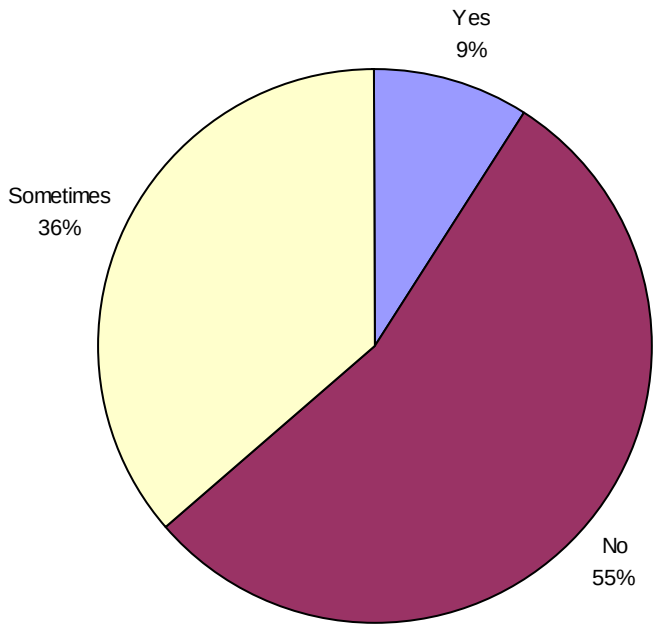
Does A Path's Horizontal And Vertical Alignment Relate In Anyway To Your Barrier Selection Policies?



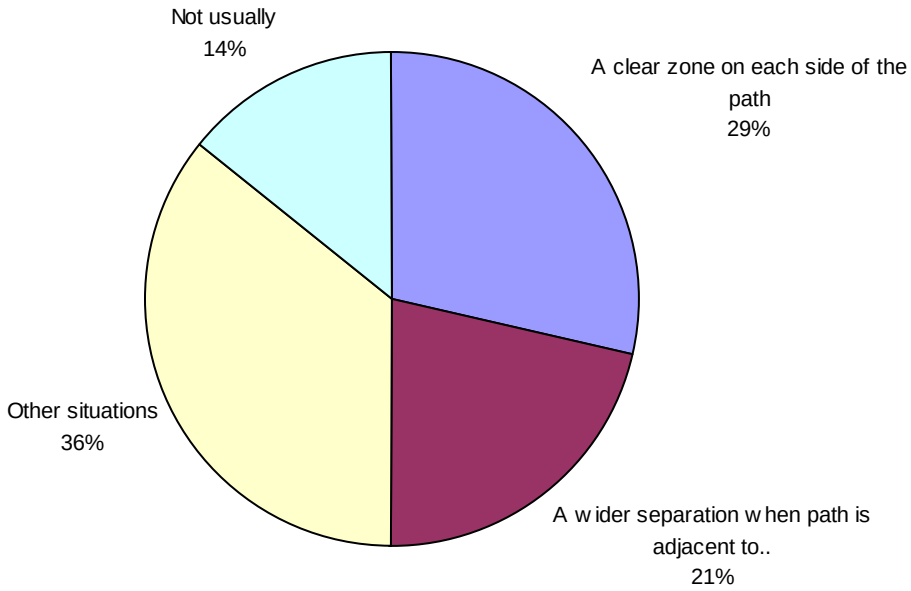
Does A Path's Shoulder Width Impact Your Decision To Use Barriers?



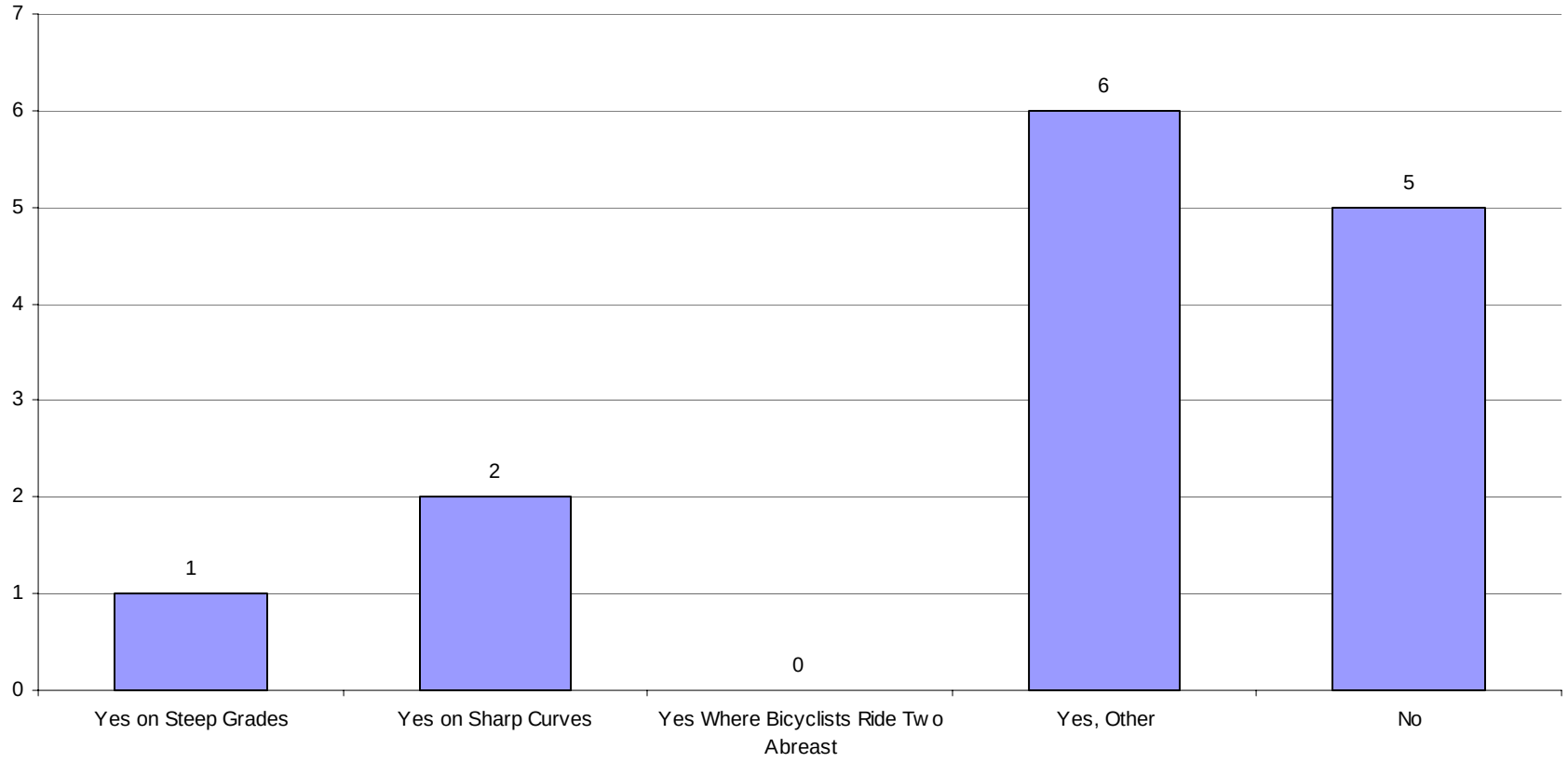
Does Your State Provide Guidelines For Additional Shy Distance To Barriers Such As Fences?



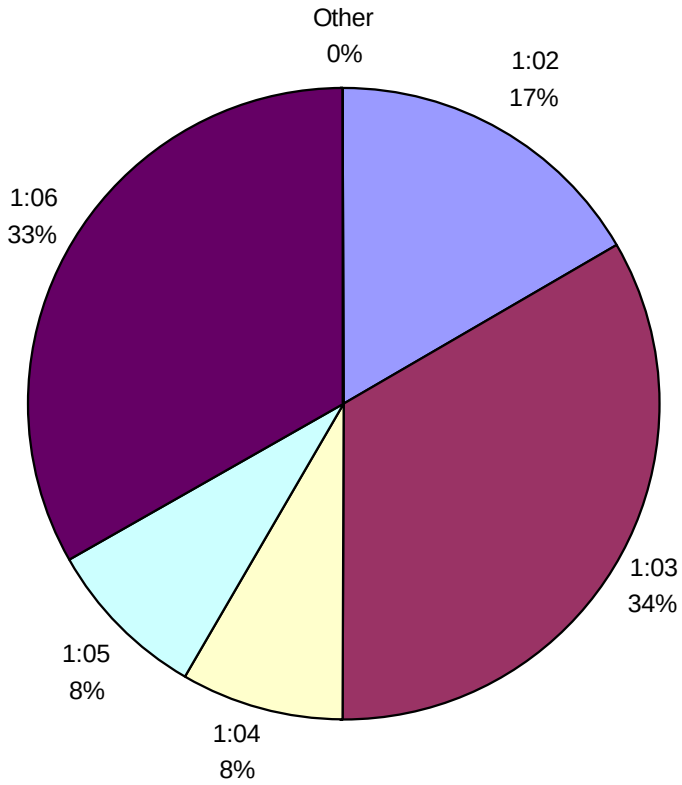
In Addition To Shy Distance, Do You Provide Any Of The Following?



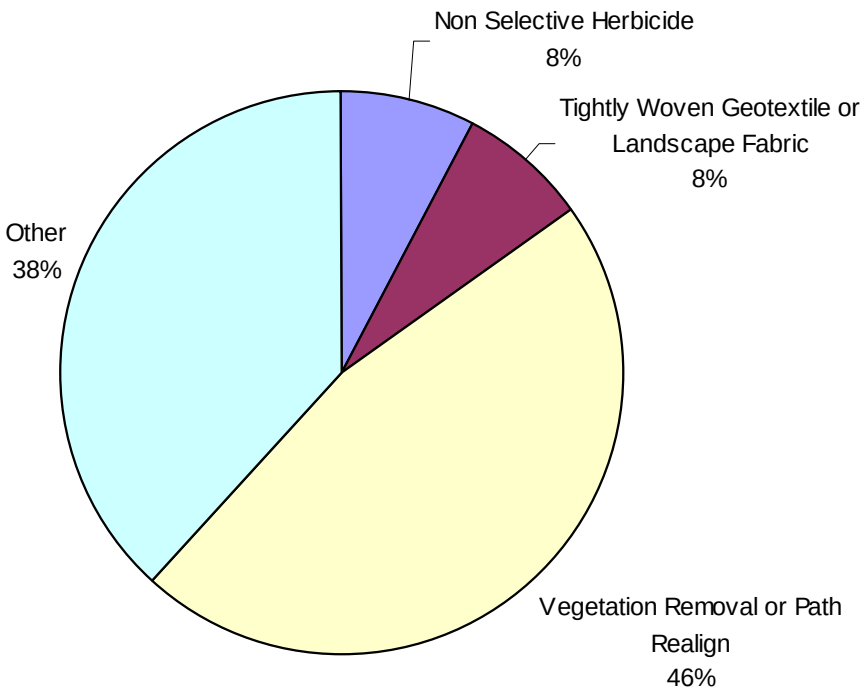
Do The Widths Of Paths Impact Your Decision To Use Barriers Under Any Circumstances?



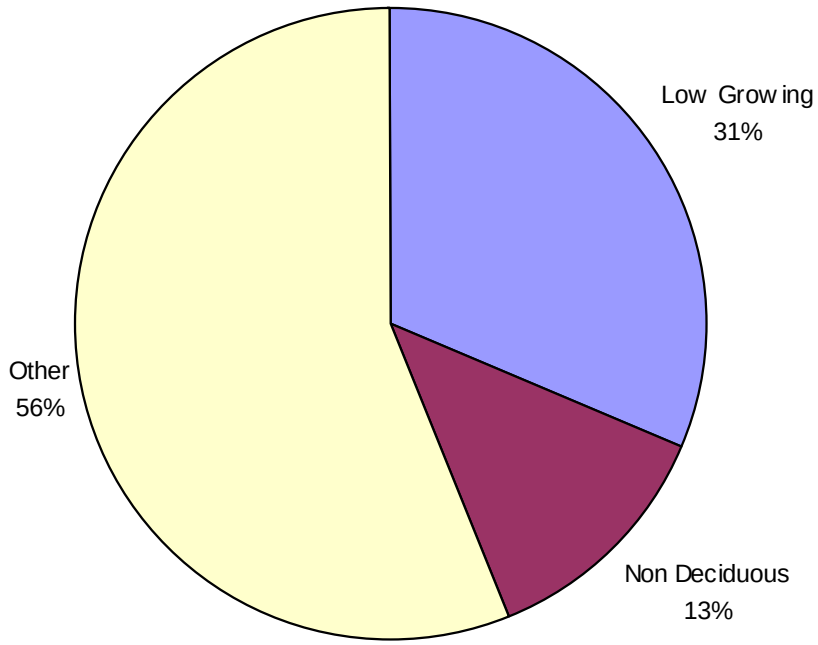
Which Of The Following Is Considered A Hazardous Side Slope In Your State?



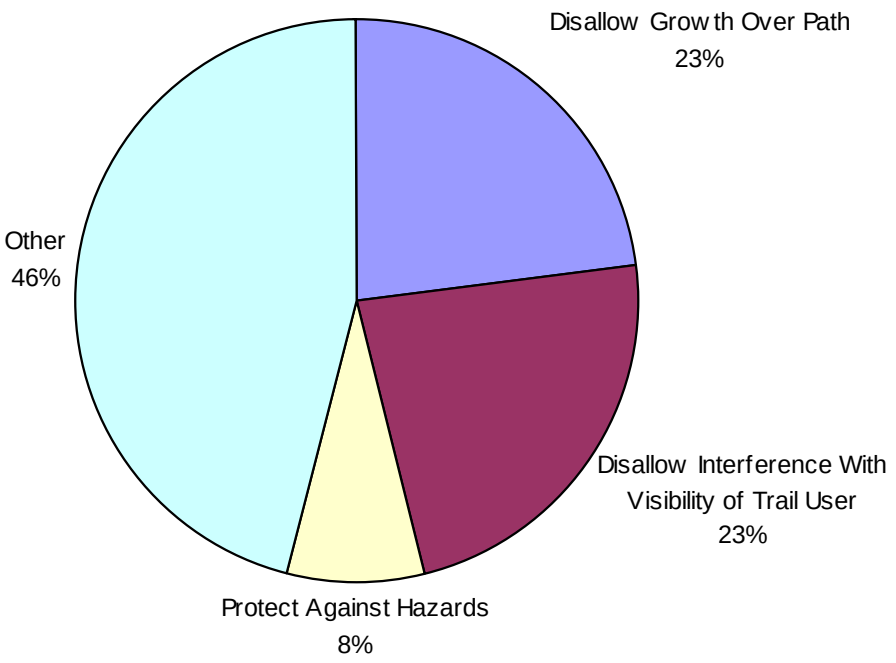
How Does Your State Promote Vegetation Control?



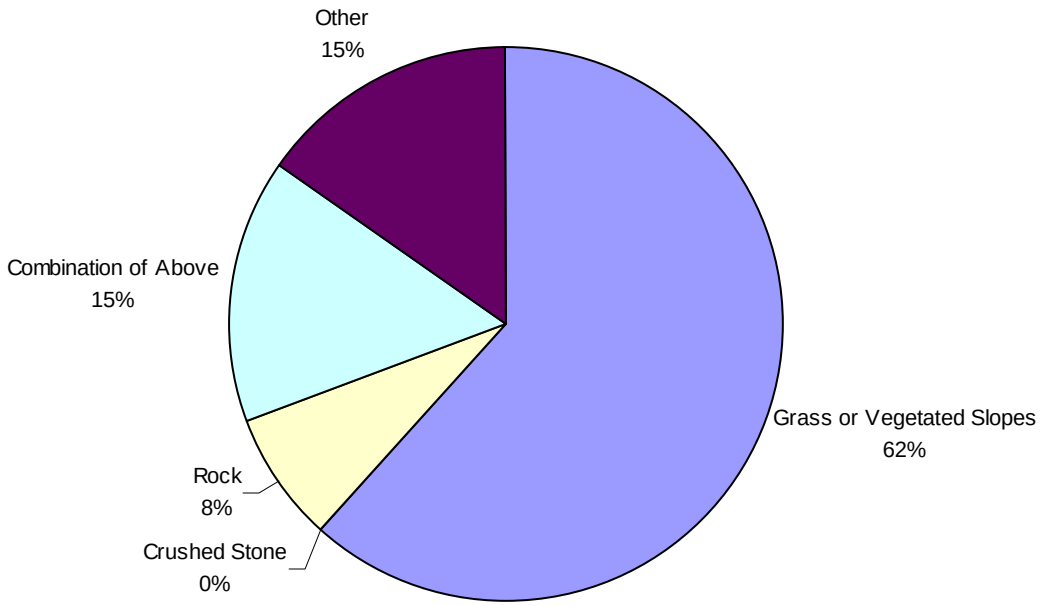
What Type Of Shrubbery, Bushes And Groundcover Are Used In Your State?



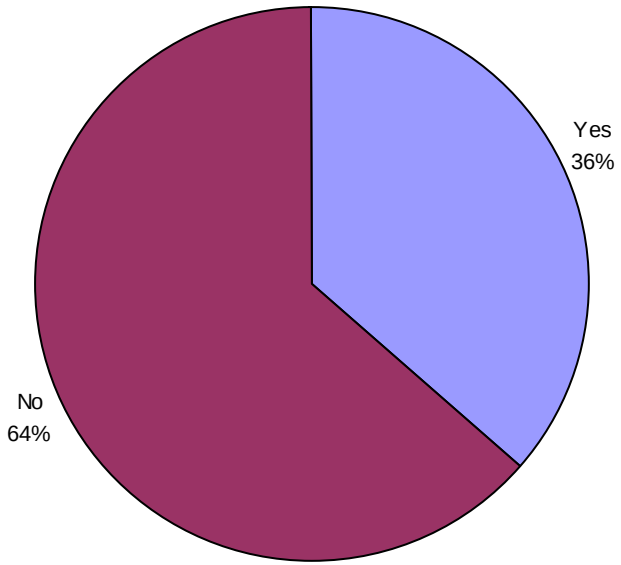
In Your State, What Is The Purpose Of Placing This Vegetation?



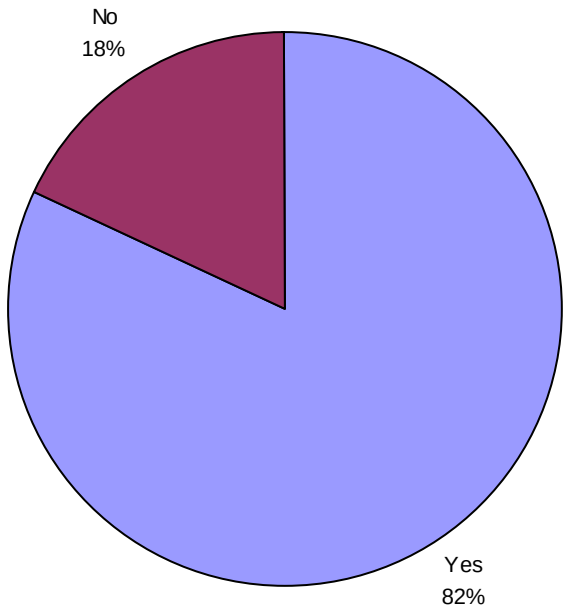
What Type Of Embankment Material Does Your State Use To Impact Path User Safety?



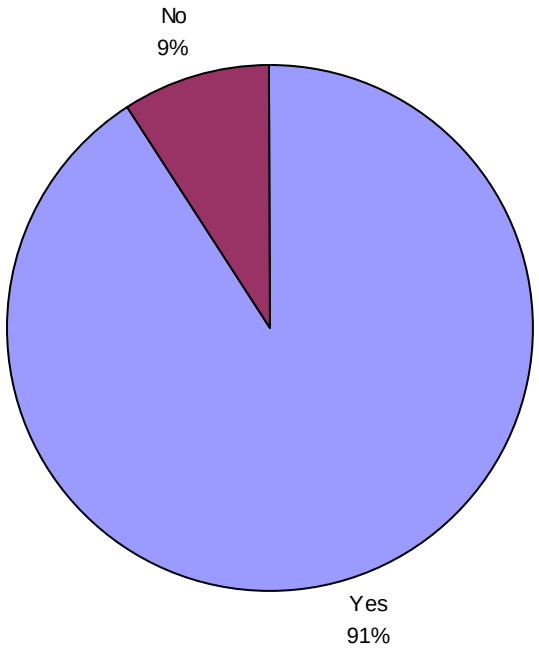
Is Your Choice Of Embankment Material Contingent Upon Its Availability And/Or Its Proximity To Barriers?



Does Your State Design And Specify Shared Use Path Barriers In Compliance With The ADA?



Does Your State Follow AASHTO Specifications And Guidelines When Designing And Specifying A Barrier For A Shared Use Path?



Appendix C

Barrier Usage Design Guideline

Shared Use Path Barrier Usage Guideline

The draft guidelines presented here are the result of research undertaken by Umass Dartmouth (UMassD) for the Vermont Agency of Transportation (VTrans) research project entitled "Shared Use Path Fencing Usage" dated May 2007. Please consult the full research report for further information on the development of this guideline.

This draft guideline was formulated based on a comprehensive literature review, field inspections of existing fencing in Vermont, interviews with shared use path users in Vermont, an Internet survey of bicycle facility experts throughout the world. This guideline is meant to be used as a guide to help determine the scenarios where barriers should be used. It is not meant as a replacement to any current AASHTO or VTrans specification.

Identification of Barrier Purposes

The first step in the barrier decision process is determining what function the barrier serves. Barriers placed adjacent to a shared use path may serve one or more functions based on their design and placement. The main functions of a barrier are:

1. Access Control
2. Aesthetics/ Decoration
3. Property Separation/Delineation
4. Safety
5. Screening
6. Wind Abatement
7. Noise Abatement

Note: *The use of barriers for functions 6 and 7 is not very frequent, especially in the experience of VTrans.*

All of these functions, except safety, and their resultant barrier design and location decisions will need to be subjectively made on a case-by-case basis using good engineering judgment. Barriers for safety purposes are discussed later.

General Barrier Considerations

In regards to barriers in general, the following items should be considered:

1. Barrier selection should be made based on user safety first and then aesthetics. With the wide variety of materials and fencing barrier types, the designer should be able to find a compromise in aesthetics without giving up safety.

2. Barriers themselves can be a safety hazard since they are a pathside obstruction. However, sometimes the placement of a barrier is required to protect path users from a more hazardous condition.

3. Caution should be used when curbing is part of a feature adjacent to a path. In some cases, curbed islands have been used to separate paths from adjacent roadways. However curbs should not be used as barriers from these hazards because they can cause hazardous conditions of their own and might restrict users with disabilities.

4. Barrier should be transitioned away from the path at the leading and trailing end, if possible. The ends of the barriers themselves can be hazardous to path users, thus a gradual transition of the barrier away from the path edge is recommended.

5. Live forms of barriers require much more maintenance and can produce their own hazards. Branches, leaves, and other vegetation can line the path surface, thus creating a possible hazardous condition for path users. Also, vegetation can easily overgrow the path if it is not maintained consistently. Hard barriers will still require maintenance, but careful selection of materials and construction should permit that these go longer periods of time without regular maintenance.

Barriers for Safety Purposes

The need of barriers for protection of path users from hazards is based on a number of factors. This determination of the need for a barrier is dependent on the width of available clear zone (recovery area), embankment slope adjacent to the path, any vertical drop adjacent to the path, any hazardous condition (waterways, ravines, etc.) at the base of the slope adjacent to the path, and the material present on the side slope. The following tables present a means to determine if a barrier is required for safety purposes. Meeting all the requirements left-to-right on a single line identifies a condition where a barrier should be used. The first table is for paths with a paved surface and the second is for paths with an unpaved surface.

To use these tables, the designer must know the relative values for recovery area (clear zone), embankment slope, and vertical drop heights for their situation as outlined in Figure 1 below. Also, the designer must know what the final side slope material will be as well as if there is, or will be, a hazard condition at the bottom of the side slope. Then, starting on the left of the table, the designer enters the table at the value of the available recovery area. Next, the designer must examine each scenario presented for that value of recovery area and determine if any are a match for their particular case. For the specified recovery area range, all scenarios must be examined. If ***ANY*** of the scenarios match the known conditions, a barrier should be used unless otherwise noted in the notes or asterisk section at the bottom of the table. If ***NONE*** of the scenarios match, then a barrier is ***NOT*** required. The scenarios shown indicate when a barrier should be used adjacent to a shared use path. Some scenarios require the designer to subjectively assess the hazards and side slope material. Two examples of how one would use the guide are shown after the presentation of the tables.

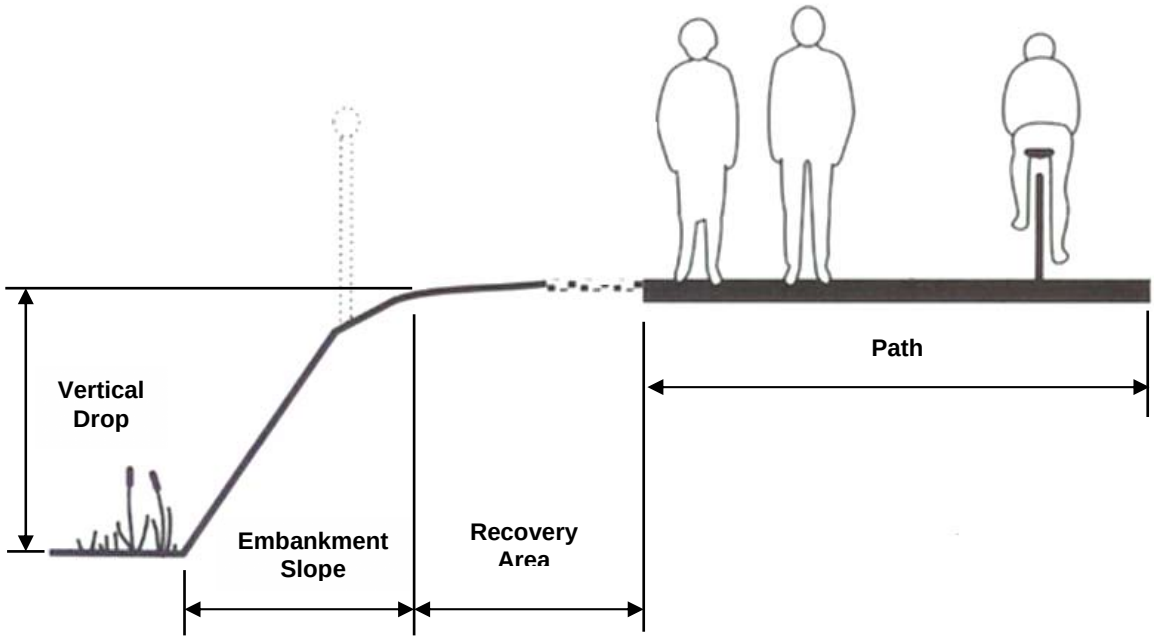


Figure 1: Description of Geometric Parameters Required for Barrier Usage Guideline
Adapted from: Vermont Pedestrian and Bicycle Facility Planning and Design Manual. December 2002.

Important Note: Other parameters like clear distance to fixed objects, sharp curves, path grades, path width, and other geometric considerations should be taken into account when designing for safety. These items should also be considered for safety purposes and their minimum design values are widely known and published.

Paved Shared Use Path Trail Surface														
		Embankment Slope				Vertical Drop				Hazard** at Bottom of Slope		Side Slope Material***		
Recovery Area	**Scenario**	1: 4 or Flatter	1:3	1:2	Steeper than 1:2*	10" - 2 ft (0.25 - 0.6m)	3 ft (0.9m)	4 ft (1.2m)	5 ft (1.5m) or Greater	Yes	No	Soft	Hard	**Remarks**
<3 ft (0.9 m)	1	X				Any Vertical Drop				Either		Either		See Notes 1-3
	2		X			Any Vertical Drop				Either		Either		
	3			X		Any Vertical Drop				Either		Either		
	4				X	Any Vertical Drop				Either		Either		
3 ft - <4 ft (0.9 -1.2m)	1		X						X	Either		Either		
	2		X			Selected Vertical Drops				X				Note 2
	3		X			Selected Vertical Drops					X		X	Note 3
	4			X		Any Vertical Drop				Either		Either		
	5				X	Any Vertical Drop				Either		Either		
4 ft - <5 ft (1.2 -1.5m)	1		X			Any Vertical Drop				X				Note 2
	2		X			Any Vertical Drop					X		X	Note 3
	3			X				Selected Vertical Drops						
	4			X		Selected Vertical Drops				X				Note 2
	5			X		Selected Vertical Drops					X		X	Note 3
	6				X	Any Vertical Drop				Either		Either		
>5 ft (1.5 m)	1	Any Embankment Slope				Any Vertical Drop				X				Note 2
	2	Any Embankment Slope				Any Vertical Drop					X		X	Note 3

* Includes vertical drop-offs next to path.

** Possible hazards include waterways, water bodies, ravines, active roadways, active railways, etc. A hazard can be any item that can comprise the safety of a path user if they encounter it.

*** Example of "Soft" materials is grass. "Hard" materials include rip-rap, rocks, boulders, etc.

Note 1: Generally no barrier necessary for 1:4 or flatter slopes. Evaluate on a case-by-case basis.

Note 2: Barrier use dependent on severity of hazard condition at bottom of slope. Evaluate on a case-by-case basis.

Note 3: Barrier use dependent on possible injury that could result from crash into side slope material. Evaluate on a case-by-case basis.

Unpaved Shared Use Path Trail Surface														
		Embankment Slope				Vertical Drop				Hazard** at Bottom of Slope		Side Slope Material***		
Recovery Area	**Scenario**	1: 4 or Flatter	1:3	1:2	Steeper than 1:2*	10" - 2 ft (0.25 - 0.6m)	3 ft (0.9m)	4 ft (1.2m)	5 ft (1.5m) or Greater	Yes	No	Soft	Hard	**Remarks**
<2 ft (0.6 m)	1	X				Any Vertical Drop				Either		Either		See Notes 1-3
	2		X			Any Vertical Drop				Either		Either		
	3			X		Any Vertical Drop				Either		Either		
	4				X	Any Vertical Drop				Either		Either		
2 ft - <3 ft (0.6 - 0.9m)	1		X						X	Either		Either		
	2		X			Selected Vertical Drops				X				Note 2
	3		X			Selected Vertical Drops					X		X	Note 3
	4			X		Any Vertical Drop				Either		Either		
	5				X	Any Vertical Drop				Either		Either		
3 ft - <5 ft (0.9 -1.5 m)	1		X			Any Vertical Drop				X				Note 2
	2		X			Any Vertical Drop					X		X	Note 3
	3			X				Selected Vertical Drops						
	4			X		Selected Vertical Drops				X				Note 2
	5			X		Selected Vertical Drops					X		X	Note 3
	6				X	Any Vertical Drop				Either		Either		
>5 ft (1.5 m)	1	Any Embankment Slope				Any Vertical Drop				X				Note 2
	2	Any Embankment Slope				Any Vertical Drop					X		X	Note 3

* Includes vertical drop-offs next to path.

** Possible hazards include waterways, water bodies, ravines, active roadways, active railways, etc. A hazard can be any item that can comprise the safety of a path user if they encounter it.

*** Example of "Soft" materials is grass. "Hard" materials include rip-rap, rocks, boulders, etc.

Note 1: Generally no barrier necessary for 1:4 or flatter slopes. Evaluate on a case-by-case basis.

Note 2: Barrier use dependent on severity of hazard condition at bottom of slope. Evaluate on a case-by-case basis.

Note 3: Barrier use dependent on possible injury that could result from crash into side slope material. Evaluate on a case-by-case basis.

Examples

Example 1

Path Surface Type: **Paved**
Width of Recovery Area: **3.5ft**
Embankment Slope Adjacent to the Path: **1:3**
Vertical Drop Adjacent to the Path: **1ft**
Hazardous Condition at the Base of the Slope: **None**
Side Slope Material: **Grassed Surface**

Step 1: Select appropriate table based on path surface. For this example, the *"Paved Shared Use Path Trail Surface"* table is used because the path surface is paved.

Step 2: Enter into the table based on the available recovery area. For this example the recovery area is 3.5 ft. Thus, the 3ft -<4ft recovery area range is applicable.

Step 3: For the specified recovery area range, all scenarios must be examined. If ***ANY*** of the scenarios match the known conditions, a barrier should be used unless otherwise noted in the notes or asterisk section at the bottom of the table. If ***NONE*** of the scenarios match, then a barrier is ***NOT*** required.

For this example, the recovery area range is 3ft -<4ft. The embankment slope is 1:3. Only scenarios 1, 2 and 3 involve a side slope of 1:3 (denoted by an X in the table), thus scenarios 4 and 5 do not match and they need no further examination.

Step 4: Next, moving left to right in the table, the remaining scenarios 1, 2 and 3 are further examined by the corresponding vertical drop. For this example the vertical drop is 1 ft. Scenario 1 requires a vertical drop of 5ft or greater (as denoted by the X in the table), thus it does not match and it needs no further examination. Scenarios 2 and 3 both fall within the "Selected Vertical Drops" ranges. Explaining further, this means if the vertical drop falls into the range of the merged columns under the vertical drop it is a match. For scenarios 2 and 3, the "Selected Vertical Drops" include the 10"- 2ft range, 3ft, and 4ft. Values falling between the ranges or values noted in the table should be rounded up to the next highest value. For this example the vertical drop of 1 ft applies to both scenarios 2 and 3 as the vertical drop matches the "Selected Vertical Drops" range for each.

Step 5: Next, moving left to right in the table, the remaining scenarios 2 and 3 are further examined by the hazard condition at the bottom of the slope. For this example there is no hazard condition at the bottom of the slope. Since scenario 2 identifies a hazard condition at the bottom of the slope (denoted by an X under the "YES" column), it is not a match and it requires no further examination. Scenario 3 identifies no hazard condition at the bottom of the slope (denoted by an X under the "NO" column) which is a match for the conditions of this example.

Step 6: Next, moving left to right in the table, the remaining scenario 3 is further examined by the side slope material. For this example the side slope material is grassy, which by the asterisk footnote is considered "Soft". Scenario 3 identifies a "Hard" side slope material (as denoted by the X under "Hard"), thus it is not a match and no further examination of this scenario is needed.

At this point all scenarios have been eliminated from examination. Thus, since there were no matching scenarios, a barrier is NOT required for path with these conditions given in the example. Please note all scenarios for a given recovery area must be examined (all columns from left to right) and eliminated before the decision to not use a barrier can be made.

Example 2

Path Surface Type: **Unpaved**
Width of Recovery Area: **2.5ft**
Embankment Slope Adjacent to the Path: **1:2**
Vertical Drop Adjacent to the Path: **4ft**
Hazardous Condition at the Base of the Slope: **None**
Side Slope Material: **Rip-Rap**

Step 1: Select appropriate table based on path surface. For this example, the *"Unpaved Shared Use Path Trail Surface"* table is used because the path surface is unpaved.

Step 2: Enter into the table based on the available recovery area. For this example the recovery area is 2.5 ft. Thus, the 2ft -<3ft recovery area range is applicable.

Step 3: For the specified recovery area range, all scenarios must be examined. If ***ANY*** of the scenarios match the known conditions, a barrier should be used unless otherwise noted in the notes or asterisk section at the bottom of the table. If ***NONE*** of the scenarios match, then a barrier is ***NOT*** required.

For this example, the recovery area range is 2ft -<3ft. The embankment slope is 1:2. Only scenario 4 involves a side slope of 1:2 (denoted by an X in the table), thus scenarios 1 through 3 and 5 do not match and they require no further examination.

Step 4: Next, moving left to right in the table, the remaining scenario 4 is further examined by the corresponding vertical drop. For this example the vertical drop is 4 ft. Scenario 4 identifies that "Any Vertical Drop" is a match. Explaining further, this means a vertical drop of any height is a match. For this example the vertical drop of 4 ft matches scenario 4.

Step 5: Next, moving left to right in the table, the remaining scenarios 4 is further examined by the hazard condition at the bottom of the slope. For this example there is no hazard condition at the bottom of the slope. Since scenario 4 identifies that a hazard condition may or may not exist (denoted by "Either"), it is a match for the conditions given in this example.

Step 6: Next, moving left to right in the table, the remaining scenario 4 is further examined by the side slope material. For this example the side slope material is rip rap, which by the asterisk footnote is considered "Hard". Scenario 4 identifies that the side slope material may be hard or soft (as denoted by "Either"), thus it is a match for the conditions given in this example.

Since the given conditions of this example have been checked from left to right in the table and matches all the conditions denoted by scenario 4, a barrier is required for the shared use path. Please note that a barrier is required if all conditions left to right match for any one or multiple scenarios for a specific recovery area range.