Nitsch Engineering

Conceptual Design Report

Belmont Community Path
Belmont Component of The MCRT (Phase 1)

Belmont, MA

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Prepared for:

Massachusetts Department of Transportation
Highway Division
10 Park Plaza, Room 6340
Boston, MA 02116

Submitted by:

Nitsch Engineering
2 Center Plaza, Suite 430
Boston, MA 02108

Nitsch Engineering Project #13548.

MassDOT Project #609204

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 Introduction

Nitsch Engineering has prepared this Conceptual Design Report (CDR) to document existing conditions, and to propose options for Phase 1 of the Belmont Community Path project, beginning at the Clark Street Pedestrian Bridge located between Clark Street and Pleasant Street and ending at Brighton Street at the terminus of the Fitchburg Cutoff Path in the Town of Belmont, MA. Figure 1 shows the Locus Map and Figure 2 shows the Study Area. The project is to be designed in two phases: Phase 1a consists of a proposed underpass at Alexander Avenue beneath the existing railroad; and Phase 1b includes the proposed path from the Clark Street bridge to Brighton Street.

As the basis of this CDR, we utilized information provided by the Belmont Community Path Advisory Committee (CPAC) and Town departments, observations based on field visits and on-the-ground survey by Nitsch Engineering, and the Feasibility Study for the Belmont Community Path dated November 2017. In preparing this CDR, we have met with the CPAC and various Town Stakeholders and departments to understand project concerns and impacts.

The purpose of this CDR is to identify path alignment alternatives with a focus on potential constrained locations along the proposed alignment; define design parameters and standards to be applied to the design of the path along the active railroad; and provide a recommendation for a preferred alignment for the construction of Phase 1 of the Belmont Community Path.

1.1 Project Background

Project History

In 1994 the Town of Belmont Board of Selectman formed a Bikeway Planning Committee. The Committee requested that the Town of Belmont be included on the initial Mass Central Rail Trail (MCRT) feasibility study in 1997. As part of the MCRT's feasibility study, analysis for the Belmont Bikeway was included. In 1998 the MCRT planned development stalled due to funding issues and participation from communities. In 2010 the Fitchburg Cutoff Path was constructed and terminated at Brighton Street in Belmont.

The Belmont Select Board formed the Community Path Implementation Advisory Group (CPIAC) in 2012 to develop and recommend strategies for the design, construction and implementation of Community Path options. The CPIAC facilitated the development of a feasibility study for the Belmont Community Path that was completed in 2017.

Phases 1a and 1b of the Belmont Community Path, identified in the Feasibility Study, were approved for funding by the Metropolitan Planning Organization (MPO) in 2018. The construction of the path will be funded with a mix of state and federal transportation funds. In 2018, the Belmont Select Board formed the Community Path Project Committee (CPPC) to select a design firm to design Phase 1a and 1b of the Community Path. The design and construction of the project will be administered by MassDOT and although the project is listed on the Transportation Improvement Program (TIP), a program date for construction has not been determined.

Project Scope

The Belmont Community Path, a planned 2-mile segment of the MCRT through Belmont, will not only provide a valuable link between Waltham and Cambridge but will open up access to many neighborhoods and points of interest including schools, parks, MBTA stations, and businesses. An integral component of the project, identified as ***Phase 1a – Alexander Avenue Underpass,*** involves the design and construction of a pedestrian/bicycle underpass beneath the existing railroad tracks at Alexander Avenue, which will provide a significant safety improvement by eliminating unsafe pedestrian crossings over the Massachusetts Bay Transportation Authority (MBTA) Fitchburg line between the neighborhood and the Belmont High School. The underpass will allow residents on the north side of the railroad to access Town amenities along Concord Avenue such as the library, park, and the music school. The safety improvements will be incorporated in conjunction with the adjacent at grade railroad crossing.

Phase 1b of the Belmont Community Path includes approximately 1.1 miles of linear path and begins at the Clark Street Pedestrian Bridge located between Clark Street and Pleasant Street and ends at the terminus of the Fitchburg Cutoff Bike Path at Brighton Street. The proposed path will be ADA-compliant and include accessible connections from the path to the north side of the Belmont Station platform, Concord Avenue, and Belmont Center. The path will also provide an accessible connection to Channing Road and the Belmont High School property at Alexander Avenue. The project will include safety improvements at the Brighton Street at-grade railroad crossing.

Ultimately the Belmont Community Path will continue to the west (under Phase II) and connect to the MCRT in Waltham which is currently in design.

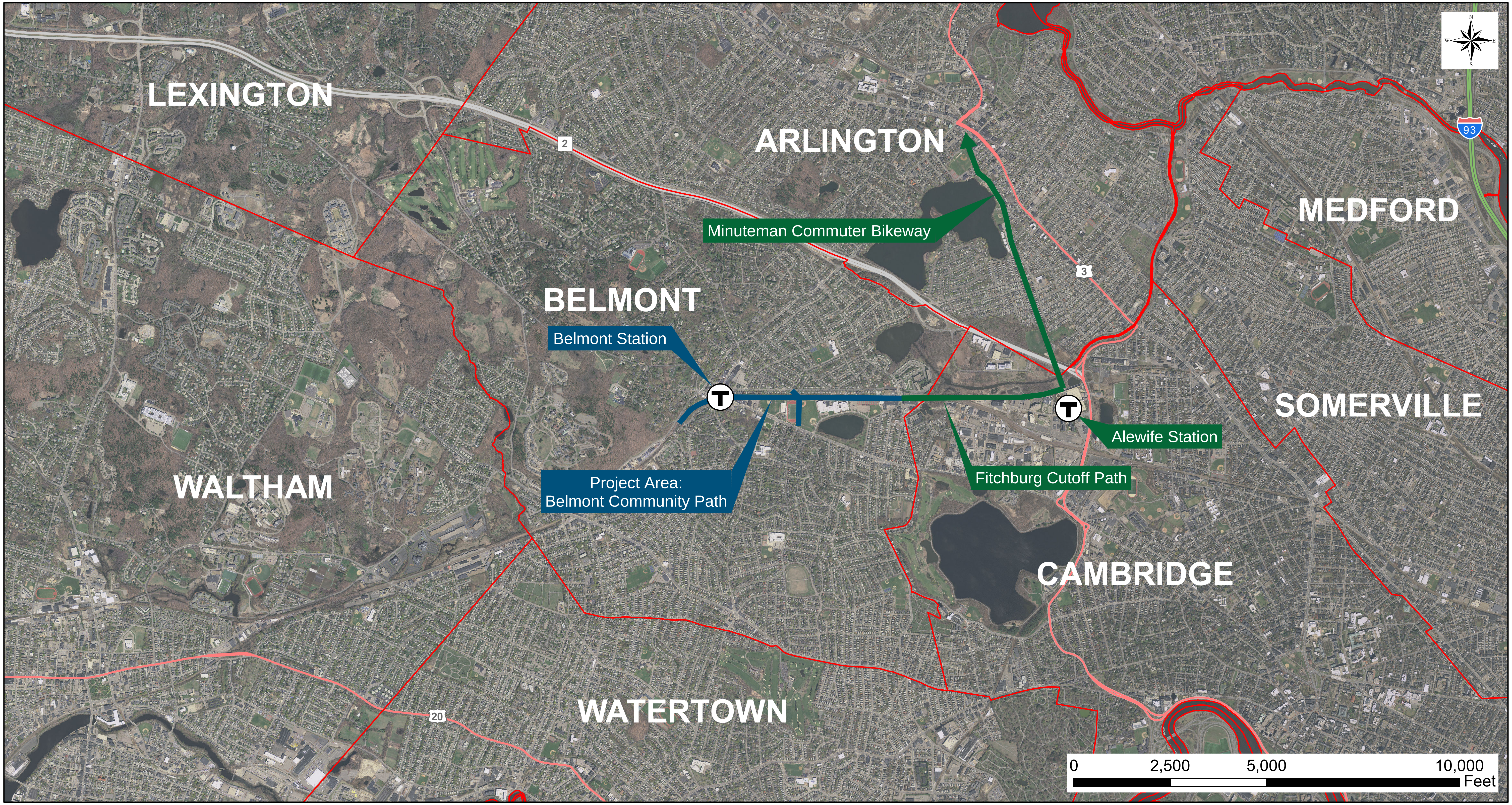

Figure 1: Locus Map
Belmont Community Path
Belmont, Massachusettes

Data Source: MassGIS
Nitsch Project #13548

Nitsch Engineering

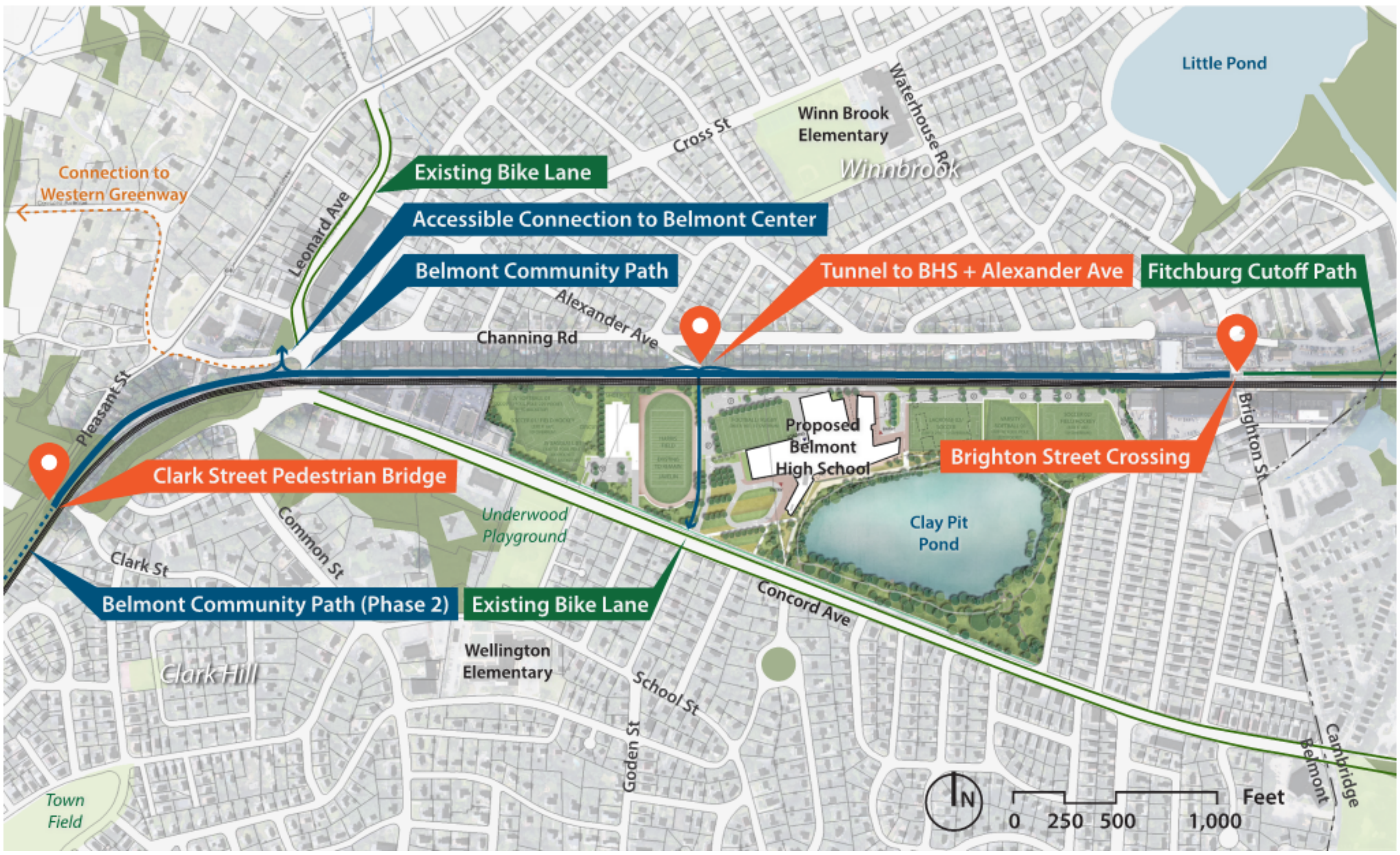

Figure 2 – Study Area

2 Existing Conditions

2.1 Right of Way

Th MBTA commuter rail operates it's Fitchburg Line through the Town of Belmont. The Fitchburg Line provides daily service from the City of Fitchburg to North Station in Boston. The MBTA Commuter Rail has two stops within the Town of Belmont: Belmont Station and Waverly Station. Belmont Station is within Phase 1b of the Community Path project limits, Waverly Station is approximately 1.4 miles to the west from Belmont Station. Within the Phase 1 project limits, the MBTA commuter rail owns a variable width right of way (50' to 130' wide). As part of the project development phase, the project team has evaluated the proposed path alignment along the MBTA ROW. It is anticipated that temporary and permanent easements will be required for construction of the path.

The Belmont Citizens Forum owns a parcel of land adjacent to the MBTA right of way from 291 Channing Road to 7 Channing Road. This parcel of land is approximately 25 feet wide and is located on the north side of the tracks between residential properties on Channing Road and MBTA property. This property will be made available to the Town for the purpose of utilizing this land as necessary for the construction of the path, to the extent possible.

As part of the recent construction of 40 Brighton Street, the property owner was required as a condition of approval by the Town to provide a 13.8-foot wide "passageway" easement to the DCR to allow for the construction of the future Community Path. The existing easement follows the property's southerly property line adjacent to the MBTA ROW and is 13.8-feet in width along the face of the building.

Additional properties within the project area that are under consideration for construction of the path include several properties owned by the Town of Belmont, including Belmont Center Station, Belmont High School and Middle School, #460 Concord Avenue, and various public layouts.

Permanent and temporary easements are anticipated to be required from some of the properties along Channing Road. Easements may be required for construction access, grading, and vegetation removal and/or planting. Once the preliminary path alignment is approved, preliminary right of way plans will be developed and submitted to MassDOT for review.

2.1.1 Segment 1 – Clark Street Bridge to #460 Concord Avenue

Clark Street Pedestrian Bridge

The Clark Street Pedestrian Bridge is an existing steel truss pedestrian bridge connecting Clark Street and Pleasant Street. The steel truss bridge has an approximate 6.5-foot wide wood deck and is not open to vehicular traffic. The bridge spans approximately 50 feet north to south over the MBTA Commuter Rail Railroad. The bridge sits on stone abutments, approximately 25 feet in height above the railroad tracks. The bridge connects to existing sidewalks along Pleasant Street, there are no sidewalks along Clark Street. The bridge is owned by the Town of Belmont.

Pleasant Street

Pleasant Street is classified as an Urban Principal Arterial under Town of Belmont jurisdiction. Pleasant Street is approximately 2.9 miles and runs in a northwest-southeast direction between Trapelo Road in Belmont and Massachusetts Avenue in Arlington. In the project area, Pleasant Street has one-lane in each direction and on-street parking is only allowed south of the project limits. Sidewalk is provided on the east side of the street. There are no bicycle facilities on Pleasant Street. The land use along Pleasant Street through the project area is both residential and commercial. The speed limit along Pleasant Street is 30 mph.

#460 Concord Avenue

The existing Belmont Municipal Light Building located at 460 Concord Avenue extends north-south from Concord Avenue to the railroad tracks. The nearest building edge is approximately 36 feet from the center of the nearest track. The parking lot on the back side of the building is enclosed by an existing chain link fence.

Concord Avenue

Concord Avenue is classified as an Urban Principal Arterial under the Town of Belmont jurisdiction. Concord Avenue runs east-west and connects Pleasant Street with Route 3 in Cambridge. The land use along Concord Avenue is both residential and commercial. The speed limit along Concord Avenue is 30 mph. Within this section of the project, Concord Avenue runs east to west connecting Pleasant Street to Leonard Street/Channing Road. Belmont Station is located on the south side of the roadway. Concord Avenue is one lane in each direction with on-street parallel parking on both sides and sidewalks are present on both sides of the road.

2.1.2 Segment 2 – Belmont Station to #7 Channing Road

Belmont Station

Belmont Station is an MBTA Commuter Rail Station on the Fitchburg line. The station is one of two stations in Belmont. The station provides access from the Commuter Rail to the center of Belmont. The station currently has no ADA accessible access on the north side of the platform from Concord Avenue. Users of the Commuter Rail currently access the platform via an existing concrete staircase from the sidewalk along Concord Avenue. There is an existing pedestrian tunnel under the railroad tracks that provides pedestrian access between inbound and outbound train platforms and the station on the south side of the tracks. The platform area on the north side of the station is supported by an existing stone retaining wall. There is on-street parallel parking on Concord Avenue adjacent to the station. There are MBTA bus stops for the 74 & 75 bus routes on Concord Road and Alexander Avenue.

Concord Avenue Bridge

The MBTA tracks cross over Concord Avenue via an existing stone block arch bridge dated 1907. The existing bridge carries two active railroad tracks. The bridge spans approximately 65 feet and is approximately 70 feet wide. The bridge clearance is posted to be 10 feet 3 inches. The bridge is surrounded by a metal picket fence. The bridge is owned and maintained by the MBTA.

Concord Avenue

Concord Avenue is classified as an Urban Principal Arterial under the Town of Belmont jurisdiction. Concord Avenue runs east-west and connects Pleasant Street with Route 3 in Cambridge. The land use along Concord Avenue is both residential and commercial. The speed limit along Concord Avenue is 30 mph. Within this section of the project, Concord Avenue crosses under the MBTA railroad bridge south of the intersection with Leonard Street and Channing Road. Concord Avenue has a posted clearance of 10’-3”. Concord Avenue is one lane in each direction with no defined shoulders and sidewalks on both sides. Concord Avenue intersects with Common Street south of the MBTA bridge over Concord Avenue.

#7 Channing Road

#7 Channing Road is currently a commercial property that is occupied by a bank. The existing building is located near the south side of the property adjacent to the MBTA ROW. The south side of the property is surrounded by a retaining wall of approximately 6 feet high. The nearest building edge is approximately 30 feet from the centerline of the nearest railroad track. Existing parking is oriented along the existing retaining wall on the north side.

2.1.3 Segment 3 – Channing Road West (#17 Channing Road to Alexander Avenue)

From #17 Channing Road to Alexander Avenue, the MBTA railroad tracks are located south of the residential properties. There is approximately 65-feet from the residential property lines to the center of the nearest track. The tracks are elevated about 8-feet above the elevation of the residential properties. The properties are separated from the tracks by fencing and wooded vegetation. The MBTA ROW contains a gravel access road that runs parallel along the north side of the tracks.

Alexander Avenue

Alexander Avenue is classified as a local roadway under the Town of Belmont jurisdiction. Alexander Avenue runs north to south connecting Leonard Street to Channing Road. The land use along Alexander Avenue is primarily residential. South of Channing Road, Alexander Avenue is a gravel roadway that is used as maintenance and emergency access to the MBTA railroad tracks. At the southern terminus of Alexander Avenue, there is an existing gate at the property line of the MBTA ROW.

Belmont High School and Middle School

Belmont High and Middle School Project is currently under construction south of the MBTA ROW and north of Concord Avenue. The project includes the replacement of the existing Belmont High School building with the new Belmont High and Middle Schools. The project also includes the construction of new athletic fields, parking lots, access driveways, multi-use path, and utilities to support the proposed building and site. The site is approximately 38 acres including the existing main building, parking areas, Claypit Pond, and associated walkways. The site is bounded by commercial properties to the west, MBTA Fitchburg line to the north, existing residences and Concord Avenue to the southeast, existing residences and Underwood Street to the southwest, and existing commercial buildings to the east. The site slopes generally south towards Claypit Pond.

The existing school building is located in the center of the site, to the north of Claypit Pond. Natural grass athletic fields are located to the west of the building. A large parking lot is located to the east of the building, Tennis courts are located to the northeast of the parking lot. Another natural grass athletic field is located to the east of the parking lot. Vehicular access to the site is provided by a driveway adjacent to Claypit Pond that connects Concord Avenue to the intersection of Hittinger Street and Underwood Street.

Concord Avenue

Concord Avenue is classified as an Urban Principal Arterial under the Town of Belmont jurisdiction. Concord Avenue runs east-west and connects Pleasant Street with Route 3 in Cambridge. The land use along Concord Avenue is both residential and commercial. The speed limit along Concord Avenue is 30 mph. Within this section of the project, Concord Avenue is one lane in each direction separated by a landscaped raised median. There are bicycle lanes along each travel lane and parallel on-street parking. Sidewalks are present along both sides of the roadway. The existing intersection of Concord Avenue and the High School driveway is currently signalized for the pedestrian crossing. The signals are pedestrian actuated on both sides of the roadway.

As part of the High School reconstruction project, the intersection of Concord Avenue, Goden Street, and the High School driveway will be reconstructed. The reconstructed intersection will include a new traffic signal system for all approaches, and the alignment for the driveway will be aligned with Goden Street. A dedicated left turn lane will be added for the eastbound and westbound approaches on Concord Avenue. The school driveway will have a dedicated right turn lane and a thru/left turn lane. Goden Street will be retained to have one approach to the intersection. As part of the improvements, new wheelchair ramps and pedestrian push buttons will be provided.

2.1.4 Segment 4 – Channing Road East (Alexander Avenue to #40 Brighton Street)

From #145 Channing Road to #40 Brighton, the MBTA railroad tracks are located south of the residential properties. There is approximately 65-feet from the residential property lines to the center of the nearest track. The tracks are elevated about 8-feet above the elevation of the residential properties. The properties are separated by fencing and wooded vegetation. The MBTA ROW contains a gravel access road that runs parallel along the north side of the tracks.

#40 Brighton Street

The property located at #40 Brighton Street was reconstructed in 2015 and occupies two commercial occupants. The property has access to Brighton Street directly north of the MBTA railroad tracks. The property contains a one-story commercial building, parallel parking (15 spaces) on both sides of the driveway, and storage area on the west side of the building. The property owners provided a 13.8-foot wide passageway easement along its southerly property line with the MBTA ROW to the DCR for the purpose of constructing the Community Path. The existing building is approximately 25-feet from the center of the nearest track.

2.1.5 Segment 5 – Brighton Street Crossing to Fitchburg Cutoff

The existing MBTA Railroad track crossing Brighton Street is currently controlled by grade crossing signals and railroad crossing gates. Sidewalks are present on both sides of Brighton Street near the tracks and a mid-block crosswalk is located immediately north of the tracks. The existing Fitchburg Cutoff Bike Path begins on the northeast corner of the railroad crossing. The exiting path connects Brighton Street to the Alewife MBTA Station, the Minuteman Trail, Alewife Greenway Path and Cambridge Linear Path. Within 100 feet, there exist several private driveways north of the railroad crossing. To the north, Vale Road approaches from the east and intersects with Brighton Street to form an unsignalized "T" intersection; however, no stop bar or stop sign is present at this intersection. To the south, Hittinger Street approaches from the west to intersects with Brighton Street to form an unsignalized "T" intersection, and a stop bar is present at the Hittinger Street approach; however, no stop sign is posted.

Brighton Street

Brighton Street is classified as an Urban Minor Arterial under Town of Belmont jurisdiction. Brighton Street is approximately 5,000-feet long, runs in a north-south direction, and extends from a point approximately 750-feet north of Pleasant Street and terminates at Blanchard Road, approximately 150-feet north of Hamilton Road. Brighton Street has one-lane in each direction separated by a double yellow center line. Parking is provided for a short block just south of Hettinger Street. Sidewalks are provided on both sides of Brighton Street. There are no bicycle facilities on Brighton Street. The land use along Brighton Street is both residential and commercial. The speed limit along Brighton Street is 30 mph.

Brighton Street Railroad Crossing Crash Analysis

Nitsch obtained and reviewed police reports from the Town of Belmont Police Department and MBTA Transit Police Department for incidents that occurred near the Brighton Street at grade railroad crossing to identify crash patterns and to propose improvements. Table 1 summarizes crash statistics for the study segment between the intersection of Brighton Street at Pond Street and the intersection of Brighton Street at Hittinger Street and includes the severity and manner of collision.

Table 1: Crash Statistics

Brighton Street Segment From Pond Road to Hittinger Street	**Year**					
	2015	**2016**	**2017**	**2018**	**2019**	**TOTAL**
Number of Crashes	2	9	3	3	7	**24**
Severity of Crash						
No Injury/Unknown	2	7	2	2	6	**19**
Injury	0	2	1	1	1	**5**
Fatality	0	0	0	0	0	**0**
Manner of Collision						
Angle	2	4	1	1	5	**13**
Rear-End	0	3	2	1	1	**7**
Sideswipe, Same Direction	0	0	0	0	1	**1**
Train	0	1	0	0	1	**2**
Single Vehicle Crash	0	1	0	0	0	**1**
Involved Cyclists or Pedestrians	0	0	0	1	2	**3**
Percent Occurring During						
Peak Hours (7-9 AM, 4-6 PM)	0%	33%	33%	0%	71%	**38%**
Adverse Weather/Roadway Conditions [b]	0%	11%	33%	0%	14%	**13%**
[b] Rain, snow, sleet/hail/freezing rain/freezing drizzle, blowing sand/snow; Wet, icy, or snowy road surface						

A total of 24 crashes were reported for the study segment from 2015 to 2019. No fatal crashes were reported, though 21% of the crashes resulted in injuries. Half of the crashes (50%) were angle crashes, and 33% were rear-end crashes. Three crashes involved cyclists (traveling straight on Brighton Street), and two crashes involved trains. 38% of the crashes occurred during peak hours, and 13% occurred under adverse weather or road surface conditions.

Based on a summary of the existing crash information and site visits conducted by the design team, we identified the following safety concerns at the study segment and are summarized below:

- Poor visibility and lack of signage on Brighton Street southbound approaching Pond Street presents a safety concern for vehicles approaching Pond Road during high congestion periods or when the railroad gates are down;

Looking southbound approaching Pond Road, the roadway curvature contributes to the poor visibility of queuing traffic at the Railroad Crossing

- No stop bar or stop sign is present on minor street approaches - crash records showed more than 50% of the crashes occurring at these intersections were angle crashes due to failure to yield the right of way;

No Stop Sign or Stop Bar for side street approaches

Unprotected crosswalk

- Unprotected high volume pedestrian/bicycle crossing;
- Closely spaced intersections and driveways near the railroad crossing (200 feet from Vale Road and 150 feet from Hittinger Street; and
- Brighton Street southbound traffic often backs up into the railroad crossing.

Existing Traffic Volumes

Nitsch obtained Turning Movement Counts (TMC) for the intersection of Brighton Street at Eliot Street conducted by BSC Group in April 2018. The intersection is located approximately 1,000 feet north of the Brighton Street railroad crossing with no major cross streets in between.

Background Growth

MassDOT records traffic volumes at various stations throughout the Commonwealth over multiple years to identify regional shifts in traffic. Nitsch Engineering researched MassDOT count stations near the study area to determine a traffic volume trend throughout the years of volume data available. There are three stations in the vicinity of the study area (1-mile radius), located on Route 2 to Pleasant Street Off-Ramp, Lake Street to Route 2 On-Ramp, and Concord Avenue west of Alewife Brook Parkway. Table 2 depicts the traffic volumes and the calculated growth rate for the one-year period.

Table 2: Background Growth Rate

COUNT LOCATION	AADT[1], YEAR		1-YEAR GROWTH RATE
	2017	2018	
Lake Street to Route 2 EB On-Ramp	1,709	1,714	2017 - 2018 0.15%
Route 2 EB to Pleasant Street Off-Ramp	5,841	5,859	2017 - 2018 0.15%
Concord Avenue west of Alewife Brook Parkway	47,202	47,863	2017 - 2018 0.70%

[1]Annual Average Daily Traffic (AADT) is the average traffic volume for the entire given calendar year
(Source: Massachusetts Department of Transportation (MassDOT) Data Management System)

We utilized the existing TMC at the intersection of Brighton Street and Eliot Street, and estimated the morning and evening peak hour traffic volumes on Brighton Street across the at-grade railroad crossing to be 1348 and 1598 vehicles per hour, respectively. To be conservative, we used 1.0% growth rate and projected the 2018 peak hour traffic volumes to the future design year (2030) and yield to 1519 and 1801 vehicles per hour.

2.1.6 Segment 6 – Existing Fitchburg Cutoff Path

Fitchburg Cutoff Path

The Fitchburg Cutoff Path is a 0.8-mile-long paved multi-use path that follows a portion of the MBTA right-of-way. The path runs in east-west direction from Brighton Street in the Town of Belmont to the Alewife station in Cambridge. At its eastern terminus, the path connects to three multi-use paths, the Minuteman Bikeway, the Alewife Brook path and the Cambridge Linear Park.

3 Design Guidelines

3.1 Multi-Use Path

Multi-use paths are non-motorized facilities most often built on exclusive rights-of-way with relatively few motor vehicle crossings. These paths are a complementary system of off-road transportation routes for bicyclists and other non-motorized users, and they supplement a system of on-road bike lanes, wide outside lanes, paved shoulders, and bike routes. Since multi-use paths are used by pedestrians, their design also needs to comply with the Americans with Disabilities Act (ADA) and Massachusetts Architectural Access Board (MAAB) requirements. Relevant references for multi-use path design include the following:

- Project Development & Design Guide (2006), MassDOT;
- Urban Bikeway Design Guide, Second Edition (2014), National Association of City Transportation Officials (NACTO);
- Guide for the Development of Bicycle Facilities, Fourth Edition (2012) with latest errata,
- American Association of State Highway and Transportation Officials (AASHTO);
- A Policy on Geometric Design of Highways and Streets, 7th Edition (2018), AASHTO;
- 521 CMR, The Rules and Regulations of the Massachusetts Architectural Access Board (2006); and
- “Rails-with-Trails” Lessons Learned, Federal Highway Administration (2002).

Multi-Use Path Users, Purposes, and Locations

Multi-use paths support a wide variety of non-motorized travelers such as bicyclists, in-line skaters, roller skaters, wheelchair users, walkers, runners, and people with baby strollers or people walking dogs. Multi-use paths are most commonly designed for two-way travel and can serve a variety of important purposes, including:

- A shortcut to a nearby destination or through a neighborhood;
- An alternative to a busy thoroughfare or a “motor vehicle-only” corridor;
- A way to get across a motorized barrier, especially a freeway;
- An enjoyable travel opportunity for individuals and families; and
- A place to exercise, recreate, or rehabilitate from injury.

To accomplish these ends, multi-use paths have been built:

- Along rivers, creeks, and lake fronts;
- Within college campuses or within and between parks;
- Between cul-de-sac streets in new developments; and
- As the case is here, on or next to railroad rights-of-way (abandoned or active), and Town land.

Design Elements

There are numerous similarities and differences between the design criteria for multi-use paths and highways. Similarities include the need for:

- Carefully designed vertical grades and curves;
- Routine maintenance (e.g., joint filling);
- Adequate curve radii;
- Adequate sight distance at curves and intersections;
- Lighting;
- Warning, regulatory, and informational signs where required;
- Basic pavement markings; and
- Routine all-weather maintenance.

Differences include such design elements as:

- Vehicle size and clearance requirements;
- Pavement width;
- Wide variety of bicycle user ages and capabilities;
- Design speeds used to determine geometrics;
- Grades that the design vehicle (bicycle versus motor vehicle) can typically negotiate; and
- Pavement structure needed to support a typical path versus road traffic.

3.1.1 Path Width

The paved width required for a multi-use path is a primary design consideration. Under most conditions, the minimum paved width for a two-way multi-use path is 10 feet, though it is desirable to increase the width of a shared use path to 12 feet, or even 14 feet to accommodate substantial use by bicycles, joggers, skaters, and pedestrians, and to provide access for maintenance vehicles. In certain instances, a reduced width of 8 feet may be acceptable where there are severe environmental, historical, and/or structural constraints. The proposed Belmont Community Path is proposed to be a 16-foot paved width. This 16-foot width was developed from extensive public input to provide proper separation from avid cyclists and slower paced users. The width may vary in critical areas to the 10-foot minimum due to site constraints.

Spurs, or side paths that provide a multi-use connection from the Belmont Community Path to grade separated crossings, are proposed to be a 10-foot minimum width. Spurs typically see less traffic than the main path and can be considered access points to the main path.

Along the path and the spurs, shoulders with a 1-foot minimum and 2-foot typical width are proposed. The material on the shoulders are proposed to be different than the paved path. Options for the shoulder material include loam and seed, or a crushed compacted aggregate such as stone dust or gravel. Loam and seed require the most maintenance, requiring regular mowing throughout the growing season. Compacted aggregates require less maintenance but could provide a less stable surface for bicyclists who veer off of the path.

3.1.2 Design Speed

The speed that a bicyclist travels is dependent on several factors including the type and condition of the bicycle, the purpose of the trip, the pavement condition, the location and grade of the bicycle path, the surface type, the speed and direction of the prevailing wind, the weather condition, the number and type of users on the path, and the physical condition of the bicyclist (AASHTO Guide, page 5-12). Multi-use paths should be designed for speeds at least as high as the preferred speed of faster bicyclists but not such that the path design encourages speed. MassDOT and AASHTO recommend a design speed of 18 MPH for general paved path surfaces on relatively flat terrain and anticipated use by experienced cyclists. Path design at intersecting roadways is configured to encourage a lower operating speed for bicyclists. Traffic calming measures such as signs and pavement markings on the approaching roadways are often implemented to heighten the motorists’ awareness of the path crossing.

The proposed design speed for the Belmont Community Path is 18 MPH because of the urban and constrained site conditions. However, this is a minimum design speed and higher design speed requirements will be a goal of the design to improve user comfort along the path.

3.1.3 *Signing and Pavement Marking*

Adequate signing and pavement marking are essential on multi-use paths. Proposed pavement markings for this project include a broken yellow centerline striping for the length of the path, stop lines and “STOP AHEAD” legends where appropriate, and a striped crosswalk across Brighton Street. Proposed signage includes stop signs, stop-ahead warning signs, bike route markers, and applicable wayfinding signs.

3.2 Offsets from Railroad Tracks

Typically, multi-use paths should be constructed with a significant distance from active railroad tracks. However, in constrained corridors, such as the Belmont Community Path, multi-use paths have been successfully constructed along active railroad tracks. Given the vast difference in railroad speeds and frequency across the country, there are no set design standards for horizontal offsets from active railroad tracks. The Federal Highway Administration (FHWA) has compiled a design guideline (Rails-with-trails, 2002) with lessons learned and best practices for designing multi-use paths along active railroads. The guidance recommends that the design parameters and minimum requirements be agreed upon with the project proponent and the owner of the adjacent railroad.

One critical element of the design of a multi-use path along an active railroad is the setback distance. The setback distance is the horizontal measurement from the nearest track centerline to the nearest edge of the multi-use path.

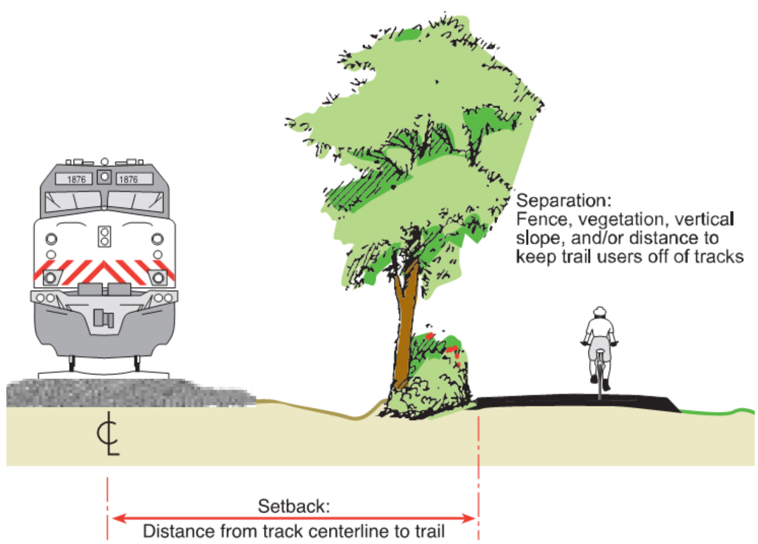

Figure 3 - Setback and separation definition (Rails-with-Trails, 2002)

The MBTA defines the foul zone as the area within 4 feet of the nearest track edge, or approximately 6-feet from the track centerline. The MBTA Commuter Rail’s encroachment zone is defined to be 15-feet from the nearest track edge, or about 17-feet from the track centerline. Access within the foul zone and encroachment zone is limited and entrance into this zone must be in accordance with MBTA and Keolis permissions and training. In constrained areas where the path is proposed to be within the encroachment zone, a suitable vertical barrier will be installed as described in Section 3.3.

The MBTA Standard Plans, dated March 18, 2018, specify a minimum setback distance of 8.5-feet and a preferred setback of 12-feet to the back edge of overhead bridge piers or abutments, retaining walls, and other obstructions (Drawing 1012). Our proposed path alignment provides a minimum setback distance of 11-feet to the edge of trail. This 11-foot setback allows for the construction of a 1-foot minimum level shoulder and width for a vertical barrier, as defined in Section 3.3, to meet the MBTA required 8.5-foot minimum setback.

MBTA Standard Plan 1015 specifies an 18-foot setback clearance on the side designated for access and maintenance. The proposed Community Path alignment typically provides an 18-foot minimum setback, except in constrained locations, to allow for maintenance vehicles to access the railroad tracks. In constrained locations, gates may be provided, as required by the MBTA, to allow maintenance and emergency vehicle access between the railroad tracks and the path. Where there is not enough width for an access road, maintenance vehicles will be expected to safely utilize the path for maintenance access. The MBTA would need to close portions of the path, as needed, to allow for access and maintenance operations. An example of the use of gates and possible locations in constrained areas are shown in Figure 4 below.

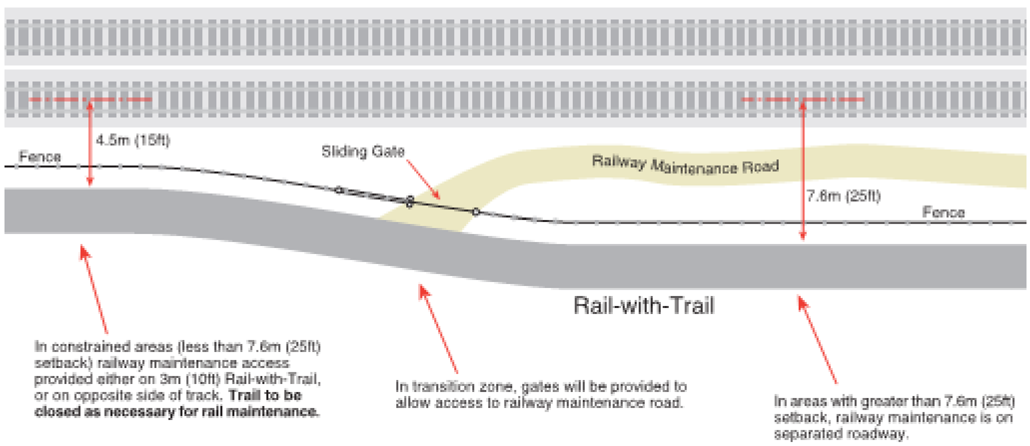

Figure 4 - Sample maintenance access transitions (Rails-with-Trails, 2002)

For the Belmont Community Path, we propose the following distances for the setback. These distances are based upon design recommendations:

Table 3: Design Setback Distances (feet)

	Setback Distance (Feet)
Required Minimum	10
Desirable	25
Minimum Proposed	11

The Belmont Community Path proposes a minimum set back distance of 25-feet in unconstrained conditions. In constrained areas, the setback distance is proposed to be a minimum of 11-feet. The one location where a 11-foot setback is proposed is adjacent to 40 Bright Street. In areas where a setback distance is less than 25-feet, vertical barriers will be provided as described in Section 3.3.

3.3 Vertical Barrier from Railroad Tracks

In locations where the proposed setback is less than 25-feet we recommend the installation of vertical barrier to separate the path from the railroad tracks. The vertical barrier will allow for path users to feel comfortable riding alongside an active train. A solid barrier will help reduce air movements caused by the train, provide visual separation from the railroad tracks, limit ability to access the tracks from the path, and protect users from small objects such as rock and debris. Proposed vertical barrier would be a minimum of 8-feet in height. The locations of access gates will be coordinated with Keolis, the MBTA, and Town public safety officers. Two potential material options for constructing solid vertical barriers are timber post/fence and a pre-cast concrete panel wall.

Below are photos showing example of the two options for vertical barriers that are being considered for separation. The timber post and wood fence consists of 6-inch timber posts embedded into the ground and clad with 2x12 timber lagging to the proposed height. There will be minimal gaps proposed between the panels so that the barrier has the full affect and will prevent dust and debris from passing through the barrier. One advantage of the timber barrier is that the material could match the proposed wood railing along the path. The other option is a pre-cast concrete panel barrier. This style barrier would be constructed by embedding steel piles into the ground and placing pre-cast concrete panels between the piles. Advantages of the concrete panels is that the color and texture can be specified to create an aesthetically pleasing design. Concrete panels can be fabricated to provide a dense barrier between the tracks and can help dampen noises.

Example Timber Vertical Barrier

Example Pre-Cast Concrete Vertical Barrier

Chain Link / Ornamental Fence

In areas where the setback distance is greater than 25-feet a chain link or ornamental fence would be installed to provide separation between the path and the tracks. Gates can be located at intervals along the fence to provide access for maintenance or emergencies.

Ornamental Fence Between Fitchburg Cutoff and the
MBTA Commuter Rail at Brighton Street, Belmont

Chain Link Fence Between East Boston Greenway and MBTA Blue Line

Wood Railing

Wood railing will be installed as required for rider protection near walls and steep slopes. Proposed wood railing will have a height of 48-inches and be constructed using timber posts and rails. In accordance with trail standards, railing will have three wooden rails spaced equally with a timber top rail. A photo of an example timber rail along a shared use path is located below.

Example Timber Railing

3.4 Public Safety

The proposed path can be located to provide a public safety benefit in additional to its transportation and recreational value. A paved corridor adjacent to the MBTA Commuter Rail will make the tracks more accessible to emergency personnel the event of an emergency on the tracks. For instance, during events that would require an evacuation of a train, passengers can access and utilize the Community Path to walk to the nearest station or crossing instead of walking along the active railroad tracks. As part of the proposed design we continue to coordinate with the Belmont Fire and Police Departments, Keolis, and the MBTA to locate access gates between the path and the tracks for emergency and maintenance access. The gate locations will be critical in areas where the path setback is proposed to be less than 18 feet and limited width for a maintenance road is available. Maintenance and emergency vehicles can access the tracks via the paved path at proposed access gate.

The construction of an underpass connecting Alexander Avenue north of the tracks and Belmont High and Middle School property to the south will provide safe pedestrian and bicycle access to the schools and to destinations south of the railroad. The Alexander Avenue underpass will eliminate the need for residents from the Channing Road neighborhood to cross the active tracks to access the school. The new underpass will provide a safe grade-separated crossing to the schools as well as points of interest south of the tracks. Currently the only access across the tracks is west of the school at Brighton Street and to the east along Concord Avenue at Belmont Center. The proposed underpass will provide a passageway for residents to safely and more directly walk and bicycle to and from destinations north and south of the tracks.

The Community Path project includes proposed improvement for the crossing of Brighton Street at the terminus of the Fitchburg Cutoff Path, located just north of the existing MBTA at-grade railroad crossing. The proposed improvements include traffic calming measures and improvements to visibility and awareness at the approaches to the crossing. Proposed measures may consist of textured colored crosswalks, new reflective warning signage, raised medians, and additional pavement markings. Alternatives also may include a new pedestrian/train actuated traffic signal at the crossing, which is more thoroughly discussed in Section 4.6.1. Additionally, we propose the installation of stop signs and markings on adjacent streets to improve safety, as required.

The installation of a pedestrian activated traffic signal at the Brighton Street crossing will reduce pedestrian and bicycle delay and improve safety. As a trade-off, we anticipate an increase in frequency of vehicle queuing that would extend to upstream intersections. The installation of stop signs and stop bars at side street approaches would help to reduce the frequency of angle crashes. Additionally, we recommend installing an advanced “red signal ahead” sign to alert southbound vehicles as they approach the railroad crossing. A queue cutter signal may also be considered as part of the new traffic signal system to further reduce the potential for vehicles stopping on or near the tracks.

4 Design Alternatives

4.1 Segment 1 – Clark Street Bridge to #460 Concord Avenue

Phase 1 of the Community Path begins at the Clark Street Pedestrian Bridge, which connect Clark Street south of the tracks to Pleasant Street to the north. Access to the Clark Street Pedestrian Bridge and Pleasant Street are to be provided as part of this project. Phase 2 of the Community Path will be done as a future project and consists of the continuation of the path from the Clark Street Pedestrian bridge westerly to Waverly Station and the Waltham City line.

4.1.1 Alternative Design 1

Alternative 1 proposes to construct the path near the elevation of the railroad tracks, and below the existing Clark Street Pedestrian Bridge. The proposed path will typically be constructed as a 16-foot wide paved surface along most of Segment 1. At the beginning of the project below the bridge, there is approximately 25-feet from the edge of the existing stone abutment to the center of the nearest railroad track. Alternative 1 requires the portion of the path beneath the bridge and adjacent to the existing stone bridge abutment to be constructed with a 11-foot setback from the railroad tracks. A proposed 11-foot setback will allow for the construction of a 12-foot wide paved path with 2-foot shoulders on both sides. A vertical barrier is proposed along the southerly shoulder, parallel to the railroad. The proposed path width would increase to 16-feet just east of the stone abutment and transition to a 25-foot setback as the path travels to the east. The proposed path profile is proposed to remain relatively flat within this area and would not require a long, steep upgradient hill climb for the main alignment. This relatively flat gradient is advantageous to users to the path by creating a generally level route. Alternative 1 does not provide for the desired 18-foot setback for maintenance requirements to incorporate a parallel gravel maintenance road for much of this segment of the corridor. Gates or access points may be provided along the path to provide access the tracks. The proposed setback from the Clark Street Pedestrian Bridge towards 460 Concord Avenue will increase from 11’ to 25’ as the alignment travels to the east.

To provide connectivity to the Clark Street Pedestrian Bridge this Alternative proposes a 600-foot spur from the main trail alignment to the north side of the bridge at Pleasant Street. The spur would begin approximately 500 feet east of the Clark Street pedestrian bridge, where it would intersect with the proposed path. This spur would run parallel along the north side of the path and proposed to be approximately 12 to 15-feet from the main trail to allow room for 2-foot shoulders along both the main path and the spur, a retaining wall, and fence and/or railing. The proposed spur profile will not exceed 4.5%, the maximum allowed per MassDOT accessibility guidelines. The spur would require the construction of an approximately 550-foot-long retaining wall of varying height from zero to 25-feet to support the spur. The wall would terminate at the existing stone abutment. This construction of the spur will require approximately 1,400 cubic yards of fill for the construction. A drainage swale will be provided along the northerly side of the spur to collect any runoff from the slope to the north.

The proposed path alignment will shift closer to the railroad tracks as it travels eastward towards Belmont Station, due to the proximity of the existing structure at 460 Concord Avenue. The proposed 16-foot wide path will transition to a 16-foot setback at this constrained location. The proposed shoulder along the path will be constructed adjacent to the existing building to maximize the setback from the railroad tracks. A vertical barrier will be provided between the path and the railroad tracks. 460 Concord Avenue is currently under construction and the proposed alignment will consider the proximity to the existing parking lot and chain link fence. A narrower path, (10-foot minimum) may be constructed to maintain a minimum setback distance of 10-feet from the railroad tracks at this location.

4.1.2 Alternative Design 2

Alternative 2 proposes to construct the main path to meet the Pleasant Street side of the Clark Street Pedestrian Bridge. This option does not include a spur connection to the bridge since the path will be elevated to the bridge elevation. Alternative 2 will provide a 34-foot typical setback from the railroad tracks. This 34-foot setback will allow MBTA maintenance vehicles to utilize an adjacent gravel road to access the tracks as they do currently. Alternative 2 proposes a 16-foot wide paved path with 2-foot shoulders, similar to Alternative 1. The path will require the construction of an approximately 700-foot long wall of variable height from 0 to 25-feet between the path and the railroad.

One disadvantage of Alternative 2 is user comfort. The path will climb along a length of approximately 750-feet at a maximum grade of 4.5%. The construction of the main path will require approximately 4,000 cubic yards of fill. A drainage swale will be provided along the northerly side of the path to collect any runoff from the slope to the north. The extension of the path under Phase 2 of the Belmont Community Path Project will require a long downgradient as it extend westward.

The path alignment and proposed setbacks adjacent to #460 Concord Avenue would be the same as proposed under Alternative 1.

4.1.3 Recommended Alternative

We recommend that Alternative 2 be constructed for Segment 1. Alternative 2 meets the goals of maintaining MBTA maintenance access, provides greater setback distances from the existing tracks, has a lower construction cost, and provides a contiguous path for users accessing the trail from Pleasant Street and Clark Street. The construction of a spur proposed under Alternative 1 includes construction of an additional a narrow path, which would increase project costs. Retaining walls of similar heights would be required under Alternative 1 and Alternative 2, requiring similar levels of design. Alternative 2 provides a direct access connection to the Clark Street Pedestrian Bridge. Alternative 2 also avoids the “pinch” point in the path alignment under the bridge (Alternative 1) where the proposed path would be narrowed to 12-feet wide to provide an 11-foot setback. Alternative 2 provides a consistent 16-foot width path at the bridge. This reduction in path width will be noticeable to path users and be visually unappealing.

Alternative 2 is also preferred because it retains maintenance access for the MBTA on the existing gravel roadway adjacent to the tracks. Alternative 1 requires maintenance vehicles utilize the Community Path for access to the tracks, as there is no room for the gravel road adjacent to the existing stone abutments. Alternative 2 would allow emergency and maintenance vehicles to access the tracks and the path from the adjacent gravel road, similar to how the tracks are accessed today.

There is no change in the design for the path at #460 Concord Avenue between the two Alternatives.

MASSDOT PFN 609204
BELMONT
BELMONT COMMUNITY PATH PHASE 1
SEGMENT 1 - ALTERNATIVE 1
FIGURE 5

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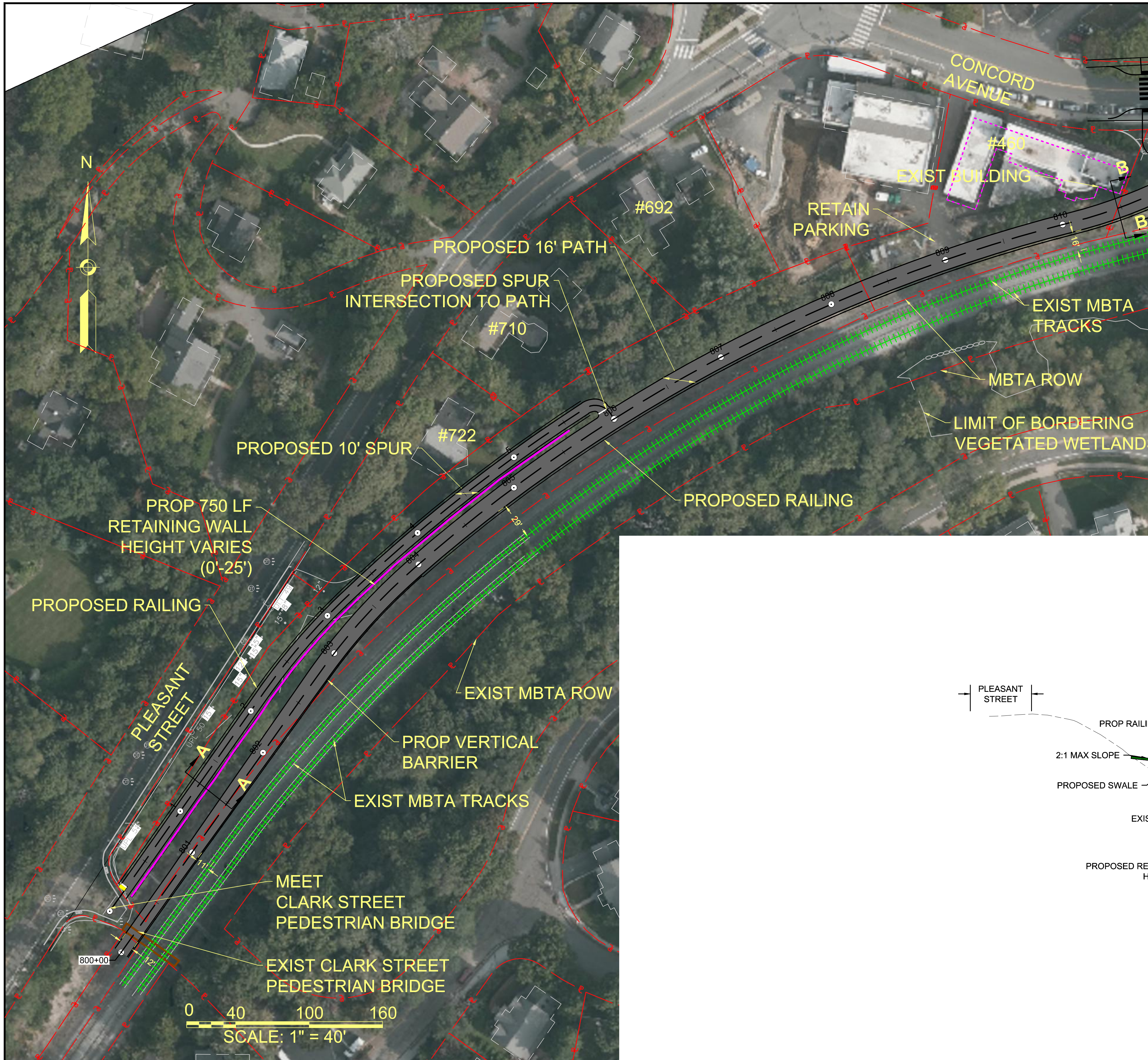

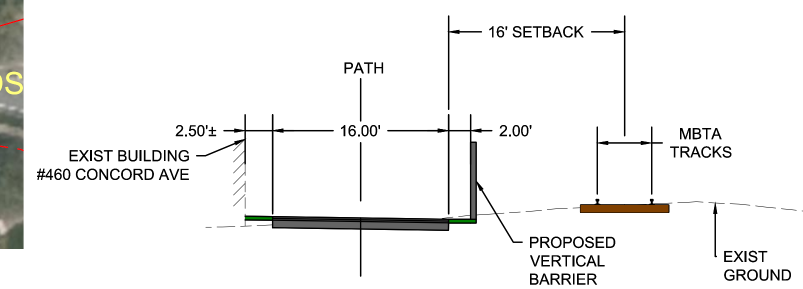

SECTION B-B

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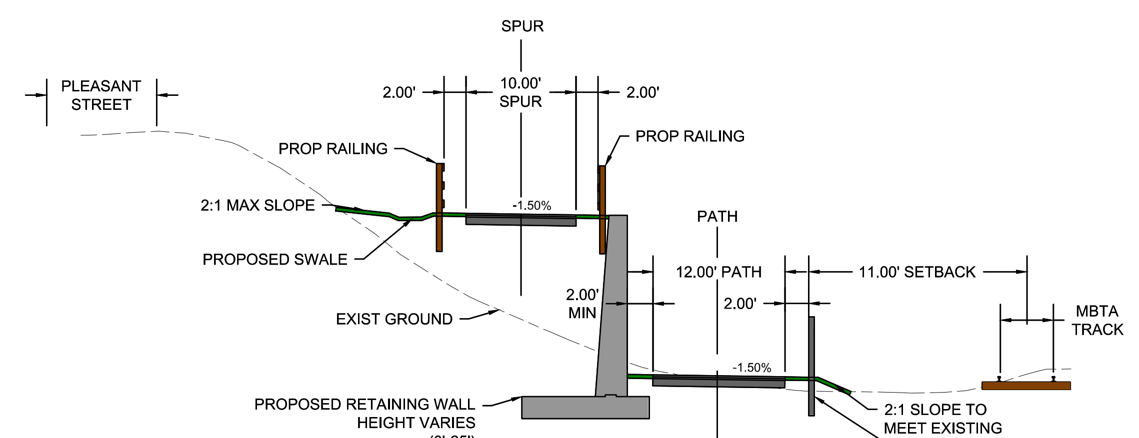

SECTION A-A

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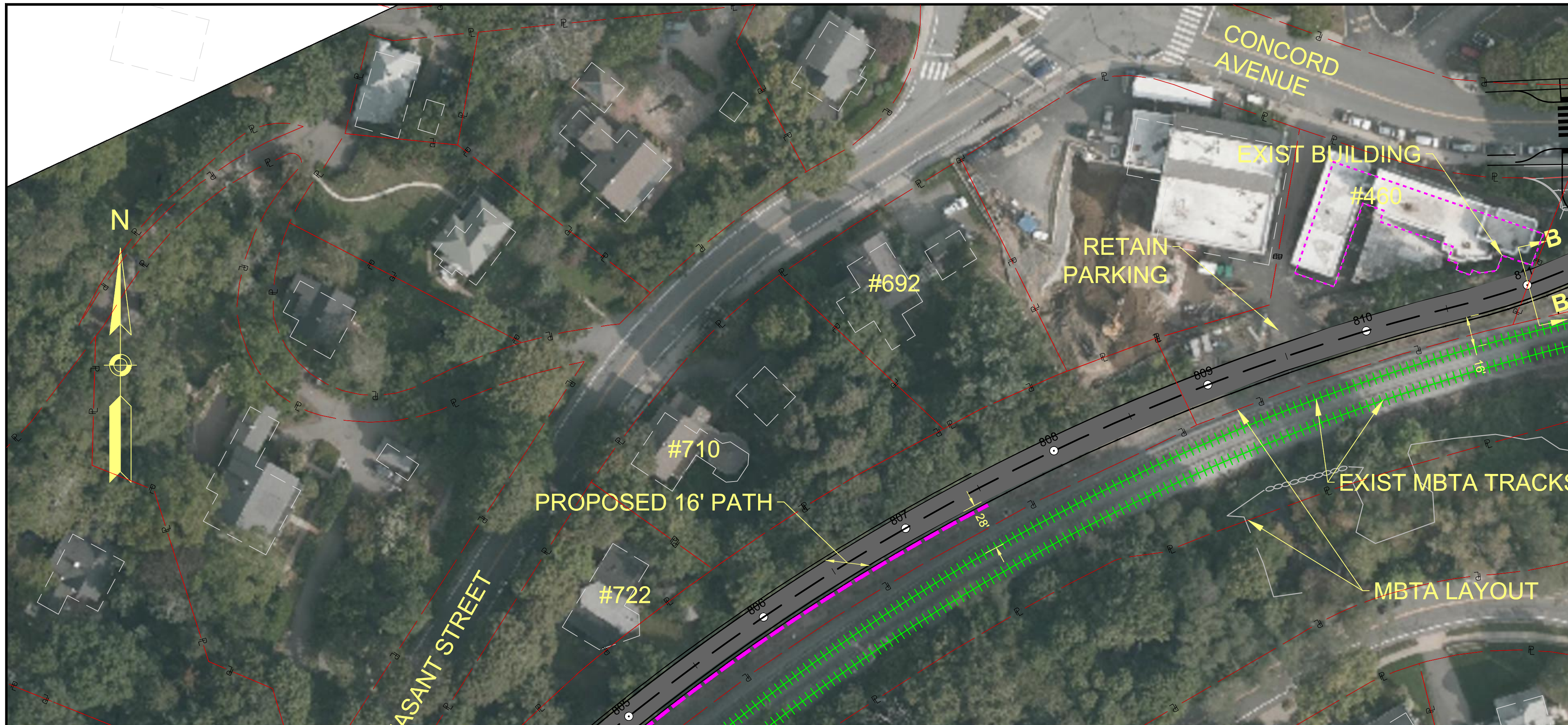
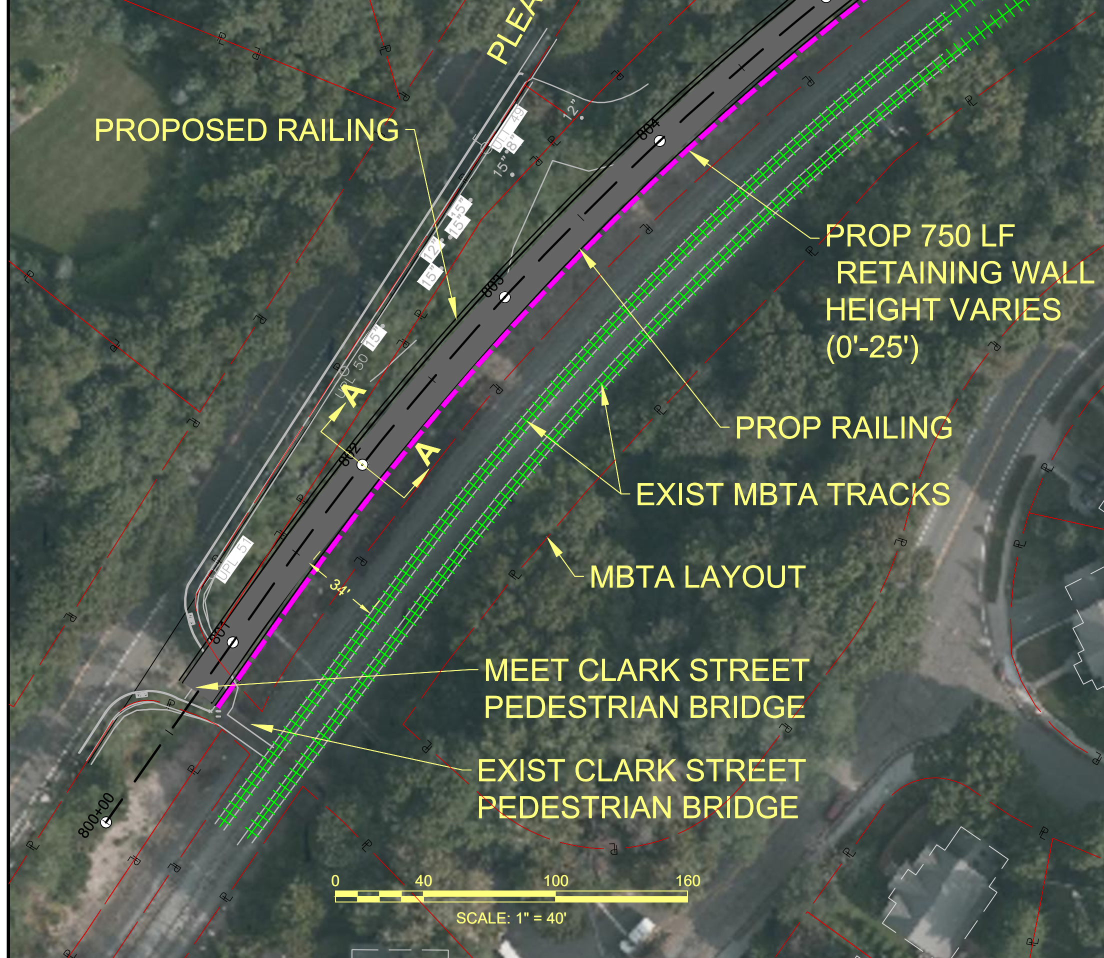
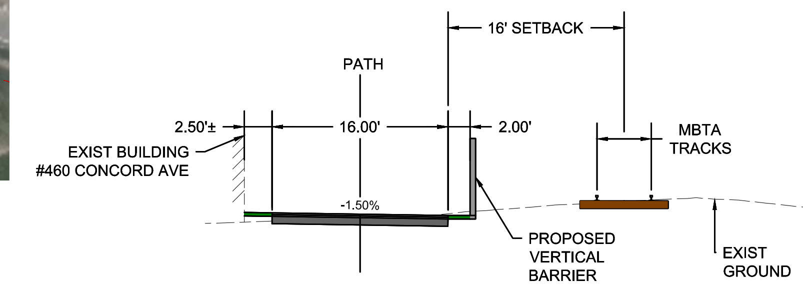
MASSDOT PFN 609204
BELMONT
BELMONT COMMUNITY PATH PHASE 1
SEGMENT 1 - ALTERNATIVE 2
FIGURE 6



SECTION B-B
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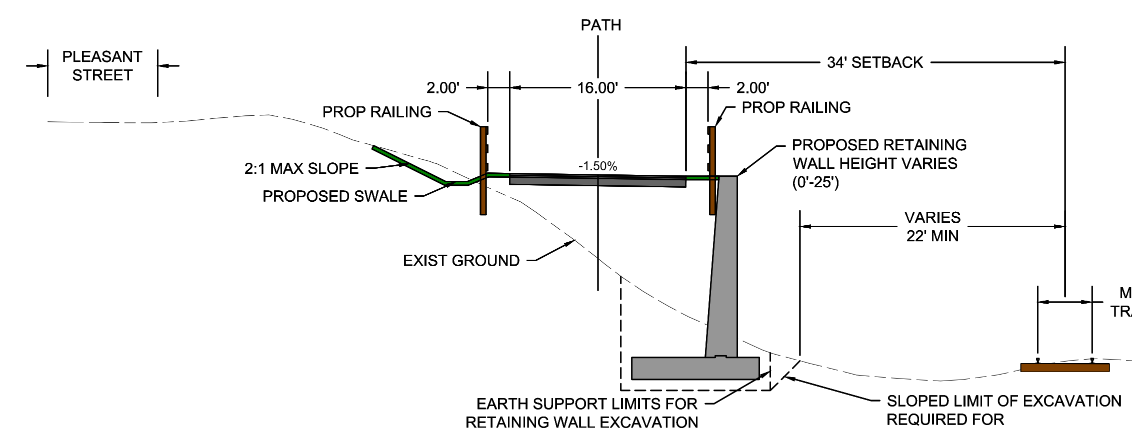

SECTION A-A
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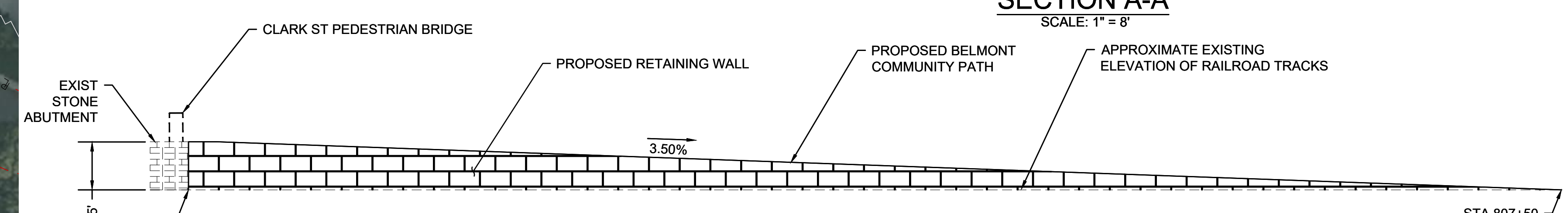


ELEVATION VIEW - PATH ALIGNMENT FROM CLARK STREET PEDESTRIAN BRIDGE
SCALE: 1" = 40'

13548_HD (DESIGN BASE-2).DWG Plotted on 5-Feb-2020 11:07 AM

4.2 Segment 2 – Belmont Station to #7 Channing Road

Providing an accessible connection from the Community Path to the north platform at Belmont Station and Belmont Center is a major objective of the project. The path will provide an accessible connection from the Belmont Station platform north of the tracks to Belmont Center via an accessible path from Concord Avenue. Providing the minimum required separation from the path to passengers utilizing the MBTA will be provided along this Segment. The path will be constructed on the existing MBTA bridge over Concord Avenue to continue eastward towards #7 Channing Road.

4.2.1 Alternative Design 1

The proposed path alignment will shift north to provide a 27-foot minimum setback as it approaches Belmont Station from the west (Segment 1). The 16-foot wide paved path will be offset approximately 12 feet from the back edge of the bituminous asphalt pedestrian platform. Near Station 812+00 a 10-foot wide accessible path will connect the main trail alignment to the existing sidewalk on the south side of Concord Road. The connection will provide an accessible route for bicyclists and pedestrians to Belmont Center and the Belmont Station platform. The proposed location of the accessible connection is near the lowest height of the existing retaining at the westernmost end of the wall along the Concord Ave sidewalk. A proposed retaining wall, with a maximum height of 5-feet, will be constructed to support the path. Railings will be installed along the path at this location. A new crosswalk will be installed across Concord Avenue, which will impact 2-4 existing parking spaces. The existing concrete stairs connecting to Concord Avenue at the eastern end of the platform are proposed to be retained.

The proposed path alignment over the existing bridge will have a minimum setback of 27-feet. Proposed fencing and railing will be installed along both sides of the path on the exiting bridge.

As the path heads easterly from the bridge, the alignment will begin to transition closer to the tracks to avoid the existing building at #7 Channing Road. Alternative 1 proposes that the 16-foot path width be maintained as the path runs alongside #7 Channing Road. The proposed path will be constructed with 2-foot shoulders on both sides. The edge of the northerly shoulder will be adjacent to the back edge of the existing structure so that the setback from the tracks can be maximized. The proposed path will have a minimum setback distance of 12-feet from the tracks. When the path is near the existing retaining wall, a 2:1 modified rockfill slope will be proposed behind the railing on the northerly side. The proposed slope will allow for construction to meet existing grades before the retaining wall, allowing the existing wall to be retained. This minimum distance will not provide for a separate access road for MBTA access. Maintenance vehicles will be expected to access from the east or west along the tracks or utilize a portion of the Community Path to access this isolated location. Propose access gate locations will be coordinated with the MBTA as part of the design. As the path continues easterly from #7 Channing Road, the path's alignment will shift to the north to increase the setback to a minimum of 25-feet to retain the MBTA' maintenance access road along the tracks.

4.2.2 Alternative Design 2

Alternative 2 is proposed to have similar geometrics as Alternative 1 at the Belmont Station platform. For Alternative 2 the paved path width is proposed to be reduced to 10-feet wide adjacent to the building at #7 Channing Road from Station 814+50 to 817+00. By reducing the width of the path, the setback will be increased to 18-feet which will provide maintenance access for the MBTA adjacent to the tracks. This will allow MBTA maintenance vehicles to access the tracks continuously from Belmont Station to Alexander Avenue. Under Alternative 2, the north edge of pavement will be held to be approximately 2 feet from the nearest building edge to maximize the setback from the path to the tracks. A 2:1 modified rockfill slope is proposed along the north side of the path, similar to Alternative 1.

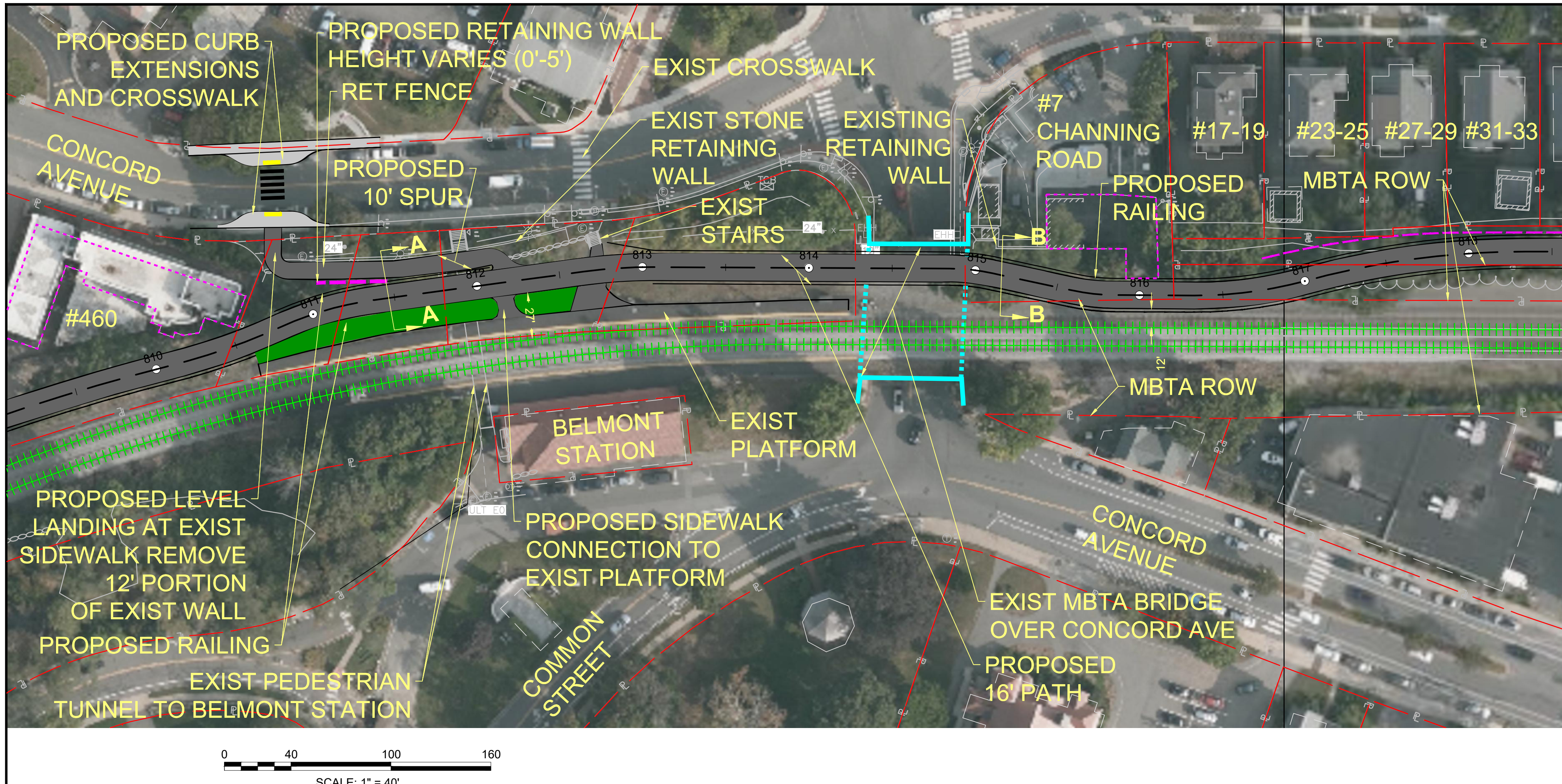
Alternative 2 would result in a “pinch-point” along the main path alignment. The proposed reduction in paved width from 16-feet to 10-feet would be noticeable to path users and could impact their comfort level and speed at this location. A 10-foot paved path is the minimum allowed width allowed per MassDOT design guidelines. The narrowing of the path to 10-feet does not achieve the project goal of providing a consistent path design that meets minimum desired cross-sectional width to allow for comfortable use by bicyclists and pedestrians.

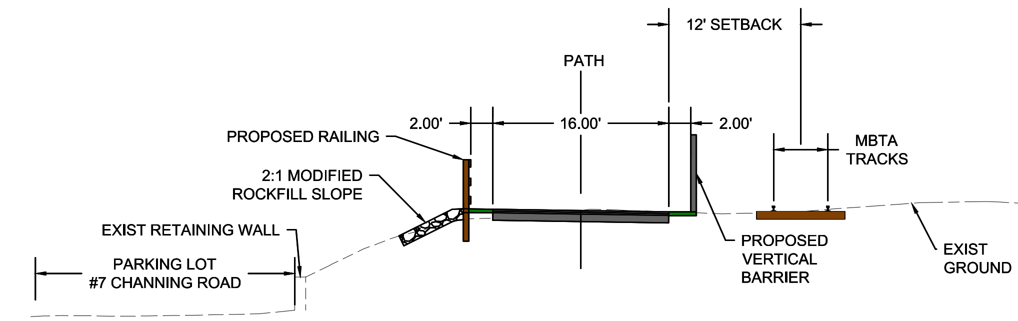
4.2.3 Recommended Alternative

We recommend Alternative 1 for Segment 2. Alternative 1 provides a uniform paved width for the path throughout the segment and still maintains minimum setbacks from the tracks. A significant reduction in width at one location will impact trail user comfort and result in potential conflicts between bicyclists and pedestrians.

Although Alternative 1 does not provide adequate width to allow for maintenance access adjacent to the tracks in an isolated location adjacent to #7 Channing Road, maintenance vehicles will be able to access the tracks from each direction or from a section of the Community Path. The proposed design will include access gates as required by the MBTA and public safety officials. The proposed reduction to the desired setback requirements from the track will occur at this isolated location and extend for a distance of approximately 100-feet.

MASSDOT PFN 609204
BELMONT
BELMONT COMMUNITY PATH PHASE 1
SEGMENT 2 - ALTERNATIVE 1
FIGURE 7





SECTION B-B

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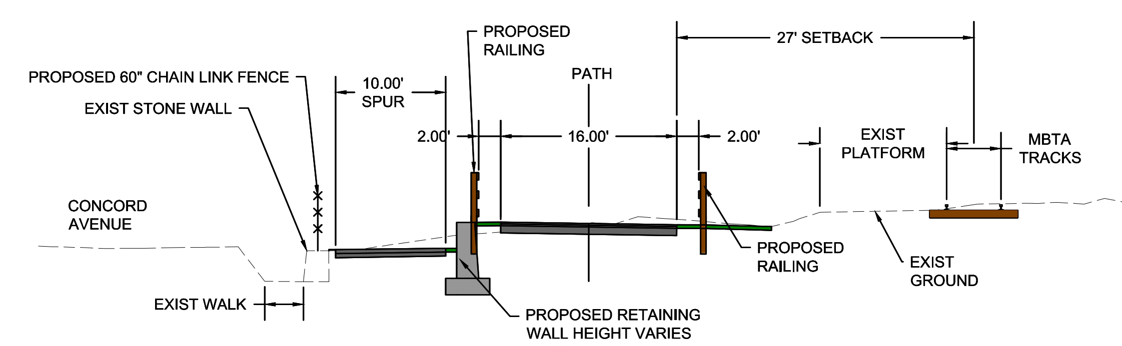

SECTION A-A

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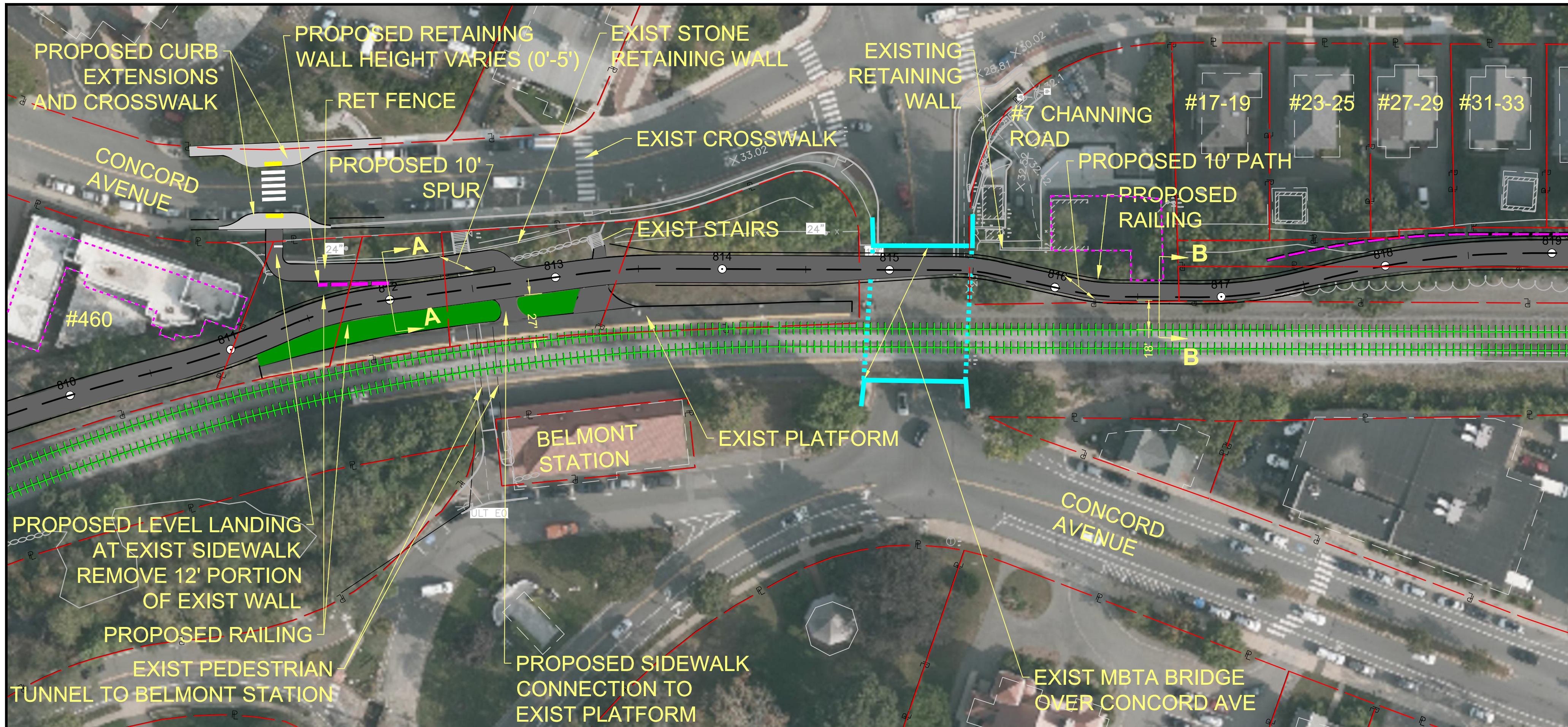
MASSDOT PFN 609204
BELMONT
BELMONT COMMUNITY PATH PHASE 1
SEGMENT 2 - ALTERNATIVE 2
FIGURE 8

N



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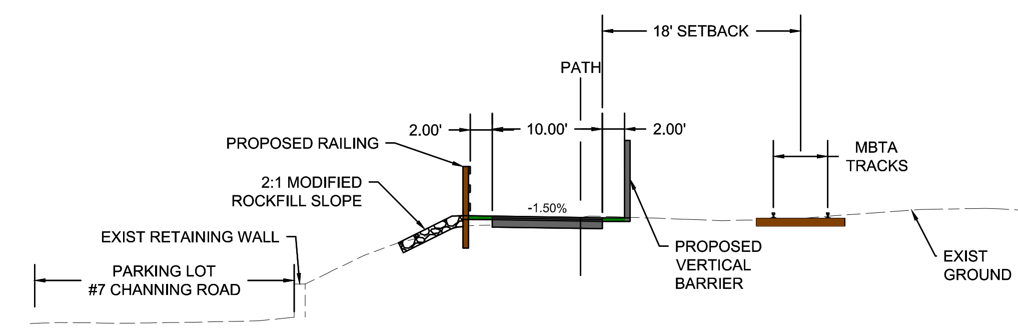

SECTION B-B
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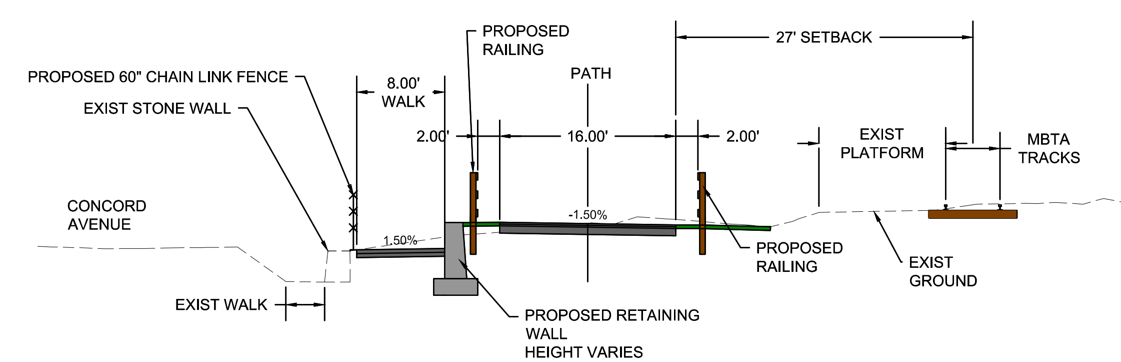

SECTION A-A
SCALE: 1" = 8'

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4.3 Segment 3 – Channing Road West (#17 Channing Road to Alexander Avenue)

As the path heads easterly, the alignment is proposed to shift to the north away from the railroad tracks. This 16-foot wide paved segment will utilize an adjacent parcel of land owned by the Belmont Citizens Forum property. The alignment continues parallel to the tracks to its intersection with Alexander Avenue. Four alternatives are presented for Segment 3. For each alternative the path is proposed to be a 16-foot wide paved trail with 2-foot shoulders on each side. Gate locations for emergency access along fences and vertical barrier will be coordinated with the MBTA, Keolis, and public safety officials. A continuous railing is proposed along the north side of the path for each alternative. The varying factor between the alternatives are the horizontal and vertical location of the path relative to the railroad tracks and adjacent private properties.

4.3.1 Alternative Design 1

The path alignment under Alternative 1 is proposed to be located within the Belmont Citizens Forum property. This alternative will situate the path near private property along Channing Road. The edge of the path will be approximately 7-feet from the northerly property line. The path would have a setback distance of approximately 40 to 50-feet from the nearest MBTA railroad track. This alternative provides the maximum setback distance from the tracks which will allow the existing maintenance road to be maintained. A fence or vertical barrier railing as required will be installed between the path and MBTA property.

The path is proposed to be vertically located between the track elevation and private properties along Channing Road. This alternative balances cut and fill quantities for construction. A retaining wall is proposed along the north side of the trail to reduce grading impacts into the private properties along Channing Road. The retaining wall varies in height up to 5-feet, based on topography. The proposed retaining wall will be located along the property line of the Belmont Citizens Forum parcel. A slope is proposed along the south side of the path that meets the existing ground. A drainage swale would be provided along the south side to capture stormwater runoff before it flows onto the path. This alternative would restrict access from private properties to the path due to the grade separation.

Alternative 1 requires that much of the existing vegetation be removed. New plantings, if desired, could be installed along the property line or behind the proposed fencing along the northerly side of the path. There would be minimal area to provide a landscape buffer between the private properties and the path due to the proposed retaining wall location. Landscaping could also be considered along the south side of the path to provide a landscaped buffer from the tracks.

4.3.2 Alternative Design 2

Alternative 2 proposes the same horizontal alignment as Alternative 1. The path alignment would be located within the Belmont Citizens Forum property. As noted under Alternative 1, this Alternative provides a setback distance from the tracks of 40 to 50-feet from the nearest track.

Alternative 2 proposes that the path be vertically located at/near the elevation of the private properties along Channing Road. This alternative would also provide for direct access from private property if desired. A retaining wall of varying height up to 10-feet would be constructed along the south side of the path. This wall would be constructed to retain the MBTA maintenance road on the north side of the tracks. Excavation limits for the construction of the retaining wall would extend to approximately 20-feet from the nearest track. The distance may be increased to approximately 30-feet by utilizing temporary earth support measures during construction. This option requires a large amount of excavation to construct the path, which may be undesirable due to increased soil disposal costs.

This Alternative would require the removal of much of the existing vegetation between Channing Road and the tracks. This alterative provides additional space for the creation of a landscaped buffer between the path and the private properties as compared to Alternative 1. Landscaping could also be provided along the southerly side of the path, between the wall and the tracks.

4.3.3 Alternative Design 3

The proposed alignment under Alternative 3 is to be located midway between the railroad tracks and private properties along Channing Road. The path would not be located within the Belmont Citizens Forum property, rather it would be located within the MBTA property further from private property. The path would have a minimum setback distance of approximately 20-feet from the nearest track. A 20-foot setback would provide ample space to maintain the MBTA’s gravel access road for maintenance. A vertical barrier would be proposed along the south side of the path, and fence or railing along the north side of the path.

The path is proposed to be vertically located at/near the elevation of the railroad tracks. This alternative will elevate the trail above private properties along Channing Road. Minimal grading would be required to match existing grades. No retaining walls would be anticipated as part of this alternative, requiring the least amount of excavation. This option would restrict abutters access to the path due to the existing vegetation and steep topography.

Alterative 3 proposes to maintain as much of the existing vegetation as possible. This option would allow for a large area for additional plantings, if desired, along the northerly side of the path. The abutting properties will maintain the existing vegetated buffer to the new path and the tracks. No landscaping is proposed to be added along the southerly side of the path and a vertical barrier will be installed between the paved path and the tracks.

4.3.4 Alternative Design 4

Alternative 4 proposes the same horizontal alignment as Alternative 3 and will provide a minimum setback from the nearest track of approximately 20-feet. The path would not be located within the Belmont Citizens Forum property, rather it would be located within the MBTA property further from private property. A 20-foot setback would provide ample space to maintain the MBTA’s gravel access road for maintenance. A vertical barrier would be proposed along the south side of the path, and fence or railing along the north side of the path.

The path is proposed to be vertically located between the elevations of the tracks and private properties along Channing Road. This alternative balances cut and fill quantities for construction. A retaining wall of varying height up to 5-feet would be constructed along the south side of the path to support the MBTA’s gravel maintenance road. Excavation limits for the construction of the retaining wall would extend to approximately 6-feet from the nearest track. The distance may be increased to approximately 17-feet by utilizing temporary earth support measures during construction. In lieu of a vertical barrier along the south side of the trail, fencing will be installed on top of the retaining wall to prevent unauthorized access of the tracks.

This alternative would allow for some of the existing vegetated buffer along the north side of the path to be retained and potentially supplemented with plantings to provide additional screening. This alternative provides the greatest opportunity for introducing a more robust vegetated buffer. Landscaping could also be considered for additional screening along the top of the retaining wall.

4.3.5 Recommended Alternative

We recommend Alternative 3 for this segment of the path. This Alternative satisfies many of the project goals including reducing project costs, limiting impacts to private property, maintaining the MBTA access road, and providing a consistent width for trail users. Alternative 3 will allow the path to be constructed at a similar elevation to the tracks in order to maintain the existing vegetated buffer. The construction of retaining walls will not be required, further reducing project costs and excavation requirements for construction.

Although the recommended alternative does not provide the MBTA's desired 25-foot setback from the nearest track, it does maintain the functionality and access provided under existing conditions. Constructing the path closer to private properties, as shown in Alternatives 1 and 2, is undesirable to most abutters.

Alternatives 1, 2, and 4 require significantly more excavation to construct the path. Construction costs would increase to account for the proper disposal of excavated materials. Alternatives 1, 2, and 4 also require the removal of some if not all of the existing vegetated buffer that is well established between private property and the tracks. The existing buffer provides visual and vertical separation from the private residences to the path and tracks. Although new landscaping can be installed, it would take time to establish a new vegetated buffer to match the current condition.

MASSDOT PFN 609204
BELMONT
BELMONT COMMUNITY PATH PHASE 1
SEGMENT 3 - ALTERNATIVES
FIGURE 9

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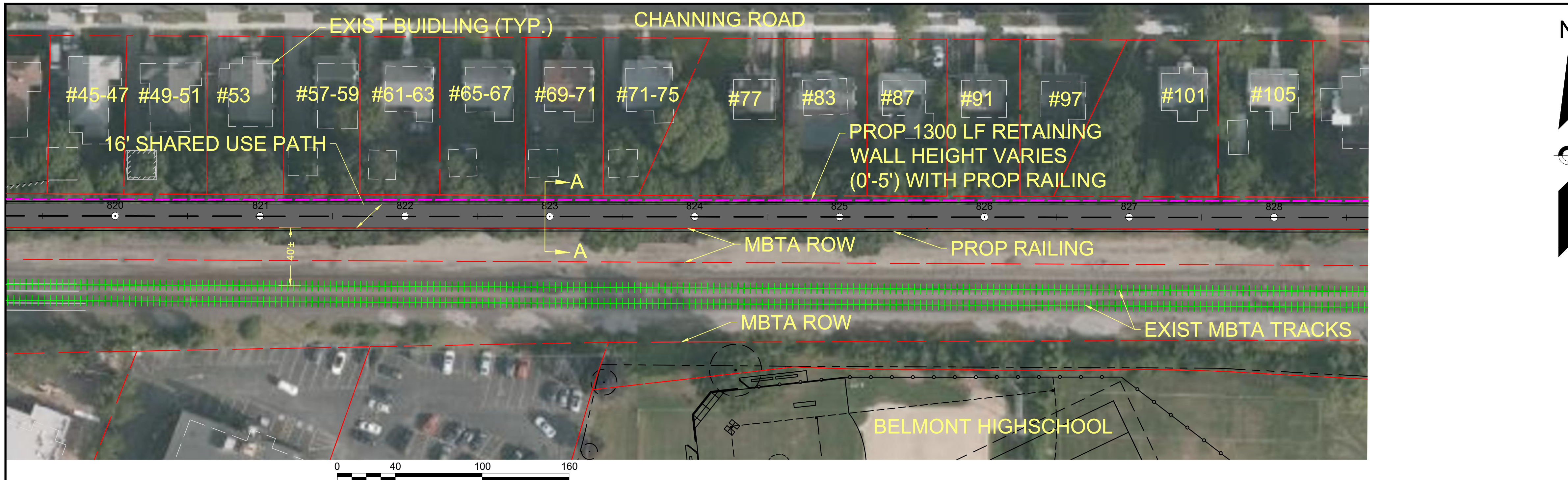

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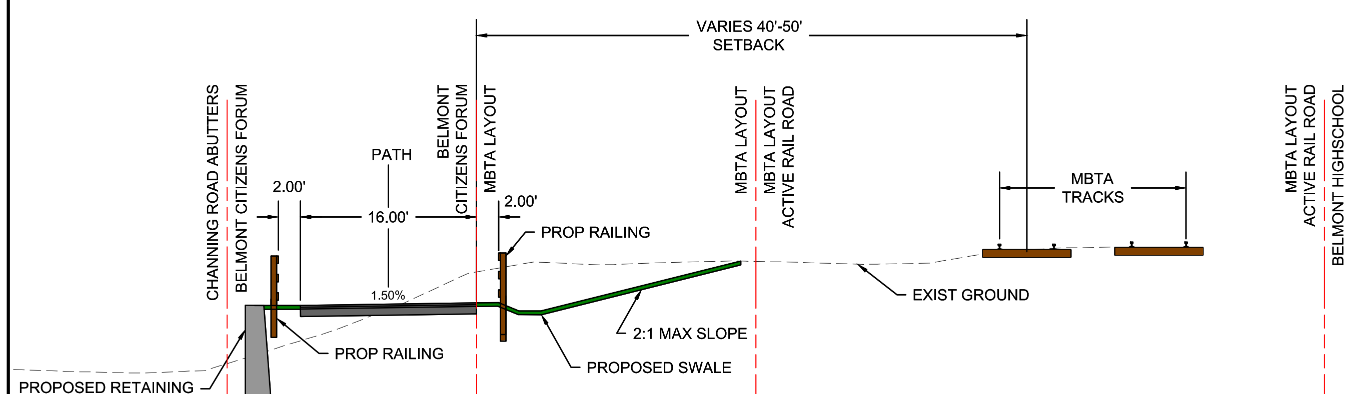

SECTION A-A
ALTERNATIVE 1
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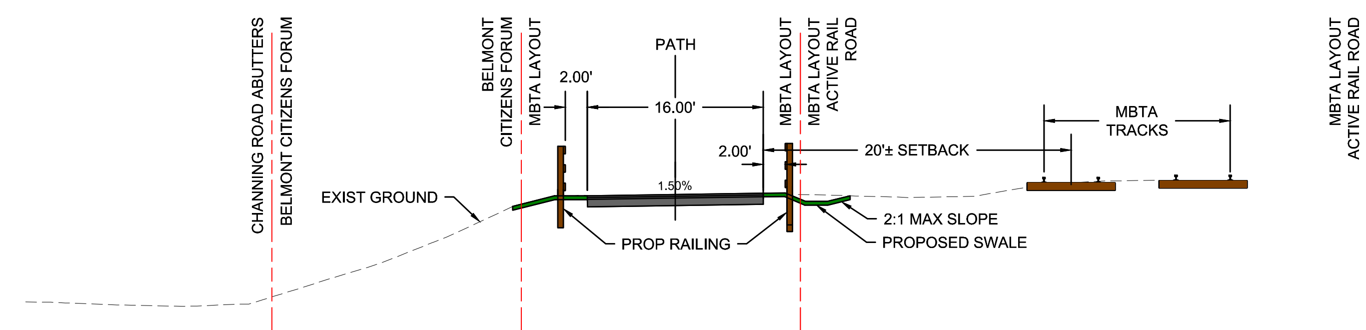

SECTION A-A
ALTERNATIVE 3
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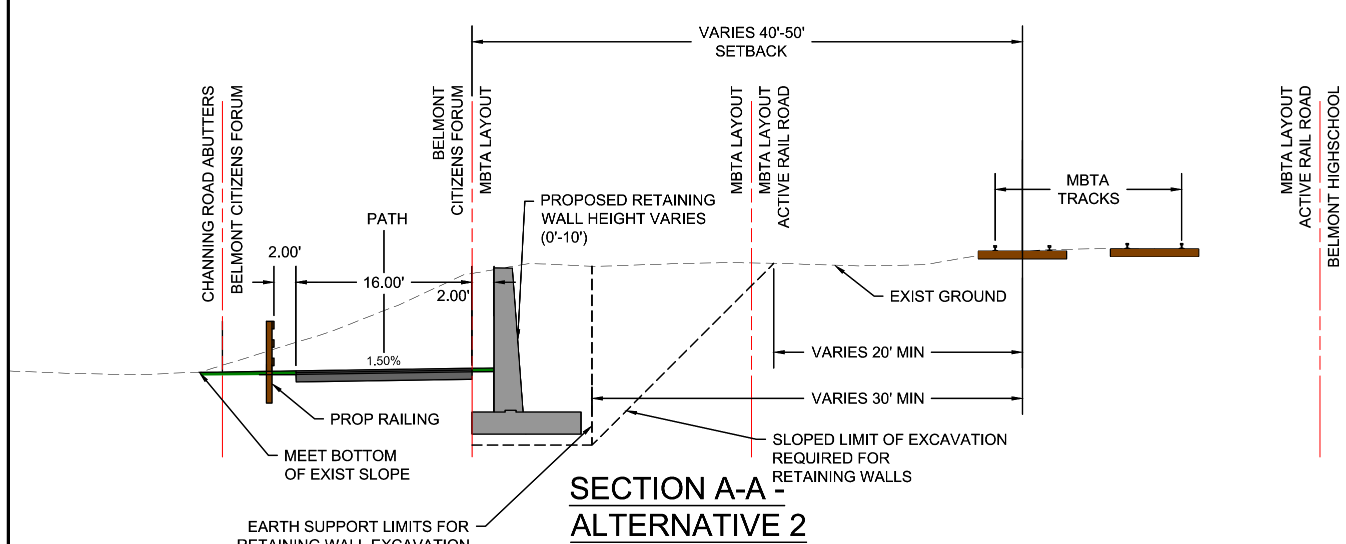
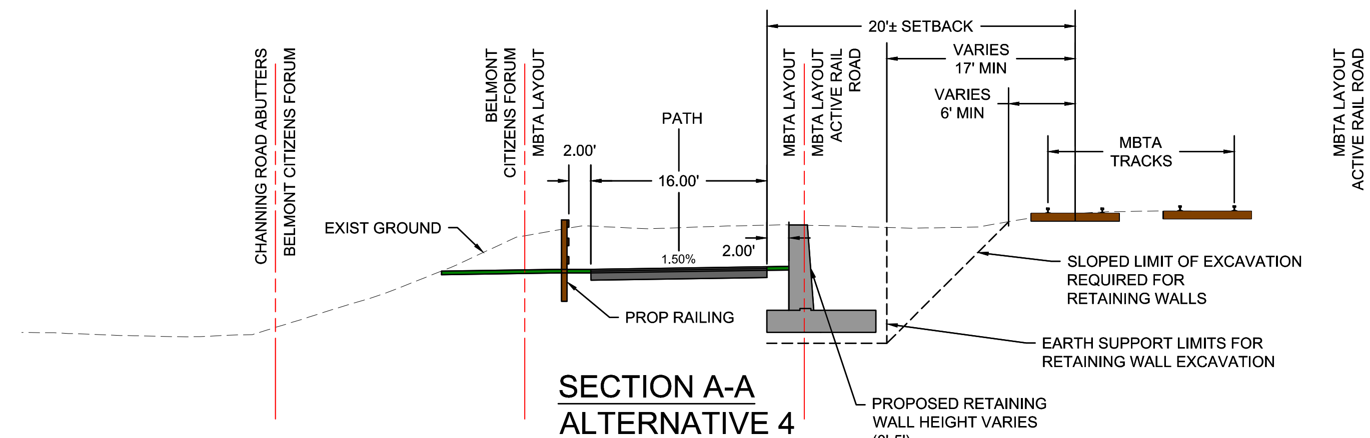


SECTION A-A -
ALTERNATIVE 2
SCALE: 1" = 8'



SECTION A-A
ALTERNATIVE 4
SCALE: 1" = 8'

4.4 Alexander Avenue

At Alexander Avenue an underpass for path users will be constructed to connect the Belmont High and Middle Schools to the neighborhood to the north. A grade separated crossing at this location is an integral component of the project and has the support of the MBTA, the Town and its residents. Two alternatives for the connection are presented in this report. The proposed Community Pave will have a paved 16-foot width, with 2-foot shoulders, fencing, and barriers where required. The connection beneath the railroad tracks to Alexander Avenue will consist of a 10-foot wide paved multi-use path with 2-foot shoulders.

4.4.1 Existing Soil Conditions

As part of the conceptual design, the design Team reviewed available record soil borings from the Belmont High and Middle School project. Record borings were available from 1968 and 2018, and the closest boring information to the proposed underpass is from approximately 400-feet away. Based on the record boring information, we present following assumptions for existing soil conditions as part of the conceptual design:

- Ground water is assumed to be at an elevation of 6 to 9 feet, or approximately 12 to 15 feet below the Alexander Avenue existing grade.
- Top 5 to 12 feet below the surface of soil is fill. This does not include the railroad built up embankment, which is assumed to be a fill material.
- Below the fill is 8 to 10 feet of stiff to very stiff clay
- Below the stiff clay is soft to very soft clay and Glacial till
- Glacial till elevation is approximately -40 to -50 feet
- Rock elevation is approximately -45 to -60 feet

This assumed soil information is also shown on Figures 15 & 16.

The design team will conduct a boring program for the proposed underpass location. These borings will provide the team with the existing soil conditions, soil profiles, type of material, ground water elevation, and identify obstructions in the embankment that may impact the construction of an underpass.

4.4.2 Alternative Design 1

Alternative 1 proposes to construct the 16-foot wide paved path near the same elevation as the railroad tracks. This alternative would position the path on top of a proposed 75-foot long reinforced concrete culvert that would act as an underpass from Alexander Avenue to the Belmont High and Middle Schools. Over the culvert, the path would have a setback of 25-feet from the centerline of the nearest track and be separated by a vertical barrier. Locating the path at nearly the same elevation as the railroad tracks will provide a more comfortable user experience on the path, as the trail profile would be relatively level and follow the existing topography with less than a 1% slope. A paved 10-foor paved connection, or spur, constructed on the north side of the main path alignment will provide an accessible connection to Alexander Avenue and the proposed underpass, as well as access to points north and south of the tracks.

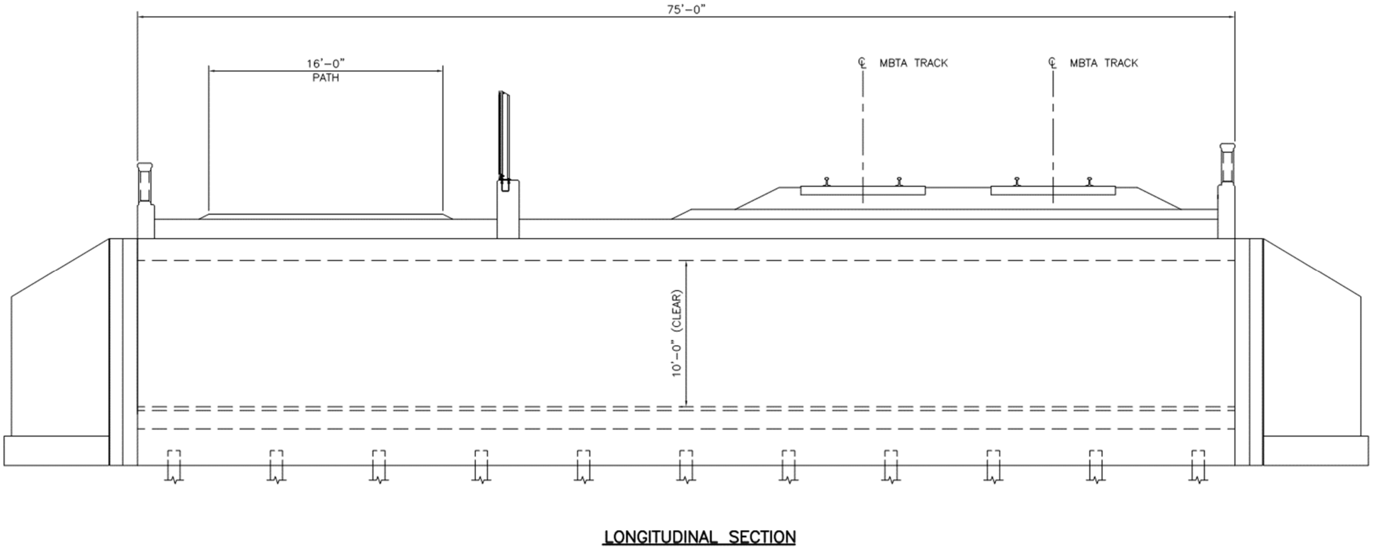
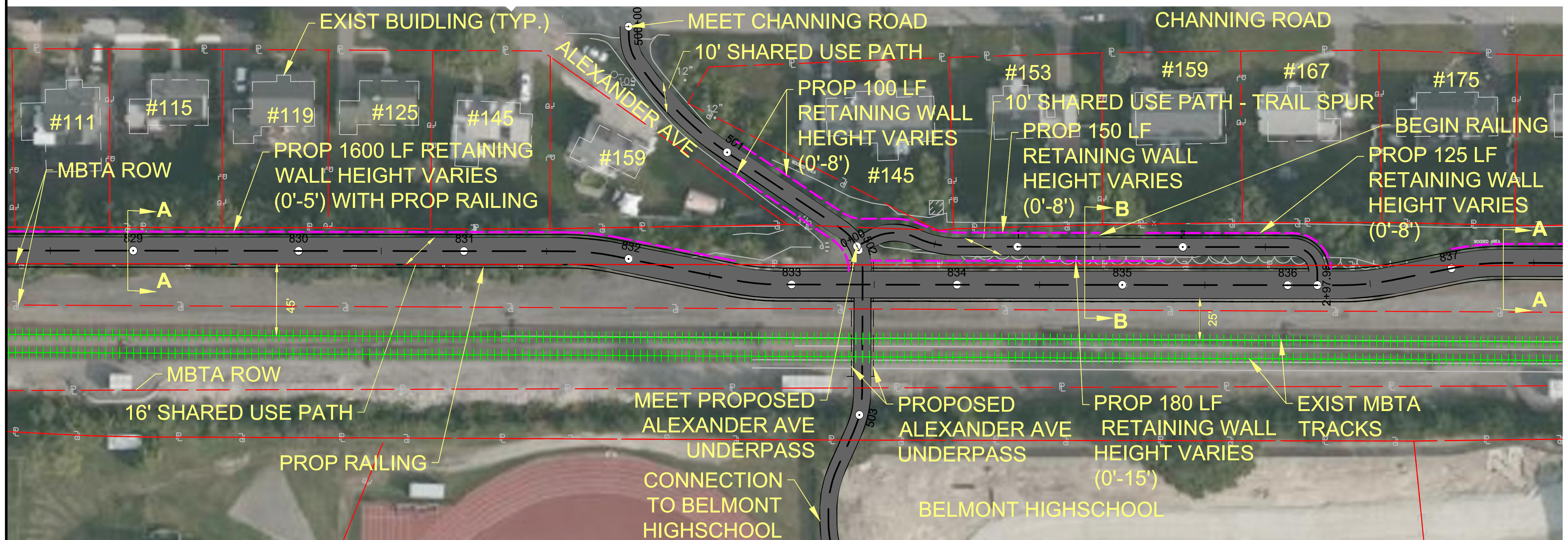
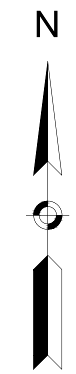


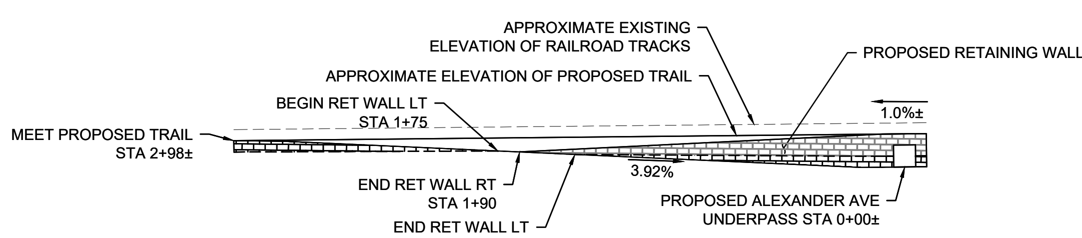
Figure 10 – Alexander Avenue – Longitudinal Section of Alternative Design 1

MASSDOT PFN 609204
BELMONT
BELMONT COMMUNITY PATH PHASE 1
ALEXANDER AVENUE - ALTERNATIVE 1
FIGURE 11



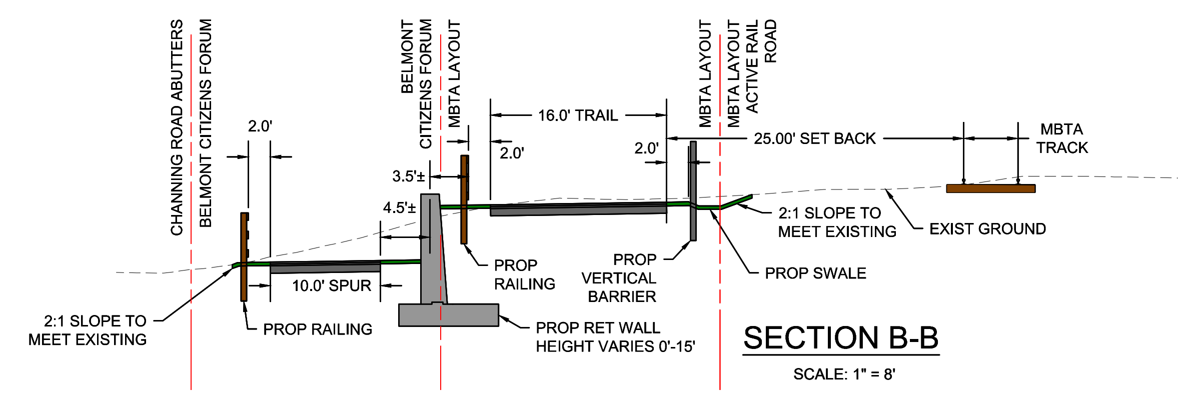


0 40 100 160
SCALE: 1" = 40'



ELEVATION VIEW - PATH ALIGNMENT AT ALEXANDER AVE SPUR

SCALE: 1" = 40'



SECTION B-B

SCALE: 1" = 8'

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Advantages

The proposed 10-foot wide paved connection, located to the east of the proposed underpass, would have an approximate profile grade of 4% and provide an accessible connection to Alexander Avenue. Retaining walls would be required along the north and south sides of the 10-foot wide path. The walls are proposed to have varying heights of 8 to 15 feet. Retaining walls would extend along a portion of the Alexander Avenue connection path from the underpass to Channing Road, with heights varying up to 8 feet. The walls are required since the path's elevation will need to be cut into the existing ground to provide adequate vertical clearance from the tracks.

To facilitate the path over the underpass, the reinforced concrete culvert would be extended to approximately 75-feet long. The culvert length will provide enough room for a level area to the south of the railroad tracks, for possible vehicular access for maintenance and emergency, shoulders on both sides of the path, and a 25-foot setback between the path and the nearest track. The culvert will be constructed of precast reinforced concrete consisting of a three-sided frame or four-sided box, depending on geotechnical conditions, suitable foundation type, and constructability. Additional information, including geotechnical investigation and design development, are required before exact culvert properties can be determined.

Disadvantages

While Alternative 1 creates a more comfortable user experience due to the level profile along the main trail, there are limitations to the size of maintenance and emergency that will be able to use the 10-foot wide connecting path. The 10-foot wide spur will be bounded by retaining walls and connect to the path at a sharp angle, which may not accommodate the turning radii of larger emergency vehicles such as fire tankers. Although there is sufficient space north of the railroad tracks for emergency vehicles, access would potentially need to be obtained from Brighton Street or other access points. Proposed concrete barriers, railing and protective screen on top of the culvert would also restrict access to the tracks from this section of the path.

The proximity of the 10-foot wide path at Alexander Avenue to the underpass may pose limitations to visibility at the intersection north of the underpass.

4.4.3 Alternative Design 2

Alternative 2 proposes to gradually lower the elevation of the path to meet the elevation at the north approach to the Alexander Avenue underpass. In this Alternative, the 16-foot wide main path would be located north of a proposed 40-foot long reinforced concrete culvert that would act as an underpass between Alexander Avenue and the Belmont High and Middle Schools. Although this alternative involves a downgrade and then upgrade along the profile of the main path alignment, it would facilitate easier access between the main path and the underpass. This alternative creates a four-way intersection at the path approach to the underpass.

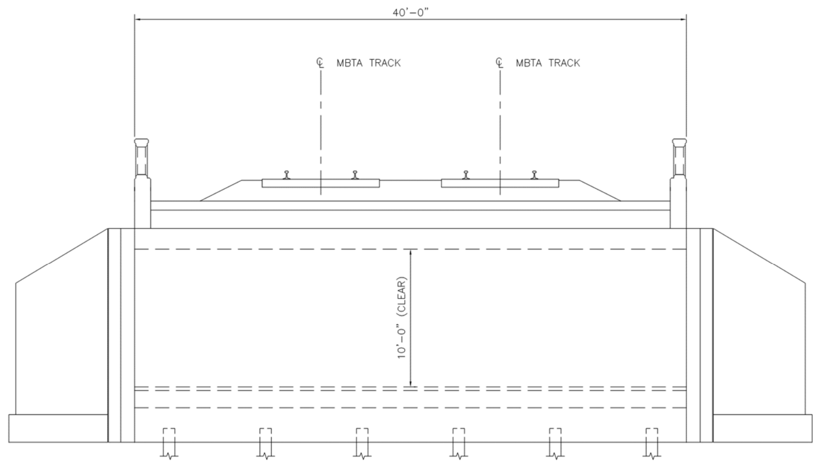


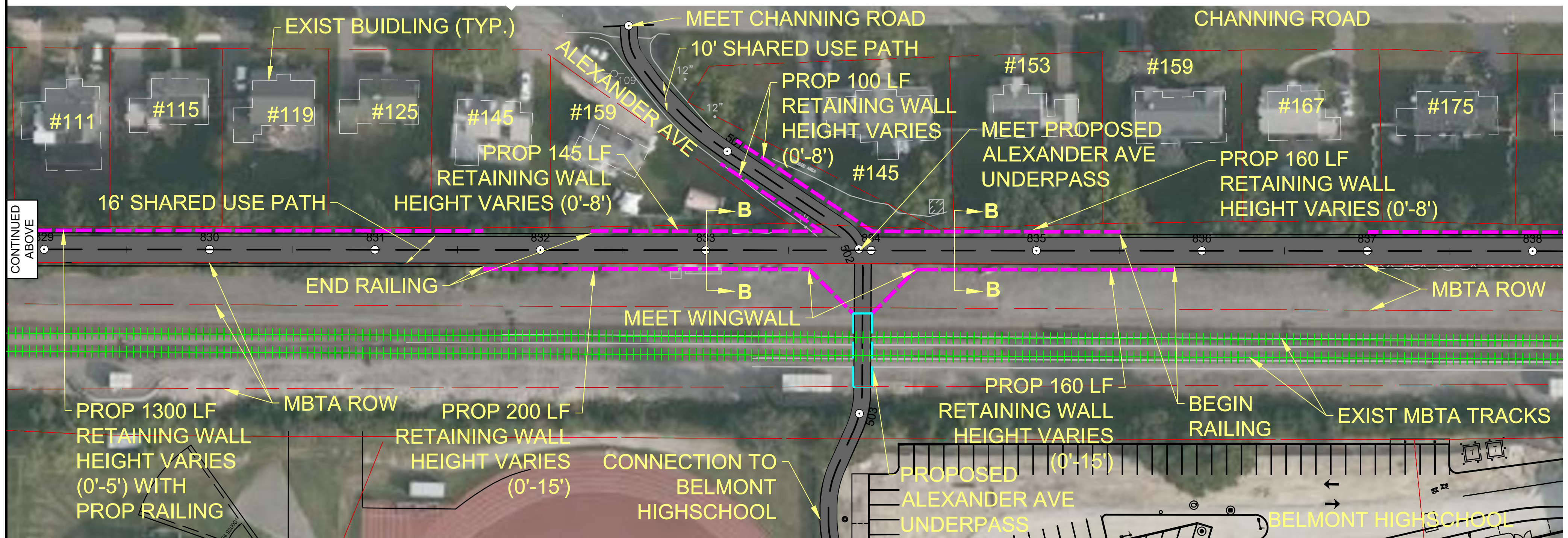
Figure 12 – Alexander Avenue – Longitudinal Section of Alternative Design 2

The 16-foot wide path would have a proposed -3.38% profile grade from the railroad track elevation to the elevation of the underpass path over a length of approximately 400-feet. After a level section at the intersection with the underpass approach, the path would ascend to meet the track elevation at a 3.33% profile grade over a length of approximately 250-feet.

Retaining walls will be constructed along the southern edge of the path, and tie into the wingwalls of the culvert. Retaining wall heights would vary to approximately 15 feet. Along the property lines on the north side of the path and both sides of the Alexander Avenue connection, retaining walls up to 8 feet in height would be required as the elevation descends below existing grades. The walls along the Alexander Avenue connection would only extend a portion of the length between the intersection with the path and the intersection with Channing Road.

The MBTA commuter rail tracks would be maintained on top of the proposed culvert. The 40-foot long culvert would accommodate the tracks and safety walks along the exteriors of the tracks. If desired by the Town of Belmont or the MBTA, the culvert can be lengthened to accommodate additional space for maintenance and emergency vehicle access. MBTA maintenance vehicles would need to access the tracks from access points east and west of the proposed culvert or from the Community Path.

MASSDOT PFN 609204
BELMONT
BELMONT COMMUNITY PATH PHASE 1
ALEXANDER AVENUE - ALTERNATIVE 2
FIGURE 13



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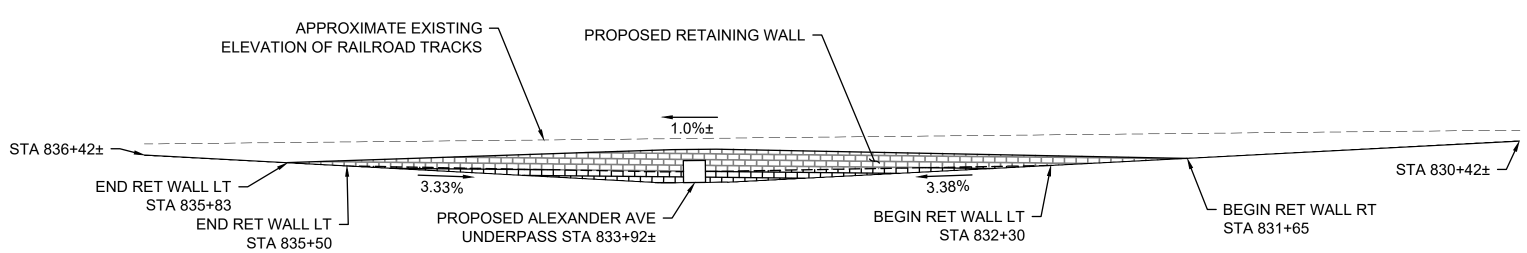
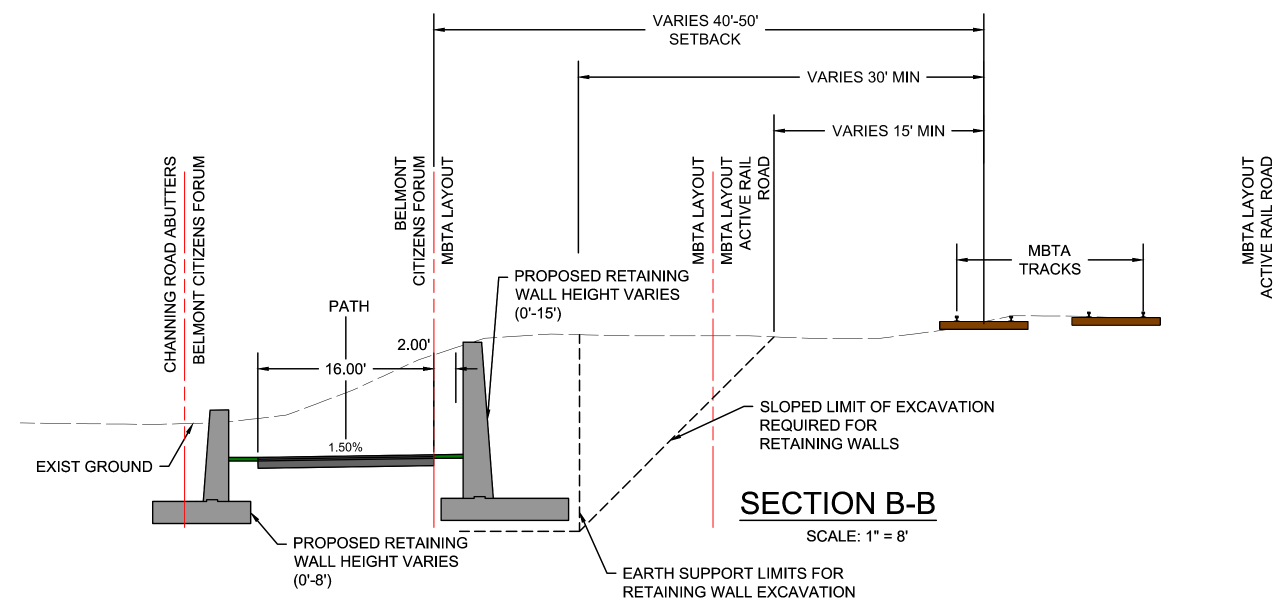
0 40 100 160
SCALE: 1" = 40'



ELEVATION VIEW - PATH ALIGNMENT AT ALEXANDER AVE

SCALE: 1" = 40'



SECTION B-B

SCALE: 1" = 8'

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Advantages

Alternative 2 would require trail users to travel downhill from the west and climb uphill to the east. Although a maximum grade of 5% is required to meet ADA/AAB requirements (4.5% for MassDOT), we propose main alignment profile grades between 3.0% and 3.5% to support use by people of all ages and abilities and lessen the effort needed by trail users than required on steeper grades. The creation of a four-way intersection along the path creates a single controlled point for providing direct access to and from the path and the underpass alignment.

Disadvantages

The proposed grade changes along the main path require additional lengths of retaining walls compared to Alternative 1, which will increase construction costs. Although Alternative 2 proposes the installation of the shortest culvert length to minimize construction costs, it creates a pinch point at the culvert and doesn't leave enough room to continue the MBTA's gravel access road.

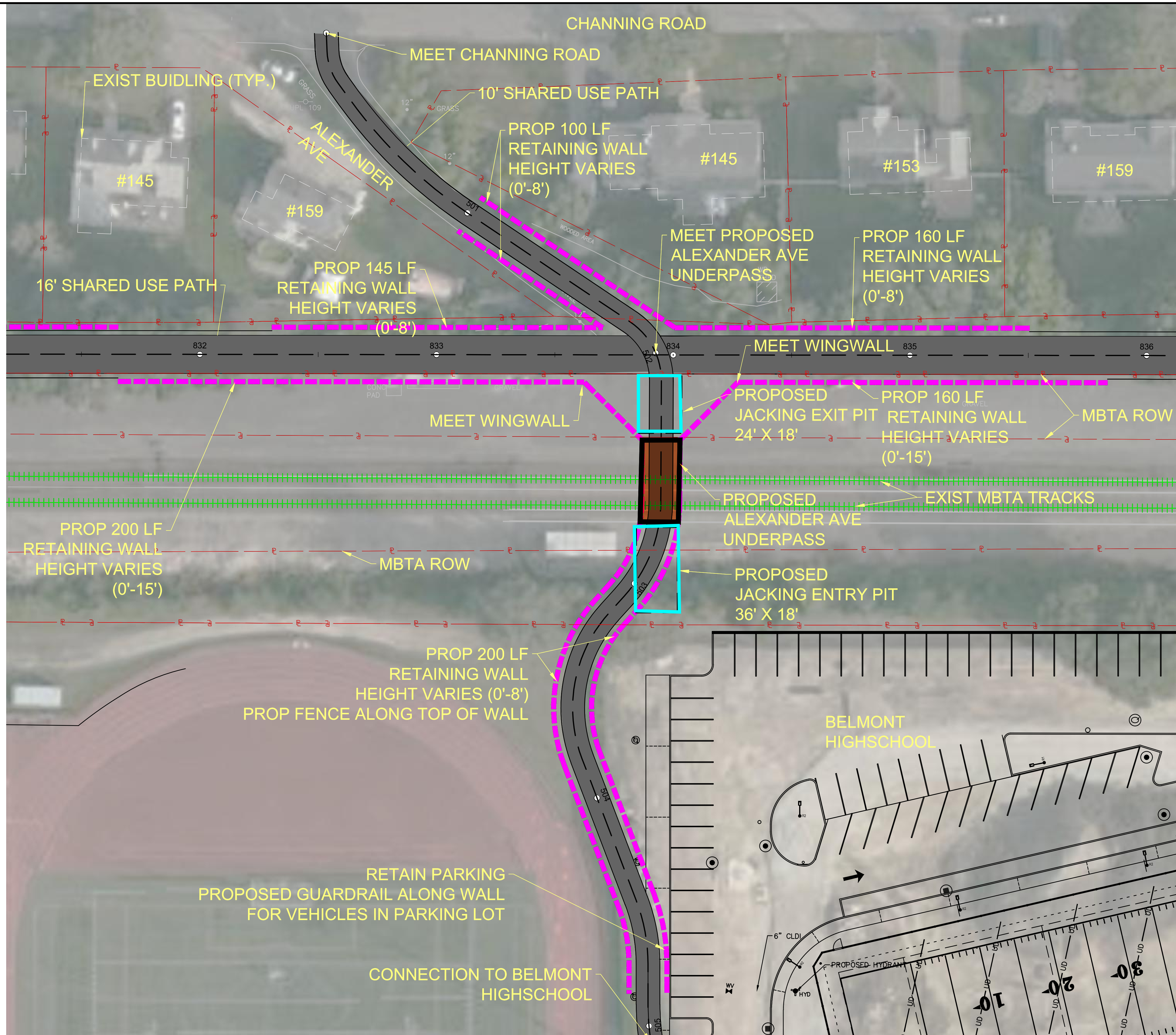
4.4.4 Underpass Construction – Tunnel Jacking Method

Constructing the Alexander Avenue underpass utilizing the tunnel jacking method will require the excavation of a jacking pit (36 foot by 18 foot by 18-foot-deep) and a receiving pit (24 foot by 18 foot by 10-foot-deep) at the ends of the proposed underpass. Temporary earth support, such as sheeting, would need to be constructed to support the earth around the proposed jacking pits. Hydraulic jacks and other specialized equipment would be used to excavate and install the box culvert underneath the railroad, working from the jacking pit located on the Belmont High and Middle Schools side of the underpass to a receiving pit on the Channing Road side north of the tracks. The MBTA commuter rail would be able to remain in service during construction, but extensive monitoring of tracks for any potential movement and additional railroad ballast would need to be provided as needed. To minimize impacts to train service, jacking would be restricted to night work or other off-train hours with no or low volume of trains.

Jacking requires a minimum 10’ of cover above the culvert, which entails additional geotechnical considerations due to deep depth of the culvert. Based on the 1968 and 2018 borings provide from the adjacent Belmont High and Middle Schools project, soil strengthening will likely to be needed below the culvert. The bottom of the culvert is proposed to sit on top of or within a soft clay layer. This soft clay layer would need to be stiffened in order to provide adequate load bearing capacity. Another option would be to install deep foundation supports such as piles, but piles are unlikely to be feasible due to installation logistics within the jacking area, and the proximity of railroad tracks. The culvert will also extend below the ground water table, requiring significant dewatering during construction which will require additional approvals from the MBTA. To construct the culvert within the ground water, well points would need to be installed to monitor the area and the culvert would need to be reinforced to prevent uplifting. Additional borings are proposed to verify soil conditions at the underpass location and identify potential obstructions in the embankment that may impact construction.

Lowering the culvert depth to accommodate jacking also has vertical and horizontal impacts on the Alexander Avenue approaches. An ADA variance and MassDOT Design Exception will be required, as proposed grades would exceed 5% between Channing Road and the schools over a distance of more than 100 feet. From beneath the tracks to the Belmont High and Middle School parking lot, the path will be designed to meet ADA and MassDOT accessibility requirements with a profile of 4.5% over approximately 200 feet. Retaining walls will be constructed along both sides of the underpass approaches and have varying heights up to approximately 8 feet. Constructing a underpass and approach paths to depths below the ground water table will require a pump for stormwater. Additionally, where the path meets the Belmont High and Middle School parking lot fence and guardrail will be installed to provide protection and separation where required.

MASSDOT PFN 609204
BELMONT
BELMONT COMMUNITY PATH PHASE 1
ALEXANDER AVENUE - PLAN OF JACKING OPTION IMPACTS
FIGURE 14



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SCALE: 1" = 20'

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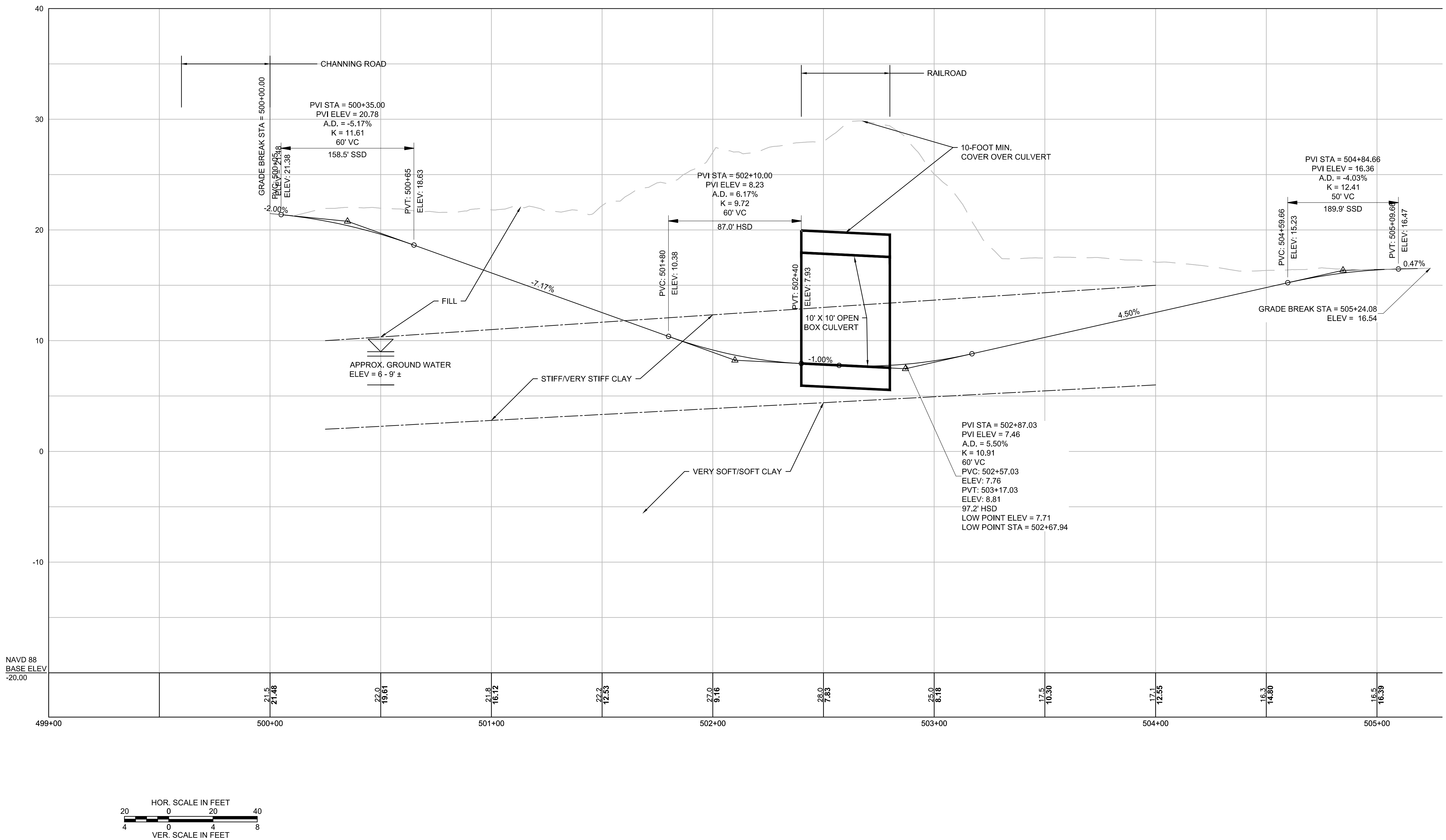
MASSDOT PFN 609204
BELMONT
BELMONT COMMUNITY PATH PHASE 1
ALEXANDER AVENUE - PROFILE OF JACKING OPTION
FIGURE 15

ALEXANDER AVENUE - CONSTRUCTION BASELINE - JACKING OPTION



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4.4.5 Underpass Construction – Open Excavation

Open excavation construction consists of traditional construction methods that will not require the use of specialized jacking equipment or track monitoring. To construct the Alexander Avenue underpass using open excavation, the existing MBTA railroad tracks and utilities would need to be temporarily removed and the embankment excavated to the elevation of the bottom of the underpass foundation. Once excavation is complete, the underpass can be installed and the embankment, utilities, and tracks restored to their original locations. We propose the use of accelerated construction to accomplish the installation of a pre-cast concrete underpass to minimize disruption to the Fitchburg commuter rail to several days or weeks. The actual duration will be better defined as the design progresses.

The proposed underpass is located inbound of Belmont station, which is the second of eighteen stops on the Fitchburg line, so service interruptions would impact many train users depending on the time of year. Accelerated construction methods will likely include advance construction preparation while the commuter line is in active service. Advanced activities could include soil strengthening for the culvert foundation or, if required, driving piles on each side of the active tracks in advance of a temporary track shut down. Close coordination with the MBTA and Keolis will be required in order to plan any pre-construction work and limit impacts on commuters. Proposed pre-construction work would likely take place on weekends and, if possible, in tandem with other maintenance or track work already scheduled by Keolis.

If the logistics associated with temporary service interruptions on the commuter rail line can be sufficiently addresses, open excavation construction offers many advantages over tunnel jacking. Construction costs would be significantly less, as would the amount of land required for construction and staging activities since the culvert does not need to be constructed adjacent to the final location and then pushed into place. Culvert construction would lessen impacts to adjacent properties. Furthermore, open excavation construction is a conventional construction method that would take place while railroad service is temporarily suspended, which will reduce risks for the MBTA, Keolis, and the contractor. Removal and restoration of the tracks to MBTA standards will be completed prior to restoring train service.

Unlike tunnel jacking, open excavation construction is also more suitable for the existing geotechnical conditions. Existing soils information provided for the area south of proposed Alexander Avenue underpass location suggests that there is a presence of clay. Clay is susceptible to settlement and is therefore an unsuitable material for the shallow foundations that would typically be used to support a culvert. If it is determined during the proposed geotechnical program that the underpass location is comprised mostly of clay, then soil strengthening options may be required. Deep foundations such as piles may be utilized if soil strengthening is not feasible or is found to be too costly. With coordination with the MBTA and Keolis, pile driving can be partially or entirely completed around existing railroad infrastructure with minor service interruptions on weekends prior to installation of the culvert.

Utilizing open excavation construction methods also allows for the use of precast elements to expedite construction durations. The culverts, wingwalls, and headwalls can all be constructed by a licensed fabricator and shipped to the site for installation. This greatly reduces construction durations, as no time is required to tie rebar, install and remove formwork, or pour and cure concrete. If open excavation construction is pursued, it is recommended that precast elements be used to reduce the construction timeline and associated impacts to railroad operations.

MASSDOT PFN 609204
BELMONT
BELMONT COMMUNITY PATH PHASE 1
ALEXANDER AVENUE - PROFILE OF OPEN EXCAVATION
FIGURE 16

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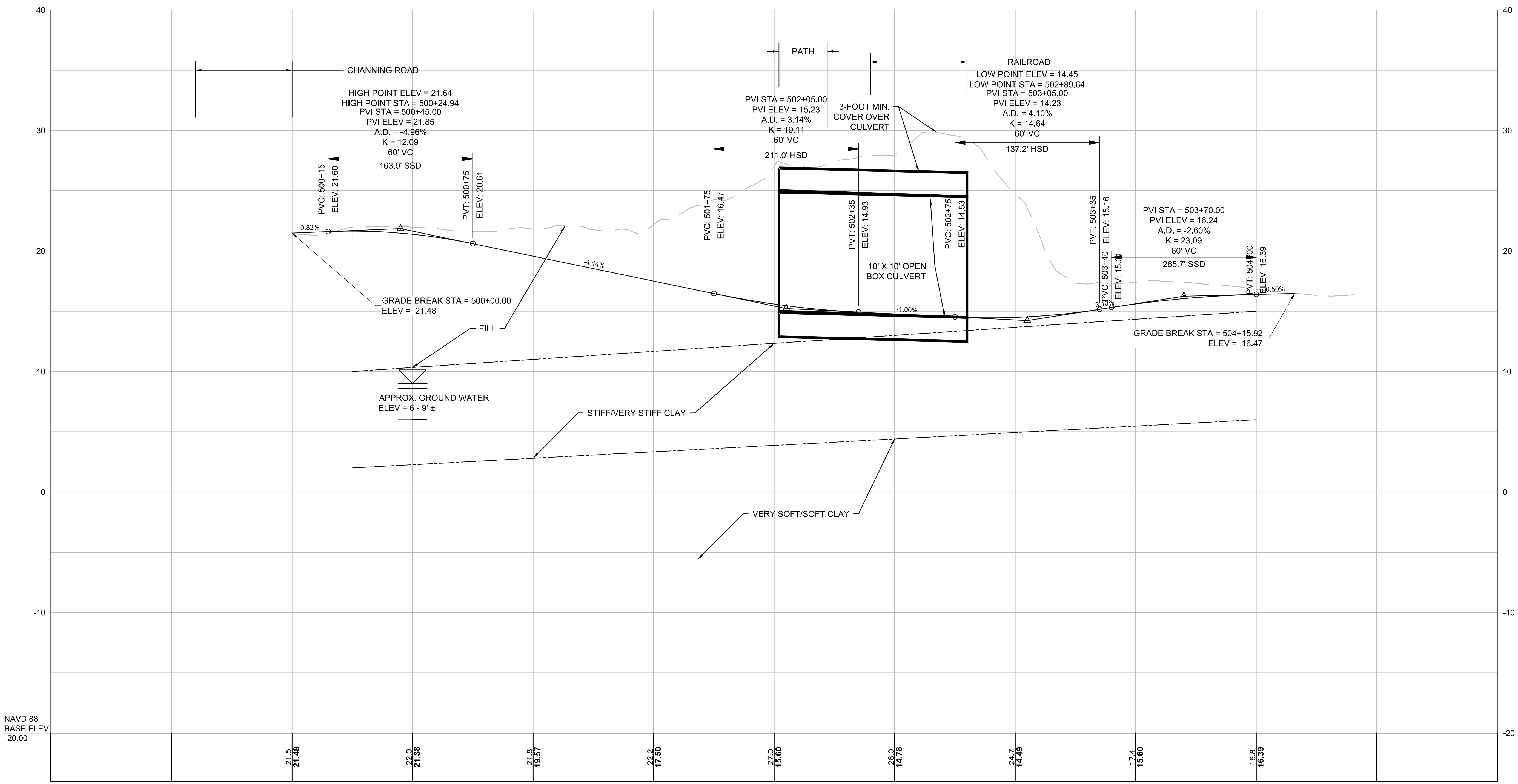
ALEXANDER AVENUE - CONSTRUCTION BASELINE - OPEN CUT EXCAVATION OPTION



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4 0 4 8
VER. SCALE IN FEET

4.4.6 Summary

The preferred design for the Alexander Avenue segment is Alternative 2. Although Alternative 2 would require additional construction of retaining walls compared to Alternative 1, the direct accessible path connection between the Community Path and the Alexander Avenue underpass is a major benefit for path users. Not only is it more convenient for path users, but it creates a vertical separation between the tracks and the path. Advanced signage will be installed on the approaches of the intersection to warn bicyclist of the upcoming crossing. Other traffic calming measures will be incorporated into the design to provide awareness of the intersection such as pavement markings, change in materials, and splitter islands.

Although Alternative 2 limits maintenance access directly over the culvert, the culvert length may be increased to accommodate maintenance access along the northerly side. Additional access points can be provided on both sides of the culvert. These locations will be coordinated with the MBTA, so that the tracks be accessed from both sides of the culvert and areas adjacent to the culvert. The access points will also be coordinated with public safety officials to incorporate their access needs. It is anticipated that an access ramp will be constructed on the west side of the Alexander Avenue path.

For the construction of the culvert, open excavation offers many advantages over tunnel jacking, but would have temporary impacts to commuter rail operations on the Fitchburg commuter rail. If it is acceptable to the MBTA and Keolis to utilize accelerated construction methods to limit the construction durations, then open excavation would become the preferred method of construction. We will work closely with the MBTA and Keolis as the design progresses to accurately determine the proposed timing and duration of temporary track shutdowns and establish work activities that can occur in advance of the temporary shutdown and culvert installation.

4.4.7 Belmont High School Connection

The extended multi-use path from Channing Road to Concord Avenue will provide a safe, off-road path connecting Concord Avenue to a number of destinations including Alewife Station and Belmont Town Center. The connection also provides improved bicycle and pedestrian accommodations to the Community Path at its proposed terminus at the intersection of Concord Avenue and the proposed Belmont High and Middle School Driveway. We incorporated the proposed intersection designs provide by the Belmont High and Middle School project and offer the following alternatives at the intersection: (Figure 17)

4.4.7.1 Alternative Design 1

Alternative 1 extends the paved path to Concord Avenue parallel to the proposed school driveway. The path will terminate 20 feet from the back of the Concord Avenue sidewalk. Between the path and the sidewalks, we propose to install a durable surface treatment such as pavers or cement concrete to create a pedestrian and bicycle mixing zone that will help to alert cyclists of the approaching an intersection. Bicyclists exiting the path are expected to utilize existing crosswalks and pedestrian ramps to access bike lanes on Concord Avenue. We propose to widen existing pedestrian ramps to 10-feet wide to accommodate both pedestrians and cyclists at the crosswalks. Bicyclists exiting Concord Avenue to the path are anticipated to utilize two-stage left turn boxes. We propose to install two-staged bicycle left-turn boxes for both Concord Avenue northbound and southbound to allow left-turn bicycles from Concord Avenue to wait in the box and proceed on green with westbound and eastbound traffic, respectively. This alternative also includes reconstructing ADA complaint pedestrian ramps on both sides of Goden Street and restriping crosswalk pavement markings.

4.4.7.2 Alternative Design 2

Alternative 2 proposes horizontal switchback curves and vertical obstructions at the end of the path to slow down cyclists as they approach the Concord Avenue sidewalk. Similar to Alternative 1, Alternative 2 proposes to widen the existing pedestrian ramps to 10-feet wide on the northeast corner and set the multi-use path terminal in between the two ramps to slow down the cyclists before crossing the intersection. Bicyclists exiting the path are expected to utilize the existing crosswalks and pedestrian ramps to access the bike lanes on Concord Avenue. Alternative 2 proposes bike boxes to be installed for both the Concord Avenue northbound and southbound to provide cyclists with a safe and visible way to get ahead of queuing traffic during the red signal phase. Bicyclists could access the path at the start of the next green phase. One negative feature of Alternative 2 is the reduced opportunity to warn bicyclists of the approaching intersection. Unlike Alternative 1, there is no proposed mixing zone before the sidewalk and bicyclists will have less room to decide their path of direction.

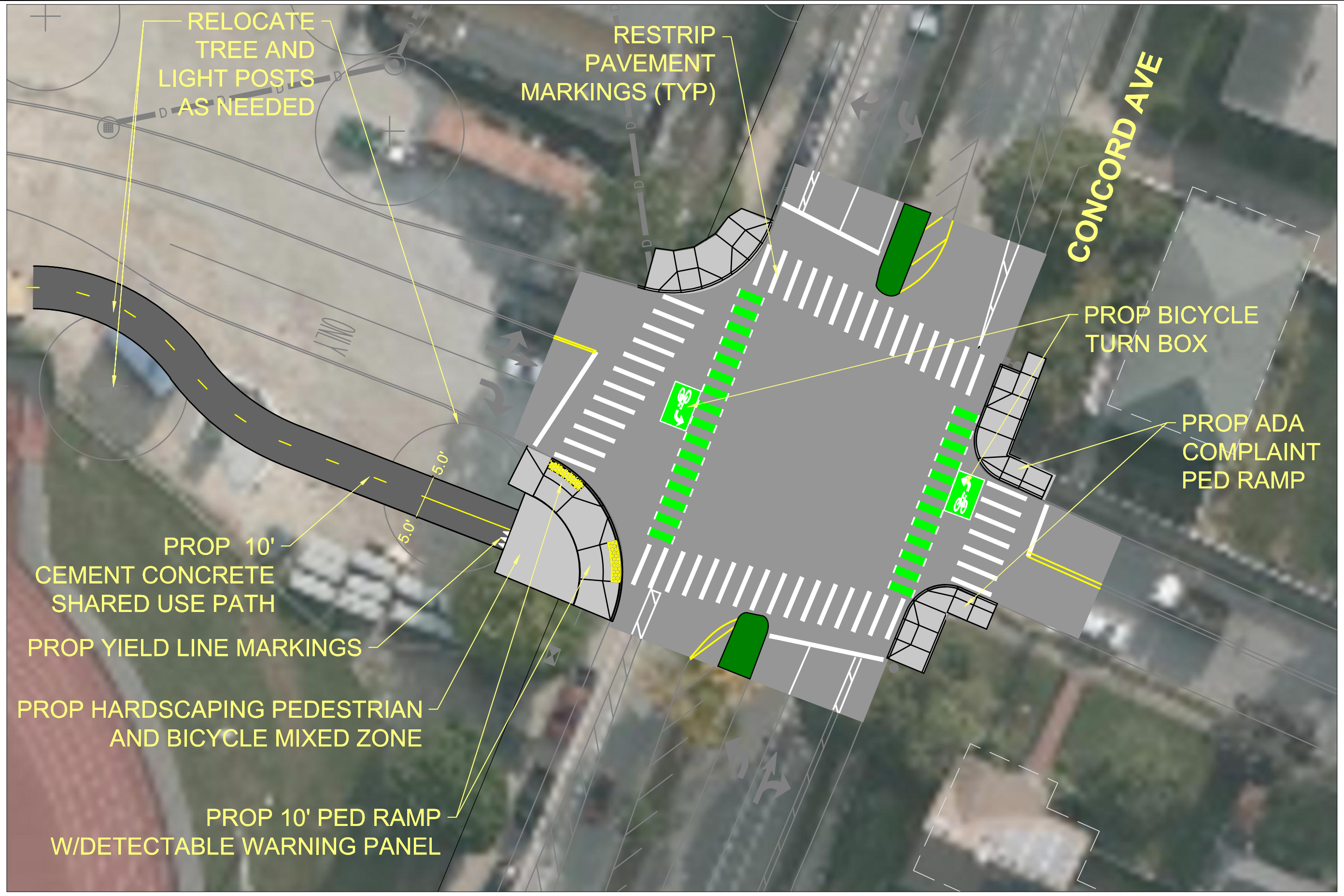
4.4.7.3 Alternative Design 3

Alternative 3 proposes similar but more gentle curvatures compared to Alternative 2. Alternative 2 proposes the installation of a scored cement concrete median to channelize the terminal of the path at the back of the Concord Avenue sidewalk. This Alternative provides traffic calming measures to alert cyclists of the approaching intersection. Alternative 3 proposes to reconstruct the northeast corner to provide a 15-foot wide apex pedestrian ramp, and the ramp opening will be offset from the path exit lane to slow down cyclists before crossing the intersection. Bicyclists exiting the path are expected to utilize the apex ramp to access their desired bike lane on Concord Avenue. Bicyclists exiting Concord Avenue to enter the path are expected to utilize two-stage left turn boxes. Similar to Alternative 1, Alternative 3 proposes to install two-staged bicycle left-turn boxes, reconstruct ADA complaint pedestrian ramps on both sides of Goden Street, and restripe crosswalk pavement markings.

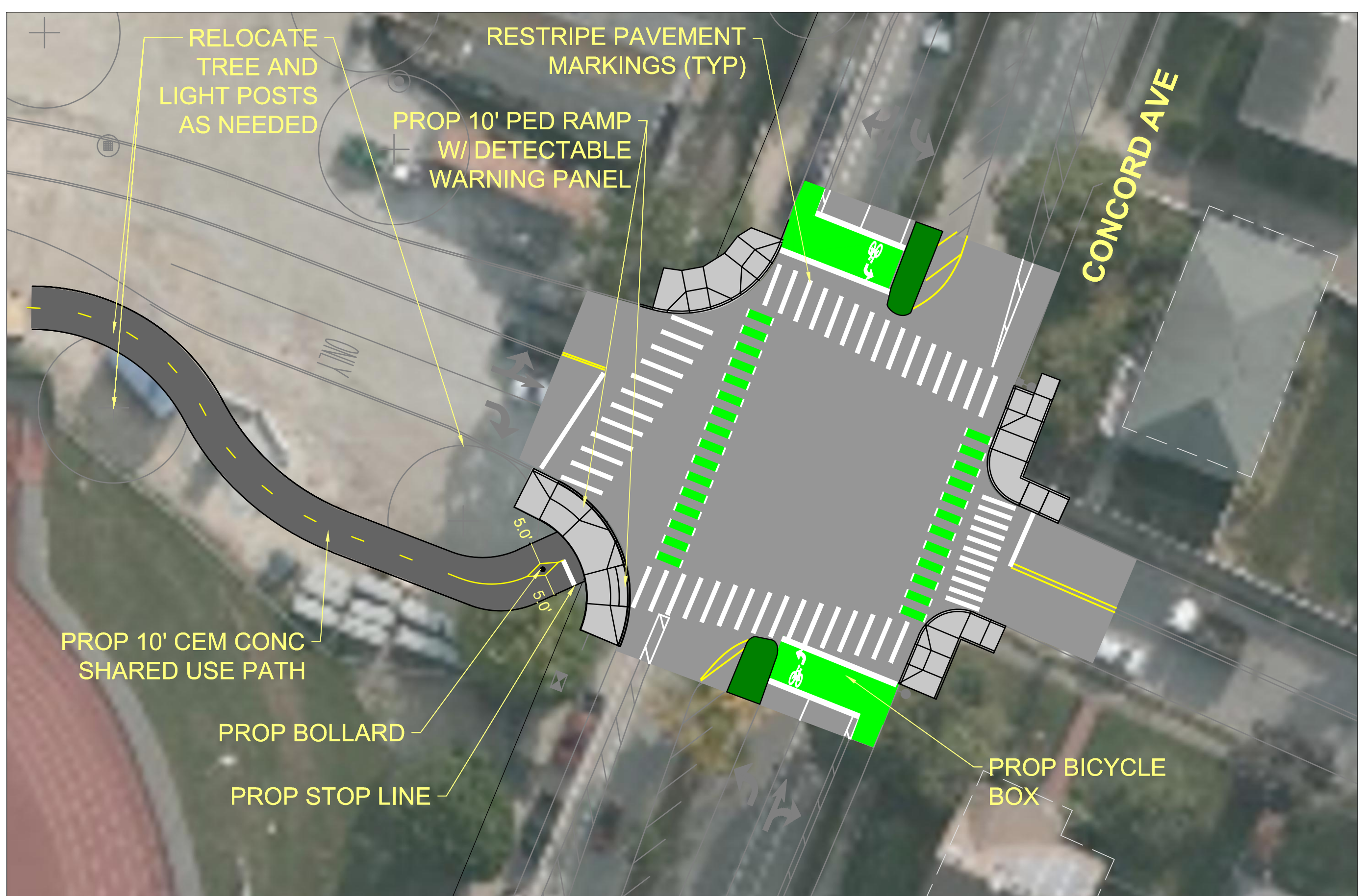
4.4.7.4 Recommended Alternative

We recommend Alternative 1, that proposes to terminate the multi-use path 20 feet in advance of the street. The path would transition to a landscaped pedestrian zone as it approaching to the intersection. This Alternative would provide a change in path material, clearly alerting path users of the approaching intersection. Path users would be expected to stop, and then slowly approach the crosswalk, wait for the pedestrian signal, then continue on the sidewalk or bike lanes to their desired destination. Terminating the path directly adjacent to the sidewalk would not give path users enough comfortable area to process the intersection and understand how to safely proceed. Vertical obstructions such as bollards, may be potentially hazardous to bicyclists if they don’t see them. Bollards also provide a maintenance access issue, by prohibiting maintenance vehicles from easily accessing the path. The wider pedestrian ramps will allow bicyclists and pedestrians to more comfortably utilize crossings. Constructing two separate pedestrian ramps instead of one apex ramp will allow bicyclists and pedestrians to proceed directly across the road.

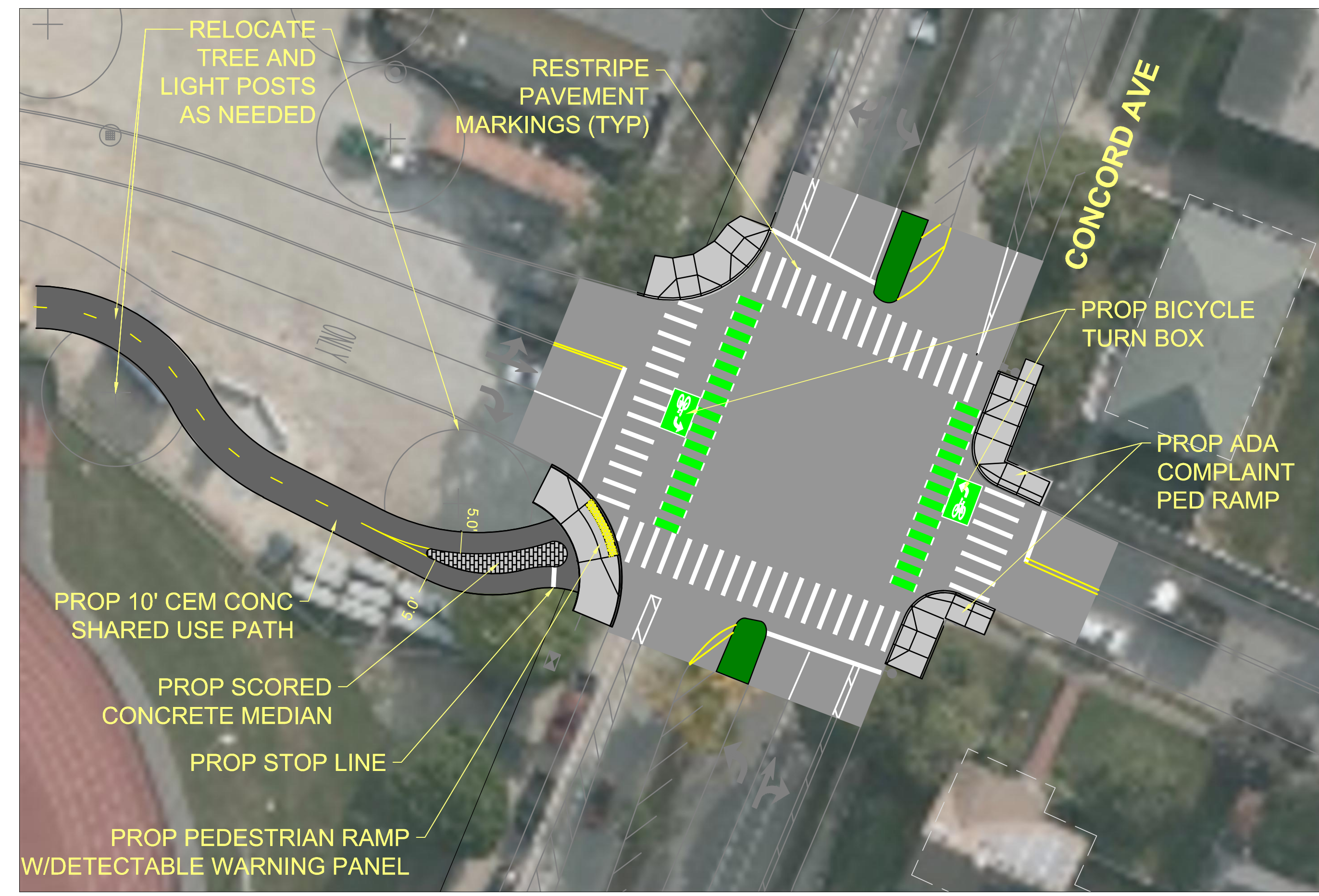
MASSDOT PFN 609204
BELMONT
BELMONT COMMUNITY PATH PHASE 1
CONCORD AVENUE INTERSECTION
ALTERNATIVES PLAN
FIGURE 17



ALTERNATIVE 1



ALTERNATIVE 2



ALTERNATIVE 3

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SCALE: 1" = 20'

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4.5 Segment 4 – Channing Road East (Alexander Avenue to #40 Brighton Street)

As the path heads easterly, the 16-foot wide paved segment will utilize an adjacent parcel of land owned by the Belmont Citizens Forum property. The alignment continues parallel to the tracks to #40 Brighton Street. Four alternatives are presented for Segment 4. For each alternative the path is proposed to be a 16-foot wide paved trail with 2-foot shoulders on each side. Gate locations for emergency access along fences and vertical barrier will be coordinated with the MBTA, Keolis, and public safety officials. A continuous railing is proposed along the north side of the path for each alternative. The varying factor between the alternatives are the horizontal and vertical location of the path relative to the railroad tracks and adjacent private properties. These options are similar to the options described in Sections 4.3.1 thru 4.3.4.

4.5.1 Alternative Design 1

The path alignment under Alternative 1 is proposed to be located within the Belmont Citizens Forum property. This alternative will situate the path near private property along Channing Road. The edge of the path will be approximately 7-feet from the northerly property line. The path would have a setback distance of approximately 40 to 50-feet from the nearest MBTA railroad track. This alternative provides the maximum setback distance from the tracks which will allow the existing maintenance road to be maintained. A fence or vertical barrier railing as required will be installed between the path and MBTA property.

The path is proposed to be vertically located between the track elevation and private properties along Channing Road. This alternative balances cut and fill quantities for construction. A retaining wall is proposed along the north side of the trail to reduce grading impacts into the private properties along Channing Road. The retaining wall varies in height up to 5-feet, based on topography. The proposed retaining wall will be located along the property line of the Belmont Citizens Forum parcel. A slope is proposed along the south side of the path that meets the existing ground. A drainage swale would be provided along the south side to capture stormwater runoff before it flows onto the path. This alternative would restrict access from private properties to the path due to the grade separation.

Alternative 1 requires that much of the existing vegetation be removed. New plantings, if desired, could be installed along the property line or behind the proposed fencing along the northerly side of the path. There would be minimal area to provide a landscape buffer between the private properties and the path due to the proposed retaining wall location. Landscaping could also be considered along the south side of the path to provide a landscaped buffer from the tracks.

4.5.2 Alternative Design 2

Alternative 2 proposes the same horizontal alignment as Alternative 1. The path alignment would be located within the Belmont Citizens Forum property. As noted under Alternative 1, this Alternative provides a setback distance from the tracks of 40 to 50-feet from the nearest track.

Alternative 2 proposes that the path be vertically located at/near the elevation of the private properties along Channing Road. This alternative would also provide for direct access from private property if desired. A retaining wall of varying height up to 10-feet would be constructed along the south side of the path. This wall would be constructed to retain the MBTA maintenance road on the north side of the tracks. Excavation limits for the construction of the retaining wall would extend to approximately 20-feet from the nearest track. The distance may be increased to approximately 30-feet by utilizing temporary earth support measures during construction. This option requires a large amount of excavation to construct the path, which may be undesirable due to increased soil disposal costs.

This Alternative would require the removal of much of the existing vegetation between Channing Road and the tracks. This alterative provides additional space for the creation of a landscaped buffer between the path and the private properties as compared to Alternative 1. Landscaping could also be provided along the southerly side of the path, between the wall and the tracks.

4.5.3 Alternative Design 3

The proposed alignment under Alternative 3 is to be located midway between the railroad tracks and private properties along Channing Road. The path would not be located within the Belmont Citizens Forum property, rather it would be located within the MBTA property further from private property. The path would have a minimum setback distance of approximately 20-feet from the nearest track. A 20-foot setback would provide ample space to maintain the MBTA's gravel access road for maintenance. A vertical barrier would be proposed along the south side of the path, and fence or railing along the north side of the path.

The path is proposed to be vertically located at/near the elevation of the railroad tracks. This alternative will elevate the trail above private properties along Channing Road. Minimal grading would be required to match existing grades. No retaining walls would be anticipated as part of this alternative, requiring the least amount of excavation. This option would restrict abutters access to the path due to the existing vegetation and steep topography.

Alterative 3 proposes to maintain as much of the existing vegetation as possible. This option would allow for a large area for additional plantings, if desired, along the northerly side of the path. The abutting properties will maintain the existing vegetated buffer to the new path and the tracks. No landscaping is proposed to be added along the southerly side of the path and a vertical barrier will be installed between the paved path and the tracks.

4.5.4 Alternative Design 4

Alternative 4 proposes the same horizontal alignment as Alternative 3 and will provide a minimum setback from the nearest track of approximately 20-feet. The path would not be located within the Belmont Citizens Forum property, rather it would be located within the MBTA property further from private property. A 20-foot setback would provide ample space to maintain the MBTA's gravel access road for maintenance. A vertical barrier would be proposed along the south side of the path, and fence or railing along the north side of the path.

The path is proposed to be vertically located between the elevations of the tracks and private properties along Channing Road. This alternative balances cut and fill quantities for construction. A retaining wall of varying height up to 5-feet would be constructed along the south side of the path to support the MBTA's gravel maintenance road. Excavation limits for the construction of the retaining wall would extend to approximately 6-feet from the nearest track. The distance may be increased to approximately 17-feet by utilizing temporary earth support measures during construction. In lieu of a vertical barrier along the south side of the trail, fencing will be installed on top of the retaining wall to prevent unauthorized access of the tracks.

This alternative would allow for some of the existing vegetated buffer along the north side of the path to be retained and potentially supplemented with plantings to provide additional screening. This alternative provides the greatest opportunity for introducing a more robust vegetated buffer. Landscaping could also be considered for additional screening along the top of the retaining wall.

4.5.5 # 40 Brighton Street

As the path approaches #40 Brighton Street, it transitions closer to the tracks to be located within the existing DCR easement between #40 Brighton Street and the MBTA property line. The path width will decrease to 12-feet in width due to existing building constraints and proximity to the MBTA property line. This reduced path width is acceptable at this location because trail user speeds are expected to be slower in the vicinity of the Brighton Street crossing. The proposed path will have a minimum setback distance of 11-feet from the nearest track within the #40 Brighton Street property easement. A 1-foot shoulder will be provided along the south side of the path to maximize the setback distance. Beyond the limits of the building, a 2-foot typical shoulder will be provided along the north side of the path with a railing. The railing will prevent access from the path to the adjacent private property. A vertical barrier is proposed along the MBTA property line between the path and the tracks.

As the path approaches the existing building at #40 Brighton Street, the northerly shoulder will be reduced to be 1-foot. The shoulder would transition from loam and seed to Hot Mix Asphalt along the building face. The railing will be proposed to meet the existing building, so that a smooth, continuous edge is provided. The property owner will be expected to access their property west of the building by going around the north side of the building or utilizing the garage doors that provided continuous access through the building.

The path alignment will impact existing parallel parking along the south side of the driveway. The 9 parking spaces are proposed to be shifted 9.5-feet to the north. The driveway aisle width will be reduced from 24-feet to 14.5-feet. There will be no loss in the total number of parking spaces for the property. Angled and perpendicular parking were investigated and found to result in a loss of the total number of parking spaces, therefore was not pursued. The path is proposed to have a 1-foot shoulder on the northerly side with a railing. Granite curb is proposed along the back side of the railing to separate the path from the parking lot.

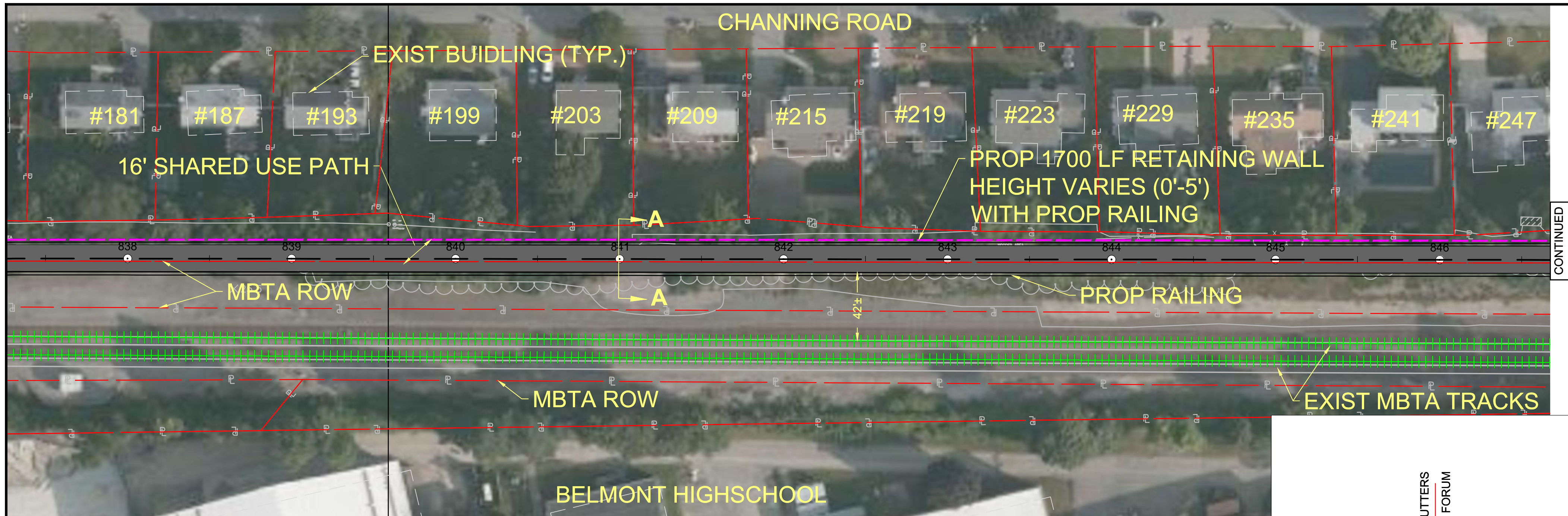
4.5.6 Recommended Alternative

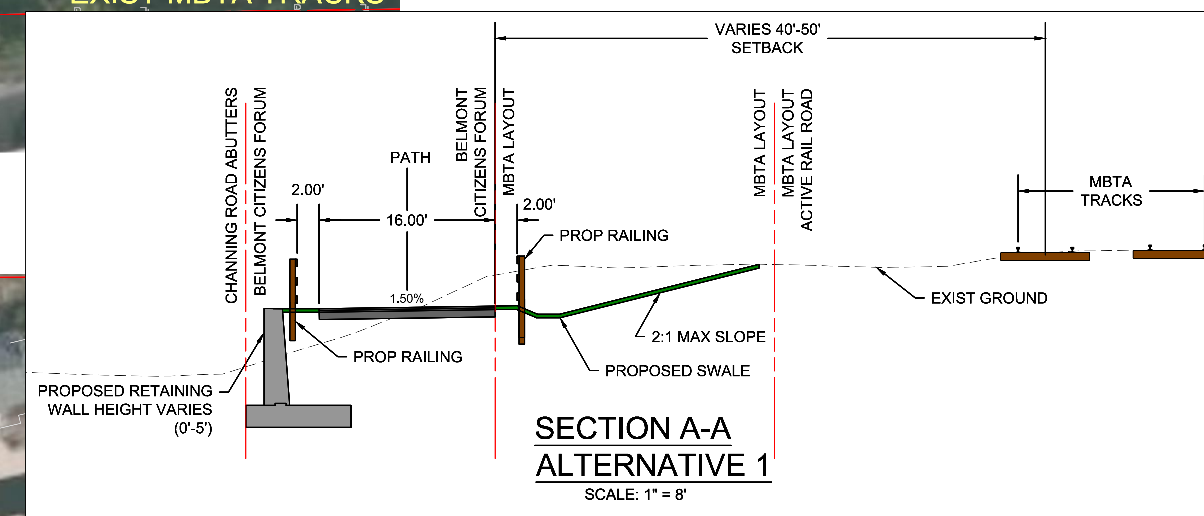
We recommend Alternative 3 for this segment of the path. This Alternative satisfies many of the project goals including reducing project costs, limiting impacts to private property, maintaining the MBTA access road, and providing a consistent width for trail users. Alternative 3 will allow the path to be constructed at a similar elevation to the tracks in order to maintain the existing vegetated buffer. The construction of retaining walls will not be required, further reducing project costs and excavation requirements for construction.

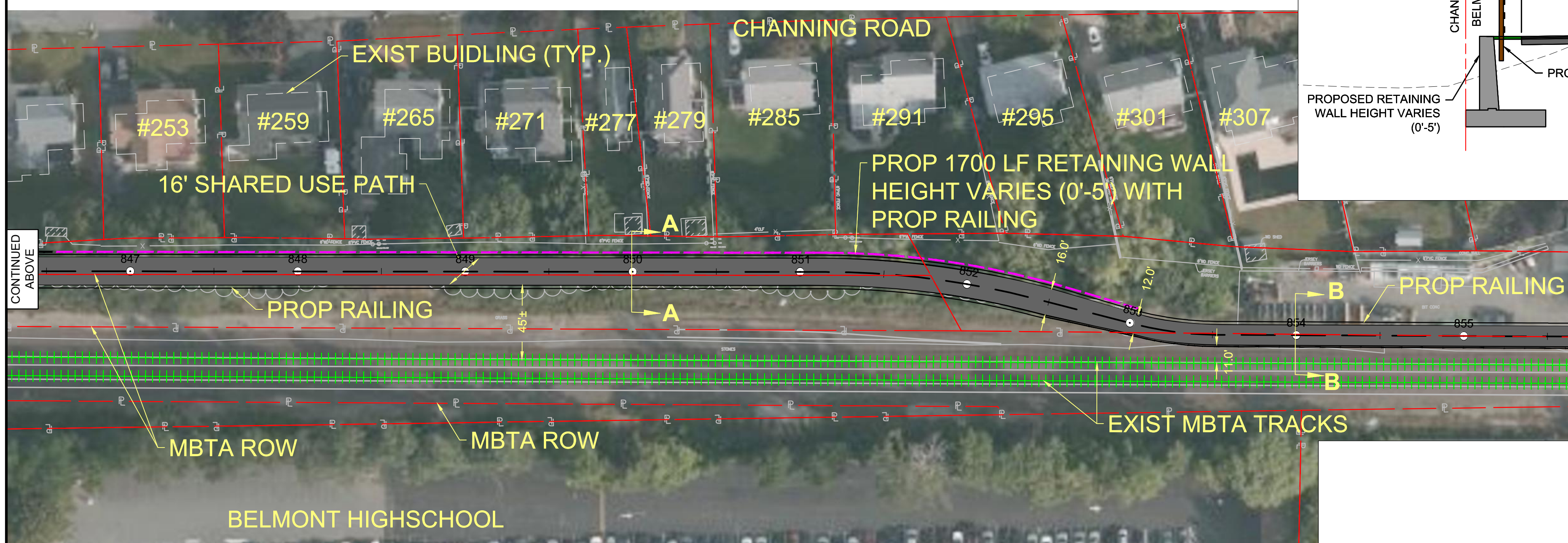
Although the recommended alternative does not provide the MBTA's desired 25-foot setback from the nearest track, it does maintain the functionality and access provided under existing conditions. Constructing the path closer to private properties, as shown in Alternatives 1 and 2, is undesirable to most abutters.

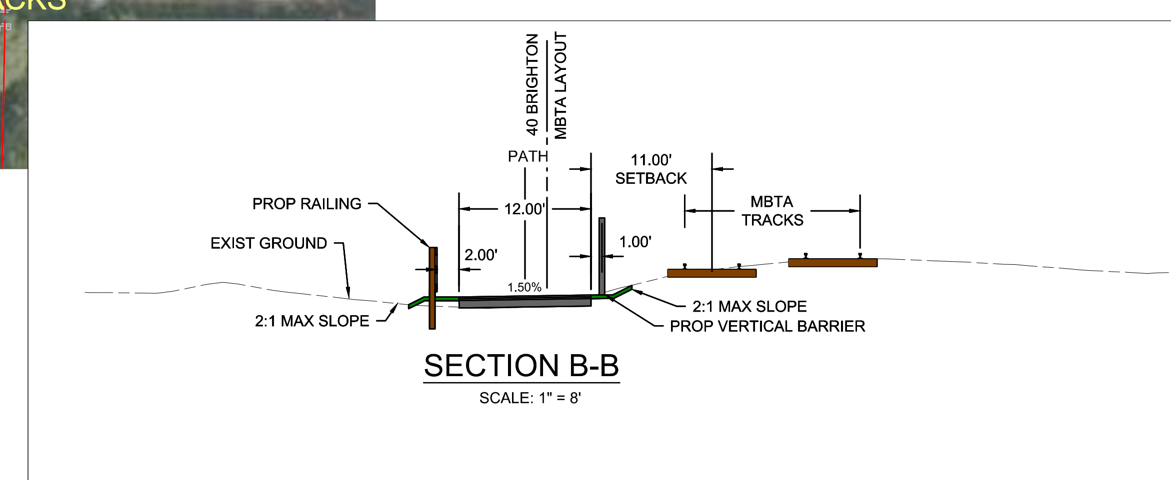
Alternatives 1, 2, and 4 require significantly more excavation to construct the path. Construction costs would increase to account for the proper disposal of excavated materials. Alternatives 1, 2, and 4 also require the removal of some if not all of the existing vegetated buffer that is well established between private property and the tracks. The existing buffer provides visual and vertical separation from the private residences to the path and tracks. Although new landscaping can be installed, it would take time to establish a new vegetated buffer to match the current condition.

MASSDOT PFN 609204
BELMONT
BELMONT COMMUNITY PATH PHASE 1
SEGMENT 4 - PLAN
FIGURE 18









0 40 100 160
SCALE: 1" = 40'

Plotted on 5-Feb-2020 11:15 AM
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MASSDOT PFN 609204
BELMONT
BELMONT COMMUNITY PATH PHASE 1
SEGMENT 4 - PLAN
FIGURE 19

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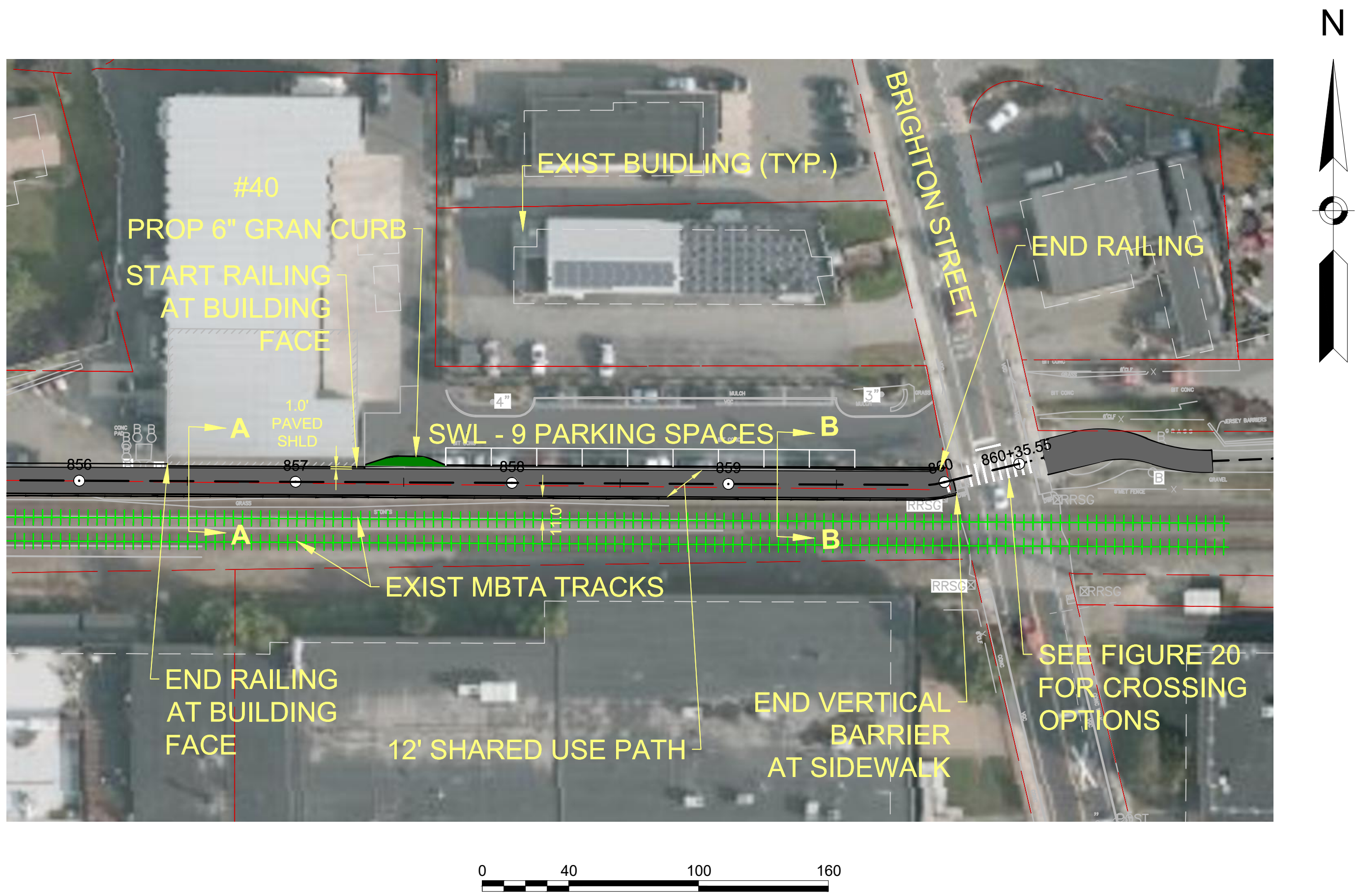
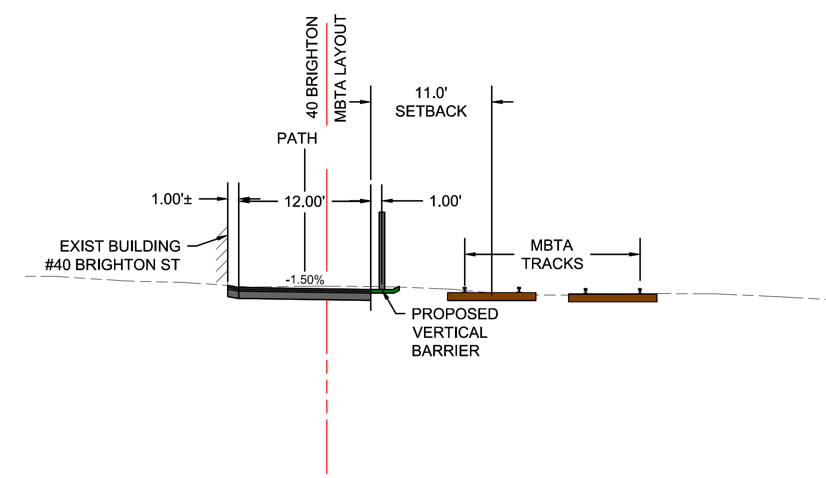
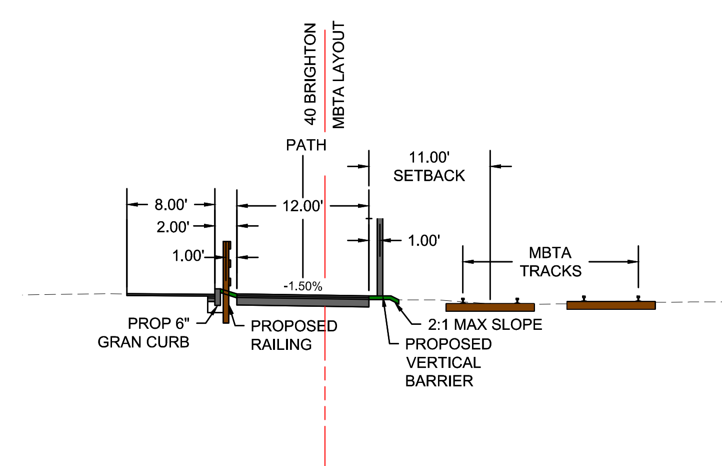




SECTION A-A

SCALE: 1" = 8'



SECTION B-B

SCALE: 1" = 8'

4.6 Segment 5 – Brighton Street Crossing to Fitchburg Cutoff

4.6.1 Proposed Alternatives

The railroad intersects with Brighton Street in a skewed angle, since the path is proposed to be parallel to the tracks this results in low visibility on the west side of the path at Brighton Street. As part of all the alternatives studied, we propose to reconstruct the existing pedestrian crossing for the new path and to implement other traffic calming devices. We propose a textured and colored crosswalk for the path crossing Brighton Street to provide visible awareness to the crossing. Additional signage and new striping will be proposed along Brighton Street to improve visibility of the crossing. Stop signs and stop bars will be installed to improve safety at the intersections of Brighton Street at Pond Road, Brighton Street at Vale Road, and Brighton Street at Hittinger Street.

On the north side of Brighton Street, we propose to construct a 6-foot wide scored concrete median within Brighton Street. This will allow for two 11-foot lanes, with 1-foot shoulders. On the south side of Brighton Street, we propose to eliminate the existing shoulder on both sides and widen the existing 5-foot wide sidewalk on the west side to a 8-foot wide shared use path with a pedestrian ramp to accommodate bicycle and pedestrian crossing on the south side. In addition, we propose to construct a 6-foot wide scored concrete median and 11-foot lanes on both sides. Existing rail crossing signals and gates will be retained. In addition to the geometry modification and traffic calming at the railroad crossing, we propose the following alternatives to improve pedestrian and bicyclist safety:

4.6.1.1 Alternative 1 - Rapid Rectangular Flashing Beacon (RRFB)

Under Alternative 1, we propose to install Rapid Rectangular Flashing Beacons (RRFB's) at crossings on both sides of the track. All four (4) RRFB's would start flashing simultaneously immediately after user activation to warn drivers that pedestrians and cyclists intend to cross the street.

Unlike traditional traffic signals and Pedestrian Hybrid Beacons (PHB's) that require a complete stop to allow pedestrians or cyclists to cross, RRFB's require driver judgement to yield. When a pedestrian or bicyclist activates the RRFB on the far side of the crossing, a car is not likely to stop at the near side crosswalk, and instead, they typically continue forward and yield at the crosswalk where the pedestrian is crossing. Due to the proximity of the crossing to the tracks, there are concerns that vehicles may stop on the railroad tracks in response to the flashing RRFB's. An example of RRFB installed adjacent to a railroad crossing in Beaverton, is shown in the photo below. The RRFB crossing is offset from the track by approximately 60 feet to allow at least 3 cars to be queued behind the crosswalk.

Rail with trail crossing with RRFB, 1797 SW 158th Ave, Beaverton, Oregon

4.6.1.2 Alternative 2 - Midblock Traffic Signal

Alternative 2 proposes to install a midblock traffic signal at this location. The traffic signal would consist of a pedestrian actuated signal that would stop vehicles to allow pedestrians and bicyclists to cross. The signal would be interconnected with the rail crossing gate, so that the vehicular signal heads would remain red during train crossings. The pedestrian crossing interval will be calculated so that pedestrians and cyclists can safely cross the street before the railroad gates open. Although the installation of a traffic signal is a more recognizable treatment, it will likely create higher control delay for pedestrians, cyclists, and vehicles. The signal would be actuated by path users as they approach the crossing. The users would need to stop and wait for the “WALK” signal to be activated.

In conjunction with the traffic signal, an advanced “RED SIGNAL AHEAD” activated blank-out sign for the Brighton Street southbound approach should also be considered. The sign would only be active and display “RED” when the traffic signal at the Brighton Street Crossing turns red.

Example of Advanced “Red” Signal Ahead” activated bank-out sign Assembly

Signal Warrant Analysis

We employed the Traffic Signal Warrant Analysis to evaluate the feasibility of traffic signal installation at the unsignalized Brighton Street railroad crossing, based on the completion of Belmont Community Path.

The current Manual on Uniform Traffic Control Devices[1] (MUTCD) contains nine traffic signal warrants, at least one of which should be satisfied to justify the installation of a traffic signal at a particular location. Satisfying one or more warrants, however, does not necessarily require the installation of a traffic signal. The traffic signal warrants are:

- Warrant 1: Eight-Hour Vehicular Volume;
- Warrant 2: Four-Hour Vehicular Volume;
- Warrant 3: Peak Hour;
- Warrant 4: Pedestrian Volume;
- Warrant 5: School Crossing;
- Warrant 6: Coordinated Signal System;
- Warrant 7: Crash Experience;
- Warrant 8: Roadway Network; and
- Warrant 9: Intersection Near a Grade Crossing.

We conducted the signal warrant analysis using the procedures contained in the MUTCD. Not all warrants are applicable to the study location, and data availability may limit which warrants can be evaluated. For the analysis of the midblock pedestrian crossing adjacent to the railroad crossing on Brighton Street, we evaluated only warrant 4: Pedestrian Volume - Peak Hour.

Under the assumptions of the future evening peak hour traffic volume on Brighton Street (1801 vehicles per hour), we expect that after the completion of the path, the future peak hour volumes pedestrians and cyclists would

[1] *Manual on Uniform Traffic Control Devices for Streets and Highways*, 2009 Edition, Federal Highway Administration.

exceed the minimum signal warrant threshold of 134 pedestrians/cyclists per hour during the peak hours, therefore warrants the installation of traffic signal at this location. The Traffic Signal Warrant Analysis worksheets are included in the Appendix D. An example of midblock traffic signal installed adjacent to a railroad crossing signal is shown below.

Midblock Traffic Signal adjacent to Railroad Crossing, 1401 NB 231st Avenue Hillsboro Oregon

4.6.1.3 Alternative 3 - Pedestrian Hybrid Beacon (PHB)

Alternative 3 proposes to install a Pedestrian Hybrid Beacon (PHB) also known as High Intensity Activated Crosswalk (HAWK) Signal. The PHB consists of two three-section signal heads and operates as shown below. The vehicular signal faces will remain in dark until activated by a crossing pedestrian or cyclist, and the pedestrian signal face will display a “DON’T WALK” indication similar to a traditional traffic signal system. Once activated, the beacon will begin to flash yellow to warn drivers that the beacon has been activated. The flashing yellow signal is followed by a steady yellow interval, then followed by a steady red signal indicating the vehicle need to come to a complete stop and wait at the stop line. In the meantime, the walk sign will be on to allow pedestrians/cyclists to cross the street. Similar to a traditional traffic signal, the “WALK” phase is followed by a flashing “DON’T WALK”, during the flashing “DON’T WALK” phase, the vehicular signal will display alternating flashing red lights that signals drivers to stop and yield for the pedestrians or cyclists in the crosswalk, and then proceed once the pedestrians and or cyclists have cleared the crossing. To enhance safety at railroad crossing, we propose to modify the MUTCD standard operation to include an all red clearance phase followed by the steady yellow interval to avoid vehicles stopping on the tracks. The photos below illustrate the PHB signal sequence when activated by pedestrian push button and by railroad crossing:

Interval	Veh Signal	Ped Signal	RR Signal	Gate
1	DARK	DW	DARK	Up
2	FY	DW	DARK	Up
3	SY	DW	DARK	Up
4	SR	DW	DARK	Up
5	SR	W	DARK	Up
6	AFR	FDW	DARK	Up
7	DARK	DW	DARK	Up

PHB Signal Sequence When Activated By Push Button

Interval	Veh Signal	Ped Signal	RR Signal	Gate
1	DARK	DW	DARK	Up
2	FY	DW	AFR	Down
3	SY	DW	AFR	Down
4	SR	DW	AFR	Down
5	SR	W	AFR	Down
6	SR	FDW	AFR	Down
7	AFR	DW	DARK	Up
8	DARK	DW	DARK	Up

PHB Signal Sequence When Activated By Railroad Crossing

Similar to a typical traffic signal, the PHB has the capability to be interconnected with the rail crossing gate. To reduce driver confusion and improve pedestrian safety at the rail crossing, we propose to modify the MUTCD standard operation for the PHB to include the operation of an alternative flashing red after the gates rise and pedestrian have a “DON’T WALK” indication to act as an all red interval. The installation of the PHB would also include additional signage. The photo below shows an example of a PHB at a midblock crossing in Quincy Center, MA.

PHB at Midblock Crossing in Quincy Center, MA

4.6.2 Recommended Alternative

We recommend Alternative 2 for the Brighton Street Crossing, which consists of the installation of a mid-block traffic signal. A traffic signal would require vehicles to stop for path users crossing Brighton Street. A traffic signal would also avoid confusion from drivers that may be inclined to stop on/near the tracks as part of the other alternatives presented. Installing a RRFB under Alternative 1 is a common and cost-effective mid-block crossing treatment, however, it poses a safety concern for this specific location if a vehicle stops on the tracks for a pedestrian or bicyclist in the crosswalk. Installing a PHB as presented in Alternative 3, reduces vehicle delay as compared to traditional traffic signal, however, due to the similarity of the alternating flashing red pattern to rail crossing signals and a lack of education for such operations, the PHB is deemed unsuitable for this location. Alternative 2 is preferred because the operation is known and generally accepted by the public, enhances the rail crossing safety by interconnecting with the railroad crossing signals and gates, and reduces potential conflicts between different modes of transportation.

MASSDOT PFN 609204
BELMONT
BELMONT COMMUNITY PATH PHASE 1
SEGMENT 5 - ALTERNATIVES PLAN
FIGURE 20

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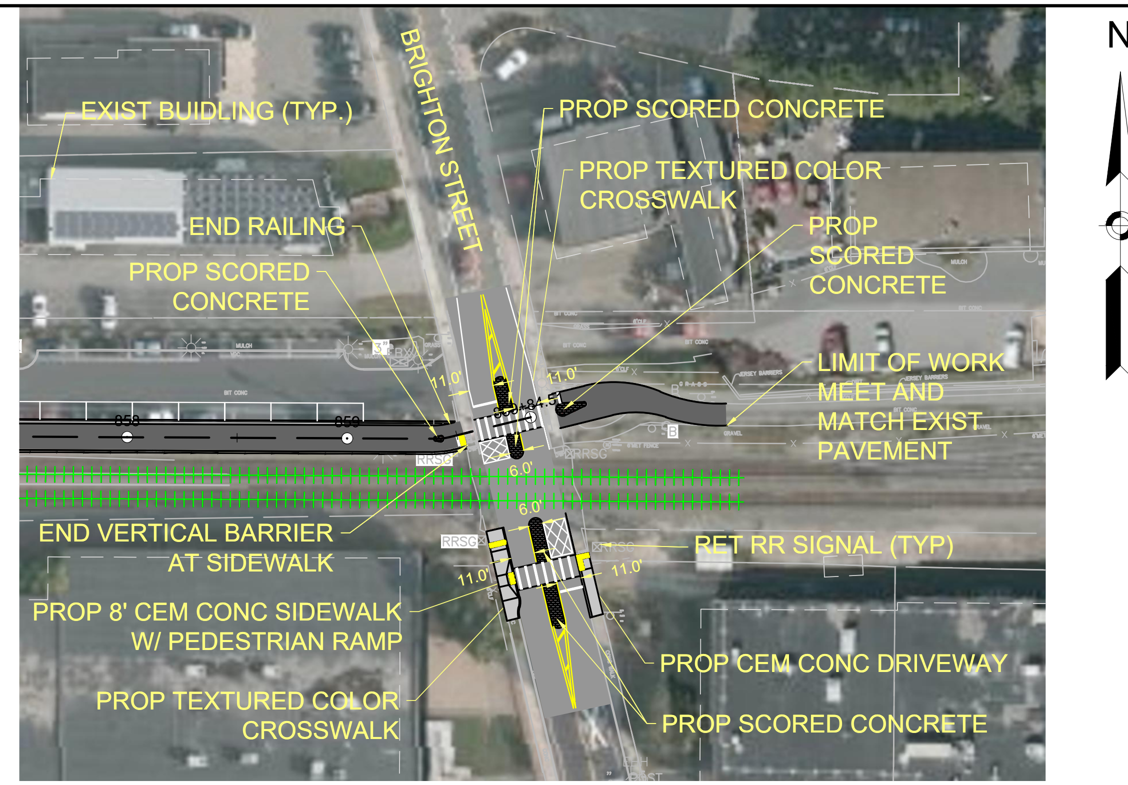
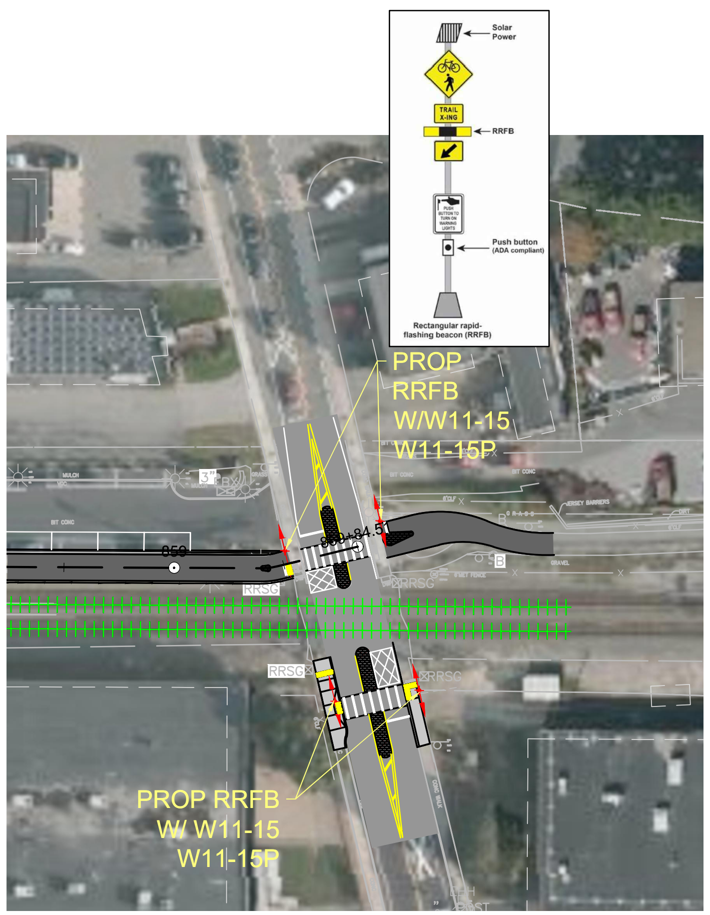
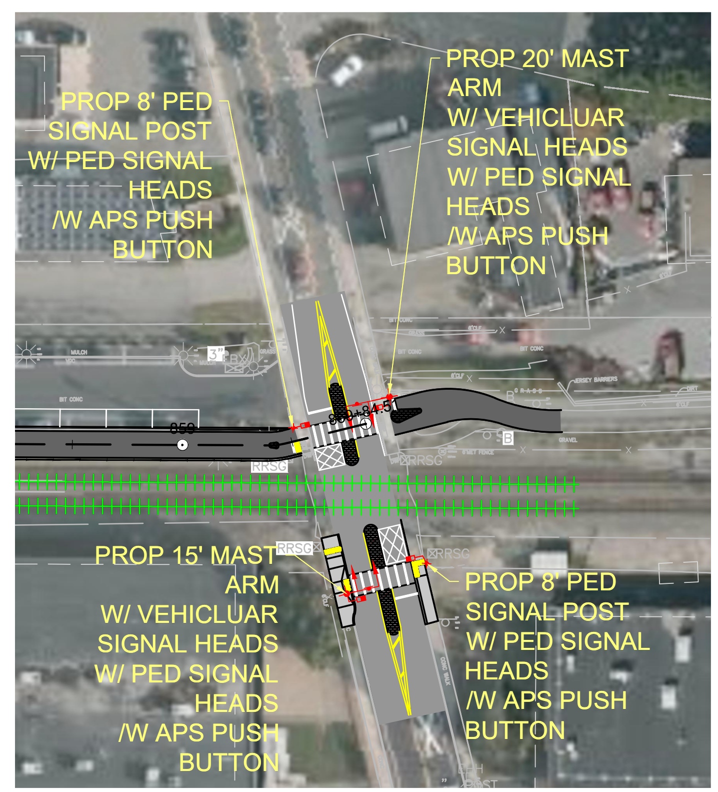
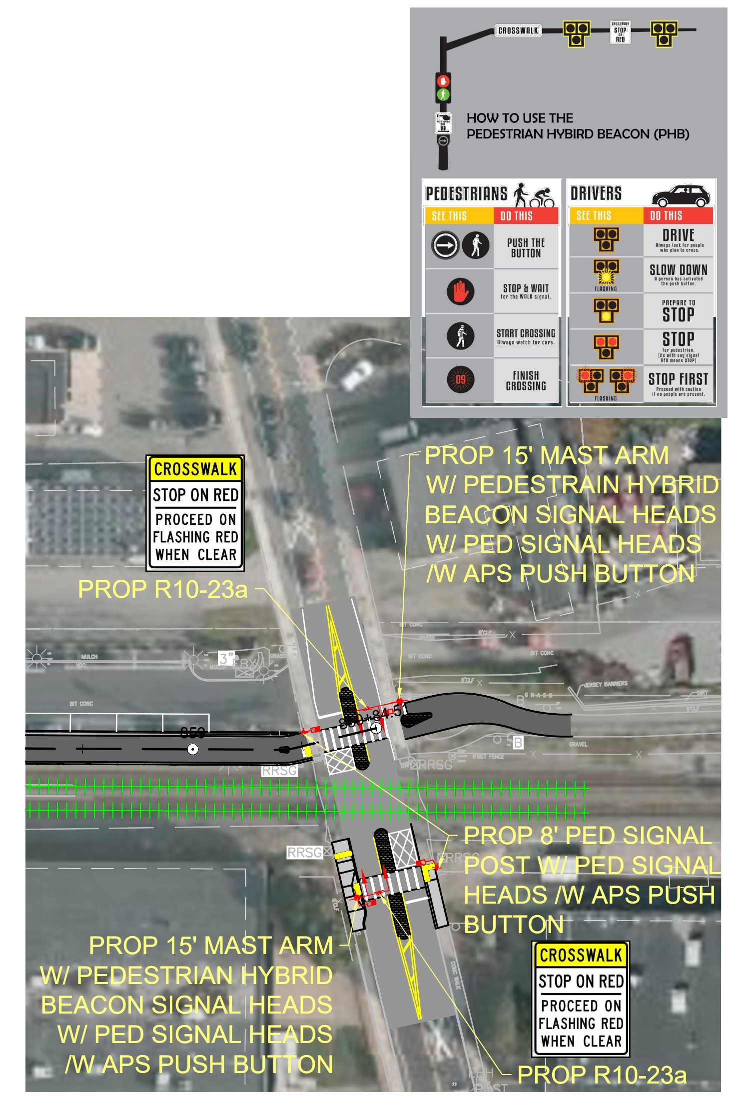




BRIGHTON STREET CROSSING
ALTERNATIVE - 1 (RRFB)



BRIGHTON STREET CROSSING
ALTERNATIVE - 2
(TRAFFIC SIGNAL)



BRIGHTON STREET CROSSING
ALTERNATIVE - 3
(PEDESTRIAN HYBRID BEACON)

0 40 100 160
SCALE: 1" = 40'

5 Conclusion

Nitsch Engineering has prepared this Concept Design Report to review existing conditions, impacts to abutting properties, and safety for path users. The report proposes path alignment options for the construction of Phases 1a and 1b of the Belmont Community Path in the Town of Belmont. The path will provide a multi-use path connection from the Fitchburg Cutoff Path to the Clark Street Pedestrian Bridge. This project consists of the first phase of a multi-phase project to construct a 2-mile segment of the MCRT through Belmont, linking the Waltham and Cambridge sections of the MCRT.

Based on our review of the existing conditions, design guidelines, and previous reports, we analyzed alternatives for the proposed design. Based on our review of the alternatives presented in the report, we recommend the design be advanced to a 25% design level. This preferred path alignment, consisting of the design alternatives for each Segment, is shown in the draft construction plans located in Appendix A.

Section of Path	Preferred Alternative
Segment 1 - Clark Street Bridge to #460 Concord Avenue	Alternative 2
Segment 2 - Belmont Station to #7 Channing Road	Alternative 1
Segment 3 - Channing Road West (#17 Channing Road to Alexander Avenue)	Alternative 3
Alexander Avenue Crossing	Alternative 2
Segment 4 - Channing Road East (Alexander Avenue to #40 Brighton Street)	Alternative 3
Segment 5 - Brighton Street Crossing to Fitchburg Cutoff	Alternative 2

The proposed design includes construction of a multi-use path, known as the Belmont Community Path, from the Clark Street pedestrian bridge to the terminus of the Fitchburg Cutoff Path at Brighton Street in Belmont. The design will include a paved multi-use trail with a typical paved width of 16-feet and a minimum paved width of 12-feet. The proposed path will include level shoulders with fence, railing, and/or vertical barriers to restrict access to/from the path and the railroad tracks and adjacent properties. The path will provide a means for residents to safely access Belmont Center, Concord Avenue, Belmont High School, and the MBTA commuter rail by means of healthy transportation methods. The Community Path will extend westward from the existing Fitchburg Cutoff Path, which provides a multi-use path connection from Brighton Street to Alewife Station in Cambridge.

The proposed project will include access accommodations for maintenance and emergency vehicles to the path and railroad tracks. We will coordinate the design with the MBTA and Keolis with a focus on providing access locations as required where the proposed alignment is located within 18-feet of the railroad tracks. We will also coordinate with public safety officials regarding their requirements for access to the path and the railroad in the event of an emergency. By providing access for emergency personal, the project will enhance public safety and provide a benefit by allowing the path to be used for evacuations of passengers in the event of an emergency.

The project includes a connection to the existing Clark Street pedestrian bridge, allowing path users to access to/from the Clark Street residential neighborhood. The project includes ADA improvements consisting of an accessible connection to the Belmont Station platform, consisting of a paved ADA-complaint ramp from Concord

Avenue to the path and the station platform north pf the tracks. The proposed connection will provide an accessible bicycle and pedestrian connection from the path to downtown Belmont.

The path will be constructed adjacent to residential properties along Channing Road.

The proposed design includes safety enhancements at the existing at-grade railroad crossing at Brighton Street. These enhancements are proposed to include the installation of traffic calming measures, advanced signage, and a new traffic signal. The new traffic signal will be coordinated with the existing railroad signal and gates so that vehicles will receive a RED phase during railroad crossings. The signal will be pedestrian actuated, providing a safer crossing for trail users. The enhanced crossing will also include ADA accessibility improvements.

The project includes a grade-separated crossing of the railroad tracks from Alexander Avenue to the Belmont High and Middle Schools. This new connection will eliminate the need for pedestrians to cross the active railroad tracks to access the school from the Channing Road neighborhood and points north.

The proposed design faces design challenges at project "pinch points", where existing features and topography require the path to be constructed closer to the existing MBTA tracks than MBTA preferred set-backs. These "pinch points" are listed within the table below. The table shows the preferred design with the proposed setback distance from the MBTA railroad tracks.

Location	**Preferred Alternative #**	**Proposed Path Width**	**Proposed Setback Distance**
Clark Street Pedestrian Bridge	2	16-feet	34-feet
#460 Concord Avenue	2	16-feet	10-feet min*
Concord Avenue Bridge	1	16-feet	27-feet
#7 Channing Road	1	16-feet	12-feet
Alexander Avenue	2	16-feet	25-feet
#40 Brighton Street	3	12-feet	11-feet

*Distance to be verified with on-the-ground survey

Per MBTA Standard Drawings, an 18-foot minimum setback distance is required to provide adequate width for maintenance access. Based upon the table above, maintenance access can be maintained with the preferred design alternatives at the Clark Street Pedestrian Bridge, Concord Avenue Bridge, and Alexander Avenue Crossing. At the locations where the 18-foot width cannot be met, Nitsch will coordinate with the MBTA, Keolis, and public safety officials to locate access gates so the tracks can be accessed by railroad and emergency personnel.

In summary, Nitsch Engineering's proposed design of the Phase 1 of the Belmont Community Path will create an accessible multi-use path for people of all ages and abilities from the Clark Street Pedestrian Bridge to the terminus of the Fitchburg Cutoff Path, connecting multiple destinations including Clark Street, Pleasant Street, Belmont Center, Alexander Avenue, Channing Road, the Belmont High and Middle Schools, Concord Avenue, and Brighton Street.

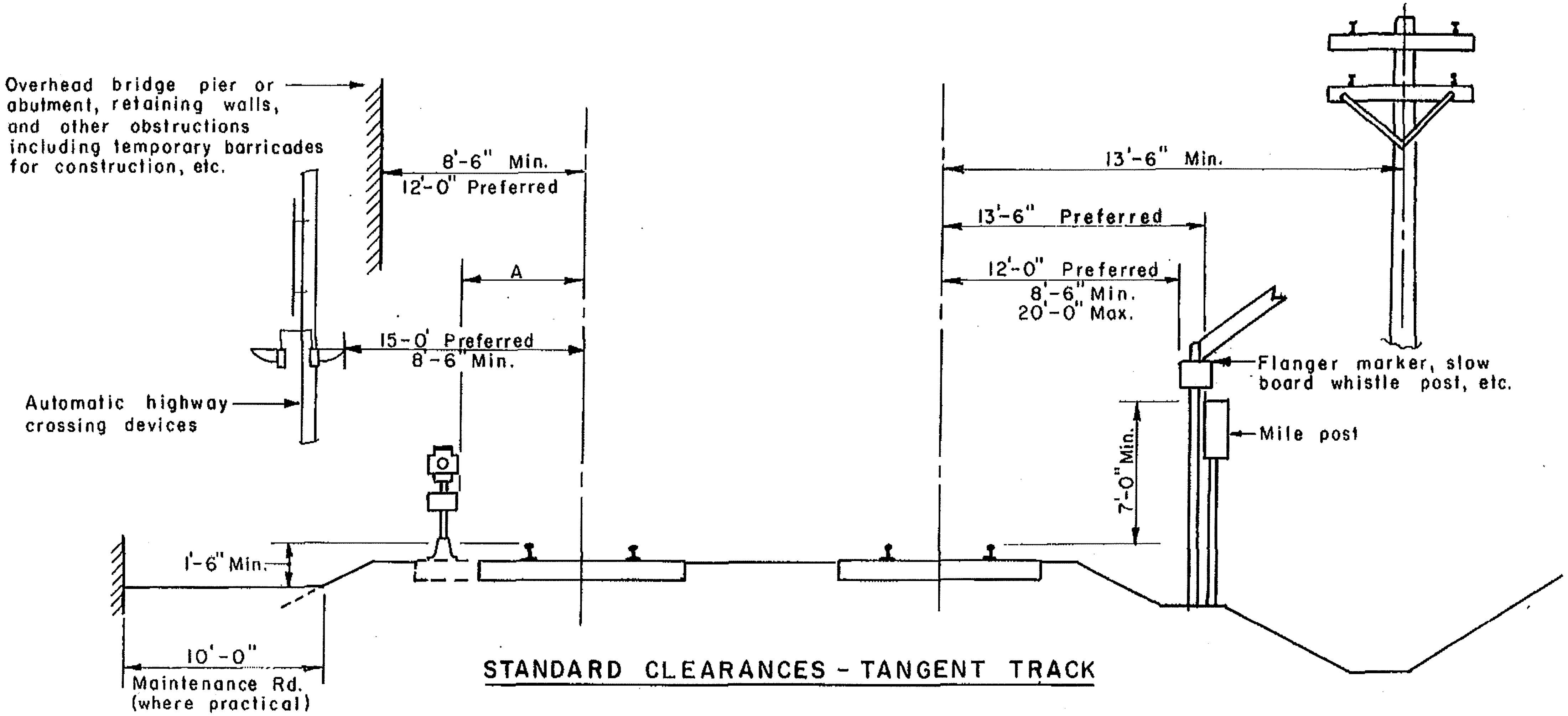
APPENDIX CONTENTS

Appendix	Description
A	Draft Construction Plans
B	MBTA Standard Drawings
C	Rails-With-Trails Sections
D	MUTCD Traffic Signal Warrant Analysis

Appendix A: Draft Construction Plans

*To be submitted under separate cover

Appendix B: MBTA Standard Drawings



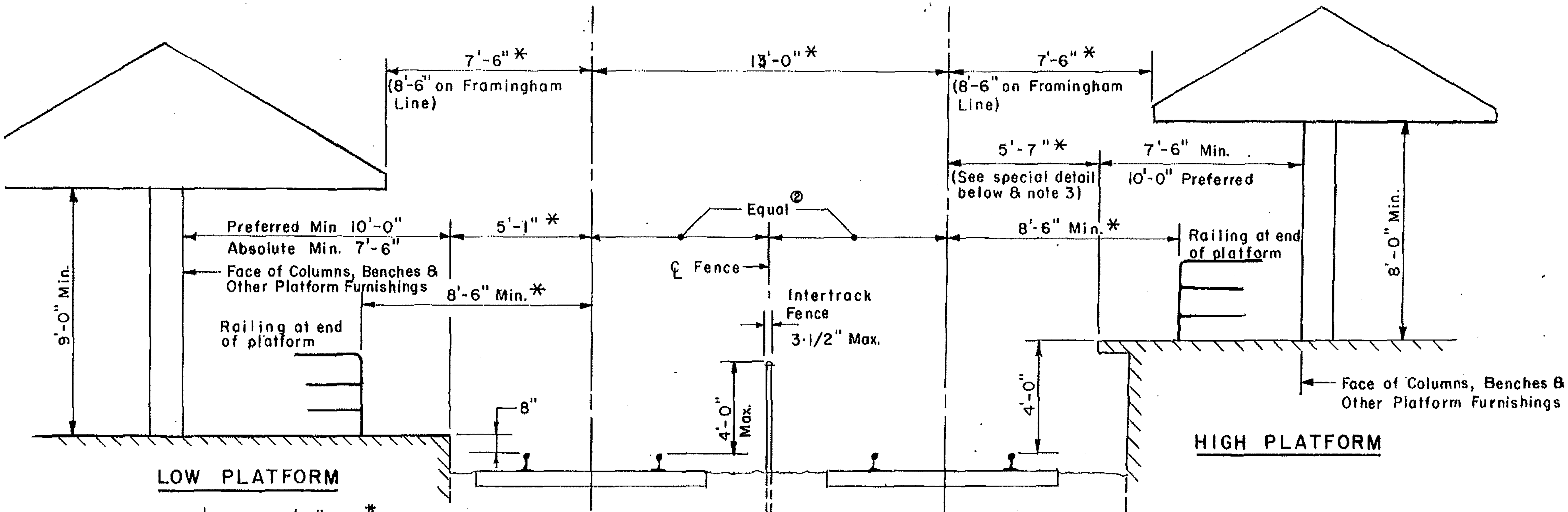
STANDARD CLEARANCES - TANGENT TRACK

A-Low switch stand or Electric lock (less than 3'-0" high) - - - - - - - 6'-6"
High switch stand (more than 3'-0" high) - - - - - - - - - - - - - - - - - - 9'-0"

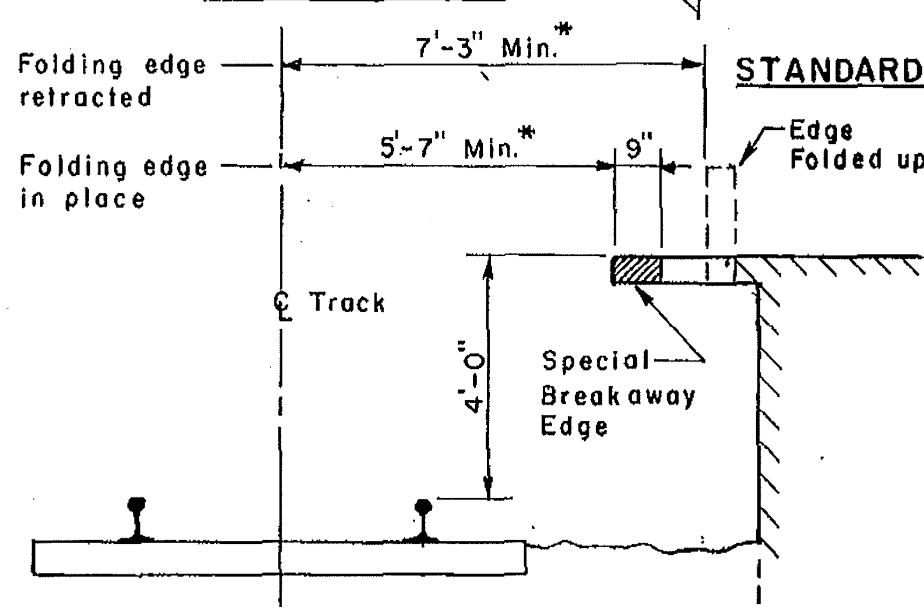
MASSACHUSETTS BAY TRANSPORTATION AUTHORITY	RAILROAD OPERATIONS	DWG. NO. 1012 Oct. 28, 1992 (ISSUE DATE) — 2 (ISSUE NO)

STANDARD CLEARANCES
GENERAL ROADWAY OBSTRUCTIONS
TANGENT TRACK

John D. Ray — ENGINEERING OFFICER
W A [illegible] — CHIEF ENGINEERING OFFICER



STANDARD CLEARANCES AT PASSENGER STATIONS



SPECIAL HIGH PLATFORM CLEARANCE

Where required by freight operator

NOTES:

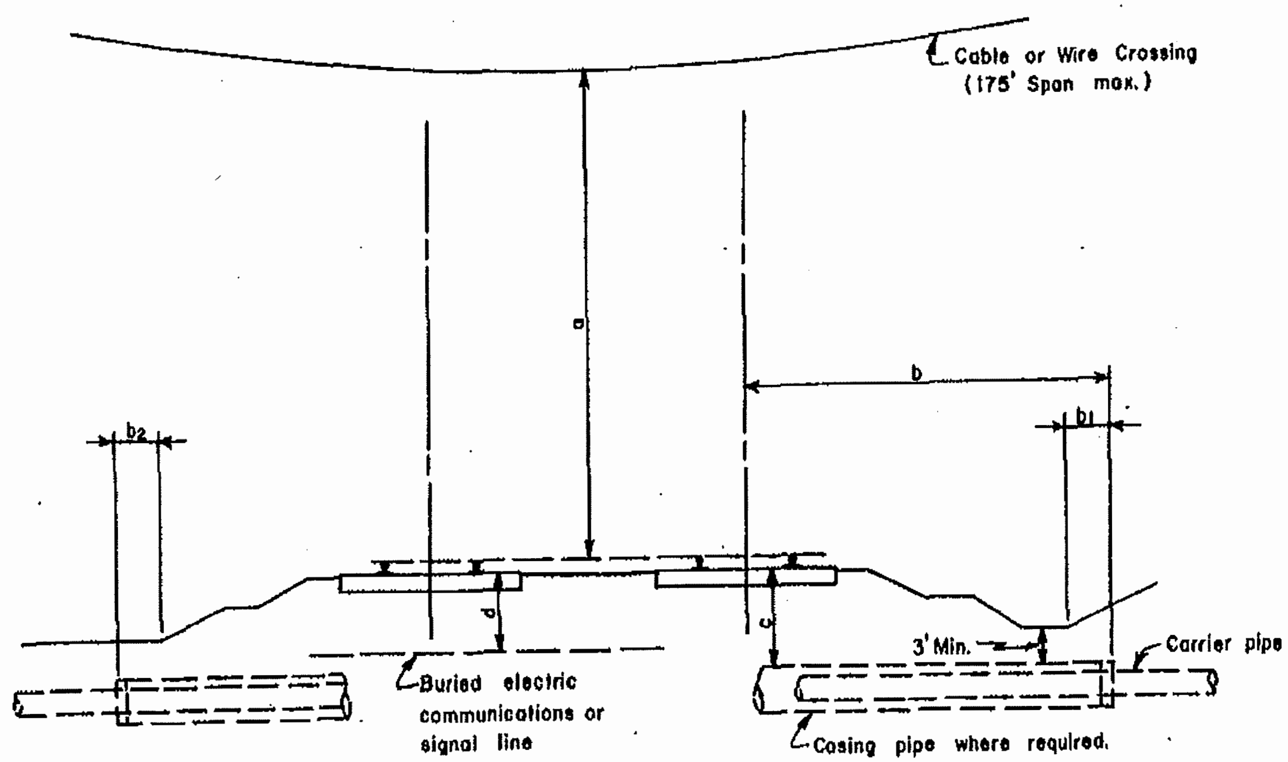
1. * Indicates dimensions to be increased for curvature as indicated on Drawings 1018 & 1019.
2. When track centers are less than 13'-0", minimum distance from ℄ of track to face of fence shall be 6'-0".
3. At major terminals with direct fixation and no freight operation, use 5'-4" to high platform.

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY	RAILROAD OPERATIONS	DWG. NO. 1013 Oct. 28, 1992 ISSUE DATE ① ISSUE NO.

STANDARD CLEARANCES AT STATIONS- TANGENT TRACK

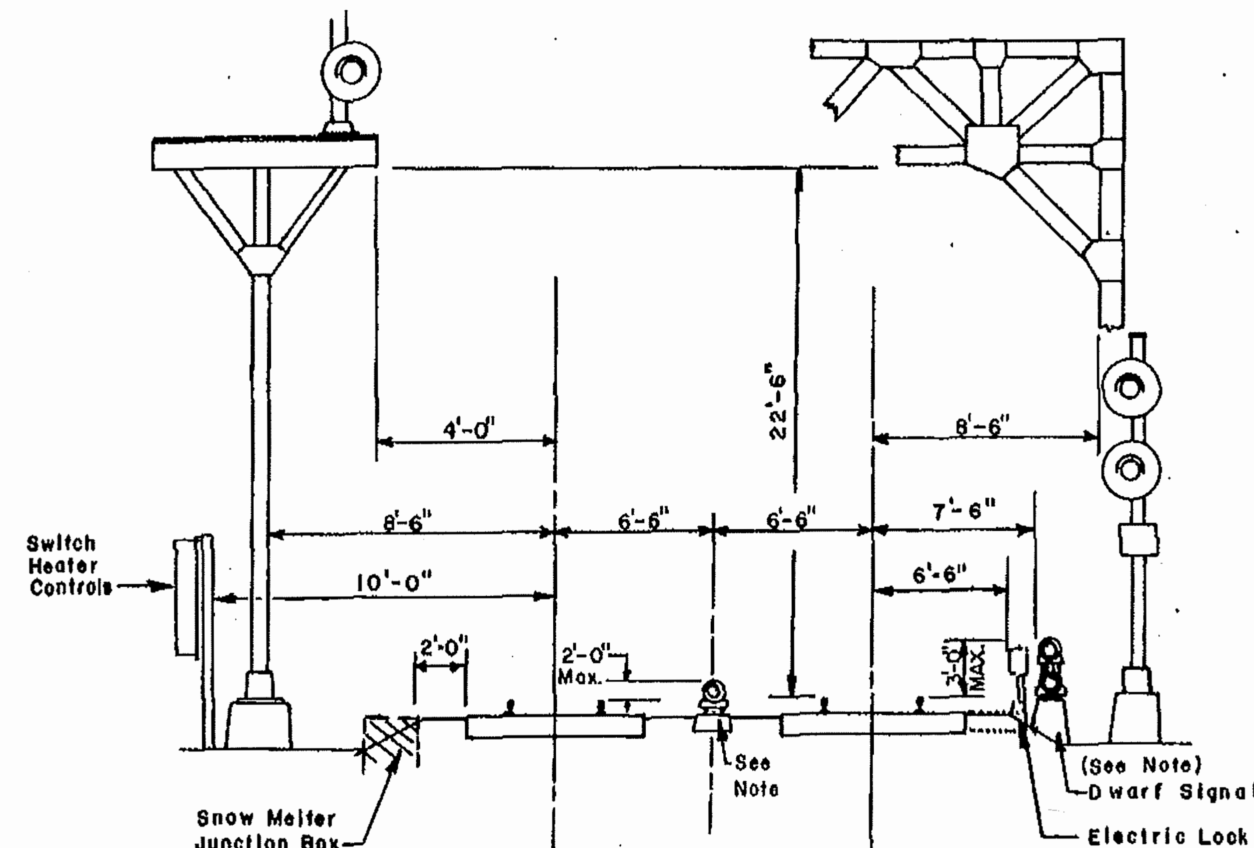
John T. Williams — ENGINEERING OFFICER

W A ... — CHIEF ENGINEERING OFFICER



Dimension	Description		
a	Power lines 0 to 750V	27'-0"	At 120°F Ambient Temperature
	Power lines 750 to 15,000V	28'-0"	
	Power lines 15 to 50 KV	30'-0"	
	Other than power lines	27'-0"	
b	Sealed ended casings	25'-0"	
	Open ended casings	45'-0"	
b_1	End casing beyond ditch	2'-0"	
b_2	End casing beyond slope	3'-0"	
c	Casing pipe	4'-6"	
	Carrier pipe without casing	4'-0"	
d	Buried electric lines	4'-0"	
	Railroad signal lines	2'-6"	
	Communications lines	3'-6"	
	Switch Heater Feeds	4'-0"	

MINIMUM CLEARANCES FOR OVERHEAD & BURIED UTILITY CROSSINGS



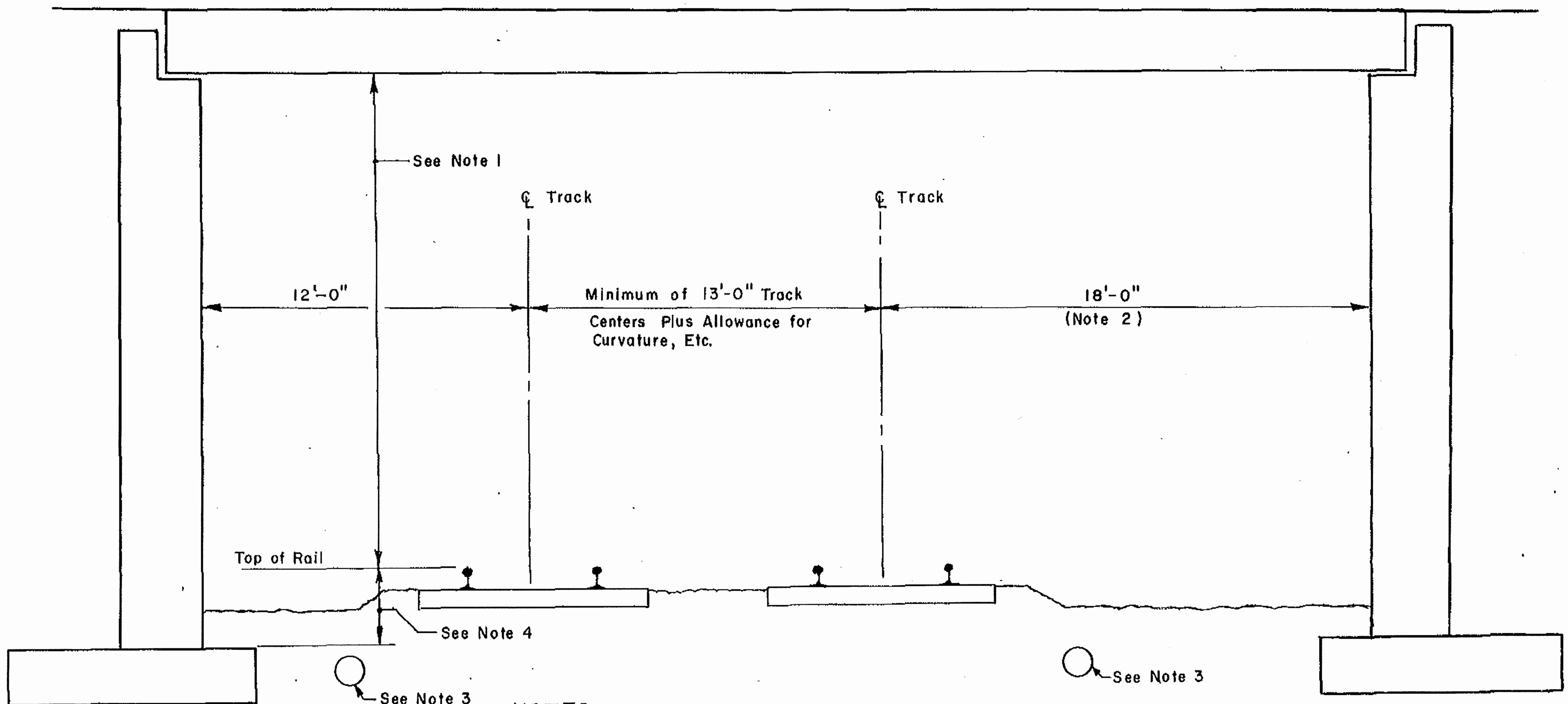
NOTE
Signal Foundations Shall Be Level with Top of Rail Except Dwarf Signals Between Tracks - Foundation to be Level with Top of Ties.

STANDARD CLEARANCE TO SIGNAL EQUIPMENT-TANGENT TRACK

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY	RAILROAD OPERATIONS	DWG. NO. 1014 Jan. 5, 1996 ISSUE DATE 3 ISSUE NO.

STANDARD CLEARANCES
TANGENT TRACK
SIGNAL EQUIPMENT & UTILITY CROSSINGS

John D. Pery
SECTION CHIEF



NOTES

1. See Drawing No. 1016 for Vertical Clearances by Route Segment.
2. Provide 18'-0" of Side Clearance on Side Designated for Access/Maintenance Roadway.
3. Provide Storm Drains Sized to have a Flow Capacity Equal To Adjacent R.O.W. Ditches, 12" Dia. Min.
4. Wherever Bridge is Built with Less Than 22'-6" Vertical Clearance, Design Footings to Allow Future Undercutting and Lowering Track To Provide 22'-6".

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY	RAILROAD OPERATIONS	DWG. NO. 1015 Oct. 28, 1992 (ISSUE DATE) — 1 (ISSUE NO.)

CLEARANCES FOR NEW OVERHEAD BRIDGES

John D. Ray — ENGINEERING OFFICER

CHIEF ENGINEERING OFFICER

Appendix C: Rails With Trails Sections

SECTION V:

Design

No national standards or guidelines dictate rail-with-trail facility design. Guidance must be pieced together from standards related to shared use paths, pedestrian facilities, railroad facilities, and/or roadway crossings of railroad rights-of-way. Trail designers should work closely with railroad operations and maintenance staff to achieve a suitable RWT design. Whenever possible, trail development should reflect standards set by adjacent railroads for crossings and other design elements. Ultimately, RWTs must be designed to meet both the operational needs of railroads and the safety of trail users. The challenge is to find ways of accommodating both types of uses without compromising safety or function.

The recommendations in this section are based on:

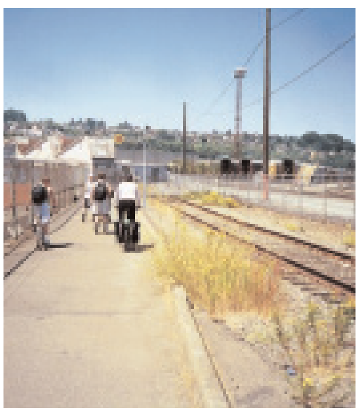
- Extensive research into all existing RWTs.
- In-depth case studies of 21 existing and planned RWTs.
- Interviews with railroad officials, trail managers, and law enforcement officials.
- Review of existing train and trail safety literature.
- Analysis of publicly-accessible trespassing and crash data.
- Input from a panel of railroad officials and experts, trail developers and managers, trail users, lawyers, railroad operators, and others.
- Extrapolation from relevant State transportation manuals, the American Association of State Highway and Transportation Officials (AASHTO) *Guide for the Development of Bicycle Facilities* (1999) (hereafter referred to as the AASHTO Bike Guide), Americans with Disabilities Act (ADA) publications for trails and pedestrian facilities, the *Manual on Uniform Traffic Control Devices* (MUTCD, 2000), and numerous Federal Railroad Administration (FRA) and other Federal Highway Administration (FHWA) documents.
- The experience and expertise of researchers and reviewers, including experienced railroad and trail design engineers, landscape architects, safety specialists, trail developers and managers, trail users, lawyers, railroad operators, operations officials, and others involved in this study.

The design recommendations should be considered a toolkit, rather than standards or guidelines. More research will be needed to develop standards that can be incorporated into AASHTO's design guides and the MUTCD. Each RWT project is different; the design should be based on the specific conditions of the site, requirements of the railroad owner, completion of a feasibility study (as discussed in *Section III*), State and other regulatory requirements, and engineering judgment.

Overview of Recommendations

1. RWT designers should maximize the setback between any RWT and active railroad track. The setback distance between a track centerline and the closest edge of the RWT should correlate to the type, speed, and frequency of train operations, as well as the topographic conditions and separation techniques.
2. Subject to railroad and State and Federal guidelines and the advice of engineering and safety experts, exceptions to the recommended setbacks may include:
    a. Constrained areas (bridges, cut and fill areas)
    b. Low speed and low frequency train operations

   In these cases and in areas with a history of extensive trespassing, fencing or other separation technique is recommended.
3. When on railroad property, RWT planners should adhere to the request or requirements for fencing by the railroad company. Fencing and/or other separation techniques should be a part of all RWT projects.
4. Trail planners should minimize the number of at-grade crossings, examine all reasonable alternatives to new at-grade track crossings, and seek to close existing at-grade crossings as part of the project.
5. RWT proposals should include a full review and incorporation of relevant utility requirements for existing and potential utilities in the railroad corridor.
6. The feasibility process should clearly document the cost and environmental impact of new bridges and trestles.
7. Trails should divert around railroad tunnels; if they need to go through a single-track railroad tunnel, they likely are not feasible.
8. Where an RWT is proposed to bypass a railroad yard (such as in Seattle, Washington), adequate security fencing must be provided along with regular patrols by the RWT manager. High priority security areas may need additional protection.
9. An environmental assessment should be conducted concurrent with, and usually independent from, the feasibility analysis, and should include project alternatives located off the railroad corridor, if at all possible.



Elliot Bay Trail. *Seattle, WA*

Rail Characteristics and Setting

Over half of the 65 existing trails run along Class I mainline or other freight railroad lines, with the remainder split between short lines and public transit (see **Figure 5.1**). Most of the RWTs are either adjacent to railroad property or on publicly-held land that is used or leased by freight or passenger railroad companies. At least 11 known RWTs (approximately 17 percent) are on privately held Class I railroad properties, and others are on privately-held Class II, shortline, or excursion lines (see **Table 5.1**). There is considerable

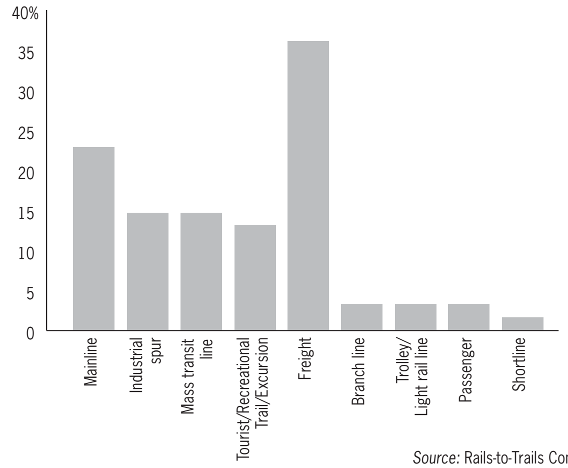
TABLE 5.1 Examples of Active RWTs by Corridor Type and Ownership

Trail Name	Corridor Owner	Railroad Operation	Location
Class I Railroads			
Arboretum Trail*	Norfolk Southern	Unknown	Pennsylvania
Cedar Lake Trail	Burlington Northern Santa Fe	Burlington Northern	Minnesota
Celina/Coldwater Bike Trail*	Norfolk Southern	RJ Corman	Ohio
Columbus Riverwalk*	Norfolk Southern	Railtex/GATX/Georgia Southwestern Railroad Company	Georgia
Eastbank Esplanade/Steel Bridge Riverwalk	Union Pacific	Union Pacific, Amtrak	Oregon
Elk River Trail*	Norfolk Southern	Norfolk Southern	West Virginia
Gallup Park Trail*	Norfolk Southern	Norfolk Southern	Michigan
Huffman Prairie Overlook Trail	CSX	CSX and Grand Trunk Western	Ohio
Schuylkill River Trail*	Norfolk Southern (3.2 km/2 mi)	Norfolk Southern	Pennsylvania
Stavich Bicycle Trail	CSX	CSX	Ohio and Pennsylvania
Union Pacific Trail	Union Pacific	Union Pacific	Colorado
Zanesville Riverfront Bikepath*	Norfolk Southern	CSX and Norfolk Southern	Ohio
Privately- owned, Class II or Other Freight			
Blackstone River Bikeway	Providence and Worcester Railroad	Providence and Worcester Railroad	Rhode Island
Central Ashland Bike Path	Rail TEX	Rail TEX	Oregon
Clarion-Little Toby Creek Trail	Buffalo to Pittsburgh Railroad	Buffalo to Pittsburgh Railroad	Pennsylvania
Heritage Trail	Illinois Central	Illinois Central	Iowa
Lehigh Gorge River Trail	Reading and Northern Railroad Company	Reading and Northern Railroad Company	Pennsylvania
Lower Yakima Valley Pathway	Washington Central	Washington Central	Washington
MRK Trail	Chicago & Northwestern	Chicago & Northwestern	Illinois
Railroad Trail	Lake State Railroad	Lake State RR	Michigan
Rock River Recreation Path	Chicago & Northwestern	CNW, Union Pacific and Soo Line	Illinois
Silver Creek Bike Trail	Dakota, Minnesota and Eastern	Dakota, Minnesota and Eastern	Minnesota
Tony Knowles Coastal Bicycle Trail	Alaska Railroad Corporation	Alaska Railroad Corporation	Alaska
Whistle Stop Park	Cimarron Valley Railroad	Cimarron Valley Railroad	Kansas
Excursion/Short-Line, Publicly or Privately Owned Land			
Animas River Greenway Trail	Durango & Silverton Narrow Gauge Railroad	Durango & Silverton Narrow Gauge Railroad	Colorado
Cottonbelt Trail	Dallas Area Rapid Transit	Fort Worth and Western Railroad	Texas
Eastern Promenade Trail	Maine Department of Transportation	Maine Narrow Gauge	Maine
Heritage Rail Trail County Park	York County	Northern Central Railway Inc.	Pennsylvania
Lowell Canal Trail	National Park Service	National Park Service	Massachusetts
Santa Fe Rail Trail	Santa Fe Southern	Santa Fe Southern	New Mexico

**Properties acquired by Norfolk Southern from Conrail.*

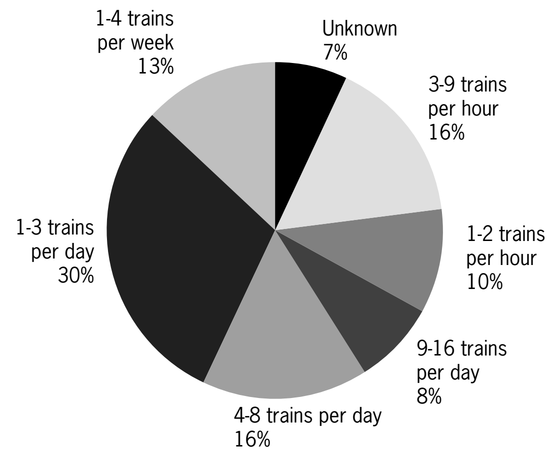
TABLE 5.1 Examples of Active RWTs by Corridor Type and Ownership (continued)

Trail Name	Corridor Owner	Railroad Operation	Location
Publicly Owned Railroad Corridors, Passenger or Freight			
Atchison, Topeka and Santa Fe Trail	Orange County Transportation Authority	Amtrak, Southern California Regional Rail	California
Bugline Trail	Waukesha County	Union Pacific	Wisconsin
Burlington Waterfront Bikeway	Vermont Agency of Transportation	Vermont Railway Company	Vermont
Cascade Trail (SR 20)	City of Burlington/Skagit County	Burlington Northern Santa Fe Railway	Washington
Duwamish Trail	City and Port of Seattle	Burlington Northern Santa Fe Railway	Washington
Eastern Promenade Trail	Maine Department of Transportation	Maine Narrow Gauge	Mane
Eliza Furnace Trail	City of Pittsburgh	CSX	Pennsylvania
Folsom Parkway Rail-Trail	Regional Transit Authority	Regional Transit Authority	California
Great Lakes Spine Trail	Iowa Dept. of Natural Resources, Dickinson County, Cities	Chicago Northwestern Transportation Company	Iowa
Heritage Rail Trail County Park	York County	Northern Central Railway Inc.	Pennsylvania
La Crosse River State Trail	State of Wisconsin	Canadian Pacific Railway, Amtrak	Wisconsin
Levee Walking Trail	City of Helena	Arkansas Midland	Montana
Myrtle Edwards Park Trail	City and Port of Seattle	Burlington Northern Santa Fe Railway	Washington
Platte River Trail	Regional Transit District	Denver Rail Heritage Society	Colorado
Porter Rockwell Trail	Utah Transit Authority	TRAX	Utah
Rock Island Trail	City of Colorado Springs	Denver & Rio Grande Western	Colorado
Rose Canyon Bike Path	Metropolitan Transit District Board	Amtrak and Santa Fe	California
Seattle Waterfront Pathway	City of Seattle	METRO Transit	Washington
Southwest Corridor Park	Massachusetts Bay Transit Authority	MBTA Commuter Rail and Amtrak	Massachusetts
Three Rivers Heritage Trail	City of Pittsburgh	CSX	Pennsylvania
Traction Line Recreation Trail	New Jersey Transit Authority	NJ Transit and Norfolk Southern	New Jersey
Traverse Area Recreation Trail (TART)	Michigan Department of Transportation	Tuscola & Saginaw Bay RR	Michigan
Watts Towers Crescent Greenway	Metropolitan Transportation Authority	Metropolitan Transportation Authority	California
West Orange Trail	Orange County Parks	CSX	California



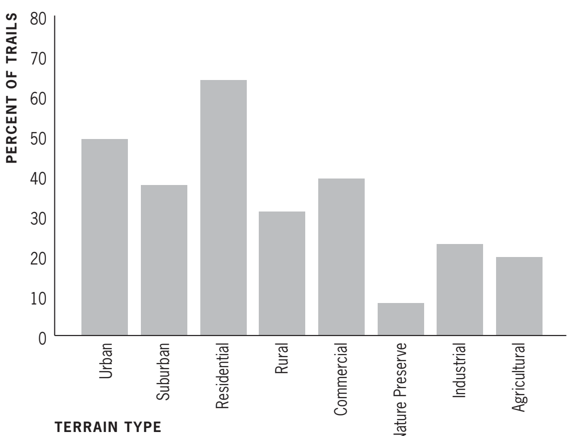
Source: Rails-to-Trails Conservancy

FIGURE 5.1 Type of railroad adjacent to existing RWTs (Note: Railroads identified their function by a variety of names. Because more than one type of railroad may operate in a corridor, percentages add up to more than 100%.)



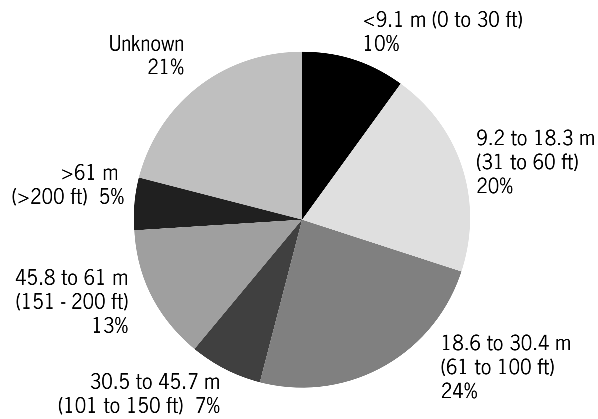
NOTE: Where a range of frequencies was given, the most frequent service was taken.
Source: Rails-to-Trails Conservancy

FIGURE 5.2 Frequency of trains, by percentage of existing RWTs



Source: Rails-to-Trails Conservancy

FIGURE 5.3 Type of terrain through which trails pass (Because trails pass through more than one type of terrain, percentages add up to more than 100%.)



(Total number of trails = 61) *Source:* Rails-to-Trails Conservancy

FIGURE 5.4 Width of full corridor, by percentage of trails (Note: corridor widths often vary.)

variance in the frequency of train operation, from three to nine trains per hour (16 percent) to just a few trains a week (13 percent) (see **Figure 5.2**). In many cases, the peak hours of rail use correspond with peak trail use hours. The average maximum train speed is 51 km/h (32 mi/h), with a range of 8 to 225 km/h (5 to 140 mi/h). All but three trains in RWT corridors travel at speeds less than 97 km/h (60 mi/h). The three fastest trains are:

- Massachusetts Bay Transit Authority Commuter Rail and Amtrak (Southwest Corridor Park, Boston, Massachusetts), maximum speed 225 km/h (140 mi/h), setback over 6.1 m (20 ft), separated by concrete wall and chain link fence.
- Orange County Transportation Authority and Amtrak (see ATSF Trail case study, p.11).
- State of Wisconsin and Amtrak (see La Crosse River State Trail case study, p. 18).

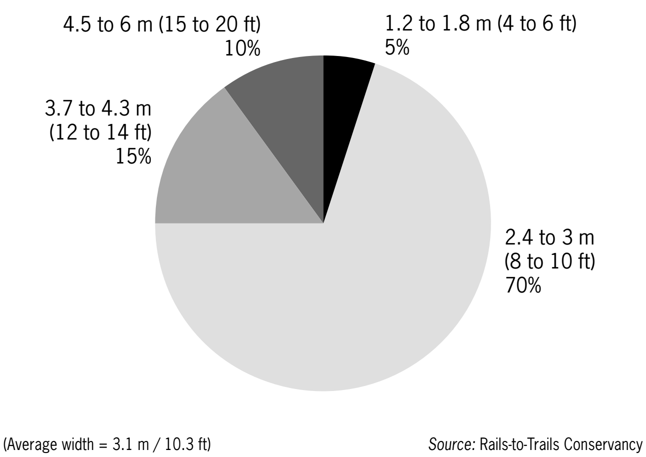


FIGURE 5.5 Width of RWT, by percentage of trails

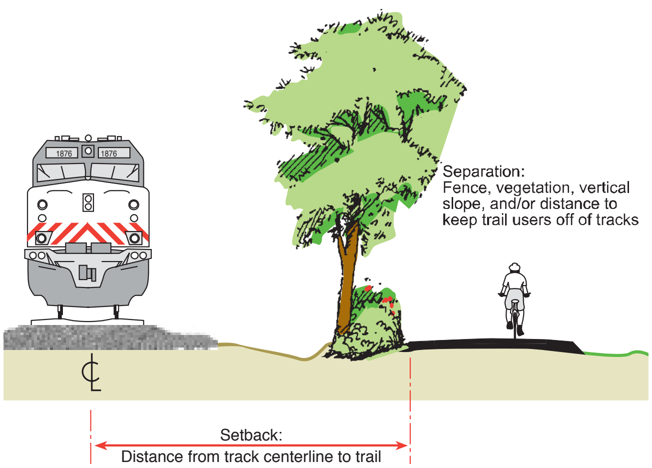


FIGURE 5.6 Setback and separation definition

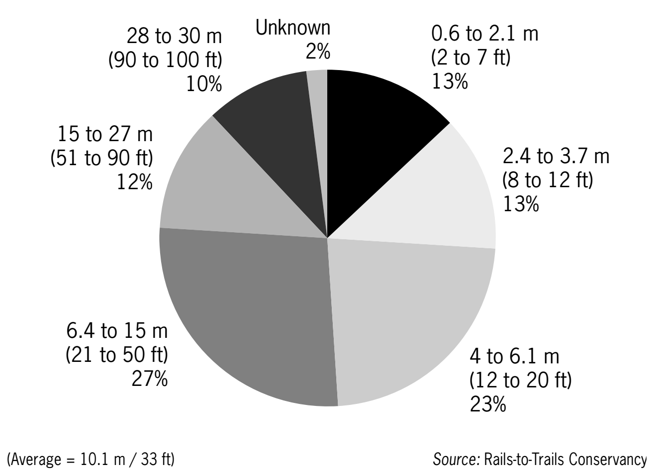


FIGURE 5.7 Distance between edge of trail and track centerline, by percentage of trails

The existing U.S. RWTs are located in 20 States, encompass 385 km (239 miles), and traverse a wide variety of terrain, including urban, suburban, residential, rural, commercial, nature preserve, industrial, and agricultural lands (see **Figure 5.3**).

The RWT corridor widths average 38 m (126 ft), while the trails are typically 2.4 to 3 m (8 to 10 ft) wide (see **Figures 5.4** and **5.5**).

Setback: Considerations

The term "setback" refers to the distance between the edge of an RWT and the centerline of the closest active railroad track while "separation" refers to the treatment of the space between an RWT and the closest active railroad tracks, including fences, vegetation, ditches, and other items (see **Figure 5.6**). When determining the minimum setback for a RWT, factors to consider include train speed and frequency, maintenance needs, applicable State standards, separation techniques, historical problems, track curvature, topography, and engineering judgment.

The range of trail setback on the existing RWTs varies from less than 2.1 m (7 ft) to as high as 30 m (100 ft) (see **Figure 5.7**), with an average of almost 10 m (33 ft) of setback from the centerline of the nearest track. A comparison of RWT setback distance to both train speed and frequency reveal little correlation; over half (33 of 61) of the existing RWTs have 7.6 m (25 ft) or less setback, even alongside high speed trains (see **Figures 5.8** and **5.9**). Many of the trails with little setback are ones that have been established many years. The trail managers for these well-established trails report few problems. However, interviews with train engineers in several areas indicate that they observe a tremendous amount of daily trespassing and problems in areas with little setback and no physical separation.

In comparison, RWTs in Perth, Australia, are typically 3 m (10 ft) wide, and separated from the adjacent railway line by a 1.8 m (6 ft) high chain link fence with three strands of barbed wire. The minimum setback from track centerline to the fence is 4.5 m (15 ft).

Researchers attempted to determine if narrower setback distances have a direct correlation to safety problems. However, based on the almost nonexistent record of claims, crashes, and other problems on any RWTs, they were unable to determine a correlation between setback distance and trail user safety. An

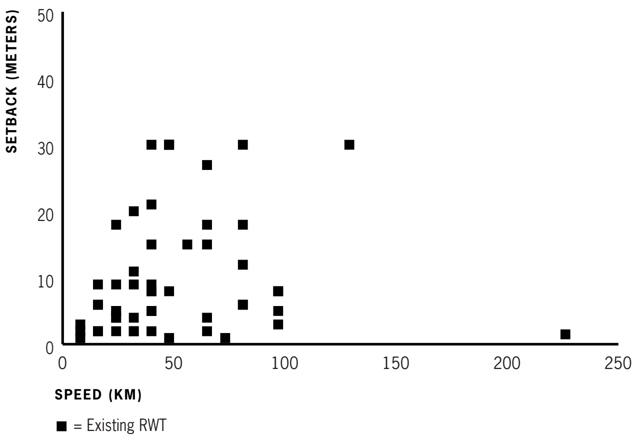


FIGURE 5.8 RWT setback/train speed correlation

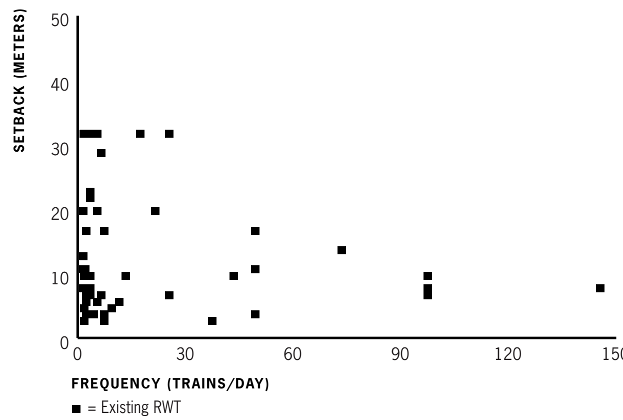


FIGURE 5.9 Setback/frequency correlation

FRA study on the impact of high train speed on people standing on boarding platforms concludes that induced airflow is a safety issue for a person within 2 m (6.5 ft) of a train traveling at 240 km/h (150 mi/h) (Volpe, 1999).

There is no consensus on either appropriate setback requirements or a method of determining the requirement. Some trail planners use the AASHTO Bike Guide for guidance. Given that bicycle lanes are set back 1.5 to 2.1 m (5 to 7 ft) from the centerline of the outside travel lane of even the busiest roadway, some consider this analogous. Others use their State Public Utilities Commission's minimum setback standards (also known as "clearance standards") for adjacent walkways (for railroad switchmen). These published setbacks represent the legal minimum setbacks based on the physical size of the railroad cars, and are commonly employed along all railroads and at public grade crossings. The minimum setback distance is typically 2.6 m (8.5 ft) on tangent and 2.9 m (9.5 ft) on curved track. However, FRA and railroad officials do not consider either of these methods to be appropriate for an RWT. This is because AASHTO's guidelines for motor vehicle facility design are not seen as comparable to rail design, and the setback distance for the general public should be much greater than that allowed for railroad workers.

Some railroads and States have established their own standards. For example, the BNSF's policy on "Trails with Rails" states, "Where train speeds are greater than 145 km/h (90 mi/h), trails are not acceptable. No trail will be constructed within 31 m (100 ft) of any mainline track where train speeds are between 113 km/h (70 mi/h) and 145 km/h (90 mi/h). Trails may be constructed between 15 m (50 ft) and 30 m (100 ft) where mainline train speed is 80 km/h (50 mi/h) to 113 km/h (70 mi/h). Trails may be constructed 15 m (50 ft) from centerline of track where train speeds are 40 km/h (25 mi/h) to 80 km/h (50 mi/h), and 9 m (30 ft) from any branchline track with speeds of 40 km/h (25 mi/h) or less. No trails less than 9 m (30 ft) from centerline of track for any reason." The Alaska Railroad Corporation rule of thumb for setbacks along main tracks is one railcar length, or 18 to 21 m (60 to 70 ft), unless careful analysis of the risks suggests otherwise. In contrast, the Maine Department of Transportation allows for trails to be set back a minimum of 5.5 m (18 ft) from track centerline, down to 4 m (12.5 ft) in constrained circumstances.

Other considerations when determining setback may be flying debris and maintenance access. Trains throw up debris from the roadbed, including rocks and other objects deliberately placed on the rails by trespassers. Fast-moving trains have thrown up large ballast rocks. Debris has been known to fall off trains, or, in some cases, to hang off rail cars. Railroad companies need access to tracks for routine and emergency maintenance, including tie and ballast replacement, cleaning culverts, and accessing switches and control equipment. While most railroad companies have the ability to maintain tracks from the tracks themselves, it often is more cost effective and less disruptive to access the tracks from maintenance vehicles operating alongside the tracks. At a minimum, railroads need at least 4.5 m (15 ft) from the track centerline to provide reasonable access to their tracks.

Further considerations when determining setback requirements may be physical constraints on or adjacent to railroad corridors, presence of separation techniques such as fencing, historical trespassing, and other problems. Finally, train densities can change at any time and location, and railroads require flexibility in their operations to meet customer requirements. Structures or right-of-way modifications that impede a railroad's ability to change or control its operations are unacceptable.

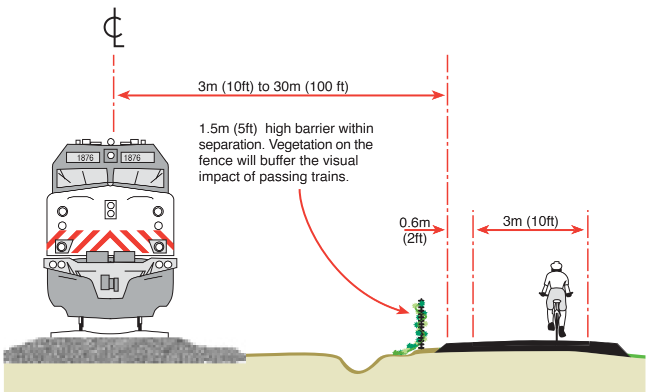


FIGURE 5.10 Minimum RWT setback depends on specific situation

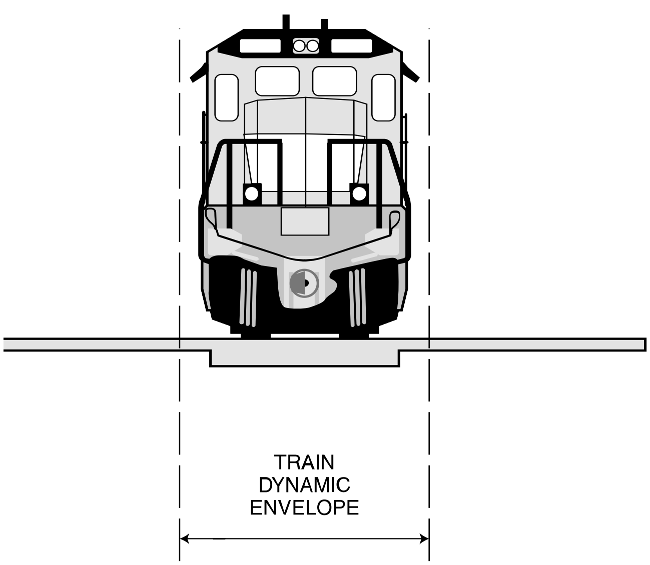


FIGURE 5.11 Dynamic envelope delineation (MUTCD Fig. 8A-1. Note: no dimensions given in MUTCD.)

Setback: Recommendations

Because of the lack of consensus on acceptable setback distances, the appropriate distance must be determined on a case-by-case basis (see **Figure 5.10**). Trail planners should incorporate into the feasibility study analysis an analysis of technical factors, including:

- Type, speed, and frequency of trains in the corridor;
- Separation technique;
- Topography;
- Sight distance;
- Maintenance requirements; and
- Historical problems.

Another determining factor may be corridor ownership. Trails proposed for privately-owned property will have to comply with the railroad's own standards. Trail planners need to be aware that the risk of injury should a train derail will be high, even for slow-moving trains. Discussions about liability assignment need to factor this into consideration.

In many cases, adequate setback widths, typically 7.6 m (25 ft) or higher, can be achieved along the majority of a corridor. However, certain constrained areas will not allow for the desired setback width. Safety should not be compromised at these pinch points – additional barrier devices should be used,

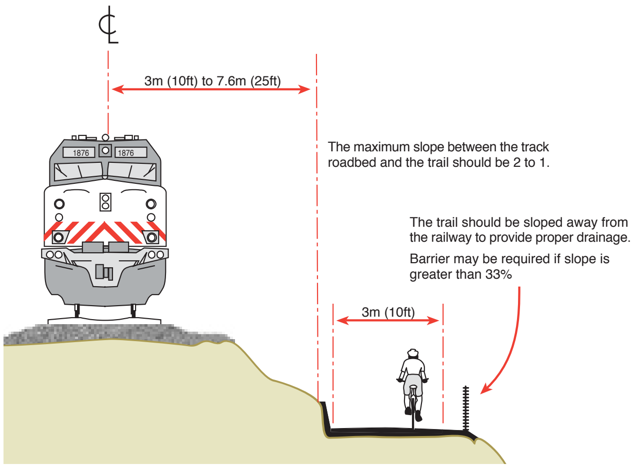


FIGURE 5.12 Minimum RWT setback – fill sections (depending on situation)

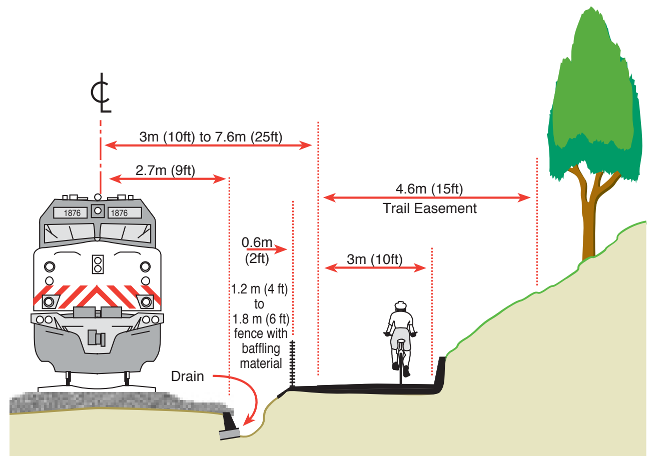


FIGURE 5.13 Minimum RWT setback – constrained sections (depending on situation)

and/or additional right-of-way purchased. In the case of high speed freight or transit lines, RWTs must be located as far from the tracks as possible and are infeasible if adequate setbacks and separation cannot be achieved.

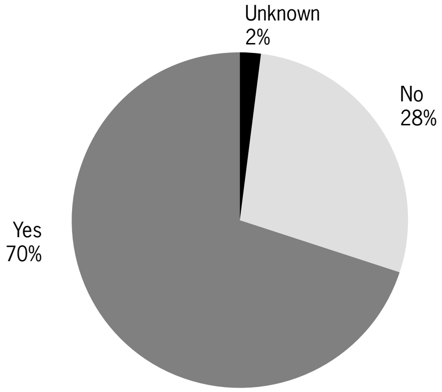
At an absolute minimum, trail users must be kept outside the "dynamic envelope" of the track – that is, the space needed for the train to operate (see **Figure 5.11**). According to the MUTCD (Section 8), the dynamic envelope is "the clearance required for the train and its cargo overhang due to any combination of loading, lateral motion, or suspension failure." It includes the area swept by a turning train.

Relatively narrow setback distances of 3 m (10 ft) to 7.6 m (25 ft) may be acceptable to the railroad, RWT agency, and design team in certain situations, such as in constrained areas, along relatively low speed and frequency lines, and in areas with a history of trespassing where a trail might help alleviate a current problem. The presence of vertical separation or techniques such as fencing or walls also may allow for narrower setback.

Constrained Areas

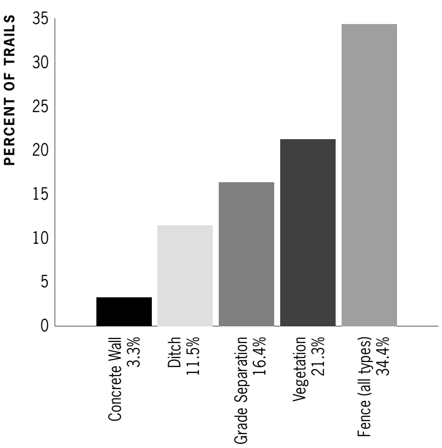
Many types of terrain pose challenges to an RWT design. While a railroad corridor may be 30 m (100 ft) wide or greater, the track section may be within a narrow cut or on a fill section, making the placement of an RWT very difficult. RWTs in very steep or rugged terrain or with numerous bridges and trestles simply may not be feasible given the need to keep a minimal setback from the tracks, meet ADA requirements, allow railroad maintenance access, and still have a reasonable construction budget. Exceptions may exist where the RWT is accompanied by a solid barrier, vertical separation, or ditch (see "Separation" section, page 66), in the case of very low speed/frequency railroad operations, or for very short distances (see **Figures 5.12** and **5.13**). The railroad company or agency should review the proposal to ensure that they will have adequate maintenance and emergency access to the tracks.

Setback (4.5m/15ft) and fencing along the Showgrounds Pathway RWT. *Perth, Australia*



NOTE: A "Yes" response does not necessarily indicate the presence of a full barrier. It includes some partial barriers and one instance of where a barrier is planned to be removed.
Source: Rails-to-Trails Conservancy

FIGURE 5.14 Percentage of existing RWTs with barrier



Source: Rails-to-Trails Conservancy

FIGURE 5.15 Barrier type, by percentage of existing RWTs

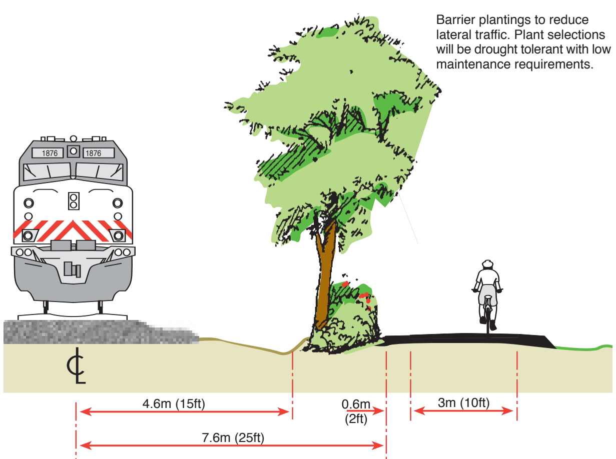


FIGURE 5.17 Trail separation example – using vegetation as a separation technique

Type of Rail Service

Lower speed and frequency train operations pose fewer hazards than higher speed and frequency trains. Numerous low speed line RWTs exist or are planned with relatively narrow setback distances. For example, Portland's Springwater-OMSI Trail, along the 32 km/h (20 mi/h) Oregon Pacific Railroad, is designed 3.2 m (10.5 ft) from the centerline to edge of trail, with a fence 0.6 m (2 ft) from the train edge the entire length. The narrower setbacks may be acceptable depending on feasibility analysis, engineering judgment, the railroad's future needs and plans, and liability assessment.

Areas of Existing High Trespassing

While trespassing on private railroad property is a common occurrence in virtually all settings, in some locations the historic pattern of trespassing has triggered legitimate concerns about the health, safety, and welfare of nearby residents. Research indicates that RWTs may be an effective tool to manage trespassing on corridors where it is physically difficult or impossible to keep trespassers off the railroad tracks. In these cases, the feasibility analysis may show that the risks of a narrower setback distance may be offset by the gains in trespassing reduction through trespasser channelization, using design features such as fencing or other barriers.

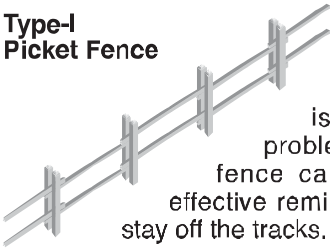
Separation

Over 70 percent of existing RWTs utilize fencing and other barriers such as vegetation for separation from adjacent active railroads and other properties (see **Figures 5.14** and **5.15**). Barriers include fencing (34 percent), vegetation (21 percent), vertical grade (16 percent), and drainage ditch (12 percent). The fencing style varies considerably, from chain link to wire, wrought iron, vinyl, steel picket, and wooden rail (see **Figure 5.16**). Fencing height ranges from 0.8 m (3 ft) to 1.8 m (6 ft), although typical height is 0.8 to 1.2 m (3 to 4 ft).

Most railroad companies require RWTs to provide fencing. Some railroad companies specify a requirement of 1.8 m (6 ft) high fencing, no matter what the setback distance is. Fencing may not be required where a significant deterrent to trespass is provided or exists. Examples include water bodies, severe grade differentials, or dense vegetation.

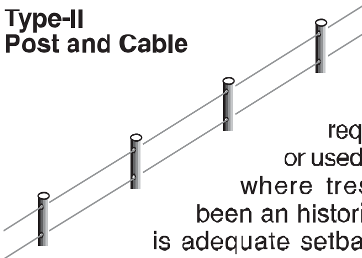
Other barrier types such as vegetation, ditches, or berms are often used to provide separation (see **Figure 5.17**), especially where an RWT is located further than 7.6 m (25 ft) from the edge of the trail to the centerline of the closest track, or where the vertical separation is greater than 3 m (10 ft). In constrained areas, using a combination of separation techniques may allow narrower acceptable setback distances.

Type-I
Picket Fence



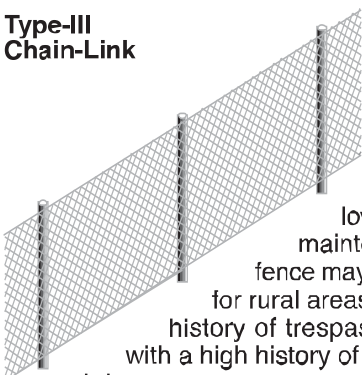
Where trespassing is not as much of a problem, a low wood rail fence can still serve as an effective reminder to trail users to stay off the tracks.

Type-II
Post and Cable



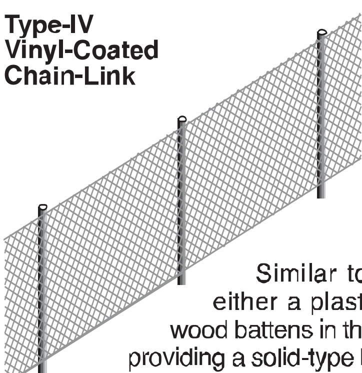
This inexpensive fence is occasionally requested by a railroad or used on a RWT primarily where trespassing has not been an historical problem, there is adequate setback, and the fence serves primarily to demarcate the railroad property boundaries. The fence does not provide any screening or anti-trespassing features.

Type-III
Chain-Link



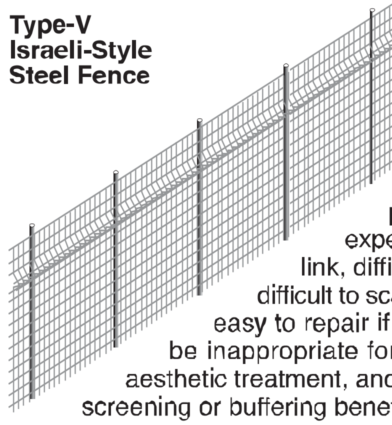
Chain-link fences are popular due to their effectiveness in keeping trail users off the tracks, relative low cost, and ease of maintenance. Chain-link fence may not be appropriate for rural areas where there is no history of trespassing, or for areas with a high history of trespassing, since it is very easy to cut and vandalize. Most chain-link fences are visually unappealing ñ and tend to project an image of an urban industrial environment. For this reason, trail designers should explore using other, more appealing types of fences whenever possible.

Type-IV
Vinyl-Coated
Chain-Link



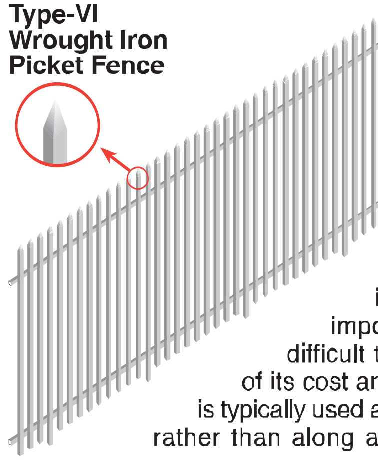
Similar to Type II, but with either a plastic woven fabric or wood battens in the chain-link material providing a solid-type barrier to help catch debris and provide wind and visual buffering.

Type-V
Israeli-Style
Steel Fence



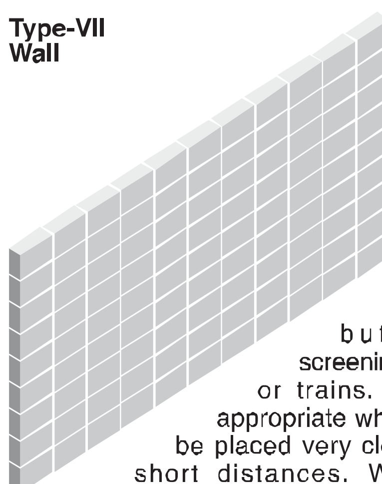
Sometimes referred to as ëIsraeli-styleí fencing for its use in Israel to protect kibbutzs, this product is more expensive than chain-link, difficult to vandalize, difficult to scale, and relatively easy to repair if it is cut. It would be inappropriate for areas requiring aesthetic treatment, and provides limited screening or buffering benefits.

Type-VI
Wrought Iron
Picket Fence



This is the ultimate in vandal-resistant fencing, and is used in locations that have a history of trespassing. It is virtually impossible to cut and difficult to scale. Because of its cost and visual impact, it is typically used at specific locations rather than along an entire corridor.

Type-VII
Wall



Very rarely used due to its cost and visual impact, solid concrete block walls are virtually indestructible and offer complete buffering and screening from rail debris or trains. A wall may be appropriate where a RWT must be placed very close to tracks for short distances. Walls are most commonly used in areas where a grade separation requires a retaining wall adjacent to the trail. Wall design in active rail corridors should be carefully coordinated with rail engineers, because they can have an effect on the structural integrity of the rail bed, alter drainage patterns in the rail corridor, and, in some circumstances, impede access by railroad maintenance equipment.

FIGURE 5.16 Fencing styles

When on railroad property, RWT planners must adhere to the request or requirements for fencing by the railroad company or agency. When not on railroad property, RWT planners still should coordinate with the railroad to determine appropriate fencing. On all existing RWTs, the trail authority is responsible for barrier installation and maintenance.

Grade separation along Schuylkill River Trail. *Norristown, PA*

Vertical Separation

Vertical or grade separation achieves many of the same benefits as horizontal separation, and is very common where an RWT is located along numerous cut and fill locations. For example, on a steep-fill section, the RWT may be located 6.1 m (20 ft) or more below the tracks (see **Figure 5.12** on page 65). In a case such as this, the setback becomes less important than the amount of vertical separation, which effectively addresses the elements of debris and wind. In cases with vertical separation of greater than 3 m (10 ft), the danger from falling objects may increase. A fence or barrier at the top of the slope may help prevent injuries on the trail below.

Vegetation and Ditches

Whether natural or planted, vegetation can serve as both a visual and physical barrier between a track and a trail (see **Figure 5.17**). The density and species of plants in a vegetative barrier determine how effective the barrier can be in deterring potential trespassers. A dense thicket can be, in some cases, just as effective as a fence (if not more so) in keeping trail users off the tracks. Even tall grasses can discourage trail users from venturing across to the tracks, although less effectively than trees and shrubs. Planted barriers typically take a few years before they become effective barriers. Separation between the trail and the track may need to be augmented with other temporary barriers until planted trees and hedges have sufficiently matured. Neither vegetation nor fencing should block the public's view of an approaching train at highway-rail crossings.

Many rail corridors contain drainage ditches that run adjacent to the tracks. The deeper and wider these ditches, the more difficult they are to cross on foot, and thus the greater deterrent to trespassing they provide. The presence of water in the ditch also will act as a deterrent. Trail and track drainage needs must be considered in the design process.

Fences and Walls

Fences and walls are the most common type of physical barrier used in RWT corridors (see **Figure 5.16**). Most railroads will require or request fencing, for which the trail management agency will be responsible. The height and type of material used on these barriers determines their effectiveness in discouraging trespassing and the resulting impact on required setback distance. A tall wall or fence constructed with materials that are difficult to climb should deter all but the most determined trespasser.

From the trail manager's perspective, fencing is a mixed blessing. Installing and maintaining fencing is expensive. Improperly maintained fencing is a higher liability risk than no fencing at all. In all but the most heavily-constructed fencing, vandals find ways to cut, climb, or otherwise overcome fences to reach their destinations. Fencing also detracts from the aesthetic quality of a trail.

At-grade crossing. *Dixon, CA*

The visual quality of fencing materials can have an impact on illegal activities along RWTs. For example, the Canadian Pacific Railway (CPR) Police Service has had dramatic results in reducing crime and trespassing through RWT designs that improved the aesthetic quality of an area. Their approach relies on the concept of "Crime Prevention through Environmental Design" (CPTED), meaning, "the proper design and effective use of the built environment can lead to a reduction in the incidence and fear of crime...." (Canadian Pacific Police Services, 2000)

Particularly for an urban trail in an area with crime problems, it may be important to maintain visual access to the trail corridor from adjacent land uses, so that portions of the trail do not become isolated from public view. Fence design in these instances should not block visual access to the trail corridor. Tall fences that block views can cause sight distance problems at intersections with roadways — both for motorists who must be able to view approaching trains, and for trail users who need adequate sight lines to view traffic conditions.

Railroad maintenance vehicles and/or emergency vehicles may need fence gates in certain areas to facilitate access to the track and/or trail (see **Figure 5.18**). Fence design should be coordinated with railroad maintenance personnel, as well as representatives from local utilities that extend along the corridor. Where trespassing is an issue, the fence should be at least 1.8 m (6 ft) tall, and constructed of a sturdy material that is difficult to vandalize.

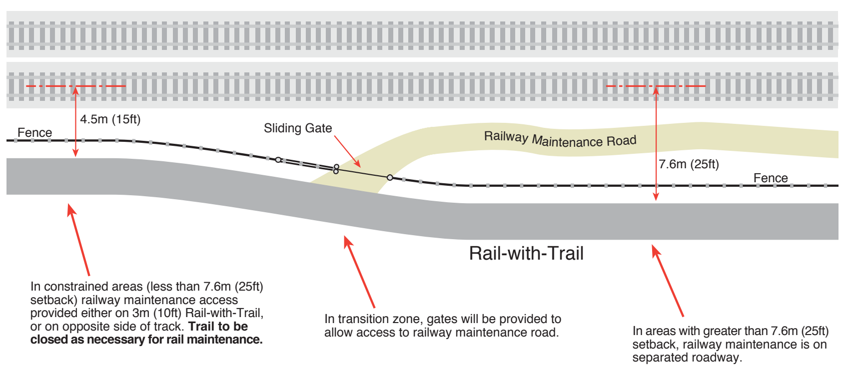


FIGURE 5.18 Sample maintenance access transitions

Railroad Track Crossings

The point at which trails cross active tracks is the area of greatest concern to railroads, trail planners, and trail users. Railroad owners, the FRA, and State DOTs have spent years working to reduce the number of at-grade crossings in order to improve public safety and increase the efficiency of service. RWT design should minimize new at-grade crossings

Crossing treatment on the suburban rail network in Perth. Gates automatically close when train is approaching. Users are alerted to the presence of approaching train by flashing lights and audible bells. Gates remain locked until trains have passed. *Perth, Australia*

wherever possible. Modifying an existing highway-rail crossing may be an option. Alternative options are below-grade (underpass), or above-grade (overpass) crossings, which are expensive and typically have been installed in limited circumstances, such as:

• Locations where an at-grade crossing would be extremely dangerous due to frequent and/or high speed trains, limited sight distances, or other conditions; and

• Locations where trains are regularly stopped at the crossing point, effectively blocking the trail intersection for long periods of time.

Some government agencies and railroad owners have adopted policies of no new at-grade crossings. In these cases, using existing crossings or building grade-separated crossings may be the only alternatives. Also, many railroads are actively working to close existing at-grade crossings to improve safety, reduce maintenance costs, improve operating efficiency, and reduce liability exposure. The RWT feasibility analysis should carefully evaluate all proposed crossings, with consideration given to:

• Train frequency and speed;

• Location of the crossing;

• Specific geometrics of the site (angle of the crossing, approach grades, sight distance);

• Crossing surface;

• Nighttime illumination; and

• Types of warning devices (passive and/or active)

The railroad company or agency, and State DOT or Public Utility Commission, will need to approve any new crossings, the design of which must be in compliance with the *MUTCD*.[1] Relevant information also is contained in the *Railroad-Highway Grade Crossing Handbook* (FHWA, 1986) and U.S. DOT Highway-Rail Grade Crossing Technical Working Group (TWG) document, *Guidance on Traffic Control Devices at Highway-Rail Grade Crossings* (FHWA, 2002).

More than half the existing RWTs in the U.S. include some sort of track crossing, mostly at-grade (RTC, 2000). The Bugline Trail, Wisconsin, Southwest Corridor Park Trail, Massachusetts, Illinois Prairie Path, and Rock River Recreation Path, Illinois, have overpasses or bridges. The Tony Knowles Coastal Bicycle Trail, Alaska, has tunnels under the tracks, and the Springwater Corridor Extension, Oregon, will have two pedestrian underpasses.

Existing at-grade crossings typically have some sort of passive warning devices — railroad "crossbucks" or railroad crossing signs (see **Figure 5.24** on page 75). Examples are on the Burlington Waterfront Bikeway, Vermont, and Lehigh River Gorge Trail, Pennsylvania. Several have active warning devices such as gates or alarms. Planned trails such as the Blackstone River Bikeway, Rhode Island, and Springwater Corridor Extension, Oregon, will have higher quality at-grade crossings, with a full complement of automatic gates, warning alarms, and signage.

[1] The MUTCD (see *Appendix A* for detailed definition) contains standards for signs, pavement markings and other devices used to regulate, warn, or guide traffic, placed on, over, or adjacent to a street, highway, pedestrian facility, or bikeway by authority of a public agency having jurisdiction.

Many bicycle routes in Perth, Australia, cross perpendicular to the suburban railway lines. Gates automatically close upon the approach of a train. When open, they have a straight-through passage, facilitating ease of movement by cyclists, pedestrians, and people in wheelchairs. The crossings feature warning bells and flashing lights. Westrail also uses a variety of pavement treatments to offer visual cues to both motorists and trail users in transit station areas (Maher, 2000).

Crossing at the City West Station. *Perth, Australia*

Location of the Crossing

Trail-rail grade crossings should reduce illegal track crossings by channelizing users to safer crossing areas. Crossings must not be located where trains may be regularly stopped, since this would encourage trail users to cross between or under railroad cars — an extremely dangerous and unacceptable movement. Crossings should not be located on railroad curves where sight lines are poor. When new at-grade crossings are not permitted, the RWT design will need to channelize users to cross the tracks at roadway locations (see p. 81) or develop a grade-separated crossing (p. 79).

Sight Distance

Adequate sight distance is particularly important at trail-rail intersections that do not have active warning devices such as flashing lights or automatic gates. Bicyclists, pedestrians, and other trail users should be given sufficient time to detect the presence of an approaching train and either stop or clear the intersection before the train arrives.

Three elements required for safe movement of trail users across the railroad tracks are as follows:

1. Advance notice of the crossing

The first element concerns stopping sight distance, a common consideration in highway intersection design. The stopping sight distance is that distance required for a trail user to see an approaching train and/or the grade crossing warning devices at the crossing, recognize them, determine what needs to be done, and then come to a safe stop at a point 4.5 m (15 ft) clear of the nearest rail, if necessary. This point usually will be marked by a pavement marking in advance of the crossing. This sight distance is measured along the trail, and is based on a trail user traveling at a given speed, and coming to a safe stop as discussed above.

2. Traffic control device comprehension

The second element involves the recognition of the grade crossing warning devices by the approaching user. Trail users should be reminded of the meaning of all traffic control devices in use at grade crossings, such as the fact that the familiar crossbuck sign should be treated as a YIELD sign at any crossing, or that flashing lights without gates, when flashing, are to be treated the same as a STOP sign.

Transit station pedestrian crossing. *Beaverton, OR*

3. Ability to see an approaching train

The third element concerns the trail user's ability to see an approaching train in order to decide whether it is safe to cross. Two different kinds of sight distance considerations are involved for safe movement across the crossing. This third element involves the sight distance available in advance of the crossing, as well as the sight distance present at the crossing itself.

Approach sight distance (also known as corner sight distance) involves the clear sight line, in both directions up and down the tracks, that allows a trail user to determine in advance of the crossing that there is no train approaching and it is safe to proceed across the tracks without having to come to a stop. These sight triangles, dependent upon both train speed and trail user speed, are determined as shown in the *Railroad-Highway Grade Crossing Handbook* (FHWA, 1986).

Often these sight triangles are obstructed by vegetation, topography, or structures. If the clear sight triangles for a given trail user speed (bicyclists and skaters will probably be the fastest trail users) cannot be obtained, then the trail should have additional warning signs or a reduced speed limit posted in advance of the crossing. As another treatment, based upon local conditions and engineering judgment, STOP or YIELD signs may be placed on the trail at the crossing.

Clearing sight distance, which applies to all crossings without automatic gates, involves the clear sight line, in both directions up and down the tracks, present at the crossing itself. A trail user stopped 4.6 m (15 ft) short of the nearest rail must be able to see far enough down the track in both directions to determine if the user can move across the tracks, to a point 4.6 m (15 ft) past the far rail, before the arrival of a train. At crossings without gates that have multiple tracks, the presence of a train on one track can restrict a trail users' view of a second train approaching on an adjacent track.

A more detailed treatment of the sight distance problem at grade crossings may be found in the document titled, *Guidance on Traffic Control Devices at Highway-Rail Grade Crossings* (FHWA, 2002).

In addition, most railroad safety books and FRA Roadway Worker Safety rules (49 CFR 214), specify that upon the approach of a train, enough warning must be given to allow someone on the track to have at least 15 seconds between the time they are clear of the track and the time the train gets to their location. This criterion applies only to railroad personnel who are working within their established limits and are prepared to vacate the track structure with proper warning. Because the average trail user most likely is not familiar with the hazards of rail operations, they would need additional warning time.

Approach Grades and Angle

The AASHTO Bike Guide and ADA specify grade requirements for shared use paths. Trail grades over 5 percent are allowed for short distances in specific circumstances. Grades over five percent are not recommended for crossing approaches. In general, the trail approach should be at the same elevation as the track (see **Figure 5.19**). Steep grades on either side of the track can cause bicyclists to lose control, may distract trail users from the conditions at the crossing, and may block sight lines.

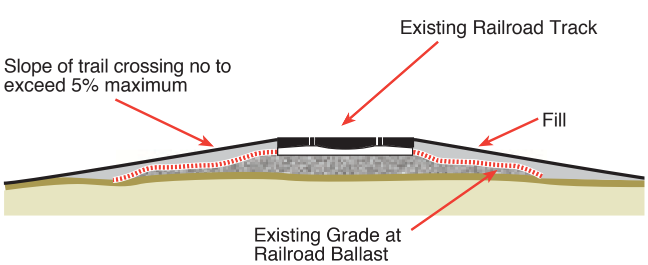


FIGURE 5.19 Approach grade at at-grade crossings

Another critical issue, particularly for bicyclists and people with disabilities, is the angle of crossing. The AASHTO Bike Guide makes the following statement with respect to the crossing angle of a bikeway at a railroad track:

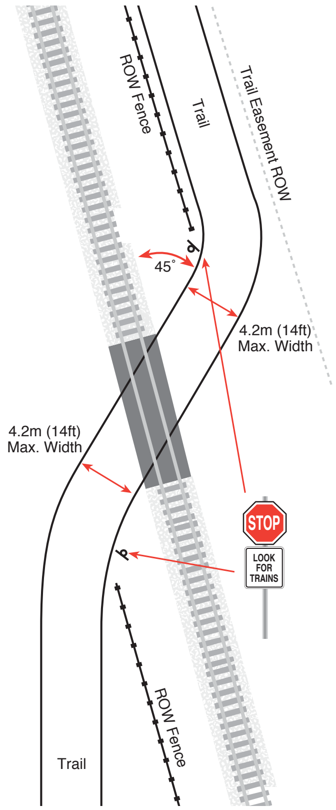


FIGURE 5.20 45° Trail-rail crossing

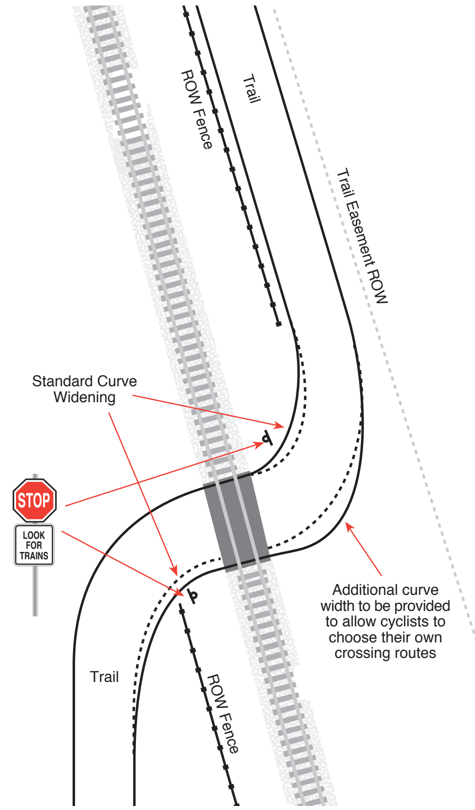


FIGURE 5.21 90° Trail-rail crossing

"Railroad-highway grade crossings should ideally be at a right angle to the rails….The greater the crossing deviates from this ideal crossing angle, the greater is the potential for a bicyclist's front wheel to be trapped in the flangeway, causing loss of steering control. If the crossing angle is less than approximately 45 degrees, an additional paved shoulder of sufficient width should be provided to permit the bicyclist to cross the track at a safer angle, preferably perpendicularly."

Flangeway is the term used for the space between the rail and the pavement edge. The standard flangeway width for commuter and transit railroad crossings is 63.5 mm (2.5 in), 76.2 mm (3 in) for freight railroads. These widths are greater than many bicycle tires and wheelchair casters. For this reason, acute angle crossings are not recommended. Also, according to the AASHTO Bike Guide, where active warning devices are not used to indicate an approaching train, the trail should cross the railroad at or nearly at right angles and where the track is straight (see **Figures 5.20** and **5.21**). Where the track is not straight (e.g., on a curve), complications exist: sight distance is restricted and the rails may be at different levels.

Dual track grade crossing.
Burlington, VT

Crossing Surface

The smoothness of the crossing surface has a profound effect on trail users. Sudden bumps and uneven surfaces can cause bicycle riders to lose control and crash. For pedestrians, trails that are designed to meet ADA Accessibility Guidelines must maintain a smooth surface.

The AASHTO Bike Guide notes, "The crossing surface itself should have a riding quality equivalent to that of the approach roadway. If the crossing surface is in poor condition, the driver's attention may be devoted to choosing the smoothest path over the crossing. This effort may well reduce the attention given to observance of the warning devices or to the primary hazard of the crossing, which is the approaching train."

Trail managers will be responsible for providing railroads with slip-resistant crossing surface materials. Accessible trails should include tactile warning strips prior to at-grade track crossings.

Nighttime Illumination

Most RWTs will experience nighttime use. Thus, lighting should be provided at trail-rail crossings. Refer to: *American National Standard Practice for Roadway Lighting, ANSI IESNA RP-8* (available from the Illuminating Engineering Society) for the appropriate location of lighting fixtures and recommended lighting levels for rail grade crossings. Lighting must be shielded from the locomotive engineer's view for safety reasons.

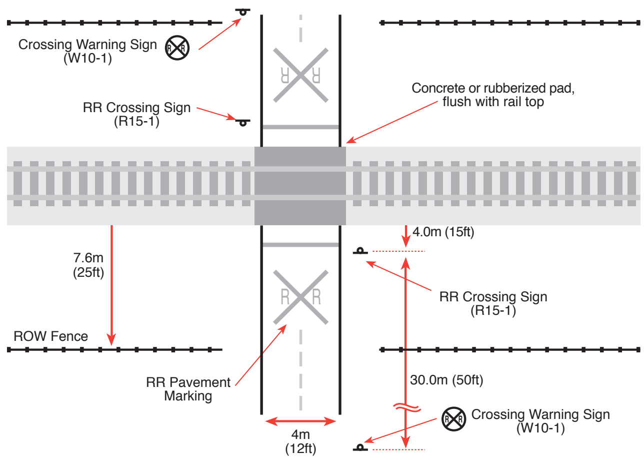


FIGURE 5.22 Crossing equipped with passive warning devices (MUTCD Fig. 9B-3)

Advanced Warning Devices at Trail-Rail Crossings

A variety of warning devices are available for trail-rail crossings. In addition to the MUTCD standard devices, there are innovative treatments developed to encourage cautious bicyclist and pedestrian behavior. This report does not sanction one type of treatment as being appropriate for all trail-rail crossings, nor does the MUTCD provide a standard design for highway-track crossings. The MUTCD states, "Because of the large number of significant variables to be considered, no single standard system of traffic control devices is universally applicable for all highway-rail grade crossings. The appropriate traffic control system should be determined by an engineering study involving both the highway agency and the railroad company." The same applies for trail-rail intersections.

There are two categories of advanced warning devices:

• Passive warning devices: signs and pavement markings that alert trail users that they are approaching a trail-rail crossing and direct them to proceed with caution and look for trains (see **Figure 5.22**).

• Active warning devices: advise trail users of the approach or presence of a train at railroad crossings. These consist of bells, flashing lights, automatic gates, and other devices that are triggered by the presence of an approaching train (see **Figure 5.23**).

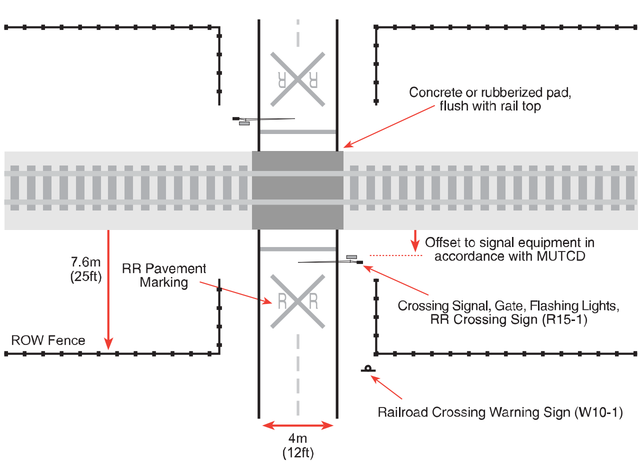


FIGURE 5.23 Crossing equipped with active warning devices and fencing

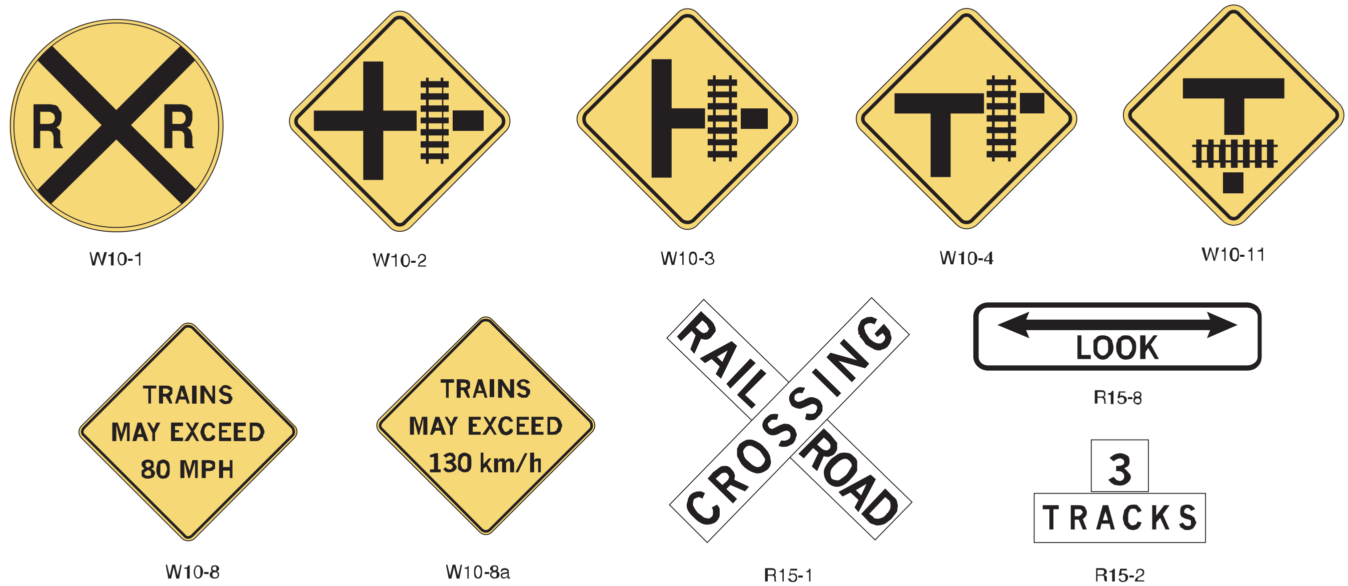


FIGURE 5.25 MUTCD-approved railroad warning signs that may be appropriate for RWTs

PASSIVE WARNING DEVICES AT TRAIL-RAIL CROSSINGS. Trail-rail crossings with passive warning devices should comply with the MUTCD's minimum recommended treatment at highway-rail grade crossings. The MUTCD states, "One Crossbuck sign shall be installed on each highway approach to every highway-rail grade crossing, alone or in combination with other traffic control devices."

The MUTCD also states that "if automatic gates are not present and if there are two or more tracks at the highway-rail grade crossing, the number of tracks shall be indicated on a supplemental Number of Tracks (R15-2) sign…mounted below the Crossbuck sign...indicated in Figure 8B-1" (see **Figure 5.24**). Refer to the MUTCD for further guidance regarding the location and retroreflectivity of these signs.

STOP AND YIELD SIGNS. The MUTCD makes the following statements about the use of STOP and YIELD signs at highway-rail grade crossings: "At the discretion of the responsible State or local highway agency, STOP or YIELD signs may be used at highway-rail grade crossings that have two or more trains per day and are without automatic traffic control devices." This may also apply to trail crossings, as determined by an engineering study that considers the number and speed of trains, sight distances, the collision history of the area, and other factors. Willingness of local law enforcement personnel to enforce the STOP signs should also be considered.

WARNING SIGNS. The MUTCD also contains a number of warning signs that can be used to indicate the configuration of the upcoming crossing, or to otherwise warn users of special conditions. Warning signs that may be appropriate for RWTs are shown in **Figure 5.25** (MUTCD signs: W10-1, W10-2, W10-3, W-10-4, W10-8, W10-8a, R15-1, R15-2, R15-8, and W10-11).

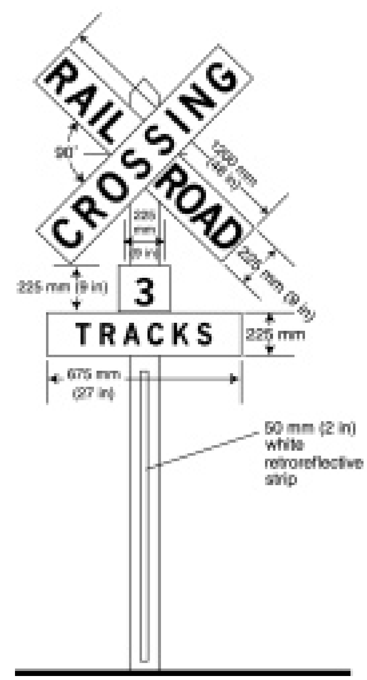
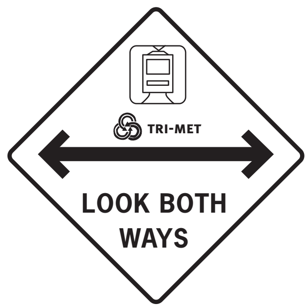


FIGURE 5.24 Highway-rail crossing (Crossbuck) sign (MUTCD Fig. 8B-1)

Steel Bridge Riverwalk. *Portland, OR*

ATSF Trail. *Irvine, CA*



Signs at transit stations. *Portland, Beaverton, and Gresham, OR*

Oregon Department of Transportation

Kennebec River Rail-Trail. *Farmingdale, ME*

FIGURE 5.26 Sample trespassing and other signs

OTHER SIGNS. The MUTCD applies to all signs that may be considered traffic control devices, whether on roads or on shared use paths. The MUTCD provides specifications on sign shapes, colors, dimensions, legends, borders, and illumination or retroreflectivity. Section 2A.06 notes that "State and local highway agencies may develop special word message signs in situations where roadway conditions make it necessary to provide road users with additional regulatory, warning, or guidance information."

Active warning devices at Burlington Waterfront Bikeway track crossing. *Burlington, VT*

The MUTCD does not apply to signs that are not traffic control devices, such as "No Trespassing" signs and informational kiosks. Many jurisdictions require "No Trespassing" signs to be posted along railroad tracks. **Figure 5.26** offers some examples.

Some railroad companies, trail developers, and State and local governments haved used a number of non-MUTCD-compliant supplemental signs at rail-trail crossings. Some of these have been adopted in State or local roadway and/or trail design guidelines. While these signs may provide information not available on MUTCD-compliant signs, they may increase the trail developer's or community's liability exposure.

The MUTCD recognizes that continuing advances in technology will produce changes that will require updating the Manual, and that unique situations often arise for signs and other traffic control devices that may require changes. Section 1A.10 describes the procedure to request changes or permission to experiment with traffic control signs and devices. Guidelines may be found on the Internet at http://mutcd.fhwa.dot.gov.

PAVEMENT MARKINGS. In the case of paved trails, pavement markings also are required by the MUTCD. At a minimum, they should consist of an "X," the letters "RR," and a stop bar line (see **Figure 5.25**, on page 75 and Parts 8 and 9 of the MUTCD).

For unpaved trails, consideration should be given to paving the approaches to trail-rail crossings, not only so that appropriate pavement markings can be installed, but also to provide a smooth crossing. If it is not possible to pave the approaches, additional warning devices may be needed.

ACTIVE WARNING DEVICES AT TRAIL-RAIL CROSSINGS. An engineering study is recommended for all trail-rail crossings to determine the best combination of active safety devices. Key considerations include train frequency and speed, sight distance, other train operating characteristics, presence of potential obstructions, and volume of trail users.

Active traffic control systems advise trail users of the approach or presence of a train at railroad crossings. Information regarding the appropriate uses, location, and clearance dimensions for active traffic control devices can be found in Part 8 of the MUTCD. In addition, Part 10 of the MUTCD contains specific recommendations for pedestrian and bicycle signals at light rail transit tracks, and should be referred to in cases where trails cross light rail transit corridors. Applicable diagrams from the MUTCD are shown in **Figures 5.27-5.30**.

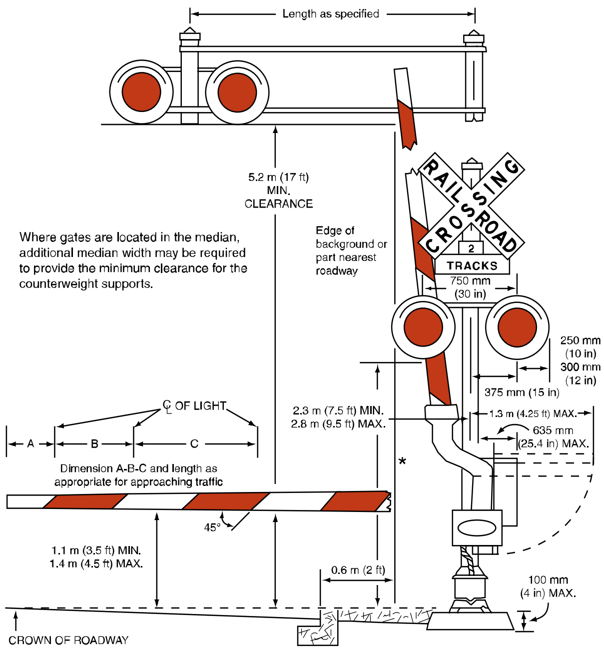


FIGURE 5.27 Composite drawing showing clearances for active traffic control devices at highway-rail grade crossings (MUTCD Fig. 8D-1)

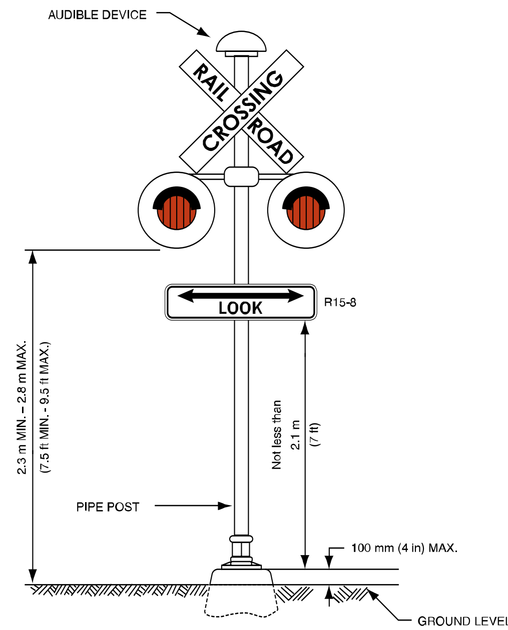


FIGURE 5.28 Typical light rail transit flashing light signal assembly for pedestrian crossings (MUTCD Fig. 10D-2)

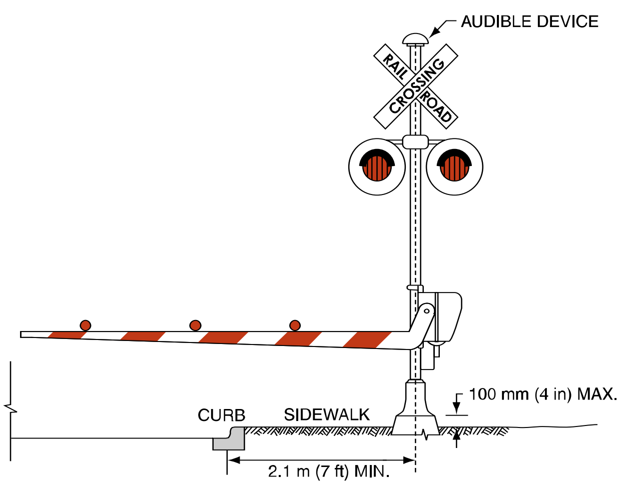


FIGURE 5.29 Typical pedestrian gate placement behind the sidewalk (MUTCD Fig. 10D-3)

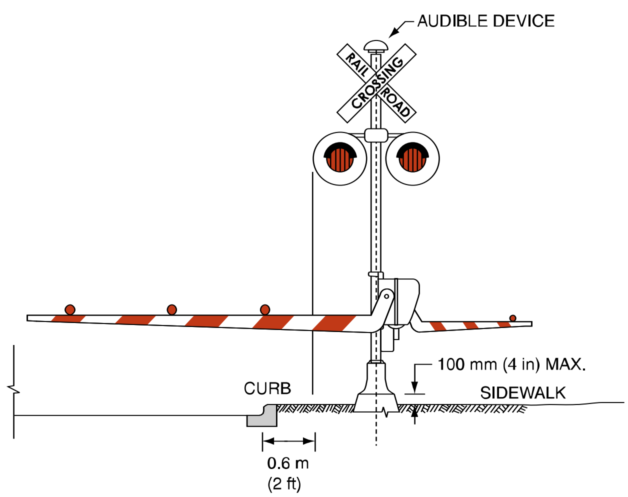


FIGURE 5.30 Typical pedestrian gate placement with pedestrian gate arm (MUTCD Fig. 10D-4)

See *Guidance on Traffic Control Devices at Highway-Rail Grade Crossings* (FHWA, 2002) for information about selection of traffic control devices. Flashing light signals combined with swing gates (see **Figure 5.30**) may be needed in cases of high speed transit or freight rail, limited sight distance, multiple tracks, and temporary sight obstructions, such as standing freight cars.

Railroad and trail planners should note that the same controls that generally keep a motor vehicle from crossing a track may not keep a pedestrian or bicyclist from proceeding through a crossing. People on foot or bicycle are reluctant to stop at barriers and will often find a way to proceed over, under, or around barricades. Photos of effective treatments in Perth, Australia, are shown on pages 70 and 71 and in Burlington, Vermont, on page 73.

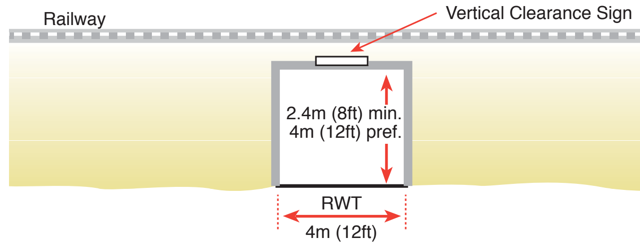


FIGURE 5.31 RWT culvert under tracks

Grade-Separated Trail-Rail Crossings

Grade-separated crossings (overpasses and underpasses) can eliminate conflicts at trail-rail crossings by completely separating the trail user from the active rail line. Refer to the AASHTO Bike Guide for specific design dimensions and lighting requirements for bridges and tunnels. In the case where a bridge or tunnel is constructed, a number of issues should be considered:

- EXISTING AND FUTURE RAILROAD OPERATIONS: Bridges and underpasses must be designed to meet the operational needs of the railroad both in present and future conditions. Trail bridges should be constructed to meet required minimum train clearances and the structural requirements of the rail corridor (see **Figures 5.31-5.34** and photos on page 80).
- SAFETY AND SECURITY OF THE FACILITY: Dark, isolated underpasses that are hidden from public view can attract illegal activity. Underpasses should be designed to be as short as possible to increase the amount of light in the underpass, and to decrease its attractiveness as a hidden area. Adequate lighting is extremely important.
- MAINTENANCE: The decision to install a bridge or underpass should be made in full consideration of the additional maintenance these facilities require.

According to the AASHTO Bike Guide, the minimum clear width of the pathway on a bridge or through a tunnel should be the same as the width of the approach path, with an additional 0.6 m (2 ft) clear area on the sides. Therefore, the minimum width of a tunnel or bridge on a 3 m (10 ft) wide trail would be 4.3 m (14 ft). Vertical clearance should be 2.4 m (8 ft) minimum (see **Figures 5.31** and **5.32**). Larger horizontal and vertical clearances may be needed for certain types of maintenance and emergency vehicles. Future needs for vehicular access should be taken into consideration when designing these structures.

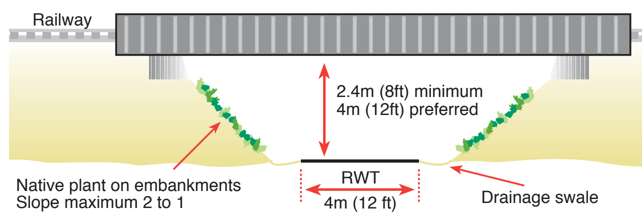


FIGURE 5.32 RWT track undercrossing

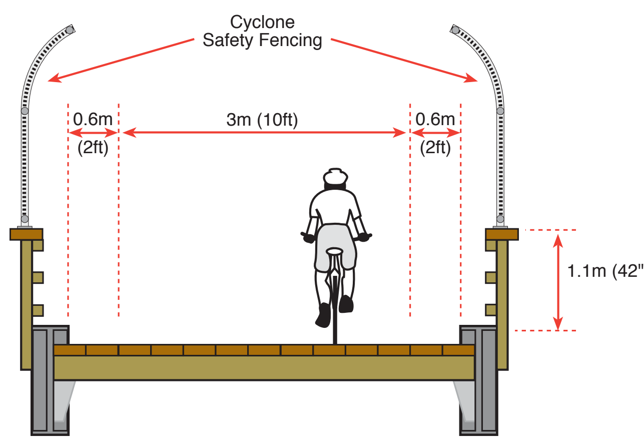


FIGURE 5.33 RWT track overcrossing

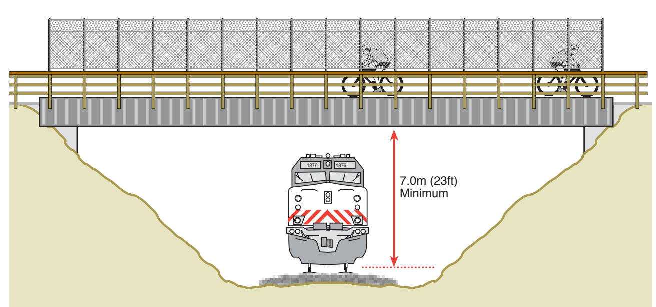


FIGURE 5.34 RWT track overcrossing (meets Amtrak required clearance height for non-electrified track)

SAMPLE UNDER- AND OVERCROSSINGS

Apple Tree Park. *Vancouver, WA*

Platte River Trail. *Denver County, CO*

Tony Knowles Coastal Rail Trail. *Anchorage, AK*

Trail-rail overcrossing. *San Luis Obispo, CA*

Bridge over Union Pacific tracks. *Portland, OR*

Approach grades for bridges and tunnels on RWTs should follow AASHTO guidelines and typically also must meet ADA Accessibility Guidelines. Again, a greater than five percent grade is not recommended.

Trail-Roadway Crossings

At-grade crossings between RWTs and roadways can be complex areas that require the designer to think from the perspective of all types of users who pass through the intersection: trains, motorists, bicyclists, and pedestrians. Trail-roadway intersections are covered in detail by both the AASHTO Bike Guide and the MUTCD. While these manuals do not specifically recommend solutions for RWT crossings, they cover basic safety principles that apply to all trail-roadway crossings.

Variables to consider when designing trail-roadway intersections include right-of-way assignment, traffic control devices, sight distances, access control, pavement markings, turning movements, traffic volume, speed, and number of lanes. Refer to the AASHTO Bike Guide for information regarding these design factors. All traffic control devices should comply with the MUTCD.

At-Grade Trail-Roadway Crossings

At-grade RWT-roadway crossings can be very complex, and typically require the involvement of both the roadway agency and the railroad company. Each must be evaluated on a case-by-case basis through engineering analysis. There are essentially three different methods for handling RWT-roadway crossings:

1. Reroute shared use path users to nearest signalized intersection (see **Figure 5.35**).
2. Provide new signal across roadway (see **Figure 5.36**).
3. Provide unprotected crossing (see **Figure 5.37**).

Another possible scenario (although undesirable) has trail users crossing both the roadway and tracks, as shown in **Figure 5.38**.

The appropriate crossing design should be selected based on the following considerations:

- Motor vehicle traffic must be warned of both types of crossings (railroad and trail). Care should be taken to keep warning devices simple and clear; ambiguous and overly complicated signage and pavement markings can distract both motorists and trail users.
- If a pedestrian-actuated traffic signal is warranted at a mid-block RWT-roadway crossing, the traffic signal should be integrated with the design of active warning devices that alert motorists of an approaching train. This may require redesigning several aspects of the intersection.
- If automatic gates are used, they should be placed in between the trail crossing and the active track(s). Where possible, the stop bar on the highway should be located behind the trail crosswalk. However, if the crossing is located at too great a distance from the automatic gate, the stop bar should be placed in a standard position near the gate, and a DO NOT BLOCK CROSSWALK sign should be used at the trail crossing.

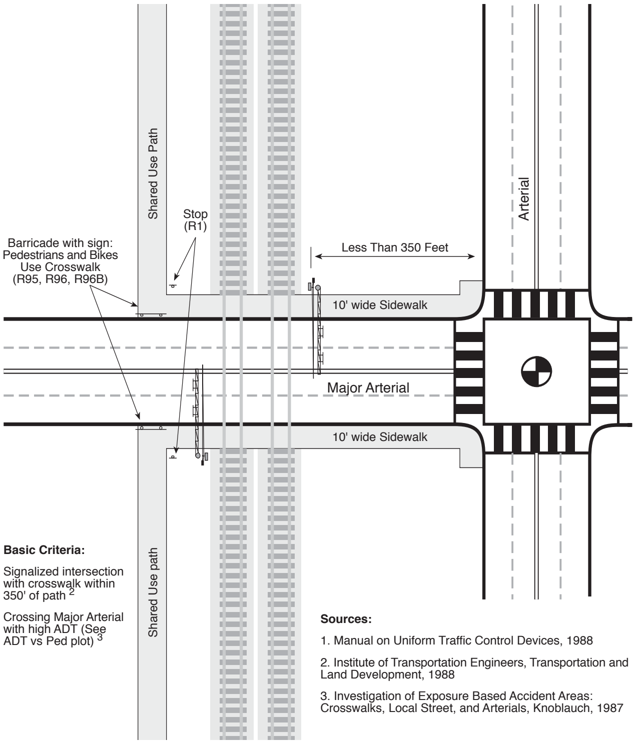


FIGURE 5.35 Roadway crossing type 1 (reroute to nearest intersection)

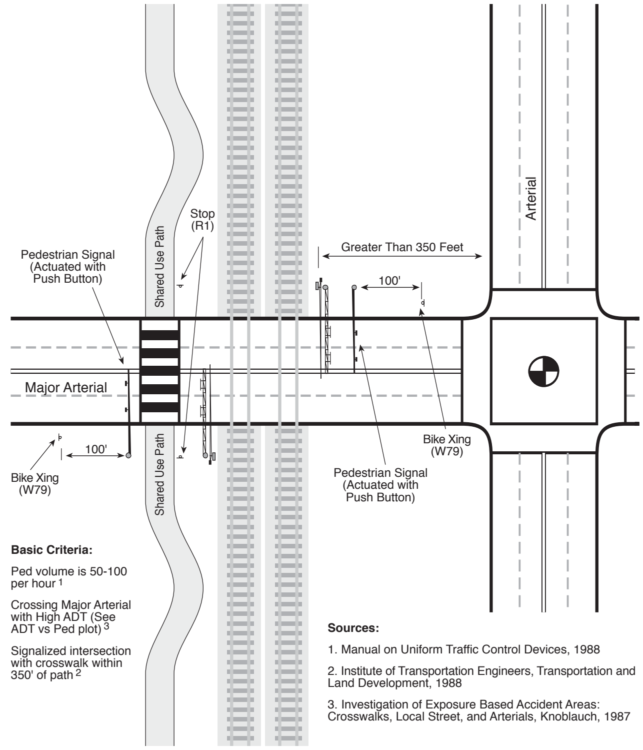


FIGURE 5.36 Roadway crossing type 2 (new signal)

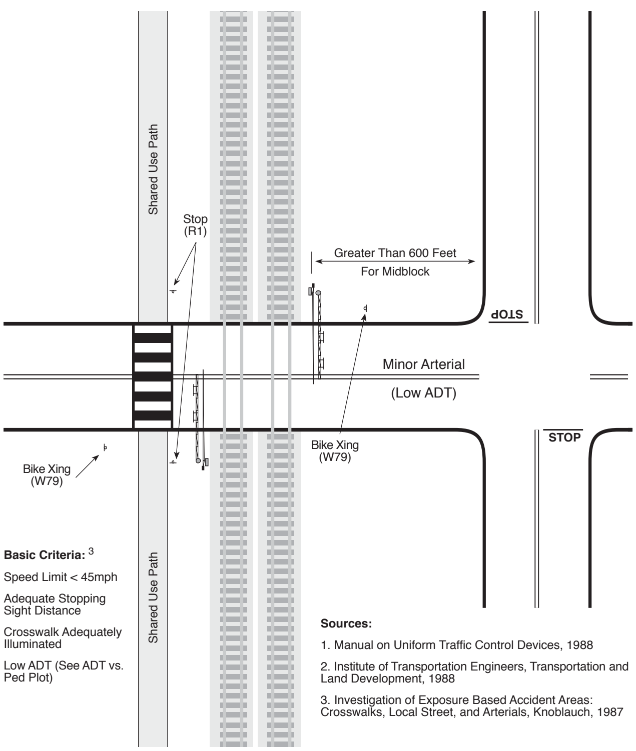


FIGURE 5.37 Roadway crossing type 3 (unprotected crossing)

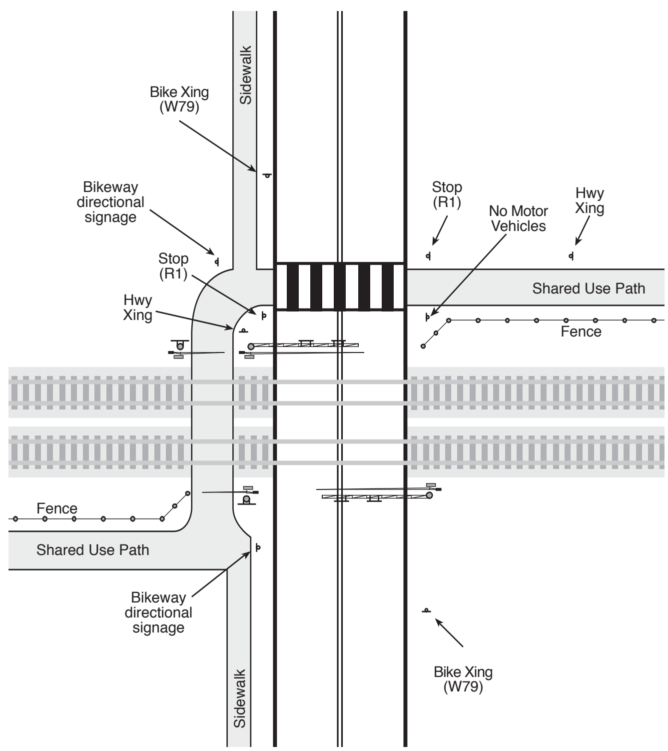


FIGURE 5.38 Roadway and track crossing

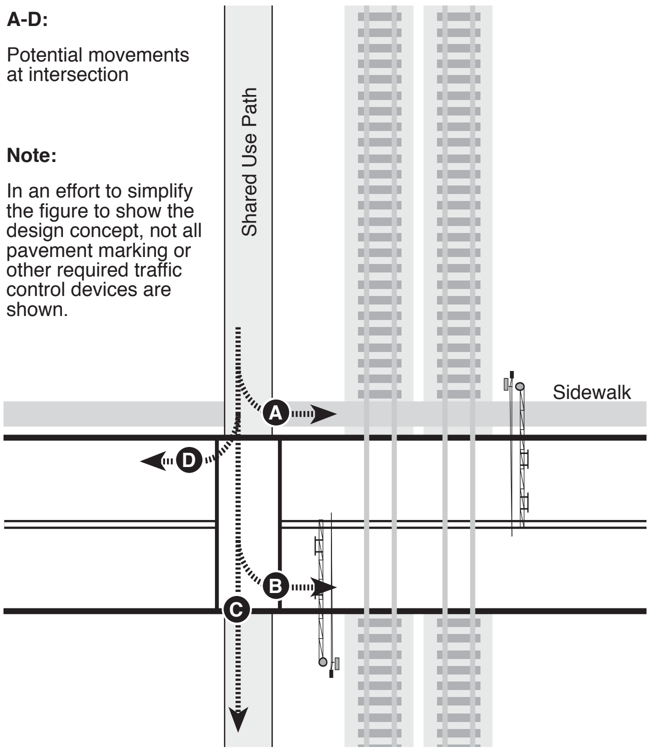


FIGURE 5.39 Summary of potential trail user movements

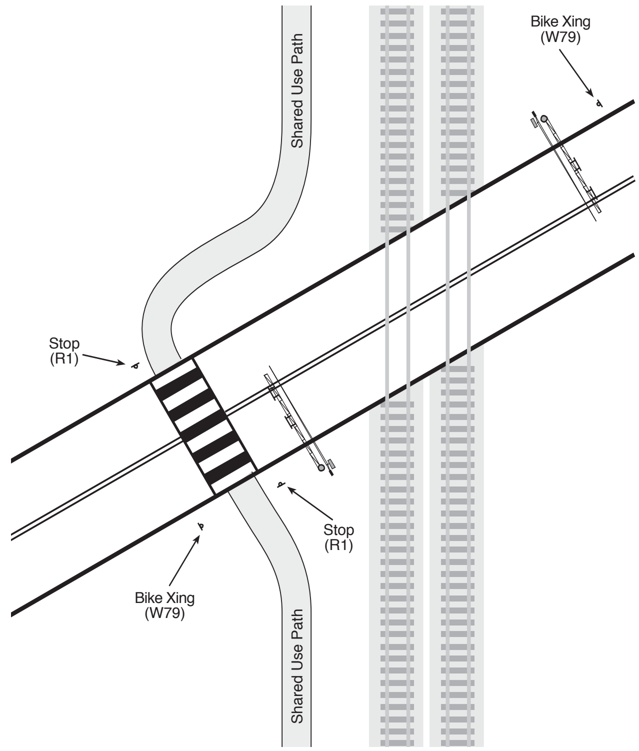


FIGURE 5.40 Angled intersection with roadway

- If active warning devices are used, the trail should be integrated so that trail users are made aware of approaching trains. Trail users may either elect to travel straight across the road, or may exit the trail and continue their journey on the roadway (see **Figure 5.39**). In this scenario, turning movements towards the tracks could be hazardous if the trail user is unable to view active warning devices, or if sight distances are restricted. The angle of approach for these trail users must be considered when placing warning devices. In cases where flashing light signals (post mounted) are used, it is important to locate these devices so that they can be seen by trail users, and to include bells and other audible warning devices to provide additional warning to bicyclists and pedestrians.

RWT-roadway intersections can become further complicated if the railroad crosses the roadway at an angle. Angled trail crossings are not recommended, because they increase the amount of exposure time in the roadway for pedestrians and bicyclists. **Figure 5.40** shows an alternative crossing design that permits trail users to cross perpendicular to the roadway at angled rail-highway crossings.

Grade-Separated Trail-Roadway Crossings

Where a proposed RWT will cross a major roadway or highway carrying heavy traffic volumes (typically more than 20,000 vehicles per day) and/or traffic at speeds greater than 72 km/h (45 mi/h), grade separation should be explored regardless of where the adjacent railroad tracks are located. The design issues related to these undercrossings or overcrossings are the same as on all other shared use paths, and are not covered in this document.

Utilities

Many railroad corridors have utilities that may impact the design, location, or even the feasibility of an RWT. At a minimum, most railroads have their own internal communication systems within their corridors, sometimes located on poles. Any RWT would need to either avoid these poles with a 0.9 m (3 ft) minimum shy distance, or relocate per specification by the railroad. Sometimes a railroad will require that their relocated communication lines be placed underground in new conduit.

Buried fiber optic cable, Washington & Old Dominion Trail. *Fairfax County, VA*

Surface and subsurface utilities often are located within the railroad right-of-way, impacting the location and construction of the RWT. Utilities include active and abandoned railroad communications cable, signal and communication boxes, fiber optic cable, and water, sewer, and telephone lines. Added to this mix, utilities may run parallel to the tracks on one or both sides of the right-of-way, and across, under, or over the tracks.

Trails may need to be closed temporarily to allow utility work. The manager of the Cottonbelt Trail, Texas, notes that one should expect to have interference when utilities companies perform maintenance. The Explorer Pipeline Company required the Cottonbelt Trail to have removable pavement where the trail crossed its pipeline.

Part of the initial feasibility study should identify existing utilities in the corridor, and specifically (a) ownership, (b) location, and (c) easement agreements with the railroad company. While it is not uncommon for a trail to be constructed on top of a subsurface utility, there typically are easement restrictions and requirements that will impact the trail design and location.

RWTs may be constructed with buried conduit under or adjacent to the path to serve existing or future utilities. Inclusion during initial construction saves immense cost and disruption in the future. Conduit and auxiliary equipment (e.g., repeater boxes) should not present slip, trip, or fall opportunities; visual obstacles; or other hazards. The feasibility study staff also must meet with both the railroad and utility representatives to discuss their concerns and requirements.

Accommodating Future Tracks and Sidings

A fundamental part of any feasibility study is to examine the possible addition of tracks and sidings (railroad car storage facilities) that will have a direct impact on RWT design and alignment. The RWT team must seek out information from the railroad operator about their future expansion plans. In many cases, a railroad company may not have specific plans but may want to reserve room to expand in the future if it is needed. In other cases, a railroad operator may have specific plans for additional tracks, either in the short, mid, or long term. In still other cases, a transit agency may have long range plans to use part of or the entire corridor for future transit or commuter rail service. Should a railroad company choose to reserve their land for future rail service, the trail project is not likely to be feasible.

Siding on site of proposed RWT.
Kelowna, BC, Canada

The issue of sidings must be clearly understood by the feasibility study team. A corridor may have existing but unused sidings that either may be removed if the land use has changed significantly or reactivated if a new tenant comes in or economic conditions change. If a rail corridor traverses an industrial or warehouse area, there may be a future need for sidings to serve future land uses, impacting the proposed RWT.

Should additional tracks or sidings seem a possibility even in the long term, they should be included in the RWT design process. In flat terrain, the additional tracks should be located on the opposite side of the proposed RWT, and there should be sufficient room for additional tracks if the RWT is located at the extreme edge of the right-of-way. In terrain with cut and fill, any future tracks would probably require major engineering that would most likely impact the overall feasibility of the RWT project within a typical 30 m (100 ft) wide railroad right-of-way.

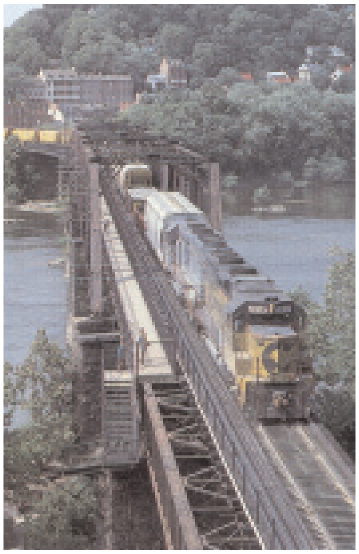
An RWT should be located and designed so as to avoid active, potentially active, or potential future sidings. RWTs that cross sidings pose operational and safety problems for the trail manager and rail operator alike. A railroad corridor with numerous sidings or industrial spurs on both sides of the existing tracks would be a poor choice for an RWT project.

One option is to include language in the easement or license agreement to remove or relocate the RWT in the event that there is a future need for additional tracks or sidings. If there are firm plans for future expansion, this is not likely to be attractive to the railroad operator because of the anticipated difficulty in removing or rerouting a popular path in the future.

Trestles and Bridges

As part of the feasibility analysis, the presence of trestles and bridges will loom large as major constraints to the overall feasibility of a project. Virtually all railroad corridors will have at least some minor bridges or culverts either as part of the local drainage system, or the local network of streams and creeks. In some cases, there will be longer trestles and bridges over roadways, highways, rivers, and canyons. In almost all cases, the railroad structures are not designed to accommodate pedestrians at all, let alone bicycles, and represent a real safety hazard (and attraction) to trespassers.

Simple prefabricated bridges over small streams, culverts, and other waterways are not expensive items. However, they may impact a project's feasibility from an environmental perspective. A new bridge over a highway or on a long trestle may have enormous costs, and may, in some cases, represent the single greatest cost on the project.



Harpers Ferry Bridge. *Harpers Ferry, VA*

Steel Bridge Riverwalk. *Portland, OR*

RWT bridges constructed over existing roadways or over corridors with existing trails or bikeways pose a special problem. Neighboring residents will want access to the RWT. Since these connections will need to meet ADA gradient standards, they may involve the construction of an expensive series of ramps.

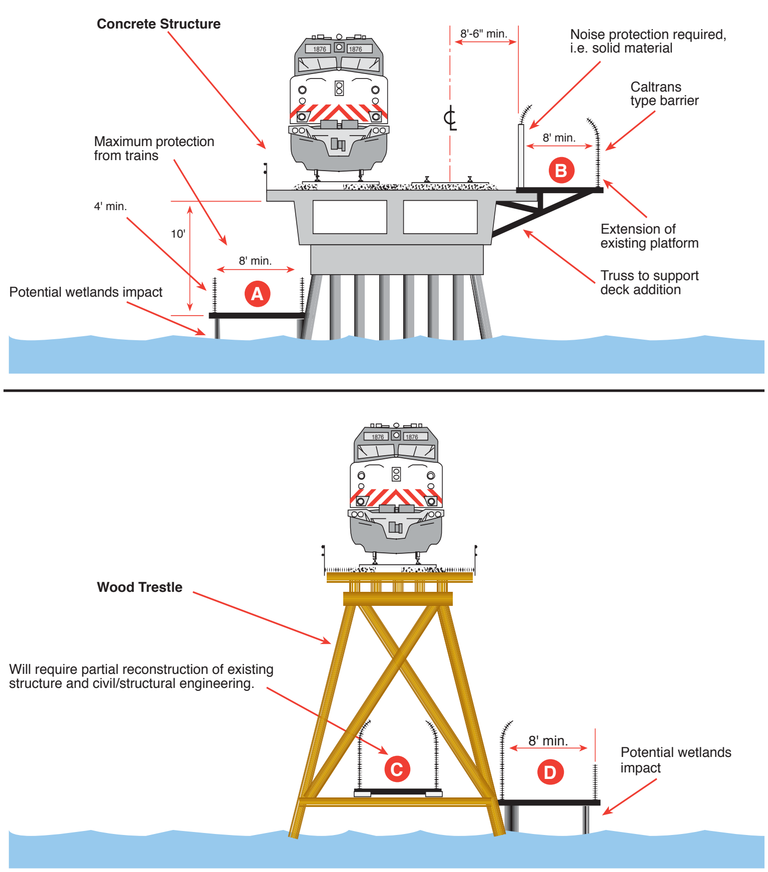


FIGURE 5.41 Trestle options

Engineers can design solutions to virtually any challenge (see **Figure 5.41**). Any trail facility that is to be appended to or otherwise incorporated into a bridge must maintain full and unimpeded bridge maintenance and inspection access. Some of the prototype solutions for RWTs on corridors with bridges and trestles include:

• *Use of existing structure.* In rare cases, an RWT has been constructed on an existing railroad structure. This has been accomplished in Harper's Ferry, Virginia, on a bridge where there were formerly two or more tracks by placing the RWT on the roadbed of the abandoned tracks and placing a security fence between the active tracks and the RWT. The other option is to construct a bridge structure that is attached in some fashion to the existing trestle or bridge. For example, in May 2001, the City of Portland, Oregon, opened a new 3 m (10 ft) shared use path, cantilevered onto the south side of the Union Pacific Railroad bridge (Steel Bridge), set back 3.7 m (12 ft) from the track centerline. While this may be less expensive than constructing a completely new

Single track tunnel on Lake Oswego Trolley Line. *Lake Oswego, OR*

bridge, the RWT developer must be prepared to make structural integrity improvements to the existing bridge and assume maintenance and liability protection for the new combined structure.

- *Construct a new structure.* This offers a simple, independent solution, rather than trying to utilize an existing railroad structure. This option may be very expensive and may have negative environmental impacts if it requires construction in a riparian or other habitat. If constructed over a State highway, it may require time-consuming permit approvals and strict design standards.

Tunnels

The presence of a single track tunnel on a railroad corridor typically signifies that an RWT is not feasible, at least on the segment where the tunnel is located. There is one known case of a shared rail-with-trail single track tunnel: the York County Heritage Trail, Pennsylvania, which is along an active tourist rail line. Trail users are required to wait when a train is in the tunnel. Usually, tunnels are constructed where the topography dictates the need for going through — rather than around — terrain, meaning that an RWT would have a difficult time traversing over or around the obstacle to avoid a tunnel.

In some cases, there is a roadway or even an abandoned railroad roadbed that could be used by an RWT to circumvent the tunnel. If the terrain is not too steep, an RWT could go over the tunnel hill. While multi-track tunnels with one or more abandoned tracks could conceivably serve dual usages, no known examples exist, and they should be avoided.

RWT designs must take endangered species into consideration. *Victorville, CA*

Environmental Constraints

If necessary, a full environmental assessment per State and Federal National Environmental Policy Act (NEPA) law should be included as part of the RWT feasibility study. Environmental impacts are not relegated simply to riparian zones, but include impacts to:

a. public safety
b. public expenditures
c. light and glare
d. geology, soils, and hydrology
e. biological resources
f. land use
g. cultural resources
h. aesthetics
i. transportation and circulation
j. economics
k. parks and recreation
l. noise levels

The environmental analysis should be conducted simultaneously with feasibility study to allow for the RWT design team to minimize or avoid significant environmental impacts. The environmental analysis also provides a good forum for public input and political approvals, and usually is a required activity if the project is to receive Federal funding. In some cases, the environmental impacts of a proposed RWT will be so great as to make the project unfeasible. In other cases, the RWT enhances a previously damaged site. Thus, the impacts may be offset by proposed mitigation and/or by the benefits accrued from the project.

Support Facilities and Amenities

Any new trail or RWT will require support facilities both to enhance the experience for trail users, and to serve basic user and manager needs. Some of these items could be considered extra amenities that are dependent on local desires and available budget, while others should be considered basic elements of any new trail facility.

Trailheads and Parking Areas

Any new RWT will attract people to drive and park near the facility, potentially impacting local neighborhoods. The best design will locate trailheads, parking areas, restrooms, and other such facilities on the same side of the tracks as the trail, so as to avoid additional crossings. A feasibility study should include a full analysis of access to the trail from local communities, along with a projection of future annual and peak day usage and

Tree-lined RWT looking north. *Burlington, VT*

modal split. Should the analysis reveal that a significant number of vehicles will be parking near the RWT, a trailhead parking scheme should be included as part of the feasibility study (see **Figure 5.42**).

Aside from parking, trailheads also offer amenities such as restrooms, entrance signs and maps, kiosks, drinking fountains, and other features. These and other details of trailheads are a standard element of most trail master plans and trailhead designs, which any landscape architecture or trail planning firm should provide as part of the design team.

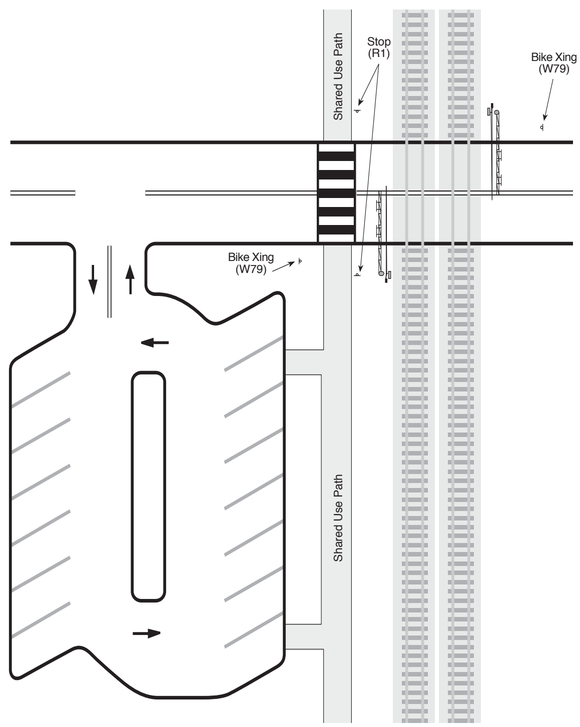


FIGURE 5.42 Trailhead and parking design

Landscaping

Landscaping is an optional but very important element of any new trail. Landscaping offers not only visual relief and aesthetic benefits, but also shelter from the sun and wind and assistance with erosion control. At the same time, landscaping can be very expensive to install and maintain, especially if it requires irrigation. Most trail projects utilize landscaping at gateways and specific areas along the corridor, and often use native, drought-resistant species that do not require irrigation. Landscaping should not interfere with track and roadbed maintenance or the visibility of motorists, trail users, or the locomotive engineers at crossings.

Lighting on Eastbank Esplanade. *Portland, OR*

Trailhead sign, Burlington Waterfront Bikeway. *Burlington, VT*

Signing on the Railroad Trail. *Gaylord, MI*

Drainage

Railroad corridors are constructed with both lateral and cross roadbed drainage in order to keep water off of the tracks and ballast. Lateral drainage consists of the ditches seen parallel to most tracks and ballast, which in turn feed into natural or built waterways. Cross-roadbed drainage pipes are used to connect lateral drainage ditches via a connection under the tracks.

Maintaining the integrity of the railroad drainage system is of paramount importance for any RWT. Since many RWTs are constructed where there is an existing lateral drainage ditch or swale, a new drainage system must be designed. The cost of this system, along with a section identifying the basic design approach, should be included in the feasibility study. Also, the RWT paved surface will add to the local surface runoff, and should be included in the drainage calculations as appropriate.

The feasibility study should include a section on drainage, and especially how the existing railroad drainage system will be maintained. Prototype designs of any changes along with cost estimates should be included if the RWT will impact the existing drainage system in any way. The railroad company or agency should review plans, even if the proposed trail is adjacent to railroad property.

Lighting

Lighting an RWT is dependent on a variety of factors, including cost to install, maintain, and operate; whether the RWT will be used as a commuter facility in the winter and low light hours; and potential impact on neighbors. Most paved paths are not illuminated due to the expense to install and maintain the lighting and the potential impacts on nearby homes. Exceptions to this are at-grade crossings and undercrossings, where lighting is a matter of safety and visibility. Trail designers should take into account lighting impacts on train operation and visibility for any RWT crossing of or under a roadway and/or tracks.

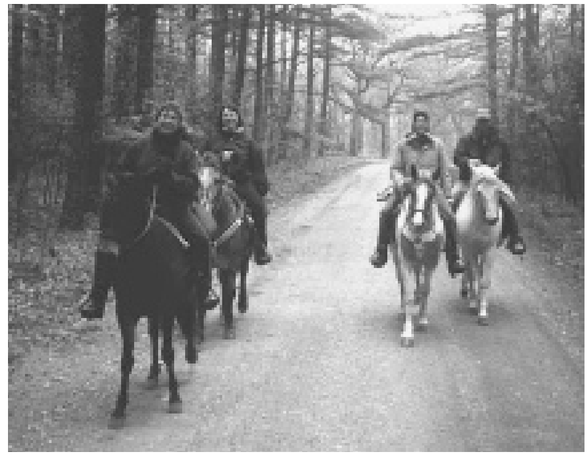
One innovative pathway lighting concept that may be considered is to have lighting activated by motion detectors, so that the trail is lighted while people approach and a few minutes after they pass, but not for the entire night.

Signing and Markings

Advisory and regulatory signs on RWTs related to transportation (stop, slow, curve ahead, etc.) should follow MUTCD standards, especially for signs that directly impact user safety. The size, frequency, location, and other aspects are clearly identified in the MUTCD or State highway design manual. Local agencies may use their own discretion for other signs, such as user protocol between pedestrians and bicyclists, speed limits, hours of use, and emergency contact information.

The feasibility study should present recommendations, designs, specifications, and costs on signing and striping that meet Federal and State standards, and the local agency needs. This may include entrance or gateway signs, natural or historic interpretation signs, or regulatory and etiquette signs.

Equestrian Considerations



Equestrian RWT users require special design consideration. *Bourbon, MO*

Lack of equestrian experience near railroads, horses' instinctual flight behavior, and equestrians' general wariness of new and potentially challenging situations require specific design considerations when planning for equestrian use on RWTs. All RWTs with potential equestrian use require site-specific analysis. Some equestrian users advocate fences of sufficient height to prevent horses jumping them when startled or frightened; however, this concern must be balanced with the need for visibility of trains for both horses and riders. Horses that cannot see an oncoming or approaching train will experience greater fear and confusion than if they are able to see and identify the source of noise. Equestrian use should not be promoted where barriers create a narrow trail environment.

Trail width is an overriding design issue when considering equestrian use on RWTs. RWTs designed to accommodate equestrian use should provide separate pathway treads for multiple users. Narrow railroad rights-of-way that afford width for only a single paved trail, or that provide inadequate shy distance for horses frightened by nearby or oncoming trains, are not appropriate candidates for accommodation of equestrian use.

Trestles and bridges require additional considerations. Many horses are frightened by bridges and other elevated environments, particularly lattice or perforated bridges and trestles that allow the animal a view of the ground surface substantially below the bridge deck. Most horses are not accustomed to this environment and will respond unpredictably with potentially negative consequences.

Considerations for Steam Locomotives

Several trails exist and/or are proposed within proximity to steam locomotives, for which special consideration is warranted. From time to time, depending on operations and the steam locomotive itself, it is necessary to blow condensation out of the steam cylinders while the locomotive is standing or moving. The outlets for this escaping steam and moisture are less than 300 mm (12 in) above the ground, and generally shoot out perpendicular to the locomotive. This may startle nearby trail users. Also, the reciprocating motion of valves and drive rods (attached to the large drive wheels) require additional lateral clearance for safety reasons. Thus, the feasibility study for RWTs proposed alongside steam locomotives should analyze the need for additional setback and other safety measures.

Appendix D: MUTCD Traffic Signal Warrant Analysis

MUTCD Traffic Signal Warrant
Summary Worksheet

The Worksheet(s) attached are provided as an attachment to the Engineering Investigation Study for:

Intersection: Brighton Street Railroad Crossing

Select one:

100%
Volume Level

Major Street: Brighton Street
Critical Approach Speed: 30 mph
Lanes: 2 or more lanes

Minor Street: Ped Crossing
Critical Approach Speed: 5 mph
Lanes: 1 lane

% Right Turns Included
From North (SB) 0%
From East (WB) 0%
From South (NB) 0%
From West (EB) 0%

In built-up area of isolated community of < 10,000 population? No
Total number of approaches at intersection? 3
Manually set volume level? 100%

Analysis based on PROJECTED volume data.

Forecast Year	Within 5 Years of Construction?	Time (HH:MM)			
		From	AM / PM	To	AM / PM

Warrant Evaluation Summary	Warrant Met:
Warrant 1: Eight - Hour Vehicular Volume	**N/A**
Condition A: Minimum Vehicular Volume	
Condition B: Interruption of Continuous Traffic	
Condition C: Combination: 80% of A and B	
Warrant 2: Four-Hour Volume	**N/A**
Warrant 3: Peak Hour Volume	**N/A**
Warrant 4: Pedestrian Volume	**Yes**
Criterion A: Four-Hour	
Criterion B: Peak-Hour	Yes
Warrant 5: School Crossing	**N/A**
Warrant 6: Coordinated Signal System	**N/A**
Warrant 7: Crash Experience	**N/A**
Warrant 8: Roadway Network	**N/A**
Warrant 9: Intersection Near a Grade Crossing	**N/A**

Warrant Analysis Conducted By:

Name:

Date:

Nitsch Engineering

Warrant 1: Eight - Hour Vehicular Volume 100%

Warrant Evaluated? No **Warrant Satisfied?** N/A **Manually Set To:**

Condition A :		
Min. Veh. Volume		
Volume Level	100%	80%
Major Rd. Req	600	480
Minor Rd. Req	150	120
Number of Hours	0	0

Satisfied?

Condition B:		
Interruption of Continuous Traffic		
Volume Level	100%	80%
Major Rd. Req	900	720
Minor Rd. Req	75	60
Number of Hours	0	0

Satisfied?

Condition C:
Combination of A & B at 80%

Satisfied?

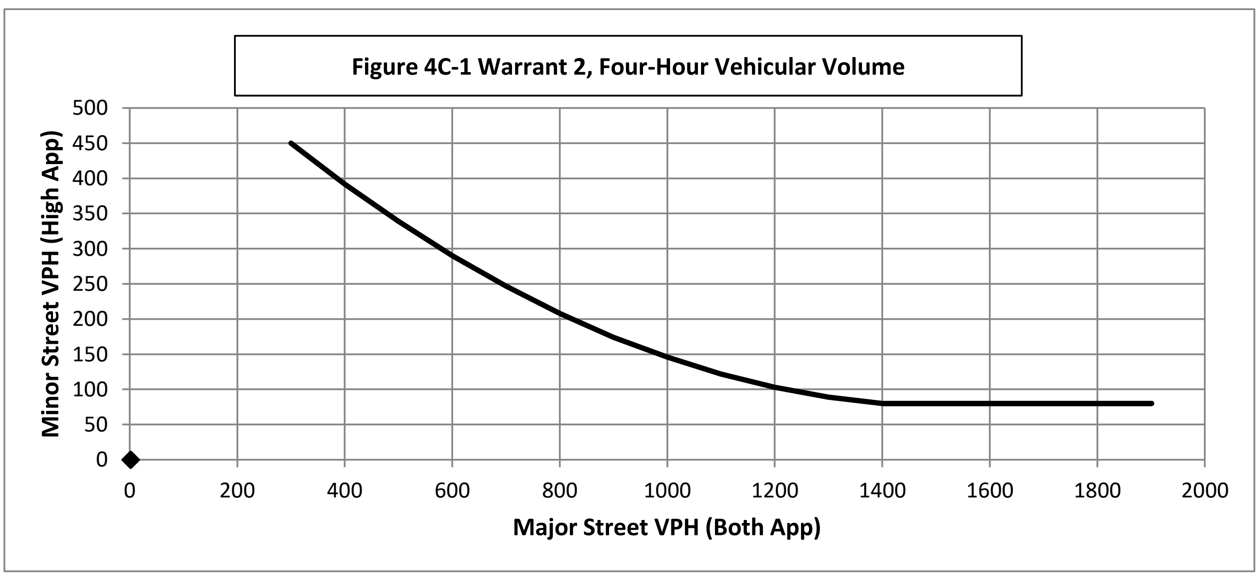
6:00 AM	Enter Start Time (Military Time) (HH:MM)				
Time Period	**From**	**To**	**Major Road: Both App. (VPH)**	**Minor Road: High App. (VPH)**	**Total**
1	6:00	7:00	0	0	0
2	7:00	8:00	0	0	0
3	8:00	9:00	0	0	0
4	9:00	10:00	0	0	0
5	10:00	11:00	0	0	0
6	11:00	12:00	0	0	0
7	12:00	13:00	0	0	0
8	13:00	14:00	0	0	0
9	14:00	15:00	1210	0	1210
10	15:00	16:00	1484	0	1484
11	16:00	17:00	1504	0	1504
12	17:00	18:00	1801	0	1801
13	18:00	19:00	0	0	0
14	19:00	20:00	0	0	0
15	20:00	21:00	0	0	0
16	21:00	22:00	0	0	0

Warrant 2: Four-Hour Volume 100%

Warrant Evaluated? No
Number of Hours N/A
Warrant Satisfied? N/A
Manually Set To:

Four hours with highest total volume meeting warrant criteria:

Hour Start				
Major Road Vol.				
Minor Road Vol.				



Warrant 3: Peak Hour Volume 100%

Warrant Evaluated? No **Warrant Satisfied?** N/A **Manually Set To:**

Condition justifying use of warrant:

Criteria		Met?
Delay on Minor Approach	4	
Volume on Minor Approach	100	
Total Entering Volume (veh/h)	650	

Manually Set Peak Hour?

Peak Hour	Major Road Vol. (Both App.)	Minor Road Vol. (High App.)
17:00	1801	0

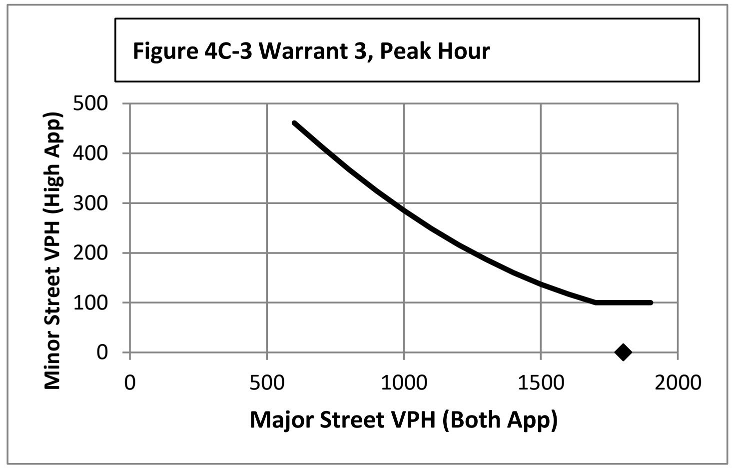


Figure 4C-3 Warrant 3, Peak Hour

Warrant 4: Pedestrian Volume 100%

Warrant Evaluated? Yes **Warrant Satisfied?** Yes **Manually Set To:**

Criterion A: Four Hour

Hour (Start)	Pedestrian Volume	Major Road Vol.
		0
		0
		0
17:00	134	1801

Manually Set Major Rd Vol? **No**

15th % walk speed < 3.5 ft/s? **No**

Criterion A Satisfied?

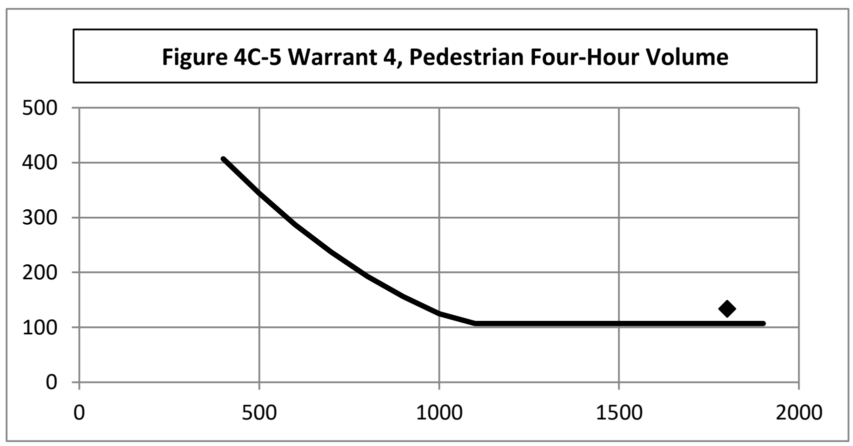


Figure 4C-5 Warrant 4, Pedestrian Four-Hour Volume

Criterion B: Peak Hour

Peak Hour	Pedestrian Vol.	Major Road Vol.
17:00	134	1801

Criterion B Satisfied? **Yes**

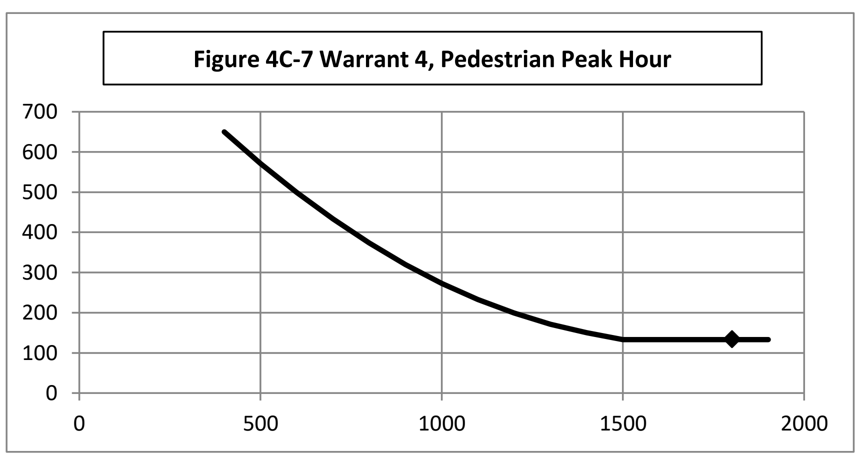


Figure 4C-7 Warrant 4, Pedestrian Peak Hour

Nitsch Engineering

Warrant 5: School Crossing

Warrant Evaluated? **No** **Warrant Satisfied?** **N/A** **Manually Set To:**

Criteria

	Criteria	Fulfilled?
1	There are a MINIMUM of 20 school children during the highest crossing hour.	
2	There are fewer adequate gaps in the major road traffic stream during the period when the school children are using the crossing than the number of minutes in the same period.	
3	The nearest traffic signal along the major road is located more than 300 ft away. Or, the nearest traffic signal is within 300 ft but the proposed traffic signal will not restrict the progressive movement of traffic.	

Warrant 6: Coordinated Signal System

Warrant Evaluated? **No** **Warrant Satisfied?** **N/A** **Manually Set To:**

Criteria

	Criteria	Fulfilled?
1	Signal spacing > 1000 ft	
2	On a one-way road or a road that has traffic predominantly in one direction, the adjacent signals are so far apart that they do not provide the necessary degree of vehicle platooning.	
3	On a two-way road, adjacent signals do not provide the necessary degree of platooning and the proposed and the adjacent signals will collectively provide a progressive operation.	

Warrant 7: Crash Experience **100%**

Warrant Evaluated? **No** **Warrant Satisfied?** **N/A** **Manually Set To:**

Criteria

	Criteria		Met?	Fulfilled?
1	Adequate trial of other remedial measures has failed to reduce crash frequency.			
	Measures Tried:			
2	Five or more reported crashes, of types susceptible to correction by signal, have occurred within a 12 month period.	# of crashes per 12 months		
3	Warrant 1, Condition A (80%)			
	Warrant 1, Condition B (80%)			
	Warrant 4, Criterion A (80%)			
	Warrant 4, Criterion B (80%)			

Warrant 8: Roadway Network

Warrant Evaluated? **No** **Warrant Satisfied?** **N/A** **Manually Set To:**

Criteria

	Criteria						Met?	Fulfilled?
1	Total entering volume of at least 1,000 veh/h during typical weekday peak hour					1801	Yes	No
	Five-year projected volumes that satisfy one or more of Warrants 1, 2, or 3.						No	
2	Total entering vol. of at least 1,000 veh/h for each of any 5 hrs of non-normal business day (Sat. or Sun.)							
		Hour						
		Volume						

Characteristics of Major Routes - Select yes if all intersecting routes have characteristic

	Characteristic	Fulfilled?
1	Part of the road or highway system that serves as the principal roadway network for through traffic flow	
2	Rural or suburban highway outside of, entering, or traversing a city	
3	Appears as a major route on an official plan	

Warrant 9: Intersection Near a Grade Crossing

Warrant Evaluated? **Warrant Satisfied? N/A** **Manually Set To:**

Adjustment Factors			Manually Set Peak Hour?				
Rail Traffic per Day	% High Occupancy Buses on Minor Road	% Tractor-Trailer Trucks on Minor Road	D	Peak Hour	Major Road Vol.	Minor Road Vol.	Adjusted Minor Vol.
					0	0	0

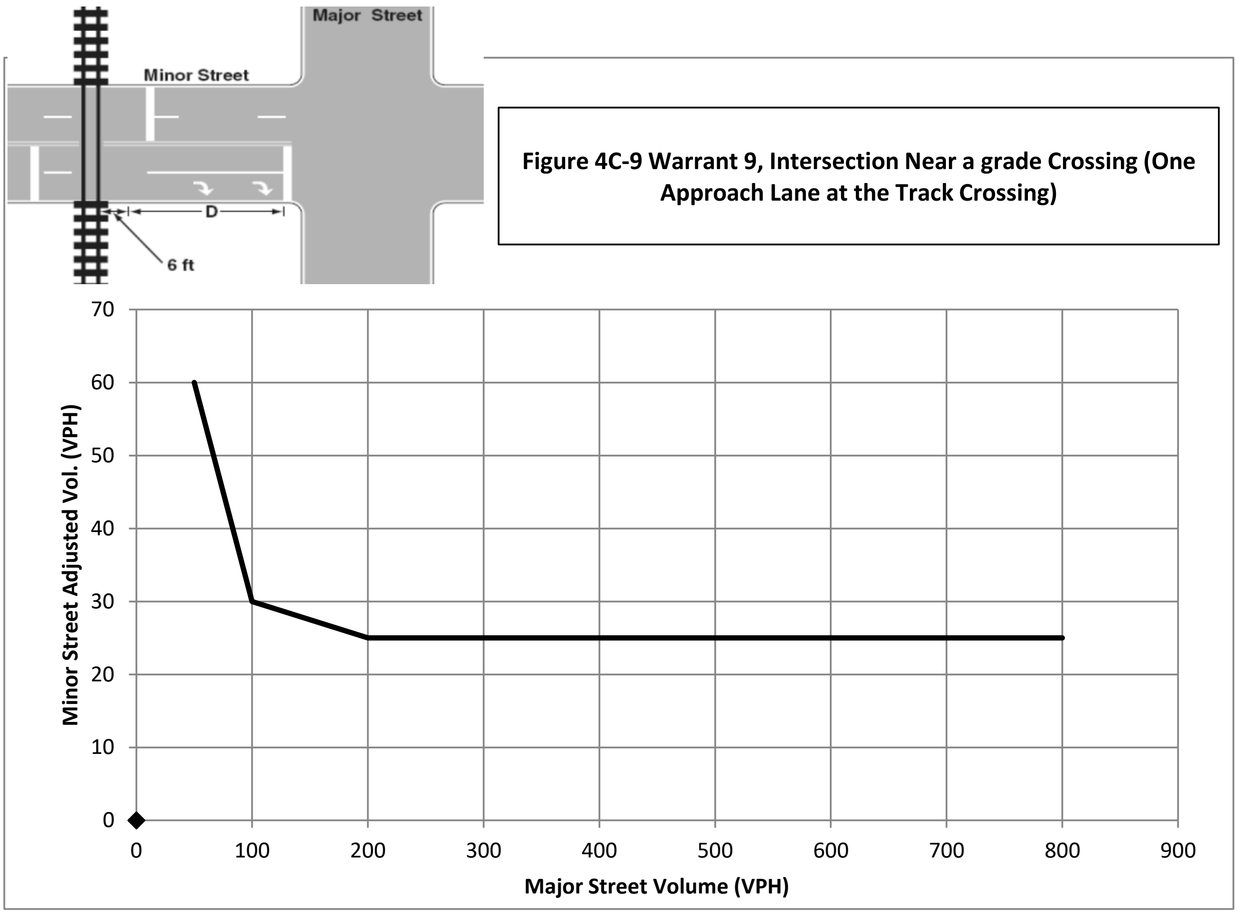


Figure 4C-9 Warrant 9, Intersection Near a grade Crossing (One Approach Lane at the Track Crossing)

Conclusions/Comments: