BRIDGE TYPE SELECTION WORKSHEET

September 2017

Bruce Freeman Rail Trail Project

Bridge No. S-31-013(XXX)

Proposed Bike Path over Pantry Brook
Sudbury, Massachusetts

PREPARED FOR

massDOT
Massachusetts Department of Transportation

PREPARED BY

vhb

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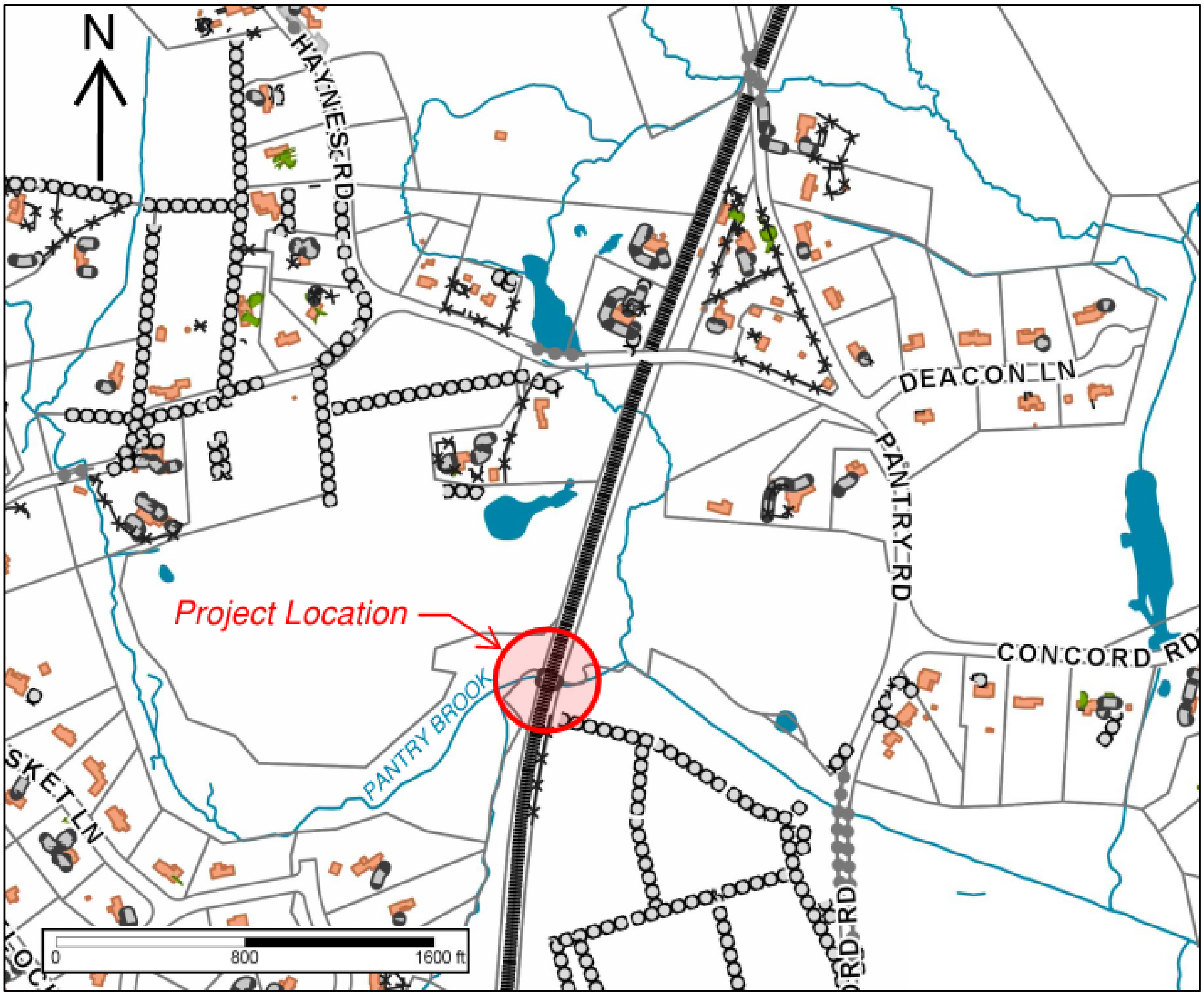
Project Location



1.1 Town: Sudbury

1.2 District: 3

1.3 Bridge Number: S-31-013

1.4 BIN: XXX (Existing: BF2)

1.5 Structure Number: S31013BF2DOTRRO

1.6 Feature Carried: Bruce Freeman Rail Trail (Existing: Abandoned Railroad)

1.7 Feature Intersected: Pantry Brook

2

Description of Existing Site Conditions

2.1 Description of Existing Bridge Structure

The existing bridge carries an abandoned railroad line over the Pantry Brook in Sudbury, Massachusetts. In 2016, the bridge was heavily damage from a breached beaver dam upstream (west of bridge). The south abutment stones have collapsed into the brook and the south wingwalls have shifted. The north abutment exhibits stone cracking and shows signs of undermining. No existing plans are available, but the abutments are presumed to have shallow foundations. The superstructure has partially collapsed on the south end where the abutment failed.

West Elevation (Looking East-Southeast)

The existing bridge is a simply supported single-span steel deck beam structure. The horizontal clearance between abutment faces is approximately 12’-0”. The single-track superstructure consists of six rolled steel I-beams, two groups of three beams, with built-up steel diaphragms, lateral bracing on the top flange, and an open deck.

The structure is supported by stone masonry abutments, square to the railroad

Looking South Across Bridge

alignment (no bridge skew). The wingwalls are oriented parallel on three corners and flared approximately 45-degrees on the northwest (upstream, left) corner.

2.2 Description of Existing Track Alignment at Approaches

The existing track alignment is situated on an elevated berm within the existing right of way (ROW). The existing track alignment runs north/south over the bridge and is tangent on both approaches.

The track curves horizontally to the east, south of the bridge.

North Approach (Looking North)

The profile of the existing track is relatively flat in the immediate area of the bridge.

South Approach (Looking South)

In the vicinity of the bridge site, the existing ROW is 66 feet wide and the existing track alignment is in the center of the ROW. The existing embankments are relatively narrow, with approximately 8-10 feet of level ground between the berm slope breaks. The level ground consists of an overgrown railroad bed with timber ties and steel tracks, and the slopes are heavily vegetated.

2.3 Description of Feature under the Bridge Structure

The existing bridge spans over the Pantry Brook.

Upstream (Looking West)

Downstream (Looking East)

The freeboard of the existing low chord above the Q100 water surface is approximately five feet.

2.4 Description of Existing Hydraulics at the Bridge Site

2.4 Existing Hydraulics

The subject crossing of the abandoned railroad bed and Pantry Brook is located in the Sudbury Assabet Concord (SuAsCo) River Watershed approximately 100 feet downstream of the confluence of Mineway Brook and Pantry Brook. Pantry Brook is a direct tributary to the Sudbury River, which is located approximately 2 miles downstream. The subject crossing is located approximately 2500 feet upstream of the Marlborough Road crossing and 1000 feet downstream of the Concord Road crossing. The contributing drainage area to Pantry Brook at the subject crossing is approximately 2.5 square miles, which consists primarily of residential, agricultural, and forested land.

The Federal Emergency Management Agency (FEMA) National Flood Insurance Program(NFIP) has studied Pantry Brook in detail. The NFIP hydrologic and hydraulic analyses of Pantry Brook were completed prior to 1982. The hydrologic analysis was performed using the USGS regression equation method (Johnson and Tasker, 1974). The hydraulic analysis was performed using the United States Army Corps of Engineers HEC-2 software. At the crossing, Pantry Brook is located in a regulatory floodplain (AE Zone) with an assigned base flood elevation (123.6 feet NAVD) and a regulatory floodway.

The Pantry Brook NFIP study is reported in the following documents:

- FEMA Flood Insurance Study for Middlesex County, July 6, 2016. Volumes 1, 2, and 6.
- FEMA Flood Insurance Rate Map 25017C0366F Panels 0366F, 0367F, 0368F, 0369F, dated July 7, 2014
- FEMA FIS for Sudbury, Massachusetts, revised November 20, 1998.

In 2016, VHB performed a field-survey of the existing crossing. The existing structure is constructed of stone masonry, portions of which have collapsed into a rubble mound within the channel. The existing structure shows signs of being undermined by scour.

During the field-survey, VHB determined that the existing crossing structure dimensions are as follows:

Table 1. Dimensions of the Existing Structure at the Crossing of the Abandoned Rail Road Bed and Pantry Brook

Dimension	Value
Width (span):	12 feet
Open height (thalweg):	14 feet
Open height (south abutment)	12 feet 3 inches
Length (@ south abutment):	40 feet
Length (@ north abutment):	26 feet

The FIS flood profile suggests that the dimensions and layout of the existing crossing have the capacity to pass the 500-year design storm with greater than 2 feet of freeboard between the water surface and the low chord. However, in-field site observations suggest that existing structural foundation elements may not be sufficient to withstand an event of this magnitude.

2.5 Description of All Utilities within the Bridge Site

There are no utilities within the bridge site.

2.6 Description of Environmentally Sensitive or Cultural Resource Areas Affecting the Bridge Site

Wetlands GIS Map

The Town of Sudbury GIS map identifies several environmental and cultural resource areas in and around the bridge site. The area around the Pantry Brook at this location is considered a Shallow Marsh/Meadow. There are no Rare Wildlife Habitats, Vernal Pools or Water Resource Protection Districts identified around this site.

Outside of the ROW corridor, the site is surrounded by conservation areas. Northwest of the bridge is Land Trust. Northeast of the bridge is Agricultural Preservation Restriction Land. South of the bridge is privately owned Conservation Restriction Land, which includes the West Pantry Brook Farm to the southeast.

For additional information reference the MassDOT Early Environmental Coordination Report.

2.7 Hazardous Materials

Hazardous materials, consistent with those found in the vicinity of former and active railways, are anticipated in the excavated soils near and within the ROW. The most common contaminants are metals, pesticides (such as lead arsenate), and petro-chemicals. Creosote from the existing cross ties is also expected.

3

Description of Project Parameters

3.1 Description of Proposed Cross Section

The proposed multi-use rail trail (hereinafter referred to as the trail) will be designed in accordance with the AASHTO Geometric Policy on Highway Design, 5th Edition, the AASHTO Guide for the Development of Bicycle Facilities, 3rd Edition, MassDOT Project Development and Design Guide, 2006, and the Americans with Disabilities Act (ADA). The trail approaches will be composed of full depth pavement with hot mix asphalt surfaces.

The trail over the bridge will conform to the following geometry:

- Width between rails of 14 feet
- Maximum gradient of five percent (5%)

Bicycle/Pedestrian railings will be required. They will be timber, to be consistent with the other railings on this project.

The bridge will be designed to carry a minimum uniform pedestrian live load of 90 pounds per square foot or H10 loading (emergency vehicle), whichever produced the greater load.

3.2 Proposed Traffic Management

The construction of this bridge is not anticipated to require any traffic control as the railroad is currently abandoned, the brook is not navigable, and access to the site will be directly via the ROW. Signage may be required along the ROW to notify pedestrians walking within the ROW of the construction.

3.3 Proposed Clearances

The proposed trail profile is being lowered by approximately one (1) foot. Additionally, the structure depth is expected to increase as the span is increased. All alternatives, however, provide clearance over the Q100 Base Flood water surface elevation.

3.4 Hydraulic Data

The existing opening has the hydraulic capacity to pass the 500-year design event with approximately 4 feet of clearance to the low chord. The proposed structure will be constructed with elements that increase the capacity of the crossing; therefore, the proposed structure is likely to meet the optimal freeboard requirement and is likely to have greater capacity to pass flood flows as compared to the existing structure.

A hydraulic study has not been completed for the proposed crossing at this time. VHB recommends that the project complete a full hydraulic report including a detailed scour analysis to support the design of structure foundations, structure transitions, and scour countermeasures. VHB also recommends that the project complete an encroachment review to certify that work within the floodway will cause no rise in the base flood profile for Pantry Brook.

HYDRAULIC DESIGN DATA

Drainage Area:	2.5 square miles
Design Flood Discharge:	240 cubic feet per second
Design Flood Frequency:	10 years
Design Flood Velocity:	not determined feet per second
Design Flood Elevation:	not determined feet, NAVD88

Base (100-YEAR) Flood Data:

Base Flood Discharge:	450 cubic feet per second
Base Flood Elevation:	123.8 feet, NAVD88

Design and Check Scour Data:

Design Scour Flood Event Return Frequency:	25 years
Check Scour Flood Event Return Frequency:	50 years

Flood of Record:

Discharge:	unknown cubic feet per second
Frequency (if known):	unknown years (percent annual chance)
Maximum Elevation:	unknown feet NAVD88
Date:	unknown
History of Ice Floes:	unknown
Evidence of Scour and Erosion:	*Field survey during 2016 indicated the presence of potentially undermined foundations.*

Scour Depth (typical): unknown

Predicted Ultimate Scour Depth: not determined, feet
Ultimate Scour Elevation: not determined, feet NAVD88

3.5 Preliminary Geotechnical Data

Geotechnical exploration and evaluation have not been completed at this time. Based on field observations, it is being proposed to found the new bridge abutment on shallow foundations. The abutments will be located within the existing embankments, which is expected to be fill material.

3.6 Constraints Imposed by Approach Track Features

The proposed trail generally follows the horizontal and vertical alignments of the existing railroad bed. In the area of this bridge, it is desirable to lower the profile by about one foot in order to avoid slope impacts or the need for retaining walls.

Construction access is limited to the existing ROW corridor. The nearest public crossing of the ROW is Haynes Road, approximately 1,000ft north. The nearest crossing to the south is Morse Road, approximately 5,000ft south. Additionally, the relatively narrow embankments (existing is approximately 10ft-11ft, proposed lowered surface will provide 16ft) along the corridor around the Pantry Brook limit the laydown areas near the bridge and could make large equipment access difficult. Because of this, consideration should be given to using construction materials that eliminate or limit the large equipment needed for construction.

3.7 Constraints Imposed by Feature Crossed

Construction access to the stream at the bottom of embankments, and on either side of the bridge will make access of larger equipment difficult; however, this does not constrain the type of structure since the in-stream work is limited to existing granite stone removal (from collapsed south abutment) and granite masonry grouting operations. This work can be completed in the wet or with limited control of water, so steel sheeting cofferdams with dewatering is not anticipated.

3.8 Constraints Imposed by Utilities

There are no known underground or overhead utilities within the general area of the bridge.

3.9 Constraints Imposed by Environmentally Sensitive Areas

To avoid impacts to environmentally sensitive areas no permanent fill is proposed within the Pantry Brook. Additionally, it is proposed to retain portions of the existing abutments and to work in the wet with limited or no dewatering.

VHB estimated the bankfull width of Pantry Brook at the subject crossing using the regional regression methods described in Bent, 2013. At this location, the bankfull width is approximately 20 feet.

A structure that meets the optimal standards for new crossings would accommodate the following features:

- An open height of 6 feet or greater
- A clear span of 1.2 x the bankfull width (1.2 x 20 = 24 feet at this location)
- An openness ratio of 2.46 or greater
- A natural streambed substrate (maintained in place or designed)

The proposed bridge will maintain the natural streambed substrate and meet the optimal dimensional requirements posed by the standards. Additionally, level banks atop the remaining stone stub abutments will provide dry passage for wildlife.

Bent, 2013. Bent, G.C., and Waite, A.M.,2013, Equations for estimating bankfull channel geometry and discharge for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2013–5155, 62 p.

3.10 Constraints Imposed by Cultural Resource Areas

There are no constraints imposed by cultural resource areas.

3.11 Hazardous Material Disposition

Hazardous materials are anticipated in some excavated soils within the ROW. On-site testing will be required to identify the limits and levels of contamination. All encountered hazardous materials will be disposed of or re-used for the trail project along the rail corridor in accordance with the Best Management Practices for Controlling Exposure to Soil during the Development of Rail Trails, by the Commonwealth of Masssachusetts Executive Office of Environmental Affairs, and all applicable regulations.

3.12 Other Bridge Constraints

The Town of Sudbury has highlighted the importance of aesthetics along this proposed trail. Aesthetics should be considered when determining structure materials, finishes, and other details.

4

Appropriate Bridge Structure Types

4.1 Alternative Identification

This site is relatively flexible and can feasibly accommodate several different bridge types and configurations; however, some of these feasible alternatives can be eliminated through initial comparison to the project goals and constraints.

The first constraint is the treatment of the existing stone masonry abutment walls and wingwalls. Re-using the full-height abutments to support a new superstructure was determined not to be practical due to the observed undermining of the north abutment footing and resulting concerns over abutment scour. Similar concerns would be present if the full-height stone walls were used as retaining walls, even if the new superstructure was supported on new abutment located behind the existing abutment walls. Scour revetment and abutment rehabilitation would be costly and have large stream impacts. Completely removing the existing stone walls would also have large impacts (for the removal and for the new full-height abutment installation or new riprap slopes). It is recommended, therefore, to leave the lower portion of the existing stone abutment walls in place as stub walls. These stub walls will likely require some rehabilitation, but they are expected to be adequate in protecting the slopes and proposed abutments from scour.

Given that stone stub walls will remain, the feasible abutment locations are directly behind the stub walls or at the tops of slopes behind the stub walls. However, a conventional abutment located directly behind the existing stone walls would still be relatively tall (approximately 14-15 feet) and expensive by observation. Additionally, the foundations would be deeper and closer to the water table. For this reason, the following two options were considered viable alternatives:

Alternative 1: Stub abutments located directly behind remaining stub stone walls with buried arch superstructure.

Alternative 2: Stub abutments (integral or conventional) located at the tops of slopes behind remaining stub stone walls with beam and slab superstructure.

Specific substructure and superstructure types and their ability to meet the project goals and constraints is discussed in the following sections.

5

Proposed Substructure Arrangement, Span and Foundation Type

5.1 Proposed Substructure Discussion

The two abutment configurations discussed in the previous section consist of cast-in-place concrete stub abutments. Precast abutments were not considered due to the heavy equipment access constraints and costs. The abutment configurations and foundations are discussed below. The foundation assumptions may have to be revised once the geotechnical investigation is completed. Approach slabs are not required for rail trails. Piers are not practical for any of the configurations due to the relatively short span lengths.

Alternative 1

The abutments for Alternative 1 (abutments placed directly behind stub walls) support one of several buried arch superstructure types. The details of the abutment will depend on the recommended superstructure type, which is discussed in the next section. The location of the abutments immediately behind the stub walls results in a span of approximately 26ft.

Shallow foundations are assumed to be adequate due to the fact that the foundations will be placed on an existing railroad fill embankment and the nature of a buried structure distributes loads so as not to create significant concentrated loads on the abutment foundation. Additionally, the foundation is protected by the portion of the existing masonry abutment to remain.

The wingwalls and headwalls are assumed to be MSE walls. The MSE Wall facing can incorporate an aesthetic finish in order to provide a more natural look. It may also be possible to incorporate the existing granite stones as part of the wingwall system.

Alternative 2

The abutments for Alternative 2 (abutments placed at the tops of slopes) support one of several beam-and-slab superstructure types. For any of these types, the abutments could either be integral or conventional. Either case results in a span length of approximately 41ft. These two abutment types for Alternative 2 are discussed below.

Integral abutments are recommended by MassDOT for highway bridges due to the fact that they have no joints. They do, however, require pile driving equipment, which can be expensive to mobilize, especially in this remote location.

Conventional abutments in this configuration can be placed on a clean subgrade, in the existing fill embankment, above the normal water surface elevation, so they are assumed to have shallow foundations. They do, however, require more concrete than integral abutments. It is assumed that the additional concrete will be more-than-offset by the cost savings of eliminating piles. Joint details for a conventional abutment can have an impact on the lifespan and maintenance, however, the impact is less on a rail trail where the exposure of the joints to corrosive runoff is less and the dynamic loads are much lower. Therefore, the preferred abutment type for Alternative 2 is a conventional stub abutment on spread footings.

Short concrete return wingwalls can be attached to the abutments. Or it may be possible to incorporate the existing granite stones as part of the wingwall system.

6

Proposed Superstructure Type

6.1 Proposed Superstructure Discussion

The proposed bridge typical section will consist of a 14ft travel way between timber railings, resulting in a bridge width of approximately 16ft. The superstructure types for both alternatives are discussed below. Drawings of the two alternatives are included in Appendix A.

Alternative 1

Three buried arch systems were considered for Alternative 1:

- Precast concrete arch
- FRP tube/decking arch (“Bridge-in-a-Backpack”)
- Galvanized steel arch

Three different vendors were contacted in order to gather information on each system’s costs and advantages. The three systems will have similar aesthetics since they are all buried arches, and the most visible element will be the headwalls and retaining walls, which would be similar for any of the systems.

While the precast concrete arch system may be the most common buried arch system for roadways, it is estimated to be the most expensive of the three arch systems. In addition to the highest delivered cost, the installation would require larger equipment for the heavier concrete elements.

The FRP tube system is estimated to be the second most expensive alternative of the three systems. Its elements are light weight, but this system is a newer and more specialized system, which could increase cost and complications during construction.

The galvanized steel arch is the cheapest and recommended superstructure type. This system has a 75-year design life, and has full HL-93 highway loading capacity. There is a miss-perception that galvanized steel is a poor material for stream crossings due to corrosion, but the corrosion is very small when the steel is above the water, and there is no bottom. This system is a proven AASHTO system.

Alternative 2

Conventional reinforced concrete slabs on abutments are inefficient for spans greater than 25’ due to their excessive depth and heavy reinforcement and were thus eliminated from further consideration. Therefore, the following three deck beam systems were considered for alternative 2:

- Adjacent Concrete Deck Beams

- Spread Concrete Deck Beams w/ Concrete Deck
- Steel Stringers w/ Concrete Deck

Preliminary beam depths were conservatively determined from Part II of the MassDOT LRFD Bridge Manual Drawings 4.1.3 and 4.1.4 using a span length of 41'. Both S36-12 and S48-12 beams were found to be applicable. Given the proposed bridge width of 16'-0", four (4) S48-12 beams were determined to be the most optimal. Adjacent precast beams provide the smallest beam depth of all of the superstructure options. Adjacent concrete deck beams are not compatible with integral abutments, since there is no practical way to fix the beam ends into the abutment cap concrete.

Preliminary beam depths were conservatively determined from Part II of the MassDOT LRFD Bridge Manual Drawings 6.1.3, 6.2.3, and 6.2.4 using a span length of 40'. The beams that work for the given geometry are a NEBT 1000, B36-24, and a B48-24. These sections are deeper and heavier than the adjacent deck beams and the steel stringers and therefore were not considered further.

Preliminary calculations for steel stringers were performed for two different beam-spacing configurations (3-beam and 4-beam cross sections) using MerlinDash. A 2-beam configuration was not evaluated due to the anticipated increased beam depth, increased deck thickness, and lack of redundancy of this alternative. The 3-beam configuration assumes beams spaced at 6'-0" with 2' overhangs. The 4-beam configuration assumes beams spaced at 4'-0" with 2' overhangs. The minimum beam depth determined using AASHTO Table 2.5.2.6.3-1 for the span to depth ratio was approximately 13.5". Therefore, the shallowest steel stringer for either spacing is a W14 section. The lightest W14 section for both a 3-beam and 4-beam configuration is a W14x109. After determining the shallowest section possible, a deeper, lighter section was investigated. The most efficient W16 section for both a 3-beam and 4-beam configuration is a W16x57. Deeper sections were investigated but found to all be heavier than the W16x57. The 4-beam configuration for both W14 and W16 sections does not provide a more efficient section and therefore a 3-beam configuration is recommended. A deeper section does not pose a problem in this case because clearance is not critical at this location. The 3-beam configuration using W16x57 beams is recommended.

The steel stringer option showed to be the cheapest, easiest to construct, and have the best aesthetics as compared to the concrete beam options. The steel stringer option is the preferred option for Alternative 2; however, as described in the following sections, it is not the overall recommended alternative.

7

Preliminary Bridge Cost Estimate

7.1 Preliminary Cost Estimate

The following cost estimates include costs for the two bridge replacement alternatives. Calculations for these estimates are included in Appendix B.

Table 1. Preliminary Cost Estimate

Alternative 1 *Galvanized steel buried arch*	**$350,000**
Alternative 2 *Steel deck beams with timber deck*	**$420,000**

8

Recommendation of Proposed Bridge Structure Type

8.1 Structure Type Recommendation

Considerations for structure selection include constructability, aesthetics, structure depths, rideability, and estimated cost and maintenance. The two alternatives require similar construction durations; however, Alternative 2 requires larger equipment to deliver and erect the longer steel beams and more clearing to create access for this equipment. Alternative 2 provides a slightly more open span and provides a look more closely matching the existing bridge; however, Alternative 1 can be detailed with aesthetic features to create a natural appearance (see examples below). Both alternatives satisfy hydraulic requirements and provide wildlife crossing accommodations below the trail. Alternative 1 will provide a smoother trail crossing and better rideability by eliminating joints and hard points; additionally, Alternative 1 has a lower estimated construction cost and is expected to have lower maintenance from having fewer components.

Based on all of these factors, Alternative 1 – galvanized steel buried arch is the selected alternative for final design.

Example 1: Galv steel buried arch with aesthetic façade

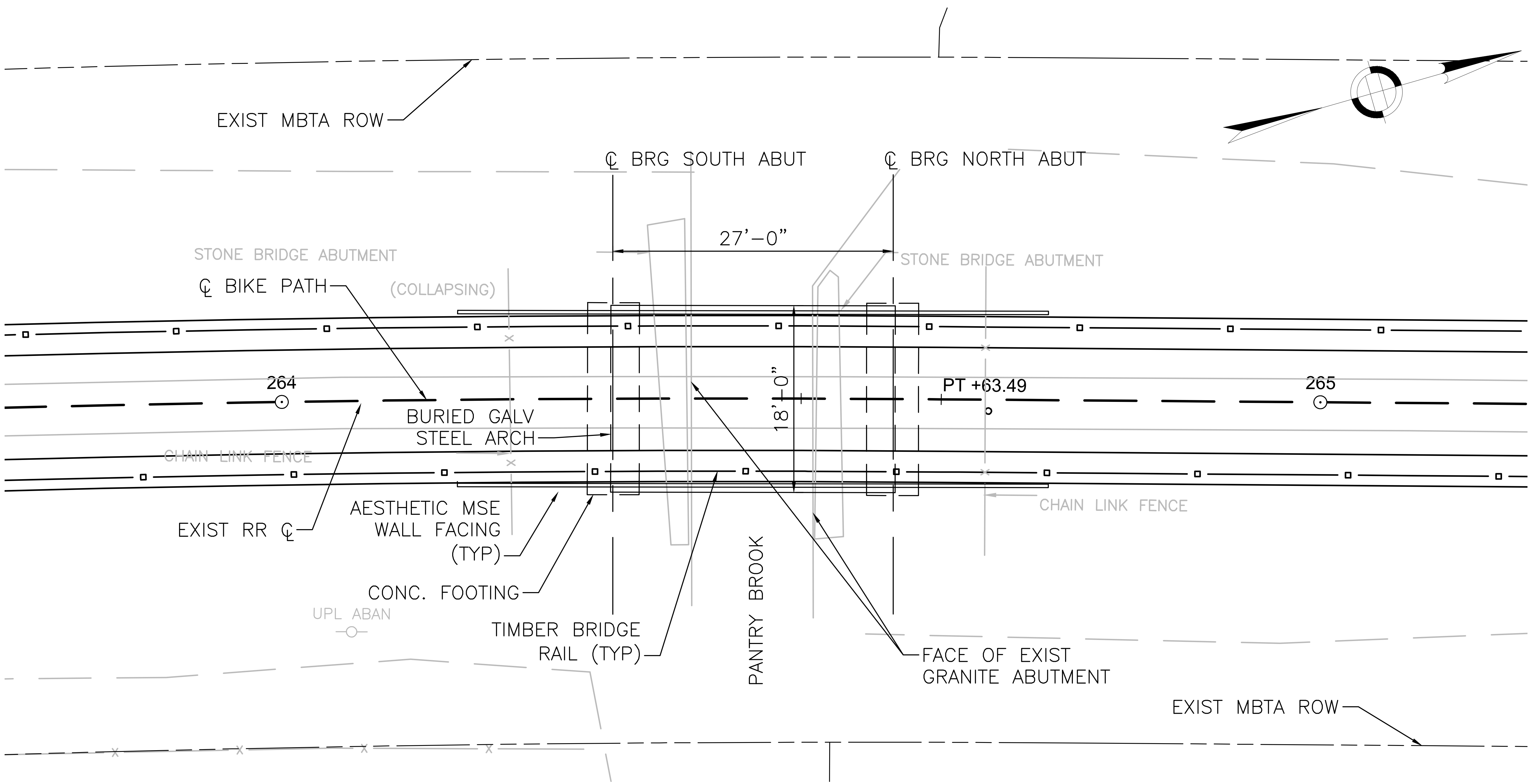
Example 2: Galv steel buried arch with aesthetic façade

Note: These examples are not intended to show renderings of the proposed crossing at Pantry Brook, but are instead illustrating the versatility of the façade appearance.

9

Appendices

Appendix A - Plan, Longitudinal Section, and Cross Sections



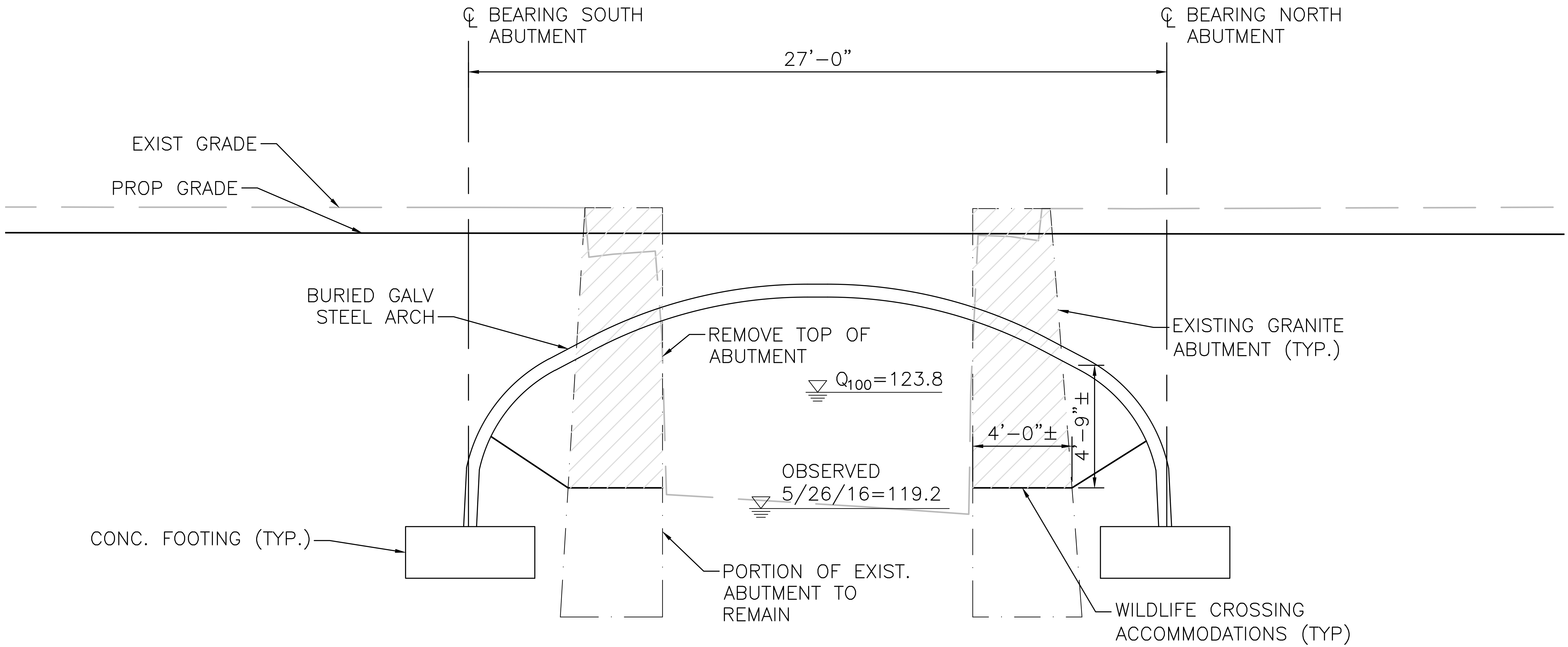
GENERAL PLAN – ALTERNATIVE 1

SCALE: 1" = 8'

Vanasse Hangen Brustlin, Inc.

Figure 1.1

GENERAL PLAN - ALT 1
Bruce Freeman Rail Trail
over Pantry Brook
Sudbury, MA



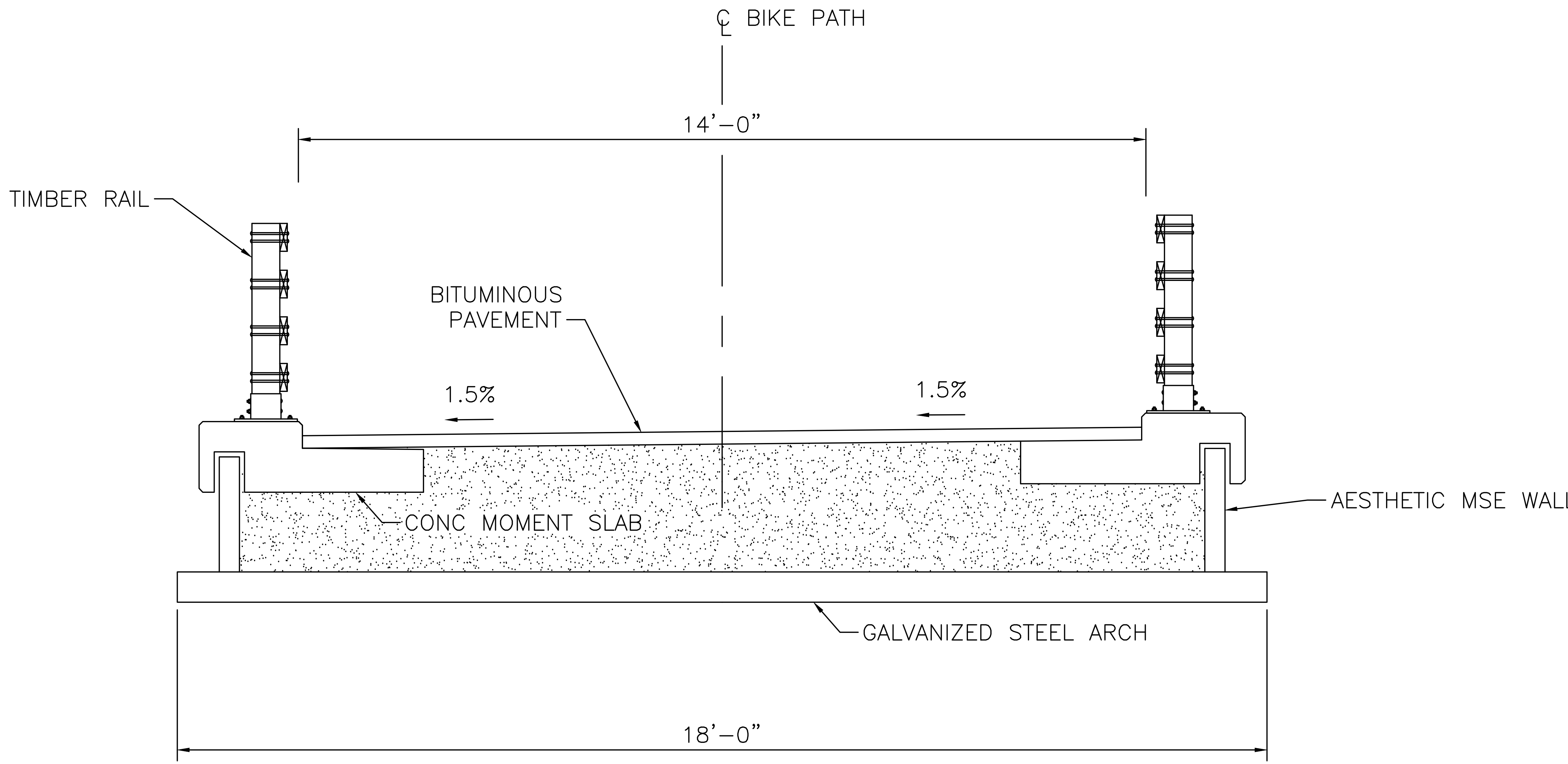
LONGITUDINAL SECTION – ALTERNATIVE 1

SCALE: $\frac{1}{4}$" = 1'-0"

Vanasse Hangen Brustlin, Inc.

Figure 1.2

LONGIT. SECTION - ALT 1
Bruce Freeman Rail Trail
over Pantry Brook
Sudbury, MA



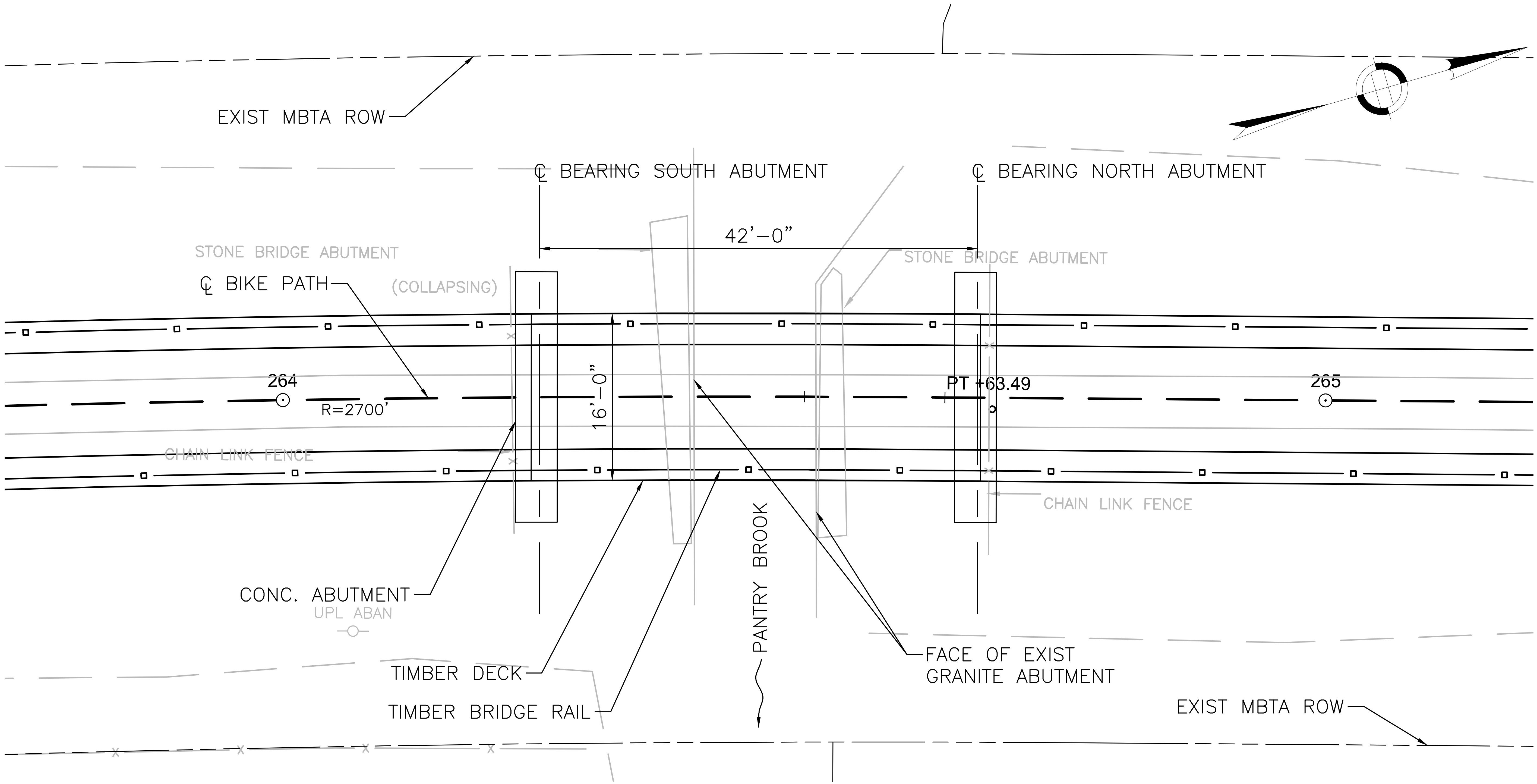
TYPICAL SECTION – ALTERNATIVE 1

SCALE: ½" = 1'-0"

Vanasse Hangen Brustlin, Inc.

Figure 1.3

TYPICAL SECTION
Bruce Freeman Rail Trail
over Pantry Brook
Sudbury, MA



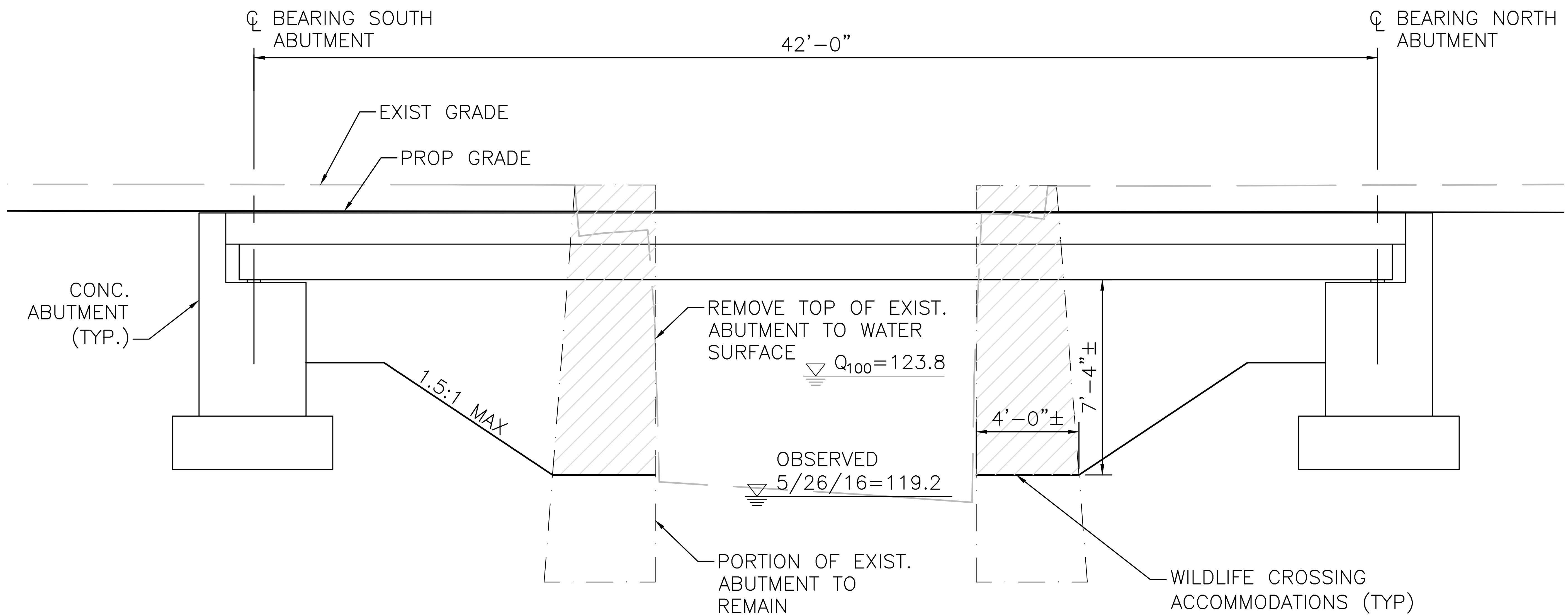
GENERAL PLAN – ALTERNATIVE 2

SCALE: 1" = 8'

Vanasse Hangen Brustlin, Inc.

Figure 2.1

GENERAL PLAN - ALT 2
Bruce Freeman Rail Trail
over Pantry Brook
Sudbury, MA



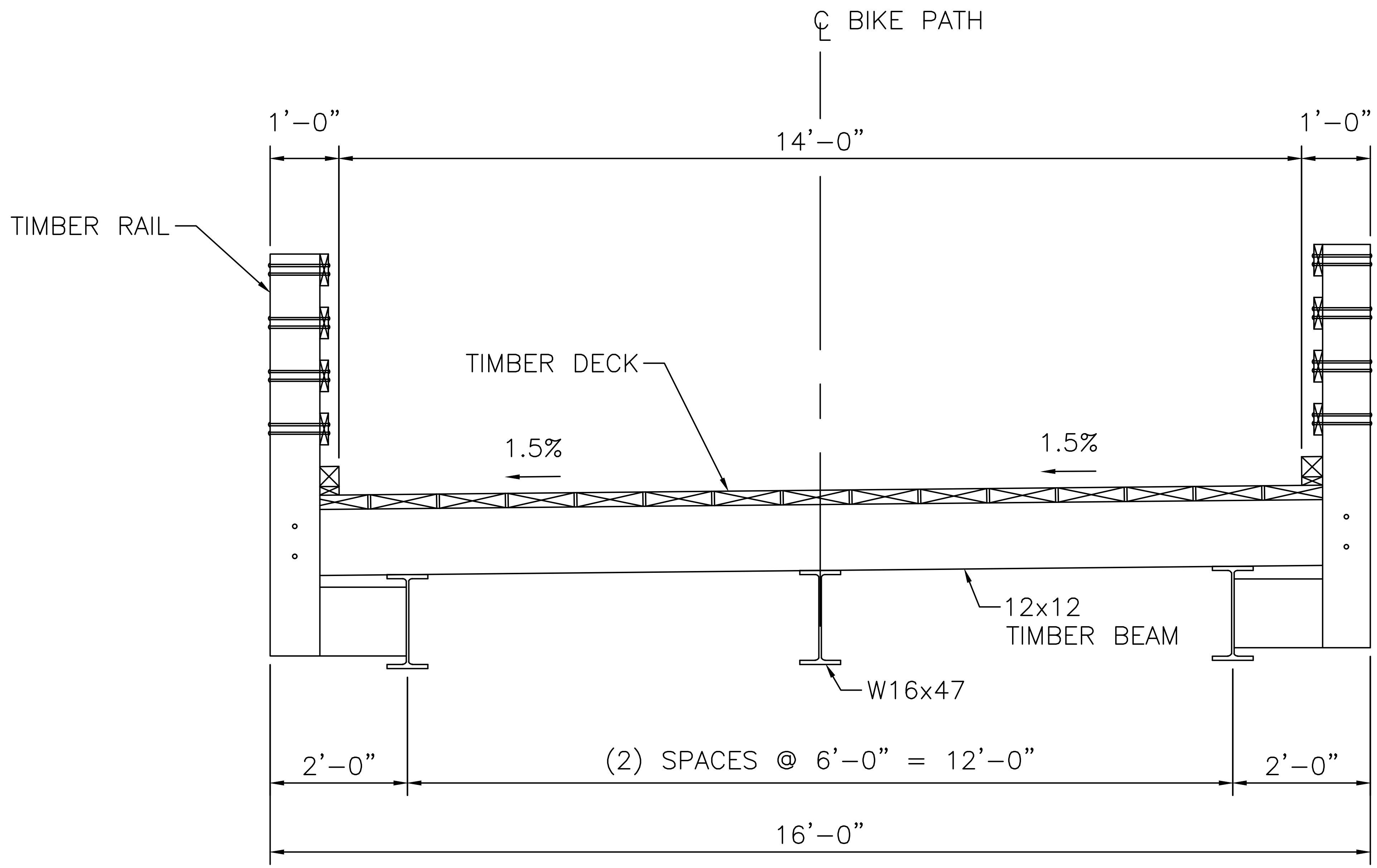
LONGITUDINAL SECTION – ALTERNATIVE 2

SCALE: ¼" = 1'-0"

Vanasse Hangen Brustlin, Inc.

Figure 2.2

LONGIT. SECTION - ALT 2
Bruce Freeman Rail Trail
over Pantry Brook
Sudbury, MA



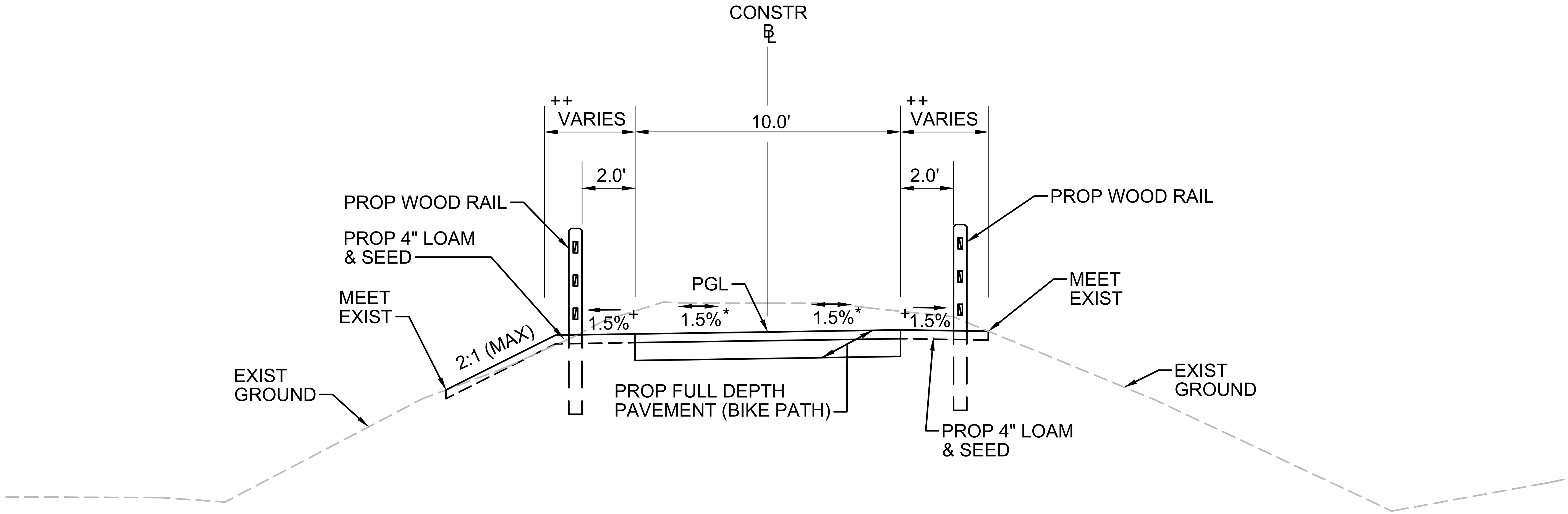
TYPICAL SECTION – ALTERNATIVE 2

SCALE: ½" = 1'-0"

Vanasse Hangen Brustlin, Inc.

Figure 2.3

TYPICAL SECTION - ALT 2
Bruce Freeman Rail Trail
over Pantry Brook
Sudbury, MA



TYPICAL APPROACH SECTION

N.T.S.

*TOLERANCE FOR CONSTRUCTION ±0.5%

SHOULDERS CAN BE UP TO 6:1 SLOPE TO AVOID CHASING SLOPES

2.0' MIN SHLD FOR NO WOOD RAIL
3.0' MIN SHLD FOR WOOD RAIL

SEE CROSS SECTIONS FOR MORE INFORMATION

Vanasse Hangen Brustlin, Inc.

Figure 4

TYPICAL APPROACH SECTION
Bruce Freeman Rail Trail
over Pantry Brook
Sudbury, MA

Appendix B – Backup Calculations

Project: Bruce Freeman Rail Trail
Location: Sudbury, MA
Calc. by: SBK
Checked by: KFJ
Title: Type Study Cost Estimate
Alt 1 - Galv Steel Arch

Project #: 12984.00
Sheet: 1 of 12
Date: 6-28-17
Date: 6-28-17

NOTE: SEE ALTERNATIVE 2 ESTIMATE FOR BREAKDOWN OF SHARED ITEMS (DEMO, MASONRY, ETC)*

Item No.	Description	Quantity	Units	Unit Cost	Cost
115.1.	DEMOLITION OF BRIDGE NO. S-31-013	1	LS	$ 16,800.00	$ 16,800.00
140.	BRIDGE EXCAVATION	232	CY	$ 50.00	$ 11,600.00
151.1	GRAVEL BORROW FOR BRIDGE FOUNDATION	14	CY	$ 49.00	$ 686.00
151.2	GRAVEL BORROW FOR BACKFILLING STRUCTURES	203	CY	$ 42.00	$ 8,526.00
655.3	TREATED TIMBER PEDESTRIAN RAILING	120	FT	$ 130.00	$ 15,600.00
690.91	MASONRY REPOINTING	25	SY	$ 100.00	$ 2,500.00
690.92	MASONRY REMOVED AND STOCKPILED	114	CY	$ 400.00	$ 45,600.00
690.93	MASONRY RESET	6	CY	$ 1,000.00	$ 6,000.00
901.	4000 PSI, 1.5 IN., 565 CEMENT CONCRETE	18	CY	$ 900.00	$ 16,200.00
904.3	5000 PSI, 3/4 IN., 685 HP CEMENT CONCRETE	13	CY	$ 1,600.00	$ 20,800.00
910.1	STEEL REINFORCEMENT FOR STRUCTURES - EPOXY	4975	LB	$ 2.65	$ 13,184.00
996.31	MSE WALL	84	SY	$ 500.00	$ 42,223.00
983.1	RIP RAP	64	TON	$ 75.00	$ 4,800.00
991	CONTROL OF WATER	1	LS	$ 20,000.00	$ 20,000.00
999	GALVANIZED STEEL CULVERT INSTALLED	1	LS	$ 52,330.00	$ 52,330.00

Sub Total =	$ 276,849.00
25% Contingency =	$ 69,212.25
Total =	$ 346,061.25
Say =	**$ 350,000.00**

995.01 BRIDGE STRUCTURE BRIDGE NO. S-31-013	$ 229,549.25

Note: Highlighted values are part of Item 995.01 Lump Sum cost

Title: Type Study Cost Estimate
Alt 1-Galv Steel Arch

Span Length =	27.00		
Existing Abutment			
Elevations			
NE =	128.98		
NW =	130.42		
SE =	129.18		
SW =	129.14		
North Exist Ground =	130.81		
South Exist Ground =	130.86		
Depth below water =	3.50	*(Assumed)*	
Water =	120.00		
Dimensions			
Length N =	25.00	24.30	
Length NE WW =	8.00	7.59	
Length NW WW =	14.00	14.00	
Length S =	32.00	31.41	
Length SW WW =	6.00	5.88	
Width all =	3.00	3.00	
Proposed Abutment			
Length =	24.00		
Footing			
Height =	2.00		
Width =	5.00		
Proposed			
Trail Elevation =	129.8		
Level landing Elev =	120.00		
Level Landing Width =	3.50		
Bridge Width =	24.00	FT	

Project: Bruce Freeman Rail Trail	Project #: 12984.00
Location: Sudbury, MA	Sheet: 3 of 12
Calc. by: SBK	Date: 6-28-17
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Title: Type Study Cost Estimate	
Alt 1-Galv Steel Arch	

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140. **BRIDGE EXCAVATION** **CY**

Note: Assume 1' excavation around perimeter in all directions
Existing dimensions obtained and estimated from survey and field notes

North Abutment

Length	=	26.0	FT	
Depth	=	15.0	FT	
Width	=	8.0	FT	*say 1ft behind plus 2ft in front (for demo of existing abut)*
Volume	=	3120.0	FT^3	

South Abutment

Length	=	26.0	FT
Depth	=	15.0	FT
Width	=	8.0	FT
Volume	=	3120.0	FT^3

Total Volume	=	231.1	CY
SAY	**=**	**232**	**CY**

Assume Unit Cost for Bridge Excavation is $50.00/CY

Unit Cost	=	$ 50.00	/CY
Total Cost	**=**	**$ 11,600.00**	

Project: Bruce Freeman Rail Trail
Location: Sudbury, MA
Calc. by: SBK
Checked by: KFJ
Title: Type Study Cost Estimate
Alt 1-Galv Steel Arch

Project #: 12984.00
Sheet: 4 of 12
Date: 6-28-17
Date: 6-28-17

151.1 **GRAVEL BORROW FOR BRIDGE FOUNDATION** **CY**

North

Depth of Borrow	=	1.0	FT	
Abutment Area	=	182.0	FT	*[1' perimeter around abutment in all directions]*
Volume	=	182.0	FT^3	

South

Depth of Borrow	=	1.0	FT	
Abutment Area	=	182.0	FT	*[1' perimeter around abutment in all directions]*
Volume	=	182.0	FT^3	

Total Volume	=	13.5	CY
SAY	**=**	**14**	**CY**

From MassDOT Weighted Bid Prices for Item No. 151.1, use $49.00/CY

Unit Cost	=	$	49.00	/CY
Total Cost	**=**	**$**	**686.00**	

151.2 **GRAVEL BORROW FOR BACKFILLING STRUCTURES AND PIPES** **CY**

North

MSE wall area 1 corner	=	190.0	FT^2
Length	=	24.0	FT
Volume Fill	=	4560.0	FT^3

South

Volume Fill	=	4560.0	FT^3

Total Volume	=	168.9	CY
Add 20% for Compaction	=	33.8	CY
SAY	**=**	**203**	**CY**

From MassDOT Weighted Bid Prices for Item No. 151.2, use $42.00/CY

Unit Cost	=	$ 42.00	/CY
Total Cost	**=**	**$ 8,526.00**	

Project: Bruce Freeman Rail Trail	Project #: 12984.00
Location: Sudbury, MA	Sheet: 6 of 12
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Title: Type Study Cost Estimate	
Alt 1-Galv Steel Arch	

655.3 **TREATED TIMBER PEDESTRIAN RAILING** **FT**

Length - N	=	60.0	FT
Length - S	=	60.0	FT

Total Length	=	120.0	FT
SAY	**=**	**120**	**FT**

From Sandwich bid tabs for a similar railing, say $130/ft

Unit Cost	=	$	130.00	/FT
Total Cost	**=**	**$**	**15,600.00**	

Project: Bruce Freeman Rail Trail	Project #: 12984.00
Location: Sudbury, MA	Sheet: 7 of 12
Calc. by: SBK	Date: 6-28-17
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Title: Type Study Cost Estimate	
Alt 1-Galv Steel Arch	

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901. **4000 PSI, 1.5 IN., 565 CEMENT CONCRETE** **CY**

Abutments *[Exclude height of backwall]*

North Abutment				*South Abutment*			
Footing				*Footing*			
Length	=	24.0	FT	Length	=	24.0	FT
Width	=	5.0	FT	Width	=	5.0	FT
Height	=	2.0	FT	Height	=	2.0	FT
Volume	=	240.0	FT^3	Volume	=	240.0	FT^3

Total Volume	=	17.8	CY
SAY	**=**	**18**	**CY**

From MassDOT Weighted Bid Prices for Item 901., Unit Cost = $700/CY

Unit Cost	=	$ 900.00	/CY
Total Cost	**=**	**$ 16,200.00**	

904.3. 5000 PSI, 3/4 IN., 685 HP CEMENT CONCRETE CY

MOMENT SLABS FOR TIMBER RAILINGS

Area	=	3.0	FT^2	measured in CAD (not including front of coping)
Length	=	57.0	FT	say between ends of walls
# Sides	=	2.0		
Volume	=	342.0	FT^3	

Total Volume	=	12.7	CY
SAY	**=**	**13**	**CY**

From MassDOT Weighted Bid Prices plus $100 for inflation and small quantity, $1500+$100=$1600/CY

Unit Cost	=	$ 1,600.00	/CY
Total Cost	**=**	**$ 20,800.00**	

Project: Bruce Freeman Rail Trail
Location: Sudbury, MA
Calc. by: SBK
Checked by: KFJ
Title: Type Study Cost Estimate
Alt 1-Galv Steel Arch

Project #: 12984.00
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Date: 6-28-17
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910.1. **STEEL REINFORCEMENT FOR STRUCTURES - EPOXY COATED** **LB**

Location	Volume (CY)	Factor (LB/CY concrete)	Reinforcing (LB)
Abutments	18.00	150	2700.0
Moment Slab	13	175	2275.0
		Weight of Steel =	4975 LB

Match Hop Br unit cost

Unit Cost	=	$ 2.65	/LB
Total Cost	**=**	**$ 13,183.75**	

Project: Bruce Freeman Rail Trail	Project #: 12984.00
Location: Sudbury, MA	Sheet: 10 of 12
Calc. by: SBK	Date: 6-28-17
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Title: Type Study Cost Estimate	
Alt 1-Galv Steel Arch	

983.1 **RIP RAP** **TON**

Length	=	20.0	FT	
Width	=	8.0	FT	
Depth	=	2.0	FT	
Volume	=	320.0	FT^2	per corner
Total Volume	=	1280.0	FT^3	

From AISC Steel Manual, weight of rip rap = 100 pcf

Total Volume	=	64.0	TON
SAY	**=**	**64**	**TON**

From MassDOT Weighted Bid Prices for Item 983.1., Unit Cost = 75.00/TON.

Unit Cost	=	$	75.00	/TON
Total Cost	**=**	**$**	**4,800.00**	

Project: Bruce Freeman Rail Trail	Project #: 12984.00
Location: Sudbury, MA	Sheet: 11 of 12
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Title: Type Study Cost Estimate	
Alt 1-Galv Steel Arch	

999. **GALVANIZED STEEL CULVERT INSTALLED** **LS**

Ref: Big R Bridge Quote	culvert delivered	$	24,330.00	
Ref: Amesbury 495 Estimate	installation	$	28,000.00	*say 4 days at $5k/day crew, plus $2k/day equi*
	Total Cost =	**$**	**52,330.00**	

Project: Bruce Freeman Rail Trail	Project #: 12984.00
Location: Sudbury, MA	Sheet: 12 of 12
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Title: Type Study Cost Estimate	
Alt 1-Galv Steel Arch	

996.31 **MSE WALL** **SY**

area		84.44444444	SY	4*190sf/9
unit cost	$	500.00		
Total Cost =	**$**	**42,222.22**		

Project: Bruce Freeman Rail Trail
Location: Sudbury, MA
Calc. by: KFJ
Checked by: SBK
Title: Type Study Cost Estimate
Alt. 2 - Steel Beams

Project #: 12984.00
Sheet: 1 of 1
Date: 6-21-17
Date: 6-21-17

Item No.	Description	Quantity	Units	Unit Cost	Cost
115.1.	DEMOLITION OF BRIDGE NO. S-31-013	1	LS	$ 16,800.00	$ 16,800.00
140.	BRIDGE EXCAVATION	368	CY	$ 50.00	$ 18,400.00
151.1	GRAVEL BORROW FOR BRIDGE FOUNDATION	18	CY	$ 49.00	$ 882.00
151.2	GRAVEL BORROW FOR BACKFILLING STRUCTURES AND PIPES	26	CY	$ 42.00	$ 1,092.00
655.3	TREATED TIMBER PEDESTRIAN RAILING	90	FT	$ 130.00	$ 11,700.00
690.91	MASONRY REPOINTING	25	SY	$ 100.00	$ 2,500.00
690.92	MASONRY REMOVED AND STOCKPILED	114	CY	$ 400.00	$ 45,600.00
690.93	MASONRY RESET	6	CY	$ 1,000.00	$ 6,000.00
901.	4000 PSI, 1.5 IN., 565 CEMENT CONCRETE	61	CY	$ 900.00	$ 54,900.00
904.	4000 PSI, 3/4 IN., 610 CEMENT CONCRETE	7	CY	$ 1,000.00	$ 7,000.00
910.	STEEL REINFORCEMENT FOR STRUCTURES	10200	LB	$ 2.65	$ 27,030.00
922.1	LAMINATED ELASTOMERIC BEARINGS W/O ANCHOR BOLTS	6	EA	$ 3,000.00	$ 18,000.00
955.	TREATED TIMBER	10	MBM	$ 3,000.00	$ 30,000.00
960.11	STRUCTURAL STEEL - UNCOATED STEEL	7524	LB	$ 9.00	$ 67,716.00
970.	BITUMINOUS DAMP-PROOFING	40	SY	$ 17.00	$ 680.00
983.1	RIP RAP	69	TON	$ 75.00	$ 5,175.00
991.	CONTROL OF WATER	1	LS	$ 20,000.00	$ 20,000.00

Sub Total =	$ 333,475.00
25% Contingency =	$ 83,368.75
Total =	$ 416,843.75
Say =	**$ 420,000.00**

Project: Bruce Freeman Rail Trail	Project #: 12984.00
Location: Sudbury, MA	Sheet: 2 of 21
Calc. by: KFJ	Date: 6-21-17
Checked by: SBK	Date: 6-21-17

Title: Type Study Cost Estimate
Precast Conc. Deck Beams

	Span Length =	43.10	
Existing Abutment			
Elevations			
	NE =	128.98	
	NW =	130.42	
	SE =	129.18	
	SW =	129.14	
	North Exist Ground =	130.81	
	South Exist Ground =	130.86	
	Depth below water =	3.50	*(Assumed)*
	Water =	120.00	
Dimensions			
	Length N =	25.00	24.30
	Length NE WW =	8.00	7.59
	Length NW WW =	14.00	14.00
	Length S =	32.00	31.41
	Length SW WW =	6.00	5.88
	Width all =	3.00	3.00
Proposed Abutment			
	Length =	24.00	
Stem			
	Height =	5.00	
	Width =	4.00	
Backwall			
	Height =	2.50	
	Width =	1.50	
Footing			
	Height =	2.00	
	Width =	7.00	
	Toe Width =	1.50	
	Heel Width =	1.50	

Project: Bruce Freeman Rail Trail	Project #: 12984.00
Location: Sudbury, MA	Sheet: 3 of 21
Calc. by: KFJ	Date: 6-21-17
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Title: Type Study Cost Estimate	
Precast Conc. Deck Beams	

Proposed

Trail Elevation =	129.8		
Level landing Elev =	124.70		
Level Landing Width =	3.00		
Embankment Width =	7.05		
Embankment Height =	4.70		
Deck Thickness =	1.17	FT	
Deck Length =	44.00	FT	
Beam Thickness =	1.33	FT	W16X57
Beam Weight =	57.00	LB/FT	
Bridge Width =	16.00	FT	

Project: Bruce Freeman Rail Trail	Project #: 12984.00
Location: Sudbury, MA	Sheet: 4 of 21
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Title: Type Study Cost Estimate	
Precast Conc. Deck Beams	

115.1 **DEMOLITION OF BRIDGE NO. S-31-013** **LS**

<u>114.1 DEMOLITION OF SUPERSTRUCTURE</u>

Bridge Deck Area = 240.0 FT^2 *[From field notes Say 12' wide x 20' long]*

Total Area	=	240.0	sf
SAY	=	240	sf

CT DOT Cost Estimating Guidelines for superstructure removal

Unit Cost	=	$ 70.00	/sf
Total Cost	**=**	**$16,800.00**	

Project: Bruce Freeman Rail Trail	Project #: 12984.00
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Title: Type Study Cost Estimate	
Precast Conc. Deck Beams	

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140. **BRIDGE EXCAVATION** **CY**

Note: Assume 1' excavation around perimeter in all directions
Existing dimensions obtained and estimated from survey and field notes

North Abutment

Length	=	26.0	FT	
Depth	=	11.5	FT	
Width	=	16.6	FT	*[From back of existing abutment to back of prop. footing]*
Volume	=	4951.5	FT^3	

South Abutment

Length	=	26.0	FT
Depth	=	11.6	FT
Width	=	16.6	FT
Volume	=	4973.0	FT^3

Total Volume	=	367.6	CY
SAY	**=**	**368**	**CY**

Assume Unit Cost for Bridge Excavation is $50.00/CY

Unit Cost	=	$ 50.00	/CY
Total Cost	**=**	**$ 18,400.00**	

Project: Bruce Freeman Rail Trail	Project #: 12984.00
Location: Sudbury, MA	Sheet: 6 of 21
Calc. by: KFJ	Date: 6-21-17
Checked by: SBK	Date: 6-21-17
Title: Type Study Cost Estimate	
Precast Conc. Deck Beams	

151.1 **GRAVEL BORROW FOR BRIDGE FOUNDATION** **CY**

North

Depth of Borrow	=	1.0	FT	
Abutment Area	=	234.0	FT	*[1' perimeter around abutment in all directions]*
Volume	=	234.0	FT^3	

South

Depth of Borrow	=	1.0	FT	
Abutment Area	=	234.0	FT	*[1' perimeter around abutment in all directions]*
Volume	=	234.0	FT^3	

Total Volume	=	17.3	CY
SAY	**=**	**18**	**CY**

From MassDOT Weighted Bid Prices for Item No. 151.1, use $49.00/CY

Unit Cost	=	$	49.00	/CY
Total Cost	**=**	**$**	**882.00**	

Project: Bruce Freeman Rail Trail	Project #: 12984.00
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Title: Type Study Cost Estimate	
Precast Conc. Deck Beams	

151.2 **GRAVEL BORROW FOR BACKFILLING STRUCTURES AND PIPES** **CY**

North

Area Behind Prop Abut.	=	20.8	FT^2
Length	=	26.0	FT
Volume Fill	=	539.5	FT^3

South

Area Behind Prop Abut.	=	26.0	FT^2
Length	=	26.0	FT
Volume Fill	=	676.0	FT^3

Total Volume	=	20.9	CY
Add 20% for Compaction	=	4.2	CY
SAY	**=**	**26**	**CY**

From MassDOT Weighted Bid Prices for Item No. 151.2, use $42.00/CY

Unit Cost	=	$	42.00	/CY
Total Cost	**=**	**$**	**1,092.00**	

Project: Bruce Freeman Rail Trail	Project #: 12984.00
Location: Sudbury, MA	Sheet: 8 of 21
Calc. by: KFJ	Date: 6-21-17
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Title: Type Study Cost Estimate	
Precast Conc. Deck Beams	

655.3 **TREATED TIMBER PEDESTRIAN RAILING** **FT**

Length - N	=	45.0	FT
Length - S	=	45.0	FT

Total Length	=	90.0	FT
SAY	**=**	**90**	**FT**

From Sandwich bid tabs for a similar railing, say $130/ft

Unit Cost	=	$	130.00	/FT
Total Cost	**=**	**$**	**11,700.00**	

Project: Bruce Freeman Rail Trail	Project #: 12984.00
Location: Sudbury, MA	Sheet: 9 of 21
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Checked by: SBK	Date: 6-21-17
Title: Type Study Cost Estimate	
Precast Conc. Deck Beams	

690.91 **MASONRY REPOINTING** **SY**

Note: Assume retain abuments and wingwalls below water elev.

<u>Abutments</u>

North Abutment

Length	=	25.0	FT
Depth	=	3.5	FT
Area	=	87.5	FT^2

South Abutment

Length	=	32.0	FT
Depth	=	3.5	FT
Area	=	112.0	FT^2

<u>Wingwalls</u>

NW Wingwall

Length	=	14.0	FT
Height	=	3.5	FT
Area	=	49.0	FT^2

NE Wingwall

Length	=	8.0	FT
Height	=	3.5	FT
Area	=	28.0	FT^2

S Wingwalls

Length	=	6.0	FT
Height	=	3.5	FT
Area	=	21.0	FT^2

Total Volume	=	33.1	SY
Say 75% of total face area	=	24.8	SY
SAY	**=**	**25**	**SY**

From MassDOT Weighted Bid Prices for Item No. 690.91, use $100.00/SY

Unit Cost	=	$ 100.00	/SY
Total Cost	**=**	**$ 2,500.00**	

Project: Bruce Freeman Rail Trail
Location: Sudbury, MA
Calc. by: KFJ
Checked by: SBK
Title: Type Study Cost Estimate
Precast Conc. Deck Beams

Project #: 12984.00

Date: 6-21-17
Date: 6-21-17

690.92 **MASONRY REMOVED AND STOCKPILED** **CY**

Note: Existing dimensions estimated from survey and field notes
Assume existing abuments and wingwalls cut down to water elev.

Abutments

North Abutment

Length	=	25.0	FT
Height	=	11.0	FT
Width	=	4.0	FT
Volume	=	1100.0	FT^3

South Abutment

Length	=	32.0	FT
Height	=	10.0	FT
Width	=	4.0	FT
Volume	=	1280.0	FT^3

Wingwalls

NW Wingwall

Length	=	14.0	FT
Height	=	11.0	FT
Width	=	4.0	FT
Volume	=	308.0	FT^3

NE Wingwall

Length	=	8.0	FT
Height	=	9.0	FT
Width	=	4.0	FT
Volume	=	144.0	FT^3

South Wingwalls

Length	=	6.0	FT
Height	=	10.0	FT
Width	=	4.0	FT
Volume	=	240.0	FT^3

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Precast Conc. Deck Beams	

Total Volume	=	113.8	CY
SAY	**=**	**114**	**CY**

*From MassDOT WBP Item No. 121., say x2 for removal, then double for stockpiling ($100/cy*2*2=$400/CY)*

Unit Cost	=	$ 400.00	/CY
Total Cost	**=**	**$ 45,600.00**	

Project: Bruce Freeman Rail Trail	Project #: 12984.00
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Precast Conc. Deck Beams	

690.93 **MASONRY RESET** **CY**

Note: Rebuild Southwest wingwall

Length	=	20.0	FT
Height	=	4.0	FT
Width	=	4.0	FT
Volume	=	160.0	FT^3

Total Volume	=	5.9	CY
SAY	**=**	**6**	**CY**

*From MassDOT Weighted Bid Prices for Item No. 685. *150% for large stones, $1000.00/CY*

Unit Cost	=	$	1,000.00	/CY
Total Cost	**=**	**$**	**6,000.00**	

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Precast Conc. Deck Beams

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901. **4000 PSI, 1.5 IN., 565 CEMENT CONCRETE** **CY**

Abutments *[Exclude height of backwall]*

North Abutment

Stem

Length	=	24.0	FT
Width	=	4.0	FT
Height	=	5.0	FT
Volume	=	480.0	FT^3

Footing

Length	=	24.0	FT
Width	=	7.0	FT
Height	=	2.0	FT
Volume	=	336.0	FT^3

South Abutment

Stem

Length	=	24.0	FT
Width	=	4.0	FT
Height	=	5.0	FT
Volume	=	480.0	FT^3

Footing

Length	=	24.0	FT
Width	=	7.0	FT
Height	=	2.0	FT
Volume	=	336.0	FT^3

Total Volume	=	60.4	CY
SAY	**=**	**61**	**CY**

From MassDOT Weighted Bid Prices for Item 901., Median Unit Cost = $1000/CY, say $900/CY for simple footing

Unit Cost	=	$ 900.00	/CY
Total Cost	**=**	**$ 54,900.00**	

904. **4000 PSI, 3/4 IN., 610 CEMENT CONCRETE** **CY**

<u>Backwalls</u>

North Backwall				*South Backwall*			
Length	=	24.0	FT	Length	=	24.0	FT
Width	=	1.5	FT	Width	=	1.5	FT
Height	=	2.50	FT	Height	=	2.50	FT
Volume	=	90.0	FT^3	Volume	=	90.0	FT^3

Total Volume	=	6.7	CY
SAY	**=**	**7**	**CY**

match Hop Brook Cost, low quantity

Unit Cost	=	$ 1,000.00	/CY
Total Cost	**=**	**$ 7,000.00**	

Project: Bruce Freeman Rail Trail
Location: Sudbury, MA
Calc. by: KFJ
Checked by: SBK
Title: Type Study Cost Estimate
Precast Conc. Deck Beams

Project #: 12984.00
Sheet: 15 of 21
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910. STEEL REINFORCEMENT FOR STRUCTURES LB

Location	Volume (CY)	Factor (LB/CY concrete)	Reinforcing (LB)
Abutments	61.00	150	9150.0
Backwalls	7	150	1050
		Weight of Steel =	10200 LB

Match Hop Br unit cost

Unit Cost = $ 2.65 /LB
Total Cost = $ 27,030.00

Project: Bruce Freeman Rail Trail
Location: Sudbury, MA
Calc. by: KFJ
Checked by: SBK
Title: Type Study Cost Estimate
Precast Conc. Deck Beams

Project #: 12984.00
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922.1. **LAMINATED ELASTOMERIC BEARINGS W/O ANCHOR BOLTS** **EA**

# of Beams	=	3
Bearings per Beam	=	2

Total # of Bearings = 6

Assume Unit Cost for Elastomeric Bearings w/o Anchor Bolts is $800.00/EA

Unit Cost	=	$	3,000.00	/EA
Total Cost	**=**	**$**	**18,000.00**	

Project: Bruce Freeman Rail Trail	Project #: 12984.00
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Precast Conc. Deck Beams	

955. **TREATED TIMBER** **MBM**

Timber Decking

Height	=	1.17	FT
Width	=	16.00	FT
Length	=	44.00	FT
Volume	=	821.3	FT^3

Members	=	9.9	MBM	*83.33 FT^3 /MBM*
SAY	**=**	**10**	**MBM**	

From MassDOT Weighted Bid Prices for Item 955., Unit Cost = $3,000.00/MBM

Unit Cost	=	$	3,000.00	MBM
Total Cost	**=**	**$**	**30,000.00**	

Project: Bruce Freeman Rail Trail	Project #: 12984.00
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Title: Type Study Cost Estimate	
Precast Conc. Deck Beams	

960.11 **STRUCTURAL STEEL - UNCOATED STEEL** **LB**

<u>W16X57</u>

Weigth	=	57.00	LB/FT
Length	=	44.00	FT
# of S36-12 Beams	=	3	

Total Length	=	7524.00	LB
SAY	**=**	**7524**	**LB**

From 2009 MassDOT Bridge Manual for Item #960.1 and U.S. Inflation Calculation, Unit Cost = $9.00/LB

Unit Cost	=	$	9.00	/LB
Total Cost	**=**	**$**	**67,716.00**	

Project: Bruce Freeman Rail Trail
Location: Sudbury, MA
Calc. by: KFJ
Checked by: SBK
Title: Type Study Cost Estimate
Precast Conc. Deck Beams

Project #: 12984.00

Date: 6-21-17
Date: 6-21-17

970. **BITUMINOUS DAMP-PROOFING** **SY**

<u>Abutments</u>

North Abutment

Height	=	7.5	FT
Length	=	24.0	FT
Area	=	180.0	FT^2

South Abutment

Height	=	7.5	FT
Length	=	24.0	FT
Area	=	180.0	FT^2

Total Area	=	40.0	SY
SAY	**=**	**40**	**SY**

From MassDOT Weighted Bid Prices for Item 970., Unit Cost = $17.00/SY

Unit Cost	=	$	17.00	/SY
Total Cost	**=**	**$**	**680.00**	

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Location: Sudbury, MA	Sheet: 20 of 21
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Precast Conc. Deck Beams	

983.1 **RIP RAP** **TON**

Length	=	30.0	FT
Width	=	11.5	FT
Depth	=	2.0	FT
Volume	=	688.4	FT^2
Total Volume	=	1376.8	FT^3

From AISC Steel Manual, weight of rip rap = 100 pcf

Total Volume	=	68.8	TON
SAY	**=**	**69**	**TON**

From MassDOT Weighted Bid Prices for Item 983.1., Unit Cost = 75.00/TON.

Unit Cost	=	$	75.00	/TON
Total Cost	**=**	**$**	**5,175.00**	

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Precast Conc. Deck Beams	

991. **CONTROL OF WATER** **LS**

Assume water control =	$	50,000.00
Total Cost =	**$**	**50,000.00**