Brook Road Bridge

Alternatives Report

PREPARED FOR

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02/12/2020

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Executive Summary

The purpose of this Alternatives Report is to evaluate options for the replacement of Bridge 21 on Brook Road in Plainfield, Vermont over the Great Brook. This report provides a detailed discussion of the existing conditions, replacement alternatives, and recommendations.

The existing bridge which conveys traffic along Brook Road over Great Brook is prone to flooding and clogging with woody debris and sediment. Recent storm events in 2011 and 2015 have caused partial clogging of the bridge forcing the flow of the Great Brook to jump its banks, resulting in damage to local homes and destroying a section of Brook Road. The Brook Road Bridge has been determined to be hydraulically undersized and characteristics of the Great Brook channel at this location also contribute to the bridge being prone to debris jams and backwatering during 10-year and larger storm events.

An Alternatives Analysis for improving the Brook Road Bridge was completed by Milone and MacBroom in February of 2016 and can be found in Appendix B of this report. The result of that analysis was that the Town of Plainfield has selected to replace the existing bridge with a structure that will span the 36 feet bankfull width of Great Brook and raise Brook Road 6 inches. Therefore, the structure alternatives studied within this report meet those requirements. The feasible bridge replacement alternatives are:

1. Pre-Cast/Pre-Stressed Concrete Slabs
2. Pre-Cast Concrete NEXT D Beams
3. Steel Beams or Girders with a Cast-In-Place Concrete Deck
4. 3-Sided Box Culvert or Arch

Each of these alternatives has two substructure alternatives. Alternative A which supports the superstructure on a driven H-pile foundation consisting of driven steel piles with a concrete pile cap. And Alternative B which supports the superstructure on a shallow foundation (six feet below the streambed) consisting of a concrete stem wall with a spread footing.

Alternative 1A, replacement of the existing bridge with a pre-cast/pre-stressed concrete slab superstructure with a driven H-pile foundation is the recommended alternative as it provides the greatest flood resiliency and life expectancy of all the alternatives and requires the least amount of future maintenance.

Environmental impacts and right-of-way needs have been conceptually considered and will be further evaluated and defined during the design phase of the project.

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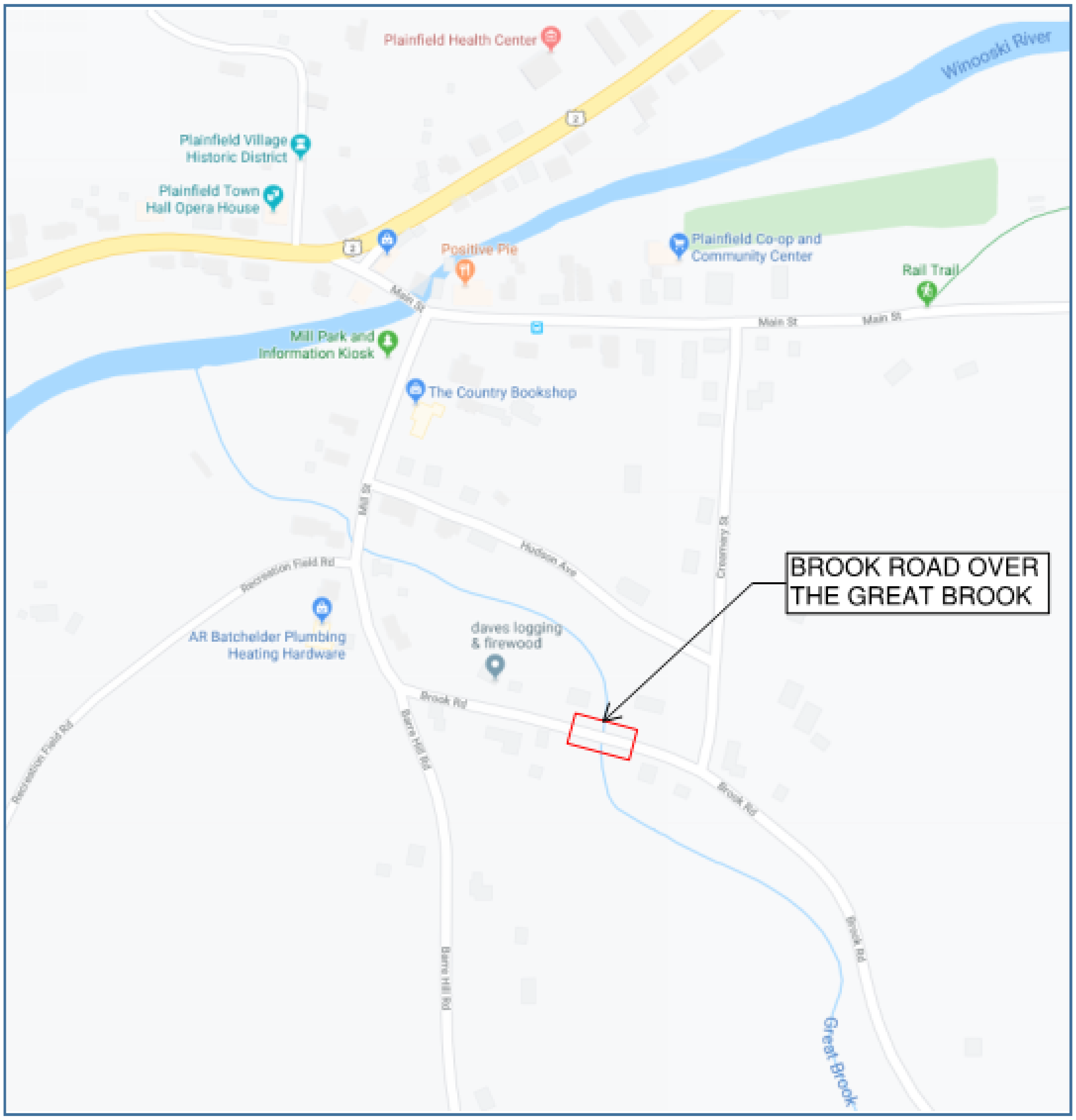
Project Overview

2.1 Project Background

The project is in the Town of Plainfield, Vermont on Brook Road (TH 2) at its crossing of the Great Brook, between Mill Street (TH 1) and Creamery Street (TH 9). The brook flows in a northerly direction under Brook Road and continues to flow in a north-west direction until its confluence with the Winooski River, also in Plainfield. The existing bridge is a single span, two lane bridge that consists of a 20 feet wide deck with concrete bridge railings carried by five concrete T-Beams which are supported on cast-in-place concrete abutments. The existing structure spans 25 feet +/-. Existing conditions are described in more detail in the following sections of this report. Site photos of the existing structure, roadway, and channel are included in Appendix A.

Figure 1 Location Map



Location Map
Bridge No. 21 over Great Brook
Plainfield, Vermont

2.1.1 Great Brook

The headwaters of the Great Brook originate on Signal Mountain in the southwest portion of the Town of Groton, Vermont. The river generally flows in a northwesterly direction to its confluence with the Winooski River in the Town of Plainfield, VT. At the project location, the Great Brook watershed consists of an area measuring approximately 14 square miles. The brook generally flows through a narrow valley with steep walls which have led to mass failures of the wall. The slope of the Great Brook, steepness of the valley walls and mass failures create a channel that has a high sediment bedload and woody debris movement during flooding.

2.1.2 Brook Road (TH 2) and Existing Bridge (BR 21)

Brook Road runs from its intersection with Mill Street (TH 1) east over the Great Brook to Creamery Street then turns and heads southeast following the Great Brook for approximately 5 miles to Orange, Vermont where it becomes Reservoir Road. The road is identified as a Class 2 Town Highway with a posted speed limit of 25 MPH within the project area.

The existing bridge consists of five concrete T-Beams with a concrete deck and bituminous asphalt wearing surface and concrete bridge railings. The bridge has a span length of approximately 25 feet and a deck width of 20 feet. The bridge and approach roadway have been damaged several times during recent flooding, which is a concern for the ongoing performance of the structure. The bottom sides of the concrete T-Beams have areas of spalling and exposed reinforcing, and the concrete abutments also have significant spalls at the waterline and end of the wingwalls. Per the latest bridge inspection report (see Appendix C) completed by VTrans on August 2, 2017, the superstructure and substructure were both rated a 6, or in satisfactory condition. The bridge deck is rated a 7, or in good condition, however the deck geometry is only appraised as a 4 for meeting the minimum tolerable criteria and the bridge and approach rails are appraised as 0 or not meeting current standards.

The bridge substructure consists of concrete abutments that are supported by a concrete foundation. The abutments are cracking and have efflorescence with localized spalling. A concrete retaining wall starts behind the northwest wingwall and extends approximately 140 feet downstream and forms the western side of the Great Brook channel. A portion of the retaining wall is also a part of the foundation for the house located on the northwest corner of the bridge. While the bridge inspection report does rate the waterway adequacy a 6 and notes occasional overtopping with insignificant roadway delays the report does not specifically address hydraulic inadequacy of the bridge or impacts to the roadway and residences when flooding does occur.

2.1.3 Utilities

There are both municipal sewer and water underground utilities along Brook Road. The municipal sewer does not cross Great Brook; however, sewer manholes are located approximately 80 feet to the west of the existing bridge and 160 feet to the east. The municipal water main running along Brook Road is believed to run along the southern side of Brook Road based on the location of a fire hydrant on the south side of Brook Road approximately 175 feet east of the existing bridge. The waterline is believed to cross the Great Brook, below the streambed, south of the existing bridge. Coordination with the town Water and Wastewater Commission will be completed to more accurately determine the location of both the water and sewer utilities and discuss the need to relocate these as necessary.

The overhead utilities on Brook Road originate from the intersection of Brook Road with Mill Street. The overhead utilities run east to west and are located on the North side of Brook Road, including the crossing of the Great brook. Due to the proximity of the overhead utilities to the roadway and the bridge, it will be necessary to relocate the overhead utilities to allow for the replacement of the existing bridge. Temporary and permanent utility relocations will be discussed with the utility companies during the design phase of the project.

2.1.4 Natural/Cultural Resources

VHB has performed a review of the Agency of Natural Resources (ANR) Atlas to determine the presence of environmental and historical resources at the project site. Based on our review, the permits that would be required are a Vermont Stream Alteration General Permit, the U.S. Army Corps of Engineers (USACE) 404 permit for work below Ordinary High Water (OHW), clearance from the Vermont Division for Historical Resources, and any local permitting requirements. These permits would be required for the removal and replacement of the existing structure and for placement of stone fill in front of the existing abutments.

Hartgen Archeological Associates, Inc. (Hartgen) conducted an Archeological Resource Assessment for the Bridge 21 replacement. Hartgen determined that based on the anticipated project impact areas and previous disturbance in these areas from flooding, filling, and armoring that the Archeological Potential of the project has been severely limited. No further archeological review was recommended unless project limits extended to areas not previously disturbed by flooding and filling. Additional information on the Archeological Resource Assessment can be found in Appendix D of this report.

3

Alternatives

3.1 Project Definition

Due to the insufficient hydraulic capacity of the bridge, the ongoing safety and performance concerns related to the existing bridge, and the alternatives analysis completed by Milone and MacBroom in their Great Brook Bridge Alternatives Report dated February 15th 2016, which can be found in Appendix B of this report, the Town of Plainfield elected to remove and replace the existing structure. The alternative selected by the Town following the Alternatives Report by Milone and MacBroom consisted of replacing the existing structure with a structure on the existing roadway alignment, increasing the length of the bridge to 36 feet to accommodate the bankfull width, raising the elevation of Brook Road six inches at the bridge, and installing a flood bench on the eastern side of the channel.

3.1.1 Purpose and Need

The purpose of the Brook Road Bridge Replacement Project is to improve the safety and reliability of the structure, enhance mobility for all modes of transportation, and ensure appropriate balance between transportation infrastructure and the natural environment.

Due to the insufficient hydraulic capacity of Bridge 21 and the condition of the concrete T-Beams, there are safety and longevity concerns for the structure, the surrounding roadway, and the local residences. If the existing conditions of the bridge were to remain without action, Great Brook would likely continue to overtop Brook Road as it has done in past storm events, causing extensive damage to the bridge and surrounding area.

Replacement of the existing structure is needed to allow for the safe crossing of Brook Road over the Great Brook. The preferred alternative will be selected and designed to carry all legal highway loads safely across the structure.

3.1.2 Proposed Geometry

As part of the previous Alternatives Analysis completed by Milone and MacBroom, the Town of Plainfield decided to replace the existing bridge with a structure that would span the bankfull width and increase the roadway elevation by six inches. Therefore, the bridge will meet or exceed a 36-foot clear span, and the vertical alignment of the roadway will be raised six inches to increase the vertical hydraulic opening of the proposed structure.

Additionally, the proposed alternative is intended to utilize the existing horizontal alignment of the structure. The roadway typical section will be designed in accordance with the Vermont State Design Standards and match into the existing roadway. For a rural local road with a speed limit of 25 MPH and an ADT of less than 1500, the Vermont State Design Standards require a roadway width of 22’-0”. This would provide two 9’-0” travel lanes with 2’-0” shoulders. As the Town of Plainfield has plans for a future sidewalk on the north side of Brook Road the total bridge width has been determined to be 29’-6” to accommodate a 5’-0” sidewalk with a 6”curb, and two bridge rails.

3.1.3 Construction Methods and Maintenance of Traffic

Methods of construction considered for this project include utilizing a closure of Brook Road at the project location, and an off-site detour to divert traffic around the construction. Accelerated bridge construction (ABC) methods will be considered for the construction of this bridge and its components.

Some of the ABC methods that could be used for this bridge include; driving piles prior to the closure period, using precast concrete abutments, and using precast superstructure and deck components. All these activities would occur off-site or adjacent to Brook Road and reduce the bridge closure period. VHB will evaluate various ABC methods once a preferred alternative is selected in order to balance methods which would be both economical to the Town and shorten the bridge closure period.

Coordination with emergency services will be required once a preferred alternative is selected to ensure an appropriate level of service and response time can be provided to the local residences throughout a closure.

3.2 Alternative Identification

This section of the report provides a discussion of alternatives which have been identified for this project. Typical sections and a plan view of each alternative are shown in the Alternative Concept Plans (Appendix E) for reference. For purposes of this report Alternatives 1 and 2 are shown with the driven H-pile foundation alternative (Alternative A) consisting of driven steel H-piles with a concrete pile cap in the plan view. Alternatives 3 and 4 show a spread footing foundation (Alternative B) consisting of a concrete stem wall on a spread footing, depicted as a dashed line around the end of the bridge in the plan view. It is important to note that each of the four alternatives could use either the deep or shallow foundations.

The following are the most critical considerations in the development and evaluation of the project alternatives (not in order of precedence):

- Construction Costs
- Environmental Impacts
- Hydraulic Capacity
- Impacts to the Residents
- Life Cycle Costs
- ROW Impacts

As each alternative could use either a driven H-pile or spread footing foundation, the following discussion on Alternatives 1 through 4 do not consider the foundation type, but only consider the superstructure. However, the Evaluation Matrix is broken out to reflect an 'A' (driven H-pile foundation) and a 'B' (spread footing foundation) alternative reflecting the two foundation types. Additionally, sections 3.2.5 and 3.2.6 contain a discussion of each foundation type and its advantages and disadvantages.

3.2.1 Alternative 1 – Precast/Prestressed Concrete Slabs

This alternative replaces the existing bridge with a precast/prestressed concrete slab superstructure with a concrete overlay or spray applied waterproofing membrane and pavement. The bridge railing would be a cast-in-place concrete and steel tubing combination bridge rail. The bridge rail will be appropriate for vehicular, bicycle and pedestrian traffic and installed on both sides of the bridge along with associated approach and transition guardrail. A concrete sidewalk will be located on the north side of the bridge. Due to standard precast slab dimensions the proposed total bridge with for this alternative is 30′-0″. It is more economical to use standard 3ft and 4ft wide slabs rather than a non-standard width slab and therefore the bridge width would be 30′-0″ rather than the 29′-6″. The anticipated design life for this alternative is 75 years.

Advantages of Alternative 1

- Largest hydraulic opening
- Greatest vertical opening
- Local contractors have experience with constructing this type of bridge
- Low future maintenance cost
- Longest anticipated design life
- Accommodates all legal highway loads

Disadvantages of Alternative 1

- High construction cost
- Requires the bridge width to be 6″ wider (30′ wide compared to 29′-6″)
- Requires more precast concrete members to be erected
- Requires specialized construction equipment for post tensioning

3.2.2 Alternative 2 – Precast/Prestressed Concrete NEXT D Beams

This alternative replaces the existing bridge with a precast/prestressed concrete NEXT D beam superstructure with spray applied waterproofing membrane and pavement. The bridge railing would be a cast-in-place concrete and steel tubing combination bridge rail. The bridge rail will be appropriate for vehicular, bicycle and pedestrian traffic and installed on both sides of the bridge along with associated approach and transition guardrail. A concrete sidewalk will be located on the north side of the bridge. The anticipated design life for this alternative is 75 years.

Advantages of Alternative 2

- Low future maintenance cost
- Longest anticipated design life
- Accommodates all legal highway loads
- Has the least number of precast members to be erected
- No specialized construction equipment required

Disadvantages of Alternative 2

- High construction cost
- Reduced hydraulic opening
- Reduced vertical opening
- Superstructure has potential for catching and trapping debris
- Bridge length is at lower end of span length for NEXT D Beams

3.2.3 Alternative 3 – Steel Beams or Girders with a Cast-In-Place Concrete Deck

This alternative replaces the existing bridge with galvanized steel beams or girders and a cast-in-place concrete deck with spray applied waterproofing membrane and pavement. The bridge railing would be a cast-in-place concrete and steel tubing combination bridge rail. The bridge rail will be appropriate for vehicular, bicycle and pedestrian traffic and installed on both sides of the bridge along with associated approach and transition guardrail. A concrete sidewalk will be located on the north side of the bridge. The anticipated design life for this alternative is 50 – 75 years.

Advantages of Alternative 3

- Local contractors have experience with constructing this type of bridge
- Less cost than the precast concrete superstructure options
- Accommodates all legal highway loads
- No specialized construction equipment required

Disadvantages of Alternative 3

- Anticipated reduced design life
- Reduced hydraulic opening
- Reduced vertical opening
- Superstructure has potential for catching and trapping debris
- Requires additional construction time to place cast-in-place concrete deck

3.2.4 Alternative 4 – 3-Sided Precast Concrete box culvert

This alternative replaces the existing bridge with a 3-sided precast concrete box culvert with spray applied waterproofing membrane and pavement. The bridge railing would be a cast-in-place concrete and steel tubing combination bridge rail. The bridge rail will be appropriate for vehicular, bicycle and pedestrian traffic and installed on both sides of the bridge along with associated approach and transition guardrail. A concrete sidewalk will be located on the north side of the bridge. The anticipated design life for this alternative is 75 years.

Advantages of Alternative 3

- Local contractors have experience with constructing this type of bridge
- Accommodates all legal highway loads
- No specialized construction equipment required

Disadvantages of Alternative 3

- Visually unappealing as the channel crosses the roadway at a skew creating protruding ends
- Significant span length for a 3-sided concrete box culvert resulting in increased thickness and design challenges
- Reduced hydraulic opening
- Reduced vertical opening
- Has the greatest number of precast concrete members that need to be erected

A precast concrete arch was also considered for this alternative but was eliminated as it requires a minimum of two feet of fill above the concrete arch which would result in a significantly reduced hydraulic capacity that would not meet the project need.

3.2.5 Alternative A – Driven H-Pile Foundation

For Alternatives 1 through 3 a driven H-pile substructure consists of a precast or cast-in-place concrete pile cap which is supported by a single row of steel H-piles which have been driven vertically into the ground. For Alternative 4 a driven H-pile substructure consists a concrete stem wall and footing with two rows of steel H-piles, the back row driven vertically and the front row driven at an angle into the ground. Excavation for a Driven H-Pile Foundation substructure is only required to the bottom of the pile cap which would be located five feet below the finished grade on the channel side of the pile cap. The driven piles would be designed to support the bridge superstructure and substructure and meet all current design requirements including scour below the pile cap

Advantages of Alternative A

- Best scour protection
- Least overall impact from excavation

Disadvantages of Alternative A

- Higher construction cost due to the need to have a subcontractor with specialized pile driving equipment

3.2.6 Alternative B – Spread Footing Foundation

A spread footing substructure consists of a cast-in-place concrete stem wall that is supported by a concrete spread footing. The spread footing would be placed at a depth to prevent undermining due to scour from the Great Brook which would be a minimum of six feet below the bottom of the streambed. The concrete abutment (stem wall and spread footing) would be designed to support the bridge superstructure and meet all current design requirements.

Advantages of Alternative B

- Potentially lower cost alternative

Disadvantages of Alternative A

- Greater overall impact from excavation due to size and bottom of footing elevation (6’-0” below bottom of streambed)
- Would require dewatering as excavation is below Great Brook’s water elevation

Figure 2 Evaluation Matrix (Alternatives 1 & 2)

Category		(1A) Precast Concrete Beam	(1B) Precast Concrete Beam	(2A) Precast Concrete NEXT D Beam	(2B) Precast Concrete NEXT D Beam
Cost	Preliminary Engineering	$93,000	$93,000	$93,000	$93,000
	ROW	$10,000	$10,000	$10,000	$10,000
	Structure	$805,000	$755,000	$795,000	$745,000
	Roadway	$135,000	$135,000	$135,000	$135,000
	Stream	$30,000	$30,000	$30,000	$30,000
	Traffic & Safety	$15,000	$15,000	$15,000	$15,000
	Misc. Construction	$32,000	$32,000	$32,000	$32,000
	Incidentals & Contingency (20%)	$210,000	$200,000	$210,000	$190,000
	Construction Engineering (8%)	$90,000	$80,000	$90,000	$80,000
	Total	$1,420,000	$1,350,000	$1,410,000	$1,330,000
Engineering	Typical Section	2-9-9-2	2-9-9-2	2-9-9-2	2-9-9-2
	Align. Change	Raise Grade	Raise Grade	Raise Grade	Raise Grade
	Bicycle Access	Enhancement	Enhancement	Enhancement	Enhancement
	Hydraulic Performance	Enhancement	Enhancement	Enhancement	Enhancement
	Utilities	Relocation	Relocation	Relocation	Relocation
Impacts	Ag. Lands	No	No	No	No
	Archaeological	No	No	No	No
	Historic	Yes	Yes	Yes	Yes
	Hazardous Materials	No	No	No	No
	Floodplains	Enhancement	Enhancement	Enhancement	Enhancement
	Fish & Wildlife	Enhancement	Enhancement	Enhancement	Enhancement
	Rare, Threatened & Endangered Species	No	No	No	No
	Public Lands - Sect. 4(f)	No	No	No	No
	LWCP - Sect. 6(f)	No	No	No	No
	Noise	No	No	No	No
	Wetlands	No	No	No	No
Local & Regional Issues	Concerns	None	None	None	None
	Aesthetics	Similar	Similar	Similar	Similar
	Community Character	No Change	No Change	No Change	No Change
	Economic Impacts	Unknown	Unknown	Unknown	Unknown
	Conformance to Reg. Transportation Plan	Yes	Yes	Yes	Yes
	Satisfies Purpose & Need	Yes	Yes	Yes	Yes
Permits	ACT 250	No	No	No	No
	401 Water Quality	Yes	Yes	Yes	Yes
	404 COE Permit	Yes	Yes	Yes	Yes
	Stream Alteration	Yes	Yes	Yes	Yes
	State Wetland Permit	No	No	No	No
	Storm Water Discharge	No	No	No	No
	Lakes & Ponds	No	No	No	No
	T & E Species	No	No	No	No
	SHPO	No	No	No	No
Other					

Figure 3 Evaluation Matrix (Alternatives 3 & 4)

Category		(3A) Steel Girders with a Conc. Deck	(3B) Steel Girders with a Conc. Deck	(4A) 3 Sided Concrete Box	(4A) 3 Sided Concrete Box
Cost	Preliminary Engineering	$93,000	$93,000	$93,000	$93,000
	ROW	$10,000	$10,000	$10,000	$10,000
	Structure	$625,000	$565,000	$615,000	$495,000
	Roadway	$135,000	$135,000	$135,000	$135,000
	Stream	$30,000	$30,000	$30,000	$30,000
	Traffic & Safety	$15,000	$15,000	$15,000	$15,000
	Misc. Construction	$32,000	$32,000	$32,000	$32,000
	Incidentals & Contingency (20%)	$170,000	$160,000	$170,000	$150,000
	Construction Engineering (8%)	$70,000	$70,000	$70,000	$70,000
	Total	$1,180,000	$1,110,000	$1,170,000	$1,030,000
Engineering	Typical Section	2-9-9-2	2-9-9-2	2-9-9-2	2-9-9-2
	Align. Change	Raise Grade	Raise Grade	Raise Grade	Raise Grade
	Bicycle Access	Enhancement	Enhancement	Enhancement	Enhancement
	Hydraulic Performance	Enhancement	Enhancement	Enhancement	Enhancement
	Utilities	Relocation	Relocation	Relocation	Relocation
Impacts	Ag. Lands	No	No	No	No
	Archaeological	No	No	No	No
	Historic	Yes	Yes	Yes	Yes
	Hazardous Materials	No	No	No	No
	Floodplains	Enhancement	Enhancement	Enhancement	Enhancement
	Fish & Wildlife	Enhancement	Enhancement	Enhancement	Enhancement
	Rare, Threatened & Endangered Species	No	No	No	No
	Public Lands - Sect. 4(f)	No	No	No	No
	LWCP - Sect. 6(f)	No	No	No	No
	Noise	No	No	No	No
	Wetlands	No	No	No	No
Local & Regional Issues	Concerns	None	None	None	None
	Aesthetics	Improvement	Improvement	Improvement	Improvement
	Community Character	No Change	No Change	No Change	No Change
	Economic Impacts	Unknown	Unknown	Unknown	Unknown
	Conformance to Reg. Transportation Plan	Yes	Yes	Yes	Yes
	Satisfies Purpose & Need	Yes	Yes	Yes	Yes
Permits	ACT 250	No	No	No	No
	401 Water Quality	Yes	Yes	Yes	Yes
	404 COE Permit	Yes	Yes	Yes	Yes
	Stream Alteration	Yes	Yes	Yes	Yes
	State Wetland Permit	No	No	No	No
	Storm Water Discharge	No	No	No	No
	Lakes & Ponds	No	No	No	No
	T & E Species	No	No	No	No
	SHPO	No	No	No	No
Other					

3.3 Recommendations

The alternative summaries above present a brief summary of advantages and disadvantages of each alternative, and the Alternatives Comparison Matrices (Figures 2 & 3) also include an order-of-magnitude cost estimate. Alternative 1A – Precast/Prestressed Concrete Slab superstructure with a pile cap substructure supported by driven H-piles is the recommended alternative because it provides the greatest hydraulic capacity, requires the least maintenance, and has the greatest anticipated design life span. Additionally, by using a substructure which is supported by driven piles it also provides the best overall resiliency from potential scour.

A scour analysis performed by Milone and MacBroom for the proposed conditions of the bridge resulted in abutment scour between 12 and 20 feet. A memo summarizing this analysis can be found in Appendix F of this report. This amount of scour creates a significant concern over the stability of the bridge during storm events and therefore a driven H-pile substructure, Alternative A, is recommended to support the bridge.

Additionally, while a driven pile foundation typically would likely have a higher cost than the spread footing, a significant cost difference is not expected for this project. The expected channel velocities and estimated scour depths indicate that a spread footing foundation with rip rap armoring would have to be significantly deeper than six feet below the streambed to abate the scour. This requirement would increase the size of the spread footing and stem wall thereby also increasing the cost of the foundation. It is anticipated that these increases in size and additional challenges resulting from excavation to the required depths would result in a difference in cost between the spread footing and driven H-pile foundation to be much closer than projects will less anticipated scour.

At a 36-foot span, and in this location where debris jams and hydraulics are key concerns a concrete slab superstructure is the optimum choice. As discussed under Alternative 2, Precast Concrete NEXT Beams, offer minimal advantages over concrete slabs, and would result in an increase to the overall depth of the superstructure, therefore reducing the hydraulic capacity of the bridge. Additionally, the lower portions of the beams would increase the potential for catching and trapping debris during high flow events.

Alternative 3, with a cast-in-place concrete deck and steel beam or girder superstructure does offer some advantages in initial cost savings. However, there would be future maintenance requirements and potential future rehabilitation making the overall life cycle cost of this alternative similar to the concrete slab alternative. A steel beam or girder superstructure also reduces the hydraulic capacity of the bridge as the superstructure depth would be greater than the concrete slabs. Additionally, the use of steel beams or girders significantly increases the potential for catching debris and causing debris jams at a location that has historically been prone to those issues.

Comparison of Alternative 1 to Alternative 4 shows many similarities in that both alternatives provide a concrete superstructure with a rectangular shape opening, and therefore possibly a similar hydraulic capacity. However, a 3-sided box with a 36-foot span would have a greater depth than a precast/prestressed concrete slab and therefore would have a lower hydraulic capacity. The 3-sided box culvert would also span the channel perpendicularly, as opposed to the other alternates that are parallel with the roadway, and have a skewed substructure that is parallel with the channel. This would result in approximately 13 feet of additional length on both ends of the structure with significant portions of exposed concrete visible.

Environmental and Historical considerations between the alternatives are anticipated to be greater for an alternative utilizing a spread footing foundation since spread footing foundations require a footing for support. A footing is wider and deeper than a pile cap used with a driven pile foundation and footings therefore require additional excavation. Alternatively, a driven H-pile foundation uses driven piles for support, and excavation is only required to the bottom of the pile cap. As all the alternatives could implement either type of foundation, this could be an advantage or disadvantage for any of the alternatives 1-4.

The recommended alternative, Alternative 1A, was chosen because it provides the greatest hydraulic capacity, and is seen as the best-fit and most constructible for the project. While other alternatives offer some potential cost savings, it is not anticipated that these would be significant, and the disadvantages of each of the other alternatives outweigh any potential cost savings.

Other recommendations and issues which require attention are as follows:

- It is recommended to coordinate with local emergency services to provide an adequate level of service throughout a bridge closure.
- Using elastomeric bearings between the superstructure and substructure elements.
- Based on environmental resource assessment that has been completed to date and the recommended alternative, the following regulatory coordination and permitting is anticipated:
    - NEPA Categorical Exclusion (If Federal monies are used. If State monies are used a similar process will be required on the State level.)
    - Army Corps of Engineers Section 404 General Permit Authorization
    - VT DEC Rivers Program Stream Alteration Permit
    - Section 106 review of the existing bridge and residences to verify their historic significance and if there will be any potential 4(f) or SHPO requirements.
    - Bridge demolition mitigation including photo documentation of the existing bridge and using the proposed bridge rail that is noted above.