ALTERNATIVES ANALYSIS AND ASSESSMENT

NORTH STREET BRIDGE

Town of Brandon, Vermont
Rutland County

Prepared for:
Town of Brandon
49 Center Street,
Brandon, VT 05733

Prepared by:

DuBois & King inc.

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Introduction

The Town of Brandon on receiving a scoping study grant through the Federal Emergency Management Agency's (FEMA) Building Resilient Communities and Infrastructure (BRIC) Program to develop cost-effective replacement alternatives for the North Street Bridge crossing (B8). The existing bridge is located toward the south end of North Street (VT-53) where it meets with Furnace Road. North Street is classified as a Major Collector Route and will need to pass the design storm of 2% AEP with a minimum of 1-ft of freeboard. The existing stream crossing of the Neshobe River is undersized for safe passage of the 50-year storm. DuBois & King, Inc., (D&K) has completed a preliminary analysis and evaluation of the stream crossing to mitigate flood damages and improve ecological benefits. The scoping level study of the North Street crossing includes a hydrologic and hydraulic analysis, the development of several alternatives, concept-level plans and initial permitting review.

This preliminary Summary Report has been generated for the Town of Brandon, VT to evaluate options for a replacement stream crossing. The current stream crossing is a single span bridge 33 feet in length, with an active open span of 31 ft due to large concrete protection installed on the right and left banks of the channel (see photos **Attachment A**). The current stream crossing is a two lane bridge 28 ft in width with a load rating of 1 ton.

Project Area and Existing Conditions

The North Street Bridge is located approximately 190-ft North of the intersection of North Street and Furnace Road and provides a crossing over the Neshobe River. The south bank upstream of the bridge is subject to frequent overtopping during storm events which causes flooding along into a manufactured home park (MHP) adjacent to the Neshobe River. The max elevation of this bank is 565-ft which is below the existing low chord of bridge, 566.11-ft. The roadway does not experience any over topping because flow will hop the bank and continue around the south side of the bridge over North Street.

Hydrologic Analysis

The Neshobe River at the North Street Bridge drains a 13.4 square mile watershed. The stream originates in Goshen on Brandon Gap Road and has contributing flows from several tributaries including Leicester Hollow Brook, and North Branch Neshobe River (see **Attachment B**). The basin is primarily wooded with some rural residential areas.

The USGS on-line tool StreamStats was used to delineate the contributing drainage area, percent of water bodies/wetlands of the watershed, and estimate the Annual Exceedance Probability (AEP) peak flows at the North Street Bridge. Stream channel slope was estimated using LiDAR information. **Table 1** summarizes the characteristics of the basin used in estimating the peak flows.

Table 1. Neshobe River Drainage Basin at North Street Bridge

Basin Characteristic	Estimated Value
Drainage Area	13.4 square miles
Land Cover/Use:	Primarily Wooded and Rural
Stream Channel Slope:	0.01213 ft/ft
Percentage of water bodies/wetlands (NLCD 2006):	1.31%

Peak flow values are estimated by StreamStats utilizing regression equations developed for and presented in “Estimation of Flood Discharges at Selected Annual Exceedance Probabilities for Unregulated, Rural Streams in Vermont” published by USGS, dated 2009. Results of the estimated peak flows values are summarized in **Table 2**. These flows are used as input to the hydraulic model for the project site.

Table *2*. Summary of Neshobe Flow Rates at North Street

Recurrence Interval (years)	Flow (cfs)
Q_2	562
Q_5	885
Q_{10}	1,130
Q_{25}	1,510
Q_{50}	1,830
Q_{100}	2,170

Hydraulic Analysis

The bridge crossing was evaluated using GeoHEC-RAS 2D, a finite-element analysis computer program that models the hydraulics of water flow through natural rivers and other channels. Required input for each model includes flow data, a topographic digital elevation model, land cover

The digital elevation model for this project was generated utilizing LiDAR and surveyed points. LiDAR information was extracted from the Vermont Open Geodata Portal, 2013 Digital Elevation Model- hydro flattened (0.7m). A survey of the stream and bridge crossing was completed by D&K on February 15, 2023. LiDAR and survey information was merged to create a model surface that includes detail at the bridge with the terrain data beyond the survey limits.

Land cover data was queried from the National Land Cover Data Base (NLCD). D&K completed a visual comparison with publicly available aerial imagery of the project area to adjust the land cover types when needed. Land cover was split into wetland, forest, roadways, residential, agriculture, gravel road, grasses and river channels. Manning's n values were assigned by DDK using NRCS guidance and recommendations. In areas where Manning's values were not specifically assigned, the GeoHEC-RAS model will default to the NLCD value.

An adaptive mesh was utilized for the GeoHEC-RAS 2D model scheme in order to maximize the efficiency of the model. An adaptive mesh reads the terrain surface in order to size the mesh appropriately. In flatter areas larger mesh cells are utilized and in rapidly changing terrain smaller mesh cells are utilized. The flow area for the mesh started 2,500 ft downstream of the bridge crossing and continued approximately 2,500-ft upstream of the bridge. To provide additional mesh definition, features within the channel and surrounding area around the roadway crossing were further refined utilizing break lines and 2D-connections. Features that were refined included river banks, bottom of slopes, and roadway centerlines.

According to the VT Culvert Bridge Inventory, the existing concrete sectional bridge has a maximum span of 31 ft and width of 28 ft. The roadway crest was surveyed at +/-669.5-ft..

In addition to the existing condition, three alternative road crossings were modeled using GeoHEC-RAS. The alternatives that were evaluated including the following:

Existing Conditions – 33 ft Span Bridge

The existing structure is a 33-ft span bridge. The side slopes are vertical due to concrete wing walls on the upstream and downstream sides of the bridge. The inlet invert was surveyed at 558.39-ft and the outlet invert at 558.01-ft. The existing low chord of the bridge was surveyed at 566.11-ft.

Alternative 1 – 30.66 ft Span Bridge

Alternative 1 is a 30.66-ft span bridge with stream channel inlet and outlet elevations of 558-ft. The bridge low chord is raised to 567-ft. The surface was generated by regarding the terrain and tying in proposed contours to existing contours. Wing walls are used on upstream and downstream ends of the bridge to allow for the proposed terrain to tie into existing. The bank along the south was regraded to have an elevation of 568-ft to prevent over topping and flooding near the MHP.

Alternative 2- Contech Con/Span Bridge System

Alternative 2 is a 36-ft span 9-ft rise precast bridge from Contech with stream channel inlet and outlet elevations of 558-ft. The bridge low chord is raised to 567-ft. The surface was generated by regarding the terrain and tying in proposed contours to existing contours. Wing walls are used on upstream and downstream ends of the bridge to allow for the proposed terrain to tie into existing. The bank along the south as regraded to have an elevation of 568-ft to prevent over topping and flooding near the MHP.

Alternative 3- Aluminum Box Culvert Contech (Structure 139)

Alternative 3 is a prefabricated aluminum box culvert from Contech. The structure utilized is advertised as Structure 139 in Contech's Aluminum Box Culvert standard details. The structure is a box culvert but has a more arched shaped to the hydraulic opening. The structure has a span of 34'-11" and rise of 10'-4.5" and hydraulic opening of 286.6 sf. The top of the culvert has an elevation of 568.375-ft, this was also used as the bridge low chord. The box culvert used inlet and outlet elevations of 558-ft. Wing walls are used on upstream and downstream ends of the bridge to allow for the proposed terrain to tie into existing. The bank along the south was regraded to have an elevation of 569-ft to prevent over topping and flooding near the mobile homes. The bank along the north was also raised to an elevation of 569-ft to prevent water from flooding near the MHP.

Table 3. Summary of Hydraulic Input Conditions

	Existing Conditions	Alternative 1	Alternative 2	Alternative 3
Structure	**33 Foot Span Bridge**	**31 Foot Span Bridge**	**36 Foot x 9 Foot Conspan**	**34’11” x 10’4.5” Aluminum Box**
Hydraulic Width (ft)	28	30.66	36	34’11”
Vertical Hydraulic Opening (ft)	7.72	9	9	10’4.5”
Hydraulic Opening (ft^2)	216	276	268	287
Length (ft)	28	31	31	31
US Low Chord Elevation	566.11	567.0	567.0	568.38

The results of the hydraulic analysis for the existing and proposed conditions are provided in **Table 4** below. Full HEC-RAS output results can be found in **Attachment F**.

Table 4. HEC-RAS Results Comparison

Description	Ex. Conditions	Alt. 1	Alt. 2	Alt. 3
2-Year (50% Annual Exceedance Probability)				
Upstream (US) Water Surface Elevation (ft)	561.56	561.78	561.61	561.85
Downstream (DS) Water Surface Elevation (ft)	560.93	561.08	561.01	561.01
US Headspace below low chord (ft)	4.551	5.22	5.39	6.53
Maximum Velocity (ft/s)	10	10.4	11	13

25-Year (4% Annual Exceedance Probability)				
Upstream (US) Water Surface Elevation (ft)	564.46	564.78	564.43	565.57
Downstream (DS) Water Surface Elevation (ft)	562.71	562.99	562.9	562.96
US Headspace below low chord (ft)	1.651	2.22	2.57	2.81
Maximum Velocity (ft/s)	15.6	17.9	17.8	18.6
50-Year (2% Annual Exceedance Probability)				
Upstream (US) Water Surface Elevation (ft)	565.29	565.65	565.32	566.76
Downstream (DS) Water Surface Elevation (ft)	563.16	563.49	563.39	563.45
US Headspace below low chord (ft)	0.821	1.35	1.68	1.62
Maximum Velocity (ft/s)	17.1	19.8	19.5	19.6
100-Year (1% Annual Exceedance Probability)				
Upstream (US) Water Surface Elevation (ft)	566.25	566.56	566.17	568
Downstream (DS) Water Surface Elevation (ft)	563.59	563.96	563.87	563.92
US Headspace below low chord (ft)	-0.139	0.44	0.83	0.38
Maximum Velocity (ft/s)	18.5	21.7	21.2	21.6

Permitting

D&K has completed an initial assessment of potential permits that may be required for the identified alternatives. Projects abutting a river or stream will likely require approval from the United States Army Corps of Engineers (USACE) along with permits from the Vermont Department of Environmental Conservation (VTDEC) including Stream Alteration, Wetlands and possibly a Stormwater Construction General Permit if the area of disturbance exceeds one acre. Once the selected alternative is identified, D&K will present a conceptual plan to the various regulatory agencies and document the necessary permits for the project. Natural resource impacts would be similar for all alternatives and therefore, permitting requirements for all alternatives are combined in the **Table 5** below.

Table 5. Permitting Summary

	Approval/ Permit		Note
State	Act 250	N	Not applicable.
	Flood Hazard Area/ River Corridor	N	Project is exempt under §29-303(b)(2) of the VT Flood Hazard Area and River Corridor Rule.
	Stream Alteration	Y	Required for work/alterations within watercourses.
	Wetlands	FR	A state regulated wetland and 50' buffer is located outside of the project site and maybe impacted.
	Shoreland Protection	N	There are no shoreland protection areas within the vicinity of the project site.
	Section 401 Water Quality Certification	Y	WQC automatically granted if USACE Section 10 general permit conditions are met.
	Construction General Permit	FR	No, if disturbance is < 1 acre.
	Construction Operational Permit	N	Not applicable.
	Section 106 (Historic Preservation)	FR	Historic structure will require VT SHPO review.
	Rare, Threatened, & Endangered Species	FR	The VTANR Natural Resource Atlas did not identify the presence of RTE species near the project site. Review is required since site is within Indiana BAT Hibernacula.
Federal	USACE Section 404	FR	A federally regulated wetland is located adjacent of the project site maybe impacted.
	USACE Section 10	Y	A Rivers and Harbors Act Section 10 permit is required for work in or over navigable waters of the United States.
	FEMA Floodplain	N	The project alternatives will not negatively impact the 100-year floodplain elevation.
	Rare, Threatened, & Endangered Species	FR	If necessary, time of year restrictions can be implemented to avoid impacts/permitting.
	NEPA	FR	Yes, if federal funding is utilized.
Local	Floodplain	N	Local review and permit not required if VTDEC Stream Alteration Permit is required.

Y = Yes, N = No, FR = Further Review. Further review implies that the conceptual level plans and information gathered during site investigations do not provide sufficient information to determine the full extent of permit applicability.

Natural Resources

D&K conducted a preliminary desktop review of natural resources in the project area. The US Fish and Wildlife Information for Planning and Consultation (IPaC) database was queried the project is within endangered species, Indiana Bat Hibernacula. No other rare, threatened or endangered species were mapped in the project area. Adjacent Class II wetlands were delineated in the southwest corner of the project. Potential buffer impacts will need to be reviewed during design. This information will be verified under subsequent investigations and regulatory coordination. D&K reviewed the following resources in the study area:

- Wetlands and water quality
- Fish and wildlife habitat
- Floodplains
- Archaeologically sensitive areas
- Rare, threatened, and endangered species/habitat
- Agricultural land
- Hazardous waste sites
- Rivers, streams, lakes, and ponds
- Wild and scenic rivers
- Vernal pools

Archaeologic and Historic Resources

D&K's sub consultant, Hartgen, performed an archeological resource assessment (Attachment I) and Historic Resource Identification (Attachment J). The existing bridge has been identified as an historic structure. Coordination for documenting the existing bridge and proposed requirements will be coordinated with the Vermont Division of Historic Preservation (SHPO) during design.

Opinion of Probable Construction Costs

Probable construction costs were estimated for the potential improvements that are feasible. Construction costs were estimated based on recently developed projects, recent bid results and engineering judgement. **Table 6** illustrating the probable cost of each alternative is listed below.

The cost of designing improvements such as the ones described in this memorandum typically range from 10 to 20 percent of the construction costs. Smaller projects will have a fee on the higher end while a large construction cost project will be on the lower end of this spectrum. Construction Administration and Resident Engineer services typically range from 10 to 15 percent of construction costs.

Table 6. Conceptual Opinion of Probable Construction Costs

Conceptual Opinion of Probable Construction Costs			
	Alternative 1	**Alternative 2**	**Alternative 3**
Structure	**31 Foot Span Bridge**	**36 Foot x 9 Foot Conspan**	**34’11” x 10’4.5” Aluminum Box**
Construction Cost OPCC	$1,534,000	$1,415,000	$1,199,000
Engineering Design (12%)	$184,080	$169,800	$143,880
Resident Engineer (10%)	$153,400	$141,500	$119,900
Total	**$1,871,480**	**$1,726,300**	**$1,462,780**

Benefit Cost Analysis

The following provides a summary of the various input values that were used in developing a Benefit-Cost Analysis (BCA) for the North Street bridge replacement. The BCA utilizes the FEMA calculation spreadsheet and method that determines the future risk reduction benefits of a hazard mitigation project and compares those benefits to its costs. DuBois & King, Inc. used FEMA-approved methodologies and tools — such as the BCA Toolkit — to demonstrate the cost-effectiveness of their projects.

For this analysis D&K selected the property structure type as Roads & Bridges within the BCA Toolkit, as the property includes a roadway, culvert or bridge land use. The Hazard type was entered as Riverine Flood. The Mitigation Action Type selected as drainage.

Based on FEMA Project Useful Life Summary Table the bridge is assumed to have a minimum useful life (Standard Value) of 50 years. D&K estimated a conceptual level opinion of probable construction cost for bridge on this project as listed above in Table 6. We selected the default value for the number of maintenance years which is the same value as the Project Useful Life. We choose Annual maintenance costs as those costs necessary for the upkeep or repair of the mitigation project which is $1,000 per year. D&K entered the analysis Year as 2024. Additionally, the Analysis Duration must be at least 10 years in order to achieve a minimal level of confidence for the calculations.

The number of vehicle trips that detoured around the project area due to loss of function of the road was obtained from Vermont Agency of Transportation – Traffic Data and Analysis, which is approximately 1,720 Trips per Day. The additional time per 10-mile One-Way Detour Trip is an approximate travel time of 20 minutes.

Adjacent manufactured home structures would be inundated during pre-mitigation conditions. The assessed damage to structure and contents utilized depth-damage ratios from USACE IWR Report 92-R-3. Structure values utilized $35/SF which equates to an approximate $30,000 structure value and $15,000 was utilized for content value.

The resulting damage values are listed in **Table 7** below.

Table 7. Structure and Content Damage

Structure and Content Damage							
STORM	No. STRUCTURES	DEPTH (FT)	STRUCTURE		CONTENT		TOTAL
			DEPTH-DAMAGE	DAMAGE	DEPTH-DAMAGE	DAMAGE	
50-YR	1	0	8 %	$ 2,400	5%	$ 750	$ 3,150
100-YR	3	1	45 %	$ 40,500	25%	$ 11,250	$ 51,750

The results of the Benefit-Cost Ratio (BCR) are listed in **Table 8** below.

Table 8. FEMA Benefit-Cost Ratios

FEMA Benefit-Cost Ratios			
	Alternative 1	**Alternative 2**	**Alternative 3**
Structure	**31 Foot Span Bridge**	**36 Foot x 9 Foot Conspan**	**34’11” x 10’4.5” Aluminum Box**
Benefit-Cost Ratio	1.04	1.12	1.32

A project is considered cost-effective when the BCR is 1.0 or greater. Each of the proposed alternatives would be deemed cost-effective. A copy of the FEMA BCA worksheets are provided in **Attachment H**.

Alternatives Analysis

No Action

The existing bridge cannot safely pass the 50-year design storm and is currently contributing to property impacts, road closures, scour, and erosion and water quality issues so a No Action alternative is not acceptable. This alternative will not be included in the alternatives discussion, nor will it be included in the comparison matrix.

Alternative 1

This option includes the replacement of the existing culvert with a 31 ft wide bridge and associated wing walls. Existing inlet and outlet inverts would be maintained and natural stream bed material would be placed.

The proposed bridge would be constructed along the same alignment as the existing bridge, minimizing the potential historic, archeologic, and environmental and right-of-way (ROW) impacts. A temporary bridge detour would be installed to maintain traffic throughout the construction period which is anticipated to be approximately six to eight months.

Advantages:

- This option provides a sufficient hydraulic opening to pass the 25-year design storm and does not induce flooding for the 100-year storm
- Maintains alignment similar to the existing conditions which limits environmental impacts
- Provides and improves AOP conditions

Disadvantages:

- Highest estimated construction cost of the three alternatives
- Longest anticipated duration of construction.

Alternative 2

This option includes placement of a 36 ft. precast conspan structure, existing inlet and outlet, inverts would be maintained, and natural streamed material would be placed. This option would include a temporary bridge detour to maintain traffic throughout the construction period. However, the duration of construction is anticipated to be shorter than Alternative 1.

Advantages:

- This option provides a sufficient hydraulic opening to pass the 25-year design storm and does not induce flooding for the 100-year storm
- Second lowest estimated construction cost of the three alternatives
- Shortest construction period which is similar construction period to alternative 3
- Maintains alignment similar to the existing conditions which limits environmental impacts
- Provides and improves AOP conditions

Disadvantages:

- Construction requires larger crane picks and staging area
- Geotechnical borings may limit use of precast footers in final design thus increasing project duration slightly

Alternative 3

This option includes construction of a 34 ft. aluminum box culvert. This option includes the replacement of the existing culvert with a 3ft wide bridge and associated wing walls. Existing inlet and outlet inverts would be maintained and natural stream bed material would be placed.

The proposed bridge would be constructed along the same alignment as the existing bridge, minimizing the potential historic, archeologic, and environmental and right-of-way (ROW) impacts. A temporary bridge detour would be installed to maintain traffic throughout the construction period which is anticipated to be approximately four to six months.

Advantages:

- This option provides a sufficient hydraulic opening to pass the 25-year design storm and does not induce flooding for the 100-year storm
- Lowest estimated construction cost of the three alternatives
- Shortest construction period which is similar construction period to alternative 2
- Maintains alignment similar to the existing conditions which limits environmental impacts
- Provides and improves AOP conditions

Disadvantages:

- Geotechnical borings may limit use of precast footers in final design thus increasing project duration slightly

Alternatives Matrix

Table 9 compares the Alternatives as presented above. The No Action alternative is not included in the matrix as that alternative does not meet the project need. This table intends to relate various aspects of the project qualitatively across the alternatives. Quantitative measures have not been developed at this phase.

Table 9. Alternatives Matrix

Item \ Alternative:	Alt. 1	Alt. 2	Alt. 3
Traffic Solution	Temporary Bridge	Temporary Bridge	Temporary Bridge
Cost	Highest	Moderate	Lowest
Environmental Impacts	Moderate	Moderate	Moderate
Hydraulic Performance	Moderate	Best	Moderate
ROW Risk	Moderate	Moderate	Moderate
Construction Duration	Longest	Moderately Long	Moderately Long
OVERALL RATING	Highest Cost	Moderate Cost Best hydraulic performance	**RECOMMENDED Lowest Cost and Similar hydraulic performance**

Recommended Alternative

Dubois & King recommends proceeding with Alternative 3, installation of a temporary bridge crossing (could be one-way alternating), and construction of a new 34 ft. aluminum box culvert. This alternative presents the lowest cost, lowest risk for environmental impacts, has nearly the best hydraulic performance, and improves AOP.