ADDENDUM TO BRIDGE ALTERNATIVES EVALUATION AND LIFE CYCLE COST COMPARISION

for

BRIDGE STREET

over

MITCHELLRIVER

BRIDGE NO. C-07-001 (437)

DISTRICT 5

CHATHAM

MASSACHUSETTS

SUPPLEMENT

Prepared for:

Commonwealth of Massachusetts

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MAY 12, 2011
Supplemented May 19, 2011

1.0 EXECUTIVE SUMMARY

This report supplements a previously prepared report, *Bridge Alternatives Evaluation and Life Cycle Cost Comparison for Bridge Street over Mitchell River*, dated April 28, 2011. The purpose of the previous study was toevaluate bridge replacement alternatives that could avoid, minimize, or mitigate the adverse effect, as required by 36 CFR 800.6(a). For the previous study, MassDOT specified development, evaluation and comparison of five (5) viable bridge replacement alternatives. This supplement includes evaluation oftwo (2) additional alternatives including:

Alternative 1A:	Timber Superstructure on Timber Substructure with Timber Bascule Span (i.e. All Timber Replacement) with 25’-0” Wide Navigation Channel
Alternative 1B:	Timber Superstructure on Timber Substructure with Timber Bascule Span (i.e. All Timber Replacement) with 25’-0” Wide Navigation Channel and Concrete Bascule Pier

These alternatives are evaluated for the same criteria used to evaluate the previous alternatives.

The matrix belowand referenced notes were presented in the previous report and have been updated to include the two additional alternatives.*The ratings provided below are a nonscientific measure of the relative strengths and/or weaknesses of the alternatives as compared against the others as evaluated by the authors.*

> ***Good*** *– Best meets the intent of the criterion compared among all alternatives considered*
> ***Satisfactory*** *– Generally meets the intent of the criterion, with some exception, relative to all alternatives considered*
> ***Fair*** *– Meets some of the intent of the criterion, but not as well as the more highly rated alternatives*
> ***Poor*** *– Essentially does not meet the intent of the criterion or meets the criterion at a low threshold as compared to the more highly rated alternatives*

RESULTS OF DESIGN CRITERIA EVALUATION							
Alt.	Primary Project Design Criteria Categories						
	Roadway Function & Safety(1)	Context Sensitive(2)	Navigation Function & Safety(3)	Initial Construction Cost(4)	Life Cycle Costs(5)	Maintenance & Service Life(6)	Environment (7)
1	Good	Good	Poor	Good	Fair	Poor	Poor
1A	Good	Good	Fair	Good	Fair	Poor	Poor
1B	Good	Satisfactory	Satisfactory	Good	Fair	Fair	Fair
2	Good	Satisfactory	Good	Fair	Poor	Fair	Fair
3	Good	Fair	Good	Fair	Satisfactory	Satisfactory	Satisfactory
4	Good	Fair	Good	Fair	Satisfactory	Satisfactory	Satisfactory
5	Good	Poor	Good	Satisfactory	Good	Good	Satisfactory

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Notes:

1. Alternatives 1 thru5including 1A and 1B equally accommodate improvements in roadway function and safety, including additional roadway and sidewalk width and safety features.
2. Alternatives 1 and 1Aare all timber solutions that would resemblethe existing bridge. Alternative 1B is an all timber solution that would resemble the existing bridge with the exception of the introduction of a concrete bascule pier to enclose the pivoting counterweight. The other alternatives contain timber in different bridge elements and other features that mitigate the replacement of the NRHP eligible resource. See table below.

CONTEXT SENSITIVE SOLUTIONS - SUMMARY OF BRIDGE ELEMENTS with TIMBER							
Alt.	Approach Substructure	Approach Beams	Deck	Sidewalks	Pedestrian Railings	Traffic Railings	Bascule Span
1	✓	✓	✓	✓	✓	✓(E)	✓
1A	✓	✓	✓	✓	✓	✓(E)	✓
1B	✓	✓	✓	✓	✓	✓(E)	✓(F)
2	✓	✓	✓	✓	✓	✓(E)	✗(D)
3	✗	✓(E)	✓	✓	✓	✓(E)	✗(D)
4	✗	✗(A)	✓	✓	✓	✓(E)	✗(D)
5	✗	✗(B)	✗(C)	✓	✓	✓(E)	✗(D)

Notes:

A. Steel stringers are obscured by the timber sidewalks.
B. Concrete deck beams are obscured by the timber sidewalks.
C. Concrete deck includes a stamped concrete pattern and color admixtures to simulate a timber deck.
D. Concrete bascule pier contains stone facing and steel bascule leaf is obscured by the timber sidewalk.
E. Denoted timber members are glue laminated (i.e. glulam) timber in lieu of sawn lumber.
F. Timber bascule leaf is supported concrete bascule pier which contains stone facing.

3. A letter from the United States Coast Guard dated February 12, 2010, states "… there have been numerous structural and operational issues involving this bridge over the past several years. A design flaw in the original construction of the bridge prevented it from fully opening for passage of vessel traffic resulting in several mishaps wherein vessels sustained damage to their rigging due to hitting the tip of the draw span. In its present condition the draw span cannot fully open to provide unobstructed vertical clearance for the full width of the bridge between fender faces. The Coast Guard, therefore, will seek to promote the optimum navigational opening for any proposed replacement structure." Alternative 1 provides only a 19'-4" navigation opening width with unlimited clearance, which would be unacceptable to the boating community, and includes non-redundant operating machinery possessing safety and reliability concerns. Alternatives 2, 3, 4 and 5 provide a 25'-0" navigation opening width with unlimited clearance, which is preferred by the boating community and redundant operating machinery that provides a higher degree of safety and reliability. Alternative 1A provides a 25'-0" navigation opening width with unlimited vertical clearance, includes non-redundant operating machinery and a counterweight that becomes submerged during operation which introduces safety and reliability concerns.Alternative 1B provides a 25'-0" navigation opening width with unlimited vertical clearance, includes a concrete bascule pier that encloses the pivoting

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counterweight, and non-redundant operating machinerypossessing safety and reliability concerns.

4. Alternatives 1, 1A and 1B have a low initial construction cost, Alternatives 2, 3 and 4 have high initial construction costs, and Alternative 5 has a moderate initial construction cost.
5. Per the life cycle cost analysis, Alternatives 1, 1A and 1B have moderate to high life cycle costs, Alternative 2 has a high life cyclecosts, Alternatives 3 and 4 have moderate life cycle costs,and Alternative 5 has low overall life cycle costs. With the exception of the initial construction costs, which will be funded under the Accelerated Bridge Program, the Town of Chatham is assumed to be responsible for all other life cycle costs.
6. Alternatives 1 and 1A provide a relatively short service life requiring complete replacement of the bridge, except for the concrete abutments,every 20 to 30 years, due to the need to replace the timber piles. Alternatives 1B and 2 provides a relatively short service life for the approach spans requiring replacement of the approach spans every 20 to 30 years, due to the need to replace the approach span timber piles. For Alternative 1B, because the bascule span is integrated with the approach spans, it will need to be replaced with the approach spans. Alternatives 3, 4, and 5 provide significantly greater service life requiring replacement of concrete and steel elements only after 80 to 100 years,although replacement of timber elements are required more frequently. Alternatives 1, 2, 3, and 4 require replacement of the timber wearing surface every 10 to 20 years and replacement of the timber structural deck every 20 to 40 years, where Alternative 5 requires only resurfacing of the concrete after 40 years. Each instance the bridge, approach spans, deck, and wearing surface are replaced result in significant disruptions to users, with corresponding user delay costs.
7. Alternatives 1, 1A, 1B and 2 include timber piles that will require replacement on more frequent intervals. Replacement of piles disturbs the waterway bottom sediments, which contain accumulations of polycyclic aromatic hydrocarbons (PAHs) and other compounds from the existing piles that are toxic to aquatic organisms. Alternatives 1, 1A, 1B and 2 contain a significantly greater number of piles and pile bents than Alternatives 3, 4 and 5, and thus disturb a greater volume of bottom sediments during pile replacement. Although, the concrete bascule pier for Alternatives 1B, 2, 3, 4 and 5 is large, the steel sheet pile cofferdam used to construct the pier will contain the sediments and minimize impacts of the disturbed sediments on the environment.New timber piles and other submerged timber substructure elements for Alternatives 1, 1A, 1B and 2 may also include timber preservative treatments that are considered hazardous to human health and the environment. Alternatives 3, 4 and 5 include piles and substructure elements with a significantly greater service life and thus minimize the occurrences when the bottom sediments would be disturbed. The piles and submerged substructure elements of Alternatives 3, 4 and 5 avoid the need for hazardous timber preservatives.

Based on evaluation and comparison, the alternatives are generally ranked as follows with regard to the project design criteria:

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RANK	ALTERNATIVE
1	Alternative 5
2	Alternative 3
3	Alternative 4
4	Alternative 2
5	Alternative 1B
6	Alternative 1
7	Alternative 1A

Alternative 5appears to best satisfy the overall project design criteria. Alternative 5 meets roadway function and safety requirements, minimizes impacts to adjacent properties, provides a cost-effective solution with the lowest overall life-cycle costs, requires least amount of maintenance andcorrespondingfewestdisruptionsto users, fully addressesnavigation function and safety needs, minimizes impacts to the environment, and provides a context sensitive solution with features that seek to mitigate the replacement of the NRHP eligible resource.

Alternatives 3 and 4 also meet roadway function and safety requirements, minimize impacts to adjacent properties,fully address navigation function and safety needs, and minimize impacts to the environment.In addition, Alternatives 3 and 4 provide a modestly more context sensitive solution than Alternative 5, given the use of timber bridge deck in lieu of concrete bridge deck. However, Alternatives 3 and 4 require greater maintenance with corresponding greater disruptions to users, a higher initial construction cost, and higher life-cycle costs. Alternatives 3 and 4 are virtually equal to each other inconstruction cost, life-cycle costs, and in meeting project design criteria. However, Alternative 3 provides a slightly more context sensitive solution than Alternative 4 with the use of approach span timber stringers in lieu of approach span steel stringers.

Alternative 2 also meetsroadway function andsafety requirements, minimizes impacts to adjacent properties, and fully addresses navigation function and safety needs. In addition, Alternative 2 provides a more context sensitive solution than Alternatives 3, 4 and 5 with the use of all timber approach span superstructure, substructure and pile foundations. However, Alternative 2 requires significantly greater maintenancewith corresponding disruptions to users, introduces greater environmental impacts, and has the highestinitial construction cost, and highestlife-cycle costs.

Alternative 1B also meets roadway function and safety requirements and minimizes impacts to adjacent propertiesand addresses navigation function and safety needs with the exception that it provides non-redundant operating machinery with safety and reliability concerns. Alternative 1B has a low initial construction cost and provides a more context sensitive solution than Alternatives 2, 3, 4 and 5 with the use of all timber single-leaf wooden draw span, except for the concrete bascule pier. However, Alternative 1B hasmoderate to high life-cycle costs, requires significantly greater maintenance and corresponding disruptions to users, and introduces the higher environmental impacts.

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Alternative 1 also meets roadway function and safety requirements and minimizes impacts to adjacent properties. In addition, Alternative 1has the lowest initial construction cost and isa solution that provides a more context sensitive solution than Alternatives 1B, 2, 3, 4 and 5 with the use of all timber single-leaf wooden draw span. However, Alternative 1 has moderate to high life-cycle costs, does not adequately address navigation function and safety needs, requires significantly greater maintenance and corresponding disruptions to users, and introduces the greatest environmental impacts.

Alternative 1Aalso meets roadway function and safety requirements and minimizes impacts to adjacent properties. Alternative 1Aaddresses some navigation function and safety needs, but the counterweight becomes submerged during operation and it provides non-redundant operating machinery with safety and reliability concerns. Alternative 1Ahas a low initial construction cost and isa solution that provides a more context sensitive solution than Alternatives 1B, 2, 3, 4 and 5 with the use of all timber single-leaf wooden draw span. However, Alternative 1 has moderate to high life-cycle costs, does not adequately address navigation function and safety needs, requires significantly greater maintenance and corresponding disruptions to users, and introduces the greatest environmental impacts.

As such, Alternative 5 offers the best *engineering*value for the project. Continued coordination and evaluation of appropriate mitigation will be required to achieve*anacceptable balance of all design criteria and aesthetic treatments.*

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3.3 Alternative Descriptions

Descriptions for the additional two alternatives are provided below.

3.3.6 Alternative 1A - Timber Superstructure on Timber Substructure with Timber Bascule Span with 25’-0” Navigation Channel

This alternative generally consists of an all timber superstructure (i.e. timber wearing surface, structural deck, beams, diaphragms, traffic railings, pedestrian railings, and lifting beam) supported on an all timber substructure (i.e. timber piles, bent caps, bracing, sheave poles, and fender system) that closely resembles the existing bridge, but is modified to include improvements.

This alternative consists of a 196’-0” long twelve-span bridge with a single-leaf bascule span over anavigation channel matching the location and width of the existing channel.The span arrangement is similar to the existing bridge and consists of five (5) 16’-0” and one 10’-0” west approach spans,14’-4” flanking span (i.e. span over the counterweight immediately west of the bascule span), a 27’-8” bascule span, and four (4) 16’-0” east approach spans, measured from center of pile bents or face of abutment back walls. (SeeExistingBridge Plans in Appendix A and the figure below.)

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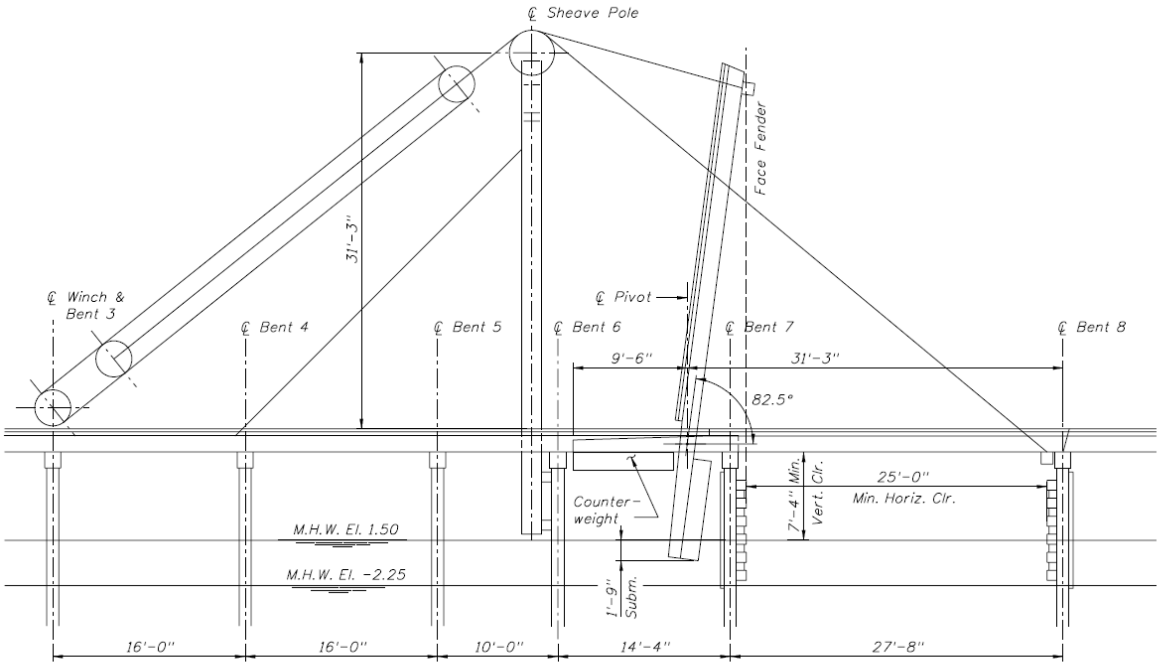
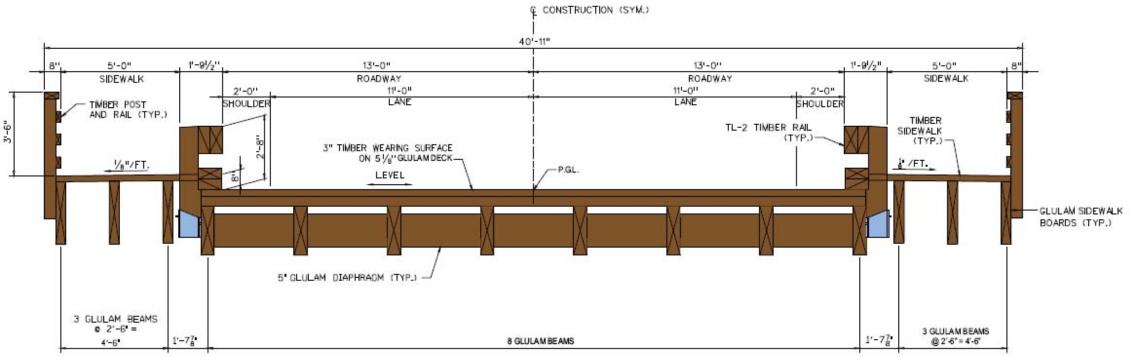


ALTERNATIVE 1A – LONGITUDINAL SECTION

The proposed superstructure includes a sawn lumber plank timber wearing surface with the planks oriented parallel to the roadway centerline and which extends the width of the roadway. The timber wearing surface is supported on and nailed to sawn lumber plank timber structural deck with the planks oriented perpendicular to the roadway centerline and that extends the full width of the bridge. The timber structural deck is supported on sawn lumber stringers.Crash tested timber traffic railings, meeting AASHTO and NCHRP 350 requirements and consisting of glue laminated timber rail elements and sawn lumber posts and curbs, separate the roadway from the sidewalk. The timber bridge railing consists of sawn lumber rails, posts and curbs with the potential to implement components from the existing timber bridge railing. The timber material is Douglas Fir Larch or Southern Yellow Pine, pressure treated per the American Wood Protection Association (AWPA) or untreated tropical timber.



ALTERNATIVES 1A and 1B - SECTION THRU APPROACH AND BASCULE SPANS

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The proposed substructure over the waterway consists of pile bents with timber piles, sawn lumber caps and sawn lumber lateral and longitudinal timber bracing members. The timber material is Douglas Fir Larch or Southern Yellow Pine, pressure treated per AWPA or untreated tropical timber. The substructure at the ends of the bridge consists of pile supported concrete abutments. The abutments include integral concrete wing walls (retaining walls) that extend along the approach roadway at the back of sidewalk that retain the roadway embankment. The retaining walls extend beyond the bridge ends approximately 90 feet at the NW quadrant, 20 feet at the SW quadrant, 20 feet at the NE quadrant and 60 feet at the SE quadrant. The embankments adjacent to the abutments and retaining walls along the waterway contain rubble rip rap slope protection.

The proposed bascule span channel provides 25’-0” of horizontal width between fenders, approximately 7’-4” of vertical clearance above mean high water with the bascule leaf in the lowered position and unlimited vertical clearance with the bascule leaf fully raised. The pivot for the bascule leaf is located on the west side of the navigation channel. The bascule leaf is approximately 31’-3” from pivot to tip and rotates to a maximum angle of approximately 82.5 degrees and fully clears the fender with the bascule leaf fully raised. In order to reduce the loads on the operating machinery, the bascule leaf is balanced by a 9’-6” long counterweightwith stainless steel plate bolted to the underside of the timber stringers that becomes submerged with the bascule leaf fully raised.

The timber stringers for the bascule leaf are located in between the timber stringers of the flanking span. The bascule leaf superstructure pivots about a steel rod that passes through steel pipe sleeves through each of the bascule leaf and flanking span timber stringers. A manually operated hinged deck flap above the pivot provides clearance between the timber stringers and deck when the bridge operates.

The fender system consists of a combination of horizontal and vertical timber membersattached to the timber pile bents each side of the navigation channel.

The proposed bascule span is operated by a pair of electric winches, located outboard each sidewalk,so as to not impair accessibility,on the approach spans west of the bascule span. Each winch draws in and pays out wire operating rope attached to a pulley system for additional mechanical advantage. The pulley system is attached to wire rope attached to the ends of a lifting beam under the bascule leaf deck near the tip ends of the leaf that deflects over a deflector sheave located at the top of a sheave pole. Each sheave pole consists of a timber mast with guy wire attached near the top of the mast and to the bridge superstructure. The wire rope, pulleys and deflector sheaves are designed to meet AASHTO requirements and will be significantly larger than the same elements of the existing bridge (e.g.the deflector sheave will be 45” in diameter compared to the existing 15”.)An electrical control cabinet is located within a timber shed located outboard the sidewalk and with an architectural style matching adjacent buildings.

3.3.7 Alternative 1B - Timber Superstructure on Timber Substructure with Timber Bascule Span with 25’-0” Navigation Channel

The bridge length and details for this alternative are generally the same as that for Alternative 1A (i.e. all-timber approach spans and all-timber single-leaf wooden draw span) with the exception that the pivoting counterweight is fully enclosed within a concrete bascule pier that prevents the counterweight from becoming submerged during operation. This alternative consists of a 194’-0” long twelve-span bridge with a single-leaf bascule span over a navigation channel matching the location and width of the existing channel. The span arrangement is similar to the existing bridge and consists of five (5) 16’-0” west approach spans, 8’-8” flanking span (i.e. span west of the bascule span), a 16’-2” long bascule pier, a 27’-2” bascule span, and four (4) 16’-0” east approach spans, measured from center of pile bents or face of abutment back walls. (See Existing Bridge Plans in Appendix A and Figure 1B.)

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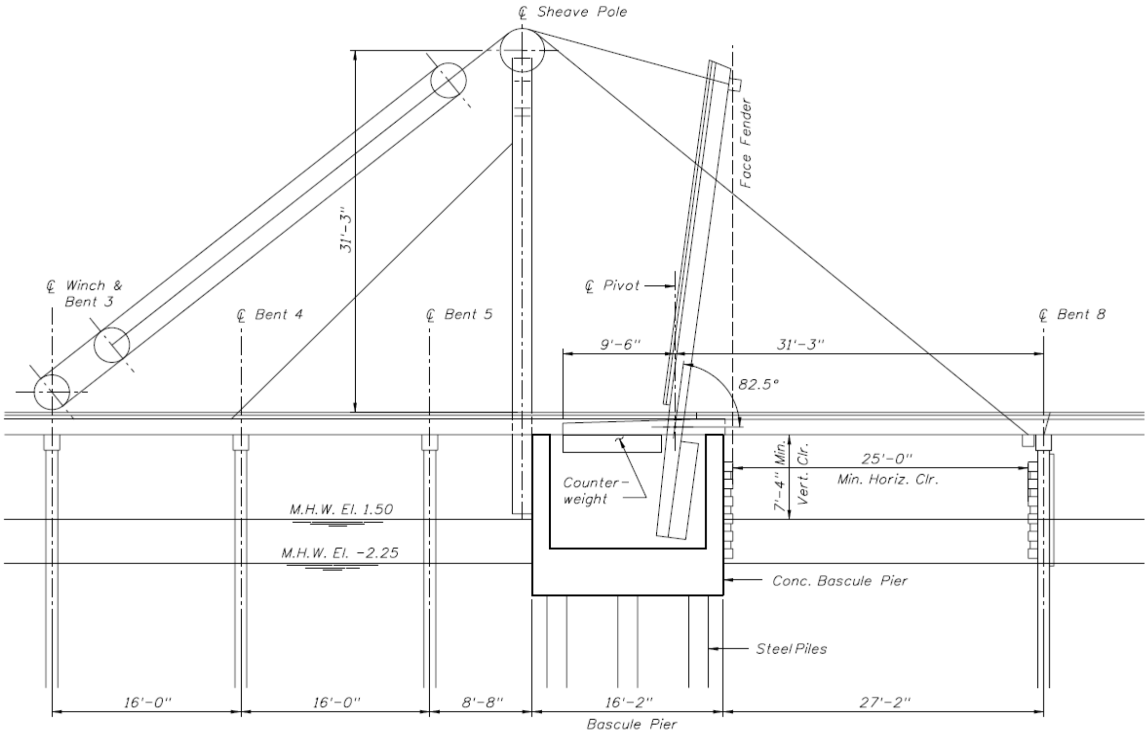

ALTERNATIVE 1B – LONGITUDINAL SECTION

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The proposed all-timber bascule leaf is supported on a reinforced concrete bascule pier that includes concrete walls that fully enclose the pier, pedestals that support the operating machinery, platforms for maintenance access to the equipment, and a footing embedded in the river bed. The bascule pier is constructed using a steel sheet pile cofferdam to permit the footing and walls below water to be constructed in the dry. The bascule pier is supported on concrete filled driven steel pipe piles. The bascule pier deck consists of a sawn lumber plank timber wearing surface with the planks oriented parallel to the roadway centerline and which extend the width of the roadway. The timber wearing surface is supported on and nailed to a glue laminated timber structural deck that spans parallel to the roadway centerline between the back and front walls of the pier. Floor hatches with vertical access ladders provide access into the piers. The exterior faces of the bascule pier will include stone facing using materials and details consistent with the local community. The concrete bascule pier will introduce local pier scour of approximately 10 feet compared to the 4 feet of local pier scour at the approach pile bents.The tip end of the bascule leaf rests on an approach pile bent (i.e. rest bent) with the leaf in the lowered position.

The fender system each side of the navigation channel consists of a combination of horizontal and vertical timber members attached to the face of the concrete bascule pier and rest bent timber piles.

3.4 Navigation Opening and Bascule Span Design

3.5.1 Navigation Opening

As the required improvements to the navigation channel include a navigation width of 25’-0” with unlimited vertical clearance, the issues associated with providing this navigation channel for alternatives with an all-timber single-leaf wooden draw span, were investigated.

3.5.2 Counterweight

The length of the shortest counterweight using the heaviest counterweight material practical (i.e. counterweight fabricated using solid stainless steel) required to balance the all-timber single-leaf bascule spanis 9’-6” long. Using the maximum bridge height , the counterweight pivots below the waterline and becomes submerged during operation. As previously discussed, this results in significant safety, reliability and maintenance concerns.

A concrete bascule pier that fully encloses the pivoting counterweight will prevent the counterweight from becoming submerged. As the operating machinery for the all-timber draw span must lift the bascule span from the tip of the leaf, the operating machinery must consist of a cable operated system with the machinery located above the deck. As such, the concrete bascule pier does not need to be sized to house the operating machinery and a smaller bascule pier can be used.

3.6 Life Cycle Cost Analysis (LCCA)

3.6.2 LCCA Results

The results of the updated LCCA are summarized in Table 1, below, with the following assessment (see Appendix B for the LCCA calculations for the additional alternatives):

Alternatives 1, 1A and 1B have low initial construction costs, Alternatives 2, 3 and 4 have high initial construction costs, and Alternative 5 has a moderate initial construction cost.

Alternatives 1, 1A and 1B have moderate to high life cycle costs, Alternative 2 has high life cycle costs, Alternatives 3 and 4 have moderate life cycle costs,and Alternative 5 has low overall life cycle costs. With the exception of the initial construction costs, which will be funded under the Accelerated Bridge Program, the Town of Chatham is assumed to be responsible for all other life cycle costs.

Alternatives 1, 1A and 1B provide a relatively short service life requiring complete replacement of the bridge, except the concrete abutments and concrete bascule pier

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(Alternative 1B only),every 20 to 30 years, due to the need to replace the timber piles. For Alternative 1B, because the bascule span is integrated with the approach spans, it will need to be replaced with the approach spans. Alternative 2 provides a relatively short service life for the approach spans requiring replacement of the approach spansevery 20 to 30 years, due to the need to replace the approach span timber piles. Alternatives 3, 4, and 5 provide significantly greater service life requiring replacement of concrete and steel elements only after 80 to 100 years,although replacement of timber elements are required more frequently. Alternatives 1, 2, 3, and 4 require replacement of the timber wearing surface every 10 to 20 years and replacement of the timber structural deck every 20 to 40 years, where Alternative 5 requires resurfacing of the concrete after 40 years. Each instance the bridge, approach spans, deck, and wearing surface are replaced result in significant disruptions to users, with corresponding user delay costs.

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TABLE 1 - LIFE CYCLE COST ANALYSIS SUMMARY

Alt.	Description	Initial Project Cost (ABP Funded)	Overall Life Cycle Cost (Present Value with 0.8% Discount Rate)		Town of Chatham Responsibility (Present Value with 0.8% Discount Rate)		Duration (e) Btwn. Bridge Closures (yrs.)	
			Worst Case	Best Case	Worst Case	Best Case	Worst	Best
1	Timber Superstr on Timber Substr Timber Bascule Span (a)	$ 8,147,000	$ 28,126,341	$ 22,519,360	$ 19,979,341	$ 14,372,360	10	20
1A	Timber Superstr on Timber Substr Timber Bascule Span (b)	$ 8,794,000	$ 30,536,392	$ 24,391,337	$ 21,742,392	$ 15,597,337	10	20
1B	Timber Superstr on Timber Substr Timber Bascule Span (c)	$ 9,296,000	$ 30,737,668	$ 24,799,074	$ 21,441,668	$ 15,503,074	10	20
2	Timber Superstr on Timber Substr Steel Bascule Leaf on Conc Pier (d)	$ 11,387,000	$ 32,435,893	$ 29,622,903	$ 21,048,893	$ 18,235,903	10	20
3	Timber Superstr on Conc-Steel Substr Steel Bascule Leaf on Conc Pier (d)	$ 11,047,000	$ 26,839,854	$ 26,241,159	$ 15,792,854	$ 15,194,159	10	20
4	Timber Deck and Steel Stringer Superstr on Conc-Steel Substr Steel Bascule Leaf on Conc Pier (d)	$ 11,189,000	$ 27,466,483	$ 26,573,530	$ 16,277,483	$ 15,384,530	10	20
5	Conc Deck and Conc Beam Superstr on Conc-Steel Substr Steel Bascule Leaf on Conc Pier (d)	$ 10,676,000	$ 23,573,735	$ 22,430,038	$ 12,897,735	$ 11,754,038	40	40

Notes:

a) Alternative provides 19’-4” navigation channel with unlimited vertical clearance and unprotected machinery. Pivoting counterweight clears mean high water.
b) Alternative provides 25’-0” navigation channel with unlimited vertical clearance and unprotected machinery. Pivoting counterweight submerges during operation.
c) Alternative provides 25’-0” navigation channel with unlimited vertical clearance with unprotected machinery. Bascule pier fully encloses pivoting counterweight.
d) Alternative provides 25’-0” navigation channel with unlimited vertical clearance. Bascule pier fully encloses pivoting counterweight and protects machinery.
e) Detour of bridge required to perform major work including wearing surface replacement, superstructure replacement, and bridge replacement.

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4.0 OVERALL CONCLUSIONS AND RECOMMENDATIONS

The matrix below and referenced notes, which summarize how well each alternative satisfies each of the primary project design criteria, were presented in the previous report and have been updated to include the two additional alternatives.

RESULTS OF DESIGN CRITERIA EVALUATION

Alt.	Primary Project Design Criteria Categories						
	Roadway Function & Safety(1)	Context Sensitive(2)	Navigation Function & Safety(3)	Initial Construction Cost(4)	Life Cycle Costs(5)	Maintenance & Service Life(6)	Environment (7)
1	Good	Good	Poor	Good	Fair	Poor	Poor
1A	Good	Good	Fair	Good	Fair	Poor	Poor
1B	Good	Satisfactory	Satisfactory	Good	Fair	Fair	Fair
2	Good	Satisfactory	Good	Fair	Poor	Fair	Fair
3	Good	Fair	Good	Fair	Satisfactory	Satisfactory	Satisfactory
4	Good	Fair	Good	Fair	Satisfactory	Satisfactory	Satisfactory
5	Good	Poor	Good	Satisfactory	Good	Good	Satisfactory

Notes:

1. Alternatives 1 thru 5 including 1A and 1B equally accommodate improvements in roadway function and safety, including additional roadway and sidewalk width and safety features.
2. Alternatives 1 and 1Aare all timber solutions that would resemblethe existing bridge. Alternative 1B is an all timber solution that would resemble the existing bridge with the exception of the introduction of a concrete bascule pier to enclose the pivoting counterweight. The other alternatives contain timber in different bridge elements and other features that mitigate the replacement of the NRHP eligible resource. See table below.

CONTEXT SENSITIVE SOLUTIONS - SUMMARY OF BRIDGE ELEMENTS with TIMBER

Alt.	Approach Substructure	Approach Beams	Deck	Sidewalks	Pedestrian Railings	Traffic Railings	Bascule Span
1	✓	✓	✓	✓	✓	✓(E)	✓
1A	✓	✓	✓	✓	✓	✓(E)	✓
1B	✓	✓	✓	✓	✓	✓(E)	✓(F)
2	✓	✓	✓	✓	✓	✓(E)	✗(D)
3	✗	✓(E)	✓	✓	✓	✓(E)	✗(D)
4	✗	✗(A)	✓	✓	✓	✓(E)	✗(D)
5	✗	✗(B)	✗(C)	✓	✓	✓(E)	✗(D)

Notes:
G. Steel stringers are obscured by the timber sidewalks.
H. Concrete deck beams are obscured by the timber sidewalks.
I. Concrete deck includes a stamped concrete pattern and color admixtures to simulate a timber deck.
J. Concrete bascule pier contains stone facing and steel bascule leaf is obscured by the timber sidewalk.
K. Denoted timber members are glue laminated (i.e. glulam) timber in lieu of sawn lumber.
L. Timber bascule leaf is supported concrete bascule pier which contains stone facing.

3. A letter from the United States Coast Guard dated February 12, 2010, states "… there have been numerous structural and operational issues involving this bridge

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over the past several years. A design flaw in the original construction of the bridge prevented it from fully opening for passage of vessel traffic resulting in several mishaps wherein vessels sustained damage to their rigging due to hitting the tip of the draw span. In its present condition the draw span cannot fully open to provide unobstructed vertical clearance for the full width of the bridge between fender faces. The Coast Guard, therefore, will seek to promote the optimum navigational opening for any proposed replacement structure." Alternative 1 provides only a 19'-4" navigation opening width with unlimited clearance, which would be unacceptable to the boating community, and includes non-redundant operating machinery possessing safety and reliability concerns. Alternatives 2, 3, 4 and 5 provide a 25'-0" navigation opening width with unlimited clearance, which is preferred by the boating community and redundant operating machinery that provides a higher degree of safety and reliability. Alternative 1A provides a 25'-0" navigation opening width with unlimited vertical clearance, includes non-redundant operating machinery and a counterweight that becomes submerged during operation which introduces safety and reliability concerns.Alternative 1B provides a 25'-0" navigation opening width with unlimited vertical clearance, includes a concrete bascule pier that encloses the pivoting counterweight, and non-redundant operating machinerypossessing safety and reliability concerns.

4. Alternatives 1, 1A and 1B have a low initial construction cost, Alternatives 2, 3 and 4 have high initial construction costs, and Alternative 5 has a moderate initial construction cost.
5. Per the life cycle cost analysis, Alternatives 1, 1A and 1B have moderate to high life cycle costs, Alternative 2 has a high life cycle costs, Alternatives 3 and 4 have moderate life cycle costs,and Alternative 5 has low overall life cycle costs. With the exception of the initial construction costs, which will be funded under the Accelerated Bridge Program, the Town of Chatham is assumed to be responsible for all other life cycle costs.
6. Alternatives 1 and 1A provide a relatively short service life requiring complete replacement of the bridge, except for the concrete abutments,every 20 to 30 years, due to the need to replace the timber piles. Alternatives 1B and 2 provides a relatively short service life for the approach spans requiring replacement of the approach spans every 20 to 30 years, due to the need to replace the approach span timber piles. For Alternative 1B, because the bascule span is integrated with the approach spans, it will need to be replaced with the approach spans. Alternatives 3, 4, and 5 provide significantly greater service life requiring replacement of concrete and steel elements only after 80 to 100 years,although replacement of timber elements are required more frequently. Alternatives 1, 2, 3, and 4 require replacement of the timber wearing surface every 10 to 20 years and replacement of the timber structural deck every 20 to 40 years, where Alternative 5 requires only resurfacing of the concrete after 40 years. Each instance the bridge, approach spans, deck, and wearing surface are replaced result in significant disruptions to users, with corresponding user delay costs.
7. Alternatives 1, 1A, 1B and 2 include timber piles that will require replacement on more frequent intervals. Replacement of piles disturbs the waterway bottom sediments, which contain accumulations of polycyclic aromatic hydrocarbons

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(PAHs) and other compounds from the existing piles that are toxic to aquatic organisms. Alternatives 1, 1A, 1B and 2 contain a significantly greater number of piles and pile bents than Alternatives 3, 4 and 5, and thus disturb a greater volume of bottom sediments during pile replacement. Although, the concrete bascule pier for Alternatives 1B, 2, 3, 4 and 5 is large, the steel sheet pile cofferdam used to construct the pier will contain the sediments and minimize impacts of the disturbed sediments on the environment. New timber piles and other submerged timber substructure elements for Alternatives 1, 1A, 1B and 2 may also include timber preservative treatments that are considered hazardous to human health and the environment. Alternatives 3, 4 and 5 include piles and substructure elements with a significantly greater service life and thus minimize the occurrences when the bottom sediments would be disturbed. The piles and submerged substructure elements of Alternatives 3, 4 and 5 avoid the need for hazardous timber preservatives.

Based on evaluation and comparison, the alternatives are generally ranked as follows with regard to the project design criteria:

RANK	ALTERNATIVE
1	Alternative 5
2	Alternative 3
3	Alternative 4
4	Alternative 2
5	Alternative 1B
6	Alternative 1
7	Alternative 1A

Alternative 5 appears to best satisfy the overall project design criteria. Alternative 5 meets roadway function and safety requirements, minimizes impacts to adjacent properties, provides a cost-effective solution with the lowest overall life-cycle costs, requires least amount of maintenance and corresponding fewest disruptionsto users, fully addresses navigation function and safety needs, minimizes impacts to the environment, and provides a context sensitive solution with features that seek to mitigate the replacement of the NRHP eligible resource.

Alternatives 3 and 4 also meet roadway function and safety requirements, minimize impacts to adjacent properties, fully address navigation function and safety needs, and minimize impacts to the environment.In addition, Alternatives 3 and 4 provide a modestly more context sensitive solution than Alternative 5, given the use of timber bridge deck in lieu of concrete bridge deck. However, Alternatives 3 and 4 require greater maintenance with corresponding greater disruptions to users, a higher initial construction cost, and higher life-cycle costs. Alternatives 3 and 4 are virtually equal to each other inconstruction cost, life-cycle costs, and in meeting project design criteria. However, Alternative 3 provides a slightly more context sensitive solution than Alternative 4 with the use of approach span timber stringers in lieu of approach span steel stringers.

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Alternative 2 also meets roadway function and safety requirements, minimizes impacts to adjacent properties, and fully addresses navigation function and safety needs. In addition, Alternative 2 provides a more context sensitive solution than Alternatives 3, 4 and 5 with the use of all timber approach span superstructure, substructure and pile foundations. However, Alternative 2 requires significantly greater maintenancewith corresponding disruptions to users, introduces greater environmental impacts, and has the highest initial construction cost, and highest life-cycle costs.

Alternative 1B also meets roadway function and safety requirements and minimizes impacts to adjacent propertiesand addresses navigation function and safety needs with the exception that it provides non-redundant operating machinery with safety and reliability concerns. Alternative 1B has a low initial construction cost and provides a more context sensitive solution than Alternatives 2, 3, 4 and 5 with the use of all timber single-leaf wooden draw span, except for the concrete bascule pier. However, Alternative 1B hasmoderate to high life-cycle costs, requires significantly greater maintenance and corresponding disruptions to users, and introduces the higher environmental impacts.

Alternative 1 also meets roadway function and safety requirements and minimizes impacts to adjacent properties. In addition, Alternative 1has the lowest initial construction cost and isa solution that provides a more context sensitive solution than Alternatives 1B, 2, 3, 4 and 5 with the use of all timber single-leaf wooden draw span. However, Alternative 1 has moderate to high life-cycle costs, does not adequately address navigation function and safety needs, requires significantly greater maintenance and corresponding disruptions to users, and introduces the greatest environmental impacts.

Alternative 1Aalso meets roadway function and safety requirements and minimizes impacts to adjacent properties. Alternative 1Aaddresses some navigation function and safety needs, but the counterweight becomes submerged during operation and it provides non-redundant operating machinery with safety and reliability concerns. Alternative 1Ahas a low initial construction cost and isa solution that provides a more context sensitive solution than Alternatives 1B, 2, 3, 4 and 5 with the use of all timber single-leaf wooden draw span. However, Alternative 1 has moderate to high life-cycle costs, does not adequately address navigation function and safety needs, requires significantly greater maintenance and corresponding disruptions to users, and introduces the greatest environmental impacts.

As such, URS recommends Alternative 5 is recommended with continued coordination of appropriate mitigation to achieve an appropriate balance of all design criteria.

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APPENDICES

A. Additional Life Cycle Cost Analysis (LCCA)

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