TOWN OF NORTHBOROUGH Community Preservation Committee
Town Hall Offices • 63 Main Street • Northborough, MA 01532 • 508-393-5019 • 508-393-6996 Fax

FY2023 APPLICATION

The Community Preservation Act provides funding for three core community concerns:

- Acquisition and preservation of open space/recreation
- Creation and support of community housing
- Acquisition and preservation of historic buildings and landscapes

DATE SUBMITTED: 11.1.2021
NAME OF PROJECT: Preliminary Design for Pedestrian Access Over the Assabet River Aqueduct Bridge
NAME OF APPLICANT: Northborough Trails Committee
CONTACT ADDRESS: Planning Office, Town Hall, 63 Main Street,
CONTACT TELEPHONE: 508-393-5015
CONTACT EMAIL ADDRESS: mmcdonald@town.northborough.ma.us
SPONSORING ORGANIZATION: Northborough Trails Committee
CPA CATEGORY: ☒ OPEN SPACE/RECREATION ☐ HOUSING ☒ HISTORIC
LOCATION: ☒ TOWN LAND ☐ SCHOOL LAND ☐ PRIVATE LAND
AMOUNT OF CPA FUNDS REQUESTED: $
OTHER FUNDING SOURCES:
TOTAL COST OF PROJECT: $ 133,658.00
BRIEF DESCRIPTION OF PROJECT, INCLUDING ANY CONSTRUCTION REQUIRED:
The application is to hire an engineering firm to conduct the preliminary design for allowing pedestrian access over the Assabet River Aqueduct Bridge.

3. **COMMUNITY SUPPORT:** What is the nature and level of support and/or opposition for this project? Include either a letter of support from the town board (Housing Partnership, Historic District Commission, Open Space Committee, Recreation Commission etc.) or a letter from the board stating why they do not support this application.

The 2019 Master Plan and 2020 Open Space and Recreation Plan both specifically list the opening of the Assabet River Aqueduct Bridge to pedestrian access as goals. Letters of support from the Conservation Commission, Parks & Recreation Commission and the Northborough Historic District Commission are included in this application.

The opening of the bridge to pedestrian traffic is Phase 3 of the Town's 8M Permit with the MWRA for the use of the aqueduct for trails. See narrative for additional details.

4. **BUDGET**: What is the total budget for the project and how will CPA funds be spent? All items of expenditure must be clearly identified and back-up documentation provided. If the project involves construction on Town or school land, it may need to meet procurement and prevailing wage requirements.

The estimate for this work is attached to this application.

7. **IMPLEMENTATION:** Who will be responsible for implementing the project? Who will the project manager be? What relevant experience does the proposed project manager have? Who else will be involved in project implementation and what arrangements have been made with them?

The Trails Committee staff, the Town's Conservation Agent, will oversee the contract and correspondence with the consulting engineer.

8. **MAINTENANCE:** If on-going maintenance is required, who will be responsible and how will it be funded?

No ongoing maintenance is required for this project.

TOWN OF NORTHBOROUGH Trails Sub-Committee
Town Hall Offices • 63 Main Street • Northborough, MA 01532 • 508-393-5019 • 508-393-6996 Fax

October 6, 2021

To: Community Preservation Committee

Re: Application for Funding for Preliminary Design for Pedestrian Access Over the Assabet River Aqueduct Bridge

Dear Community Preservation Committee Members –

The Northborough Trails Committee is excited to apply for funding for proposed preliminary design for pedestrian access over the Assabet River Aqueduct Bridge. The goal of this project is to obtain design for replacement decking and security railings, as well as structural inspection, relocation of utilities and submission of plan to MWRA for their approval as required in the Town's 8M Permit for access.

The bridge is currently owned by the Massachusetts Water Resource Authority. After a multi-year application process, NTC and the Board of Selectmen were successfully awarded their application for an 8M Permit from Massachusetts Water Resource Authority (MWRA) for pedestrian access over the aqueduct from the Marlborough line to the Berlin line in 2013. Phase 1 opened a 1.2 mile section in 2014 from the Marlborough line to the Assabet River Aqueduct Bridge. Phase 2 opened a 4 mile stretch from the bridge to the Berlin line in 2019. Phase 3, the most intensive project, is to open the bridge to pedestrian access and connect the entire 4.2 mile stretch.

The bridge is currently not suitable for pedestrian access due to uneven surfacing and inadequate safety fencing along the sides. A structural report completed by professional engineers at Stantec for MWRA in 2017 confirms the bridge is structurally sound for pedestrian use. The report recommends the relocation of the overhead utilities, then to proceed to design and engineering to verify steel beam and deck load-carrying capacities, new decking and railings.

Town Staff has been working with local utilities who own overhead wires located so close to the bridge to prevent pedestrian access for many months. National Grid owns these poles and the top-most cable, with Verizon and Spectrum owning the lower cables. As owners, Grid requires their in-house engineers determine if there is room in the right-of-way and then design the new trench and contract their own or approved subcontractors and oversee the construction; the town would be responsible for the construction costs. The in-house engineers at Grid have determined there is room in the right-of-way within Hudson Street for the new trench. The preliminary design report would include this process and costs in the final project scope.

This application is eligible for CPC Funding under the Open Space, Historic and Recreation Criteria:

Open Space Criteria met:

- Provide opportunities for passive recreation and environmental education.
- Preserve and/or restore threatened or deteriorating public lands.
- Provide connections with existing trails or potential trail linkages.

Stantec

Memo

To:	William Sullivan, MWRA	From:	Christopher Nichols, PE Michael McCall, PE
File:	Assabet River Bridge	Date:	December 21, 2017

Reference: Assabet River Bridge – Evaluation for Use as Part of a Public-Use Path

Introduction

Under Technical Assistance Contract 7407, Stantec evaluated the Assabet River Bridge for the proposed use as part of the Town of Northborough hiking trail under an MWRA 8(m) permit. The bridge was constructed in 1898 as part of the original Wachusett Aqueduct and was bypassed by a siphon structure constructed in the mid-twentieth century.

Our investigation included review of historic plans and photographs, review of a previous inspection report, visual inspection of the interior and exterior of the aqueduct bridge, structural evaluation of the bridge deck (the "roof" of the old aqueduct), and development of alternatives to allow the bridge deck to be safely used as part of the proposed hiking trail. The scope of work included a condition assessment of the bridge structure and preparation of this memo to recommend economical, constructible and maintainable repairs that will achieve the Authority's and Town's goals.

For this evaluation, the live load on the bridge deck was assumed to be restricted to pedestrian and bicycle traffic. We did not anticipate any vehicular traffic.

This memo does not address provisions of the Americans with Disabilities Act (ADA) or the requirements of the Massachusetts Architectural Access Board (AAB). Evaluation of ADA/AAB compliance is not part of our scope of services. No sampling of building materials was conducted to identify potential hazardous building materials, i.e. lead, asbestos, PCBs or similar common contaminants. Any work undertaken to the bridge structure may require approval from local or state historical commissions.

Background & Existing Conditions

General Description of Bridge

The structure is a seven-arch-span bridge that originally carried part of the Wachusett Aqueduct in a brick-masonry-lined channel on top of the concrete-filled stone-masonry arches. The aqueduct channel is covered with a roof structure that also provides pedestrian access on top of the now-abandoned section of aqueduct. The roof structure consists of shallow brick arches (backfilled with concrete and topped with an additional outer concrete slab) that span between the bottom flanges of steel I-beams. The I-beams are supported on the brick-masonry side walls of the aqueduct channel (see Figure A).

The main arches are composed of finely cut mortared granite stones. Each arch is semi-circular, having a rise (and radius) of 14'-9" above the spring line and a clear span of 29'-6". The spandrel

- A copy of the MWRA 8(m) permit, Permit No. 13-1549, dated July 1, 2013, directed to the Town of Northborough Board of Selectman, addressing the conditions for use of MWRA property along the aqueduct route for the proposed public-use path.

- A copy of a letter from the Town of Northborough Trails Committee to the Authority, dated June 19, 2017, in which the Committee describes its latest plans to implement the public-use path, including the section over the Assabet River Bridge.

- A copy of an email message from Marcis Kempe to Marianne Connolly, dated June 30, 2017, in which Mr. Kempe offers his opinions on some possible causes that may have contributed to the decision to bypass the bridge with the siphon. Mr. Kempe states his opinion that leakage of water from the bridge structure was the main cause.

We reviewed digital images of three additional original construction drawings, and of numerous original construction photos, available from Digital Commonwealth at their internet website www.digitalcommonwealth.org. (Digital Commonwealth describes itself as a statewide consortium of libraries, museums, archives, and historical societies from across Massachusetts.) The drawings are as follows:

- Sheet No. 1, Nashua Aqueduct, Plan and Profile of Sections 2 and 3 (date not legible), which shows the aqueduct crossing the Nashua River.

- Nashua Aqueduct, Assabet River Bridge, Coffer-Dam (date not legible).

- Wachusett Aqueduct, Railing for Assabet Bridge (date not legible).

Existing Conditions

We inspected the interior of the aqueduct bridge on October 10, 2017 (following a heavy rainfall the previous day) and the exterior (including from a small boat in the river) on October 18, 2017.

Observations of Interior Structural Conditions (see Photos 1 – 4):

- The interior surfaces of the invert, walls, and underside of the brick roof and steel beams are covered with mortar. We measured the thickness of the mortar at a spall in the wall; the total mortar thickness is 1 3/8", with the outer 1/8" appearing to be a different, finer material compared to the inner 1 ¼" of mortar.

- Mortar on the underside of the roof and beams is completely intact. Some of the mortar is cracked, but we observed no spalls on the underside.

- Efflorescence is present on mortar under the steel beams, indicating past leakage. This efflorescence is mainly white in color. At a few locations, there is some brown staining of this material, indicating some rusting of embedded beams and strap plates.

- Active leakage through the mortar below the roof beams was occurring at a few locations.

Other Observations:

- Low wires (communication lines spanning between poles on either side of the bridge) hang over the deck near the west end of the bridge. Electrical lines pass over, spanning between the same poles, at a higher elevation.
- Vegetation is overgrowing the stairs, walls, fences, and bridge deck at both ends of bridge.
- Chain link fences at the bridge ends are damaged.
- Gates in the chain link fences at the stairways are locked with padlocks.

Structural Analysis of Aqueduct Roof / Bridge Deck for Existing Conditions

Based on our review of existing drawings, our field observations, and our assumptions concerning unknown information, we performed a preliminary structural analysis of the aqueduct roof structure that will serve as the bridge deck for the proposed public-use path.

Steel or Iron Beams

The metal beams are not visible, because of the mortar covering the bottom flanges and the encasement of the remainder of the beams in the brick and concrete structural system. The existing drawings only indicate the size of these members as 10" I-beams. From our review of the drawings, which we assume were drawn approximately to scale; historic photos of the bridge construction; and historic steel-beam and wrought-iron-beam data, we assume the beams to be steel (rather than wrought iron) rolled sections with the following dimensions, section properties, and allowable bending stress:

Depth: $d = 10"$

Flange width: $b_f = 4.95"$

Flange thickness: $t_f = 0.31"$ at edges, and 0.67" at web

Web thickness: $t_w = 0.60"$

Cross-sectional area: $A = 10.3\ in^2$

Weight: 35.0 lb/ft.

Moment of inertia, strong axis: $I_x = 147\ in^4$

Section modulus, strong axis: $S_x = 29.3\ in^3$

Allowable bending stress, $F_b = 14{,}000$ lb/sq. in. (psi)

Asphalt topping: Not part of original construction; approximately 12 psf

Using this information, and assuming no composite action between the brick arches and the concrete topping, the system was analyzed as a fixed-end arch with a midspan hinge using the RISA-3D software package. The calculated existing maximum dead-load compressive stress was only 17 psi. Under the same dead load, plus the full 90 psf AASHTO live load, the maximum compressive stress was only 24 psi, much less than the 115 psi allowable stress for the brick masonry.

The steel beams, therefore, control the capacity of the roof/bridge-deck structural system, rather than the brick arches between the beams.

Structural Analysis of Aqueduct Roof / Bridge Deck for Proposed Conditions

Under all proposed conditions, the existing deteriorated 4" concrete/granolithic topping slab, and the 1" asphalt topping, will be removed and not replaced. Repeating the analysis described above for the steel beams, with this dead load removed, the allowable live load increases by the magnitude of this removed dead load, which is approximately 60 psf. Adding this to the 38 psf previously calculated results in a total allowable live load of approximately 98 psf, which exceeds the AASHTO recommended design value of 90 psf for new pedestrian bridges.

Evaluation of Supporting Structure Below Aqueduct Roof / Bridge Deck

By inspection, the supporting structure consisting of the masonry sidewalls of the aqueduct channel, the stone arches and spandrel walls backfilled with concrete, and the stone-faced concrete piers, can resist the current dead loads and the proposed pedestrian live load. This is known with confidence because they have withstood, with no observable structural distress, the "proof load" of the weight of water in the aqueduct for many years; this is a much greater load than the supporting structure will ever experience under its proposed use as a pedestrian bridge for a public-use hiking path.

Summary and Discussion of Findings

Interior Structural Conditions

The interior conditions are generally good. Following is a discussion of the few deficiencies noted:

- The generally white color of the efflorescence exuding from cracks in the mortar on the interior of the structure indicates that the steel beams and wrought iron strap plates embedded in the masonry are not heavily rusted. Brown staining in the efflorescence, indicating the presence of some rust, is visible in a few locations; however, the underlying corrosion is probably not heavy, because steel and iron expand greatly (about seven times its original volume) when oxidized/rusted, and any significant expansion would spall the thin layer of mortar off the rusting metal – yet, we did not observe any such spalling below the steel beams, even at locations of active leakage.

- The few spalls in the mortar on the walls may be caused by freeze-thaw action of water that penetrated the brick masonry, although the locations of the spalls do not seem correlated

clearance over pedestrians' heads). A greater clearance is desirable to discourage vandalism of the wires.

- Vegetation sprouting from the ground around the stairways and chain-link fences at the ends of the bridge obstructs access and will have to be removed to allow pedestrian access.

- Gates in the fences at the ends of the bridge will have to be unlocked or removed to accommodate the proposed public-use path. The damaged fences should be repaired and remain in place to act as fall protection along the tops of the stone stairway walls and wingwalls at the bridge ends.

Structural Calculations

The results of our calculations are not conclusive because we were not able to determine the exact load-carrying capacity of the steel roof/deck beams from the original plans or from our site observations. However, using reasonable assumptions for beam properties, the resulting 50 psf live-load capacity seems realistic as a live load that designers of the 1890s would have used. Stress calculations on steel beams were routinely performed for structures of that era, and a design live load in the range of 40 to 60 psf would have been common for building structures of that time. Removing the 4" of outer concrete topping effectively doubles that live load capacity by removing approximately 50 psf of dead load.

Although we are recommending verification of steel-beam properties by field measurements, or verification of load-carrying capacity by in situ load-testing (if measurements are inconclusive or negative), we note that this roof/deck structure has likely already been effectively load-tested for the weight of the 1" asphalt topping (12 psf) plus the weight of the maximum snow loading the structure has seen in its 120-year life. Because the structure is unheated and has not been subject to snow removal for at least the last 70 years (if ever), this maximum snow load is likely based on at least 2 ft. of densely packed, built-up snow, which at an assumed density of 15 pcf yields a snow load of about 30 psf. The 42 psf (12 psf asphalt + 30 psf snow) effective "load test" is not scientific or conclusive, but it does add confidence to our recommendation of using the existing aqueduct roof structure as the proposed pedestrian bridge deck, especially combined with our recommendation to remove the existing 4" outer concrete topping and 1" of asphalt and to only put back a waterproofing membrane.

Rehabilitation Alternatives

The goal of the Town of Northborough is to repair the bridge so it can be safely used as part of the public-use path for which it has obtained the MWRA 8(m) permit. The main structural issues that must be addressed to achieve this goal are as follows:

- The outer concrete topping slab and asphalt topping are severely deteriorated or missing over most of the area of the bridge deck. Vegetation is growing from within cracks and spalls in this surface. This topping slab and asphalt must be completely removed. The removal of these non-structural components has the advantage of reducing the dead load on the steel beams that support the remaining bridge deck.

Reference: Assabet River Bridge – Evaluation for Use as Part of a Public-Use Path

The "alternatives" to repair the bridge to achieve the Town's goal are actually a sequence of recommended actions, with each of the "follow-on" actions only being necessary if the "preceding" action has a negative outcome. The recommended sequence, to address the issues discussed above, is summarized as follows:

1. Verify the assumed steel-beam section properties by field measurements. If the result of the verification is positive, then remove the existing 4" concrete/granolithic topping slab, asphalt, and iron railings. Repair the surface of the underlying concrete, and place a pedestrian-traffic-bearing waterproofing membrane over the repaired concrete. Install a new historically appropriate and code-compliant railing by anchoring posts to the existing granite edge stones. Perform other repairs and modifications, common to all options, as described below.

2. If the result of the verification of beam properties based on field measurements is negative, then perform in situ, instrumented load-testing of the bridge roof/deck structure in accordance with ACI 437 – *Code Requirements for Load Testing of Existing Concrete Structures and Commentary*. If the result of the load-testing is positive, then perform the same rehabilitation described in (1), above.

3. If the result of the load-testing is negative, then consider the following two options and choose the less costly option. Both options include removal of the existing 4" concrete/granolithic topping slab, asphalt, and iron railings:

    a. Shore the steel beams from within the interior of the aqueduct channel. This is assumed to involve making two large openings in the existing brick-arch-and-concrete-deck system to facilitate the installation of shoring in the confined space. Then perform the same rehabilitation described in (1), above.

    b. Waterproof the top of the existing underlying concrete slab with a non-traffic-bearing membrane. Place a new deck of precast concrete panels over the existing deck, with the new deck only supported on the masonry side walls of the aqueduct channel. Install a new historically appropriate and code-compliant railing by anchoring posts to the edge of the new precast panels.

For whatever level of repair is necessary, the following repairs and remediation are also necessary. Except for the first item, these are relatively minor:

- Raise the communication wires over the bridge. (This is expected to be a costly undertaking.)

- Repoint/fill granite mortar joints at isolated locations, mainly at the extrados (upper edge) of some arch stones.

- Modify the bottom step and/or bridge deck at granite stairways at each end of bridge to mitigate the odd riser height at the bottom step.

- Repair/modify chain-link fences and gates to accommodate pedestrian use.

Evaluation and Comparison of Alternatives

Based on our investigation, we identified the following options. All options include removal of the extremely deteriorated 4" outer concrete topping slab and the 1" asphalt layer.

Option 1 – Field Verify Steel Beam Properties by Direct Measurements; Provide New Traffic-Bearing Waterproofing Membrane and Steel Railings (see Figure B)

This is the least costly option, and should be implemented if assumed steel beam properties (indicating adequate live-load carrying capacity) can be field verified.

Option 2 – Verify Deck Load-Carrying Capacity by Load-Testing; Provide New Traffic-Bearing Waterproofing Membrane and Steel Railings (see Figure B)

This option should only be implemented if assumed steel beam properties cannot be field verified, or if measurements indicate inadequate live-load carrying capacity of existing steel beams.

Option 3 a. – Provide New Traffic-Bearing Waterproofing Membrane and Steel Railings, with Internal Shoring of Deck (see Figure C)

This option should only be implemented if field measurements and load testing prove negative in confirming adequate live-load carrying capacity of existing roof/deck system.

Option 3 b. – Provide New Non-Traffic-Bearing Waterproofing Membrane, with New Precast Concrete Deck Panels and Steel Railings (see Figure D)

This option should only be implemented if it is less costly that Option 3.a., and if field measurements and load testing prove negative in confirming adequate live-load carrying capacity of existing roof/deck system. Our initial opinion of probable construction cost indicate that Option 3.a. would be substantially less expensive than Option 3.b.; however, the cost premium of working within the confined space to install the shoring for Option 3.a. is a major unknown – and this would not be an issue with Option 3.b., which can be accomplished without entering the confined space.

Budget Opinion of Probable Construction Costs

We compute the following opinion of probable construction costs (including 30% contingency) for the sequential options described previously. The approximate breakdown of these total costs by major anticipated work items is given below.

Item	Cost
Raising Overhead Wires	$100,000
Mobilization	$100,000
Clearing and Grubbing	$25,000
Concrete Excavation	$17,500

Reference: Assabet River Bridge – Evaluation for Use as Part of a Public-Use Path

Recommendation

Based on our evaluation, we recommend implementing Option 1, and implementing the remaining options, only as necessary, in numerical sequence. If Option 3 proves necessary, it appears that Option 3.a. (shoring) will be less expensive than Option 3.b. (precast deck panels), but, if it came to considering Option 3, it may be advisable to bid the project with both options and/or allow the contractors to bid Option 3.b. as an Add Alternate.

Reference: Assabet River Bridge – Evaluation for Use as Part of a Public-Use Path

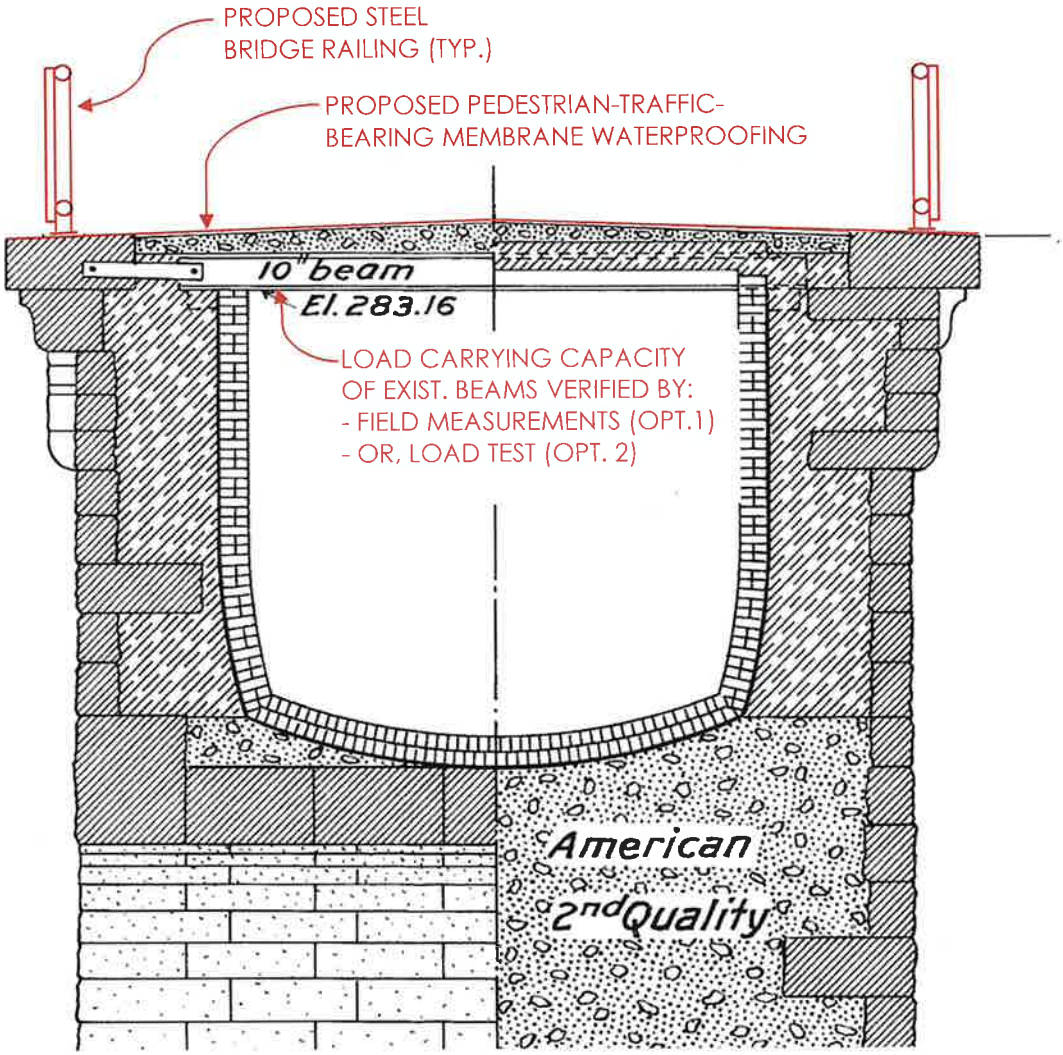


Figure B: Option 1 and Option 2

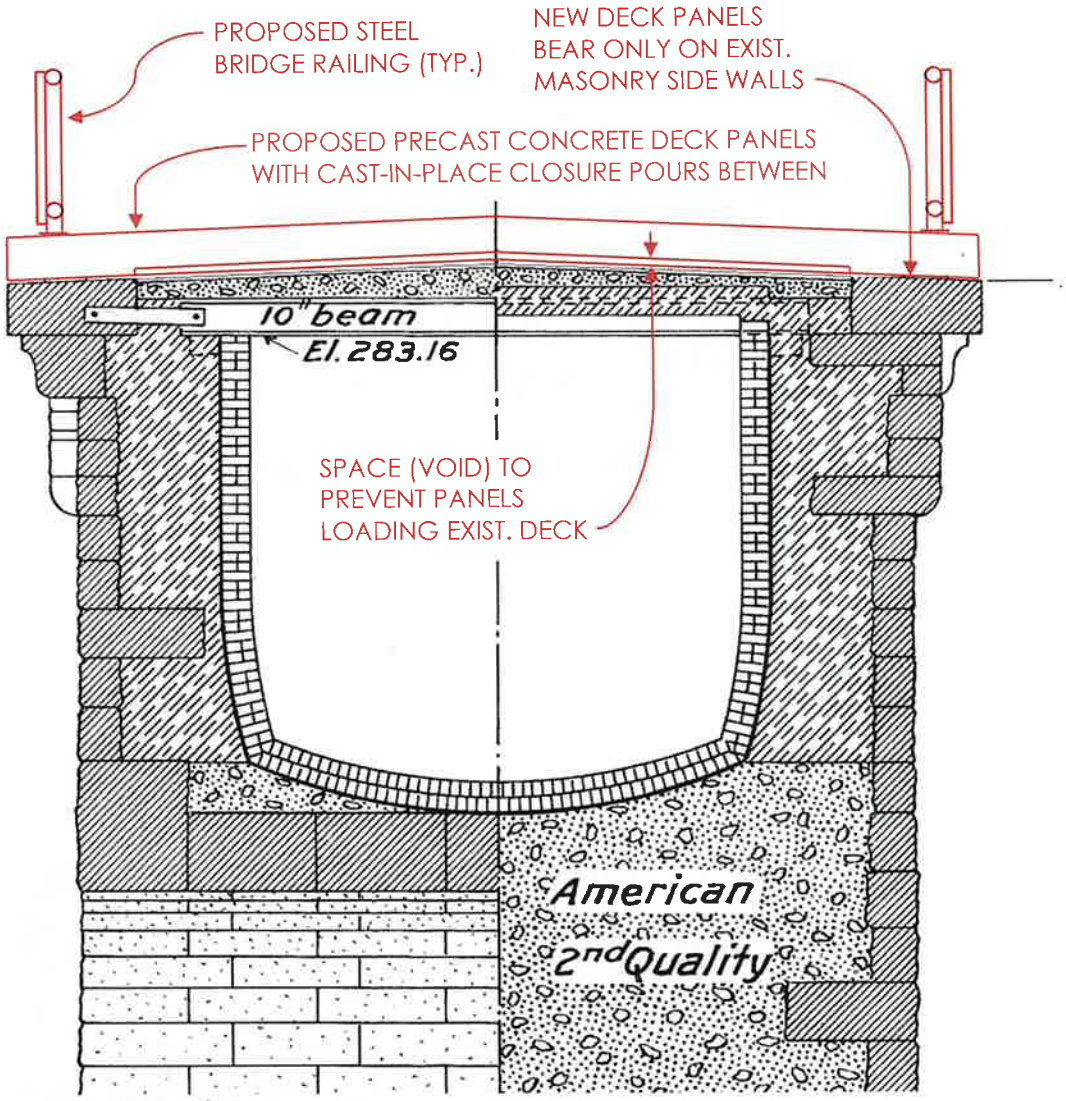


Figure D: Option 3b

Figure G: Boston Pattern Railing (Foreground) on DCR Blackstone Greenway

Figure H: Close-up View of Boston Pattern Railing

Reference: Assabet River Bridge – Evaluation for Use as Part of a Public-Use Path

Photos (Continued)

Photo 5: General Exterior View – South Elevation, Land Spans

Photo 6: South Elevation, River Spans

Photo 7: General Exterior View – Bridge Deck, Looking West

Photo 8: Low-Hanging Wires, Vegetation - West End of Bridge

NATIONAL REGISTER CRITERIA STATEMENT (if applicable)

The Wachusett Aqueduct Linear District consists of twelve miles of aqueduct punctuated by bridges and chambers along its length. It is significant as the first aqueduct built under the auspices of the Metropolitan WAter Board to increase the supply of fresh water for the metropolitan area. It also possesses distinctive features of design and construction typical of the water system as it evolved between 1845-1926. The district possesses integrity of location, design, setting, materials, workmanship, feeling and associations, and meets criteria A and C of the NRHP. The boundaries are drawn in red on the attached three maps entitled "Plan and Profile, Wachusett Aqueduct Land" drawn at a scale of 600' to 1". The boundaries encompass the aqueduct structure and its associated chambers and bridges, as it travels from Wachusett Reservoir on the west to Sudbury Reservoir on the east.

ARCHITECTURAL SIGNIFICANCE Describe important architectural features and evaluate in terms of other areas within the community.

The Wachusett Aqueduct Linear District extends from the Wachusett Dam (Area G) in Clinton southeasterly to Sudbury Reservoir in Southborough. This linear district consists of an aqueduct that is composed of two miles of tunnel, seven miles of masonry conduit, and three miles of open channel. Along this length, are sited four chambers, one aqueduct bridge, six vehicular bridges, and three small dams. The covered portions of the aqueduct (8-1) average about eleven feet wide and ten feet high. For about half its length, the tunnel section is unlined, the remainder being lined with concrete facing, with three to six rings of brick. The masonry portion of the aqueduct consists of concrete and brick, with a horseshoe-shaped section or profile. The bottom and sie walls of the conduit are of natural cement concrete, lined with one or more rings of brick. The arch itself is of Portland cement concrete.

Other elements include Shaft 4 Chamber (8-2) in Berlin, built over one of four shafts sunk during the original excavation. The chamber is circular in plan and about ten feet in diameter, with an Roman brick exterior walls set on a single course of granite. The conical roof is covered with asphalt shingles and has wood eaves and scrolled projecting rafter ends. The single opening contains a steel door, welded shut. (CONT)

HISTORICAL SIGNIFICANCE Explain historical importance of area and how the area relates to the development of other areas of the community.

The Wachusett Aqueduct Linear District, along with the related Wachusett Dam Historic District (Area G), represents the third stage in the evolution of the metropolitan Boston water supply system (1895-1926; please refer to Overview, Section 8, pp. 2 and 7-9 for additional information). This phase expanded the system northwestward from the Sudbury Reservoir to the Nashua River in Clinton. It was the first project of the Metropolitan Water Board, created by the state legislature in 1895. The Board's first major task was completion of the Sudbury Reservoir, originally begun by the City of Boston in 1893, and construction of the Wachusett Aqueduct (1896-98) to bring pure water from the Nashua River to supplement the supply from the various reservoirs of the Sudbury watershed. With completion of the Wachusett Reservoir (see Area G) in 1906-07, the Wachusett Aqueduct conveyed water southeast from a supply that was the Boston area's principal source until completion of Quabbin Reservoir in the 1940s. Wachusett Aqueduct was removed from service when it was bypassed by the Wachusett-Marlboro Tunnel in the mid-1960s. The Hultman Aqueduct Headhouse and Circular Dam which cross the Wachusett Aqueduct in the town's of Southboro and Marlboro, were part of this post-1940 effort to put all water carrying elements of the system underground to prevent polution in the heavily developed eastern portion of the state (see Sec8-pp 11-12).

Designs for the Wachusett Aqueduct were generated in the office of the Metropolitan Water Board's Chief Engineer, Frederic P1 Stearns, with contributions from Ruben Shirreffs of the Board's Dam and Aqueduct section, particularly for the Assebet River Bridge. The project was built under a number of different contractors: Moulton & O'Malley of Boston for the open channel and associated bridges and dams; Jones, Pollard & Co. of Baltimore for the Assebet River Bridge, and the closed (CONT)

BIBLIOGRAPHY and/or REFERENCES

Metropolitan Water Board, Annual Reports 1896, 1897, 1898
Report of the Massachusetts State Board of Health upon a Metropolitan Water Supply. Boston, Wright & Potter. 1895.

Community: Clinton, Berlin, Northboro, Southboro, Marlboro	Form No: C
Property Name: Wachusett Aqueduct Linear District	

Indicate each item on inventory form which is being continued below.

HISTORICAL SIGNIFICANCE (Cont)

portions of the conduit by E. D1 Smith & Co., Philadelphia.

The structures that make up the district, and described in the Architecture section, combine to perform the basic function of carrying water from its source to distribution points. The open and closed sections of the aqueduct define and channel the course of water; the chambers provide for access/monitoring, ventilation or diversion; and the bridges carry the aqueduct over impediments like rivers or roads. Refer to Overview section 7: Aqueducts, Chambers for additional information.

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

NATIONAL REGISTER OF HISTORIC PLACES
EVALUATION/RETURN SHEET

REQUESTED ACTION: NOMINATION

PROPERTY NAME: Wachusett Aqueduct Linear District

MULTIPLE NAME: Water Supply System of Metropolitan Boston MPS

STATE & COUNTY: MASSACHUSETTS, Worcester

DATE RECEIVED: 12/05/89 DATE OF PENDING LIST: 12/19/89
DATE OF 16TH DAY: 1/04/90 DATE OF 45TH DAY: 1/19/90
DATE OF WEEKLY LIST:

REFERENCE NUMBER: 89002276

NOMINATOR: STATE

REASONS FOR REVIEW:

APPEAL:	N	DATA PROBLEM:	N	LANDSCAPE:	N	LESS THAN 50 YEARS:	N
OTHER:	N	PDIL:	N	PERIOD:	N	PROGRAM UNAPPROVED:	N
REQUEST:	N	SAMPLE:	Y	SLR DRAFT:	N	NATIONAL:	N

COMMENT WAIVER: N

✓ ACCEPT ___ RETURN ___ REJECT 1/18/90 DATE

ABSTRACT/SUMMARY COMMENTS:

Locally significant aqueduct, the first built under the auspices of the Metropolitan Water Board. This district is separated from the Wachusett Dam Historic District by large scale, intrusive new development. The district includes the aqueduct, 4 chambers, an aqueduct bridge, 6 vehicular bridges and 3 dams. The system carries water from the Wachusett Dam to the Sudbury Reservoir.

RECOM./CRITERIA Accept A+C
REVIEWER Swaze
DISCIPLINE Arch/Historical History
DATE 01-18-90

DOCUMENTATION see attached comments Y/N see attached SLR Y/(N)

Town of Northborough

Conservation Commission

BRIDGE FEASIBILITY STUDY

FOR

WACHUSETT AQUEDUCT

BRIDGE OVER ASSABET RIVER

NORTHBOROUGH, MASSACHUSETTS

June, 1990

Prepared by:
LOUIS BERGER & ASSOCIATES, INC.
WALTHAM, MASSACHUSETTS

DESCRIPTION OF BRIDGE

TOWN	LOCATION
Northborough	Wachusett Aqueduct Bridge over Assebet River

Date of Construction:	Approx. 1896 (Date of Plans)
Aqueduct Bridge Composition:	The bridge is comprised of 7 spans of stone masonry arches. The aqueduct extends the length of the bridge and is supported by the arches. The ceiling of the aqueduct is incorporated in the bridge decking system. The decking consists of 10" steel I-Beams encased in brick jack arches supporting a concrete deck.
Skew:	None
Span:	Overall aqueduct structure length = 334'-0"± Centerline pier to centerline pier = 37'-0"± 10" I-Beam Interior clear span = 11' -6"± Effective span length = 13'-10"±
Width of Bridge Deck:	23'-10" maximum Out To Out
Deck Walkway:	18'-6"± wide waterproofing cover comprised of 3" concrete and 1" granolithic block wearing surface.
Railing:	The ornamental metal rail, approximately 3'-9"± above surface, has post spaced 10'-7"± o.c.
Bridge:	7 span stone masonry arches
Aqueduct:	The inside of the Aqueduct is 11'-6"± wide by 10'-0"± high. The walls and floor are brick lined and have been covered by mortar. Steel 10" I-Beams, spaced 5'-3"± o.c. are encased in the brick jack arch deck system.
Modification to Original Bridge:	None
Modification to Original Aqueduct:	In 1943 a 1"± mortar lining was placed on the walls and floor throughout the aqueduct. The aqueduct was abandoned in 1948 when a siphon was built under the Assebet River.

ANALYSIS ASSUMPTIONS AND CRITERIA

The aqueduct's 10" steel I-Beams, encased in the brick jack arches, were considered the critical elements for this analysis. The bridge's stone masonry arches showed no signs of distress, therefore, they were not considered critical.

The allowable stress for the 10" steel I-Beams, are not indicated on the design plans. The weight per linear foot is given on the plan entitled "STEEL BEAMS AND FITTINGS" as 35 lbs. Using this information in conjunction with AISC's "Historical Record Dimensions and Properties, Rolled Shapes Steel and Wrought Iron Beams and Columns as Rolled in U.S.A., Period 1873 to 1952", a 10" American Standard beam of 1896 origin, weighing 35 pounds per foot, was selected for strength analysis. Although these beams were not visible during the inspection there was no evidence of excessive rusting. Rust expansion would have caused the mortar lining to spall. Therefore, the section properties were not reduced.

The allowable bending stress used in this analysis was obtained from the aforementioned reference. According to this reference, an allowable stress of 16,000 psi was published in Carnegie Steel Company's 1896 catalog.

AVAILABLE PLANS

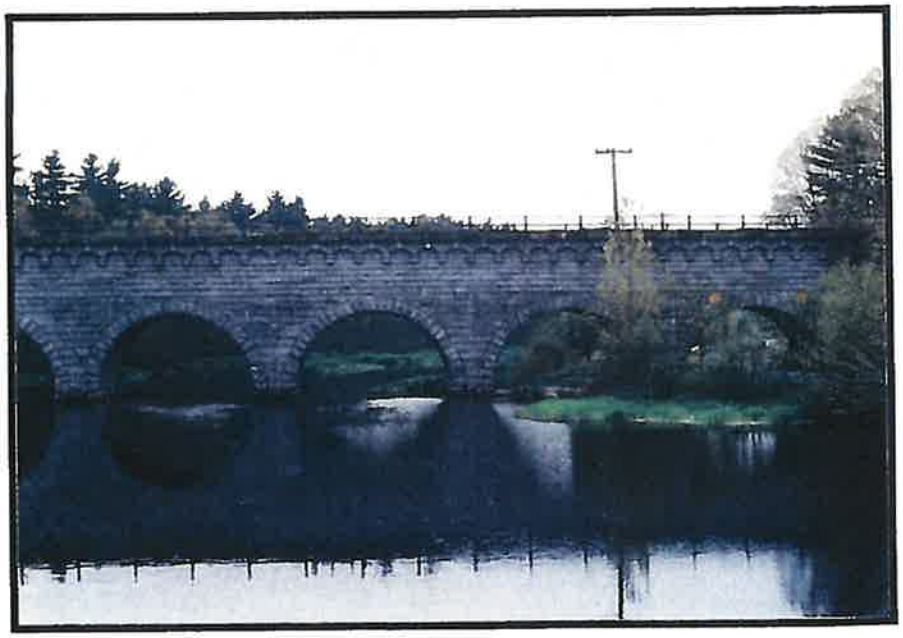
1. Commonwealth of Massachusetts Metropolitan Water Works, "ASSABET BRIDGE, STEEL BEAMS AND FITTINGS", July 13, 1896.

2. Commonwealth of Massachusetts Metropolitan Water Works, "NASHUA AQUEDUCT ASSEBET BRIDGE", July 20th 1896.

2. Commonwealth of Massachusetts Metropolitan District Water Supply Commission, "WACHUSETT AQUEDUCT MORTAR LINING - ASSABET BRIDGE", April 16, 1940.

3. Commonwealth of Massachusetts Metropolitan District Water Supply Commission, "WACHUSETT AQUEDUCT ASSABET RIVER CROSSING", November 10, 1948.

1. Partial North Elevation



2. Partial North Elevation

Wachusett Aqueduct
over Assabet River
Northborough, Massachusetts

5. Deck Surface Looking West

6. West Approach

9. Aqueduct Ceiling

10. Aqueduct Ceiling

Wachusett Aqueduct
over Assabet River
Northborough, Massachusetts

APPENDIX B

COMPUTATION SHEETS

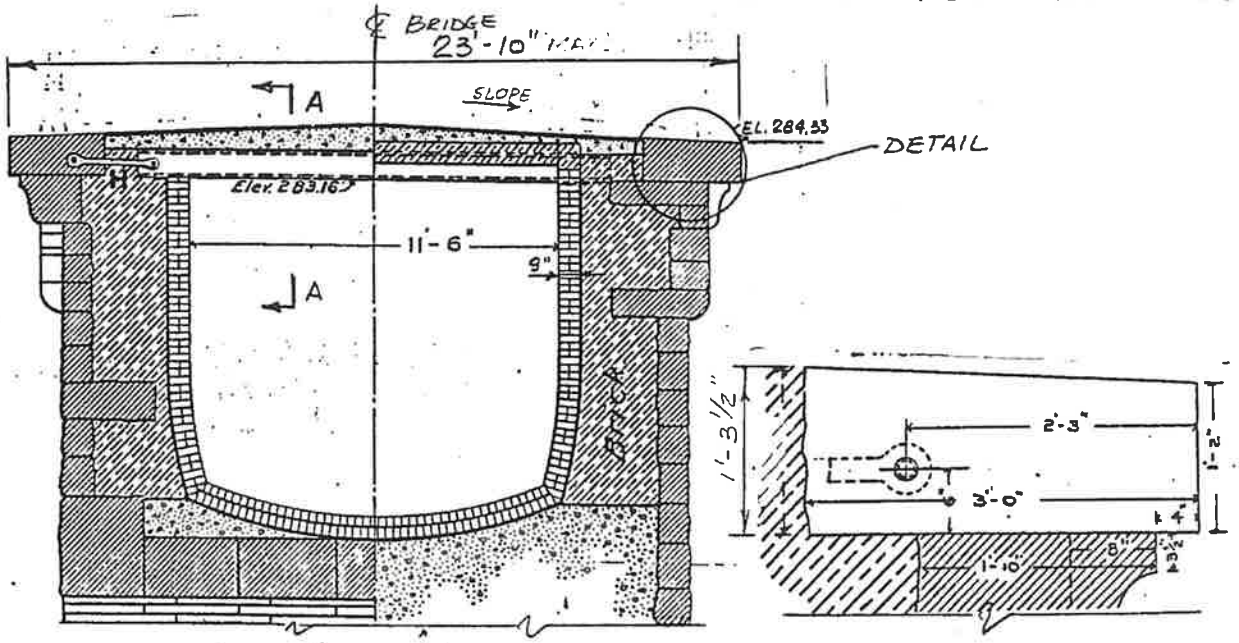
Wachusett Aqueduct Bridg
Over Assabet River
Northborough, Mass.

BY J.M.S. DATE 06/14/90 **LOUIS BERGER & ASSOCIATES, INC.** SHEET NO. 2 OF 5

CHKD. BY I.S DATE 06/14/90 WACHUSETT AQUEDUCT PROJECT CW88

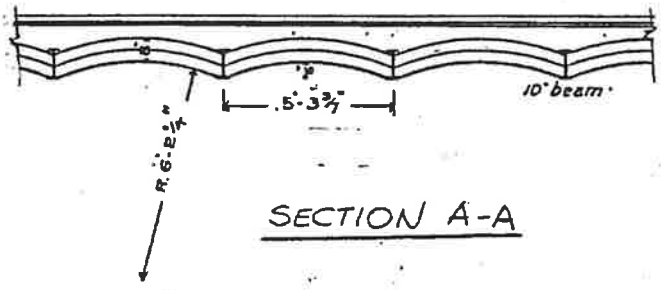
SUBJECT 10" BEAM CAPACITY

REF. ALL DIMENSIONS AN ELEVATIONS ARE TAKEN FROM EXIST. DRA...



CROSS SECTION

DETAIL



SECTION A-A

SLOPE : (FROM DETAIL)

$(15\frac{1}{2}" - 14")/3' = 0.5"/FT$

ELEVATION @ TOP OF PAV. @ ℄ BRIDGE :

$(23.83'/2)(0.5"/FT) = 5.96" = 0.5'$

@℄ EL. = 284.33' + 0.5' = 284.83'

ELEVATION @ BEAM SUPPORT

$[(11.5'/2) + .75' + (10"/2)/12] \times 0.5"/FT = 3.46" = 0.29'$

EL. = 284.83' − 0.29' = 284.54

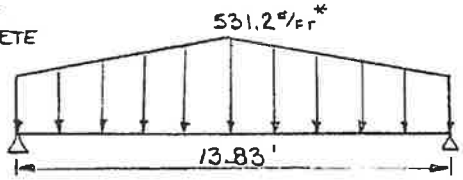
EFFECTIVE SPAN LENGTH: ASSUME CLEAR SPAN PLUS MEMBER DEPTH

CLEAR SPAN = 11.5 FT + 2 (9"/12") = 13.0' (ASSUMING LINING LAYER OF BRICK NOT SUPPORTING)
↑ LINING LAYER OF BRICK

EFFECTIVE SPAN = 13.0' + 10"/12 (MEMBER DEPTH) = 13.83'

DEAD LOADS

FROM CONCRETE



* SEE SHT. 3 OF 5

$M = \frac{1}{8}(301.3)(13.83)^2 + \frac{1}{6}(\frac{1}{2}(13.83)(531.2 - 301.3))(13.83) = 10{,}868^{\text{ft-lb}}$

FROM OTHER DEAD LOADS

$M = \frac{1}{8}(\underbrace{264.3 + 422.9 + 35.0 + 99.1}_{\text{SEE SHT. 3 OF 5}})(13.83)^2 = 19{,}636^{\text{ft-lb}}$

$M_{DL} = 10{,}868 + 19{,}636 = 30{,}504^{\text{ft-lb}}$

MOMENT CAPACITY

NO SECTION LOSS ASSUMED BECAUSE NO EVIDENCE OF EXCESSIVE RUSTING (LACK OF LARGE AREAS OF SPALLING AT BEAMS)

$M_{CAP} = 16{,}000 \text{ PSI} \times 293 \text{ in}^3/12" = 39{,}067^{\text{ft-\#}}$ $\quad M_{CAP} = f_{all} S$

$M_{LL} = 39{,}067 - 30{,}504 = 8{,}563^{\text{ft-lb}}$ $\quad M_{LL} = M_{CAP} - M_{DL}$

$w_{LL} = \frac{8563^{\text{ft-lb}} \times 8}{(13.83')^2} = 358.2 \text{ \#/FT}$

CAPACITY - LIVE LOAD = 358.2 #/FT / 5.28 G_{FT} = 67.8 PSF AVAIL. FOR LIVE LOAD

MINIMUM LIVE LOAD CAPACITY

REF: MASSACHUSETTS STATE BUILDING CODE SECTION 706.0

FROM TABLE 706

MIN. UNIF. DISTRIBUTED LIVE LOAD = 100 PSF (YARDS AND TERRACES, PEDESTRIANS)

ACTUAL CAPACITY (67.8 PSF) < MIN. CAPACITY (100 PSF) NO GOOD

Town of Northborough

Conservation Commission
63 Main Street
Northborough, Massachusetts 01532-1994
(508) 393-5015 Office (508) 393-6996 Fax

October 18, 2021

Re: Design of Assabet River Aqueduct Bridge

To Whom It May Concern-

The Northborough Conservation Commission voted to unanimously support the application to the Community Preservation Committee for design of the Assabet River Aqueduct Bridge for pedestrian access. The redevelopment of the bridge has been one of the longtime goals of both the Town of Northborough Master Plan and the Open Space and Recreation Plan.

We feel this project would benefit everyone in town. The opening of this iconic structure to residents would be a wonderful contribution to the Town. The Commission is extremely grateful for the opportunity to apply for this funding and we hope you consider this application a worthy project. Thank you for your consideration.

Sincerely,

Greg Young

Greg Young, Chair
Northborough Conservation Commission

Stantec Consulting Services Inc.
65 Network Drive 2nd Floor, Burlington MA 01803-2767

November 15, 2021
File: 179489301

Attention: Mia MacDonald, Conservation Agent/Staff Liaison
Northborough Trails Committee
Town Hall 63 Main Street
Northborough, MA 01532

Reference: Assabet River Aqueduct Bridge – Design Services

Dear Ms. McDonald,

Stantec is pleased to submit the attached revised scope and fee proposal for engineering services associated with the reuse of the Assabet River Aqueduct Bridge as part of the Aqueduct Recreational Trail. As requested our proposed scope of services has been revised to include only preliminary design for the trail connections and bridge modifications. Structural scope of work is based on the recommendations from a previous assessment of the Assabet River Aqueduct Bridge performed by Stantec in 2017 and discussions with the Town.

As noted in Stantec's previous assessment, the extent of improvements necessary to upgrade the structure for trail use is dependent on the load carrying capacity of the existing bridge. The attached proposed scope of work and total fee of $133,658 is based on a conservative assumption that the existing beams are inadequate to support loads associated with the proposed use as part of the trail and internal shoring of the structure is required.

Please contact me or Mike McCall should there be any questions or clarifications associated with our proposed scope of services and fee. We look forward to this opportunity to support the Trails Committee and its' goal of expanding the trail system in Northborough.

Regards,

Stantec Consulting Services Inc.

Frederick A. Moseley, PE
Principal
Phone: 781 221 1131
Frederick.Moseley@stantec.com

Michael McCall, PE
Associate
Phone: 781 221 1139
Michael.McCall@stantec.com

Attachment: Assabet River Bridge Proposal_rev 2021-11-15,pdf

fm v:\1794\business_development\01 proposals\2021\179489301 northborough aqueduct bridge\assabet river aqueduct bridge proposal tm_rev 2021-11-15.docx

1.6 Construction Plans and Profiles

Stantec will prepare preliminary construction plans at the scale of 1" = 20' identifying the items of work associated with the trail work. Preliminary profile sheets at the scale 1" = 20' horizontal and 1" = 4' vertical will be prepared indicating proposed vertical geometry and existing/proposed grades along the centerline of the trail.

1.7 Ramp/Stair Details for MHC

Stantec will prepare alternative details for provision of ADA compliant transitions between the trail approaches and the bridge in the vicinity of the existing stairs for use in the filing with Mass Historical Commission.

1.8 Opinion of Probable Cost

Using MassDOT pay items and current average bid prices, Stantec will prepare an opinion of probable cost for construction of the trail. This cost will include trails and estimate for structural work developed in Task 2, contain construction contingencies, and account for inflation based on the anticipated year of construction for the Town's use in obtaining construction funding.

2.0 Structural Design

The memorandum prepared as part of the bridge assessment performed in 2017 included repair alternatives that were a sequence of recommended actions intended to identify cost effective repairs based on the existing condition of the bridge. Structural design services will include a conceptual design to determine the level of improvements required.

Conceptual design will involve field measurements to verify the load carrying capacity of the bridge and identify the preferred improvements. If field measurements are inconclusive, load testing could be performed to verify structural capacity of the existing aqueduct roof, but this would be performed as an additional service that is not included in this proposal.

2.1 Measure Steel Beams (Including Prep & Planning)

Perform field assessments/testing to confirm the load carrying capacity of the existing bridge to identify the level of improvements needed for the structure to support loads for use as a bicycle/pedestrian trail.

Field work will include:

- Verify the steel-beam section properties assumed in the 2017 assessment by field measurements.
- If the field measurements are not conclusive regarding the steel-beam properties and structural capacity, then Stantec could perform in situ, instrumented load-testing of the bridge roof/deck structure in accordance with ACI 437- Code Requirements for Load Testing of Existing Concrete Structures and Commentary as an additional service (not included in this proposal).

2.2 Concept Plan Development

Prepare sketch plans for the recommended repair action based on the assessment performed in the preceding task in accordance with the MassDOT *Bridge Manual*. For the purpose of preparing a fee estimate, it has been assumed the more extensive improvements consisting of providing shoring

Assabet River Aqueduct Bridge - Northborough, MA
Preliminary Design

Task	Project Manager	Senior Engineer	Design Engineer	Assistant Engineer	Engineering Technician	Total Hours
1.0 Trail Design	18	48	68	84	8	226
2.0 Structural Design	36	104	112	72	40	364
3.0 Mass Historic - PNF	4	8	20	4	0	36
4.0 Meetings/Coord	12	10	0	0	0	22
Total	70	170	200	160	48	648
Rate	$252.00	$180.00	$130.00	$108.00	$106.00	
Labor	$17,640.00	$30,600.00	$26,000.00	$17,280.00	$5,088.00	$96,608.00

Direct Expenses			
Survey		$16,250.00	
Contractor assistance for inspection		$20,000.00	
Mileage		$300.00	
Printing/Reproductions		$500.00	
	Total	$37,050.00	$37,050.00
	Total fee		**$133,658.00**

11/15/2021

1.0 SCOPE OF SERVICES

Task 1.1 Research

1.1.1 Dawood will perform research at Northborough Town Hall, MassDOT, and the Worcester District Registry of Deeds to obtain record information concerning the property lines.

1.1.2 Dawood will undertake research at the various utility companies, MassDOT and town departments to obtain record information concerning utility line locations.

Task 1.2 Field Surveys

1.2.1 Mobilization.

1.2.2 Dawood will establish baseline at opposite end so the projects limits using the KeyNetGPS Virtual Reference System (VRS) network. The control will be referenced horizontally to the North American Datum of 1983 (NAD 83, 2011, Epoch 2010.00) and vertically to North American Vertical Datum of 1988 (NAVD 88). The control will be connected using conventional traversing techniques.

1.2.2 Dawood will perform field surveys to locate planimetric and topographic details as outlined in the 'Survey Request' file which accompanied the e-mail message referenced in the opening paragraph.

1.2.3 Spot elevations will be taken at sufficient intervals throughout the project site.

1.2.4 Dawood will obtain invert elevations of drain and sewer structures.

1.2.5 Dawood will establish two semi-permanent benchmarks at opposite ends of the project.

Task 1.3 Preparation of Plans

1.3.1 Following the completion of the field surveys, the coordinates, and elevations of the points of detail will be calculated and will be utilized to prepare the drawings.

1.3.2 Contours will be developed at 1-foot intervals; in addition, spot elevations will be shown to adequately depict the topography of the site.

1.3.3 Dawood will compile the location of the MWRA property line based on available record plans and recovered and located monuments. Dawood will only compute the layout of crossing streets where it is necessary to help establish the MWRA