Historic Structures Report
Memorial Bridge
Piscataqua River
Portsmouth, New Hampshire and Kittery, Maine

Project # BHF-T-0101(015)/13678

Memorial Bridge 1924
(Collection of Portsmouth Athenaeum)

Prepared for the New Hampshire Department of Transportation by

PRESERVATION COMPANY

in association with:

HNTB Corporation

Independent Archaeological Consulting

McFarland-Johnson, Inc.

March 2009

Table of Contents

Tab A. Introduction

1. Executive Summary

Memorial Bridge spans the Piscataqua River between Portsmouth, New Hampshire and Kittery, Maine.[1] Ownership and responsibility for the bridge are shared by New Hampshire and Maine. The Portsmouth Approach to Memorial Bridge is owned and maintained by the City of Portsmouth. The Kittery Approach to Memorial Bridge is owned and maintained by MaineDOT.

To assess the structural condition of Memorial Bridge and Memorial Bridge's Portsmouth Approach, in June 2003, the New Hampshire Department of Transportation, under contract BHF-T-0101(015)/NH Project No. 13678, retained HNTB Corporation (HNTB) of Boston, Massachusetts, to conduct an engineering study of the bridge. Work under the contract included in-depth inspections, recommendations for the correction of deficiencies, and an investigation of moving the bridge operator's house. In late 2003, HNTB produced a report summarizing their findings; McFarland-Johnson, Inc. (McFarland-Johnson) produced a similar report for the Portsmouth Approach. In early 2004, the firms produced Preliminary Structures Reports for the two structures. To deal with immediate concerns identified in the reports, emergency repairs to the Bridge's stringers and lower chord gusset plates were made in 2004.

To address long-term issues related to the condition of the historically significant Memorial Bridge, the staffs of the NHDOT and the New Hampshire Division of Historic Resources (NHDHR) recommended the preparation of a Historic Structures Report (HSR). This multidisciplinary Historic Structures Report was envisioned as a way to partially meet obligations under both the Department of Transportation Act of 1966 (Section 4f) and Section 106 of the National Historic Preservation Act of 1966 (amended 2000, 2004) (Section 106) (see below in this Tab). By assembling a diverse collection of information, the project and the site were understood as a whole, thus enabling reviewing agencies to determine the most appropriate rehabilitation alternative for Memorial Bridge and the Portsmouth Approach. Preservation Company of Kensington, New Hampshire, was retained to produce this report and consult on the implications of the rehabilitation on the historic structure. Earlier drafts of this HSR were produced in 2004 and 2005.

To arrive at an appropriate strategy for addressing its condition issues, an alternatives evaluation of Memorial Bridge was completed in the course of a series of meetings held by NHDHR, NHDOT and the Federal Highway Administration (FHWA) between 2004 and 2006. This group of agencies formed a consensus opinion as to the effects of various alternatives under Section 106 and Section 4(f) and developed a preferred alternative for the bridge's rehabilitation (the Modified Replacement In-Kind of the Existing Lift Span). (The official determinations of effects and findings concerning mitigation appear in TAB H of this document.) The preferred alternative involves complete replacement of the center (movable) lift span and rehabilitation of the flanking fixed trusses and towers of the Memorial Bridge. The proposed replacement lift span would largely mirror the historic appearance of the existing lift span, by replicating the structure's highly visible character-defining laced members. For the Portsmouth Approach,

[1] Memorial Bridge, as it is usually referred to, consists of a number of separate components: the south/Portsmouth Approach, three river spans (two tower/flanking spans and the lift span) and the north/Kittery Approach. To differentiate the central section (lift and flanking/tower spans) from the other sections, in this report the central section is referred to as Memorial Bridge and the other sections are referred to as the Portsmouth Approach and the Kittery Approach.

active corrosion of the steel and rebar and deterioration of the concrete made rehabilitation impractical, so a new two-span continuous, steel beam structure with a cast-in-place concrete deck became the recommended alternative. For the Kittery Approach, the preferred alternative included retrofitting roadway stringers and floor beams and partial areas of deck replacement. The preferred alternative, which developed from the alternatives evaluation, is discussed in detail at Tab G.

Based on the preferred alternative, HNTB produced drawings for the planned rehabilitation, some of which are included in Tab G of this document. A bid package went out and bids were opened October 9, 2008. The low bid came in at $59,460,000 – $15.3 million (35%) higher than the engineering team's $46.42 million estimate. Given the higher costs, the rehabilitation project was placed on hold. Maine and New Hampshire agreed to step back and study the future transportation needs in the Portsmouth and Kittery area, including corridors associated with the Memorial Bridge, Sarah Mildred Long Bridge on the Route 1 Bypass, and the I-95 Bridge. The approach to treating all three bridges would then be informed by the results of this study. Then, to address these larger concerns, in late 2008 the Maine DOT and NHDOT entered into a Memorandum of Agreement (MOA) that specified this study. The study is aimed at evaluating all three bridges that cross the Piscataqua in this area and looking at options "that may exist in rehabilitating one or more and/or consolidating one or more of the existing bridges and/or constructing one or more new bridges" (NHDOT 2009). In early 2009, as this report was being produced, NHDOT was seeking federal stimulus package funding for the original preferred alternative (the Modified Replacement In-Kind of the Existing Lift Span).

2. Location of Information in this Report/Authors

Tab A of the report includes introductory materials: an executive summary, a summary of proposed treatment alternatives and a summary statement of significance for Memorial Bridge. **Tab B** covers the background and development of Memorial Bridge. It includes the area's geographic and environmental context, the development of the waterfront, the history of the planning and construction of the bridge, and a discussion of the evolution of vertical lift bridge design. This section also includes a description of the bridge's historic design and discussion of alterations to Memorial Bridge. **Tab C** includes historical, contextual and descriptive information about the Portsmouth Approach to Memorial Bridge. **Tab D** covers the background and history of the Kittery Approach to the bridge. **Tab E** includes a description/conditions report (current to 2007) of Memorial Bridge and its approaches. **Tab F** consists of a table listing the character-defining features of Memorial Bridge and the Portsmouth and Kittery Approaches. **Tab G** discusses the various alternatives considered for remedying the bridge's condition deficiencies and includes drawings of the preferred alterative. **Tab H** addresses the effects of the project and the mitigation of those effects, including the result of agency meetings. **Tab I** includes archaeological assessments of the area. **Tab J** is a visual study of the area surrounding the Portsmouth Approach. **Tab K** is the NHDHR Form for the Portsmouth Approach. **Tab** L is the location of information relating to the sculpture on Memorial Bridge. **Tab M** is the location of large format photos of the bridge and its approaches taken in 2004.[2] **Tab N** is the location of

[2] Original prints of the photos and negatives will be housed at NHDHR (see NH State No. 627). Prints will also be located at Portsmouth repositories, including Portsmouth Athenaeum, Strawbery Banke, and Portsmouth Public Library.

historic (ca. 1920-1924) photos of the bridge and its construction. **Tab O** is the location of original drawings of the bridge.[3] **Tab P** is the bibliography.

Figures and plates throughout the document are referenced first by their tab and then by their numeric order within the section. (Thus, the third photo in the archaeological assessment is labeled Plate I-3.)

The work of three disciplines is reflected in this Historic Structures Report. The major contributors to this report are:

Preservation Company	Historic Resources/Editing[4]
HNTB Corporation	Engineering
Independent Archaeological Consulting	Archaeology
McFarland-Johnson, Inc	Engineering (Portsmouth Approach)

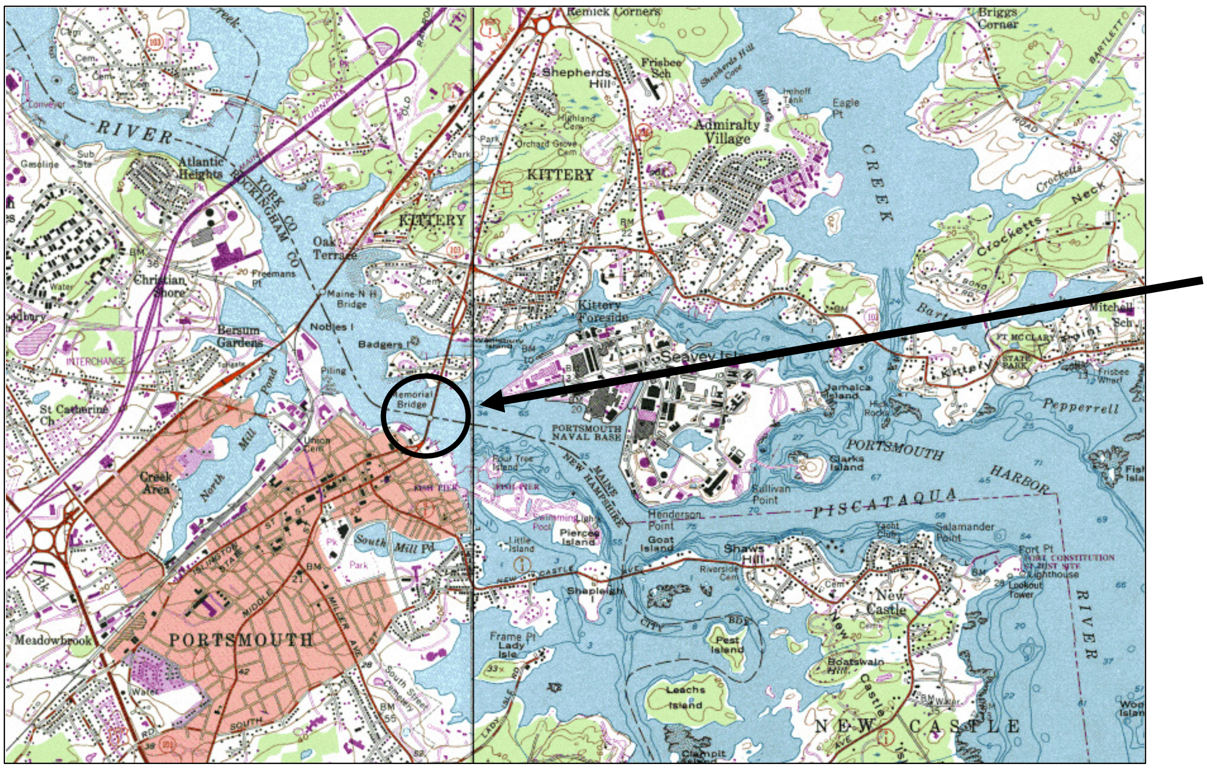

Figure A-1: USGS Map showing location of Memorial Bridge

---

[3] Large format photographic copies of these plans will be housed at NHDHR (see NH State No. 627).

[4] Dr. Frank Griggs, a consulting engineer specializing in historic bridge restoration, augmented research and writing efforts. Dr. Woodard Openo, author of The Sarah Mildred Long Bridge, also assisted in the research effort. Large format photographs of the bridge, which appear at Tab M, were taken by Charley Freiberg. Conservator Kent Severson provided consulting services relating to the sculpture on the bridge, his findings are located at Tab L.

3. Purpose of the Report/Need

a. National Register Status

Memorial Bridge and a number of adjoining and/or related historic resources have been determined eligible for the National Register of Historic Places. Eligible resources include:

- The Memorial Bridge Historic District, which includes the Memorial Bridge and extends south to include the Memorial Park in Portsmouth and north to include the John Paul Jones Memorial Park in Kittery.
- Memorial Bridge, which was determined individually eligible for the National Register of Historic Places in 1988 and includes the lift span (determined eligible in 1982) and the flanking tower/truss spans.[5]
- The Portsmouth Approach to Memorial Bridge and adjoining Memorial Park which were determined to be individually eligible for the National Register in 2004.
- The Kittery Approach spans, extending north to Badgers Island, are also individually eligible for the National Register.
- The Badgers Island Bridge, extending north from Badgers Island to the mainland in Maine, was determined to be National Register-eligible in July 2001.
- The John Paul Jones Memorial Park, north of the Badgers Island Bridge, was listed in the National Register of Historic Places in 1977.
- The Portsmouth National Register Historic District has also been determined to be eligible for listing in the National Register of Historic Places.

Archaeological and historical resources that are listed, or eligible for listing, on the National Register of Historic Places are afforded protection under Section 4(f) of the Department of Transportation Act of 1966 (Section 4f) and Section 106 of the National Historic Preservation Act of 1966 (amended 2000, 2004) (Section 106). Because the work that is planned for Memorial Bridge affects the historic fabric of the National Register-eligible structure, and because the project is receiving federal funding, both acts are applicable to this project.

Under Section 4(f), any transportation project funded by the Federal Highway Administration (FHWA) that uses land from historic sites of national, state or local significance must: 1) demonstrate that there is no feasible and prudent alternative to the use of such land and 2) include all possible planning to minimize harm to the property resulting from such use.

Section 106 requires the federal agency involved to ascertain the property's eligibility and the subsequent effect of the undertaking on it, following procedures outlined by the Advisory Council on Historic Preservation (36 CFR Part 800). This process affords the opportunity for the State Historic Preservation Office (SHPO), local government, and other interested parties to comment on any undertakings that could affect historic properties. In New Hampshire, the State Historic Preservation Office is the New Hampshire Division of Historical Resources (NHDHR).

---

[5] In 1982, Memorial Bridge was identified as being eligible for the National Register under Criteria A and C as part of the New Hampshire Historic Bridge Inventory (Sverdrup 1982:9). The bridge evaluation committee gave it a score of 30 out of 38 potential points for its engineering significance, making it one of the highest scoring bridges in the state. A summary of the National Register significance of Memorial Bridge is located later in this section.

NHDHR has established a procedure to meet the requirements of the historic preservation review process under RSA 227-C:9.

b. Condition Issues and Factors Giving Rise to the Project

In 2003, bridge inspections indicated that the overall condition of the superstructure of the Memorial Bridge (steel framing and deck above the concrete piers) was serious. Particularly problematic was the deterioration of the bottom chord of the lift span and the joints where the chords and verticals and diagonals join. (Non-original open-grating deck on this portion of the bridge had contributed to this significant deterioration.) Decks on both the Memorial Bridge and the Kittery Approach spans were in poor condition. For the Portsmouth Approach to Memorial Bridge, structural inspections indicated active corrosion of the steel and rebar and the deterioration of the concrete. These factors dictated that complete replacement of this approach to the bridge was required.

The mechanical components of the Memorial Bridge were also of concern. These included the counterweight ropes and sheaves that support the lift span from the two bridge towers, the trunnions (the axles of the sheaves), counterweights, and equalizers (that attach the ropes to the counterweights). As discussed below, the fatigue life of the existing trunnion shafts, condition of the equalizers, and overstress in the counterweight ropes were of particular concern.

The existing trunnion shafts, in addition to being under-designed by today's standards, were at the end of their useful life due to the number of lift cycles over their years of service. As part of the 2003 inspection and study, calculations performed revealed that the trunnions do not meet current AASHTO standards for design and are at the end of their useful life due to fatigue. This is the primary reason that NHDOT scheduled inspections every six months since that time. Subsequent inspections through the fall of 2007 revealed no further visible deterioration in the trunnion shafts, but continued semi-annual inspections were recommended until trunnion removal and replacement during construction.

The existing size and number of counterweight ropes do not meet current AASHTO standards for rope capacity. The equalizers that attach the ropes to the counterweights also showed signs of wear at the attachment points (boreholes and pins). Calculations showed that stresses on the equalizers were within allowable limits, but the sizes of some of the boreholes that hold the pins in place had become enlarged or elongated and required monitoring. Subsequent inspections through the fall of 2007 revealed further deterioration in both the ropes and the equalizer boreholes. Three counterweight ropes were replaced under an emergency contract in April 2008.

Monitoring of the condition of the bridge's mechanical components is required, and the bridge is now on a six-month inspection schedule.

Other deficiencies addressed by the project include:

- The location of the operator's control house on the bridge tower posed logistical safety concerns in the event that the bridge is stuck in the up position and also does not permit access to facilities such as running water and sanitary facilities.
- The steel grating on the floor of the lift span does not permit safe interaction of bicycles and motor vehicles on the roadway surface.
- The wood planking and railing on the sidewalks of the bridge require replacement, and the sidewalk surface is slippery when wet.

- Bridge fendering is deteriorated and wooden fender boards require replacement.
- The multiple piers under the Portsmouth Approach present impediments to vehicular and safe pedestrian access under the bridge, and the steel grating on the overhead sidewalks does not allow safe bicycle access.

4. Summary of Proposed Treatment Alternatives

a. Memorial Bridge

Alternative	Summary
"Modified" Replacement In Kind of the Existing Lift Span (Preferred Alternative)	**TO LIFT SPAN** • Replicates existing lift span with built up members, lacing, and multiple lateral bracing members to echo original lift span appearance • Maintain existing Warren Truss configuration and geometry • Utilize similar sized vertical, diagonal, and truss chord member • Roadway and cross-section widths on the new lift span same as existing • Panel points constructed with gusset plates and bolted connections • Replace trunnions, sheaves, equalizers, and ropes; modify equalizer system • Replace mechanical components • Replace trolley system for electrical supply with droop cables • Add approx. 2 feet to counterweight sides and bottom • New machinery room similar size to existing and located at same location on lift span **TO FLANKING SPANS:** • Replace concrete deck with new concrete deck • Replace 40% of the roadway framing and 65% of the sidewalk framing • Repair 40% of roadway framing and 25% of sidewalk framing, and clean and paint remaining 20% and 10%, respectively. (Cantilevered brackets under sidewalks repaired) • Replace 6 of 9 steel roadway stringers and 1 of the 11 transverse floorbeams, rehabilitate remaining floorbeams • Repair 80% of the diagonals and vertical member sand clean and paint the remaining 20% • Repair 50% of the truss upper and lower chords (particularly at the panel point connections), and clean and paint the remaining 50% • Strengthen and/or replace various gusset connection plates on the towers, including bolting of steel plates to the existing members. The new steel plates are small and would be 35 to 150 feet above the roadway surface • Relocate operator's control house to south tower above approach roadway • Overall (all spans) HS-15 Design Load

Alternative	Summary
Replacement In Kind of Existing Lift Span	**TO LIFT SPAN** • Completely replace lift span to replicate the appearance of the existing lift span • Construct new lift span entirely with built up members, lacing, and multiple lateral bracing members to imitate the original bridge appearance • Maintain the existing Warren Truss configuration and geometry • Utilize similar sized vertical, diagonal, and truss chord members • Maintain existing roadway and cross-section widths on new lift span • Construct panel points with gusset plates and bolted connections • Replace trunnions, sheaves, equalizers, and ropes; equalizer system will be modified • Replace mechanical components • Replace trolley system for electrical supply with droop cables • Add approximately 2 feet to counterweight sides and bottom • The new machinery room will be similar size to the existing and still be located on the lift span SEE PREFERRED ALTERNATIVE FOR FLANKING SPANS
Preserve Upper Portion of Lift Span, Float Off Site, Replace Lift Span Structure Below Deck	**TO LIFT SPAN** • Replace roadway deck, roadway framing, sidewalk framing, diagonals, verticals, and lower chords below deck • Repair 80% of the diagonals and vertical members above the deck, and clean and paint remaining 20% • Repair 40% of the truss upper chords, and clean and paint the remaining 60% • Will require modification to accept connection to the newly fabricated structure below the deck level • Replace open grating with solid concrete surface • Replace timber sidewalks with concrete filled steel grating • Repair machinery room • Repair sidewalk railing • Replace roadway railing • Replace trunnions, sheaves, equalizers, and ropes; modify equalizer system • Replace mechanical components • Replace trolley system for electrical supply with droop cables • Add approx. 2 feet to counterweight sides and bottom

Alternative	Summary
	SEE PREFERRED ALTERNATIVE FOR FLANKING SPANS
Lift Span Replacement	**TO LIFT SPAN** • Complete replacement of lift span • New lift span to be constructed with solid shapes and limited bracing members • Maintain the existing Warren Truss configuration and geometry • Utilize similar sized vertical, diagonal, and truss chord members • Roadway and cross-section widths on the new lift span same as existing • Panel points to be constructed with gusset plates and bolted connections • Replace trunnions, sheaves, equalizers, and ropes; equalizer system will be modified • Replace mechanical components • Replace trolley system for electrical supply with droop cables • Add approximately 2 feet to counterweight sides and bottom • New machinery room will be similar size to the existing and still be located on the lift span • HS-25 Design Load • 50 Year Design Life SEE PREFERRED ALTERNATIVE FOR FLANKING SPANS
Lift Span Rehabilitation	**TO LIFT SPAN** • Replace all roadway framing and 65% of sidewalk framing • Replace all roadway and sidewalk steel stringers and all transverse floorbeams • Repair 25% and clean/paint 10% of sidewalk framing, repair cantilevered brackets under sidewalks • Repair 80% of diagonals and vertical members, clean and paint remaining 20% • Repair 40% of truss upper and lower chords (particularly at the panel point connections), clean and paint remaining 60% • Replace open grating deck on lift span with solid concrete surface • Relocate control house to south tower • Replace timber sidewalks with concrete filled steel grating • Repair machinery room • Repair sidewalk and roadway railings • Replace trunnions, sheaves, equalizers, and ropes; modify equalizer system

Alternative	Summary
	• Replace mechanical components • Replace trolley system for electrical supply with droop cables • Add approx. 2 feet to counterweight sides and bottom • HS-20 Design Load • 30 Year Design Life SEE PREFERRED ALTERNATIVE FOR FLANKING SPANS
Fabricate New Deck and Steel Framing System, Float in, Join to Existing	**TO LIFT SPAN** • See Lift span rehab option • This alternative varies only in the method used to reconstruct the roadway deck and associated steel framing SEE PREFERRED ALTERNATIVE FOR FLANKING SPANS
Construct Secondary Support Truss to Brace Existing Bridge	**TO LIFT SPAN** • See Lift span rehab option • This alternative varies only in the method used to maintain the structural integrity of the truss during construction • Additionally, the final constructed condition would result in wider bridge piers in the river SEE PREFERRED ALTERNATIVE FOR FLANKING SPANS
Float out Lift Span for Rehab	**TO LIFT SPAN** • See Lift span rehab option • This alternative varies only in the float out method, the location to perform the repairs, and duration of traffic closure • HS-20 Design Load • 30 Year Design Life SEE PREFERRED ALTERNATIVE FOR FLANKING SPANS

Alternative	Summary
Limited Lift Span Rehabilitation **(Conceptual Design Only)**	• Rehabilitate existing lift span • Rehabilitate existing concrete decks and steel grid • Rehabilitate machinery and electrical system • New trunnions/sheave assemblies • Rehabilitate selected truss members and selected roadway strings • Partial cleaning and full painting of all steel • Repair existing fender system/no seismic upgrade • Rehabilitate substructure • Relocate operators control house • Equivalent to HS-15 Design Load • 15 Year Design Life
New On-Line Vertical Lift **(Conceptual Design Only)**	• New vertical lift structure • On existing alignment • HS-25 Design Load • 75 Year Design Life
New On-Line Bascule **(Conceptual Design Only)**	• New bascule structure • On existing alignment • Reduces exiting vertical clearance in closed position • Unlimited vertical clearance in open position • HS-25 Design Load • 75 Year Design Life

For additional information on these alternatives see Tab G

b. Portsmouth Approach

Alternative/ Description	Additional Info.	Construction Issues
Alternative 1 **2-Span Steel Beams w/ Cast-in Place Concrete Deck**	• Approach Slab • Granite-faced concrete sidewalks • NHDOT 3-Rail pedestrian railing • Barrier membrane	• Significant impact to traffic • Conducted in conjunction with rehab of Memorial Bridge • Would be completed in 9-12 months with Memorial Bridge closed or 12 to 18 months under one-way alternating traffic
Alternative 2 **3-Span Steel Beams w/ Cast-in-place Concrete Deck**	• Approach Slab • Granite-faced concrete sidewalks • NHDOT 3-Rail pedestrian railing • Barrier membrane	• Significant impact to traffic • Conducted in conjunction with rehab of Memorial Bridge • Would be completed in 9-12 months with Memorial Bridge closed or 12 to 18 months under one-way alternating traffic
Alternative 3 **3-Span Cast-in-place Rigid Frame**	• Approach Slab • Granite-faced concrete sidewalks • NHDOT 3-Rail pedestrian railing • Barrier membrane	• Significant impact to traffic • Conducted in conjunction with rehab of Memorial Bridge • Would be completed in 9-12 months with Memorial Bridge closed or 12 to 18 months under one-way alternating traffic
Alternative 4 **4-Span Cast-in-place Rigid Frame**	• Approach Slab • Granite-faced concrete sidewalks • NHDOT 3-Rail pedestrian railing • Barrier membrane	• Significant impact to traffic • Conducted in conjunction with rehab of Memorial Bridge • Would be completed in 9-12 months with Memorial Bridge closed or 12 to 18 months under one-way alternating traffic

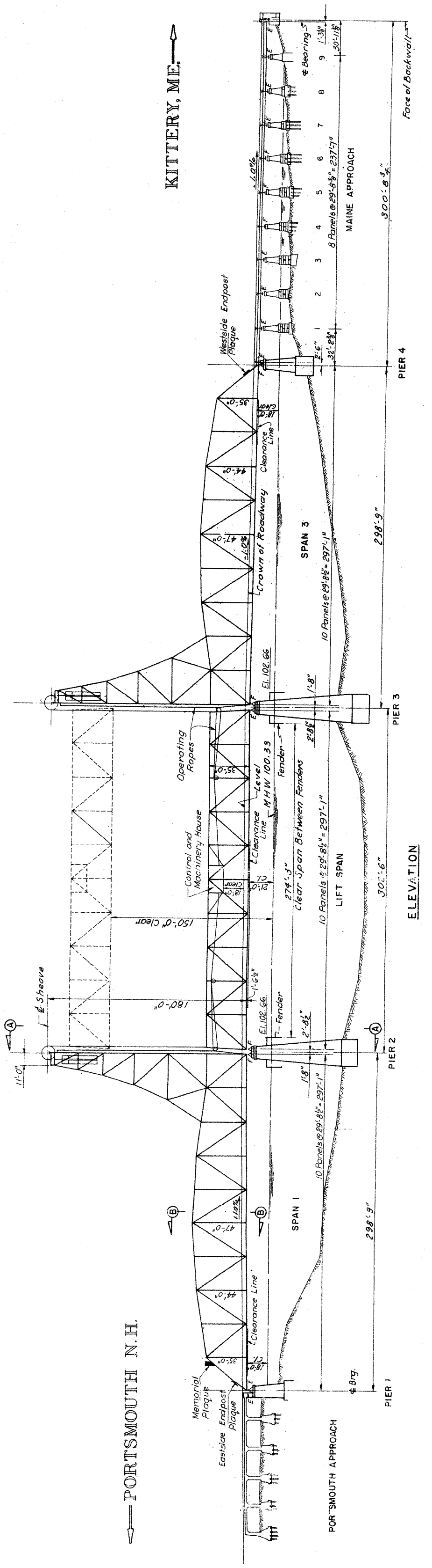

Figure A-2: Memorial Bridge General Elevation (NHDOT)

5. Summary Statement of Significance

Memorial Bridge (including its approaches) qualifies for listing on the National Register of Historic Places under Criteria A, C and, potentially, D.

a. Criterion A: Transportation/Community Planning and Development/Social History

Under Criterion A, Memorial Bridge was the first modern, free, operable bridge linking New Hampshire and Maine along the great coastal highway, US Route 1 (which had been designated in 1922, just prior to the opening of the bridge). As such, the bridge greatly furthered interstate eastern seaboard travel. Designed for automobiles, electric trolley cars, and pedestrians, the span eliminated tolls over a private bridge upstream and provided a direct light rail connection over the Piscataqua River between Portsmouth and Kittery, supplanting the Portsmouth, Kittery & York Street Railway ferry. Providing direct and rapid transportation to the Portsmouth Navy Yard, the bridge simultaneously eliminated the Navy ferry. Memorial Bridge is also significant under Criterion A for its role in the history of transportation both locally and on a regional level. The bridge is significant in the development of the City of Portsmouth, and its construction represented the culmination of a long and difficult campaign on the part of the citizens of Portsmouth to link Kittery (and Portsmouth Naval Shipyard) with the town via a free bridge. The bridge may also have significance for its role in local maritime history. Finally, since the design intent of the original project was to create a memorial to World War I veterans, the bridge links memorial parks in both Maine and New Hampshire, and has ties to commemorative structures throughout the country.

b. Criterion C: Engineering

<u>Memorial Bridge</u>

Under Criterion C, Memorial Bridge claimed many superlatives when new. It was designed by J. A. L. Waddell (1854-1938), one of the world's preeminent bridge designers, the developer of vertical lift bridges in the United States, and the holder of patents on most aspects of the operation of these bridges. Memorial Bridge was the first major vertical lift bridge in the eastern United States. At its dedication in 1923, it had the longest lift span in the country (297'), making it the direct prototype for later vertical lift bridges with clear spans of over 300'. Its lift towers, extending 210' above mean high water, were also among the highest in the nation, and its 135' vertical clearance was one of the highest. Based upon the success of the Memorial Bridge design and two contemporary bridges in Newark, New Jersey, Waddell's vertical lift design was adopted in locations throughout the world where spans of greater than 300' were required. The bridge was also a stepping-stone towards the later, even longer lift spans, such as that over the Cape Cod Canal, which had openings of greater than 500'. The durability and simplicity of operation of the lift span design has been proven over time; many of the bridges built between 1910 and 1940 are still operating today and still have low operation and maintenance costs. Today, Memorial Bridge is one of the oldest operational lift bridges in the United States. The bridge retains its original main structure with alterations limited largely to the deck, railings and mechanical systems. Under National Register Criterion C, the bridge embodies the distinctive characteristics of its type, the Vertical Lift Bridge, and possesses integrity of location, design, setting, materials, workmanship, feeling and association.

Portsmouth Approach Span

As the approach to Memorial Bridge, the Portsmouth Approach span (Scott Avenue Bridge) is a component part of an important engineering achievement, the central portion of which was designed by eminent engineer and originator of the long span vertical lift bridge, J.A.L. Waddell. However, the Portsmouth Approach span is also significant in the area of engineering in its own right. It is one of very few access spans in the state. Compared to other bridges, it is the single longest concrete bridge built before 1925 extant in the state today. It is also the longest extant non-arched concrete bridge constructed in New Hampshire before 1935. It is the earliest identified concrete continuous slab bridge in New Hampshire and it appears to be the longest continuous span concrete bridge built before 1935 in the state. Of the over 300 pre-1930 concrete bridges in New Hampshire, it is the only five-span concrete bridge. It is also unique in its curved design. For these reasons, the Portsmouth Approach Bridge qualifies for listing on the National Register of Historic Places under Criterion C, for significance in the area of engineering.

c. Criterion D: Archaeology

With respect to Criterion D, the project area is sensitive for both Native American and Euroamerican archaeological resources. Euroamerican sensitivity is high, while sensitivity for Native American archaeological resources is moderate. While it is tempting to believe that urban settings offer no intact archaeological resources because of constant building and re-building, urban archaeologists have demonstrated that, in spite of massive undertakings, undisturbed sediments can lie buried beneath parking lots, old streets, building footprints, and bridge overpasses. In particular, Scott Avenue is built over a former neighborhood block, where beneath its deep fill prism, buried archaeological resources probably remain intact. Expected Euroamerican resources at the western approach include dwelling cellars and foundations, yard deposits, wells, privies, and other features related to 19th-century urban life along Portsmouth's waterfront.

Native American archaeological sensitivity depends on the location of the original shoreline. 19th-century maps indicate consistency in the shape and location of the shoreline. However, what the maps do not show is the original natural shoreline, which was probably at least partially built over and covered by wharves. Because the Memorial Bridge was erected on concrete piers, it is possible some of the underlying soils around the piers might still be intact. Possible resources within intact soils include sections of Euroamerican wharves, which in turn may cover sections of the original natural shoreline. Intact sections of shoreline could contain Native American shell middens or other types of food procurement sites.

The project area is sensitive for archaeological resources until it can be determined that the entire Area of Potential Effect has been disturbed by the 1920s bridge construction. The level of disturbance should be ascertained through mechanical trenching at the western end of the project area (where Euroamerican urban features are anticipated) and by archaeological monitoring at the east end to verify whether sections of the original, natural shoreline are still intact.