From: Richard A. Rainer  
Sent: Thursday, March 24, 2022 3:07 PM  
To: Jennifer M. West  
Subject: FW: MHB Dehumidification Project  
Importance: High

From: Lori C. Silveira [mailto:lsilveira@ritba.org]  
Sent: Thursday, March 24, 2022 11:04 AM  
To: Richard A. Rainer <rainer@portsmouthri.com>  
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Subject: MHB Dehumidification Project  
Importance: High

Rich,

Here is the narrative from last year’s RAISE grant submission. Since we narrowly missed being selected the first time, we will be resubmitting the proposal in the weeks ahead. This is the proposal that I’ll be discussing with the Council on Monday evening.

Thank you.

Lori

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Application Information

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Project Type:  Capital Grant Request, Bridge, Urban
DUNS Number:  063924641
1. PROJECT DESCRIPTION

1.1 Project Overview

The Mount Hope Bridge Cable and Anchorage Dehumidification Project (the “Project” or “MHB” hereafter) creatively applies a new but proven technology to cost-effectively address a state of good repair problem with the potential to disrupt regional traffic in Rhode Island. The historically protected Mount Hope Bridge, shown in Figure 1-1, is a 92-year old suspension bridge that traverses Mount Hope Bay, which is part of Narragansett Bay. Although the cables have been maintained using traditional methods such as painting, oiling and caulking, decades of water ingress have corroded the thousands of individual wires that make up both cables. Over decades of wire breakage and repair, the cables have gradually lost some of their initial strength. Climate change impacts accelerate the corrosive process.

The Project...

- Employs an innovative technology to maintain the Mount Hope Bridge in a state of good repair.
- Protects a historically designated structure.
- Reduces life cycle operations and maintenance costs.
- Demonstrates the use of a technology that will benefit many bridges in the United States that face similar challenges.

Figure 1-1: Mount Hope Bridge over Narragansett Bay

[Image of Mount Hope Bridge]

Photo – Mark Bulmer

The Project will install a dehumidification system to the main cables and anchorages of the bridge. Dehumidification creates a dry state within the cables that effectively stops corrosion and wire breaks, and maintains the bridge in a state of good repair. This approach adapts the bridge to the projected impacts of climate change and makes it more resilient.

The two-lane suspension bridge carries State Route 114 over the 1.2 mile-long crossing above Mount Hope Bay in coastal Rhode Island, connecting Portsmouth, Rhode Island, to Bristol, Rhode Island. It is one of only three connections between the mainland and Aquidneck Island.

July 2021
(see the map in Section 2, Project Location). If the bridge is not open, the nearest alternative crossing is 20 miles away. Approximately 6.9 million vehicles use the bridge annually, based on pre-COVID counts obtained from the Rhode Island Department of Transportation (RIDOT). The bridge is on the National Register of Historic Places (NRHP) and is owned and operated by the Rhode Island Turnpike and Bridge Authority (RITBA).

1.2 The Transportation Challenge

Time is of the essence; there is only a limited window of opportunity to apply this dehumidification technology and stabilize the bridge cables. The cables must be put in a dry state by 2028, according to best engineering estimates, in order to preserve sufficient load-carrying capacity in the cables and maintain the bridge with a sufficient factor of safety. The target level of humidity is 40 percent. See Figure 1-2. When humidity ranges between 0 and 40 percent, corrosion is halted. Once humidity begins to rise and approach 60 percent, the rate of corrosion accelerates quickly.

Figure 1-2: Illustration of How Corrosion Varies with Relative Humidity

If the deterioration of the Mount Hope Bridge cables is not halted within that time frame, the loss of cable strength will accelerate and the cable factor of safety could likely fall to an unacceptable level. Intervention would then be required to keep the bridge operational—either by supplementing or replacing the cables. Both options are significantly more costly than dehumidification and much more disruptive to bridge travelers, and both would have a greater visual impact on the historic structure.

The Project addresses two key transportation challenges, as shown in Table 1-1.
Table 1-1: Summary of Transportation Challenges Addressed by the Project

<table>
<thead>
<tr>
<th>Transportation Challenge</th>
<th>Project Element/Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional methods for maintaining a suspension bridge’s cables in a state of good repair are less effective than previously understood. These methods represent the industry standard and have been used for 100 years on bridges throughout the world. Moisture is still able to infiltrate the many wires that make up the cables and weaken the cables over time.</td>
<td>The state-of-the-art dehumidification system is able to reduce the humidity surrounding the cables and halt the corrosion process.</td>
</tr>
<tr>
<td>Climate change is accelerating the corrosion of the cables that support the Mount Hope Bridge.</td>
<td>The dehumidification system adapts the bridge to the effects of climate change—rising humidity in this case—and makes it resilient.</td>
</tr>
</tbody>
</table>

Suspension bridges such as the Mount Hope Bridge, Golden Gate Bridge, or Brooklyn Bridge are unique in their structural form. The roadway on a suspension bridge is supported on a steel and concrete bridge deck and truss that is hung from the two main cables by a number of suspenders spaced along each side of the bridge deck. The two main cables are supported on two tall towers; the cables are anchored at each end of the bridge into either rock or by massive concrete blocks.

All the load from the weight of the bridge and the traffic it carries is carried up the suspenders in tension to the main cables, which are also in tension, to the towers and anchorages. The towers carry the load in compression directly to the ground, and the tension in the cables is anchored into the rock or concrete blocks at the ends of the bridge.

This unique suspension bridge design means that three key components of the Mount Hope Bridge—the main cables, the anchorages, and the towers—have no redundancy. That is, if failure of one of these key components occurs, there is no other path for the load to go and the bridge’s structure will be compromised.

Of these three critical components, the main cables are the most vulnerable. The main cables are among the most important components of the bridge because they serve as the primary structural load path and are nonredundant structural members. Each main cable on the Mount Hope Bridge contains 2,450 individual steel wires bundled in seven strands of 350 parallel wires. Each cable is wrapped circumferentially using galvanized (zinc-coated) steel wire of standard No. 6 gauge (diameter of 0.196 inch). Figure 1-3 shows one of the cables being re-wrapped after inspection in 1996.

1.2.1 Main Cable Deterioration

The wires that comprise the main cables on the bridge create numerous voids and concealed wire surfaces that trap moisture and promote corrosion. Voids make up approximately 20 percent of the cable cross section. The protective system used on Mount Hope Bridge over the years is similar to that used on most other suspension bridges in an attempt to protect the cables against corrosion.
This protective system, shown in Figure 1-4, includes hot-dip galvanizing the cable wires, then applying a red lead paste over the outer wires of the cable, followed by the application of a soft-annealed, galvanized wire wrapping spirally applied around the cable under tension, and then finished with an outer coating of paint. More recently, on modern bridges, zinc paste has been used in place of the red lead paste for health and environmental reasons and improved durability.

This system attempts to protect the cable wires from corrosion by placing multiple physical barriers between the steel wires and ambient sources of water. The cable wire itself is galvanized with a sacrificial barrier of zinc and further protected with a pliable layer of protective paste before being encased in a tightly applied spiral winding of galvanized wire and coated with a membrane of paint.

Even with these protections, water either typically migrates through compromised areas of the protective barriers or forms internally by condensation, providing the catalyst for atmospheric corrosion, hydrogen-induced stress-corrosion cracking, and broken wires. Wires can break under these ambient load conditions at one-third of their tensile strength. Figure 1-5 shows the stages
of wire deterioration. This type of deterioration is not unique to Mount Hope Bridge; it is found in the majority of suspension bridge cables in the United States and around the world.

**Figure 1-5: Stages of Wire Deterioration**

Inspectors also identified high levels of residual nitrates on the bridge cables. They concluded that this nitrate residue came from the waxlike coating that was applied to preserve the wires during transportation and installation of the cable at the time of original construction (1927 to 1929). The nitrate concentrations are sufficiently high to cause stress corrosion cracking of the steel wire in the presence of water (water activates the corrosive process caused by the nitrates).

During an inspection in the 1960s, water was observed dripping from the main cables of the bridge, near midspan. This prompted unwrapping sections of the cable by removing the circumferential wrapping wire and wedging open the cable. Over 100 broken wires were found, and as many as possible were repaired using threaded ferrules. These lower panels were treated with Vitalife 400 oil, recompacted, and rewrapped with Herculite fabric rather than wire wrapping. A recommendation to inspect the cables every 5 years was made following this work.

A 1989 inspection revealed that water intrusion into the cables had persisted. As a result, a main cable inspection was carried out in 1990 as part of the bridge’s annual inspection regimen. During this inspection, inspectors found that the wrapping wire at the southwest cable shroud on the backstay at the wall of the anchorage had come loose due to excessive corrosion of the wrapping wire at the interface with the shroud. Earlier stages of the same condition were occurring at the remaining three shroud locations. At that time, 16 feet of wrapping wire adjacent to the southwest cable shroud was unwrapped, wedged, and inspected. Seven broken wires were found, and they exhibited signs of stress corrosion cracking. The wires in the lower portion of the cable perimeter four to five layers deep were noted to have lost most of their zinc coating to corrosion.

The 1994 Annual Bridge Inspection noted another wire wrapping unraveling location on the east side backstay. In response, in 1996 the main cable backstays were rehabilitated using traditional methods of oiling, caulking, and painting. These portions of the cable exhibited widely varying levels of deterioration, and the southeast backstay had over 300 broken wires, as shown in
Figure 1-6. With 2,450 wires in the original section, this number of broken wires represented more than 12 percent of the original cable area.

Figure 1-6: Main Cable Wire Breaks

Given the uncertain condition of the remaining length of main cable plus the known stress corrosion cracking history of the wires, a recommendation to rehabilitate the remaining length of cables on the suspended spans was made. This rehabilitation consisted of:

- Removing existing wrapping wire and Herculite fabric wrapping
- Repairing any exposed broken wires (154 total wires repaired)
- Introducing oil to the main cable interior to flush water from between individual wires
- Compacting, applying paste, and rewrapping with new galvanized steel wrapping wire
- Painting main cables with a Noxyde coating system

A visual inspection of the cable condition also was initiated in 1999 and completed in the 2000 construction season.

Table 1-2 summarizes the history of reported wire breaks and cracked wires noted between 1960 and 2000.

Table 1-2: Reported Wire Breaks and Cracked Wires, 1960 to 2000

<table>
<thead>
<tr>
<th>Date</th>
<th>Location on cable</th>
<th>Number of reported broken wires</th>
<th>Cracked wires noted</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>Main Span, both cables</td>
<td>100+</td>
<td>Yes</td>
</tr>
<tr>
<td>1990</td>
<td>Southwest Shroud</td>
<td>7</td>
<td>Yes</td>
</tr>
<tr>
<td>1996</td>
<td>Northeast Backstay</td>
<td>44</td>
<td>Yes</td>
</tr>
<tr>
<td>1996</td>
<td>Northwest Backstay</td>
<td>13</td>
<td>Yes</td>
</tr>
<tr>
<td>1996</td>
<td>Southwest Backstay</td>
<td>71</td>
<td>Yes</td>
</tr>
<tr>
<td>1996</td>
<td>Southeast Backstay</td>
<td>303</td>
<td>Yes</td>
</tr>
<tr>
<td>2000</td>
<td>Northeast Side Span</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>2000</td>
<td>East Main Span</td>
<td>29</td>
<td>Yes</td>
</tr>
<tr>
<td>Date</td>
<td>Location on cable</td>
<td>Number of reported broken wires</td>
<td>Cracked wires noted</td>
</tr>
<tr>
<td>------</td>
<td>------------------------</td>
<td>---------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>2000</td>
<td>Southeast Side Span</td>
<td>34</td>
<td>Yes</td>
</tr>
<tr>
<td>2000</td>
<td>Northwest Side Span</td>
<td>21</td>
<td>Yes</td>
</tr>
<tr>
<td>2000</td>
<td>West Side Span</td>
<td>15</td>
<td>Yes</td>
</tr>
<tr>
<td>2000</td>
<td>Southwest Side Span</td>
<td>105</td>
<td>Yes</td>
</tr>
</tbody>
</table>

During the four inspections carried out between 1960 and 2000, 744 wire breaks were recorded. Most but not all of these wires were repaired; however, this is a significant number given that the total number of wires in the cable is 2,450. Also significant is that cracked wires have been found in all of these investigations. Previous studies and experience have shown that cracked wires will become broken within a relatively short period of time if the environment that surrounds them remains corrosive.

Over the years the cable preservation strategy included painting, caulking, partial oiling, and a trial wrapping of limited sections of the cables—all in order to prevent water ingress. However, from the numbers of corroded, cracked, and broken wires found during all the inspections carried out between 1960 and 2000, it is evident that none of the preservation strategy measures has been effective over the long term in keeping moisture out of the cables due to water ingress or condensation. Indeed, some of the wrapping areas may have actually trapped moisture inside the cables. Consequently, corrosion has continued and the loss of cable strength and the subsequent reduction in the safety factor of the cables is accelerating.

A methodology for carrying out the internal inspection and strength evaluation of main cables was not established until 2004 with the publication of the National Cooperative Highway Research Program (NCHRP) Report 534 Guidelines for Inspection and Strength Evaluation of Suspension Bridge Parallel-Wire Cables. This methodology calculates a safety factor, and this metric is used to monitor the bridge’s condition and determine whether it continues to be safe to cross. As a reference, the Mount Hope Bridge was constructed with a 2.95 safety factor; when a suspension bridge cable falls below a safety factor of 2.15, expensive protective and remedial measures must be considered.

In 2015, a further internal cable inspection was carried out, and wire samples were removed in order to determine the loss of cable strength and the resulting safety factor within the cables. The cables were wedged open at nine locations spread over both cables, and widespread corrosion and cracked wires were found, but only nine broken wires were found. A computed main cable safety factor for the locations opened in 2015 was determined to be 2.62. The location with the lowest safety factor of the nine panels opened was at Cable Bent 21NE. This safety factor of 2.62 is a reduction from the original reported safety factor of 2.95 (for the entire bridge) at the time the bridge was constructed.

However, there is reason to believe that the 2.62 value could be optimistic. All internal main cable inspections, which are intrusive in nature, are only able to provide an insight into a small fraction of the wires making up the cables. In 2015, approximately 7.6 percent of the total length of both cables was opened up, and even within the small total length exposed, only a fraction of the wire area could be examined.
A bridge suspension cable is like a chain in that it is only as strong as the weakest link, which identifies the cable’s controlling safety factor. The challenge during an inspection is to identify where the location of the weakest link might be and ensure that it is included in the places opened for evaluation. Based on inspections prior to 2015, the southeast backstay was identified as the likely location that would determine the overall cable’s controlling safety factor. As this location was not included in the 2015 estimate of a 2.62 safety factor, is it likely that this estimate is optimistic and the true safety factor at that time was lower.

Working with the observed values reported over time, which may be optimistic for the reasons described above, Figure 1-5 shows the predicted loss of strength envelope at Cable Bent 21 NE based on the safety factor 2.62 established in 2015. The envelope follows the NCHRP 534 non-linear deterioration model for predicting cable deterioration, which shows deterioration continuing and at an accelerating rate. The envelope assumes that zinc depletion would have started immediately, and areas of complete loss are estimated to have occurred 30 years after bridge opening. **Given the estimated 2015 value and shape of the curve, the safety factor may fall to 2.15 as early as 2028 at this location.** This predicted value of 2.15 is significant, as NCHRP Report 534 recommends that the minimum acceptable safety factor is 2.15. Below 2.15, NCHRP recommends consideration of several actions. These include reducing traffic as a form of load control, such as by implementing a ban on trucks on the bridge.

**This means that for the dehumidification technology to work, it must be designed, installed, and operating by 2026 in order to provide sufficient time for the humidity in the cables to fall to a level that halts the corrosive process.** Based on the experience of other dehumidification applications, it may take anywhere from 6 months to 2 years for the humidity in the cables to fall to 40 percent, depending on the characteristics of the cables, the extent of the oiling, local weather, and climate conditions.

**Figure 1-7: Predicted Cable Deterioration Curve**
Other concerns over the current and future cable safety factor include the following:

- Compared to conventional wastage by general corrosion, high-strength cold-drawn bridge wires are susceptible to failure when localized pitting corrosion is present.
- From the 2015 laboratory tests, the wires indicated a lower ductility than expected from bridge wire and are consequently more prone to cracking and breaking.
- In 2015 it was noted that most wires exhibited localized areas of depleted zinc coating thickness as a result of wear at contact locations between wires, and corrosion likely occurred after the zinc coating was depleted.
- The concentrations of nitrates has caused stress corrosion cracking of the steel wire in the presence of moisture in the cables.
- The deterioration curve shows an envelope of probable reduction in the cable safety factor with time. This is a best estimate using the limited data available, and previous rehabilitation projects may have affected the in-situ conditions in varying ways.

From the available data, the best engineering judgment is that unless some form of effective intervention action is taken soon, the deterioration rate of the main cables on the Mount Hope Bridge will continue at an accelerating rate and the safety factor against failure may fall below the threshold value of 2.15 within the next 5 to 7 years.

**There is no practical way to replace the strength lost in a cable due to corrosion. The only option available to preserve the remaining strength within the cables is to apply a system of dehumidification. If RITBA cannot secure funding to install the dehumidification system in time, more costly and disruptive interventions may be required to ensure the current functionality of the bridge is maintained.**

**How Does the System Work?**

The dehumidification system pumps very dry air at low pressure through the voids within the cables, using a small number of discrete injection sleeves, and the dry air infiltrates the spaces among the individual wires. A small number of discrete exhaust sleeves provide outlets to remove excess air and water. The dry air is produced in a small chamber housing a dehumidifier and the pumps. The process is illustrated in **Figure 1-7**. In practice, the sleeves are a small addition to the bridge (as shown in **Figure 1-8**) and will not change the look of the bridge, either from the deck or in profile from a distance. RITBA will paint the equipment to match the color of the cables, making it blend in with the bridge.
Figure 1-8: Dehumidification System Process

Figure 1-9: Injection and Exhaust Sleeves: a Small Modification to the Cables

Note: The injection sleeve is shown in the left panel; the exhaust sleeve is shown in the right panel.

The exhaust sleeves provide a means for removing condensation. Figure 1-10 shows water draining from an exhaust sleeve on another dehumidification application.

Figure 1-10: Draining Water from a Bridge Cable
1.3 Project History of Previously Incurred Costs

To date, RITBA has incurred regular maintenance and inspection costs related to the cables, but the Authority has not incurred costs related to the installation of dehumidification equipment.

1.4 The Broader Context of the Project

Accessing the individual wires that make up the cables to carry out an internal inspection is a challenging and high-cost process that includes removing the wrapping wire and wedging the cables open to allow access to inspect and repair the individual wires, as shown in Figure 1-11.

*Figure 1-11: Cable Inspection*
Following the inspection/repair, the individual wires are compacted into the wire strands. The wire strands are then enclosed by new wrapping wire, which is then painted. In 2015, a targeted inspection that included individual wire inspection was performed on the main cables. A subsequent cable investigation and evaluation report was developed in 2016. Part of the summary of the 2016 Cable Investigation and Evaluation Report states:

**These cables have a well-documented history of stress-corrosion cracking due to the depletion of zinc protection and ferrous corrosion...** Dehumidifying the cables, we believe, is the most effective way of prolonging the life of the cables, theoretically indefinitely. The cables are in a stage where areas of the zinc layer are nearly depleted, which has historically resulted in stress-corrosion cracking at this bridge. Without a proactive effort to stop the zinc depletion, the wires will deteriorate at an accelerated pace.

The last main cable rehabilitation occurred between 1999 and 2001 (main suspended span) and 1995 (side suspended spans). Main cable rehabilitation involves the same access process as detailed above and typically includes the splicing and/or replacement of individual wires at broken or heavily deteriorated locations.

Individual wire corrosion and section loss is typically caused from the breakdown of the galvanization coupled with the infiltration of water and atmospheric pollutants. Main cable dehumidification can dramatically reduce the corrosion of the individual wires. Similarly, anchorage dehumidification systems regulate the moisture levels of the strands within the anchorages to prevent further corrosion of the cable wires at this critical location.
2. PROJECT LOCATION

2.1 Spatial Coordinates

The Mount Hope Bridge connects Newport County, Rhode Island, with Bristol County, Rhode Island (Figure 2-1); it is located at Latitude: 41.6397941 and Longitude: -71.2578805.

2.2 Geographic Description of the Proposed Project

Traveling south to north, the Mount Hope Bridge connects Portsmouth to Bristol (in route to Providence) across Mount Hope Bay. Mount Hope Bay is part of the larger Narragansett Bay. The bridge, which is part of State Route 114, is one of only three connections between Aquidneck Island (where Portsmouth and Newport are located) and the mainland.

2.3 Connections to Existing Transportation Infrastructure

From the bridge, State Route 114 travels north through Bristol and connects with Interstate 195 (I-195) in the vicinity of Providence.

Figure 2-1: Location of the Mount Hope Bridge in Rhode Island
2.4 Area of Persistent Poverty

The bridge is not located in an area of persistent poverty; it is, however, used by travelers who live in Providence’s areas of persistent poverty to commute to Portsmouth and Newport (see Figure 2-2). Most of Providence is in an area of persistent poverty; approximately 2 percent of its commuters use the bridge daily for work. If the bridge were not available, the travel time to access this market from Providence would be much longer in terms of time and require a higher travel cost. The map shows Census LEHD data to illustrate commuter flows. Residents in these same tracts will also use the bridge to access recreational amenities. There are many tracts classified as areas of persistent poverty in Providence that could have commuters using the bridge. The tract closest to the bridge and State Route 114 is Tract 37. Also, in Bristol County, Tract 305 is located on State Route 114 making it easy for residents to pursue opportunities in Newport County.

Figure 2-2: Map of Areas of Persistent Poverty with Commuting Flows
3. **GRANT FUNDS, SOURCES AND USES OF ALL PROJECT FUNDING**

The estimated cost of the overall Project is $32.2 million (2019$). This is equivalent to $34.6 million in year of expenditure dollars (YOE$). These values will not match the cost estimate used in the benefit cost analysis, as the cost estimate is discounted for the purposes of that assessment. RITBA is requesting RAISE grant funding of $25.0 million.

3.1 **Previously Incurred Expenses**

There are no previously incurred expenses for the Project.

3.2 **Future Eligible Costs**

The Project cost is $34.6 million; all parts of the Project are eligible costs.

3.3 **Source and Amount of Funds**

If awarded a RAISE grant, RITBA would have two sources of funding for this Project. RITBA would provide $9.6 million of its own toll revenues and related bond proceeds, and would close the funding gap with RAISE grant funding of $25.0 million.

3.4 **Documentation of the Funding Commitment for Non-Federal Funds**

RITBA has provided a letter of funding commitment for the $9.6 million of non-federal match with this application. The letter is in the supplemental materials for this application.

3.5 **Federal Funds Applied and Source of Any Required Non-Federal Match**

No federal dollars are applied to this project beyond the $25 million requested in RAISE funds. The source of RITBA’s non-federal match is toll revenues and related bond proceeds.

3.6 **Budget Showing Sources and Uses of Funds**

RITBA requests $25.0 million in RAISE funding. This represents 72.25 percent of the total Project cost in YOE$. Table 3-1 summarizes the Project costs by major cost categories. The Project funding sources are allocated across the major project components listed in Table 3-2.
Table 3-1: Summary of Project Costs by Major Cost Category (in YOES)

<table>
<thead>
<tr>
<th>Major Cost Category</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>$ -</td>
<td>$ 13,910,678</td>
<td>$ 14,189,084</td>
<td>$ 28,099,762</td>
</tr>
<tr>
<td>Design</td>
<td>$ 763,829</td>
<td>$ -</td>
<td>$ -</td>
<td>$ 763,829</td>
</tr>
<tr>
<td>CM/CI</td>
<td>$ -</td>
<td>$ 1,058,899</td>
<td>$ 1,080,092</td>
<td>$ 2,138,991</td>
</tr>
<tr>
<td>Design support during construction</td>
<td>$ -</td>
<td>$ 103,814</td>
<td>$ 105,891</td>
<td>$ 209,705</td>
</tr>
<tr>
<td>Air Flow Test</td>
<td>$ 356,453</td>
<td>$ -</td>
<td>$ -</td>
<td>$ 356,453</td>
</tr>
<tr>
<td>Backstay Rehab</td>
<td>$ 407,375</td>
<td>$ -</td>
<td>$ -</td>
<td>$ 407,375</td>
</tr>
<tr>
<td>Acoustic Monitoring</td>
<td>$ -</td>
<td>$ 519,068</td>
<td>$ 529,457</td>
<td>$ 1,048,525</td>
</tr>
<tr>
<td>Internal Cable Inspection</td>
<td>$ 865,673</td>
<td>$ -</td>
<td>$ -</td>
<td>$ 865,673</td>
</tr>
<tr>
<td>Cable Band Bolt Replacement</td>
<td>$ -</td>
<td>$ 726,695</td>
<td>$ -</td>
<td>$ 726,695</td>
</tr>
<tr>
<td>Total</td>
<td>$ 2,393,331</td>
<td>$ 16,319,154</td>
<td>$ 15,904,524</td>
<td>$ 34,617,009</td>
</tr>
</tbody>
</table>

Note: Costs are year of expenditure dollars (YOES). Escalation assumes using GDP deflator rates.

Table 3-2: Major Project Component by Funding Source, YOES

<table>
<thead>
<tr>
<th>Major Cost Category</th>
<th>Committed</th>
<th>Committed</th>
<th>% Total</th>
<th>RAISE Funds</th>
<th>% Total</th>
<th>Total Cost</th>
<th>Previously Expended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>$ -</td>
<td>$ 2,099,762</td>
<td>9%</td>
<td>$ 25,000,000</td>
<td>72%</td>
<td>$ 28,099,762</td>
<td>$ 0</td>
</tr>
<tr>
<td>Design</td>
<td>$ 763,829</td>
<td>$ -</td>
<td>2%</td>
<td>$ -</td>
<td>0%</td>
<td>$ 763,829</td>
<td>$ 0</td>
</tr>
<tr>
<td>CM/CI</td>
<td>$ 2,138,991</td>
<td>$ -</td>
<td>6%</td>
<td>$ -</td>
<td>0%</td>
<td>$ 2,138,991</td>
<td>$ 0</td>
</tr>
<tr>
<td>Design support during construction</td>
<td>$ 209,705</td>
<td>$ -</td>
<td>1%</td>
<td>$ -</td>
<td>0%</td>
<td>$ 209,705</td>
<td>$ 0</td>
</tr>
<tr>
<td>Air Flow Test</td>
<td>$ 356,453</td>
<td>$ -</td>
<td>1%</td>
<td>$ -</td>
<td>0%</td>
<td>$ 356,453</td>
<td>$ 0</td>
</tr>
<tr>
<td>Backstay Rehab</td>
<td>$ 407,375</td>
<td>$ -</td>
<td>1%</td>
<td>$ -</td>
<td>0%</td>
<td>$ 407,375</td>
<td>$ 0</td>
</tr>
<tr>
<td>Acoustic Monitoring</td>
<td>$ 1,048,525</td>
<td>$ -</td>
<td>3%</td>
<td>$ -</td>
<td>0%</td>
<td>$ 1,048,525</td>
<td>$ 0</td>
</tr>
<tr>
<td>Internal Cable Inspection</td>
<td>$ 865,673</td>
<td>$ -</td>
<td>3%</td>
<td>$ -</td>
<td>0%</td>
<td>$ 865,673</td>
<td>$ 0</td>
</tr>
<tr>
<td>Cable Band Bolt Replacement</td>
<td>$ 726,695</td>
<td>$ -</td>
<td>2%</td>
<td>$ -</td>
<td>0%</td>
<td>$ 726,695</td>
<td>$ 0</td>
</tr>
<tr>
<td>Total</td>
<td>$ 9,617,008</td>
<td>$ 25,000,000</td>
<td>28%</td>
<td>$ 25,000,000</td>
<td>72%</td>
<td>$ 34,617,008</td>
<td>$ 0</td>
</tr>
</tbody>
</table>

4. SELECTION CRITERIA

4.1 Primary Selection Criteria

This section discusses the primary selection criteria.

4.1.1 Safety

This Project is primarily about maintaining a critical asset in a state of good repair and adapting it to changing climate conditions. RITBA is monitoring the bridge conditions closely and consistently performs maintenance on the Mount Hope Bridge to preserve this asset. Thus, there are no direct safety benefits due to the project. There are, however, indirect safety concerns if the dehumidification equipment cannot be installed in a timely manner. First, as discussed elsewhere in this application, the available window to install the dehumidification equipment is limited. If
that opportunity is missed, the cables will have to be supplemented or replaced; this is a much longer, expensive, and more disruptive construction process that will create longer and larger work zones for bridge travelers to navigate, with all the associated delay and intensified crash risk that creates. Second, if travel restrictions are put in place to protect the bridge, some vehicles above a certain weight would need to travel a longer distance to get to their destination. The greater volume of vehicle miles traveled (VMT) increases the potential for crashes to occur.

4.1.2 Environmental Sustainability

This Project directly addresses the impacts of climate change. As a consequence of rising temperatures, the atmosphere over Mount Hope Bay (part of Narraganset Bay) is becoming more humid. This intensifies the corrosion process on the suspension cables that support the Mount Hope Bridge. The Project will make the Mount Hope Bridge resilient to this climate change impact.

The Earth is warming and hotter air can hold more water vapor. Rhode Island has warmed by 3 degrees Fahrenheit (3°F) over the past century, a temperature rise that is twice that of the rest of the contiguous 48 states, according to data from the U.S. Environmental Protection Agency. The map in Figure 4-1 shows the rate of temperature change across the nation. Of all the states, Rhode Island has experienced one of the fastest rates of global warming.

**Figure 4-1: Rate of Temperature Change in the United States, 1901–2020**

Source: U.S. EPA, Climate Change Indicators in the United States, as reported in What Climate Change Means for Rhode Island

As a consequence, more water is evaporating from the Earth’s surface—particularly its oceans—and more water is being held in the air as a gas. Climate modeling indicates that the air can
generally hold around 7 percent more moisture for every 1°C of temperature rise.² Adjusting Rhode Island’s 3°F change in average temperature (described above) to a Celsius scale, the change in temperature translates to an 11.9 percent change in specific humidity. Specific humidity is also known as the “moisture content” of the atmosphere.³ Climate Central reports the change in moisture in the air by the dew point temperature and finds the same overall trend, as shown in Figure 4-2.

Figure 4-2: Providence’s Summers are Becoming More Humid

![Graph showing increasing dew point temperature](https://example.com/graph-4-2.png)

Source: Climate Central [https://statesatrisk.org/rhode-island/all](https://statesatrisk.org/rhode-island/all)

The average annual temperature of the ocean below the Bridge (Mount Hope Bay, part of Narragansett Bay) has warmed approximately 3.6°F (with winters even greater) since the 1960s, and the Bay is expected to continue warming throughout the century.⁴

A secondary environmental impact will occur if the bridge is restricted or closed. As noted in the safety discussion above, this would cause traffic to slow or detour, both of which would increase fuel consumption and emissions released into the atmosphere.

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¹ One degree Celsius is 1.8 times larger than 1°F. Therefore, the 3°F increase in Rhode Island’s average temperature translates into a 1.7°C degree change in temperature or an 11.9 percent change in potential humidity.


³ It is measured in grams of water vapor per kilogram of moist air and describes how much water vapor there is in relation to the total mass of water vapor and air combined.

4.1.3 Quality of Life

The Project will preserve an essential link between Aquidneck Island and the mainland, in the vicinity of Providence. It represents the most direct path for Island residents traveling to Worcester or the western suburbs of Boston. As noted in Section 2, Project Location, the Mount Hope Bridge is one of only three links to the mainland, and the most direct link to Providence. It also represents an important redundancy if one of the other bridges is blocked or otherwise compromised. It is also a historic landmark, listed on the National Register of Historic Places.

4.1.4 Economic Competitiveness

Given Rhode Island’s physical geography, bridges are critical components of the state’s transportation network. If the Mount Hope Bridge was compromised or not available for travelers, the direct link between Bristol/Providence and Portsmouth/Newport would be severed. Travelers from Portsmouth/Newport would have to take a more circular route to access the state’s largest commercial center and state capital. Roger Williams University is proximate to the bridge on the Bristol side but draws students and employees from both sides.

The Bridge is a lifeline for businesses in the area. Many of them are small businesses, which are vital to the area and the State’s economy, including two key sectors, defense and tourism. The range of businesses in Middletown, Newport, and Portsmouth includes tourism, technological research, defense, retail, health care, and agriculture. Newport is a major regional tourist destination visited annually by approximately 3.5 million people drawn to the coastal environment, waterfront businesses, and shoreline access found on Aquidneck Island. The three municipalities all depend on each other for their economic well-being. For example, many tourists stay at hotels outside of Newport, and more than a quarter of the employees of Newport businesses live in either Middletown or Portsmouth.

The United States Navy is Newport County’s largest single employer in terms of payroll and personnel statistics. The Navy generates large numbers of high-tech and defense-related jobs indirectly on Aquidneck Island. In the 1980s, Middletown and Portsmouth experienced a high-tech boom stimulated partly by the Naval Underwater Systems Center in Newport. The Island as a whole is becoming a high-tech hub with more than 80 software and engineering firms employing a large portion of the labor force. The ability to access the universities and technology firms in Boston is important for the health of this industry at this location.

The Mount Hope Bridge benefits the tourism industry, as it is the primary route for visitors to Aquidneck Island from Providence, Boston, Albany, or points north. Travel economy expenditures directly generated over 8,000 jobs, and when indirect and induced impacts are considered, over 10,750 jobs for the City of Newport. Moreover, travel economy expenditures directly generated nearly 3,900 jobs, and when indirect and induced impacts are considered in, nearly 5,450 jobs in the rest of the Island. To put these estimates in context, the number of jobs sustained by the travel economy in the city of Newport accounts for 26 percent of all jobs in Newport County (40,805). Stepping back from just the employment numbers, the $179 million in state and local taxes generated by the travel economy on Aquidneck Island is enough to cover the
average salaries of 2,975 public school teachers in Newport County (about $60,000 according to Salary.com)\(^5\).

### 4.1.5 State of Good Repair

While the Project delivers favorable outcomes in terms of safety, environmental sustainability, quality of life, and economic competitiveness, at its core it is a state of good repair project. The bridge has received regular maintenance using industry best practices, including oiling and painting the cables at regular intervals. Even so, the bridge’s age—92 years—and rising humidity are taking their toll on its condition. Operation and maintenance costs for the cables (excluding maintenance of other parts of the bridge) are $42,000 annually for spot painting and $3.5 million for inspection every 5 years. Inspection of the cables requires removing the wrapping wire around the cable in 6 to 9 locations then wedging the cable open around its circumference, and noting the degree of corrosion and number of broken wires. Wires are removed for testing and strength evaluation and new wires to repair broken and sampled wires are “swaged” into the existing bundle. The cable is then recompacted, re-wrapped, and repainted.

By adding dehumidification to the cables and anchorages, the progressive deterioration and loss of strength associated with corrosion will be halted, and the cables and anchorages will be preserved in their current condition and strength for the balance of the bridge’s useful life—at least another 50 years. (See Figure 4-3) The catch, however, is that the dehumidification must take effect before the cables deteriorate to the point that their strength will no longer support the combined weight of the bridge and traffic. While the exact condition cannot be known without fully unwrapping the cables and inspecting their length, the best engineering estimate of when dehumidification alone is no longer an option is 2028, given past inspection reports.

**Figure 4-3: An Illustration of How Dehumidification Stops Wire Breaks Below 40 Percent Relative Humidity**

![Diagram showing the effect of dehumidification on wire breaks](image)

\(^5\) Information summarized from Economic Impact of Tourism in the City of Newport and Aquidneck Island, 2018, published in August 2019.
If RITBA is unable to secure funding for dehumidification system, get it installed, and provide the necessary 2 years of operational time to bring the humidity down to approximately 40 percent by 2028, more costly and disruptive remedies will be required. These options could be adding cables to supplement the existing cables or completely replacing the existing cables. Both options would still require a dehumidification system and are much more expensive and disruptive to the community and the commercial enterprises that use this bridge. Table 4-1 below shows the options to return the Mount Hope Bridge to a state of good repair, the window of opportunity for each option, and the cost of each option.

Table 4-1: Summary of Options to Return the Mount Hope Bridge to a State of Good Repair (2021$)

<table>
<thead>
<tr>
<th>Option</th>
<th>Cost</th>
<th>Timeline</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option 1: No Action</td>
<td>$750M-$900M</td>
<td>If funding cannot be secured before 2030 for any type of remedy, the bridge’s integrity would become compromised from sustaining its own weight and it would have to be rebuilt</td>
<td>Full bridge replacement becomes necessary. Loss of historically protected structure.</td>
</tr>
<tr>
<td>Option 2: Install Dehumidification System</td>
<td>$33M</td>
<td>Must be installed by 2026 in order bring cable humidity down to 40 percent by 2028</td>
<td>Preserves 50 years of bridge’s useful life. Modelled in the benefit cost assessment (BCA) presented in Section 6, Benefit Cost, of this application and the supplemental materials.</td>
</tr>
<tr>
<td>Option 3: Cable Supplement</td>
<td>$60M + Cost of Alternating Lane Operation and Periodic Full Closures during Installation</td>
<td>Must be accomplished as soon as possible after 2028</td>
<td>Estimate includes dehumidification system to protect future investment. Modelled in BCA presented in Section 6, Benefit Cost, of this application and the supplemental materials.</td>
</tr>
<tr>
<td>Option 4: Full Cable Replacement</td>
<td>$250M to 300M + Cost of Extended Travel Disruptions</td>
<td>Must be accomplished as soon as possible after 2028</td>
<td>Estimate includes dehumidification system to protect future investment. Modelled in BCA presented in Section 6, Benefit Cost, of this application and the supplemental materials.</td>
</tr>
</tbody>
</table>

RITBA maintains an asset management system for its assets and regularly programs funding for maintenance and repair. In the case of this Project, maintenance and repair costs will fall once the humidification system is in place, as only one location would need to be opened for inspection at a much less frequent internal.

### 4.2 Secondary Selection Criteria

This section describes the secondary selection criteria.
4.2.1 Partnership

The Rhode Island Turnpike and Bridge Authority (RITBA) is the applicant. RITBA will be responsible for the design, construction, operation, maintenance, and monitoring of the dehumidification Project. The Authority was created in 1954 by the Rhode Island General Assembly as a body corporate and body politic, with powers to construct, acquire, maintain, and operate bridge projects as defined by law. A body corporate is a legal entity. A body politic is a civil division of the state for purposes of governmental administration.

The governor directly appoints four out of the five members of the board to 4-year terms. The Director of the Rhode Island Department of Transportation is the fifth member of the board ex officio. As a quasi-state agency, RITBA comports with state purchasing, financial reporting, open meetings, and other public governance laws, and is empowered to issue bonds to support replacement and renewal efforts. RITBA is a component unit of the State of Rhode Island for financial reporting purposes; is exempt from federal and state income taxes; and its audited financial statements are included in the state’s annual financial report.

The Mount Hope Bridge was operated as a toll bridge until 1998. Tolls were removed when the Authority concluded that the toll plaza design was unsafe, but also because the costs associated with toll collection were more than the 30-cent tolls could generate. Despite the removal of tolls, RITBA has undertaken rehabilitation projects on the bridge and associated components. Between 1998 and 2004, the Authority spent more than $15 million to replace wires in the main cables and suspender ropes, make minor repairs to the roadway deck (which was fully replaced in 1985), upgrade the electrical system, replace the railing, and repaint the bridge. The repairs were paid for by tolls on the Pell (Newport) Bridge.

Tolls on the Pell Bridge account for approximately one-half of RITBA’s revenue. As a result of 2014 legislation, RITBA’s revenue now includes a percentage of the gasoline tax from Rhode Island. Toll rates on the Pell Bridge are $0.83 for Rhode Island residents with transponders, $0.91 for out-of-state commuters with a pass, and $2.00 per axle for cash and out-of-state users.

The current capital investment plan (CIP) runs through 2029 and totals $229.6 million ($2018); it is funded primarily by bond proceeds, toll revenues, and residual motor fuel tax revenues, with no expectation of additional debt secured by toll revenues at current toll rates. Fitch Ratings reviewed RITBA’s debt in December 2020 and affirmed the “A” rating on approximately $48 million of RITBA’s toll revenue bonds; the Rating Outlook remained “Stable.”

How Many Suspension Bridges Are There in the U.S.?

The United States has one of the largest and oldest inventories of suspension bridges in the world.

<table>
<thead>
<tr>
<th>Age of Bridges</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 100 Years</td>
<td>22</td>
</tr>
<tr>
<td>51-100 Years</td>
<td>65</td>
</tr>
<tr>
<td>31-50 Years</td>
<td>2</td>
</tr>
<tr>
<td>11-30 Years</td>
<td>5</td>
</tr>
<tr>
<td>0-10 Years</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>97</td>
</tr>
</tbody>
</table>

Source: Federal Highway Administration Office of Bridges and Structures
Why Is the Grant Needed?

As described above, RITBA funds its capital and operations from two sources: toll revenues collected on the Pell Bridge and an allocation of Rhode Island’s state gas tax collections. Each is described below.

Rhode Island Fuel Taxes. Rhode Island assesses a fuel tax of 34 cents per gallon. The tax is indexed to inflation. By statute, the Division of Taxation must consider whether inflation requires an adjustment every other year. Although the State’s gas tax is indexed, rising fuel economy and the greater use of hybrid or electric cars translates into lower tax revenues collected per vehicle mile driven. As a result, RITBA collects less revenue per mile driven.

Toll Revenues Post COVID-19. The COVID-19 pandemic led to lower toll revenue and decreased gas tax revenue. As a result, RITBA expects total collections to be approximately $20 million less in fiscal years 2020, 2021, and 2022 when compared to the annualized revenue from fiscal year 2019. This significant shortfall – which has not been offset by any state or federal support – leaves the agency without the ability to fund this important project without potentially pushing out other capital projects that are included in RITBA’s 10-year capital plan. Unlike the Rhode Island DOT and the Rhode Island Public Transit Authority, RITBA has not received any funding from the CARES Act.

Why Not Just Increase Tolls?

The last toll increase took place in 2009 after 40 years of unchanged rates. RITBA has full rate-setting ability but when toll increases have been proposed in recent years, has faced pushback from the community and businesses that use the bridges. Local anti-tolling sentiment is so strong that tolls imposed on the new (2013) Sakonnet River Bridge (also managed by RITBA) were replaced by an annual allocation of the State motor fuel tax revenues.

4.2.2 Innovation (Technology)

The Notice of Funding Opportunity (NOFO) recognizes innovations in three key areas for infrastructure innovation: these are: technology, project delivery, and financing. This Project’s innovation is technical and addresses a challenge that will need to be addressed by nearly 100 other bridges the United States, which is home to some of the oldest suspension bridges in the world (see the callout box). The example of the Mount Hope Bridge application will provide lessons learned that will help bridge owners in multiple locations across the nation.

All equipment needed to install a cable dehumidification system is produced in the United States; this Project meets all requirements of Buy America regulations.

5. ENVIRONMENTAL RISK

This section discusses the project schedule (Table 5-1), required approvals and permits, National Environmental Policy Act (NEPA) status, and risk and mitigation strategies.

5.1.1 Project Schedule

Assuming that the U.S. Department of Transportation announces awards on or before November 22, 2021, and allowing 6 months for grant negotiation, RITBA can have the system designed and
other preconstruction activities completed in the last 6 months of 2022. This is well before the required date of September 2024 outlined in the NOFO.

Construction of the system on the bridge can be completed in 24 months (2023 to 2024). This is well ahead of the September 2029 date specified in the NOFO. This schedule includes buffer time for unusual weather conditions that could affect available work days, as much of the work must take place outdoors up on the cables.

Understanding that the humidity rate in the cables may fall to 40 percent in 6 to 12 months as with other bridges, but allowing the maximum time ever recorded as a conservative assumption, the corrosion process in the Mount Hope Bridge cables will be halted by 2026, which is well ahead of the 2028 date at which other interventions might be needed to protect the bridge.

Table 5-1: Mount Hope Bridge Cable and Anchorage Dehumidification Project Schedule

<table>
<thead>
<tr>
<th>Activity</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
<th>2025</th>
<th>2026</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Flow Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Backstay Rehabilitation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal Cable Inspection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cable Band Bolt Replacement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction of Dehumidification System</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design Support During Construction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction Management/Construction Inspection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installation of Acoustic Monitoring</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dehumidification Process Reduces Cable Moisture to 40%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40%</td>
</tr>
</tbody>
</table>

5.1.2 Required Approvals and Permits

As the bridge owner charged with maintaining the facility in a state of good repair, RITBA has full authority to install the dehumidification system. The bridge is listed on the NRHP. As proposed, the Project would not change the historic integrity of the structure and has received a letter of support from the State of Rhode Island Historical Preservation and Heritage Commission. The equipment installation would likely result in a negligible effect on the appearance of the structure. In compliance with Section 106 of the National Historic Preservation Act, coordination with the Rhode Island State Historic Preservation Officer will occur to receive an effect determination on the Project.

5.1.3 NEPA Status

The Project has not undergone a NEPA evaluation. It is expected that the equipment installation will qualify for a Categorical Exclusion, as no significant long-term or temporary impacts are expected. The Project occurs within the existing footprint of the structure. Most of the work occurs along the cables, above the deck level (see Figure 5-1). Temporary impacts associated with the installation of the equipment are expected. RITBA expects an estimated 360 days of alternating lane closures during installation. However, the advantage of the Project is that disturbance to bridge users is minimized compared to the other options that would require both alternating lanes and outright bridge closures to accomplish the work. No temporary platforms
would be required in the water below the bridge. A boat will be required below the bridge for safety when workers are up on the cables. Additional boats may be required to bring materials to the site.

**Figure 5-1: Work on Suspension Cables above a Bridge**

Photo sources: Daniel Faust and Barry Colford.

### 5.1.4 Risk and Mitigation Strategies

**Table 5-** lists the main Project risks and discusses their impact on the delivery and how the project plan mitigates their impact on successful delivery of the Project.

**Table 5-2: Assessment of Project Risks by Type of Risk**

<table>
<thead>
<tr>
<th>Project Risk</th>
<th>Assessment/Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application of New Technology in the U.S.</td>
<td>The technology chosen has been deployed with success for 21 years, primarily in Europe and Asia. Main cable dehumidification has now been installed and commissioned successfully on five bridges in the United States, including: the twin Chesapeake Bay Bridges, the twin Delaware Memorial Bridges, and the South Tenth Street Bridge in Pittsburgh. Cable dehumidification is also currently being installed on the George Washington Bridge in New York City, the Anthony Wayne Bridge in Toledo, Ohio, and the Ben Franklin Bridge between Pennsylvania and New Jersey. The systems on the Chesapeake Bay Bridges have been running for over 7 years, and the systems on the Delaware Memorial Bridges for 2 years. Both have shown a successful reduction in relative humidity within the cables to below the 40 percent level where corrosion ceases. In the UK, cable dehumidification systems on the Forth Road Bridge and the Severn Bridge have both been running for over 12 years. Both bridges were fitted with an acoustic monitoring system, and on both bridges, no significant numbers of new wire breaks were recorded after the RH values in the cables dropped below 60 percent. The engineering staff at Rhode Island Turnpike and Bridge Authority (RITBA) have reached out to their peers in the engineering community to identify best practices and lessons learned in the application of this technology.</td>
</tr>
<tr>
<td>Project Risk</td>
<td>Assessment/Mitigation</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Schedule Risk</td>
<td>The largest schedule risk is not in the installation of the equipment, but in the time it takes for the humidity in the sealed cable to fall to 40 percent. The observed range for this to occur has ranged from 6 months to nearly 2 years. The upper bound was for a bridge in a cold climate, where cold temperatures decelerated the drop in humidity. As Rhode Island’s climate is more temperate, the expectation is that humidity will fall in less than 2 years. This risk is mitigated by including a full 2 years in the project schedule, even though the engineering team does not believe the full 2 years will be required.</td>
</tr>
<tr>
<td>Procurement Delays</td>
<td>None expected. All required equipment is “off the shelf.”</td>
</tr>
<tr>
<td>Environmental Uncertainties</td>
<td>None expected. The installation of dehumidification equipment is more environmentally friendly than chemically treating the cables with special oils and paints.</td>
</tr>
<tr>
<td>Increases in Real Estate Acquisition Costs</td>
<td>None expected. No real estate acquisition is required.</td>
</tr>
<tr>
<td>Uncommitted Local Match</td>
<td>None expected. The non-federal match is identified, available, and committed. Please see the letter of commitment included with this application.</td>
</tr>
<tr>
<td>Unavailability of Domestically Manufactured Equipment</td>
<td>None expected. All required equipment is manufactured in the U.S. See, for example, Munter’s, a global producer of dehumidification equipment with five production locations in the U.S. (<a href="https://www.munter.com/en/about-us/munter-in-short/">https://www.munter.com/en/about-us/munter-in-short/</a>) The material needed to wrap the cables to form an air-tight seal is Cableguard, made by DS Brown of Ohio. (<a href="https://www.dsbrown.com">https://www.dsbrown.com</a>)</td>
</tr>
<tr>
<td>Lack of Legislative Approval</td>
<td>None expected. No legislative approvals are required.</td>
</tr>
</tbody>
</table>

6. **BENEFIT COST**

The benefit cost assessment compares a baseline scenario with the Project scenario and assesses the net change in a variety of metrics. Although the Project scenario is well defined, the future baseline could be framed in a variety of ways, as detailed in Table 4-1 in Section 4.

The simplest baseline is that the bridge closes and travelers have to divert to other locations. As a quick estimate of this scenario, 6.9 million vehicles use the bridge each year. If the bridge is closed and alternative routes are required, it is estimated that the average trip would increase by 12.5 minutes (12.75 miles). That equates to 1.4 million hours of increased travel time per vehicle or 2.4 million people hours when adjusted for an average vehicle occupancy of 1.67 people. At $17.90 per hour (per BCA Guidance), that translates to $43 million in annual avoided travel time. The discounted value of this stream of savings is $533 million for a BCR of 20:1. This simple scenario omits the travel cost, emissions, pavement wear and tear, increased congestion, and safety benefits that would also be generated by avoiding the loss of the bridge.

RITBA in reality will do everything possible to keep the bridge in service; as a result, two alternative baselines were assessed against the Build Alternative.

- The simplest baseline is that funding cannot be secured in time to address the failing cables and the bridge must be closed to the public. All travelers must detour to one of the two remaining crossings, incurring travel costs and time, and adding VMT to the network and emissions to the environment. This is a worst-case or nuclear scenario.
- RITBA will do everything possible to protect this asset and keep it available to the public—that is the Authority’s mission—so two alternative baseline scenarios were considered:
Optional Baseline 1: Funding cannot be secured in time to stabilize the cable deterioration—with or without supplementation—and a full replacement of the cable is required. This increases the cost to $250 to $300 million, or a net increase of $217 to $267 million (in 2021$).

Optional Baseline 2: Funding cannot be secured in time to allow the cables to dry and preserve the necessary strength to support the bridge and traffic load. Cable supplements must be installed in addition to the dehumidification system – the net incremental increase in cost is $26.9 million (in 2021$) over a humidification system alone.

The benefit cost analysis shows the results using both baselines, summarized in Table 6-1. The detailed calculations and benefit cost memorandum provided in the supplemental materials to this application describe the findings in detail. The analysis was conducted in accordance with the 2021 Benefit-Cost Analysis Guidance for Discretionary Grant Programs for a full 30-year assessment period. Capital outlays are scheduled to begin in 2022 and operations would resume in 2025.

Table 6-1: Benefit Cost Analysis Results

<table>
<thead>
<tr>
<th>Scenarios:</th>
<th>Project versus Cable Replacement (No Build 1)</th>
<th>Project versus Cable Augmentation (No Build 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Costs (2019 $M)</td>
<td>Benefits (2019 $M)</td>
</tr>
<tr>
<td>Capital Costs</td>
<td>$27.4</td>
<td>$27.4</td>
</tr>
<tr>
<td><strong>Total Costs</strong></td>
<td>$27.4</td>
<td>$27.4</td>
</tr>
<tr>
<td>State of Good Repair</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repair Cost Savings</td>
<td>$199.1</td>
<td>$40.4</td>
</tr>
<tr>
<td><strong>Sub-Total State of Good Repair</strong></td>
<td>$199.1</td>
<td>$40.4</td>
</tr>
<tr>
<td>Economic Competitiveness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Travel Time Savings</td>
<td>$10.2</td>
<td>$5.1</td>
</tr>
<tr>
<td>Travel Cost Savings</td>
<td>$3.3</td>
<td>$1.3</td>
</tr>
<tr>
<td>Residual Value</td>
<td>Qualitatively assessed</td>
<td>Qualitatively assessed</td>
</tr>
<tr>
<td><strong>Sub-Total Economic Competitiveness</strong></td>
<td>$13.5</td>
<td>$6.5</td>
</tr>
<tr>
<td>Environmental Sustainability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emissions Savings</td>
<td>$0.2</td>
<td>$0.1</td>
</tr>
<tr>
<td><strong>Sub-Total Environmental Sustainability</strong></td>
<td>$0.2</td>
<td>$0.1</td>
</tr>
<tr>
<td>Safety</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced Fatalities and Injuries</td>
<td>$0.5</td>
<td>$0.2</td>
</tr>
<tr>
<td><strong>Sub-Total Safety</strong></td>
<td>$0.5</td>
<td>$0.2</td>
</tr>
<tr>
<td>O&amp;M Savings</td>
<td>-$1.0</td>
<td>$2.3</td>
</tr>
<tr>
<td><strong>Net O&amp;M</strong></td>
<td>-$1.0</td>
<td>$2.3</td>
</tr>
<tr>
<td><strong>Total Benefits</strong></td>
<td>$212.3</td>
<td>$49.4</td>
</tr>
<tr>
<td>Outcome</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC Ratio</td>
<td>7.7</td>
<td>1.8</td>
</tr>
<tr>
<td>Net Benefits</td>
<td>$184.9</td>
<td>$22.0</td>
</tr>
</tbody>
</table>