

E-183 115 kV Transmission Line Underground Relocation Project

Initial Evaluation of Bridge Structures

July 11, 2017

Introduction

Robinson and Cole, LLP contacted Power Delivery Consultants, Inc. (PDC) to perform an engineering study on the feasibility of attaching a 115 kV cable circuit (two cables per phase) on seven bridges in Providence and East Providence, Rhode Island. The bridge attachment is being considered as an alternate to crossing the Providence and Seekonk rivers using horizontal directional drilling (HDD) technology. Due to historical activities along the river, there is a strong likelihood for geotechnical obstructions in the rivers and along the river banks that will complicate the HDD, due to its low entry and exit angles.

The bridges to be evaluated include:

1. I-195 Providence River Bridges – West Span and East (Arch) Span
2. I-195 Bridge Street Overpass
3. I-195 South Water Street Overpass
4. I-195 South Main Street Overpass
5. I-195 Washington Bridges (Eastbound spans)
6. I-195 Washington Bridges (Westbound spans)
7. Washington Pedestrian Bridge

The purpose of this study is to find at least one bridge to attach the cables and conduit over each of the two rivers, to eliminate the risks associated with installing the cables using HDD technology. Should it be determined that there is no feasible way to attach the cables and conduit to any of the bridges over both of the rivers, this would result in the need to use HDD at some location.

PDC, an electrical engineering consulting firm, contracted with CDR Maguire (Maguire) to perform the structural evaluation of the bridges. Maguire is a structural/civil engineering firm local to the Providence area, and they routinely perform bridge analysis for the Rhode Island Department of Transportation (RIDOT).

Attachment 1 to this report summarizes the results of Maguire's investigation into the suitability of attaching the cable and conduits to the bridges from a structural perspective. This report summarizes the results of Maguire's report and discusses the challenges of getting the cables onto and off of the bridges that Maguire has determined to be suitable for supporting the cables and conduits.

PDC would like to thank RIDOT for their participation and timely assistance with this analysis.

Discussion

Figure 1 shows the bridges that were evaluated for attachment of the 115 kV electrical circuit. There are two (I-195 East and West bound) bridges across the Providence River (item 1 above). Attached directly to the east end of the Providence River bridges are three additional bridge spans (items 2-4 above). The last three bridges are in parallel across the Seekonk River (items 5-7).

The Point Street Bridge is noted for reference only, but there is no open space to attach the cables and conduits for the E183 line. The center of the bridge is blocked by the presence of the bridge's large swing mechanism, while the south side of the bridge houses several existing distribution circuits and the north side of the bridge is where the Q143 and R144 submarine transmission lines come out of the Providence River. National Grid is planning to relocate these self-contained fluid filled (SCFF) submarine cables from the river to the north side of the bridge. Therefore, there is no room available to install the E183 circuit on the Point Street Bridge.

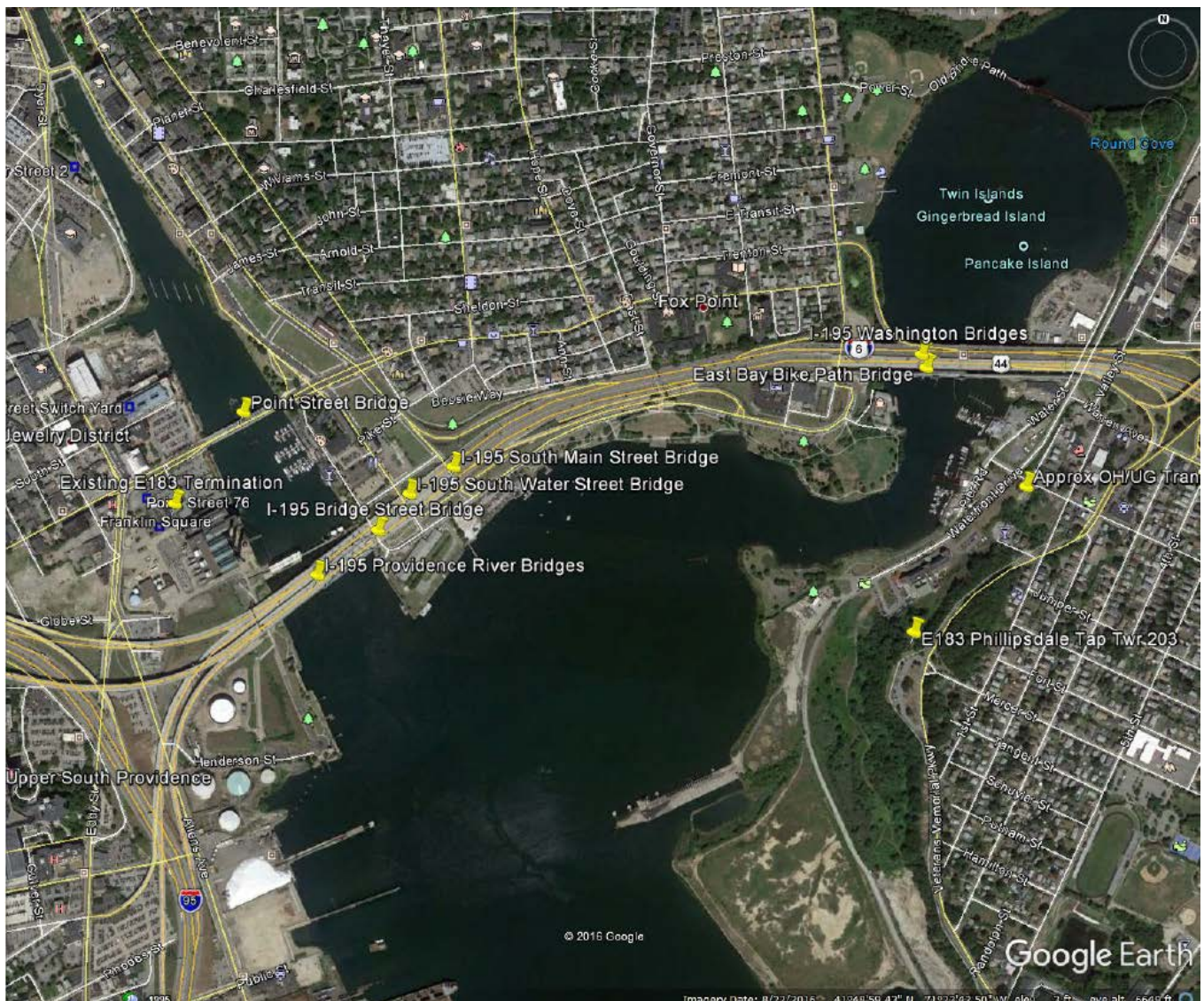


Figure 1 – Bridge Location in Providence and East Providence, Rhode Island

Site Visit and Examination of the Bridges

On Thursday, June 1, National Grid's Dave Campilli hosted a site visit of the bridges to be evaluated. Those in attendance in addition to Mr. Campilli included:

1. Dave Beron – National Grid
2. Ed Parker – Maguire
3. Alessandra Keller – Maguire
4. Mike Savella – RIDOT
5. Peter Lacouture - Robinson & Cole, LLP
6. Eriks Surmanis – PDC
7. Pete Tirinzoni - PDC
8. Adrienne Southgate – City of Providence Legal Council
9. Leo Wold – with the Rhode Island Attorney General's Office
10. Mark Russo – Attorney for East Providence.

PDC approached this evaluation in two steps. The first step was a go/no-go evaluation of each bridge, to determine if it warranted further review or identify if there was a fatal flaw that would take it out of consideration. Once this first step has been completed, PDC will evaluate the remaining bridges with a more detailed engineering study. This first step included the following tasks:

- PDC and Maguire participated in a visual inspection of all bridges with National Grid and Rhode Island Department of Transportation (RIDOT) for initial screening for suitability.
- PDC and Maguire evaluated, with RIDOT input, potential corridors within each bridge for cable system attachment.
- PDC performed a weight calculation for the proposed in-bridge cable system for National Grid review and for discussion with the RIDOT. Since specific cable construction details are not finalized, for bridge design purposes, PDC assumed a typical AEIC CS9 cable construction with 5000 kcmil copper conductor, 115-kV XLPE cable system with a lead sheath in order to develop maximum potential weight. PDC calculated the weight of the cable and conduit system to be approximately 234 lbs./ft.
- PDC and Maguire evaluated, with RIDOT input, potential obstructions within the bridge alignments and potential geometry/construction/cable pulling issues associated with getting past these obstructions.
- Maguire evaluated the various bridge designs and weight capacities to determine suitability for accepting the estimated weight of the cable and conduits and all necessary clamps and support structures.
- PDC evaluated geometric issues associated with entering and exiting each bridge relative to number of bends required, cable pulling issues, potential need for in-bridge splicing chambers, and other alignment/geometry issues.

Discussion of Specific Bridges

Providence River Bridge - Bridge Street, South Water Street, and South Main Street Overpasses

The Bridge Street, South Water Street, and South Main Street overpasses all consist of pre-stressed, adjacent butted box beams (Figures 2 & 3). Maguire has determined that the design of these overpasses does not allow for the installation of the conduits, since the butted box beams are set adjacent to each other, with no space in between for utilities. Additionally, the conduits cannot be suspended below the beams since drilling holes in the pre-stressed members would adversely affect the structural integrity of the beams. Lastly, the existing bump outs for the light standards prevent the attachment of the cables and conduits to the exterior sides of these spans.



Figure 2 – Bridge Street Overpass



Figure 3 – Bridge Street Overpass Looking East

Providence River Bridges – West Span and East (Arch) Span

Before the cables and conduits could be attached to the Providence River bridges, they would need to get from the substation onto the bridges. Figure 4 shows the west side of the Providence River bridges. Getting the cables and conduits from the Franklin Square substation to the Providence River bridges will require microtunnelling or a similar trenchless technology to go under the hurricane barrier protecting Providence from storm surges associated with coastal hurricanes. Once in the area of Figure 4, it will require two 90-degree bends to transition from bridge attachment to underground duct bank, and anchor cleats or some other support design would be needed to prevent damage to the cable given the 15-20 foot change in elevation.



Figure 4– West Side of Providence River Bridges

The bridges over the Providence River consist of two different span designs. See the West Span (Figure 5) and the East (Arch) Span (Figures 6 and 7).

In order to cross the Providence River, the cables and conduits would need to be attached to both span designs. Attaching the cables and conduits to the west span is possible, although not without its share of issues, such as needing to close down I-195 East in order to make the necessary structural modifications.



Figure 5 – West Span of I-195 Providence River Bridges



Figure 6 – Arch Span of I-195 Providence River Bridge

However, on the east span (arch design), Maguire has determined that holes cannot be drilled into the floor beams, necessary to accommodate the conduits, without adversely impacting structural integrity. This would require the cables and conduit to be supported below the beams, which would create clearance issues with boaters on the river as they pass under the bridge. Also, holes cannot be drilled in the support structure between the eastern and western bridge spans (Figure 7), as that would compromise the structural integrity. Therefore, all of the conduits would need to go under this support. The large bend radius of the cables and conduits (approximately 10-12 feet minimum) would impose additional clearance issues on the boating traffic going under the bridge.



Figure 7 – Underside of Arch Span of I-195 Providence River Bridges

As previously discussed, the cables and conduits cannot be attached to the bridges immediately east of the Providence River (Bridge Street Overpass, South Water Street Overpass and South Main Street Overpass). This would require the cables to come off the Providence River Bridge as soon as they reach the eastern edge of the river (Figure 2). Similar to the western side of the bridge, transitioning from the bridge attachment to underground will require two 90-degree bends and anchor cleats or some other support design to prevent damage to the cable given the 15-20 foot change in elevation. The torturous path caused by the sum of these bends would cause the pulling tension and sidewall bearing pressure to significantly exceed the limits typical for these cables. This would prohibit crossing the bridge using single lengths of cable, thus requiring six cable joints and joint bays (one per cable) to be installed and attached to the underside of the bridge. The presence of the cable joints and joint bays will again affect the clearances to boating traffic, and may pose a safety issue.

Conclusion on Attaching to the Bridges Over and Adjacent to the Providence River

The Bridge Street Overpass, South Water Street Overpass, and South Main Street Overpass all consist of pre-stressed, adjacent butted box beams. Drilling into these pre-stressed members would adversely affect the structural integrity of the beams, and the existing bump outs for the light standards prevent the attachment of the cables and conduits to the exterior sides of these spans.

While the cables and conduits could, in theory, be routed along the Providence River Bridge, there are many significant flaws with this solution.

1. A trenchless installation method would be needed to get the cables under the hurricane barrier that protects the City of Providence from coastal storms.
2. Lane closures would be needed on I-195 to allow for structural modifications to be made to the bridge structure.
3. The design of the Arch span and center bridge support would require the conduits to be routed in a manner that would significantly infringe on the clearance to boaters crossing under the bridge.
4. The required number of bends in the route would eliminate the ability to install single lengths of cable along the bridge, thus necessitating cable joints and associated joint bays for each of the six cables. This imposes both a clearance and a potential safety issue to the boaters going under the bridge.
5. It would be very difficult to make the conduits coming off the eastern edge of the bridge match the appearance of the existing architecture.

Based on these concerns, PDC concurs with Maguire's assessment that the I-195 bridges over the Providence River are not suitable for installing the E183 cable system.

Seekonk River Bridges

Washington Bridges (I-195 Westbound)

Maguire evaluated the structural reports for the I-195 westbound span over the Seekonk River and noted it is rated below the statutory loads. However, rehabilitation of the westbound spans began in April 2017 and is expected to take approximately 2-1/2 to 3 years. According to RIDOT, the design has been finalized and any additional loads such as the cable and conduit will need further structural analysis.

In addition to delaying the relocation of this circuit until after the rehabilitation and subsequent analysis, the westbound span is the farthest north of the bridges. Locating the circuit in this location was ruled out, due to the significant lane closures needed to cross several traffic lanes of I-195 and at least one breakdown lane, both to get on and get off the westbound span. In addition to the lane closures, there would be issues getting the cables and conduits off the east end of the bridge, since it is elevated for several blocks after crossing the river. Getting off the bridge would require two back-to-back 90-degree elbows to transition from bridge attachment to underground duct bank and anchor cleats or some other support design will be needed to prevent damage to the cable given the 15-20 foot change in elevation.

Washington Bridges (I-195 Eastbound)

Maguire has evaluated the structural reports for the I-195 eastbound span over the Seekonk River and, as was the case for the westbound lane, noted it is rated below the statutory loads and cannot accommodate any additional loads. Additionally, there is no active RIDOT project to rehabilitate this span.

Even if the structural loading of the eastbound spans were not an issue, attaching the cables and conduit to the bridge may require lane closures of I-195 depending on which of the bridge bays are determined to be most suitable to accommodate the cables and conduits. In addition to the lane closures, there would be issues getting the cables and conduits off the east end of the bridge, just like with the westbound side.

Washington Pedestrian Bridge (Seekonk River, Water Street, and Waterfront Drive)

The Washington Pedestrian Bridge consists of three different spans; over the Seekonk River, Water Street, and Waterfront Drive.

The western section of the Washington Pedestrian Bridge goes over the Seekonk River, and is an old concrete arch bridge. This section was once open to both vehicular and pedestrian traffic, but now it is only open to pedestrian traffic.



Figure 8 – Two Bridge Designs of the Washington Pedestrian Bridge

As shown in Figure 9 below, the bridge currently carries distribution or street lighting circuits, in addition to storm water drain piping. There appears to be sufficient space available to install the new conduits necessary for the E183 circuit, should the structural analysis confirm the ability of the bridge to handle the additional weight.



Figure 9 – Distribution or Street Lighting Circuits and Storm Water Drains Attached to Arch Portion of Bridge

The eastern section of the Washington Pedestrian Bridge includes the Water Street and Waterfront Drive Bridges. These are both newer steel stringer bridges with a concrete deck. However, these bridges include both vehicular and pedestrian traffic since they support an exit ramp off I-195 East.



Figure 10 – Distribution or Street Lighting Circuits and Storm Water Drains Attached to the Water Street and Waterfront Drive Bridges

Figure 10 shows that the Water Street and Waterfront Drive Bridges also carry distribution or street lighting circuits, in addition to storm water drain piping. However, investigation by Maguire has determined that these bridges would require structural modifications at the abutment back walls as well as modifications or full replacement of the steel end and intermediate diaphragms in order to install the conduits for the E183 circuit. These modifications would require RIDOT approval and possibly lane closures of the exit ramp off I-195 East. It may also require the relocation of the existing distribution and/or street lighting circuits.



Figure 11 – Area between Bridges Requiring Open Cut Trenching

As shown in Figure 11 above, installing the conduits in the pavement between the Water Street and Waterfront Drive Bridges would require open-cut trenching in the roadway. This would require RIDOT approval for the closure of this bridge for pedestrian and bicycle access.



Figure 12 – Westside On-Ramp to the Washington Pedestrian Bridge

Figure 12 shows the gradual slope leading to the Washington Pedestrian Bridge from the west side. A similar slope is provided on the east side when exiting the Washington Pedestrian Bridge. The gentle slope and open area on both ends of the Washington Pedestrian Bridge is amenable to the installation of the cables and conduits. However, the installation of the conduits in these ramps will require RIDOT approval for the closure of the bridge for an extended period of time to allow the open-cut trenching of the pavement.

Conclusion on Attaching to the Bridges Over the Seekonk River

Maguire and PDC have determined that the eastbound and westbound spans of I-195 are not suitable for the installation of the cables and conduits necessary for the E183 circuit due to the structural and cable-related issues discussed.

The Washington Pedestrian Bridge is the best option for routing the cables and conduits across the Seekonk River. The majority of the bridge is only open to pedestrian traffic and the approaches on both sides are gradual. However, structural modifications will be necessary to the Water Street and Waterfront Drive Bridges, which are also used by vehicles getting off I-195 East. This will require closure of the exit while the structural modifications are being made, as well as close off the pedestrian bridge to allow for the open-cut trenching of the on and off ramps and the paved areas between the bridge spans.



Date: June 24, 2017

Peter L. Tirinzoni, PE
Power Delivery Consultants, Inc.
12 Plains Rd, Suite 308
Essex, CT 06426

Re: National Grid – E 183 Transmission Line Relocation

Dear Mr. Tirinzoni,

CDR Maguire has investigated the possibility of using the existing bridges over the Providence River and/or the Seekonk River to carry transmission cables as part of the E-183 transmission line relocation project. CDR Maguire's scope involved investigation of the attachment of the transmission line ducts to the structures, limited to the structural capacity and geometric constraints of each of the bridges. The feasibility of connecting the cables and ducts on and off the bridges was not investigated.

The Providence River Crossing is comprised of a series of bridges, including the Providence River West span and Main Arch Span, followed by the Bridge Street, South Water Street and South Main Street bridges. The Seekonk River Crossings are comprised of the Washington Bridges (Route I-195 East and Westbound), the Washington Pedestrian Bridge and the Valley Street Bridge. For the purpose of discussion, each bridge is listed separately.

Below is a bulleted list of reasons, facts and discussion points addressed during the field visit and further analyzed for the purpose of this memo. Representatives from CDR Maguire, National Grid, PDC Cables, RIDOT, Robinson & Cole, the counsel for Providence, East Providence and the Attorney General's office were present at the field meeting on June 1st, 2017. Please refer to the Attendance sheet attached to this Memo for contact information.

PROVIDENCE RIVER CROSSINGS

The Providence River Bridge is comprised of two separate structures. The west most structure is referred to as the West Span and the middle portion is the main Arch Span. These structures carry east and west bound sections of Route I-195.

**CDR** | MAGUIRE**The Providence River West Spans – Overall Suitability: YES**

The West Spans are comprised of a two-span five “tub” steel girder system bridge, each span approximately 250 feet long:

- Steel Tub girders may accommodate utilities if placed in between two girders, however, utility supports will need to be installed along the span. Currently there are no intermediate diaphragms, but there are steel end diaphragms at the pier and abutments. These diaphragms include a small opening at the abutments but no openings at the pier. The openings at the abutment purpose is to allow an inspector to be able to look through and check the beam ends and bearings. In essence, the end diaphragms would need to be modified to allow openings for the conduits to go through. In order to modify these end diaphragms, construction operations would require closures of I-195 traffic as the bridge should not be carrying live loads during the retrofit. The abutments back walls will need to be modified as currently there are no sleeves cast in the concrete. That would entail retrofitting the abutment as rebar would need to be cut to allow room for the conduits. The retrofit would require traffic closures, pavement removal, approach slab removal, and excavation behind the abutment which would require driving of sheet piling for support of excavation during construction, this operation would require longer traffic closures of the highway. In essence, this may be a possible alternative, but it will be expensive and it will require RIDOT approval of closures of I-195.
- It was noted that the outermost exterior bay of the span supports a storm water pipe and therefore additional utilities cannot be added and the decorative pylons in between the East and West bound bridges would not allow any utility support to be added.

The Arch Span – Overall Suitability: NO

The arch span is a 167 feet wide steel cable arch bridge that spans approximately 400 feet.

- As a continuation from the West Span, the conduits would need to be somewhere in the inside of the bridge. However, the geometry of the arch bridge does not allow for additional utilities.
- The bridge is comprised of floor beams, which cannot have any opening for conduits. This would adversely impact the structural integrity of the beams.
- The concrete pier caps cannot be cut to fit cable sittings as it is heavily reinforced with rebar and stirrups.
- Hanging the cables under the pier caps and beams is not possible since it would reduce significantly the vertical clearance.



Bridge Street, South Main and South Water Street Bridges – Overall Suitability: NO

These structures are comprised of pre-stressed adjacent butted box beams.

- The geometry of the bridges does not allow utilities as the butted box beams are set adjacent to each other, without any spaces in between. In addition, utilities cannot suspend from the beams bottoms since supports cannot be drilled into the beams due to the locations of the pre-stressing strands located in the inside of the beams.
- Attaching cables to the exterior sides of the bridge is not possible due to existing bump outs for light standards and aesthetic issues.

SEEKONK RIVER CROSSINGS

Washington Bridge (I-195 Westbound) - Overall Suitability: Possible

- The West bound section of the bridge is currently being rehabilitated; the existing concrete arch was structurally rated below statutory loads and therefore could not accommodate any additional loads. After the rehabilitation, further structural analysis will be required to evaluate the bridge feasibility to carry additional utilities.

Washington Bridge (I-195 Eastbound) - Overall Suitability: NO

- The East bound section of the bridge is comprised of steel girders and is structurally rated below statutory loads and therefore could not accommodate any additional loads.

Washington Pedestrian Bridge

(Seekonk River, Water Street and Waterfront Drive) –Overall Suitability: Possible

The bridge spans consist of portions of the old concrete arch bridge retrofit to carry only pedestrian traffic. The pedestrian bridge may be a suitable candidate for additional utility supports.

- The bridge currently carries a series of conduits and what appears to be a 12-inch pipe. These utilities may need to be relocated to accommodate the new conduits.
- It appears the new conduits could span in between the spandrel supports, depending upon further structural analysis.


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Valley Street Bridge (No. 462) - Overall Suitability: Possible

The bridge is a simple span, 10-steel stringer system with a composite concrete deck. Seven out of the ten stringers are set below the ramp portion of the bridge, while the remaining three stringers are set beneath the Linear Park. The fact that the bridge shares both vehicular and pedestrian traffic imposes difficulties in any modifications to the structure as traffic may need to be interrupted and would require RIDOT's approval.


- The bridge would require structural modifications at the abutment back walls as well as modifications or full replacement of the steel end and intermediate diaphragms.
- The stringers underneath the ramp demonstrate an excess structural capacity based on the Rating Report dated May 29th, 2013. However, the stringers underneath the pedestrian linear park would need to be evaluated as they were not rated in the named report.
- Duct installation between the Linear Park Pedestrian Bridge and the Valley Street Bridge would require open cuts on the roadway, therefore the bridge will need to be closed for pedestrian and bicycle access. The bridge closure will require RIDOT's approval.

In summary, the Providence River Crossing Bridges are not candidates for retrofit to accommodate the cables and fittings due to each separate bridge geometry and construction constraints as mentioned above. The Seekonk River Crossing Bridges, particularly the Washington Pedestrian Bridge, presents a possibility, however, it is noted that any retrofit will be costly, it will require closures of pedestrian traffic, bicycle access and perhaps intermittent closures of the interstate I-195, contingent upon RIDOT's approval.

Please let us know if you have any questions.

Very truly yours,

CDR MAGUIRE INC.



Alessandra Keller, PE

cc: Yihui Wu, Joseph Cardello, Ed Parker