Sarah Mildred Long Bridge Benefit Cost Analysis

Constructed in 1940, the Sarah Mildred Long Bridge (SML) is located over the Piscataqua River and connects Kittery, Maine and Portsmouth, New Hampshire via U.S. Route 1 Bypass. The bridge services highway, rail and marine traffic and consists of a 22-span girder structure (15 spans on the NH approach and 7 spans on the ME approach) measuring 2,804 feet. SML has one combined highway and rail vertical lift structure and one retractable span for the lower rail level that is not in the main ship channel but in shallower water close to the Kittery shore. SML has been closed several times over the past 9 years closed for several weeks at a time in order to allow for emergency repairs. The bridge has been posted at 20 tons since July 10, 2009. Bridge inspections are conducted at six-month intervals due its condition and show the bridge and its approaches are in Poor Condition. It is classified as Structurally Deficient by FHWA. The truss spans are Fracture Critical – meaning that failure of certain steel tension members could result in bridge failure. Even with increased maintenance, SML has reached the end of its effective service life.

SML is one of three crossings over the Piscataqua River between Portsmouth, New Hampshire and Kittery, Maine. The effective operation of these bridges provides a multimodal transportation system that impacts trade and commerce, tourism, community life and the historic and aesthetic character of Kittery and Portsmouth. Without improvements, SML would need to permanently close within a few years.

To accommodate various sizes of passing cargo ships and recreational watercraft, and to minimize vehicular traffic disruption, the bridge has one combined highway-rail lift span and one retractable railroad span. The lift span raises both the railroad and the highway; it is used to accommodate passing watercraft. The retractable railroad span is located in shallow water outside the navigation channel. It is left normally open to allow passage of smaller watercraft, and does not interfere with, nor disrupt vehicular traffic. The bridge provides the only freight rail connection to the Portsmouth Naval Shipyard (PNS), in Kittery, Maine. PNS overhauls, repairs, and modernizes the LOS ANGELES Class and the new VIRGINIA Class nuclear submarines for the US Navy. As a result, the vital railroad link to PNS would be lost, threatening its future existence. PNS must have a rail connection to the national railroad system in order to transport spent nuclear fuel from its servicing of the U.S. Navy submarine fleet.

An innovative hybrid bridge replacement featuring an integrated rail-highway deck and elimination of the retractable railroad span is proposed. The lift span will be raised for tall ships and will lower to accommodate rail movements. The bridge will provide a much wider opening with fenders and will be at a higher elevation to better accommodate navigational needs, reduce vehicular and navigational delay costs and will allow for the addition of bicycle access.

A benefit-cost analysis was conducted on replacing the SML. The analysis looks at the project from the standpoint of society as a whole, and accounts for the net benefits and net costs based on the criteria described in the TIGER 2014 Grant NOFA. The analysis presented here addresses benefits from travel time savings, user costs, safety, and air quality. Several other benefits of the SML replacement are difficult to quantify. These benefits include increased economic competitiveness, livability enhancement, productivity increases, and national security.

Base Case Assumption

The benefit-cost analysis (BCA) focuses on full replacement of SML, and compares the replacement to the "no-build" scenario. The no-build base case assumes the existing bridge would be closed permanently to both vehicle and rail traffic. The BCA also uses information from sources which are referenced and can be found in the Appendices. The chosen alternative is a hybrid two-lane option and would be located on an alignment upstream from the current bridge. A rehabilitation option and a standard two-lane replacement bridge were also evaluated. The rehabilitation alternative was found to not be a viable alternative because (1) it would not eliminate the safety hazard and major impediment to river shipping and navigation, (2) the bridge would continue to cause traffic delays, and (3) the State of New Hampshire, a partner with Maine in the ownership of the bridge, enacted legislation that in Section 193:9 requires "the center lift span being of sufficient length to allow safe passage of the upcoming generation of cargo vessels to ensure the economic well-being of the Port of Portsmouth and the businesses utilizing this important shipping lane."

Project Benefits

Travel Costs

If SML were closed and taken out of service, travelers would be forced to use alternate crossings resulting in significant detour routes. The total increase in vehicle-miles-traveled would be around 7.3 million miles annually.

The highway user costs of the No-Build scenario, which assumes loss of SML include four major components: 1) the additional vehicle-miles traveled (VMT) for SML users due to the need to use other bridges, 2) the additional vehicle-hours traveled (VHT) for SML users due to the need to use other bridges, 3) the additional VHT of delay for I-95 users due to the addition of SML users to the I-95 traffic stream, and 4) the additional crashes due to the added travel distance required for SML users. The highway user benefits of the Project derive from the avoidance of these costs associated with the No-Build scenario.

The estimates of the user cost impacts of redirecting SML traffic to other bridges is based on the volume changes obtained from the travel demand model from the Maine – New Hampshire Connections Study (Study). A travel demand model developed for the study was used to estimate bridge volumes on the Memorial, SML, and I-95 High Level bridges over the Piscataqua River between Kittery, Maine and Portsmouth, New Hampshire for a variety of bridge scenarios, including one that involved the loss of the SML. SML users were redirected to the other two bridges in the study area. Estimates of the additional VMT and VHT were calculated on the basis of the modified travel paths SML users would use to cross the river. These VMT and VHT increases were estimated for 2009, the base year of the Study, and 2035, the horizon year of the Study. The VMT and VHT increases for intermediate years were estimated by straight-line interpolation between 2009 and 2035. The Study estimated SML traffic volumes would increase by 20% between 2009 and 2035. No forecasts of traffic volumes were available beyond 2035, so volumes beyond 2035 were kept at 2035 levels for this analysis of highway user costs.

The estimates of the I-95 delay were based on Study forecasts, bridge volumes and use of traffic volume data from MaineDOT's permanent traffic counting station on the Maine approach of the

I-95 High Level Bridge. Traffic volumes on the I-95 High Level Bridge are much higher during the summer tourist season. Daily volumes on the bridge may be twice as high in the summer as they are in the winter. On some summer days, the hourly volumes in one direction may approach the 3-lane capacity in that direction, depending on the day and the peak direction of traffic. Based on the Study, 2035 volumes are expected to be 27% higher than 2009 volumes, meaning that the I-95 High Level Bridge will be increasingly vulnerable to traffic congestion, when travel demand approaches or exceeds the hourly capacity of the bridge. If SML is closed to traffic, most of the SML traffic and all large commercial vehicles would be expected to shift to the I-95 High Level Bridge. This shift in traffic would increase the level of seasonal congestion on I-95. To estimate the impact of redirected SML traffic on I-95 congestion, a MaineDOT queuing analysis tool was utilized to establish baseline congestion conditions and estimate congestion levels with the addition of SML traffic to the I-95 volumes. The tool uses a 24-hour distribution of volume and the hourly capacity of the I-95 High Level Bridge to identify hours when traffic demand exceeds traffic capacity and to estimate the VHT of delay that results. When the 24-hour distribution of SML traffic was overlaid on the 365-day, 24-hour distribution of I-95 traffic to estimate congestion, comparisons to the congestion without the addition of SML traffic could be made. The differences in VHT of delay between the No-Build and the SML replacement scenarios provide the measure of the seasonal congestion impact on I-95. This comparison was made for years 2009, 2035, and 2022. Because the growth of seasonal congestion is expected to be non-linear, the intermediate year 2022 was also evaluated to improve the interpolation of results between 2009 and 2035. As stated previously, no traffic forecasts are available beyond 2035, so 2035 values were used for the years beyond the Study horizon.

The increases in travel distances and travel times that are avoided by replacing the bridge, rather than allowing the crossing to be lost, represent the benefits of a replacement bridge. For this analysis the per-vehicle mile detour cost has been weighted due to the volume of heavy trucks (13%). The adjusted cost per vehicle mile is $0.39.

Vehicle Operating Costs

An increase in vehicle operating costs would result from the additional VMT created by closing the bridge. For this analysis the per vehicle hour detour cost has also been weighted due to the volume of heavy trucks. The adjusted cost per vehicle hour is $15.51. These operating costs are avoided by bridge replacement.

Safety

If SML were to be permanently closed, the additional travel would increase crashes on alternate routes in the transportation network. The increased crash costs are estimated by a multiplier of $0.072 per VMT which has been developed from historic Maine crash history. The estimates of additional crashes under the No-Build scenario were based on the increased VMT due to the loss of the SML. Assuming an expected two crashes per million VMT and a cost per crash of $36,000, from Maine statewide averages, MaineDOT estimated the added number of crashes and the increases in crash costs for 2009, 2035, and each of the intermediate years. Beyond 2035, crashes and crash costs were estimated at the 2035 level.

State of Good Repair

SML was built in 1940. It is a double-deck truss bridge with a combined highway-rail vertical lift span and a railroad retractable span. Annualized maintenance costs are estimated at $587,127. This number was derived from actual costs incurred from 2003 to 2012. If SML were to be closed these costs would be avoided. In this BCA the annualized costs are added to user benefits since they are avoided costs to society if a new bridge is constructed.

Sustainability

The avoided air emissions are based on avoided VMT and VHT beginning in 2015 from closure of the bridge and the loss of this crossing location. The emission savings have been calculated for nitrogen oxides, volatile organics, and carbon dioxide. The calculations are based on factors that were applied to the avoided VMT resulting from closure of the bridge. Data is not available for sulfur dioxide or particulate emissions. Based on the annual VMT and VHT it is estimated that over 4,100 metric tons of CO2, 4 metric tons of VOCs, and 4 metric tons of NOX are avoided. The cost of carbon in CO2 emissions however has been calculated separately in the BCA spreadsheet using the social cost of carbon (SCC) assumptions found in "Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866" (Report). The SCC increases over time because future emissions are expected to produce larger incremental damages as physical and economic systems become more stressed in response to greater climatic change. In conformance with this viewpoint, this analysis escalates the CO2 portion of the air emissions cost increases estimated on Table 5: "Changes in the Average Annual Growth Rates of SCC Estimates between 2010 and 2050" in the Report. The interpolated values for SCC and the CPI can be found in the SCC and CPI spreadsheet. The total net present value of air emissions is $ 7.6 million discounted at 3%.

Non-Quantified Benefits

Freight Shipment

The rail line crossing the bridge is the only rail link for the Portsmouth Naval Shipyard (PNS). Without rail access, rail freight would not be possible for the PNS. Rail access is a necessity to PNS, as this is the only viable transportation mode available for its shipment of spent nuclear fuel from its servicing of the U.S. naval submarine fleet. The increased costs due to the lack of rail access are difficult to quantify. This BCA does not quantify these costs, though it is likely that they would be significant. Without rail access, the future of the shipyard could be at risk, along with its 3,500-person workforce, most of which are blue-collar workers. The loss of PNS would be a devastating blow to the regional economy.

Impediments to Navigational

As mentioned previously, SML includes a lift span that must be raised for large ocean-going vessels entering the Port of Portsmouth. There are five port terminals located upriver from SML. The navigational width of the SML limits ships to a 106-foot beam width, seriously limiting the size of ships that can pass under the bridge. In fact, the SML has the narrowest width of all major northern New England ports. The bridge is also skewed with respect to the navigable channel. The bridge skew requires vessels to maneuver into alignment with the bridge piers to proceed through and under the bridge. The narrow bridge opening also means that two lead tugboats that assist large vessels must disconnect their tow lines prior to the bridge, then reconnect after going

through the opening. The navigational risk is also complicated by the fact that the Piscataqua River at this location has one of the fastest flowing tidal currents (5 knots) of all commercial harbors in the lower 48 States. As a result, large ships are currently restricted to slack tides when crossing SML.

The replacement bridge will largely eliminate the bridge skew and increase the opening width, making a more direct navigation for these vessels and allowing safe passage of the upcoming generation of cargo vessels to ensure the economic well-being of the Port of Portsmouth and the businesses utilizing this important shipping lane. The reduction in bridge skew and larger bridge opening will result in fewer vessel delays, as well. The replacement bridge will also be higher in elevation, resulting in 64% fewer lifts. These enhancements to navigation will reduce navigational delays, leading to cost reductions and greater efficiencies. Potential impacts include reduced operating costs, larger loads for existing vessels, switching to larger vessels, reduced transportation costs, reduced accident rates, reduced cargo handling costs, and reduced tugboat assistance.

The importance of the navigational access to the Ports of Portsmouth and Newington through the SML has been emphasized in an economic impact report by Magnusson, Colgan, & Gittell. As stated in the report, up to $1.4 billion in commerce could be at risk at the upriver locations if the maritime industry cannot be serviced because of SML. It is difficult to quantify the benefits that would accrue in the future from a widened bridge; that would depend on the size of the vessels using the port. The global trend however has been towards larger, wider ships. This trend will continue to place the port at a competitive disadvantage if SML is not replaced with a wider opening. This BCA does not quantify the productivity increases or reduced costs from the navigational efficiencies accruing from a replacement of SML; however these non-quantified benefits could be significant.

Project Costs

Total Construction Costs

The benefit-cost analysis uses the estimated replacement construction cost of $172 million (includes preliminary engineering, right-of-way acquisition, construction and construction engineering), over a period of two years. Maintenance costs would include periodic wearing surface treatment; however these costs would be of small magnitude. The deck will be integral with the structure so a deck replacement will not be necessary. Maintenance and operational costs for the replacement structure are considered negligible for this analysis.

Conclusion

The annual benefits and costs values were discounted at 3% and 7% over a 50-year time horizon. Three percent is the most appropriate rate for the analysis because the bridge is being designed for a 100-year life, and in addition, the alternate use of funds would be a public expenditure as opposed to a private investment. The full analysis can be found in the spreadsheet attachment to this application. A summary of the present value of the benefits and costs follows.

- Total Benefits of $ 403.4 million
- Avoided Air Quality Impacts valued at $ 7.6 million

- Reduced User Costs estimated at $ 377.8 million
- Avoided Crash Costs of $ 15.0 million
- Avoided Maintenance Costs of $ 15.1 million
- Total Costs of $ 163.5 million
- Benefit-Cost ratio of 2.5

When discounted at 7%, the benefits and costs are lower. A larger discount rate implies that time preference for future amounts are preferentially discounted more severely. The amounts are show below.

- Total Benefits of $ 184.1 million
- Avoided Air Quality Impacts valued at $ 3.7 million
- Reduced User Costs estimated at $ 177.2 million
- Avoided Crash Costs of $ 7.9 million
- Avoided Maintenance Costs of $ 8.1 million
- Total Costs of $ 153.4 million
- Benefit-Cost ratio of 1.2

Based on a 3% discount rate, it is estimated that travel cost savings alone due to avoided VMT and VHT amount to $377,821,480 over a 50-year period. On an annual basis, these costs savings represent almost 90% of the total annual benefits.