Appendix 8

Keeping Our Bridges Safe Report (2014)

Keeping Our Bridges Safe
2014 Report

MaineDOT

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Executive Summary

On November 26, 2007 the Maine Department of Transportation presented a report on the safety of Maine's bridges, *Keeping Our Bridges Safe (KOBS)*. The 2007 Report was written to meet an Executive Order issued after the August 1, 2007 bridge collapse in Minneapolis, Minnesota. A number of recommendations were made and additional funding was provided by the Maine Legislature to accomplish many of the action items in the report.

In early 2014, MaineDOT Commissioner David Bernhardt directed the Chief Engineer to reconvene a team of bridge experts to examine the department's progress on keeping Maine bridges safe. The team included MaineDOT bridge engineers, consultants, academics and construction engineers. Specifically, the Commissioner instructed the team to:

- Report on the department's progress on the 2007 report recommendations;
- Define the current status of bridges in Maine;
- Establish strategies to improve overall bridge conditions and safety;
- Find opportunities to impact costs; and
- Identify funding needs.

Maine bridges continue to be safe. The 2007 recommendations have been or are nearly completed. The department has made strides in load rating its bridges and addressing scour issues. This has led to bridge strengthening and scour countermeasure construction. At the same time, there is an active bridge posting team making posting and closing recommendations. Several bridges are currently posted with more to come.

The 2007 KOBS report resulted in a legislatively authorized four-year increase in funding provided through the TransCap Trust Fund. Public Law 2007, chapter 647, An Act To Keep Bridges Safe and Roads Passable, authorized up to $160 million in TransCap bonds to be issued over a four-year period. This increased MaineDOT's bridge funding from approximately $70 million per year to $110 million per year for four years, ending in 2013. Currently MaineDOT is funding bridges at roughly $70 million per year, which is half of what is necessary to maintain and extend bridge life as needed.

The 2007 KOBS report summarized two strategies to protect public safety over the long-term:
1) repair or replace poor bridges and 2) preserve fair bridges before they become poor. This report takes those two strategies and goes further with the concept of lengthening bridge life by prioritizing preservation work. Consistent and reliable funding is necessary. The ability to plan and budget accordingly for bridge preservation and replacement activities is essential to protecting the taxpayers' assets.

This report calls for MaineDOT to increase the life of new bridges through use of materials, design advancements and construction techniques. The replacement or major rehabilitation of extraordinary bridges needs to be planned to avoid financial and work impacts to the entire bridge network. Bridge funding needs to address both the need to rehabilitate or replace poor bridges and to proactively pursue preservation as a strategy to achieve long-term savings. A funding level of $140 million a year will allow us to maintain a safe bridge network and extend bridge life as needed.

The requested funding level will eliminate at least 90% of bridges in Poor condition or Structurally Deficient on Highway Corridor Priority's 1-3; as well as many Corridor Priority 4-6 bridges.

Maine's Response to Minnesota's Tragedy: *Keeping Our Bridges Safe*, The 2007 Report

The 2007 KOBS report included numerous action items and recommendations to strengthen the "safety net" for Maine bridges. The vast majority of these are complete, while some are ongoing. The entire list of recommendations and action items are listed in Appendix A with the corresponding level of completion.

A major task identified was to improve bridge inventory management, allowing MaineDOT to plan and prioritize work more appropriately. An ancillary structures management plan was developed so these structures are now cataloged and inspected on a regular basis. Given the advancing age of our bridge inventory, one of the needs outlined in the 2007 KOBS report was to obtain as much life from our bridges as practical and to take calculated risks when determining the health of a bridge. This strategy heavily depends on risk-based inspections and engineering judgment. The characteristics of a bridge that would deem it high risk were determined to be scour potential and the presence of fracture-critical members. The Minneapolis bridge collapse that led to the 2007 report involved a fracture critical bridge. Bridge load rating postings were also identified as an underutilized safety-enhancing measure.

Scour

The vast majority of the nation's bridge failures are due to scour. Scour is the physical change to the streambed from flow that undermines a bridge foundation, resulting in a partially supported or unsupported structure. As part of the 2007 KOBS report, all bridges in Maine were evaluated to determine if they were scour critical, meaning at risk of failure due to scour. If deemed scour critical, a "Scour Plan of Action" was developed for that structure. Many of these bridges have received scour countermeasures and are no longer scour critical. MaineDOT and municipalities, who are responsible for monitoring the bridges during high water events, have been trained in accordance with the Plans of Action.

Fracture Critical Bridges

Fracture critical bridges are bridges with no redundancy so that if a single member within the bridge fails it could ultimately lead to a major collapse. Trusses and two-girder bridges are a few examples. The bridge carrying Interstate 35 in Minneapolis, Minnesota, which failed catastrophically in 2007 resulting in deaths and injuries, was a fracture critical bridge. This unfortunate collapse did result in MaineDOT and the rest of the nation improving how and when we inspect and evaluate these structure types. "Fracture Critical Inspection Plans" were developed to assist the inspector with hands-on inspection by identifying fracture critical members and fatigue-prone details. The inspection staff also attended fracture critical inspection training. The through trusses received fracture critical inspections where the thickness of the gusset plates was measured and load rated in accordance with the Manual for Bridge Evaluation. This family of bridges now has fracture critical inspections every 24 months, which require the inspector to be within an arm's reach of all fracture critical elements. In 2007, MaineDOT's bridge inventory included 44 fracture critical, steel through- truss bridges; 11 have been replaced and 10 are funded for construction.

Bridge Rating & Posting

New Bridge Rating and Bridge Posting Guides were developed and are being actively used. All of Maine's bridges have been or will be re-rated by 2019; to date we have completed load ratings on 52% of the bridges in Maine. The bridges with the most severe weight limits were the first to be tested and re-rated resulting in the timely elimination of weight restrictions where possible. Understanding what a bridge can safely carry is critical to public safety and mobility. At times, posting a re-rated bridge for less than legal loads may have minimal impacts, such as Emerson Bridge in Oakland which serves a local road with a short detour. Other times it could pose hardships, such as the Androscoggin River Bridge which connects the towns of Peru and Mexico. The detour for this bridge is several miles and unfortunately there is no practical strengthening option for this bridge with replacement the only prudent long term solution.

MaineDOT is more diligent than ever in its inspection and evaluation of Maine's inventory of bridges and structures. This has been, and will continue to be, the first step in keeping our bridges safe and providing initial guidance for maximizing the life and function of our assets. Knowing how to interpret numbers from a rating and how to apply them to a bridge posting is complex and requires MaineDOT's most knowledgeable and seasoned bridge engineers. Maintaining this expertise has been a priority of MaineDOT and we have taken steps to retain engineers by providing them with a clear, attainable career path. MaineDOT's Posting Committee meets weekly to review and discuss the results of the ongoing ratings. The Posting Committee is using engineering judgment to make risk-based decisions on keeping bridges open without posting for weight limits. However, we are posting more bridges than ever before. From 2006 to 2012, twenty-one bridges were posted. From 2013 to present, twenty-two bridges have been posted. Of the 254 bridges brought to the posting committee, 136 are pending load tests or refined analysis. The reality is that Maine bridges are aging and we are unable to take on more risk to keep certain bridges open without additional funding.

Today's Heavier Vehicles Test the Strength of Yesterday's Bridges

Maine has many older bridges that were not originally designed for today's heavier loads. For those not showing signs of structural distress, we utilize strategies that include strengthening and finding reserve capacity not normally accounted for in traditional designs to keep the bridges unposted. Research and testing performed by the University of Maine has assisted with this strategy.

To find reserve capacity, MaineDOT is utilizing advanced structural analysis techniques to evaluate potential conservatism in load rating calculations. A major revision to the load rating manual has been adopted. The revised manual is in its early stages and was calibrated conservatively to start. The new methodology has several optional factors that are being evaluated for their applicability to Maine bridges. Some of the new provisions underestimate the load capacity observed in the field: those older bridges that do not show signs of distress but have load ratings that indicate they need to be posted. Through advanced testing and improved analytical techniques, MaineDOT has verified this higher load capacity.

MaineDOT has currently advertised three strengthening projects that have increased the structure carrying capacity to handle legal loads. These strengthening projects have focused on steel bridge members. However, strengthening is a last resort as the cost benefit ratio is typically quite low. Every effort is made to find increased load capacity through advance analysis, testing and experienced engineering judgment. These techniques have avoided strengthening projects for large groups of bridges.

MaineDOT Partners with the University of Maine to Test Our Infrastructure

MaineDOT is partnering with the University of Maine to perform load tests and determine the actual performance of existing bridges. In addition to developing new bridge technologies (e.g. Bridge-in-a-Backpack®) and novel methods of strengthening existing bridges, UMaine has performed field live load testing of existing structures to more accurately assess their capacity. In the past three years, UMaine has tested and analyzed a total of 15 bridges for MaineDOT, including multiple-span truss bridges over large rivers, concrete structures, and steel stringer bridges. While data analysis and result interpretation are still ongoing for some of these structures, five of the 15 tested bridges (which were at risk for posting or closure) have been allowed to remain open with minimal or no rehabilitation based on the results of these live load tests and subsequent analyses. It is expected that several more of these 15 bridges will also be deemed structurally sufficient once all analyses are completed in early 2015.

Other recent UMaine research, supporting MaineDOT's bridge program, is the development of the SlabRate finite-element software for the load rating of flat concrete slab bridges. UMaine research published in 2013, in which fourteen existing slab bridges in Maine were load-rated using conventional methods and SlabRate, showed that seven of the slab bridges which were at risk for posting or closure are structurally sufficient. Based on these analyses, MaineDOT has kept these seven bridges open to traffic with no posting restrictions. Further, SlabRate is being used by MaineDOT, and consulting engineers retained by MaineDOT, to load rate additional slab bridges and establish more realistic and generally less conservative capacity estimates.

The Current State of Maine Bridges

This report is the first update of the 2007 report, *Keeping Our Bridges Safe (KOBS)*. It will compare 2007 data to current (2014) data, and illustrate current trends regarding the state of our bridges. There are 2,515 bridges (span defined as longer than 20 feet) and 1,374 minor spans (10-to-20 feet) in the state of Maine. In this report, "bridges" generally refers to both categories. The state of Maine owns and manages 70% (2,744) of these bridges. This report will focus on those bridges that are under MaineDOT jurisdiction. Note that this number has increased from 2,722 in 2007 to 2,744 today. This increase is mostly due to highway culverts that have been replaced with larger structures that now meet the criteria of minor spans. Please note that a few numbers from the charts published in 2007 have been updated.

Maine's Bridges are Aging

The 2007 KOBS report used age, condition, and structural deficiency to describe the state of bridges. The Charts separate traditional bridges from steel bridge culverts, since traditional bridges on average have a service life of 70 years, compared to metal culverts which generally last about 50 years. Chart 1 indicates that the number of traditional bridges that are older than the average service life increased 4.3 percent over the past seven years, from 675 to 776 today. Similarly, Chart 2 shows that the number of steel bridge culverts that are older than the average steel bridge culvert service life has increased 6.8 percent over the past seven years, from 124 to 150 today. Although the age of bridges may not be a precise indicator of need, it shows that, overall, Maine's bridges are getting older.

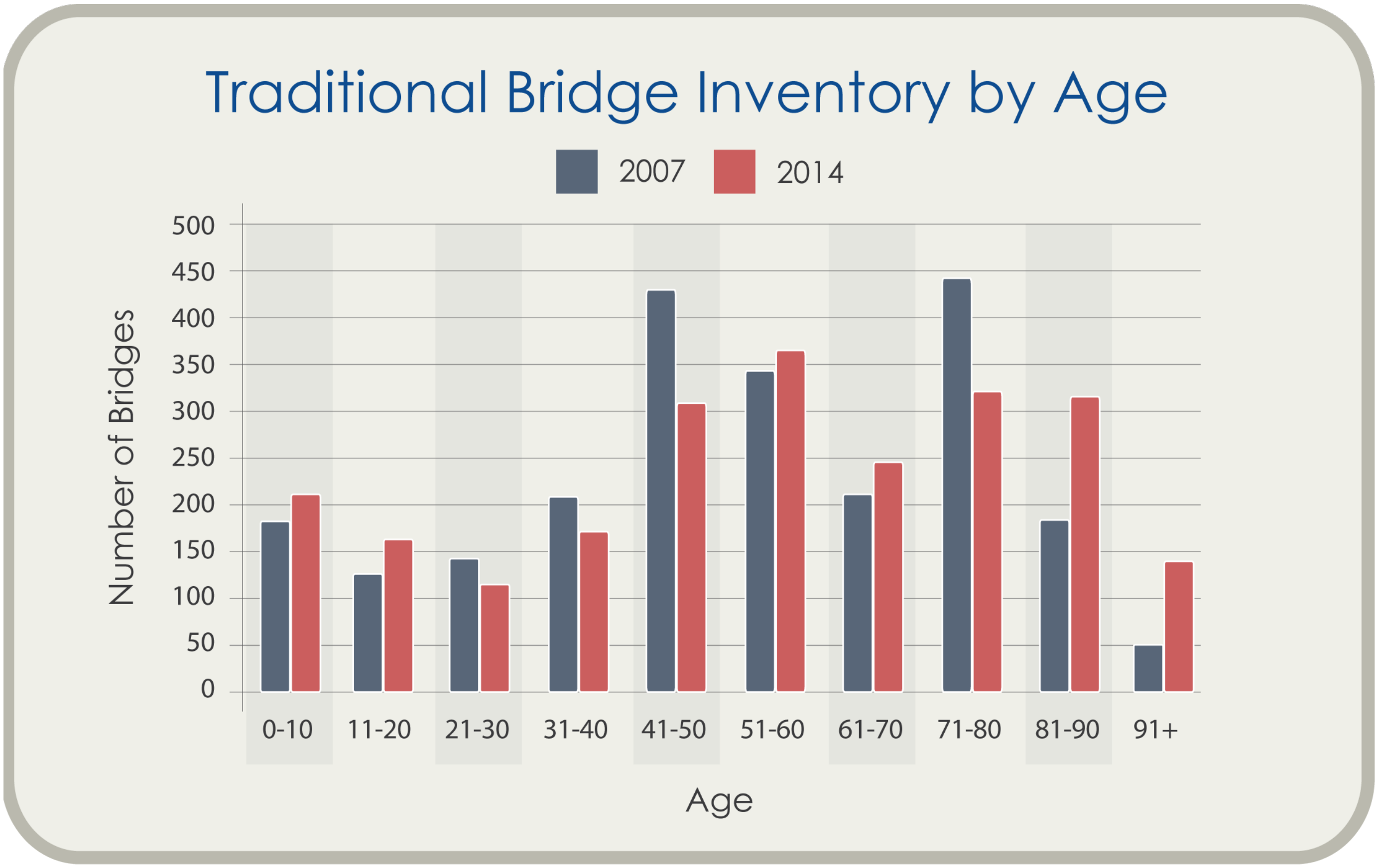


Chart 1

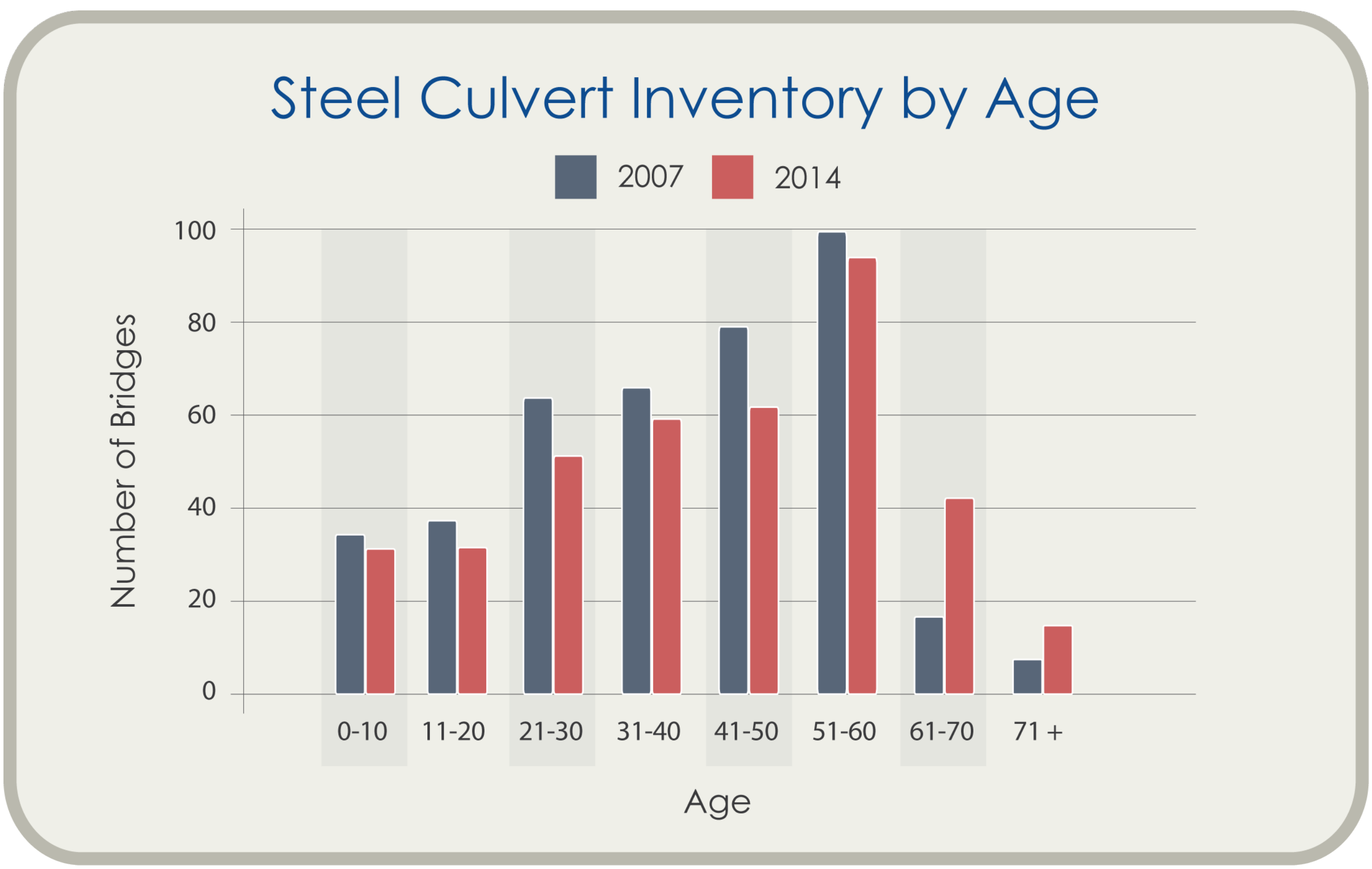


Chart 2

More must be done to slow the rate of bridges dropping from fair to poor condition.

In 2007, the KOBS report categorized the condition of the state-owned bridges as good, fair or poor. Over the past seven years, the number of bridges in good condition has increased by 2%, the number of bridges in fair condition has decreased by 4%, and the number of bridges in poor condition has increased by 2%. Charts 3 and 4 show the difference from 2007 to 2014. Although we gained, some through change in ownership, 57 bridges in good condition (22 bridges were new to the MaineDOT system), this gain was mostly offset by 45 additional bridges in poor condition. This is an indication that, despite efforts to ramp up replacements of bridges in poor condition, more must be done to slow the rate of bridges dropping from fair to poor condition. Preservation investments will slow the rate at which bridges fall from good to poor condition.

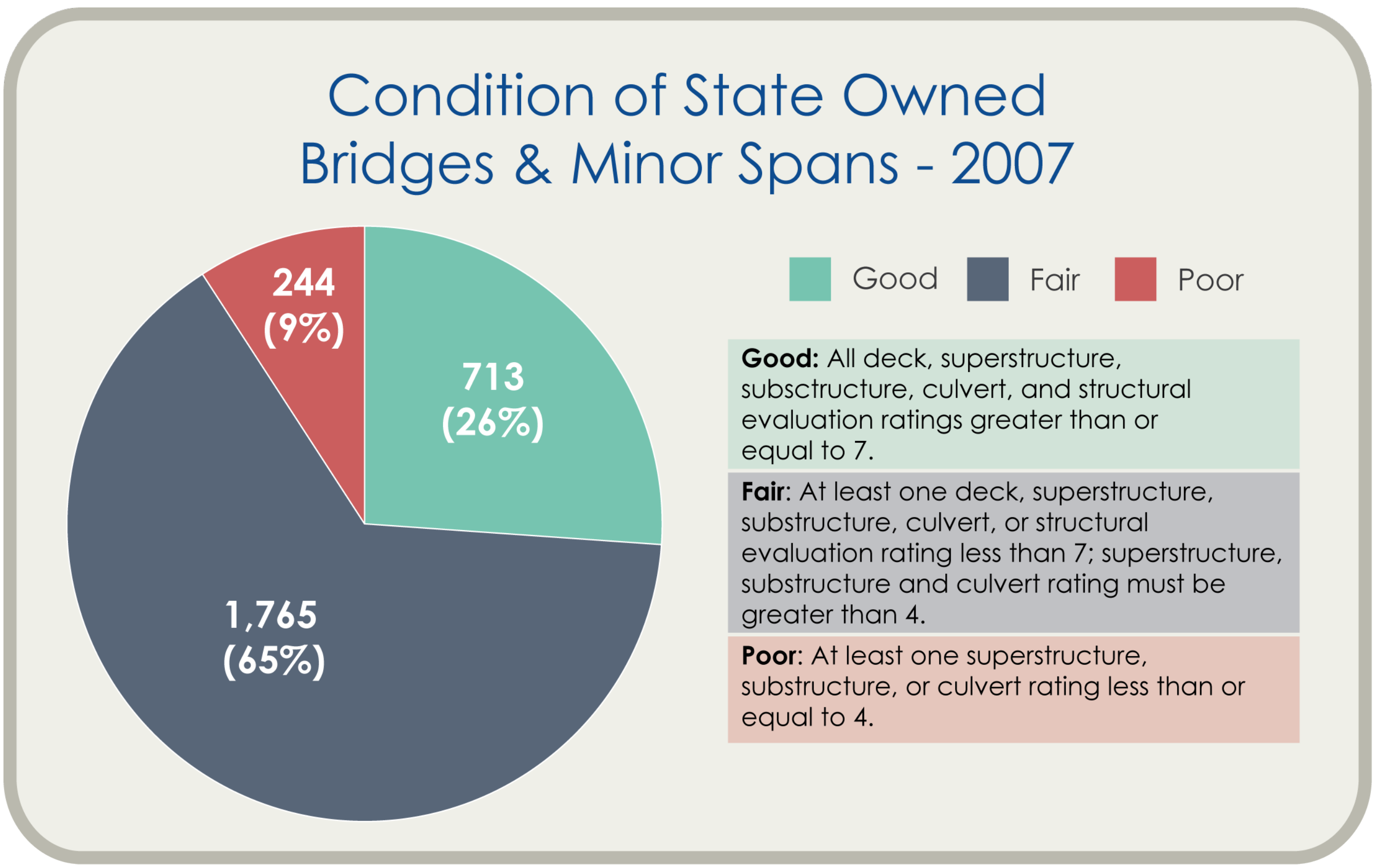


Chart 3

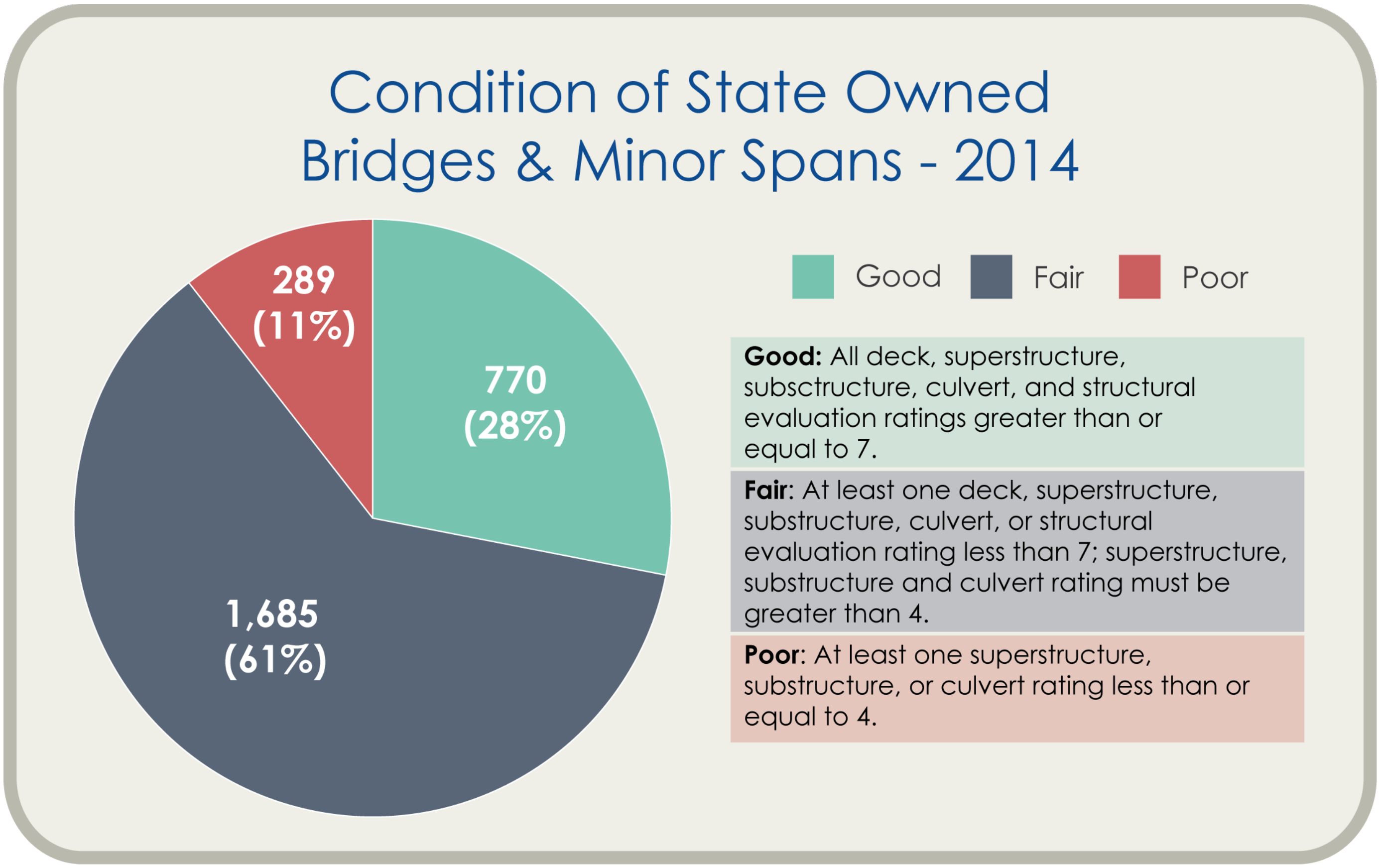


Chart 4

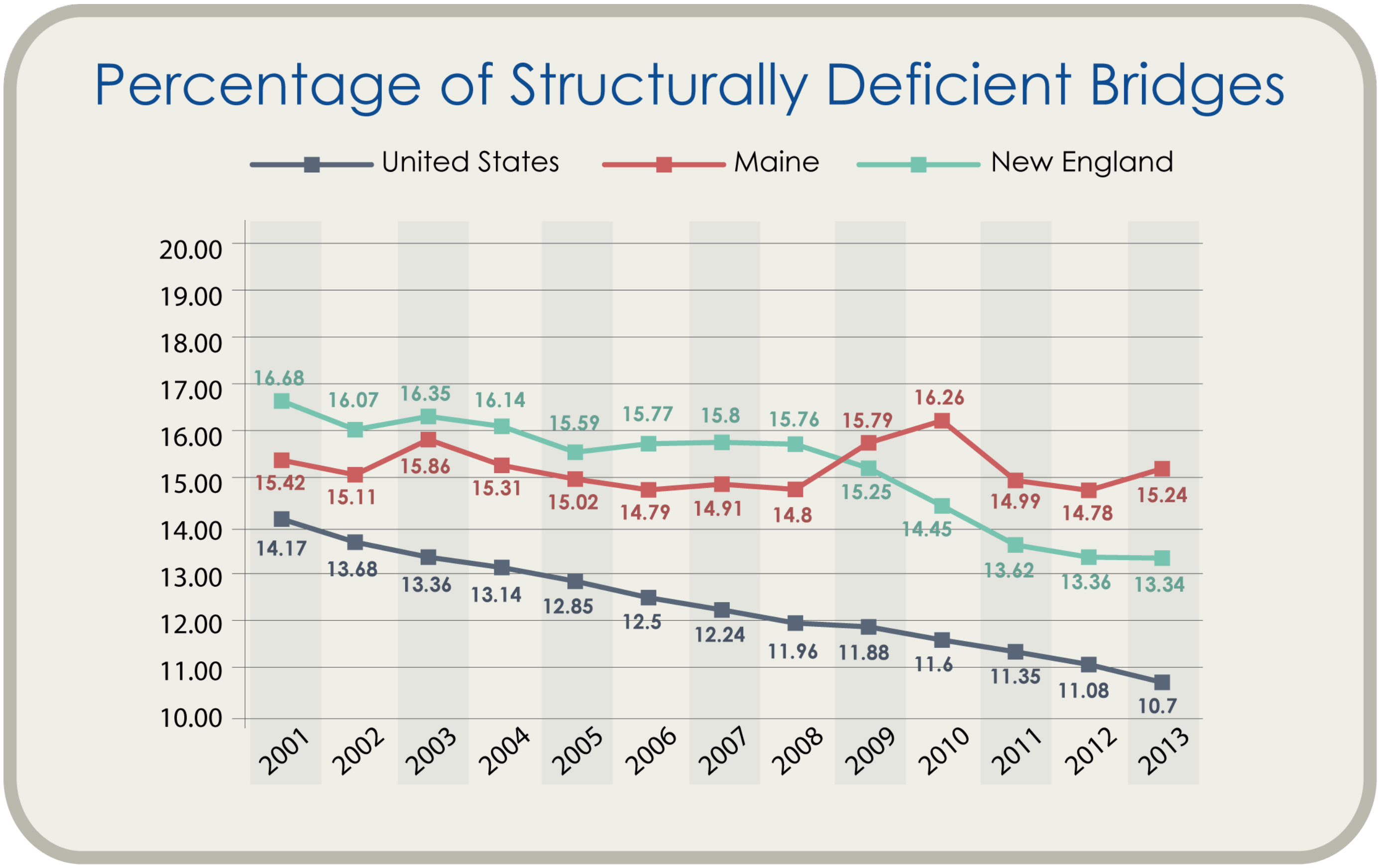
Maine's Structurally Deficient Bridges are on the Rise While National Numbers Decline.

Nationally, news media commonly report on the condition of bridges in terms of being Structurally Deficient (SD). Bridges are considered SD if:

- significant load carrying elements are found to be in poor condition due to deterioration and/or damage; or
- if the adequacy of the waterway opening is determined to be extremely insufficient.

This rating only applies to federal bridges, defined as a 20 foot or longer span, and excludes minor spans that are otherwise included in this report. These numbers underestimate the population of poor bridges.

Chart 5 illustrates that the percent of SD bridges in Maine increased sharply from 2008 to 2010, and then decreased temporarily following a brief period of higher funding levels. Now it is starting to rise again. By comparison, the New England states, and the nation as a whole, have achieved a steady decline in their numbers of SD bridges. The trend outlined in Chart 5 represents all Maine bridges, not just bridges owned by MaineDOT.



Percentage of Structurally Deficient Bridges
United States
Maine
New England
20.00
19.00
18.00
17.00
16.00
15.00
14.00
13.00
12.00
11.00
10.00
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
16.68
16.07
16.35
16.14
15.59
15.77
15.8
15.76
15.25
14.45
13.62
13.36
13.34
15.42
15.11
15.86
15.31
15.02
14.79
14.91
14.8
15.79
16.26
14.99
14.78
15.24
14.17
13.68
13.36
13.14
12.85
12.5
12.24
11.96
11.88
11.6
11.35
11.08
10.7

Chart 5

Preservation Efforts Will Extend Bridge Life

New bridges are typically designed for a 75-year life and culverts are designed for a 50-year life. In reality, bridge life ranges widely depending on a variety of factors. One way to stretch bridge dollars is to extend the life of a bridge so replacement costs can be pushed out over time. Routine bridge washing, joint replacements, and other basic preventative work are part of achieving the 75-year life design target. Bridges may need new paint, replaced members or replaced wearing surfaces as part of meeting the design target. This work keeps a bridge from prematurely deteriorating and extends the years of life before a bridge needs to be replaced. Past funding hasn't allowed MaineDOT to keep pace with preservation activities while rehabilitating and replacing poor bridges.

The Value of Preservation Work

The three 'scoping' types used to maintain our network of bridges are:

- preservation;
- rehabilitation; and
- replacement.

Bridge preservation is essentially any work that preserves or extends the useful life of a bridge. Preservation may include washing, sealing deck joints, facilitating drainage, sealing concrete, painting steel, removing channel debris, and protecting against stream erosion. Rehabilitation involves major work required to restore the structural integrity of a bridge as well as work necessary to correct major safety defects. Replacement projects include total replacements, superstructure replacements, and bridge widening.

As a bridge deteriorates from good to fair to poor, the cost to restore the bridge to good condition increases dramatically. Unfortunately, high priority bridges in poor condition tend to demand the vast majority of available funding. This creates a funding cycle where it becomes impossible to keep pace with the needed preservation activities. For example, when a bridge is painted, it is done so knowing that another bridge in the network may need to be posted.

An ideal bridge program would provide the correct cost-effective treatment, applied at the correct time, to preserve and extend the useful life of every bridge. Unfortunately, there is insufficient funding to provide all needed treatments to all of our bridges. Therefore, MaineDOT must be very diligent in how we spend the money that is available. This is accomplished by selecting those bridges that will provide the highest benefits, while maintaining the right balance between funding bridge replacements, bridge rehabilitations, and bridge preservation. As an example, a large structure (i.e. high value asset) on a high priority corridor, with a failed paint system, but otherwise in good condition, would indicate a very high priority for bridge painting.

The reality is that many bridges are not receiving timely preservation. These bridges will reach poor condition sooner than expected and compete with other bridges for replacements. As Maine can't fund all the replacements in a timely manner, choices are made to ensure bridge safety.

Prioritization – Highway Corridor Priorities and Customer Service Levels

MaineDOT has significantly improved its methodology for prioritizing its highway assets. The first step was to classify all 23,090 miles of Maine's public highways into six priority levels (HCP).

Priority 1 roads include the Maine Turnpike, the interstate system, and key principal arterials such as routes 1, 9 and 302.
Priority 2 roads are non-interstate, high value arterials.
Priority 3 roads represent the remaining arterials and most significant major collector highways.
Priority 4 roads are the remainder of the major collector highways, and often include Maine's unique "state aid" system, where responsibilities are shared between the state and municipalities.
Priority 5 roads are minor collectors and are almost all in the "state aid" system.
Priority 6 roads are local roads and streets that are fully the responsibility of municipalities.

The table below shows the number of miles and the percentage of traffic by Corridor Priority.

Corridor Priority	Miles	% of Traffic
1	1400	40%
2	940	11%
3	2050	19%
4	1900	10%
5	2500	7%
6	14300	13%

The second step was to define customer service levels (CSLs). CSLs are generated by using existing data that is based on reliability, condition and service. The resulting CSLs are similar to high school report cards (A, B, C, D and F): A is "excellent"; B is "good"; C is "fair"; D is "poor"; and F is "unacceptable." When you combine highway priority with customer service levels, project candidates can be better evaluated. For example, a high priority road with a D rating needs work, and addressing it will yield a high value. The D rating may be due to either a roadway deficiency or a bridge deficiency.

Bridges are rated by three CSL factors.

- Bridge Reliability CSL (A-F) is pass/fail with an automatic fail if one or more of the major components of the bridge is in serious condition and/or if the bridge is scour critical.
- Bridge Condition CSL (A-F) is created from the 0-9 National Bridge Inventory (NBI) condition ratings.
- Bridge Service CSL (A-F) is created based on a posted weight restriction on a sliding scale relative to the Highway Corridor Priorities.

Highway Corridor Priorities and Customer Service Levels are described in Maine Law as a means of reporting priorities, service levels, and capital goals. One obvious goal would be to minimize the number of bridges with a D or F on all corridors. Chart 6 compares the number of bridges with D's or F's relative to the remaining bridges (A-C), and will likely serve as a benchmark for future KOBS reporting.

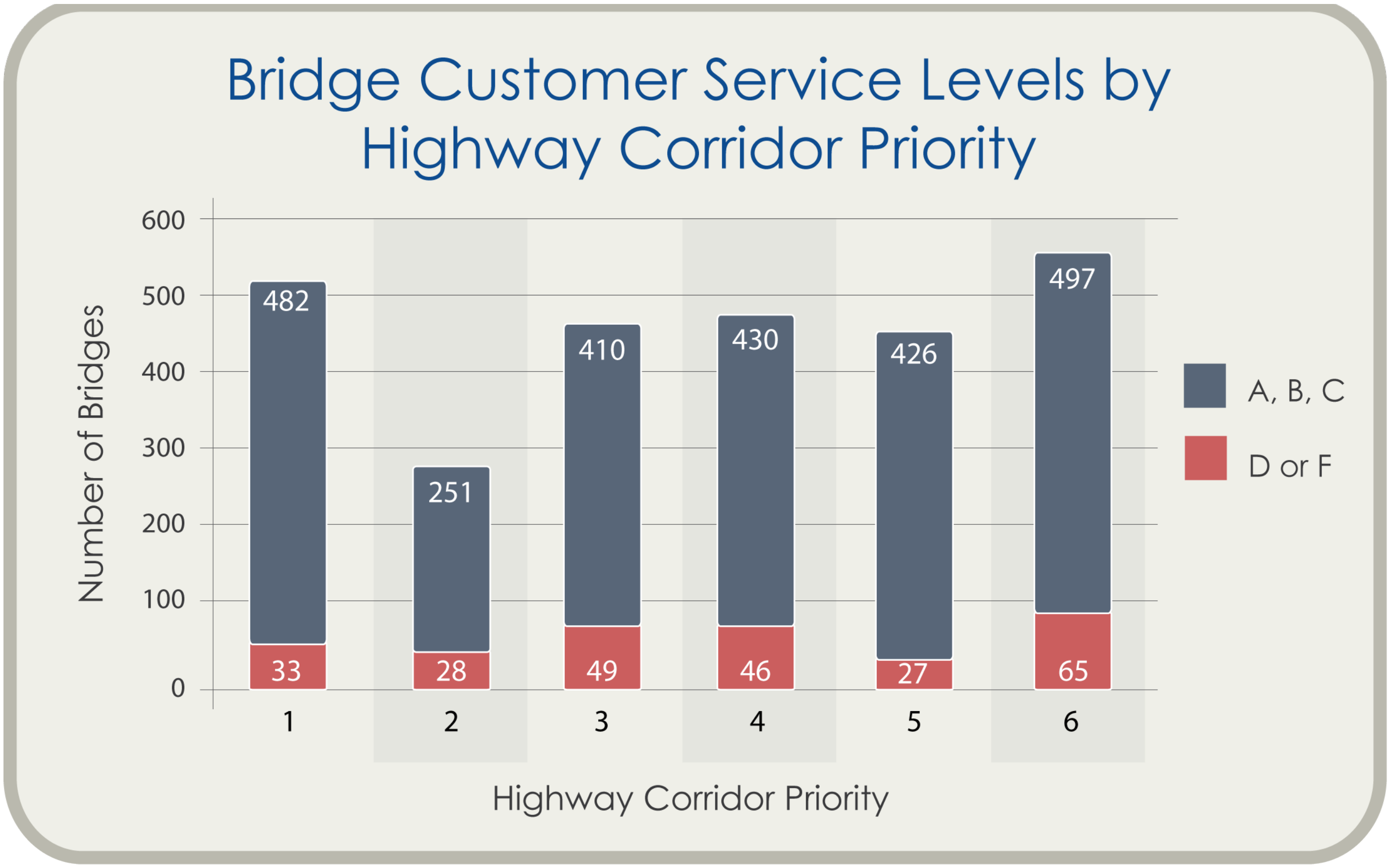


Chart 6

The Right Mix of New Bridges, Preservation and Rehabilitation

The bridge portion of MaineDOT's Work Plan is developed by a team of bridge engineers who conduct field evaluations and ultimately scope, prioritize, and estimate project costs from a list of project candidates. The team then works together to create the annual work plan, mindful of condition, service, and safety, in order to provide the best plan that meets available funding. As described earlier, the HCP's and CSL's also factor into prioritizing projects in the work plan.

The team makes every effort to include as many preservation projects as possible. The highest priority preservation actions include:

1) painting and fluid film to protect steel from corrosion;
2) wearing surfaces to protect the bridge decks from chlorides; and
3) sealing bridge joints to protect the bearings and beam ends.

Extending the Life of a Bridge through Design and Materials

Extending the service life of bridges is gaining importance as limited resources challenge our ability to keep our infrastructure in a state of good repair. As bridge needs increase, and funding levels remain flat, we are forced to address structurally deficient bridges first at the expense of pushing off preservation and rehabilitation which can extend life and defer replacement costs.

One way to address this trend is to design new bridges using materials and techniques that will extend service life and reduce maintenance over the life of the structure. The cost of addressing service life at design can be significantly less than continued maintenance and preservation actions for the life of the structure. This approach is gaining momentum nationwide and there is considerable research available. Available research includes the Strategic Highway Research Programs, SHRP 2 Reports: R19A Bridges for Service Life beyond 100 Years: Innovative Systems, Subsystems and Components and R19B Bridges for Service Life Beyond 100 Years: Service limit State Design.

The Federal Highway Administration (FHWA) has also recently created the Long-Term Bridge Performance Program which is a 20-year research program designed to compile data on various bridge types and materials that can be used to improve knowledge of bridge performance and promote reliability and longevity. MaineDOT currently employs many of the strategies outlined in this research to extend service; however additional savings could be realized by approaching it in a more systematic manner. Appendix B includes key practices and materials that MaineDOT is using, or experimenting with, to reduce future maintenance costs and extend the life of our new bridges.

All new bridges should be designed with the goal of extending their service lives by 5-10 years. In some cases, life cycle costs may show a benefit to extending service life even longer. Over time, the extension of bridge life will reap real financial savings beyond the investment in preservation. New materials, design advancements and construction techniques should also lower the cost of preservation in the long term.

Maine's Bridge Network Replacement Cost - $7.56 Billion

A total cost of ownership model can illustrate bridge funding needs and provide investment strategies. This model uses basic accounting principles such as direct and indirect costs over the life of a bridge. The goal is to reduce the total cost of ownership for the bridge network. The concept for a bridge network is that by doing timely preservation work and planned rehabilitation bridges will meet their desired life without unexpected expenditures due to unplanned deterioration. To say simply, spend less money over time to improve the reliability of the bridge network.

The bridge network replacement cost is approximately $7.56 billion. When taking into account the current condition (depreciation) the value drops to $5.55 billion. The depreciated number still represents a huge asset value. Just as a business managing a fleet of airplanes, buses or trucks needs to manage its capital to get a lower total cost of ownership, the State needs to manage its bridge network in a similar fashion.

Improving the Management of Transportation Assets

MaineDOT and Deighton Associates Limited have implemented an Asset Management System that is designed to improve the management of MaineDOT's transportation assets. The current effort regarding bridges is focused on realistic asset management plans for the future repair, preservation, rehabilitation, and replacement of bridge assets. This software serves to consider alternative preservation strategies as well as to ensure sustainable management of the transportation network for future generations. In other words, the system is using the idea of total cost of ownership to predict the right treatment to spend less money over the life cycle of the bridge.
As part of managing bridge assets, future plans by type of bridge must be established. Every bridge in the inventory must have a preservation and maintenance strategy as part of a documented plan. All work on these bridges will also be documented.

Funding Needs Scenarios

For the 2007 KOBS report, two methods were used to quantify Maine's structural bridge needs. The first method used bridge age distribution to estimate an appropriate replacement rate. The second method grouped bridges by condition (good, fair, poor). These bridges were prioritized by Federal Functional Class of the roadway carried. The second method did not fully consider preservation actions, but did assume limited preservation/rehabilitation for the one-third of bridges that are in fair condition.

The results of the 2007 KOBS report concluded that $130 million per year in capital investment in bridges was necessary to maintain the bridge network at the current levels; that is, to not fall further behind. That level of investment required continued tough decisions including weight postings or bridge closures for a few low-priority, redundant bridges.

In response, the Governor and Legislature agreed that additional bridge funding was needed. Using a new TransCap Trust Fund bonding mechanism, 30-A MRSA 6006-G, $160 M over 4 years, or about $40 million a year was injected into our bridge program. When combined with other funds, bridge funding from 2009 to 2013 reached an average of $112 million per year, still short of the identified 2007 need. Moreover, the TransCap bridge bonding has all been allocated, meaning a new source is needed.

For the 2014 KOBS report, bridge needs were computed using the Deighton asset management software. The software generated bridge conditions and customer service levels for the next twenty-five years for the following funding levels: $70 million per year, $105 million per year, $140 million per year and $175 million per year. The results indicate that overall, bridge condition would continue to deteriorate with a funding level of less than $140 million per year, and would improve at funding levels in excess of $140 million per year. These results are consistent with other analysis conducted over the past several years. However, just maintaining average condition will not meet our goal of eliminating the number of D and F bridges.

The program was run with no limit on funding to determine what it would take to fund all beneficial bridge needs. It concluded that an average of $217 million per year would be required to maintain the entire bridge system and substantially meet service, condition and safety goals.

Average condition is defined by federal indices. In Maine, it is more appropriate to use CSL to better describe the difference between keeping current funding levels and increased funding.

Chart 7 shows even with the $140 million funding level, the percentage of CSL D's and F's increase over the next ten years before the number declines. This is strategic, as these represent bridges on lower corridors with less traffic or where there are redundant bridges. In order to fund preservation to make a difference over the long term, we recognize some bridges will stay as D's and F's until they can be replaced or rehabilitated. These bridges will be safe to the public but may be posted. The $140 million funding level does achieve the goal of having very few structurally deficient or poor bridges on Highway Corridor Priorities 1-3 in ten years. This spending level represents 2.5% of the depreciated value of the bridge network.

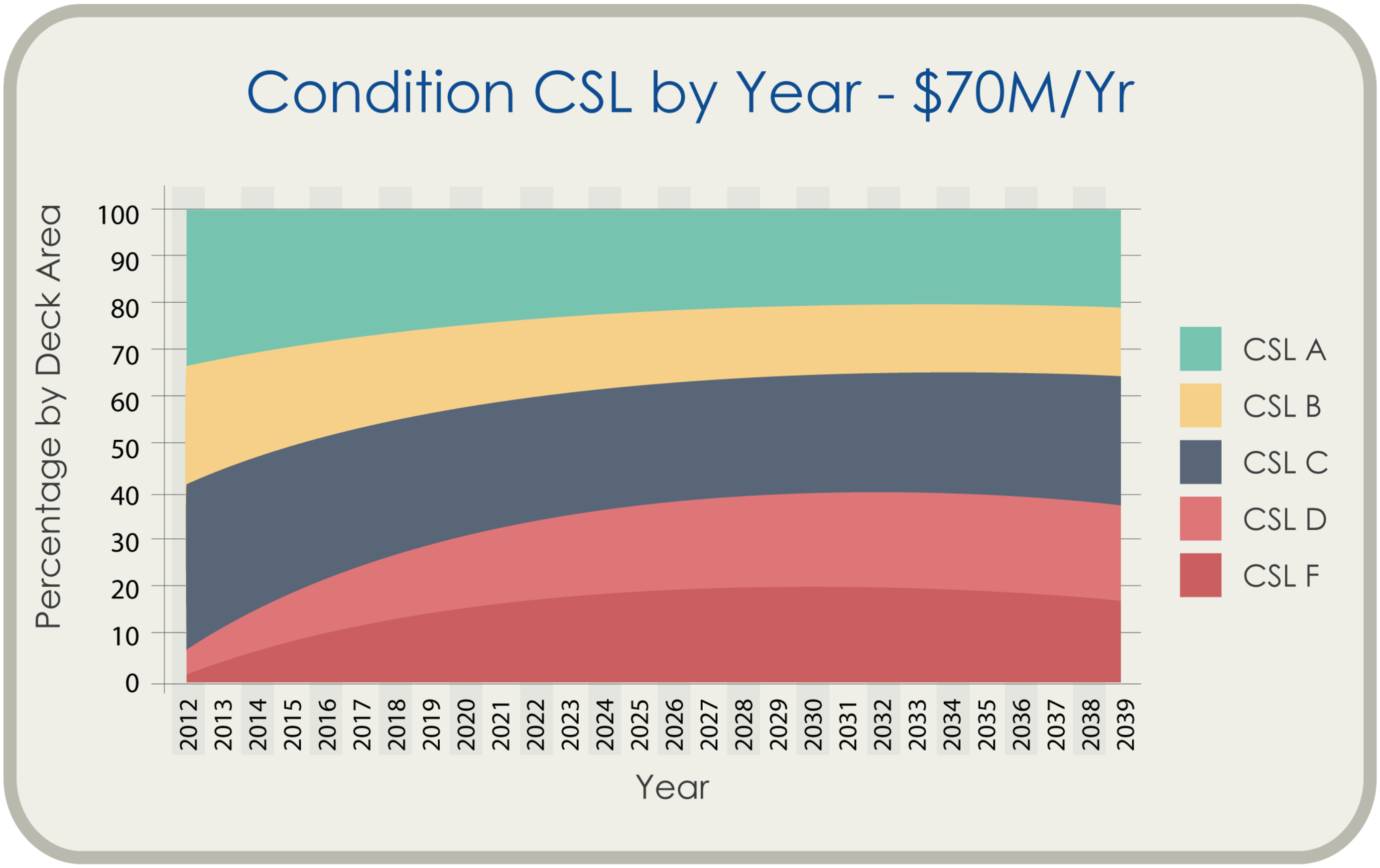


Chart 7

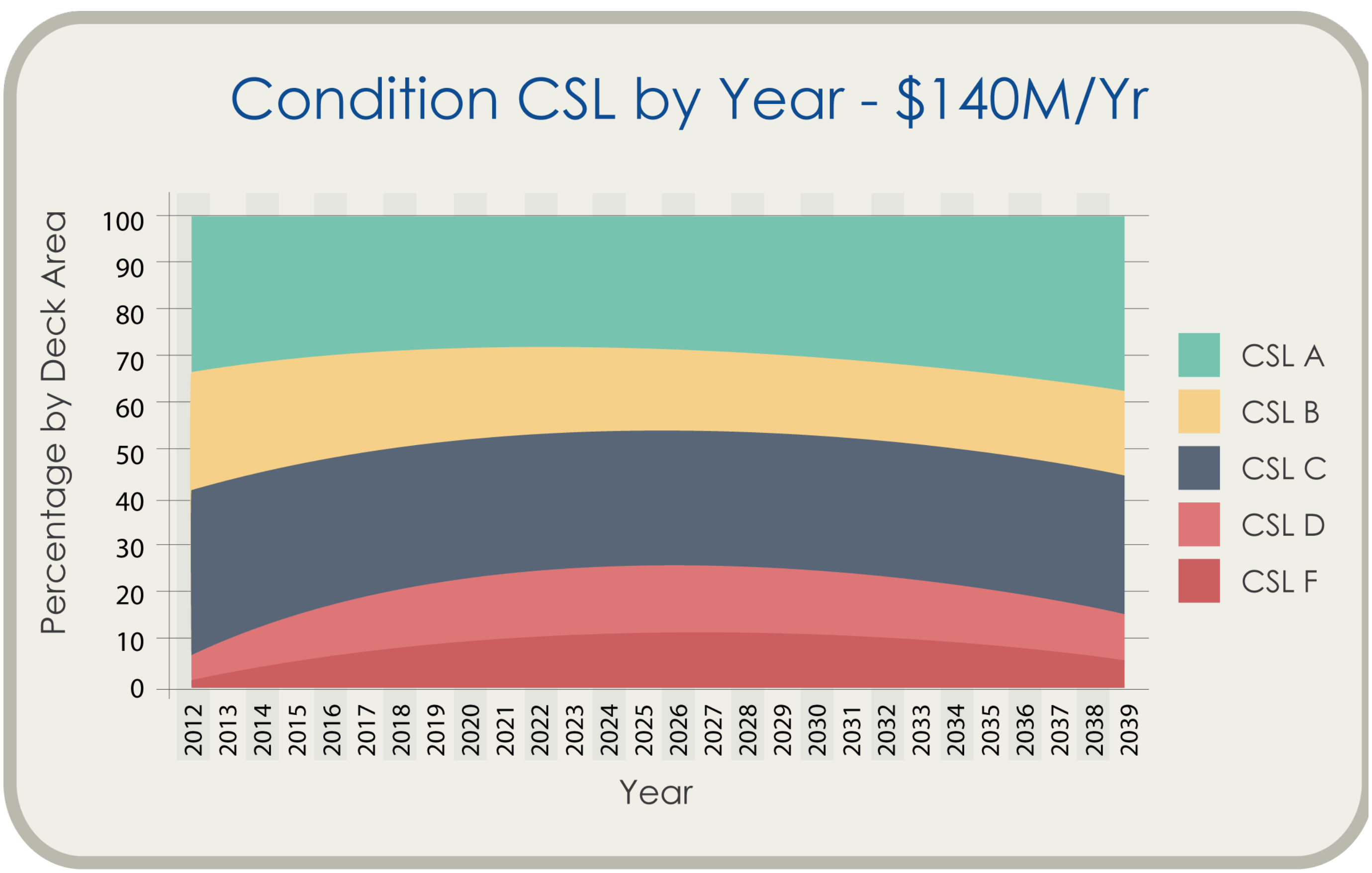


Chart 8

At the current yearly average funding level of $70 million, we expect approximately 40% of the bridges in Maine will move to a CSL of D or F. This means that more than a third of all Maine bridges will be in poor or unacceptable condition. Considering 87% of all freight in Maine is carried by trucks, this number poses significant economic issues. When a bridge is at CSL D or F, preservation is not effective in improving the CSL of a bridge. More than a third of the bridges in Maine will need major rehabilitation or replacement to prevent postings or closings.

In comparison, a funding level of $140 million has approximately 15% of bridges at a CSL D or F. In the same time period, preservation efforts start to increase the number of bridge in CSL A so the rate of deterioration is slowing for a larger number of bridges. We can conclude that the investing in preservation now is key to saving significant dollars in the future. Major rehabilitations and replacements will not be needed on bridges with CSLs between A-C.

The charts do show the percentage of CSL D's and F's increasing over the next 25 years even with the $140 million per year funding level. This is strategic, as these represent bridges on lower corridors with less traffic or where there are redundant bridges. In order to fund preservation to make a difference over the long term, we recognize some bridges will stay as D's or F's until they can be replaced or rehabilitated. These bridges will be safe to the public but may be posted.

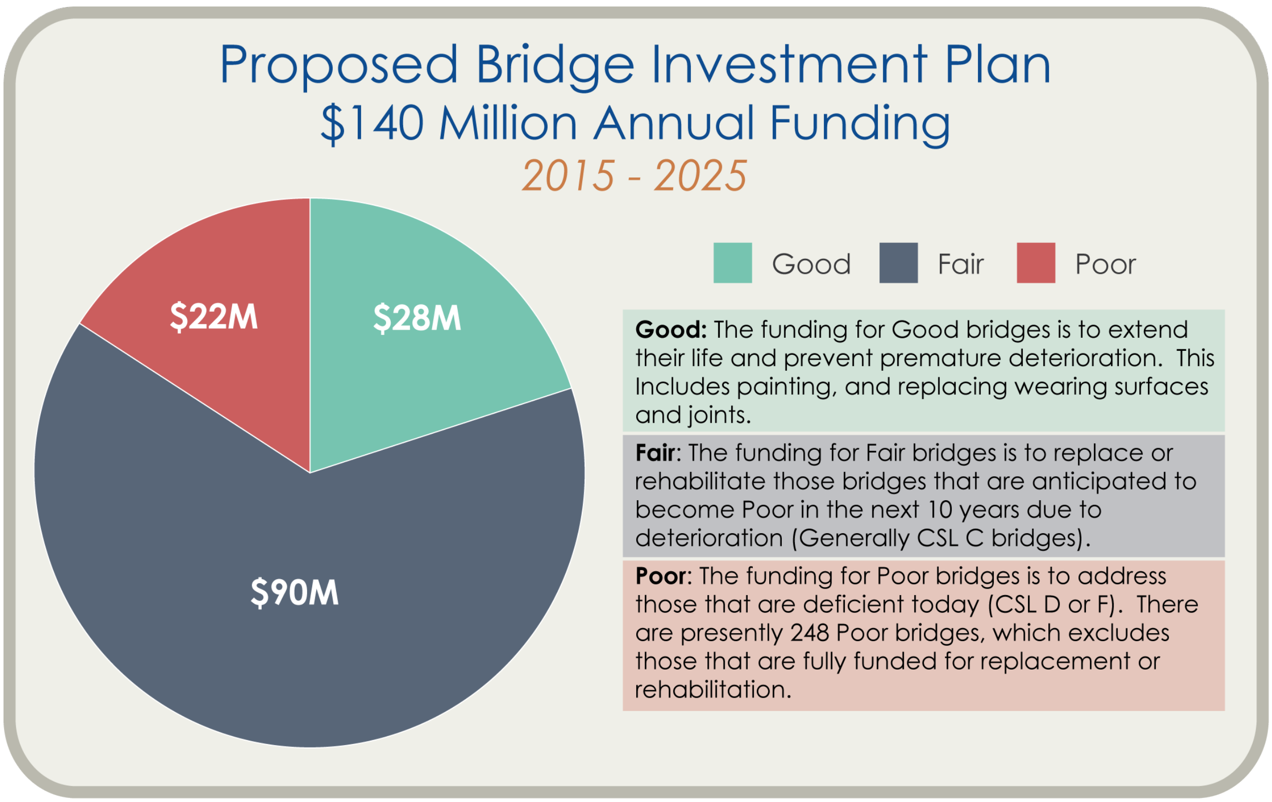


Chart 9

Funding Conclusions

Consistent with past reporting, this report concludes that a long-term investment of $140 million per year will eliminate at least 90% of the structurally deficient and poor bridges on Highway Corridor Priorities 1-3. This funding level will improve the average condition of Maine's bridges over the next twenty-five years. It will also reduce the deterioration of bridges that are in good condition which presents the opportunity to save money in the future. It will not be enough to eliminate all bridges with CSLs of D's and F's. It does dramatically change the number of bridges with D and F ratings from 38% at the current funding levels to 15% over the next 25 years.

Maintaining the Health of Maine's Forever Bridges

"Forever bridges" are high-value bridges which, when replaced, will create extraordinary impacts to customers or create significant funding needs that could severely impact bridge resources. These bridges must last at least 100 years and, in some cases, longer. See Appendix C for a complete list. These bridges would typically be structures that:

1) Would have an extraordinary replacement cost (e.g. Deer Isle Bridge);
2) Have special features that require non-standard maintenance and preservation; and/or
3) Have components (or the entire bridge) that would be very difficult and costly to replace (e.g. pre-cast segmental box decks); or
4) Bridge replacement costs are over $20 million.

Maine has constructed, replaced or rehabilitated a number of these bridges over the last ten years (e.g., Veteran's Memorial Bridge in Portland - South Portland, the Memorial Bridge in Kittery-Portsmouth, and the new International Bridge in Calais.) Over a 15-year period, 2002-2017, we will spend approximately $490 million on construction or heavy capital work on these bridges. This represents over one-third of the annual bridge funding, and has caused a drain on bridge resources which has led to fewer resources available for preservation work and bridge replacements. Fortunately, MaineDOT received additional funding in the form of federal TIGER monies that helped supplement funding. We must proactively preserve "forever bridges" far into the future, as they can significantly impact a single year of bridge funding. Expensive rehabilitation work and replacements need to be planned allowing work to be spread out over time.

Operating plans specific to these individual bridges need to be established to sufficiently plan the work needed to extend the life of these bridges. Upcoming work needs to be prioritized and completed work documented to ensure these bridges last long into the future.

Opportunities

MaineDOT Weighs Competing Environmental and Economic Demands

Increased funding is only a partial solution to improving bridge safety. We also need to find opportunities to cut costs. When one asks why the cost of designing and constructing a bridge has increased with time, the following items are a significant piece of the explanation.

Over time, MaineDOT has changed its work practices to minimize its impact on the environment. This comes with a financial cost. In recent years, there are three significant issues related to the environment that have led to increased costs.

1) The allowable time to work in the water is getting shorter and shorter. This can extend a single season project into a multiyear project, or require expensive construction means and methods when building the project. These work windows are related to fish and marine mammal passage and sensitivity to noise from pile driving.

2) Issues related to fish passage and stream connectivity are requiring an increase in the size of structures. In the past, retrofitting an existing culvert with a liner was an inexpensive and efficient way to increase the life of the culvert. Due to fish passage concerns, it is very difficult to find locations the natural resource agencies will permit for a lining. These same agencies are also concerned with all aquatic organisms and are asking that stream connectivity be provided via structures that are all but invisible to inhabitants of streams. This means they not only want fish to pass, but they want natural bottom structures that can pass 1.2 times the bankfull condition. This means a culvert between six and eight feet in diameter needs to become a bridge span of 15-20 feet to meet 1.2 bankfull conditions. In the past two years, this explains, in part, why MaineDOT has added bridges to its inventory. It is increasing the cost of construction as well as requiring additional maintenance costs into the future. Also, as municipalities are required to upsize crossing structures, they will increasingly be looking to MaineDOT to absorb maintenance and replacement responsibilities.

3) We are under increasing pressure to lengthen bridges due to wetland issues and animal passage. There are far fewer permitting requirements if the bridge can stay out of the water. The department often faces a tradeoff between the time it takes to negotiate permits and the cost of adding length to a bridge.

Other factors influencing costs are related to providing safe access for bicyclists and pedestrians, as well as potential community enhancements based on public feedback and desires. There has been a trend on larger scale and urban bridges to add many features above and beyond a simply designed structure that meets all code and design guides. These may include upgraded lighting, alternate materials, signage, pedestrian viewing areas, and larger multiuse lanes and walkways where safety issues exist. The department has a recently developed local cost-sharing policy that has been newly implemented (June 2014). This policy addresses the cost responsibilities for these issues and is found under Appendix F.

Federal law and state policies ensure that sidewalks are built on bridges (where feasible) where there is a safety need to provide space for pedestrians. Paved shoulders are included on most transportation construction projects to ensure motor vehicle safety as well as a safer place for bicyclists (and pedestrians on bridges that don't have a need for a sidewalk). Sidewalks are built as part of a bridge or road reconstruction project in pedestrian qualifying areas. This is defined in the local cost sharing policy as an area that will have substantive pedestrian activity or use during the expected life-cycle of the project. In making the determination on whether a proposed bridge is in a pedestrian qualifying area, MaineDOT is guided by the existing, planned, or forecasted sidewalks and/or pedestrian "generators" (including neighborhoods, businesses, government buildings, village areas, schools, recreational facilities, etc.), directly adjacent to or within reasonable walking distance of the proposed project.

There is occasional pressure to provide sidewalks and wider shoulders/shared use facilities for bicycle and pedestrian use on bridges that do not currently "need" the facilities. Many argue that because new structures last so long, as a matter of public policy the state should plan for future use even if there are no documented or planned pedestrian or bicycle generators within the foreseeable future. MaineDOT remains very careful to ensure that when a new bridge is built, sidewalks and additional space for bicyclists are provided only where there is an identified existing or foreseeable need. The bridges we build are important elements of the communities in which they exist, and MaineDOT is careful to help ensure the proposed bridge is safely built for all users, and that other public interest elements are considered and approved only where appropriate in the context of the community environment. MaineDOT is very careful to ensure all community interest options considered are warranted, feasible, and financially constrained.

Funding bridges at $140 million per year does not include enough money to build all new bridges at 1.2 bankfull conditions or to accommodate pedestrians on all bridges.

Risk Drives Cost

MaineDOT can impact cost by our methods of planning, scheduling, and bidding out work. It is agreed that risk drives cost. If the contractor has to assume more risk, they add cost. If MaineDOT assumes more risk, the contractor's cost is typically reduced. MaineDOT continues to work with industry to identify ways to reduce risk. MaineDOT projects are governed by contract language and construction specifications. We continually ask contractors to identify items that do not add value. A good example of this is the recent change to the contract language that allows a contractor to be paid for significant damage or delays due to large storm events. Previously, there had to be a declaration of an emergency in order for MaineDOT to reimburse a contractor.

When designing bridges, we need to be aware of and react to market conditions. The cost-effectiveness of a particular structure fluctuates depending on world market prices for raw materials. When steel prices are up, concrete is more cost effective and vice versa. Market competition and the Canadian exchange rate impact MaineDOT. For example, there are fewer precast suppliers because the Canadian exchange rate has made Stresscon, a New Brunswick precast company, uncompetitive. This has driven market prices up on precast items for bridge work.

MaineDOT needs to more effectively package maintenance work for contractors. For example, if MaineDOT puts out a package of joint replacements that represent a season's (summer's) work, it would result in more competitive pricing in relation to single joint replacement contracts. The packaging of the work would allow the contractor to assemble a crew, with all the appropriate resources, to do the work. The volume of work allows them to be more efficient. MaineDOT would also realize a savings in bidding preparation costs. Winter bidding of this type of contract would allow proper planning and scheduling of the work.

MaineDOT's Plan to Cost-Effectively Ensure Safe Bridges

The $140 million per year funding level will allow us to maintain a safe bridge network and extend bridge life when coupled with the specific actions detailed below.

- Eliminate 90% structurally deficient and poor bridges on Highway Corridor Priorities 1-3.
- Improve the average condition of Maine's bridges over the next twenty-five years. MaineDOT will use current asset management techniques to determine the appropriate blend of preservation and replacement activities to cost-effectively extend bridge life.
- All bridges shall have operating plans by type that document the most effective preservation and rehabilitation activities.
- "Forever Bridges" shall have individual operating plans to proactively extend the life of these bridges to more than 100 years.
- Remove redundant bridges that have reached the end of their safe service life from the inventory when possible.
- Continually assess new technologies and materials for extending bridge life and reducing maintenance, and incorporate them in new construction and rehabilitation when appropriate.
- Reduce costs associated with inefficiencies such as extended time spent on permitting.

In closing, Maine bridges continue to be safe. The 2007 recommendations have been or are nearly completed. We have made strides in load rating our bridges and addressing scour issues. Like most things in life, there is nothing more money couldn't fix, or in this case, at least have a significant impact. Over the last few years, MaineDOT has right-sized our goals for Maine roadways: less full reconstruction in locations where maintenance preservation will meet our customer's needs. It has allowed us to stretch the dollar.

The same concept is being applied to bridges – regular, well-targeted maintenance measures will have a significant impact on the lifespan of our structures. The TransCap Trust Fund, created by the legislature in 2007, as a result of our first KOBS report, increased MaineDOT's bridge funding from approximately $70 million per year to $112 million per year for four years, ending in 2013. The additional funding was enough to keep the structurally deficient bridge percentage from steeply rising, but did not fully address rehabilitation and preservation needs.

Currently, MaineDOT is funding bridges at approximately $70 million per year, which is approximately half of what is necessary to maintain and extend bridge life. Consistent, predictable targeted funding is needed to execute these simple, right-sized goals. The ability to plan and budget accordingly for bridge preservation and replacement activities is essential to protecting the taxpayers' assets.

Appendices

Appendix A

Keeping Our Bridges Safe 2007 Report, List of Recommendations and Actions Taken

Plans and Specifications	Complete	Ongoing	In Development	No Action
A standard note will be added to contact plans indicating what construction loads were considered during the design			X	
A subsection will be added to the MaineDOT Standard Specifications to address construction loadings on bridges. The subsection will address the contractor's equipment (both construction equipment and equipment within legal loads) that will be used on the structure under construction, and materials placed or stored on the structure during construction.	X			
Other Critical Infrastructure	Complete	Ongoing	In Development	No Action
Highway lighting and traffic signals		X		
Overhead signs		X		
Pedestrian structures		X		
Ports and piers		X		
Retaining walls and earth-retaining structures			X	
Dams			X	
Cell phone towers (NO ASSETS)				X
Private structures (walkways) over public highways		X		
Struts (large culvert pipes)		X		
Scour	Complete	Ongoing	In Development	No Action
Complete Scour Plans of Action and implement the plans.	X			
Evaluate tidal and unknown foundations in accordance with FHWA's pending guidelines.	X			
Create statewide water-basin maps to evaluate critical bridges during high water events.	X			
Prioritize and implement scour countermeasures on critical routes.		X		
Document at least one stream cross-section at each bridge for baseline comparison and identification of scour susceptible bridges.		X		

Connections and Fracture Critical Members	Complete	Ongoing	In Development	No Action
Review plans and other documentation of existing bridges and perform structural analysis as needed to identify all potentially problematic connections and fracture critical members.		X		
Create schematics of the above connections and fracture critical members for ready reference in the bridge inspectors' file for each bridge.	X			
Develop special written procedures for inspecting and monitoring critical members and connections.	X			
Monitor and evaluate the research into new technologies and techniques for inspection and evaluation of connections and fracture critical members, and implement them, if appropriate.		X		

Age and Deterioration	Complete	Ongoing	In Development	No Action
Repair or replace critical deteriorated bridges or components before they become a safety issue requiring a bridge to be posted or closed.		X		
Continue to replace or repair overhead concrete structures that pose a hazard to the public.		X		
Focus maintenance attention on work that will reduce exposure to corrosive elements on critical structural members and connections, thereby extending service life.		X		
Provide cathodic protection (a technique for steel protection using sacrificial metal, therefore preserving the structure) for substructure units exposed to corrosive environments.		X		

Inspection Program	Complete	Ongoing	In Development	No Action
Review quality assurance procedures of the inspection program and posting process, information systems and data gathering.	X			
Adopt a new posting policy.	X			
Improve documentation of bridge inspection policies and procedures.	X			
Respond to upcoming changes in National Bridge Inspection Standards (NBIS) Quality Assurance (QA) procedures.	X			
Develop guidelines for triggers requiring field review and load rating by a professional engineer.	X			
Implement a 24-month inspection cycle in place of the current biennial cycle in order to more fully comply with federal standards.	X			
Implement enhanced procedure for town bridges.				

To ensure that towns receive and understand notifications recommending needed repairs, postings or closure, MaineDOT will send such notifications to the town's chief officer (town manager, head selectman, etc.) via certified mail.		X		
To ensure proper notification and protect public safety, these letters will be copied to the public works director or road commissioner.		X		
MaineDOT will provide in these notifications directions to MaineDOT's public bridge web site which will contain the bridge posting and closure processes, pertinent bridge laws, typical weights of various style of vehicles, and information on how small towns may acquire engineering support.			X	
MaineDOT will continue to maintain and update its information on the condition, posting, and closure status of town-maintained bridges.		X		
Overloads	Complete	Ongoing	In Development	No Action
The state should work with the trucking industry on enabling legislation to allow enforceable photo/ WIM technology on critical bridges where weight compliance is particularly necessary to ensure public safety.				X
Competence	Complete	Ongoing	In Development	No Action
MaineDOT should implement a technical career track for bridge designers that would provide an avenue for advancement without having to leave the bridge design work to enter the management career ladder.	X			
Capital-Related Recommendations	Complete	Ongoing	In Development	No Action
Increase capital funding \$50 to \$60 million per year (from approximately \$70 million per year today) to between \$120 to \$130 million per year.		X (only increased by \$40m)		
Continue reviewing MaineDOT's current bridge-related programming to ensure that bridge safety remains adequately considered.		X		
Enhance bridge preservation actions to increase average service life.		X		

Appendix B

Design Enhancement and Material Usage to Extend the Life of a Bridge

Concrete

The deterioration of reinforced concrete in our bridges is a significant problem and the cost of repairing or replacing these structures is a major liability for MaineDOT. The primary cause of this deterioration is the corrosion of steel reinforcing due to the chlorides penetrating the concrete. When steel corrodes, the corrosion products (rust) that form around the steel have six times the volume of the original material and this increased volume causes the concrete over the bars to delaminate and spall. The rate of corrosion is dependent on the amount of water, oxygen, and chloride ions reaching the steel reinforcing. A variety of methods exist to reduce or eliminate this deterioration ranging from improved detailing practices to non-corrosive reinforcing. These measures are easy and cost effective to incorporate into new designs and have a high potential to extend service life and reduce maintenance costs.

High Performance Concrete (HPC): The use of HPC with improved performance characters such as low permeability, low shrinkage, freeze/thaw durability, high strength, and abrasion resistance is the first line of defense for protecting reinforcing steel. HPC slows the penetration of chlorides through concrete and limits cracking, both of which delay the start of corrosion. MaineDOT fully transitioned to HPC around 2000 and in 2004 implemented a quality level analysis method of Quality Control Quality Assurance (QCQA). This generates a composite pay factor for concrete based on compressive strength, entrained air content, and rapid chloride permeability. MaineDOT has consistently seen high quality concrete since the transition to HCP with one of the key factors being the addition of pozzolans which improve strength, durability, and resistance to chloride penetration.

Detailing of Concrete Structures: Two effective ways of improving the performance of reinforced concrete are:

1. increase the cover over the reinforcing and
2. detail structures to prevent water and deicing chemicals from collecting on them.

As with HPC, these methods extend service life by increasing the time it takes chloride ions to reach the reinforcing steel.

Corrosion Resistant Reinforcing Steel: High performance corrosion resistant reinforcing includes products that are coated to protect them from chlorides to bars that are made of corrosion resistant steel. These products vary widely in cost and the level of protection they offer, and it can often be difficult to determine which one is the best for a particular application based on the vast amount of information available on the subject. Some of the more common types include:

- Epoxy-coated Reinforcing Steel (ECR)
- Galvanized Reinforcement
- Duel-Coated Reinforcing Steel
- Stainless Steel Reinforcing

Fiber-Reinforced Polymer (FRP): FRP composite reinforcing is gaining traction as a corrosion resistant alternative to steel reinforcing in bridge decks. In 2009, American Association of State Highway and Transportation Officials (AASHTO) published the Design Guide Specification for Glass Fiber Reinforced Polymer-Reinforced

Concrete Bridge Decks. FRP reinforcing is readily available from several manufactures in the U.S. and Canada. MaineDOT recently used GFRP reinforcing in two bridge decks and the cost appears to be comparable to epoxy-coated reinforcing. Added benefits of FRP reinforcing include:

- the ability to reduce concrete cover in some applications,
- the ability to construct bridges with integral wearing surfaces since there is little concern about premature deck deterioration due to corrosion, and
- ease of construction due to reduced weight.

Steel

Steel bridge systems have the potential for achieving a service life of 100 years or more. However, poor designs and a limited maintenance can lead to severe corrosion and reduced service life. Corrosion of steel is the result of exposure to oxygen and moisture, and is greatly accelerated in the presence of chlorides. The fact that steel corrodes is one of its fundamental limitations as a bridge material. In the past, the primary means of protecting steel from corrosion has been paint. Unfortunately in Maine's harsh environment, protective paint systems don't last long and repainting is required frequently. This is very costly, particularly on bridges with lead- based paint systems, and bridges such as trusses that have many "hard to reach" areas. More effective methods do exist to protect steel bridge elements, including more durable, longer lasting protective coatings, and corrosion-resistant steels. The following are some of the promising methods to extend service life and reduce maintenance costs:

Weathering Steels: Uncoated weathering steels have a chemical composition containing small amounts of copper, phosphorous, chromium, nickel, and silicon that allow the steel to develop a protective coating (patina) when properly exposed to alternate wet/dry cycles. The patina effectively seals the steel, preventing further corrosion. Once the patina forms, weathering steel requires very little maintenance for the life of the bridge. Weathering steel must be used in suitable environments; if it is continuously wet, or exposed to high levels of salt spray, the patina will not properly develop. Weathering steel should not be used in immediate coastal environments; areas exposed to excessive salt spray, or where tunnel-like conditions exist that can prevent drying of the steel. Weathering steel bridges should be detailed so that no areas exist that can trap debris, and the beam ends under bridge joints or at integral abutments should be painted.

Galvanized Steel: Hot-dip galvanizing is a process in which fabricated steel is immersed in a kettle or vat of molten zinc, resulting in a metallurgically-bonded coating that protects the steel from corrosion. During the galvanizing process, the molten zinc reacts with the surface of the steel forming a series of zinc/iron alloy layers that are very durable and well-adhered to the steel. Hot-dip galvanized steel has been observed to last 50-75 years maintenance-free in many types of atmospheric environments, including industrial, urban, marine, and rural. Limitations include the fact that the fabricated steel needs to be shipped to a galvanizer, adding time to the fabrication process, and most vats are limited to about 40' limiting the total beam lengths to about 75' if they are double dipped.

Metalizing: Metalizing is a thermally sprayed metal coating consisting of zinc, or a zinc/aluminum mixture, in wire form that is fed into a heated gun, melted, and spray applied to clean steel. Like hot-dip galvanizing, metallizing is a zinc coating to protect steel from corrosion, and both provide barrier and cathodic protection to the steel below the zinc coating. Metalizing can be used on any size or shape steel object, eliminating limitations due to vat size. The process can also be done at the steel fabrication shop, eliminating the need to ship the members to a galvanizer's plant. As metalizing is becoming more popular, and process improvements are made, it appears that the price is coming down. Estimates to the time of first maintenance for metalizing vary based on the coating thickness and atmospheric environments, but a service life of 30 years or longer can be expected.

Polyuria Elastomer Coatings: In recent years MaineDOT has experimented with the use of polyuria elastomer coatings to protect steel in extremely harsh locations such as pipe piles in pile bent piers. These piles are often exposed salt water, abrasion, and damage when they are driven. Pile bent piers are very cost-effective; however the fusion bonded epoxy coating typically used on the exposed portion of the piles tends to be brittle and easily damaged. Once damaged, it is nearly impossible to repair the coating and corrosion starts rapidly limiting service life of the bridge. MaineDOT has used two different proprietary polyuria elastomer coatings on pile bents in the past and both have produced promising results with the coating exhibiting exceptional abrasion resistance and bond strength to the base steel.

Jointless Bridges

Bridges joints are the weakest link on many of our existing bridges and a major cause of reduced service life. They are subject to continuous abuse from traffic and the joint seals often fail after just a few years, allowing salt and sand onto the beam ends, bearings, bridge seats, and pier caps. If joints are not continuously maintained, beam ends corrode, bearings freeze, and reinforced concrete substructure units deteriorate rapidly. Failed joints can lead to extensive concrete rehabilitation; complete pier replacements, and strengthening of beam ends. These repairs can be so extensive that at times it is more cost-effective to replace the entire structure. Elimination of bridge joints is therefore one of the most important considerations when trying to extend service life.

Integral Abutment Bridges: Integral abutment bridges have superstructures that are either rigidly connected or pinned to flexible pile supported abutments, and movement of the superstructure is accommodated by the foundation, eliminating the need for joints. Integral abutment bridges have also proven to be cost-effective since they typically stay out of the water, avoiding the need for extensive cofferdams. MaineDOT's policy is to evaluate the use of integral abutments on all bridge replacements. The use of integral abutments can be limited by shallow bedrock and maximum span length. Based on research done with the University of Maine, the department has reduced the required pile length to as little as 10'. Also, in a recent revision to Bridge Design Guide, the maximum span length was increased to about 300' for steel bridges and 500' for concrete. These changes allow many of our bridge replacements to be constructed without joints.

Semi-integral Abutments: Semi-integral abutment bridges typically have reinforced concrete end diaphragms that encase the superstructure ends and serve as the abutment backwall. The abutments are rigid, either pile-supported or founded on bedrock, and the superstructure is free to move longitudinally on expansion bearings. Thermal movement can be accommodated by either pushing the movement into the backfill behind the abutment, with the use of an at-grade approach slab/sleeper slab system, or with a compressible layer between the end diaphragm and abutment backwall, all of which eliminate the need for conventional bridge joints. Semi-integral abutments can be used in locations with shallow bedrock and for spans that exceed the limits of integral abutments.

Converting Simple-Span Bridges to Continuous: Maine has a large number of bridges that were constructed as simple spans with expansion joints at each pier. This was a popular concept in the 1950s and 60s, since it was an easy way to design and construct bridges. Unfortunately, leaking joints over piers have become a leading cause of deterioration and reduced service life. This is readily apparent driving on the interstate in Maine; the overpasses constructed with simple spans typically have severely deteriorated piers while the piers on continuous span structures tend to be in good condition. These joints can be eliminated, and service life extended, by converting simple-span bridges to continuous. Several options exist to accomplish this, including converting girders to fully continuous for dead and live load, converting to continuous for live load only, and converting by using a continuous slab over the joint.

Composites

Fiber Reinforced Polymer (FRP) Composites offer great potential to reduce required maintenance costs and extend the overall service life of bridges. FRP composites are strong, durable, lightweight, and highly corrosion-resistant. Typical applications include composite hybrid systems and composite bridge components. Composit hybrid systems combine FRP with other conventional bridge materials such as concrete and steel, maximizing each material's strengths, and reducing the overall cost of the system. Composite bridge components, such as composite bridge drains, can be very valuable in extending the life of bridge elements and preventing further damage that could be caused by failure of the component. Maine has been at the forefront in the use of composites in bridge building due to research done at the University of Maine, and the fact that we have many composite manufacturers. A measure of acceptance that composites have received is the publication of AASHTO LRFD Guide Specifications on GFRP Reinforced Concrete Bridge Decks and the design of Concrete- Filled FRP Tubes for Flexural and Axial Members. Examples of composite bridge systems and components that are available include:

Hybrid Composite Arches: These composite hybrid bridges consist of a composite exoskeleton tube that is filled with structural concrete. The composite exoskeleton adds significant strength and durability to the concrete. The composite arches are typically installed on a reinforced concrete footing on bedrock or pile supported and the arch is decked over with corrugated composite sheeting. Spans typically range from 25 to 70 feet. It is expected that these buried structures will last in more than 100 years with very little required maintenance.

Hybrid Composite Beams (HCB): HCBs are another composite hybrid that uses structural concrete and galvanized steel prestressing strand to form a shallow tied arch that is encased in a FRP composite shell for durability and corrosion protection. HCBs are expected to have a service life in excess of 100 years and can be used for spans up to 80 feet. An added benefit of HCBs is that they are very lightweight before they are filled in with concrete after erection at the jobsite, which can result in ease of shipping and erection. HCBs are of particular interest in locations with extremely harsh conditions such as bridges close to salt water or locations that receive a lot of salt spray. MaineDOT constructed an eight-span 540 foot continuous HCB bridge in Boothbay in 2011 and we continue to consider this as an alternative in locations with harsh exposure conditions.

Other areas where MaineDOT has used composites to extend service life include:

- FRP Reinforcing – discussed above
- Carbon Fiber Composite Cable (CFCC) for post tensioning and pre-stressing
- Composite bridge drains

Appendix C

Forever Bridges

Bridge #	Town	Bridge Name
#2026	Arrowsic	Max Wilder
#6400	Augusta	Cushnoc Crossing
#5196	Augusta	Memorial
#5312	Bangor-Brewer	Joshua Chamberlain
#1558	Bangor-Brewer	I-395/Penobscot
#2038	Bangor-Brewer	Penobscot
#6388	Bath-Woolwich	Sagadahoc
#5750	Belfast	Veterans Memorial
#6371	Brunswick-Topsham	Merrymetting Bay
#1510	Brunswick-Topsham	I-295 SB/Androscoggin River
#6268	Brunswick-Topsham	I-295 NB/Androscoggin River
#6440	Calais	International
#5572	Caribou	Aroostook River
#3257	Deer Isle-Sedgwick	Deer Isle
#1456	Fairfield-Benton	C.A. Clauson SB
#6000	Fairfield-Benton	C.A. Clauson NB
#2033	Harpswell	Bailey Island
#5500	Jonesport-Beals	Beals Island
#6330	Kittery-Portsmouth	Piscataqua River
#3641	Kittery-Portsmouth	Sarah Mildred Long
#2546	Kittery-Portsmouth	Memorial
#1477	Kittery	I-95/Rt. 103
#1410	Medway	Vaughan Daggett SB
#6078	Medway	Vaughan Daggett NB
#2187	Norridgewock	Covered
#3088	Portland	Tukey's
#2515	Portland-Falmouth	Martin's
#5900	Portland-South Portland	Casco Bay
#3945	Portland-South Portland	Veterans Memorial
#6421	Prospect-Verona	PNBO
#2506	Richmond-Dresden	Maine Kennebec
#5817	Waterville	I-95 NB/Messalonskee Stream
#1458	Waterville	I-95 SB/Messalonskee Stream
#1141	Waterville-Winslow	Donald V. Carter
#2262	Wiscasset-Edgecomb	Donald Davey
#5635	Yarmouth	Ellis C. Snowdgrass Memorial

Appendix D

Case Study ~ Brownville, Whetstone Bridge #3588
Analysis of Bridge Alternatives and Costs

Background

Prior to replacement in the summer of 2014, Whetstone Bridge in Brownville consisted of a 15' diameter steel structural plate pipe arch carrying Route 11 over Whetstone Brook. Route 11 is classified as a major collector (MaineDOT HCP 3) and in 2011 the AADT was 1,880 vehicles per day. The structure was built in 1961 and was in poor condition with heavy rusting along the flow line with holes within 10' of either end. A hydraulic analysis indicated that the pipe was adequately sized, flowing less than 80% full at Q50. Whetstone Brook is considered critical habitat for Atlantic Salmon and formal Section 7 consultation was anticipated for any repair or replacement option proposed. The bridge was originally programmed for replacement for $500,000.

Analysis of Options

During preliminary design the Bridge Program investigated the following options:
Option #1 – Rehabilitate the existing structure by installing a reinforced concrete invert lining with three internal weirs to facilitate fish passage. The invert lining would reduce the opening by approximately 6% and increase the headwater depth by about 4% at Q50. The total estimated cost was $335,000 and was expected to extend the life of the existing pipe by 40 years. This option had minimal impact on traffic.

Option #2 – This option consisted of replacement with a 22' span by 12' rise precast concrete box culvert which corresponds to the bankfull width as measured by MaineDOT biologists. This option reduced the headwater elevation at Q50 by over 4'. The total estimated cost for this option was $690,000 with a 75 to 100 year service life. Traffic would be maintained on site using staged construction.

Option #3 - This option consisted of replacement with a 26-foot span by 11-foot rise precast concrete box culvert which corresponds to 1.2 bankfull width. This option provided an opening 31% larger than the existing pipe. The total estimated cost for this option was $915,000 with a 75 to 100 year service life. Traffic would be maintained on site using staged construction. Preliminary design was completed in June 2011 and recommended option #1 since it had the lowest up-front cost, minimized traffic impacts, and would provide acceptable hydraulic performance.

Final Design and Permitting

The Bridge Program carried the invert lining through design with the intent of advertising the project in 2012; however, MaineDOT was unable to permit this option since it was determined to be an adverse impact to the Atlantic Salmon critical habitat.

After further consultation with the environmental agencies, MaineDOT chose to advance option #3 – 26' span precast concrete box meeting the 1.2 bankfull width requirement. This option was permitted and ultimately advertised February 2014. The final details of the project included:

- 26-foot span by 11-foot rise by 198 foot long precast concrete box culvert;
- The invert placed 2 feet below the streambed with 13 rock weirs and 2 feet of special fill to simulate the natural streambed;
- 225 feet of roadway reconstruction with extensive riprap slope stabilization;
- Traffic maintained on site using staged construction

Bids for the project ranged from $1.394 to $1.863 million for construction, and at the completion of the project the total cost including construction, engineering and ROW is $1.6 million. The original program amount of $500,000 was based on historic cost information for an in-kind replacement. The cost increase can be attributed to many factors, including the change from a steel pipe to a concrete box, complexity of maintaining traffic using staged construction, and inflationary increases from 2011 to 2014. However, the most significant increases were due to environmental requirements such as increasing the span to 26 feet and simulating the natural stream by lowering the invert 2 feet below the stream bed and installing rock weirs and stream bed material. This project was developed during a time of increased focus on endangered species. Prior to 2011, we had successfully permitted culvert rehabilitation projects in areas classified as critical habitat as long as fish passage was provided. During this project the bar was raised with the expectation being that bridge projects restore habitat. This project demonstrated the importance of coordination with the MaineDOT Environmental Office during development of the Work Plans to ensure that projects are correctly scoped and funded.

Appendix E
MaineDOT - Local Cost-Sharing Policy

A. Purpose and Applicability

1. **Purpose** - The purpose of this policy is to create fair and consistent basis for sharing the cost of major investments to the state highway and bridge system.

2. **Applicability**

   a. **Projects Selected through the MaineDOT Work Plan Process** - This policy applies to Major Treatments funded in a MaineDOT Work Plan. except those projects located within a Metropolitan Planning Organization (MPO) Capital Management Area, or those subject to an alternative cost-sharing arrangement that has been negotiated and executed by MaineDOT and the municipality prior to the effective date of this policy. An MPO may apply this match policy at its discretion, provided that it is outlined in the MaineDOT/MPO/Municipal three-party agreement.

   b. **Project Requests Outside of MaineDOT's Work Plan Process** - If a municipality or other public entity seeks to develop a new project outside the MaineDOT Work Plan process, prior to considering the project, MaineDOT may require a project-funding commitment of 20% to 50% for project planning, design and construction,. *[This municipal commitment is required because accelerating new projects may delay projects that have been in the planning or design phase for years, waiting for scarce transportation funding. The increased local share may also create an incentive for MaineDOT to invest on highways of more local significance, (as opposed to statewide or regional significance)—investments that MaineDOT would not otherwise make, given other transportation needs across the state.]* MaineDOT's decisions regarding project approval and percentage of local match will be subject to available state and federal transportation funding, Highway Corridor Priority, Customer Service Levels, potential statewide and regional transportation benefits, and other possible considerations.

B. Cost-Sharing Policies

1. **Highway Portion of a Project** - MaineDOT will pay 100% of the costs necessary to improve the Highway Portion of the Project, as determined by MaineDOT.

2. **Highway Sidewalks**

   a) **Existing Sidewalks** - Except as otherwise provided in this policy, the municipality will be responsible for 20% of the cost of replacing or rehabilitating Existing Sidewalks. No local share will be required for Existing Sidewalk replacement or rehabilitation when the sole reason for the work is due to the Highway Portion of the Project, as determined by MaineDOT. ADA compliance and feasibility must be determined pursuant to 28 CFR 35.150 and ADAAG sec.4.1.6(j.).

   b) **New Sidewalks** –

      If a New Sidewalk is located within a Compact Area or Qualifying Pedestrian Area, the municipality will be responsible for 20% of the cost of New Sidewalks. If the New Sidewalk is located outside of a Compact Area or Qualifying Pedestrian Area, the sidewalk will be considered a Local-Interest Element.

   c) **Scope of Sidewalk Costs** - Sidewalk costs include all costs associated with the construction of the sidewalk, including necessary drainage improvements (including underground storm drainage systems) and property acquisition that are directly related to the existence or installation of the sidewalk.

   d) **Sidewalk Maintenance** - Municipalities will be responsible for year-round maintenance of new or replaced/rehabilitated pedestrian facilities, as necessary, MaineDOT reserves the right to perform maintenance and invoice the municipality if appropriate maintenance is not satisfactorily performed by the municipality.

3. **Bridge Portion of a Project** - MaineDOT will pay 100% of the costs necessary to improve the Bridge Portion of the Project, as determined by MaineDOT.

4. **Bridge Sidewalks**

   a. If a bridge is located within a Compact Area or Qualifying Pedestrian Area, there will be no local share for the cost of replacement or new sidewalks or multi-use shoulders on the bridge.

   b. If a bridge is located outside a Compact Area or Qualifying Pedestrian Area, sidewalks including replacement sidewalks or multi-use shoulder will be considered Local-Interest Elements.

5. **Local-Interest Elements** - Subject to available funding and to the extent of monetary contributions from local sources, MaineDOT, at its discretion, may contribute up to 50% of the cost of Local-Interest Elements that are eligible for state Highway Fund and Federal Highway Administration funding, provided that MaineDOT's share of such costs will not exceed 10% of the overall project cost.

C. Definitions

ADA - The American with Disabilities Act, 42 U.S.C § 12101, et. seq.

ADAAG - ADA Accessibility Guidelines, 28 CFR § 36.406.

Compact Area - (State Urban Compact Area) - An area where structures are nearer than 200 feet apart for a distance of one-quarter mile or more, as defined in 23 MRSA §2.

CFR - Code of Federal Regulations.

Highway Portion of a Project - That portion of a project located from curb to curb, including existing curbing and related drainage, or between highway ditches, and structures necessary to sustain or improve that portion of the highway carrying vehicular travel.

Bridge Portion of a Project – That portion of a project that is necessary to sustain or improve vehicular travel, including highway approach work, foundations, abutments, piers, superstructure and bridge railing.

Local-Interest Elements - Project elements outside the scope of the Highway Portion or Bridge Portion of the Project that have more local (as opposed to statewide) benefit, as determined by MaineDOT. Local-Interest Elements include pedestrian lighting, landscaping, plantings, streetscape furniture (benches, bike racks, trash cans, etc.), alternative pavement treatments, shoulder surface treatments or modified striping, additional or modified parking, granite curbing, concrete pavement, architectural treatments on bridges or other structures, and auxiliary lanes, jug handles, frontage roads, etc. that are primarily for local community-development purposes. Local-Interest Elements also include planning, design, or public input processes that are not approved by MaineDOT in advance.

MPO - Metropolitan Planning Organization as provided by 23 U.S.C. § 134.

MaineDOT - The Maine Department of Transportation.

Major State Highways - Arterial highways, major collector highways, and urban collector highways that are part of a highway corridor that would be classified as a major collector outside of the federal urbanized area.

Major Treatment - Any new-alignment project, or substantial improvement or rehabilitation of the structural base and drainage structures of the highway. Regarding bridge projects, Major Treatment means full replacement, superstructure replacement, or widening. Major Treatments do not include safety or system preservation activities such as hazard elimination projects, rail crossing upgrades, maintenance paving projects, pavement preservation projects, bridge painting, and bridge deck replacements.

Multi-Use Shoulder - A shoulder designed to accommodate bicycle and pedestrian activity and/or motorized recreational vehicle use, including ATVs and snowmobiles.

Qualifying Pedestrian Area - An area that MaineDOT determines will have substantive pedestrian activity or use during the expected life-cycle of the project. In making this determination, MaineDOT will be guided by existing, planned, or forecasted sidewalks and/or pedestrian generators (including neighborhoods, businesses, government buildings, village areas, schools, recreational facilities, etc.), directly adjacent or within reasonable walking distance. Other factors include whether the existing or future pedestrian activity is consistent with the municipal transportation plan, comprehensive plans, capital plans, zoning, and/or other longer-term planning and investment (including documented funding implementation) documents that have been adopted by the legislative body of the municipality.

Sidewalks - Paved areas for pedestrians, usually on the side of a street or roadway, separated from vehicular traffic by either a curb or esplanade. Existing Sidewalks are sidewalks that are existing and maintained in a usable condition at the time the project is being programmed. "New Sidewalks" mean all sidewalks that are not already existing and maintained.

D. Implementation

1. **Prior Written Agreement** - For projects to which this policy applies, written Local Cost-Sharing Agreements consistent with this policy will be developed during the project scoping process and executed prior to programming the project in a MaineDOT Work Plan for design or construction. In the absence of such an agreement, the municipality shall be responsible for 10% of the total project cost (including the Highway or Bridge Portion).
2. **Municipally Funded Items** - Upon mutual agreement between MaineDOT and the municipality, items that are funded entirely by the municipality may be added to the project. Such items may include highway treatments or project elements that are beyond the scope of the Highway or Bridge Portion of the Project, certain Sidewalks, and Local Interest Elements.

E. Appeal Process

Municipalities may appeal decisions made by MaineDOT under this policy to the Director of the Maine Bureau of Planning. The letter of appeal should be submitted to:

Director, Bureau of Planning
Maine Department of Transportation
16 State House Station
Augusta, Maine 04333-0016

F. Effective Date

The policy is effective as of June 18, 2014.

Herb Thomson, Director

MaineDOT Bureau of Planning

Appendix F
Team Biographies (Alphabetical)

Mark Buckbee
Title: Director, Bridge and Marine Construction
Affiliation: Reed & Reed, Inc., Woolwich, Maine
Date of PE: 1988 (26 years)
Education:
- Major: B.S. in Civil Engineering, University of Maine, 1982

Present Work: Reed & Reed is a heavy civil contractor, performing bridge, marine, wind power and other heavy civil work throughout New England. Mr. Buckbee oversees the estimating and management of bridge and marine work. He was Project Manager for the joint-venture contract on MDOT's Penobscot Narrow Bridge design-build, and Contract Manager for MDOT's Veteran Memorial Bridge and Turner-Greene design-builds.

John (Jack) Burgess
Title: Senior Structural Engineer
Affiliation: Becker Structural Engineers, Inc.
Date of PE: 1987 (27 years)
Education:
- Major: M.S. in Civil Engineering, University of Texas at Austin, 1986
- Major: B.S. in Civil Engineering, University of Vermont, 1980

Present Work: Senior Structural Engineer at Becker Structural Engineers, an engineering consulting firm in Portland, Maine. Mr. Burgess's current responsibilities include design and project management of bridge projects with the MaineDOT and local municipalities.

General: Mr. Burgess has over twenty seven years of structural engineering experience as a registered engineer in the State of Maine. He has been designing bridges for the MaineDOT as a consulting engineer for twenty years. Prior to joining Becker Structural Engineers in 2007, he worked at Caswell Engineering in Brunswick for 16 years. Mr. Burgess has designed a wide variety of steel and concrete bridges ranging from minor spans to multi-span river crossings. His bridge experience also includes load ratings, hydraulic analyses, maintenance of traffic studies, preliminary design reports and preparation of plans, specifications and estimates.

John E. Buxton
Title: Bridge Maintenance Engineer/Deputy Chief Engineer
Affiliation: MaineDOT, Bureau of Maintenance and Operations, Bridge Maintenance Division
Date of PE: 1986 (28 years)
Education:
- B.S. Civil Engineering/Structural, University of Maine at Orono, 1980

Present Work: The Bridge Maintenance Engineer is responsible for maintaining public bridges, state rail lines and providing technical support for all other ancillary transportation structures. The position ensures public safety through a diligent bridge inspection program, prioritizing bridge activities in the capital and maintenance work plans, actively participating in the rating and posting of the bridge inventory and advising municipalities of the safety, maintenance and repair of their bridges. Active member and participant in the Northeast Bridge Preservation Partnership.

General: 20 years' experience in Bridge Design and 13 years' experience in Bridge Maintenance

John Cannell

Title: MaineDOT Southern Region Manager
Affiliation: MaineDOT
Date of PE: 1/24/2000 (15 years January)
Education:
B. S. in Civil Engineering, Worcester Polytechnic Institute
Present Work: John is currently the Region Manager for MaineDOT's Southern Region which includes all of York and Cumberland Counties and parts of Oxford, Androscoggin, and Sagadahoc Counties. In that capacity he is responsible for maintenance of 2600 summer lane miles, 1300 winter lane miles, and 561 bridges. In order to achieve this goal he manages a staff of 189, a budget of $22 million, and a fleet that that includes 72 plow trucks, 20 pieces of heavy construction equipment, and all other related gear. John was heavily involved in the development of the Departments' Municipal Partnership Initiative (MPI) program, the development of the Transportation Worker Program, and has piloted contracting initiatives in Region 1 that include contracting mechanic labor in the Scarborough Fleet Services facility and contracting select bridge maintenance activities in the Region. As Region Manager, John sits on the Maintenance and Operations Board of Directors which sets statewide policy for the Bureau.

General: John has also served at MaineDOT as the Statewide Fleet Manager and the Statewide Building Manager. In those capacities he implemented and managed replacement and repair plans for the entire MaineDOT fleet and MaineDOT building network.

Bill Davids

Title: John C. Bridge Professor and Chair of the Civil and Environmental Engineering Department, UMaine
Affiliation: Dept. of Civil and Environmental Engineering, University of Maine
Date of PE: Dec. 19, 1995 (19 years)
Education:
- Ph.D. Major: Ph.D. in Civil Engineering, University of Washington, 1998
- Major: M.S. in Civil Engineering, University of Maine, 1991
- Major: B.S. in Civil Engineering, University of Maine, 1989

Present Work: Dr. Davids has been a faculty member at the University of Maine since 1998 and Department Chair since 2012. He has taught undergraduate courses in structural analysis and design as well as graduate courses in bridge engineering, advanced structural analysis, and numerical methods. Dr. Davids maintains an active research program in the areas of bridge engineering, the testing and analysis of inflatable fabric structures for space and terrestrial applications, and the mechanics of wood and engineered wood. He has published over 40 journal articles and has released four finite-element software packages for the analysis of pavements, bridges, and inflatable structures. Dr. Davids has directed over $6M of state and federally-funded research while at the University of Maine.

Maria Drozd

Title: Bridge Engineer
Affiliation: FHWA Maine Division Office
Date of P.E.: July 1991 (23 years)
Education:
- Major: Civil Engineering/Structural, University of New Hampshire

Present Work: Ms. Drozd administers the Federal-Aid bridge program in Maine. Her responsibilities include bridge design, inspection, construction, and maintenance, and bridge hydraulics and geotechnical engineering.
General: Structural Engineer, FHWA, FLH Bridge Design Office, 1992-2003
Highway Engineer, FHWA, FLH Roadway Design Office 1991-1992
Highway Engineer, FHWA, Highway Engineer Training Program/Bridge Design, 1989-1991

Ben Foster

Title: Assistant Bridge Maintenance Engineer
Affiliation: MaineDOT
Date of PE: January 2002 (12 years)
Education:
- Major: M.S. Civil Engineering, University of Maine, 1998
- Major: B.S. Civil Engineering, University of Maine, 1996

Present Work: The Assistant Bridge Maintenance Engineer is responsible for the Bridge Inspection Program and the engineering section of Bridge Maintenance. Core responsibilities include approving all bridge inspections, assuring the Inspection Program meets all federal requirements, and assists in maintenance repairs and rehabilitations designs. The position also sits on the Bridge Committee, helps develop MaineDOT's Work Plan, and sits on the Bridge Posting Committee.

General: Mr. Foster has 16 years of bridge experience at MaineDOT comprised of 9 years designing bridges and 7 years in Bridge Maintenance.

Jim Foster

Title: Bridge Management Engineer
Affiliation: MaineDOT
Date of PE: 1986 (28 years)
Education:
- Major: B.S. in Agricultural Engineering Technology, University of Maine Orono, 1978
- Major: Civil Engineering, continuing education through 1983, University of Maine Orono

Present Work: The Bridge Management Engineer analyzes current and future funding needs and strategies, utilizing asset management software, for the preservation, rehabilitation and replacement of Maine's bridge network. This position is also responsible for the bridge portion of MaineDOT's Work Plan.

General: Mr. Foster has 35 years of experience at MaineDOT, including 13 years in the Bridge Design Division, 2 years of bridge inspection, and 19 years in Bridge Management. He is a current member of the Bridge Committee and the Bridge Posting Committee.

Wayne Frankhauser Jr.

Title: Bridge Program Manager
Affiliation: MaineDOT, Bureau of Project Development
Date of PE: 2000 (14 years)
Education:
- B.S. in Civil Engineering, University of Maine

Present Work: Wayne Frankhauser is currently Manager of the MaineDOT Bridge Program and is responsible for all aspects of capital bridge improvement projects from inception to construction complete. Wayne also works closely with other members of the Bridge Committee to develop the MaineDOT Work Plan and is a member of the MaineDOT Bridge Posting Committee.

General: Wayne has over 20 years of experience with MaineDOT working as a bridge designer, project manager and as the Engineer of Design for the Bridge Program before becoming the Program Manager.

Chip Getchell

Title: Director – Work Plan Division
Affiliation: MaineDOT
Date of PE: 1995 (19 years)
Education:
- University of Maine - Advanced mathematics and structural engineering courses

Present Work: Chip leads and manages the Work Plan Division, which is responsible for development of the Department's Work Plan. The Work Plan includes all highway, bridge, and multimodal investments over a three year period, with a value of approximately $650M per year. This Division also developed and operates MaineDOT's Asset Management System and fulfills certain Federal reporting requirements.

General: Prior to leading the Work Plan Division, Chip split his time between the Chief Engineer's Office and the Executive Office, where he provided Department-wide engineering policy oversight and certain legislative functions. He is past Chair of the MaineDOT Engineering Council and the Bridge Committee. Prior to joining the Executive Office, Chip spent 10 years in the Bridge Section where he gained design and construction experience, and went on to manage the Local Bridge Program. He also assisted with the delivery of two major Design-Build projects – Sagadahoc Bridge and the Penobscot Narrows Bridge and Observatory.

Peter Krakoff

Title: Vice President/Chief Engineer
Affiliation: CPM Constructors, Freeport, Maine
Date of PE: 1984 (30 years)
Education:
- Major: B.S. in Civil Engineering, University of Maine 1980
- Major: B.A. in Liberal Arts, Colby College 1972

Present Work: CPM is a general contractor performing bridge, highway and other heavy civil work throughout northern New England. Mr. Krakoff manages the company's estimating department as well as overseeing the in-house engineering and design functions for the company. In 2005-2006, he was also the on-site project manager for the rehabilitation of the Augusta Memorial Bridge. He was project manager for two MaineDOT design build projects: The Martin's Point Bridge between Portland and Falmouth and the Garland Road Bridge in Winslow.

Dale Peabody

Title: Transportation Research Division Director
Affiliation: MaineDOT
Date of PE: 1987 (27 years)
Education:
- B.S. Civil Engineering , University of Maine, 1983

Present Work: Responsible for planning and delivering the department research program. Serve as administrator and coordinator for numerous Bridge related research studies that are contracted with the University of Maine. Projects include use of advanced modelling and live load testing diagnostics for effective load rating, improvements to concrete filled FRP tubes for bridge construction, investigation and testing of FRP piles. Also leads activities on evaluation and mitigation of alkali silica reactivity in our concrete structures.

General: Mr. Peabody has over 31 years of experience with MaineDOT, including 10 years with Bridge Design, Maintenance and Construction.

Eric C. Shepherd

Title: Assistant Program Manager
Affiliation: MaineDOT Bridge Program
Date of PE: July 1988 (26 years)
Education:
- Major: B.S. in Civil Engineering, University of Maine, 1983

Present Work: Responsible for management of all aspects of construction oversight of projects developed by the Bridge Program; Area Construction Engineer; Fabrication Engineer.

Additional Experience: Mr. Shepherd has worked for the MaineDOT since 1990. Work experience at the MaineDOT includes Construction Inspector, Resident Engineer and Assistant Construction Engineer in the Construction Division, Construction Support Manager in the Highway Program and Area Construction Engineer in the Bridge Program. Prior to working for the MaineDOT, Mr. Shepherd was a Senior Engineer for Great Northern Paper Company, Millinocket, Maine.

Joyce Noel Taylor

Title: Chief Engineer
Affiliation: MaineDOT
Date of PE: February 1991 (23 years)
Education:
- Major: B.S. in Chemical Engineering, University of Maine at Orono, 1986

Present Work: Responsible for managing the transportation assets of MaineDOT. Duties include: setting engineering standards and policies applicable for the entire department, assure that engineered products are safe and cost effective, establish and maintain engineering excellence through innovation, research and calculated risk taking, post bridges, asset inventory and condition and for better defining highway and bridge adequacy, assure on-going engineering excellence through recruitment and training. She has worked on various high profile department projects, most recently heading the Sarah Mildred Long project between Maine and New Hampshire using the CMCG procurement method.

General: Joyce has over 19 years of experience with MaineDOT. Mrs. Taylor started at the department by working in the Construction Division as the Environmental Engineer and has held various positions including Bureau Director of Project Development until she became Chief Engineer in 2013.

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