FINAL REPORT

Implementation of the 2013 AASHTO Manual for Bridge Element Inspection

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
AREA				
in^2	Square inches	645.2	square millimeters	mm^2
ft^2	Square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5(F-32)/9 or (F-32)/1.8	Celsius	°C

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003).

APPROXIMATE CONVERSIONS FROM SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
AREA				
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
TEMPERATURE (exact degrees)				
°C	Celsius	1.8C+32	Fahrenheit	°F

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
ILLUMINATION				
lx	Lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per	lbf/in^2

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16. Abstract

The Florida Department of Transportation (FDOT) has been collecting bridge element condition data and using its AASHTOWare Pontis bridge management system since the 1990s. FDOT has prepared its own version of the new AASHTO Bridge Element Inspection Manual to address some identified potential improvements. FDOT will need to adapt its decision support models to the new standards in order to use them with the new inspection data in AASHTO's Bridge Management System (BMS) software.

This study has revised the existing methodology for computing the bridge health index (BHI) by investigating various approaches to assigning state weights and element importance weights. A list of recommended element weights is presented to FDOT as well as a methodology for calculating the BHI. A revised list of preservation actions was formulated to be compatible for use in the BMS software, based on the description of bridge elements, their condition states, and various levels and extents of defects in the FDOT Bridge Inspection Guide. New transition times for deterioration between states were developed to enhance the migration of the Pontis deterioration model to the BMS software. The action effectiveness model was revised, based on the new bridge element inspection manual. Based on historical costs and some assumptions, preservation unit costs and other cost parameters were provided as necessary to run the BMS software. Finally, the research team developed the migration of preservation benefits and optimization results to the BMS software, and performed the necessary enhancements to the Project Level Analysis Tool to support decision making at FDOT.

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EXECUTIVE SUMMARY

The Florida Department of Transportation (FDOT) has been collecting bridge element condition data since the late-1990s, implementing the AASHTO CoRe Element Guide (AASHTO, 1998) for use with its AASHTOWare Pontis bridge management system. Over time, the Department augmented its bridge inspection process to incorporate specialized elements that are of particular maintenance concern in Florida. The Department has conducted innovative research to develop its own deterioration models, action cost and effectiveness models, and decision support tools for life cycle cost analysis and risk analysis at the project level and program level. Departments of transportation in Florida and in many other states have identified a number of potential improvements: more precise definition of the specific types of defects that are considered in condition state assessments; separate assessment of certain types of protective systems from their underlying elements, especially deck wearing surfaces, coating systems, and cathodic protection systems; and standardization of the number of condition states possible for each element. AASHTO has developed a new manual to aid the states in accomplishing these improvements. FDOT has prepared its own version of this manual, containing its agency-defined elements. The Department will need to adapt its decision support models to the new standards in order to use them with the new inspection data in the AASHTOWare Bridge Management System (BMS) software and the Project Level Analysis Tool.

Bridge inspection practice is increasingly moving toward a standard that makes a separate assessment of each major deterioration process or protective system. The 2013 AASHTO Manual for Bridge Element Inspection (AASHTO, 2013) provides four condition states for increasing levels of severity of each of the following defects: delaminations, spalls, and patched areas; exposed rebar or prestressing tendons; efflorescence and rust staining; corrosion; cracking (distinguishing concrete, steel, and timber), load capacity, and collision damage; damaged connections; timber decay; timber checks; abrasion; distortion; settlement; scour; mortar breakdown; masonry displacement; restricted movement or misalignment of bearings; bulging, splitting, or tearing of elastomeric bearings; loss of bearing area; debris impaction; and damage to expansion joint hardware or deck interface. The latest version of the AASHTOWare BMS is a substantial change from Pontis, because of the new element inspection process and because of new functionality under development to take advantage of the improved element data. Although major differences exist between the earlier CoRe Element Guide and the new Element Manual, both documents describe fundamentally the same thing, the condition of bridge elements.

Florida's current Pontis implementation uses a failure cost analysis to compute health index weights, considering both agency and user costs. BMS does not have failure costs in its analytical framework, so an alternative system of element weights was developed. The researchers performed a search of bridge management literature to look for examples of agency experience in customizing the health index weights. BMS defines a concept of bridge-level actions which is much broader than earlier versions of Pontis. An action in BMS can be any combination of elements: maintenance, repair, and rehabilitation activities on any or all elements; risk mitigation; and functional improvements. A bridge level preservation action is defined as a list of element/state actions which are consistent with earlier versions of Pontis. Like Pontis, BMS uses hybrid Markov/Weibull deterioration models to forecast bridge condition through most of the deterioration profile. The advantage of these models is that they are very simple and can be developed in a variety of ways using small cross-sectional data sets (Thompson et al., 2012) or expert judgment (Cambridge, 2003).

Revised health index

The methodology and sample calculations have been presented for developing the bridge health index for implementation in the BMS software. Investigation was made into various approaches of assigning health index weights, and a simple method is described. Element importance weights have been developed and discussed, considering the use of element replacement unit costs, element long-term unit costs, the element's vulnerability to hazards, and the BMS element classification (element class, category, and type). A consideration is also presented on the use of the Analytic Hierarchy Process (AHP) as a tool for estimating element weights. Finally, after incorporating engineering judgment, a list of recommended element weights is summarized.

Preservation actions

This task involved the revision of preservation actions for use in the new BMS software. Based on the FDOT Bridge Inspection Guide, the research team utilized the description of bridge elements, their condition states and various levels and extents of defects, to formulate a set of appropriate feasible preservation actions. An initial list was developed and submitted to the FDOT State Maintenance Office. After a review by FDOT and suggested corrections, the list was revised and finalized for use.

Deterioration model migration

New transition times were developed using a set of probabilistic correspondences between CoRe element condition states and the new state definitions – a migration probability matrix -- to yield a deterioration model for every element in the new FDOT Manual. The result can be imported directly into the new PON_MOD_DETER table in AASHTOWare Bridge Management once it is ready. An Excel file containing this information was delivered during the study. The biggest shortcoming with the new models is the fact that the migration probability matrix had to be developed from judgment. Once FDOT completes a year or two of inspections under the new manual, a better approach will be possible. The most recent CoRe element inspection on each bridge can be projected forward two years using the CoRe element deterioration model. Then a migration probability matrix can be computed by comparing the new inspections against the projected estimates, using an algebraic method similar to the one-step method (Sobanjo and Thompson, 2011). In the longer term, after two or more complete cycles of inspections are completed under the new manual, a new set of deterioration models can be developed as was done in the 2011 study.

Action effectiveness model

In research completed in 2010, a 14-year history of FDOT element inspections was analyzed to compute typical transition probabilities describing the change in bridge element condition between successive inspections when a preservation action was taken for use in Pontis. AASHTOWare Bridge Management uses the same types of effectiveness models and a similar structure of transition probabilities as Pontis. The same migration probability matrix, developed for deterioration models, combined with expert judgment, was used to convert the previous research results to fit the new elements, condition states, and preservation actions. Since the models are very consistent with the 2010 research, they should be suitable for FDOT production use in the interim period until the Department has sufficient inspections under the 2015 element manual to enable a new statistical analysis.

Migration of cost models

It was necessary to provide preservation unit costs and other cost parameters necessary to run the BMS software for FDOT. An assignment mechanism was developed to match new BMS elements to old Pontis

elements, in order to make use of the historical cost records. The new list of feasible actions from this study was matched to corresponding element state action data from the historical costs. The concept of action subcategory, utilized in the previous FDOT BMS studies, was also applied in assigning costs.

Migration of preservation benefits and optimization results

An algorithm was developed to convert network optimization results from Pontis to be compatible with the new elements, condition states, and actions for use in PLAT. Every element has a recommended do-something action in condition state 4. This action is usually element replacement, except for large elements and substructure elements that are very expensive to replace, where major repairs were found to be optimal. About half of the elements have optimal corrective actions in state 3 and/or 2. Long-term benefits were affected by the environment category, usually (but not always) providing higher benefits for elements in more severe environments. In no cases did the difference in benefits affect the choice of action, however. Since the models are very consistent with the 2010 research, they should be suitable for FDOT production use in the interim period until the Department has sufficient inspections under the 2015 element manual to enable a new statistical analysis. In the initial testing using the revised PLAT model, some judgment-based modifications were found to be necessary to the life cycle costs for wearing surfaces, deck substrates, and coatings, which were not separately modeled under the CoRe element system.

PLAT enhancements

To support decision making in the central office and districts, FDOT uses a spreadsheet model developed in earlier research, known as the Project Level Analysis Tool (PLAT). This model is based on many of the same analysis inputs as Pontis, and uses Pontis bridge inspection data, but is adapted to the management requirements of FDOT. PLAT includes a number of modeling refinements to enable a more realistic project level scope and cost estimate than is possible in Pontis. The algorithms for these refinements were modified in order to operate correctly with the new data. Among the affected refinements are deterioration adjustments, scoping rules, and quantity prediction rules. Much of the new functionality involves interactions among elements. New releases of the PLAT and NAT software and Users Manuals and a refreshed version of the PLAT Results Database have been delivered to FDOT. This Final Report describes only the changes made to PLAT in the current study. Consult the user manuals for a complete description of the models' functionality.

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1. Introduction and background

The Florida Department of Transportation began gathering bridge element condition data as part of its routine biennial inspections in the late 1990s, implementing the AASHTO CoRe Element Guide (AASHTO, 1998) for use with its AASHTOWare Pontis bridge management system. Over time, the Department augmented its bridge inspection process to incorporate the specialized elements of movable bridges, to add elements that are of particular maintenance concern in Florida (such as pile jackets, drainage systems, fenders, dolphins, and seawalls), and to add non-bridge structures such as sign supports, high-mast light poles, mast arms, and certain retaining walls (FDOT, 2008).

Using its element inspection standards, the Department conducted innovative research to develop its own deterioration models, action cost and effectiveness models, and decision support tools for life cycle cost analysis and risk analysis at the project level and program level. In particular, FDOT has statistically rigorous bridge deterioration and cost models that it uses for many purposes in planning of bridge work (Sobanjo and Thompson, 2011).

As many states gained experience with the element inspection process, a number of potential improvements were identified. Among them were the following:

- A more precise definition of the specific types of defects that are considered in condition state assessments
- Separate assessment of certain types of protective systems from their underlying elements, especially deck wearing surfaces, coating systems, and cathodic protection systems
- Standardization of the number of condition states possible for each element.

An initial version of a new guide manual was adopted in 2010 (AASHTO, 2011), and was revised as an official AASHTO Manual shortly thereafter (AASHTO, 2013). FDOT prepared its own version of this manual, containing its agency-defined elements, the next year (FDOT, 2014). Currently the Department is preparing to begin inspections using the new manual (FDOT, 2015a), as soon as the corresponding AASHTOWare Bridge Management software revisions are completed. FDOT will need to adapt its decision support models to the new standards in order to use them with the new inspection data in AASHTO's new software.

Prior to commencement of the research, a search was conducted for relevant literature on topics to be addressed by the study. The literature is summarized in the following areas:

- An overview of the evolution of element inspection, leading up to the latest FDOT Draft Bridge Inspection Field Guide.
- Experiences with migration to the new AASHTO Element Inspection Manual.
- Definition and customization of the health index.
- Preservation actions, costs, and effectiveness.
- Deterioration models.

This literature was used in later tasks to assist in preparing Florida bridge management models for use in the new AASHTOWare Bridge Management software.

1.1 Evolution of element inspection

Since the 1970s, states have been required to gather a standardized data set of bridge inventory and biennial inspection data for submittal to FHWA each April. These are compiled into a National Bridge Inventory (NBI), intended to keep the Congress informed of the conditions and performance of the

nation's more than 600,000 bridges (FHWA, 1995). The NBI has only four data items describing bridge condition:

58 – Deck condition rating
59 – Superstructure condition rating
60 – Substructure condition rating
62 – Culvert condition rating

These four items represent separate parts of a structure, with a focus on the primary load-bearing components. Since the NBI Coding Guide is focused on safety rather than on maintenance needs, certain components having significant maintenance costs (such as expansion joints) receive little or no consideration when assigning a condition rating. Each item is recorded using a coding scheme as follows:

9 EXCELLENT CONDITION

8 VERY GOOD CONDITION - no problems noted.

7 GOOD CONDITION - some minor problems.

6 SATISFACTORY CONDITION - structural elements show some minor deterioration.

5 FAIR CONDITION - all primary structural elements are sound but may have minor section loss, cracking, spalling or scour.

4 POOR CONDITION - advanced section loss, deterioration, spalling or scour.

3 SERIOUS CONDITION - loss of section, deterioration, spalling or scour have seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present.

2 CRITICAL CONDITION - advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken.

1 "IMMINENT" FAILURE CONDITION - major deterioration or section loss present in critical structural components or obvious vertical or horizontal movement affecting structure stability. Bridge is closed to traffic but corrective action may put back in light service.

0 FAILED CONDITION - out of service - beyond corrective action.

N NOT APPLICABLE

Proposed federal rules require the development of condition targets based on these four condition ratings (FHWA, 2015). The targets are expressed as the percent of NHS deck area on bridges in Good condition and Poor condition, based on the worst applicable NBI condition rating on each bridge, defined as follows:

Good = NBI ratings 7, 8, or 9
Fair = NBI rating 5 or 6
Poor = NBI rating 0, 1, 2, 3, or 4

When any of the NBI condition ratings is 4 or below, the bridge is considered "structurally deficient". Other criteria can also sometimes cause a bridge to be classified structurally deficient. A bridge receives only one value for each condition rating. If it receives a rating for item 62, it usually does not receive a condition rating for any of the other items.

Although the FHWA Coding Guide is still mandatory, bridge owners have found that the four condition ratings are insufficient for asset management purposes. They do not provide enough information on the

cause of deterioration, to forecast future condition or select appropriate maintenance actions, and they do not provide enough information on the extent of deterioration for cost estimation.

As a result, nearly all bridge management systems worldwide use a more extensive condition description organized according to elements and condition states. In the United States, most of these systems are based on the AASHTO CoRe Element Guide (AASHTO, 1998). The guide defines more than 100 common structural elements (Table 1.1) and provides objective visual language for recognizing 3-5 condition states for each element (Table 1.2). Inspectors record the quantity or percentage of each element found to be in each condition state.

Table 1.1. AASHTO Commonly-Recognized (CoRe) Bridge Elements (AASHTO, 1998)

Deck elements	
12	Concrete Deck - Bare
13	Concrete Deck - Unprotected w/ AC Overlay
14	Concrete Deck - Protected w/ AC Overlay
18	Concrete Deck - Protected w/ Thin Overlay
22	Concrete Deck - Protected w/ Rigid Overlay
26	Concrete Deck - Protected w/ Coated Bars
27	Concrete Deck - Protected w/ Cathodic System
28	Steel Deck - Open Grid
29	Steel Deck - Concrete Filled Grid
30	Steel Deck - Corrugated/Orthotropic/Etc.
31	Timber Deck - Bare
32	Timber Deck - w/ AC Overlay
38	Concrete Slab - Bare
39	Concrete Slab - Unprotected w/ AC Overlay
40	Concrete Slab - Protected w/ AC Overlay
44	Concrete Slab - Protected w/ Thin Overlay
48	Concrete Slab - Protected w/ Rigid Overlay
52	Concrete Slab - Protected w/ Coated Bars
53	Concrete Slab - Protected w/ Cathodic System
54	Timber Slab
55	Timber Slab - w/ AC Overlay
Superstructure elements	
101	Unpainted Steel Closed Web/Box Girder
102	Painted Steel Closed Web/Box Girder
104	P/S Conc Closed Web/Box Girder
105	Reinforced Concrete Closed Webs/Box Girder
106	Unpainted Steel Open Girder/Beam
107	Painted Steel Open Girder/Beam
109	P/S Conc Open Girder/Beam
110	Reinforced Conc Open Girder/Beam
111	Timber Open Girder/Beam
112	Unpainted Steel Stringer
113	Painted Steel Stringer
115	P/S Conc Stringer
116	Reinforced Conc Stringer
117	Timber Stringer
120	Unpainted Steel Bottom Chord Thru Truss
121	Painted Steel Bottom Chord Thru Truss
125	Unpainted Steel Thru Truss
Superstructure elements (continued)	
126	Painted Steel Thru Truss
130	Unpainted Steel Deck Truss
131	Painted Steel Deck Truss
135	Timber Truss/Arch
140	Unpainted Steel Arch
141	Painted Steel Arch
143	P/S Conc Arch
144	Reinforced Conc Arch
145	Other Arch
146	Cable - Uncoated (not embedded in concrete)
147	Cable - Coated (not embedded in concrete)
151	Unpainted Steel Floor Beam
152	Painted Steel Floor Beam
154	P/S Conc Floor Beam
155	Reinforced Conc Floor Beam
156	Timber Floor Beam
160	Unpainted Steel Pin and Hanger Assembly
161	Painted Steel Pin and Hanger Assembly
Substructure elements	
201	Unpainted Steel Column or Pile Extension
202	Painted Steel Column or Pile Extension
204	P/S Conc Column or Pile Extension
205	Reinforced Conc Column or Pile Extension
206	Timber Column or Pile Extension
210	Reinforced Conc Pier Wall
211	Other Material Pier Wall
215	Reinforced Conc Abutment
216	Timber Abutment
217	Other Material Abutment
220	Reinforced Conc Submerged Pile Cap/Footing
225	Unpainted Steel Submerged Pile
226	P/S Conc Submerged Pile
227	Reinforced Conc Submerged Pile
228	Timber Submerged Pile
230	Unpainted Steel Cap
231	Painted Steel Cap
233	P/S Conc Cap
234	Reinforced Conc Cap
235	Timber Cap
Culverts	
240	Unpainted Steel Culvert
241	Reinforced Concrete Culvert
242	Timber Culvert
243	Other Culvert
Expansion joints	
300	Strip Seal Expansion Joint
301	Pourable Joint Seal
302	Compression Joint Seal
303	Assembly Joint/Seal (modular)
304	Open Expansion Joint
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311	Moveable Bearing (roller, sliding, etc.)
312	Enclosed/Concealed Bearing
313	Fixed Bearing
314	Pot Bearing
315	Disk Bearing
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331	Reinforced Conc Bridge Railing
332	Timber Bridge Railing
333	Other Bridge Railing
334	Metal Bridge Railing - Coated
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356	Steel Fatigue
357	Pack Rust
358	Deck Cracking
359	Soffit of Concrete Deck or Slab
360	Settlement
361	Scour
362	Traffic Impact
363	Section Loss

Table 1.2. Examples of AASHTO CoRe elements and condition states (AASHTO, 1998)

13 - Concrete Deck - Unprotected w/ AC Overlay	107 - Painted Steel Open Girder/Beam
1. The surfacing on the deck has no patched areas and there are no potholes in the surfacing.	1. There is no evidence of active corrosion, and the paint system is sound and functioning as intended to protect the metal surface.
2. Patched areas and/or potholes or impending potholes exist. Their combined area is 10% or less of the total deck area.	2. There is little or no active corrosion. Surface or freckled rust has formed or is forming. The paint system may be chalking, peeling, curling, or showing other early evidence of paint system distress, but there is no exposure of metal.
3. Patched areas and/or potholes or impending potholes exist. Their combined area is more than 10% but 25% or less of the total deck area.	3. Surface or freckled rust is prevalent. There may be exposed metal, but there is no active corrosion which is causing loss of section.
4. Patched areas and/or potholes or impending potholes exist. Their combined area is more than 25% but less than 50% of the total deck area.	4. Corrosion may be present but any section loss due to active corrosion does not yet warrant structural analysis of either the element or the bridge.
5. Patched areas and/or potholes or impending potholes exist. Their combined area is 50% or more of the total deck area.	5. Corrosion has caused section loss and is sufficient to warrant structural analysis to ascertain the impact on the ultimate strength and/or serviceability of either the element or the bridge.

300 - Strip Seal Expansion Joint	311 - Moveable Bearing (roller, sliding, etc.)
1. The element shows minimal deterioration. There is no leakage at any point along the joint. Gland is secure and has no defects. Debris in joint is not causing any problems. The adjacent deck and/or header are sound.	1. The element shows little or no deterioration. The paint system, if present, is sound and functioning as intended to protect the metal. The bearing has minimal debris and corrosion. Vertical and horizontal alignments are within limits. Bearing support member is sound. Any lubrication system is functioning properly.
2. Signs of seepage along the joint may be present. The gland may be punctured, ripped, or partially pulled out of the extrusion. Significant debris is in all or part of the joint. Minor spalls in the deck and/or header may be present, adjacent to the joint.	2. The paint system, if present, may show moderate to heavy corrosion with some pitting but still functions as intended. The assemblies may have moved enough to cause minor cracking in the supporting concrete. Debris buildup is affecting bearing movement. Bearing alignment is still tolerable.
3. Signs or observance of leakage along the joint may be present. The gland may have failed from abrasion or tearing. The gland has pulled out of the extrusion. Major spalls may be present in the deck and/or header adjacent to the joint.	3. There is advanced corrosion with section loss. There may be loss of section of the supporting member sufficient to warrant supplemental supports or load restrictions. Bearing alignment may be beyond tolerable limits. Shear keys may have failed. The lubrication system, if any, may have failed.

One of the criticisms of the AASHTO CoRe Elements was the lack of detail on bridge decks, and the fact that deterioration processes were often commingled. It was difficult, for example, to separate deterioration of paint systems from deterioration of the underlying steel. An alternative element inspection process was developed in NCHRP Project 12-28(2)A, B, and C as a part of a bridge management system called Bridgit (Hawk, 1999). Washington State DOT implemented Bridgit and adapted its bridge inspection process to its own needs. Although Bridgit is no longer in use, Washington's bridge inspection process still uses the innovations in its bridge inspection process, particularly the separate inspection of protective systems (WSDOT, 2012).

Internationally, the experiences of the AASHTO CoRe Elements and Bridgit contributed to development of the Ontario Structure Inspection Manual, which is widely used in Canada (MTO, 2000). In Finland, a further enhancement was the separate recording of each type of damage, which could, for example, distinguish cracking from corrosion. These innovations were eventually brought back to US practice in the 2011 AASHTO Guide Manual for Bridge Element Inspection (AASHTO, 2011).

Each element has a set of condition states, which classify the physical conditions found in a field inspection, usually by quick visual observation by trained personnel. When defining condition states, the difference from one state to the next should make a difference in:

- The type of maintenance or corrective action that may be feasible and effective.
- The cost of maintenance or corrective action.

- The rate of further deterioration.
- Performance of the element as perceived by road users or as it impacts the performance of the asset as a whole. This can incorporate considerations of life cycle cost, mobility, safety, risk, or other performance concerns.

Bridge inspection practice is increasingly moving toward a standard that makes a separate assessment of each major deterioration process or protective system. The 2013 AASHTO Manual for Bridge Element Inspection (AASHTO, 2013) provides four condition states for increasing levels of severity of each of the following defects: delaminations, spalls, and patched areas; exposed rebar or prestressing tendons; efflorescence and rust staining; corrosion; cracking (distinguishing concrete, steel and timber), load capacity, collision damage; damaged connections; timber decay; timber checks; abrasion; distortion; settlement; scour; mortar breakdown; masonry displacement; restricted movement or misalignment of bearings; bulging, splitting, or tearing of elastomeric bearings; loss of bearing area; debris impaction; and damage to expansion joint hardware or deck interface.

The new manual also incorporates multiple damage paths for protective systems such as bridge deck waterproofing systems, steel coatings, expansion joint seals, and cathodic protection systems. All of these deterioration processes and protective systems can potentially deteriorate at different rates, can interact with each other to accelerate deterioration, and have different sets of feasible corrective and preventive actions. It is not yet known how many agencies will record these distresses separately, since proposed Federal guidelines only require an overall condition assessment for each element, combining the effects of all applicable distresses.

Bridge element inspection procedures are increasingly applied to non-bridge structural assets where the same element and condition state philosophy is useful for asset management. Many agencies now inspect sign structures, high-mast light poles, and traffic signal mast arms using an element level philosophy (LONCO, 2007).

1.2 Migration to the new AASHTO Manual

The latest version of the AASHTOWare Bridge Management System (BMS) software is a substantial change from Pontis, because of the new element inspection process and because of new functionality under development to take advantage of the improved element data. Although major differences exist between the earlier CoRe Element Guide and the new Element Manual, both documents describe fundamentally the same thing, the condition of bridge elements. The listing of elements is nearly the same in the two inspection processes, and both documents describe primarily the severity of material distress. The most important differences are:

- Protective systems such as paint and deck wearing surfaces are now described separately from their underlying structural element.
- Certain elements, such as bridge decks, whose condition was previously described in terms of extent of distress, are now described in terms of severity instead.
- A detailed catalog of defects has been defined, to guide the assignment of a condition state to each part of each element. Data on individual defects may also be recorded. FDOT plans to record the most significant defect on each element, as is recommended in the AASHTO Manual.
- All elements now have four condition states. Previously the number of states varied from three to five.

BMS provides functionality to store legacy CoRe element data, but will not use the old data in any of its analyses. An agency can choose to store its legacy data in a separate database, can maintain access to its

Pontis database in an unchanged form for research purposes, or can archive it. Agencies that have not used Pontis so far can still adopt BMS without ever having gathered any Pontis CoRe Element data.

Agencies like FDOT which have been gathering element data under the CoRe Element Guide may have one or more reasons to want to migrate their legacy data to conform to the new AASHTO Manual:

- If legacy CoRe element data can be converted to a form compatible with the new AASHTO Manual, this will provide a reasonable starting point to help bridge inspectors collect the first set of elements for BMS. Having the old elements as a guide may reduce the number of missed elements and other types of errors, and may help to remind the inspector of ongoing distress issues that the Department is tracking on each structure.
- If the converted legacy data are sufficiently consistent with the new data, the Department may be able to continue plotting meaningful long-term trendlines of bridge condition going back as far as the first Florida element inspections in the late 1990s.
- With converted legacy data in the same database as new inspection data, the Department will continue to have, in one place, an extensive condition history for each bridge.
- Migration of legacy data into the new element system may facilitate the development of deterioration, cost, and effectiveness models for the new elements based on past inspections.

For reasons such as these, AASHTO commissioned the development of its Element Migrator tool. This software was first developed for the 2011 AASHTO Guide Manual, and was updated for the 2013 AASHTO Manual (Marshall, 2014). The Migrator is an interactive environment for setting up and testing element conversion rules, downloading element data and element specifications, converting existing data, and reviewing the results. The migrated output file can be imported to BMS using the built-in import feature of that application. A detailed account of Oregon's experience using the Migrator was distributed at the 2013 meeting of the AASHTOWare Bridge Management User Group (Novakovich, 2013).

The Element Migrator is a deterministic process, in that the user must establish a direct correspondence between old and new elements, and old and new condition states. The conversion must consider smart flags if present. In some cases one CoRe element (painted steel, for example) becomes two new elements (a coating element and a steel substrate). In some cases a CoRe element has five condition states but the corresponding new element has only four, so it is possible that some information could be lost. In other cases the old element has only three condition states, so the new element with four states may necessarily have one state left vacant.

There are many cases in the new AASHTO Manual where an element may have the same number of condition states as in the CoRe Element Guide, but the definitions of the condition states may have changed. The new AASHTO Manual generally considers a greater number of distresses, so in some cases a change in the condition state assessment may be perfectly legitimate even if the total number of condition states has not changed, because additional distresses are considered.

The Migrator program specifies element conversion rules using a kind of programming language, and outputs its results in the form of an XML file. However, there is no requirement in BMS that these specific tools be used. The programming language could be an Excel spreadsheet, for example, and the output could be an SQL script to insert the results into the BMS database. In fact, the entire migration process could be a big SQL script without any intermediate output files.

1.3 Health index

For most transportation assets, multiple symptoms of distress contribute to an overall actionable assessment of current or future condition. In condition data sets, each asset may have multiple elements,

and each element may exhibit multiple condition states. This level of detail is very useful for deterioration forecasting, action selection, and cost estimation. However, it is too much detail for presentation or for higher-level decision support requirements. A common tool for summarizing conditions is the condition index, or health index (Foltz and McKay, 2008). Some examples of condition indexes are:

- Pavement Condition Index (PCI), which combines multiple pavement distresses into an overall indicator (ASTM, 2012). A large number of observable distresses, such as roughness, rutting, various kinds of cracking, and various kinds of surface defects, are typically included in the index.
- Bridge Health Index (BHI), which combines bridge elements into an overall indicator of bridge condition (Shepard and Johnson, 2001).

Condition indexes are typically expressed on a scale of 0 to 100, where 100 is the best possible and 0 is the worst possible. They are computed as a weighted average, using steps similar to the following (Patidar et al., 2007):

- Each individual element, defect, or condition measure contributing to the index is individually converted to a relative value scale of 0 to 100. For example, if an element has five condition states, the scores for condition states A, B, C, D, and F might be 100, 75, 50, 25, and 0 respectively. The scores do not have to be evenly-spaced as in this example, but should represent points on a uniform scale of utility. The process of converting a raw condition measure to a scaled 0-100 value is called a *scaling function*.
- The individual condition scores are then combined into an overall index, using weights to represent the relative importance of each separate indicator. The result is a weighted average, and the process of computing it is called an *amalgamation function*.

The scores and weights are typically determined using a small research project, using a panel of experts or, sometimes, a panel of randomly-selected customers. Various interview and gaming techniques have been used to develop these weights; NCHRP Report 590 has an extensive survey of them. In the most sophisticated applications, the Analytic Hierarchy Process is a way of developing unbiased weights (Saaty, 2006). It is also possible to use econometric techniques to develop the weights; for example, the bridge health index weights are usually computed from life cycle cost data and vary from one agency to another, since deterioration rates and unit costs can vary. Elements that have higher life cycle costs (i.e. a larger portion of agency expenditures over the long-term) receive more weight in the index (Cambridge, 2003). Nonetheless, the index is still a consistent indicator of condition that can be used for making comparisons across agencies.

Once the weights have been determined, the condition index for any specific asset at a given point in time can be computed using current or forecast conditions. When this process is used consistently, any two assets of the same type, or even of different types, can easily be compared.

Element condition state language is highly specific to individual components of structures, yet the general pattern of 3-5 condition states representing type and severity of deterioration, is common across all elements. This makes it possible to derive a relatively straight-forward procedure for characterizing overall condition of any facility made up of elements.

The Health Index was first proposed by the California Department of Transportation as a type of weighted average condition measure for a bridge or any subset of an inventory (Shepard and Johnson, 2001). It includes all condition states, weighting each element by its replacement cost, failure cost, or by

some other appropriate weight. This gives emphasis to elements that have the biggest economic or structural impact on bridge functionality. The Health Index is computed as follows:

$$Health\ index\ HI = \frac{CEV}{TEV} \times 100 \tag{1-1}$$

$$Current\ element\ value\ CEV = \sum_{e} W_e \sum_{j}^{N_e} Q_{ej} W_{ej} \tag{1-2}$$

$$Total\ element\ value\ TEV = \sum_{e} W_e \sum_{j}^{N_e} Q_{ej} \tag{1-3}$$

$$State\ weight\ W_{ej} = 1 - \frac{j-1}{N_e - 1} \tag{1-4}$$

Where W_e = Weight given to element *e*, usually replacement or failure cost
Q_{ej} = Quantity of element *e* in condition state *j*
N_e = Number of condition states defined for element *e*

The weights W_e are typically economic quantities only because the health index is easiest to use if weights are either unitless, or at least use consistent units across all elements. The formula for condition state weight W_{ej} is hard-wired into Pontis. For an element with four condition states, it yields 1, 2/3, 1/3, and 0 for j=1..4 respectively. This is also the default for BMS, where all elements have four condition states.

Florida's current Pontis implementation uses a failure cost analysis to compute health index weights, considering both agency and user costs. BMS does not have failure costs in its analytical framework, so an alternative system of element weights will need to be developed. The researchers performed a search of bridge management literature to look for examples of agency experience in customizing the health index weights. The search focused on conference proceedings (including the Pontis User Group) since that is the venue where this type of work is most likely to be documented. Although there is anecdotal knowledge of a few agencies which have done this using the judgment of one or more experts, no articles or data have been published.

1.4 Preservation actions

BMS defines a concept of bridge-level actions which is much broader than earlier versions of Pontis. An action in BMS can be any combination of: maintenance, repair, and rehabilitation activities on any or all elements; risk mitigation; and functional improvements. A bridge level preservation action is defined as a list of element/state actions, which are consistent with earlier versions of Pontis.

When a bridge-level action is applied to a bridge, the result is a work candidate. BMS examines the bridge in its current or forecast condition, to see if it contains any of the elements and condition states listed for the action. In each case where there is a match between the needs of the bridge and the capabilities of the action, a cost and an effect is simulated.

Certain work candidates are automatically created by BMS, and others may be added manually by the engineer. Each work candidate is evaluated by the model to determine its feasibility, cost, and

effectiveness. The engineer can manipulate this matrix by selecting or deselecting work candidates to be considered further.

Ultimately work candidates feed into the project level for grouping into projects, and these projects feed into the program level for priority setting and programming. BMS performs all computations of direct cost and performance at the bridge level, but indirect cost is computed at the project level.

Each bridge-level preservation action has as part of its definition several essential data items:

- A warrant formula for each relevant element, indicating condition state percent thresholds which would cause the action to be considered. (This replaces the Pontis 4.5 Agency Policy Rule table.)
- A list of element/state/action definitions that are included in the work. Unit costs and action effectiveness probabilities are taken from the indicated actions. Each action can also indicate other condition states to which the same action should be applied. For example, painting can be applied to condition state 1 of a coating system element as part of a total recoating action.
- For any bridge-level action, a bridge-level performance warrant for each performance measure, a formula that must evaluate to TRUE in order for the action to be considered. This takes the place of Pontis 4.5 paint rules and other feasibility rules that apply at the bridge level rather than the element level.
- A formula to calculate the direct cost. This is first computed by summing costs over all applicable element/state actions, but the cost formula can modify this result.
- Deferment periods before and after the action, in which no other action may be considered.

Table 1.3 has a listing of what are expected to be typical bridge-level preservation actions, provided by Caltrans (unpublished correspondence). These are the same as what Caltrans had previously been using as Pontis 4.5 flex actions.

Table 1.3. Examples of flex actions

IMMS Action Code	BMS Action Code	Description
H30020	1	Deck-Patch spalls
H30030	2	Deck-Repair Potholes
H30012	3	Deck-Rehab
H30013	4	Deck-Resurface
H30060	5	Deck-Place Overlay
H30050	6	Deck-Methacrylate
H30011	7	Deck-Replace
H30090	9	Deck-Misc.
H20010	10	Super-Patch spalls
H20012	11	Super-Rehab
H20011	12	Super-Replace
H20013	13	Super-Epoxy Inject
NA	14	Super- Strengthen
H20090	19	Super-Misc.
H10010	20	Sub-Patch spalls
H10013	21	Sub-Epoxy Inject
H10012	23	Sub-Rehab
H10011	24	Sub-Replace
NA	25	Sub-Scour Mitigate
H10040	26	Sub-Nav. Protect
H10090	29	Sub-Misc.

Table 1.3. Examples of flex actions (Cont'd)

IMMS Action Code	BMS Action Code	Description
H40010	30	Joint Seals - Repair/Clean
H40012	31	Joint Seals - Rehab
H40011	32	Joint Seals - Replace
		Joint - Asphaltic Plug
		Expansion Dam
H41050	40	Bearings-Clean
H41013	41	Bearings-Reset
H41012	42	Bearings-Rehab
H41011	43	Bearings-Replace
H31080	50	Appr. Slab-mudjack
NA	51	Appr. Slab-Repair
H31060	52	Appr. Slab-Overlay
H31011	53	Appr. Slab-Replace
H50010	60	Railing-Repair
H50012	61	Railing-Rehab
H50011	62	Railing-Replace
NA	69	Railing-Misc.
H91040	70	Seismic-Retrofit
H91010	71	Seismic-Maintenance
NA	79	Seismic-Misc. Repair
H90011	80	Bridge-Replace
NA	81	Bridge-Rehab
NA	82	Bridge-Collision Damage
NA	83	Bridge-Paint ID
NA	84	Bridge-Widen
NA	89	Bridge-Misc
H70060	90	Paint-Rigging/Contain
H70061	91	Paint-Spot Prep/Spot Paint
H70062	92	Paint-Spot Prep/ Full Paint
H70063	93	Paint-Full Prep/Full Paint
H70069	99	Paint-Misc activities
NA	MA	Mech/Elect-Clean
H80010	MB	Mech/Elect-Repair/Adj.
H80012	MC	Mech/Elect-Rehab/Upgrade
H80011	MD	Mech/Elect-Replace
NA	ME	Mech/Elect-Monitor/Test
H80090	MZ	Mech/Elect-Misc.

Previous Florida research in Sobanjo and Thompson (2001 and 2011) have developed agency cost models and action effectiveness for Pontis actions, which can be migrated to be compatible with BMS 5.2.2. A methodology using cost allocation principles to do this is described in Hearn et al (2010).

FDOT's Project Level Analysis Tool (PLAT) (Sobanjo and Thompson, 2004) provides a mechanism to adjust the scope of preservation projects to account for additional work and costs often found in these projects. As a result, the present study needed to reconfigure the PLAT analysis to be consistent with the features expected in BMS, including the anticipated data format for the model formulas and parameters.

1.5 Deterioration models

Like Pontis, BMS uses Markov deterioration models to forecast bridge condition through most of the deterioration profile. The advantage of Markov models is that they are very simple and can be developed in a variety of ways using small cross-sectional data sets (Thompson et al., 2012) or expert judgment (Cambridge, 2003). With small data sets, it is possible to stratify the model by element type and material to gain insight into the differences among elements (Sobanjo and Thompson, 2011). A number of creative refinements have been developed to respond to various data quality and modeling problems in bridge management (Jiang and Sinha, 1989; Zhang et al., 2003; Morcous, 2006).

A disadvantage of Markov models is that they cannot easily consider age as a causal factor in deterioration rates (Ng and Moses, 1996). This is especially a problem for new bridges, which normally do not experience any sign of deterioration for many years after construction. To overcome this limitation, AASHTO is planning to introduce a simple refinement in BMS, using a Weibull model to forecast the initial onset of deterioration. The method for developing these models is documented in previous Florida research (Sobanjo and Thompson, 2011) and in NCHRP Report 713 (Thompson et al., 2012). Weibull models have also been developed for the National Bridge Inventory form of 0-9 scale condition data described earlier in this chapter (Agrawal and Kawaguchi, 2009).

FDOT's PLAT provides a mechanism for the condition of one element (for example, expansion joints) to affect the deterioration of another element (for example, pier caps). In BMS, AASHTO is planning to create a more general feature, known as protection factors, to model the interaction among elements. This is especially important for accurate modeling of coatings and wearing surfaces, but can also be used for expansion joints and drainage systems. PLAT can adopt a similar feature for its analysis. As of this writing, AASHTO is not planning to model the deterioration of individual defects and their effect on the element as a whole (unpublished correspondence).

2. Revised health index

As described in the previous section, the Bridge Health Index (BHI) is computed based on the condition of the individual elements and assigned to represent the overall physical condition of the bridge, with a value zero for a failed bridge and 100 for a bridge in an excellent condition. The computation of the BHI can also be summarized in the equations 1.1 to 1.4 as stated in the previous section. There are two issues arising when computing the BHI. The first is the determination or assignment of the state weight for each condition state of an element, indicated by equation 1.4. This equation assumes a simple linear relationship between the state weights and the condition state. Arguments can be made that this relationship may be non-linear. The second issue is that while these equations (1.1 to 1.4) are still applicable (in principle) to the new AASHTO elements, there is a new dimension introduced by the condition states now being evaluated and expressed in terms of the extent of deterioration due to some specific defects on each bridge element. This section will discuss this issues in the following paragraphs and also formulate a methodology for computing the BHI.

Some recent studies have looked closely at the computation and applications of BHI, investigating the BHI's sensitivity to costs and element condition (Adams and Kang, 2009), and also suggesting new methods for computing the state weights (Jiang and Rens, 2010a, 2010b, and Jiang 2012). Rens et al. (2011) presented the use of element weights for condition index computation on a non-bridge structure (sheet piles). Jiang and Rens (2010a, 2010b) and Jiang (2012) evaluated using bridge data from Denver, Colorado, the trends over time of BHI computed using the Shepard and Johnson (2001)'s equations. It was observed by Jiang and Rens (2010a, 2010b) and Jiang (2012) that the BHI values do not portray the actual observed deterioration patterns in the bridges, or the actual damages on the bridges.

In calculating the overall BHI, it will be necessary to have the element weights, using either the element costs (repair costs, replacement costs, or failure costs) or weights elicited from experts, as the measure of relative importance of each element. Jiang and Rens (2010b) suggested that rather than using costs, that *"….element weighting point should stress the effect of element damage on bridge health and function."* In the Jiang and Rens (2010b) study, data for element weights were elicited from bridge engineers. In addition, a weight amplification concept was proposed, learned from previous studies by the U.S. Army Corps of Engineers on condition assessment procedures for various components of lock and dam structures. The weight adjustment is basically to increase the weight of elements with health condition index below a threshold. The reasoning is that as this element gets into its worst condition states, especially due to age, it becomes more critical and important to the bridge (Jiang and Rens, 2010b). In order to elicit element weights, a study by Patidar et al. (2007) in NCHRP Report 590, indicated for multicriteria decision making, two known methods of establishing relative weights: direct weighting (based on simple ranking) or the Analytical Hierarchy Process (AHP). The AHP involves constructing a pairwise comparison matrix from the criteria, and this matrix is utilized to determine the relative criteria weights.

The following equation, similar to that used in the AASHTO CoRe elements, computes the BHI by utilizing the element health index and the weights, without considering the element quantities.

$$Bridge\ Health\ Index\ BHI = \frac{\sum_e W_e EHI_e}{\sum_e W_e} \quad (2\text{-}1)$$

Where W_e = Weight given to element *e*, i.e., repair, replacement or failure cost, or expert opinion.
EHI_e = Element health index of element *e*

Adams and Kang (2009) found that BHI is far more sensitive to element condition than to element failure cost, and that the BHI becomes more sensitive to the element failure costs as bridge conditions get worse; it was recommended that BHI not be used for bridges in poor condition.

2.1. Element condition weights

In determining the condition index of a specific bridge element, one of the important steps is estimating the weights for each condition state. Jiang and Rens (2010a, 2010b) and Jiang (2012) suggested the use of a nonlinear relationship between the state weight (termed health index coefficient) and the condition state (Figure 2.1); this relationship obviously shows a relatively faster deterioration rate between the states, reducing the values of element health indexes. Sobanjo and Thompson (2011) presented a similar reasoning in the process of developing an NBI Translator for Florida bridges.

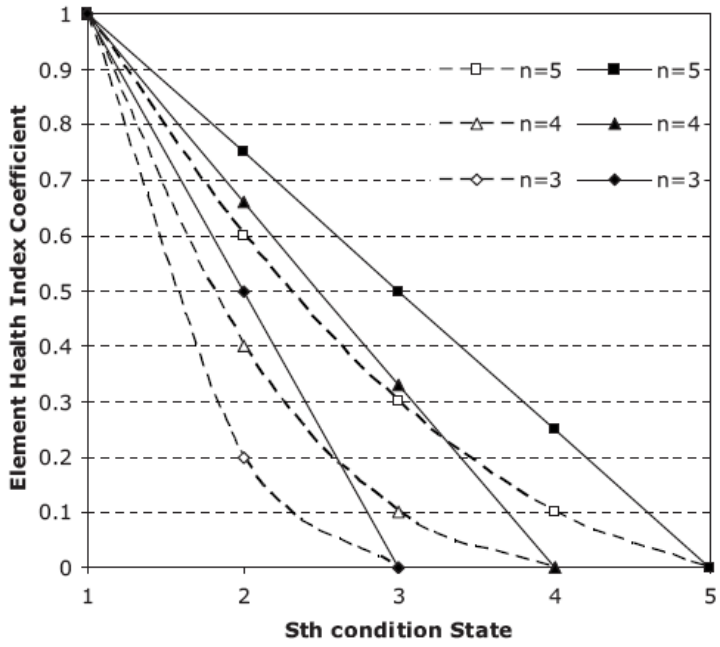

Figure 2.1. Comparison of trends of linear and nonlinear health index coefficient of condition states (Jiang and Rens, 2010b)

In assigning the condition weights, four approaches are suggested based on the reasoning of what is the remaining service life at each state as described (for the inspector) under the various defects. All approaches consider that the condition weights for a bridge element in states 1 (best state) and 4 (worst state) will be 100 and 0 respectively. The first approach, the default approach as recommended by the AASHTO Manual, will have a simple linear distribution of the weights between 100 for condition state 1 and 0 for the state 4. It may be assumed that material degradation, as described at the various condition states will represent an estimate of the economic value for the particular bridge element. For example for the default approach, an element as described in a condition state 1 has 100% of its economic value, whereas in states 2 and 3 it has say 67% or 33% respectively of its economic value; the element will be considered with minimal economic value in state 4. Another approach may assume that the state 2 is almost as good as new, with a weight of 80 while the state 3 will have a weight of 40; this can be termed the optimistic approach. The third approach, a pessimistic approach, will assume that states 2 and 3 are really bad with weights 50 and 25 respectively. The last approach, which will be termed the “proposed”

approach, reasons that the state 3 will have a weight of 50 while state 2 will have 75. An argument for the proposed case of weights is that in state 3 for many elements, it is indicated that structural review is not warranted; this should imply that there is at least 50% of life remaining on element. So condition state 3 can be assigned a condition weight of 50% or 0.5. Similarly, same argument can be made to assign state a weight of 75% or 0.75 to state 2. Table 2.1 and Figure 2.2 summarize and illustrate these condition weights under the various approaches.

Table 2.1. Cases for assignment of element condition weights

State	Default Case1	Optimistic Case2	Pessimistic Case3	Proposed Case4
4	0.00	0.00	0.00	0.00
3	0.33	0.40	0.25	0.50
2	0.67	0.80	0.50	0.75
1	1.00	1.00	1.00	1.00

There are still other options to ascertain element weights. One method will be based on the remaining life, through an extensive literature review on experimental work that has been done on bridge element material degradation, including accelerated tests. Another method is to elicit such information by survey from experienced bridge maintenance engineers. In determining the condition weights, one question also is if it will be more realistic to develop a set of weights for each group of materials that have similar interpretations of the specific defects at the various condition states.

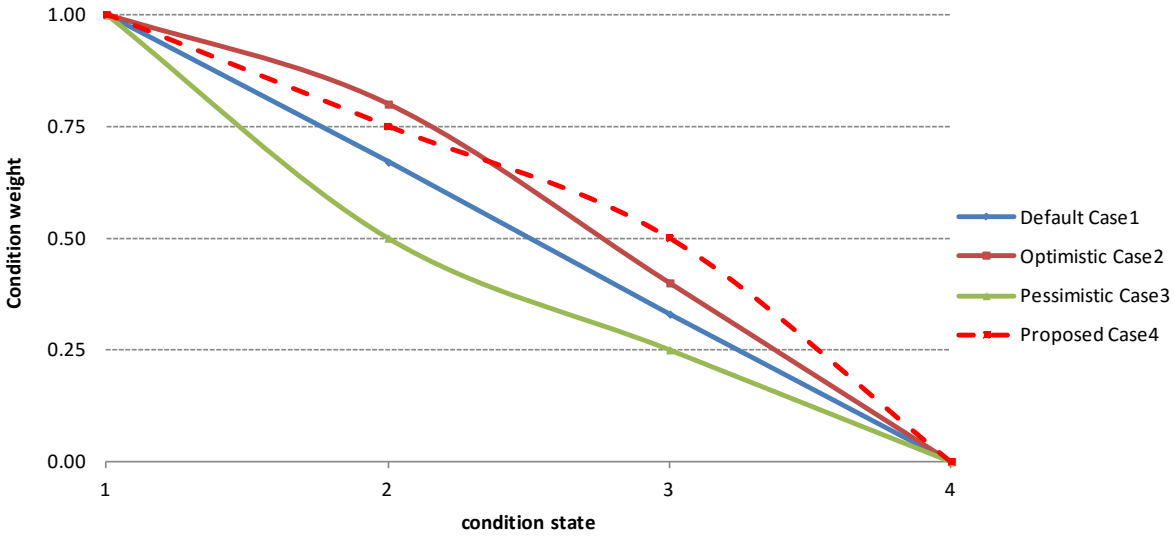

Figure 2.2. Cases for assignment of element condition weights

All the reported efforts and studies described above in the literature, are based on the AASHTO CoRe element definition in the old Pontis BMS. As mentioned earlier, there is a change in the new definition of element condition states. All elements now have four condition states, and specific defects are observed at each element and recorded in terms of the condition states. Table 2.2 shows the condition states and defects listing for FDOT's Reinforced Concrete Deck and Slab Elements, including the following elements: 12-Reinforced Concrete Deck; 16-Reinforced Concrete Top Flange; 38-Reinforced Concrete Slab; and 98-Concrete on Precast Deck Panels. To conform to the current BMS software configuration, the conventional (linear) relationship between condition states and the state weights are assumed in the following illustration of the computation of the element condition index.

In computing the element condition index from the defects observed, two approaches will be presented. In the first approach (Method 1), based on the example shown in the AASHTO Manual, defects in each condition state are summed up for the total deficiency in that state for the element. Each defect will have equal weights or relative importance. In this approach some defects can be ignored and priority given to the defects that the agency considers most important. This may make sense in that some defects are correlated, e.g., spalling and exposed rebar. The second approach (Method 2) will involve assigning weights to the defects observed and incorporating these defect weights into the computed condition index. One reasoning for doing this may be that, for example, efflorescence is really not as important a defect as cracking or spalling. So efflorescence may be weighted much less than cracking or spalling. In this approach, the defects are also summed up but weighted in the sums.

The two approaches described above are illustrated in the following tables for two scenarios of bridge deteriorated conditions (good and bad) for Reinforced Concrete Deck and Slab Elements. Reinforced Concrete Top Flange; 38-Reinforced Concrete Slab; and 98-Concrete on Precast Deck Panels. First the descriptions for the defects are shown in Table 2.2. Expert opinions are assumed as reflected in Table 2.3 for the defect weights (0 to 100), that Exposed Rebar and Damage is the most important defect, followed by Delamination/Spall/Patched Area and Cracking (RC and Other), and Efflorescence/ Rust Staining is judged to be the least relevant. These preferences are normalized into defect weights. The weights for the condition states shown are based on the linear approach discussed earlier.

Table 2.2. FDOT's condition state table for reinforced concrete deck and slab elements

Defect	**Condition State 1**	**Condition State 2**	**Condition State 3**	**Condition State 4**
	GOOD	FAIR	POOR	SEVERE
Delamination/Spall /Patched Area (1080)	None	Delaminated. Spall 1 in. or less deep or less than 6 in. diameter. Patched area that is sound.	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress. Does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or service-ability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Exposed Re-bar(1090)	None	Present without measurable section loss.	Present with measurable section loss that does not warrant structural review.	
Efflorescence/ Rust Staining(1120)	None	Surface white without build-up or leaching with-out rust staining.	Heavy build-up with rust staining.	
Cracking (RC and Other)(1130)	Widths less than 0.012 in. or spacing greater than 3.0 ft.	Widths 0.012–0.05 in. or spacing of 1.0–3.0ft.	Width greater than 0.05 in. or spacing of less than 1 ft.	
Damage (7000)	Not applicable	The element has impact damage. The specific damage caused by the impact has been captured in condition state 2 under the appropriate material defect entry.	The element has moderate damage caused by vehicular or vessel impact. The specific damage caused by the impact has been captured in condition state 3 under the appropriate material defect entry.	The element has severe damage caused by vehicular or vessel impact. The specific damage caused by the impact has been captured in condition state 4 under the appropriate material defect entry.

Table 2.3. Assigned defect and condition weights

Defects/Element Condition	Defect weight		weight for condition states			
	weight	normalized	State 1	State 2	State 3	State 4
			100	67	33	0
Delamination/Spall/Patched Area (1080)	60	0.18	100	67	33	0
Exposed Rebar (1090)	100	0.29	100	67	33	0
Efflorescence/ Rust Staining (1120)	20	0.06	100	67	33	0
Cracking (RC and Other)(1130)	60	0.18	100	67	33	0
Damage (7000)	100	0.29	100	67	33	0

For method 1 applied to a bridge deck in good condition, the bridge inspector's entry will be in the white cells while the cells containing the computed numbers are gray, as shown in Table 2.4. For the bridge deck with a total element quantity of 11800 SF, it is inspected and found that the deck has 800 SF of the defect Delamination/Spall/Patched Area, all fitting the extent described for state 3. It was observed that there is Exposed Rebar on 400 SF of the deck area, also classified for state 3. There is Efflorescence/ Rust Staining on 250 SF deck area but classified as state 2 of deterioration. The defect Cracking (RC and Other) was observed to cover 450 SF of deck area to the severity classified as state 3. There is no Impact Damage defect on the deck. The element quantity in state 1 for each defect is indicated as the total element quantity minus the sum of quantities in the states 2, 3, and 4. So, for the defect Delamination/Spall/Patched Area, the quantity in state 1 will be 11800 – 800 or 11000. The last entry in the table is the last column where the inspector can indicate whether a particular defect should be used or ignored in the computations. In this example, Efflorescence/ Rust Staining is considered not very relevant and indicated with a zero in the column.

Table 2.4. Inspection data and condition index for "Good" bridge deck element (Method 1)

Defects/Element Condition	Total element quantity	Condition State 1		Condition State 2		Condition State 3		Condition State 4		Use/ Ignore Defect (1/0)
		Quantity	%	Quantity	%	Quantity	%	Quantity	%	
Delamination/Spall/Patched Area (1080)	11800	11000	93%	0	0%	800	7%	0	0%	1
Exposed Rebar (1090)	11800	11400	97%	0	0%	400	3%	0	0%	1
Efflorescence/ Rust Staining (1120)	11800	11550	98%	250	2%	0	0%	0	0%	0
Cracking (RC and Other)(1130)	11800	11350	96%	0	0%	450	4%	0	0%	1
Damage (7000)	11800	11800	100%	0	0%	0	0%	0	0%	1
Element (effective) quantity	11800	10150	86%	0	0%	1650	14%	0	0%	
STATUS (STRUCTURAL REVIEW)	OKAY									
CONDITION INDEX	**90.63**									
CEV	1069450									
TEV	11800									
Index (Caltrans Method) =	**90.63**									

The row titled "Element (effective) quantity" in Table 2.4 with the computed data shows the effective quantities and percentages in each state based on the quantities for each defect and relevance of the defect. Basically, for each state, each defect quantity is multiplied by the relevance (1 or 0) and these are added up for all the defects. For example, the effective quantity in condition state 3 is (800*1) + (400*1) + (0*0) + (450*1) + (0*) = 1650. For state 2 all defects have zero entries except Efflorescence/ Rust

Staining which has 250. But due to the irrelevance of this defect, the effective quantity is 250*0 = 0. The quantities in states 2, 3 and 4 are summed up and deducted from the total quantity to obtain the quantity in state 1, i.e., 11800 – (0 + 1650 + 0) = 10150.

The element condition index is computed by multiplying the percentage (decimal format) in each state by the corresponding state weight (0 to 100), and then summing them up. For the example above, the condition index = (0.85*100) + (0.0*0.67) + (0.14*0.33) + (0.0*0.0) = 90.63. It is noted that the same results will be obtained by using the equations 1.1 to 1.3 described earlier, which calculates the CEV (1069450) and TEV (11800) value giving the same index or CEV/TEV ratio of 90.63. The use of the cell captioned "STATUS" was to indicate if the bridge element is under structural review, i.e., if there is any quantity for any defect in state 4. The condition index is still calculated with state 4 considered as a terminal condition state. Though FDOT rarely has any bridge element in this state 4, if the agency deems it necessary to close the bridge or replace element because of this single defect, then the entire element can be judged to have a zero health.

To perform computations for Method 2, the same "good" bridge data is used, with the bridge inspector's entries in the white cells in Table 2.4 of Method 1 serving as the input data as well as the weights shown in Table 2.3. All the cells in Method 2 contain computed numbers (Table 2.5). The reported quantity for the defects are adjusted based on the defect weights. For example, the 800 SF of Delamination/Spall/ Patched Area described for state 3 is adjusted as 800*(60/100) or 480 because this defect has a weight of 60 on the 0 to 100 scale. The Exposed Rebar defect, which has a defect weight of 100 was observed on 400 SF of the deck area in state 3, implying an adjusted quantity of 400. The Efflorescence/ Rust Staining on 250 SF deck area in state 2 is adjusted to 250*(20/100) or 50. The defect Cracking (RC and Other) was observed on 450 SF of deck area in state 3 is similarly adjusted to 270*(60/100) or 270. Using the relevance numbers (0 or 1) as mentioned in method 1 (Table 2.4 last column), the effective quantity is calculated in a similar manner for each state, as well as the quantity in state 1. The condition index is then computed using the same formula described for method 1, i.e., (0.90*100) + (0.0*0.67) + (0.10*0.33) + (0.0*0.0) = 93.47.

Table 2.5. Inspection data and condition index for "Good" bridge deck element (Method 2)

Defects/Element Condition	Total element quantity	Condition State 1		Condition State 2		Condition State 3		Condition State 4	
		Quantity	%	Quantity	%	Quantity	%	Quantity	%
Delamination/Spall/Patched Area (1080)	11800	11320	96%	0	0%	480	4%	0	0%
Exposed Rebar (1090)	11800	11400	97%	0	0%	400	3%	0	0%
Efflorescence/ Rust Staining (1120)	11800	11750	100%	50	0%	0	0%	0	0%
Cracking (RC and Other)(1130)	11800	11530	98%	0	0%	270	2%	0	0%
Damage (7000)	11800	11800	100%	0	0%	0	0%	0	0%
Element (effective) quantity	11800	10650	90%	0	0%	1150	10%	0	0%
STATUS (STRUCTURAL REVIEW)	OKAY								
CONDITION INDEX	**93.47**								
CEV	1102950								
TEV	11800								
Index (Caltrans Method) =	**93.47**								

The example bridge used for the illustration above was assumed to be in a good condition. For a bridge in an assumed worse deteriorated condition, the procedures (Methods 1 and 2) are repeated and the results are as shown in Tables 2.6 and 2.7 below.

Table 2.6. Inspection data and condition index for "Bad" bridge deck element (Method 1)

Defects/Element Condition	Total element quantity	Condition State 1		Condition State 2		Condition State 3		Condition State 4		Use/ Ignore Defect (1/0)
		Quantity	%	Quantity	%	Quantity	%	Quantity	%	
Delamination/Spall/Patched Area (1080)	11800	10250	87%	0	0%	1550	13%	0	0%	1
Exposed Rebar (1090)	11800	10700	91%	0	0%	1100	9%	0	0%	1
Efflorescence/ Rust Staining (1120)	11800	10550	89%	0	0%	1250	11%	0	0%	0
Cracking (RC and Other)(1130)	11800	10050	85%	0	0%	1750	15%	0	0%	1
Damage (7000)	11800	11800	100%	0	0%	0	0%	0	0%	1
Element (effective) quantity	11800	7400	63%	0	0%	4400	37%	0	0%	
STATUS (STRUCTURAL REVIEW)	OKAY									
CONDITION INDEX	**75.02**									
CEV	885200									
TEV	11800									
Index (Caltrans Method) =	**75.02**									

Table 2.7. Inspection data and condition index for "Bad" bridge deck element (Method 2)

Defects/Element Condition	Total element quantity	Condition State 1		Condition State 2		Condition State 3		Condition State 4	
		Quantity	%	Quantity	%	Quantity	%	Quantity	%
Delamination/Spall/Patched Area (1080)	11800	10870	92%	0	0%	930	8%	0	0%
Exposed Rebar (1090)	11800	10700	91%	0	0%	1100	9%	0	0%
Efflorescence/ Rust Staining (1120)	11800	11550	98%	0	0%	250	2%	0	0%
Cracking (RC and Other)(1130)	11800	10750	91%	0	0%	1050	9%	0	0%
Damage (7000)	11800	11800	100%	0	0%	0	0%	0	0%
Element (effective) quantity	11800	8720	74%	0	0%	3080	26%	0	0%
STATUS (STRUCTURAL REVIEW)	OKAY								
CONDITION INDEX	**82.51**								
CEV	973640								
TEV	11800								
Index (Caltrans Method) =	**82.51**								

Comparing the results from the two methods, it can be observed that Method 2 gives a slightly higher condition index than that of Method 1, with the difference more for bridge in a bad condition, than for that in a good condition.

In computing the element health index, it has been demonstrated that it is not necessary to include the element quantities in the calculations if unit costs are not to be used in determining the condition state weights. It should be noted that in FDOT's implementation of the AASHTO BMS, the new software calculates the health index based on only the element condition states and uses the 100%, 67%, 33%, 0% breakdown as shown for the linear relationship between the condition states and state weights.

2.2. Element importance weights

As demonstrated in the initial part of this chapter, computation of the bridge health index is basically an aggregation of the individual element condition indexes, weighted by the relative importance of each element. Estimates of the importance factors or weights for each element have been done using four methods: based on element replacement costs; based on element long-term costs; based on vulnerability to hazard risks; and based on the element definition in terms of class, category and type.

2.2.1. Element weights based on replacement costs

The first approach is to compute the element replacement costs based on the unit costs, and then find the ratio of each element replacement cost to the overall total bridge element replacement cost. These ratios will serve as the element weights based on element replacement costs. Sample calculation of such costs and ratios as element weights, are demonstrated in Table 2.8 for three bridges from the FDOT bridge inventory for 2009. From the calculations in Table 2.8, it could be seen that for Bridge ID 010104, the overall total bridge element replacement cost is $28,181,661.50. This was utilized to compute the various element weights: The element “P/S Conc Column” has the highest element weight of 0.42, followed by “Bare Concrete Deck” with a weight of 0.23. The elements “Elastomeric Bearing” and “R/Conc Column” have weights of 0.11 and 0.10 respectively, while many other elements have very small weights. Using the bridge inventory, a variation among the estimates of weights for sample elements is shown in Figure 2.3

Table 2.9 shows the element weights, revised on a scale of 0 to 99 based on the element cost data from the 2009 bridge inventory; this shows only the elements from the old Pontis database, and not the new set of elements in BMS. It could be seen here that elements such as girders have weights ranging from 17 to 56 while the weights of column elements range from 7 to 31. Element nos. 30 (Corrugated/Orthotropic Deck), and 241 (Concrete Culvert) each has the highest weight of 63. The reason for these values is that the specific deck type (element no. 30) has a very high unit replacement cost while the culvert‘s cost for the culvert “barrel” is also very high relative to the cost of the wingwalls and other peripheral elements on the culvert. It can also be observed that primarily because their replacement costs are small, elements such as joints, bearings, railings, and moveable bridge elements all have very small importance weights.

Table 2.8. Sample calculations of importance weights based on bridge replacement costs

BRKEY	ELEMKEY	ELEMSHORT	QUANTITY	UnitMetric	Unit cost	TotalCost	ElemWt	TotalBridgeCost
010104	12	Bare Concrete Deck	9015.0	sq.m.	724.57	6,531,987.70	0.23	28,181,661.50
010104	109	P/S Conc Open Girder	3427.0	m.	3,476.19	11,912,918.10	0.42	
010104	205	R/Conc Column	64.0	ea.	43,122.08	2,759,813.27	0.10	
010104	215	R/Conc Abutment	45.0	m.	5,800.83	261,037.39	0.01	
010104	234	R/Conc Cap	334.0	m.	4,321.76	1,443,469.30	0.05	
010104	290	Channel	1.0	ea.	0.00	0.00	0.00	
010104	300	Strip Seal Exp Joint	65.0	m.	293.50	19,077.70	0.00	
010104	310	Elastomeric Bearing	276.0	ea.	11,261.85	3,108,270.51	0.11	
010104	321	R/Conc Approach Slab	2.0	ea.	29,166.44	58,332.87	0.00	
010104	331	Conc Bridge Railing	842.0	m.	867.80	730,688.96	0.03	
010104	333	Other Bridge Railing	842.0	m.	1,041.35	876,819.95	0.03	
010104	394	R/Conc Abut Slope Pr	26.2	sq.m.	1,468.31	38,468.23	0.00	
010104	396	Other Abut Slope Pro	291.0	sq.m.	1,284.86	373,892.81	0.01	
010104	475	R/Conc Walls	15.0	m.	4,315.24	64,728.61	0.00	
010104	580	Navigational Lights	1.0	ea.	2,156.10	2,156.10	0.00	
030029	38	Bare Concrete Slab	636.8	sq.m.	724.57	461,441.62	0.20	2,325,632.02
030029	204	P/S Conc Column	19.0	ea.	43,122.08	819,319.56	0.35	
030029	215	R/Conc Abutment	27.1	m.	5,800.83	157,359.14	0.07	
030029	234	R/Conc Cap	43.0	m.	4,321.76	185,736.47	0.08	
030029	290	Channel	1.0	ea.	0.00	0.00	0.00	
030029	301	Pourable Joint Seal	27.1	m.	293.50	7,961.86	0.00	
030029	321	R/Conc Approach Slab	2.0	ea.	29,166.44	58,332.87	0.03	
030029	331	Conc Bridge Railing	98.1	m.	867.80	85,171.26	0.04	
030029	396	Other Abut Slope Pro	415.0	sq.m.	1,284.86	533,212.25	0.23	
030029	475	R/Conc Walls	4.0	m.	4,315.24	17,096.98	0.01	
100243	12	Bare Concrete Deck	1408.6	sq.m.	724.57	1,020,627.59	0.13	7,702,840.85
100243	109	P/S Conc Open Girder	608.4	m.	3,476.19	2,114,850.54	0.27	
100243	205	R/Conc Column	16.0	ea.	43,122.08	689,953.32	0.09	
100243	215	R/Conc Abutment	69.5	m.	5,800.83	403,122.96	0.05	
100243	234	R/Conc Cap	69.5	m.	4,321.76	300,336.71	0.04	
100243	301	Pourable Joint Seal	139.0	m.	293.50	40,793.70	0.01	
100243	310	Elastomeric Bearing	88.0	ea.	11,261.85	991,042.77	0.13	
100243	321	R/Conc Approach Slab	2.0	ea.	29,166.44	58,332.87	0.01	
100243	331	Conc Bridge Railing	104.2	m.	867.80	90,461.37	0.01	
100243	394	R/Conc Abut Slope Pr	1334.3	sq.m.	1,468.31	1,959,120.73	0.25	
100243	475	R/Conc Walls	7.9	m.	4,315.24	34,198.28	0.00	

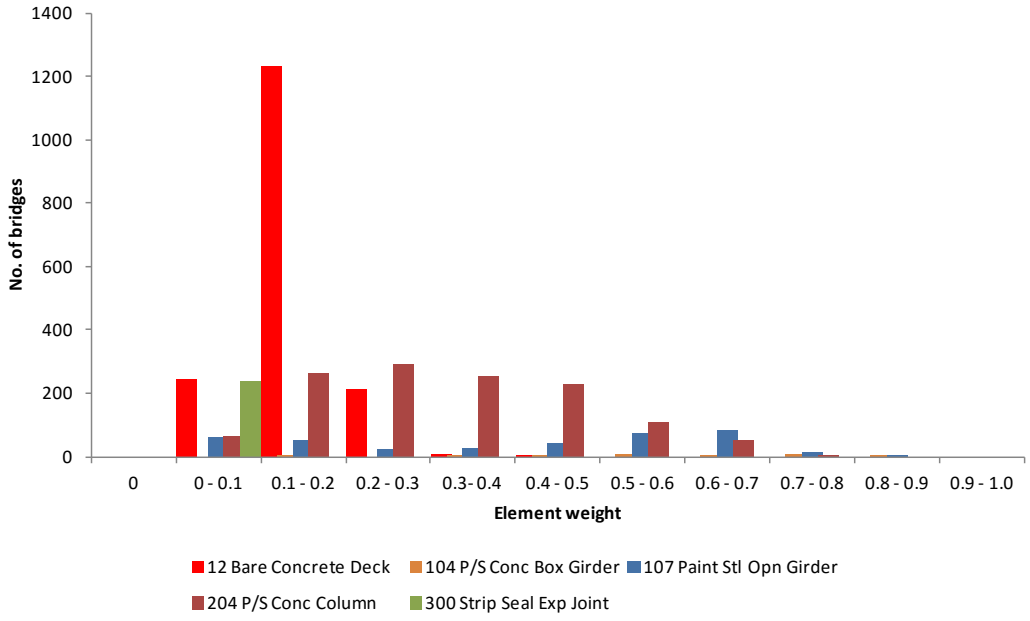

Figure 2.3. Variation in the weights based on element replacement cost for sample bridge elements.

Table 2.9. Importance weights based on element replacement costs

Elemkey Old	ElemShortOld	Mean	Count	ElementWt (maxof99)	Elemkey Old	ElemShortOld	Mean	Count	ElementWt (maxof99)
12	Bare Concrete Deck	0.1487	1702	15	235	Timber Cap	0.0438	306	4
13	Unp Conc Deck/AC Ovl	0.0893	219	9	240	Metal Culvert	0.4365	77	43
28	Steel Deck/Open Grid	0.0255	93	3	241	Concrete Culvert	0.6363	554	63
29	Steel Deck/Conc Grid	0.0116	67	1	290	Channel	0.0000	2727	0
30	Corrug/Orthotpc Deck	0.6337	15	63	298	Pile Jacket Bare	0.0073	205	1
31	Timber Deck	0.0388	209	4	299	Pile Jacket/Cath Pro	0.0043	32	0
32	Timber Deck/AC Ovly	0.0517	19	5	300	Strip Seal Exp Joint	0.0021	242	0
38	Bare Concrete Slab	0.1666	415	16	301	Pourable Joint Seal	0.0054	2073	1
39	Unp Conc Slab/AC Ovl	0.1346	214	13	302	Compressn Joint Seal	0.0051	588	1
54	Timber Slab	0.0089	4	1	303	Assembly Joint/Seal	0.0017	95	0
55	Timber Slab/AC Ovly	0.0298	3	3	304	Open Expansion Joint	0.0052	97	1
98	Conc Deck on PC Pane	0.1268	52	13	310	Elastomeric Bearing	0.0947	1561	9
99	PS Conc Slab	0.1617	462	16	311	Moveable Bearing	0.0362	366	4
102	Paint Stl Box Girder	0.4378	66	43	312	Enclosed Bearing	0.0542	2	5
104	P/S Conc Box Girder	0.5566	32	55	313	Fixed Bearing	0.0352	338	3
105	R/Conc Box Girder	0.1717	4	17	320	P/S Conc Appr Slab	0.0415	1	4
106	Unpnt Stl Opn Girder	0.5698	15	56	321	R/Conc Approach Slab	0.0211	2558	2
107	Paint Stl Opn Girder	0.4020	387	40	330	Metal Rail Uncoated	0.0515	98	5
109	P/S Conc Open Girder	0.3282	1466	32	331	Conc Bridge Railing	0.0261	2307	3
110	R/Conc Open Girder	0.2382	113	24	332	Timb Bridge Railing	0.0370	82	4
111	Timber Open Girder	0.5156	258	51	333	Other Bridge Railing	0.0337	988	3
112	Unpnt Stl Stringer	0.0594	2	6	334	Metal Rail Coated	0.0396	368	4
113	Paint Stl Stringer	0.0489	84	5	386	Fender/Dolphin Uncoa	0.0062	6	1
117	Timber Stringer	0.4504	3	45	387	P/S Fender/Dolphin	0.0089	82	1
120	U/Stl Thru Truss/Bot	0.2218	1	22	389	Timber Fender/Dolphi	0.0115	48	1
121	P/Stl Thru Truss/Bot	0.1065	19	11	390	Other Fender/Dolphin	0.0134	5	1
125	U/Stl Thru Truss/Top	0.2495	1	25	393	Blkhd Sew l Metal Unc	0.0074	48	1
126	P/Stl Thru Truss/Top	0.1255	19	12	394	R/Conc Abut Slope Pr	0.1388	958	14
131	Paint Stl Deck Truss	0.1780	3	18	395	Timber Abut Slope Pr	0.0722	204	7
141	Paint Stl Arch	0.0778	2	8	396	Other Abut Slope Pro	0.1434	1362	14
144	R/Conc Arch	0.2939	13	29	397	Drain. Syst Metal	0.0068	53	1
146	Misc Cable Uncoated	0.3439	1	34	398	Drain. Syst Other	0.0034	121	0
147	Misc Cable Coated	0.1794	1	18	399	Other Xpansion Joint	0.0029	60	0
151	Unpnt Stl Floor Beam	0.0642	1	6	474	Walls Uncoated	0.0128	73	1
152	Paint Stl Floor Beam	0.0726	105	7	475	R/Conc Walls	0.0917	2799	9
154	P/S Conc Floor Beam	0.0188	1	2	476	Timber Walls	0.0659	279	7
155	R/Conc Floor Beam	0.1198	6	12	477	Other Walls	0.1988	109	20
156	Timber Floor Beam	0.0681	1	7	478	MSE Walls	0.0584	441	6
201	Unpnt Stl Column	0.2304	64	23	487	Sign Member Horiz	0.5540	1526	55
202	Paint Stl Column	0.2113	65	21	488	Sign Member Vertical	0.4452	1526	44
204	P/S Conc Column	0.3166	1273	31	495	Uncoat High Mast L.	0.8333	95	82
205	R/Conc Column	0.1296	1164	13	496	Painted High Mast L.	0.8333	15	82
206	Timber Column	0.0741	383	7	497	Galvan. High Mast L.	0.8333	127	82
207	P/S Conc Holl Pile	0.1661	13	16	499	H. M. L. P. Found.	0.1701	238	17
210	R/Conc Pier Wall	0.1497	206	15	540	Open Gearing	0.0320	60	3
215	R/Conc Abutment	0.0701	2893	7	541	Speed Reducers	0.0151	50	1
216	Timber Abutment	0.1085	284	11	542	Shafts	0.0042	60	0
217	Other Mtl Abutment	0.1248	21	12	543	Shaft Brgs and Coupl	0.0024	60	0
220	R/C Sub Pile Cap/Ftg	0.2122	215	21	544	Brakes	0.0006	52	0
230	Unpnt Stl Cap	0.0079	6	1	545	Emergency Drive	0.0014	61	0
231	Paint Stl Cap	0.0213	78	2	546	Span Drive Motors	0.0027	47	0
233	P/S Conc Cap	0.0112	10	1	547	Hydraulic Pow er Unit	0.0127	26	1
234	R/Conc Cap	0.0589	2352	6	548	Hydraulic Piping Sys	0.0009	26	0

Table 2.9. Importance weights based on element replacement costs (cont'd)

Elemkey Old	ElemShortOld	Mean	Count	ElementWt (max of 99)
549	Hydraulic Cylinders	0.0060	20	1
550	Hopkins Frame	0.0076	20	1
560	Locks	0.0012	65	0
561	Live Load Shoes	0.0052	68	1
562	Counterw eight Suppor	0.0016	65	0
563	Acc Ladd & Plat	0.0035	107	0
564	Counterw eight	0.0031	68	0
565	Trun/Str and Cur Trk	0.0058	64	1
570	Transformers	0.0005	50	0
571	Submarine Cable	0.0048	63	0
572	Conduit & Junc. Box	0.0001	93	0
573	PLCs	0.0067	34	1
574	Control Console	0.0053	61	1
580	Navigational Lights	0.0005	135	0
581	Operator Facilities	0.0049	62	0
582	Lift Bridge Spec. Eq	0.0560	6	6
583	Sw ing Bridge Spec. E	0.0159	5	2
590	Resistance Barriers	0.0002	13	0
591	Warning Gates	0.0040	67	0
592	Traffic Signals	0.0017	67	0

2.2.2. Element weights based on long-term costs

The second approach is to utilize the element long-term unit costs resulting from the optimization run under the network level preservation model. The unit cost employed was for the "Do Nothing" action at each element's worst condition state. The ratio is calculated for each element's long-term cost (unit cost times the element quantity) relative to the overall bridge long-term costs (sum of element long-term costs). These ratios will serve as the element importance weights based on long-term costs. Sample calculation of such costs and ratios as element weights, are demonstrated in Table 2.10 for three bridges from the FDOT bridge inventory for 2009. From the calculations in Table 2.10, it could be seen that for Bridge ID 010104, the total bridge long-term cost is $ 18,739,391.08 (sum of element long-term costs), and it was utilized to compute the various element weights. The element "P/S Conc Open Girder" has the highest element weight of 0.51, followed by "Bare Concrete Deck" with a weight of 0.28, and many other elements have very small weights. Using the bridge inventory, a variation among the estimates of weights for sample elements is shown in Figure 2.4.

As previously done using the replacement costs, Table 2.11 shows the element weights, revised on a scale of 0 to 99, based on the element cost data from the 2009 bridge inventory. It could be seen here that elements such as girder elements have significant weights, ranging from 16 to 62, while the weights of deck and slab elements, excluding timber elements, range from 10 to 19. Element no. 30 (Corrugated/Orthotropic Deck) has a weight of 49. There are high values of element weights (ranging from 82 to 84) for the major components of sign structures, i.e., element nos. 495, 496, and 497, because these main components are relatively costlier on the long-term than the other sign components such as the foundation. It can also be observed that primarily because their long-term costs are small, elements such as joints, bearings, railings, and moveable bridge elements all have very small importance weights.

Table 2.10. Sample calculations of importance weights based on bridge element long-term costs

BRKEY	ELEMKEY	ELEMSHORT	QUANTITY	UnitMetric	Unit cost	TotalCost	ElemWt	TotalBridgeCost
010104	12	Bare Concrete Deck	9015.00	sq.m.	581.49	5,242,106.95	0.28	18,739,391.08
010104	109	P/S Conc Open Girder	3427.00	m.	2,806.66	9,618,425.19	0.51	
010104	205	R/Conc Column	64.00	ea.	10,061.84	643,957.75	0.03	
010104	215	R/Conc Abutment	45.00	m.	3,217.66	144,794.55	0.01	
010104	234	R/Conc Cap	334.00	m.	3,269.46	1,091,999.38	0.06	
010104	290	Channel	1.00	ea.	570,708.63	570,708.63	0.03	
010104	300	Strip Seal Exp Joint	65.00	m.	266.28	17,308.10	0.00	
010104	310	Elastomeric Bearing	276.00	ea.	1,640.34	452,734.50	0.02	
010104	321	R/Conc Approach Slab	2.00	ea.	23,381.41	46,762.82	0.00	
010104	331	Conc Bridge Railing	842.00	m.	706.16	594,583.41	0.03	
010104	333	Other Bridge Railing	842.00	m.	301.57	253,920.10	0.01	
010104	394	R/Conc Abut Slope Pr	26.20	sq.m.	56.39	1,477.43	0.00	
010104	396	Other Abut Slope Pro	291.00	sq.m.	69.40	20,194.37	0.00	
010104	475	R/Conc Walls	15.00	m.	2,521.82	37,827.32	0.00	
010104	580	Navigational Lights	1.00	ea.	2,590.57	2,590.57	0.00	
030029	38	Bare Concrete Slab	636.85	sq.m.	605.36	385,525.36	0.25	1,538,643.86
030029	204	P/S Conc Column	19.00	ea.	10,004.70	190,089.34	0.12	
030029	215	R/Conc Abutment	27.13	m.	3,217.66	87,285.38	0.06	
030029	234	R/Conc Cap	42.98	m.	3,269.46	140,511.55	0.09	
030029	290	Channel	1.00	ea.	570,708.63	570,708.63	0.37	
030029	301	Pourable Joint Seal	27.13	m.	356.23	9,663.53	0.01	
030029	321	R/Conc Approach Slab	2.00	ea.	23,381.41	46,762.82	0.03	
030029	331	Conc Bridge Railing	98.15	m.	706.16	69,306.40	0.05	
030029	396	Other Abut Slope Pro	415.00	sq.m.	69.40	28,799.40	0.02	
030029	475	R/Conc Walls	3.96	m.	2,521.82	9,991.46	0.01	
100243	12	Bare Concrete Deck	1408.60	sq.m.	581.49	819,082.83	0.23	3,547,871.49
100243	109	P/S Conc Open Girder	608.38	m.	2,806.66	1,707,518.81	0.48	
100243	205	R/Conc Column	16.00	ea.	10,061.84	160,989.44	0.05	
100243	215	R/Conc Abutment	69.49	m.	3,217.66	223,607.85	0.06	
100243	234	R/Conc Cap	69.49	m.	3,269.46	227,207.81	0.06	
100243	301	Pourable Joint Seal	138.99	m.	356.23	49,512.47	0.01	
100243	310	Elastomeric Bearing	88.00	ea.	1,640.34	144,350.13	0.04	
100243	321	R/Conc Approach Slab	2.00	ea.	23,381.41	46,762.82	0.01	
100243	331	Conc Bridge Railing	104.24	m.	706.16	73,611.12	0.02	
100243	394	R/Conc Abut Slope Pr	1334.27	sq.m.	56.39	75,242.77	0.02	
100243	475	R/Conc Walls	7.93	m.	2,521.82	19,985.43	0.01	

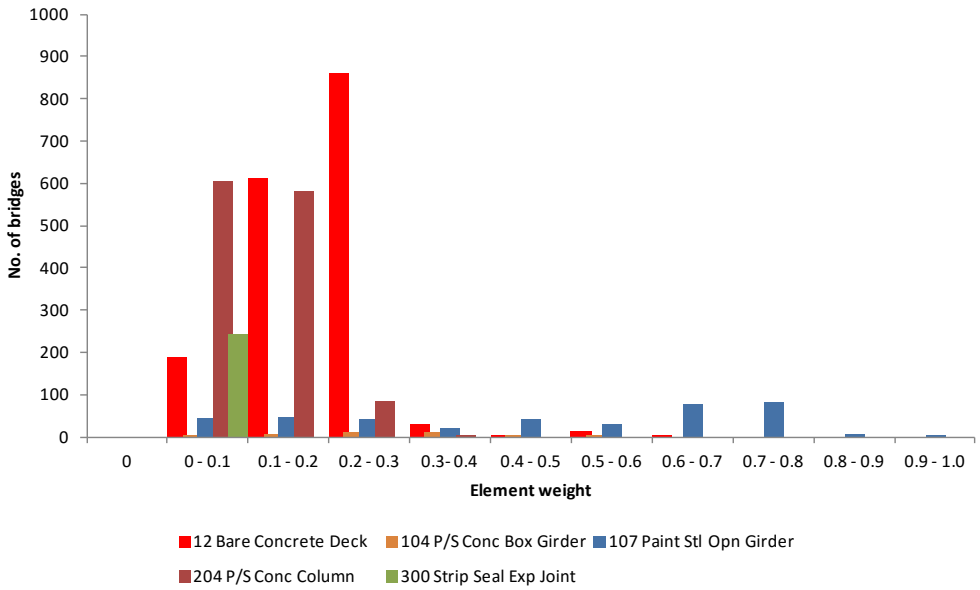

Figure 2.4. Variation in the weights based on element long-term cost for sample bridge elements.

Table 2.11. Importance weights based on element long-term costs

Elemkey Old	ElemShortOld	Mean	Count	ElementWt (maxof99)	Elemkey Old	ElemShortOld	Mean	Count	ElementWt (maxof99)
12	Bare Concrete Deck	0.1950	1702	19	235	Timber Cap	0.0162	306	2
13	Bare Concrete Deck	0.0981	219	10	240	Metal Culvert	0.1877	77	19
28	Steel Deck/Open Grid	0.0320	94	3	241	Concrete Culvert	0.3239	554	32
29	Steel Deck/Conc Grid	0.0115	67	1	290	Channel	0.4265	2727	42
30	Corrug/Orthotpc Deck	0.4940	15	49	298	Pile Jacket Bare	0.0041	205	0
31	Timber Deck	0.0238	210	2	299	Pile Jacket/Cath Pro	0.0016	32	0
32	Timber Deck/AC Ovly	0.0431	19	4	300	Strip Seal Exp Joint	0.0030	242	0
38	Bare Concrete Slab	0.1942	416	19	301	Pourable Joint Seal	0.0094	2074	1
39	Unp Conc Slab/AC Ovl	0.1343	215	13	302	Compressn Joint Seal	0.0094	588	1
54	Timber Slab	0.0022	4	0	303	Assembly Joint/Seal	0.0026	95	0
55	Timber Slab/AC Ovly	0.0097	3	1	304	Open Expansion Joint	0.0061	97	1
98	Conc Deck on PC Pane	0.1752	52	17	310	Elastomeric Bearing	0.0233	1561	2
99	PS Conc Slab	0.1799	462	18	311	Moveable Bearing	0.0093	366	1
102	Paint Stl Box Girder	0.5060	66	50	312	Enclosed Bearing	0.0382	2	4
104	P/S Conc Box Girder	0.2690	32	27	313	Fixed Bearing	0.0137	338	1
105	R/Conc Box Girder	0.2230	4	22	320	P/S Conc Appr Slab	0.0405	1	4
106	Unpnt Stl Opn Girder	0.6290	15	62	321	R/Conc Approach Slab	0.0229	2558	2
107	Paint Stl Opn Girder	0.4583	388	45	330	Metal Rail Uncoated	0.0534	98	5
109	P/S Conc Open Girder	0.4310	1466	43	331	Conc Bridge Railing	0.0321	2307	3
110	R/Conc Open Girder	0.2665	114	26	332	Timb Bridge Railing	0.0274	82	3
111	Timber Open Girder	0.1581	258	16	333	Other Bridge Railing	0.0110	988	1
112	Unpnt Stl Stringer	0.0766	2	8	334	Metal Rail Coated	0.0295	368	3
113	Paint Stl Stringer	0.0602	84	6	386	Fender/Dolphin Uncoa	0.0108	6	1
117	Timber Stringer	0.1127	3	11	387	P/S Fender/Dolphin	0.0148	82	1
120	U/Stl Thru Truss/Bot	0.2655	1	26	389	Timber Fender/Dolphi	0.0111	48	1
121	P/Stl Thru Truss/Bot	0.0948	19	9	390	Other Fender/Dolphin	0.0177	5	2
125	U/Stl Thru Truss/Top	0.3027	1	30	393	Blkhd Sew l Metal Unc	0.0068	48	1
126	P/Stl Thru Truss/Top	0.1079	19	11	394	R/Conc Abut Slope Pr	0.0100	958	1
131	Paint Stl Deck Truss	0.0763	3	8	395	Timber Abut Slope Pr	0.0011	204	0
141	Paint Stl Arch	0.0956	2	9	396	Other Abut Slope Pro	0.0127	1363	1
144	R/Conc Arch	0.0833	13	8	397	Drain. Syst Metal	0.0101	53	1
146	Misc Cable Uncoated	0.3478	1	34	398	Drain. Syst Other	0.0062	121	1
147	Misc Cable Coated	0.1724	1	17	399	Other Xpansion Joint	0.0033	60	0
151	Unpnt Stl Floor Beam	0.0741	1	7	474	Walls Uncoated	0.0102	73	1
152	Paint Stl Floor Beam	0.0739	105	7	475	R/Conc Walls	0.0416	2799	4
154	P/S Conc Floor Beam	0.0229	1	2	476	Timber Walls	0.0251	279	2
155	R/Conc Floor Beam	0.1194	6	12	477	Other Walls	0.0900	110	9
156	Timber Floor Beam	0.0242	1	2	478	MSE Walls	0.0661	441	7
201	Unpnt Stl Column	0.0188	64	2	487	Sign Member Horiz	0.5190	1526	51
202	Paint Stl Column	0.0146	65	1	488	Sign Member Vertical	0.4154	1526	41
204	P/S Conc Column	0.1109	1273	11	489		0.0656	1513	6
205	R/Conc Column	0.0453	1164	4	495	Uncoat High Mast L.	0.8399	95	83
206	Timber Column	0.0349	383	3	496	Painted High Mast L.	0.8529	17	84
207	P/S Conc Holl Pile	0.0749	13	7	497	Galvan. High Mast L.	0.8332	127	82
210	R/Conc Pier Wall	0.0347	207	3	499	H. M. L. P. Found.	0.1663	238	16
215	R/Conc Abutment	0.0508	2893	5	540	Open Gearing	0.0428	60	4
216	Timber Abutment	0.0440	284	4	541	Speed Reducers	0.0203	50	2
217	Other Mtl Abutment	0.0569	21	6	542	Shafts	0.0055	60	1
220	R/C Sub Pile Cap/Ftg	0.0180	215	2	543	Shaft Brgs and Coupl	0.0033	60	0
230	Unpnt Stl Cap	0.0097	6	1	544	Brakes	0.0011	52	0
231	Paint Stl Cap	0.0304	78	3	545	Emergency Drive	0.0022	61	0
233	P/S Conc Cap	0.0106	10	1	546	Span Drive Motors	0.0042	47	0
234	R/Conc Cap	0.0664	2352	7	547	Hydraulic Pow er Unit	0.0179	26	2

Table 2.11. Importance weights based on element long-term costs (cont'd)

Elemkey Old	ElemShortOld	Mean	Count	ElementWt (maxof99)
548	Hydraulic Piping Sys	0.0007	26	0
549	Hydraulic Cylinders	0.0088	20	1
550	Hopkins Frame	0.0018	20	0
560	Locks	0.0020	65	0
561	Live Load Shoes	0.0038	68	0
562	Counterw eight Suppor	0.0013	65	0
563	Acc Ladd & Plat	0.0031	107	0
564	Counterw eight	0.0020	68	0
565	Trun/Str and Cur Trk	0.0078	64	1
570	Transformers	0.0001	50	0
571	Submarine Cable	0.0020	63	0
572	Conduit & Junc. Box	0.0002	93	0
573	PLCs	0.0060	34	1
574	Control Console	0.0060	61	1
580	Navigational Lights	0.0010	135	0
581	Operator Facilities	0.0054	62	1
582	Lift Bridge Spec. Eq	0.0395	6	4
583	Sw ing Bridge Spec. E	0.0171	5	2
590	Resistance Barriers	0.0003	13	0
591	Warning Gates	0.0039	67	0
592	Traffic Signals	0.0016	67	0

2.2.3. Element weights based on vulnerability to hazards

In a previous research effort sponsored by FDOT on vulnerability of bridges to natural and manmade hazards in Florida, each element was assessed and assigned a vulnerability index on a scale of 0 to 5 (Sobanjo and Thompson, 2012). The results are first summarized in Table 2.12 for the following hazards: tornadoes and strong winds; hurricane (non-coastal bridges) cat 3; hurricane (coastal bridges) cat 3; wildfires; flooding; truck collision; vessel collision; and overhead collision. By assigning some importance points to each hazard, a set of relative weights was established for each type of hazard. These relative weights are then utilized to compute a weighted average importance weight for each element. The weight is finally converted to a scale of 0 to 99. It should be noted that the study was done using the old Pontis elements, thus the old element numbers had to be matched to equivalent new elements. As shown in Table 2.12, it was observed that element importance weights based on vulnerability to hazards are relatively high for most elements, particularly when compared to the importance weights derived from the element replacement and long-term costs. The primary reason for the high importance weights is that all elements are vulnerable to one hazard or the other. To account for the new elements with no direct match to the old Pontis elements, some assignments were done based on similarities and functions of the elements as shown in Table 2.13.

2.2.4. Element weights based on combined cost and vulnerability factors

As shown in Table 2.14, the importance weights derived from the three approaches (element replacement costs, element long-term costs, and hazard vulnerability) are utilized to compute simple and weighted average values for the element importance weights. The relative importance of each approach is reflected in the weighted average. The computed values shown in Table 2.14 can be used as a default set of values which can be modified by the user. In Table 2.14, the element long-term costs are weighted four times more important as the vulnerability index while the element replacement cost is ignored. Figure 2.5 portrays the overall variation in the assigned element weights, with most elements in the 11 to 20 range. It can be seen that under this approach some girder, beam, and stringer elements have relatively large weights (as high as 62). Elements in sign structures also have large weights (as high as 76) due to the reasons mentioned earlier under the previous approaches considering costs and they are also

very vulnerable to some hazards. But in this approach, most of the elements have weights that are not minimal; elements with zero or near zero importance weights in the previous approaches, particularly, the movable bridge elements, now have some weights indicated.

2.2.5. Element weights based on BMS classification

Another approach considered used the new BMS element definitions in terms of the classification of the element (BME, NBE, or ADE), category, and element type. As shown in Table 2.15, a basic evaluation of the elements by class would suggest that NBE elements are the most important elements, as they are used in the final compilation of the inventory condition on a national basis. Within the NBE class, a look at the categories indicates that all elements except category q (railings), assigned a low score of 20, are very important in computing the overall health of the bridge. Most of the other NBE elements are assigned the maximum 100 score, except for the bearings, which are assigned a score of 80. The BME elements (joints and approach slabs) are considered not critical and assigned a score of 40. The class of ADE elements is further refined by category and element type to assign the scores.

2.2.6. Review of element weights by FDOT

During the course of the study, the FDOT made slight revisions to the element numbers and listing. Finally, FDOT engineers reviewed the calculated element weights, as well as the weights based on element BMS classification. The calculated element weights are the same as those computed using the combined cost and vulnerability factors. FDOT then assigned another set of element weights for a few of the elements based on engineering judgment. These element weights are summarized in Table 2.16, including the final set of recommended element weights (last column) for BMS implementation.

Table 2.12. Assigned Element importance weights based on vulnerability to hazard risks

			hazard points	10	20	60	10	30	30	30	0	190	
			hazard relative w eight	0.05	0.11	0.32	0.05	0.16	0.16	0.16	0.00		
Elemkey Old	ElemShortOld	Elemkey New	ElemNameNew	TORNADO/ STRONG WINDS	HURRICANE (NON-COASTAL BRIDGES) CAT 3	HURRICANE (COASTAL BRIDGES) CAT 3	WILDFIRES	FLOODING	TRUCK COLLISION	VESSEL COLLISION	OVERHEAD COLLISION	Weighted Index (maxof5)	Weighted Index (maxof99)
12	Bare Concrete Deck	12	Reinforced Concrete Deck	1	1	5	1	1	3	1	3	2.6	51
13	Unp Conc Deck/AC Ovl	13	Prestressed Concrete Deck	1	1	5	1	1	3	1	3	2.6	51
		15	Prestressed Concrete Top Flange (Slab)										
		16	Reinforced Concrete Top Flange										
28	Steel Deck/Open Grid	28	Steel Deck w ith Open Grid	1	1	5	1	1	3	1	3	2.6	51
29	Steel Deck/Conc Grid	29	Steel Deck w ith Concrete Filled Grid	1	1	5	1	1	3	1	3	2.6	51
30	Corrug/Orthotpc Deck	30	Steel Deck Corrugated/Orthotropic/Etc	1	1	5	1	1	3	1	3	2.6	51
31	Timber Deck	31	Timber Deck	2	1	5	5	2	3	1	3	3.0	59
38	Bare Concrete Slab	38	Reinforced Concrete Slab	1	1	5	1	1	3	1	3	2.6	51
54	Timber Slab	54	Timber Slab	2	1	5	5	2	3	1	3	3.0	59
		60	Other Deck										
		65	Other Slab										
98	Conc Deck on PC Pane	98	Concrete Deck on Precast Deck Panels	1	1	5	1	1	3	1	3	2.6	51
99	PS Conc Slab	99	Prestressed Concrete Slab (Sonovoid)	1	1	5	1	1	3	1	3	2.6	51
102	Paint Stl Box Girder	102	Steel Closed Web/Box Girder	1	0.5	5	2	2	5	2	5	3.2	64
104	P/S Conc Box Girder	104	Prestressed Concrete Closed Web/Box Girder	1	0.5	5	2	1	5	2	5	3.1	60
105	R/Conc Box Girder	105	Reinforced Concrete Closed Web/Box Girder	1	0.5	5	2	1	5	2	5	3.1	60
106	Unpnt Stl Opn Girder	106	Other Material Closed Web/Box Girder	1	0.5	5	2	1	5	2	5	3.1	60
107	Paint Stl Opn Girder	107	Steel Open Girder/Beam	2	0.5	5	2	2	5	2	5	3.3	65
109	P/S Conc Open Girder	109	Prestressed Open Girder/Beam	1	0.5	5	1	1	5	2	5	3.0	59
110	R/Conc Open Girder	110	Reinforced Concrete Open Girder/Beam	1	0.5	5	1	1	5	2	5	3.0	59
111	Timber Open Girder	111	Timber Open Girder/Beam	2	0.5	5	5	2	5	2	5	3.4	68
112	Unpnt Stl Stringer	112	Other Material Open Girder/Beam	1	0.5	5	1	1	5	2	5	3.0	59
113	Paint Stl Stringer	113	Steel Stringer	2	0.5	5	2	2	5	2	5	3.3	65
		115	Prestressed Concrete Stringer										
		116	Reinforced Concrete Stringer										
117	Timber Stringer	117	Timber Stringer	3	0.5	5	5	2	5	2	5	3.5	69
		118	Other Material Stringer										
120	U/Stl Thru Truss/Bot	120	Steel Truss	4	0.5	4	2	2	3	1	3	2.6	51
		135	Timber Truss										
		136	Other Material Truss										
141	Paint Stl Arch	141	Steel Arch	2	0.5	4	2	2	3	1	3	2.5	49
		142	Other Material Arch										
		143	Prestressed Concrete Arch										
144	R/Conc Arch	144	Reinforced Concrete Arch	1	0.5	4	1	1	3	1	3	2.2	44
		145	Masonry Arch										
146	Misc Cable Uncoated	146	Timber Arch	1	0.5	4	5	2	3	1	3	2.6	51
147	Misc Cable Coated	147	Steel Main Cables	4	0.5	4	2	3	3	1	3	2.7	54
		148	Secondary Steel Cables										
		149	Other Material Secondary Cable										

Table 2.12. Assigned Element importance weights based on vulnerability to hazard risks (cont'd)

			hazard points	10	20	60	10	30	30	30	0	190	
			hazard relative weight	0.05	0.11	0.32	0.05	0.16	0.16	0.16	0.00		
Elemkey Old	ElemShortOld	Elemkey New	ElemNameNew	TORNADO/ STRONG WINDS	HURRICANE (NON-COASTAL BRIDGES) CAT 3	HURRICANE (COASTAL BRIDGES) CAT 3	WILDFIRES	FLOODING	TRUCK COLLISION	VESSEL COLLISION	OVERHEAD COLLISION	Weighted Index (maxof5)	Weighted Index (maxof99)
152	Paint Stl Floor Beam	152	Steel Floor Beam	3	0.5	5	2	2	3	1	3	2.8	56
154	P/S Conc Floor Beam	154	Prestressed Concrete Floor Beam	2	0.5	5	1	1	3	1	3	2.6	51
155	R/Conc Floor Beam	155	Reinforced Concrete Floor Beam	2	0.5	5	1	1	5	1	3	2.9	57
156	Timber Floor Beam	156	Timber Floor Beam	3	0.5	5	5	2	5	1	3	3.3	66
		157	Other Material Floor Beam										
		158	External Post Tensioning Duct										
		161	Steel Pin and Pin & Hanger Assembly or Both										
		162	Steel Gusset Plate										
202	Paint Stl Column	202	Steel Column	3	1	3	2	2	3	1	3	2.3	45
		203	Other Material Column										
204	P/S Conc Column	204	Prestressed Concrete Column	2	1	3	1	1	3	1	3	2.0	40
205	R/Conc Column	205	Reinforced Concrete Column	2	1	3	1	1	3	1	3	2.0	40
206	Timber Column	206	Timber Column	3	1	3	5	2	3	1	3	2.4	48
207	P/S Conc Holl Pile	207	Steel Tow er	2	1	3	1	2	3	1	3	2.2	43
		208	Timber Trestle										
210	R/Conc Pier Wall	210	Reinforced Concrete Pier Wall	1	2	3	1	3	1	1	1	2.1	41
		211	Other Material Pier Wall										
		212	Timber Pier Wall										
		213	Masonry Pier Wall										
215	R/Conc Abutment	215	Reinforced Concrete Abutment	1	2	3	1	3	2	1	1	2.2	44
216	Timber Abutment	216	Timber Abutment	2	2	3	5	3	2	1	1	2.5	49
217	Other Mtl Abutment	217	Masonry Abutment	1	2	3	1	3	2	1	1	2.2	44
		218	Other Material Abutment										
		219	Steel Abutment										
220	R/C Sub Pile Cap/Ftg	220	Reinforced Concrete Pile Cap/Footing	1	1	3	1	4	1	1	1	2.1	42
		225	Steel Pile										
		226	Prestressed Concrete Pile										
		227	Reinforced Concrete Pile										
		228	Timber Pile										
		229	Other Material Pile										
231	Paint Stl Cap	231	Steel Pier Cap	1	1	3	2	3	1	1	1	2.0	40
233	P/S Conc Cap	233	Prestressed Concrete Pier Cap	1	1	3	1	3	1	1	1	1.9	39
234	R/Conc Cap	234	Reinforced Concrete Pier Cap	1	1	3	1	3	1	1	1	1.9	39
235	Timber Cap	235	Timber Pier Cap	2	1	3	5	3	1	1	1	2.2	44
		236	Other Material Pier Cap										
240	Metal Culvert	240	Steel Culvert	1	3	4	2	4	1	1	1	2.7	53
241	Concrete Culvert	241	Reinforced Concrete Culvert	1	3	4	1	4	0	1	0	2.5	49
		242	Timber Culvert										
		243	Other Culvert										
		244	Masonry Culvert										
		245	Prestressed Concrete Culvert										

Table 2.12. Assigned Element importance weights based on vulnerability to hazard risks (cont'd)

			hazard points	10	20	60	10	30	30	30	0	190	
			hazard relative weight	0.05	0.11	0.32	0.05	0.16	0.16	0.16	0.00		
Elemkey Old	ElemShortOld	Elemkey New	ElemNameNew	TORNADO/ STRONG WINDS	HURRICANE (NON-COASTAL BRIDGES) CAT 3	HURRICANE (COASTAL BRIDGES) CAT 3	WILDFIRES	FLOODING	TRUCK COLLISION	VESSEL COLLISION	OVERHEAD COLLISION	Weighted Index (maxof5)	Weighted Index (maxof99)
290	Channel	290	Channel	3	3	5	2	5	1	1	1	3.3	65
		291	Channel Protection Devices										
		297	Prestressed Concrete Hollow Core Pile										
298	Pile Jacket Bare	298	Pile Jacket	3	2	4	2	4	1	1	1	2.7	53
300	Strip Seal Exp Joint	300	Strip Seal Expansion Joint	2	1	4	4	3	3	1	3	2.8	55
301	Pourable Joint Seal	301	Pourable Joint Seal	2	1	4	4	3	3	1	3	2.8	55
302	Compressn Joint Seal	302	Compression Joint Seal	2	1	4	4	3	3	1	3	2.8	55
303	Assembly Joint/Seal	303	Assembly Joint with Seal	2	1	4	4	3	3	1	3	2.8	55
304	Open Expansion Joint	304	Open Expansion Joint	2	1	4	4	3	3	1	3	2.8	55
		305	Assembly Joint without Seal										
		306	Other Joint										
310	Elastomeric Bearing	310	Elastomeric Bearing	2	1	4	4	3	3	1	3	2.8	55
311	Moveable Bearing	311	Movable Bearing (roller, sliding, etc.)	2	1	4	4	3	3	1	3	2.8	55
312	Enclosed Bearing	312	Enclosed/Concealed Bearing	2	1	4	4	3	3	1	3	2.8	55
313	Fixed Bearing	313	Fixed Bearing	2	1	4	4	3	3	1	3	2.8	55
		314	Pot Bearing										
		315	Disk Bearing										
		316	Other Bearing										
320	P/S Conc Appr Slab	320	Prestressed Concrete Approach Slab	1	2	5	1	4	1	1	1	2.8	56
321	R/Conc Approach Slab	321	Reinforced Concrete Approach Slab	1	2	5	1	4	1	1	1	2.8	56
330	Metal Rail Uncoated	330	Metal Bridge Railing	4	2	5	3	1	3	1	3	2.9	58
331	Conc Bridge Railing	331	Reinforced Concrete Bridge Railing	4	2	5	2	1	3	1	3	2.9	57
332	Timb Bridge Railing	332	Timber Bridge Railing	4	2	5	5	1	3	1	3	3.1	60
333	Other Bridge Railing	333	Other Bridge Railing	4	2	5	4	1	3	1	3	3.0	59
334	Metal Rail Coated	334	Masonry Bridge Railing	4	2	5	2	1	3	1	3	2.9	57
386	Fender/Dolphin Uncoa	386	Fender/Dolphin System (Metal)	2	2	5	2	3	0	5	0	3.3	65
387	P/S Fender/Dolphin	387	Fender/Dolphin System (Prestressed Concrete)	2	2	5	2	3	0	5	0	3.3	65
		388	Fender/Dolphin System (Reinforced Concrete)										
389	Timber Fender/Dolphi	389	Fender/Dolphin System (Timber)	2	2	5	5	3	0	5	0	3.4	68
390	Other Fender/Dolphin	390	Fender/Dolphin System (Other material)	2	2	5	4	3	0	5	0	3.4	67
393	Blkhd Sew l Metal Unc	393	Bulkhead/Seawall	2	2	5	1	3	0	1	0	2.6	51
394	R/Conc Abut Slope Pr	394	Abutment Slope Protection (Reinforced or Plain Concrete)	2	2	5	1	4	2	1	1	3.1	60
395	Timber Abut Slope Pr	395	Abutment Slope Protection (Timber)	3	2	5	5	4	2	1	1	3.3	66
396	Other Abut Slope Pro	396	Abutment Slope Protection (Other material)	2	2	5	4	4	2	1	1	3.2	64
397	Drain. Syst Metal	397	Metal Drainage System	2	1	4	3	3	1	0	1	2.3	45
398	Drain. Syst Other	398	Other Material Drainage System	2	1	4	3	3	1	0	1	2.3	45
474	Walls Uncoated	474	Wingwall/Retaining Wall (Metal)	2	3	4	2	4	2	0	1	2.7	54
475	R/Conc Walls	475	Wingwall/Retaining Wall (Reinforced or Plain Concrete)	2	3	4	1	4	2	0	1	2.7	53
476	Timber Walls	476	Wingwall/Retaining Wall (Timber)	3	3	4	5	4	2	0	1	2.9	58
477	Other Walls	477	Wingwall/Retaining Wall (Other material)	2	3	4	4	4	2	0	1	2.8	56
478	MSE Walls	478	Mechanically Stabilized Earth Wall	2	3	4	2	4	2	0	1	2.7	54

Table 2.12. Assigned Element importance weights based on vulnerability to hazard risks (cont'd)

			hazard points	10	20	60	10	30	30	30	0	190	
			hazard relative weight	0.05	0.11	0.32	0.05	0.16	0.16	0.16	0.00		
Elemkey Old	ElemShortOld	Elemkey New	ElemNameNew	TORNADO/ STRONG WINDS	HURRICANE (NON-COASTAL BRIDGES) CAT 3	HURRICANE (COASTAL BRIDGES) CAT 3	WILDFIRES	FLOODING	TRUCK COLLISION	VESSEL COLLISION	OVERHEAD COLLISION	Weighted Index (maxof5)	Weighted Index (maxof99)
		480	Mast Arm Foundation										
		481	Mast Arm Vertical Member										
		484	Mast Arm Horizontal Member										
487	Sign Member Horiz	487	Overlane Sign Structure Horizontal Member	4	4	4	2	1	1	0	0	2.3	46
488	Sign Member Vertical	488	Overlane Sign Structure Vertical Member	4	4	4	2	1	1	0	0	2.3	46
		489	Overlane Sign Structure Foundation										
496	Painted High Mast L.	496	High Mast Light Poles	4	4	4	2	1	1	0	0	2.3	46
499	H. M. L. P. Found.	499	High Mast Light Pole Foundation	4	4	4	2	1	1	0	0	2.3	46
		510	Wearing Surfaces										
		515	Steel Protective Coating										
		516	Paint on Steel										
		517	Weathering Steel Patina										
		518	Galvanized or Metalized Steel										
		519	Other Steel Protective Coatings										
		520	Concrete Reinforcing Steel Protective System										
		521	Concrete Protective Coating										
540	Open Gearing	540	Open Gearing	3	2	4	3	4	1	1	0	2.7	54
541	Speed Reducers	541	Speed Reducers	3	2	4	3	4	1	1	0	2.7	54
542	Shafts	542	Shafts	3	2	4	3	4	1	1	0	2.7	54
543	Shaft Brgs and Coupl	543	Shaft Bearing/Shaft Couplings	3	2	4	3	4	1	1	0	2.7	54
544	Brakes	544	Brakes	3	2	4	3	4	1	1	0	2.7	54
545	Emergency Drive	545	Emergency Drive and Back Up Power System	3	2	4	3	4	1	1	0	2.7	54
546	Span Drive Motors	546	Span Drive Motors	3	2	4	3	4	1	1	0	2.7	54
547	Hydraulic Power Unit	547	Hydraulic Power Units	3	2	4	3	4	1	1	0	2.7	54
548	Hydraulic Piping Sys	548	Hydraulic Piping Systems	3	2	4	3	4	1	1	0	2.7	54
549	Hydraulic Cylinders	549	Hydraulic Cylinders/Motors/Rotary Actuators	3	2	4	3	4	1	1	0	2.7	54
550	Hopkins Frame	550	Hopkins Frame	3	2	4	3	4	1	1	0	2.7	54
560	Locks	560	Span Locks/Toe Locks/Heel Stops/Tail Locks	3	2	4	3	4	1	1	0	2.7	54
561	Live Load Shoes	561	Live Load Shoes/Strike Plates/Buffer Cylinders	3	2	4	3	4	1	1	0	2.7	54
562	Counterweight Suppor	562	Counterweight Support	3	2	4	3	4	1	1	0	2.7	54
563	Acc Ladd & Plat	563	Access Ladders & Platform (Other material)	3	2	4	3	4	1	1	0	2.7	54
		563	Access Ladders & Platforms (movable bridge support system)										
564	Counterweight	564	Counterweight	3	2	4	3	4	1	1	0	2.7	54
565	Trun/Str and Cur Trk	565	Trunnion/Straight and Curved Track	3	2	4	3	4	1	1	0	2.7	54
570	Transformers	570	Transformers and Thyristors	3	2	4	3	4	1	1	0	2.7	54
571	Submarine Cable	571	Submarine Cable	3	2	4	3	4	1	1	0	2.7	54
572	Conduit & Junc. Box	572	Conduit & Junction Boxes (Misc. superstructure elements)	3	2	4	3	4	1	1	0	2.7	54
		572	Conduit & Junction Boxes (Movable bridge control system)	3	2	4	3	4	1	1	0	2.7	54
573	PLCs	573	Programmable Logic Controllers	3	2	4	3	4	1	1	0	2.7	54
574	Control Console	574	Control Console	3	2	4	3	4	1	1	0	2.7	54
580	Navigational Lights	580	Navigational Light System (Misc. substructure elements)	4	2	4	3	4	1	1	0	2.8	55
		580	Navigational Light System (Movable bridge control system)										
581	Operator Facilities	581	Operator Facilities	4	5	4	3	4	1	1	0	3.1	61
582	Lift Bridge Spec. Eq	582	Lift Bridge Specific Equipment	3	2	4	3	4	1	1	0	2.7	54
583	Swing Bridge Spec. E	583	Swing Bridge Specific Equipment	3	2	4	3	4	1	1	0	2.7	54
590	Resistance Barriers	590	Resistance Gates	3	2	4	3	4	1	1	0	2.7	54
591	Warning Gates	591	Warning Gates	4	5	4	3	4	1	1	0	3.1	61
592	Traffic Signals	592	Traffic Signals	4	5	4	3	4	1	1	0	3.1	61

Table 2.13. Assumed equivalent elements for costs and hazard risk

		Assumed equivalent element	
Elemkey New	ElemNameNew	Elemkey New	ElemNameNew
15	Prestressed Concrete Top Flange (Slab)	38	Reinforced Concrete Slab
16	Reinforced Concrete Top Flange	12	Reinforced Concrete Deck
60	Other Deck	12	Reinforced Concrete Deck
65	Other Slab	38	Reinforced Concrete Slab
115	Prestressed Concrete Stringer	109	Prestressed Open Girder/Beam
116	Reinforced Concrete Stringer	110	Reinforced Concrete Open Girder/Beam
118	Other Material Stringer	115	Prestressed Concrete Stringer
135	Timber Truss	120	Steel Truss
136	Other Material Truss	120	Steel Truss
142	Other Material Arch	144	Reinforced Concrete Arch
143	Prestressed Concrete Arch	144	Reinforced Concrete Arch
145	Masonry Arch	144	Reinforced Concrete Arch
146	Timber Arch	144	Reinforced Concrete Arch
148	Secondary Steel Cables	147	Steel Main Cables
149	Other Material Secondary Cable	147	Steel Main Cables
157	Other Material Floor Beam	155	Reinforced Concrete Floor Beam
158	External Post Tensioning Duct	147	Steel Main Cables
161	Steel Pin and Pin & Hanger Assembly or Both	310	Elastomeric Bearing
162	Steel Gusset Plate	310	Elastomeric Bearing
203	Other Material Column	202	Steel Column
208	Timber Trestle	206	Timber Column
211	Other Material Pier Wall	210	Reinforced Concrete Pier Wall
212	Timber Pier Wall	210	Reinforced Concrete Pier Wall
213	Masonry Pier Wall	210	Reinforced Concrete Pier Wall
218	Other Material Abutment	215	Reinforced Concrete Abutment
219	Steel Abutment	215	Reinforced Concrete Abutment
225	Steel Pile	202	Steel Column
226	Prestressed Concrete Pile	204	Prestressed Concrete Column
227	Reinforced Concrete Pile	205	Reinforced Concrete Column
228	Timber Pile	206	Timber Column
229	Other Material Pile	204	Prestressed Concrete Column
236	Other Material Pier Cap	234	Reinforced Concrete Pier Cap
242	Timber Culvert	240	Steel Culvert
243	Other Culvert	240	Steel Culvert
244	Masonry Culvert	240	Steel Culvert
245	Prestressed Concrete Culvert	241	Reinforced Concrete Culvert
291	Channel Protection Devices	386	Fender/Dolphin System (Metal)
297	Prestressed Concrete Hollow Core Pile	226	Prestressed Concrete Pile
305	Assembly Joint without Seal	303	Assembly Joint with Seal
306	Other Joint	303	Assembly Joint with Seal
314	Pot Bearing	310	Elastomeric Bearing
315	Disk Bearing	310	Elastomeric Bearing
316	Other Bearing	310	Elastomeric Bearing
388	Fender/Dolphin System (Reinforced Concrete)	387	Fender/Dolphin System (Prestressed Concrete)
480	Mast Arm Foundation		
481	Mast Arm Vertical Member		
484	Mast Arm Horizontal Member		
489	Overlane Sign Structure Foundation		
510	Wearing Surfaces		
515	Steel Protective Coating		
516	Paint on Steel		
517	Weathering Steel Patina		
518	Galvanized or Metalized Steel		
519	Other Steel Protective Coatings		
520	Concrete Reinforcing Steel Protective System		
521	Concrete Protective Coating		
563	Access Ladders & Platforms (movable bridge support system)		
572	Conduit & Junction Boxes (Movable bridge control system)		
580	Navigational Light System (Movable bridge control system)		

Table 2.14. Assigned Element importance weights based on replacement cost, long-term cost, and hazard risk

			Index Source Weights:	0	0.8	0.2	0	
				Element importance weights (0 - 99)				
Elemkey Old	ElemShortOld	Elemkey New	ElemNameNew	Based on element replacement cost	Based on element long term cost	Based on element vulnerability to hazard risks	Simple Average Index	Weghted Average Index
12	Bare Concrete Deck	12	Reinforced Concrete Deck	15	19	51	28	25
13	Unp Conc Deck/AC Ovl	13	Prestressed Concrete Deck	9	10	51	23	18
		15	Prestressed Concrete Top Flange (Slab)	16	19	51	29	25
		16	Reinforced Concrete Top Flange	15	19	51	28	25
28	Steel Deck/Open Grid	28	Steel Deck with Open Grid	3	3	51	19	13
29	Steel Deck/Conc Grid	29	Steel Deck with Concrete Filled Grid	1	1	51	18	11
30	Corrug/Orthotpc Deck	30	Steel Deck Corrugated/Orthotropic/Etc	63	49	51	54	49
31	Timber Deck	31	Timber Deck	4	2	59	22	13
38	Bare Concrete Slab	38	Reinforced Concrete Slab	16	19	51	29	25
54	Timber Slab	54	Timber Slab	1	0	59	20	12
		60	Other Deck	15	19	51	28	25
		65	Other Slab	16	19	51	29	25
98	Conc Deck on PC Pane	98	Concrete Deck on Precast Deck Panels	13	17	51	27	24
99	PS Conc Slab	99	Prestressed Concrete Slab (Sonovoid)	16	18	51	28	25
102	Paint Stl Box Girder	102	Steel Closed Web/Box Girder	43	50	64	52	53
104	P/S Conc Box Girder	104	Prestressed Concrete Closed Web/Box Girder	55	27	60	47	34
105	R/Conc Box Girder	105	Reinforced Concrete Closed Web/Box Girder	17	22	60	33	30
106	Unpnt Stl Opn Girder	106	Other Material Closed Web/Box Girder	56	62	60	59	62
107	Paint Stl Opn Girder	107	Steel Open Girder/Beam	40	45	65	50	49
109	P/S Conc Open Girder	109	Prestressed Open Girder/Beam	32	43	59	45	46
110	R/Conc Open Girder	110	Reinforced Concrete Open Girder/Beam	24	26	59	36	33
111	Timber Open Girder	111	Timber Open Girder/Beam	51	16	68	45	26
112	Unpnt Stl Stringer	112	Other Material Open Girder/Beam	6	8	59	24	18
113	Paint Stl Stringer	113	Steel Stringer	5	6	65	25	18
		115	Prestressed Concrete Stringer	32	43	59	45	46
		116	Reinforced Concrete Stringer	24	26	59	36	33
117	Timber Stringer	117	Timber Stringer	45	11	69	42	23
		118	Other Material Stringer	32	43	59	45	46
120	U/Stl Thru Truss/Bot	120	Steel Truss	22	26	51	33	31
		135	Timber Truss	22	26	51	33	31
		136	Other Material Truss	22	26	51	33	31
141	Paint Stl Arch	141	Steel Arch	8	9	49	22	17
		142	Other Material Arch	29	8	44	27	15
		143	Prestressed Concrete Arch	29	8	44	27	15
144	R/Conc Arch	144	Reinforced Concrete Arch	29	8	44	27	15
		145	Masonry Arch	29	8	44	27	15
146	Misc Cable Uncoated	146	Timber Arch	29	34	51	38	37
147	Misc Cable Coated	147	Steel Main Cables	18	17	54	30	24
		148	Secondary Steel Cables	18	17	54	30	24
		149	Other Material Secondary Cable	18	17	54	30	24

Table 2.14. Assigned Element importance weights based on replacement cost, long-term cost, and hazard risk (Cont'd)

			Index Source Weights:	0	0.8	0.2	0	
				Element importance weights (0 - 99)				
Elemkey Old	ElemShortOld	Elemkey New	ElemNameNew	Based on element replacement cost	Based on element long term cost	Based on element vulnerability to hazard risks	Simple Average Index	Weghted Average Index
152	Paint Stl Floor Beam	152	Steel Floor Beam	7	7	56	23	17
154	P/S Conc Floor Beam	154	Prestressed Concrete Floor Beam	2	2	51	18	12
155	R/Conc Floor Beam	155	Reinforced Concrete Floor Beam	12	12	57	27	21
156	Timber Floor Beam	156	Timber Floor Beam	7	2	66	25	15
		157	Other Material Floor Beam	12	12	57	27	21
		158	External Post Tensioning Duct	18	17	54	30	24
		161	Steel Pin and Pin & Hanger Assembly or Both	9	2	55	22	13
		162	Steel Gusset Plate	9	2	55	22	13
202	Paint Stl Column	202	Steel Column	21	1	45	22	10
		203	Other Material Column	21	1	45	22	10
204	P/S Conc Column	204	Prestressed Concrete Column	31	11	40	27	17
205	R/Conc Column	205	Reinforced Concrete Column	13	4	40	19	11
206	Timber Column	206	Timber Column	7	3	48	19	12
207	P/S Conc Holl Pile	207	Steel Tow er	16	7	43	22	14
		208	Timber Trestle	7	3	48	19	12
210	R/Conc Pier Wall	210	Reinforced Concrete Pier Wall	15	3	41	20	11
		211	Other Material Pier Wall	15	3	41	20	11
		212	Timber Pier Wall	15	3	41	20	11
		213	Masonry Pier Wall	15	3	41	20	11
215	R/Conc Abutment	215	Reinforced Concrete Abutment	7	5	44	19	13
216	Timber Abutment	216	Timber Abutment	11	4	49	21	13
217	Other Mtl Abutment	217	Masonry Abutment	12	6	44	21	14
		218	Other Material Abutment	7	5	44	19	13
		219	Steel Abutment	7	5	44	19	13
220	R/C Sub Pile Cap/Ftg	220	Reinforced Concrete Pile Cap/Footing	21	2	42	22	10
		225	Steel Pile	21	1	45	22	10
		226	Prestressed Concrete Pile	31	11	40	27	17
		227	Reinforced Concrete Pile	13	4	40	19	11
		228	Timber Pile	7	3	48	19	12
		229	Other Material Pile	31	11	40	27	17
231	Paint Stl Cap	231	Steel Pier Cap	2	3	40	15	10
233	P/S Conc Cap	233	Prestressed Concrete Pier Cap	1	1	39	14	9
234	R/Conc Cap	234	Reinforced Concrete Pier Cap	6	7	39	17	13
235	Timber Cap	235	Timber Pier Cap	4	2	44	17	10
		236	Other Material Pier Cap	6	7	39	17	13
240	Metal Culvert	240	Steel Culvert	43	19	53	38	26
241	Concrete Culvert	241	Reinforced Concrete Culvert	63	32	49	48	35
		242	Timber Culvert	43	19	53	38	26
		243	Other Culvert	43	19	53	38	26
		244	Masonry Culvert	43	19	53	38	26
		245	Prestressed Concrete Culvert	63	32	49	48	35

Table 2.14. Assigned Element importance weights based on replacement cost, long-term cost, and hazard risk (Cont'd)

			Index Source Weights:	0	0.8	0.2	0	
				Element importance weights (0 - 99)				
Elemkey Old	ElemShortOld	Elemkey New	ElemNameNew	Based on element replacement cost	Based on element long term cost	Based on element vulnerability to hazard risks	Simple Average Index	Weghted Average Index
290	Channel	290	Channel	0	42	65	36	47
		291	Channel Protection Devices	1	1	65	22	14
		297	Prestressed Concrete Hollow Core Pile	31	11	40	27	17
298	Pile Jacket Bare	298	Pile Jacket	1	0	53	18	11
300	Strip Seal Exp Joint	300	Strip Seal Expansion Joint	0	0	55	18	11
301	Pourable Joint Seal	301	Pourable Joint Seal	1	1	55	19	12
302	Compressn Joint Seal	302	Compression Joint Seal	1	1	55	19	12
303	Assembly Joint/Seal	303	Assembly Joint with Seal	0	0	55	18	11
304	Open Expansion Joint	304	Open Expansion Joint	1	1	55	19	12
		305	Assembly Joint without Seal	0	0	55	18	11
		306	Other Joint	0	0	55	18	11
310	Elastomeric Bearing	310	Elastomeric Bearing	9	2	55	22	13
311	Moveable Bearing	311	Movable Bearing (roller, sliding, etc.)	4	1	55	20	12
312	Enclosed Bearing	312	Enclosed/Concealed Bearing	5	4	55	21	14
313	Fixed Bearing	313	Fixed Bearing	3	1	55	20	12
		314	Pot Bearing	9	2	55	22	13
		315	Disk Bearing	9	2	55	22	13
		316	Other Bearing	9	2	55	22	13
320	P/S Conc Appr Slab	320	Prestressed Concrete Approach Slab	4	4	56	21	14
321	R/Conc Approach Slab	321	Reinforced Concrete Approach Slab	2	2	56	20	13
330	Metal Rail Uncoated	330	Metal Bridge Railing	5	5	58	23	16
331	Conc Bridge Railing	331	Reinforced Concrete Bridge Railing	3	3	57	21	14
332	Timb Bridge Railing	332	Timber Bridge Railing	4	3	60	22	14
333	Other Bridge Railing	333	Other Bridge Railing	3	1	59	21	13
334	Metal Rail Coated	334	Masonry Bridge Railing	4	3	57	21	14
386	Fender/Dolphin Uncoa	386	Fender/Dolphin System (Metal)	1	1	65	22	14
387	P/S Fender/Dolphin	387	Fender/Dolphin System (Prestressed Concrete)	1	1	65	22	14
		388	Fender/Dolphin System (Reinforced Concrete)	1	1	65	22	14
389	Timber Fender/Dolphi	389	Fender/Dolphin System (Timber)	1	1	68	23	14
390	Other Fender/Dolphin	390	Fender/Dolphin System (Other material)	1	2	67	23	15
393	Blkhd Sew l Metal Unc	393	Bulkhead/Seaw all	1	1	51	18	11
394	R/Conc Abut Slope Pr	394	Abutment Slope Protection (Reinforced or Plain Concrete)	14	1	60	25	13
395	Timber Abut Slope Pr	395	Abutment Slope Protection (Timber)	7	0	66	24	13
396	Other Abut Slope Pro	396	Abutment Slope Protection (Other material)	14	1	64	26	14
397	Drain. Syst Metal	397	Metal Drainage System	1	1	45	16	10
398	Drain. Syst Other	398	Other Material Drainage System	0	1	45	15	10
474	Walls Uncoated	474	Wingw all/Retaining Wall (Metal)	1	1	54	19	12
475	R/Conc Walls	475	Wingw all/Retaining Wall (Reinforced or Plain Concrete)	9	4	53	22	14
476	Timber Walls	476	Wingw all/Retaining Wall (Timber)	7	2	58	22	13
477	Other Walls	477	Wingw all/Retaining Wall (Other material)	20	9	56	28	18
478	MSE Walls	478	Mechanically Stabilized Earth Wall	6	7	54	22	16

Table 2.14. Assigned Element importance weights based on replacement cost, long-term cost, and hazard risk (Cont'd)

			Index Source Weights:	0	0.8	0.2	0	
				Element importance weights (0 - 99)				
Elemkey Old	ElemShortOld	Elemkey New	ElemNameNew	Based on element replacement cost	Based on element long term cost	Based on element vulnerability to hazard risks	Simple Average Index	Weghted Average Index
		480	Mast Arm Foundation	44	41	46	44	42
		481	Mast Arm Vertical Member	55	51	46	51	50
		484	Mast Arm Horizontal Member	17	16	46	26	22
487	Sign Member Horiz	487	Overlane Sign Structure Horizontal Member	55	51	46	51	50
488	Sign Member Vertical	488	Overlane Sign Structure Vertical Member	44	41	46	44	42
		489	Overlane Sign Structure Foundation	17		46	31	9
496	Painted High Mast L.	496	High Mast Light Poles	82	84	46	71	76
499	H. M. L. P. Found.	499	High Mast Light Pole Foundation	17	16	46	26	22
		510	Wearing Surfaces					
		515	Steel Protective Coating					
		516	Paint on Steel					
		517	Weathering Steel Patina					
		518	Galvanized or Metalized Steel					
		519	Other Steel Protective Coatings					
		520	Concrete Reinforcing Steel Protective System					
		521	Concrete Protective Coating					
540	Open Gearing	540	Open Gearing	3	4	54	20	14
541	Speed Reducers	541	Speed Reducers	1	2	54	19	12
542	Shafts	542	Shafts	0	1	54	18	12
543	Shaft Brgs and Coupl	543	Shaft Bearing/Shaft Couplings	0	0	54	18	11
544	Brakes	544	Brakes	0	0	54	18	11
545	Emergency Drive	545	Emergency Drive and Back Up Power System	0	0	54	18	11
546	Span Drive Motors	546	Span Drive Motors	0	0	54	18	11
547	Hydraulic Power Unit	547	Hydraulic Power Units	1	2	54	19	12
548	Hydraulic Piping Sys	548	Hydraulic Piping Systems	0	0	54	18	11
549	Hydraulic Cylinders	549	Hydraulic Cylinders/Motors/Rotary Actuators	1	1	54	19	12
550	Hopkins Frame	550	Hopkins Frame	1	0	54	18	11
560	Locks	560	Span Locks/Toe Locks/Heel Stops/Tail Locks	0	0	54	18	11
561	Live Load Shoes	561	Live Load Shoes/Strike Plates/Buffer Cylinders	1	0	54	18	11
562	Counterweight Suppor	562	Counterweight Support	0	0	54	18	11
563	Acc Ladd & Plat	563	Access Ladders & Platform (Other material)	0	0	54	18	11
		563	Access Ladders & Platforms (movable bridge support system)					
564	Counterweight	564	Counterweight	0	0	54	18	11
565	Trun/Str and Cur Trk	565	Trunnion/Straight and Curved Track	1	1	54	19	12
570	Transformers	570	Transformers and Thyristors	0	0	54	18	11
571	Submarine Cable	571	Submarine Cable	0	0	54	18	11
572	Conduit & Junc. Box	572	Conduit & Junction Boxes (Misc. superstructure elements)	0	0	54	18	11
		572	Conduit & Junction Boxes (Movable bridge control system)					

Table 2.14. Assigned Element importance weights based on replacement cost, long-term cost, and hazard risk (Cont'd)

			Index Source Weights:	0	0.8	0.2	0	
				Element importance weights (0 - 99)				
Elemkey Old	ElemShortOld	Elemkey New	ElemNameNew	Based on element replacement cost	Based on element long term cost	Based on element vulnerability to hazard risks	Simple Average Index	Weghted Average Index
573	PLCs	573	Programmable Logic Controllers	1	1	54	19	12
574	Control Console	574	Control Console	1	1	54	19	12
580	Navigational Lights	580	Navigational Light System (Misc. substructure elements)	0	0	55	18	11
		580	Navigational Light System (Movable bridge control system)					
581	Operator Facilities	581	Operator Facilities	0	1	61	21	13
582	Lift Bridge Spec. Eq	582	Lift Bridge Specific Equipment	6	4	54	21	14
583	Swing Bridge Spec. E	583	Swing Bridge Specific Equipment	2	2	54	19	12
590	Resistance Barriers	590	Resistance Gates	0	0	54	18	11
591	Warning Gates	591	Warning Gates	0	0	61	20	12
592	Traffic Signals	592	Traffic Signals	0	0	61	20	12

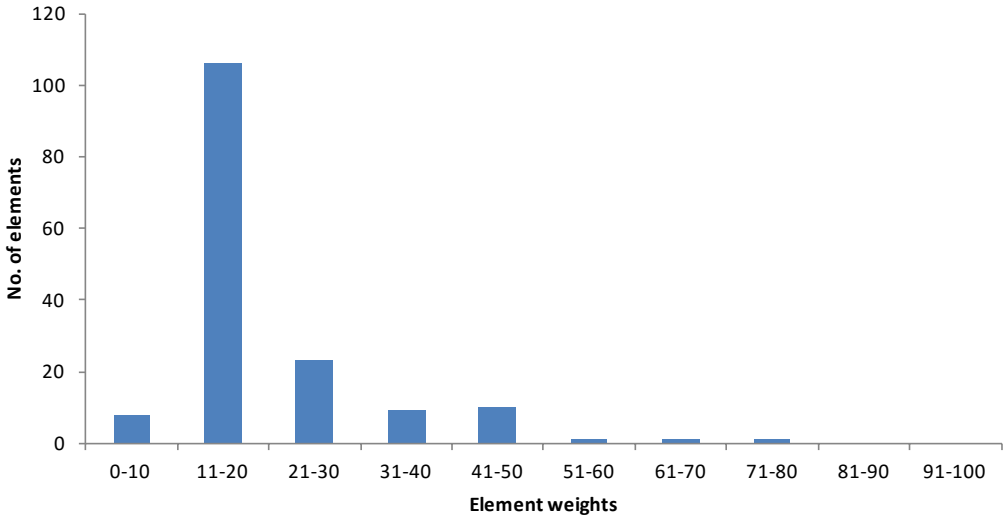

Figure 2.5. Variation in the weights (0-99) based on replacement cost, long-term cost, and hazard risk for bridge elements.

Table 2.15. Suggested element weights based on classification

Elem Class	Elem Category	Elem Type	No. of elements	Suggested element weight	Comments
NBE	1		33	100	Girder, truss, arch; appear critical to bridge safety
NBE	2		33	100	Columns, caps; appear critical to bridge safety
NBE	4		7	80	Bearings; also critical but not as much as NBE element categories 1 and 2
NBE	6		12	100	Decks and slabs; critical components
NBE	q		5	20	Railings; not critical
BME			9	40	Joints and approach slabs; important but not critical
ADE	1		2	40	Drainage system
ADE	2		12	80	Pile, dolphin, slope protection; critical
ADE	3		1	40	Joint; not critical
ADE	5		6	80	Walls; semi-critical
ADE	6		3	100	Slabs; critical
ADE	9		16	100	Sign elements; each relatively critical on an assembly
ADE	C		1	100	Channel; critical
ADE	r	56	4	20	movable bridge elements (signs, gates, etc. non-critical components)
ADE	r	others	25	80	movable bridge elements (gearing, etc., critical components)
PRTSYS	8		8	30	protective systems; important but not critical
DEFECT			2	0	

Table 2.16. Final list of importance weights for BMS elements

New ElemNum	ElemName	Elem Class	Prev Elemkey*	Prev ElemName*	Calculated ElemWeight	ElemWeight by Class Category and Type#	Engineering Judgment ElemWeight	**Recommended ElemWeight**
12	RC Concrete Deck	NBE	12	Reinforced Concrete Deck	25	100		**25**
13	PSC Concrete Deck	NBE	13	Prestressed Concrete Deck	18	100	30	**30**
15	PSC Concrete Top Flange	NBE	15	Prestressed Concrete Top Flange (Slab)	25	100		**25**
16	RC Concrete Top Flange	NBE	16	Reinforced Concrete Top Flange	25	100		**25**
28	Steel Deck/Open Grid	NBE	28	Steel Deck with Open Grid	13	100	27	**27**
29	Steel Deck/Conc Grid	NBE	29	Steel Deck with Concrete Filled Grid	11	100	27	**27**
30	Corrug/Orthotpc Deck	NBE	30	Steel Deck Corrugated/Orthotropic/Etc	49	100		**49**
31	Timber Deck	NBE	31	Timber Deck	13	100		**13**
38	RC Concrete Slab	NBE	38	Reinforced Concrete Slab	25	100		**25**
54	Timber Slab	NBE	54	Timber Slab	12	100		**12**
60	Other Deck	NBE	60	Other Deck	25	100		**25**
65	Other Slab	NBE	65	Other Slab	25	100		**25**
102	Stl Box Girder	NBE	102	Steel Closed Web/Box Girder	53	100		**53**
104	PSC Box Girder	NBE	104	Prestressed Concrete Closed Web/Box Girder	34	100	70	**70**
105	RC Box Girder	NBE	105	Reinforced Concrete Closed Web/Box Girder	30	100		**30**
106	Other Closed Web/Box Girder	NBE	106	Other Material Closed Web/Box Girder	62	100		**62**
107	Steel Opn Girder	NBE	107	Steel Open Girder/Beam	49	100		**49**
109	PSC Open Girder	NBE	109	Prestressed Open Girder/Beam	46	100		**46**
110	RC Open Girder	NBE	110	Reinforced Concrete Open Girder/Beam	33	100		**33**
111	Timber Open Girder	NBE	111	Timber Open Girder/Beam	26	100		**26**
112	Other Open Girder	NBE	112	Other Material Open Girder/Beam	18	100	30	**30**
113	Steel Stringer	NBE	113	Steel Stringer	18	100		**18**
115	PSC Stringer	NBE	115	Prestressed Concrete Stringer	46	100		**46**
116	RC Stringer	NBE	116	Reinforced Concrete Stringer	33	100		**33**
117	Timber Stringer	NBE	117	Timber Stringer	23	100	15	**15**
118	Other Stringer	NBE	118	Other Material Stringer	46	100		**46**
120	Steel Truss	NBE	120	Steel Truss	31	100	50	**50**
135	Timber Truss	NBE	135	Timber Truss	31	100		**31**
136	Other Truss	NBE	136	Other Material Truss	31	100		**31**
141	Steel Arch	NBE	141	Steel Arch	17	100	50	**50**
142	Other Arch	NBE	142	Other Material Arch	15	100		**15**
143	PSC Arch	NBE	143	Prestressed Concrete Arch	15	100		**15**
144	RC Arch	NBE	144	Reinforced Concrete Arch	15	100		**15**
145	Masonry Arch	NBE	145	Masonry Arch	15	100		**15**
146	Timber Arch	NBE	146	Timber Arch	37	100		**37**

* Based on the intial list of new elements by FDOT (prior to May 2015) used for assigning element weights

#Suggested weights based on element classifications, NBE, BME, ADE, categories, types, etc.

Table 2.16. Final list of importance weights for BMS elements (Cont'd)

New ElemNum	ElemName	Elem Class	Prev Elemkey*	Prev ElemName*	Calculated ElemWeight	ElemWeight by Class Category and Type#	Engineering Judgment ElemWeight	**Recommended ElemWeight**
147	Steel Main Cables	NBE	147	Steel Main Cables	24	100	80	**80**
148	Secondary Steel Cables	NBE	148	Secondary Steel Cables	24	100	50	**50**
149	Other Sec Steel Cables	NBE	149	Other Material Secondary Cable	24	100		**24**
152	Steel Floor Beam	NBE	152	Steel Floor Beam	17	100		**17**
154	PSC Floor Beam	NBE	154	Prestressed Concrete Floor Beam	12	100		**12**
155	RC Floor Beam	NBE	155	Reinforced Concrete Floor Beam	21	100		**21**
156	Timber Floor Beam	NBE	156	Timber Floor Beam	15	100		**15**
157	Other Floor Beam	NBE	157	Other Material Floor Beam	21	100		**21**
161	Steel Pin / Pin and Hanger	NBE	161	Steel Pin and Pin & Hanger Assembly or Both	13	100	70	**70**
162	Steel Gusset Plate	NBE	162	Steel Gusset Plate	13	100		**13**
202	Steel Column	NBE	202	Steel Column	10	100	30	**30**
203	Other Column	NBE	203	Other Material Column	10	100	30	**30**
204	PSC Column	NBE	204	Prestressed Concrete Column	17	100	50	**50**
205	RC Column	NBE	205	Reinforced Concrete Column	11	100	40	**40**
206	Timber Column	NBE	206	Timber Column	12	100		**12**
207	Steel Tower	NBE	207	Steel Tower	14	100		**14**
208	Timber Trestle	NBE	208	Timber Trestle	12	100		**12**
210	RC Pier Wall	NBE	210	Reinforced Concrete Pier Wall	11	100		**11**
211	Other Pier Wall	NBE	211	Other Material Pier Wall	11	100		**11**
212	Timber Pier Wall	NBE	212	Timber Pier Wall	11	100		**11**
213	Masonry Pier Wall	NBE	213	Masonry Pier Wall	11	100		**11**
215	RC Abutment	NBE	215	Reinforced Concrete Abutment	13	100		**13**
216	Timber Abutment	NBE	216	Timber Abutment	13	100		**13**
217	Masonry Abutment	NBE	217	Masonry Abutment	14	100		**14**
218	Other Abutment	NBE	218	Other Material Abutment	13	100		**13**
219	Steel Abutment	NBE	219	Steel Abutment	13	100		**13**
220	RC Pile Cap/Ftg	NBE	220	Reinforced Concrete Pile Cap/Footing	10	100		**10**
225	Steel Pile	NBE	225	Steel Pile	10	100		**10**
226	PSC Pile	NBE	226	Prestressed Concrete Pile	17	100		**17**
227	RC Pile	NBE	227	Reinforced Concrete Pile	11	100		**11**
228	Timber Pile	NBE	228	Timber Pile	12	100		**12**
229	Other Pile	NBE	229	Other Material Pile	17	100		**17**
231	Steel Pier Cap	NBE	231	Steel Pier Cap	10	100		**10**
233	PSC Cap	NBE	233	Prestressed Concrete Pier Cap	9	100		**9**

* Based on the intial list of new elements by FDOT (prior to May 2015) used for assigning element weights

#Suggested weights based on element classifications, NBE, BME, ADE, categories, types, etc.

Table 2.16. Final list of importance weights for BMS elements (Cont'd)

New ElemNum	ElemName	Elem Class	Prev Elemkey*	Prev ElemName*	Calculated ElemWeight	ElemWeight by Class Category and Type#	Engineering Judgment ElemWeight	**Recommended ElemWeight**
234	RC Cap	NBE	234	Reinforced Concrete Pier Cap	13	100		**13**
235	Timber Cap	NBE	235	Timber Pier Cap	10	100		**10**
236	Other Cap	NBE	236	Other Material Pier Cap	13	100		**13**
240	Steel Culvert	NBE	240	Steel Culvert	26	100		**26**
241	RC Culvert	NBE	241	Reinforced Concrete Culvert	35	100		**35**
242	Timber Culvert	NBE	242	Timber Culvert	26	100		**26**
243	Other Culvert	NBE	243	Other Culvert	26	100		**26**
244	Masonry Culvert	NBE	244	Masonry Culvert	26	100		**26**
245	PSC Culvert	NBE	245	Prestressed Concrete Culvert	35	100		**35**
300	Strip Seal Expansion Joint	BME	300	Strip Seal Expansion Joint	11	40		**11**
301	Pourable Joint Seal	BME	301	Pourable Joint Seal	12	40		**12**
302	Compression Joint Seal	BME	302	Compression Joint Seal	12	40		**12**
303	Assembly Joint With Seal	BME	303	Assembly Joint with Seal	11	40		**11**
304	Open Expansion Joint	BME	304	Open Expansion Joint	12	40		**12**
305	Assembly Joint Without Seal	BME	305	Assembly Joint without Seal	11	40		**11**
306	Other Joint	BME	306	Other Joint	11	40		**11**
310	Elastomeric Bearing	NBE	310	Elastomeric Bearing	13	80		**13**
311	Moveable Bearing	NBE	311	Movable Bearing (roller, sliding, etc.)	12	80		**12**
312	Enclosed Bearing	NBE	312	Enclosed/Concealed Bearing	14	80		**14**
313	Fixed Bearing	NBE	313	Fixed Bearing	12	80		**12**
314	Pot Bearing	NBE	314	Pot Bearing	13	80		**13**
315	Disk Bearing	NBE	315	Disk Bearing	13	80		**13**
316	Other Bearing	NBE	316	Other Bearing	13	80		**13**
320	PSC Approach Slab	BME	320	Prestressed Concrete Approach Slab	14	40		**14**
321	RC Approach Slab	BME	321	Reinforced Concrete Approach Slab	13	40		**13**
330	Metal Bridge Railing	NBE	330	Metal Bridge Railing	16	20		**16**
331	RC Bridge Railing	NBE	331	Reinforced Concrete Bridge Railing	14	20		**14**
332	Timber Bridge Railing	NBE	332	Timber Bridge Railing	14	20		**14**
333	Other Bridge Railing	NBE	333	Other Bridge Railing	13	20		**13**
334	Masonry Bridge Railing	NBE	334	Masonry Bridge Railing	14	20		**14**
510	Wearing Surfaces	PRTSYS	510	Wearing Surfaces		30	5	**5**
515	Steel Protective Coating	PRTSYS	515	Steel Protective Coating		30	5	**5**
520	Deck/Slab Protection Systems	PRTSYS	520	Deck/Slab Protection Systems		30	5	**5**
521	Concrete Protective Coating	PRTSYS	521	Concrete Protective Coating		30	5	**5**

* Based on the intial list of new elements by FDOT (prior to May 2015) used for assigning element weights

#Suggested weights based on element classifications, NBE, BME, ADE, categories, types, etc.

Table 2.16. Final list of importance weights for BMS elements (Cont'd)

New ElemNum	ElemName	Elem Class	Prev Elemkey*	Prev ElemName*	Calculated ElemWeight	ElemWeight by Class Category and Type#	Engineering Judgment ElemWeight	**Recommended ElemWeight**
1120	~~Efflorescence/Rust Staining~~	~~DEFECT~~				~~0~~	~~N/A~~	~~**N/A**~~
1130	~~Cracking (RC and Other)~~	~~DEFECT~~				~~0~~	~~N/A~~	~~**N/A**~~
8097	PS Conc Slab (Hybrid)	ADE	97	PS Conc Slab (Hybrid)	25	100		**25**
8098	Conc Deck on PC Pane	ADE	98	Concrete Deck on Precast Deck Panels	24	100		**24**
8099	PS Conc Slab (Sonovoid)	ADE	99	Prestressed Concrete Slab (Sonovoid)	25	100		**25**
8199	External Post Tensioning Duct	ADE				80	35	**35**
8207	Hollow Core Pile	ADE				80	11	**11**
8290	Channel	ADE	290	Channel	47	100		**47**
8298	Pile Jacket Bare	ADE	298	Pile Jacket	11	80		**11**
8299	~~Pile Jacket/Cath Pro~~	~~ADE~~	~~299~~	~~Pile Jacket/Cath Pro~~	~~11~~	~~80~~	longer eleme	**o longer elemen**
8386	Fender/Dolphin Uncoa	ADE	386	Fender/Dolphin System (Metal)	14	80		**14**
8387	P/S Fender/Dolphin	ADE	387	Fender/Dolphin System (Prestressed Concrete)	14	80		**14**
8388	R/Conc Fender/Dolphi	ADE	388	Fender/Dolphin System (Reinforced Concrete)	14	80		**14**
8389	Timber Fender/Dolphi	ADE	389	Fender/Dolphin System (Timber)	14	80		**14**
8390	Other Fender/Dolphin	ADE	390	Fender/Dolphin System (Other material)	15	80		**15**
8393	Blkhd Sewl Any Mater	ADE	393	Bulkhead/Seawall	11	80		**11**
8394	R/Conc Abut Slope Pr	ADE	394	Abutment Slope Protection (Reinforced or Plain Concrete)	13	80		**13**
8395	Timber Abut Slope Pr	ADE	395	Abutment Slope Protection (Timber)	13	80		**13**
8396	Other Abut Slope Pro	ADE	396	Abutment Slope Protection (Other material)	14	80		**14**
8397	Drain. Syst Metal	ADE	397	Metal Drainage System	10	40		**10**
8398	Drain. Syst Other	ADE	398	Other Material Drainage System	10	40		**10**
8399	Other Xpansion Joint	ADE	399	Other Xpansion Joint	11	40		**11**
8474	Walls Uncoated	ADE	474	Wingwall/Retaining Wall (Metal)	12	80		**12**
8475	R/Conc Walls	ADE	475	Wingwall/Retaining Wall (Reinforced or Plain Concrete)	14	80		**14**
8476	Timber Walls	ADE	476	Wingwall/Retaining Wall (Timber)	13	80		**13**
8477	Other Walls	ADE	477	Wingwall/Retaining Wall (Other material)	18	80		**18**
8478	MSE Walls	ADE	478	Mechanically Stabilized Earth Wall	16	80		**16**
8480	Mast Arm Found	ADE	480	Mast Arm Foundation	42	100	22	**22**
8481	~~Paint~~ Mast Arm Vert	ADE	481	Mast Arm Vertical Member	50	100		**50**
~~8482~~	~~Galvan Mast Arm Vert~~	~~ADE~~	~~482~~	~~Galvan Mast Arm Vert~~	~~42~~	~~100~~		~~**42**~~
8483	RC Mast Arm Vert	ADE	483	RC Mast Arm Vert	42	100		**42**
8484	~~Paint~~ Mast Arm Horzn	ADE	484	Mast Arm Horizontal Member	22	100		**22**
~~8485~~	~~Galvan Mast Arm Horz~~	~~ADE~~	~~485~~	~~Galvan Mast Arm Horz~~	~~50~~	~~100~~		~~**50**~~

* Based on the intial list of new elements by FDOT (prior to May 2015) used for assigning element weights

#Suggested weights based on element classifications, NBE, BME, ADE, categories, types, etc.

Table 2.16. Final list of importance weights for BMS elements (Cont'd)

New ElemNum	ElemName	Elem Class	Prev Elemkey*	Prev ElemName*	Calculated ElemWeight	ElemWeight by Class Category and Type#	Engineering Judgment ElemWeight	**Recommended ElemWeight**
~~8486~~	~~Other Mast Arm Horzn~~	~~ADE~~	~~486~~	~~Other Mast Arm Horzn~~	~~50~~	~~100~~		**~~50~~**
8487	Sign Member Horiz	ADE	487	Overlane Sign Structure Horizontal Member	50	100		**50**
8488	Sign Member Vertical	ADE	488	Overlane Sign Structure Vertical Member	42	100		**42**
8489	Sign Foundation	ADE	489	Overlane Sign Structure Foundation	9	100	22	**22**
8491	RC Overlane Sign Vertical	ADE	491	RC Overlane Sign Vertical	42	100		**42**
8495	Uncoat High Mast L.	ADE	495	Uncoat High Mast L.	76	100		**76**
8496	High Mast Light Pole	ADE	496	High Mast Light Poles	76	100		**76**
8497	Galvan. High Mast L.	ADE	497	Galvan. High Mast L.	76	100		**76**
8498	Other High Mast L.P.	ADE	498	Other High Mast L.P.	76	100		**76**
8499	H. M. L. P. Found.	ADE	499	High Mast Light Pole Foundation	22	100		**22**
8516	Painted Steel	PRTSYS	516	Paint on Steel		30	5	**5**
8517	Weathering Steel	PRTSYS	517	Weathering Steel Patina		30	5	**5**
8518	Galvanized Steel	PRTSYS	518	Galvanized or Metalized Steel		30	5	**5**
8519	Other Steel Coatings	PRTSYS	519	Other Steel Protective Coatings		30	5	**5**
8540	Open Gearing	ADE	540	Open Gearing	14	80		**14**
8541	Speed Reducers	ADE	541	Speed Reducers	12	80		**12**
8542	Shafts	ADE	542	Shafts	12	80		**12**
8543	Shaft Brgs and Coupl	ADE	543	Shaft Bearing/Shaft Couplings	11	80		**11**
8544	Brakes	ADE	544	Brakes	11	80		**11**
8545	Emergency Drive	ADE	545	Emergency Drive and Back Up Power System	11	80		**11**
8546	Span Drive Motors	ADE	546	Span Drive Motors	11	80		**11**
8547	Hydraulic Power Unit	ADE	547	Hydraulic Power Units	12	80		**12**
8548	Hydraulic Piping Sys	ADE	548	Hydraulic Piping Systems	11	80		**11**
8549	Hydraulic Cylinders	ADE	549	Hydraulic Cylinders/Motors/Rotary Actuators	12	80		**12**
8550	Hopkins Frame	ADE	550	Hopkins Frame	11	80		**11**
8560	Locks	ADE	560	Span Locks/Toe Locks/Heel Stops/Tail Locks	11	80		**11**
8561	Live Load Shoes	ADE	561	Live Load Shoes/Strike Plates/Buffer Cylinders	11	80		**11**
8562	Counterweight Suppor	ADE	562	Counterweight Support	11	80		**11**
8563	Acc Ladd & Plat	ADE	563	Access Ladders & Platform (Other material)	11	80		**11**
8564	Counterweight	ADE	564	Counterweight	11	80		**11**
8565	Trun/Str and Cur Trk	ADE	565	Trunnion/Straight and Curved Track	12	80		**12**
8570	Transformers	ADE	570	Transformers and Thyristors	11	80		**11**
8571	Submarine Cable	ADE	571	Submarine Cable	11	80		**11**

* Based on the intial list of new elements by FDOT (prior to May 2015) used for assigning element weights

#Suggested weights based on element classifications, NBE, BME, ADE, categories, types, etc.

Table 2.16. Final list of importance weights for BMS elements (Cont'd)

New ElemNum	ElemName	Elem Class	Prev Elemkey*	Prev ElemName*	Calculated ElemWeight	ElemWeight by Class Category and Type#	Engineering Judgment ElemWeight	**Recommended ElemWeight**
8572	Conduit & Junc. Box	ADE	572	Conduit & Junction Boxes (Misc. superstructure elements)	11	80		**11**
8573	PLCs	ADE	573	Programmable Logic Controllers	12	80		**12**
8574	Control Console	ADE	574	Control Console	12	80		**12**
8580	Navigational Lights	ADE	580	Navigational Light System (Misc. substructure elements)	11	20		**11**
8581	Operator Facilities	ADE	581	Operator Facilities	13	80		**13**
8582	Lift Bridge Spec. Eq	ADE	582	Lift Bridge Specific Equipment	14	80		**14**
8583	Swing Bridge Spec. E	ADE	583	Swing Bridge Specific Equipment	12	80		**12**
8590	Resistance Barriers	ADE	590	Resistance Gates	11	20		**11**
8591	Warning Gates	ADE	591	Warning Gates	12	20		**12**
8592	Traffic Signals	ADE	592	Traffic Signals	12	20		**12**

* Based on the intial list of new elements by FDOT (prior to May 2015) used for assigning element weights

#Suggested weights based on element classifications, NBE, BME, ADE, categories, types, etc.

2.2.7 Element weights based on expert opinion survey

As mentioned in the previous sections of this report, expert opinions are also very useful in assigning element weights. The Analytical Hierarchy Process (AHP) is an accepted methodology for pairwise comparison of alternative situations and coming up with a set of relative weights. Since the FDOT bridge element list is very long, the approach adopted in this study is to create element groups by the element *ecatkey* and *etypkey* fields in the bridge element records (Tables 2.17 and 2.18). Based on the just-described approach of using the element unit costs, the elements observed to have weights above minimal values are used to construct a list of element groups for which expert opinions will be elicited. This approach was not implemented in this study but will be recommended for future research. Chapter 9 shows the survey questionnaire that was developed in a Microsoft Excel spreadsheet as a tool to elicit this information from the bridge experts. This survey can be used by FDOT to develop element weights.

Table 2.17. Element groups based on *ecatkey* and *etypkey*

Element Group	ECATKEY	ETYPKEY
Girder	1	1
	1	2
Stringer	1	3
Truss	1	4
	1	5
	1	6
Arch	1	7
	1	8
	1	9
Cable	1	9
Floor beam	1	10
Pin hanger	1	11
Column	2	12
Pier wall	2	13
Abutment	2	14
Pile cap/ftg	2	15
Pile jacket/cath pro	2	16
Cap	2	17
Fender/dolphin	2	58
Slope protection/bulkhead	2	59
Bearing	4	24
	4	25
	4	26
	4	27
	4	28
	4	29
Approach slab	5	30
Walls	5	61
Slab	6	32
	6	33
	6	42
Deck	6	33
	6	43
Steel/Ortho Deck	6	39
	6	40
	6	41

Table 2.18. Grouping bridge elements for establishing element weights

ELEMKEY	ECATKEY	ETYPKEY	MATLKEY	ELEMSHORT
290	0	53	6	Channel
101	1	1	1	Unpnt Stl Box Girder
102	1	1	2	Paint Stl Box Girder
104	1	1	3	P/S Conc Box Girder
105	1	1	4	R/Conc Box Girder
106	1	2	1	Unpnt Stl Opn Girder
107	1	2	2	Paint Stl Opn Girder
109	1	2	3	P/S Conc Open Girder
110	1	2	4	R/Conc Open Girder
111	1	2	5	Timber Open Girder
112	1	3	1	Unpnt Stl Stringer
113	1	3	2	Paint Stl Stringer
115	1	3	3	P/S Conc Stringer
116	1	3	4	R/Conc Stringer
117	1	3	5	Timber Stringer
120	1	4	1	U/Stl Thru Truss/Bot
121	1	4	2	P/Stl Thru Truss/Bot
125	1	5	1	U/Stl Thru Truss/Top
126	1	5	2	P/Stl Thru Truss/Top
130	1	6	1	Unpnt Stl Deck Truss
131	1	6	2	Paint Stl Deck Truss
135	1	7	5	Timber Truss/Arch
140	1	8	1	Unpnt Stl Arch
141	1	8	2	Paint Stl Arch
143	1	8	3	P/S Conc Arch
144	1	8	4	R/Conc Arch
145	1	8	6	Other Arch
146	1	9	6	Misc Cable Uncoated
147	1	9	6	Misc Cable Coated
151	1	10	1	Unpnt Stl Floor Beam
152	1	10	2	Paint Stl Floor Beam
154	1	10	3	P/S Conc Floor Beam
155	1	10	4	R/Conc Floor Beam
156	1	10	5	Timber Floor Beam
160	1	11	1	Unpnt Stl Pin/Hanger
161	1	11	2	Paint Stl Pin/Hanger
397	1	60	2	Drain. Syst Metal
398	1	60	6	Drain. Syst Other
201	2	12	1	Unpnt Stl Column
202	2	12	2	Paint Stl Column
204	2	12	3	P/S Conc Column
205	2	12	4	R/Conc Column
206	2	12	5	Timber Column
207	2	12	3	P/S Conc Holl Pile
210	2	13	4	R/Conc Pier Wall
211	2	13	6	Other Mtl Pier Wall
215	2	14	4	R/Conc Abutment
216	2	14	5	Timber Abutment
217	2	14	6	Other Mtl Abutment
220	2	15	4	R/C Sub Pile Cap/Ftg
298	2	16	4	Pile Jacket Bare
299	2	16	4	Pile Jacket/Cath Pro

Table 2.18. Grouping bridge elements for establishing element weights (Cont'd)

ELEMKEY	ECATKEY	ETYPKEY	MATLKEY	ELEMSHORT
230	2	17	1	Unpnt Stl Cap
231	2	17	2	Paint Stl Cap
233	2	17	3	P/S Conc Cap
234	2	17	4	R/Conc Cap
235	2	17	5	Timber Cap
240	2	18	1	Metal Culvert
241	2	18	4	Concrete Culvert
242	2	18	5	Timber Culvert
243	2	18	6	Misc Culvert
386	2	58	1	Fender/Dolphin Uncoa
387	2	58	3	P/S Fender/Dolphin
388	2	58	4	R/Conc Fender/Dolphi
389	2	58	5	Timber Fender/Dolphi
390	2	58	6	Other Fender/Dolphin
393	2	59	1	Blkhd Sew l Metal Unc
394	2	59	4	R/Conc Abut Slope Pr
395	2	59	5	Timber Abut Slope Pr
396	2	59	6	Other Abut Slope Pro
300	3	19	6	Strip Seal Exp Joint
301	3	20	6	Pourable Joint Seal
302	3	21	6	Compressn Joint Seal
303	3	22	6	Assembly Joint/Seal
399	3	22	6	Other Xpansion Joint
304	3	23	6	Open Expansion Joint
310	4	24	6	Elastomeric Bearing
311	4	25	6	Moveable Bearing
312	4	26	6	Enclosed Bearing
313	4	27	6	Fixed Bearing
314	4	28	6	Pot Bearing
315	4	29	6	Disk Bearing
320	5	30	3	P/S Conc Appr Slab
321	5	30	4	R/Conc Approach Slab
474	5	61	1	Walls Uncoated
475	5	61	4	R/Conc Walls
476	5	61	5	Timber Walls
477	5	61	6	Other Walls
478	5	61	6	MSE Walls
487	5	62	2	Sign Member Horiz
488	5	62	2	Sign Member Vertical
489	5	62	2	Sign Foundation
495	5	63	1	Uncoat High Mast L.
496	5	63	2	Painted High Mast L.
497	5	63	2	Galvan. High Mast L.
498	5	63	6	Other High Mast L.P.
499	5	63	1	H. M. L. P. Found.
480	5	65	1	Mast Arm Found
481	5	65	2	Paint Mast Arm Vert
482	5	65	2	Galvan Mast Arm Vert
483	5	65	6	Other Mast Arm Vert
484	5	65	2	Paint Mast Arm Horzn
485	5	65	2	Galvan Mast Arm Horz
486	5	65	6	Other Mast Arm Horzn

Table 2.18. Grouping bridge elements for establishing element weights (Cont'd)

ELEMKEY	ECATKEY	ETYPKEY	MATLKEY	ELEMSHORT
12	6	32	7	Bare Concrete Deck
38	6	32	8	Bare Concrete Slab
98	6	32	7	Conc Deck on PC Pane
13	6	33	7	Unp Conc Deck/AC Ovl
39	6	33	8	Unp Conc Slab/AC Ovl
99	6	33	8	PS Conc Slab
28	6	39	7	Steel Deck/Open Grid
29	6	40	7	Steel Deck/Conc Grid
30	6	41	7	Corrug/Orthotpc Deck
31	6	42	7	Timber Deck
54	6	42	8	Timber Slab
32	6	43	7	Timber Deck/AC Ovly
55	6	43	8	Timber Slab/AC Ovly
356	7	44	9	Steel Fatigue SmFlag
357	7	45	9	Pack Rust Smart Flag
358	7	46	9	Deck Cracking SmFlag
359	7	47	9	Soffit Smart Flag
360	7	48	9	Settlement SmFlag
361	7	49	9	Scour Smart Flag
362	7	50	9	Traf Impact SmFlag
363	7	51	9	Section Loss SmFlag
369	7	51	9	Sub.Sect Loss SmFlag
370	7	52	9	Alert Smart Flag
540	8	54	2	Open Gearing
541	8	54	2	Speed Reducers
542	8	54	2	Shafts
543	8	54	2	Shaft Brgs and Coupl
544	8	54	2	Brakes
545	8	54	6	Emergency Drive
546	8	54	2	Span Drive Motors
547	8	54	6	Hydraulic Pow er Unit
548	8	54	6	Hydraulic Piping Sys
549	8	54	6	Hydraulic Cylinders
550	8	54	2	Hopkins Frame
570	8	55	6	Transformers
571	8	55	6	Submarine Cable
572	8	55	6	Conduit & Junc. Box
573	8	55	6	PLCs
574	8	55	6	Control Console
580	8	56	6	Navigational Lights
590	8	56	6	Resistance Barriers
591	8	56	6	Warning Gates
592	8	56	6	Traffic Signals
581	8	57	6	Operator Facilities
582	8	57	2	Lift Bridge Spec. Eq
583	8	57	2	Sw ing Bridge Spec. E
560	8	64	2	Locks
561	8	64	2	Live Load Shoes
562	8	64	2	Counterw eight Suppor
563	8	64	2	Acc Ladd & Plat
564	8	64	4	Counterw eight
565	8	64	2	Trun/Str and Cur Trk
330	9	31	1	Metal Rail Uncoated
331	9	31	4	Conc Bridge Railing
332	9	31	5	Timb Bridge Railing
333	9	31	6	Other Bridge Railing
334	9	31	1	Metal Rail Coated

2.3 Conclusions

The methodology and sample calculations have been presented for developing the bridge health index towards implementation in the BMS software. Investigation was made into various approaches of assigning health index (state) weights, and a simple method is described. Element importance weights have been developed and discussed, considering the use of element replacement unit costs, element long-term unit costs, the element's vulnerability to hazards, and the BMS element classification (element class, category and type). A consideration is also presented on the use of the Analytic Hierarchy Process (AHP) as a tool for estimating element weights, but it was not implemented in this study.

Element weights calculated using replacement and long-term costs were observed to be high for certain elements because they have with high costs or due to their high costs relative to other components on the structure. Girders and decks are examples of the former while culverts and sign structures are examples of the latter. These cost-based approaches indicated low weights, as low as zero, for elements such as bearings, joints, and movable bridge elements. The third approach introduced the element's vulnerability to hazards (hurricane, wildfire, etc.). Combining the cost factors with the hazard risks, new weights were computed as a weighted average. In this case, the long-term costs were considered four times more important than the hazard risks, while replacement costs were ignored. The computed values reflected a similar trend from the previous two approaches, with similar elements having the larger weights, but this approach indicated weights for most elements that would be considered reasonable and not minimal. The BMS element classification suggests large weights for NBE elements and smaller values for the BME and ADE elements.

The calculated weights from the third approach, as well as the suggested weights from the BMS classification-based approach, were presented to FDOT for review. Revisions by FDOT to the results included the revision of some element weights based on engineering judgment. Finally, based on the FDOT review, a list of recommended element weights are summarized in Table 2.16 for BMS implementation.

3. Preservation actions

According to the FDOT Bridge Inspection Guide, bridge elements are grouped based on the typical defects found on the elements (FDOT, 2015a). As shown in Table 3.1, the "Reinforced Concrete Deck and Slab Elements" group consists of the following elements: 12-Reinforced Concrete Deck; 16-Reinforced Concrete Top Flange; 38-Reinforced Concrete Slab; and 98-Concrete on Precast Deck Panels. These elements experience five types of defects typically -- Delamination/Spall/Patched Area (1080); Exposed Rebar (1090); Efflorescence/ Rust Staining (1120); Cracking (RC and Other) (1130); and Damage (7000) -- to different extents as classified under the various condition states. In formulating the feasible actions at the level of element condition states, these defects were considered in first establishing a long description for the action needed, with the intent of capturing all the defects as much as possible. For instance, at condition state 2 for this group of elements, a definition is needed to address each of the first four defects listed; the damage defect is expressed in terms of these four defects also. Thus at condition state 2, three actions are needed (for the preservation model):

0 – Do Nothing
1 - Minor repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands
2 - Minor repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands; Add a protective system.

For condition state 3, the suggested actions are as follows:

0 – Do Nothing
1 - Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strand
2 - Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands; Add a protective system.

It should be mentioned also that it was necessary to review the old Pontis element state actions list for similar elements as a form of comparison and guide.

While these actions are well-described, they appear too long to store in a field of the database, so shorter forms of the statements were developed. The corresponding definition for the "Reinforced Concrete Deck and Slab Elements" group of elements was as follows (omitting the "Do Nothing" options): state 1: 1-Miscellaneous Maintenance, 2-Add a protective system; state 2: 1-Minor repair, 2-Minor repair & add a protective system; state 3: 1-Major repair, 2-Major repair & add a protective system; and state 4: 1-Major repair; 2-Replace deck. It may be useful to incorporate some uniqueness in the short action descriptions by indicating the element name or other attributes unique to this action or element. For instance, "Minor repair" could be replaced by "Minor repair of concrete deck" or "Minor repair of concrete top flange" as the "Minor repair" action resembles a flex action already. For another illustration, the defects and condition states for "Steel Deck Elements" group are shown in Table 3.2.

Each bridge element group in the FDOT Guide was reviewed in detail for the various bridge components/categories: deck, superstructure, substructure, culvert, channel, movable bridges, and miscellaneous. The methodology described above was followed, and the feasible actions were formulated in terms of the long and short definitions. Table 3.3 shows the initial listing of the actions for

sample bridge deck elements, including reinforced and prestressed concrete deck elements. Table 3.4 shows a sample listing of the initial feasible actions for elements under the “Steel Deck Elements” group; here it was possible to incorporate some uniqueness in the short action descriptions. Following a meeting between the research team and FDOT State Maintenance Office, some revisions were made to the list of feasible actions. The comments are summarized in the next section of this memo. Sample listings of the revised feasible actions are also shown in Tables 3.5 to 3.9.

Table 3.1. Listing of defects for Reinforced Concrete Deck and Slab Elements (FDOT, 2015a)

12-Reinforced Concrete Deck				
16-Reinforced Concrete Top Flange				
38-Reinforced Concrete Slab				
98-Concrete on Precast Deck Panels				
Defect	**Condition State 1**	**Condition State 2**	**Condition State 3**	**Condition State 4**
	GOOD	FAIR	POOR	SEVERE
Delamination/Spall/Patched Area (1080)	None	Delaminated. Spall 1 in. orless deep or less than 6 in. diameter. Patched area that is sound.	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress. Does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or service-ability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Exposed Rebar(1090)	None	Present without measurable section loss.	Present with measurable section loss that does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or service-ability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Efflorescence/ Rust Staining (1120)	None	Surface white without buildup or leaching without rust staining.	Heavy buildup with rust staining.	The condition warrants a structural review to determine the effect on strength or service-ability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Cracking (RC and Other) (1130)	Widths less than 0.012 in. or spacing greater than 3.0 ft.	Widths 0.012–0.05 in. or spacing of 1.0–3.0ft.	Width greater than 0.05 in. or spacing of less than 1 ft.	The condition warrants a structural review to determine the effect on strength or service-ability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Damage (7000)	Not applicable	The element has impact damage. The specific damage caused by the impact has been captured in condition state 2 under the appropriate material defect entry.	The element has moderate damage caused by vehicular or vessel impact. The specific damage caused by the impact has been captured in condition state 3 under the appropriate material defect entry.	The element has severe damage caused by vehicular or vessel impact. The specific damage caused by the impact has been captured in condition state 4 under the appropriate material defect entry.

Table 3.2. Listing of defects for Steel Deck and Elements (FDOT, 2015a)

28-Steel Deck with Open Grid				
29-Steel Deck with Concrete Filled Grid				
30-Steel Deck Corrugated/Orthotropic/Etc.				
Defect	**Condition State 1**	**Condition State 2**	**Condition State 3**	**Condition State 4**
	GOOD	FAIR	POOR	SEVERE
Corrosion (1000)	None	Freckled Rust. Corrosion of the steel has initiated.	Section loss is evident or pack rust is present but does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Cracking (1010)	None	Freckled Rust. Corrosion of the steel has initiated.	Identified crack exists that is not arrested but does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, broken welds, fasteners or pack rust with distortion but does not warrant a structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Damage (7000)	Not applicable	The element has impact damage. The specific damage caused by the impact has been captured in condition state 2 under the appropriate material defect entry.	The element has moderate dam-age caused by vehicular or vessel impact. The specific damage caused by the impact has been captured in condition state 3 under the appropriate material defect entry.	The element has severe damage caused by vehicular or vessel impact. The specific damage caused by the impact has been captured in condition state 4 under the appropriate material defect entry.

Table 3.3. Initial list of feasible actions for sample reinforced and prestressed concrete deck and slab elements

Elemkey New	ElemNameNew	skey	akey	actlongNew	actshortNew
12	Reinforced Concrete Deck	1	1	Miscellaneous Maintenance	Miscellaneous Maintenance
12	Reinforced Concrete Deck	1	2	Add a protective system	Add a protective system
12	Reinforced Concrete Deck	2	1	Minor repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands	Minor repair
12	Reinforced Concrete Deck	2	2	Minor repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands; Add a protective system	Minor repair & add a protective system
12	Reinforced Concrete Deck	3	1	Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
12	Reinforced Concrete Deck	3	2	Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands; Add a protective system	Major repair & add a protective system
12	Reinforced Concrete Deck	4	1	Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
12	Reinforced Concrete Deck	4	2	Replace deck	Replace deck
13	Prestressed Concrete Deck	1	1	Miscellaneous Maintenance	Miscellaneous Maintenance
13	Prestressed Concrete Deck	1	2	Add a protective system	Add a protective system
13	Prestressed Concrete Deck	2	1	Minor repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands	Minor repair
13	Prestressed Concrete Deck	2	2	Minor repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands; Add a protective system	Minor repair & add a protective system
13	Prestressed Concrete Deck	3	1	Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
13	Prestressed Concrete Deck	3	2	Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands; Add a protective system	Major repair & add a protective system
13	Prestressed Concrete Deck	4	1	Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
13	Prestressed Concrete Deck	4	2	Replace deck	Replace deck
15	Prestressed Concrete Top Flange (Slab)	1	1	Miscellaneous Maintenance	Miscellaneous Maintenance
15	Prestressed Concrete Top Flange (Slab)	1	2	Add a protective system	Add a protective system
15	Prestressed Concrete Top Flange (Slab)	2	1	Minor repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands	Minor repair
15	Prestressed Concrete Top Flange (Slab)	2	2	Minor repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands; Add a protective system	Minor repair & add a protective system
15	Prestressed Concrete Top Flange (Slab)	3	1	Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
15	Prestressed Concrete Top Flange (Slab)	3	2	Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands; Add a protective system	Major repair & add a protective system
15	Prestressed Concrete Top Flange (Slab)	4	1	Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
15	Prestressed Concrete Top Flange (Slab)	4	2	Major rehab and repair slab	Replace deck

Table 3.4. Initial list of feasible actions for sample steel deck elements

Elemkey New	ElemNameNew	skey	akey	actlongNew	actshortNew
28	Steel Deck w ith Open Grid	1	1	Surface clean	Surface clean
28	Steel Deck w ith Open Grid	1	2	Miscellaneous Maintenance	Miscellaneous Maintenance
28	Steel Deck w ith Open Grid	2	1	Surface clean	Surface clean
28	Steel Deck w ith Open Grid	2	2	Surface clean and minor repair of corrosion and connectors	Surface clean and minor repair
28	Steel Deck w ith Open Grid	3	1	Surface clean and minor repair of corrosion and connectors	Surface clean and minor repair
28	Steel Deck w ith Open Grid	3	2	Surface clean and major repair of corrosion and connectors	Surface clean and major repair
28	Steel Deck w ith Open Grid	4	1	Spot blast, surface clean and major repair of corrosion and connectors	Spot blast, surface clean and major repair
28	Steel Deck w ith Open Grid	4	2	Replace unit	Replace unit
29	Steel Deck w ith Concrete Filled Grid	1	1	Surface clean	Surface clean
29	Steel Deck w ith Concrete Filled Grid	1	2	Miscellaneous Maintenance	Miscellaneous Maintenance
29	Steel Deck w ith Concrete Filled Grid	2	1	Surface clean	Surface clean
29	Steel Deck w ith Concrete Filled Grid	2	2	Surface clean and minor repair of corrosion and connectors	Surface clean and minor repair
29	Steel Deck w ith Concrete Filled Grid	3	1	Surface clean and minor repair of corrosion and connectors	Surface clean and minor repair
29	Steel Deck w ith Concrete Filled Grid	3	2	Surface clean and major repair of corrosion and connectors	Surface clean and major repair
29	Steel Deck w ith Concrete Filled Grid	4	1	Spot blast, surface clean and major repair of corrosion and connectors	Spot blast, surface clean and major repair
29	Steel Deck w ith Concrete Filled Grid	4	2	Replace unit	Replace unit
30	Steel Deck Corrugated/Orthotropic/Etc	1	1	Surface clean	Surface clean
30	Steel Deck Corrugated/Orthotropic/Etc	1	2	Miscellaneous Maintenance	Miscellaneous Maintenance
30	Steel Deck Corrugated/Orthotropic/Etc	2	1	Surface clean	Surface clean
30	Steel Deck Corrugated/Orthotropic/Etc	2	2	Surface clean and minor repair of corrosion and connectors	Surface clean and minor repair
30	Steel Deck Corrugated/Orthotropic/Etc	3	1	Surface clean and minor repair of corrosion and connectors	Surface clean and minor repair
30	Steel Deck Corrugated/Orthotropic/Etc	3	2	Surface clean and major repair of corrosion and connectors	Surface clean and major repair
30	Steel Deck Corrugated/Orthotropic/Etc	4	1	Spot blast, surface clean and major repair of corrosion and connectors	Spot blast, surface clean and major repair
30	Steel Deck Corrugated/Orthotropic/Etc	4	2	Replace unit	Replace unit

Table 3.5. Revised list of feasible actions for sample Reinforced and Prestressed Concrete Deck Elements

New Elemkey	New ElemName	New skey	New akey	New actlong	New actshort
12	RC Concrete Deck	1	2	Crack sealing	Crack sealing
12	RC Concrete Deck	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair
12	RC Concrete Deck	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair
12	RC Concrete Deck	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair
12	RC Concrete Deck	4	2	Replace deck	Replace deck
13	PSC Concrete Deck	1	2	Crack sealing	Crack sealing
13	PSC Concrete Deck	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair
13	PSC Concrete Deck	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
13	PSC Concrete Deck	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar/prestressing strands	Major repair deck
13	PSC Concrete Deck	4	2	Replace deck	Replace deck
15	PSC Concrete Top Flange	1	2	Crack sealing	Crack sealing
15	PSC Concrete Top Flange	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair
15	PSC Concrete Top Flange	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
15	PSC Concrete Top Flange	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
15	PSC Concrete Top Flange	4	2	Major repair and rehab of flange	Major repair and rehab of flange
16	RC Concrete Top Flange	1	2	Crack sealing	Crack sealing
16	RC Concrete Top Flange	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair
16	RC Concrete Top Flange	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair
16	RC Concrete Top Flange	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair
16	RC Concrete Top Flange	4	2	Major repair and rehab of flange	Major repair and rehab of flange

Table 3.6. Revised list of feasible actions for sample Steel and Corrugated/Orthotropic Deck Elements

New Elemkey	New ElemName	New skey	New akey	New actlong	New actshort
28	Steel Deck/Open Grid	2	1	Spot blast	Spot blast deck
28	Steel Deck/Open Grid	2	2	Minor repair of corrosion, cracks, and connectors	Minor repair deck
28	Steel Deck/Open Grid	3	1	Spot blast and minor repair of corrosion and connectors	Spot blast and minor repair deck
28	Steel Deck/Open Grid	3	2	Spot blast and major repair of corrosion and connectors	Spot blast and major repair deck
28	Steel Deck/Open Grid	4	1	Spot blast and major repair of corrosion and connectors	Spot blast and major repair deck
28	Steel Deck/Open Grid	4	2	Replace deck	Replace deck
29	Steel Deck/Conc Grid	2	1	Spot blast	Spot blast deck
29	Steel Deck/Conc Grid	2	2	Minor repair of concrete filling, corrosion, cracks, and connectors	Minor repair deck
29	Steel Deck/Conc Grid	3	1	Spot blast and minor repair of concrete filling, corrosion, cracks, and connectors	Spot blast and minor repair deck
29	Steel Deck/Conc Grid	3	2	Spot blast and major repair of concrete filling, corrosion, cracks, and connectors	Spot blast and major repair deck
29	Steel Deck/Conc Grid	4	1	Spot blast and major repair of concrete filling, corrosion, cracks, and connectors	Spot blast and major repair deck
29	Steel Deck/Conc Grid	4	2	Replace deck	Replace deck
30	Corrug/Orthotpc Deck	2	1	Spot blast	Spot blast deck
30	Corrug/Orthotpc Deck	2	2	Minor repair of corrosion, cracks, and connectors	Minor repair deck
30	Corrug/Orthotpc Deck	3	1	Spot blast and minor repair of corrosion and connectors	Spot blast and minor repair deck
30	Corrug/Orthotpc Deck	3	2	Spot blast and major repair of corrosion and connectors	Spot blast and major repair deck
30	Corrug/Orthotpc Deck	4	1	Spot blast and major repair of corrosion and connectors	Spot blast and major repair deck
30	Corrug/Orthotpc Deck	4	2	Replace deck	Replace deck

Table 3.7. Revised list of feasible actions for sample timber and reinforced concrete slab Elements

New Elemkey	New ElemName	New skey	New akey	New actlong	New actshort
31	Timber Deck	2	1	Minor repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Minor repair deck
31	Timber Deck	3	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair deck
31	Timber Deck	4	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair deck
31	Timber Deck	4	2	Replace deck	Replace deck
38	Reinforced Concrete Slab	1	2	Crack sealing	Crack sealing
38	Reinforced Concrete Slab	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair
38	Reinforced Concrete Slab	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair
38	Reinforced Concrete Slab	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair
38	Reinforced Concrete Slab	4	2	Replace slab	Replace slab
54	Timber Slab	2	1	Minor repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Minor repair slab
54	Timber Slab	3	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair slab
54	Timber Slab	4	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair slab
54	Timber Slab	4	2	Replace slab	Replace slab
60	Other Deck	2	2	Minor repair: clean stains, repair corrosion, connectors, and spalled/delamination	Minor repair deck
60	Other Deck	3	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination and exposed rebar/prestressing strands	Major repair deck
60	Other Deck	4	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination and exposed rebar/prestressing strands	Major repair deck
60	Other Deck	4	2	Replace deck	Replace deck

Table 3.8. Revised list of feasible actions for sample slabs and deck panels

New Elemkey	New ElemName	New skey	New akey	New actlong	New actshort
65	Other Slab	2	2	Minor repair: clean stains, repair corrosion, connectors, and spalled/delamination	Minor repair slab
65	Other Slab	3	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination and exposed rebar/prestressing strands	Major repair slab
65	Other Slab	4	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination and exposed rebar/prestressing strands	Major repair slab
65	Other Slab	4	2	Replace slab	Replace slab
98	Concrete Deck on Precast Deck Panels	1	2	Crack sealing	Crack sealing deck
98	Concrete Deck on Precast Deck Panels	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair
98	Concrete Deck on Precast Deck Panels	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair deck
98	Concrete Deck on Precast Deck Panels	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair deck
98	Concrete Deck on Precast Deck Panels	4	2	Replace deck panels	Replace deck panels
99	Prestressed Concrete Slab (Sonovoid)	1	2	Crack sealing	Crack sealing
99	Prestressed Concrete Slab (Sonovoid)	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair
99	Prestressed Concrete Slab (Sonovoid)	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
99	Prestressed Concrete Slab (Sonovoid)	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
99	Prestressed Concrete Slab (Sonovoid)	4	2	Replace slab	Replace slab

Table 3.9. Revised list of feasible actions for sample girder elements

New Elemkey	New ElemName	New skey	New akey	New actlong	New actshort
102	Steel Closed Web/Box Girder	2	1	Spot blast	Spot blast
102	Steel Closed Web/Box Girder	2	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and minor repair
102	Steel Closed Web/Box Girder	3	1	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
102	Steel Closed Web/Box Girder	3	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
102	Steel Closed Web/Box Girder	3	3	Repair distortion	Repair distortion
102	Steel Closed Web/Box Girder	4	1	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
102	Steel Closed Web/Box Girder	4	2	Repair distortion	Repair distortion
102	Steel Closed Web/Box Girder	4	3	Replace unit	Replace unit
104	Prestressed Concrete Closed Web/Box Girder	1	1	Crack sealing	Crack sealing
104	Prestressed Concrete Closed Web/Box Girder	2	2	Minor repair: clean stains, and repair spalled/delamination	Minor repair
104	Prestressed Concrete Closed Web/Box Girder	3	1	Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
104	Prestressed Concrete Closed Web/Box Girder	4	1	Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
104	Prestressed Concrete Closed Web/Box Girder	4	2	Replace unit	Replace unit
105	Reinforced Concrete Closed Web/Box Girder	1	1	Crack sealing	Crack sealing
105	Reinforced Concrete Closed Web/Box Girder	2	2	Minor repair: clean stains, and repair spalled/delamination	Minor repair
105	Reinforced Concrete Closed Web/Box Girder	3	1	Major repair: clean stains, repair spalled/delamination and exposed rebar	Major repair
105	Reinforced Concrete Closed Web/Box Girder	4	1	Major repair: clean stains, repair spalled/delamination and exposed rebar	Major repair
105	Reinforced Concrete Closed Web/Box Girder	4	2	Replace unit	Replace unit

3.1. Compilation and review of feasible actions

The preservation actions can be worded to apply to all relevant defects, since in many cases, the crew can handle any of these defects they happen to find without affecting the cost. However, there are a few cases where a specific defect, if noted in the inspection, implies a different crew or special equipment, where the cost would be affected. The BMS models in the present form cannot predict defects, but it is hoped that in the future, the models will be capable in a few instances of selecting a particular action based on the existence of a defect on an element.

In condition state 1, Maintenance, Surface Clean, or any other actions may not be needed except in the case of concrete elements, where state 1 still describes slight levels of cracks. So crack sealing may be an appropriate feasible action for state 1 in this case. But experience suggests that it is difficult to quantify the benefits of annual routine maintenance actions and to decide on the optimal criteria and intervals. For preservation actions, it will be necessary to develop an action that considers adding coatings, cathodic protection, and wearing surfaces as protection systems. Repairs to a protective system would be generated only on the protective system element. In many of these cases if no reference is made to the protective system, the action becomes redundant with another action for the same element/state.

For all of the concrete elements (including deck, slab, super, and sub), it would be appropriate to add a crack-sealing action to states 2 and 3. This would be selected only on elements where a cracking defect already exists. For the steel deck elements, there can be cracking, but this would be minor and might be repaired by a small welding action, which would happen at the same time as any corrosion-related or connector repairs. So the description of the actions should include “repair of corrosion, cracks, and connectors.” Similarly, for concrete-filled steel grids, the action should include repairs to the concrete filling. For the Other Deck and Other Slab elements, it is suggested for now using generic terms such as routine maintenance, minor repair, major repair, etc.

For the steel elements, it will be necessary to treat corrosion, cracks, and connectors together. However, rather than “surface clean,” as used in previous Pontis element actions, it would be more accurate to say “spot blast” in every case, even for weathering steel. Distortion is a more expensive action which would be selected only if the Distortion or Damage defects are present. This will involve replacement of a piece of the structure or heat-straightening, which generically could be called Repair Distortion for states 3 and 4. Repair Distortion action can be omitted for cables and included with the other defects for steel culverts. For the steel elements in condition state 4, action 1 should be “Major repair.” For concrete elements, major repairs would apply if there is any exposed rebar or prestressing strands, as well as reset or replacement of bearings that would probably involve closing the bridge and jacking up the superstructure.

There would be a unique action “Mitigate settlement or scour” for substructures and culverts for states 3 and 4. This would be selected only if a Settlement or Scour defect already exists on the element. For approach slabs, just as in the case of concrete decks, there is no need yet to add a protective system. For settlement, there should be a separate action in states 3 and 4 called Mudjacking. It would be selected only if there is a Settlement defect. A refined complete set of feasible actions are shown in Table 3.10.

Table 3.10. Complete list of element actions

New element key	New element name	New state key	New action key	New action long label	New action short label
12	RC Concrete Deck	1	2	Crack sealing	Crack sealing
12	RC Concrete Deck	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair
12	RC Concrete Deck	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair
12	RC Concrete Deck	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair
12	RC Concrete Deck	4	2	Replace deck	Replace deck
13	PSC Concrete Deck	1	2	Crack sealing	Crack sealing
13	PSC Concrete Deck	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair
13	PSC Concrete Deck	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
13	PSC Concrete Deck	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar/prestressing strands	Major repair deck
13	PSC Concrete Deck	4	2	Replace deck	Replace deck
15	PSC Concrete Top Flange	1	2	Crack sealing	Crack sealing
15	PSC Concrete Top Flange	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair
15	PSC Concrete Top Flange	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
15	PSC Concrete Top Flange	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
15	PSC Concrete Top Flange	4	2	Major repair and rehab of flange	Major repair and rehab of flange
16	RC Concrete Top Flange	1	2	Crack sealing	Crack sealing
16	RC Concrete Top Flange	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair
16	RC Concrete Top Flange	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair
16	RC Concrete Top Flange	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair
16	RC Concrete Top Flange	4	2	Major repair and rehab of flange	Major repair and rehab of flange
28	Steel Deck/Open Grid	2	1	Spot blast	Spot blast deck
28	Steel Deck/Open Grid	2	2	Minor repair of corrosion, cracks, and connectors	Minor repair deck
28	Steel Deck/Open Grid	3	1	Spot blast and minor repair of corrosion and connectors	Spot blast and minor repair deck
28	Steel Deck/Open Grid	3	2	Spot blast and major repair of corrosion and connectors	Spot blast and major repair deck
28	Steel Deck/Open Grid	4	1	Spot blast and major repair of corrosion and connectors	Spot blast and major repair deck
28	Steel Deck/Open Grid	4	2	Replace deck	Replace deck
29	Steel Deck/Conc Grid	2	1	Spot blast	Spot blast deck
29	Steel Deck/Conc Grid	2	2	Minor repair of concrete filling, corrosion, cracks, and connectors	Minor repair deck
29	Steel Deck/Conc Grid	3	1	Spot blast and minor repair of concrete filling, corrosion, cracks, and connectors	Spot blast and minor repair deck
29	Steel Deck/Conc Grid	3	2	Spot blast and major repair of concrete filling, corrosion, cracks, and connectors	Spot blast and major repair deck
29	Steel Deck/Conc Grid	4	1	Spot blast and major repair of concrete filling, corrosion, cracks, and connectors	Spot blast and major repair deck
29	Steel Deck/Conc Grid	4	2	Replace deck	Replace deck
30	Corrug/Orthotpc Deck	2	1	Spot blast	Spot blast deck
30	Corrug/Orthotpc Deck	2	2	Minor repair of corrosion, cracks, and connectors	Minor repair deck
30	Corrug/Orthotpc Deck	3	1	Spot blast and minor repair of corrosion and connectors	Spot blast and minor repair deck
30	Corrug/Orthotpc Deck	3	2	Spot blast and major repair of corrosion and connectors	Spot blast and major repair deck
30	Corrug/Orthotpc Deck	4	1	Spot blast and major repair of corrosion and connectors	Spot blast and major repair deck
30	Corrug/Orthotpc Deck	4	2	Replace deck	Replace deck
31	Timber Deck	2	1	Minor repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Minor repair deck
31	Timber Deck	3	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair deck
31	Timber Deck	4	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair deck
31	Timber Deck	4	2	Replace deck	Replace deck
38	Reinforced Concrete Slab	1	2	Crack sealing	Crack sealing
38	Reinforced Concrete Slab	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair
38	Reinforced Concrete Slab	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair
38	Reinforced Concrete Slab	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair
38	Reinforced Concrete Slab	4	2	Replace slab	Replace slab

Table 3.10. Complete list of element actions (Cont'd)

New element key	New element name	New state key	New action key	New action long label	New action short label
54	Timber Slab	2	1	Minor repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Minor repair slab
54	Timber Slab	3	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair slab
54	Timber Slab	4	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair slab
54	Timber Slab	4	2	Replace slab	Replace slab
60	Other Deck	2	2	Minor repair: clean stains, repair corrosion, connectors, and spalled/delamination	Minor repair deck
60	Other Deck	3	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination and exposed rebar/prestressing strands	Major repair deck
60	Other Deck	4	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination and exposed rebar/prestressing strands	Major repair deck
60	Other Deck	4	2	Replace deck	Replace deck
65	Other Slab	2	2	Minor repair: clean stains, repair corrosion, connectors, and spalled/delamination	Minor repair slab
65	Other Slab	3	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination and exposed rebar/prestressing strands	Major repair slab
65	Other Slab	4	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination and exposed rebar/prestressing strands	Major repair slab
65	Other Slab	4	2	Replace slab	Replace slab
98	Concrete Deck on Precast Deck Panels	1	2	Crack sealing	Crack sealing deck
98	Concrete Deck on Precast Deck Panels	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair
98	Concrete Deck on Precast Deck Panels	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair deck
98	Concrete Deck on Precast Deck Panels	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair deck
98	Concrete Deck on Precast Deck Panels	4	2	Replace deck panels	Replace deck panels
99	Prestressed Concrete Slab (Sonovoid)	1	2	Crack sealing	Crack sealing
99	Prestressed Concrete Slab (Sonovoid)	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair
99	Prestressed Concrete Slab (Sonovoid)	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
99	Prestressed Concrete Slab (Sonovoid)	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
99	Prestressed Concrete Slab (Sonovoid)	4	2	Replace slab	Replace slab
102	Steel Closed Web/Box Girder	2	1	Spot blast	Spot blast
102	Steel Closed Web/Box Girder	2	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and minor repair
102	Steel Closed Web/Box Girder	3	1	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
102	Steel Closed Web/Box Girder	3	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
102	Steel Closed Web/Box Girder	3	3	Repair distortion	Repair distortion
102	Steel Closed Web/Box Girder	4	1	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
102	Steel Closed Web/Box Girder	4	2	Repair distortion	Repair distortion
102	Steel Closed Web/Box Girder	4	3	Replace unit	Replace unit
104	Prestressed Concrete Closed Web/Box Girder	1	1	Crack sealing	Crack sealing
104	Prestressed Concrete Closed Web/Box Girder	2	2	Minor repair: clean stains, and repair spalled/delamination	Minor repair
104	Prestressed Concrete Closed Web/Box Girder	3	1	Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
104	Prestressed Concrete Closed Web/Box Girder	4	1	Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
104	Prestressed Concrete Closed Web/Box Girder	4	2	Replace unit	Replace unit
105	Reinforced Concrete Closed Web/Box Girder	1	1	Crack sealing	Crack sealing
105	Reinforced Concrete Closed Web/Box Girder	2	2	Minor repair: clean stains, and repair spalled/delamination	Minor repair
105	Reinforced Concrete Closed Web/Box Girder	3	1	Major repair: clean stains, repair spalled/delamination and exposed rebar	Major repair
105	Reinforced Concrete Closed Web/Box Girder	4	1	Major repair: clean stains, repair spalled/delamination and exposed rebar	Major repair
105	Reinforced Concrete Closed Web/Box Girder	4	2	Replace unit	Replace unit
106	Other Material Closed Web/Box Girder	2	2	Minor repair: clean stains, repair corrosion, connectors, spalled/delamination, and cracks	Minor repair
106	Other Material Closed Web/Box Girder	3	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks and exposed rebar	Major repair

Table 3.10. Complete list of element actions (Cont'd)

New element key	New element name	New state key	New action key	New action long label	New action short label
106	Other Material Closed Web/Box Girder	4	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks and exposed rebar	Major repair
106	Other Material Closed Web/Box Girder	4	2	Replace unit	Replace unit
107	Steel Open Girder/Beam	2	1	Spot blast	Spot blast
107	Steel Open Girder/Beam	2	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and minor repair
107	Steel Open Girder/Beam	3	1	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
107	Steel Open Girder/Beam	3	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
107	Steel Open Girder/Beam	3	3	Repair distortion	Repair distortion
107	Steel Open Girder/Beam	4	1	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
107	Steel Open Girder/Beam	4	2	Repair distortion	Repair distortion
107	Steel Open Girder/Beam	4	3	Replace unit	Replace unit
109	Prestressed Open Girder/Beam	1	1	Crack sealing	Crack sealing
109	Prestressed Open Girder/Beam	2	2	Minor repair: clean stains, and repair spalled/delamination	Minor repair
109	Prestressed Open Girder/Beam	3	1	Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
109	Prestressed Open Girder/Beam	4	1	Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
109	Prestressed Open Girder/Beam	4	2	Replace unit	Replace unit
110	Reinforced Concrete Open Girder/Beam	1	1	Crack sealing	Crack sealing
110	Reinforced Concrete Open Girder/Beam	2	2	Minor repair: clean stains, and repair spalled/delamination	Minor repair
110	Reinforced Concrete Open Girder/Beam	3	1	Major repair: clean stains, repair spalled/delamination and exposed rebar	Major repair
110	Reinforced Concrete Open Girder/Beam	4	1	Major repair: clean stains, repair spalled/delamination and exposed rebar	Major repair
110	Reinforced Concrete Open Girder/Beam	4	2	Replace unit	Replace unit
111	Timber Open Girder/Beam	2	1	Minor repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Minor repair
111	Timber Open Girder/Beam	3	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair
111	Timber Open Girder/Beam	4	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair
111	Timber Open Girder/Beam	4	2	Replace unit	Replace unit
112	Other Material Open Girder/Beam	2	2	Minor repair: clean stains, repair corrosion, connectors, and spalled/delamination	Minor repair
112	Other Material Open Girder/Beam	3	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks and exposed rebar	Major repair
112	Other Material Open Girder/Beam	4	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks and exposed rebar	Major repair
112	Other Material Open Girder/Beam	4	2	Replace unit	Replace unit
113	Steel Stringer	2	1	Spot blast	Spot blast
113	Steel Stringer	2	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and minor repair
113	Steel Stringer	3	1	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
113	Steel Stringer	3	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
113	Steel Stringer	3	3	Repair distortion	Repair distortion
113	Steel Stringer	4	1	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
113	Steel Stringer	4	2	Repair distortion	Repair distortion
113	Steel Stringer	4	3	Replace unit	Replace unit
115	Prestressed Concrete Stringer	1	1	Crack sealing	Crack sealing
115	Prestressed Concrete Stringer	2	2	Minor repair: clean stains, and repair spalled/delamination	Minor repair
115	Prestressed Concrete Stringer	3	1	Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
115	Prestressed Concrete Stringer	4	1	Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
115	Prestressed Concrete Stringer	4	2	Replace unit	Replace unit
116	Reinforced Concrete Stringer	1	1	Crack sealing	Crack sealing
116	Reinforced Concrete Stringer	2	2	Minor repair: clean stains, and repair spalled/delamination	Minor repair
116	Reinforced Concrete Stringer	3	1	Major repair: clean stains, repair spalled/delamination and exposed rebar	Major repair
116	Reinforced Concrete Stringer	4	1	Major repair: clean stains, repair spalled/delamination and exposed rebar	Major repair
116	Reinforced Concrete Stringer	4	2	Replace unit	Replace unit

Table 3.10. Complete list of element actions (Cont'd)

New element key	New element name	New state key	New action key	New action long label	New action short label
117	Timber Stringer	2	1	Minor repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Minor repair
117	Timber Stringer	3	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair
117	Timber Stringer	4	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair
117	Timber Stringer	4	2	Replace unit	Replace unit
118	Other Material Stringer	2	2	Minor repair: clean stains, repair corrosion, connectors, spalled/delamination, and cracks	Minor repair
118	Other Material Stringer	3	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks and exposed rebar	Major repair
118	Other Material Stringer	4	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks and exposed rebar	Major repair
118	Other Material Stringer	4	2	Replace unit	Replace unit
120	Steel Truss	2	1	Spot blast	Spot blast
120	Steel Truss	2	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and minor repair
120	Steel Truss	3	1	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
120	Steel Truss	3	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
120	Steel Truss	3	3	Repair distortion	Repair distortion
120	Steel Truss	4	1	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
120	Steel Truss	4	2	Repair distortion	Repair distortion
120	Steel Truss	4	3	Replace unit	Replace unit
135	Timber Truss	2	1	Minor repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Minor repair
135	Timber Truss	3	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair
135	Timber Truss	4	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair
135	Timber Truss	4	2	Replace unit	Replace unit
136	Other Material Truss	2	2	Minor repair: clean stains, repair corrosion, connectors, spalled/delamination, and cracks	Minor repair
136	Other Material Truss	3	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks and exposed rebar	Major repair
136	Other Material Truss	4	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks and exposed rebar	Major repair
136	Other Material Truss	4	2	Replace unit	Replace unit
141	Steel Arch	2	1	Spot blast	Spot blast
141	Steel Arch	2	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and minor repair
141	Steel Arch	3	1	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
141	Steel Arch	3	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
141	Steel Arch	3	3	Repair distortion	Repair distortion
141	Steel Arch	4	1	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
141	Steel Arch	4	2	Repair distortion	Repair distortion
141	Steel Arch	4	3	Replace unit	Replace unit
142	Other Material Arch	2	2	Minor repair: clean stains, repair corrosion, connectors, spalled/delamination, and cracks	Minor repair
142	Other Material Arch	3	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks and exposed rebar	Major repair
142	Other Material Arch	4	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks and exposed rebar	Major repair
142	Other Material Arch	4	2	Replace unit	Replace unit
143	Prestressed Concrete Arch	1	1	Crack sealing	Crack sealing
143	Prestressed Concrete Arch	2	2	Minor repair: clean stains, and repair spalled/delamination	Minor repair
143	Prestressed Concrete Arch	3	1	Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
143	Prestressed Concrete Arch	4	1	Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
143	Prestressed Concrete Arch	4	2	Replace unit	Replace unit
144	Reinforced Concrete Arch	1	1	Crack sealing	Crack sealing
144	Reinforced Concrete Arch	2	2	Minor repair: clean stains, and repair spalled/delamination	Minor repair
144	Reinforced Concrete Arch	3	1	Major repair: clean stains, repair spalled/delamination and exposed rebar	Major repair

Table 3.10. Complete list of element actions (Cont'd)

New element key	New element name	New state key	New action key	New action long label	New action short label
144	Reinforced Concrete Arch	4	1	Major repair: clean stains, repair spalled/delamination and exposed rebar	Major repair
144	Reinforced Concrete Arch	4	2	Replace unit	Replace unit
145	Masonry Arch	2	2	Minor repair: clean stains, repair mortar, cracks, splits/spalls, and patched areas	Minor repair
145	Masonry Arch	3	1	Major repair: clean stains, repair mortar, cracks, splits/spalls, patched areas, and realign stone	Major repair
145	Masonry Arch	4	1	Major repair: clean stains, repair mortar, cracks, splits/spalls, patched areas, and realign stone	Major repair
145	Masonry Arch	4	2	Replace unit	Replace unit
146	Timber Arch	2	1	Minor repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Minor repair
146	Timber Arch	3	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair
146	Timber Arch	4	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair
146	Timber Arch	4	2	Replace unit	Replace unit
147	Steel Main Cables	2	1	Spot blast	Spot blast
147	Steel Main Cables	2	2	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
147	Steel Main Cables	3	1	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
147	Steel Main Cables	3	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
147	Steel Main Cables	4	1	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
147	Steel Main Cables	4	2	Replace unit	Replace unit
148	Secondary Steel Cables	2	1	Spot blast	Spot blast
148	Secondary Steel Cables	2	2	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
148	Secondary Steel Cables	3	1	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
148	Secondary Steel Cables	3	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
148	Secondary Steel Cables	4	1	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
148	Secondary Steel Cables	4	2	Replace unit	Replace unit
149	Other Material Secondary Cable	2	2	Minor repair: clean stains, repair corrosion, connectors, spalled/delamination, and cracks	Minor repair
149	Other Material Secondary Cable	3	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks and exposed rebar	Major repair
149	Other Material Secondary Cable	4	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks and exposed rebar	Major repair
149	Other Material Secondary Cable	4	2	Replace unit	Replace unit
152	Steel Floor Beam	2	1	Spot blast	Spot blast
152	Steel Floor Beam	2	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and minor repair
152	Steel Floor Beam	3	1	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
152	Steel Floor Beam	3	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
152	Steel Floor Beam	3	3	Repair distortion	Repair distortion
152	Steel Floor Beam	4	1	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
152	Steel Floor Beam	4	2	Repair distortion	Repair distortion
152	Steel Floor Beam	4	3	Replace unit	Replace unit
154	Prestressed Concrete Floor Beam	1	1	Crack sealing	Crack sealing
154	Prestressed Concrete Floor Beam	2	2	Minor repair: clean stains, and repair spalled/delamination	Minor repair
154	Prestressed Concrete Floor Beam	3	1	Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
154	Prestressed Concrete Floor Beam	4	1	Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands	Major repair
154	Prestressed Concrete Floor Beam	4	2	Replace unit	Replace unit
155	Reinforced Concrete Floor Beam	1	1	Clean	Clean
155	Reinforced Concrete Floor Beam	1	2	Miscellaneous Maintenance	Miscellaneous Maintenance
155	Reinforced Concrete Floor Beam	2	2	Minor repair: clean stains, and repair spalled/delamination	Minor repair
155	Reinforced Concrete Floor Beam	3	1	Major repair: clean stains, repair spalled/delamination and exposed rebar	Major repair
155	Reinforced Concrete Floor Beam	3	2	Major rehab: clean stains, repair spalled/delamination and exposed rebar	Major rehab
155	Reinforced Concrete Floor Beam	4	1	Major rehab: clean stains, repair spalled/delamination and exposed rebar	Major rehab
155	Reinforced Concrete Floor Beam	4	2	Replace unit	Replace unit

Table 3.10. Complete list of element actions (Cont'd)

New element key	New element name	New state key	New action key	New action long label	New action short label
156	Timber Floor Beam	2	1	Minor repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Minor repair
156	Timber Floor Beam	3	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair
156	Timber Floor Beam	4	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair
156	Timber Floor Beam	4	2	Replace unit	Replace unit
157	Other Material Floor Beam	2	2	Minor repair: clean stains, repair corrosion, connectors, spalled/delamination, and cracks	Minor repair
157	Other Material Floor Beam	3	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks and exposed rebar	Major repair
157	Other Material Floor Beam	4	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks and exposed rebar	Major repair
157	Other Material Floor Beam	4	2	Replace unit	Replace unit
161	Steel Pin and Pin & Hanger Assembly or Both	2	1	Spot blast	Spot blast
161	Steel Pin and Pin & Hanger Assembly or Both	2	2	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
161	Steel Pin and Pin & Hanger Assembly or Both	3	1	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
161	Steel Pin and Pin & Hanger Assembly or Both	3	2	Spot blast and major repair of corrosion, cracks, connectors, and distortion	Spot blast and major repair
161	Steel Pin and Pin & Hanger Assembly or Both	4	1	Spot blast and major repair of corrosion, cracks, connectors, and distortion	Spot blast and major repair
161	Steel Pin and Pin & Hanger Assembly or Both	4	2	Replace unit	Replace unit
162	Steel Gusset Plate	2	1	Spot blast	Spot blast
162	Steel Gusset Plate	2	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and minor repair
162	Steel Gusset Plate	3	1	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
162	Steel Gusset Plate	3	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
162	Steel Gusset Plate	3	3	Repair distortion	Repair distortion
162	Steel Gusset Plate	4	1	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
162	Steel Gusset Plate	4	2	Repair distortion	Repair distortion
162	Steel Gusset Plate	4	3	Replace unit	Replace unit
202	Steel Column	2	1	Spot blast	Spot blast
202	Steel Column	2	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and minor repair
202	Steel Column	3	1	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
202	Steel Column	3	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
202	Steel Column	3	3	Repair distortion	Repair distortion
202	Steel Column	3	4	Mitigate settlement or scour	Mitigate settlement or scour
202	Steel Column	4	1	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
202	Steel Column	4	2	Repair distortion	Repair distortion
202	Steel Column	4	3	Mitigate settlement or scour	Mitigate settlement or scour
202	Steel Column	4	4	Replace unit	Replace unit
203	Other Material Column	2	1	Spot blast	Spot blast
203	Other Material Column	2	2	Spot blast and minor repair of corrosion, connectors, spalled/delamination, and cracks	Spot blast and minor repair
203	Other Material Column	3	1	Spot blast and major repair of corrosion, connectors, spalled/delamination, cracks, and exposed rebar	Spot blast and major repair
203	Other Material Column	3	2	Repair distortion	Repair distortion
203	Other Material Column	3	3	Mitigate settlement or scour	Mitigate settlement or scour
203	Other Material Column	4	1	Spot blast and major repair of corrosion, connectors, spalled/delamination, cracks, and exposed rebar	Spot blast and major repair
203	Other Material Column	4	2	Repair distortion	Repair distortion
203	Other Material Column	4	3	Mitigate settlement or scour	Mitigate settlement or scour
203	Other Material Column	4	4	Replace unit	Replace unit
204	Prestressed Concrete Column	2	2	Minor repair: clean stains, and repair spalled/delamination	Minor repair
204	Prestressed Concrete Column	3	1	Major repair: clean stains, repair spalled/delamination, and exposed rebar/prestressing strands	Major repair
204	Prestressed Concrete Column	3	2	Mitigate settlement or scour	Mitigate settlement or scour
204	Prestressed Concrete Column	4	1	Major repair: clean stains, repair spalled/delamination, exposed rebar/prestressing strands	Major repair
204	Prestressed Concrete Column	4	2	Mitigate settlement or scour	Mitigate settlement or scour
204	Prestressed Concrete Column	4	3	Replace unit	Replace unit
205	Reinforced Concrete Column	2	2	Minor repair: clean stains, repair cracks, spall/delamination, and wearing	Minor repair

Table 3.10. Complete list of element actions (Cont'd)

New element key	New element name	New state key	New action key	New action long label	New action short label
205	Reinforced Concrete Column	3	1	Major repair: clean stains, repair cracks, spall/delamination, wearing, and exposed rebar	Major repair
205	Reinforced Concrete Column	3	2	Mitigate settlement or scour	Mitigate settlement or scour
205	Reinforced Concrete Column	4	1	Major repair: clean stains, repair cracks, spall/delamination, wearing, and exposed rebar	Major repair
205	Reinforced Concrete Column	4	2	Mitigate settlement or scour	Mitigate settlement or scour
205	Reinforced Concrete Column	4	3	Replace unit	Replace unit
206	Timber Column	2	1	Minor repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Minor repair
206	Timber Column	3	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Major repair
206	Timber Column	3	2	Mitigate settlement or scour	Mitigate settlement or scour
206	Timber Column	4	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Major repair
206	Timber Column	4	2	Mitigate settlement or scour	Mitigate settlement or scour
206	Timber Column	4	3	Replace unit	Replace unit
207	Steel Tower	2	1	Spot blast	Spot blast
207	Steel Tower	2	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and minor repair
207	Steel Tower	3	1	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
207	Steel Tower	3	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
207	Steel Tower	3	3	Repair distortion	Repair distortion
207	Steel Tower	3	4	Mitigate settlement or scour	Mitigate settlement or scour
207	Steel Tower	4	1	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
207	Steel Tower	4	2	Repair distortion	Repair distortion
207	Steel Tower	4	3	Mitigate settlement or scour	Mitigate settlement or scour
207	Steel Tower	4	4	Replace unit	Replace unit
208	Timber Trestle	2	1	Minor repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Minor repair
208	Timber Trestle	3	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Major repair
208	Timber Trestle	3	2	Mitigate settlement or scour	Mitigate settlement or scour
208	Timber Trestle	4	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Major repair
208	Timber Trestle	4	2	Mitigate settlement or scour	Mitigate settlement or scour
208	Timber Trestle	4	3	Replace unit	Replace unit
210	Reinforced Concrete Pier Wall	2	2	Minor repair: clean stains, repair cracks, spall/delamination, and wearing	Minor repair
210	Reinforced Concrete Pier Wall	3	1	Major repair: clean stains, repair cracks, spall/delamination, wearing, and exposed rebar	Major repair
210	Reinforced Concrete Pier Wall	3	2	Mitigate settlement or scour	Mitigate settlement or scour
210	Reinforced Concrete Pier Wall	4	1	Major repair: clean stains, repair cracks, spall/delamination, wearing, and exposed rebar	Major repair
210	Reinforced Concrete Pier Wall	4	2	Mitigate settlement or scour	Mitigate settlement or scour
210	Reinforced Concrete Pier Wall	4	3	Replace unit	Replace unit
211	Other Material Pier Wall	2	1	Spot blast	Spot blast
211	Other Material Pier Wall	2	2	Spot blast and minor repair of corrosion, connectors, spalled/delamination, and cracks	Spot blast and minor repair
211	Other Material Pier Wall	3	1	Spot blast and major repair of corrosion, connectors, spalled/delamination, cracks, and exposed rebar	Spot blast and major repair
211	Other Material Pier Wall	3	2	Repair distortion	Repair distortion
211	Other Material Pier Wall	3	3	Mitigate settlement or scour	Mitigate settlement or scour
211	Other Material Pier Wall	4	1	Spot blast and major repair of corrosion, connectors, spalled/delamination, cracks, and exposed rebar	Spot blast and major repair
211	Other Material Pier Wall	4	2	Repair distortion	Repair distortion
211	Other Material Pier Wall	4	3	Mitigate settlement or scour	Mitigate settlement or scour
211	Other Material Pier Wall	4	4	Replace unit	Replace unit
212	Timber Pier Wall	2	1	Minor repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Minor repair
212	Timber Pier Wall	2	2	Minor repair of connectors, decay, checks/shakes, cracks, splits/delamination, abrasion, and settlement/scour; Add a protective system	Minor repair & add a protective system
212	Timber Pier Wall	3	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination, abrasion, and settlement/scour	Major repair
212	Timber Pier Wall	3	2	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination, abrasion, and settlement/scour; Add a protective system	Major repair & add a protective system
212	Timber Pier Wall	4	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination, abrasion, and settlement/scour	Major repair
212	Timber Pier Wall	4	2	Replace unit	Replace unit
213	Masonry Pier Wall	2	2	Minor repair: clean stains, repair cracks, splits/spalls, and patch area	Minor repair

Table 3.10. Complete list of element actions (Cont'd)

New element key	New element name	New state key	New action key	New action long label	New action short label
213	Masonry Pier Wall	3	1	Major repair: clean stains, repair cracks, splits/spalls, patch area, and realign stone	Major repair
213	Masonry Pier Wall	3	2	Mitigate settlement or scour	Mitigate settlement or scour
213	Masonry Pier Wall	4	1	Major repair: clean stains, repair cracks, splits/spalls, patch area, realign stone, and settlement/scour	Major repair
213	Masonry Pier Wall	4	2	Mitigate settlement or scour	Mitigate settlement or scour
213	Masonry Pier Wall	4	3	Replace unit	Replace unit
215	Reinforced Concrete Abutment	2	2	Minor repair: clean stains, repair cracks, spall/delamination, and wearing	Minor repair
215	Reinforced Concrete Abutment	3	1	Major repair: clean stains, repair cracks, spall/delamination, wearing, and exposed rebar	Major repair
215	Reinforced Concrete Abutment	3	2	Mitigate settlement or scour	Mitigate settlement or scour
215	Reinforced Concrete Abutment	4	1	Major repair: clean stains, repair cracks, spall/delamination, wearing, and exposed rebar	Major repair
215	Reinforced Concrete Abutment	4	2	Mitigate settlement or scour	Mitigate settlement or scour
215	Reinforced Concrete Abutment	4	3	Replace unit	Replace unit
216	Timber Abutment	2	1	Minor repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Minor repair
216	Timber Abutment	3	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Major repair
216	Timber Abutment	3	2	Mitigate settlement or scour	Mitigate settlement or scour
216	Timber Abutment	4	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Major repair
216	Timber Abutment	4	2	Mitigate settlement or scour	Mitigate settlement or scour
216	Timber Abutment	4	3	Replace unit	Replace unit
217	Masonry Abutment	2	2	Minor repair: clean stains, repair cracks, splits/spalls, and patch area	Minor repair
217	Masonry Abutment	3	1	Major repair: clean stains, repair cracks, splits/spalls, patch area, and realign stone	Major repair
217	Masonry Abutment	3	2	Mitigate settlement or scour	Mitigate settlement or scour
217	Masonry Abutment	4	1	Major repair: clean stains, repair cracks, splits/spalls, patch area, realign stone, and settlement/scour	Major repair
217	Masonry Abutment	4	2	Mitigate settlement or scour	Mitigate settlement or scour
217	Masonry Abutment	4	3	Replace unit	Replace unit
218	Other Material Abutment	2	1	Spot blast	Spot blast
218	Other Material Abutment	2	2	Spot blast and minor repair of corrosion, connectors, spalled/delamination, and cracks	Spot blast and minor repair
218	Other Material Abutment	3	1	Spot blast and major repair of corrosion, connectors, spalled/delamination, cracks, and exposed rebar	Spot blast and major repair
218	Other Material Abutment	3	2	Repair distortion	Repair distortion
218	Other Material Abutment	3	3	Mitigate settlement or scour	Mitigate settlement or scour
218	Other Material Abutment	4	1	Spot blast and major repair of corrosion, connectors, spalled/delamination, cracks, and exposed rebar	Spot blast and major repair
218	Other Material Abutment	4	2	Repair distortion	Repair distortion
218	Other Material Abutment	4	3	Mitigate settlement or scour	Mitigate settlement or scour
218	Other Material Abutment	4	4	Replace unit	Replace unit
219	Steel Abutment	2	1	Spot blast	Spot blast
219	Steel Abutment	2	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and minor repair
219	Steel Abutment	3	1	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
219	Steel Abutment	3	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
219	Steel Abutment	3	3	Repair distortion	Repair distortion
219	Steel Abutment	3	4	Mitigate settlement or scour	Mitigate settlement or scour
219	Steel Abutment	4	1	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
219	Steel Abutment	4	2	Repair distortion	Repair distortion
219	Steel Abutment	4	3	Mitigate settlement or scour	Mitigate settlement or scour
219	Steel Abutment	4	4	Replace unit	Replace unit
220	Reinforced Concrete Pile Cap/Footing	2	2	Minor repair: clean stains, repair cracks, spall/delamination, and wearing	Minor repair
220	Reinforced Concrete Pile Cap/Footing	3	1	Major repair: clean stains, repair cracks, spall/delamination, wearing, and exposed rebar	Major repair
220	Reinforced Concrete Pile Cap/Footing	3	2	Mitigate settlement or scour	Mitigate settlement or scour
220	Reinforced Concrete Pile Cap/Footing	4	1	Major repair: clean stains, repair cracks, spall/delamination, wearing, and exposed rebar	Major repair
220	Reinforced Concrete Pile Cap/Footing	4	2	Mitigate settlement or scour	Mitigate settlement or scour
220	Reinforced Concrete Pile Cap/Footing	4	3	Replace unit	Replace unit
225	Steel Pile	2	1	Spot blast	Spot blast
225	Steel Pile	2	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and minor repair
225	Steel Pile	3	1	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
225	Steel Pile	3	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair

Table 3.10. Complete list of element actions (Cont'd)

New element key	New element name	New state key	New action key	New action long label	New action short label
225	Steel Pile	3	3	Repair distortion	Repair distortion
225	Steel Pile	3	4	Mitigate settlement or scour	Mitigate settlement or scour
225	Steel Pile	4	1	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
225	Steel Pile	4	2	Repair distortion	Repair distortion
225	Steel Pile	4	3	Mitigate settlement or scour	Mitigate settlement or scour
225	Steel Pile	4	4	Replace unit	Replace unit
226	Prestressed Concrete Pile	2	2	Minor repair: clean stains, and repair spalled/delamination	Minor repair
226	Prestressed Concrete Pile	3	1	Major repair: clean stains, repair spalled/delamination, and exposed rebar/prestressing strands	Major repair
226	Prestressed Concrete Pile	3	2	Mitigate settlement or scour	Mitigate settlement or scour
226	Prestressed Concrete Pile	4	1	Major repair: clean stains, repair spalled/delamination, exposed rebar/prestressing strands	Major repair
226	Prestressed Concrete Pile	4	2	Mitigate settlement or scour	Mitigate settlement or scour
226	Prestressed Concrete Pile	4	3	Replace unit	Replace unit
227	Reinforced Concrete Pile	2	2	Minor repair: clean stains, repair cracks, spall/delamination, and wearing	Minor repair
227	Reinforced Concrete Pile	3	1	Major repair: clean stains, repair cracks, spall/delamination, wearing, and exposed rebar	Major repair
227	Reinforced Concrete Pile	3	2	Mitigate settlement or scour	Mitigate settlement or scour
227	Reinforced Concrete Pile	4	1	Major repair: clean stains, repair cracks, spall/delamination, wearing, and exposed rebar	Major repair
227	Reinforced Concrete Pile	4	2	Mitigate settlement or scour	Mitigate settlement or scour
227	Reinforced Concrete Pile	4	3	Replace unit	Replace unit
228	Timber Pile	2	1	Minor repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Minor repair
228	Timber Pile	3	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Major repair
228	Timber Pile	3	2	Mitigate settlement or scour	Mitigate settlement or scour
228	Timber Pile	4	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Major repair
228	Timber Pile	4	2	Mitigate settlement or scour	Mitigate settlement or scour
228	Timber Pile	4	3	Replace unit	Replace unit
229	Other Material Pile	2	1	Spot blast	Spot blast
229	Other Material Pile	2	2	Spot blast and minor repair of corrosion, connectors, spalled/delamination, and cracks	Spot blast and minor repair
229	Other Material Pile	3	1	Spot blast and major repair of corrosion, connectors, spalled/delamination, cracks, and exposed rebar	Spot blast and major repair
229	Other Material Pile	3	2	Repair distortion	Repair distortion
229	Other Material Pile	3	3	Mitigate settlement or scour	Mitigate settlement or scour
229	Other Material Pile	4	1	Spot blast and major repair of corrosion, connectors, spalled/delamination, cracks, and exposed rebar	Spot blast and major repair
229	Other Material Pile	4	2	Repair distortion	Repair distortion
229	Other Material Pile	4	3	Mitigate settlement or scour	Mitigate settlement or scour
229	Other Material Pile	4	4	Replace unit	Replace unit
231	Steel Pier Cap	2	1	Spot blast	Spot blast
231	Steel Pier Cap	2	2	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
231	Steel Pier Cap	3	1	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
231	Steel Pier Cap	3	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair
231	Steel Pier Cap	3	3	Repair distortion	Repair distortion
231	Steel Pier Cap	4	1	Spot blast and major repair of corrosion, cracks, connectors, and distortion	Spot blast and major repair
231	Steel Pier Cap	4	2	Repair distortion	Repair distortion
231	Steel Pier Cap	4	3	Replace unit	Replace unit
233	Prestressed Concrete Pier Cap	2	2	Minor repair: clean stains, repair cracks, and spall/delamination	Minor repair
233	Prestressed Concrete Pier Cap	3	1	Major repair: clean stains, repair cracks, spall/delamination, and exposed rebar/prestressing strands	Major repair
233	Prestressed Concrete Pier Cap	4	1	Major repair: clean stains, repair cracks, spall/delamination, and exposed rebar/prestressing strands	Major repair
233	Prestressed Concrete Pier Cap	4	2	Replace unit	Replace unit
234	Reinforced Concrete Pier Cap	2	2	Minor repair: clean stains, repair cracks, and spall/delamination	Minor repair
234	Reinforced Concrete Pier Cap	3	1	Major repair: clean stains, repair cracks, spall/delamination, and exposed rebar	Major repair
234	Reinforced Concrete Pier Cap	4	1	Major repair: clean stains, repair cracks, spall/delamination, and exposed rebar	Major repair
234	Reinforced Concrete Pier Cap	4	2	Replace unit	Replace unit
235	Timber Pier Cap	2	1	Minor repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Minor repair

Table 3.10. Complete list of element actions (Cont'd)

New element key	New element name	New state key	New action key	New action long label	New action short label
235	Timber Pier Cap	3	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delaminationand abrasion	Major repair
235	Timber Pier Cap	4	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Major repair
235	Timber Pier Cap	4	2	Replace unit	Replace unit
236	Other Material Pier Cap	2	1	Minor repair: clean stains, repair corrosion, connectors, spalled/delamination, and cracks	Minor repair
236	Other Material Pier Cap	3	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks, exposed rebar, and distortion	Major repair
236	Other Material Pier Cap	4	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks, exposed rebar, and distortion	Major repair
236	Other Material Pier Cap	4	2	Replace unit	Replace unit
240	Steel Culvert	2	1	Spot blast	Spot blast
240	Steel Culvert	2	2	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
240	Steel Culvert	3	1	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
240	Steel Culvert	3	2	Mitigate settlement or scour	Mitigate settlement or scour
240	Steel Culvert	4	1	Spot blast and major repair of corrosion, cracks, connectors, settlement/scour and distortion; Mitigate settlement or scour	Spot blast and major repair
240	Steel Culvert	4	2	Mitigate settlement or scour	Mitigate settlement or scour
240	Steel Culvert	4	3	Replace unit	Replace unit
241	Reinforced Concrete Culvert	2	2	Minor repair: clean stains, repair cracks, spall/delamination, and wearing	Minor repair
241	Reinforced Concrete Culvert	3	1	Major repair: clean stains, repair cracks, spall/delamination, wearing, and exposed rebar	Major repair
241	Reinforced Concrete Culvert	3	2	Mitigate settlement or scour	Mitigate settlement or scour
241	Reinforced Concrete Culvert	4	1	Major repair: clean stains, repair cracks, spall/delamination, wearing, and exposed rebar; Mitigate settlement or scour	Major repair
241	Reinforced Concrete Culvert	4	2	Mitigate settlement or scour	Mitigate settlement or scour
241	Reinforced Concrete Culvert	4	3	Replace unit	Replace unit
242	Timber Culvert	2	1	Minor repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Minor repair
242	Timber Culvert	3	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Major repair
242	Timber Culvert	3	2	Mitigate settlement or scour	Mitigate settlement or scour
242	Timber Culvert	4	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion; Mitigate settlement or scour	Major repair
242	Timber Culvert	4	2	Mitigate settlement or scour	Mitigate settlement or scour
242	Timber Culvert	4	3	Replace unit	Replace unit
243	Other Culvert	2	2	Minor repair: clean stains, repair corrosion, connectors, spalled/delamination, and cracks	Minor repair
243	Other Culvert	3	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks, and exposed rebar	Major repair
243	Other Culvert	3	2	Mitigate settlement or scour	Mitigate settlement or scour
243	Other Culvert	4	1	Major repair; clean stains, repair corrosion, connectors, spalled/delamination, cracks, and exposed rebar; Repair distortion, and Mitigate settlement or scour	Major repair
243	Other Culvert	4	2	Mitigate settlement or scour	Mitigate settlement or scour
243	Other Culvert	4	3	Replace unit	Replace unit
244	Masonry Culvert	2	2	Minor repair: clean stains, repair cracks, splits/spalls, and patch area	Minor repair
244	Masonry Culvert	3	1	Major repair: clean stains, repair cracks, splits/spalls, patch area, and realign stone	Major repair
244	Masonry Culvert	3	2	Mitigate settlement or scour	Mitigate settlement or scour
244	Masonry Culvert	4	1	Major repair: clean stains, repair cracks, splits/spalls, patch area, and realign stone; Mitigate settlement or scour	Major repair
244	Masonry Culvert	4	2	Replace unit	Replace unit
245	Prestressed Concrete Culvert	2	2	Minor repair: clean stains, and repair spalled/delamination	Minor repair
245	Prestressed Concrete Culvert	3	1	Major repair: clean stains, repair spalled/delamination, and exposed rebar/prestressing strands	Major repair
245	Prestressed Concrete Culvert	3	2	Mitigate settlement or scour	Mitigate settlement or scour
245	Prestressed Concrete Culvert	4	1	Major repair: clean stains, repair spalled/delamination, and exposed rebar/prestressing strands; Mitigate settlement or scour	Major repair
245	Prestressed Concrete Culvert	4	2	Mitigate settlement or scour	Mitigate settlement or scour
245	Prestressed Concrete Culvert	4	3	Replace unit	Replace unit
300	Strip Seal Expansion Joint	2	2	Minor repair – Remove debris, clean steel, repair spalls, restore seal integrity	Minor repair

Table 3.10. Complete list of element actions (Cont'd)

New element key	New element name	New state key	New action key	New action long label	New action short label
300	Strip Seal Expansion Joint	3	2	header and steel components, repair or replace seal	Major repair
300	Strip Seal Expansion Joint	4	1	Major repair – Remove debris, correct damage to header and steel components, repair or replace	Major repair
300	Strip Seal Expansion Joint	4	2	Replace joint	Replace joint
301	Pourable Joint Seal	2	2	Minor repair – Remove debris, clean steel, repair spalls, restore seal integrity	Minor repair
301	Pourable Joint Seal	3	2	Major repair – Remove debris, correct damage to header and steel components, repair or replace	Major repair
301	Pourable Joint Seal	4	1	Major repair – Remove debris, correct damage to header and steel components, repair or replace	Major repair
301	Pourable Joint Seal	4	2	Replace joint	Replace joint
302	Compression Joint Seal	2	2	Minor repair – Remove debris, clean steel, repair spalls, restore seal integrity	Minor repair
302	Compression Joint Seal	3	2	Major repair – Remove debris, correct damage to header and steel components, repair or replace	Major repair
302	Compression Joint Seal	4	1	Major repair – Remove debris, correct damage to header and steel components, repair or replace	Major repair
302	Compression Joint Seal	4	2	Replace joint	Replace joint
303	Assembly Joint with Seal	2	2	Minor repair – Remove debris, clean steel, repair spalls, restore seal integrity	Minor repair
303	Assembly Joint with Seal	3	2	header and steel components, repair or replace seal	Major repair
303	Assembly Joint with Seal	4	1	header and steel components, repair or replace seal	Major repair
303	Assembly Joint with Seal	4	2	Replace joint	Replace joint
304	Open Expansion Joint	2	2	Minor repair – Remove debris, clean steel, and repair spalls	Minor repair
304	Open Expansion Joint	3	2	Major repair – Remove debris, clean steel, and repair spalls	Major repair
304	Open Expansion Joint	4	1	Major repair – Remove debris, clean steel, and repair spalls	Major repair
304	Open Expansion Joint	4	2	Replace joint	Replace joint
305	Assembly Joint without Seal	2	2	Minor repair – Remove debris, clean steel, and repair spalls	Minor repair
305	Assembly Joint without Seal	3	2	Major repair – Remove debris, clean steel, and repair spalls	Major repair
305	Assembly Joint without Seal	4	1	Major repair – Remove debris, clean steel, and repair spalls	Major repair
305	Assembly Joint without Seal	4	2	Replace joint	Replace joint
306	Other Joint	2	2	Minor repair – Remove debris, clean steel, and repair spalls	Minor repair
306	Other Joint	3	2	Major repair – Remove debris, clean steel, and repair spalls	Major repair
306	Other Joint	4	1	Major repair – Remove debris, clean steel, and repair spalls	Major repair
306	Other Joint	4	2	Replace joint	Replace joint
310	Elastomeric Bearing	2	2	Minor repair: repair corrosion, connnectors, restriction, bulging/splitting/tearing, loss of bearing and re-align	Minor repair
310	Elastomeric Bearing	3	1	Major repair: repair corrosion, connnectors, restriction, bulging/splitting/tearing, loss of bearing and re-align	Major repair
310	Elastomeric Bearing	4	1	Major repair: repair corrosion, connnectors, restriction, bulging/splitting/tearing, loss of bearing and re-align	Major repair
310	Elastomeric Bearing	4	2	Replace unit	Replace unit
311	Movable Bearing (roller, sliding, etc.)	2	2	Minor repair: repair corrosion, connnectors, restriction, loss of bearing and re-align	Minor repair
311	Movable Bearing (roller, sliding, etc.)	3	1	Major repair: repair corrosion, connnectors, restriction, loss of bearing and re-align	Major repair
311	Movable Bearing (roller, sliding, etc.)	4	1	Major repair: repair corrosion, connnectors, restriction, loss of bearing and re-align	Major repair
311	Movable Bearing (roller, sliding, etc.)	4	2	Replace unit	Replace unit
312	Enclosed/Concealed Bearing	2	2	Minor repair: repair corrosion, connnectors, restriction, loss of bearing and re-align	Minor repair
312	Enclosed/Concealed Bearing	3	1	Major repair: repair corrosion, connnectors, restriction, loss of bearing and re-align	Major repair
312	Enclosed/Concealed Bearing	4	1	Major repair: repair corrosion, connnectors, restriction, loss of bearing and re-align	Major repair
312	Enclosed/Concealed Bearing	4	2	Replace unit	Replace unit
313	Fixed Bearing	2	2	Minor repair: repair corrosion, connnectors, restriction, loss of bearing and re-align	Minor repair
313	Fixed Bearing	3	1	Major repair: repair corrosion, connnectors, restriction, loss of bearing and re-align	Major repair
313	Fixed Bearing	4	1	Major repair: repair corrosion, connnectors, restriction, loss of bearing and re-align	Major repair
313	Fixed Bearing	4	2	Replace unit	Replace unit

Table 3.10. Complete list of element actions (Cont'd)

New element key	New element name	New state key	New action key	New action long label	New action short label
314	Pot Bearing	2	2	Minor repair: repair corrosion, connnectors, restriction, bulging/splitting/tearing, loss of bearing and re-align	Minor repair
314	Pot Bearing	3	1	Major repair: repair corrosion, connnectors, restriction, bulging/splitting/tearing, loss of bearing and re-align	Major repair
314	Pot Bearing	4	1	Major repair: repair corrosion, connnectors, restriction, bulging/splitting/tearing, loss of bearing and re-align	Major repair
314	Pot Bearing	4	2	Replace unit	Replace unit
315	Disk Bearing	2	2	Minor repair: repair corrosion, connnectors, restriction, loss of bearing and re-align	Minor repair
315	Disk Bearing	3	1	Major repair: repair corrosion, connnectors, restriction, loss of bearing and re-align	Major repair
315	Disk Bearing	4	1	Major repair: repair corrosion, connnectors, restriction, loss of bearing and re-align	Major repair
315	Disk Bearing	4	2	Replace unit	Replace unit
316	Other Bearing	2	2	Minor repair: repair corrosion, connnectors, restriction, loss of bearing and re-align	Minor repair
316	Other Bearing	3	1	Major repair: repair corrosion, connnectors, restriction, loss of bearing and re-align	Major repair
316	Other Bearing	4	1	Major repair: repair corrosion, connnectors, restriction, loss of bearing and re-align	Major repair
316	Other Bearing	4	2	Replace unit	Replace unit
320	Prestressed Concrete Approach Slab	2	1	Minor repair: repair spalled/delamination, and cracks	Minor repair
320	Prestressed Concrete Approach Slab	3	1	Major repair: repair spalled/delamination, cracks, and exposed rebar/prestressing strands	Major repair
320	Prestressed Concrete Approach Slab	3	2	Mudjacking	Mudjacking
320	Prestressed Concrete Approach Slab	4	1	Major repair: repair spalled/delamination, cracks, exposed rebar/prestressing strands, and	Major repair and mudjacking
320	Prestressed Concrete Approach Slab	4	2	Mudjacking	Mudjacking
320	Prestressed Concrete Approach Slab	4	3	Replace unit	Replace unit
321	Reinforced Concrete Approach Slab	2	1	Minor repair: repair spalled/delamination, and	Minor repair
321	Reinforced Concrete Approach Slab	3	1	Major repair: repair spalled/delamination, cracks, and exposed rebar	Major repair
321	Reinforced Concrete Approach Slab	3	2	Mudjacking	Mudjacking
321	Reinforced Concrete Approach Slab	4	1	Major repair: repair spalled/delamination, cracks, exposed rebar, and mudjacking	Major repair and mudjacking
321	Reinforced Concrete Approach Slab	4	2	Mudjacking	Mudjacking
321	Reinforced Concrete Approach Slab	4	3	Replace unit	Replace unit
330	Metal Bridge Railing	2	1	Spot blast	Spot blast
330	Metal Bridge Railing	2	2	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
330	Metal Bridge Railing	3	1	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
330	Metal Bridge Railing	3	2	Spot blast and major repair of corrosion, cracks, connectors, and distortion	Spot blast and major repair
330	Metal Bridge Railing	4	1	Spot blast and major repair of corrosion, cracks, connectors, and distortion	Spot blast and major repair
330	Metal Bridge Railing	4	2	Replace railing	Replace railing
331	Reinforced Concrete Bridge Railing	2	2	Minor repair: clean stains, repair cracks, and spall/delamination	Minor repair
331	Reinforced Concrete Bridge Railing	3	1	Major repair: clean stains, repair cracks, spall/delamination, and exposed rebar	Major repair
331	Reinforced Concrete Bridge Railing	4	1	Major repair: clean stains, repair cracks, spall/delamination, and exposed rebar	Major repair
331	Reinforced Concrete Bridge Railing	4	2	Replace railing	Replace railing
332	Timber Bridge Railing	1	2	Miscellaneous Maintenance	Miscellaneous Maintenance
332	Timber Bridge Railing	2	2	Minor repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Minor repair
332	Timber Bridge Railing	3	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair
332	Timber Bridge Railing	4	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair
332	Timber Bridge Railing	4	2	Replace unit	Replace unit
333	Other Bridge Railing	1	2	Miscellaneous Maintenance	Miscellaneous Maintenance
333	Other Bridge Railing	2	2	Minor repair: clean stains, repair corrosion, connectors, spalled/delamination, and cracks	Minor repair
333	Other Bridge Railing	3	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks and exposed rebar	Major repair
333	Other Bridge Railing	4	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks and exposed rebar	Major repair
333	Other Bridge Railing	4	2	Replace unit	Replace unit
334	Masonry Bridge Railing	2	2	Minor repair: clean stains, repair cracks, splits/spalls, and patch area	Minor repair
334	Masonry Bridge Railing	3	1	Major repair: clean stains, repair cracks, splits/spalls, patch area, distortion, and realign	Major repair

Table 3.10. Complete list of element actions (Cont'd)

New element key	New element name	New state key	New action key	New action long label	New action short label
334	Masonry Bridge Railing	4	1	Major repair: clean stains, repair cracks, splits/spalls, patch area, distortion, and realign	Major repair
334	Masonry Bridge Railing	4	2	Replace unit	Replace unit
580	Navigational Light System (Movable bridge control system)	2	2	Minor repair for operation and paint	Minor repair
580	Navigational Light System (Movable bridge control system)	3	1	Minor repair for operation and paint	Minor repair
580	Navigational Light System (Movable bridge control system)	3	2	Major repair for operation and paint	Major repair
580	Navigational Light System (Movable bridge control system)	4	1	Major repair for operation and paint	Major repair
580	Navigational Light System (Movable bridge control system)	4	2	Replace unit	Replace unit
8097	PS Conc Slab (Hybrid)	1	2	Crack sealing	Crack sealing slab
8097	PS Conc Slab (Hybrid)	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair slab
8097	PS Conc Slab (Hybrid)	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar/prestressing strands	Major repair slab
8097	PS Conc Slab (Hybrid)	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar/prestressing strands	Major repair slab
8097	PS Conc Slab (Hybrid)	4	2	Replace slab	Replace slab
8098	Conc Deck on PC Pane	1	2	Crack sealing	Crack sealing deck
8098	Conc Deck on PC Pane	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair deck
8098	Conc Deck on PC Pane	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair deck
8098	Conc Deck on PC Pane	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair deck
8098	Conc Deck on PC Pane	4	2	Replace deck	Replace deck
8099	PS Conc Slab (Sonovoid)	1	2	Crack sealing	Crack sealing slab
8099	PS Conc Slab (Sonovoid)	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair slab
8099	PS Conc Slab (Sonovoid)	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar/prestressing strands	Major repair slab
8099	PS Conc Slab (Sonovoid)	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar/prestressing strands	Major repair slab
8099	PS Conc Slab (Sonovoid)	4	2	Replace slab	Replace slab
8199	External Post Tensioning Duct	2	2	Minor repair: clean stains, repair corrosion, connectors, spalled/delamination, and cracks	Minor repair
8199	External Post Tensioning Duct	3	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks and exposed rebar	Major repair
8199	External Post Tensioning Duct	4	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks and exposed rebar	Major repair
8199	External Post Tensioning Duct	4	2	Replace unit	Replace unit
8290	Channel	2	2	Minor repair: clean, realign, and repair erosion, Thalweg movement, and degradation/aggradation	Minor repair
8290	Channel	3	1	Major repair: clean, realign, and repair erosion, Thalweg movement, and degradation/aggradation	Major repair
8290	Channel	4	1	Major repair: clean, realign, and repair erosion, Thalweg movement, and degradation/aggradation	Major repair
8290	Channel	4	2	Major repair/rehab: clean, realign, and repair erosion, Thalweg movement, and degradation/aggradation	Major repair/rehab
8298	Pile Jacket	2	2	Minor repair: clean stains, repair cracks, and spall/delamination	Minor repair
8298	Pile Jacket	3	1	Major repair: clean stains, repair cracks, spall/delamination, and exposed rebar	Major repair
8298	Pile Jacket	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8298	Pile Jacket	4	1	Major repair: clean stains, repair cracks, spall/delamination, and exposed rebar	Major repair
8298	Pile Jacket	4	2	Mitigate settlement or scour	Mitigate settlement or scour
8298	Pile Jacket	4	3	Replace unit	Replace unit
8386	Fender/Dolphin System (Metal)	2	2	Minor repair: clean stains, repair cracks, and spall/delamination	Minor repair
8386	Fender/Dolphin System (Metal)	3	1	Major repair: clean stains, repair cracks, spall/delamination, exposed rebar, and settlement/scour	Major repair
8386	Fender/Dolphin System (Metal)	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8386	Fender/Dolphin System (Metal)	4	1	Major repair: clean stains, repair cracks, spall/delamination, exposed rebar, and settlement/scour	Major repair
8386	Fender/Dolphin System (Metal)	4	2	Mitigate settlement or scour	Mitigate settlement or scour
8386	Fender/Dolphin System (Metal)	4	3	Replace unit	Replace unit

Table 3.10. Complete list of element actions (Cont'd)

New element key	New element name	New state key	New action key	New action long label	New action short label
8387	Fender/Dolphin System (Prestressed Concrete)	2	2	Minor repair: clean stains, repair cracks, and spalled/delamination	Minor repair
8387	Fender/Dolphin System (Prestressed Concrete)	3	1	Major repair: clean stains, repair cracks, spalled/delamination, and exposed rebar/prestressing strands	Major repair
8387	Fender/Dolphin System (Prestressed	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8387	Fender/Dolphin System (Prestressed Concrete)	4	1	Major repair: clean stains, repair cracks, spalled/delamination, and exposed rebar/prestressing strands	Major repair
8387	Fender/Dolphin System (Prestressed	4	2	Mitigate settlement or scour	Mitigate settlement or scour
8387	Fender/Dolphin System (Prestressed	4	3	Replace unit	Replace unit
8388	Fender/Dolphin System (Reinforced Concrete)	2	2	Minor repair: clean stains, and repair spalled/delamination	Minor repair
8388	Fender/Dolphin System (Reinforced Concrete)	3	1	Major repair: clean stains, repair spalled/delamination, and exposed rebar/prestressing strands	Major repair
8388	Fender/Dolphin System (Reinforced Concrete)	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8388	Fender/Dolphin System (Reinforced Concrete)	4	1	Major repair: clean stains, repair spalled/delamination, exposed rebar/prestressing strands	Major repair
8388	Fender/Dolphin System (Reinforced Concrete)	4	2	Mitigate settlement or scour	Mitigate settlement or scour
8388	Fender/Dolphin System (Reinforced Concrete)	4	3	Replace unit	Replace unit
8389	Fender/Dolphin System (Timber)	2	1	Minor repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Minor repair
8389	Fender/Dolphin System (Timber)	3	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Major repair
8389	Fender/Dolphin System (Timber)	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8389	Fender/Dolphin System (Timber)	4	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Major repair
8389	Fender/Dolphin System (Timber)	4	2	Mitigate settlement or scour	Mitigate settlement or scour
8389	Fender/Dolphin System (Timber)	4	3	Replace unit	Replace unit
8390	Fender/Dolphin System (Other material)	2	2	Minor repair: clean stains, repair corrosion, connectors, spalled/delamination, and cracks	Minor repair
8390	Fender/Dolphin System (Other material)	3	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks, exposed	Major repair
8390	Fender/Dolphin System (Other material)	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8390	Fender/Dolphin System (Other material)	4	1	connectors, spalled/delamination, cracks, exposed rebar, and distortion	Major repair
8390	Fender/Dolphin System (Other material)	4	2	Mitigate settlement or scour	Mitigate settlement or scour
8390	Fender/Dolphin System (Other material)	4	3	Replace unit	Replace unit
8393	Bulkhead/Seawall	2	2	Minor repair: clean stains, repair corrosion, connectors, spalled/delamination, and cracks	Minor repair
8393	Bulkhead/Seawall	3	1	connectors, spalled/delamination, cracks, exposed rebar, and distortion	Major repair
8393	Bulkhead/Seawall	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8393	Bulkhead/Seawall	4	1	connectors, spalled/delamination, cracks, exposed rebar, and distortion	Major repair
8393	Bulkhead/Seawall	4	2	Mitigate settlement or scour	Mitigate settlement or scour
8393	Bulkhead/Seawall	4	3	Replace unit	Replace unit
8394	Abutment Slope Protection (Reinforced or Plain Concrete)	2	2	Minor repair: clean stains, repair cracks, and spall/delamination	Minor repair
8394	Abutment Slope Protection (Reinforced or Plain Concrete)	3	1	Major repair: clean stains, repair cracks, spall/delamination, and exposed rebar	Major repair
8394	Abutment Slope Protection (Reinforced or Plain Concrete)	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8394	Abutment Slope Protection (Reinforced or Plain Concrete)	4	1	Major repair: clean stains, repair cracks, spall/delamination, and exposed rebar	Major repair
8394	Abutment Slope Protection (Reinforced or Plain Concrete)	4	2	Mitigate settlement or scour	Mitigate settlement or scour
8394	Abutment Slope Protection (Reinforced or Plain Concrete)	4	3	Replace unit	Replace unit
8395	Abutment Slope Protection (Timber)	2	1	Minor repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Minor repair
8395	Abutment Slope Protection (Timber)	3	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Major repair
8395	Abutment Slope Protection (Timber)	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8395	Abutment Slope Protection (Timber)	4	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Major repair
8395	Abutment Slope Protection (Timber)	4	2	Mitigate settlement or scour	Mitigate settlement or scour
8395	Abutment Slope Protection (Timber)	4	3	Replace unit	Replace unit
8396	Abutment Slope Protection (Other material)	2	2	Minor repair: clean stains, repair corrosion, connectors, spalled/delamination, and cracks	Minor repair
8396	Abutment Slope Protection (Other material)	3	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks, exposed	Major repair
8396	Abutment Slope Protection (Other material)	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8396	Abutment Slope Protection (Other material)	4	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks, exposed	Major repair
8396	Abutment Slope Protection (Other material)	4	2	Mitigate settlement or scour	Mitigate settlement or scour
8396	Abutment Slope Protection (Other material)	4	3	Replace unit	Replace unit

Table 3.10. Complete list of element actions (Cont'd)

New element key	New element name	New state key	New action key	New action long label	New action short label
8397	Metal Drainage System	2	2	Minor repair: clean stains, repair cracks, connectors, and distortion	Minor repair
8397	Metal Drainage System	3	1	Major repair: clean stains, repair cracks, connectors, and distortion	Major repair
8397	Metal Drainage System	4	1	Major repair: clean stains, repair cracks, connectors, and distortion	Major repair
8397	Metal Drainage System	4	2	Replace unit	Replace unit
8398	Other Material Drainage System	2	2	Minor repair: clean stains, repair cracks, spall/delamination, connectors, and distortion	Minor repair
8398	Other Material Drainage System	3	1	Major repair: clean stains, repair cracks, spall/delamination, connectors, and distortion	Major repair
8398	Other Material Drainage System	4	1	Major repair: clean stains, repair cracks, spall/delamination, connectors, and distortion	Major repair
8398	Other Material Drainage System	4	2	Replace unit	Replace unit
8474	Wingwall/Retaining Wall (Metal)	2	2	Minor repair: clean stains, repair cracks, and spall/delamination	Minor repair
8474	Wingwall/Retaining Wall (Metal)	3	1	Major repair: clean stains, repair cracks, spall/delamination, exposed rebar, and settlement/scour	Major repair
8474	Wingwall/Retaining Wall (Metal)	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8474	Wingwall/Retaining Wall (Metal)	4	1	Major repair: clean stains, repair cracks, spall/delamination, exposed rebar, and settlement/scour	Major repair
8474	Wingwall/Retaining Wall (Metal)	4	2	Mitigate settlement or scour	Mitigate settlement or scour
8474	Wingwall/Retaining Wall (Metal)	4	3	Replace unit	Replace unit
8475	Wingwall/Retaining Wall (Reinforced or Plain Concrete)	2	2	Minor repair: clean stains, repair cracks, and spall/delamination	Minor repair
8475	Wingwall/Retaining Wall (Reinforced or Plain Concrete)	3	1	Major repair: clean stains, repair cracks, spall/delamination, and exposed rebar	Major repair
8475	Wingwall/Retaining Wall (Reinforced or Plain Concrete)	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8475	Wingwall/Retaining Wall (Reinforced or Plain Concrete)	4	1	Major repair: clean stains, repair cracks, spall/delamination, and exposed rebar	Major repair
8475	Wingwall/Retaining Wall (Reinforced or Plain Concrete)	4	2	Mitigate settlement or scour	Mitigate settlement or scour
8475	Wingwall/Retaining Wall (Reinforced or Plain Concrete)	4	3	Replace unit	Replace unit
8476	Wingwall/Retaining Wall Timber	2	1	Minor repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Minor repair
8476	Wingwall/Retaining Wall Timber	3	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Major repair
8476	Wingwall/Retaining Wall Timber	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8476	Wingwall/Retaining Wall Timber	4	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination, and abrasion	Major repair
8476	Wingwall/Retaining Wall Timber	4	2	Mitigate settlement or scour	Mitigate settlement or scour
8476	Wingwall/Retaining Wall Timber	4	3	Replace unit	Replace unit
8477	Wingwall/Retaining Wall Other Material	2	2	Minor repair: clean stains, repair corrosion, connectors, spalled/delamination, and cracks	Minor repair
8477	Wingwall/Retaining Wall Other Material	3	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks, exposed	Major repair
8477	Wingwall/Retaining Wall Other Material	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8477	Wingwall/Retaining Wall Other Material	4	1	connectors, spalled/delamination, cracks, exposed rebar, and distortion	Major repair
8477	Wingwall/Retaining Wall Other Material	4	2	Mitigate settlement or scour	Mitigate settlement or scour
8477	Wingwall/Retaining Wall Other Material	4	3	Replace unit	Replace unit
8478	Mechanically Stabilized Earth Wall	2	2	Minor repair: clean stains, repair corrosion, connectors, spalled/delamination, and cracks	Minor repair
8478	Mechanically Stabilized Earth Wall	3	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks, exposed	Major repair
8478	Mechanically Stabilized Earth Wall	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8478	Mechanically Stabilized Earth Wall	4	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination, cracks, exposed	Major repair
8478	Mechanically Stabilized Earth Wall	4	2	Mitigate settlement or scour	Mitigate settlement or scour
8478	Mechanically Stabilized Earth Wall	4	3	Replace unit	Replace unit
8480	Mast Arm Foundation	2	1	Spot blast	Spot blast
8480	Mast Arm Foundation	2	2	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
8480	Mast Arm Foundation	3	1	Spot blast and major repair of corrosion, cracks, connectors, and distortion	Spot blast and major repair
8480	Mast Arm Foundation	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8480	Mast Arm Foundation	4	1	Spot blast and major repair of corrosion, cracks, connectors, settlement and distortion	Spot blast and major repair
8480	Mast Arm Foundation	4	2	Replace unit	Replace unit
8481	Mast Arm Vertical Member	2	1	Spot blast	Spot blast
8481	Mast Arm Vertical Member	2	2	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
8481	Mast Arm Vertical Member	3	1	Spot blast and major repair of corrosion, cracks, connectors, and distortion	Spot blast and major repair
8481	Mast Arm Vertical Member	3	2	Mitigate settlement or scour	Mitigate settlement or scour

Table 3.10. Complete list of element actions (Cont'd)

New element key	New element name	New state key	New action key	New action long label	New action short label
8481	Mast Arm Vertical Member	4	1	Spot blast and major repair of corrosion, cracks, connectors, settlement/scour and distortion	Spot blast and major repair
8481	Mast Arm Vertical Member	4	2	Replace unit	Replace unit
8483	Concrete Mast Arm Vertical Member	2	2	Minor repair: clean stains, repair cracks, spall/delamination, and wearing	Minor repair
8483	Concrete Mast Arm Vertical Member	3	1	Major repair: clean stains, repair cracks, spall/delamination, wearing, and exposed rebar	Major repair
8483	Concrete Mast Arm Vertical Member	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8483	Concrete Mast Arm Vertical Member	4	1	Major repair: clean stains, repair cracks, spall/delamination, wearing, and exposed rebar	Major repair
8483	Concrete Mast Arm Vertical Member	4	2	Mitigate settlement or scour	Mitigate settlement or scour
8483	Concrete Mast Arm Vertical Member	4	3	Replace unit	Replace unit
8484	Mast Arm Horizontal Member	2	1	Spot blast	Spot blast
8484	Mast Arm Horizontal Member	2	2	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
8484	Mast Arm Horizontal Member	3	1	Spot blast and major repair of corrosion, cracks, connectors, and distortion	Spot blast and major repair
8484	Mast Arm Horizontal Member	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8484	Mast Arm Horizontal Member	4	1	Spot blast and major repair of corrosion, cracks, connectors, settlement/scour and distortion	Spot blast and major repair
8484	Mast Arm Horizontal Member	4	2	Replace unit	Replace unit
8487	Overlane Sign Structure Horizontal Member	2	1	Spot blast	Spot blast
8487	Overlane Sign Structure Horizontal Member	2	2	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
8487	Overlane Sign Structure Horizontal Member	3	1	Spot blast and major repair of corrosion, cracks, connectors, and distortion	Spot blast and major repair
8487	Overlane Sign Structure Horizontal Member	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8487	Overlane Sign Structure Horizontal Member	4	1	Spot blast and major repair of corrosion, cracks, connectors, settlement/scour and distortion	Spot blast and major repair
8487	Overlane Sign Structure Horizontal Member	4	2	Replace unit	Replace unit
8488	Overlane Sign Structure Vertical Member	2	1	Spot blast	Spot blast
8488	Overlane Sign Structure Vertical Member	2	2	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
8488	Overlane Sign Structure Vertical Member	3	1	Spot blast and major repair of corrosion, cracks, connectors, and distortion	Spot blast and major repair
8488	Overlane Sign Structure Vertical Member	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8488	Overlane Sign Structure Vertical Member	4	1	Spot blast and major repair of corrosion, cracks, connectors, settlement/scour and distortion	Spot blast and major repair
8488	Overlane Sign Structure Vertical Member	4	2	Replace unit	Replace unit
8489	Overlane Sign Structure Foundation	2	1	Spot blast	Spot blast
8489	Overlane Sign Structure Foundation	2	2	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
8489	Overlane Sign Structure Foundation	3	1	Spot blast and major repair of corrosion, cracks, connectors, and distortion	Spot blast and major repair
8489	Overlane Sign Structure Foundation	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8489	Overlane Sign Structure Foundation	4	1	Spot blast and major repair of corrosion, cracks, connectors, settlement and distortion	Spot blast and major repair
8489	Overlane Sign Structure Foundation	4	2	Replace unit	Replace unit
8491	Concrete Overlane Sign Structure Vertical Member	2	2	Minor repair: clean stains, repair cracks, spall/delamination, and wearing	Minor repair
8491	Concrete Overlane Sign Structure Vertical Member	3	1	Major repair: clean stains, repair cracks, spall/delamination, wearing, and exposed rebar	Major repair
8491	Concrete Overlane Sign Structure Vertical Member	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8491	Concrete Overlane Sign Structure Vertical Member	4	1	Major repair: clean stains, repair cracks, spall/delamination, wearing, and exposed rebar	Major repair
8491	Concrete Overlane Sign Structure Vertical Member	4	2	Mitigate settlement or scour	Mitigate settlement or scour
8491	Concrete Overlane Sign Structure Vertical Member	4	3	Replace unit	Replace unit
8496	High Mast Light Poles	2	1	Spot blast	Spot blast
8496	High Mast Light Poles	2	2	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
8496	High Mast Light Poles	3	1	Spot blast and major repair of corrosion, cracks, connectors, and distortion	Spot blast and major repair
8496	High Mast Light Poles	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8496	High Mast Light Poles	4	1	Spot blast, Spot blast and major repair of corrosion, cracks, connectors, settlement/scour and distortion	Spot blast and major repair
8496	High Mast Light Poles	4	2	Replace unit	Replace unit
8499	High Mast Light Pole Foundation	2	1	Spot blast	Spot blast
8499	High Mast Light Pole Foundation	2	2	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair
8499	High Mast Light Pole Foundation	3	1	Spot blast and major repair of corrosion, cracks, connectors, and distortion	Spot blast and major repair
8499	High Mast Light Pole Foundation	3	2	Mitigate settlement or scour	Mitigate settlement or scour
8499	High Mast Light Pole Foundation	4	1	Spot blast and major repair of corrosion, cracks, connectors, settlement and distortion	Spot blast and major repair
8499	High Mast Light Pole Foundation	4	2	Replace unit	Replace unit
8510	Wearing Surfaces	2	2	Minor repair: clean stains, repair cracks, splits/spalls/delaminations, patch area, and	Minor repair

Table 3.10. Complete list of element actions (Cont'd)

New element key	New element name	New state key	New action key	New action long label	New action short label
8510	Wearing Surfaces	3	1	splits/spalls/delaminations, patch area, and potholes	Major repair
8510	Wearing Surfaces	4	1	Major repair: clean stains, repair cracks, splits/spalls/delaminations, patch area, and	Major repair
8510	Wearing Surfaces	4	2	Replace unit	Replace unit
8515	Steel Protective Coating	2	1	Spot blast	Spot blast
8515	Steel Protective Coating	2	2	Polish paint/coating	Polish paint/coating
8515	Steel Protective Coating	3	1	Minor touching of paint/coating	Minor touching of paint/coating
8515	Steel Protective Coating	3	2	Spot blast and reapply partial paint/coating	Spot blast and reapply partial paint/coating
8515	Steel Protective Coating	4	1	Spot blast and reapply partial paint/coating	Spot blast and reapply partial paint/coating
8515	Steel Protective Coating	4	2	Spot blast and reapply full paint/coating	Spot blast and reapply full paint/coating
8516	Paint on Steel	2	1	Spot blast	Spot blast
8516	Paint on Steel	2	2	Polish paint/coating	Polish paint/coating
8516	Paint on Steel	3	1	Minor touching of paint/coating	Minor touching of paint/coating
8516	Paint on Steel	3	2	Spot blast and reapply partial paint/coating	Spot blast and reapply partial paint/coating
8516	Paint on Steel	4	1	Spot blast and reapply partial paint/coating	Spot blast and reapply partial paint/coating
8516	Paint on Steel	4	2	Spot blast and reapply full paint/coating	Spot blast and reapply full paint/coating
8517	Weathering Steel Patina	2	1	Spot blast	Spot blast
8517	Weathering Steel Patina	2	2	Polish paint/coating	Polish paint/coating
8517	Weathering Steel Patina	3	1	Minor touching of paint/coating	Minor touching of paint/coating
8517	Weathering Steel Patina	3	2	Spot blast and reapply partial paint/coating	Spot blast and reapply partial paint/coating
8517	Weathering Steel Patina	4	1	Spot blast and reapply partial paint/coating	Spot blast and reapply partial paint/coating
8517	Weathering Steel Patina	4	2	Spot blast and reapply full paint/coating	Spot blast and reapply full paint/coating
8518	Galvanized or Metalized Steel	2	1	Spot blast	Spot blast
8518	Galvanized or Metalized Steel	2	2	Polish paint/coating	Polish paint/coating
8518	Galvanized or Metalized Steel	3	1	Minor touching of paint/coating	Minor touching of paint/coating
8518	Galvanized or Metalized Steel	3	2	Spot blast and reapply partial paint/coating	Spot blast and reapply partial paint/coating
8518	Galvanized or Metalized Steel	4	1	Spot blast and reapply partial paint/coating	Spot blast and reapply partial paint/coating
8518	Galvanized or Metalized Steel	4	2	Spot blast and reapply full paint/coating	Spot blast and reapply full paint/coating
8519	Other Steel Protective Coatings	2	1	Clean surface	Clean surface
8519	Other Steel Protective Coatings	2	2	Polish paint/coating	Polish paint/coating
8519	Other Steel Protective Coatings	3	1	Minor touching of paint/coating	Minor touching of paint/coating
8519	Other Steel Protective Coatings	3	2	Spot blast and reapply partial paint/coating	Spot blast and reapply partial paint/coating
8519	Other Steel Protective Coatings	4	1	Spot blast and reapply partial paint/coating	Spot blast and reapply partial paint/coating
8519	Other Steel Protective Coatings	4	2	Spot blast and reapply full paint/coating	Spot blast and reapply full paint/coating
8520	Concrete Reinforcing Steel Protective System	2	1	Miscellaneous maintenance	Miscellaneous maintenance
8520	Concrete Reinforcing Steel Protective System	2	2	Minor repair of protective system	Minor repair
8520	Concrete Reinforcing Steel Protective System	3	1	Minor repair of protective system	Minor repair
8520	Concrete Reinforcing Steel Protective System	3	2	Major repair of protective system	Major repair
8520	Concrete Reinforcing Steel Protective System	4	1	Major repair of protective system	Major repair
8520	Concrete Reinforcing Steel Protective System	4	2	Replace protective system	Replace system
8521	Concrete Protective Coating	2	1	Clean surface	Clean surface
8521	Concrete Protective Coating	2	2	Minor touching of coating	Minor touching of coating
8521	Concrete Protective Coating	3	1	Minor touching of coating	Minor touching of coating
8521	Concrete Protective Coating	3	2	Spot blast and reapply partial coating	Spot blast and reapply partial coating
8521	Concrete Protective Coating	4	1	Spot blast and reapply partial coating	Spot blast and reapply partial coating
8521	Concrete Protective Coating	4	2	Spot blast and reapply full coating	Spot blast and reapply full coating
8540	Open Gearing	2	2	Minor repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Minor repair
8540	Open Gearing	3	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8540	Open Gearing	4	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8540	Open Gearing	4	2	Replace unit	Replace unit
8541	Speed Reducers	2	2	Minor repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Minor repair
8541	Speed Reducers	3	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8541	Speed Reducers	4	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8541	Speed Reducers	4	2	Replace unit	Replace unit
8542	Shafts	2	2	Minor repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Minor repair

Table 3.10. Complete list of element actions (Cont'd)

New element key	New element name	New state key	New action key	New action long label	New action short label
8542	Shafts	3	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8542	Shafts	4	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8542	Shafts	4	2	Replace unit	Replace unit
8543	Shaft Bearing/Shaft Couplings	2	2	Minor repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Minor repair
8543	Shaft Bearing/Shaft Couplings	3	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8543	Shaft Bearing/Shaft Couplings	4	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8543	Shaft Bearing/Shaft Couplings	4	2	Replace unit	Replace unit
8544	Brakes	2	2	Minor repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Minor repair
8544	Brakes	3	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8544	Brakes	4	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8544	Brakes	4	2	Replace unit	Replace unit
8545	Emergency Drive and Back Up Power System	2	2	Minor repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Minor repair
8545	Emergency Drive and Back Up Power System	3	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8545	Emergency Drive and Back Up Power System	4	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8545	Emergency Drive and Back Up Power System	4	2	Replace unit	Replace unit
8546	Span Drive Motors	2	2	Minor repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Minor repair
8546	Span Drive Motors	3	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8546	Span Drive Motors	4	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8546	Span Drive Motors	4	2	Replace unit	Replace unit
8547	Hydraulic Power Units	2	2	Minor repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Minor repair
8547	Hydraulic Power Units	3	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8547	Hydraulic Power Units	4	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8547	Hydraulic Power Units	4	2	Replace unit	Replace unit
8548	Hydraulic Piping Systems	2	2	Minor repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Minor repair
8548	Hydraulic Piping Systems	3	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8548	Hydraulic Piping Systems	4	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8548	Hydraulic Piping Systems	4	2	Replace unit	Replace unit
8549	Hydraulic Cylinders/Motors/Rotary Actuators	2	2	Minor repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Minor repair
8549	Hydraulic Cylinders/Motors/Rotary Actuators	3	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8549	Hydraulic Cylinders/Motors/Rotary Actuators	4	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8549	Hydraulic Cylinders/Motors/Rotary Actuators	4	2	Replace unit	Replace unit
8550	Hopkins Frame	2	2	Minor repair: clean, repair corrosion, cracks, and connectors	Minor repair
8550	Hopkins Frame	3	1	Major repair: clean, repair corrosion, cracks, and connectors	Major repair
8550	Hopkins Frame	4	1	Major repair: clean, repair corrosion, cracks, and connectors	Major repair
8550	Hopkins Frame	4	2	Replace unit	Replace unit
8560	Span Locks/Toe Locks/Heel Stops/Tail Locks	2	2	Minor repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Minor repair
8560	Span Locks/Toe Locks/Heel Stops/Tail Locks	3	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8560	Span Locks/Toe Locks/Heel Stops/Tail Locks	4	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8560	Span Locks/Toe Locks/Heel Stops/Tail Locks	4	2	Replace unit	Replace unit
8561	Live Load Shoes/Strike Plates/Buffer Cylinders	2	2	Minor repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Minor repair
8561	Live Load Shoes/Strike Plates/Buffer Cylinders	3	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8561	Live Load Shoes/Strike Plates/Buffer Cylinders	4	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8561	Live Load Shoes/Strike Plates/Buffer Cylinders	4	2	Replace unit	Replace unit
8562	Counterweight Support	2	2	Minor repair: repair corrosion, cracks and connectors	Minor repair & add a protective system
8562	Counterweight Support	3	1	Major repair: repair corrosion, cracks and connectors	Major repair

Table 3.10. Complete list of element actions (Cont'd)

New element key	New element name	New state key	New action key	New action long label	New action short label
8562	Counterweight Support	4	1	Major repair: repair corrosion, cracks and connectors	Major repair
8562	Counterweight Support	4	2	Replace unit	Replace unit
8563	Access Ladder & Platforms	2	2	Minor repair: repair corrosion, cracks and connectors	Minor repair
8563	Access Ladder & Platforms	3	1	Major repair: repair corrosion, cracks and connectors	Major repair
8563	Access Ladder & Platforms	4	1	Major repair: repair corrosion, cracks and connectors	Major repair
8563	Access Ladder & Platforms	4	2	Replace unit	Replace unit
8564	Counterweight	2	2	Minor repair: clean stains, repair cracks, spall/delamination/patch, and exposed rebar	Minor repair
8564	Counterweight	3	1	Major repair: clean stains, repair cracks, spall/delamination/patch, and exposed rebar	Major repair
8564	Counterweight	4	1	Major repair: clean stains, repair cracks, spall/delamination/patch, and exposed rebar	Major repair
8564	Counterweight	4	2	Replace unit	Replace unit
8565	Trunnion/Straight and Curved Track	2	2	Minor repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Minor repair
8565	Trunnion/Straight and Curved Track	3	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8565	Trunnion/Straight and Curved Track	4	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8565	Trunnion/Straight and Curved Track	4	2	Replace unit	Replace unit
8570	Transformers & Thyristors	2	2	Minor repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Minor repair
8570	Transformers & Thyristors	3	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8570	Transformers & Thyristors	4	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8570	Transformers & Thyristors	4	2	Replace unit	Replace unit
8571	Submarine Cable	2	2	Minor repair: outer coating and cable	Minor repair
8571	Submarine Cable	3	1	Major repair: outer coating and cable	Major repair
8571	Submarine Cable	4	1	Major repair: outer coating and cable	Major repair
8571	Submarine Cable	4	2	Replace unit	Replace unit
8572	Conduit & Junction Boxes (Movable bridge control system)	2	2	Minor repair: repair corrosion and connectors	Minor repair
8572	Conduit & Junction Boxes (Movable bridge control system)	3	1	Major repair: repair corrosion and connectors	Major repair
8572	Conduit & Junction Boxes (Movable bridge control system)	4	1	Major repair: repair corrosion and connectors	Major repair
8572	Conduit & Junction Boxes (Movable bridge control system)	4	2	Replace unit	Replace unit
8573	Programmable Logic Controllers	2	2	Minor repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Minor repair
8573	Programmable Logic Controllers	3	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8573	Programmable Logic Controllers	4	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8573	Programmable Logic Controllers	4	2	Replace unit	Replace unit
8574	Control Console	2	2	Minor repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Minor repair
8574	Control Console	3	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8574	Control Console	4	1	Major repair: lubrication, repair misalignment, corrosion, clearance problem, and wear/abrasion	Major repair
8574	Control Console	4	2	Replace unit	Replace unit
8580	Navigational Light System (Misc. substructure elements)	2	2	Minor repair for operation and paint	Minor repair
8580	Navigational Light System (Misc. substructure elements)	3	1	Minor repair for operation and paint	Minor repair
8580	Navigational Light System (Misc. substructure elements)	3	2	Major repair for operation and paint	Major repair
8580	Navigational Light System (Misc. substructure elements)	4	1	Major repair for operation and paint	Major repair
8580	Navigational Light System (Misc. substructure elements)	4	2	Replace unit	Replace unit
8581	Operator Facilities	2	2	Minor repair for operation and paint	Minor repair
8581	Operator Facilities	3	1	Minor repair for operation and paint	Minor repair
8581	Operator Facilities	3	2	Major repair for operation and paint	Major repair
8581	Operator Facilities	4	1	Major repair for operation and paint	Major repair
8581	Operator Facilities	4	2	Replace unit	Replace unit
8582	Lift Bridge Specific Equipment	2	2	Minor repair for operation and paint	Minor repair
8582	Lift Bridge Specific Equipment	3	1	Minor repair for operation and paint	Minor repair
8582	Lift Bridge Specific Equipment	3	2	Major repair for operation and paint	Major repair
8582	Lift Bridge Specific Equipment	4	1	Major repair for operation and paint	Major repair
8582	Lift Bridge Specific Equipment	4	2	Replace unit	Replace unit
8583	Swing Bridge Specific Equipment	2	2	Minor repair for operation and paint	Minor repair
8583	Swing Bridge Specific Equipment	3	1	Minor repair for operation and paint	Minor repair
8583	Swing Bridge Specific Equipment	3	2	Major repair for operation and paint	Major repair

Table 3.10. Complete list of element actions (Cont'd)

New element key	New element name	New state key	New action key	New action long label	New action short label
8583	Swing Bridge Specific Equipment	4	1	Major repair for operation and paint	Major repair
8583	Swing Bridge Specific Equipment	4	2	Replace unit	Replace unit
8590	Resistance Gates	2	2	Minor repair for operation and paint	Minor repair
8590	Resistance Gates	3	1	Minor repair for operation and paint	Minor repair
8590	Resistance Gates	3	2	Major repair for operation and paint	Major repair
8590	Resistance Gates	4	1	Major repair for operation and paint	Major repair
8590	Resistance Gates	4	2	Replace unit	Replace unit
8591	Warning Gates	2	2	Minor repair for operation and paint	Minor repair
8591	Warning Gates	3	1	Minor repair for operation and paint	Minor repair
8591	Warning Gates	3	2	Major repair for operation and paint	Major repair
8591	Warning Gates	4	1	Major repair for operation and paint	Major repair
8591	Warning Gates	4	2	Replace unit	Replace unit
8592	Traffic Signals	2	2	Minor repair for operation and paint	Minor repair
8592	Traffic Signals	3	1	Minor repair for operation and paint	Minor repair
8592	Traffic Signals	3	2	Major repair for operation and paint	Major repair
8592	Traffic Signals	4	1	Major repair for operation and paint	Major repair
8592	Traffic Signals	4	2	Replace unit	Replace unit
9207	Prestressed Concrete Hollow Core Pile	2	2	Minor repair: clean stains, and repair spalled/delamination	Minor repair
9207	Prestressed Concrete Hollow Core Pile	3	1	Major repair: clean stains, repair spalled/delamination, and exposed rebar/prestressing strands	Major repair
9207	Prestressed Concrete Hollow Core Pile	3	2	Mitigate settlement or scour	Mitigate settlement or scour
9207	Prestressed Concrete Hollow Core Pile	4	1	Major repair: clean stains, repair spalled/delamination, exposed rebar/prestressing strands	Major repair
9207	Prestressed Concrete Hollow Core Pile	4	2	Mitigate settlement or scour	Mitigate settlement or scour
9207	Prestressed Concrete Hollow Core Pile	4	3	Replace unit	Replace unit

3.2 Flex Actions

In order to run models in Pontis or BMS, a single action can be defined and mapped to a set of specific actions taken on bridge elements at various element/state/action definitions. These are called Flex Actions. For instance, a flex action for preservation models is defined as a list of maintenance, repair, or rehabilitation (MRR) actions such as those described above in Tables 3.5 to 3.9. As shown in Table 3.11, a flex action "Deck-Clean" is applicable to "Surface clean" actions on the deck and slab elements while for superstructure elements, the Flex Action "Super-Minor repair" covers minor repair actions, including spot blast and cleaning, on many elements such as beams, girders, floor beams, etc. Also the Flex Action "Joint-Minor repair" will be applicable to all the types of joints in the bridge inventory.

3.3 Conclusions

This task described in this section involved the revision of preservation actions for use in the new BMS software for the Florida BMS. Based on the FDOT Bridge Inspection Guide, the research team utilized descriptions of bridge elements, their condition states and various levels and extents of defects, to formulate a set of appropriate feasible preservation actions. An initial list was developed and submitted to the FDOT State Maintenance Office. After a review by FDOT and suggested corrections, the list was revised and finalized for use.

Table 3.11. Sample list of flex actions

Bridge component/category	Flex Action Long	Flex Action Short
Deck/slab	Surface clean	Deck-Clean
	Miscellaneous Maintenance	Deck-Misc maint
	Minor repair (incl. clean)	Deck-Minor repair
	Major repair	Deck-Major repair
	Major rehab	Deck-Major rehab
	Deck-Overlay	Deck-Overlay
	Deck-Repair wearing surface	Deck-Repair wearing surface
	Replace unit/deck/slab	Deck-Replace
Superstructure	Spot blast	Super-Spot blast
	Miscellaneous Maintenance	Super-Misc maint
	Add a protective system	Super-Protect
	Minor repair (incl. spot blast, clean)	Super-Minor repair
	Major repair (incl. clean or add prot system)	Super-Major repair
	Replace unit	Replace
Joints	Clean	Joint-Clean
	Miscellaneous Maintenance	Joint-Misc maint
	Minor repair (incl. clean)	Joint-Minor repair
	Major repair	Joint-Major repair
	Replace joint	Joint-Replace
Bearings	Clean	Bearing-Clean
	Lubricate	Bearing-Lubricate
	Reset	Bearing-Reset
	Replace	Bearing-Replace
Bridge	Paint general	Bridge-Paint general
	Spot blast	Bridge-Spot blast
	Spot blast and paint	Bridge-Spot blast and paint
	Repair steel general	Bridge-Repair steel general
	Repair steel distortion with heat strengthening	Bridge-Repair steel distortion
	Patch spall/delamination on concrete	Bridge-patch spall/delamination
	Spot blast rebar/prestressing strand on concrete	Bridge-spot blast rebar/prestressing strand
	Seal crack on concrete	Bridge-seal crack
	Place riprap	Bridge-place riprap
	Minor rehab	Bridge-minor rehab
	Major rehab	Bridge-major rehab

4. Deterioration model migration

In order to assist agencies in making the transition to the new element inspection process, AASHTO developed a software program called the Visual Element Migrator. The Migrator operates on a database of CoRe Element inspections from Pontis, and attempts to convert them into a form compatible with the 2013 Element Manual for use in future versions of Pontis, which are re-branded as AASHTOWare Bridge Management (BMS). Using the Migrator software, an engineer can design a script to specify how new elements are to be created, based on old elements and other characteristics of each bridge. The Migrator also attempts to translate CoRe Element condition states so they are compatible with the new manual.

The migration process is necessarily inexact because the Pontis database does not contain enough information to identify the new elements and condition states precisely. Analysis of the preliminary Migrator output for Florida bridges showed that the program was not able to identify 27% of the new element types defined in the 2014 FDOT manual and was not able to populate 43% of the condition states. This was after FDOT engineers had made an initial attempt to customize the script to incorporate the FDOT agency-defined elements.

As an example of elements that were not identified, the Migrator was unable to determine whether a bridge deck was reinforced concrete or prestressed, nor whether it consisted of the top flange of girders or was a separate slab component. As an example of unidentified condition states, the migrator had no basis for populating four condition states of expansion joints when only three states are provided in the Pontis data. These are not necessarily shortcomings of the migrator software, but are merely a consequence of the fact that the new inspection process is somewhat more detailed than the old one.

When an element's condition states are redefined, or the number of states is changed, there is, in principle, a probabilistic relationship between the old states and the new ones. For example, if a large group of expansion joints are inspected under both the old and new systems, all four of the new condition states will be populated even though only three states existed under the old system. The AASHTO Migrator program is a deterministic simplification of this transition. However, for the deterioration models, it is necessary to approximate more closely the actual correspondence between old and new since the deterioration models must produce realistic transitions of real inspection data gathered under the new definitions.

4.1 Overview of approach

One way this correspondence could be modeled would be a statistical analysis comparing inspection results of the same set of bridges, performed at the same time, under both systems of elements. This would require a dual inspection, recording two sets of results under different standards for the same observations. Another similar and somewhat more practical approach is to apply the existing deterioration model to a set of recent CoRe Element inspections and compare the result to actual element inspections, two years later, under the new system. Unfortunately for the present study, neither type of data set is available at this time.

The selected approach is based on expert judgment, informed by the substantive definitions of elements and condition states in the old and new manuals. The input and output of the Migrator program were summarized to assist in this process.

To make the application of judgment feasible and consistent, a common denominator was developed to aggregate both manuals into a set of element groups, based on the same element groupings used in earlier FDOT research to develop deterioration models (Sobanjo and Thompson, 2011). The elements within each group have the same number of condition states with the same or very similar definitions and are expected to deteriorate at similar rates.

Using expert judgment, a migration probability matrix was developed for each element group, to relate the 3-5 condition states of the CoRe Elements to the uniform 4 condition states of the new AASHTO manual. This was based primarily on interpretation of the definitions in the FDOT manuals, with assistance from the Migrator data. The Migrator data is assumed to incorporate the previous judgments of the developers of the program and the FDOT engineers who customized it. FDOT provided a summary of the rationale it intended when configuring the Migrator program.

The migration probability matrix was multiplied by the vector of deterioration transition times developed for each element group in the earlier research. This process allocated segments of the lifespan of each element, previously associated with the old CoRe Element definitions, to the new condition states for future use. The result was that all four condition states of each element group were given reasonable estimates of their transition times.

In addition to its use for deterioration modeling, the migration probability matrix will also be useful in future tasks for migrating the action effectiveness and cost models.

4.2. Data preparation

FDOT prepared a test database for AASHTOWare Bridge Management in February 2015 using the then-current version of the software and Migrator. The entire database, except District 1, was covered in the test. FDOT provided a summary of customizations they had made, or intended to make, to the Migrator scripts, and indicated that the software was not yet able to perform all the conversions they needed. However, the result was sufficient for the purposes of this task.

4.2.1 Raw data

Selected tables from the database were provided to the researcher in the form of Microsoft Excel worksheets for analysis. These tables may be summarized as follows:

ELEMDEFS – Element definitions under the 2008 FDOT manual. The table contains 177 element definitions as used in Pontis, which have been the basis of all inspections up to this point. Ten of the element definitions are smart flags, which do not have deterioration models and are not carried over to the 2014 Manual. So a net 167 element definitions participated in the analysis.

PON_ELEMDEFS – Element definitions under the 2014 FDOT manual, containing 225 records. Of these, 47 records are “defects,” a type of element which is recorded only under specific circumstances and does not participate in the deterioration model. An additional 9 records were inserted for temporary purposes and are not mentioned in the 2014 FDOT manual, so they were excluded. There is also one roll-up element (515 – Steel protective coating) that is not meant to be recorded in the field, but is meant to gather aggregated data from four sub-elements representing different types of coating systems, for reporting. So a net 168 element definitions participated in the analysis.

INSPEVNT – This table has one record for each visit by an inspection team to each bridge. The entire table, containing 175,891 records going back to 1998, was provided by FDOT. For the present analysis only the most recent inspection on each bridge was needed, leaving 35,489 records.

ELEMINSP – FDOT provided a table of the 193,187 element inspection records associated with the most recent inspections on 33,397 bridges. These were the element data recorded by inspectors in the field.

PON_ELEMINSP – FDOT provided a table of 131,004 element inspection records generated by the Migrator program. Of these, 92,001 records were associated with the most recent inspection of 13,729 bridges that also

had ELEMINSP records. In the AASHTOWare Bridge Management database, the migrated element inspection records in PON_ELEMINSP are associated with the same INSPEVNT records as the original ELEMINSP records, making it reasonably straight-forward to match them. The 21,760 structures which had ELEMINSP records but did not have PON_ELEMINSP records were either in district 1, or failed to migrate for some other reason.

Although the number of element definitions is nearly unchanged between the 2008 and 2014 manuals, there are significant differences. In addition to the differing classification of bridge decks noted earlier, there is the separation of wearing surfaces, coatings, and cathodic protection from substrate elements, and the addition of more prestressed, masonry, and "other material" elements. It should also be noted that only 151 elements were assigned deterioration models in the 2011 deterioration research. The other elements either did not occur in the FDOT inventory, or had only recently been inspected for the first time (e.g., traffic signal mast arms).

4.2.2 Element groups

In the deterioration modeling research reported in Sobanjo and Thompson (2011), the 151 element definitions covered by the research were associated with 69 groups. The elements within each group have the same number of condition states with the same or very similar definitions, and are expected to deteriorate at similar rates. They also had sufficient populations to assure that a statistically valid deterioration model could be generated. Relatively uncommon elements, such as cables, were grouped with more common elements, such as steel girders, to assure a sufficient population.

This same grouping was equally useful for the present research, since it assured that the migration of the deterioration model would be reasonably concise and consistent. Each of the 168 new element definitions was assigned to the same element groups developed in the earlier study. The result at the element level is shown in Table 4.1, and the group level is shown in Table 4.2.

Some of the groups were defined by the existence of protective systems. For example, there was a group for uncoated metal railings (4 condition states) and a separate group for coated metal railings (5 states). As a result, some of the groups did not have any corresponding elements in the new definitions. In general the choice of group was based on interpretation of condition state definitions and examination of the deterioration model, to determine which one would be most applicable based on professional judgment.

Some of the new element definitions, such as mast arms, were not addressed in the 2011 research. These were handled by assigning them to the group whose deterioration model was judged to be most applicable. Protective system elements were associated with new groups of their own, but inherited deterioration models from the old CoRe elements which were judged to be most applicable:

- Deck wearing surfaces were based on a weighted average of concrete decks and concrete slabs, considering that both groups were influenced by the condition of asphalt concrete wearing surfaces.
- Paint on steel and stain on concrete were based on the model for painted steel girders and floor beams.
- Weathering steel patina was based on the model for unpainted steel superstructures and substructures.
- Galvanized and metallized coatings were based on the model for metal culverts.
- Reinforcing steel protective systems (such as cathodic protection) were based on the model for pile jackets with cathodic protection.

4.2.3 Analysis of Migrator results

In addition to the group assignment, Tables 4-1 and 4-2 report the results of the Migration program for each element. It can be seen that 46 of the 168 defined elements (27%) were not produced by any migrator rules. For the individual condition states, 288 of the possible 672 states (43%) were not populated. This is important

because the methods for developing deterioration models from inspection data require that every condition state have a non-zero quantity. Both the linear regression and one-step methods fail if this is not the case (Sobanjo and Thompson, 2011). Only 52 elements (31%) satisfied this criterion.

Clearly, therefore, the Migrator output is not currently suitable for deterioration modeling. This is only a preliminary conclusion, because FDOT has requested improvements in the Migrator program which may enable more complete coverage of the new elements in the future.

4.3. Analysis and results

The remaining analysis work was performed at the level of element groups as in Table 4.2.

4.3.1 Migration probability matrix

It was necessary to find a way to adapt the earlier deterioration model, based on CoRe elements having 3 to 5 condition states, to new elements having a uniform 4 condition states with often different and always more detailed definitions. In the absence of a statistical basis to do this, it was decided to use an expert judgment based process. The first step was to develop a transition probability matrix from CoRe element states to new condition states, based on interpretation of the differences between the old and new definitions.

If the migration probability matrix is well formed, the process should guarantee that all condition states are populated if element inspection data were to be generated using the matrix. However, it is emphasized that the purpose is only to migrate deterioration, action effectiveness, and cost models, not element inspection data.

Table 4.3 reports the migration probability matrix. The four major sets of columns are the four new condition states defined for each new AASHTO element. Within each set are five columns, representing the up to five condition states of old CoRe elements. Some of the element groups have fewer than five old states, in which case any excess states show 100% probability of transition to new state 4. If the definition of a new condition state is found equivalent to a corresponding old state, then a 100% transition probability is shown. Otherwise, a probability of less than 100% is assigned, and the remainder is assigned to one or more other condition states. The sum of each row is 500%, indicating that all five possible CoRe condition states are fully assigned to new states. The footnotes in the table describe in detail the rationale for each decision.

Seventeen of the element groups, representing just 20% of the element inspections, were able to migrate directly across from the old to new definitions without adjustment. In most other cases the definitions did not exactly match. Examples of common issues were:

- The CoRe elements with 5 states which needed to be merged to four.
- The CoRe elements with 3 states which needed to be divided into four.
- Differences in whether structural review is warranted in the worst condition state.
- Differences in whether reinforcing steel is exposed in the second condition state.

Bridge decks were most difficult to interpret since the old definitions are largely based on extent of distress, while the new elements are based on severity.

4.3.2 Transition times and shaping parameters

A way to use the migration probability matrix to estimate a new deterioration model, is to assume that the allocation of transition times among condition states is roughly proportional to the allocation of element quantities. This is not the same thing as saying condition is uniform with age. It says rather than if a change in condition state definitions causes 10% of an element quantity to be reclassified into the next condition state,

that it is reasonable to reclassify 10% of the transition time also. There isn't an easy way to prove or disprove this assumption, without repeating a full-scale study as was done in 2011. It makes intuitive sense, however.

Accepting this assumption, new transition times were computed by multiplying the old vector of transition times (from the 2011 research) by the migration probability matrix. The old and new transition times thus computed are reported in Table 4.4.

There were six element groups where this matrix multiplication resulted in a transition time of zero from state 3 to state 4. When this occurred, the transition time from state 2 to state 3 was arbitrarily divided, with half reassigned to the 3-4 transition. In most cases this occurred with three CoRe element condition states when the model didn't provide clear guidance on the division of old state 3 into new states 3 and 4.

For use in the revised PLAT model, the transition times for unprotected steel elements were further transformed by dividing by the paint protection modifier factors of 1.52 for state 1, 1.35 for state 2, and 1.17 for state 3. The PLAT Element Definitions worksheet also permits additional adjustments based on experience with the use of PLAT. Thus, the latest PLAT template should be consulted for the most up-to-date version of these transition times.

None of the definitional changes had any identifiable impact on the value of the shaping parameter used in the Weibull model for transitions from state 1 to state 2. Lacking a clear reason to change these values, it is recommended that they stay the same as in the 2011 research.

4.3.3 Environment factors

The 2010 FDOT research on deterioration found the following environmental factors:

Low 0.96
Moderate 1.13
Severe 0.93

Because of the new protective system elements there may be changes in the future in how inspectors use the environmental classes, perhaps placing less emphasis on the protective systems and more on marine environment and operational factors. Nonetheless, the environmental factors will likely remain close together. A judgment was made to keep the Severe environment at 0.93 but use the 1.13 factor for Low environment rather than moderate. Moderate was set at the intermediate level of 1.03. This decision can be revisited once field inspection data are obtained under the new inspection process.

4.4 Conclusions

The new transition times in Table 4.4 can be expanded using the correspondences given in Table 4.1 to yield a deterioration model for every element in the 2014 FDOT Manual. The result can be imported directly into the new PON_MOD_DETER table in AASHTOWare Bridge Management once it is ready. An Excel file containing this information was delivered in Task 4 of the study.

The biggest shortcoming with the new models is the fact that the migration probability matrix had to be developed from judgment. Once FDOT completes a year or two of inspections under the new manual, a better approach will be possible. The most recent CoRe element inspection on each bridge can be projected forward two years using the CoRe element deterioration model. Then a migration probability matrix can be computed by comparing the new inspections against the projected estimates, using an algebraic method similar to the one-step method (Sobanjo and Thompson, 2011). In the longer term, after two complete cycles of inspections are completed under the new manual, a new set of deterioration models can be developed as was done in the 2011 study.

Table 4.1. Grouping of new element definitions
See Table 4.2 for the names of the groups.

Element number and name		Group	Count and quantity of element inspections migrated				
				Quantity by condition state			
			Count	State 1	State 2	State 3	State 4
12	Re Concrete Deck	A1	3324	8694680	257696	371	0
13	Pre Concrete Deck	A1	0	0	0	0	0
15	Pre Concrete Top Flange	A1	0	0	0	0	0
16	Re Conc Top Flange	A1	0	0	0	0	0
28	Steel Deck - Open Grid	A4	126	7344	18415	1407	0
29	Steel Deck - Conc Fill Grid	A4	71	7503	6629	469	0
30	Steel Deck - Orthotropic	A4	32	6763	3492	0	0
31	Timber Deck	A5	329	9698	20041	1957	0
38	Re Concrete Slab	A2	1009	584802	20618	0	0
54	Timber Slab	A5	7	334	483	0	0
60	Other Deck	A1	0	0	0	0	0
65	Other Slab	A2	0	0	0	0	0
102	Steel Clsd Box Gird	D2	114	36385	12796	249	1
104	Pre Clsd Box Girder	D6	101	62439	11442	476	0
105	Re Clsd Box Girder	D7	5	142	1305	0	0
106	Othr Clsd Web/Box Girder	D1	0	0	0	0	0
107	Steel Opn Girder/Beam	D2	629	253512	120078	7041	143
109	Pre Opn Conc Girder/Beam	D6	2505	3119874	60194	3674	1052
110	Re Conc Opn Girder/Beam	D7	228	67113	12288	3789	312
111	Timber Open Girder	D8	368	80471	12040	508	76
112	Other Open Girder/Beam	D1	0	0	0	0	0
113	Steel Stringer	D3	106	48316	7227	3325	917
115	Pre Conc Stringer	D6	0	0	0	0	0
116	Re Conc Stringer	D7	0	0	0	0	0
117	Timber Stringer	D8	3	439	0	0	0
118	Other Stringer	D1	0	0	0	0	0
120	Steel Tuss	D5	70	9597	4346	388	0
135	Timber Truss	D8	0	0	0	0	0
136	Other Truss	D1	0	0	0	0	0
141	Stl Arch	D5	1	0	291	61	0
142	Other Arch	D1	0	0	0	0	0
143	Pre Conc Arch	D6	0	0	0	0	0
144	Re Conc Arch	D7	24	331	334	56	0
145	Masonry Arch	D7	0	0	0	0	0
146	Timber Arch	D8	0	0	0	0	0
147	Stl Main Cables	D2	6	534	117	0	0
148	Sec Steel Cables	D2	0	0	0	0	0
149	Otr Secondary Cable	D1	0	0	0	0	0
152	Steel Floor Beam	D2	175	17781	9721	1031	13
154	Prestress Floor Beam	D6	1	4106	0	0	0
155	Re Conc Floor Beam	D7	6	1317	29	4	0
156	Timber Floor Beam	D8	0	0	0	0	0
157	Other Floor Beam	D1	0	0	0	0	0
161	Stl Pin Pin/Han both	D2	4	8	50	6	0
162	Stl Gus Plate	D2	0	0	0	0	0
202	Steel Column	F1	0	0	0	0	0
203	Other Column	F3	0	0	0	0	0
204	Pre Conc Column	F2	0	0	0	0	0
205	Re Conc Column	F3	0	0	0	0	0
206	Tim Col or Pile Ext	F8	0	0	0	0	0
207	Stl Tower	F1	0	0	0	0	0
208	Timber Trestle	F8	0	0	0	0	0
210	Re Conc Pier Wall	F3	289	11022	1221	609	5
211	Other Pier Wall	F3	0	0	0	0	0
212	Timber Pier Wall	F8	0	0	0	0	0
213	Masonry Pier Wall	F3	0	0	0	0	0
215	Re Conc Abutment	F5	4613	152386	4071	1066	4
216	Timber Abutment	F8	458	3925	1740	126	26

Table 4.1. Grouping of new element definitions (cont'd)

Element number and name		Group	Count and quantity of element inspections migrated				
			Count	Quantity by condition state			
				State 1	State 2	State 3	State 4
217	Masonry Abutment	F5	0	0	0	0	0
218	Other Abutments	F5	32	312	184	33	0
219	Stl Abutment	F1	0	0	0	0	0
220	Re Conc Pile Cap/Ftg	F7	402	3157	2487	881	2
225	Steel Pile	F1	309	4433	2244	797	376
226	Pre Conc Pile	F2	2002	61866	23021	7656	348
227	Re Conc Pile	F3	2049	28888	5973	3769	120
228	Timber Pile	F8	588	8487	3733	617	140
229	Other Pile	F3	0	0	0	0	0
231	Steel Pier Cap	F1	112	3083	1002	83	5
233	Pre Conc Pier Cap	F2	26	3541	17	4	3
234	Re Conc Pier Cap	F6	3977	370991	18021	2729	68
235	Timber Pier Cap	F8	443	7606	1744	157	46
236	Other Pier Cap	F6	0	0	0	0	0
240	Steel Culvert	G2	135	2025	2676	1114	120
241	Re Conc Culvert	G1	1490	50299	68082	17490	388
242	Timber Culvert	G2	0	0	0	0	0
243	Other Culvert	G2	0	0	0	0	0
244	Masonry Culvert	G1	4	88	70	0	0
245	Pre Concrete Culvert	G1	0	0	0	0	0
300	Strip Seal Exp Joint	B1	403	11761	10519	0	378
301	Pourable Joint Seal	B2	3646	171391	60750	0	24740
302	Compressn Joint Seal	B3	678	11006	28203	0	9448
303	Assem Jnt With Seal	B4	173	6454	1715	0	418
304	Open Expansion Joint	B5	210	14265	4087	0	270
305	Assem Jnt Wthut Seal	B5	0	0	0	0	0
306	Other Joint	B6	76	2605	700	293	0
310	Elastomeric Bearing	E1	2761	206064	30853	0	276
311	Moveable Bearing	E2	669	18662	6800	0	1461
312	Enclosed Bearing	E2	2	64	0	0	0
313	Fixed Bearing	E2	654	16175	6216	0	608
314	Pot Bearing	E2	166	2199	780	0	9
315	Disk Bearing	E2	5	50	8	0	0
316	Other Bearing	E2	0	0	0	0	0
320	Pre Conc Appr Slab	A6	3	140	46	93	0
321	Re Conc Approach Slab	A6	4231	807968	171461	23806	1182
330	Metal Bridge Railing	C2	800	82639	6032	114	15
331	Re Conc Bridge Railing	C3	3937	1101503	61180	1552	65
332	Timb Bridge Railing	C4	107	2916	1571	0	73
333	Other Bridge Railing	C5	1310	222234	13699	0	1838
334	Masry Bdge Rling	C3	0	0	0	0	0
510	Wearing Surfaces	P1	1070	416352	10264	0	0
520	Conc Re Prot Sys	P5	87	14406	0	0	0
521	Conc Prot Coating	P2	0	0	0	0	0
8097	PS/RC Hybrid Slab	A3	0	0	0	0	0
8098	Conc Deck on PC Pane	A2	146	115042	273595	0	0
8099	Sonovoid	A3	447	144490	185667	1246	0
8199	Duct	D6	0	0	0	0	0
8207	Hollow Core Pile	F2	51	14969	6105	105	0
8290	Channel	H1	4937	2208	2190	525	19
8298	Pile Jacket Bare	I1	461	4721	3799	1654	268
8386	Steel Fender/Dolphin System	I3	15	655	506	335	223
8387	Prestressed Conc Fender/Dolphin	I3	139	12698	1763	1139	34
8388	RC Conc Fender Dolphin System	I3	1	3	0	0	0
8389	Timber Fender/Dolphin System	I3	50	1160	1000	1239	208
8390	Other Fender/Dolphin System	I3	10	768	94	0	0
8393	Other Material Bulkhead/Seawall	I3	143	5304	1658	2940	249
8394	RC Conc Abutment Slope Prot	I4	1580	956262	34816	5135	160
8395	Timber Abutment Slope Protection	I5	377	5196	1524	250	8
8396	Other Abutment Slope Protection	I6	2571	1012956	155818	9726	4113
8397	Metal Drainage System	I7	53	157	46	25	44
8398	Other Material Drainage System	I7	237	864	267	121	99

Table 4.1. Grouping of new element definitions (cont'd)

			Count and quantity of element inspections migrated				
				Quantity by condition state			
Element number and name		Group	Count	State 1	State 2	State 3	State 4
8474	Wingwall/Retaining Wall Metal Uncoated	J1	167	2587	1744	1798	85
8475	R/Conc Walls	J2	5106	118003	13676	4784	113
8476	Wingwall/Retaining Wall Timber	J3	467	4808	1336	892	309
8477	Wingwall/Retaining Wall Other Material	J4	156	2941	1506	437	63
8478	Mechanically Stabilized Earth Wall	J5	670	52762	1921	260	9
8480	Mast arm foundation	K1	1449	3512	819	12	2
8481	Vertical mast arm member - metal	K1	1052	1500	1496	32	12
8483	Vertical mast arm member - Concrete	K1	5	9	1	0	0
8484	Horizontal mast arm member - metal	K1	590	950	1135	39	3
8487	Overlane Sign Struct Horiz Member Metal	K1	2541	38227	6683	17	2
8488	Overlane Sign Struct Vert Member Metal	K1	1316	14811	1383	18	0
8489	Overlane Sign Structure Foundation	K1	3695	3766	926	39	3
8491	RC Overlane Sign Vertical	K1	0	0	0	0	0
8496	High Mast Light Poles Metal Coated	K1	1049	756	276	11	6
8499	High Mast Light Pole Foundations	K1	1671	1335	301	32	3
8516	Painted Steel	P2	7832	947006	0	0	0
8517	Weathering Steel	P3	434	87490	0	0	0
8518	Galvanized Steel	P4	2041	189358	0	0	0
8519	Other Steel Coating	P4	0	0	0	0	0
8540	Open Gearing	L1	57	151	190	6	0
8541	Speed Reducers	L1	50	114	39	1	0
8542	Shafts	L1	57	445	53	0	0
8543	Shaft Bearings and Shaft Couplings	L1	57	856	217	8	0
8544	Brakes	L2	54	201	32	17	0
8545	Emergency Drive and Back Up Power System	L3	62	62	20	5	1
8546	Span Drive Motors	L3	45	127	8	2	0
8547	Hydraulic Power Units	L4	32	33	35	2	0
8548	Hydraulic Piping System	L5	32	43	20	2	0
8549	Hydraulic Cylinders/Motors/Rotary Actuators	L4	27	120	18	14	4
8550	Hopkins Frame	L6	12	14	6	3	0
8560	Span Locks/Toe Locks/Heel Stops/Tail Locks	L7	70	25	105	27	2
8561	Live Load Shoes/Strike Plates/Buffer Cylinders	L8	71	162	145	1	0
8562	Counterweight Support	L6	72	172	58	30	0
8563	Access Ladder & Platforms	L6	162	1236	174	67	2
8564	Counterweight	L9	73	103	23	16	0
8565	Trunnion/Straight and Curved Track	L9	70	165	109	14	0
8570	Transformers & Thyristors	M1	57	108	1	0	0
8571	Submarine Cable	M2	65	212	11	2	0
8572	Conduit & Junction Boxes	L5	161	145	49	12	0
8573	Programmable Logic Controllers	M1	43	41	6	3	0
8574	Control Console	M3	63	50	13	6	0
8580	Navigational Light System	M4	253	296	56	11	0
8581	Operator Facilities	M5	60	56	5	2	0
8582	Lift Bridge Specific Equipment	M6	8	0	7	1	0
8583	Swing Bridge Specific Equipment	M6	3	1	2	0	0
8590	Resistance Barriers	M7	15	20	7	0	0
8591	Warning Gates	M7	70	162	91	0	0
8592	Traffic Signal	M8	70	134	10	1	0

Table 4.2. Element groups and migrated conditions

	Count and percent by state of element inspections migrated				
		Percent by condition state			
Element group	Count	State 1	State 2	State 3	State 4
A1- Concrete deck	3324	97.12	2.88	0.00	0.00
A2- Concrete slab	1155	70.40	29.60	0.00	0.00
A3- Prestressed concrete slab	447	43.60	56.02	0.38	0.00
A4- Steel deck	229	41.54	54.85	3.60	0.00
A5- Timber deck/slab	336	30.86	63.12	6.02	0.00
A6- Approach slabs	4234	80.43	17.07	2.38	0.12
B1- Strip Seal expansion joint	403	51.91	46.43	0.00	1.67
B2- Pourable joint seal	3646	66.72	23.65	0.00	9.63
B3- Compression joint seal	678	22.62	57.96	0.00	19.42
B4- Assembly joint/seal	173	75.16	19.97	0.00	4.87
B5- Open expansion joint	210	76.60	21.95	0.00	1.45
B6- Other expansion joint	76	72.40	19.46	8.13	0.00
C1- Uncoated metal rail	0				
C2- Coated metal rail	800	93.06	6.79	0.13	0.02
C3- Reinforced concrete railing	3937	94.61	5.25	0.13	0.01
C4- Timber railing	107	63.94	34.45	0.00	1.61
C5- Other railing	1310	93.47	5.76	0.00	0.77
D1- Unpainted steel super/substructure	0				
D2- Painted girder/floorbeam/cable/p&h	928	67.08	31.07	1.81	0.03
D3- Painted steel stringer	106	80.82	12.09	5.56	1.53
D4- Painted steel truss bottom	0				
D5- Painted steel truss/arch top	71	65.36	31.58	3.06	0.00
D6- Prestressed concrete superstr	2607	97.65	2.20	0.13	0.03
D7- Reinforced concrete superstructure	263	79.18	16.04	4.42	0.36
D8- Timber superstructure	371	86.50	12.87	0.54	0.08
E1- Elastomeric bearings	2761	86.88	13.01	0.00	0.12
E2- Metal bearings	1496	70.05	26.03	0.00	3.92
F1- Painted steel substructure	421	62.52	27.00	7.32	3.17
F2- Prestressed column/pile/cap	2079	68.33	24.77	6.60	0.30
F3- Reinforced concrete column/pile	2338	77.33	13.94	8.48	0.24
F5- Reinforced concrete abutment	4645	96.61	2.69	0.70	0.00
F6- Reinforced concrete cap	3977	94.69	4.60	0.70	0.02
F7- Pile cap/footing	402	48.37	38.10	13.50	0.03
F8- Timber substructure	1489	70.62	25.46	3.18	0.75
G1- Reinforced concrete culverts	1494	36.94	49.96	12.82	0.28
G2- Metal and other culverts	135	34.12	45.08	18.77	2.03
H1- Channel	4937	44.68	44.31	10.62	0.38
I1- Pile jacket w/o cathodic protection	461	45.21	36.38	15.84	2.57
I2- Pile jacket with cathodic protection	0				
I3- Fender/dolphin/bulkhead/seawall	358	64.39	15.70	17.68	2.23
I4- Reinforced conc slope protection	1580	95.97	3.49	0.52	0.02
I5- Timber slope protection	377	74.46	21.84	3.58	0.12
I6- Other (incl asphalt) slope protection	2571	85.65	13.18	0.82	0.35
I7- Drainage system - other materials	290	62.91	19.28	9.00	8.81
I7- Drainage system - metal	290	62.91	19.28	9.00	8.81
J1- Uncoated metal wall	167	41.63	28.07	28.93	1.37
J2- Reinforced concrete wall	5106	86.40	10.01	3.50	0.08
J3- Timber wall	467	65.45	18.19	12.15	4.21
J4- Other (incl masonry) wall	156	59.44	30.45	8.84	1.27
J5- Mechanically stabilized earth wall	670	96.01	3.50	0.47	0.02
K1- Sign structures/hi-mast light poles	13368	83.04	16.67	0.26	0.04
K1- Sign str/hi-mast light poles (coated)	928	67.08	31.07	1.81	0.03
L1- Moveable bridge mechanical	221	75.29	23.99	0.72	0.00
L2- Moveable bridge brakes	54	80.40	12.80	6.80	0.00
L3- Moveable bridge motors	107	84.00	12.44	3.11	0.44
L4- Moveable bridge hydraulic power	59	67.70	23.45	7.08	1.77
L5- Moveable bridge pipe and conduit	193	69.37	25.46	5.17	0.00
L6- Moveable bridge structure	246	80.70	13.51	5.68	0.11
L7- Moveable bridge locks	70	15.72	66.04	16.98	1.26
L8- Moveable bridge live load items	71	52.60	47.08	0.32	0.00

Table 4.2. Element groups and migrated conditions (cont'd)

	Count and percent by state of element inspections migrated				
		Percent by condition state			
Element group	Count	State 1	State 2	State 3	State 4
L9- Moveable bridge cw/trunion/track	143	62.33	30.70	6.98	0.00
M1- Moveable bridge electronics	100	93.71	4.40	1.89	0.00
M2- Moveable bridge submarine cable	65	94.22	4.89	0.89	0.00
M3- Moveable bridge control console	63	72.46	18.84	8.70	0.00
M4- Moveable bridge navigational lights	253	81.54	15.43	3.03	0.00
M5- Moveable bridge operator facilities	60	88.89	7.94	3.17	0.00
M6- Moveable bridge misc equipment	11	9.09	81.82	9.09	0.00
M7- Moveable bridge barriers/gates	85	65.00	35.00	0.00	0.00
M8- Moveable bridge traffic signals	70	92.41	6.90	0.69	0.00
P1- Deck wearing surface	1070	97.59	2.41	0.00	0.00
P2- Paint on steel or stain on concrete	9250	100.00	0.00	0.00	0.00
P3- Weathering steel patina	434	100.00	0.00	0.00	0.00
P4- Galvanized / metalized /other	2041	100.00	0.00	0.00	0.00
P5- Reinforcing steel protective system	87	100.00	0.00	0.00	0.00

Table 4.3. Migration probability matrix

	Probability to state 1					Probability to state 2					Probability to state 3					Probability to state 4					Foot
Element type name	From 1	From 2	From 3	From 4	From 5	From 1	From 2	From 3	From 4	From 5	From 1	From 2	From 3	From 4	From 5	From 1	From 2	From 3	From 4	From 5	**note**
A1- Concrete deck	100%	0%	0%	0%	0%	0%	80%	30%	0%	0%	0%	20%	70%	70%	0%	0%	0%	0%	30%	100%	1
A2- Concrete slab	100%	0%	0%	0%	0%	0%	80%	60%	20%	0%	0%	20%	40%	70%	50%	0%	0%	0%	10%	50%	1
A3- Prestressed concrete slab	100%	0%	0%	0%	0%	0%	80%	60%	20%	0%	0%	20%	40%	70%	50%	0%	0%	0%	10%	50%	1
A4- Steel deck	100%	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	2
A5- Timber deck/slab	100%	0%	0%	0%	0%	0%	60%	0%	0%	0%	0%	40%	70%	0%	0%	0%	0%	30%	100%	100%	3
A6- Approach slabs	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	60%	0%	0%	0%	0%	40%	100%	4
B1- Strip Seal expansion joint	100%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	50%	30%	0%	0%	0%	0%	70%	100%	100%	5
B2- Pourable joint seal	100%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	50%	30%	0%	0%	0%	0%	70%	100%	100%	5
B3- Compression joint seal	100%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	50%	30%	0%	0%	0%	0%	70%	100%	100%	5
B4- Assembly joint/seal	100%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	50%	30%	0%	0%	0%	0%	70%	100%	100%	5
B5- Open expansion joint	100%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	50%	30%	0%	0%	0%	0%	70%	100%	100%	5
B6- Other expansion joint	100%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	50%	30%	0%	0%	0%	0%	70%	100%	100%	5
C1- Uncoated metal rail	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	100%	6
C2- Coated metal rail	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	100%	6
C3- Reinforced concrete railing	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	100%	6
C4- Timber railing	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	50%	100%	100%	7
C5- Other railing	100%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	50%	30%	0%	0%	0%	0%	70%	100%	100%	5
D1- Unpainted steel super/substructure	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	100%	6
D2- Painted girder/floorbeam/cable/p&h	100%	50%	0%	0%	0%	0%	50%	100%	50%	0%	0%	0%	0%	50%	0%	0%	0%	0%	0%	100%	8
D3- Painted steel stringer	100%	50%	0%	0%	0%	0%	50%	100%	50%	0%	0%	0%	0%	50%	0%	0%	0%	0%	0%	100%	8
D4- Painted steel truss bottom	100%	50%	0%	0%	0%	0%	50%	100%	50%	0%	0%	0%	0%	50%	0%	0%	0%	0%	0%	100%	8
D5- Painted steel truss/arch top	100%	50%	0%	0%	0%	0%	50%	100%	50%	0%	0%	0%	0%	50%	0%	0%	0%	0%	0%	100%	8
D6- Prestressed concrete superstr	100%	0%	0%	0%	0%	0%	100%	20%	0%	0%	0%	0%	80%	0%	0%	0%	0%	0%	100%	100%	8
D7- Reinforced concrete superstructure	100%	0%	0%	0%	0%	0%	100%	30%	0%	0%	0%	0%	70%	0%	0%	0%	0%	0%	100%	100%	9
D8- Timber superstructure	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	60%	0%	0%	0%	0%	40%	100%	100%	10
E1- Elastomeric bearings	100%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	50%	0%	0%	0%	0%	0%	100%	100%	100%	12
E2- Metal bearings	100%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	50%	0%	0%	0%	0%	0%	100%	100%	100%	13
F1- Painted steel substructure	100%	50%	0%	0%	0%	0%	50%	100%	50%	0%	0%	0%	0%	50%	0%	0%	0%	0%	0%	100%	13
F2- Prestressed column/pile/cap	100%	0%	0%	0%	0%	0%	100%	20%	0%	0%	0%	0%	80%	0%	0%	0%	0%	0%	100%	100%	8
F3- Reinforced concrete column/pile	100%	0%	0%	0%	0%	0%	100%	30%	0%	0%	0%	0%	70%	0%	0%	0%	0%	0%	100%	100%	11
F5- Reinforced concrete abutment	100%	0%	0%	0%	0%	0%	100%	30%	0%	0%	0%	0%	70%	0%	0%	0%	0%	0%	100%	100%	10
F6- Reinforced concrete cap	100%	0%	0%	0%	0%	0%	100%	30%	0%	0%	0%	0%	70%	0%	0%	0%	0%	0%	100%	100%	10
F7- Pile cap/footing	100%	0%	0%	0%	0%	0%	100%	30%	0%	0%	0%	0%	70%	0%	0%	0%	0%	0%	100%	100%	10
F8- Timber substructure	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	60%	0%	0%	0%	0%	40%	100%	100%	10
G1- Reinforced concrete culverts	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	50%	0%	0%	0%	0%	50%	100%	12
G2- Metal and other culverts	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	50%	0%	0%	0%	0%	50%	100%	14
H1- Channel	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	100%	14
I1- Pile jacket w/o cathodic protection	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	100%	6
I2- Pile jacket with cathodic protection	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	100%	15
I3- Fender/dolphin/bulkhead/seawall	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	100%	15
I4- Reinforced conc slope protection	100%	0%	0%	0%	0%	0%	100%	30%	0%	0%	0%	0%	70%	0%	0%	0%	0%	0%	100%	100%	6
I5- Timber slope protection	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	60%	0%	0%	0%	0%	40%	100%	100%	10

Table 4.3. Migration probability matrix (cont'd)

	Probability to state 1					Probability to state 2					Probability to state 3					Probability to state 4					Foot
Element type name	From 1	From 2	From 3	From 4	From 5	From 1	From 2	From 3	From 4	From 5	From 1	From 2	From 3	From 4	From 5	From 1	From 2	From 3	From 4	From 5	**note**
I6- Other (incl asphalt) slope protection	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	100%	12
I7- Drainage system - other materials	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	100%	6
I7- Drainage system - metal	100%	50%	0%	0%	0%	0%	50%	100%	50%	0%	0%	0%	0%	50%	0%	0%	0%	0%	0%	100%	6
J1- Uncoated metal wall	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	100%	8
J2- Reinforced concrete wall	100%	0%	0%	0%	0%	0%	100%	30%	0%	0%	0%	0%	70%	0%	0%	0%	0%	0%	100%	100%	6
J3- Timber wall	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	60%	0%	0%	0%	0%	40%	100%	100%	10
J4- Other (incl masonry) wall	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	100%	12
J5- Mechanically stabilized earth wall	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	50%	0%	0%	0%	0%	50%	100%	6
K1- Sign structures/hi-mast light poles	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	100%	16
K1- Sign str/hi-mast light poles (coated)	100%	50%	0%	0%	0%	0%	50%	100%	50%	0%	0%	0%	0%	50%	0%	0%	0%	0%	0%	100%	6
L1- Moveable bridge mechanical	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	100%	6
L2- Moveable bridge brakes	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	100%	6
L3- Moveable bridge motors	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	100%	6
L4- Moveable bridge hydraulic power	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	100%	6
L5- Moveable bridge pipe and conduit	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	50%	0%	0%	0%	0%	50%	100%	7
L6- Moveable bridge structure	100%	50%	0%	0%	0%	0%	50%	100%	50%	0%	0%	0%	0%	50%	0%	0%	0%	0%	0%	100%	8
L7- Moveable bridge locks	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	100%	6
L8- Moveable bridge live load items	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	50%	0%	0%	0%	0%	50%	100%	7
L9- Moveable bridge cw/trunion/track	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	100%	6
M1- Moveable bridge electronics	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	50%	0%	0%	0%	0%	50%	100%	7
M2- Moveable bridge submarine cable	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	50%	0%	0%	0%	0%	50%	100%	7
M3- Moveable bridge control console	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	50%	0%	0%	0%	0%	50%	100%	7
M4- Moveable bridge navigational lights	100%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	50%	100%	0%	0%	0%	0%	0%	100%	100%	17
M5- Moveable bridge operator facilities	100%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	50%	100%	0%	0%	0%	0%	0%	100%	100%	17
M6- Moveable bridge misc equipment	100%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	50%	100%	0%	0%	0%	0%	0%	100%	100%	17
M7- Moveable bridge barriers/gates	100%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	50%	100%	0%	0%	0%	0%	0%	100%	100%	17
M8- Moveable bridge traffic signals	100%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	50%	100%	0%	0%	0%	0%	0%	100%	100%	17
P1- Deck wearing surface	50%	20%	0%	0%	0%	40%	70%	50%	20%	0%	10%	10%	50%	60%	10%	0%	0%	0%	20%	90%	18
P2- Paint on steel or stain on concrete	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	50%	100%	100%	19
P3- Weathering steel patina	100%	0%	0%	0%	0%	0%	100%	50%	0%	0%	0%	0%	50%	0%	0%	0%	0%	0%	100%	100%	20
P4- Galvanized / metalized /other	100%	0%	0%	0%	0%	0%	100%	50%	0%	0%	0%	0%	50%	0%	0%	0%	0%	0%	100%	100%	21
P5- Reinforcing steel protective system	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	100%	22

Footnotes:

These footnotes describe the rationale for the assigned probabilities, based on the definitions of element condition states (FDOT, 2008 and 2014).

1. (Concrete decks and slabs) - The definitions have changed from extent-based to severity-based, so there is little correspondence except for state 1. State 4 warrants a structural review, which is seen as less common on bridge decks than the old condition state 5.
2. (Steel decks) - The old states 1 and 2 both clearly fit within the new state 1, and the old state 5 clearly fits the new state 4. The remaining two states also have a reasonable correspondence with each other.
3. (Timber decks and slabs) - The old state 4 requires that serviceability be affected, but the new state 4 only warrants structural review, a lower standard. So a portion of the old state 3 is also allowed to be in new state 4. State 1 is a more direct match.

4. (Approach slabs) - Old condition states 1, 2, and 3 seem to correspond reasonably well with the new ones, though the old language is not very precise. Old state 4 is more permissive than the new one, since it doesn't warrant structural review; so only a portion of old state 4 was assigned to the new state 4, the rest to new state 3.
5. (Expansion joints) - Condition state 1 is essentially the same in both the old and new language. The severity range of distresses covered by the remaining two CoRe element states appear to be evenly spread over the remaining three new states. New state 4 includes conditions more severe than those described in old state 3.
6. (Various elements, mostly FDOT custom) - Condition state language appears to be equivalent between the old and new elements.
7. (Various movable bridge elements) - Condition state 1 is essentially the same in both the old and new language. Old condition state 3 contributes to both states 3 and 4 in the new system, and state 2 is roughly unchanged. In these cases there was no basis for splitting the transition time between states 3 and 4, so they were arbitrarily split evenly.
8. (Most steel elements) - Part of old state 2 is included in the new state 1. Old condition state 5 is essentially the same as new condition state 4. The severity range of distresses covered by the remaining three CoRe element states appear to be evenly split between the remaining two new states.
9. (Prestressed concrete superstructures) - Mostly the old and new condition states are equivalent. One difference is that old state 3 has no deterioration of the prestress system, while new state 3 has section loss in the prestressing (that doesn't warrant review).
10. (Various reinforced concrete elements) - Mostly the old and new condition states are equivalent. One difference is that old condition state 2 does not allow exposed reinforcing while new state 2 does. Therefore a part of state 3 is moved to state 2.
11. (Prestressed substructure elements) - Mostly the old and new condition states are equivalent. One difference is that old state 3 has no deterioration of the prestress system, while new state 3 has section loss in the prestressing (that doesn't warrant review).
12. (Various timber elements) - The old and new condition states are roughly equivalent, with the exception that old state 4 asserts that serviceability is affected, while new state 4 only warrants a review. Therefore part of old state 3 must be allocated to new state 4.
13. (Bearings) - Old condition state 1 agrees with new state 1. Old state 3 agrees with new state 4. Old state 2 appears to be divided between new states 2 and 3.
14. (Culverts) - The old and new condition states are roughly equivalent except for old state 4, which is much broader than new state 4 (which warrants structural review).
15. (Pile jackets) - It is difficult to relate the old and new condition states because the old language is quite vague. But they appear roughly equivalent.
16. (Mechanically stabilized earth walls) - The old and new language focus on different distresses, making them difficult to compare. There is little reason to believe they aren't equivalent, with the exception of the new state 4, which is much broader than the old state 4.
17. (Various movable bridge elements) - States 1 and 3 are roughly equivalent between old and new. Old state 2 is divided between new states 2 and 3.
18. (Deck wearing surface) - Relied mainly on old elements 13 and 39, belonging to element types A1 and A2, which are the most common elements having wearing surfaces. The condition state language for these elements mainly describes the wearing surface. However, there is very little correspondence between the old and new language since the old language is purely extent-based and the new language is purely severity-based.
19. (Paint on steel or stain on concrete) - Relied mainly on painted steel superstructure elements of type D2. State 1 is equivalent between the old and new language. Old state 2 remains in new state 2. Old state 3 feeds into both new states 3 and 4. Old states 4 and 5 are included in new state 4.
20. (Weathering steel patina) - Relied mainly on unpainted steel super/substructure of type D1. States 1 and 2 remain in the same condition. Old state 3 is divided between new states 2 and 3. State 4 remains in state 4.
21. (Galvanized / metalized /other) - Relied mainly on metal culverts of type G2. States 1 and 2 remain in the same condition. Old state 3 is divided between new states 2 and 3. State 4 remains in state 4.
22. (Reinforcing steel protective system) - The old condition state language did not address cathodic protection system condition directly, but in terms of evident corrosion the states roughly correspond to old element 299 in element type I24.

Table 4.4. New deterioration model
Transition times between condition states (years)

	Based on 2008 FDOT Element Manual				Shape	New 2014 FDOT Manual		
Element type name	1-2	2-3	3-4	4-5	(beta)	1-2	2-3	3-4
A1- Concrete deck	6	47	36	23	1.3	6	48	51
A2- Concrete slab	4	45	14	15	1.3	4	47	25
A3- Prestressed concrete slab	5	72	21	39	1.3	5	79	50
A4- Steel deck	3	2	11	11	1.1	5	11	11
A5- Timber deck/slab	5	12	15	0	1.9	5	7	15
A6- Approach slabs	12	25	28	0	1.0	12	25	28
B1- Strip Seal expansion joint	13	45	0	0	1.0	13	23	23
B2- Pourable joint seal	10	8	0	0	1.0	10	4	4
B3- Compression joint seal	6	11	0	0	1.4	6	5	5
B4- Assembly joint/seal	14	14	0	0	1.4	14	7	7
B5- Open expansion joint	18	30	0	0	1.4	18	15	15
B6- Other expansion joint	19	60	0	0	1.4	19	30	30
C1- Uncoated metal rail	74	5	0	0	1.1	74	3	3
C2- Coated metal rail	18	10	4	2	1.8	18	10	4
C3- Reinforced concrete railing	68	24	38	0	2.0	68	24	38
C4- Timber railing	12	9	0	0	1.9	12	4	4
C5- Other railing	37	16	0	0	2.5	37	8	8
D1- Unpainted steel super/substructure	13	9	13	0	1.1	13	9	13
D2- Painted girder/floorbeam/cable/p&h	10	8	8	57	1.8	14	40	28
D3- Painted steel stringer	10	17	5	275	1.8	19	150	137
D4- Painted steel truss bottom	13	5	13	7	1.8	15	19	3
D5- Painted steel truss/arch top	7	5	11	152	1.8	10	90	76
D6- Prestressed concrete superstr	293	13	14	0	2.0	293	16	11
D7- Reinforced concrete superstructure	32	9	21	0	2.0	32	16	15
D8- Timber superstructure	41	27	6	0	1.9	41	27	3
E1- Elastomeric bearings	96	242	0	0	1.9	96	121	121
E2- Metal bearings	14	48	0	0	1.9	14	24	24
F1- Painted steel substructure	8	7	2	5	1.8	12	9	2
F2- Prestressed column/pile/cap	16	24	77	0	2.0	16	40	62
F3- Reinforced concrete column/pile	41	10	120	0	2.0	41	46	84
F5- Reinforced concrete abutment	87	15	496	0	2.0	87	164	347
F6- Reinforced concrete cap	145	9	199	0	2.0	145	68	139
F7- Pile cap/footing	9	14	79	0	2.0	9	38	55
F8- Timber substructure	24	18	5	0	3.5	24	18	3
G1- Reinforced concrete culverts	7	37	138	0	2.0	7	37	138
G2- Metal and other culverts	8	29	34	0	1.1	8	29	34
H1- Channel	9	17	26	0	1.0	9	17	26
I1- Pile jacket w/o cathodic protection	13	17	18	0	2.0	13	17	18
I2- Pile jacket with cathodic protection	19	56	43	0	2.0	19	56	43
I3- Fender/dolphin/bulkhead/seawall	11	9	27	0	2.0	11	9	27
I4- Reinforced conc slope protection	56	12	15	0	2.0	56	16	10
I5- Timber slope protection	62	17	136	0	3.5	62	17	82
I6- Other (incl asphalt) slope protection	35	13	9	0	2.5	35	13	9
I7- Drainage system - other materials	8	2	3	0	1.1	8	2	3
I7- Drainage system - metal	6	3	1	2	1.1	8	3	1
J1- Uncoated metal wall	9	6	71	0	1.1	9	6	71
J2- Reinforced concrete wall	50	11	66	0	2.0	50	31	46
J3- Timber wall	24	9	14	0	3.5	24	9	8
J4- Other (incl masonry) wall	10	18	19	0	2.5	10	18	19
J5- Mechanically stabilized earth wall	76	10	17	0	1.6	76	10	17
K1- Sign structures/hi-mast light poles	15	18	7	0	1.0	15	18	7
K1- Sign str/hi-mast light poles (coated)	10	8	8	57	1.0	14	40	28
L1- Moveable bridge mechanical	12	34	12	0	1.6	12	34	12
L2- Moveable bridge brakes	5	7	6	0	1.1	5	7	6
L3- Moveable bridge motors	9	7	10	0	1.6	9	7	10
L4- Moveable bridge hydraulic power	8	15	13	0	1.1	8	15	13
L5- Moveable bridge pipe and conduit	6	28	0	0	1.6	6	14	14
L6- Moveable bridge structure	10	4	2	11	4.1	13	10	6

Table 4.4. New deterioration model (cont'd)

	Based on 2008 FDOT Element Manual				Shape	New 2014 FDOT Manual		
Element type name	1-2	2-3	3-4	4-5	(beta)	1-2	2-3	3-4
L7- Moveable bridge locks	4	6	15	0	1.1	4	6	15
L8- Moveable bridge live load items	6	22	0	0	1.6	6	11	11
L9- Moveable bridge cw/trunion/track	13	14	81	0	1.6	13	14	81
M1- Moveable bridge electronics	38	20	0	0	3.0	38	10	10
M2- Moveable bridge submarine cable	10	7	0	0	3.0	10	3	3
M3- Moveable bridge control console	9	17	0	0	3.0	9	8	8
M4- Moveable bridge navigational lights	9	9	0	0	3.0	9	5	5
M5- Moveable bridge operator facilities	14	37	0	0	1.1	14	19	19
M6- Moveable bridge misc equipment	1	10	0	0	1.1	1	5	5
M7- Moveable bridge barriers/gates	10	20	0	0	1.6	10	10	10
M8- Moveable bridge traffic signals	30	6	0	0	3.0	30	3	3
P1- Deck wearing surface	6	47	35	23	1.3	12	57	36
P2- Paint on steel or stain on concrete	10	8	8	57	1.8	10	8	4
P3- Weathering steel patina	13	9	13	0	1.1	13	15	7
P4- Galvanized / metalized /other	8	29	34	0	1.1	8	46	17
P5- Reinforcing steel protective system	19	56	43	0	2.0	19	56	43

5. Action effectiveness model

In research completed in 2010, a 14 year history of FDOT element inspections was analyzed to compute typical transition probabilities describing the change in bridge element condition between successive inspections when a preservation action was taken, for use in Pontis. AASHTOWare Bridge Management uses the same types of effectiveness models and a similar structure of transition probabilities as Pontis, but relies on a considerably revised bridge element inspection manual. Comparing the 2015 manual with the manual used in 2010, the following differences affect the research:

- In 2015, every element has four condition states defined for it, ranging from State 1 (new or nearly new, with no notable defects) to State 4 (defects so significant that a structural review is warranted). In 2010 elements could have anywhere from 3 to 5 condition states.
- In 2015, protective systems such as deck wearing systems, steel coatings, and cathodic protection equipment are defined as separate elements, each having four possible condition states. In 2010, these systems were integral with the underlying elements and not assessed separately.
- In 2015, the definitions of condition states are much more detailed than in 2010, considering multiple possible defects. The 2010 language typically considered only one or two primary defects.
- The 2015 manual changes the criteria for the worst-defined condition state, in most cases requiring a structural review to be warranted in order to assign a condition state 4. The 2010 practice was more permissive, in most cases saying that a structural review *may* be warranted.
- Other changes occurred in condition state language, such as whether exposed reinforcing steel necessitates a condition state 3 assessment in concrete elements.

Because of these differences, it is not accurate to use the 2010 action effectiveness models in AASHTOWare BMS with the new element data. However, FDOT does not yet have enough element inspection data under the new manual to re-estimate the models. Therefore it is necessary to transform the 2010 models to be compatible with 2015 inspections, taking into account the differences in the inspection process. This same concern arose in Task 4 for bridge element deterioration models, and a methodology was developed there to migrate the 2010 models. A similar methodology will be used here to migrate the effectiveness models. The process consists of the following steps:

1. For each of the 895 preservation actions defined in Task 3, assign an action subcategory in the same manner as has been done in previous FDOT research starting in 1999. It was necessary to define a few new action subcategories because of new preservation actions that were not considered previously in Pontis.
2. Assign the 2010 effectiveness models, which were developed at the action subcategory level, to the Task 3 preservation actions. For new action subcategories, it was necessary to develop effectiveness models using expert judgment, either by re-using the model from an existing action subcategory, or by populating the new model entirely from judgment guided by the 2010 models.
3. Convert the assigned 2010 action effectiveness models, which follow the 2010 condition state language, to make them compatible with the 2015 language. This involves application of the migration probability matrix developed under Task 4.

4. Refine the new models as needed to ensure that they satisfy modeling requirements of the AASHTOWare Bridge Management Software.

Ultimately, after implementation of AASHTOWare BMS 5.2.2, the new models will be imported into the pon_mod_action table of the BMS database by FDOT personnel for production use.

5.1 Assignment of action subcategories

In the original 1999 research to develop action cost and effectiveness models for Pontis, a set of action categories and subcategories were created to facilitate the analysis. These were defined carefully to be compatible with Pontis and with FDOT maintenance and contract management systems. The action categories were Replace, Rehab, Repair, and Maintain.

The subcategories further classified actions according to the material, element type, or problem that they were intended to address. Thus, for example, 101 was Replace Deck, 301 was Repair Deck, and 302 was Repair Steel Elements. Within each subcategory, actions are assumed to have similar cost and effectiveness. This same classification system has been used in subsequent research for several purposes including the organization of parts of the Project Level Analysis Tool, because it simplifies usage of the Pontis models to have a more compact way of describing groups of similar actions.

For the current research, the action subcategory system continues to be useful for its original purposes, as well as for associating preservation actions with the new AASHTOWare BMS actions (previously known as “flex actions”). Because of new element definitions in the 2015 manual, and new BMS capabilities, a number of changes are required in the action subcategory scheme to maintain compatibility with BMS and to take advantage of the new functionality. Table 5.1 shows the revised matrix. The significant changes are as follows:

- The 200-series action category previously called “Rehab” is now called “Major Repairs,” and the 300 series is “Minor Repairs.” The term “Rehab” is now used in the flex action definitions to denote projects that include major components such as functional improvements, risk mitigations, or replacement or major repair of elements.
- The 400-series action category was never used in Pontis analysis and still is not used in BMS. So it has been deleted from the numbering scheme.
- The 2015 element manual adds a significant number of elements composed of “Other” materials (i.e. not steel, concrete, timber, masonry, or stabilized earth). Although these are not used very much yet in the FDOT inventory, they were added to the action subcategory scheme to accommodate innovative new materials that may be used in the future, such as fiber-reinforced polymers.
- A new set of action subcategories 109, 209, and 309 were created for actions focused on wearing surface elements. Action subcategory 201 in the old system included replacement of the deck overlay, but now this action is separated into subcategory 109.
- Since coatings were added as separate elements, their actions were assigned to a new set of action subcategories 119, 219, and 319. Old action subcategory 102, used for paint system replacement, was changed to 119.
- All of the steel elements have an action “spot blast” which is also a part of coating system actions. These were assigned the action subcategory 319 so they would be grouped with coating work in the calculation of project costs.

- New action subcategories were added for actions that are focused on new defects that previously were treated as smart flags. These include 247 (mitigate settlement or scour) and 248 (repair distortion).
- A few additional action subcategories were added within the existing scheme for new types of actions created under Task 3. These include minor repairs of timber, MSE, and masonry elements; and channels and drainage systems.

Table 5.1. Action categories and subcategories

		Object	Action Category: 100-Replace	200-Major repair	300-Minor repair
Materials	1	Deck	101	201	301
	2	Steel/metal		202	302
	3	Concrete		203	303
	4	Timber		204	304
	5	Masonry		205	305
	6	MSE		206	306
	7	Other material		207	307
	9	Wearing surface	109	209	309
Hi-Maint	10	Other element			
	11	Joint	111	211	311
	12	Joint seal	112		
	13	Bearing (incl p/h)	113	213	313
	14	Railing	114		
	19	Coatings	119	219	319
Drainage	21	Slope prot	121	221	
	22	Channel		222	322
	23	Drain sys	123	223	323
Machinery	31	Machinery (1)	131	231	331
	32	Cath prot	132	232	332
Major	41	Beam	141		
	42	Truss/arch/box	142		
	43	Cable	143	243	
	44	Substr elem (exc cap)	144 (2)		
	45	Culvert	145		
	46	Appr slab	146	246 (3)	
	47	Settlement/scour		247 (4)	
	48	Distortion		248 (5)	
Appurtenances	51	Pole/sign	151		

White cells represent valid sub-categories; numbers in parentheses refer to footnotes

Footnotes
1. Incl. elec, hydraulic, and mech elements
2. Incl. fenders, dolphins, and pile jackets
3. Mudjacking
4. Mitigate settlement or scour
5. Heat straightening and repair of distortion

Since the action subcategory scheme is meant to be a simplified tool, it does not attempt to make fine distinctions in element types that are unlikely to be discernable in maintenance data sources. As a result, certain relatively uncommon elements are grouped with more common ones for convenience. For example:

- Concrete-filled steel decks, slabs, the top flange of concrete girders, and approach slabs are all grouped with regular concrete decks for repair actions.
- Movable bridge counterweights are grouped with concrete structural elements.
- Movable bridge counterweight supports and Hopkins frames are grouped with steel structural elements.
- Gusset plates are grouped with steel bearings since they are counted as eaches.

- Post-tensioning ducts are grouped with concrete girders.

Many of these assumptions are the same as those made in earlier versions of the scheme used with Pontis.

Every preservation action defined in Task 3 was assigned to one of the action subcategories in Table 5.1. As a final step, it was verified that no two preservation actions have the same combination of element number, condition state (skey), and action subcategory. This fact is helpful in simplifying database queries and minimizing the possibility of ambiguous action selections (where two actions have the same cost and effectiveness).

5.2 Augmentation and assignment of the 2010 model

Table 5.2 is extracted from the action effectiveness model developed in the 2010 research using element inspection data and maintenance work accomplishment records. The action subcategories listed in the table are limited to the ones that are still applicable for the 2015 elements. The 2010 research had variations on some of the models based on the number of condition states, but in the current study, all elements have four condition states.

Table 5.2. Action effectiveness models from the 2010 research

		Probability of each condition state after action				
Action subcategory		1	2	3	4	5
201	Rehab deck/replace overlay	43.8777	56.1223	0.0000	0.0000	0.0000
202	Rehab steel	57.8200	38.1454	4.0346	0.0000	0.0000
203	Rehab concrete	45.8536	45.5504	8.5174	0.0786	0.0000
204	Rehab timber	33.9553	59.4861	6.5586	0.0000	0.0000
205	Rehab masonry	100.0000	0.0000	0.0000	0.0000	0.0000
206	Rehab MSE	94.5840	0.0000	5.4160	0.0000	0.0000
211	Rehab joint	88.5697	11.3062	0.1241	0.0000	0.0000
213	Rehab bearing	68.5993	31.4007	0.0000	0.0000	0.0000
221	Rehab slope protection	72.9296	26.9754	0.0950	0.0000	0.0000
222	Rehab channel	98.7013	0.0000	1.2987	0.0000	0.0000
223	Rehab drainage system	57.8200	38.1454	4.0346	0.0000	0.0000
231	Rehab machinery	93.5297	6.4703	0.0000	0.0000	0.0000
243	Rehab cable	57.8200	38.1454	4.0346	0.0000	0.0000
246	Mudjacking	95.7931	4.2069	0.0000	0.0000	0.0000
301	Repair deck and substrate	89.7056	9.7301	0.5643	0.0000	0.0000
302	Spot paint	41.9576	57.7780	0.2644	0.0000	0.0000
303	Clean rebar and patch	84.0889	0.5200	15.3911	0.0000	0.0000
311	Repair joint	62.3554	37.6446	0.0000	0.0000	0.0000
331	Repair/lubricate machinery	92.9449	7.0551	0.0000	0.0000	0.0000

Since the action subcategory scheme has expanded, it is necessary to augment the model to incorporate the new elements. Table 5.3 shows the result of the decisions that were made. The rows in this table are the new action subcategories as listed in Table 5.1. The table indicates the number of actions included and the corresponding 2010 action subcategory used as the source of the action effectiveness model. If it was not appropriate to re-use one of the 2010 models, the table shows a model based on expert judgment, consistent with the 2010 models. This was needed for minor repair actions that are not as aggressive or effective as the major repairs considered in the 2010 models.

In all cases of 100-series element replacement actions, the resulting condition was assumed to be 100 percent in state 1.

5.3 Conversion of the 2010 models to 2015 condition states

The model shown in Table 5.3 still uses the system of up to 5 condition states that existed in 2010. It is necessary to convert it to fit the new 2015 definitions. This was done using the same method as in Task 4, by means of the migration probability matrix developed in that task. Migration probabilities vary by the same element grouping system used in developing deterioration models, which is orthogonal to the action subcategory scheme. Therefore the matrix multiplication must take place at the preservation action level. Since there are 895 preservation actions, the result is not tabulated in this report, but may be viewed in the delivered Excel file. An example result for one element is shown in the upper part of Table 5.4.

Table 5.3. Action effectiveness models from the 2010 research, augmented for new elements

Action subcategory		Action count	Source	Probability of each condition state after action				
				1	2	3	4	5
201	Major deck repairs	28	201	43.8777	56.1223	0.0000	0.0000	0.0000
202	Major steel repairs	43	202	57.8200	38.1454	4.0346	0.0000	0.0000
203	Major concrete repairs	74	203	45.8536	45.5504	8.5174	0.0786	0.0000
204	Major timber repairs	34	204	33.9553	59.4861	6.5586	0.0000	0.0000
205	Major masonry repairs	10	205	100.0000	0.0000	0.0000	0.0000	0.0000
206	Major MSE wall repairs	2	206	94.5840	0.0000	5.4160	0.0000	0.0000
207	Major repairs - other material	32	202	57.8200	38.1454	4.0346	0.0000	0.0000
209	Major wearing surface repairs	2	201	43.8777	56.1223	0.0000	0.0000	0.0000
211	Major joint repairs	12	211	88.5697	11.3062	0.1241	0.0000	0.0000
213	Major bearing repairs	16	213	68.5993	31.4007	0.0000	0.0000	0.0000
219	Zone or spot coating	16	302	41.9576	57.7780	0.2644	0.0000	0.0000
221	Major slope protection repairs	4	221	72.9296	26.9754	0.0950	0.0000	0.0000
222	Major channel repairs	2	222	98.7013	0.0000	1.2987	0.0000	0.0000
223	Major drainage system repairs	4	223	57.8200	38.1454	4.0346	0.0000	0.0000
231	Major machinery repairs	52	231	93.5297	6.4703	0.0000	0.0000	0.0000
232	Major cathodic protection repairs	2	231	93.5297	6.4703	0.0000	0.0000	0.0000
243	Major cable repairs	6	243	57.8200	38.1454	4.0346	0.0000	0.0000
246	Mudjacking of slabs	4	246	95.7931	4.2069	0.0000	0.0000	0.0000
247	Mitigation of settlement or scour	97	203	45.8536	45.5504	8.5174	0.0786	0.0000
248	Repair of distortion	32	202	57.8200	38.1454	4.0346	0.0000	0.0000
301	Repair of bridge deck	21	301	89.7056	9.7301	0.5643	0.0000	0.0000
302	Repair of steel	43	302	41.9576	57.7780	0.2644	0.0000	0.0000
303	Repair of concrete	46	303	84.0889	0.5200	15.3911	0.0000	0.0000
304	Repair of timber	18	Judgment	17.0000	83.0000	0.0000	0.0000	0.0000
305	Repair of masonry	5	Judgment	50.0000	50.0000	0.0000	0.0000	0.0000
306	Repair of MSE wall	1	Judgment	70.0000	30.0000	0.0000	0.0000	0.0000
307	Repair of other materials	17	303	84.0889	0.5200	15.3911	0.0000	0.0000
309	Repair of wearing surface	1	301	89.7056	9.7301	0.5643	0.0000	0.0000
311	Repair of joints	9	311	62.3554	37.6446	0.0000	0.0000	0.0000
313	Repair of bearings	9	Judgment	40.0000	60.0000	0.0000	0.0000	0.0000
319	Surface restoration of coating	44	302	41.9576	57.7780	0.2644	0.0000	0.0000
322	Repair of channel	2	Judgment	50.0000	50.0000	0.0000	0.0000	0.0000
323	Repair of drainage system	2	331	92.9449	7.0551	0.0000	0.0000	0.0000
331	Repair of machinery	33	331	92.9449	7.0551	0.0000	0.0000	0.0000
332	Repair of cathodic protection	2	331	92.9449	7.0551	0.0000	0.0000	0.0000

5.4 Final adjustments

It was noted that the migrated models in some cases allowed conditions to get worse than the condition state where they started. This is a consequence of the migration probability matrix, which tends to distribute parts of an old condition state into multiple new states, some worse than the original state. This is a small discrepancy, affecting an unweighted average of 1.6% of the transitions, but was significant enough to need correction.

To make the correction, any fraction of an element found to be in a worse state than where it started, was moved to the starting state. As a result, the adjusted model does not allow an action to cause conditions to get worse. Table 5.4 shows an example (yellow highlighted cells) of the adjustment and the final model. The BMS and PLAT models do consider deterioration after an action is taken, so it is still possible for a treated element to be in worse condition in the next inspection after an action.

Consideration was given to a further adjustment that would prohibit condition state 4 after an action, given that structural review is usually required. It was decided not to make adjustments for this, because it is possible that emergency, stop-gap, or partial repairs might be made in advance of a structural review being completed. This is especially true for scour mitigation, for timber bridges having low traffic volume, and for elements not on the primary load path such as wearing surfaces, coatings, and expansion joints.

Table 5.4. Example of final adjustment of the model (Element 12 – Reinforced Concrete Deck)

				Probability of each condition state after action			
Initial state	Action		Subcategory	State 1	State 2	State 3	State 4
Migrated 2015 model after application of the migration probability matrix							
2	1	Minor repair	301	89.7056	7.9534	2.3411	0.0000
3	1	Major repair	201	43.8777	44.8979	11.2245	0.0000
4	1	Major repair	201	43.8777	44.8979	11.2245	0.0000
4	2	Replace deck	101	100.0000	0.0000	0.0000	0.0000
Final model after adjustment for unexpected deterioration							
2	1	Minor repair	301	89.7056	10.2944	0.0000	0.0000
3	1	Major repair	201	43.8777	44.8979	11.2245	0.0000
4	1	Major repair	201	43.8777	44.8979	11.2245	0.0000
4	2	Replace deck	101	100.0000	0.0000	0.0000	0.0000

Note: No actions were defined for condition state 1

5.5 Conclusions

The final recommended models were delivered in an Excel file under Task 5, and are in a form that can be imported into BMS and PLAT when ready. Since the models are very consistent with the 2010 research, they should be suitable for FDOT production use in the interim period until the Department has sufficient inspections under the 2015 element manual to enable a new statistical analysis.

6. Migration of cost models

A major challenge in implementing BMS is the reliance on historical cost data based on the old Pontis definitions of the element, condition states and actions. There was a need to correlate data from historical element records to the desired information for the new BMS list of elements. One of the tasks on this research project is to update the costs of preservation actions as defined in Section 3 of this report for the condition states for each new BMS element. These updated costs will therefore depend on results from pertinent previous BMS studies at FDOT. Two approaches were used to accomplish this task. The first approach was to adopt and slightly modify Action Subcategory (actsub) definitions used in the two previous bridge cost studies for FDOT BMS (Sobanjo and Thompson, 2001, 2010). Then the newly defined set of BMS element-state-actions, from section 3 were matched to the most appropriate actsub number. Each actsub had costs estimated from the previous studies. With this matching, actsub costs can be further refined by bridge element type to get more specific values. The second approach involves matching the new BMS element-state-actions directly to the specific costs at the element-state-action level from the old Pontis element-state-action cost records. In other words, for the latter method, costs of an element from the old records at a condition state and action, were matched to the most comparable new BMS element and the appropriate state and action.

6.1 Matching to Action Subcategories

Sobanjo and Thompson (2001 and 2010) applied the concept of Action subcategories in extracting and refining historical costs of bridge preservation actions to be used in Pontis. As shown in Figure 6.1, a matrix is used to cross reference the action category with the materials or type of element.). The revised definitions of action subcategories were shown earlier in Table 5.1. As mentioned earlier, the first approach was to match the new BMS element state-action list to the appropriate Action subcategory. All preservation actions listed as major repairs, mitigation of scour, and repair distortion are considered as significant repairs and classified as a rehab (actsub 2XX) action while minor repairs are classified as repairs (actsub 3XX). Maintenance actions (actsub 4XX) were assigned also based on element type, e.g., Spot blast on steel elements, and actions on signs and poles, except for coatings, pins, plates, hanger, etc., where the maintenance actions are assigned based on material as 402; Concrete protective coatings are assigned actsub 403. A sample of the BMS element state actions as assigned is shown in Table 6.1.

Number of bridges where each action subcategory is feasible (2001 inventory)
Footnotes are in parentheses

Object			Action Category			
			100-Replace	200-Rehab	300-Repair	400-Maint
Materials	0	Other material				4714 (1)
	1	Deck	8675	7727 (2)	3863 (3)	8675 (4)
	2	Steel/coat (incl metal)	1275 (5)	5539	3900 (6)	3062 (7)
	3	Concrete		10824	8759 (8)	10838 (9)
	4	Timber		1258		1225
	5	Masonry		3034		7210
	6	MSE		146		146
Hi-Maint	10	Other element				
	11	Joint	3773	5654	3094	7929
	12	Joint seal	7544			
	13	Bearing (incl p/h)	6879	6878		6878
	14	Railing	9122			
Drainage	21	Slope prot	7132	3786		
	22	Channel		8259		8259
	23	Drain sys	3969	24		3969
Machinery	31	Machinery	201 (10)	201 (10)	154 (10,11)	201 (10)
	32	Cath prot	4474			
Major	41	Beam	8598			
	42	Truss/arch/box	234			
	43	Cable	41	41		
	44	Substr elem (exc cap)	11286 (12)			
	45	Culvert	2076			
	46	Appr slab	7260	7260 (13)		7260
Appurtenances	51	Pole/sign	180			

Footnotes

1. Wash structure
2. Rehab deck and replace overlay
3. Repair deck and substrate
4. Repair potholes
5. Replace paint system
6. Spot paint
7. Restore top coat
8. Clean rebar and patch
9. Patch minor spalls
10. Includes electrical, hydraulic, and mechanical elements
11. Repair and lubricate
12. Includes fenders, dolphins, and pile jackets
13. Mudjacking

Figure 6.1 Original Action Subcategory definitions for bridge preservation actions (Sobanjo and Thompson, 2001)

Table 6.1. Matching New BMS listing of element state actions with action subcategories

New Elemkey	New ElemName	New skey	New akey	New actlong	New actshort	asubcat
12	RC Concrete Deck	1	2	Crack sealing	Crack sealing	401
12	RC Concrete Deck	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair	301
12	RC Concrete Deck	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair	201
12	RC Concrete Deck	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair	201
12	RC Concrete Deck	4	2	Replace deck	Replace deck	101
13	PSC Concrete Deck	1	2	Crack sealing	Crack sealing	401
13	PSC Concrete Deck	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair	301
13	PSC Concrete Deck	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar/prestressing strands	Major repair	201
13	PSC Concrete Deck	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar/prestressing strands	Major repair deck	201
13	PSC Concrete Deck	4	2	Replace deck	Replace deck	101
15	PSC Concrete Top Flange	1	2	Crack sealing	Crack sealing	401
15	PSC Concrete Top Flange	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair	301
15	PSC Concrete Top Flange	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar/prestressing strands	Major repair	201
15	PSC Concrete Top Flange	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar/prestressing strands	Major repair	201
15	PSC Concrete Top Flange	4	2	Major repair and rehab of flange	Major repair and rehab of flange	201
16	RC Concrete Top Flange	1	2	Crack sealing	Crack sealing	401
16	RC Concrete Top Flange	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair	301
16	RC Concrete Top Flange	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair	201
16	RC Concrete Top Flange	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair	201
16	RC Concrete Top Flange	4	2	Major repair and rehab of flange	Major repair and rehab of flange	201

Table 6.1. Matching New BMS listing of element state actions with action subcategories (Cont'd)

New Elemkey	New ElemName	New skey	New akey	New actlong	New actshort	asubcat
28	Steel Deck/Open Grid	2	1	Spot blast	Spot blast deck	401
28	Steel Deck/Open Grid	2	2	Minor repair of corrosion, cracks, and connectors	Minor repair deck	301
28	Steel Deck/Open Grid	3	1	Spot blast and minor repair of corrosion and connectors	Spot blast and minor repair deck	301
28	Steel Deck/Open Grid	3	2	Spot blast and major repair of corrosion and connectors	Spot blast and major repair deck	201
28	Steel Deck/Open Grid	4	1	Spot blast and major repair of corrosion and connectors	Spot blast and major repair deck	201
28	Steel Deck/Open Grid	4	2	Replace deck	Replace deck	101
29	Steel Deck/Conc Grid	2	1	Spot blast	Spot blast deck	401
29	Steel Deck/Conc Grid	2	2	Minor repair of concrete filling, corrosion, cracks, and connectors	Minor repair deck	301
29	Steel Deck/Conc Grid	3	1	Spot blast and minor repair of concrete filling, corrosion, cracks, and connectors	Spot blast and minor repair deck	301
29	Steel Deck/Conc Grid	3	2	Spot blast and major repair of concrete filling, corrosion, cracks, and connectors	Spot blast and major repair deck	201
29	Steel Deck/Conc Grid	4	1	Spot blast and major repair of concrete filling, corrosion, cracks, and connectors	Spot blast and major repair deck	201
29	Steel Deck/Conc Grid	4	2	Replace deck	Replace deck	101
30	Corrug/Orthotpc Deck	2	1	Spot blast	Spot blast deck	401
30	Corrug/Orthotpc Deck	2	2	Minor repair of corrosion, cracks, and connectors	Minor repair deck	301
30	Corrug/Orthotpc Deck	3	1	Spot blast and minor repair of corrosion and connectors	Spot blast and minor repair deck	301
30	Corrug/Orthotpc Deck	3	2	Spot blast and major repair of corrosion and connectors	Spot blast and major repair deck	201
30	Corrug/Orthotpc Deck	4	1	Spot blast and major repair of corrosion and connectors	Spot blast and major repair deck	201
30	Corrug/Orthotpc Deck	4	2	Replace deck	Replace deck	101

Table 6.1. Matching New BMS listing of element state actions with action subcategories (Cont'd)

New Elemkey	New ElemName	New skey	New akey	New actlong	New actshort	asubcat
31	Timber Deck	2	1	Minor repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Minor repair deck	301
31	Timber Deck	3	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair deck	201
31	Timber Deck	4	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair deck	201
31	Timber Deck	4	2	Replace deck	Replace deck	101
38	Reinforced Concrete Slab	1	2	Crack sealing	Crack sealing	401
38	Reinforced Concrete Slab	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair	401
38	Reinforced Concrete Slab	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair	201
38	Reinforced Concrete Slab	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair	201
38	Reinforced Concrete Slab	4	2	Replace slab	Replace slab	101
54	Timber Slab	2	1	Minor repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Minor repair slab	301
54	Timber Slab	3	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair slab	201
54	Timber Slab	4	1	Major repair of connectors, decay, checks/shakes, cracks, splits/delamination and abrasion	Major repair slab	201
54	Timber Slab	4	2	Replace slab	Replace slab	101
60	Other Deck	2	2	Minor repair: clean stains, repair corrosion, connectors, and spalled/delamination	Minor repair deck	301
60	Other Deck	3	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination and exposed rebar/prestressing strands	Major repair deck	201
60	Other Deck	4	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination and exposed rebar/prestressing strands	Major repair deck	201
60	Other Deck	4	2	Replace deck	Replace deck	101

Table 6.1. Matching New BMS listing of element state actions with action subcategories (Cont'd)

New Elemkey	New ElemName	New skey	New akey	New actlong	New actshort	asubcat
65	Other Slab	2	2	Minor repair: clean stains, repair corrosion, connectors, and spalled/delamination	Minor repair slab	301
65	Other Slab	3	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination and exposed rebar/prestressing strands	Major repair slab	201
65	Other Slab	4	1	Major repair: clean stains, repair corrosion, connectors, spalled/delamination and exposed rebar/prestressing strands	Major repair slab	201
65	Other Slab	4	2	Replace slab	Replace slab	101
98	Concrete Deck on Precast Deck Panels	1	2	Crack sealing	Crack sealing deck	401
98	Concrete Deck on Precast Deck Panels	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair	301
98	Concrete Deck on Precast Deck Panels	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair deck	201
98	Concrete Deck on Precast Deck Panels	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar	Major repair deck	201
98	Concrete Deck on Precast Deck Panels	4	2	Replace deck panels	Replace deck panels	101
99	Prestressed Concrete Slab (Sonovoid)	1	2	Crack sealing	Crack sealing	401
99	Prestressed Concrete Slab (Sonovoid)	2	1	Minor repair: clean stains, crack sealing, and repair spalled/delamination	Minor repair	301
99	Prestressed Concrete Slab (Sonovoid)	3	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar/prestressing strands	Major repair	201
99	Prestressed Concrete Slab (Sonovoid)	4	1	Major repair: clean stains, crack sealing, repair spalled/delamination and exposed rebar/prestressing strands	Major repair	201
99	Prestressed Concrete Slab (Sonovoid)	4	2	Replace slab	Replace slab	101

Table 6.1. Matching New BMS listing of element state actions with action subcategories (Cont'd)

New Elemkey	New ElemName	New skey	New akey	New actlong	New actshort	asubcat
102	Steel Closed Web/Box Girder	2	1	Spot blast	Spot blast	442
102	Steel Closed Web/Box Girder	2	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and minor repair	342
102	Steel Closed Web/Box Girder	3	1	Spot blast and minor repair of corrosion, cracks, and connectors	Spot blast and minor repair	342
102	Steel Closed Web/Box Girder	3	2	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair	242
102	Steel Closed Web/Box Girder	3	3	Repair distortion	Repair distortion	242
102	Steel Closed Web/Box Girder	4	1	Spot blast and major repair of corrosion, cracks, and connectors	Spot blast and major repair	242
102	Steel Closed Web/Box Girder	4	2	Repair distortion	Repair distortion	242
102	Steel Closed Web/Box Girder	4	3	Replace unit	Replace unit	142
104	Prestressed Concrete Closed Web/Box Girder	1	1	Crack sealing	Crack sealing	442
104	Prestressed Concrete Closed Web/Box Girder	2	2	Minor repair: clean stains, and repair spalled/delamination	Minor repair	342
104	Prestressed Concrete Closed Web/Box Girder	3	1	Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands	Major repair	242
104	Prestressed Concrete Closed Web/Box Girder	4	1	Major repair: clean stains, repair spalled/delamination and exposed rebar/prestressing strands	Major repair	242
104	Prestressed Concrete Closed Web/Box Girder	4	2	Replace unit	Replace unit	142
105	Reinforced Concrete Closed Web/Box Girder	1	1	Crack sealing	Crack sealing	442
105	Reinforced Concrete Closed Web/Box Girder	2	2	Minor repair: clean stains, and repair spalled/delamination	Minor repair	342
105	Reinforced Concrete Closed Web/Box Girder	3	1	Major repair: clean stains, repair spalled/delamination and exposed rebar	Major repair	242
105	Reinforced Concrete Closed Web/Box Girder	4	1	Major repair: clean stains, repair spalled/delamination and exposed rebar	Major repair	242
105	Reinforced Concrete Closed Web/Box Girder	4	2	Replace unit	Replace unit	142

6.2 Matching to specific element state actions

The second approach involved attempting to match new BMS element state actions directly to the specific historical costs. In order to make efficient use of the historical records, an element conversion table was first developed to match the old Pontis element key (ID) to the new BMS element key, based primarily on the descriptions of the element in both tables (Table 6.2). There were several direct matches (same element key and description), with many element pairs having almost the same descriptions, and some cases where assumptions had to be made to assign the old element to the closest element in the new list. For example, old element no. 106, Unpnt Stl Opn Girder, is matched to new element no. 107, Steel Opn Girder, as these two descriptions appear close in meaning. Many cases also have just a basic difference in the numbering, e.g., old element no. 98, Conc Deck on PC Pane, is the same as the new element no. 8098, Conc Deck on PC Pane. Some elements in the old list have no apparent match in the new list, for example, old element no. 13 Unp Conc Deck/AC Ovl , is actually composed of two elements in the new BMS list: bare deck and the protective system. In this case, the bare deck element is chosen as the closest one in the new list (12, RC Concrete Deck).

The next step taken was to utilize the revised action subcategories (Table 5.1) and assign each number appropriately to element state actions in the new BMS list. The research team was informed that FDOT does not currently collect bridge cost information on element maintenance, repair, and replacement (MR&R). Thus the latest most recent cost data available was that from the 2010 BMS study. In order to make use of these data, the conversion table (*convert*) described above was employed, to modify the 2009 cost data table (*cost2009*), providing equivalent and matching elements. The overall data relationship is roughly shown in Figure 6.2. A sample of the resulting list of matched new element state actions and costs is shown in Table 6.3. It should be noted that the number of condition states is now four for all elements in the BMS while it ranged from three to five states for the old Pontis elements. Thus each element condition state has to be carefully considered in the Old Pontis list before assigning the corresponding actions in the new BMS equivalent states. It was observed that in elements from the old Pontis with five states, the actions in state 5 (worst state) translated in most of the cases to actions in state four of the new list (worst state). The new BMS actions list has very few actions in state 1, thus many of the old element state actions in state 1 may not be useful in the BMS list. Some unique actions have also been defined for the new BMS, such as “repair distortion” on steel elements and “mitigate scour” in substructure elements; these actions have no matches in the old Pontis list.

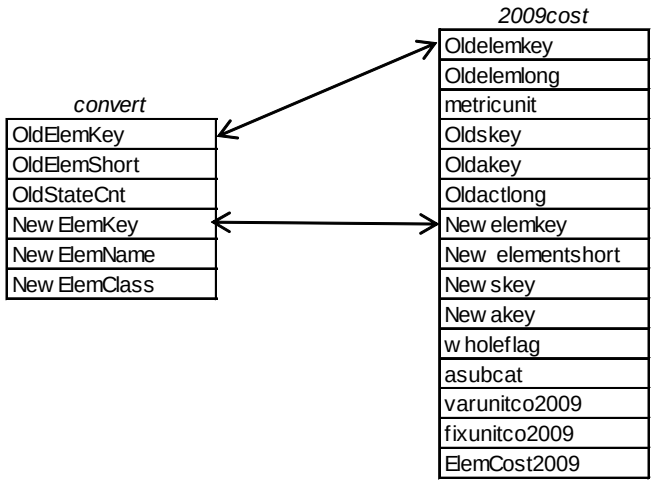

Figure 6.2. Data relationship diagram to derive BMS element state actions

These matched old historical costs are from 2009 and had to be converted to the 2015 costs. This was done using the inflation factors published by FDOT (2015b). The latest year available on the inflation factors list is 2013, (Table 6.4) which is listed same as the factor for 2009 (1.0). Thus the 2009 costs can be assumed to same for the current study. Looking at the two approaches described above, the first approach will identify actsubs for the all element actions, with a need to assign the actsubs to specific elements. The second approach will yield costs for the specific elements. Due to its direct results on the costs for the specific elements, the second approach was adopted and implemented in obtaining the necessary costs.

Table 6.2. Matching Old Pontis elements to new BMS list of elements

Old elemkey	Oldelemshort	OldState Cnt	MatchNew ElemKey	ElemName	ElemClass#
12	Bare Concrete Deck	5	12	RC Concrete Deck	NBE
13	Unp Conc Deck/AC Ovl	5	12	RC Concrete Deck	NBE
28	Steel Deck/Open Grid	5	28	Steel Deck/Open Grid	NBE
29	Steel Deck/Conc Grid	5	29	Steel Deck/Conc Grid	NBE
30	Corrug/Orthotpc Deck	5	30	Corrug/Orthotpc Deck	NBE
31	Timber Deck	4	31	Timber Deck	NBE
32	Timber Deck/AC Ovly	4	31	Timber Deck	NBE
38	Bare Concrete Slab	5	38	RC Concrete Slab	NBE
39	Unp Conc Slab/AC Ovl	5	38	RC Concrete Slab	NBE
54	Timber Slab	4	54	Timber Slab	NBE
55	Timber Slab/AC Ovly	4	54	Timber Slab	NBE
98	Conc Deck on PC Pane	5	8098	Conc Deck on PC Pane	ADE
99	PS Conc Slab	5	8099	PS Conc Slab (Sonovoid)	ADE
101	Unpnt Stl Box Girder	4	102	Stl Box Girder	NBE
102	Paint Stl Box Girder	5	102	Stl Box Girder	NBE
104	P/S Conc Box Girder	4	104	PSC Box Girder	NBE
105	R/Conc Box Girder	4	105	RC Box Girder	NBE
106	Unpnt Stl Opn Girder	4	107	Steel Opn Girder	NBE
107	Paint Stl Opn Girder	5	107	Steel Opn Girder	NBE
109	P/S Conc Open Girder	4	109	PSC Open Girder	NBE
110	R/Conc Open Girder	4	110	RC Open Girder	NBE
111	Timber Open Girder	4	111	Timber Open Girder	NBE
112	Unpnt Stl Stringer	4	112	Other Open Girder	NBE
113	Paint Stl Stringer	5	113	Steel Stringer	NBE
115	P/S Conc Stringer	4	115	PSC Stringer	NBE
116	R/Conc Stringer	4	116	RC Stringer	NBE
117	Timber Stringer	4	117	Timber Stringer	NBE
120	U/Stl Thru Truss/Bot	4	120	Steel Truss	NBE
121	P/Stl Thru Truss/Bot	5	120	Steel Truss	NBE
125	U/Stl Thru Truss/Top	4	120	Steel Truss	NBE
126	P/Stl Thru Truss/Top	5	120	Steel Truss	NBE
130	Unpnt Stl Deck Truss	4	120	Steel Truss	NBE
131	Paint Stl Deck Truss	5	120	Steel Truss	NBE
135	Timber Truss/Arch	4	135	Timber Truss	NBE
140	Unpnt Stl Arch	4	141	Steel Arch	NBE
141	Paint Stl Arch	5	141	Steel Arch	NBE
143	P/S Conc Arch	4	143	PSC Arch	NBE
144	R/Conc Arch	4	144	RC Arch	NBE
145	Other Arch	4	142	Other Arch	NBE
146	Misc Cable Uncoated	4	147	Steel Main Cables	NBE
147	Misc Cable Coated	5	147	Steel Main Cables	NBE
151	Unpnt Stl Floor Beam	4	152	Steel Floor Beam	NBE
152	Paint Stl Floor Beam	5	152	Steel Floor Beam	NBE
154	P/S Conc Floor Beam	4	154	PSC Floor Beam	NBE
155	R/Conc Floor Beam	4	155	RC Floor Beam	NBE
156	Timber Floor Beam	4	156	Timber Floor Beam	NBE
160	Unpnt Stl Pin/Hanger	4	161	Steel Pin / Pin and Hanger	NBE
161	Paint Stl Pin/Hanger	5	161	Steel Pin / Pin and Hanger	NBE
201	Unpnt Stl Column	4	202	Steel Column	NBE
202	Paint Stl Column	5	202	Steel Column	NBE
204	P/S Conc Column	4	204	PSC Column	NBE
205	R/Conc Column	4	205	RC Column	NBE
206	Timber Column	4	206	Timber Column	NBE
207	P/S Conc Holl Pile	4	207	Steel Tow er	NBE
210	R/Conc Pier Wall	4	210	RC Pier Wall	NBE
211	Other Mtl Pier Wall	4	211	Other Pier Wall	NBE

Table 6.2. Matching Old Pontis elements to new BMS list of elements (Cont'd)

Old elemkey	Oldelemshort	OldState Cnt	MatchNew ElemKey	ElemName	ElemClass#
215	R/Conc Abutment	4	215	RC Abutment	NBE
216	Timber Abutment	4	216	Timber Abutment	NBE
217	Other Mtl Abutment	4	217	Masonry Abutment	NBE
220	R/C Sub Pile Cap/Ftg	4	220	RC Pile Cap/Ftg	NBE
230	Unpnt Stl Cap	4	231	Steel Pier Cap	NBE
231	Paint Stl Cap	5	231	Steel Pier Cap	NBE
233	P/S Conc Cap	4	233	PSC Cap	NBE
234	R/Conc Cap	4	234	RC Cap	NBE
235	Timber Cap	4	235	Timber Cap	NBE
240	Metal Culvert	4	240	Steel Culvert	NBE
241	Concrete Culvert	4	241	RC Culvert	NBE
242	Timber Culvert	4	242	Timber Culvert	NBE
243	Misc Culvert	4	243	Other Culvert	NBE
290	Channel	4	8290	Channel	ADE
298	Pile Jacket Bare	4	8298	Pile Jacket Bare	ADE
299	Pile Jacket/Cath Pro	4	8299	Pile Jacket/Cath Pro	ADE
300	Strip Seal Exp Joint	3	300	Strip Seal Expansion Joint	BME
301	Pourable Joint Seal	3	301	Pourable Joint Seal	BME
302	Compressn Joint Seal	3	302	Compression Joint Seal	BME
303	Assembly Joint/Seal	3	303	Assembly Joint With Seal	BME
304	Open Expansion Joint	3	304	Open Expansion Joint	BME
310	Elastomeric Bearing	3	310	Elastomeric Bearing	NBE
311	Moveable Bearing	3	311	Moveable Bearing	NBE
312	Enclosed Bearing	3	312	Enclosed Bearing	NBE
313	Fixed Bearing	3	313	Fixed Bearing	NBE
314	Pot Bearing	3	314	Pot Bearing	NBE
315	Disk Bearing	3	315	Disk Bearing	NBE
320	P/S Conc Appr Slab	4	320	PSC Approach Slab	BME
321	R/Conc Approach Slab	4	321	RC Approach Slab	BME
330	Metal Rail Uncoated	4	330	Metal Bridge Railing	NBE
331	Conc Bridge Railing	4	331	RC Bridge Railing	NBE
332	Timb Bridge Railing	3	332	Timber Bridge Railing	NBE
333	Other Bridge Railing	3	333	Other Bridge Railing	NBE
334	Metal Rail Coated	5	330	Metal Bridge Railing	NBE
356	Steel Fatigue SmFlag	3			
357	Pack Rust Smart Flag	4			
358	Deck Cracking SmFlag	4			
359	Soffit Smart Flag	5			
360	Settlement SmFlag	3			
361	Scour Smart Flag	3			
362	Traf Impact SmFlag	3			
363	Section Loss SmFlag	4			
369	Sub.Sect Loss SmFlag	4			
370	Alert Smart Flag	4			
386	Fender/Dolphin Uncoa	4	8386	Fender/Dolphin Uncoa	ADE
387	P/S Fender/Dolphin	4	8387	P/S Fender/Dolphin	ADE
388	R/Conc Fender/Dolphi	4	8388	R/Conc Fender/Dolphi	ADE
389	Timber Fender/Dolphi	4	8389	Timber Fender/Dolphi	ADE
390	Other Fender/Dolphin	4	8390	Other Fender/Dolphin	ADE
393	Blkhd Sew l Metal Unc	4	8393	Blkhd Sew l Any Mater	ADE
394	R/Conc Abut Slope Pr	4	8394	R/Conc Abut Slope Pr	ADE
395	Timber Abut Slope Pr	4	8395	Timber Abut Slope Pr	ADE
396	Other Abut Slope Pro	4	8396	Other Abut Slope Pro	ADE
397	Drain. Syst Metal	5	8397	Drain. Syst Metal	ADE
398	Drain. Syst Other	4	8398	Drain. Syst Other	ADE
399	Other Xpansion Joint	3	8399	Other Xpansion Joint	ADE

Table 6.2. Matching Old Pontis elements to new BMS list of elements (Cont'd)

Old elemkey	Oldelemshort	OldState Cnt	MatchNew ElemKey	ElemName	ElemClass#
474	Walls Uncoated	4	8474	Walls Uncoated	ADE
475	R/Conc Walls	4	8475	R/Conc Walls	ADE
476	Timber Walls	4	8476	Timber Walls	ADE
477	Other Walls	4	8477	Other Walls	ADE
478	MSE Walls	4	8478	MSE Walls	ADE
480	Mast Arm Found	4	8480	Mast Arm Found	ADE
481	Paint Mast Arm Vert	5	8481	Paint Mast Arm Vert	ADE
482	Galvan Mast Arm Vert	5	8482	Galvan Mast Arm Vert	ADE
483	Other Mast Arm Vert	4	8483	RC Mast Arm Vert	ADE
484	Paint Mast Arm Horzn	5	8484	Paint Mast Arm Horzn	ADE
485	Galvan Mast Arm Horz	5	8485	Galvan Mast Arm Horz	ADE
486	Other Mast Arm Horzn	4	8486	Other Mast Arm Horzn	ADE
487	Sign Member Horiz	5	8487	Sign Member Horiz	ADE
488	Sign Member Vertical	5	8488	Sign Member Vertical	ADE
489	Sign Foundation	4	8489	Sign Foundation	ADE
495	Uncoat High Mast L.	4	8495	Uncoat High Mast L.	ADE
496	Painted High Mast L.	5	8496	High Mast Light Pole	ADE
497	Galvan. High Mast L.	5	8497	Galvan. High Mast L.	ADE
498	Other High Mast L.P.	4	8498	Other High Mast L.P.	ADE
499	H. M. L. P. Found.	4	8499	H. M. L. P. Found.	ADE
540	Open Gearing	4	8540	Open Gearing	ADE
541	Speed Reducers	4	8541	Speed Reducers	ADE
542	Shafts	4	8542	Shafts	ADE
543	Shaft Brgs and Coupl	4	8543	Shaft Brgs and Coupl	ADE
544	Brakes	4	8544	Brakes	ADE
545	Emergency Drive	4	8545	Emergency Drive	ADE
546	Span Drive Motors	4	8546	Span Drive Motors	ADE
547	Hydraulic Pow er Unit	4	8547	Hydraulic Pow er Unit	ADE
548	Hydraulic Piping Sys	3	8548	Hydraulic Piping Sys	ADE
549	Hydraulic Cylinders	4	8549	Hydraulic Cylinders	ADE
550	Hopkins Frame	5	8550	Hopkins Frame	ADE
560	Locks	4	8560	Locks	ADE
561	Live Load Shoes	3	8561	Live Load Shoes	ADE
562	Counterw eight Suppor	5	8562	Counterw eight Suppor	ADE
563	Acc Ladd & Plat	5	8563	Acc Ladd & Plat	ADE
564	Counterw eight	4	8564	Counterw eight	ADE
565	Trun/Str and Cur Trk	4	8565	Trun/Str and Cur Trk	ADE
570	Transformers	3	8570	Transformers	ADE
571	Submarine Cable	3	8571	Submarine Cable	ADE
572	Conduit & Junc. Box	3	8572	Conduit & Junc. Box	ADE
573	PLCs	3	8573	PLCs	ADE
574	Control Console	3	8574	Control Console	ADE
580	Navigational Lights	3	8580	Navigational Lights	ADE
581	Operator Facilities	3	8581	Operator Facilities	ADE
582	Lift Bridge Spec. Eq	3	8582	Lift Bridge Spec. Eq	ADE
583	Sw ing Bridge Spec. E	3	8583	Sw ing Bridge Spec. E	ADE
590	Resistance Barriers	3	8590	Resistance Barriers	ADE
591	Warning Gates	3	8591	Warning Gates	ADE
592	Traffic Signals	3	8592	Traffic Signals	ADE

Table 6.3. Matching old Pontis element state actions and specific costs to new BMS actions

Oldelemkey	Oldelemlong	metricunit	Oldskey	Oldakey	Oldactlong	New elemkey	New elementshort	New skey	New akey	asubcat	varunitco2009	fixunitco2009	ElemCost2009
12	Concrete Deck - Bare	sq.m.	5	2	Replace deck	12	RC Concrete Deck	4	2	101	579.66	144.91	724.57
28	Steel Deck - Open Grid	sq.m.	5	2	Replace unit	28	Steel Deck/Open Grid	4	2	101	676.26	169.07	845.33
29	Steel Deck - Concrete Filled Grid	sq.m.	5	2	Replace unit	29	Steel Deck/Conc Grid	4	2	101	772.86	193.21	966.07
30	Steel Deck - Corrugated/Orthotropic/Etc.	sq.m.	5	2	Replace unit	30	Corrug/Orthotpc Deck	4	2	101	31196.53	7799.13	38995.66
31	Timber Deck - Bare	sq.m.	3	2	Replace deck	31	Timber Deck	4	2	101	193.22	48.30	241.52
31	Timber Deck - Bare	sq.m.	4	1	Replace deck	31	Timber Deck	4	2	101	193.22	48.30	241.52
38	Concrete Slab - Bare	sq.m.	5	2	Replace deck	38	RC Concrete Slab	4	2	101	579.66	144.91	724.57
54	Timber Slab	sq.m.	4	1	Replace deck	54	Timber Slab	4	2	101	19.33	4.83	24.16
12	Concrete Deck - Bare	sq.m.	5	1	Repair spalled areas	12	RC Concrete Deck	3	1	132	4679.51	1169.88	5849.39
38	Concrete Slab - Bare	sq.m.	5	1	Repair spalled areas	38	RC Concrete Slab	4	1	132	3431.52	857.88	4289.40
107	Painted Steel Open Girder/Beam	m.	5	2	Replace unit	107	Steel Opn Girder	4	3	141	6088.05	1522.01	7610.07
109	P/S Conc Open Girder/Beam	m.	4	2	Replace unit	109	PSC Open Girder	4	2	141	2502.86	625.71	3128.57
110	Reinforced Conc Open Girder/Beam	m.	4	2	Replace unit	110	RC Open Girder	4	2	141	2502.86	625.71	3128.57
111	Timber Open Girder/Beam	m.	4	2	Replace unit	111	Timber Open Girder	4	2	141	1014.67	253.67	1268.33
112	Unpainted Steel Stringer	m.	4	2	Replace unit	112	Other Open Girder	4	2	141	1420.54	355.14	1775.68
113	Painted Steel Stringer	m.	5	2	Replace unit	113	Steel Stringer	4	3	141	1420.54	355.14	1775.68
116	Reinforced Conc Stringer	m.	4	2	Replace unit	116	RC Stringer	4	2	141	1826.41	456.60	2283.02
117	Timber Stringer	m.	4	2	Replace unit	117	Timber Stringer	4	2	141	771.14	192.79	963.93
152	Painted Steel Floor Beam	m.	5	2	Replace unit	152	Steel Floor Beam	4	3	141	3111.67	777.92	3889.59
154	P/S Conc Floor Beam	m.	4	2	Replace unit	154	PSC Floor Beam	4	2	141	1826.41	456.60	2283.02
102	Painted Steel Closed Web/Box Girder	m.	5	2	Replace unit	102	Stl Box Girder	4	2	142	8489.01	2122.25	10611.26
104	P/S Conc Closed Web/Box Girder	m.	4	2	Replace unit	104	PSC Box Girder	4	2	142	16978.02	4244.51	21222.53
105	Reinforced Concrete Closed Webs/Box Girder	m.	4	2	Replace unit	105	RC Box Girder	4	2	142	3452.19	863.05	4315.24
120	Unpainted Steel Bottom Chord Thru Truss	m.	4	2	Replace unit	120	Steel Truss	4	3	142	4527.47	1131.87	5659.33
135	Timber Truss/Arch	m.	4	2	Replace unit	135	Timber Truss	4	2	142	4527.47	1131.87	5659.33
141	Painted Steel Arch	m.	5	2	Replace unit	141	Steel Arch	4	3	142	5093.41	1273.35	6366.76
143	P/S Conc Arch	m.	4	2	Replace unit	143	PSC Arch	4	2	142	990.39	247.60	1237.99
144	Reinforced Conc Arch	m.	4	2	Replace unit	144	RC Arch	4	2	142	9620.88	2405.22	12026.10
147	Cable - Coated (not embedded in concrete)	ea.	5	2	Replace unit	147	Steel Main Cables	4	2	143	275981.27	68995.32	344976.59
102	Painted Steel Closed Web/Box Girder	m.	5	1	Major rehab unit	102	Stl Box Girder	3	2	202	119844.86	29961.22	149806.08
107	Painted Steel Open Girder/Beam	m.	5	1	Major rehab unit	107	Steel Opn Girder	4	1	202	35953.46	8988.37	44941.83
112	Unpainted Steel Stringer	m.	4	1	Rehab unit	112	Other Open Girder	4	1	202	23968.98	5992.24	29961.22
113	Painted Steel Stringer	m.	5	1	Major rehab unit	113	Steel Stringer	4	1	202	23968.98	5992.24	29961.22
120	Unpainted Steel Bottom Chord Thru Truss	m.	4	1	Rehab unit	120	Steel Truss	4	1	202	179767.30	44941.83	224709.13
141	Painted Steel Arch	m.	5	1	Major rehab unit	141	Steel Arch	4	1	202	149806.09	37451.52	187257.61
152	Painted Steel Floor Beam	m.	5	1	Major rehab unit	152	Steel Floor Beam	4	1	202	23968.98	5992.24	29961.22
28	Steel Deck - Open Grid	sq.m.	3	2	Rehab connectors	28	Steel Deck/Open Grid	3	1	202	176.96	44.24	221.20
28	Steel Deck - Open Grid	sq.m.	4	2	Rehab connectors	28	Steel Deck/Open Grid	3	2	202	294.92	73.73	368.65
28	Steel Deck - Open Grid	sq.m.	5	1	Rehab connectors+rep	28	Steel Deck/Open Grid	4	1	202	393.22	98.30	491.52
29	Steel Deck - Concrete Filled Grid	sq.m.	3	2	Rehab connectors+con	29	Steel Deck/Conc Grid	3	2	202	212.33	53.08	265.41
29	Steel Deck - Concrete Filled Grid	sq.m.	4	2	Rehab connectors+con	29	Steel Deck/Conc Grid	4	1	202	353.89	88.47	442.36
29	Steel Deck - Concrete Filled Grid	sq.m.	5	1	Rehab connectors+con	29	Steel Deck/Conc Grid	4	1	202	471.85	117.96	589.82
30	Steel Deck - Corrugated/Orthotropic/Etc.	sq.m.	5	1	Rehab/replace paint	30	Corrug/Orthotpc Deck	4	1	202	21162.50	5290.63	26453.13
104	P/S Conc Closed Web/Box Girder	m.	4	1	Rehab unit	104	PSC Box Girder	3	1	203	2829.66	707.42	3537.08
105	Reinforced Concrete Closed Webs/Box Girder	m.	4	1	Rehab unit	105	RC Box Girder	3	1	203	2829.66	707.42	3537.08
109	P/S Conc Open Girder/Beam	m.	4	1	Rehab unit	109	PSC Open Girder	4	1	203	2829.66	707.42	3537.08
110	Reinforced Conc Open Girder/Beam	m.	4	1	Rehab unit	110	RC Open Girder	4	1	203	2829.66	707.42	3537.08
116	Reinforced Conc Stringer	m.	4	1	Rehab unit	116	RC Stringer	4	1	203	2829.66	707.42	3537.08
143	P/S Conc Arch	m.	4	1	Rehab unit	143	PSC Arch	4	1	203	2829.66	707.42	3537.08
144	Reinforced Conc Arch	m.	4	1	Rehab unit	144	RC Arch	4	1	203	2829.66	707.42	3537.08
154	P/S Conc Floor Beam	m.	4	1	Rehab unit	154	PSC Floor Beam	4	1	203	2829.66	707.42	3537.08

Table 6.3. Matching old Pontis element state actions and specific costs to new BMS actions (Cont'd)

Oldelemkey	Oldelemlong	metricunit	Oldskey	Oldakey	Oldactlong	New elemkey	New elementshort	New skey	New akey	asubcat	varunitco2009	fixunitco2009	ElemCost2009
111	Timber Open Girder/Beam	m.	3	1	Rehab unit	111	Timber Open Girder	4	1	204	509.35	127.34	636.68
117	Timber Stringer	m.	3	1	Rehab unit	117	Timber Stringer	4	1	204	384.83	96.21	481.04
135	Timber Truss/Arch	m.	3	1	Rehab unit	135	Timber Truss	4	1	204	2376.92	594.23	2971.15
31	Timber Deck - Bare	sq.m.	2	1	Rehab and/or protect	31	Timber Deck	2	1	204	115.94	28.98	144.92
31	Timber Deck - Bare	sq.m.	3	1	Rehab deck	31	Timber Deck	3	1	204	0.00	0.00	0.00
147	Cable - Coated (not embedded in concrete)	ea.	5	1	Rehab unit and repla	147	Steel Main Cables	3	1	243	206985.95	51746.49	258732.44
31	Timber Deck - Bare	sq.m.	4	2	Repair	31	Timber Deck	4	1	301	43833.62	10958.41	54792.03
54	Timber Slab	sq.m.	4	2	Repair	54	Timber Slab	3	1	301	5731.95	1432.99	7164.94
102	Painted Steel Closed Web/Box Girder	m.	3	1	Spot blast, clean &	102	Stl Box Girder	2	2	302	25167.42	6291.86	31459.28
107	Painted Steel Open Girder/Beam	m.	4	1	Spot blast, clean &	107	Steel Opn Girder	2	2	302	467.40	116.85	584.25
113	Painted Steel Stringer	m.	3	1	Spot blast, clean &	113	Steel Stringer	2	2	302	299.61	74.90	374.51
141	Painted Steel Arch	m.	3	1	Spot blast, clean &	141	Steel Arch	2	2	302	3775.11	943.78	4718.89
152	Painted Steel Floor Beam	m.	4	1	Spot blast, clean &	152	Steel Floor Beam	2	2	302	485.37	121.34	606.72
28	Steel Deck - Open Grid	sq.m.	4	1	Spot blast, clean an	28	Steel Deck/Open Grid	2	1	302	196.60	49.15	245.75
29	Steel Deck - Concrete Filled Grid	sq.m.	4	1	Spot blast, clean an	29	Steel Deck/Conc Grid	2	2	302	235.93	58.98	294.91
30	Steel Deck - Corrugated/Orthotropic/Etc.	sq.m.	4	1	Spot blast,clean,pai	30	Corrug/Orthotpc Deck	3	1	302	846.58	211.65	1058.23
104	P/S Conc Closed Web/Box Girder	m.	3	1	Clean steel & patch	104	PSC Box Girder	2	2	303	3236.73	809.18	4045.91
105	Reinforced Concrete Closed Webs/Box Girder	m.	3	1	Clean rebar & patch,	105	RC Box Girder	2	2	303	3236.73	809.18	4045.91
109	P/S Conc Open Girder/Beam	m.	3	1	Clean steel & patch,	109	PSC Open Girder	2	2	303	647.35	161.84	809.19
110	Reinforced Conc Open Girder/Beam	m.	3	1	Clean rebar & patch,	110	RC Open Girder	2	2	303	647.35	161.84	809.19
116	Reinforced Conc Stringer	m.	3	1	Clean rebar & patch,	116	RC Stringer	2	2	303	647.35	161.84	809.19
143	P/S Conc Arch	m.	3	1	Clean steel & patch,	143	PSC Arch	2	2	303	647.35	161.84	809.19
144	Reinforced Conc Arch	m.	3	1	Clean rebar & patch,	144	RC Arch	2	2	303	647.35	161.84	809.19
154	P/S Conc Floor Beam	m.	3	1	Clean steel and patc	154	PSC Floor Beam	2	2	303	647.35	161.84	809.19
102	Painted Steel Closed Web/Box Girder	m.	2	1	Surface clean	102	Stl Box Girder	2	1	400	91.70	22.93	114.63
107	Painted Steel Open Girder/Beam	m.	1	1	Surface clean	107	Steel Opn Girder	2	1	400	91.70	22.93	114.63
152	Painted Steel Floor Beam	m.	2	1	Surface clean	152	Steel Floor Beam	2	1	400	91.70	22.93	114.63
28	Steel Deck - Open Grid	sq.m.	2	1	Surface clean	28	Steel Deck/Open Grid	2	1	400	15.65	3.91	19.56
29	Steel Deck - Concrete Filled Grid	sq.m.	2	1	Surface clean	29	Steel Deck/Conc Grid	2	1	400	15.65	3.91	19.56
12	Concrete Deck - Bare	sq.m.	2	1	Repair spalled/delam	12	RC Concrete Deck	2	1	401	14.12	3.53	17.65
12	Concrete Deck - Bare	sq.m.	3	1	Repair spalled areas	12	RC Concrete Deck	3	1	401	28.24	7.06	35.29
12	Concrete Deck - Bare	sq.m.	4	1	Repair spalled areas	12	RC Concrete Deck	4	1	401	56.47	14.12	70.59
30	Steel Deck - Corrugated/Orthotropic/Etc.	sq.m.	2	1	Seal cracks and/or r	30	Corrug/Orthotpc Deck	2	1	401	30.38	7.60	37.98
38	Concrete Slab - Bare	sq.m.	2	1	Repair spalled/delam	38	RC Concrete Slab	2	1	401	14.12	3.53	17.65
38	Concrete Slab - Bare	sq.m.	3	1	Repair spalled areas	38	RC Concrete Slab	3	1	401	28.24	7.06	35.29
147	Cable - Coated (not embedded in concrete)	ea.	2	1	Clean & Restore Coat	147	Steel Main Cables	2	1	402	13697.60	3424.40	17122.00
28	Steel Deck - Open Grid	sq.m.	3	1	Surface clean+restor	28	Steel Deck/Open Grid	2	2	402	19.67	4.92	24.59
29	Steel Deck - Concrete Filled Grid	sq.m.	3	1	Surface clean+restor	29	Steel Deck/Conc Grid	3	1	402	19.67	4.92	24.59
30	Steel Deck - Corrugated/Orthotropic/Etc.	sq.m.	3	1	Surface clean+restor	30	Corrug/Orthotpc Deck	2	2	402	634.84	158.71	793.55
104	P/S Conc Closed Web/Box Girder	m.	2	1	Seal cracks minor pa	104	PSC Box Girder	2	1	403	226.38	56.60	282.98
105	Reinforced Concrete Closed Webs/Box Girder	m.	2	1	Seal cracks minor pa	105	RC Box Girder	1	1	403	254.68	63.67	318.35
109	P/S Conc Open Girder/Beam	m.	2	1	Seal cracks minor pa	109	PSC Open Girder	1	1	403	254.68	63.67	318.35
110	Reinforced Conc Open Girder/Beam	m.	2	1	Seal cracks minor pa	110	RC Open Girder	2	1	403	254.68	63.67	318.35
116	Reinforced Conc Stringer	m.	2	1	Seal cracks minor pa	116	RC Stringer	1	1	403	254.68	63.67	318.35
143	P/S Conc Arch	m.	2	1	Seal cracks minor pa	143	PSC Arch	1	1	403	254.68	63.67	318.35
144	Reinforced Conc Arch	m.	2	1	Seal cracks minor pa	144	RC Arch	1	1	403	254.68	63.67	318.35
154	P/S Conc Floor Beam	m.	2	1	Seal cracks minor pa	154	PSC Floor Beam	2	1	403	254.68	63.67	318.35

Table 6.4. Prior Year Construction Cost Inflation Factors (FDOT, 2015b)

Fiscal Year	PDC* Multiplier
1987	2.22
1988	2.20
1989	2.15
1990	2.08
1991	2.01
1992	2.01
1993	2.02
1994	1.99
1995	1.94
1996	1.88
1997	1.82
1998	1.78
1999	1.80
2000	1.75
2001	1.63
2002	1.62
2003	1.66
2004	1.63
2005	1.50
2006	1.33
2007	1.20
2008	1.14
2009	1.00
2010	1.08
2011	1.03
2012	1.01
2013	1.00

*PDC stands for Present Day Cost

6.3 Estimating costs of new unique element state actions

As mentioned earlier, the implementation of BMS has generated some new unique element state actions, which were not available in the old Pontis database. Two examples of such actions are “Repair distortion” and “Mitigate settlement or scour.” The following subsections describes the efforts and results in estimating the costs of these two actions.

6.3.1 Cost of “Repair Distortion”

There are rare documented literatures on cost estimates for steel repair on bridges by heat-straightening. The two most relevant sources of such information obtained were the FDOT’s document from the Basis of Estimates (FDOT, 2015c) and an Iowa’s report on in-house cost for repair by heat-straightening on a steel bridge (TranSafety, 1997). The FDOT document describes a Pay Item 460-85 “Structural steel repair” with unit of LB or KG and “intended on rehabilitation for in-place heat-straightening, with the quantity based on the weight of steel components to be repaired.”

Based on the specific pay item 460-95, FDOT historical bid unit costs were reviewed and three records were identified where steel repairs (heat-straightening) were done using this pay item. The summary of

the costs are shown in Table 6.5. The results, though with limited data, shows an average cost of $61.17/LB to do such steel repairs.

Table 6.5. Historical costs of heat-straightening repairs on Florida bridges (FDOT, 2015c)

Item	No. of Conts	Weighted Average	Total Amount	Total Quantity	Unit Meas	Obs?	Description	BidYear
0460 95	2	$66.88	$5,350.00	80.000	LB	N	STRUCTURAL STEEL REPAIR	2013
0460 95	2	$113.64	$37,500.00	330.000	LB	N	STRUCTURAL STEEL REPAIR	2012
0460 95	1	$3.00	$30,381.30	10,127.100	LB	N	STRUCTURAL STEEL REPAIR	2010
	Mean	$61.17						

The Iowa report describes the efforts by the Iowa Department of Transportation (IDOT) in training its own personnel to do heat-straightening repairs on steel bridges, with an example bridge used to illustrate the costs in terms of both the In-house costs and the cost to do it by contract. More details on the methodology mentioned in the Iowa report are shown in Avent and Brakke (1996). The bridge repaired was the IA 130 overpass over I-80 near Davenport, where one girder was hit by a vehicle at the bottom flange, and repaired using heat-straightening. Figure 6.3 shows the damage and repaired sections while Figure 2 illustrates the specific areas and length of the steel girder that was repaired. The report provided the detailed costs as summarized in Table 6.6. Using the length of 5.49 m as shown in Figure 6.4, the average of the in-house and contract costs were estimated per unit length and converted to cost per linear feet of the bridge steel girder. Finally location and time factors were utilized to adjust the cost estimate to Florida costs for 2015. There are various sources of information for cost comparison between cities in the United States, including the Consumer Price Index (CPI). The most relevant source found and related to transportation cost was the report on the work done by Anderson et al. (2015) on estimating, on a national scale, the cost for construction of transit facilities. Based on an industry-accepted reference (R.S. Means Construction Cost Data), Anderson et al. (2015) listed city indexes for some established regions in the U.S., including the index for some specific cities: Des Moines, Iowa (93.7) and three cities from Florida: Jacksonville (85.0), Pensacola (84.8), and Tampa (91.1), resulting in an average of 87.0 for the Florida's cities. According to FDOT's cost index, the cost in 2015 is 1.9 times the cost in 1997 (Table 6.4 shown earlier: 1.82 for 2013 most recent available, but used 1.9 for 2015). The revised costs show an estimate of $1,510.45 or $1,600 per LF to do steel repair by heat-straightening.

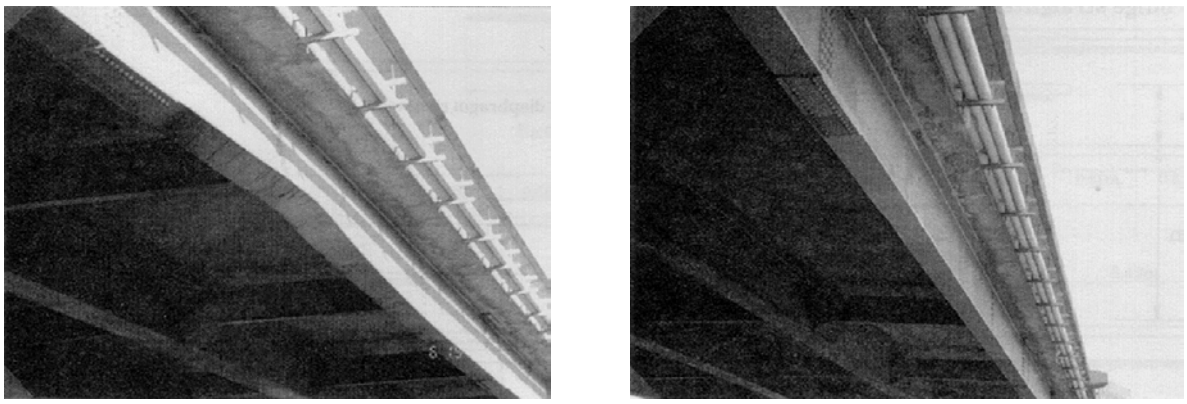

Figure 6.3. Damaged bridge steel girder before and after repair

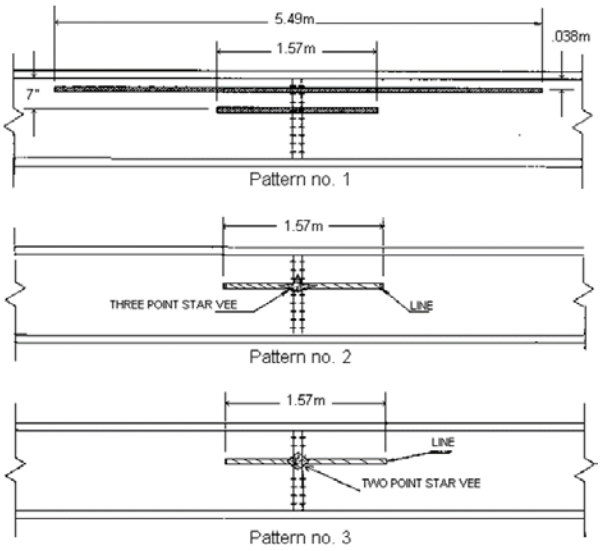

Figure 6.4. Repaired sections (length) of the Iowa steel bridge

Table 6.6. Cost estimate from Iowa report for heat-straightening repairs

By contract:	$20,000
In-house:	
Equipment purchase:	$5,320
Equipment rental:	$735
Cost of technical guidance, the training course, on-site assistance, and travel and expenses	$4,800
Total	$10,855
Length of repair (m)	5.49
Length of repair (ft)	18.01
Cost/LF (In-house)	$602.66
Cost/LF (Contract)	$1,110.38
Average Cost/LF	$856.52
Revised Cost/LF (Florida, 2015)	$1,510.45
Approx: USE/LF	$1,600.00

6.3.2 Cost of "Mitigate Settlement or Scour"

Based on a relevant prior study for FDOT BMS costs (Sobanjo and Thompson, 2010), data were available for costs related to scour mitigation and repairs: total project costs for riprap projects; and bid unit costs for pay items. The latter were available for pay items measured by SF (e.g., "0530 78 RIPRAP (ARTICULATING BLOCK)," "0547 70 RIPRAP FABRIC-FORMED CONCRETE (8" FILTER POINTS)," and "0547 70 2 RIPRAP FABRIC-FORMED CONCRETE (10" FILTER POINTS)") and items measured by CY ("0530 1 RIPRAP (SAND-CEMENT)"). Estimated cost for the two pay item categories (SF and CY) were $17.20/SY and $1,015.14/CY respectively. Using the total costs of eight riprap projects as indicated in Sobanjo and Thompson (2010), the project costs were estimated relative to the deck area, bridge length, and number of main spans. The average values were respectively, $39.28/SF, $1,708.66/LF, and $46,825.06/Span

(Table 6.7). The cost per span was used to estimate a cost per length of abutment/pierwidth (per LF), assuming each abutment has same width as the bridge. Then, assuming four columns per abutment/pier, an average cost estimate was derived for each column as $9,430.96/EA. The cost for columns and abutment elements were assigned directly to the BMS list of element state actions. Trestles, Caps/Footings, Culverts, and Walls were assumed to be similar to abutments and measured by LF. Piles and Poles, both measured by EA were assumed to be similar to Columns. For the elements needing "Mitigate settlement or scour" actions, and measured by SF, e.g., Abutment Slope Protection, the project cost per deck area were used to estimate the costs instead of the bid unit price of riprap. Due to unit incompatibility, costs could not be estimated for the Steel tower elements. The list of recommended costs for the "Mitigate settlement or scour" actions are shown in Table 6.8, along with some of the assumptions.

Table 6.7. Estimates from FDOT Riprap project costs

BridgeNo	TypeWork	LetYear	ProjCost2009	MAIN SPANS	CostPer LengthLF	CostPerDeck AreaSF	CostPer Span	CostPer Abutment/Pier	CostPerAbutment /PierPerWidthLF	CostPer Column
130082	RIPRAP	2005	425,166.22	5	$2,837.03	$27.71	$85,033.24	$70,861.04	$692.17	$17,715.26
160026	RIPRAP	2005	113,348.64	2	$2,454.02	$69.91	$56,674.32	$37,782.88	$1,076.76	$9,445.72
500082	RIPRAP	2005	465,048.40	6	$807.58	$18.92	$77,508.07	$66,435.49	$1,554.47	$16,608.87
030076	RIPRAP	2008	192,634.23	8	$1,595.92	$48.67	$24,079.28	$21,403.80	$652.75	$5,350.95
030082	RIPRAP	2008	27,452.70	4	$480.05	$14.45	$6,863.18	$5,490.54	$165.43	$1,372.64
030099	RIPRAP	2008	34,763.22	4	$598.79	$17.65	$8,690.81	$6,952.64	$205.14	$1,738.16
170037	RIPRAP	2008	129,425.59	3	$2,391.46	$55.81	$43,141.86	$32,356.40	$754.42	$8,089.10
920011	RIPRAP	2007	363,048.45	5	$2,504.42	$61.09	$72,609.69	$60,508.07	$1,476.16	$15,127.02
				Means:	$1,708.66	$39.28	$46,825.06	$37,723.86	$822.16	$9,430.96

Table 6.8. Recommended costs for "Mitigate settlement or scour"

New Elemkey	NewElemName	Newskey	Newakey	Newactlong	Cost 2015 ($)	Units	Comments
202	Steel Column	3	4	Mitigate settlement or scour	$9,430.96	EA	
202	Steel Column	4	3	Mitigate settlement or scour	$9,430.96	EA	
203	Other Material Column	3	3	Mitigate settlement or scour	$9,430.96	EA	
203	Other Material Column	4	3	Mitigate settlement or scour	$9,430.96	EA	
204	Prestressed Concrete Column	3	2	Mitigate settlement or scour	$9,430.96	EA	
204	Prestressed Concrete Column	4	2	Mitigate settlement or scour	$9,430.96	EA	
205	Reinforced Concrete Column	3	2	Mitigate settlement or scour	$9,430.96	EA	
205	Reinforced Concrete Column	4	2	Mitigate settlement or scour	$9,430.96	EA	
206	Timber Column	3	2	Mitigate settlement or scour	$9,430.96	EA	
206	Timber Column	4	2	Mitigate settlement or scour	$9,430.96	EA	
207	Steel Tower	3	4	Mitigate settlement or scour		FT	Incompatible unit (LF vs. EA)
207	Steel Tower	4	3	Mitigate settlement or scour		FT	Incompatible unit (LF vs. EA)
208	Timber Trestle	3	2	Mitigate settlement or scour	822.16	FT	Trestle assumed similar to abutment/truss.
208	Timber Trestle	4	2	Mitigate settlement or scour	822.16	FT	Trestle assumed similar to abutment/truss.
210	Reinforced Concrete Pier Wall	3	2	Mitigate settlement or scour	822.16	FT	
210	Reinforced Concrete Pier Wall	4	2	Mitigate settlement or scour	822.16	FT	
211	Other Material Pier Wall	3	3	Mitigate settlement or scour	822.16	FT	
211	Other Material Pier Wall	4	3	Mitigate settlement or scour	822.16	FT	
213	Masonry Pier Wall	3	2	Mitigate settlement or scour	822.16	FT	
213	Masonry Pier Wall	4	2	Mitigate settlement or scour	822.16	FT	
215	Reinforced Concrete Abutment	3	2	Mitigate settlement or scour	822.16	FT	
215	Reinforced Concrete Abutment	4	2	Mitigate settlement or scour	822.16	FT	
216	Timber Abutment	3	2	Mitigate settlement or scour	822.16	FT	
216	Timber Abutment	4	2	Mitigate settlement or scour	822.16	FT	
217	Masonry Abutment	3	2	Mitigate settlement or scour	822.16	FT	
217	Masonry Abutment	4	2	Mitigate settlement or scour	822.16	FT	
218	Other Material Abutment	3	3	Mitigate settlement or scour	822.16	FT	
218	Other Material Abutment	4	3	Mitigate settlement or scour	822.16	FT	
219	Steel Abutment	3	4	Mitigate settlement or scour	822.16	FT	
219	Steel Abutment	4	3	Mitigate settlement or scour	822.16	FT	
220	Reinforced Concrete Pile Cap/Footing	3	2	Mitigate settlement or scour	822.16	FT	Cap/Footing assumed similar to abutment
220	Reinforced Concrete Pile Cap/Footing	4	2	Mitigate settlement or scour	822.16	FT	Cap/Footing assumed similar to abutment
225	Steel Pile	3	4	Mitigate settlement or scour	$9,430.96	EA	Assumed cost for column
225	Steel Pile	4	3	Mitigate settlement or scour	$9,430.96	EA	Assumed cost for column
226	Prestressed Concrete Pile	3	2	Mitigate settlement or scour	$9,430.96	EA	Assumed cost for column
226	Prestressed Concrete Pile	4	2	Mitigate settlement or scour	$9,430.96	EA	Assumed cost for column
227	Reinforced Concrete Pile	3	2	Mitigate settlement or scour	$9,430.96	EA	Assumed cost for column
227	Reinforced Concrete Pile	4	2	Mitigate settlement or scour	$9,430.96	EA	Assumed cost for column
228	Timber Pile	3	2	Mitigate settlement or scour	$9,430.96	EA	Assumed cost for column
228	Timber Pile	4	2	Mitigate settlement or scour	$9,430.96	EA	Assumed cost for column
229	Other Material Pile	3	3	Mitigate settlement or scour	$9,430.96	EA	Assumed cost for column
229	Other Material Pile	4	3	Mitigate settlement or scour	$9,430.96	EA	Assumed cost for column
240	Steel Culvert	3	2	Mitigate settlement or scour	822.16	FT	Culvert assumed similar to abutment (LF)
240	Steel Culvert	4	2	Mitigate settlement or scour	822.16	FT	Culvert assumed similar to abutment (LF)
241	Reinforced Concrete Culvert	3	2	Mitigate settlement or scour	822.16	FT	Culvert assumed similar to abutment (LF)
241	Reinforced Concrete Culvert	4	2	Mitigate settlement or scour	822.16	FT	Culvert assumed similar to abutment (LF)
242	Timber Culvert	3	2	Mitigate settlement or scour	822.16	FT	Culvert assumed similar to abutment (LF)
242	Timber Culvert	4	2	Mitigate settlement or scour	822.16	FT	Culvert assumed similar to abutment (LF)
243	Other Culvert	3	2	Mitigate settlement or scour	822.16	FT	Culvert assumed similar to abutment (LF)
243	Other Culvert	4	2	Mitigate settlement or scour	822.16	FT	Culvert assumed similar to abutment (LF)
244	Masonry Culvert	3	2	Mitigate settlement or scour	822.16	FT	Culvert assumed similar to abutment (LF)
245	Prestressed Concrete Culvert	3	2	Mitigate settlement or scour	822.16	FT	Culvert assumed similar to abutment (LF)
245	Prestressed Concrete Culvert	4	2	Mitigate settlement or scour	822.16	FT	Culvert assumed similar to abutment (LF)
8298	Pile Jacket	3	2	Mitigate settlement or scour	$9,430.96	EA	Assumed cost for column
8298	Pile Jacket	4	2	Mitigate settlement or scour	$9,430.96	EA	Assumed cost for column
8386	Fender/Dolphin System (Metal)	3	2	Mitigate settlement or scour	822.16	FT	Assume cost for abutment
8386	Fender/Dolphin System (Metal)	4	2	Mitigate settlement or scour	822.16	FT	Assume cost for abutment
8387	Fender/Dolphin System (Prestressed Concrete)	3	2	Mitigate settlement or scour	822.16	FT	Assume cost for abutment
8387	Fender/Dolphin System (Prestressed Concrete)	4	2	Mitigate settlement or scour	822.16	FT	Assume cost for abutment
8388	Fender/Dolphin System (Reinforced Concrete)	3	2	Mitigate settlement or scour	822.16	FT	Assume cost for abutment
8388	Fender/Dolphin System (Reinforced Concrete)	4	2	Mitigate settlement or scour	822.16	FT	Assume cost for abutment
8389	Fender/Dolphin System (Timber)	3	2	Mitigate settlement or scour	822.16	FT	Assume cost for abutment
8389	Fender/Dolphin System (Timber)	4	2	Mitigate settlement or scour	822.16	FT	Assume cost for abutment
8390	Fender/Dolphin System (Other material)	3	2	Mitigate settlement or scour	822.16	FT	Assume cost for abutment
8390	Fender/Dolphin System (Other material)	4	2	Mitigate settlement or scour	822.16	FT	Assume cost for abutment
8393	Bulkhead/Seawall	3	2	Mitigate settlement or scour	822.16	FT	Assume cost for abutment
8393	Bulkhead/Seawall	4	2	Mitigate settlement or scour	822.16	FT	Assume cost for abutment
8394	Abutment Slope Protection (Reinforced or Plain Concrete)	3	2	Mitigate settlement or scour	39.28	SF	Assumed project cost/SF for Riprap
8394	Abutment Slope Protection (Reinforced or Plain Concrete)	4	2	Mitigate settlement or scour	39.28	SF	Assumed project cost/SF for Riprap
8395	Abutment Slope Protection (Timber)	3	2	Mitigate settlement or scour	39.28	SF	Assumed project cost/SF for Riprap
8395	Abutment Slope Protection (Timber)	4	2	Mitigate settlement or scour	39.28	SF	Assumed project cost/SF for Riprap
8396	Abutment Slope Protection (Other material)	3	2	Mitigate settlement or scour	39.28	SF	Assumed project cost/SF for Riprap
8396	Abutment Slope Protection (Other material)	4	2	Mitigate settlement or scour	39.28	SF	Assumed project cost/SF for Riprap
8474	Wingwall/Retaining Wall (Metal)	3	2	Mitigate settlement or scour	822.16	FT	Assume cost for abutment
8474	Wingwall/Retaining Wall (Metal)	4	2	Mitigate settlement or scour	822.16	FT	Assume cost for abutment
8475	Wingwall/Retaining Wall (Reinforced or Plain Concrete)	3	2	Mitigate settlement or scour	822.16	FT	Assume cost for abutment
8475	Wingwall/Retaining Wall (Reinforced or Plain Concrete)	4	2	Mitigate settlement or scour	822.16	FT	Assume cost for abutment
8476	Wingwall/Retaining Wall Timber	3	2	Mitigate settlement or scour	822.16	FT	Assume cost for abutment
8476	Wingwall/Retaining Wall Timber	4	2	Mitigate settlement or scour	822.16	FT	Assume cost for abutment
8477	Wingwall/Retaining Wall Other Material	3	2	Mitigate settlement or scour	822.16	FT	Assume cost for abutment
8477	Wingwall/Retaining Wall Other Material	4	2	Mitigate settlement or scour	822.16	FT	Assume cost for abutment
8478	Mechanically Stabilized Earth Wall	3	2	Mitigate settlement or scour	822.16	FT	Assume cost for abutment
8478	Mechanically Stabilized Earth Wall	4	2	Mitigate settlement or scour	822.16	FT	Assume cost for abutment

Table 6.8. Recommended costs for mitigation of settlement and scour repairs (Cont'd)

New Elemkey	NewElemName	Newskey	Newakey	Newactlong	Cost 2015 ($)	Units	Comments
8480	Mast Arm Foundation	3	2	Mitigate settlement or scour	$9,430.96	EA	Assumed cost for column
8481	Mast Arm Vertical Member	3	2	Mitigate settlement or scour	$9,430.96	EA	Assumed cost for column
8483	Concrete Mast Arm Vertical Member	3	2	Mitigate settlement or scour	$9,430.96	EA	Assumed cost for column
8483	Concrete Mast Arm Vertical Member	4	2	Mitigate settlement or scour	$9,430.96	EA	Assumed cost for column
8484	Mast Arm Horizontal Member	3	2	Mitigate settlement or scour	$9,430.96	EA	Assumed cost for column
8487	Overlane Sign Structure Horizontal Member	3	2	Mitigate settlement or scour		FT	
8488	Overlane Sign Structure Vertical Member	3	2	Mitigate settlement or scour	$9,430.96	FT	Assumed cost for column
8489	Overlane Sign Structure Foundation	3	2	Mitigate settlement or scour	$9,430.96	EA	Assumed cost for column
8491	Concrete Overlane Sign Structure Vertical Member	3	2	Mitigate settlement or scour		FT	
8491	Concrete Overlane Sign Structure Vertical Member	4	2	Mitigate settlement or scour		FT	
8496	High Mast Light Poles	3	2	Mitigate settlement or scour	$9,430.96	EA	Assumed cost for column
8499	High Mast Light Pole Foundation	3	2	Mitigate settlement or scour	$9,430.96	EA	Assumed cost for column
9207	Prestressed Concrete Hollow Core Pile	3	2	Mitigate settlement or scour	$9,430.96	EA	Assumed cost for column
9207	Prestressed Concrete Hollow Core Pile	4	2	Mitigate settlement or scour	$9,430.96	EA	Assumed cost for column

6.4 Compiling final costs for element state actions

There was an initial list of 915 element-state-actions, but 62 were removed because though they were in the old Pontis BMS, they are not needed in the new BMS (Table 6.9). For 255 of the 915 actions, no historical data were directly available, so some assumptions had to be made on the similarity between these elements and corresponding elements which had historical costs. For instance, for new elements such as "PSC Concrete Decks," the estimated costs for new element "RC decks" were assumed. This appears reasonable as data to use until FDOT can collect historical cost data on this new element. Another major assumption was that for cases of similar actions being performed at different condition states (typically states 3 and 4) on the same element, the same costs were assumed for both states; these costs may have to be factored to give a higher cost to the action at the worse state.

For the new elements beginning with "Other" the costs were assumed to be that of the most common element in the type of new elements. For example, cost for an action on "Other Material Truss" was assumed to be that of the corresponding cost for BMS element "Steel Truss." For new elements such as "Steel Gusset Plate," the costs were assumed to be same as the estimated costs for new element "Steel Pin & Hanger Assembly." Due to geometrical similarities, new element "Timber Trestles" was assumed to be similar to "Timber Trusses," which had estimated costs available. For new element "Wearing Surfaces," the costs of minor repairs were assumed to be same as the corresponding costs for the new BMS element "RC Deck." The costs for the new element "Steel Pile" were assumed to be the same as those of new BMS element "Steel Column" (same units EA), but the same could not be done for new element "Steel Tower" (LF) because of the difference in the units of measure.

For a few of the elements, some "loose" assumptions were made, such as the following: cost for actions on BMS element "Secondary Steel Cable" being 2/3 of corresponding available cost on the BMS element "Main Steel Cable"; cost of major repairs on "Wearing Surfaces" were assumed to be 1/2 of major repairs' cost on "RC decks." There are also cases like the "Mast Arm Vertical Member" (EA units) where costs were assumed to be the same as available costs for "Overlane Sign Structure Vertical Member" (LF units), but there is a need convert the cost from LF to EA units. The complete list of element state actions and the costs are shown in Table 6.10, along with the assumptions.

6.5 Conclusions

One of the major tasks in this study is to provide preservation unit costs and other cost parameters necessary to run the BMS software for FDOT. Efforts have been described in this section on extracting historical costs from results of previous BMS research projects at FDOT. An assignment mechanism was developed to match new BMS element to old Pontis elements, in order to make use of these historical

cost records. The list of feasible actions from Table 3.10 was matched to corresponding element state action data from the historical costs. The concept of action subcategory, utilized in the previous FDOT BMS studies was also applied in assigning costs.

Table 6.9. List of element state actions omitted from the BMS

New Elemke	NewElemName	Newsk	Newak	Newactshort
12	RC Concrete Deck	1	2	Crack sealing
13	PSC Concrete Deck	1	2	Crack sealing
15	PSC Concrete Top Flange	1	2	Crack sealing
16	RC Concrete Top Flange	1	2	Crack sealing
28	Steel Deck/Open Grid	2	1	Spot blast deck
29	Steel Deck/Conc Grid	2	1	Spot blast deck
30	Corrug/Orthotpc Deck	2	1	Spot blast deck
38	Reinforced Concrete Slab	1	2	Crack sealing
98	Concrete Deck on Precast Deck Panels	1	2	Crack sealing deck
99	Prestressed Concrete Slab (Sonovoid)	1	2	Crack sealing
102	Steel Closed Web/Box Girder	2	1	Spot blast
104	Prestressed Concrete Closed Web/Box Girder	1	1	Crack sealing
105	Reinforced Concrete Closed Web/Box Girder	1	1	Crack sealing
107	Steel Open Girder/Beam	2	1	Spot blast
109	Prestressed Open Girder/Beam	1	1	Crack sealing
110	Reinforced Concrete Open Girder/Beam	1	1	Crack sealing
113	Steel Stringer	2	1	Spot blast
115	Prestressed Concrete Stringer	1	1	Crack sealing
116	Reinforced Concrete Stringer	1	1	Crack sealing
120	Steel Truss	2	1	Spot blast
141	Steel Arch	2	1	Spot blast
143	Prestressed Concrete Arch	1	1	Crack sealing
144	Reinforced Concrete Arch	1	1	Crack sealing
147	Steel Main Cables	2	1	Spot blast
148	Secondary Steel Cables	2	1	Spot blast
152	Steel Floor Beam	2	1	Spot blast
154	Prestressed Concrete Floor Beam	1	1	Crack sealing
155	Reinforced Concrete Floor Beam	1	1	Clean
155	Reinforced Concrete Floor Beam	1	2	Miscellaneous Maintenance
161	Steel Pin and Pin & Hanger Assembly or Both	2	1	Spot blast
162	Steel Gusset Plate	2	1	Spot blast
202	Steel Column	2	1	Spot blast
203	Other Material Column	2	1	Spot blast
207	Steel Tower	2	1	Spot blast
211	Other Material Pier Wall	2	1	Spot blast
218	Other Material Abutment	2	1	Spot blast
219	Steel Abutment	2	1	Spot blast
225	Steel Pile	2	1	Spot blast
229	Other Material Pile	2	1	Spot blast
231	Steel Pier Cap	2	1	Spot blast
240	Steel Culvert	2	1	Spot blast
330	Metal Bridge Railing	2	1	Spot blast
332	Timber Bridge Railing	1	2	Miscellaneous Maintenance
333	Other Bridge Railing	1	2	Miscellaneous Maintenance
8097	PS Conc Slab (Hybrid)	1	2	Crack sealing slab
8098	Conc Deck on PC Pane	1	2	Crack sealing deck
8099	PS Conc Slab (Sonovoid)	1	2	Crack sealing slab
8298	Pile Jacket	2	2	Minor repair
8480	Mast Arm Foundation	2	1	Spot blast
8481	Mast Arm Vertical Member	2	1	Spot blast
8484	Mast Arm Horizontal Member	2	1	Spot blast
8487	Overlane Sign Structure Horizontal Member	2	1	Spot blast
8488	Overlane Sign Structure Vertical Member	2	1	Spot blast
8489	Overlane Sign Structure Foundation	2	1	Spot blast
8496	High Mast Light Poles	2	1	Spot blast
8499	High Mast Light Pole Foundation	2	1	Spot blast
8515	Steel Protective Coating	2	1	Spot blast
8515	Steel Protective Coating	2	2	Polish paint/coating
8515	Steel Protective Coating	3	1	Minor touching of paint/coating
8515	Steel Protective Coating	3	2	Spot blast and reapply partial paint/coating
8515	Steel Protective Coating	4	1	Spot blast and reapply partial paint/coating
8515	Steel Protective Coating	4	2	Spot blast and reapply full paint/coating

Table 6.10. Complete listing of costs for BMS element state actions

New Elemkey	New Element Name	New state key	New action key	New action short label	Cost 2015 ($)	Units	Comments
12	RC Concrete Deck	1	2	Crack sealing		SF	Not needed in BrM
12	RC Concrete Deck	2	1	Minor repair	1.82	SF	
12	RC Concrete Deck	3	1	Major repair	543.43	SF	
12	RC Concrete Deck	4	1	Major repair	543.43	SF	
12	RC Concrete Deck	4	2	Replace deck	67.31	SF	
13	PSC Concrete Deck	1	2	Crack sealing		SF	Not needed in BrM
13	PSC Concrete Deck	2	1	Minor repair	1.82	SF	Assumed same as RC deck
13	PSC Concrete Deck	3	1	Major repair	543.43	SF	Assumed same as RC deck
13	PSC Concrete Deck	4	1	Major repair deck	543.43	SF	Assumed same as RC deck
13	PSC Concrete Deck	4	2	Replace deck	67.31	SF	PSC same as RC
15	PSC Concrete Top Flange	1	2	Crack sealing	1.82	SF	Not needed in BrM
15	PSC Concrete Top Flange	2	1	Minor repair	1.82	SF	Assumed same as RC deck
15	PSC Concrete Top Flange	3	1	Major repair	543.43	SF	Assumed same as RC deck
15	PSC Concrete Top Flange	4	1	Major repair	543.43	SF	Assumed same as RC deck
15	PSC Concrete Top Flange	4	2	Major repair and rehab of flange	543.43	SF	Assumed same as RC deck
16	RC Concrete Top Flange	1	2	Crack sealing	1.82	SF	Not needed in BrM
16	RC Concrete Top Flange	2	1	Minor repair	1.82	SF	Assumed same as RC deck
16	RC Concrete Top Flange	3	1	Major repair	543.43	SF	Assumed same as RC deck
16	RC Concrete Top Flange	4	1	Major repair	543.43	SF	Assumed same as RC deck
16	RC Concrete Top Flange	4	2	Major repair and rehab of flange	543.43	SF	Assumed same as RC deck
28	Steel Deck/Open Grid	2	1	Spot blast deck	22.83	SF	Not needed in BrM
28	Steel Deck/Open Grid	2	2	Minor repair deck	2.28	SF	
28	Steel Deck/Open Grid	3	1	Spot blast and minor repair deck	20.55	SF	
28	Steel Deck/Open Grid	3	2	Spot blast and major repair deck	34.25	SF	
28	Steel Deck/Open Grid	4	1	Spot blast and major repair deck	45.66	SF	
28	Steel Deck/Open Grid	4	2	Replace deck	78.53	SF	
29	Steel Deck/Conc Grid	2	1	Spot blast deck	2.02	SF	Not needed in BrM
29	Steel Deck/Conc Grid	2	2	Minor repair deck	27.40	SF	
29	Steel Deck/Conc Grid	3	1	Spot blast and minor repair deck	2.28	SF	
29	Steel Deck/Conc Grid	3	2	Spot blast and major repair deck	24.66	SF	
29	Steel Deck/Conc Grid	4	1	Spot blast and major repair deck	54.80	SF	
29	Steel Deck/Conc Grid	4	2	Replace deck	89.75	SF	
30	Corrug/Orthotpc Deck	2	1	Spot blast deck	3.92	SF	Not needed in BrM
30	Corrug/Orthotpc Deck	2	2	Minor repair deck	73.72	SF	
30	Corrug/Orthotpc Deck	3	1	Spot blast and minor repair deck	98.31	SF	
30	Corrug/Orthotpc Deck	3	2	Spot blast and major repair deck	54.80	SF	Assumed same as steel deck/open grid
30	Corrug/Orthotpc Deck	4	1	Spot blast and major repair deck	2,457.58	SF	
30	Corrug/Orthotpc Deck	4	2	Replace deck	3,622.81	SF	
31	Timber Deck	2	1	Minor repair deck	5,655.94	SF	
31	Timber Deck	3	1	Major repair deck	13.46	SF	
31	Timber Deck	4	1	Major repair deck	13.46	SF	Same as state 3 repair
31	Timber Deck	4	2	Replace deck	22.44	SF	
38	Reinforced Concrete Slab	1	2	Crack sealing		SF	Not needed in BrM
38	Reinforced Concrete Slab	2	1	Minor repair	1.82	SF	
38	Reinforced Concrete Slab	3	1	Major repair	398.50	SF	Same as RC slab repair in state 4
38	Reinforced Concrete Slab	4	1	Major repair	398.50	SF	
38	Reinforced Concrete Slab	4	2	Replace slab	67.31	SF	
54	Timber Slab	2	1	Minor repair slab	739.60	SF	Same as state 3 repair
54	Timber Slab	3	1	Major repair slab	739.60	SF	
54	Timber Slab	4	1	Major repair slab	1.35	SF	Based on timber slab rehab (old) cost data
54	Timber Slab	4	2	Replace slab	2.24	SF	
60	Other Deck	2	2	Minor repair deck	1.82	SF	Assumed same as RC deck
60	Other Deck	3	1	Major repair deck	543.43	SF	Assumed same as RC deck
60	Other Deck	4	1	Major repair deck	543.43	SF	Assumed same as RC deck
60	Other Deck	4	2	Replace deck	67.31	SF	Other same as RC
65	Other Slab	2	2	Minor repair slab	1.82	SF	Assumed same as RC slab
65	Other Slab	3	1	Major repair slab	398.50	SF	Assumed same as RC slab
65	Other Slab	4	1	Major repair slab	398.50	SF	Assumed same as RC slab
65	Other Slab	4	2	Replace slab	67.31	SF	Other same as RC
98	Concrete Deck on Precast Deck Panels	1	2	Crack sealing deck		SF	Not needed in BrM
98	Concrete Deck on Precast Deck Panels	2	1	Minor repair	1.82	SF	Assumed same as RC deck
98	Concrete Deck on Precast Deck Panels	3	1	Major repair deck	543.43	SF	Assumed same as RC deck
98	Concrete Deck on Precast Deck Panels	4	1	Major repair deck	543.43	SF	Assumed same as RC deck
98	Concrete Deck on Precast Deck Panels	4	2	Replace deck panels	67.31	SF	Assumed same as RC

Table 6.10. Complete listing of costs for BMS element state actions (Cont'd)

New Elemkey	New Element Name	New state key	New action key	New action short label	Cost 2015 ($)	Units	Comments
99	Prestressed Concrete Slab (Sonovoid)	1	2	Crack sealing		SF	Not needed in BrM
99	Prestressed Concrete Slab (Sonovoid)	2	1	Minor repair	1.82	SF	Assumed same as RC slab
99	Prestressed Concrete Slab (Sonovoid)	3	1	Major repair	398.50	SF	Assumed same as RC slab
99	Prestressed Concrete Slab (Sonovoid)	4	1	Major repair	398.50	SF	Assumed same as RC slab
99	Prestressed Concrete Slab (Sonovoid)	4	2	Replace slab	67.31	SF	Assumed same as RC
102	Steel Closed Web/Box Girder	2	1	Spot blast	38.82	FT	Not needed in BrM
102	Steel Closed Web/Box Girder	2	2	Spot blast and minor repair	9,588.79	FT	Same as repair in state 3
102	Steel Closed Web/Box Girder	3	1	Spot blast and minor repair	9,588.79	FT	
102	Steel Closed Web/Box Girder	3	2	Spot blast and major repair	45,660.89	FT	
102	Steel Closed Web/Box Girder	3	3	Repair distortion	1,600.00	FT	
102	Steel Closed Web/Box Girder	4	1	Spot blast and major repair	45,660.89	FT	
102	Steel Closed Web/Box Girder	4	2	Repair distortion	1,600.00	FT	
102	Steel Closed Web/Box Girder	4	3	Replace unit	3,234.31	FT	
104	Prestressed Concrete Closed Web/Box Girder	1	1	Crack sealing		FT	Not needed in BrM
104	Prestressed Concrete Closed Web/Box Girder	2	2	Minor repair	1,370.22	FT	
104	Prestressed Concrete Closed Web/Box Girder	3	1	Major repair	1,078.10	FT	Same as repair in state 4
104	Prestressed Concrete Closed Web/Box Girder	4	1	Major repair	1,078.10	FT	
104	Prestressed Concrete Closed Web/Box Girder	4	2	Replace unit	6,468.63	FT	
105	Reinforced Concrete Closed Web/Box Girder	1	1	Crack sealing	97.03	FT	Not needed in BrM
105	Reinforced Concrete Closed Web/Box Girder	2	2	Minor repair	1,370.22	FT	
105	Reinforced Concrete Closed Web/Box Girder	3	1	Major repair	1,078.10	FT	Same as repair in state 4
105	Reinforced Concrete Closed Web/Box Girder	4	1	Major repair	1,078.10	FT	
105	Reinforced Concrete Closed Web/Box Girder	4	2	Replace unit	1,315.29	FT	
106	Other Material Closed Web/Box Girder	2	2	Minor repair	1,370.22	FT	Assumed same as Prestressed concrete web/box girder
106	Other Material Closed Web/Box Girder	3	1	Major repair	1,078.10	FT	Same as repair in state 4
106	Other Material Closed Web/Box Girder	4	1	Major repair	1,078.10	FT	Assumed same as Reinforced Concrete Closed Web/Box Girder
106	Other Material Closed Web/Box Girder	4	2	Replace unit	1,315.29	FT	Assumed same as RC closed web/box girder
107	Steel Open Girder/Beam	2	1	Spot blast	38.82	FT	Not needed in BrM
107	Steel Open Girder/Beam	2	2	Spot blast and minor repair	155.25	FT	
107	Steel Open Girder/Beam	3	1	Spot blast and minor repair	155.25	FT	Same as repair in state 2
107	Steel Open Girder/Beam	3	2	Spot blast and major repair	13,698.27	FT	
107	Steel Open Girder/Beam	3	3	Repair distortion	1,600.00	FT	
107	Steel Open Girder/Beam	4	1	Spot blast and major repair	13,698.27	FT	
107	Steel Open Girder/Beam	4	2	Repair distortion	1,600.00	FT	
107	Steel Open Girder/Beam	4	3	Replace unit	2,577.28	FT	
109	Prestressed Open Girder/Beam	1	1	Crack sealing	97.03	FT	Not needed in BrM
109	Prestressed Open Girder/Beam	2	2	Minor repair	274.04	FT	
109	Prestressed Open Girder/Beam	3	1	Major repair	1,078.10	FT	Same as repair in state 4
109	Prestressed Open Girder/Beam	4	1	Major repair	1,078.10	FT	
109	Prestressed Open Girder/Beam	4	2	Replace unit	1,059.54	FT	
110	Reinforced Concrete Open Girder/Beam	1	1	Crack sealing		FT	Not needed in BrM
110	Reinforced Concrete Open Girder/Beam	2	2	Minor repair	274.04	FT	
110	Reinforced Concrete Open Girder/Beam	3	1	Major repair	1,078.10	FT	Same as repair in state 4
110	Reinforced Concrete Open Girder/Beam	4	1	Major repair	1,078.10	FT	
110	Reinforced Concrete Open Girder/Beam	4	2	Replace unit	1,059.54	FT	
111	Timber Open Girder/Beam	2	1	Minor repair	53.91	FT	misc. maint. from old cost data
111	Timber Open Girder/Beam	3	1	Major repair	194.06	FT	Same as repair in state 4
111	Timber Open Girder/Beam	4	1	Major repair	194.06	FT	
111	Timber Open Girder/Beam	4	2	Replace unit	429.54	FT	
112	Other Material Open Girder/Beam	2	2	Minor repair	274.04	FT	Assumed same as Reinforced Concrete Open Girder/Beam
112	Other Material Open Girder/Beam	3	1	Major repair	1,078.10	FT	Assumed same as Reinforced Concrete Open Girder/Beam
112	Other Material Open Girder/Beam	4	1	Major repair	1,078.10	FT	Assumed same as Reinforced Concrete Open Girder/Beam
112	Other Material Open Girder/Beam	4	2	Replace unit	601.36	FT	
113	Steel Stringer	2	1	Spot blast		FT	Not needed in BrM
113	Steel Stringer	2	2	Spot blast and minor repair	114.15	FT	Same as repair in state 3
113	Steel Stringer	3	1	Spot blast and minor repair	114.15	FT	
113	Steel Stringer	3	2	Spot blast and major repair	9,132.18	FT	Same as steel repair in state 4
113	Steel Stringer	3	3	Repair distortion	1,600.00	FT	
113	Steel Stringer	4	1	Spot blast and major repair	9,132.18	FT	

Table 6.10. Complete listing of costs for BMS element state actions (Cont'd)

New Elemkey	New Element Name	New state key	New action key	New action short label	Cost 2015 ($)	Units	Comments
113	Steel Stringer	4	2	Repair distortion	1,600.00	FT	
113	Steel Stringer	4	3	Replace unit	601.36	FT	
115	Prestressed Concrete Stringer	1	1	Crack sealing		FT	Not needed in BrM
115	Prestressed Concrete Stringer	2	2	Minor repair	274.04	FT	Assume same as RC Stringer
115	Prestressed Concrete Stringer	3	1	Major repair	1,078.10	FT	Assumed same as RC stringer
115	Prestressed Concrete Stringer	4	1	Major repair	1,078.10	FT	Assumed same as RC stringer
115	Prestressed Concrete Stringer	4	2	Replace unit	709.89	FT	Assumed 2/3 of Prestressed open girder/beam
116	Reinforced Concrete Stringer	1	1	Crack sealing	97.03	FT	Not needed in BrM
116	Reinforced Concrete Stringer	2	2	Minor repair	274.04	FT	
116	Reinforced Concrete Stringer	3	1	Major repair	1,078.10	FT	Same as repair in state 4
116	Reinforced Concrete Stringer	4	1	Major repair	1,078.10	FT	
116	Reinforced Concrete Stringer	4	2	Replace unit	773.18	FT	
117	Timber Stringer	2	1	Minor repair	53.91	FT	misc. maint. from old cost data
117	Timber Stringer	3	1	Major repair	146.62	FT	Same as repair in state 4
117	Timber Stringer	4	1	Major repair	146.62	FT	
117	Timber Stringer	4	2	Replace unit	326.45	FT	
118	Other Material Stringer	2	2	Minor repair	274.04	FT	Assumed same as RC stringer
118	Other Material Stringer	3	1	Major repair	1,078.10	FT	Assumed same as RC stringer
118	Other Material Stringer	4	1	Major repair	1,078.10	FT	Assumed same as RC stringer
118	Other Material Stringer	4	2	Replace unit	773.18	FT	Assumed same as RC stringer
120	Steel Truss	2	1	Spot blast		FT	Not needed in BrM
120	Steel Truss	2	2	Spot blast and minor repair	404.10	FT	Same as state 3
120	Steel Truss	3	1	Spot blast and minor repair	404.10	FT	
120	Steel Truss	3	2	Spot blast and major repair	68,491.34	FT	
120	Steel Truss	3	3	Repair distortion	1,600.00	FT	
120	Steel Truss	4	1	Spot blast and major repair	68,491.34	FT	
120	Steel Truss	4	2	Repair distortion	1,600.00	FT	
120	Steel Truss	4	3	Replace unit	1,724.97	FT	
135	Timber Truss	2	1	Minor repair	53.91	FT	misc. maint. from old cost data
135	Timber Truss	3	1	Major repair	905.61	FT	Same as repair in state 4
135	Timber Truss	4	1	Major repair	905.61	FT	
135	Timber Truss	4	2	Replace unit	1,724.97	FT	
136	Other Material Truss	2	2	Minor repair	404.10	FT	Assumed same as steel truss
136	Other Material Truss	3	1	Major repair	68,491.34	FT	Assumed same as steel truss
136	Other Material Truss	4	1	Major repair	68,491.34	FT	Assumed same as steel truss
136	Other Material Truss	4	2	Replace unit	1,724.97	FT	Assumed same as steel truss
141	Steel Arch	2	1	Spot blast		FT	Not needed in BrM
141	Steel Arch	2	2	Spot blast and minor repair	1,438.32	FT	Same as repair in state 3
141	Steel Arch	3	1	Spot blast and minor repair	1,438.32	FT	
141	Steel Arch	3	2	Spot blast and major repair	57,076.12	FT	
141	Steel Arch	3	3	Repair distortion	1,600.00	FT	
141	Steel Arch	4	1	Spot blast and major repair	57,076.12	FT	
141	Steel Arch	4	2	Repair distortion	1,600.00	FT	
141	Steel Arch	4	3	Replace unit	1,940.59	FT	
142	Other Material Arch	2	2	Minor repair	1,438.32	FT	Assumed same as steel arch
142	Other Material Arch	3	1	Major repair	57,076.12	FT	Assumed same as steel arch
142	Other Material Arch	4	1	Major repair	57,076.12	FT	Same as repair in state 3
142	Other Material Arch	4	2	Replace unit	1,940.59	FT	Assumed same as steel arch
143	Prestressed Concrete Arch	1	1	Crack sealing	97.03	FT	Not needed in BrM
143	Prestressed Concrete Arch	2	2	Minor repair	274.04	FT	
143	Prestressed Concrete Arch	3	1	Major repair	1,078.10	FT	Same as repair in state 4
143	Prestressed Concrete Arch	4	1	Major repair	1,078.10	FT	
143	Prestressed Concrete Arch	4	2	Replace unit	377.34	FT	
144	Reinforced Concrete Arch	1	1	Crack sealing	97.03	FT	Not needed in BrM
144	Reinforced Concrete Arch	2	2	Minor repair	274.04	FT	
144	Reinforced Concrete Arch	3	1	Major repair	1,078.10	FT	Same as repair in state 4
144	Reinforced Concrete Arch	4	1	Major repair	1,078.10	FT	
144	Reinforced Concrete Arch	4	2	Replace unit	3,665.55	FT	
145	Masonry Arch	2	2	Minor repair	274.04	FT	Assumed same as RC arch
145	Masonry Arch	3	1	Major repair	1,078.10	FT	Assumed same as RC arch
145	Masonry Arch	4	1	Major repair	1,078.10	FT	Assumed same as RC arch
145	Masonry Arch	4	2	Replace unit	3,665.55	FT	Assumed same as RC arch
146	Timber Arch	2	1	Minor repair	53.91	FT	same as timber truss
146	Timber Arch	3	1	Major repair	53.91	FT	Same as repair in state 2

Table 6.10. Complete listing of costs for BMS element state actions (Cont'd)

New Elemkey	New Element Name	New state key	New action key	New action short label	Cost 2015 ($)	Units	Comments
146	Timber Arch	4	1	Major repair	905.61	FT	
146	Timber Arch	4	2	Replace unit	3,665.55	FT	Assumed same as RC arch
147	Steel Main Cables	2	1	Spot blast	11,414.67	FT	Not needed in BrM
147	Steel Main Cables	2	2	Spot blast and minor repair	17,122.00	FT	
147	Steel Main Cables	3	1	Spot blast and minor repair	17,122.00	FT	
147	Steel Main Cables	3	2	Spot blast and major repair	258,732.44	FT	Assumerd same as state 4
147	Steel Main Cables	4	1	Spot blast and major repair	258,732.44	FT	
147	Steel Main Cables	4	2	Replace unit	344,976.59	FT	
148	Secondary Steel Cables	2	1	Spot blast		FT	Not needed in BrM
148	Secondary Steel Cables	2	2	Spot blast and minor repair	11,471.74	FT	Assumed 2/3 of steel main cables
148	Secondary Steel Cables	3	1	Spot blast and minor repair	11,471.74	FT	Assumed 2/3 of steel main cables
148	Secondary Steel Cables	3	2	Spot blast and major repair	173,350.74	FT	Assumed 2/3 of steel main cables
148	Secondary Steel Cables	4	1	Spot blast and major repair	173,350.74	FT	Assumed 2/3 of steel main cables
148	Secondary Steel Cables	4	2	Replace unit	231,134.32	FT	Assumed 2/3 of steel main cables
149	Other Material Secondary Cable	2	2	Minor repair	11,471.74	FT	Assumed 2/3 of steel main cables
149	Other Material Secondary Cable	3	1	Major repair	173,350.74	FT	Assumed 2/3 of steel main cables
149	Other Material Secondary Cable	4	1	Major repair	173,350.74	FT	Assumed 2/3 of steel main cables
149	Other Material Secondary Cable	4	2	Replace unit	231,134.32	FT	Assumed 2/3 of steel main cables
152	Steel Floor Beam	2	1	Spot blast	38.82	FT	Not needed in BrM
152	Steel Floor Beam	2	2	Spot blast and minor repair	184.93	FT	Same as state 3
152	Steel Floor Beam	3	1	Spot blast and minor repair	184.93	FT	
152	Steel Floor Beam	3	2	Spot blast and major repair	9,132.18	FT	
152	Steel Floor Beam	3	3	Repair distortion	1,600.00	FT	
152	Steel Floor Beam	4	1	Spot blast and major repair	9,132.18	FT	
152	Steel Floor Beam	4	2	Repair distortion	1,600.00	FT	
152	Steel Floor Beam	4	3	Replace unit	1,317.27	FT	
154	Prestressed Concrete Floor Beam	1	1	Crack sealing		FT	Not needed in BrM
154	Prestressed Concrete Floor Beam	2	2	Minor repair	274.04	FT	
154	Prestressed Concrete Floor Beam	3	1	Major repair	1,078.10	FT	Same as repair in state 4
154	Prestressed Concrete Floor Beam	4	1	Major repair	1,078.10	FT	
154	Prestressed Concrete Floor Beam	4	2	Replace unit	773.18	FT	
155	Reinforced Concrete Floor Beam	1	1	Clean		FT	Not needed in BrM
155	Reinforced Concrete Floor Beam	1	2	Miscellaneous Maintenance		FT	Not needed in BrM
155	Reinforced Concrete Floor Beam	2	2	Minor repair	274.04	FT	Assume same as Prestressed Floor beam
155	Reinforced Concrete Floor Beam	3	1	Major repair	1,078.10	FT	Assume same as Prestressed Floor beam
155	Reinforced Concrete Floor Beam	3	2	Major rehab	1,078.10	FT	Same as repair in state 4
155	Reinforced Concrete Floor Beam	4	1	Major rehab	1,078.10	FT	
155	Reinforced Concrete Floor Beam	4	2	Replace unit	773.18	FT	
156	Timber Floor Beam	2	1	Minor repair	53.91	FT	
156	Timber Floor Beam	3	1	Major repair	215.62	FT	Same as repair in state 4
156	Timber Floor Beam	4	1	Major repair	215.62	FT	
156	Timber Floor Beam	4	2	Replace unit	326.45	FT	
157	Other Material Floor Beam	2	2	Minor repair	274.04	FT	Assume same as RC Floor beam
157	Other Material Floor Beam	3	1	Major repair	274.04	FT	Assume same as RC Floor beam
157	Other Material Floor Beam	4	1	Major repair	274.04	FT	Assume same as RC Floor beam
157	Other Material Floor Beam	4	2	Replace unit	773.18	FT	Assumed same as RC floor beam
161	Steel Pin and Pin & Hanger Assembly or Both	2	1	Spot blast		EA	Not needed in BrM
161	Steel Pin and Pin & Hanger Assembly or Both	2	2	Spot blast and minor repair	259.34	EA	same as state 3
161	Steel Pin and Pin & Hanger Assembly or Both	3	1	Spot blast and minor repair	259.34	EA	
161	Steel Pin and Pin & Hanger Assembly or Both	3	2	Spot blast and major repair	171,220.00	EA	
161	Steel Pin and Pin & Hanger Assembly or Both	4	1	Spot blast and major repair	171,220.00	EA	
161	Steel Pin and Pin & Hanger Assembly or Both	4	2	Replace unit	2,136,972.25	EA	
162	Steel Gusset Plate	2	1	Spot blast		EA	Not needed in BrM
162	Steel Gusset Plate	2	2	Spot blast and minor repair	259.34	EA	assembly
162	Steel Gusset Plate	3	1	Spot blast and minor repair	259.34	EA	assembly
162	Steel Gusset Plate	3	2	Spot blast and major repair	171,220.00	EA	assembly
162	Steel Gusset Plate	3	3	Repair distortion	1,240.00	EA	
162	Steel Gusset Plate	4	1	Spot blast and major repair	171,220.00	EA	assembly
162	Steel Gusset Plate	4	2	Repair distortion	1,240.00	EA	
162	Steel Gusset Plate	4	3	Replace unit	2,136,972.25	EA	assembly
202	Steel Column	2	1	Spot blast		EA	Not needed in BrM
202	Steel Column	2	2	Spot blast and minor repair	57.07	EA	Same as state 3
202	Steel Column	3	1	Spot blast and minor repair	57.07	EA	
202	Steel Column	3	2	Spot blast and major repair	2,282.93	EA	

Table 6.10. Complete listing of costs for BMS element state actions (Cont'd)

New Elemkey	New Element Name	New state key	New action key	New action short label	Cost 2015 ($)	Units	Comments
202	Steel Column	3	3	Repair distortion	24,000.00	EA	
202	Steel Column	3	4	Mitigate settlement or scour	9,430.96	EA	
202	Steel Column	4	1	Spot blast and major repair	2,282.93	EA	
202	Steel Column	4	2	Repair distortion	24,000.00	EA	
202	Steel Column	4	3	Mitigate settlement or scour	9,430.96	EA	
202	Steel Column	4	4	Replace unit	43,122.08	EA	
203	Other Material Column	2	1	Spot blast		EA	Not needed in BrM
203	Other Material Column	2	2	Spot blast and minor repair	2,282.93	EA	Same as state 3
203	Other Material Column	3	1	Spot blast and major repair	2,282.93	EA	Assumed same as steel column
203	Other Material Column	3	2	Repair distortion	24,000.00	EA	
203	Other Material Column	3	3	Mitigate settlement or scour	9,430.96	EA	
203	Other Material Column	4	1	Spot blast and major repair	2,282.93	EA	Assumed same as steel column
203	Other Material Column	4	2	Repair distortion	24,000.00	EA	
203	Other Material Column	4	3	Mitigate settlement or scour	9,430.96	EA	
203	Other Material Column	4	4	Replace unit	43,122.08	EA	Assumed same as RC column
204	Prestressed Concrete Column	2	2	Minor repair	685.07	EA	
204	Prestressed Concrete Column	3	1	Major repair	10,780.52	EA	Same as repair in state 4
204	Prestressed Concrete Column	3	2	Mitigate settlement or scour	9,430.96	EA	
204	Prestressed Concrete Column	4	1	Major repair	10,780.52	EA	
204	Prestressed Concrete Column	4	2	Mitigate settlement or scour	9,430.96	EA	
204	Prestressed Concrete Column	4	3	Replace unit	43,122.08	EA	
205	Reinforced Concrete Column	2	2	Minor repair	685.07	EA	
205	Reinforced Concrete Column	3	1	Major repair	10,780.52	EA	Same as repair in state 4
205	Reinforced Concrete Column	3	2	Mitigate settlement or scour	9,430.96	EA	
205	Reinforced Concrete Column	4	1	Major repair	10,780.52	EA	
205	Reinforced Concrete Column	4	2	Mitigate settlement or scour	9,430.96	EA	
205	Reinforced Concrete Column	4	3	Replace unit	43,122.08	EA	
206	Timber Column	2	1	Minor repair	215.62	EA	
206	Timber Column	3	1	Major repair	1,293.67	EA	Same as repair in state 4
206	Timber Column	3	2	Mitigate settlement or scour	9,430.96	EA	
206	Timber Column	4	1	Major repair	1,293.67	EA	
206	Timber Column	4	2	Mitigate settlement or scour	9,430.96	EA	
206	Timber Column	4	3	Replace unit	2,156.10	EA	
207	Steel Tower	2	1	Spot blast		FT	Not needed in BrM
207	Steel Tower	2	2	Spot blast and minor repair		FT	Cannot be assumed same as column; different units
207	Steel Tower	3	1	Spot blast and minor repair		FT	Cannot be assumed same as column; different units
207	Steel Tower	3	2	Spot blast and major repair		FT	Cannot be assumed same as column; different units
207	Steel Tower	3	3	Repair distortion	1,600.00	FT	
207	Steel Tower	3	4	Mitigate settlement or scour		FT	Cannot be assumed same as column; different units
207	Steel Tower	4	1	Spot blast and major repair		FT	Cannot be assumed same as column; different units
207	Steel Tower	4	2	Repair distortion	1,600.00	FT	
207	Steel Tower	4	3	Mitigate settlement or scour	0.00	FT	Cannot be assumed same as column; different units
207	Steel Tower	4	4	Replace unit	43,122.08	FT	
208	Timber Trestle	2	1	Minor repair	53.91	FT	Similar to timber truss
208	Timber Trestle	3	1	Major repair	905.61	FT	Assume same as timber truss
208	Timber Trestle	3	2	Mitigate settlement or scour		FT	
208	Timber Trestle	4	1	Major repair	905.61	FT	Assume same as timber truss
208	Timber Trestle	4	2	Mitigate settlement or scour	822.16	FT	
208	Timber Trestle	4	3	Replace unit	1,724.97	FT	Assumed same as timber truss
210	Reinforced Concrete Pier Wall	2	2	Minor repair	479.58	FT	
210	Reinforced Concrete Pier Wall	3	1	Major repair	1,078.10	FT	Same as repair in state 4
210	Reinforced Concrete Pier Wall	3	2	Mitigate settlement or scour	822.16	FT	
210	Reinforced Concrete Pier Wall	4	1	Major repair	1,078.10	FT	
210	Reinforced Concrete Pier Wall	4	2	Mitigate settlement or scour	822.16	FT	
210	Reinforced Concrete Pier Wall	4	3	Replace unit	6,468.63	FT	
211	Other Material Pier Wall	2	1	Spot blast		FT	Not needed in BrM
211	Other Material Pier Wall	2	2	Spot blast and minor repair	479.58	FT	Assumed same as RC Pier wall
211	Other Material Pier Wall	3	1	Spot blast and major repair	479.58	FT	Assumed same as RC Pier wall
211	Other Material Pier Wall	3	2	Repair distortion	1,600.00	FT	
211	Other Material Pier Wall	3	3	Mitigate settlement or scour	822.16	FT	
211	Other Material Pier Wall	4	1	Spot blast and major repair	479.58	FT	Assumed same as RC Pier wall

Table 6.10. Complete listing of costs for BMS element state actions (Cont'd)

New Elemkey	New Element Name	New state key	New action key	New action short label	Cost 2015 ($)	Units	Comments
211	Other Material Pier Wall	4	2	Repair distortion	1,600.00	FT	
211	Other Material Pier Wall	4	3	Mitigate settlement or scour	822.16	FT	
211	Other Material Pier Wall	4	4	Replace unit	6,468.63	FT	
212	Timber Pier Wall	2	1	Minor repair	53.91	FT	Assumed same as Timber abutment
212	Timber Pier Wall	2	2	Minor repair & add a protective system	53.91	FT	Assumed same as Timber abutment
212	Timber Pier Wall	3	1	Major repair	797.80	FT	Assumed same as Timber abutment
212	Timber Pier Wall	3	2	Major repair & add a protective system	797.80	FT	Assumed same as Timber abutment
212	Timber Pier Wall	4	1	Major repair		FT	Assumed same as Timber abutment
212	Timber Pier Wall	4	2	Replace unit	1,336.85	FT	Assumed same as Timber abutment
213	Masonry Pier Wall	2	2	Minor repair		FT	
213	Masonry Pier Wall	3	1	Major repair	1,056.54	FT	Assume same as repair on masonry abutment/LF
213	Masonry Pier Wall	3	2	Mitigate settlement or scour	822.16	FT	
213	Masonry Pier Wall	4	1	Major repair	1,056.54	FT	Assume same as repair on masonry abutment/LF
213	Masonry Pier Wall	4	2	Mitigate settlement or scour	822.16	FT	
213	Masonry Pier Wall	4	3	Replace unit	6,468.63	FT	Assumed same as RC pier wall
215	Reinforced Concrete Abutment	2	2	Minor repair	205.53	FT	
215	Reinforced Concrete Abutment	3	1	Major repair		FT	
215	Reinforced Concrete Abutment	3	2	Mitigate settlement or scour	822.16	FT	
215	Reinforced Concrete Abutment	4	1	Major repair	1,078.10	FT	
215	Reinforced Concrete Abutment	4	2	Mitigate settlement or scour	822.16	FT	
215	Reinforced Concrete Abutment	4	3	Replace unit	1,768.09	FT	
216	Timber Abutment	2	1	Minor repair	53.91	FT	
216	Timber Abutment	3	1	Major repair	797.80	FT	Same as repair in state 4
216	Timber Abutment	3	2	Mitigate settlement or scour	822.16	FT	
216	Timber Abutment	4	1	Major repair	797.80	FT	
216	Timber Abutment	4	2	Mitigate settlement or scour	822.16	FT	
216	Timber Abutment	4	3	Replace unit	1,336.85	FT	
217	Masonry Abutment	2	2	Minor repair		FT	
217	Masonry Abutment	3	1	Major repair	1,056.54	FT	Same as repair in state 4
217	Masonry Abutment	3	2	Mitigate settlement or scour	822.16	FT	
217	Masonry Abutment	4	1	Major repair	1,056.54	FT	
217	Masonry Abutment	4	2	Mitigate settlement or scour	822.16	FT	
217	Masonry Abutment	4	3	Replace unit	1,768.09	FT	
218	Other Material Abutment	2	1	Spot blast		FT	Not needed in BrM
218	Other Material Abutment	2	2	Spot blast and minor repair		FT	
218	Other Material Abutment	3	1	Spot blast and major repair	205.53	FT	Assumed same as RC Abutment
218	Other Material Abutment	3	2	Repair distortion	1,600.00	FT	
218	Other Material Abutment	3	3	Mitigate settlement or scour	822.16	FT	
218	Other Material Abutment	4	1	Spot blast and major repair	205.53	FT	Assumed same as RC Abutment
218	Other Material Abutment	4	2	Repair distortion	1,600.00	FT	
218	Other Material Abutment	4	3	Mitigate settlement or scour	822.16	FT	
218	Other Material Abutment	4	4	Replace unit	1,768.09	FT	Assumed same as RC abutment
219	Steel Abutment	2	1	Spot blast		FT	Not needed in BrM
219	Steel Abutment	2	2	Spot blast and minor repair		FT	
219	Steel Abutment	3	1	Spot blast and minor repair		FT	
219	Steel Abutment	3	2	Spot blast and major repair		FT	
219	Steel Abutment	3	3	Repair distortion	1,600.00	FT	
219	Steel Abutment	3	4	Mitigate settlement or scour	822.16	FT	
219	Steel Abutment	4	1	Spot blast and major repair		FT	
219	Steel Abutment	4	2	Repair distortion	1,600.00	FT	
219	Steel Abutment	4	3	Mitigate settlement or scour	822.16	FT	
219	Steel Abutment	4	4	Replace unit		FT	
220	Reinforced Concrete Pile Cap/Footing	2	2	Minor repair	685.07	FT	
220	Reinforced Concrete Pile Cap/Footing	3	1	Major repair	10,780.52	FT	Same as repair in state 4
220	Reinforced Concrete Pile Cap/Footing	3	2	Mitigate settlement or scour		FT	
220	Reinforced Concrete Pile Cap/Footing	4	1	Major repair	10,780.52	FT	
220	Reinforced Concrete Pile Cap/Footing	4	2	Mitigate settlement or scour	822.16	FT	
220	Reinforced Concrete Pile Cap/Footing	4	3	Replace unit	215,610.38	FT	
225	Steel Pile	2	1	Spot blast		EA	Not needed in BrM
225	Steel Pile	2	2	Spot blast and minor repair	57.07	EA	Assume same as steel column
225	Steel Pile	3	1	Spot blast and minor repair	57.07	EA	Assume same as steel column
225	Steel Pile	3	2	Spot blast and major repair	2,282.93	EA	Assume same as steel column
225	Steel Pile	3	3	Repair distortion	24,000.00	EA	

Table 6.10. Complete listing of costs for BMS element state actions (Cont'd)

New Elemkey	New Element Name	New state key	New action key	New action short label	Cost 2015 ($)	Units	Comments
225	Steel Pile	3	4	Mitigate settlement or scour	9,430.96	EA	
225	Steel Pile	4	1	Spot blast and major repair	2,282.93	EA	Assume same as steel column
225	Steel Pile	4	2	Repair distortion	24,000.00	EA	
225	Steel Pile	4	3	Mitigate settlement or scour	9,430.96	EA	
225	Steel Pile	4	4	Replace unit	43,122.08	EA	Assumed same as steel column
226	Prestressed Concrete Pile	2	2	Minor repair		EA	
226	Prestressed Concrete Pile	3	1	Major repair	685.07	EA	
226	Prestressed Concrete Pile	3	2	Mitigate settlement or scour	9,430.96	EA	
226	Prestressed Concrete Pile	4	1	Major repair	685.07	EA	
226	Prestressed Concrete Pile	4	2	Mitigate settlement or scour	9,430.96	EA	
226	Prestressed Concrete Pile	4	3	Replace unit	43,122.08	EA	Assumed same as prestressed concrete column
227	Reinforced Concrete Pile	2	2	Minor repair		EA	
227	Reinforced Concrete Pile	3	1	Major repair	685.07	EA	
227	Reinforced Concrete Pile	3	2	Mitigate settlement or scour	9,430.96	EA	
227	Reinforced Concrete Pile	4	1	Major repair	685.07	EA	
227	Reinforced Concrete Pile	4	2	Mitigate settlement or scour	9,430.96	EA	
227	Reinforced Concrete Pile	4	3	Replace unit	43,122.08	EA	Assumed same as RC column
228	Timber Pile	2	1	Minor repair	215.62	EA	same as timber column
228	Timber Pile	3	1	Major repair	1,293.67	EA	Same as repair in state 4
228	Timber Pile	3	2	Mitigate settlement or scour	9,430.96	EA	
228	Timber Pile	4	1	Major repair	1,293.67	EA	Same as timber column
228	Timber Pile	4	2	Mitigate settlement or scour	9,430.96	EA	
228	Timber Pile	4	3	Replace unit	2,156.10	EA	Assumed same as timber column
229	Other Material Pile	2	1	Spot blast		EA	Not needed in BrM
229	Other Material Pile	2	2	Spot blast and minor repair	685.07	EA	Assumed same as RC column
229	Other Material Pile	3	1	Spot blast and major repair	10,780.52	EA	Assumed same as RC column
229	Other Material Pile	3	2	Repair distortion	24,000.00	EA	
229	Other Material Pile	3	3	Mitigate settlement or scour	9,430.96	EA	
229	Other Material Pile	4	1	Spot blast and major repair	10,780.52	EA	Assumed same as RC column
229	Other Material Pile	4	2	Repair distortion	24,000.00	EA	
229	Other Material Pile	4	3	Mitigate settlement or scour	9,430.96	EA	
229	Other Material Pile	4	4	Replace unit	43,122.08	EA	Assumed same as RC column
231	Steel Pier Cap	2	1	Spot blast		FT	Not needed in BrM
231	Steel Pier Cap	2	2	Spot blast and minor repair	198.63	FT	Same as state 3
231	Steel Pier Cap	3	1	Spot blast and minor repair	198.63	FT	
231	Steel Pier Cap	3	2	Spot blast and major repair	2,283.05	FT	
231	Steel Pier Cap	3	3	Repair distortion	1,600.00	FT	
231	Steel Pier Cap	4	1	Spot blast and major repair	2,283.05	FT	
231	Steel Pier Cap	4	2	Repair distortion	1,600.00	FT	
231	Steel Pier Cap	4	3	Replace unit	1,317.27	FT	
233	Prestressed Concrete Pier Cap	2	2	Minor repair	274.04	FT	
233	Prestressed Concrete Pier Cap	3	1	Major repair	1,078.10	FT	
233	Prestressed Concrete Pier Cap	4	1	Major repair	1,078.10	FT	
233	Prestressed Concrete Pier Cap	4	2	Replace unit	1,317.27	FT	
234	Reinforced Concrete Pier Cap	2	2	Minor repair	274.04	FT	
234	Reinforced Concrete Pier Cap	3	1	Major repair	1,078.10	FT	
234	Reinforced Concrete Pier Cap	4	1	Major repair	1,078.10	FT	
234	Reinforced Concrete Pier Cap	4	2	Replace unit	1,317.27	FT	
235	Timber Pier Cap	2	1	Minor repair	53.91	FT	
235	Timber Pier Cap	3	1	Major repair	194.06	FT	Same as repair in state 4
235	Timber Pier Cap	4	1	Major repair	194.06	FT	
235	Timber Pier Cap	4	2	Replace unit	429.54	FT	
236	Other Material Pier Cap	2	1	Minor repair	274.04	FT	Assumed same as RC pier cap
236	Other Material Pier Cap	3	1	Major repair	274.04	FT	Assumed same as RC pier cap
236	Other Material Pier Cap	4	1	Major repair	1,078.10	FT	Assumed same as RC pier cap
236	Other Material Pier Cap	4	2	Replace unit	1,317.27	FT	Assumed same as RC pier cap
240	Steel Culvert	2	1	Spot blast		FT	Not needed in BrM
240	Steel Culvert	2	2	Spot blast and minor repair	57.08	FT	
240	Steel Culvert	3	1	Spot blast and minor repair	57.08	FT	Same as state 3
240	Steel Culvert	3	2	Mitigate settlement or scour	822.16	FT	
240	Steel Culvert	4	1	Spot blast and major repair	3,424.57	FT	
240	Steel Culvert	4	2	Mitigate settlement or scour	822.16	FT	
240	Steel Culvert	4	3	Replace unit	1,717.17	FT	

Table 6.10. Complete listing of costs for BMS element state actions (Cont'd)

New Elemkey	New Element Name	New state key	New action key	New action short label	Cost 2015 ($)	Units	Comments
241	Reinforced Concrete Culvert	2	2	Minor repair	55.04	FT	
241	Reinforced Concrete Culvert	3	1	Major repair	1,342.92	FT	
241	Reinforced Concrete Culvert	3	2	Mitigate settlement or scour	822.16	FT	
241	Reinforced Concrete Culvert	4	1	Major repair	2,003.37	FT	
241	Reinforced Concrete Culvert	4	2	Mitigate settlement or scour	822.16	FT	
241	Reinforced Concrete Culvert	4	3	Replace unit	1,585.09	FT	
242	Timber Culvert	2	1	Minor repair	55.04	FT	
242	Timber Culvert	3	1	Major repair	1,497.02	FT	Same as repair in state 4
242	Timber Culvert	3	2	Mitigate settlement or scour	822.16	FT	
242	Timber Culvert	4	1	Major repair	1,497.02	FT	
242	Timber Culvert	4	2	Mitigate settlement or scour	822.16	FT	
242	Timber Culvert	4	3	Replace unit	5,944.07	FT	
243	Other Culvert	2	2	Minor repair	55.04	FT	
243	Other Culvert	3	1	Major repair	1,342.92	FT	Assumed same as RC culvert
243	Other Culvert	3	2	Mitigate settlement or scour	822.16	FT	
243	Other Culvert	4	1	Major repair	2,003.37	FT	Assumed same as RC culvert
243	Other Culvert	4	2	Mitigate settlement or scour	822.16	FT	
243	Other Culvert	4	3	Replace unit	5,944.07	FT	
244	Masonry Culvert	2	2	Minor repair	55.04	FT	
244	Masonry Culvert	3	1	Major repair	1,056.54	FT	Assume same as repair on masonry abutment/LF
244	Masonry Culvert	3	2	Mitigate settlement or scour	822.16	FT	
244	Masonry Culvert	4	1	Major repair	1,056.54	FT	Assume same as repair on masonry abutment/LF
244	Masonry Culvert	4	2	Replace unit	1,585.09	FT	Assumed same as RC culvert
245	Prestressed Concrete Culvert	2	2	Minor repair	55.04	FT	Assume same as Prestressed Culvert
245	Prestressed Concrete Culvert	3	1	Major repair	1,342.92	FT	Assumed same as RC culvert
245	Prestressed Concrete Culvert	3	2	Mitigate settlement or scour	822.16	FT	
245	Prestressed Concrete Culvert	4	1	Major repair	2,003.37	FT	Assumed same as RC culvert
245	Prestressed Concrete Culvert	4	2	Mitigate settlement or scour	822.16	FT	
245	Prestressed Concrete Culvert	4	3	Replace unit	1,585.09	FT	Assumed same as RC culvert
300	Strip Seal Expansion Joint	2	2	Minor repair	146.95	FT	
300	Strip Seal Expansion Joint	3	2	Major repair	239.68	FT	
300	Strip Seal Expansion Joint	4	1	Major repair	239.68	FT	Same as in state 3
300	Strip Seal Expansion Joint	4	2	Replace joint	89.46	FT	
301	Pourable Joint Seal	2	2	Minor repair	64.82	FT	
301	Pourable Joint Seal	3	2	Major repair	95.26	FT	Same as in state 4
301	Pourable Joint Seal	4	1	Major repair	95.26	FT	
301	Pourable Joint Seal	4	2	Replace joint	89.46	FT	
302	Compression Joint Seal	2	2	Minor repair	72.27	FT	
302	Compression Joint Seal	3	2	Major repair	202.88	FT	
302	Compression Joint Seal	4	1	Major repair	202.88	FT	
302	Compression Joint Seal	4	2	Replace joint	111.46	FT	
303	Assembly Joint with Seal	2	2	Minor repair	7.33	FT	
303	Assembly Joint with Seal	3	2	Major repair	244.58	FT	
303	Assembly Joint with Seal	4	1	Major repair	244.58	FT	
303	Assembly Joint with Seal	4	2	Replace joint	307.98	FT	
304	Open Expansion Joint	2	2	Minor repair	7.33	FT	
304	Open Expansion Joint	3	2	Major repair	231.71	FT	
304	Open Expansion Joint	4	1	Major repair	231.71	FT	Same as in state 3
304	Open Expansion Joint	4	2	Replace joint	222.92	FT	
305	Assembly Joint without Seal	2	2	Minor repair	7.33	FT	
305	Assembly Joint without Seal	3	2	Major repair	231.71	FT	
305	Assembly Joint without Seal	4	1	Major repair	231.71	FT	
305	Assembly Joint without Seal	4	2	Replace joint	222.92	FT	Assumed same as open expansion joint
306	Other Joint	2	2	Minor repair	146.95	FT	
306	Other Joint	3	2	Major repair	239.68	FT	Assumed same as Strip Seal Expansion Joint
306	Other Joint	4	1	Major repair	239.68	FT	Assumed same as Strip Seal Expansion Joint
306	Other Joint	4	2	Replace joint	222.92	FT	Assumed same as open expansion joint
310	Elastomeric Bearing	2	2	Minor repair	65.72	EA	
310	Elastomeric Bearing	3	1	Major repair	2,005.17	EA	Assumed same as state 4
310	Elastomeric Bearing	4	1	Major repair	2,005.17	EA	
310	Elastomeric Bearing	4	2	Replace unit	11,261.85	EA	
311	Movable Bearing (roller, sliding, etc.)	2	2	Minor repair	215.62	EA	
311	Movable Bearing (roller, sliding, etc.)	3	1	Major repair		EA	

Table 6.10. Complete listing of costs for BMS element state actions (Cont'd)

New Elemkey	New Element Name	New state key	New action key	New action short label	Cost 2015 ($)	Units	Comments
311	Movable Bearing (roller, sliding, etc.)	4	1	Major repair	1,940.49	EA	
311	Movable Bearing (roller, sliding, etc.)	4	2	Replace unit	11,261.85	EA	
312	Enclosed/Concealed Bearing	2	2	Minor repair	215.62	EA	
312	Enclosed/Concealed Bearing	3	1	Major repair	7,977.58	EA	
312	Enclosed/Concealed Bearing	4	1	Major repair	7,977.58	EA	
312	Enclosed/Concealed Bearing	4	2	Replace unit	11,261.85	EA	
313	Fixed Bearing	2	2	Minor repair	215.62	EA	
313	Fixed Bearing	3	1	Major repair	2,889.18	EA	
313	Fixed Bearing	4	1	Major repair	2,889.18	EA	
313	Fixed Bearing	4	2	Replace unit	11,261.85	EA	
314	Pot Bearing	2	2	Minor repair	215.62	EA	
314	Pot Bearing	3	1	Major repair	3,234.16	EA	Assumed same as state 4
314	Pot Bearing	4	1	Major repair	3,234.16	EA	
314	Pot Bearing	4	2	Replace unit	38,465.56	EA	
315	Disk Bearing	2	2	Minor repair	194.04	EA	
315	Disk Bearing	3	1	Major repair	323.42	EA	Assumed same as state 4
315	Disk Bearing	4	1	Major repair	323.42	EA	
315	Disk Bearing	4	2	Replace unit	6,410.95	EA	
316	Other Bearing	2	2	Minor repair	65.72	EA	
316	Other Bearing	3	1	Major repair	2,005.17	EA	Assumed same as elastomeric bearing
316	Other Bearing	4	1	Major repair	2,005.17	EA	Assumed same as elastomeric bearing
316	Other Bearing	4	2	Replace unit	11,261.85	EA	Assumed same as elastomeric bearing
320	Prestressed Concrete Approach Slab	2	1	Minor repair	13.77	SF	
320	Prestressed Concrete Approach Slab	3	1	Major repair	398.50	SF	Different from mudjacking (old cost data)
320	Prestressed Concrete Approach Slab	3	2	Mudjacking	13,461.44	SF	Same as in state 4
320	Prestressed Concrete Approach Slab	4	1	Major repair	398.50	SF	
320	Prestressed Concrete Approach Slab	4	2	Mudjacking	13,461.44	SF	
320	Prestressed Concrete Approach Slab	4	3	Replace unit	29,166.44	SF	
321	Reinforced Concrete Approach Slab	2	1	Minor repair	13.77	SF	
321	Reinforced Concrete Approach Slab	3	1	Major repair	398.50	SF	
321	Reinforced Concrete Approach Slab	3	2	Mudjacking	13,461.44	SF	Same as in state 4
321	Reinforced Concrete Approach Slab	4	1	Major repair	398.50	SF	
321	Reinforced Concrete Approach Slab	4	2	Mudjacking	13,461.44	SF	
321	Reinforced Concrete Approach Slab	4	3	Replace unit	29,166.44	SF	
330	Metal Bridge Railing	2	1	Spot blast		FT	Not needed in BrM
330	Metal Bridge Railing	2	2	Spot blast and minor repair	66.21	FT	Same as state 3
330	Metal Bridge Railing	3	1	Spot blast and minor repair	66.21	FT	
330	Metal Bridge Railing	3	2	Spot blast and major repair	294.51	FT	
330	Metal Bridge Railing	4	1	Spot blast and major repair	294.51	FT	
330	Metal Bridge Railing	4	2	Replace railing	370.32	FT	
331	Reinforced Concrete Bridge Railing	2	2	Minor repair	100.97	FT	
331	Reinforced Concrete Bridge Railing	3	1	Major repair	1,121.84	FT	Same as repair in state 4
331	Reinforced Concrete Bridge Railing	4	1	Major repair	1,121.84	FT	
331	Reinforced Concrete Bridge Railing	4	2	Replace railing	264.51	FT	
332	Timber Bridge Railing	1	2	Miscellaneous Maintenance		FT	Not needed in BrM
332	Timber Bridge Railing	2	2	Minor repair	56.10	FT	
332	Timber Bridge Railing	3	1	Major repair	44.87	FT	
332	Timber Bridge Railing	4	1	Major repair	44.87	FT	
332	Timber Bridge Railing	4	2	Replace unit	177.22	FT	
333	Other Bridge Railing	1	2	Miscellaneous Maintenance		FT	Not needed in BrM
333	Other Bridge Railing	2	2	Minor repair	100.97	FT	
333	Other Bridge Railing	3	1	Major repair	1,121.84	FT	Assumed same as RC railing
333	Other Bridge Railing	4	1	Major repair	1,121.84	FT	Assumed same as RC railing
333	Other Bridge Railing	4	2	Replace unit	317.40	FT	
334	Masonry Bridge Railing	2	2	Minor repair		FT	
334	Masonry Bridge Railing	3	1	Major repair	1,056.54	FT	Assume same as repair on masonry abutment/LF
334	Masonry Bridge Railing	4	1	Major repair	1,056.54	FT	Assume same as repair on masonry abutment/LF
334	Masonry Bridge Railing	4	2	Replace unit	264.51	FT	Assumed same as RC bridge railing
8097	PS Conc Slab (Hybrid)	1	2	Crack sealing slab		SF	Not needed in BrM
8097	PS Conc Slab (Hybrid)	2	1	Minor repair slab	1.82	SF	Assumed same as RC slab
8097	PS Conc Slab (Hybrid)	3	1	Major repair slab	398.50	SF	Assumed same as RC slab
8097	PS Conc Slab (Hybrid)	4	1	Major repair slab	398.50	SF	Assumed same as RC slab
8097	PS Conc Slab (Hybrid)	4	2	Replace slab	67.31	SF	Assumed same as RC

Table 6.10. Complete listing of costs for BMS element state actions (Cont'd)

New Elemkey	New Element Name	New state key	New action key	New action short label	Cost 2015 ($)	Units	Comments
8098	Conc Deck on PC Pane	1	2	Crack sealing deck		SF	Not needed in BrM
8098	Conc Deck on PC Pane	2	1	Minor repair deck	1.82	SF	Assumed same as RC deck
8098	Conc Deck on PC Pane	3	1	Major repair deck	543.43	SF	Assumed same as RC deck
8098	Conc Deck on PC Pane	4	1	Major repair deck	543.43	SF	Assumed same as RC deck
8098	Conc Deck on PC Pane	4	2	Replace deck	67.31	SF	
8099	PS Conc Slab (Sonovoid)	1	2	Crack sealing slab		SF	Not needed in BrM
8099	PS Conc Slab (Sonovoid)	2	1	Minor repair slab	1.82	SF	Assumed same as RC slab
8099	PS Conc Slab (Sonovoid)	3	1	Major repair slab	398.50	SF	Assumed same as RC slab
8099	PS Conc Slab (Sonovoid)	4	1	Major repair slab	398.50	SF	Assumed same as RC slab
8099	PS Conc Slab (Sonovoid)	4	2	Replace slab	69.56	SF	
8199	External Post Tensioning Duct	2	2	Minor repair		FT	
8199	External Post Tensioning Duct	3	1	Major repair		FT	
8199	External Post Tensioning Duct	4	1	Major repair		FT	
8199	External Post Tensioning Duct	4	2	Replace unit		FT	
8290	Channel	2	2	Minor repair	2,107.32	EA	
8290	Channel	3	1	Major repair	2,107.32	EA	
8290	Channel	4	1	Major repair	210,732.30	EA	
8290	Channel	4	2	Major repair/rehab	632,196.92	EA	
8298	Pile Jacket	2	2	Minor repair		EA	Not needed in BrM
8298	Pile Jacket	3	1	Major repair	646.83	EA	
8298	Pile Jacket	3	2	Mitigate settlement or scour	9,430.96	EA	
8298	Pile Jacket	4	1	Major repair	456.59	EA	
8298	Pile Jacket	4	2	Mitigate settlement or scour	9,430.96	EA	
8298	Pile Jacket	4	3	Replace unit	1,078.05	EA	
8386	Fender/Dolphin System (Metal)	2	2	Minor repair	79.91	FT	
8386	Fender/Dolphin System (Metal)	3	1	Major repair		FT	
8386	Fender/Dolphin System (Metal)	3	2	Mitigate settlement or scour	822.16	FT	
8386	Fender/Dolphin System (Metal)	4	1	Major repair		FT	
8386	Fender/Dolphin System (Metal)	4	2	Mitigate settlement or scour	822.16	FT	
8386	Fender/Dolphin System (Metal)	4	3	Replace unit	517.49	FT	
8387	Fender/Dolphin System (Prestressed Concrete)	2	2	Minor repair	97.03	FT	
8387	Fender/Dolphin System (Prestressed Concrete)	3	1	Major repair	1,078.10	FT	Same as repair in state 4
8387	Fender/Dolphin System (Prestressed Concrete)	3	2	Mitigate settlement or scour	822.16	FT	
8387	Fender/Dolphin System (Prestressed Concrete)	4	1	Major repair	1,078.10	FT	
8387	Fender/Dolphin System (Prestressed Concrete)	4	2	Mitigate settlement or scour	822.16	FT	
8387	Fender/Dolphin System (Prestressed Concrete)	4	3	Replace unit	517.49	FT	
8388	Fender/Dolphin System (Reinforced Concrete)	2	2	Minor repair	53.91	FT	
8388	Fender/Dolphin System (Reinforced Concrete)	3	1	Major repair	1,078.10	FT	Same as repair in state 4
8388	Fender/Dolphin System (Reinforced Concrete)	3	2	Mitigate settlement or scour	822.16	FT	
8388	Fender/Dolphin System (Reinforced Concrete)	4	1	Major repair	1,078.10	FT	
8388	Fender/Dolphin System (Reinforced Concrete)	4	2	Mitigate settlement or scour	822.16	FT	
8388	Fender/Dolphin System (Reinforced Concrete)	4	3	Replace unit	517.49	FT	
8389	Fender/Dolphin System (Timber)	2	1	Minor repair	53.91	FT	
8389	Fender/Dolphin System (Timber)	3	1	Major repair		FT	
8389	Fender/Dolphin System (Timber)	3	2	Mitigate settlement or scour	822.16	FT	
8389	Fender/Dolphin System (Timber)	4	1	Major repair		FT	
8389	Fender/Dolphin System (Timber)	4	2	Mitigate settlement or scour	822.16	FT	
8389	Fender/Dolphin System (Timber)	4	3	Replace unit	517.49	FT	
8390	Fender/Dolphin System (Other material)	2	2	Minor repair		FT	
8390	Fender/Dolphin System (Other material)	3	1	Major repair		FT	
8390	Fender/Dolphin System (Other material)	3	2	Mitigate settlement or scour	822.16	FT	
8390	Fender/Dolphin System (Other material)	4	1	Major repair		FT	
8390	Fender/Dolphin System (Other material)	4	2	Mitigate settlement or scour	822.16	FT	
8390	Fender/Dolphin System (Other material)	4	3	Replace unit	517.49	FT	
8393	Bulkhead/Seawall	2	2	Minor repair	329.59	FT	
8393	Bulkhead/Seawall	3	1	Major repair		FT	
8393	Bulkhead/Seawall	3	2	Mitigate settlement or scour	822.16	FT	
8393	Bulkhead/Seawall	4	1	Major repair		FT	

Table 6.10. Complete listing of costs for BMS element state actions (Cont'd)

New Elemkey	New Element Name	New state key	New action key	New action short label	Cost 2015 ($)	Units	Comments
8393	Bulkhead/Seawall	4	2	Mitigate settlement or scour	822.16	FT	
8393	Bulkhead/Seawall	4	3	Replace unit	65.79	FT	
8394	Abutment Slope Protection (Reinforced or Plain Concrete)	2	2	Minor repair	5.39	SF	
8394	Abutment Slope Protection (Reinforced or Plain Concrete)	3	1	Major repair	118.60	SF	
8394	Abutment Slope Protection (Reinforced or Plain Concrete)	3	2	Mitigate settlement or scour	39.28	SF	
8394	Abutment Slope Protection (Reinforced or Plain Concrete)	4	1	Major repair	118.60	SF	
8394	Abutment Slope Protection (Reinforced or Plain Concrete)	4	2	Mitigate settlement or scour	39.28	SF	
8394	Abutment Slope Protection (Reinforced or Plain Concrete)	4	3	Replace unit	136.41	SF	
8395	Abutment Slope Protection (Timber)	2	1	Minor repair	5.39	SF	
8395	Abutment Slope Protection (Timber)	3	1	Major repair	57.08	SF	
8395	Abutment Slope Protection (Timber)	3	2	Mitigate settlement or scour	39.28	SF	
8395	Abutment Slope Protection (Timber)	4	1	Major repair	57.08	SF	
8395	Abutment Slope Protection (Timber)	4	2	Mitigate settlement or scour	39.28	SF	
8395	Abutment Slope Protection (Timber)	4	3	Replace unit	170.51	SF	
8396	Abutment Slope Protection (Other material)	2	2	Minor repair		SF	
8396	Abutment Slope Protection (Other material)	3	1	Major repair		SF	
8396	Abutment Slope Protection (Other material)	3	2	Mitigate settlement or scour	39.28	SF	
8396	Abutment Slope Protection (Other material)	4	1	Major repair		SF	
8396	Abutment Slope Protection (Other material)	4	2	Mitigate settlement or scour	39.28	SF	
8396	Abutment Slope Protection (Other material)	4	3	Replace unit	119.37	SF	
8397	Metal Drainage System	2	2	Minor repair	1,141.47	EA	
8397	Metal Drainage System	3	1	Major repair	1,293.67	EA	
8397	Metal Drainage System	4	1	Major repair	1,293.67	EA	
8397	Metal Drainage System	4	2	Replace unit	1,768.00	EA	
8398	Other Material Drainage System	2	2	Minor repair	1,141.47	EA	assume same as metal drainage system
8398	Other Material Drainage System	3	1	Major repair	1,293.67	EA	assume same as metal drainage system
8398	Other Material Drainage System	4	1	Major repair	1,293.67	EA	sam as state 3
8398	Other Material Drainage System	4	2	Replace unit	1,768.00	EA	
8474	Wingwall/Retaining Wall (Metal)	2	2	Minor repair	57.08	FT	
8474	Wingwall/Retaining Wall (Metal)	3	1	Major repair	273.97	FT	Same as repair in state 4
8474	Wingwall/Retaining Wall (Metal)	3	2	Mitigate settlement or scour	822.16	FT	
8474	Wingwall/Retaining Wall (Metal)	4	1	Major repair	273.97	FT	
8474	Wingwall/Retaining Wall (Metal)	4	2	Mitigate settlement or scour	822.16	FT	
8474	Wingwall/Retaining Wall (Metal)	4	3	Replace unit	131.53	FT	
8475	Wingwall/Retaining Wall (Reinforced or Plain Concrete)	2	2	Minor repair	86.25	FT	
8475	Wingwall/Retaining Wall (Reinforced or Plain Concrete)	3	1	Major repair	797.80	FT	Same as repair in state 4
8475	Wingwall/Retaining Wall (Reinforced or Plain Concrete)	3	2	Mitigate settlement or scour	822.16	FT	
8475	Wingwall/Retaining Wall (Reinforced or Plain Concrete)	4	1	Major repair	797.80	FT	
8475	Wingwall/Retaining Wall (Reinforced or Plain Concrete)	4	2	Mitigate settlement or scour	822.16	FT	
8475	Wingwall/Retaining Wall (Reinforced or Plain Concrete)	4	3	Replace unit	1,315.29	FT	
8476	Wingwall/Retaining Wall Timber	2	1	Minor repair	53.91	FT	
8476	Wingwall/Retaining Wall Timber	3	1	Major repair	388.12	FT	Same as repair in state 4
8476	Wingwall/Retaining Wall Timber	3	2	Mitigate settlement or scour	822.16	FT	
8476	Wingwall/Retaining Wall Timber	4	1	Major repair	388.12	FT	
8476	Wingwall/Retaining Wall Timber	4	2	Mitigate settlement or scour	822.16	FT	
8476	Wingwall/Retaining Wall Timber	4	3	Replace unit	657.65	FT	
8477	Wingwall/Retaining Wall Other Material	2	2	Minor repair	86.25	FT	Assumed same as RC wingwall/retining wall
8477	Wingwall/Retaining Wall Other Material	3	1	Major repair	797.80	FT	Assumed same as RC wingwall/retining wall
8477	Wingwall/Retaining Wall Other Material	3	2	Mitigate settlement or scour	822.16	FT	
8477	Wingwall/Retaining Wall Other Material	4	1	Major repair	797.80	FT	Assumed same as RC wingwall/retining wall
8477	Wingwall/Retaining Wall Other Material	4	2	Mitigate settlement or scour	822.16	FT	
8477	Wingwall/Retaining Wall Other Material	4	3	Replace unit	1,315.29	FT	
8478	Mechanically Stabilized Earth Wall	2	2	Minor repair		FT	
8478	Mechanically Stabilized Earth Wall	3	1	Major repair	646.86	FT	Same as repair in state 4
8478	Mechanically Stabilized Earth Wall	3	2	Mitigate settlement or scour	822.16	FT	
8478	Mechanically Stabilized Earth Wall	4	1	Major repair	646.86	FT	
8478	Mechanically Stabilized Earth Wall	4	2	Mitigate settlement or scour	822.16	FT	
8478	Mechanically Stabilized Earth Wall	4	3	Replace unit	789.17	FT	

Table 6.10. Complete listing of costs for BMS element state actions (Cont'd)

New Elemkey	New Element Name	New state key	New action key	New action short label	Cost 2015 ($)	Units	Comments
8480	Mast Arm Foundation	2	1	Spot blast		EA	Not needed in BrM
8480	Mast Arm Foundation	2	2	Spot blast and minor repair		EA	
8480	Mast Arm Foundation	3	1	Spot blast and major repair	2,156.10	EA	Assume same as High Mast Light Pole Foundation
8480	Mast Arm Foundation	3	2	Mitigate settlement or scour	9,430.96	EA	
8480	Mast Arm Foundation	4	1	Spot blast and major repair	2,156.10	EA	Assume same as High Mast Light Pole Foundation
8480	Mast Arm Foundation	4	2	Replace unit	222,292.26	EA	Assumed same as High mast light pole foundation
8481	Mast Arm Vertical Member	2	1	Spot blast		EA	Not needed in BrM
8481	Mast Arm Vertical Member	2	2	Spot blast and minor repair		EA	
8481	Mast Arm Vertical Member	3	1	Spot blast and major repair	232.87	EA	Unit not same as comparable items.
8481	Mast Arm Vertical Member	3	2	Mitigate settlement or scour	9,430.96	EA	
8481	Mast Arm Vertical Member	4	1	Spot blast and major repair	232.87	EA	Unit not same as comparable items.
8481	Mast Arm Vertical Member	4	2	Replace unit		EA	
8483	Concrete Mast Arm Vertical Member	2	2	Minor repair		EA	
8483	Concrete Mast Arm Vertical Member	3	1	Major repair		EA	
8483	Concrete Mast Arm Vertical Member	3	2	Mitigate settlement or scour	9,430.96	EA	
8483	Concrete Mast Arm Vertical Member	4	1	Major repair		EA	
8483	Concrete Mast Arm Vertical Member	4	2	Mitigate settlement or scour	9,430.96	EA	
8483	Concrete Mast Arm Vertical Member	4	3	Replace unit		EA	
8484	Mast Arm Horizontal Member	2	1	Spot blast		EA	Not needed in BrM
8484	Mast Arm Horizontal Member	2	2	Spot blast and minor repair		EA	
8484	Mast Arm Horizontal Member	3	1	Spot blast and major repair		EA	Unit not same as comparable items.
8484	Mast Arm Horizontal Member	3	2	Mitigate settlement or scour	9,430.96	EA	
8484	Mast Arm Horizontal Member	4	1	Spot blast and major repair	232.87	EA	Unit not same as comparable items.
8484	Mast Arm Horizontal Member	4	2	Replace unit		EA	Could assume same as Overlane Sign Structure Horizontal Member but need to convert from LF to EA
8487	Overlane Sign Structure Horizontal Member	2	1	Spot blast		FT	Not needed in BrM
8487	Overlane Sign Structure Horizontal Member	2	2	Spot blast and minor repair		FT	
8487	Overlane Sign Structure Horizontal Member	3	1	Spot blast and major repair	232.87	FT	Same as repair in state 4
8487	Overlane Sign Structure Horizontal Member	3	2	Mitigate settlement or scour		FT	
8487	Overlane Sign Structure Horizontal Member	4	1	Spot blast and major repair	232.87	FT	
8487	Overlane Sign Structure Horizontal Member	4	2	Replace unit	23,341.75	FT	
8488	Overlane Sign Structure Vertical Member	2	1	Spot blast		FT	Not needed in BrM
8488	Overlane Sign Structure Vertical Member	2	2	Spot blast and minor repair		FT	
8488	Overlane Sign Structure Vertical Member	3	1	Spot blast and major repair	232.87	FT	Same as repair in state 4
8488	Overlane Sign Structure Vertical Member	3	2	Mitigate settlement or scour	9,430.96	FT	
8488	Overlane Sign Structure Vertical Member	4	1	Spot blast and major repair	232.87	FT	
8488	Overlane Sign Structure Vertical Member	4	2	Replace unit	23,341.75	FT	
8489	Overlane Sign Structure Foundation	2	1	Spot blast		EA	Not needed in BrM
8489	Overlane Sign Structure Foundation	2	2	Spot blast and minor repair		EA	
8489	Overlane Sign Structure Foundation	3	1	Spot blast and major repair	232.87	FT	Same as repair in state 4
8489	Overlane Sign Structure Foundation	3	2	Mitigate settlement or scour	9,430.96	EA	
8489	Overlane Sign Structure Foundation	4	1	Spot blast and major repair	2,156.10	EA	
8489	Overlane Sign Structure Foundation	4	2	Replace unit	991.81	EA	
8491	Concrete Overlane Sign Structure Vertical Member	2	2	Minor repair		FT	
8491	Concrete Overlane Sign Structure Vertical Member	3	1	Major repair		FT	
8491	Concrete Overlane Sign Structure Vertical Member	3	2	Mitigate settlement or scour		FT	
8491	Concrete Overlane Sign Structure Vertical Member	4	1	Major repair		FT	
8491	Concrete Overlane Sign Structure Vertical Member	4	2	Mitigate settlement or scour		FT	
8491	Concrete Overlane Sign Structure Vertical Member	4	3	Replace unit		FT	
8496	High Mast Light Poles	2	1	Spot blast		EA	Not needed in BrM
8496	High Mast Light Poles	2	2	Spot blast and minor repair	13,697.60	EA	
8496	High Mast Light Poles	3	1	Spot blast and major repair	13,697.60	EA	Same as state 4
8496	High Mast Light Poles	3	2	Mitigate settlement or scour	9,430.96	EA	
8496	High Mast Light Poles	4	1	Spot blast and major repair	13,697.60	EA	
8496	High Mast Light Poles	4	2	Replace unit	1,111,460.44	EA	
8499	High Mast Light Pole Foundation	2	1	Spot blast		EA	Not needed in BrM
8499	High Mast Light Pole Foundation	2	2	Spot blast and minor repair		EA	
8499	High Mast Light Pole Foundation	3	1	Spot blast and major repair	2,156.10	EA	Same as repair in state 4
8499	High Mast Light Pole Foundation	3	2	Mitigate settlement or scour	9,430.96	EA	

Table 6.10. Complete listing of costs for BMS element state actions (Cont'd)

New Elemkey	New Element Name	New state key	New action key	New action short label	Cost 2015 ($)	Units	Comments
8499	High Mast Light Pole Foundation	4	1	Spot blast and major repair	2,156.10	EA	
8499	High Mast Light Pole Foundation	4	2	Replace unit	222,292.26	EA	
8510	Wearing Surfaces	2	2	Minor repair	1.82	SF	Assumed same as minor repairs on RC deck
8510	Wearing Surfaces	3	1	Major repair	271.71	SF	Assumed same as half of major repairs on RC deck
8510	Wearing Surfaces	4	1	Major repair	271.71	SF	Assumed same as half of major repairs on RC deck
8510	Wearing Surfaces	4	2	Replace unit	543.43	SF	Assumed same as major repairs on RC deck
8515	Steel Protective Coating	2	1	Spot blast		SF	Not needed in BrM
8515	Steel Protective Coating	2	2	Polish paint/coating		SF	Not needed in BrM
8515	Steel Protective Coating	3	1	Minor touching of paint/coating		SF	Not needed in BrM
8515	Steel Protective Coating	3	2	Spot blast and reapply partial paint/coating		SF	Not needed in BrM
8515	Steel Protective Coating	4	1	Spot blast and reapply partial paint/coating		SF	Not needed in BrM
8515	Steel Protective Coating	4	2	Spot blast and reapply full paint/coating		SF	Not needed in BrM
8516	Paint on Steel	2	1	Spot blast		SF	Need paint items from old cost data are for various units (LF, Sq. m., decks, ea, etc.)
8516	Paint on Steel	2	2	Polish paint/coating		SF	Need paint items from old cost data are for various units (LF, Sq. m., decks, ea, etc.)
8516	Paint on Steel	3	1	Minor touching of paint/coating		SF	Paint from old cost data are for various units (LF, Sq. m., decks, ea, etc.)
8516	Paint on Steel	3	2	Spot blast and reapply partial paint/coating		SF	Need paint items from old cost data are for various units (LF, Sq. m., decks, ea, etc.)
8516	Paint on Steel	4	1	Spot blast and reapply partial paint/coating		SF	Need paint items from old cost data are for various units (LF, Sq. m., decks, ea, etc.)
8516	Paint on Steel	4	2	Spot blast and reapply full paint/coating	2,457.58	SF	rehab/repalce paint from old cost data are for steel deck (only item based of SF)
8517	Weathering Steel Patina	2	1	Spot blast		SF	
8517	Weathering Steel Patina	2	2	Polish paint/coating		SF	
8517	Weathering Steel Patina	3	1	Minor touching of paint/coating		SF	
8517	Weathering Steel Patina	3	2	Spot blast and reapply partial paint/coating		SF	
8517	Weathering Steel Patina	4	1	Spot blast and reapply partial paint/coating		SF	
8517	Weathering Steel Patina	4	2	Spot blast and reapply full paint/coating		SF	Need paint items from old cost data are for various units (LF, Sq. m., decks, ea, etc.)
8518	Galvanized or Metalized Steel	2	1	Spot blast		SF	
8518	Galvanized or Metalized Steel	2	2	Polish paint/coating		SF	
8518	Galvanized or Metalized Steel	3	1	Minor touching of paint/coating		SF	
8518	Galvanized or Metalized Steel	3	2	Spot blast and reapply partial paint/coating		SF	
8518	Galvanized or Metalized Steel	4	1	Spot blast and reapply partial paint/coating		SF	
8518	Galvanized or Metalized Steel	4	2	Spot blast and reapply full paint/coating		SF	
8519	Other Steel Protective Coatings	2	1	Clean surface		SF	
8519	Other Steel Protective Coatings	2	2	Polish paint/coating		SF	
8519	Other Steel Protective Coatings	3	1	Minor touching of paint/coating		SF	
8519	Other Steel Protective Coatings	3	2	Spot blast and reapply partial paint/coating		SF	
8519	Other Steel Protective Coatings	4	1	Spot blast and reapply partial paint/coating		SF	
8519	Other Steel Protective Coatings	4	2	Spot blast and reapply full paint/coating		SF	
8520	Concrete Reinforcing Steel Protective System	2	1	Miscellaneous maintenance		SF	
8520	Concrete Reinforcing Steel Protective System	2	2	Minor repair		SF	
8520	Concrete Reinforcing Steel Protective System	3	1	Minor repair		SF	
8520	Concrete Reinforcing Steel Protective System	3	2	Major repair		SF	
8520	Concrete Reinforcing Steel Protective System	4	1	Major repair		SF	
8520	Concrete Reinforcing Steel Protective System	4	2	Replace system		SF	
8521	Concrete Protective Coating	2	1	Clean surface		SF	
8521	Concrete Protective Coating	2	2	Minor touching of coating		SF	
8521	Concrete Protective Coating	3	1	Minor touching of coating		SF	
8521	Concrete Protective Coating	3	2	Spot blast and reapply partial coating		SF	
8521	Concrete Protective Coating	4	1	Spot blast and reapply partial coating		SF	
8521	Concrete Protective Coating	4	2	Spot blast and reapply full coating		SF	
8540	Open Gearing	2	2	Minor repair	12,117.31	EA	
8540	Open Gearing	3	1	Major repair	24,363.97	EA	Same as repair in state 4
8540	Open Gearing	4	1	Major repair	24,363.97	EA	
8540	Open Gearing	4	2	Replace unit	61,448.96	EA	
8541	Speed Reducers	2	2	Minor repair	17,507.57	EA	
8541	Speed Reducers	3	1	Major repair	35,144.50	EA	Same as repair in state 4
8541	Speed Reducers	4	1	Major repair	35,144.50	EA	

Table 6.10. Complete listing of costs for BMS element state actions (Cont'd)

New Elemkey	New Element Name	New state key	New action key	New action short label	Cost 2015 ($)	Units	Comments
8541	Speed Reducers	4	2	Replace unit	84,088.04	EA	
8542	Shafts	2	2	Minor repair	905.57	EA	
8542	Shafts	3	1	Major repair	1,940.49	EA	Same as repair in state 4
8542	Shafts	4	1	Major repair	1,940.49	EA	
8542	Shafts	4	2	Replace unit	6,252.70	EA	
8543	Shaft Bearing/Shaft Couplings	2	2	Minor repair	711.52	EA	
8543	Shaft Bearing/Shaft Couplings	3	1	Major repair	1,509.27	EA	Same as repair in state 4
8543	Shaft Bearing/Shaft Couplings	4	1	Major repair	1,509.27	EA	
8543	Shaft Bearing/Shaft Couplings	4	2	Replace unit	1,617.07	EA	
8544	Brakes	2	2	Minor repair	970.25	EA	
8544	Brakes	3	1	Major repair	1,940.49	EA	
8544	Brakes	4	1	Major repair	5,821.48	EA	
8544	Brakes	4	2	Replace unit	2,112.97	EA	
8545	Emergency Drive and Back Up Power System	2	2	Minor repair	991.81	EA	
8545	Emergency Drive and Back Up Power System	3	1	Major repair	4,096.59	EA	Same as repair in state 4
8545	Emergency Drive and Back Up Power System	4	1	Major repair	4,096.59	EA	
8545	Emergency Drive and Back Up Power System	4	2	Replace unit	9,702.47	EA	
8546	Span Drive Motors	2	2	Minor repair	1,530.83	EA	
8546	Span Drive Motors	3	1	Major repair	6,252.70	EA	Same as repair in state 4
8546	Span Drive Motors	4	1	Major repair	6,252.70	EA	
8546	Span Drive Motors	4	2	Replace unit	14,445.90	EA	
8547	Hydraulic Power Units	2	2	Minor repair	2,953.87	EA	
8547	Hydraulic Power Units	3	1	Major repair	11,858.58	EA	Same as repair in state 4
8547	Hydraulic Power Units	4	1	Major repair	11,858.58	EA	
8547	Hydraulic Power Units	4	2	Replace unit	89,478.30	EA	
8548	Hydraulic Piping Systems	2	2	Minor repair	711.52	EA	
8548	Hydraulic Piping Systems	3	1	Major repair	3,018.54	EA	Same as repair in state 4
8548	Hydraulic Piping Systems	4	1	Major repair	3,018.54	EA	
8548	Hydraulic Piping Systems	4	2	Replace unit	6,899.53	EA	
8549	Hydraulic Cylinders/Motors/Rotary Actuators	2	2	Minor repair	1,617.07	EA	
8549	Hydraulic Cylinders/Motors/Rotary Actuators	3	1	Major repair	6,468.31	EA	Same as repair in state 4
8549	Hydraulic Cylinders/Motors/Rotary Actuators	4	1	Major repair	6,468.31	EA	
8549	Hydraulic Cylinders/Motors/Rotary Actuators	4	2	Replace unit	19,404.93	EA	
8550	Hopkins Frame	2	2	Minor repair	3,018.54	EA	
8550	Hopkins Frame	3	1	Major repair	19,404.93	EA	Same as repair in state 4
8550	Hopkins Frame	4	1	Major repair	12,074.18	EA	
8550	Hopkins Frame	4	2	Replace unit	75,463.62	EA	
8560	Span Locks/Toe Locks/Heel Stops/Tail Locks	2	2	Minor repair	2,953.87	EA	
8560	Span Locks/Toe Locks/Heel Stops/Tail Locks	3	1	Major repair		EA	
8560	Span Locks/Toe Locks/Heel Stops/Tail Locks	4	1	Major repair		EA	
8560	Span Locks/Toe Locks/Heel Stops/Tail Locks	4	2	Replace unit	6,037.10	EA	
8561	Live Load Shoes/Strike Plates/Buffer Cylinders	2	2	Minor repair	3,234.16	EA	
8561	Live Load Shoes/Strike Plates/Buffer Cylinders	3	1	Major repair	6,468.31	EA	
8561	Live Load Shoes/Strike Plates/Buffer Cylinders	4	1	Major repair	6,468.31	EA	
8561	Live Load Shoes/Strike Plates/Buffer Cylinders	4	2	Replace unit	15,092.72	EA	
8562	Counterweight Support	2	2	Minor repair & add a protective system	862.44	EA	
8562	Counterweight Support	3	1	Major repair	3,449.76	EA	Same as state 4
8562	Counterweight Support	4	1	Major repair	3,449.76	EA	
8562	Counterweight Support	4	2	Replace unit	6,468.31	EA	
8563	Access Ladder & Platforms	2	2	Minor repair	970.25	EA	
8563	Access Ladder & Platforms	3	1	Major repair	3,880.99	EA	Same as state 4
8563	Access Ladder & Platforms	4	1	Major repair	3,880.99	EA	
8563	Access Ladder & Platforms	4	2	Replace unit	6,252.70	EA	
8564	Counterweight	2	2	Minor repair		EA	
8564	Counterweight	3	1	Major repair	9,702.47	EA	Same as state 4
8564	Counterweight	4	1	Major repair	9,702.47	EA	
8564	Counterweight	4	2	Replace unit	19,404.93	EA	
8565	Trunnion/Straight and Curved Track	2	2	Minor repair	1,401.47	EA	
8565	Trunnion/Straight and Curved Track	3	1	Major repair	2,802.94	EA	Same as state 4
8565	Trunnion/Straight and Curved Track	4	1	Major repair	2,802.94	EA	
8565	Trunnion/Straight and Curved Track	4	2	Replace unit	19,404.93	EA	
8570	Transformers & Thyristors	2	2	Minor repair	323.42	EA	

Table 6.10. Complete listing of costs for BMS element state actions (Cont'd)

New Elemkey	New Element Name	New state key	New action key	New action short label	Cost 2015 ($)	Units	Comments
8570	Transformers & Thyristors	3	1	Major repair	646.83	EA	Same as state 4
8570	Transformers & Thyristors	4	1	Major repair	646.83	EA	
8570	Transformers & Thyristors	4	2	Replace unit	3,234.16	EA	
8571	Submarine Cable	2	2	Minor repair	625.28	EA	
8571	Submarine Cable	3	1	Major repair	2,479.52	EA	
8571	Submarine Cable	4	1	Major repair	4,959.04	EA	
8571	Submarine Cable	4	2	Replace unit	23,285.92	EA	
8572	Conduit & Junction Boxes (Movable bridge control system)	2	2	Minor repair	215.62	EA	
8572	Conduit & Junction Boxes (Movable bridge control system)	3	1	Major repair	3,557.57	EA	Same as state 4
8572	Conduit & Junction Boxes (Movable bridge control system)	4	1	Major repair	3,557.57	EA	
8572	Conduit & Junction Boxes (Movable bridge control system)	4	2	Replace unit	1,293.67	EA	
8573	Programmable Logic Controllers	2	2	Minor repair	13,648.13	EA	
8573	Programmable Logic Controllers	3	1	Major repair	54,549.42	EA	Same as state 4
8573	Programmable Logic Controllers	4	1	Major repair	54,549.42	EA	
8573	Programmable Logic Controllers	4	2	Replace unit	87,106.58	EA	
8574	Control Console	2	2	Minor repair	10,953.01	EA	
8574	Control Console	3	1	Major repair	43,768.90	EA	Same as state 4
8574	Control Console	4	1	Major repair	43,768.90	EA	
8574	Control Console	4	2	Replace unit	66,623.60	EA	
8580	Navigational Light System (Misc. substructure elements)	2	2	Minor repair	1,056.50	EA	
8580	Navigational Light System (Misc. substructure elements)	3	1	Minor repair	1,056.50	EA	same as state2
8580	Navigational Light System (Misc. substructure elements)	3	2	Major repair	66,623.60	EA	Same as state 4
8580	Navigational Light System (Misc. substructure elements)	4	1	Major repair	1,056.50	EA	
8580	Navigational Light System (Misc. substructure elements)	4	2	Replace unit	1,056.50	EA	
8581	Operator Facilities	2	2	Minor repair	4,678.74	EA	
8581	Operator Facilities	3	1	Minor repair	4,678.74	EA	same as state2
8581	Operator Facilities	3	2	Major repair	66,623.60	EA	Same as state 4
8581	Operator Facilities	4	1	Major repair	4,678.74	EA	
8581	Operator Facilities	4	2	Replace unit	4,678.74	EA	
8582	Lift Bridge Specific Equipment	2	2	Minor repair	13,475.65	EA	
8582	Lift Bridge Specific Equipment	3	1	Minor repair	13,475.65	EA	same as state2
8582	Lift Bridge Specific Equipment	3	2	Major repair	66,623.60	EA	Same as state 4
8582	Lift Bridge Specific Equipment	4	1	Major repair	13,475.65	EA	
8582	Lift Bridge Specific Equipment	4	2	Replace unit	13,475.65	EA	
8583	Swing Bridge Specific Equipment	2	2	Minor repair	13,475.65	EA	
8583	Swing Bridge Specific Equipment	3	1	Minor repair	13,475.65	EA	same as state2
8583	Swing Bridge Specific Equipment	3	2	Major repair	66,623.60	EA	Same as state 4
8583	Swing Bridge Specific Equipment	4	1	Major repair	13,475.65	EA	
8583	Swing Bridge Specific Equipment	4	2	Replace unit	13,475.65	EA	
8590	Resistance Gates	2	2	Minor repair	280.29	EA	
8590	Resistance Gates	3	1	Minor repair	280.29	EA	same as state2
8590	Resistance Gates	3	2	Major repair	66,623.60	EA	Same as state 4
8590	Resistance Gates	4	1	Major repair	280.29	EA	
8590	Resistance Gates	4	2	Replace unit	280.29	EA	
8591	Warning Gates	2	2	Minor repair	711.52	EA	
8591	Warning Gates	3	1	Minor repair	711.52	EA	same as state2
8591	Warning Gates	3	2	Major repair	66,623.60	EA	Same as state 4
8591	Warning Gates	4	1	Major repair	711.52	EA	
8591	Warning Gates	4	2	Replace unit	711.52	EA	
8592	Traffic Signals	2	2	Minor repair	625.28	EA	
8592	Traffic Signals	3	1	Minor repair	625.28	EA	same as state2
8592	Traffic Signals	3	2	Major repair	66,623.60	EA	Same as state 4
8592	Traffic Signals	4	1	Major repair	625.28	EA	
8592	Traffic Signals	4	2	Replace unit	625.28	EA	
9207	Prestressed Concrete Hollow Core Pile	2	2	Minor repair		EA	
9207	Prestressed Concrete Hollow Core Pile	3	1	Major repair	685.07	EA	
9207	Prestressed Concrete Hollow Core Pile	3	2	Mitigate settlement or scour	9,430.96	EA	
9207	Prestressed Concrete Hollow Core Pile	4	1	Major repair		EA	
9207	Prestressed Concrete Hollow Core Pile	4	2	Mitigate settlement or scour	9,430.96	EA	

Table 6.10. Complete listing of costs for BMS element state actions (Cont'd)

New Elemkey	NewElemName	Newskey	Newakey	Newactshort	Cost 2015 ($)	Units	Comments
12	RC Concrete Deck	1	2	Crack sealing		SF	Not needed in BrM
12	RC Concrete Deck	2	1	Minor repair	1.82	SF	
12	RC Concrete Deck	3	1	Major repair	543.43	SF	
12	RC Concrete Deck	4	1	Major repair	543.43	SF	
12	RC Concrete Deck	4	2	Replace deck	67.31	SF	
13	PSC Concrete Deck	1	2	Crack sealing		SF	Not needed in BrM
13	PSC Concrete Deck	2	1	Minor repair	1.82	SF	Assumed same as RC deck
13	PSC Concrete Deck	3	1	Major repair	543.43	SF	Assumed same as RC deck
13	PSC Concrete Deck	4	1	Major repair deck	543.43	SF	Assumed same as RC deck
13	PSC Concrete Deck	4	2	Replace deck	67.31	SF	PSC same as RC
15	PSC Concrete Top Flange	1	2	Crack sealing	1.82	SF	Not needed in BrM
15	PSC Concrete Top Flange	2	1	Minor repair	1.82	SF	Assumed same as RC deck
15	PSC Concrete Top Flange	3	1	Major repair	543.43	SF	Assumed same as RC deck
15	PSC Concrete Top Flange	4	1	Major repair	543.43	SF	Assumed same as RC deck
15	PSC Concrete Top Flange	4	2	Major repair and rehab of flange	543.43	SF	Assumed same as RC deck
16	RC Concrete Top Flange	1	2	Crack sealing	1.82	SF	Not needed in BrM
16	RC Concrete Top Flange	2	1	Minor repair	1.82	SF	Assumed same as RC deck
16	RC Concrete Top Flange	3	1	Major repair	543.43	SF	Assumed same as RC deck
16	RC Concrete Top Flange	4	1	Major repair	543.43	SF	Assumed same as RC deck
16	RC Concrete Top Flange	4	2	Major repair and rehab of flange	543.43	SF	Assumed same as RC deck
28	Steel Deck/Open Grid	2	1	Spot blast deck	22.83	SF	Not needed in BrM
28	Steel Deck/Open Grid	2	2	Minor repair deck	2.28	SF	
28	Steel Deck/Open Grid	3	1	Spot blast and minor repair deck	20.55	SF	
28	Steel Deck/Open Grid	3	2	Spot blast and major repair deck	34.25	SF	
28	Steel Deck/Open Grid	4	1	Spot blast and major repair deck	45.66	SF	
28	Steel Deck/Open Grid	4	2	Replace deck	78.53	SF	
29	Steel Deck/Conc Grid	2	1	Spot blast deck	2.02	SF	Not needed in BrM
29	Steel Deck/Conc Grid	2	2	Minor repair deck	27.40	SF	
29	Steel Deck/Conc Grid	3	1	Spot blast and minor repair deck	2.28	SF	
29	Steel Deck/Conc Grid	3	2	Spot blast and major repair deck	24.66	SF	
29	Steel Deck/Conc Grid	4	1	Spot blast and major repair deck	54.80	SF	
29	Steel Deck/Conc Grid	4	2	Replace deck	89.75	SF	
30	Corrug/Orthotpc Deck	2	1	Spot blast deck	3.92	SF	Not needed in BrM
30	Corrug/Orthotpc Deck	2	2	Minor repair deck	73.72	SF	
30	Corrug/Orthotpc Deck	3	1	Spot blast and minor repair deck	98.31	SF	
30	Corrug/Orthotpc Deck	3	2	Spot blast and major repair deck	54.80	SF	Assumed same as steel deck/open grid
30	Corrug/Orthotpc Deck	4	1	Spot blast and major repair deck	2,457.58	SF	
30	Corrug/Orthotpc Deck	4	2	Replace deck	3,622.81	SF	
31	Timber Deck	2	1	Minor repair deck	5,655.94	SF	
31	Timber Deck	3	1	Major repair deck	13.46	SF	
31	Timber Deck	4	1	Major repair deck	13.46	SF	Same as state 3 repair
31	Timber Deck	4	2	Replace deck	22.44	SF	
38	Reinforced Concrete Slab	1	2	Crack sealing		SF	Not needed in BrM
38	Reinforced Concrete Slab	2	1	Minor repair	1.82	SF	
38	Reinforced Concrete Slab	3	1	Major repair	398.50	SF	Same as RC slab repair in state 4
38	Reinforced Concrete Slab	4	1	Major repair	398.50	SF	
38	Reinforced Concrete Slab	4	2	Replace slab	67.31	SF	
54	Timber Slab	2	1	Minor repair slab	739.60	SF	Same as state 3 repair

7. Migration of preservation benefits and optimization results

In research completed in 2010, a 14 year history of FDOT element inspections was analyzed to develop models of bridge element deterioration and the effectiveness of preservation actions (Sobanjo and Thompson, 2011). Unit costs of these actions were also updated, to account for inflation. These new models were incorporated into an analysis using the Pontis network optimization and a user cost model, in order to determine the total social cost of bridge element failure. Using all of these results in the Pontis network optimization, an estimate of discounted long-term unit cost (LTC) was developed, suitable for the computation of project benefits.

For each element at the network level, Pontis computes LTC for a do-nothing case and for each possible preservation action. The do-nothing case entails zero cost and zero benefit in the year of analysis, followed by taking whatever action is optimal in the following year. The benefit of a preservation action is the LTC of do-nothing minus the LTC of the action. It is therefore the maximum possible savings in life cycle social cost if the action is taken in the analysis year rather than postponing work for one year. For any given element and condition state, the optimal action is the one with the highest benefit. If the benefit of every action is less than or equal to zero, then do-nothing is the optimal action.

FDOT's Project Level Analysis Tool (PLAT) uses the optimal action determined in this way, to compute project-level initial cost and life cycle cost. This result is used, along with risk mitigation and functional improvement costs, in the determination of project benefit. Project benefit divided by project cost (B/C ratio) is used as the prioritization criterion in PLAT and in the Network Analysis Tool (NAT).

7.1. Analysis process and results

Because of changes in the FDOT bridge inspection manual as a result of BMS implementation, the 2010 long-term cost models cannot be used directly in the revised PLAT. Comparing the 2015 manual with the manual used in 2010, the following differences affect the research:

- In 2015, every element has four condition states defined for it, ranging from State 1 (new or nearly new, with no notable defects) to State 4 (defects so significant that a structural review is warranted). In 2010 elements could have anywhere from 3 to 5 condition states.
- In 2015, protective systems such as deck wearing systems, steel coatings, and cathodic protection equipment are defined as separate elements, each having four possible condition states. In 2010, these systems were integral with the underlying elements and not assessed separately.
- In 2015, the definitions of condition states are much more detailed than in 2010, considering multiple possible defects. The 2010 language typically considered only one or two primary defects.
- The 2015 manual changes the criteria for the worst-defined condition state, in most cases requiring a structural review to be warranted in order to assign a condition state 4. The 2010 practice was more permissive, in most cases saying that a structural review *may* be warranted.
- Other changes occurred in condition state language, such as whether exposed reinforcing steel necessitates a condition state 3 assessment in concrete elements.
- Because of the level of detail of defect assessment, more types of preservation actions can be identified, requiring more action subcategories. These were defined in Tasks 3 and 5 of the present study.

- Costs developed for the 2010 research were based on 2009 dollars. They need to be updated now to 2015 dollars. Task 6 found that the inflation factor from 2009 to 2015 is 1.0, so no conversion was necessary.
- All quantities in the 2015 manual are expressed in US Customary units, so costs must be converted from the 2010 metric units.

Because of these differences, it is necessary to transform the 2010 models to be compatible with 2015 inspections, taking into account the differences in the inspection process. This same concern arose in Task 4 for bridge element deterioration models, and a methodology was developed there to migrate the 2010 models. A similar methodology will be used here to migrate the long-term cost models. The process consists of the following steps:

1. Using the data from the final 2010 Pontis actmodls table, prepare a data set of long-term cost results produced by the Pontis network optimization. For all costs denominated in meters or square meters, convert to feet and square feet, respectively. Each of the 4275 cost values is identified with element, environment, state, action, and action subcategory according to the 2010 system. Do-nothing is included in this data set. Environments 2, 3, and 4 were used, since these are the three environment categories that are allowed in FDOT element inspections.
2. Prepare a data set of 2015 preservation actions, which includes the 985 do-something actions from Task 5 and 676 do-nothing actions (169 element definitions × 4 condition states). These are identified with element, state, action, and action subcategory under the new 2015 system developed in Task 5.
3. For each 2015 action, determine whether there is a unique match to a 2010 action having the same element and action subcategory. If so, use the long-term cost in US Customary units from that corresponding 2010 action.
4. If a 2015 action has more than one 2010 matching action by element and action subcategory, choose the correspondence with the most similar condition state. Note that condition state numbers in some cases have shifted.
5. If a 2015 action has no 2010 actions with the same element and action subcategory, find another action, possibly from a different element, whose costs should be reasonably similar and have the same units of measure. The 2015 action list has a considerable number of elements and actions which do not exactly match the 2010 list.
6. Once all of the 2015 actions have valid values for LTC, subtract each do-something LTC from the do-nothing LTC for the same element and condition state. This is the preservation benefit. The benefit of all do-nothing actions is zero.
7. For each element and condition state, the action with highest benefit is flagged as optimal.

Table 7.1 shows the results of the analysis, for elements in environment category 3 (Moderate). This table is reproduced from the pon_elemedefs worksheet in the Excel file delivered under Task 7, where the intermediate results may also be found, along with environments 2 and 4 (Low and Severe, respectively). The detailed correspondence table between 2010 actions and 2015 actions is in the pon_mod_action worksheet. Table 7.2 reproduces, from Task 5, the revised system of action subcategories used in the center columns of Table 7.1 to present the optimal actions by condition state.

7.2. Conclusions

Every element has a recommended do-something action in condition state 4. This action is usually element replacement, except for large elements and substructure elements that are very expensive to replace, where major repairs were found to be optimal. About half of the elements have optimal corrective actions in state 3 and/or 2. Long-term benefits were affected by the environment category, usually (but not always) providing higher benefits for elements in more severe environments. In no cases did the difference in benefits affect the choice of action, however.

Since the models are very consistent with the 2010 research, they should be suitable for FDOT production use in the interim period until the Department has sufficient inspections under the 2015 element manual to enable a new statistical analysis. In the initial testing using the revised PLAT model, some judgment-based modifications were found to be necessary to the life cycle costs for wearing surfaces, deck substrates, and coatings, which were not separately modeled under the CoRe element system.

Table 7.1. Results for elements in the Moderate environment

Element		Optimal action by condition state				Benefit in $ per unit			
ID Name	Units	1	2	3	4	1	2	3	4
12 Re Concrete Deck	sq feet	0	0	0	101	0.00	0.00	0.00	2.82
13 Pre Concrete Deck	sq feet	0	0	0	101	0.00	0.00	0.00	2.82
15 Pre Concrete Top Flange	sq feet	0	0	0	203	0.00	0.00	0.00	2.82
16 Re Conc Top Flange	sq feet	0	0	0	203	0.00	0.00	0.00	2.82
28 Steel Deck - Open Grid	sq feet	0	0	0	202	0.00	0.00	0.00	0.10
29 Steel Deck - Conc Fill Grid	sq feet	0	0	0	101	0.00	0.00	0.00	2.82
30 Steel Deck - Orthotropic	sq feet	0	0	0	101	0.00	0.00	0.00	2.82
31 Timber Deck	sq feet	0	0	0	101	0.00	0.00	0.00	0.16
38 Re Concrete Slab	sq feet	0	0	0	101	0.00	0.00	0.00	1.95
54 Timber Slab	sq feet	0	0	0	204	0.00	0.00	0.00	0.72
60 Other Deck	sq feet	0	0	0	101	0.00	0.00	0.00	2.82
65 Other Slab	sq feet	0	0	0	101	0.00	0.00	0.00	0.16
102 Steel Clsd Box Gird	feet	0	0	0	142	0.00	0.00	0.00	5.38
104 Pre Clsd Box Girder	feet	0	0	203	203	0.00	0.00	1.94	1.94
105 Re Clsd Box Girder	feet	0	0	203	203	0.00	0.00	1.48	1.48
106 Othr Clsd Web/Box Girder	feet	0	0	207	207	0.00	0.00	1.48	1.48
107 Steel Opn Girder/Beam	feet	0	0	302	141	0.00	0.00	12.71	4.34
109 Pre Opn Conc Girder/Beam	feet	0	303	0	141	0.00	14.02	0.00	1.86
110 Re Conc Opn Girder/Beam	feet	0	303	0	141	0.00	3.32	0.00	1.44
111 Timber Open Girder	feet	0	0	0	204	0.00	0.00	0.00	0.41
112 Other Open Girder/Beam	feet	0	0	0	141	0.00	0.00	0.00	4.34
113 Steel Stringer	feet	0	0	0	141	0.00	0.00	0.00	1.11
115 Pre Conc Stringer	feet	0	0	0	141	0.00	0.00	0.00	0.61
116 Re Conc Stringer	feet	0	0	0	141	0.00	0.00	0.00	0.61
117 Timber Stringer	feet	0	0	0	204	0.00	0.00	0.00	0.13
118 Other Stringer	feet	0	0	0	141	0.00	0.00	0.00	1.11
120 Steel Tuss	feet	0	319	302	142	0.00	24.51	1017.85	1.40
135 Timber Truss	feet	0	0	0	204	0.00	0.00	0.00	0.83
136 Other Truss	feet	0	0	0	142	0.00	0.00	0.00	1.40
141 Stl Arch	feet	0	0	0	142	0.00	0.00	0.00	2.76
142 Other Arch	feet	0	307	207	207	0.00	6.11	1.62	1.62
143 Pre Conc Arch	feet	0	0	0	142	0.00	0.00	0.00	0.28
144 Re Conc Arch	feet	0	303	203	203	0.00	6.11	1.62	1.62
145 Masonry Arch	feet	0	305	205	205	0.00	6.11	40.38	40.38
146 Timber Arch	feet	0	0	0	204	0.00	0.00	0.00	0.83
147 Stl Main Cables	feet	0	0	0	143	0.00	0.00	0.00	1.11
148 Sec Steel Cables	each	0	0	0	143	0.00	0.00	0.00	1.11
149 Otr Secondary Cable	each	0	0	0	143	0.00	0.00	0.00	1.11
152 Steel Floor Beam	feet	0	0	302	141	0.00	0.00	0.67	2.32
154 Prestress Floor Beam	feet	0	303	0	141	0.00	3.72	0.00	0.58
155 Re Conc Floor Beam	feet	0	0	303	141	0.00	0.00	368.49	0.95
156 Timber Floor Beam	feet	0	0	0	204	0.00	0.00	0.00	0.20
157 Other Floor Beam	feet	0	0	0	141	0.00	0.00	0.00	2.32
161 Stl Pin Pin/Han both	each	0	319	311	211	0.00	43.28	43.28	2.01
162 Stl Gus Plate	each	0	319	313	213	0.00	43.28	43.28	2.01
202 Steel Column	each	0	0	302	202	0.00	0.00	237.87	4.86
203 Other Column	each	0	307	207	207	0.00	10.90	17.39	17.39
204 Pre Conc Column	each	0	303	203	203	0.00	36.62	27.97	27.97
205 Re Conc Column	each	0	303	203	203	0.00	10.90	17.39	17.39
206 Tim Col or Pile Ext	each	0	0	0	204	0.00	0.00	0.00	6.62
207 Stl Tower	feet	0	0	302	202	0.00	0.00	237.87	4.86
208 Timber Trestle	feet	0	0	0	204	0.00	0.00	0.00	0.83
210 Re Conc Pier Wall	feet	0	0	203	203	0.00	0.00	1.42	1.42
211 Other Pier Wall	feet	0	0	207	207	0.00	0.00	5.62	5.62
212 Timber Pier Wall	feet	0	0	0	204	0.00	0.00	0.00	1.85
213 Masonry Pier Wall	feet	0	0	205	205	0.00	0.00	1.42	1.42
215 Re Conc Abutment	feet	0	0	203	203	0.00	0.00	1.19	1.19
216 Timber Abutment	feet	0	0	0	204	0.00	0.00	0.00	1.85
217 Masonry Abutment	feet	0	0	205	205	0.00	0.00	1.02	1.02
218 Other Abutments	feet	0	0	207	207	0.00	0.00	28.16	28.16

Table 7.1. Results for elements in the Moderate environment (cont'd)

Element		Optimal action by condition state				Benefit in $ per unit			
ID Name	Units	1	2	3	4	1	2	3	4
219 Stl Abutment	feet	0	0	302	144	0.00	0.00	110.27	1.68
220 Re Conc Pile Cap/Ftg	feet	0	303	203	203	0.00	29.12	13.81	13.81
225 Steel Pile	each	0	0	302	202	0.00	0.00	237.87	4.86
226 Pre Conc Pile	each	0	303	203	203	0.00	36.62	27.97	27.97
227 Re Conc Pile	each	0	303	203	203	0.00	10.90	17.39	17.39
228 Timber Pile	each	0	0	0	204	0.00	0.00	0.00	6.62
229 Other Pile	each	0	319	248	248	0.00	10.90	7887.85	7887.85
231 Steel Pier Cap	feet	0	0	302	141	0.00	0.00	110.27	1.68
233 Pre Conc Pier Cap	feet	0	0	203	203	0.00	0.00	1.32	1.32
234 Re Conc Pier Cap	feet	0	0	203	203	0.00	0.00	1.37	1.37
235 Timber Pier Cap	feet	0	0	0	204	0.00	0.00	0.00	0.45
236 Other Pier Cap	feet	0	0	207	207	0.00	0.00	737.28	1.37
240 Steel Culvert	feet	0	0	0	145	0.00	0.00	0.00	3.01
241 Re Conc Culvert	feet	0	0	0	145	0.00	0.00	0.00	2.01
242 Timber Culvert	feet	0	0	0	145	0.00	0.00	0.00	25.75
243 Other Culvert	feet	0	0	0	207	0.00	0.00	0.00	1.16
244 Masonry Culvert	feet	0	0	0	205	0.00	0.00	0.00	337.40
245 Pre Concrete Culvert	feet	0	0	0	145	0.00	0.00	0.00	2.01
300 Strip Seal Exp Joint	feet	0	0	0	111	0.00	0.00	0.00	0.44
301 Pourable Joint Seal	feet	0	0	0	111	0.00	0.00	0.00	0.48
302 Compressn Joint Seal	feet	0	0	0	111	0.00	0.00	0.00	0.54
303 Assem Jnt With Seal	feet	0	0	112	211	0.00	0.00	0.57	0.57
304 Open Expansion Joint	feet	0	0	211	111	0.00	0.00	92.25	0.44
305 Assem Jnt Wthut Seal	feet	0	0	211	211	0.00	0.00	0.57	0.57
306 Other Joint	feet	0	0	211	211	0.00	0.00	0.57	0.57
310 Elastomeric Bearing	each	0	0	213	213	0.00	0.00	1.76	1.76
311 Moveable Bearing	each	0	0	213	213	0.00	0.00	2.01	2.01
312 Enclosed Bearing	each	0	0	213	213	0.00	0.00	10.62	10.62
313 Fixed Bearing	each	0	0	213	213	0.00	0.00	3.57	3.57
314 Pot Bearing	each	0	0	213	213	0.00	0.00	3.90	3.90
315 Disk Bearing	each	0	0	213	213	0.00	0.00	0.53	0.53
316 Other Bearing	each	0	0	213	213	0.00	0.00	3.90	3.90
320 Pre Conc Appr Slab	sq feet	0	0	201	201	0.00	0.00	540.54	540.54
321 Re Conc Approach Slab	sq feet	0	0	201	201	0.00	0.00	540.54	540.54
330 Metal Bridge Railing	feet	0	0	302	114	0.00	0.00	11.39	195.14
331 Re Conc Bridge Railing	feet	0	0	0	114	0.00	0.00	0.00	0.23
332 Timb Bridge Railing	feet	0	0	204	204	0.00	0.00	64.46	64.46
333 Other Bridge Railing	feet	0	0	0	207	0.00	0.00	0.00	0.12
334 Masry Bdge Rling	feet	0	0	0	205	0.00	0.00	0.00	123.42
510 Wearing Surfaces	sq feet	0	0	0	109	0.00	0.00	0.00	0.16
515 Steel Protective Coating	sq feet	0	0	0	219	0.00	0.00	0.00	12.71
520 Conc Re Prot Sys	sq feet	0	0	0	232	0.00	0.00	0.00	0.16
521 Conc Prot Coating	sq feet	0	0	0	219	0.00	0.00	0.00	12.71
8097 PS/RC Hybrid Slab	sq feet	0	0	0	101	0.00	0.00	0.00	0.16
8098 Conc Deck on PC Pane	sq feet	0	0	0	101	0.00	0.00	0.00	0.16
8099 Sonovoid	sq feet	0	0	0	101	0.00	0.00	0.00	0.16
8199 Duct	each	0	0	0	141	0.00	0.00	0.00	1.86
8207 Hollow Core Pile	each	0	303	203	203	0.00	686.32	27.94	27.94
8290 Channel	each	0	0	0	322	0.00	0.00	0.00	979.88
8298 Pile Jacket Bare	each	0	303	203	144	0.00	10.90	17.39	9037.16
8386 Steel Fender/Dolphin System	feet	0	0	0	144	0.00	0.00	0.00	1.13
8387 Prestressed Conc Fender/Dolpin	feet	0	303	203	144	0.00	10.90	9007.18	9541.58
8388 RC Conc Fender Dolphin System	feet	0	303	203	144	0.00	10.90	9007.18	9541.58
8389 Timber Fender/Dolphin System	feet	0	0	0	204	0.00	0.00	0.00	0.61
8390 Other Fender/Dolphin System	feet	0	307	207	144	0.00	10.90	9007.18	9550.47
8393 Other Material Bulkhead/Seawall	feet	0	0	0	203	0.00	0.00	0.00	0.15
8394 RC Conc Abutment Slope Prot	sq feet	0	0	221	221	0.00	0.00	0.02	0.02
8395 Timber Abutment Slope Protection	sq feet	0	0	0	204	0.00	0.00	0.00	0.01
8396 Other Abutment Slope Protection	sq feet	0	0	0	221	0.00	0.00	0.00	0.01
8397 Metal Drainage System	each	0	0	0	223	0.00	0.00	0.00	1.88
8398 Other Material Drainage System	each	0	0	0	123	0.00	0.00	0.00	3.69
8474 Wingwall/Retaining Wall Metal Uncoated	feet	0	0	0	144	0.00	0.00	0.00	0.23

Table 7.1. Results for elements in the Moderate environment (cont'd)

Element		Optimal action by condition state				Benefit in $ per unit			
ID Name	Units	1	2	3	4	1	2	3	4
8475 R/Conc Walls	feet	0	0	203	203	0.00	0.00	1.04	1.04
8476 Wingwall/Retaining Wall Timber	feet	0	0	0	204	0.00	0.00	0.00	0.49
8477 Wingwall/Retaining Wall Other Material	feet	0	0	207	207	0.00	0.00	120.71	120.71
8478 Mechanically Stabilized Earth Wall	feet	0	0	0	206	0.00	0.00	0.00	362.68
8480 Mast arm foundation	each	0	0	0	144	0.00	0.00	0.00	1.17
8481 Vertical mast arm member - metal	each	0	0	0	202	0.00	0.00	0.00	0.32
8483 Vertical mast arm member - Concrete	each	0	303	203	203	0.00	10.90	17.39	17.39
8484 Horizontal mast arm member - metal	each	0	0	0	202	0.00	0.00	0.00	0.32
8487 Overlane Sign Struct Horiz Member Metal	feet	0	0	0	202	0.00	0.00	0.00	0.32
8488 Overlane Sign Struct Vert Member Metal	feet	0	0	0	202	0.00	0.00	0.00	0.32
8489 Overlane Sign Structure Foundation	each	0	0	0	151	0.00	0.00	0.00	1.17
8491 RC Overlane Sign Vertical	feet	0	303	203	203	0.00	10.90	17.39	17.39
8496 High Mast Light Poles Metal Coated	each	0	0	0	202	0.00	0.00	0.00	18.17
8499 High Mast Light Pole Foundations	each	0	0	203	203	0.00	0.00	3.74	3.74
8516 Painted Steel	sq feet	0	0	319	219	0.00	0.00	12.71	12.71
8517 Weathering Steel	sq feet	0	0	0	219	0.00	0.00	0.00	12.71
8518 Galvanized Steel	sq feet	0	0	0	219	0.00	0.00	0.00	12.71
8519 Other Steel Coating	sq feet	0	0	0	219	0.00	0.00	0.00	12.71
8540 Open Gearing	each	0	0	231	231	0.00	0.00	460.41	29578.94
8541 Speed Reducers	each	0	0	231	231	0.00	0.00	472.37	39003.55
8542 Shafts	each	0	0	231	231	0.00	0.00	93.92	3442.24
8543 Shaft Bearings and Shaft Couplings	each	0	0	0	231	0.00	0.00	0.00	83.34
8544 Brakes	each	0	0	0	131	0.00	0.00	0.00	6.02
8545 Emergency Drive and Back Up Power System	each	0	0	231	231	0.00	0.00	37.24	4410.57
8546 Span Drive Motors	each	0	0	231	231	0.00	0.00	37.58	6458.29
8547 Hydraulic Power Units	each	0	0	231	231	0.00	0.00	2347.31	62136.29
8548 Hydraulic Piping System	each	0	0	231	231	0.00	0.00	6.74	6.74
8549 Hydraulic Cylinders/Motors/Rotary Actuators	each	0	0	231	231	0.00	0.00	146.72	10313.02
8550 Hopkins Frame	each	0	0	0	202	0.00	0.00	0.00	8129.91
8560 Span Locks/Toe Locks/Heel Stops/Tail Locks	each	0	0	0	131	0.00	0.00	0.00	17.56
8561 Live Load Shoes/Strike Plates/Buffer Cylinders	each	0	0	231	231	0.00	0.00	11.25	11.25
8562 Counterweight Support	each	0	0	0	202	0.00	0.00	0.00	7.69
8563 Access Ladder & Platforms	each	0	0	0	231	0.00	0.00	0.00	6.74
8564 Counterweight	each	0	0	0	203	0.00	0.00	0.00	10.44
8565 Trunnion/Straight and Curved Track	each	0	0	0	231	0.00	0.00	0.00	13270.98
8570 Transformers & Thyristors	each	0	0	231	231	0.00	0.00	1.76	1.76
8571 Submarine Cable	each	0	0	231	231	0.00	0.00	12.60	12.60
8572 Conduit & Junction Boxes	each	0	0	0	131	0.00	0.00	0.00	2.52
8573 Programmable Logic Controllers	each	0	0	231	231	0.00	0.00	76.30	76.30
8574 Control Console	each	0	0	231	231	0.00	0.00	73.45	73.45
8580 Navigational Light System	each	0	0	0	131	0.00	0.00	0.00	4.68
8581 Operator Facilities	each	0	0	331	231	0.00	0.00	49.55	49.55
8582 Lift Bridge Specific Equipment	each	0	0	331	231	0.00	0.00	159.23	159.23
8583 Swing Bridge Specific Equipment	each	0	0	331	231	0.00	0.00	159.23	159.23
8590 Resistance Barriers	each	0	0	331	231	0.00	0.00	3.96	3.96
8591 Warning Gates	each	0	0	331	231	0.00	0.00	21.11	21.11
8592 Traffic Signal	each	0	331	331	231	0.00	212.51	11.69	11.69

Table 7.2. Action categories and subcategories

		Object	Action Category 100-Replace	200-Major repair	300-Minor repair
Materials	1	Deck	101	201	301
	2	Steel/metal		202	302
	3	Concrete		203	303
	4	Timber		204	304
	5	Masonry		205	305
	6	MSE		206	306
	7	Other material		207	307
	9	Wearing surface	109	209	309
Hi-Maint	10	Other element			
	11	Joint	111	211	311
	12	Joint seal	112		
	13	Bearing (incl p/h)	113	213	313
	14	Railing	114		
	19	Coatings	119	219	319
Drainage	21	Slope prot	121	221	
	22	Channel		222	322
	23	Drain sys	123	223	323
Machinery	31	Machinery (1)	131	231	331
	32	Cath prot	132	232	332
Major	41	Beam	141		
	42	Truss/arch/box	142		
	43	Cable	143	243	
	44	Substr elem (exc cap)	144 (2)		
	45	Culvert	145		
	46	Appr slab	146	246 (3)	
	47	Settlement/scour		247 (4)	
	48	Distortion		248 (5)	
Appurtenances	51	Pole/sign	151		

White cells represent valid sub-categories; numbers in parentheses refer to footnotes

Footnotes

1. Incl. elec, hydraulic, and mech elements
2. Incl. fenders, dolphins, and pile jackets
3. Mudjacking
4. Mitigate settlement or scour
5. Heat straightening and repair of distortion

8. PLAT enhancements

To support decision making in the central office and districts, FDOT uses a spreadsheet model developed in earlier research, known as the Project Level Analysis Tool (PLAT). This model is based on many of the same analysis inputs as Pontis, and uses Pontis bridge inspection data, but is adapted to the management requirements of FDOT. PLAT includes a number of modeling refinements to enable a more realistic project level scope and cost estimate than is possible in Pontis. It is desired to carry over these capabilities to the new version of PLAT. However, the algorithms for these refinements had to be modified in order to operate correctly with the new data. Among the affected refinements are deterioration adjustments, scoping rules, and quantity prediction rules. Much of the new functionality involves interactions among elements.

FDOT envisions that the districts will continue to use the existing PLAT with Pontis data until the full transition to the new inspection manual. At that point FDOT will use BMS release 5.2.2 to collect and store inspection data, and the revised PLAT models will then be deployed to work with that new database. Release 5.2.3 of BMS might not be implemented until some period of time after that, which may be 2017 or later. As a result, the revised PLAT models should be designed to work with release 5.2.2.

8.1. Deterioration refinements

Certain bridge elements, namely expansion joint seals and drainage systems, exist primarily to slow the deterioration of other elements. The secondary effect of one element on another cannot be modeled effectively in the Pontis network optimization, but is significant and should be addressed at the project level. AASHTOWare Bridge Management adds a feature, known as the protection factor, which is meant to modify the deterioration model to represent the interaction among elements. This is especially important because coating systems, deck wearing surfaces, and cathodic protection are now separate elements which have a significant impact on the deterioration of their substrates. The protection factor increases the median years to transition, thus slowing deterioration of a substrate element (such as a steel girder), if the protecting element (such as paint system) is partially or fully functional.

When forecasting deterioration for a specific element on a specific bridge, the transition time is computed as follows:

$$T'_j = f \times T_j^o \tag{8-1}$$

Where T_j^o = the transition time for state *j* for the given element if protective systems are absent and the element is in a Moderate environment

T'_j = the modified transition time

f = the protection factor, considering all characteristics of the bridge and element

The protection factor for a given element on a given bridge takes into account the various influences which can modify the transition time. It is calculated by multiplying together all the contributing factors as follows:

$$f = f^E \prod_e f_e^M \tag{8-2}$$

Where f^E = the Environment factor, reflecting climate and operating conditions of the location
f_e^M = Modifier factors, the effects of each of the associated protective system elements *e*

The modifier factor for each protecting element depends on its condition, as follows:

$$f_e^M = pp_e^+ - \left(1 - (y_1 + \frac{2}{3}y_2 + \frac{1}{3}y_3)\right)(pp_e^+ - pp_e^-) \quad (8\text{-}3)$$

Where y_k = the forecast fraction of the protecting element in state *k*
pp_e^+ = the protection parameter for protecting element *e* for condition state 1
pp_e^- = the protection parameter for protecting element *e* for condition state 4

So if a deck in a Moderate environment is protected by a wearing surface with *f=1.2*, and a cathodic protection system with *f=2.0*, then the total protection factor is 1.2 ×2.0 = 2.4. If such element had not been protected by other elements (for example, a bare slab), its protection factor *f=1.0*. After modifying the transition time in this way, Weibull and Markov deterioration occur in the same manner as currently exists in PLAT, but using the new transition time to compute the transition probabilities. As a result, the rate of deterioration of a substrate element can vary over the life of a bridge as the protecting element deteriorates.

The revised PLAT model uses the same protection factors as are provided in BMS release 5.2.2, as determined by the AASHTO Technical Review Team. For joints and drainage systems, the previous PLAT model changes the environment of an element if its protector element is deteriorated, but the new model eliminates this feature and uses the protection factor system instead. PLAT users can edit the protection factors. These refinements to the deterioration model are applied during the period before a work candidate is programmed, and again for a period of 10 years after the candidate.

8.2. Scoping rules

To generate a reasonable project scope for the Auto MRR&I candidate, the PLAT operates in a manner similar to the Pontis program simulation, in that it uses the network-optimal action for each condition state of each element where possible. However, the PLAT also imposes several refinements that modify the project to make it more realistic. The effect of the refinements is that the candidate is more practical, but might not be strictly optimal in a pure economic sense. The engineer can modify candidates, by creating Custom candidates, as a part of the gaming process. Regardless of whether a candidate is economically optimal, the model provides valid feedback in the form of predicted conditions, life cycle costs, and other performance measures.

The following steps are executed as a part of generating an Auto MRR&I candidate for a given bridge and implementation year:

- Scale feasibility – The potential quantities of feasible actions are investigated to ensure that the implied quantity of work is in a practical range. This eliminates actions too small to be performed economically, and actions so large that a higher-type action (such as replacement) would normally be more appropriate.
- Total recoating or deck resurfacing– A special variation on the scale feasibility model is evaluated to determine whether all coated elements on the bridge should have their paint

system replaced, rather than spot painting or over-coating. A similar model is provided for wearing surface replacement.

- Action selection and quantity prediction – From among the actions that are still feasible after the scale feasibility model, the one with lowest life cycle cost for each condition state is selected. This may or may not be the original Pontis optimal action. Certain actions may be expanded to encompass more condition states (usually states 2 and/or 3), as a way of forestalling the need to revisit the bridge any time soon.
- Deck replacement – If the deck is replaced, all barriers, joints and drainage systems on the bridge are also replaced.

These refinements are somewhat similar to what is done in Pontis 4.0 with its scoping rules, and BMS has similar functionality that will be provided eventually (in release 5.2.3) through its bridge-level actions. However, the emphasis is quite different. The objective is not to scope projects automatically, but rather to give the engineer a more realistic starting point for his or her own investigation.

8.2.1 Scale feasibility

Scale feasibility determines whether the amount of a particular type of need on a bridge is sufficient to affect the choice of action. This decision is not strictly limited to individual elements, because each bridge could have several elements with the same type of need: for example, concrete girders, floor beams, and stringers may all need minor repairs of spalls. In each condition state, the scale feasibility model is applied to the action with the lowest long-term cost.

For each action subcategory, all the elements on the bridge that can use it are grouped together. This is done by computing a weighted average percent in the states where the action is optimal. Weighting is according to the estimated cost if the action were applied to the entire element. The action is marked infeasible if the combined percentage is below a minimum threshold. It would be better to wait until the quantity becomes larger, to make the work more economical.

Thresholds are set on the Action Subcategories worksheet. It is recommended that these thresholds be set loosely. Their purpose is to improve the convenience of the tool by eliminating scope items that are obviously impractical, not to make scoping decisions on behalf of the engineer.

8.2.2 Coating or wearing surface replacement

A special scale feasibility model is provided to determine whether the bridge should be scoped as total paint system or wearing surface replacement. This affects what scope items are created for the Auto MR&R Candidate. The engineer is still free to create Custom candidates that are scoped differently.

The previous version of the PLAT needed to look at each painted steel element to evaluate whether painting would make sense, and then to decide whether the quantity of painting would be high enough to justify repainting. Under the new element definitions, the process is more like the regular scale feasibility model, except that the entire coating element is replaced regardless of condition state as long as the minimum threshold is met.

8.2.3 Deck replacement

Deck replacement in Pontis is a unitary action; that is, it is always applied to the entire condition unit. In BMS there are no unitary actions, but it is still necessary to consider total deck replacement. This makes the consideration of deck replacement similar to the situation with total recoating. If the deck element

exceeds a threshold in the scale feasibility model in condition states where deck replacement is optimal, then the entire deck is replaced even if some of it is still in better condition states.

Whenever the Auto MRR&I Candidate includes a deck replacement scope item, special handling in the model ensures that any additional deck elements, wearing surfaces, joints, barriers, and drainage systems on the bridge are also replaced. The engineer is still free to create Custom Candidates that are scoped differently.

8.3 Quantity prediction and applicability

After feasibility issues are settled, typically the actual quantity of work done in a bridge project is more than the quantity of deterioration that motivated the work. The primary reasons for this are:

- Certain types of work have significant economies of scale if performed on the entirety of an element rather than just a part of it. Deck replacement and paint system replacement are good examples.
- Often maintenance crews in the field discover additional problems not noticed in the inspection. This is especially true with hidden distresses such as concrete delamination.
- It is usually cost-effective, when visiting a structure to address a relatively poor condition state, to take advantage of the opportunity to address other deteriorated states on the same element, if this can be done with the same equipment and crew skills.

The project level model allows each action to apply to more condition states than those for which it is considered feasible, as long as the action is effective and not unreasonably expensive in addressing the deficiencies of the other condition states to which it is applied.

The new version of PLAT takes advantage of the restructuring of element condition states in the new inspection manual, to simplify the applicability rules. Element replacement is considered applicable to condition states 3 and 4 of every element. Major repair is applicable to states 2, 3, and 4. Minor repair is applicable to states 2 and 3. In addition, if an action is defined as feasible for a given condition state, it is also considered applicable.

The application of each action to each condition state may have a different unit cost and effectiveness vector than the same action applied to other states. This is consistent with the revised cost model from Task 6. The means of deciding what unit costs and effectiveness vectors to use is determined in the preservation output model.

When an action does not address all deteriorated condition states of an element, it is possible that there could be more than one action on different parts of the same element. This would occur most often when a part of an element is replaced. The final scope of work of a model-generated project on a given element is determined from the following algorithm:

For each condition state of the element (starting with the worst)
    Find the feasible action with lowest long-term cost
        Apply the action to all the states to which it is applicable
        Calculate the action quantity as the sum of quantities in the applicable states
        Then skip to the next condition state that has not already been addressed

8.4. Other PLAT changes

All data in BMS are stored in US Customary units, rather than the metric units used in Pontis. The older version of PLAT contained code to convert to US Customary, but this is no longer necessary. On the Model Parameters screen, all the decision rules are expressed in US Customary units. All unit costs are converted also.

Task 6 found that the inflation factor from 2009 to 2015 happens to be 1.0, so no inflation adjustment was necessary in the PLAT update.

PLAT in its previous form relied on the primary key fields of several of the tables in the Pontis database to identify bridges and elements. This is not permissible in the revised PLAT because the database has changed the way primary key fields are populated and stored. The struct_num and elemkey fields, in particular, no longer agree with the primary keys of their respective tables. This means that most of the database queries in PLAT had to be revised so they would work correctly with the BMS database.

FDOT has made the decision to move its enterprise systems to Microsoft SQL Server rather than Oracle. Therefore the database queries in PLAT have all been tested for correct operation using the Microsoft syntax for SQL.

FDOT currently deploys Microsoft Office 365 to all users. This is the most up-to-date version of the software. PLAT was developed initially for Office 97. PLAT is still operable on all versions of Microsoft Office since Office 2007. The new PLAT version was specifically created to fit the AASHTOWare database modifications made in BMS release 5.2.2, and will not work with earlier versions of BMS.

In most places where element data are used in PLAT, only the most recent inspection is accessed. The one exception is the inspection history graph on the main dashboard. The revised PLAT accesses only the pon_elem_insp table for this information, so there is no discontinuity between the old and new element definitions in the graph.

The older version of the FDOT BMS database contained a considerable number of occurrences of element inspection records having environments 0 and 1. These are treated as environment 2 in the new software.

All structures assigned to district 9, and all structures lacking element inspection records, are ignored in the revised models. It is possible to view these bridges by typing their bridge_id specifically on the Dashboard, but they are never listed on the Screening worksheet.

Element defects, if present in the database, are shown only in the element comments on the main dashboard, rather than having separate rows for them in the elements pane. The smart flags row of the bridge pane has been removed. Protective elements that are assigned by the inspector to specific substrate elements are listed immediately below those substrate elements on the Dashboard.

The storage of operating and inventory ratings has been changed in the BMS database, following recent FHWA guidance, so that in some cases the database contains rating factors rather than weights. If ortype or irtype are greater than or equal to 6, then the corresponding orload and irload are rating factors and not tons. In that case, it is necessary to multiply by 36 to get US tons.

PLAT previously devoted a considerable amount of code and worksheet space to the fact that CoRe elements have a variable number of condition states from 3 to 5. The revised model was simplified in many places since all elements have 4 condition states.

8.5 Delivery of revised software and manuals

New releases of the PLAT and NAT software and Users Manuals, and a refreshed version of the PLAT Results Database, have been delivered to FDOT. This Final Report describes only the changes made to PLAT in the current study. Consult the Users Manuals for a complete description of the models' functionality.

9. Recommendations for further research

The present study has been viewed as a transitional effort to enable the Department to maintain the full decision support functionality of its bridge management system and the Project Level Analysis Tool during the migration from the AASHTO CoRe Element Manual and Pontis to the new 2013 AASHTO Element Inspection Manual and AASHTOWare Bridge Management. Through some resourceful use of some old and new resources, the study has been able to create a migration path for the FDOT health index, deterioration model, preservation cost and effectiveness models, and life cycle cost analysis so all the tools will work correctly with the new data and systems.

Under current plans, the Department will begin gathering element inspection data under its new Field Guide (revised February 2016) in October of 2016. This will mark the point when the inspection process starts to use AASHTOWare Bridge Management release 5.2.2, and decision support functionality transitions to the new version of the Project Level Analysis Tool. The Pontis software is expected to be retired at that point. In this time frame, several opportunities and requirements will emerge:

- Improved understanding of bridge element systems. The new AASHTO manual, and especially the inspection of protective systems, will usher in a new area of potential research on the interaction of related elements on a bridge. Of particular interest are:
  - Decks with wearing surfaces and joints;
  - Steel elements with coating systems;
  - Concrete elements with coatings and cathodic protection;
  - Joint seals and drainage systems with superstructure and substructure elements;
  - Life cycles of sign structure and light pole assets;
  - Moveable bridge systems.
- An ability, for the first time, to start to separate the various deterioration processes, such as corrosion and cracking, by mining the new defect elements as well as the detailed notes that inspectors have been keeping over the years in Pontis.
- The uniformity of element and condition state definitions in the new manual will simplify some areas of data analysis, particularly element interactions, which may have been prohibitively complex to analyze in the past. Communication and implementation potential for such research will be improved.
- New steps have been taken in risk analysis, such as NCHRP Project 20-07(378), due to be completed in summer of 2016, that may be implementable in Florida.
- Finalization of new federal regulations for performance measures and Transportation Asset Management Plans. This is expected to occur between summer 2016 and summer 2017.
- Continued experience and feedback on the use of the Department's PLAT and NAT tools.

These developments will open opportunities for new bridge management research that has not been possible up to now. The following sections describe some of these possible initiatives.

9.1 Integrated network level life cycle cost and risk analysis for element systems

PLAT relies on the Pontis network optimization model in order to compute life cycle costs and determine, for each condition state of each element, the action that is most economical in the long-term. Developed more than 25 years ago, the Pontis model was conceived at a time when element-level

data was not well understood and when computer analytical power was in its infancy. This model is used even in the most recent version of PLAT because an alternative model is not yet available.

9.1.1 Need to fully retire the Pontis network optimization

Unfortunately, the Pontis model is becoming less relevant to PLAT. The work performed in the current study on deterioration, cost, and risk models cannot be incorporated into the Pontis optimization because they are incompatible with it. Failure probability and cost are an important part of the Pontis life cycle cost analysis, but BMS and PLAT no longer use this information. Pontis has never been able to consider the extent of distress, interactions among elements, nor fiscal constraints in the determination of actions in its network optimization.

The combined effect of all the recent innovations in PLAT and BMS increasingly calls into question the optimality of the Pontis model and the accuracy of the life cycle cost estimates. Future research described here can reset the analysis to incorporate all these innovations right into the optimization.

9.1.2 Desired capabilities of a new optimization

The opportunities and requirements listed above, as well as the newly-improved data collection process and the increased performance of spreadsheet models, introduces the possibility of an entirely new network optimization with substantially improved realism and relevance to bridge preservation decisions. The new model could:

- Take into account the interactions among related elements, especially protective systems and their substrates.
- Incorporate PLAT capabilities such as scale feasibility, output prediction, and Weibull onset of deterioration into the network optimization so they affect the choice of recommended action for each element.
- Adopt a multi-objective approach, optimizing the combination of life cycle cost, risk, safety, and mobility.
- Optimize at the bridge level rather than element level, so bridge characteristics can be taken into account.
- Develop action selection policies that are more compact, more relevant, easier to test and fine-tune, and easier to implement than the Pontis recommendations.
- Focus more effective attention on developing better criteria for whole-bridge actions such as repainting, wearing surface replacement, and bridge replacement.
- Produce network-level fiscally-constrained outcome forecasts and performance targets that fit federal and state performance management needs.
- Make the computations more easily visible for understanding and validation.

Having the new model in place would enable FDOT to fully retire the Pontis model, and may allow the Network Analysis Tool (NAT) to be re-engineered to be more useful and relevant to the Department's modern decision making processes. In particular, the tool would facilitate:

- Development of asset management strategies – including resource requirements, decision criteria, and performance expectations – for portions of the inventory that might come under asset management contracts.

- Support development of a stronger linkage between funding allocation and performance targets at the district level.
- Consider safety and mobility concerns related to both functionality and risk as a part of resource allocation strategies.
- Provide guidance on strategies to minimize life cycle cost and maximize performance, which may be valuable to county and city governments that do not have the capability to operate their own bridge management tools.
- Support a re-engineered and streamlined version of PLAT that is oriented toward implementation of the optimized strategies.

The Pontis network optimization model produces a long list of recommendations that are difficult to evaluate, and considers very few bridge characteristics. A new model would produce a much smaller list of subsystems, where each subsystem contains a group of related elements on a bridge. To illustrate, the models migrated from Pontis in the current study contain 4,809 estimates of life cycle cost by element, environment, condition state, and action. However, the actual development of these models in previous FDOT research only distinguished among 74 element types and 50 action subcategories, and it would be groups of these that make up the subsystems as the unit of analysis for the new model.

9.1.3 How the model would work

Each group of related elements in a subsystem would be combined into a single spreadsheet-based simulation model that projects conditions and performance year-by-year over a long timeframe, perhaps 200 years, incorporating repair, rehabilitation, and replacement cycles as needed. Deterioration would reflect the Weibull model for onset of deterioration, and the new protection factors for element interactions and environments. Scoping rules similar to those already included in PLAT would be applied.

Functional deficiencies and risk would also be modeled, based on the existing FDOT research, to generate estimates of agency risk and user costs. The risk of advanced deterioration is especially important to the optimization because it replaces the failure cost previously used in Pontis. Bridge-level indirect costs and work zone user costs could be added if developed in future research.

What would be most distinctive about the analysis is that it would generate its action selections using a sensitivity analysis of bridge size, traffic volume range, threshold levels for element condition (considering both severity and extent of distress), levels of service, fiscal constraints, and other relevant inputs. The research would determine which inputs are most significant and the level of granularity.

Inputs to the model would include a network-level summary of existing quantity by condition state, and distributions of other independent variables such as deck area and traffic volume, based on queries of subsets of bridges from BMS. Outputs would include selections of actions, and incremental life cycle costs and benefits as they vary with changes in the inputs. The outputs together would form a decision matrix that can then be applied to specific bridges in the PLAT, and fine-tuned by the engineer in the same way as is done now in PLAT. The subsystems within a typical bridge would be optimized separately; for example, concrete decks separately from steel super/sub-structures.

Also provided in the outputs would be network performance measures such as health index, percent good, percent poor, and percent structurally deficient, sensitive to fiscal constraints. The actual inventory would be subdivided according to the decision matrix, the needs on each segment analyzed

separately as though they were individual bridges, and then aggregated to the inventory level according to aggregate deck area, fiscal constraints, and equalization of marginal benefit/cost ratio.

The model would take advantage of Excel's highly optimized multi-core spreadsheet recalculation ability, rather than relying on linear programming or other traditional computational methods. This would provide more flexibility to take full advantage of the existing research, much of which is non-linear in nature. It will also facilitate the ability to see any of the intermediate results at any time, and to set up scenarios to fit specific questions an analyst might want to investigate. Currently the optimization workload of PLAT and NAT has to operate on each district workstation, but the new models would centralize most of the computational work. This means a more powerful computer can be used for fine-tuning and adjusting the optimization, and less power is required for most PLAT users.

Since much of the difficult work in NAT related to resource allocation would be repositioned to occur before (rather than after) PLAT in the analytical process, the result might be a better fit to the way FDOT plans its work. In fact, it may become possible to implement the remaining functions of NAT within PLAT so a separate spreadsheet file is not necessary for producing the final priority lists.

9.2 Development of an improved NBI Translator

A problem noted in the new version of PLAT is that the widespread changes in condition state definitions in the new inspection manual have biased the calculation of NBI condition ratings, so they no longer closely match the NBI ratings produced by inspectors. For example, Figure 9-1 shows a bridge where the inspector-assigned substructure rating is 6, but the translator converted the element conditions to a rating of 9.

Some of the discrepancy could be due to biases within the migrator program, which might resolve themselves once FDOT begins gathering the new element data in the field. But in general the condition state definitions used in the new manual do tend to increase the likelihood of states 1 and 2, and reduce the likelihoods of states 3 and 4, especially for the elements having the biggest impact on NBI ratings for superstructures and substructures. This pattern is evident in the migration probability matrix developed in Task 4.

PLAT performs all of its deterioration modeling at the element level, so a translator is still necessary in order to show forecasts of condition in terms of NBI ratings. In order to meet the needs of upcoming federal requirements, there is also a need for the forecasting of the probability of Good and Poor overall condition ratings for each bridge, which can be aggregated over the inventory to evaluate asset management performance targets.

Recalibration of this model will need to rely on field-collected element data, preferably dual inspections where the inspector has determined the element conditions and the NBI rating. It may be necessary to take defects into account, although the reliability of these data is still unknown.

One approach that should be investigated is a probabilistic multinomial choice model such as the ordered probit method discussed in NCHRP Report 713. Such a model would simultaneously consider the separate effects of element composition of the bridge and the condition states. It could consider bridge characteristics such as age and functionality in different ways for different NBI rating levels, and would not require a linear continuous scale for approximation of the categorical NBI ratings.

To forecast NBI ratings, the multinomial choice model would produce a probability of each NBI value, from which the most likely value would be selected. The probabilities of Good, Poor, and Structurally Deficient should be forecast directly, rather than computing them from forecasts of NBI ratings. This would improve the statistical reliability of the forecasts of network-level outcomes.

As a future PLAT enhancement, the probabilities of Good and Poor should be incorporated into the PLAT dashboard in some way to give the engineer a feel for the likelihood that a bridge is to make the transition to the next level at a given time. This is especially important for big bridges, since the federal performance measure is weighted by deck area. An impending transition to the next level might increase the priority of corrective action.

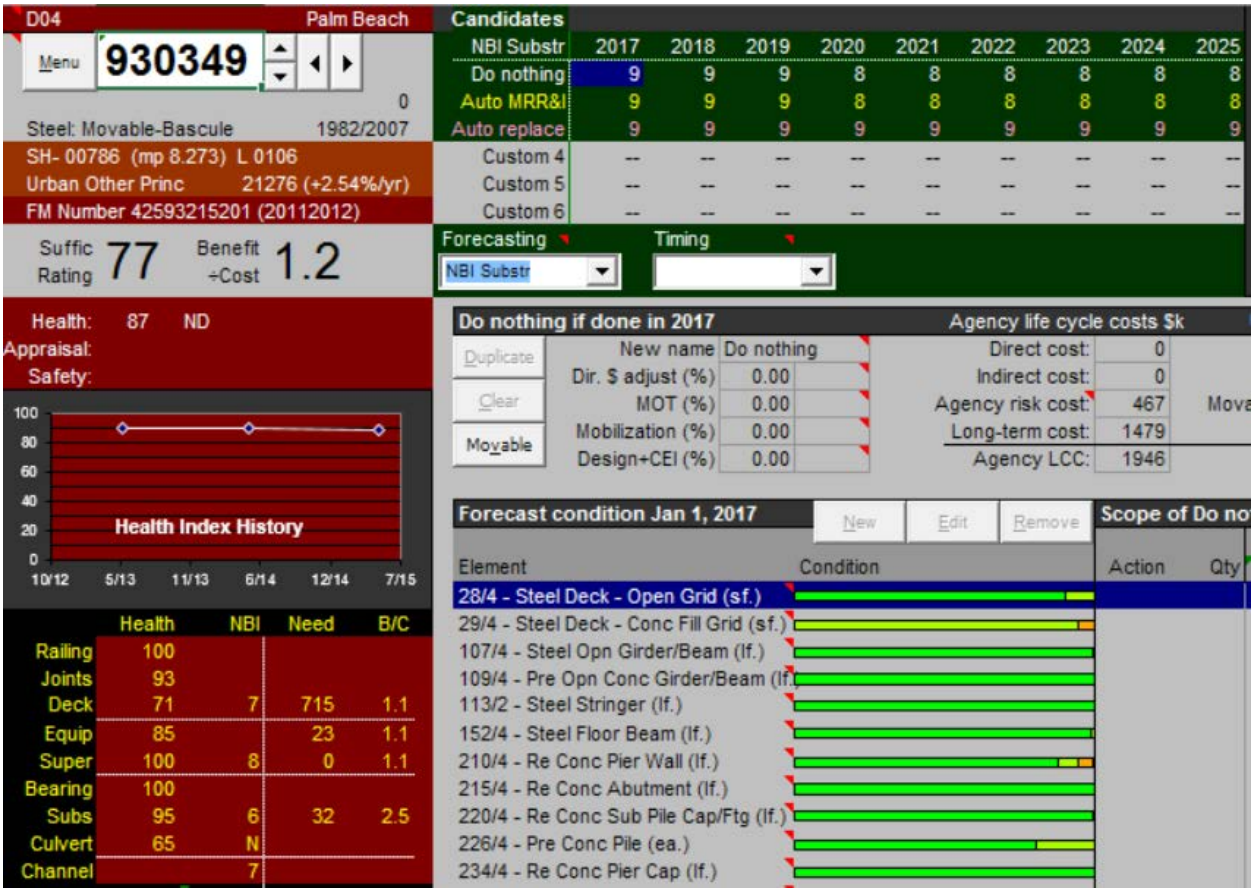

Figure 9.1. Example of translator output compared with inspector ratings

9.3 Validation and enhancement of the migration probability matrix

Task 4 of the current study developed a migration probability matrix as a means of converting previous FDOT research on deterioration, action effectiveness, and costs into a form compatible with the new inspection manual. The migration probability matrix was based entirely on judgment, using expert knowledge of the old and new inspection manuals and the differences in definitions. There is a considerable degree of uncertainty in these estimates.

One way to validate the estimates may be feasible after approximately one year of field inspections is completed under the new manual. The following steps would be conducted:

1. For each bridge inspected under the new manual, the most recent previous CoRe element inspection is identified.
2. The CoRe element inspection is deteriorated for two years using the deterioration model developed in the earlier research (Sobanjo and Thompson, 2011).
3. The result of step 2 is multiplied by the migration probability matrix.
4. The results of step 3, aggregated over all bridges, are compared with the aggregated new inspections under the new manual.

Any discrepancies between the two data sets would indicate the amount of error in either the migration probability matrix or the deterioration model. However, since the deterioration model is validated from actual inspection data and the migration probability matrix is not, it would be presumed that the error is primarily in the migration probability matrix. The migration probability matrix could then be adjusted to compensate for the error, and then portions of Tasks 4 through 7 could be updated accordingly.

The result would be a more accurate set of interim models. This would not obviate the need for updating the deterioration model from BMS inspection data, but would ensure that the interim models are accurate for decision support during the 4+ years until the new models can be developed. This work could be performed concurrently with the development of the network optimization model and NBI translator.

9.4 Models of indirect cost and work zone user cost

A significant source of uncertainty in bridge management systems industry-wide is the estimation of indirect agency costs and user costs concerned with bridge work zones. These costs currently are not modeled in PLAT except as an overhead factor, because of a lack of industry research. Yet, they are very significant in decision making.

Work zone agency costs include maintenance of traffic, mobilization, demolition, and land acquisition. Together these often make up half or more of bridge project costs. These costs are site-specific and in current practice require some level of design work to estimate. However, there remains a need to improve the accuracy of the programmatic cost estimates in PLAT. The next major improvement in this accuracy would come from a better programmatic estimate of indirect costs, to be available before the design phase begins since it is instrumental in the prioritization and funding of such design work.

Work zone user costs have for many years been a significant factor in the decision to use night work and maintenance methods that are least disruptive to traffic. However, the Department lacks a formal means of estimating these costs and using them in scoping, timing, and prioritization decisions for bridge work. When one or more lanes are closed, or side friction is increased due to the presence of temporary barriers and construction equipment, there is a distinct effect on roadway capacity. The reduction in capacity causes vehicle queuing and detours. It increases travel times and accident risk.

The Office of Construction has conducted some research on roadway construction work zones but the scope of such studies was limited to roadway surface construction. Bridge construction for rehabilitation, repair or replacement constitutes a very different and unique situation, because of the significant detour typically involved, and particularly the challenge when there is a roadway underpass for the bridge. National efforts at work zone research have focused more on the roadway construction work zones and studies on bridge user costs have emphasized functional deficiencies due to the bridge attributes, but not on the costs during bridge construction. Incorporation of work zone models is also

now being nationally recognized as a near-term desired improvement to the AASHTOWare Bridge Management System.

The products of this research will include a work zone model, a data set of cost parameters needed for the Project Level Analysis Tool, and a report describing the methodology and updating procedures for future use by the Department. These would be immediately used by the headquarters Maintenance Office and by the District Structures and Facilities Engineers in the Department's maintenance planning processes, can be built into the new network optimization model described above, and will be of great interest to the entire national bridge management community beyond Florida.

9.5 Development of a deterioration model for element systems

In 2010 FDOT developed a deterioration model based on 14 years of CoRe Element data. Task 4 of the current study used a migration probability matrix, based on changes in element and condition state definitions, to convert the 2010 model into a form that is compatible with the 2015 Field Guide. Although the results are reasonable, the migration is based on judgment rather than statistical analysis. The new inspection process is more detailed than the old one, so a new statistical analysis of inspection data under the new Field Guide should yield much better models. In fact, much of the justification for the new inspection process has been to improve deterioration modeling.

Two inspection cycles are necessary, at a minimum, to develop Markovian deterioration models. As a result, an effort to produce these models is still fairly far in the future. Any analysis to estimate new transition times should also quantify element interactions by estimating protection factors based on protective element condition. Environment factors and action effectiveness models can also be estimated in the same process.

9.6 Development of Analytic Hierarchy Process (AHP) tool for bridge element weights

As briefly described in chapter 2 of this report, the Analytic Hierarchy Process (AHP) is a suitable method for computing bridge element weights. It is an accepted methodology for pairwise comparison of alternative situations and coming up with a set of relative weights. A survey tool will be developed and distributed among FDOT bridge engineers and managers. The objective of this survey is to ascertain from expert opinions, how bridge elements are relatively important in terms of each bridge element influencing the overall bridge condition. For instance, consider the sample case of a bridge expert trying to estimate the overall bridge condition index by aggregating the inspected condition data of several elements including, say, girder elements and column elements. Which of these two elements would the expert consider to be more important, i.e., give a higher weight, in the combination of the element condition indexes. The expert will be presented with a set of bridge element groups. Each group will be compared in pairs, i.e., which is more important among two elements? This degree of importance will also be quantified using a scale of 1 to 9, on how strong the comparison (importance) is (Table 9.1).

Table 9.1. Degree of comparison importance

Degree of Importance	Definition
1	Equal importance
2	Slightly more important
3	Moderately More Important
4	Moderately to Strongly More Important
5	Strongly More Important
6	Strongly to Very Strongly More Important
7	Very Strongly More Important
8	Very, Very Strongly Important
9	Extremely More Important

The survey has been developed in simple Microsoft Excel spreadsheet formats. Figures 9.2 and 9.3 show screen plots of such survey entries, with example of comparing girder elements with cap elements. In this case you may select using the drop down selection boxes in each cell, say that a girder is more important than a cap in combining the condition indexes of these two elements for determining the overall bridge condition, and that as shown in the Figure 9.3, the degree of this importance is say 5, "Strongly More Important."

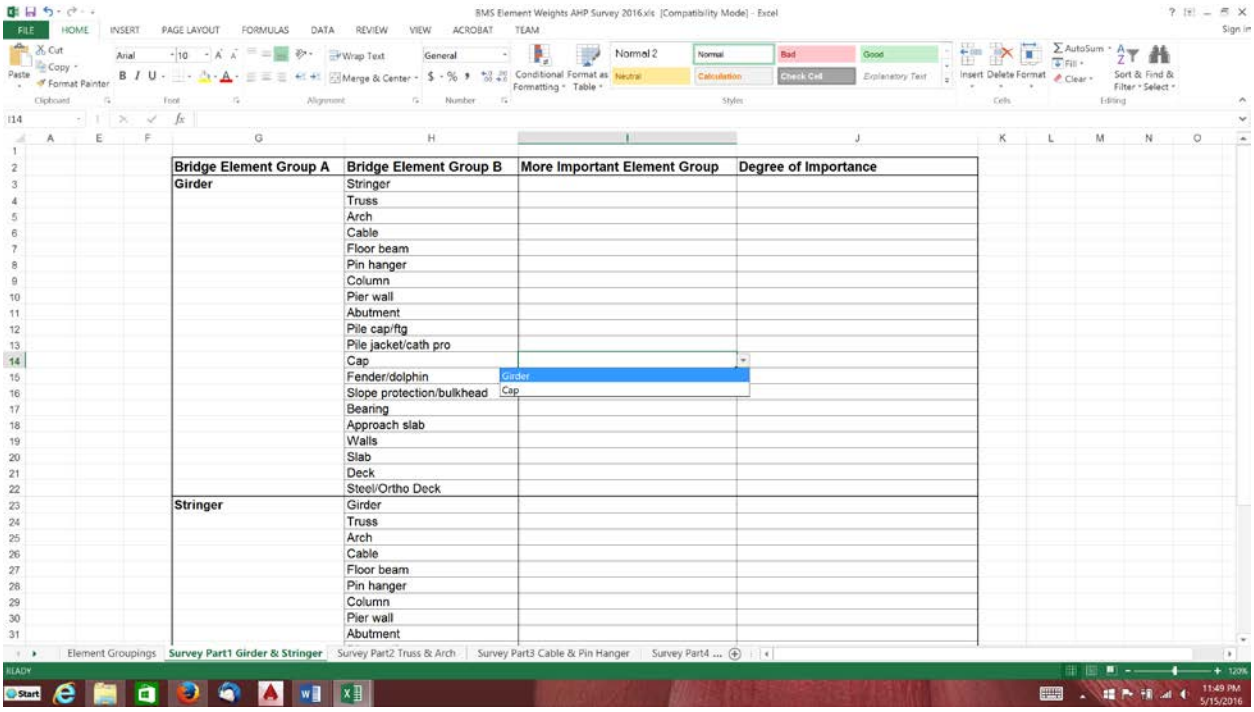

Figure 9.2. Making pairwise comparison of importance between two bridge elements

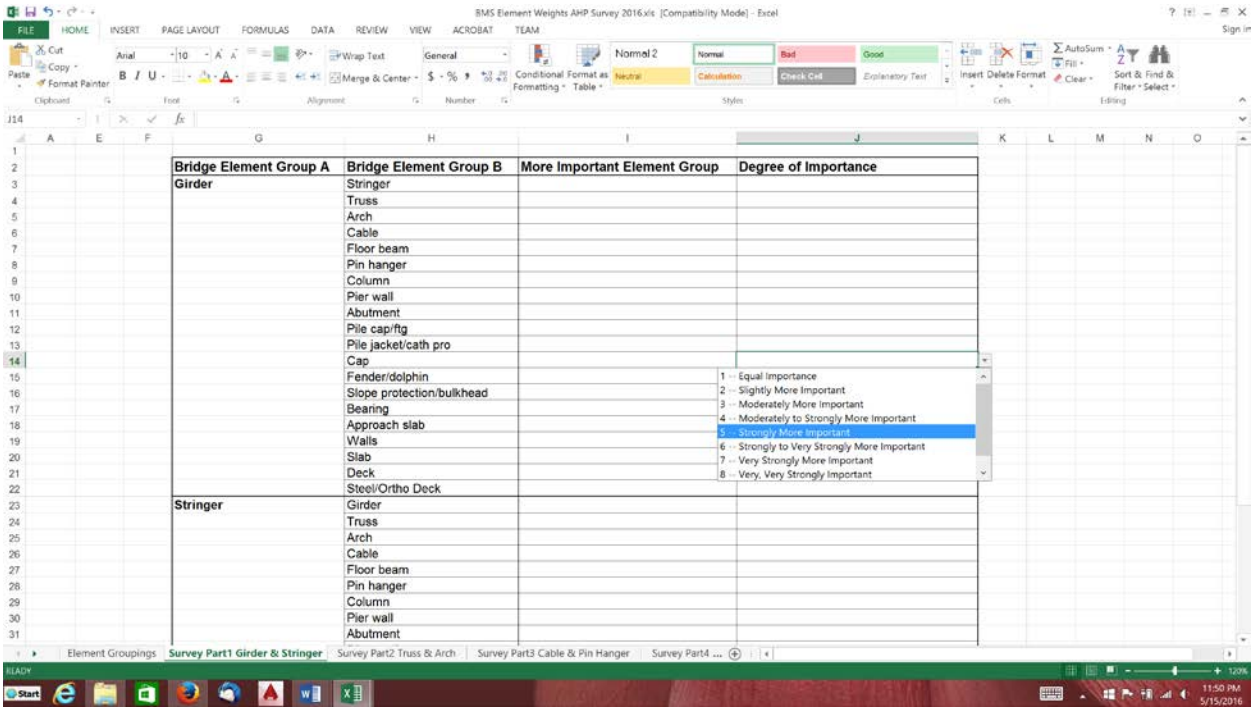

Figure 9.3. Entering the degree of importance of comparison between two bridge elements

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