Bridge Management Systems
A Practical Tour

David Juntunen, Bridge Development Engineer

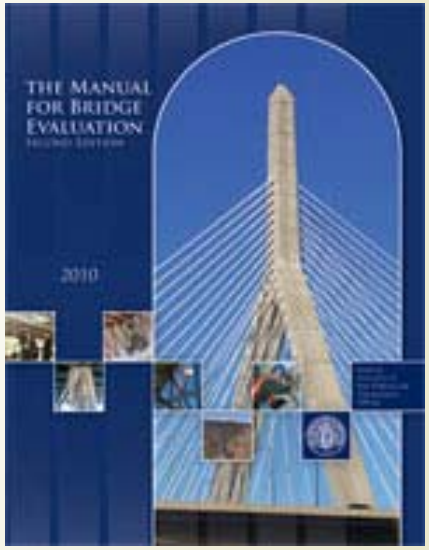
Michigan Department of Transportation

Vice-Chair AASHTO SCOBS T-18 (Bridge Evaluation and Management)

Chair AASHTO SCOB T-11 (Research)

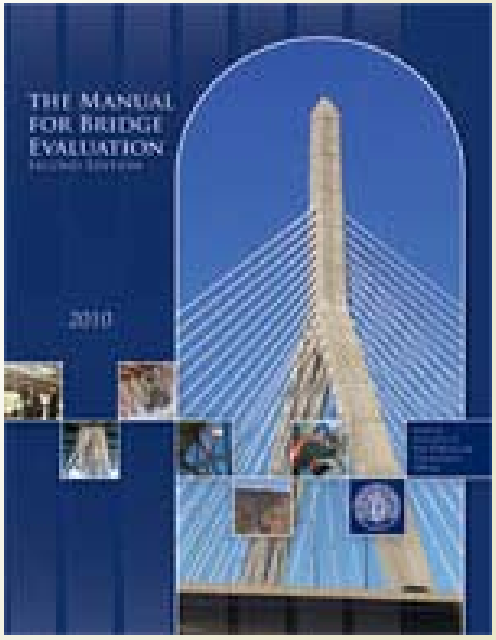
AASHTO Manual For Bridge Evaluation: Section 3, Bridge Management Systems

- AASHTO SCOBS T-18 (Bridge Evaluation and Management) has recently updated Section 3, “Bridge Management Systems
  - Up for Ballot at the 2017 AASHTO SCOBS meeting

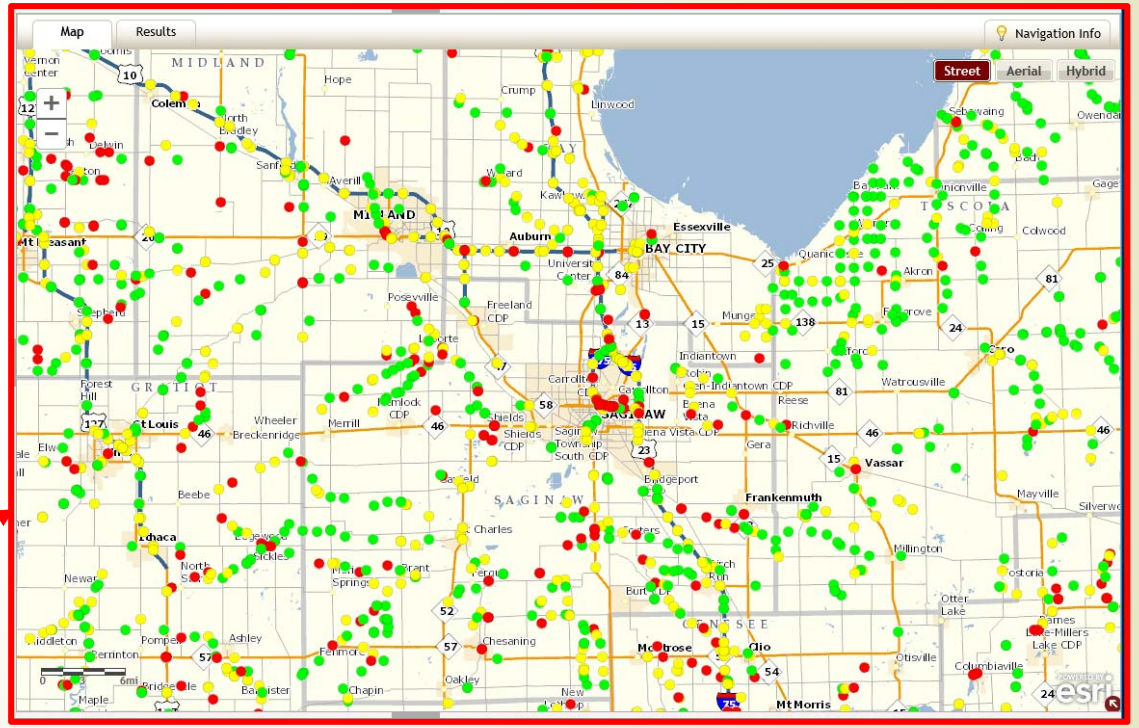


AASHTO Manual For Bridge Evaluation: Section 3, Bridge Management Systems

- 3.2 - Objectives of Bridge Management Systems
- 3.3 - Components of a Bridge Management System
  - 3.3.1- Information Management
    - 3.3.1.1- Bridge Inventory, General Condition Ratings and Bridge Element Ratings
      - 3.3.1.1.1 - Bridge Inventory
      - 3.3.1.1.2 - General Condition Ratings
      - 3.3.1.1.3 - Bridge Element Ratings
    - 3.3.1.2 - Agency Performance Measures
    - 3.3.1.3 - Preservation and Improvement Action Data
    - 3.3.1.4 - Cost Data and Financial Plans
  - 3.3.2 - Data Integration
    - 3.3.2.1 - Data Analysis
    - 3.3.2.2 - Risk Assessment
    - 3.3.2.3 - Agency Rules
    - 3.3.2.4 - Cost/Benefit Analysis
      - 3.3.2.4.1 - Condition Driven Cost/Benefit Analysis
      - 3.3.2.4.2 - Improvement Cost/Benefit Analysis
      - 3.3.2.4.3 - Life-Cycle Cost/Benefit Analysis
    - 3.3.2.5 - Prioritization and Optimization
      - 3.3.2.5.1 Multi-Objective Optimization
  - 3.3.3—Decision Support



MBE Chapter 3 – Quote, “A BMS should meet the needs of both upper management, where it is a strategic planning tool, and technical decision makers, where it is an engineering tool.

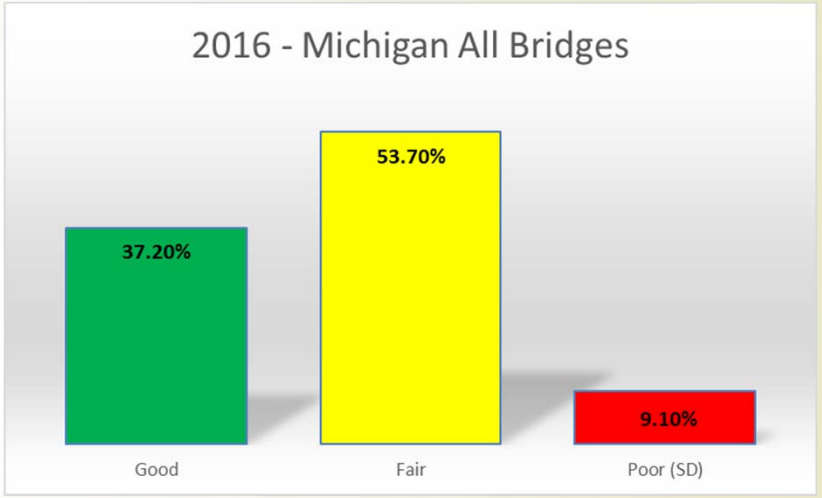


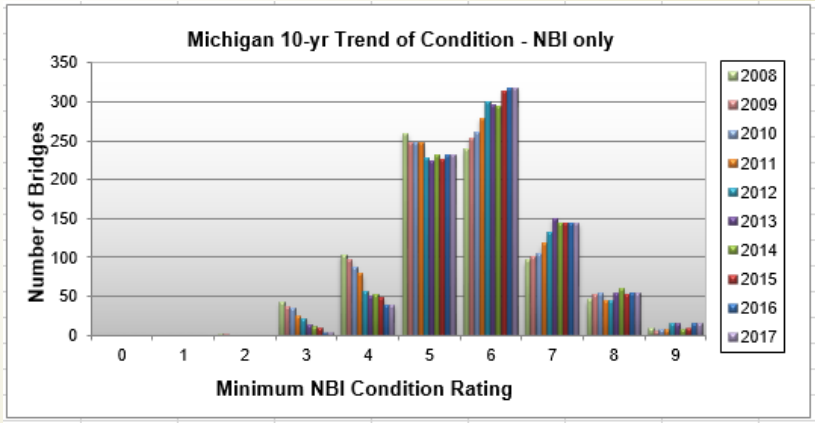
Network Level and Project Level Management.

Network Management of Bridges

- Bridge Inventory
  - General Condition Ratings
    - National Bridge Inventory (NBI)
  - Bridge Element Ratings - AASHTO Manual for Bridge Element Inspection (MBEI)
- Performance Measures
  - National Performance Measures (FHWA)
    - Report Good (NBI 7-9), Poor (0-4) by Deck Area (Fair (5-6) is calculated)
  - **State Defined Performance Measures**

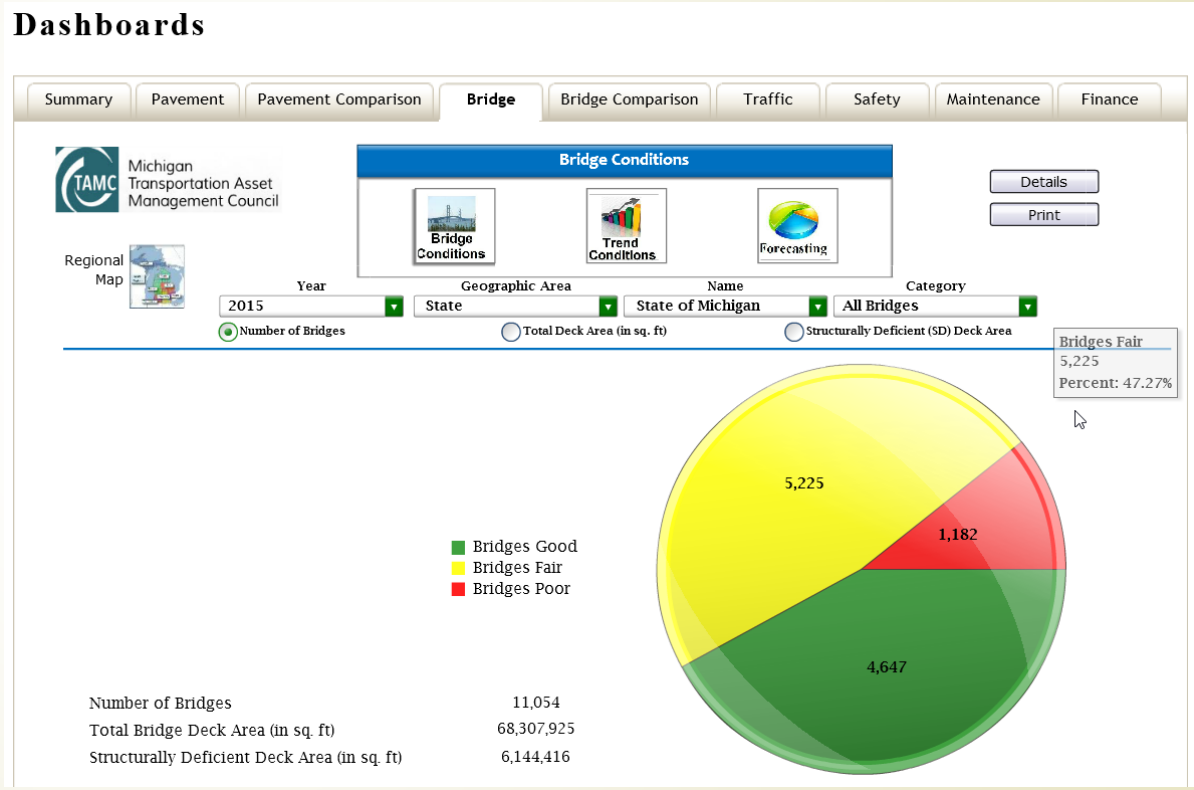
Monitoring Trends



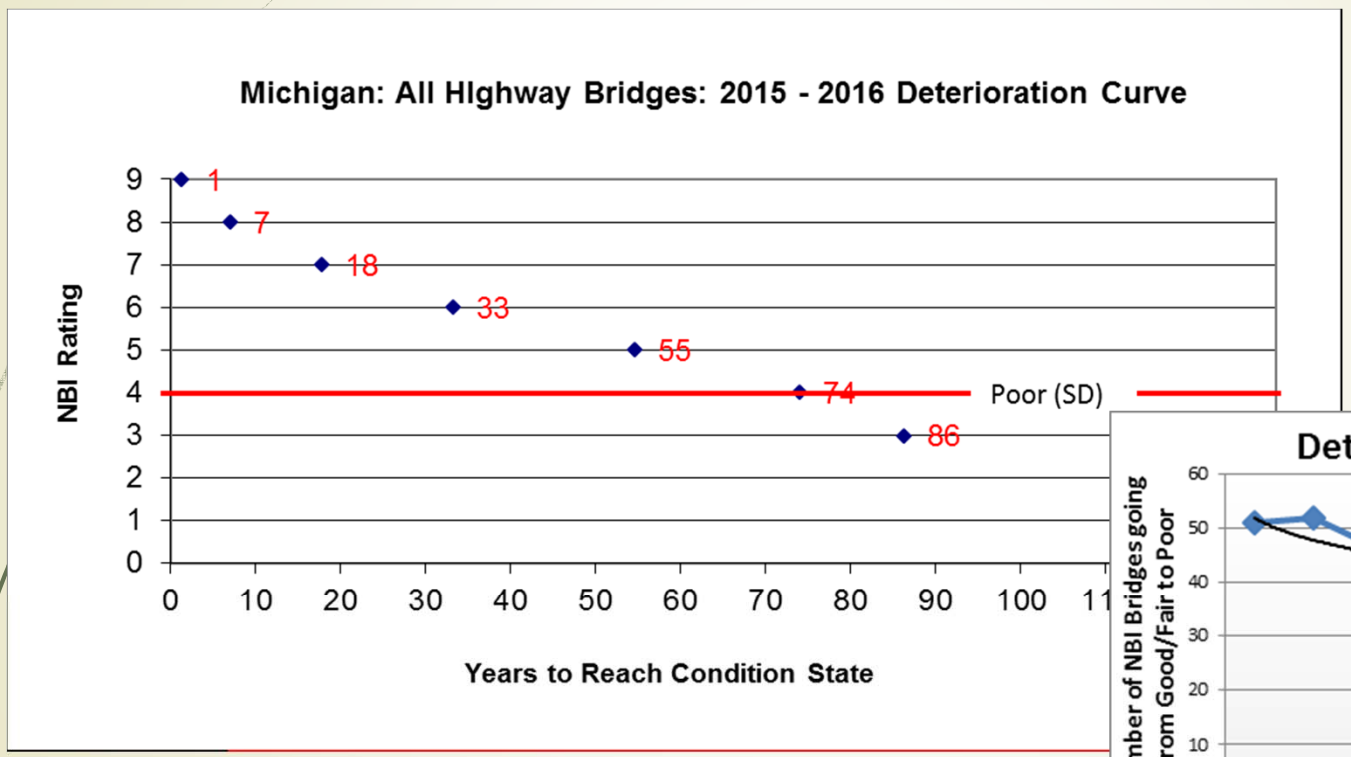


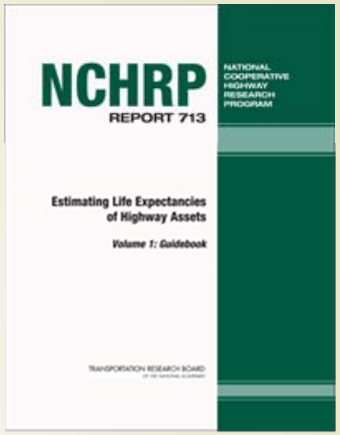
State Defined Performance Measures

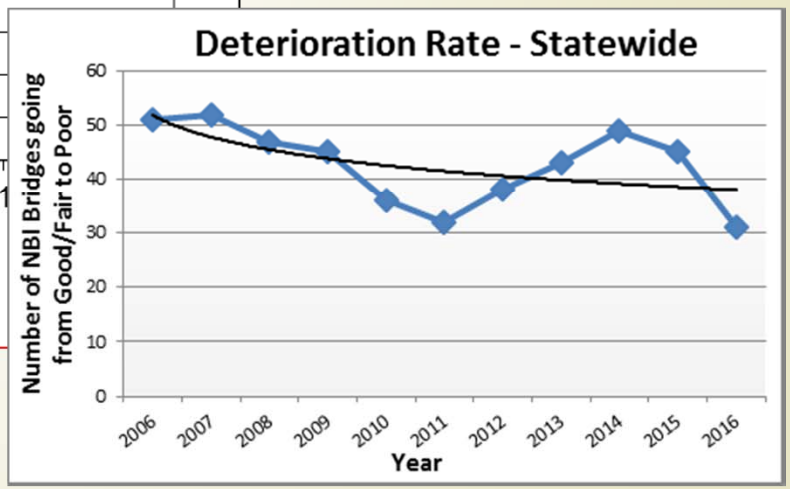
- Michigan Performance Measures
  - Take care of all critical needs
  - Freeway 95% Good or Fair
  - Non-Freeway 85% Good or Fair
  - Reduce the number of scour critical bridges carrying the interstate
  - **Reduce reactionary actions on our bridges**



Deterioration Modeling







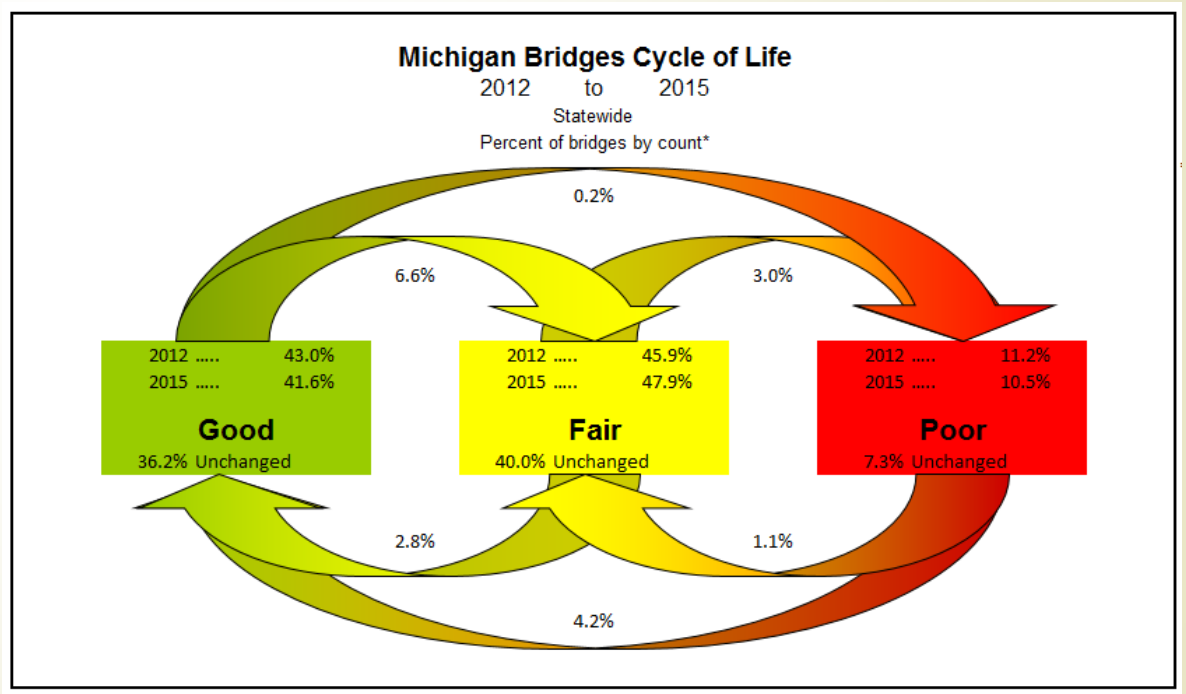
Bridge Related Cost Models

- Project Costs
  - Direct
  - Indirect
    - Mobilization
    - Traffic Control

- Michigan Averages
  - Preventive Maintenance Cost = $550,000 per bridge project
  - Rehabilitation Cost = $1,400,000 per bridge project
  - Replacement Cost = $4,200,000 per bridge project

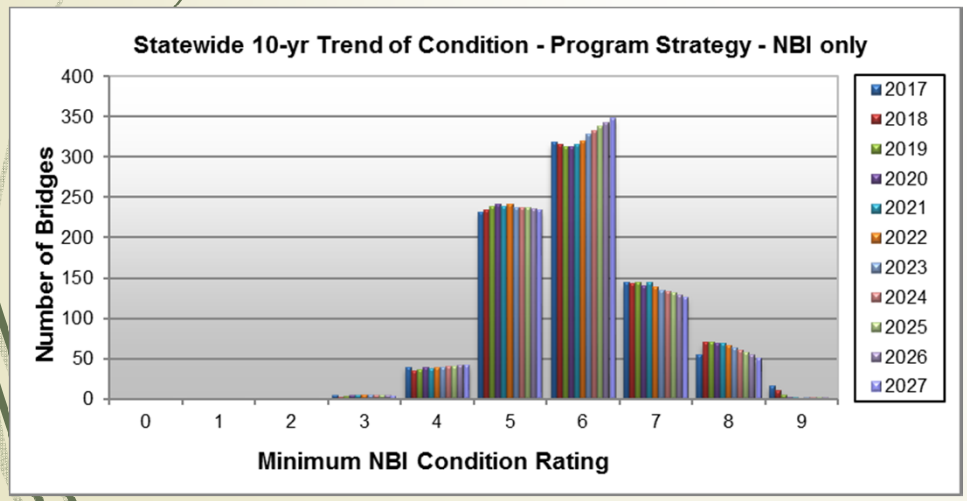
Strategy, Funding and Agency Rules

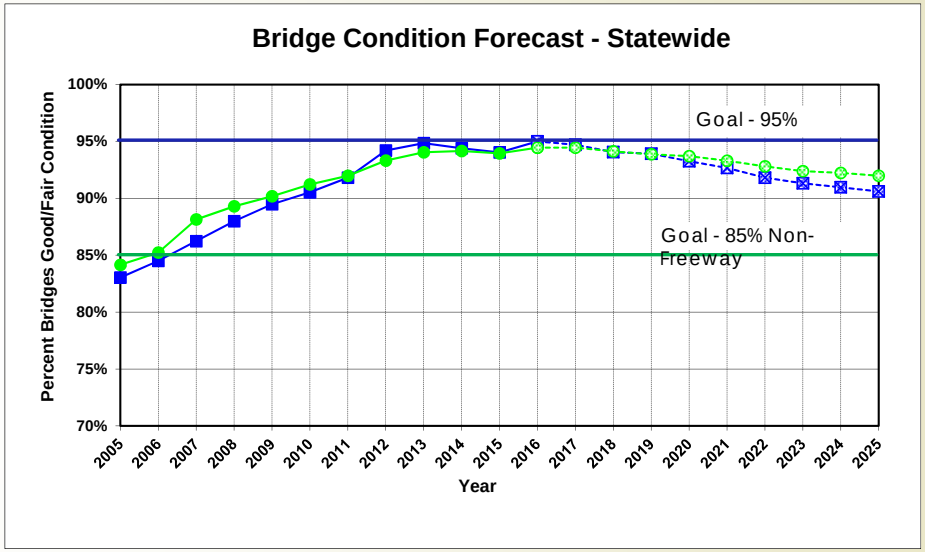
- Do cyclic maintenance when ....
- Do preventive maintenance when ...
- Do rehabilitation when ...
- Replace the Bridge when ....



Forecasting Bridge Condition

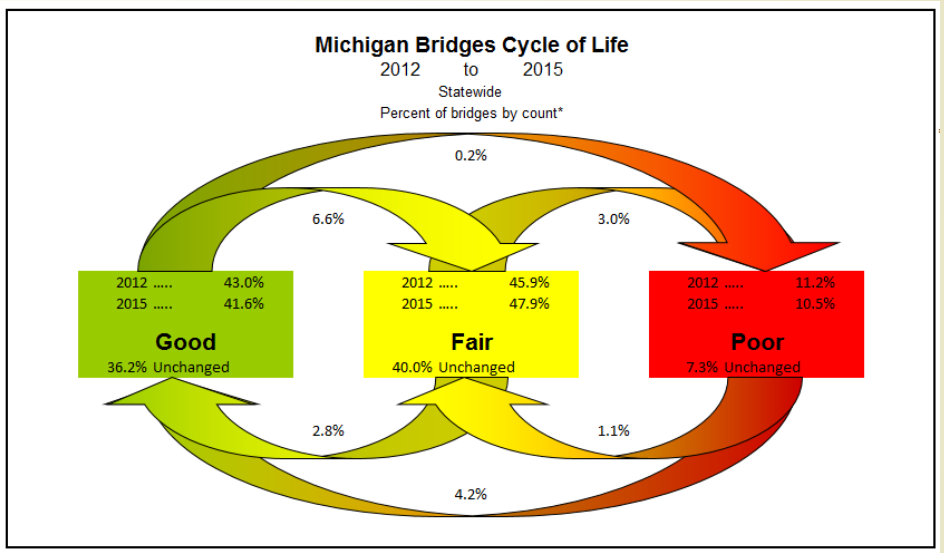
- Bridge Condition Forecasting
  - Help justify budget
  - Needs to be responsive
  - Easy to understand

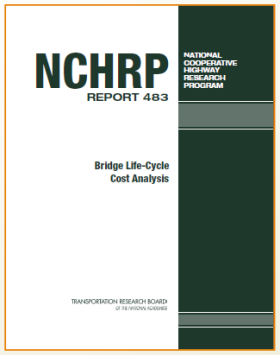


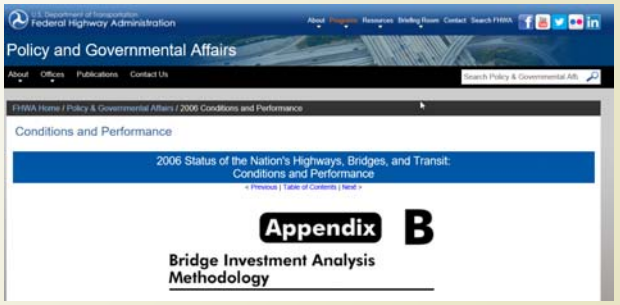


Project Level Bridge Management

- Detailed Bridge Decisions
  - Bridge Element Ratings - AASHTO Manual for Bridge Element Inspection (MBEI)
    - National Bridge Elements (NBEs)
    - Bridge Management Elements (BMEs)
    - Agency-Defined Elements (ADEs)
- Project **Prioritization**
  - Cost/Benefit Analysis
  - Risk Assessment
  - Managing Fair Bridges
    - Remaining Service Life or Time to Poor
  - Multi-objective **Optimization**

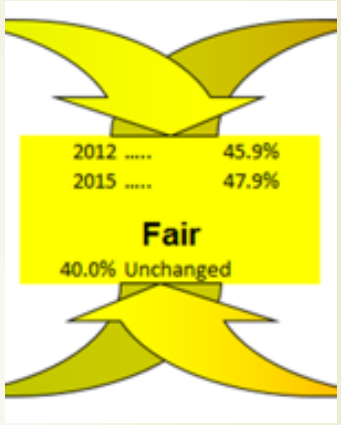






Managing Fair Bridges

- Reduce the number of bridges becoming poor each year.
- Prioritize by Time to poor (Remaining Service Life)
- Touch every bridge every 8-10 years
- Bundle projects and coordination with road projects



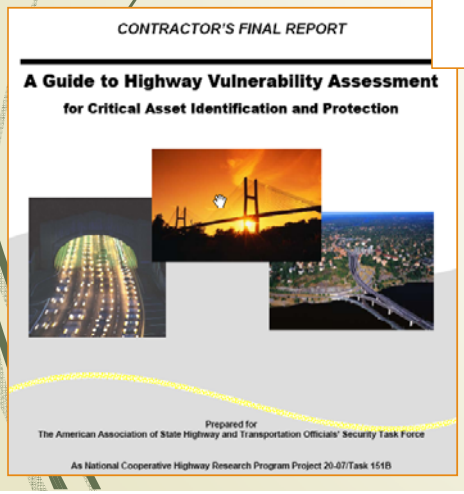
Managing Poor Bridges

- Reduce the number of poor
  - Coordinate with road program
- Prioritize by risk assessment

NCHRP 20-07/Task 378 [Final]

Assessing Risk for Bridge Management
[NCHRP 20-07 (Research for AASHTO Standing Committee on Highways)]

Project Data	
Funds:	$100,000
Research Agency:	Western Management & Consulting LLC
Principal Investigator:	Mr. Jeffrey L. Western
Effective Date:	8/25/2015
Completion Date:	9/30/2016



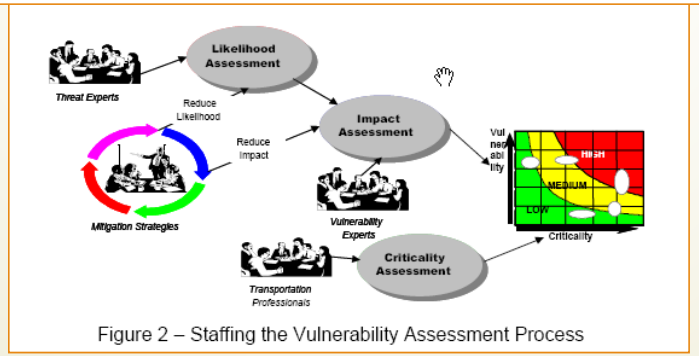
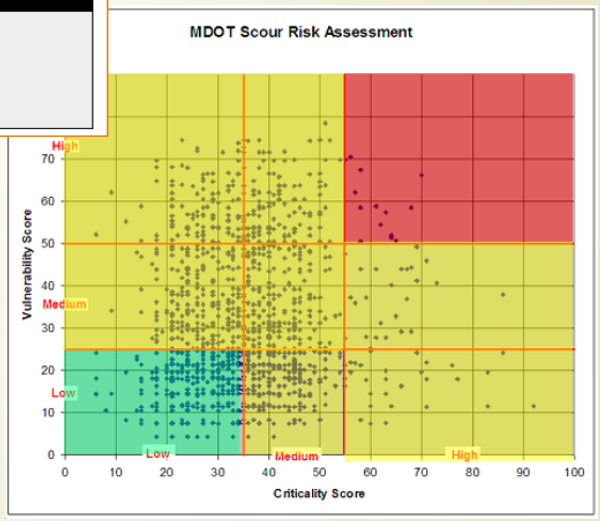


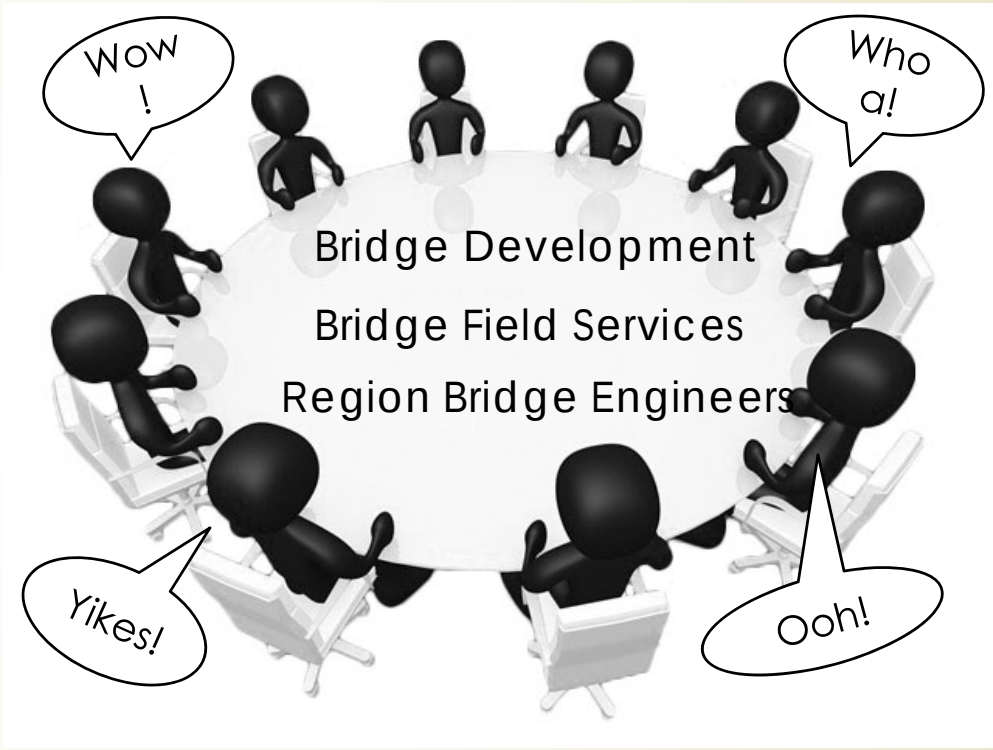
Figure 2 – Staffing the Vulnerability Assessment Process



Managing the Serious/Critical

- Regions must justify NOT working on serious or critical bridges. Must indicate how the bridge will be kept safe until work can be done.
- Request For Action Program

RFA Coordination Committee



Responsible for Reviewing, Prioritizing, Initiating Action, Monitoring, and/or Ensuring Resolution

Multi-objective Optimization

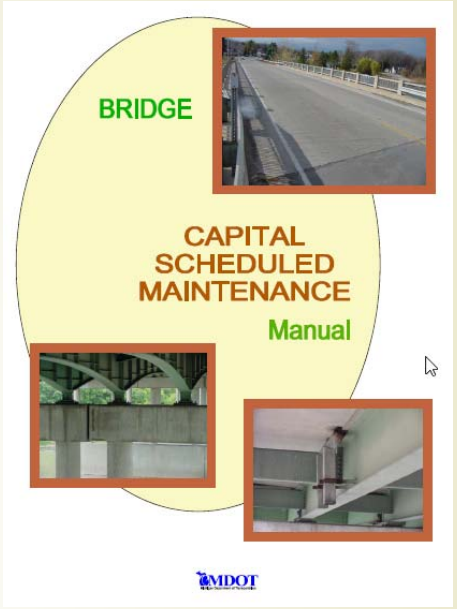
- Michigan Bridge Multi-Objectives
  - Meet and maintain freeway bridge condition goal (95%) good or fair
  - Reduce scour critical bridges carrying the interstate.
  - Make bridges more resilient to reactive activities resulting from advanced deterioration. (Reduce need to close traffic lanes because of advanced bridge deterioration.)

Michigan's Project Level Objectives of our BMS

- For every bridge not already programed, deteriorate the network five years, then using bridge elements and the AASHTOWare BrM software, indicate what the needs are for that bridge, what category of work it fits into, and estimate the cost for the work.

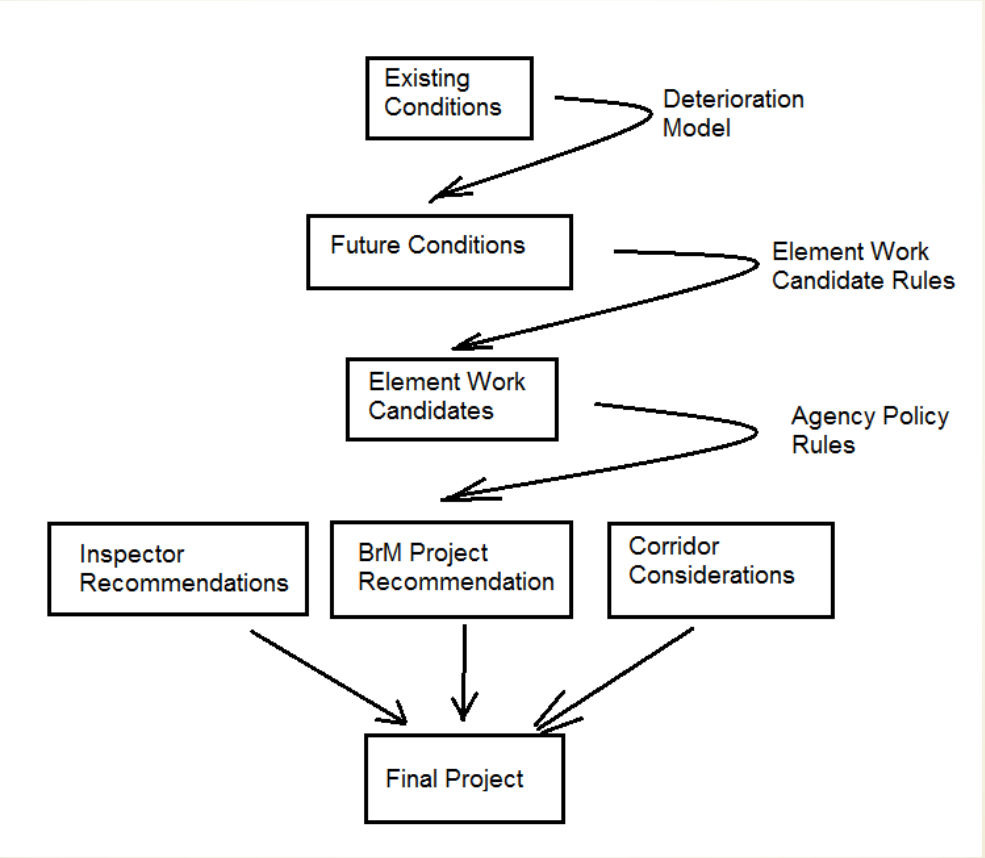
Agency Rules

- Cyclic
  - Example – Do bridge washing when ….
- Condition
  - Example - Replace seals in strip seal expansion joints when quantity in Condition State 2 (fair) exceeds 20%
  - Conditional rules most often need to be considered concurrently with related elements that could impact how the rules should be applied.



AASHTOWare BrM Bridge Management

Project Level BMS Process Overview

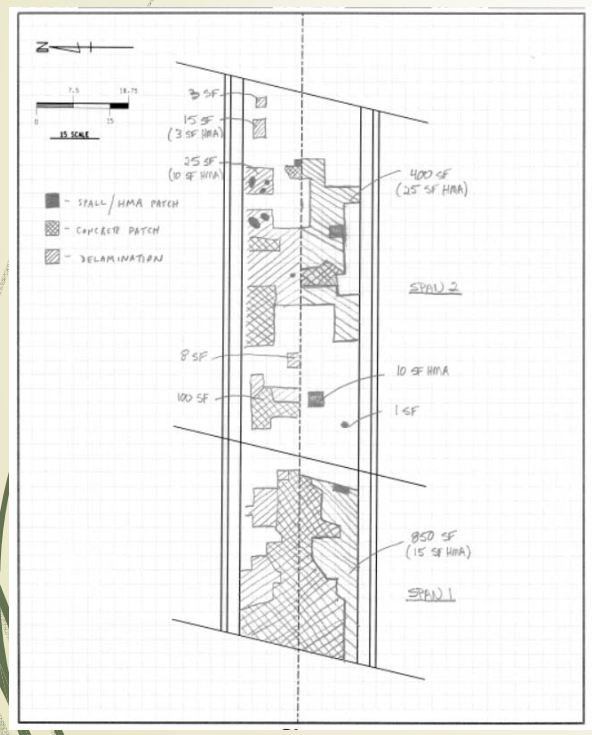


Example Bridge Project
(44th AVENUE OVER I-196)

Bridge Element Condition Ratings							
Decks/slabs							
Elem No	Element Name	Quantity	Units	Good (CS1)	Fair (CS 2)	Poor (CS 3)	Serious (CS4)
800	Reinf. Conc Deck Black Bars	6965	SFT	61%	13%	25%	0%
810	Reinforced Concrete Deck Top Surface	6965	SFT	31%	22%	47%	
811	Reinf. Conc. Deck Bottom Surf.	6965	SFT	92%	5%	3%	0%
812	Reinf. Concrete Fascia	444	LFT	95%	5%	0%	0%
331	Metal Bridge Railing	444	LFT	40%	60%	0%	0%
Joints							
Elem No	Element Name	Quantity	Units	Good (CS1)	Fair (CS 2)	Poor (CS 3)	Serious (CS4)
401	Pourable Joint Seal	96	LFT	0%	85%	15%	0%
Superstructure							
Elem No	Element Name	Quantity	Units	Good (CS1)	Fair (CS 2)	Poor (CS 3)	Serious (CS4)
109	Prestr Conc Girder/Beam	1182	LFT	98%		2%	0%
Bearings							
Elem No	Element Name	Quantity	Units	Good (CS1)	Fair (CS 2)	Poor (CS 3)	Serious (CS4)
310	Elastomeric Bearings	32	EACH	0%	0%	100%	0%
313	Fixed Bearing	8	EACH	0%	100%	0%	0%
515	Steel Protective Coating	8	SFT	0%	0%	100%	0%
Substructure							
Elem No	Element Name	Quantity	Units	Good (CS1)	Fair (CS 2)	Poor (CS 3)	Serious (CS4)
215	Reinforced Concrete Abutment	80	LFT	96%	4%	0%	0%
205	Reinforced Concrete Column	4	EACH	45%	22%	33%	0%
234	Reinforced Concrete Pier Cap	40	LFT	47%	2%	51%	0%

Deck Surface Condition

- Deck surface
  - 47% Poor



Typical Deck Joint Condition

- Pourable Joint Seals
  - 85% Fair
  - 15% Poor

Deck Bottom Surface Condition

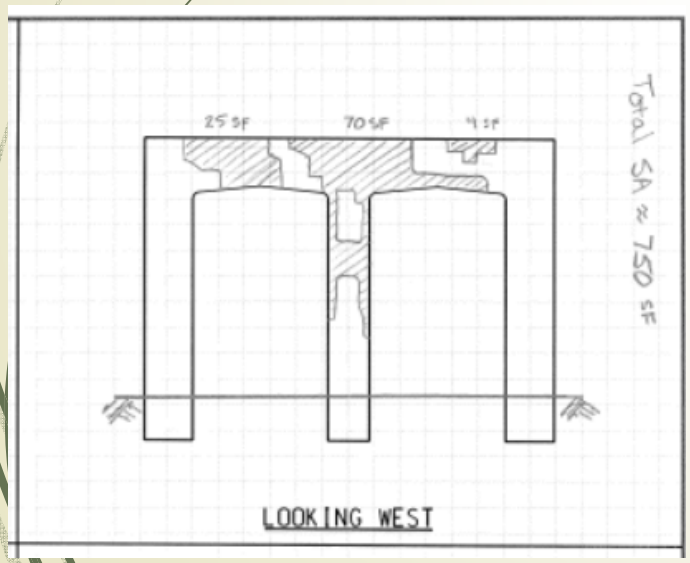
- **Deck Bottom Surface**
  - **3% Poor**

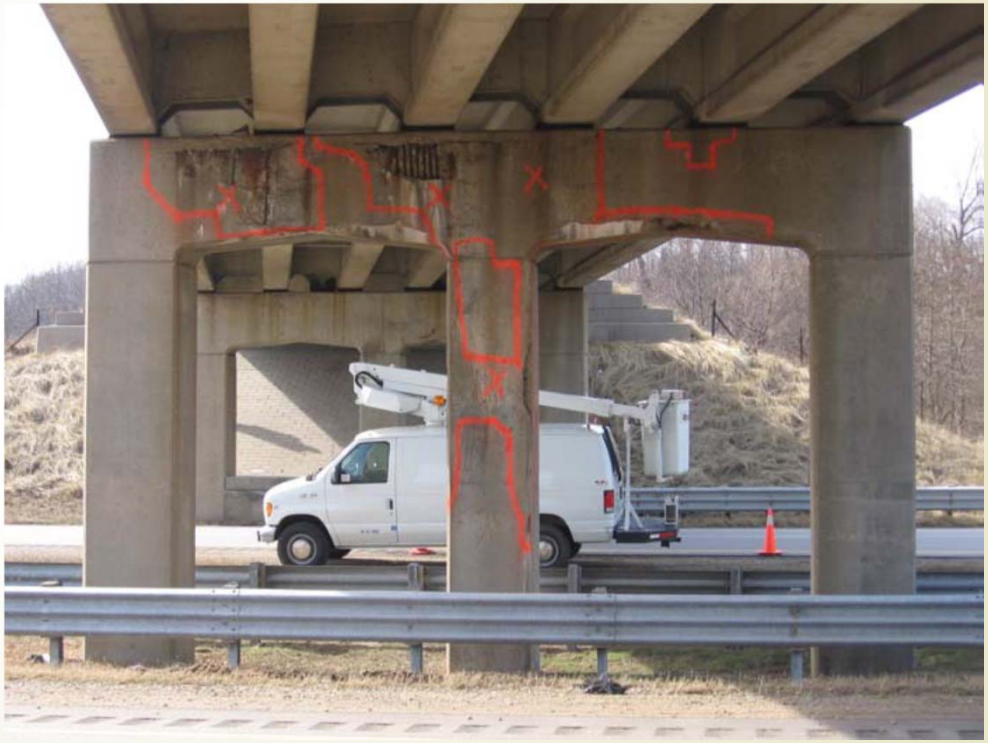
Prestressed Beam End Condition

- **Beams**
  - **2% Poor (at the Beam Ends)**

Pier Condition

- Columns
  - 33% Poor
- Pier caps
  - 51% Poor





Bridge Railing with Thrie-Beam Retrofit

- **Concrete/Steel Railing with Thrie-Beam retrofit**
  - **85% Good**
  - **15% Fair**

Decision – do you bring up to current standard?

Element Work Recommendations

BRIDGE DECK PRESERVATION MATRIX – Decks with Uncoated "Black" Rebar

DECK CONDITION STATE				REPAIR OPTIONS	POTENTIAL RESULT TO DECK BSIR		ANTICIPATED FIX LIFE
Top Surface		Bottom Surface			Top Surface	Bottom Surface	
BSIR #58a	Deficiencies % (a)	BSIR #58b	Deficiencies % (b)		BSIR #58a	BSIR #58b	
≥ 5	N/A	N/A	N/A	Hold (c) Seal Cracks/Healer Sealer (d)	No Change	No Change	1 to 4 years
	≤ 5%	> 5	≤ 2%	Epoxy Overlay	8, 9	No Change	10 to 15 years
	≤ 10%	≥ 4	≤ 25%	Deck Patch (e)	Up by 1 pt.	No Change	3 to 10 years
4 or 5	10% to 25%	5 or 6	≤ 10%	Deep Concrete Overlay (h)	8, 9	No Change	25 to 30 years
		4	10% to 25%	Shallow Concrete Overlay (h, i)	8, 9	No Change	20 to 25 years
				HMA Overlay with water-proofing membrane (f, h, i)	8, 9	No Change	8 to 10 years
		2 or 3	> 25%	HMA Cap (g, h, i)	8, 9	No Change	2 to 4 years
≤ 3	>25%	> 5	< 2%	Deep Concrete Overlay (h)	8, 9	No Change	20 to 25 years
		4 or 5	2% to 25%	Shallow Concrete Overlay (h, i)	8, 9	No Change	10 years
				HMA Overlay with water-proofing membrane (f, h, i)	8, 9	No Change	5 to 7 years
		2 or 3	>25%	HMA Cap (g, h, i)	8, 9	No Change	1 to 3 years
				Replacement Deck with Epoxy Coated Rebar (ECR)	9	9	60+ years

(a) Percent of deck surface area that is spalled, delaminated, or patched with temporary patch material.
(b) Percent of deck underside area that is spalled, delaminated or map cracked.
(c) The "Hold" option implies that there is on-going maintenance of filling potholes with cold patch and scaling of incipient spalls.
(d) Seal cracks when cracks are easily visible and minimal map cracking. Apply healer sealer when crack density is too great to seal individually by hand. Sustains the current condition longer.
(e) Crack sealing can also be used to seal the perimeter of deck patches.
(f) Hot Mix Asphalt overlay with waterproofing membrane. Deck patching required prior to placement of waterproofing membrane.
(g) Hot Mix Asphalt cap without waterproofing membrane for ride quality improvement. Deck should be scheduled for replacement in the 5 year plan.
(h) If bridge crosses over traveled lanes and the deck contains slag aggregate, do deck replacement.
(i) When deck bottom surface is rated poor (or worse) and may have loose or delaminated concrete over traveled lanes, an in-depth inspection should be scheduled. Any loose or delaminated concrete should be scaled off and false decking should be placed over traveled lanes where there is potential for additional concrete to become loose.

Bridge Deck Preservation Matrix June 8, 2011 Rev

- **Deck Top Surface**
  - **47% Poor**
- **Deck Bottom Surface**
  - **3% Poor**
- **Repair Chosen**
  - **Deep Concrete Overlay**

Rehab Project ($590,000).

Hydro deck to expose top mat of rebar

Deep Overlay (Silica Fume Modified Concrete Overlay).

New concrete deck surface

New Expansion Joints

Prestressed concrete beam end repair, bearing replacement, substructure repair, concrete surface coating.

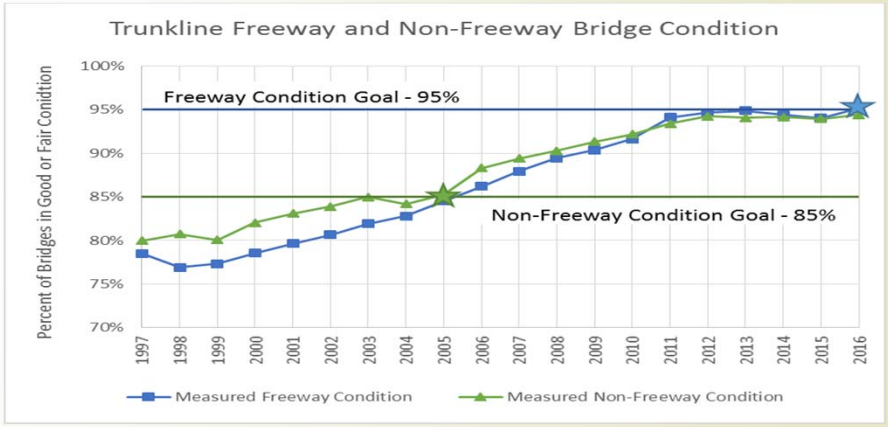
Post Construction Element Inspection

Bridge Element Condition Ratings							
Decks/slabs							
Elem No	Element Name	Quantity	Units	Good (CS1)	Fair (CS 2)	Poor (CS 3)	Serious (CS4)
800	Reinf. Conc Deck Black Bars	6965	SFT	96%	3%	2%	0%
815	Rigid Overlay	6965	SFT	100%	0%	0%	0%
811	Reinf. Conc. Deck Bottom Surf.	6965	SFT	92%	5%	3%	0%
812	Reinf. Concrete Fascia	444	LFT	95%	5%	0%	0%
331	Metal Bridge Railing	444	LFT	40%	60%	0%	0%
Joints							
Elem No	Element Name	Quantity	Units	Good (CS1)	Fair (CS 2)	Poor (CS 3)	Serious (CS4)
300	Strip Seal Expansion Joint	72	LFT	100%	0%	0%	0%
301	Pourable Joint Seal	48	LFT	100%	0%	0%	0%
Superstructure							
Elem No	Element Name	Quantity	Units	Good (CS1)	Fair (CS 2)	Poor (CS 3)	Serious (CS4)
109	Prestr Conc Girder/Beam	1182	LFT	98%	0%	2%	0%
521	Conc Protective Coating	1444	SFT	100%	0%	0%	0%
Bearings							
Elem No	Element Name	Quantity	Units	Good (CS1)	Fair (CS 2)	Poor (CS 3)	Serious (CS4)
310	Elastomeric Bearings	32	EACH	100%	0%	0%	0%
313	Fixed Bearing	8	EACH	0%	100%	0%	0%
515	Steel Protective Coating	8	SFT	100%	0%	0%	0%
Substructure							
Elem No	Element Name	Quantity	Units	Good (CS1)	Fair (CS 2)	Poor (CS 3)	Serious (CS4)
215	Reinforced Concrete Abutment	80	LFT	100%	0%	0%	0%
205	Reinforced Concrete Column	4	EACH	100%	0%	0%	0%
234	Reinforced Concrete Pier Cap	40	LFT	100%	0%	0%	0%
521	Conc Protective Coating	1062	SFT	100%	0%	0%	0%

A BMS is Decision Support

- The function of a BMS is to provide bridge information and data analysis capabilities to improve the decision-making abilities of bridge managers.
- Bridges cannot be managed without the practical, experienced, and knowledgeable input of the engineer/manager.
- Managers should use the BMS as a tool to evaluate various policy initiatives, often referred to as “what if” analysis.
- The available choices may relate to network-level decisions or project-level decisions.

Bridge Management Works!



BMS - The many things you learn on the journey are as valuable as the finished product.

Thank You!