



Incorporating Performance Measures into NCDOT's Bridge Management System

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Jim Edgerton

April 24, 2012

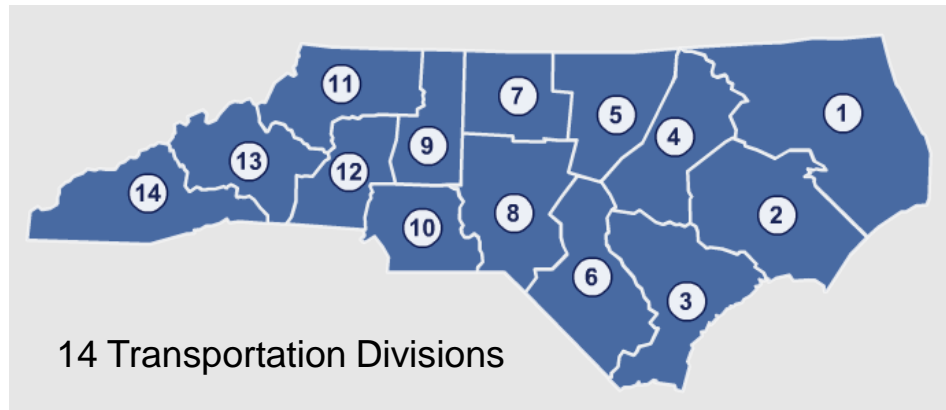
- About NCDOT
- Departmental Goals
- NCDOT's Integrated AMS
- Performance Management
 - ❑ Framework
 - ❑ Planning & Decision Making
- Summary

❖ NCDOT Highway Inventory

- ❖ **Approximately 80,000 miles** of highway statewide. Texas is the only other state in the country that maintains more mileage.
- ❖ **More than 18,300** bridges and culverts

❖ Asset Maintenance Operations

- ❖ In-house Maintenance Crews (60%)
- ❖ Contractors (40%)



NCDOT GOALS

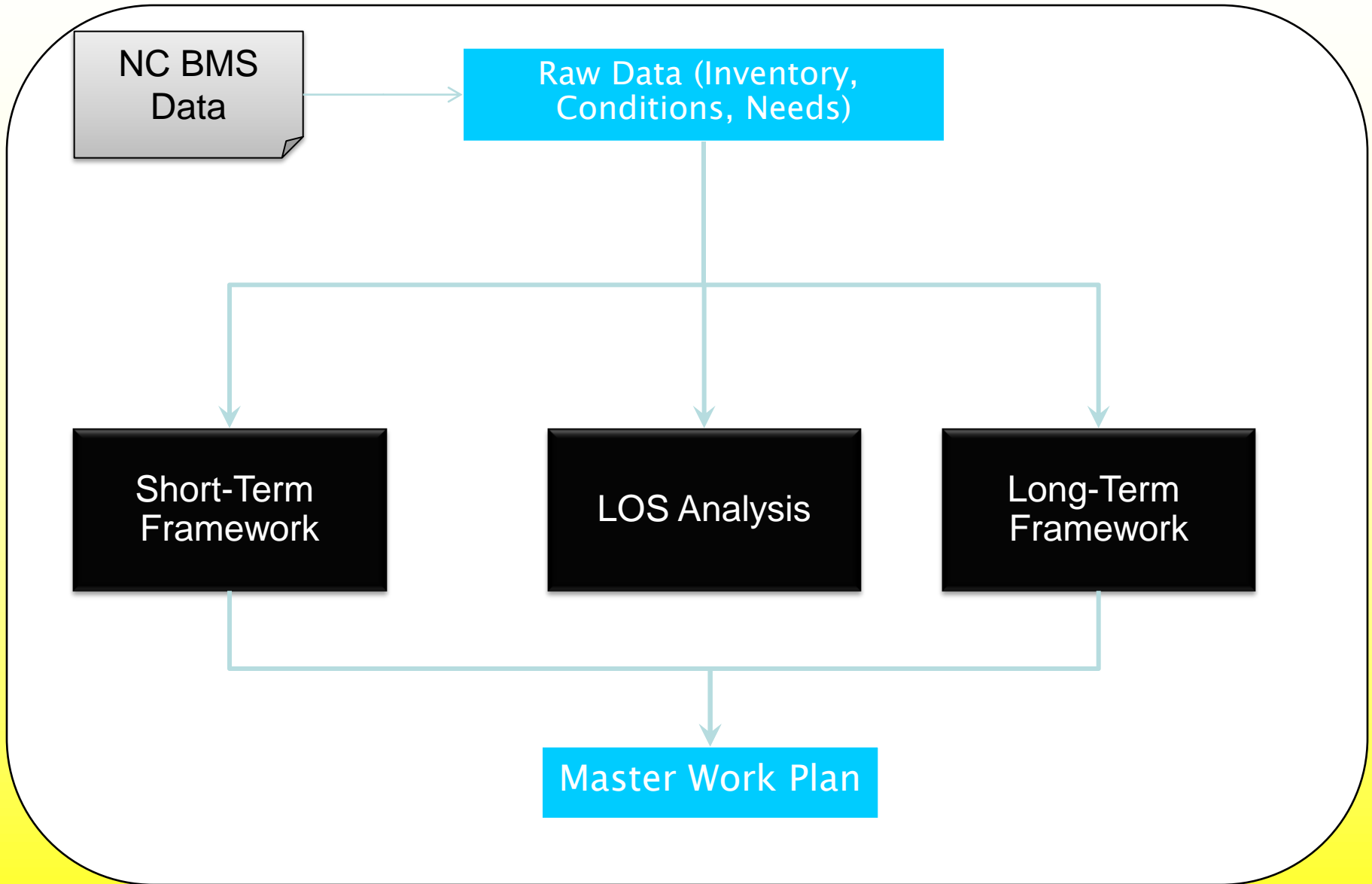
- Make our transportation network **safer**
- Make our transportation network move people and goods more **efficiently**
- Make our infrastructure **last longer**
- Make our organization a place that **works well**
- Make our organization **a great place to work**

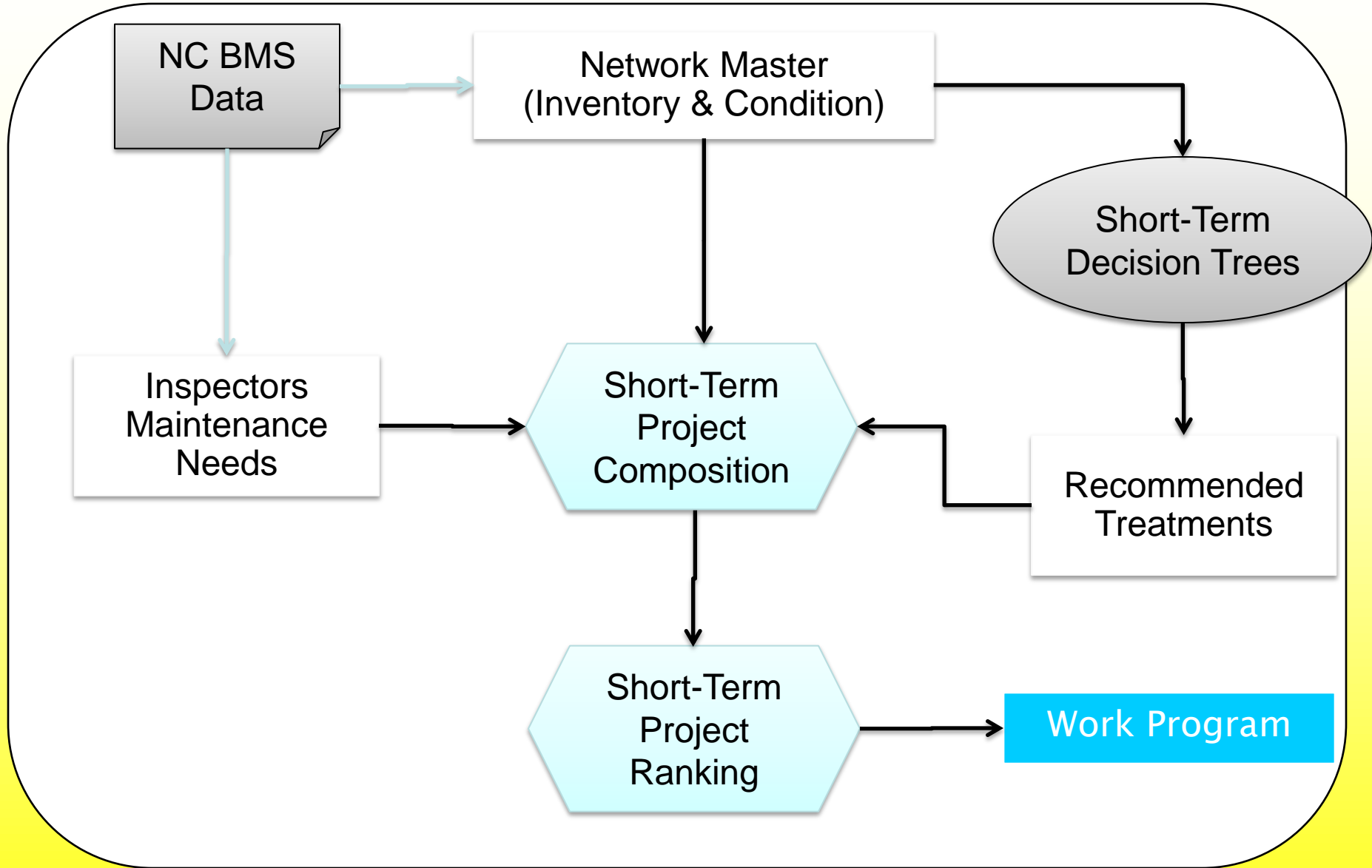
***Preservation of Bridges and Other Highway Assets
Using Efficient & Advanced Techniques,
Processes & Management Systems
To Make the Highway Infrastructure Last Longer***

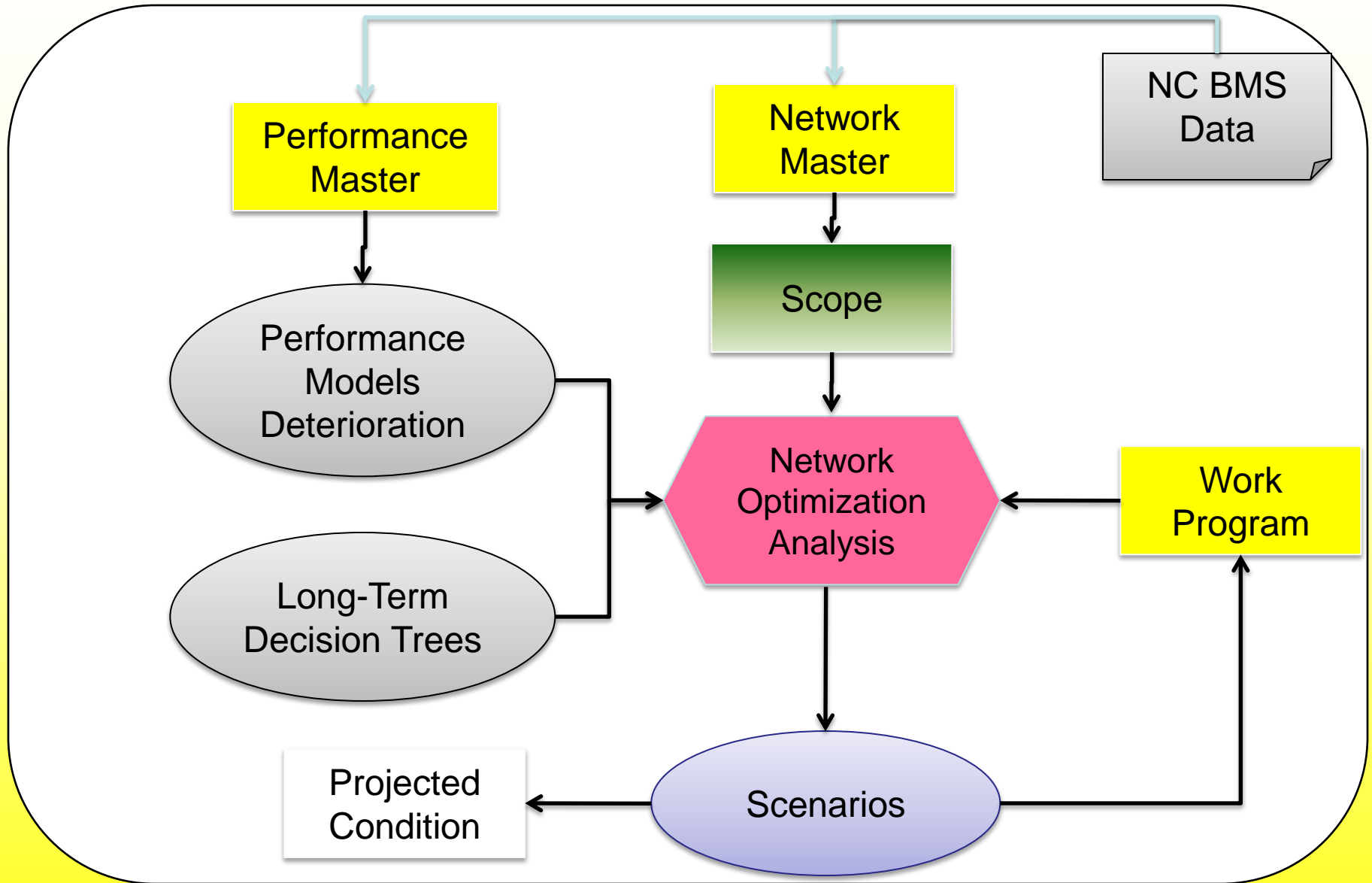
Goals:

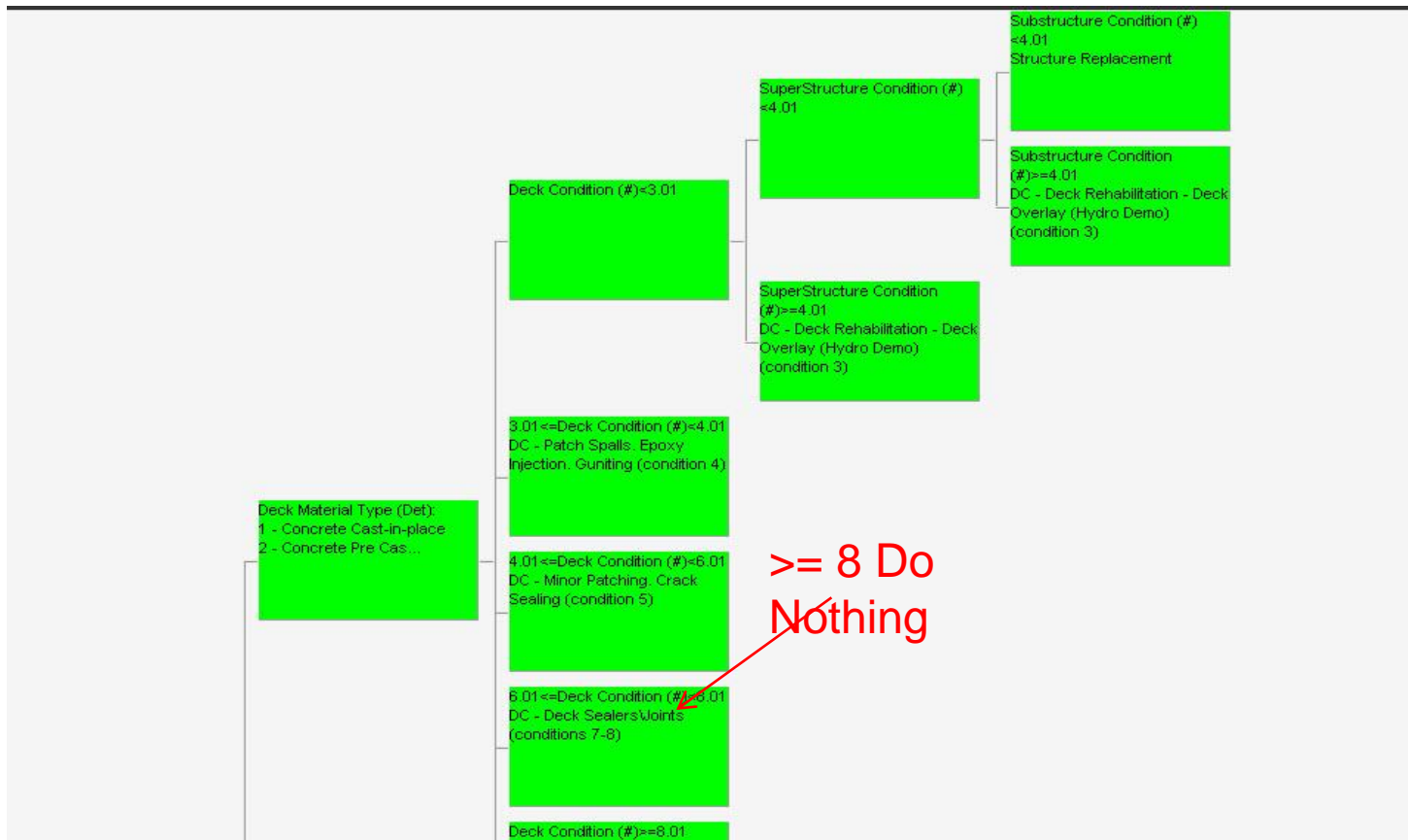
- Centralize all Inventory and Survey Data
- Facilitate Data Access and Dissemination
- Create and Maintain Performance Models (Deterioration Models and Decision Trees)
- Run Network Analysis (Optimization Scenarios)
- Produce a Work Plan

Bottom Line: *“Better Bridges Managed Efficiently”*



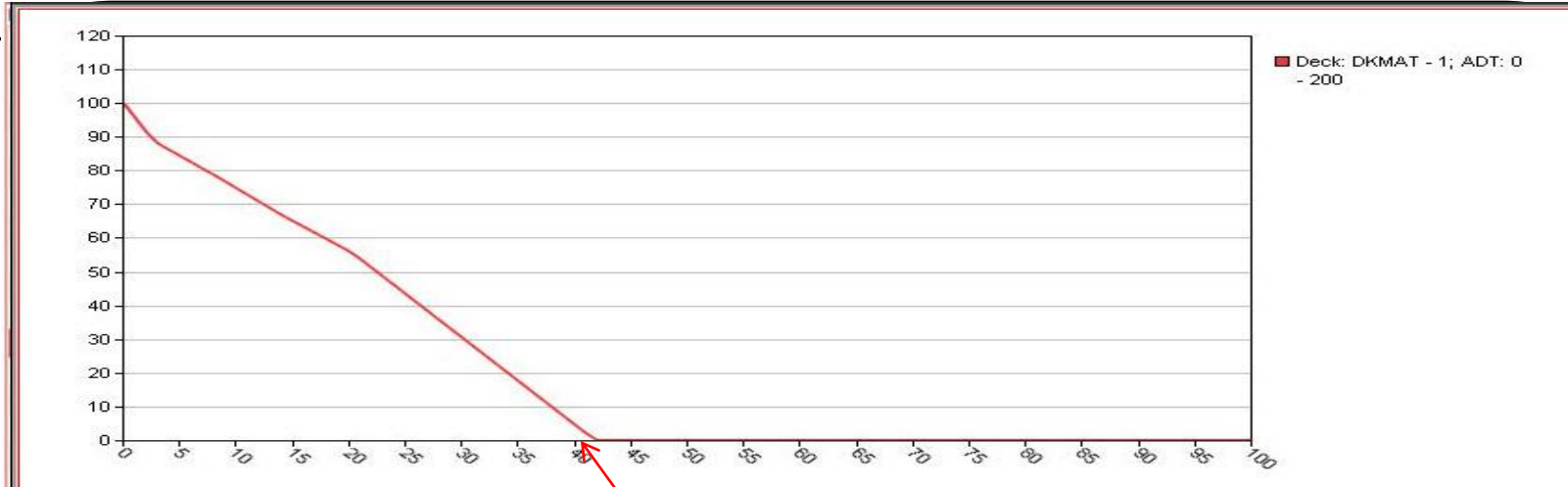






**>= 8 Do
Nothing**

Treatment Name	Unit Cost	Cost	Year Intervals	Condition Improvement (3-9)
DC - Deck Rehabilitation - Deck Overlay (Hydro Demo) (condition 3)	\$25.00	\$/Sq. Feet	20	+6
DC - Deck Sealers/Joints (conditions 7)	\$2.50	\$/Sq. Feet	5	+0
DC - Minor Patching. Crack Sealing (condition 5)	\$3.00	\$/Sq. Feet	3	+2
DC - Patch Spalls. Epoxy Injection. Guniting (condition 4)	\$10.00	\$/Sq. Feet	7	+3
Structure Replacement	\$550.00	Replacement	50	9



Constraints						
1 pages (6 rows)						
Scenario Y	Constraint Column	Constr. Type	Constraint Limit Value	Cond. T		
	Average Index (BMS)	Weighted Avg				
1	Treatment Cost	Total	15000000			
2	Treatment Cost	Total	15000000			
3	Treatment Cost	Total	15000000			
4	Treatment Cost	Total	15000000			
5	Treatment Cost	Total	15000000			

Constraints							
Is Objective	Constraint Column	Constr. Type	Constraint Limit Value	Cond. Threshold	Scenario Year	Add	
<input checked="" type="checkbox"/>	BHI Score (#)	Percent Above Threshold		6			
<input type="checkbox"/>	Treatment Cost	Total	10000000				1
<input type="checkbox"/>	Treatment Cost	Total	10000000				2
<input type="checkbox"/>	Treatment Cost	Total	10000000				3
<input type="checkbox"/>	Treatment Cost	Total	10000000				4
<input type="checkbox"/>	Treatment Cost	Total	10000000				5

Annual Budgets

Objective Threshold

Constr Results							
Scenario Year Number	Constr. Type	Constraint Column	Constraint Limit Value	Cond. Threshold	Resulting Value	Add Constr.	Co
1	Total	Treatment Cost	15000000		14908449.89		
2	Total	Treatment Cost	15000000		14339701.93		
3	Total	Treatment Cost	15000000		13742271.47		
4	Total	Treatment Cost	15000000		14986077.49		
5	Total	Treatment Cost	15000000		10578416.34		
1	Weighted Avg	Average Index (BMS)			7.14		
2	Weighted Avg	Average Index (BMS)			6.99		
3	Weighted Avg	Average Index (BMS)			6.84		
4	Weighted Avg	Average Index (BMS)			7.34		
5	Weighted Avg	Average Index (BMS)			7.16		

Funding

Effected Index

Constraints					
1 pages (6 rows)					
Scenario Y	Constraint Column	Constr. Type	Constraint Limit Value	Cond. T	
	Average Index (BMS)	Weighted Avg			
1	Treatment Cost	Total	15000000		
2	Treatment Cost	Total	15000000		
3	Treatment Cost	Total	15000000		
4	Treatment Cost	Total	15000000		

Results										
Structures					Treatments					
28 pages (583 rows)										
1 pages (3 rows)										
Plan Year	Structure Ilo.	MWP	Project Status	Project Cost	Benefit	Fr	Element	Structure Ilo.	Plan Year	Treatment
1	000120	1	Preliminary	163156.6112			Deck	000120	1	DC - Minor Patching, Crack Sealing (con
1	000148	1	Preliminary	407514.072			Substructure	000120	1	SUBST-CONCPLE - Seal Cracks (condit
1	000163	1	Preliminary	197679.7454			Superstructure	000120	1	SUPERST - PPC - Crack Sealing (condit
1	100024	1	Preliminary	252757.6646						
1	100071	1	Preliminary	180846.4896						
1	100156	1	Preliminary	44131.1976						
1	100210	1	Preliminary	88428.6144						
1	100215	1	Preliminary	97072.0128						
1	100313	1	Preliminary	142915.2682						
1	100339	1	Preliminary	124160.9932						

Selected Project
for Year 1

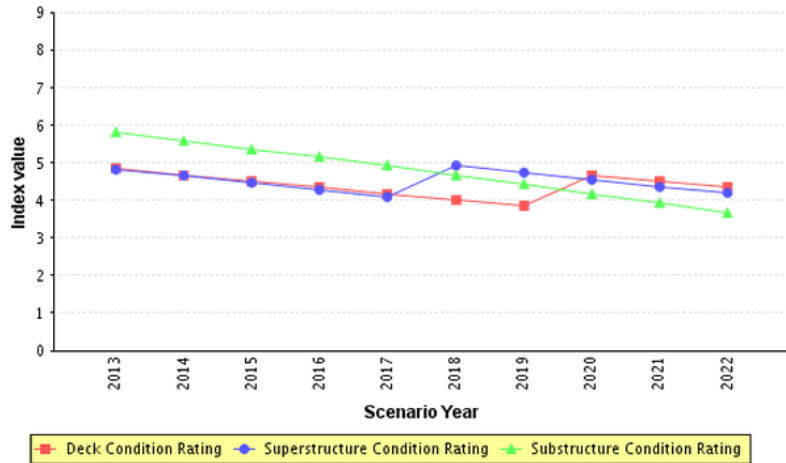
3 recommended
treatment activities per
project



Scenario Name: Division 5 - 2 years : Number of Years: 10

Date: 04/20/2012
Time: 3:31 PM

Scenario Results for Bridge: 310118



Estimated Remaining Service Life (from Inspector): 7



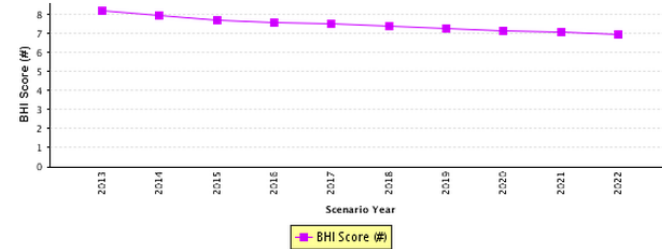
Scenario Highlights for scenario: Division 5 - 2 years

Date: 04/20/2012
Time: 3:30 PM

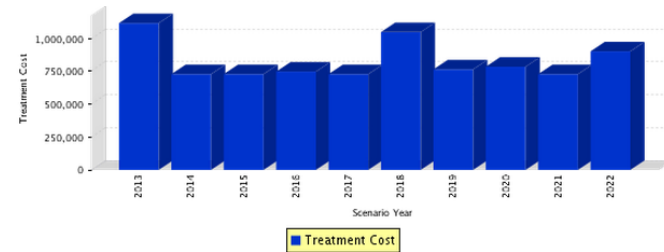
[Go To Data](#)

Start Year: 2012 Number of Years: 10

BHI Score (#) - Weighted Avg -



Treatment Cost - Total -





Real-Time Tracking of Bridge Maintenance Work



MMS	PMS	BMS	Resources	TradeOff	System						
Utilities	Setup	Database	Analysis	Reports							
Menu BMS > Database > Network Master											
BMS Network Master											
1 pages (25 rows)											
Structure No.	Tier ID	Bridge Age	ADT	ADT Year	Maint. History	Deficiency Points	Route Name	Lane Direction	Lane	From MP	To MP
140021	Regional	63	4600	2007	Yes	3.50	30000343/015	All	All	23.145	23.145
140007	Sub-Regional	37	760	2008	Yes	63.62	40001200/015	All	All	1.55	1.55
140014	Regional	77	2600	1999	Yes	72.50	29000017/015	All	All	1.017	1.017
140041	Sub-Regional	51	110	2000	Yes	6.00	40001148/015	All	All	0.239	0.239
140016	Sub-Regional	34	230	2009	Yes	0.00	40001135/015	All	All	3.38	3.38
140001	Statewide	30	5700	2009	Yes	0.00	20000158/015	All	All	7.038	7.038
140008	Sub-Regional	6	1300	2009	Yes	0.00	40001147/027	All	All	4.09	4.09
140009	Statewide	9	5700	2009	Yes	0.00	20000158/015	All	All	7.463	7.463
140043	Statewide	29	6000	2009	Yes	0.00	20400017/015	All	All	6.967	6.967
140017	Regional	31	2600	2009	Yes	0.00	30000343/015	All	All	7.678	7.678
140044	Statewide	29	6000	2009	Yes	0.00	20000017/015	All	All	2.581	2.581
140002	Sub-Regional	4	2000	2009	Yes	0.00	40001224/015	All	All	1.864	1.864
140003	Sub-Regional	18	250	2009	Yes	0.00	40001211/015	All	All	0.59	0.59
140010	Statewide	28	12000	2008	Yes	12.00	20000017/015	All	All	0.888	0.888
140018	Regional	31	4100	2009	Yes	0.00	30000343/015	All	All	8.78	8.78
140048	Sub-Regional	9	2700	2008	Yes	12.00	40001224/015	All	All	4.316	4.316
140050	Regional	5	2200	2009	Yes	12.00	30000343/015	All	All	18.532	18.532



Detailed Bridge Maintenance & Preservation Work History



Structure No.	Tier ID	Bridge Age	ADT	ADT Year	Maint. History	Deficiency Points	Route Name	Lane Direction	Lane	From MP	To MP	TIP Bridge No.	Rep
140021	Regional	63	4600	2007	Yes	3.50	30000343/015	All	All	23.145	23.145	07	K
140007	Sub-Regional	37	760	2008	Yes	63.62	40001200/015	All	All	1.55	1.55		
140014	Regional	77	2600	1999	Yes	72.50	29000017/015	All	All	1.017	1.017		
140041	Sub-Regional	51	110	2000	Yes	6.00	40001148/015	All	All	0.239	0.239		O

Maintenance History (show maint hist)

Task #	Administrative Unit	Work Function	WBS	Asset Type	Responsible Crew	Start Date	Finish Date
140008	632701 01 Bri Harbinger	3102-Removal of Hazards/Debris From ROW (HR)	1B.101511	Sections	Bridge Crew	1/20/2010 0:0:0	11/16/2010 0:0:0
140009	632292 01 Bri Harbinger	3310-Maintenance/Repair/Replacement of Standard Bridge Expansion Joints	1SP.10154.1	Sections	Bridge Crew	1/19/2010 0:0:0	1/19/2010 8:0:0
140043	632253 01 Bri Harbinger	3376-Clean/Wash Bridge Decks (SFT)	1SP.10154.1	Sections	Bridge Crew	1/19/2010 0:0:0	3/22/2011 0:0:0
140017	632235 01 Bri Harbinger	3314-Maintain Steel Superstructure Components (LFT)	1SP.10154.1	Sections	Bridge Crew	1/19/2010 0:0:0	1/19/2010 8:0:0
140044	568208 01 Bri Harbinger	3314-Maintain Steel Superstructure Components (LFT)	1SP.10154.1	Sections	Bridge Crew	5/4/2009 0:0:0	5/4/2009 8:0:0
140002	551096 01 Bri Harbinger	3310-Maintenance/Repair/Replacement of Standard Bridge Expansion Joints	1SP.10154.1	Sections	Bridge Crew	3/24/2009 0:0:0	3/24/2009 8:0:0
140003	550382 01 Bri Harbinger	3376-Clean/Wash Bridge Decks (SFT)	1SP.10154.1	Sections	Bridge Crew	3/24/2009 0:0:0	1/19/2010 0:0:0
140010	470930 01 Bri Harbinger	3376-Clean/Wash Bridge Decks (SFT)	1B.101511	Sections	Bridge Crew	6/10/2008 0:0:0	10/15/2008 8:0:0

How work was tracked ?

What was done ?

When ?

For Each Maintenance Work Item – Detailed Record of Resources Utilized

BMS Network Master
 << < 1 Go > >> 1 pages (25 rows)

Structure No.	Tier ID	Bridge Age	ADT	ADT Year	Maint. History	Deficiency Points	Route Name	Lane Direction	Lane	From MP	To MP	TIP Bridge No.	Replacement Status (TIP)	Abutment Car
140021	Regional	63	4600	2007	Yes	3.50	30000343/015	All	All	23.145	23.145	07	K	121
140007	Sub-Regional	37	760	2008	Yes	63.62	40001200/015	All	All	1.55	1.55			531
140014	Regional	77	2600	1999	Yes	72.50	29000017/015	All	All	1.017	1.017			321
140041	Sub-Regional	51	110	2000	Yes	6.00	40001148/015	All	All	0.239	0.239		O	711

Maintenance History (show maint hist)

140001 << < 8 Go > >> 8 pages (8 rows)

Task #	470930	Att.	
Administrative Unit	01 Bri Harbinger	User Update	JCRANK
Work Function	3376-Clean/Wash Bridge Dec	Date Update	2/12/2009
WBS	1B.101511	DC LAB EXISTS	1
Asset Type	Sections	DC EQP EXISTS	1
Responsible Crew	Bridge Crew	DC MAT EXISTS	0
Start Date	6/10/2008 0:0:0	DC ACC EXISTS	1
Finish Date	10/15/2008 8:0:0	DC CST EXISTS	0
Duration	736	NO LOCATION EXISTS	1
Plan Amount	55000		
Amount	8869.08		
Labor Cost (\$)	\$334.81		
Equipment Cost (\$)	\$161.03		
Material Cost (\$)	\$0.00		
Other Cost	\$0.00		
Status	Completed		
Completion Date	12/16/2008		
Comments	Clean/Wash Bridge Deck Car		

Labor Daycards (show dc lab)
 << < 1 Go > >> 2 pages (22 rows)

Employee	Employee Name	Work Date	TRC	Total Hrs	Total Cost
Baum, Josephus	Baum, Josephus	6/10/2008	Regular - Do not touch	3	\$84.60
Baum, Josephus	Baum, Josephus	6/12/2008	Regular - Do not touch	8	\$225.60
Baum, Josephus	Baum, Josephus	10/9/2008	Regular - Do not touch	5	\$146.15
Baum, Josephus	Baum, Josephus	10/15/2008	Regular - Do not touch	3.5	\$102.31
Mcpherson, Reginal	Mcpherson, Reginal	6/10/2008	Regular - Do not touch	3	\$84.60
Mcpherson, Reginal	Mcpherson, Reginal	6/12/2008	Regular - Do not touch	8	\$225.60
Mcpherson, Reginal	Mcpherson, Reginal	10/9/2008	Regular - Do not touch	5	\$146.15
Mcpherson, Reginal	Mcpherson, Reginal	10/15/2008	Regular - Do not touch	3	\$87.69
Crank, Jonathan	Crank, Jonathan	6/10/2008	Regular - Do not touch	2	\$83.08
Crank, Jonathan	Crank, Jonathan	6/12/2008	Regular - Do not touch	4	\$166.16
Crank, Jonathan	Crank, Jonathan	10/9/2008	Regular - Do not touch	2	\$85.14
Crank, Jonathan	Crank, Jonathan	10/15/2008	Regular - Do not touch	1	\$42.57
Davenport, Terry	Davenport, Terry	6/10/2008	Regular - Do not touch	3	\$124.62
Davenport, Terry	Davenport, Terry	6/12/2008	Regular - Do not touch	8	\$332.32
Davenport, Terry	Davenport, Terry	10/9/2008	Regular - Do not touch	5	\$212.85

Labor Details ? (points to DC LAB EXISTS)

Amount of Work ? Costs ? (points to Labor Cost (\$))

Develop Activity Performance Guidelines / Quantity Standards Based on Actual Costs and Duration

Bridge
Maintenance
&
Preservation
Activities

Maint. Activity Code*	Number of times activity was Performed	No. of Bridges on which activity was Performed	Actual Unit 'Total' Cost	Perf. Guid. Unit 'Total' Cost	Actual Unit 'Labor' Cost	Perf. Guid. Unit 'Labor' Cost	Actual Unit 'Equip.' Cost	Perf. Guid. Unit 'Equip.' Cost	Actual Unit 'Mat.' Cost	Perf. Guid. Unit 'Mat.' Cost
2816	7	7	\$168.61	\$67.90	\$45.26	\$14.71	\$11.62	\$9.69	\$2.50	\$43.50
3250	181	163	\$9.53	\$19.98	\$6.99	\$2.01	\$2.51	\$0.95	\$0.00	\$17.02
3252	78	73	\$33.80	\$54.91	\$25.07	\$12.22	\$8.63	\$11.51	\$0.00	\$31.18
3308	3	3	\$105.11	\$143.93	\$79.86	\$47.73	\$17.38	\$6.20	\$7.87	\$90.00
3310	35	35	\$42.55	\$55.20	\$7.96	\$11.82	\$2.53	\$13.68	\$0.82	\$29.70
3312	5	5	\$196.39	\$78.13	\$92.00	\$67.94	\$94.81	\$10.19	\$9.39	\$0.00
3324	46	43	\$38.65	\$36.24	\$21.14	\$13.64	\$7.94	\$8.88	\$7.47	\$13.72
3328	12	9	\$54.98	\$75.86	\$23.79	\$4.57	\$9.31	\$0.98	\$21.73	\$70.31
3368	3	3	\$777.60	\$714.19	\$235.71	\$496.33	\$63.65	\$217.86	\$429.57	\$0.00
3370	15	15	\$112.89	N/A	\$78.03	N/A	\$25.03	N/A	\$3.84	\$N/A
3372	7	7	\$122.01	N/A	\$59.46	N/A	\$26.64	N/A	\$27.09	\$N/A

*Maintenance Activity Name

- 2816 - Asphalt Pavement Repair / Patching (SYD)
- 3250 - Install / Replace Ground Mounted Signs (SFT)
- 3252 - Repair Ground Mounted Signs (EA)
- 3308 - Maint. Of Steel Plate Bridge Joints (LFT)
- 3310 - Maintenance/Repair/Replacement of Standard Bridge Expansion Joints (LFT)

- 3312 - Maint/Replace/Repair Modular Bridge Joints (LFT)
- 3324 - Maint / Repair / Replace Timber Deck Components (SFT)
- 3328 - Maintenance/Repair/ Replace Steel Plank Bridge Floor (SFT)
- 3368 - Installation and Replacement of NBIS Pipes and Culverts (LFT)
- 3370 - Maintenance and Repair of NBIS Pipes and Culverts (LFT)
- 3372 - Bridge Installation & Replacement (SFT)

Develop Activity Performance Guidelines / Quantity Standards Based on Actual Costs and Duration of Work

Analyzing 3324-Maint / Repair / Replace Timber Deck Components (SFT)

Analyze a Maintenance Activity Across Years

Year	Number of times activity was Performed	No. of Bridges on which activity was Performed	Total Work Amount (SFT)	Total Work Duration (Hours)	Total Work Expenditure (\$)	Actual 'Total' Unit Cost (\$)	Perf. Guideline Unit Cost	Total Area (SFT)	Percentage of Deck Area Maintained
2005	82	75	34,514	2,920	\$623,123	\$18.05	N/A	105,377	33%
2006	80	71	19,605	1,832	\$518,546	\$26.45	N/A	93,350	21%
2007	97	88	36,999	4,921	\$997,474	\$26.96	N/A	134,619	27%
2008	83	76	49,082	3,628	\$1,053,242	\$21.46	N/A	113,274	43%
2009	75	70	25,511	3,573	\$582,694	\$22.84	N/A	111,554	23%
2010	46	43	11,639	3,008	\$449,828	\$38.65	\$36.24	68,779	17%
Avg.	77	70	29,558	3,314	\$704,151	\$25.74		104,492	28%

- Timber Deck Preservation was done 77 times every year, on approx. 70 bridges
- Each year approx. \$700,000 were spent
- Each year approx. 28% of the bridge deck was preserved

Track Location of each Maintenance / Preservation Activity on the Map

Map Themes

- Bridge Maintenance Work Orders (Filter)
 - 3308-Maint. Of Steel Plate Brid
 - 3310-Maintenance/Repair/Repl
 - 3314-Maintain Steel Superstruc
 - 3322-Maint to Steel Handrail (L
 - 3328-Maintenance/Repair/ Rep
 - 3330-Maintenance/Repair Oper
 - 3342-Clean and Paint Structur
 - 3354-Maintain Steel Substruct
 - 3372-Bridge Installation & Rep
 - 3326-Maintain Concrete Deck (
- OpenStreets Tiles
- Selected BMS Network Master

Identify Features (s identify)


- Bridges (Brid Group)
 - 140004
 - Bridge Age -> 28.0
 - Location ID# -> 66825917
 - Maint. History -> Yes
 - Abutment Cap -> 000
 - Abutment Footing -> 000
 - Abutment Substructure -> 000
 - ADT -> 13000
 - ADT Year -> 2007
 - Alignment -> TAN
 - Approach Align. Appraisal -> 8
 - Approach Pier Cap -> 000
 - Approach Pier Footing -> 000
 - Approach Pier Substructure -> 000
 - Approach Rwy Condition -> 7
 - Approach Rdwy Width -> 83
 - Approach Trwy Wifith -> 56

**For each location,
Analyze Cost-Effectiveness of Work**

**Validate Impact of Bridge Maintenance / Preservation by Analyzing
any Pictures, Files, Drawings
Acquired during Bridge Inspection**

General	Service	Geometric Data	Classifications	Loads/Infra./Hydr.	PI'S / Inspec.	Misc
<< < 1 Go > >> 1 pages (1 rows)						
01.01 Structure No.	S-BRG-00000800					
*01.02 Structure name	6 - I-25-10.78-ABF					
01.03 Structure Identification Mark	0001-S-BRG-00000800					
01.04 General Description						
01.05 Region	Central					
Route	ML1118					
Start MP					10.780	
End MP					10.780	
Att.						
01.10 Ordinate - N					655533	
01.11 Ordinate - E					187713	
Comments	262373					

Work With Attachments



➤ Network Level

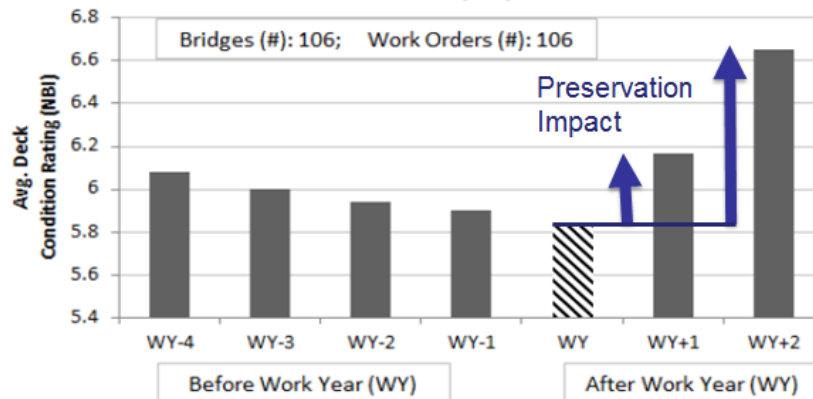
- ❖ Did the Maintenance / Preservation Activity Improve the Bridge-Element Condition Rating across the entire Network ?
- ❖ Which Maintenance / Preservation Activities had the maximum positive Impact ?
- ❖ Would such Maintenance / Preservation Activities extend life of the Bridge (Element) Infrastructure Network ?

➤ Project Level (Bridge Level)

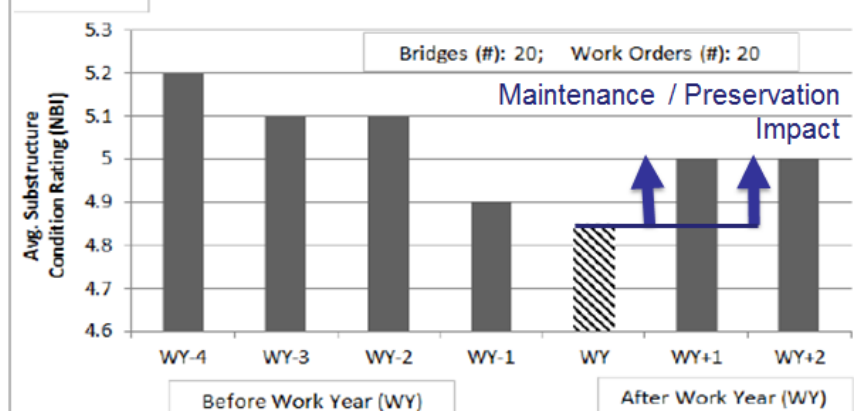
- ❖ How does the Maintenance / Preservation impact health of a bridge?
 - Compare Bridge Condition With and Without Maintenance

Evaluate Impact of Bridge Maintenance / Preservation Activities on Bridge Element Condition Rating (Network Level)

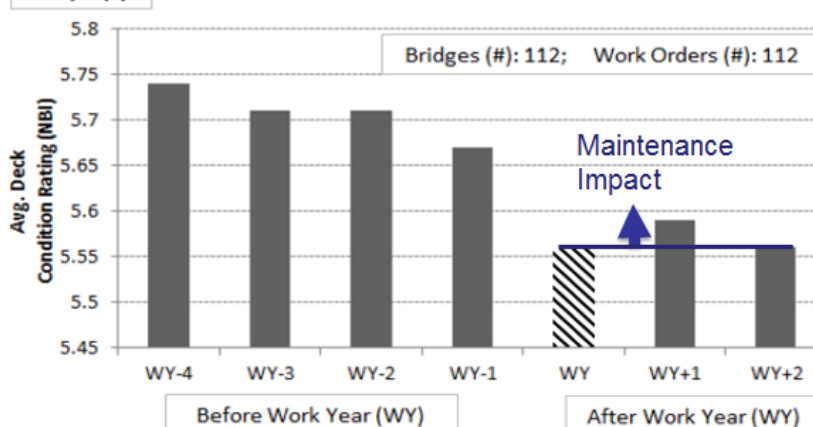
Graph (a) 3324-Maint / Repair / Replace Timber Deck Components (SFT)



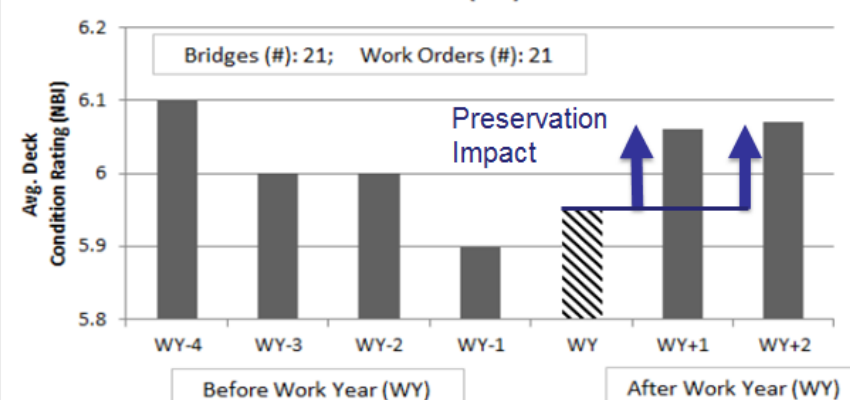
Graph (h) 3346-Repair / Maintain Timber Wings & Blkhd (SFT)



Graph (c) 3326-Maintain Concrete Deck (SFT)



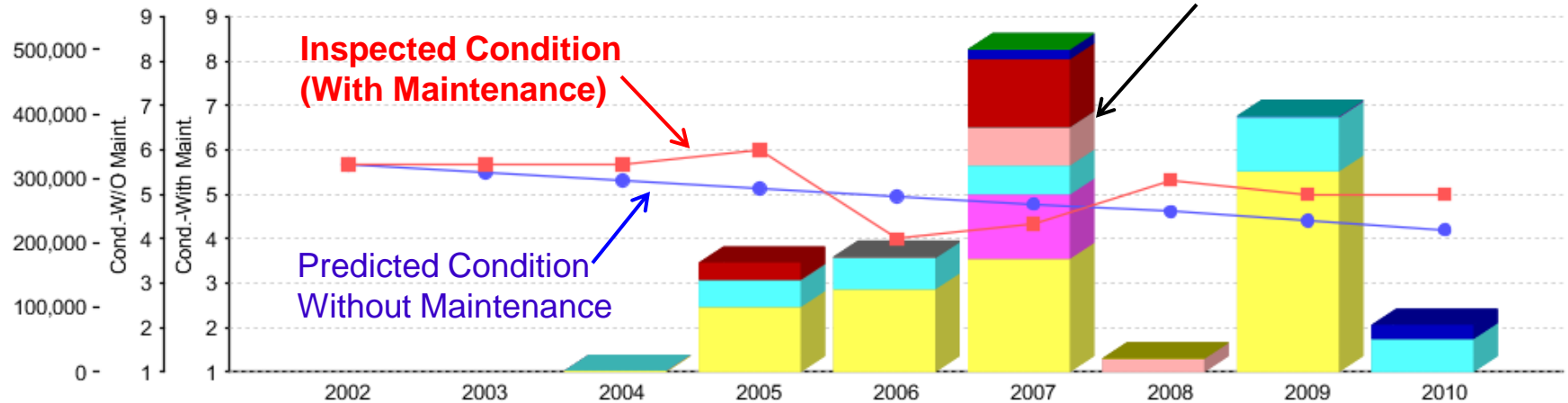
Graph (d) 3328-Maintenance/Repair/ Replace Steel Plank Bridge Floor (SFT)



Evaluate Impact of Bridge Maintenance / Preservation Activities on Bridge Element Condition Rating (Project / Bridge Level)

STRUCTURE NO: 700016

Actual Field Maintenance Work



- Cond - With Maint. ● Cond - W/O Maint. ■ No Maint. Trt ■ 3338-Moveable Bridges (Operations) (DOL) ■ 3354-Maintain Steel Substructure Components (LFT)
- 3336-Moveable Bridges (Maintenance) (HR) ■ 3314-Maintain Steel Superstructure Components (LFT) ■ 6040-CONSTR/MAINT OF FACILITY (HR)
- 4701-BRIDGE DMGS DUE TO ACCID (HR) ■ 3362-Maintenance and Repair of Fender System (LFT) ■ 5905-C SWEEPING/WASHING RDWYS (SHM)
- 3132-Sweep / Wash Roadway (SHM) ■ 3318-Maint to Concrete Handrail (LFT) ■ 3324-Maint / Repair / Replace Timber Deck Components (SFT)

- ✓ Implementation of an Integrated Framework, across the various organizations, allows for:
 - Real-time Tracking & Communication of Bridge Maintenance / Preservation Work
 - Evaluation of various Maintenance and Preservation Activities/Programs in terms of Network Health and Performance
 - Identification of Efficient Bridge Preservation Work Activities, that extend Infrastructure Life