Developing Maintenance Cost Models based on Asset Condition

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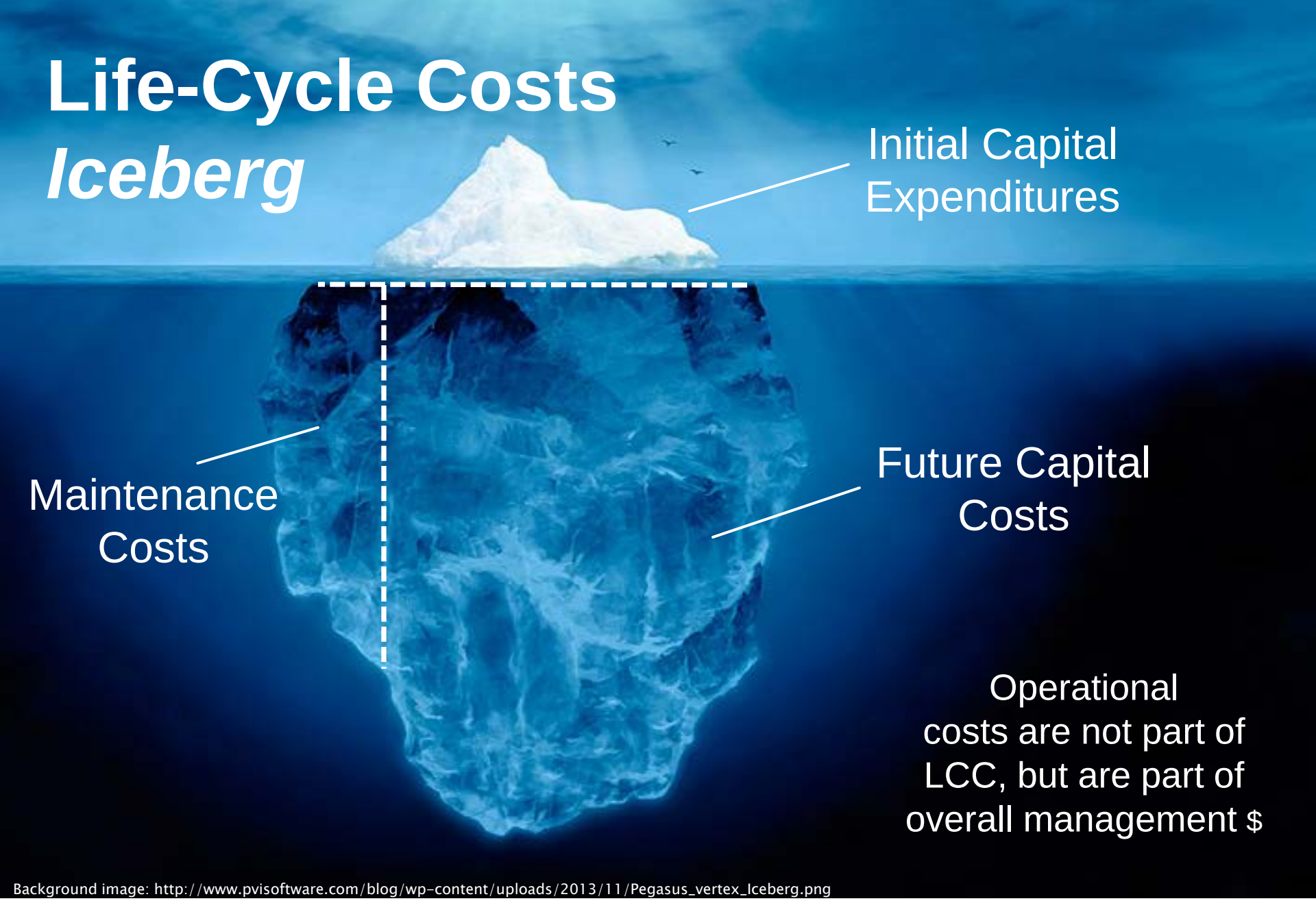
11th National Asset Management Conference

July 12, 2016

Minneapolis Marriot City Center

Life-Cycle Costs
Iceberg



Background image: http://www.pvisoftware.com/blog/wp-content/uploads/2013/11/Pegasus_vertex_Iceberg.png

Goals for Data

- Life Cycle Cost Scenarios
  - Capital strategies = predicted cond. = Maint. $'s
  - Best practices – economically analyzed, deterministic
- Capital Investment Scenarios
  - Predicted system condition, maintenance costs
  - Tradeoff efforts
- Budgeting by Products and Services
  - Needs driven
- Local Work Planning
  - Labor hours, costs by Season/District

Asset Classes Addressed

- Pavements (Bituminous NHS and Non-NHS)
- Bridges (Trunk Highway Deck bridges)
- Culverts (< 10’ span Mainline pipes)
- Overhead Sign Structures
- Tower/High Mast Lighting Structures

General Approach

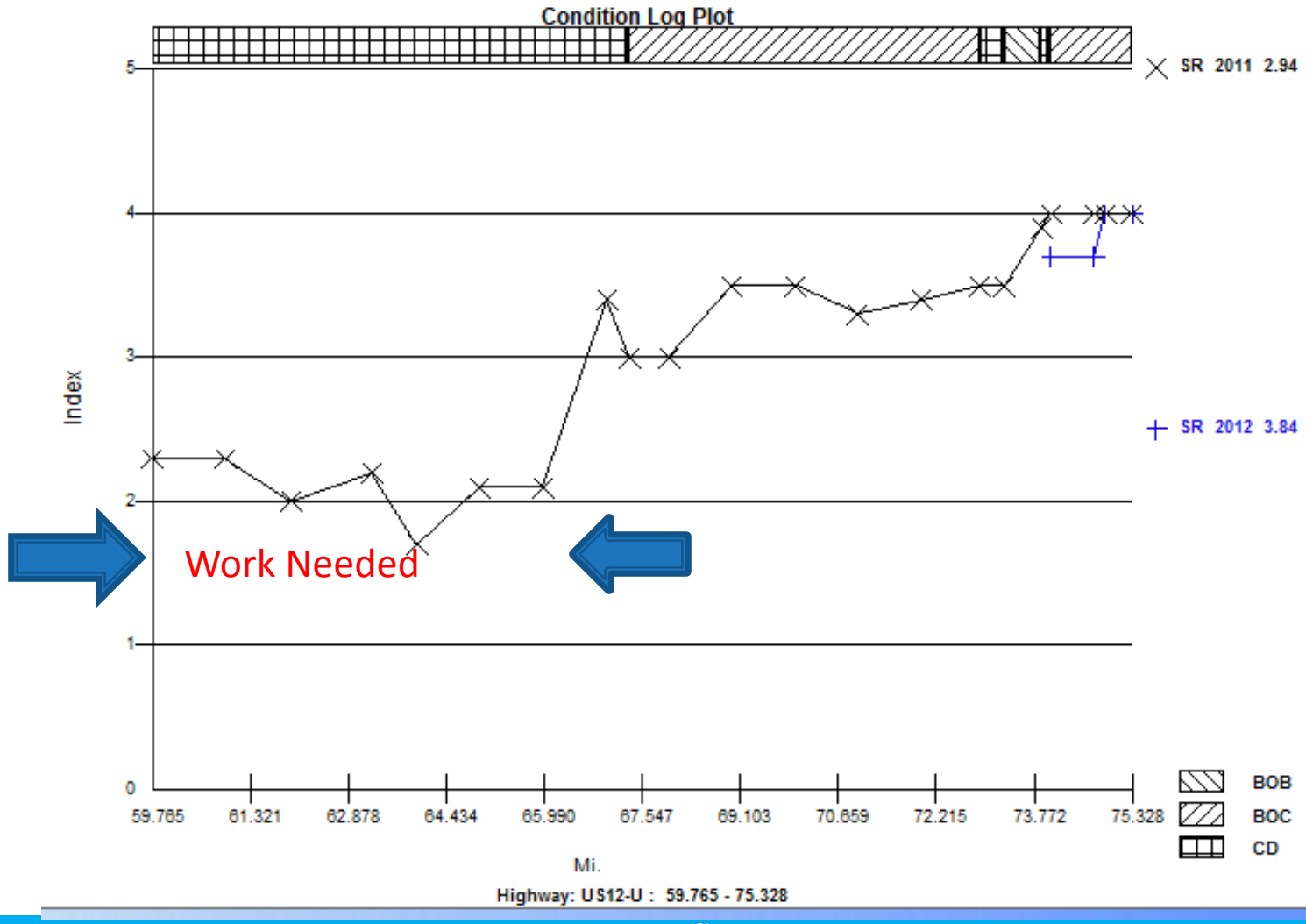
1. Determine Strategy: collect and correlate expended costs to asset condition.
2. Evaluate Asset Information Available
3. Determine Cost Information Needed – Level of Detail
4. Build recording tools
5. Train Workforce
6. Validate Data – Real-time processes
7. Analyze Data – correlations – models

Asset Management Cost Models - Pavement

MnDOT Pavement Maintenance

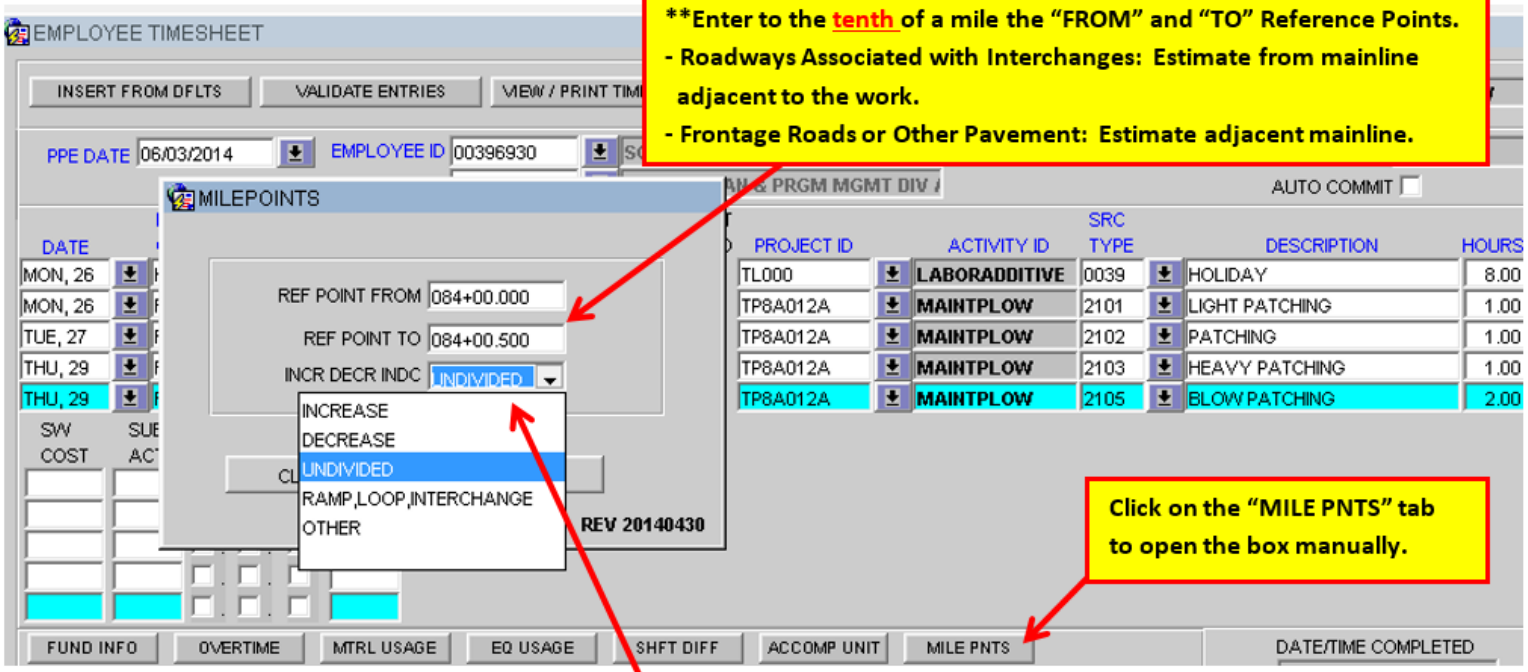
- Random Pothole Patching
- “Heavy” patching (Skidloader/Roller)
- “Ribbon Paving” (Bellydump Semi’s)
- Crack Sealing
- “Mastic” material applications
- “Blow Patching”
- Thin Surface Treatment
- Shoulder Repair

Pavement Condition Info



Pavement Repair Recording

Example:



Reference Points:

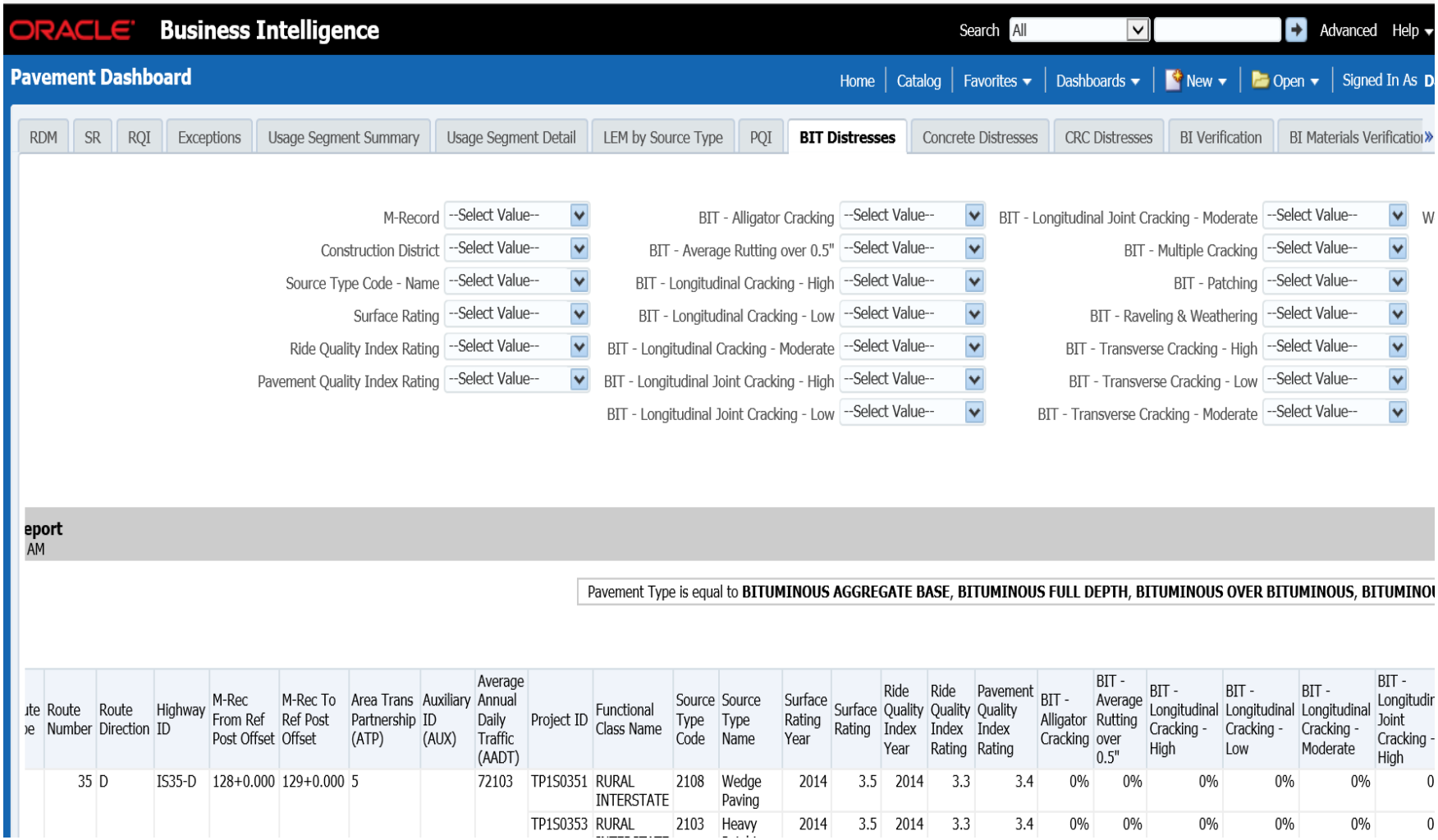
**Enter to the tenth of a mile the "FROM" and "TO" Reference Points.

- Roadways Associated with Interchanges: Estimate from mainline adjacent to the work.
- Frontage Roads or Other Pavement: Estimate adjacent mainline.

Click on the "MILE PNTS" tab to open the box manually.

- **Multi-lane Road:** Select "Increase" or "Decrease", should coincide with direction of work being done (i.e. north/south or east/west).
- **Two-lane/Two-way:** Select "Undivided".
- **Roadways Associated with an Interchange:** Select "Ramp, Loop, Interchange".
- **Frontage Road or Other Pavement:** Select "Other".

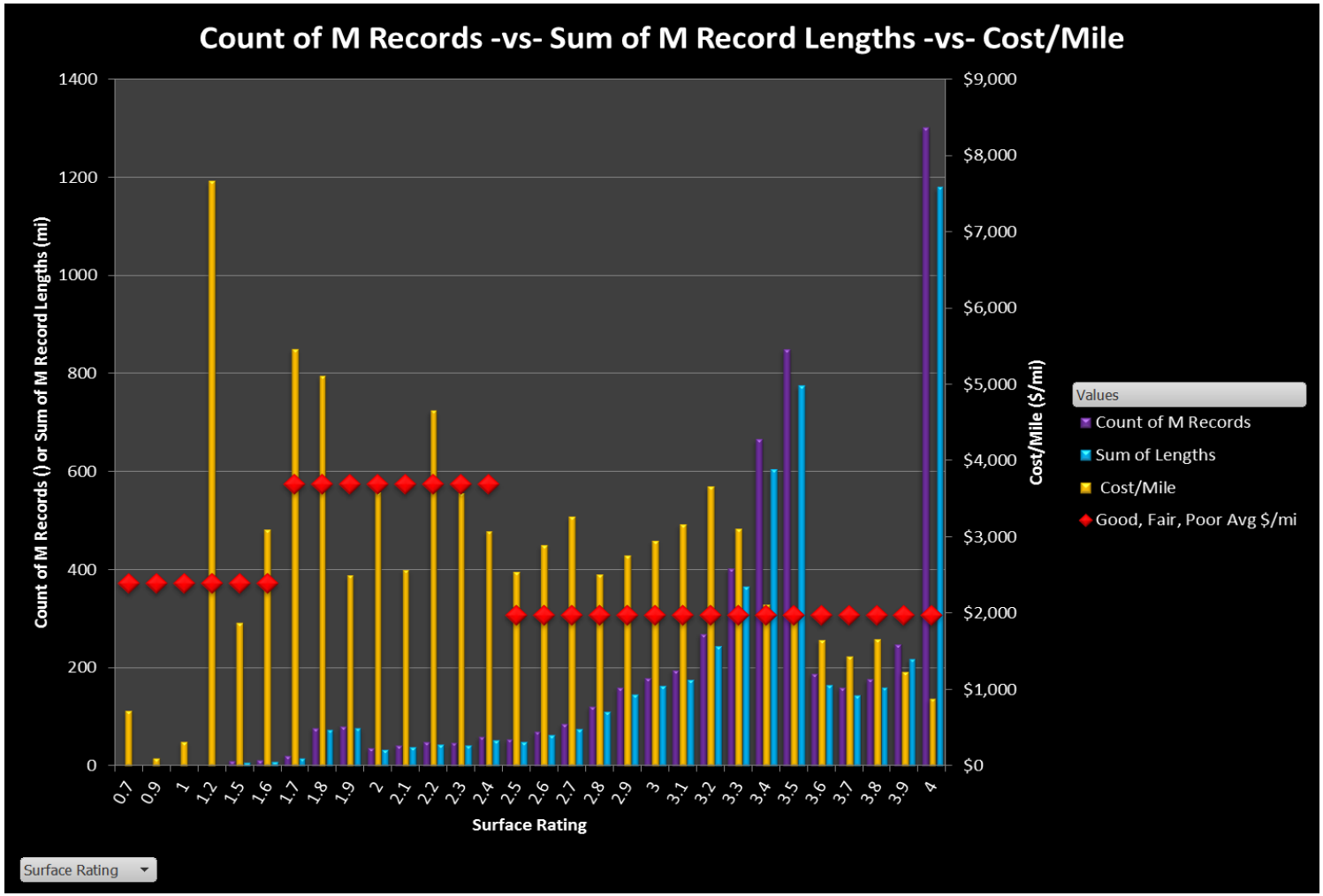
Data Extraction & Processing



ute / e	Route Number	Route Direction	Highway ID	M-Rec From Ref Post Offset	M-Rec To Ref Post Offset	Area Trans Partnership (ATP)	Auxiliary ID (AUX)	Average Annual Daily Traffic (AADT)	Project ID	Functional Class Name	Source Type Code	Source Type Name	Surface Rating Year	Surface Rating	Ride Quality Index Year	Ride Quality Index Rating	Pavement Quality Index Rating	BIT - Alligator Cracking	BIT - Average Rutting over 0.5"	BIT - Longitudinal Cracking - High	BIT - Longitudinal Cracking - Low	BIT - Longitudinal Cracking - Moderate	BIT - Longitudinal Joint Cracking - High
	35	D	IS35-D	128+0.000	129+0.000	5		72103	TP1S0351	RURAL INTERSTATE	2108	Wedge Paving	2014	3.5	2014	3.3	3.4	0%	0%	0%	0%	0%	0
									TP1S0353	RURAL	2103	Heavy	2014	3.5	2014	3.3	3.4	0%	0%	0%	0%	0%	0

Pavement Data Modeling – Surface Rating

(sample data only)



Pavement Maintenance Cost Model

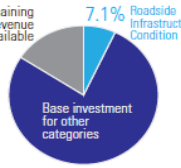
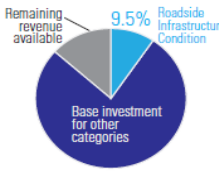
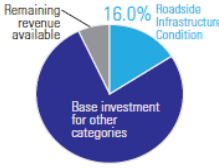
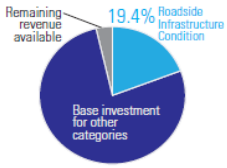
Pavement Maintenance Resource Demand Model 2015				
Pavement Condition	**Surface Rating Low Value**	**Surface Rating High Value**	**Labor Hours per Lane Mile ***	**Project Full Cost per Lane Mile**
Very Poor	0.0	1.0	31	$4,650
Poor	1.1	1.6	24	$3,800
Fair	1.7	2.4	17	$2,950
Good	2.5	3.7	9	$2,100
Very Good	3.8	4.0	2	$1,250

* These values are illustrative only.
Future efforts will refine these values.

Roadside Infrastructure Condition

Overarching Goal: Effectively manage non-pavement and non-bridge asset infrastructure to support a safe, accessible, and reliable roadway system.

Performance Objectives: Install, maintain, replace and upgrade critical infrastructure elements to manage performance and life-cycle costs to improve efficiency and condition, and reduce risks to the public.

	Performance Level 0 *Lowest cost, greatest risk*	Performance Level 1 *Lower cost, higher risk*	Performance Level 2 *Greater cost, lower risk*	Performance Level 3 *Greater cost, lowest risk*
Investment Approach *(See Approaches Folio)*	**Approach A, C**	**Approach B** Approximately corresponds with current investment	PL does not correspond with an Investment Approach	PL does not correspond with an Investment Approach
Investment Level *Total* *Years 5-10 (2022-2027)* *Years 11-20 (2028-2037)*	**$1,157 M** $57.0 M/yr $81.5 M/yr 	**$1,544 M** $76.1 M/yr $108.7 M/yr 	**$2,596 M** $127.9 M/yr $182.8 M/yr 	**$3,149 M** $155.2 M/yr $221.8 M/yr 
Investment Description	Reduction from current funding. Rely primarily on Pavement investment to initiate much of Roadside Infrastructure Condition. Stand-alone work only initiated through maintenance.	Maintain current funding. Rely primarily on Pavement investment to initiate much of Roadside Infrastructure Condition. Some stand-alone work initiated.	Maintain current conditions. Rely on both Pavement investment and stand-alone work to initiate Roadside Infrastructure Condition.	Meet performance targets. Rely on both Pavement investment and stand-alone work to initiate Roadside Infrastructure Condition. Allocate a sizeable amount of funding to replace and repair assets at the end of service life.
Outcomes *To what extent would MnDOT meet performance targets for Roadside Infrastructure Condition?*	• Poor culverts increases to more than 15% • More than 75% of tunnels will be in poor/very poor condition • Reflectivity of most signs below standards - illegible • Significant increase in poor/ very lighting, signals, and ITS infrastructure - replacement occurs beyond expected service life • More than 40% of noise walls in poor/very poor condition or older than design life • Significant increase in poor-quality pavement markings	• Meet 3% percent very poor target but poor increases to 13% • Tunnels in 50% poor and 24 poor condition • All signs replaced at or beyo years • Increase in poor/very lightin signals, and ITS infrastructu majority of replacements oc end of expected service life • 33% of noise walls in poor condition or older than design life • Increase in poor-quality pavement markings	rcent very oor ars ements fe remains at l concrete • 10,000 miles of pavement markings refreshed annually	• Culvert, drainage and tunnel condition at 3% percent very poor and 8% poor • Signs begin to be replaced at 15 years • Signals, lighting, signs/sign structures, and ITS condition at 2% very poor and 4% poor • Noise walls condition at 2% poor • Average pavement markings refreshment decreased to two years with use of more durable material; markings increased from 4" to 6" wide and recessed
Risks	**High** • Replace/repair burden shifts from capital to maintenance budget • Reduced reliability leads to system closures - greater interruptions and increased safety risk • Delayed replace/repair not aligned with optimal life cycle investments results in increased costs • Decreased replace/repair results to an inability to meet public expectations and standards	**Medium** • Replace/repair burden shifts from capital to maintenance budget • Reduced reliability leads to system closures - greater interruptions and increased safety risk • Delayed replace/repair not aligned with optimal life cycle investments results in increased costs • Decreased replace/repair results to an inability to meet public expectations and standards	**Medium** • Delayed replace/repair not aligned with optimal life cycle investments results in increased costs **Low** • Replace/repair burden shifts from capital to maintenance budget • Reduced reliability leads to system closures - greater interruptions and increased safety risk • Decreased replace/repair results to an inability to meet public expectations and standards	**Low** • Replace/repair burden shifts from capital to maintenance budget • Reduced reliability leads to system closures - greater interruptions and increased safety risk • Delayed replace/repair not aligned with optimal life cycle investments results in increased costs • Decreased replace/repair results to an inability to meet public expectations and standards
System Investment Strategies *What strategies would MnDOT use to manage risk?*	• Rely on maintenance budget to keep system in good repair • Respond to non-functional or very poor condition elements only through pavement and bridge investment	• Repair/replace infrastructure in very poor condition or beyond service life • Replace assets with greatest exposure to traveling public through pavement and bridge investment and some stand-alone projects	• Repair failed infrastructure as needed • Replace infrastructure that is functional but damaged/outdated • Invest in preventive repairs to avoid future higher replacement costs	• Repair/replace infrastructure in poor and very poor condition or at end of service life • Long-term replacements made when appropriate • Upgrades and innovations to improve functionality and improve life cycle

Outcomes/ Performance Targets

Capital Planning Scenarios

Roadside Infrastructure Condition

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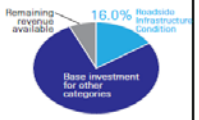
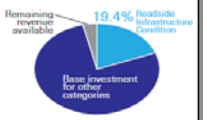
Investment Level *Total* *Years 5-10 (2022-2027)* *Years 11-20 (2028-2037)*	**$1,157 M** $57.0 M/yr $81.5 M/yr 	**$1,544 M** $76.1 M/yr $108.7 M/yr 	**$2,596 M** $127.9 M/yr $182.8 M/yr 	**$3,149 M** $155.2 M/yr $221.8 M/yr 
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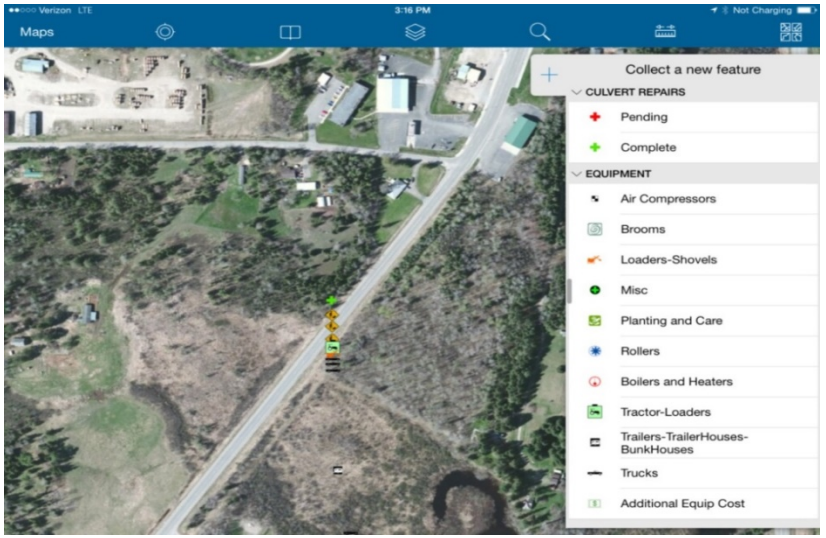
"MnSHIP" Total Pavement Investment Analysis

Early Draft MnSHIP Based Maintenance Patching Needs										
	PL0		PL1		PL2		PL3		PL4	
Interstate										
% Poor 2037	2%		5%		2%		2%		2%	
Funding Needs ($Billions)	$2.00		$1.60		$2.00		$2.00		$2.00	
Other NHS										
% Poor 2037	18%		11%		4%		4%		3%	
Funding Needs ($Billions)	$4.20		$5.00		$7.10		$7.10		$7.60	
Non-NHS										
% Poor 2037	24%		14%		14%		10%		4%	
Funding Needs ($Billions)	$3.40		$4.70		$4.70		$5.90		$8.80	
AVG Est. Maint Cost ($Millions/YR)	'18-'27	'28-'37	'18-'27	'28-'37	'18-'27	'28-'37	'18-'27	'28-'37	'18-'27	'28-'37
	$27.8	$26.5	$27.6	$24.7	$27.5	$24.2	$27.5	$23.8	$27.3	$23.3
Maint. Cost in 2037 ($Million)	$30.1		$29.2		$28.1		$27.7		$24.9	

Sample Data – Not Final

Asset Management Cost Models - Culverts

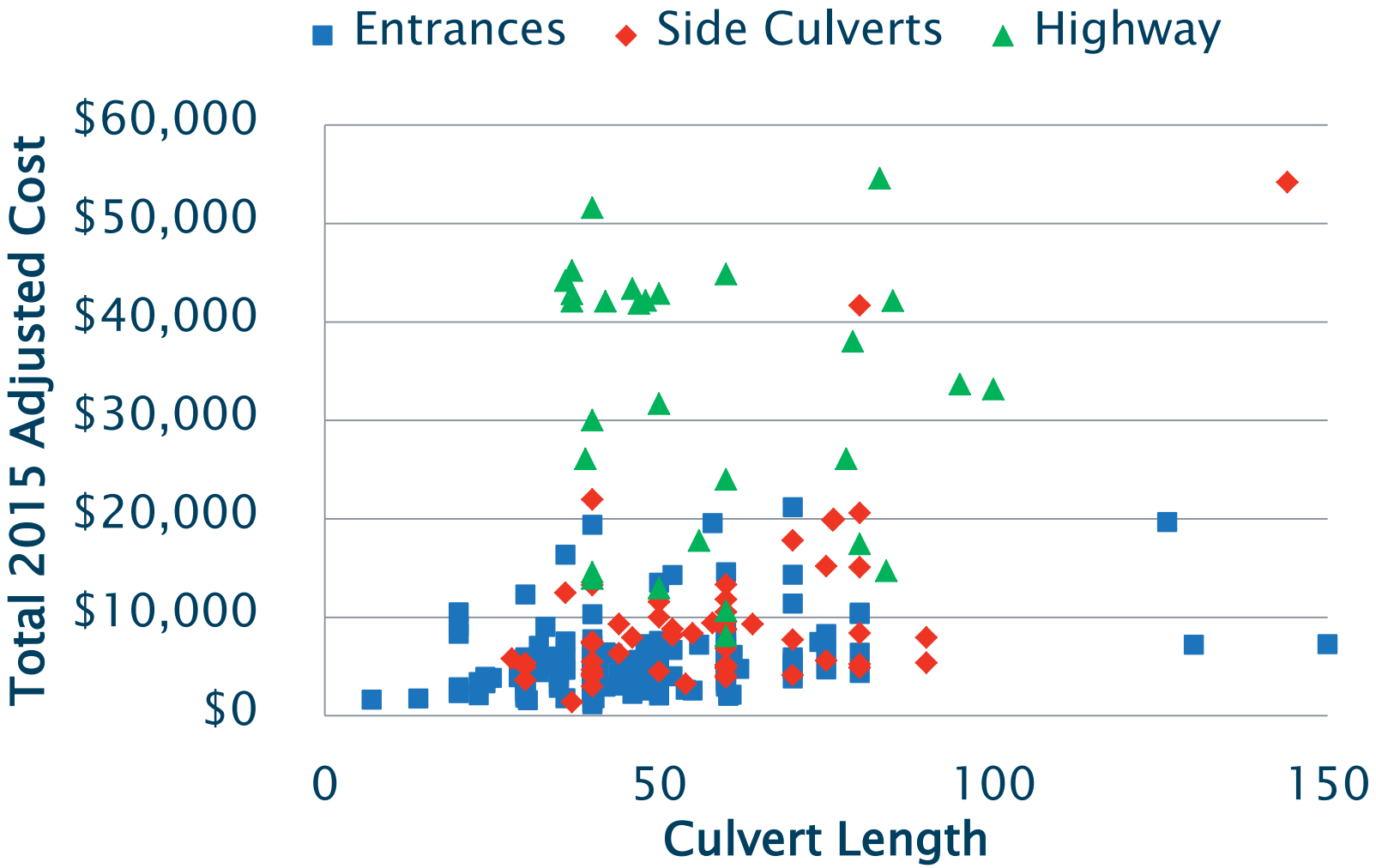


- "Hydinfra" Database for Assets
  - Condition info 1-4
- ARCGIS Collector Application written
- Repair info collected:
  - Repair Type
  - Final Condition
  - LEM Resources Consumed

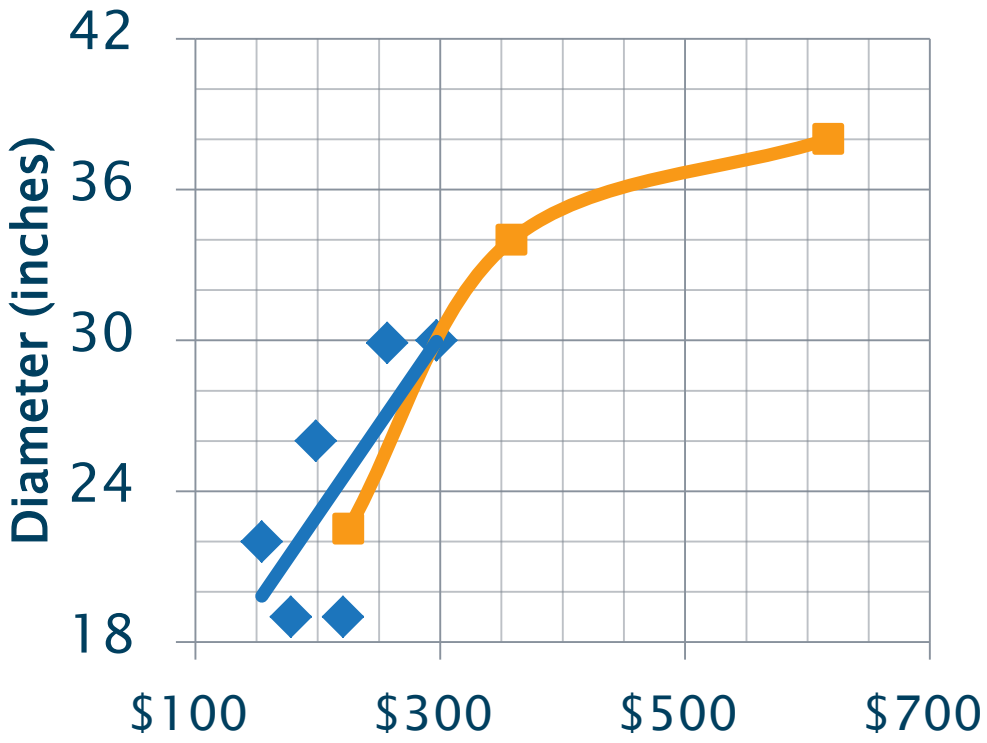
Asset Management Cost Models - Culverts

Type of Repair	Completed 2014	Completed 2015	Total Both Years	% of Total Repairs
Trench New Pipe	149	165	314	57%
Slipline Pipe	9	38	47	9%
Reset Apron and Pipe	41	25	66	12%
Replace Apron and Pipe	11	41	52	9%
Joint Repair	17	16	33	6%
Pipe Extension	4	11	15	3%
Fix Pipe Hole	2	2	4	1%
Fill Void	1	5	6	1%
Other Repair	5	8	13	2%
Total Repairs	239	311	550	

Trench New Pipe



Slipline

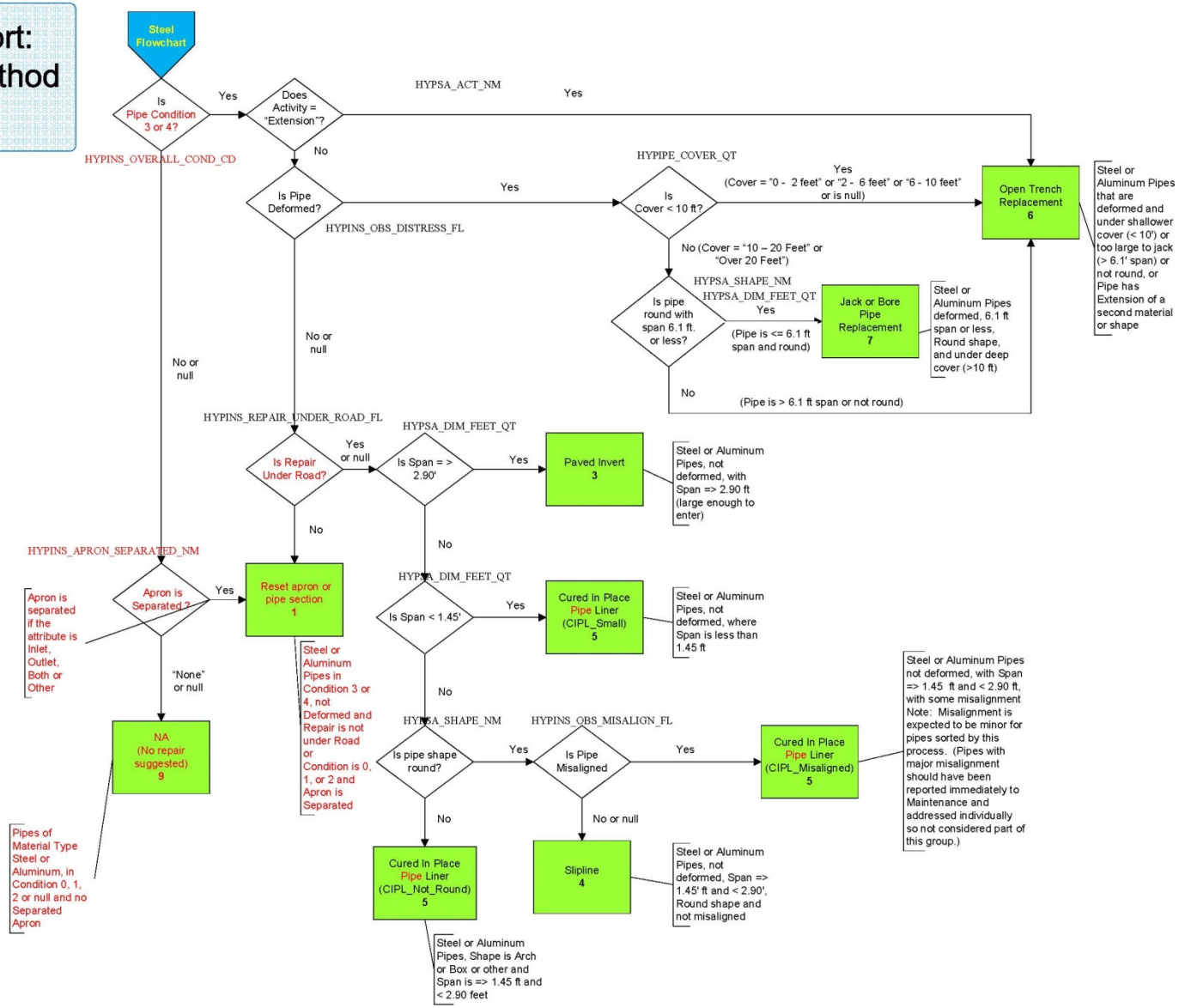

42
36
30
24
18
Diameter (inches)
$100
$300
$500
$700
Slipline only
Slipline and Clean
Cost per Foot

Resource Demand Model

Average Maintenance Cost of Culvert Repair By Category and Roadway Classification					
Repair Category	# of Repairs	Cntrline Hwy	Side and Other [1]	Entrances [2]	All Rdwy Classification
Trench New Pipe	153	$26,700	$8,000	$5,600	$7,800
Slipline	9				$16,600
Joint Repair	8				$3,400
Hole and Void Repair	3				$1,800
Replace Apron	11	$8,400	$2,700	$1,200	$4,400
Reset	40				$2,600
Reset ($/segment)	40				$1,600
Other [3]	12				$3,600

Sorting Process for Steel or Aluminum Culverts

Flowchart of HydInfra Report:
Pipe Suggested Repair Method
Steel or Aluminum Pipes



Culvert Maintenance Planning

	A	B	C	D	E	F	G	H	I	L	R
1			Repair method	Number	Length	Contract average bid					Contract
2						Unit price	units	Unit Price	units	Total Contract Cost	Total Cost
3	District	1									
4			CIPL	24	1290	$129.65	foot			$183,973	
5			Grout	21	2166	$32.48	foot			$77,387	
6			Jack				ot			$968,165	
7			Paved Inv							$40,212	
8			Reset					$2,449.80	each	$323,374	
9			Slipline				t			$1,552,383	
10			Trench				t			$2,260,010	$5,405,504
11	District	2									
12			CIPL				t			$106,533	
13			Grout				t			$36,978	
14			Jack				t			$576,593	
15			Paved Inv							$19,597	
16			Reset							$61,980	
17			Slipline				t			$365,255	
18			Trench				t			$726,406	$1,893,341
19	District	3									
20			CIPL				t			$518,691	
21			Grout				t			$23,009	
22			Jack	8	1286	$725.00	foot			$1,025,585	
23			Paved Invert	2	152	$16.24				$2,715	
24			Reset	11	1029			$2,449.80	each	$29,643	
25			Slipline	44	3833	$93.22	foot			$393,043	
26			Trench	27	1848	$65.37	foot	$26,362.84	each	$915,860	$2,908,546

		Repair method
District	1	
		CIPL
		Grout
		Jack
		Paved Invert
		Reset
		Slipline
		Trench

Cost
$183,973
$77,387
$968,165
$40,212
$323,374
$1,552,383
$2,260,010

Asset Management Cost Models - Bridge

MnDOT Bridge Maintenance

- Robust Inventory and Condition Data Available “Pontis/BrM
- Repair info collected “SIMS”
- Resource Consumption via Employee Timesheet system
- Data Processed via Oracle BI

Analysis/Modeling

Deck

Preventive Reactive	Work Category	NBI	Labor Hours	Labor Hours / SF Deck Area	Estimated Labor Full Cost	Estimated Labor Full Cost / SF Deck Area	Estimated Equipment Full Cost	Estimate Equipme Full Cost SF Deck Area
Preventive	Flushing	Good (NBI >= 7)	9,749.09	0.0008	$450,036	$0.0364	$247,777	$0.0
		Satisfactory (NBI = 6)	2,996.40	0.0007	$138,098	$0.0318	$81,910	$0.0
		Fair (NBI = 5)	984.35	0.0007	$41,895	$0.0317	$20,891	$0.0
		Poor (NBI <= 4)	86.25	0.0010	$3,846	$0.0432	$2,749	$0.0
	Joint Maintenance	Good (NBI >= 7)	6,187.84	0.0013	$288,866	$0.0601	$124,010	$0.0
		Satisfactory (NBI = 6)	3,554.63	0.0013	$175,431	$0.0636	$56,313	$0.0
		Fair (NBI = 5)	161.33	0.0007	$7,523	$0.0328	$2,452	$0.0
	Sealing	Good (NBI >= 7)	7,607.75	0.0025	$340,600	$0.1126	$100,302	$0.0
		Satisfactory (NBI = 6)	3,792.75	0.0022	$174,839	$0.1012	$54,019	$0.0
		Fair (NBI = 5)	295.00	0.0012	$14,066	$0.0592	$3,730	$0.0
		Poor (NBI <= 4)	64.00	0.0116	$3,197	$0.5810	$1,373	$0.2
Reactive	Approach, Curb, Walk, Rail Maintenance	Good (NBI >= 7)	9,414.50	0.0038	$437,700	$0.1768	$154,152	$0.0
		Satisfactory (NBI = 6)	2,569.00	0.0013	$124,743	$0.0630	$32,047	$0.0
		Fair (NBI = 5)	1,209.50	0.0023	$56,994	$0.1107	$20,031	$0.0
		Unknown	28.50	0.0270	$1,480	$1.4012	$497	$0.4
	Deck Repair	Good (NBI >= 7)	3,334.00	0.0019	$161,144	$0.0900	$49,709	$0.0
		Satisfactory (NBI = 6)	4,086.00	0.0014	$202,267	$0.0716	$54,999	$0.0

Asset Management Cost Models - Bridge

Bridge Deck Resource Demand Model 2015		
Work Type/Condition	Labor Hours per 1000 sq ft deck	Project Full Cost per 1000 sq ft Deck
Deck Flushing		
good	0.8	$57
satisfactory	0.7	$51
fair	0.7	$71
poor	0.9	$47
Joint Maintenance		
good	1.3	$27
satisfactory	1.4	$47
fair	0.7	$11
poor	na	na
Sealing		
good	2.5	$41
satisfactory	2.1	$34
fair	1.8	$122
poor	na	na
Approach, Curb, Walk Maintenance		
good	3.8	$103
satisfactory	1.3	$36
fair	2.3	$33
poor	na	na
Deck Repair		
good	1.9	$14
satisfactory	1.5	$14
fair	2.1	$29
poor	74.8	$415
Includes Preventive and Reactive maintenance activities		

Overhead Sign Structures, Tower Lighting

MnDOT Maintenance

- Inventory and Condition Data limited
- Inspection practices codified
- Resource Consumption via Employee Timesheet system
- Data Processed Spreadsheet
- “Resource Demand Models” similar to other assets

Takeaways

- Dedication of resources and clear direction moved the department quickly
- Can now begin to credibly quantify costs
- Data quality is a continual struggle
- Model refinement possibilities unlimited
- AgileAssets (underway) will reduce data recording redundancies and issues
- Movement toward expanded Asset Classes
- Movement toward expanded use of info.
- Oracle BI tool is powerful but expensive

Thank You!

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