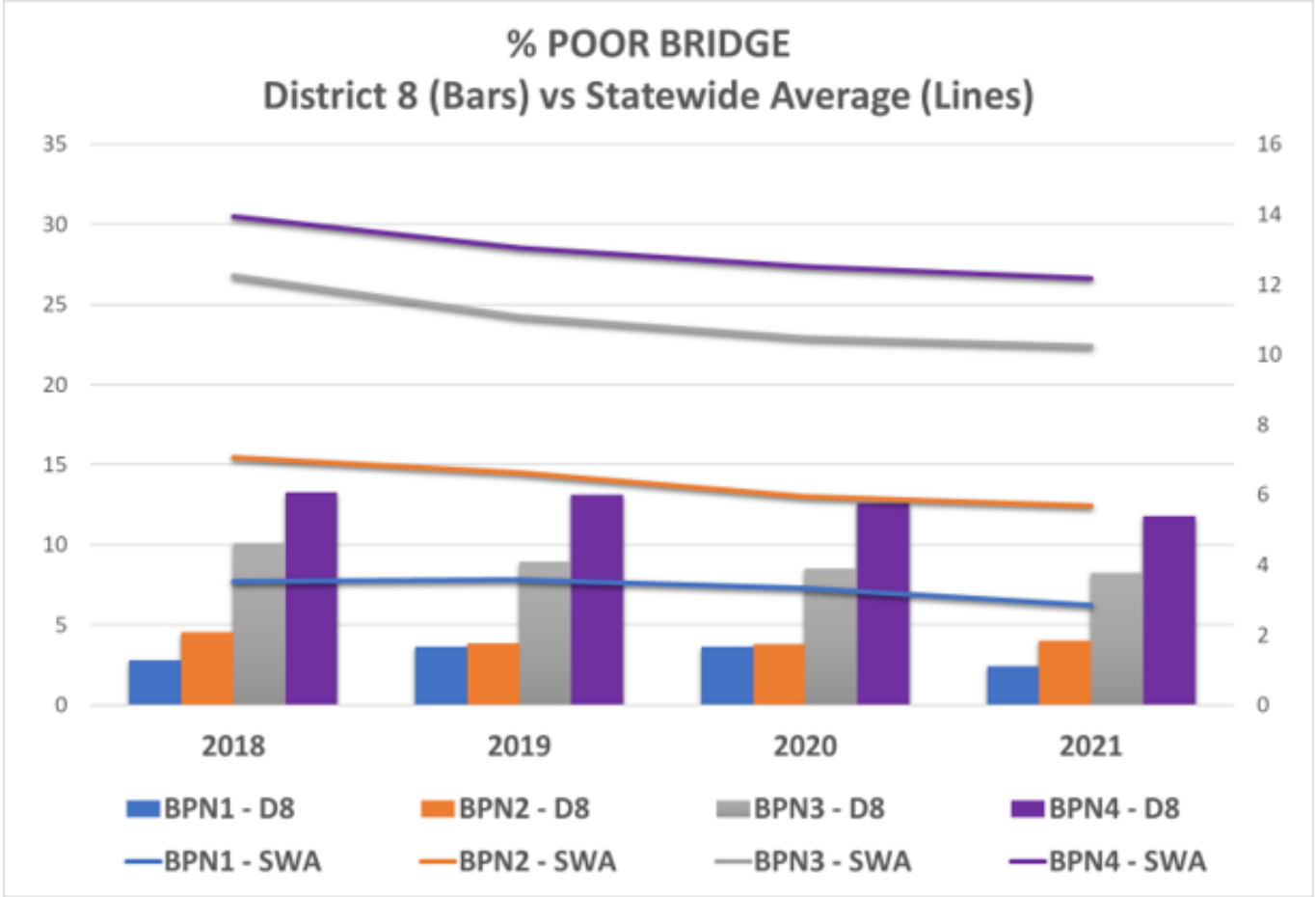
BRIDGE PLANNING

- Derek Mitch, P.E., District Bridge Engineer – Background
- Emphasis has switched from lowering number of “poor” bridge to a Lowest Life Cycle Cost.
- Taking a deeper look at our bridge program.
- LLC is based on “risk score”.



BRIDGE PLANNING

Bridge Risk Score Calculation

The risk score for each bridge is calculated using the formula below. Appendix Table J.2 defines the factors and the parameters that determine factor values.

$$\text{Bridge Risk} = \left(\sqrt{\text{Deck Area} * \text{Annual Average Daily Traffic}}\right) * F_s * F_{fc} * F_{det} * F_{aadtt} * F_{flood}$$

Appendix Table J.2: Bridge Risk Score Factors

Factor	Definition	Parameter	Factor Value
F_s	Scour Factor	Scour Rating = A	1.2
		Scour Rating ≠ A	1.0
F_{fc}	Fracture Critical Factor	Fracture Critical Rating < 5	1.4
		Fracture Critical Rating ≥ 5	1.0
F_{det}	Detour Length Factor	Detour Length > 30 miles	2.0
		Detour Length ≥ 10 miles	1.5
		Detour Length < 10 miles	1.0
F_{aadtt}	Annual Average Daily Truck Traffic Factor	Truck traffic > 20% total traffic	2.0
		Truck traffic ≥ 10% total traffic	1.5
		Truck traffic < 10% total traffic	1.0
F_{flood}	Bridge Closed for Flooding Event Factor	Bridge has been closed for flooding	3.0
		Bridge has been overtopped due to flooding	1.5
		Bridge has not been closed or overtopped due to flooding	1.0

BRIDGE PLANNING

- **Condition Rating (CR) 9 → Brand new**
- **Condition Rating (CR) 4 → Poor**
- **Condition Rating (CR) 0 → Collapsed in river**
- **A quick look at CR tells the story - a "wave" coming**

Treat Network by CR – Examine Next 30 Years

- CR = 0-2, Deck Area = 16,192 → Needs Replacement (5 years)
- CR = 3, Deck Area = 434,201 → Needs Replacement (10 years)
- CR = 4, Deck Area = 522,953 → Needs Replacement (15 years)
- CR = 5, Deck Area = 6,834,689 → Needs Rehab (15 years)
- CR = 6, Deck Area = 3,010,595 → Needs Rehab (25 years)
- CR = 7, Deck Area = 2,405,674 → Needs Preservation (15 years)
- CR = 8, Deck Area = 518,795 → Needs Preservation (25 years)
- CR = 9, Deck Area = 62,563 → Needs Preservation (40 years)

BRIDGE PLANNING

- Bridge design life ~75 years
- Eisenhower Interstate System – started 1956, ended 1972
- 1956 + 75 = 2031, 1972 + 75 = 2047
- 61% of our network in 1950-1979

Deck area by Year built

	Adams	Cumberland	Dauphin	Franklin	Lancaster	Lebanon	Perry	York	Total
Before 1929	39,799.60	38,866.90	310,331.10	34,323.90	370,681.30	10,585.00	37,127.70	38,931.70	880,647.21
1930-39	39,470.40	29,984.70	141,061.31	59,610.30	98,780.70	40,290.50	78,018.30	119,943.40	607,159.62
1940-49	45,020.90	10,788.80	82,812.90	44,378.90	163,229.70	78,598.30	19,726.10	77,995.90	522,551.51
1950-59	53,002.00	66,973.00	510,886.40	41,055.30	203,651.51	14,597.90	132,319.90	646,443.52	1,668,929.52
1960-69	188,054.80	670,364.31	1,221,608.81	259,340.11	553,047.41	330,182.21	182,685.60	196,419.50	3,601,702.77
1970-79	8,619.90	306,924.21	1,768,922.20	39,376.80	1,213,390.27	31,411.00	0.00	221,574.00	3,590,218.38
1980-89	39,369.10	50,909.60	383,495.51	45,252.40	134,534.50	25,648.40	9,732.50	97,815.50	786,757.52
1990-99	59,398.20	202,012.20	150,322.80	18,469.10	136,783.91	8,675.20	11,632.20	32,825.30	620,118.91
2000-09	50,049.40	74,398.20	30,321.70	55,438.10	487,132.62	138,792.21	45,588.40	157,955.41	1,039,676.04
2010+	120,145.40	220,978.51	141,533.80	136,124.80	240,241.11	74,223.50	40,084.80	321,177.61	1,294,509.54
Total	**642,929.71**	**1,672,200.43**	**4,741,296.54**	**733,369.72**	**3,601,473.03**	**753,004.23**	**556,915.51**	**1,911,081.85**	**14,612,271.02**

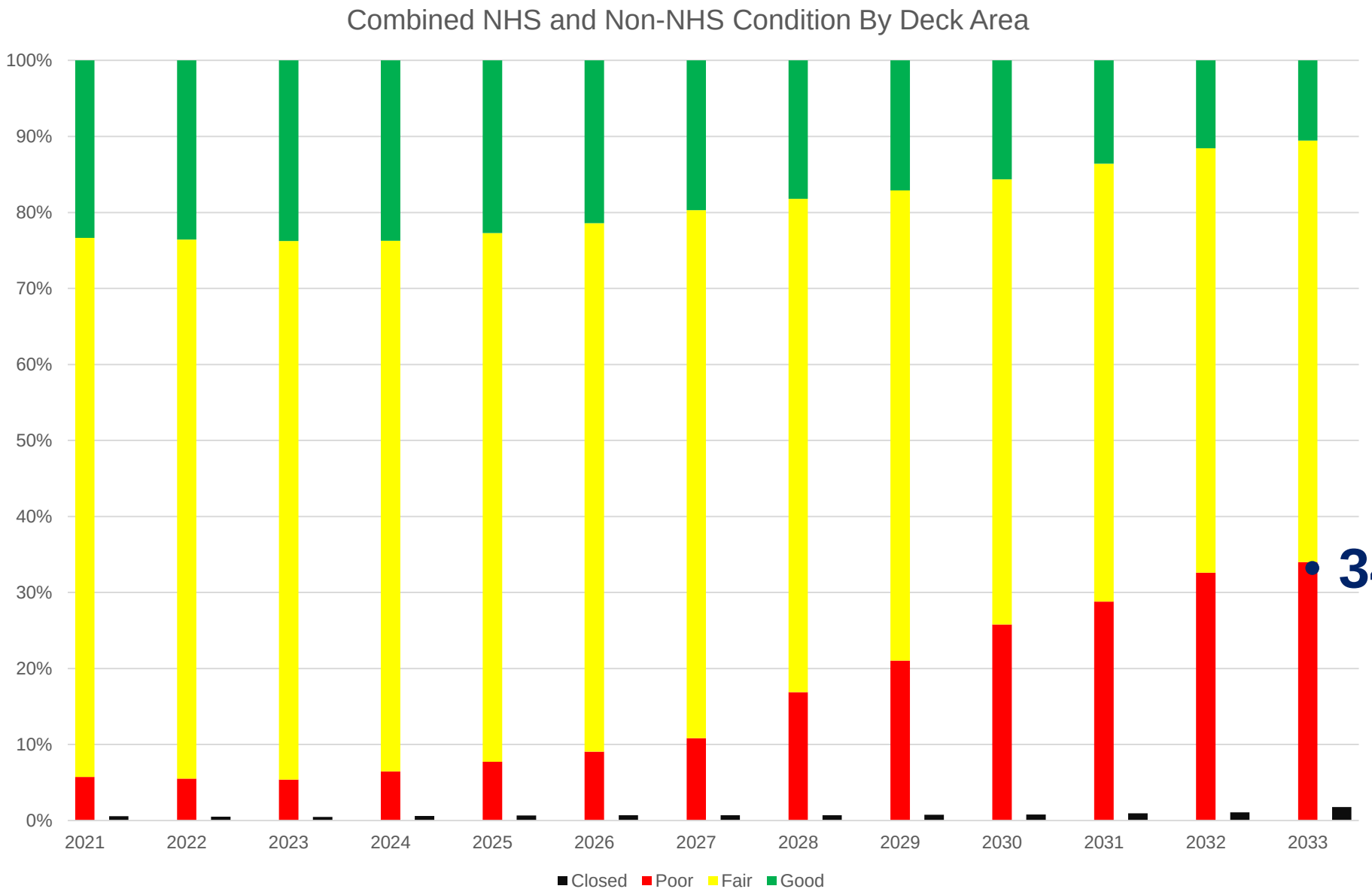
BRIDGE PLANNING

- Bridge design life ~75 years
- Eisenhower Interstate System – started 1956, ended 1972
- 1956 + 75 = 2031, 1972 + 75 = 2047
- 61% of our network in 1950-1979

Poor Deck Area by Year Built

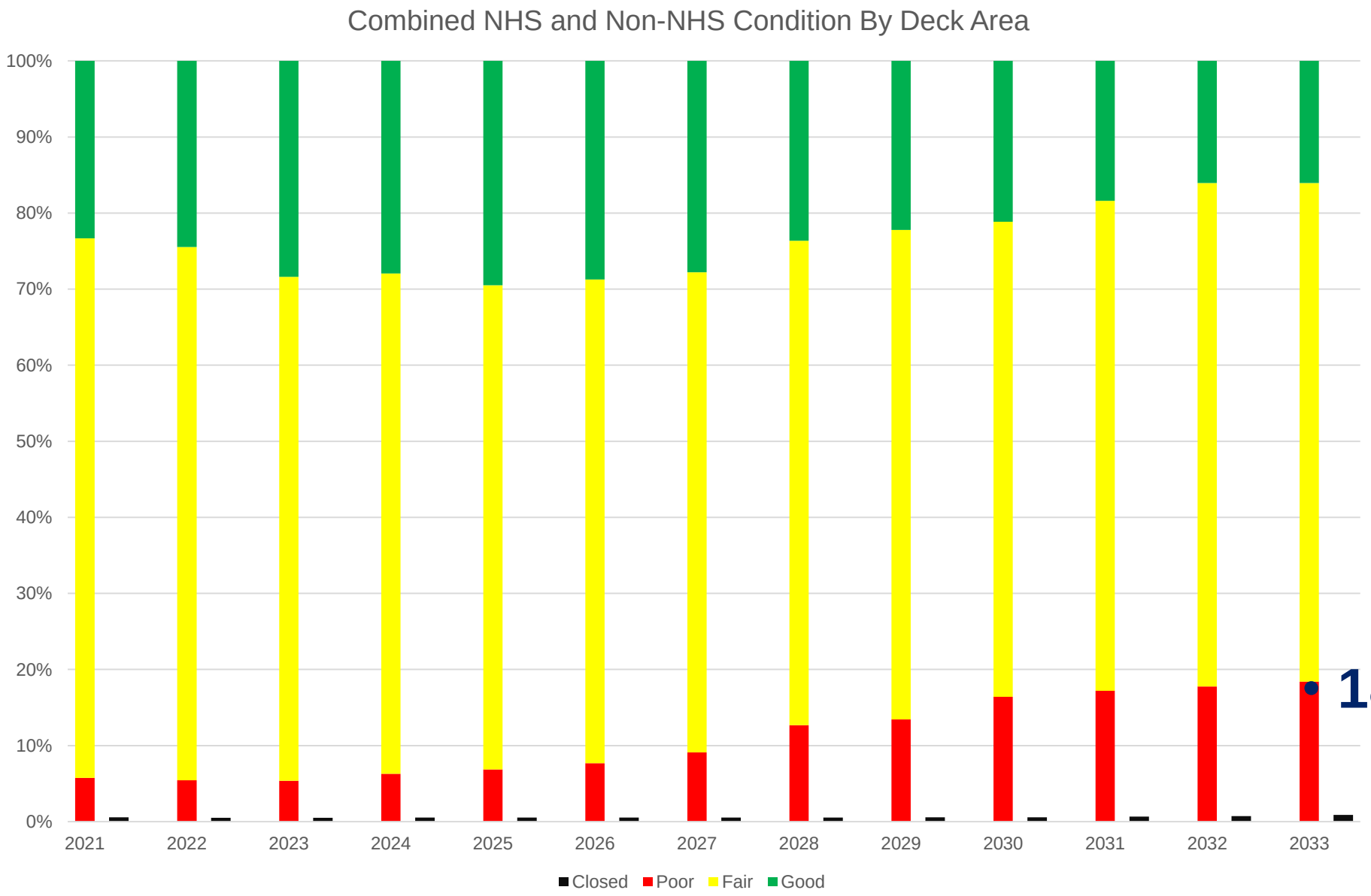
	Adams	Cumberland	Dauphin	Franklin	Lancaster	Lebanon	Perry	York	Total
Before 1929	8,474.80	6,928.50	97,970.20	5,381.90	19,381.00	2,749.80	9,673.90	6,128.30	156,688.40
1930-39	5,241.70	1,719.60	3,385.70	7,243.80	16,551.10	1,017.50	10,032.80	18,424.80	63,617.00
1940-49	7,237.30	2,652.00	31,474.30	5,037.40	24,691.50	1,085.60	4,969.70	10,943.60	88,091.40
1950-59	1,896.00	1,868.10	3,232.10	3,101.90	22,262.00	1,254.30	3,985.20	82,118.20	119,717.81
1960-69	14,147.00	17,492.00	7,227.00	9,017.10	29,684.40	1,948.00	7,000.50	8,405.00	94,921.00
1970-79	0.00	352.00	19,900.40	1,452.00	3,776.00	11,237.60	0.00	3,812.80	40,530.80
1980-89	0.00	676.00	3,834.00	0.00	5,475.00	0.00	0.00	782.00	10,767.00
1990-99	0.00	0.00	1,206.00	0.00	0.00	0.00	0.00	0.00	1,206.00
2000-09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**36,996.80**	**31,688.20**	**168,229.70**	**31,234.10**	**121,821.00**	**19,292.80**	**35,662.10**	**130,614.70**	**575,539.42**

WORST 1ST



34% Poor

LOWEST LIFE CYCLE COST



18% Poor

BRIDGE PLANNING

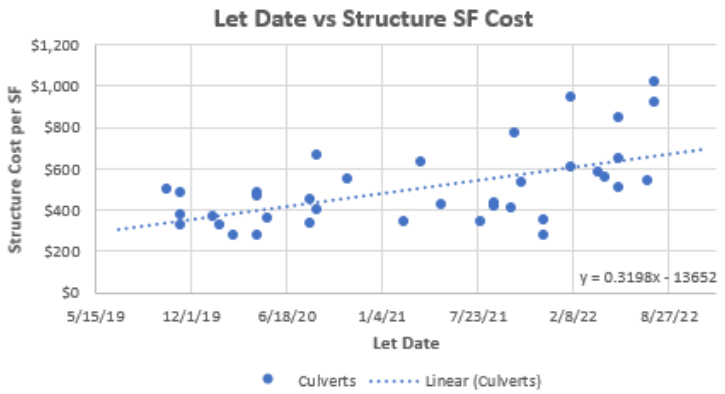
Unit Cost Data: Replacement - Culvert
ECMS Data Range: 08/02/2019 to 08/02/2022

Last Updated: 09/13/22
Updated By: KJS

Data Set Count: 37 Culvert Projects

Instructions:
(1) Cells shaded green are input.
(2) To add a new project, copy a row from the middle of the table and insert the row in the middle of the table. This will retain the drop downs, eliminate the need to reapply the filters to the column headings, and automatically add the new data point to the graph. After insertion, edit all shaded data fields
(3) After all new projects are added, re-sort data using by newest first.
(4) After new cost data is entered, adjust trendline formula input based off of chart.

Notes:
(1) Items/cost associated with natural streambed material placement/storage
(2) Items/cost associated with unique issues (e.g. sinkhole stabilization) that appear on structures tab block were excluded.
(3) Over-excavation and backfilling of unsuitable material included under other
(4) SF Costs include temporary excavation support and removal of existing structures.



	Structure	Total
2020 Average SF Cost =	$414	$826
2021 Average SF Cost =	$449	$877
2022 Average SF Cost =	$719	$1,301
Overall Average SF Cost =	$507	$974
Trendline Slope =	0.3198	
Trendline Y-intercept =	-13652	

Structure Trendline		
Date	SF Cost	
#########	$696	Today
6/30/2023	$773	
6/30/2024	$890	
6/30/2025	$1,007	
6/30/2026	$1,124	

Project Data						Structure Data										Construction Cost Data							
																Low Bidder - Structure Cost							
ECMS Project	Let Date	Dist.	County	Route & Section	Structure Plan Number	No. of Spans	Structure Type	Wing Type	Barrier Type	Span (FT)	Wall Width (FT)	Rise (FT)	Culv. Length (FT)	Staged Constr. ?	Dist. Slab ?	Str. Area (SF)	Lump Sum	Rebar	Rock	TES&PS	Other Str. Item	Existing Removal	Total Structure	Structure SF Cost	Total Constr. SF Cost
87538	7/28/22	8	Lancaster	0772 - 048	S-40076	1	Box - Precast	Combo	Combo G/R	6.00	0.67	3.00	42.13	No	Yes	309	$284,000	$4,800	in LS	$0	$300	$25,000	$314,100	$1,017	$2,198
100292	7/28/22	8	Lebanon	0419 - 009	S-40249	1	Box - Precast	Combo	Combo G/R	7.50	0.67	6.00	57.23	No	Yes	506	$406,976	$26,495	$3,612	$0	$13,179	$17,495	$467,757	$924	$1,606
90846	7/14/22	8	Dauphin	4006 - 006	S-40454	1	Box - Precast	End Section	10M	26.00	1.08	7.50	29.25	No	No	824	$400,000	$4,096	$21,350	$0	$2,070	$20,000	$447,516	$543	$872
89288	5/12/22	8	Lancaster	7101 - BRG	L-65	1	Box - Precast	End Section	10M	16.00	1.08	4.00	31.50	Yes	Yes	573	$391,900	Alt. Bid	$9,800	$37,500	$4,565	$40,000	$483,765	$844	$1,715
89288	5/12/22	8	Lancaster	7101 - BRG	L-64	2	Box - Precast	End Section	10M	12.00	1.00	5.00	43.50	Yes	Yes	1,218	$655,735	Alt. Bid	$9,800	$37,500	$7,500	$80,000	$790,535	$649	$1,318
92562	5/12/22	8	York	2079 - 005	S-40014	1	Box - Precast	End Section	SM G/R	27.00	1.08	6.00	33.75	No	Yes	985	$460,000	$11,820	in LS	$0	$2,240	$30,000	$504,060	$512	$796
100211	4/14/22	8	York	3035 - 001	S-39942	1	Box - Precast	End Section	SM G/R	25.00	1.08	6.00	32.33	No	No	879	$408,719	$3,135	$21,871	$12,276	$3,467	$40,761	$490,228	$558	$922
78655	3/31/22	8	Cumberland	0997 - 039	S-39668	1	Box - Precast	End Section	PA Bridge	18.00	1.08	7.00	35.83	No	Yes	723	$389,900	$8,525	$5,040	$0	$520	$20,000	$423,985	$586	$877
91359	2/3/22	8	York	2002 - 019	S-39830	1	Box - Precast	End Section	SM G/R	7.50	0.67	5.00	29.38	No	Yes	260	$229,000	$850	in LS	$10,000	$2,250	$4,000	$246,100	$947	$1,803

Page

BRIDGE PLANNING

Cost Analysis:

			Total Replacement			Partial Replacement		Rehabilitation		
			Culvert [2]	Bridge [3]	Com-bined	Super-structure	Deck	Stone Arch	Conc. Arch	Preser-vation
Design Cost (Total Cost)		Preliminary Engineering	$296,242	$319,848	$310,518	$215,915	$138,765	$196,528	$220,848	$107,492
		Final Design	$175,172	$229,551	$198,113	$202,539	$257,226	$112,583	$139,289	$163,241
		Preliminary + Final	$471,414	$549,398	$508,631	$418,454	$395,991	$309,111	$360,136	$270,733
		Right-of-Way	$17,438	$19,732	$18,385	$4,271	$7,098	$18,365	$26,709	$238
Design Cost (Cost per SF)		No. of Projects with Design Costs	37	27	64	10	3	3	5	10
		Total Associated SF Area	30,912	100,284	131,196	25,303	20,722	4,222	11,883	143,199
		Average SF Area	835	3,714	2,050	2,530	6,907	1,407	2,377	14,320
		Total Design Cost (PE + FD + R/W)	$18,383,784	$15,346,797	$33,710,629	$4,227,253	$1,209,270	$982,427	$1,934,228	$2,709,704
		Average Cost per SF	$595	$153	$257	$167	$58	$233	$163	$19
Construction Cost (Cost per SF)	Structure Only	2020 Average	$414	$342	$378	(1)	(1)	(1)	(1)	$73
		2021 Average	$449	$406	$426	(1)	(1)	(1)	(1)	$64
		2022 Average	$719	$353	$634	(1)	(1)	(1)	(1)	$97
		Overall Average	$507	$365	$446	$236	$143	$372	$157	$72
	Low Bid (w/o CENG)	2020 Average	$826	$567	$697	(1)	(1)	(1)	(1)	$103
		2021 Average	$877	$752	$812	(1)	(1)	(1)	(1)	$125
		2022 Average	$1,301	$494	$1,115	(1)	(1)	(1)	(1)	$184
		Overall Average	$974	$627	$825	$402	$233	$596	$356	$133
		Constr. Engineering (CENG)	$122	$78	$103	$50	$29	$75	$44	$17
		Low Bid Average + CENG	$1,096	$706	$928	$452	$262	$671	$400	$149
Total (Cost per SF)			$1,690	$859	$1,185	$619	$320	$904	$563	$168

Page 1

BRIDGE PLANNING

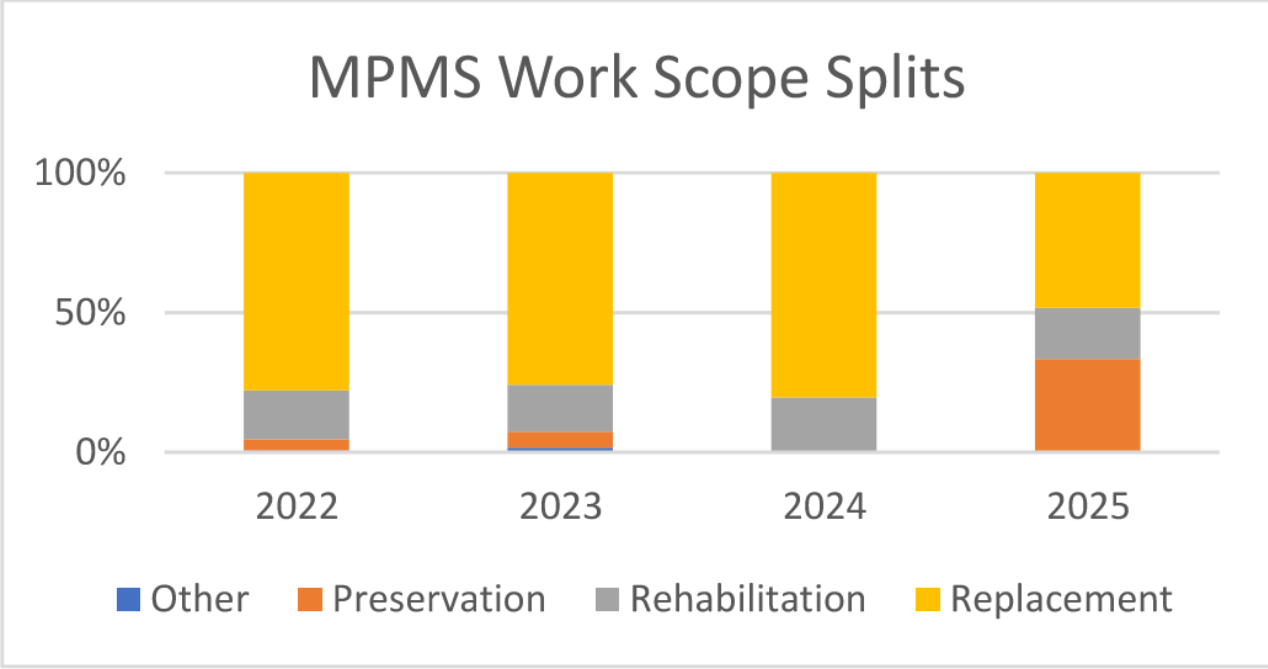
- CR = 4, Deck Area = 522,953 → Needs Replacement (15 years)
- CR = 5, Deck Area = 6,834,689 → Needs Rehab (15 years)

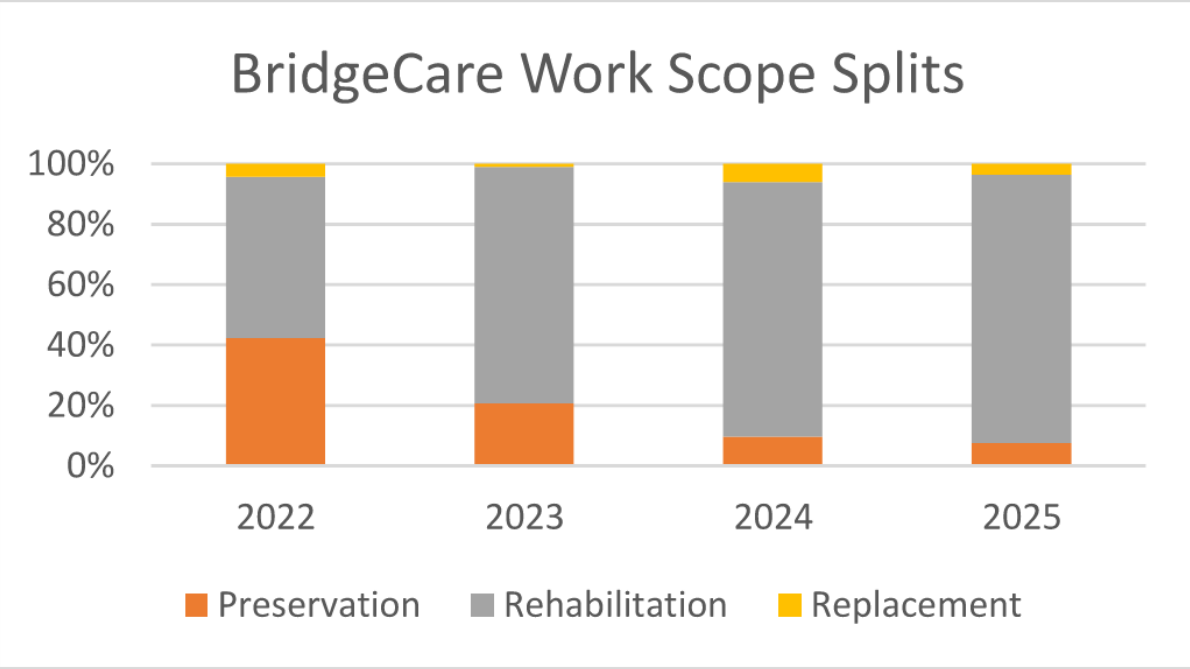
- **Bridge (Light) Preservation → $ 25 / SF**
- **Bridge (Medium) Preservation → $ 75 / SF**
- **Bridge (Heavy) Preservation → $ 150 / SF**
- **Bridge Deck Replacement → $ 250 / SF**
- **Bridge Beam & Deck Replace → $ 450 / SF**
- **Bridge Total Replacement → $ 750 / SF**
- **Culvert Replacement → $1000 / SF**

Avg = $350/sf
vs. $750/sf

BRIDGE PLANNING

- Another angle - BAMS
- Bridge Asset Management → BridgeCares Software
- Can compare our planned project (MPMS) to our theoretical "perfect" LLC scopes.
- Reality is in between, because it will always be a mix.





BRIDGE PLANNING

- Current 12 year plan (by count)
  - 272 (34%) are preservation → ??
  - 60 (7%) are rehabilitation → ??
  - 475 (59%) are replacement → ??

2024+ Projects	Programmed by $
Preservation	3%
Rehabilitation	13%
Replacement	84%

- We are rethinking preservation work to get closer to LLC
  - Re-scope projects (future, 2024+ projects)
  - Emphasize rehab & (heavy) preservation (future)
  - **Light & Medium Preservations do not warrant individual TIP projects.**
    - **Expand use of task-specific contracts (next slides)**

BRIDGE PLANNING

- Task Specific Contract – Example is our current Bridge Maintenance Contract
  - 409 Funded – BMC - $1.5M/yr (50% on-call)
- Future Bridge (Medium) Preservation Contract
  - TIP Funded - $2.0M/yr (focus on “surgical” major structure work)
  - Prevent full TIP projects
- Future Bridge (Light) Preservation Contract
  - TIP Funded - $2.0M/yr (focus on joints & scour)
  - Reduce long term degradation of bridges

- These Task-Specific Contracts will need funded, but are more efficient than traditional TIP projects.

BRIDGE PLANNING

- Task Specific Contract – Example is our current Bridge Maintenance Contract
  - 409 Funded – BMC - $1.5M/yr (50% on-call)
- **Future Bridge (Medium) Preservation Contract**
  - **TIP Funded - $2.0M/yr (focus on “surgical” major structure work)**
  - **Prevent full TIP projects**
- Future Bridge (Light) Preservation Contract
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  - Reduce long term degradation of bridges

- These Task-Specific Contracts will need funded, but are more efficient than traditional TIP projects.

BRIDGE (MEDIUM) PRESERVATION

BRIDGE (MEDIUM) PRESERVATION

- **Example Medium Preservation**
- **Scope ~$75/SF**

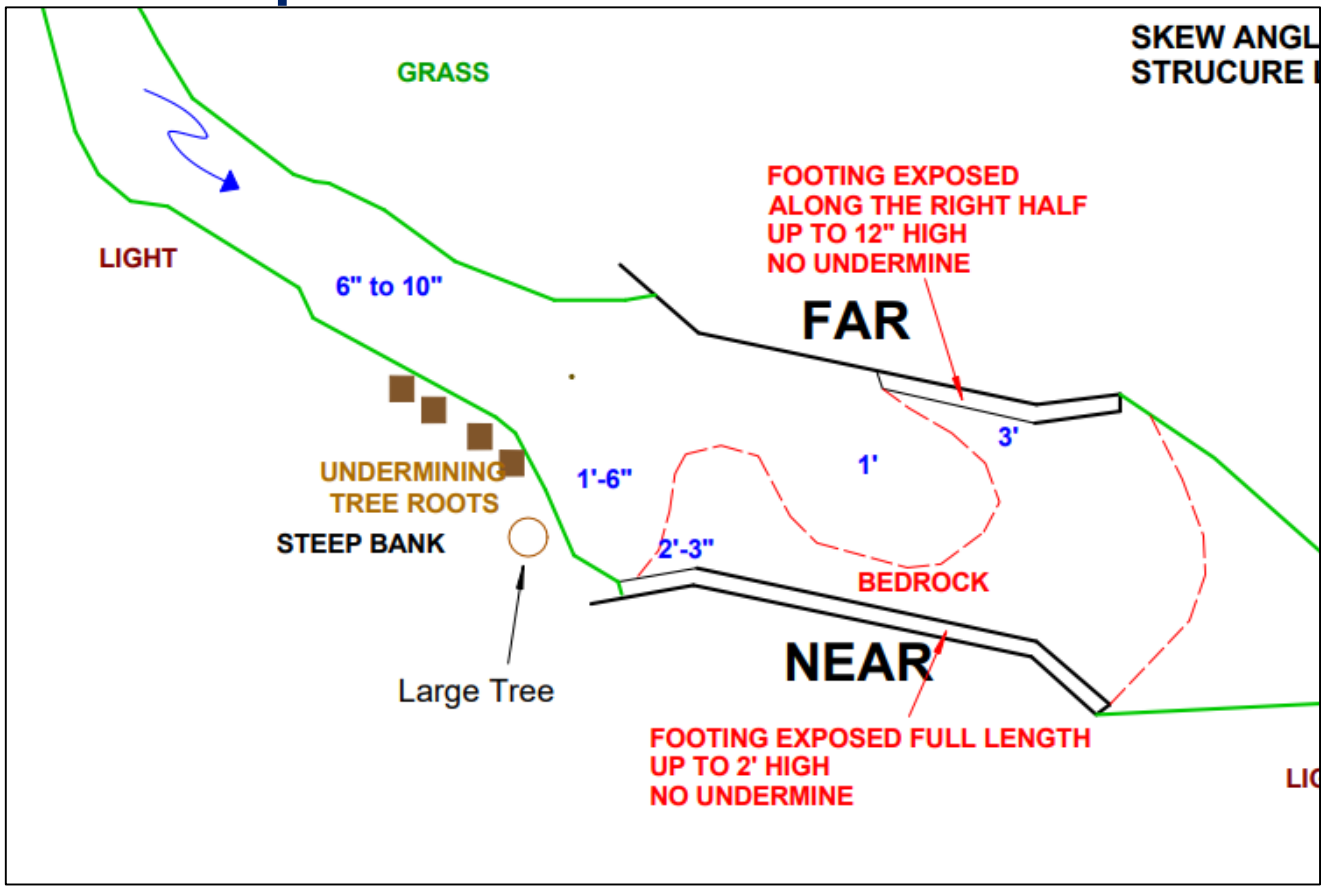
BRIDGE PLANNING

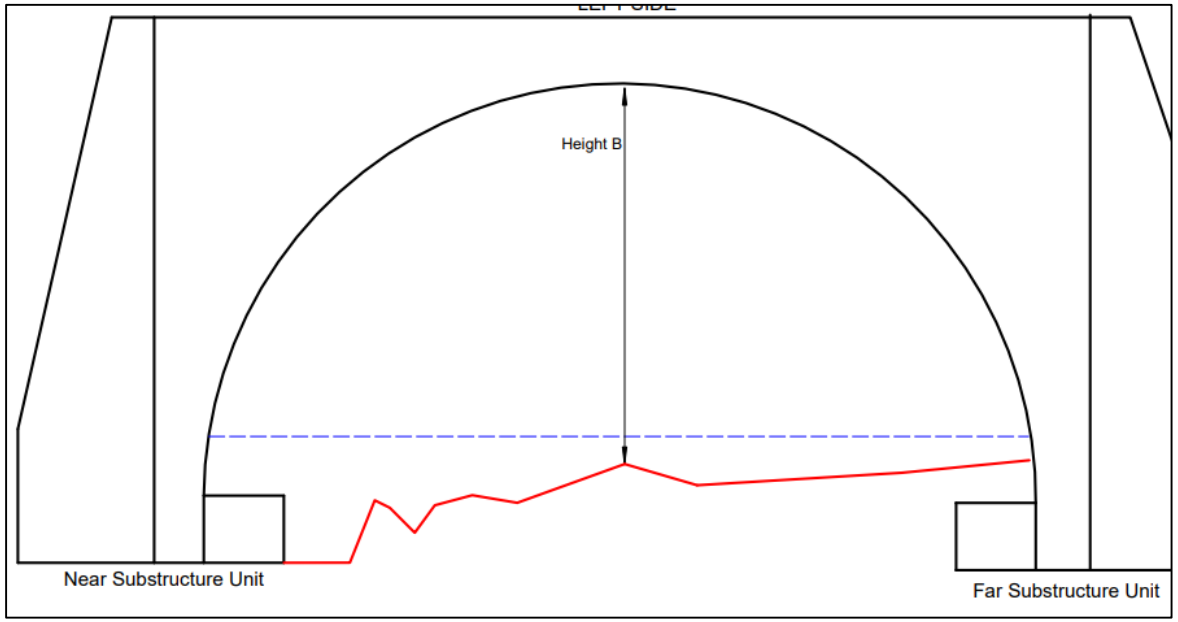
- Task Specific Contract – Example is our current Bridge Maintenance Contract
  - 409 Funded – BMC - $1.5M/yr (50% on-call)
- Future Bridge (Medium) Preservation Contract
  - TIP Funded - $2.0M/yr (focus on “surgical” major structure work)
  - Prevent full TIP projects
- **Future Bridge (Light) Preservation Contract**
  - **TIP Funded – $2.0M/yr (focus on joints & scour)**
  - **Reduce long term degradation of bridges**

- These Task-Specific Contracts will need funded, but are more efficient than traditional TIP projects.

BRIDGE (LIGHT) PRESERVATION

- Example Light Preservation Contract
- Scope ~$25/SF





BRIDGE (LIGHT) PRESERVATION

- **Example Light Preservation Contract**
- **Scope ~$25/SF**

BRIDGE (LIGHT) PRESERVATION

2020		2022
	→	
	→	

BRIDGE (LIGHT) PRESERVATION

County	Joint Issue PC1/2	Scour Issue PC1/2
Adams	11	23
Cumberland	37	8
Dauphin	34	21
Franklin	9	1
Lancaster	56	46
Lebanon	17	13
Perry	13	10
York	29	47
D8-0	206	169

BRIDGE PLANNING

Example Deck Area =	1800	SF
Medium Preservation Cost =	$75	SF
Light Preservation Cost =	$25	SF
Cycle Length =	4	Yrs

County		Allocated %	Medium Preservation		Light Preservation	
#	Name		$/Yr	Total #	$/Yr	Total #
01	Adams	*12%*	*$240,000*	*7*	*$240,000*	*44*
21	Cumberland	*8%*	*$160,000*	*5*	*$160,000*	*30*
22	Dauphin	*18%*	*$360,000*	*11*	*$360,000*	*67*
28	Franklin	*10%*	*$200,000*	*6*	*$200,000*	*37*
36	Lancaster	*20%*	*$400,000*	*12*	*$400,000*	*74*
38	Lebanon	*8%*	*$160,000*	*5*	*$160,000*	*30*
50	Perry	*4%*	*$80,000*	*2*	*$80,000*	*15*
66	York	*20%*	*$400,000*	*12*	*$400,000*	*74*
Total		100%	$2,000,000	60	$2,000,000	371

BRIDGE PLANNING

- Next Steps:
  - Re-scope projects
  - Emphasize rehab & preservation
  - BAMS / Bridge Cares to be incorporated
  - **How to fund task-specific contracts**
    - **Nothing today**
    - **Will come back with future changes to fund this**

  - Thank you!