



# Iowa Bridge Program Optimization

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2015

MULTI-OBJECTIVE OPTIMIZATION FOR LONG-TERM  
NETWORK-LEVEL RENEWAL PLANNING OF BRIDGES IN  
IOWA: PHASE II PROGRESS REPORT

*Submitted To:*



Iowa Department of Transportation

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# IDS Program Objectives

- ◆ Comprehensive analysis of Iowa bridge inventory and condition data.
- ◆ Development of deterioration models to predict bridge performance based on historical Iowa NBI data
- ◆ Development of a risk-based prioritization model to rank bridges based on both the likelihood of failure and consequence of failure, and then assign priority indices to indicate relative urgency of preservation actions
- ◆ Development of 20-year optimal preservation plans that maximize system-wide performance and minimize risks under a range of budget and performance target scenarios
- ◆ Investigating trade-offs between funding levels and system-wide performance and risk levels

# Bridge Type Groupings

Group ID	Bridge type (NBI Items 43A/43B)	Route Type (NBI Item 5B)	Type of Service on bridge (NBI Item 42A)
<b>Group #1</b>	Continuous Steel	Interstate	Mainline Highway only
<b>Group #2</b>	Prestressed Girder	Interstate	Mainline Highway only
<b>Group #3</b>	Continuous Steel	Interstate	Overpass at Interchange
<b>Group #4</b>	Prestressed Girder	Interstate	Overpass at Interchange
<b>Group #5</b>	Continuous Slab	Interstate	Mainline/Overpass at interchange
<b>Group #6</b>	Simple span Steel	All Routes	All Types
<b>Group #7</b>	Continuous Steel	U.S. or State	All Types
<b>Group #8</b>	Prestressed Girder	U.S. or State	All Types
<b>Group #9</b>	Simple Span Slab	All Routes	All Types
<b>Group #10</b>	Continuous Slab	U.S. or State	All Types
<b>Group #11</b>	Two Girder Steel	All Routes	All Types
<b>Group #12</b>	Continuous/Simple Span Steel	County or City	All Type
<b>Group #13</b>	Prestressed Girder	County or City	All Types

# Bridge Evaluation

- ◇ 6 different preservation methods using 16 different scenarios
  - ◇ Concrete Overlay
  - ◇ Deck Repair
  - ◇ Deck Replacement
  - ◇ Bridge Replacement
  - ◇ Bridge Widening
  - ◇ Prestressed Beam End Repair

# Project Criteria

Method	Unit Cost	Maximum Total Budget	Condition Improvement	Material (Item 43A)	Deck Condition (Item 58)	Superstructure Condition (Item 59)	Substructure Condition (Item 60)	Operating Rating (Item 64)	Wearing Surface (Item 108A)	Deck Protection (Item 108C)	Deck Geometry (Item 68)	Condition Index - S1	Agency Rules
Low Slump Concrete Overlay	\$50/sq. ft.	15%	3 point increase in Deck with a maximum deck condition rating of 7, increase superstructure and substructure by 1 point with a maximum condition rating of 7.	1,2,3,4,5	4,5	>5	>5	>32.4 tons	4	0,1,2	>3	>30	Do not re-overlay. Do not replace or re-deck for 10 years.
Low Slump Concrete Overlay	\$50/sq. ft.	15%	3 point increase in Deck with a maximum deck condition rating of 7, increase superstructure and substructure by 1 point with a maximum condition rating of 7.	1,2,3,4,5	4,5,6	>5	>5	>32.4 tons	1	0	>3	>30	Do not re-overlay, replace, or re-deck for 15 years.
Low Slump Concrete Overlay	\$50/sq. ft.	15%	3 point increase in Deck with a maximum deck condition rating of 7, increase superstructure and substructure by 1 point with a maximum condition rating of 7.	1,2,3,4,5	5	>4	>4	>32.4 tons	1	1,2	>3	>25	Do not re-overlay, replace, or re-deck for 15 years.
Deck Replacement (Interstate)	\$115/sq. ft.	25%	Deck to condition 8, Superstructure to condition 7, Substructure to condition 7	1,2,3,4,5	<=5	>=5	>=5	>32.4 tons	1, 4	0,1,2	>4	>20	Do not replace bridge for 10 years
Deck Replacement (Non-Interstate)	\$115/sq. ft.	25%	Deck to condition 8, Superstructure to condition 7, Substructure to condition 7	1,2,3,4,5	<=5	>=5	>=5	>32.4 tons	1, 4	0,1,2	>3	>20	Do not replace bridge for 15 years
Deck Repair	\$25/sq. ft.	1%	2 points increase in Deck	1,2,3,4,5	4,5	>4	>4	any	4	0,1	any	>25	Only repair deck twice. After second repair, deck should be overlaid or replaced.
Bridge Replacement (non-Interstate)	\$325/sq. ft.	75%	New	1,2,3,4,5	<6	<6	<6	any	any	any	<=5	<35	
Bridge Replacement (Interstate)	\$275/sq. ft.	75%	New	1,2,3,4,5	<6	<6	<6	any	any	any	<=5	<35	
Bridge Replacement (non-interstate)	\$325/sq. ft.	75%	New	1,2,3,4,5	any	<5	any	any	any	any	any	<35	
Bridge Replacement (Interstate)	\$275/sq. ft.	75%	New	1,2,3,4,5	any	<5	any	any	any	any	any	<35	
Bridge Replacement (non-interstate)	\$325/sq. ft.	75%	New	1,2,3,4,5	any	any	<5	any	any	any	any	<35	
Bridge Replacement (Interstate)	\$275/sq. ft.	75%	New	1,2,3,4,5	any	any	<5	any	any	any	any	<35	
Bridge Replacement (non-Interstate)	\$325/sq. ft.	75%	New	1,2,3,4,5	<5	<=7	<=7	any	any	any	any	<35	
Bridge Replacement (Interstate)	\$275/sq. ft.	75%	New	1,2,3,4,5	<5	<=7	<=7	any	any	any	any	<35	
Bridge Widening	\$100/sq.ft. of new deck width	5%	2 point increase in Deck with a maximum rating of 8, Superstructure to condition 7, Substructure to condition 7	3,4,5	>4	>4	>4	>32.4 tons	any	any	2	>25	Do not replace deck or bridge for 20 years.
Prestressed Beam End Repair	\$1500/ beam end	5%	Superstructure increase 2 points to a maximum of 7, Substructure to condition 7	5	>4	<5	>4	any	any	any	any	>30	If deck condition <=4, deck repair or deck replacement should be done with this work.

# Deterioration Factors

- ◇ Age
- ◇ ADT
- ◇ ADTT
- ◇ Length of Maximum Span
- ◇ Number of Lanes
- ◇ Deck Protection (wearing surface)
- ◇ Deck Protection (Reinforcing Steel)
- ◇ Design Load
- ◇ Skew Angle

# Risk Factors

- ◇ Highway System (NHS vs. Non-NHS) - 25%
- ◇ Functional Class of Route - 30%
- ◇ Detour Length – 15%
- ◇ Type of Service Under Bridge – 5%
- ◇ ADT – 25%



# Programming Budget

- ◇ Multiple budget scenarios can be assessed.
- ◇ Scenarios can have limits on individual maintenance methods.
- ◇ Targets for overall inventory condition can be based on agencies individual criteria.
- ◇ The program output should be viewed as an overall system need or shortfall.
- ◇ The program output shows what the most efficient use of program dollars should be based on work types.

# Program Scenarios

- ◇ \$70 million per year
- ◇ \$100 million per year
- ◇ \$100-\$120-\$140-\$160 million stepped every 5 years
- ◇ \$100 million min. to \$250 million max.
- ◇ No limit per year with condition index threshold of 42

## Budget limit examples:

- ◇ 40% of budget for replacements
- ◇ 60% of budget for replacements
- ◇ 75% of budget for replacements
- ◇ No limit on replacements

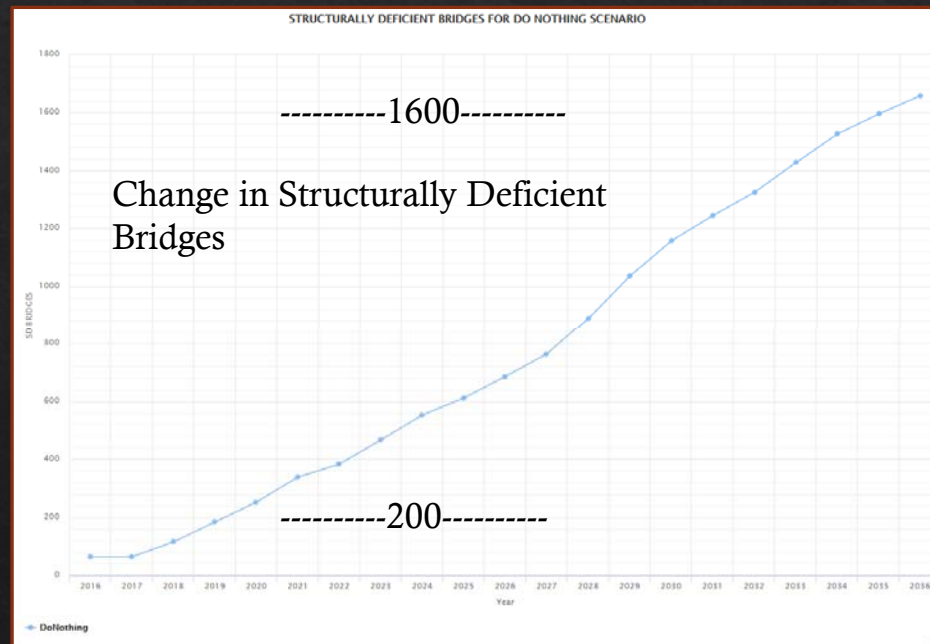
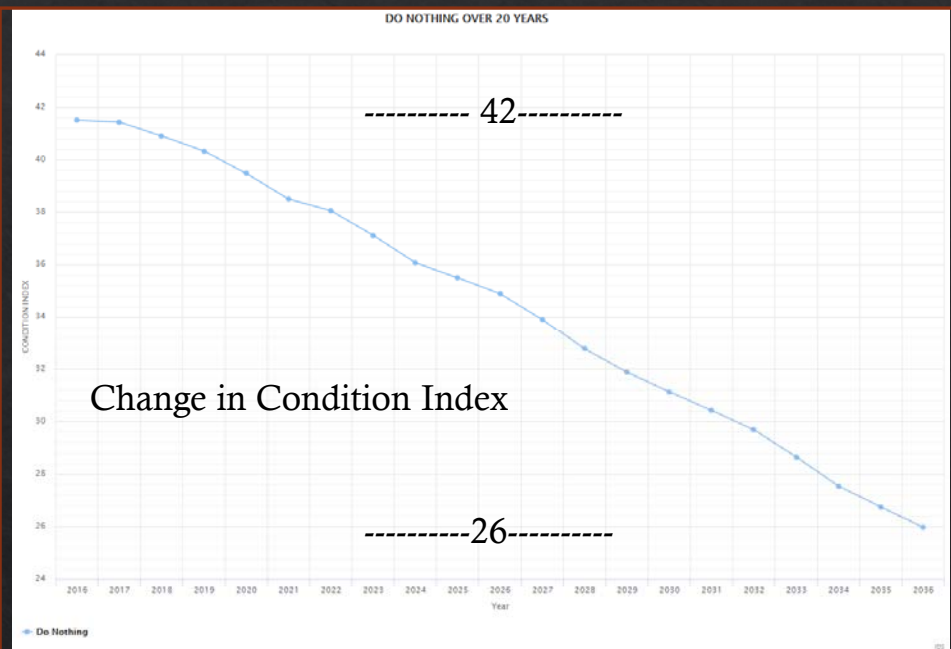
## Large Project Limits:

- ◇ Any project over \$5 million
- ◇ \$120 million annual limit
- ◇ No annual budget limit
- ◇ Different project criteria

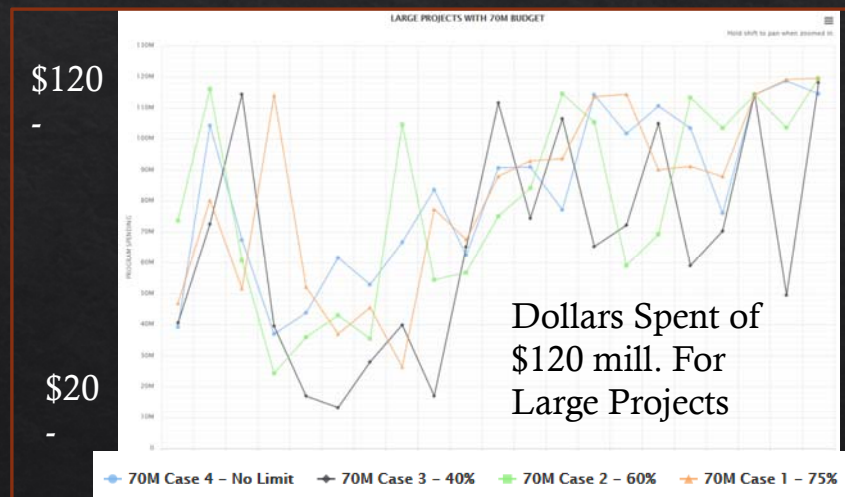
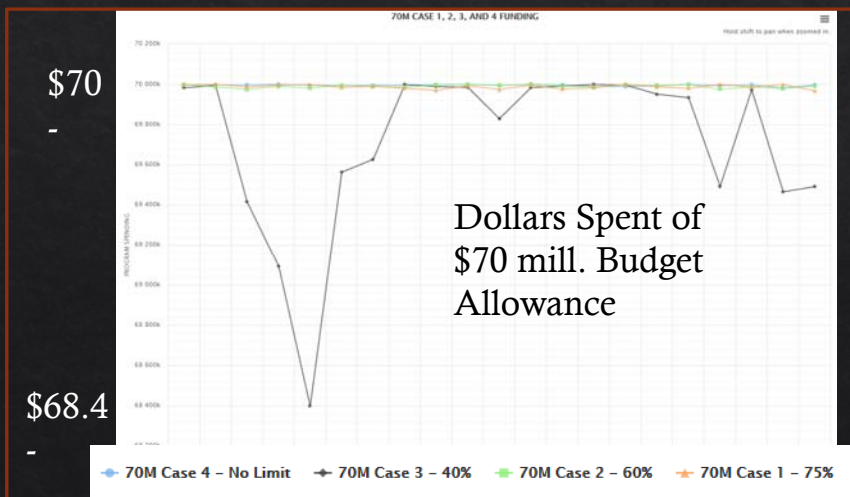
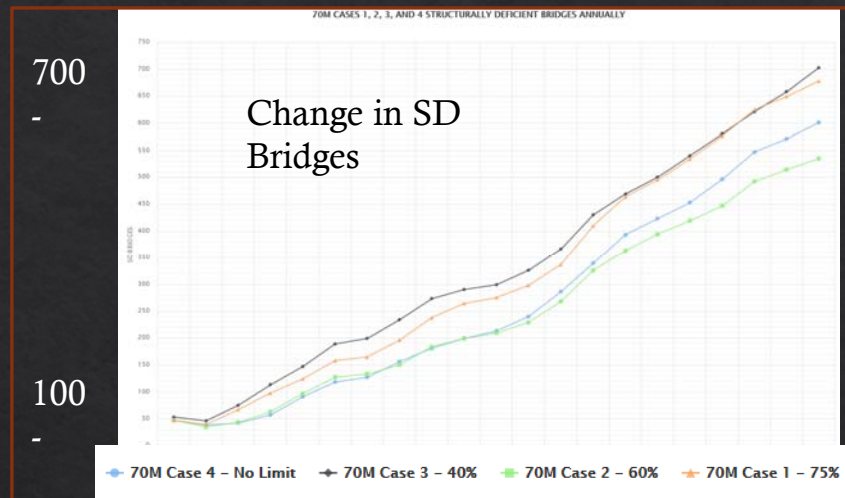
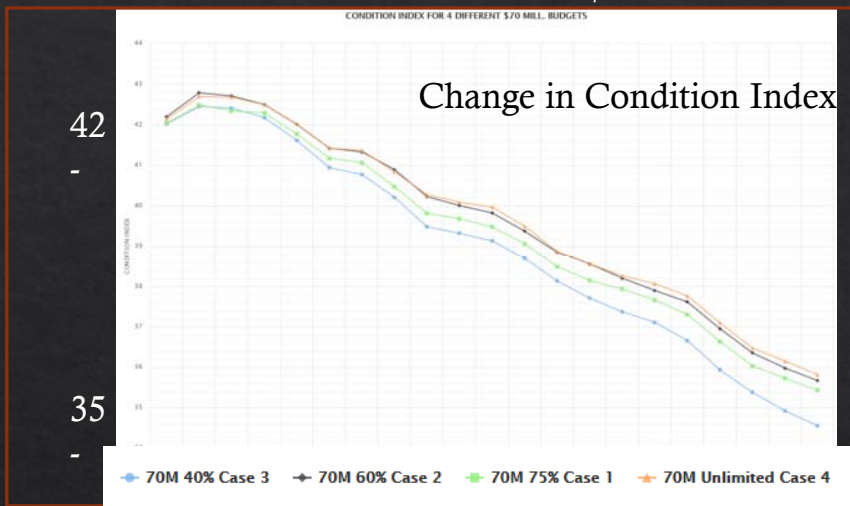
# IDS Program vs. Iowa Program

- ◇ IDS proposed 1632 projects over 20 years from 2014 thru 2033
- ◇ 384 of the 1632 projects are already programmed or were completed in 2011, 2012, or 2013
- ◇ 142 of the 384 are in the first 5 years of IDS's program
- ◇ 854 of the 1632 projects have a proposed work item in our Structure Inventory and Inspection Management System

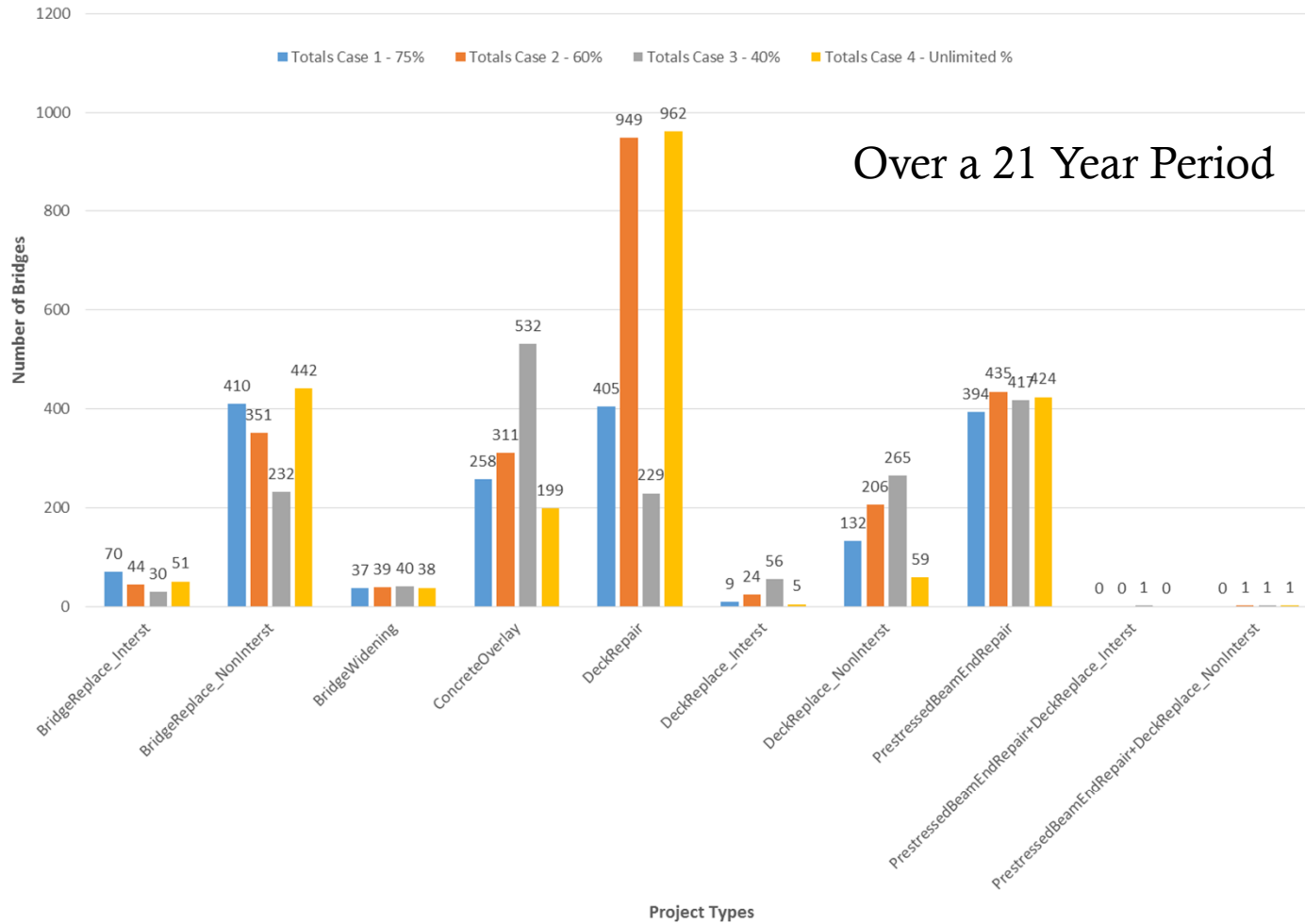
# Do Nothing for 20 Years



## \$70 Mill. Annual Budget

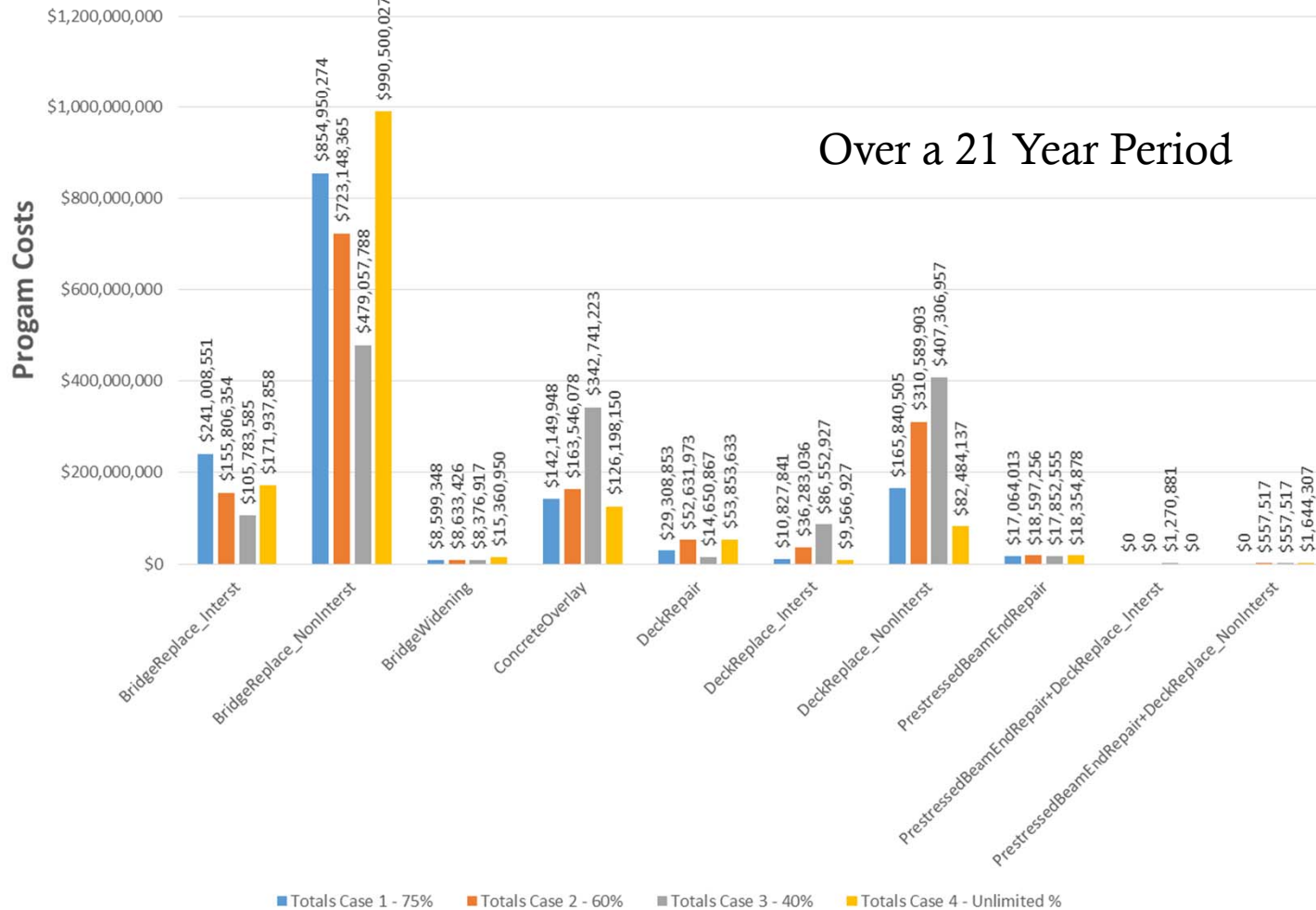


### \$70 mill. Budget Scenarios

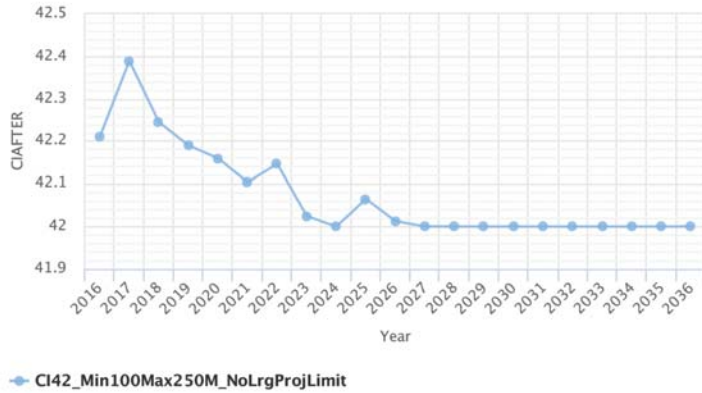


## Program Costs for \$70 mill. Budget Scenarios

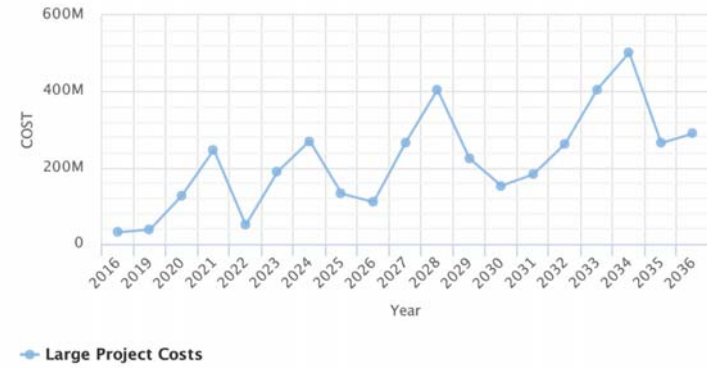
Over a 21 Year Period



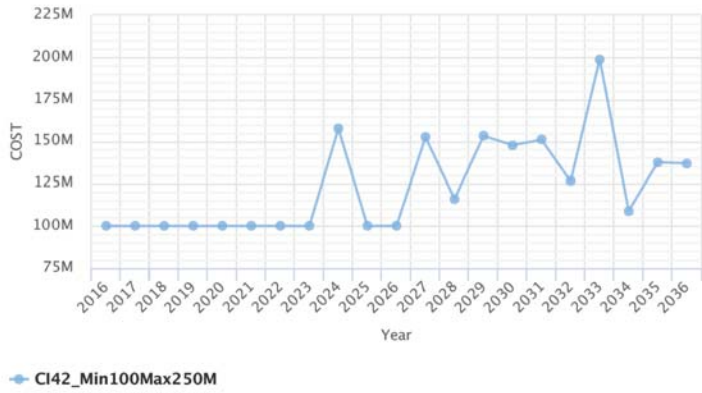
CI42\_MIN100MAX250M\_NOLRGPROJLIMIT AND YEAR VS CIAFTER



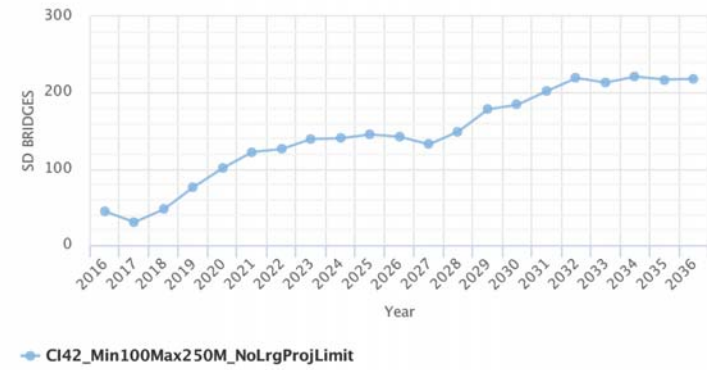
LARGE PROJECT COSTS WHEN REGULAR PROGRAM BUDGET IS CI42\_MIN100MAX250M



CI42\_MIN100MAX250M  
No Budget Limit on Large Projects

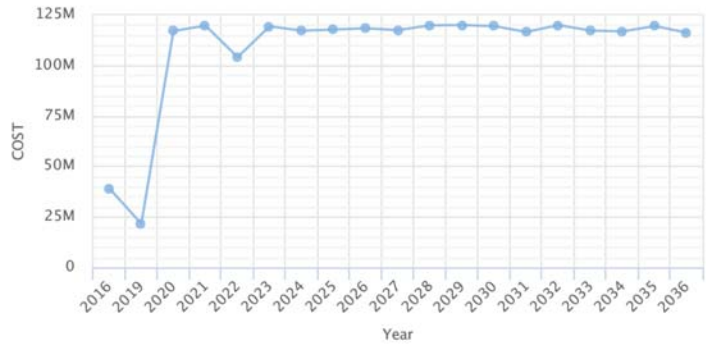


STRUCTURALLY DEFICIENT BRIDGES FOR CI42\_MIN100MAX250M\_NOLRGPROLIMIT





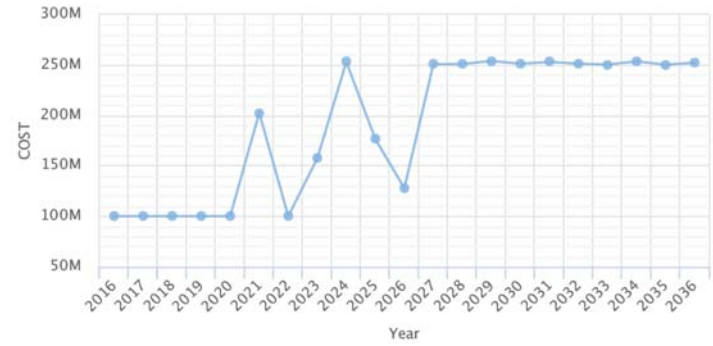
**LARGE PROJECTS WITH CI42\_MIN100MAX250M**



Large Project Costs With Budget Limit Of \$120 Mill. Max

IDS

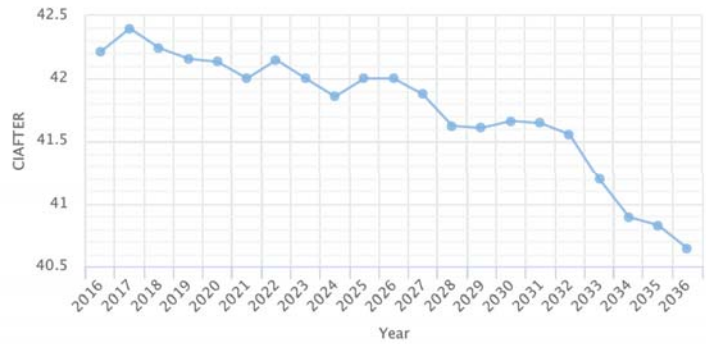
**CI42\_MIN100MAX250M AND YEAR VS COST**



CI42\_Min100Max250M

IDS

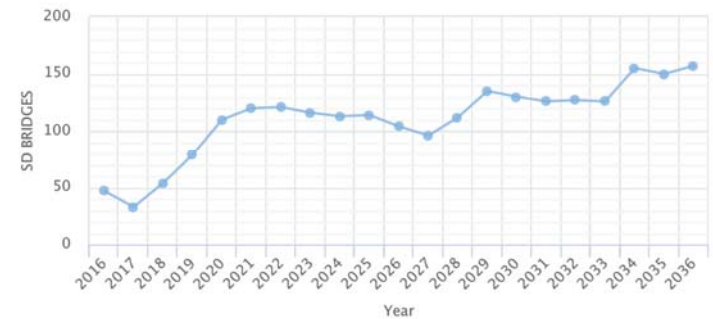
**CI42\_MIN100MAX250M VS CIAFTER**



Condition Index with Limited Large Project Budget of \$120 mill.

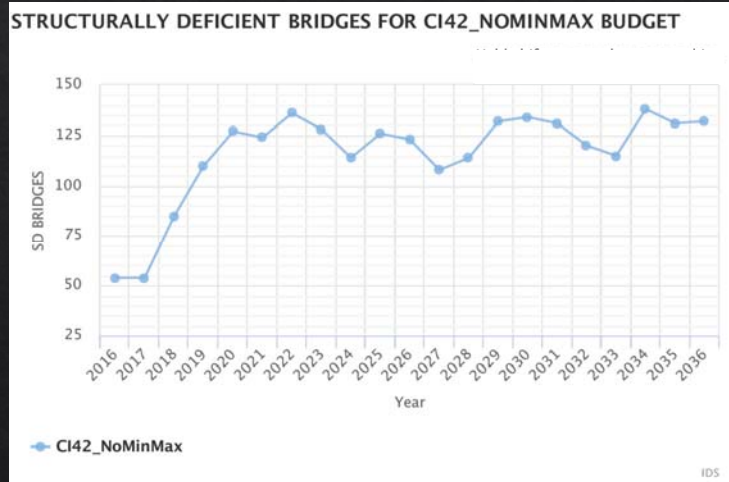
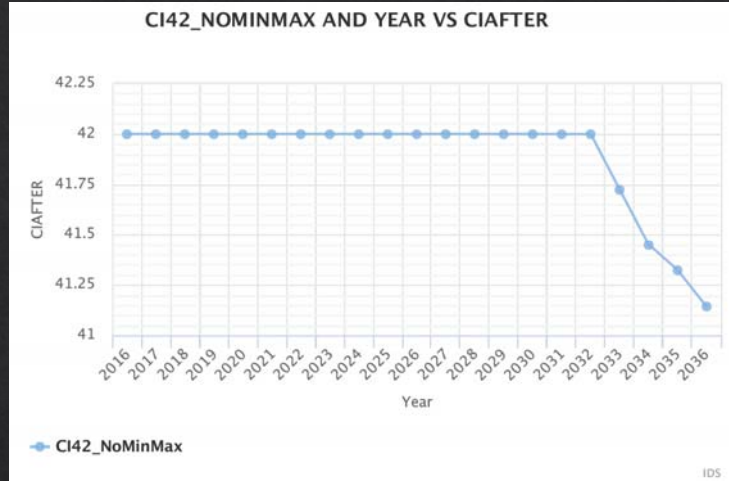
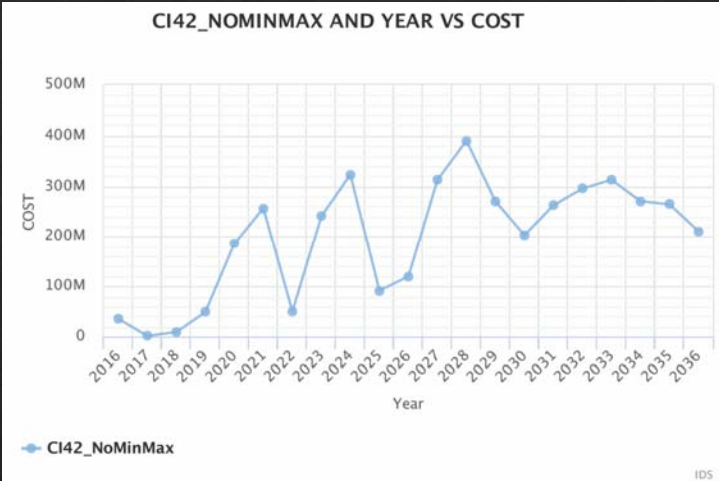
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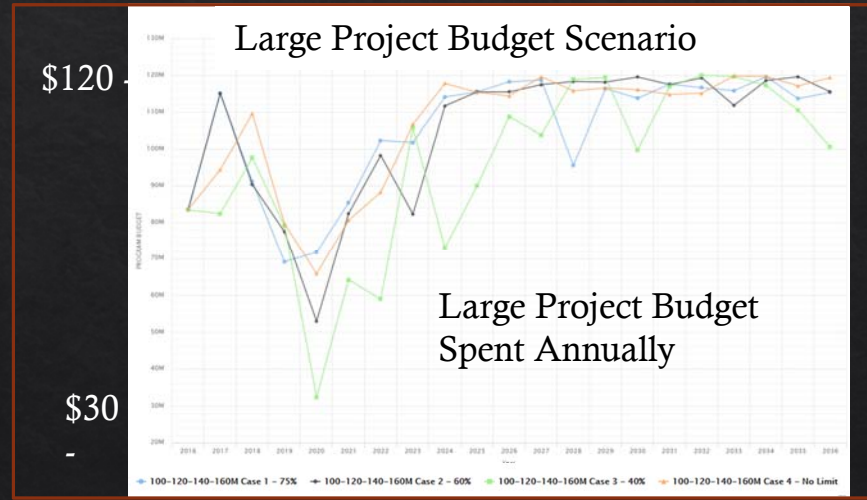
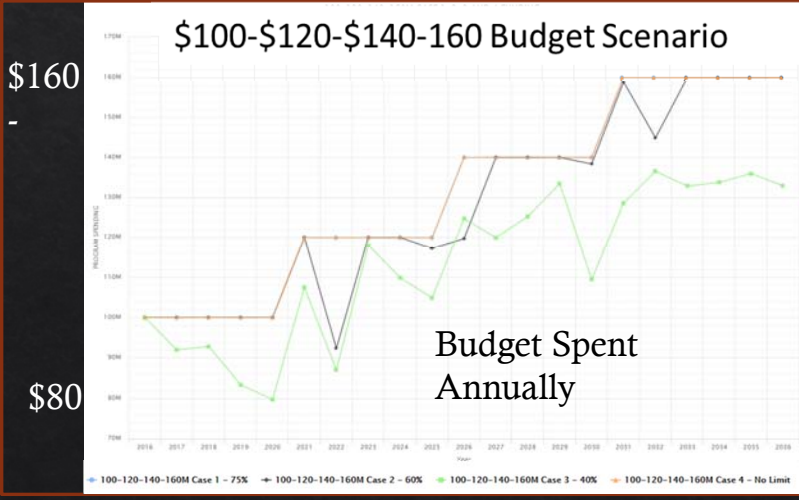
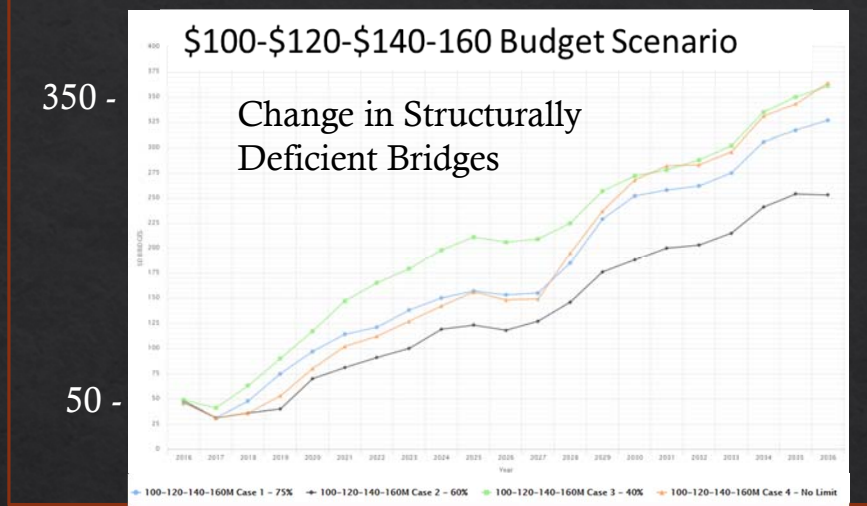
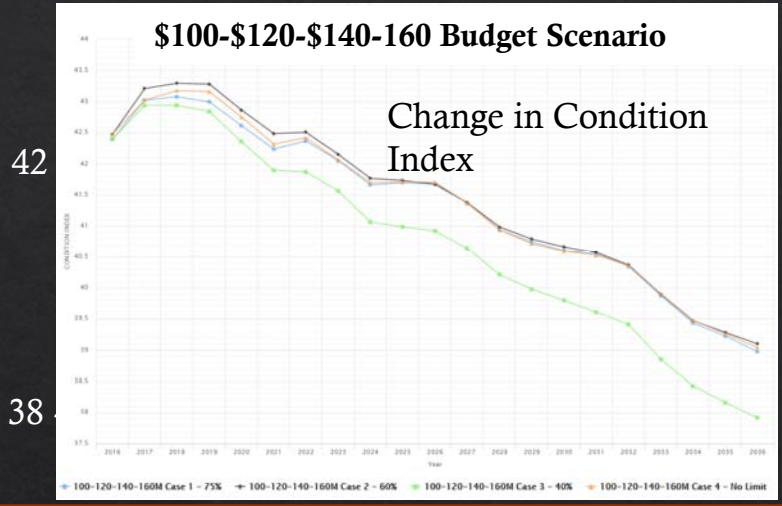
**STRUCTURALLY DEFICIENT BRIDGES FOR CI42\_MIN100MAX250M BUDGET**



CI42\_Min100Max250M with \$120 mill. Large Project Limit

IDS

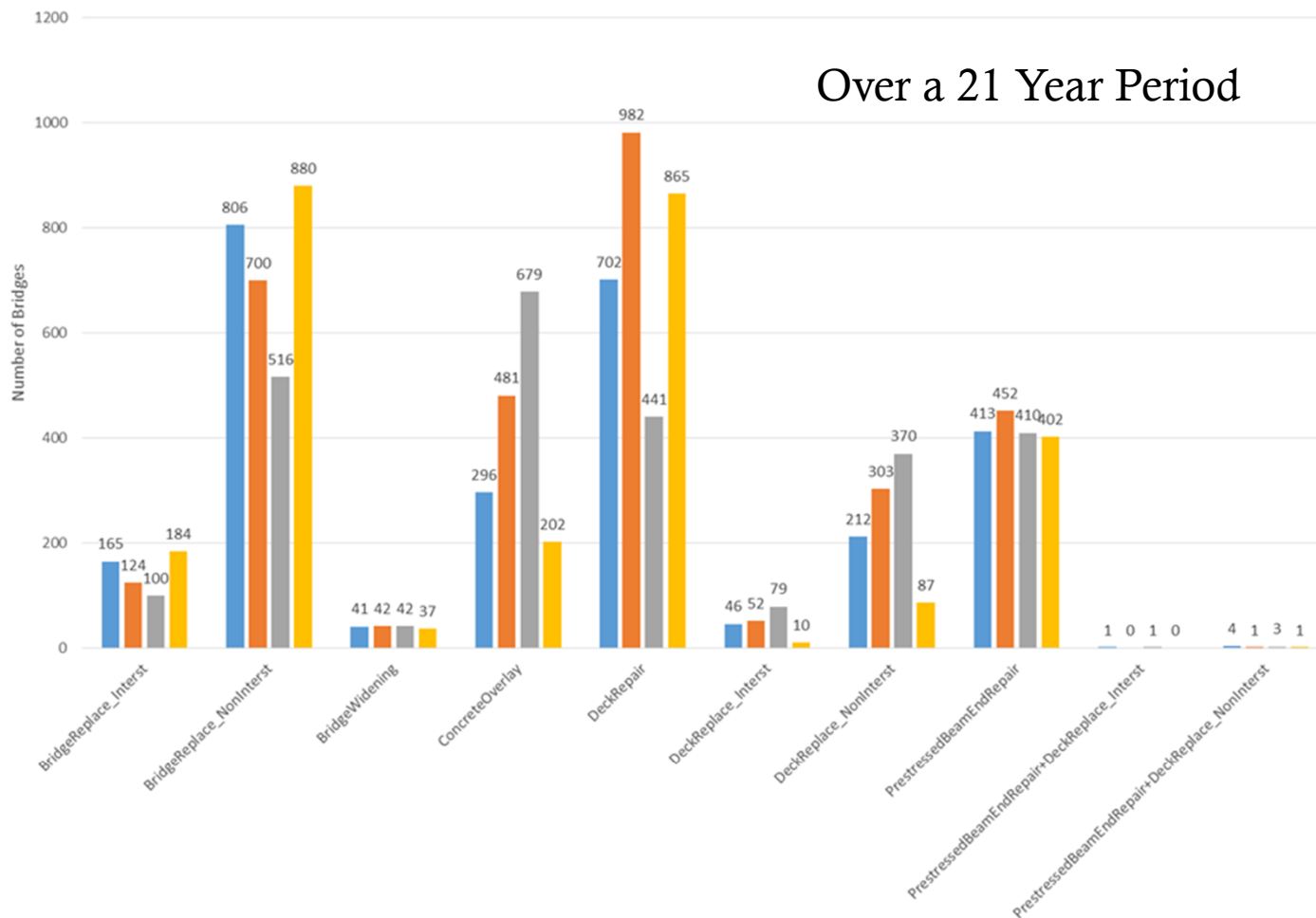




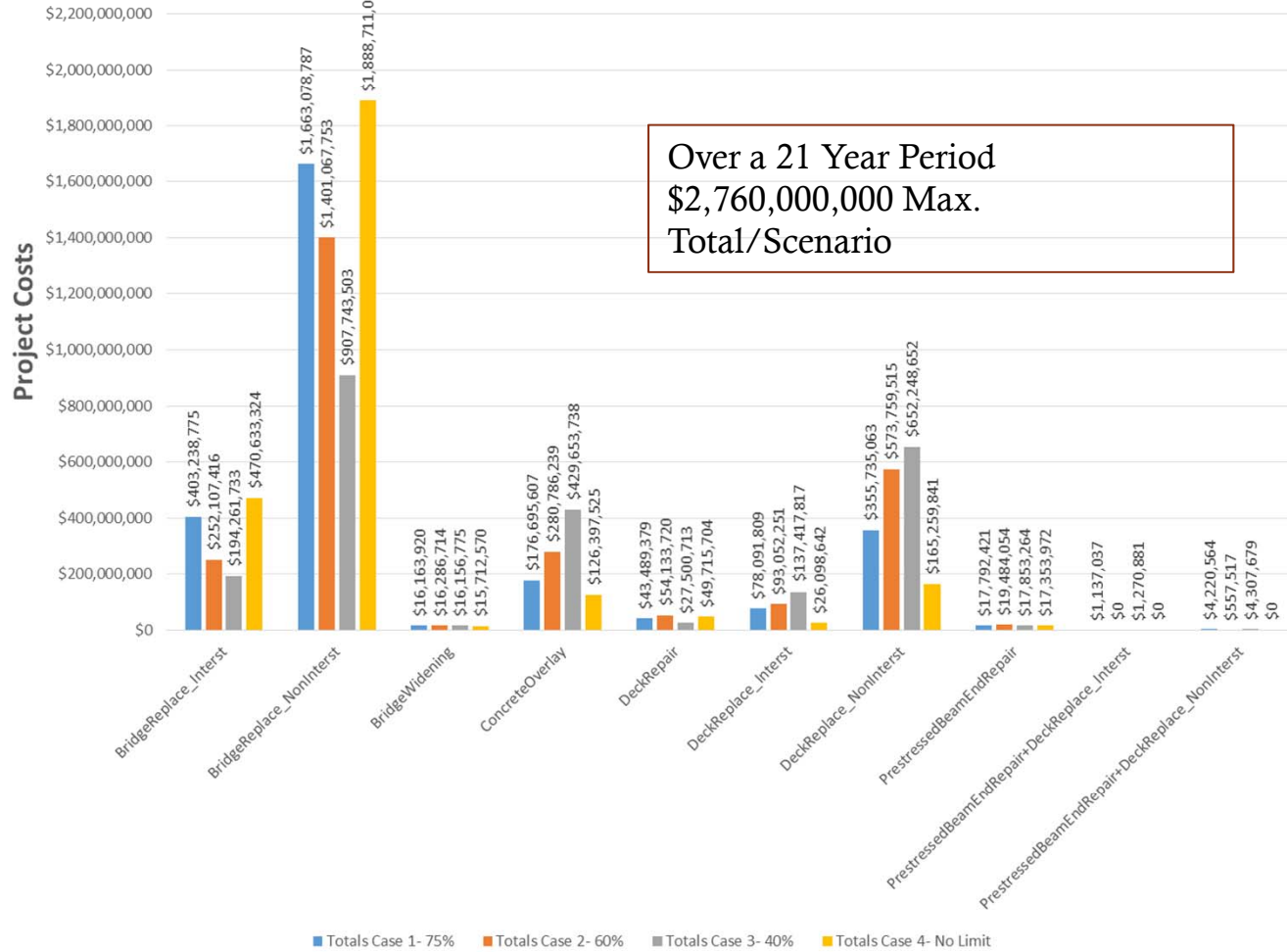
\$100-\$120-\$140-\$160 Mill. Scenarios

Totals Case 1- 75%    Totals Case 2- 60%    Totals Case 3- 40%    Totals Case 4- No Limit

Over a 21 Year Period



**Project Costs per Work Type**  
**\$100-\$120-\$140-\$160 Budget Scenario**



Over a 21 Year Period  
 \$2,760,000,000 Max.  
 Total/Scenario

# Questions?

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