

# WSDOT's Concrete Bridge Deck Preservation Program

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WSDOT Bridge Asset Management Engineer

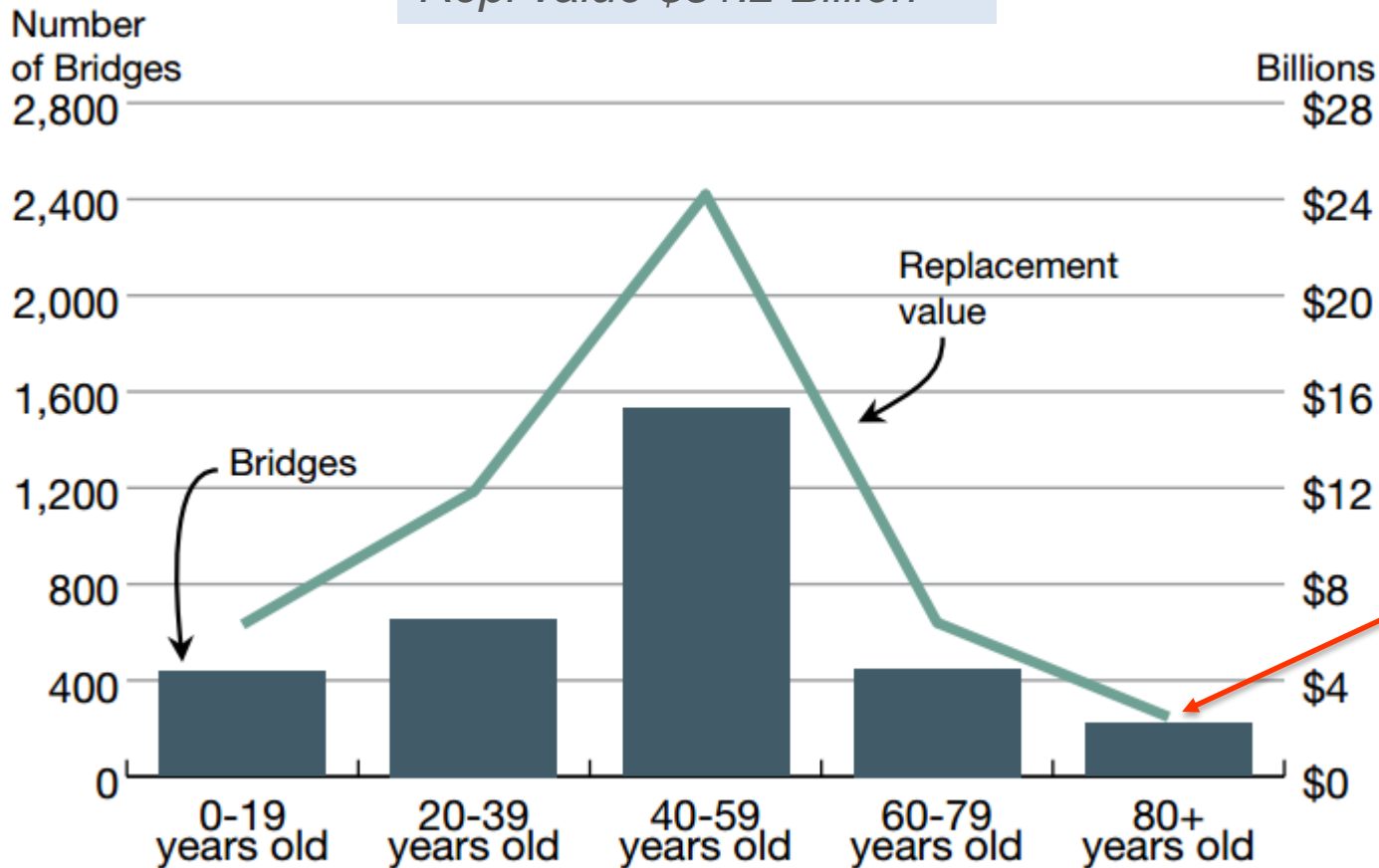


# Washington State's Bridge System

Ave Age - 47

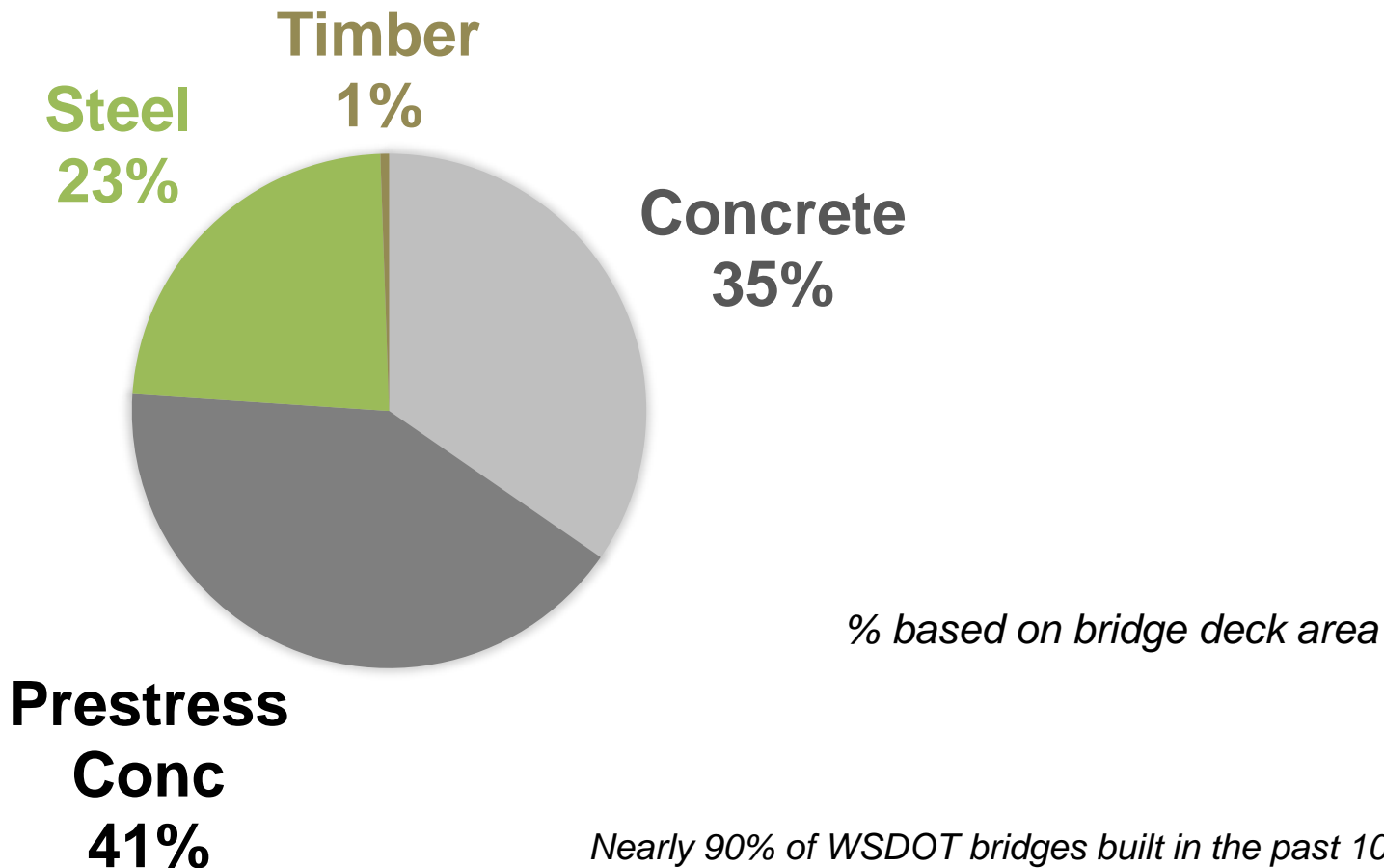
3,120 bridges (53.5 M SF)  
Repl value \$51.2 Billion

Oldest - 1910



80+ yrs old – 241 bridges (1.6 M SF)  
100+ yrs old – 8 bridges (43,356 SF)

# Washington State's Bridge System

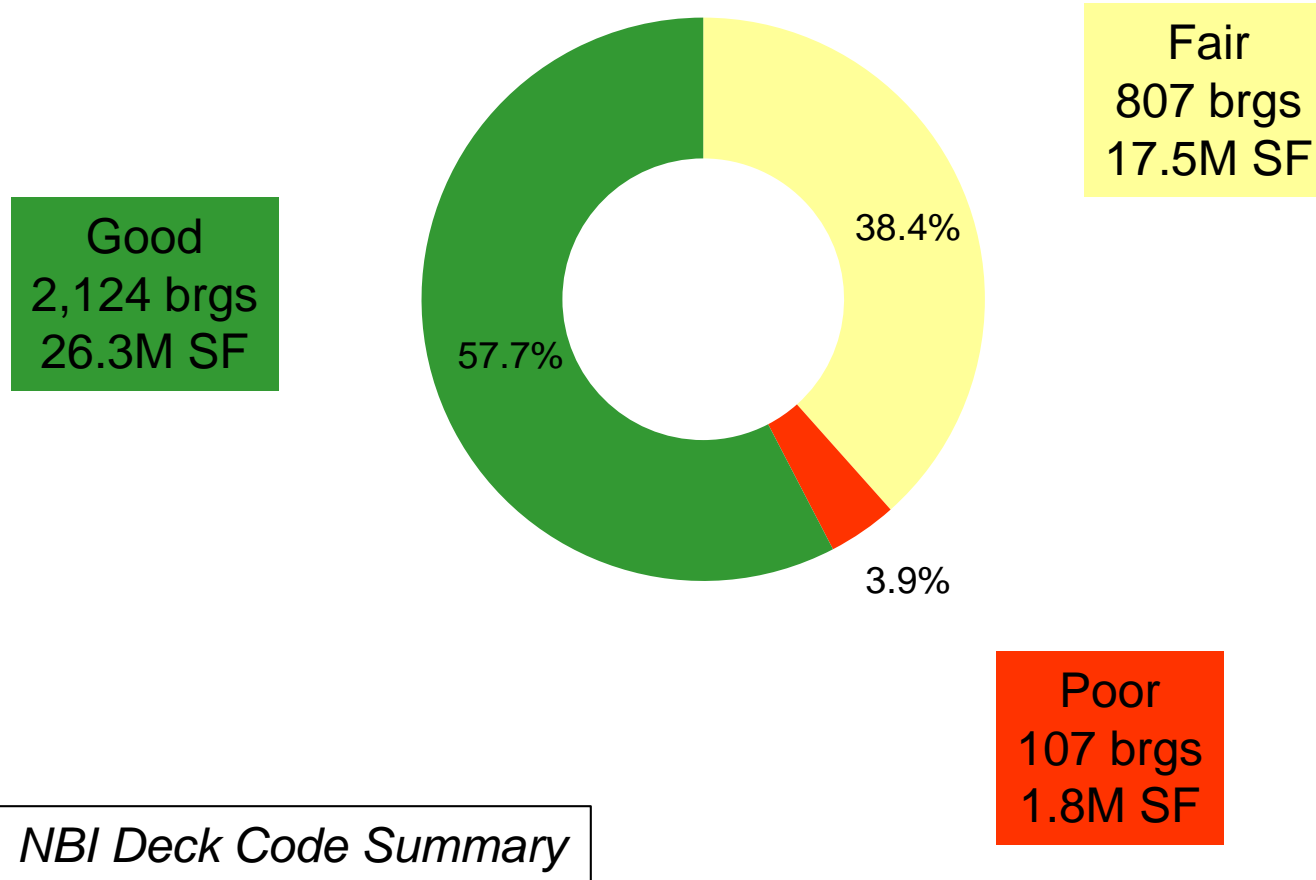


*% based on bridge deck area*

*Nearly 90% of WSDOT bridges built in the past 10 years are precast prestressed/post-tensioned concrete*

# WSDOT Conc Bridge Deck Condition

3,038 WSDOT Bridges with Conc Deck



# WSDOT Concrete Bridge Decks



Steel Girder



Prestress Girder



Precast Units



Steel Truss



Concrete Arch



Precast Prestress Slab



Steel Arch

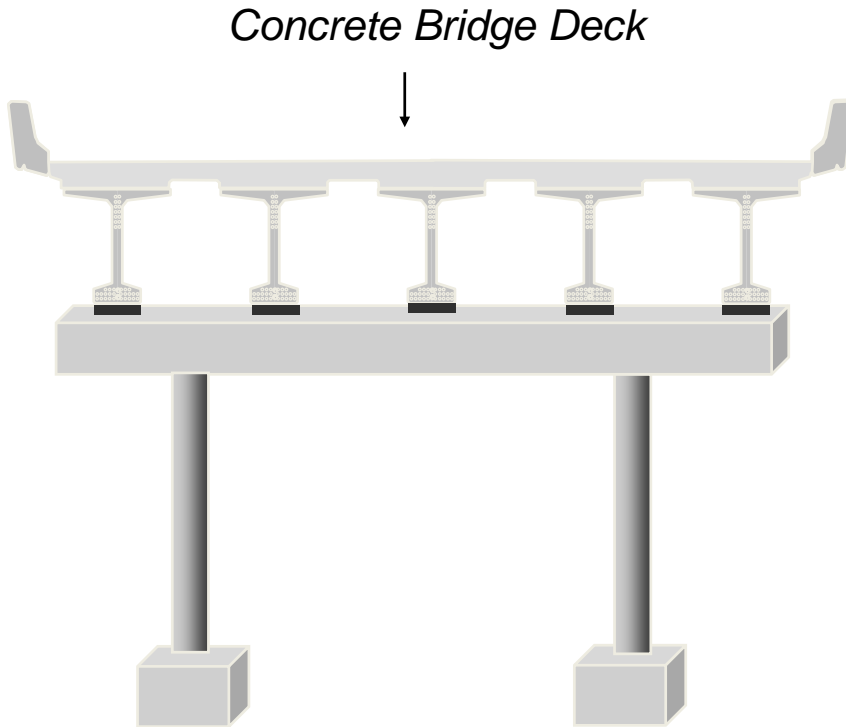


Segmental Post-Tension Box



Post-Tension Box

# Typical Concrete Bridge Deck



## Concrete Bridge Deck issues:

- Deterioration /Rebar Corrosion
- Rutting
- Rebar Cover
- Poor Quality Concrete

# Typical Concrete Bridge Deck

I-90 Franklin Falls Bridge

Weathering Steel Girder  
Deck – 8”

Standard rebar in Deck

Year Built – 1980 (37yrs)

LMC Overlay – 1980 (37yrs)

Patching – 3,700SF (10%)

Deterioration / Rebar Corrosion

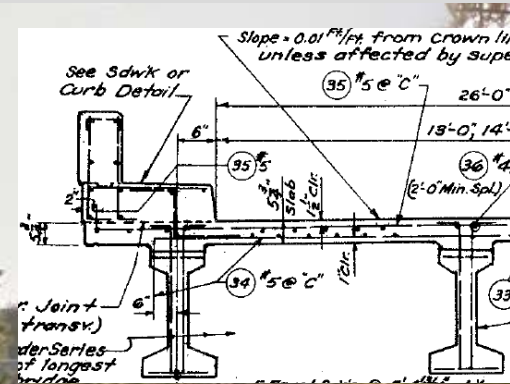


08/27/2014

# Typical Concrete Bridge Deck

## Rutting

US2 Geiger Blvd OC  
Spokane, Wa



rtation

Prestress Conc Girder  
Deck – 5.75"  
Year Built – 1964 (53yrs)  
Conc Overlay – 1987 (30yrs)



# Typical Concrete Bridge Deck

## Rutting



US2 Geiger Blvd OC  
Spokane, Wa

# Rutting



Oregon Trail  
Guernsey State Park  
Near Fort Laramie Wyoming



# Typical Concrete Bridge Deck

## Rebar Cover

# Typical Concrete Bridge Deck



SR10 Bristol Fill  
Near Cle Elum  
Built in 1937 – Deck Repl 2012

## DESIGN ASSUMPTIONS.

CONCRETE IN ROADWAY SLAB:  
Class "A" mix - Vibrated.  
 $f_c = 1200$  #per sq. inch.  
 $f_s = 18,000$  #per " "  
 $n = 10$

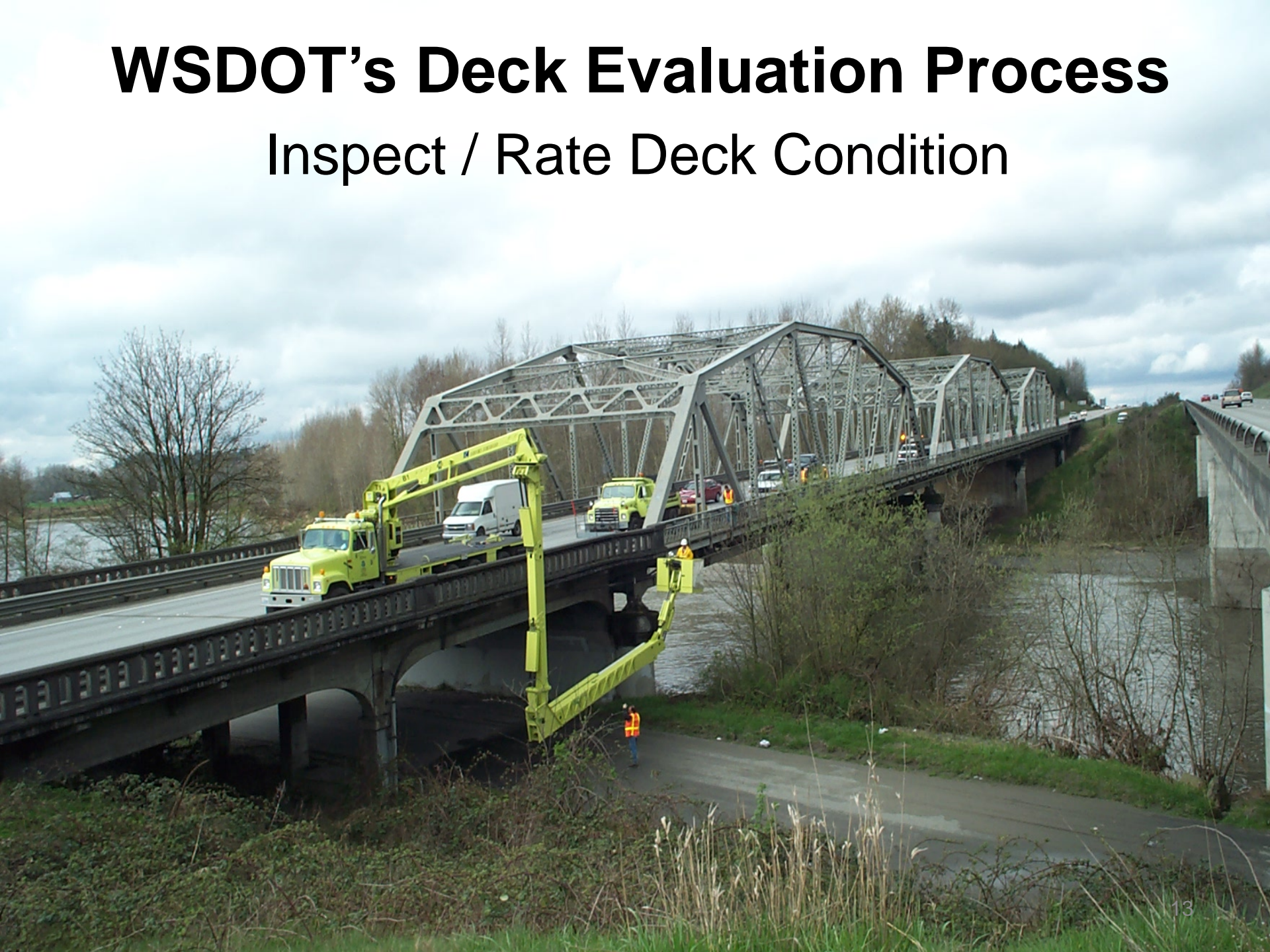


Poor Concrete



# WSDOT's Deck Evaluation Process

## Inspect / Rate Deck Condition



## WSDOT Deck & Overlay Elements



# WSDOT Bridge Deck Inspection

Condition State 1

The deck surface has no spalls/delaminations or previous repairs. May have cracking or rutting.

Condition State 2

The deck surface has previous repairs.

Condition State 3

The deck surface has spalling.

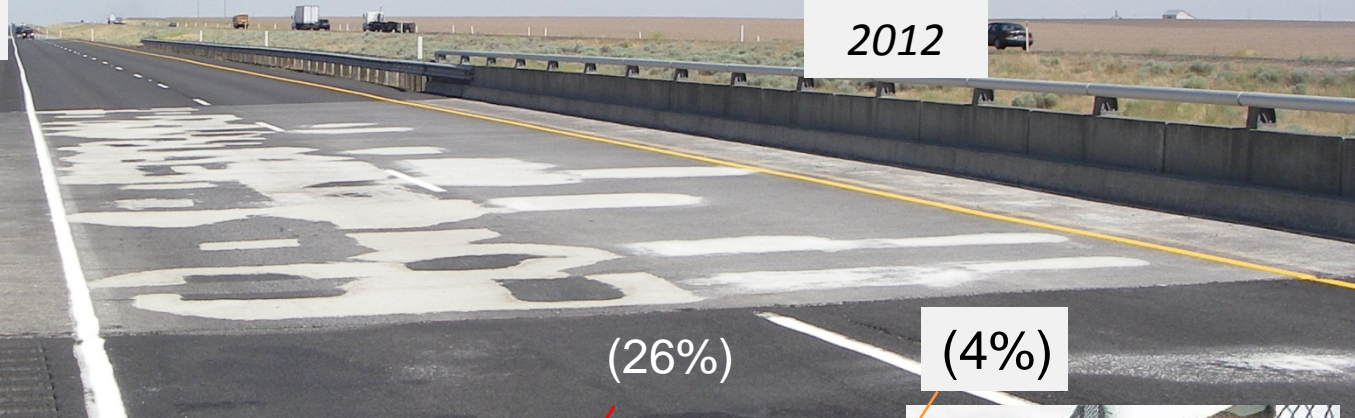
Condition State 4

Delamination Test Results.

Year Built – 1972 (45 yrs)  
Deck Thickness – 7"

90/316N Paha Rd OC - milepost 215.24

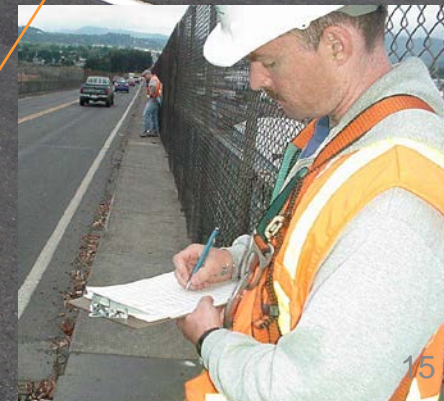
2012



(26%)

(4%)

Elem	Description	Total	Unit	State1	State2	State3	State4
12	Conc. Deck	3,990	SF	2,774	1,053	0	163
35	Soffit	3,990	SF	3,990	0	0	0
376	Delam Testing	3,990	SF	3,827	0	0	163



Delam Test - October 2001

# WSDOT Bridge Deck Inspection

*Year Built – 1972 (45 yrs)  
Deck Thickness – 7"*

*90/316N Paha Rd OC - milepost 215.24  
Deck Rehab/Conc Overlay - 2013*



*Bridge Length – 105 FT*



# WSDOT Bridge Deck Inspection

*90/316N Paha Rd OC - milepost 215.24  
Deck Rehab/Conc Overlay - 2013*



# WSDOT Bridge Deck Inspection



*90/316N Paha Rd OC - milepost 215.24*

# WSDOT Bridge Deck Inspection

*Condition State 1*

*The deck surface has no spalls/delaminations or previous repairs. May have cracking or rutting.*

*Condition State 2*

*The deck surface has previous repairs.*

*Condition State 3*

*The deck surface has spalling.*

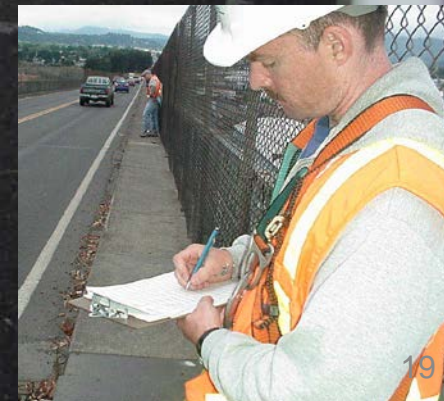
*Condition State 4*

*Delamination Test Results.*

90/316N Paha Rd OC - milepost 215.24

NBI Deck – 7  
“Good” Condition

Elem	Description	Total	Unit	State1	State2	State3	State4
12	Conc. Deck	3,990	SF	3,990	0	0	0
35	Soffit	3,990	SF	3,990	0	0	0
803	Conc Overlay	3,990	SF	3,990	0	0	0



# WSDOT Concrete Deck Evaluation/Rating

BMS Condition  
(Top of Deck)

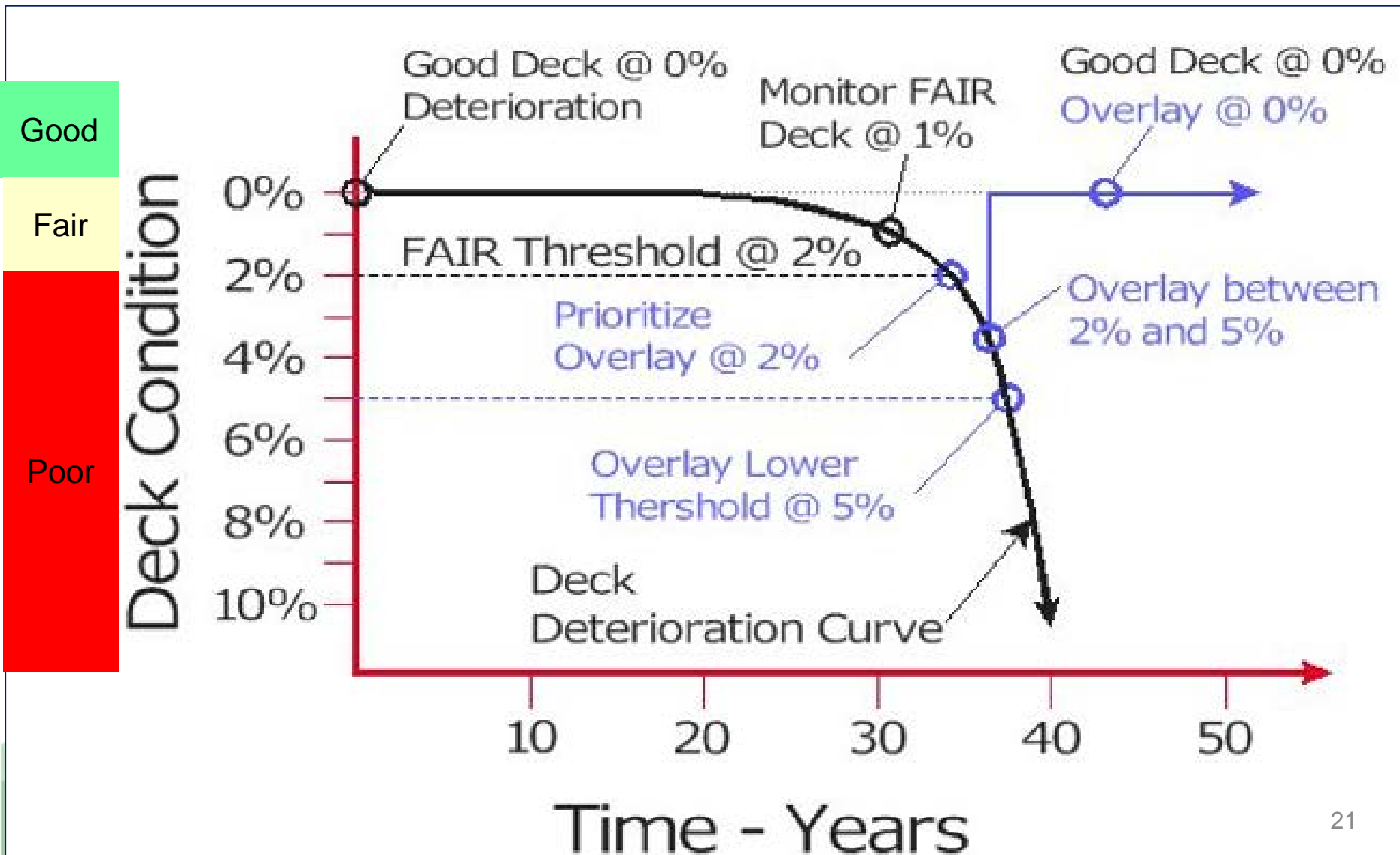
BMS Condition  
(Bottom of Deck)

NBI Deck Code

Percent of Concrete Deck Patches, Spalls, and Delaminations (CS2 + CS3 + CS4)	Percent of Concrete Deck Soffit in CS3 (CS3 only)	NBI Deck Condition Code	
N/A	N/A	9	
None	None	8	Good
None	None	7	
< 1%	< 1%	6	Fair
1% to 2%	1% to 2%	5	
2% to 5%	2% to 5%	4	Poor
> 5%	> 5%	3	

**WSDOT Deck Condition to NBI Deck Overall**  
*Table 4.1.6*

# WSDOT Concrete Deck Deterioration Curve



# WSDOT Concrete Deck – 10 yr Preservation Needs

## Thirty-eight bridge decks are past due for repair

*As of June 2016; Dollars in millions*

Bridge deck needs	Number of bridges	Cost to repair
Past due for repair <sup>1</sup>	38	\$38.4
Due for repair <sup>2</sup>	47	\$77.2
Due within the next 10 years	223	\$726.5
Border bridge deck repairs	2	\$22.3
<b>Total 10-year needs</b>	<b>310</b>	<b>\$864.4</b>

85 < 38 + 47 > \$115.6M

Data source: WSDOT Bridge and Structures Office.

Notes: 1 Bridges with more than 5% of deck area patched or spalled are classified as “past due.” 2 Bridges with 2% to 5% of deck area patched or spalled are classified as “due.”

*Should be funded for – \$86M per year*

*2015-19 budget – \$10M per year*

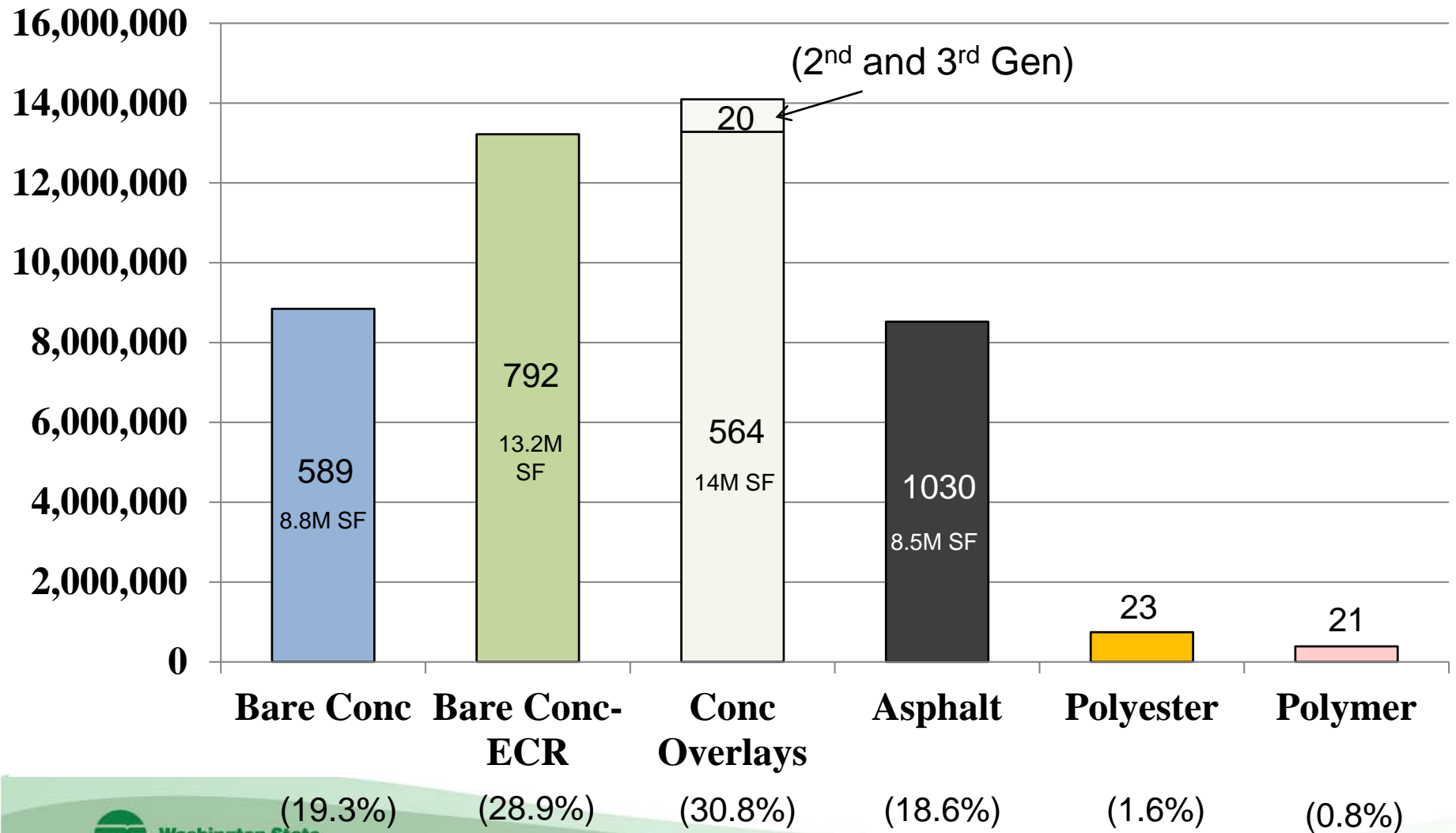
# WSDOT Concrete Deck – 10 yr Preservation Needs



*With constrained Funding for Deck Rehab  
This is the new "Normal"*

# Washington State's Concrete Bridge Deck Program

*3,039 Bridges with Concrete Decks  
45.8 million SF deck area*





# WSDOT Bare Concrete Decks

43 Bridges  
1.0 M SF  
(11.9%)



Poor

Good

Fair

286 Bridges  
5.3 M SF  
(59.8%)

589 Bridges  
8.8 M SF

Ave Age – 52yrs  
Oldest – 94yrs

Range 33 – 94yrs  
(1923 – 1984)

25 bridges  
> 75 yrs

259 Bridges  
2.5 M SF  
(28.3%)



Omak Ave

Omak Ave

# WSDOT Bare Concrete Decks

*Year Built – 1923 (94 yrs)*  
*Deck Thickness – 10"*  
*Width 20 feet*

*ADT – 6,884 / day*

*SR155 – Okanogan River*  
*Located in Omak*

*84<sup>th</sup> Omak Stampede*  
*August 10-13 2017*



**NBI Deck – 6**  
**“Fair” Condition**

## BMS Elements

Element	Element Description	Total	Units	State 1	State 2	State 3	State 4
13	Bridge Deck Surface	8,200	SF	8,191	0	6	3
36	Deck Rebar Cover Flag	8,200	SF	8,194	6	0	0
38	Concrete Slab	8,200	SF	8,180	20	0	0

# WSDOT Bare Concrete Decks

*Year Built – 1952 (65 yrs)*

*SR99 – Alaskan Way Viaduct  
Located in Seattle*



*ADT – 41,000 / day*

# WSDOT Bare Concrete Decks

*Year Built – 1952 (65 yrs)*

*SR99 – Alaskan Way Viaduct  
Located in Seattle*



*Damaged in 2001 Nisqually Earthquake  
Demolition planned for 2019*

# WSDOT Bare Concrete Decks

Year Built – 1952 (65 yrs)

SR99 – Alaskan Way Viaduct  
Located in Seattle



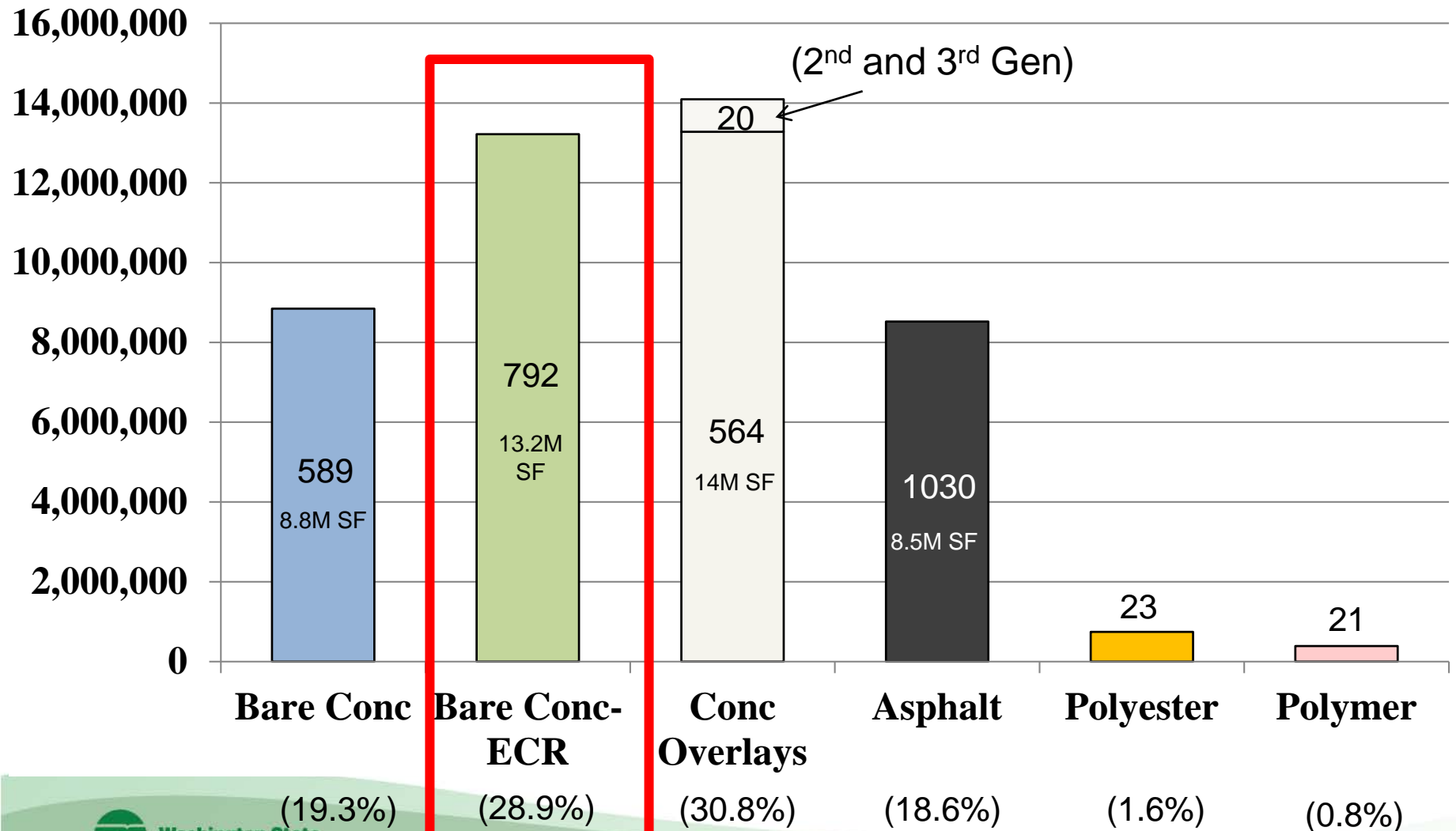
NBI Deck – 4  
“Poor” Condition

Deck Patching / Spalls  
5,419 SF (1.9%)

BMS Elements						
Element	Element Description	Total	Units	CS 1	CS 2	CS 3
12	Concrete Deck	288,446	SF	281,841	5,058	361
35	Concrete Deck Soffit	288,446	SF	288,370	70	6

# Washington State's Concrete Bridge Deck Program

3,039 Bridges with Concrete Decks  
45.8 million SF deck area



(2<sup>nd</sup> and 3<sup>rd</sup> Gen)

20

792

13.2M  
SF

564  
14M SF

1030

8.5M SF

23

21

Bare Conc

Bare Conc-  
ECR

Conc  
Overlays

Asphalt

Polyester

Polymer

(19.3%)

(28.9%)

(30.8%)

(18.6%)

(1.6%)

(0.8%)

# Concrete Decks with Epoxy Coated Rebar

792 Bridges  
13.2 M SF

1910 - 78

1979 - 2007

2007 - present

Uncoated  
Rebar

Top Mat  
Coated

Both Mats  
Coated

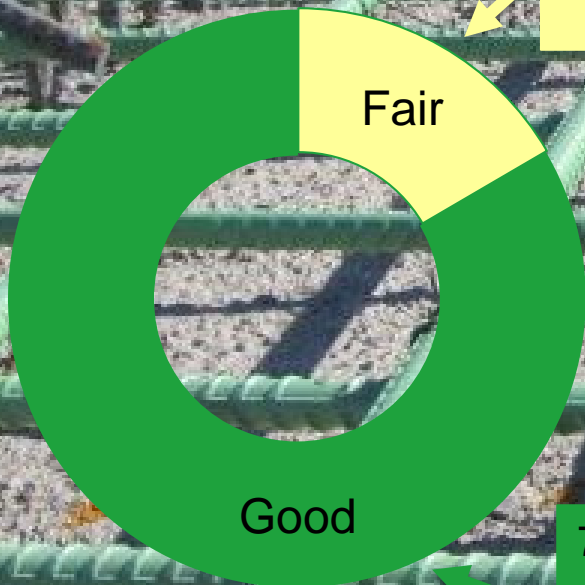


# Concrete Decks with Epoxy Coated Rebar

792 Bridges  
13.2 M SF

Ave Age – 20yrs  
Oldest – 38yrs

84 Bridges  
2.2 M SF  
(16.6%)



709 Bridges  
11.0 M SF  
(83.3%)

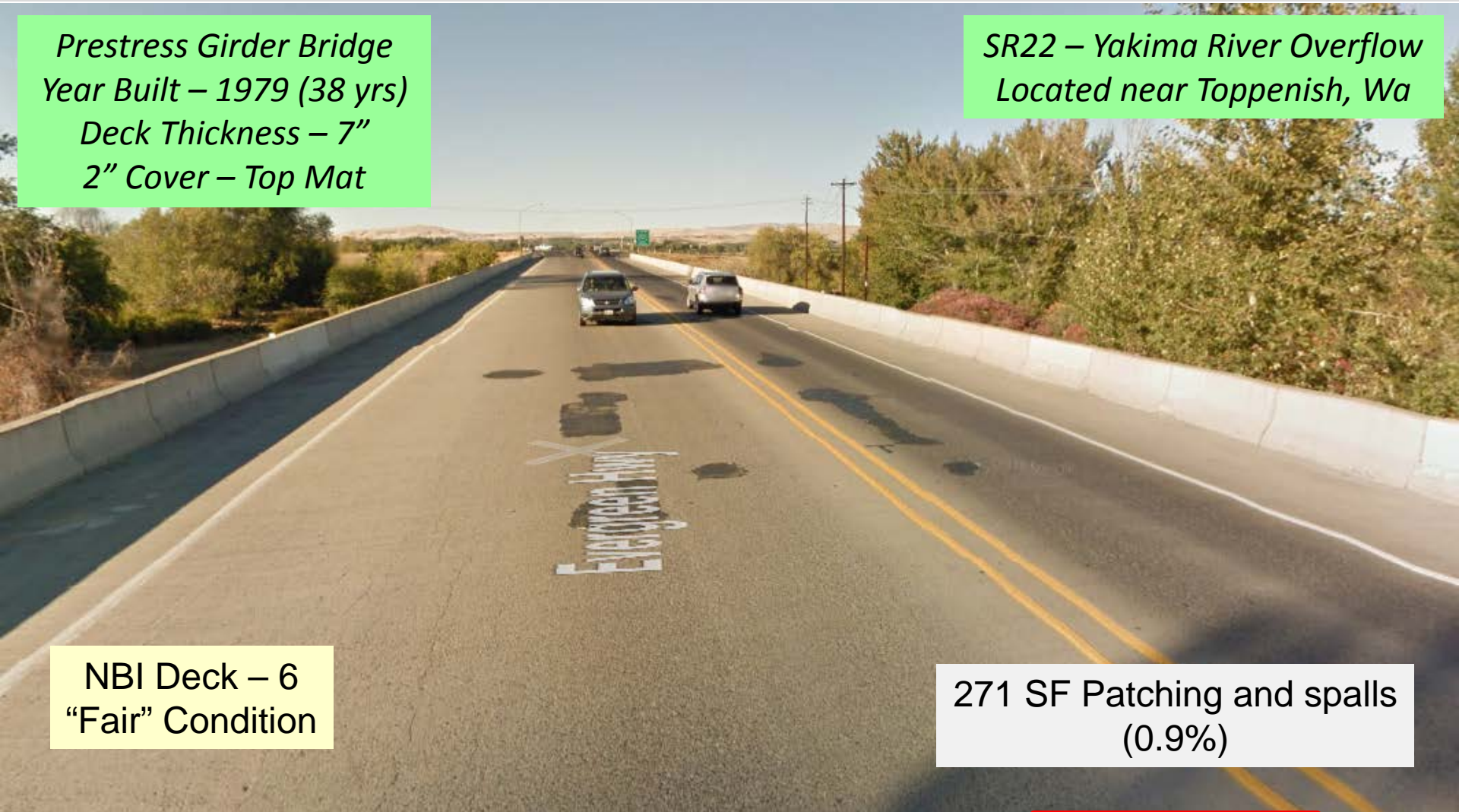
09/04/2012 10:09



# Concrete Decks with Epoxy Coated Rebar

*Prestress Girder Bridge  
Year Built – 1979 (38 yrs)  
Deck Thickness – 7”  
2” Cover – Top Mat*

*SR22 – Yakima River Overflow  
Located near Toppenish, Wa*



NBI Deck – 6  
“Fair” Condition

271 SF Patching and spalls  
(0.9%)

Element	Element Description	Total	Units	State 1	State 2	State 3	State 4
12	Concrete Deck	29,640	SF	29,369	8	263	0
35	Concrete Deck Soffit	29,640	SF	29,640	0	0	0

# Concrete Decks with Epoxy Coated Rebar

Worlds Longest Floating Bridge

Floating section - 7,710 Feet

SR520  
Albert D Rosellini Br  
Yr Open - 2016



# WSDOT Concrete Deck Evaluation Study

## Mitigation Strategies for Early-Age Shrinkage Cracking in Bridge Decks

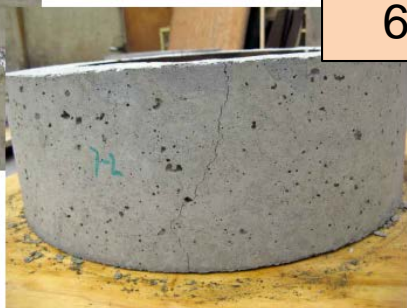
WA-RD 747.1

Pizhong Qiao  
David McLean  
Jianmin Zhuang

April 2010



Full-Depth Shrinkage Cracking on Prestressed Girder Bridge



Restrained Shrinkage Cracking Test

Washington State  
Department of Transportation  
Office of Research & Library Services

WSDOT Research Report

## Evaluation of Performance Based Concrete for Bridge Decks

WA-RD 845.1

Eric Ferluga  
Patrick Glassford

June 2015

Brgs w/Performance  
Deck Conc  
Built since 2013  
69brgs – 2.2M SF



Washington State  
Department of Transportation  
Office of Research & Library Services

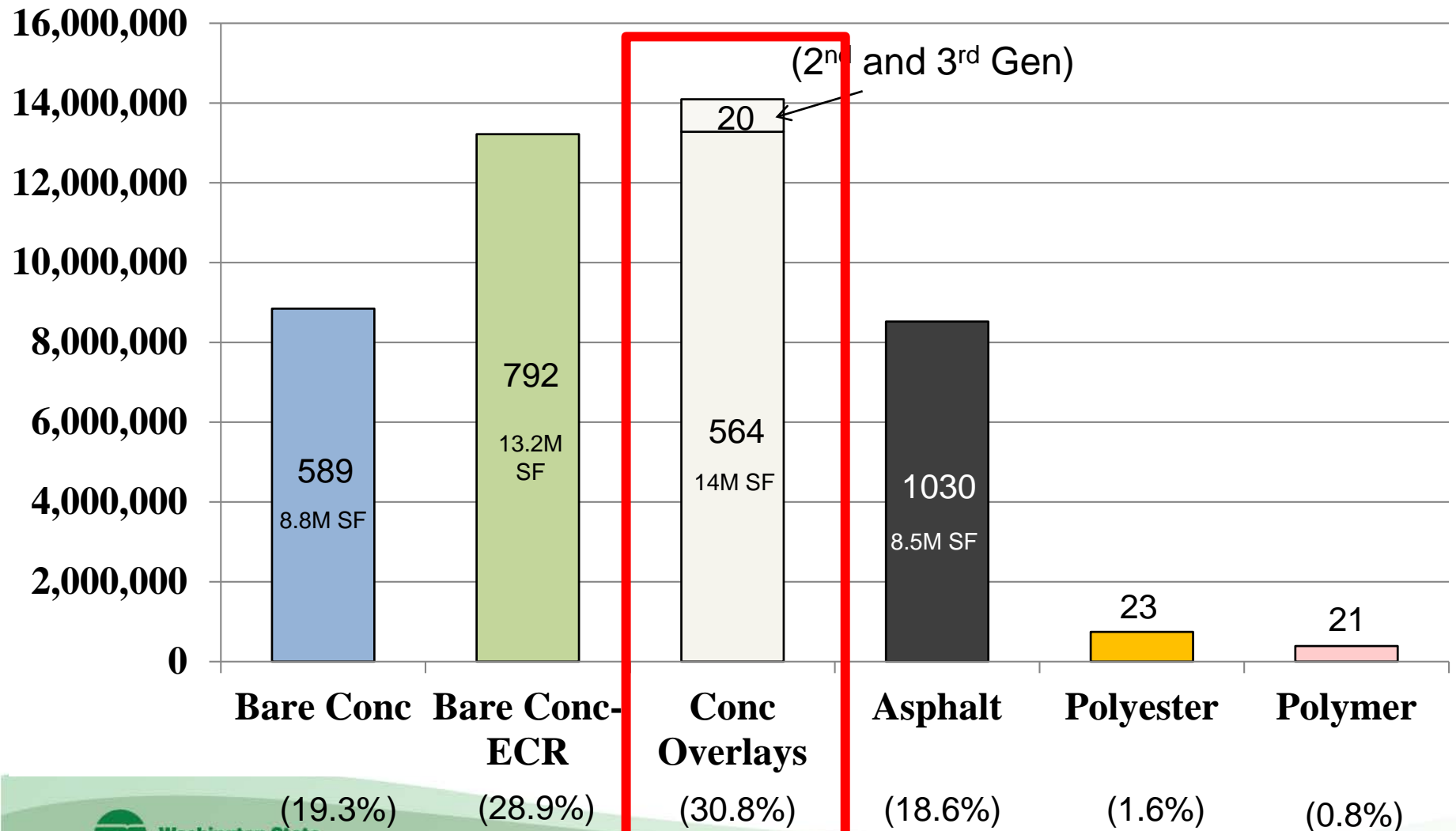
WSDOT Research Report

## WA-RD 747.1

## WA-RD 845.1

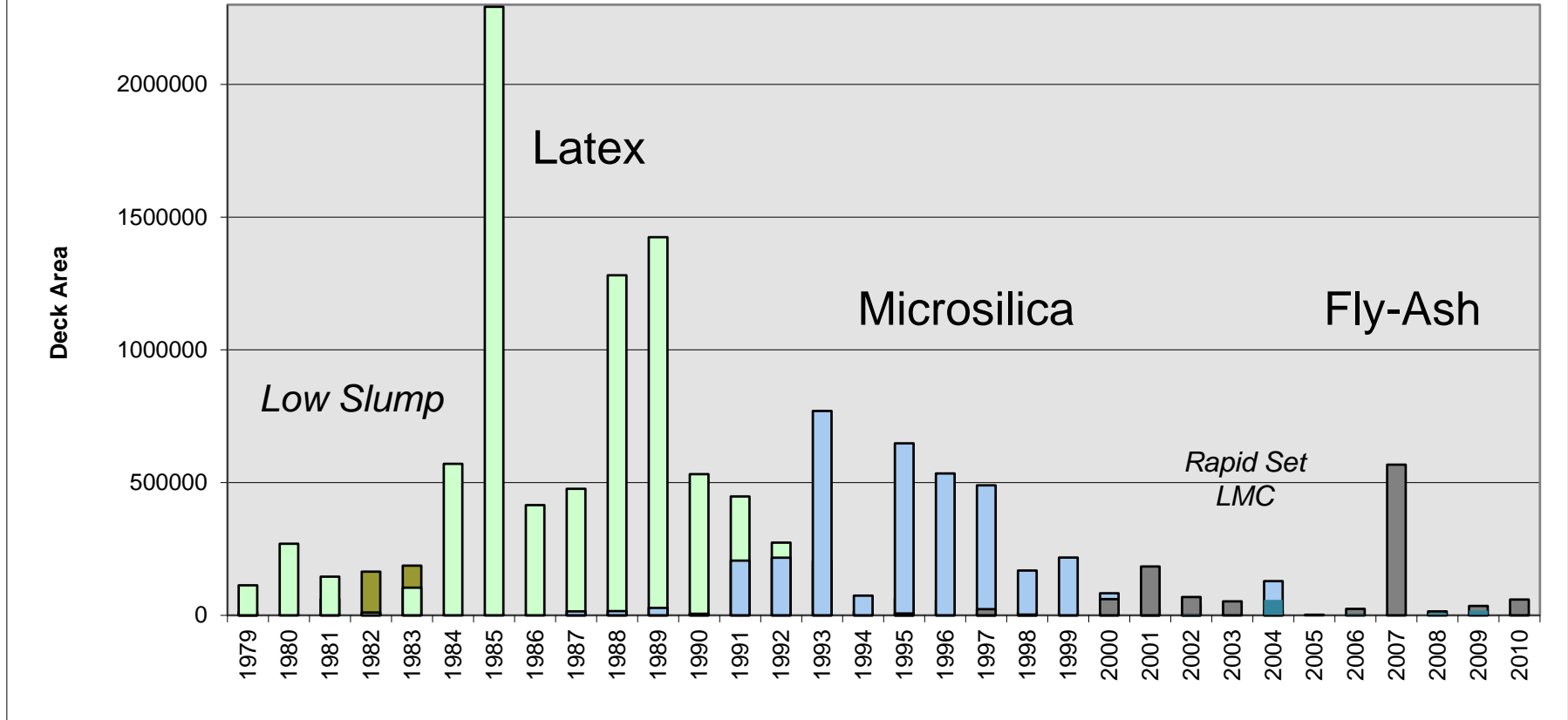
# Washington State's Concrete Bridge Deck Program

*3,039 Bridges with Concrete Decks  
45.8 million SF deck area*



# Bridges with a Modified Concrete Overlay

Total # Brgs = 584  
Deck area = 14.1 mil SF



1979	1983	1987	1995	2002-10	2016
1st Mod Conc Overlay	Low Slump Discontinued	1st Microsilica Conc Overlay	1st Fly-Ash Conc Overlay	Rapid Set Discontinued	1st Perf Mix Design Conc Overlay

# Modified Concrete Overlays

## Standard Specifications

for Road, Bridge, and  
Municipal Construction

# 2016

## M 41-10

 Washington State  
Department of Transportation

 AMERICAN PUBLIC WORKS ASSOCIATION  
**APWA**  
Washington State Chapter

**6-09**

*Modified Concrete Overlays*

### **6-09 Modified Concrete Overlays**

#### **6-09.1 Description**

This Work consists of scarifying concrete bridge decks, preparing and repairing bridge deck surfaces designated and marked for further deck preparation, and placing, finishing, and curing modified concrete overlays.

# Modified Concrete Overlays

44 Bridges  
0.6M SF  
(4.4%)



183 Bridges  
7.0M SF  
(49.6%)

584 Bridges  
14.1M SF

Ave Age – 26yrs  
Oldest – 38yrs

187 bridges  
4.9M SF  
> 30 yrs

357 Bridges  
6.5M SF  
(46%)

09/20/11  
SR# 090-DEC  
SRMP 86.26  
DIR ≅ NW

# Modified Concrete Overlays

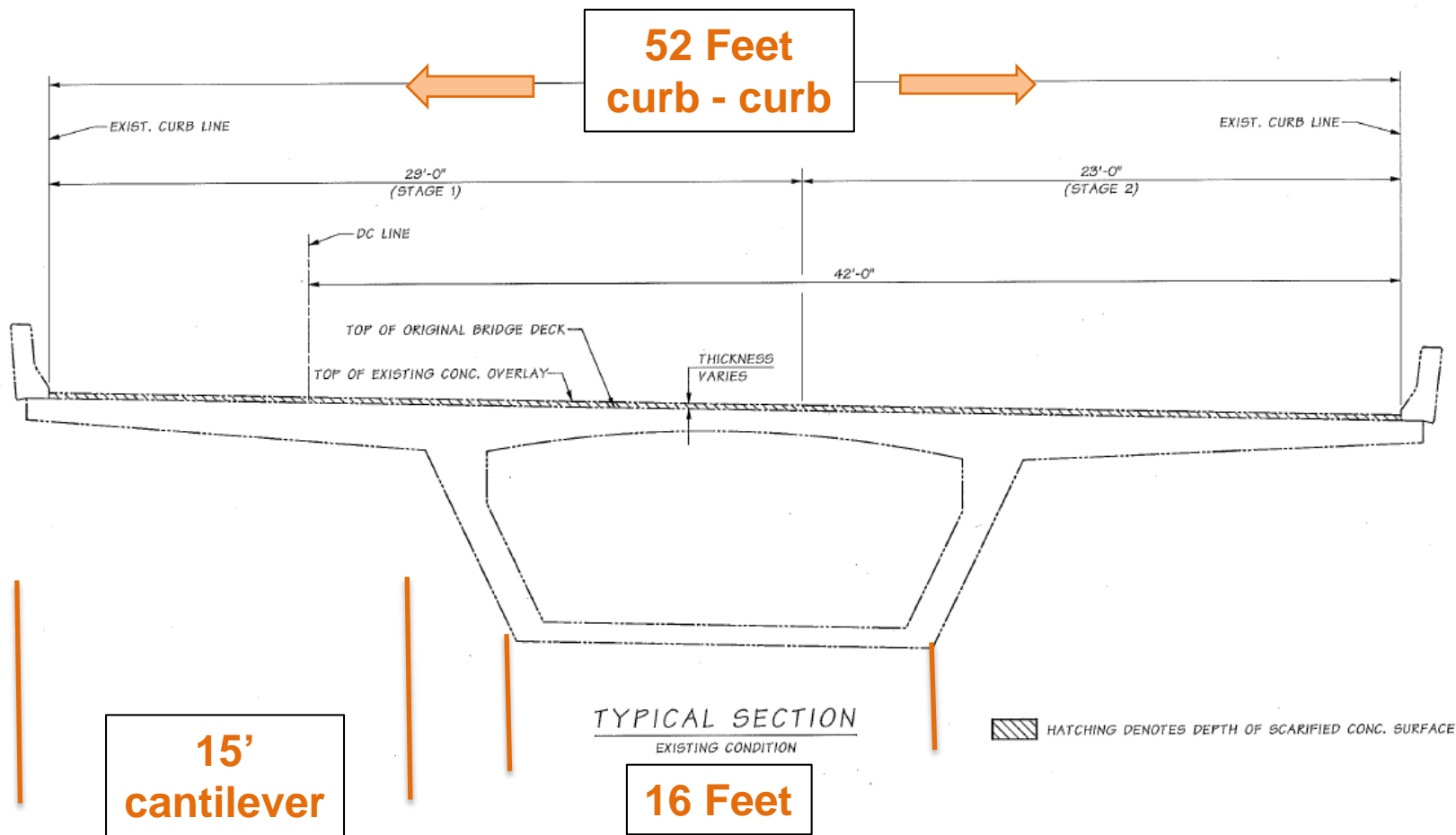
I-90 Denny Creek Bridge

Segmental Post-Tension Box  
Standard rebar in Deck  
Year Built – 1980 (37yrs)  
LMC Overlay – 1980 (37yrs)  
Deck – 10"

Length – 3,620 feet  
Width – 52 feet  
Repl Value - \$200M



# Modified Concrete Overlays



I-90 Denny Creek Bridge

Transverse Post Tensioning  
3.5" below top of deck

# Modified Concrete Overlays

I-90 Denny Creek Bridge

NBI Deck – 6  
“Fair” Condition

Deck Patching / Spalls  
1,871 SF (1.0%)

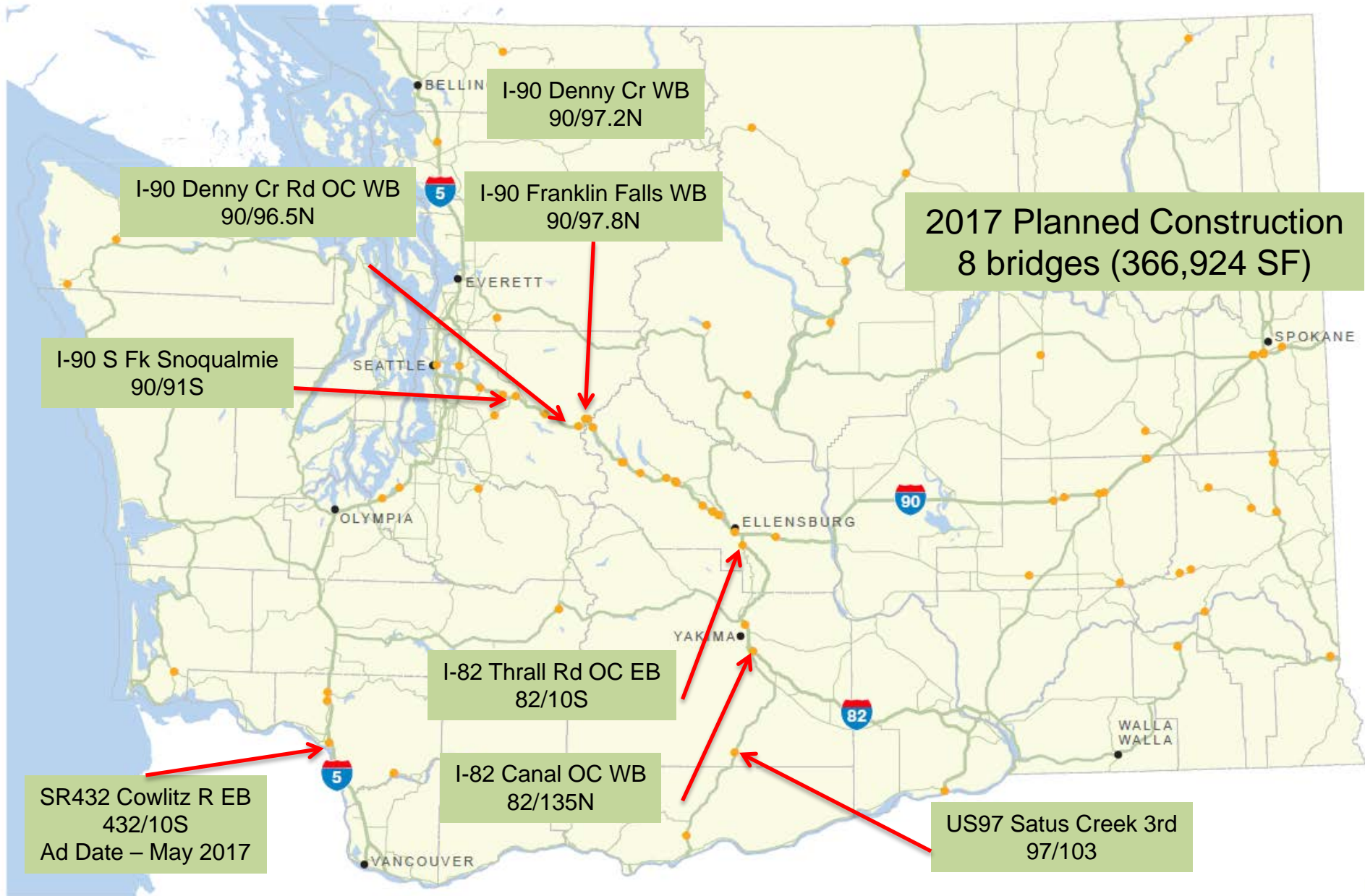
BMS Elements							
Element	Element Description	Total	Units	CS 1	CS 2	CS 3	CS 4
12	Concrete Deck	188,240	SF	186,369	1,770	101	0
803	Modified Concrete Overlay	188,240	SF	186,369	1,770	101	0

# Modified Concrete Overlays



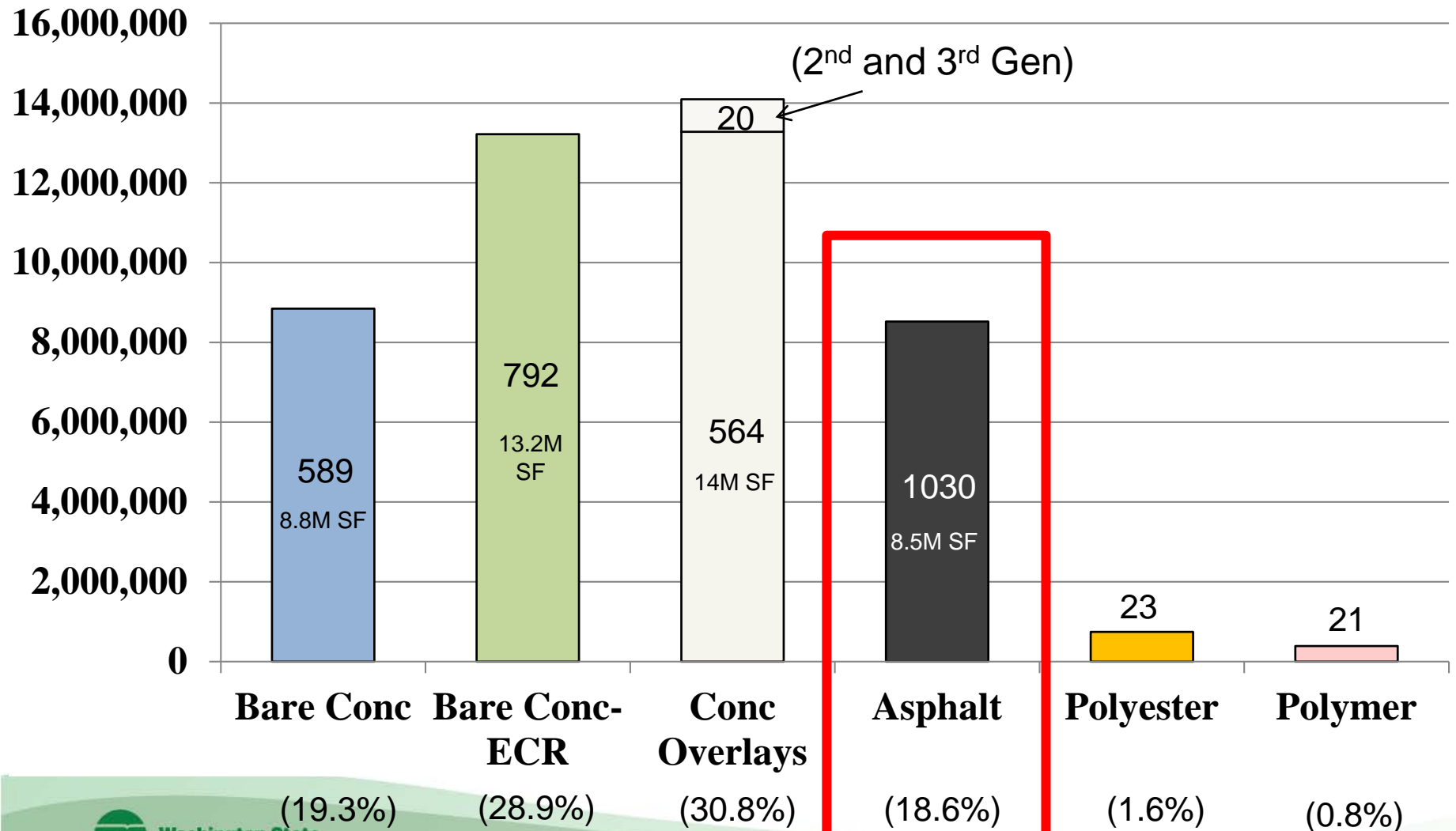
WSDOT has 6 Segmental Box Girder bridges with a Modified Concrete Overlay  
Plus the I-205 Col R bridge that is shared with Oregon

# WSDOT Concrete Deck Overlays – 2017



# Washington State's Concrete Bridge Deck Program

3,039 Bridges with Concrete Decks  
45.8 million SF deck area



# Asphalt with membrane Bridge Deck Overlay



# Asphalt Removal



# Asphalt Removal – Milling Machine

Rotary milling has the risk of damaging the concrete deck.





# Asphalt Removal - Scraping



Scraping to remove ACP Required when:

- Bridges over 100 feet in length
- Bridges with integral bridge decks

# Asphalt with Membrane Overlay

*1<sup>st</sup> Cable Stayed Bridge in USA*



*Open – Sept 1978 (39 yrs)*

*Length – 2,503 feet  
Max Span – 981 feet  
Deck Width – 60 feet*

*SR397 – Columbia R  
Ed Hendler Bridge  
Located near Pasco/Kennewick*

*Original Cost - \$30M  
Replacement Cost - \$120M+*

# Asphalt with Membrane Overlay

## Asphalt History

1978 - 1<sup>st</sup> ACP Overlay

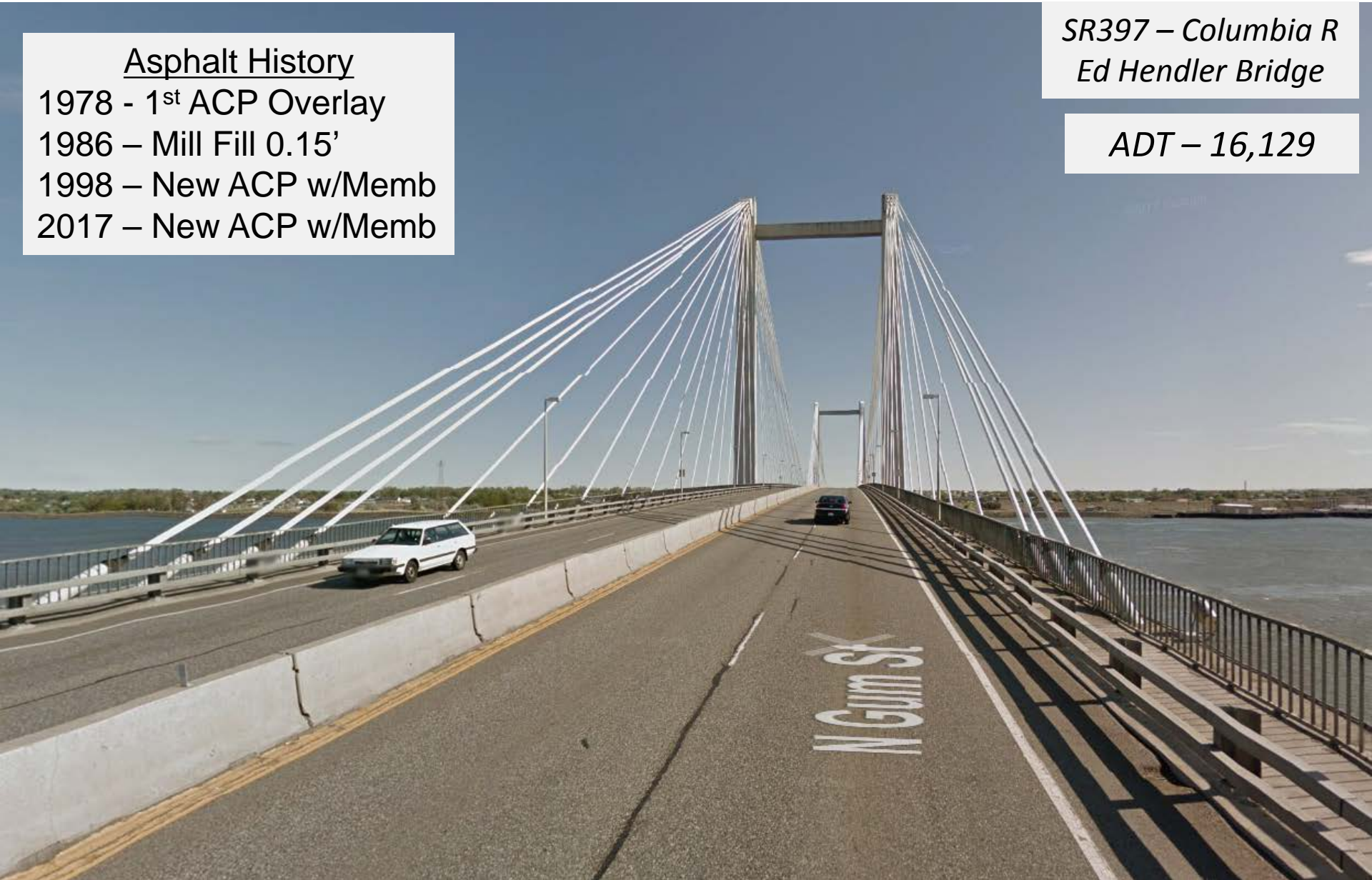
1986 – Mill Fill 0.15'

1998 – New ACP w/Memb

2017 – New ACP w/Memb

*SR397 – Columbia R  
Ed Hendler Bridge*

*ADT – 16,129*



# Asphalt with Membrane Overlay

*8" Top Deck  
2" Conc Cover  
Standard Rebar*

*SR397 – Columbia R  
Ed Hendler Bridge*

*Each Segment is  
27 x 80 feet  
Weight - 300 tons*



# Asphalt with Membrane Overlay

SR397 – Columbia R  
Ed Hendler Bridge



2017. 4.25 10:02

# Asphalt with Membrane Overlay



*SR397 – Columbia R  
Ed Hendler Bridge*

2017. 4. 27 13:23

# Asphalt with Membrane Overlay

*SR397 – Columbia R  
Ed Hendler Bridge*

*Applying Membrane*

2017. 5. 9 15:45



# Bridge Deck Asphalt Performance



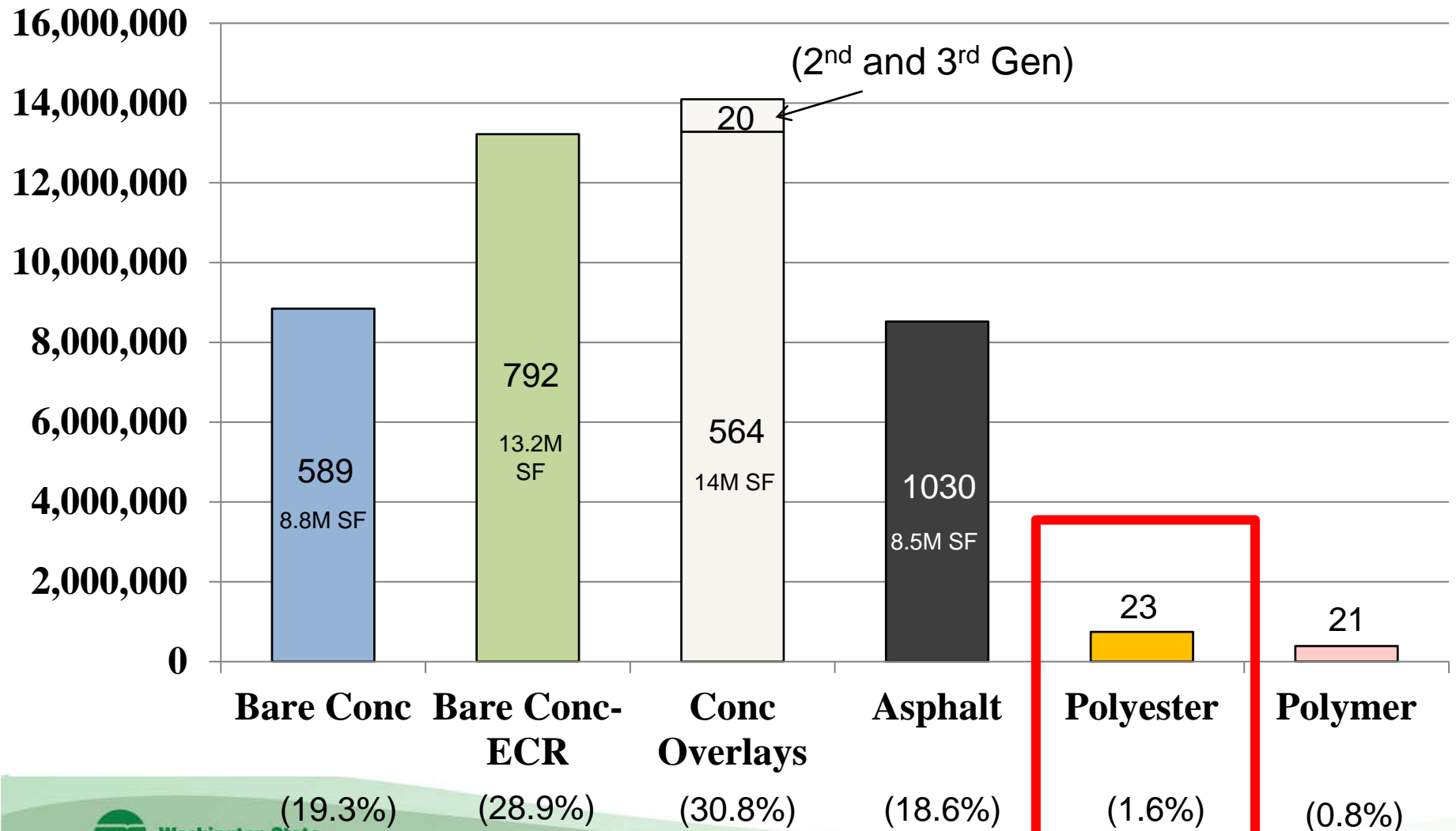
Jan 21, 2017, 10:14:05 AM





# Washington State's Concrete Bridge Deck Program

3,039 Bridges with Concrete Decks  
45.8 million SF deck area



# Polyester Concrete Overlays

3 Bridges  
26.5K SF  
(3.2%)

Good



Fair

4 Bridges  
533.5K SF  
(63.7%)

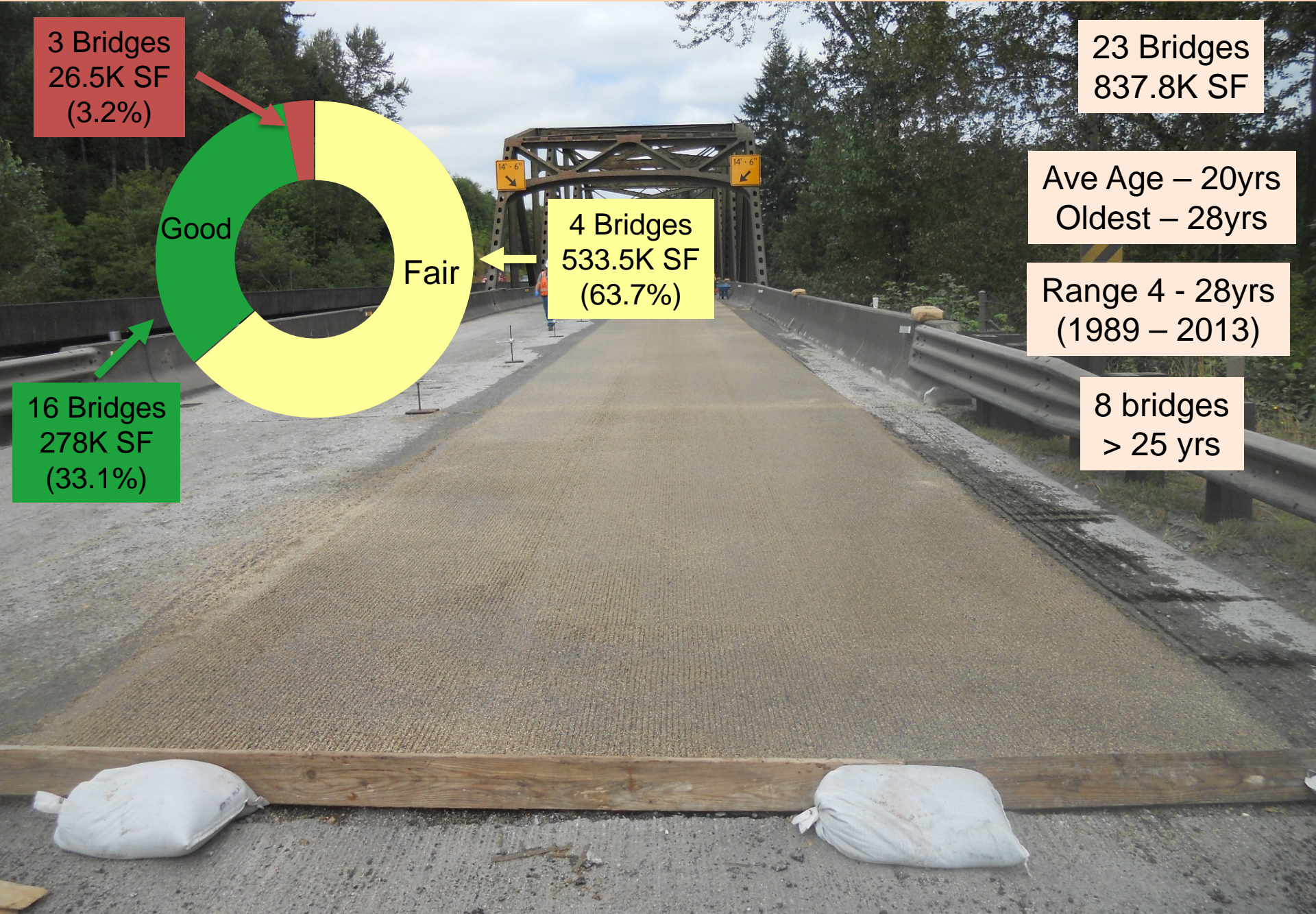
23 Bridges  
837.8K SF

Ave Age – 20yrs  
Oldest – 28yrs

Range 4 - 28yrs  
(1989 – 2013)

8 bridges  
> 25 yrs

16 Bridges  
278K SF  
(33.1%)



# Polyester Concrete Overlays



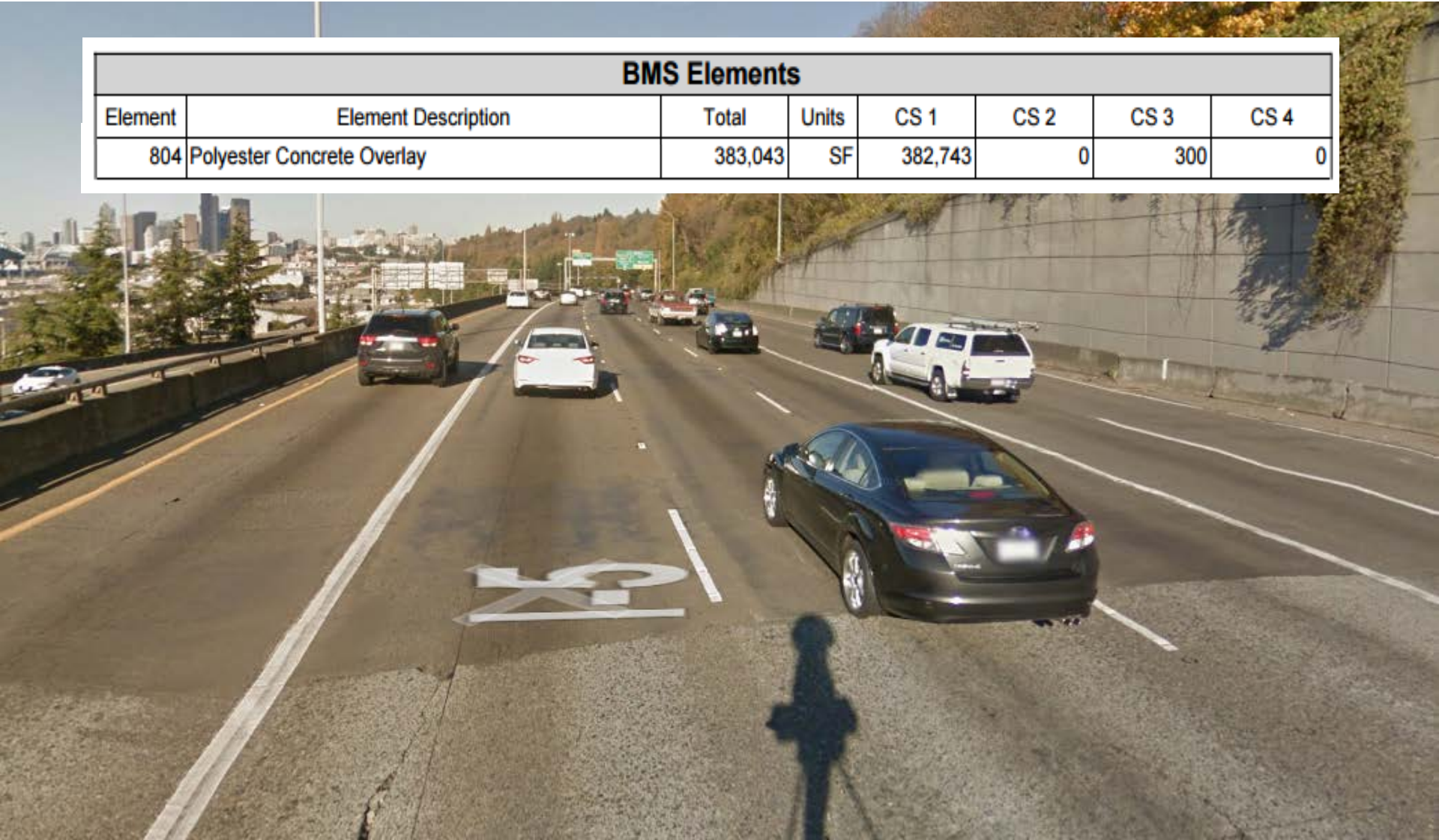
# Polyester Concrete Overlays

*Bridge Built – 1966  
Polyester applied - 2007*

*ADT – 90,000*

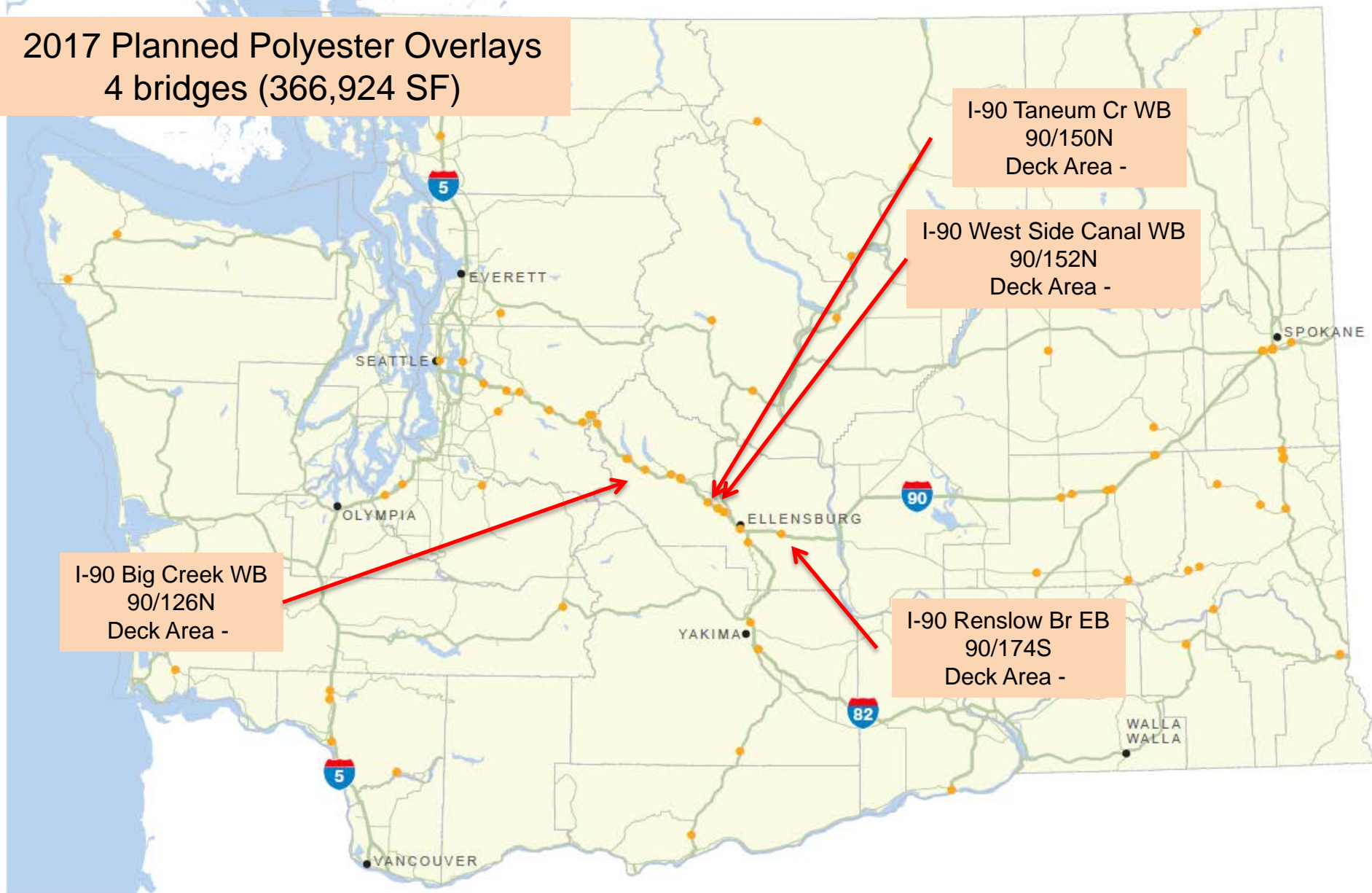
*I-5 NB Viaduct  
Located in Seattle*

BMS Elements							
Element	Element Description	Total	Units	CS 1	CS 2	CS 3	CS 4
804	Polyester Concrete Overlay	383,043	SF	382,743	0	300	0



# Polyester Concrete Overlays - 2017

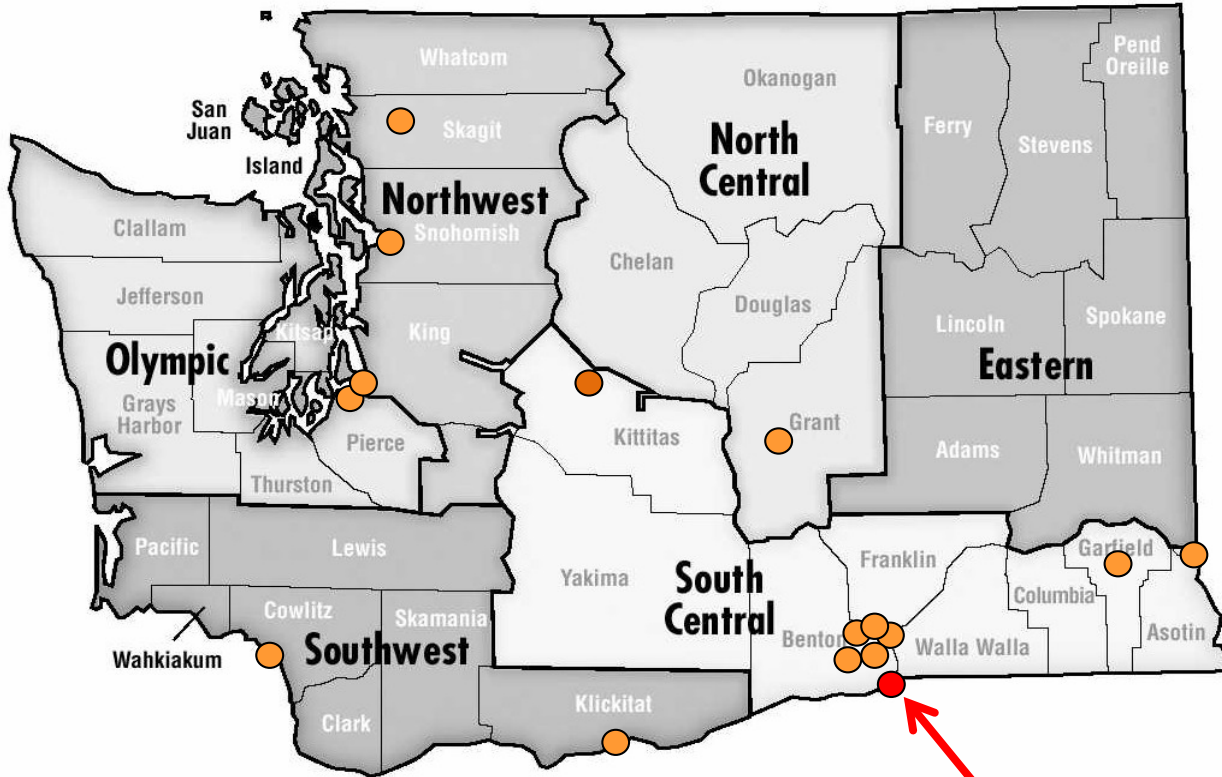
2017 Planned Polyester Overlays  
4 bridges (366,924 SF)



# WSDOT's Concrete Bridge Deck Preservation Program

## How do we Measure Success?

# WSDOT Bridge Deck Replacements



82/280S Col R Umatilla  
Under Contract 2017

Br Num	Yr	Length
395/40	1986	2,451
12/512N	1987	1,270
82/280S	1988	1,471
395/16	1988	72
240/32W	1989	244
281/1	1990	196
9/130	1991	344
529/10E	1994	1,544
397/10	1995	261
509/101	1995	562
509/103	1995	264
433/1	2004	5,478
97/1	2009	2,567
10/143	2012	430
5/670W	2014	859
82/280S	2017	1,920

16 bridges (588,536 sq ft)

[1.5% of total Statewide Deck Area]

# WSDOT Bridge Deck Replacements

*Bridge Built – 1955  
Approaches Rebuilt- 1990*

*ADT – 8,947*

*I-82 Col R Umatilla  
Located near Umatilla Or*

*Bridge Length – 3,403 feet  
Truss spans – 1,920 feet*



**Patches and Spalls  
3,884 SF (7.4%)**

BMS Elements						
Element	Element Description	Total	Units	State 1	State 2	State 3
20	Concrete Deck - Lightweight Aggregate	52,800	SF	48,916	3,020	864
26	Concrete Deck w/Coated Bars	40,600	SF	40,600	0	0
35	Concrete Deck Soffit	93,400	SF	92,561	282	557



# WSDOT Bridge Deck Replacements

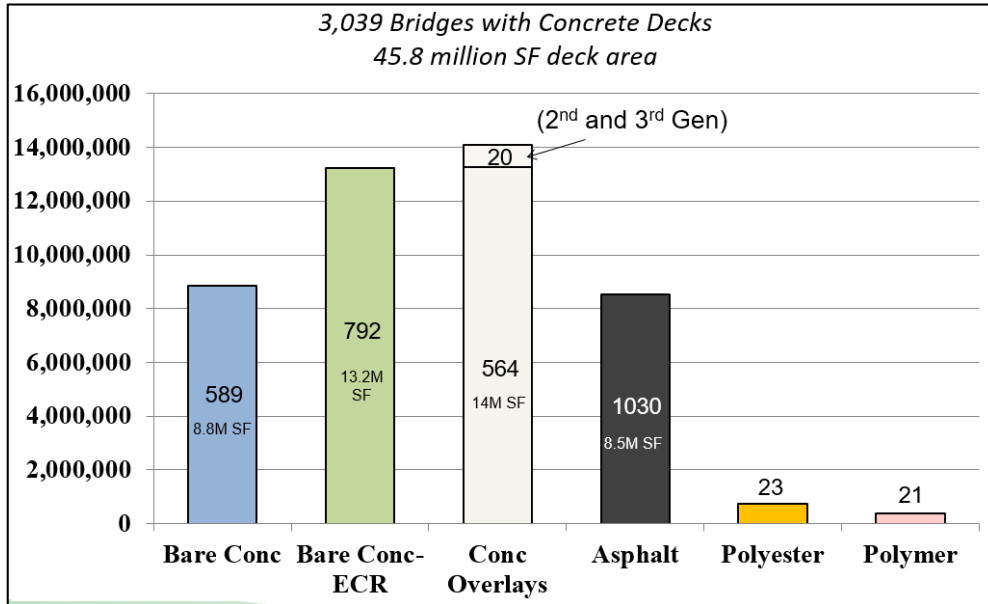
*I-82 Col R Umatilla  
Located near Umatilla Or*

*Deck Replacement Contract  
Awarded to Max J Kuney  
\$9.5 M*



01/09/2015 13:09

# WSDOT Br Deck Preservation Savings



ECR -	\$1/SF
ACP w/membr -	\$20/SF
Conc Overlay -	\$80/SF
Polyester Overlay -	\$120/SF
Replace Deck -	\$250/SF
Replace Bridge -	\$800/SF

$14\text{M SF} / 2 \times \$170/\text{SF} = \text{\$1.2 Billion Savings}$

# WSDOT's Concrete Bridge Deck Preservation Program

**Questions ?**

