HMA Field Cracking and Performance Test

David L. Lippert, PE
Sustainability Implementation Engineer

December 12, 2017

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Illinois Department of Transportation

Disclaimer

This presentation is partly based upon work in progress under project:

ICT-R27-161- CONSTRUCTION AND PERFORMANCE MONITORING OF VARIOUS ASPHALT MIXES

Project Chair: James S. Trepanier

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161 Study Reports

2015 Interim Report

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CONSTRUCTION AND PERFORMANCE MONITORING OF VARIOUS ASPHALT MIXES IN ILLINOIS: 2015 INTERIM REPORT

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A report of the findings of
ICT-R27-161
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Final Report Coming Soon..

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UTILIZING LAB TESTS TO PREDICT ASPHALT CONCRETE OVERLAY PERFORMANCE

Prepared By
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Illinois Department of Transportation

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A report of the findings of

ICT PROJECT R27-161
CONSTRUCTION AND PERFORMANCE MONITORING OF VARIOUS ASPHALT MIXES

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Focus on Cracking

Thermal Cracking (Full Depth HMA)

Block Cracking (All HMA)

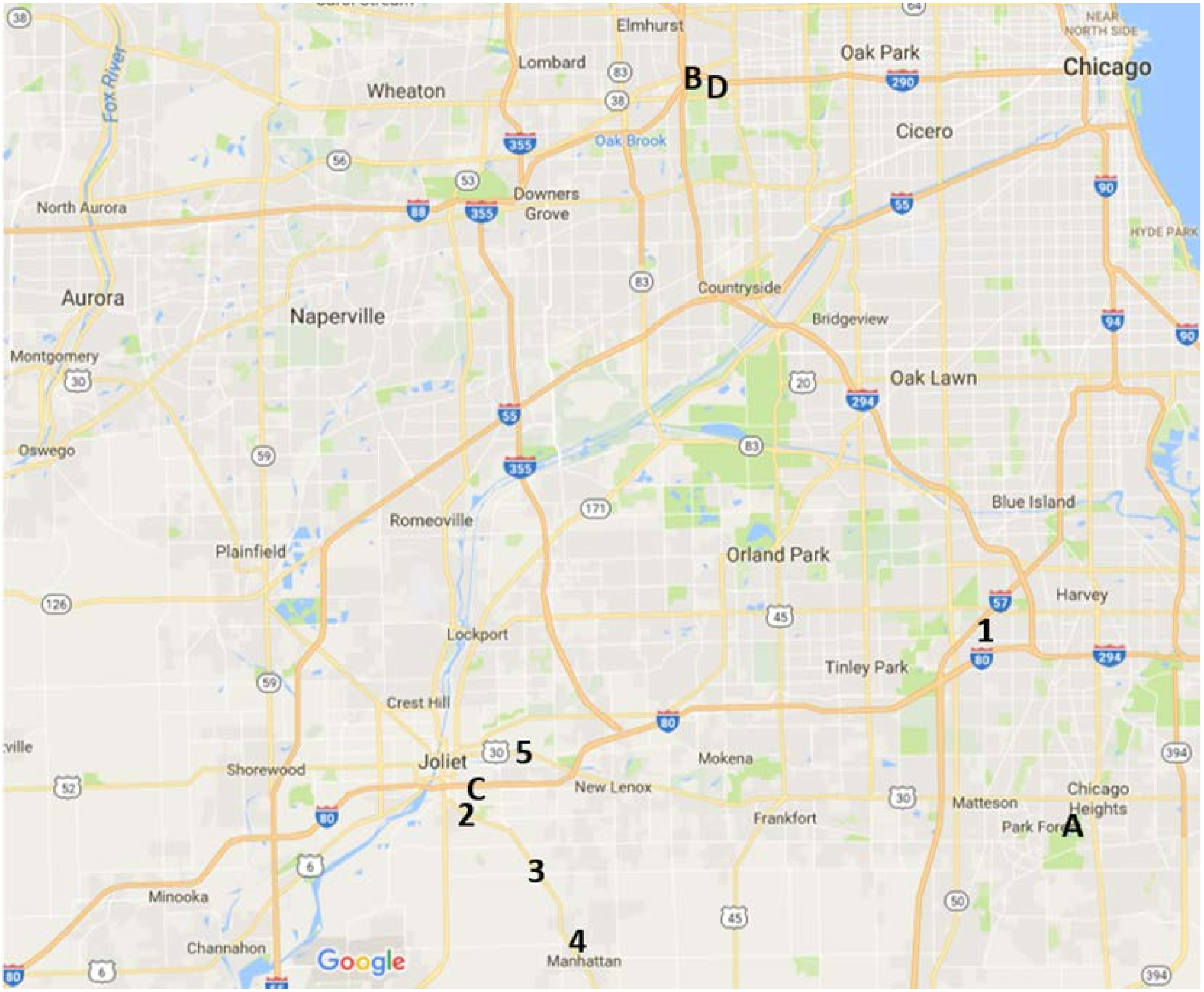
Reflective Cracking (Composite)

Outline

- Construction Project Review
- Crack Performance
- Pavement Profile
- Analysis
- Findings
- Conclusions
- Recommendations

Construction Project Review

Region 1/ District 1 Projects



2013 Let TRA Projects

April 26, 2013 Letting Projects										
Map ID/ Construction Year	Project	Net Length (mi.)	Surface Mix Details							
			Dir.	Mix	ABR %	RAS[3] %	RAP[3] %	Virgin PG	Surface Tons
A /2013	26th Street (Chicago Heights) from Western Ave to East End Ave **137 L62**	2.0	Both	N50 TRA[2] 60L62-137M	60	4.6	51	52-28	3,060
B /2013	Harrison Street (Hillside) from IL 38/Roosevelt Rd. to Wolf Rd. **338 N67**	1.1	Both	N50 TRA[2] 60N67-338K	56	5.0	53	52-28	2,131
C /2013	Richards Street (Joliet) from 5th Ave to Manhattan Road **138 P70**	0.9	Both	N50 TRA 60P70-138Z	37	None	27	58-28	2,223
D /2013	Wolf Road (Hillside) from IL 38/Roosevelt Rd. to Harrison St. **306 M30**	0.5	Both	N70 Mix D 60M30-306K	20	None	30	58-28	1,382

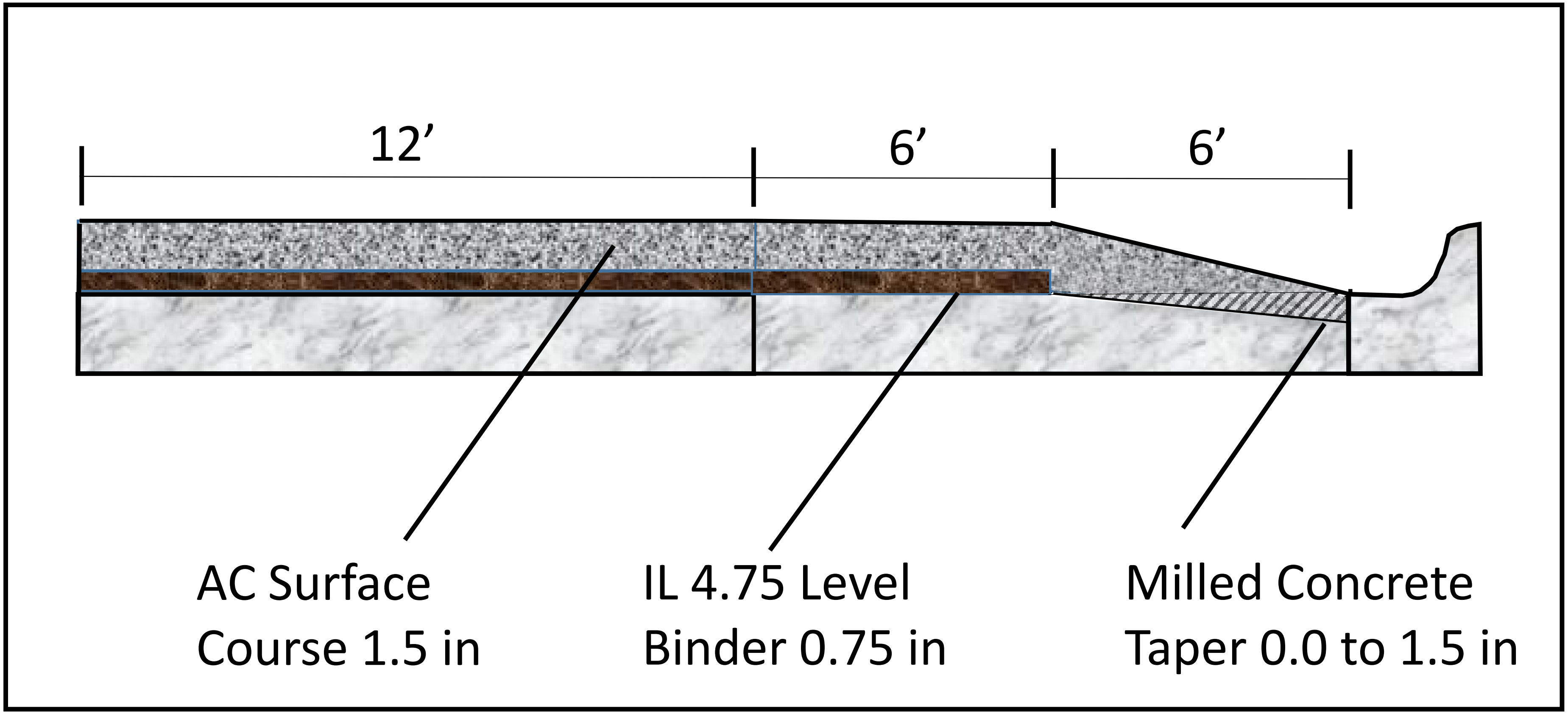
[1] Total recycle asphalt (100% recycled aggregate with high ABR)
[2] Percent of mixture that contributes to the indicated ABR%
Note: Maximum 5% RAS allowed in total mix by specification

2014/2015 Monitoring Projects

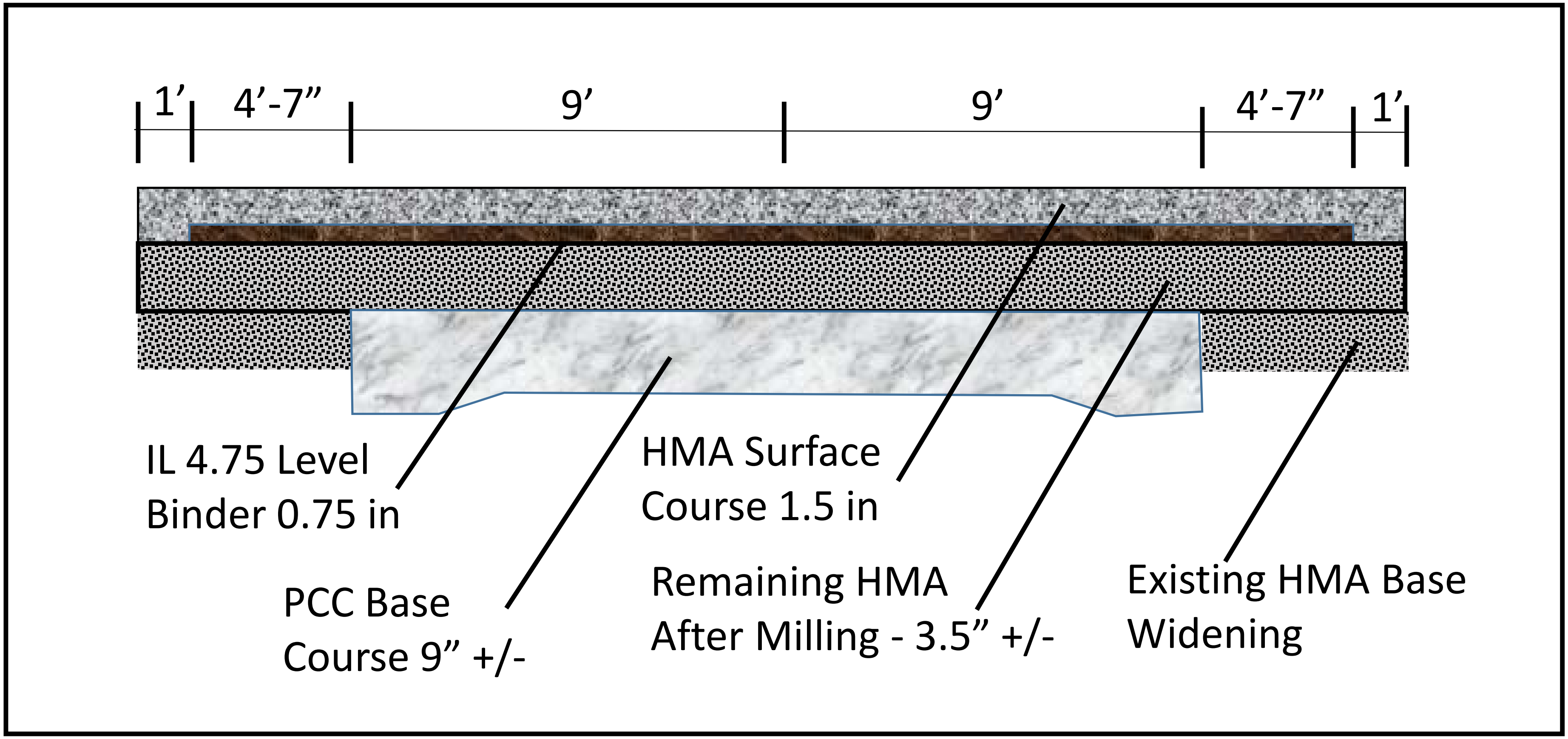
June 13, 2014 Letting Projects									
Map ID/ Construction Year	Project	Net Length (mi.)	Surface Mix Details						
			Dir.	Mix	ABR %	RAS[2] %	RAP[2] %	Virgin PG	Surface Tons
1 /2014	Crawford Ave/Pulaski Rd from 172nd to US Rt. 6 **157 Y03/ 156 Y03**	1.5	S	N70-30% ABR 60Y03-157M	29	5.0	9.9	58-28	2,150
			N	N70-15% ABR 60Y03-156M	15	2.5	4.9	64-22	2,150
2 /2014	US 52 From Chicago St. (IL 53) to Laraway Road **140 Y02/ 159 Y02**	3.3	E	N70-30% ABR 60Y02-140M	30	3.1	20	58-28	2,320
			W	N70-30% ABR 60Y02-159M	29	None	34	58-28	2,320
3 /2015	US 52 from Laraway Road to Gouger Road **185 N08**	3.3	Both	N70 TRA[1] 60N08-185M	48	5.0	39	52-34	5,236
4 /2015	US 52 from Gouger Road to Second Street **185 N07**	1.5	Both	N70 TRA[1] 60N07-185M	48	5.0	39	52-28	3,014
5 /2015	Washington Street from Briggs Street to US 30) **177 Y04/ 159 Y04**	1.9	W	N70-30% ABR 60Y04-177M	30	3.1	20	58-34	1,580
			E	N70-30% ABR 60Y04-159M	29	None	34	58-34	1,580

[1] Total recycle asphalt (100% recycled aggregate with high ABR)
[2] Percent of mixture that contributes to the indicated ABR%
Note: Maximum 5% RAS allowed in total mix by specification

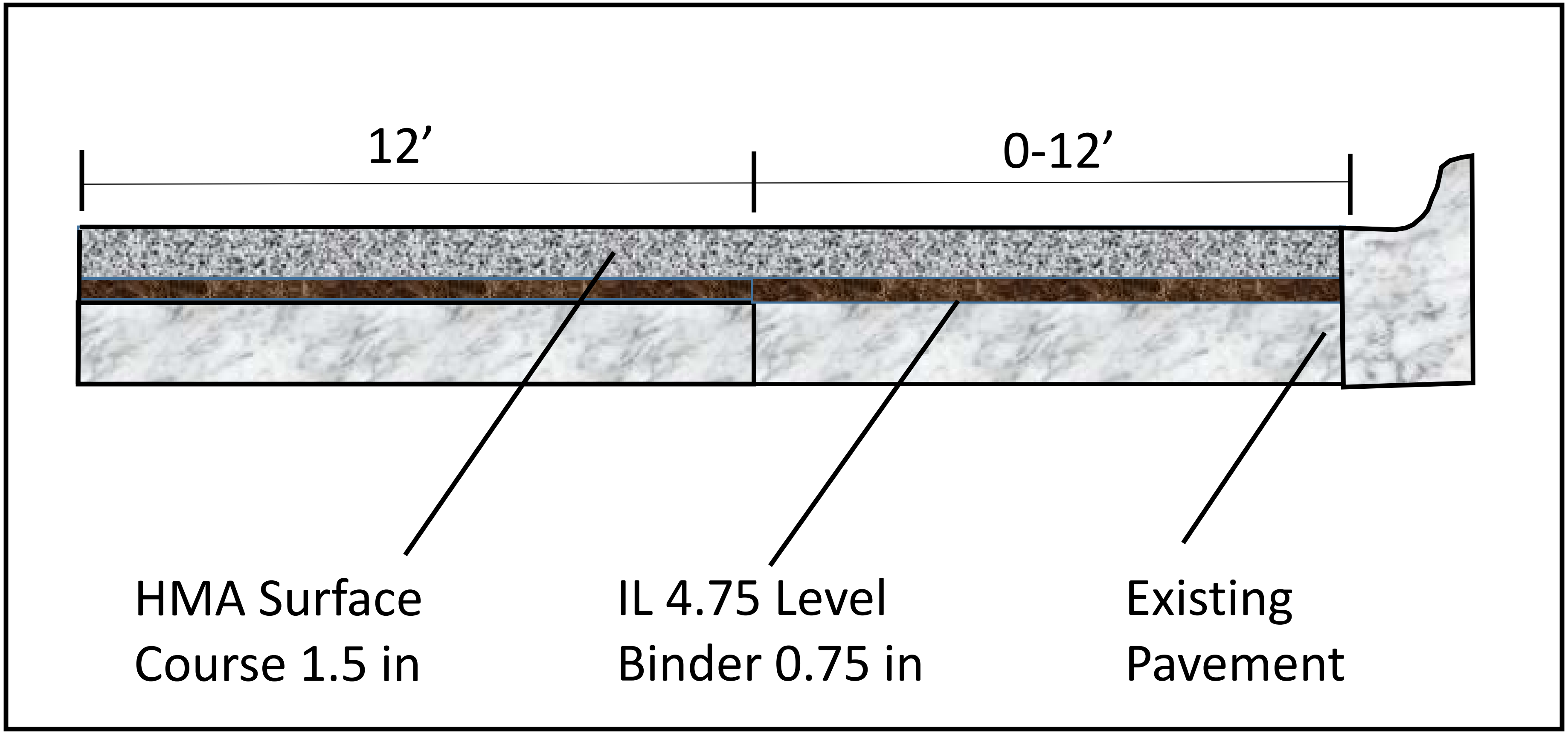
Urban Bare PCC Detail



Rural Detail (Thick)

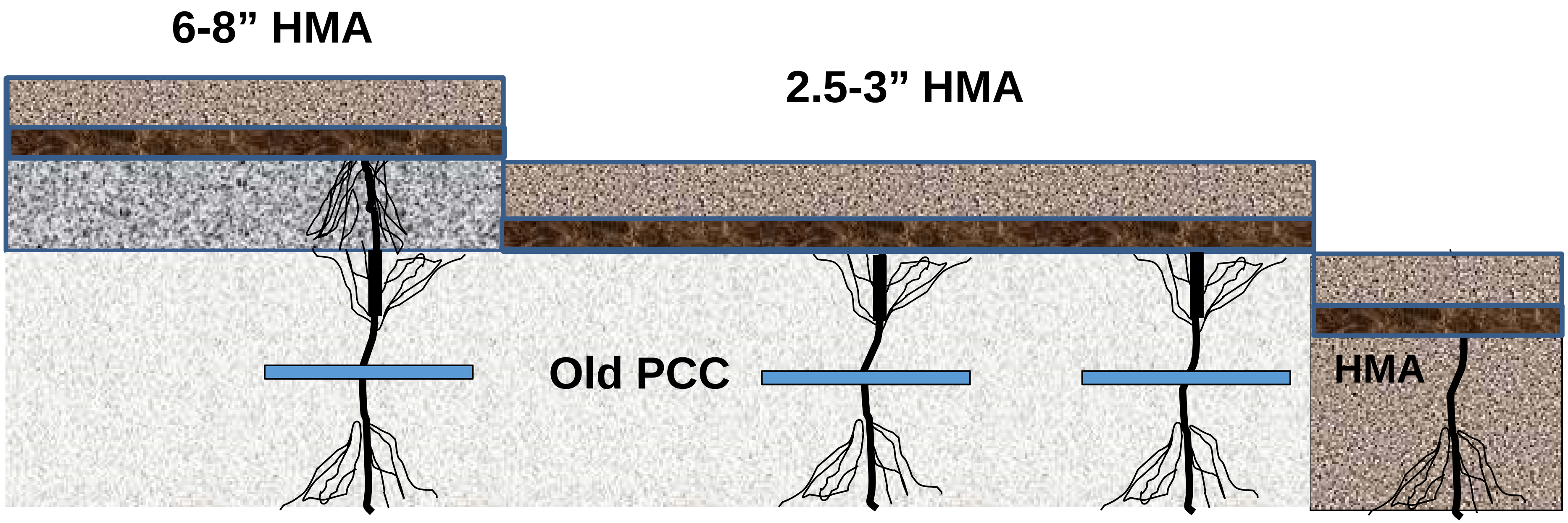


Urban Mill and Fill



Typical HMA Rehabilitation Designs

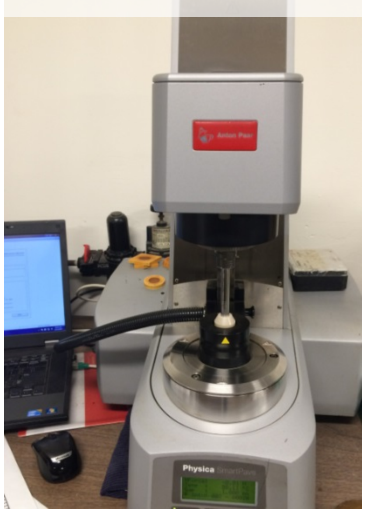
Rehabilitated Thick & Thin HMA/PCC/Bare PCC and Full Depth HMA



Plant Mix and Core Sample Testing

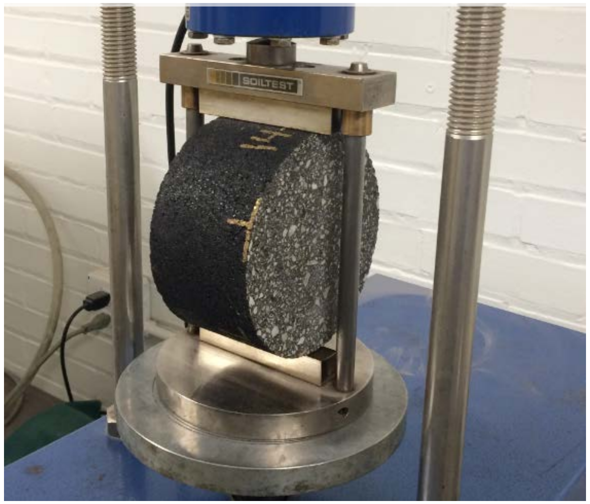
Testing

Binder PG Grading

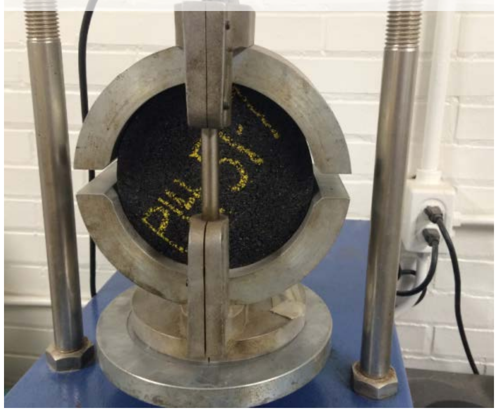


Asphalt Content/Mix Verification

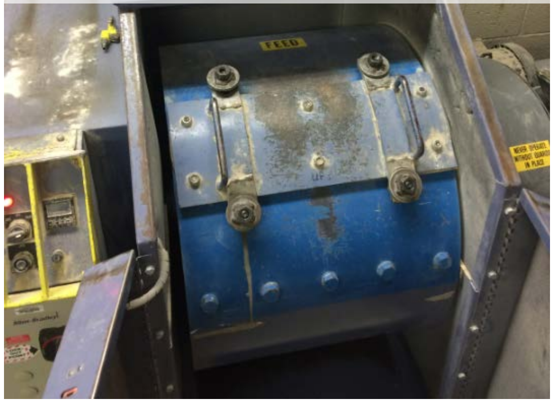
Moisture Damage (TSR)



Marshall Stability



Cantabro Loss



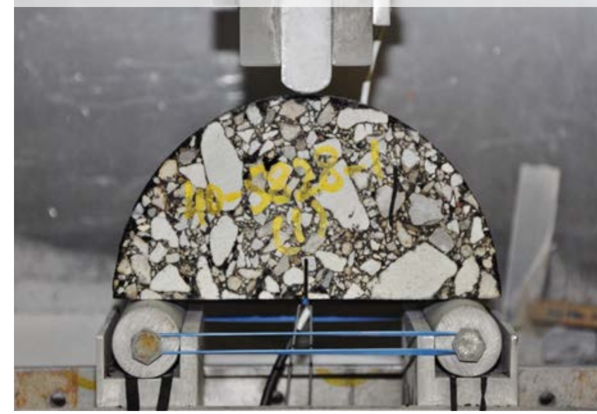
Texas Overlay

Testing

Complex Modulus Test

Hamburg Wheel Track

Semi Circular Bending Beam



Flow Number

IDT Fracture / Creep Compliance

Beam Fatigue

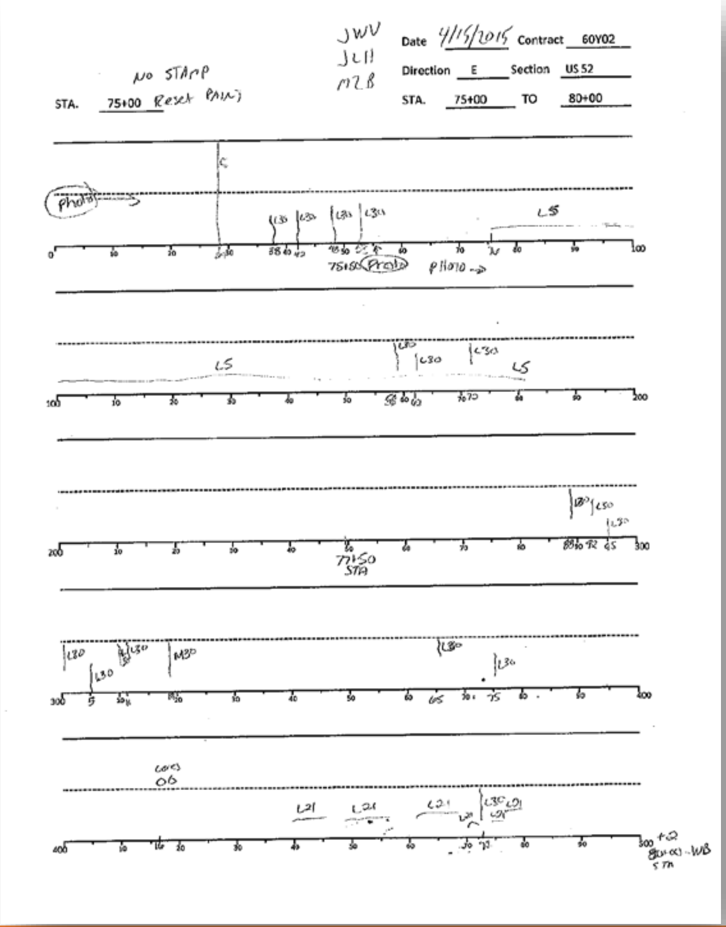
Summary of Testing

Test	Specification	Field Core		Plant Mix		Laboratory
		2013 Let	2014 Let	2013 Let	2014 Let	
Asphalt binder content	AASHTO T 164-13 (Illinois Modified 01/01/15)			X	X	BMPR
Aggregate gradation	AASHTO T-27 (Illinois Modified 3/1/2013)			X	X	BMPR
G_{mm}	AASHTO T 209-12 (Illinois Modified 01/01/15)			X	X	BMPR
Marshall stability and flow	ASTM D 1559 (Illinois Modified w/150 mm fixture)				X	BMPR
Cantabro loss	TxDOT Test: Tex-245-F				X	BMPR
TSR	AASHTO T 283-07 (2011) (Illinois Modified 01/01/15)				X	BMPR
Texas overlay	TxDOT Test: Tex-248-F				X	BMPR
Complex modulus	AASHTO T 342-11			X	X	ICT
Flow number	AASHTO TP 79-13			X	X	ICT
Beam fatigue	AASHTO T-321-14				X	ICT
Creep compliance/IDT strength	AASHTO T-322-07 (2011)B	X	X		X	ICT
Hamburg wheel tracking	AASHTO T 324-11 (Illinois Modified 01/01/15)	X	X	X	X	ICT
I-FIT	AASHTO TP 105-13	X	X	X	X	ICT
Performance-graded asphalt binder	AASHTO M 320	Binder sample from Plant				BMPR

Crack Performance

Crack Surveys

- **Conducted by BMPR – Lead Joe Vespa**
- **Survey sheets provided to ICT**
  - Translated into spreadsheets
  - Summary/analysis/graphs



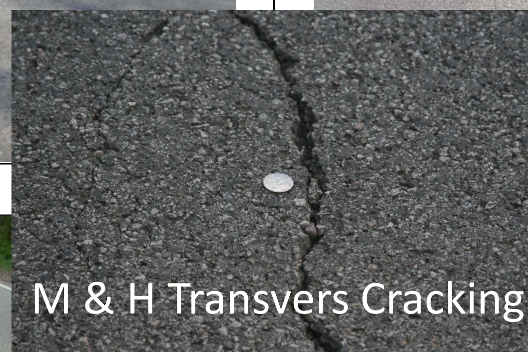
2013 Let Projects

Distress Summary

26th Street - 137 L62

2014

2015



2016

2017

Harrison Street – 338 N67

2014

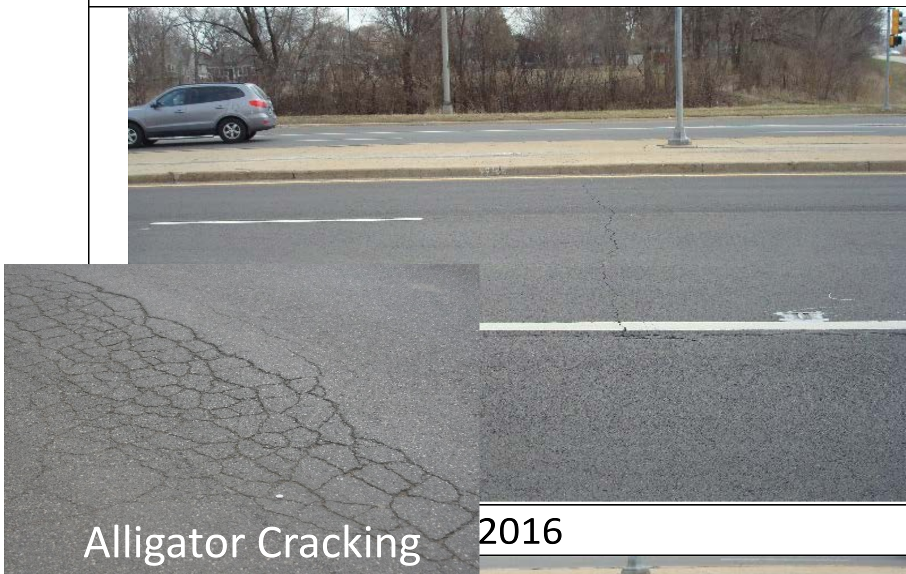
2015

2016

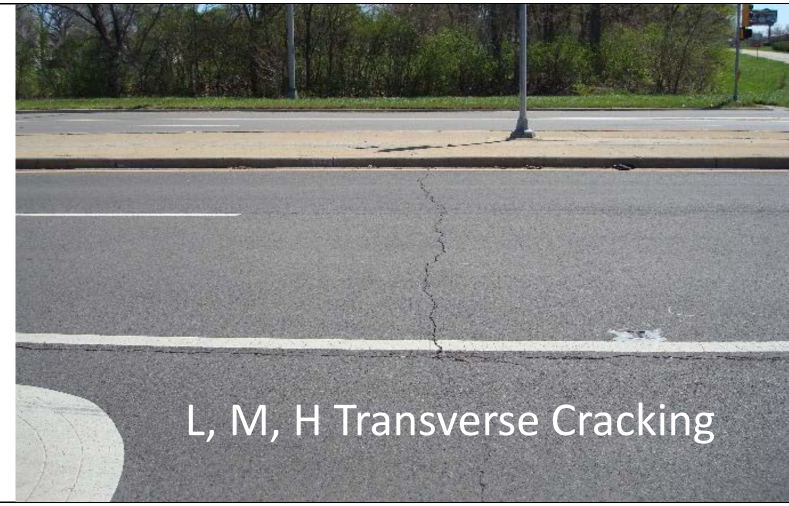
2017

Richards Street – 138 P70

2014



2015



2016

2017

Wolf Road – 306 M30

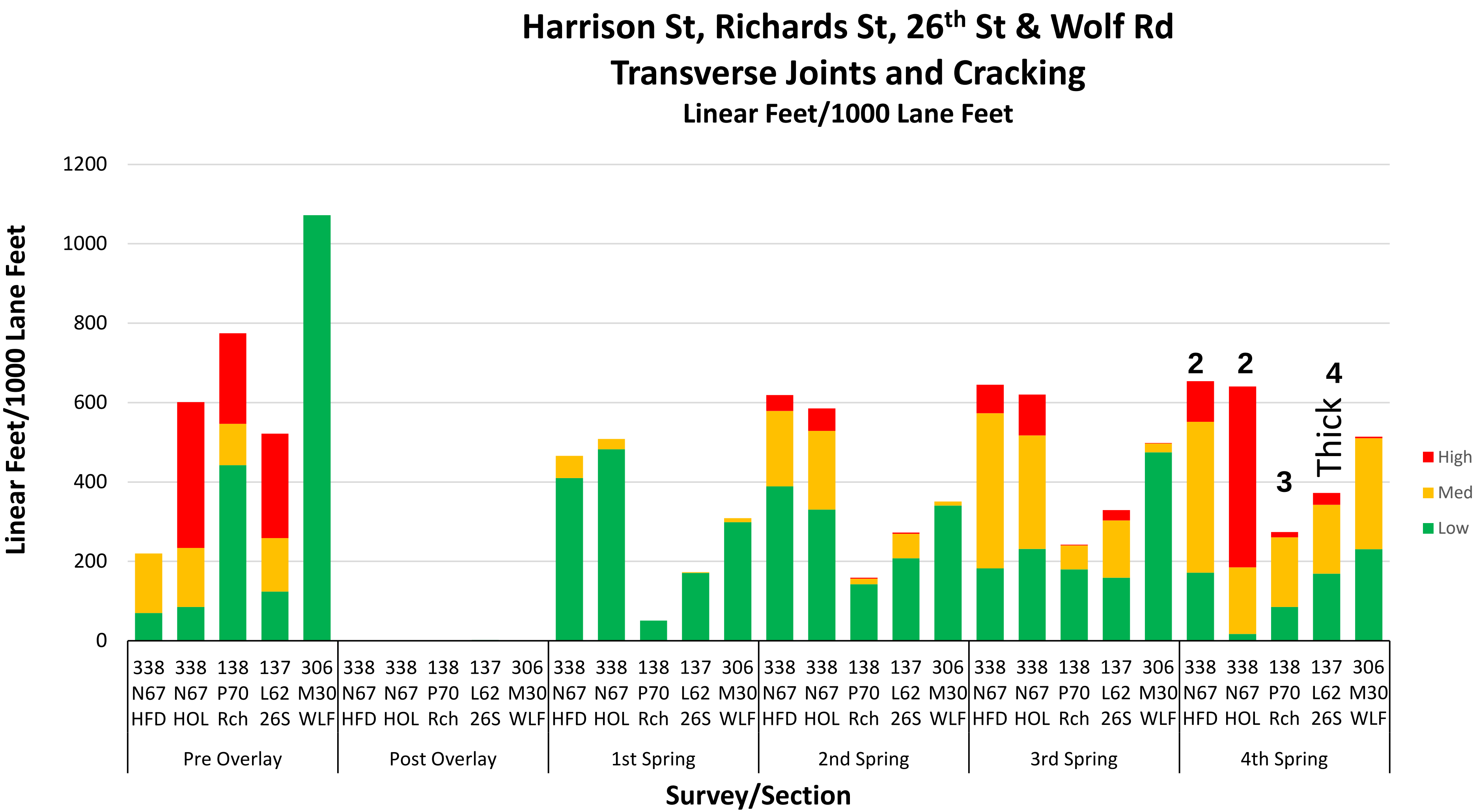
2014

2015

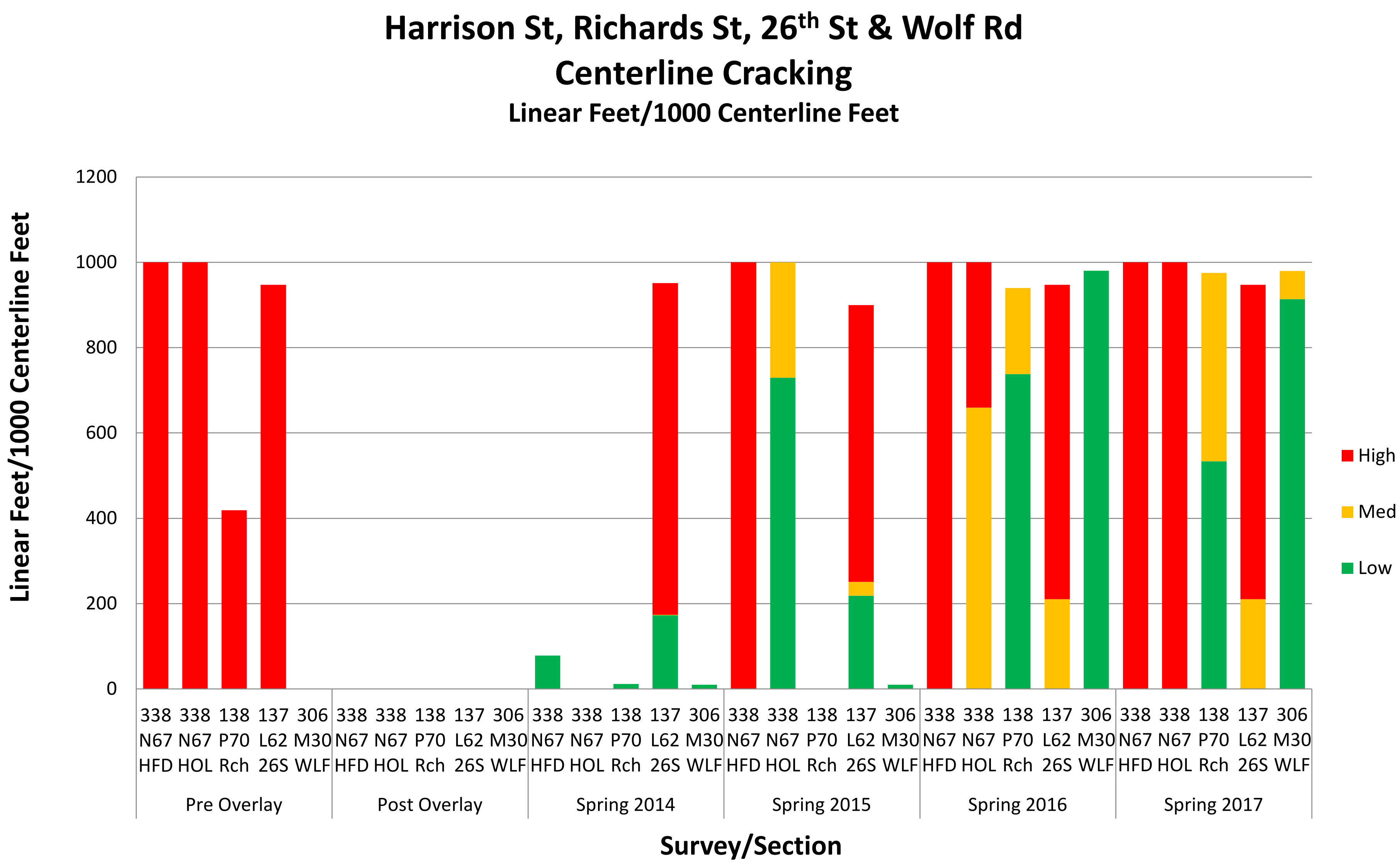
2016

2017

Cracking Progression



Centerline Cracking



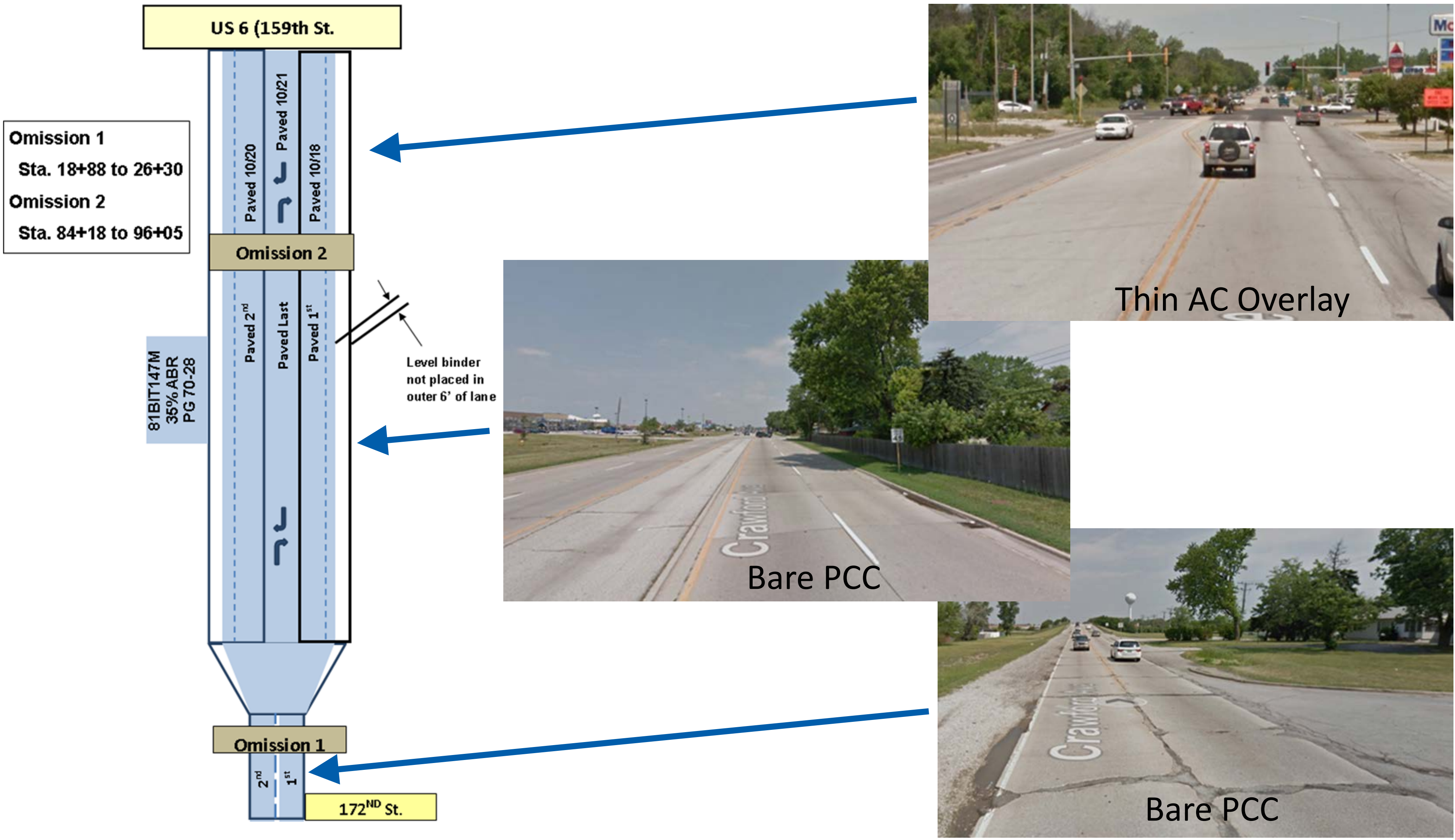
Main Observations (2013 Projects)

- **Richards (non-RAS) and Wolf Road**
  - Transverse cracking at lower severity
  - Wolf Road average slab length ~11’
    - Many slabs – little movement – less severity
- **26th Street severe centerline problems**
- **Harrison and Richards Alligator Cracking**
- **Harrison: extensive early transverse cracking and higher severity sooner than other projects (Mix 338 N67, FI = 1)**

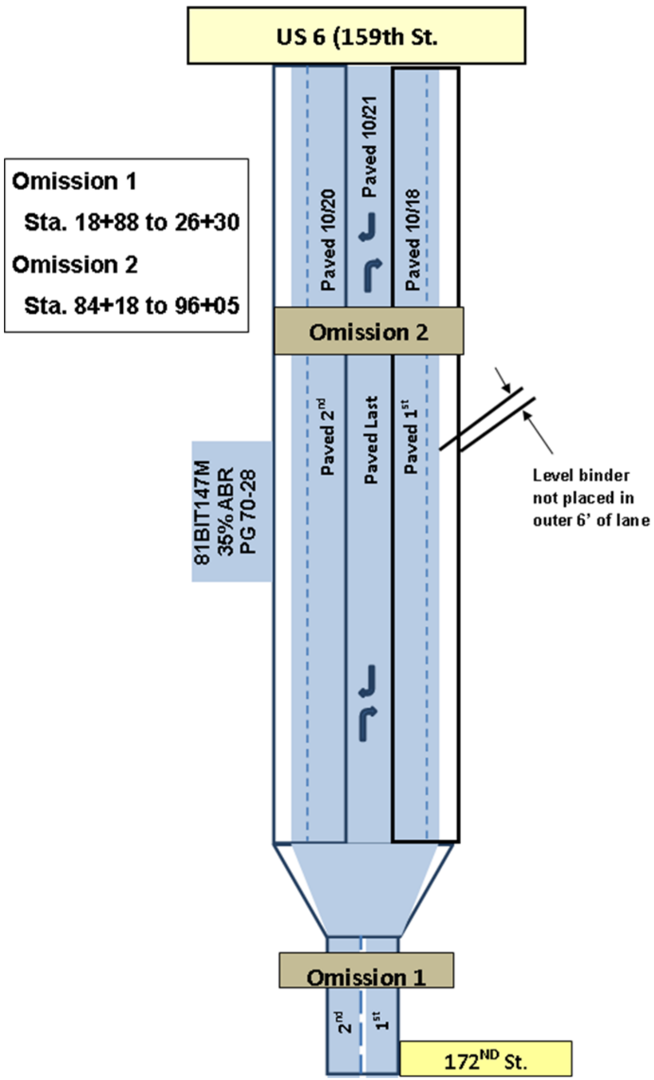
2014 Let Projects

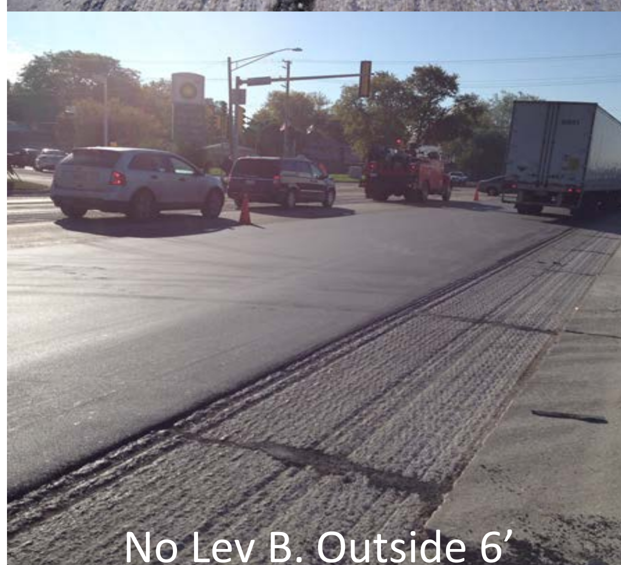
2014 Construction

Crawford/ Pulaski - 157 Y03/ 156 Y03

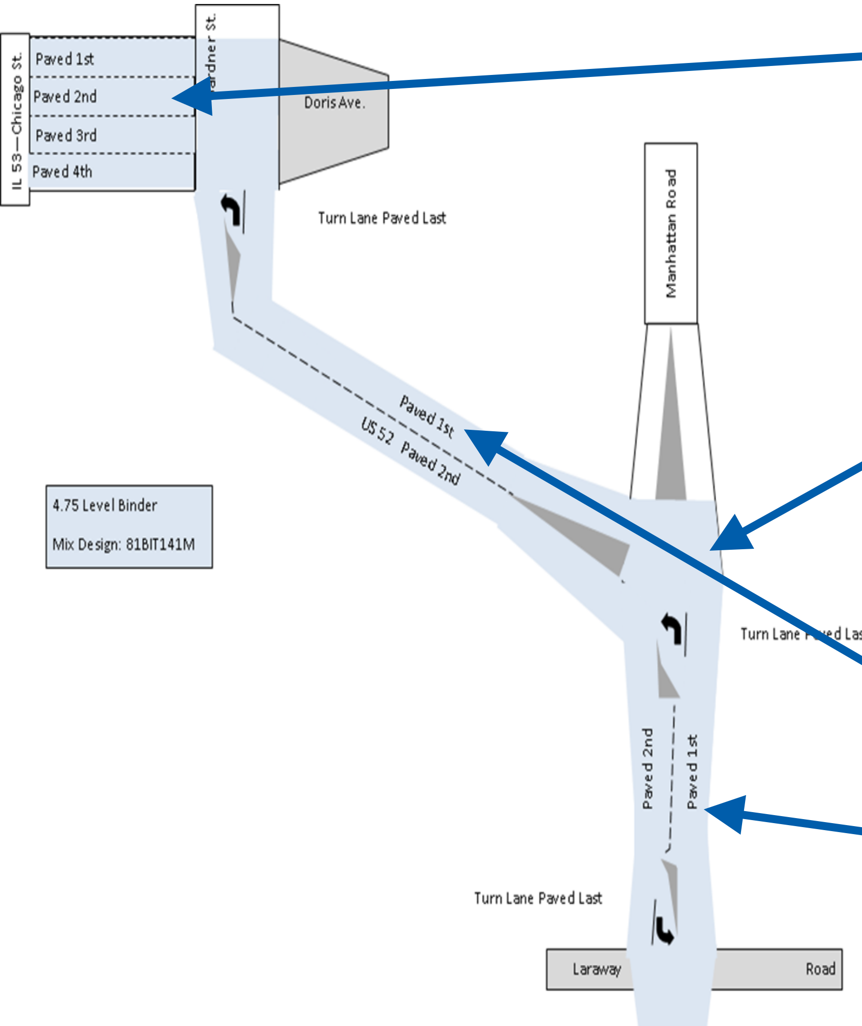


Crawford/ Pulaski - 157 Y03/ 156 Y03

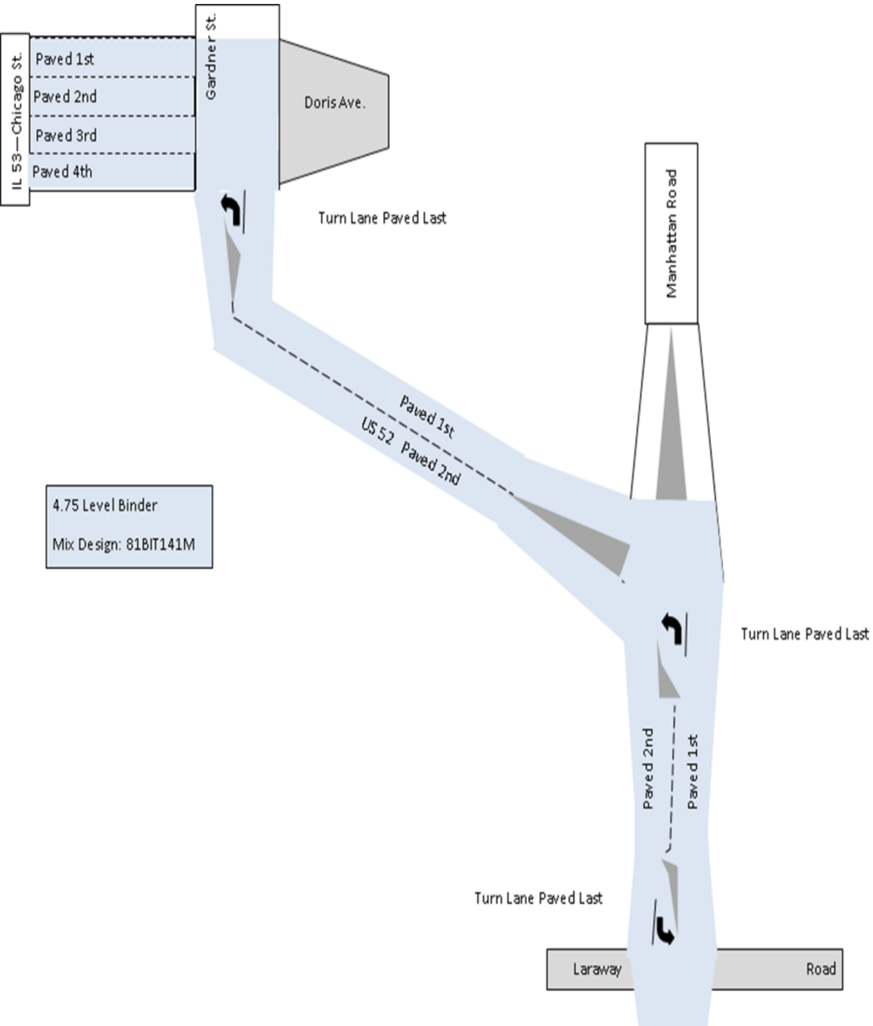




US 52 (IL 53 to Laraway Rd) - 140 Y02/ 159 Y02



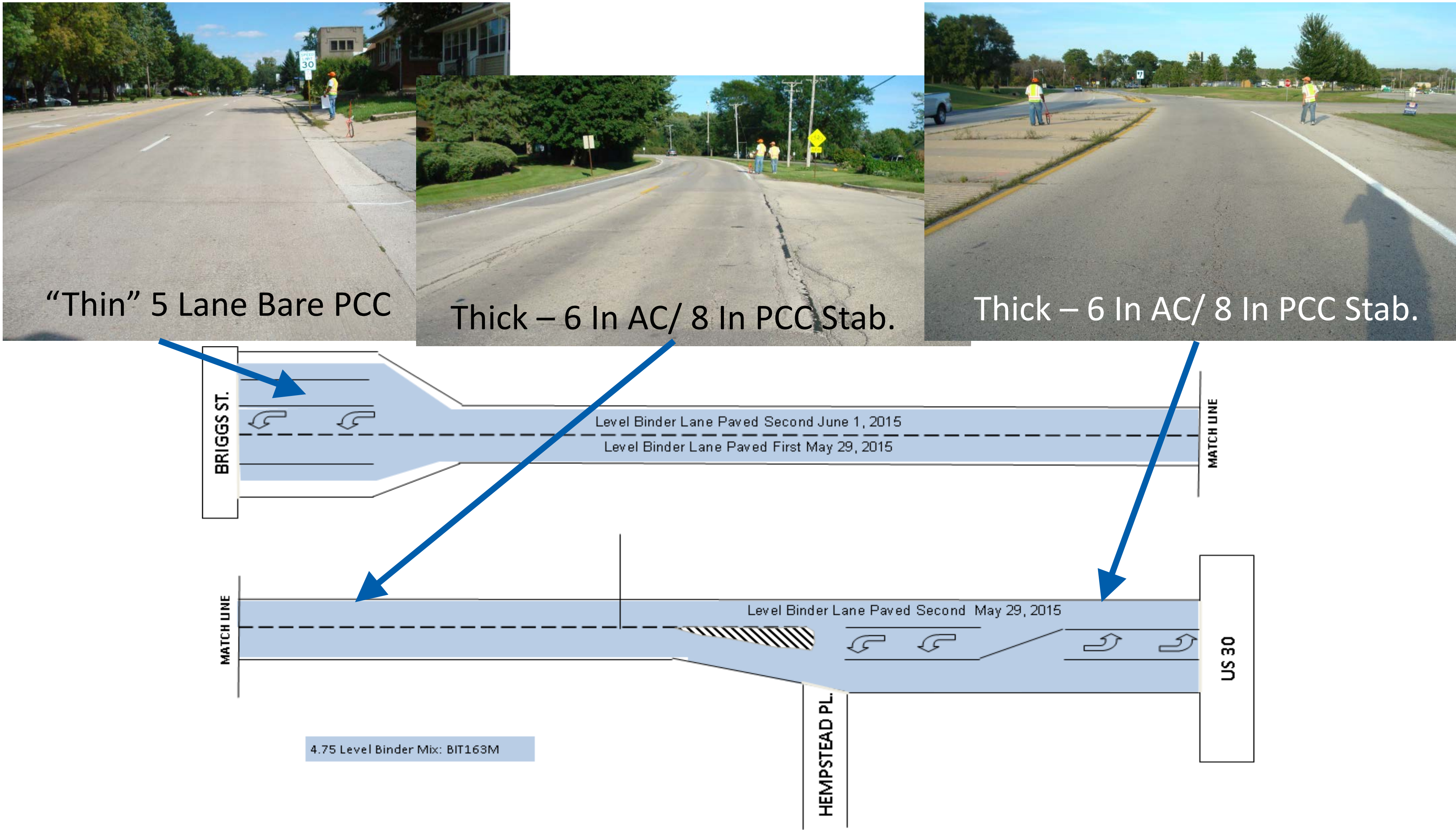
US 52 (IL 53 to Laraway Rd) - 140 Y02/ 159 Y02



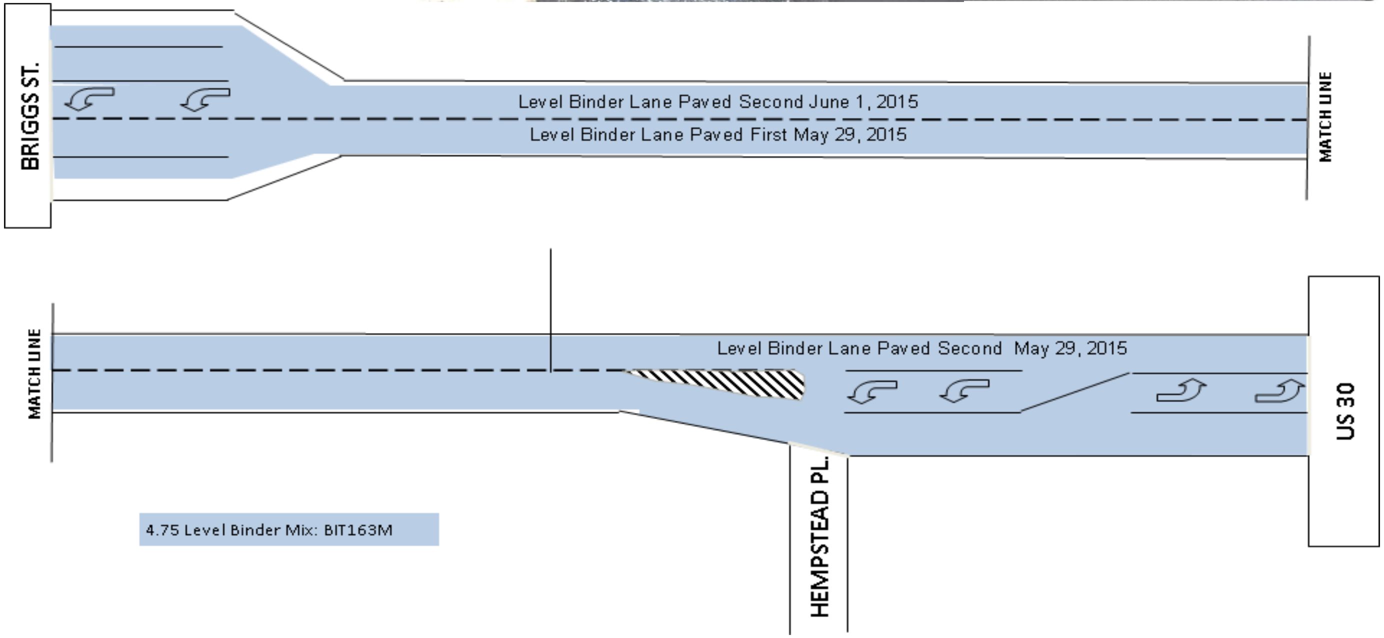
2014 Let Projects

2015 Construction

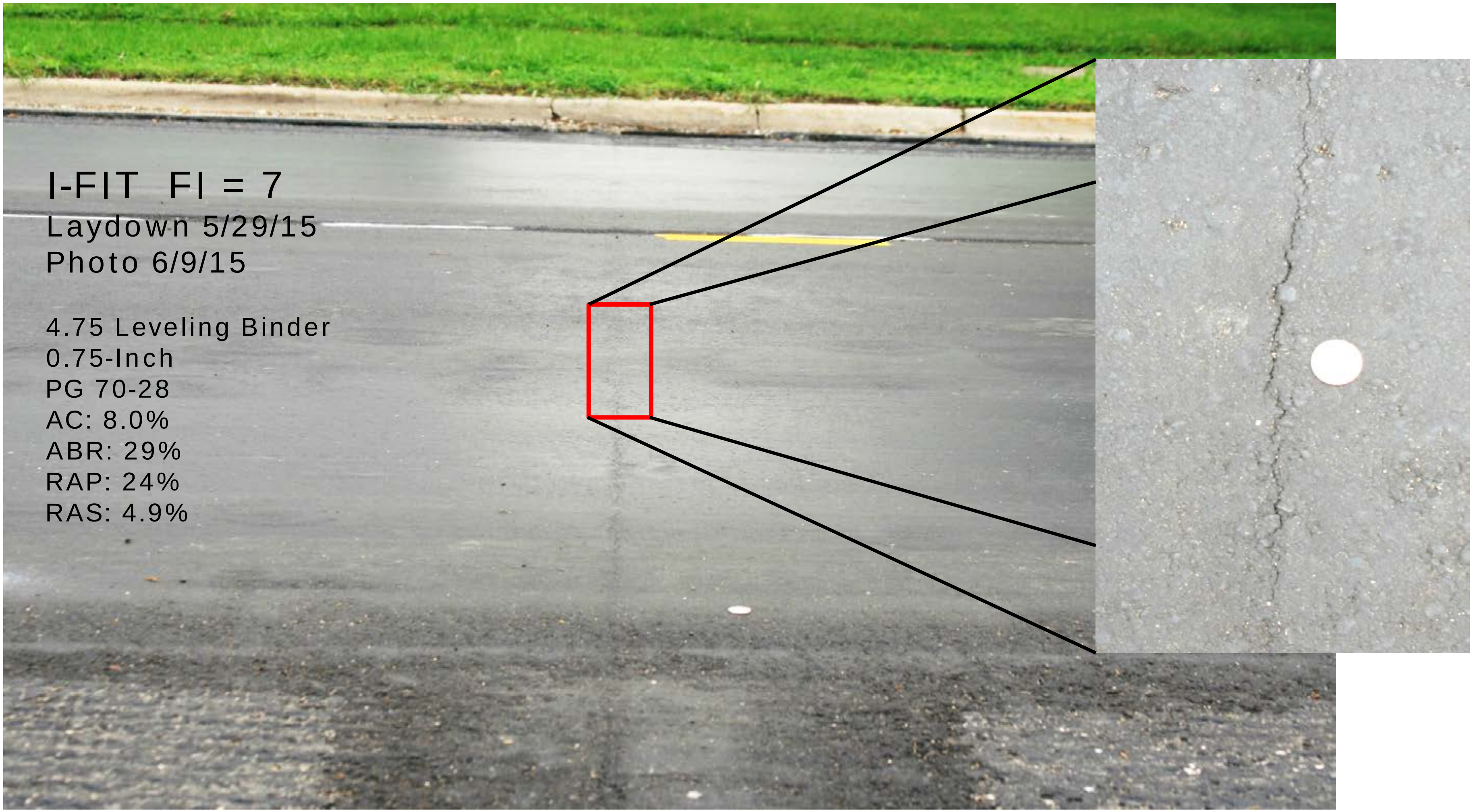
Washington St. - 177 Y04/ 159 Y04



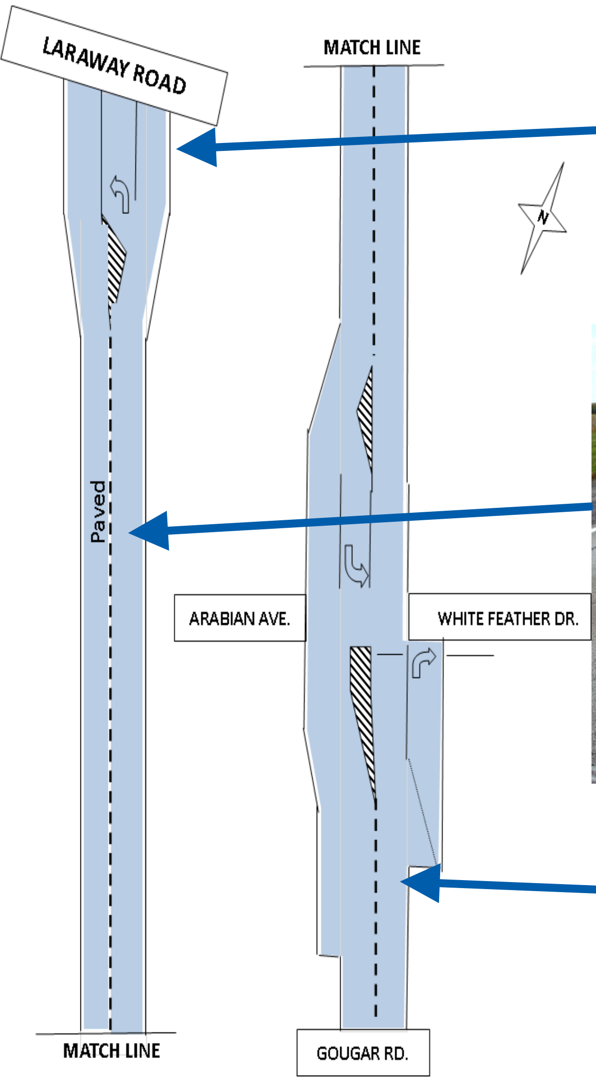
Washington St. - 177 Y04/ 159 Y04



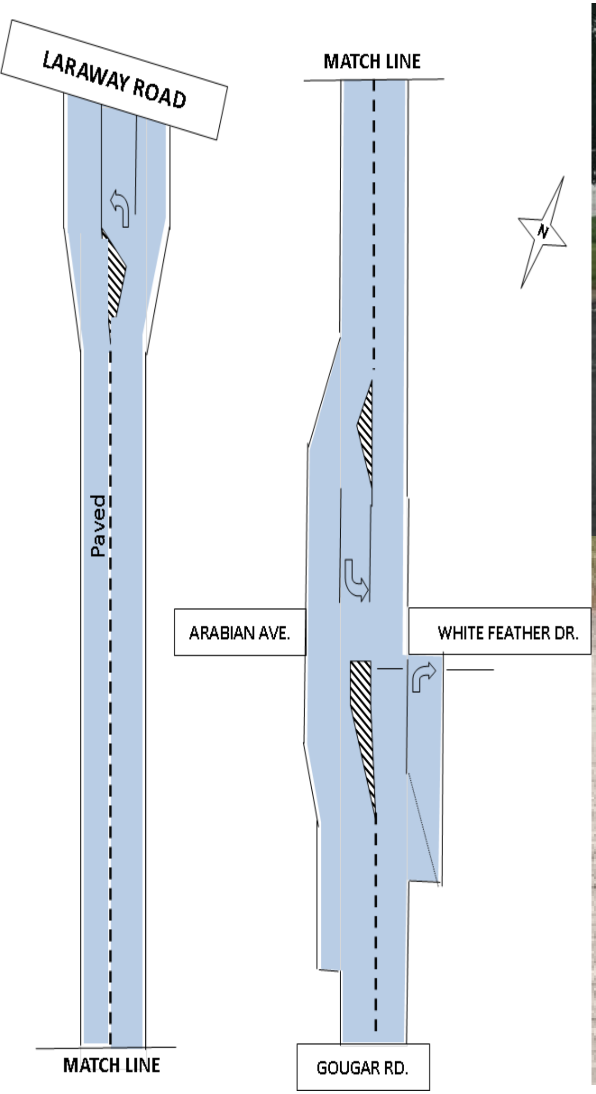
Washington St. Leveling Binder



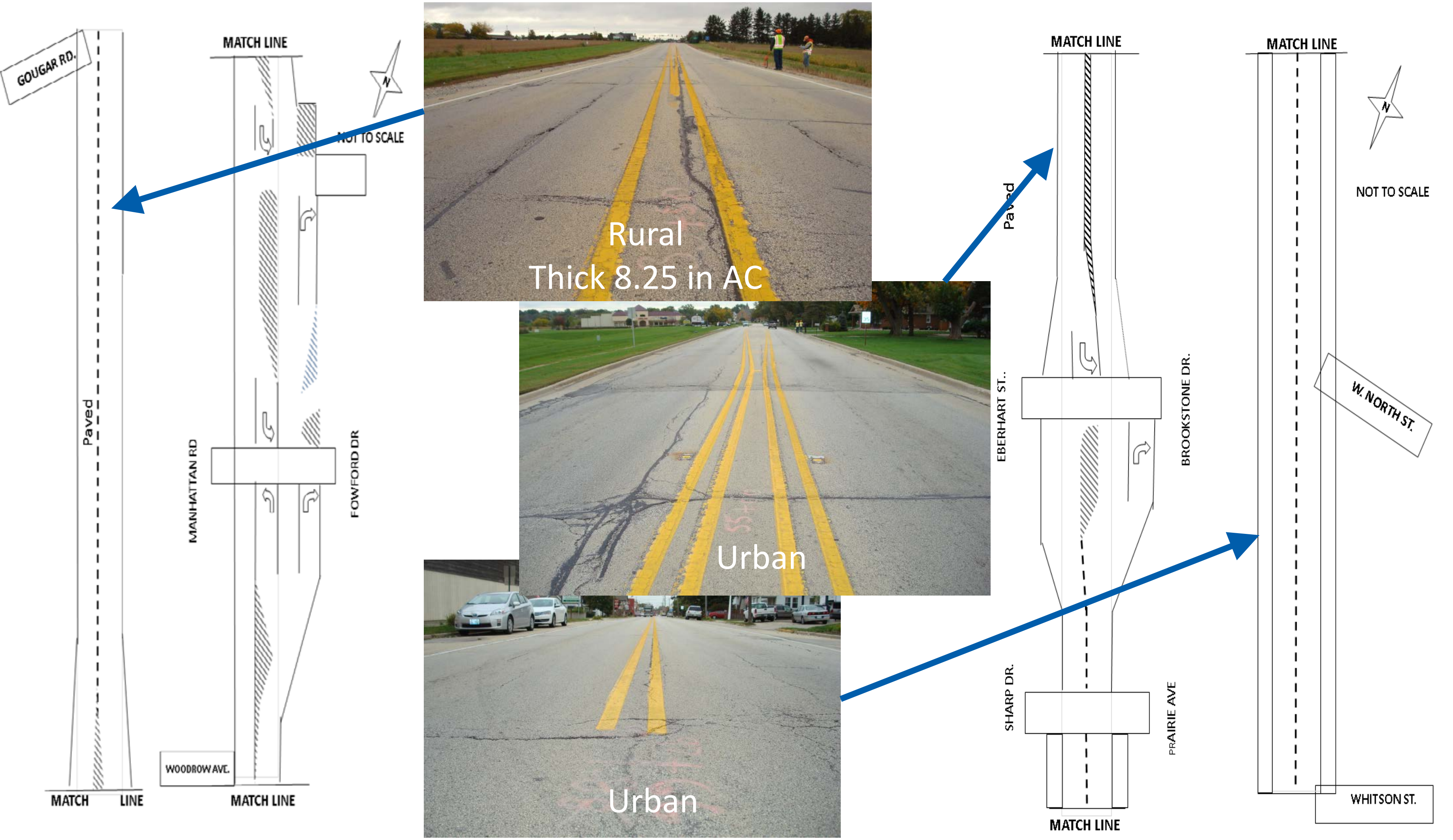
US 52 (Laraway to Gougar) - 185 N08



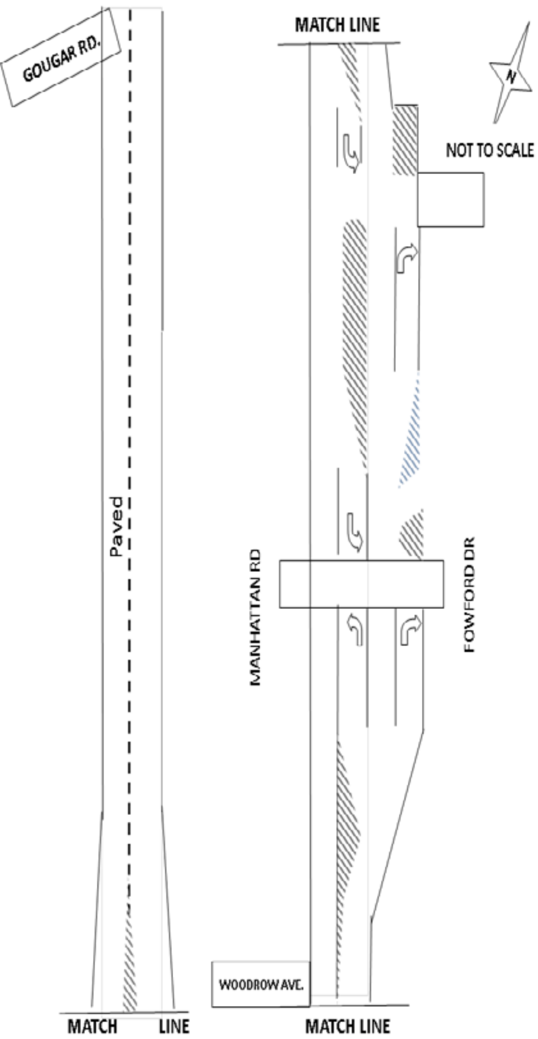
US 52 (Laraway to Gougar) - 185 N08

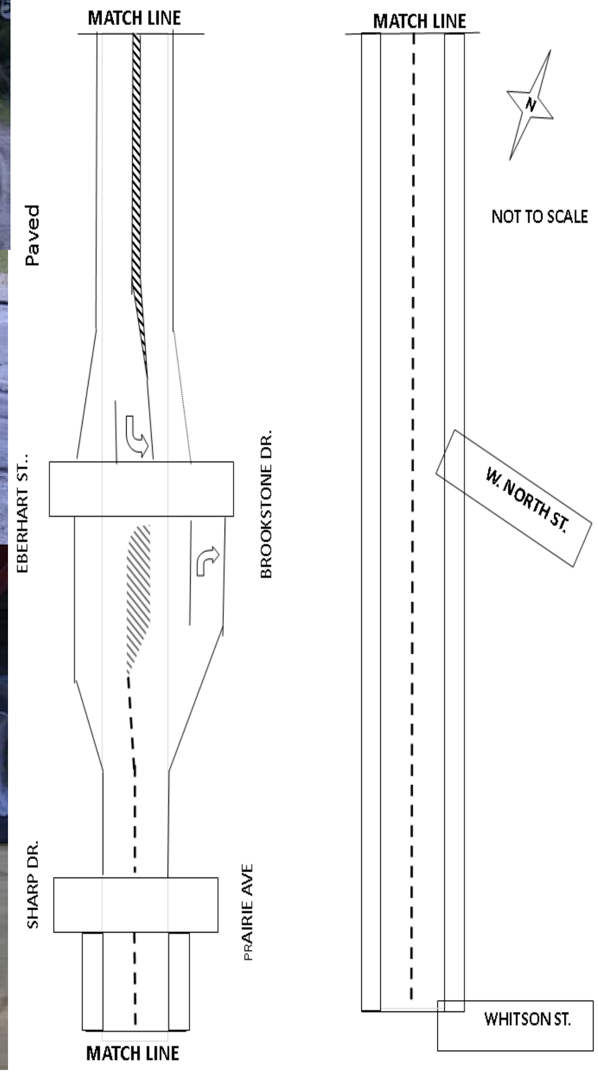


US 52 (Gougar to 2nd St.) - 185 N07



US 52 (Gougar to 2nd St.) - 185 N07





Construction Observations

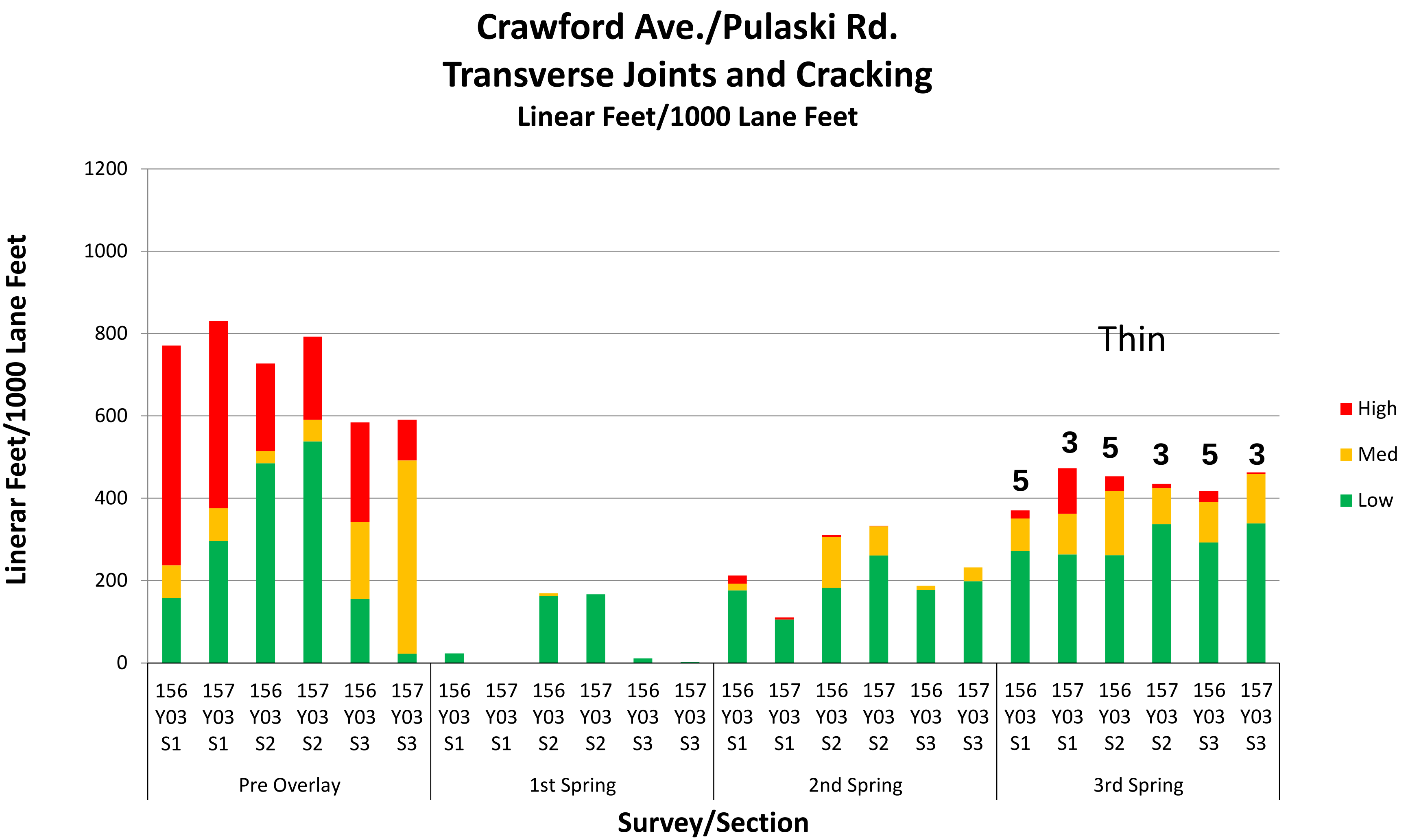
- **2014 milling operations could be improved upon (deep grooves from new teeth in worn head). – enforce existing specifications or adopt finer mill texture?**
- **2015 milling operation adequate**
- **Tack coat** adequate – with limited zebra stripes**.**
- Plan patching and cracking filling quantities were adequate.

2014 Let Projects

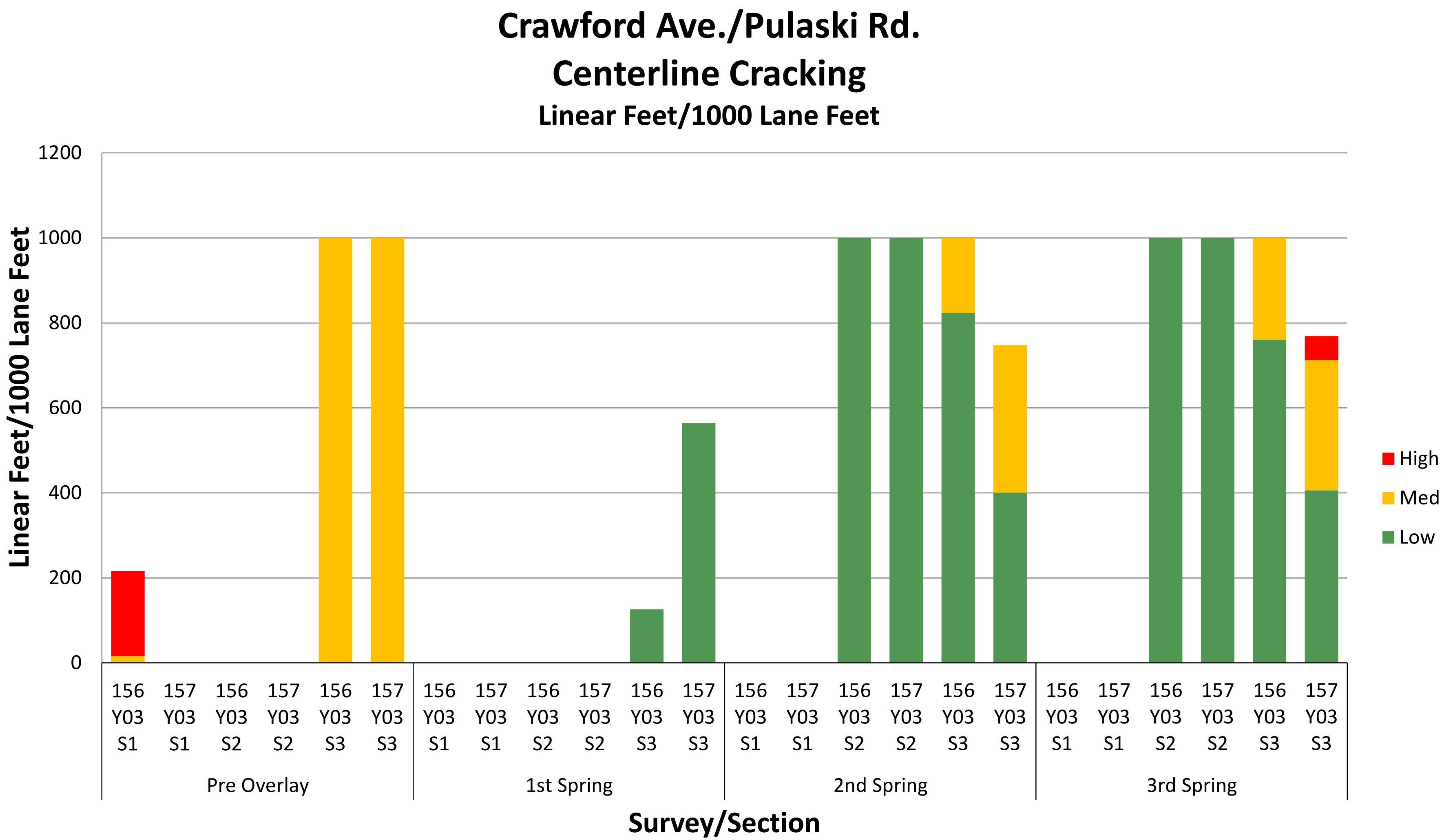
2014 Construction Distress Summary

Crawford/ Pulaski - 157 Y03 & 156 Y03

Transverse Joints and Cracking



Centerline Cracking

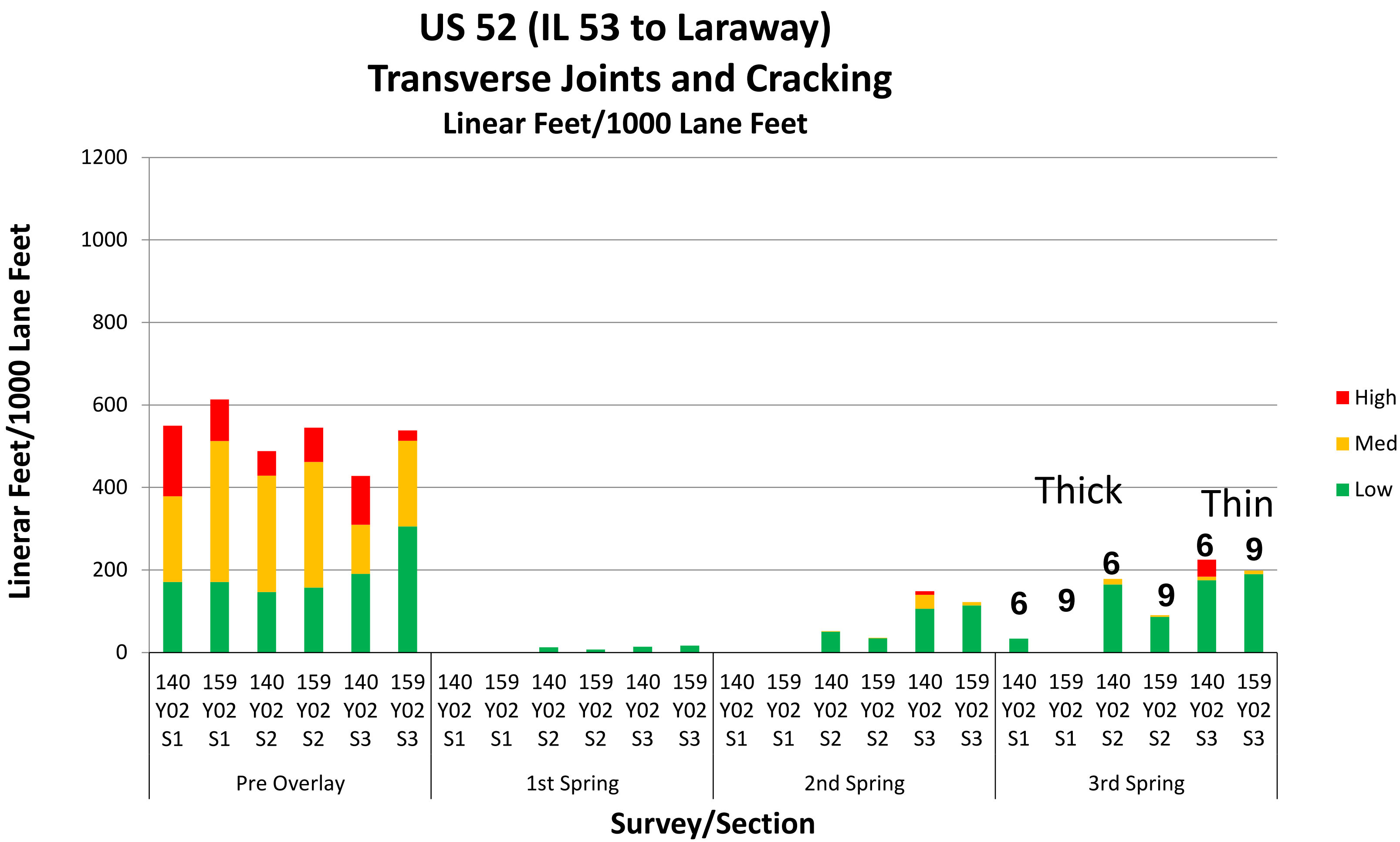


2014 Let Projects

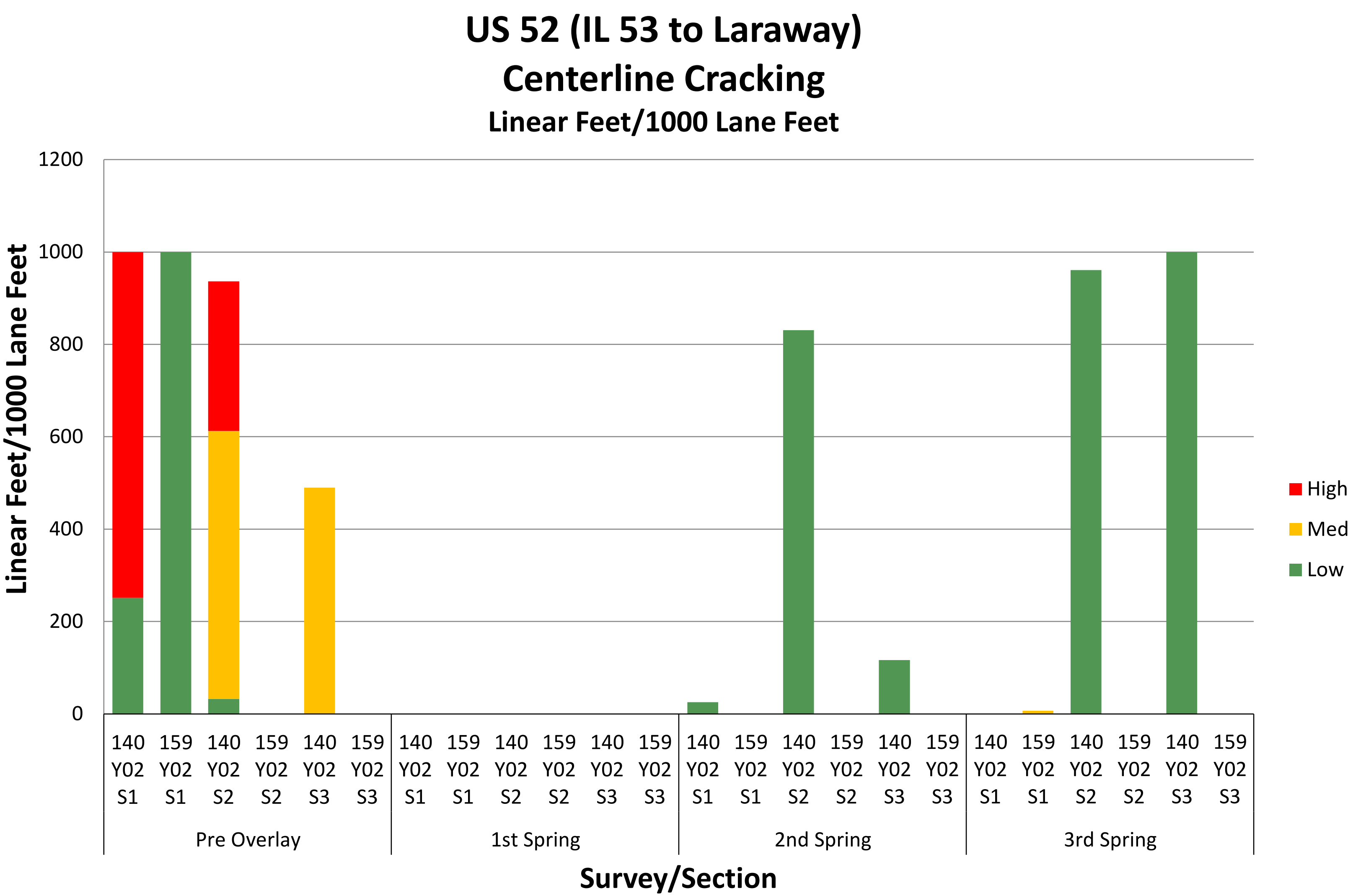
2015 Construction Distress Summary

US 52 (IL 53 to Laraway Y02) 140 Y02; 159 Y02

Transverse Joints and Cracking



Centerline Cracking



Main Observations
(2014 Let & Constructed Projects)

- **Transverse cracking similar by project more than segment or different mixes on a project.**
- **Higher amount of transverse cracking on Crawford/Pulaski "thin" project.**
  - 157 (SB) – ABR 30% w/PG58-28, RAS 5%
  - 156 (NB) – ABR 15% w/PG64-22, RAS 2.5%
- **Lower amount of transverse cracking on US 52 (Y02) project "thick" and "thin" segments.**
  - 140 (EB) – ABR 30% w/PG58-28, RAS 3.1%
  - 159 (WB) – ABR 29% w/PG58-28, No RAS
- **Raveling/Weathering/Segregation on nearly all project measured in 1st spring after construction on US 52.**
- **Fewer distresses at lower severity than 2013 projects.**

2014 Let Projects

2015 Construction Distress Summary

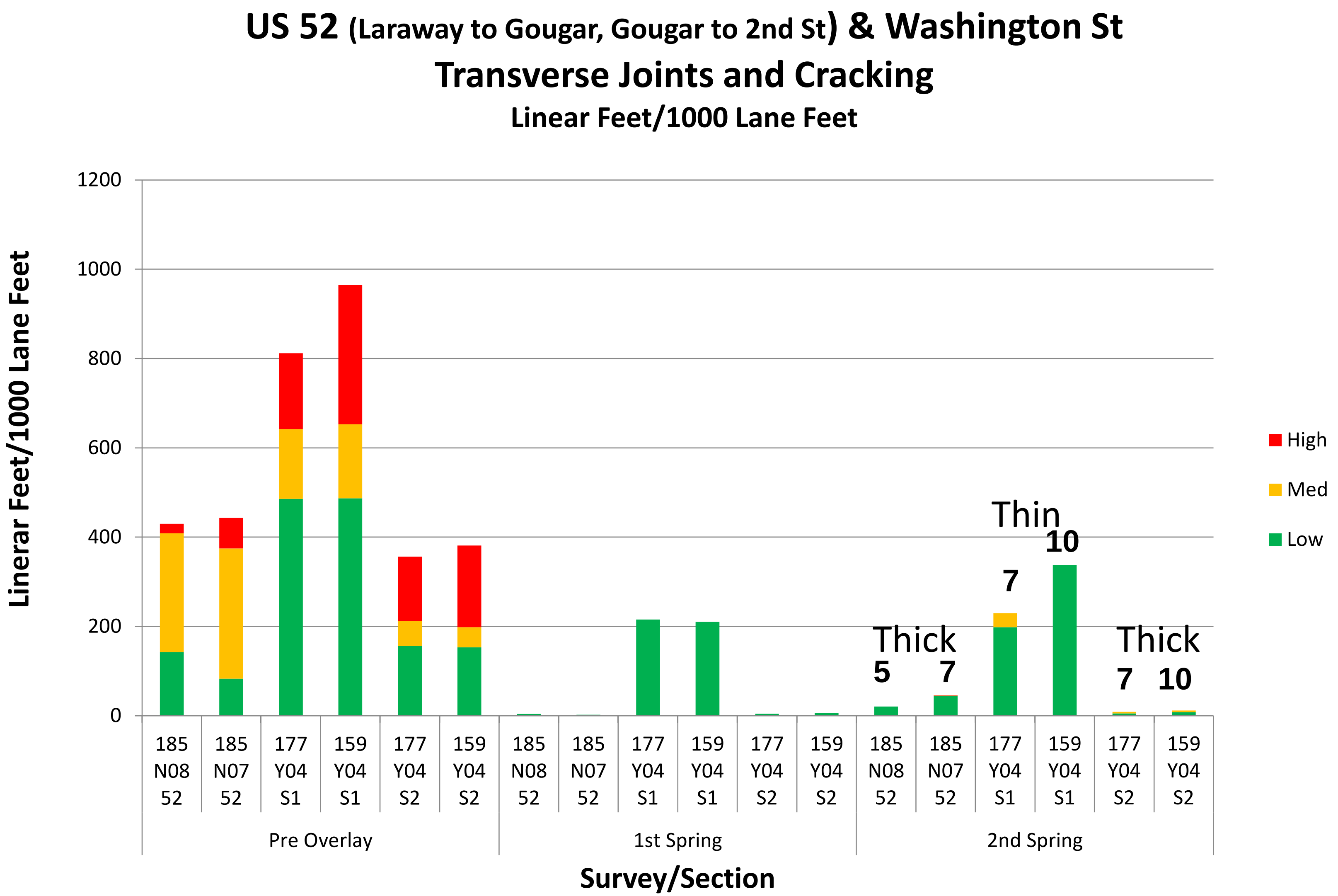
US 52 (Laraway to Gougar N08)

US 52 (Gougar to 2nd N07)

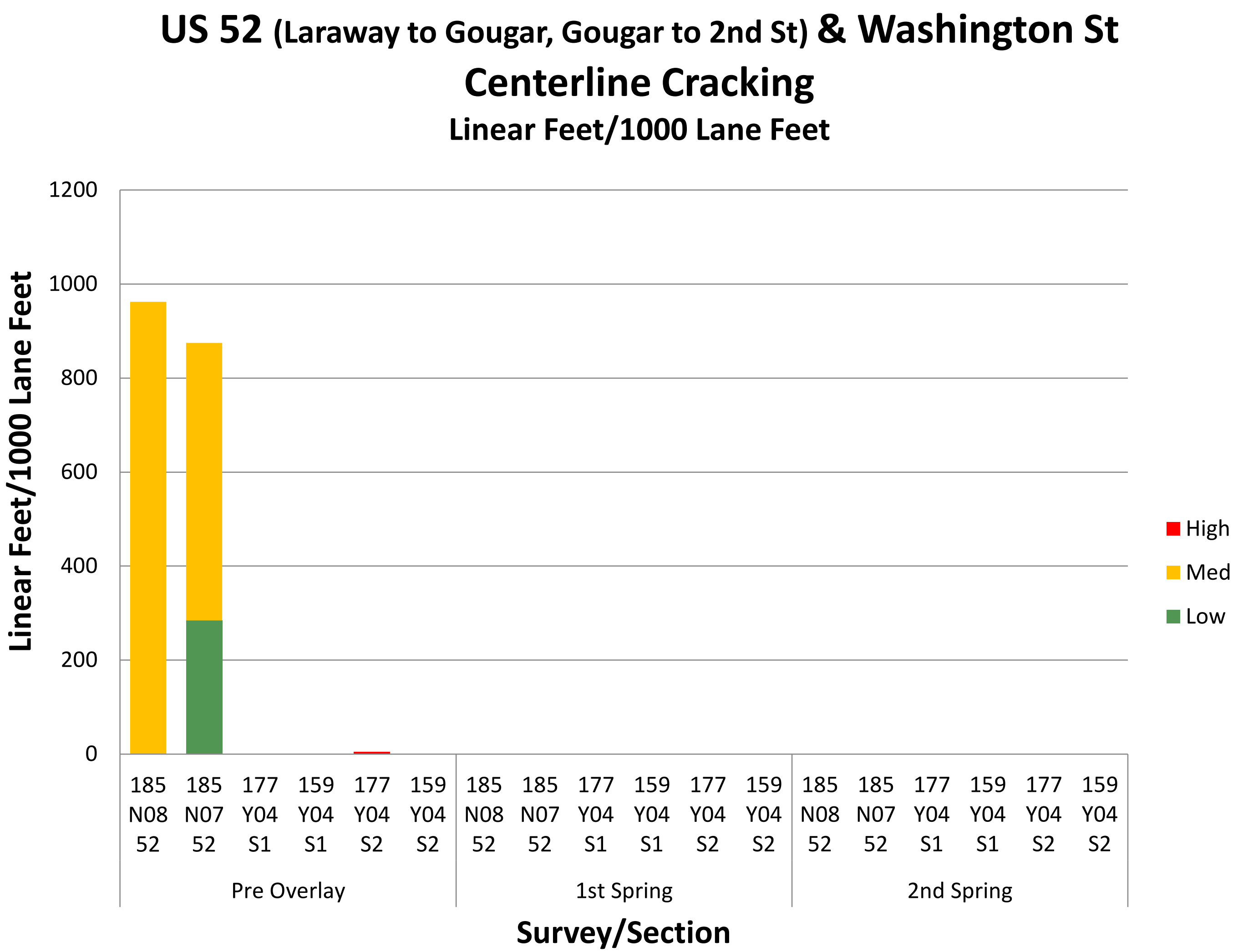
Washington St.

- Sec 1 (Thin)
- Sec 2 (Thick)

Transverse Joints and Cracking



Centerline Cracking



Main Distress Observations
(2014 Let Projects)

- **"Thin" overlays reflecting cracks/joints quickly**
  - West end Washington
  - Crawford/ Pulaski
- **"Thick" overlays (not removed by milling) reduces transverse cracking**
  - US 52 sections
  - Washington St. Segment 2
- **2015 TRA mixes performing much better than 2013 TRA mixes (thus far)**

Pavement Profile

High Speed Inertial Profiler

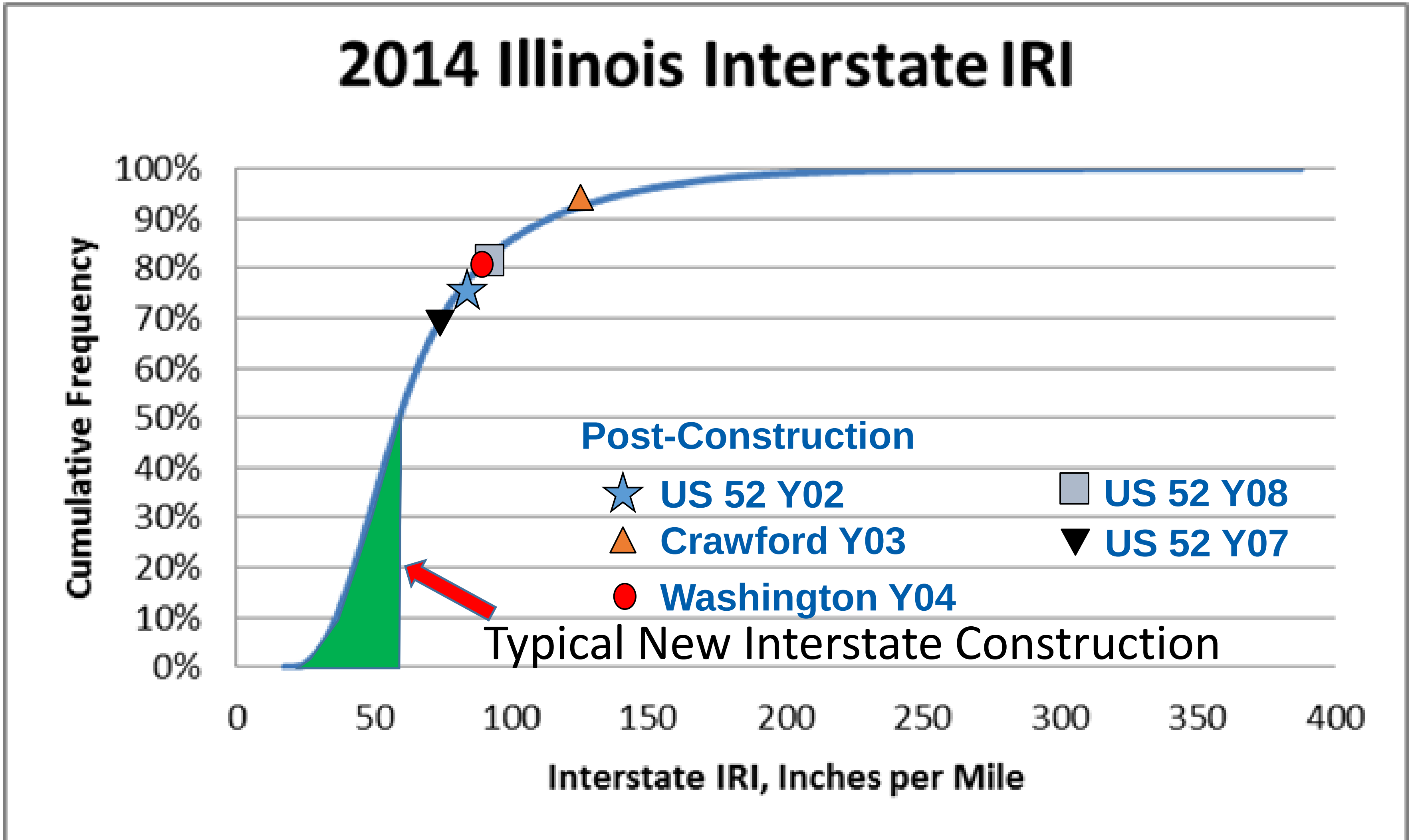
- IDOT tested pre-overlay
- ERI tested post-overlay
  - After Construction
  - 1st Winter Frozen
  - Annually thereafter
  - 2016 Spring and Fall
  - Spring 2017 – Final run

Data collected:

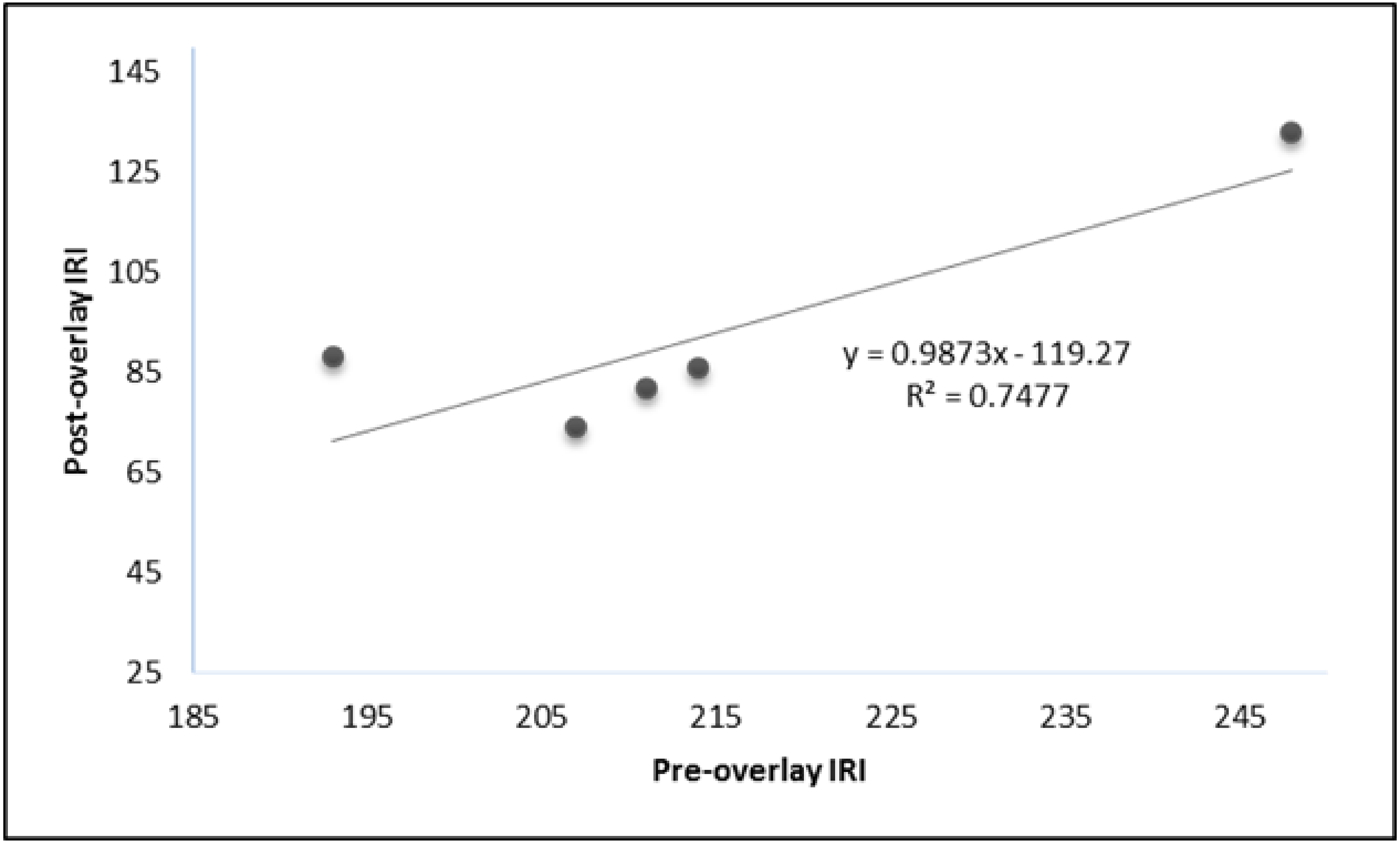
Roughness: International Roughness Index, in/mi

Rutting: Five point (each wheel path), in

IRI/Rutting


2014 Illinois Interstate IRI
Cumulative Frequency
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
50
100
150
200
250
300
350
400
Interstate IRI, Inches per Mile
Post-Construction
US 52 Y02
Crawford Y03
Washington Y04
US 52 Y08
US 52 Y07
Typical New Interstate Construction

IRI before and after Overlay

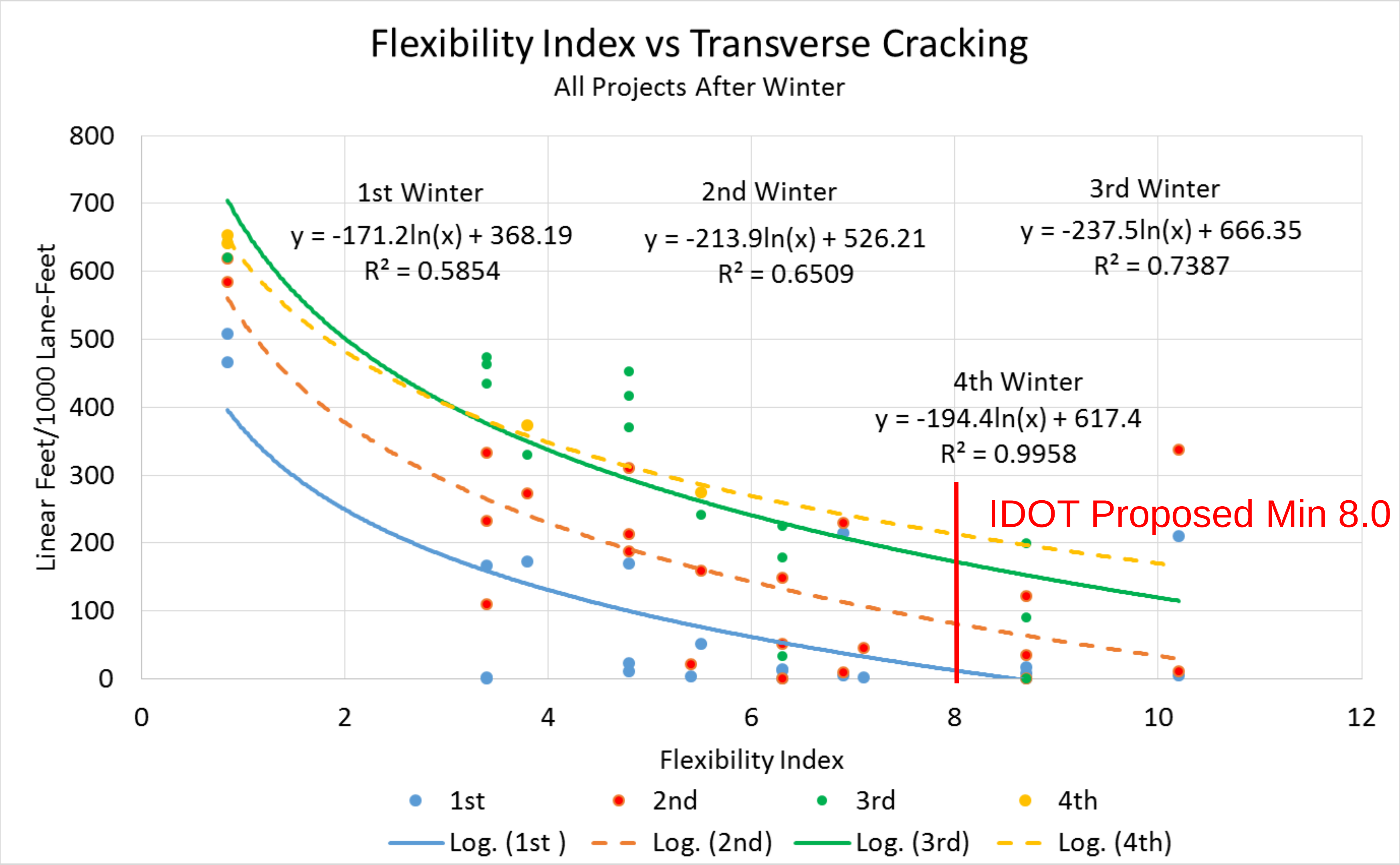


Profile Trend Observations

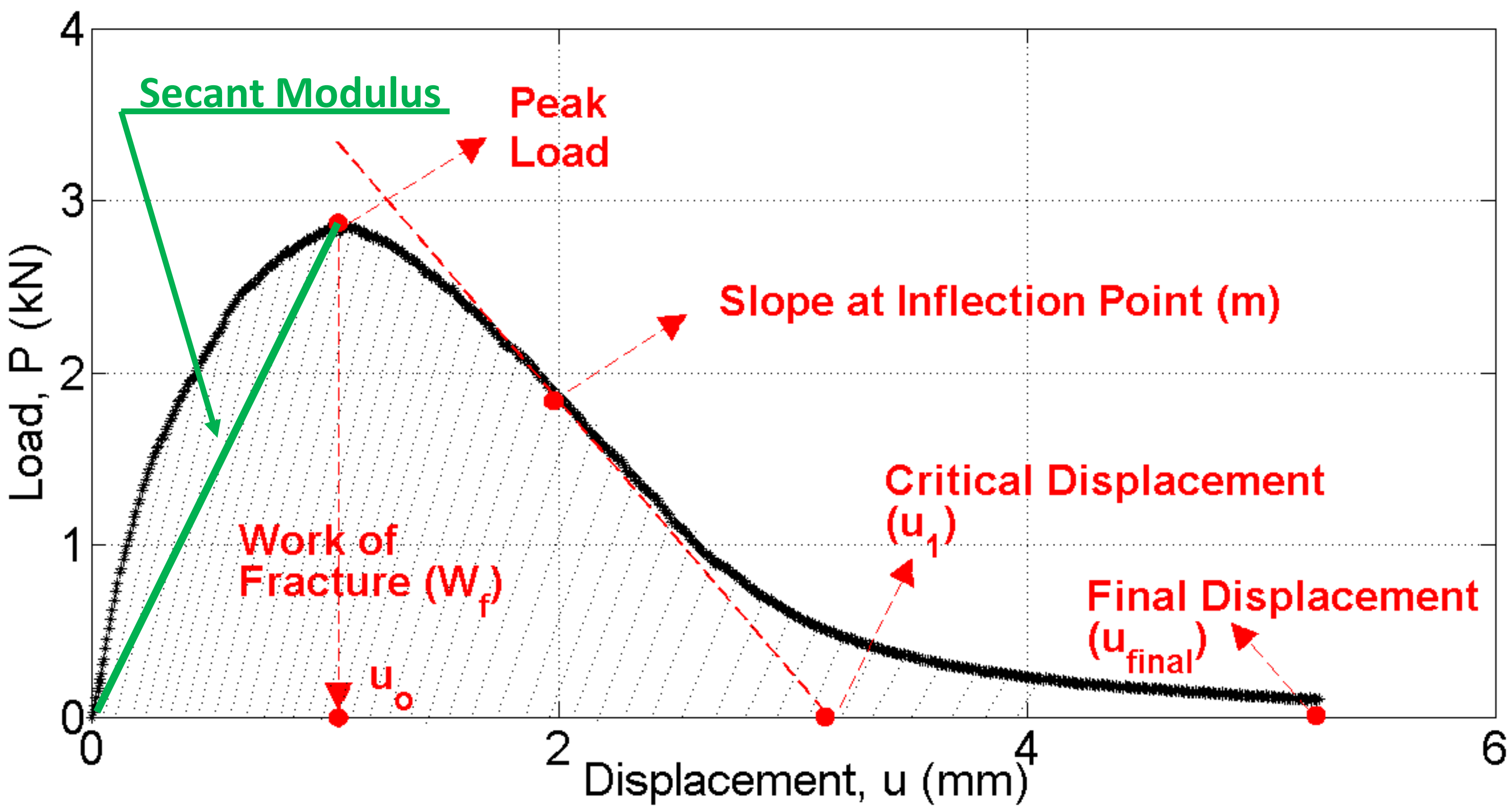
- IRI in the right wheel path higher than left wheel path.
- Annual increase in IRI higher in right wheel path
- Little difference by mix for both IRI and rutting - rutting low thus far
- Initial IRI could be smoother – Requires spec changes

Analysis

Flexibility Index

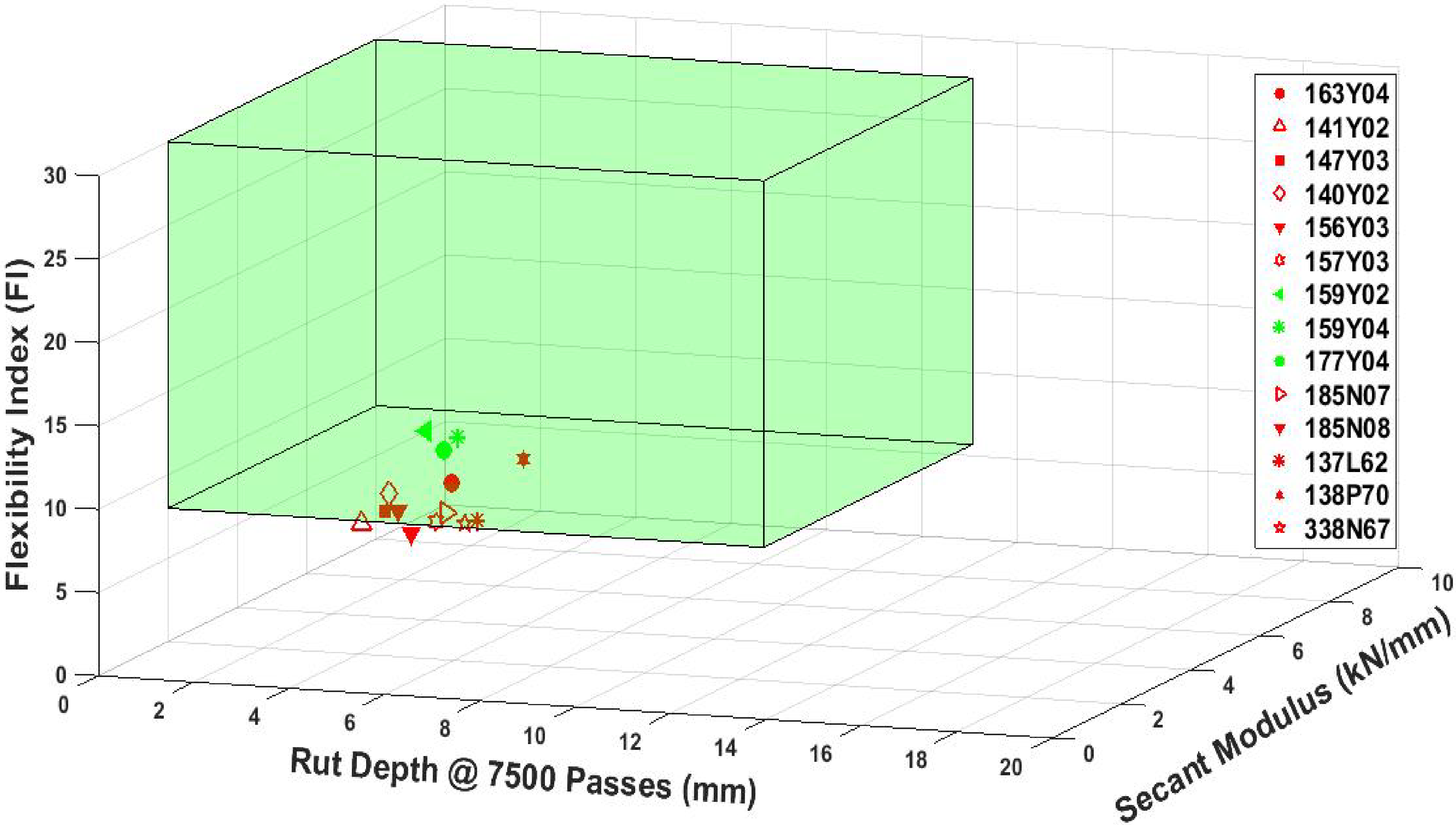


Typical I-FIT Test Result



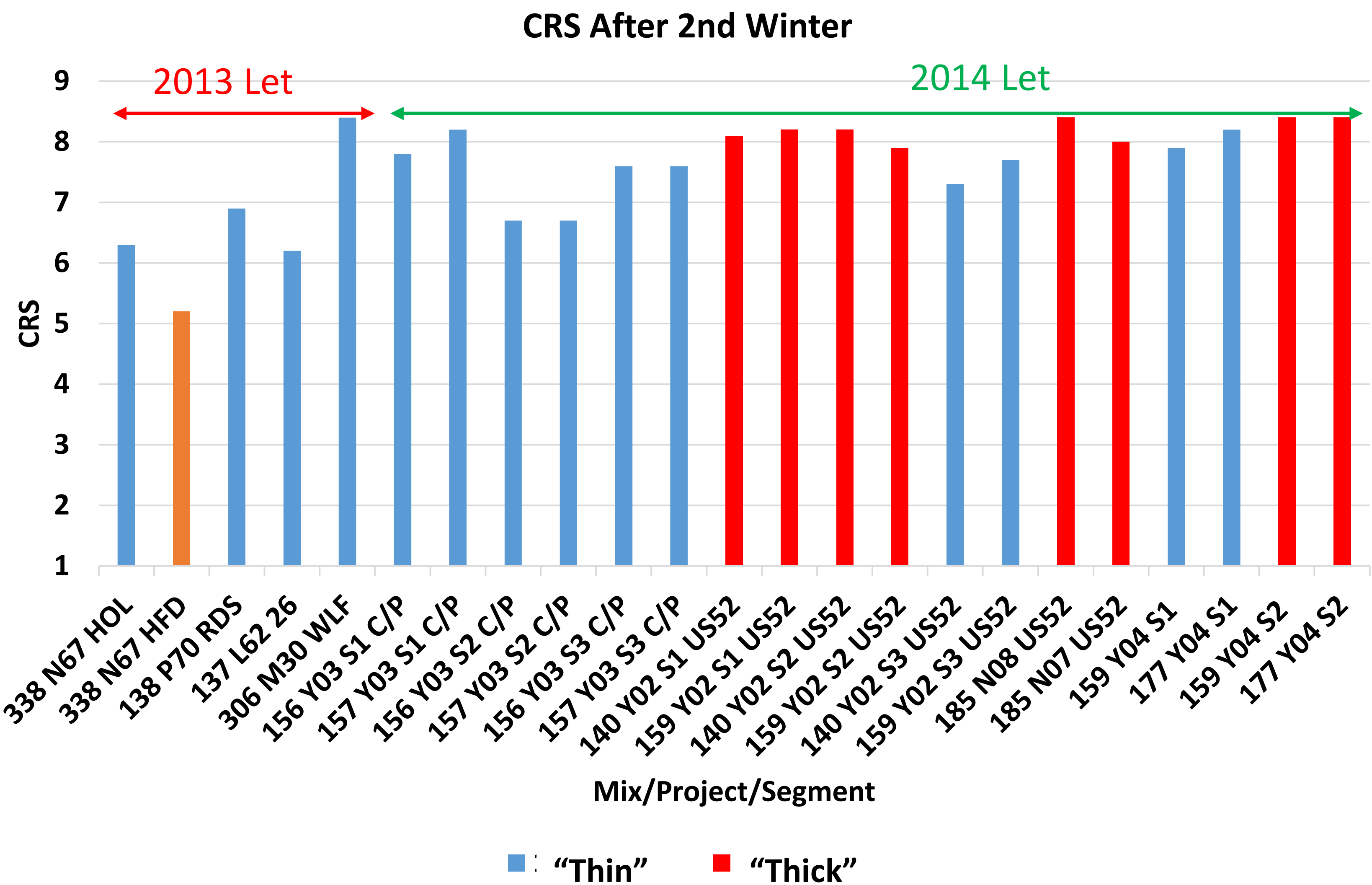
3D-BMD for PMLC

(Balanced Mix Design)

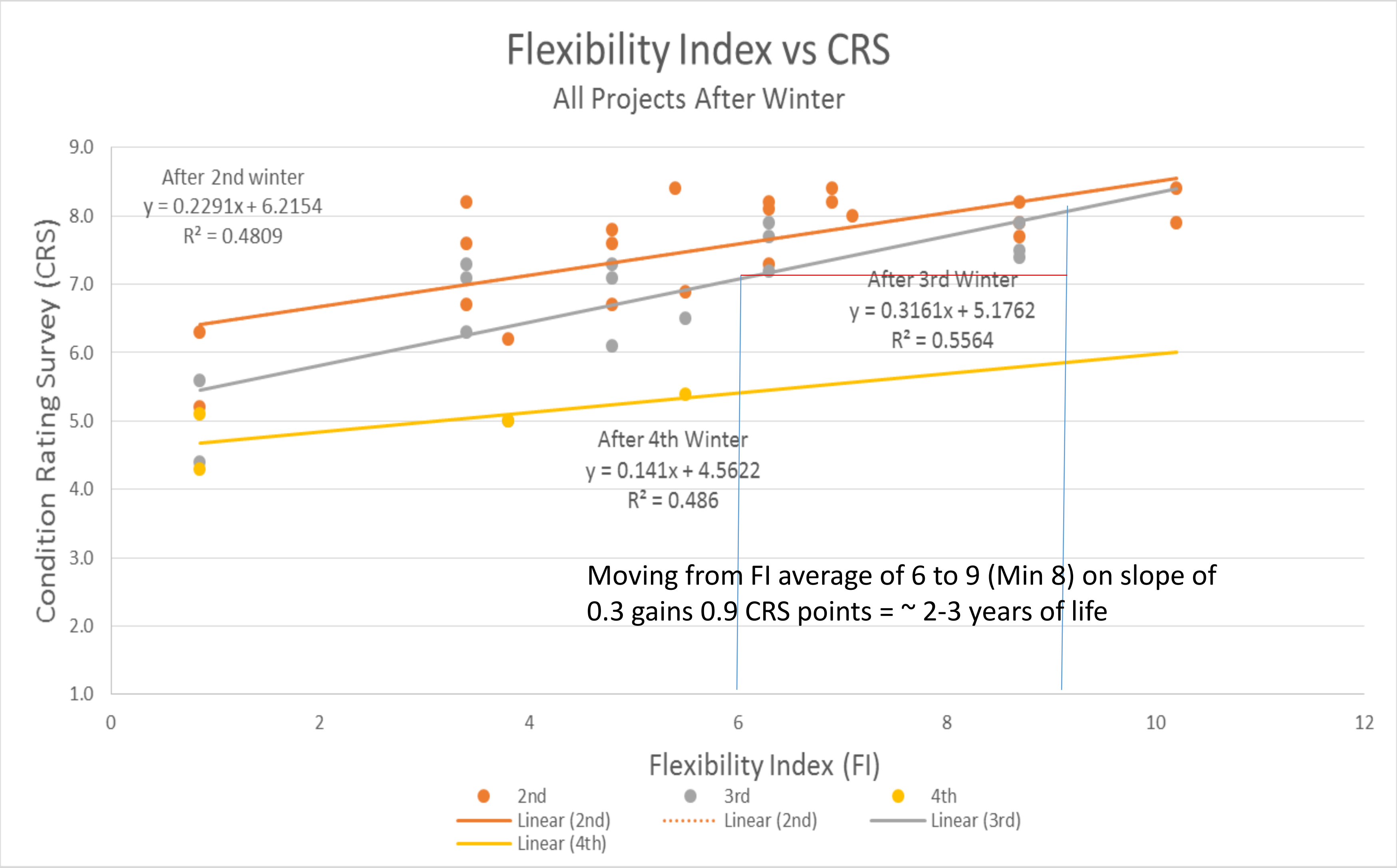


CRS Analysis

CRS after 2nd Winter



CRS



Moving from FI average of 6 to 9 (Min 8) on slope of 0.3 gains 0.9 CRS points = ~ 2-3 years of life

Main CRS Observations

- 2013 (N50) TRA projects performed worse at any given time.
  - After 4 years nearly same CRS as pre-construction on Harrison – Mix 338 N67 (FI = 1.6)
- Wolf Road (2013 let– No RAS and N70) performed similar to 2014 let projects
- "Thin"/"Thick" CRS trends are different, but not as strong as transverse cracking trends

Findings

Overall Study Findings

- Projects that left an AC layer of 3.5 in or more in place after milling resulted in less cracking in the new overlay.
- The highest FI in the study, over 10, was the result soft -binder (PG 58-34) and moderate ABR rate (30%) - Washington Street project.
- Increase FI values correlated to higher Condition Rating Survey (CRS) values as the pavement aged and therefore longer pavement life.
- The Texas overlay test did not correlate to transverse-cracking development in the first four years.
- Pavement rutting is well within values that would be expected for the pavements under study.

Findings (Continued)

- For the 2013 let TRA projects, pavement distress, (types, extent, and severity) is developing sooner than for the comparison project on Wolf Road.
  - TRA with 37 to 60% ABR, while Wolf Road project has 20% ABR with no RAS.
- The TRA projects on US 52 (60N07 and 60N08) are performing much better than the TRA projects constructed in 2013, which correlates to FI of the AC mixture and pavement families.
- Alternatives to the "mill and fill" approach of pavement rehabilitation such as hot or cold in-place recycling should be considered where appropriate in order to obtain the benefits of reduced cracking of the "thick" pavement family.

Conclusions

CONCLUSIONS

- The Illinois Flexibility Index Test (I-FIT) and resulting flexibility index (FI) can be used on plant sampled laboratory compacted AC mixtures to characterize the potential of transverse cracking in pavements.
- Transverse cracking initiation and propagation are influenced by both the AC mixture characteristics and pavement family.
- The regression analysis of FI and transverse cracking indicates that transverse cracking can be reduced in both thin- and thick-pavement families by using AC with a minimum FI of 8.
- Low FI values and thin-AC overlays of PCC pavement, may result in high amounts of reflective cracking early in the overlay life. i.e. Harrison Street mix 338.

CONCLUSIONS (cont.)

- The use of polymer asphalt-binder (PG 70-28) in the 4.75 level binder with approximately 30% ABR (RAP/RAS) resulted in FI values similar to the surface AC mixes in this study. Limited use for controlling reflective cracking.

Recommendations

Recommendations

- **I-FIT should be adopted** for use as a specification requirement **in AC mixture design** and/or production.
- The proposed Flexibility Index (**FI**) value of **8.0** by IDOT **should be adopted**
- **Balance mix design** should be used and explore the **3D balance mix design**.
- Use of **virgin aggregates** rather than all recycled aggregates, would result in **better** production **control** of the AC mix and **less absorption** which would **reduce cost** of TRA mixes.


Thank You