PAVEMENT FRICTION AND SAFETY PERFORMANCE

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PAVEMENT FRICTION AND SAFETY: HISTORICAL

- Friction data has primarily been used for evaluating surface mix performance
- Consideration of safety and friction
  - Reactionary
  - Crashes are random in nature
  - Analysis period of 3 to 5 years
  - Without friction data, difficult to identify trends/contributing factors
  - Friction data collected for a specific location and provided upon request
  - Spot friction measurement with a locked-wheel trailer: limited at curves and intersections

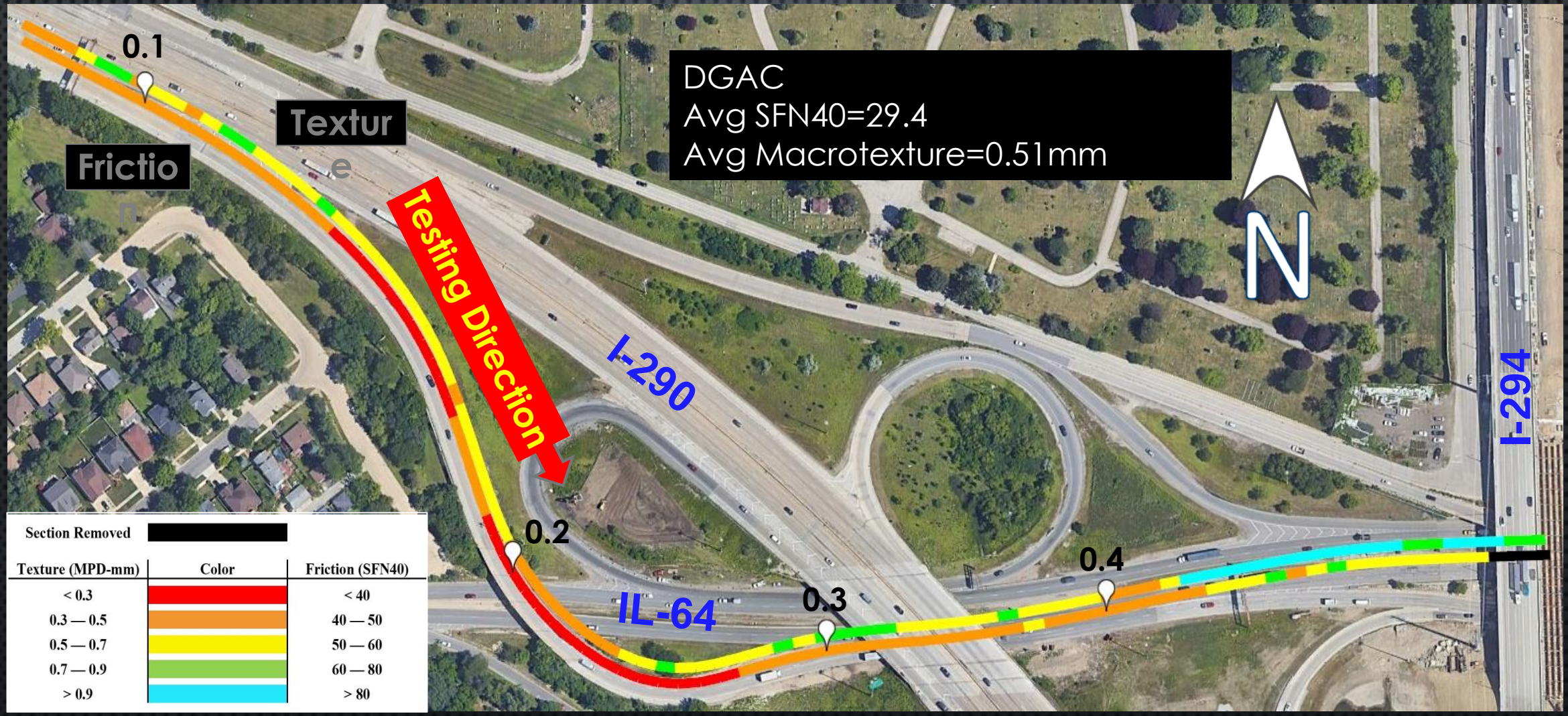
PAVEMENT FRICTION AND SAFETY PERFORMANCE

MYTH: FRICTION ONLY CONSIDERS WET CRASHES

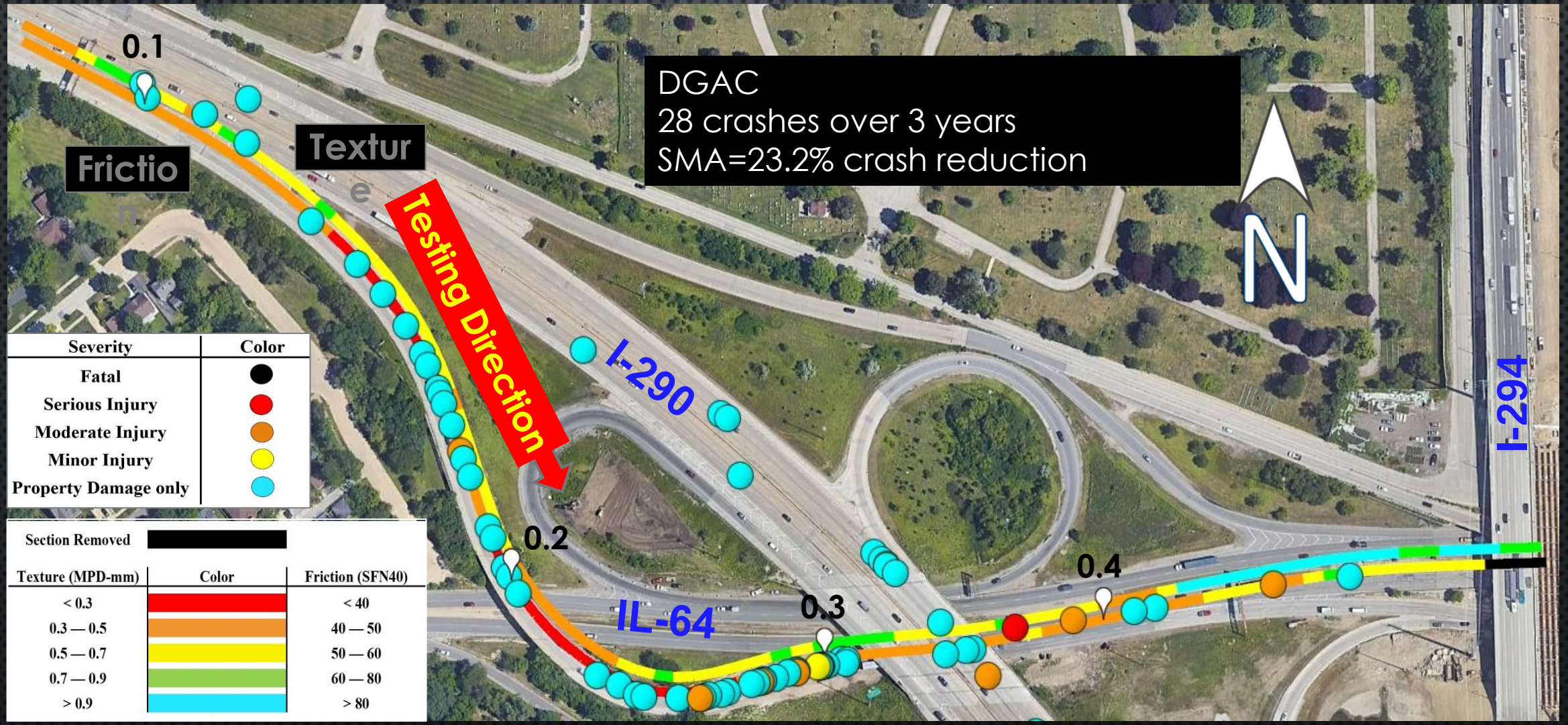
FRICTION DEMAND ROADWAY CHARACTERISTICS

- Varies based on roadway characteristics.
  - Changing geometrics (e.g., horizontal curves, intersections, steep grades).
  - Site conditions (traffic volumes, congestion, sight distance, lane changes, ramp/mainline entry, quarries).
  - Driver characteristics (reaction time, alertness, experience)
  - Vehicle characteristics (tires, vehicle weight, brakes, suspension system)
  - Speed

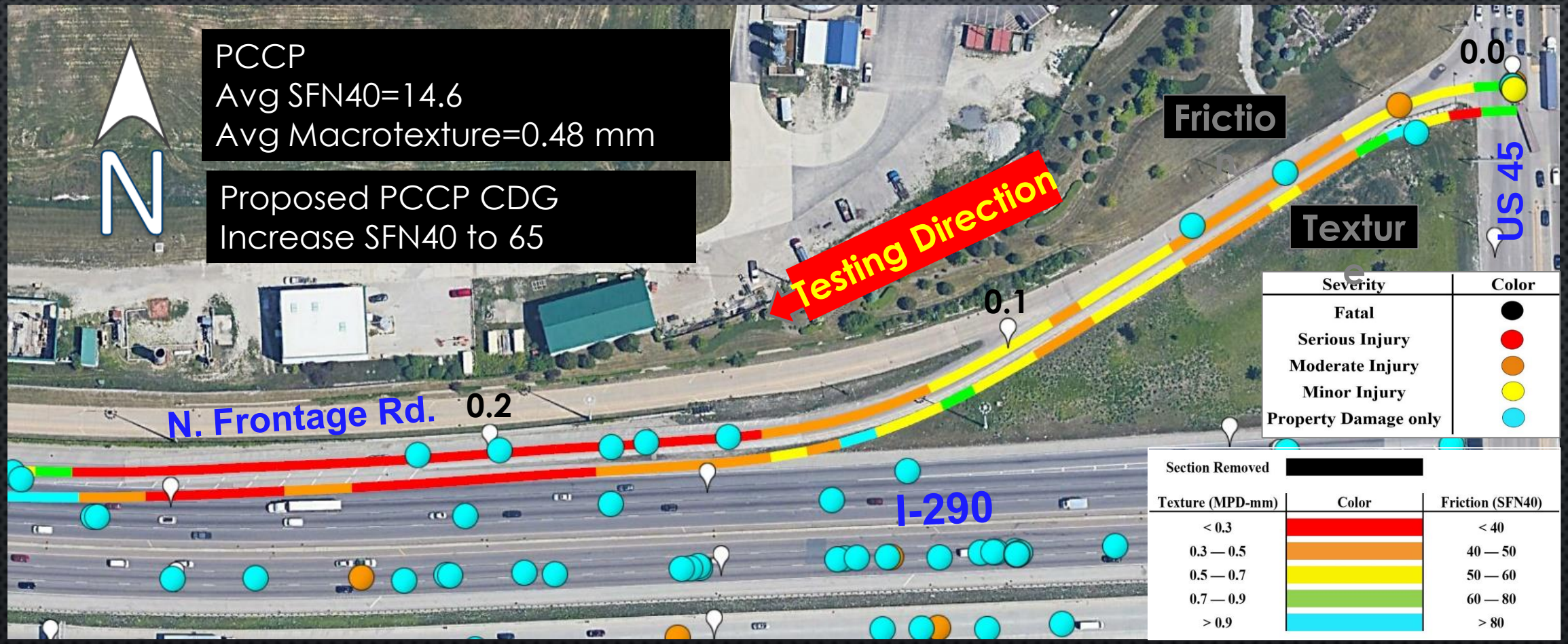
IDOT District 1



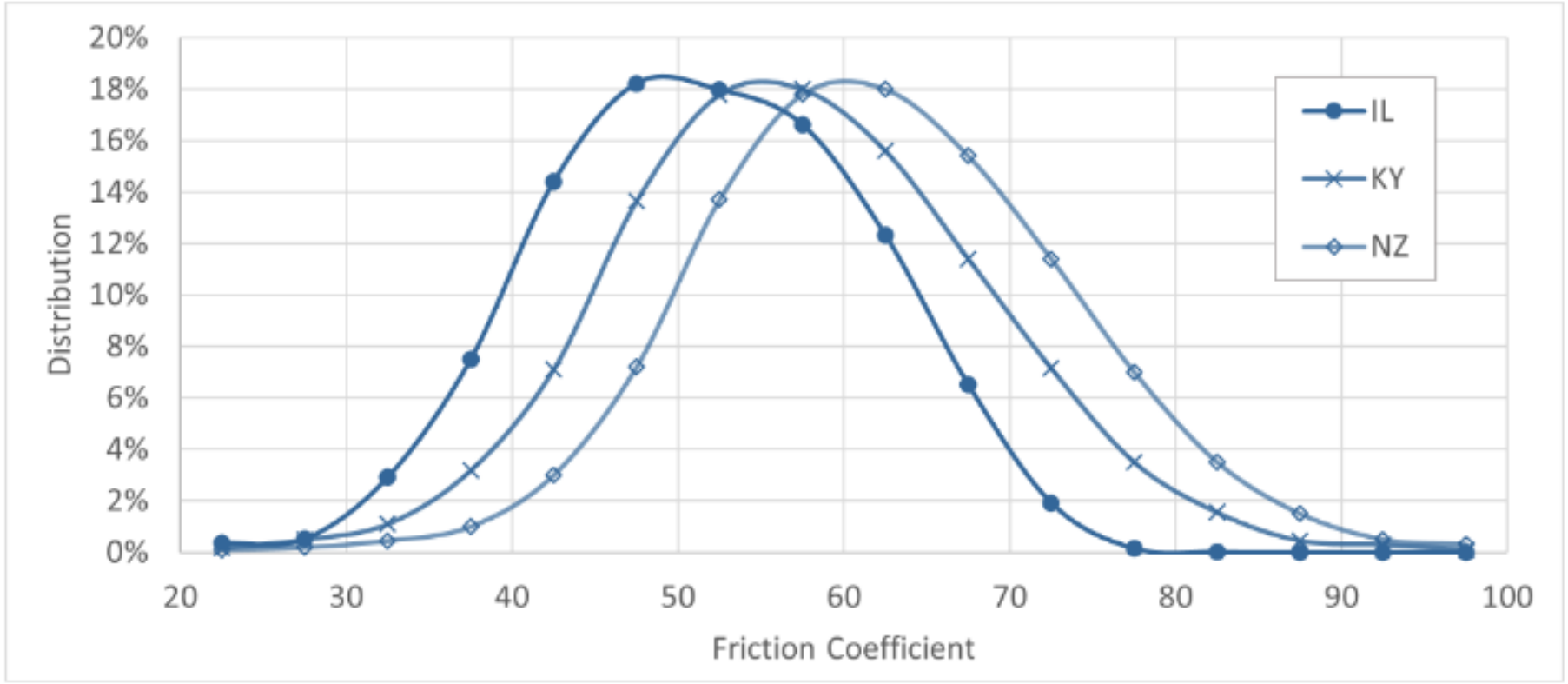
IDOT District 1



IDOT District 1



PAVEMENT FRICTION PERFORMANCE



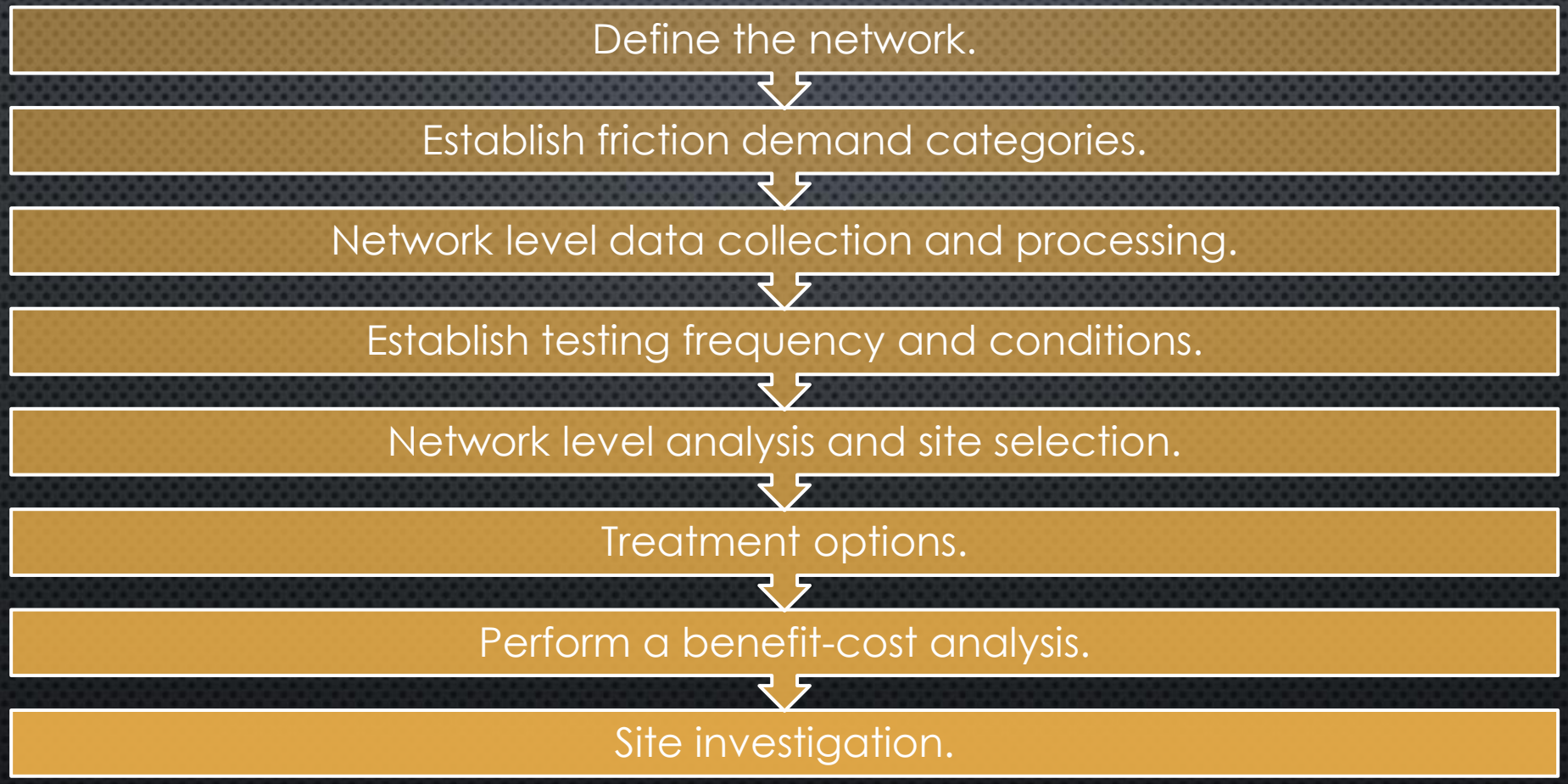
Source: UIUC, ICT R27-264

Comparison of SCRIM data distribution: Illinois vs Kentucky vs New Zealand

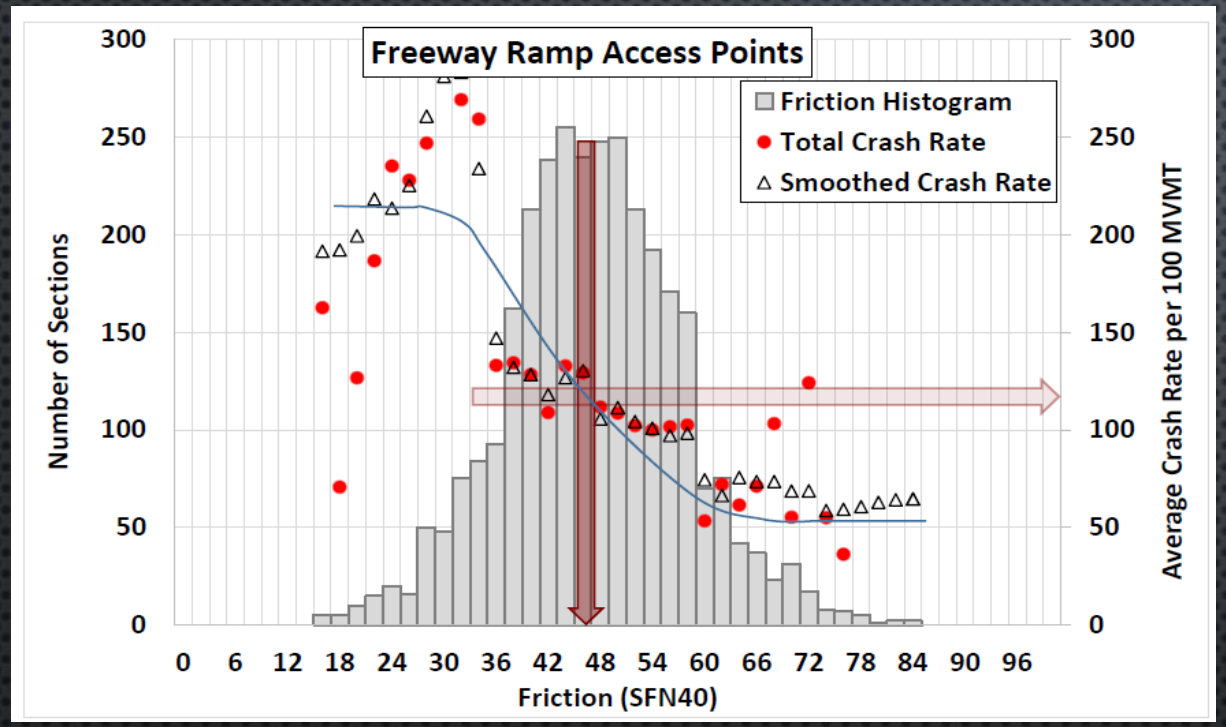
Vaughn, M. (2024). Safety and friction enhancement. In TRB Annual Meeting, Pavement Friction Management Continuous Pavement Friction Measurement, and Safety Analysis, Workshop 1024, Washington, DC.

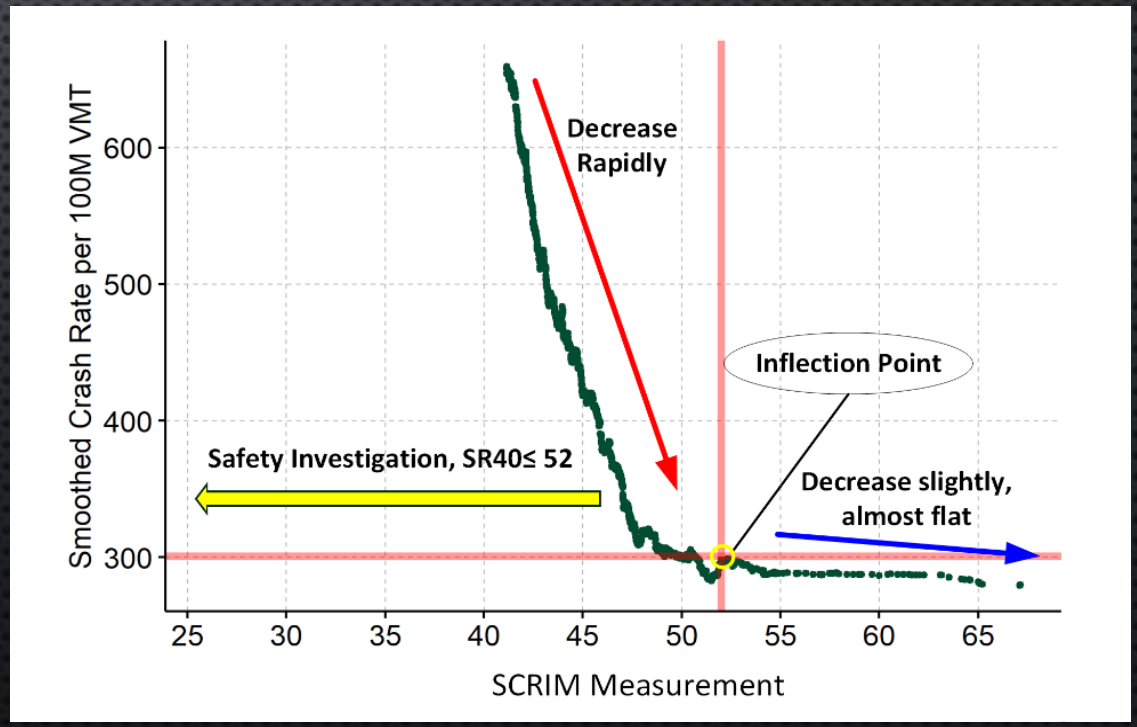
Izeppi, E., McCarthy, R., Flintsch, G. W., and Tobias, P. (2023). Continuous friction measurement and pavement friction management demonstration for the Illinois department of transportation. Draft final report, Virginia Tech Transportation Institute (VTTI). TPF-5(345) Pavement Surface Properties Consortium – Managing the Pavement Properties for Improved Safety.

PAVEMENT FRICTION MANAGEMENT PROGRAM



Investigatory Levels (Graphical Representation)





FRICTION DEMAND AND INVESTIGATORY LEVELS

Roadway Facility Type	Site Type	Suggested per FHWA
Freeways	Tangents	40
	Curves	45
	Ramp Access	45
Rural Multilane Roadways	Divided Tangents	50
	Undivided Tangents	50
	Curves	55
	Intersections	55
Rural 2-lane, 2-way Roadways	Tangents	50
	Curves	55
	Intersections	55
Urban and Suburban Arterials	Divided Tangents	50
	Undivided Tangents	50
	Curves	50
	Intersections	55

- FHWA RECOMMENDED INVESTIGATORY LEVELS

- FLORIDA DOT
- RECOMMENDED INVESTIGATORY LEVELS

Area	Pavement Type	Suggested IL	
		SR40	MPD (mm)
Urban and Suburban	Open	≤50	≤2.6
	Dense and Rigid	≤52	≤1.6
Rural	All	≤52	≤1.8

Economic Analysis

Treat sections with B/C ≥ 1.0:

$$B/C = \frac{\text{CR Savings}}{\text{Estimated Treatment Cost}}$$

Average Crash Cost=$169,816 & 10,931 crashes

Treatment Selection Criteria: these could sometimes be:

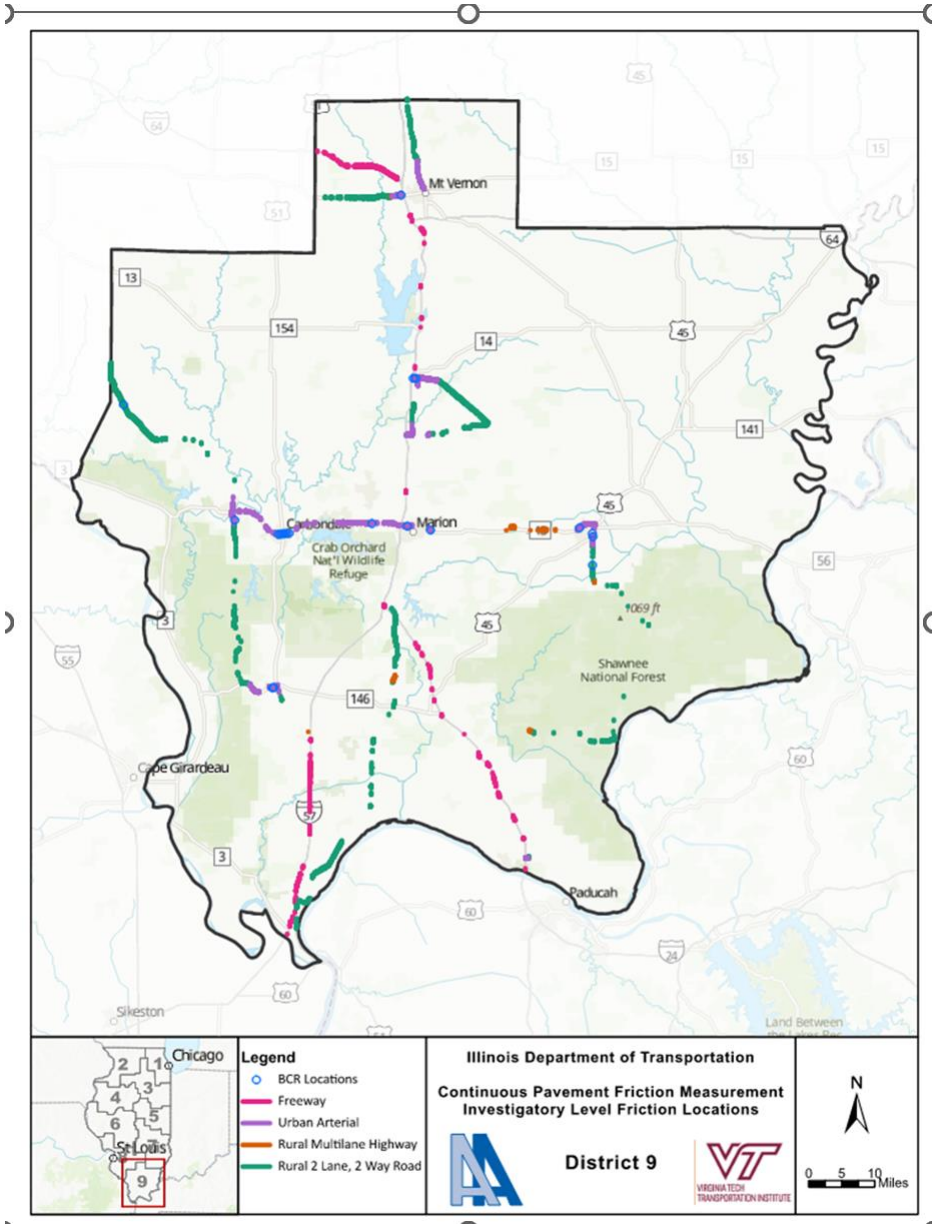
- **Interstate:**
  - i. DGAC & SMA: SMA Overlay
  - ii. PCCP CDG: PCCP Conventional Diamond Grinding
- **Primary:**
  - i. PCCP CDG > 5 Yrs : PCCP Conventional Diamond Grinding
  - ii. DGAC > 5 Yrs: DGAC Overlay
  - iii. SMA > 5 Yrs: SMA Overlay

However, for Illinois DOT it was just considered a replacement.

Illinois Friction Enhancement Economic Analysis Results

Savings/ Sections	Number of Treated Sections					Predicted Crash Reductions	Treatment Cost ($MM)	Total Savings ($MM))	Average B/C
	DGAC	SMA	CDG	HFST	Total				
$1.0 M	0	1	0	1	2 (0.01%)	14 (0.13%)	$0.055	$2.320	43
$0.5 M	1	1	1	8	11 (0.06%)	42 (0.38%)	$0.376	$6.677	19
$0.4 M	1	0	3	10	14 (0.08%)	38 (0.35%)	$0.504	$5.983	13
$0.3 M	9	1	4	5	19 (0.11%)	47 (0.43%)	$0.377	$6.487	18
$0.2 M	16	1	8	20	45 (0.25%)	70 (0.64%)	$1.080	$10.794	11
$0.1 M	79	6	38	45	168 (0.93%)	153 (1.40%)	$3.258	$22.783	8
Total	**106**	**10**	**54**	**89**	**259 (1.43%)**	**364 (3.33%)**	**$5.652**	**$55.044**	**10.7**

Pavement Friction Management Using CFME



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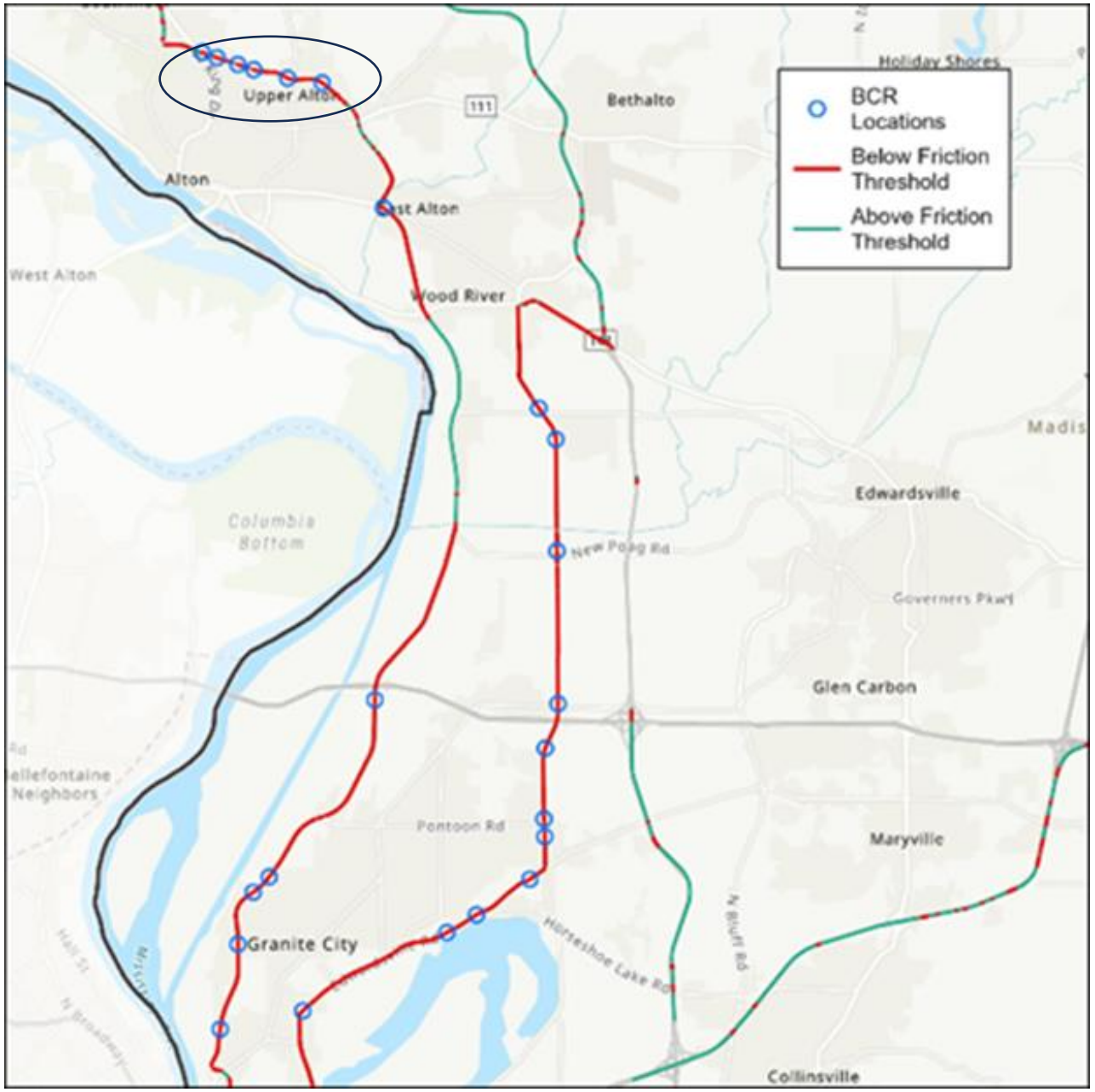
Pavement Friction Management Using CFME



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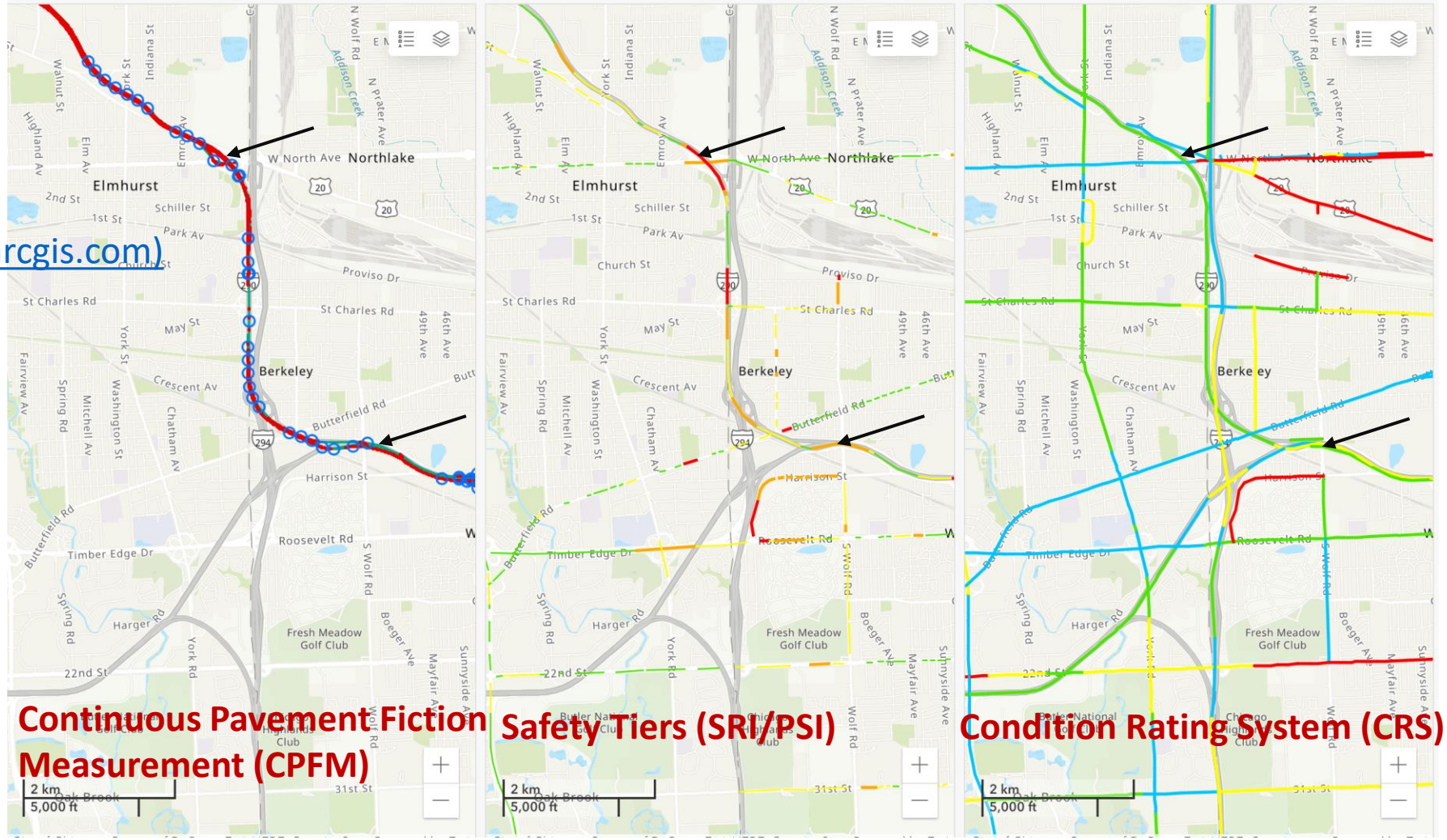
Asset Management
Interaction of CPFM, Safety Tier (PSI), and CRS

[CPFM Web Map (arcgis.com)]



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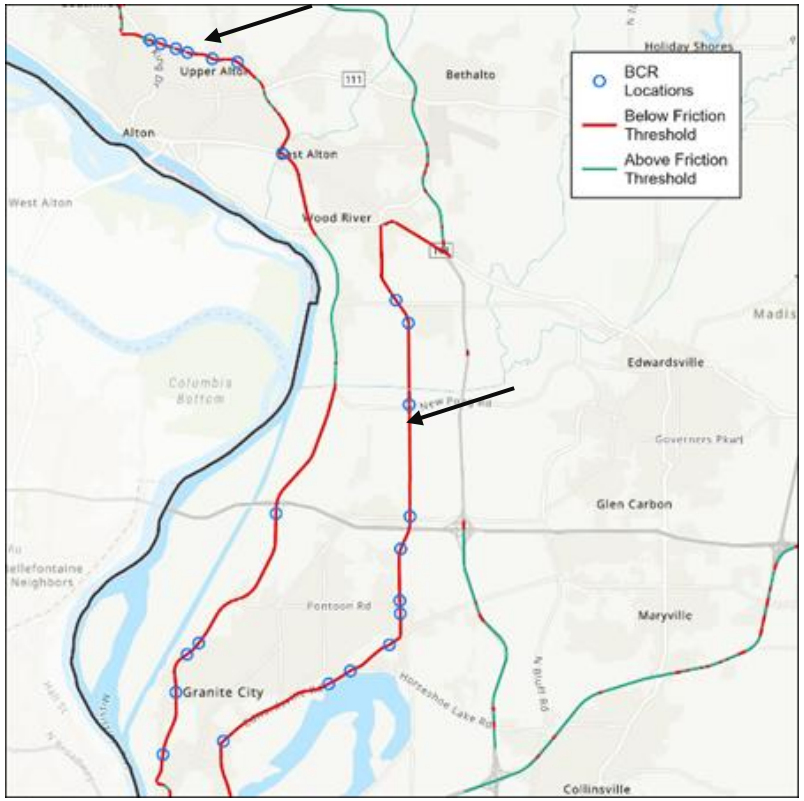
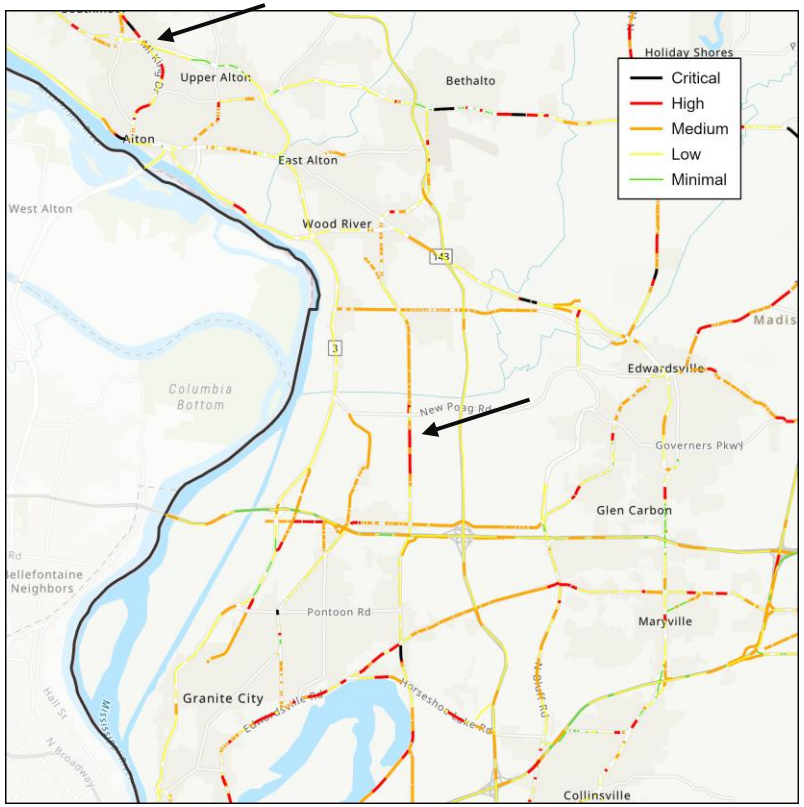
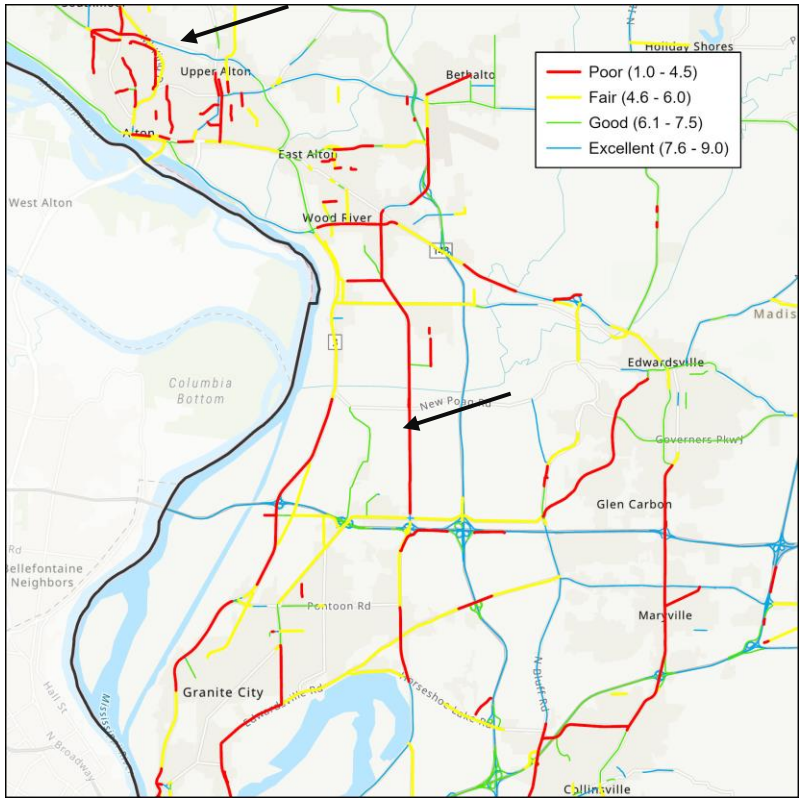


Continuous Pavement Fiction Measurement (CPFM)



Safety Tiers (SRI/PSI)



Condition Rating System (CRS)

[CPFM Web Map (arcgis.com)]

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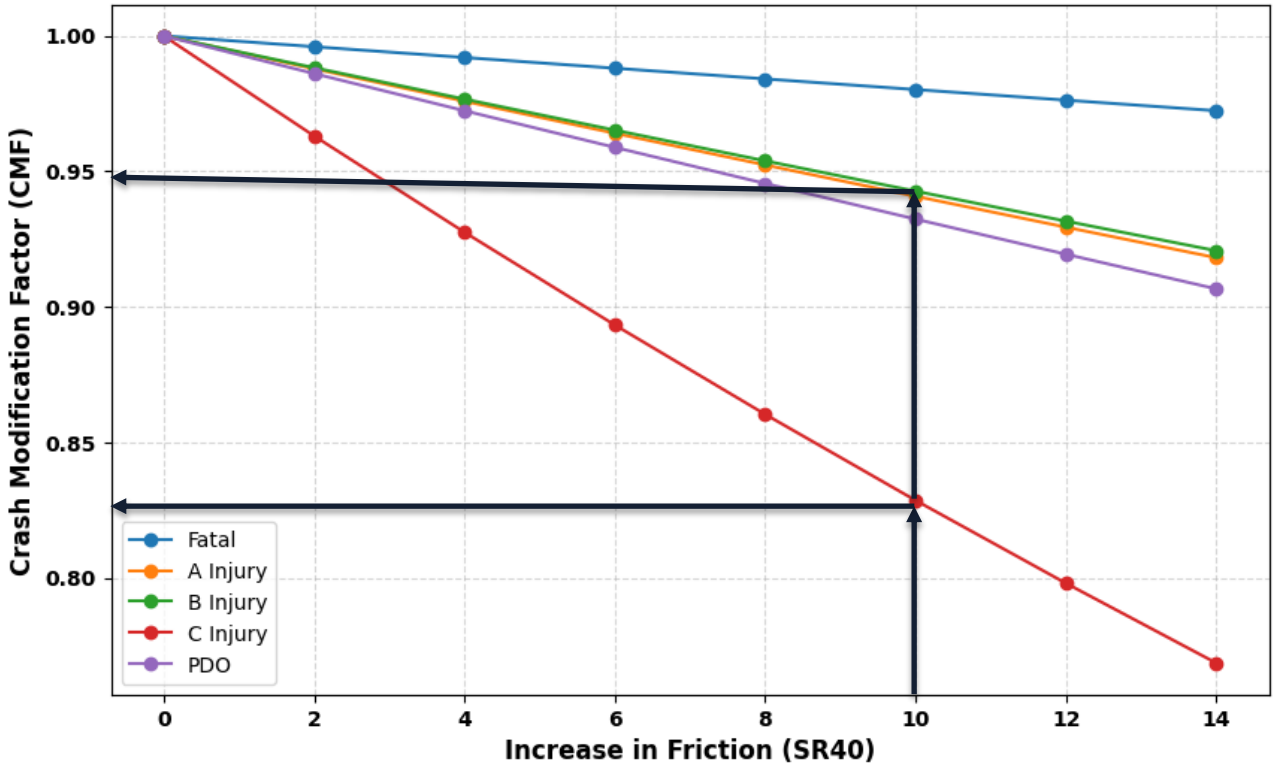
ICT R27-264 Preliminary Results

Crash Modification Factor: Increasing friction number reduces crash frequency for various severity levels.

- Formula: relative reduction

$$CMF = e^{(\beta_f \cdot \Delta f)}$$

- 10-Unit increase in friction results in reduction of more than 15% of C - Injury crashes and 5% of other crashes
- Absolute reduction for 10-unit friction increase:
  - K – 0.000056
  - A – 0.0008
  - PDO – 0.02



Comparison of CMFs for Friction Increase on Different Crash Severities

PAVEMENT FRICTION AND SAFETY

- **KENTUCKY TC**: A 10-UNIT INCREASE IN AVERAGE FRICTION VALUE ON PRIMARY/SECONDARY ROUTES.
  - 17-33% REDUCTION IN WET AND DRY CRASHES,
  - UP TO 24% REDUCTION IN FATAL AND SERIOUS INJURY CRASHES OVER A 5-YEAR PERIOD
- **WYOMING DOT**:
  - PAVEMENT FRICTION WAS A CRITICAL FACTOR ASSOCIATED WITH CRASHES
  - INCREASE IN PAVEMENT FRICTION VALUES FROM 25 TO 45 SIGNIFICANTLY DECREASE SEVERE INJURY AND FATAL CRASHES.
- **FLORIDA DOT DISTRICT 7**:
  - GOAL IS TO INCORPORATE NETWORK LEVEL PAVEMENT FRICTION AND SAFETY ANALYSIS INTO 3R PROJECTS.
  - 1,484 SEGMENTS IN SAFETY TIERS 1-3, INCORPORATING INTO 3R.

SAFETY TIER	PSI THRESHOLDS	DESCRIPTION
1 - CRITICAL	TOP 5%	MOST OPPORTUNITY FOR SAFETY IMPROVEMENT
2 - HIGH	5% - 10%	2ND MOST OPPORTUNITY FOR SAFETY IMPROVEMENT
3 - MEDIUM	10% - 25%	3RD MOST OPPORTUNITY FOR SAFETY IMPROVEMENT

Florida DOT Crash Reduction Estimation

- Estimate expected crash frequency before pavement improvement.
  - For each segment on the candidate list.
  - Match SCRIM data to identified segments.
  - EB adjustment using SPFs.
- Estimate crash reduction after pavement improvement.
  - Use developed CMFs.
  - Assume pavement conditions change from current values to the average values of new project.
  - Crash reduction calculated using non-HFST and HFST treatments.

Pavement Measure	Pavement Type	Average Value of New Project
IRI	Open	25
MPD	Open	1.5
SR40	Open	50
MPD Standard Deviation	Open	0.13
SR40 Standard Deviation	Open	3.44
IRI	Dense & Rigid	35
MPD	Dense & Rigid	1
SR40	Dense & Rigid	50
MPD Standard Deviation	Dense & Rigid	0.22
SR40 Standard Deviation	Dense & Rigid	3

Crash Modification Functions (CMF) – SR (40) Urban/Suburban

Table 4-3. CMFs and CRFs for A 10-unit Increase in SR40 on Urban and Suburban Roads

Pavement Type	Crash Type	Coef. in SPF (β)[1]	SE of Coef.	CMF	SE of CMF	CMF CI of 95%	CRF
Dense and Others	ALL	-0.0237	0.0029	0.789	0.0229	[0.744, 0.834]	21.1%
	FI	-0.0225	0.0032	0.799	0.0258	[0.748, 0.850]	20.1%
	WET*	-0.0155	0.0035	0.856	0.0300	[0.797, 0.915]	14.4%
	RE	-0.0176	0.0034	0.839	0.0288	[0.783, 0.895]	16.1%
	LD	-0.0173	0.0033	0.841	0.0278	[0.787, 0.895]	15.9%
Open	ALL	-0.0250	0.0044	0.779	0.0344	[0.712, 0.846]	22.1%
	FI	-0.0165	0.0053	0.848	0.0448	[0.760, 0.936]	15.2%
	WET	-0.0406	0.0060	0.666	0.0402	[0.587, 0.745]	33.4%
	RE	-0.0295	0.0050	0.745	0.0372	[0.672, 0.818]	25.5%
	LD	-0.0226	0.0044	0.798	0.0351	[0.729, 0.867]	20.2%

Note: 1.β is the estimated coefficient for the SR40 in SPF models.

Crash Modification Functions (CMF) – MPD Urban/Suburban

CMF FOR 0.50-MM INCREASE IN MACROTEXTURE URBAN AND SUBURBAN ROADS

Crash Type	Coef. in SPF (β)[1]	SE of Coef.	CMF	SE of CMF	CMF CI of 95%	CRF
ALL	-0.1726	0.0649	0.917	0.0018	[0.913, 0.921]	8.3%
WET	-0.2105	0.0925	0.900	0.0025	[0.895, 0.905]	10.0%
RE	-0.4148	0.0721	0.813	0.0018	[0.809, 0.817]	18.7%

Note: 1.β is the estimated coefficient for the MPD in SPF models.

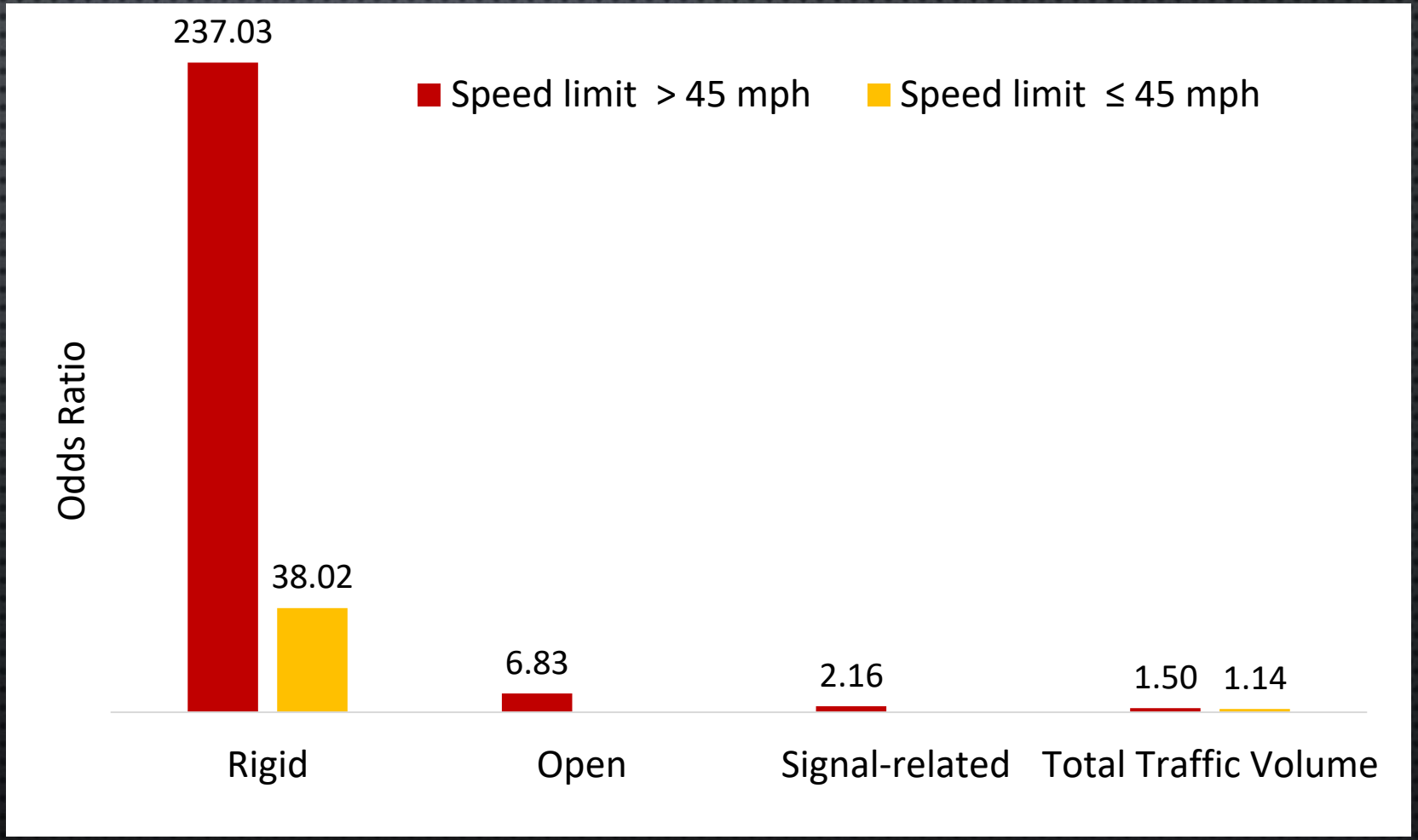
(DENSE AND OTHER)

Crash type	Coef. in SPF (β_1)[1]	Coef. in SPF (β_2)[2]	SE of β_1	SE of β_2	CMF[3]	SE of CMF	CMF CI of 95%	CRF
ALL	-0.1188	-	0.0422	-	0.942	0.0199	[0.903, 0.981]	5.8%
FI	-0.1993	0.0018	0.0718	0.0004	0.973	0.0377	[0.899, 1.047]	2.7%
WET	-0.2383	0.0017	0.0856	0.0005	0.950	0.0444	[0.863, 1.037]	5.0%
RE	-0.2429	-	0.0471	-	0.886	0.0208	[0.845, 0.927]	11.4%
LD	-0.1090	0.0012	0.0632	0.0004	0.992	0.0343	[0.925, 1.059]	0.8%

(OPEN)

KEY Findings-Good Pavement Condition But Poor Friction

- Speed
- Total Traffic Volume
- Pavement Mix Types
- Signalization



QUESTIONS