

Safety Evaluations:

Sinusoidal Rumble Strips, 55-60mph Speed Limit Change, Lane Constrictors, Reflective Signal Backplates, J-Turns

Max Moreland, MnDOT Office of Traffic Engineering

MN TZD Conference - November 15, 2022



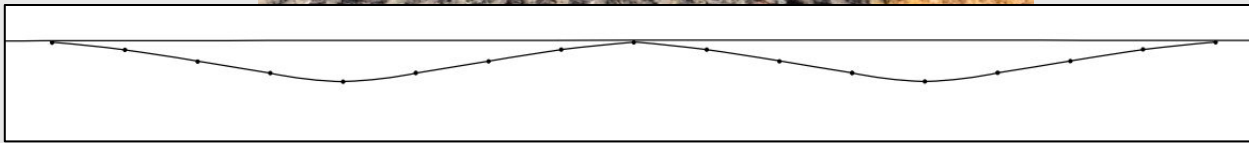
Sinusoidal Rumble Strips



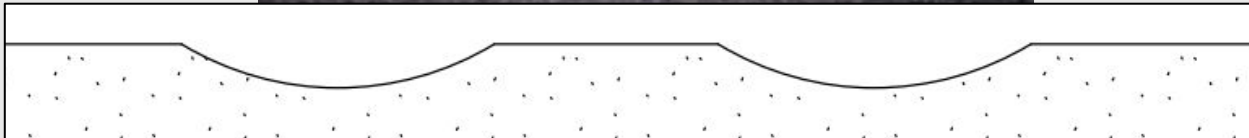


Sinusoidal Rumble Strips

Sinusoidal Rumbles



Rectangular Rumbles



m DEPARTMENT OF TRANSPORTATION

Rectangular Rumble Strip Safety Evaluation

Richard Storm, Principal Investigator
HDR

April 2020

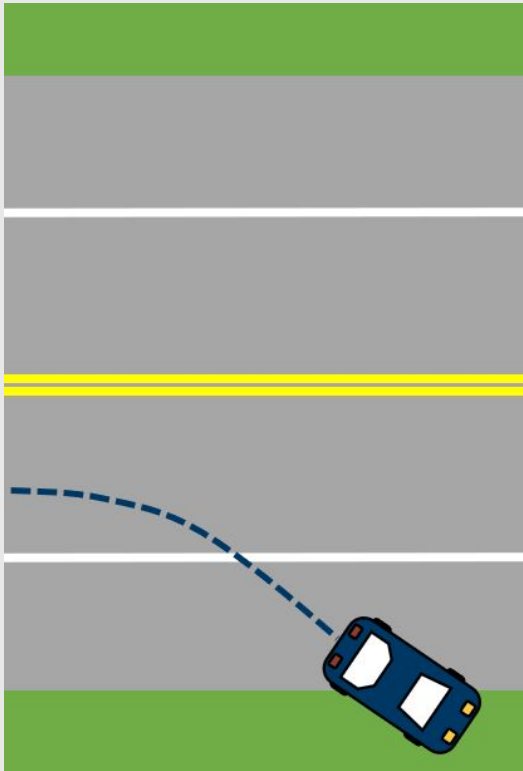
Research Project
Final Report 2020-07

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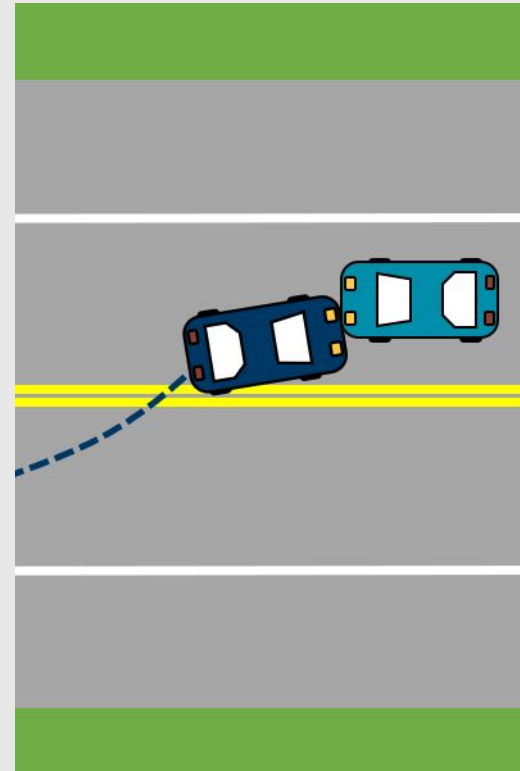


Why Rumble Strips?

2018-2022 in Minnesota



Single Vehicle
Run Off Road Crashes
Fatal/Serious Injury Crashes
2,840 (32% of total)



Head-On Crashes
Fatal/Serious Injury Crashes
1,020 (11% of total)



Head-On Fatal Crash Contributing Factors

Table 1: Vehicle action prior to a fatal head-on crash (2009-2013)

Description	Number of Crashes	Percent of Crashes
Drifting over centerline	162	64.5%
Loss of Control	77	30.7%
Passing	7	2.8%
Incorrect Lane Use	5	2.0%
Total	251	100%



Sinusoidal Rumble Strips Results

Crash Modification Factors CMF





Sinusoidal Rumble Strips Results

Rumble Strip Placement	Crash Type	CMF (Relative to Rectangular)	Statistically Significant?
Shoulder	Total	1.37	No
Centerline	Total	1.34	No
Both	Total	1.36	No
Shoulder	Run-off-Road	1.19	No
Any	Head-on	1.46	No
Any	KA	1.38	No

Sinusoidal rumble strip results not statistically significantly different from rectangular rumble strips.
No better or worse than rectangular rumble strips.



55 mph to 60 mph





55 mph to 60 mph

Scoring system based on the following criteria:

- Access Points per Mile
- Shoulder Widths
- Vertical Grades
- Clear Zones
- Crash Rates
- KA Rates
- Critical Crash Rates
- Passing Zones
- 85th Percentile, 10mph Pace

SPEED STUDY FIELD REVIEW Stonebrooke
SUMMARY REPORT

US/MNTH: MN 28 Speed Limit: 55 MPH
 Study Limits: 0.000-0.790 Segment Length: 0.79 MILES
 Speed Sampling Location: RP 0.32 Road Type: 2-Lane, 2-Way
 District/County(s): 4/Big Stone ADT Range: 1,394
 Control Sect(s): 7804 Date: 07/11/2017

Project Photo

Data Summary for Representative Section

- 12' bit Lane Width & Material
- 2" bit & 8'-6" gravel Shoulder Width & Material
- NO Centerline Rumble Strips
If yes, % with CLRS: 0%
- YES Shoulder Rumble Strips
If yes, % with SRS: 100%
- 7.6 Average Access Points/Mile
- YES Vertical Grade less than 3%
- 1 Roadside Hazard Index
1 - usable shoulder, few fixed objects
2 - no usable shoulder, few fixed objects
3 - usable shoulder, with fixed objects
4 - no usable shoulder, with fixed objects
- YES Inslope 1:4 or flatter

LEGEND*
 Acceptable
 Closer Look
 * See page 2 for definitions

Project Location (from South Dakota border to Browns Valley)

Field Speed Study Chart (Data Collection Radar)
 MN 28 Speed Sample (RP 000+00.000-000+00.790)

Crash Rate Tables

Category	MN 28	Average	CRITICAL
Crash Rates	0.00	0.00	0.00
Fatal and A Crash Rates	0.00	0.00	0.00

MN 28 RP 0.000 (04 C57804)_TDI_rep 1 OF 2

SPEED STUDY FIELD REVIEW Stonebrooke
SUMMARY REPORT

GENERAL COMMENTS
 The speed study was conducted on Tuesday, July 11, 2017. The weather condition at the time of the study was observed as sunny. The road and shoulder surface was clear.

Lanes & Shoulders
 The representative section consists of 12' bituminous lanes with 2' bituminous and 8'-6" gravel shoulders. The pavement is relatively in fair condition with transverse cracks and patches throughout the study section.

Rumble Strips
 There are no centerline rumble strips present in the study section. There are shoulder rumble strips present for 100% of the study section.

Access Points per Mile
 The study section has an average access points per mile of 7.6, consisting of 0 public, 3 private, and 3 field access points.

Vertical Grades < 3%
 The study section is generally flat with no vertical grades measured to be in excess of 3%.

Roadside Hazard Assessment
 The study section is generally a fill section and is free of fixed objects, except for the following locations:

- Power poles located south of the study section between Reference Point (RP) 0 & 0.5 that is within the clear zone of the roadway.
- Presence of cable barriers about RP 0 that is protecting from water body.

Inslope
 The inslope measured at the representative section is 1:4.

Adjacent Development
 The area is rural/agriculture, with no large traffic generators in the study section.

Regulatory and Advisory Speed Reductions
 There are no regulatory or advisory speed reductions.

Traffic Control
 There are no traffic control devices for mainline.

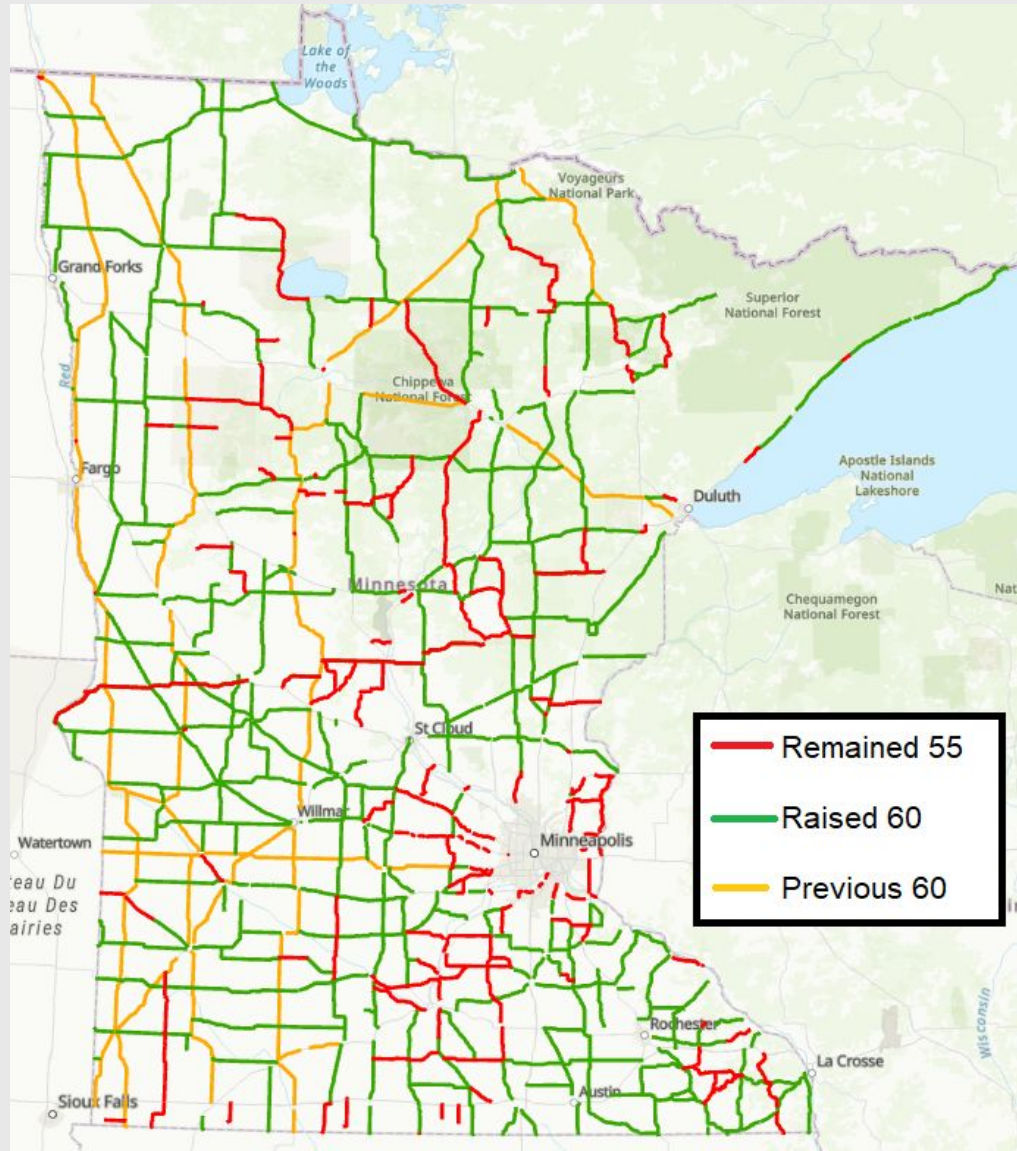
Performance Determined (Continued from Page 1)

Lane Width	≥ 11 feet
Shoulder Width	≥ 5 feet
Centerline Rumbles	Present on ≥ 75%
Shoulder Rumbles	Present on ≥ 75%
Access/mile	≤ 10/mile (including field entrances)
Vertical grade	>95% with grades less than 3%
Roadside Hazards	Rating 1 or 2
Inslope	1:4 or flatter

MN 28 RP 0.000 (04 C57804)_TDI_rep 2 OF 2



55 mph to 60 mph



- 1,760 miles remained at 55 mph
- 5,240 miles raised from 55 mph to 60 mph



Speed Limit Change (55 mph to 60 mph) Safety Evaluation

Richard Storm, Principal Investigator
HDR, Inc.

February 2020

Research Project
Final Report 2020-06



55 mph to 60 mph – Speed Impacts

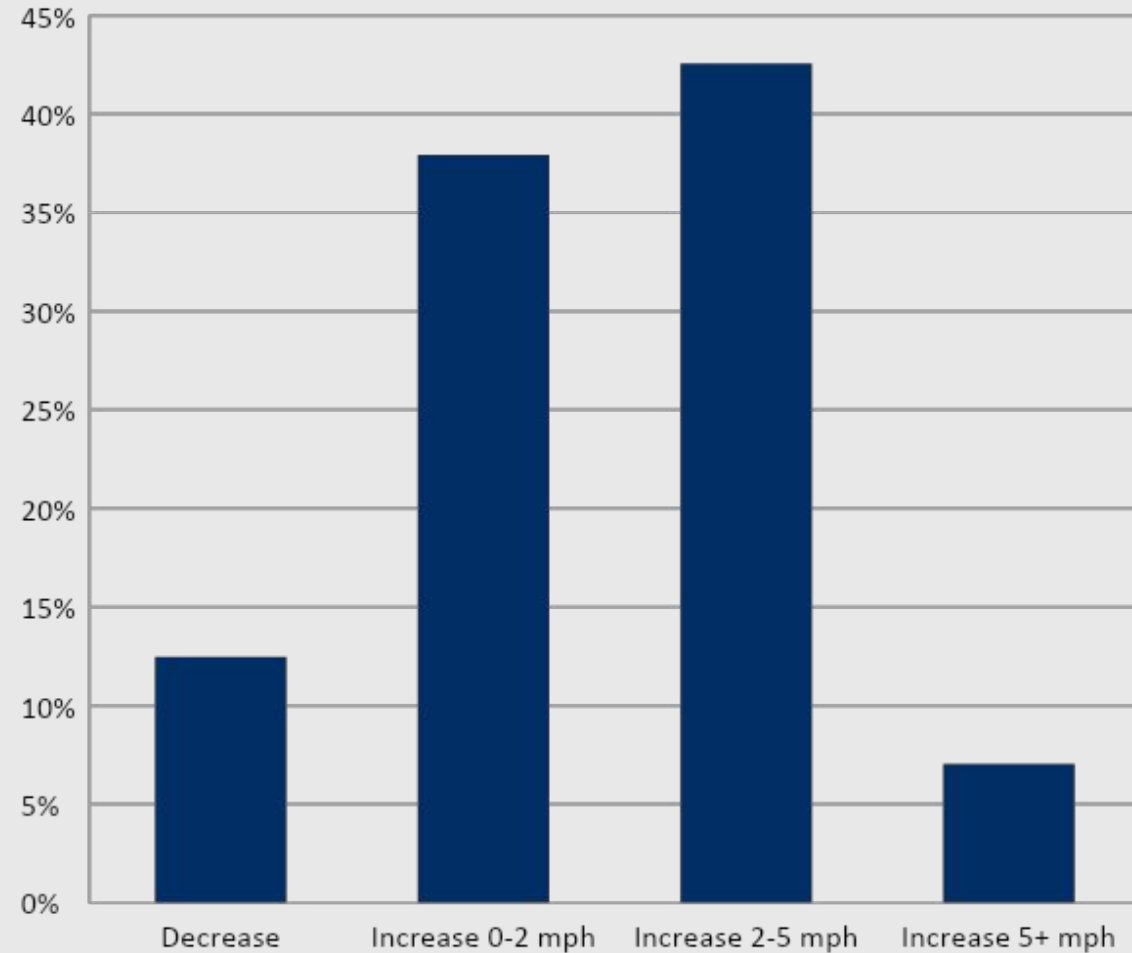
Before & after speed results at 68 random locations

Speed	Before Speed Limit Change	After Speed Limit Change
85 th Percentile Speed	65 mph	65 mph
Mean Speed	59 mph	60 mph
Standard Deviation	6.4 mph	6.1 mph
Average of Five Highest Speeds	76 mph	76 mph

After period is 2019 only

Before-After Average Operating Speed Changes

Based on StreetLight Data (<10% of changed mileage)



After period includes 2020-2022



55 mph to 60 mph - Results

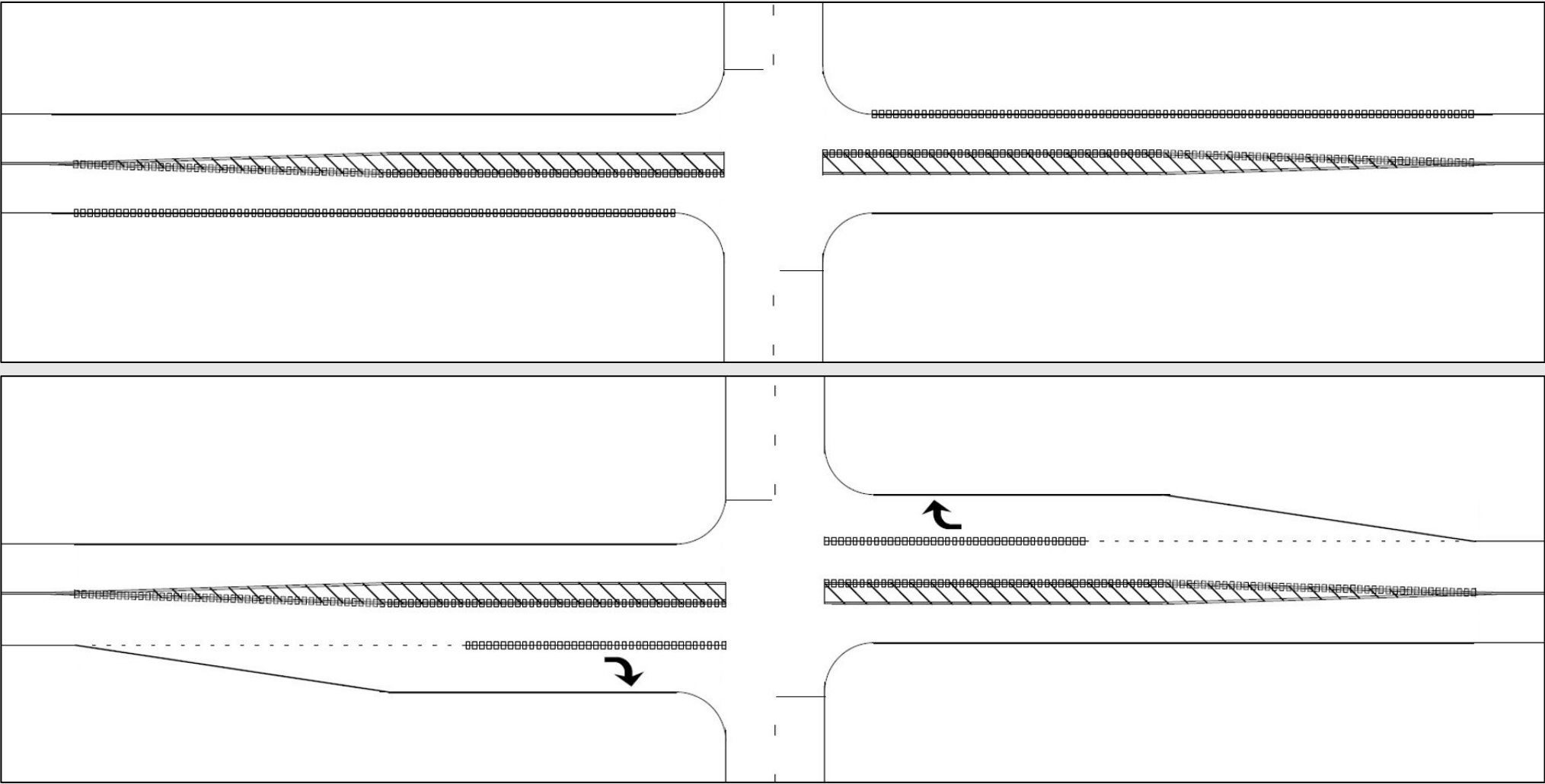
Aggregate Crash Effect (All Segments and Intersections Combined)

Crash Type	CMF	Standard Error of CMF
Total	0.873*	0.017
Injury (KABC)	0.926*	0.024
Injury (KAB)	1.045**	0.029

* Statistically Significant at the 95-percent Confidence Level

** Statistically Significant at the 85-percent Confidence Level

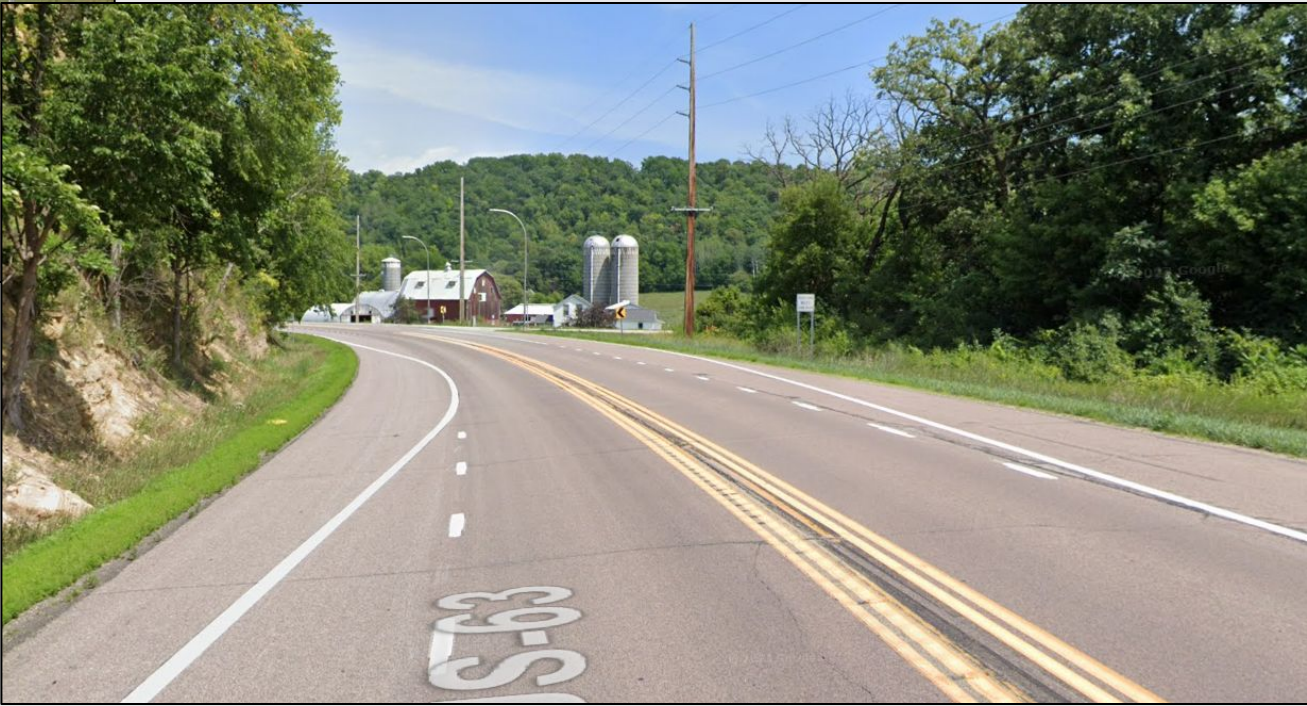
Lane Constrictors



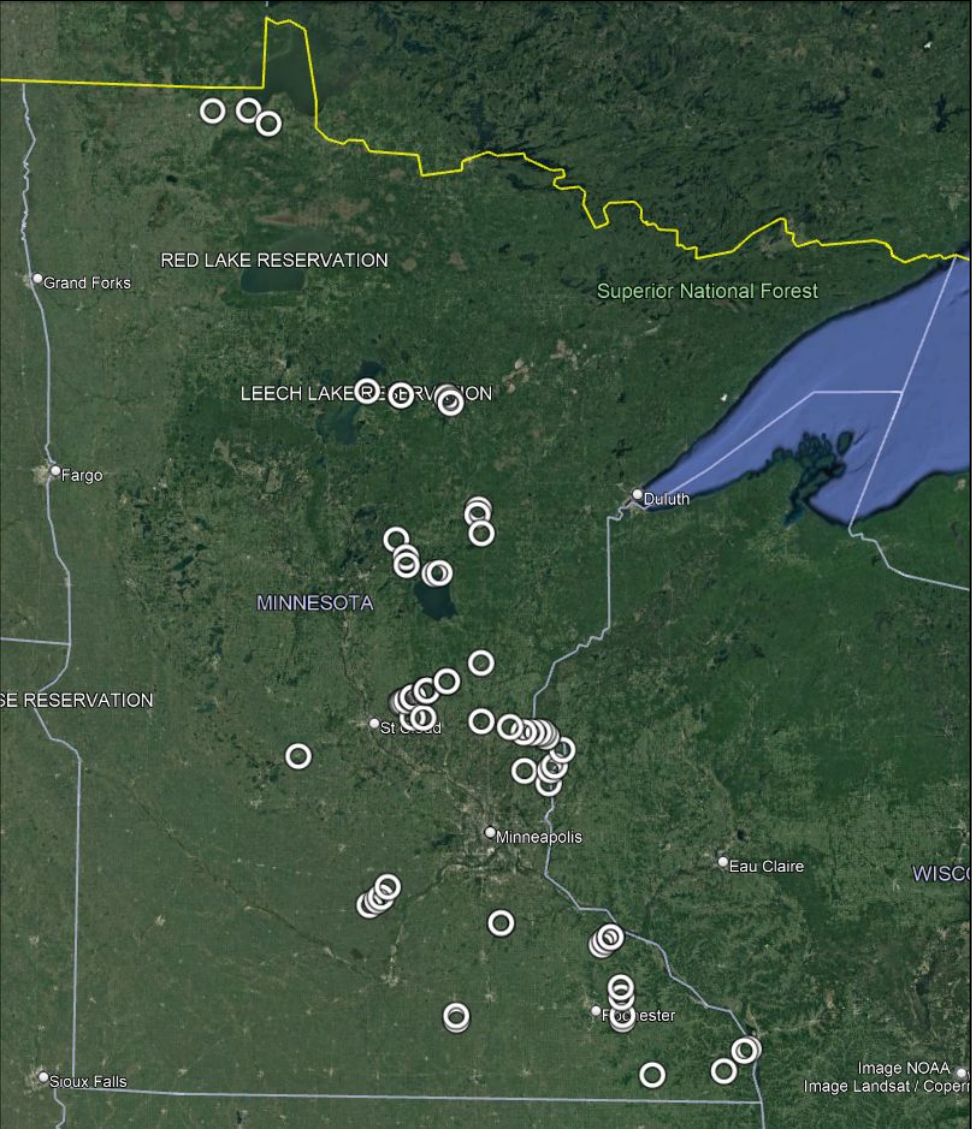
Lane Constrictors



Lane Constrictors

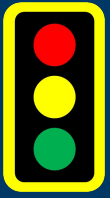


Lane Constrictors



Lane Constrictors Preliminary Results

	Change in Crash Rate with Lane Constrictor Added	Change in Crash Rate at Control Intersections	Statistically Significant Difference at $\alpha=.05$?
Total Crashes	+4% (126 before/126 after)	+10%	No
Fatal & Serious Injury Crashes (KA)	-9% (8 before/7 after)	+57%	Yes
Fatal & All Injury Crashes (KABC)	-23% (62 before/46 after)	+21%	Yes
Property Damage Only Crashes	+29% (64 before/80 after)	+5%	No
Head-On/Sideswipe Opposing Crashes	+4% (10 before/10 after)	+5%	No
Angle Crashes	+6% (40 before/41 after)	+40%	No




Reflective Signal Backplates





Reflective Signal Backplates Preliminary Results

	Change in Crash Rate with Reflective Backplate Added	Change in Crash Rate at Control Intersections	Statistically Significant Difference at $\alpha=.05$?
Total Crashes	-2% (1,653 before/1,519 after)	+3%	No
Fatal & Serious Injury Crashes (KA)	+27% (21 before/25 after)	-22%	No
Fatal & All Injury Crashes (KABC)	-8% (463 before/399 after)	+1%	No
Rear End Crashes	-14% (942 before/762 after)	-5%	No
Angle Crashes	+36% (314 before/399 after)	+22%	No
Darkness Crashes 	-5% (389 before/347 after)	+9%	No

J-Turns

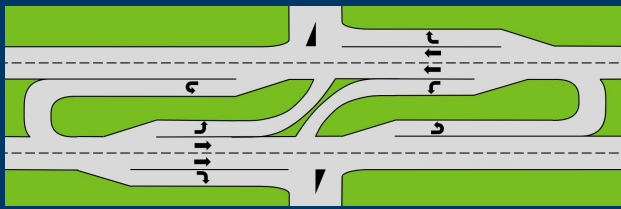
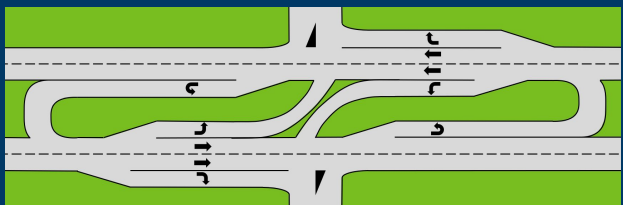


Image Source: Google Earth

J-turns



Conventional

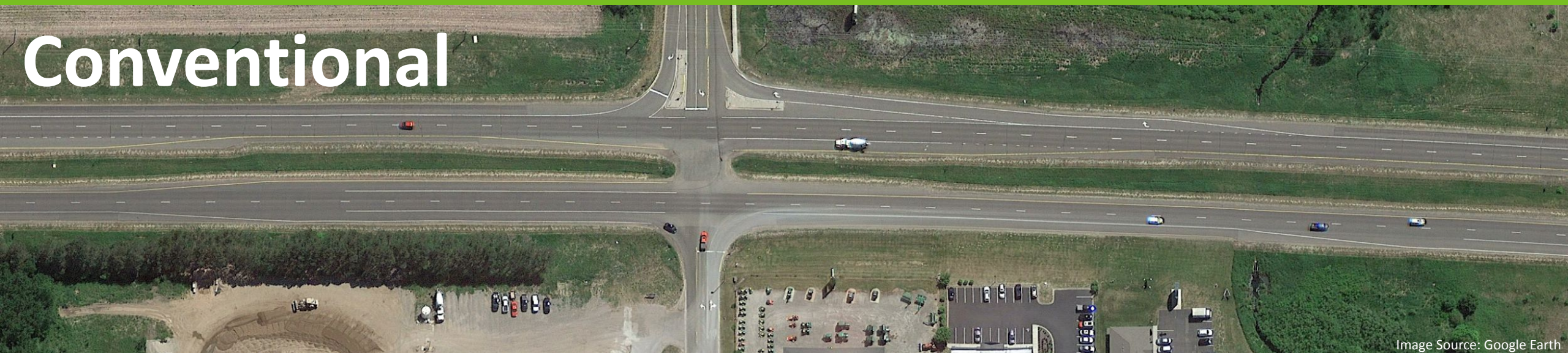
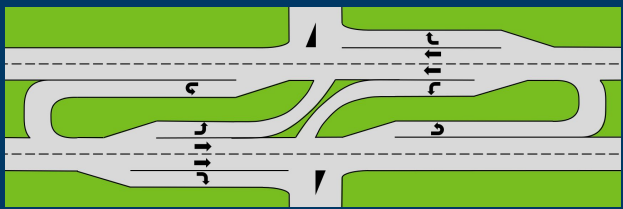


Image Source: Google Earth

J-turn



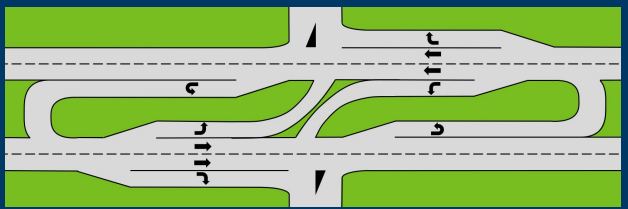
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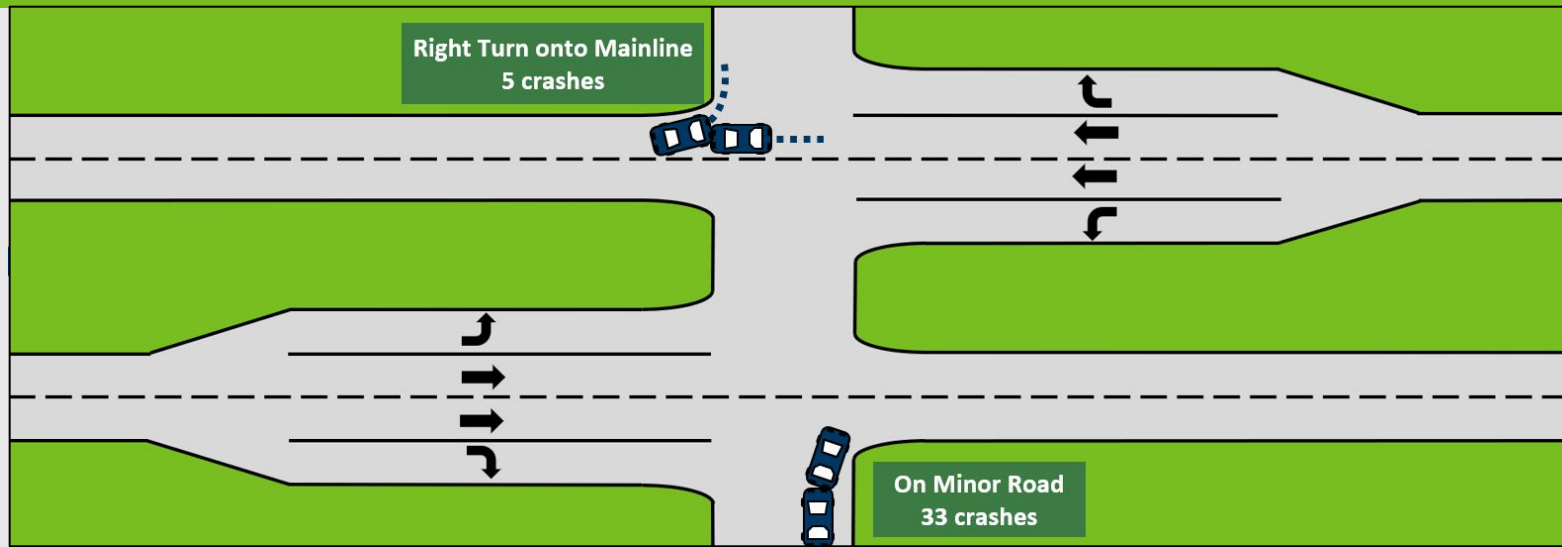
J-Turn – Results

	Change in Crash Rate with J-Turn Added	Change in Crash Rate at Control Intersections	Statistically Significant Difference at $\alpha=.05$?
Fatal & Serious Injury Crashes (KA)	-67%	0%	Yes
Fatal & All Injury Crashes (KABC)	-54%	+9%	Yes
Angle Crashes	-66%	+5%	Yes
Fatal & Serious Injury Angle Crashes	-88%	+23%	Yes
Rear End Crashes	+68%	-21%	Yes
Total Crashes	-18%	-5%	No

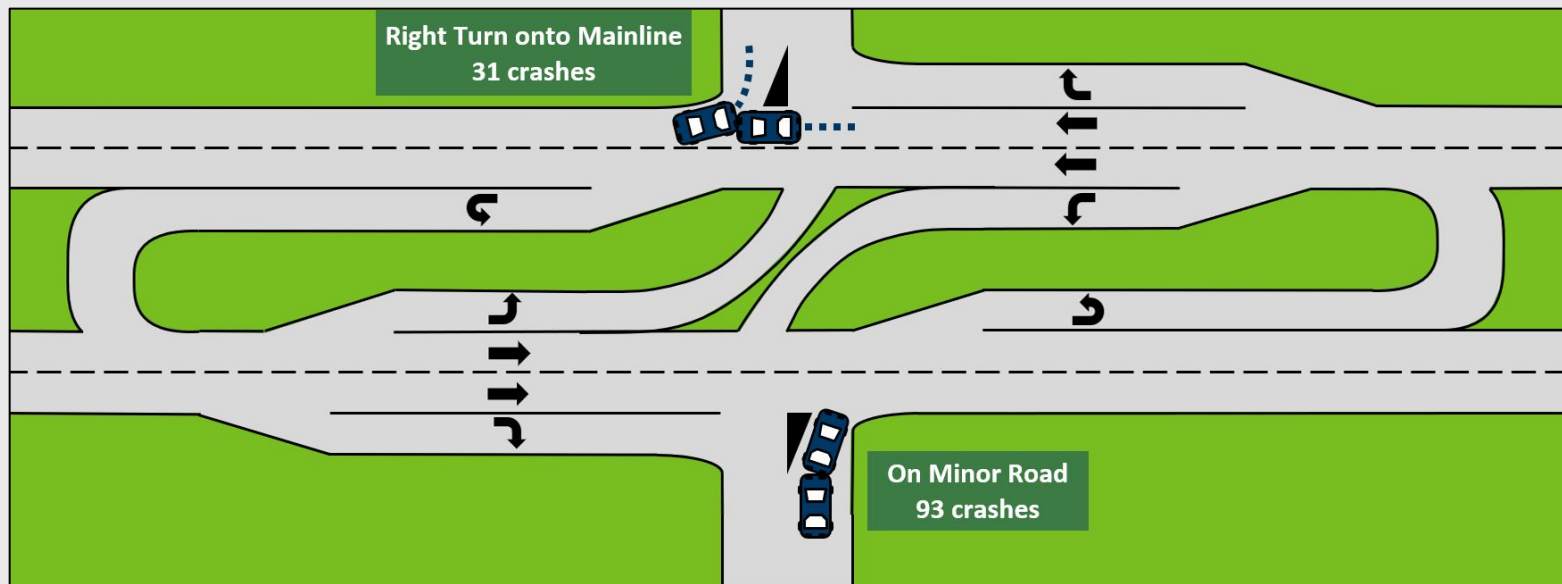
J-turn Rear End Crashes



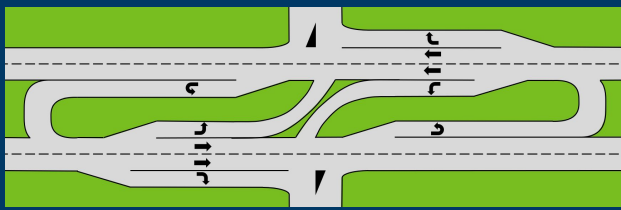
“Before” Crashes at Standa Intersections



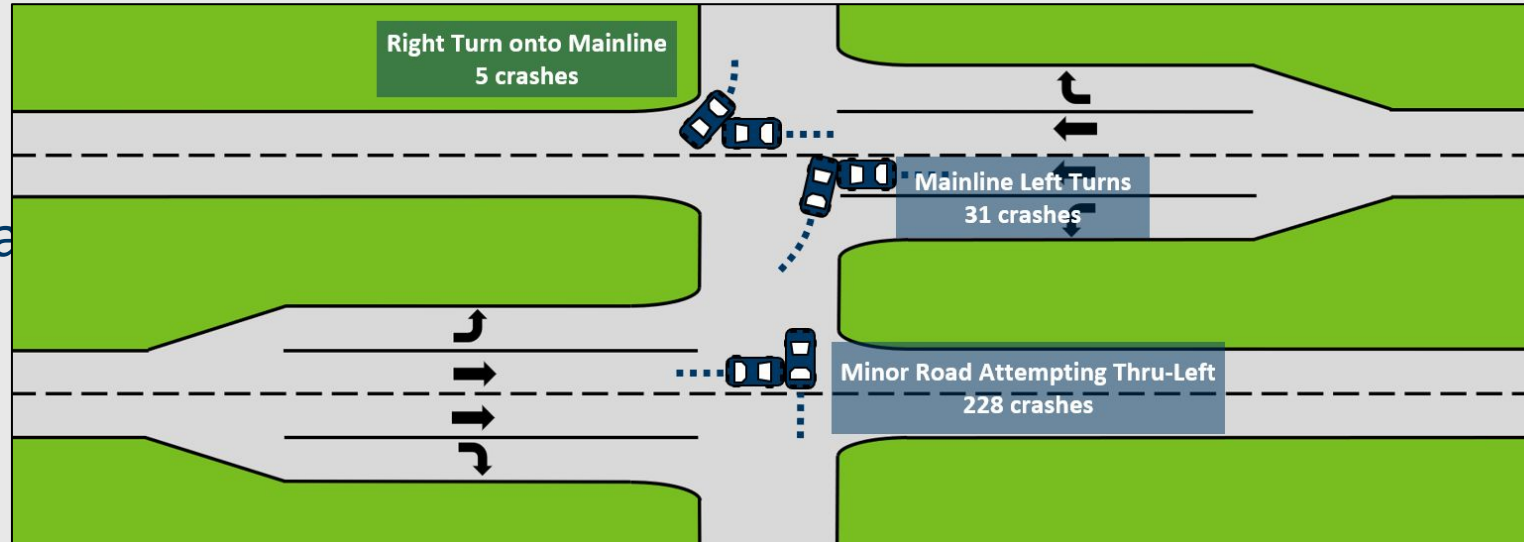
“After” Crashes at J-Turns



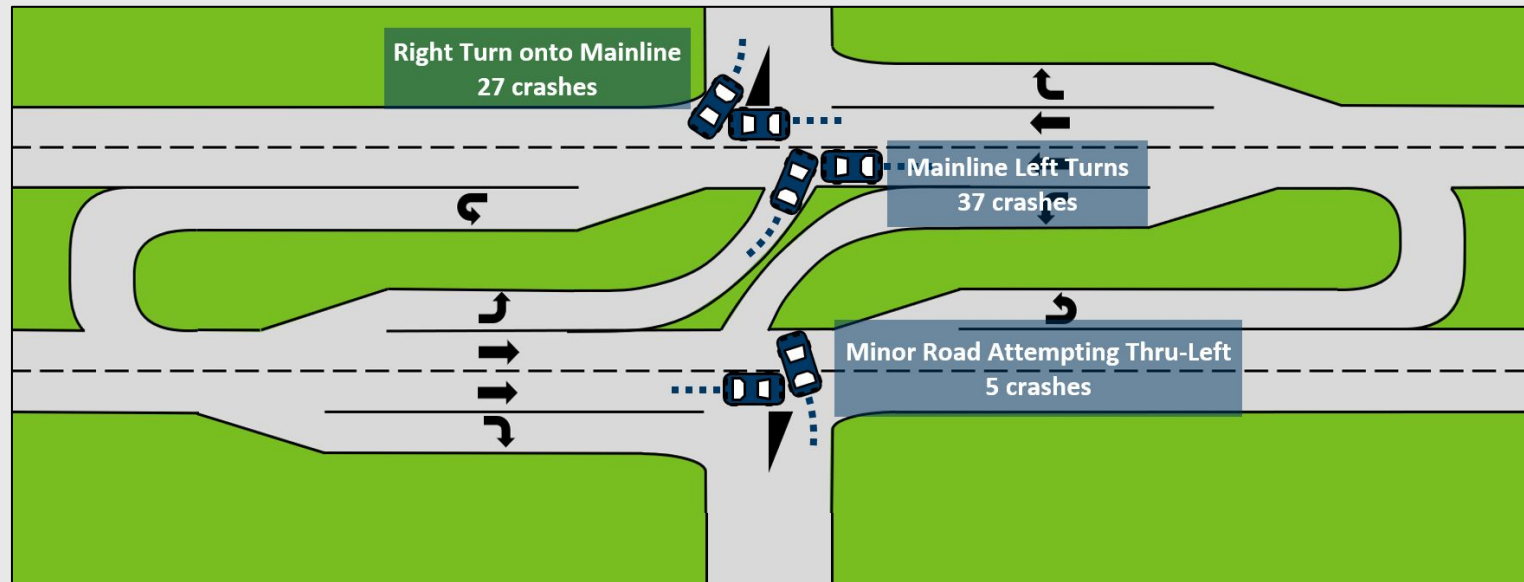
J-Turn Angle Crashes



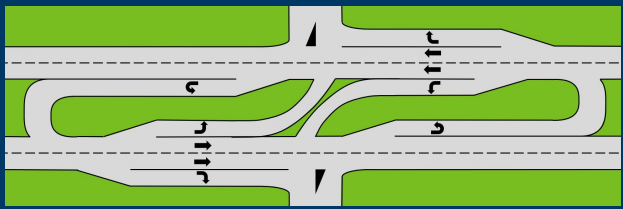
“Before” Crashes at Standard Intersections



“After” Crashes at J-Turns

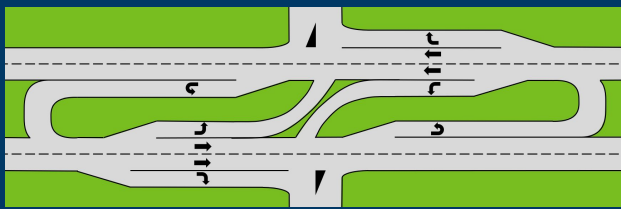


J-Turn – 5 Additional Analyses



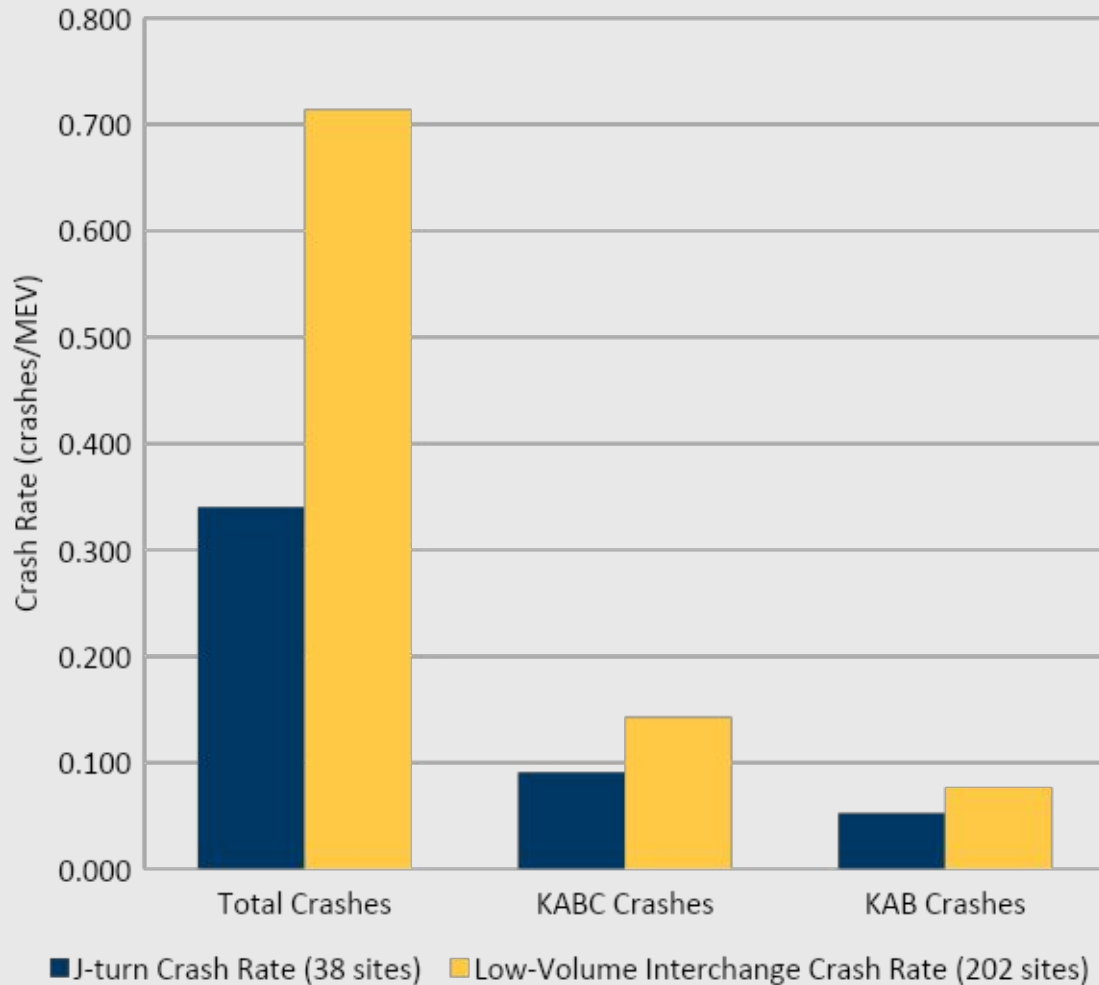
- J-turns vs Low Volume Interchanges vs Rural High-Speed Signals
- U-turn lane starting point
- U-turn distance from minor road
- Presence of median left turn lanes
- Mainline AADT

J-Turn vs Interchange vs Signal



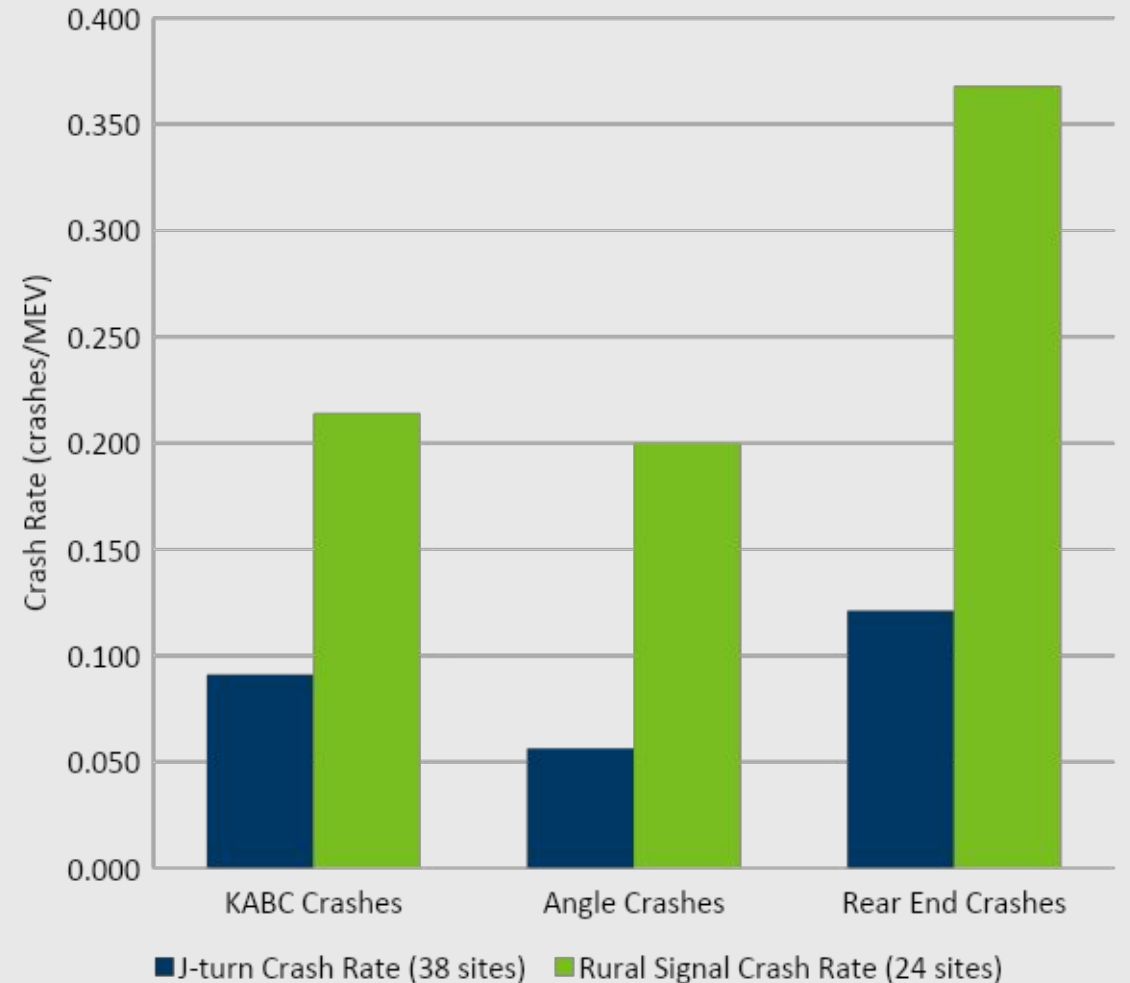
J-turn & Low Volume Interchange Crash Rates

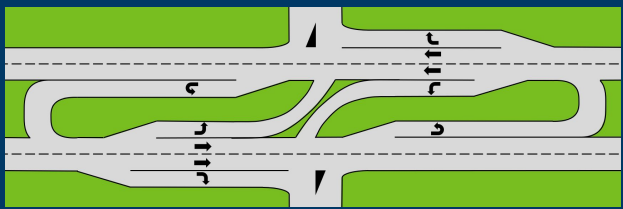
Statistically Significant at $p=.10$
2020-2022 Crash Data



J-turn & Rural Signal Crash Rates

Statistically Significant at $p=.10$
2020-2022 Crash Data





J-Turn – U-turn Lane Location



Direct into
U-turn Lane



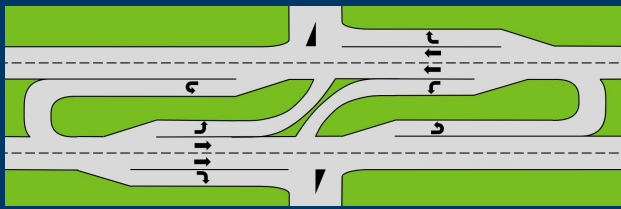
Nearly Direct into
U-turn Lane



Not Direct into
U-turn Lane

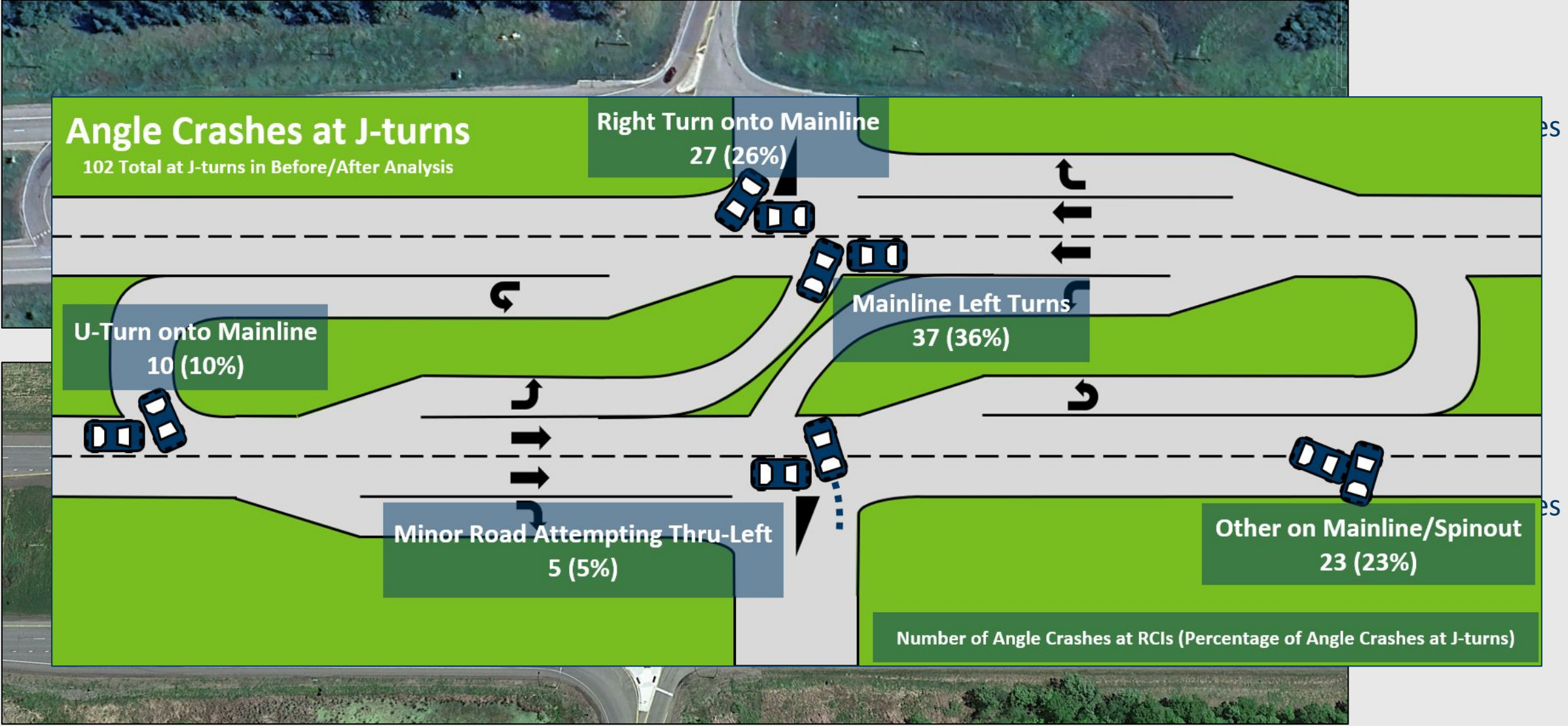
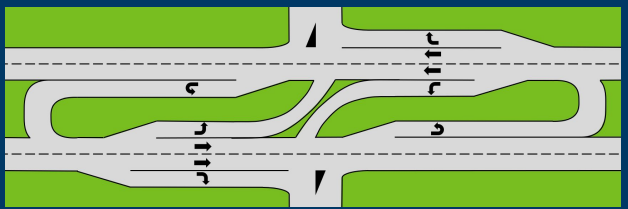
Little difference
between groups

J-Turn – U-turn Distance




Little difference
between groups

J-Turn – Mainline Left Turns

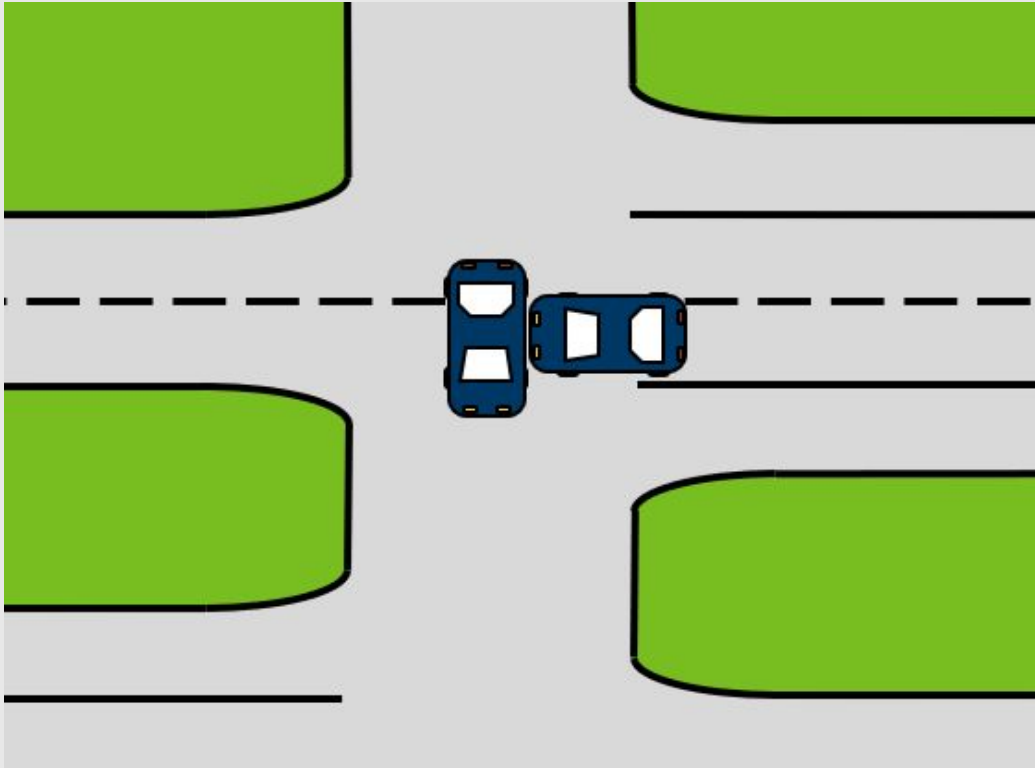
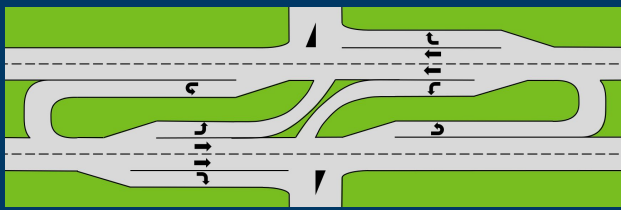


J-Turn – Mainline AADT



Mainline AADT Range	Number of Sites	Angle Crash Reduction	KA Angle Crash Reduction
0 – 10,000	15	-87%	-100%
10,000 – 20,000	19	-59%	-71%
20,000+	20	-60%	-91%

J-Turn - Summary



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Sinusoidal Rumble Strips

- CMFs > 1 compared to rectangular rumbles
- Not statistically different than rectangular rumbles

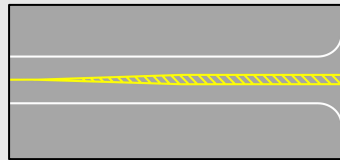


55 to 60 mph Speed Limit Change

- Small impact to operating speeds
- Reduction in total crashes

Lane Constrictor Intersections

- Reduced injury crashes compared to controls
- Small overall crash impacts
- More analysis needed

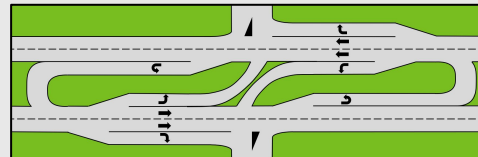


Reflective Signal Backplates

- No significant differences compared to controls
- More analysis needed

J-turns

- Large reduction in severe and angle crashes



All reports coming soon

Thank You!

Max Moreland

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