Crash Data Analysis for Converting 4-lane Roadway to 5-lane Roadway in Urban Areas

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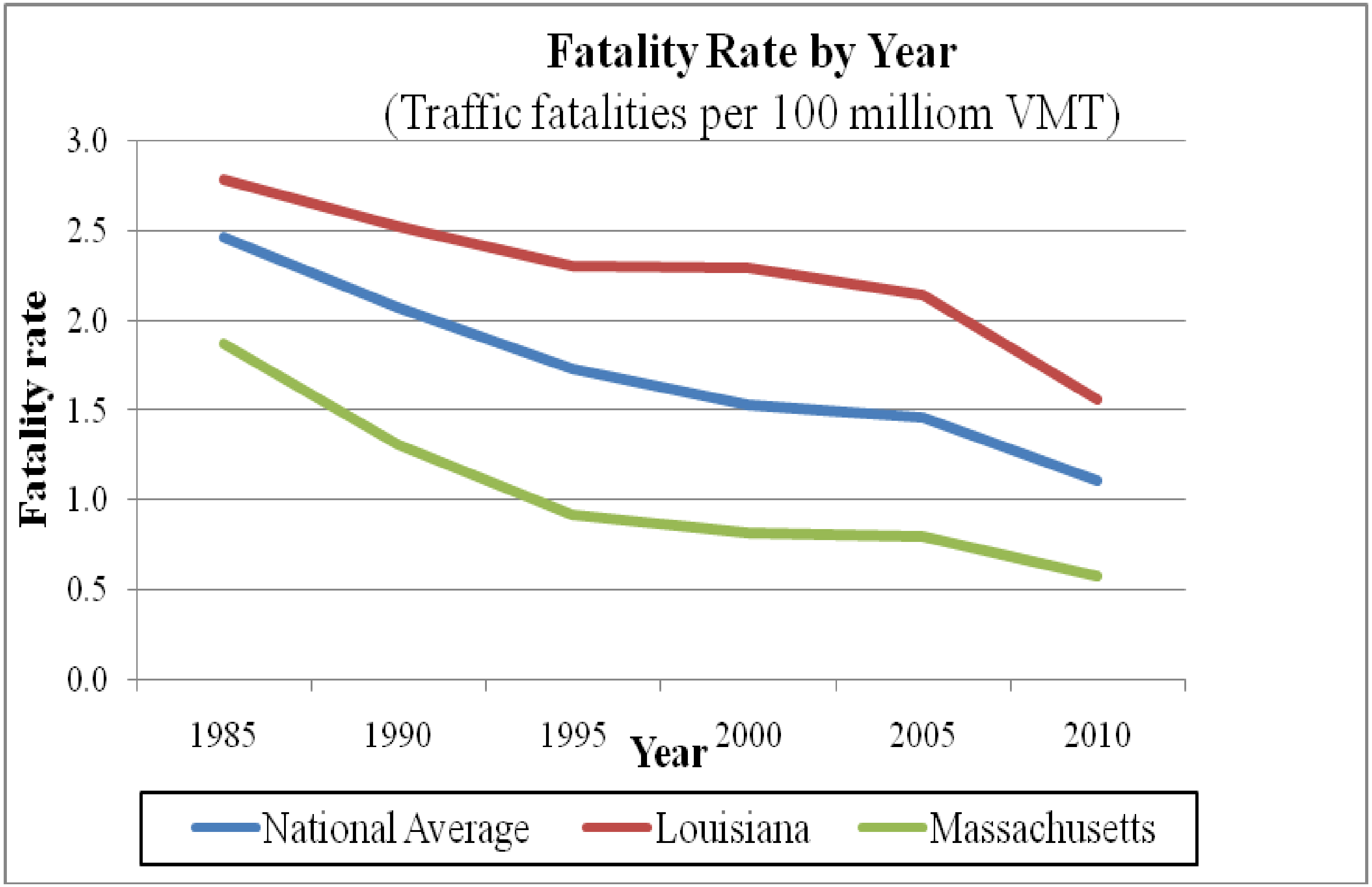
Outline

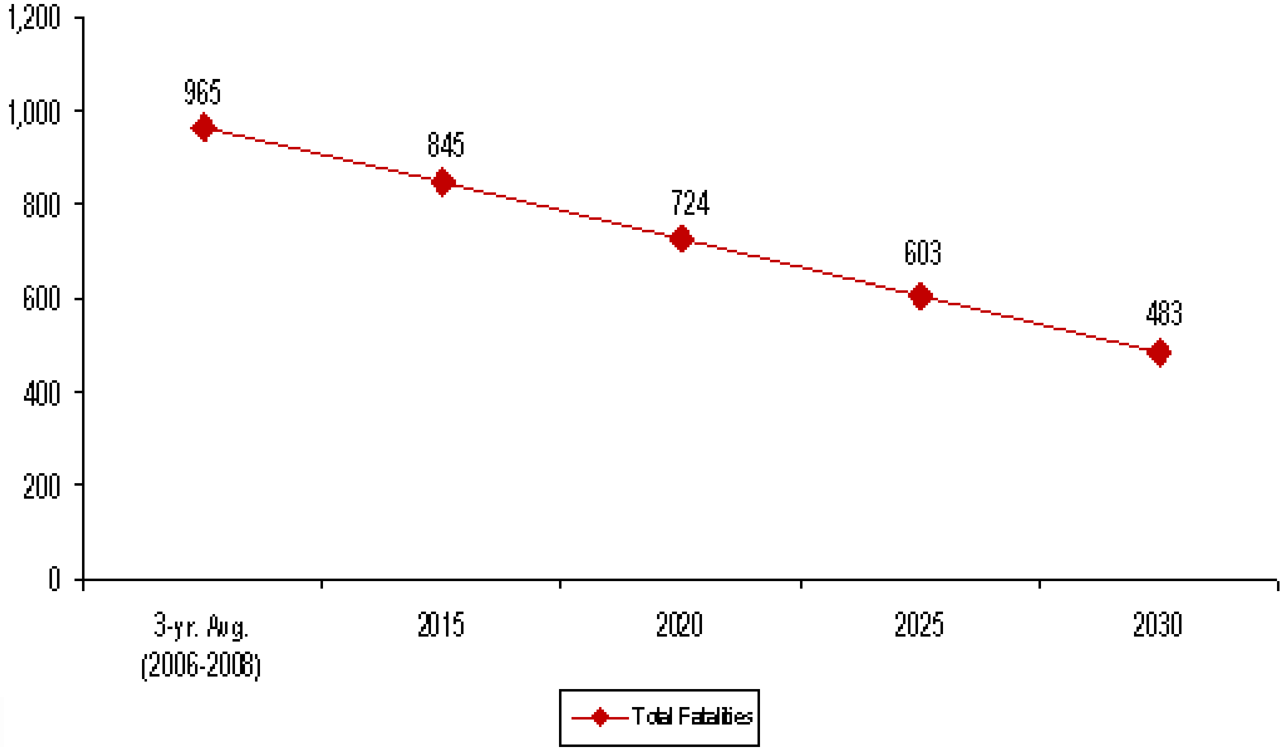
- **Background**
- Lane Converting Projects
- Crash Characteristics Analysis
- Estimating Safety Effectiveness
- Discussion

Daunting Challenges



Louisiana Destination Zero Deaths

Goal: Halve Fatalities by 2030



All possible actions are called for

- Improving existing highway geometrics
- Application of new traffic control devices
- ITS implementations
- Changes of user behavior by enforcement and education actions
- Better and faster emergency services

Crash Countermeasures for Louisiana

- While the majority of crash countermeasures would be the same as the once used by other states, a few countermeasures may be unique in Louisiana
- Developing CMFs that have not documented elsewhere is the main objective of the study sponsored by Louisiana Transportation Research Center

Urban undivided multilane highways consistently exhibit low safety performance in the U.S.

	Fatal Accidents	Injury Accidents	Total Accidents
RURAL	Number per MVM	Number per MVM	Number per MVM
2 Lanes	0.07	0.94	2.39
4 or more lanes, divided subtotal	0.063	0.77	2.09
Freeway	0.025	0.27	0.79
URBAN			
2 Lanes	0.045	1.51	4.94
4 or more lanes, undivided	0.04	2.12	6.65
4 or more lanes, divided	0.027	1.65	4.86
Freeway	0.012	0.4	1.43

– 1,530 miles of undivided multilane roadways under LADOTD system. 93% these roadways are in urban and suburban areas

Solutions?

- Expensive solution: installing physical separation either by barrier or by green space (boulevard) has been the most recommended crash countermeasure for the problem

Solutions?

- Inexpensive option: with sufficient pavement width, a four-lane undivided highway can also be easily changed to a five-lane roadway with the center lane for left-turns, which expectedly reduces rear-end collisions.

Pros and Cons of Two Options

- Physical barrier
  - Better traffic (motorized or non-motorized) management
  - Expensive
- Five lane
  - Inexpensive with sufficient ROW
  - Not recommended for new road in Louisiana

However

- Under the current budgetary situation, the expensive option is not financially feasible
- Going with the inexpensive but not perfect solution to reduce the crashes has been one option for the situation
- Several roadway segments in various LADOTD districts have implemented this inexpensive crash countermeasure in the past

CMF for the lane converting

- There is no CMF listed in the first edition of the HSM and nor is on the popular CMF clearinghouse for converting four-lane undivided roadway (4U) to TWLTL (5T)
- Only two documents list impact of such conversions based on the past studies
  - Minnesota Statewide Urban Design and Specifications—crash rates 6.75 for 4U and 4.01 for 5T
  - NCHRP Report 282, National Cooperative Highway Research Program, Transportation Research Board, 1986 – reducing crashes by 45%

The five-lane design alternative including a center TWLTL in the median has, in the past 20 years, become a very common multilane design alternative for upgrading urban arterials. This design alternative has two through lanes of travel in each direction and a center TWLTL to provide for left-turn maneuvers at driveways and minor intersections. The total roadway width for a five-lane TWLTL section on an urban arterial ranges from 48 ft to 72 ft depending on the lane widths employed.

From NCHRP 330, 1990

From NCHRP 330, Five Lane Roadway:

Pros

1. Provides additional lanes to increase capacity for through traffic movement
2. Reduces delay to through vehicles by left-turning vehicles
3. Reduces frequency of rear end and angle crashes associated with left-turn maneuvers
4. Provides spatial separation between opposing lanes to reduce head-on crashes
5. Increases operational flexibility

Cons

1. Required street width may not be available
2. No refuge area in median for pedestrians
3. May generate safety problems at closely spaced driveways and intersections

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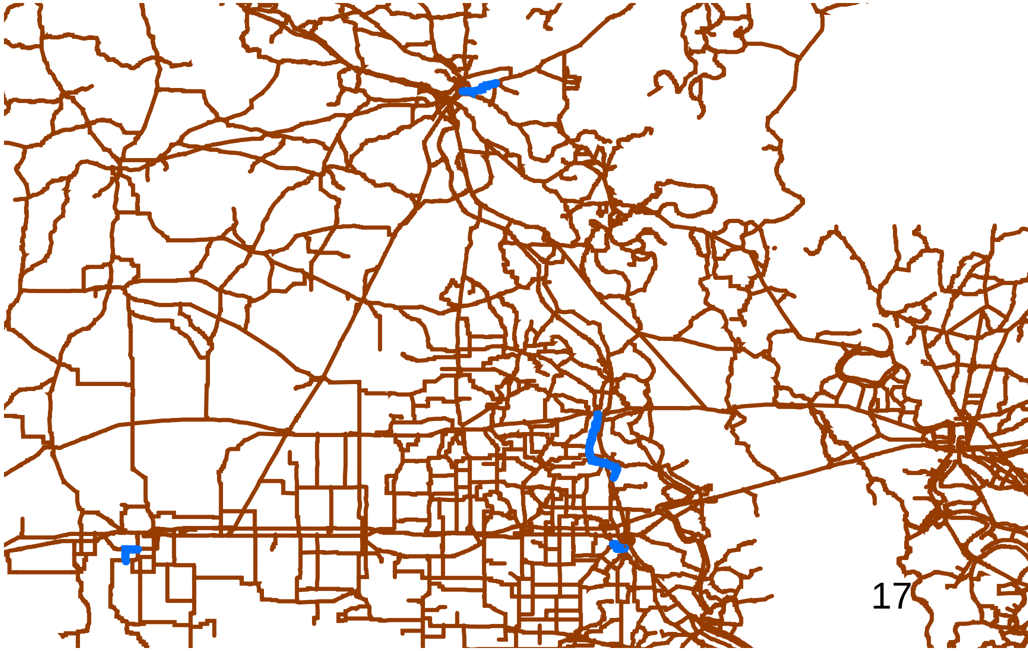
Four segments were selected for analysis

- South College Road, part of LA3025
- LA182 in Opelousas
- LA1138 in Lake Charles
- LA28 in Alexandria

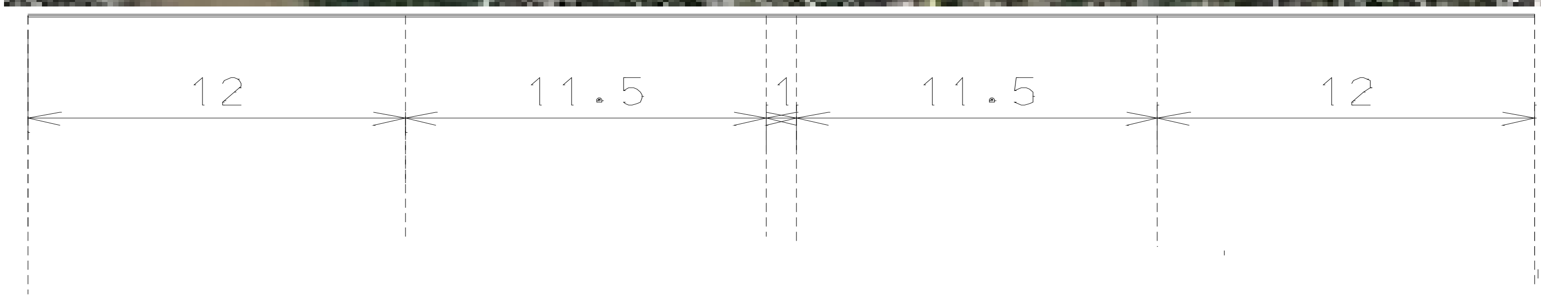


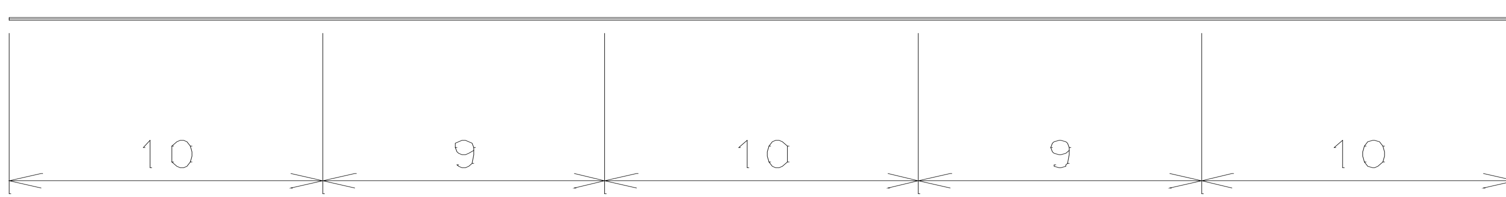
Summary

	District	Control Section	Length (mi)	Installation Year	Estimated # of Driveways	Location
LA 3025	D3	828-23	1.228	2003	45	Lafayette
LA 182	D3	032-02	1	2007	50	Opelousas
LA 28	D8	074-01	0.92	2005	45	Alexandria
LA 1138	D7	810-06	1.07	1999	50	Lake Charles

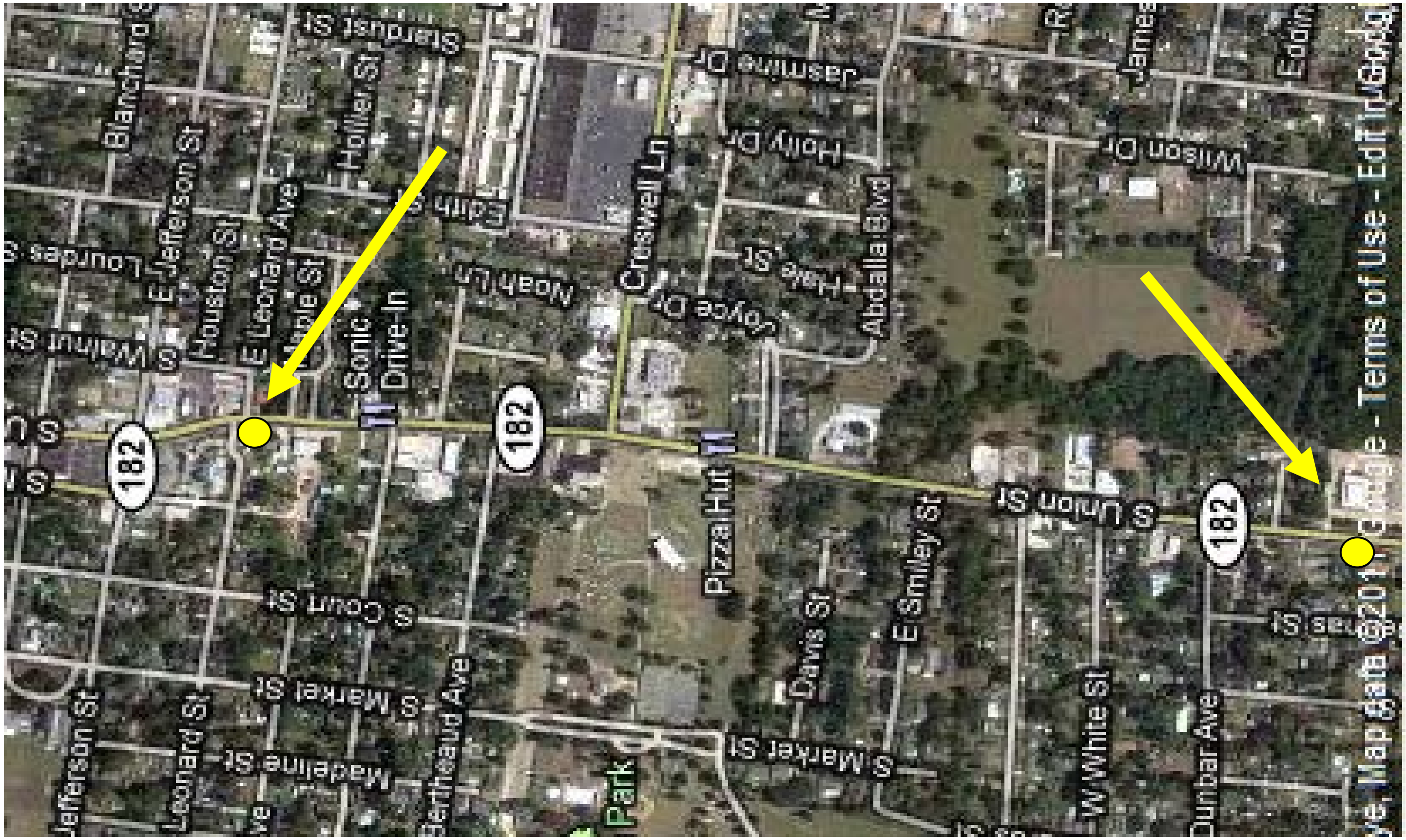
Roadway Configuration

LA3025

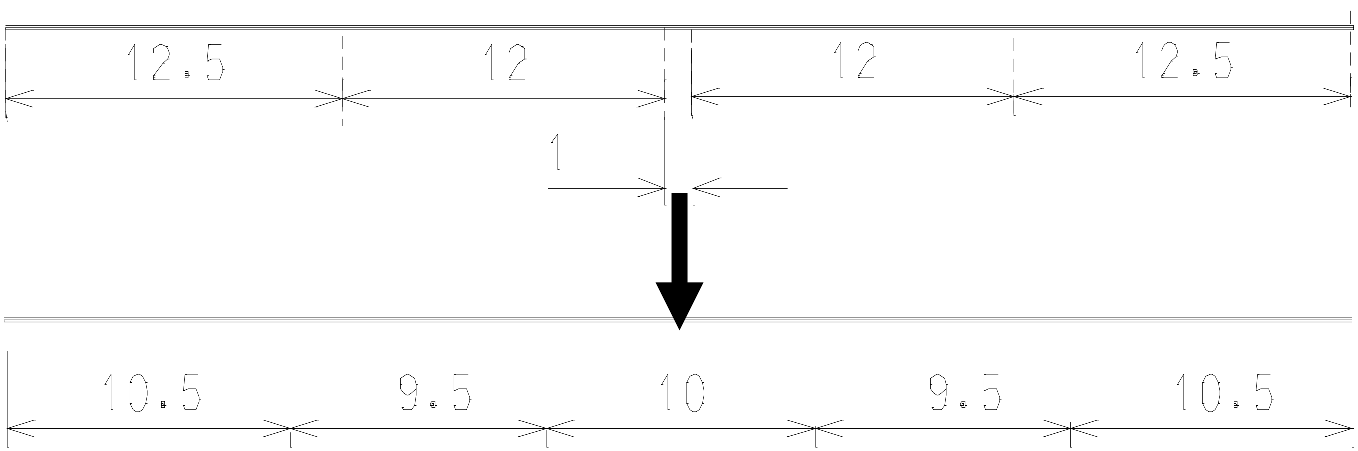




LA 3025 (from 2012 Google Earth)


Stardust St
Blanchard St
Hollier St
Jasmine Dr
Holly Dr
Wilson Dr
Edith St
E Jefferson St
Houston St
E Leonard Ave
Creswell Ln
Hale St
Abdalla Blvd
Noah Ln
Joyce Dr
S Walnut St
Sonic Drive-In
182
Pizza Hut
S Union St
E Smiley St
Davis St
S Court St
S Market St
Bertheaud Ave
Madeline St
Leonard St
Jefferson St
W White St
Dunbar Ave
Park

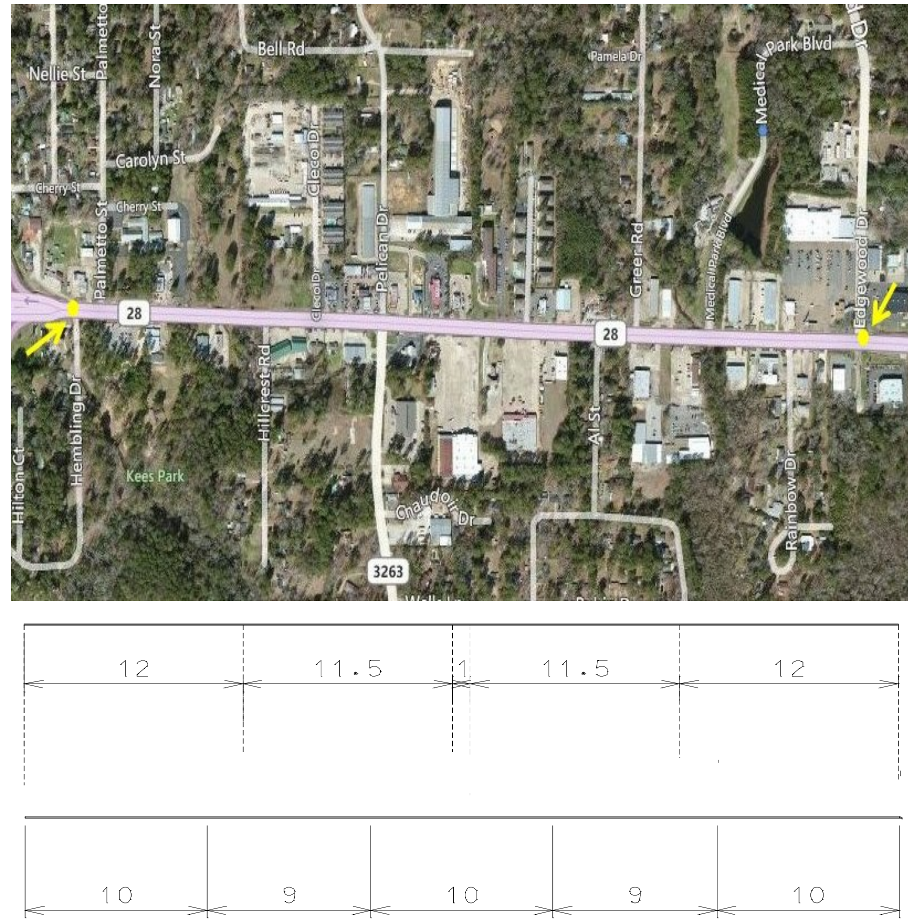
LA182


12.5
12
12
12.5
1
10.5
9.5
10
9.5
10.5

LA182 (from 2012 Google Earth)

Roadway Configuration

LA1138



LA28

(from 2012 Google Earth)

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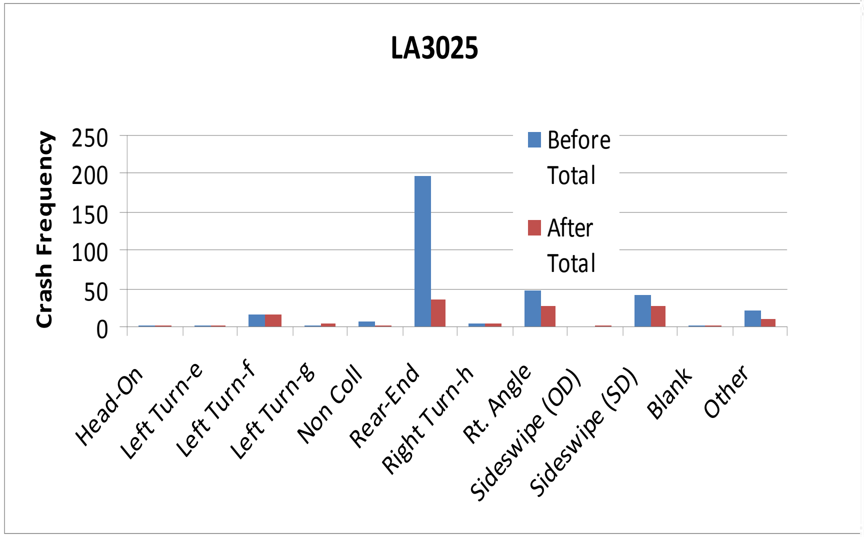
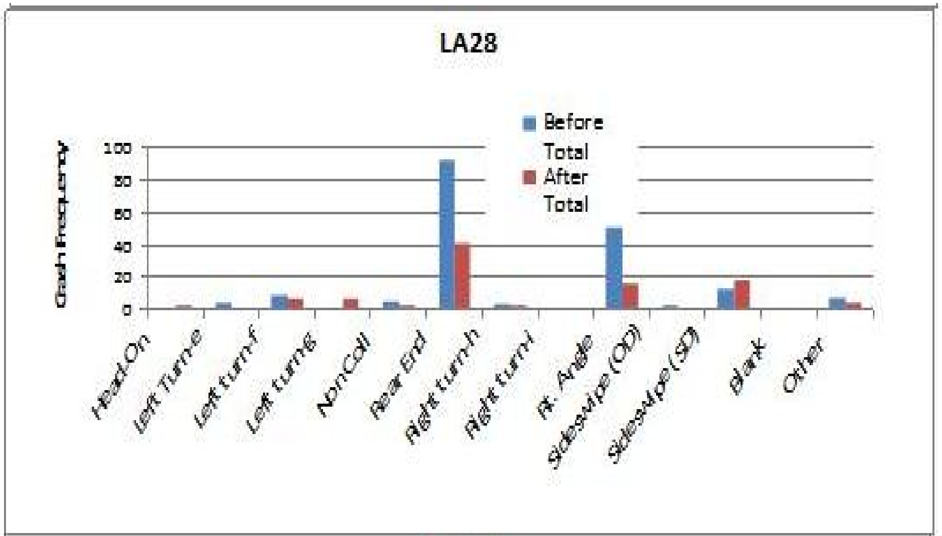
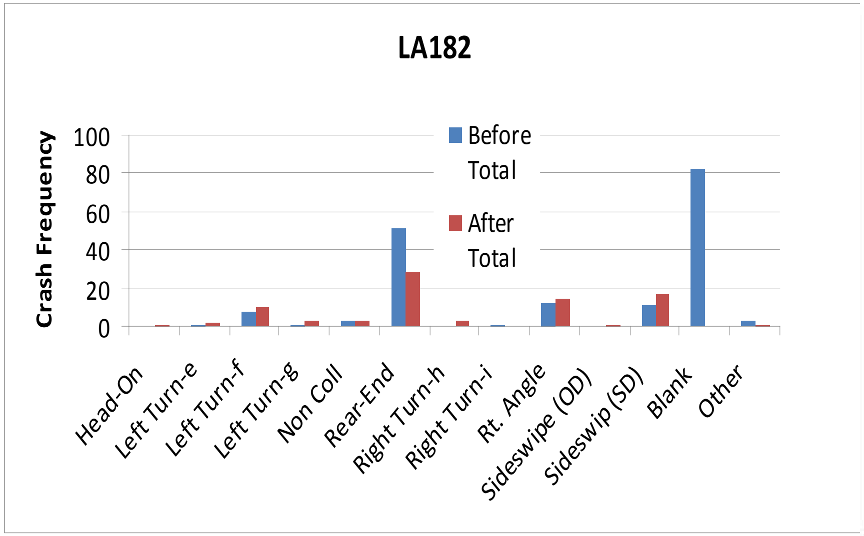
Summary of Crashes
(3 years before and after)

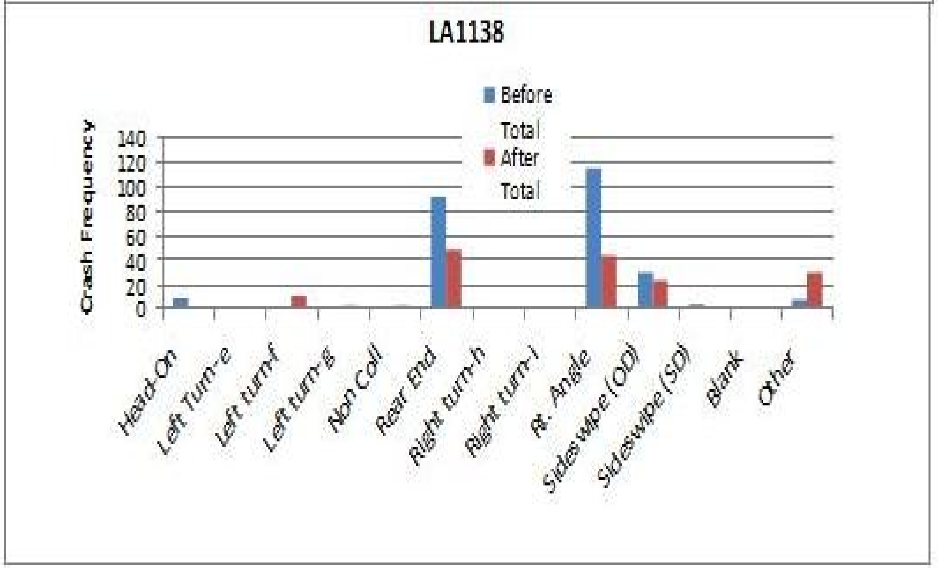
	Before		After		Percentage Change	
	Crashes	Average Crash Rate	Crashes	Average Crash Rate	Crashes	Crash Rate
LA3025	358	10.05	147	4.59	-59%	-54%
LA182	178	8.12	85	3.53	-52%	-51%
LA28	206	7.38	99	4.09	-52%	-45%
LA1138	260	16.01	167	10.63	-36%	-34%

Changes by Crash Type

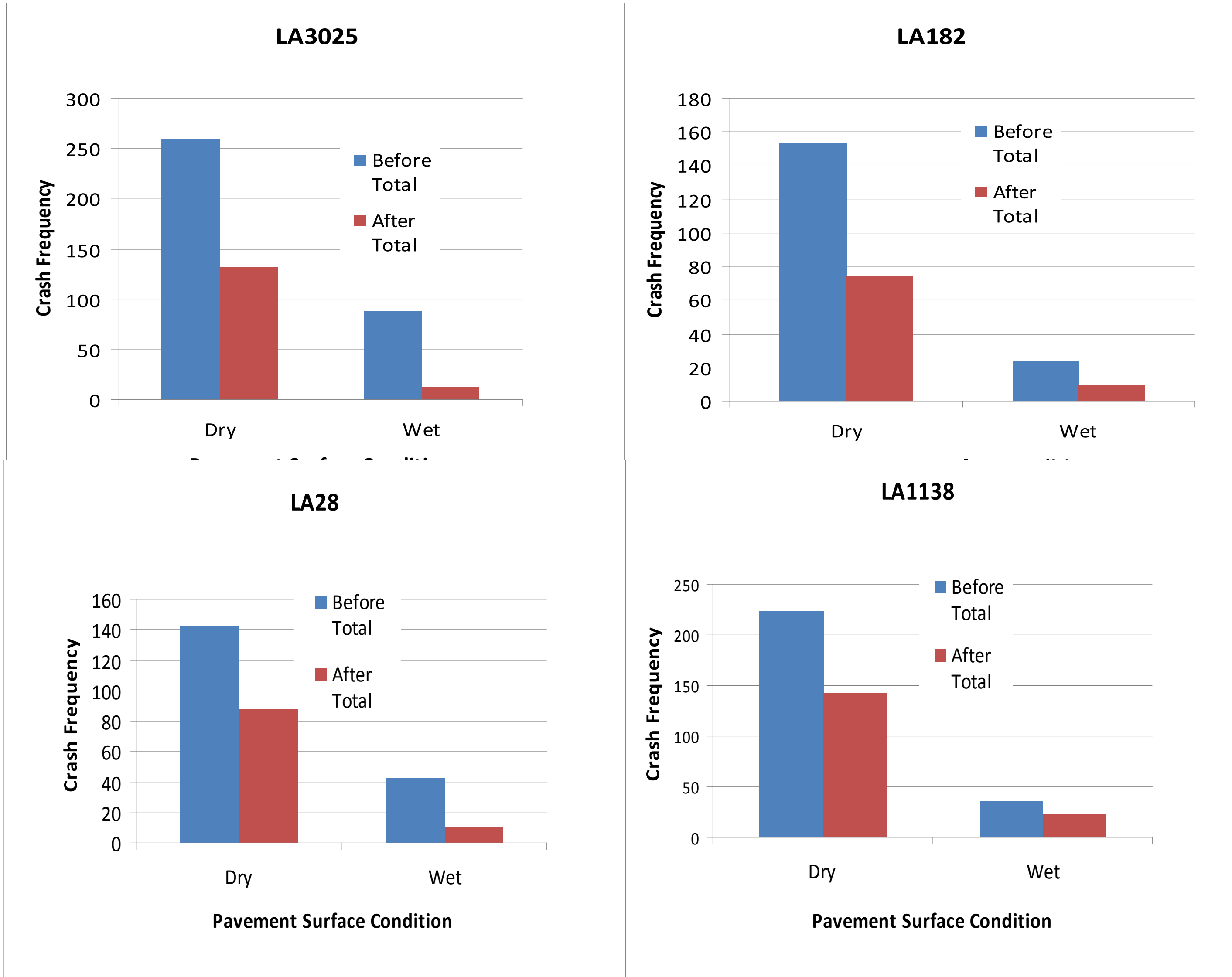




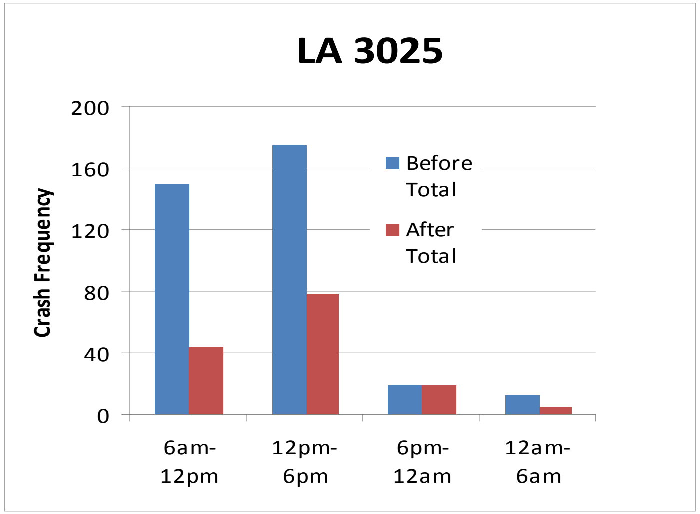


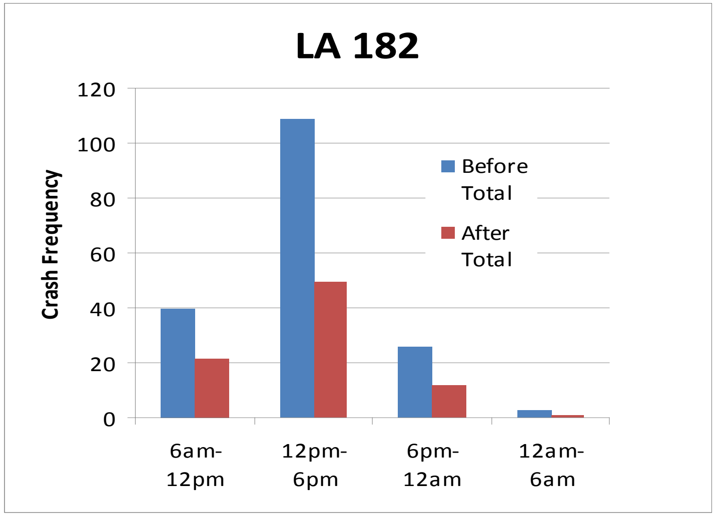


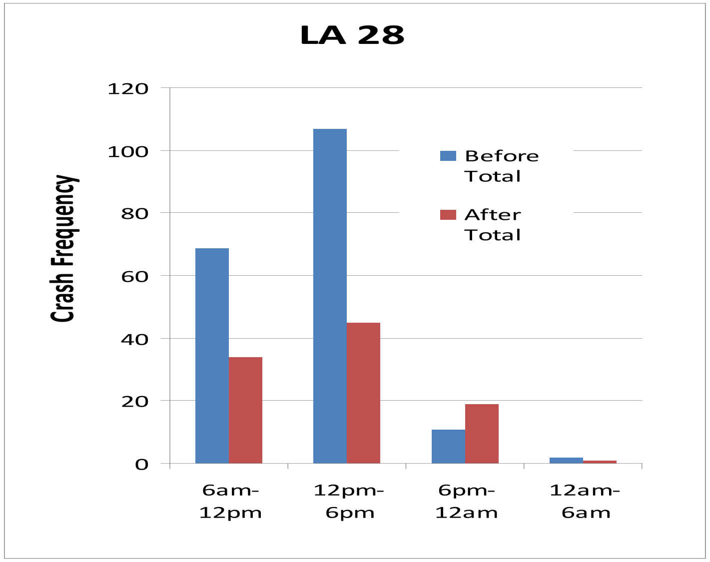
Changes by Pavement Surface Condition

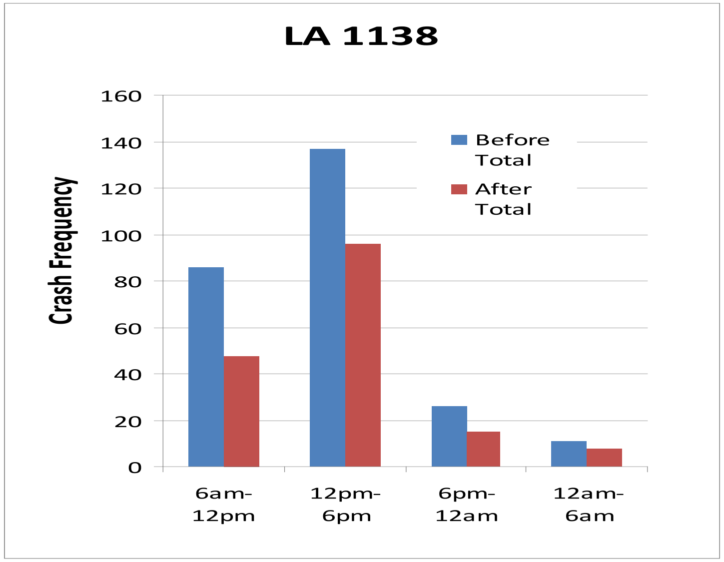


Changes by Time of the Day









Changes by Crash Severity

Crashes by Severity	LA3025			LA182			LA28			LA1138		
	Before	After	% Change	Before	After	% Change	Before	After	% Change	Before	After	% Change
Total	358	147	-58.90%	178	85	-52.30%	206	99	-51.94%	260	167	-35.77%
PDO	277	105	-62.10%	124	63	-49.20%	148	76	-48.68%	172	119	-30.81%
Injury Crashes	81	40	-50.60%	54	22	-59.30%	58	23	-60.34%	88	48	-45.45%
Fatal	0	2	increase	0	0	0%	0	0	0%	0	0	0%

Benefit/Cost Ratio

- Benefit—saving from reduced crashes
- Cost – striping
- B/C=166!

Severity Level	LA 3025 Reduction	LA 182 Reduction	LA 28 Reduction	LA 1138 Reduction
PDO	172	61	72	53
Injury	41	32	35	40

Segment	Total Benefits ($)	Total Cost ($)	B/C Ratio
LA 3025	2,753,868	14,100	195
LA 182	1,913,808	11,500	166
LA 28	2,110,212	10,600	199
LA 1138	2,317,488	12,300	188

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Estimating the Effectiveness

- Based on the principle: the true impact of a crash countermeasure should be **the difference between the safety after the crash countermeasure implementation and the safety in the after period if the crash countermeasure were not implemented**
- Ideally, the predicted expected safety should be calculated by the Empirical Bayes (EB) method with a rigorously developed and carefully calibrated safety performance function
- However…..

Safety Evaluating without SPF and EB

- The “four-step” procedure introduced by Hauer in his book *Observational Before –After Studies in Road Safety: Estimating the effect of Highway and Traffic Engineering measures on Road Safety,*
- Used crash and AADT data three years before and three years after the project for the analysis
- Used all crashes including intersection crashes

Step 1: Estimating the safety if the re-striping were not installed during the after period, and the safety with the re-striping project

$$\hat{\lambda} = N \qquad \hat{VAR}\{\hat{\lambda}\} = N$$

$$\hat{\pi} = \hat{r}_{tf} K \qquad \hat{VAR}\{\hat{\pi}\} = (r_d)^2[(\hat{r}_{tf})^2 K + K^2 \hat{VAR}\{\hat{r}_{tf}\}]$$

Where:

$\hat{\lambda}$*: estimated expected number of crashes in the after period with the project*

N: observed annual crashes after the project implementation

$\hat{\pi}$*: estimated expected number of crashes in the after period without the project*

K: observed crashes before the project implementation

Step 2: Estimating the crash difference and the ratio

$$\hat{\delta} = \hat{\pi} - \hat{\lambda}$$

$$\hat{\theta} = (\hat{\lambda} / \hat{\pi}) / [1 + \widehat{VAR}\{\hat{\pi}\} / \hat{\pi}^2]$$

	Estimated Expected Crash Reduction	Estimated CMF
LA3025	175	0.45
LA182	110	0.43
LA28	111	0.47
LA1138	87	0.65

Step 3: Estimating the variance of expected crash reduction and ratio

$$\hat{\sigma}\{\hat{\delta}\} = \sqrt{\widehat{VAR}\{\hat{\pi}\} + \widehat{VAR}\{\hat{\lambda}\}}$$

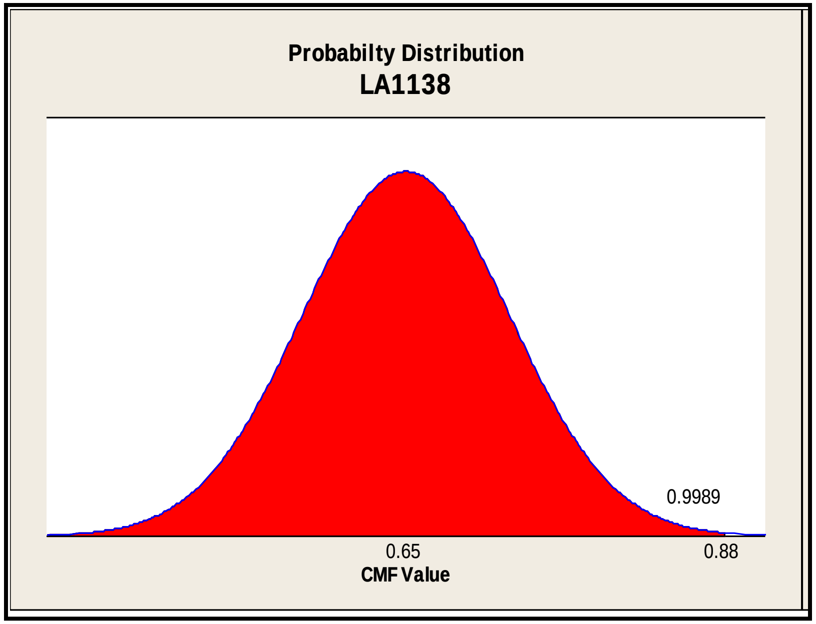
$$\hat{\sigma}\{\hat{\theta}\} = \frac{\hat{\theta}\sqrt{\widehat{VAR}\{\hat{\lambda}\} / \hat{\lambda}^2) + (\widehat{VAR}\{\hat{\pi}\} / \hat{\pi}^2)}}{(1 + \widehat{VAR}\{\hat{\pi}\} / \hat{\pi}^2)}$$

Results

	Expected Crash Reduction	Standard Deviation	Estimated the CMF	Standard Deviation
LA3025	175	27.62	0.45	0.051
LA182	110	20.53	0.43	0.062
LA28	111	21.28	0.47	0.062
LA1138	87	25.42	0.65	0.075

What does the result mean?
A certainty in crash reduction

Roadway	Estimated CMF	Standard Deviation	CMF+ 3*Standard Deviation
LA3025	0.45	0.051	0.60
LA182	0.43	0.062	0.62
LA28	0.47	0.062	0.66
LA1138	0.65	0.075	0.88



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Results Discussion

- The crash reduction by the re-striping/lane conversion projects is striking and the estimated CMF is impressive (crash countermeasures, as listed in the first edition of the HSM, seldom yield CMF values smaller than 0.5)
- The estimated CMF and standard deviation on all roadway segments indicate a certainty that a re-striping project reduces crashes.

Results Discussion

- Reductions are consistent cross crash category
- It is a very cost-effective crash countermeasure

Results Discussion

- Demonstrating the need for flexibility in selecting the best safety improvement project under the existing constraints (financial or otherwise).
- If and when funds do become available and sufficient right-of-way (ROW) can be obtained, these two 5-lane roadway segments can be converted to a boulevard roadway type, a concept very much promoted today in urban and suburban areas in Louisiana

Results Discussion

- Speed limit reduction (from 50 mph to 45 mph) on 44% of LA182 segment after the re-striping project may not have impact on crashes frequency but may have on crash severity based on our knowledge on operating speed
- Although all the intersection crashes are not excluded from the analysis, the impact of the re-striping project should not be overestimated since the configurations of all intersections remain the same before and after the re-striping projects.

Results Discussion

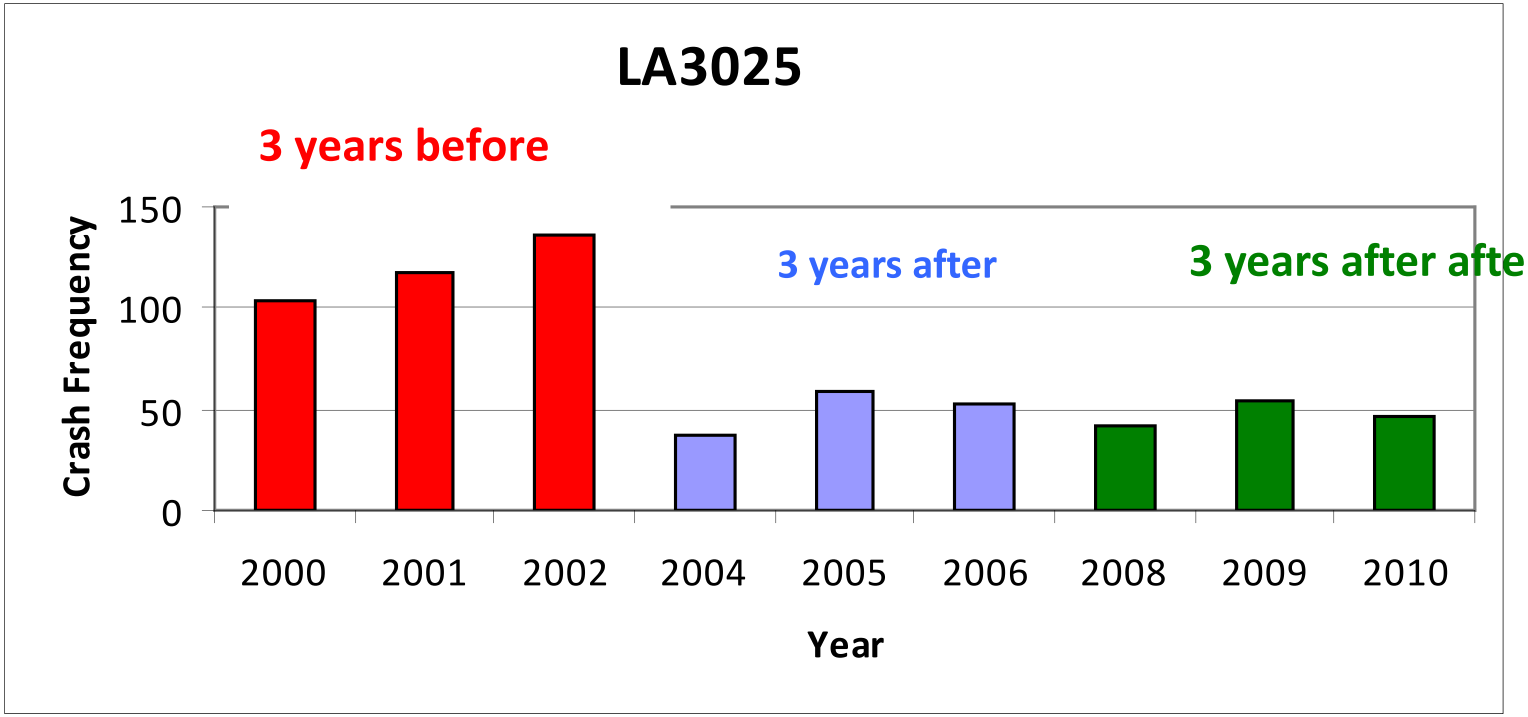
- Possible effect of “road diet”?
- Lack of operating speed data before the project makes the analysis impossible

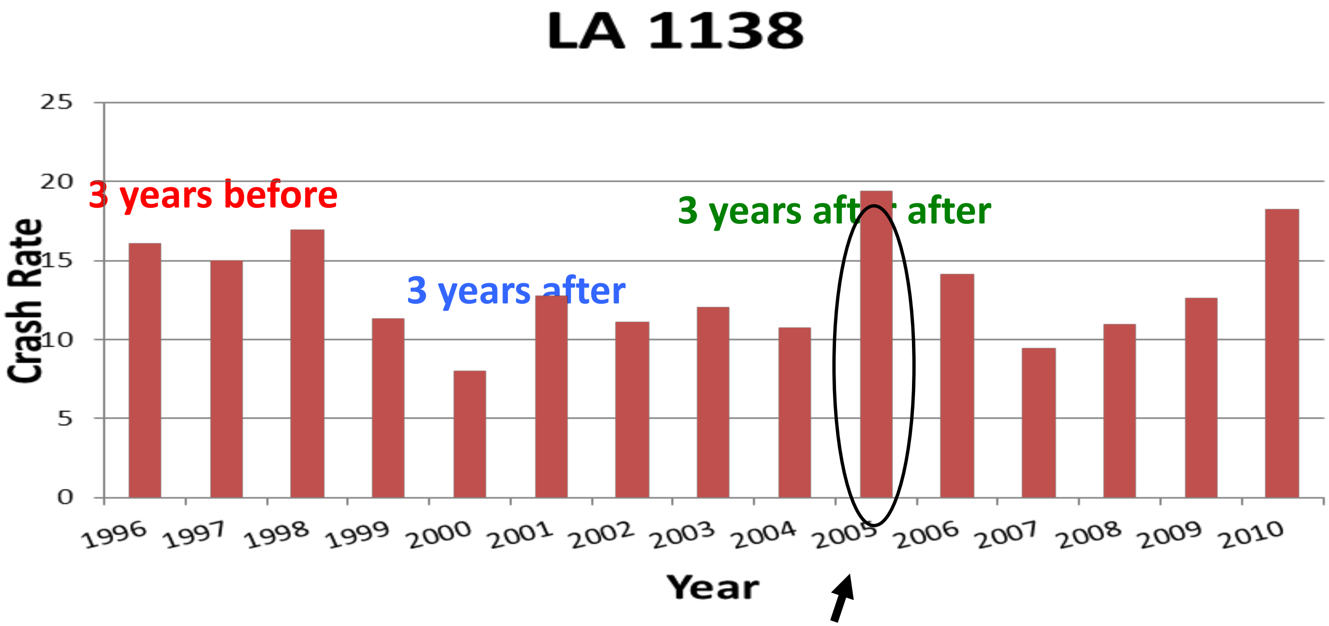
Evaluation of Lane Reduction "Road Diet" Measures on Crashes

FHWA-HRT-10-053

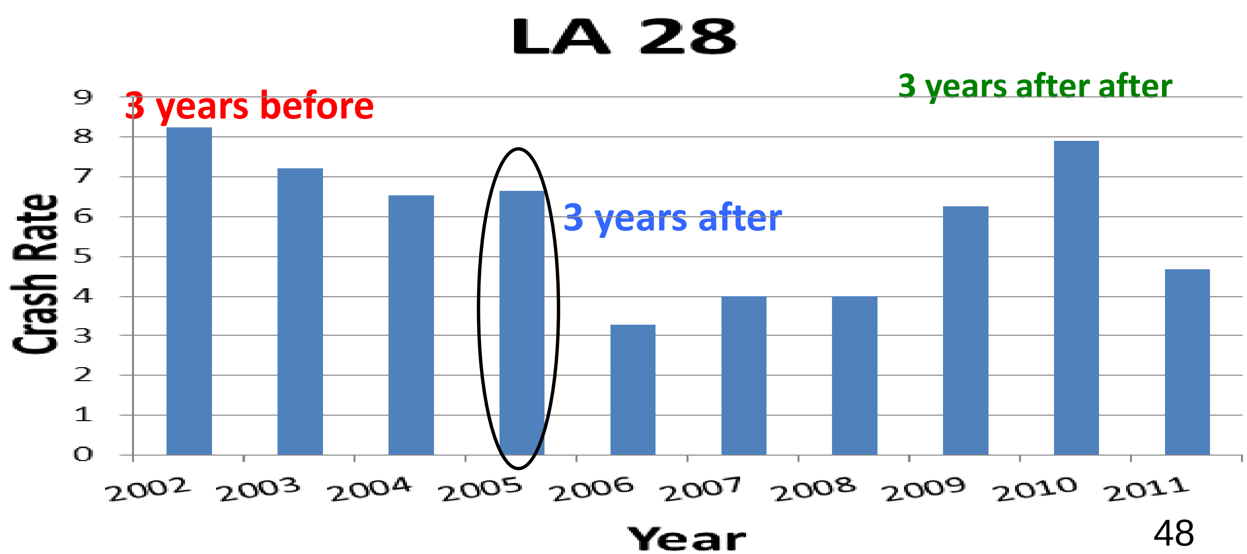
- A ***road diet*** involves narrowing or eliminating travel lanes on a roadway to make more room for pedestrians and bicyclists

Sustainable crash reduction

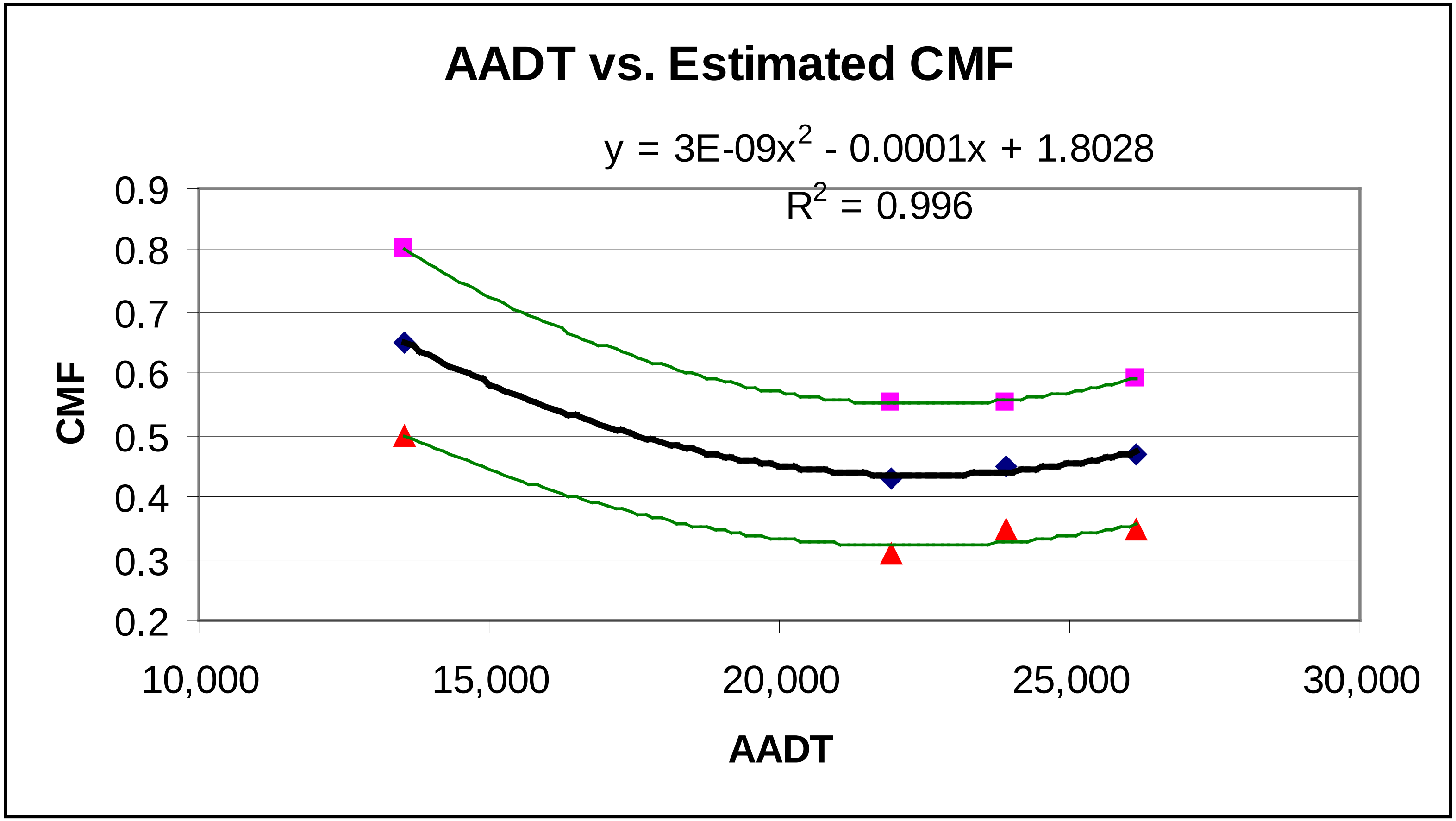




Hurricane Rita



CMF as a function of AADT



Due to the huge success of the lane-conversion project, 3, more segments from LADOTD District 3 have been recently re-striped:

- LA 14-Bypass in Abbeville
- LA 14 in Abbeville
- US 190 in Eunice
- LA 93 in Sunset
- LA 14 in New Iberia

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Thank you!

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