

Hazard Elimination Project Evaluation

Order # 41000019148

Hazard Elimination Project W-4827

**Evaluation of the Rumble Strip Installation
US-1 from Milepost 8.91 in Lee County to the Wake County Line
Lee & Chatham Counties**

Documents Prepared By:

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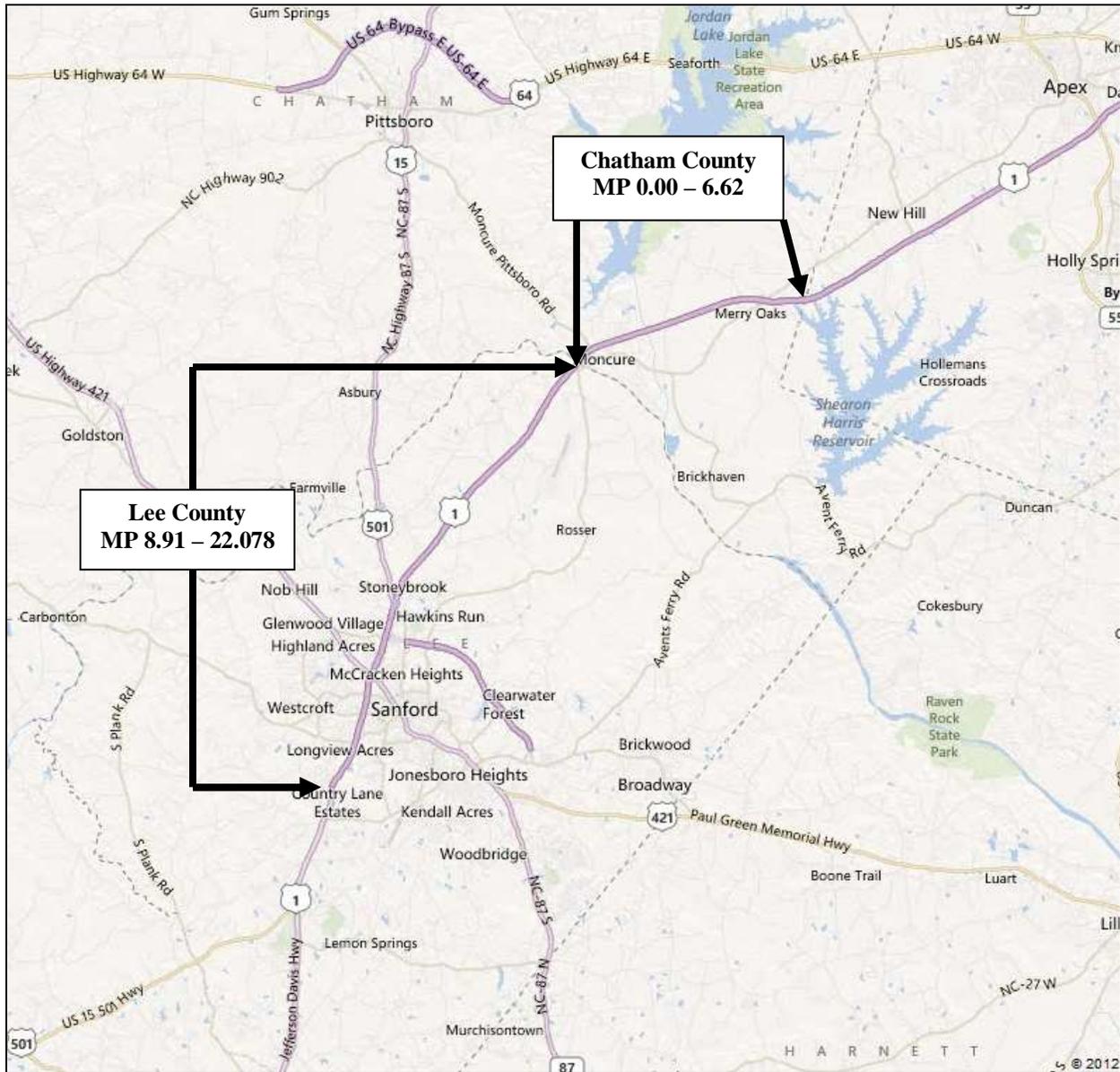
8-20-2012
Date

Hazard Elimination Project Evaluation Documentation

Subject Location

Evaluation of Hazard Elimination Project Number W-4827 located along US-1 from Milepost 8.91 in Lee County (start of the freeway segment) to the Wake County Line in Lee and Chatham Counties, including the City of Sanford. The Total Segment is 19.788 miles.

Lee County: Milepost 8.91 to Chatham County (MP 8.91 – 22.078)
Chatham County: Lee County Line to Wake County Line (MP 0.00 – 6.62)



Map Provided by BING Maps

Project Information and Background from the Project File Folder

The hazard elimination project improvement chosen for the subject locations were the installation of milled rumble strips along the inside and outside shoulders of this freeway segment.

US-1 is mostly a four-lane median divided facility with two lanes in both directions of travel. Roadway photos indicate approximately a 4-foot median paved shoulder and a 10-foot outside paved shoulder. The median maintains protection with three-strand cable and W-beam guardrail along the entire route, which was installed in 2002. The speed limit is posted at 65-mph. This roadway acts as the main connector access to Raleigh and the Triangle from the Southern Piedmont Region. The total segment length is 19.788 miles.

The original statement of problem mentioned that vehicles were running off the road resulting in fatalities, serious injuries, and property damage. Casual factors for vehicles leaving the roadway include driver fatigue and/or inattention. Rumble strips provide both noise and vibration as a warning to motorists that they are leaving the travel lane.

The initial crash analysis was completed from August 1, 2000 to July 31, 2003 with 138 reported crashes, with 111 crashes considered correctable Ran-Off Road collisions. The improvement was completed on July 17, 2006 with a total cost of \$150,000. The projected B/C Ratio was 29.25.

Naive Before and After Analysis

After reviewing the project file folder along with all the crashes along the subject segment, the crash data omitted from this analysis to consider for an adequate construction period were the months of May through July 2006. The before period consisted of reported crashes from October 1, 2000 through April 30, 2006 (5 years, 7 months); and the after period consisted of reported crashes from August 1, 2006 through February 29, 2012 (5 years, 7 months). The ending date for this analysis was determined by the date of available crash data at the time of analysis.

The treatment data consisted of all crashes along US-1 with a zero (0) foot y-line (No Ramps).
Please see attached location map for further details.

The following data table depicts the Naive Before and After Analysis for the treatment location. Please note that Interstate Lane Departure Crashes were the target crashes for the applied countermeasure. The Freeway Lane Departure Crash types considered are as follows: Angle; Fixed Object; Head-On; Jackknife; Overturn/Rollover; Parked Motor Vehicle; Ran-Off Roadway (Right, Left, Straight); and Sideswipe (Same and Opposite Direction). All Lane Departure Crashes were independently verified for this evaluation.

<u>Treatment Information – Both Counties</u>	Before	After	Percent Reduction (-)/ Percent Increase (+)
Total Crashes – Both Counties & Both Directions	448	563	25.7 %
Total Severity Index	3.68	3.63	- 1.4 %
LD Crashes – Both Counties & Both Directions	303	380	25.4 %
Lane Departure Severity Index	4.08	4.29	5.1 %

US-1 Lee County (MP 8.91 – 22.078)	Before	After	Percent Reduction (-)/ Percent Increase (+)
Total Crashes – Both Directions	324	357	10.2 %
Total Severity Index	3.51	4.42	25.9 %
Lane Departure Crashes – Both Directions			
Lane Departure Crashes – Both Directions	227	245	7.9 %
LD Severity Index	3.69	5.13	39.0 %
Lane Departure WET – Both Directions			
Lane Departure WET – Both Directions	99	128	29.3 %
LD WET Severity Index	3.56	4.63	30.1 %
Lane Departure WINTER – Both Directions			
Lane Departure WINTER – Both Directions	22	24	9.1 %
LD WINTER Severity Index	3.69	2.23	- 39.6 %
Volume (2003, 2009)	19,800	21,000	6.1 %
Total Crash Rate (100 Million Vehicle Miles)	60.98	63.32	3.8 %
Injury Crashes			
Fatal Injury Crashes	3	5	66.7 %
Class-A Injury Crashes	0	3	300.0 %
Class-B Injury Crashes	20	18	- 10.0 %
Class-C Injury Crashes	59	65	10.2 %
Property Damage Only Crashes	242	266	9.9 %
Contributing Factors			
Night Crashes	121	154	27.3 %
Animal Crashes	46	57	23.9 %
Wet Road Crashes	113	135	19.5 %
Alcohol Related	15	12	- 20.0 %
Lane Departure Crash Types			
Angle	6	1	- 83.3 %
Fixed Object	23	141	513.0 %
Head On	1	2	100.0 %
Jackknife	2	1	- 50.0 %
Movable Object	3	2	- 33.3 %
Other Collision With Vehicle	3	4	33.3 %
Other Non-Collision	1	4	300.0 %
Overturn / Rollover	0	4	400.0 %
Parked Motor Vehicle	2	4	100.0 %
Ran Off Road (Left)	85	37	- 56.5 %
Ran Off Road (Right)	81	26	- 67.9 %
Right Turn, Same Roadway	3	0	- 100.0 %
Sideswipe, Opposite Direction	1	1	0.0 %
Sideswipe, Same Direction	16	18	12.5 %

<u>US-1 Lee County - Northbound</u>	Before	After	Percent Reduction (-)/ Percent Increase (+)
Total Crashes	124	128	3.2 %
Total Severity Index	3.28	3.50	6.7 %
Lane Departure Crashes	79	79	0.0 %
LD Severity Index	4.02	4.11	2.2 %
Lane Departure WET	23	35	52.2 %
LD WET Severity Index	2.93	2.90	- 1.0 %
Lane Departure WINTER	15	7	- 53.3 %
LD WINTER Severity Index	2.48	1.00	- 59.7 %

<u>US-1 Lee County – Southbound</u>	Before	After	Percent Reduction (-)/ Percent Increase (+)
Total Crashes	200	229	14.5 %
Total Severity Index	3.65	4.93	35.1 %
Lane Departure Crashes	148	166	12.2 %
LD Severity Index	3.51	5.61	59.8 %
Lane Departure WET	76	93	22.4 %
LD WET Severity Index	3.75	5.28	40.8 %
Lane Departure WINTER	7	17	148.9 %
LD WINTER Severity Index	6.29	2.74	- 56.4 %

The naive before and after analysis at the treatment location through Lee County resulted in a 10 percent increase in Total Crashes, an 8 percent increase in Lane Departure Target Crashes, and a 26 percent increase in the Total Severity Index. The before period ADT year was 2003 and the after period ADT year was 2009.

Lee County Lane Departure crashes were further analyzed by weather conditions as coded on the crash reports. Lane Departure WET included rain and standing water (codes 2 & 3), which experienced a 29 percent increase through the evaluation with a 30 percent increase in the severity index. Lane Departure WINTER included ice, snow, and slush (codes 4, 5, & 6); which saw a 9 percent increase in crashes but a 40 percent reduction in the severity index.

The increase in Severity Index is highlighted by an increase in Severe Injury Crashes along this segment. Fatal crashes increased from three (3) to five (5) throughout the evaluation and A-injury collisions jumped from zero (0) in the before period to three (3) in the after period.

The Directional Analysis of US-1 in Lee County indicates a steady increase in both directions with the southbound direction experiencing the greater Severity Index increase at 35 percent. The northbound direction experienced the same number of lane departure crashes in the after period as the before and the southbound direction saw an increase of 12 percent.

Weather Data was obtained by the North Carolina State Climate Office for this segment but was unable to be analyzed due to large gaps (months) of missing precipitation type and amount information. From the TIP Search of other projects along this segment in Lee County, guardrail was installed in 2002, the new US-421 Bypass interchange was constructed in 2003, and resurfacing occurred in 2004 and 2009.

US-1 Chatham (MP 0.00 – 6.62)	Before	After	Percent Reduction (-)/ Percent Increase (+)
Total Crashes – Both Directions	124	206	66.1 %
Total Severity Index	4.13	2.26	- 45.3 %
Lane Departure Crashes – Both Directions			
Lane Departure Crashes – Both Directions	76	135	77.6 %
LD Severity Index	5.23	2.75	- 47.4 %
Lane Departure WET – Both Directions			
Lane Departure WET – Both Directions	17	49	188.2 %
LD WET Severity Index	2.74	2.21	- 19.3 %
Lane Departure WINTER – Both Directions			
Lane Departure WINTER – Both Directions	20	24	20.0 %
LD WINTER Severity Index	2.48	2.54	2.4 %
Volume (2003, 2009)	17,500	18,000	2.9 %
Total Crash Rate (100 Million Vehicle Miles)	52.52	84.79	61.4 %
Injury Crashes			
Fatal Injury Crashes	0	0	0.0 %
Class-A Injury Crashes	2	0	- 100.0 %
Class-B Injury Crashes	6	10	66.7 %
Class-C Injury Crashes	26	25	- 3.8 %
Property Damage Only Crashes	90	171	90.0 %
Contributing Factors			
Night Crashes	46	81	76.1 %
Animal Crashes	31	46	48.4 %
Wet Road Crashes	20	54	170.0 %
Alcohol Related	4	7	75.0 %
Lane Departure Crash Types			
Fixed Object	25	108	332.0 %
Other Collision With Vehicle	3	3	0.0 %
Other Non-Collision	1	0	- 100.0 %
Overturn / Rollover	0	1	100.0 %
Parked Motor Vehicle	0	3	300.0 %
Ran Off Road (Left)	18	3	- 83.3 %
Ran Off Road (Right)	24	4	- 83.3 %
Sideswipe, Opposite Direction	1	0	- 100.0 %
Sideswipe, Same Direction	4	13	225.0 %

<u>US-1 Chatham County - Northbound</u>	Before	After	Percent Reduction (-)/ Percent Increase (+)
Total Crashes	58	103	77.6 %
Total Severity Index	3.17	2.08	- 34.4 %
Lane Departure Crashes	39	74	89.7 %
LD Severity Index	2.90	2.40	- 17.2 %
Lane Departure WET	7	25	257.1 %
LD WET Severity Index	2.06	2.78	35.0 %
Lane Departure WINTER	18	19	5.6 %
LD WINTER Severity Index	2.23	1.78	- 20.2 %

<u>US-1 Chatham County - Southbound</u>	Before	After	Percent Reduction (-)/ Percent Increase (+)
Total Crashes	66	103	56.1 %
Total Severity Index	4.98	2.44	- 51.0 %
Lane Departure Crashes	37	61	64.9 %
LD Severity Index	7.70	3.18	- 58.7 %
Lane Departure WET	10	24	140.0 %
LD WET Severity Index	3.22	1.62	- 49.7 %
Lane Departure WINTER	2	5	150.0 %
LD WINTER Severity Index	4.70	5.44	15.7 %

The naive before and after analysis at the treatment location through Chatham County resulted in a 66 percent increase in Total Crashes, a 78 percent increase in Lane Departure Target Crashes, but a 45 percent reduction in the Total Severity Index. The before period ADT year was 2003 and the after period ADT year was 2009.

Chatham County Lane Departure crashes were further analyzed by weather conditions as coded on the crash reports. Lane Departure WET included rain and standing water (codes 2 & 3), which experienced a 188 percent increase through the evaluation but a 19 percent reduction in the severity index. Lane Departure WINTER included ice, snow, and slush (codes 4, 5, & 6); which saw a 20 percent increase in crashes and a 2 percent increase in the severity index.

The Severe Injury Crashes along this Chatham County segment were eliminated through the evaluation with two (2) A-injury collisions in the before period to zero (0) in the after period.

The Directional Analysis of US-1 in Chatham County indicates greater than 50 percent increase of both total and lane departure target crashes for both directions. The Lane Departure WET collisions for northbound motorists increased more than 200 percent with a 35 percent increase in the severity index.

Again, the weather data was obtained by the North Carolina State Climate Office for this segment but was not able to be analyzed due to large gaps (months) of missing precipitation type and amount

information. From the TIP Search of other projects along this segment in Chatham County, guardrail was installed in 2002 and resurfacing occurred in 2010.

Results and Discussion

The calculated benefit to cost ratio (both counties) for this project is **(-19.89) considering total crashes**. The benefit to cost ratio **considering only target lane departure crashes is (-19.21)**. The benefits are calculated using the change in annual crash costs from the before to the after period. Operational and other benefits related to the project are not considered in this analysis. The costs of the project include the actual construction costs as well as the increase in annual maintenance and utility costs.

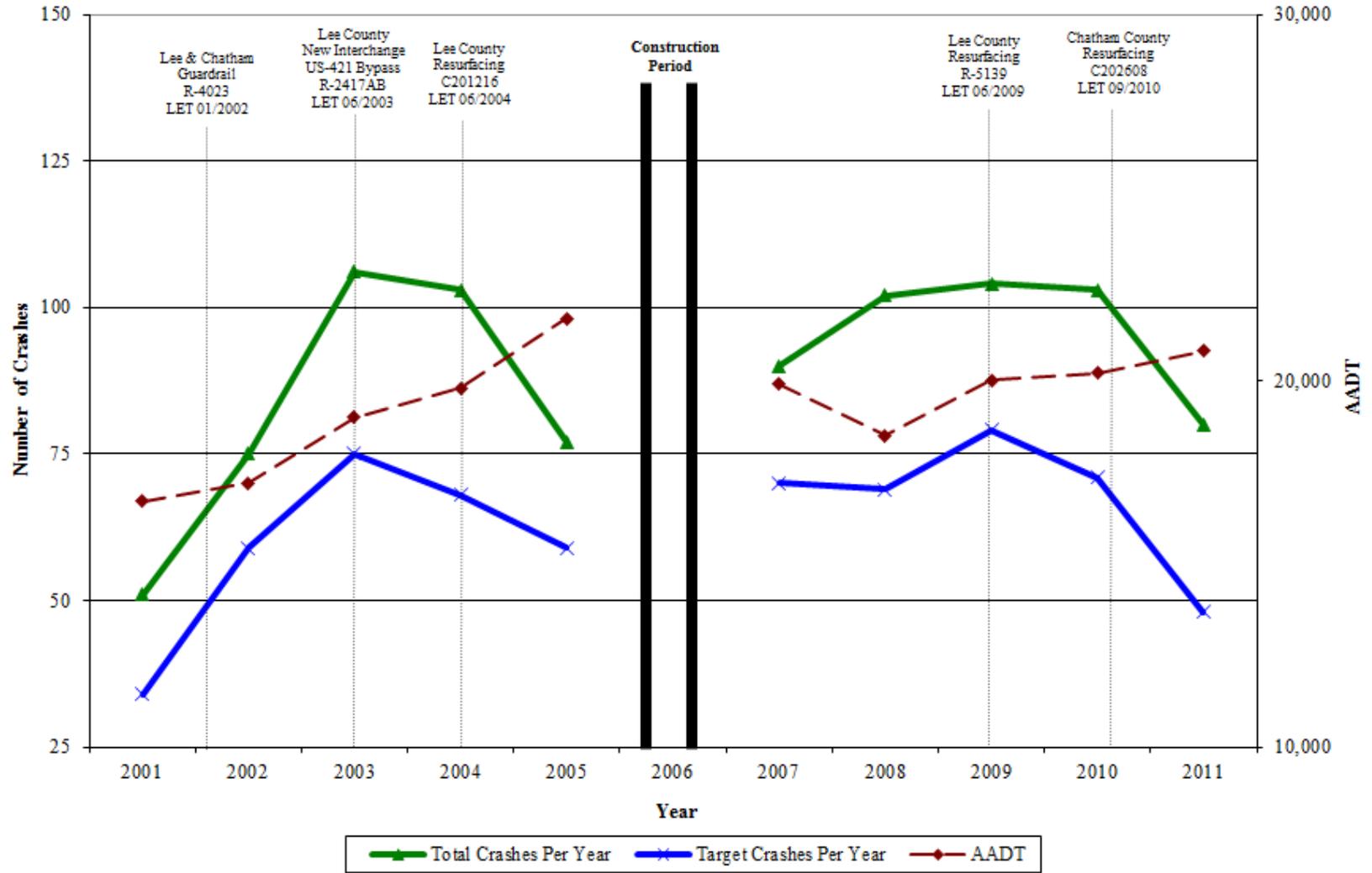
The following charts depict the number of Total and Target Crashes per year plotted in the before and after period, along with the AADT for both counties combined and then each county individually.

Based off the diagrams below, crashes per year appear to have increased dramatically with the Guardrail project in early 2002 but decline after the resurfacings. Also, Lee County total crashes spiked after the US-421 Bypass interchange was constructed in 2004 and Chatham County experienced a spike in total and lane departure collisions in 2010 prior to resurfacing. Due to the number of other projects that likely influenced crashes during the study period, the increase change in crash values cannot be attributed solely to the rumble strip installations.

As the Safety Evaluation Group completes additional safety reviews for this type of countermeasure, we will be able to provide objective and definite information regarding actual crash reduction factors for this type of treatment.

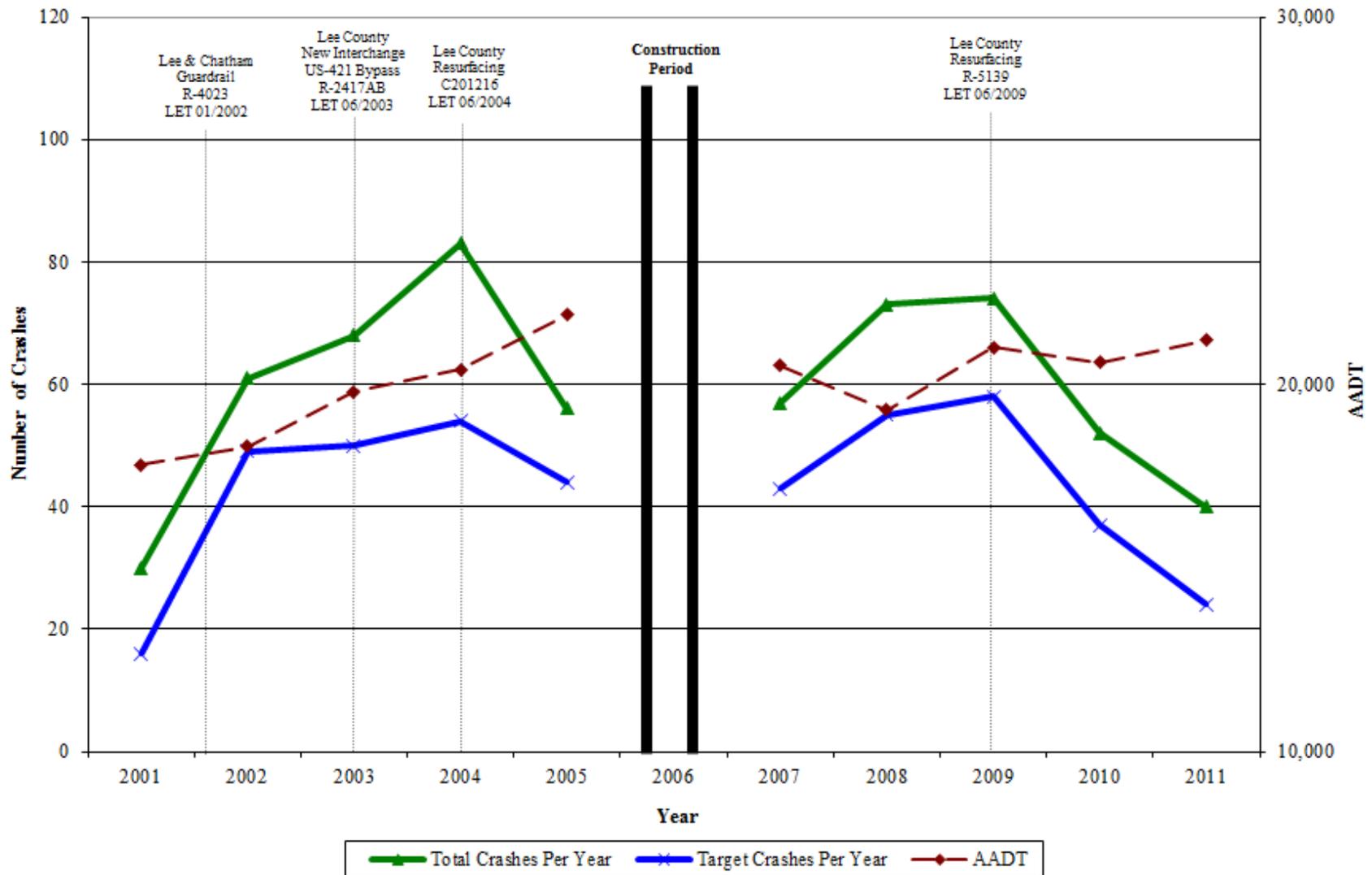
US-1: Freeway in Lee & Chatham Counties

Rumble Strips Completed 07/2006



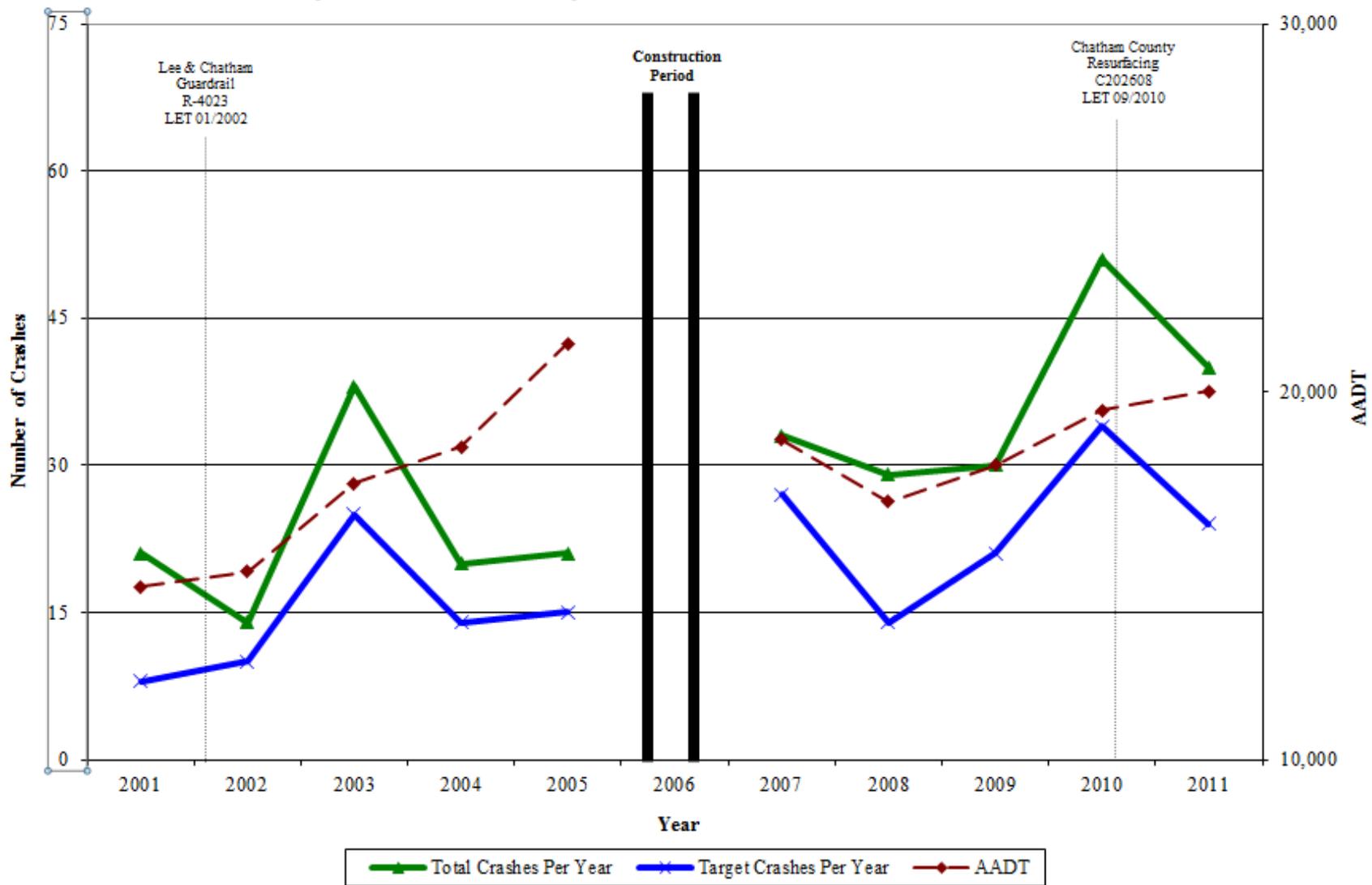
US-1: Freeway in Lee County - Crashes Per Year

Rumble Strips Completed 07/2006



US-1: Freeway in Chatham County - Crashes Per Year

Rumble Strips Completed 07/2006



BENEFIT-COST ANALYSIS WORKSHEET - Total Crashes

LOCATION: US-1 Freeway		BY: JBS						
COUNTY: Lee & Chatham		DATE: 7/12/2012						
FILE NO.: W-4827								
DETAILED COST:	TYPE IMPROVEMENT -	Rumble Strips						
	ITEMS	TOTAL	SERVICE	CRF	ANNUAL COST			
	Construction	\$150,000	10	0.149	\$22,354			
		\$0	0	0.000	\$0			
	Right-of-Way	\$0	0	0.000	\$0			
	TOTALS	\$150,000	10	0.149	\$22,354			
	ESTIMATED INCREASE IN ANNUAL MAINT. COST =				\$0			
	ESTIMATED INCREASE IN ANNUAL UTILITY COST =				\$0			
	TOTAL ANNUAL COST=				\$22,354			
	TOTAL COST OF PROJECT=				\$150,000			
COMPREHENSIVE COST REDUCTION:								
ESTIMATED NUMBER OF ANNUAL ACCIDENT DECREASES								
TIME PERIOD	YEARS	K & A CRASHES	K & A CRASHES PER YR	B & C CRASHES	B & C CRASHES PER YR	PDO CRASHES	PDO CRASHES PER YR	ANNUAL COSTS
BEFORE	5.58	5	0.90	111	19.89	332	59.50	\$1,218,208
AFTER	5.58	8	1.43	118	21.15	437	78.32	\$1,662,921
Annual Benefits from Crash Cost Savings								(\$444,713)
NET AVG. ANNUAL BENEFITS = AVG. ANNUAL BENEFITS - TOTAL ANNUAL COST					=	(\$467,068)		
BENEFIT-COST RATIO = AVG ANNUAL BENEFITS/TOTAL ANNUAL COST					=	-19.89		
TOTAL COST OF PROJECT		-	\$150,000	COMPREHENSIVE B/C RATIO		-	-19.89	

BENEFIT-COST ANALYSIS WORKSHEET - Target Crashes

LOCATION: US-1 Freeway		BY: JBS						
COUNTY: Lee & Chatham		DATE: 7/12/2012						
FILE NO.: W-4827		Lane Departure Target Crashes						
DETAILED COST:	TYPE IMPROVEMENT -	Rumble Strips						
	ITEMS	TOTAL	SERVICE	CRF	ANNUAL COST			
	Construction	\$150,000	10	0.149	\$22,354			
		\$0	0	0.000	\$0			
	Right-of-Way	\$0	0	0.000	\$0			
	TOTALS	\$150,000	10	0.149	\$22,354			
	ESTIMATED INCREASE IN ANNUAL MAINT. COST =				\$0			
	ESTIMATED INCREASE IN ANNUAL UTILITY COST =				\$0			
	TOTAL ANNUAL COST=				\$22,354			
	TOTAL COST OF PROJECT=				\$150,000			
COMPREHENSIVE COST REDUCTION:								
ESTIMATED NUMBER OF ANNUAL ACCIDENT DECREASES								
TIME PERIOD	YEARS	K & A CRASHES	K & A CRASHES PER YR	B & C CRASHES	B & C CRASHES PER YR	PDO CRASHES	PDO CRASHES PER YR	ANNUAL COSTS
BEFORE	5.58	4	0.72	85	15.23	214	38.35	\$921,183
AFTER	5.58	7	1.25	97	17.38	276	49.46	\$1,350,681
Annual Benefits from Crash Cost Savings								(\$429,498)
NET AVG. ANNUAL BENEFITS = AVG. ANNUAL BENEFITS - TOTAL ANNUAL COST					=	(\$451,853)		
BENEFIT-COST RATIO = AVG ANNUAL BENEFITS/TOTAL ANNUAL COST					=	-19.21		
TOTAL COST OF PROJECT		-	\$150,000	COMPREHENSIVE B/C RATIO		-	-19.21	