

# **Hazard Elimination Project Evaluation**

Order # 41000011372

Hazard Elimination Project W-4814

**Evaluation of the Rumble Strip Installation on I-540 in Wake and Durham Counties and on SR 3097 (Aviation Pkwy) in Wake County**

Documents Prepared By:

Safety Evaluation Group  
Traffic Safety Systems Management Section  
Transportation Mobility and Safety Division  
North Carolina Department of Transportation

**Principal Investigator**



Brad Robinson, PE

3/18/2011

Date

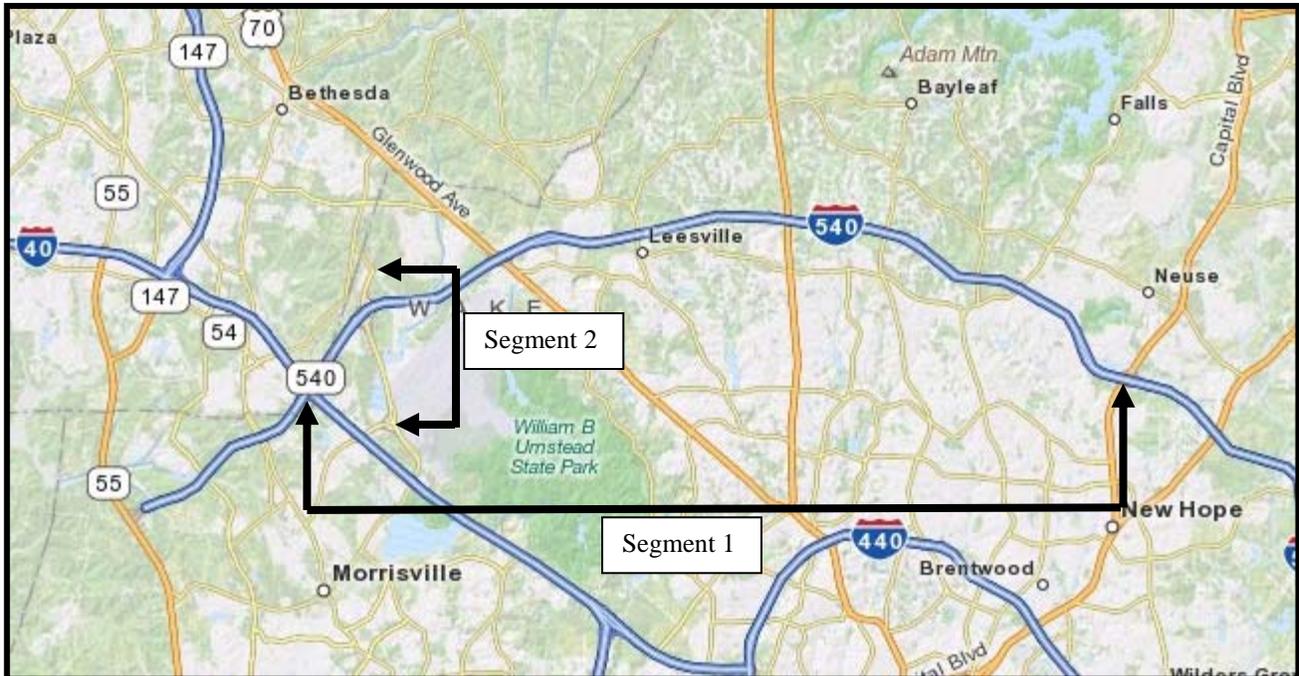
Traffic Safety Project Engineer

# *Hazard Elimination Project Evaluation Documentation*

## **Subject Location**

The project included two locations:

1. I-540 from I-40 in Durham County to US 1 in Wake County
2. SR 3097 (Aviation Pkwy) From SR 1644 (Globe Rd) to Terminal Blvd



## **Project Information and Background from the Project File Folder**

The hazard elimination project improvements chosen for the subject locations were the installation of rumble strips along the inside and outside shoulders.

I-540 and SR 3097 (Aviation Pkwy) are multi-lane, divided facilities. The speed limit is 65 mph on I-540 and 45 mph on SR 3097. I-540 has paved shoulder widths of 10 ft. on the majority of the section. SR 3097 has an inside paved shoulder width of 4 ft. and an outside paved shoulder width of 9 ft.

When the project was constructed, I-540 ended at the same interchanges as the project limits. Soon afterwards it was extended on both sides.

The initial crash analysis was completed from July 31, 2000 to June 30, 2003 with 169 reported Ran Off Road crashes. The improvement was completed in April, 2006 with a total cost of \$150,000. The projected B/C Ratio was 30.53

## Naive Before and After Analysis

After reviewing the project file folder along with all the crashes at the subject location, the crash data omitted from this analysis to consider for an adequate construction period were from February 1, 2006 through May 30, 2006. The before period consisted of reported crashes from July 1, 2001 through January 31, 2006 (4.58 years); and the after period consisted of reported crashes from June 1, 2006 through December 31, 2010 (4.58 years). The ending date for this analysis was determined by the date of available crash data at the time of analysis. The before period ADT year was 2003 and the after period ADT year was 2008.

The treatment data for Segment 1 consisted of all mainline crashes on I-540 in Wake County from the Durham County Line to approximately 0.75 miles west of US 1. The reason for leaving the last 0.75 miles of the project in addition to the Durham County portion (approximately 0.75 miles) is that when the project was constructed, I-540 ended at the same end points as the project. During the periods analyzed, I-540 was extended at both ends. The evaluation limits were changed in order to account for the construction and to make sure that the same portion of roadway is analyzed in both time periods. (For example, prior to the extensions many crash reports referred to crashes on the ramps from I-40 to I-540 as being on I-540.)

The treatment data for Segment 2 consisted of all mainline crashes on SR 3097 from Terminal Blvd to 150 feet south of SR 1644 (Globe Rd).

### **Segment 1 I-540**

<b><u>Segment 1 Treatment Information</u></b>	<b>Before</b>	<b>After</b>	<b>Percent Reduction (-)/ Percent Increase (+)</b>
Total Crashes – Both Directions	758	1,223	61.3
Total Severity Index	3.08	2.78	-9.7
Lane Departure Crashes – Both Directions	428	634	48.1
Lane Departure Severity Index	3.66	2.91	-20.5
Volume	46,500	79,400	70.8

<b>Segment 1</b>	<b>Before</b>	<b>After</b>	<b>Percent Reduction (-)/ Percent Increase (+)</b>
<b>Injuries</b>			
Fatal Injury Crashes	5	3	-40.0
Class-A Injury Crashes	3	3	0.0
Class-B Injury Crashes	36	50	38.9
Class-C Injury Crashes	95	182	91.6
Property Damage Only Crashes	619	985	59.1
<b>Contributing Factors</b>			
Night Crashes	256	359	40.2
Wet Road Crashes	238	407	71.0
Alcohol Related	19	34	78.9
<b>Lane Departure Crash Types</b>			
Angle	14	23	64.3
Fixed Object	243	311	28.0
Head On	3	1	-66.7
Jackknife	1	3	200.0
Overturn / Rollover	21	15	-28.6
Parked Motor Vehicle	9	5	-44.4
Ran Off Road (Left)	57	90	57.9
Ran Off Road (Right)	15	42	180.0
Sideswipe, Same Direction	63	142	125.4
Sideswipe, Opposite Direction	2	2	0.0

The following tables divide the crash data for Segment 1 by direction of travel:

<b>Segment 1 Eastbound</b>	<b>Before</b>	<b>After</b>	<b>Percent Reduction (-)/ Percent Increase (+)</b>
Total Crashes	345	561	62.6
Total Severity Index	3.5	2.53	-27.7
Lane Departure Crashes	202	293	45.0

<b>Segment 1 Westbound</b>	<b>Before</b>	<b>After</b>	<b>Percent Reduction (-)/ Percent Increase (+)</b>
Total Crashes	413	662	60.3
Total Severity Index	2.73	2.98	9.2
Lane Departure Crashes	226	341	50.9

The naive before and after analysis for *Segment 1* resulted in an overall 61 percent increase in Total Crashes and a 48 percent increase in the Target Crashes. The eastbound lanes experienced a 45 percent increase in Target Crashes and the westbound lanes experienced a 51 percent increase in Target Crashes.

**Segment 2 SR 3097 (Aviation Pkwy)**

<b><u>Segment 2</u></b>	<b>Before</b>	<b>After</b>	<b>Percent Reduction (-)/ Percent Increase (+)</b>
Total Crashes – Both Directions	21	23	9.5
Total Severity Index	13.59	5.9	-56.6
Lane Departure Crashes – Both Directions	13	15	15.4
Lane Departure Severity Index	20.2	7.53	-62.7
Volume	20,700	25,000	20.8

<b><u>Segment 2</u></b>	<b>Before</b>	<b>After</b>	<b>Percent Reduction (-)/ Percent Increase (+)</b>
<b>Injuries</b>			
Fatal Injury Crashes	2	1	-50.0
Class-A Injury Crashes	1	0	-100.0
Class-B Injury Crashes	0	3	N/A
Class-C Injury Crashes	5	2	-60.0
Property Damage Only Crashes	13	17	30.8
<b>Contributing Factors</b>			
Night Crashes	9	8	-11.1
Wet Road Crashes	3	8	166.7
Alcohol Related	4	0	-100.0
<b>Lane Departure Crash Types</b>			
Angle	0	1	N/A
Fixed Object	2	1	-50.0
Head On	0	0	N/A
Jackknife	0	0	N/A
Overturn / Rollover	1	0	-100.0
Parked Motor Vehicle	0	0	N/A
Ran Off Road (Left)	3	10	233.3
Ran Off Road (Right)	6	1	-83.3
Sideswipe, Same Direction	1	2	100.0
Sideswipe, Opposite Direction	0	0	N/A

The following tables divide the crash data for Segment 2 by direction of travel:

<b><u>Segment 2 Northbound</u></b>	<b>Before</b>	<b>After</b>	<b>Percent Reduction (-)/ Percent Increase (+)</b>
Total Crashes	11	9	-18.2
Total Severity Index	16.8	11.89	-29.2
Lane Departure Crashes	7	5	-28.6

<b><u>Segment 2 Southbound</u></b>	<b>Before</b>	<b>After</b>	<b>Percent Reduction (-)/ Percent Increase (+)</b>
Total Crashes	10	14	40.0
Total Severity Index	10.06	2.06	-79.5
Lane Departure Crashes	6	10	66.7

The naive before and after analysis for *Segment 2* resulted in an overall 10 percent increase in Total Crashes and a 15 percent increase in Target Crashes. The northbound lanes experienced a 29 percent decrease in Target Crashes and the southbound lanes experienced a 67 percent increase in Target Crashes.

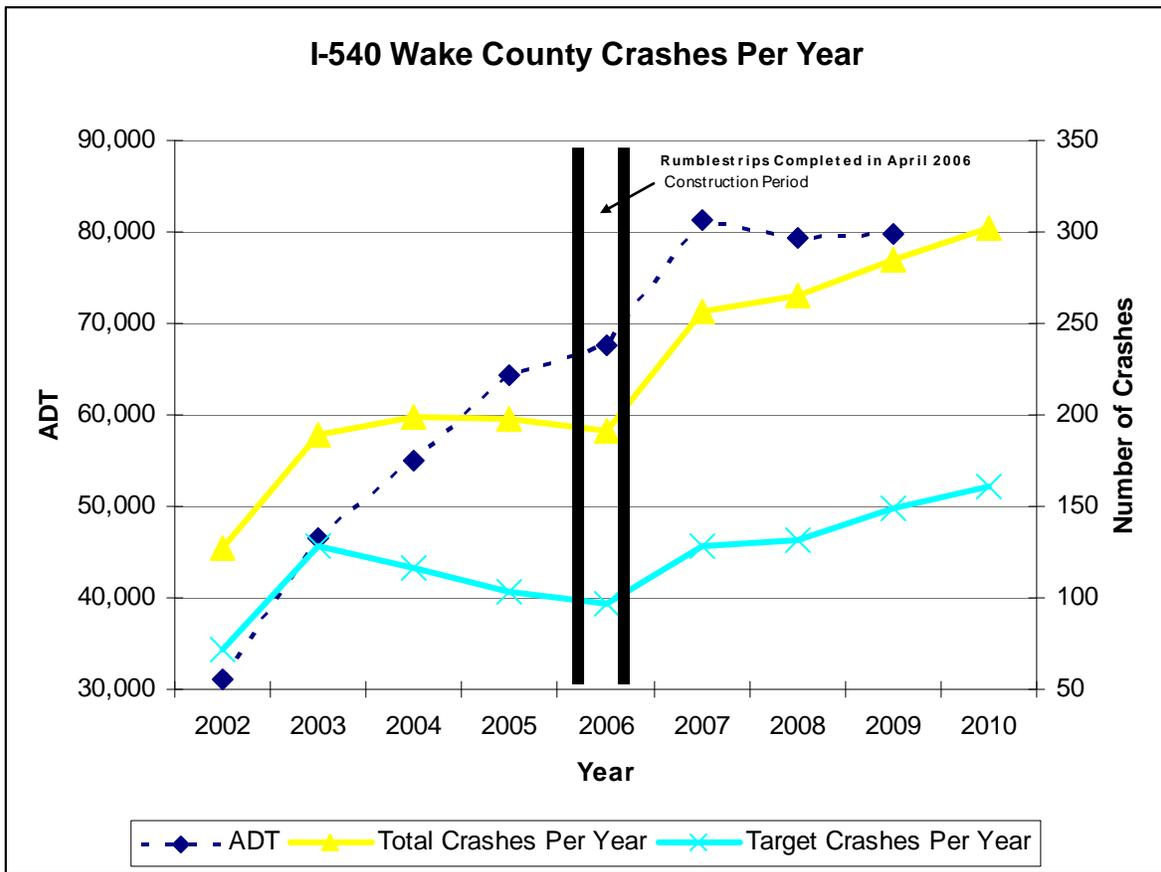
## Results and Discussion

Overall, Total Crashes increased by 61 percent and Target Crashes increased by 48 percent on Segment 1 (I-540). Total crashes increased by 10 percent and Target Crashes increased by 15 percent on Segment 2 (Aviation Pkwy). The severity indices decreased for both Total and Target Crashes on both segments.

The calculated benefit to cost ratio for the project is **-10.63** considering Total Crashes. The benefit to cost ratio considering only Target Crashes is **20.07**. 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 costs when applicable.

There are two factors that likely contributed to the increase in crashes on I-540. One is that when I-540 was first opened to traffic there was not a median barrier present. Cable barrier was later installed in pieces. Cable was installed from east of US 70 to east of Honeycutt Rd in early 2002, then from Durham County Line to east of US 70 in mid-2007, and the rest was installed in 2003. The addition of a barrier along a roadway typically results in more lane departure type crashes due to a fixed object being placed near the travel lanes. The second factor is that I-540 experienced a large increase in ADT over the time frame. Not only was I-540 a relatively new roadway in the before period, but as previously mentioned it was expanded on both sides of the study limits during the study period, leading to an increase in traffic.

The following chart depicts the crash trends along I-540 in Wake County. The number of Total and Target Crashes per year are plotted in the before and after period, along with the ADT.



Also included are crash severity diagrams for SR 3097. A diagram was not created for I-540 due to the large number of crashes that occurred during both time periods.

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.

**BENEFIT-COST ANALYSIS WORKSHEET**

LOCATION: I-540 and SR 3097  
 COUNTY: Wake  
 FILE NO.: W-4814

BY: bdr  
 DATE: 3/10/2011

DETAILED COST: TYPE IMPROVEMENT - Rumblestrips

ITEMS	TOTAL	SERVICE	CRF	ANNUAL COST
Construction	\$0	0	0.000	\$0
Right-of-Way	\$150,000	10	0.149	\$22,354
	\$0	0	0.000	\$0
<b>TOTALS</b>	<b>\$150,000</b>	<b>10</b>	<b>0.149</b>	<b>\$22,354</b>

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	4.59	11	2.40	136	29.63	632	137.69	\$2,694,466
AFTER	4.59	7	1.53	237	51.63	1002	218.30	\$2,932,157

Annual Benefits from Crash Cost Savings (\$237,691)

NET AVG. ANNUAL BENEFITS = AVG. ANNUAL BENEFITS - TOTAL ANNUAL COST = (\$260,045)

BENEFIT-COST RATIO = AVG ANNUAL BENEFITS/TOTAL ANNUAL COST = -10.63

TOTAL COST OF PROJECT - \$150,000 COMPREHENSIVE B/C RATIO - -10.63

**BENEFIT-COST ANALYSIS WORKSHEET**

LOCATION: I-540 and SR 3097  
 COUNTY: Wake  
 FILE NO.: W-4814 Target Crashes Only

BY: bdr  
 DATE: 3/10/2011

DETAILED COST: TYPE IMPROVEMENT - Rumblestrips

ITEMS	TOTAL	SERVICE	CRF	ANNUAL COST
Construction	\$0	0	0.000	\$0
Right-of-Way	\$150,000	10	0.149	\$22,354
	\$0	0	0.000	\$0
<b>TOTALS</b>	<b>\$150,000</b>	<b>10</b>	<b>0.149</b>	<b>\$22,354</b>

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	ESTIMATED NUMBER OF ANNUAL ACCIDENT DECREASES				PDO		ANNUAL COSTS
		K & A CRASHES	K & A CRASHES PER YR	B & C CRASHES	B & C CRASHES PER YR	CRASHES	CRASHES PER YR	
BEFORE	4.59	10	2.18	85	18.52	346	75.38	\$2,067,059
AFTER	4.59	4	0.87	136	29.63	509	110.89	\$1,618,453

Annual Benefits from Crash Cost Savings \$448,606

NET AVG. ANNUAL BENEFITS = AVG. ANNUAL BENEFITS - TOTAL ANNUAL COST = \$426,251  
 BENEFIT-COST RATIO = AVG ANNUAL BENEFITS/TOTAL ANNUAL COST = 20.07

TOTAL COST OF PROJECT - \$150,000 COMPREHENSIVE B/C RATIO - 20.07

Treatment Site Photos from Google Street-View



Looking east on I-540



Looking west on I-540



Looking south on SR 3097 (Aviation Pkwy)

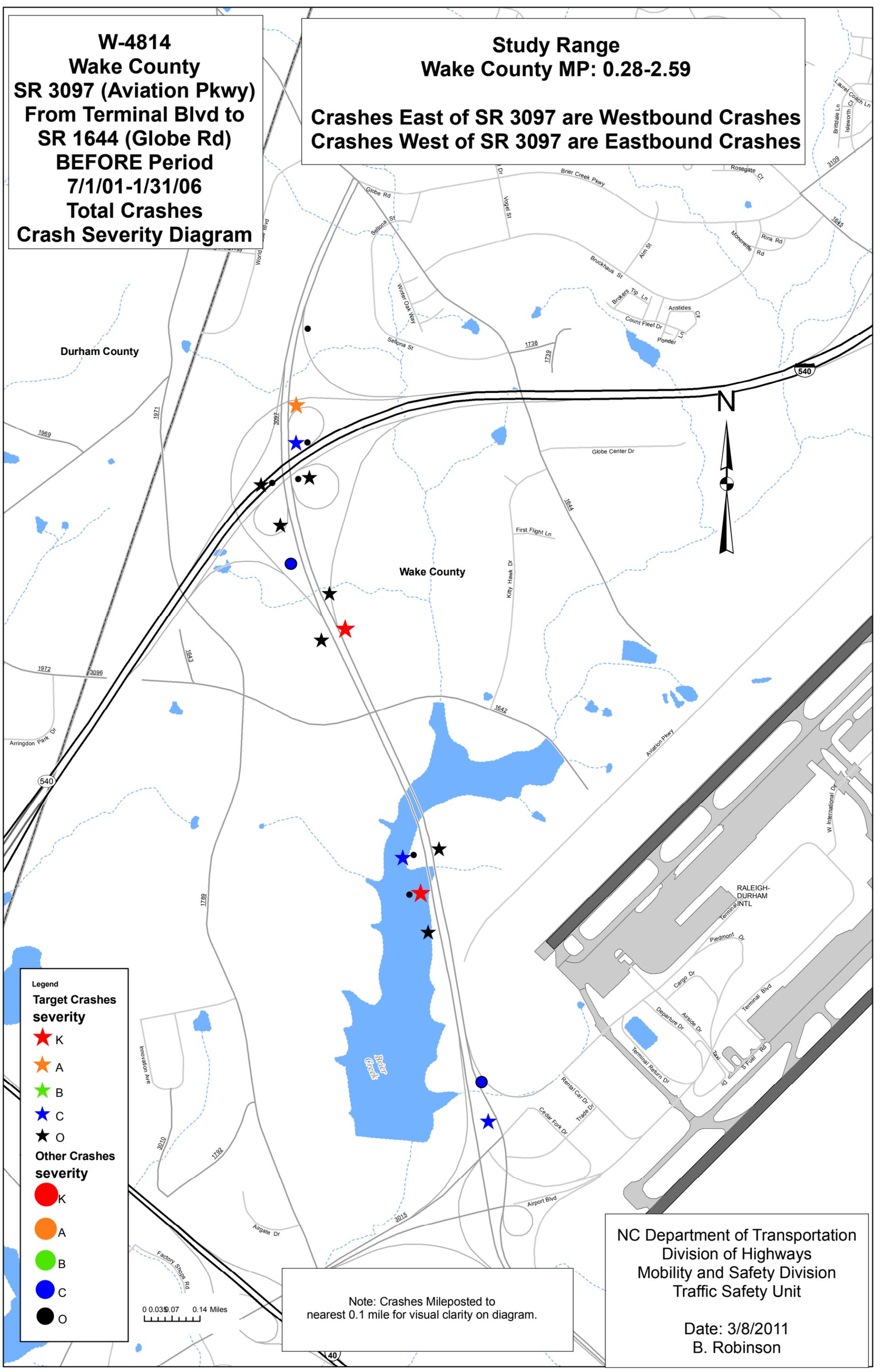


Looking south on SR 3097 (Aviation Pkwy)

**W-4814**  
**Wake County**  
**SR 3097 (Aviation Pkwy)**  
**From Terminal Blvd to**  
**SR 1644 (Globe Rd)**  
**BEFORE Period**  
**7/1/01-1/31/06**  
**Total Crashes**  
**Crash Severity Diagram**

**Study Range**  
**Wake County MP: 0.28-2.59**

**Crashes East of SR 3097 are Westbound Crashes**  
**Crashes West of SR 3097 are Eastbound Crashes**



Note: Crashes Mileposted to nearest 0.1 mile for visual clarity on diagram.

NC Department of Transportation  
 Division of Highways  
 Mobility and Safety Division  
 Traffic Safety Unit

Date: 3/8/2011  
 B. Robinson

