



Vehicles Entering When Flashing (VEWF) Evaluation

*For ENTERPRISE Intersection Warning
System Project Workshop 2 – 09-15-2011*

Database Characteristics

- Spot Safety Database Characteristics
 - Completed Projects within Database
 - Spot Safety funds are \$9.1 Million per year
 - Spot Safety projects are less than \$250,000 per project
 - Completed Projects from January 1, 1997 through April 30, 2011
 - » 2,188 Total Projects
 - » **84 projects for potential use in the VEFW evaluation**
 - » Most project development files available in electronic format
 - » Most signal diagram files available in electronic format
 - Future “On Hold List” Projects
 - » Typically 100-150 Total Projects at any given time
 - All data listed in spreadsheet format

Database Characteristics

- Spot Safety Database Characteristics
 - 83 potential data fields from the Project Development
 - Data fields most used for Evaluations
 - File number
 - County
 - Location description
 - Project improvement description
 - Countermeasure summary
 - Project completion data
 - Total cost estimate

File Number	County	Description Of Location	Project Improvement Description	Project Type - Countermeasure Summary	Phase I - Strategy Listing	Phase II - Strategy Listing	Completion	Total Cost Estimate
13-95-209	Buncombe	US 19-23 at SR 1245-Action Circle and Shoney's McDonald's Drive near	Force left turn motorists from the Shoney's Drive to access SR 1245-Action Circle. Signalize Action	channelization	U 12 - Channelize or close median openings		10/19/1998	\$75,000.00
09-99-209	Forsyth	SR 4315 (Main Street) and SR 2648 (Old Winston Road)/Kerners Village	install raised median channelization on three approaches	channelization	U 15 - Indirect left-turn treatments to minimize conflicts at divided highway		30-Jun-00	\$52,500.00
02-01-241	Beaufort	NC 32 (River Road) and SR 1303 (Brick Kiln Road).	Install a prefabricated raised channelization barrier.	channelization	U 15 - Indirect left-turn treatments to minimize conflicts at divided highway		2/3/2003	\$18,000.00
13-02-204	Buncombe	SR 1003 (Heems Creek Road) at SR 2122 (Union Chapel Road).	Install a center island on the side street to physically prohibit drivers from crossing the travel	channelization	U 15 - Indirect left-turn treatments to minimize conflicts at divided highway		06-Jan-04	\$5,000.00
13-03-205	Burke	SR 1713 (Summers Road) at SR 1716 (Burke Memorial Park Road)	Install a center island on the sidestreet in order to add an additional left side stop sign and better	channelization	U 15 - Indirect left-turn treatments to minimize conflicts at divided highway		19-Mar-04	\$5,500.00
09-01-207	Davie	SR 1147 (Salisbury St./Hardison St.) and Salisbury St. (NS)/S. Davie Drive	Install two raised channelization islands and convert existing 2-way stop to a 4-way stop.	channelization - four way stop	U 12 - Channelize or close median openings		12/2/2002	\$5,000.00
02-99-011	Carteret	US 70 at SR 1148 (Carl Garner Rd)/SR 1252 (Training Ground Rd).	Construct monolithic island in the median to allow only left turn from US 70 eastbound onto SR 1148	channelization - left turn installation	U 12 - Channelize or close median openings		9/4/2003	\$75,000.00
12-02-207	Cleveland	US 74 Bypass, 0.77 mile east of NC 226 (Earl Road).	Recommend installing left turn channelization that would prohibit vehicles from crossing from frontage	channelization - left turn lane	U 12 - Channelize or close median openings		8/27/2003	\$120,000.00

Simple Before and After

- Location Photos



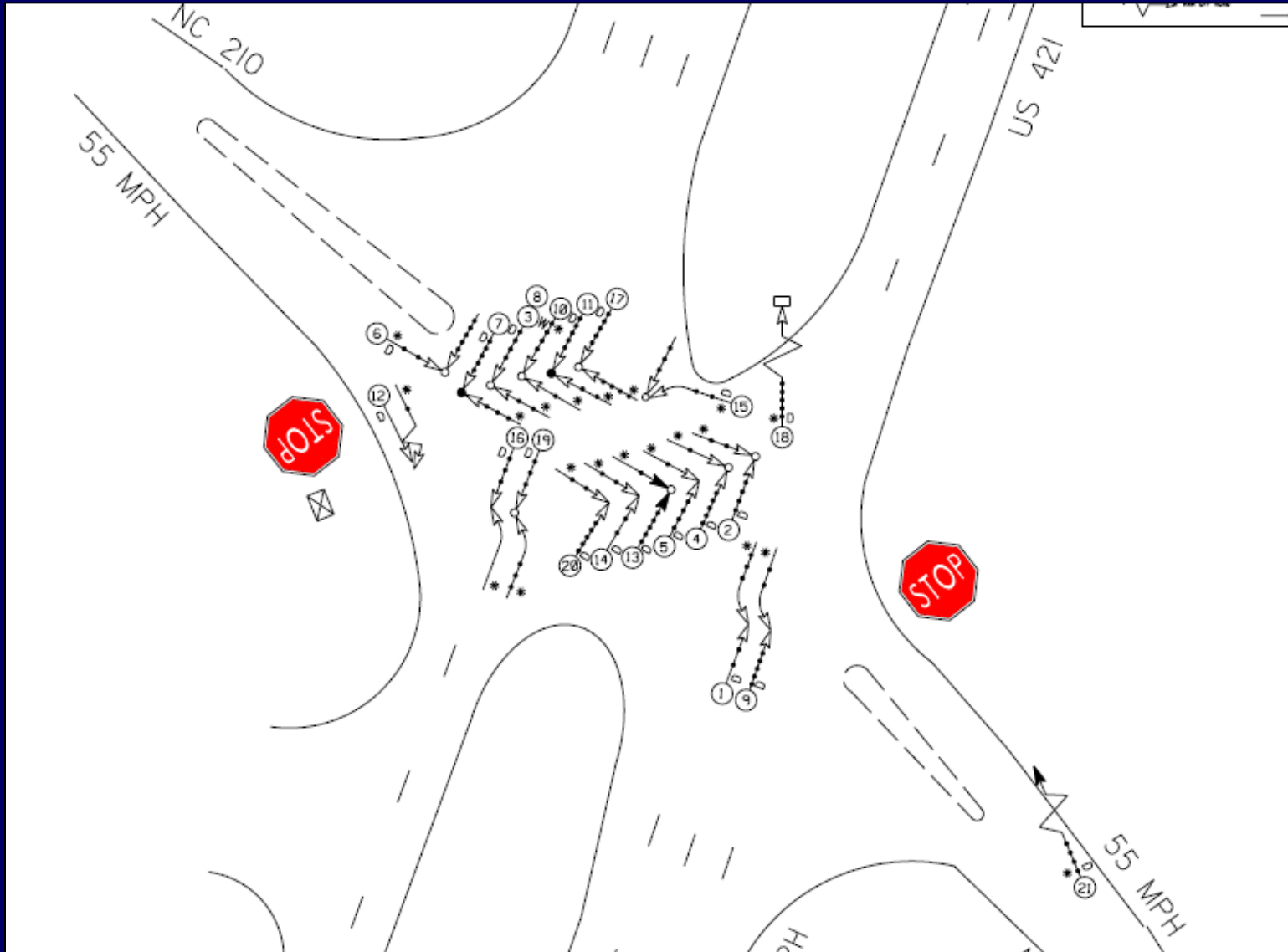
Simple Before and After

- Location Photos



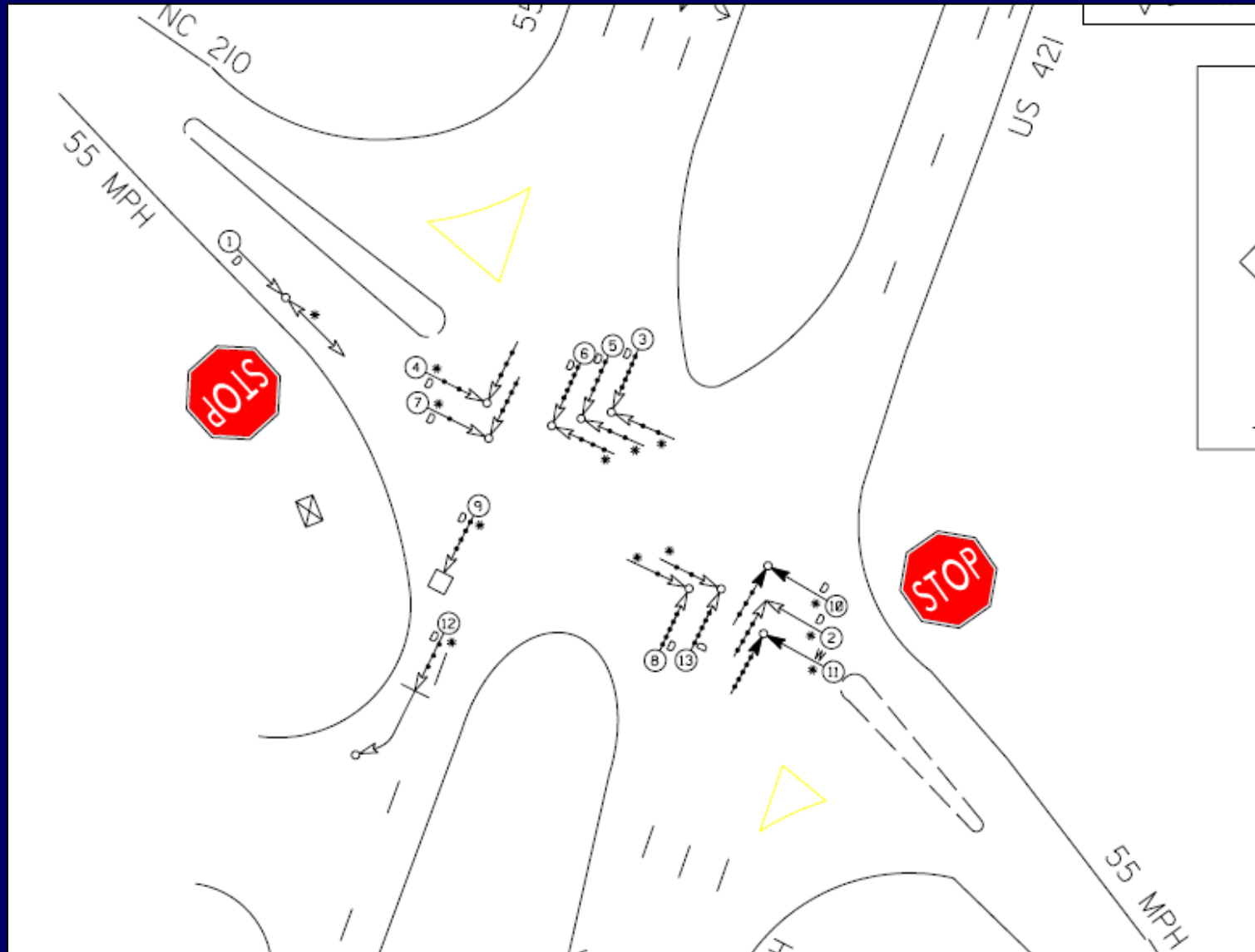
Simple Before and After

- Collision Diagram – Before Period (5 years, 7 months)



Simple Before and After

- Collision Diagram – After Period (5 years, 7 months)



VEWF Evaluation

- Vehicle Entering when Flashing Locations
 - 84 potential locations
 - 3 locations were unable to be determined what was actually done
 - 81 locations left for the evaluation analysis
- 81 Locations for Analysis *(70 sites)*
 - *Category 1 (27 sites)*
 - Overhead Signs and Flashers on Major, Loop on Minor
 - *Category 2 (19 sites)*
 - Overhead Signs and Flashers on Minor, Loop on Major
 - *Category 3 (24 sites)*
 - Post Mounted Signs and Flashers on Major, Loop on Minor
 - Category 4 (11 sites)
 - Combination of Category 1 through Category 3

VEWF Evaluation Issues

- Installations per Year for the 70 Locations

	<u>Category 1</u>	<u>Category 2</u>	<u>Category 3</u>	<u>Total</u>
1997	2	1	2	5
1998	1	1	6	8
1999	2	1	0	3
2000	5	1	1	7
2001	4	2	1	7
2002	1	4	5	10
2003	2	3	0	5
2004	0	3	0	3
2005	1	0	2	3
2006	2	1	0	3
2007	0	0	1	1
2008	4	1	2	7
2009	0	0	1	1
2010	2	1	3	6
2011	1	0	0	1

VEWF Evaluation Issues

- Installations per “Geometry” for the 70 Locations

	<u>Category 1</u>	<u>Category 2</u>	<u>Category 3</u>	<u>Total</u>
3-leg 2@2	1	1	0	2
3-leg 4@2	2	1	0	3
<i>4-leg 2@2</i>	<i>17</i>	<i>15</i>	<i>12</i>	<i>44</i>
4-leg 3@2	1	0	1	2
<i>4-leg 4@2</i>	<i>5</i>	<i>2</i>	<i>11</i>	<i>18</i>
4-leg 5@2	1	0	0	1

VEWF Evaluation Issues

- Installations per “Sign Message” for the 70 Locations

	<u>Cat 1</u>	<u>Cat 2</u>	<u>Cat 3</u>	<u>Total</u>
<i>Vehicle Entering when Flashing</i>	25	8	17	50
<i>Vehicle Entering</i>	1	9	6	16
Watch for Approaching Vehicles	1	1	1	3
Vehicle Entering when Flashing from Left	0	1	0	1

VEWF Evaluation Issues

- Installations per “Other Improvements” for the 70 Locations

	<u>Cat 1</u>	<u>Cat 2</u>	<u>Cat 3</u>	<u>Total</u>
Flasher on Intersection Warning Sign	1	0	1	2
Flasher on Stop Ahead Sign	2	0	1	3
Flasher on Stop Sign	0	9	2	11
Overhead Flashers in Before Period	3	6	6	15
Overhead Flashers Installed with Post Flashers	0	0	7	7
Location Changed to Signal in After Period	8	2	1	11

VEWF Evaluation Issues

- Items that may Contribute to Effectiveness in Addition to the Last Four Slides
 - Approach Speed Limit on Major and Minor
 - Approach Grade on Major and Minor
 - Constant Flash on Major (yellow) or Minor (red) – *very few*
 - Major Distance to Signs from Intersection - *post mounted*
 - Major and Minor Distance to Loops from Intersection
 - Number of Loops on Minor – *some have lead in loops*
 - Variability of Detector Timing Setting – *in seconds*
 - Size of Signs

VEWF Evaluation

- Preliminary Crash Data (% Reduction – Simple B&A)

	<u>Cat 1</u>	<u>Cat 2</u>	<u>Cat 3</u>	<u>Total</u>
<i>4-leg 2-lane @ 2-lane</i>	<i>17</i>	<i>15</i>	<i>12</i>	<i>44</i>
Sites with Data Complete	3	7	4	14
– Total Crashes	(3.6)	(-5.9)	(-46.1)	
– Target Crashes	(-2.2)	(1.1)	(-36.0)	

	<u>Cat 1</u>	<u>Cat 2</u>	<u>Cat 3</u>	<u>Total</u>
<i>4-leg 4-lane @ 2-lane</i>	<i>5</i>	<i>2</i>	<i>11</i>	<i>18</i>
Sites with Data Complete	2	1	6	9
– Total Crashes	(22.9)	(-36.4)	(-19.9)	
– Target Crashes	(18.2)	(0.0)	(-21.7)	

VEWF Evaluation

- Evaluation Goals:
 - Compare Category 1 vs. Category 2 vs. Category 3
 - Assume “Vehicle Entering when Flashing” and “Vehicle Entering” are giving the driver the same message
 - Compare 4-leg, 2-lane @ 2-lane vs. 4-leg, 4-lane @ 2-lane for each of the three (3) categories independently
 - Will attempt to investigate “other improvements” and their impact at the locations
 - Will attempt to have a NC Based Crash Reduction Factor for each of the three (3) categories
 - CRF’s may be based on Total Crashes and Severity, as well as, Target Crashes and Severity
 - A workplan will be established once we can begin this evaluation (fit into our workload)



“Be Prepared to Stop When Flashing” Sign Evaluation

**Carrie L. Simpson, PE
Safety Evaluation Group
October 20, 2010**

NCDOT Transportation Mobility & Safety Division

NCDOT Evaluation



GOALS:

1. Determine if the installation of AAWS reduce the severity and number of crashes caused by red light running at a signalized intersection.
2. Determine if a particular sign configuration, placement, and activation time provides more safety benefit and efficient intersection operation.

NCDOT Evaluation

Crash Analysis

Compared Crashes Before & After the AAWS Installation:

Measures of Effectiveness

- Change in number & severity of total crashes
- Change in number & severity of target crashes

Target Crashes

- Frontal Impact crashes where mainline thru vehicle ran the red light*
- Rear-End crashes on mainline approaching signal

*Includes crashes where mainline vehicle appeared to run the red light, but fault could not be determined from crash report.

NCDOT Evaluation

Crash Analysis Results – All Sites

Percent Increase (+)/Percent Decrease (-)

“+/-” notation indicates the standard deviation of an estimated value.

Numbers in parentheses are before period sample size.

All [15 sites]	Naïve			With Linear Traffic Adjustment		
	Percent Change	Standard Deviation	Sample Size	Percent Change	Standard Deviation	Sample Size
TOTAL (1147)	-6.1%	+/-	7.5%	-18.3%	+/-	6.3%
INJURY (582)	-24.9%	+/-	8.4%	-34.8%	+/-	7.1%
TARGET REAREND (323)	+3.1%	+/-	18.6%	-8.2%	+/-	16.1%
TARGET FRONTAL (183)	-69.8%	+/-	5.6%	-74.3%	+/-	4.7%



NCDOT Evaluation

Target Frontal Impact Crashes - All Sites

Percent Increase (+)/Percent Decrease (-)

“+/-” notation indicates the standard deviation of an estimated value.

Numbers in parentheses are before period sample size.

TARGET FRONTAL BREAKDOWN [15 sites]	Naïve			With Linear Traffic Adjustment		
	TARGET FRONTAL (183)	-69.8%	+/-	5.6%	-74.3%	+/-
RLR – ANGLE (123)	-68.2%	+/-	6.8%	-72.9%	+/-	5.7%
RLR – NON-ANGLE (30)	-62.6%	+/-	18.3%	-67.9%	+/-	15.6%
FAULT UNDETERMINED* (30)	-82.7%	+/-	9.0%	-85.3%	+/-	7.6%

*Crashes where mainline vehicle appeared to run the red light but fault could not be determined from report.

NCDOT Evaluation

Injury Crashes– All Sites

Percent Increase (+)/Percent Decrease (-)

“+/-” notation indicates the standard deviation of an estimated value.

Numbers in parentheses are before period sample size.

TOTAL CRASHES	Naïve			With Linear Traffic Adjustment		
K+A Crashes (65)	-62.8%	+/-	12.8%	-68.0%	+/-	10.8%
B+C Crashes (517)	-18.2%	+/-	9.7%	-28.8%	+/-	8.2%
TARGET FRONTAL CRASHES	Naïve			With Linear Traffic Adjustment		
K+A Crashes (23)	-77.1%	+/-	10.9%	-80.5%	+/-	9.2%
B+C Crashes (110)	-62.2%	+/-	8.4%	-67.9%	+/-	7.0%
TARGET REAREND	Naïve			With Linear Traffic Adjustment		
K+A Crashes (7)	-100.0%			-100.0%		
B+C Crashes (146)	-11.7%	+/-	24.0%	-20.4%	+/-	21.2%

NCDOT Evaluation

SUMMARY

Does AAWS reduce the severity & number of crashes caused by red light running at signalized intersections?

- **Not overwhelming evidence to suggest signs were effective at reducing Total Crashes. However, appears to be reductions in Target Frontal Impacts & High Severity Crashes.**

Does a particular sign configuration, placement, & timing provide more safety benefit & efficient operation?

- **Too few locations in our data set to determine relationship between crashes & placement/timing.**
- **Not conclusive evidence to say that one sign type performs significantly better than others.**

Evaluation of the Conversion from Two-Way Stop Sign Control to All-Way Stop Sign Control at 53 Locations Statewide

Findings of a Report Authored by:

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&

**Joseph E. Hummer, Ph.D., PE
North Carolina State University**

March 24, 2010

NCDOT Transportation Mobility & Safety Division

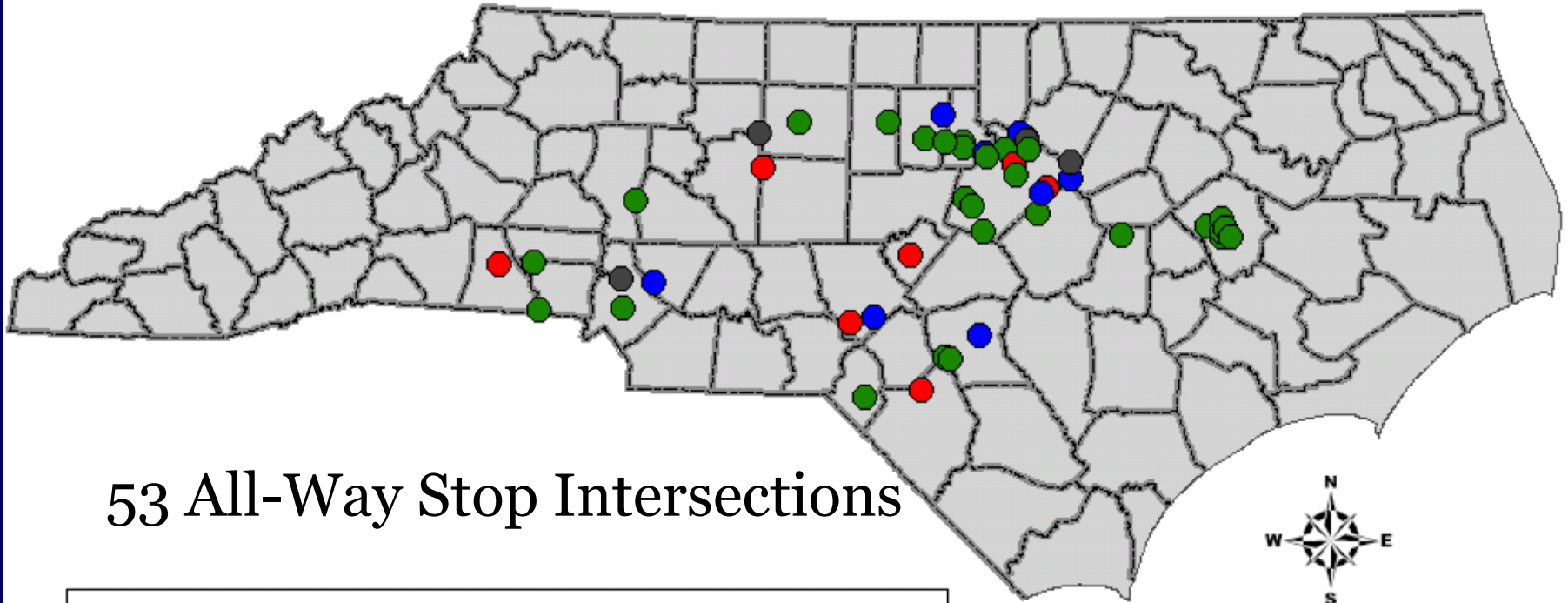
Introduction

- Growing interest in all-way stop conversion
 - Low cost
 - Quick to implement
 - Treats pattern of high severity frontal impact crashes
- Few current, up-to-date studies quantifying safety benefits
- Goal: Develop crash reduction factors that reflect North Carolina conditions and decision-making

Evaluation Objectives

1. What is the reduction in total and target crashes at intersections converted to all-way stop control?
2. Is there a difference in crash reductions when all-way stop intersections are equipped with a flashing beacon?
3. What role do intersection volume and approach speed limits play in crash reductions at converted intersections?

Site Selection



53 All-Way Stop Intersections

Legend

- Group 1: 33 Sites Without Flashing Beacons
- Group 2: 8 Sites With Flashing Beacons in Before and After Period
- Group 3: 8 Sites With Flashing Beacons Only in After Period
- 4 Additional Sites

Crash Types Analyzed

Total, Frontal Impact, Injury, & “Ran Stop Sign” Crashes –

- Target: Frontal Impact Crashes occurring in the intersection or related to the intersection.
- Injury crashes include both fatal & non-fatal injury crashes.
- “Ran Stop Sign” crashes defined as a crash in which the officer noted that the vehicle disregarded the stop sign or it could be reasonably inferred from the speeds at impact that the vehicle did not stop at the stop sign.

Crash Analysis Results

Recommended CRF's:

Total: -68%

Injury: -77%

FI: -75%

Ran Stop: -15%

		Percent Reduction	
Total Crashes			
All Sites	⇒	-68.1%	+/- 2.2%
Group 1		-60.7%	+/- 3.3%
Group 2		-80.2%	+/- 3.9%
Group 3		-81.7%	+/- 3.5%
Injury Crashes			
All Sites	⇒	-77.0%	+/- 2.5%
Group 1		-72.4%	+/- 3.7%
Group 2		-86.5%	+/- 4.8%
Group 3		-86.6%	+/- 4.0%
Frontal Impact Crashes			
All Sites	⇒	-75.3%	+/- 2.0%
Group 1		-70.1%	+/- 3.0%
Group 2		-84.4%	+/- 3.7%
Group 3		-85.7%	+/- 3.3%
"Ran Stop Sign" Crashes			
All Sites	⇒	-14.5%	+/- 11.2%
Group 1		-5.7%	+/- 15.2%
Group 2		-33.3%	+/- 27.5%
Group 3		-39.9%	+/- 20.1%

Group 1:
Without Flashers

Group 2:
With Flashers in
Both
Before & After
Periods

Group 3:
Flashers Installed
With All-Way Stop

“+/-” notation indicates the standard deviation of an estimated value.

Crash Analysis Results

Naïve Before and After Analysis (All Sites):

Rear End Crashes	+6.2% +/- 22.3%
Ran Off Road Crashes	-46.9% +/- 12.2%
Other Crashes	+5.9% +/- 24.1%

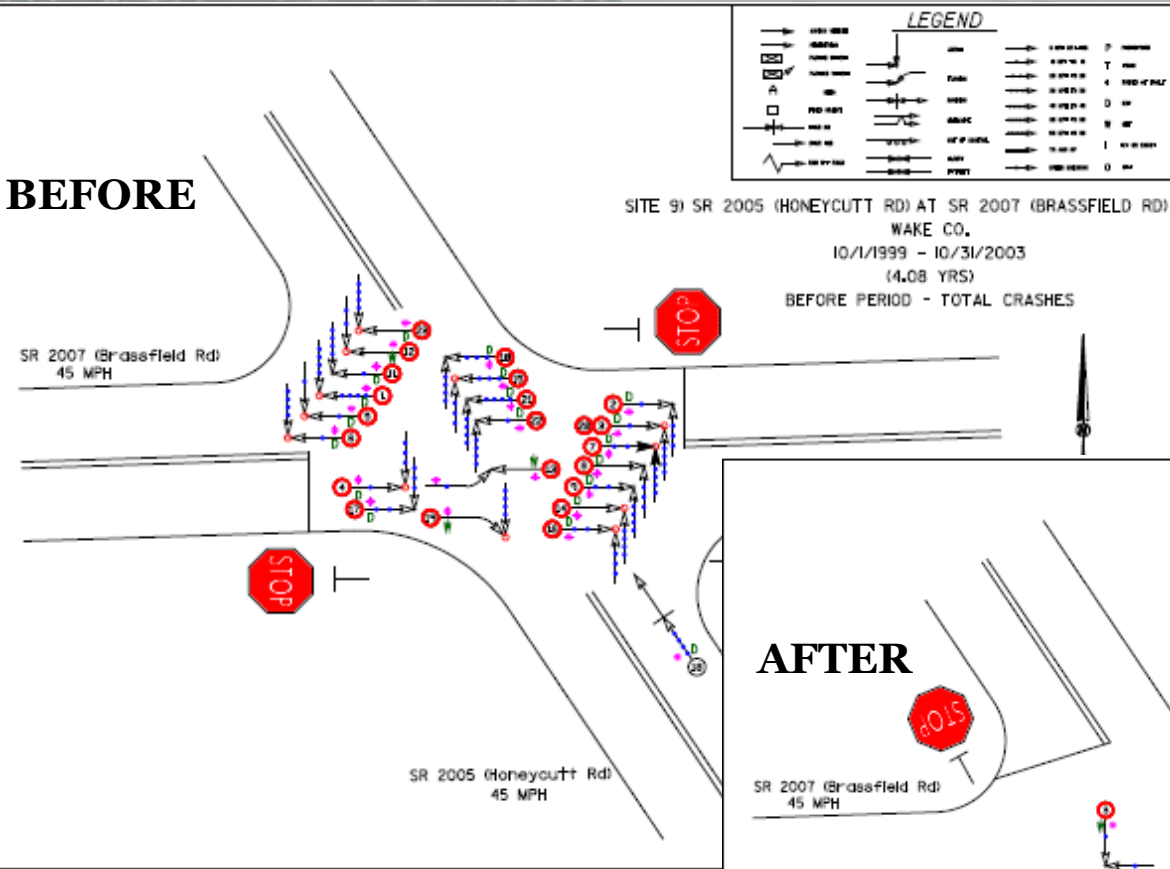
Before and After Crash Diagrams

Honeycutt Rd at
Brassfield Rd

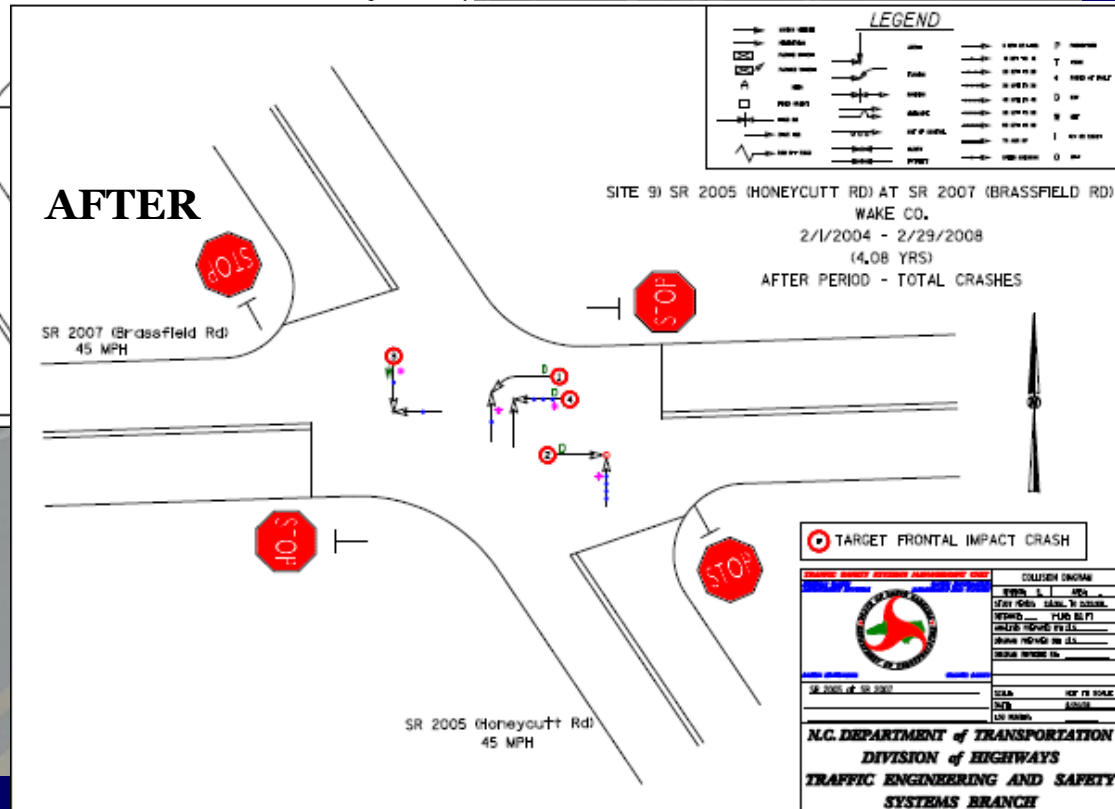
Wake County

Division 5

BEFORE



AFTER



Approach Speeds: 45
Entering AADT: 5300
Volume Split: 62%/38%
Non-Flasher

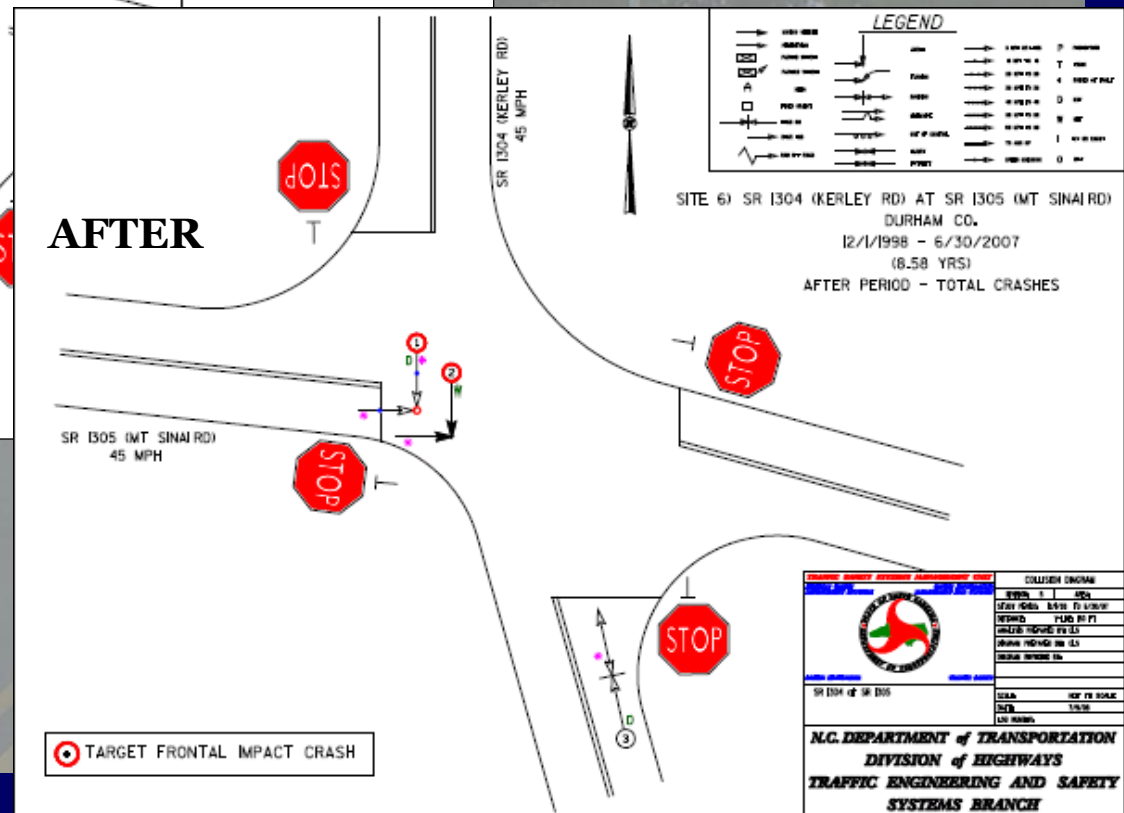
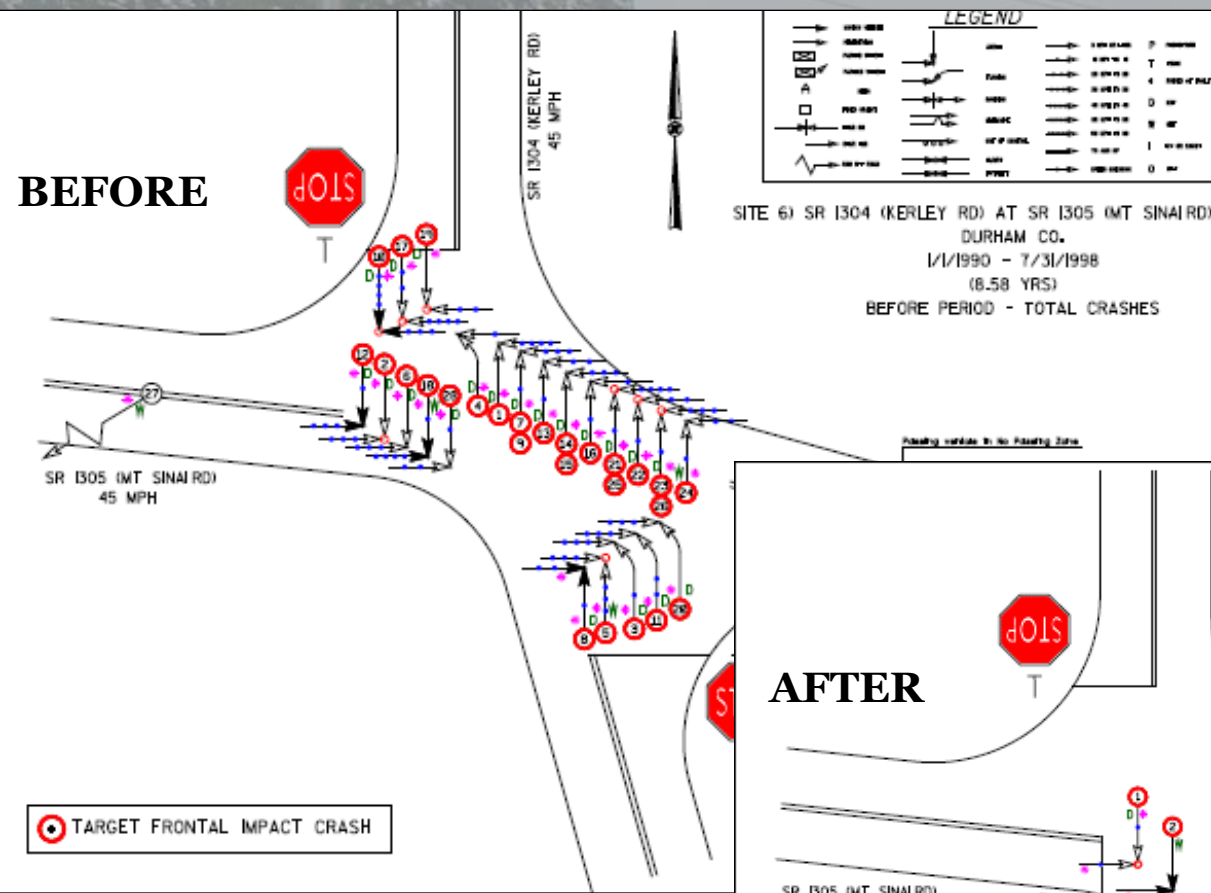
⊙ TARGET FRONTAL IMPACT CRASH

COLLISION DIAGRAM	
EVENT NO.	0001
STAY CODE	1000 - 100000
CRASH NO.	1000 - 100000
CRASH TYPE	FRONTAL IMPACT
CRASH DATE	02/29/2008
CRASH TIME	10:00 AM
CRASH LOCATION	SR 2005 (Honeycutt Rd) at SR 2007 (Brassfield Rd)
CRASH COUNTY	Wake
CRASH DIVISION	5
CRASH SECTION	
CRASH SPAN	
CRASH TYPE	
CRASH SEVERITY	
CRASH DAMAGE	
CRASH DAMAGE	

N.C. DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
TRAFFIC ENGINEERING AND SAFETY
SYSTEMS BRANCH

Before and After Crash Diagrams

Kerley Rd at Mt Sinai Rd
Durham County
Division 5

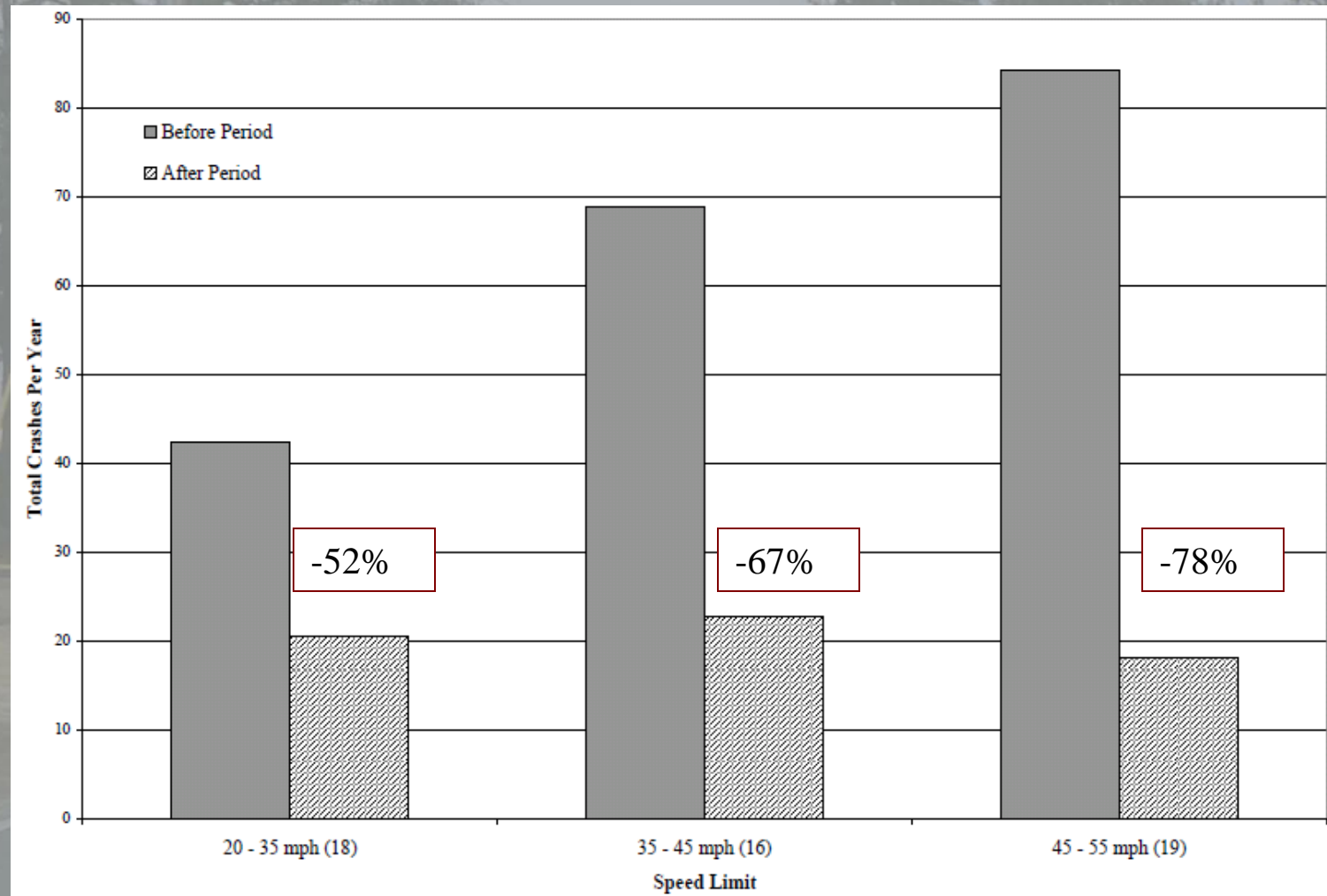


Approach Speeds: 45
Entering AADT: 4200
Volume Split: 59%/41%
Non-Flasher

		COLLISION DIAGRAM SHEET NO. 1 OF 1 DRAWN BY: [Name] CHECKED BY: [Name] DATE: [Date]
SR 1304 AT SR 1305		SCALE: 1/4" = 100' DATE: 1/1/98 L.S. NAME: [Name]
N.C. DEPARTMENT of TRANSPORTATION DIVISION of HIGHWAYS TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH		

Influence of Speed Limits

Relationship between Speed Limits & Total Crashes at Treatment Sites All Locations



Additional Signing & Marking

Rural, 45 mph Location – 2 Weeks Post Installation



Safety Effect of Flashers

	Percent Reduction		
Total Crashes			
All Sites	-68.1%	+/-	2.2%
Group 1	-60.7%	+/-	3.3%
Group 2	-80.2%	+/-	3.9%
Group 3	-81.7%	+/-	3.5%

Group 1:

Without Flashers

Group 2:

With Flashers in Both
Before & After Periods

Group 3:

Flashers Installed
With All-Way Stop

Percent of Sites with Moderate to High
Approach Speed Limits:

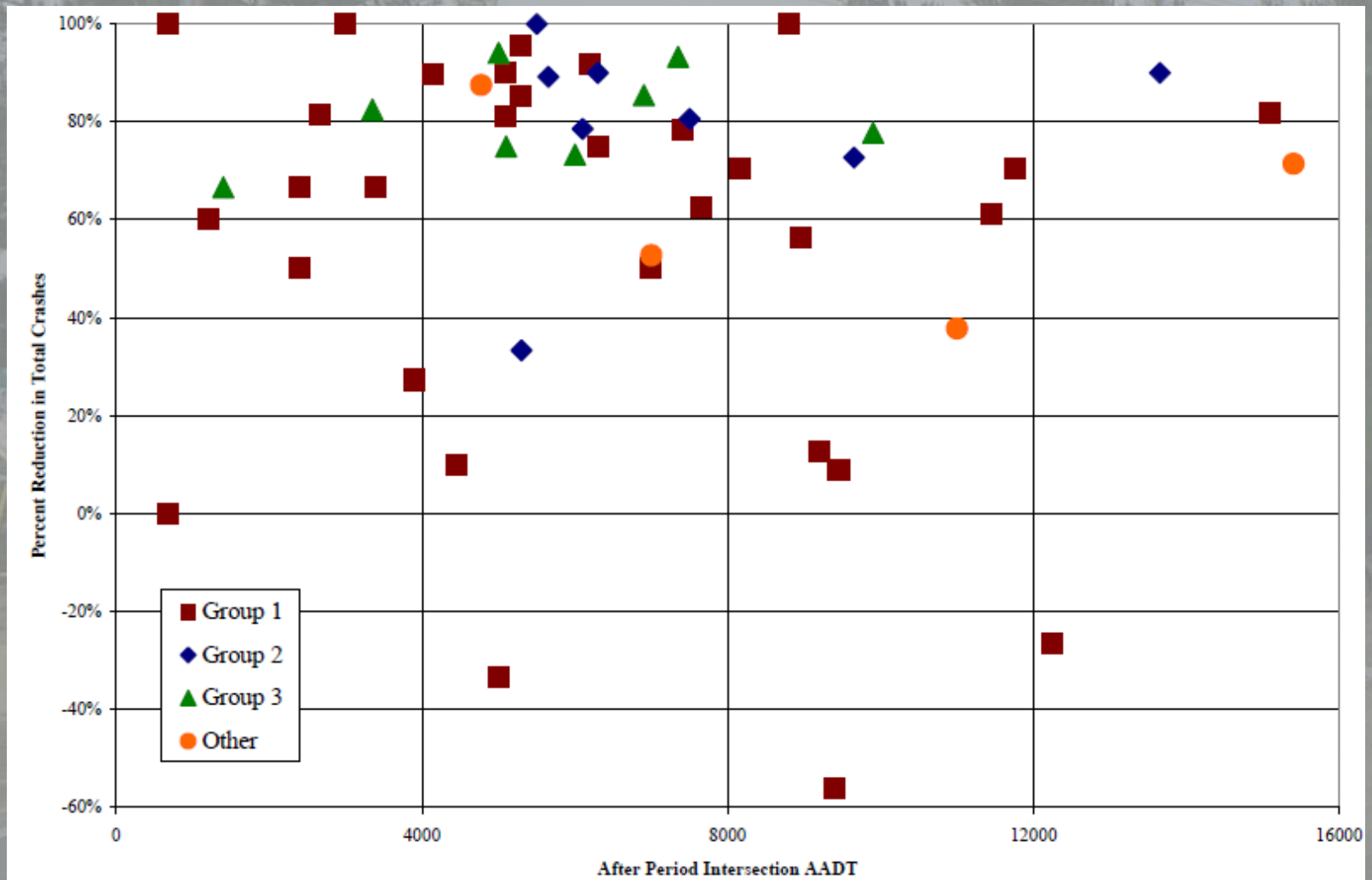
Group 1: 58%

Group 2: 87%

Group 3: 75%

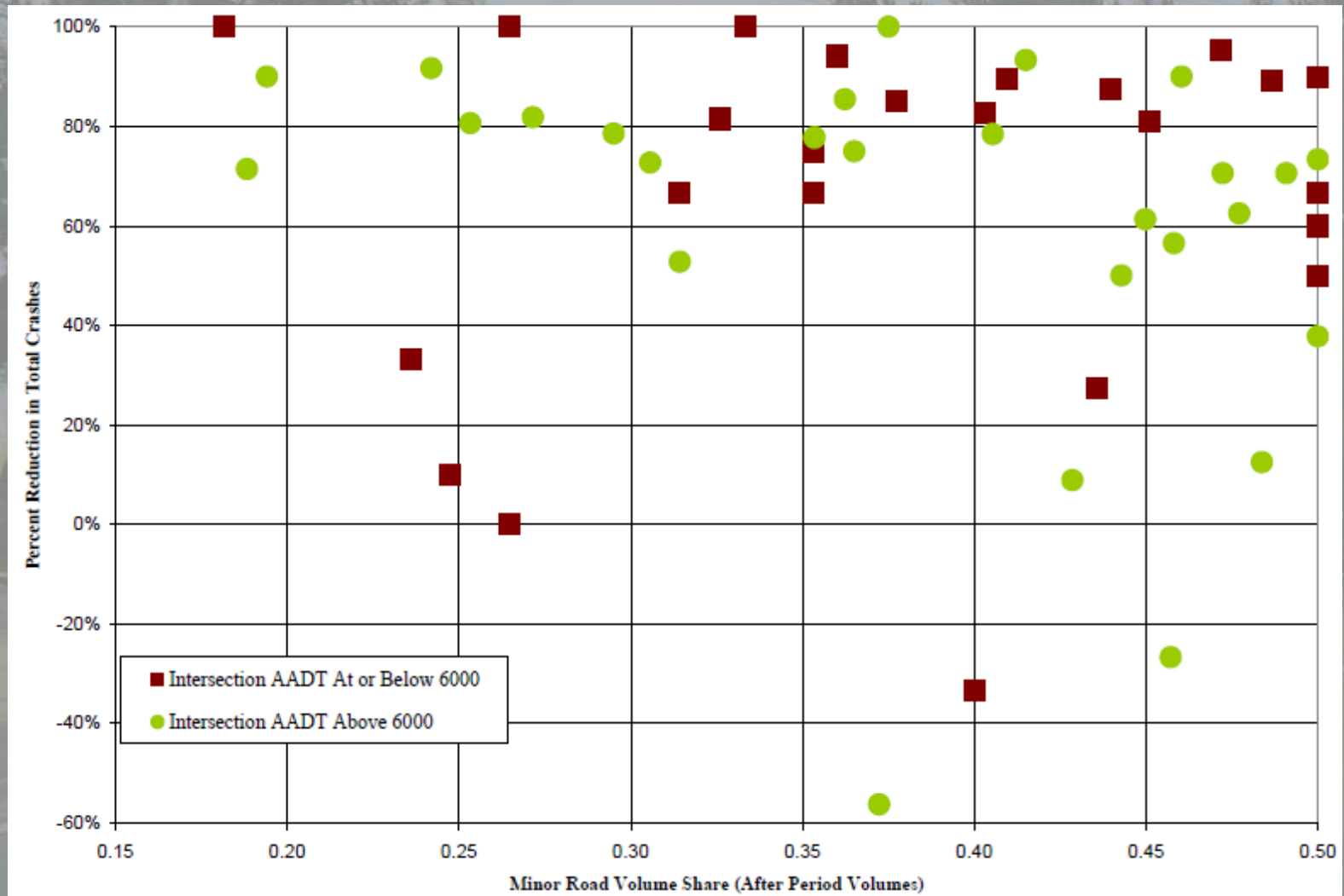
Influence of Entering AADT

Influence of Intersection AADT on Crash Reductions at Treatment Sites



Influence of Volume Share

Influence of Minor Road Volume Share on Crash Reductions at Treatment Sites



NCDOT Transportation Mobility & Safety Division

Conclusions

Recommended Crash Reduction Factors:

Total Crashes	-68%
Injury Crashes	-77%
Frontal Impact Crashes	-75%
Ran Stop Sign Crashes	-15%

Conclusions

- Substantial reductions in total and target crash frequency & severity (no after-period fatalities at 53 sites)
- No noticeable increase in rear end crashes
- Overall decrease in “ran stop sign” crashes and much lower speeds at impact
- Effective at a wide range of AADT & volume share
- Greater reductions at higher speed limit sites
- Greater reductions at flasher sites
- Additional signing and marking likely contributes to greater crash reductions
- Extremely cost effective from a safety standpoint
- Increase in intersection delay