



Safety Evaluation of Roundabouts in North Carolina

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Introduction

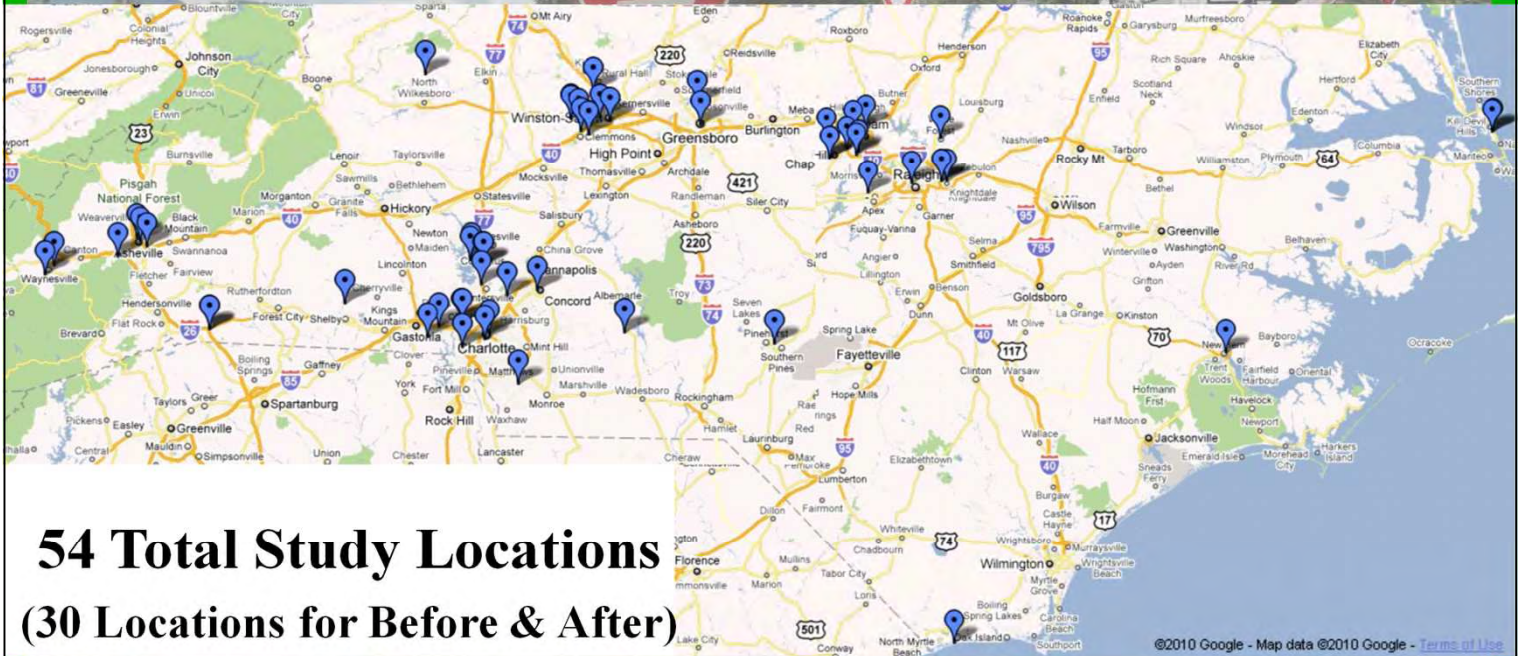
Evaluation Objectives:

The Purpose of this Evaluation is to Determine the Safety Effectiveness of Roundabouts Installations Statewide

- Crash Frequency
- Severity
- Crash Types
- Night Crashes & Lighting Conditions
- Relationships between Intersection Geometry & Crashes
- Relationships between Entering Volume & Crashes
- Vehicle Speeds
- Signing and Marking Practices

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Roundabout Study Locations



54 Total Study Locations
(30 Locations for Before & After)

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- At the time the study was completed, after period crash data was available for 54 Study Locations statewide (30 sites had before and after crash data).
- As of April 2011, we had about 85 roundabouts on the state system.
- We couldn't evaluate locations that were under private jurisdiction or those that were too new and didn't have after period data.

Roundabout Study Locations



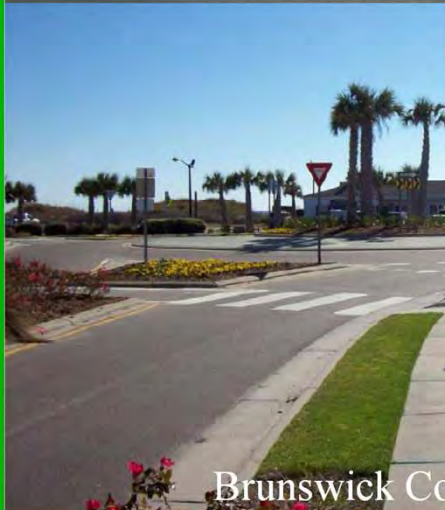
Suburban
Buncombe County



Rural
Union County



Urban
Mecklenburg County



Brunswick County



Mecklenburg County

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- The study included a wide variety of sites across North Carolina from the mountains to the coast (from downtown to rural locations; from high volume to low volume; and from low speed to high speed).
- The roundabouts were installed for a variety of reasons – many for operational or traffic calming purposes and a handful for safety reasons.
- Some were converted from two-way stop control and others were converted from a signal to a roundabout.

Roundabout Study Locations



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We categorized the data into seven different roundabout types:

- There were four single lane roundabout types based on inscribed circle diameter: Mini (45-80'); Compact (81-100'); Single (101-130'); and Large Single (>130').
- There were also multilane lane roundabouts and roundabouts at ramp terminals.
- There was one very large one north of Charlotte, which was classified as a traffic circle with an inscribed diameter of almost 300'.



Crash Analysis Results

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North Carolina Crash Analysis Results

Percent Crash Reductions at NC Roundabouts
(Naïve Before & After with Linear Traffic Factor)

	All 30 Sites
Total Crashes	46.2% (5.2)
Injury Crashes - All Types	75.3% (4.9)
Injury Crashes - KAB	85.0% (6.5)
Frontal Impact Crashes*	75.6% (3.9)
Rear End Crashes*	29.9% (13.2)
Sideswipe Crashes*	20.1% (28.9)
Day	56.0% (5.0)
Night	2.8% (18.2)

* As crash classified in DMV 349
() = standard deviation of an estimated value

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These are the recommended CRFs from all 30 sites with before and after data (no matter the type, size, or the before period control): 46% reduction in total crashes; 75% reduction in injury crashes; 85% reduction in high severity injury crashes; and 76% reduction in frontal impact crashes.

- Note: 29/30 were single lane roundabouts and the traffic circle was not included.
- Injury and frontal impact crashes especially benefited from the treatment.
- There was a 30% reduction in rear end crashes, although there is higher standard deviation around this estimate. There was an increase in sideswipe crashes, although crash frequencies are low and there is a high standard deviation.
- There seemed to be more benefit for day time crashes.
- A naïve before and after analysis was used and volume increases were accounted for with a linear traffic factor. Empirical Bayes methodology was not used since many of the sites were not installed specifically for safety reasons.

National Roundabout Safety Statistics

SOURCE: NCHRP 672 (2010)

Estimate of the Percent Reduction in Crashes (and Standard Error)

Exhibit 5-9
Comparisons to Previous Intersection Treatments in the United States

Control Before	Sites	Setting	Lanes	All	Injury + Fatal
All Sites	55	All	All	35.4% (3.4)	75.8% (3.2)
	9	All	All	47.8% (4.9)	77.7% (6.0)
Signalized	4	Suburban	2	66.7% (4.4)	Sample too small to analyze
	5	Urban	All	Effects insignificant	60.1% (11.6)
All-way stop	10	All	All	Effects insignificant	Effects insignificant
	36	All	All	44.2% (3.8)	81.8% (3.2)
	9	Rural	1	71.5% (4.0)	87.3% (3.4)
	17		All	29.0% (9.0)	81.2% (7.9)
	12	Urban	1	39.8% (10.1)	80.3% (10.0)
Two-way stop	5		2	Sample too small to analyze	Sample too small to analyze
	10		All	31.8% (6.7)	71.0% (8.3)
	4	Suburban	1	78.2% (5.7)	77.6% (10.4)
	6		2	19.3% (9.1)	68.0% (11.6)
	27	Urban/	All	30.8% (5.5)	74.4% (6.0)
	16	Suburban	1	56.3% (6.0)	77.7% (7.4)
	11		2	17.9% (8.2)	71.8% (9.3)

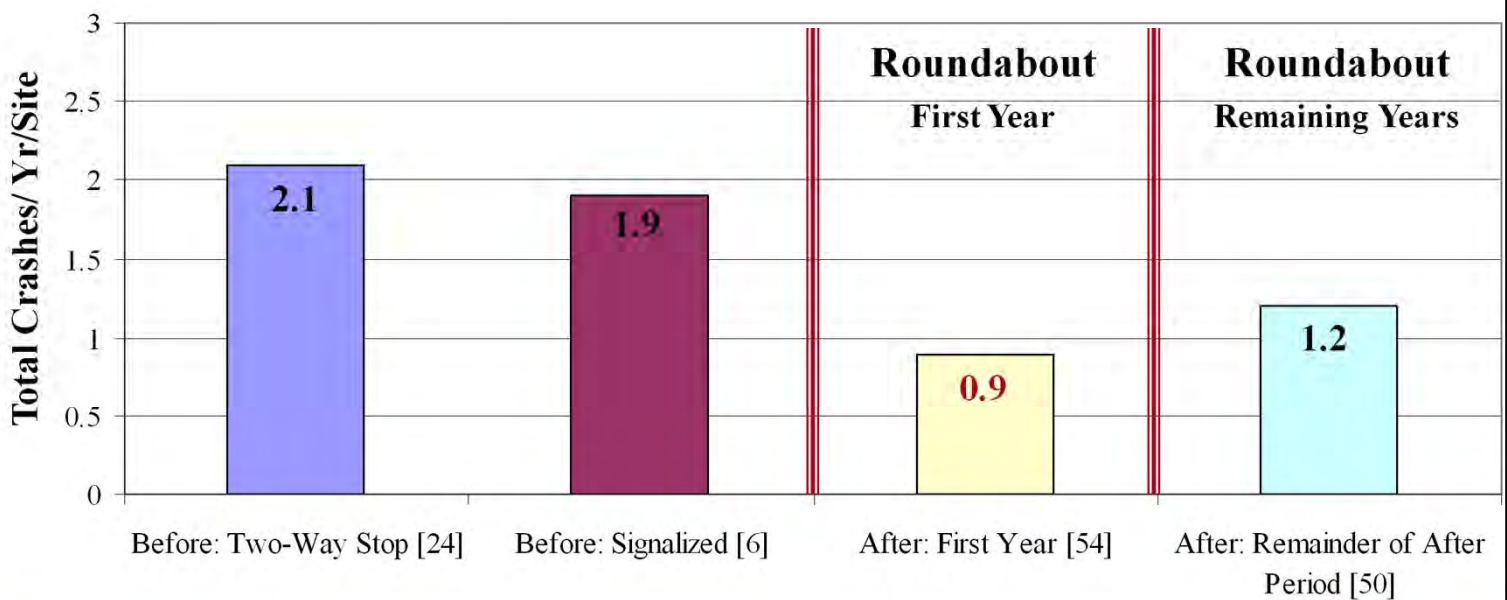
Overall, there is an observed reduction of 35% and 76% in total and injury crashes, respectively, following conversion to a roundabout. These values are consistent with results from international studies, as shown in Exhibit 5-10.

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- National statistics are pretty comparable with our results. A 55-location study sited in the NCHRP Roundabout Guide observed a 35% reduction in total crashes and a 76% reduction in injury crashes using Empirical Bayes methodology. This study included a group of 15 two-lane roundabouts and 10 sites converted from all-way stop control.

Crash Analysis Results - Immediately After

Safety Performance First Year After Installation



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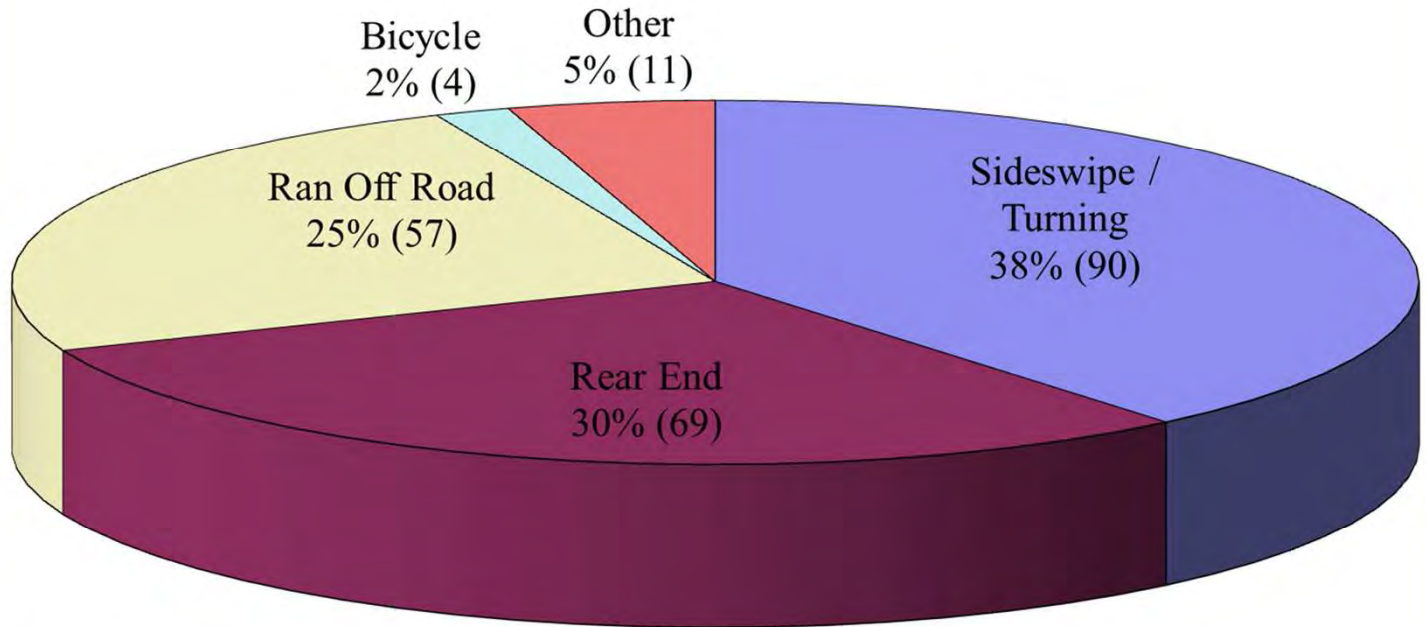
- We analyzed the number of total crashes that occurred within the first year after conversion to a roundabout.
- We looked to see if there was an increase in crashes immediately following the installation, but we actually found that the crash rates were the lowest in this period.
- Crash rates for the remainder of the after period were still lower than the before period, whether prior control was stop or signal.



Crash Analysis Results: Crash Types

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Roundabout Crash Types



0 Pedestrian Crashes

() = Crash Frequency

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- The largest after period crash types were: Sideswipe/Turning Crashes, Rear End Crashes, and Ran Off Road Crashes.
- The crash frequencies (in parenthesis) are relatively low considering the number of sites analyzed and the number of years studied. There were several bicycle crashes, which is discussed next.

Bicycle and Pedestrian Involved Crashes



Bicycle Crashes

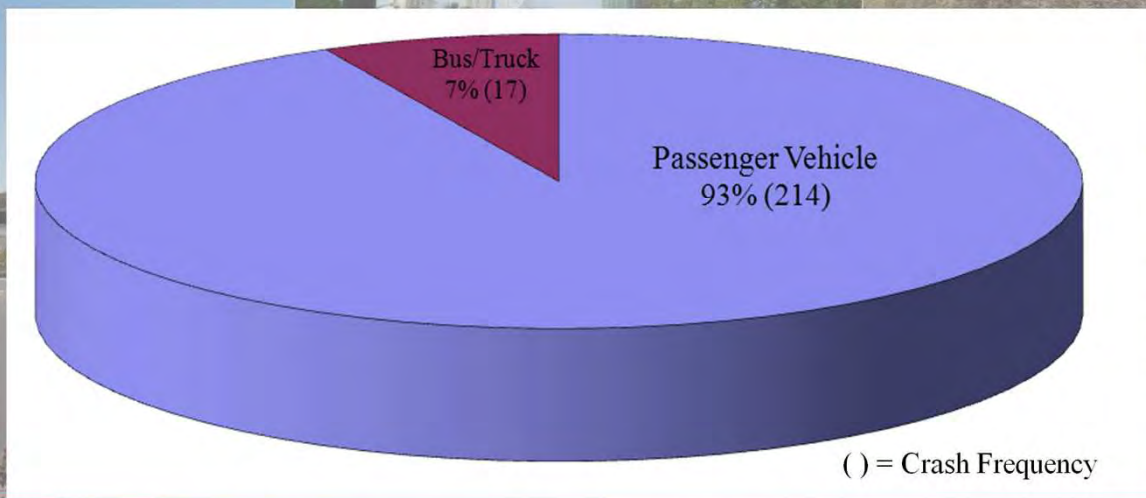
<i>Sites with Bicycle Crashes</i>	Study Years	Before (30 Sites)				After (54 Sites)			
		#	Injury Type	Vehicle Impact Speed	Location	#	Injury Type	Vehicle Impact Speed	Location
WT Weaver @ University Heights	7	1	B	10 mph	inside	0	---	---	---
US 421 NB Ramp @ Williams	6	0	---	---	---	1	B	5 mph	entry
US 421 SB Ramp @ Williams	9	0	---	---	---	1	C	15 mph	inside
Ninth @ Davidson	8	1	B	5 mph	xwalk	0	---	---	---
Voit Gilmore @ Knoll	4	0	---	---	---	1	B	20 mph	xwalk
Pullen @ Stinson	6	1	C	5 mph	xwalk	1	C	5 mph	entry
SUM		3				4			

No Pedestrian Crashes (Before or After)

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- Four sites had reported bicycle crashes in the after period. There were 2 class-B injury crashes and 2 class-C injury crashes. The estimated vehicle impact speeds were 5 to 20 mph.
- There were no reported pedestrian crashes in the study after period.
- At the 54 sites, we pulled data from 150 study-years before and 232 study-years after.

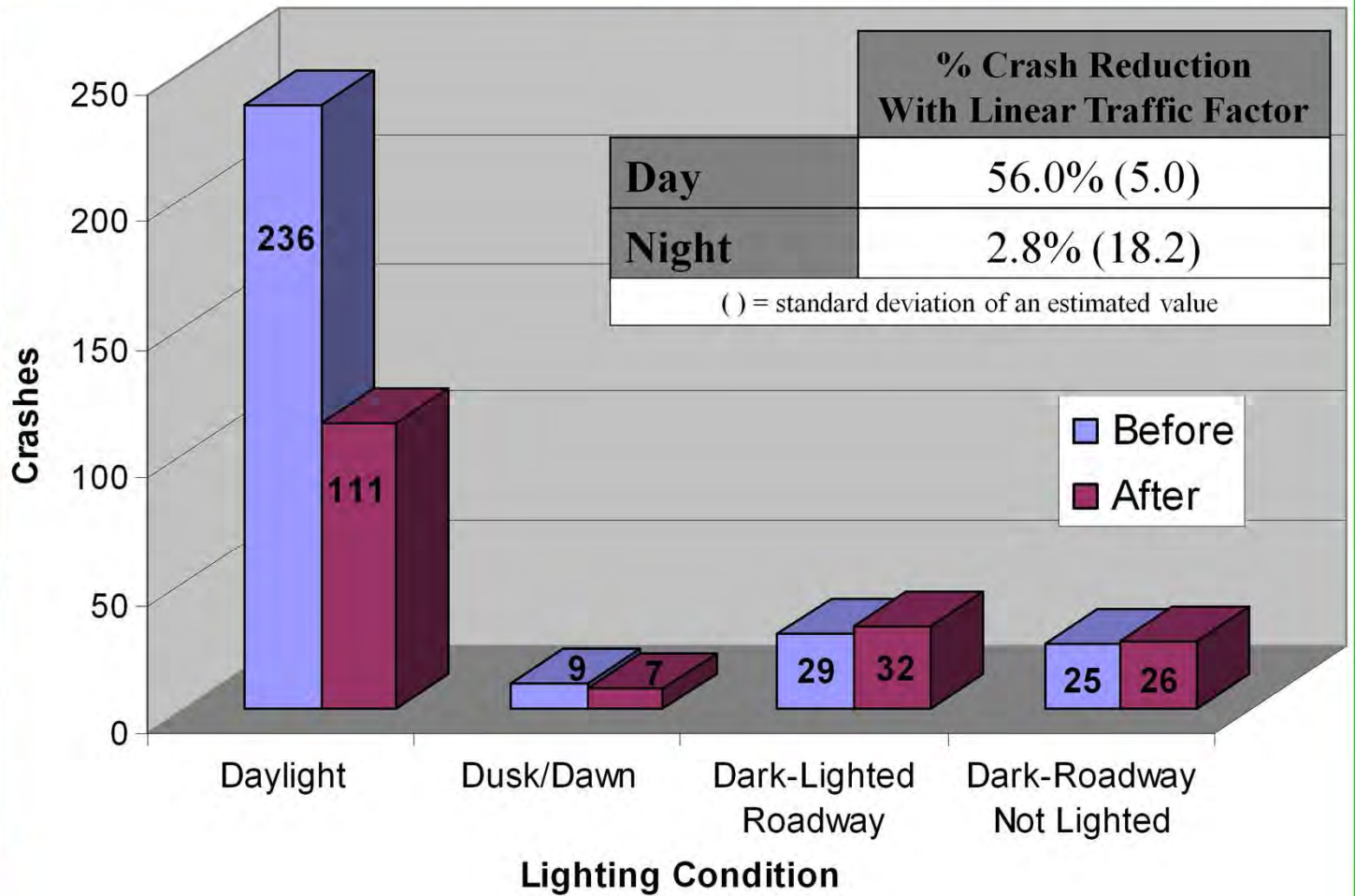
Heavy Vehicle Involvement



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- Passenger vehicles comprised 93% of vehicles involved in crashes, while buses and trucks comprised 7%.
- Statewide Bus & Truck crash involvement is about 4% per NCDOT crash facts (2006), so the percentage is a little higher than the statewide average.
- There were 17 total bus/truck crashes in the after period. Bus/Truck Crash Frequency: 2 Commercial Buses; 1 School Bus; 4 Single Unit Trucks; 7 Tractor/Semi-Trailers; 2 Truck/Trailers; and 1 Unknown Heavy Vehicle

Day Vs. Night Crashes



- The before and after results are different when analyzing day time or night time conditions.
- There were substantial decreases in daylight crashes; however, there was not a big overall change in the number of night crashes.
- There was not much of a change when analyzing lighted or un-lighted roadways. Note that 20 of 30 sites had some form of overhead lighting present.
- Considering the number of years and sites studied, there was not a high frequency of night crashes. Only two sites had more than one night crash/year.



Crash Analysis Results: Intersection Features & Crashes

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Crash Analysis Results – Size Categories

Percent Crash Reductions at NC Roundabouts
(Naïve Before & After with Linear Traffic Factor)

<i>SINGLE LANE</i>	Sites	Total Crashes	KAB Injury Crashes
Mini & Compact	9	60.7% (7.5)	100%
<i>Mini</i>	4	57.7% (17.1)	100%
<i>Compact</i>	5	61.9% (8.1)	100%
Standard & Large	14	56.3% (6.3)	84.8% (9.0)
<i>Standard</i>	10	58.9% (7.3)	90.5% (9.0)



For the single lane roundabouts, there were consistent reductions in total and severe injury crashes regardless of size.

For the study intersections, we found little correlation between:

- inscribed circle diameter and after period crashes
- intersection entry width and after period crashes
- circulatory lane width and after period crashes.

Crash Analysis Results – Size Categories

Percent Crash Reductions at NC Roundabouts
(Naïve Before & After with Linear Traffic Factor)

	Sites	Total Crashes	KAB Injury Crashes
Single Lane (All, Non-Ramp)	23	57.8% (4.9)	89.6% (6.1)
Double Lane	1	-11.2% (42.1)	N/A
Ramp	6	2.5% (19.8)	75.8% (14.5)



- The study included only one multi-lane roundabout with complete before and after data, which is located in Winston-Salem, NC. This location experienced an increase in crashes, from 11 before period to 13 after period crashes. However, the severity index decreased almost by half.
- There were six roundabouts at interchange terminals with before and after data. There was a slight decrease in total crashes, but a large standard deviation around the estimate. There was a large overall decrease in severe injury crashes.

Crash Analysis Results – Prior Control

Percent Crash Reductions at NC Roundabouts
(Naïve Before & After with Linear Traffic Factor)

<i>Before Period Control Type</i>	Sites	Total Crashes	KAB Injury Crashes
Two-Way Stop	24	47.7% (5.7)	78.1% (9.6)
Signalized	6	41.2% (11.8)	100%



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- Sites converted from two-way stop control experienced similar crash reductions as those converted from signals.
- There were no KAB crashes (severe injury crashes) in the after period at the 6 sites converted from a signal.

Crash Analysis Results – Number of Legs

Percent Crash Reductions at NC Roundabouts
(Naïve Before & After with Linear Traffic Factor)

<i>Number of Legs</i>	Sites*	Total Crashes	KAB Injury Crashes
3 Leg	8	57.1% (9.7)	89.3% (10.1)
4 Leg	15	58.2% (5.6)	90.2% (6.9)

* All Sizes of Single Lane, Non-Ramp Roundabouts



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- The results were similar for 3-leg or 4-leg intersections.

Crash Analysis Results – Bypass Lanes



<i>Avg. Sideswipe Crashes/Yr/Site</i>	Sites	Before	After	Avg. AADT (Excluding Ramps)
Bypass Lane	5	0.2	0.1	10,800
No Bypass Lane	25	0.1	0.1	8,000

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- There was not a noticeable increase in the average number of sideswipe crashes/year.
- The data was separated into sites with bypass lanes and those without. There was some concern that with bypass lanes the number of merging sideswipe crashes downstream of the roundabout may increase, but this didn't seem to happen at the study sites. Crash reductions at the sites with bypass lanes were lower than those without, but the overall crash frequencies were still low.
- In the after period, there were 13 sideswipe crashes at our 30 sites with before and after data (which includes 143 study years).



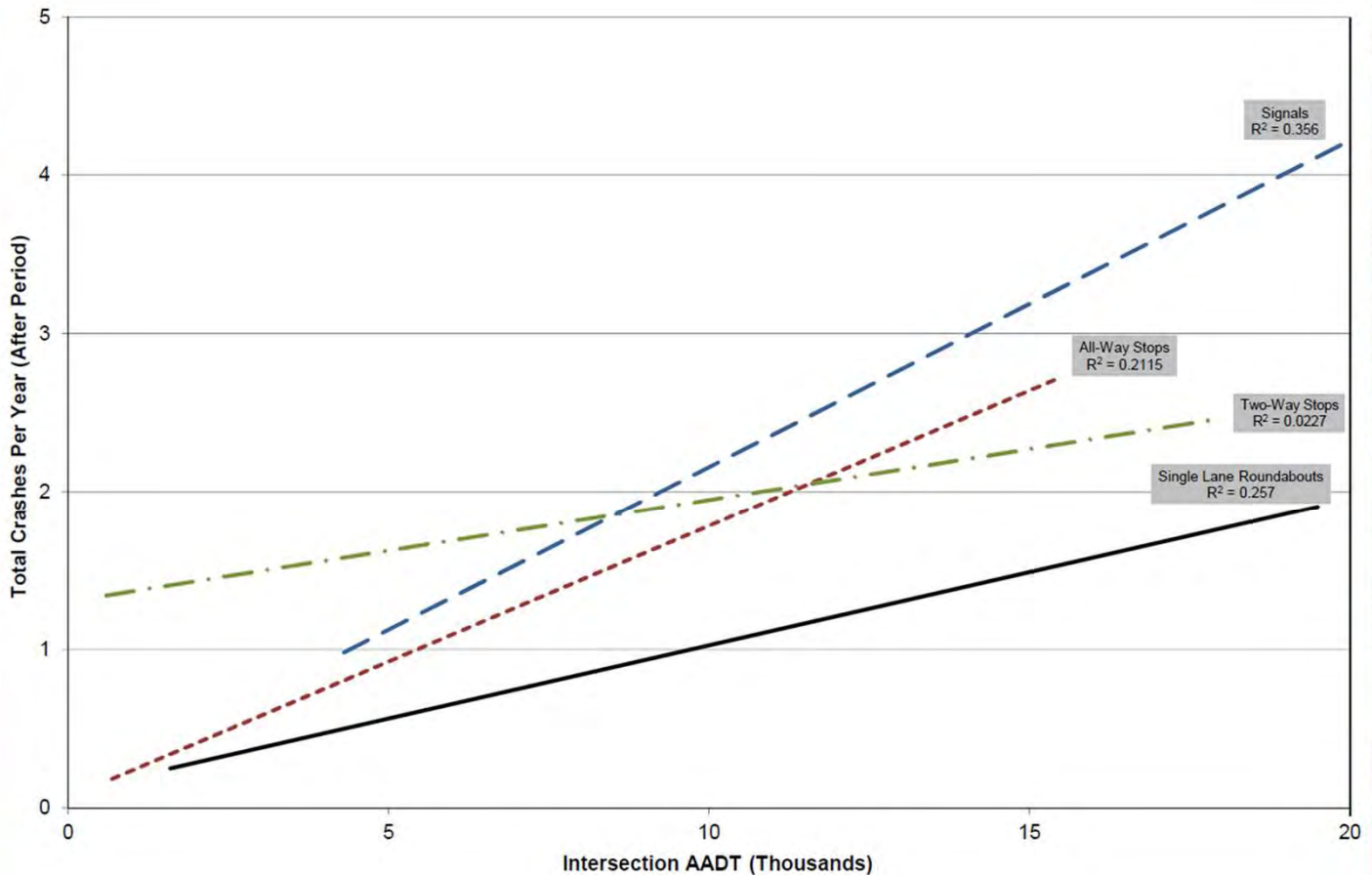
Crash Analysis Results: Entering Volume & Crashes

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Entering Volume vs. Crashes/Yr

Comparison of Single Lane Roundabouts, All-Way Stops, Two-Way Stops & Signals

Intersection AADT vs. Total Crashes Per Year (Single Lane Roundabouts)



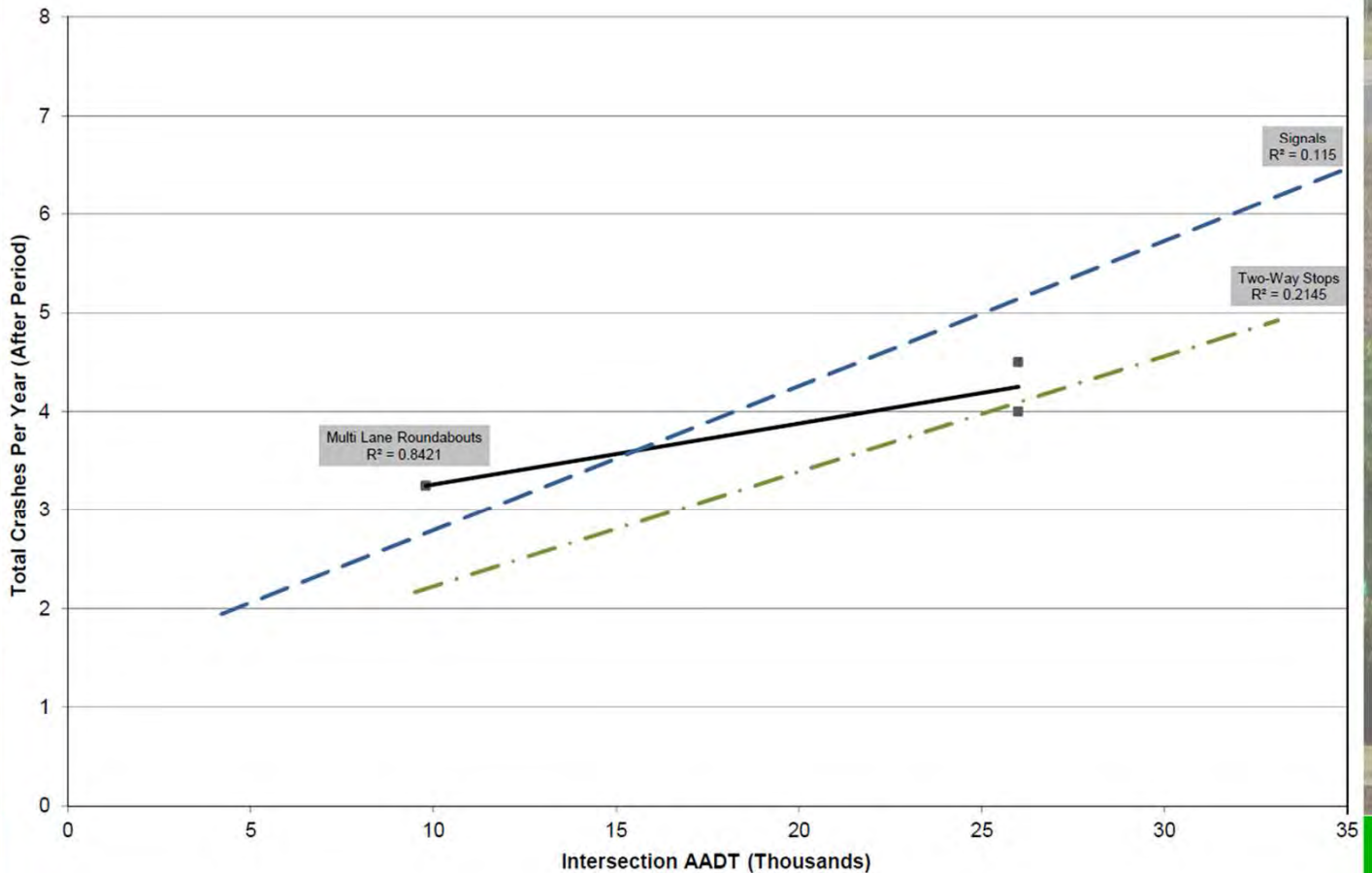
- The intersection volume was plotted with crashes per year at the single lane roundabouts (excluding ramp sites, for which we have no volume data). It seems that crash frequency has a weak linear relationship with the intersection volume. However, it appears that there is generally an increasing crash rate with increasing AADT at the study sites.

- The volume-crash relationship was plotted for other intersection types, using trend lines for all-way stops, two-way stops, and signals on 2-lane at 2-lane roads in North Carolina. The correlation between volume and crashes per year is relatively weak for all of the intersection types (as shown by low R squared for all trend lines). Generally though it seems that the safety performance of single lane roundabouts are as good as or better than the other intersection types at comparable volumes.

Entering Volume vs. Crashes/Yr

Comparison of Multi Lane Roundabouts, 2-Way Stops & Signals

Intersection AADT vs. Total Crashes Per Year (Multi Lane Roundabouts)



- The same volume-crash graphs were plotted for the small multilane roundabout data set, as well as a group of signals with multilane approaches and two-way stops at similar volumes. Again, the volume-crash relationship is relatively weak for the signal and two-way stop group. Generally, though, it does not appear that the multilane roundabouts are performing a great deal worse than the other intersection types at similar volumes. The multi-lane roundabout trend line (with only 3 data points) is pretty comparable with the others.

- The safety performance of multi-lane roundabouts should be re-examined as more are installed in North Carolina.



Crash Analysis Results: Speed Related Data

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Crash Analysis Results - Speed Limits

Percent Crash Reductions at NC Roundabouts
(Naïve Before & After with Linear Traffic Factor)

<i>Approach Speed Limits</i>	Sites	Total Crashes	KAB Injury Crashes
Low Speed (< 45 mph)	19	39.9% (7.9)	90.9% (6.4)
High Speed (≥ 45 mph)	11	52.6% (6.7)	79.0% (11.1)



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- It appears that the higher speed sites (those with speed limits at or greater than 45 mph) experienced greater crash reductions than the lower speed sites, although both performed well overall.
- The greater crash reductions at the higher speed limit sites may be due to this group including more locations installed specifically for safety.

Speeds at Impact (mph)

<i>Estimated Speeds at Crash Impact (30 Sites)</i>	Before	After	% Difference
Average Speed	18.2	15.1	-17%
Average Speed: Vehicle 1	16.8	16.4	-2%
Average Speed: Vehicle 2	19.7	13.3	-32%
Max Speed	70	55	
Interquartile Range (IQR)*	5-30 [25]	5-20 [15]	

*IQR is the range of the middle 50% of data.

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- The after period average vehicle speeds at impact are about 15 mph, using the complete listing of 54 sites.
- When looking at the before and after data, the most noticeable difference in speeds at impact is in vehicle 2 speeds, which decreased by over 6 mph from the before to the after period. Vehicle 2 is more often the not-at-fault vehicle, which under two-way stop or signal control would be the through vehicles.
- There was a decrease and shortening of the interquartile range of speeds at impact, which likely means that drivers are traveling slower and at more uniform speeds.



Signing & Marking Practices

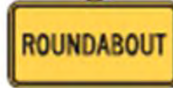
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Advanced Warning Signs

MUTCD 2009



W2-6



OR



W16-17P
(optional)

W16-12P
(optional)

MUTCD 2009

Page 128

2009 Edition

02 The Circular Intersection (W2-6) symbol sign (see Figure 2C-9) may be installed in advance of a circular intersection (see Figures 2B-21 through 2B-23).

Guidance:

03 *If an approach to a roundabout has a statutory or posted speed limit of 40 mph or higher, the Circular Intersection (W2-6) symbol sign should be installed in advance of the circular intersection.*

Option:

04 An educational plaque (see Figure 2C-9) with a legend such as ROUNDABOUT (W16-17P) or TRAFFIC CIRCLE (W16-12P) may be mounted below a Circular Intersection symbol sign.

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- The 2009 MUTCD states that the circular intersection sign may be used in advance of the roundabout. If an approach has a posted speed of 40 mph or greater, the this advance warning sign should be installed. This sign was introduced in the 2003 MUTCD.
- A “Roundabout” plaque may be mounted below the sign.
- The NCHRP Roundabout Guide discusses the use of the Circular intersection sign and it’s benefits over previous warning signs, some of which are still in use in North Carolina. The circular intersection sign is easily recognizable, provides the proper direction of circulation, and can be universally used.

NC Advanced Warning Sign Practices



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The signing at roundabouts is inconsistent. The location above has two different types of advanced warning signs on different approaches.

Advisory Speed Limits

Section 2C.08 Advisory Speed Plaque (W13-1P)

2009 MUTCD

Option:

01 The Advisory Speed (W13-1P) plaque (see Figure 2C-1) may be used to supplement any warning sign to indicate the advisory speed for a condition.

Standard:

02 **The use of the Advisory Speed plaque for horizontal curves shall be in accordance with the information shown in Table 2C-5. The Advisory Speed plaque shall also be used where an engineering study indicates a need to advise road users of the advisory speed for other roadway conditions.**

03 **If used, the Advisory Speed plaque shall carry the message XX MPH. The speed displayed shall be a multiple of 5 mph.**

04 **Except in emergencies or when the condition is temporary, an Advisory Speed plaque shall not be installed until the advisory speed has been determined by an engineering study.**

05 **The Advisory Speed plaque shall only be used to supplement a warning sign and shall not be installed as a separate sign installation.**

06 **The advisory speed shall be determined by an engineering study that follows established engineering practices.**



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- Advisory speed plaques are currently allowed to supplement any warning sign per MUTCD, including intersection warning signs like the circular intersection sign.
- In the roundabouts studied, advisory speeds were used with the circular intersection sign at 63% of sites (34 of 54 sites).

Advisory Speed Limits

NCHRP 672 Roundabout Guide (2010):

MUTCD. In practice it is difficult to define an appropriate advisory speed: Should it be related to the slowest speed for through traffic (V2), the slowest speed of all movements (typically V4), or another speed (such as zero for potentially coming to a stop at the yield sign)? In addition, advisory speed plaques are usually only used for turns and curves, not intersections.

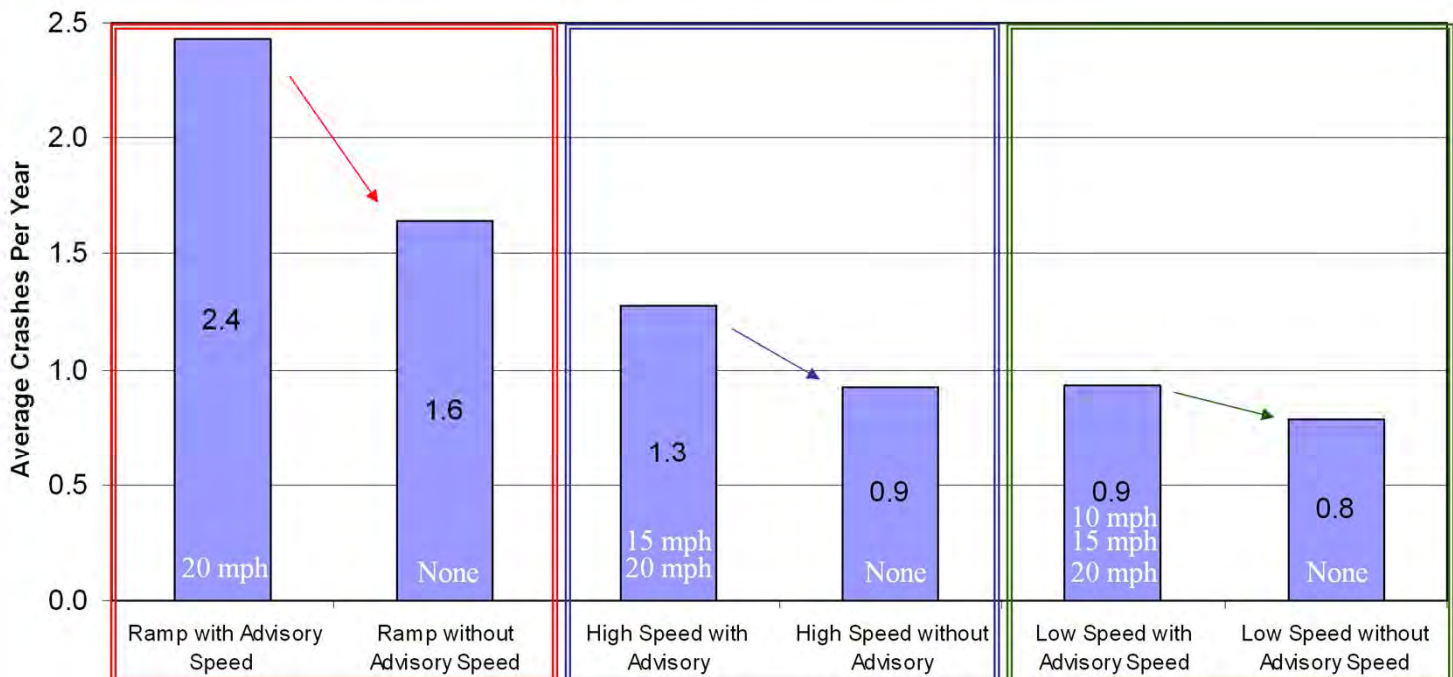


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The NCHRP roundabout guide discusses using advisory speed plaques at roundabouts and states that it is difficult to define an appropriate advisory speed (text above). There is no guidance on how the speed should be set (whether it be entering speed, through movement speed, left turn speed, etc.)

Advisory Speed Limits & Crashes/Yr

Average Crashes Per Year at Sites With and Without Advisory Speed Limits

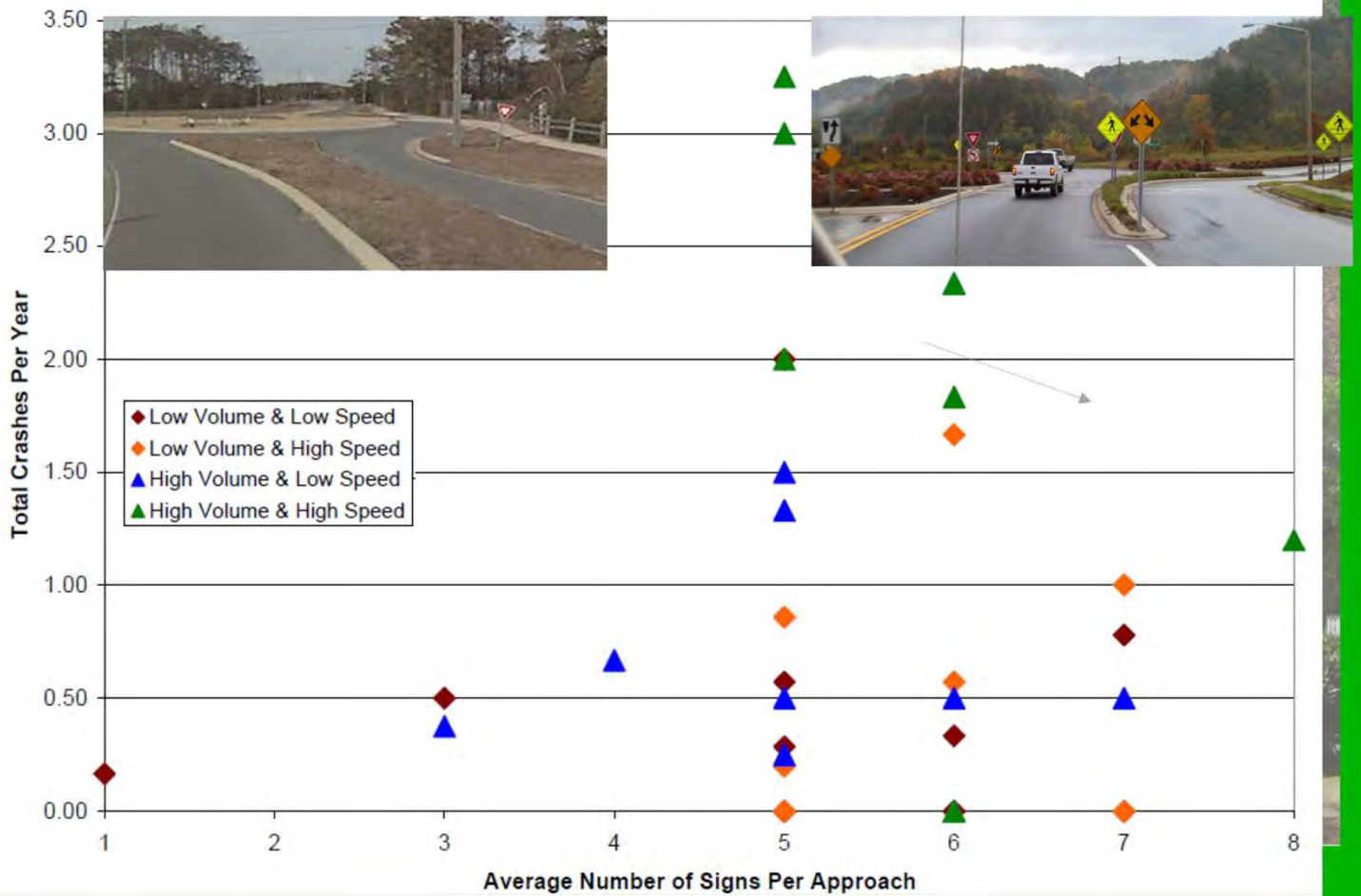


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- This study analyzed the relationship between crashes and posted advisory speed limits.
- The data was separated by ramp locations and locations with low and high approach speed limits, where high speed is defined as sites with posted speed limits of 45 mph or greater on at least one approach.
- It appears that the average crashes/year/site is less at sites without advisory speed limits than with, with a more noticeable difference at the ramp and high speed sites. However, the crash frequencies are relatively low, regardless of the advisory speeds.
- The range of posted advisory speed limits are listed in white on the bars.

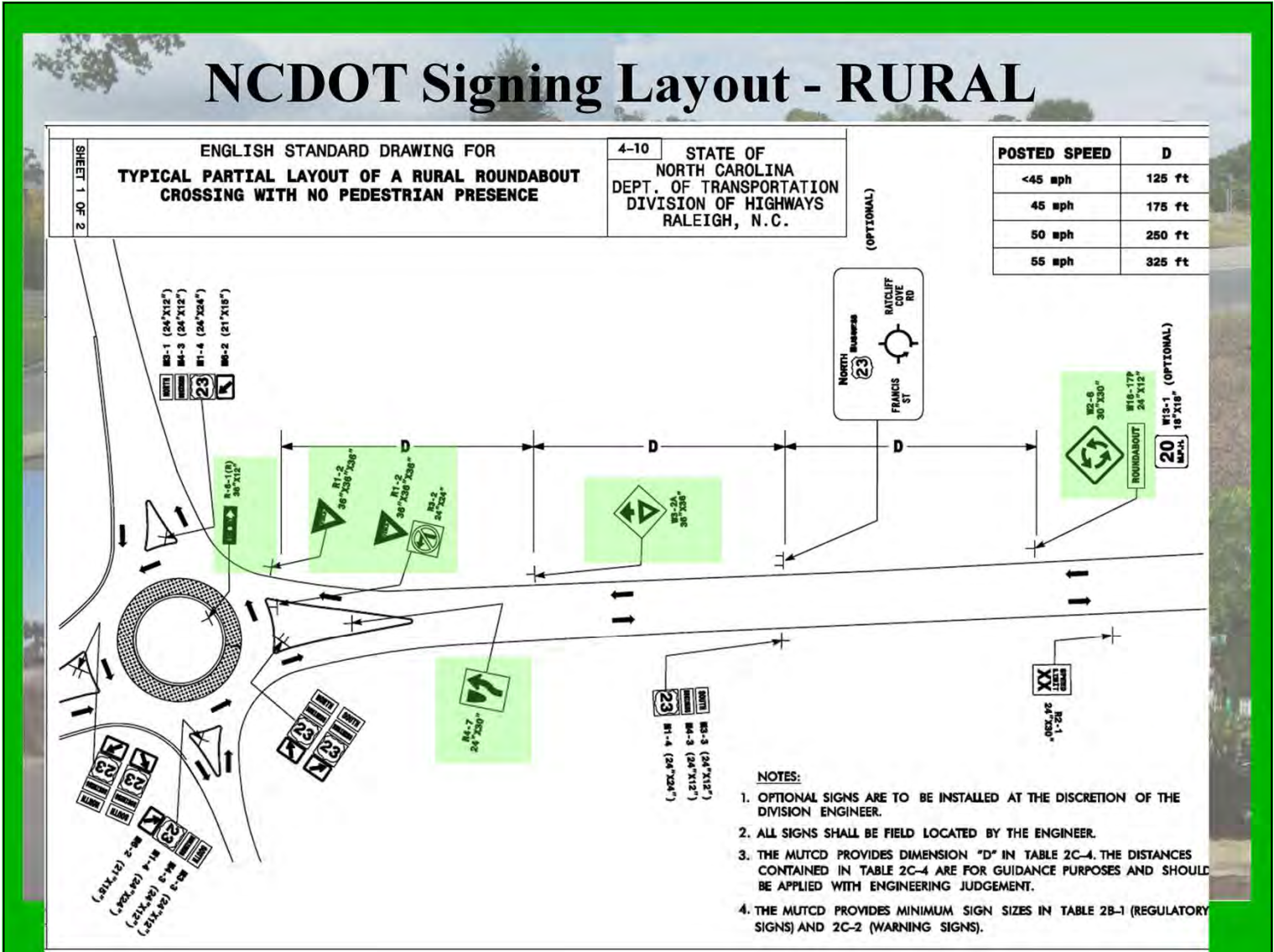
Number of Signs Per Approach

Number of Signs Vs. Crashes Per Year (37 Single Lane Sites, Excluding Minis & Ramps)



- This plot demonstrates the pure magnitude of signage used at many roundabouts in the State. Many of the single lane roundabouts average 5 to 7 signs on each approach (which equates to over 20 signs per roundabout).
- The number of signs per approach was plotted with crashes per year at the single lane roundabouts. Note that specific sign types were not examined because there are too many different combinations of signs. When the data was broken into volume and speed groups, there appeared to be little relation between the numbers of signs used and total crashes per year.

NCDOT Signing Layout - RURAL



This is the NCDOT Typical layout of a rural roundabout with no pedestrian presence. Optional signs are to be installed at the discretion of the Division Engineer.

Rural Signing & Marking Examples



Safety Division

Above are some examples of signing and marking used at rural roundabouts in North Carolina.

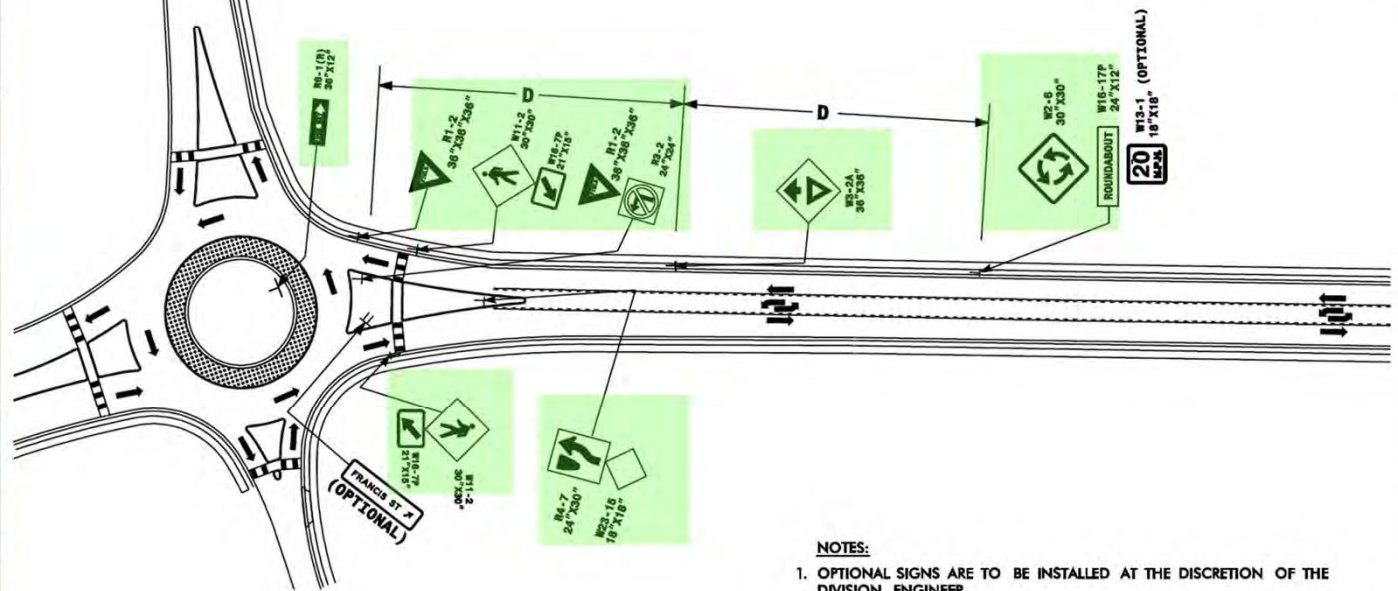
NCDOT Signing Layouts - URBAN

SHEET 2 OF 2

ENGLISH STANDARD DRAWING FOR
TYPICAL PARTIAL LAYOUT OF AN URBAN ROUNDABOUT
CROSSING WITH PEDESTRIAN PRESENCE

4-10 STATE OF
NORTH CAROLINA
DEPT. OF TRANSPORTATION
DIVISION OF HIGHWAYS
RALEIGH, N.C.

POSTED SPEED	D
<45 mph	125 ft
45 mph	175 ft
50 mph	250 ft
55 mph	325 ft



NOTES:

1. OPTIONAL SIGNS ARE TO BE INSTALLED AT THE DISCRETION OF THE DIVISION ENGINEER.
2. ALL SIGNS SHALL BE FIELD LOCATED BY THE ENGINEER.
3. THE MUTCD PROVIDES DIMENSION "D" IN TABLE 2C-4. THE DISTANCES CONTAINED IN TABLE 2C-4 ARE FOR GUIDANCE PURPOSES AND SHOULD BE APPLIED WITH ENGINEERING JUDGEMENT.
4. THE MUTCD PROVIDES MINIMUM SIGN SIZES IN TABLE 2B-1 (REGULATORY SIGNS) AND 2C-2 (WARNING SIGNS).

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This is the NCDOT Typical layout of an urban roundabout with pedestrian presence.

Pedestrian Accommodations



Above are some examples of signing and marking at roundabouts with different types of pedestrian accommodations in North Carolina.

Pedestrian Accommodations



Additional photographs from roundabouts with pedestrian accommodations in North Carolina. A couple things are amiss in these photos.

Pedestrian Accommodations



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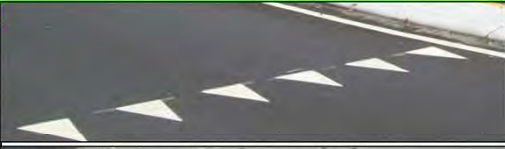





Examples of curb ramps leading to the center of the roundabout.

Bicycle Accommodations



Above are several examples of bike lanes approaching roundabouts. In 3 of 4 locations above the bike lane terminates prior to the roundabout.

Pavement Marking Practices

<i>Marking Type</i>		% of Roundabouts [#]
Yield Entry Lines		72% [39]
Dashed Entry Lines		72% [39]
“Yield” Markings		6% [3]
Advance Arrow Markings		13% [7]
In Circle Arrow Markings		19% [10]
Marked Crosswalks		59% [32]

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- The chart above indicates the percentage [and number] of roundabouts with each type of pavement marking.
- A majority of locations have yield entry lines and/or dashed entry lines.
- Also, over ½ have marked pedestrian crosswalks.

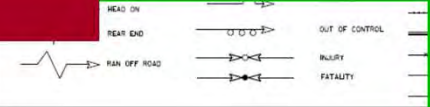


- The following slides provide representative before and after collision diagrams for each type of roundabout studied.
- In several cases where the roundabout was installed for safety purposes and the frequency of crashes was high in the before period, there were large reductions in crashes after the roundabout was installed. In some cases there was no decrease in crashes after installation, although crash types (and crash severity) changed.
- The duration of the study time periods are listed on each diagram.

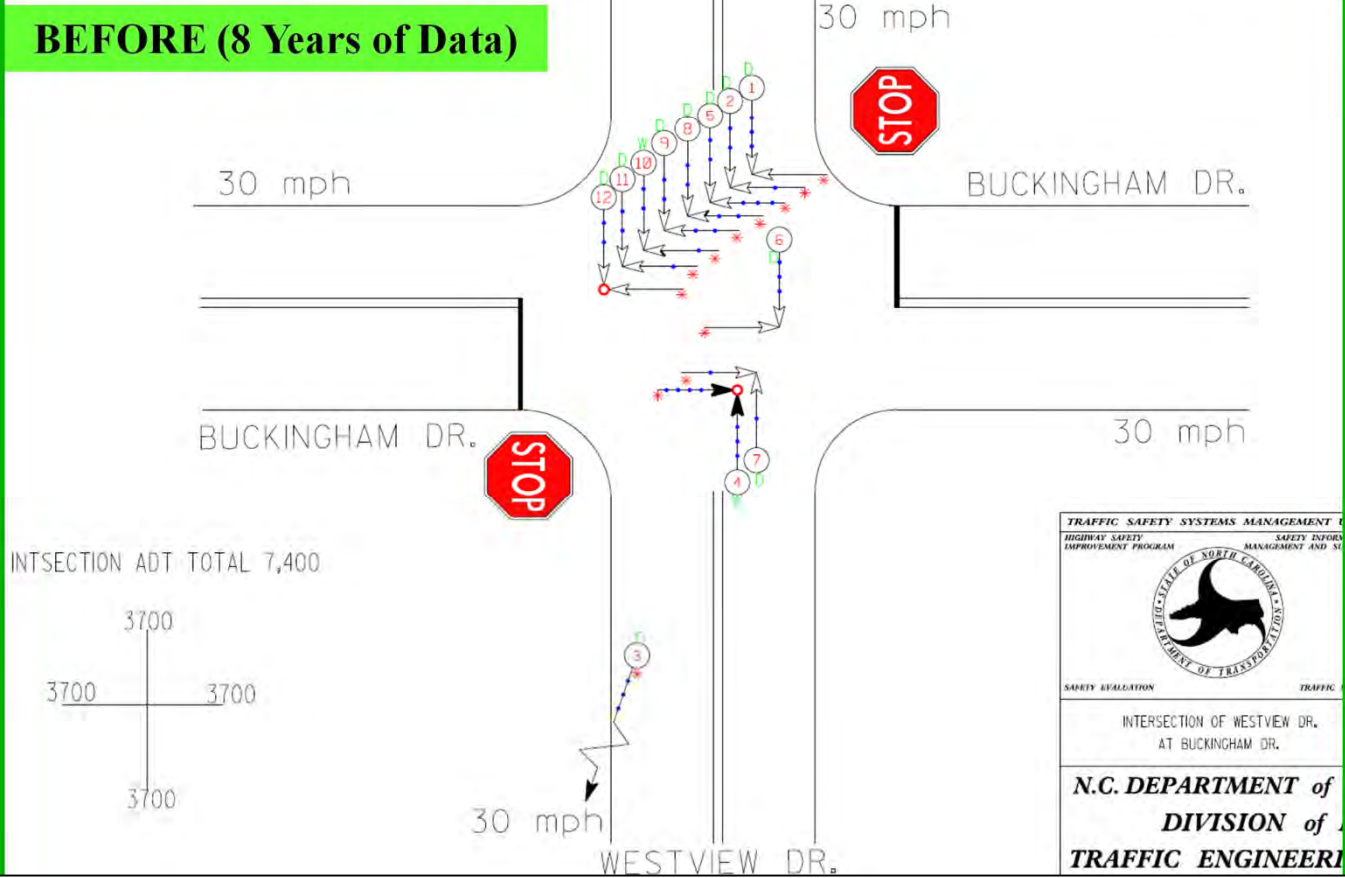
Crash Diagrams: Westview @ Buckingham, Forsyth Co.

(8.00 YR)
 FORE PERIOD - TOTAL CRASHES

MINI SINGLE LN



BEFORE (8 Years of Data)



Crash Diagrams: Westview @ Buckingham, Forsyth Co.

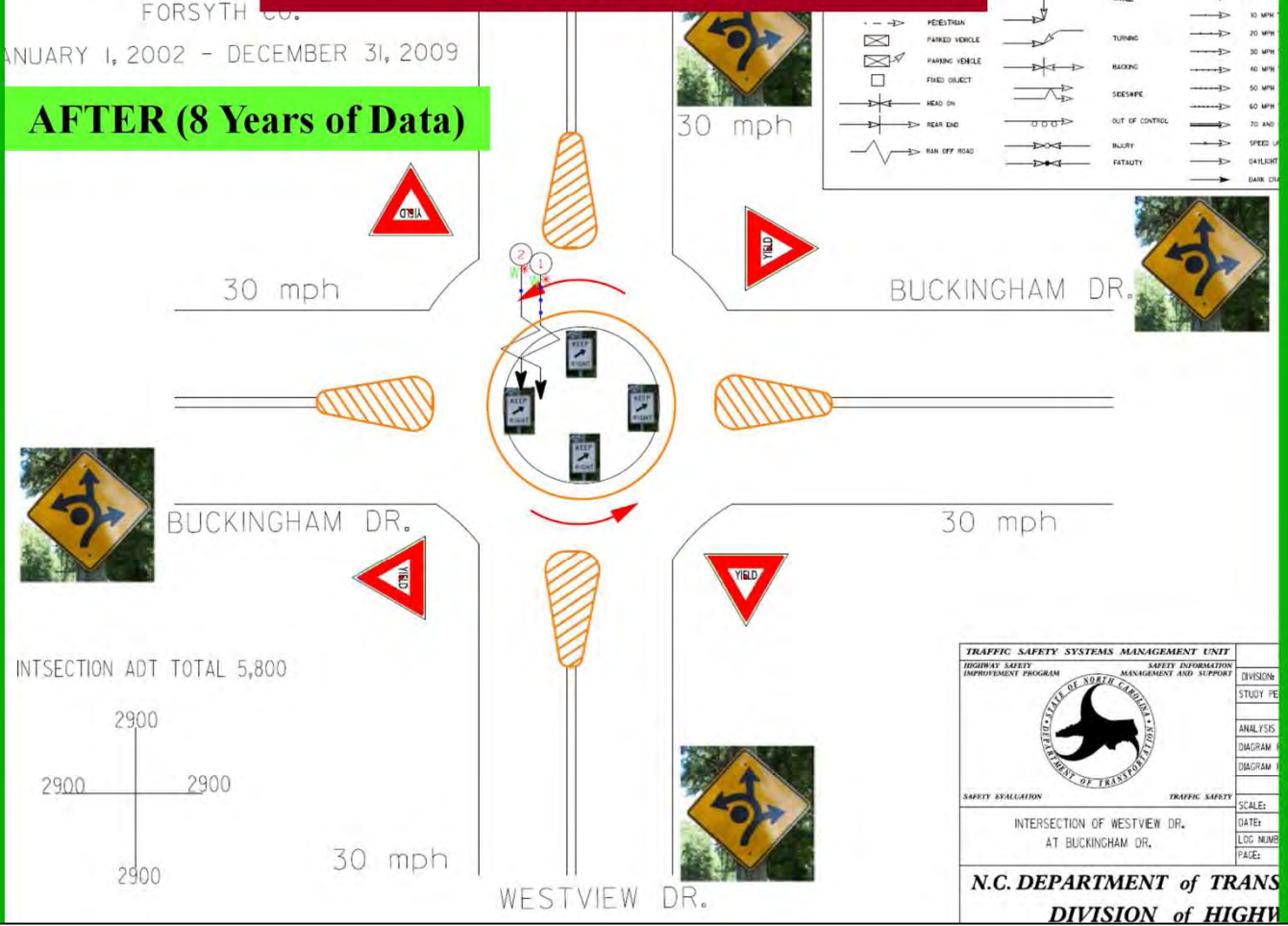
WESTVIEW DR. AT BUCKINGHAM DR.
 FORSYTH CO.
 JANUARY 1, 2002 - DECEMBER 31, 2009

AFTER (8 Years of Data)

MINI SINGLE LN

LEGEND

PEDESTRIAN	ANGLE	9 MPH OR LESS
PARKED VEHICLE	TURNING	10 MPH OR LESS
PARKING VEHICLE	BACKING	20 MPH OR LESS
FIXED OBJECT	DEESHAPE	30 MPH OR LESS
HEAD ON	OUT OF CONTROL	40 MPH OR LESS
REAR END	INQUIRY	50 MPH OR LESS
RAN OFF ROAD	FATALITY	70 AND OVER
		DARK LIGHT
		DAY LIGHT



Crash Diagrams: WT Weaver @ University Heights, Buncombe Co.

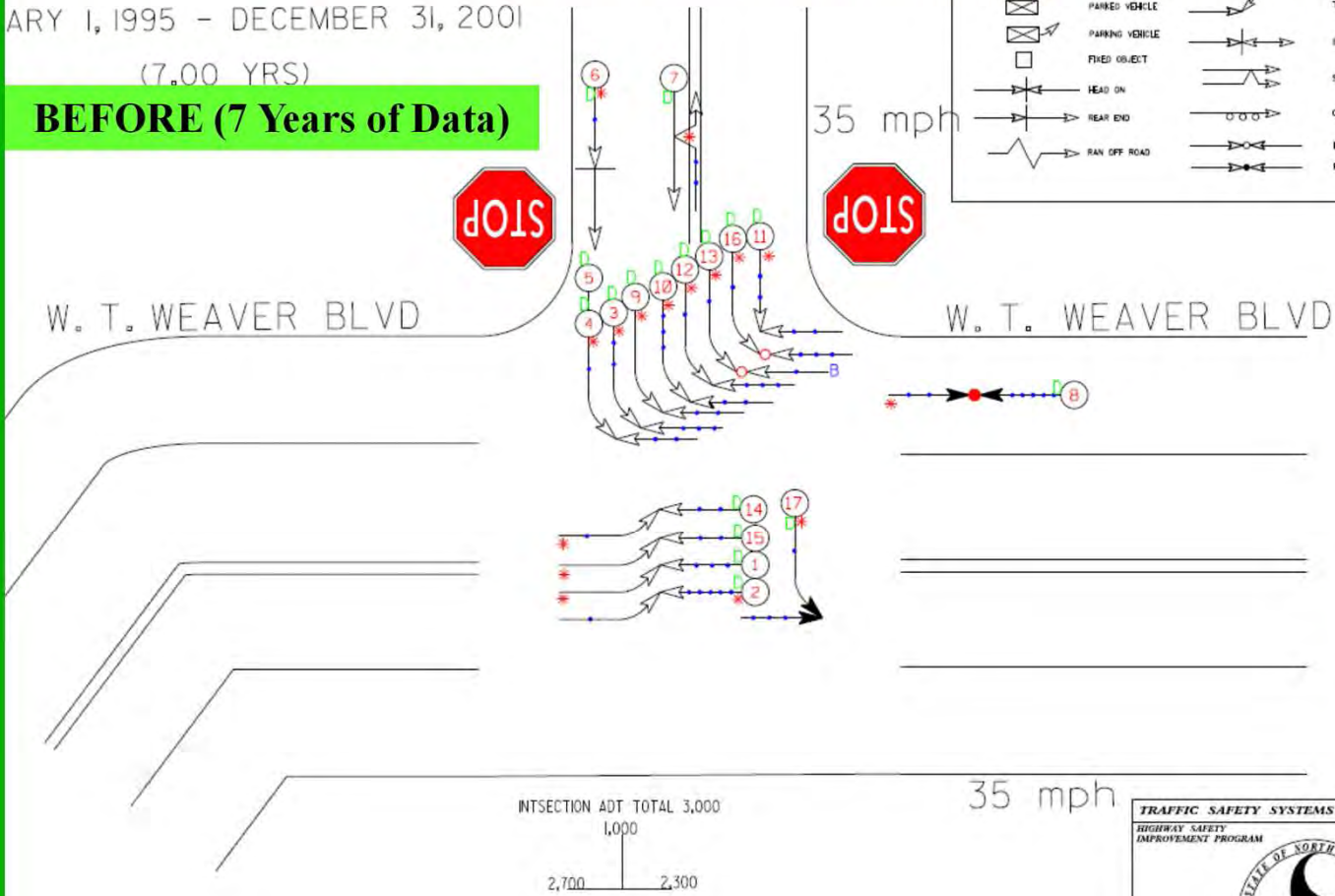
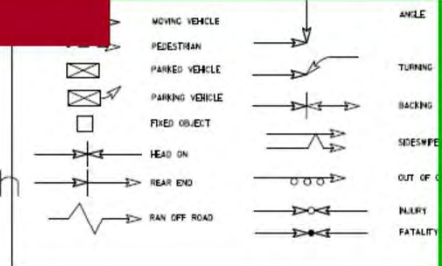
COMPACT SINGLE LN

BUNCOMBE CO

JANUARY 1, 1995 - DECEMBER 31, 2001

(7.00 YRS)

BEFORE (7 Years of Data)



TRAFFIC SAFETY SYSTEMS MAN
HIGHWAY SAFETY
IMPROVEMENT PROGRAM

Crash Diagrams: WT Weaver @ University Heights, Buncombe Co.

COMPACT SINGLE LN

R BLVD AT UNIVERSITY HEIGHTS
BUNCOMBE CO.

1, 2003 - DECEMBER 31, 2009

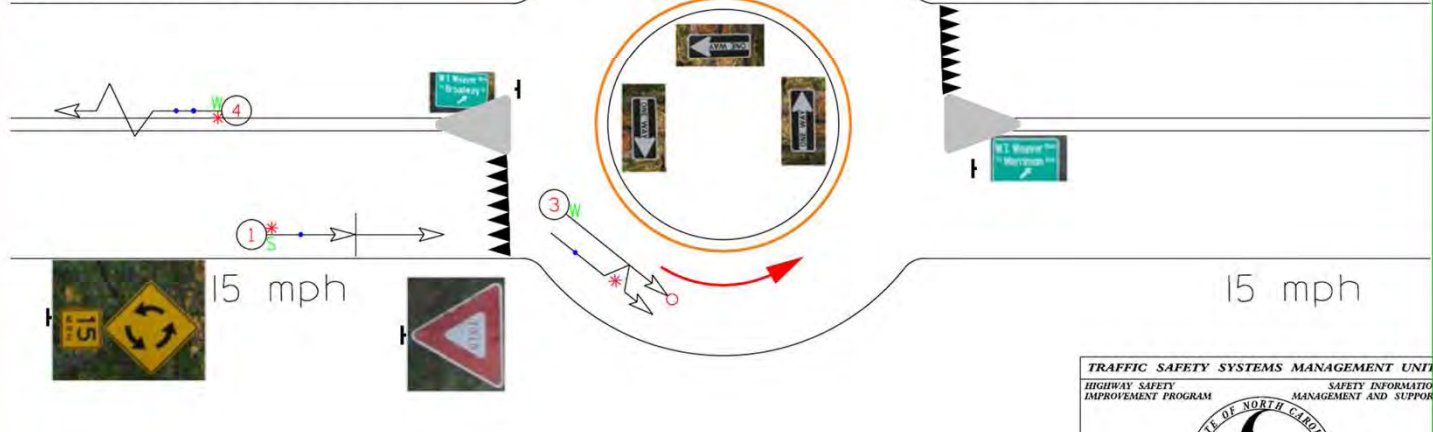
(7.00 YRS)

AFTER (7 Years of Data)

INTERSECTION ADT TOTAL 3,200
1,000
3,200 3,200

W. T. WEAVER BLVD

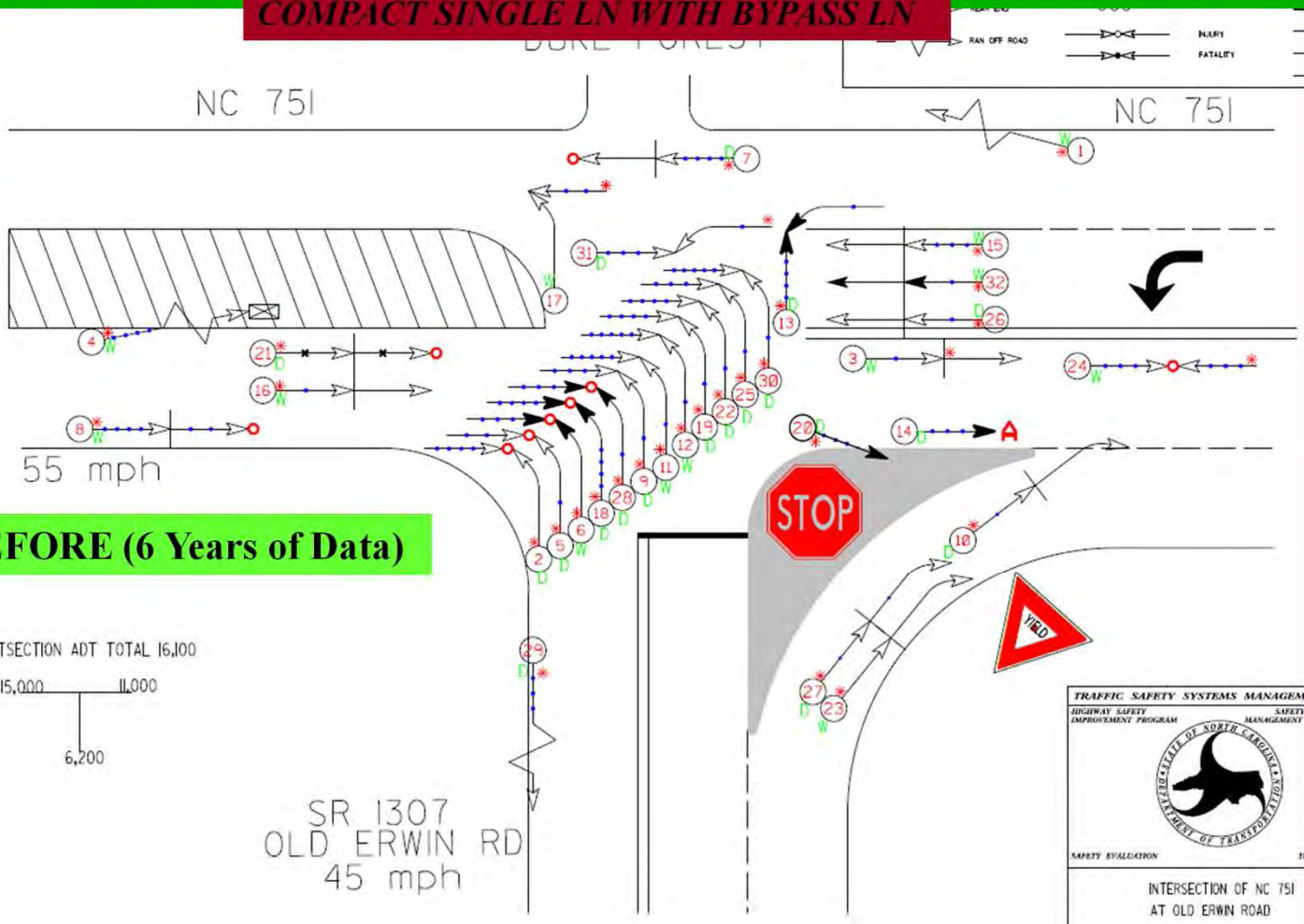
W. T. WEAVER BLVD



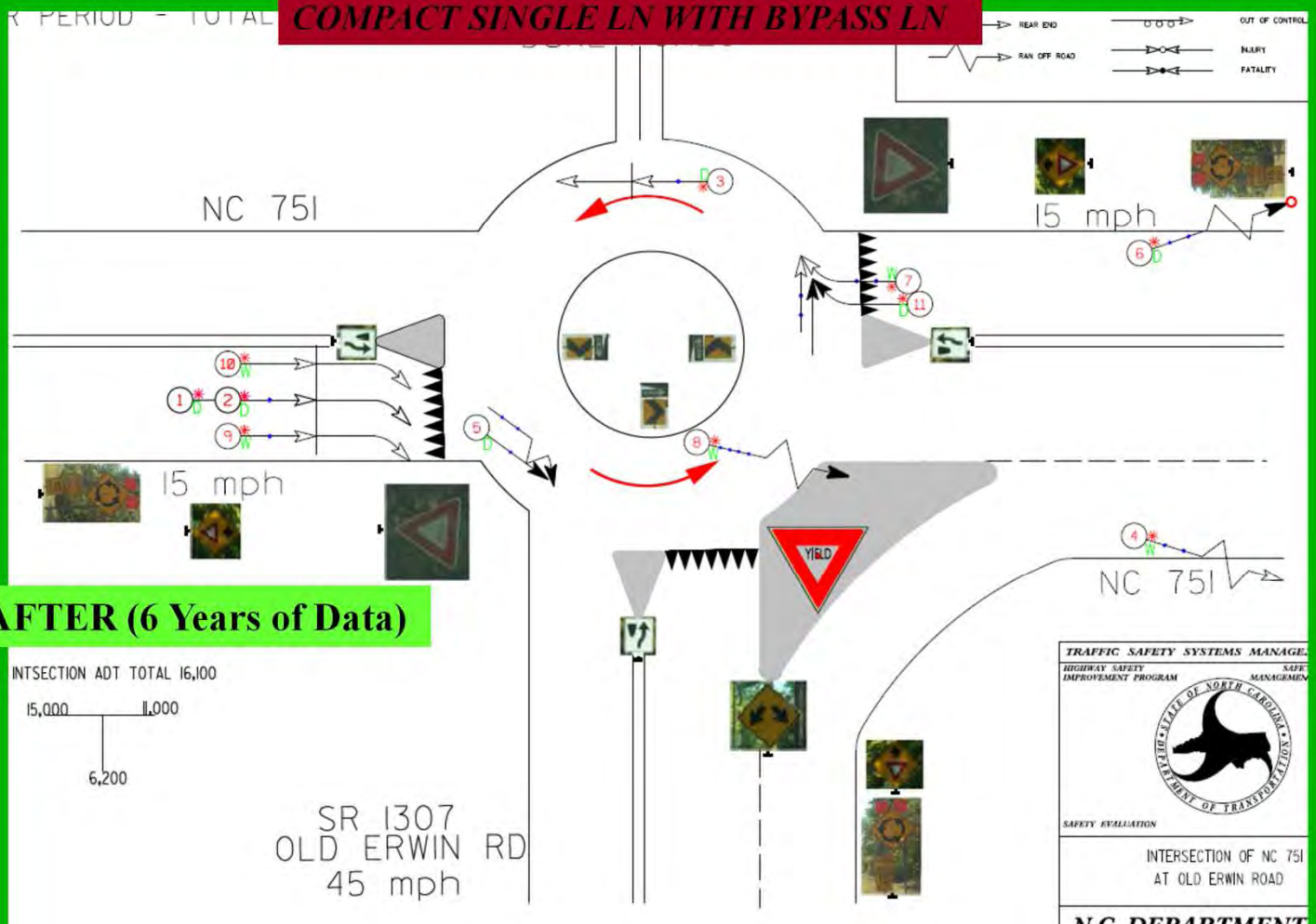
TRAFFIC SAFETY SYSTEMS MANAGEMENT UNIT
HIGHWAY SAFETY IMPROVEMENT PROGRAM
SAFETY INFORMATION MANAGEMENT AND SUPPORT
STATE OF NORTH CAROLINA

Crash Diagrams: NC 751 @ Erwin Rd, Durham Co.

COMPACT SINGLE LN WITH BYPASS LN



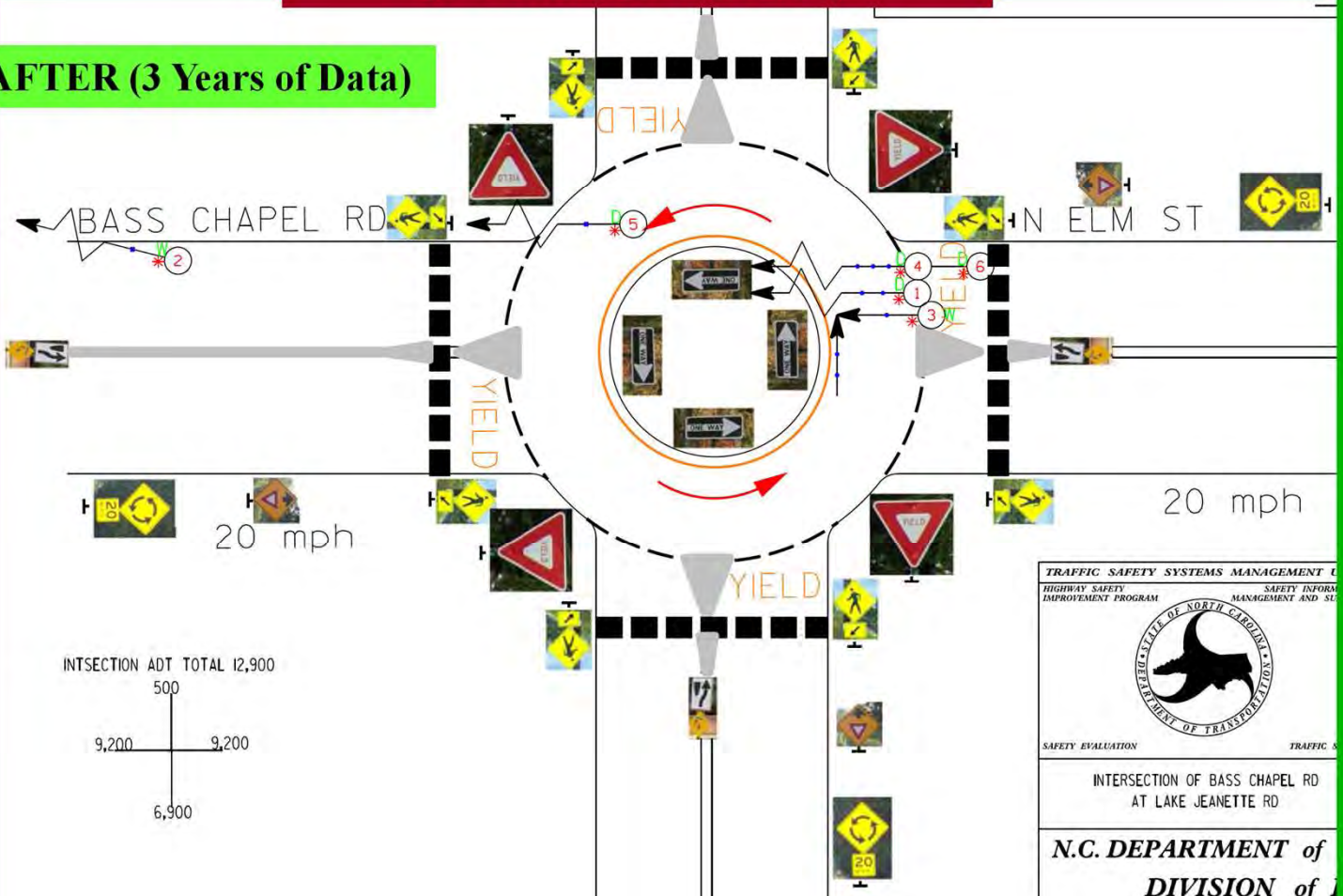
Crash Diagrams: NC 751 @ Erwin Rd, Durham Co.



Crash Diagrams: Lake Jeanette @ Elm, Guilford Co.

STANDARD SINGLE LANE

AFTER (3 Years of Data)

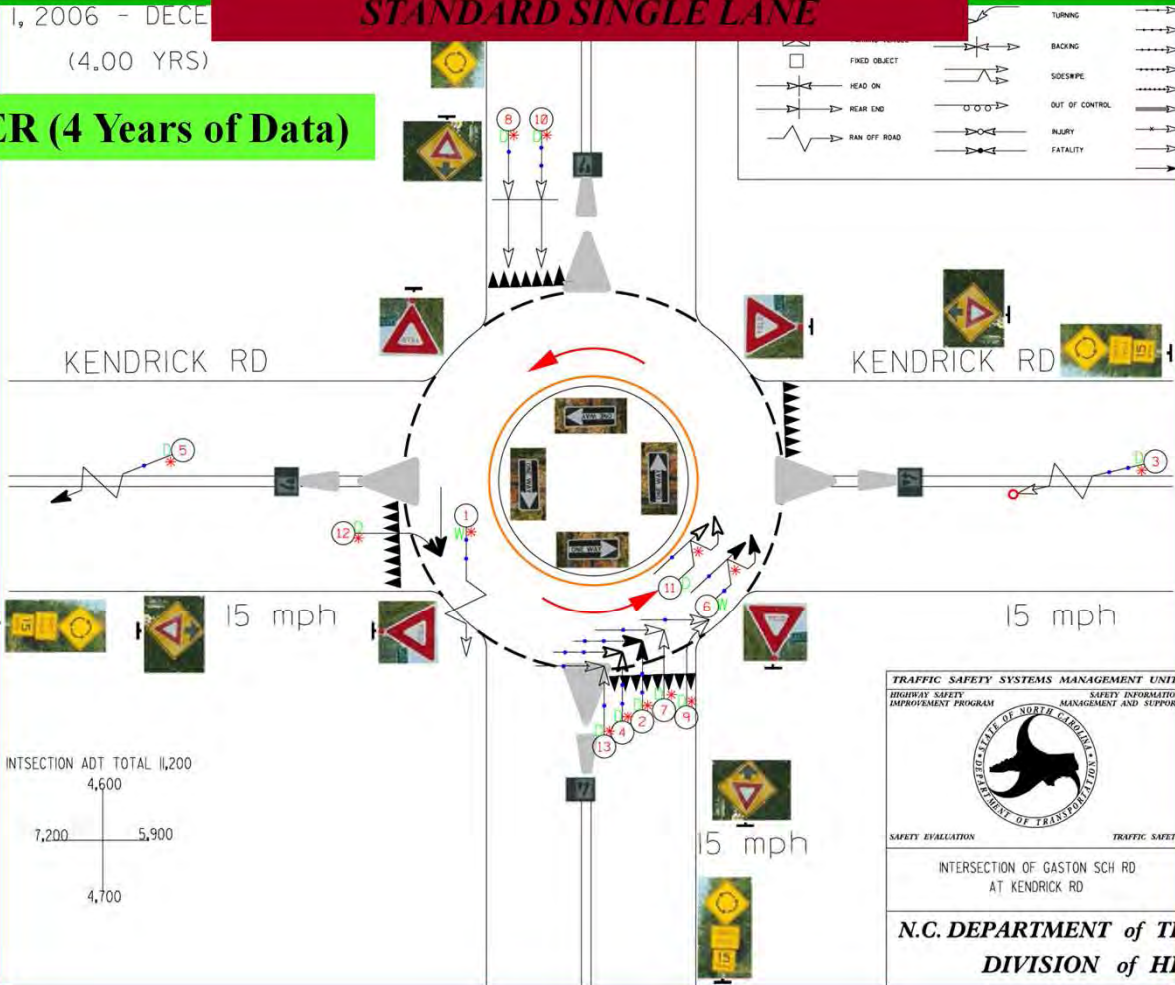


Crash Diagrams: Gaston Day School @ Kendrick, Gaston Co.

1, 2006 - DECEMBER
(4.00 YRS)

STANDARD SINGLE LANE

AFTER (4 Years of Data)



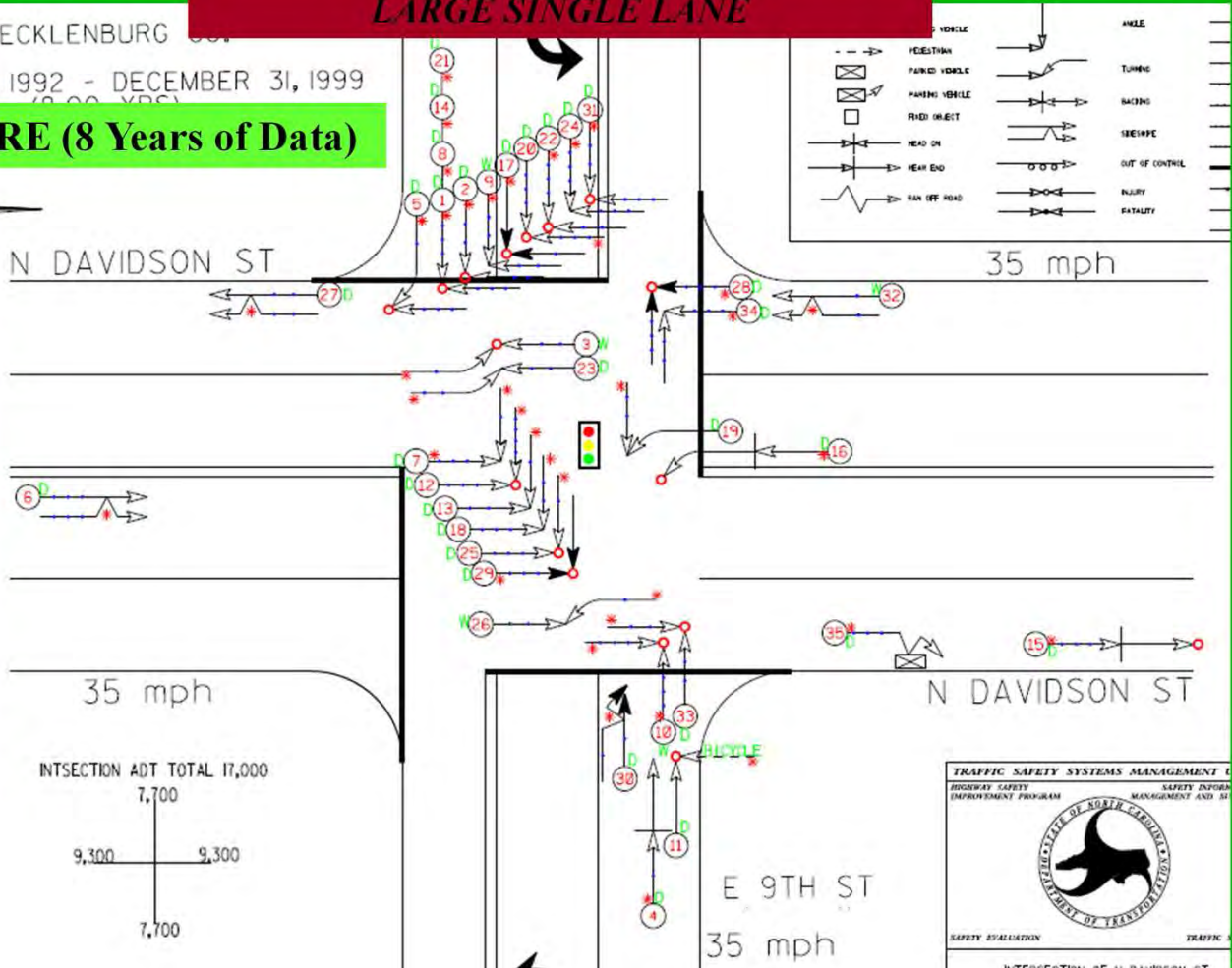
Crash Diagrams: Ninth @ Davidson, Mecklenburg Co.

LARGE SINGLE LANE

MECKLENBURG COUNTY

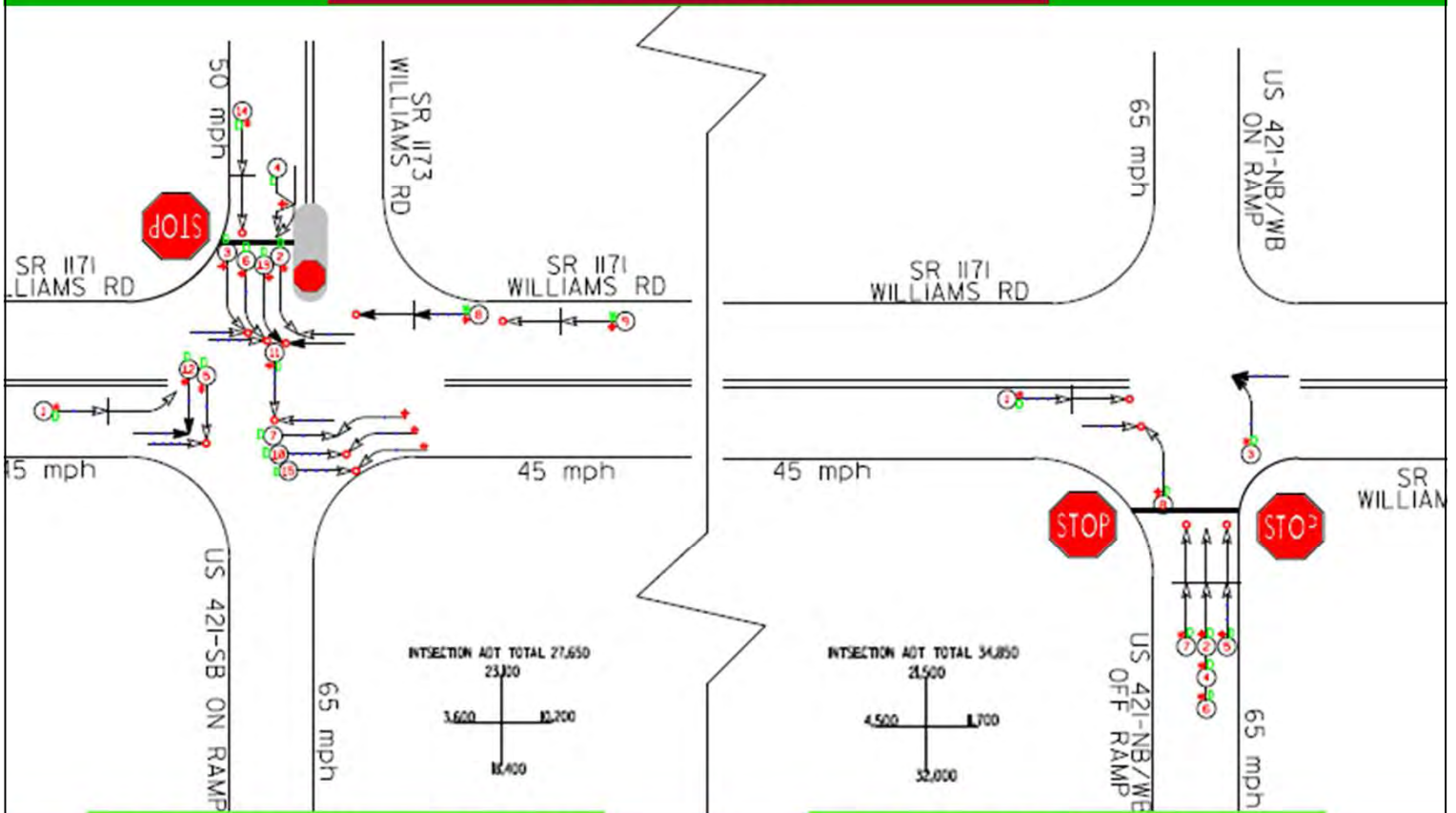
JANUARY 1, 1992 - DECEMBER 31, 1999

BEFORE (8 Years of Data)



Crash Diagrams: US 421 @ Williams Rd, Forsyth Co.

INTERCHANGE

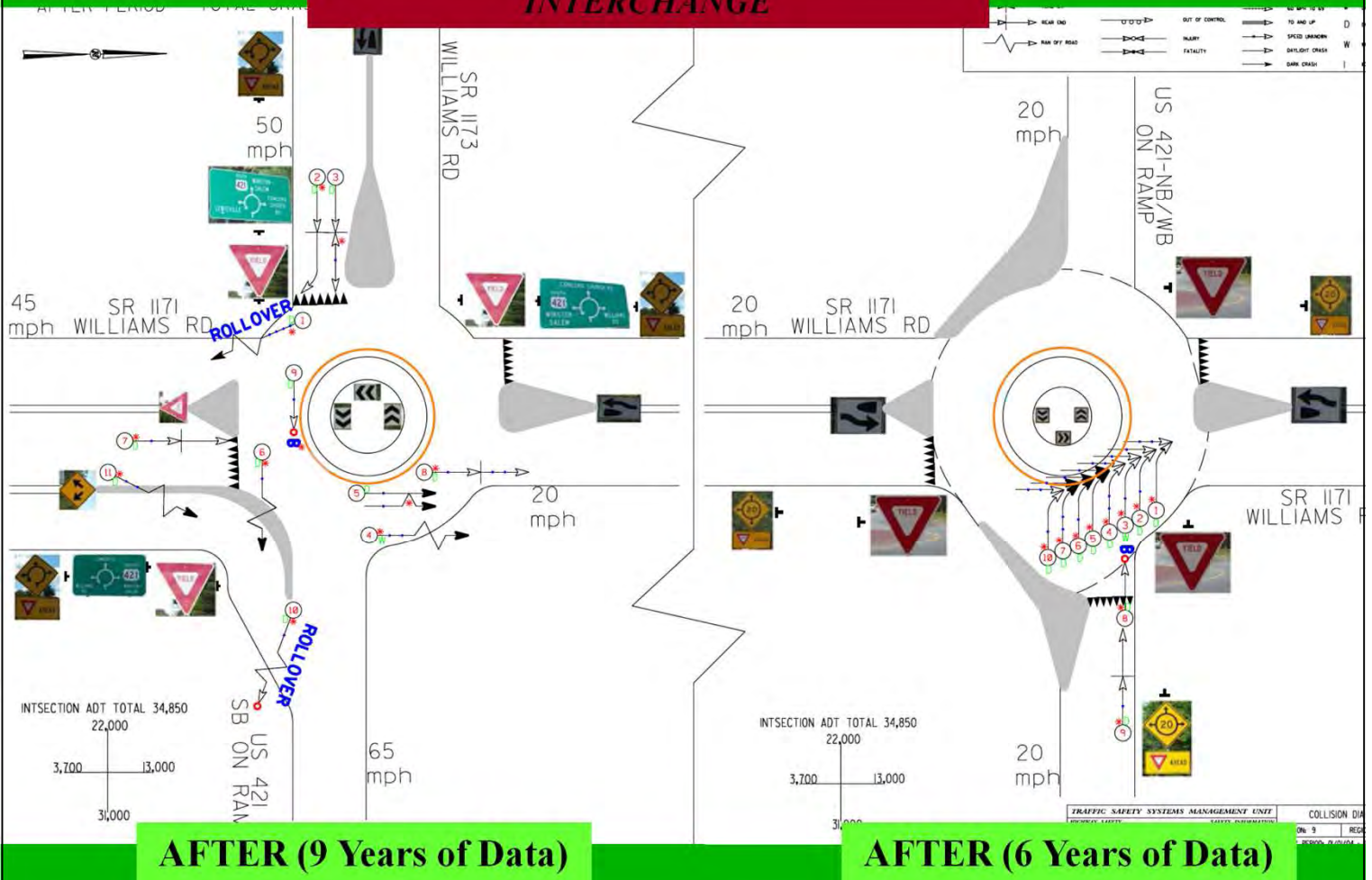


BEFORE (9 Years of Data)

BEFORE (6 Years of Data)

Crash Diagrams: US 421 @ Williams Rd, Forsyth Co.

INTERCHANGE



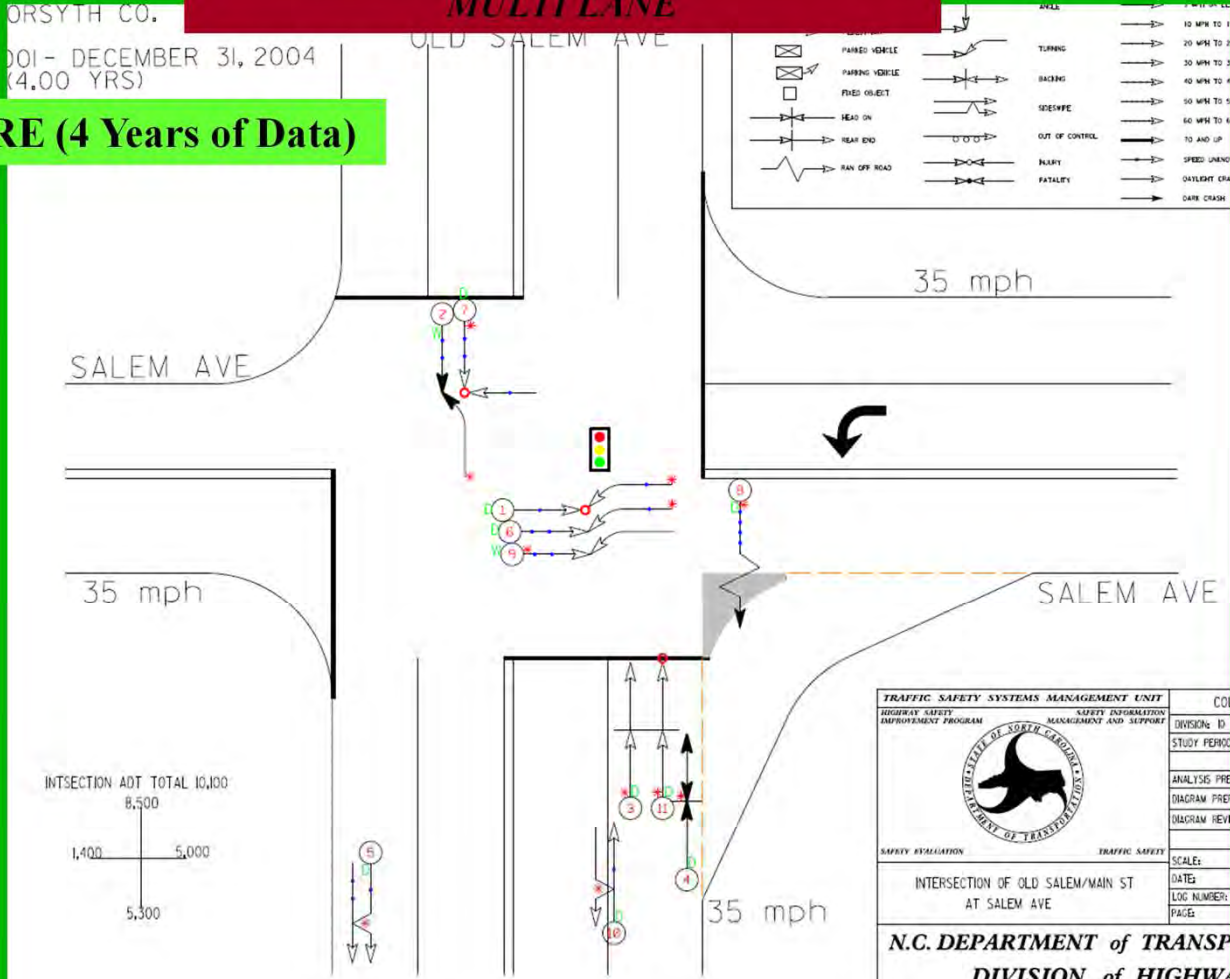
A pattern developed at the ramp on the right. Keep in mind, however, that this represents a six year time frame of data.

Crash Diagrams: Main @ Salem, Forsyth Co.

MULTI LANE

FORSYTH CO.
 DOI - DECEMBER 31, 2004
 (4.00 YRS)

BEFORE (4 Years of Data)





The intersection of Hillsborough St and Pullen Rd in Raleigh, NC was converted to a multi-lane roundabout in 2010. It was not included in the previous before and after crash study because there was not enough after period data at the time the study was completed. The following summarizes the crash data at this location 8 months after its installation. It is a high volume location adjacent to NCSU that has experienced a high crash frequency since the roundabout was completed.

Hillsborough St @ Pullen Rd / Oberlin Rd

MULTI LANE

	Traffic Control	
	Before	After
Hillsborough @ Pullen	Signal	Roundabout
Oberlin @ Groveland/Pullen	Stop	Roundabout
Hillsborough @ Oberlin	Signal	Signal



Aerial photographs before and after the intersection of Pullen Rd and Hillsborough St was converted to a multi-lane roundabout. The configuration of adjacent intersections changed as well.

Hillsborough St @ Pullen Rd / Oberlin Rd

MULTI LANE

Hillsborough @ Pullen/Oberlin Raleigh, NC	Crashes/Yr - 3 Intersections		
	Before 3 Yrs (5/1/06-4/30/09)	After 8 Mo (8/1/10-3/31/11)	% Difference
Total	21.3	81.0	280%
Injury	4.7	6.0	29%
Frontal Impact	8.0	51.0	538%
Sideswipe	3.7	18.0	391%
Rear End	5.3	9.0	69%
Bicycle	1.0	0.0	-100%
Night	5.3	25.5	378%
Severity Index	2.6	1.55	-41%



- There was a 280% increase in crashes per year at the three intersections above using 8 months of after period data; however, the severity index of crashes decreased by 41%.
- The numbers in red on the aerial photograph represent the total after period crashes at each intersection.



CONCLUSION

Recommended Crash Reduction Factors:

Total Crashes	-46%
Injury Crashes	-75%
Frontal Impact Crashes	-76%

NCDOT Transportation Mobility & Safety Division

- Here again are the recommended crash reduction factors, which demonstrate a substantial reduction in crashes at the North Carolina sites.
- These numbers use data from the overall group, regardless of whether the intersection is rural, low volume and high speed or urban, higher volume and low speed. The overall conclusion is based on the most expansive group to provide the widest scope possible.



QUESTIONS?

Presentation Soon Available at

<http://www.ncdot.org/doh/preconstruct/traffic/safety/Reports/completed.html>

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919-662-4607

NCDOT Transportation Mobility & Safety Division