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Safer Driver Actions at Stop Signs

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16. Abstract Final report covering driver stopping habits at stop-controlled intersections in Clearfield and Centre Counties. This was a two (2) phase project. Phase I dealt with finding out negative trends and problems in driver actions at stop signs, while Phase II evaluated the effectiveness of a variety of intersection improvements which sought to correct these negative trends and problems.			
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Executive Summary

The stop sign is one of the most common traffic control devices used by motorists daily, yet many people still are unsure or misinterpret the correct way to navigate through a stop-controlled intersection. With this in mind, this study was undertaken to determine the specific problems drivers were having and then to conceive ways to help correct these problems. The project was divided into two (2) phases.

Phase I studied thirty-two (32) intersections in Clearfield and Centre Counties. After field observations and research (including crash history, pavement history, and Average Daily Traffic), analysis determined several trends in drivers' stopping behavior. The physical location of the stop sign was determined to be the most important factor in where drivers stopped. Physical obstructions to sight distance also pulled drivers closer to the intersections, however stop bar and dashed edge-line pavement markings seemed to have little effect by themselves. A list of low-cost improvements was then developed which sought to help reduce the negative trends which were found.

Phase II studied twenty-four (24) of the original intersections where low-cost improvements were made. The intersections were divided into three (3) groups. One (1) group had the "STOP" pavement marking painted at each intersection near the edge of the main road. Another group had an "AT WHITE LINE" sign mounted below the stop sign at each intersection. Finally, the third group had both of these improvements installed at each intersection.

Once the improvements were installed, each intersection, with the exception of one (1) where a paving project delayed the installation process, was observed once again in the field. The observations from Phase I and Phase II were then compared to determine which improvement was most effective. Age, gender, and speed limit were included in the evaluation. The main categories of data that emerged were:

- How many drivers rolled through the stop signs
- How many drivers did not stop at the stop signs
- What was the average stopping distance from the edge of the main road

The table on the following page summarizes the relevant data from the analysis. The numerical increase or decrease from Phase I to Phase II in rolling stops, did not stops, and average stopping distance is shown. Also included is the numerical increase or decrease in average stopping distance from the edge of road. From the data it can be seen that the combination of "STOP" on the pavement and the "AT WHITE LINE" sign proved most effective in reducing rolling stops and did not stops. Meanwhile, used by itself, the "STOP" pavement marking reduced average distance from the edge of road by the greatest margin. All three improvements showed a reduction in this category, albeit fairly minimal.



Summary of Relevant Data from Phase I to Phase II

Type of Improvement	Intersection Number	Rolling Stops (Numerical Increase/Decrease)		Did Not Stops (Numerical Increase/Decrease)		Average Distance from Edge of Road (Numerical Increase/Decrease)	
		Increase	Decrease	Increase	Decrease	Increase	Decrease
"STOP" on Pavement	121		-21		0		-0.68
	131		--		--		--
	211	+11			0		-3.71
	242		-14		-18		-7.75
	311		-6		-1	+3.92	
	341	+1		+1		+2.05	
	412	+15			0		-0.97
	441	+7			-2		-1.97
	AVERAGE		-1.00		-2.86		-1.30
"AT WHITE LINE" Sign	112		-4	+1			-1.40
	142	+17			-1	+0.10	
	222		-29		-1		-1.85
	232	+15			0	+5.39	
	312		-16		-9		-7.14
	322		-8		0		-0.80
	432	+2			0		-1.52
	442		-11		0	+1.20	
	AVERAGE		-4.25		-1.25		-0.75
"STOP" on Pavement & "AT WHITE LINE" Sign	111		-7		-6		-2.25
	141	+13			0	+0.68	
	221		-15		-2	+0.40	
	231	+4			-4		-5.88
	331	+26			-26	+6.15	
	342		-19		-3		-8.23
	421		-23		-1	+4.36	
	431		-20		-8		-1.02
	AVERAGE		-5.13		-6.25		-0.72

Note:

Increase (+) : Indicates **more** rolling stops or did not stops were recorded in Phase II than in Phase I, or drivers are stopping at a location **farther** from the edge of road. For example, at Intersection 141, "+13" indicates that thirteen (13) more rolling stops were recorded after the improvements were installed.

Decrease (-) : Indicates **less** rolling stops or did not stops were recorded in Phase II than in Phase I, or drivers are stopping at a location **closer** to the edge of road. For example, at Intersection 312, "-7.14" indicates that drivers stopped over seven (7) feet closer to the edge of roadway after the improvements were installed.



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I. Purpose of the Study

The stop sign is one of the most recognizable traffic control devices in the country. The command is quite simple and easy to understand, yet there are many drivers that fail to follow the instructions. This failure to comply has the potential to create devastating results. Though most drivers encounter stop signs several times on a daily basis, their understanding of rules governing placement of signs as well as the proper procedure for safe movement through the intersection is lacking.

The Federal Highway Administration governs the use and proper placement of the R1-1 Stop Sign on the national level. The most recent version of their publication, the *Manual on Traffic Control Devices* (MUTCD), was released in 2003. In the Commonwealth of Pennsylvania, *Publication 212: Official Traffic Control Devices* (Pub. 212) adopts the National MUTCD on the state level. Pub. 212 was released in March 2006. It is important to note that, while both these documents are quite specific as to how the stop sign is to be used, none of the documents actually mandate how drivers navigate the stop-controlled intersection.

The duties of the driver are thoroughly stated in Pa. Code Title 75, which is commonly referred to as the Vehicle Code. In section 3323, part b, it states:

“Except when directed to proceed by a police officer or appropriately attired persons authorized to direct, control or regulate traffic, every driver of a vehicle approaching a stop sign shall stop at a clearly marked stop line or, if no stop line is present, before entering a crosswalk on the near side of the intersection or, if no crosswalk is present, then at the point nearest the intersecting roadway where the driver has a clear view of approaching traffic on the intersecting roadway before entering. If, after stopping at a crosswalk or clearly marked stop line, a driver does not have a clear view of approaching traffic, the driver shall after yielding the right-of-way to any pedestrian in the crosswalk slowly pull forward from the stopped position to a point where the driver has a clear view of approaching traffic. The driver shall yield the right-of-way to any vehicle in the intersection or approaching on another roadway so closely as to constitute a hazard during the time when the driver is moving across or within the intersection or junction of roadways and enter the intersection when it is safe to do so.”

According to the MUTCD, the use of a stop sign may be warranted at an intersection where one or more of the following conditions exist:

1. Intersection of a less important road with a main road where application of the normal right-of-way rule would not be expected to provide reasonable compliance with the law
2. Street entering a through highway or street
3. Unsignalized intersection in a signalized area
4. High speeds, restricted view, or crash records indicate a need for control by the STOP sign

The proper type and placement of a stop sign is also governed by the MUTCD. Generally, this document provides the requirements and guidance as to the size of the sign, height of the sign, and actual placement of the sign. For a stop sign or any traffic control device to be effective, it has to be visible to the motorist and placed in such a location as to allow enough time for the driver to follow the instructions safely. Having a stop sign with restricted sight distance is maybe as bad as not having a stop sign at all. These factors make it very important to examine the placement and visibility of the stop signs at rural intersections.

The rules that govern the placement of stop signs as well as the proper method for drivers approaching a stop-controlled intersection are listed in the documents previously discussed.

Because of the issues discussed above, PennDOT commissioned a study to be conducted to evaluate possible improvements on how drivers are to negotiate through an unsignalized intersection. The study was conducted in two (2) phases:

Phase I

The purpose of Phase I of the study was to observe drivers' actions at the intersections and to identify improper driving habits, if they existed, as well as analyze the intersections themselves in a manner similar to that of safety review.

Phase II

In Phase II, a series of low-cost improvements were then implemented at selected intersections from Phase I. These locations were then observed and analyzed in order to find the most effective means of improving driver behavior and awareness. Also, an implementation plan for a media campaign, public awareness, and public educational programs were provided.

II. Project Overview

The process of finding bad driver habits and developing low cost solutions to ensure safer driver actions at stop signs has been divided into multiple phases with several tasks performed in each phase. These tasks are listed and briefly summarized below:

Literature Search: An extensive search was performed of available literature involving stop signs. Most of the sources were found online through searches on library databases as well as general searches on the Internet. These documents were reviewed and summarized, highlighting any information pertinent to this study including findings and recommendations made in previous studies. This information was summarized in table format along with the supporting literature. There was not an abundance of pertinent information found through the literature search, though some ideas presented were helpful through the progression of this study.

Observations:

Phase I

In Phase I, a two-person team traveled to 32 intersections to observe driver actions. Most of the work was completed during November and December of 2004, but a few intersections were done in April 2005 in order to complete the first phase. The goal was 200 observations at each intersection or two 8-hour days of observations. In observing drivers at the selected intersections, a few factors had to be taken into account before any observations were made. First, in order to judge where drivers stop in relation to the edge of the road, the approach was marked in five-foot increments using a measuring wheel and marking paint. From there, a location was selected in which the observers had a good view of the drivers while at the same time not distracting the approaching motorists. As drivers pulled up to the stop approach, the two observers noted the following measurable items:

- total time spent at the intersection until completion of the movement
- where the driver stopped
- how many times the driver looked in each direction
- what type of turning movement was performed
- length of gaps in seconds on the main road
- whether the gap was accepted or rejected

Other observations were made which are more qualitative such as whether the driver was distracted, gender and age of the driver, if the driver had difficulty seeing approaching traffic, if the main road traffic was speeding, and if there was a conflict.

Phase II

In Phase II, 24 intersections were chosen from Phase I to be observed again once improvements had been implemented. This work was completed in July and August of 2006. Once again the goal was 200 observations or two 8-hour days of observations. These observations were made in a similar fashion to Phase I, however only one person was used to collect data at each intersection instead of two people. Previously, in Phase I, a second person was needed to collect time of gap and other data.

For both phases of the project, all of the observations were recorded on-site onto observation recording sheets by each of the observers. From the recording sheets, the data was entered into a spreadsheet so that queries and summaries could be conducted to help with the analysis of the field observations.

Data Collection:

Phase I

Several measurements were taken prior to observing drivers as they negotiated the stop approach. Using a 100 foot measuring tape, a distance of 14.4 feet from the edge of the road was measured out and marked on the pavement with marking paint. This point is the decision point of the departure sight triangle on the minor road as directed in PennDOT's *Publication 13M: Design Manual, Part 2, Highway Design* (Pub. 13M, July 2002), section 2.18, part F, for assessing sight distance at a stop-controlled intersection. The grades for both the left and the right approaches on the main road were the second measurement. Using these grades, as well as the design speed for the road, the minimum stopping sight distances were calculated using a sight distance table. One observer would stand at the pavement marking while the other observer walked off the designated sight distance using a measuring wheel. A traffic cone with a reference marking 3.5 feet high, representing the object height specified in PennDOT's *Publication 282: Highway Occupancy Permit Guidelines* (Pub. 282, April 2004), was placed at the proper sight distance and the observer remaining at the intersection looked from an eye height of 3.5 feet to see if sight distance was adequate.

If the sight distance was not adequate, the position of the driver's eye was moved closer to the intersection at a distance of 10 feet from the edge of the main road to verify that the proper stopping sight distance was available from that point. Similarly, the stopping sight distance was checked to verify proper sight distance was available for the stopping approach.

The next step in the process was to make a sketch of the intersection, including an approximate north arrow, any pavement markings, widths of lanes and shoulders, any signs, sight obstructions, pavement condition, and any vertical geometric features such as the grades of the left and right approach. All of these



items were included in the sketch as well as any other characteristics of the surrounding area that are pertinent to the study. To accompany the sketches, photographs were taken at each intersection to further document the conditions specific to each intersection.

Along with measuring the available sight distances and making the sketches, traffic volumes for each intersection were obtained through PennDOT's computer database. These volumes were in terms of Average Daily Traffic (ADT).

Phase II

A comparison chart is included in the "Part III: Intersections" section for each of the study intersections. This chart shows the basic observational data which is expanded upon in the "Part IV: Analysis" section. The average distance a driver stops from the edge of roadway is given in feet. The average number of times a driver looks to the left and to the right is given as an average, rounded to the nearest 0.5 looks. Then, the most common maneuver (left, through, or right) is shown with the accompanying average time which was required for drivers to find a gap and complete their turning movement. Finally, the percentage of drivers that performed a rolling stop, as well the percentage of drivers that did not stop at all is shown.

Analysis/Conclusions:

Phase I

Utilizing the data collected from the PennDOT files as well as the Phase I observation data, an analysis was performed to discover possible causation factors for drivers not stopping properly at stop signs. General trends and patterns were examined through "visual analysis diagrams," tables, and figures to explore the differences in effect that the intersection scenarios had on drivers advancing on the stop-controlled approaches.

From the information gained through the analysis, a list of eight (8) low-cost improvements was prepared. These deal mainly with altering or introducing new pavement markings, as well as a slight change in the use of signing. Diagrams of these changes can be seen in Appendix H.

Phase II

Three (3) of the low-cost improvements were implemented, Phase II data was collected, then observation data from Phase I and from Phase II was used to perform a detailed analysis in a "before and after" manner. As in Phase I, "visual analysis diagrams" were completed first, followed by a series of tables and figures which sought to explore the effectiveness of the three types of improvements which were installed at designated intersections.

From the insight gained in this analysis, a series of conclusions were then compiled. Through these conclusions, suggested further actions to take in



regards to each of the improvements can be found. Also included is updated information on the Public Awareness Campaign which considers the conclusions found in Phase II observations and analysis.

III. Intersections

Phase I

A total of 32 intersections were studied throughout Clearfield and Centre Counties. These intersections were chosen because of physical characteristics that matched one of the 16 distinct scenarios for the intersection layouts. Two locations of each scenario were observed and analyzed in order to determine the differences, if any, in the way that drivers react to the different layouts. A coding system was developed for the different scenarios as follows:

- The first digit describes the intersection by its stop sign location and pavement markings
 - 1XX: Stop Sign at Intersection
 - 2XX: Stop Sign at a Distance (from the intersection)
 - 3XX: Stop Sign with a Dashed Edge-Line (on the major road)
 - 4XX: Stop Sign with a Stop Bar
- The second digit describes the intersection by main line speed limit and the presence of sight obstructions
 - X1X: Low Speed (25-40 mph)/No Sight Obstruction
 - X2X: Low Speed (25-40 mph)/Sight Obstruction
 - X3X: High Speed (> 40 mph)/No Sight Obstruction
 - X4X: High Speed (> 40 mph)/Sight Obstruction
- The third digit differentiates between the two examples of each scenario
 - XX1: First example of a particular scenario
 - XX2: Second example of a particular scenario

Table 1 – Intersection Numbers

	Stop Sign At Intersection		Stop Sign A Distance From Intersection		With Dashed Edge-Line		With a Stop Bar	
	111	112	211	212	311	312	411	412
Low Speed (25-40 mph) No Sight Obstruction at Stop Sign	111	112	211	212	311	312	411	412
Low Speed (25-40 mph) With a Sight Obstruction at Stop Sign	121	122	221	222	321	322	421	422
High Speed (> 40 mph) No Sight Obstruction at Stop Sign	131	132	231	232	331	332	431	432
High Speed (> 40 mph) With a Sight Obstruction at Stop Sign	141	142	241	242	341	342	441	442

Table 2 – Intersection Locations

Int. No.	Intersection Name	Int. No.	Intersection Name	Int. No.	Intersection Name	Int. No.	Intersection Name
111	S.R. 1009 & S.R. 53	211	S.R. 3018 & Blue Course Dr	311	S.R. 3022 & S.R. 729	411	S.R. 1004 & Fourth St
112	S.R. 1008 & Wilson St.	212	S.R. 2011 & S.R. 2018	312	T 919 & S.R. 253	412	S.R. 3014 & Loop Rd.
121	S.R. 1008 & Wilson St.	221	S.R. 3012 & S.R. 3011	321	S.R. 550 & S.R. 3003	421	S.R. 322 & Ninth St
122	S.R. 3032 & S.R. 3030	222	S.R. 969 & S.R. 453	322	S.R. 550 & S.R. 3008	422	S.R. 26 & T-334
131	T 919 & S.R. 2001	231	S.R. 3005 & T-344	331	S.R. 4003 & S.R. 119	431	S.R. 322 & S.R. 144
132	S.R. 2014 & S.R. 2017	232	S.R. 153 & S.R. 2012	332	S.R. 150 & S.R. 1002	432	S.R. 45 & T-718
141	S.R. 45 & 2012	241	S.R. 970 & S.R. 1010	341	S.R. 144 & S.R. 504	441	S.R. 45 & T-845
142	S.R. 2014 & S.R. 2007	242	S.R. 729 & S.R. 969	342	S.R. 219 & S.R. 36	442	S.R. 45 & T-354

Phase II

A total of 24 intersections were chosen from Phase I to be studied in Phase II. These included six locations from each of the main categories (represented by the first digit in the intersection coding). They were then divided into three groups. The first group would have Modification Option 3 (“STOP” on Pavement) installed. The second group would have Modification Option 4 (“AT WHITE LINE” Sign) installed. Finally, the third group would have Modification Option 7 (“STOP” on Pavement and “AT WHITE LINE” sign) installed together. Also, it was decided that each intersection would also have a dashed edge-line painted at the edge of roadway. This dashed edge-line is the “white line” referred to in the sign posted in Modification Option 4 and Modification Option 7. These intersections were then observed and analyzed to determine differences in the ways drivers’ stopping habits changed due to the three (3) improvements. Modification Options 1, 2, 5, 6, and 8 were not implemented.

Stop Sign At Intersection

- **Low Speed, No Sight Obstruction**

111-S.R. 1009 & S.R. 0053: Clearfield County- S.R. 0053 is the major road with an Average Daily Traffic (ADT) of 6,300 vehicles and S.R. 1009 is the stopping approach with an ADT of 1,700 vehicles. From field measurements it was determined that the corner sight distance in both directions is adequate as is the stopping sight distance. The posted speed limit on all approaches is 35 miles per hour.

Due to driver behavior and proper road conditions, no specific recommendations for improvement were initially made in Phase I. However, it was later decided to modify the intersection by painting “STOP” on the pavement and installing an “AT WHITE LINE” sign directly below the current stop sign prior to Phase II observations. The following table illustrates pertinent data comparing the Phase I and Phase II observations:

Table 3 – Intersection 111

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	9.63	2L, 1.5R	R	6.48	6.0	3.0
Phase II	7.38	1.5L, 1R	R	4.28	2.5	0.0

Notes: L = left, T = through, R = right

112-S.R. 1008 & Wilson Street: Centre County – S.R. 1008 is the major road with an ADT of 3,500 vehicles and Wilson Street is the stopping approach with an ADT of 900 vehicles. The stop sign observed is for the southbound leg of Wilson Street. Corner sight distance to the left is obstructed only for drivers stopped at the stop sign and all other sight distances are proper. The posted speed limit on all approaches is 25 miles per hour.

Initially, no improvements were recommended for this intersection due to the driver behavior exhibited at the stop sign. Though there have been reported crashes, drivers that were observed stopped at a point that provided more than adequate sight distance for them to enter the intersection. Eventually, an “AT WHITE LINE” sign was chosen to be installed below the stop sign on the side street as part of the improvements prior to conducting Phase II observations. However, for the Phase II observations only a dashed edge-line existed at this location. The following table illustrates pertinent data comparing the Phase I and Phase II observations:

Table 4 – Intersection 112

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	4.18	2L, 2R	T	8.22	5.5	0.0
Phase II	2.78	2L, 1.5R	T	7.18	3.5	0.5

Notes: L = left, T = through, R = right

- **Low Speed, Sight Obstruction**

121-S.R. 1008 & Wilson Street: Centre County – S.R. 1008 is the major road with an ADT of 3,500 vehicles and Wilson Street is the stopping approach with an ADT of 900 vehicles. The stop sign observed is for the northbound leg of Wilson Street. Proper corner sight distance to the right is obstructed by a set of stairs on a hill only when drivers are stopped at the stop sign. Sight distances are more than adequate when stopped closer to the edge of the main road. This is the other approach on Wilson Street that intersects S.R. 1008 opposite intersection 112 listed above.

The initial improvement suggested for Phase I to add a stop bar 11 feet from the intersection in order to encourage drivers to stop at a location where the proper corner sight distance is available. This was not installed, but instead it was decided to paint the word “STOP” near the edge of roadway prior to Phase II observations. However for the Phase II evaluation, an “AT WHITE LINE” sign was also installed at this location. The following table illustrates pertinent data comparing the Phase I and Phase II observations:

Table 5 – Intersection 121

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	9.28	2L, 2R	T	7.45	14.5	0.0
Phase II	8.60	2L, 1.5R	T	7.46	4.0	0.0

Notes: L = left, T = through, R = right

- **High Speed, Sight Obstruction**

141-S.R. 0045 & S.R. 2012: Centre County – S.R. 0045 is the major road with an ADT of 6,000 vehicles and S.R. 2012 is the stopping approach with an ADT of 1,500 vehicles. The corner sight distance to the left is not adequate if drivers stop at the stop sign. The sight distance is obstructed by the supports of a bridge, though before arriving at the stop sign, the sight distance is sufficient. The corner sight distance to the right and the stopping sight distance are proper. Speed limits are 45 miles per hour for S.R. 0045 and 30 miles per hour for S.R. 2012.

Due to the behavior of the drivers and the lack of crashes, no specific recommendations for improvement were initially made for this intersection in Phase I. However, for Phase II of the project, both the “STOP” on pavement and the “AT WHITE LINE” sign were utilized as improvements. The following table illustrates pertinent data comparing the Phase I and Phase II observations:

Table 6 – Intersection 141

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	8.45	2.5L, 3R	L	12.24	3.5	0.0
Phase II	9.13	2L, 1.5R	L	9.72	10.0	0.0

Notes: L = left, T = through, R = right

142-S.R. 2014 & S.R. 2007: Clearfield County – S.R. 2014 is the major road and S.R. 2007 is the stopping approach with both roads having a comparable ADT of 300 vehicles. A house constructed very close to the intersection obstructs the corner sight distance to the right only if drivers stop at the stop sign. The sight distance to the left and approaching the stop sign are proper. The speed limit on all approaches is 45 miles per hour.

Due to the house on the right obstructing the view of oncoming traffic if drivers stop at the stop sign, and drivers stopping just inside of the range of good visibility, it was proposed in Phase I that a dashed edge-line be added to the intersection. The dashed edge-line provides drivers with a visual mark of the edge of the main road, allowing them to pull up closer to the intersection and allowing better corner sight distance. In addition to the dashed edge-line, for Phase II of observations, an “AT WHITE LINE” sign was also added to the stop sign on the approach. The following table illustrates pertinent data comparing the Phase I and Phase II observations:

Table 7 – Intersection 142

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	7.28	1.5L 1.5R	T	4.75	7.5	0.5
Phase II	7.38	1L, 1R	T	4.97	16.0	0.0

Notes: L = left, T = through, R = right

Stop Sign At A Distance

- **Low Speed, No Sight Obstruction**

211-S.R. 3018 & Blue Course Drive: Centre County – S.R. 3018 is the main road with an ADT of 12,000 vehicles and Blue Course Drive is the stopping approach with an ADT of 4,000 vehicles. The sight distances in both directions as well as the stopping sight distance are all proper based on the posted speeds of 45 miles per hour and 35 miles per hour, respectively.

In an effort to encourage drivers to pull even closer to the road, it was suggested in Phase I that a dashed edge-line be painted through the intersection. This was installed along with the pavement marking “STOP,” which was painted near the edge of roadway on Blue Course Drive as preparation for Phase II of the project. The following table illustrates pertinent data comparing the Phase I and Phase II observations:

Table 8 – Intersection 211

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	9.68	2L, 2R	L	11.73	7.0	0.0
Phase II	5.97	1.5L, 1R	L	9.41	12.5	0.5

Notes: L = left, T = through, R = right

- **Low Speed, Sight Obstruction**

221-S.R. 3012 & S.R. 3011: Centre County – S.R. 3011 is the major road with an ADT of 3,600 vehicles and S.R. 3012 is the stopping approach with an ADT of 2,300 vehicles. Proper corner sight distance is obstructed in both directions only if drivers stop at the stop sign, due to bushes on both sides. The stopping sight distance is proper due to a long straightaway leading to the intersection on the stopping approach. The speed limit on the major road (25 miles per hour) is lower than the speed limit on the minor approach (35 miles per hour).

Due to the driver behavior exhibited, no recommendations for improvement were initially made in Phase I. For Phase II, the “STOP” pavement marking and the “AT WHITE LINE” sign were installed. The following table illustrates pertinent data comparing the Phase I and Phase II observations:

Table 9 – Intersection 221

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	6.75	2L, 1.5R	L	8.15	8.0	1.0
Phase II	7.15	1.5L, 1R	L	8.70	0.5	0.0

Notes: L = left, T = through, R = right

222-S.R. 0969 & S.R. 0453: Clearfield County – S.R. 0453 is the major road with an ADT of 7,100 vehicles and S.R. 0969 is the stopping approach with an ADT of 1,600 vehicles. The corner sight distance is obstructed in both directions by a building on the left and a phone booth and signs on the right, only if drivers stop at the stop sign. The stopping sight distance is adequate for the 35 mile per hour speed of the minor approach. The major road has a speed limit of 25 miles per hour.

A dashed edge-line was initially installed at the location in Phase I. Also, an “AT WHITE LINE” sign was installed on the stop sign post for Phase II observations. The following table illustrates pertinent data comparing the Phase I and Phase II observations:

Table 10 – Intersection 222

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	9.08	2L, 2R	L	8.60	16.0	1.0
Phase II	7.23	2L, 1.5R	L	6.97	1.5	0.5

Notes: L = left, T = through, R = right

- **High Speed, No Sight Obstruction**

231-S.R. 3005 & T-344: Centre County – S.R. 3005 is the major road with an ADT of 5,100 vehicles and T-344 is the stopping approach with an ADT of 600 vehicles. Corner sight distances as well as the stopping sight distance are proper. Speed limits posted for S.R. 3005 and T-344 are 45 and 35 miles per hour respectively.

Due to the lack of a crash history and the driving habits exhibited during observation, no recommendations for improvement were initially suggested for this intersection in Phase I. Eventually, it was decided to paint “STOP” on the pavement and mount an “AT WHITE LINE” sign below the current stop sign for Phase II observations. The following table illustrates pertinent data comparing the Phase I and Phase II observations:

Table 11 – Intersection 231

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	10.43	1.5L, 1R	R	6.13	7.5	3.5
Phase II	4.55	1.5L, 1R	R	4.98	9.5	1.5

Notes: L = left, T = through, R = right

232-S.R. 0153 & S.R. 2012: Clearfield County – S.R. 0153 is the major road with an ADT of 3,100 vehicles and S.R. 2012 is the stopping road

with an ADT of 550 vehicles. The corner sight distances and the stopping sight distance are proper. The speed limit on S.R. 0153 is 55 miles per hour and on S.R. 2012 it is 35 miles per hour.

Due to driver behavior, lack of crashes, and adequate corner sight distance in both directions, there was no need for improvements to this intersection in Phase I. However, an “AT WHITE LINE” sign was added for Phase II observations. The following table illustrates pertinent data comparing the Phase I and Phase II observations:

Table 12 – Intersection 232

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	18.83	2L, 2R	R	8.26	2.5	0.5
Phase II	24.22	1.5L, 1R	L	9.09	12.4	0.6

Notes: L = left, T = through, R = right

- **High Speed, Sight Obstruction**

242-S.R. 0729 & S.R. 0969: Clearfield County – S.R. 0969 is the major roadway with an ADT of 1,000 vehicles and S.R. 0729 is the stopping approach with an ADT of 1,800 vehicles. The corner sight distance in both directions is obstructed on the left by poles and some bushes, and on the right by a shed only if drivers stop at the stop sign. The stopping sight distance is proper. The speed limit on S.R. 0969 is 55 miles per hour and on S.R. 0729 it is 35 miles per hour. There is a stop bar located sixty (60) feet back from the edge of roadway.

After analyzing the intersection as well as the behavior of the drivers, it was recommended in Phase I that the stop sign should be moved closer to the intersection and a dashed edge-line be carried through the intersection. This would prompt drivers to stop closer to the intersection. The dashed edge-line was painted, however the stop sign remained at the same location. In addition, the word “STOP” was painted near the edge of roadway as part of Phase II. The following table illustrates pertinent data comparing the Phase I and Phase II observations:

Table 13 – Intersection 242

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	16.28	1.5L, 1R	R	5.60	16.5	9.0
Phase II	8.53	1L, 1.5R	L	6.63	9.5	0.0

Notes: L = left, T = through, R = right

Stop Sign With Dashed Edge-Line

- **Low Speed, No Sight Obstruction**

311-S.R. 3022 & S.R. 0729: Clearfield County – S.R. 0729 is the major road with an ADT of 900 vehicles and S.R. 3022 is the stopping road with an ADT of 350 vehicles. The corner sight distances and the stopping sight distance are proper. The speed limit on all of the approaches is 35 miles per hour.

Due to the driver behavior exhibited, the absence of any crashes, and the adequate intersection geometry, it was initially deemed that no improvements were necessary in Phase I. Eventually, for Phase II observations, the pavement marking “STOP” was added to the S.R. 3022 approach being studied. The following table illustrates pertinent data comparing the Phase I and Phase II observations:

Table 14 – Intersection 311

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	8.53	1L, 1R	L	6.21	5.0	0.5
Phase II	12.45	1.5L, 1R	R	5.17	2.0	0.0

Notes: L = left, T = through, R = right

312-S.R. 0253 & T-919: Clearfield County – S.R. 0253 is the major road with an ADT of 1,600 vehicles and T-919 is the stopping approach with an ADT of 250 vehicles. All of the sight distances are proper. The speed limit on S.R. 0253 is 35 miles per hour and 25 miles per hour on T-919.

Due to the lack of crashes and the geometry of the intersection, no recommendations for improvement were made in Phase I. However, an “AT WHITE LINE” sign was added to the stop sign for Phase II observations. The following table illustrates pertinent data comparing the Phase I and Phase II observations:

Table 15 – Intersection 312

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	15.50	1.5L 1.5R	L	5.75	12.5	5.5
Phase II	8.36	1.5L, 1R	L	6.03	4.5	1.0

Notes: L = left, T = through, R = right

- **Low Speed, Sight Obstruction**

322-S.R. 0550 & S.R. 3008: Centre County – S.R. 0550 is the major roadway with an ADT of 3,500 vehicles and S.R. 3008 is the stopping road with an ADT of 2,700 vehicles. Drivers stopped only at the stop sign do not have the required corner sight distance to the left due to trees. The corner sight distance to the right and the stopping sight distance are both proper. The speed limits on S.R. 0550 and S.R. 3008 are 40 miles per hour and 35 miles per hour, respectively.

From the driver behavior observed, and the geometry of the intersection, no recommendations for improvement were made in Phase I. An “AT WHITE LINE” sign was mounted below the stop sign on the side street approach for the purpose of Phase II. The following table illustrates pertinent data comparing the Phase I and Phase II observations:

Table 16 – Intersection 322

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	10.15	1.5L, 1R	R	6.08	16.5	0.0
Phase II	9.35	1L, 0.5R	R	4.04	12.5	0.0

Notes: L = left, T = through, R = right

- **High Speed, No Sight Obstruction**

331-S.R. 4003 & S.R. 0119: Clearfield County – S.R. 0119 is the major road with an ADT of 6,800 vehicles and S.R. 4003 is the stopping approach with an ADT of 900 vehicles. The corner sight distances and the stopping sight distance are proper. The speed limit on S.R. 0119 to the left is 45 miles per hour and to the right is 35 miles per hour. The speed limit on S.R. 4003 is 35 miles per hour.

In Phase I, it was suggested that a stop bar be placed at the stop sign as a pavement marking emphasizing the stop sign. This was not done, but instead both the pavement marking “STOP” and the “AT WHITE LINE” sign were added to the approach for Phase II observations. The following table illustrates pertinent data comparing the Phase I and Phase II observations:

Table 17 – Intersection 331

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	11.70	1L, 0R	R	6.92	11.5	17.0
Phase II	17.85	1L, 0R	R	6.57	24.5	4.0

Notes: L = left, T = through, R = right

- **High Speed, Sight Obstruction**

341-S.R. 0144 & S.R. 0504: Centre County – S.R. 0504 is the major road with an ADT of 13,000 vehicles and S.R. 0144 is the stopping approach with an ADT of 3,900 vehicles. The corner sight distances are not proper only if drivers stop at the stop sign, due to a gas station sign on the left and a series of utility poles on the right. The stopping sight distance is proper. The speed limit on S.R. 0504 is 35 miles per hour and on S.R. 0144 is 45 miles per hour.

It was suggested in Phase I that a stop bar could be placed close to the intersection at a location enabling better corner sight distance. Instead, the word “STOP” was painted at the intersection as an improvement prior to Phase II observations. The following table illustrates pertinent data comparing the Phase I and Phase II observations:

Table 18 – Intersection 341

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	10.70	3L, 2.5R	L	14.13	10.0	2.0
Phase II	12.75	2L, 1.5R	L	13.11	10.5	2.5

Notes: L = left, T = through, R = right

342-S.R. 0219 & S.R. 0036: Clearfield County – S.R. 0219 is the major road with an ADT of 2,300 vehicles and S.R. 0036 is the stopping approach with an ADT of 2,000 vehicles. The stop sign is 75 feet from the intersection. The proper corner sight distance in both directions is unavailable if a driver pulls out from the stop sign. The stopping sight distance is proper.

Phase I recommendations at this intersection included an 8-inch dashed edge-line and a stop bar placed close to the road. The dashed edge-line was painted, but the stop bar was not. Instead, the pavement marking “STOP” and an “AT WHITE LINE” sign were added to S.R. 0036 prior to Phase II observations. The following table illustrates pertinent data comparing the Phase I and Phase II observations:

Table 19 – Intersection 342

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	24.88	1.5L, 2R	L	8.15	13.0	2.0
Phase II	16.65	1.5L, 1R	L	6.41	3.5	0.5

Notes: L = left, T = through, R = right

Stop Sign With A Stop Bar

- **Low Speed, No Sight Obstruction**

412-S.R. 3014 & Loop Road: Centre County – S.R. 3014 is the major road with an ADT of 5,500 vehicles and Loop Road is the stopping approach with an ADT of 300 vehicles. The stopping and corner sight distances in both directions are proper. The speed limit is 40 miles per hour on S.R. 3014 and 25 miles per hour on Loop Road. Also, there was a stop bar located 17 feet from the edge of roadway.

In view of the driver behavior that was observed, the good sight distances, and the absence of crashes, no recommendations for improvement were made in Phase I. For Phase II, it was decided to add the word “STOP” to the pavement near the intersection with S.R. 3014. The following table illustrates pertinent data comparing the Phase I and Phase II observations:

Table 20 – Intersection 412

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	10.70	2L, 2R	L	9.44	11.0	0.0
Phase II	9.73	1.5L, 2R	L	9.45	20.9	0.0

Notes: L = left, T = through, R = right

- **Low Speed, Sight Obstruction**

421-S.R. 0322 & Ninth Street: Centre County – S.R. 0322 is the major road with an ADT of 12,000 vehicles and Ninth Street is the stopping approach with an ADT of 6,800 vehicles. Rows of trees exist on both sides of the intersection making the proper corner sight distance deficient when drivers are positioned at the stop sign. The speed limit on S.R. 0322 is 35 miles per hour and 25 miles per hour on Ninth Street.

From observations of driver behavior and intersection marking and geometry, it was recommended in Phase I that the stop bar be repainted in hopes of lowering the number of rolling stops. When the intersection was observed during Phase II, the stop bar had not been repainted but “STOP” was painted on the pavement and an “AT WHITE LINE” sign was installed below the stop sign, as specified prior to Phase II observations. The following table illustrates pertinent data comparing the Phase I and Phase II observations:

Table 21 – Intersection 421

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	6.80	2.5L, 2R	R	6.91	17.0	0.5
Phase II	11.16	1.5L 0.5R	R	5.67	5.5	0.0

Notes: L = left, T = through, R = right

- **High Speed, No Sight Obstruction**

431-S.R. 0322 & S.R. 0144: Centre County – S.R. 0322 is the major road with an ADT of 11,000 vehicles and S.R. 0144 is the stopping approach with an ADT of 5,200 vehicles. The corner sight distances on both sides as well as the stopping sight distance are proper. The speed limit is 45 miles per hour on S.R. 0322 and 35 miles per hour on S.R. 0144.

Two improvements were suggested in Phase I at this intersection due to the number of rolling stops and crash history. They included repainting the stop bar and placing an 8-inch dashed edge-line. The stop bar was not repainted but “STOP” was painted on the pavement as well as adding an “AT WHITE LINE” sign to the stop sign installation. This was done

prior to Phase II observations. The following table illustrates pertinent data comparing the Phase I and Phase II observations:

Table 22 – Intersection 431

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	9.83	2.5L 2.5R	L	10.32	17.5	4.5
Phase II	8.81	2L, 1.5R	L	9.45	7.5	0.5

Notes: L = left, T = through, R = right

432-S.R. 0045 & T-718: Centre County – S.R. 0045 is the major road with an ADT of 10,000 vehicles and T-718 is the stopping approach with an ADT of 900 vehicles. The corner sight distances in both directions as well as the stopping sight distance are all proper. The speed limit on S.R. 0045 is 45 miles per hour and 25 miles per hour on T-718. Initially there was a dashed edge-line as well as a stop bar painted twenty (20) feet behind it. These were both removed during a paving project and were not replaced at the time of Phase II observations.

Due to observed driver behavior, minimal crash history, and good visibility, no recommendations were made in Phase I. However, as part of Phase II, an “AT WHITE LINE” sign was added below the stop sign on the minor approach. The following table illustrates pertinent data comparing the Phase I and Phase II observations:

Table 23 – Intersection 432

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	12.25	1.5L, 1R	R	8.27	14.0	0.0
Phase II	10.73	1.5L 0.5R	R	9.01	15.0	0.0

Notes: L = left, T = through, R = right

- **High Speed, Sight Obstruction**

441-S.R. 0045 & T-845: Centre County – S.R. 0045 is the major road with an ADT of 5,000 vehicles and T-845 is the stopping approach with an ADT of 2,000 vehicles. For drivers stopped at the stop sign, corner sight distances in both directions are obstructed due to a combination of intersection geometry and bushes on both sides of the road. The speed limit on S.R. 0045 is 45 miles per hour. The stopping sight distance is more than adequate for the posted speed of 25 miles per hour on T-845. A stop bar is located 22 feet from the edge of roadway.

After examining the driver behavior and the intersection geometry, two suggestions for Phase I were considered. The first was to remove the stop bar or move it closer to the edge of S.R. 0045, and the second was to add a dashed edge-line along the edge of S.R. 0045. Also, trimming or removing the bushes was discussed as a quick way to provide additional corner sight distance. The stop bar remained in the same location, but the dashed edge-line was painted. In addition, the word “STOP” was painted on the pavement between the stop bar and the edge line prior to the start of Phase II observations. The following table illustrates pertinent data comparing the Phase I and Phase II observations:

Table 24 – Intersection 441

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	10.80	1.5L, 1R	R	6.81	14.0	1.0
Phase II	8.83	1L, 1R	R	4.33	17.5	0.0

Notes: L = left, T = through, R = right

442-S.R. 0045 & T-354: Centre County – S.R. 0045 is the major road with an ADT of 5,400 vehicles and T-354 is the stopping approach with an ADT of 300 vehicles. The corner sight distance to the left is not adequate only for drivers stopped at the stop sign due to trees and bushes located on the side of S.R. 0045. The corner sight distance to the right and the stopping sight distance are both sufficient for the speeds of 45 miles per hour on S.R. 0045 and 25 miles per hour on T-354. A stop bar is located 18 feet from the edge of roadway.

In order to encourage drivers to stop closer to the edge of the major road for better visibility and increased ease of entering traffic, it was suggested in Phase I that the stop bar be removed and a dashed edge-line be placed along S.R. 0045. In addition, trimming or removing the trees and bushes causing sight obstructions was suggested to help improve sight distances. The stop bar was not removed but the dashed edge-line was placed along the main road. At the time of Phase II observations, the trees along the main road still appeared to be overgrown. Also, for the minor approach of this intersection, an “AT WHITE LINE” sign was added below the current stop sign for Phase II observations. The following table illustrates pertinent data comparing the Phase I and Phase II observations:

Table 25 – Intersection 442

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	9.48	1.5L, 1R	R	7.61	6.5	0.0
Phase II	10.68	1.5L 0.5R	R	5.86	1.0	0.0

Notes: L = left, T = through, R = right

IV. Overall Analysis

Phase I

In order to fully analyze the data collected and the observations noted, it is necessary to search for trends in the data in broader groups. Each individual intersection was already examined in terms of trends occurring in driver behavior and intersection geometry. These items were examined and some conclusions could be drawn about each intersection, though in a very focused scale. Broadening the extent of the analysis was necessary in order to discern any universal trends that existed in each of the four family groupings (At Intersection, At a Distance, With a Dashed Edge-Line, With a Stop Bar). The ultimate goal was to discover if the intersections in each grouping presented any data that stood out in both expected and unexpected ways.

The first step taken in the overall analysis was the creation of visual analysis diagrams. These diagrams were made as a result of the preliminary study, in which one of the main focuses emerging was the point at which drivers stopped. There were four sheets made in total, one for each group. A T-shaped, scaled diagram was created for each intersection with markings on the left side to signify the location of the physical characteristics of the intersection (i.e. edge of shoulder, stop sign, stop bar). On the right side, the drivers' stopping points were placed based on the statistical average, mean, and 85th percentile. This allowed for an instant image of where drivers stopped in relation to the physical characteristics and, in the case of intersections with sight obstructions present, if the drivers were stopping past the point where the required corner sight distance became available. Also, these analysis diagrams made it possible to overlap sheets to examine differences between different groups, which was made easier due to the same scale being used on all of the diagrams. These diagrams are included in Appendix C.

Once the diagrams were created and examined, an investigation was made of the effects of particular intersection types on approaching drivers. The accepted gap times were excluded from this analysis as no trends were evident, as well as the large number of gaps of 20 seconds or more. The results of the comparisons follow:

1. Average Stopping Point by Family Grouping

The first item that was examined involved which of the four overall groupings caused drivers to stop the closest to the intersection. From Table 26 below, it is clear that when the stop sign is placed close to the intersection, the drivers are more inclined to stop in a closer proximity to the intersection than in the other scenarios.

Table 26 – Family Groupings

	At Intersection	At a Distance	Dashed Edge-line	Stop Bar
Average Stopping Point (ft)	7.85	10.66	11.02	9.99

2. Average Stopping Point by Sight Obstruction

These groups were then subdivided into intersections where sight obstructions were present and intersections without sight obstructions. From this comparison, it was clear that the scenario that encouraged drivers to stop the closest to the intersection was at those intersections where the stop sign is close to the intersection and sight obstructions were present. This showed that drivers were inclined to pull up to a point where the sight obstruction was no longer problematic in viewing oncoming traffic before stopping. Below is Table 27 showing the average stopping points for all of these subdivisions:

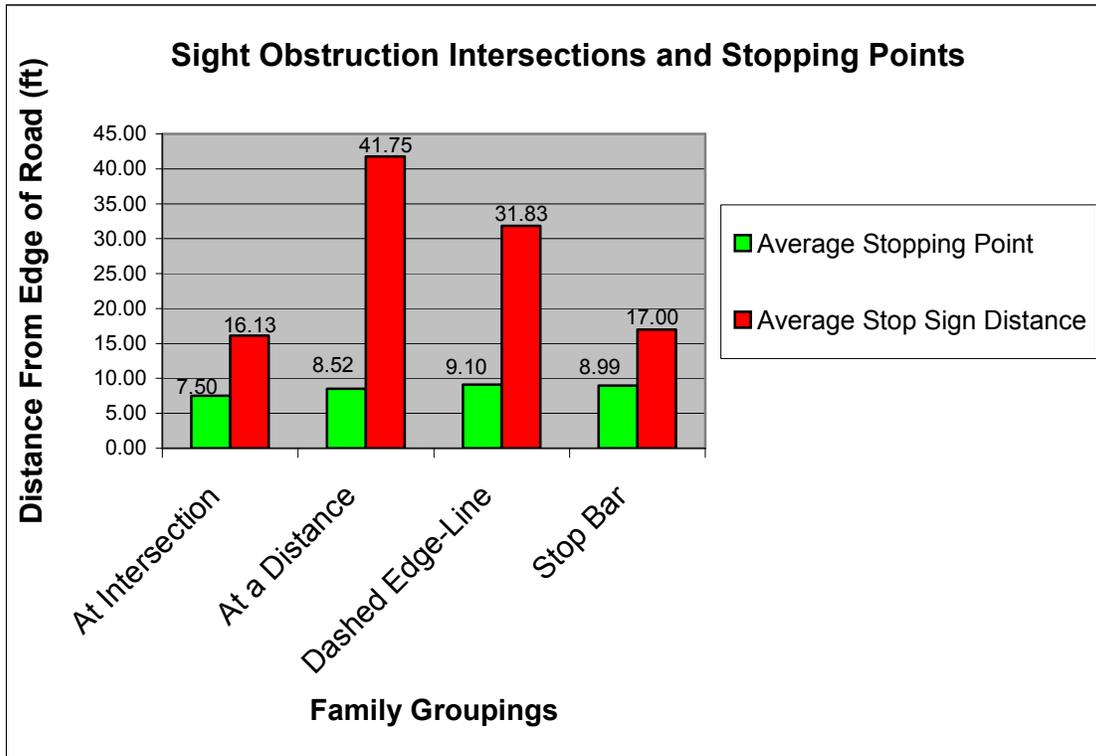
Table 27 – Sight Obstructions

	At Intersection		At a Distance	
Average Stopping Point (ft)	No Obstruction	Sight Obstruction	No Obstruction	Sight Obstruction
	8.08	7.5	12.81	8.52
	Dashed Edge Line		Stop Bar	
Average Stopping Point (ft)	No Obstruction	Sight Obstruction	No Obstruction	Sight Obstruction
	12.17	9.10	11.00	8.99

3. Comparison of Average Stopping Point and Stop Sign Location

After seeing that the presence of sight obstructions had such an effect on drivers' stopping closer to the intersection, graphs were created comparing the stopping points and stop sign locations across each of the four parent groups as well as the average first available sight distances. The graphs confirmed the perceived trend that drivers are more affected by the sight obstructions than the placement of the stop sign. Figure 1 shows the stop sign placement and the stopping points. Notice the large difference between the two:

Figure 1



4. Comparison of Average Stopping Point and First Available Sight Distance

Figure 2 demonstrates that the point of first available proper corner sight distance has more of an effect on how close to the intersection drivers stop. Figure 3 at the bottom of the page combines the previous two graphs and further exhibits the greater effect sight distance has on drivers than the location of the stop sign.

Figure 2

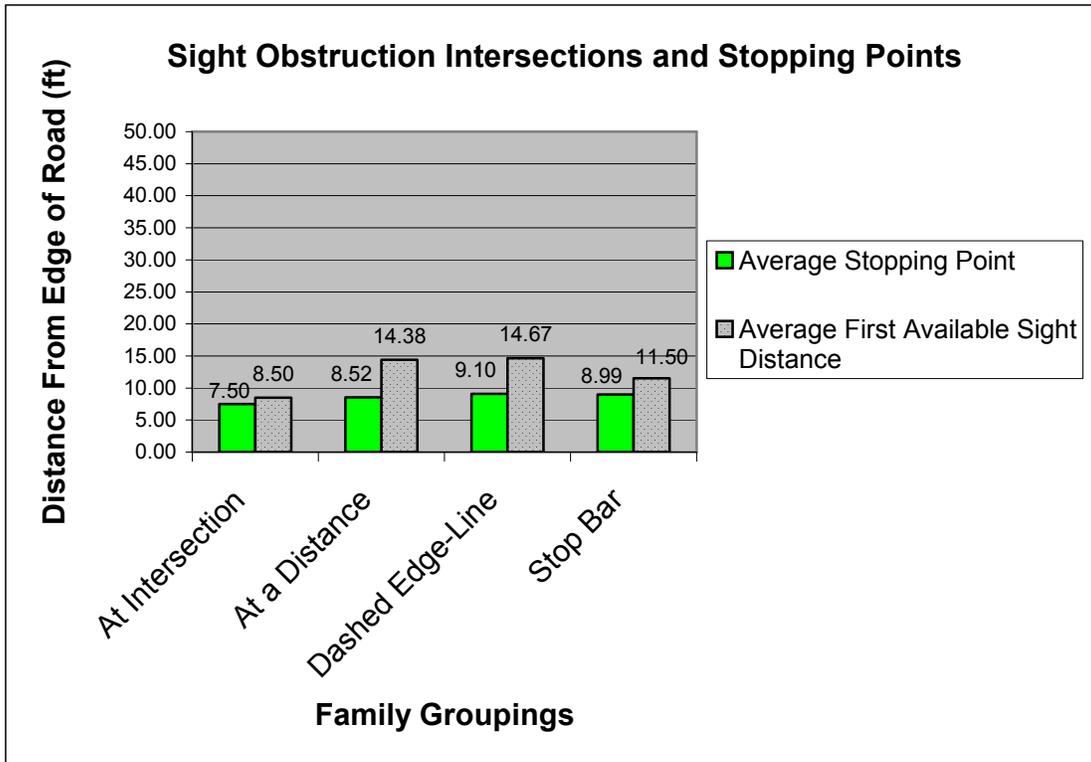
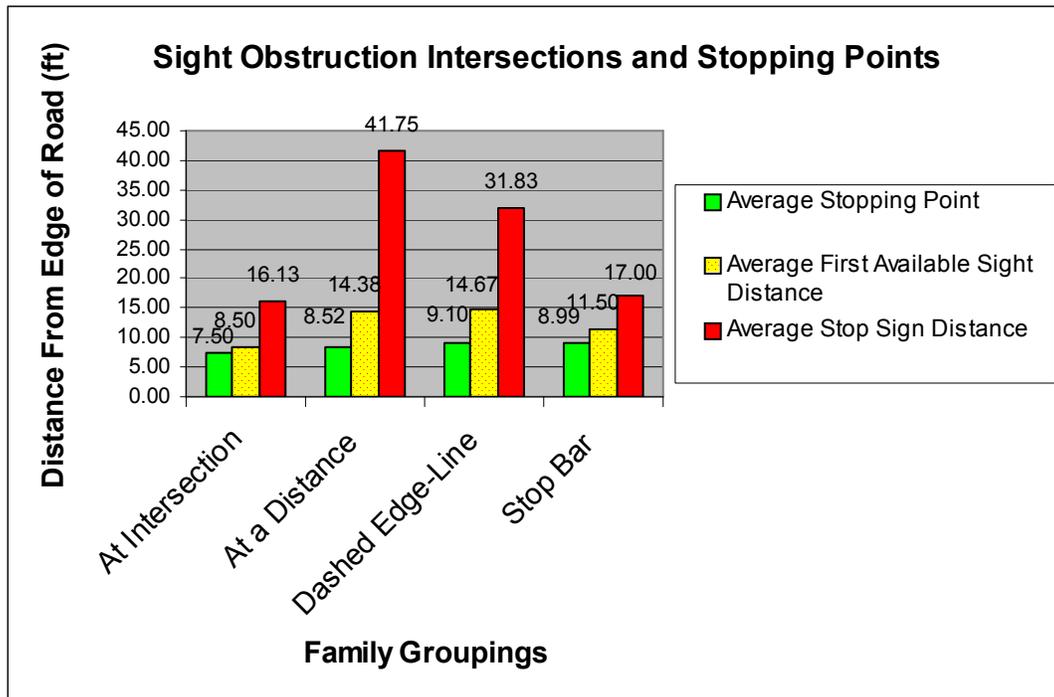


Figure 3



5. Effect of Dashed Edge-Line and Stop Sign Placement

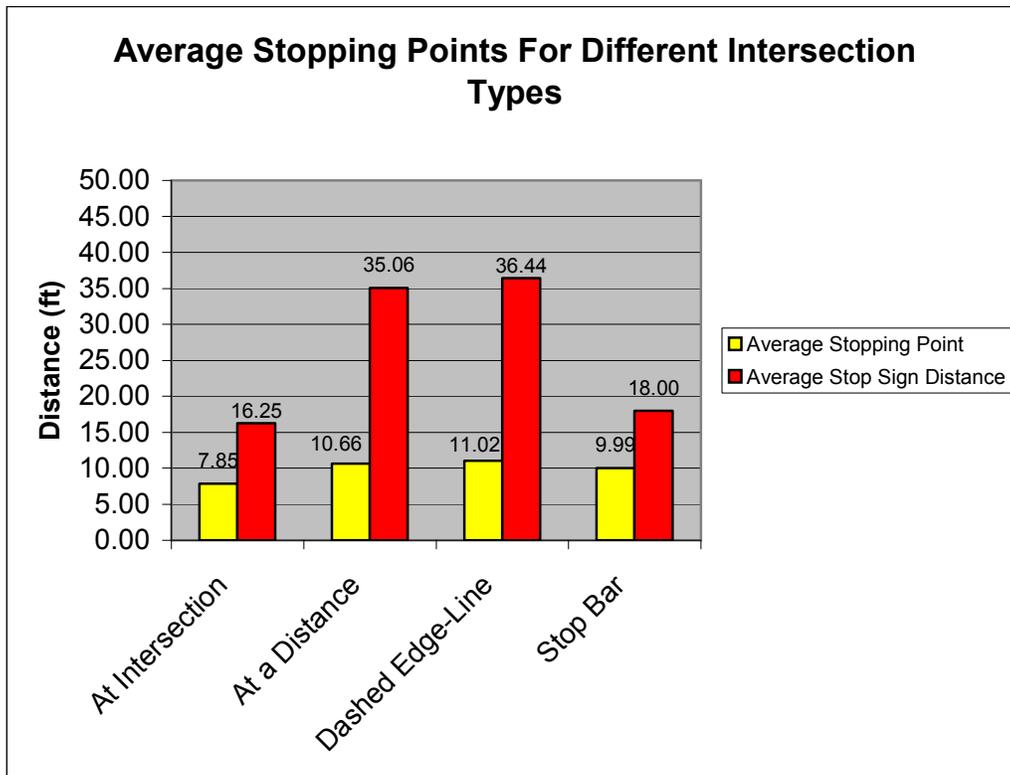
One initial assumption tested was if the dashed edge-line had the effect of drawing drivers closer to the edge of the main road, increasing visibility, and making traversing the intersection safer. Upon examining the average stopping points again, it was discovered that drivers stopped farthest away from the intersection in these cases, which was contrary to the assumption. After looking into stop sign placement, it was revealed that at these intersections with a dashed edge-line, the stop sign was placed farthest away from the edge of the main road, leading to the finding that placement of the stop sign does affect where drivers stop. This can be demonstrated below in Table 28. For example as the location of the stop sign is located further away from the intersection, the average stopping point also increases away from the edge of pavement.

Table 28 – Dashed Edge-Line and Stop Sign Placement

	At Intersection	At a Distance	Dashed Edge-line	Stop Bar
Average Stop Sign Distance (ft)	16.25	35.06	36.44	18.00
	At Intersection	At a Distance	Dashed Edge-line	Stop Bar
Average Stopping Point (ft)	7.85	10.66	11.02	9.99

To more easily see the trends this data was graphed and shown in Figure 4:

Figure 4



6. Proportional Comparison of Stopping Point to Stop Sign Distance

It was established in Figure 4 that the location of a stop sign does have an effect on how close to the intersection the drivers stop, though it was determined that the effect is lessened the farther the stop sign is from the intersection. To test this, a simple proportion was used by dividing the stopping point distance by the stop sign distance, multiplied by 100. Therefore if the average place the drivers stopped was at the stop sign, the proportion would be 100; conversely, if the drivers stopped at the edge of the main road, the proportion would produce a result of zero.

Table 29 – Proportional Comparison of Stopping Point to Stop Sign Distance

Proportion of stopping point to stop sign distance*	At Intersection	At a Distance	Dashed Edge-line	Stop Bar
	48.31	30.40	30.24	55.50

*-Based on proportion: (stopping point distance/stop sign distance) x 100

As can be seen from Table 29 above, at the two types of intersections that have the stop signs the farthest distance from the edge of the main road (At a Distance, Dashed Edge-line) the drivers stop less than a third of the distance

from the edge of the road to the stop sign, demonstrating the stop sign has less of an effect on the drivers' stopping points. Likewise, at the two types that place the stop sign close to the intersection (At Intersection, Stop Bar), drivers were stopping around halfway between the stop sign and the edge of the road.

7. Comparison of Low Speed and High Speed Intersections

The final test involving the stopping points that resulted in a conclusive comparison was between how far from the intersection drivers were found stopping at high speed and low speed main roads. As was expected, the drivers at the low speed intersections for each scenario stopped at a point closer to the edge of the main road than at the high speed intersections. Table 30 below illustrates the findings:

Table 30 – Comparison of Low Speed and High Speed Intersections

	At Intersection	At a Distance	Dashed Edge-line	Stop Bar
Low Speed Ave	7.32'	8.59'	10.43'	9.14'
High Speed Ave	8.38'	14.12'	14.26'	10.84'

8. Time Required to Complete Turning Movements

The other aspect of the drivers' actions that was explored and resulted in conclusive findings dealt with the amount of time required for drivers to complete turning movements. This was examined to see if the intersection layout or pavement markings had an effect on how quickly or slowly the motorists negotiated the intersections. Again, the four major groupings were examined and compared as seen in Table 31.

Table 31 – Time Required to Complete Turning Movements

	At Intersection	At a Distance	Dashed Edge-line	Stop Bar
Average Time (sec)	6.96	7.92	7.45	8.12

The results were quite similar to the results for the stopping points, as the fastest time to complete a turning movement occurred at intersections where the stop sign is close to the edge of the main road. The scenario that made drivers take the most time was when a stop bar is at the intersection, presumably due to the line on the road having the effect of slowing down the drivers more as they approach the intersection.

Lastly, there was a discernable difference in the amount of time required to navigate the intersection with and without sight obstructions present in each of the main intersection groupings.

Table 32 – Time to Complete Turning Movements Related to Sight Obstructions

Average Time (sec)	At Intersection		At a Distance	
	No Obstruction	Sight Obstruction	No Obstruction	Sight Obstruction
	6.79	7.13	7.80	8.04

Average Time (sec)	Dashed Edge Line		Stop Bar	
	No Obstruction	Sight Obstruction	No Obstruction	Sight Obstruction
	6.77	8.13	7.97	8.28

Examining Table 32 above, it is evident that drivers tend to take more time while at an intersection in which there is some difficulty seeing the oncoming traffic due to the presence of a sight obstruction. This appears to be a demonstration of somewhat cautious driver behavior, as drivers require slightly more time to acquire the proper corner sight distance before proceeding into traffic on the major road.

9. Other Analysis

The findings discussed in this section were a result of several analyses conducted using the data collected and observations made at the intersections for Phase I. There were also several comparisons checked and data analyzed in groupings that produced no pattern and no conclusions could be drawn from the data. These tests included:

- Examining the driver age and average time at each type of intersection
- The rate of rolling stops and incidents of drivers failing to stop, as related to:
 - Category of intersection (at intersection, at a distance, dashed edge-line, or stop bar)
 - High speed/low speed
 - Sight obstructions/no sight obstructions

Likewise, some of the categories of data did not produce enough significant results to allow for analysis. Overall, these examinations as well as others proved inconclusive and offered no insight into the effects on drivers' behavior.

Phase II

The analysis of the first phase focused around finding trends in how people stop at different types of intersections and providing the Department with various types of enhancements that may improve the stopping characteristics of the driver. With these trends in mind, several improvements were installed at the intersections prior to conducting Phase II observations. In Phase II, the analysis dealt with finding out how effective the various improvements were on driver

behavior. This included conducting two rounds of observations at a few of the same intersections. The second round of observations was conducted to determine if the drivers have the same response to the improvements over time.

Once again, the first step for Phase II was to compile the visual analysis diagrams. This time, the T-shaped diagrams were arranged so that the Phase I and Phase II figures were next to each other. This way a person could review and more easily determine where stopping habits improved and where they did not between Phase I and Phase II. Once again, on the left side of the diagrams the physical characteristics (i.e., edge of shoulder, stop sign, and stop bar) were marked, and on the right side the drivers' stopping points were marked. These points included the statistical average, mean, and 85th percentile. The drawings are to scale so these characteristics can easily be compared visually. The diagrams are included in Appendix C.

Once the diagrams were updated with the data from Phase II, an analysis was conducted to determine which of the three improvements that were put in place at the various intersections was most effective. The results of the comparisons follow:

1. Overall Data by Family Grouping

In addition to the stopping distance from the intersection, Phase II observations also focused on the amount of rolling stops and did not stops. First, the 23 intersections were examined altogether to determine, in general, which of the three improvements worked the best. Table 42 shows this data by the type of improvement. From this table it can be seen that the combination of the "At White Line" sign and the "STOP" on pavement provided the greatest reduction in rolling stops and did not stops. Meanwhile, the pavement marking of "STOP" brought about the largest decrease in stopping distance. Table 43 shows the percentage of decrease in each category.

Table 33 – Overall Data by Family Groupings between Phase I and Phase II

Phase II Improvement	Phase	ROLLING STOP (Observations)	DID NOT STOP (Observations)	Distance from Edge of Road (Feet)
"STOP" on Pavement	I	156	25	10.85
	II	149	6	9.55
"AT WHITE LINE" Sign	I	162	15	10.84
	II	128	5	10.09
"STOP" on Pavement & "AT WHITE LINE" Sign	I	168	63	11.06
	II	127	13	10.34

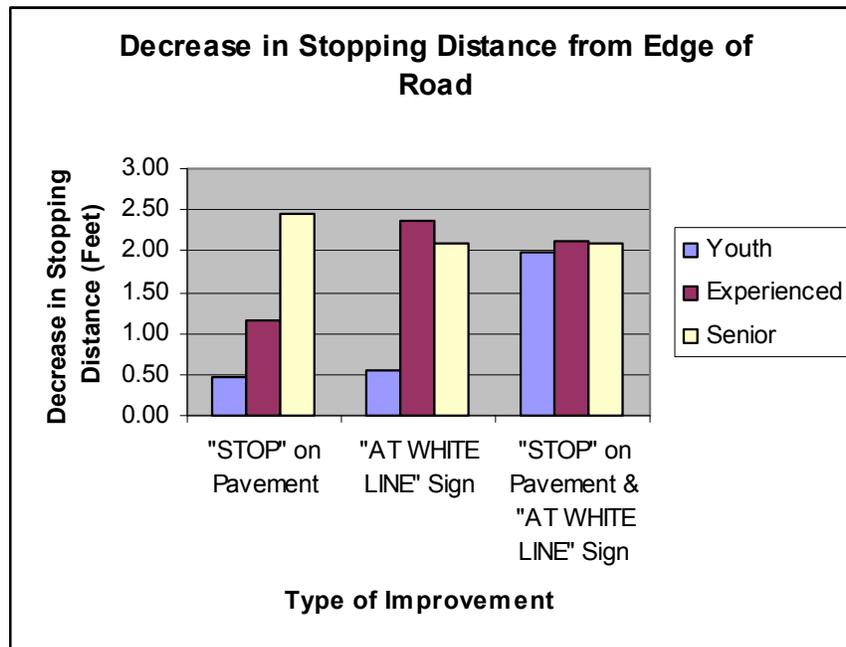
Table 34 – Overall by Percentages by Family Grouping between Phase I and Phase II

Phase II Improvement	ROLLING STOP (Observations)	DID NOT STOP (Observations)	Distance from Edge of Road (Feet)
"STOP" on Pavement	-4.5%	-76.0%	-12.0%
"AT WHITE LINE" Sign	-21.0%	-66.7%	-6.9%
"STOP" on Pavement & "AT WHITE LINE" Sign	-24.4%	-79.4%	-6.5%

2. Comparison of Data by Age

The next step was to determine if these general trends carried through to more specific subdivisions. One of these cases was to determine if a driver's age had any effect on which improvement worked the best. In the observations, age was broken down into the categories of Youth (under 25), Experienced (25-60), and Senior. When the data was compiled, no definitive trends could be found. However it could be seen that, for youth drivers, the combination of both improvements provided a much larger positive change than the use of either of the improvements individually. For experienced and senior drivers, the improvement in driving habits stayed more consistently positive throughout the three different installations. A visual representation of the data can be seen below in Figure 5.

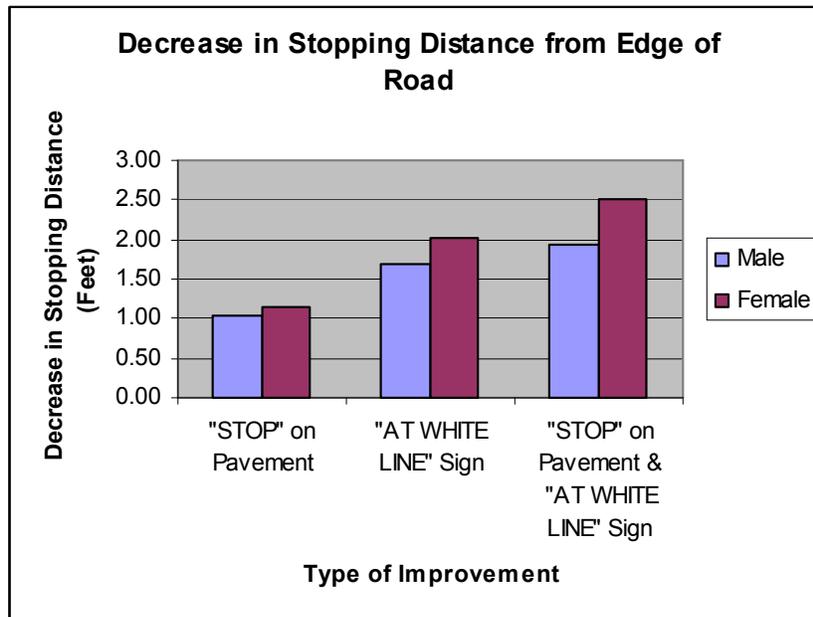
Figure 5



3. Comparison of Data by Gender

Gender was also analyzed but no important differences could be discerned from this data. Male and Female stopping distances were very similar to one another. When the "AT WHITE LINE" sign and the "STOP" on pavement were both used, male drivers had the greatest reduction in rolling stops while females showed the greatest increase in rolling stops. When these improvements were used separately, there was little difference between the stopping habits of the genders.

Figure 6



4. Comparison of Data by Speed Limit on Main Road

Another aspect analyzed was whether or not the speed limit of the main road had any effect on stopping behavior on the side road. Overall, drivers entering high speed roads improved their stopping distance more than drivers entering low speed roads. At low speeds the "AT WHITE LINE" sign worked best to pull drivers closer to the intersection, while at high speeds it was the least effective. Meanwhile the "STOP" pavement marking was most effective at high speeds, but the least effective at low speeds. The results of this comparison can be seen below in Table 35.

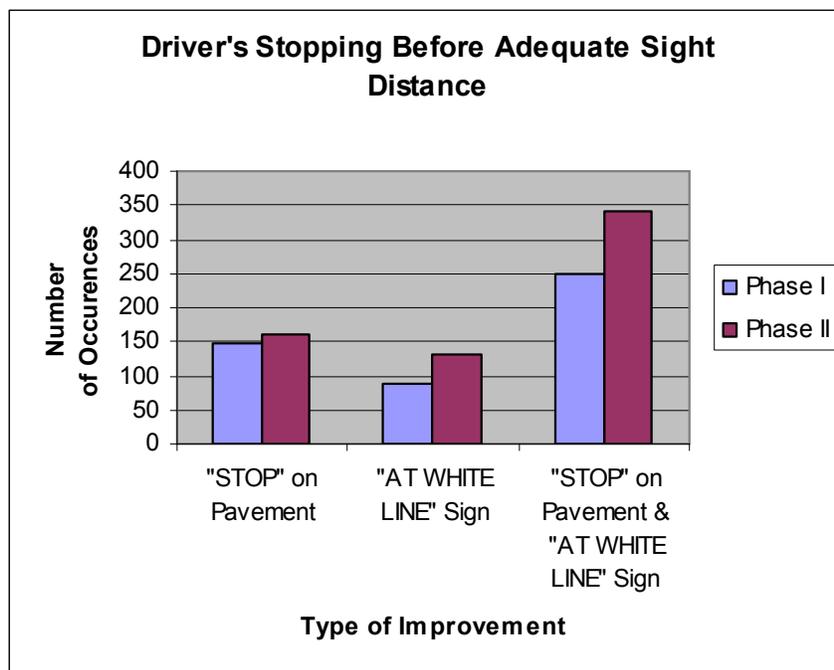
Table 35 – Comparison of Speed on Main Road

Type of Improvement	Main Road Speed	Distance from Edge of Road (Before)	Distance from Edge of Road (After)	Distance from Edge of Road (Feet)
"STOP" on Pavement	Low	9.87	9.58	-0.29
	High	10.88	8.81	-2.07
"AT WHITE LINE" Sign	Low	9.23	12.50	3.28
	High	9.42	7.52	-1.90
"STOP" on Pavement & "AT WHITE LINE" Sign	Low	9.32	7.71	-1.62
	High	7.63	10.15	2.52
Overall	Low	9.47	9.93	0.45
	High	9.31	8.83	-0.48

5. Driver's Stopping Before Adequate Sight Distance

A concern at the beginning of the study was to determine how many drivers were stopping before they reached adequate sight distance. These were assumed to be people who were unaware that they could pull up to the edge of roadway and as a result stopped farther back at a stop sign or stop bar. A goal of the project was that the improvements that were installed would help to bring these people closer to the intersection, thereby improving their sight distance. Surprisingly, at intersections with sight obstructions, stopping distances actually increased for all types of improvement and intersection categories. Sight obstructions were defined as any objects which hindered a driver's view so that they had less than the required sight distance when stopped at the intersection. Only a slight increase in stopping distance was evident at intersections with "STOP" on the pavement, while the other two improvements caused increases in stopping distance of between 36-50%. The data can be seen below in Figure 7.

Figure 7



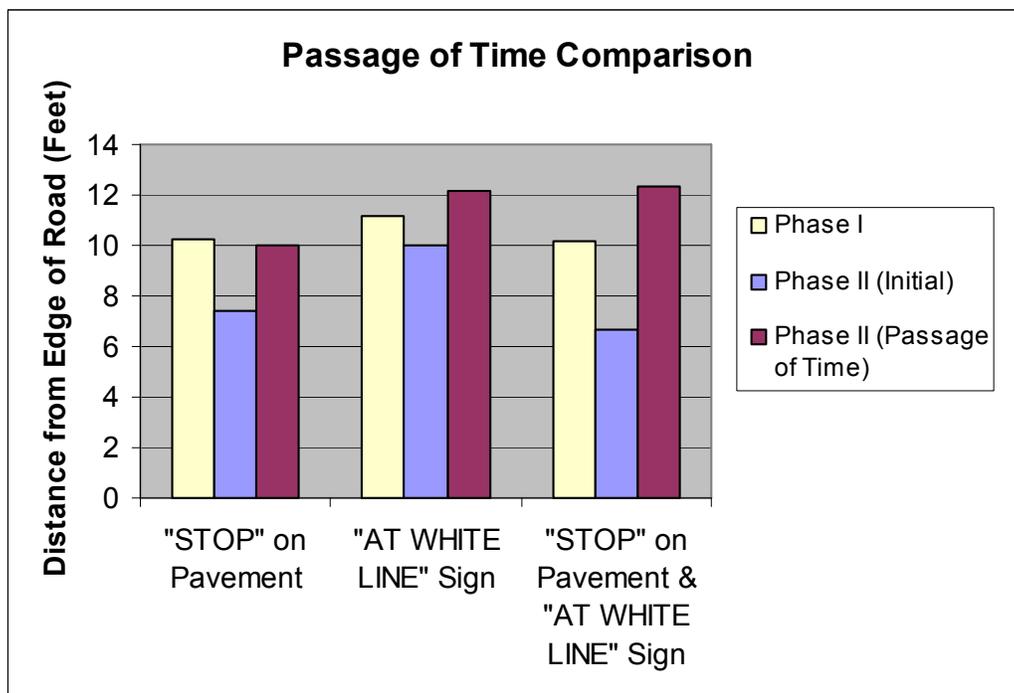
6. Effect of Passage of Time on Effectiveness of Improvements

The Department requested that the study evaluate if the effectiveness of the improvement would change over time, i.e., would drivers revert to their old habits after the improvements had been installed for some period of time. With this in mind, a second round of Phase II observations was taken at six intersections during October 2006, approximately three (3) months after the first round of observations and approximately five (5) months after they were originally installed.

These intersections represented two examples of each of the types of improvements.

In this round of observations, the data reflected that, in general, drivers had returned to their old habits in many cases. The three different improvements all yielded a larger stopping distance than they had in the first part of Phase II. The largest increase in stopping distance was where intersections with both the "STOP" on Pavement and the "AT WHITE LINE" Sign improvements were installed. At intersections with the "STOP" pavement marking, stopping distances returned to an average very close to that of Phase I. At intersections with the other two improvements, average stopping distances actually increased even beyond the distances recorded in Phase I. The stopping distances can more easily be examined below in Figure 8. Meanwhile, the amount of rolling stops and did not stops was more erratic from intersection to intersection.

Figure 8



V. Summary of Findings

Phase I

Based on the observations and analysis performed on all 32 intersections, the following is a summary of the findings:

1. The physical location of a stop sign is the single most important factor in determining where a driver will stop on a side road in relationship to the main road. That is:
 - The closer the stop sign is to the intersection the more likelihood of the driver pulling up close to the edge of the main road to assess his or her ability to safely enter the intersection.
 - As the distance from the edge of the main road to the stop sign increases, so does the driver's tendency to stop further back from the main road even if he or she could safely move closer to the main road before stopping.
2. The presence of either a stop bar or the painted extension of the main road edge-line through the intersection does not significantly increase the probability that a driver will pull up to either the edge of the main road or to the stop bar.
3. A sight obstruction at a stop sign will cause a driver to move closer to the edge of the main road to improve his or her sight distance.

Phase II

Based on the observations and analysis performed on the 23 selected intersections, the following is a summary of our findings:

1. There was an overall reduction in rolling stops, did not stops, and average stopping distance as a result of installing improvements.
 - Rolling stops decreased at 13 intersections, while they increased at 10 intersections.
 - Did not stops decreased at 13 intersections, while they increased at four intersections. At six intersections, there were no drivers who did not stop.
 - Average stopping distance decreased at 14 intersections, while increasing at nine intersections.

- The combination of the word “STOP” on the pavement and the “AT WHITE LINE” sign decreased rolling stops and did not stops by the greatest margin.
 - The pavement marking “STOP” placed at the edge of the road led to the largest improvement in stopping distance.
2. Overall, drivers entering high speed roads improved their stopping distance (i.e., stopped closer to the edge line) more than drivers entering low speed roads.
 - At low speeds, the “AT WHITE LINE” sign was most effective, while the “STOP” pavement marking was least effective
 - At high speeds, the “STOP” on pavement was the most effective, while the “AT WHITE LINE” sign was least effective
 3. No definitive trends were found when stopping habits were compared within the categories of age and gender.
 4. The number of drivers stopping before they reached adequate sight distance increased for all three improvements, especially in both cases where the “AT WHITE LINE” sign was used. This implied that drivers were still stopping around the location of the stop sign instead of pulling up to the edge of the road to improve their sight distance.
 5. Based on the second set of observations in Phase II, it was determined that over time the improvements became less effective, as drivers reverted to their old habits and stopped further back from the edge of road. In the two scenarios where the “AT WHITE LINE” sign was utilized, drivers actually stopped farther back in the second part of Phase II observations than they had in the original Phase I observations. This was of course over a limited time frame.

VI. Conclusions

Phase I

1. As the distance from the edge of the main road to the stop sign increases, drivers appear to enter a “gray” area, which is defined as that distance from the stop sign to the edge of road, and unless there is a sight obstruction at the stop sign the driver is unsure of where he or she should stop.
2. Drivers are unaware of their responsibilities regarding where they can and should stop when approaching a stop sign, especially if there is no main road edge line or stop bar to guide them.
3. Motorists need to be better informed of their duties at a stop sign. Assuming that there are no pedestrian(s), crosswalks or a stop bar present at the intersection, motorists need to be encouraged to pull as close to the edge of the main road as possible to assess their ability to enter the intersection.

Phase II

1. The “STOP” on pavement and “AT WHITE LINE” sign improvements encouraged drivers to pull somewhat closer to the edge of the main road. The most noticeable change, however, was the dramatic reduction in the number of drivers who executed rolling stops and those who did not stop at all when negotiating the stop-controlled approach of the intersection.
2. Based on the small sample taken, it seemed that over time the improvements may become less effective. This was seen from the second round of observations taken in Phase II, which were recorded 2-3 months after the first round of Phase II observations. Stopping distances increased at all six intersections that were monitored. At intersections with an “AT WHITE LINE” sign stopping distances actually increased beyond the average stopping distance observed in Phase I.
3. The use of the “STOP” pavement marking could become more effective if used more consistently. In most locations it was painted directly before the dashed edge-line and/or edge of the main road. However, at other intersections it was painted at a distance from the intersection, such as directly after a stop bar. Finally, at other locations it was painted somewhere in the “gray” area between the stop sign and the edge of roadway. The optimal location for this pavement marking should be at the edge of roadway, if no stop bar is present, in order to best pull the driver

- closer towards the intersection. However, each intersection is unique and should be evaluated as to how the improvements should be best made.
4. The “AT WHITE LINE” sign could potentially cause confusion when used in conjunction with a stop bar. Leaving the driver to wonder whether the white line referred to is the stop bar, the dashed edge-line, or both lines.
 5. The Phase II observations showed that motorists still need to be better informed of their duties at a stop sign. In addition, they also need to be informed about the new improvements if they are indeed used on a larger scale. In some cases, the “STOP” pavement marking and the “AT WHITE LINE” sign caused confusion for drivers unfamiliar with them.
 6. The goal of the project was to get drivers to pull up closer to the edge of the roadway but, on average, stopping distances improved by less than 11 inches.
 7. With the improvement in stopping distance combined with the sizeable improvement in rolling stops and did not stops, one or more of the options could begin to be installed at more intersections.
 - One of the improvements could be implemented. If stopping distance is taken as the top priority, the “STOP” pavement marking would be the most effective scenario to utilize. If, however, the comparatively large improvements in reduction of rolling stops and did not stops are taken as more important, then the combination of “STOP” on the pavement and the “AT WHITE LINE” would be the most effective method of improvement.
 - Another option which could be taken would be to examine each intersection on a case-by-case basis. The characteristics of each intersection would be looked at and compared to similar study intersections to determine which improvement would be the most effective for each case. For example, at high speed intersections (main line speed limit greater than 40 miles per hour) the “STOP” pavement marking would be most effective in pulling drivers closer to the edge of the road. Meanwhile at low speed intersections the “AT WHITE LINE” would be the best choice.

Based on the findings from Phase I, a two part program was developed to better inform motorists of their duties and responsibilities when approaching a stop sign at an intersection that has no pedestrian traffic, no crosswalks and no stop bars. The first part of the program was executed in Phase II of this project by developing and evaluating a series of traffic control devices as far as their

potential to encourage drivers to advance safely to the edge line of the main road before coming to a stop. The second part of the program would be a Media and Public Information Program to inform motorists of how to properly stop at a stop sign controlled intersection.

The Media and Public Information Program

1. Observations

The on-site surveys conducted throughout this project revealed significant differences in the stop-sign behavior of motorists. While some of the physical features that were added to the study intersections proved to be moderately effective in causing drivers to move closer before actually entering the intersection, their effectiveness appears to have diminished significantly within a very short period. Although the stopping behavior that was observed varied considerably in relation to the actual location of the stop sign, virtually all drivers exhibited that most valuable trait: common sense. However, it appears to be evident that drivers are ambivalent about exactly where they are supposed to stop when a stop sign lies between their vehicle and the intersecting roadway. More troubling is the fact that the guidance for stopping at stop signs is weak, confusing and frequently contradictory. Several quotes from current Department of Transportation publications clearly illustrate this confusion:

- Pennsylvania Driver's Manual (Pub 95 (4-05))

When you see a crosswalk or a stop line, stop before the front of your car reaches the painted line. If you cannot see traffic, yield to any pedestrians, then carefully pull forward past the line until you can see clearly. Stop, check for traffic and pedestrian then go ahead when the intersection is clear.

This text does not address stopping at a stop sign at all. It does not address the need to move beyond the stop sign to a position where the driver has an unobstructed view of oncoming traffic.

- Commercial Driver's Manual (PUB 223 (*-05))

Two quotes from "Section 12: On Road Driving Test" follow which both relate to stop sign behavior:

Turns: "If you must stop before making a turn, come to a complete stop behind the stop line, crosswalk or stop sign."

Intersections: “As you approach an intersection, if necessary, come to a complete stop (no coasting) behind any stop signs, signals, sidewalks or stop lines maintaining a safe gap behind any vehicle in front of you.”

This text directs the driver to stop BEHIND the stop sign and makes no provision for the fact that the driver might actually have to move forward in order to obtain a position from which he can view oncoming traffic clearly.

- School Bus Driver’s Manual (PUB. 117 (6-05))

Unit F: Driving Fundamentals

Entering the Flow of Traffic: “Stop just before the point of entry.”

In a preceding paragraph, Drivers are given this advice: “In other cases, the merging points or intersections will be controlled only by stop or yield signs and your good judgment.”

While the advice does not specifically address the presence of a stop sign, it is clear and unambiguous: stop just before the point of entry.

- Special Point Examination Driver’s Handbook (PUB. 248 (1-04))

Part Z: Avoiding Accidents Through Safe Driving Decisions:

The possibility of conflict with other vehicles is a fact of driving. This is true in the city, the suburbs, and even on country roads. The chances of an accident go up as the amount of traffic increases. The chances of an accident also go up at intersections...

This publication uses diagrams to present the driver with a situation and various driver actions that result in an accident. The driver is asked to assume the role of one of the drivers and to choose actions that would have avoided the incident. This same technique could be used to show drivers where to stop at a stop-sign controlled intersection, including visual obstructions, etc. to teach the driver to move beyond the stop sign to the point of entry.

- Stop for Your Safety (tri-fold brochure)

“Come to a full stop and pay close attention to oncoming traffic.”

This is the only reference to a “stop” even though the word “stop” is prominently featured on the front cover along with a red stop sign. There

are no instructions about where to stop and how to move forward to the point of entry safely.

- Teaching your teen to survive the Fatal Five (8 panel brochure)

Under left turn strategies: “If you are turning left from a driveway, a parking lot or a stop sign, pull up close enough that you have a good view of cross traffic.”

Although this deals with making a left turn, it does direct the teen-age driver to move “up close enough”. This technique could be developed more thoroughly with appropriate sketches.

2. Interview Results

As part of this project, a number of organizations and individuals were contacted to ascertain the stop sign guidance they provide or, in the case of the Pennsylvania State Police, enforce. Those contacts are shown in Appendix I. There was universal agreement that the regulations were unclear and that the behavior of drivers mirrored that confusion. Every person interviewed admitted that proper stop sign behavior was seldom, if ever, clearly identified. The American Automobile Association (AAA) provides training for novice and mature drivers, as well as other defensive driving courses. The Lead Instructor for Driver Training at their national headquarters in Florida indicated that AAA was very aware of this ambivalence and is in the process of revising their materials to better address this and other problems. They do not anticipate that any revisions or new publications will appear before 2009 at the earliest.

At the National Safety Council’s Headquarters in Illinois, the librarian and the Director of Program Development for the NSC’s Defensive Driving course agreed that there is confusion about appropriate behavior related to stop signs, not just in Pennsylvania but across the country.

A trooper at the Pennsylvania State Police barracks in Findlay Township originally said that a driver had to stop at the stop sign but later admitted that a stop sign is just to show that a stop-controlled intersection is ahead. Drivers have two legal options:

- Stop at the sign and then pull up to the intersection where they can see clearly, stop again and proceed into the intersection when it is safe to do so.
- Observe the stop sign, be alert, move carefully to the intersection where they will come to a full stop, and then proceed into the intersection when conditions permit.

While both options are “legal” according to the Pennsylvania Motor Vehicle Code, enforcement depends on an officer’s interpretation of them, and, if it goes farther, to the Magistrate’s understanding of the regulations.

At the Pennsylvania State Police Academy in Hershey, PA, there was additional agreement that, while the bottom line is the Motor Vehicle Code, messages are confusing and enforcement is uneven. While common sense should prevail, one can’t be sure that all drivers have or use it. During the discussion, two scenarios were presented based on the following conditions:

- A driver is approaching a stop sign located 20 feet before an intersection that has a white stop line at the edge of the intersection.
- Driver #1 stops directly opposite the stop sign and then proceeds cautiously forward into the intersection
- Driver #2 observes stop sign but does not stop there, proceeding forward cautiously until he reaches the white stop line where he comes to a full stop before entering the intersection.

The Colonel was asked which driver would be ticketed and responded by saying that the second driver would not be given a citation. Driver #1 would be cited because he violated regulations about entering an intersection which require vehicles to stop at a stop line. In neither case was the behavior at the stop sign relevant to the behavior at the stop line painted on the pavement, which ultimately dictates driver behavior.

The President of a large local Driver Training School indicated that they use a variety of training materials in their program which includes 30 hours of theory and 6 hours of on-road instruction. There are several books available to augment the knowledge of their instructors who are certified by the Pennsylvania Department of Education. However, the teachers are very cognizant of the expectations of area License Examiners relative to behavior at stop signs. Consequently, they teach what the License Examiner is going to expect. Unfortunately that lesson varies since there are several different instructors and different examiners.

The Examiners, in turn, expressed a wish for a consistent message relative to stop sign behavior. While they take guidance from the Driver’s Manual, individual examiners might each interpret the regulations slightly differently. The strongest message is the requirement to stop at a white line before entering an intersection. The supervisor believes that Driver Education teachers tell novice drivers to stop twice – once at the stop sign and again before the point of entry. Supervisors audit examiners every 3 months, frequently riding along when a student driver is being tested. The student is asked for permission for the supervisor to ride along and is made aware that while he or she is being tested

by the examiner, the supervisor is also auditing the examiner himself. According to the Supervisor, different examiners evaluate stopping behaviors differently with “old school” examiners most likely to insist on a stop at the stop sign (The Supervisor himself actually failed his Commercial Truck Driver’s exam when he didn’t stop at the sign but moved up to the intersection before stopping. He was immediately told that he had failed because he didn’t stop at the stop sign).

As part of this investigation into behavior at stop signs, we became aware of the American Driver and Traffic Safety Education Association (ADTSEA), a “professional association which represents traffic safety educators throughout the United States and abroad. ADTSEA has over 1000 professional and corporate members and is located at the Indiana University of Pennsylvania Highway Safety Center in Indiana, PA.” ADTSEA produces curriculum materials in both written and DVD formats which are used by Driver Training schools as well as public and private high school and college courses. One of the new discs in Driver Education Curriculum 2.0 is entitled “Signs, Signals and Markings; Understanding the Language of the Road,” produced by AAA Foundation for Traffic Safety. Included in the content of Unit 4-7 is this message:

Stopping at Intersections – When approaching an intersection with a stop sign, stop line or crosswalk, it may be necessary to stop where visibility is totally or partially blocked. The driver must then pull ahead slightly, after stopping at the legal position behind the stop line or crosswalk, and stop again where visibility is improved.

Once again, there is no mention of stopping behind, at or in front of the stop sign.

In Where to Stop at Intersections, Unit 4-26 of the same document, this guidance is provided:

If there are no identifying pavement markings and the sign or traffic control device says stop, then the stop must be made with the front bumper ...behind an imaginary line called a curb line which stretches from curb to curb closest to the driver. If there are no curbs present, then it must be imagined where they would be and the stop completed at that imaginary line.”

It is hard enough to get drivers to stop at real markings, asking them to stop at “imaginary” lines may put an even greater burden on our drivers.

3. Conclusions

- A. There is widespread agreement that guidance for appropriate behavior at stop sign-controlled intersections is unclear, ambiguous and frequently contradictory.

- B. Interpretations of the appropriate behavior for stopping at stop sign-controlled intersections differ significantly among publications, educators, trainers, examiners and police officers.
- C. Despite this ambiguity, drivers almost invariably exhibit common sense and do not enter an intersection foolishly.

It is clear that we have two tasks before us:

- To develop legal, enforceable and clear guidelines for stop sign behavior and to ensure consistency of these guidelines within all PennDOT publications and among all personnel charged with teaching, evaluating, auditing and enforcing them.
- To develop a methodology to educate drivers about the appropriate behavior when they come upon a stop sign that is some distance from an intersection. (It should be noted that our study focused only on relatively low occupancy roadways and our findings may not necessarily be replicated at more heavily traveled intersections in urban and suburban areas.)

In discussions with the various agencies and individuals, it was discussed how best to educate (or re-educate) drivers about stop sign behavior. While attention has been focused on stop signs, it is recognized that this issue is not critical in and of itself. Common sense prevails, despite “guidance” that only confuses the issue. Therefore a public relations “campaign”, complete with television ads, public meetings, press conferences, would seem to be “over kill” and inappropriate. In addition, these measures have been shown to have only a limited effect on people’s behavior, especially if there is no “enforcement”.

Given this information and observing behavior at relatively rural intersections, it would appear that publications used to prepare new and experienced drivers must clarify the guidance for stopping at stop signs and stop sign-controlled intersections. It is equally important that we emphasize the need to differentiate between normal stop sign behavior and behavior when the stop sign is, of necessity, situated some distance before an intersection. The new guidance for behavior at stop signs must not undermine the traditional “stop at the stop sign” message. Because confusing advice could lead to possible accidents and some liability for PennDOT, it is essential that the wording and any accompanying graphics are unambiguous and specific to intersection locations.

The first task to clarify the regulations rightly belongs to PennDOT and its legal staff although we would be pleased to help develop and test new language to ensure that it is “user friendly” and clearly understood.

The second task involves dealing with the drivers themselves and is more challenging. Basically we see two segments of the driving community.

The first segment consists of novice or mature drivers who are taking instruction from a reputable training facility. For them, we recommend that once the “rules” for stop sign behavior have been clarified, the new regulations should be made available to all Driver Training schools, private instructors, and organizations such as the AAA and NSC. This new information should also be provided to magistrates at their periodic training sessions and to State, County, and Local law enforcement personnel. License examiners should also receive training related to the new regulations. This should ensure that new drivers and those older drivers seeking a “refresher” course learn the rules as part of their education.

The second segment is the cohort of experienced drivers, those between 21 and 65 who “know how to drive.” Reaching them presents more of a challenge, especially since their driving habits are fully ingrained. To reach those drivers we recommend several techniques that could be adopted simultaneously:

- Public Service Announcements (PSAs) on television and radio. Most stations will air these announcements, without charge, if they are provided in a usable format. Unfortunately, most PSAs are aired after midnight when few if any people see or hear them.
- Prepare an article for publication in AAA and AARP newsletters.
- Develop a 4x7” flyer that could be inserted into the envelopes with the applications for renewal of automobile registrations. It would be glossy, colorful, and easily understood. We propose that it include a diagram, showing the unique situation where drivers might pass a stop sign prior to stopping at an intersection.
- Develop a paper placemat with a Driver’s quiz that would include several diagrams showing tricky traffic situations and 4 or 5 possible responses. Stop sign behavior could be one of several “tests” including the new regulations for snow removal and use of headlights. Answers would appear at the bottom of the placemat. These could be mass-produced and distributed to restaurants along the turnpike as well as at a variety of fast food establishments. People enjoy “reading” placemats while they wait for their meals and this would not only be educational but fun.

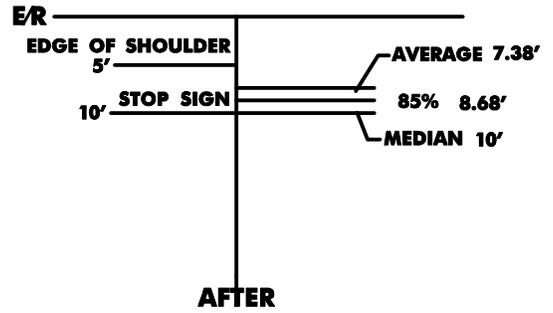
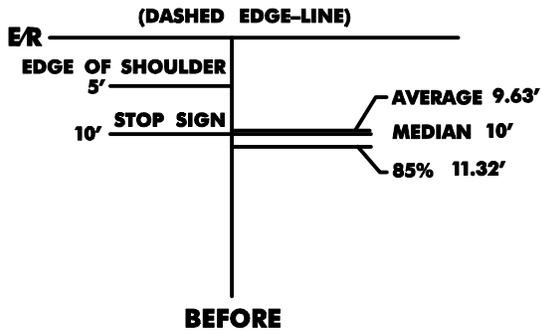
Appendix A
Before & After Summary Sheets

Appendix B
Comparison Summary Sheets

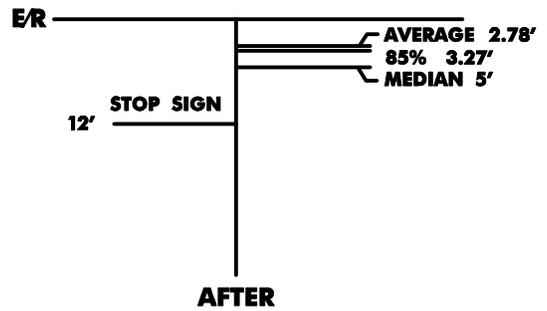
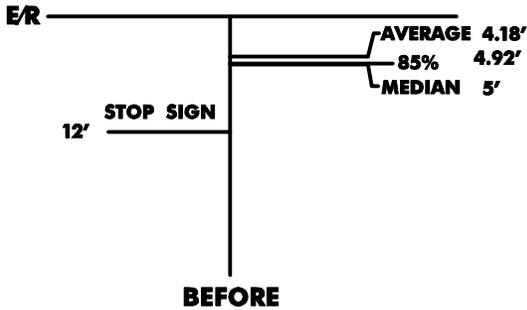
Appendix C
Visual Analysis Diagrams

STOP SIGN AT INTERSECTION

LOW SPEED, NO SIGHT OBSTRUCTION

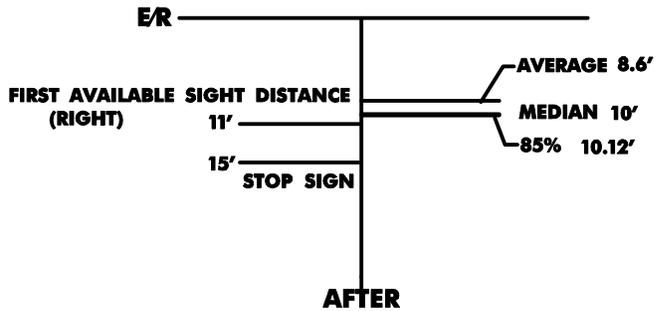
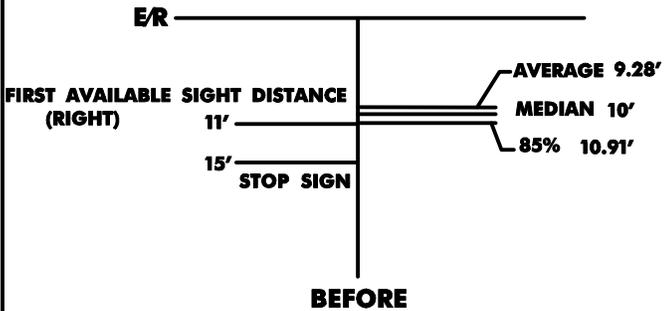


111 - SR 1009 & SR 0053

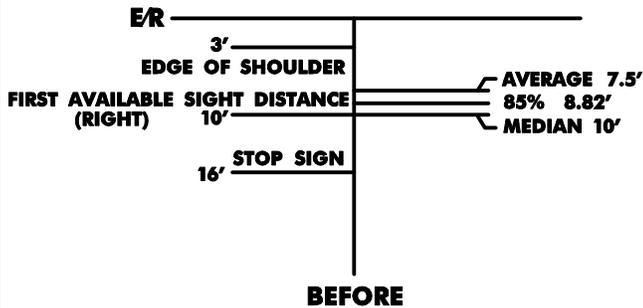


112 - SR 1008 & WILSON ST

LOW SPEED, SIGHT OBSTRUCTION



121 - SR 1008 & WILSON ST



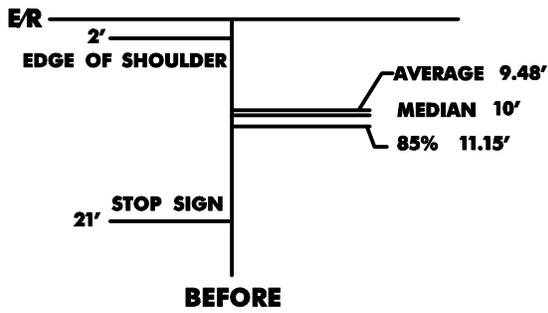
NO MODIFICATIONS MADE

AFTER

122 - SR 3032 & SR 3030

STOP SIGN AT INTERSECTION

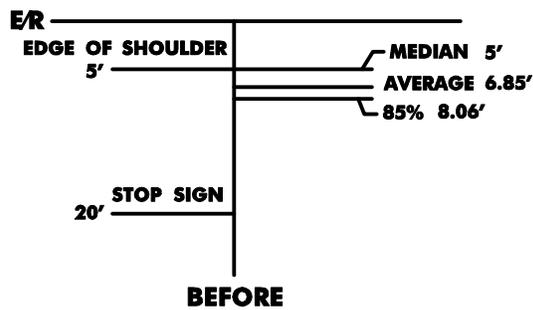
HIGH SPEED, NO SIGHT OBSTRUCTION



**UNDER
CONSTRUCTION**

AFTER

131 - SR 1009 & SR 0053

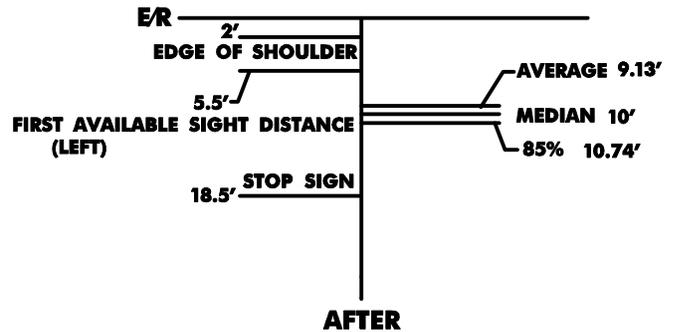
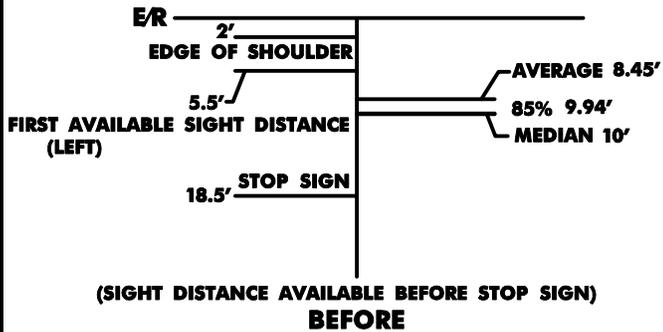


**NO MODIFICATIONS
MADE**

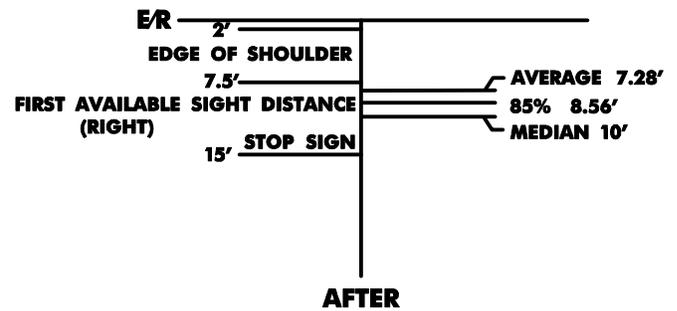
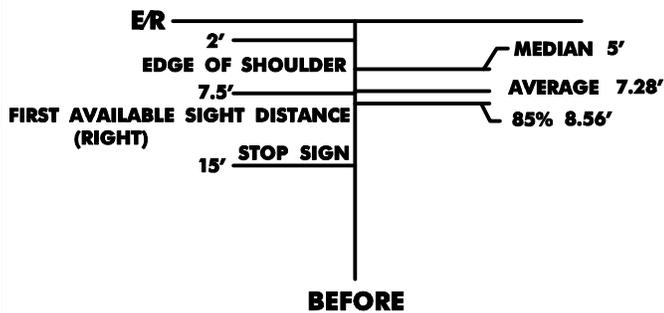
AFTER

132 - SR 2014 & SR 2017

HIGH SPEED, SIGHT OBSTRUCTION



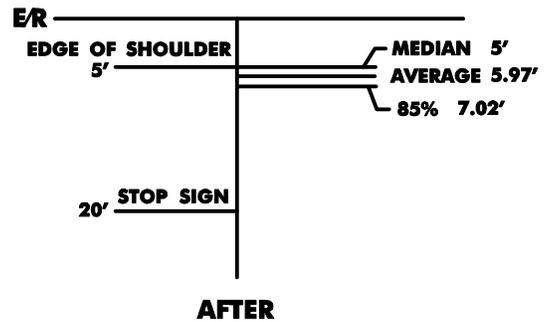
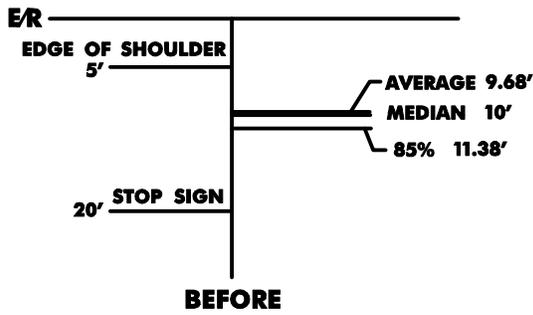
141 - SR 0045 & SR 2012N



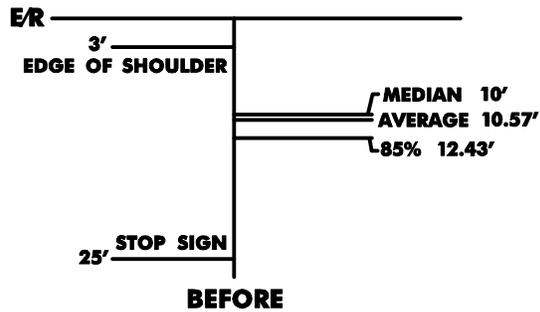
142 - SR 2014 & SR 2007

STOP SIGN AT A DISTANCE

LOW SPEED, NO SIGHT OBSTRUCTION



211 - SR 3018 & BLUE COURSE DRIVE

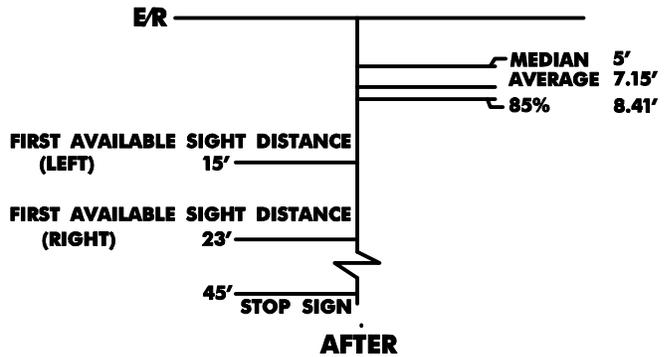
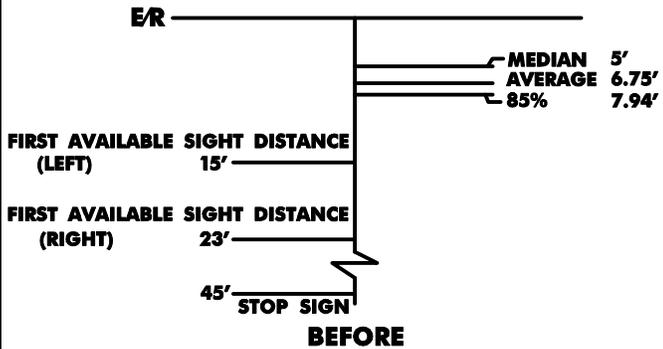


NO MODIFICATIONS MADE

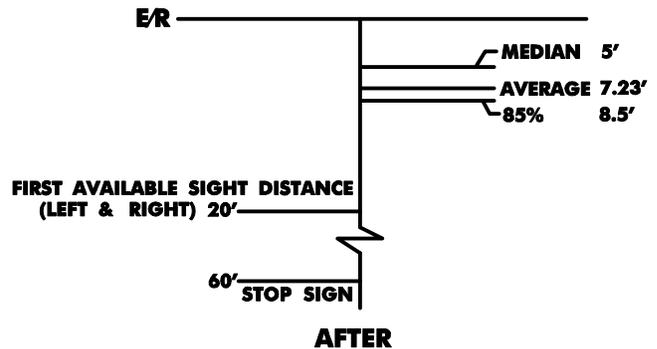
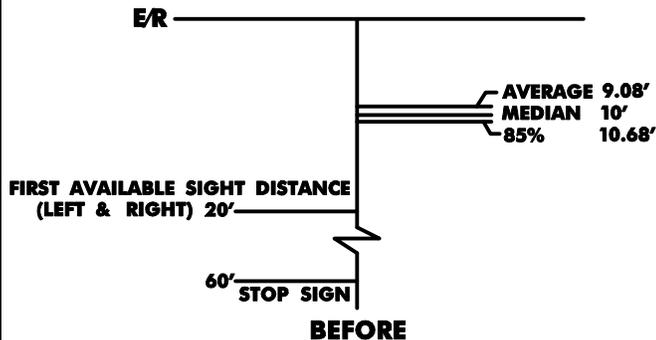
AFTER

212 - SR 2011 & SR 2018

LOW SPEED, SIGHT OBSTRUCTION



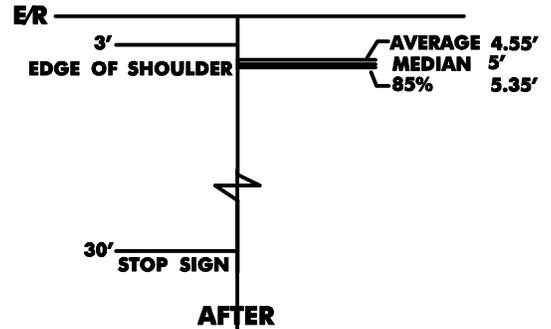
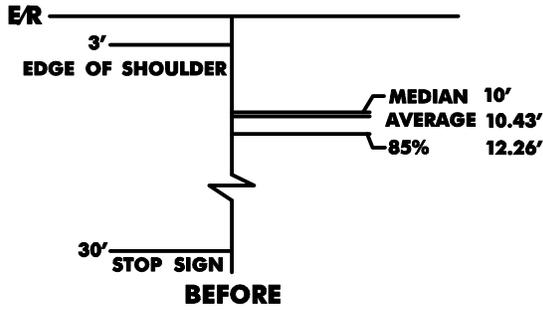
221 - SR 3011 & SR 3012



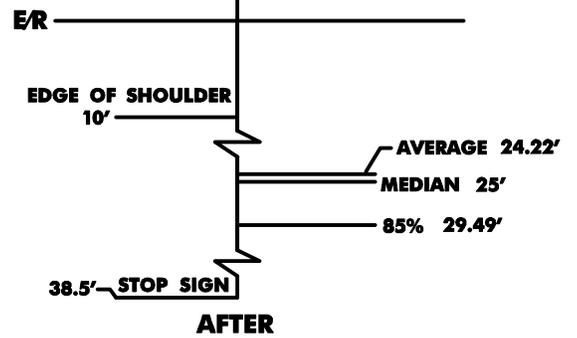
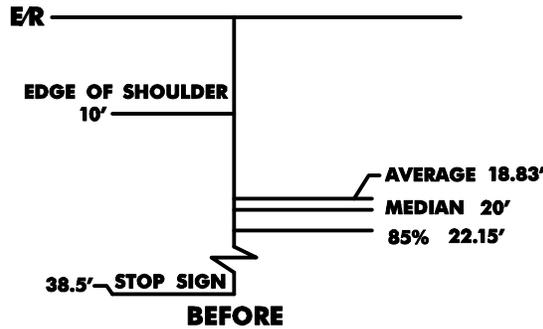
222 - SR 0453 & SR 0969

STOP SIGN AT INTERSECTION

HIGH SPEED, NO SIGHT OBSTRUCTION

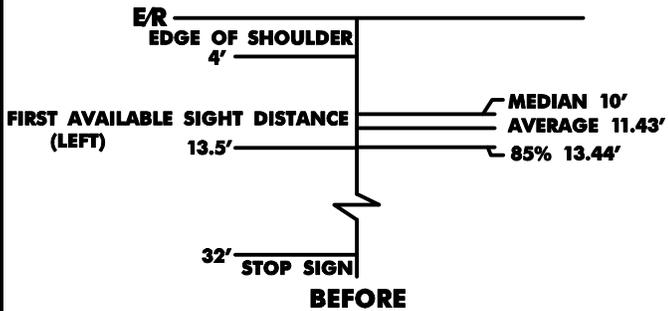


231 - SR 3005 & T 344



232 - SR 0153 & SR 2012W

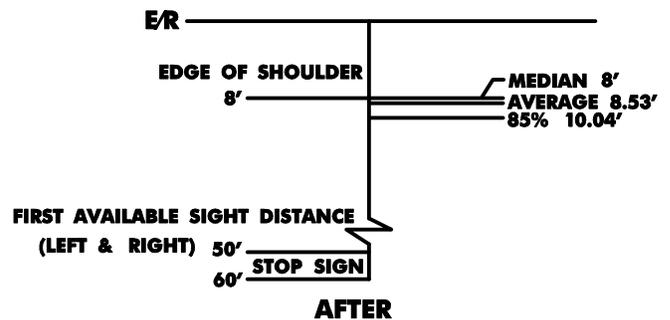
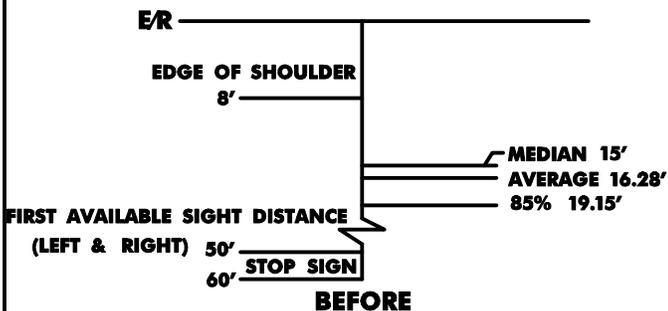
HIGH SPEED, SIGHT OBSTRUCTION



NO MODIFICATIONS MADE

AFTER

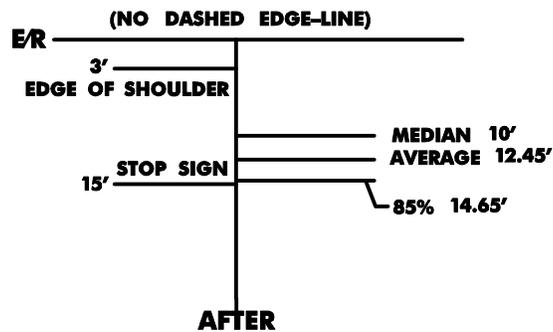
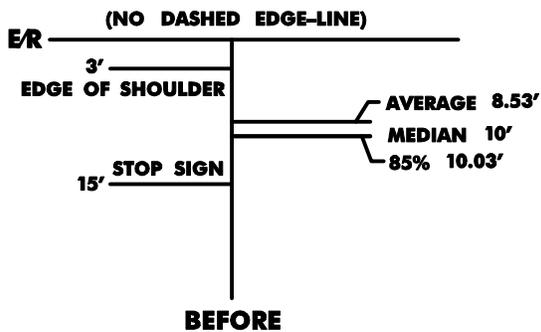
241 - SR 1010 & SR 0970



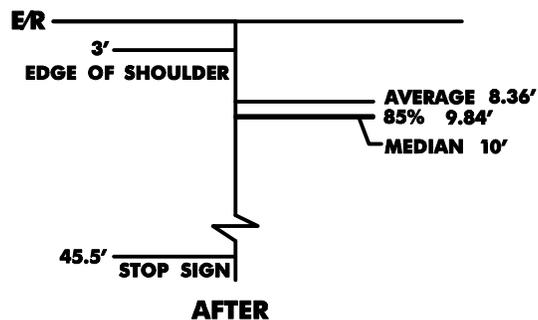
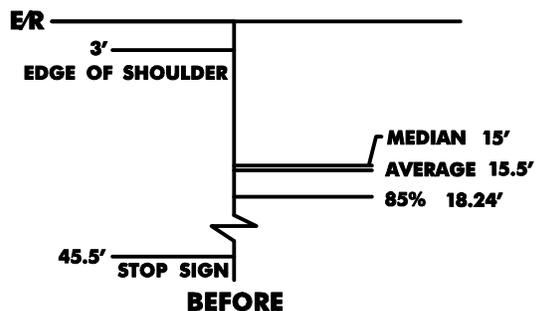
242 - SR 0729N & SR 0969

STOP SIGN WITH DASHED EDGE-LINE

LOW SPEED, NO SIGHT OBSTRUCTION

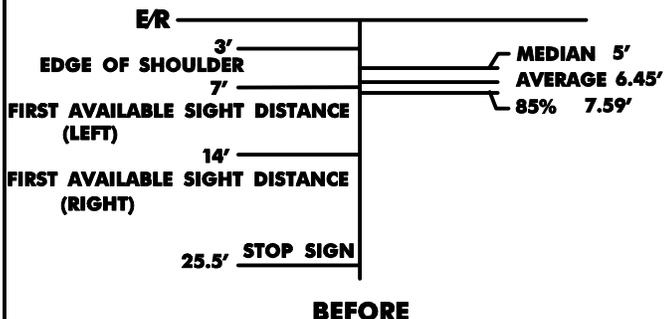


311 - SR 0729 & SR 3022



312 - SR 0253 & T 919

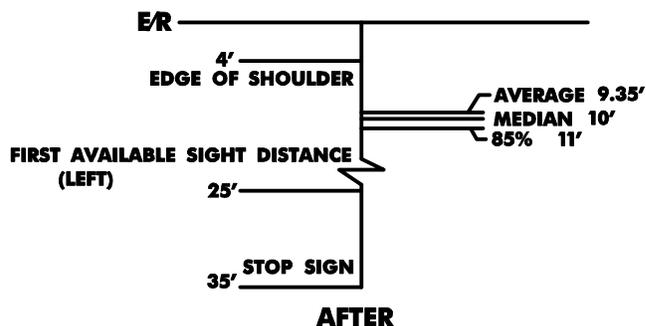
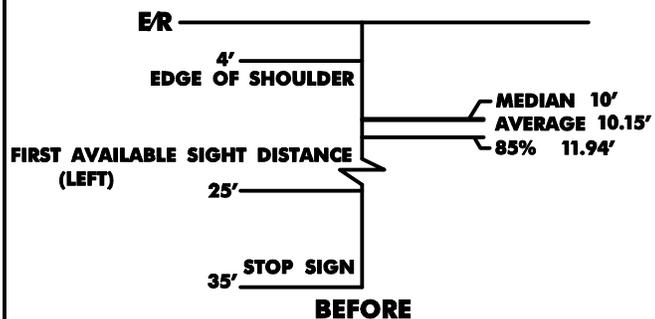
LOW SPEED, SIGHT OBSTRUCTION



NO MODIFICATIONS MADE

AFTER

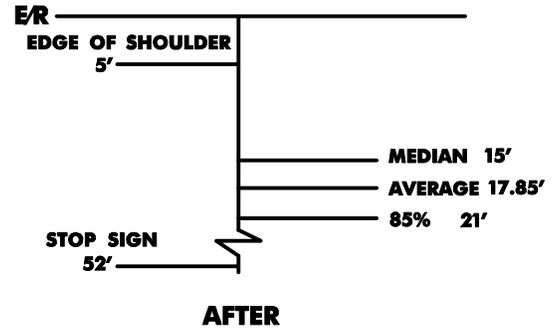
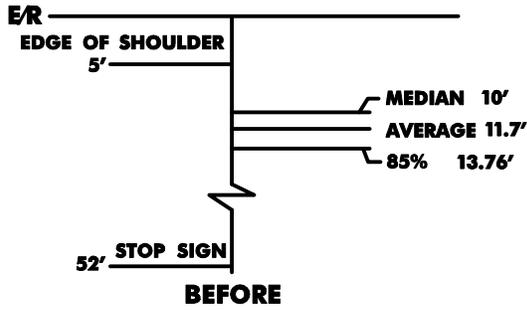
321 - SR 0550 & SR 3003



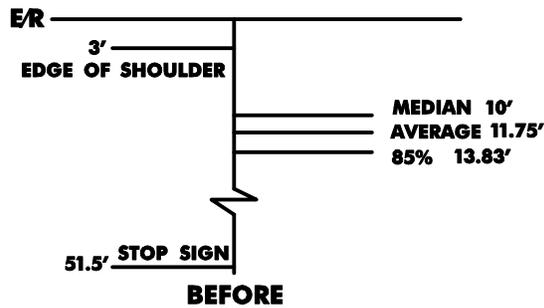
322 - SR 0550 & SR 3008

STOP SIGN WITH DASHED EDGE-LINE

HIGH SPEED, NO SIGHT OBSTRUCTION



331 - SR 0119 & SR 4003

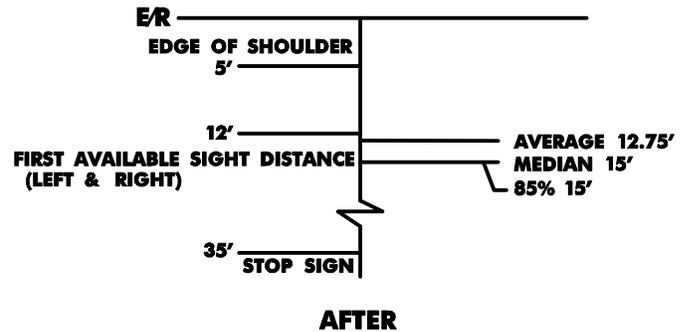
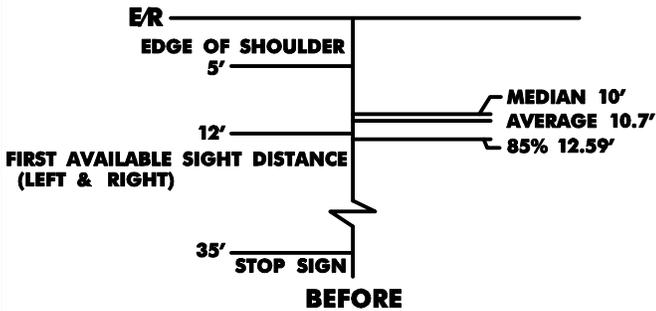


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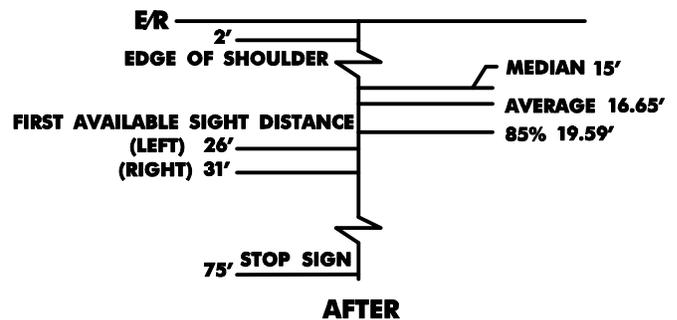
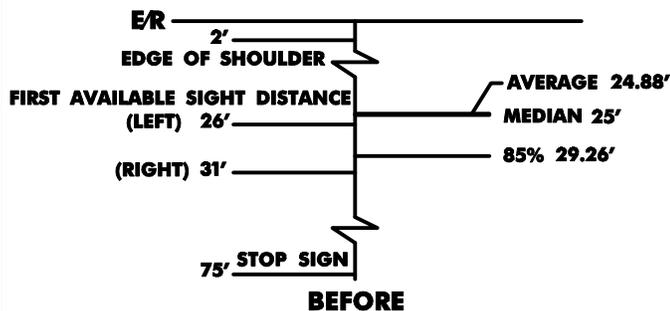
AFTER

332 - SR 0150 & SR 1002W

HIGH SPEED, SIGHT OBSTRUCTION



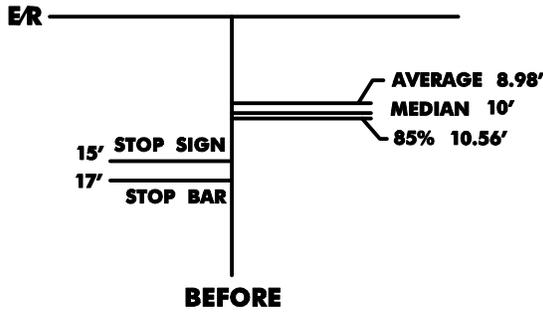
341 - SR 0144 & SR 0504



342 - SR 0219 & SR 0036

STOP SIGN WITH STOP BAR

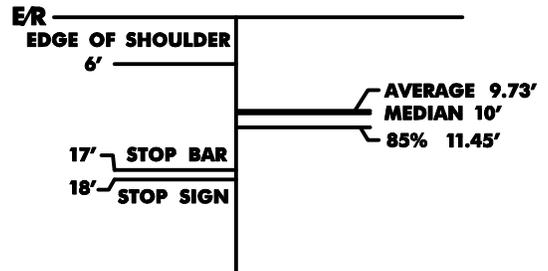
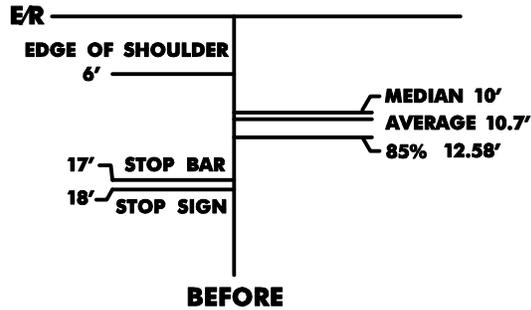
LOW SPEED, NO SIGHT OBSTRUCTION



NO MODIFICATIONS
MADE

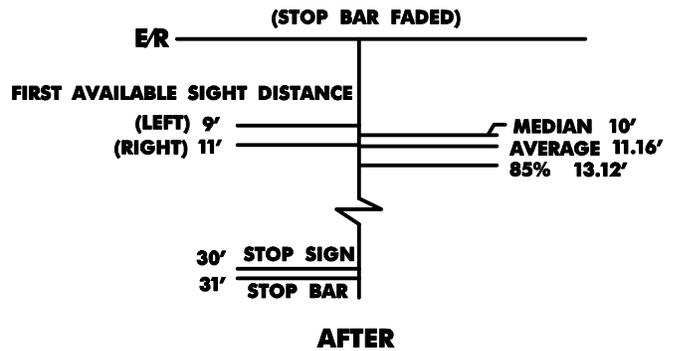
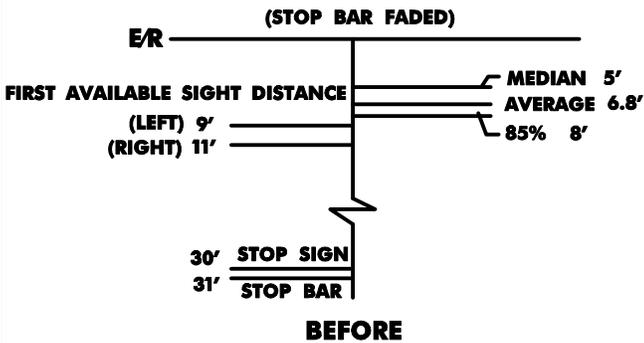
AFTER

411 - SR 1004 & FOURTH ST

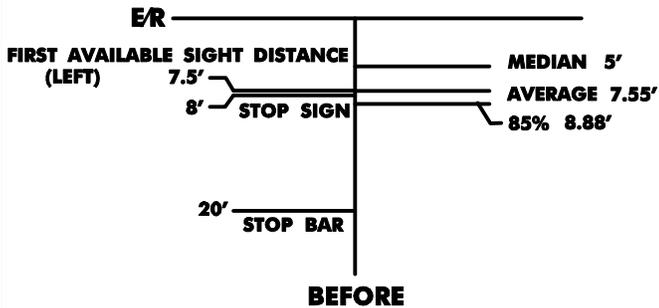


412 - SR 3014 & LOOP RD

LOW SPEED, SIGHT OBSTRUCTION



421 - SR 0322 & NINTH ST



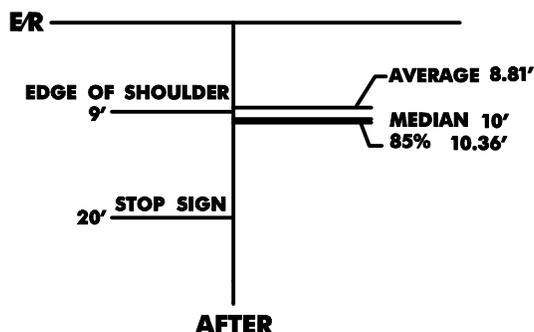
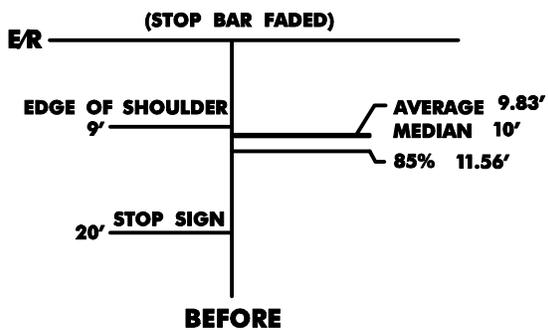
NO MODIFICATIONS
MADE

AFTER

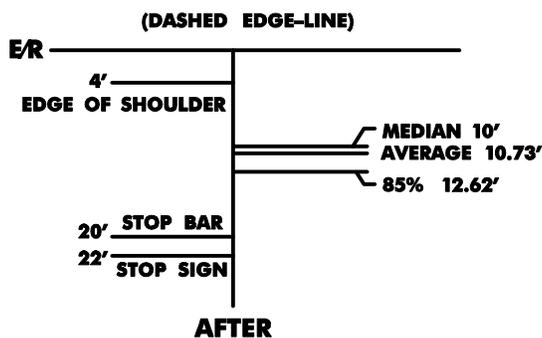
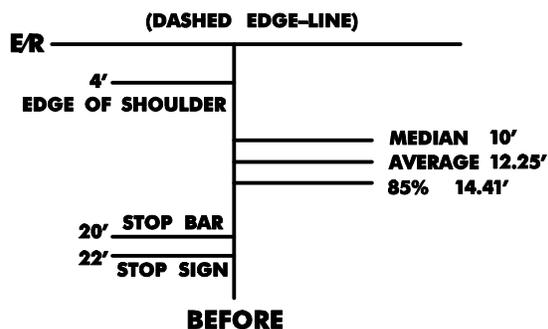
422 - SR 0026 & T 334

STOP SIGN WITH STOP BAR

HIGH SPEED, NO SIGHT OBSTRUCTION

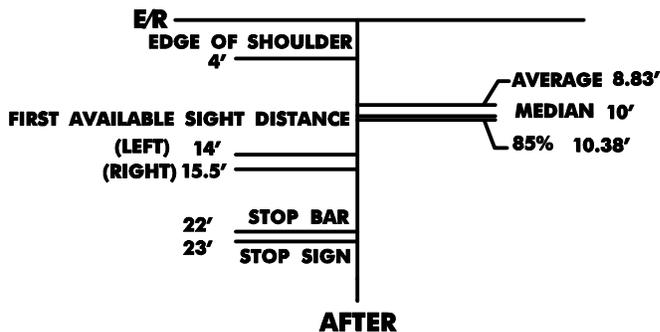
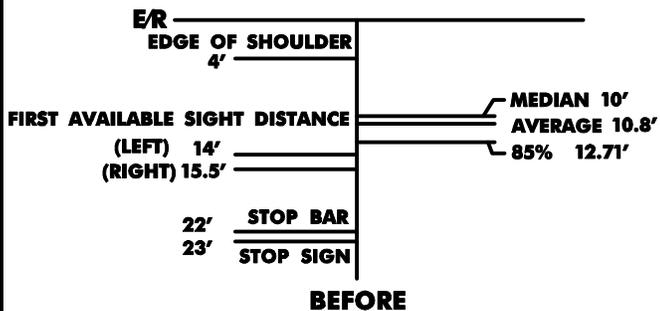


431 - SR 0322 & SR 0144

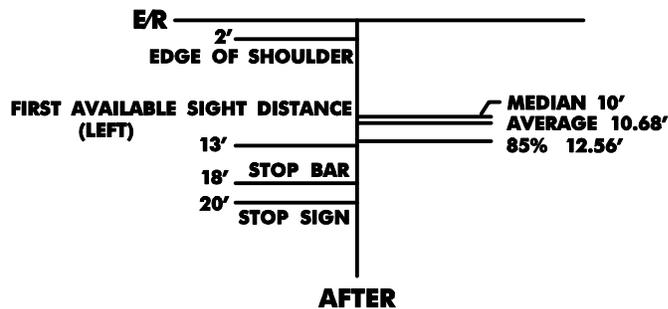
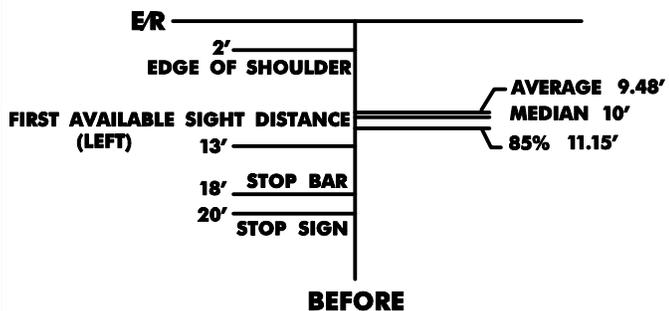


432 - SR 0045 & T 718

HIGH SPEED, SIGHT OBSTRUCTION



441 - SR 0045 & T 845



442 - SR 0045 & T 354

Appendix D
Analysis of the Effect of Age

Before/After
by Type of Improvement
Comparison of Age

		ROLLING STOP (Phase I)	ROLLING STOP (Phase II)	% of ROLLING STOPS	DID NOT STOP (Phase I)	DID NOT STOP (Phase II)	% of DID NOT STOPS	Distance from Edge of Road (Phase I)	Distance from Edge of Road (Phase II)	Distance from Edge of Road (Feet)
"STOP" on Pavement	Youth	14.3%	19.3%	5.0%	2.5%	0.0%	-2.5%	9.48	9.03	-0.45
	Experienced	10.7%	11.6%	0.8%	1.7%	0.6%	-1.2%	10.65	9.50	-1.15
	Senior	9.2%	4.1%	-5.1%	0.0%	0.0%	0.0%	12.37	9.92	-2.45
"AT WHITE LINE" Sign	Youth	10.2%	11.7%	1.5%	3.6%	1.7%	-1.9%	10.09	9.54	-0.55
	Experienced	8.4%	9.5%	1.1%	0.0%	0.3%	0.3%	12.55	10.19	-2.36
	Senior	3.0%	3.6%	0.6%	0.0%	0.0%	0.0%	13.29	11.19	-2.10
"STOP" on Pavement & "AT WHITE LINE" Sign	Youth	13.3%	11.1%	-2.2%	9.1%	1.2%	-7.9%	10.82	8.84	-1.98
	Experienced	10.7%	8.1%	-2.5%	4.0%	0.8%	-3.1%	12.27	10.15	-2.11
	Senior	7.3%	5.7%	-1.6%	2.8%	0.5%	-2.3%	14.38	12.30	-2.08
Overall	Youth	12.9%	14.3%	1.4%	4.6%	0.9%	-3.7%	10.13	9.14	-1.00
	Experienced	10.2%	9.6%	-0.6%	2.0%	0.6%	-1.4%	11.82	9.95	-1.87
	Senior	6.7%	4.3%	-2.4%	1.0%	0.1%	-0.9%	13.35	11.14	-2.21

Appendix E
Analysis of the Effect of Gender

Before/After
by Type of Improvement
Comparison of Gender

		ROLLING STOP (Phase I)	ROLLING STOP (Phase II)	% of ROLLING STOPS	DID NOT STOP (Phase I)	DID NOT STOP (Phase II)	% of DID NOT STOPS	Distance from Edge of Road (Phase I)	Distance from Edge of Road (Phase II)	Distance from Edge of Road (Feet)
"STOP" on Pavement	Male	11.7%	11.4%	-0.3%	1.6%	0.5%	-1.2%	10.65	9.61	-1.04
	Female	10.1%	13.5%	3.3%	1.6%	0.4%	-1.3%	10.66	9.51	-1.16
"AT WHITE LINE" Sign	Male	7.4%	8.8%	1.3%	1.0%	0.5%	-0.5%	11.89	10.21	-1.68
	Female	12.1%	13.6%	1.5%	0.0%	0.0%	0.0%	12.60	10.58	-2.03
"STOP" on Pavement & "AT WHITE LINE" Sign	Male	11.9%	8.1%	-3.8%	4.8%	0.8%	-4.0%	12.12	10.18	-1.94
	Female	8.4%	13.3%	4.9%	4.3%	1.4%	-3.0%	12.94	10.44	-2.50
Overall	Male	10.6%	9.3%	-1.3%	2.3%	0.6%	-1.7%	11.55	10.00	-1.55
	Female	10.2%	13.5%	3.3%	1.9%	0.6%	-1.4%	12.07	10.18	-1.89

Appendix F
Analysis of the Effect of Speed

Before/After
by Type of Improvement
Comparison of Speed

	ROLLING STOP (Phase I)	ROLLING STOP (Phase II)	% of ROLLING STOPS	DID NOT STOP (Phase I)	DID NOT STOP (Phase II)	% of DID NOT STOPS	Distance from Edge of Road (Phase I)	Distance from Edge of Road (Phase II)	Distance from Edge of Road (Feet)
25 MPH	112	5.5%	3.5%	-2.0%	0.0%	0.5%	4.18	2.78	-1.40
	121	14.5%	4.0%	-10.5%	0.0%	0.0%	9.28	8.60	-0.68
	221	8.0%	0.5%	-7.5%	1.0%	0.0%	6.75	7.15	0.40
	222	16.0%	1.5%	-14.5%	1.0%	0.5%	9.08	7.23	-1.85
35 MPH	111	6.0%	2.5%	-3.5%	3.0%	0.0%	9.63	7.38	-2.25
	311	5.0%	2.0%	-3.0%	0.5%	0.0%	8.53	12.45	3.92
	312	12.5%	4.5%	-8.0%	5.5%	1.0%	15.50	8.36	-7.14
	331	11.5%	24.5%	13.0%	17.0%	4.0%	11.70	17.85	6.15
	341	10.0%	10.5%	0.5%	2.0%	2.5%	10.70	12.75	2.05
	342	13.0%	3.5%	-9.5%	2.0%	0.5%	24.88	16.65	-8.23
	421	17.0%	5.5%	-11.5%	0.5%	0.0%	6.80	11.16	4.36
	422	16.5%	12.5%	-4.0%	0.0%	0.0%	10.15	9.35	-0.80
40 MPH	412	11.0%	20.9%	9.9%	0.0%	0.0%	10.70	9.73	-0.97
	131			0.0%					0.00
45 MPH	141	3.5%	10.0%	6.5%	0.0%	0.0%	8.45	9.13	0.68
	142	7.5%	20.3%	12.8%	0.5%	0.0%	7.28	7.38	0.10
	211	7.0%	12.5%	5.5%	0.0%	0.5%	9.68	5.97	-3.71
	231	7.5%	9.5%	2.0%	3.5%	1.5%	10.43	4.55	-5.88
	431	17.5%	7.5%	-10.0%	4.5%	0.5%	9.83	8.81	-1.02
	432	14.0%	15.0%	1.0%	0.0%	0.0%	12.25	10.73	-1.52
	441	14.0%	17.5%	3.5%	1.0%	0.0%	10.80	8.83	-1.97
	442	6.5%	1.0%	-5.5%	0.0%	0.0%	9.48	10.68	1.20
	232	2.5%	12.4%	9.9%	0.5%	0.6%	18.83	24.22	5.39
	242	16.5%	9.5%	-7.0%	9.0%	0.0%	16.28	8.53	-7.75

Appendix G
Phase I Only Intersection Reports

122-S.R. 3032 & S.R. 3030: Centre County- S.R. 3032 is the major road with an ADT of 350 vehicles and S.R. 3030 is the stopping road with an ADT of 450 vehicles. If drivers are stopped at the stop sign, corner sight distance to the left is obstructed by a row of trees. The sight distance to the right is proper. The posted speed limit on S.R. 3032 is 40 miles per hour and is 35 miles per hour on S.R. 3030.

The review of the crash history indicated that there were no crashes in the past five years at this intersection. Pavement history indicates that S.R. 3030 was resurfaced in 1989. Low volumes on the main road made it easier for drivers on the stopped approach as the gaps in traffic were often in terms of minutes, providing plenty of time for navigation of the intersection.

There were no specific recommendations made in Phase I for improvement at this intersection due to the observed driving habits, low volumes, and lack of crash activity. This intersection was not chosen for Phase II. The following table illustrates pertinent data from Phase I observations:

Table 6 – Intersection 122

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	7.50	1.5L 1.5R	L	4.77	11.9	0.0
Phase II	--	--	--	--	--	--

Notes: L = left, T = through, R = right

131-T-919 & S.R. 2001: Clearfield County- S.R. 2001 is the major road with an ADT of 250 vehicles and T-919 is the stopping approach with an ADT of 200 vehicles. Corner sight distances and the stopping sight distance are all adequate. The speed limit on S.R. 2001 is 45 miles per hour and is 25 miles per hour on T-919.

There have been no crashes at this intersection in the past five years. The roads were resurfaced in 1994. Low volumes on both roads made it difficult to find situations where drivers had to perform the task of gap acceptance/rejection before proceeding.

Due to the observed driver behavior and the absence of crashes, recommendations for improvement were not deemed necessary for this intersection in Phase I. Despite these favorable conditions, it was decided that the word “STOP” would be painted on the pavement at this intersection for the second phase of

observations. A paving project delayed the implementation of this improvement, however, and this intersection could not be studied for Phase II. The following table illustrates pertinent data from Phase I observations:

Table 7 – Intersection 131

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	9.48	1L 1R	L	5.28	11.0	0.5
Phase II	--	--	--	--	--	--

Notes: L = left, T = through, R = right

132-S.R. 2014 & S.R. 2017: Clearfield County- S.R. 2014 is the major road with an ADT of 350 vehicles and S.R. 2017 is the stopping approach with an ADT of 100 vehicles. Sight distances approaching the stop sign in each direction are proper. The speed limit on S.R. 2014 is 45 miles per hour and on is 35 miles per hour S.R. 2017.

Upon reviewing the crash history, it was found that no crashes had occurred in the past five (5) years at this intersection. The roadway was resurfaced in 1995. Due to the low volumes on the intersecting roads, the drivers observed did not need to make a judgment on gaps in oncoming traffic.

Due to the observed driving habits, the crash history, and the intersection geometry, no need for improvements was specified in Phase I. The location was not chosen for Phase II, but the following table illustrates pertinent data from Phase I observations:

Table 8 – Intersection 132

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	6.85	1L 1R	R	4.71	9.9	1.2
Phase II	--	--	--	--	--	--

Notes: L = left, T = through, R = right

212-S.R. 2011 & S.R. 2018: Centre County- S.R. 2011 is the major roadway with an ADT of 750 vehicles and S.R. 2018 is the stopping approach with 250 vehicles. The sight distance is proper at the approach. The speed limit on the mainline is 35 miles per hour and the speed limit on the stopping approach is 25 miles per hour.

There were no crashes at this intersection. S.R. 2011 was last resurfaced in 1989 and S.R. 2018 in 1982. The average gap in traffic on S.R. 2011 was 14.67 seconds.

Based on observations, no improvements were specified during Phase I at this intersection. The location was not chosen for Phase II. The following table illustrates pertinent data from Phase I observations:

Table 12 – Intersection 212

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	10.57	1L 0.5R	R	3.09	23.4	13.2
Phase II	--	--	--	--	--	--

Notes: L = left, T = through, R = right

241-S.R. 0970 & S.R. 1010: Clearfield County- S.R. 0970 is the major road with an ADT of 6,100 vehicles and S.R. 1010 is the stopping road with an ADT of 2,000 vehicles. The proper corner sight distance to the left is obstructed by bushes and some rock piles only if the driver stops at the stop sign. The corner sight distance to the right and the stopping sight distance are proper. The speed limit is 45 miles per hour on S.R. 0970 and 35 miles per hour on S.R. 1010.

There were two (2) relevant crashes at this intersection. One (1) of them placed fault on a driver pulling into traffic on S.R. 0970 from S.R. 1010. S.R. 1010 and S.R. 0970 were resurfaced in 1993 and 1999 respectively. The average accepted gap time was 13.29 seconds.

After studying the intersection geometry and driver behavior it was recommended in Phase I that a dashed edge-line be placed along S.R. 0970 in order to encourage drivers to pull up closer to the intersection, providing additional sight distance and safer advancement into traffic. This intersection was not included in Phase II though, so it can not be certain that this edge-line was indeed painted. The following table illustrates pertinent data from Phase I observations:

Table 17 – Intersection 241

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	11.43	2L 1.5R	R	7.26	16.0	0.0
Phase II	--	--	--	--	--	--

Notes: L = left, T = through, R = right

321-S.R. 0550 & S.R. 3003: Centre County- S.R. 0550 is the main road with an ADT of 3,000 vehicles and S.R. 3003 is the stopping road with an ADT of 3,600 vehicles. Bushes and trees obstruct the proper corner sight distance in both directions only if drivers stop at the stop sign. The stopping sight distance is proper. The speed limit on S.R. 0550 is 35 miles per hour and on S.R. 3003 it is 40 miles per hour.

One (1) crash occurred at this intersection in the past five (5) years and that crash was a driver hitting a fixed object due to drowsiness. S.R. 0550 was last resurfaced in 1987 and S.R. 2003 was last resurfaced in 1998. The average accepted gap time was 13.3 seconds.

Even though there was no crash history, the removal of the trees and bushes were mentioned as possible improvements in Phase I in order to provide for additional visibility. The completion of this suggestion could not be confirmed though, because this intersection was not chosen for Phase II. The following table illustrates pertinent data from Phase I observations:

Table 21 – Intersection 321

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	6.45	1.5L 1R	R	5.85	5.5	0.5
Phase II	--	--	--	--	--	--

Notes: L = left, T = through, R = right

332-S.R. 0150 & S.R. 1002: Centre County- S.R. 0150 is the major road with an ADT of 4,400 vehicles and S.R. 1002 is the stopping road with an ADT of 600 vehicles. The corner sight distances as well as the stopping sight distance are

proper. The speed limit is 55 miles per hour on S.R. 0150 and 35 miles per hour on S.R. 1002.

There were two (2) crashes that occurred--both angle collisions. The drivers pulled out in front of traffic on S.R. 0150. S.R. 0150 was resurfaced in 2000 and S.R. 1002 was resurfaced in 1995. The average length of accepted gaps was 12.16 seconds.

Due to the intersection geometry and an uphill grade from S.R. 1002 onto S.R. 0150, it was difficult for driver's to see the dashed edge-line along S.R. 0150. It was recommended in Phase I that a thicker dashed edge-line be painted along S.R. 0150 in order for drivers to more easily be able to see it and encourage drivers to stop closer to the intersection. The completion of this can not be confirmed since the location was not chosen for Phase II. The following table illustrates pertinent data from Phase I observations:

Table 24 – Intersection 332

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	11.75	1.5L 1.5R	L	7.75	3.9	0.0
Phase II	--	--	--	--	--	--

Notes: L = left, T = through, R = right

411-S.R. 1004 & Fourth Street: Clearfield County- S.R. 1004 is the major road with an ADT of 5,200 vehicles and Fourth Street is the stopping road with an ADT of 500 vehicles. All sight distances are proper. The speed limit on Fourth Street and S.R. 1004 is 25 miles per hour.

Two (2) crashes occurred at this intersection. They were both angle collisions occurring due to the driver not stopping on the Fourth Street approach. Both of the roads were resurfaced in 1998. The average length of accepted gaps was 12.17 seconds.

The crash analysis and driver habits did not justify any specific improvements at the intersection during Phase I and it was not chosen to be observed for Phase II. The following table illustrates pertinent data from Phase I observations:

Table 27 – Intersection 411

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	8.98	2L 1.5R	R	6.56	3.5	0.5
Phase II	--	--	--	--	--	--

Notes: L = left, T = through, R = right

422-S.R. 0026 & T-334: Centre County- S.R. 0026 is the major road with an ADT of 10,000 vehicles and T-334 is the stopping approach with an ADT of 500 vehicles. Houses built close to the road make it difficult to obtain proper corner sight distance to the left; only if drivers stop at the stop sign and to the right there is proper sight distance. Stopping sight distance is proper. The speed limit on all approaches is 25 miles per hour.

One (1) relevant crash occurred as a result of improper turning from the stopped approach and resulted in an angle collision. Both roads were resurfaced in 1990. The averaged accepted gap time was just over ten (10) seconds.

Due to observed driving behavior and the lack of a crash history at this intersection, no recommendations for improvements were made in Phase I. The intersection was not chosen for Phase II, but the following table illustrates pertinent data from Phase I observations:

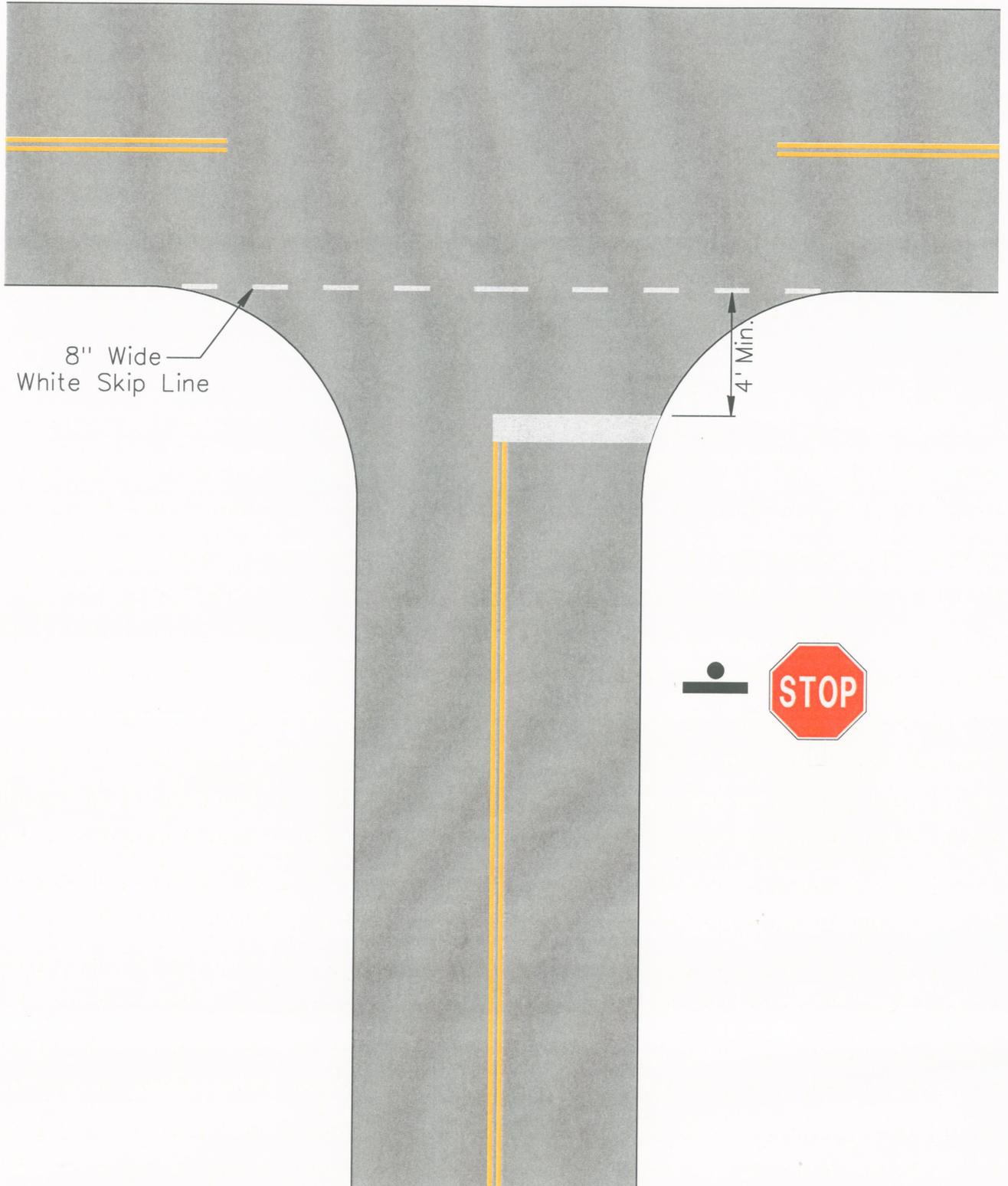
Table 30 – Intersection 422

	Average Stopping Distance from Edge of Roadway (Feet)	Average Number of Times Drivers Looked in Each Direction	Maneuver (L T R)	Time Required to Complete Movement (Seconds)	% of Drivers That Performed a Rolling Stop	% of Drivers That Did Not Stop
Phase I	7.55	1.5L 1R	R	6.45	6.0	0.0
Phase II	--	--	--	--	--	--

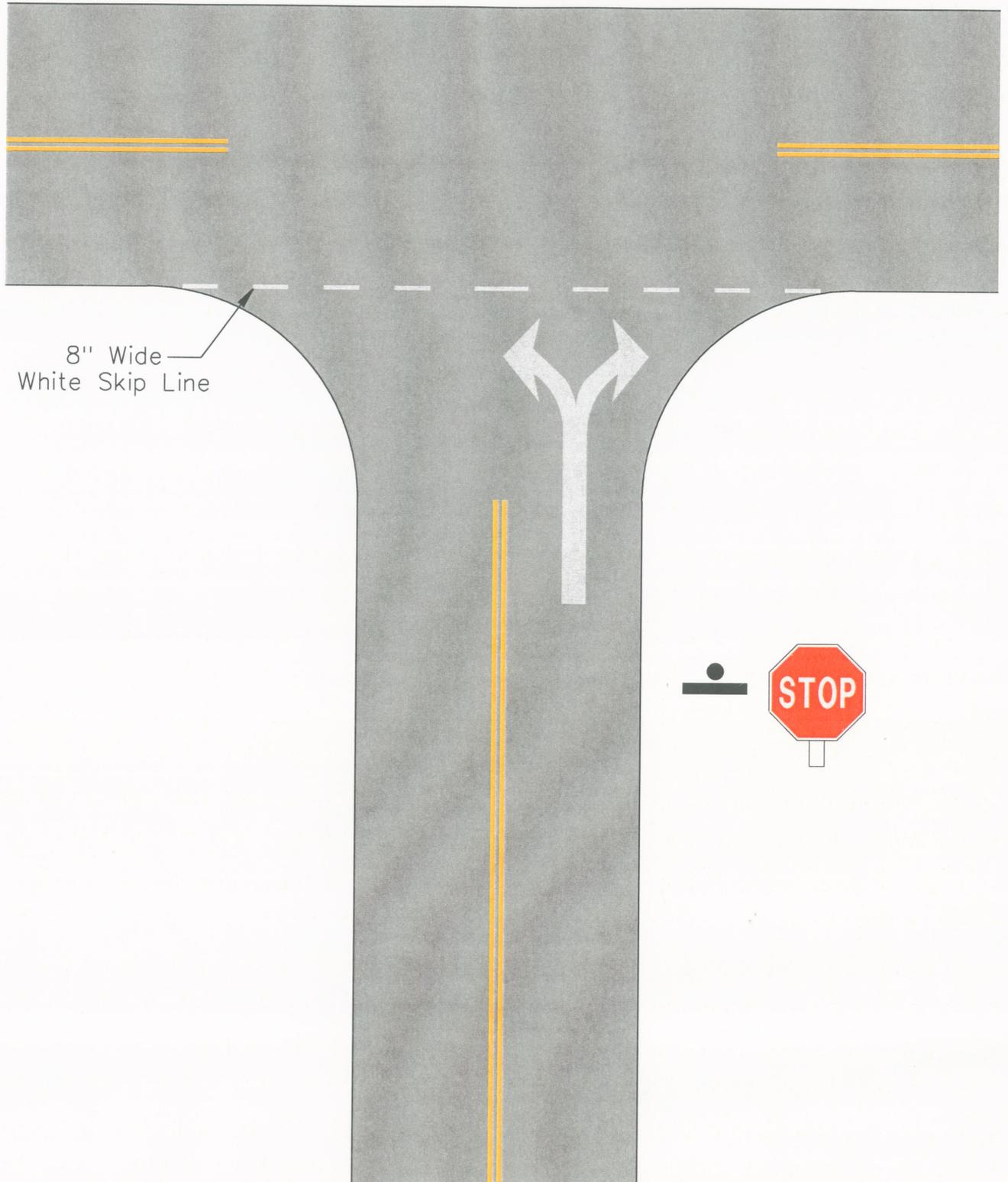
Notes: L = left, T = through, R = right

Appendix H
Phase I Low-Cost Improvement Diagrams

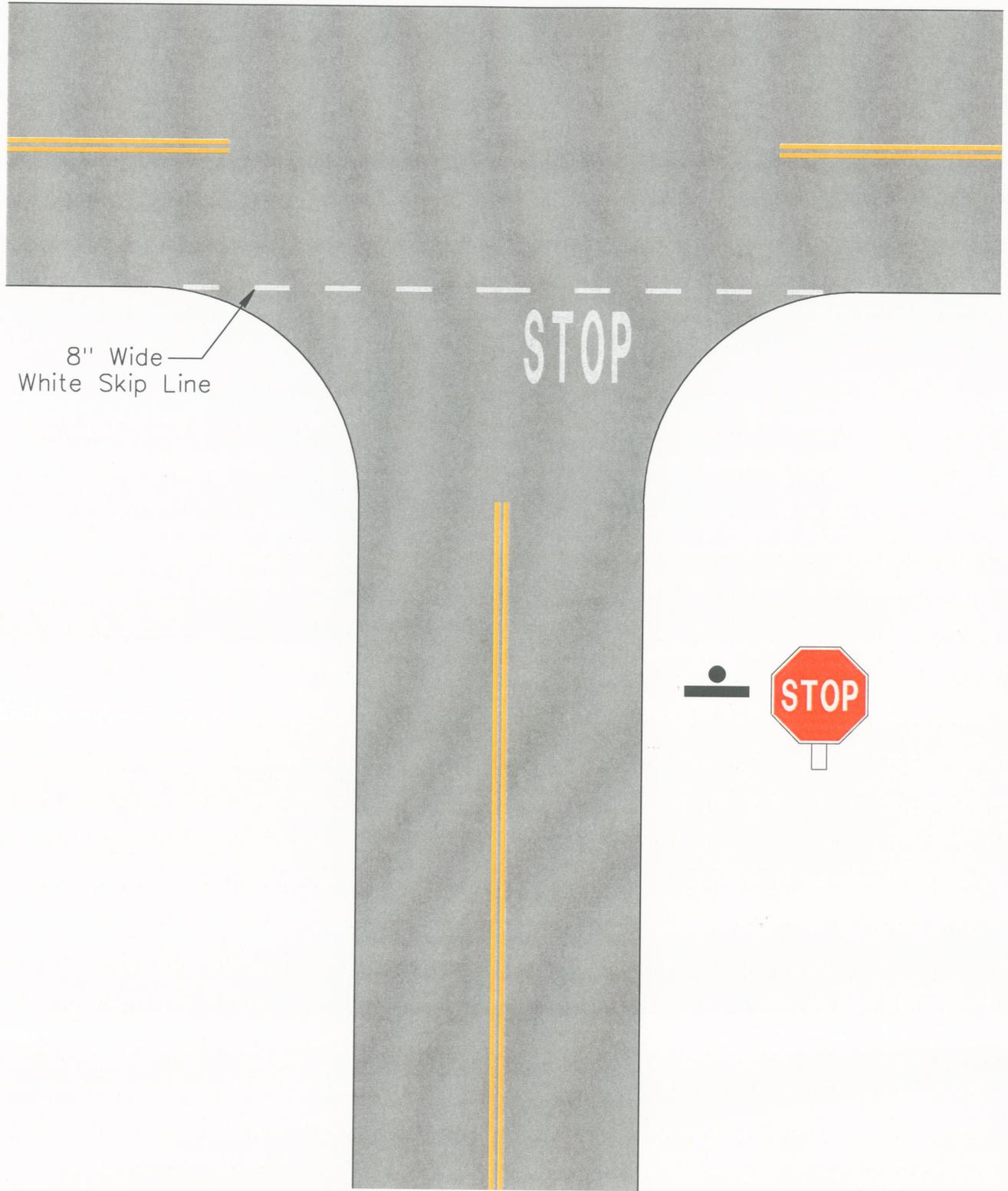
Safer Driver Actions at Stop Signs
Diagram No. 1 - Stop Line



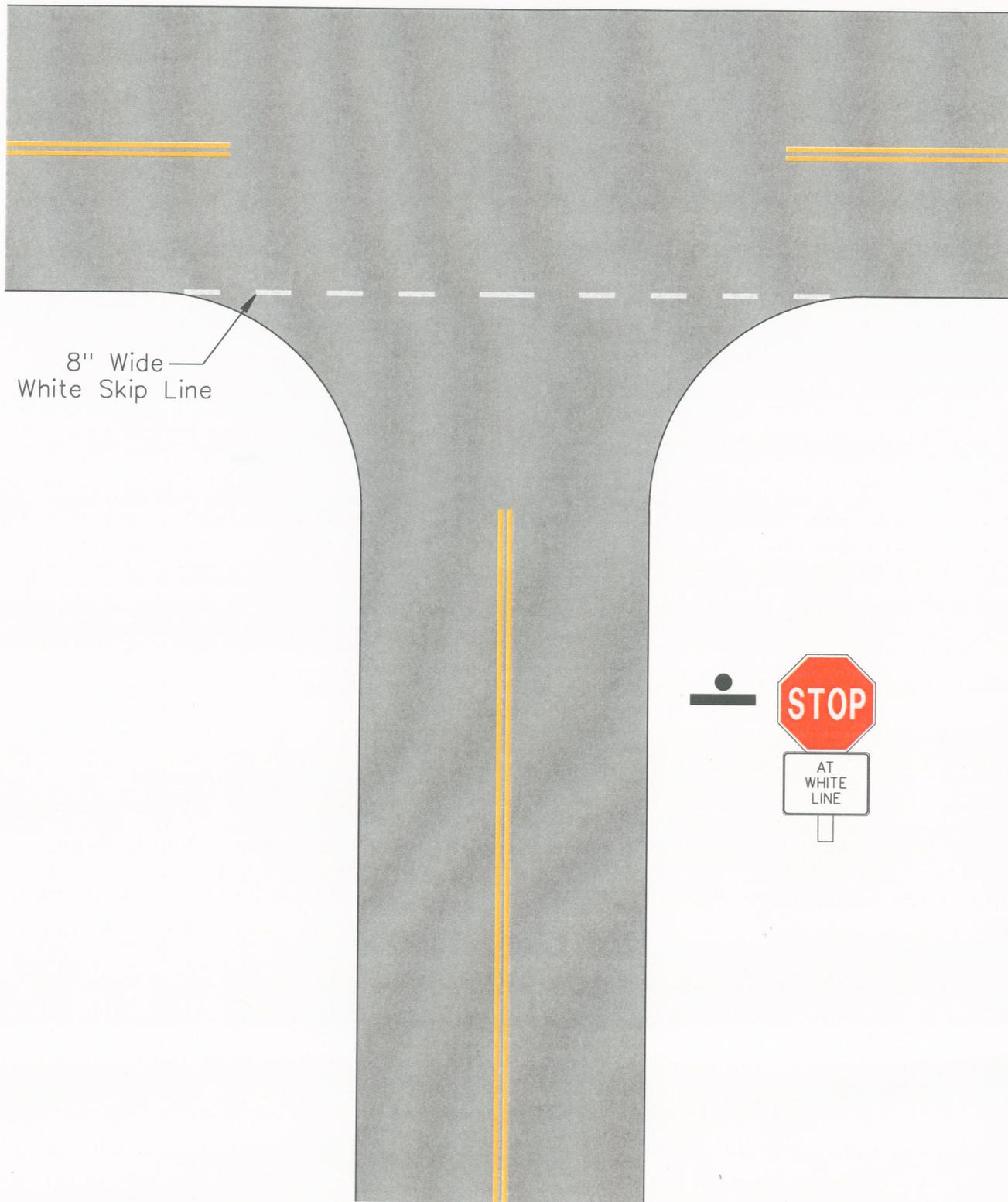
*Safer Driver Actions at Stop Signs
Diagram No. 2 - Pavement Arrows*



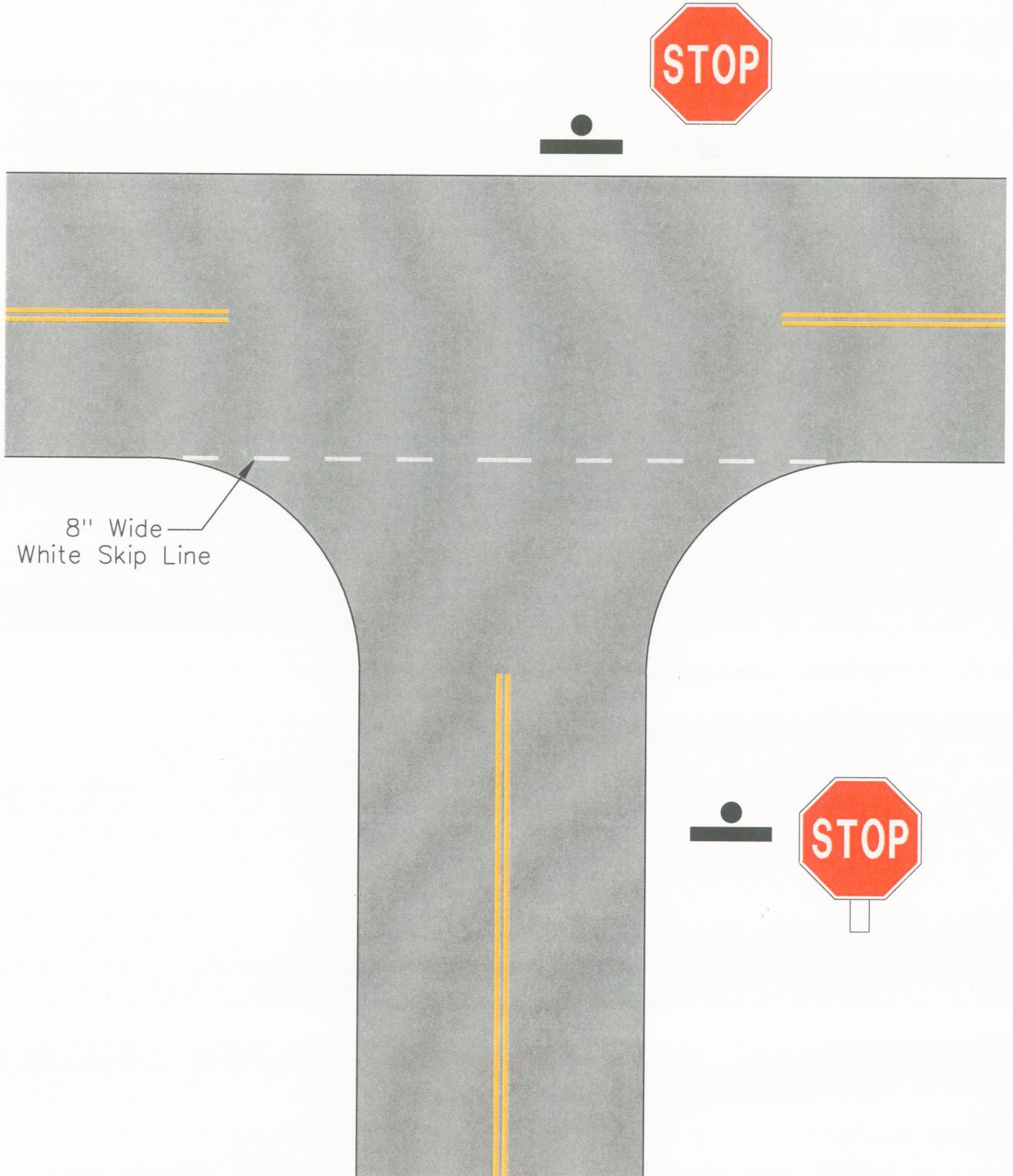
*Safer Driver Actions at Stop Signs
Diagram No. 3 - "STOP" on Pavement*



Safer Driver Actions at Stop Signs
Diagram No. 4 - "AT WHITE LINE" Sign



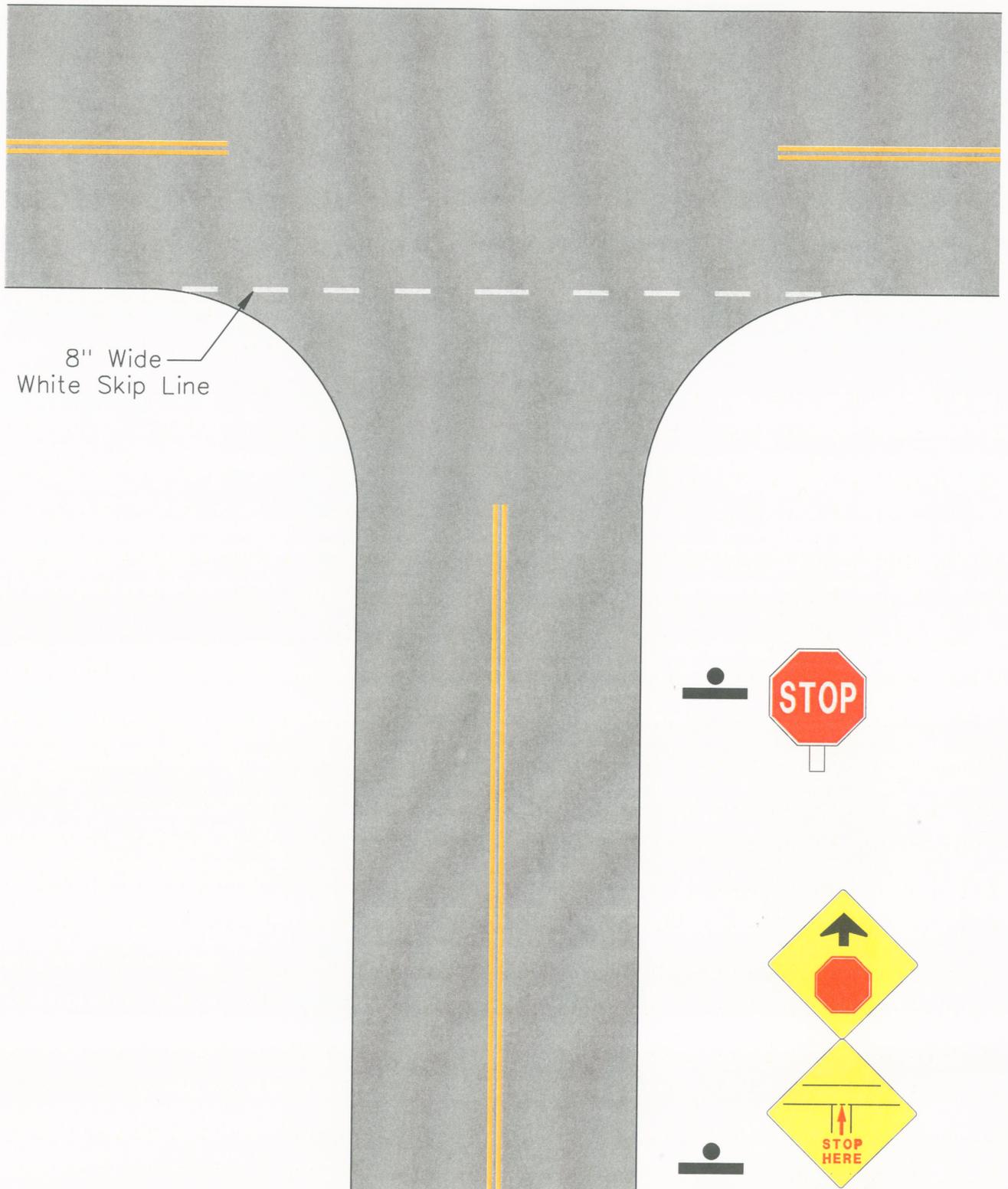
*Safer Driver Actions at Stop Signs
Diagram No. 5 - Far Side Stop Sign*



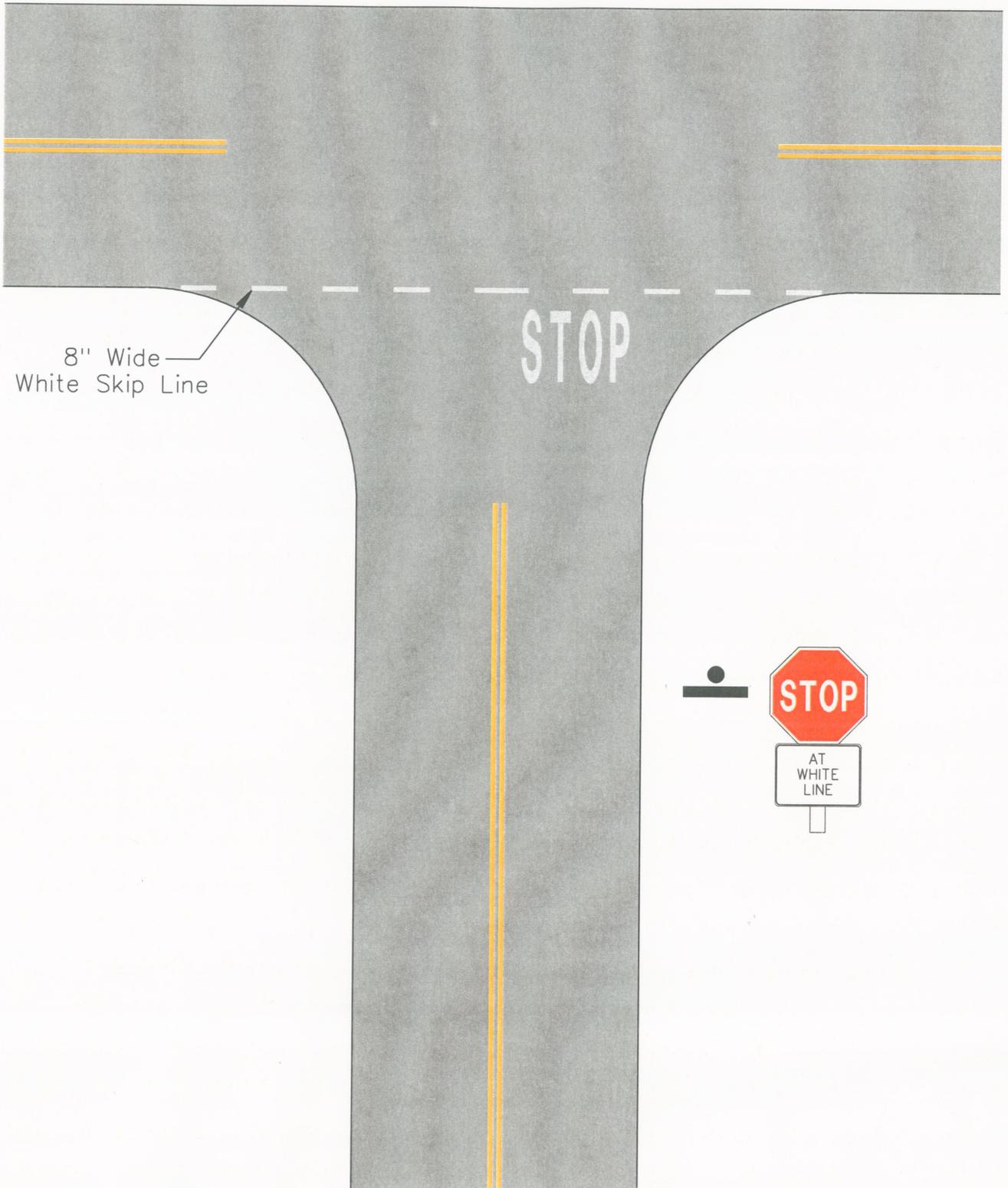
8" Wide
White Skip Line

Safer Driver Actions at Stop Signs

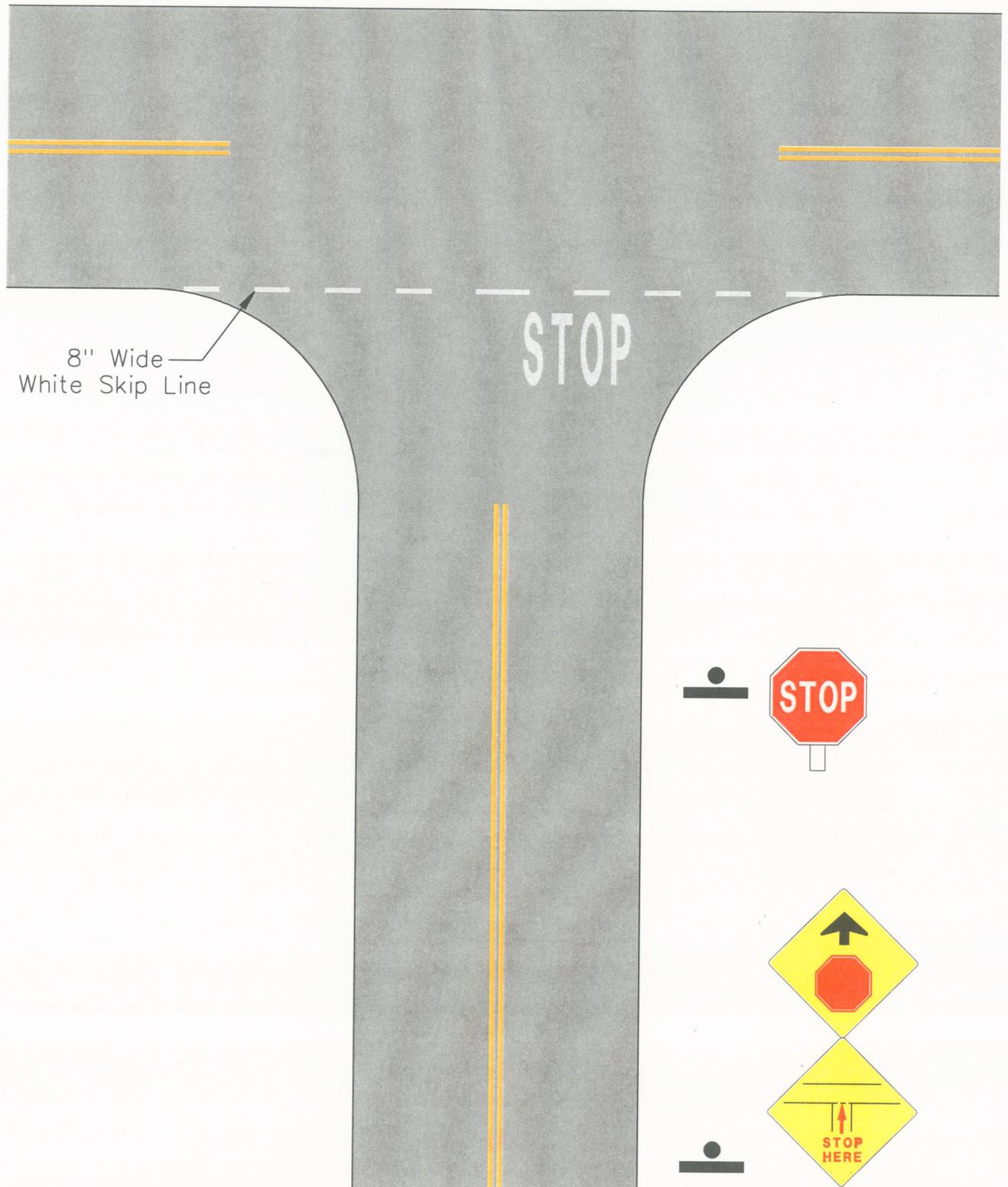
Diagram No. 6 - Stop Ahead Sign



*Safer Driver Actions at Stop Signs
Diagram No. 7 -
"STOP" on Pavement & "AT WHITE LINE" Sign*



*Safer Driver Actions at Stop Signs
Diagram No. 8 -
"STOP" on Pavement & Stop Ahead Sign*



Appendix I
Contact Information for Interview Participants

Contacts:

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