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Final Report**

ANALYSIS OF RURAL INTERSECTION ACCIDENTS CAUSED BY STOP SIGN VIOLATION AND FAILURE TO YIELD THE RIGHT-OF-WAY

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K-TRAN

**A COOPERATIVE TRANSPORTATION RESEARCH PROGRAM BETWEEN:
KANSAS DEPARTMENT OF TRANSPORTATION
THE KANSAS STATE UNIVERSITY
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Analysis of Rural Intersection Accidents Caused by Stop Sign Violation and Failure to Yield the Right-of-Way

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PREFACE

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INTRODUCTION

Accidents caused by drivers who fail to stop, or fail to yield the right-of-way to cross traffic after stopping, are becoming increasingly frequent at some rural intersections on the state highway system. Due to the relatively high speed of the cross traffic, accidents caused by failure to stop or failure to yield the right-of-way can be severe. These accidents continue to occur even though the traffic control devices in place at rural highway intersections meet or exceed the requirements set forth in the Manual on Uniform Traffic Control Devices (MUTCD). There is a need to identify the causes of these accidents and to determine what traffic control devices or other measures could be effective in reducing their frequency and severity.

STUDY OBJECTIVES

The objectives of this study were 1) to identify the factors that contribute to accidents caused by failure to stop and failure to yield the right-of-way at rural two-way stop-controlled intersections on the state highway system, and 2) to determine what traffic control devices or other measures could be effective in reducing the frequency of these accidents.

LITERATURE REVIEW

A number of studies have been conducted to identify the factors that might affect accidents at two-way stop controlled intersections. While several previous studies have shown that stop sign violation rates decrease with increasing traffic volumes on the major (uncontrolled) roadway, there is considerable evidence that suggests that accident frequency is not correlated with stop sign violation rates. In short, the results of many previous studies suggest that accidents at two-way stop controlled intersections are more closely related to driver error, such as failure to accurately judge the speed of major roadway vehicles, than to roadway geometry, sight distance and driver compliance with traffic control devices.

A summary of the findings from previous research efforts in this area is provided below.

Picha et al. (1996) conducted laboratory and field studies to determine ways to improve two-way stop-controlled (TWSC) intersections that either experience high/severe crash frequencies or driver confusion concerning right-of-way conditions. Based on the results of their study, Picha et al. (1996) formulated several general guidelines concerning traffic control devices at TWSC intersections. With regards to TWSC intersections, Picha et al. (1996) suggested that the existence of any one of the following seven conditions may be indicative of a location where drivers may misinterpret a TWSC intersection as being a four-way stop-controlled intersection.

- 1) The intersection of two single-jurisdictional roadways in a rural or isolated area.
- 2) Average daily volumes on all approaches are similar but not large enough to warrant the use of a traffic signal (volumes of 5,000 to 10,000 ADT).
- 3) A rate of four traffic conflicts (one or both drivers take evasive action to avoid a collision) for every 1000 vehicles.
- 4) Right-angle crash frequency of three or more per year.
- 5) A system of roadway intersections that are not consistent with respect to traffic control schemes.
- 6) Similar, high speeds (greater than 80 km/h) on all approaches.
- 7) Similar cross-sectional elements (number of lanes, width, etc) on all approaches.

If one of these conditions is met, Picha et al. (1996) recommend adding the supplemental sign “CROSS TRAFFIC DOES NOT STOP” with the two-way arrow.

Kalakota et al. (1994) studied variations in accidents as a function of geometric variables. The following summarizes their findings concerning variations in accident rates.

- 1) An increase in average daily traffic is the most significant factor in increasing the number of injury and fatality accidents at signalized intersections.

- 2) Nonsignalized intersections with higher posted speed limits (50 to 55 mph) are prone to more accidents than comparable low speed intersections.
- 3) The wider the pavement, the fewer the accidents.
- 4) Shoulder width is not a significant factor in accidents on curves.

Jarvis et al. (1990) assessed the effectiveness of yellow bar markings as a speed-reducing device for drivers on approaches to isolated rural intersections. In their study, Jarvis et al. placed 30 yellow bar markings beginning 35 m from the stop bar of the study intersection approaches. They found that the yellow bar markings significantly reduced driver speeds. Reduction in driver approach speed reached a maximum at 200 m from the stop (50 m after the beginning of the markings). The maximum reductions varied from three to five km/h. However, the researchers suggested that the greatest benefit of the markings was to increase driver awareness, rather than directly causing drivers to reduce speed.

Solomon (1974) studied the relationships between factors affecting the accident rates on major rural highways. The most relevant findings of the study are:

- 1) The greater the difference in speed of a vehicle relative to the average roadway speed, the greater the chance of that vehicle being in an accident.
- 2) Local drivers tended to have higher accident rates than other drivers.
- 3) Passenger cars with low horsepower had higher involvement rates in accidents, possibly due to low acceleration capability.
- 4) Nearly half of all accidents were either rear-end collisions or same-direction sideswipes.
- 5) The proportion of angle collisions was highest at low speeds (less than 25 mph).
- 6) Drivers of older cars were more likely to be involved in an accident than drivers of newer vehicles.

Zaidel et al. (1986) studied the effectiveness of transverse paint stripes and similarly placed

rumble strips in inducing drivers to decrease speed and stop at intersections. They found that either application, rumble strips or paint stripes, had positive effects on driver behavior. The primary change in driver behavior attributed to the paint stripes was an increase in the percentage of drivers that stopped. In the before condition, 79 percent of the drivers made a complete stop, 11 percent made a rolling stop, and 10 percent did not stop. After application of the paint stripe treatment, 85 percent stopped, 7 percent rolled through, and 8 percent did not stop. The main effect of the rumble strips was a reduction in driver speeds. Specifically, intersection approach speeds were reduced by an average of 40 percent following the application of the rumble strips .

Stockton et al. (1981) have proposed criteria for the application of two-way Stop, Yield, and No Control at low-volume intersections. The researchers determined that intersection geometry does not play a significant role in either safety or operational considerations for choosing between control type (Stop, Yield, or No Control). However, major road volume did significantly affect accident potential at low-volume intersections and should be included in the criteria for determining the appropriate type of traffic control device. Stockton et al. (1981) also concluded that sight distance had no significant effect on accidents, as long as the sight distance was based on the “safe approach speed” of 10 mph recommended by the MUTCD for stop signs.

Mounce (1981) reports that the data from 2,830 observations at 66 intersections indicate that 1) the Stop sign violation rate decreases with increasing major roadway volume, 2) the violation rate is significantly higher when sight distance is unrestricted than it is when sight distance is restricted, and 3) there is no correlation between stop sign violation rates and accidents.

Mounce (1981) concluded that the operational effectiveness of low volume intersections could be enhanced without negatively affecting intersection safety by the application of no sign control when major roadway volumes are less than 2000 vpd, application of Yield sign control at major roadway volumes between 2000 - 5000 vpd, and, depending on minor roadway volume, application of Stop sign control or signalization when major roadway volumes exceed 5000 vpd.

Gattis (1995) has studied the effectiveness of supplemental signing for stop signs. The researchers performed the study by 1) reviewing the literature on the topic of supplemental signs that display the general message “CROSS TRAFFIC DOES NOT STOP,” 2) mailing out a survey to identify agencies that use supplemental signing on stop signs, and 3) surveying state and local highway officials concerning the effectiveness of supplemental signing for stop signs. Over 300 traffic officials responded to the survey.

Gattis (1995) concluded that the “CROSS TRAFFIC DOES NOT STOP” type of supplemental signing should be used on a limited basis. It should be in place at locations where there are repeated occurrences of possible misunderstandings regarding the assignment of intersection right of way. Otherwise, drivers may expect the sign at all two-way stop-controlled intersections.

Gattis (1995) cites a study by Pietrucha et al. that addressed the question of why drivers violate stop controls. Using data from field studies of 142 urban sites over 528 hours of observation, Pietrucha et al. found a 67.6 percent stop sign violation rate. Over a third of the drivers who violated the Stop sign stated they did so because cross-street volumes were low. Gattis notes that Pietrucha et al. reported that for major roadway volumes under 6000 vehicles per day, Stop sign violation rates decreased with increasing traffic volumes on the major roadway. Mounce (1981) reports similar results.

Chalupnik, in a 1998 study of the use of traffic control at low volume intersections in Minnesota, reports findings very similar to those of Stockton et al. (1981) and Mounce (1981). Specifically, Chalupnik found that for high speed, rural intersections, the type of control (Stop, Yield, and no control) has no appreciable effect on accident rates.

ANALYSIS OF FAILURE-TO-YIELD ACCIDENTS IN KANSAS

The analysis of accidents resulting from failure to yield the right-of-way at rural two-way stop controlled intersections in Kansas was accomplished by 1) developing a database containing information concerning roadway characteristics, environmental conditions, contributing

circumstances, traffic control and driver and vehicle characteristics for angle-collision motor vehicle accidents that occurred at rural state highway system intersections for the period 1994-1996, 2) selecting a preliminary sample of two-way stop controlled rural intersections with accidents attributable to failure-to-yield the right-of-way, 3) reviewing the accident reports for the intersections in the preliminary sample, and 4) conducting field studies at the intersections in the preliminary sample.

The results from the preliminary sample provided the basis for the design and implementation of a second sample of intersections that would permit a more comprehensive assessment of the problem. The second sample differed from the preliminary sample in that it included contributory factors in addition to “failure to yield the right-of-way”. The consideration of factors other than “failure to yield the right-of-way” was deemed important as this allowed for possible errors in reporting the cause(s) of the intersection accidents. The basic study tasks are described in detail in the following subsections of this report.

Database Development

The data used in this study were extracted from four data files provided by the Kansas Department of Transportation, Bureau of Transportation Planning. These files contained information concerning roadway characteristics, environmental conditions, driver and environmental circumstances that may have contributed to the accidents (contributing circumstances), traffic control and driver and vehicle characteristics for 1710 angle-collision motor vehicle accidents that occurred at rural state highway system intersections during the period 1994-1996.

The information in the file containing data concerning the driver, vehicle, roadway and environmental factors that may have contributed to the accidents was used as the basis for merging selected elements of the four databases into a single, master database. The master database included only those accidents for which “contributing circumstances” data were available. This database contained information for a total of 1462 angle-collision motor vehicle

accidents that occurred at rural state highway system intersections during the period 1994-1996. The following information concerning the most frequently cited driver actions that may have contributed to the accidents was extracted from the master data file. Note that failure to yield the right-of-way and driver inattention were cited as contributing factors in a substantial number of rural intersection angle-collision accidents.

<u>Driver Action</u>	<u>Percent of Accidents</u>
<i>Failed to Yield Right-of-Way</i>	42.1%
<i>Failed to Give Full Attention</i>	32.8%
<i>Disregarded Signs, Signals, Markings</i>	8.8%

The master database was used to create a third file that contained information on angle-collision accidents at two-way stop controlled rural intersections where “failure to yield the right-of-way” was reported as a contributing factor. This file contained information on 134 angle-collision accidents for the period 1994-1996.

Table 1 provides a comparison of the characteristics of angle-collision accidents at all rural intersections and angle-collision accidents attributable to “failure to yield the right-of-way” at two-way stop controlled rural intersections. The following observations concerning the information in Table 1 are relevant to objectives of this study.

- 1) The total number of accidents and the number of fail-to-yield accidents increased between 1994 and 1995.
- 2) Adverse weather or lighting conditions do not appear to be significant contributing factors in angle-collision accidents at rural intersections. The highest percent of total accidents and fail-to-yield accidents occurred during daylight hours between 12 noon and 6 pm. Likewise, roughly 85% of total accidents and fail-to-yield accidents occurred during “clear” weather conditions (i.e., no adverse weather

conditions were cited).

- 3) The percentage of fail-to-yield accidents that occurred on a Saturday is higher than the comparable percent for all accidents. The prevalence of fail-to-yield accidents on Saturdays could indicate that fail-to-yield accidents are related to trip purposes.

- 4) Fail-to-yield accidents were most prevalent during the summer months. In the case of all accidents, the highest accident frequencies were observed during the months of October through December.

Table 1. Summary of Characteristics for Rural Intersection Angle-Collision Accidents (1994-1996).

Characteristic	All Accidents ^a		Fail-to-Yield Accidents ^b	
	Number	Percent	Number	Percent
Year				
1994	489	28.6	41	30.6
1995	597	34.9	47	35.1
1996	624	36.5	46	34.3
Time of Day				
00:00 - 06:00	48	2.8	4	3.0
06:01 - 12:00	505	29.6	42	31.6
12:01 - 18:00	837	49.1	69	51.9
18:01 - 24:00	314	18.4	18	13.5
Day of Week				
Monday	219	12.8	14	10.4
Tuesday	232	13.6	16	11.9
Wednesday	234	13.7	23	17.2
Thursday	256	15.0	24	17.9
Friday	307	18.0	21	15.7
Saturday	255	14.9	23	17.2
Sunday	207	12.1	13	9.7
Quarter of Year				
January - March	331	19.4	32	23.9
April - June	452	26.4	31	23.1
July - September	446	26.1	39	29.1
October - December	481	28.1	32	23.9
Weather Conditions				
No Adverse Conditions	1489	87.1	113	84.3
Rain	113	6.6	10	7.5
Snow/Sleet/Freezing Rain	40	2.3	4	3.0
Fog	38	2.2	4	3.0
Strong Winds	21	1.2	3	2.2
Not Reported	9	0.5	-	-
Light Conditions				
Daylight	1328	77.7	102	76.1
Dawn/Dusk	84	4.9	8	5.9
Dark	284	16.6	23	17.2
Not Reported	14	0.8	1	0.7

^a All angle-collision accidents for which “contributing circumstances” data were available for the period 1994-96 (1462 accidents).

^b Angle-collision accidents at two-way stop controlled intersections where “fail-to-yield” was reported as a contributing factor for the period 1994-96 (134 accidents).

Identification of Preliminary Study Sites

Intersection accident frequencies were tabulated for the 134 angle-collision accidents that occurred at two-way stop controlled rural intersections where “failure to yield the right-of-way” was reported as a contributing factor. A preliminary sample of 10 intersections that experienced more than one accident during the analysis period (1994-96) was selected for preliminary, exploratory analyses. The 10 intersections selected for the preliminary analyses were intended to represent a cross-section of locations and roadway types. Table 2 provides a listing of the intersections selected for the preliminary analyses. Note that over 50% of the intersections selected are not isolated rural intersections. However, because the objective of this study was to identify contributing factors in fail-to-yield accidents, the inclusion of sites with more than one accident was considered to be important regardless of the location of the intersection.

Table 2. Summary of Preliminary Intersection Study Sites.

Intersection Approach ^a		Number of “Fail To Yield” Accidents (1994-96)	Location (County)
On Route (Uncontrolled Approach)	At Route (Stop Controlled Approach)		
K015	Clifton	2	Sedgwick
K042	263 rd	2	Sedgwick
K061	43 rd	2	Reno
K196	K254	2	Butler
U024	K014	2	Mitchell
U036	M Street	2	Republic
U056	Industrial	2	Johnson
U081	79 th Street	2	Sedgwick
K263	Angela	3	Miami
K015	K018 (W. Jct.)	2	Dickinson

^a Intersection approach identification follows the CANSYS database “On Route/At Route” notation. “On route” denotes the highway on which the accident occurred. “At route” denotes the intersecting roadway.

Review of Accident Reports for the Preliminary Sample

The initial task in analyzing the preliminary sample of intersections was to obtain and review the individual intersection accident reports. Table 3 provides a summary of selected information extracted from the accident reports. The following general observations can be made concerning the information summarized in Table 3.

- 1) Over 75% of the accidents occurred during daylight conditions.
- 2) 29% of all drivers involved in the accidents at the preliminary study sites were 60 years of age or older.
- 3) 38% of all drivers involved in the accidents at the preliminary study sites were 20 years of age or younger.
- 4) 60% of the accidents involved drivers attempting a left-turn maneuver onto the major roadway.
- 5) Only two accidents involved minor roadway drivers who failed to stop before entering the intersection.
- 6) 76% of the accidents at the study sites involved situations where vehicles on the major roadway hit vehicles entering the intersection from the minor roadway.

Table 3. Accident Report Summaries for the Preliminary Study Sites.

Intersection Approach		Accident Report Number	Time of Accident	Age of Drivers ^a	Accident Description
On Route (Uncontrolled Approach)	At Route (Stop Controlled Approach)				
K015	Clifton	1. 199500310830 2. 199600466180	1440 1550	28/50 25/43	1. Driver stopped at Stop sign on EB approach. Attempted left turn onto K-15 and was hit by SB veh on K-15. 2. Driver stopped at Stop sign on EB approach. Attempted left turn onto K-15 and was hit by SB veh on K-15.
K042	263 rd	1. 199500476880 2. 199500641200	1630 1540	37/43/52 84/18	1. Driver ran the Stop sign on SB approach. Attempted SB crossing maneuver and was broad-sided by EB veh on K-42. Driver subsequently spun into a third veh stopped at NB approach of 263 rd . 2. Driver stopped at Stop sign on NB approach. Attempted left turn onto K-42 and was hit by EB veh on K-42.
K061	43 rd	1. 199400300890 2. 199400539450	1640 1100	38/18 56/51	1. Driver attempted EB crossing maneuver on 43 rd and was hit by NB veh on K-16. 2. Driver stopped at Stop sign. Attempted EB crossing maneuver on 43 rd and hit NB veh on K-16.
K196	K254	1. 199500201270 2. 199500201260	0930 1105	69/19 55/38	1. Driver stopped at Stop sign on SB approach. Attempted left turn onto K-254 and was hit by WB veh on K-254. 2. Driver stopped at Stop sign on SB approach. Attempted left turn onto K-254 and was hit by WB veh on K-254.
U024	K014	1. 199400526230 2. 199600590270	2230 1130	77/24 82/39	1. Driver stopped at Stop sign. Attempted NB crossing maneuver and was hit by WB veh on K-24. 2. Driver stopped at Stop sign. Attempted SB crossing maneuver and hit EB veh on K-24.
U036	M Street	1. 199400433730 2. 199600726170	1705 1440	37/39 88/61	1. Driver stopped at Stop sign on SB approach. Attempted left turn onto US-36 and was hit by WB veh on US-36. 2. Driver stopped at Stop sign on SB approach. Attempted left turn onto US-36 and hit EB veh on US-36.

Table 3. (Cont.)

Intersection Approach		Accident Report Number	Time of Accident	Age of Drivers ^a	Accident Description
On Route (Uncontrolled Approach)	At Route (Stop Controlled Approach)				
U056	Industrial	1. 199400281230 2. 199600135720	1425 1905	56/27 NA/39	1. Driver stopped at Stop sign on NB approach. Attempted left turn onto US-56 and was hit by EB veh on US-56. 2. Driver ran the Stop sign on NB approach and hit EB veh on US-56. Driver fled the scene.
U081	79 th Street	1. 199400399100 2. 199500069250	2030 0930	54/52 29/68	1. Driver stopped at Stop sign on EB approach. Attempted left turn onto US-81 and hit NB veh on US-81. 2. Driver stopped at Stop sign on EB approach. Attempted left turn onto US-81 and was hit by SB veh on US-81
K263	Angela	1. 199500485110 2. 199600107680 3. 199600598080	2230 1900 0745	16/18 18/40 34/16/28	1. Driver stopped at Stop sign. Attempted SB crossing maneuver and was hit by EB veh on K-263. 2. Driver stopped at Stop sign on NB approach. Attempted left turn onto K-263 and was hit by EB veh on K-263. 3. Driver stopped at Stop sign on NB approach. Attempted left turn onto K-263 and was hit by WB veh on K-263. WB veh subsequently struck a third veh stopped on SB approach of Angela.
K015	K018 (W. Jct.)	1. 199400135490 2. 199600036910	1635 1615	34/26 61/65	1. Driver stopped at Stop sign on NB approach. Attempted NB crossing maneuver and was hit by WB veh on K-18. 2. Driver stopped at Stop sign on NB approach. Attempted NB crossing maneuver and was hit by WB veh on K-18.

^a First entry denotes age of “fail-to-yield” driver. Subsequent entries indicate age of other drivers involved in the accident.

The review of the preliminary study site accident reports suggests that many fail-to-yield accidents may be due to the inability of drivers entering the intersection from minor roadways to accurately judge the speed of vehicles on the major roadway. The failure of drivers to allow sufficient time to accelerate to major roadway speed is particularly critical in left-turn maneuvers from the minor (Stop-controlled) roadway. This inability to judge speeds may be a function of the driver's age. Young, inexperienced drivers (38% of the drivers at the preliminary study sites) and older drivers (29% of the drivers at the preliminary study sites) may be particularly prone to misjudge the speeds of oncoming vehicles.

Field Studies at the Preliminary Study Sites

Field studies were conducted at each of the preliminary study sites to identify any intersection-specific conditions that may have contributed to the fail-to-yield accidents. Photographs of the study sites are provided in the Appendix of this report. A description of the conditions observed at the study sites is provided below.

K-15 and Clifton

Clifton is a two-lane residential collector with a posted speed limit of 30 mph. K-15 is a four-lane divided highway with a posted speed of 50 mph. The intersection is just south of the intersection of K-15 and MacArthur in far southeast Wichita. The intersection experienced two fail-to-yield accidents during the period 1994-1996. Both accidents involved vehicles attempting left-turns from Clifton onto K-15. The intersection is a "T" intersection with good sight distance on all approaches to the intersection (see Photo 1, Appendix).

K-42 and 263rd Street West

The minor roadway (263rd Street) is a two-lane rural arterial street with a posted speed of 55 mph. K-42 is a two-lane state highway with a posted speed of 55 mph. The intersection is just north of the city of Viola in southwest Sedgwick County. The intersection experienced two fail-

to-yield accidents during the period 1994-1996. One accident involved a vehicle attempting a left-turn from 263rd onto K-42. The second accident involved a vehicle attempting a south bound crossing maneuver on 263rd. The intersection is a skewed intersection with 263rd running north and south and K-42 running northeast and southwest. There is a convenience store in the northeast quadrant of the intersection but sight distances appear to be adequate (see Photo 2).

K-61 and 43rd Avenue

The minor roadway (43rd Avenue) is a two-lane rural collector highway with a posted speed of 55 mph. K-61 is a two-lane state highway with a posted speed of 55 mph. The intersection is just north of the city of Hutchinson in Reno County. The intersection experienced two fail-to-yield accidents during the period 1994-1996. Both accidents involved vehicles attempting crossing maneuvers on 43rd Avenue. K-61 has a gentle grade through the intersection but sight distances appear adequate on all approaches to the intersection (see Photo 3).

K-196 and K-254

The intersection of K-196 and K-254 is a “T” intersection just west of the city of El Dorado in Butler County. In 1995, the intersection experienced two fail-to-yield accidents. At that time the intersection was an at-grade intersection. Sometime after 1995 the intersection was reconstructed and is now a grade separated intersection. As a result, no site visit/investigation was possible.

US-24 and K-14

The intersection of US-24 and K-14 is located just north of the city of Beloit in Mitchell County. Both roadways have posted speed limits of 45 mph. The intersection experienced two fail-to-yield accidents during the period 1994-1996. Both accidents involved vehicles on K-14 (Stop controlled) attempting to cross US-24. US-24 has a slight grade through the intersection but sight distance is good on all four approaches to the intersection (see Photo 4).

US-36 and M Street

The intersection of US-36 and M Street is a “T” intersection on the southern edge of the city of Belleville in Republic County. The intersection experienced two fail-to-yield accidents during the period 1994-1996. Both accidents involved vehicles on M Street (Stop controlled) attempting to make a left turn onto US-36. There is considerable “visual clutter” (signs, utility poles, etc.) along US-36, but sight distances appear to be adequate (see Photo 5).

US-56 and Industrial

The intersection of US-56 and Industrial is a “T” intersection on the eastern edge of the city of Gardner, Johnson County. The intersection experienced two fail-to-yield accidents during the period 1994-1996. Both accidents involved vehicles on Industrial (Stop controlled) attempting to make a left turn onto US-56. The posted speed on US-56 is 50 mph. Industrial has a posted speed of 35 mph. Industrial intersects US-56 on a long horizontal curve, but sight distances appear to be adequate on all approaches to the intersection (see Photo 6).

US-81 and 79th Street

The intersection of US-81 and 79th Street is located south of Wichita in Sedgwick County. The intersection experienced two fail-to-yield accidents during the period 1994-1996. Both accidents involved vehicles on 79th Street (Stop controlled) attempting to make a left turn onto US-81. The posted speed on US-81 is 50 mph and 79th Street has a posted speed of 35 mph. There are utility poles and large trees along the western edge of US-81, but sight distances appear to be adequate on all approaches to the intersection (see Photo 7).

K-263 and Angela

The intersection of K-263 and Angela is located in the city of Paola in Miami County. The

intersection experienced three fail-to-yield accidents during the period 1994-1996. Two of the accidents involved vehicles on Angela (Stop controlled) attempting to make a left turn onto K-263. The third accident involved a vehicle on Angela (Stop controlled) attempting to cross K-263. The posted speed on K-263 is 45 mph. Angela has a posted speed of 30 mph. Angela is basically a driveway serving commercial activities on both sides of K-263. Sight distances appear to be adequate on all approaches to the intersection (see Photo 8).

K-15 and K-18 (W. Jct.)

The intersection of K-15 and K-18 is an isolated rural intersection in Dickinson County. The intersection experienced two fail-to-yield accidents during the period 1994-1996. Both of the accidents involved vehicles on K-15 (Stop controlled) attempting to cross K-18. The posted speed on both roadways is 55 mph. K-15 intersects K-18 near the crest of a long vertical curve and sight distance to the west of K-15 may be restricted (see Photo 9). It should be noted, however, that both accidents involved westbound vehicles on K-18 (i.e., vehicles approaching the crest of the vertical curve on K-18).

Identification of Study Sites for the Second Sample

The second sample of intersections was drawn from a list of high accident frequency locations (HAFL) provided by the KDOT, Bureau of Traffic Engineering. As noted earlier in this report, the intent of the second sample was to broaden the investigation to include contributing circumstances in addition to “failure to yield the right-of-way.” The original intent was to examine 10 HAFL locations. However, due to recent intersection improvement projects at several of the intended study sites, the sample was reduced to seven intersections. The seven intersections in the second sample are listed below.

1. US 54 and 119th W. (Sedgwick County).

2. US 50 and Schulman (Finney County).
3. K 61 and E. 43rd St. (Reno County).
4. K 68 and Old KC Rd. (Miami County).
5. US 160 and C3 (Cowley County).
6. US 50 and K 156 (Finney County).
7. US 69 and K 126 (Crawford County).

Review of Accident Reports for the Second Sample

Tables 4 through 10 provide summaries of key information extracted from the intersection accident reports for the intersections in the second sample. Note that each of the intersections in the second sample experienced at least 10 accidents during the analysis period. The following observations concerning the study objectives can be drawn from the information presented in Tables 4 - 10.

- 1) Eighty-seven (87) percent of the accidents were attributed to drivers failing to yield the right-of-way.
- 2) For the accidents attributed to failure to yield the right-of-way, 15% involved drivers 20 years of age or younger. Sixteen percent involved drivers 60 years of age or older. While these percentages are substantially lower than those observed in the preliminary sample, there still appears to be a relatively high percentage (over 30%) of "fail to yield" accidents that involve younger and older drivers.
- 3) Seventy-nine (79) percent of the accidents occurred during daylight hours.
- 4) Eight-eight (88) percent of the accidents involved situations where vehicles on the major roadway collided with vehicles entering the intersection from the minor roadway.

- 5) Twenty-seven (27) percent of the accidents involved vehicles attempting a left turn from the minor roadway. Note that this is substantially lower than the comparable percentage observed in the preliminary sample (in the preliminary sample, 60% of the accidents involved left-turning vehicles).

- 6) Only 11 % of the accidents involved situations where the accident report explicitly stated that the offending driver failed to stop at the intersection.

Table 4. Accident Report Summaries for the Intersection of U054 and 119th W.

Intersection Approach		Accident Report Number	Time of Accident	Contributing Circumstance (See Table 11)	Age of Drivers ^a	Accident Description
On Road	At Road					
U054	119 th W.	1. 199400398890	0015	D-02	20/_	Driver SB on 119 th ran a stop sign and was struck by WB vehicle on U54
U054	119 th W.	2. 199400639060	1115	D-16	63/75	Driver was attempting a left turn onto 119 th and turned in front of an oncoming vehicle.
U054	119 th W.	3. 199400117670	1250	D-16, D-03	16/26	Driver SB on 119 th , failed to yield at intersection of 119 th and 54 and struck EB vehicle on 54
U054	119 th W.	4. 199400261700	0840	D-03	46/34	Driver NB on 119 th pulled out from stop sign in front of W.B. vehicle on U054.
U054	119 th W.	5. 199400249600	2205	D-03	51/49	Driver EB on U054 failing to yield, turned left in front of vehicle WB
U054	119 th W.	6. 199500475300	2050	D-03, D-16	70/25	Driver EB on U054 failing to yield, turned left in front of vehicle WB
U054	119 th W.	7. 199500475320	1600	D-03	19/25	Driver SB on 119 th failed to yield at the intersection and hit WB vehicle on U054
U054	119 th W.	8. 199500225220	0815	D-03	32/32	Driver WB on U054 failing to yield, turned left onto 119 th in front of EB vehicle and was struck
U054	119 th W.	9. 199500435130	1505	D-03	16/16	Driver EB on U054 failing to yield, turned left onto 119 th and was struck by a vehicle WB on U054
U054	119 th W.	10. 199500437240	1625	D-03, D-16	25/18	Driver WB on U054 failing to yield, turned in front of vehicle EB on U054
U054	119 th W.	11. 199500647800	1900	D-16	20/25	Driver failed to yield and attempted a left turn onto 119 th , and was struck by EB vehicle on U054
U054	119 th W.	12. 199500247050	1702	D-07, D-16	36/17	Driver failed to yield and attempted a left turn onto 119 th , and was struck by vehicle EB on U054
U054	119 th W.	13. 199500717600	1630	D-03, D-16	22/59	Driver NB on 119 th failed to yield at stop sign and was hit by vehicle EB on U054
U054	119 th W.	14. 199500719580	1535	D-03	66/33	Driver making a left turn onto 119th failed to yield right of way and was struck by a vehicle WB on U054
U054	119 th W.	15. 199600350610	1650	D-03	32/23	Driver WB on U054 failed to yield while attempting a left turn onto 119 th and was struck by EB vehicle on U054

^a First entry denotes age of “fail-to-yield” driver. Subsequent entries indicate age of other drivers involved in the accident.

Table 5. Accident Report Summaries for the Intersection of U050 and Schulman Ave.

Intersection Approach		Accident Report Number	Time of Accident	Contributing Circumstance (See Table 11)	Age of Drivers ^a	Accident Description
On Road	At Road					
U050	Schulman	1. 199400051740	2150	D-03, D-16, D-06	40/16	Driver on Schulman made a running stop and was hit by a vehicle on U050
U050	Schulman	2. 199400053800	1450	D-4, D-16	27/_	Driver EB on Schulman failed to stop and hit NB vehicle on U050
U050	Schulman	3. 199400139610	2035	D-03, D-04, D-16	44/50	Driver EB on Schulman failed to stop and hit NB vehicle on U050
U050	Schulman	4. 199400070280	2230	D-03, D-04	34/16	Driver WB on Schulman failed to stop and struck NB vehicle on U050
U050	Schulman	5. 199400626930	1510	D-03, D-16	18/26	Driver WB on Schulman stopped at the stop sign then entered the intersection and was struck by SB vehicle
U050	Schulman	6. 199500041040	1225	D-03, D-16, D-05	17/24	Driver EB on Schulman failed to yield to vehicle NB on U050 and hit him
U050	Schulman	7. 199500200810	1215	D-03, D-16, D-13	16/29	Driver WB on Schulman stopped at the stop sign then entered the intersection and was struck by NB vehicle
U050	Schulman	8. 199500218500	1430	D-12,16	24/28	Driver WB on U050 attempted left turn onto Schulman Ave. another car WB on U050 attempted to pass him .
U050	Schulman	9. 199500226690	1237	D-3, D-15	27/44	Driver EB on Schulman pulled out from the stop sign and was hit by NB vehicle on U050
U050	Schulman	10. 199500715230	1050	D-16,03	39/46	Driver WB on Schulman pulled into intersection in front of another vehicle on U050
U050	Schulman	11. 199500723140	1853	D-02, D-03, D-04, D-16	38/29	Driver WB on Schulman failed to yield and collided with a vehicle SB on U050
U050	Schulman	12. 199600250480	0836	D-16, D-03	37/58	Driver WB on Schulman pulled out from the stop sign into the path of vehicle SB on U050
U050	Schulman	13. 199600590050	2005	D-03	25/47	Driver NB on U050 attempting a left turn, failed to yield and was struck by a vehicle WB on Schulman.

^a First entry denotes age of “fail-to-yield” driver. Subsequent entries indicate age of other drivers involved in the accident.

Table 6. Accident Report Summaries for the Intersection of K61 and E. 43rd Ave.

Intersection Approach		Accident Report Number	Time of Accident	Contributing Circumstance (See Table 11)	Age of Drivers ^a	Accident Description
On Road	At Road					
K61	E. 43 rd Ave	1. 199400050080	1505	D-03	38/60	Driver WB on 43 rd , after stopping at the stop sign, started to cross K61 and was struck by SB vehicle on K61
K61	E. 43 rd Ave	2. 199400109550	1640	--	19/37	Driver was attempting a left turn onto 43 rd and was hit from behind
K61	E. 43 rd Ave	3. 199400187710	2050	D-02, D-03, D-04, D-16	50/83	Driver WB on 43 rd failed to yield at the stop sign and struck vehicle SB on K61
K61	E. 43 rd Ave	4. 199400300900	1515	D-03	27/55	Driver WB on 43 rd failed to yield at a stop sign and struck NB vehicle on K61
K61	E. 43 rd Ave	5. 199400300890	1641	D-03	18/33	Driver EB on 43 rd failed to yield and struck NB vehicle on K61
K61	E. 43 rd Ave	6. 199400539450	1100	D-03, D-16	56/51	Driver EB on 43 rd pulled out from the stop sign in front of a vehicle NB on K61
K61	E. 43 rd Ave	7. 199500472640	0750	--	16/27	Driver EB on 43 rd stopped, then attempted a left turn in front of a WB vehicle on K61
K61	E. 43 rd Ave	8. 199500012930	0750	D-03, D-16	15/44	Driver WB on 43 rd stopped at stop sign then pulled into traffic and was hit by SB vehicle on K61
K61	E. 43 rd Ave	9. 199600073170	1505	D-03	56/55	Driver WB on 43 rd was unable to stop at K61 and was hit by NB vehicle on K61
K61	E. 43 rd Ave	10. 199600073180	1620	D-03	52/44	Driver WB on 43 rd stopped at stop sign and proceeded to cross K61 and was struck by SB vehicle on K61
K61	E. 43 rd Ave	11. 199600089120	1850	D-12	25/41	Driver SB on K61 attempted a left turn onto 43rd. Another vehicle on K61 tried to pass as SB driver was turning and collided with SB veh.
K61	E. 43 rd Ave	12. 199600246660	2053	D-12, D-16	62/16	Driver NB on K61 was turning left onto 43 rd when another vehicle on K61 started to pass and they hit.
K61	E. 43 rd Ave	13. 199600089130	1043	D-03	17/20	Driver WB on 43 rd failed to yield at a stop and started across K61 where he hit a SB vehicle on K61

^a First entry denotes age of “fail-to-yield” driver. Subsequent entries indicate age of other drivers involved in the accident.

Table 7. Accident Report Summaries for the Intersection of K68 and Old K.C. Rd.

Intersection Approach		Accident Report Number	Time of Accident	Contributing Circumstance (See Table 11)	Age of Drivers ^a	Accident Description
On Road	At Road					
K68	Old K.C. Rd	1. 199400128300	1550	D-03, D-16	52/54	Driver SB on Old KC, failed to yield at the stop and pulled into the path of vehicle on K68
K68	Old K.C. Rd	2. 199400266790	0750	D-03, D-16	70/19	Driver NB on Old KC failed to yield at the stop and pulled out in front of a vehicle EB on K68
K68	Old K.C. Rd	3. 199400050760	1725	D-03, D-16	22/46	Driver SB on Old KC failed to yield at the stop , pulled out into the intersection and was hit by EB vehicle on K68
K68	Old K.C. Rd	4. 199400053340	1720	D-03	24/25	Driver SB on Old KC failed to yield at intersection and proceeded across K68 and hit EB vehicle on K68
K68	Old K.C. Rd	5. 199400463020	1505	D-03, D-16	26/55	Driver NB on Old KC failed to yield at stop and pulled out into the path of EB vehicle on K68
K68	Old K.C. Rd	6. 199500439310	1818	D-03, D-07, D-16	26/32	Driver NB on Old KC, failing to yield, turned left into the path of EB vehicle on K68
K68	Old K.C. Rd	7. 199500375090	1120	D-02, D-03	42/36	Driver SB on Old KC failed to yield at stop and pulled into intersection in front of EB vehicle on K68
K68	Old K.C. Rd	8. 199500644860	1655	D-03, D-16	17/32	Driver NB on Old KC failed to yield at stop and pulled out in front of WB vehicle on K68
K68	Old K.C. Rd	9. 199500033070	0810	D-06	43/39	Driver SB on Old KC was unable to stop due to snow and collided with WB vehicle on K68
K68	Old K.C. Rd	10. 199500181040	1005	D-03, D-16	30/30	Driver NB on Old KC failed to yield the right of way and was struck by WB vehicle on K68
K68	Old K.C. Rd	11. 199600060900	1535	D-03, D-16	46/25	Driver NB on Old KC failed to yield at the stop and drove into the path of WB vehicle on K68
K68	Old K.C. Rd	12. 199600314530	1555	D-03	18/24	Driver NB on Old KC failed to yield the right of way at the stop and pulled into the path of WB vehicle on K68
K68	Old K.C. Rd	13. 199600736830	1245	D-03, D-16	47/88	Driver SB on Old KC failed to yield at the stop and crossed in front of EB vehicle on K68

^a First entry denotes age of “fail-to-yield” driver. Subsequent entries indicate age of other drivers involved in the accident.

Table 8. Accident Report Summaries for the Intersection of U160 and C3.

Intersection Approach		Accident Report Number	Time of Accident	Contributing Circumstance (See Table 11)	Age of Drivers ^a	Accident Description
On Road	At Road					
U160	C3	1. 199400070630	1610	--	43/22	Driver SB on C3 failed to yield at stop sign and started across in front of EB vehicle on U160
U160	C3	2. 199400175910	0700	--	48/37	Driver NB on C3 failed to yield at stop and crossed in front of EB vehicle on U160
U160	C3	3. 199400254940	0933	D-03	70/68	Driver SB on C3 failed to yield at stop and was struck by EB vehicle on U160
U160	C3	4. 199400427140	1115	D-04	23/44	Driver NB on C3 failed to yield at stop and ran into EB vehicle on U160
U160	C3	5. 199400223690	1440	D-03	27/21	Driver SB on C3 failed to yield at stop and was hit by EB vehicle on U160
U160	C3	6. 199400672530	2025	--	35/44	Driver SB on C3 failed to yield at stop and was hit by EB vehicle on U160
U160	C3	7. 199500239310	1255	D-03	24/57	Driver NB on C3 failed to yield at stop and was hit by WB vehicle on U160
U160	C3	8. 199500251290	0905	--	31/72	Driver SB on C3 failed to yield at stop and was hit by EB vehicle on U160
U160	C3	9. 199500299190	2155	D-03	25/60	Driver SB on C3 failed to yield at stop and was hit by EB vehicle on U160
U160	C3	10. 199500089330	1415	D-06	37/47	Driver SB on C3 was unable to stop due to icy road and slid out into the intersection in front of WB vehicle on U160

^a First entry denotes age of “fail-to-yield” driver. Subsequent entries indicate age of other drivers involved in the accident.

Table 9. Accident Report Summaries for the Intersection of U050 and K156.

Intersection Approach		Accident Report Number	Time of Accident	Contributing Circumstance (See Table 11)	Age of Drivers ^a	Accident Description
On Road	At Road					
U50	K156	1. 199400187620	1245	D-03, D-04, D-16	28/53	Driver EB on K156 failed to yield at stop and was hit by SB vehicle on U050
U50	K156	2. 199400458850	0655	D-03, D-16	41/47	Driver WB on K156 failed to yield at stop and was struck by NB vehicle on U050
U50	K156	3. 199400490970	1020	D-04	77/57	Driver WB on K156 failed to stop at intersection and struck NB vehicle on U050
U50	K156	4. 199400053010	1300	D-03, D-16	75/30	Driver EB on K156 ran stop sign and was hit by NB vehicle on U050
U50	K156	5. 199400098080	1615	D-03, D-16	82/56	Driver EB on K156 was attempting to make a left turn onto U50 and was hit by a vehicle NB on U050
U50	K156	6. 199400223260	1530	D-03	47/50	Driver EB on K156 failed to yield at the stop and hit a vehicle NB on U050
U50	K156	7. 199400262540	1745	D-09, D-16, D-02, D-03	21/_	Driver involved in a single car accident
U50	K156	8. 199500084950	1730	D-02, D-03, D-16	41/26	Driver EB on K156 failed to yield at the stop and was hit by NB vehicle on U050
U50	K156	9. 199500343170	1245	D-03, D-16	79/18	Driver EB on K156 failed to yield at stop and was hit by SB vehicle on U050
U50	K156	10. 199500724010	1245	D-04	41/42	Driver EB on K156 failed to stop at the stop sign and hit SB vehicle on U050

^a First entry denotes age of “fail-to-yield” driver. Subsequent entries indicate age of other drivers involved in the accident.

Table 10. Accident Report Summaries for the Intersection of U069 and K126.

Intersection Approach		Accident Report Number	Time of Accident	Contributing Circumstance (See Table 11)	Age of Drivers ^a	Accident Description
On Road	At Road					
U069	K126	1. 199400454990	1720	--	24/66	Driver WB on U069, failed to yield at stop and turned left into the path of SB vehicle on K126 who was turning left.
U069	K126	2. 199400227230	1218	D-03, D-16	23/30	Driver NB on U069 failed to yield at stop and struck EB vehicle on K126
U069	K126	3. 199400491070	1645	D-03, D-16	74/57	Driver NB on U069 failed to yield right of way at stop and struck SB vehicle on U069 who was making a left turn
U069	K126	4. 199400619420	0905	D-03	21/64	Driver WB on K126 failed to yield and struck SB vehicle on U069
U069	K126	5. 199500153250	1815	D-03	77/29	Driver SB on U069 failed to yield at stop and struck WB vehicle on K126
U069	K126	6. 199500165330	1420	D-03	60/64	Driver WB on K126 failed to yield at stop and attempted a left turn . NB vehicle on U069 collided with WB veh.
U069	K126	7. 199500612890	1425	D-03, D-04, D-16	44/90	Driver SB on U069 failed to yield at stop and struck WB vehicle on K126
U069	K126	8. 199500153070	0726	D-16	41/31	Driver NB on U069 failed to yield at stop and struck EB vehicle on K126
U069	K126	9. 199500193370	1401	D-03, D-16	85/32	Driver WB on K126 failed to yield right of way at stop and pulled out in front of SB vehicle on U069
U069	K126	10. 199600306640	1600	--	81/60	Driver EB on K126 failed to yield at stop and pulled across intersection in front of SB vehicle on U069

^a First entry denotes age of “fail-to-yield” driver. Subsequent entries indicate age of other drivers involved in the accident.

Table 11. Contributing Circumstance Codes (Driver).

- 01 Under influence of drugs
- 02 Under the influence of alcohol
- 03 Failed to yield right of way
- 04 Disregarded traffic signs, signals, or road markings
- 05 Exceeded posted speed
- 06 Too fast for conditions
- 07 Made improper turn
- 08 Wrong side or wrong way
- 09 Followed too closely
- 10 Improper lane change
- 11 Improper backing
- 12 Improper passing
- 13 Improper or no signal
- 14 Improper parking
- 15 Fell asleep, fainted, ill, etc.
- 16 Failed to give full time and attention
- 17 Did not comply with license restrictions
- 18 Interference/obstruction by passenger

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Based on the results of the literature review, field investigations and analyses of the accident reports for a sample of fail-to-yield accidents, the following basic hypothesis concerning the causes of fail-to-yield accidents at two-way Stop controlled intersections is suggested.

The majority of the accidents reviewed in this study do not appear to be directly related to Stop sign violations. The majority of the accidents appear to be due to drivers who enter the major roadway and do not (or cannot) accelerate quickly enough to avoid being struck by major roadway vehicles. This would suggest that drivers on the minor roadway either did not see oncoming vehicles or failed to accurately estimate the speeds of oncoming vehicles on the major roadway. This hypothesis, if correct, suggests that effective solutions to the “fail-to-yield” problem may have to focus on the entire intersection, including the major roadway approaches to the intersection. Treatments to reduce the speeds of vehicles on the major roadway approaches to two-way Stop controlled intersections should be considered. Such treatments could include advance warning signs and reduced speed zones.

Findings from a recent Nebraska study suggest that stationary observers may, in fact, have difficulty estimating the speeds of oncoming vehicles. Buhman et al. (undated report) have studied the ability of stationary observers to estimate oncoming vehicle velocities at urban and rural locations in "natural" (live) traffic settings and laboratory (videotape) environments. Buhman and his colleagues report the following results from their studies.

- 1) The results from field studies where observers were seated 3 to 5 meters from the roadway shoulders indicate that observers consistently underestimate oncoming vehicle speeds in rural environments and consistently overestimate oncoming vehicle speeds in urban environments. The researchers observed a consistent bias in the speed estimates in terms of vehicle size. Specifically, the test subjects tended to more accurately estimate the

speeds of larger vehicles (sedans, commercial vehicles and large trucks) than smaller, compact vehicles and motorcycles. Given the trends toward smaller vehicles on the roadway, this vehicle size bias is particularly germane to the present study.

- 2) In the laboratory setting, where test subjects viewed the roadway study sections on video tape, the overall speed estimates were consistently lower than those obtained from the field study method. The laboratory tests included videotape displays with and without sound. The researchers hypothesized that the "removal of tactile and vestibular cues (i.e., acceleration) in the laboratory condition may have caused the decline in speed estimates." Buhman and his colleagues note that "The decrease in performance [i.e., ability to accurately estimate vehicle speeds] in the laboratory setting is consistent with previous research findings." It could be observed that the laboratory conditions used by Buhman et al. are not entirely unlike those experienced by drivers inside an automobile waiting at a rural intersection.

With regards to potential treatments to reduce the speeds of vehicles on the major roadway approaches to two-way Stop controlled intersections, the work of Lyles (1980) is particularly noteworthy. Lyles evaluated the effectiveness of six different sign treatments (or sign sequences) for two-lane rural highways in informing motorists of an intersection on the road ahead. The six treatments studied by Lyles are shown in Figure 1.

Lyles (1980) reports that "a regulatory speed-zone configuration and lighted warning signs were more effective than more traditional unlighted warning signs in reducing motorists' speeds in the vicinity of the intersection and in increasing their awareness of both the signs and conditions at the intersection." Of the six treatments evaluated, Lyles reported that the activated "when flashing" sign configuration was the most effective in reducing motorists' speeds.

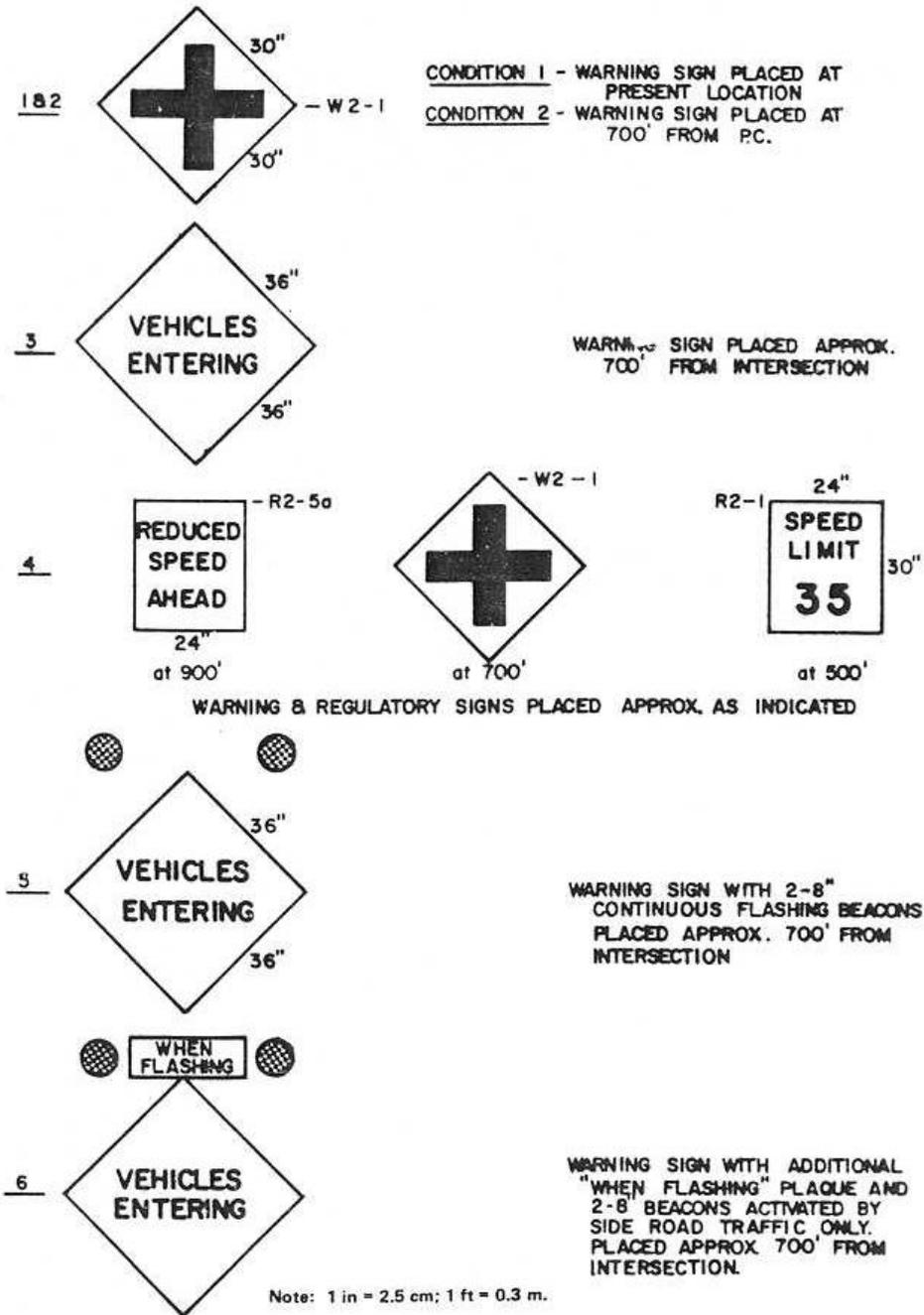


Figure 1. Sign Treatments Evaluated by Lyles (1980).

Recommendations

The results of this study (and previous studies) suggest that disregard for Stop signs and other traffic control devices is not the primary cause of accidents at rural two-way stop controlled intersections. The majority of the accidents appear to be due to drivers who enter the major roadway and do not (or cannot) accelerate quickly enough to avoid being struck by major roadway vehicles. This would suggest that drivers on the minor roadway either did not see oncoming vehicles or failed to accurately estimate the speeds of oncoming vehicles on the major roadway. On the basis of these conclusions, the following general recommendations are put forth for the department's consideration.

- 1) The Department should continue to follow its current signing practices on the minor roadway approaches of rural intersections.

- 2) In the case of rural two-way stop controlled intersections where accident histories indicate characteristics similar to those reported in this study, the Department should consider implementing signing treatments directed at reducing the speeds of motorists' on the major roadway in the vicinity of the intersection. The treatments evaluated by Lyles (1980) provide a useful starting point for identifying appropriate treatments.

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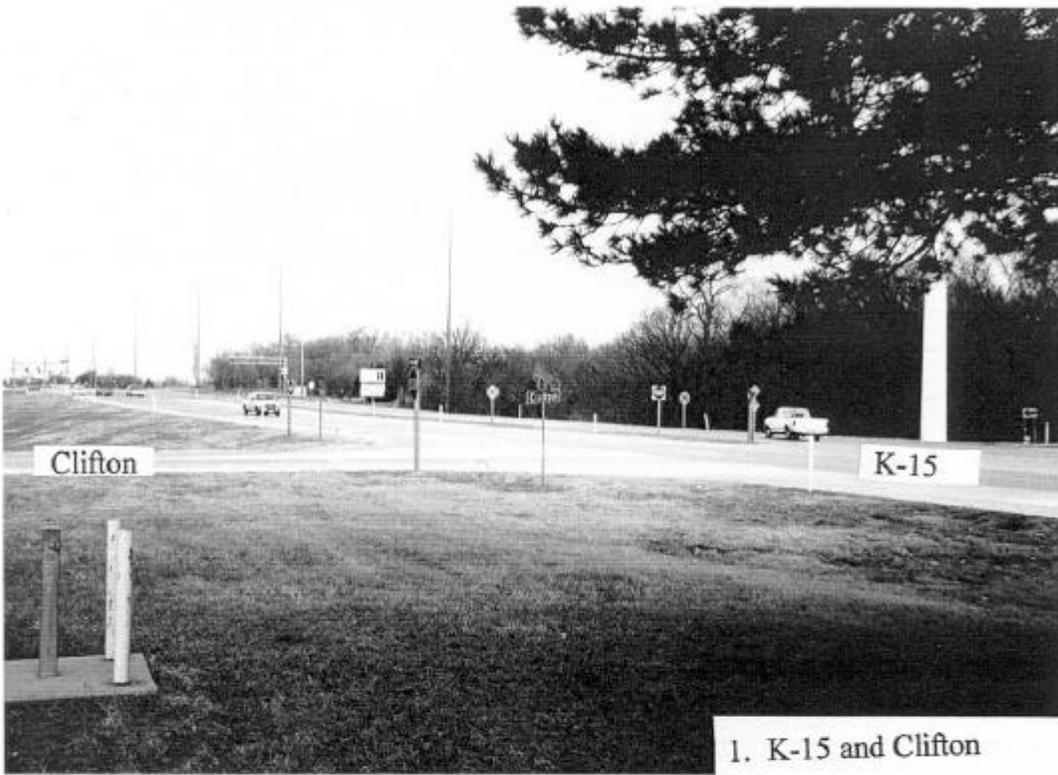
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APPENDIX: PHOTOS OF PRELIMINARY STUDY SITES





3. K-61 and 43rd



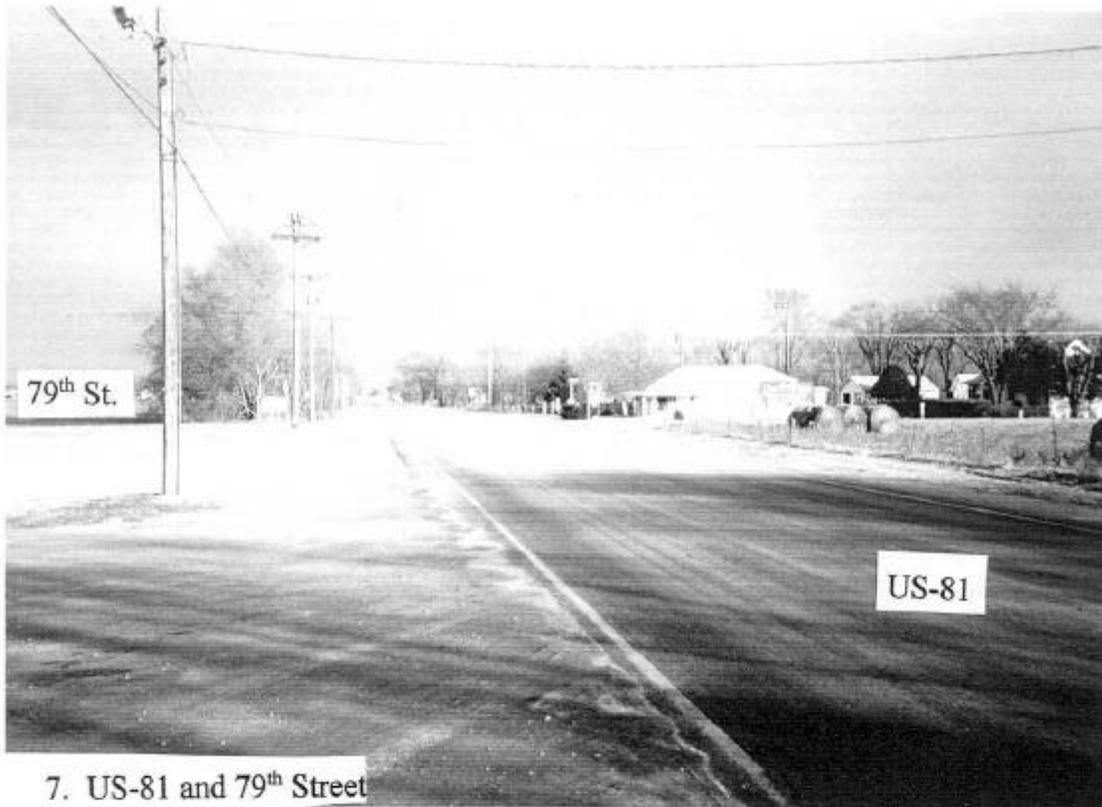
4. US-24 and K-14



5. US-36 and M Street



6. US-56 and Industrial



7. US-81 and 79th Street



8. K-263 and Angela



9. K-15 and K-18