



## KENTUCKY TRANSPORTATION CENTER

### LOW-COST SAFETY MEASURES AT SIGNALIZED INTERSECTIONS





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**LOW-COST SAFETY MEASURES AT SIGNALIZED INTERSECTIONS**

by

Kenneth R. Agent  
Transportation Research Engineer

Kentucky Transportation Center  
College of Engineering  
University of Kentucky  
Lexington, Kentucky

in cooperation with

Kentucky Transportation Center  
Commonwealth of Kentucky

and

Federal Highway Administration  
U.S. Department of Transportation

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## EXECUTIVE SUMMARY

The objectives of this study were to: a) identify intersections with a high number of crashes involving a driver disregarding the traffic signal, b) identify types of low-cost safety measures which may be used as a countermeasure for red-light running, and c) evaluate the effectiveness of the installation of some of these countermeasures at a sample of intersections.

The following procedures were followed to achieve the objectives of the study: a) a literature review was conducted to determine the types of low-cost countermeasures which have been used at signalized intersections, b) low-cost countermeasures to test were identified (using information from the literature review and from traffic engineers across the state), c) the CRASH data base was used to identify signalized intersections which have had a high number and rate of crashes (an emphasis was placed on locations where “disregard traffic control” was listed as a contributing factor), d) the identified countermeasures were installed at selected intersections and e) the effectiveness of the countermeasures was evaluated (using before and after crash data) with a limited amount of conflict data.

The available before and after crash data show the benefit of the various low-cost safety countermeasures to reduce the number of crashes at intersections, specifically angle crashes. A small amount of conflict data support the crash data. The low cost of most of the evaluated countermeasures, when compared to the reduction in crashes, would result in a high benefit cost ratio. Examples of the types of low cost countermeasures included in the evaluation are: double red indications, retro-reflective backplates, and adding signal heads so there are one signal head per lane. The public response to the countermeasures, as reported by traffic engineers, has been positive with requests for additional installations.

Given the severity of the angle collisions resulting from a driver disregarding a traffic signal, the installation of relatively low-cost safety countermeasures are warranted at intersections where this type of crash has occurred or conditions exist which may result in this type of crash. The type of crash analysis described in this report should be used to identify intersections where these countermeasures have the highest potential for reducing crashes. The countermeasures identified should be considered at these intersections with the intersection characteristics and specific crash history used to select the specific countermeasure to implement at a given intersection.

## **1.0 INTRODUCTION**

Traffic signals are used to reduce traffic congestion and certain types of traffic crashes. However, in some instances, traffic crashes may not be reduced and some types of crashes may increase. Intersections with traffic signals at both high volume, urban locations and high speed, rural locations have been identified as high crash locations. The potential exists to address these high-crash signalized locations with relatively low-cost countermeasures such as additional signal heads or adding delineation to make the signal heads more visible.

The objectives of this study were to: a) identify intersections with a high number of crashes (with an emphasis those involving a driver disregarding the traffic signal) , b) identify types of low-cost safety measures which may be used as a countermeasure for red-light running, and c) evaluate the effectiveness of the installation of some of these countermeasures at a sample of intersections.

## **2.0 PROCEDURE**

The following procedures were followed to achieve the objectives of the study.

### **2.1 Literature Review**

A review of literature was conducted to determine the types of low-cost countermeasures which have been used at signalized intersections. The information from this review was used as input to determine the types of countermeasures to be included in the evaluation.

### **2.2 Identify Low-Cost Countermeasures to Test**

Using the information obtained from the literature review, and after consulting with members of the Study Advisory Committee and traffic engineers across the state, specific low-cost countermeasures were identified to test.

### **2.3 Identify High-Crash Signalized Intersections**

The Collision Report Analysis for Safer Highways (CRASH) data base was used to identify signalized intersections which have had a high number and rate of crashes. An emphasis was placed on locations where “disregard traffic control” was listed as a contributing factor. The lists of high-crash intersections were used to identify locations where low-cost countermeasures could be tested. Input was also obtained from traffic engineers across the state to identify intersections where specific countermeasures should be tested.

## **2.4 Install Low-Cost Countermeasures**

The Kentucky Transportation Cabinet installed the identified countermeasures at selected intersections. The costs of the various types of countermeasures were documented as well as any other relevant issues related to the installations.

## **2.5 Evaluate Effectiveness of Low-Cost Countermeasures**

A list of intersections where the types of safety countermeasures were placed was developed. Crash data were obtained at each intersection for a period before and after installation of the countermeasures installed as part of this study. Other intersections where these types of countermeasures have been installed were also identified with crash data obtained.

Conflict data were obtained at a sample of the intersections with an emphasis on some of the intersections which had the highest number of “disregard traffic signal” crashes. The primary conflict type of interest occurred when a vehicle crossed the stop bar on an approach after the start of the red indication. Conflicts related to accelerating through the yellow interval or rapidly decelerating were also obtained. Data were typically collected for 100 cycles at each intersection.

# **3.0 RESULTS**

## **3.1 Literature Review**

In 2003, the Federal Highway Administration (FHWA) and Institute of Transportation Engineers (ITE) published an informational report entitled “Making Intersections Safer: A Toolbox of Engineering Countermeasures to Reduce Red-Light Running” (1). The types of countermeasures identified included:

- improving signal visibility (placement and number of signal heads, size of signal display, and line of sight to signal heads),
- improve signal conspicuity (provide two red-signal displays within each signal head, use of LED signal lenses, backplates, strobe lights),
- increase likelihood of stopping (signal-ahead signs, advanced-warning flashers, rumble strips, left-turn signal sign, and pavement surface condition),
- address intentional violations (signal timing optimization, modifications to signal-cycle length, yellow-change interval, all-red clearance interval and dilemma zone protection), and
- eliminate need to stop (remove unwarranted signals, roundabout intersection design and flash mode for signals).



An informational guide for signalized intersections was published by the FHWA in 2004. One chapter dealt with approach treatments. These improvements included:

- signal head placement and visibility (convert to mast arm or span wire mounted signal heads, add near-side signal heads, increase size of signal heads, use two red signal sections, increase number of signal heads, provide backplates, provide advance warning)
- signing and speed control treatments (improve signing, reduce operating speed, roadway surface improvements, improve pavement surface, provide rumble strips, improve cross section, remove obstacles from clear zone)
- sight distance treatments (improve sight lines)

The National Cooperative Highway Research Program (NCHRP) has published a series of reports as guidance for implementation of the AASHTO strategic highway safety plan. Volume 12 is a guide for reducing collisions at intersections (3). Following is a list of some low cost strategies given in this guide which related to the subject of this study.

- optimize clearance intervals
- improve visibility of intersections on approaches (improve signing and delineation, install larger signs, provide intersection lighting, install rumble strips, install queue detection system)
- improve visibility of signals and signs at intersections (install additional signal head, provide visors or louvers or special lenses, install backplates, install larger signal lenses, provide far side signal, use signal head with double red section)

The FHWA published a report presenting the results of an investigation into low cost traffic engineering improvements, including types of actions, costs, and benefits (4). Low cost was defined as a project or strategy that generally requires an investment in the range of \$10,000 to \$50,000 with many of the strategies ranging from several hundred to several thousand dollars. Following is a list of the relevant low cost improvements at intersections.

- install all-red intervals
- replace 8-inch with 12-inch lenses
- relocate signal heads (place over each lane, use box span)
- install secondary post-mounted signal heads
- install backplates
- add advance warning signs
- install red "T" displays (two red signal lenses)
- install strobe lights in signal lenses
- signal timing improvements

FHWA and ITE published intersection safety issue briefs in 2004 which included engineering countermeasures to reduce red light running (5). The countermeasures listed were those as noted in reference 1. Emphasis was placed on improvements which increase signal visibility and conspicuity (such as placing one signal for each approach lane) or increase the likelihood of stopping (such as advance warning flashers).

A safety workshop dealing with intersection safety has been developed by FHWA (6). It includes countermeasures to reduce crashes at signalized intersections. Some related countermeasures include:

- clearance interval timing (including all red)
- improve visibility (increase lenses size and supplemental heads)
- add backplates
- add advance warning signs with active flashers
- use overhead red “T heads

More conspicuous traffic signals have been listed as a type of improvement which can be used to benefit the increasing percentage of older drivers in the driving population (7). The types of countermeasures include the following:

- signal location (such as one signal head per lane)
- supplemental signal heads (such as far-left and far-right or two left-turn signals)
- signal head conspicuousness (use of LED signals or “red T display”)
- backplates (with yellow reflective strip)

A detailed list of intersection design and operational techniques to assist older drivers to navigate intersections safely provides a good summary of the types of countermeasures which can be used (8). Following is a summary of these techniques:

- improve signal visibility (size of lens, new signals, change signal position)
- install separate left turn and right turn lanes
- modify yellow and red clearance intervals
- provide indirect left turn (U-turn instead of left turn)
- construct roundabouts
- advance street name and lane use signs and pavement marking messages
- advance traffic signal warning signs with flashers
- providing or upgrading illumination
- restriping corridor
- realigning skewed intersections
- dotted-line marking to delineate turning path
- improve sight distance for turning traffic (offset turn lane)

### **3.2 Low-Cost Countermeasures**

A list of possible countermeasures was developed using information obtained from the literature review. Other suggestions were obtained from the advisory committee. The committee discussed each potential countermeasure and decided that installations using the following traffic signal improvements would be made at intersections identified either through the identification of high crash locations or identified through input from district traffic engineers.

- advance overhead street signs
- advance LED warning signs
- advance lane assignment signs
- advance lane assignment markings
- yellow signal heads
- double red indications
- retro-reflective backplates
- one signal head per lane
- supplemental signal heads (near right/far left)
- convert diagonal to box span
- signal coordination
- right light running confirmation lights
- new protected/permitted signal heads
- signal ahead markings on pavement
- lane delineation into intersection pavement markings
- rumble strips
- lighting
- countdown pedestrian signal heads
- advance warning flashers

These countermeasures were considered. Not all were installed. Also, some countermeasures (such as reflectorized backplates) were installed at many more intersections than others. Almost all signals on state-maintained roads currently have 12-inch LED lenses with backplates routinely used on high speed approaches. All-red intervals are also typically used.

### **3.3 High-Crash Signalized Intersections**

The uniform crash report contains a code for the type of traffic control with one code for a traffic signal. There is also a code for human contributing factors with one for disregarding the traffic control. Following is a summary of the number of crashes for the past six years which occurred at a traffic signal and those in which “disregarding traffic control” was listed as a contributing factor. There were additional angle crashes where the driver did not stop for a red signal indication where “disregarding traffic control” was not coded. When reviewing crash reports at locations where countermeasures were installed, it was noted that “failure to yield right of way” and “driver inattention” were sometimes coded when a driver disregarded a red signal.

<u>Year</u>	<u>Total at Signal</u>	<u>Disregard Traffic Control at Signal</u>
2007	27,165	2,632
2006	27,719	2,694
2005	27,613	2,962
2004	27,417	2,948
2003	24,911	2,796
2002	25,168	2,970
2001	25,167	2,831
2000	24,644	2,858

Considering all crashes, about 20 percent occurred at a traffic signal. About 19 percent of the crashes at a traffic signal occurred during darkness compared to 23 percent for all crashes. For injury crashes, about 20 percent occur at a traffic signal. For fatal crashes, the percentage at a traffic signal is only 5.5 percent.

About 11 percent of all crashes at a traffic signal involved a driver disregarding the traffic control. This percent increases to 20 percent for injury crashes and 35 percent of fatal crashes. This shows the severity of this type of crash which typically involves an angle collision. There were 126 fatal crashes of this type in the seven years of 2000 through 2007 with a maximum of two fatal crashes at the following four intersections: Hardin County at US 31W and KY 61; Hardin County at US 31W and Pine Valley Drive; Jefferson County at US 31E and I-265; and Pulaski County at KY 914 and KY 769.

Past research has dealt with crash rates at intersections in Kentucky (9). A computer program was developed which identified crashes at intersections involving state maintained roads and then determined the crash rate at each intersection. A critical rate factor (CRF) is determined for each intersection using a comparison of the statewide rate with the rate at a specific intersection. If the CRF is over one, the intersection has a rate significantly above the statewide average. This type of analysis was conducted using crashes at signalized intersections where a contributing factor of “disregard traffic control” was listed on the police report.

An average statewide rate was determined for crashes at a signalized intersection where disregarding traffic control was listed as a contributing factor. A list of the intersections with the highest CRFs are given in Table 1. This table gives the location (county and intersecting routes), the number of crashes involving a driver disregarding the traffic control, and the CRF for the intersection. The data is for a five year period (2000 through 2004). The intersections are ordered by CRF with all intersections with a CRF of one or more listed. When the number of crashes at specific intersections are checked, it must be remembered that the accuracy of the data is a function of the accuracy of the milepoints coded on the police report.

The same type of analysis used to determine the data given in Table 1 was conducted considering all crashes at signalized intersections. The results of this analysis is given in Appendix A.

The crash analysis was used to obtain lists of candidate intersections. Using the data from Table 1 and Appendix A, the following list was developed showing signalized intersections with: a) 10 or more crashes in the five years involving the code for a driver disregarding the traffic control and b) a CRF factor over 1.0 as shown in Table 1. The data from Appendix A were used to determine the total number of crashes and the percentage of all crashes where disregarding traffic control (traffic signal) was listed as a contributing factor.

County	Route	Intersection	Total		Disregard Traffic Control		
			Crashes	CRF	Crashes	Percent	CRF
Boone	KY 18	KY 3157	113	1.72	23	20	1.76
Boone	KY 18	KY 842	163	2.12	17	10	1.15
Boone	KY 18	KY 1017	77	1.66	12	16	1.09
Boyd	US 23	US 23X	58	1.19	13	22	1.26
Campbell	KY 9	KY 1998	46	1.18	10	22	1.15
Christian	US 41	KY 107	26	1.14	13	50	2.26
Christian	US 41A	KY 380	40	1.15	11	28	1.39
Daviess	US 431	KY 2245	*	*	10	*	1.38
Fayette	US 27	US 60-1	49	1.12	24	49	2.54
Fayette	US 25-1	US 27	53	1.00	22	42	1.79
Fayette	US 27	US 60	*	*	19	*	1.55
Hardin	US 31W	KY 3005	92	1.53	32	35	1.53
Hardin	KY 1600	KY 3005	27	1.09	11	41	1.81
Hardin	US 31W	KY 434	74	2.00	12	16	1.45
Hardin	US 31W	KY 313	98	2.16	15	15	1.24
Hardin	US 31W	KY 251	*	*	10	*	1.07
Hopkins	US 41	KY 70-1	35	1.20	20	57	2.90
Hopkins	US 41	KY 1178	30	1.01	11	37	1.57
Jefferson	US 42	US 60-1	*	*	22	*	3.49
Jefferson	US 31	US 31E/US 31W	*	*	19	*	1.81
Jefferson	US 150	KY 1020	*	*	17	*	1.24
Jefferson	US 60	KY 146	*	*	17	*	1.04
Kenton	KY 7	KY 1120	31	1.27	10	32	1.65
Knox	US 25E	KY 1629	48	1.30	13	27	1.57
Knox	US 25E	KY 312	56	1.48	12	21	1.43
Madison	KY 876	KY 2327	67	1.39	17	25	1.33
McCracken	US 45	KY 731	85	2.12	10	12	1.14
Pulaski	US 27	KY80	67	1.26	18	27	1.64
Pulaski	US 27	KY 1642	*	*	13	*	1.36
Pulaski	US 27	KY 2298	*	*	12	*	1.23
Pulaski	US 27	KY 1577	57	1.32	11	19	1.18
Rowan	US 60	KY 32	*	*	10	*	1.03
Warren	KY 234	KY 2158/KY 6144	33	3.26	10	30	4.87
Warren	US 231	KY 2158	88	2.32	11	12	1.31
Warren	US 231	KY 884	92	1.88	11	12	1.07
Whitley	US 25W	KY 727	39	2.14	12	39	2.46

The asterisk refers to intersections not on the list of signalized intersections with a CRF of 1.00 or more (considering all crashes).

The following list was prepared to show intersections which had a CRF of 1.00 or more for both all crashes and crashes where a driver disregarded the traffic control but where there were less than 10 crashes involving disregarding the traffic control.

County	Route	Intersection	Total		Disregard Traffic Control		
			Crashes	CRF	Crashes	Percent	CRF
Boone	KY 842	KY 3503	32	1.38	6	19	1.03
Breathitt	KY 15	KY 3231	25	1.17	7	28	2.25
Campbell	US 27	KY 8	24	1.15	7	29	1.30
Campbell	KY 8	KY 9	25	1.00	7	28	1.03
Floyd	US 23	KY 1428	39	1.69	5	13	1.53
Grayson	US 62	KY 920	30	1.42	5	17	1.62
Harrison	US 27	KY 36	22	1.20	5	23	1.02
Hopkins	KY 70	KY 254	39	1.53	9	23	1.43
Johnson	KY 40	KY 321	22	1.06	5	23	1.64
Logan	US 68	US 68X	20	1.03	7	35	1.36
Marshall	US 641	KY 58/KY 408	19	1.32	9	47	3.63
Marshall	US 641	KY 80	16	1.08	3	19	1.19
Mason	KY 9	KY 11	22	1.33	3	14	1.00
McCracken	US 60X	KY 305	27	1.70	6	22	1.36
McCracken	US 60	KY 996	27	2.11	3	11	1.29
McCreary	US 27	KY 92/KY 1651	18	1.16	4	22	1.55
Meade	US 31W	KY 868/KY 1638	47	1.71	4	9	1.11
Muhlenberg	US 62	KY 189	18	1.21	5	28	1.97
Muhlenberg	US 62	KY 181	25	1.48	4	16	1.47
Muhlenberg	US 431	KY 277	16	1.29	3	19	1.31
Muhlenberg	US 62	KY 176	29	1.44	3	10	1.00
Scott	US 62	US 460B	24	1.48	4	17	1.51
Washington	US 150	KY 55/KY 555	50	2.28	9	18	2.85
Wayne	KY 90	KY 1275/KY 90X	50	2.34	5	10	1.61

The following list gives the intersections of two or more state maintained highways with the highest number of “disregard traffic signal” crashes (for the five years of 2000 through 2004).

County	Route	Intersection	Number of Crashes
Hardin	US 31W	KY 3005 (Ring Road)	32
Fayette	US 27 (Broadway)	US 60 (High Street)	24
Boone	KY 18	KY 3157 (Mall Road)	23
Fayette	US 27	US 25 (Main/Vine)	22
Boone	KY 1017	KY 18	21
Hopkins	US 41	KY 70	20
Fayette	US 27	US 60 (Maxwell)	19
Pulaski	US 27	KY 80	18
Boone	KY 18	KY 842	17
Jefferson	US 150 (Broadway)	KY 1020 (Second Street)	17
Jefferson	US 60 (Shelbyville)	KY 146 (LaGrange)	17
Madison	KY 876	KY 2327	17

Hardin US 31W                      KY 313                                      15

<u>County</u>	<u>Route</u>	<u>Intersection</u>	<u>Number of Crashes</u>
Christian	US 41	KY 107	13
Knox	US 25E	KY 312	13
Pulaski	US 27	KY 1642	13
Boyd	US 23	US 23X	13
Whitley	US 25W	KY 727	12
Hardin US 31W		KY 434	12
Pulaski	US 27	KY 1577	11
Warren	US 231	KY 2158	11
Christian	US 41A	KY 308	11
Warren	US 231	KY 884	11
Pulaski	US 27	KY 2298	10
Campbell	KY 9	KY 1998	10
Daviess	US 431	KY 2245 (5 <sup>th</sup> Street)	10
Washington	US 150	KY 55/KY 555	9

The preceding crash analysis involved crashes at the intersections of two state-maintained roads. An additional analysis was conducted where the road intersecting a state route could be any type of road. Following is a list of the intersections with the highest number of crashes where a contributing factor was “disregarding traffic control.” There were 52 intersections identified with 12 or more crashes in the five years of 2000 through 2004. The milepoint is listed. As previously noted, the accuracy of the data is related to the accuracy of the location data coded by the investigating police officer. Individual reports would have to be checked to determine an accurate number of crashes at a specific intersection.

<u>County</u>	<u>Route</u>	<u>Intersecting Road (Milepoint)</u>	<u>Number of Crashes</u>
Hardin US 31W		Town Mall entrance (19.799)	35
Hardin US 62		West Poplar Street (18.06)	31
Hardin US 31W		Ring Road (19.478)	26
Taylor	US 68	KY 289 (5.992)	26
McCracken	US 45	I 24/Jack Paxton (7.925)	25
Fayette	US 25	Rose (13.602)	23
Fayette	US 27	High (13.602)	23
Boyd	US 60	Carter (12.159)	21
Fayette	US 27	Lowery (3.112)	21
Fayette	US 27	3 <sup>rd</sup> (6.938)	21
McCracken	US 45	I 24/Jack Paxton (8.093)	21
Hardin US 31W		Walmart (19.695)	20
Fayette	US 27	Vine (6.491)	19
Hopkins	US 41	KY 70 (16.249)	19
Warren	US 231	American (11.238)	19

Fayette	US 27	Reynolds (2.035)	18
Mercer	US 127	US 68 (4.402)	17

<u>County</u>	<u>Route</u>	<u>Intersecting Road (Milepoint)</u>	<u>Number of Crashes</u>
Taylor	US 68	KY 3183 (5.756)	17
Boyd	US 60	Carter (0.4)	16
Fayette	US 27	Maxwell (6.186)	16
Jefferson	US 60	LaGrange (5.765)	16
Warren	US 60	10 <sup>th</sup> (13.064)	16
Fayette	US 60	Eastland (10.508)	15
Jefferson	US 150	2 <sup>nd</sup> (2.56)	15
Warren	US 231	I 65 (9.085)	15
Fayette	US 25	Limestone (13.94)	14
Fayette	US 27	Canary (2.142)	14
Hardin	US 31W	KY 313 (24.408)	14
Jefferson	US 60A	Noble (0.399)	14
McCracken	US 60	James Sanders Blvd. (10.626)	14
Boone	KY 18	KY 3157 (14.748)	13
Calloway	KY 121	16 <sup>th</sup> Street (14.604)	13
Fayette	US 25	Man O War (9.734)	13
Fayette	US 27	Wilson Downing (1.679)	13
Fayette	US 27	KY 4 (2.517)	13
Hardin	US 31W	Elm (28.267)	13
Hopkins	KY 70	Kentucky (18.929)	13
Kenton	US 25	Sunset/Main (5.24)	13
Knox	US 25E	KY 1629 (26.077)	13
McCracken	US 60	New Hold Road (10.272)	13
Taylor	US 68	KY 527 (5.876)	13
Boone	KY 18	KY 842 (14.63)	12
Boyd	US 23	US 23X (19.09)	12
Fayette	US 25	Patchen (10.475)	12
Fayette	US 27	4 <sup>th</sup> (7.09)	12
Hardin	US 31W	Mantle (17.3)	12
Henderson	US 41A	Washington (15.624)	12
Henderson	US 41A	1 <sup>st</sup> Street (15.787)	12
Henderson	US 41A	2 <sup>nd</sup> Street (15.884)	12
Kenton	KY 236	I 75 (2.359)	12
Knox	US 25E	Master St. (25.787)	12
Pulaski	US 27	KY 80 (16.782)	12

The preceding list had several intersections in Hardin County on US 31W. A review of the crashes along this section of road found that the following intersections had a high number of



crashes involving a driver disregarding the traffic signal. Following is a summary of the crashes at these intersections in the five years of 2000 through 2004.

<u>Intersection with US 31W</u>	<u>Milepoint</u>	<u>Number of Crashes</u>
North Mantle Avenue	17.3	12
Diecks Drive	18.012	10
Ring Road	19.478	26
Walmart	19.695	20
Town Mall entrance	19.799	35
Towne Drive	19.904	10
Hutcherson Road/Pine Valley Drive	21.143	11
KY 434	23.967	11
KY 313	24.408	14
Elm Road	28.267	13

The various types of analysis using the crash data were used as one source of input when deciding where to install the countermeasures. The district traffic engineers were also familiar with other intersections where they felt that specific countermeasure could be beneficial.

### 3.4 Installations

Using information from the review of literature to identify potential countermeasures and the crash analysis to identify high crash intersections, a list of intersections with various countermeasures was developed by the advisory committee. Other intersections were added by traffic engineers in the highway districts. Some of the countermeasures have been added to various intersections independent of this study. When installation information could be obtained, these intersections were also included in the analysis. Following is a list of the intersections included in the analysis organized by type of countermeasure. Photographs showing examples of installations of the various countermeasures are given in Appendix B.

<u>Countermeasure</u>	<u>County</u>	<u>Intersection</u>	
Double red indications	Boyd	US 23 at River Hill Drive	
		Daviess	US 431 at KY 2245 (Fifth Street)
		Fayette	US 27 at: KY 4 ramps Man O War
	US 25 at: Man O War Fontaine Road		
	Floyd	Man O War at: Sir Barton Pink Pigeon Pkwy.	
		KY 4 at: Bryan Station Road Boardwalk	
		Broadway at Vine	
		US 23 at KY 1428	

	Henderson	US 41 at Watson Lane
	Hopkins	US 41A at KY 70 (Arch Street)
	Mason	KY 9 at KY 11
<u>Countermeasure</u>	<u>County</u>	<u>Intersection</u>
Double red indications (cont)	Muhlenberg	US 62 at KY 189
	Pulaski	US 27 at KY 80B
	Wayne	KY 90 at: KY 92
		KY 1275/KY 90X
One signal head per lane	Boone	KY 18 at KY 3157
	Hardin	US 31W at: KY 3005 (Ring Road)
		Walmart
		Towne Mall
		Towne Drive
	Pulaski	US 27 at: KY 1577
		KY 80
		KY 1642
	Warren	KY 234 at KY 2158
Retro-reflective backplates	Allen	US 31E at KY 101
	Boyd	US 60 at: KY 180
		Walmart Drive
		KY 3291
		River Hill Drive
		Galleria Mall
		KY 538
		Summitt Road
		KY 716
		KY 1012
		KY 766
		KY 1134
	Christian	US 41A at: KY 380
		US 68 bypass
	Floyd	US 23 at KY 1428
	Franklin	US 127 at: KY 3166
		Leonardwood
		Capital Plaza/K-Mart
		KY 676
		Limestone
		Century Plaza
		US 60 at: US 127
		KY 1659

	Hardin	US 31W at: KY 220 Blackjack Road KY 313 KY 434
<u>Countermeasure</u>	<u>County</u>	<u>Intersection</u>
Retro-reflective backplates (cont)	Henderson	US 41 at Watson Lane US 60 at KY 136/KY 425
	Hopkins	US 41 at: KY 70/KY 481 US 41A/KY 281
	Knox	US 25E at: shopping center entr. KY 11 KY 3041
	Larue	KY 61 at KY 84
	Laurel	US 25E at: US 25/US 25W shopping center entr.
	Logan	US 68 at: US 68X/US 431 KY 178 US 431 US 431X/KY 3519 KY 79 US 68B high school entrance KY 103
	Mason	US 79 at US 68X KY 9 at: KY 11 KY 1448 Walmart Drive Market Square Drive US 62/US 68 Kenton Station US 62X
	Meade	US 31W at KY 1638
	Muhlenberg	US 62 at KY 189
	Rowan	US 60 at: KY 32 KY 519 KY 3030 KY 3031
Yellow retro-reflective backplates	Floyd	US 23 at: KY 979 KY 1428
	Pike	US 23 at: KY 3227 Power Drive

<u>Countermeasure</u>	<u>County</u>	<u>Intersection</u>
Supplemental Head (Near Right/Far Left)	Franklin	Goldenrod Lane strip mall entrance (three) Weddington Branch Road KY 2061 Mossy Bottom Road US 60 at KY 1659 US 127 at: KY 676 Limestone US 60
Supplemental Head (Right turn lane)	Franklin	US 127 at: Leonardwood Capital Plaza/K-Mart KY 676 Limestone Century Plaza
Yellow signal heads	Christian	US 41A and KY 380
Advance warning flashers (AWF) (sample of intersections)	Boyd Davies Floyd Hardin Lawrence Mason Pike	US 23 at I 64 ramps US 60 at US 231 US 23 at: KY 979 Church Street KY 80 at KY 122 US 31W at: KY 434 KY 313 Blackjack US 23 at KY 2565 KY 9 at: KY 11 KY 1448 Kenton Station US 62X US 23 at: US 119 KY 3496 KY 1426 Mossy Bottom Road (SB)
Advance LED Warning Sign	Rowan	US 60 at: KY 519 KY 32
Pedestrian countdown signals (sample of intersections)	Rowan Boyd	US 60 at KY 3030 KY 3030 at Main US 23X at: 14 <sup>th</sup> Street

Signal coordination	Boyd	US 23 at I 64 ramps
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<u>Countermeasure</u>	<u>County</u>	<u>Intersection</u>
Advance Lane Assignment Signs	Franklin	US 60 at KY 1659 US 127 at US 60

Offset Left Turn Lane	Knox	US 25E at KY 3041
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### 3.5 Before and After Crash Data (by Intersection)

Many of the installations were made late in 2006 and in 2007 which limited the amount of crash data available after the installations. Following are case studies showing before and after crash data at locations where at least one year of crash data after the installation are available. Crash data are provided at a few locations showing data only before the installation since there has not been sufficient time to obtain after data. This data are included to allow future comparisons of before and after data for these locations. The total number of crashes are given by year along with various types of crashes. All the crashes may not be placed into a category if there it is an isolated type of crash.

Crash data were obtained for at least 0.25 mile on either side of the milepoint (MP) listed for the intersection. When appropriate, crash data using the MP range for more than one route were reviewed. The wide MP range was used to allow crashes to be identified when inaccurate location data were reported. Reports within this range were reviewed to determine if the crash occurred at the intersection and also to determine the type of crash. When possible, the crash report was reviewed to determine if the angle crashes involved disregarding the signal. However, in many instances, the large number of crashes at the intersection made this impractical so the more general category of angle crashes was used.

Some of the intersections were identified as high-crash locations while other intersections were identified by the district traffic engineer as a location where the types of countermeasures being evaluated in this study could be beneficial. This is shown by the crash data where some intersections had a large number of crashes involving a driver disregarding the traffic signal prior to the installation while there were only a few or no crashes of this type at other intersections. Where appropriate and practical, the number of crashes for a specific type of crash (such as a driver disregarding the traffic signal or a rear end collision) were identified on the approaches where the countermeasure was installed.

The format of the summary is a brief description of the intersection and the countermeasures installed followed by the crash summary which is provided by year. The date of

the installation is noted. The before data is listed first, followed by a blank line, with the after data then given. There is typically several years of before crash data with one or two years of after data.

Allen County; US 31E at KY 101; MP 10.582

This intersection is at Scottsville. Both roads have two lanes. The countermeasure was placing retro-reflective tape on the backplates. Following is a summary of crash data for five years before and two years after the installation (April 3, 2006).

<u>Dates</u>	<u>Total Crashes</u>	<u>Disregard Signal</u>
4/3/01-4/2/02	2	2
4/3/02-4/2/03	2	0
4/3/03-4/2/04	2	1
4/3/04-4/2/05	0	0
4/3/05-4/2/06	7	6
4/3/06-4/2/07	1	1
4/3/07-4/2/08	0	0

Boone County; KY 18 and KY 3157; MP 14.728

This intersection is on a six-lane section of KY 18 with protected left turn phasing. The countermeasure was installing additional signal heads on KY 18 to provide one signal head per lane. Following is a summary of crash data for six years before and two years after the installation (on February 28, 2006).

<u>Dates</u>	<u>Total Crashes</u>	<u>Disregard Signal</u>	<u>Rear End</u>
2/28/00-2/27/01	31	10	15
2/28/01-2/27/02	31	3	13
2/28/02-2/27/03	32	7	16
2/28/03-2/27/04	36	10	16
2/28/04-2/27/05	30	8	11
2/28/05-2/27/06	32	6	19
2/28/06-2/27/07	19	3	10
2/28/07-2/27/08	26	2	17

Boyd County; US 23 at I-64 ramps; MP10.527 and 10.667

There are two intersections on US 23 at the I-64 ramps. The countermeasures included coordination between the signals at the interstate ramps and installation of advance warning flashers. Following is a summary of the crash data at both signals for six years before and two years after the installation (on January 24, 2006).

<u>Dates</u>	<u>Total Crashes</u>	<u>Opposing LT</u>	<u>Disregard Signal</u>	<u>Rear End</u>
1/24/00-1/23/01	7	4	0	2
1/24/01-1/23/02	5	4	1	0
1/24/02-1/23/03	4	3	0	1
1/24/03-1/23/04	9	5	2	0
1/24/04-1/23/05	15	6	2	4
1/24/05-1/23/06	9	1	0	6
1/24/06-1/23/07	5	1	0	4
1/24/07-1/23/08	7	2	1	4

Boyd County; US 23 at River Hill Drive; MP 19.8

This intersection is on a four-lane section of US 23. The speed limit is 45 mph. The countermeasures installed were retro-reflective backplates and double red indications. Following are the crashes at this intersection in the two years prior and one year after the installation on February 9, 2007.

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Sideswipe</u>	<u>Single Vehicle</u>
2/9/05-2/8/06	5	4	1	0
2/9/06-2/8/07	4	3	0	1
2/9/07-2/8/08	7	7	0	0

Boyd County; US 60 at KY 180; MP 4.023

This intersection is on a four-lane section on US 60. The countermeasure was installing retro-reflective backplates. Following is a summary of crash data for six years before and one year after the installation (February 11, 2007).

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Disregard Signal</u>	<u>Opposing LT</u>
2/12/01-2/11/02	7	7	0	0
2/12/02-2/11/03	5	3	2	0
2/12/03-2/11/04	3	3	0	0
2/12/04-2/11/05	6	6	0	0
2/12/05-2/11/06	6	5	1	0
2/12/06-2/11/07	6	5	1	0
2/12/07-2/11/08	4	2	1	0

Boyd County; US 60 at Walmart; MP 4.123

This intersection is on a four-lane section on US 60. The countermeasure was installing retro-reflective backplates. Following is a summary of crash data for six years before and one year after the installation (February 21, 2007).

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Disregard Signal</u>	<u>Opposing LT</u>
2/21/01-2/20/02	4	2	1	1
2/21/02-2/20/03	8	6	1	1
2/21/03-2/20/04	3	3	0	0
2/21/04-2/20/05	4	1	2	1
2/21/05-2/20/06	7	6	1	0
2/21/06-2/20/07	1	1	0	0
2/21/07-2/20/08	4	4	0	0

Boyd County; US 60 at KY 3291; MP 5.075

This intersection is on a four-lane section on US 60. The countermeasure was installing retro-reflective backplates. Following is a summary of crash data for six years before and one year after the installation (February 19, 2007).

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Disregard Signal</u>	<u>Opposing LT</u>
2/19/01-2/18/02	8	6	2	0
2/19/02-2/18/03	6	4	2	0
2/19/03-2/18/04	7	6	0	1
2/19/04-2/18/05	6	5	1	0
2/19/05-2/18/06	2	2	2	0
2/19/06-2/18/07	4	3	1	0
2/19/07-2/18/08	9	4	2	1

Boyd County; US 60 at Galleria Mall; MP 5.3

This intersection is on a four-lane section on US 60. The countermeasure was installing retro-reflective backplates. Following is a summary of crash data for six years before and one year after the installation (March 14, 2007).

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Disregard Signal</u>
3/14/01-3/13/02	6	4	2
3/14/02-3/13/03	2	2	0
3/14/03-3/13/04	0	0	0
3/14/04-3/13/05	0	0	0
3/14/05-3/13/06	0	0	0
3/14/06-3/13/07	0	0	0



3/14/07-3/13/08                      0                      0                      0

Boyd County; US 60 at KY 538; MP 6.5

This intersection is on a four-lane section on US 60. The countermeasure was installing retro-reflective backplates. Following is a summary of crash data for six years before and one year after the installation (March 20, 2007).

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Disregard Signal</u>	<u>Opposing LT</u>
3/20/01-3/19/02	6	5	1	0
3/20/02-3/19/03	4	3	1	0
3/20/03-3/19/04	11	10	0	1
3/20/04-3/19/05	2	2	0	0
3/20/05-3/19/06	4	3	0	1
3/20/06-3/19/07	7	5	1	0
3/20/07-3/19/08	7	5	0	0

Boyd County; US 60 at Summitt; MP 7.13

This intersection is on a four-lane section on US 60. The countermeasure was installing retro-reflective backplates. Following is a summary of crash data for six years before and one year after the installation (March 27, 2007).

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Disregard Signal</u>	<u>Opposing LT</u>
3/27/01-3/26/02	3	3	0	0
3/27/02-3/26/03	2	0	1	1
3/27/03-3/26/04	2	1	1	0
3/27/04-3/26/05	3	3	0	0
3/27/05-3/26/06	2	2	0	0
3/27/06-3/26/07	4	3	0	0
3/27/07-3/26/08	2	2	0	0

Boyd County; US 60 at KY 716; MP 8.016

This intersection is on four-lane section of US 60 with a speed limit of 55 mph. The countermeasure was retro-reflective backplates on US 60. Following is a summary of crash data for the six years before and one year after the installation (March 29,2007).

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Sideswipe</u>	<u>Opposing Left Turn</u>
3/29/01-3/28/02	4	3	0	0	1
3/29/02-3/28/03	2	1	1	0	0
3/29/03-3/28/04	7	4	0	3	0
3/29/04-3/28/05	5	4	0	1	0
3/29/05-3/28/06	5	4	1	0	0
3/29/06-3/28/07	7	6	0	1	0

3/29/07-3/28/08	5	3	2	0	0
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Boyd County; US 60 at KY 1012; MP 8.617

This intersection is on a four-lane section on US 60. The countermeasure was installing retro-reflective backplates. Following is a summary of crash data for the three years after a signal was installed and before the installation of the backplates (March 26, 2007) along with one year after installation of the backplates..

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>
3/26/04-3/25/05	3	3	0
3/26/05-3/25/06	1	1	0
3/26/06-3/25/07	1	1	0
3/26/07-3/25/08	5	4	1

Boyd County; US 60 at KY 766; MP 9.0

This intersection is on a four-lane section on US 60. The countermeasure was installing retro-reflective backplates. Following is a summary of crash data for six years before and one year after the installation (March 27, 2007).

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Disregard Signal</u>	<u>Opposing LT</u>
3/27/01-3/26/02	5	1	4	0
3/27/02-3/26/03	2	1	1	0
3/27/03-3/26/04	3	3	0	0
3/27/04-3/26/05	10	7	2	1
3/27/05-3/26/06	6	3	2	1
3/27/06-3/26/07	7	4	3	0
3/27/07-3/26/08	7	3	2	2

Boyd County; US 60 at KY 1134; MP 9.638

This intersection is on a four-lane section on US 60. The countermeasure was installing retro-reflective backplates. Following is a summary of crash data for six years before and one year after the installation (April 5, 2007).

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Disregard Signal</u>
4/5/01-4/4/02	1	0	1
4/5/02-4/4/03	3	1	1
4/5/03-4/4/04	3	1	2
4/5/04-4/4/05	6	6	0
4/5/05-4/4/06	6	4	2

4/5/06-4/4/07	2	1	0
4/5/07-4/4/08	6	6	0

Boyd County; US 23X (Winchester Road) at 14<sup>th</sup> and 15<sup>th</sup> Streets

Pedestrian countdown signals were installed at these two intersections in downtown Ashland on July 19, 2006. In the six years before the installations, a review of the data found one pedestrian collision at each intersection with none in the year after.

Christian County; US 41A at KY 380; MP 14.41

This intersection is on a four-lane section on US 41A. The countermeasures were installing yellow signal heads and retro-reflective backplates on the US 41A approaches. Following is a summary of crash data for six years before and one year after the installation (on October 23, 2006). Most of the crashes were on US 41A. All the crashes on the KY 380 approach were rear end.

<u>Dates</u>	<u>Total Crashes</u>	<u>Opposing LT</u>	<u>Disregard Signal</u>	<u>Rear End</u>
10/23/00-10/22/01	13	1	2	9
10/23/01-10/22/02	8	0	4	3
10/23/02-10/22/03	19	5	2	11
10/23/03-10/22/04	12	0	2	8
10/23/04-10/22/05	15	1	1	12
10/23/05-10/22/06	14	2	2	10
10/23/06-10/22/07	14	7	0	5

Christian County; US 41A at US 68 bypass; MP 12.561

This intersection is on four-lane sections of US 41A and the US 68 bypass. The countermeasure was placing retro-reflective tape on the backplates. Following is a summary of crash data for six years before and one year after the installation (November 8, 2006). Most of the crashes were rear end with most on US 41A.

<u>Dates</u>	<u>Total Crashes</u>	<u>Opposing LT</u>	<u>Disregard Signal</u>	<u>Rear End</u>
11/8/00-11/7/01	8	1	4	2
11/8/01-11/7/02	13	1	3	5
11/8/02-11/7/03	7	2	1	4
11/8/03-11/7/04	21	0	2	17
11/8/04-11/7/05	21	0	5	12
11/8/05-11/7/06	14	1	0	11
11/8/06-11/7/07	12	1	0	9

Daviess County; US 60 at US 231; MP 22.82

This intersection is on a rural section of US 60 with a 55 mph speed limit. The countermeasure was installing an advance warning flasher. Following is a summary of crash data for five years before and one year after the installation (March 27, 2007).

<u>Dates</u>	<u>Total Crashes</u>	<u>Angle</u>	<u>Opposing LT</u>	<u>Rear End</u>	<u>SV</u>	<u>Sideswipe</u>
3/27/02-3/26/03	3	0	1	0	1	1
3/27/03-3/26/04	2	0	1	0	1	0
3/27/04-3/26/05	6	1	2	0	3	0
3/27/05-3/26/06	8	5	2	0	1	0
3/27/06-3/26/07	8	3	2	2	0	1
3/27/07-3/26/08	3	1	0	1	1	0

Daviess County; US 431 (Frederica Street) at KY 2245 (Fifth Street); MP 14.445

This intersection is on a four-lane urban section of US 431. The countermeasure was installing double red signal heads. Following is a summary of crash data for six years before and one year after the installation (November 21, 2006).

<u>Dates</u>	<u>Total Crashes</u>	<u>Disregard Signal</u>
11/21/00-11/20/01	8	8
11/21/01-11/20/02	1	1
11/21/02-11/20/03	9	8
11/21/03-11/20/04	12	5
11/21/04-11/20/05	4	1
11/21/05-11/20/06	0	0
11/21/06-11/20/07	0	0

Floyd County; US 23 at KY 979; MP 0.869

This intersection is on a four-lane section of US 23 with protected left turn phasing. The countermeasure was installing an advance warning flasher (AWF) on the US 23 approaches. The speed limit is 55 mph. Following is a summary of crash data for three years before and four years after the installation (on November 7, 2003).

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Disregard Signal</u>	<u>Opposing Left Turn</u>
11/7/00-11/6/01	10	8	1	1
11/7/01-11/6/02	7	6	1	0
11/7/02-11/6/03	5	5	0	0
11/7/03-11/6/04	4	4	0	0
11/7/04-11/6/05	6	6	0	0

11/7/05-11/6/06	5	4	0	1
11/7/06-11/6/07	3	3	0	0

Floyd County; US 23 at Church Street; MP 1.802

This intersection is on a four-lane section of US 23 with protected left turn phasing. The countermeasure was installing an advance warning flasher (AWF) on the US 23 approaches. The speed limit is 55 mph. Following is a summary of crash data for three years before and four years after the installation (on November 20, 2003).

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Disregard Signal</u>	<u>Opposing Left Turn</u>
11/20/00-11/21/01	3	1	2	0
11/20/01-11/21/02	5	2	2	1
11/20/02-11/21/03	3	2	1	0
11/20/03-11/21/04	1	1	0	0
11/20/04-11/21/05	2	0	1	0
11/20/05-11/21/06	2	0	0	1
11/20/06-11/21/07	2	1	1	0

Floyd County; KY 80 at KY 122; MP 8.579

This intersection is on a four-lane section of KY 80. The countermeasure was installing an AWF on the KY 80 approaches (on July 15, 2005). The speed limit is 55 mph. Crash records showed only two crashes in the four years prior to the installation and one crash in the two years after. All the crashes were angle.

Franklin County; US 60 at US 127; MP 6.3

This intersection is on four-lane section of US 60 at US 127 with protected left turn phasing. The speed limit is 45 mph. The countermeasures included retro-reflective backplates, supplemental heads near right and far left for US 127 and far left on US 60, and lane use signs on US 60. Following is a summary of crash data for the six years before and one year after the installations (between February 15 and April 15, 2007).

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Sideswipe</u>	<u>Opposing Left Turn</u>
2/15/01-2/14/02	13	9	0	2	2
2/15/02-2/14/03	16	11	2	2	0
2/15/03-2/14/04	21	16	1	3	0
2/15/04-2/14/05	18	14	0	4	0
2/15/05-2/14/06	12	9	1	0	2
2/15/06-2/14/07	10	8	1	1	0

2/15/07-2/14/08            11            10            0            1            0

Franklin County; US 60 at KY 1659; MP 9.338

This intersection is on a four-lane section of US 60 with protected left turn phasing. The speed limit is 35 mph. The countermeasures on US 60 included supplemental heads on the US 60 approaches, lane assignment signs northbound, and retro-reflective backplates. Following is a summary of crash data for the seven years before and one year after the installations (between February 15 and April 15, 2007).

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Sideswipe</u>	<u>Opposing Left Turn</u>
2/15/00-2/14/01	13	9	3	0	1
2/15/01-2/14/02	5	4	1	0	0
2/15/02-2/14/03	7	6	0	1	0
2/15/03-2/14/04	4	2	0	0	2
2/15/04-2/14/05	11	9	1	0	1
2/15/05-2/14/06	13	8	2	0	3
2/15/06-2/14/07	12	8	1	2	1
2/15/07-2/14/08	9	7	0	1	1

Franklin County; US 127 at Leonardwood; MP 4.88

This intersection is on a four-lane section of US 127 with protected/permissive left turn phasing. The speed limit is 45 mph. The countermeasures on US 127 included retro-reflective backplates on US 127 and adding signal heads for the right turn lanes on US 127. Following is a summary of crash data for the seven years before and one year after the installations (between February 15 and April 15, 2007).

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Sideswipe</u>	<u>Opposing LT</u>	<u>Ped.</u>
2/15/00-2/14/01	16	12	3	1	0	0
2/15/01-2/14/02	22	19	3	0	0	0
2/15/02-2/14/03	7	3	0	3	0	1
2/15/03-2/14/04	20	16	3	1	0	0
2/15/04-2/14/05	27	19	7	1	0	0
2/15/05-2/14/06	12	10	2	0	0	0
2/15/06-2/14/07	18	10	4	3	1	0
2/15/07-2/14/08	13	9	1	2	1	0

Franklin County; US 127 at KY 3166; MP 3.909

This intersection is on a four-lane section of US 127 with protected/permissive left turn phasing. The speed limit is 45 mph. The countermeasure on US 127 included retro-reflective backplates on US 127. Following is a summary of crash data for the seven years before and one year after the installations (between February 15 and April 15, 2007).

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Sideswipe</u>	<u>Opposing LT</u>	<u>SV.</u>
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2/15/00-2/14/01	5	2	0	0	3	0
2/15/01-2/14/02	8	1	3	1	3	0
2/15/02-2/14/03	8	3	3	0	2	0
2/15/03-2/14/04	4	2	0	0	2	0
2/15/04-2/14/05	4	2	0	1	1	0
2/15/05-2/14/06	5	2	1	0	1	1
2/15/06-2/14/07	4	0	2	0	2	0
2/15/07-2/14/08	3	2	0	1	0	0

Franklin County: US 127 at Capital Plaza/K-Mart; MP 5.04

This intersection is on a four-lane section of US 127 with protected/permissive left turn phasing. The speed limit is 45 mph. The countermeasures on US 127 included retro-reflective backplates and adding signal heads over the right turn lanes on US 127. Following is a summary of crash data for the seven years before and one year after the installations (between February 15 and April 15, 2007).

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Sideswipe</u>
2/15/00-2/14/01	12	8	2	2
2/15/01-2/14/02	9	7	2	0
2/15/02-2/14/03	13	11	1	1
2/15/03-2/14/04	18	18	0	0
2/15/04-2/14/05	21	20	1	0
2/15/05-2/14/06	13	11	2	0
2/15/06-2/14/07	11	6	1	4
2/15/07-2/14/08	3	3	0	0

Franklin County: US 127 at KY 676; MP 5.194

This intersection is on a four-lane section of US 127 with protected/permissive left turn phasing. The speed limit is 45 mph. The countermeasures on US 127 included retro-reflective backplates, adding signal heads over the right turn lanes, and adding supplemental signal heads (near left northbound and near right southbound). Following is a summary of crash data for the seven years before and one year after the installations (between February 15 and April 15, 2007).

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Sideswipe</u>	<u>Opposing Left Turn</u>
2/15/00-2/14/01	16	8	4	4	0
2/15/01-2/14/02	5	2	1	2	0
2/15/02-2/14/03	5	3	1	1	0
2/15/03-2/14/04	15	8	4	2	1
2/15/04-2/14/05	11	6	2	2	1
2/15/05-2/14/06	12	6	1	4	1
2/15/06-2/14/07	12	8	0	4	0
2/15/07-2/14/08	6	3	0	2	0

Franklin County; US 127 at Limestone; MP 5.416

This intersection is on a four-lane section of US 127 with protected/permissive left turn phasing. The speed limit is 45 mph. The countermeasures on US 127 included retro-reflective backplates, adding signal heads over the right turn lanes, and adding supplemental signal heads (near left northbound and near right southbound). Following is a summary of crash data for the seven years before and one year after the installations (between February 15 and April 15, 2007).

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Sideswipe</u>	<u>Opposing Left Turn</u>
2/15/00-2/14/01	7	5	1	1	0
2/15/01-2/14/02	13	7	2	1	3
2/15/02-2/14/03	12	5	2	1	5
2/15/03-2/14/04	9	5	0	1	3
2/15/04-2/14/05	9	3	2	2	2
2/15/05-2/14/06	13	7	2	1	3
2/15/06-2/14/07	17	8	3	2	4
2/15/07-2/14/08	10	3	1	1	5

Franklin County; US 127 at Century Plaza; MP 5.76

This intersection is on a four-lane section of US 127 with protected/permissive left turn phasing. The speed limit is 45 mph. The countermeasures on US 127 included retro-reflective backplates and adding a signal head over the northbound right turn lane. Following is a summary of crash data for the six years before and one year after the installations (between February 15 and April 15, 2007).

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Sideswipe</u>	<u>Opposing Left Turn</u>
2/15/01-2/14/02	3	0	2	0	1
2/15/02-2/14/03	11	6	1	2	2
2/15/03-2/14/04	4	1	1	1	1
2/15/04-2/14/05	6	2	0	1	3
2/15/05-2/14/06	4	2	0	0	2
2/15/06-2/14/07	3	2	0	0	1
2/15/07-2/14/08	7	0	5	0	2

Hardin County; US 31W at KY 3005 (Ring Road); MP 19.478

This intersection is in a six lane section with two left turn lanes on US 31W. The countermeasure was adding signal heads resulting in one per lane. Following is a summary of the types of crashes for six years before and two years after adding the supplemental signal heads on January 22, 2006.

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Sideswipe</u>	<u>Opposing Left Turn</u>
1/22/00-1/21/01	27	16	6	5	0



1/22/01-1/21/02	21	13	3	2	3
1/22/02-1/21/03	35	25	8	2	0
1/22/03-1/21/04	44	20	16	7	1
1/22/04-1/21/05	43	34	5	4	0
1/22/05-1/21/06	45	28	9	7	0
1/22/06-1/21/07	29	19	5	2	3
1/22/07-1/21/08	28	22	1	4	0

Hardin County; US 31W at Walmart; MP 19.695

This intersection is in a six lane section with two left turn lanes on US 31W. The countermeasure was adding signal heads resulting in one per lane. Following is a summary of the types of crashes for six years before and two years after adding the supplemental signal heads on January 22, 2006.

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Sideswipe</u>	<u>Opposing Left Turn</u>
1/22/00-1/21/01	19	7	7	3	2
1/22/01-1/21/02	17	5	10	2	0
1/22/02-1/21/03	19	9	4	4	2
1/22/03-1/21/04	23	9	8	5	0
1/22/04-1/21/05	25	13	4	4	1
1/22/05-1/21/06	20	2	12	2	4
1/22/06-1/21/07	19	12	4	2	1
1/22/07-1/21/08	12	6	1	5	0

Hardin County; US 31W at Towne Mall entrance; MP 19.799

This intersection is in a six lane section with two left turn lanes on US 31W. The countermeasure was adding signal heads resulting in one per lane. Following is a summary of the types of crashes for six years before and two years after adding the supplemental signal heads on January 22, 2006.

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Sideswipe</u>	<u>Opposing Left Turn</u>
1/22/00-1/21/01	20	8	11	1	0
1/22/01-1/21/02	23	13	9	1	0
1/22/02-1/21/03	35	14	16	2	2
1/22/03-1/21/04	29	14	13	2	0
1/22/04-1/21/05	21	7	13	0	1
1/22/05-1/21/06	25	10	12	1	1
1/22/06-1/21/07	17	8	6	1	2
1/22/07-1/21/08	15	13	1	0	1

Hardin County; US 31W at Towne Drive; MP 19.904

This intersection is in a six lane section with two left turn lanes on US 31W. The

countermeasure was adding signal heads resulting in one per lane. Following is a summary of the types of crashes for six years before and two years after adding the supplemental signal heads on January 22, 2006.

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Sideswipe</u>	<u>Opposing Left Turn</u>
1/22/00-1/21/01	14	8	4	2	0
1/22/01-1/21/02	20	12	7	0	0
1/22/02-1/21/03	13	8	3	2	0
1/22/03-1/21/04	11	5	3	1	1
1/22/04-1/21/05	10	5	3	2	0
1/22/05-1/21/06	18	13	5	0	0
1/22/06-1/21/07	11	9	2	0	0
1/22/07-1/21/08	9	4	1	2	2

Hardin County; US 31W at KY 220; MP 22.601

This intersection is on a four lane, divided highway with a speed limit of 55 mph. The countermeasure was installing retro-reflective backplates in October 2006. Following is a summary of the types of crashes for six years before and one year after installation of the backplates.

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Sideswipe</u>	<u>Opposing LT</u>
10/1/00-9/30/01	4	3	1	0	0
10/1/01-9/30/02	4	4	0	0	0
10/1/02-9/30/03	7	5	1	0	0
10/1/03-9/30/04	10	6	2	1	0
10/1/04-9/30/05	7	4	2	1	0
10/1/05-9/30/06	7	4	1	1	0
10/1/06-9/30/07	5	3	0	0	2

Hardin County; US 31W at KY 434; MP 23.967

This intersection is on a four lane, divided highway with a speed limit of 55 mph. The countermeasures were installing an AWF in June 2006 on US 31W and retro-reflective backplates in October 2006. Following is a summary of the types of crashes for six years before and one year after installation of the AWF.

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Sideswipe</u>
7/1/00-6/30/01	17	11	1	3

7/1/01-6/30/02	28	21	5	2
7/1/02-6/30/03	17	13	2	1
7/1/03-6/30/04	22	16	6	0
7/1/04-6/30/05	31	24	5	1
7/1/05-6/30/06	13	11	1	0
7/1/06-6/30/07	13	9	2	1

Hardin County; US 31W at KY 313; MP 24.408

This intersection is on a four lane, divided highway with a speed limit of 55 mph. The countermeasures were installing an AWF in June 2006 on US 31W and retro-reflective backplates in October 2006. Following is a summary of the types of crashes for six years before and one year after installation of the AWF.

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Opposing LT</u>
7/1/00-6/30/01	22	14	1	5
7/1/01-6/30/02	10	7	2	0
7/1/02-6/30/03	19	14	2	3
7/1/03-6/30/04	20	10	9	0
7/1/04-6/30/05	25	20	1	0
7/1/05-6/30/06	18	8	5	4
7/1/06-6/30/07	22	16	0	5

Hardin County; US 31W at Blackjack Road; MP 26.036

This intersection is on a four lane, divided highway with a speed limit of 55 mph. The countermeasures were installing an AWF in June 2006 on US 31W and retro-reflective backplates in October 2006. Following is a summary of the types of crashes for six years before and one year after installation of the AWF.

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Opposing Left Turn</u>
10/1/00-9/30/01	4	1	1	2
10/1/01-9/30/02	8	6	2	0
10/1/02-9/30/03	7	4	1	0
10/1/03-9/30/04	16	11	2	1
10/1/04-9/30/05	27	17	4	2
10/1/05-9/30/06	6	5	1	0
10/1/06-9/30/07	8	2	0	5

Henderson County; US 41 at Watson Lane; MP 17.559

This intersection is on a four lane urban section on US 41 in Henderson. The speed limit

is 45 mph. The countermeasures were installing double red signal indications and retro-reflective backplates on the US 41 approaches. Following is a summary of the types of crashes for seven years before and one year after the installation date of January 4, 2007.

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Opposing LT</u>	<u>Sideswipe</u>
1/4/00-1/3/01	18	15	1	0	2
1/4/01-1/3/02	18	15	2	0	1
1/4/02-1/3/03	17	11	1	2	3
1/4/03-1/3/04	16	13	2	0	1
1/4/04-1/3/05	23	17	4	1	1
1/4/05-1/3/06	19	11	3	1	3
1/4/06-1/3/07	16	12	1	0	3
1/4/07-1/3/08	15	12	1	0	2

Henderson County; US 60 at KY 136/KY 425; MP 8.71

This intersection is on a four lane urban section on US 60 in Henderson. The speed limit is 45 mph. The countermeasure was installing retro-reflective backplates on all approaches. Following is a summary of the types of crashes for seven years before and one year after the installation date of January 11, 2007.

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Opposing LT</u>	<u>Sideswipe</u>
1/11/01-1/10/01	8	3	1	2	1
1/11/01-1/10/02	5	3	1	1	0
1/11/02-1/10/03	7	3	1	3	0
1/11/03-1/10/04	7	2	1	2	2
1/11/04-1/10/05	5	3	1	1	0
1/11/05-1/10/06	6	5	0	1	0
1/11/06-1/10/07	3	0	1	2	0
1/11/07-1/10/08	4	3	0	1	0

Hopkins County; US 41 at KY 70 (Arch Street); MP 16.249

This intersection is on a two lane urban section of US 41 in Madisonville. The countermeasure was installing double red signal indications. Following is a summary of crashes for six years before and one year after the installation date of December 13, 2006.

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Opposing LT</u>
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12/13/00-12/12/01	9	4	5	0
12/13/01-12/12/02	12	4	8	0
12/13/02-12/12/03	15	3	11	1
12/13/03-12/12/04	4	0	4	0
12/13/04-12/12/05	2	2	0	0
12/13/05-12/12/06	8	6	2	0
12/13/06-12/12/07	9	6	2	0

Hopkins County; US 41 at KY 70/KY 481 (McLaughlin Street); MP 15.421

This intersection is on a four lane urban section of US 41 in Madisonville. The countermeasure was installing retro-reflective backplates on the US 41 approaches. Following is a summary of crashes for seven years before and one year after the installation on January 2, 2007.

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Opposing LT</u>	<u>Sideswipe</u>
1/2/00-1/1/01	8	4	0	2	2
1/2/01-1/1/02	4	1	1	1	1
1/2/02-1/1/03	11	7	1	2	1
1/2/03-1/1/04	7	2	2	2	1
1/2/04-1/1/05	11	5	1	2	3
1/2/05-1/1/06	5	4	0	0	1
1/2/06-1/1/07	6	4	2	0	2
1/2/07-1/1/08	9	6	2	0	1

Hopkins County; US 41 at US 41A/KY 281; MP 17.548

This intersection is on a four lane urban section of US 41 in Madisonville. The countermeasure was installing retro-reflective backplates on all approaches. Following is a summary of crashes for the seven years before and one year after the installation in May 2007.

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Opposing LT</u>	<u>Sideswipe</u>
5/1/00-4/30/01	13	12	0	0	1
5/1/01-4/30/02	16	13	1	1	1
5/1/02-4/30/03	15	12	0	0	3
5/1/03-4/30/04	21	17	1	2	0
5/1/04-4/30/05	19	17	0	2	0
5/1/05-4/30/06	16	13	1	0	1
5/1/06-4/30/07	8	6	1	0	1
5/1/07-4/30/08	10	9	0	0	1

Knox County; US 25E at KY 3041; MP 24.221

This intersection is on a four lane section of US 25E. The speed limit is 55 mph. The countermeasure was constructing offset left turn lanes, placing retro-reflective tape on the backplates, adding right turn lanes, installing luminaries, adding left turn radius hatch marking stripes, and installing a median post mounted “left turn yield on green ball” sign. Following is a summary of the types of crashes for seven years before the improvements completed June 20, 2007.

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Sideswipe</u>	<u>Opposing Left Turn</u>
6/20/00-6/19/01	12	6	0	1	5
6/20/01-6/19/02	14	5	1	0	8
6/20/02-6/19/03	17	3	2	1	11
6/20/03-6/19/04	17	6	1	1	9
6/20/04-6/19/05	5	0	0	0	5
6/20/05-6/19/06	5	2	1	1	1
6/20/06-6/19/07	6	1	0	1	4

Larue County; KY 61 at KY 84; MP 9.127

This intersection is at Hodgenville on KY 61 which is a four lane road with no left turn phasing. The speed limit is 55 mph. The countermeasure was placing retro-reflective tape on the backplates. Following is a summary of crash data for six years before and one year after the installation (October 2006).

<u>Dates</u>	<u>Total Crashes</u>	<u>Disregard Signal</u>	<u>Rear End</u>	<u>Opposing Left Turn</u>
10/25/00-10/24/01	4	1	1	1
10/25/01-10/24/02	3	1	0	3
10/25/02-10/24/03	6	2	3	1
10/25/03-10/24/04	5	1	2	1
10/25/04-10/24/05	3	1	1	1
10/25/05-10/24/06	9	1	2	6
10/25/06-10/24/07	2	1	0	1

Lawrence County; US 23 at KY 2565; MP 14.660

This intersection is on a four-lane section of US 23. The countermeasure was installing an advance warning flasher (AWF) on the US 23 approaches. The speed limit is 55 mph. Following is a summary of crash data for five years before and two years after the installation (on April 14, 2005).

<u>Dates</u>	<u>Total Crashes</u>	<u>Angle</u>	<u>Opposing Left Turn</u>	<u>Single Vehicle</u>
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4/14/00-4/13/01	3	2	0	1
4/14/01-4/13/02	4	2	1	1
4/14/02-4/13/03	3	3	0	0
4/14/03-4/13/04	1	0	1	0
4/14/04-4/13/05	0	0	0	0
4/14/05-4/13/06	0	0	0	0
4/14/06-4/13/07	0	0	0	0
4/14/07-4/13/08	2	1	0	1

Logan County; US 68 bypass at US 68 business/US 431; MP 8.297

This intersection is on the Russellville bypass which is a four lane road with protected left turn phasing. The countermeasure was placing retro-reflective tape on the backplates. Following is a summary of crash data for six years before and two years after the installation (March 2006).

<u>Dates</u>	<u>Total Crashes</u>	<u>Disregard Signal</u>	<u>Rear End</u>	<u>Opposing Left Turn</u>
3/1/00-2/28/01	3	1	1	1
3/1/01-2/28/02	2	0	1	1
3/1/02-2/28/03	3	1	1	0
3/1/03-2/28/04	1	1	0	0
3/1/04-2/28/05	4	1	3	0
3/1/05-2/28/06	2	1	0	0
3/1/06-2/28/07	0	0	0	0
3/1/07-2/28/08	2	1	0	0

Logan County; US 68 bypass at KY 178; MP 8.87

This intersection is on the Russellville bypass which is a four lane road. The countermeasure was placing retro-reflective tape on the backplates. Following is a summary of crash data for five years before and two years after the installation (March 2006).

<u>Dates</u>	<u>Total Crashes</u>	<u>Disregard Signal</u>	<u>Opposing Left Turn</u>	<u>Rear End</u>
3/1/01-2/28/02	2	0	1	1
3/1/02-2/28/03	1	0	1	0
3/1/03-2/28/04	1	0	1	0
3/1/04-2/28/05	3	1	2	0
3/1/05-2/28/06	5	1	3	1
3/1/06-2/28/07	4	0	2	1
3/1/07-2/28/08	6	0	1	3

Logan County; US 68 bypass at US 431; MP 9.878

This intersection is on the Russellville bypass which is a four lane road with protected left

turn phasing. The countermeasure was placing retro-reflective tape on the backplates. Following is a summary of crash data for five years before and two years after the installation (March 2006).

<u>Dates</u>	<u>Total Crashes</u>	<u>Disregard Signal</u>	<u>Opposing Left Turn</u>	<u>Rear End</u>
3/1/01-2/28/02	3	1	0	2
3/1/02-2/28/03	3	2	1	0
3/1/03-2/28/04	2	1	1	0
3/1/04-2/28/05	2	2	0	0
3/1/05-2/28/06	1	1	0	0
3/1/06-2/28/07	4	1	0	3
3/1/07-2/28/08	0	0	0	0

Logan County; US 68 bypass at US 431X/KY 3519; MP 10.261

This intersection is on the Russellville bypass which is a four lane road. The countermeasure was placing retro-reflective tape on the backplates. Following is a summary of crash data for five years before and two years after the installation (March 2006).

<u>Dates</u>	<u>Total Crashes</u>	<u>Disregard Signal</u>	<u>Rear End</u>	<u>Opposing Left Turn</u>
3/1/01-2/28/02	3	1	1	1
3/1/02-2/28/03	2	1	1	0
3/1/03-2/28/04	6	3	3	0
3/1/04-2/28/05	4	0	4	1
3/1/05-2/28/06	2	0	2	0
3/1/06-2/28/07	7	3	4	0
3/1/07-2/28/08	2	1	1	0

Logan County; US 68 bypass at KY 79; MP 12.368

This intersection is on the Russellville bypass which is a four lane road. The countermeasure was placing retro-reflective tape on the backplates. Following is a summary of crash data for six years before and two years after the installation (March 2006).

<u>Dates</u>	<u>Total Crashes</u>	<u>Disregard Signal</u>	<u>Rear End</u>	<u>Opposing Left Turn</u>
3/1/00-2/28/01	6	3	3	0
3/1/01-2/28/02	2	1	1	0
3/1/02-2/28/03	5	0	4	0
3/1/03-2/28/04	5	1	1	2
3/1/04-2/28/05	1	0	0	0
3/1/05-2/28/06	0	0	0	0
3/1/06-2/28/07	5	0	5	0
3/1/07-2/28/08	3	0	2	1

Logan County; US 68 bypass at US 68 business; MP 14.095



This intersection is on the Russellville bypass which is a four lane road. This intersection has three approaches. The countermeasure was placing retro-reflective tape on the backplates. Following is a summary of crash data for six years before and two years after the installation (March 2006).

<u>Dates</u>	<u>Total Crashes</u>	<u>Disregard Signal</u>	<u>Rear End</u>	<u>Single Vehicle</u>
3/1/00-2/28/01	1	0	1	0
3/1/01-2/28/02	2	0	1	1
3/1/02-2/28/03	2	1	1	0
3/1/03-2/28/04	1	0	1	0
3/1/04-2/28/05	5	0	3	2
3/1/05-2/28/06	5	0	3	2
3/1/06-2/28/07	2	0	2	0
3/1/07-2/28/08	1	0	1	0

Logan County; US 68 at KY 103; MP 23.237

This intersection is on the US 68 bypass around Auburn (a two lane road with a speed limit of 55 mph). The countermeasure was retro-reflective tape on the backplates. Following is a summary of crash data for six years before and two years after the installation (March 2006).

<u>Dates</u>	<u>Total Crashes</u>	<u>Disregard Signal</u>	<u>Rear End</u>	<u>Opposing LT</u>
3/1/00-2/28/01	3	0	0	3
3/1/01-2/28/02	0	0	0	0
3/1/02-2/28/03	2	1	0	0
3/1/03-2/28/04	2	1	1	0
3/1/04-2/28/05	1	0	1	0
3/1/05-2/28/06	1	0	0	0
3/1/06-2/28/07	4	0	1	1
3/1/07-2/28/08	2	0	2	0

In addition to the two crashes noted above where a driver on US 68 disregarded the red signal, there were four crashes on KY 103 where a driver disregarded a red indication.

Logan County; US 68 bypass at High School Entrance; MP 14.828

This intersection is near Russellville bypass and is a four lane road. The countermeasure

was placing retro-reflective tape on the backplates. Following is a summary of crash data for six years before and two years after the installation (March 2006).

<u>Dates</u>	<u>Total Crashes</u>	<u>Disregard Signal</u>	<u>Rear End</u>	<u>Opposing Left Turn</u>
3/1/00-2/28/01	4	1	1	1
3/1/01-2/28/02	0	0	0	0
3/1/02-2/28/03	3	1	2	0
3/1/03-2/28/04	0	0	0	0
3/1/04-2/28/05	0	0	0	0
3/1/05-2/28/06	2	0	1	1
3/1/06-2/28/07	1	0	1	1
3/1/07-2/28/08	1	1	0	0

Mason County; KY 9 at KY 11; MP 7.56

The countermeasures were installing double red indications, retro-reflective backplates, and AWF on KY 9 (a four lane road with a speed limit of 55 mph) at KY 11. Following is a summary of crash data for seven years before the completion of the installations (June 11, 2007).

<u>Dates</u>	<u>Total Crashes</u>	<u>Angle</u>	<u>Rear End</u>
6/11/00-6/10/01	11	2	9
6/11/01-6/10/02	5	2	3
6/11/02-6/10/03	7	2	4
6/11/03-6/10/04	3	0	3
6/11/04-6/10/05	5	1	4
6/11/05-6/10/06	6	2	4
6/11/06-6/11/07	4	0	4

Mason County; KY 9 at Walmart; MP 9.435

The countermeasure was installing retro-reflective backplates. The road is a four-lane road with a speed limit of 45 mph. Following is a summary of crash data for two years before and one year after the installation on January 20, 2007.

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>
1/20/05-1/19/06	3	2	1
1/20/06-1/19/07	3	2	1
1/20/07-1/19/08	2	2	0

Mason County; KY 9 at Market Square Drive; MP 9.992

The countermeasure was installing retro-reflective backplates. The road is a four-lane road with a speed limit of 45 mph. Following is a summary of crash data for five years before and one year after the installation on January 22, 2007.

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Sideswipe</u>	<u>Opposing LT</u>
1/22/02-1/21/03	4	3	1	0	0

1/22/03-1/21/04	5	2	2	0	1
1/22/04-1/21/05	3	3	0	0	0
1/22/05-1/21/06	4	0	1	2	1
1/22/06-1/21/07	3	2	0	0	1
1/22/07-1/21/08	2	1	1	0	0

Mason County; KY 9 at US 62/US 68; MP 10.256

The countermeasure was installing retro-reflective backplates. The road is a four-lane road with a speed limit of 45 mph. Following is a summary of crash data for seven years before and one year after the installation on January 20, 2007.

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Sideswipe</u>	<u>Single Vehicle</u>
1/20/00-1/19/01	17	10		2	5
1/20/01-1/19/01	15	12		0	2
1/20/02-1/19/03	8	6		0	2
1/20/03-1/19/04	15	9		2	2
1/20/04-1/19/05	19	12		1	5
1/20/05-1/19/06	10		6	0	4
1/20/06-1/19/07	10	8		1	1
1/20/07-1/19/08	13	9		0	4

Meade County; US 31W at KY 1638; MP 2.286

This intersection is on a four lane, divided highway with a speed limit of 55 mph. The countermeasure was installing retro-reflective backplates in October 2006. Following is a summary of the types of crashes for six years before and one year after installation of the backplates.

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>
10/1/00-9/30/01	13	4	6
10/1/01-9/30/02	3	2	1
10/1/02-9/30/03	10	7	3
10/1/03-9/30/04	5	0	2
10/1/04-9/30/05	4	2	2
10/1/05-9/30/06	3	1	1
10/1/06-9/30/07	2	2	0

Muhlenberg County; US 62 at KY 189; MP 8.78

This intersection is the first with a traffic signal eastbound into Greenville. The speed limit is 45 mph on US 62 with two lanes and a left turn lane. Countermeasures were a double red

signal indication and retro-reflective backplates on US 62. Following is a summary of the types of crashes in six years before and one year after installation of the countermeasures in January 9, 2007.

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Angle</u>	<u>Single Veh</u>	<u>Opposing LT</u>
1/9/01-1/8/02	1	1	0	0	0
1/9/02-1/8/03	6	1	2	2	1
1/9/03-1/8/04	7	3	3	0	1
1/9/04-1/8/05	6	1	3	0	2
1/9/05-1/8/06	2	1	1	0	0
1/9/06-1/8/07	5	2	0	2	1
1/9/07-1/8/08	1	0	0	0	1

Pike County; US 23 at Mossy Bottom Road; MP 29.600

This intersection is at the transition between a four-lane and six-lane section of US 23 with protected left turn phasing. The countermeasure was installing an advance warning flasher (AWF) on the southbound approach. The speed limit changes from 55 mph to 45 mph just north of the intersection. It should be noted that yellow retro-reflective backplates were installed in 2007. Following is a summary of crash data for four years before and four years after the installation (on March 4, 2004).

<u>Dates</u>	<u>Total Crashes</u>	<u>Southbound Rear End</u>
3/4/00-3/3/01	2	2
3/4/01-3/3/02	4	3
3/4/02-3/3/03	2	0
3/4/03-3/3/04	3	0
3/4/04-3/3/05	3	1
3/4/05-3/3/06	3	2
3/4/06-3/3/07	7	2
3/4/07-3/3/08	5	0

Pike County; US 23 at US 119; MP 26,284

This intersection is on a four-lane section of US 23 with protected left turn phasing. The countermeasure was installing an advance warning flasher (AWF) on the US 23 approaches. The speed limit is 55 mph. Following is a summary of crash data for four years before and three years after the installation (on May 6, 2004).

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End</u>	<u>Disregard Signal</u>	<u>Opposing LT</u>
5/6/00-5/5/01	22	17	2	2
5/6/01-5/5/02	32	27	1	1
5/6/02-5/5/03	27	22	0	2

5/6/03-5/5/04	31	27	0	4
5/6/04-5/5/05	23	17	0	2
5/6/05-5/5/06	22	17	0	1
5/6/06-5/5/07	17	15	0	0

Pike County; US 23 at KY 3496; MP 23.063

This intersection is on a four-lane section of US 23. The countermeasure was installing an advance warning flasher (AWF) on the US 23 southbound approach. The speed limit is 55 mph. Following is a summary of crash data for five years before and two years after the installation (on June 7, 2005).

<u>Dates</u>	<u>Total Crashes</u>	<u>Rear End (SB)</u>	<u>Disregard Signal (SB)</u>
6/7/00-6/6/01	8	3	1
6/7/01-6/6/02	8	1	3
6/7/02-6/6/03	5	0	0
6/7/03-6/6/04	5	2	0
6/7/04-6/6/05	7	3	1
6/7/05-6/6/06	13	3	1
6/7/06-6/6/07	2	0	0

Pulaski County; US 27 at KY 1642; MP 12.862

This intersection is on a six-lane section on US 27 with protected left turn phasing. The countermeasure was installing one signal head per lane. Following is a summary of crash data for six years before the installation (on February 23, 2006) and two years after.

<u>Dates</u>	<u>Total Crashes</u>	<u>Disregard Signal</u>	<u>Rear End</u>
2/23/00-2/22/01	8	2	4
2/23/01-2/22/02	19	6	11
2/23/02-2/22/03	13	5	8
2/23/03-2/22/04	15	8	5
2/23/04-2/22/05	11	2	7
2/23/05-2/22/06	15	2	12
2/23/06-2/22/07	6	0	3
2/23/07-2/22/08	5	1	4

Pulaski County; US 27 at KY 1577; MP 15.461

This intersection is on a six-lane section on US 27 with protected left turn phasing. The

countermeasure was installing one signal head per lane. Following is a summary of crash data for six years before the installation (on April 28, 2006) and two years after. It should be noted that the seven of the eight crashes where the driver disregarded the signal after the additional signal heads involved a southbound vehicle on US 27.

<u>Dates</u>	<u>Total Crashes</u>	<u>Disregard Signal</u>	<u>Rear End</u>
4/28/00-4/27/01	9	4	5
4/28/01-4/27/02	14	1	11
4/28/02-4/27/03	10	2	7
4/28/03-4/27/04	19	2	14
4/28/04-4/27/05	35	5	26
4/28/05-4/27/06	12	3	9
4/28/06-4/27/07	12	5	6
4/28/07-4/27/08	16	3	12

Pulaski County; US 27 at KY 80; MP 16.782

This intersection is on a six-lane section on US 27 with protected left turn phasing. The countermeasure was installing one signal head per lane. Following is a summary of crash data for six years before the installation (on April 28, 2006) and two years after.

<u>Dates</u>	<u>Total Crashes</u>	<u>Disregard Signal</u>	<u>Rear End</u>	<u>Sideswipe</u>
4/28/00-4/27/01	15	3	10	2
4/28/01-4/27/02	22	4	9	3
4/28/02-4/27/03	31	7	21	2
4/28/03-4/27/04	28	8	19	1
4/28/04-4/27/05	24	5	16	1
4/28/05-4/27/06	20	3	15	1
4/28/06-4/27/07	27	2	16	9
4/28/07-4/27/08	20	2	16	2

Pulaski County; US 27 at the KY 80 bypass; MP 16.854

This intersection is on a six-lane section on US 27 with protected left turn phasing. The countermeasure was installing double red signal indications. Following is a summary of crash data for six years before the installation (on April 28, 2006) and two years after.

<u>Dates</u>	<u>Total Crashes</u>	<u>Disregard Signal</u>	<u>Rear End</u>	<u>Sideswipe</u>
4/28/00-4/29/01	19	0	14	4
4/28/01-4/29/02	32	1	22	5
4/28/02-4/29/03	34	4	21	2
4/28/03-4/29/04	36	1	24	5
4/28/04-4/29/05	43	1	28	5
4/28/05-4/29/06	29	0	22	4

4/28/06-4/29/07	22	1	13	8
4/28/07-4/29/08	24	1	23	0

Rowan County; Morehead; US 60/KY 3030 and KY 3030/Main Street

Pedestrian countdown signals were installed at these two intersections on December 6, 2005. The data did not show any pedestrian crashes in the five years prior to the installation or two years after. These intersections are close to the campus of Morehead University which was the reason for these installations. Reflectorized backplates were installed at the US60/KY 3030 intersection on May 29, 2007.

Rowan County; US 60 at KY 519; MP 7.099

The intersection is the first signal eastbound on US 60 into Morehead. One countermeasure was installing a traffic signal ahead warning sign with LED on the eastbound approach. Following is a summary of crash data for the six years before the LED sign installation (on October 26, 2006). Reflectorized backplates were installed on June 5, 2007.

<u>Dates</u>	<u>Total Crashes</u>	<u>Angle</u>	<u>Rear End</u>	<u>Opposing LT</u>
10/26/00-10/25/01	0	0	0	0
10/26/01-10/25/02	1	0	1	0
10/26/02-10/25/03	9	4	3	2
10/26/03-10/25/04	7	4	3	0
10/26/04-10/25/05	3	1	1	1
10/26/05-10/25/06	5	0	3	2

Rowan County; US 60 at KY 32; MP 9.683

The intersection is the first signal westbound on US 60 into Morehead. One countermeasure was installing a traffic signal ahead warning sign with LED on the westbound approach. Following is a summary of crash data for the six years before the LED warning sign installation (on October 26, 2006). Reflectorized backplates were installed on May 29, 2007.

<u>Dates</u>	<u>Total Crashes</u>	<u>Angle</u>	<u>Rear End</u>	<u>Opposing LT</u>	<u>Sideswipe</u>
10/26/00-10/25/01	3	0	2	0	1
10/26/01-10/25/02	2	0	2	0	0
10/26/02-10/25/03	6	1	5	0	0
10/26/03-10/25/04	4	1	3	0	0
10/26/04-10/25/05	5	1	4	0	0
10/26/05-10/25/06	6	2	2	1	1

Rowan County; US 60 at KY 3031; MP 8.14

The countermeasure was installing retro-reflective backplates on US 60. Following is a summary of crash data for the five years before the installation (on June 5, 2007).

<u>Dates</u>	<u>Total Crashes</u>	<u>Angle</u>	<u>Rear End</u>
6/5/02-6/4/03	2	1	1

6/5/03-6/4/04	4	0	4
6/5/04-6/4/05	7	1	6
6/5/05-6/4/06	5	1	4
6/5/06-6/4/07	1	0	1

Wayne County; KY 90 at KY 92; MP 11.034

This intersection is on a two-lane section on KY 90 with protected/permissive left turn phasing. The countermeasure was installing double red signal indications. Following is a summary of crash data for six years before the installation (on March 2, 2006) and two years after.

<u>Dates</u>	<u>Total Crashes</u>	<u>Disregard Signal</u>	<u>Rear End</u>	<u>Opposing LT</u>
3/2/00-3/1/01	11	3	4	3
3/2/01-3/1/02	9	0	5	2
3/2/02-3/1/03	5	0	3	1
3/2/03-3/1/04	11	1	5	4
3/2/04-3/1/05	8	1	3	4
3/2/05-3/1/06	15	7	4	2
3/2/06-3/1/07	5	1	0	2
3/2/07-3/1/08	10	1	7	2

Wayne County; KY 90 at KY 1275; MP 12.721

This intersection is on a two-lane section on KY 90 with protected/permissive left turn phasing. The countermeasure was installing double red signal indications. Following is a summary of crash data for six years before the installation (on March 2, 2006) and two years after.

<u>Dates</u>	<u>Total Crashes</u>	<u>Disregard Signal</u>	<u>Rear End</u>	<u>Opposing LT</u>
3/2/00-3/1/01	10	0	5	3
3/2/01-3/1/02	12	0	4	5
3/2/02-3/1/03	4	1	2	1
3/2/03-3/1/04	8	0	2	5
3/2/04-3/1/05	11	2	5	3
3/2/05-3/1/06	5	1	4	0
3/2/06-3/1/07	9	0	3	4
3/2/06-3/1/08	6	0	4	2



### 3.6 Summary of Crash Data

The crash data for intersections with both before and after data available were combined by type of countermeasure. The number of crashes per year were summarized for each intersection before and after the installation date. The date of the installation did not allow after data to be available at some intersections. It should be noted there were substantially more years of data available before the installations than after.

Total crashes, angle crashes (which were primarily involving a driver disregarding the traffic signal), and rear end crashes were included in the analysis. Other types of crashes were not summarized. As noted in the description provided for each intersection, in many cases more than one countermeasure was installed. Following is a summary of the number of intersections having before and after crash data with the various countermeasures, or combination of countermeasures. The number of years of before and after available crash data are given. The amount of after data was very limited for some of the countermeasure combinations.

<u>Countermeasure(s)</u>	<u>Number</u>	<u>Years Before Data</u>	<u>Years After Data</u>
Double red indications	5	30	8
One signal head per lane	8	48	16
Retro-reflective backplates	30	173	39
Advance warning flashers	8	33	23
Pedestrian countdown	4	22	6
Double red/backplates	3	15	3
Refl. backplates/yellow head	1	6	1
Refl. backplates/supplemental heads/signing	2	13	2
One head per lane/supplemental heads	1	7	1
One head per lane/refl. backplates	2	13	2
Refl. backplates/supplemental heads	2	14	2
Refl. backplates/AWF	2	12	2
AWF/coordination	1	5	1

Following is a summary of the number of crashes per year before and after the addition of various countermeasures or combinations of countermeasures which had at least three years of after data.

<u>Countermeasure</u>	<u>Crashes per Year</u>						<u>Crashes per Year Change (Before - After)</u>		
	<u>Total</u>	<u>Before</u>		<u>After</u>			<u>Total</u>	<u>Angle</u>	<u>Rear End</u>
Double red	12.6	2.5	6.5	10.6	0.8	7.0	2.0	1.7	-0.5

Double red/ refl. backplates	9.4	1.5	4.0	7.7	0.3	6.3		1.7	1.2
							-2.3		
One head per lane	22.2	6.4	12.4	16.9	2.4	11.1		5.3	4.0
							1.3		
Refl. backplates	5.1	0.9	3.0	4.1	0.5	2.7		1.0	0.4
							0.3		
AWF	6.9	1.0	4.0	5.5	0.3	3.4		1.4	0.7
							0.6		

Data were reviewed at four intersections where the pedestrian countdown signals were installed. Only two pedestrian crashes were identified in 22 years of data prior to installation with no pedestrian crashes in the six years of after data.

The before and after data show that the addition of the countermeasures was associated with a reduction in crashes. The only exception was a couple of instances with an increase in rear end collisions. When all intersections are considered (excluding those with only an AWF or pedestrian countdown signal), the following results were obtained:

	<u>Before (per year)</u>	<u>After (per year)</u>	<u>Change (per year)</u>	<u>Percent</u>
<u>Change</u>				
Total crashes	9.8	8.2	1.6	16
Angle crashes	2.0	1.0	1.0	50
Rear end crashes	5.8	5.3	0.5	9

### 3.7 Conflict Data

Conflict data were taken at a limited number of intersections. The objective was to obtain data before and after countermeasures were installed. At several locations, no countermeasure has been installed but the before data are included to show the range of conflict data found. The data were taken at locations where there had been several crashes involving a driver disregarding the traffic signal. The number of conflicts in 100 cycles is given for the listed approaches. In a few instances, when data were taken for less than 100 cycles, the data were factored to estimate the number for 100 cycles. The types of conflicts originally observed involved a driver disregarding a traffic signal, stopping abruptly, or accelerating through the yellow indication. Disregarding the traffic signal was defined as crossing the stop bar after the start of the red indication. The “abrupt stop” and “acceleration through yellow” conflicts were very subjective and varied dramatically by observer. Therefore, only the “disregarding the traffic signal” or “ran red” conflict was used in the analysis. Following is a summary of the data.

<u>COUNTY</u>	<u>ROUTE</u>	<u>INTERSECTION</u>	<u>DIR.</u>	<u>RAN RED CONFLICT*</u>	
				<u>BEFORE</u>	<u>AFTER</u>
Hardin	US 31W	KY 3005	SB	19	12
	US 31W	KY 434	NB	5	3
	US 31W	KY 313	SB/NB	8	4

	US 31W	Town Drive	NB	18	10
	US 31W	Towne Mall Ent.	SB	18	10
Fayette	US 27	Reynolds	SB	5	**
			NB	20	**
	US 27	Canary	SB	4	**
	US 27	Wilson Downing	SB	4	**
	US 27	KY 4 (inner loop)	NB	5	0
	US 27	Southpark	NB/SB	3	**
	US 27	Rojay	NB/SB	4	**
	US 27	Tiverton	NB/SB	9	**
	High	Broadway	WB	8	**
	Broadway	High	NB	4	**
	Broadway	Maxwell	SB	8	**
	Maxwell	Broadway	EB	1	**
Madison	KY 876	KY 2327	EB	6	**
Boone	KY 18	KY 3157	WB	16	9
Franklin	US 127	Leonardwood	SB	5	2
Pike	US 23	Weddington Branch	NB/SB	21	16
Knox	US 25E	KY 1629	NB/SB	7	**

\* Number of cycles in which a vehicle crossed the stop bar after the start of the red interval out of 100 cycles.

\*\* No countermeasure has currently been installed.

The reduction in conflicts involving a driver disregarding the red signal, at all the locations with before and after data, was 43 percent. This is similar to the overall reduction in angle crashes of 50 percent.

### 3.8 Cost of Installations

The various countermeasures were installed by the Kentucky Transportation Cabinet. Following is a summary of the typical cost for specific countermeasures.

<u>Countermeasure</u>	<u>Material Cost</u>	<u>Labor Cost</u>
double red indications (each signal head)	\$320	\$130
double red signal head with yellow backplates	550	130
one signal head per lane (each signal head)	100	130
retro-reflective backplates (each signal head)	50	100
yellow reflectorized backplates (each signal head)	50	130
supplemental signal heads (near right/far left)	100	130
yellow signal head	130	130
yellow signal head with yellow backplate	300	130
advance warning flashers (per approach)	12,500	5,000
LED signal ahead warning sign	1,370	100

pedestrian countdown signal	160	125
advance lane assignment sign	30	100

#### 4.0 CONCLUSIONS

The before and after crash data show the benefit obtained from the various low-cost safety countermeasures in reducing the number of crashes at intersections, especially angle crashes. The limited amount of conflict data support the crash data. The low cost of most of the evaluated countermeasures, when compared to the reduction in crashes, would result in a high benefit cost ratio. The public response to the countermeasures, as reported by traffic engineers, has been positive with requests for additional installations.

#### 5.0 RECOMMENDATIONS

Given the severity of the angle collisions resulting from a driver disregarding a traffic signal, the installation of relatively low-cost safety countermeasures is warranted at intersections where this type of crash has occurred or conditions exist which may result in this type of crash. The crash analysis described in this report should be used to identify intersections where these countermeasures have the highest potential for reducing crashes. The countermeasures identified should be considered at these intersections with the intersection characteristics and specific crash history used to select the specific countermeasure to implement at a given intersection.

#### 6.0 REFERENCES

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4. "Low Cost Traffic Engineering Improvements: A Primer," Federal Highway Administration, FHWA-OP-03-078, April 2003.
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9. Green, E.R. and Agent, K.R.; "Crash Rates at Intersections," University of Kentucky, Transportation Center, Report KTC-03-21, August 2003.

Table 1. Crashes at Signalized Intersections involving Disregarding Traffic Control as a Contributing Factor (2000-2004)

<u>County</u>	<u>Routes</u>	<u>Number Crashes</u>		<u>CRF</u>
Warren	KY 234/KY 2158/KY 6144	10		4.87
Marshall	US 641/KY 58/KY 408	9		3.63
Jefferson	US 42/US 60	22		3.49
Jefferson	KY 864/KY 2053	8		3.42
Hopkins	US 41/KY 70	20		2.90
Washington	US 150/KY 55/KY 555	9		2.85
Hardin	KY 1357/KY 3005	7	2.66	
Hardin	US 31W/KY 3005	32	2.65	
Fayette	US 27/US 60	24		2.54
Whitley	US 25W/KY 727	12		2.46
Knox	US 25E/KY 2417	8		2.33
Christian	US 41/KY 107	13		2.26
Breathitt	KY 15/KY 3231	7		2.25
Marshall	US 641S/KY 58	5		2.09
Fayette	KY 169/KY 1974	4		2.03
Washington	KY 528/KY 555	4		2.00
Christian	US 41/KY 1453	3		1.98
Muhlenburg	US 62/KY 189	5		1.97
Jefferson	US 31/US 31E/US 31W	19		1.81
Hardin	KY 1600/KY 3005	11	1.81	
Fayette	US 25/US 27	22		1.79
Harlan	US 421/KY 72	6		1.77
Boone	KY 18/KY 3157	23		1.76
Calloway	KY 821/KY 822	8		1.75
Taylor	KY 55/KY 3183	4		1.68
Kenton	KY 7/KY 1120	10		1.65
Rowan	KY 32/KY 377	4		1.64
Pulaski	US 27/KY 80	18		1.64
Johnson	KY 40/KY 321	5		1.64
Grayson	US 62/KY 920	5		1.62
Muhlenburg	KY 70/KY 189	4		1.61
Wayne	KY 90/KY 1275/KY 90X	5	1.61	
Knox	US 25E/KY 1629	13		1.57
Hopkins	US 41/KY 1178	11		1.57
Washington	US 150/KY 528	4		1.56
McCreary	US 27/KY 92/KY 1651	4		1.55
Fayette	US 27/US 60	19		1.55
Warren	US 231/KY 622	5		1.53

Table 1. Crashes at Signalized Intersections involving Disregarding Traffic Control as a Contributing Factor (2000-2004) (continued)

<u>County</u>	<u>Routes</u>	<u>Number Crashes</u>		<u>CRF</u>
Floyd	US 23/KY 1428	5		1.53
Franklin	US 460/KY 2822	8		1.51
Scott	US 62/US 460B	4		1.51
Rockcastle	US 150/KY 461	4		1.48
Muhlenburg	US 62/KY 181	4		1.47
Hardin	US 31W/KY 434	12	1.45	
Hopkins	KY 70/KY 254	9		1.43
Knox	US 25E/KY 312	12		1.43
Hardin	US 31W/KY 2802	5	1.40	
Jefferson	KY 1230/KY 1931	4		1.39
Christian	US 41A/KY 380	11		1.39
Jessamine	KY 29/KY 3433	3		1.39
Daviess	US 431/KY 2245	10		1.38
McCracken	US 60X/KY 305	6		1.36
Pulaski	US 27/KY 1642	13		1.36
Logan	US 68/US 68X	7		1.36
Madison	KY 876/KY 2327	17		1.33
Marshall	US 641/KY 58	3		1.32
Muhlenberg	US 431/KY 277	3		1.31
Jefferson	KY 907/KY 1065	9		1.31
Madison	KY 21/KY 52	2		1.31
Warren	US 231/KY 2158	11		1.31
Harlan	US 421/KY 72	5		1.31
Campbell	US 27/KY 8	7		1.30
McCracken	US 60/KY 996	3		1.29
Harlan	US 421/KY 6256	4		1.28
Boyd	US 23/US 23X	13		1.26
Franklin	US 127/KY 1665	4		1.24
Jefferson	US 150/KY 1020	17		1.24
Hardin	US 31W/KY 313	15	1.24	
Pulaski	US 27/KY 2298	12		1.23
Meade	US 60/KY 144	3		1.23
Marshall	US 62/KY 1523	3		1.22
Franklin	KY 420/KY 2261	5		1.21
Marshall	US 641/KY 80	3		1.19
Letcher	US 119/KY 15/KY 15X	3		1.19
Pulaski	US 27/KY 1577	11		1.18
Campbell	KY 9/KY 1998	10		1.15

Table 1. Crashes at Signalized Intersections involving Disregarding Traffic Control as a Contributing Factor (2000-2004) (continued)

<u>County</u>	<u>Routes</u>	<u>Number Crashes</u>	<u>CRF</u>
Jefferson	US 31W/US 150	6	1.15
Boone	KY 18/KY 842	17	1.15
Scott	US 62/KY 2906	8	1.14
Carroll	KY 227/KY 320	3	1.14
McCracken	US 45/KY 731	10	1.14
Graves	US 45/KY 1276	3	1.14
Christian	US 41/KY 380	7	1.12
Knox	KY 2419/KY 2420/KY 2421	3	1.11
Meade	US 31W/KY 868/KY 1638	4	1.11
Floyd	KY 80/KY 1210	3	1.10
Boone	KY 18/KY 1017	12	1.09
Pulaski	US 27/KY 2297	9	1.09
Pike	US 119/KY 1426	3	1.08
Warren	US 231/KY 884	11	1.07
Hardin	US 31W/KY 251	10	1.07
Jefferson	KY 1447/KY 1932	7	1.05
Calloway	KY 94/KY 1660	2	1.05
Jefferson	US 31E/US 42	6	1.05
Fayette	US 25/KY 1928	9	1.05
Kenton	US 25/KY 8	8	1.05
Jefferson	US 60/KY 146	17	1.04
Harlan	US 421/KY 72/KY 3459	4	1.03
Campbell	KY 8/KY 9	7	1.03
Boone	KY 842/KY 3503	6	1.03
Rowan	US 60/KY 32	10	1.03
Harrison	US 27/KY 36	5	1.02
McCreary	US 27/KY 478	3	1.02
Christian	US 68/KY 1007	8	1.01
Muhlenberg	US 62/KY 176	3	1.00
Mason	KY 9/KY 11	3	1.00



Appendix A. All Signalized Intersections (Two or More State Maintained Roads) by CRF

Table A-1. Crashes at Signalized Intersections (2000-2004)

<u>County</u>	<u>Routes</u>	<u>Number Crashes</u>		<u>CRF</u>
Warren	KY 234/KY 2158/KY 6144	33		3.26
Christian	US 41A/KY 117	62		3.18
Nelson	US 31E/KY 245	128		2.86
Carroll	US 42/KY 320	37		2.42
Clay	US 421/KY 80/KY 2076	48		2.40
Wayne	KY 90/KY 1275/KY 90X	50	2.34	
Warren	US 231/KY 2158	88		2.32
Nelson	US 62/KY 245	82		2.30
Washington	US 150/KY 55/KY 555	50		2.28
Hardin	US 31W/KY 313	98	2.16	
Whitley	US 25W/KY 727	39		2.14
Boone	KY 18/KY 842	163		2.12
Laurel	US 25/KY 192	98		2.12
McCracken	US 45/KY 731/US 62	85		2.12
McCracken	US 60/KY 996	27		2.11
Kenton	KY 236/KY 2975	65		2.11
Warren	US 68/US 231	119		2.09
Warren	US 31W/US 231	108		2.08
Warren	US 231/KY 880	64		2.00
Hardin	US 31W/KY 434	74	2.00	
Bourbon	US 27/US 68X	85		1.98
Garrard	US 27/KY 39	30		1.95
Madison	US 25/KY 52	84		1.92
Warren	US 231/KY 884	92		1.88
Marshall	US 68/US 641	33		1.87
Fayette	KY 4/KY 1927	106		1.85
McCracken	US 45X/US 60X	24		1.85
McCracken	US 45/KY 1310	55		1.84
Kenton	KY 8/KY 2374	39		1.81
Lawrence	KY 3/KY 32	36		1.79
Hopkins	US 41/KY 281	82		1.76
Hardin	US 31W/KY 1815	86	1.73	
Kenton	KY 1303/KY 1829	55		1.73
Boone	KY 18/KY 3157	133		1.72
Meade	US 31W/KY 868/KY 1638	47		1.71
McCracken	US 60X/KY 305	27		1.70
Floyd	US 23/KY 1428	39		1.69
Mason	KY 8/KY 2511	19		1.68
Boone	KY 18/KY 1017	77		1.66

Table A-1. Crashes at Signalized Intersections (2000-2004) (continued)

<u>County</u>	<u>Routes</u>	<u>Number Crashes</u>		<u>CRF</u>
Warren	US 231/KY 880	100		1.65
Wayne	KY 90/KY 92	36		1.64
Anderson	US 127/KY 151	37		1.60
Henderson	US 60/KY 136/ KY425	36		1.54
Hardin	US 31W/KY 3005	92	1.53	
Hopkins	KY 70/KY 254	39		1.53
Christian	US 41/KY 1682	33		1.52
Laurel	KY 192/KY 363	63		1.52
Floyd	KY 302/KY 1428	19		1.52
Jefferson	KY 155/KY 1747	132		1.52
Warren	US 31W/KY 526	25		1.51
Laurel	US 25/US 25E	54		1.51
Bullitt	KY 1450/KY 1526	43		1.50
Scott	US 62/US 460B	24		1.48
Knox	US 25E/KY 312	56		1.48
Muhlenberg	US 62/KY 181	25		1.48
Warren	US 31W/US 231X	47		1.47
McCracken	US 60/KY 284	51		1.47
Marion	US 68/KY 55	46		1.46
Larue	US 31E/KY 61/KY 1618	23		1.45
Muhlenberg	US 62/KY 176	29		1.44
Muhlenberg	US 62/US 431	26		1.43
Grayson	US 62/KY 920	30		1.42
Madison	KY 876/KY 2327	67		1.39
Boone	KY 842/KY 3503	32		1.38
Lewis	KY 8/KY 59/KY 2525	18		1.37
Franklin	US 60/KY 420	31		1.35
McCracken	US 45/KY 305	28		1.35
McCracken	US 62/KY 1286	36		1.35
Nelson	US 31E/KY 1430	39		1.34
Madison	US 25/KY 2875	43		1.33
Mason	KY 9/KY 11	22		1.33
Boone	KY 18/KY 237	72		1.33
Pulaski	US 27/KY 1577	57		1.32
Marshall	US 641/KY 58/KY 408	19		1.32
Kenton	KY 8/KY 17	34		1.31
Knox	US 25E/KY 1629	48		1.30
Muhlenberg	US 431/KY 277	16		1.29
Lincoln	US 27/US 150	22		1.28

Table A-1. Crashes at Signalized Intersections (2000-2004) (continued)

<u>County</u>	<u>Routes</u>	<u>Number Crashes</u>	<u>CRF</u>
McCracken	US 45/KY 1286	47	1.27
Crittenden	US 60/US 641	23	1.27
Kenton	KY 7/KY 1120	31	1.27
McCracken	US 62/KY 787	25	1.26
Pulaski	US 27/KY 80	67	1.26
Marshall	US 641/KY 348	24	1.26
Washington	US 150/KY 528	19	1.24
Boone	US 25/KY 338	23	1.24
Ohio	US 231/KY 69/KY 1543	20	1.24
Boone	KY 842/KY 1017	68	1.24
Henderson	US 60/KY 145	15	1.23
Madison	KY 52/KY 876	71	1.23
Hopkins	US 41/KY 70/KY 481	44	1.22
Kenton	KY 17/KY 536	29	1.22
Madison	US 25/KY 876	73	1.22
Boone	US 25/KY 842	34	1.21
Logan	US 68/KY 79	15	1.21
Larue	KY 61/KY 84	16	1.21
Logan	US 79/KY 2146	32	1.21
Muhlenberg	US 62/KY 189	18	1.21
Harrison	US 27/KY 36	22	1.20
Hopkins	US 41/KY 70	35	1.20
Muhlenberg	US 431/KY 176	15	1.20
Laurel	KY 80/KY 192	38	1.20
Allen	US 31E/KY 100	16	1.19
Pulaski	US 27/KY 80B/LN 9008	63	1.19
Henry	KY 22/KY 55	16	1.19
Boyd	US 23/US 23X	58	1.19
Carroll	US 42/KY 36	19	1.19
Crittenden	US 60/KY 91/KY 120	26	1.19
Campbell	KY 9/KY 1998	46	1.18
Calloway	US 641/KY 121	51	1.18
Warren	US 31W/US 68	43	1.18
Floyd	US 23/KY 979	28	1.18
Breathitt	KY 15/KY 3231	25	1.17
Boone	US 25/KY 536	41	1.17
McCreary	US 27/KY 92/KY 1651	18	1.16
Graves	KY 121/KY 303	16	1.16
McCracken	US 45/KY 3074	40	1.15

Table A-1. Crashes at Signalized Intersections (2000-2004) (continued)

<u>County</u>	<u>Routes</u>	<u>Number Crashes</u>		<u>CRF</u>
Fayette	US 60/KY 1723	44		1.15
Madison	US 25X/KY 388	32		1.15
Campbell	US 27/KY 8	24		1.15
Kenton	KY 17/KY 371	47		1.15
Christian	US 41A/KY 380	40		1.15
Muhlenberg	KY 181/KY 189	19		1.14
Hardin KY 144/KY 1646		23	1.14	
Christian	US 41/KY 107	26		1.14
Boyle	US 127/US 127B	63		1.14
Campbell	US 27/KY 10	42		1.13
Jefferson	KY 155/KY 1819	37		1.13
Boone	KY 20/KY 237	39		1.13
Henderson	US 41/KY 812	24		1.13
Estill	KY 52/KY 499	17		1.12
Fayette	US 27/US 60	49		1.12
Jefferson	KY 61/KY 1065	80		1.11
Hopkins	US 41/KY 260	11		1.11
Boone	KY 18/KY 3168	57		1.10
McCracken	US 60/KY 994	32		1.10
Franklin	US 60/US 127	55		1.10
Hardin KY 1600/KY 3005		27	1.09	
Grayson	US 62/KY 259	26		1.09
Lawrence	US 23/KY 3	19		1.09
Wayne KY 90/KY 90X/KY 3284		26	1.08	
McCracken	US 60/KY 1954/US 60X	55		1.08
Christian	US 41A/KY 400	40		1.08
Muhlenberg	US 62/KY 189	16		1.08
Marshall	US 641/KY 80	16		1.08
Nelson	US 150/KY 49	19		1.07
Marion	US 68/KY 55S	21		1.07
Allen	US 31E/US 231/KY 980	16		1.07
Trimble	US 42/US 421	12		1.07
Bourbon	US 27/KY 1939	16		1.06
Breathitt	KY 15/KY 1812/KY 3068	14		1.06
Marshall	US 68/US 641	18		1.06
Johnson	KY 40/KY 321	22		1.06
McLean	KY 81/KY 136	13		1.05
Boone	US 42/KY 536	30		1.05
Campbell	US 27/KY 709	40		1.04

Table A-1. Crashes at Signalized Intersections (2000-2004) (continued)

<u>County</u>	<u>Routes</u>	<u>Number Crashes</u>	<u>CRF</u>
Shelby	US 60/KY 53/KY 55	34	1.04
Warren	US 31W/KY 1402	42	1.04
Pike	US 460/KY 1460	19	1.03
Christian	US 41/KY 2544	30	1.03
Nelson	US 62/US 150	27	1.03
Logan	US 68/US 68X	20	1.03
Bourbon	US 68X/KY 1678	29	1.02
Calloway	KY 94/KY 822	18	1.02
Campbell	US 27/KY 8	15	1.01
Hopkins	US 41/KY 1178	30	1.01
Bullitt	KY 44/KY 61	32	1.01
Jefferson	KY 907/KY 1865	45	1.00
McCracken	US 60/KY 1154	13	1.00
Campbell	KY 8/KY 9	25	1.00
Fayette	US 25/US 27	53	1.00

Appendix B. Photographs of Low-Cost Safety Countermeasures

## List of Photographs

- Figure A-1. Double Red Indications.
- Figure A-2. Retro-reflective Backplates.
- Figure A-3. Double Red Indications (Nighttime).
- Figure A-4. Retro-reflective Backplates (Nighttime).
- Figure A-5. Yellow Signal Head.
- Figure A-6. Yellow Retro-reflective Backplates.
- Figure A-7. One Signal Head per Lane (Before and After).
- Figure A-8. Supplemental Signal Heads.
- Figure A-9. LED Signal Ahead Warning Sign.
- Figure A-10. Pedestrian Countdown Signal.
- Figure A-11. Advance Warning Flashers.





Figure A-1. Double Red Indications

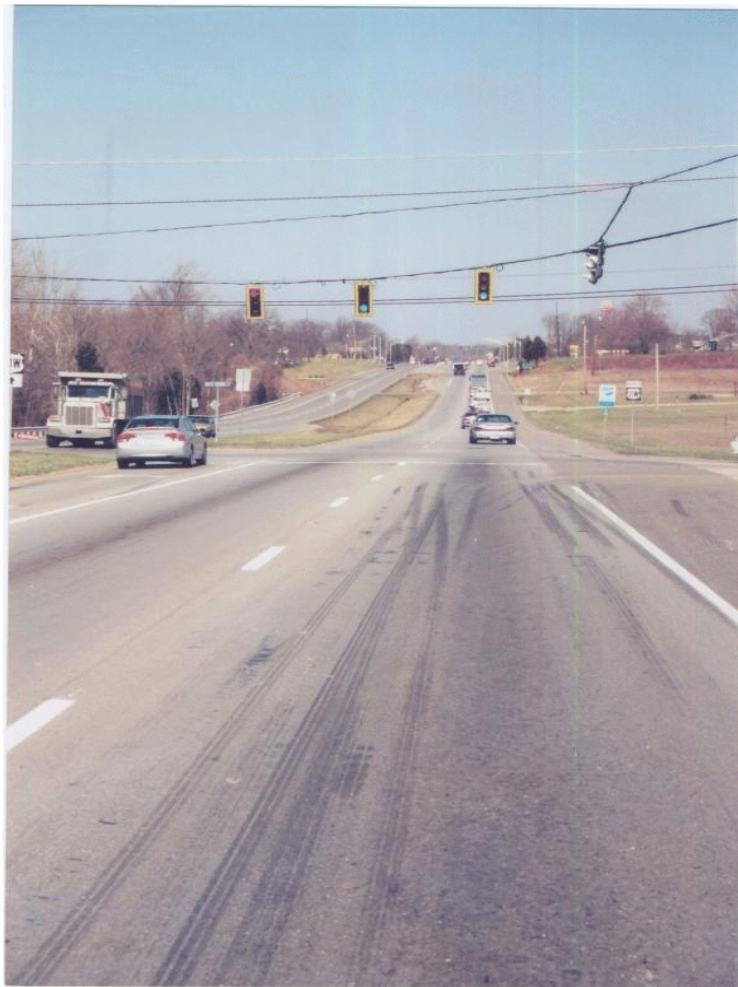


Figure A-2. Retro-reflective Backplates





Figure A-3. Double Red Indications (Nighttime)



Figure A-4. Retro-reflective Backplates (Nighttime)





Figure A-5. Yellow Signal Head



Figure A-6. Yellow Retro-reflective Backplates





Before



After

Figure A-7. One Signal Head per Lane (Before and After)





Figure A-8 Supplemental Signal Heads





Figure A-9. LED Signal Ahead Warning Sign



Figure A-10. Pedestrian Countdown Signal





Figure A-11. Advance Warning Flashers



*For more information or a complete publication list, contact us at:*

**KENTUCKY TRANSPORTATION CENTER**

176 Raymond Building  
University of Kentucky  
Lexington, Kentucky 40506-0281

(859) 257-4513  
(859) 257-1815 (FAX)  
1-800-432-0719  
[www.ktc.uky.edu](http://www.ktc.uky.edu)  
[ktc@engr.uky.edu](mailto:ktc@engr.uky.edu)

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