K. A. Brewer

Drivers' Behavior at Railroad Grade Crossings: Before and After Safety Campaign

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Sponsored by the
Iowa Department of Transportation,
Highway Division, and the
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Iowa DOT Project HR-335
ERI Project 3440
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Department of Civil and Construction Engineering
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Iowa Department of Transportation

report

College of Engineering
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ABSTRACT

In April 1991 the Iowa Department of Transportation, the CNW Transportation Company, the SOO Line, and local agencies and business in the Mason City/Clear Lake area initiated an Operation Lifesaver program to attempt to increase public awareness of safety issues and safe behavior at railroad-highway grade crossings. This document reports an initial study of data on traffic characteristics at a selected set of grade crossings in Cerro Gordo County taken before and after the safety program. Twenty-two crossings were studied. The 13 crossings at which collisions were reported for the five years prior to the study were included in the sample of sites. Two field observations were made at each study crossing before the Operation Lifesaver campaign was in full swing, and two observations were made after the conclusion of the main effort of the campaign. The summary of each data set is contained in the companion volume entitled, "Drivers' Behavioral Railroad Grade Crossings: Before and After Safety Campaign, Survey Data Summaries."

A radar speedgun was used to record the speed of vehicles approaching the crossing and as they crossed the tracks. Observers also noted whether drivers looked for trains or gave other evidence of checking to be sure the crossing was clear of trains before proceeding across the tracks. Observers recorded the frequency with which drivers braked and were prepared to stop as they approached the tracks.

Analysis of these data revealed that at crossings in 25 mph speed zone areas, drivers reduced their average overall speed significantly after Operation Lifesaver. In areas with increasing speed limits (and generally much lower roadway traffic volumes), reductions in average speeds were seen but the change was not consistently significant statistically.

When the vehicle speed data were broken out by crossings where accidents had occurred versus those with no accident history, the approach and crossing speeds recorded at the accident crossings generally were lower after Operation Lifesaver. The data on drivers' attention were also examined with respect to accident and nonaccident sites. On average, drivers were more attentive in looking for a crossing hazard at the accident sites after Operation Lifesaver, the reverse was true for the nonaccident sites. Although there were differences in the rate of observed application of brakes at both accident and nonaccident sites after Operation Lifesaver, nothing was statistically significant. Thus braking differences were not reliable indicators of the effectiveness of the safety campaign.

The research shows that Operation Lifesaver, as conducted in Mason City and Cerro Gordo County in April 1991, altered drivers' behavior in the following ways: (1) reduced approach speeds and crossing speeds at crossings with low speed limits, (2) reduced the percent of drivers approaching the crossing at speeds in excess of the posted speed limit, and (3) increased alertness

of drivers to railroad crossing hazards as evidenced by more drivers looking for a clear track. Thus, Operation Lifesaver enhanced safety in street and highway traffic operations in the vicinity of railroad-highway grade crossings.

INTRODUCTION

General Situation

Collisions at railroad-highway grade crossings have long been a safety concern. Fifty years ago automotive collisions at railroad crossings were a major portion of all highway accidents. Since then several factors have combined to significantly reduce the frequency of these collisions. Railroad mileage has been reduced. Many high-volume streets and highways have been grade-separated at railroads. Improved signs, flashing train-activated signals, and train-activated crossings gates have been installed in increasing numbers every year. Maintenance and reconstruction projects undertaken jointly by railroads and highway agencies have improved drivers' sight distance at railroad-highway grade crossings. However, even with these improvements, a significant safety concern continues to exist because collisions at these crossings frequently produce tragic injuries, often resulting in fatalities. Since engineering improvements at many crossings have been developed as far as can be justified economically, increased emphasis is now needed on improving drivers' awareness of railroad-highway crossings and enhancing their response to the existing traffic controls.

Previous Research

Much research has been done to assess motorists' understanding of traffic control at railroad-highway grade crossings (for example, Richards and Heathington). Also, the various and sundry devices used at railroad-highway crossings to control automotive traffic and to warn drivers have been studied (for example, Fambro, Heathington, and Richards). Furthermore, much has been done to try to create formulas and equations to predict whether a crossing will be safe or not, to predict the relative hazard of a crossing, and to predict the probability of a collision (for example, Faghri and Demetsky). Collisions at railroad-highway grade crossings happen very infrequently and are almost random in the rate of occurrence. This makes it very difficult to estimate the average number of collisions at some specific crossing for any given time period, say five years. In addition, any estimate of collisions has a large probable error; that is, the estimate will not be very accurate. However, traffic engineers have known for a long time that intersections with low accident rates but high levels of traffic flow conflicts are good candidates for safety improvements. Changing a street or highway intersection to reduce traffic conflicts will reduce future accidents. In the same way it is important to see if railroad crossing safety campaigns cause more safe driver behavior and reduce the potential for future collisions at railroad crossing in the campaign area.

General Problem

The Iowa Department of Transportation has been working with the Federal Highway Administration, the Federal Railroad Administration, operating railroad companies, and local highway agencies for many years to improve safety at railroad-highway grade crossings in the state. This program includes improving sight distance at crossings, increasing the quality and quantity of signs and markings, increasing the number of signals and gates installed, installing train motion sensors, and improving train signal detection systems. The Iowa Department of Transportation, Iowa cities, Iowa counties, and operating railroad companies have also recognized the need to improve drivers' behavior and their awareness of the proper motorist response at railroad-highway grade crossings and have instituted numerous cooperative "Operation Lifesaver" programs.

Study Objective

The objective of the current research is to document drivers' behavior in the vicinity of a set of grade crossings before and after an Operation Lifesaver campaign and to evaluate the amount and significance of any change in drivers' behavior.

Conduct of Study

An Operation Lifesaver campaign was scheduled for April 1991 in the Mason City, Iowa area. This area was small enough to be manageable and yet had significant railroad mileage and a history of crossing accidents. Thus an evaluation study was considered to be feasible without incurring major research expenses. The study was designed to sample crossings across Cerro Gordo County (Mason City is the largest city and county seat) so that some crossings would be observed far enough away from Mason City to minimize the impact of the safety campaign. The original study design suggested that the crossings studied should have one of three levels of protection:

(1) Gates

(2) Flashing signals

(3) Crossbucks and advance warning signs only

The original study was designed to include enough crossings to also factor the data by the following site conditions:

(1) Street or highway traffic volume crossing the tracks

(2) Land use development environment

(a) Urban or town

(b) Rural

(3) Railroad environment

(a) Single or multiple tracks

(b) Through traffic or switching operations

(c) Train frequency and speed

(d) Train visibility from highway on approach to crossing

All Cerro Gordo County crossings for which a collision had been recorded in the past five years were included. In addition, at least two study crossings in each cell of a matrix for all study factors were considered desirable. A preliminary estimate of the number of crossings that could be observed and studied in the time available "before" and "after" the safety campaign suggested that 24 to 30 crossings were the limit. Thirteen crossings in Cerro Gordo County had recorded collisions in the five years prior to the study. Table 1 lists these crossings with selected classifying information about each one. After an on-site reconnaissance of the potential sites, additional crossings were added to those listed in Table 1 to achieve a balance among the factors listed above and yet hold the total survey sites to 24 or less. After conducting a pilot data collection test , the researchers estimated that 24 sites were the maximum number of sites that could be observed both before and after the safety campaign within the time limits of the project . The crossings without a five-year history of accidents that were added to the study are listed in Table 2. Note that one crossing was lost due to street construction and a second was deleted to retain study balance leaving a total of 22 crossings that were surveyed in this project. The location of the final set of study crossings are shown in Figures 1-4.

Prior to the study, researchers decided that the measures of drivers' behavior that might be affected by a safety campaign and might also be related to reducing the potential for collisions at the crossings included:

(1) Speed of vehicles approaching the crossing

(2) Speed of vehicles crossing the tracks

(3) Drivers looking for signs, signals, and trains

(4) Obeying or disobeying any signals flashing, gates down, or train warnings

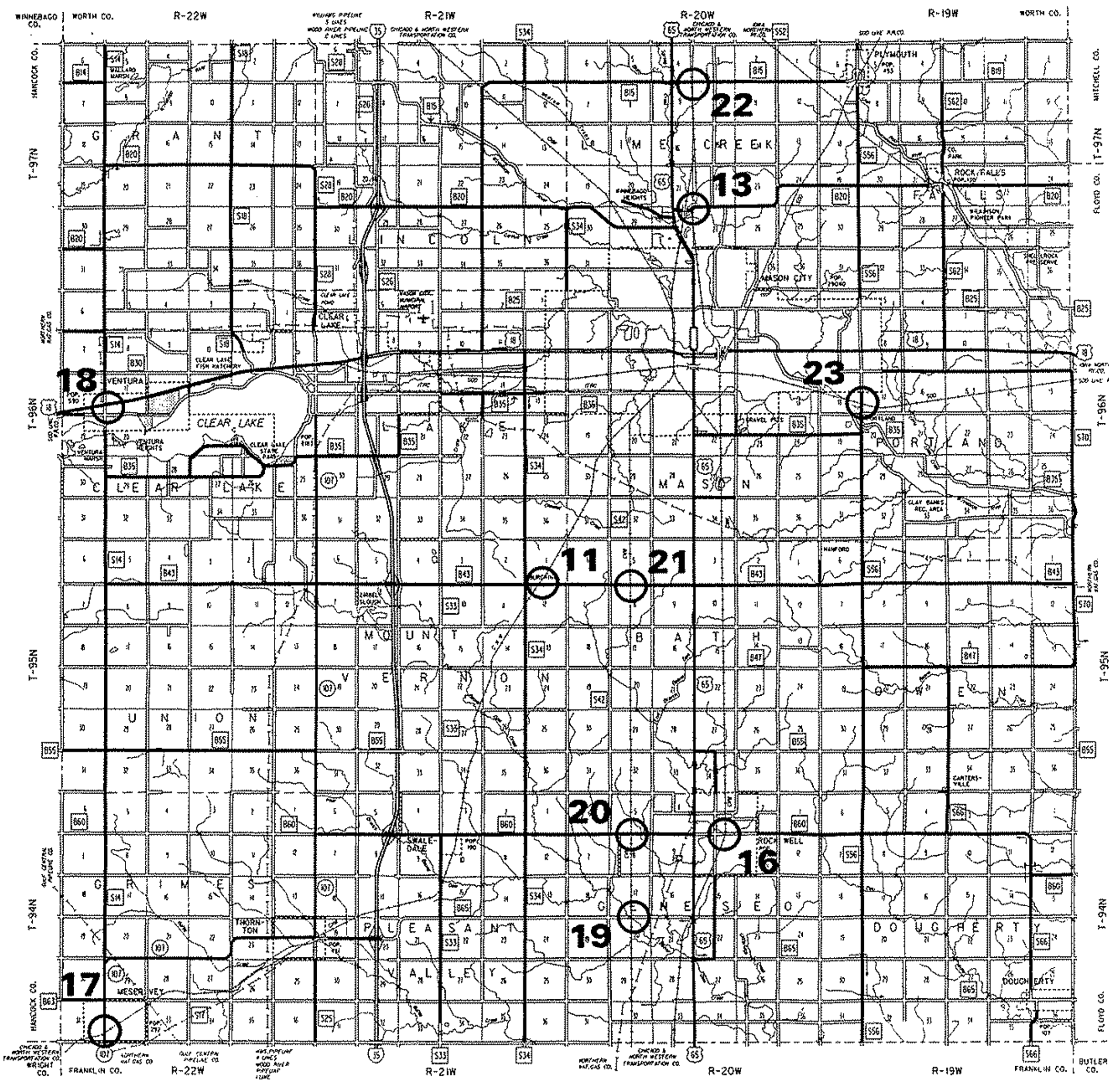

Fig. 1. Cerro Gordo County railroad-highway grade crossing sites.

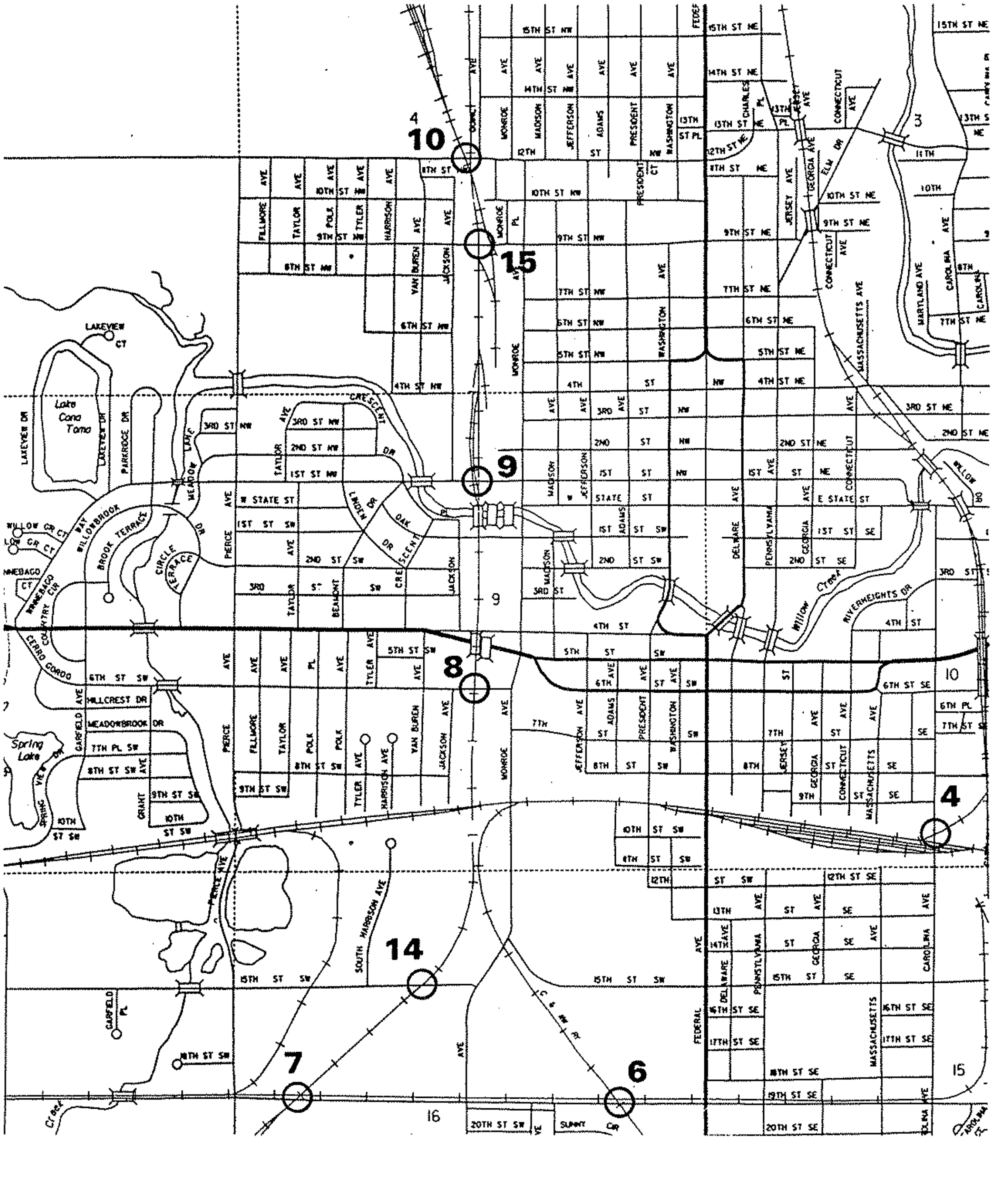

Fig. 2. Mason City railroad-highway grade crossing sites.

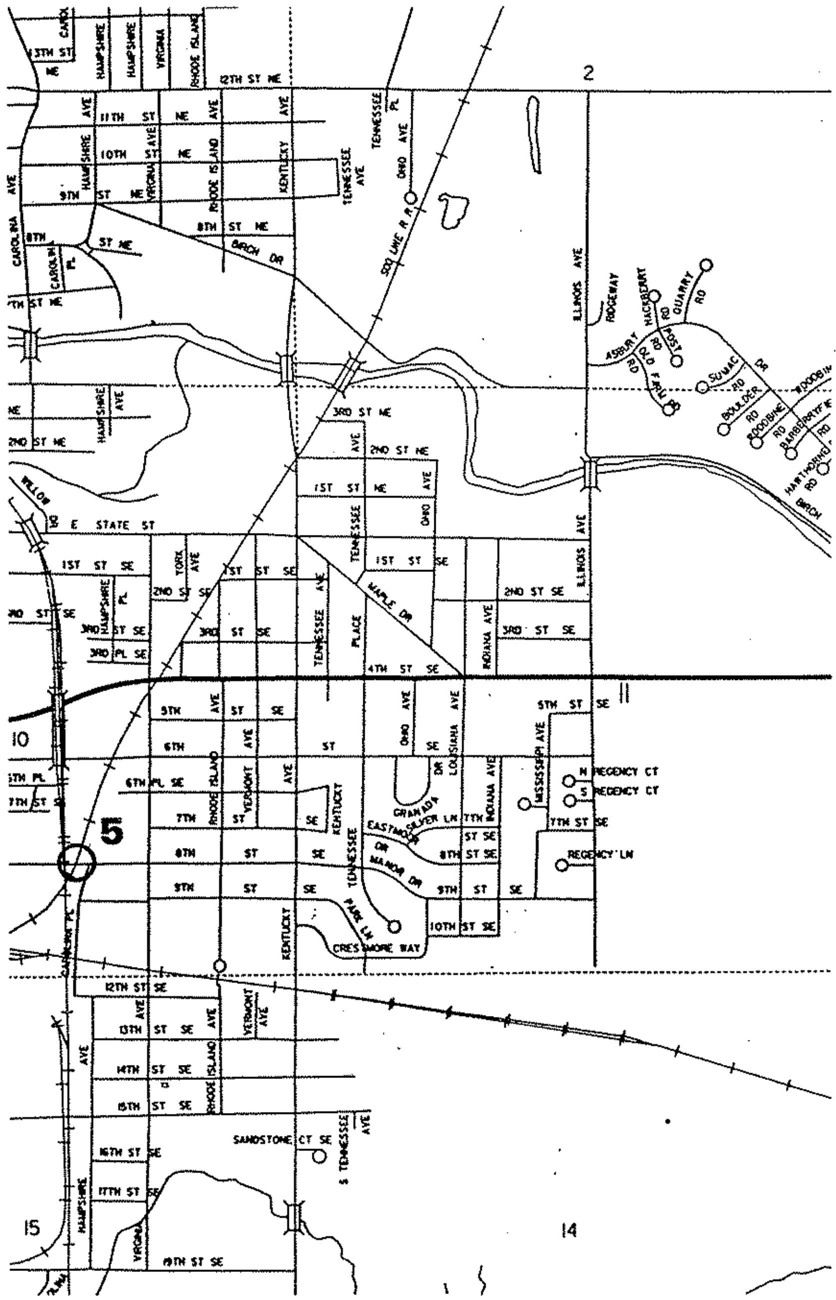

Fig. 3. Mason City railroad-highway grade crossing sites.

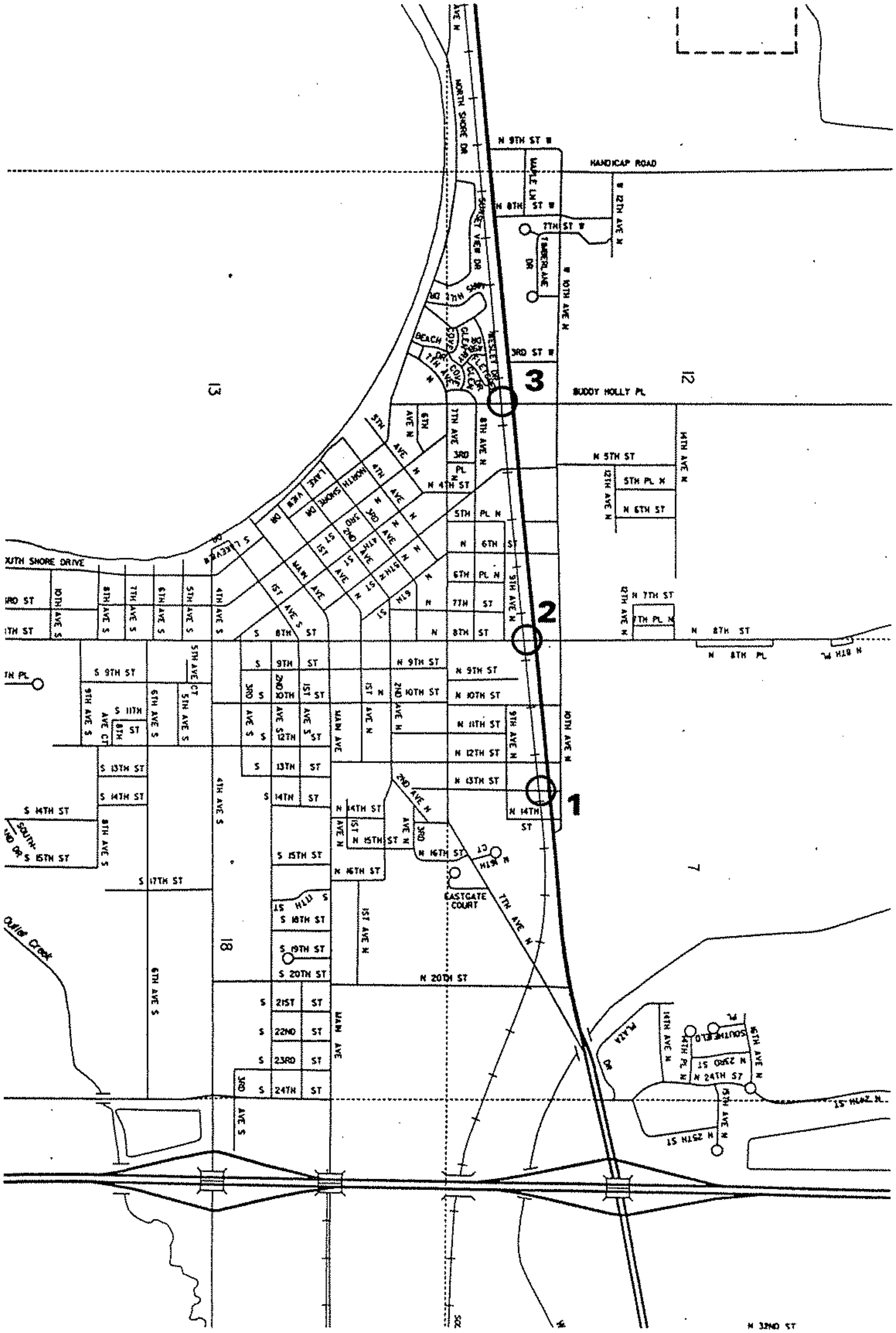

Fig. 4. Clear Lake railroad-highway grade crossing sites.

Table 1. Railroad crossings in Cerro Gordo County with accidents in the 5 years prior to study.

Location	Xing Protection	Daily Trains	Trks	Veh./ Day	Acci- dents	Site No.
Clear Lake, 13th St. N	X-bucks	1	1	436	1	1
Clear Lake 8th St. N	Gates	1	1	4970	1	2
Clear Lake, 2nd Pl. N	Signals	1	2	2780	2	3
Mason City, 12th St. NW	Signals	5	4	5584	5	10
Mason City, 1st St. NW	Gates	5	1	4550	1	9
Mason City, 6th St. SW	Signals	5	1	5990	2	8
Mason City, 19th St. SW (west)	Signals	5	1	6740	2	7
Mason City, 19th St. SW (east)	Signals	0	1	6670	1	6
Mason City, S. Carolina Ave.	Signals	8	6	1920	2	4
Mason City, 8th St. SE	X-bucks	0	1	1358	1	5
Cerro Gordo Co., Sec. 20-94-20	X-bucks	6	1	50	1	19
Cerro Gordo Co., Sec. 12-95-21	X-bucks	1	1	640	1	11
Cerro Gordo Co., Sec. 21-97-20	X-bucks	5	1	55	1	13

These measures were collected in the before condition during February and March 1991. Each site was observed twice to collect two data samples. Several of the rural sites outside Mason City were observed during the first part of April. Data was collected after the Operation Lifesaver campaign in the latter half of May and in June 1991.

Speed data for the vehicles approaching the crossing and for vehicles crossing the tracks were measured with a radar speed gun. Data collection personnel parked in a driveway, parking lot, field entrance, or other location near the crossing where a vehicle might be expected to be sitting in a normal operating environment. When any advertising sign, shrub line, or other screening was available, these features were used to hide the observation crew as much as possible because it is important to avoid being obvious in observing the traffic flow. Some drivers will alter their behavior if they suspect police enforcement may be associated with the data collection. Other drivers will alter their behavior due to curiosity in what is commonly called the "gawker effect" if data collection personnel are too obvious in their presence. As much as possible, approach speeds

Table 2. Nonaccident crossings added to study for balance and coverage.

Location	Xing Protection	Daily Trains	Trks	Veh./ Day	Acci- dents	Site No.
Rockwell, Elm St.*	Gates	0	4	219	0	NA
Rockwell, Madison St. (Hwy B60)	Signals	0	1	1044	0	16
Meservey, 1st St. (Iowa 107)	Signals	1	3	1060	0	17
Mason City, 9th St. NW	Gates	5	2	1320	0	15
Mason City, 15th St. SW	Signals	12	1	2971	0	14
Mason City, Carolina Place SE**	X-bucks	8	1	580	0	NA
Ventura, Main St. (Hwy S14)	Gates	1	2	1640	0	18
Cerro Gordo Co., Sec. 8-94-20	Gates	6	1	770	0	20
Cerro Gordo Co., Sec. 8-95-20	Signals	6	1	640	0	21
Cerro Gordo Co., Sec. 9-97-20	Signals	5	1	440	0	22
Cerro Gordo Co., Sec. 17-96-19	Signals	4	2	800	0	23

*Deleted after Carolina Place was lost; no accidents; gates already sufficient; low volume.

**Lost due to construction which began after project was initiated.

NA = Not Applicable; no site number assigned; crossing was deleted prior to field data.

were matched with crossing speeds on the same driver/vehicle. This matching of speeds in the approach and crossing could be done most of the time until a roadway had average annual daily traffic (AADT) levels of about 2,000 vehicles per day. Once the AADT reaches about 6,000 vehicles per day it was found to be nearly impossible to match approach speeds with crossing speeds.

One member of the observer team was assigned to watch the drivers to note whether the driver indicated any caution at the crossing by looking up and down the track before crossing. This observer remained in the observation vehicle with the person recording speeds. Therefore, the observer team was forced to watch the driver through rear and side windows of the vehicle crossing the tracks. For trucks, sport hatchback automobiles, and cars with black tint windows, observers found it difficult to always note the driver's behavior.

When a train approached the tracks, a gate was down, or a flashing signal was activated, all vehicles approaching the crossing were observed for correct behavior. Vehicles trying to "beat" a train to the crossing, driving around lowered gates, and not stopping before crossing when a signal was flashing were noted. Since train traffic is almost always sparse, traffic was not often observed having the opportunity to show their willingness to obey or disobey protection devices.

Mason City Operation Lifesaver Content

A wide range of activities were conducted in the Operation Lifesaver campaign in Mason City. The original Operation Lifesaver plan was for all the activities to take place in April. However, some activities that require public service cooperation of the media cannot be strictly controlled. As a result, one of the billboard safety messages along U.S. 18 near the Mason City Municipal Airport was erected in March because of other billboard space commitments, and some of the billboard displays along U. S. 18 in Clear Lake and near Ventura were erected in May and June. The range of safety campaign activities follows:

1. An accident investigation course was conducted for law enforcement officials.
2. A three-day open house was held at the Soo Line railway depot in Mason City.
3. Presentations were made in schools with special emphasis on high schools and driver education classes.
4. Posters were provided to business and industries to place on company bulletin boards and check stuffers on railroad crossing safety were provided to organizations that were willing to insert them in payroll check envelopes.
5. An increase in general public awareness was attempted through the public media and publicity:
    A. **Billboards**: Billboards were put up in the Mason City area at the rate of two per month (on average) from March 1991 on. Each billboard had a safety message and a different tag line at the bottom that could be used for any location or any time of year.
    B. **Newspaper articles:** Two articles were printed in the Mason City newspaper.
    C. **Video billboards**: Messages were broadcast for a month with the assistance of the local cable television channel community bulletin board.

D. **Mayoral proclamation**: The Mayor of Mason City was involved in proclaiming April 1991 as Operation Lifesaver month. His messages were broadcast on television.

E. **Information booths at public malls:** Booths were set up at the local shopping mall for one weekend to distribute public information. A $100 gift certificate give-away was used to attract people to the booth.

F. **Safety messages at some businesses with high public contact:** Safety messages were put on McDonald's restaurant tray food liners for two months. Hy-Vee grocery store put fliers with an Operation Lifesaver safety message into each grocery bag during the campaign.

ANALYSIS AND INTERPRETATION OF RESULTS

In analyzing and interpreting the data collected, the researcher used the student's t-test, a commonly accepted and frequently used statistical method to evaluate the significance of any difference in the mean value between two samples from similar data. It is a standard traffic engineering practice to use this method to evaluate the change in vehicle speeds from one traffic condition to another. Any reader desiring to learn more about it is encouraged to consult *Statistics Manual* by Crow, Davis, and Maxfield. This is a clearly and concisely written paperback book of modest cost. Chapter 2 thoroughly explains the principles used in this research. The computational form used in this research comes from Sections 7.9 and 7.10 of *Statistics in Research* by Ostle.

A "two-tailed" test is used because the average speed after the safety campaign could be either larger or smaller than the average speed before Operation Lifesaver. Generally accepted probability levels for determining the significance of differences between means are 0.10, 0.05, and 0.01. Any probability level greater than 0.10 usually indicates low reliability in any observed differences since random variation in the data implies that the difference in means could likely be due to chance variation rather than the experimental treatment.

Overall Grouped Speed Samples

Approach Speeds in 25 mph Zones

The data for all sites having an approach speed of 25 miles per hour were grouped together to test for any speed change from the before campaign data to the after campaign data. These data include sites 1-5, 8-10, 15, 17, and 18. The average speed before on 2809 vehicles was 25.54 mph. The average speed after was 23.19 mph on 2421 vehicles. The student's t-test value to test the significance of the 2.35 mph difference was 1.83, which is significant for a two-tailed test at the 0.10 level. This suggests that the reduced average speed shows a small but significant overall change from before to after the safety campaign.

Crossing Speeds in 25 mph Zones

Data sites 1-5, 8-10, 15, 17, and 18 (25 mph approach speed limit) were grouped together for analyzing crossing speed behavior before and after the safety campaign. The average crossing speed before the campaign on 3949 vehicles was 19.10 mph. The average crossing speed after it on 3183 vehicles was 16.87 mph. The student's t-test value to test the significance of the 2.23 mph reduction in average crossing speed was 2.05, which is significant at the 0.05 level. This suggests that the reduced speed is a small but significant change from before the safety campaign to after the safety campaign.

Approach Speeds in 55 mph Zones

Sites with 55 mph approach speed limits included 11, 13, and 19-23. These are all fairly low-volume routes to very low-volume routes. The average speed before the campaign was 47.26 mph for 397 vehicles approaching the crossings. The average speed after it was 45.77 mph for 378 vehicles. The student's t-test value to test the significance of the 1.49 mph difference was 0.23 which is totally insignificant. Thus, while the average speed of vehicles approaching the crossings having a 55 mph approach speed limit did go down after the safety campaign, the reduction in speed could have very easily been due to chance variation or factors not associated with Operation Lifesaver.

Crossing Speeds in 55 mph Zones

Sites with 55 mph crossing speeds were also numbers 11, 13 and 19-23. The average speed before the safety campaign for vehicles crossing the tracks was 43.39 mph for 463 vehicles and the average speed after it was 39.98 mph for 450 vehicles. The student's t-test value to test the significance of the 3.41 mph difference was 0.37, which is also totally insignificant. Again, even though the average speed of vehicles crossing the tracks was reduced 3.41 mph, that difference could easily have been due to chance or factors other than the safety campaign.

Approach Speeds in 35 mph Zones

Only two sites, 14 and 16, had 35 mph speed limits on the approach to the crossings. The average approach speed was 32.52 mph on 484 vehicles before the safety campaign and 30.44 mph on 175 vehicles after it. This 2.08 mph reduction in approach speeds had a student's t-test value of 0.28, which is also totally insignificant. Thus, it is more likely that this approach speed reduction after the safety campaign was due to random chance than the campaign.

Crossing Speeds in 35 mph Zones

The average crossing speed before the campaign was 28.83 mph on 570 vehicles and was 27.44 mph on 317 vehicles after the safety campaign. This 1.39 mph reduction in crossing speeds had a student's t-test value of 0.30, which is once again totally insignificant. Thus, changes in speeds crossing the tracks in 35 mph speed zone sites cannot be said to be caused by the safety campaign.

Approach Speeds in 30 mph Zone

Only site 6 had an approach speed limit of 30 mph. The average approach speed before was 33.34 mph on 482 vehicles and the average approach speed after was 32.04 mph. The 1.30 mph reduction in average speed in approach speeds had a student's t-test of 0.33, which is totally insignificant. Therefore, the difference in average approach speeds can not be seen as significant.

Crossing Speeds in 30 mph Zone

Site 6 had an average speed of 32.37 mph for 528 vehicles crossing the tracks before and 31.69 mph for 452 vehicles crossing after. This 0.68 mph reduction in average speed crossing the tracks from before to after the safety campaign had a student's t-test value of 0.17, which is totally insignificant. Thus, the difference in average crossing speeds from before to after is more likely due to random chance than to the safety campaign.

Approach Speeds in 45 mph Zone

Only site 7 had approach speed limits of 45 mph. An average approach speed of 39.44 mph was observed before the campaign condition on 403 vehicles and an average speed of 41.04 mph on 424 vehicles was observed after the safety campaign. The 1.60 mph increase in the average speed had a student's t-test associated with it of 0.29. This is totally insignificant. The increase in speed from before to after is likely to be a random chance rather than anything done in Operation Lifesaver.

Crossing Speeds in 45 mph Zone

Site 7 had average crossing speeds of 38.62 mph before the campaign on 556 vehicles and 37.53 mph on 427 vehicles after it. These data gave a student's t-test of 0.25, which is totally insignificant. Crossing speeds did decline an average of 1.09 mph from before to after the safety campaign, but most likely this is random chance and not the effect of the safety campaign.

Conclusions for Sites Grouped by Speed Limit on Approach

When the data are grouped by the speed limit on the approach to the crossing, only those crossings with a 25 mph speed limit have significant speed differences from before the campaign to after it. All of the other speed groups except the average approach speed changes at site 7 (45 mph speed limit) produced a reduced average speed from before to after, but it was not statistically significant. Thus, the data indicate that the urban sites with low speed limits and higher traffic volumes can be affected by Operation Lifesaver, and this effect should lead to potentially safer railroad-highway grade crossings.

Percent of Vehicles Above the Speed Limit

During the early stages of data collection, drivers at some sites were obviously not obeying the speed limit. Most computations to determine any flashing signal or gates protection design for a crossing will assume drivers are not exceeding the speed limit. Thus, the degree to which Operation Lifesaver affected driver behavior in obeying the speed limit in the vicinity of the railroad crossing was analyzed.

Approach Speeds at Accident Sites

The sites at which accidents had occurred in the previous five years were tabulated with the percent of all observed approach speeds that exceeded the posted speed limit. (See Table 3.) Each site result for before and after was then considered on an equal weight value. An average percent change before and after was calculated and a student's t-test was conducted to see if any change was significant. A computed t-test value of 2.24 had a 0.0226 level of significance (a one-tailed test was used because the only concern was being above the speed limit). This result suggests that

Operation Lifesaver had an impact on drivers' behavior by reducing the percentage of drivers at the accident sites who exceed the approach speed limit. The "one-tailed" statistical test was necessary in estimating the probability of erroneous interpretation of any differences because we were only interested in the proportion of the drivers exceeding the speed limit.

Approach Speeds at Nonaccident Sites

The percent of drivers on the approach to the crossing who were exceeding the posted speed limit was tabulated for all the sites that had not experienced an accident in the previous five years. (See Table 4.) The average percent of drivers exceeding the speed limit was reduced more at nonaccident sites after the safety campaign than it was at accident sites. However, this larger difference yielded a t-test value of 1.903, which had an associated probability of 0.0414 and is a little less significant statistically than for the accident sites. However the computed t-test value of 1.983 had a little less significance at 0.0414 level. This is still quite significant and indicates Operation Lifesaver had an impact on drivers' behavior at the nonaccident sites as well as the sites with a history of accidents.

Crossing Speeds at Accident Sites

Since Operation Lifesaver was found to have an effect in reducing the percent of drivers exceeding the speed limit on the approach to the crossings having a history of accidents, it may be expected that since drivers were exercising more caution on the approach, they might not make as much adjustment in speed in crossing the tracks. The percent of vehicles exceeding the speed limit while crossing the tracks was tabulated for all crossings that had an accident in the previous five years. (Table 5 indicates an average reduction per site of 5.15 mph.) The computed t-test value for these data was 1.80 which provided a 0.0484 level of significance indicating a highly significant reduction due to Operation Lifesaver, just as had been found on the approach speeds.

Crossing Speeds at Nonaccident Sites

The percent of drivers who were observed to be exceeding the speed limit in crossing the tracks for the sites that had no accidents in the previous five years is tabulated in Table 6. These

Table 3. Percent of approach speeds exceeding speed limit at accident sites

Site No.	% Before Campaign	% After Campaign
1	14.29	8.33
2	74.01	73.02
3	39.02	22.86
4	54.42	66.86
5	40.87	32.56
6	57.50	53.92
7	27.72	27.78
8	40.24	27.45
9	32.23	22.44
10	78.10	66.80
11	6.56	3.23
13	0	0
19	0	0
Average	35.76	31.76

Table 4. Percent of approach speeds exceeding speed limit at nonaccident sites.

Site No.	% Before Campaign	% After Campaign
14	21.73	21.37
15	16.06	6.06
16	52.63	56.90
17	50.67	52.43
18	61.29	42.35
20	21.88	11.69
21	15.52	3.57
22	0	0
23	11.97	10.92
Average	27.97	22.91

Table 5. Percent of crossing speeds exceeding speed limit at accident sites.

Site No.	% Before Campaign	% After Campaign
1	0	0
2	3.51	0
3	1.35	0.74
4	18.81	19.80
5	17.19	7.05
6	70.37	56.45
7	14.41	14.09
8	20.00	8.40
9	19.67	27.80
10	47.64	11.64
11	3.23	0
13	0	0
19	0	0
Average	19.53	14.38

Table 6. Percent of crossing speeds exceeding speed limit at nonaccident sites.

Site No.	% Before Campaign	% After Campaign
14	14.71	12.56
15	5.49	2.34
16	25.65	17.27
17	10.71	4.69
18	0.32	0
20	14.79	3.28
21	7.46	2.82
22	2.33	2.38
23	0	0.74
Average	9.05	5.12

data produce a t-test value of 2.85 with a significance level of 0.0094. This highly significant level indicates the effect of Operation Lifesaver on drivers' behavior at the nonaccident sites by reducing the overall rate at which drivers exceeded the speed limit in crossing the tracks.

Drivers' Attention

The percent of all drivers who could actually be observed looking for trains or in some other way checking the clearance of the tracks before crossing was tabulated for each crossing before and after the safety campaign. The data were separated by accident site versus nonaccident site to examine any effect on drivers' perception of potential hazards from their general awareness of past accident history.

Drivers' Attention at Accident Sites

Table 7 lists the percent of observed drivers looking and making an effort to be attentive in crossing at the sites that had accidents in the previous five years. These data produced a t-test value with a 0.1058 level of significance, just barely over 0.10 that is usually taken to be the maximum value for reliably assigning significance to sample differences. Thus, a person should be hesitant to say the overall average increase in drivers' attention was strongly associated with Operation Lifesaver. Although at most of the crossings observers noted a good-sized increase in the percent of drivers looking for trains, several showed noticeable decreases, which reduces the statistical reliability of this measure. However, these results do not cancel out the obvious indication that there was an overall average increase in the number of drivers looking and exercising caution.

Drivers' Attention at Nonaccident Sites

Table 8 contains the percent of drivers observed to be looking and exercising caution while crossing the tracks at the sites that had no accidents in the previous five years. Note that the overall average attentiveness decreased after the Operation Lifesaver campaign. This change in average rate of looking produced a t-test value of 1.385 with an associated significance level of 0.0719 that indicates a significant effect of the safety campaign. While Operation Lifesaver had an overall positive effect on drivers' behavior in reducing the degree to which drivers exceeded the speed limit in approaching and crossing railroad tracks at sites with no obvious history of accidents, drivers tended to reduce the degree of looking and paying attention to the possibility of a train. One

Table 7. Percent of drivers looking at accident site crossings.

Site No.	% Before Campaign	% After Campaign
1	46.27	40.54
2	14.72	22.27
3	12.83	7.98
4	42.57	45.56
5	46.53	35.90
6	22.90	10.00
7	27.72	14.15
8	30.35	46.94
9	35.62	37.66
10	45.95	61.75
11	6.45	12.12
13	44.44	83.33
19	46.15	100.00
Average	14.46	28.49

Table 8. Percent of drivers at nonaccident sites looking at crossing.

Site No.	% Before Campaign	% After Campaign
14	49.42	31.41
15	57.26	42.86
16	42.27	35.14
17	49.53	30.43
18	39.68	30.85
20	8.84	18.85
21	11.76	16.90
22	11.63	28.57
23	14.17	21.05
Average	19.65	8.30

interpretation is that when a crossing does not have a reputation of being dangerous, drivers are content to make some kind of adjustment in their behavior as a result of the urging of the safety campaign rather than to make multiple positive responses.

Vehicle Braking at Crossings

Data were recorded on the percent of vehicles braking prior to entering the crossing. Prior to collecting the data, observers reasoned that even if drivers did not significantly alter their speeds approaching the crossing or actually crossing the tracks or increase their rate of looking and paying attention while crossing the tracks, increasing the frequency of applying brakes would indicate an increase in being prepared to stop if necessary. This was thought to be an important potential measure of change in drivers' behavior. However, field data collection showed that this measure is greatly affected by factors not related to the safety campaign, such as perceived roughness of the crossing, closeness to an intersection, and a signal ahead changing to red.

Braking at Accident Sites

Table 9 lists the observed percent of drivers braking when approaching crossings at which an accident had occurred in the previous five years. There was a very slight overall average increase in braking, which produced a t-test value of 0.0108 with an associated level of significance of 0.46. This is an insignificant change, suggesting that for these sites Operation Lifesaver had no reliable effect on braking.

Braking at Nonaccident Sites

Table 10 contains the percent of drivers observed to be braking at crossing sites that had no accidents in the previous five years. The large average increase in the observed rate of braking at these sites produced a t-test value of 3.097 with an associated level of significance of 0.0074. This is highly significant and suggests that Operation Lifesaver had a substantial impact on braking at the nonaccident sites. These sites were mostly in street and highway environments with few intersection or traffic restrictions that would cause a driver to be prepared to stop independent of the

Table 9. Percent of drivers braking when approaching accident sites.

Site No.	% Before Campaign	% After Campaign
1	71.64	83.33
2	46.33	58.28
3	47.12	66.10
4	59.14	67.13
5	54.59	52.76
6	6.25	5.32
7	16.73	6.93
8	39.39	48.01
9	35.33	35.69
10	66.99	67.79
11	6.45	18.46
13	100.00	92.31
19	100.00	53.85
Average	49.99	50.46

Table 10. Percent of drivers braking when approaching nonaccident sites.

Site No.	% Before Campaign	% After Campaign
14	29.32	32.13
15	51.76	45.00
16	56.97	57.07
17	59.05	75.00
18	64.35	74.07
20	16.33	25.88
21	27.94	49.30
22	27.91	44.44
23	36.30	58.82
Average	41.1	51.4

crossing. This may explain why such a dramatic difference in response resulted for the nonaccident sites compared to the accident sites.

CONCLUSIONS

On the basis of the findings and the analysis presented, the following conclusions are suggested.

- Overall the Operation Lifesaver safety campaign conducted in the Mason City area nominally beginning in April 1991 did have an effect on drivers' behavior at railroad-highway grade crossings immediately following the safety campaign.
- The impact of Operation Lifesaver was most significant at crossings with low approach speed limits and high-volume vehicular traffic in reducing speeds as a measure of the driver's increased caution. Since these same crossings were also closest to the "center" of the campaign, this conclusion may also be interpreted that increased exposure to the message increases drivers' caution.
- Drivers appear to respond to Operation Lifesaver with more and stronger positive behavioral changes at crossings with a history of accidents. This suggests that safety campaigns need to stress the potential for collision at crossings where trains are not frequently seen and are otherwise considered "safe" by drivers.
- Drivers did not alter their behavior for braking and looking in the same pattern as they did in making speed adjustments, leading to the conclusion that drivers make tradeoffs in how they will respond to publicity campaigns designed to improve the safety of their driving at railroad crossings on the basis of what they perceive to be a good selective response.

One concern with the data presented in this report supporting these conclusions is the degree to which the observed changes in the behavior of drivers are stable over time. One method to assess the impact of the safety campaign is to conduct a followup study at these sites to see whether these effects of Operation Lifesaver remain after some time or whether they fade away.

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