Evaluation of Low Cost Traffic Calming for Rural Communities – Phase II

MTC
MIDWEST TRANSPORTATION CONSORTIUM

Final Report
January 2013


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Center for Transportation Research and Education

IOWA STATE UNIVERSITY
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Federal Highway Administration
Iowa Department of Transportation
Iowa Highway Research Board
(IHRB Project TR-630)
Midwest Transportation Consortium
(InTrans Project 11-393)

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Iowa Department of Transportation Statements

The preparation of this document was financed in part through funds provided by the Iowa Department of Transportation through its "Second Revised Agreement for the Management of Research Conducted by Iowa State University for the Iowa Department of Transportation" and its amendments.

Technical Report Documentation Page

1. Report No.
IHRB Project TR-630

2. Government Accession No.

3. Recipient's Catalog No.

4. Title and Subtitle
Evaluation of Low Cost Traffic Calming for Rural Communities – Phase II

5. Report Date
January 2013

6. Performing Organization Code

7. Author(s)
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8. Performing Organization Report No.
InTrans Project 11-393

9. Performing Organization Name and Address
Center for Transportation Research and Education
Institute for Transportation
Iowa State University
2711 South Loop Drive, Suite 4700
Ames, IA 50010-8664

10. Work Unit No. (TRAIS)

11. Contract or Grant No.

12. Sponsoring Organization Name and Address
Iowa Highway Research Board and
Iowa Department of Transportation
800 Lincoln Way
Ames, IA 50010

Midwest Transportation Consortium
2711 South Loop Drive, Suite 4700
Ames, IA 50010-8664

Federal Highway Administration
U.S. Department of Transportation
1200 New Jersey Avenue SE
Washington, DC 20590

13. Type of Report and Period Covered
Final Report

14. Sponsoring Agency Code

15. Supplementary Notes
Color pdfs of this and other InTrans research reports are available at www.intrans.iastate.edu/.

16. Abstract

The main goal of the research described in this report was to evaluate countermeasures that agencies can use to reduce speeds as drivers enter rural communities located on high-speed roadways. The objectives of this study were as follows:

- Identify and summarize countermeasures used to manage speeds in transition zones
- Demonstrate the effectiveness of countermeasures that are practical for high- to low-speed transition zones
- Acquire additional information about countermeasures that may show promise but lack sufficient evidence of effectiveness
- Develop an application toolbox to assist small communities in selecting appropriate transition zones and effective countermeasures for entrances to small rural communities

The team solicited small communities that were interested in participating in the Phase II study and several communities were also recommended. The treatments evaluated were selected by carefully considering traffic-calming treatments that have been used effectively in other countries for small rural communities, as well as the information gained from the first phase of the project. The treatments evaluated are as follows:

- Transverse speed bars
- Colored entrance treatment
- Temporary island
- Radar-activated speed limit sign
- Speed feedback sign

The toolbox publication and four focused tech briefs also cover the results of this work.

17. Key Words
colored pavement markings—physical displacement—radar-activated signs—roadway treatments—rural traffic calming—rural transitions—speed feedback signs—temporary center islands—traffic management—transition zones—transverse speed bars

18. Distribution Statement
No restrictions.

19. Security Classification (of this report)	20. Security Classification (of this page)	21. No. of Pages	22. Price
Unclassified.	Unclassified.	57	NA

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

EVALUATION OF LOW COST TRAFFIC CALMING FOR RURAL COMMUNITIES – PHASE II

Final Report
January 2013

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Sponsored by
the Federal Highway Administration,
Midwest Transportation Consortium,
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Preparation of this report was financed in part
through funds provided by the Iowa Department of Transportation
through its Research Management Agreement with the
Institute for Transportation
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ACKNOWLEDGEMENTS

The team would like to thank the Iowa Department of Transportation, the Iowa Highway Research Board, the Midwest Transportation Consortium, and the Federal Highway Administration for funding this project. We would like to thank the Iowa cities of Hazleton, Jesup, Ossian, Quasqueton, St. Charles, and Rowley for participating in the study. We would especially like to thank Brian Keierleber, county engineer for Buchanan County, Iowa for his assistance and enthusiastic support.

1. INTRODUCTION

1.1 Background

Small rural communities often lack the expertise and resources necessary to address speeding and the persistent challenge of slowing high-speed through traffic. The entrances to community are especially problematic given that the drivers must transition from a high-speed, often-rural roadway setting to a low-speed community setting.

The rural roadway provides high-speed mobility outside the community, yet the same road within town provides local access and accommodates pedestrians of all ages, on-street parking, bicycles, and other features unique to the character of a small community. Drivers who have been traveling for some distance on the high-speed road, and are traveling through the community, may not receive the appropriate clues that the character of the roadway is changing and may not adjust their speeds appropriately.

Addressing speeding issues is an even greater challenge given that smaller communities typically lack engineering staff and resources, which can lead to decisions that may not conform to accepted design guidance. For instance, many rural communities set speed transition zones too low a significant distance outside the community before there is any practical need for drivers to slow down.

Communities may also have unrealistic expectations about what speed reductions are practical and, in some cases, may even implement strategies to reduce speeds that are not appropriate for the situation. For instance, some small communities with speeding issues simply use stop signs to slow traffic, which can diminish both enforcement and compliance.

Information is lacking about effective strategies to reduce and manage speeds in high- to low-speed transitions. While traffic calming has been evaluated and used extensively on lower-speed urban roadways in the US, little information is available regarding the types of traffic-calming techniques that are appropriate and effective along a high-speed rural highway entering a community. Typical traffic-calming techniques used on lower-speed roadways cannot be assumed to be portable to higher-speed roadways.

The research team recently completed a project to evaluate a number of traffic-calming treatments that were placed at the entrances to small rural communities. This research was funded by the Iowa Department of Transportation (DOT), Iowa Highway Research Board (IHRB), and the U.S. Department of Transportation through the Midwest Transportation Consortium (www.intrans.iastate.edu/research/detail.cfm?projectID=-226410767). Several types of treatments were shown to be effective while a few of the others tested did not prove effective. However, each treatment was only applied in one location.

As a result, firm conclusions could not be drawn about whether the effectiveness or lack thereof was due to the treatment itself or to other factors. In addition, because traffic calming in rural communities is relatively unknown in the US, there were several other treatments that may have been effective but could not be evaluated under the scope of that project. Agencies submitted subsequent requests for additional guidance in selecting and applying traffic-calming measures in small communities.

1.2 Project Objectives

To address the challenges outlined above, the main goal of the research described in this report was to provide tools that agencies can use to design transition zones from high-speed to low-speed roadways. To accomplish this goal, the following objectives were proposed:

- Identify and summarize techniques used to manage speeds in transition zones
- Demonstrate the effectiveness of techniques that are practical for high- to low-speed transition zones
- Acquire additional information about techniques that may show promise but lack sufficient evidence of effectiveness
- Develop an application toolbox to assist small communities in selecting appropriate transition zones and selecting effective techniques for transitioning from high-speed to low-speed roadways

1.3 Toolbox

A toolbox was developed to summarize the effectiveness of various known traffic-calming treatments. The toolbox focuses on roadway-based rural treatments. Education, enforcement, and policy countermeasures should also be considered, but were not the focus of this toolbox. Furthermore, the focus of this toolbox is on strategies for rural communities with transition zones.

The research team identified treatments based on their own research, through a review of the literature, and through discussion with other professionals. The list of treatments to evaluate was not necessarily comprehensive. Each treatment that the team was aware of is covered in the toolbox using the format outlined in Table 1-1.

Table 1-1: Outline of information provided for treatments in the toolbox

Subsection	Summarizes
Description	Countermeasure
Placement	How the countermeasure has been applied, where the countermeasure is most effective, and so forth
Advantages	Countermeasure advantages
Disadvantages	Main countermeasure disadvantages
Effectiveness	Studies showing whether the countermeasure is effective, information about crash reductions, and speed changes, with the assumption that speed change can be used as a crash surrogate
Appropriateness	What situations countermeasure can be used in
Cost	Price to install countermeasure

The purpose of targeted traffic-calming treatments in rural communities is to notify drivers that they are entering a community and must adjust their speed accordingly. Speed reduction is also used as a surrogate measure for safety.

A variety of strategies can be applied to the roadway to slow drivers physically or psychologically. The different types of treatments are laid out into separate strategies. Different strategies may be more beneficial in other locations and must be considered when selecting the treatment. The strategies presented in the toolbox and this report are summarized in Table 1-2.

Table 1-2: Categorization of strategies evaluated

Strategy	Description
Physical Displacement-Horizontal	A form of displacement that requires drivers to move horizontally, left or right, to require them to slow down
Physical Displacement-Vertical	A form of displacement that moves drivers vertically, giving them an unpleasant feeling to encourage them to slow down
Narrowing	Used to psychologically make drivers adjust their speeds because they cannot drive faster with the narrowed lane
Surroundings	Treatments that are placed off the roadway to alert drivers that they are entering a community
Pavement Markings	Markings on pavements to alert drivers a speed change occurs or to give drivers a sense of feeling they are speeding up
Traffic Control Signs	Types of signs that can draw more attention to slow down
Other	Other treatments that do not fit in the other categories

The toolbox was prepared as a standalone document and can be found at www.intrans.iastate.edu/research/projects/detail/?projectID=43176957.

2. SITE SELECTION

The team solicited small communities that were interested in participating in the follow-up study and several communities were also recommended. To be included in the study, the following characteristics needed to be present for the roadway where traffic calming was being considered:

- Main road through a rural community (i.e., serves a major road into and out of the community and does not terminate within the community) with rural defined as a population less than 5,000
- Paved roadway
- Speed limit of 45 mph or under within the community
- Demonstrated speeding problem or crash problem attributed to speed (determined by study team)
- Volume of 500 vehicles per day(vpd) or higher entering the community
- Sites with unusual characteristics, such as presence of a railroad crossing, unusual geometry, or large volumes of traffic turning onto or off of the roadway within the transition zone, which may affect data collection and analysis of results would be given lower priority

The team visited each potential community to determine whether the evaluation conditions were met and whether part of the traffic-calming study would feasible and relevant within that community. In addition, spot speed studies were conducted to determine whether a speeding problem existed. A speeding problem was defined as the mean or 85th percentile speed being 5 or more mph over the posted speed limit.

Six communities were selected and a variety of treatments were installed as shown in Table 1-3.

Table 1-3: Rural Iowa communities for selected for traffic-calming evaluations

Community	Roadway	AADT	Treatment
Hazleton	C-57/Hayes Street	760 vpd	Transverse bars
Jesup	220th Street/SH 939	2,850 vpd east; 3,070 west	Colored entrance
Ossian	W-42	870 vpd	Colored entrance
Quasqueton	W-40	1,530 vpd north; 890 vpd south	Transverse bars
St. Charles	R-35	410 vpd north; 940 vpd south	Raised curbing
	SH 251	1,200 vpd west	Raised curbing
	SH 251	2,240 vpd east	LED speed limit sign
Rowley	D-47	610 vpd east	Speed feedback sign
	D-47	980 vpd west	LED speed limit sign

AADT = annual average daily traffic
vpd = vehicles per day

When necessary, experimental approval was requested from and granted by the MUTCD Experimentation Approval Team.

3. OVERVIEW OF TREATMENTS SELECTED

In a previous study by the research team, several traffic-calming treatments that were appropriate for small rural communities were evaluated (www.intrans.iastate.edu/research/detail.cfm?projectID=-226410767). Several types of treatments were shown to be effective while a few of the others were not. However, each treatment was only applied in one location. As a result, firm conclusions could not be drawn about whether the effectiveness or lack of effectiveness was due to the treatment itself or was related to other factors.

In addition, the effectiveness of traffic calming in rural communities is relatively unknown in the US, so there were several other treatments that may have been effective but could not be evaluated under the scope of that project. There have also been subsequent requests from Iowa agencies and other communities nationally for additional guidance in selecting and applying traffic calming in small communities.

The treatments evaluated for this Phase II study and described in this report were selected by carefully considering traffic-calming treatments that have been used effectively in other countries for small rural communities, as well as the information gained from the first phase of the project. The treatments evaluated are as follows:

- Transverse speed bars
- Colored entrance treatment
- Temporary island
- Radar-activated speed limit sign
- Speed feedback sign

3.1 Transverse Speed Bars

3.1.1 Description

Transverse or optical speed bars have been used in several applications. Katz (2007) reported on use of the peripheral transverse markings at sites in New York (freeway exit), Mississippi (two-lane road), and Texas (two-lane road on curve). Overall, Katz found a 4 mph reduction in average speeds and a 5 mph reduction in 85th percentile speeds. The differences were statistically significant.

Speed reduction markings were used at the entrance to Union, Iowa along State Highway 215 and County Road D-65 as part of a previous CTRE study on rural traffic-calming applications. The treatment resulted in a reduction in mean speed up to 1.9 mph and a reduction in 85th percentile speed up to 2 mph. The percentage of drivers traveling 5 or more mph over the posted speed limit was reduced by up to 5 percent and the percentage of drivers traveling 10 or more mph over the posted speed limit was reduced by up to 8.5 percent (Hallmark et al., 2007).

The transverse speed bar (also called optical speed bar) treatment was based on the concept of speed-reduction markings that are covered in Section 3B.22 of the MUTCD (2009 edition).

The transverse markings by themselves were only moderately effective in an earlier phase of this study. So, the treatments were modified to provide more visual effect. The middle bar provides additional visual contrast for drivers and the bar spacing also encourages drivers to place their vehicles between the bars, which is expected to cause drivers to slow as they concentrate on the driving task.

3.1.2 Treatment Design

The treatment design is shown in Figures 3-1. The treatment consists of a series of three horizontal bars as shown in Figure 3-2.

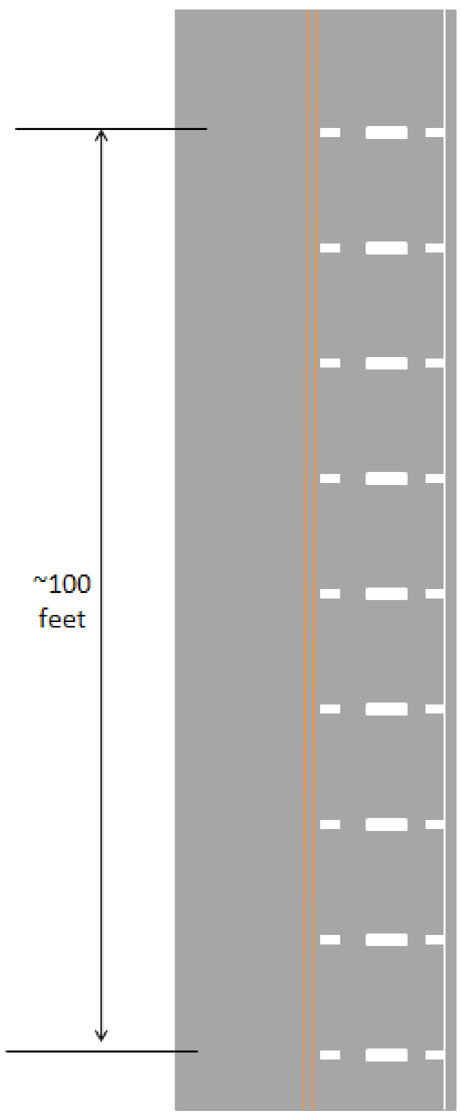


Figure 3-1: Schematic of overall transverse bar treatment

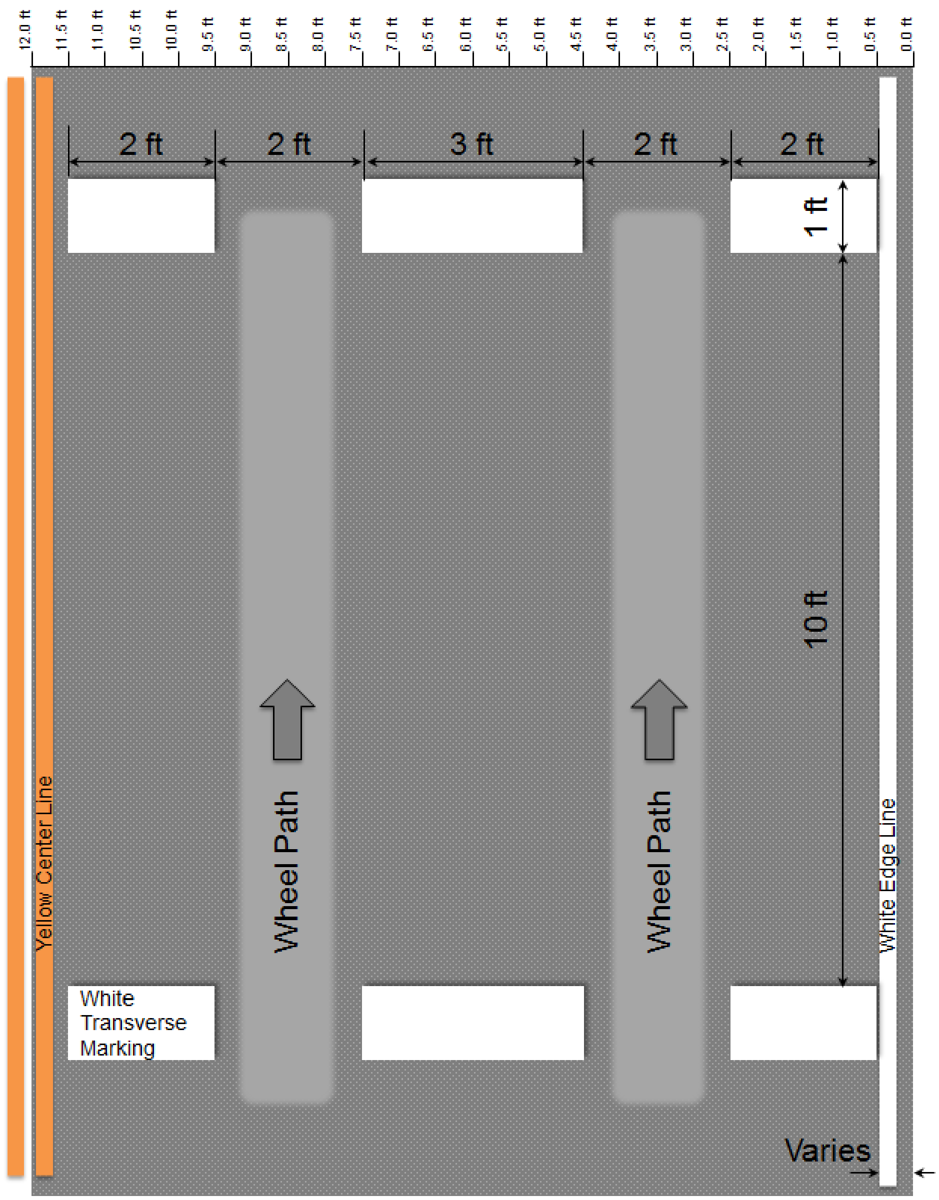


Figure 3-2: Details of transverse bar treatment

The bars were spaced at intervals so that drivers are able to position their vehicles within the wheel paths. The treatment was spaced for approximately 100 feet before the first posted speed limit where drivers are encouraged to slow down. Approximate transverse bar spacing was 10 to 12 feet apart.

Although spacing and size of bars was consistent for this application, in other applications, spacing and treatment width have been placed so that the bars are closer together as drivers traverse the treatment and the bars become thinner. This is thought to create the perception that the driver is traveling faster than they actually are, thus encouraging them to slow down.

3.1.3 Installation

The treatment was a thermoplastic product, which is placed through heating as shown in Figure 3-3. Glass beads are added while the treatment is placed to increase visibility and skid resistance.

Figure 3-3: Application of transverse bar treatments

3.2 Colored Entrance Treatment

3.2.1 Description

Colored surface dressing or textured surfaces are common traffic-calming treatments in the United Kingdom (UK) and are often used in conjunction with gateways or other traffic-calming measures to emphasize the presence of traffic-calming features. Colored or textured surface treatments draw attention to the fact that something about the roadway is changing and provide visual clues to drivers that they have entered a different area. A common European entrance treatment using lane narrowing and red surface markings is shown in Figure 3-4.

Figure 3-4: Red markings with posted speed limits used in European gateways (Sustrans, 2004)

A study in Shropshire, UK reported on the use of colored surface treatments in conjunction with speed limit signs (DETR, 2005). They used red patches 26.25 feet (8 meters) long across the full width of the roadway along with speed limit signs placed for each direction. This configuration was repeated at 10 locations throughout the city and was used along with other traffic-calming measures. The study indicated that reductions in both mean and 85th percentile speeds occurred although actual values were not provided.

In a previous Iowa study, a modification of the European treatment was evaluated at the entrances to Dexter, Iowa along 350th Street (State Highway 925), as shown in Figure 3-5.

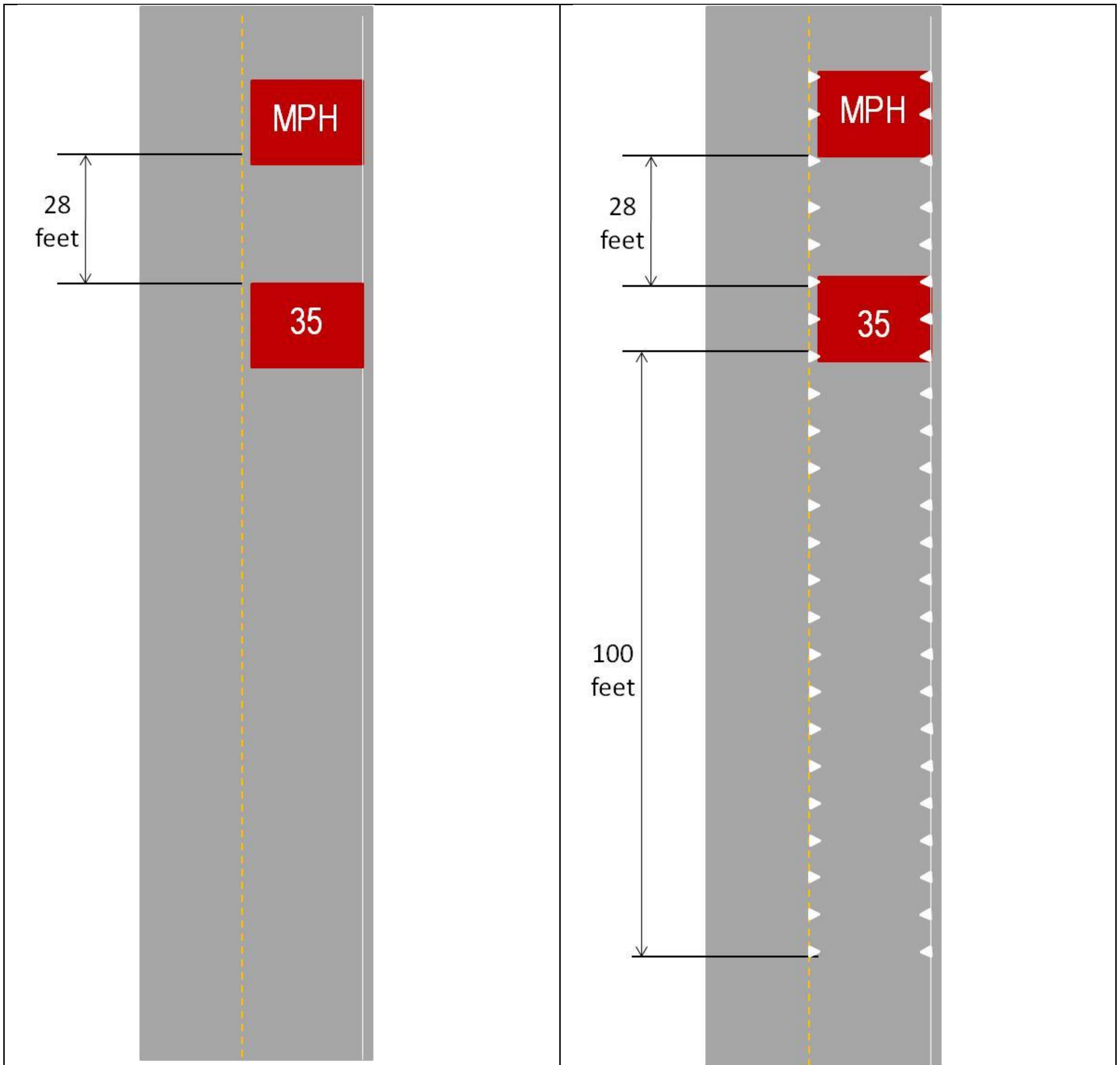
Figure 3-5: European-style traffic-calming treatment used in Dexter, Iowa

The treatment in Dexter resulted in a reduction in mean speed of 5.4 mph and a reduction in 85th percentile speed of 8 mph. The percentage of drivers traveling 5 or more mph over the posted speed limit was reduced by up to 32 percent and the percentage of drivers traveling 10 or more mph over the posted speed limit was reduced by 14.5 percent (Hallmark et al., 2007).

The colored entrance treatment used in this study was based on the Dexter treatment but was modified to reflect treatments used in Europe more closely.

3.2.2 Treatment Design

The colored pavement marking treatment design tested in this study is shown in Figure 3-6 and Figure 3-7 shows additional design details.



a) Initial treatment (Phase I)   b) Final treatment (Phase II)

Figure 3-6: Schematics of colored entrance treatments

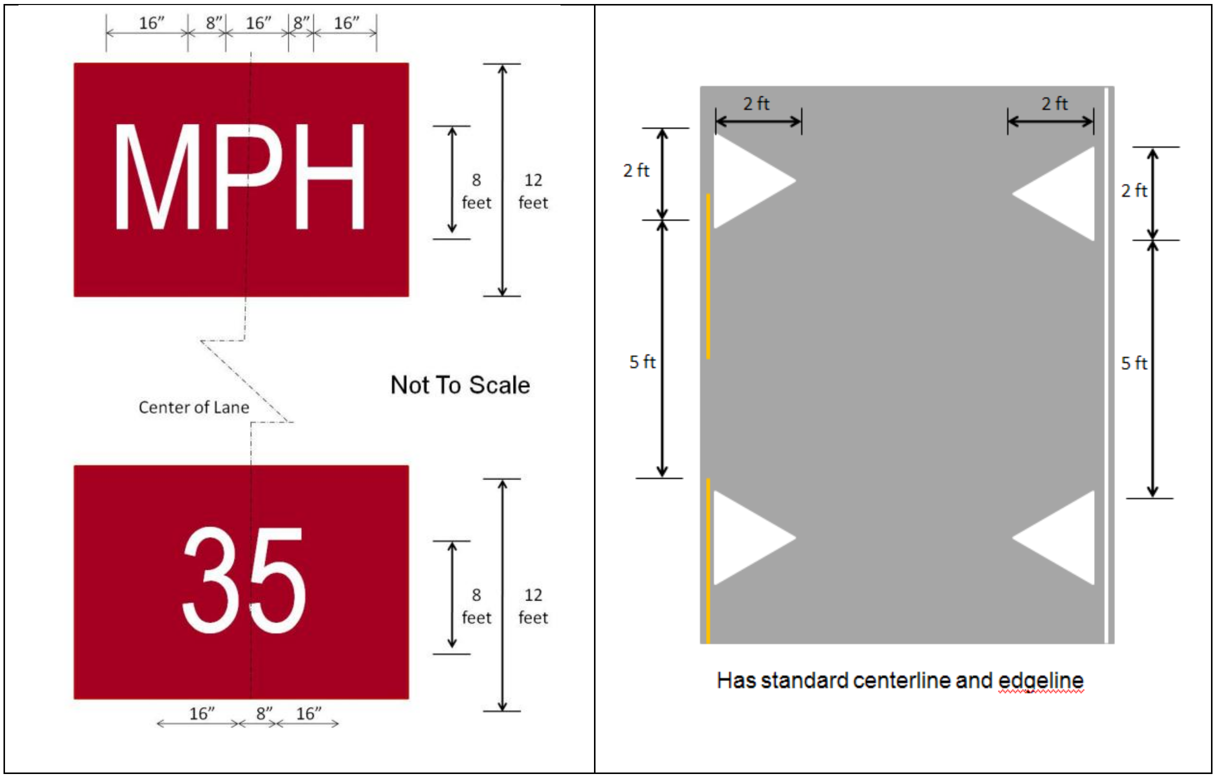


Figure 3-7: Details of colored entrance treatments

The treatment consisted of "dragon's teeth" for approximately 100 feet followed by two colored boxes, which reinforce the speed limit. The treatment was set to terminate at the beginning of the speed limit at the community entrance given this is where it is desirable to slow drivers as they enter the community.

The colored-box portion of the treatment reminds drivers that the roadway is changing and reinforces the change in posted speed limit. The box provides significant visual contrast. The box is approximately 12 feet tall with 8 foot lettering and standard font and spacing. The boxes are spaced 28 feet apart so that drivers can read the message sequentially.

The "dragon's teeth" are used to lengthen the area of the treatment so it is more visible to drivers. The red treatment was very effective in the previous study in Dexter; however, the red treatment is not that large and is somewhat unusual. The white "dragon's teeth" provide some transition that may be effective in getting driver attention in advance of the red treatments. The white portion also provides some visual narrowing of the lanes.

The "dragon's teeth" pattern was evaluated instead of the speed reduction markings covered in Section 3B.22 of the MUTCD because a study in Union, Iowa using the speed-reduction markings showed them as being only moderately effective. The dragon's teeth are larger and more unusual, so it was felt that the pattern could be more likely to get driver attention.

The original design was to use both the red marking and dragon's teeth together. The MUTCD experimentation team requested that the red markings be tested first and then add the white "dragon's teeth" one year later so that the effect of only the red treatment compared to the entire design can be assessed. As a result, the treatment is being applied in two phases.

Given the study period on Phase II is not long enough for the required 24 month after analysis period, this report provides results for the first year (red markings only). The dragon's teeth will be installed in the summer of 2013 and the results will be published when they are available.

The use of on-pavement speed limit markings (35 mph) are allowed as described in Section 3B.20 of the MUTCD (2009 version). Use of the colored box is not covered in the MUTCD although Section 3A.05 states that pavement markings shall be yellow, white, red, or blue.

The "dragon's teeth" are similar to speed reduction markings (Section 3B.22) but are not covered specifically in the MUTCD. Orientation and size of the triangle used in the design was selected so that the markings would not be confused with yield lines (Section 3B.16), advance speed hump markings (3B.26), or any other type of marking covered in the MUTCD. The markings are white for both sides in compliance with Section 3B.15, which states that transverse markings should be white.

3.2.3 Installation

The colored-box portion of the treatment was constructed from a thermoplastic high-friction material so that the area is skid resistant. The treatment is placed on the roadway by heating as shown in Figure 3-8. Glass beads are added while the treatment is placed to increase the visibility and skid resistance. The "dragon's teeth" will be added in 2013 using the same process.

Figure 3-8: Installation of colored entrance treatment

3.3 Temporary Island

3.3.1 Description

Use of vertical devices creates the sensation of less space and some discomfort to drivers, which encourages them to slow. In the previous traffic-calming study conducted by CTRE, 36 inch tall yellow tubular channelizers where spaced approximately 2 feet apart creating a center island, which narrowed travel lanes to approximately 11 feet for each direction as shown in Figure 3-9.

Figure 3-9: Temporary island treatment in Slater, Iowa

The treatment was placed in Slater, Iowa and was very effective with reductions of up to 3 mph in both mean 85th percentile speeds.

3.3.2 Treatment Design

Although the treatment was effective, it required a number of channelizers that had to be replaced occasionally, given farm vehicles and snowplow equipment often struck them. In addition, use of the wider center area of a rural two-lane roadway is not appropriate in many cases given it may cause drivers to leave the roadway to avoid the treatment.

As a result, an alternative design using temporary curbing was tested. Both temporary curbing and channelizers have been used to prohibit movements such as lane changes or going around crossbars at rural railroad crossings.

Given the temporary curbing treatment is available commercially, the MUTCD does not require approval for experimentation with it.

The temporary curbing that was purchased is approximately 2 inches high by 40 inches long by 8 inches wide. The curbing has a rounded design that can be mounted by errant vehicles.

3.3.3 Installation

The treatment was placed at community entrances and extended into the community by several hundred feet depending on location. The first several sections of 40 inch curb sections were placed approximately 1 foot apart and subsequent sections were placed about 5 feet apart.

In general, the treatment was placed after the normal speed limit was posted along each roadway within the community. For instance, if a road was 55 mph outside of town, then had a transition to 35 mph, and transitioned to a 25 mph speed limit through the community, the treatment was placed after the 25 mph limit.

While rural traffic calming has been used within the transition zone to slow drivers as they enter the community in many cases, in this case, the treatment was placed within the community because there was some concern that drivers entering the transition zone at a high rate of speed may strike the channelizers in the center of the roadway. Although the hazard signs used are strikable and the curb sections are mountable, it was decided to be judicious in where they were placed.

Hazard markers were placed at the beginning and end of the treatment so that drivers were aware that a vertical object was located within the traveled roadway as shown in Figure 3-10.

Figure 3-10: Raised median with hazard markers at each end

The treatment was affixed to the pavement using bolts as shown in Figure 3-11. As a result, the treatment could be removed and replaced as needed. This was important given the treatment needed to be removed for the winter months so that the city and county snowplow operators did not need to worry about plowing around the treatments during winter storm events.

Figure 3-11: Installation of raised curbing (left) and close-up of raised curbing (right)

3.4 RADAR-ACTIVATED LED SPEED LIMIT SIGN

3.4.1 Description

Another treatment evaluated was a speed limit sign that has radar-activated light-emitting diodes (LEDs) embedded around the border of the sign. The LED signs have been used extensively on stop signs and were recently available for speed limit signs. The sign is a normal speed limit sign with white LEDs around the periphery as shown in Figure 3-12.

Figure 3-12: Radar-activated LED speed limit sign

The purpose of the radar-activated LEDs is to get the attention of drivers traveling above a set speed threshold. As far as the team is aware, no studies have evaluated the effectiveness of the signs in reducing speeds.

3.4.3 Installation

The LED signs were used for the first speed limit sign at two community entrances after the transition speed zones. The signs, which use solar panels for power, replaced existing speed limit signs on the existing posts (Figure 3-13).

Figure 3-13: Installation of LED speed limit sign

3.5 Speed Feedback Sign

3.5.1 Description

Dynamic speed feedback signs (DSFSs) consist of a speed measuring device, which may be a loop detector or radar, and a message sign that displays feedback to drivers who exceed a predetermined speed threshold. The feedback may be the driver’s actual speed, a message such as SLOW DOWN, or activation of some warning device, such as beacons or a curve warning sign, when a vehicle exceeds a certain speed. The devices can be portable or permanent. They alert drivers that they are speeding and create a sense of being monitored to the driver. They may also slow drivers who have radar detectors.

The Texas Transportation Institute (TTI) evaluated the use of a portable speed display trailer in work zones (Fontaine et al., 2000). The researchers found that passenger vehicle speeds were reduced by 7 to 9 mph at one site and 2 to 3 mph at another. Truck speeds were reduced 3 to 10 mph at both sites.

The Department of Transport, UK, found that average speeds can be reduced by 1 to 7 mph using dynamic speed signs; they also suggest that signs are more effective on a mobile basis, given drivers may become immune when the signs are installed on a permanent basis (Sustrans, 2005).

Chang et al. (2004) tested the use of radar speed signs in reducing speeds and found the devices were effective and had a sustained effect in maintaining lower 85th percentile and average speeds.

Two different dynamic speed feedback signs were evaluated as part of the previous traffic-calming research project by Hallmark (2007). One sign technology involving displaying the current speed of the driver in Union, Iowa was effective at reducing speeds significantly. Another sign was evaluated in Slater, Iowa that was capable of providing different messages to drivers in addition to their current speed. The sign reduced the average speed of drivers by 5 mph and the 85th percentile speed by 7 mph.

3.5.3 Installation

One dynamic speed feedback sign was installed as shown in Figure 3-14. The sign was placed near the first static speed limit sign entering the community.

Figure 3-14: Dynamic speed feedback sign

4. DATA COLLECTION AND REDUCTION PROTOCOL

Pneumatic road tubes were used to collect speed and volume data before and after installation of the rural traffic-calming treatments. Pneumatic road tubes are fairly accurate (99 percent accuracy for individual vehicle speeds), can collect individual vehicle data (speed, volume, headway, and classification), and are fairly low-cost. Data were collected using JAMAR FLEX HS counters.

Road tubes were laid typically just downstream of the treatment or at the treatment. The most common statistics used in the speed analyses are mean and 85th percentile speeds. These statistics provide an adequate analysis of speeds both before and after implementation of the safety treatment. Data were also collected at an upstream location where drivers were not yet influenced by the treatment. This provides a comparison site that can show if there were speed trends that may have occurred independent of the signs.

Data were typically collected for 48 hours on a Monday through Friday under mostly dry weather conditions. In a few cases, due to issues with the traffic counters, data were available for only a 24 hour period. Use of full 24 hour periods avoids biasing the speed sample to speed choices based on time of day. The collection periods occurred Monday through Friday while avoiding holidays to avoid any unusual traffic patterns.

Typical speed statistics, such as change in average speed, were calculated for each location where data were collected as described below.

When comparing speed differences after installation of a treatment, the most common metrics reported are change in mean or average speed, 85th percentile speed, and standard deviation of speed. The 85th percentile speed is the speed where 85 percent of drivers are traveling at or below that speed and 15 percent are traveling above that speed. This can be determined by ordering the data from smallest to largest and then placing an integer value from one to the total sample size. By determining what integer is 85 percent of the sample size, the 85th percentile speed can be located.

A number of studies have also reported change in the number of drivers traveling a certain threshold over the posted or advisory speed. For instance, the fraction of drivers in the sample traveling 10 or more mph over the posted speed limit before installation of the treatment is compared with the fraction traveling 10 or more mph over after the treatment is installed. This metric may be more meaningful because it reflects reduction in high-end speeding and not just average changes in speed.

Average or mean speed is the average of all spot speeds at the location in question. Mean speed was calculated using equation 4-1:

$$\bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i \qquad \textbf{(4-1)}$$

where:

$\bar{x}$ = arithmetic average or mean of observed values
x_i = ith individual value of statistic
N = sample size, number of values x_i

Change in average speed between analysis periods were compared at the 95 percent confidence level using a t-test (assuming unequal variances). Eighty-fifth percentile speeds were also compared, although there is no simple statistical test to compare whether the differences are statistically significant.

The fraction of drivers traveling at or above the posted speed limit or advisory speed by a certain threshold amount was also calculated. This metric provides a measure of the number of drivers traveling at high speeds. In many cases, agencies are more concerned with reducing the number of drivers traveling at excessive speeds than with simply reducing average speeds.

A z-test (equation 4-2) was used to detect differences between two population proportions at the 95 percent confidence level:

$$z = \frac{\hat{\pi}_1 - \hat{\pi}_2}{\sqrt{\frac{\hat{\pi}_1(1-\hat{\pi}_1)}{n_1} + \frac{\hat{\pi}_2(1-\hat{\pi}_2)}{n_2}}} \qquad \textbf{(4-2)}$$

Unless indicated otherwise, difference in means and percent over the posted or advisory speed were statistically significant at the 95 percent level of significance.

The percent change between the fraction of vehicles exceeding the posted or advisory speed before and after installation of the signs was calculated using equation 4-3:

$$C_p = \{FR_{(before,x)} - FR_{(after,x,i)}\} \div FR_{(before,\ x)} \qquad \textbf{(4-3)}$$

where:

$FR_{(before,x)}$ = fraction of vehicles exceeding posted or advisory speed by x mph for before period
$FR_{(after,x,\ i)}$ = fraction of vehicles exceeding posted or advisory speed by x mph for after period i
C_p = percent change

For example, if the fraction of vehicles traveling 5 or more mph over the posted speed limit was 0.413 for the before period, and the fraction of vehicles traveling 5 mph or more at 1 month after installation is 0.083, the percent change is: (0.413 – 0.083) ÷ 0.413 = 0.799. Therefore, 79.9 percent fewer vehicles exceeded the posted or advisory speed by 5 or more mph after the sign had been in place for 1 month. The percent change was the metric used to assess differences in the fraction of vehicles that exceeded the posted or advisory speed by 5, 10, 15, or 20 or mph.

ADT was computed for each site. Total volume was averaged by the number of days of data (i.e., total volume for a 48 hour count was divided by 2). ADT is presented only for the upstream site since volume is not expected to vary over the study section.

5. STUDY SITES

5.1 HAZLETON, IOWA

Traffic calming was installed in Hazleton, Iowa (population 892) along County Road C-57, which is the main east/west road through the community as shown in Figure 5-1. The site was recommended by the Buchanan County engineer who was concerned about speeding and safety.

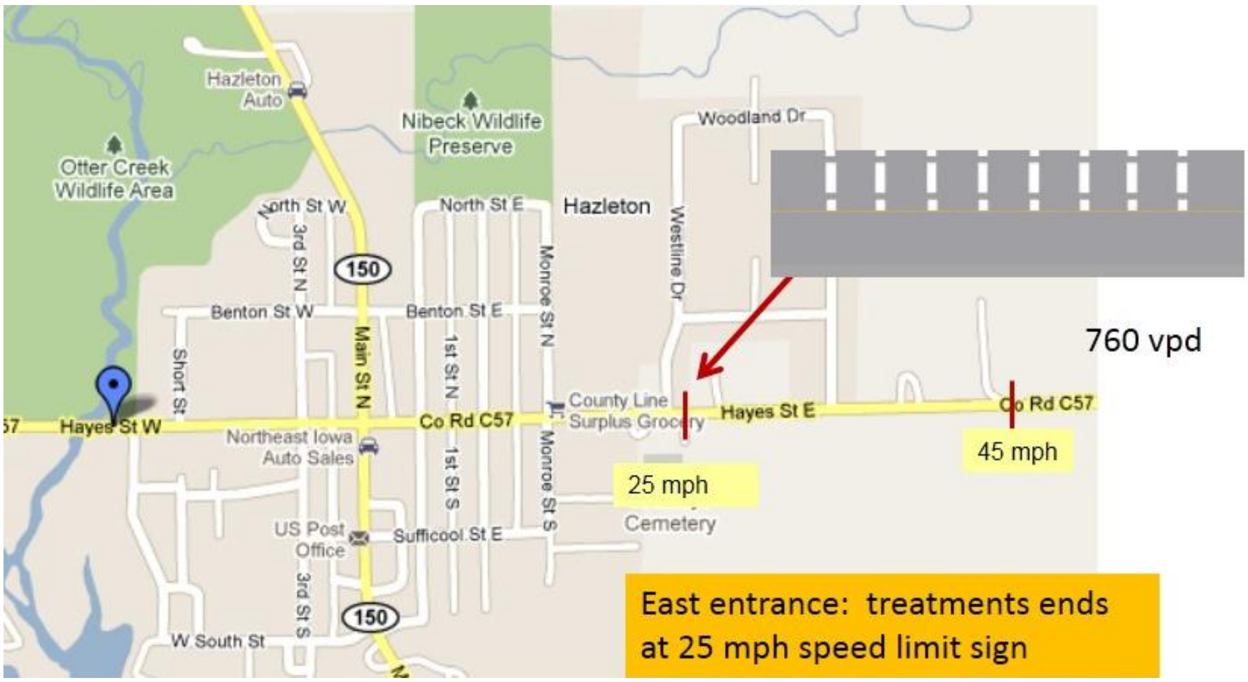


Figure 5-1: Location of treatment for Hazleton, Iowa (Google map)

A number of residential areas are located along both sides of the roadway. The speed limit is 55 mph outside of the community and drops to 25 mph at the community entrance on the east (760 vehicles per day/vpd) and west (820 vpd). The community entrances were of the most concern so initial speed studies were conducted at those locations. As shown in Table 5-1, the mean and 85th percentile speeds for the east entrance were 11 and 18 mph over the posted speed limit, respectively, before installation of the treatment.

A transverse bar treatment was installed at the east side of the community (Figure 5-2). The bars were placed so they terminated at the first 25 mph speed limit sign. The treatment was placed in May 2012. The team worked with the Buchanan County engineer for installation and monitoring. The west community entrance was also a concern but, due to the presence of a bridge just at the community entrance, a suitable traffic-calming treatment was not available.

Figure 5-2: Transverse bar treatment at Hazleton east entrance

Table 5-1 shows speed metrics before and after installation of the transverse bars.

Table 5-1: Results for transverse bars at Hazleton east community entrance

	Before	1 Month	Change
ADT	843	695	-148
Sample	764	626	
Mean speed	36.2	34.6	-1.6
Standard deviation	6.9	7.0	
85th percentile speed	43	42.0	-1
Upstream mean speed	55.8	55.0	-0.8
Fraction of Vehicles Traveling Over Posted Speed Limit			
≥ 5 mph	0.84	0.77	-8.3%
≥ 10 mph	0.59	0.52	-11.9%
≥ 15 mph	0.32	0.24	-25.0%
≥ 20 mph	0.10	0.06	-40.0%

Mean speed decreased by 1.6 mph and 85th percentile speed decreased by 1 mph. The change in mean speed from the upstream comparison site to the treatment site decreased by 0.8 mph.

Speeds upstream had little change (also a 0.8 mph decrease), so there is not expected to be an impact due to unrelated speed trends.

The most significant change was in the fraction of vehicles traveling over the posted speed limit. An 8 percent decrease was noted for vehicles traveling 5 or more mph over with a 12 percent decrease for vehicles traveling 10 or more mph over, 25 percent for 15 or more mph over, and 40 percent for 20 or more mph over.

5.2 JESUP, IOWA

Traffic calming was installed in Jesup, Iowa (population 2,212) along 220th Street (State Highway 939 outside of Jesup), which is the main road through community, as shown in Figure 5-3.

Figure 5-3: Traffic-calming treatment locations for Jesup, Iowa (Google map)

A number of business and residential areas are located along both sides of the roadway. The speed limit is 55 mph outside of the community and it drops to 35 mph at 1st Street on the west and just east of 12th Street on the east. Relative to the community, these sites have high traffic volumes with 3,070 vpd at the west entrance and 2,850 vpd at the east entrance. The site was recommended by the Buchanan County engineer who was concerned about speeding and safety. As shown in Tables 5-2 and 5-3, the 85th percentile speeds were 6 to 8 mph over the posted speed limit before installation of the treatments.

Colored entrance treatments were placed at both the east and west community entrances along 220th Street as shown in Figures 5-4 and 5-5. Both treatments were placed so they terminated at the 35 mph posted speed limit. The treatments were placed in May 2012.

Figure 5-4: Colored entrance treatment for Jesup east community entrance

Figure 5-5: Colored entrance treatment for Jesup west entrance

Results for the east entrance of Jesup are shown in Table 5-2.

Table 5-2: Results for colored treatment at Jesup east community entrance

	Before	1 Month	Change
ADT	3232	3142	-90
Sample	3004	2842	
Mean speed	35.3	34.0	-1.3
Standard deviation	6.9	5.9	
85th percentile speed	41	39	-2
Upstream mean speed	54.6	55.1	0.5
Fraction of Vehicles Traveling Over Posted Speed Limit			
≥ 5 mph	0.23	0.13	-43.5%
≥ 10 mph	0.05	0.03	-40.0%
≥ 15 mph	0.01	0.00	-100.0%
≥ 20 mph	0.00	0.00	0.0%

Mean speed decreased by 1.3 mph and 85th percentile speed decreased by 2 mph. Although this decrease was only moderate, much more significant decreases were noted in the fraction of vehicles traveling 5, 10, or 15 or more mph over the posted speed limit of 35 mph. A 40 to 43.5 percent decrease resulted for vehicles traveling 5 or 10 mph with a 100 percent reduction for vehicles traveling 15 or more mph over.

Table 5-3 shows speed metrics for the colored entrance treatment for the west entrance.

Table 5-3: Results for colored treatment at Jesup west community entrance

	Before	1 Month	Change
ADT	4083	4089	6
Sample	4037	4149	
Mean speed	38.5	37.0	-1.5
Standard deviation	4.7	4.6	
85th percentile speed	43	41	-2
Upstream mean speed	54.6	54.2	-0.4
Fraction of Vehicles Traveling Over Posted Speed Limit			
≥ 5 mph	0.37	0.26	-29.7%
≥ 10 mph	0.10	0.06	-40.0%
≥ 15 mph	0.02	0.01	-50.0%
≥ 20 mph	0.00	0.00	0.0%

Similar decreases in mean and 85th percentile speeds were noted as for the east entrance (1.5 and 2 mph, respectively). Significant changes in vehicles traveling over the posted speed limit of 35 mph were noted with a reduction of almost 30 percent in the fraction of vehicles traveling 5 or more mph over the speed limit and 40 and 50 percent in the fractions traveling 10 or 15 mph over the speed limit, respectively.

The upstream mean speeds, which were used as a comparison, showed little change in speed indicating that speeds overall independent of the signs were not much different from the before to after period.

5.3 OSSIAN, IOWA

Colored entrance treatments were placed along the main road through the community along County Road W-42 in Ossian, Iowa (population 800). County Road W-42 serves as one of the main routes through Ossian as shown in Figure 5-6.

Figure 5-6: Traffic-calming treatment location for Ossian, Iowa (Google map)

Residential areas are located along both sides of the roadway. The speed limit is 55 mph outside of Ossian and 25 mph at the community entrance. The traffic volume on County Road W-42 is 870 vpd. The site was recommended by the Winneshiek County engineer who was concerned about speeding and safety.

The treatment was placed so that it terminated at the first 25 mph speed limit sign as shown in Figure 5-7. The treatment was placed in May 2012.

Figure 5-7: Colored entrance treatment for north community entrance in Ossian

Results for the north Ossian community entrance are shown in Table 5-4.

Table 5-4: Results for colored treatment at Ossian north community entrance

	Before	1 Month	Change
ADT	1049	1128	79
Sample	1009	1086	
Mean speed	30.2	27.9	-2.3
Standard deviation	6.3	6.2	
85th percentile speed	36	34	-2
Upstream mean speed	56.6	57.2	0.6
Fraction of Vehicles Traveling Over Posted Speed Limit			
≥ 5 mph	0.54	0.38	-29.6%
≥ 10 mph	0.22	0.14	-36.4%
≥ 15 mph	0.07	0.03	-57.1%
≥ 20 mph	0.01	0.01	0.0%

Reductions in mean and 85th percentile speeds resulted. The fraction of vehicles traveling 5 mph over the posted speed limit of 25 mph decreased by almost 30 percent while the fraction traveling 10 or more mph over decreased by more than 36 percent. The fraction of vehicles traveling 15 or more mph over decreased by almost 60 percent.

5.4 Quasqueton, Iowa

Transverse bar treatments were installed in Quasqueton, Iowa (population 574) along the main road, Country Road W-40, through the community, as shown in Figure 5-8.

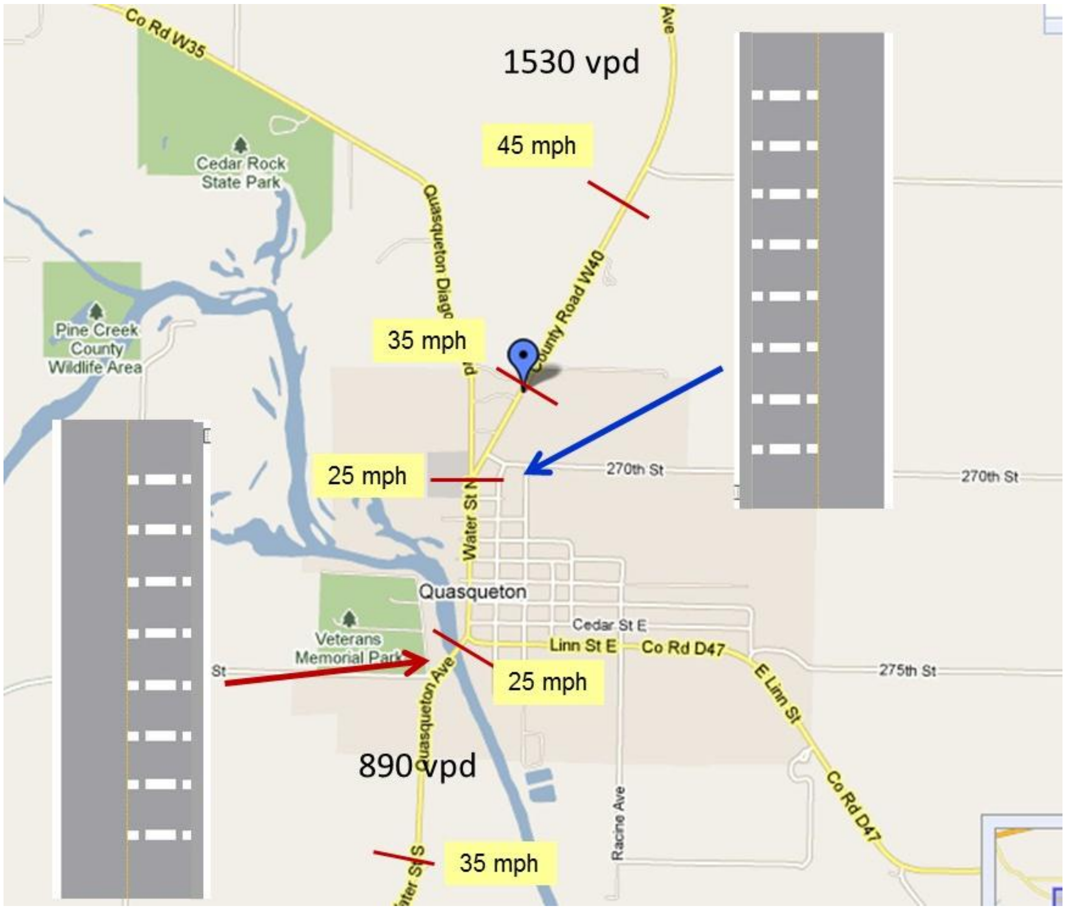


Figure 5-8: Locations of transverse bars for Quasqueton, Iowa (Google map)

A number of business and residential areas are located along both sides of the roadway. The speed limit is 55 mph outside of the community and it drops to 35 mph at the community entrance on the north. At the north entrance (1,530 vpd), the speed limit remains 35 mph until well into the community, so the treatment was placed at the community entrance at the 35 mph speed limit sign. At the south entrance to the community (890 vpd), the speed reduces to 25 mph and the treatment was placed to end at the first 25 mph speed limit sign..

The site was recommended by the Buchanan County engineer who was concerned about speeding and safety. The treatments are shown in Figures 5-9 through 5-11.

Figure 5-9: Transverse bar treatment for north Quasqueton community entrance

Figure 5-10: Close-up of transverse treatment at south Quasqueton entrance

Figure 5-11: Transverse bar treatment at south Quasqueton entrance

At the north entrance, the mean speed was almost 7 mph over the posted speed limit of 35 mph and the 85th percentile speed was 13 mph over the posted speed limit before installation of the treatments. At the south entrance, the mean speed was almost 10 mph over the posted speed limit of 25 mph and the 85th percentile speed was 16 mph over.

Table 5-5 shows results for the Quasqueton north entrance.

Table 5-5: Results for transverse bars at Quasqueton north community entrance

	Before	1 Month	Change
ADT	1868	1871	3
Sample	1768	946	
Mean speed	41.6	43.0	1.4
Standard deviation	7.7	7.5	
85th percentile speed	48	50	2
Upstream mean speed	57.9	58.5	0.6
Fraction of Vehicles Traveling Over Posted Speed Limit			
≥ 5 mph	0.68	0.74	8.8%
≥ 10 mph	0.37	0.46	24.3%
≥ 15 mph	0.11	0.15	36.4%
≥ 20 mph	0.02	0.04	100.0%

Speeds increased 1.4 mph for the mean and 2 mph for the 85th percentile. However, the mean speed also increased upstream by 0.6 mph independent of the treatment, which suggests that speeds may have increased independent of the treatment.

Results for the south entrance at Quasqueton are shown in Table 5-6.

Table 5-6: Results for transverse bars at Quasqueton south community entrance

	Before	1 Month	Change
ADT	1947	1981	34
Sample	1907	1920	
Mean speed	34.7	33.5	-1.2
Standard deviation	6.7	6.8	
85th percentile speed	41	40	-1
Upstream mean speed	54.7	55.6	0.9
Fraction of Vehicles Traveling Over Posted Speed Limit			
≥ 5 mph	0.80	0.73	-8.8%
≥ 10 mph	0.57	0.50	-12.3%
≥ 15 mph	0.24	0.20	-16.7%
≥ 20 mph	0.04	0.03	-25.0%

Mean and 85th percentile speeds decreased by only about 1 mph while significant decreases were noted in the fraction of vehicles traveling over the posted speed limit. the results showed a decrease of almost 9 percent in the fraction of vehicles traveling 5 or more mph over the speed limit and 12 percent in the fraction traveling 10 or more mph over. Large decreases were also noted for vehicles traveling 15 or more mph over (almost 17 percent) and 25 percent in the fraction traveling 20 or more mph over. Speeds at the comparison site upstream increased by almost 1 mph indicating the trend independent of the treatment was a slight increase in speed.

5.5 St. Charles, Iowa

The community of St. Charles, Iowa (population 653) is located southwest of Des Moines, Iowa. Speed problems were present at all four community entrances shown in Figure 5-12.

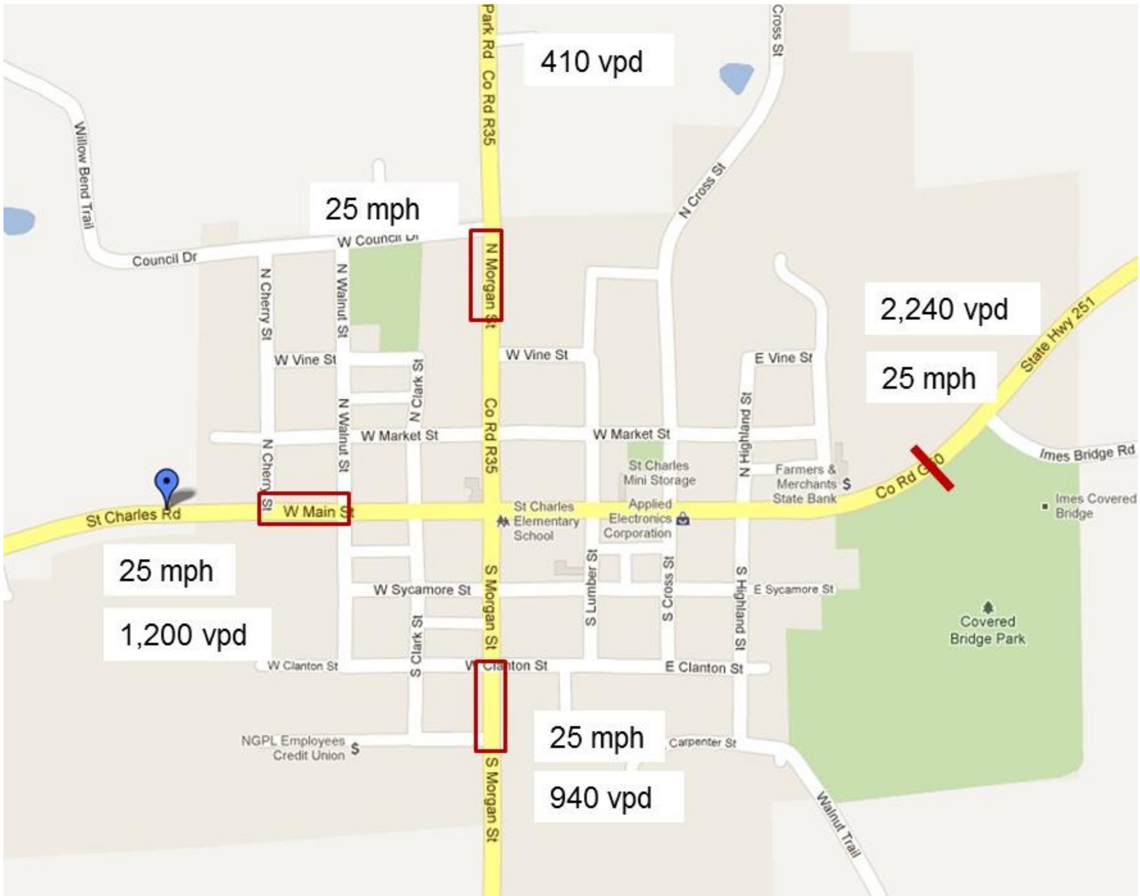


Figure 5-12: Locations of treatments for St. Charles, Iowa (Google map)

County Road R-35 is oriented north/south and has a traffic volume of 410 vpd at the north community entrance and 940 vpd at the south entrance. State Highway 251/West Main Street is oriented east/west and has a volume of 1,200 vpd at the west community entrance and 2,240 at the east entrance. State Highway 251 serves as a major collector route for drivers commuting to metro Des Moines. As shown in Tables 5-6 through 5-9, mean speeds before installation of the treatments were about 5 mph over the 25 mph posted speed limits and 85th percentile speeds were about 10 mph over.

Temporary islands were created using mountable curbing at the north, west, and south entrances. A radar-activated LED speed limit sign was placed at the east entrance. Mountable curbing was not appropriate for the east entrance given a horizontal curve, which may lead to some sight-distance issues for drivers being able to see the curbing in time. The treatments are shown in Figures 5-13 through 5-15.

Figure 5-13: Mountable curbing installed at west St. Charles community entrance

Figure 5-14: Mountable curbing at south entrance to St. Charles

Figure 5-15: Radar-activated LED speed limit sign at east St. Charles community entrance

Results for the north temporary island treatment are shown in Table 5-7.

Table 5-7: Results for temporary center island at St. Charles north community entrance

	Before	1 Month	Change
ADT	593	535	-58
Sample	648	593	
Mean speed	29.3	27.1	-2.2
Standard deviation	7.3	6.4	
85th percentile speed	37	34	-3
Upstream mean speed	50.2	50.2	0*
Fraction of Vehicles Traveling Over Posted Speed Limit			
≥ 5 mph	0.49	0.35	-28.6%
≥ 10 mph	0.24	0.13	-45.8%
≥ 15 mph	0.07	0.02	-71.4%
≥ 20 mph	0.01	0.00	-100.0%

* Not statistically significant at 95% level of significance

Mean speed decreased by 2.2 mph and 85th percentile decreased by 3 mph after installation of the temporary curbing. A significant decrease was found in the fraction of vehicles traveling over the posted speed limit. A decrease of almost 30 percent was noted in the fraction traveling 5 or more mph over and almost 46 percent in the fraction traveling 10 or more mph over. A much more significant decrease resulted for the fraction of vehicles traveling 15 and 20 or more mph over with decrease of 71 and 100 percent, respectively. No change occurred in the mean speeds for the upstream comparison site.

Table 5-8 shows results for the temporary island treatment at the south community entrance to St. Charles.

Table 5-8: Results for temporary center island at St. Charles south community entrance

	Before	1 Month	Change
ADT	1360	1341	-19
Sample	1322	1301	
Mean speed	29.2	27.3	-1.9
Standard deviation	6.8	6.9	
85th percentile speed	36	35	-1
Upstream mean speed	53.0	52.9	-0.1*
Fraction of Vehicles Traveling Over Posted Speed Limit			
≥ 5 mph	0.47	0.36	-23.4%
≥ 10 mph	0.21	0.15	-28.6%
≥ 15 mph	0.07	0.05	-28.6%
≥ 20 mph	0.02	0.01	-50.0%

* Not statistically significant at 95% level of significance

As noted mean speed decreased by almost 2 mph and 85th percentile speed was reduced by 1 mph. The fraction of vehicles traveling 5, 10, or 15 or more mph over the posted speed limit decreased by 23 to 29 percent and the fraction of vehicles traveling 20 or more mph over decreased by 50 percent. Little change resulted for the upstream comparison site.

Table 5-9 shows the results for the temporary island treatment at the west St. Charles community entrance.

Table 5-9: Results for temporary center island at St. Charles west community entrance

	Before	1 Month	Change
ADT	1448	1287	-161
Sample	1418	1285	
Mean speed	27.6	28.0	0.4
Standard deviation	5.2	5.3	
85th percentile speed	33	33	0
Upstream mean speed	53.3	51.7	-1.6
Fraction of Vehicles Traveling Over Posted Speed Limit			
≥ 5 mph	0.34	0.36	5.9%*
≥ 10 mph	0.09	0.10	11.1%*
≥ 15 mph	0.02	0.02	0.0%*
≥ 20 mph	0.00	0.00	0.0%*

* Not statistically significant at 95% level of significance

As noted, little change occurred in mean and 85th percentile speeds. Minor increases also resulted in the fraction of vehicles traveling 5 or 10 or more mph over the posted speed limit. No changes occurred for vehicles traveling 15 or 20 mph over the posted speed limit. The mean speed at the upstream site decreased slightly, which suggests speeds overall may have decreased independent of the treatment.

Table 5-10 shows results for the east community entrance where the radar-activated LED speed limit sign was installed.

Table 5-10: Results for radar-activated LED speed limit sign at St. Charles east community entrance

	Before	1 Month	Change
ADT	2283	2208	-75
Sample	2479	2209	
Mean speed	29.0	28.6	-0.4
Standard deviation	6.0	6.0	
85th percentile speed	35	35	0
Upstream mean speed	53.7	53.8	0.1*
Fraction of Vehicles Traveling Over Posted Speed Limit			
≥ 5 mph	0.46	0.42	-8.7%
≥ 10 mph	0.18	0.16	-11.1%
≥ 15 mph	0.04	0.05	25.0%*
≥ 20 mph	0.01	0.01	0.0%*

* Not statistically significant at 95% level of significance

Only minor changes occurred with minor reductions in mean speed and the fraction of vehicles traveling 5 or 10 mph over the speed limit. Increases in the fraction of vehicles traveling 15 or more mph over increased from 4 percent to 5 percent (25 percent increase). No changes were noted in the upstream comparison site.

5.6 ROWLEY, IOWA

The city of Rowley, Iowa (population 264) is located southeast of Waterloo, Iowa. County Road D-47 is the main street through Rowley and is oriented east/west as shown in Figure 5-16.

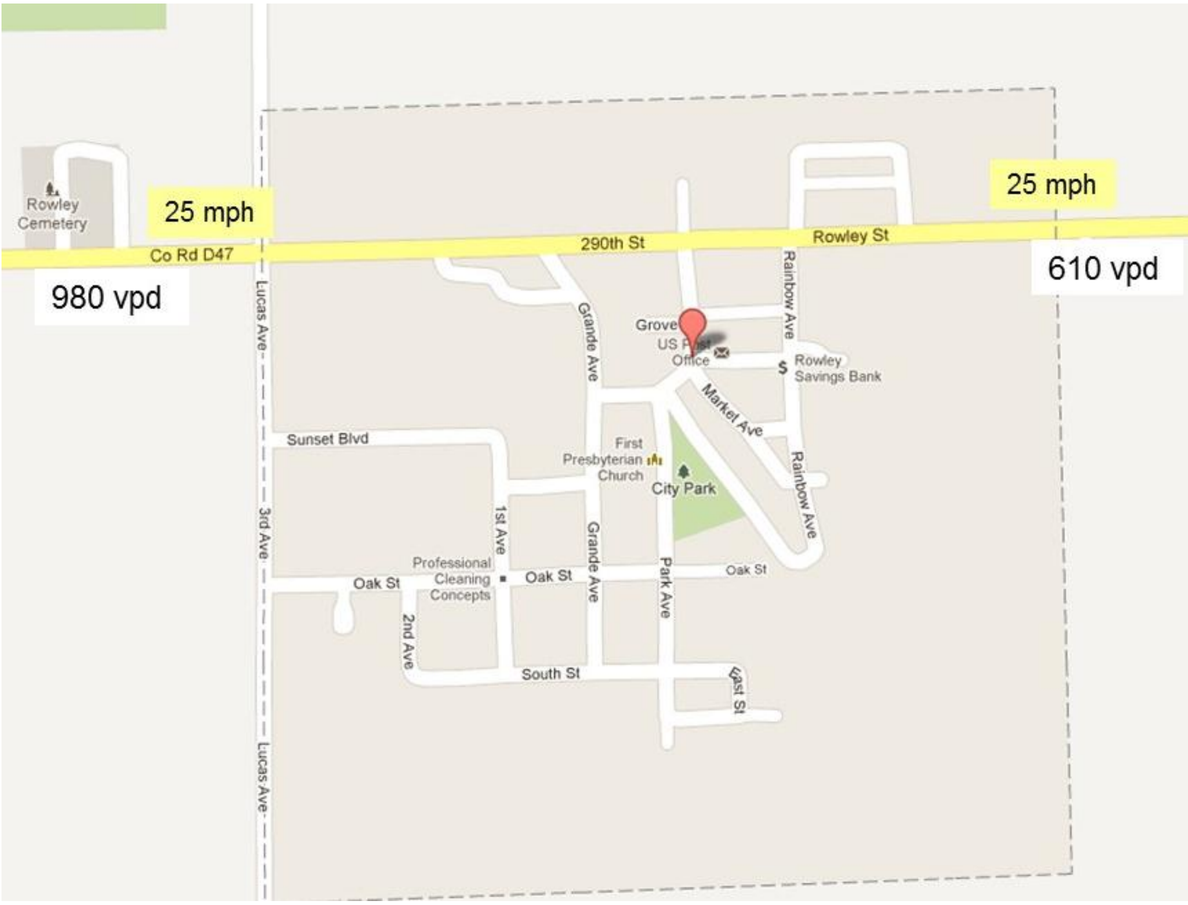


Figure 5-16: Map of Rowley, Iowa (Google map)

County Road D-47 is 55 mph outside the community and 25 mph within the community. The traffic volume is 610 vpd at the east community entrance and 980 vpd at the west community entrance.

The community was suggested by the Buchanan County engineer who was installing traffic calming at select communities within the county. A dynamic speed feedback sign (DSFS) was installed at the same point as the first 25 mph speed limit at the east entrance as shown in Figure 5-17. A radar-activated LED speed limit sign was installed at west community entrance at the first 25 mph speed limit as shown in Figure 5-18.

Figure 5-17: DSFS installed at east Rowley community entrance

Figure 5-18: Radar-activated LED speed limit sign installed at west Rowley community entrance

Table 5-11 shows results for the DSFS at the east community entrance of Rowley.

Table 5-11: Results for speed feedback sign at Rowley east community entrance

	Before	1 Month	Change
ADT	653	774	121
Sample	646	735	
Upstream mean speed	55.7	53.6	-2.1
Mean speed	36.7	29.1	-7.6
Standard deviation	7.7	7.1	
85th percentile speed	44	35	-9
Upstream mean speed	55.7	53.6	-2.1
Fraction of Vehicles Traveling Over Posted Speed Limit			
≥ 5 mph	0.84	0.46	-45.2%
≥ 10 mph	0.64	0.17	-73.4%
≥ 15 mph	0.38	0.08	-78.9%
≥ 20 mph	0.15	0.03	-80.0%

Mean speed decreased by almost 8 mph after installation of the DSFS and the 85th percentile speed decreased by 9 mph. A large decrease in the fraction of vehicles traveling over the posted speed limit also resulted with 45 percent in the fraction traveling 5 or more mph over and 73 to 80 percent decrease in the fraction traveling 10, 15, and 20 or more mph over the posted speed limit.

Major reductions in speed were also noted for the radar-activated LED speed limit sign, which was installed at the west entrance to Rowley, as shown in Table 5-12.

Table 5-12: Results for radar-activated LED speed limit sign at Rowley west community entrance

	Before	1 Month	Change
ADT	1081	1239	158
Sample	1064	1215	
Upstream mean speed	56.0	54.8	-1.2
Mean speed	37.8	31.9	-5.9
Standard deviation	11	9.9	
85th percentile speed	49	42	-7
Upstream mean speed	56.0	54.8	-1.2
Fraction of Vehicles Traveling Over Posted Speed Limit			
≥ 5 mph	0.75	0.56	-25.3%
≥ 10 mph	0.67	0.40	-40.3%
≥ 15 mph	0.51	0.24	-52.9%
≥ 20 mph	0.31	0.11	-64.5%

A decrease of almost 6 mph in mean speed and 7 mph in 85th percentile speed occurred after installation of the sign. The decrease in the fraction of vehicles traveling 5 or more mph over the posted speed limit was about 25 percent and 40 percent in the fraction of vehicles traveling 10 or more mph over. A reduction in the fraction traveling 15 or more mph over was 50 percent and it was 65 percent for the fraction traveling 20 or more mph over.

6. SUMMARY OF KEY FINDINGS

Five different traffic-calming treatments were evaluated along the main roads through small communities.

One treatment was a set of transverse bars, which were placed upstream of the first regular speed limit sign through the community. The treatment was placed at three locations in two different communities. The treatment was moderately effective in reducing mean and 85th percentile speeds (1 to 2 mph) at two sites. However, the treatment was quite effective in reducing the fraction of vehicles that exceeded the posted speed limit with decreases of up to 9 percent, 12 percent, 25 percent, and 40 percent for the fraction traveling 5, 10, 15, and 20 or more mph over the posted speed limit, respectively. Speeds increased moderately at one site with an increase of 1 mph in mean speed and 2 mph in 85th percentile speed. Moderate increases in vehicles traveling over the posted speed limit also resulted for that one site.

The second treatment was colored entrance treatments, which were applied at three sites within two communities. Decreases were noted at all three sites with decreases in mean speed between 1 and 2.3 mph and a decrease of up to 2 mph in the 85th percentile speed. Decreases up to 44 percent resulted in the fraction of vehicles traveling 5 or more mph over the posted speed limit, 40 percent in the fraction traveling 10 or more mph over, and up to 57 percent in the fraction traveling 15 or more mph over the posted speed limit. No change occurred in the fraction of vehicles traveling 20 or more mph over the posted speed limit at any of the sites. Speeds increased at the third site with increases of 1 to 2 mph in mean and 85th percentile speeds and the fraction traveling over the posted speed limit.

The third treatment was use of temporary curbing to create a sense of vertical friction. The treatment was applied at three locations within one community. Decreases in mean speed and 85th percentile speed between 1 and 2 mph resulted for two of the locations. Decreases in the fraction of vehicles traveling 5 mph over the speed limit of up to 29 percent were noted and decreases of up to 46 percent, 71 percent, and 100 percent in the fraction traveling 10, 15, and 20 or more mph over, respectively. At the third location, little change in speed resulted for any of the speed metrics.

The fourth treatment was use of radar-activated LED speed limit signs, which were installed at one community entrance of two different communities. In one community, little change occurred in speeds before and after installation of the sign. In the second community, significant decreases were noted with a reduction of 6 and 7 mph in mean and 85th percentile speeds. Decreases in the fraction of vehicles traveling 5, 10, 15, or 20 mph over the posted speed limit up to 65 percent occurred.

The final treatment was use of a dynamic speed feedback sign, which was installed at one community entrance where mean speed decreased by 8 mph and the 85th percentile speed decreased by 9 mph. Decreases in the fraction of vehicles traveling 5 or more mph over the posted speed limit of 45 percent were noted and a decrease of 73 and 79 percent occurred for the fraction traveling 10 and 15 or more mph over. A decrease of 80 percent in the fraction of vehicles traveling 20 or more mph over the posted speed limit occurred.

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