Evaluation of Gateway and Low-Cost Traffic-Calming Treatments for Major Routes in Small, Rural Communities

Final Report
November 2007

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16. Abstract

Many rural communities have developed around highways or major county roads; as a result, the main street through small rural communities is often part of a high-speed rural highway. Highways and county roads are characterized by high speeds outside the city limits; they then transition into a reduced speed section through the rural community. Consequently, drivers passing through the community often enter at high speeds and maintain those speeds as they travel through the community. Traffic calming in small rural communities along major roadways is common in Europe, but the U.S. does not have experience with applying traffic-calming measures outside of major urban areas.

The purpose of the project was to evaluate traffic-calming treatments on the major road through small Iowa communities using either single-measure low-cost or gateway treatments. The project was partially funded by the Iowa Highway Research Board (IHRB). The focus of the IHRB portion was to evaluate single-measure, low-cost, traffic-calming measures that are appropriate to major roads through small rural communities. Seven different low-cost traffic treatments were implemented and evaluated in five rural Iowa communities. The research evaluated the use of two gateway treatments in Union and Roland; five single-measure treatments (speed table, on-pavement "SLOW" markings, a driver speed feedback sign, tubular markers, and on-pavement entrance treatments) were evaluated in Gilbert, Slater, and Dexter.

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EVALUATION OF GATEWAY AND LOW-COST TRAFFIC-CALMING TREATMENTS FOR MAJOR ROUTES IN SMALL RURAL COMMUNITIES

Final Report
October 2007

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EXECUTIVE SUMMARY

Many rural communities have developed around highways or major county roads; as a result, the main street through small rural communities is often part of a high-speed rural highway. Highways and county roads are characterized by high speeds outside the city limits; they then transition into a reduced speed section through the rural community. Consequently, drivers passing through the community often enter at high speeds and maintain those speeds as they travel through the community. Traffic calming in small rural communities along major roadways is common in Europe, but the U.S. does not have experience with applying traffic-calming measures outside of major urban areas.

The purpose of the project was to evaluate traffic-calming treatments on the major road through small Iowa communities using either single-measure low-cost or gateway treatments. The project was partially funded by the Iowa Highway Research Board (IHRB). The focus of the IHRB portion was to evaluate single-measure, low-cost, traffic-calming measures that are appropriate to major roads through small rural communities. Seven different low-cost traffic treatments were implemented and evaluated in five rural Iowa communities. The research evaluated the use of two gateway treatments in Union and Roland; five single-measure treatments (speed table, on-pavement "SLOW" markings, a driver speed feedback sign, tubular markers, and on-pavement entrance treatments) were evaluated in Gilbert, Slater, and Dexter.

1. INTRODUCTION

1.1 Background

Many rural communities have developed around highways or major county roads; as a result, the main street through small Iowa communities is often part of a high speed rural highway. Highways and county roads are characterized by high speeds outside the city limits; they then transition into a reduced speed section through the rural community (Figure 1.1). Consequently, drivers passing through the community often enter at high speeds and then maintain those speeds as they travel through the community. Additionally, as rural subdivisions are frequently built along high speed roadways, they encounter similar safety problems.

Figure 1.1. Major highway entering a small Iowa community

Main streets in small communities function much like main streets in any community; they are characterized by pedestrian activity, bicycles, and children crossing to community activities such as pools or playgrounds (Figure 1.2). Combined with high-speed through traffic, a potential safety problem exists because, at higher speeds, drivers are able to process less in their field of view, they have less time to react, and more severe injuries or fatalities occur when a pedestrian or bicyclist is struck.

Figure 1.2. An older resident using a small town roadway

In 2004, there were 13,192 traffic fatalities (30% of all traffic fatalities) in the United States resulted from speed-related crashes (NHTSA 2005a). The total number of crashes in rural areas is often lower than urban areas, but crashes are more likely to be severe due to higher vehicle speeds. Crashes in rural communities may be more likely to have a severe outcome since many small communities do not have emergency management services and, consequently, it takes longer for emergency personnel to reach crash victims. A Washington State University study evaluated pedestrian/vehicle collisions over a three-year period and determined that the likelihood of a pedestrian dying in a rural collision was more than twice that of a pedestrian struck in an urban area (Mueller et al. 1988). The study noted that the higher risk was most likely due to less rapidly available emergency services. High speeds also diminish quality of life for residents in small communities.

Traffic calming has been used extensively in the United States in urban areas; a number of documents and studies are available that provide guidance on the use of different traffic-calming devices on residential urban roadways. Most traffic-calming techniques, however, have been only been evaluated on low-speed urban roadways. The effectiveness of traffic calming along major routes that transition from high-speed facilities to low-speed facilities through rural communities is not well documented. Guidelines on the appropriate use of traffic-calming devices are also not readily available.

Use of traffic calming in rural areas in the United Kingdom and other areas in Europe is more advanced than in the U.S. Several documents are available that address rural traffic calming. The National Road Association of Ireland (NRA 2005) produced a set of guidelines for the use of traffic-calming devices in towns along national routes, particularly in the high speed transition zone into a community. Traffic-calming techniques such as cross-hatching; rumble strips, signing, and landscaping were presented. The Department for Transport (UK) also provides a set of guidelines for traffic calming on major roads through villages. The guide discusses techniques such as road narrowing and pavement markings (DFT 2005). However, although traffic calming in rural communities is widespread in Europe, the effectiveness of the different techniques in reducing speeds or accidents was not documented in any of the European literature that was reviewed.

Traffic-calming techniques are typically intended to reduce speed, control traffic volumes, improve transit access, encourage the use of bicycles, and to reclaim the street as a multi-use public space (Kamyab 2002). However, the use of traffic calming is usually considered in the context of local urban streets; a different approach is needed on higher-speed roadways, since their primary function is carrying traffic (Macbeth 1998). One of the major challenges for traffic calming in rural communities is to balance personal safety against regional mobility needs and preserve a route’s unique rural character (PSRC 2003)

1.2 Definition of Traffic Calming

The Institute of Transportation Engineers (ITE) developed a standard definition of traffic calming in 1997:

> Traffic calming is the combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver behavior, and improve conditions for non-motorized street users (Ewing, 1999)

Traffic calming typically either focuses on reducing speed or reducing traffic volume. On major rural routes, reducing speed is the primary goal, since volume reduction is neither feasible nor desirable. Traffic calming essentially reduces vehicle speeds through the use of self-enforcing traffic engineering methods or through road design. Posting of speed limits alone does not result in a significant reduction in speed (O’Connor 1999), since drivers typically drive at the speed they perceive as being safe. A driver’s perception of what is safe is related to road design, which includes lane width, curvature, corner radii and available stopping-sight distance (O’Connor 1999). Traffic calming slows traffic using either physical or psychological means (ODOT 1999). When appropriate, physical constraints, such as curb extensions, medians, chicanes, or on-street parking create friction and help hold down speeds. In many instances, physical narrowing of the roadway is not feasible or appropriate, such as along rural major through routes. Measures that create the illusion of less space, such as lane narrowing using pavement markings or landscaping, convey the message to drivers that they are no longer on an open highway and they need to reduce their speed. These measures also provide the psychological effect of friction. (ODOT 1999)

1.3 Benefits of Traffic Calming

Lower vehicle speeds produce several safety benefits. Lower speeds provide drivers more time to react and be aware of their surroundings. Figures 1.3 through 1.6 illustrate differences in what a driver is able to perceive as his/her speed increases from 15 to 40 mph (ODOT 1999). As shown, a driver's area of focus is significantly increased at lower speeds.

Figure 1.3. Driver focus at 40 mph (source: ODOT 1999)

Figure 1.4. Driver focus at 30 mph (source: ODOT 1999)

Figure 1.5. Driver focus at 20 mph (source: ODOT 1999)

Figure 1.6. Driver focus at 15 mph (source: ODOT 1999)

Lower speeds also reduce the likelihood and severity of vehicle crashes. The National Highway Traffic Safety Administration (NHTSA) estimates that the probability of death, disfigurement, or debilitating injury doubles for every 10 mph over 50 mph (NHTSA 2005a). Kloeden et al. (1997) looked at the risk of crash involvement for sober drivers of cars in 60 km/h (37.3 mph) speed limit zones in Adelaide, Australia. The study included crashes where at least one person was transported from the crash in ambulance. They found that 68% of vehicles involved in crashes were exceeding the speed limit. A total of 14% of drivers involved in fatal crashes were traveling faster than 80 km/h (49.7 mph). They also found that the risk of crash involvement approximately doubled for every 5 km/h (3.1 mph) increase above 50 km/h risk (31.1 mph). The authors indicated that the crash risk due to speeding is similar to the risk of driving with a blood alcohol concentration of 0.05 in urban areas.

The Oregon DOT reported speed statistics indicating that there is an 85% likelihood of death for a pedestrian struck at 40 mph. One struck at 30 mph has a 45% chance of being killed and the risk drops to 15% if the pedestrian is struck at 20 mph (ODOT 1999).

The Federal Highway Administration (FHWA) estimates that each one mile per hour reduction in speed may reduce injury crashes by five percent (TRB 2002). In another source, FHWA (1994) cites studies in Denmark and France that analyzed traffic calming on through roads in small towns and villages. In France, speed reductions of 7–13 mph have been observed while still preserving free-flowing traffic conditions. Along with reduced speeds, a 60% reduction in the average number of accidents was found in the 10 towns studied. The Denmark locations, in particular, reported a 5–6 mph reduction in speed and a reduction of 50% and 33% in total and injury accidents, respectively, in three towns.

Another benefit of traffic calming is that it may affect how residents of a community interact with one another. Bicycling, walking, and other forms of street life are encouraged. Appleyard (1981) studied the effect of traffic calming on neighborhood interaction. He found that as the amount of traffic increased on a street, residents tended to have fewer friends and acquaintances among their neighbors, and the area they considered “home territory” declined.

Burrington et al. (1998) indicated that traffic calming may also discourage crime in a community. In a Dayton, Ohio case study, Burrington studied the effects of reducing traffic on neighborhood streets by utilizing traffic-calming measures such as speed humps and street and alley closures. He found that traffic calming reduced violent crimes by 50%, non-violent crimes by 24%; in addition, there was increased community involvement. Reducing speeds through a community can also help to reduce crime. Lockwood (2003) studied the effects of reducing traffic and speed on an arterial in West Palm Beach, Florida. The case study found that when a community or urban neighborhood is no longer bisected by fast-moving traffic, people living along the arterial tend to use it more for pedestrian and cycling activity. Community interaction and crime prevention are often difficult to measure, but they are important secondary benefits that traffic calming may create.

The possible benefits of less noise and emissions, less crime, and more community interaction can also lead to higher property values. This can occur after a reduction in either traffic volume or speed. Studies by Bagby and Hughes (1980; 1992) indicate that traffic calming that reduced traffic volumes on residential streets by several hundred vehicles per day increased house values by an average of 18 percent. Bagby (1980) attempted to quantify this impact further, estimating that each reduction of 100 vehicles per day below 2,000 provides a 1% increase in adjacent residential property values.

Other studies have examined the effect that reducing traffic speed has on adjacent residential property values. Modra (1984) reported that a 5–10 mph reduction in traffic speed can increase adjacent residential property values by about 2 percent. Lockwood (1998) examined the effects of traffic calming in the Old Northwood neighborhood of West Palm Beach, Florida. The city used street closures, traffic circles, neckdowns, and speed humps in order to reduce speeds. A few years later, home sale prices had risen from an average of $65,000 to an average of $106,000. Other studies are not as conclusive. Edwards (1998) paired neighborhoods in Gwinnett County, GA, that were treated with speed tables to similar neighborhoods that were untreated. The rate of price appreciation for home sales was then compared. For six neighborhood pairs, the neighborhoods that had speed tables showed more appreciation. For three pairs, there was less appreciation. For one pair, appreciation was the same. Edwards noted that, for most cases, the differences were only slight. Therefore, the researchers were "unable to demonstrate that installing humps will affect property values in any predictable way."

1.4 Overview of Project

High speeds through small rural communities in Iowa are a concern since Iowa is largely a rural state with a number of small towns along county or state roadways, sometimes every 10 to 12 miles. Additionally, small rural communities often lack the resources to select, implement, or evaluate traffic-calming strategies.

The purpose of the project was to evaluate traffic-calming treatments on the major road through small Iowa communities using either single-measure low-cost or gateway treatments. The project was partially funded by the Iowa Highway Research Board (IHRB). The focus of the IHRB portion was to evaluate single-measure low-cost traffic-calming measures that are appropriate to major roads through small rural communities.

The project was also funded by the Federal Highway Administration (FHWA). The FHWA portion of the project focused on evaluation of gateway traffic-calming treatments in rural communities. Gateways are a traffic-calming technique used in Europe and cited in many European studies on traffic calming in rural communities. Gateways have also been used to some extent in the U.S. Community gateways are a measure or set of measures strategically located as motorists enter a community which announces to motorists that they are entering a community and are no longer on an open, high-speed roadway. Effective community gateways communicate to motorists that they are making a transition from a rural roadway to a city street (ODOT 1999).

A gateway marks the entry point to a rural community. In some cases, a gateway may consist of elaborate landscape and sign installations. Many European gateways are a combination of traffic-calming measures, such as colored pavement, lane narrowing, or pavement markings. For the purpose of this research, FHWA defined a gateway as a "combination of traditional and nontraditional traffic control treatments, such as enhanced signing, lane reduction, colored pavements, pavement markings, experimental striping, gateway structures, and traditional traffic-calming techniques or other identifiable features."

Gateways have been demonstrated to be effective in reducing speeds in European studies. The Department for Transport, UK, indicated that mean speed reductions of 3–13 mph, with an average of 5 mph, were achieved using gateways (Sustrans 2005). It also reported that up to 15 mph speed reductions for the 85^{th} percentile were achieved using gateways in combination with other treatments (DETR 2005). The Department for Transport (DFT 2005) suggests that gateway treatments may be an effective way to slow drivers if there are high approach speeds to a rural community or if the start of community is not obvious.

Although gateways have been used extensively in Europe for traffic calming along major roads through rural communities, their effectiveness in reducing speeds and accidents in the United States is not as well documented. Additionally, guidelines on the use of gateways for rural communities in the U.S are not readily available.

Figure 1.7. Farm traffic through a small Iowa community

All treatments considered for this study had to be reasonably low cost. They had to accommodate large trucks and farm vehicles (Figure 1.7.), which are prevalent in small communities. They could not change the character of the roadway. For instance, use of chicanes was expensive and would have required major changes to the roadway.

The research evaluated the use of two gateway treatments in Union and Roland, Iowa; five single-measure treatments (speed table, on-pavement “SLOW” markings, a driver speed feedback sign, tubular markers, and on pavement entrance treatments) were evaluated in Gilbert, Slater, and Dexter, Iowa.

2. SUMMARY OF TRAFFIC-CALMING MEASURES APPLICABLE TO RURAL MAIN STREETS

As part of the project, traffic-calming treatments that may be appropriate along the major road through a small community were identified. Many of the treatments selected have been used in urban areas of the U.S., while others are those which have been tried in small communities in Europe but have not been tested in the U.S.

This section summarizes the existing information about traffic-calming treatments. A summary of traffic-calming treatments evaluated for this research is presented in Section 3. Traffic calming can affect the driver physically and/or psychologically. Physical cues for transitions discussed in other sections include rumble strips, pavement markings, and shoulder treatments. Visual cues, such as gateways (signs) and landscaping changes, can remind the driver they are entering a different segment of roadway.

All measures listed are appropriate for rural traffic calming but may not be appropriate for all situations. Effectiveness and appropriateness depend on posted and desired speed limit, layout of community, and community characteristics. Other characteristics to consider include characteristics of the major route, such as design features, number and type of vehicles, and presence of farm equipment and other large vehicles which need to negotiate the community.

The traffic-calming measures listed are presented individually. However, a number of studies and experiences suggest that traffic-calming measures that are part of a concerted overall traffic management plan are more effective than application of a single treatment at a single location.

2.1 Need for Traffic Calming

The decision to implement traffic calming should be based on good engineering judgment and there should be a demonstrated need for traffic calming. Situations that may suggest a need for traffic calming include the following (FHWA, 1994b):

- High volumes of cut-through traffic
- Documented speeding problem
- Careless driving
- Inadequate space for roadside activities
- Need to provide a slower, safer environment for non-automobile users
- Crash problem that could be reduced by implementation of roundabouts

Section 5 discusses speed metrics that can be used to evaluate whether there is a documented speeding problem.

2.2 Traffic Calming in Rural Areas

Considerations for implementation of traffic-calming devices in rural communities versus urban areas include the following:

- **Design driver:** the typical user of roadway facilities is likely to be a rural resident, who may be less likely to have encountered typical traffic-calming devices than a resident of an urban community. Furthermore, the typical user may be an older resident. Iowa ranks near the top in all older driver percentage groups—second only to Florida in drivers over age 85 (www.iowasms.org 2006).
- **Design vehicle:** heavy trucks frequently use rural arterials; farm equipment is also prevalent on roadways around and through small communities, so devices need to accommodate large farm equipment;
- **Maintenance:** smaller communities and rural counties are less likely to have experience with maintaining traffic-calming devices than larger urban areas. Additionally, they may have fewer resources to direct towards upkeep of the devices.
- **Roadway type:** Most major roads through small communities are also major county roads. Devices that significantly alter the roadway may not be acceptable on high-volume roadways with high speeds and large percentages of larger and heavier vehicles.

2.3 Setting Appropriate Speed Limits and Use of Appropriate Signing

While visiting small communities to select pilot study locations, the research team observed that speed limits are often improperly set. Small communities often do not have a traffic engineer. As a result, one solution used by small communities to address perceived speeding problems is to lower the speed limit, believing that this will change driver behavior. It was not unusual to see a posted speed limit of 20 mph on a major road within a small community. The roads often have a speed limit of 60 mph outside the community and then drivers are forced to slow to 20 mph. Speed limits that are set lower than is necessary, given surrounding community characteristics or roadway functional class, lead to disregard of the speed limit.

It was also noted that some small communities improperly use stop signs as traffic-calming measures. A four-way stop is sometimes placed at a location where the community perceives a speeding problem, even though the location does not meet the volume, speed, or crash warrants for a multi-way stop. Use of stop signs to slow traffic is ineffective, since drivers may speed up once they are away from the stop sign. Additionally, drivers may ignore an individual stop sign when they do not perceive a need for the sign and overuse of stop signs may result in disregard for stop signs in general.

2.4 Setting Appropriate Transition Zones

Another observation made the by research team is that speed transition zones in small communities are often improperly set. In some cases, transition zones are much too long, extending significantly past the edge of a community into agricultural areas where there is no reason for reduced speeds. In other cases, the speed transitions are abrupt and do no allow for a gradual change in speed. In the most extreme case, one community has a transition zone that changes immediately from 55 mph to 25 mph.

Transition zones are the segment of highway immediately preceding and following the low-speed section through a small community. The town is a different driving environment than the rural segment; the transition zone should reinforce this upcoming change. Usually, the town section is much shorter than the rural segment and drivers must be given notice and motivation to reduce speed.

Drivers need an adequate distance to slow down to urban speeds, which can be provided by proper speed limit signing. Speed should not change abruptly from 65 to 25 mph, but rather should reduce in stages from 65 to 55 mph, 55 to 45 mph, and so on. The speed will also gradually return to rural highway speed as the driver exits town. Transition zones should also not be placed so far outside the community that there is no motivation for drivers to slow to the transition zone speed.

3. APPROPRIATE TRAFFIC-CALMING MEASURES FOR RURAL MAIN STREETS

The following sections summarize traffic-calming measures which may be appropriate for use along the main street in small rural communities. The following presents a summary of available information. A description of the traffic-calming treatments evaluated for this project is presented in Section 5.

3.1 Bulb-Outs, Neckdowns, Chokers, or Mid-Block Crossings

3.1.1 Definition

Neckdowns, bulb-outs, chokers, and mid-block crossings are physical devices placed in the roadway to create horizontal deflections by narrowing points along the roadway. Vehicles are forced to slow to negotiate the narrowed points on the roadway. Narrowing of the main road section is referred to as a *chokes* or *mid-block crossing* (when refuge and pavement markings are added); narrowing at an intersection is referred to as a *neckdown* or *bulb-out* (Figure 3.1). When applied on a two-lane road (each direction), these techniques can be used to narrow the lanes and slow traffic or to reduce the two lanes to one.

Figure 3.1. Bulb-outs (source: DWS 2005)

Chokers and bulb-outs have been used in many locations:

- local and collector streets
- pedestrian crossings
- main roads through small communities
- in conjunction with speed humps, speed tables, raised intersections, textured crosswalks, curb radius reductions, and raised median islands (ITE 2005)

3.1.2. Placement

One source indicated that, on facilities that are 30 mph or lower, chokers or bulb-outs should be at least 600 feet apart (Ewing 1999).

3.1.3. Advantages

- Neckdowns, bulb-outs, chokers, and mid-block crossings shorten pedestrian crossing distances.
- Neckdowns, bulb-outs, chokers, and mid-block crossings lead to tighter turning radii, forcing turning vehicles to slow.

3.1.4. Disadvantages

- Neckdowns, bulb-outs, chokers, and mid-block crossings interrupt drainage patterns at intersections and mid-block, which adds to the cost of implementation.
- Neckdowns, bulb-outs, chokers, and mid-block crossings may be difficult for large or oversized vehicles, such as farm equipment, to negotiate.

3.1.5. Effectiveness

An ITE study indicates that narrowing results in a 2.6 mph speed reduction (Ewing 1999).

3.1.6. Appropriateness

Devices used to physically narrow lanes should be used with caution for the types and amounts of traffic on primary roadways through small communities. Use of neckdowns, bulb-outs, chokers, and mid-block crossings may not be appropriate with heavy truck traffic and/or large farm equipment.

3.2 Transverse Rumble Strips

3.2.1. Definition

Rumble strips are grooves placed in the roadway surface which transmit sound and vibration to alert drivers to changing conditions. Several agencies have used temporary rumble strips, which consist of strips of durable tape, rather than permanent installation.

Rumble strips are typically placed longitudinal to the roadway surface on the shoulder or edge of pavement to alert drivers that they are leaving the roadway in order to reduce run-off-the-road crashes. They have also been placed perpendicular to the direction of traffic and used to alert drivers of a change in upcoming conditions. They have been used in advance of rural stop signs and prior to curves. In Iowa, transverse rumble strips are sometimes used on the approach to stop signs on rural roads. Typically, three sets of rumble strips are used to alert motorists approaching stop signs.

The City of Twin Lakes, Minnesota implemented rumble strips as a traffic-calming measure. They installed a set of nine grooved rumble strips perpendicular to the vehicle path (Figure 3.2) to remind motorists of upcoming speed reduction zones. Rumble strips were used in speed transition zones where posted speeds changed from 55 mph to 40 mph to 30 mph. The strips were placed on the highway before the 40 mph speed transition zone (Kamyab, 2002).

Figure 3.2. Rumble strips (source: Kamyab 2002)

3.2.2 Placement

Meyer (2000) suggested that a series of rumble strips should be placed seven times the posted speed limit before the change the driver is being alerted to. In a series of rumble strips, the spacing between each strip should be one foot for every 10 mph of the vehicle speed. For example, on a roadway posted at 45 mph, each strip would be 4.5 feet apart.

3.2.3. Advantages

- Rumble strips do not adversely affect emergency response services.
- Rumble strips do not interfere with vehicle operation.

3.2.4. Disadvantages

- Rumble strips are noisy.
- They may be a hazard to motorcyclists and bicyclists.
- Rumble strips require a high level of maintenance (CPVE 2001).
- Drainage can cause water or ice to pond in the strips.
- Vehicles may swerve around rumble strips to avoid them. Consequently, they should be used with caution on high-volume roads (Fontaine et al. 2000) or placed across the entire width of the road.
- The effect on pavement wear is unknown when rumble strips are milled into the roadway surface.

3.2.5. Effectiveness

A study by Texas Technology Institute (Fontaine et al. 2000) evaluated the use of portable rumble strips in work zones to reduce vehicle speeds. Rumble strips consisted of 12-foot strips that were four inches wide and bright orange with adhesive backing. While they did not find a reduction in passenger vehicle speeds, they did find a reduction in truck speeds of 3–5 mph.

3.2.6. Appropriateness to Rural Main Streets

Rumble strips are appropriate for speed transition zones in rural traffic-calming areas to alert drivers of upcoming speed changes. Use of rumble strips in transition zones for a rural area is less likely to have an adverse noise impact since the transition area is likely to be located in a less populated area than for an urban area. Rumble strips are also appropriate for crosswalks in high pedestrian areas.

Rumble strips are used in frequently in Iowa in advance of stop signs on rural roadways. It should be noted that their use in applications other than in advance of stop signs is strongly discouraged by the Iowa Department of Transportation. This information was included for consideration for areas outside of Iowa.

3.2.7. Cost

Portable rumble strips are available. Rumble strips can be milled into the roadway surface as well. Cost depends on which method is used.

3.3 Chicanes

3.3.1. Definition

Chicanes (Figures 3.3 and 3.4) are short, horizontal displacements in the roadway that create a curvilinear alignment, which encourages slower speeds (Iowa DOT 2001). They are also called serpentines, as the physical constrictions at curbside create a 45º bend in a straight road, which forces vehicles to negotiate the narrowed street in a snakelike fashion (Ewing 1999). Traditional chicanes often require a change in the roadway alignment; they physically change the roadway.

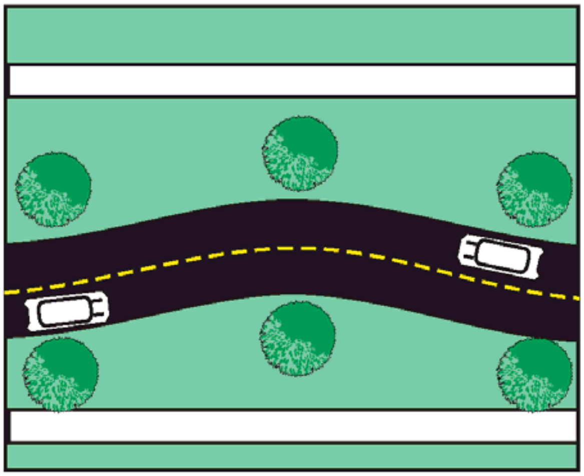

Figure 3.3. Chicanes (source: Iowa MUTCD)

Figure 3.4. Chicanes (source: DSW 2005)

A similar effect can be achieved by alternating on-street parking from one side of the street to the other. This can be done by re-striping pavement markings for parking, or by constructing islands for parking bays (Ewing 1999). The City of Nashville, Tennessee used zigzag pavement markings which allowed for two full lanes plus short stretches of parking on alternating sides of the street to create a chicane pattern (Hamburg 2005). The street in question was marked at 25 mph but had significant speeding problems. Other measures were tried but were not successful. The city felt that les- intrusive measures should be tried before implementing more drastic devices, such as speed humps. The pattern and location are show in Figure 3.5. No information on effectiveness was provided.

3.3.2. Placement

Chicanes should be placed 400 to 600 feet apart and the normal turning radii for design vehicles should be accommodated. Key considerations are visibility and provision of advance warning signs (Kastenhofer 1997). Alignment of the chicane should be shifted at least one lane-width and deflection angles should be at least 45º. Center islands are also recommended, where appropriate, to prevent drivers from cutting across the center line and continuing to speed.

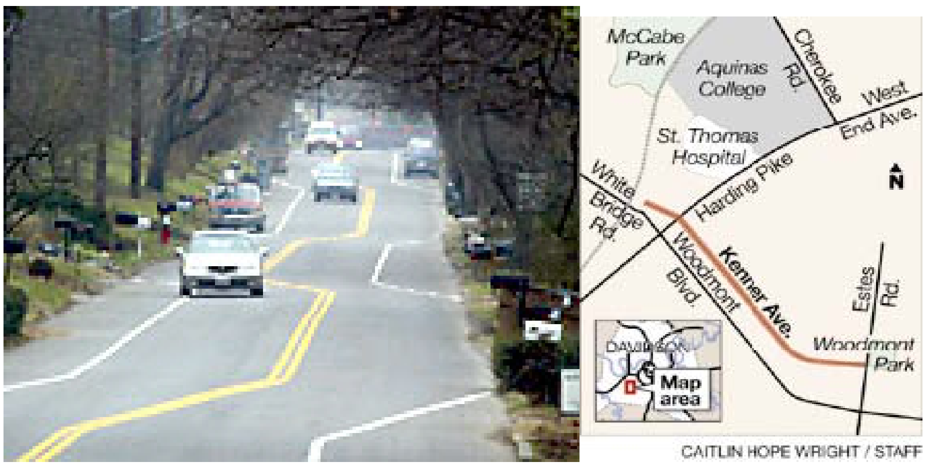

Figure 3.5. Use of pavement markings to create a chicane using lane shifts and alternating parking (source: Hamburg 2005)

3.3.3. Advantages

- Negotiating curves forces vehicles to slow down.
- Chicanes can be aesthetically pleasing.

3.3.4. Disadvantages

- Installing chicanes can potentially lead to high costs for curb realignment and landscaping.
- Drainage problems (ponding) can occur.
- There is the potential for head on collisions with the use of chicanes.
- Chicanes may be difficult for large trucks and farm equipment to negotiate if not properly designed.
- Chicanes can negatively impact emergency response times.

3.3.5. Effectiveness

Chicanes were evaluated on an 8,000 vph arterial in Toronto. The roadway was 28 feet wide and chicanes were created using modular traffic-calming islands. The road was narrowed to 21 feet with chicanes. A reduction in the 85th percentile speed from 50 km/h to 45 km/h occurred (Macbeth 1998). The Seattle Engineering Department found that chicanes were an effective means of reducing speeds and traffic volumes under certain circumstances (FHWA 1994a). A study by the Minnesota Local Road Research Board (LRRB) summarized information from other studies and reported a 6% change in 85th percentile speeds (Corkle et al. 2001).

3.3.6. Appropriateness to Rural Main Streets

Chicanes, when properly designed, may be appropriate for rural main streets. Special considerations must be given to geometrics if there is a high percentage truck traffic, because curb overtopping could be a problem if the shifts are too tight or closely spaced. Consideration must be given to alignment so that heavy trucks and farm equipment are able to negotiate the alignment.

3.3.7. Cost

One source indicated costs are $4,000 to $5,000 (Kastenhofer 1997). Another source indicated $4,000 to $8,000, depending on the length of roadway (CWS 2005). Temporary chicanes are also available. Use of pavement markings to create chicanes can be relatively inexpensive.

3.4 Landscaping

3.4.1. Definition

Landscaping (Figure 3.6) is often used in conjunction with other traffic-calming treatments, such a raised medians or islands, chokers, roundabouts, traffic circles, and chicanes. This has two purposes: to make the traffic-calming treatment more attractive and to further communicate to the motorist that a slower speed is advisable.

Figure 3.6. Median landscaping

A more interesting question in the literature on traffic calming is whether landscaping alone can be employed as a traffic-calming device. The theory of using landscaping for traffic calming is that it can work in two ways:

1. By planting alongside the road or street in such a way that the roadway appears narrower to the driver. (The “optical width” of the road is narrowed as opposed to the “physical width.”) A “tunnel effect” is created and the driver’s field of view is narrowed. This, in turn, should encourage drivers to slow down as shown in Figure 3.7.
2. By communicating a change in the character of the roadway from “rural” to “urban.” This is done by changing the nature of plantings alongside the roadway. For instance, in rural areas, trees are found in naturalistic clumps or groups; in urban areas, trees are planted in formal rows and spaced at regular intervals.

Figure 3.7. Italian street with a narrow optical width

Although the discussion in this section is specifically about landscaping, similar effects could also be achieved with "hardscaping," e.g., buildings and building setbacks, street cross-sections, on-street parking, and street fixtures. With these treatments, the goals would again be to narrow the optical width of the street and/or communicate the "urban" nature of the street. However, "hardscaping" approaches will generally be much more expensive than landscaping solutions to traffic calming.

3.4.2. Placement

Landscaping should be placed along the entire length of the street where traffic calming is desired, on both sides of the street. It is particularly critical to place landscaping that narrows the optical width of the roadway and communicates that the road is changing from "rural" to "urban" in the transition zone where the largest decrease in speed is sought. Figure 3.8 from the National Forest Service shows how trees planted at fairly regular intervals communicate the message that the street is "urban."

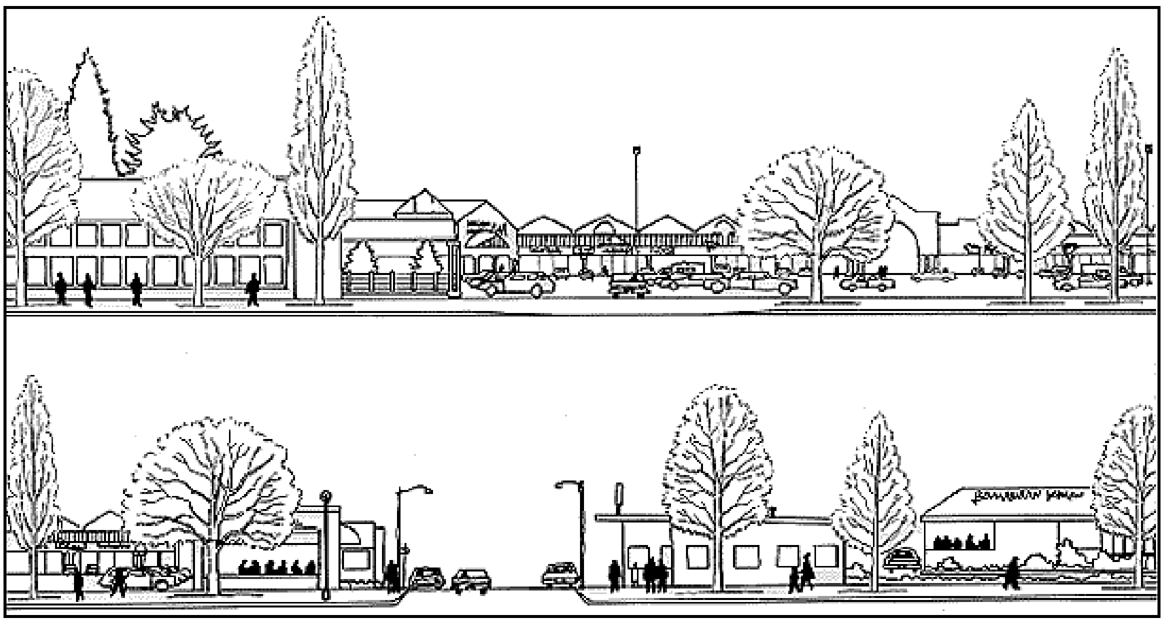

Figure 3.8. Regular spacing of trees (Image source: National Forest Service)

The photos in Figures 3.9–3.11 below illustrate the difference between urban and rural road landscaping using mature trees.

Figure 3.9. Formal urban tree placement in Paris, France

Figure 3.10. Rural tree placement

Figure 3.11. Rural tree placement

Trees will generally be the most effective form of landscaping in terms of traffic calming, due to the fact that they can grow large enough to provide the “optical narrowing” effect that should, in turn, reduce traffic speeds. Care should be taken in planting not to create additional driving hazards, such as blocking sight distance triangles at driveways and public road intersections. Clear zone issues should also be considered.

3.4.3. Advantages

Landscaping can serve multiple purposes, including community development and beautification and traffic calming.

3.4.4. Disadvantages

- Landscaping can be high-cost.
- Maintenance is required.
- Objects in clear zone can create traffic hazards if not properly designed.

3.4.5. Effectiveness

It is not clear from research literature whether landscaping alone will be sufficiently effective to calm traffic in the absence of other traffic-calming treatments, including physical treatments and enforcement.

Lakewood, Colorado used a series of landscaped medians and curbside islands to create a narrow serpentine roadway alignment for traffic calming on a collector street. The alignment was 1,150 feet. The goal was to reduce speed but not volume, due to concerns that traffic would be diverted to other residential streets. Vehicles speeds were compared before and one year after completion of the project. The traffic-calming measure proved very effective at reducing speeds. The number of vehicles traveling 10 mph over the speed limit (>40 mph) was reduced from 35% to 2.5%. The 85^{th} percentile speed was reduced from approximately 45 mph to 35 mph. The mean speed was reduced from approximately 36 mph to 29 mph. Vehicle volumes decreased slightly from 11, 400 vehicles per day through the project area to 10,900 vph one year after. The crash rate for a period 31 months before to 17 months after was compared. No statistically significant difference in crashes occurred. However, only a very short after-analysis period was used. The project was completed in 1998, with construction costs for sidewalks, landscaped medians, curb and gutter, etc. totaling $240,000 (Buchholz et al. 2000).

3.4.6. Appropriateness

Landscaping should logically be used along with other traffic-calming treatments to achieve the desired result. It should be part of a comprehensive traffic-calming plan for a community wishing to slow speeds and maintain traffic flow along an arterial roadway.

3.4.7. Cost

Cost varies depending on treatment.

3.5 Center Islands

3.5.1. Definition

Lane narrowing reduces the width of the travel portion of a lane. Narrowed lanes provide a feeling of constraint and cause drivers to reduce their speed. Lanes can either be physically narrowed or visually narrowed by increasing the marked width portion of a shoulder or median. Physical narrowing can be accomplished by using center islands, curb build-outs, or chicanes, but it should be preceded by other traffic-calming devices to prevent accidents (Sustans 2005). A narrowing using a center island is shown in Figure 3.13.

Center islands are usually raised islands (also called medians) within the roadway centerline. They usually narrow the travel lane at that location and separate opposing traffic movements. When landscaped, they can improve the aesthetics of the corridor, and they can act as a gateway when placed at endpoints of a town. They are feasible without major roadway changes when the right of way is in excess of the minimum required street width. Center islands may also be painted areas, but these may be less effective than center islands with raised curbs and landscaping, since vehicles can still traverse a painted island (CPVE 2001).

Figure 3.12. Use of a small, painted center island (source: Isebrands)

The City of Drakesville in southern Iowa has a large center island widening along the main street as shown in Figures 3.13–3.15. The widening area is surrounded by shops and forms a town square of sorts, with a gazebo and playground in the center. The island physically forces traffic to divert around the island and has an aesthetically pleasing appearance.

Figure 3.13. View of Drakesville center island as drivers enter the main area of town from the east

Figure 3.14. Close-up view of the Drakesville island

Figure 3.15. Side view of Drakesville center island showing gazebo and picnic area

Center island widening was used as part of the gateway treatment in Union and is discussed in Section 5.

3.5.2. Placement

Median treatments can be continuous or placed in short sections.

3.5.3. Advantages

- Center islands provide physical separation between travel lanes.
- Center islands create refuge areas for pedestrian.
- Landscaping may contribute to pastoral nature of area and be aseptically pleasing.
- Center islands may reduce head on collisions.

3.5.4. Disadvantages

- Depending on the roadway cross-section, separated lanes, in some cases, could lead to higher speeds, since drivers have less friction with on-coming vehicles.
- Center islands reduce access to businesses.
- Center islands require additional maintenance needs.
- Center islands may impact drainage.

3.5.5. Effectiveness

Median treatments may be more effective when they provide a short interruption of traffic flow than when long center islands are used.

3.5.6. Appropriateness to Rural Main Streets

A rural main street must have adequate additional right of way for a center island. If it does, then center islands are especially appropriate for rural main streets when turning movements should be restricted or channelized downstream of an intersection, or in areas that would benefit from a pedestrian refuge. Care should be used in areas with heavy truck volumes or prevalence of large farm vehicles so that larger vehicles can utilize the roadway.

3.5.7. Cost

Use of a raised median is a significant capital improvement. Use of pavement markings may be fairly inexpensive.

3.6 Community Gateways

3.6.1. Definition

Community gateways are simply landscaped sign installations that announce to motorists that they are entering a community. Although often installed for community development and community pride purposes, effective community gateways will communicate to motorists that they are making a transition from a rural roadway to a city street.

Shown below in Figures 3.16–3.18 are examples of community gateway signage used in rural Iowa.

Figure 3.16. Gateway sign in Tiffin, Iowa

Figure 3.17. Gateway sign in Rockwell City, Iowa

Figure 3.18. Gateway sign in Sioux Center, Iowa

Gateway signs provide an indication to motorists that they are leaving a rural area and entering a city or town where land use, pedestrian, and motor vehicle activities will be more intense. The motorist should, in turn, respond by slowing down.

3.6.2. Placement

A community gateway should be placed where a reduction in traffic speed is desired; it should be close to the boundary of the community. Gateways would best be placed in the speed transition zones where a gradual reduction of speed is desired. Community gateways are generally be placed to the right of the roadway, although some are so large that they span the roadway. A large community gateway from Milwaukee, Wisconsin that completely spans the roadway is shown in the photo below in Figure 3.19. The gateway needs to be large enough to attract the attention of drivers and it also must be formal enough so that it communicates the message that the character of the roadway is changing from rural to municipal.

Figure 3.19. Gateway entrance in Milwaukee, WI

3.6.3. Advantages

A community gateway will probably not be installed for traffic calming purposes alone. It will more likely be done for community development purposes, perhaps by a service club or garden club. This can help keep the installation and maintenance cost low for the community. Other advantages include the following:

- Gateways can be personalized to reflect community identity (CPVE 2001).
- Gateways are aesthetically pleasing.

3.6.4. Disadvantages

- Gateways require considerable ongoing maintenance such as painting the sign and renewing and watering the vegetation.
- Gateways may infringe on clear zone.

3.6.5. Effectiveness

The Department of Transport, UK, indicated that mean speed reductions of 3–13 mph, with an average of 5 mph, were achieved using gateways (Sustrans 2005). It also reported that up to 15 mph speed reductions for the 85th percentile were achieved using gateways with other treatments (DETR 2005). The main purpose of a gateway entrance treatment is to remind drivers that they are transitioning from a rural high-speed roadway to a community. Simple use of an entrance sign, however, may have limited effectiveness.

3.6.6. Appropriateness

The most appropriate application for a community gateway would be as an integral part of a more extensive community traffic calming and corridor beautification program. Since they do not infringe on the roadway, gateways are appropriate for use along major roads through small communities. Use of gateway entrance treatments should be consistent with clear zone requirements, since they are often made of immovable material that presents a fixed object hazard.

3.6.7. Cost

A very elaborate community gateway may cost $10,000 including all materials and labor. An example of a $10,000 community gateway from Fort Dodge, Iowa is shown below in Figure 3.20. It is masonry construction, which adds to the expense. Reductions in cost may be achieved through outside grants (e.g., the Keep Iowa Beautiful grant program), volunteer labor, donated materials, and use of less-expensive construction techniques.

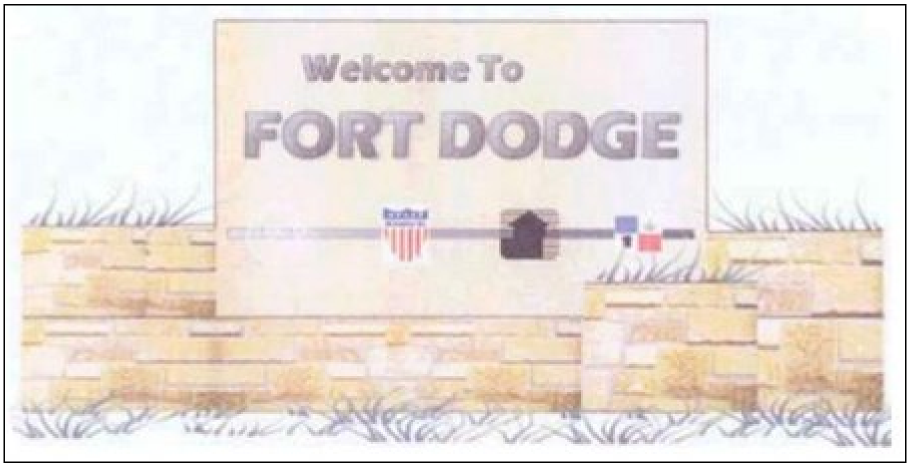

Figure 3.20. Fort Dodge gateway treatment

3.7 Transverse Lane Markings

3.7.1. Definition

Transverse pavement markings are usually transverse bars or chevrons. The transverse bars are typically spaced to give drivers the perception that they are speeding up. This encourages drivers to be aware of their speeds and slow down. They also alert drivers that they are entering a different area. They are a low cost solution and have been used in work zones and along horizontal curves to slow speeds (Katz 2004). Pavement markings such as "Dragon Teeth" have been used in the United Kingdom to provide a visual change of the roadway and alert drivers that they are entering a rural community, as shown in Figure 3.21.

Figure 3.21. Dragon teeth
(source:www.cornwall.gov.uk/Transport/trafcalm/calmhome.htm)

Optical speed bars have been used at roundabouts in Great Britain (Meyer 2001), in highway work zones, and on a four-lane undivided highway in Virginia (VTRC 2006). They were used in the gateway treatment as part of this study in Union, Iowa, as shown in Figure 3.22, and are discussed in Section 5.

Figure 3.22. Optical speed bars used in Union (facing back towards markings)

Converging chevrons have also been used to slow speeds. Converging chevrons were used as part of the gateway treatment in Roland, Iowa, as shown in Figure 3.23, and are discussed in Section 5.

Figure 3.23. Use of converging chevrons in Roland, Iowa

3.7.2. Placement

Transverse pavement markings should be spaced with decreasing space as a driver enters a transition zone. This gives drivers the perception of going too fast or speeding up and encourages them to reduce their speeds.

3.7.3. Advantages

- Transverse pavement markings are cost-effective.
- They do not affect vehicle operation.
- They do not impact emergency vehicles.
- They do not impact drainage.
- Transverse markings are low cost.

3.7.4. Disadvantages

- Additional maintenance is required to maintain markings.
- Transverse markings may be less effective in winter conditions when markings are not visible.

3.7.5. Effectiveness

A study in Minnesota used a converging chevron pattern in each travel lane as a traffic-calming measure (Figure 3.24). The width of chevrons and spacing were decreased to give the illusion that vehicles were traveling faster than they actually were. The Minnesota research project also placed 30 mph pavement markings and added high visibility wind spinners on speed limit signs. The roadway was a community collector street with an ADT of 4000. Data were collected before installation and one week after. A reduction of 5 and 3 mph in mean speed (depending on the lane) were observed and a 7 and 5 mph reduction in 85th percentile speed was found. Speeds were also collected 28 weeks after installation. Additionally, the highest speeds recorded were reduced from 58 mph to 44 mph and 53 to 45 mph one week after installation and 58 to 48 mph and 53 to 48 mph at 28 weeks after installation. The markings were repainted after four years, since the researchers felt that the fading paint impacted the results. After repainting, the researchers found similar speed reduction results as those conducted one week after initial installation (Corkle 2001).

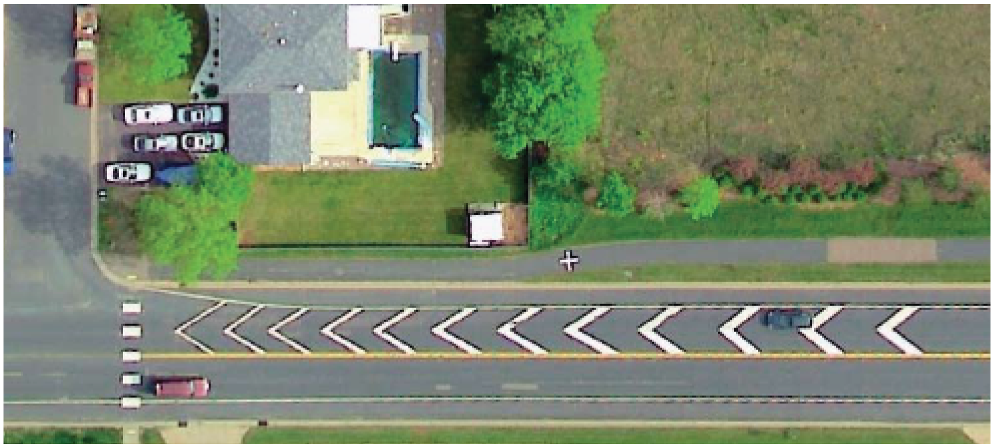

Figure 3.24. Aerial view of chevron lane markings in Eagan, MN (source: Corkle 2001)

3.7.6. Appropriateness to Rural Main Streets

Transverse pavement markings are appropriate for rural traffic calming, especially in transition zones, where the driver is being reminded of a change in roadway character. They are low cost and do not present safety hazards associated with horizontal or vertical deflections. They can accommodate all types of vehicles without interfering with vehicle operation and do not physically change the characteristic of the roadway.

3.7.7. Cost

Transverse markings are low cost, with the initial cost to lay markings and cost of subsequent maintenance.

3.8 Surface Treatments

3.8.1. Definition

Colored surface dressing or textured surfaces are common traffic-calming treatments in the Europe and are often used in conjunction with gateways or other traffic-calming measures to emphasize the presence of traffic-calming features. Surface treatments are usually implemented on the full width of roadway and can be done with pavement markings (Figures 3.25 and 3.26) or textured pavement (Figure 3.27). They draw attention to the fact that something about the roadway is changing and provide visual clues and, in the case of textured pavement, an auditory clue to drivers that they have entered a different area.

Figure 3.25. Red markings with posted speed limit signs (source: DETR 2005)

Figure 3.26. Pavement markings used at entrance treatment (source: DETR 2005)

Figure 3.27. Textured surface treatment (source: DWS 2005)

A colored surface treatment was used as an entrance treatment in Dexter, Iowa, as shown in Figure 3.28, and is discussed in Section 5.

Figure 3.28. Colored pavement markings creating an entrance treatment in Dexter, Iowa

3.8.2. Placement

Textured surfaces are typically placed in the transition zones before entering a town and are often used in conjunction with other techniques, such as landscaping. Colored surface marking should be skid resistant and should be placed across both lanes so that drivers aren't tempted to change lanes to avoid the treatments.

3.8.3. Caution

Surface treatments that cover a significant portion of a lane should meet state or local skid resistance requirements.

3.8.4. Advantages

- Surface treatments can be aesthetically pleasing.
- They do not affect vehicle operation.
- They do not impact emergency vehicles.
- They do not impact drainage.
- Surface coloring does not have noise impacts.

3.8.5. Disadvantages

- Surface treatments requires regular maintenance.
- They may be less effective in winter conditions when markings are not visible.
- Some textured surfaces, like cobblestones or bricks, can be difficult for bicyclists and pedestrians to negotiate.
- Textured surfaces have increased noise.

3.8.6. Effectiveness

There is often an initial reduction in speed after installation. Surface treatments are considered most effective in combination with other techniques. Colored surfaces may be less effective in winter months due to snow/ice cover.

One study in Shropshire, UK reported on the use of colored surface treatments in conjunction with speed limit signs (DETR 2005). The study reports on use of red patches eight meters long across full width of roadway, along with speed limit signs placed for each direction as shown in Figure 3.29. This configuration was repeated at 10 locations throughout the city and was used along with other traffic-calming measures. Reductions in both mean and 85th percentile speeds decreased, although the study did not provide the exact number for this treatment.

Figure 3.29. Treatment used in Shropshire, UK (source: DETR 2005)

3.8.7. Appropriateness to Rural Main Streets

Surface treatments are appropriate for traffic calming along major roadways in rural communities, especially in transition zones where the driver is being reminded of a change in roadway character. They are low cost and do not present safety hazards associated with horizontal or vertical deflections. Textured surfaces, such as cobblestones or other materials, may not be appropriate with heavy loadings that may occur on major rural roads.

3.8.8. Cost

Use of painted roadway surfaces is generally low cost and entails the initial cost to paint the roadway and subsequent costs to maintain. Paint must be skid resistant. Other roadway surface treatments, such as use of different textures or incorporating dyes into the roadway or shoulder pavement, are more expensive.

3.9 Raised Intersection

3.9.1. Definition

A raised intersection is a raised plateau, usually four inches above adjacent streets, used at an intersection. It is reached using slight ramps from the intersection approaches and motorists are forced to slow to negotiate it (CPVE 2001). It slows vehicles in a manner similar to a speed table, since drivers have to slow to avoid physical discomfort.

3.9.2. Placement

Raised intersections are only used at intersections and are a good measure for high-pedestrian areas. Crosswalks should be on the raised section.

3.9.3. Advantages

- Raised intersections can slow vehicles in critical problem areas (CPVE 2001).

- They provide visual clues to drivers.
- Attractive paving stones or bricks add to aesthetics (CPVE 2001).

3.9.4. Disadvantages

- Raised intersections require additional maintenance.
- They may impact drainage.
- Turning movements may be impacted (CPVE 2001).
- There is a need to warn drivers about the raised intersection.

3.9.5. Effectiveness

Ewing indicated minimal speed reductions, since vehicles may already be slowing for the intersection (1999). In other cases, raised intersections may have the same effectiveness as speed tables.

3.9.6. Appropriateness to Rural Main Streets

Raised intersections can be applied to rural main streets, especially those with high pedestrian volumes. They will affect traffic operations, so large trucks and farm equipment should be considered.

3.9.7. Cost

Installation of a raised intersections is a major investment .

3.10 Dynamic Speed Displays and Vehicle Actuated Signs

3.10.1. Definition

Dynamic speed signs and displays (two examples are shown in Figures 3.20 and 3.31) are usually radar-activated signs that dynamically display approaching speeds for individual vehicles or display messages such as ‘SLOW DOWN’ or ‘REDUCE SPEED’ 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.

Figure 3.30. Radar dynamic speed sign

Figure 3.31. Speed camera (source: www.cornwall.gov.uk/transport/trafcalm/calmhome.htm)

Two different dynamic speed feedback signs were evaluated as part of this research project. One sign technology was evaluated in Union, Iowa, as described in Section 5, and the other was evaluated in Slater, Iowa, as described in Section 5.

3.10.2. Placement

Devices are placed in the location where a reduction in speed is desired. They may also be used in transition zones to slow traffic in advance of lower speed areas.

3.10.3. Advantages

- Dynamic speed signs do not affect vehicle operation.
- They do not impact emergency vehicles.
- They do not impact drainage.
- Portable devices can be moved and used at different locations/
- Speed signs are less expensive than enforcement in the long term (CWS 2005).
- They may be implemented immediately.

3.10.4 Disadvantages

- Dynamic speed signs are high cost.
- They require regular maintenance and a power source.
- Motorists may speed up to see how fast they can go (this can be addressed by only posting speeds in a certain range).
- Drivers may become immune to devices if there is no further perception of enforcement.
- Dynamic speed signs are only effective for one direction of travel.

3.10.5. Effectiveness

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

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

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

3.10.6. Appropriateness to Rural Main Streets

Dynamic speed signs are appropriate for rural main streets.

3.10.7. Cost

Dynamic speed signs cost from $2,000-11,000 per display.

3.11 Enforcement

3.11.1 Definition

Enforcement is typically a police presence to monitor speeds and issue tickets for violations (Figure 3.31). It is often used with other traffic-calming devices to regulate behavior. Enforcement may also be used by itself to reduce speeds to the appropriate speed range.

3.11.2. Placement

Enforcement should occur in the area where reductions in speed are desired.

Figure 3.32. Use of enforcement to slow speeds (source: city of Winston-Salem)

3.11.3. Advantages

- Enforcement is effective in getting drivers' attention.
- It does not affect vehicle operation.
- It does not impact emergency vehicles.
- It does not impact drainage.
- Enforcement can be moved and targeted at different locations.
- Secondary benefits may include reduced crime and increased sense of security (CWS 2005).

3.11.4. Disadvantages

- Enforcement is expensive (one source indicated that additional revenue for tickets does not pay for officer work time).
- It requires a regular presence.

3.11.5. Effectiveness

Enforcement is effective when used regularly.

3.11.6. Appropriateness to Rural Main Streets

Police enforcement is already used to maintain speed limits in several small Iowa communities. Photo-enforcement can be used as well.

3.11.7. Cost

The cost depends on the amount of officer time used to monitor a location. One source indicated that photo-radar enforcement equipment, if purchased, has an initial cost of $85,000, with annual cost of $145,000 and potential annual revenue of $40,000. When the equipment is leased, an annual cost of $214,000 and annual revenue of $40,000 have been cited (Ewing 1999).

3.12 Four- to Three-Lane Conversion

3.12.1. Definition

A four- to three-lane conversion is used to reduce an existing four-lane roadway to a 2+1 facility, in which the third lane acts as an alternating passing lane. Removal of two of the through lanes can either physically or visually narrow the roadway and may result in reduced speeds (Brewer et al. 2001). The treatment is common in rural areas in Europe, with the middle lane serving as a passing lane with alternating right of way.

3.12.2. Placement

The treatment can be used along the length of a main road through a small community or for specific sections.

3.12.3. Advantages

- Four- to three-lane conversion provides a refuge area for vehicles entering and exiting the roadway.
- It does not impact drainage.
- It does not affect emergency vehicles.
- It can be rapidly implemented.
- There is no increase in noise.
- It does not affect vehicle operation.

3.12.4. Disadvantages

- Lane conversion can increase queue delay on minor street intersections.
- It may reduce road capacity.

3.12.5. Effectiveness

Knapp (2003) reported on the use of four- to three-lane conversions. He reported moderate reductions in 85^{th} percentile speed of up to 5 mph and a 60%–70% reduction in the number of vehicles traveling more than 5 mph above posted speed. Crash reductions from 17%–62% were also documented.

Corkle et al. (2001) evaluated four- to three-lane conversion in Minnesota on a 35 mph minor arterial. They reported reductions in both mean and 85th percentile speed of up to four mph.

3.12.6. Appropriateness to Rural Main Streets

Four- to three-lane conversions are especially applicable to areas where the highway has many access points along the through-town segment.

3.12.7. Cost

If four- to three-lane conversions are accomplished using pavement markings and the existing right-of -way, the treatment is relatively inexpensive.

3.13 Shoulder Widening to Narrow Travel Lanes

3.13.1. Definition

Lane narrowing reduces the width of the travel portion of a lane. Narrowed lanes provide a feeling of constraint and cause drivers to reduce their speed. Lanes can be either physically narrowed or visually narrowed by increasing the marked width portion of a shoulder or median. Visually narrowing lanes is accomplished by re-painting shoulder and median markings to widen the shoulder or median and decrease lane width.

Reducing the width of lanes provides space for wider shoulders, bicycle lanes, left turn lanes, etc. It may decrease speeds and smooth traffic flow. According to Caltrans (2002), lane narrowing is normally implemented as a highway transitions from rural to downtown and is suggested for main streets with AADT less than 10,000. Reduction in level of service should also be considered.

Another option to give the appearance of lane narrowing is to provide shoulder surfaces that are different than the roadway surface, as shown in Figure 3.33. Use of colored shoulders contrasts the travel lanes with the shoulders and can visually narrow the roadway. Colored shoulders typically last longer than markings on the roadway, due to lower vehicle traffic. Another treatment is to actually construct travel lanes out of one material and the shoulders from another, such as concrete with asphalt, or to use different roadway material, such as cobblestones.

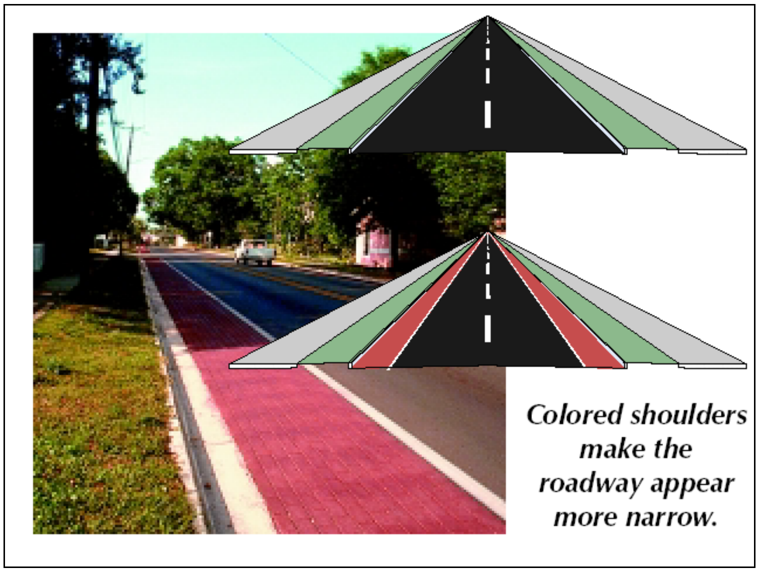

Figure 3.33. Colored shoulder (source: Oregon DOT)

Shoulder widening was used in the Roland, Iowa as part of the gateway traffic-calming treatment which was evaluated in that community, as shown in Figure 3.34.

Figure 3.34. Use of shoulder widening in Roland, Iowa as part of gateway treatment

3.13.2. Placement

Shoulder widening to narrow lanes is implemented along the length of the area selected for traffic calming. Transition should be provided in advance.

3.13.3. Advantages

- Shoulder widening to narrow lanes provides additional space for shoulders, bike lanes, and sidewalks.
- When shoulder widening is implemented using pavement markings, it is low cost.
- It can be rapidly implemented.
- Shoulder widening does not lead to an increase in noise.
- There is no impact to emergency vehicles.
- It does not affect vehicle operation.

3.13.4. Disadvantages

- Lane narrowing reduces separation between oncoming vehicles.
- Pavement markings require maintenance.

3.13.5. Effectiveness

Kamyab (2002) reported on the use of lane narrowing as a traffic-calming measure in Twin Lakes, Minnesota. Lane width was reduced to 11 feet using pavement markings, creating 8-foot shoulders. Transverse stripes were also created on the shoulders, as shown in Figure 3.35.

Figure 3.35. Lane narrowing with transverse shoulder stripes

3.13.6. Appropriateness to Rural Main Streets

Visually narrowing lanes by re-painting lane edge lines is an acceptable strategy, since it does not impede large vehicles or farm equipment.

3.13.7. Cost

The cost of initial pavement markings and subsequent maintenance are the costs associated with visually narrowing the roadway. One source indicated a cost of $0.15 to $1.00 per linear foot for painting and $1.00 to $5.00 per linear foot for plastic (DSW 2005).

3.14 Pavement Marking Legends

3.14.1. Definition

Some communities have painted the speed limit on the roadway to remind drivers of the speed limit or to indicate a transition zone, as shown in Figure 3.36. In other cases, use of the words "SLOW" or "SCHOOL" are used. Use of the wording on the pavement surface is more dramatic than just using signing, which can get lost in the clutter of a streetscape.

Figure 3.36. Speed limit pavement markings (source: CWS 2005)

On-pavement speed markings were used as part of the gateway treatment in Roland, Iowa, as shown in Figure 3.37, as part of this research project. Use of the wording "SLOW" was utilized as part of this research project along one section of roadway in the vicinity of areas where pedestrians cross a state road through the community of Slater, Iowa, as shown in Figure 3.38. Additional information on pavement markings is provided in Section 5.

Figure 3.37. Use of on-pavement speed markings in Roland, Iowa as part of a gateway treatment

Figure 3.38. Use of on-pavement "SLOW" marking around a pedestrian crossing area in Slater, Iowa

3.14.2. Placement

No guidance was found on exactly where on-pavement markings should be placed. However, it is assumed that speed limit legends would be placed on the pavement in the same locations as speed limits signs.

3.14.3. Advantages

- Pavement markings are inexpensive.

- They can be rapidly implemented.
- There is no increase in noise associated with pavement markings.
- There is no impact to emergency vehicles from using pavement markings.
- Pavement markings do not affect vehicle operation.

3.14.4. Disadvantages

- There are increased maintenance costs associated with pavement markings.

3.14.5. Effectiveness

No additional information was available on the effectiveness of pavement markings.

3.14.6. Appropriateness to Rural Main Streets

Use of pavement markings does not affect vehicle operation and is appropriate for use along major roads through small communities.

3.14.7. Cost

CSW (2005) indicated a cost of $25 to $50 per letter or number and $100 to $200 per symbol.

3.15 Roundabouts

3.15.1. Definition

Roundabouts (see Figure 3.39), by their very nature, manage traffic speeds. They also provide locations for gateway artwork and special landscaping (PSRC 2003). Roundabouts are designed to slow entering traffic to allow pedestrians and bicyclists to cross streets. Rural roundabouts typically have high average approach speeds. This requires additional geometric and traffic control treatments to slow traffic before entering the roundabout. Supplemental features to slow traffic may include a raised splitter, or island, approaching the roundabout. Use of roundabouts may increase delay on the main highway, since all approaches are treated equally. They can also require significant right of way but can eliminate the need for long turn lanes.

Roundabouts have been used in Europe as gateway treatments that serve as part of the transition from rural highway to town center. The center island could be used for a gateway or landscaping treatment (PSRC 2003). Caltrans (2002) suggests that, in the appropriate location, roundabouts can reduce the number and severity of collisions and improve traffic circulation, in addition to reducing speed.

Figure 3.39. Roundabout in Coralville, Iowa (source: Runge 2005)

3.15.2. Placement

Roundabouts can be place either at intersections or as part of transition areas entering communities.

3.15.3. Advantages

- Roundabouts physically force traffic to slow.
- Evidence shows that they reduce accidents.
- Roundabouts can be used with landscaping.

3.15.4. Disadvantages

- There are significant costs associated with installing a roundabout.
- Roundabouts require significant right of way.
- It may be difficult for large farm equipment to negotiate roundabouts.

3.15.5. Effectiveness

Roundabouts are typically only used at intersections. The FHWA (Robinson et al. 2000) evaluated eight single-lane roundabouts in the U.S. and reported a 51% reduction in crashes. Roundabouts also physically force vehicles to slow in the vicinity of the roundabout. The use of roundabouts at gateway treatments is not well documented in the U.S.

3.15.6. Appropriateness to Rural Main Streets

Roundabouts are appropriate for the main street through rural communities if they can accommodate large farm vehicles that may be present.

3.15.7. Cost

Cost depends on a number of factors including size, acquisition of right of way, etc. NCHRP Synthesis 264 (1998) indicates that the average construction cost for 14 U.S. roundabouts was approximately $250,000 per intersection, not including purchase of additional right of way.

3.16 Speed Humps and Tables

3.16.1. Definition

Speed tables are asphalt or rubber mounds that cover the full width of the roadway. Speed tables are essentially speed humps that have been modified with a flat top, thus reducing the disruption to vehicle operation. The flat top is typically long enough for the entire wheelbase of a passenger car to rest on. The ramps of the speed table are also sloped more gently than speed humps. Therefore, design speeds for speed tables are higher than for speed humps. The most common type of speed table is the one designed by Seminole County, FL. The Seminole profile is three to four inches high and 14 to 22 feet long (Ewing 1999). An illustration of a typical speed table, compared to a typical speed hump, is shown in Figure 4-32.

Speed tables are commonly being preferred over speed humps. This is in large part due to the delay of emergency service vehicles. Speed tables are less jarring and can allow larger emergency vehicles to cross with minimal disruption. Like speed humps, speed tables are designed according to the desired target speed. For instance, the speed table in Figure 3.40 is designed with a 30 mph design speed. The target speed can range up to 45 mph.

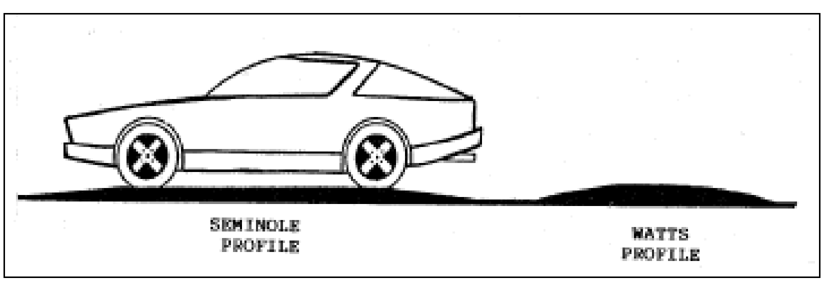

Figure 3.40. Seminole 22-foot speed table versus Watts 12-foot speed hump

The Delaware Department of Transportation (2000) established a set of guidelines describing when particular treatments should be installed. They do not recommend using speed tables for interstates or principal arterials. However, they do recommend using speed tables on minor arterials, collectors, and local roads where the daily volume is less than 10,000 vehicles per day and the posted speed limit is not greater than 35 mph.

Ewing (1999) evaluated the effects of speed tables at 58 locations and reported that 22-foot speed tables can reduce 85th percentile speeds by about 18%. He also noted that longer tables are less effective at reducing speeds; for longer tables, 85th percentile speeds can be reduced by about nine percent. Ewing also studied the number of collisions at eight locations before and after a speed table was introduced. He found that collisions were reduced by 45% with the use of speed tables.

Figure 3.41. 30 mph speed table used in a Center for Transportation Research and Education (CTRE) study for residential traffic calming in small Iowa communities

A previous study by members of the team evaluated the effectiveness of temporary speed humps and speed tables in small communities in Iowa (see Figure 3.41). Temporary speed tables in particular can be designed to accommodate a range of desired speeds up to 45 mph (Recycled Technology, Inc. 2004; http://www.tapconet.com/ traffic_control_ recycledtech.html). While it is not suggested that speed humps are appropriate for transitions from high speed roadways, results of the research may be useful to small communities. Results can be summarized, effectiveness presented and economic benefits evaluated. A copy of the study report is available at: http://www.ctre.iastate.edu/Research/detail.cfm?projectID=396.

A speed table was used in the city of Gilbert, Iowa, as part of this research. The table was designed for 30 mph and results are discussed in Section 5.

3.16.2. Placement

Speed humps/tables should not be placed near intersections. Several studies have indicated that they are most effective when placed in a series.

3.16.3. Advantages

Tables allow larger vehicles to cross with minimal disruption

3.16.4. Disadvantages

- Speed tables may delay emergency service vehicles.
- They may cause noise.
- Speed tables may impact drainage.
- Drivers may swerve to avoid them, impacting pedestrians and other vehicles.

3.16.5. Effectiveness

A study by LRRB (Corkle et al. 2001) summarized information from other studies, reporting a 28% change in 85^{th} percentile speed, a 15% change in average speed, and a 28% decrease in auto collisions from using speed tables. A previous study by the Center for Transportation Research and Education (CTRE) evaluated temporary speed humps and speed tables in three locations in rural Iowa communities. The speed hump and speed table were evaluated in the same location in each of the three communities. Average and 85^{th} percentile speeds decreased at the location of the device by up to 9 mph and 10 mph, respectively (Hallmark et al. 2002).

3.16.6. Appropriateness to Rural Main Streets

Speed tables and speed humps are appropriate when the design speed of the speed table or hump corresponds to the posted speed limit. Consideration should be given to farm vehicles and routes with a large number of heavy trucks.

3.16.7. Cost

Cost, according to one source, is $2,000 to $4,000 (Kastenhofer 1997).

3.17 Mini-Roundabouts

3.17.1. Definition

Mini-roundabouts are one-way circular intersections similar to both a full scale, modern roundabout and a traffic circle. Both of these are used extensively in the United States (there are about 800 modern roundabouts now in the U.S.) and elsewhere already. Mini-roundabouts are a new development in the U.S., but they are already found in large numbers in the United Kingdom and France. As its name implies, a mini-roundabout is a small and inexpensive roundabout that still has all of the standard features of a full-scale roundabout, including yield on entry, deflection, flare, and a low design speed. (The first three of these features are NOT found in older-style traffic circles.) As of 2005, there was only one known mini-roundabout in the U.S.; it is located in Dimondale, Michigan, a small town near the state capital, Lansing, as shown in Figures 3.42 to 3.44.

Figure 3.42. Mini-roundabout in Michigan

The above photo of the Dimondale, Michigan mini-roundabout shows a splitter island with lighted bollard, yield pavement marking, and the very small, slightly raised center island.

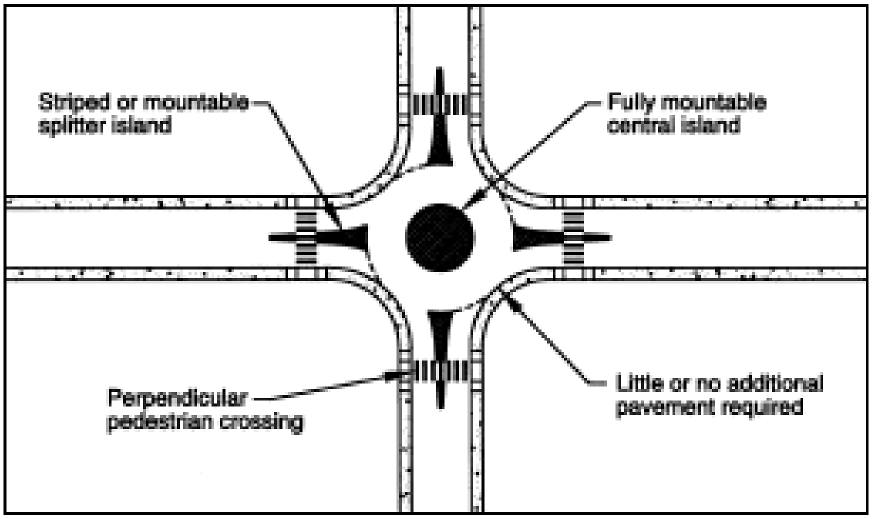

Figure 3.43. Mini-roundabout plan view

Figure 3.44. Another view of the Dimondale, Michigan installation

3.17.2. Placement

Mini-roundabouts can replace some signalized or stop-controlled intersections. Typically, no additional right of way is required to accommodate them. An ideal location would be a four-way or three-way stop intersection in a small town.

3.17.4. Advantages

- The combination of deflection, flare, and curvature limits approach speeds at all entrances of the Dimondale mini-roundabout to between 15 and 25 miles per hour. Crash rate severity for vehicular and pedestrian crashes is usually reduced very significantly. A 10 mph or greater speed reduction can easily be achieved.

- Mini-roundabouts have much lower ongoing maintenance costs than traffic signals. The life cycle cost of a mini roundabout will be significantly lower than that of a signalized intersection.
- Mini-roundabouts allow high traffic capacity but low traffic speed. Traffic is calmed without any loss of capacity.

3.17.5. Disadvantages

- Drivers must learn how to use them. This is only a disadvantage for a short time period.
- Mini-roundabouts may face resistance from the general public, adjacent small business owners, and local decision makers due to its novelty. This resistance usually ends once the roundabout is installed and is used for a few weeks. The benefits for traffic flow, traffic calming, and safety tend to become more evident to casual observers by then.

3.17.6. Effectiveness

Although experience with mini-roundabouts in the United States and Canada is limited, they are very common in Europe, particularly France and the United Kingdom. Studies conducted there indicated that mini-roundabouts are very effective in terms of both traffic calming and safety. They are very compatible with pedestrian traffic, provided pedestrian crossings are located away from the central island (upstream and downstream from the splitter islands) and are clearly marked and signed.

3.17.7. Appropriateness

The most appropriate application for a mini-roundabout would be as a replacement for a traffic signal or a four-way, stop-controlled intersection on an arterial street inside a small community. There should be a significant amount of turning traffic at the intersection; otherwise some other, less expensive traffic-calming treatment will be more appropriate.

3.17.8. Cost

Mini-roundabouts vary in cost from less than $10,000 up to $35,000. The cost of the Dimondale mini-roundabout was about $35,000, much of which paid for complete pavement resurfacing and new curbing. A low-end roundabout (a typical UK design) will use paint rather than raised curbing.

3.18 Hardscaping

3.18.1. Definition

"Hardscaping" can be thought of as the hard-surfaced complements to landscaping. The complete cross section of the roadway is considered, including parking, sidewalks, and the facades of the adjacent buildings. Other elements of hardscaping may include pavement and crosswalk textures or colored pavements. Hardscaping is usually combined with landscaping, such as tree planting, to create a comprehensive "streetscaping" project, as shown in Figure 3.45.

As is true with landscaping, streetscaping and hardscaping are thought to encourage calmer traffic in two main ways:

1. By placing design elements, such as building facades, sidewalks, on-street parking, and street fixtures, close to the through lanes of road or street in such a way that the roadway appears narrower to the driver (i.e., the "optical width" of the road is narrowed as opposed to the "physical width"). As described before, with trees planted along a roadway, a "tunnel effect" is created and the driver's field of view is narrowed. This, in turn, should encourage drivers to slow down.
2. By clearly communicating a change in the character of the roadway from "rural" to "urban" by providing an overall design experience that simply looks relatively dense and urban. This provides a visual cue to drivers that they should slow down.

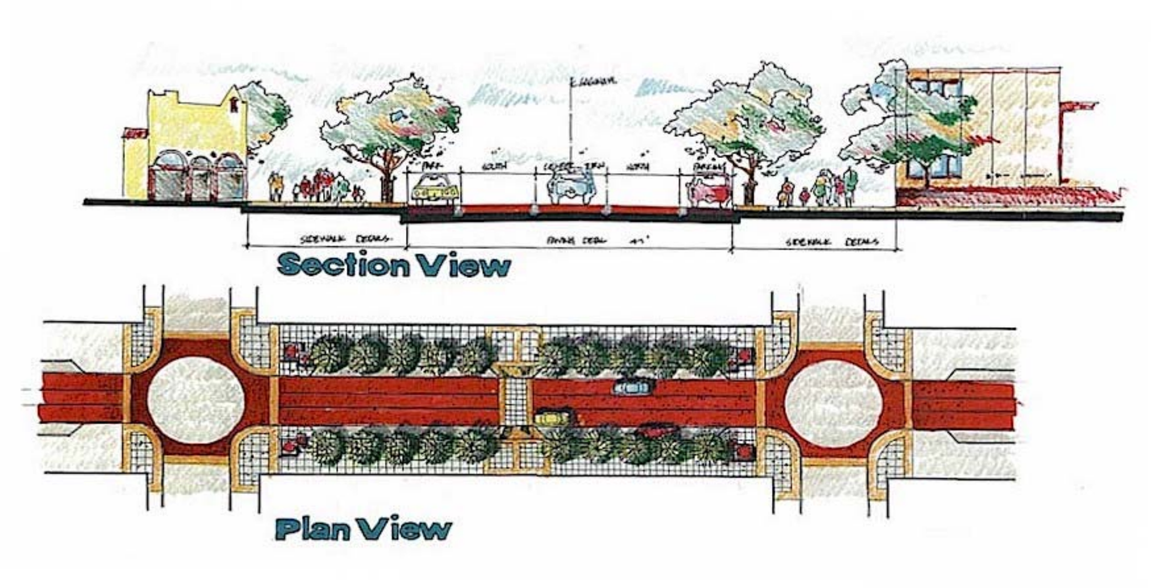

Figure 3.45. Proposed streetscape in Flint, Michigan

3.18.2. Placement

Streetscaping (Figure 3.46) or hardscaping should be placed along the entire length of the street where traffic calming is desired, on both sides of the street. It is particularly critical to place features in such a way that they narrow the optical width of the roadway and communicate that the road is changing from “rural” to “urban” in the transition zone where the largest decrease in speed is sought.

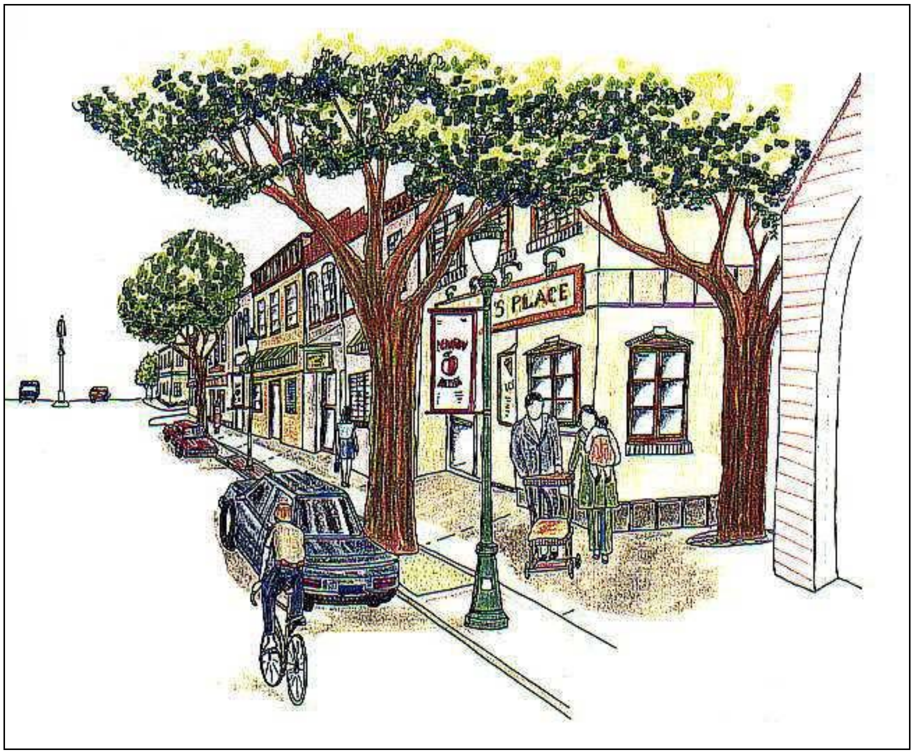

Figure 3.46. Streetscape concept drawing for Taylor, Michigan that communicates an urban environment in a small town setting

3.18.3. Advantages

Like landscaping, enhanced hardscaping or streetscaping can serve multiple purposes, including community development and beautification and traffic calming.

3.18.4. Disadvantages and Effectiveness

It is not clear from research literature whether hardscaping or streetscaping alone will be sufficiently effective to calm traffic in the absence of other traffic-calming treatments, including physical treatments and enforcement.

3.18.5. Appropriateness

Hardscaping or streetscaping should logically be used along with other traffic-calming treatments to achieve the desired result. It should be part of a comprehensive traffic-calming plan for a community wishing to slow speeds and maintain traffic flow along an arterial roadway.

3.18.6. Cost

Cost depends on the treatment but can entail a significant capital investment.

3.19 Longitudinal Channelizers

Longitudinal channelizers are delineators that are commonly used to direct vehicles and prevent particular movements. Depending on where the channelizers are used, they may be between 18 and 36 inches tall, spaced about 32 inches apart, and may be yellow or orange in color. Figure 3.47 shows yellow channelizers being used to separate traffic movements.

The ability of longitudinal channelizers to reduce speed, however, is not well documented. The majority of research regarding these devices pertains to their use at highway–railroad grade crossings. The North Carolina DOT, for instance, placed the delineators along the centerline of the roadway extending about 100 feet from the railroad gates in order to dissuade drivers from going around the gates. Afterward, they found that the delineators reduced violations by 77% (ATSSA 2006). Channelizers have been used in work zones, HOV lanes, and ramp exits as well.

Figure 3.47. Longitudinal channelizers (source: Sun Safety, Inc. 2006)

Longitudinal channelizers are also able to withstand an impact with a vehicle. Their flexible structure allows them to quickly return to their initial position. Repeated impacts, however, may take a toll on the delineators and they may eventually require some maintenance. One disadvantage of placing the delineators along the centerline is that wide trucks and farm machinery, which are common on rural Iowa roadways, may have difficulty maneuvering around them. The delineators also should not be placed so that they block driveways or cross-streets.

4. OTHER AGENCY GUIDELINES FOR SELECTING TRAFFIC-CALMING STRATEGIES FOR RURAL MAJOR ROADS

Before traffic calming is implemented on major roadways in rural communities, the need for traffic calming should be established. Residents may complain about speeding when, in fact, no evidence suggests that a speeding problem exists. Similarly, residents may perceive a location to be "dangerous" when even one bad accident occurs, even if it was sometime in the past. A site study should be used to evaluate the location and determine whether a speeding or accident problem exists and warrants traffic calming.

The Virginia DOT, for instance, set criteria for consideration of traffic-calming strategies (Kastenhofer 2005). In order to be considered, the street must be a local residential street or collector street, the 85^{th} percentile speed must be at least 10 mph higher than the speed limit, and a petition for traffic calming must be signed by at least 75% of the total occupied households within the petition area.

Additionally, certain types of traffic-calming measures are not appropriate for major roads through rural communities. Consideration must be given to farm vehicles and heavy trucks. The measures should also be appropriate for the posted speed limit and roadway volumes.

Several agencies have developed guidelines regarding which traffic-calming measures are appropriate for different roadway types. The Virginia DOT bases traffic-calming measures by ADT and uses the following guidelines (Kastenhofer 2005):

- ADT < 600 vehicles per day
    - Suggested measures: education, enforcement, non-physical devices (no physical devices)
- ADT 600 to 4,000 vehicles per day
    - Suggested measures: physical devices (speed hump, choker, raised crosswalk, traffic circle, crosswalk refuge, and chicane), education, enforcement, non-physical devices
- ADT > 4,000 vehicles per day
    - Suggested measures: education, enforcement, suggest alternative actions (no physical devices)

The Delaware DOT also has guidelines for use of different traffic-calming measures, as shown in Table 4.1. Guidelines from the city of Winston-Salem (2003) are shown in Table 4.2.

Table 4.1. Guidelines on maximum volume and posted speed for different traffic-calming measures (source: Delaware DOT 2000)

	FHWA/DELDOT FUNCTION CLASSIFICATIONS						SUBDIVISION STREETS			
	Interstates Freeways Expressways	Principal Arterials	Minor Arterials	Major Collectors	Minor Collectors	Local Roads	Major Collector Subdivision Streets	Minor Collector Subdivision Streets	Minor Streets	Other Restrictions
Volume Control Measures										
Full Closure Half Closure	Not Recommended					Only on an exception basis.	Not Recommended		≥500 vpd ≥25% non-local traffic	
Diagonal Diverter Median Barriers Forced Turn Islands	Not Recommended					≤5,000 vpd ≥25% non-local traffic	Not Recommended		≥500 vpd ≥25% non-local traffic	
Vertical Speed Control Measures										
Speed Humps	Not Recommended					Only on an exception basis.	Daily volume ≤3,000 Posted speed ≤30 mph			grade ≤8% not on primary emergency routes or bus routes
Speed Tables Raised Crosswalks Raised Intersections	Not Recommended		Daily volume ≤ 10,000 vpd posted speed ≤ 35mph							grade ≤8% not on primary emergency routes
Horizontal Speed Control Measures										
Mini-traffic Circles	Not Recommended					Combined approaches - daily volume ≤ 5,000 vpd posted speed ≤ 35mph				grade ≤10% not on primary emergency routes or bus routes
Roundabouts	Not Recommended		Combined approaches - daily volume ≤ 20,000 vpd posted speed ≤45mph						Not Recommended	grade ≤6%
Lateral Shifts	Not Recommended		≤10,000 vpd posted speed ≤35mph							
Chicanes	Not Recommended			Daily volume ≤5,000 vpd posted speed ≤35mph						grade ≤8%
Realigned Intersections	Not Recommended							Daily volume ≤5,000 vpd posted speed ≤35mph		grade ≤8%
Narrowings										
Neckdowns Two-Lane Chokers Center Islands	Not Recommended		Daily volume ≤ 20,000 vpd posted speed ≤ 45mph							
Combined Measures	Not Recommended		Subject to limitations of component measures							

Table 4.2. Guidelines on maximum volume and posted speed for different traffic calming measures (source: city of Winston-Salem 2003)

	Allowable Uses				Roadway Uses			Speed Reduction			Volume Reduction			Noise & Pollution Increase			Implementation Cost			Enforcement Required
	Thoroughfare	Commercial Street	Residential Collector	Local Residential	Emergency Route	Transit Route	NCDOT Route	Low	Med.	High	Low	Med.	High	Low	Med.	High	Low	Med.	High	
Non-Physical Measures																				
1. Speed Enforcement	✓	✓	✓	✓	✓	✓	✓			✓	Negligible Impact			Negligible Impact					✓	✓
2. Radar Trailer	✓	✓	✓	✓	✓	✓	✓		✓		Negligible Impact			Negligible Impact				✓		
3. Lane Striping	✓	✓	✓	✓	✓	✓	Note 1	✓	✓		✓			✓			✓			
4. Signage	✓	✓	✓	✓	✓	✓	Note 1	✓			Negligible Impact			Negligible Impact			✓			
5. Pavement Marking Legends	✓	✓	✓	✓	✓	✓	Note 1	✓			Negligible Impact			✓			✓			
6. High Visibility Crosswalks	✓	✓	✓	✓	✓	✓	Note 1	✓			✓			✓			✓			
7. On-Street Parking	Note 1	✓	✓	✓	Note 1	Note 1	Note 1	✓	✓		✓	✓		✓			✓			
8. Raised Pavement Markers	✓	✓	✓	✓	✓	✓	✓	✓			Negligible Impact			✓			✓			
9. Streetscaping	✓	✓	✓	✓	✓	✓	Note 1	✓			✓			Negligible Impact				✓	✓	
10. Multi-way Stops	Note 2	Note 2	Note 1	✓	✓	✓	Note 2	✓				✓				✓	✓			✓
11. Turn Prohibitions/Restrictions	Note 1	Note 1	✓	✓	✓	✓	Note 1	✓				✓	✓	Negligible Impact			✓			✓
12. Gateways/Entryways	✓	✓	✓	✓	✓	✓	Note 1	✓			✓			Negligible Impact			✓	✓		
13. Colored Pavements	✓	✓	✓	✓	✓	✓	Note 1	✓	✓		Negligible Impact			Negligible Impact			✓	✓		
Vertical Measures																				
14. Textured Pavements	✓	✓	✓	✓	✓	✓	Note 1	✓	✓		✓				✓	✓		✓	✓	
15. Speed Humps			✓	✓						✓	✓				✓		✓			
16. Speed Lumps			✓	✓	✓	✓				✓	✓				✓		✓			
17. Speed Tables			✓	✓						✓	✓				✓			✓		
18. Raised Crosswalks		Note 1	✓	✓					✓		✓				✓			✓		
19. Raised Intersections		Note 1	✓	✓					✓		✓				✓			✓	✓	
Horizontal Measures																				
20. Traffic Circles			✓	✓	Note 1	✓			✓			✓		Negligible Impact				✓		
21. Roundabouts	✓	✓	✓	✓	✓	✓	Note 1			✓	Negligible Impact							✓	✓	
22. Curb Extensions				✓	✓	✓			✓		Negligible Impact			Negligible Impact				✓		
23. Chicanes				✓						✓			✓		✓			✓	✓	
24. Lateral Shifts	Note 1	✓	✓	✓	✓	✓	Note 1		✓		✓			✓				✓		
25. Neckdowns			✓	✓					✓			✓		✓				✓		
26. Realigned Intersections				✓	✓	✓			✓			✓			✓			✓	✓	
27. Bulbouts	✓	✓	✓	✓	✓	✓	Note 1		✓		Negligible Impact			Negligible Impact				✓		
28. Two-Lane Chokers		✓	✓	✓	✓	✓			✓		Negligible Impact			Negligible Impact				✓		
29. One-Lane Chokers				✓		✓				✓			✓	✓				✓		
30. Center Island Narrowing			✓	✓		✓	Note 1			✓	Negligible Impact			Negligible Impact				✓		
31. Medians	Note 1	Note 1	✓	✓	Note 1	✓	Note 1	✓					✓	Negligible Impact				✓		
Diversions																				
32. Street Closures				✓						✓			✓					✓	✓	
33. Diagonal Diverters				✓				Negligible Impact					✓					✓	✓	
34. Semi-Diverters				✓				Negligible Impact					✓					✓		

Note 1 – Use of this measure may be allowed on this type of facility under certain circumstances with approval of the appropriate review agencies.
Note 2 – Multi-way stops may be used on this type of facility only at intersections that meet the warrants of the Manual on Uniform Traffic Control Devices (MUTCD).

5. EFFECTIVENESS OF TREATMENTS IN REDUCING SPEEDS

As discussed in Section 1, the purpose of this project was to evaluate the effectiveness of traffic-calming treatments in small rural communities. Many rural communities have developed around highways or major county roads, and, as a result, the main street through small rural communities has often become part of a high-speed rural highway. Highways and county roads are characterized by high speeds outside the city limits and then transition into a reduced speed section through the rural community. Consequently, drivers passing through the community often enter at high speeds and then maintain those speeds throughout. Traffic calming in small rural communities along major roadways is common in Europe, but the United States does not have experience with applying traffic calming outside of major urban areas.

Traffic calming has been used extensively in the United States in urban areas but it is generally unknown how effective traffic calming is in rural areas. In addition, different traffic-calming measures have been used in small rural communities in Europe, but their effectiveness is also unknown in the United States.

Seven different low-cost traffic treatments were implemented and evaluated in five rural Iowa communities. This included the use of two gateway treatments in Union and Roland, Iowa, and five single-measure treatments (speed table, on-pavement “Slow” markings, a driver speed feedback sign, tubular markers, and on-pavement entrance treatment) were evaluated in Gilbert, Slater, and Dexter, Iowa.

The Iowa Highway Research Board (IHRB) and Federal Highway Administration (FHWA) funded the research. The focus for the IHRB project was to evaluate low-cost traffic-calming measures that are appropriate to major roads through small rural communities. The focus of FHWA was to evaluate two gateway traffic-calming treatments.

5.1 Solicitation of Pilot-Study Communities

In order to solicit pilot-study communities, the project was advertised in the Iowa League of Cities newsletter. The project scope was outlined in the newsletter, and rural Iowa communities that met a certain set of criteria and were interested in serving as a pilot-study location were asked to contact the study team. The criteria included having

- a population less than or equal to 5,000;
- no existing or planned traffic-calming treatments;
- no recent or scheduled construction, reconstruction, or significant maintenance activities;
- a roadway that must be a paved major through county or state route;
- a roadway that must continue through the community (roadway cannot terminate within or shortly beyond the community);

- a roadway that is not access-controlled; and
- no adverse geometry present, such as sharp horizontal curves or steep vertical curves at the entrances of the community.

A total of 22 communities responded to the newsletter and expressed their interest in the project. Of those, 20 (listed in Appendix A) met the criteria, and site visits were made. Ten appeared to be the most promising and were selected for initial speed studies. In addition to the 20 towns that responded and met the criteria, eight additional communities that met the criteria were identified by the study team. Initial speed studies were conducted in 10 of the communities that responded and in eight additional communities (a total of 18) to determine whether speed problems existed.

5.2 Final Site Selection

The main criterion in selecting the final pilot-study locations for implementation of traffic-calming treatments was whether the community demonstrated speed problems. Speed problems may exist at either the entrance to the community and/or within the community. Initial speed data were collected at each location using pneumatic road tubes (JAMAR TRAX Plus or TRAX I series automatic traffic data recorders). The initial speed studies were used to determine whether a speeding problem existed in order to select final pilot-study locations. A comprehensive before speed study was collected for each community finally selected, as described in this section.

The magnitude of the initial speeding problems and several other factors were used to select the final communities. One factor considered was whether the community had sensitive land uses such as schools, playgrounds, or other pedestrian generators near the major through route that would benefit from traffic calming. Other factors included whether the roadway geometry was conducive to traffic calming, location of other traffic controls (i.e. stop signs, flashing beacons), fleet mix, crash history, and any other factors that would have influenced implementation of traffic calming. The final factor was whether the study team was able to obtain approval from the city and state or county officials who had jurisdiction over the facility.

The initial speed studies indicated that nine of the 18 communities demonstrated speeding problems and that traffic calming was viable. The nine communities were then narrowed to five after qualitatively ranking them in terms of the magnitude of the speeding problems and other factors described in the previous paragraph. Two communities were selected for the full gateway treatment (funded by FHWA) and three were selected for single-measure traffic calming (funded by IHRB).

5.3 Selection of Treatments

An exhaustive list of traffic-calming treatments that were appropriate for use along major routes through small rural communities was compiled and is described in Section 3.

The FHWA portion of the project called for a full gateway treatment similar to that used in European communities located along major routes. For the purpose of this project, the FHWA defined a gateway treatment as a "combination of traditional and nontraditional traffic-control treatments such as enhanced signing, lane reduction, colored pavements, pavement markings, experimental striping, gateway structures, and traditional traffic-calming techniques or other identifiable features."

A technique used in Europe and cited in many European studies on traffic calming in rural communities is the use of a gateway at the community entrance. Gateways have also been used to some extent in the United States. Community gateways are a measure, or set of measures, strategically located as motorists enter a community, that announces to motorists that they are entering a community and are no longer on an open high-speed roadway. Effective community gateways communicate to motorists that they are making a transition from a rural roadway to a city street (Oregon DOT, 1999).

A gateway marks the entry point to a rural community. In some cases, a gateway may consist of elaborate landscape and sign installations. Many European gateways are a combination of traffic-calming measures such as colored pavement, lane narrowing, or pavement markings. For the purpose of this project, FHWA defined a gateway as a "combination of traditional and nontraditional traffic-control treatments such as enhanced signing, lane reduction, colored pavements, pavement markings, experimental striping, gateway structures, and traditional traffic-calming techniques or other identifiable features."

Gateways have been demonstrated to be effective in reducing speeds in European studies. The UK Department for Transport indicated that mean speed reductions of 3–13 mph, with an average of 5 mph, were achieved using gateways (Sustrans, 2005). They also reported that up to 15 mph speed reductions for the 85^{th} percentile were achieved using gateways with other treatments (DETR, 2005). The Department for Transport (2004) suggests that gateway treatments may be an effective way to slow drivers if there are high approach speeds to a rural community or if the start of a community is not obvious.

Both single-measure and gateway treatments considered had to be reasonably low cost. They had to accommodate large trucks and farm vehicles, which are prevalent in small communities. They could not change the roadway alignment or result in significant permanent changes to the roadway.

The treatments and locations were selected after considering where the speeding problems existed (downtown and/or in the transition zones of the town). The treatments were selected based on cost, nature of the speeding problem, and how they fit in with the character of the roadway and community itself. Other factors that were considered in the selection of the traffic-calming treatments included whether or not farm vehicles could be accommodated, driver expectation in rural communities, and whether snowplows could negotiate the treatments. Consideration was also given to treatments which could be applied or maintained by small communities themselves.

Several potential traffic-calming plans were presented to each city council. Additional input and recommendations were considered and plans updated based on input from the city. At least a second visit to each city council took place to present the final treatment plan and to receive council approval. In several cases, multiple visits were made. The county engineer was also notified if the treatment occurred on any portion of a roadway maintained by the county. The Iowa DOT Office of Traffic and Safety were presented final plans and their approval for the treatment on one state route was obtained.

Each treatment was evaluated to determine whether it conformed to the *Manual on Uniform Traffic Control Devices* (MUTCD) or was an experimental treatment not already approved by FHWA. Treatments that were not covered in either category were submitted to and received formal MUTCD approval.

5.4 Data Collection

A number of data elements were collected for each pilot-study community as described in the following sections. Initial speed studies were collected to determine whether a speeding problem existed but are not included in this section because a full before speed and volume study was conducted for each community prior to installation of the treatments. The before data were typically collected in different locations than the initial speed studies.

5.4.1. Traffic Data Collection and Processing

Before and after speeds and volumes were collected for each community before installation, one month after installation, and at three-month intervals thereafter (three-months, six-months, nine-months, and twelve-months). Speed, volume, and vehicle classification data were collected for each before and after period using pneumatic road tubes (JAMAR TRAX Plus or TRAX I series automatic traffic data recorders). The TRAX counters have the capability of recording data for individual vehicles.

Data were collected immediately downstream of the traffic-calming devices for the non-gateway communities. Speed and volume data for the two gateway communities were collected at a control location upstream of each entrance treatment to reflect traffic conditions not influenced by the gateway treatments, immediately following the gateway entrance treatments, and at one other location at some distance downstream for each gateway entrance to the community. The data-collection protocol for the FHWA project required collection of the data at control locations to provide a measure of what was happening independently of the traffic calming. The team originally attempted to collect data at control locations for the other sites as well, but the task became so resource intensive it was decided that it was not practical.

Road tubes were placed away from intersections or major driveways to avoid turning vehicles. Data for each community were collected at the same time at all locations within the community. The road tubes were set up one day before the data-collection period desired, and data were collected for either a 48- or 72-hour period. In most cases this was Tuesday through Thursday. The majority of data were collected with dry pavements. When adverse weather conditions prevailed during the study, data were discarded and recollected, usually the following week. Road tubes were removed and data recollected when snow was forecast to avoid damage by snowplows. Deviations from the data-collection protocol are noted in each pilot study's results section.

After data were collected in each community, the automatic traffic data collectors were downloaded and data were extracted into raw data files. Data sets were then manually cleaned and processed. Originally, the team utilized JAMAR's TRAXPro software to process the raw data files. However, when comparing raw data with software-processed data files, it was discovered that the software processed some of the data erroneously. The software representative was contacted and they indicated that this problem could occur when using the filter option for TRAXPro on computers where the user does not have administrator privileges. Based on this, the team decided to manually process the data files to ensure data quality.

Each data file was processed by first removing unclassified vehicles and vehicles with very low speeds (speed less than or equal to 5 mph). JAMAR recommends removing these two sets of data because the accuracy of speeds for unclassified vehicles is more likely to be erroneous than data for vehicles that can be classified, and very low speeds also indicate data errors or turning vehicles. Data processing consisted of sorting data by direction (e.g., eastbound and westbound), extracting days of the week not used, removing data around school start and finish times when a school was in the vicinity of the treatment location, and sorting the data by vehicle type. Vehicle types included all vehicles, passenger vehicles (FHWA classes 1–3), and heavy trucks (FHWA classes 4–13). Data were removed for a short period before school start times and after school finish times at all locations where students were likely to be crossing or school traffic was likely to influence traffic operations around the data collection locations. Data were removed because traffic during the school year may be affected by roll-out stop signs, crossing guards, overflow traffic from the school, large volumes of students crossing, or other school activities where these activities do not affect traffic in the summer months.

Results for the before and after study are presented in the corresponding section for each pilot-study location. Speed study results within the body of the report are presented for the vehicle category, which included all vehicles unless the passenger car and heavy truck categories demonstrated significantly different trends.

In order to ensure data quality, speed from the road tubes was regularly compared against speeds collected using a radar gun for a short interval (usually 50 vehicles) at the same location as the road tubes. The automatic traffic data recorders cannot be configured to display individual vehicle speeds while the counters are in operation. As a result, when speed data were collected simultaneously with a radar gun, data for same time period was extracted from the automatic traffic counter data and the data from the two devices compared. In all cases, the automatic traffic counter data were not statistically different from data collected with the radar gun when compared using a t-test.

The automatic traffic data recorders and road tubes were also regularly checked during the data collection period so that malfunctions or unusual conditions at the site could be identified. Data were recollected when the counters malfunctioned, the road tubes came loose or were cut by lawn mowers, or something occurred during data collection at the site conditions that represented unusual conditions (e.g., chip sealing was undertaken by a contractor while the road tubes were down at one location). This resulted in a significant amount of data recollection. Due to the difficulty in collecting and recollecting data in so many locations, and because of a long period of extremely low temperatures and blizzards between January and mid-March, several data collection periods were missed in the course of the study.

5.4.2. Accident Data

The number of accidents for the major roadways where traffic calming was considered in each community was also determined for each community. Crash data from 2001 to 2005 were extracted from the crash database provided by the Iowa DOT. The Iowa DOT maintains their crash data in a spatial database, which allows crashes to be linked to a spatial road database. Crash data represent the before period. Location and number of crashes were considered in the selection of pilot-study locations. Because there was not a sufficiently long after period, no crash analysis was conducted.

5.4.3. Other Data Items

A number of other data items were collected for each pilot-study location, as follows:

1. Aerial imagery
2. Annual average daily traffic by segment (AADT)
3. School information
    a. Physical location of school
    b. Location of school zones
    c. Start and dismiss times
    d. Location of crossing guards
    e. Use of roll-out stop signs (allowed by Iowa code)
    f. School start (fall) and end dates (spring)
4. Geometric roadway features
    a. Roadway width
    b. Shoulder type and width
    c. Shoulder cross section
    d. Curb and gutter
    e. Roadway cross section
    f. Location of sidewalks, including location of curb cuts
    g. Location of railroad crossings
5. Signing
    a. Location and type of signing (speed limit signs, speed zone, and traffic control)
    b. Transition-zone configuration

6. Other
    a. Location of pedestrian crossings within the community, walking paths to school, parks, and recreational facilities
    b. Location of commercial facilities
    c. Type and frequency of enforcement

Plan drawings were developed for the two gateway communities in AutoCAD. Schematics for the other three communities were developed in Microsoft PowerPoint. A visual record was made of each roadway before and after treatments were applied.

5.5 Measures of Effectiveness

Several different measures are frequently used to evaluate the effectiveness of traffic-calming treatments. A reduction in crashes is the best measure of effectiveness for a traffic-calming measure. However, evaluation of the number of reduction in crashes usually requires 3–5 years after implementation of a traffic-calming measure. Because the study only intended to evaluate the treatments for a year after, there was not enough information available to conduct a crash analysis. In most cases, reduction in speed is the typical measure used to evaluate the effectiveness of traffic-calming strategies. The speeds measured are typically spot speeds. The different speed metrics used to evaluate the traffic-calming measures in this research included the following:

Mean or Average Speed

Mean speed is the average of all spot speeds at the location in question. Mean speed was calculated using:

$$\bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i \qquad \text{Equation (5.1)}$$

where:

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

A t-test was used to compare mean speeds from the before period to each after period.

Standard Deviation

Standard deviation (s.d.) indicates amount of variability for a given speed. It can be used to show how speeds are dispersed around a mean speed. Standard deviation indicates variability in the data.

85th Percentile Speed

The 85^{th} percentile speed is the point at which 85 percent of the vehicles are traveling at or below that speed. For example, if the 85^{th} percentile speed is 55 mph, 85 percent of the vehicles were observed at a speed of 55 mph or less.

Percent of Vehicles Traveling a Certain Threshold above the Posted Speed Limit

The percent of vehicles traveling at or above a certain threshold over the posted speed limit indicates the fraction of vehicles traveling at a specified threshold (e.g., percent of vehicles traveling at or above 15 mph over the speed limit). It provides a measure of the number of vehicles traveling at high speeds. In many cases, agencies are more concerned with reducing the number of drivers traveling at excessive speeds than simply reducing average speeds.

Minimum and Maximum Speed

The minimum speed is the lowest measured speed recorded in a speed study and the maximum speed is the highest recorded speed.

The mean, standard deviation of the average, 85^{th} percentile, minimum and maximum speeds, and percent of vehicles traveling at or above 5, 10, 15, 20, and 25 mph over the posted speed limit were calculated at each location for each data collection period. Average speed represents time mean speed. Mean speeds were compared at either the 90 or 95 percent confidence level using a t-test (assuming unequal variances). All datasets were evaluated to ensure that they were normally distributed before the t-test was applied. The percent of vehicles traveling at 5, 10, 15, 20, and 25 mph above the posted speed limit were compared from the before to after periods at the 90 or 95 percent confidence level using a statistical test to infer differences between two population proportions (Ott and Longnecker, 2001) using equation 5.2:

$$z = \frac{\hat{\pi}_1 - \hat{\pi}_2}{\sqrt{\frac{\hat{\pi}_1(1-\hat{\pi}_1)}{n_1} + \frac{\hat{\pi}_2(1-\hat{\pi}_2)}{n_2}}} \qquad \text{Equation (5.2)}$$

Results and a description of each traffic-calming treatment are provided in the following sections. Results are not provided for the percentage of vehicles traveling 25 mph and over the posted speed limit when the values are very low.

5.6 Union, IA (Gateway Traffic-Calming Treatment Site)

5.6.1. Community Description

Union is located approximately 60 miles northeast of Des Moines, IA, and has a population of 427. City officials responded to the initial newsletter. They noted that speeding was occurring on two main routes through town, County Highway D-65 and County Highway S-62/State Highway 215. County Highway D-65 is a two-lane roadway oriented east/west through the middle of town. County Highway S-62 (Main Street) is a two-lane roadway that oriented north/south, intersecting with D-65. Main Street continues after the intersection as State Highway 215 north out of town. The intersection at S-62/SH 215 and D-65 had a two-way stop control (north and south). Residents complained of high speeds on the north, south, and west edges of town. Figure 5.1 shows an aerial view of the town along with the locations of speed zones. On the east edge of town, railroad tracks that crossed Highway D-65 helped to significantly slow drivers that were entering town from the east. Therefore, this edge of town was not analyzed in the study. Some sensitive areas near the highways included a middle school, swimming pool, and golf course.

Corresponding information is provided in Table 5.1, including AADT, crash history, length, and speed limits for the roadways where traffic-calming treatments were applied.

Table 5.1. Roadway section descriptions for Union

Road Section	AADT (vpd)	Length (feet)	Cross-section	Crashes (2001-05)
D-65 from western city limit to intersection with ST 215/S 62	830	1,398	Asphalt paved with unpaved shoulders, 2-lane, total paved width 22.4 feet	3
ST 215 (northern section of Main Street) to intersection with D-65	1,680	1,329	concrete curb and gutter width, 2-lane, 40 feet total paved width	1
S-62 (southern section of Main Street) to intersection with D-65	800 to 1,080	2,657	asphalt paved with unpaved shoulders, 2-lane, total paved width 22.4 feet	1

Figure 5.1. Location of signing for Union (image source: www.gis.iastate.edu)

5.6.2. Traffic-Calming Treatment

Union was selected as a gateway treatment community, so a series of treatments were applied starting at the community entrances. Three roadway sections were selected for treatments, including

- the west section of County Road D-65 from the western transition zone to the intersection with SH 215/S-62;
- the north section of SH 215/S-62 from the northern transition zone to the intersection with D-65; and
- the south section of SH 215/S-62 from the southern transition zone to the intersection with D-65.

The treatments included the use of (1) peripheral transverse pavement markings, (2) median widening, and (3) driver feedback signs.

The final treatment plan is shown in Figure 5.2.

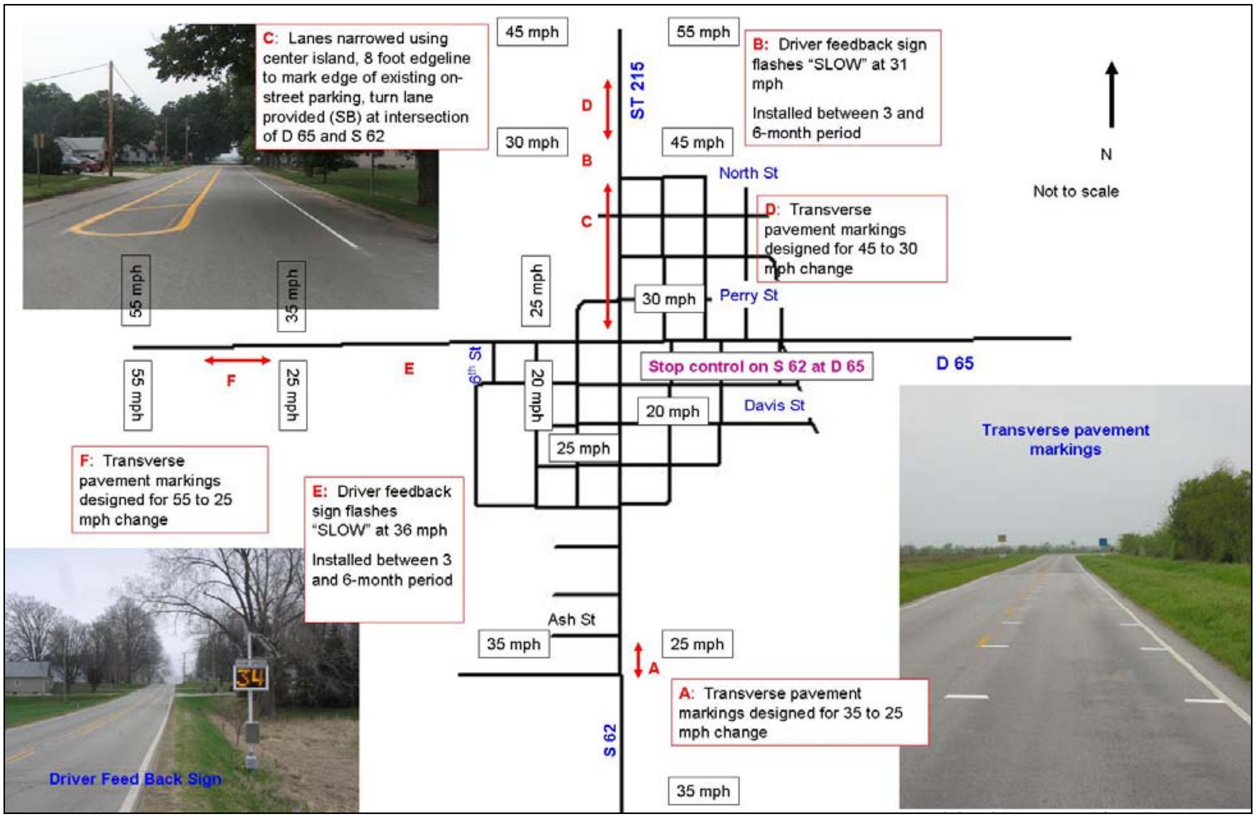

Figure 5.2. Schematic of Union traffic-calming plan

Peripheral Transverse Pavement Markings (Transverse Bars)

Peripheral transverse pavement markings were used to slow incoming traffic at the community entrance. The markings were placed so that they terminated at the first speed limit sign entering the community, which marked the speed zone that was continued throughout the community for that section of roadway. This did not include transition-speed zoning. Peripheral transverse pavement markings were typically spaced so that the driver was given the perception that they were speeding up. These encouraged drivers to be aware of their speeds and slow down. The treatment consisted of a series of parallel bars that decreased in distance as the driver approached the community. The bars used in the study were 12-inches wide (parallel to roadway edge) by 18-inches long (perpendicular to roadway edge).

Spacing between each pair of bars was determined using a decreasing velocity linear equation based on one proposed by Katz (2004) and Le (1998) (see equation 5.3), which was used for converging chevrons. The spacing between pairs of bars was based on beginning and ending speed limits, a deceleration rate typically less than 10 feet/sec^2, and the total length of the treatment. Each of the three entrances had different beginning and ending speeds, so the spacing was different for each (north entrance, 45–30 mph; west entrance, 55–25 mph; south entrance, 35–25 mph). The beginning speed was the posted speed limit for the transition zone just prior to the community entrance. The end speed was the posted speed limit at the community entrance. The length and deceleration rate was determined by setting up a series of temporary pavement markings at a separate test location. Temporary markings were laid out for several different deceleration rates and treatment lengths, and the test section was driven several times by the study team. The team made a qualitative judgment on which set of markings gave the feel that the driver was speeding up to determine maximum length. Decelerations used in other studies for transverse markings or chevrons were also considered. The deceleration rate used was 3.47 feet/second^2 for the northern section, 2.94 ft/sec^2 for the southern section, and 6.87 ft/sec^2 for the western section. The layout for the southern entrance markings is shown in Figure 5.3.

$$L = v_1 * t_b + \frac{(v_1^2 - v_2^2)}{2a} \qquad \text{Equation (5.3)}$$

where:

L = distance between successive pair of transverse bar pairs $pair_1$ and $pair_2$ (feet)
v_1 = speed at pair 1 (ft/sec) {speed at the first pair is the transition zone speed, speed at the last pair is the entrance posted speed limit}
v_2 = speed at pair 2
t_b = perception reaction time (0.5 seconds)
a = deceleration rate (feet/sec^2)

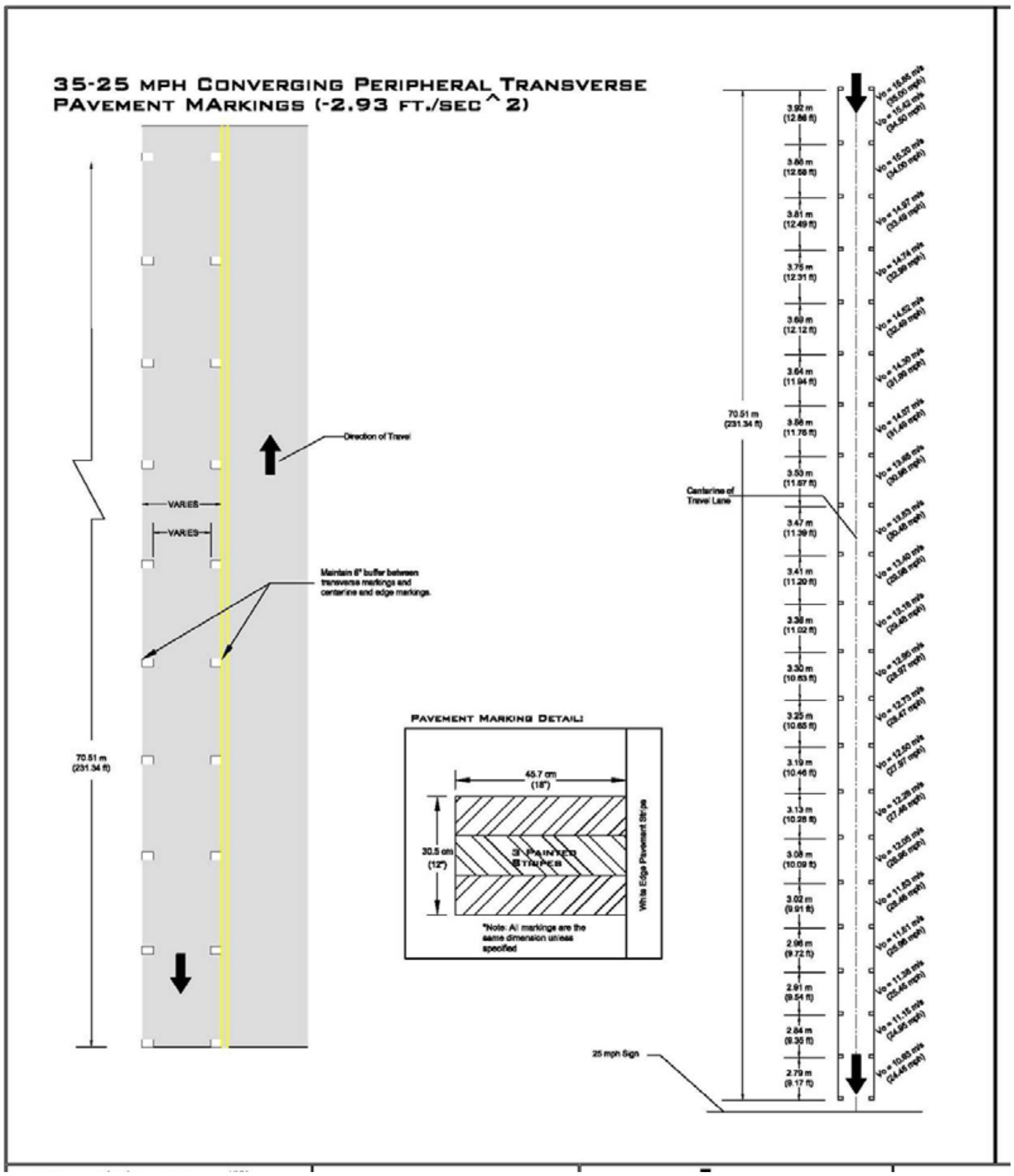

Figure 5.3. Layout of peripheral transverse markings for southern gateway

In addition to the transverse pavement markings, the gateway entrance treatments also consisted of restriping the edge and centerline.

Lane Narrowing Using Median Widening

Median widening was used to narrow lanes to 11 feet for the northern treatment section. This section of SH 215 had a curb and gutter with a width of 40 feet curb to curb. “No Parking” signs were posted on the west side of SH 215, and signs indicating parallel parking is allowed were located on the east side. An eight-foot center median island was created using pavement markings, and an eight-foot delineated shoulder was provided on the east side of SH 215 where parallel parking is allowed. This configuration narrowed the north and southbound lanes to 10 feet and 11 inches for the northbound lane and 12 feet and 9 inches for the southbound lane. A left turn lane was created at the intersection with D-62.

The southern treatment section had a paved shoulder and unpaved shoulder cross-section with a total paved width of 22.4 feet. The distance measured from inside-lane-line to inside-lane-line was 20.8 feet, resulting in lanes that were less than 11 feet wide. The western treatment section also had a paved shoulder and unpaved shoulder cross-section with a total paved width of 23.4 feet. The distance from the inside to inside-lane-line was only 21.8 feet, also resulting in lane widths shorter than 11 feet. As a result, lane narrowing was not used for the southern and western treatment sections. The treatments are shown in Figures 5.4 through 5.7.

Figure 5.4. Before installation of lane narrowing in Union

Figure 5.5. After lane narrowing was installed

Figure 5.6. Before implementation of traffic calming in Union

Figure 5.7. Image after implementation of traffic calming

Driver Feedback Signs

Two signs were placed within Union for motorists entering town from west and north. The sign on the west community entrance was oriented for eastbound motorists on county road D-65 and was located west of 6th Street. The sign on the north community entrance was oriented for southbound motorists on county road S-62 and was located south of North Street. The signs are shown in Figures 5.8 through 5.11.

Figure 5.8. Driver feedback sign in Union without posted speed

Figure 5.9. Feedback sign with driver's posted speed


Figure 5.10. Location of feedback sign without driver's speed

Figure 5.11. Location of speed feedback sign with posted speed

The sign settings were as follows:

1. West-side settings
   a. Sign will not display above 50 mph
   b. Vehicles speeds will flash above 45 mph
   c. Sign will turn off when vehicle speed is at or below 25 mph
2. North-side previous settings
   a. Sign will not display above 55 mph
   b. Sign will turn off when vehicle speed is at or below 25 mph

5.6.3. Deviations from Data Collection or Data Analysis Plan

Union residents use a number of golf carts during the summer months on SH 215/S 62 and D-65. Because this group of vehicles is usually not present during the winter months, and isn't representative of typical conditions, golf-cart traffic was removed from all datasets. A JAMAR representative indicated that golf carts would correspond to vehicle class 1. (This could also have represented motorcycles as well, but it was not possible to separate the two.) As a result, vehicle class 1 was removed from the Union datasets.

The speed signs were ordered so that they could be placed with the other traffic-calming treatments. However, the signs were backordered for four months, and, once they arrived, it was determined the manufacturer had shipped the wrong parts. Once this error was resolved, the speed feedback signs were installed. As a result, the first after period for the signs corresponds to the nine-month after period.

An unusual period of extremely low temperatures and blizzards occurred between January and mid-March 2007. As a result, data could not be collected for the six-month after period.

5.6.4. Physical Condition of Treatments over Time and Problems Noted

The treatments wore normally over time. The optical speed bars were repainted in June 2007 before the final twelve-month data collection occurred. The speed feedback signs functioned well and no maintenance problems occurred. The signs were installed on metal breakaway poles. A different speed feedback sign was used in Slater and had significant problems. It was installed on a 6-inch-by-6-inch wood post. It is unknown if the wood post sustained enough vibration that it contributed to the problems with the sign. The team suggests using the metal pole configuration for installation of the sign.

5.6.5. Results

Results are presented by data collection location. Data collection locations are shown in Figure 5.12. Results are presented for data collection locations where speed reduction was desired and for the control locations. Data were portioned by direction, so results are not presented when the direction was not of interest (vehicles exiting the community) or vehicles had not encountered a treatment for that direction of traffic.

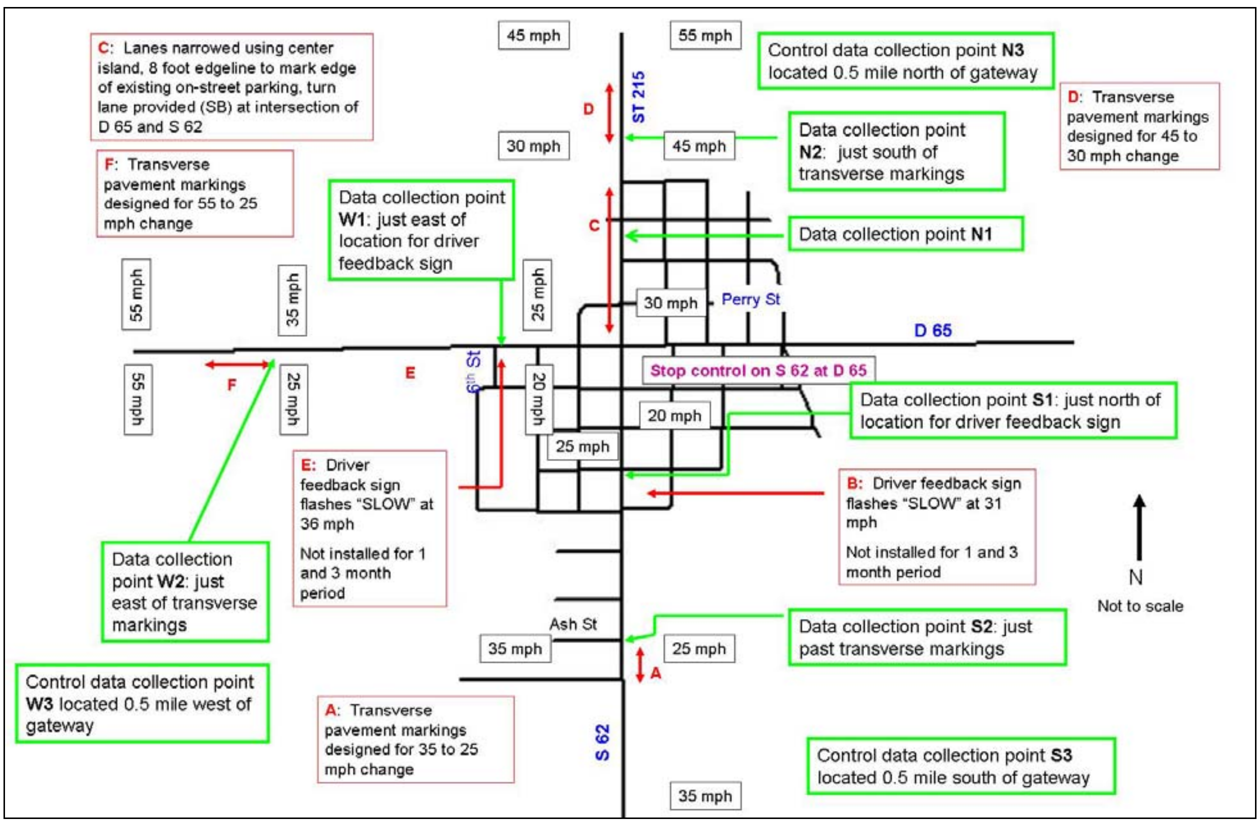

Figure 5.12. Data collection locations for Union

Temporal differences

Speed data for the two gateway treatment locations (Union and Roland) were also evaluated by time of day. Data were analyzed for the morning peak period (7–9:00 AM), evening peak period (4–6:00 PM), daytime off-peak (9:00 AM to 4:00 PM), daytime (6:30 AM to 8:00 PM), and nighttime (8:00 PM to 6:30 AM). It was thought that speed reductions might be higher or lower at certain times of the day. For instance, speed decreases might be more significant for off-peak periods because vehicles might be more impacted by other vehicles during periods. Differences were noted when data were analyzed by time of day. However, no pattern emerged to indicate that the treatments were necessarily more or less effective during certain time periods.

Union South 3, North 3, and West 3

Locations South 3 (S3), North 3 (N3), and West 3 (W3) served as control speed locations. Data were collected 0.5 miles upstream of the respective gateway entrance treatment. Data were collected upstream of the gateway treatments to serve as a control, so general speed trends that were not likely to be associated with the gateway treatment could be observed. Speeds are shown for the direction of traffic that would be entering the community.

Results for S3 are provided in Table 5.2 for the northbound direction of traffic who would eventually encounter the transverse markings at the south entrance. Table 5.3 shows results for N3. Vehicles at this location were southbound and would cross the transverse markings and speed feedback sign entering Union from the north. Results for W3 are given in Table 5.4 for the eastbound traffic who would enter Union at the west entrance and would cross the transverse markings and the western speed feedback sign. As indicated, speeds increased almost consistently in the after periods for all three of the locations, with the exception of the nine-month after period for S3 and W3. This suggests that speeds increased from the before period to most of the after periods independently of the treatments applied.

Table 5.2. Union South 3 northbound (55 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon	Change	12-mon	Change
Sample	870	761		769		795		895	
ADT	290	263		299		270		302	
Mean	57.5	58.2	-0.7	58.7	-1.2%	57.0	0.5	58.8	-1.3[A]
Std	9.8	9.3		7.7		8.8		8.0	
Min	14	14		12		10		14	
Max	83	84		90		83		79	
85^{th} Percentile	65	65	0	65	0	65	0	66	-1
% >= 5 mph over	43.3%	49.7%	-6.4%[C]	46.8%	-3.5%[D]	38.6%	4.7%[C]	50.5%	-7.2%[C]
% >= 10 mph over	16.1%	18.4%	-2.3%[D]	17.9%	-1.8%	15.3%	0.8%	17.9%	-1.8%

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

Table 5.3. Union North 3 southbound (55 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon	Change	12-mon	Change
Sample	1,817	1,816		1,848		1,762		1,666	
ADT	606	635		638		609		589	
Mean	55.4	57.4	-2.0[A]	58.1	-2.7[A]	57.2	-1.8 [A]	57.6	-2.2[A]
Std	6.3	6.6		6.5		6.7		6.5	
Min	27	19		19		18		16	
Max	90	93		90		82		83	
85^{th} Percentile	61	63	-2	63	-2	63	-2	63	-2
% >= 5 mph over	23.3%	36.9%	-13.6% [C]	40.9%	-17.6% [C]	35.7%	-12.4%[C]	39.3%	-16.0% [C]
% >= 10 mph over	6.2%	9.3%	-3.1% [C]	12.3%	-6.1%[C]	8.5%	-2.3%[C]	10.2%	-4.0% [C]

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

Table 5.4. Union West 3 eastbound (55 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon	Change	12-mon	Change
Sample	637	653		681		726		661	
ADT	212	225		237		250		220	
Mean	59.1	60.3	-1.2[A]	59.7	-0.6	57.9	1.2[A]	59.2	-0.1
Std	8.2	8.7		9.2		9.0		8.9	
Min	19	18		19		19		14	
Max	82	82		84		84		84	
85^{th} Percentile	66.0	67.0	-1	67	-1	66	0	67	-1
% >= 5 mph over	51.2%	60.0%	-8.8%[C]	55.7%	-4.5%[D]	48.2%	3.0%	58.5%	-7.3%[C]
% >= 10 mph over	23.1%	29.2%	-6.1%[C]	27.8%	-4.7% [C]	20.8%	2.3%	23.4%	-0.3%

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

Union South 2

Location South 2 (S2) was located just north of the southern set of transverse bars. Speeds for the northbound direction of traffic were measured after vehicles crossed the gateway treatment. Southbound vehicles were about to exit Union. Results for northbound traffic are presented in Table 5.5. As shown, modest decreases in mean and 85^{th} percentile speeds resulted for all of the after periods. The percent of vehicles traveling 5 and 10 mph over the posted speed limit decreased by up to 5.3 percent and 8.5 percent, respectively, in the after periods while the percent of vehicles traveling 15 mph and 20 mph over the speed limit decreased by up to 8.3 percent and 7.0 percent, respectively.

A minor increase resulted for the number of vehicles traveling 5 mph or more over the posted speed limit for the twelve-month period, but the differences were not statistically significant. Data were not collected for the six-month after period because of adverse weather. It should also be noted that speed increases were noted for all of the after periods for the south data collection location. This indicates that speeds might have increased overall because of factors other than the treatments. This might also suggest that speeds may have decreased even more at the treatments had overall speeds not increased.

Table 5.5. Union South 2 northbound (25 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon	Change	12-mon	Change
Sample	886	783		943		908		871	
ADT	295	367		337		325		318	
Mean	37.8	37.0	0.8 [A]	36.7	1.1[A]	35.9	1.9[A]	37.4	0.4
Std	8.4	8.9		8.3		8.6		8.2	
Min	14	7		9		7		7	
Max	61	63		63		69		62	
85th Percentile	46	45	1	45	1	44	2	45	1
% >= 5 mph over	84.5%	81.5%	3.0% [D]	81.3%	3.2%[C]	79.2%	5.3%[C]	85.1%	-0.6%
% >= 10 mph over	69.6%	65.9%	3.7% [D]	63.1%	6.5%[C]	61.1%	8.5% [C]	66.8%	2.8%[D]
% >= 15 mph over	45.3%	42.7%	2.6%	39.9%	5.4%[C]	37.0%	8.3% [C]	43.1%	2.2%
% >= 20 mph over	20.8%	19.8%	1.0%	16.1%	4.7%[C]	13.8%	7.0% [C]	18.3%	2.5%[D]
% >= 25 mph over	5.9%	5.0%	0.9%	4.1%	1.8%[C]	3.4%	2.5% [C]	4.8%	1.1%

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

Union South 1

Location South 1 (S1) was almost four blocks north of the southern gateway treatment. The only other traffic-calming treatment in the area of S1 was the repainted center and edge lines. Through vehicles traveling northbound would have crossed the transverse markings at the southern gateway entrance treatment (Table 5.6), and southbound through vehicles would have stopped at the two-way stop control at the intersection of S-62/SH 215 and D-65 after crossing the northern gateway treatments (Table 5.7).

Northbound vehicle speeds increased for the one-month after data collection period and decreased slightly for the three-, nine-, and twelve-month after periods. Decreases, however, were fairly small. Southbound vehicle speeds decreased for the one- and nine-month after periods. Speeds increased for the three-month after period and results were mixed for the twelve-month after period. Results are not consistent but suggest that the treatments were somewhat effective in reducing speeds at downstream or upstream locations from the actual treatments.

Table 5.6. Union South 1 northbound (25 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon	Change	12-mon	Change
Sample	1,157	980		1,094		1,027		1,132	
ADT	386	349		385		372		397	
Mean	31.8	35.5	-3.7[A]	31.7	0.1	31.2	0.6[B]	31.1	0.7[A]
Std	6.8	8.1		6.2		6.3		6.1	
Min	10	13		5		10		9	
Max	51	62		61		52		51	
85th Percentile	39	44	-5	38	1	38	1	37	2
% >= 5 mph over	63.7%	75.5%	-11.8%[C]	64.5%	-0.8%	61.4%	2.3%	59.0%	4.7%[C]
% >= 10 mph over	35.3%	55.2%	-19.9%[C]	32.5%	2.8%[D]	30.5%	4.8%[C]	28.9%	6.4%[C]
% >= 15 mph over	12.4%	31.1%	-18.7%[C]	10.1%	2.3% [C]	9.8%	2.6%[C]	8.0%	4.4%[C]
% >= 20 mph over	2.6%	4.1%	-1.5%[C]	1.8%	0.8%[D]	2.0%	0.6%	1.1%	1.5%[C]
% >= 25 mph over	0.3%	1.3%	-1.0%[C]	0.2%	0.1%	0.3%	0%	0.1%	0.2%

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

Table 5.7. Union 1 South southbound all vehicles (25 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon	Change	12-mon	Change
Sample	1,128	1,023		1,105		1032		1,083	
ADT	376	365		393		369		379	
Mean	31.5	28.8	2.7[A]	32.3	-0.8[A]	30.9	0.6[A]	31.7	-0.2
Std	6.5	5.1		6.3		6.2		5.9	
Min	9	10		11		8		12	
Max	54	48		57		51		54	
85th Percentile	38.0	34	4	39	-1	37	1	37	1
% >= 5 mph over	61.4%	47.7%	13.7%[C]	70.0%	-8.6%[C]	57.5%	3.9%[C]	67.0%	-5.6%[C]
% >= 10 mph over	32.7%	11.2%	21.5%[C]	35.7%	-3.0%[D]	28.6%	4.1%[C]	31.1%	1.6%
% >= 15 mph over	9.0%	1.3%	7.7%[C]	12.1%	-3.1%[C]	8.1%	0.9%	7.6%	1.4
% >= 20 mph over	2.5%	0.3%	2.2%[C]	1.7%	0.8%[D]	1.6%	0.9%[D]	1.5%	1.0%[C]
% >= 25 mph over	0.3%	0%	0.3%[C]	0.4%	-0.1%	0.1%	0.2%	0.3%	0%

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

Union North 1

Location North 1 (N1) was located several blocks south of the northern transverse markings and one and a half blocks north of the stop sign at D-65. The full center island was implemented at this point, as well as the shoulder striping on the east side of SH 215/S 62.

Results are presented in Tables 5.8 and 5.9. Northbound through vehicles would have crossed the southern gateway entrance treatment, which consisted of transverse pavement markings, and stopped at the two-way stop control at the intersection of S-62/SH 215 and D-65. Southbound through vehicles crossed the northern gateway entrance treatments, which consisted of transverse pavement markings followed by a speed feedback sign.

As shown, speeds increased for most of the after periods for northbound vehicles. Results were inconsistent for southbound traffic. In some cases, speeds decreased slightly, but, in others, speeds actually increased.

The changes were not expected, so the corresponding datasets were evaluated carefully to ensure that no problems or miscalculations had occurred. No errors were found. Speeds had increased at the northern control location, so it is unknown if this affected speeds within Union.

It may be assumed that the center island widening had no impact on speeds and that the transverse marking had no residual effect this far downstream. It is unlikely that the treatment itself caused speeds to increase.

Table 5.8. Union North 1 northbound all (30 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon	Change	12-mon	Change
Sample	2,055	1,808		1,840		1,807		2,064	
ADT	734	657		671		657		907	
Mean	28.5	29.5	-1.0[A]	26.9	1.6 [A]	30.3	-1.8[A]	28.9	-0.4[A]
Std	5.9	6.0		4.9		5.7		5.9	
Min	9	9		6		6		6	
Max	51	47		44		46		50	
85th Percentile	35	36	-1	32	3	36	-1	35	0
% >= 5 mph over	15.3%	20.7%	-5.4%[C]	30.2%	-14.9%	23.1%	-7.8%[C]	18.2%	-2.9%[C]
% >= 10 mph over	2.5%	3.0%	-0.5%	3.5%	-1.0%[C]	4.3%	-1.8%[C]	3.4%	-0.9%[C]
% >= 15 mph over	0.1%	0.3%	-0.2%[D]	0.6%	-0.5%[C]	0.3%	-0.2%[D]	0.4%	-0.3%[C]
% >= 20 mph over	0%	0%	0%	0%	0%	0%	0%	0.0%	0%
% >= 25 mph over	0%	0%	0%	0%	0%	0%	0%	0.0%	0%

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

Table 5.9. Union North 1 southbound (30 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon	Change	12-mon	Change
Sample	2,058	1,930		1,911		1,881		1,771	
ADT	731	698		697		675		687	
Mean	28.0	28.0	0	30.6	-2.6[A]	27.2	0.8 [A]	28.7	-0.7[A]
Std	5.5	5.4		6.2		4.8		5.2	
Min	6	7		9		8		6	
Max	48	63		51		44		52	
85th Percentile	33	33	0	37	-4	32	1	34	-1
% >= 5 mph over	9.8%	10.6%	-0.8%	25.0%	-15.2%[C]	5.7%	4.1%[C]	11.1%	-1.3%[D]
% >= 10 mph over	1.9%	1.4%	0.5%	7.3%	-5.4%[C]	0.7%	1.2%[C]	1.6%	0.3
% >= 15 mph over	0.2%	0.2%	0%	1.3%	-1.1c	0.0%	0.2%[C]	0.3%	-0.1
% >= 20 mph over	0%	0.1%	-0.1%	0.2%	-0.2%[C]	0.0%	0%	0.1%	-0.1%[D]
% >= 25 mph over	0%	0.1%	-0.1%	0%	0%	0.0%	0%	0%	0%

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

Union North 2

The North 2 data collection location was just south of the northern set of transverse bars. Vehicles in the southbound direction of traffic would have just crossed the transverse bars and passed the speed feedback sign (Table 5.10). The road tubes were approximately 6 feet south of the speed feedback sign. Northbound vehicles were exiting Union, so data results for these vehicles were not provided.

Speeds decreased after installation of the transverse speed bars gateway entrance for the one- and three-month after periods. However, speed decreases were smaller for the south gateway entrance treatment. The speed feedback sign was installed between the six- and nine-month after periods. As shown, speeds decreased significantly more for the nine- and twelve-month after period once the signs were installed than for the analysis periods with just the transverse bar entrance treatments. The transverse speed bars were also repainted before the twelve-month data collection period.

Table 5.10. Union North 2 southbound (30 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon	Change	12-mon	Change
Sample	1,870	1,785		1,794		1,737		1,693	
ADT	662	657		689		646		599	
Mean	33.8	33.9	-0.1	33.9	-0.1	29.3	4.5[A]	29.4	4.4 [A]
Std	7.3	6.8		6.7		6.2		5.3	
Min	7	10		10		9		8	
Max	65	62		63		58		52	
85th Percentile	41	41	0	40	1	35	6	34	7
% >= 5 mph over	48.4%	48.2%	0.2%	45.0%	3.4%[C]	16.9%	31.5%[C]	14.9%	33.5%[C]
% >= 10 mph over	21.0%	19.7%	1.3%	18.8%	2.2%[C]	5.0%	16.0%[C]	4.4%	16.6%[C]
% >= 15 mph over	5.8%	5.1%	0.7%	5.5%	0.3%	1.3%	4.5%[C]	0.9%	4.9%[C]
% >= 20 mph over	1.3%	0.4%	0.9%[C]	1.1%	0.2%	0.4%	0.9%[C]	0.1%	1.2%[C]
% >= 25 mph over	0.3%	0.2%	0.1%	0.1%	0.2%[D]	0.0%	0.3%[C]	0%	0.3%[C]

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

Location West 2

Location West 2 (W2) was located just east of the western gateway. Eastbound vehicles would have just crossed the transverse speed bars, and, for the analysis periods where the speed feedback sign was in place, would have encountered the speed feedback sign. Traffic for the westbound direction at W2 was well past the edge of development and in all cases was exiting Union. No traffic-calming treatment was implemented in the westbound lane.

As indicated in Table 5.11, speeds decreased for the one-month after period (only transverse speed bars were in place). Of significant note are the almost 6.0 and 3.0 percent decreases in very high-end speeds. For the three-month after period, there was no statistical difference in changes from the before period. A speed feedback sign, as previously described, was installed between the six- and nine-month after period. As noted, speeds decreased significantly, especially for high-end speeds. Differences of 3–5 mph resulted for the average and 85th percentile speeds, and the percent of vehicles traveling over the speed limit decreased by almost 28.0 percent. The signs were much more effective than just the transverse speed bars in reducing speeds. It is unknown what portion of the decrease for the last two data collection periods can be attributed to either of the two treatments, however.

Table 5.11. Union West 2 eastbound (25 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon	Change	12-mon	Change
Sample	893	659		684		749		666	
ADT	234	231		243		263		230	
Mean	43.9	42.9	1[A]	44.0	-0.1	38.7	5.2[A]	40.5	3.4[A]
Std	8.6	8.1		8.7		9.2		9.4	
Min	18	18		18		13		16	
Max	71	65		72		66		66	
85th Percentile	53	51.0	2	52	1	49	4	50	3
% >= 5 mph over	93.8%	93.0%	0.8%	93.6%	0.2%	82.4%	11.4%[C]	85.9%	7.9%[C]
% >= 10 mph over	86.5%	85.4%	1.1%	86.0%	0.5%	64.8%	21.7%[C]	69.1%	17.4%[C]
% >= 15 mph over	71.8%	69.3%	2.5%	73.0%	-1.2%	45.1%	26.7%[C]	53.6%	18.2%[C]
% >= 20 mph over	49.8%	43.9%	5.9%[C]	51.9%	-2.1%	29.1%	20.7%[C]	38.1%	11.7%[C]
% >= 25 mph over	24.6%	21.4%	3.2%[D]	26.6%	-2.0%	13.2%	11.4%[C]	17.9%	6.7%[C]

Speeds are in mph
[A] statistically significant at 95% CI using t-test
[B] statistically significant at 90% CI using t-test
[C] statistically significant at 95% CI using test of proportionality
[D] statistically significant at 95% CI using test of proportionality

Location West 1

Location West 1 (W1) was several blocks east of the western gateway treatment. Through vehicles traveling eastbound would have crossed the western treatment several blocks earlier. Westbound through vehicles would have not encountered any of the traffic-calming treatments and data for these vehicles are not included. Results for the eastbound vehicles are shown in Table 5.12. Results are similar to those for the Union West 2 location. Speeds were somewhat decreased for the one-month period when only the transverse bars were in place and no statistically significant decreases occurred for the three-month period. Once the signs were in place, speeds decreased significantly from before to nine- and twelve-month after periods. The results suggest that the traffic-calming treatments did have some downstream effect.

Table 5.12. Union West 1 eastbound (25 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon	Change	12-mon	Change
Sample	762	818		869		922		896	
ADT	268	298		312		332		312	
Mean	29.8	29.9	-0.1	30.1	-0.3	27.7	2.1[A]	28.5	1.3[A]
Std	7.7	6.9		7.5		6.1		6.2	
Min	9	11		12		11		9	
Max	52	53		63		49		55	
85^{th} Percentile	38	37	1	38	0	34	4	35	3
% >= 5 mph over	53.5%	50.7%	2.8%	51.7%	1.8%	33.4%	20.1%[C]	40.4%	13.1%[C]
% >= 10 mph over	28.2%	26.2%	2.0%	29.6%	-1.4%	14.0%	14.2%[C]	17.9%	10.3%[C]
% >= 15 mph over	10.6%	8.3%	2.3%[D]	10.6%	0%	4.4%	6.2%[C]	4.5%	6.1%[C]
% >= 20 mph over	2.0%	2.2%	-0.2%	2.5%	-0.5%	1.1%	0.9%[D]	1.0%	1.0%[C]
% >= 25 mph over	0.4%	0.6%	-0.2%	0.6%	-0.2%	0%	0.4%[C]	0.1%	0.3%

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C] statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D] statistically significant at 95% CI using test of proportionality

5.6.6 Overall

The transverse markings appeared to be moderately effective in decreasing vehicle speeds directly downstream of the markings for all three gateways, although none of the differences were large. The lane narrowing using center island widening did not appear to be effective. Once the speed feedback signs were installed, significant speed decreases resulted.

Union appeared to have experienced a general upward trend in speeds independent of the gateway treatments. Speeds measured at control locations where the effect of the treatments would not have been felt indicated that speeds overall increased over the study period. This may suggest that the full effect of the treatments is not reflected in the data presented. It could be argued that if overall speeds had remained the same, greater speed decreases than recorded may have resulted. An attempt to adjust the after data at the treatments locations to reflect the overall upward speed trends was attempted using a normal transformation. However, the speed data were slightly non-normal. This did not affect the results of the statistical tests to compare before and after data (t-test, test of proportionality). However, data could not be transformed with any confidence in the accuracy of the final results. Consequently the team feels that the treatments were likely more effective than are reflected in the final results.

5.7 Roland, IA (Gateway Traffic-Calming Treatment Site)

5.7.1. Community Description

Roland is located approximately 45 miles north of Des Moines and has a population of 1,324. City officials responded to our initial newsletter, requesting to be a pilot-study community. They indicated that speeding occurs on County Highway E-18, which is the main route through town. E-18 is a two-lane roadway oriented east/west. Figure 5.13 shows an aerial view of the town, along with the locations of speed zones. The posted speed limit is 55 mph outside of town and 25 mph at the center of town, with long transition zones on the west end of town and short transition zones on the east end of town. There is also a four-way, stop-controlled intersection at E-18 and Main Street. Some sensitive areas near the highway included a middle school, park, and swimming pool. Corresponding information is provided in Table 5.13. A total of four crashes occurred along E-18 in the vicinity of Roland from 2001 to 2005.

Table 5.13. Characteristics for Roland

Road Section	AADT	Length (feet)	Cross-section	Crashes (2001-05)
E-18 from western city limit to intersection with Main St. (4-way stop)	2,420	4,109	Asphalt paved/unpaved shoulder, 2-lane, paved width 20.7 feet	2
E-18 from eastern city limit to intersection with Main St. (4-way stop)	2,200	3,697	Concrete curb and gutter, 2-lane, paved width 36.0 feet	2

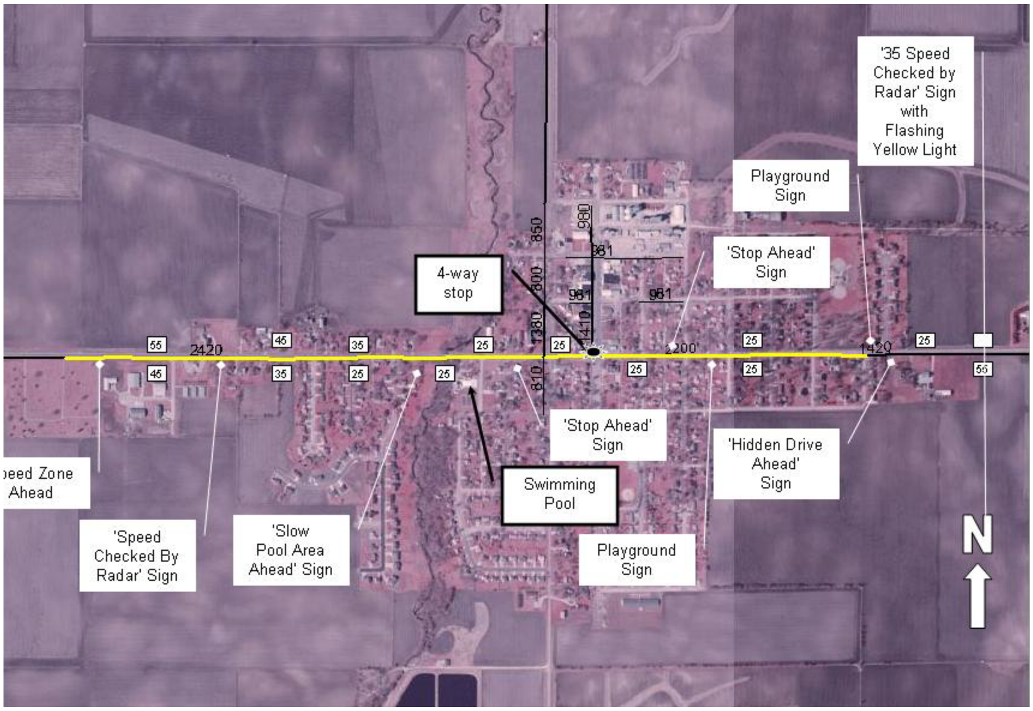

Figure 5.13. Location of signing for Roland (image source: www.gis.iastate.edu)

5.7.2. Traffic-Calming Treatment

Roland was a gateway treatment area, so a series of treatments were applied starting at the community entrances. Two roadway sections were selected for treatments, including

- the west section of County Road E-18 from the western transition zone to the intersection with Main Street and
- the east section County Road E-18 from the eastern transition zone to the intersection with Main Street.

The treatments included (1) converging chevrons, (2) shoulder widening, and (3) on-pavement speed marking. The final treatment plan is shown in Figure 5.14.

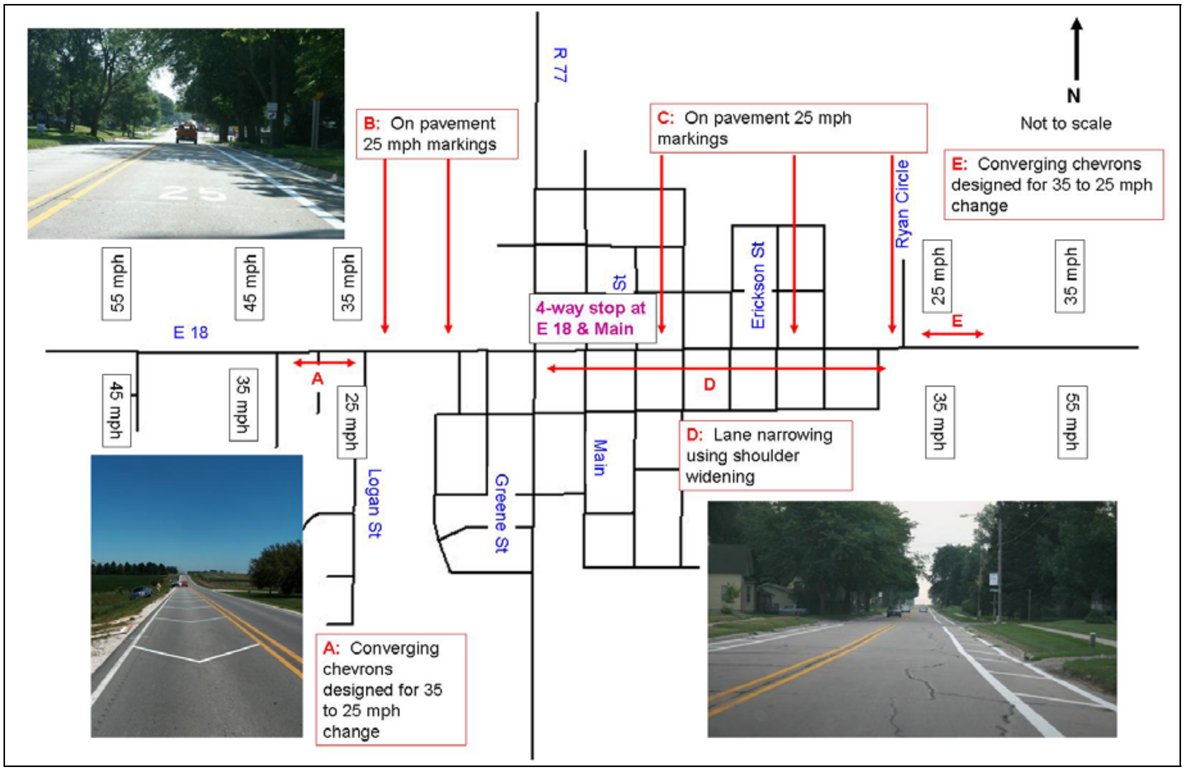

Figure 5.14. Schematic of Roland traffic-calming plan

Converging Chevrons

Converging chevrons were used to slow incoming traffic at the east and west community entrances. The markings were placed so that they terminated at the first speed limit sign entering the community, which marked the speed zone continued throughout the community for that section of roadway.

Converging chevrons were spaced with decreasing spaces as a driver entered a transition zone. This gave the driver the perception of going too fast, or speeding up, and encouraged the driver to reduce speed. Spacing depended on the initial speed limit and how much speed reduction was desired. The conceptual design for the converging chevrons is provided in Figure 5.15. The spacing was based on a 10 mph reduction from an initial speed of 35 mph. The size of the chevrons also decreased as the driver moved forward. The design can easily be changed to accommodate other speed limits and speed reductions. The size of the chevron also decreased as the driver entered the transition zone. Spacing between successive chevrons was based on the same equation used for the transverse markings (equation 5.3).

Converging chevrons were placed at both the east and west entrances to Roland as shown in Figures 5.16 and 5.17.

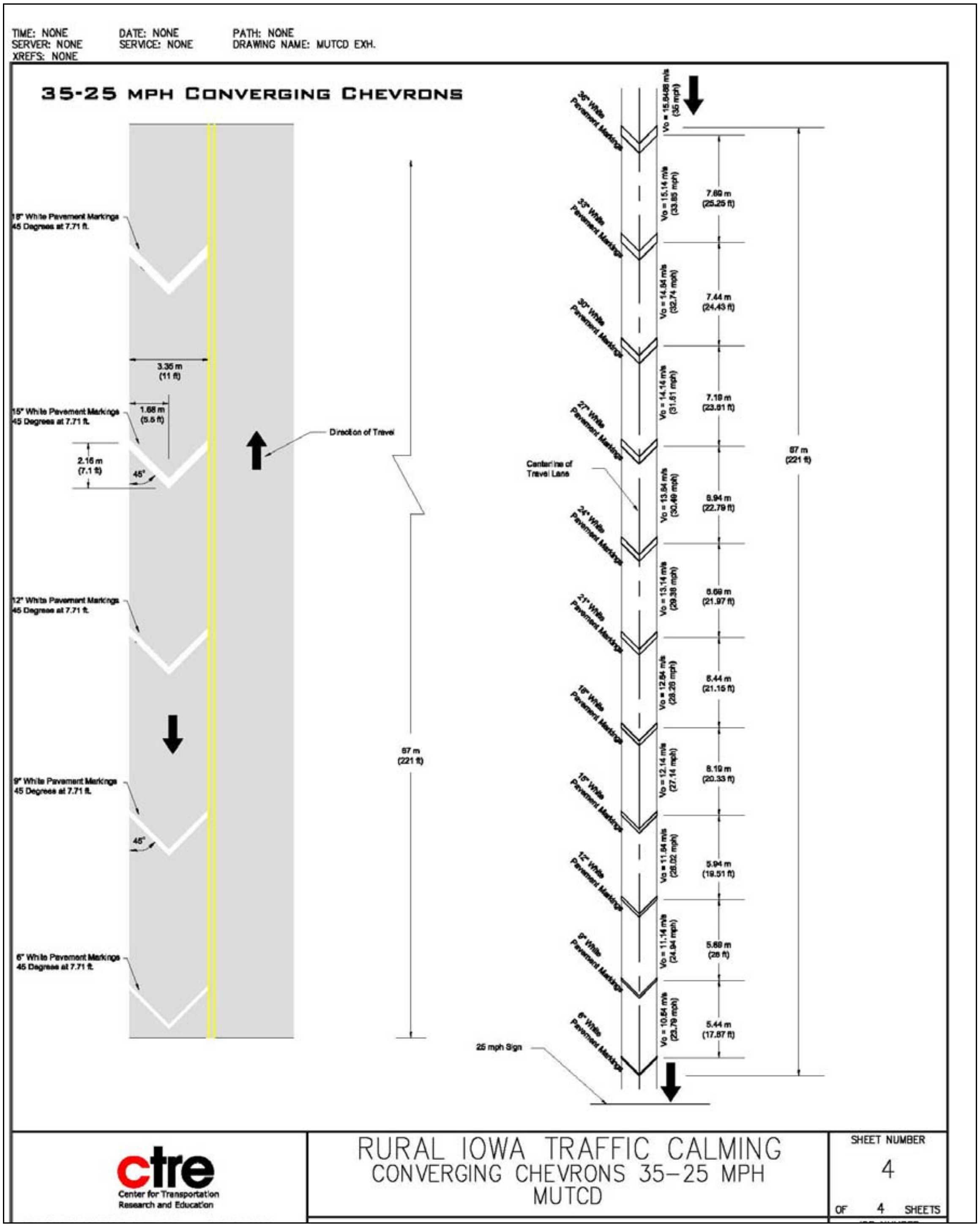

Figure 5.15. Layout of chevron design

Lane Narrowing Using Shoulder Widening

Shoulder widening was used to narrow lanes to 10–10.5 feet for the eastern section. This eastern section of E-18 from the eastern gateway to the four-way stop (Main Street) was concrete and had a paved width (edge-of-curb to edge-of-curb) of approximately 36 feet. Shoulder lane narrowing was used along both sides of the roadway from the four-way stop at Main Street to approximately Ryan Street on the east. The shoulder narrowing was terminated when the roadway cross section transitions from curb and gutter to a rural cross section with asphalt and gravel shoulders.

The west section of the community lay from the town corporate limits to the four-way stop at Main Street and E-18, with the exception of locations marked with parking, had an average paved width of 22.3 feet (asphalt). White edge lines sat on both the north and south sides of the pavement. The centerline was a double yellow line. The distance from the inside edge of lane line to inside edge of lane line was an average of 20.7 feet. This left a lane width of less than 10.5 feet, including the centerline. As a result, lane narrowing for this section of the community was not practical.

On-Pavement Speed Limit Markings

On-pavement speed limit markings were regularly spaced throughout the eastern and western sections of the gateway treatment area. On-pavement speed limit markings were painted on the roadway to remind drivers of the speed limit. Both sections were 25 mph throughout. A single marking, “25 mph,” was placed to the east of the western gateway, and another set (one marking placed in each direction of travel) was placed between the gateway and the four-way stop at Main Street along the western section. A single marking, “25 mph,” was placed west of the eastern gateway. Two more sets of markings (one marking placed in each direction of travel) were spaced between the eastern gateway and the four-way stop.

Figures 5.16 through 5.20 illustrate locations in Roland before and after installation of the traffic-calming treatments, and an aerial view is provided in Figures 5.21 and 5.22.

Figure 5.16. West section of E-18 before converging chevrons

Figure 5.17. West section after converging chevrons

Figure 5.18. East side of E-18 before lane narrowing

Figure 5.19. East section after lane narrowing

Figure 5.20. On-pavement speed signing

Figure 5.21. Aerial view of Roland treatment

Figure 5.22. Another aerial view of Roland treatment

5.7.3. Physical Condition of Treatments over Time

The pavement markings faded over time similarly as to what would be expected for any pavement markings. The on-street speed limit and converging chevrons were repainted 10 months after the treatments were applied.

5.7.4. Deviations from Data Collection or Data Analysis Plan

Data were not collected for the six-month period. Very low temperatures and blizzards made data collection impossible during the six-month after interval. As a result, no data are presented for this time period.

5.7.5. Results

Results are presented by data collection location. Data collection locations are shown in Figure 5.23.

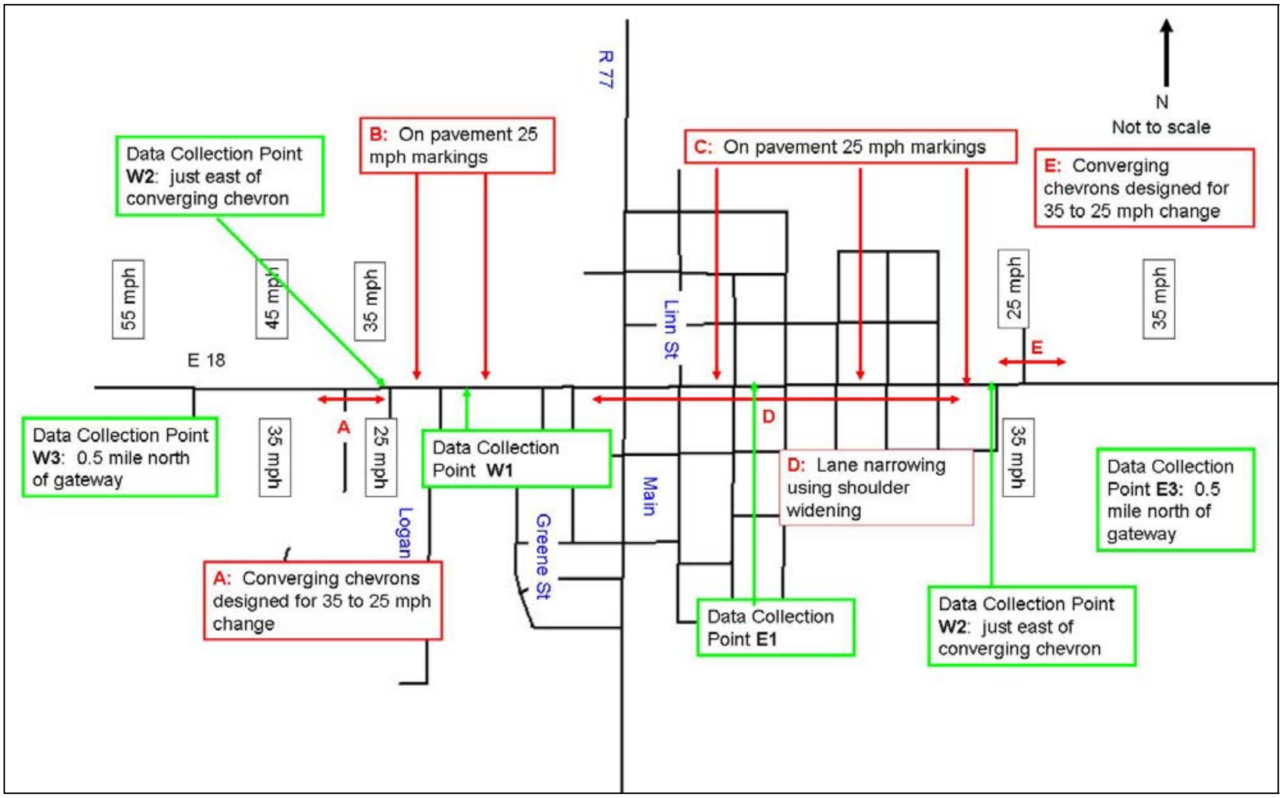

Figure 5.23. Data collection locations for Roland

Temporal Differences

Speed data for the two gateway treatment locations (Union and Roland) were also evaluated by time of day. Data were analyzed for the morning peak period (7–9:00 AM), evening peak period (4–6:00 PM), daytime off-peak (9:00 AM to 4:00 PM), daytime (6:30 AM to 8:00 PM), and nighttime (8:00 PM to 6:30 AM). It was thought that speed reductions might be higher or lower at certain times of the day. For instance, speed decreases might be more significant for off-peak periods because vehicles might be more impacted by other vehicles during periods. Differences were noted when data were analyzed by time of day. However, no pattern emerged to indicate that the treatments were necessarily more or less effective during certain time periods. In the interest of space, results for the temporal analysis are presented in Appendix A.

Roland West 3 and East 3

Locations West 3 (W3) and East 3 (E3) corresponded to the data collection locations that were 0.5 miles upstream of each gateway. Data were collected at these locations to serve as a control, so general speed trends that were not likely to be associated with the gateway treatment could be observed. Results are presented for the eastbound direction of W3 in Table 5.14. Eastbound vehicles entered the west gateway. As noted, only minor deviations occurred in the one-, three-, and nine-month analysis periods. A small increase occurred in the percent of vehicles traveling 5 mph and higher over the speed limit for the twelve-month period.

Table 5.14. Roland West 3 eastbound (55 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9 -mon	Change	12-mon	Change
Sample	4,021	3,847		3,693		3,764		3,785	
ADT	1,341	1,296		1,241		1,273		1,273	
Mean	53.2	51.9	1.3[A]	52.6	0.6	53.3	-0.1	54.1	-0.9
Std	5.7	6.7				5.7		5.9	
Min	11	8		16		17		20	
Max	73	76		82		77		79	
85th Percentile	59	58	1	58	1	59	0	60	-1
% >= 5 mph over	11.7%	11.0%	0.2%	8.9%	2.8%[C]	11.9%	-0.2%	17.7%	-6.0%[C]
% >= 10 mph over	1.3%	1.5%	-0.2%	1.2%	0.1%	2.0%	-0.7%[C]	2.7%	-1.4%[C]

Speeds are in mph

[A] statistically significant at 95% CI using t-test [C] statistically significant at 95% CI using test of proportionality

[B] statistically significant at 90% CI using t-test [D] statistically significant at 95% CI using test of proportionality

Results are presented in Table 5.15 for the westbound direction of E3. Westbound vehicles entered the east gateway. Modest decreases in speed occurred for the one- and nine-month after periods, as compared to the before period. Alternatively, modest increases in speeds occurred for the three- and twelve-month after periods.

Table 5.15. Roland East 3 westbound (55 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon	Change	12-mon	Change
Sample	2,043	1,740		1,752		1,865		2,082	
ADT	681	742		588		629		694	
Mean	55.9	56.1	-0.2	56.6	-0.7	55.7	0.2	56.9	-1.0 [A]
Std	8.5	6.7				7.4		7.8	
Min	9	16		14		18		15	
Max	78	79		88		79		86	
85th Percentile	62	61	1	63	-1	61	1	63	-1
% >= 5 mph over	31.7%	27.2%	4.5%[C]	36.1%	-4.4%	26.7%	5.0%[C]	37.2%	-5.5%[C]
% >= 10 mph over	8.0%	6.0%	2.0%[C]	9.4%	-1.4%	6.3%	1.7%[C]	9.7%	-1.7%[C]

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C] statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D] statistically significant at 95% CI using test of proportionality

Roland West 2

Location West 2 (W2) was located just east of the western gateway (approximately 20 feet), as shown in Figure 5.12. Vehicles traveling eastbound crossed the chevrons in the eastbound lane before their speeds were recorded at W2. The first on-pavement speed markings were located east of W2. Results are presented in Table 5.16. Westbound vehicles were about to exit Roland, so data for these vehicles are not presented. As indicated, speeds decreased for all speed metrics for the one-, three-, nine-, and twelve-month after periods, as compared to the before data collection period. As noted, speeds were not collected for the six-month after period because of adverse weather. The chevrons appeared to be effective in slowing vehicles down and the decreases in speed remained relatively constant over the twelve-month after period.

Table 5.16. Roland West 2 eastbound (25 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon	Change	12-mon	Change
Sample	4,216	4,135		3,812		3,958		3,945	
ADT	1,409	1,410		1,292		1,335		1,315	
Mean	30.8	29.7	1.1	27.8	3.0[A]	30.1	0.7[A]	29.6	1.2 [A]
Std	4.9	4.9		4.1		4.9		4.8	
Min	7	8		9		8		9	
Max	49	56		45		56		53	
85^{th} Percentile	35	34	1	32	3	35	0	34	1
% >= 5 mph over	63.4%	51.8%	11.6%[C]	32.2%	31.2%[C]	57.3%	6.1%[C]	52.1%	11.3%[C]
% >= 10 mph over	20.7%	14.2%	6.5% [C]	5.2%	15.5%[C]	16.5%	4.2%[C]	13.5%	7.2%[C]
% >= 15 mph over	3.1%	2.6%	0.5%[D]	0.6%	2.5%[C]	2.4%	0.7%[C]	2.0%	1.1%[C]
% >= 20 mph over	0.4%	0.3%	0.1%	0%	0.4%[C]	0.3%	0.1%	0.3%	0.1
% >= 25 mph over	0%	0.1%	-0.1%	0%	0%	0.2%	-0.2%	0.1%	-0.1%[C]

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

Roland West 1

The West 1 data collection location was on the western section of E-18 between the converging chevrons and the four-way stop at Main Street. It was near one of the on-pavement 25 mph speed limit pavement markings. On-pavement speed markings were close to this location in both lanes of traffic, so results are presented for the east and westbound directions of traffic. Eastbound vehicles would have crossed the chevrons upstream. Westbound vehicles would have stopped at the four-way stop at E-18 and Main Street and may have crossed the gateway treatments for the eastern section of E-18. Results are presented for eastbound traffic in Table 5.17 and westbound traffic in Table 5.18. Results for the eastbound direction of traffic are inconsistent. Minor increases in speeds occurred for all of the speed metrics for the one- and three-month after periods. Speed decreases are noted for the nine- and twelve-month after periods. Results are also inconsistent for the westbound traffic. Minor decreases in speed resulted for the one- and three-month after periods. Speeds increased significantly for the nine-month after period and then moderate decreases resulted for the twelve-month after period. It should be noted that the treatments were somewhat faded by the nine-month data collection period and were repainted before the twelve-month after period. As noted, speeds were not collected for the six-month after period because of adverse weather.

Table 5.17. Roland West 1 eastbound all (25 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon	Change	12-mon	Change
Sample	4,092	4,017		3,675		3,832		3,856	
ADT	1,368	1,364		1,243		1,301		1,285	
Mean	28.8	29.1	-0.3[A]	29.3	-0.5[A]	27.0	1.8[A]	28.4	0.4[A]
Std	4.5	4.8		4.4		3.8		4.4	
Min	8	10		12		9		11	
Max	48	50		57		57		49	
85th Percentile	33	33	0	34	-1	31	2	32	1
% >= 5 mph over	43.6%	44.7%	-1.1%	46.7%	-3.1%[C]	22.7%	20.9%[C]	39.7%	3.9%[C]
% >= 10 mph over	9.0%	10.3%	-1.3%[C]	11.2%	-2.2%[C]	2.7%	6.3%[C]	7.0%	2.0%[C]
% >= 15 mph over	1.0%	1.3%	-0.3%[D]	1.6%	-0.6%[C]	0.3%	0.7%[C]	0.9%	0.1%
% >= 20 mph over	0.1%	0.2%	-0.1%	0.2%	-0.1%	0.1%	0%	0.1%	0%
% >= 25 mph over	0%	0%	0%	0.1%	-0.1%	0.1%	-0.1%	0%	0%

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

Table 5.18. Roland West 1 westbound (25 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon	Change	12-mon	Change
Sample	4,512	4,269		3,944		4,129		4,174	
ADT	1,507	1,446		1,332		1,398		1,392	
Mean	31.5	31.1	0.4[A]	31.8	-0.3[A]	34.9	-3.4%[A]	30.3	1.2[A]
Std	5.3	4.9				6.2		5.0	
Min	7	8		9		7		8	
Max	59	51		58		61		66	
85th Percentile	37	36	1	37	0	41	-4	35	2
% >= 5 mph over	70.2%	66.0%	4.2%[C]	70.2%	0%	84.0%	-13.8%[C]	58.1%	12.1%[C]
% >= 10 mph over	28.3%	23.4%	4.9%[C]	27.6%	0.7%	54.5%	-26.2%[C]	17.4%	10.9%[C]
% >= 15 mph over	4.8%	3.8%	1.0%[C]	0.7%	4.1%[C]	21.2%	-16.4%[C]	3.0%	1.9%[C]
% >= 20 mph over	0.4%	0.4%	0%	0.2%	0.2%[C]	5.5%	-5.1%[C]	0.5%	-0.1
% >= 25 mph over	0.1%	0.1%	0%	0.2%	-0.1%	1.2%	-1.1%[C]	0.1%	0%1

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

Roland East 1

Location East 1 (E1) was located midway between the four-way stop at Main Street and the eastern gateway. Shoulder widening and on-street speed limit signs were located in this area. Eastbound vehicles (Table 5.19) would have stopped at the four-way stop at E-18 and Main Street and may have crossed the gateway treatments in the western section. Westbound vehicles would have crossed the eastern set of converging chevrons (Table 5.20). The pneumatic tubes were located between the two sets of on-pavement 25 mph speed limit markings. Westbound vehicles experienced no change or minor increases in speed from the before to one-month after period. As shown, modest decreases in speed were observed for the westbound traffic. As shown, modest increases occurred for several of the after periods for the eastbound traffic and modest decreases occurred for others. No consistent pattern was noted. Results for the westbound direction of traffic are similar. In some cases, minor increases resulted, but, in other minor cases, minor decreases occurred. As noted, speeds were not collected for the six-month after period because of adverse weather.

Table 5.19. Roland East 1 eastbound (25 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon	Change	12-mon	Change
Sample	2,884	2,708		2,324		2,489		2,727	
ADT	964	921		738		839		909	
Mean	29.2	29.9	-0.7[A]	29.4	-0.2	28.9	0.3[A]	30.0	-0.8 [A]
Std	4.7	4.5				4.4		4.5	
Min	9	9		12		10		9	
Max	46	60		54		51		53	
85^{th} Percentile	34	34	0	34	0	33	1	34	0
% >= 5 mph over	46.7%	51.5%	-4.8%[C]	46.0%	0.7%	42.8%	3.9%[C]	53.0%	-6.3%[C]
% >= 10 mph over	12.0%	13.5%	-1.5%[C]	12.2%	-0.2%	9.4%	2.6%[C]	14.3%	-2.3%[C]
% >= 15 mph over	1.9%	2.3%	-0.4%	1.9%	0%	1.3%	0.6%[C]	1.8%	0.1
% >= 20 mph over	0.1%	0.4%	-0.3%[C]	0.3%	-0.2%[D]	0.1%	0%	0.4%	-0.3%[C]
% >= 25 mph over	0%	0.1%	-0.1%[C]	0%	0%	0%	0%	0%	0

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

Table 5.20. Roland East 1 westbound (25 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon	Change	12-mon	Change
Sample	2,864	2,681		2,361		2,562		2,835	
ADT	956	911		798		862		945	
Mean	27.3	27.0	0.3[A]	27.6	-0.3	27.2	0.1	27.9	-0.6 [A]
Std	4.1					3.9		4.1	
Min	7	11		9		11		10	
Max	49	46		54		45		49	
85^{th} Percentile	31	29	2	31	0	31	0	32	-1
% >= 5 mph over	27.4%	23.6%	-1.5%	28.4%	-1.0%	24.5%	2.9%[C]	32.3%	-4.9%[C]
% >= 10 mph over	4.0%	2.6%	0.8%	4.5%	-0.5%	3.5%	0.5%	4.9%	-0.9%[C]
% >= 15 mph over	0.4%	0.2%	0.1%	0.5%	-0.1%	0.5%	-0.1%	0.6%	-0.2
% >= 20 mph over	0%	0%	0%	0%	0%	0%	0%	0.1%	-0.1%[C]
% >= 25 mph over	0%	0%	0%	0%	0%	0%	0%	0%	0

Speeds are in mph
[A] statistically significant at 95% CI using t-test
[B] statistically significant at 90% CI using t-test
[C]statistically significant at 95% CI using test of proportionality
[D]statistically significant at 95% CI using test of proportionality

Roland East 2

Data collection location East 2 (E2) was located to the west of the chevrons (approximately 20 feet) and after the first on-pavement 25 mph markings for the eastern section of E-18. Vehicles traveling westbound crossed the chevrons, and the first on-pavement marking before their speeds were recorded at E2. Results for the westbound traffic are shown in Table 5.21. Vehicles traveling eastbound were exiting Roland as they crossed the pneumatic tubes at E2, so data for these vehicles are not presented. As indicated, speeds decreased for all of the after periods for all of the speed metrics. Minor decreases in the mean and 85^{th} percentile speeds resulted for the after periods. However, decreases were consistent across the year of study. The percent of vehicles traveling more than 5 mph over the posted speed limit decreased by up to 14.7 percent, and those traveling 10 and 15 mph over decreased by up to 13.6 and 4.9 percent, respectively. The treatments were repainted before the twelve-month after period. As noted, speeds were not collected for the six-month after period because of adverse weather.

Table 5.21. Roland East 2 westbound (25 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon	Change	12-mon	Change
Sample	2,397	2,426		2,071		2,196		1,778	
ADT	793	819		702		752		989	
Mean	29.6	29.2	0.4[A]	28.9	0.7	28.3	1.3[A]	28.4	1.2 [A]
Std	6.4	6.0				6.0		3.9	
Min	11	11		11		10		11	
Max	60	54		50		50		44	
85th Percentile	36	35	1	35	1	34	2	32	4
% >= 5 mph over	51.4%	47.7%	3.7%[C]	45.9%	5.5%[C]	43.2%	8.2%[C]	36.7%	14.7%[C]
% >= 10 mph over	19.7%	16.6%	3.1%[C]	16.7%	3.0%[C]	13.8%	5.9%[C]	6.1%	13.6%[C]
% >= 15 mph over	5.3%	4.0%	1.3%[C]	3.6%	1.7%[C]	3.1%	2.2%[C]	0.4%	4.9%[C]
% >= 20 mph over	1.5%	0.9%	0.6%[C]	0.5%	1.0%[C]	0.6%	0.9%[C]	0%	1.5%[C]
% >= 25 mph over	0.3%	0.3%	0%	0.1%	0.2%	0.1%	0.2%[D]	0%	0.3%[C]

Speeds are in mph

[A] statistically significant at 95% CI using t-test [C] statistically significant at 95% CI using test of proportionality

[B] statistically significant at 90% CI using t-test [D] statistically significant at 95% CI using test of proportionality

5.7.6 Overall

The gateway entrance treatments, which consisted of converging chevrons and a “25 mph” on-street pavement marking, were reasonably effective. Speeds decreased for all speed metrics for all of the after periods, and decreases remained constant over the year-long data collection period. The gateway treatments within the community did not appear to affect speeds in any meaningful manner. Speeds were evaluated at control locations away from the treatments and speeds appeared to be consistent from the before to after period, which suggests that no upward or downward trends in speeds independent of the gateway treatments occurred.

5.8 Gilbert , IA

5.8.1. Community Description

Gilbert is located approximately 40 miles north of Des Moines and has a population of 987. The main road through Gilbert is County Highway E-23, which is a two-lane roadway (ADT ~1,480) oriented east/west through the middle of the community. E-23 is 1.31 miles from the city limit on the west to the city limit on the east. Figure 5.24 shows an aerial view of the town, along with the locations of speed zones. The posted speed limit is 55 mph outside of town and 25 mph at the center of town, with transition zones on each end of town. There is also a four-way, stop-controlled intersection at the center of town. The town was in the process of building a new high school as the study commenced near Highway E-23, and two other schools were already near the route.

Furthermore, there were two parks nearby that generated additional pedestrian traffic. These sensitive areas were also shown in Figure 5.13. A total of nine crashes occurred along E-23 in the vicinity of Gilbert from 2001 to 2005.

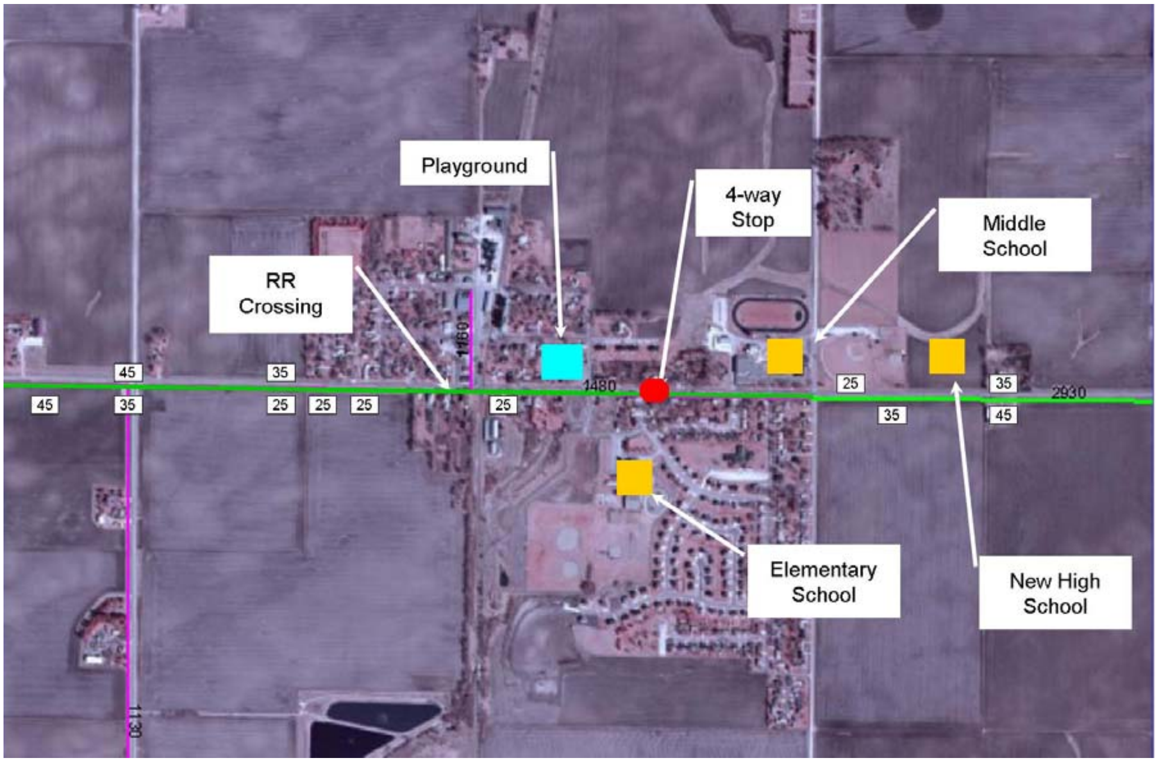

Figure 5.24. Location of signing for Gilbert (image source: http://www.gis.iastate.edu)

5.8.2. Traffic-Calming Treatment

Initial speed studies indicated speeding existed through the center of town and on the east end of town. Near the west edge of town, railroad tracks that crossed Highway E-23 slowed drivers. Therefore, traffic calming was not considered in this area. After the first meeting with the Gilbert city council, a series of speed tables were planned and tentatively approved. The first was planned near the playground, the second in front of the middle school, and the third to the east of the middle school. Before installation occurred, the city decided to place a four-way stop at the intersection just east of the middle school. The team met with the city council again and asked to try speed tables for the duration of the planned study, rather than a four-way stop, but the city council decided to proceed with the four-way stop. As a result, it was determined that the four-way stop would affect operations for the planned second and third speed tables, and the team decided to only place one near the playground, as shown in Figure 5.25. The speed limit on E-23 throughout Gilbert was 25 mph, so a design speed of 30 mph was selected for the speed table. The Iowa DOT does not have formal guidelines for the design of speed tables, so guidelines from the the Delaware DOT (2000) for speed tables were used with approval from the Iowa DOT. Speed-table pavement markings were those approved by the MUTCD for speed tables. Figures 5.26 and 5.27 show the site before and after traffic calming was implemented. An aerial view is provided in Figure 5.28.

Figure 5.25. Location of Gilbert speed table

Figure 5.26. Image of Gilbert before installation of speed table

Figure 5.27. Gilbert after installation of speed table

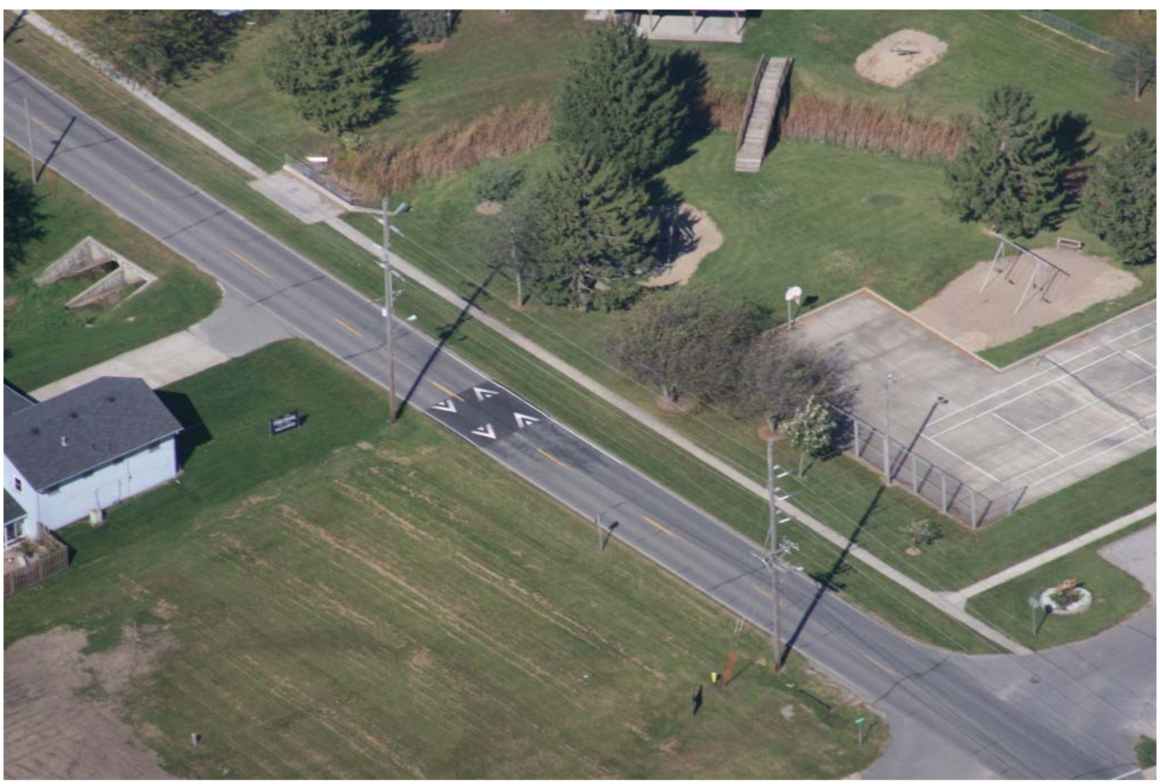

Figure 5.28. Aerial view of speed table

5.8.3. Physical Condition of Treatments over Time

The speed table itself did not require any additional maintenance. The pavement markings wore over time and were repainted in May 2007.

5.8.4. Results

Results are presented by data collection location, which are shown in Figure 5.29. Data were collected at a location to the east and west of the speed table. Although drivers in one direction would only have crossed the speed table at each data collection location, results are presented for each direction because drivers may slow to prepare to cross the table.

West Location by Railroad Crossing

Results for the data collection location west of the speed table (within 200 feet) are presented in Tables 5.22 and 5.23 Drivers traveling eastbound were about to cross the speed table and westbound drivers would have crossed the speed table. The mean and 85th percentile speeds decreased for both directions between 4 and 5 mph for all of the after periods. The percent of vehicles traveling greater than or equal to 5 and 10 mph over the speed limit decreased significantly for both directions of traffic. The fraction of vehicles traveling greater than or equal to 5 mph over the speed limit was decreased by approximately 30.0 percent for both directions of travel for all of the after periods. The fraction of vehicles traveling greater than or equal to 10 mph over the speed limit decreased by approximately 13.0 percent for the eastbound direction and 10.0 percent for the westbound direction for all of the after periods. All of the differences were statistically significant at the 95% level of significance.

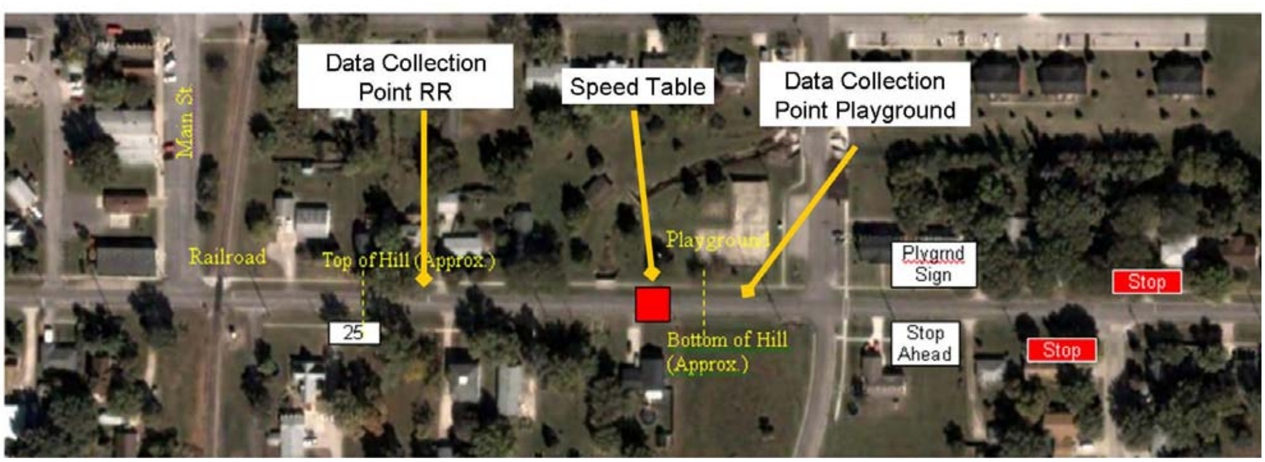

Figure 5.29. Data collection location for Gilbert

Table 5.22. Gilbert West by Railroad eastbound (25 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon	Change	12-mon	Change
Sample	2,361	2,192		2,960		4,009		3,858	
ADT	1,282	1,216		1,197		1,429		1,372	
Mean	30.2	25.8	4.4[A]	26.0	4.2 [A]	25.1	5.1[A]	26.0	4.2[A]
Std	4.3	3.8		3.8		3.6		3.7	
Min	9	9		6		7		8	
Max	46	42		44		55		48	
85^{th} Percentile	34	30	4	30	4	29	5	30	4
% >= 5 mph over	55.4%	15.3%	40.1%[C]	16.4%	39.0%[C]	9.4%	46.0%[C]	15.6%	39.8%[C]
% >= 10 mph over	14.3%	1.3%	13.0%[C]	1.4%	12.9%[C]	0.6%	13.7%[C]	1.8%	12.5%[C]
% >= 15 mph over	1.9%	0.1%	1.8%[C]	0.3%	1.6%[C]	0%	1.9%[C]	0.1%	1.8%[C]
% >= 20 mph over	0.3%	0%	0.3%[C]	0%	0.3%[C]	0%	0.3%[C]	0%	0.3%[C]

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

Table 5.23. Gilbert West by Railroad westbound (25 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon	Change	12-mon	Change
Sample	2,257	2,199		2,763		3,885		3,886	
ADT	1,253	1,236		1,206		1,426		1,831	
Mean	29.5	25.8	3.7[A]	26.3	3.2[A]	25.7	3.8[A]	26.1	3.4 [A]
Std	4.4	4.1		4.2		4.2		4.1	
Min	8	8		5		5		9	
Max	48	41		55		41		40	
85^{th} Percentile	34	30.0	4	30	4	30	4	30	4
% >= 5 mph over	50.7%	16.6%	34.1%[C]	19.8%	30.9%[C]	17.1%	33.6%[C]	19.0%	31.7%[C]
% >= 10 mph over	12.1%	2.0%	10.1%[C]	2.7%	9.4%[C]	2.0%	10.1%[C]	2.1%	10.0%[C]
% >= 15 mph over	1.1%	0.1%	1.0%[C]	0.1%	1.0%[C]	0.1%	1.0%[C]	0.1%	1.0%[C]
% >= 20 mph over	0%	0%	0%	0%	0%	0%	0%	0%	0%

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

East Location by Playground Crossing

The east data collection location was approximately 15 feet east of the speed table. Results for the data collection location east of the speed table are presented in Tables 5.24 and 5.25. The mean speeds decreased for both directions between 2 and 3 mph for all of the after periods. The 85^{th} percentile speeds decreased 4–5 mph for the eastbound direction and 2–3 mph for the westbound direction. The percent of vehicles traveling greater than or equal to 5 and 10 mph decreased significantly for both directions of traffic.

Table 5.24. Gilbert East by Playground eastbound (25 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon	Change	12-mon	Change
Sample	3,685	3,355		3,413		3,982		3,279	
ADT	1,322	1,254		1,230		1,426		1,093	
Mean	26.0	22.6	3.4[A]	23.4	2.6[A]	22.6	3.4[A]	22.9	3.1[A]
Std	5.9	4.5		4.4		4.3		4.3	
Min	7	8		5		6		7	
Max	45	46		45		39		47	
85th Percentile	32.0	27.0	5	28	4	27	5	27	5
% >= 5 mph over	28.5%	6.3%	22.2%[C]	7.8%	20.7%[C]	5.7%	22.8%[C]	5.9%	22.6%[C]
% >= 10 mph over	6.3%	0.7%	5.6%[C]	1.0%	5.3%[C]	0.5%	5.8%[C]	0.6%	5.7%[C]
% >= 15 mph over	0.8%	0.1%	0.7%[C]	0.1%	0.7%[C]	0%	0.8%[C]	0.1%	0.7%[C]
% >= 20 mph over	0%	0%	0%	0%	0%	0%	0%	0.1%	-0.1%[C]

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

Table 5.25. Gilbert East by Playground westbound (25 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon	Change	12-mon	Change
Sample	3,610	3,619		3,479		3,879		3,175	
ADT	1,323	1,283		1,206		1,420		1,058	
Mean	28.1	25.5	2.6[A]	26.4	1.7[A]	25.8	2.3[A]	26.2	1.9[A]
Std	5.2	4.6		4.4		4.7		4.5	
Min	10	8		10		8		6	
Max	51	53		50		43		43	
85th Percentile	33.0	30.0	3	31	2	30	3	30	3
% >= 5 mph over	40.7%	17.0%	23.7%[C]	22.4%	18.3%[C]	20.1%	20.6%[C]	19.7%	21.0%[C]
% >= 10 mph over	9.7%	2.4%	7.3%[C]	3.1%	6.6%[C]	2.9%	6.8%[C]	2.9%	6.8%[C]
% >= 15 mph over	1.0%	0.2%	0.8%[C]	0.2%	0.8%[C]	0.3%	0.7%[C]	0.2%	0.8%[C]
% >= 20 mph over	0.1%	0.1%	0%	0.1%	0%	0%	0.1%[C]	0%	0.1%[C]

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

5.8.5. Summary for Gilbert

The speed table was successful in decreasing speeds for all speed metrics, both immediately upstream and downstream, of the speed table for all of the after periods. The table slowed speeds in both directions. Several residents have complained because they do not like the speed table. The effectiveness of the speed table remained relatively constant over time. This was expected because the device physically forces vehicles to slow down.

5.9 Slater, IA

5.9.1. Community Description

Slater is located approximately 20 miles north of Des Moines and has a population of 1,306. Slater was one of the communities identified by the study team. Two major routes pass through Slater. State Highway 210 is a two-lane road, oriented east/west, and County Highway R-38 is also a two-lane road, oriented north/south. Both serve as major commuter routes. A four-way stop exists at the intersection of the two roadways. Some sensitive areas near the highways include an elementary school near Highway R-38 and a park near SH 210.

Initial speed studies indicated a speeding problem on three sections of the two major routes:

1. SH 210 from the western city limit to the intersection with R-38
2. R-38 from the south city limit to the intersection with SH 210
3. R-38 from the north city limit to the intersection with SH 210

Roadway characteristics are shown in Table 5.26. The eastern section of SH 210 did not have a demonstrated speed limit and was not considered. Because this community was used for the IHRB, the goal was to evaluate low-cost traffic-calming strategies. As a result, three unrelated traffic-calming measures were evaluated. Several strategies were selected and presented in an initial meeting with Slater's city council. After treatments were finalized, the measures were approved in a second meeting with the city council.

Table 5.26. Roadway section descriptions for Slater

Road Section	AADT (vpd)	Length	Cross section	Crashes (2001-05)
SH 210 from west city limit to intersection with	2,940	1225 m	Asphalt paved with unpaved shoulders, 2-lane, total paved width xxx feet	7*
R-38 northern section to intersection with ST 210	2,870	1,199 m	Asphalt paved with unpaved shoulders, 2-lane, total paved width 22.6 feet	5*
R-38 (southern section of Main Street) to intersection with D-65	2,060	805 m	concrete curb and gutter width, 2-lane, 25.8 feet total paved width	1*

*an additional 8 crashes occurred at the intersection of R-38 and SH 210

A total of four crashes occurred over the five-year period considered (2001–2005) along the northern section of R-38. Seven crashes occurred along the western section of SH 210, and one crash was noted along the southern section of R-38. In addition, eight crashes were reported in the five-year period at the intersection of R-38 and ST 210, which is a four-way, stop-controlled intersection.

5.9.2. Traffic-Calming Treatments

For the southern section of R-38, two center island widening were created using longitudinal channelizers, as shown in Figure 5.30. The southern section was concrete with a curb and gutter approximately 25.8 feet wide. Islands were formed by placing 36-inch tall yellow channelizers approximately 3.5 feet apart, forming a center island, which left approximately 11 feet for lanes in each direction. The channelizers were spaced 4 feet apart in the taper and 8 feet elsewhere. A 25 mph speed limit sign was placed on a mountable sign support similar to those used for in-street "Yield for Pedestrians Within Crosswalk" signs. The first island was located at the southern entrance to Slater just after the first 25 mph speed limit (before 10th Street) to slow down northbound traffic upon entering town from the south. The second island was located approximately one block after the first island terminated (between 8th and 9th Streets). The treatment was designed to accommodate farm vehicles and a snowplow.

A European-type pavement-marking treatment was initially planned and approved by Slater's city council for the southern section of SH 210. Variations are shown in Figure 5.31. The treatment also required approval from the Iowa DOT because it was located on a state highway. The Iowa DOT was uncomfortable with the treatment as planned, and as a result, a modified version was used, as shown in Figure 5.32.

A speed feedback sign with the capability of displaying different alphanumeric messages was the treatment selected for the northern section of R-38 (Figure 5.33). The sign can be programmed to display two lines of text with any five alphanumeric characters. The sign differed from those used in Union. The Slater sign was selected so different messages could be evaluated. Because certain procurement requirements had to be followed, the speed feedback sign was not installed at the same time as the other traffic-calming treatments in Slater. The feedback sign was placed just before the collection of the three-month after period in October 2006.

The electronic feedback sign was installed for southbound traffic on Linn Street/510th Avenue in Slater. The feedback sign was placed in a 25 mph speed zone close to the four-way stop located just south of the sign, as shown below in Figure 5.33.

Across the street was Ballard West Elementary School, where a crossing guard helped students cross Linn Avenue in the mornings and afternoons. The feedback sign was mounted on a 6-inch-by-6-inch wood post and was installed by the Iowa DOT with the oversight of a sales representative and researchers from the Center for Transportation Research and Education (CTRE).

To prevent drivers from testing the signs' capabilities, tolerances were programmed into the onboard memory card, which included the following:

- The sign will not display anything if a vehicle is traveling over 75 mph.
- The sign will flash "Slow Down 25" if an approaching vehicle is traveling over 40 mph.
- If an approaching vehicle is between 26 and 29 mph it will display the approach speed and "Your Speed."
- The sign turns off at 25 mph.
- The radar records all speeds (even over or under the tolerances), 24 hours a day.
- The sign dims after 11:30 PM and brightens at 5:00 AM.

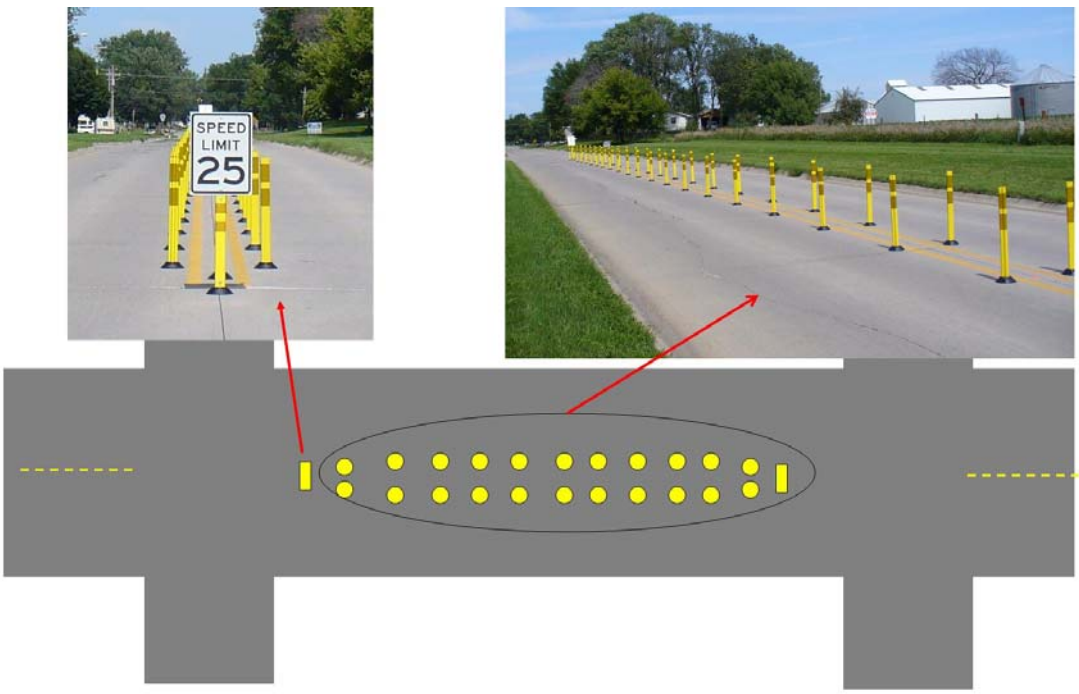

Figure 5.30. Layout of tubular channelizers for southern section of R-38

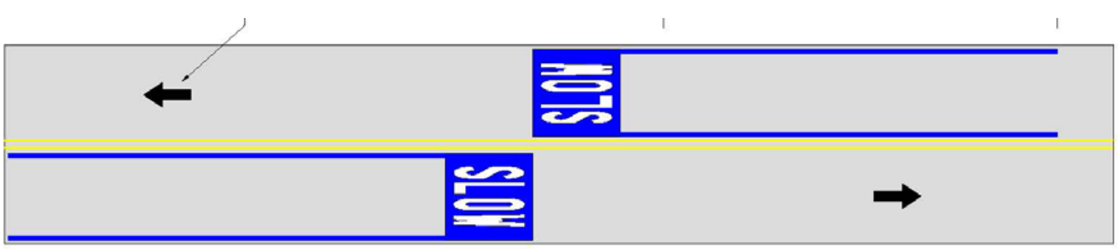

Figure 5.31. Schematic of proposed treatments for western section of SH 210

Figure 5.32. Final treatment for western section of SH 210

Figure 5.33. Speed feedback sign for northern section of R-38

The complete traffic-calming plan for Slater is shown in Figure 5.34.

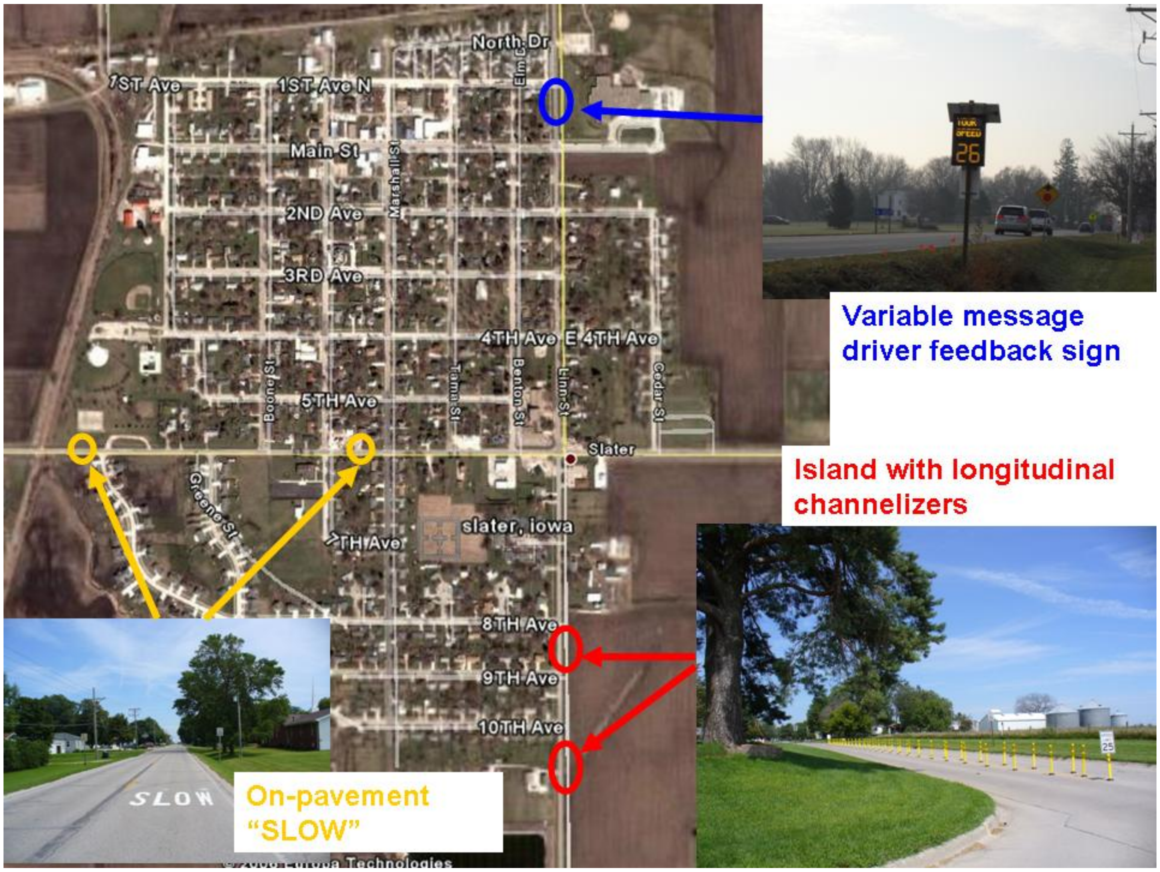

Figure 5.34. Traffic-calming plan for Slater

5.9.3. Physical Condition of Treatments over Time

Unfortunately, the feedback sign was plagued by numerous electrical failures due to unforeseen events and the harsh winter weather of 2006 and 2007. During the winter months, the sign would turn off and would not record speeds with the onboard radar system. New parts were installed to attempt to fix the problem, including new ballast for the solar control panel, six light-emitting diode (LED) panels, and updated software. Along with ordering and installing new parts, existing wires inside the cabinet were upgraded to a heavier gauge, and the ends were soldered to various electrical parts to prevent loose connections due to swaying of the wooden post and cold weather. Researchers made sure the sign worked properly for the after speed studies by checking the sign twice a day.

The tubular channelizers were frequently struck by vehicles. The "25 mph" speed limit sign was completely damaged and replaced a number of times. The city snowplow operator was contacted before the treatment was designed, and she felt that the snowplow would be able to fit through the treatments. This turned out to be true. However, unknown by the team was the fact that the county snowplow also goes through Slater and has a wider blade. The period from January to

March 2007 was plagued by numerous snowstorms and blizzards. The majority of the tubular markers were knocked over by the county snowplow after the first few storms. The markers were then removed until April 2007, when they were replaced. Markers that were heavily damaged were replaced by new markers at that time.

5.9.4. Deviations from Data Collection or Data Analysis Plan

Data were not collected for the three-month after period because of several weeks of bad weather during the three-month interval. As a result, no data are presented for this time period. Because certain procurement requirements had to be followed, the speed feedback sign was not installed at the same time as the other traffic-calming treatments in Slater.

As noted, the tubular markers were removed for approximately 90 days near the nine-month interval and then replaced. Data were collected just before the markers were replaced and then immediately after. This provided an opportunity to evaluate conditions during the middle of the study when the markers were not present and then evaluate what happened when they were replaced.

The feedback sign was placed just before collection of the three-month after period in October 2006. Data were collected approximately one month after the sign was installed and then at the three-month interval. After the three-month interval, County Road R-38 was reconstructed north of the Slater city limit. As a result, data were not collected after the three-month interval. The western section of SH 210 was repaved just before the twelve-month data collection, and, consequently, data were not collected for the twelve-month after period. The team questioned the city and Iowa DOT about any major renovations but was not made aware that renovations would occur or interfere with data collection.

5.9.5. Results

The location where each set of pneumatic tubes was placed for data collection before and after installation of the individual treatments is shown in Figure 5.35. Results are presented by location in the following sections. Results are only presented for directions of interest.

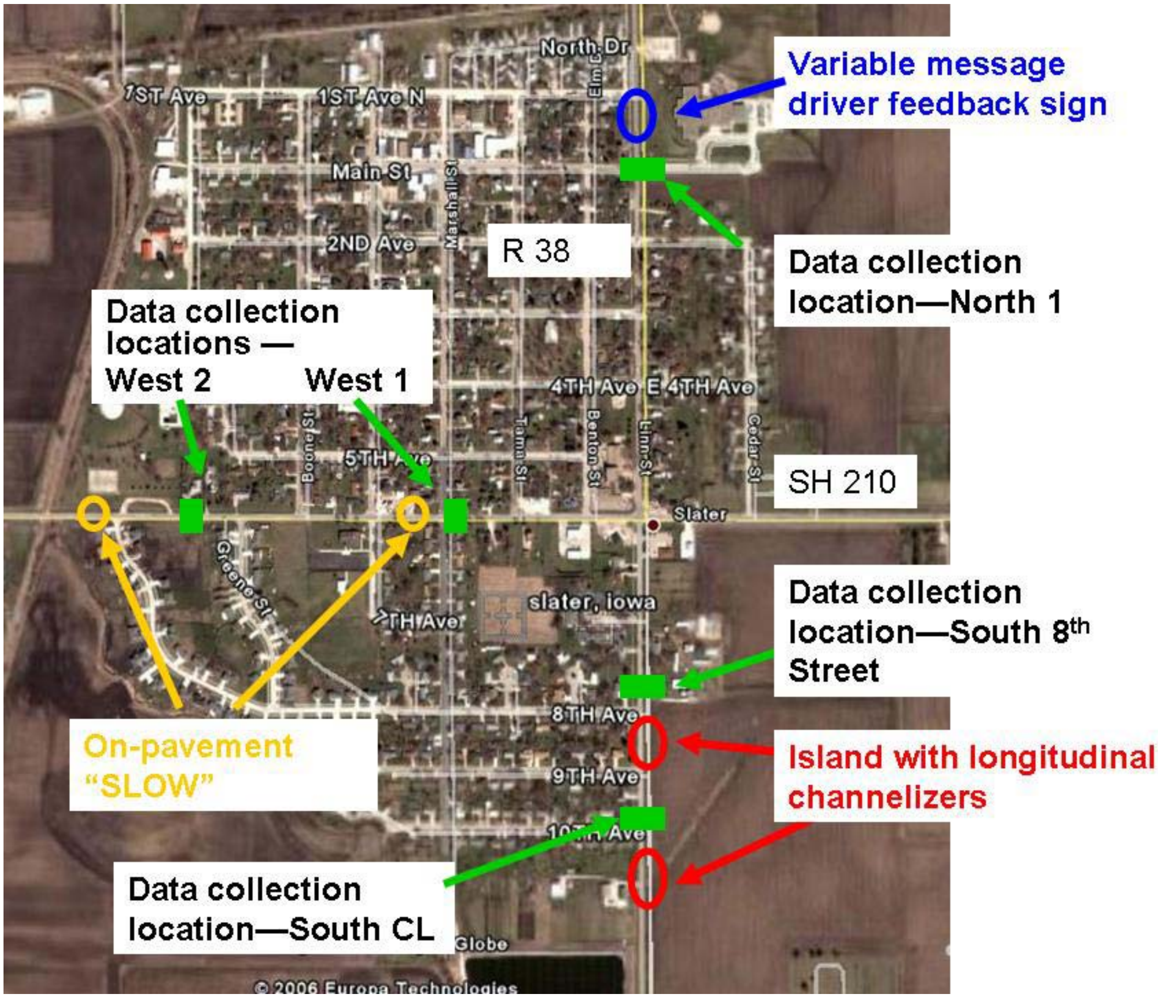

Figure 5.35. Location of data collection for Slater (image source: Digital Globe.com)

South City Limit

Data were collected near the south city limit just to the north of the first longitudinal channelizer island. Through vehicles for the southbound and northbound directions of travel would have crossed one set of channelizers and were about to cross a second set. Results are presented in Tables 5.27 and 5.28. As noted, data were not collected during the three-month after interval because of adverse weather. The tubular markers were removed approximately 90 days before the scheduled nine-month data collection period, as noted above. Data for the nine-month period were collected before the markers were replaced and then recollected shortly after, still within the nine-month period. Note how all speed metrics increased for the time period when the markers were removed and how speed metrics again decreased significantly when the markers were replaced.

Table 5.27. Slater South City Limit northbound (25 mph speed limit)

	Before	1-mon	Change	6-mon	Change	9-mon no markers	Change	9-mon w/ markers	Change	12-mon	Change
Sample	2,669	2,453		2,234		1,807		1,549		2,207	
ADT	1,449	1,290				943		818		788	
Mean	33.3	30.8	2.5[A]	32.6	0.7 [A]	34.9	-1.6[A]	30.7	2.6[A]	32.8	0.5 [A]
Std	7.0	6.5				7.3		6.5		7.0	
Min	12	11		13		7		10		12	
Max	64	62		65		66		53		68	
85th Percentile	40	38	2	39	1	44	-4	37	3	40	0
% >= 5 mph over	74.2%	54.6%	19.6%[C]	66.8%	7.4%[C]	77.7%	-3.5%[C]	56.4%	17.8%[C]	67.8%	6.4%[C]
% >= 10 mph over	43.8%	27.2%	16.6%[C]	36.3%	7.5%[C]	50.5%	-6.7%[C]	26.3%	17.5%[C]	39.5%	4.3%[C]
% >= 15 mph over	17.3%	9.3%	8.0%[C]	14.4%	2.9%[C]	26.0%	-8.7%[C]	8.5%	8.8%[C]	16.5%	0.8%
% >= 20 mph over	4.5%	2.4%	2.1%[C]	4.2%	0.3	9.4%	-4.9%[C]	2.3%	2.2% [C]	5.3%	-0.8%[C]
% >= 25 mph over	0.9%	0.5%	0.4%[C]	1.3%	-0.4%[D]	2.5%	-1.6%[C]	0.5%	0.4%[D]	1.1%	-0.2

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

Table 5.28. Slater South City Limit southbound (25 mph speed limit)

	Before	1-mon	Change	6-mon	Change	9-mon w/o marker	Change	9-mon With Markers	Change	12-mon	Change
Sample	2,806	2,657		2,387		1,665		1,402		2172	
ADT	1,560	1,388				882		737		760	
Mean	37.6	35.6	2.0[A]	35.6	2.0 [A]	38.3	-0.7[A]	34.6	3.0[A]	36.7	0.9 [A]
Std	8.1	6.5				7.5		7.3		7.3	
Min	12	8		8		14		10		9	
Max	66	75		61		69		63		68	
85th Percentile	45	42	3	42	3	45	0	42	3	43	2
% >= 5 mph over	87.1%	86.0%	1.1	85.5%	1.6%[C]	90.6%	-3.5%[C]	78.9%	8.2%[C]	87.8%	-0.7%
% >= 10 mph over	71.5%	56.5%	15.0%[C]	57.1%	14.4%[C]	73.7%	-2.2%[D]	51.5%	20.0%[C]	65.7%	5.8c
% >= 15 mph over	44.2%	25.5%	18.7%[C]	24.8%	19.4%[C]	43.6%	0.6%	23.6%	20.6%[C]	34.9%	9.3%[C]
% >= 20 mph over	17.6%	7.1%	10.5%[C]	6.1%	11.5%[C]	18.7%	-1.1%	7.2%	10.4%[C]	11.6%	6.0%[C]
% >= 25 mph over	3.9%	2.1%	1.8%[C]	1.7%	2.2%[C]	5.5%	-1.6%[C]	1.6%	2.3%[C]	3.1%	0.8%[C]

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

As shown, speeds decreased during the after analysis periods when the tubular markers were in place. The mean speeds decreased by up to 2.6 mph and the 85th percentile speeds decreased by up to 3 mph. Vehicles traveling 5 and 10 mph over the posted speed limit decreased by up to 19.6 percent and vehicles traveling 15 and 20 mph over the speed limit decreased by up to 2.2 percent.

South 8th Street

The second data collection location for the southern section was slightly north of 8th street on R-38. Northbound vehicles would have just passed through the markers and southbound vehicles were about to enter. Results are presented by direction in Tables 5.29 and 5.30. As indicated, the mean speeds and 85th percentile speeds decreased for the northbound vehicles around 1.4 and 3.3 mph and from 1.0 to 2.7 mph for the southbound direction of traffic. A significant reduction in the number of vehicles traveling 5 and 10 mph over the posted speed limit of 25 mph occurred for both directions of traffic, with modest reductions for 15 and 20 mph. A very small increase occurred for 25 mph over the speed limit, but the difference was not statistically significant. A large difference in the percentage of vehicles traveling 5, 10, or 15 mph over the posted speed limit occurred from the before to after period, with small decreases in the percentage traveling 20 and 25 mph over the posted speed limit for the southbound direction of traffic.

Table 5.29. Slater South 8th Street northbound (25 mph speed limit)

	Before	1-mon	Change	6-mon	Change	9-mon No markers	Change	9-mon With markers	Change	12-mon	Change
Sample	2,929	2,553		1,773		1,902		1,638		1,428	
ADT	1,523	1,350				998		872		767	
Mean	31.5	28.2	3.3[A]	30.1	1.4[A]	31.5	0	28.4	3.1[A]	29.1	2.4[A]
Std	4.7	5.1		5.4		6.3		5.2		5.9	
Min	12	10		8		10		11		9	
Max	52	64		54				51		55	
85th percent	36	33	3	35	1	38	-2	33	3	35	1
% >= 5 mph over	66.0%	34.2%	31.8%[C]	53.9%	12.1%[C]	58.9%	7.1%[C]	37.8%	28.2%[C]	43.9%	22.1%[C]
% >= 10 mph over	23.5%	11.0%	12.5%[C]	19.7%	3.8%[C]	28.4%	-4.9%[C]	11.1%	12.4%[C]	15.9%	7.6%[C]
% >= 15 mph over	5.3%	2.3%	3.0%[C]	3.8%	1.5%[C]	10.2%	-4.9%[C]	3.0%	2.3%[C]	4.1%	1.2%[C]
% >= 20 mph over	1.0%	0.5%	0.5%[C]	1.0%	0	2.5%	-1.5%[C]	0.7%	0.3%	0.9%	0.1
% >= 25 mph over	0.1%	0.2%	-0.1%	0.2%	-0.1	0.7%	-0.6%[C]	0.1%	0%[C]	0.2%	-0.1

Speeds are in mph

[A] statistically significant at 95% CI using t-test [C] statistically significant at 95% CI using test of proportionality

[B] statistically significant at 90% CI using t-test [D] statistically significant at 95% CI using test of proportionality

Table 5.30. Slater South 8th Street southbound (25 mph speed limit)

	Before	1-mon	Change	6-mon	Change	9-mon No markers	Change	9-mon with markers	Change	12-mon	Change
Sample	3,035	2,745		2,471		1,759		1,488		1,443	
ADT	1,588	1,442				926		790		763	
Mean	34.8	32.6	2.2[A]	33.0	1.8 [A]	35.6	-0.8[A]	32.1	2.7[A]	33.8	1.0 [A]
Std	5.7	5.6		5.7		6.6		6.3		6.4	
Min	12	13		9		13		10		10	
Max	59	57		57		62		63		62	
85th Percentile	40	38	2	39	1	42	-2	38	2	40	0
% >= 5 mph over	82.7%	70.2%	12.5%[C]	72.9%	9.8%[C]	83.2%	-0.5%	65.2%	17.5%[C]	78.6%	4.1%[C]
% >= 10 mph over	50.6%	33.8%	16.8%[C]	37.8%	12.8%[C]	56.7%	-6.1%[C]	33.4%	17.2%[C]	43.9%	6.7%[C]
% >= 15 mph over	19.2%	10.1%	9.1%[C]	11.6%	7.6%[C]	26.5%	-7.3%[C]	10.6%	8.6%[C]	16.7%	2.5%[C]
% >= 20 mph over	5.1%	2.3%	2.8%[C]	2.8%	2.3%[C]	8.0%	-2.9%[C]	2.9%	2.2%[C]	4.6%	0.5
% >= 25 mph over	0.9%	0.5%	0.4%[C]	0.7%	0.2	2.4%	-1.5%[C]	0.8%	0.1%	1.2%	-0.3

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

North at School

Data were collected just south of the driver feedback sign. As noted, the sign was not installed until three months after the other treatments. Data were collected three months after installation of the signs. The three-month after period corresponds to three months after installation of the signs and does not correspond to the same after periods for the rest of the Slater treatments. In addition, as noted, R-38 north of Slater was reconstructed, and, owing to frequent road closures, no additional after periods were collected. Vehicles traveling southbound would have just passed the speed feedback sign. Results shown in Table 5.31 indicate all speed metrics decreased significantly after installation of the sign.

Table 5.31. Slater North at School southbound (25 mph speed limit)

	Before	3-mon	Change
Sample	4,566	4,121	
ADT	2,343	2,223	
Mean	31.3	25.9	5.4[A]
Std	5.7	4.0	
Min	7	6	
Max	59	52	
85th Percentile	37	30	7
% >= 5 mph over	64.3%	15.7%	48.6%[C]
% >= 10 mph over	29.2%	2.7%	26.5%[C]
% >= 15 mph over	6.9%	0.5%	6.4%[C]
% >= 20 mph over	0.7%	0.2%	0.5%[C]
% >= 25 mph over	0.1%	0%	0.1%[C]

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

Slater West 1

The West 1 data collection location is located on SH 210 several blocks east of the four-way stop between SH 210 and R-38, as shown in Figure 5.35. The first on-pavement "Slow" marking was just to the west. Eastbound vehicles would have just crossed the markings. Results for eastbound vehicles are presented in Table 5.32. Due to adverse weather, data were not collected for the three-month after period. As indicated, only a very minor decrease in any of the speed metrics occurred from before the one-month after period.

As also indicated, only modest decreases in the mean and 85th percentile speeds, or in the percentage traveling 5, 10, or 15 mph above the posted speed limit (25 mph), occurred for the eastbound direction of traffic. Minor increases or no change in speeds occurred for the percent of vehicles traveling 25 or above the posted speed limit.

Table 5.32. Slater West 1 eastbound (25 mph speed limit)

	Before	1-mon	Change	6-mon	Change	9-mon	Change
Sample	3,503	3,294		2,886		3,084	
ADT	1,848	1,777				1,634	
Mean	29.3	29.1	0.2[B]	26.7	2.6 [A]	28.4	0.9[A]
Std	5.0	4.9				4.7	
Min	9	12		6		10	
Max	51	50		46		53	
85th Percentile	34	34	0	32	2	33	1
% >= 5 mph over	48.2%	46.7%	1.5%	32.3%	15.9%[C]	40.2%	8.0%[C]
% >= 10 mph over	14.7%	13.1%	1.6%[C]	7.2%	7.5%[C]	9.3%	5.4%[C]
% >= 15 mph over	2.5%	1.9%	0.6%[C]	0.8%	1.7%[C]	1.0%	1.5%[C]
% >= 20 mph over	0.1%	0.2%	-0.1%	0.1%	0	0.3%	-0.2%[C]

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

West Crosswalk

The second data collection for the western section of SH 210 is presented in Tables 5.33 and 5.34 for the east and westbound directions of traffic, respectively. The data collection location was between the two sets of on-pavement “Slow” markings. Both east and westbound vehicles would have crossed one set of markings. Due to adverse weather, data were not collected for the three-month after period. In addition, the road was repaved just before the final data collection period, so data were not collected at the twelve-month after period.

As indicated, moderate to large increases occurred for all speed metrics for both directions of traffic. It is unlikely that the treatment (the on-pavement “Slow” marking) caused drivers to increase their speeds, so the speeds overall along SH 210 may have increased over the study period.

Table 5.33. Slater West by Crosswalk eastbound (25 mph speed limit)

	Before	1-mon	Change	6-mon	Change	9-mon	Change
Sample	2,812	2,888		2,901		2,570	
ADT	1,497	1,519				1,349	
Mean	35.8	38.2	-2.4[A]	35.8	0	36.4	-0.6[A]
Std	5.3	5.6				5.4	
Min	13	17		12		11	
Max	58	64		88		59	
85^{th} Percentile	41	44	-3	42	-1	42	-1
% >= 5 mph over	90.6%	94.3%	-3.7%[C]	83.6%	7.0%[C]	91.3%	-0.7%
% >= 10 mph over	59.9%	76.1%	-16.2%[C]	55.7%	4.2%[C]	67.4%	-7.5%[C]
% >= 15 mph over	23.3%	41.3%	-18.0%[C]	26.9%	-3.6%[C]	27.4%	-4.1%[C]
% >= 20 mph over	5.3%	12.2%	-6.9%[C]	9.7%	-4.4%[C]	5.9%	-0.6%
% >= 25 mph over	1.1%	2.4%	-1.3%[C]	3.5%	-2.4%[C]	0.7%	0.4%

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

Table 5.34. Slater West by Crosswalk westbound (25 mph speed limit)

	Before	1-mon	Change	6-mon	Change	9-mon	Change
Sample	2,748	2,824		1,604		2,411	
ADT	1,466	1,498				1,260	
Mean	40.0	42.7	-2.7[A]	56.6	-16.6	41.4	-1.4[A]
Std	6.2	6.4				6.5	
Min	10	11		12		9	
Max	63	67		89		66	
85^{th} Percentile	46	49	-3	72	-26	48	-2
% >= 5 mph over	96.4%	96.8%	-0.4%	95.6%	-0.8	95.1%	1.3%[C]
% >= 10 mph over	84.4%	91.4%	-7.0%[C]	90.6%	-6.2	88.1%	-3.7%[C]
% >= 15 mph over	56.0%	73.4%	-17.4%[C]	84.5%	-28.5	66.0%	-10.0%[C]
% >= 20 mph over	22.2%	39.3%	-17.1%[C]	76.4%	-54.2	31.6%	-9.4%[C]
% >= 25 mph over	5.3%	12.2%	-6.9%[C]	67.8%	-62.5	8.7%	-3.4%[C]

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

5.9.6. Results for Slater

Results indicate that the tubular markers used to form a center island for the southern section of R-38, and the use of a driver speed feedback sign for the northern section of R-38, in Slater reduced speeds significantly. Use of the on-pavement markings “Slow” did not appear to be effective.

5.10 Dexter, IA

5.10.1. Community Description

Dexter is located approximately 30 miles west of Des Moines and has a population of 689. City officials responded to the initial newsletter because they were concerned about speeding on the main route through Dexter, County Highway F-65. Residents complained of drivers entering town at high speeds. The posted speed limit was 55 mph outside of town and dropped to 35 mph at the eastern and western transition zones with 35 mph throughout. There is also a “25 mph when flashing” zone near the center of town, which is in effect for about 45 minutes for the morning arrival and afternoon dismissal periods when school is in session. Some sensitive areas near the highways included an elementary school, park, and metal fabrication plant (near the western city limit). Trucks entering Ramark Industries, Inc., the fabrication plant, are required to back into the plant from the highway. The city had expressed a safety concern because vehicles are traveling at high speeds when they enter the western city limits. A layout of the community is provided in Figure 5.36.

F-65 is an asphalt-paved, two-lane roadway with unpaved shoulders, except through the center of town, which has a curb and gutter. The roadway is approximately 25.4-feet wide in the location where traffic-calming treatments were applied for the western entrance to the community, and approximately 24.2-feet wide at the eastern location where the traffic-calming treatments were placed. Both areas are paved with unpaved shoulders.

Figure 5.36. Layout for Dexter (image source: http://www.gis.iastate.edu)

5.10.2. Traffic-calming treatments

Initial speed studies indicated high vehicle speeds entering the communities in both directions. Speeds were not problematic in the center of town. After examining the initial speed studies and receiving input from city officials, a traffic-calming plan was created. The plan was modeled after European gateway treatments similar to those shown in Figures 5.37 and 5.38**.** A schematic of the final treatment is presented in Figure 5.39 and the traffic-calming plan is shown in Figure 5.40.

One set of treatments was placed on the eastern side of town as vehicles entered the community. This is some distance from the first 35 mph speed limit sign on the eastern edge of town. However, very little development was present near this area. As a result, the set of treatments were placed just at the edge of development. One treatment was placed just inside the city limits on the western edge of Dexter for the eastbound traffic. Immediately after this location were several driveways for Ramark Industries, Inc. There was no other development for several blocks to the east. The city was concerned about high vehicle speeds entering the community combined with heavy trucks backing into the plant.

The first western treatment was placed to slow drivers before they reached the plant. Because this location did not mark the edge of the community, a second set of treatments was placed several blocks to the east at the beginning of the development on the west. The surface treatments were selected after confirming that the measures did not violate guidelines set forth by the MUTCD. In addition to red markings with “35 mph,” an 8-inch edgeline was painted along the sets of treatments. Figures 5.41 through 5.44 show the site before and after traffic calming was implemented.

Figure 5.37. Image of a European gateway entrance treatment

Figure 5.38. European gateway entrance treatments (image source: DETR 2005)

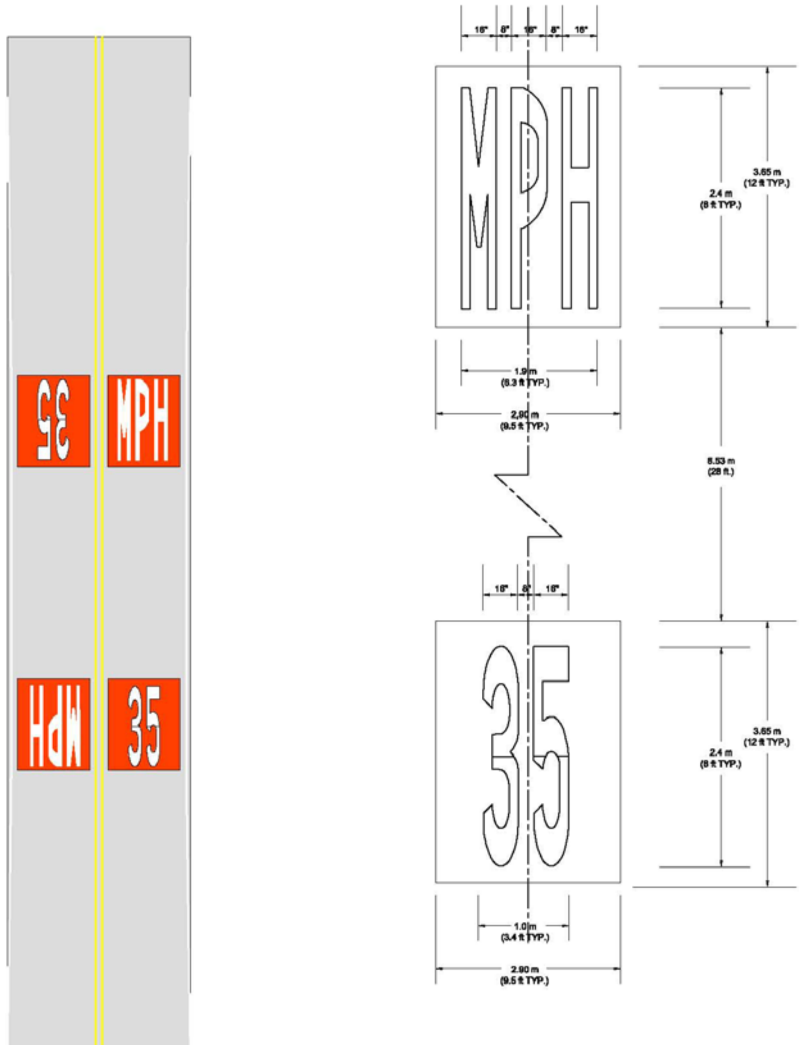

Figure 5.39. Schematic of Dexter treatments

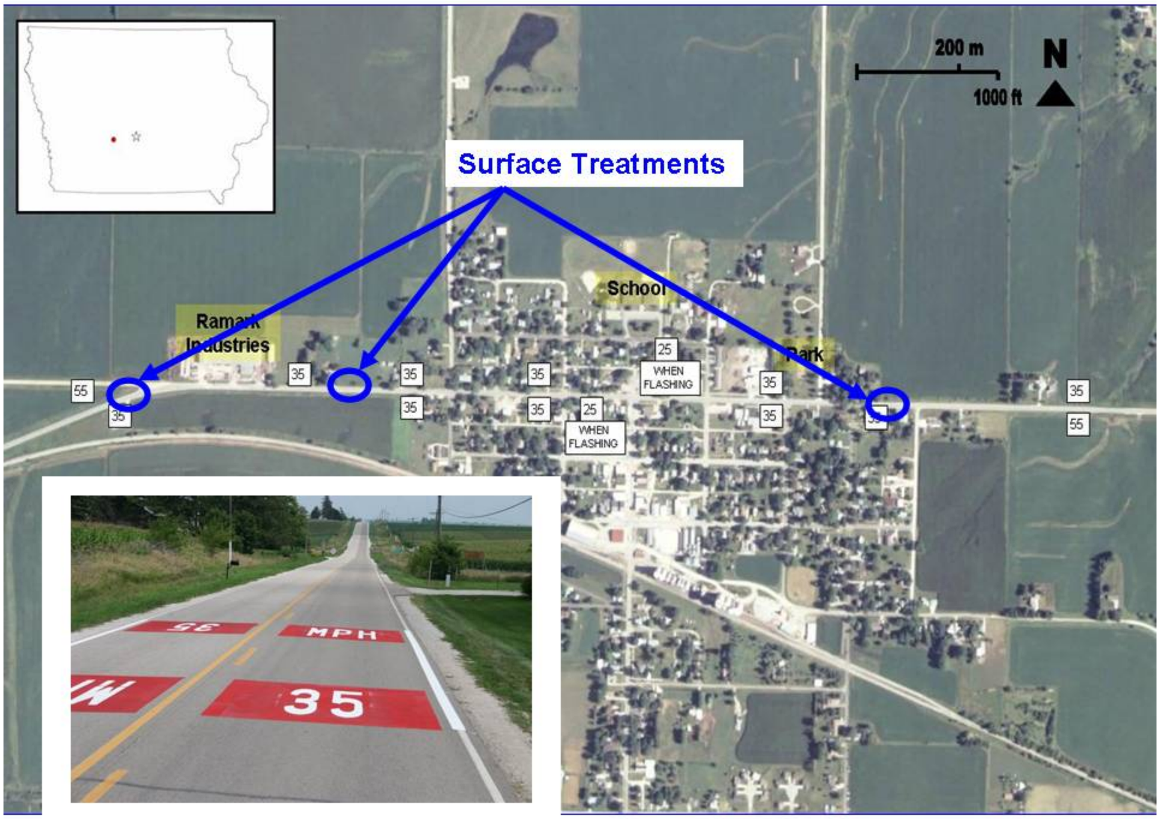

Figure 5.40. Final traffic-calming plan for Dexter

5.10.3. Deviations from Data Collection or Data Analysis Plan

Data were not collected for the six-month after period. As noted, very low temperatures and blizzards made data collection impossible during the six-month after interval. As a result, data are not presented for this time period.

Figure 5.41. Before installation of treatment outside of Dexter industrial plant

Figure 5.42. After installation of treatment before industrial plant

Figure 5.43. Before installation of treatment at Dexter eastern entrance

Figure 5.44. After installation of treatment

5.10.4. Physical condition of treatments over time

The red pavement markings faded fairly quickly. This treatment was the first time that the Iowa DOT maintenance crew had completed this type of work, so it was difficult to tell whether the right amount of paint was applied. The markings were fairly faded by the three-month after period and nearly faded by the nine-month after period. The markings were repainted about two months before the twelve-month after period. The team suggested considering thermoplastic treatments because any treatment should meet requirements for skid resistance. The fading of the markings after only three to four and six months is shown in Figure 5.45.

Figure 5.45. Wear of Dexter treatment over time.

5.10.5. Results

Locations for data collection are shown in Figure 5.46. Results are presented by location in the following section

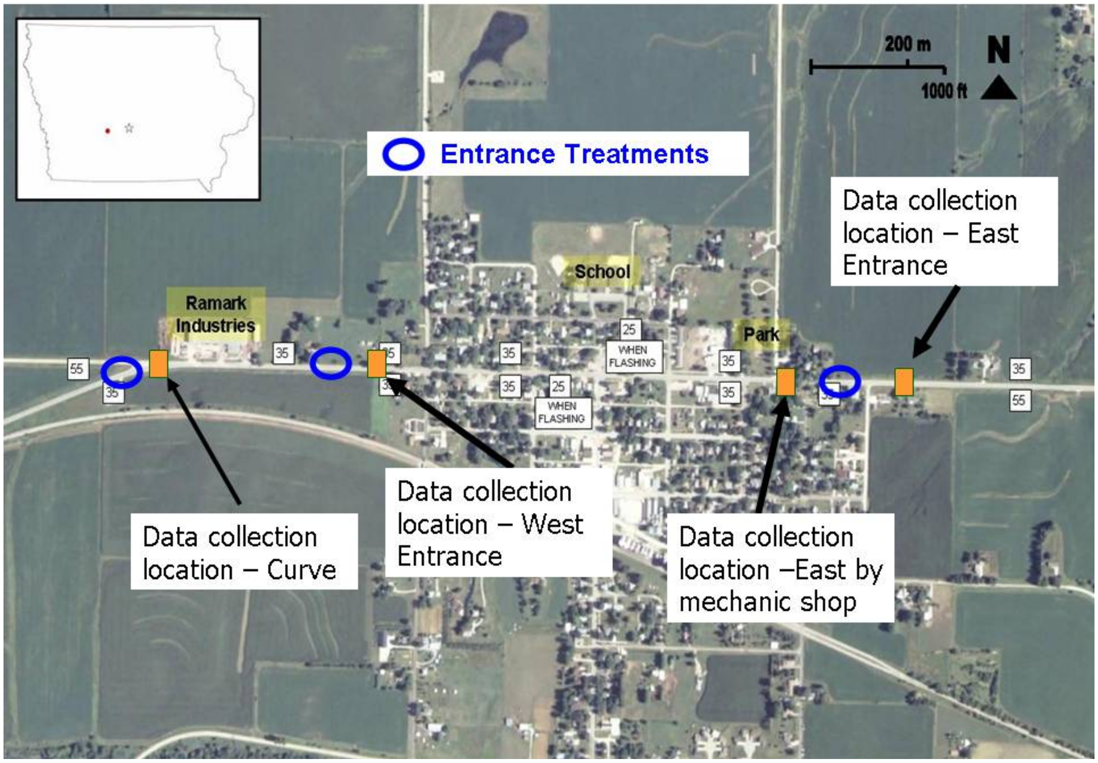

Figure 5.46. Location of data collection in Dexter

Dexter West Curve

Speed data for the eastbound direction are shown in Table 5.35. Vehicles traveling eastbound would just have crossed the gateway treatment. The west curve location only had a treatment in the eastbound lane. As a result, drivers in the westbound direction, who were about to exit the city limit to a 55 mph speed zone, would not have encountered the treatment. Therefore, results are only presented for the eastbound direction of traffic. As indicated, fairly substantial speed reductions occurred for all of the after periods, and results were statistically significant at the 95% level of significance. The markings faded over time, and, as a result, were repainted before the twelve-month data collection period. The decreases for the twelve-month data collection period were smaller than the decreases for previous time periods. It is unknown why this was the case because the treatments had just been repainted. Although the twelve-month period had the smallest reductions, speed reductions were maintained over time.

Table 5.35. Dexter West Curve eastbound (35 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon Markings faded	Change	12-mon Markings repainted	Change
Sample	2,190	2,150		2,022		4,033		2,031	
ADT	1,109	1,084		1,029		1,361		1,016	
Mean	44.9	39.9	5.0[A]	40.4	4.5[A]	37.5	7.4[A]	44.1	0.8[A]
Std	6.8	6.4		6.7		5.9		6.7	
Min	16	13		10		11		16	
Max	76	67		66		63		74	
85^{th} Percentile	52	47	5	47	5	43	9	51	1
% >= 5 mph over	78.0%	46.3%	31.7%[C]	51.5%	26.5%[C]	34.7%	43.3%[C]	73.6%	4.4%[C]
% >= 10 mph over	53.3%	23.0%	30.3%[C]	26.9%	26.4%[C]	11.1%	42.2%[C]	47.2%	6.1%[C]
% >= 15 mph over	25.4%	8.0%	17.4%[C]	9.3%	16.1%[C]	2.8%	22.6%[C]	21.9%	3.5%[C]
% >= 20 mph over	7.8%	2.0%	5.8%[C]	2.5%	5.3%[C]	0.4%	7.4%[C]	5.7%	2.1%[C]
% >= 25 mph over	1.6%	0.6%	1.0%[C]	0.4%	1.2%[C]	0.1%	1.5%[C]	1.1%	0.5%[D]

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

After Industrial Plant (West)

The next data collection location was located to the east of an industrial plant. Drivers traveling eastbound would have crossed the treatment before encountering the road tubes, and drivers traveling westbound would not have encountered the road tubes. As a result only data for the eastbound drivers are shown. As indicated in Table 5.36, large differences were noted for all speed metrics for all time periods. The differences were statistically significant at the 95 percent level of significance for most of the metrics.

Table 5.36. Dexter West after Plant eastbound (35 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon Markings faded	Change	12-mon Markings repainted	Change
Sample	2,369	2,256		2,119		4,027		3,168	
ADT	1,207	1,133		1,075		1,355		1,074	
Mean	38.0	35.3	2.7[A]	36.2	1.8[A]	32.6	5.4 [A]	36.5	1.5 [A]
Std	6.6	4.8		4.9		4.8		4.8	
Min	8	6		10		9		12	
Max	62	61		60		58		63	
85th Percentile	45	40	5	41	4	37	8	41	4
% >= 5 mph over	38.5%	15.1%	23.4%[C]	21.3%	17.2%[C]	6.3%	32.2%[C]	23.7%	14.8%[C]
% >= 10 mph over	15.2%	3.9%	11.3%[A]	5.2%	10.0%[C]	0.7%	14.5%[C]	5.7%	9.5%[C]
% >= 15 mph over	4.9%	0.8%	4.1%[A]	1.1%	3.8%[C]	0.1%	4.8%[C]	1.2%	3.7%[C]
% >= 20 mph over	1.1%	0.2%	0.9%[A]	0.3%	0.8%[C]	0.1%	1.0%[C]	0.2%	0.9%[C]
% >= 25 mph over	0.2%	0.1%	0.1%	0%	0.2%[C]	0%	0.2%[C]	0%	0.2%[C]

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

Dexter East Entrance

Westbound traffic at the data collection location for the east entrance would have just crossed the traffic-calming treatment on the east side of town. Eastbound traffic were measured just upstream of the treatment (before crossing), and as a result data for this traffic are not shown. Results are presented in Table 5.37. Small decreases in all speed metrics occurred for the one- and three-month after periods. Speeds increased slightly at the nine-month data collection period, and most of the increases were not statistically significant. As indicated, the treatment faded significantly and was repainted before the twelve-month data collection period. Speeds decreased slightly for the twelve-month after period for most of the speed metrics.

Table 5.37. Dexter East Entrance westbound (35 mph speed limit)

	Before	1-mon	Change	3-mon	Change	9-mon Markings faded	Change	12-mon Markings repainted	Change
Sample	4,254	3,998		2,900		487		4,031	
ADT	1,443	1,336		1,318		996		1,357	
Mean	34.5	34.1	0.4[A]	33.9	0.6 [A]	35.1	-0.6 [A]	34.0	0.5[A]
Std	5.2	4.8				4.8		5.0	
Min	9	12		11		14		9	
Max	56	61		63		56		64	
85th Percentile	40	38	2	39	1	40	0	39	1
% >= 5 mph over	15.0%	11.2%	3.8%[C]	12.2%	2.8%[C]	15.2%	-0.2%	11.7%	3.3%[C]
% >= 10 mph over	3.5%	2.2%	1.3%[C]	2.2%	1.3%[C]	3.3%	0.2%	2.4%	1.1%[C]
% >= 15 mph over	0.5%	0.5%	0%	0.4%	0.1%[C]	1.4%	-0.9%[C]	0.5%	0%[C]
% >= 20 mph over	0%	0.1%	-0.1%[C]	0.1%	-0.1%[C]	0.4%	-0.4%	0.1%	-0.1%[C]
% >= 25 mph over	0%	0%	0%	0%	0%	0%	0%	0.1%	-0.1%[C]

Speeds are in mph
[A] statistically significant at 95% CI using t-test [C]statistically significant at 95% CI using test of proportionality
[B] statistically significant at 90% CI using t-test [D]statistically significant at 95% CI using test of proportionality

5.10.6. Summary for Dexter

The treatments were effective in reducing speeds at all three of the testing locations. The effectiveness varied over time. With the exception for one location during the nine-month after period, when the markings had faded somewhat, the treatments remained effective over time. Several members of the city council indicated that they felt that the treatments were effective as well.

6. SUMMARY

This project evaluated traffic-calming treatments on major roads through small Iowa communities using either single-measure low-cost or gateway treatments. Seven different low-cost traffic treatments were implemented and evaluated in five rural Iowa communities. The research evaluated the use of two gateway treatments in Union and Roland, Iowa; five single-measure treatments (speed table, on-pavement “SLOW” markings, driver speed feedback sign, tubular markers, and on-pavement entrance treatment) were evaluated in Gilbert, Slater, and Dexter, Iowa. Speed data were collected before each treatment was laid and at one-, three-, six-, nine-, and twelve-month intervals after. In some cases, an interval was missed due to extreme weather conditions that existed over a period of time.

Roland, Iowa was a gateway treatment community. The gateway treatment consisted of a set of converging chevrons placed as vehicles entered Roland from the east and west. On-pavement speed signing and lane narrowing using shoulder widening were also used. Results of the speed analysis indicate the gateway entrance treatments, which consisted of converging chevrons and a “25 MPH” on-street pavement marking, were reasonably effective. Speeds decreased for all speed metrics for all of the after periods and decreases remained constant over the year-long data collection period. The gateway treatments (lane narrowing and on-pavement speed markings) within the community did not appear to affect speeds in any meaningful manner. Speeds were evaluated at control locations away from the treatments and speeds appeared to be consistent from the before to after period, which suggests that no upward or downward trends in speeds occurred independent of the gateway treatment.

Union, Iowa was also a gateway treatment community. The treatments for Union included peripheral transverse pavement markings, median and shoulder widening, and driver feedback signs. Entrance treatments consisting of the on-pavement transverse bars were used at the west, south, and north community entrances. Median and shoulder widening were used for the north section of S-62/SH 215 since it is the only section that has curb and gutter. Driver speed feedback signs were installed before the nine-month data collection interval. The transverse markings appear to be moderately effective in decreasing vehicle speeds directly downstream of the markings for all three gateways, although none of the differences were large. The lane narrowing using center island widening did not appear to be effective. Once the speed feedback signs were installed, significant speed decreases resulted.

Union appeared to have experienced a general upward trend in speeds independent of the gateway treatments. Speeds measured at control locations where the effect of the treatments would not have been felt indicated that speeds overall increased over the study period. This may suggest that the full effect of the treatments is not reflected in the data presented. It could be argued that if overall speeds had remained the same, greater speed decreases than recorded may have resulted. An attempt to adjust the after data at the treatment locations to reflect the overall upward speed trends was attempted using a normal transformation. However, the speed data were slightly non-normal. This did not affect the results of the statistical tests to compare before and after data (t-test, test of proportionality). However, data could not be transformed with any confidence in the accuracy of the final results. Consequently, the team feels that the treatments were likely more effective than are reflected in the final results.

Gilbert, Iowa received one of the low-cost treatments. A single speed table was placed on the main through road. The speed table was successful in decreasing speeds for all speed metrics both immediately upstream and downstream of the speed table for all of the after periods. The table slowed speeds in both directions. Several residents have complained because they do not like the speed table. The effectiveness of the speed table remained relatively constant over time. This was expected, since the device physically forces vehicles to slow down.

Dexter, Iowa also received low-cost treatments. In this case, a gateway entrance treatment was used. A gateway entrance differs from a full gateway treatment in that the treatment is placed only at the entrances and is not carried throughout the community. The treatment was a modification of a European entrance treatment which consisted of red pavement markings and on-pavement speed signing. The treatments were effective in reducing speeds at all three of the locations where they were tested. The effectiveness varied over time, with the exception for one location during the nine-month after period when the markings had faded somewhat.

Slater, Iowa had three different areas of concern, so three different low-cost treatments were applied. A speed feedback sign was used for a northern section of roadway. Due to late procurement, sign malfunctions, and road construction, the sign was only evaluated for one after period. A western roadway section received on-pavement “SLOW” markings. The treatments were not judged to be effective. The final treatment was creation of a center island using tubular channelizers. Two islands were created one block apart. Speeds were significantly reduced with the channelizer islands.

In many cases, even the most effective treatments, only reduced mean and 85th percentile speeds by a modest amount. The true effectiveness is their ability to significantly reduce the number of vehicles traveling over the speed limit.

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