

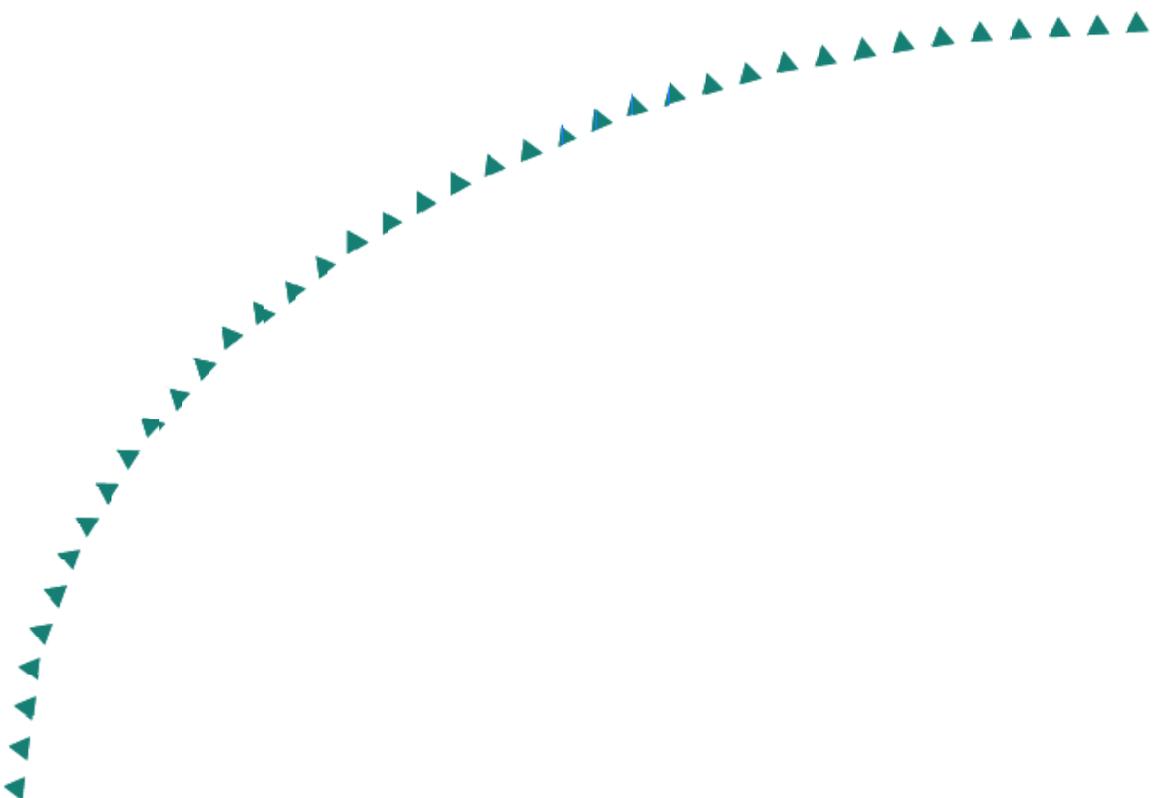
2006-42

Final Report

Stopping Behavior at Real-World
Stop-Controlled Intersections
with and without In-Lane Rumble Strips



Research



Technical Report Documentation Page

1. Report No. MN/RC-2006-42	2.	3. Recipients Accession No.	
4. Title and Subtitle Stopping Behavior at Real-World Stop-Controlled Intersections <i>with</i> and <i>without</i> In-Lane Rumble Strips		5. Report Date November 2006	
		6.	
7. Author(s) Kathleen A. Harder, Ph.D., John R. Bloomfield, Ph.D. and Benjamin Chihak, BA		8. Performing Organization Report No.	
9. Performing Organization Name and Address Center for Human Factors Systems Research and Design University of Minnesota Suite 225 1425 University Ave. SE Minneapolis, MN 55414		10. Project/Task/Work Unit No.	
		11. Contract (C) or Grant (G) No. (c) 81655 (wo) 71	
12. Sponsoring Organization Name and Address Minnesota Department of Transportation 395 John Ireland Boulevard Mail Stop 330 St. Paul, Minnesota 55155		13. Type of Report and Period Covered	
		14. Sponsoring Agency Code	
15. Supplementary Notes http://www.lrrb.org/PDF/200642.pdf			
16. Abstract (Limit: 200 words) This was the third in a series of studies investigating various aspects of rumble strips. In this study, to determine the effect of rumble strips on the real-world stopping behavior of drivers, we used a radar gun to collect speed data from over 400 vehicles on the approaches to ten intersections selected from a sample of 274 approaches. We found that, after drivers encountered the first set of in-lane rumble strips, they slowed down earlier on real-world approaches <i>With Rumble Strips</i> than on real-world approaches <i>Without Rumble Strips</i> —the difference was, on average, 2.0 mph to 5.0 mph (depending on vehicle category and type of approach). In addition, speeding outliers were more likely to slow down earlier on approaches <i>With Rumble Strips</i> . The effect of the presence of in-lane rumble strips on stopping behavior was greater for approaches where the driver's view of traffic on the major road is <i>obscured</i> on one or both sides of the road. The study suggests that stop-controlled intersections at which cross-traffic is obscured by man-made structures and/or vegetation on one or both sides of the intersection would be good candidates for implementing in-lane rumble strips. It is worth noting that while in-lane rumble strips are likely to reduce crashes, they cannot eliminate them. Some drivers might still run stop signs and others might misjudge gaps.			
17. Document Analysis/Descriptors In-lane rumble strips, real-world study, stopping behavior		18. Availability Statement No restrictions. Document available from: National Technical Information Services, Springfield, Virginia 22161	
19. Security Class (this report) Unclassified	20. Security Class (this page) Unclassified	21. No. of Pages 364	22. Price

**Stopping Behavior at Real-World Stop-Controlled
Intersections
*with and without In-Lane Rumble Strips***

Prepared by:

Kathleen A. Harder, Ph.D.
John R. Bloomfield, Ph.D.
Benjamin J. Chihak, BA

**Center for Human Factors Systems Research and Design
University of Minnesota**

November 2006

Published by:

Minnesota Department of Transportation
Research Services Section
Mail Stop 330
395 John Ireland Boulevard
St. Paul, Minnesota 55155-1899

This report represents the results of research conducted by the authors and does not necessarily represent the view or policy of the Minnesota Department of Transportation and/or the Center for Transportation Studies. This report does not contain a standard or specified technique.

Acknowledgements

The authors would like to thank the Local Road Research Board for providing funding for the project.

We would also like to thank the following individuals and organizations for their contributions to this project:

- Benjamin J. Chihak, Research Assistant, University of Minnesota
- Brad Wentz, Becker County Engineer—Technical Liaison
- Dan Warzala, Research Project Coordinator, Minnesota Department of Transportation—Administrative Liaison
- Susan Miller, Freeborn County Engineer
- Rick West, Ottertail County Engineer

Table of Contents

Chapter 1. Introduction	1
1.1 Objective	1
1.2 Background.....	1
Chapter 2. Method	4
2.1 Site Visits	4
2.2 Intersection Categories.....	5
2.3 Selected Intersections.....	7
2.4 Data Collection Methodology	9
Chapter 3. Results and Discussion	11
3.1 Data Analysis	11
3.2 Stopping Behavior in the <i>Obscure Both</i> Intersection Category.....	13
3.3 Stopping Behavior in the <i>Obscure/Visible</i> Intersection Category	18
3.4 Stopping Behavior in the <i>Visible Both</i> Intersection Category.....	26
3.5 Stopping Behavior in the <i>Horizontal Curve</i> Intersection Category.....	34
3.6 Stopping Behavior in the <i>Vertical Curve</i> Intersection Category	40
3.7 Summary	46
3.8 Conclusions.....	47
References	50
Appendix A1. Illustrated List of Stop-Controlled Intersections: Introduction	A1.1
Appendix A2. Lincoln County	A2.1
Appendix A3. Pipestone County	A3.1
Appendix A4. Rock County.....	A4.1
Appendix A5. Nobles County	A5.1
Appendix A6. Jackson County	A6.1
Appendix A7. Scott County.....	A7.1
Appendix A8. Dakota County.....	A8.1
Appendix A9. Benton County.....	A9.1
Appendix A10. Kandiyohi County.....	A10.1
Appendix A11. Wright County.....	A11.1
Appendix A12. Clay County.....	A12.1
Appendix A13. Hubbard County	A13.1
Appendix A14. Becker County.....	A14.1
Appendix A15. Todd County.....	A15.1
Appendix A16. Washington County.....	A16.1
Appendix A17. Anoka County	A17.1
Appendix B: Illustrated List of Selected Stop-Controlled Intersections.....	B1

List of Tables

2.1. County-by-County Categorization of 155 Approaches <i>With Rumble Strips</i>	6
2.2. County-by-County Categorization of 119 Approaches <i>Without Rumble Strips</i>	7
2.3. Categorization of 274 Approaches <i>With Rumble Strips</i> and <i>Without Rumble Strips</i>	7
2.4. Selected Intersections	8
3.1. Percentage of Vehicles in Each Category.....	11
3.2. Segmentation of Approaches for the <i>Obscure Both</i> , <i>Obscure/Visible</i> , and <i>Visible Both</i> Intersections.....	12
3.3. Distribution of Vehicles Approaching <i>Obscure Both</i> Intersections.....	13
3.4. ANOVA Summary for the <i>Obscure Both</i> Intersections—for the SUV/Pick-Up Truck/Van Category.....	13
3.5. ANOVA Summary for the <i>Obscure Both</i> Intersections—for the Passenger Car Category	14
3.6. ANOVA Summary for the <i>Obscure Both</i> Intersections—for the Commercial Vehicle/Heavy Truck Category	14
3.7. Distribution of Vehicles Approaching <i>Obscure/Visible</i> Intersections.....	19
3.8. ANOVA Summary for the <i>Obscure/Visible</i> Intersections—for the SUV/Pick-Up Truck/Van Category	19
3.9. ANOVA Summary for the <i>Obscure/Visible</i> Intersections—for the Passenger Car Category	19
3.10. ANOVA Summary for the <i>Obscure/Visible</i> Intersections—for the Commercial Vehicle/Heavy Truck Category.....	20
3.11. Distribution of Vehicles Approaching <i>Visible Both</i> Intersections.....	27
3.12. ANOVA Summary for the <i>Visible Both</i> Intersections—for the SUV/Pick-Up Truck/Van Category	27
3.13. ANOVA Summary for the <i>Visible Both</i> Intersections—for the Passenger Car Category.....	27
3.14. ANOVA Summary for the <i>Visible Both</i> Intersections—for the Commercial Vehicle/Heavy Truck Category.....	28
3.15. Distribution of Vehicles Approaching <i>Horizontal Curve</i> Intersections.....	35
3.16. ANOVA Summary for the <i>Horizontal Curve</i> Intersections—for the SUV/Pick-Up Truck/Van Category	35
3.17. ANOVA Summary for the <i>Horizontal Curve</i> Intersections—for the Passenger Car Category	36
3.18. ANOVA Summary for the <i>Horizontal Curve</i> Intersections—for the Commercial Vehicle/Heavy Truck Category	36
3.19. Distribution of Vehicles Approaching <i>Vertical Curve</i> Intersections.....	41
3.20. ANOVA Summary for the <i>Vertical Curve</i> Intersections—for the SUV/Pick-Up Truck/Van Category.....	41
3.21. ANOVA Summary for the <i>Vertical Curve</i> Intersections—for the Passenger Car Category	42
3.22. ANOVA Summary for the <i>Vertical Curve</i> Intersections—for the Commercial Vehicle/Heavy Truck Category.....	42

List of Figures

3.1. SUV/Pick-Up Truck/Van Category—Mean Speeds on the Approach to <i>Obscure Both</i> Intersections <i>With Rumble Strips</i> and <i>Without Rumble Strips</i>	15
3.2. SUV/Pick-Up Truck/Van Category—Boxplots of Individual Mean Speeds in the Segments on the Approach to <i>Obscure Both</i> Intersections <i>With Rumble Strips</i> and <i>Without Rumble Strips</i>	16
3.3. Commercial Vehicle/Heavy Truck Category—Mean Speeds on the Approach to <i>Obscure Both</i> Intersections <i>With Rumble Strips</i> and <i>Without Rumble Strips</i>	17
3.4. Commercial Vehicle/Heavy Truck Category—Boxplots of Individual Mean Speeds in the Segments on the Approach to <i>Obscure Both</i> Intersections <i>With Rumble Strips</i> and <i>Without Rumble Strips</i>	18
3.5. SUV/Pick-Up Truck/Van Category—Mean Speeds on the Approach to <i>Obscure/Visible</i> Intersections <i>With Rumble Strips</i> and <i>Without Rumble Strips</i>	21
3.6. SUV/Pick-Up Truck/Van Category—Boxplots of Individual Mean Speeds in the Segments on the Approach to <i>Obscure/Visible</i> Intersections <i>With Rumble Strips</i> and <i>Without Rumble Strips</i>	22
3.7. Passenger Car Category—Mean Speeds on the Approach to <i>Obscure/Visible</i> Intersections <i>With Rumble Strips</i> and <i>Without Rumble Strips</i>	23
3.8. Passenger Car Category—Boxplots of Individual Mean Speeds in the Segments on the Approach to <i>Obscure/Visible</i> Intersections <i>With Rumble Strips</i> and <i>Without Rumble Strips</i>	24
3.9. Commercial Vehicle/Heavy Truck Category—Mean Speeds on the Approach to <i>Obscure/Visible</i> Intersections <i>With Rumble Strips</i> and <i>Without Rumble Strips</i>	25
3.10. Commercial Vehicle/Heavy Truck Category—Boxplots Mean Speeds on the Approach to <i>Obscure Both</i> Intersections <i>With Rumble Strips</i> and <i>Without Rumble Strips</i>	26
3.11. SUV/Pick-Up Truck/Van Category—Mean Speeds on the Approach to <i>Visible/Both</i> Intersections <i>With Rumble Strips</i> and <i>Without Rumble Strips</i>	29
3.12. SUV/Pick-Up Truck/Van Category—Boxplots of Individual Mean Speeds in the Segments on the Approach to <i>Visible Both</i> Intersections <i>With Rumble Strips</i> and <i>Without Rumble Strips</i>	30
3.13. Passenger Car Category—Mean Speeds on the Approach to <i>Visible Both</i> Intersections <i>With Rumble Strips</i> and <i>Without Rumble Strips</i>	31
3.14. Passenger Car Category—Boxplots of Individual Mean Speeds in the Segments on the Approach to <i>Visible Both</i> Intersections <i>With Rumble Strips</i> and <i>Without Rumble Strips</i>	32
3.15. Commercial Vehicle/Heavy Truck Category—Mean Speeds on the Approach to <i>Visible Both</i> Intersections <i>With Rumble Strips</i> and <i>Without Rumble Strips</i>	33
3.16. Commercial Vehicle/Heavy Truck Category—Boxplots of Individual Mean Speeds in the Segments on the Approach to <i>Visible Both</i> Intersections <i>With Rumble Strips</i> and <i>Without Rumble Strips</i>	34
3.17. SUV/Pick-Up Truck/Van Category—Mean Speeds on the Approach to <i>Horizontal Curve</i> Intersections <i>With Rumble Strips</i> and <i>Without</i>	

<i>Rumble Strips</i>	37
3.18. SUV/Pick-Up Truck/Van Category—Boxplots of Individual Mean Speeds in the Segments on the Approach to <i>Horizontal Curve</i> Intersections <i>With Rumble Strips</i> and <i>Without Rumble Strips</i>	38
3.19. Commercial Vehicle/Heavy Truck Category—Mean Speeds on the Approach to <i>Horizontal Curve</i> Intersections <i>With Rumble Strips</i> and <i>Without Rumble Strips</i>	39
3.20. Commercial Vehicle/Heavy Truck Category —Boxplots of Individual Mean Speeds in the Segments on the Approach to <i>Horizontal Curve</i> Intersections <i>With Rumble Strips</i> and <i>Without Rumble Strips</i>	40
3.21. Passenger Car Category—Mean Speeds on the Approach to <i>Vertical Curve</i> Intersections <i>With Rumble Strips</i> and <i>Without Rumble Strips</i>	43
3.22. Passenger Car Category—Boxplots of Individual Mean Speeds in the Segments on the Approach to <i>Vertical Curve</i> Intersections <i>With Rumble Strips</i> and <i>Without Rumble Strips</i>	44
3.23. Commercial Vehicle/Heavy Truck Category—Mean Speeds on the Approach to <i>Vertical Curve</i> Intersections <i>With Rumble Strips</i> and <i>Without Rumble Strips</i> ...	45
3.24. Commercial Vehicle/Heavy Truck Category —Boxplots of Individual Mean Speeds in the Segments on the Approach to <i>Vertical Curve</i> Intersections <i>With Rumble Strips</i> and <i>Without Rumble Strips</i>	46

EXECUTIVE SUMMARY

Summary of Findings

This was the third in a series of studies investigating various aspects of rumble strips. In this study, to determine the effect of rumble strips on the real-world stopping behavior of drivers, we used a radar gun to collect speed data from over 400 vehicles on the approaches to ten selected intersections. The vehicles approaching the intersections were assigned to one of the following three categories—(1) the SUV/Pick-Up Truck/Van Category; (2) the Passenger Car Category; and (3) the Commercial Vehicle/Heavy Truck category. There were five categories of intersections, with a pair of intersections in each category. The intersection categories were as follows—(1) *Obscure Both* Intersections, with the traffic on *both* sides of the major road *obscured*; (2) *Obscure/Visible* Intersections, with the traffic on one side of the major road *obscured* and the traffic on the other side of the major road *visible*; (3) *Visible Both* Intersections, with the traffic on *both* sides of the major road *visible*; (4) *Horizontal Curve* Intersections, where there is a *horizontal curve* just before the intersection; and (5) *Vertical Curve* Intersections, where there is a *vertical curve* just before the intersection. In each category, one of the pair of intersections was in the *With Rumble Strips* Condition, while the other was in the *Without Rumble Strips* Condition. The speed data obtained at each pair of intersections can be summarized as follows:

- For the *Obscure Both* Intersections, after drivers encountered the first set of rumble strips, driving speeds were significantly *slower* on the approach *With Rumble Strips*, than they were on the approach *Without Rumble Strips* by, on average, 2.4 mph for drivers in the SUV/Pick-up Truck/Van Category, and 5.0 mph for drivers in the Commercial Vehicle/Heavy Truck Category.
- For the *Obscure/Visible* Intersections, after drivers encountered the first set of rumble strips, on the approach *With Rumble Strips* speeds were significantly *slower* than they were on the approach *Without Rumble Strips* by, on average, 3.3 mph (adjusted) for drivers in the SUV/Pick-up Truck/Van Category, 3.3 mph for drivers in the Passenger Car Category, and 5.5 mph (adjusted) for drivers in the Commercial Vehicle/Heavy Truck Category.
- For the *Visible Both* Intersections, after drivers encountered the first set of rumble strips, on the approach *With Rumble Strips*, speeds were significantly *slower* than they were on the approach *Without Rumble Strips* by, on average, 3.2 mph for drivers in the SUV/Pick-up Truck/Van Category.
- For the *Horizontal Curve* Intersections, after encountering the first set of rumble strips, drivers in the SUV/Pick-up Truck/Van Category and the Commercial Vehicle/Heavy Truck Category, who were on the approach *With Rumble Strips*, *reduced* speed earlier than those who were on the approach *Without Rumble Strips*.
- For the *Vertical Curve* Intersections, after encountering the first set of rumble strips, drivers in the Passenger Car category and the Commercial Vehicle/Heavy Truck Category, *reduced* speed on the approach *With Rumble Strips*, while drivers

- on the approach *Without Rumble Strips* did not slow down until later in the approach. (However, in this case the difference could be because of the presence of rumble strips *or* it could be because drivers were traveling slower on the approach *Without Rumble Strips*, which had a lower speed limit.)
- For all five Intersection Categories, we found that on the approaches to the intersections *With Rumble Strips* almost all the faster outliers reduced speed after crossing the first set of rumble strips.

Conclusions

The first two studies in the series investigated the effect of in-lane rumble strips on stopping behavior at simulated rural stop-controlled intersections—the first with *attentive* drivers; the second with *sleep-deprived* drivers. The results of those two studies were similar to the findings of this third study which investigated stopping behavior at real-world rural stop-controlled intersections. In all three studies, drivers reduced speed earlier and to a greater extent at intersections *With Rumble Strips*.

The three studies provide compelling evidence that in-lane rumble strips promote safer stopping behavior on approaches to stop-controlled intersections. Stopping behavior is safer when rumble strips are installed because drivers slow down earlier on the approach and thus they have more time to respond to an unexpected event (e.g., a slippery road surface).

The findings from the current study confirm and expand the results from the two preceding in-lane rumble strip studies in this series. In the current study, after drivers encountered the first set of in-lane rumble strips, their stopping patterns showed that they slowed down earlier on real-world approaches *With Rumble Strips* than on real-world approaches *Without Rumble Strips*—the difference was, on average, 2.0 mph to 5.0 mph (depending on vehicle category and type of approach). In addition, speeding outliers were more likely to slow down earlier on approaches *With Rumble Strips*.

The effect of the presence of in-lane rumble strips on stopping behavior is greater for approaches where the driver's view of traffic on the major road is *obscured* on one or both sides of the road. And, of the 274 approaches we visited, traffic was *obscured* on both sides of the major road in 89 (32.5%) instances, and it was *obscured* on one side of the major road in 58 (21.2%). Stop-controlled intersections at which cross-traffic is obscured on one or both sides of the minor road would be good candidates for implementing in-lane rumble strips. It would be most beneficial to install in-lane rumble strips on the approaches to intersections at which the cross traffic is obscured by man-made structures and/or vegetation on one or both sides of the intersection.

It would be less beneficial to install rumble strips on the approaches to intersections at which, in normal conditions, the cross traffic is *visible* on both sides of the intersection—we do not believe that rumble strips should be installed at this type of intersection to combat the relatively infrequent cases where the cross-traffic is obscured *only* because of

the weather (e.g., fog, driving rain, falling snow). In these cases drivers should take personal responsibility and reduce their speed so that it is appropriate to the driving conditions. In addition, rumble strips are often ineffective on snow-covered roads.

It should be noted that none of the drivers in the three studies ran the stop sign at the intersections *With Rumble Strips* or *Without Rumble Strips*. However, this is not surprising. Incidents involving drivers running (i.e., “blowing”) stop signs are relatively rare, making it extremely unlikely that we would have witnessed such an event while collecting data.

It is also worth noting that while the noise and vibration of in-lane rumble strips warns drivers they are approaching a stop-controlled intersection, the rumble strips themselves cannot actually stop drivers, nor can they give drivers who have stopped better judgment when selecting gaps in cross-traffic. In-lane rumble strips are likely to reduce crashes, but they cannot eliminate them. Some drivers might still run stop signs and others might misjudge gaps.

The results of this study clearly reveal that in-lane rumble strips facilitate safer stopping behavior at various intersection types, though their effect is most pronounced at intersections where cross-traffic is obscured. Consequently, we believe that it would be beneficial to implement in-lane rumble strips at stop-controlled intersections where drivers on the minor road approaching the intersection cannot see the cross-traffic on one or both sides of the intersection.

CHAPTER 1 INTRODUCTION

1.1 Objective

This was the third in a series of studies investigating various aspects of in-lane rumble strips at stop-controlled intersections. The Manual on Uniform Traffic Devices defines rumble strips as “intermittent, narrow, transverse areas of rough-textured or slightly raised or depressed road surface” (MUTCD, 2001, page F-64). In-lane (transverse) rumble strips are used to attract the attention of drivers, through noise and vibration, thus alerting them of the presence of an upcoming intersection.

The objective of this third study was to conduct an on-the-road study of natural stopping behavior at stop-controlled intersections and to generate recommendations that will facilitate standardized rumble strip usage in Minnesota. Our goal was to identify situations in which rumble strips are an asset. The first step towards these ends was to visit a variety of stop-controlled intersections in Minnesota. We visited 151 intersections in the following 16 Minnesota counties— Lincoln, Pipestone, Rock, Nobles, Jackson, Scott, Dakota, Benton, Kandiyohi, Wright, Clay, Hubbard, Becker, Todd, Washington, and Anoka Counties. The particular intersections visited were chosen with the help of county engineers. The second step was to investigate the stopping behavior of drivers at representative intersections. The 151 intersections yielded 274 approaches, from which we selected pairs of intersections with similar sightlines—one member of each pair had rumble strips; while the other member of the pair did not have rumble strips. Then using a radar speed gun, we recorded the speed of real-world drivers on the approach to the selected intersections. We compared the stopping behavior of drivers on each of the pairs of intersections. In this way, we were able determine how rumble strips affect real-world stopping behavior. The final step was to use the stopping behavior data in developing guidelines aimed at standardizing rumble strip usage in Minnesota.

1.2 Background

In the first two studies of this series (Harder, Bloomfield & Chihak, 2001; Harder & Bloomfield, 2005), we investigated the effect of rumble strips on stopping behavior at *simulated* rural controlled intersections. The first study (Harder *et al.*, 2001) was conducted using a fixed-based wrap-around driving simulator which provided a 156-deg forward view on a curved screen. The simulator vehicle was a full-body 1990 Acura Integra RS. During the drive through the simulated driving environment, when the front wheels of the car touched the virtual rumble strips, an auditory cue was sent through the audio system and the steering wheel vibrated. The frequency of the vibration in the steering wheel was dependant on the speed of the car at the time the wheel touched the rumble strip. Thirty-two participants drove the 25-mile (40.23-km) route with twelve intersections—some with rumble strips, some without rumble strips. The point at which

drivers took their foot off the accelerator pedal as they approached the intersections was not affected by the presence of rumble strips; however the point at which they put foot on the brake was affected by presence of rumble strips. Rumble strips affected the *braking pattern* of the driver; he or she used the brakes to a greater extent *earlier* in the slowdown process than when there were no rumble strips. This result supported the belief of many—both professional and lay people—that rumble strips warn drivers of an upcoming traffic control device or changes in road conditions.

Prior to the Harder *et al* study, no empirical work had indicated whether or not in-lane rumble strips are actually helpful as warning devices. The field studies that had been conducted were inconclusive. But, soon after the Harder *et al* study was published, Fitzpatrick, Brewer and Parham (2002) reported speeds on 14 approaches to rural intersections near Abilene and Gatesville, in Texas, *before* and *after* rumble strips were installed. The results of this study were similar to those obtained by Harder *et al*—Fitzpatrick *et al* reported that on the approaches to intersections there was “a less gradual deceleration for drivers in the *after* period” than there was *before* the rumble strips were installed.

The state of the drivers observed in the Fitzpatrick *et al* is not known—and the participants in Harder *et al*'s study were *attentive* drivers. In contrast, participants in the second rumble strips study (Harder & Bloomfield, 2005) were *sleep-deprived*. The participants were twenty commercial motor vehicle drivers and they were tested over a twenty-hour period, throughout which they were kept awake. They drove four times—in the morning (at 9:00 a.m.), the afternoon (at 3:00 p.m.), the evening (at 9:00 p.m.) and at night (at 3:00 a.m.). The route was 59.5 miles (95.8 km) in length—sections of the route were 4-lane divided highway (with two lanes in each direction with a median between them) and 2-lane road (with one lane in each direction). There were several intersections on the route, two of which, on the 2-lane section of the route, were stop-controlled. Rumble strips were installed at the first of these stop-controlled intersections—when the front wheels of the simulator vehicle touched the virtual rumble strips an auditory cue simulating the sound of a vehicle crossing rumble strips was sent through the driving simulator's audio system and, simultaneously, the steering wheel of the simulator vehicle vibrated at 10 Hz. There were no rumble strips at the second stop-controlled intersection.

The results of the study indicated that from the appearance of the first set of rumble strips, 715 feet (218 meters) from the intersection, up to 305 feet (93 meters) before the intersection, the mean speeds for the intersection *With Rumble Strips* were slower than the mean speeds for the intersection *Without Rumble Strips*. Only in the last 305 feet (93 meters) before the intersection did the difference in the mean speeds for the two intersections decrease. The *braking pattern* of the drivers was affected by the presence of the rumble strips: The *presence* of rumble strips caused the drivers to brake to a greater extent earlier in the approach. Although sleep deprivation affected steering performance—there was more variability in steering during the fourth drive (at 3:00 a.m.) than during the first drive (at 9:00 a.m.)—it did not affect the braking patterns of the drivers as they approached the stop-controlled intersections.

In the first two studies of this series, we investigated the effect of rumble strips on stopping behavior at *simulated* rural controlled intersections. In contrast, in the third study in the series, we recorded the stopping behavior of drivers at actual intersections at various locations in Minnesota.

At this time, lay knowledge is used to determine whether rumble strips should be implemented at a particular intersection. Apart from the first two studies in this series and the Fitzpatrick *et al* study, we are aware of no other literature that could serve as a guide on the topic. Despite the paucity in literature regarding the effectiveness of in-lane rumble strips, a survey by SRF Consulting Engineers revealed that rumble strips are used by 56 of the 68 Minnesota counties that responded to their survey. Some of the responding counties use in-lane rumble strips at all paved intersections that are stop-controlled. Despite their extensive use, in-lane rumble strips are not listed in the Manual of Uniform Traffic Control Devices as an approved traffic control device. Solid research is needed to inform county engineers about the utility of rumble strips at problem intersections. The current series of studies provides useful information regarding the effect of in-lane rumble strips and is helpful in developing guidelines aimed at standardizing rumble strip usage in Minnesota.

CHAPTER 2 METHOD

2.1 Site Visits

We visited 151 stop-controlled intersections at various locations throughout Minnesota. The intersections were selected with the help of county engineers: Some engineers indicated problem intersections within their counties; others listed all the intersections within their county at which rumble strips were located; while others gave details of all the intersections, including road types and, in one case, traffic levels.

The 151 intersections were located in 16 Minnesota counties. Those counties along with the number we assigned to each of the intersections visited are listed below.

- Lincoln County (Intersections #1-19)
- Pipestone County (Intersections #20-27)
- Rock County (Intersections #28-36)
- Nobles County (Intersections #37-48)
- Jackson County (Intersections #49-53)
- Scott County (Intersections #54-65 & 141)
- Dakota County (Intersections #66-72)
- Benton County (Intersections #73-90)
- Kandiyohi County (Intersections #91-102)
- Wright County (Intersections #103-109)
- Clay County (Intersections #110-117)
- Hubbard County (Intersections #118-125)
- Becker County (Intersections #126-128)
- Todd County (Intersections #129-140)
- Washington County (Intersections #142-149)
- Anoka County (Intersections #150-151)

The use of rumble strips differs from county to county. For example, in Lincoln County, rumble strips have been installed at practically all stop-controlled intersections where the minor road has a hard top road surface. In contrast, in Jackson County, rumble strips are not used at any of the stop-controlled intersections. And in other counties, like Nobles County, there are rumble strips at some stop-controlled intersections but not at others.

Several photographs were taken at each of the 151 intersections. At intersections with two-way controlled stops, photographs were taken on the minor road approaches to the intersections—however, photographs were not taken on the major road approaches, on which traffic is not required to stop. At intersections where one of the approaches on the minor road is a dirt road, photographs were not taken on the dirt road approach. In the case of intersections at which there are four-way stops, photographs were taken on all

four approaches. Finally, at intersections that are T-junctions, photographs were taken on the lower leg of the “T”—i.e., on the approaches that are stop-controlled.

At intersections where rumble strips are installed, at least one photograph was taken just before the point at which a driver approaching the intersections would encounter the first set of rumble strips. At intersections where rumble strips are not installed, at least one photograph was taken close to the point at which the driver would have encountered the first set of rumble strips if they were installed at the intersection. The photographs taken from these vantage points were used to make comparisons between stop-controlled intersections with and without rumble strips. Appendix A presents a listing, with photographs, of the 151 intersections that were visited. These intersections are arranged by county.

2.2 Intersection Categories

The 151 intersections yielded a total of 274 approaches. Each approach was first classified in terms of whether or not rumble strips were installed—there were 155 approaches *With Rumble Strips* and 119 *Without Rumble Strips*. Then, within the two groups, each of the approaches was assigned to one of the following nine categories.

Obscure Both—indicates an intersection at which the traffic on *both* sides of the major road is *obscured* from the viewpoint of a driver who is at the point on the minor road where he or she encounters the first set of rumble strips, or would encounter the first set of rumble strips, if they were installed at the intersection.

Visible Both—indicates an intersection at which the traffic on *both* sides of the major road is *visible* from the viewpoint of a driver who is at the point on the minor road where he or she encounters the first set of rumble strips, or would encounter the first set of rumble strips, if they were installed at the intersection.

Partial Both—indicates an intersection at which the traffic on *both* sides of the major road is *partially obscured* from the viewpoint of a driver who is at the point on the minor road where he or she encounters the first set of rumble strips, or would encounter the first set of rumble strips, if they were installed at the intersection.

Obscure/Visible—indicates an intersection at which the traffic on one side of the major road is *obscured*, and traffic on the other side of the major road is *visible*, from the viewpoint of a driver who is at the point on the minor road where he or she encounters the first set of rumble strips or would encounter the first set of rumble strips if they were installed at the intersection.

Obscure/Partial—indicates an intersection at which the traffic on one side of the major road is *obscured*, and traffic on the other side of the major road is *partially obscured*, from the viewpoint of a driver who is at the point on the minor road where he or she

encounters the first set of rumble strips or would encounter the first set of rumble strips if they were installed at the intersection.

Visible/Partial—indicates an intersection at which the traffic on one side of the major road is *visible*, and traffic on the other side of the major road is *partially obscured*, from the viewpoint of a driver who is at the point on the minor road where he or she encounters the first set of rumble strips or would encounter the first set of rumble strips if they were installed at the intersection.

T-Junction—indicates an approach to an intersection that is a T-junction.

Horizontal Curve—indicates an intersection at which there is a *horizontal curve* just before the intersection. At all the intersections in this category that we visited, the intersection itself and the traffic on the major road is obscured from the viewpoint of a driver who is at the point on the minor road where he or she encounters the first set of rumble strips or would encounter the first set of rumble strips if they were installed at the intersection.

Vertical Curve—indicates an intersection at which there is a *vertical curve* just before the intersection. At most of the intersections in this category that we visited, the intersection itself and the traffic on the major road is obscured from a driver who is at the point on the minor road where he or she encounters the first set of rumble strips or would encounter the first set of rumble strips if they were installed at the intersection.

Table 2.1 indicates the way in which the 155 approaches *With Rumble Strips* are distributed into the nine categories for each of the 16 counties.

Table 2.1: County-by-County Categorization of 155 Approaches With Rumble Strips

County	Obscure	Visible	Partial	Obscure /Visible	Obscure /Partial	Visible /Partial	T-Junction	Horizontal Curve	Vertical Curve
Lincoln	4	2	-	1	-	2	3	1	3
Pipestone	3	2	-	4	2	1	-	-	1
Rock	3	1	-	6	-	2	1	-	3
Nobles	7	5	-	5	-	1	-	-	2
Jackson	-	-	-	-	-	-	-	-	-
Scott	1	-	-	-	-	-	-	-	-
Dakota	-	-	-	-	-	-	-	-	-
Benton	11	2	1	9	3	4	-	-	1
Kandiyohi	3	5	1	4	3	1	-	-	2
Wright	1	-	-	-	1	-	-	-	-
Clay	2	5	-	2	1	1	-	-	-
Hubbard	-	-	-	-	1	-	-	-	-
Becker	-	-	-	-	-	1	1	-	-
Todd	6	1	1	6	5	1	-	-	3
Washington	-	-	-	-	-	-	-	-	-
Anoka	-	-	-	-	-	-	-	-	-
Total (Percent)	41 (26.5)	23 (14.8)	3 (1.9)	37 (23.9)	16 (10.3)	14 (9.0)	5 (3.2)	1 (0.6)	15 (9.8)

Similarly, Table 2.2 shows how the 119 approaches *Without Rumble Strips* are distributed into the nine categories for each of the 16 counties.

Table 2.2: County-by-County Categorization of 119 Approaches *Without Rumble Strips*

County	Obscure Both	Visible Both	Partial Both	Obscure /Visible	Obscure /Partial	Visible /Partial	T-Junction	Horizontal Curve	Vertical Curve
Lincoln	3	5	1	2	1	1	-	1	-
Pipestone	1	-	-	-	-	-	-	-	-
Rock	-	-	-	-	-	-	-	-	-
Nobles	-	-	-	-	-	-	-	-	-
Jackson	3	1	-	5	-	-	-	-	-
Scott	8	2	-	5	2	3	1	2	2
Dakota	3	4	-	2	1	-	2	-	-
Benton	3	1	-	-	-	-	-	-	-
Kandiyohi	1	2	1	1	-	-	-	-	-
Wright	5	-	-	4	2	1	-	-	-
Clay	5	-	-	-	1	-	-	-	-
Hubbard	4	-	-	1	1	-	3	2	-
Becker	1	-	-	1	1	-	-	-	-
Todd	1	-	-	-	-	-	-	-	-
Washington	9	-	-	-	1	-	2	-	1
Anoka	1	-	-	-	-	-	1	-	1
Total (Percent)	48 (40.3)	15 (12.6)	2 (1.7)	21 (17.6)	10 (8.4)	5 (4.2)	9 (7.6)	5 (4.2)	4 (3.4)

The data shown county-by-county for both rumble strip conditions in Tables 2.1 and 2.2 are summarized below in Table 2.3.

Table 2.3: Categorization of 274 Approaches *With Rumble Strips* and *Without Rumble Strips*

Rumble Strip Condition	Obscure Both	Visible Both	Partial Both	Obscure /Visible	Obscure /Partial	Visible /Partial	T-Junction	Horizontal Curve	Vertical Curve
<i>With</i>	41	23	3	37	16	14	5	1	15
<i>Without</i>	48	15	2	21	10	5	9	5	4
Total (Percent)	89 (32.5)	38 (13.9)	5 (1.8)	58 (21.2)	26 (9.5)	19 (6.9)	14 (5.1)	6 (2.2)	19 (6.9)

As Table 2.3 shows, the categories that occurred with the greatest frequency with the highest counts were *Obscure Both* (with 89; 32.5%), *Obscure/Visible* (with 58; 21.2%), and *Visible Both* (with 38; 13.9%).

2.3 Selected Intersections

We selected intersections from five of the nine categories for the data collection phase of this study. Three categories (*Partial Both*, *Obscure/Partial*, and *Visible/Partial*) were

omitted because the definition “Partial” includes a range of obscured conditions, from a few trees, or a building, obstructing the view of traffic on the major road, to many trees and/or several buildings obstructing the view.

We would like to have included the remaining condition (“T-junction”). Unfortunately, we could not include the category because we were unable to find a safe, relatively unobtrusive place from which to collect data for both rumble strip conditions for this type of intersection.

The ten intersections that were selected for the data collection phase of the study are listed by intersection category and rumble strip condition in Table 2.4. [Photographs of the pairs of selected intersections are presented in Appendix B.]

Table 2.4: Selected Intersections

Intersection Type	<i>With Rumble Strips</i>	<i>Without Rumble Strips</i>
<i>Obscure Both</i>	<u>Pipestone County</u> (<u>Intersection #26-South Side</u>) Major Road: State Route 30 Minor Road: County Route 13 Located—5 miles West of Pipestone	<u>Scott County</u> (<u>Intersection #141-East side</u>) Major Road: County Route 27 Minor Road: CR-62/240 th St. Located—2 miles North & 1 mile West of New Market
<i>Obscure/Visible</i>	<u>Todd County</u> (<u>Intersection #138-North side</u>) Major Road: County Route 10 Minor Road: County Route 11 Located—4.5 miles West & 2 miles South of Long Prairie	<u>Wright County</u> (<u>Intersection #106-South side</u>) Major Road: County Route 37 Minor Road: County Route 15 Located—3 miles South of Monticello
<i>Visible Both</i>	<u>Kandiyohi County</u> (<u>Intersection #101—North side</u>) Major Road: State Route 7 Minor Road: County Route 44 Located—12 miles South & 3 miles East of Willmar	<u>Kandiyohi County</u> (<u>Intersection #97—North side</u>) Major Road: State Route 40 Minor Road: County Route 1 Located—8 miles West of Willmar
<i>Horizontal Curve</i>	<u>Lincoln County</u> (<u>Intersection #7—East side</u>) Major Road: U.S Route 75 Minor Road: County Route 13 Located—5.5 miles North of Lake Benton	<u>Scott County</u> (<u>Intersection #56-South side</u>) Major road: Credit River Boulevard/County Route 12 Minor road: Natchez Avenue (North)/Vernon Avenue (South) Located—4.5 miles South & 3 miles East of Prior Lake
<i>Vertical Curve</i>	<u>Lincoln County</u> (<u>Intersection #9—West side</u>) Major Road: County Route 1 Minor Road: County Route 13 Located—3 miles North & 7 miles West of Lake Benton	<u>Anoka County</u> (<u>Intersection #150—West side</u>) Major Road: County Route 9 Minor Road: County Road 58 Located—8 miles North & 2 miles East of Anoka

Nine of the ten intersections listed in Table 2.4 are two-way controlled stops. The exception is in the *Vertical Curve-Without* Rumble Strips sub-category—this intersection in Anoka County is a four-way stop controlled intersection. (However, it should be noted that at this intersection it is clear that County Road 9, the North-South road, is the major road and that County Route 58, the East-West road, is the minor road.) It should also be noted that the speed limit on the selected approach to the *Vertical Curve-Without* Rumble Strips intersection is 45 mph, whereas the speed limit is 55 mph on the intersection it is paired with in Lincoln County. We would, of course, have preferred to have approaches with the same speed limit—unfortunately our choices were limited. As can be seen from Table 2.2, there were only four *Vertical Curve-Without* Rumble Strips approaches in our sample of 274 approaches: they were—(1) Intersection #146 (East Side) in Washington County, which has paved road from the intersection to the crest of the hill, but is a dirt road for the rest of the approach; (2) Intersection #57 (North Side) in Scott County, at which there is a sharp drop off from the pavement, making it impossible for us to find a location from which to record radar data; (3) Intersection #58 (North Side) in Scott County, which was our first choice, but at which there was road construction throughout the period of time when we collected speed data; and (4) Intersection #150 (West Side) in Anoka County, the only intersection in this category that we were able to use. [Please note the numbers associated with the intersections can be used to find photographs of them in Appendix A.]

As Table 2.4 shows, for the *Visible Both* Category, we selected a pair of intersections, *With* and *Without* Rumble Strips that were both located in Kandiyohi County. If possible, we would have selected pairs of intersections that were close to each other geographically for the other intersection categories. However, there were two reasons why we could not do this. First, on the approaches to some intersections that we considered, we were unable to find a safe, relatively unobtrusive place from which it was possible to collect radar data. Second, some of the selected intersections were located in counties in which rumble strips are installed at practically all the stop-controlled intersections.

2.4 Data Collection Methodology

A radar gun (Stalker ATS professional radar gun) and a laser rangefinder (Nikon Laser 400) were used to obtain the speeds at which real-world drivers traveled on the approach to each of the ten selected intersections. The radar gun was connected to a laptop computer, activated, and aimed at an approaching or departing vehicle. It recorded a data stream (updated at a rate of 30 Hz) that gave speed, time, and distance information for the vehicle. [For details of the radar see Applied Concepts (2004)]. However, the distance information provided by the radar gun was relative, not absolute. The laser rangefinder was used to anchor the relative distance information provided by the radar gun to the stopping behavior.

Three intersection categories—*Obscure Both*, *Obscure/Visible*, and *Visible Both*—involve right angle intersections and flat terrain. For the six intersections in these three categories, the radar gun and laser rangefinder were located in a vehicle that was parked on the shoulder of the road on the opposing approach to the intersection. The vehicle was positioned as far away from the intersection as possible, while maintaining line-of-sight between the radar gun and the approaching vehicles.

However, for the remaining two categories—*Horizontal Curve* and *Vertical Curve* Intersections—data collection locations on the opposite side of the intersection do not afford the direct line-of-sight necessary to collect radar data. In these cases, the vehicle containing the radar gun and laser rangefinder was located upstream of the intersections—and, inevitably, we were only able to record the approach up to the beginning of the horizontal curve and the crest of the vertical curve.

When several vehicles approach an intersection at the same time, the way in which the leading vehicle stops may influence the stopping behavior of the drivers in the following cars. Therefore, when a line of vehicles was approaching an intersection, only data for the lead vehicle was recorded.

Radar data were obtained for at least forty real-world drivers for each pair of intersections—one *With Rumble Strips* and one *Without Rumble Strips*—in each of the five intersection categories.

CHAPTER 3 RESULTS AND DISCUSSION

3.1 Data Analysis

In order to determine the effect of rumble strips on the real-world stopping behavior of drivers, we collected data from pairs of intersections from five categories—*Obscure Both*, *Obscure/Visible*, *Visible Both*, *Horizontal Curve*, and *Vertical Curve* Intersections. In each category, one of the pair of intersections was in the *With Rumble Strips* Condition, while the other was in the *Without Rumble Strips* Condition.

3.1.1 Vehicles in Study

Using a radar gun, we collected speed data from over 400 vehicles as they approached the selected intersections. Data were recorded from at least 40 vehicles for each of the ten intersections. The vehicles that approached the intersections were assigned to one of three vehicle categories. The categories and the percentage of vehicles that fell into them are shown in Table 3.1.

Table 3.1: Percentage of Vehicles in Each Category

Vehicle Category	Percentage
SUV/Pick-Up Truck/Van	48.0%
Passenger Cars	29.8%
Commercial Vehicle/Heavy Truck	22.2%

We found that there were differences in stopping behavior between the three vehicle categories. Because of this, the data obtained from the three vehicle categories were analyzed separately.

3.1.2 Segmentation

In order to examine stopping behavior, the approach to each of the selected intersections was segmented. We used a similar segmentation scheme to that used in the second study of this series (Harder & Bloomfield, 2005). In that study, the segmentation began when the drivers were 1,371 feet (418 meters) from the intersection. In this study, we began the segmentation 328 feet (100 meters) further from the intersections—at 1,700 feet (518 meters). The approaches to the intersections *With Rumble Strips* were segmented in the same way as the approaches to the intersections *Without Rumble Strips*. This allowed direct segment-by-segment comparisons between the approaches in each of the intersection categories. The mean speed in each of the segments was determined, so that the speeds on the two approaches could be compared. The segmentation scheme for three intersection categories—*Obscure Both*, *Obscure/Visible*, and *Visible Both*—is shown in Table 3.2. [It should be noted that for the other two intersection categories—

Horizontal Curve and *Vertical Curve*—the segmentation scheme necessarily had to be abbreviated. This was because, as mentioned earlier in this report, for these intersection categories we could only record the approaches up to the beginning of the horizontal curve and the crest of the vertical curve. The segmentation schemes used for these two categories are presented later in this section.]

Table 3.2: Segmentation of Approaches for the *Obscure Both*, *Obscure/Visible*, and *Visible Both* Intersections

Segment Number	Segment Location, in Meters (and Feet) from the Edge Line at the Intersection
1	518-468 (1,699.5 - 1,535.4)
2	468-418 (1,535.4 - 1,371.4)
3	418-393 (1,371.4 - 1289.4)
4	393-368 (1289.4 – 1,207.3)
5	368-343 (1207.3 - 1125.3)
6	343-318 (1125.3 - 1043.3)
7	318-293 (1,043.3 – 961.3)
8	293-268 (961.3 – 879.3)
9	268-243 (879.3 – 797.2)
10	243-218 (797.2 – 715.2)
11	218-193 (715.2 – 633.2)
12	193-168 (633.2 – 551.2)
13	168-143 (551.2 – 469.2)
14	143-118 (469.2 – 387.1)
15	118-93 (387.1 – 305.1)
16	93-68 (305.1 – 223.1)
17	68-43 (223.1 – 141.1)
18	43-18 (141.1 – 59.1)
19	18-stopping point (59.1-stopping point)

For each intersection in the *Obscure Both*, *Obscure/Visible*, and *Visible Both* categories, the mean speed in each segment listed in Table 3.2 was calculated for each driver. Then, we focused on each intersection category, in turn. Within each intersection category, for each category of vehicles we compared the data obtained for the intersection *With Rumble Strips* with the data obtained for the intersection *Without Rumble Strips*.

3.2 Stopping Behavior in the *Obscure Both* Intersection Category

Photographs of the two *Obscure Both* intersections are shown in Appendix B. For the two *Obscure Both* intersections, approach speeds of 40 drivers were recorded for the intersection *With Rumble Strips*, while approach speeds of 46 drivers were recorded for the intersection *Without Rumble Strips*. Each vehicle approaching the two intersections was assigned to one of three vehicle categories—with the results shown in Table 3.3.

Table 3.3: Distribution of Vehicles Approaching *Obscure Both* Intersections

Intersection Condition	SUV/Pick-Up Truck/Van	Passenger Car	Commercial Vehicle/ Heavy Truck	Total
<i>With Rumble Strips</i>	19	8	13	40
<i>Without Rumble Strips</i>	28	12	6	46

As the table shows there were unequal numbers of vehicles in the three categories. To deal with these inequalities, we used the formulation provided by Winer, Brown and Michaels (1991) when conducting Analyses of Variance (ANOVAs) on the speed data. We conducted three ANOVAs—one for each vehicle category—on the mean speed data obtained in each segment on the approach to the intersection *With Rumble Strips*, and the approach to the intersection *Without Rumble Strips*. Summaries of the three ANOVAs are presented below in Table 3.4 (for the SUV/Pick-Up Truck/Van Category), Table 3.5 (Passenger Car Category), and Table 3.6 (Commercial Vehicle/Heavy Truck Category).

Table 3.4: ANOVA Summary for the *Obscure Both* Intersections—for the SUV/Pick-Up Truck/Van Category

Source of Variance	Degrees of Freedom	Sum of Squares	Variance Estimate	F-Value	Significance Level
Rumble Strip Conditions (RS)	1	76.360	73.360	0.239	<i>ns</i>
Subjects within Groups (SwG)	44	14,029.667	318.856		
Segments (SEG)	18	164,200.106	9,122.228	1,255.574	<0.0001
Interaction RS x SEG	18	537.54	29.863	4.110	<0.0001
SEG x SwG	792	5,754.19	7.265		

Table 3.5: ANOVA Summary for the *Obscure Both* Intersections—for the Passenger Car Category

Source of Variance	Degrees of Freedom	Sum of Squares	Variance Estimate	F-Value	Significance Level
Rumble Strip Conditions (RS)	1	290.622	290.622	0.833	<i>ns</i>
Subjects within Groups (SwG)	17	5,934.338	349.079		
Segments (SEG)	18	77,147.725	4,285.985	716.632	<0.0001
Interaction RS x SEG	18	59.649	3.314	0.554	<i>ns</i>
SEG x SwG	306	1,830.104	5.981		

Table 3.6: ANOVA Summary for the *Obscure Both* Intersections—for the Commercial Vehicle/Heavy Truck Category

Source of Variance	Degrees of Freedom	Sum of Squares	Variance Estimate	F-Value	Significance Level
Rumble Strip Conditions (RS)	1	1,099.192	1,099.192	1.100	<i>ns</i>
Subjects within Groups (SwG)	18	17,982.156	999.009		
Segments (SEG)	18	56,306.600	3,218.144	306.911	<0.0001
Interaction RS x SEG	18	409.515	22.751	2.232	0.003
SEG x SwG	324	3,302.326	10.192		

Tables 3.4, 3.5, and 3.6 show there were statistically significant segment effects for all three vehicle categories (with, in all cases, $p < 0.0001$): This segment effect was inevitable—the drivers were slowing down as they drove towards the intersection. However, Tables 3.4 and 3.6 also show statistically significant interactions between Rumble Strip Conditions and Segments for the SUV/Pick-Up Truck/Van Category ($p < 0.0001$) and for the Commercial Vehicle/Heavy Truck category ($p = 0.003$)—although (as Table 3.5 shows), this interaction was not significant for the Passenger Car Category.

The significant interaction between Rumble Strip Conditions and Segments, for the SUV/Pick-Up Truck/Vans category, is illustrated in Figure 3.1.

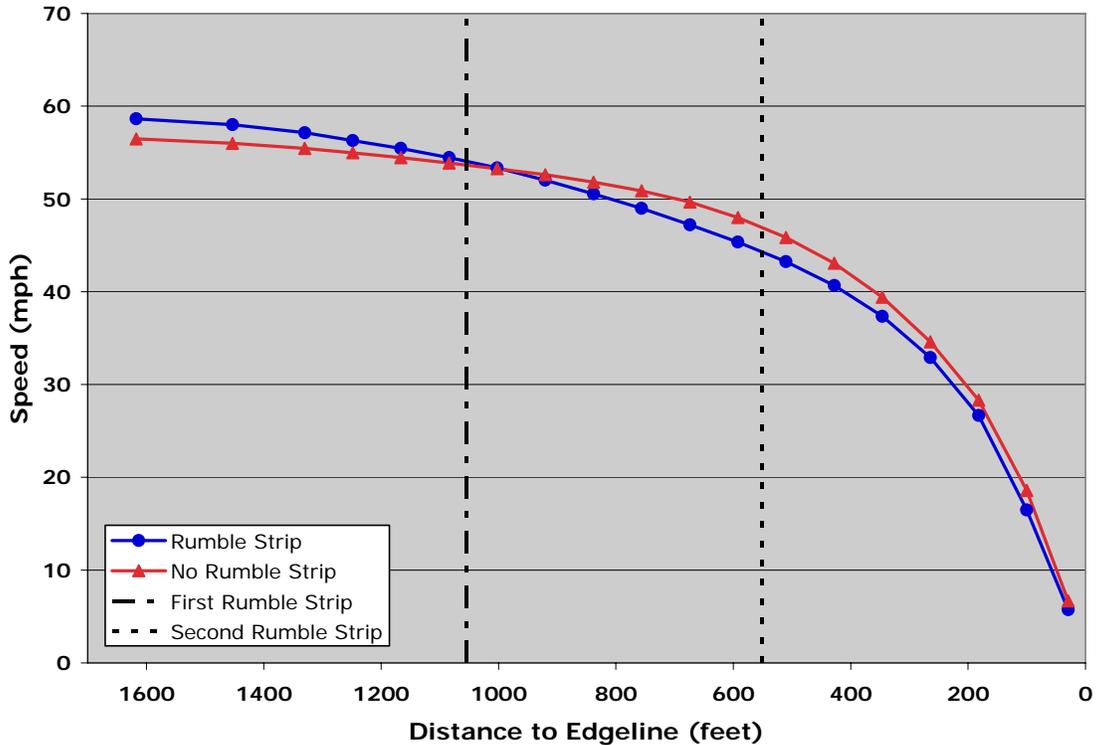


Figure 3.1: SUV/Pick-Up Truck/Van Category—Mean Speeds on the Approach to *Obscure Both* Intersections With Rumble Strips and Without Rumble Strips.

Figure 3.1 shows that, for the SUV/Pick-Up Truck/Van Category, initially the drivers on the approach *With Rumble Strips* were driving faster on average than were the drivers on the approach *Without Rumble Strips*. The drivers who approached the intersection *With Rumble Strips* encountered the first rumble strips when they were 1,054.5 feet (321.4 meters) from the edge line at the intersection. Within 134 feet (40 meters) of encountering the first rumble strips, these drivers were, on average, driving slower than the drivers on the approach *Without Rumble Strips*. The drivers approaching the intersection *With Rumble Strips* continued to drive slower—until they were 29.5 feet (9 meters) from the intersection. The biggest difference in average speed between the drivers on the approach *With Rumble Strips* and those on the approach *Without Rumble Strips* occurred between 633 feet (193 meters) and 469 feet (143 meters) from the intersection—over that distance, the drivers on the approach *With Rumble Strips* were driving an average of 2.5 mph slower than those on the approach *Without Rumble Strips*.

Figure 3.1 shows the effect of rumble strips on the *average* speed of drivers of vehicles in the SUV/Pick-Up Truck/Van category as they approached an intersection with traffic obscured on both sides of the crossing road. However, the figure does not show their effect on *individual drivers*. In particular, it does not show the effect of rumble strips on those who may be driving faster than average. We used boxplots to further explore the speed data on the approaches to the *Obscure Both* intersections and to examine the effect of rumble strips on individual speeders. Boxplots—which were introduced by Tukey

(1977) and are discussed in detail by Emerson and Strenio (1983)—provide a compact visual description of the distribution of data within a sample. Boxplots are particularly useful in that they reveal the presence of outliers. The boxplots associated with the mean speeds shown in Figure 3.1 are presented in Figure 3.2.

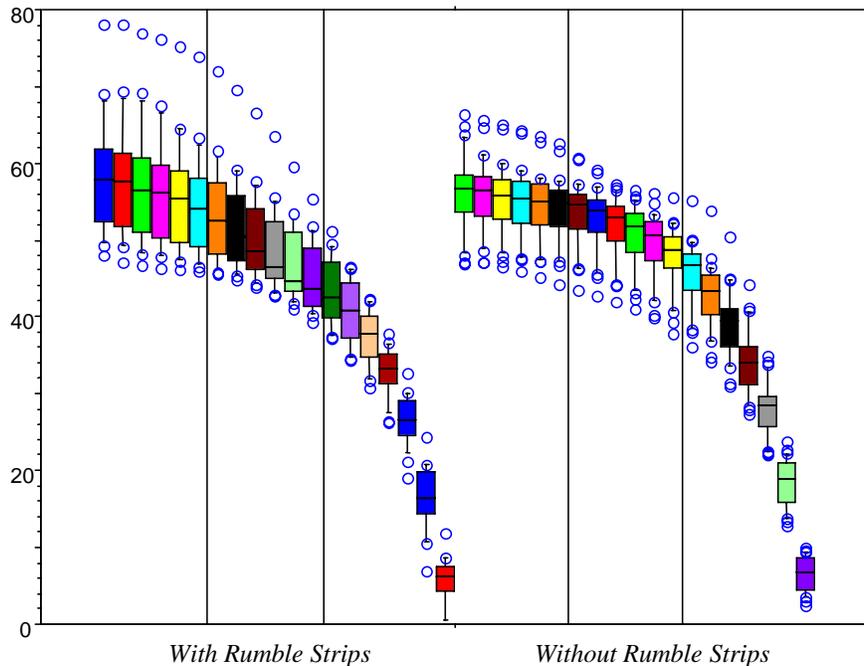


Figure 3.2: SUV/Pick-Up Truck/Van Category—Boxplots of Individual Mean Speeds in the Segments on the Approach to *Obscure Both Intersections With Rumble Strips* and *Without Rumble Strips*.

The boxplots presented in Figure 3.2 reveal that, on the approach *With Rumble Strips* one outlier was traveling at a speed that was considerably faster than that of the other drivers on this approach. For example, when he or she was 1,617.5 feet (493 meters) from the intersection, he or she was driving at approximately 78 mph—20 mph faster than the average of the other drivers. The boxplot also reveals that he or she slowed down rapidly after encountering the first set of rumble strips, demonstrating stopping behavior similar to the other drivers on the approach *With Rumble Strips*.

In contrast, on the approach *Without Rumble Strips*, the boxplots shown in Figure 3.2 indicate that there was one driver who did not exhibit the same stopping behavior as the other drivers. This driver, who was driving faster on the approach, began to slow down, but then coasted for approximately 246 feet (75 meters)—while between 756 feet (230.5 meters) and 510 feet (155.5 meters) from the intersection. Subsequently, he or she had to slow down more abruptly than the other drivers.

The significant interaction between Rumble Strip Conditions and Segments, for the Commercial Vehicle/Heavy Truck Category—indicated in Table 3.6—is illustrated in Figure 3.3.

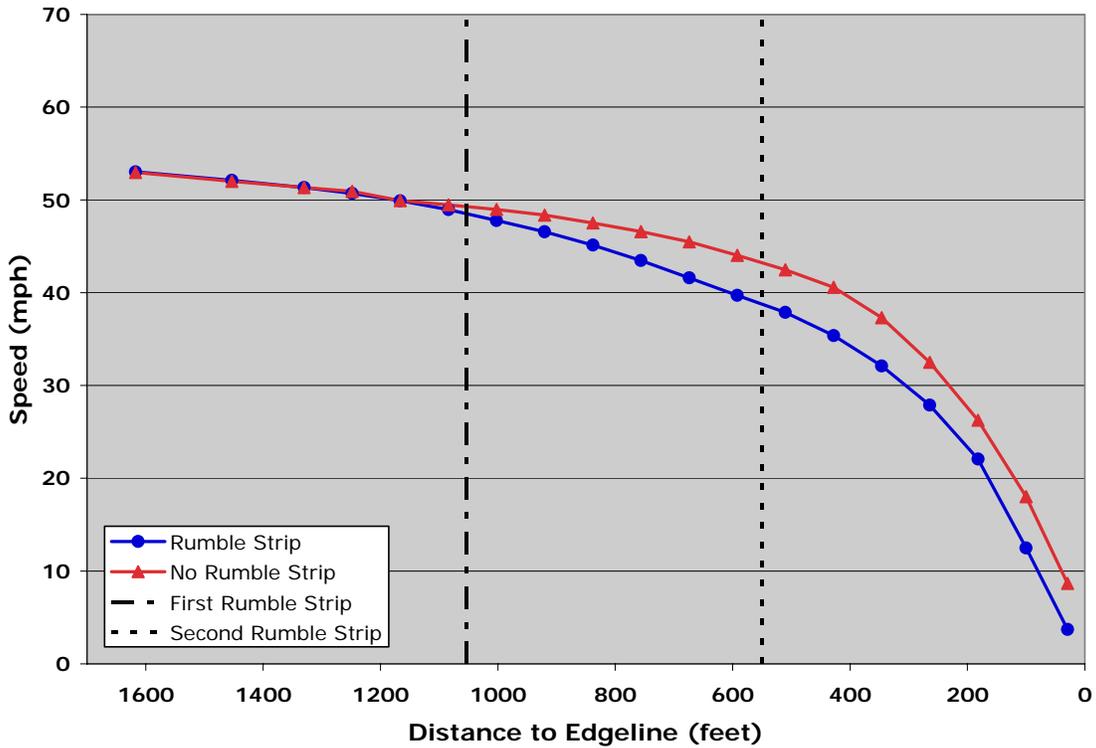


Figure 3.3: Commercial Vehicle/Heavy Truck Category—Mean Speeds on the Approach to *Obscure Both* Intersections With Rumble Strips and Without Rumble Strips.

Figure 3.3 shows that, for the Commercial Vehicle/Heavy Truck Category, initially the drivers on both the approach *With Rumble Strips* and the approach *Without Rumble Strips* were driving, on average, at similar speeds. The figure also shows that, after encountering the first set of rumble strips, when they were 1,054.5 feet (321.4 meters) from the edge line at the intersection, the drivers on the approach *With Rumble Strips* slowed down more than did the drivers on the approach *Without Rumble Strips*. Further, they continued to drive slower until they reached the intersection—the average difference in speed between the drivers on the approach *With Rumble Strips* and those on the approach *Without Rumble Strips* was 4.8 mph to 6.3 mph over the last 674 feet (205.5 meters) to the intersection.

Figure 3.3 shows the effect of rumble strips on the *average* speed of drivers of vehicles in the Commercial Vehicle/Heavy Truck Category as they approached an intersection with traffic obscured on both sides of the crossing road. The figure does not, however, show the effect of rumble strips on *individual drivers*. In order to further explore the speed

data, we examined the boxplots associated with the mean speeds shown in Figure 3.3. These boxplots are presented in Figure 3.4.

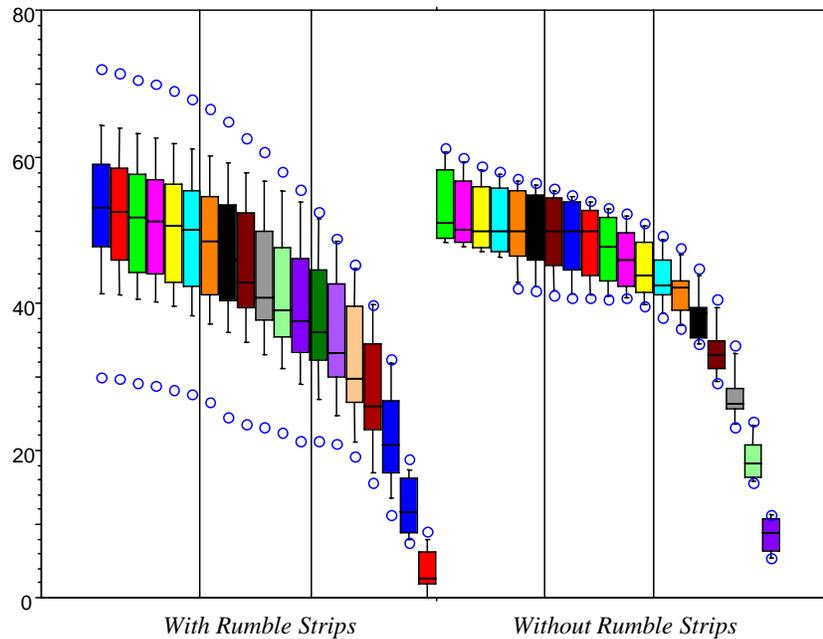


Figure 3.4: Commercial Vehicle/Heavy Truck Category—Boxplots of Individual Mean Speeds in the Segments on the Approach to *Obscure Both* Intersections With Rumble Strips and Without Rumble Strips.

The boxplots presented in Figure 3.4 show that on the approach *With Rumble Strips* there was a driver in the Commercial Vehicle/Heavy Truck Category who was driving considerably faster than that the other drivers. The boxplots also reveal that this driver slowed down rapidly after encountering the first set of rumble strips, demonstrating stopping behavior similar to the other drivers on the approach *With Rumble Strips*.

With regard to the approach *Without Rumble Strips*, the boxplots shown in Figure 3.4 do not indicate any differences between the faster drivers and those driving at the average speed for this group. However, comparison of the two sets of boxplots shown in Figure 3.4 reinforces the conclusion that, on the approach *Without Rumble Strips*, as a group the drivers in the Commercial Vehicle/Heavy Truck Category were traveling considerably faster on the final 674.2 feet (205.5 meters) before the intersection, than were the drivers on the approach *With Rumble Strips*.

3.3 Stopping Behavior in the *Obscure/Visible* Intersection Category

Photographs of the two *Obscure/Visible* intersections are shown in Appendix B. The numbers of drivers from whom data were obtained on the approaches to these two intersections were 41, for the *With Rumble Strips* approach, and 46 for the intersection

Without Rumble Strips. Table 3.7 shows the distribution of the vehicles used by these drivers into the three vehicle categories.

Table 3.7: Distribution of Vehicles Approaching *Obscure/Visible* Intersections

Intersection Condition	SUV/Pick-Up Truck/Van	Passenger Car	Commercial Vehicle/ Heavy Truck	Total
<i>With Rumble Strips</i>	21	11	9	41
<i>Without Rumble Strips</i>	19	20	7	46

Table 3.7 shows that again there were unequal numbers of vehicles in the three categories. Therefore again, to deal with the inequalities, we used the formulation given by Winer, Brown and Michaels (1991) when conducting ANOVAs. Again, we conducted three ANOVAs—one for each vehicle category—on the mean speed data obtained in each segment on the approaches to the intersections *With Rumble Strips* and *Without Rumble Strips*. Summaries of these ANOVAs are shown in Table 3.8 (for the SUV/Pick-Up Truck/Van Category), Table 3.9 (Passenger Car category), and Table 3.10 (Commercial Vehicle/Heavy Truck Category).

Table 3.8: ANOVA Summary for the *Obscure/Visible* Intersections—for the SUV/Pick-Up Truck/Van Category

Source of Variance	Degrees of Freedom	Sum of Squares	Variance Estimate	F-Value	Significance Level
Rumble Strip Conditions (RS)	1	2,535.808	2,535.808	8.177	0.0073
Subjects within Groups (SwG)	33	10,233.767	310.114		
Segments (SEG)	18	122,378.413	6,798.801	1,569.771	<0.0001
Interaction RS x SEG	18	365.751	20.320	4.462	<0.0001
SEG x SwG	594	2,572.661	4.331		

Table 3.9: ANOVA Summary for the *Obscure/Visible* Intersections—for the Passenger Car Category

Source of Variance	Degrees of Freedom	Sum of Squares	Variance Estimate	F-Value	Significance Level
Rumble Strip Conditions (RS)	1	291.903	291.903	0.542	<i>ns</i>
Subjects within Groups (SwG)	26	14,010.870	538.880		
Segments (SEG)	18	78,763.129	4,375.729	495.314	<0.0001
Interaction RS x SEG	18	297.354	16.520	1.870	0.0164
SEG x SwG	468	4,134.432	8.834		

Table 3.10: ANOVA Summary for the *Obscure/Visible* Intersections—for the Commercial Vehicle/Heavy Truck Category

Source of Variance	Degrees of Freedom	Sum of Squares	Variance Estimate	F-Value	Significance Level
Rumble Strip Conditions (RS)	1	2,152.961	2,152.961	2.310	<i>ns</i>
Subjects within Groups (SwG)	13	12,117.100	932.085		
Segments (SEG)	18	37,429.504	2,079.417	306.224	<0.0001
Interaction RS x SEG	18	294.158	16.342	2.407	0.0015
SEG x SwG	234	1,588.981	6.791		

Inevitably, Table 3.8, Table 3.9, and Table 3.10 show there were statistically significant segment effects (at the $p < 0.0001$ level) for all three vehicle categories: The segment effects are inevitable because all the drivers slowed down as they passed through the segments as they approached the intersections. However, Table 3.8 also shows that there was a statistically significant effect of rumble strips (with $p = 0.0073$) for the SUV/Pick-Up Truck/Van Category. And, in addition, all three tables indicate that there were statistically significant interactions between Rumble Strip Conditions and Segments—with $p < 0.0001$ for the SUV/Pick-Up Truck/Van Category, $p = 0.0164$ for the Passenger Car Category, and $p = 0.0015$ for the Commercial Vehicle/Heavy Truck Category.

The significant Rumble Strips effect and the significant interaction between Rumble Strip Conditions and Segments, for the SUV/Pick-Up Truck/Vans category, are illustrated in Figure 3.5.

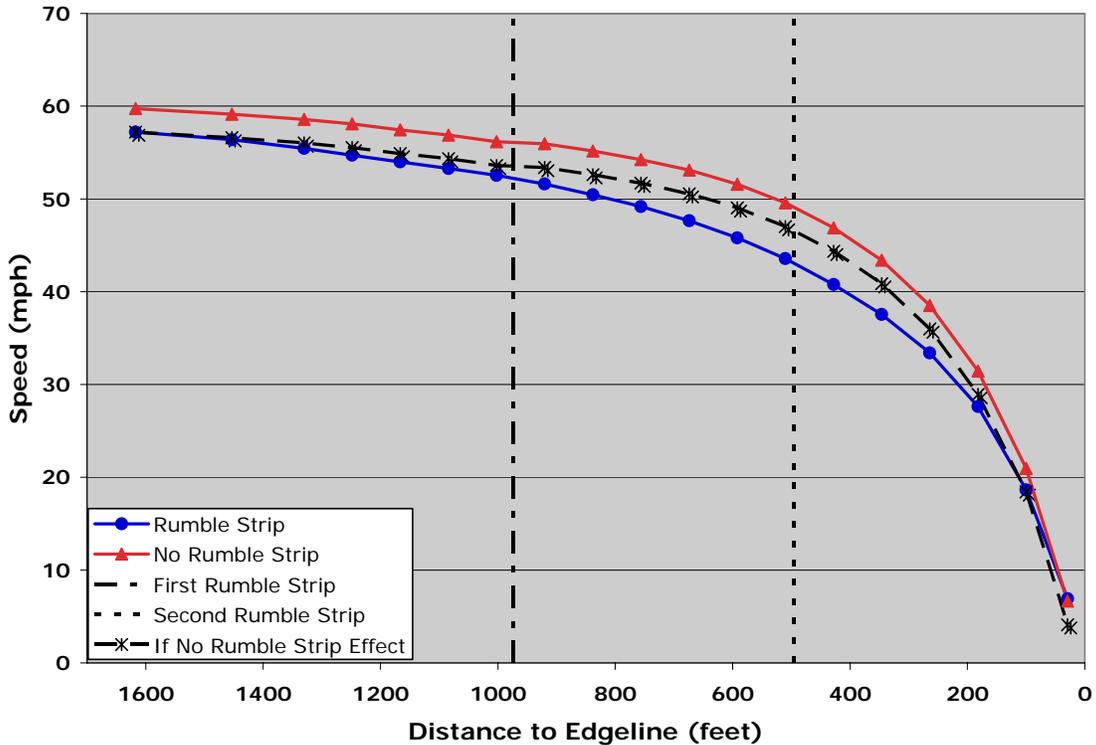


Figure 3.5: SUV/Pick-Up Truck/Van Category—Mean Speeds on the Approach to *Obscure/Visible* Intersections *With Rumble Strips* and *Without Rumble Strips*.

Figure 3.5 shows that the drivers who approached the intersection *Without Rumble Strips* drove faster throughout the approach than the drivers who approached the intersection *With Rumble Strips*. Figure 3.5 also includes an *adjusted* curve (labeled “If No Rumble Strip Effect” in the figure). This *adjusted* curve shows the speed at which drivers in the *With Rumble Strips* Condition would have driven *if* there had been no effect of encountering the rumble strips—i.e., *if* the average speed differential between them and the drivers in the *Without Rumble Strips* Condition had been maintained at the level it was early in the approach, 1,700 feet (468 meters), from the intersection and well before the first set of rumble strips were encountered. The difference between the adjusted curve and the curve for the drivers in the *With Rumble Strips* Condition accounts for the statistically significant interaction between Rumble Strip Conditions and Segments. The adjusted difference, which is as much as 3.3 mph, can be attributed to the effect that encountering the rumble strips had on the drivers in the *With Rumble Strips* Condition.

Figure 3.5 shows the effect of rumble strips on the *average* speed of drivers of vehicles in the SUV/Pick-Up Truck/Van category as they approached an intersection with traffic obscured on one side of the crossing road but visible on the other. It does not show the effect of rumble strips on *outliers*. To further explore the speed data, we examined the boxplots associated with the mean speeds shown in Figure 3.5. The resultant boxplots are presented in Figure 3.6.

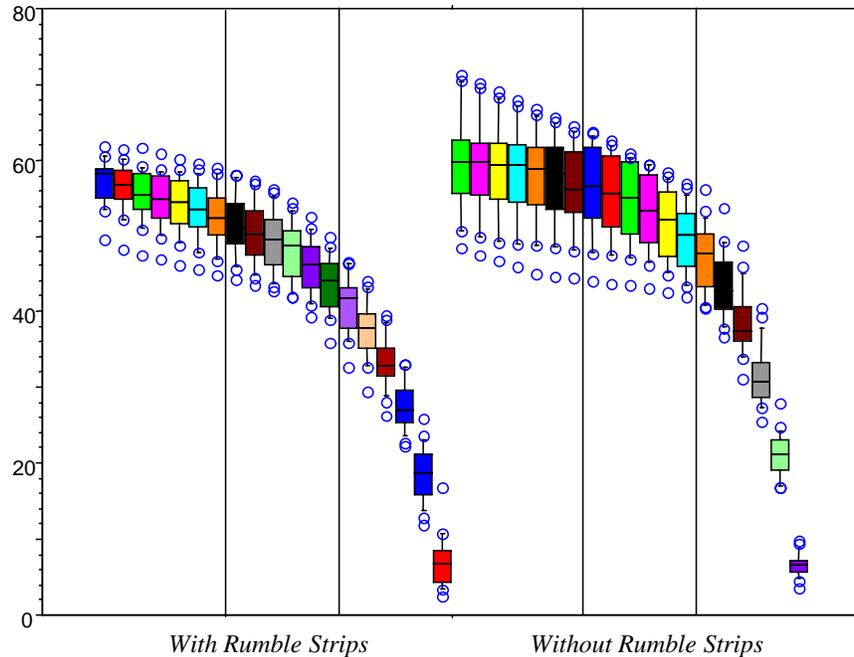


Figure 3.6: SUV/Pick-Up Truck/Van Category—Boxplots of Individual Mean Speeds in the Segments on the Approach to *Obscure/Visible* Intersections *With Rumble Strips* and *Without Rumble Strips*.

When the two sets of boxplots presented in Figure 3.6 are compared, the effect of rumble strips becomes more apparent. The drivers in the *With Rumble Strips* Condition show a gradual reduction in speed after encountering the first set of rumble strips. In contrast, Figure 3.6 reveals that most drivers in the *Without Rumble Strips* Condition—including the outliers who were driving fastest—have much smaller early reductions in speed, so that when they are relatively close to the intersection, have to slow down much more abruptly than the drivers in the *With Rumble Strips* Condition.

The significant interaction between Rumble Strip Conditions and Segments, for the Passenger Cars category that was indicated in Table 3.9 is illustrated in Figure 3.7.

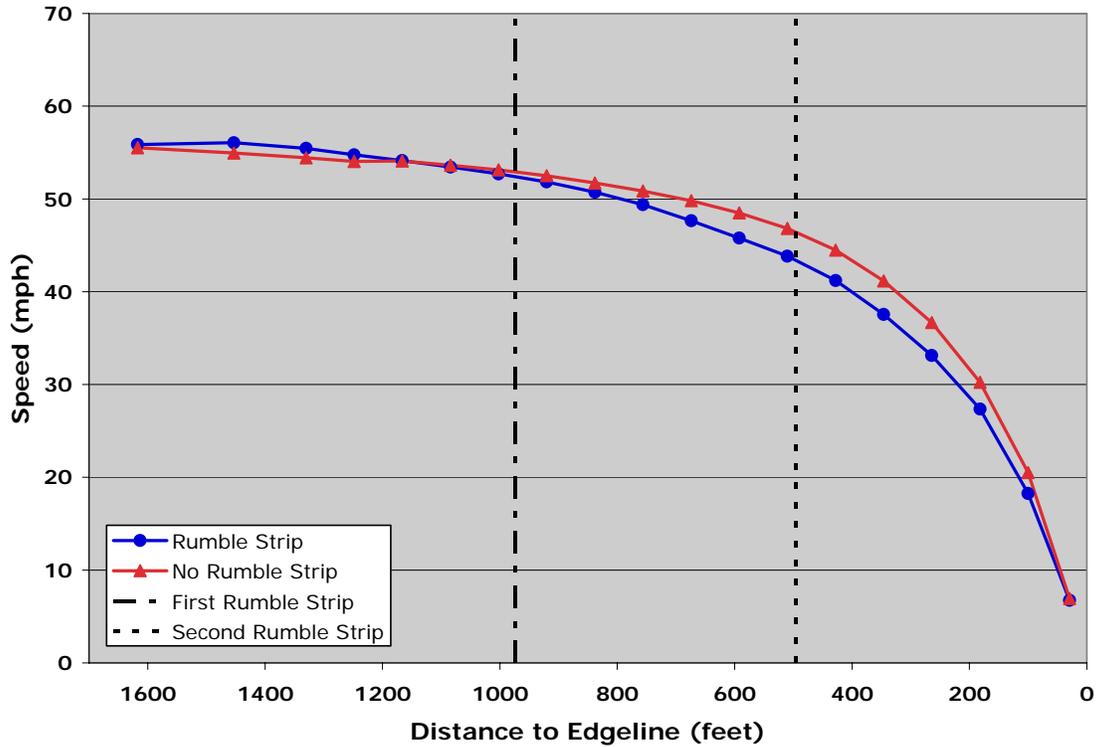


Figure 3.7: Passenger Car Category—Mean Speeds on the Approach to Obscure/Visible Intersections With Rumble Strips and Without Rumble Strips.

As Figure 3.7 shows, for the Passenger Car Category, initially the average speed of drivers on the approach *With Rumble Strips* and of drivers on the approach *Without Rumble Strips* was very similar. The drivers on the approach *With Rumble Strips* encountered the first set of rumble strips 973.5 feet (297 meters) from the edge line of the intersection, and after this point—as Figure 3.7 shows—these drivers reduced speed more than the drivers on the approach *Without Rumble Strips*. Throughout the section of the approach from 592 feet (180.5 meters) to 182 feet (55.5 meters) from the intersection, the drivers on the approach *With Rumble Strips* drove 3.0 mph to 4.0 mph slower than those on the approach *Without Rumble Strips*.

In order to explore the effect of rumble strips on *individual drivers* in the Passenger Car Category, we examined the boxplots associated with the mean speeds shown in Figure 3.7. These boxplots are presented in Figure 3.8.

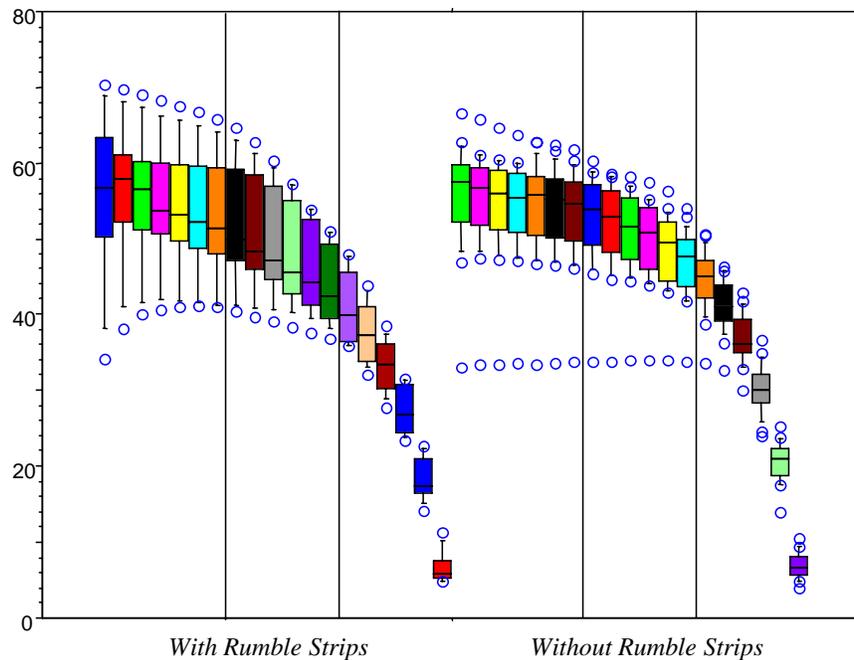


Figure 3.8: Passenger Car Category—Boxplots of Individual Mean Speeds in the Segments on the Approach to *Obscure/Visible* Intersections *With Rumble Strips* and *Without Rumble Strips*.

Interestingly, Figure 3.8 shows that on the approaches to both the intersection *With Rumble Strips* and the intersection *Without Rumble Strips* there were single drivers, both outliers, who were driving much slower than the others on their respective approaches.

The boxplots shown in the figure also indicate that on the approach *Without Rumble Strips* one driver, who was traveling faster, did not exhibit the same stopping behavior as the other drivers on the approach. This driver was reducing speed at a slower rate than the other drivers, and eventually had to slow down more abruptly than them.

The significant interaction between Rumble Strip Conditions and Segments, for the Commercial Vehicle/Heavy Truck Category—indicated in Table 3.10—is illustrated in Figure 3.9.

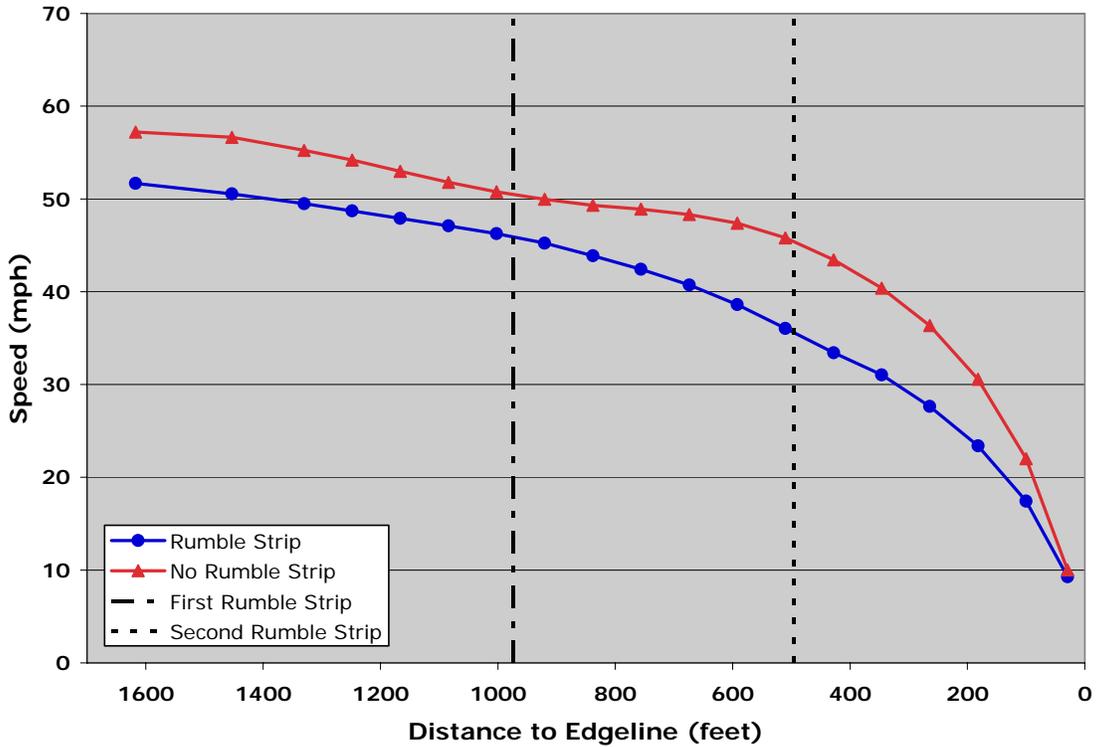


Figure 3.9: Commercial Vehicle/Heavy Truck Category—Mean Speeds on the Approach to *Obscure/Visible* Intersections *With Rumble Strips* and *Without Rumble Strips*.

Figure 3.9 shows that for the Commercial Vehicle/Heavy Truck Vehicle Category on the initial part of the approach to the intersection—i.e., before the first set of rumble strips were encountered by the drivers in the *With Rumble Strips* Condition—there was already a difference in speed, with the drivers in the *Without Rumble Strips* Condition driving approximately 4.0 mph faster than the drivers in the *With Rumble Strips* Condition. Then, later in the approach—i.e., after the drivers in the *With Rumble Strips* Condition encountered the first set of rumble strips—the speed differential between the drivers in the two conditions increased. The greatest difference in speed occurs when the drivers are between 592 feet (180.5 meters) and 264 feet (80.5 meters) from the intersection. Then the drivers in the *With Rumble Strips* Condition are traveling 8 mph to 9 mph slower than the drivers in the *Without Rumble Strips* Condition. Therefore, when we consider that the drivers in the *With Rumble Strips* Condition were already driving approximately 4.0 mph slower, it appears that the effect of encountering the first set of rumble strips accounts for an additional reduction in speed of 4.0 mph to 5.0 mph, when these drivers are compared with the drivers in the *Without Rumble Strips* Condition.

Figure 3.9 shows the effect of rumble strips on the *average* speed of drivers of vehicles in the Commercial Vehicle/Heavy Truck category as they approached an intersection with traffic obscured on one side of the crossing road, but visible on the other. In order to look at the effect of rumble strips on the speed of *outliers*, we examined the boxplots

associated with the mean speeds shown in Figure 3.9. These boxplots are presented in Figure 3.10.

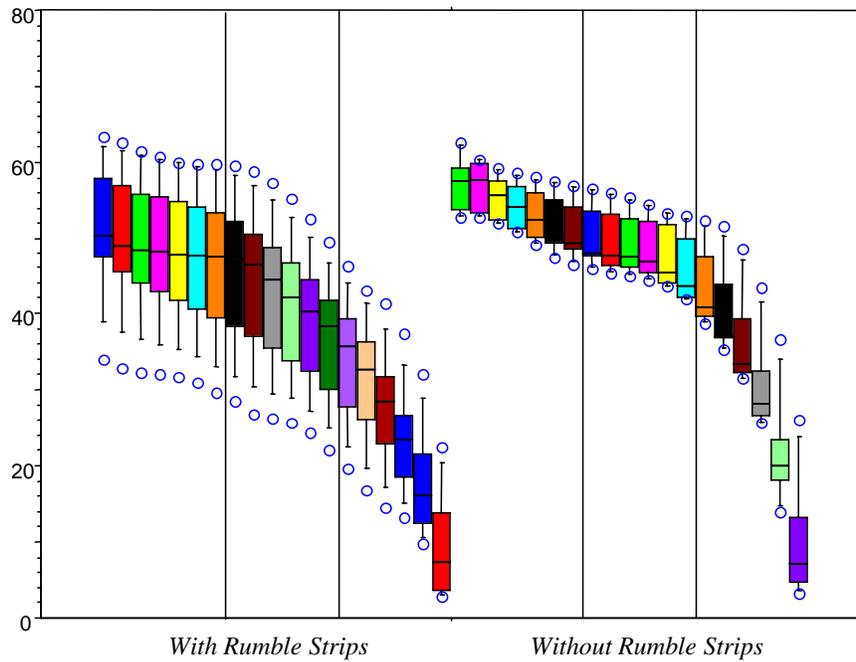


Figure 3.10: Commercial Vehicle/Heavy Truck Category—Boxplots Mean Speeds on the Approach to *Obscure Both* Intersections *With Rumble Strips* and *Without Rumble Strips*.

Figure 3.10 shows that, on the approach to the intersection *With Rumble Strips*, one outlier who was traveling much faster exhibited similar stopping behavior to the other drivers in the group. It also shows that *all* the drivers on the approach to the intersection *Without Rumble Strips*, continued to travel at relatively high speeds until they were close to the intersection and then had to slow down abruptly.

3.4 Stopping Behavior in the *Visible Both* Intersection Category

Photographs of the two intersections used to explore the effects of rumble strips on intersections in the *Visible Both* Category are presented in Appendix B. The numbers of drivers from whom data were obtained on the approaches to these two intersections were 40, for the *With Rumble Strips* approach, and 41 for the intersection *Without Rumble Strips*. Table 3.11 shows the distribution of the vehicles used by these drivers into the three vehicle categories.

Table 3.11: Distribution of Vehicles Approaching Visible Both Intersections

Intersection Condition	SUV/Pick-Up Truck/Van	Passenger Car	Commercial Vehicle/ Heavy Truck	Total
<i>With Rumble Strips</i>	18	6	16	40
<i>Without Rumble Strips</i>	26	11	4	41

Since Table 3.11 shows that once again there were unequal numbers of vehicles in the three categories. And again, to deal with the inequalities, we used the Winer-Brown-Michaels (1991) formulation to conduct ANOVAs. We conducted three ANOVAs—one for each vehicle category—on the mean speed data obtained in each segment on the approaches to the intersections *With Rumble Strips* and *Without Rumble Strips*. Summaries of the results of these ANOVAs are shown in Table 3.12 (for the SUV/Pick-Up Truck/Van Category), Table 3.13 (Passenger Car Category), and Table 3.14 (Commercial Vehicle/Heavy Truck Category).

Table 3.12: ANOVA Summary for the Visible Both Intersections—for the SUV/Pick-Up Truck/Van Category

Source of Variance	Degrees of Freedom	Sum of Squares	Variance Estimate	F-Value	Significance Level
Rumble Strip Conditions (RS)	1	185.679	185.679	0.351	<i>ns</i>
Subjects within Groups (SwG)	39	20,630.195	528.979		
Segments (SEG)	18	154,143.984	8,563.555	1,377.173	<0.0001
Interaction RS x SEG	18	265.130	14.729	2.369	0.0012
SEG x SwG	702	4,365.186	6.218		

Table 3.13: ANOVA Summary for the Visible Both Intersections—for the Passenger Car Category

Source of Variance	Degrees of Freedom	Sum of Squares	Variance Estimate	F-Value	Significance Level
Rumble Strip Conditions (RS)	1	32.815	32.815	0.069	<i>ns</i>
Subjects within Groups (SwG)	14	6,700.527	478.609		
Segments (SEG)	18	60,777.204	3,376.511	477.341	<0.0001
Interaction RS x SEG	18	23.381	1.299	0.184	<i>ns</i>
SEG x SwG	252	1,782.543	7.074		

Table 3.14: ANOVA Summary for the *Visible Both* Intersections—for the Commercial Vehicle/Heavy Truck Category

Source of Variance	Degrees of Freedom	Sum of Squares	Variance Estimate	F-Value	Significance Level
Rumble Strip Conditions (RS)	1	5,944.560	5,944.560	40.760	<0.0001
Subjects within Groups (SwG)	19	2,770.991	145.842	679.178	
Segments (SEG)	18	49,754.114	2,764.117	1.665	<0.0001
Interaction RS x SEG	18	121.971	6.776		0.0438
SEG x SwG	342	1,391.871	4.070		

As with the *Obscure Both*, and *Obscure/Visible* Intersection Categories, Tables 3.12, 3.13, and 3.14 show that for the *Visible Both* Intersection Category there were statistically significant segment effects (all at the $p < 0.0001$ level) for all three vehicle categories: Table 3.14 also shows that there was a statistically significance effect of rumble strips (with $p = 0.0073$) for the Commercial Vehicle/Heavy Truck Category. And, in addition, Table 3.12 and Table 3.14 indicate that there were statistically significant interactions between Rumble Strip Conditions and Segments—with $p = 0.0012$ for the SUV/Pick-Up Truck/Van Category, and $p = 0.0438$ for the Commercial Vehicle/Heavy Truck Category.

The significant interaction between Rumble Strip Conditions and Segments, for the SUV/Pick-Up Truck/Vans category, is illustrated in Figure 3.11.

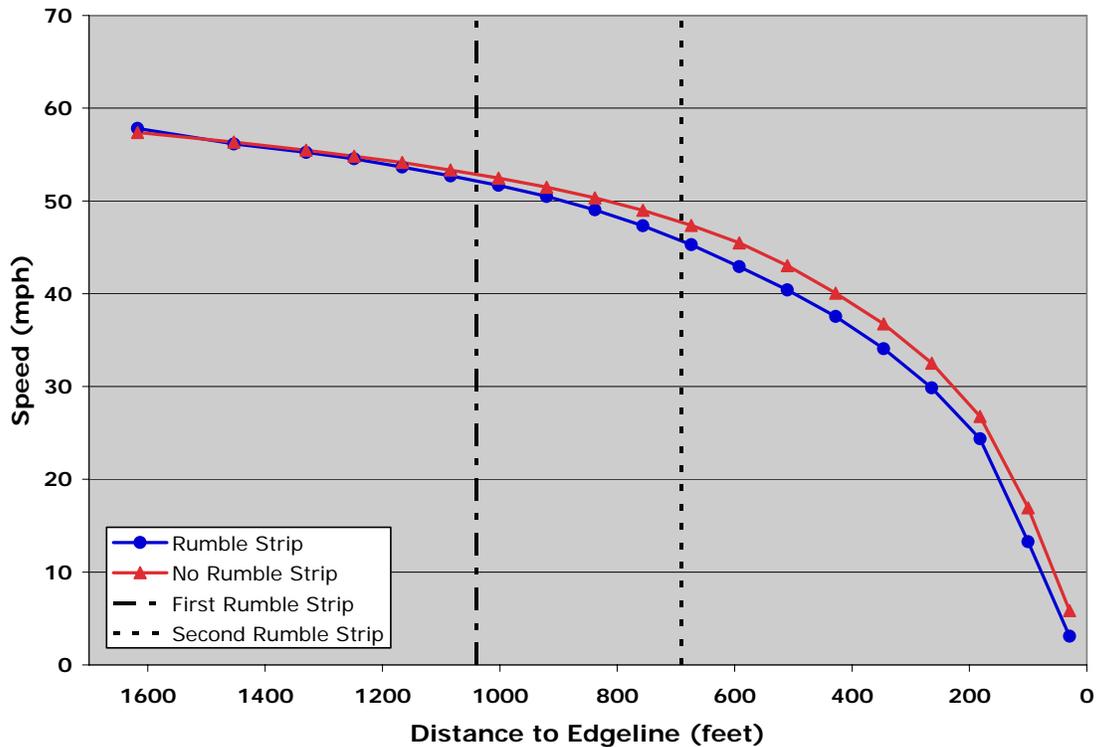


Figure 3.11: SUV/Pick-Up Truck/Van Category—Mean Speeds on the Approach to Visible/Both Intersections With Rumble Strips and Without Rumble Strips.

Figure 3.11 shows that, for the SUV/Pick-Up Truck/Van Category, initially the average speed for the drivers on both the approach *With Rumble Strips* and the approach *Without Rumble Strips* was similar. Then, after the drivers on the approach *With Rumble Strips* encountered the first set of rumble strips—1039.5 feet (317 meters) from the edge line at the intersection—the average speeds of the two groups of drivers began to differ, with the drivers on the approach *With Rumble Strips* slowing down more than the drivers on the approach *Without Rumble Strips*. On average the drivers on the approach *With Rumble Strips* drove approximately 2.0 mph slower than those on the approach *Without Rumble Strips*—with the greatest difference in average speed (of 3.4 mph) occurring when the drivers were only 100 feet (30.5 meters) from the intersection.

Figure 3.11 shows the effect of rumble strips on the *average* speed of the drivers of vehicles in the SUV/Pick-Up Truck/Van Category, as they approached an intersection with traffic visible on both sides of the crossing road. The effect of rumble strips on the speed of *individual drivers* is explored in the boxplots shown in Figure 3.12.

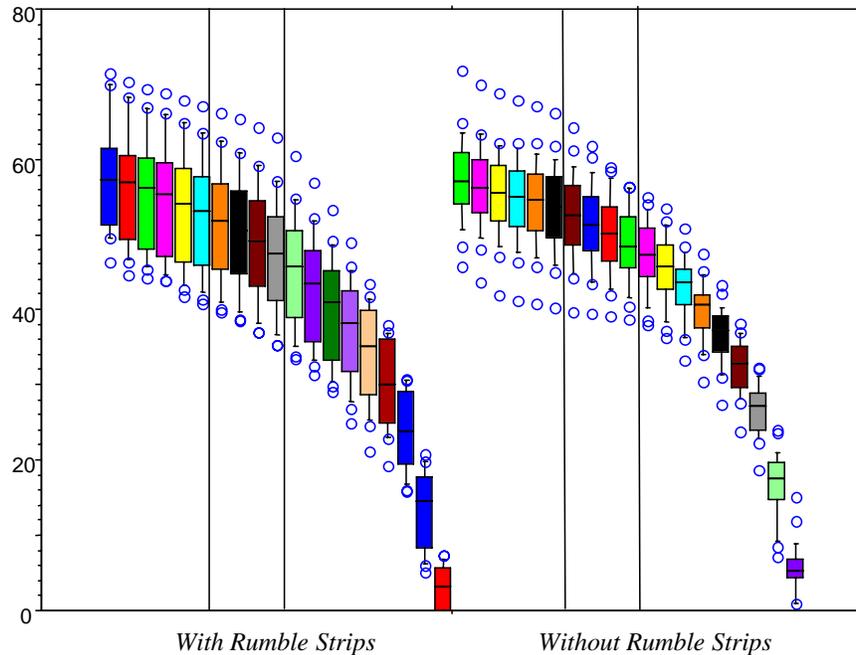


Figure 3.12: SUV/Pick-Up Truck/Van Category—Boxplots of Individual Mean Speeds in the Segments on the Approach to Visible Both Intersections With Rumble Strips and Without Rumble Strips.

Earlier boxplot presentations show that, on the approach to the intersection *With Rumble Strips*, outliers who were traveling much faster exhibited similar stopping behavior to the other drivers in their group. Figure 3.12 shows one outlier who behaves in this way and another outlier whose does not reduce speed as quickly—the figure shows that this driver only conforms to the same pattern as the other drivers after he or she encounters the second set of rumble strips.

As with the boxplot presentations shown earlier in this section, Figure 3.12 shows that *all* the drivers on the approach *Without Rumble Strips* continued to travel at relatively high speeds until they were close to the intersection—then they had to slow down abruptly.

For the Passenger Cars Category, the interaction between Rumble Strip Conditions and Segments was *not* statistically significant—as Figure 3.13 shows.

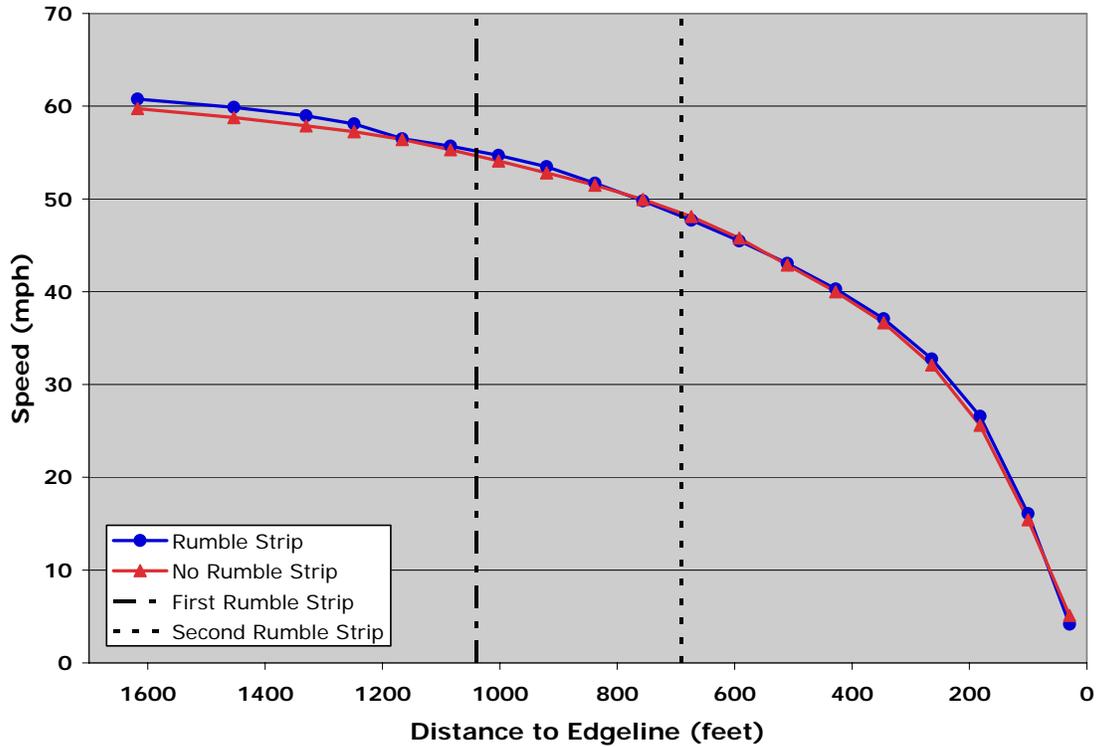


Figure 3.13: Passenger Car Category—Mean Speeds on the Approach to *Visible Both Intersections With Rumble Strips and Without Rumble Strips.*

Since the interaction between Rumble Strip Conditions and Segments was not statistically significant, it was to be expected that, as Figure 3.13 shows, the mean speeds for the drivers at the intersection *With Rumble Strips* were almost the same as those for the drivers at the intersection *Without Rumble Strips* throughout the approach. However, when the data for the individual drivers were examined, using boxplots, it was apparent that there were some outliers with interesting stopping behaviors—as Figure 3.14 shows.

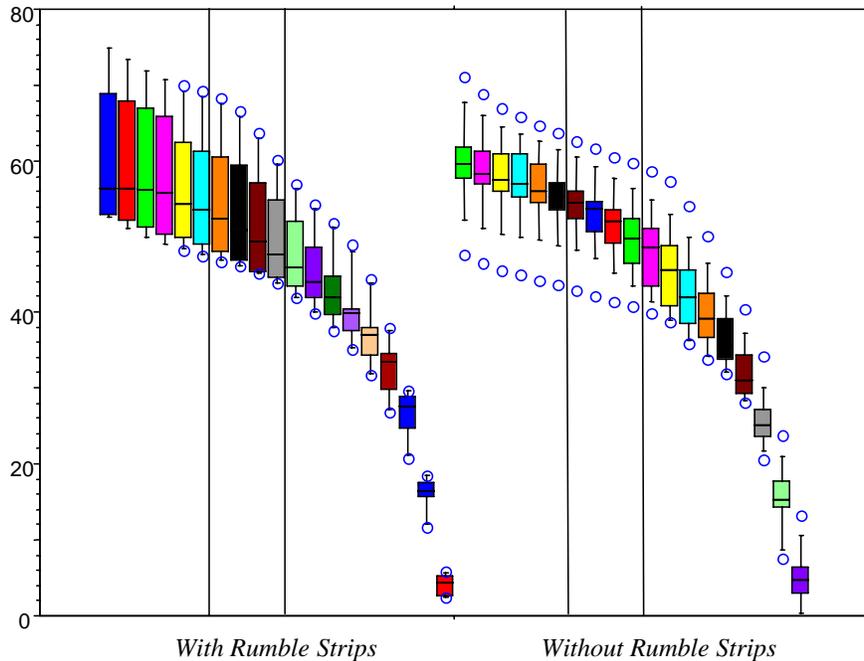


Figure 3.14: Passenger Car Category—Boxplots of Individual Mean Speeds in the Segments on the Approach to *Visible Both* Intersections *With Rumble Strips* and *Without Rumble Strips*.

As can be seen from the boxplots in Figure 3.14, for the drivers approaching the intersection *Without Rumble Strips*, there were two outliers—one traveling considerably faster and one traveling considerably slower than the other drivers. The figure shows that for both of these outliers there was only a very gradual reduction in their speed until they were relatively close to the intersection at which point they both reduced speed abruptly. In contrast, the behavior of the drivers who were outliers on the approaching to the intersection *With Rumble Strips* mirrors the behavior of the other drivers in the group.

The significant interaction between Rumble Strip Conditions and Segments, for the Commercial Vehicle/Heavy Truck Category, is illustrated in Figure 3.15.

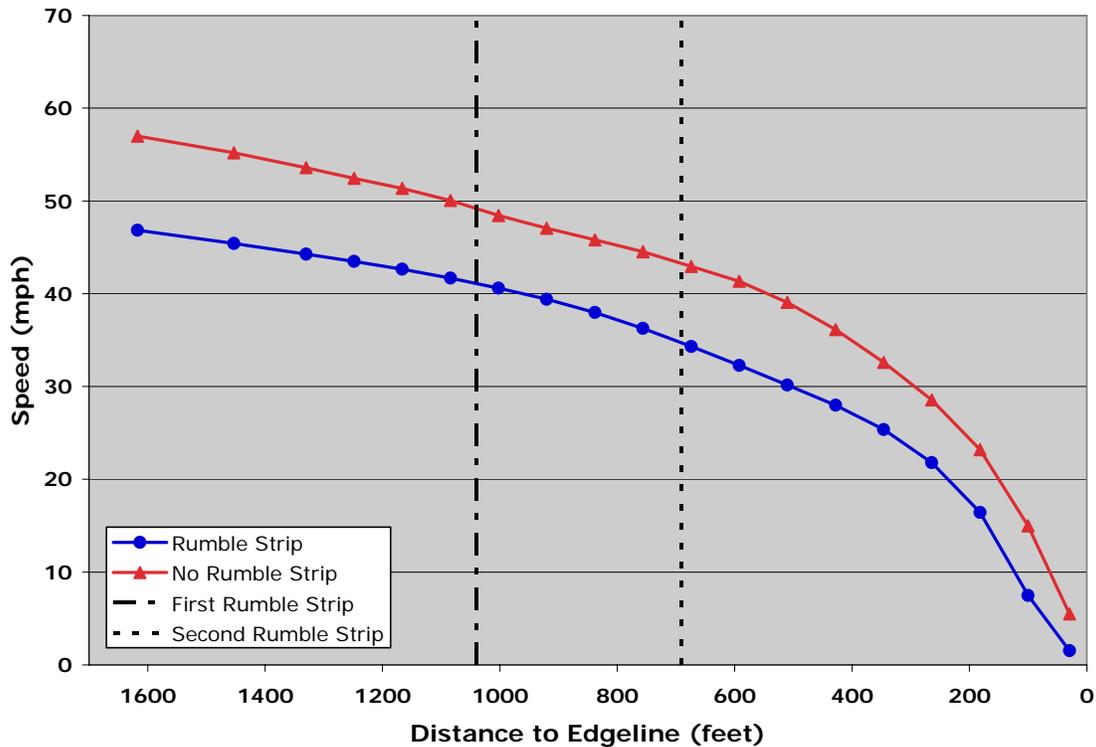


Figure 3.15: Commercial Vehicle/Heavy Truck Category—Mean Speeds on the Approach to *Visible Both* Intersections With Rumble Strips and Without Rumble Strips.

Figure 3.15 shows that, for the Commercial Vehicle/Heavy Truck Category, there was a considerable difference in speed throughout the approaches to the two intersections. The drivers on the approach *With Rumble Strips* were already driving relatively slowly on average, at 47 mph, when they were 1,700-1535 feet (518-468 meters) from the edge line at the intersection. Not only is this considerably slower than the drivers on the approach *Without Rumble Strips* (their average speed was 57 mph), but it is also considerably slower than the average for drivers on both the *With* and *Without Rumble Strip* approaches to the *Obscure Both* and the *Obscure/Visible* Intersections. It is not clear why the drivers in the Commercial Vehicle/Heavy Truck Category were driving so slowly on this particular approach—particularly since the drivers of vehicles in the SUV/Pick-Up Truck/Van Category and Passenger Car Category did not drive at slower speeds on this approach. However, it is likely that the speed of the drivers in the Commercial Vehicle/Heavy Truck Category was not affected when they crossed the first set of rumble strips because they were already driving sufficiently slowly.

The effect of rumble strips on the speed of the *outliers* in the Commercial Vehicle/Heavy Truck Category is explored in the boxplots shown in Figure 3.16.

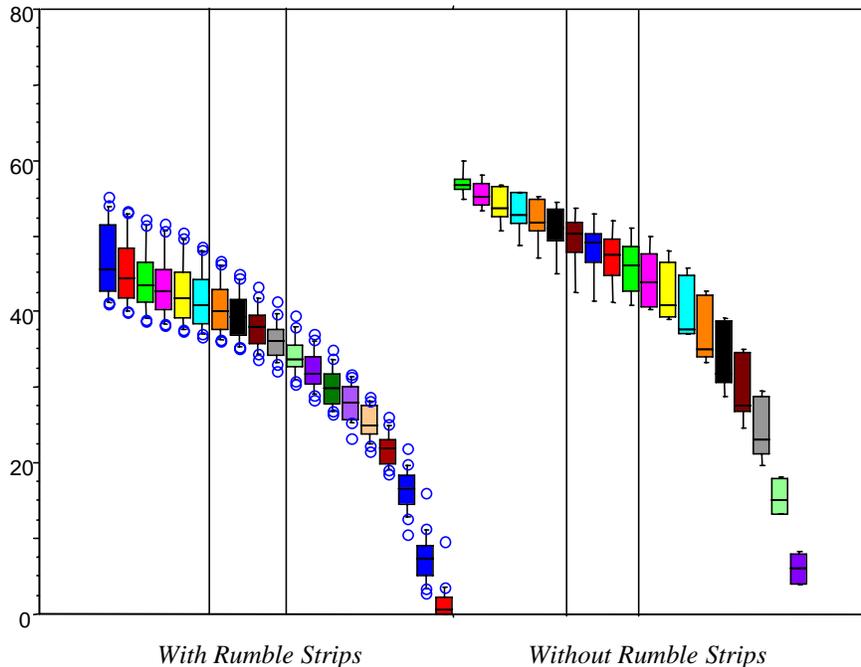


Figure 3.16: Commercial Vehicle/Heavy Truck Category—Boxplots of Individual Mean Speeds in the Segments on the Approach to *Visible Both* Intersections *With Rumble Strips* and *Without Rumble Strips*.

As can be seen from the boxplots in Figure 3.16, there was a very narrow range in speeds for the drivers of vehicles in the Commercial Vehicle/Heavy Truck Category approaching the *Visible Both* Intersections. This is not surprising for the drivers approaching the intersection *Without Rumble Strips*, since there were only four of them. However, it is notable for the drivers approaching the intersection *With Rumble Strips*, since there were 16 of them.

3.5 Stopping Behavior in the *Horizontal Curve* Intersection Category

Photographs of the two intersections used in exploring the effects of rumble strips on intersections in the *Horizontal Curve* Category are presented in Appendix B. As mentioned earlier for the *Horizontal Curve* Intersections, data collection locations on the opposite side of the intersection do not afford the direct line-of-sight necessary to collect radar data. Instead for these intersections, the vehicle containing the radar gun and laser rangefinder was located upstream of the intersections. Inevitably, we were only able to record the vehicle approach up to the beginning of the horizontal curve. Because of this, we had to utilize an abbreviated segmentation scheme for the *Horizontal Curve* Intersections. From the data recording location on the approach to the intersection *With Rumble Strips*, there were ten segments before the drivers reached the beginning of the horizontal curve—the first of these segments was 75.5 feet (23 meters), then there were nine 82.02-foot (25-meter) segments to the beginning of the curve. From the data recording location on the approach to the intersection *Without Rumble Strips*, we were

able to obtain speed data over a distance of 574 feet (175 meters)—at this intersection, there were seven 82.02-foot (25-meter) segments to the beginning of the curve.

The numbers of drivers from whom data were obtained on the approaches to these two intersections was 41, for both the *With* and *Without Rumble Strips* approaches. Table 3.15 shows the distribution of the vehicles used by these drivers into the three vehicle categories.

Table 3.15: Distribution of Vehicles Approaching *Horizontal Curve* Intersections

Intersection Condition	SUV/Pick-Up Truck/Van	Passenger Car	Commercial Vehicle/ Heavy Truck	Total
<i>With Rumble Strips</i>	20	11	10	41
<i>Without Rumble Strips</i>	23	12	6	41

Once again there were unequal numbers of vehicles in the three categories. Therefore, to deal with the inequalities, we again used the Winer-Brown-Michaels (1991) formulation to conduct three ANOVAs—one for each vehicle category. In these ANOVAs, we compared the mean speeds obtained from each driver in the last seven of the nine segments on the approach *With Rumble Strips* with the mean speeds obtained in the seven segments on the approach *Without Rumble Strips*. Summaries of the results of these ANOVAs are shown in Table 3.16 (for the SUV/Pick-Up Truck/Van Category), Table 3.17 (Passenger Car Category), and Table 3.18 (Commercial Vehicle/Heavy Truck Category).

Table 3.16: ANOVA Summary for the *Horizontal Curve* Intersections—for the SUV/Pick-Up Truck/Van Category

Source of Variance	Degrees of Freedom	Sum of Squares	Variance Estimate	F-Value	Significance Level
Rumble Strip Conditions (RS)	1	2,204.235	2,204.235	12.530	0.0011
Subjects within Groups (SwG)	37	6,508.725	175.911		
Segments (SEG)	6	724.178	120.696	86.004	<0.0001
Interaction RS x SEG	6	50.015	8.336	5.940	<0.0001
SEG x SwG	222	311.552	1.403		

Table 3.17: ANOVA Summary for the *Horizontal Curve* Intersections—for the Passenger Car Category

Source of Variance	Degrees of Freedom	Sum of Squares	Variance Estimate	F-Value	Significance Level
Rumble Strip Conditions (RS)	1	1425.609	1425.609	3.975	<i>ns</i>
Subjects within Groups (SwG)	22	7,889.175	358.599		
Segments (SEG)	6	532.184	88.697	38.941	<0.0001
Interaction RS x SEG	6	8.238	1.373	0.603	<i>ns</i>
SEG x SwG	132	300.663	2.278		

Table 3.18: ANOVA Summary for the *Horizontal Curve* Intersections—for the Commercial Vehicle/Heavy Truck Category

Source of Variance	Degrees of Freedom	Sum of Squares	Variance Estimate	F-Value	Significance Level
Rumble Strip Conditions (RS)	1	26.221	26.221	0.128	<i>ns</i>
Subjects within Groups (SwG)	13	2,658.054	204.466		
Segments (SEG)	6	148.412	24.735	21.390	<0.0001
Interaction RS x SEG	6	57.068	9.511	8.225	<0.0001
SEG x SwG	78	90.199	1.156		

Tables 3.16, 3.17, and 3.18 show that for the *Horizontal Curve* Intersection Category there were statistically significant segment effects (with $p < 0.0001$) for all three vehicle categories. In addition, Table 3.17 shows that there was a statistically significant effect of rumble strips (at the $p = 0.0011$ level) for the SUV/Pick-Up Truck/Van Category. And, Table 3.16 and Table 3.18 indicate that there were statistically significant interactions between Rumble Strip Conditions and Segments—with $p < 0.0001$ for both the SUV/Pick-Up Truck/Van Category and the Commercial Vehicle/Heavy Truck Category.

The significant interaction between Rumble Strip Conditions and Segments, for the SUV/Pick-Up Truck/Vans category, is illustrated in Figure 3.17.

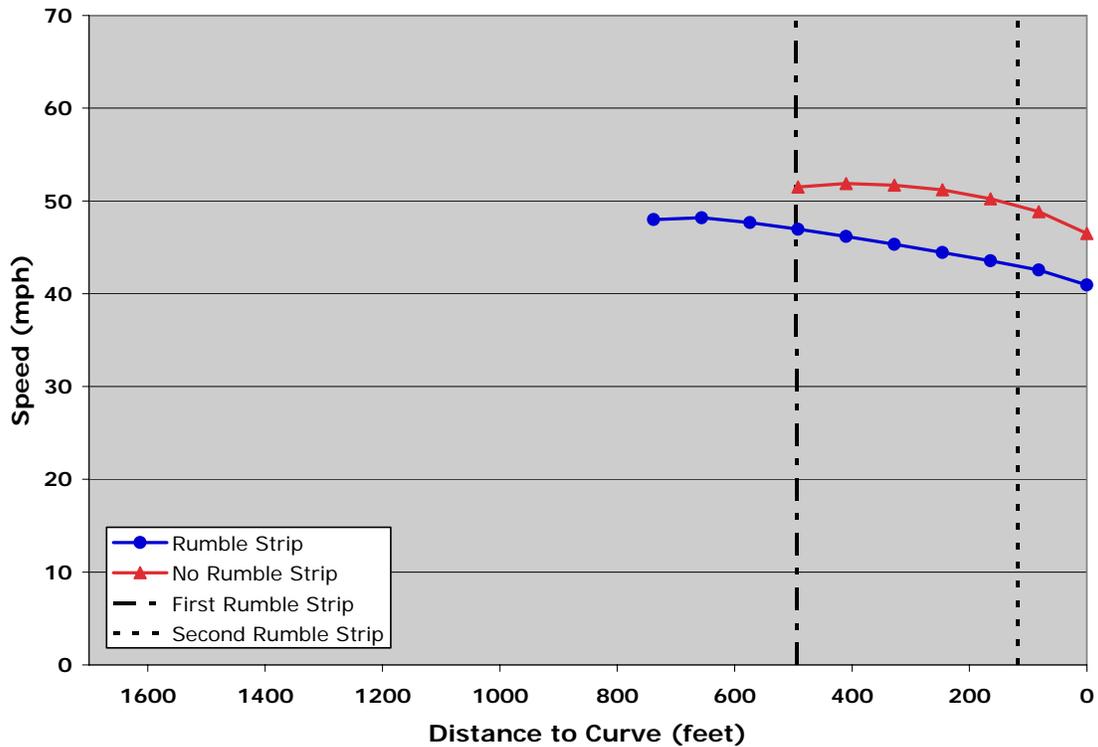


Figure 3.17: SUV/Pick-Up Truck/ Van Category—Mean Speeds on the Approach to Horizontal Curve Intersections With Rumble Strips and Without Rumble Strips.

As can be seen in Figure 3.17, there are far less data for the *Horizontal Curve* Intersections on which to base conclusions than for the *Obscure Both*, *Obscure Visible*, and *Visible Both* Intersections. However, Figure 3.17 shows that, in the SUV/Pick-Up Truck/ Van Category, the average speed for the drivers on the approach *With Rumble Strips* dropped after they crossed the first set of rumble strips. In contrast, on the approach *Without Rumble Strips* the average speed of the drivers increased after this point—i.e., when the drivers were 574 feet (175 meters) from the beginning of the curve—and on average they entered the curve traveling 5.5 mph faster than the drivers on the approach *With Rumble Strips*

The boxplots presented in Figure 3.18 show the effect of rumble strips on the speed of individual drivers of vehicles in the SUV/Pick-Up Truck/ Van Category, as they approached an intersection with traffic visible on both sides of the crossing road.

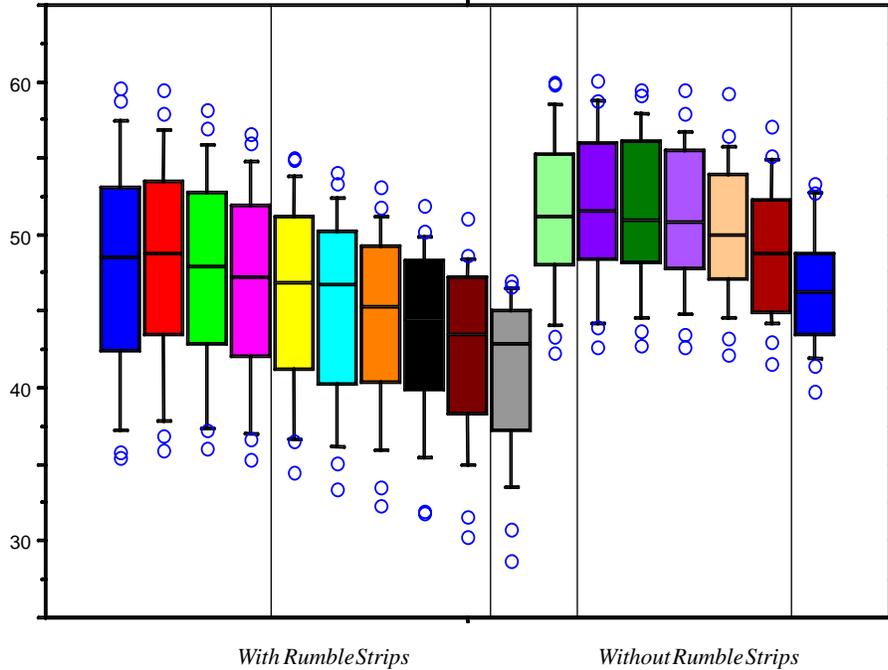


Figure 3.18: SUV/Pick-Up Truck/Van Category—Boxplots of Individual Mean Speeds in the Segments on the Approach to *Horizontal Curve* Intersections *With Rumble Strips* and *Without Rumble Strips*.

Figure 3.18 shows that on the approach to the intersection *With Rumble Strips*, the outliers who were traveling faster reduced speed on crossing the first set of rumble strips in much the same way as most of the other drivers on this approach. On the approach to the intersection *Without Rumble Strips*, one of the outliers who was traveling faster continued at that speed and then reduced speed more abruptly just before reaching the beginning of the horizontal curve.

The interaction between Rumble Strip Conditions and Segments was *not* statistically significant for the Passenger Cars Category. However, the interaction was significant for the Commercial Vehicle/Heavy Truck Category—this interaction is illustrated in Figure 3.19.

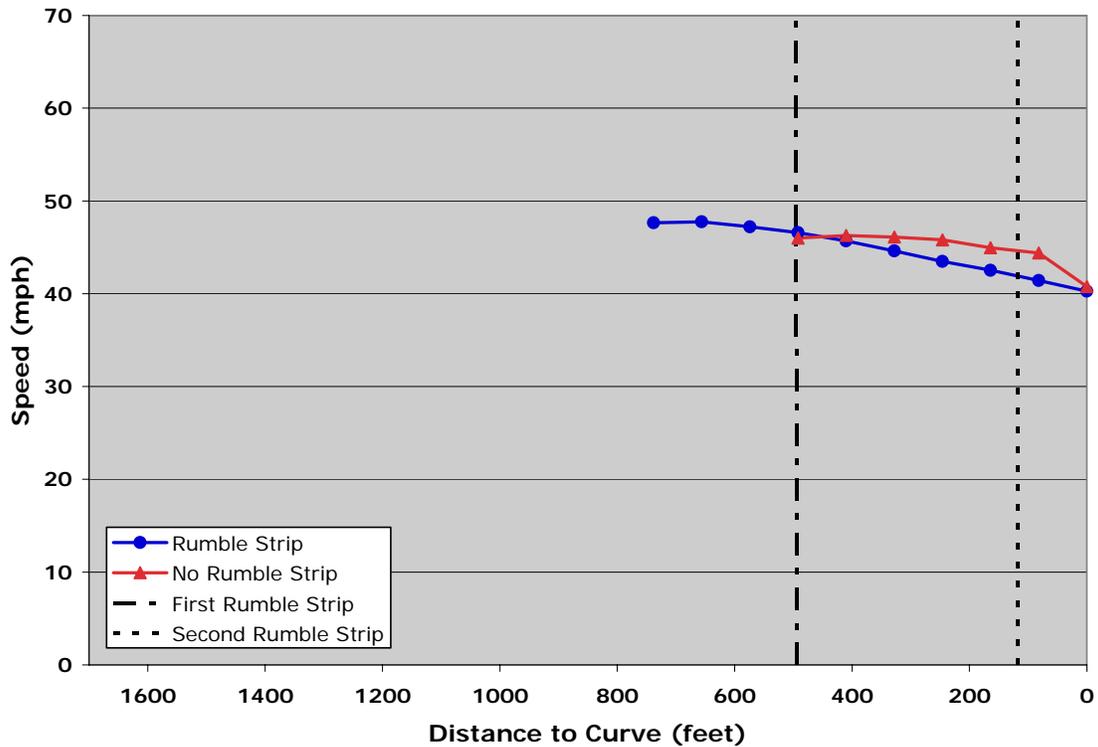


Figure 3.19: Commercial Vehicle/Heavy Truck Category—Mean Speeds on the Approach to *Horizontal Curve* Intersections *With Rumble Strips* and *Without Rumble Strips*.

Figure 3.19 shows that, on average, in the Commercial Vehicle/Heavy Truck Category the drivers on both the approach *With Rumble Strips* and the approach *Without Rumble Strips* were traveling at similar speeds when they were 574 feet (175 meters) from the beginning of the curve. However, those on the approach *With Rumble Strips* slowed down gradually after they crossed the first set of rumble strips, while the drivers on the approach *Without Rumble Strips* did not reduce speed, instead coasting for 328 feet (100 meters) before reducing speed more abruptly just before the beginning of the curve.

The effect of rumble strips on the speed of the *individual* drivers of vehicles in the Commercial Vehicle/Heavy Truck Category is explored in the boxplots shown in Figure 3.20.

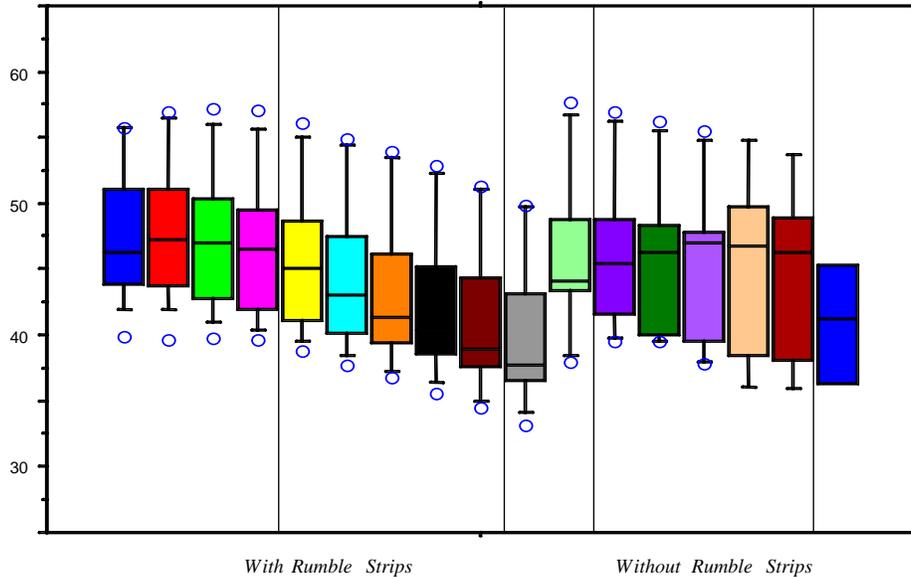


Figure 3.20: Commercial Vehicle/Heavy Truck Category —Boxplots of Individual Mean Speeds in the Segments on the Approach to *Horizontal Curve* Intersections *With Rumble Strips* and *Without Rumble Strips*.

Figure 3.20 shows that on the approach to the intersection *With Rumble Strips*, the outliers who were traveling faster reduced speed on crossing the first set of rumble strips in much the same way as most of the other drivers on this approach.

Although the data are clearly more limited for the *Horizontal Curve* approaches it appears that, after the point at which the first set of rumble strips occur, on the approach *With Rumble Strips* drivers of in the SUV/Pick-up Trucks/Vans Category and in the Commercial Vehicle/Heavy Truck Category did slow down earlier than the drivers on the approach *Without Rumble Strips*.

3.6 Stopping Behavior in the *Vertical Curve* Intersection Category

Photographs of the two intersections used in exploring the effects of rumble strips on intersections in the *Vertical Curve* Category are presented in Appendix B. As mentioned earlier in this report, the speed limits were different on the two approaches. The speed limit was 55 mph on the approach *With Rumble Strips* and 45 mph on the approach *Without Rumble Strips*. We selected this particular approach for the *Without Rumble Strips* approach because the three alternatives in this category were unsuitable or could not be used during the time frame of the study.

As with the *Horizontal Curve* Intersections, data collection locations on the opposite side of the *Vertical Curve* Intersections do not afford the direct line-of-sight necessary to collect radar data. For these intersections, the vehicle containing the radar gun and laser rangefinder were located upstream of the intersections. And inevitably, we were only

able to record the approach until the vehicles disappeared beyond the crest of the vertical curve. Because of this, we had to utilize an abbreviated segmentation scheme for the *Vertical Curve* Intersections.

From the data recording location on the approach to the intersection *With Rumble Strips*, we were able to obtain speed data for a distance of 1394 feet (425 meters) before vehicles were lost beyond the crest of the vertical curve—this distance was segmented into seventeen 82.02-foot (25-meter) segments. On the approach to the intersection *Without Rumble Strips*, we established a data recording location that provided speed data for a distance of 738 feet (225 meters) before vehicles were lost beyond the crest of the vertical curve—this distance was segmented into nine 82.02-foot (25-meter) segments.

The numbers of drivers from whom data were obtained on the approaches to these two intersections was 40 for for the *With Rumble Strips* approach and 42 for the *Without Rumble Strips* approach. Table 3.19 shows the distribution of the vehicles used by these drivers into the three vehicle categories.

Table 3.19: Distribution of Vehicles Approaching *Vertical Curve* Intersections

Intersection Condition	SUV/Pick-Up Truck/Van	Passenger Car	Commercial Vehicle/ Heavy Truck	Total
<i>With Rumble Strips</i>	8	17	15	40
<i>Without Rumble Strips</i>	20	17	5	42

As can be seen from Table 3.19, there were unequal numbers of vehicles in two of the three categories. Because of these inequalities, we again used the Winer-Brown-Michaels (1991) formulation to conduct three ANOVAs—one for each vehicle category. In the ANOVAs, we compared the mean speeds obtained from each driver in the last nine of the 17 segments on the approach *With Rumble Strips* with the mean speeds obtained in the nine segments on the approach *Without Rumble Strips*. Summaries of the results of these ANOVAs are shown in Table 3.20 (SUV/Pick-Up Truck/Van Category), Table 3.21 (Passenger Car Category), and Table 3.22 (Commercial Vehicle/Heavy Truck Category).

Table 3.20: ANOVA Summary for the *Vertical Curve* Intersections—for the SUV/Pick-Up Truck/Van Category

Source of Variance	Degrees of Freedom	Sum of Squares	Variance Estimate	F-Value	Significance Level
Rumble Strip Conditions (RS)	1	2,682.077	2,682.077	7.358	0.0119
Subjects within Groups (SwG)	25	9,112.684	364.507		
Segments (SEG)	8	336.737	42.092	13.781	<0.0001
Interaction RS x SEG	8	13.431	1.679	0.550	<i>ns</i>
SEG x SwG	200	610.859	3.054		

Table 3.21: ANOVA Summary for the *Vertical Curve* Intersections—for the Passenger Car Category

Source of Variance	Degrees of Freedom	Sum of Squares	Variance Estimate	F-Value	Significance Level
Rumble Strip Conditions (RS)	1	7,894.824	7,894.824	18.604	0.0002
Subjects within Groups (SwG)	27	11,457.745	424.361		
Segments (SEG)	8	677.581	84.698	41.925	<0.0001
Interaction RS x SEG	8	160.254	20.032	9.916	<0.0001
SEG x SwG	216	436.365	2.020		

Table 3.22: ANOVA Summary for the *Vertical Curve* Intersections—for the Commercial Vehicle/Heavy Truck Category

Source of Variance	Degrees of Freedom	Sum of Squares	Variance Estimate	F-Value	Significance Level
Rumble Strip Conditions (RS)	1	807.449	807.449	1.458	<i>ns</i>
Subjects within Groups (SwG)	18	9,970.225	553.901		
Segments (SEG)	8	216.473	27.059	15.904	<0.0001
Interaction RS x SEG	8	113.236	14.154	8.319	<0.0001
SEG x SwG	144	244.999	1.701		

Tables 3.20, 3.21, and 3.22 show that for the *Vertical Curve* Intersection Category (as was the case for all the other Intersection Categories) there were statistically significant segment effects (with $p < 0.0001$) for all three vehicle categories. In addition, Table 3.20 and Table 3.21 show that there the rumble strips had a statistically significant effect on approach speeds for the SUV/Pick-Up Truck/Van Category (at the $p = 0.0019$ level) and the Passenger Car Category (at the $p = 0.0002$ level). And, Table 3.21 and Table 3.22 indicate that there were statistically significant interactions between Rumble Strip Conditions and Segments—with $p < 0.0001$ for both the Passenger Car Category and the Commercial Vehicle/Heavy Truck Category.

The significant interaction between Rumble Strip Conditions and Segments, for the Passenger Car Category, is illustrated in Figure 3.21.

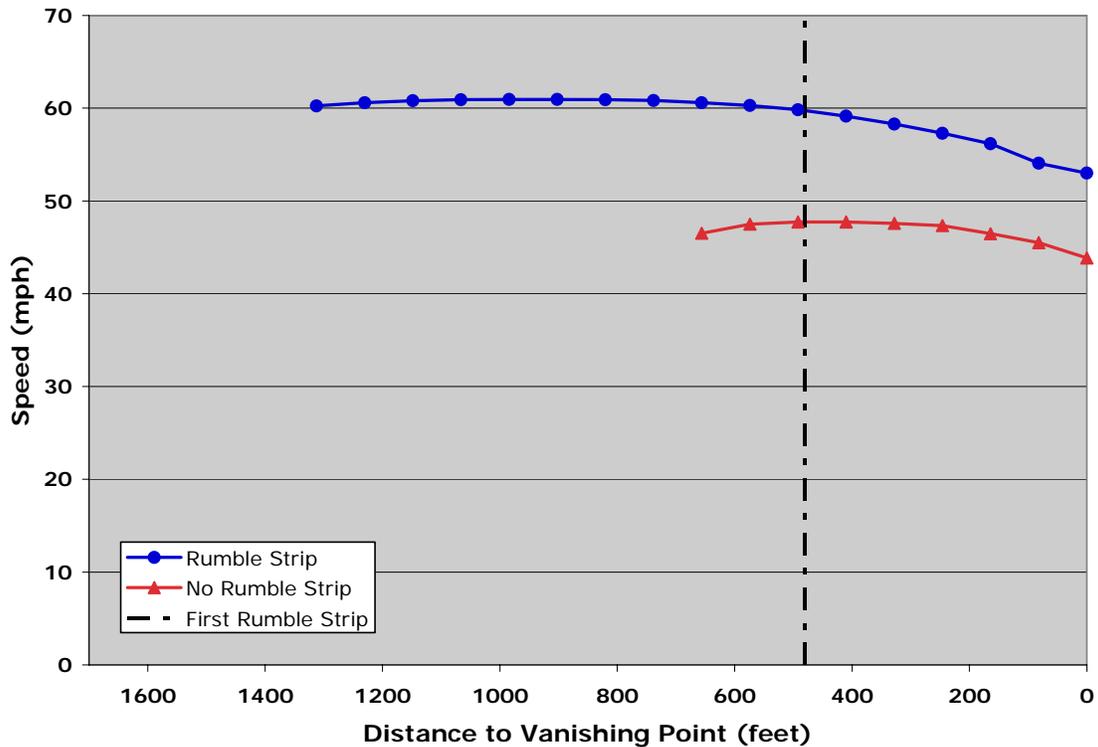


Figure 3.21: Passenger Car Category—Mean Speeds on the Approach to *Vertical Curve* Intersections *With Rumble Strips* and *Without Rumble Strips*.

As Figure 3.21 shows, for the Passenger Car Category, on average the drivers on the approach *With Rumble Strips* were traveling faster than the drivers on the approach *Without Rumble Strips*—this was to be expected given the difference in the speed limits on the two approaches. Figure 3.21 also shows that the drivers on the approach *With Rumble Strips* begin to reduce speed after encountering the first set of rumble strips.

The effect of rumble strips on the speed of the *individual* drivers of vehicles in the Passenger Car Category as they approached the *Vertical Curve* intersections is explored in the boxplots shown in Figure 3.22.

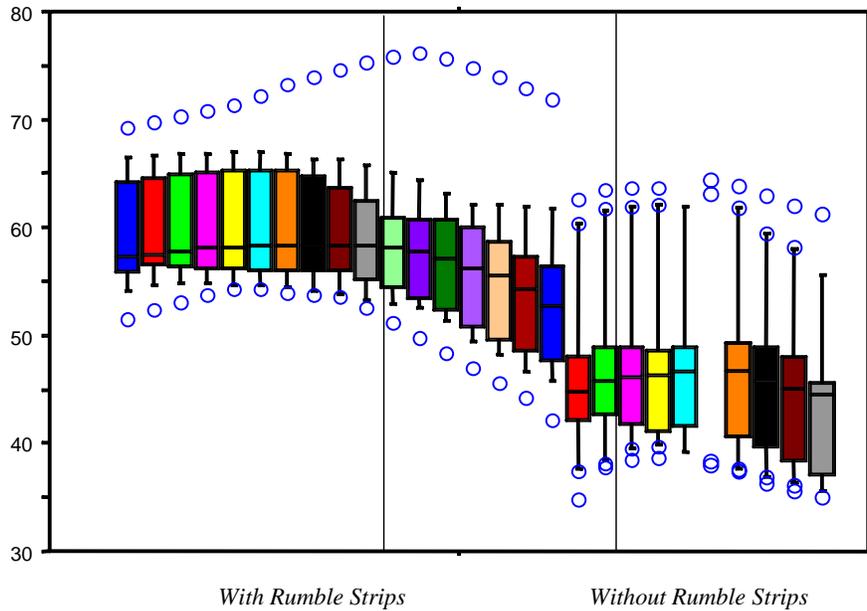


Figure 3.22: Passenger Car Category—Boxplots of Individual Mean Speeds in the Segments on the Approach to Vertical Curve Intersections *With Rumble Strips* and *Without Rumble Strips*.

In the boxplots shown earlier, we found in most cases that on the approaches to the intersections *With Rumble Strips*, the faster outliers reduced speed shortly after crossing the first set of rumble strips. Figure 3.22 shows the same pattern for the faster outlier on the *With Rumble Strips* approach to the *Horizontal Curve* Intersection. In this case, the driver was accelerating on the approach but, after crossing the first set of rumble strips, he or she stopped accelerating and began to reduce speed.

The significant interaction between Rumble Strip Conditions and Segments, for the Commercial Vehicle/Heavy Truck Category, is illustrated in Figure 3.23.

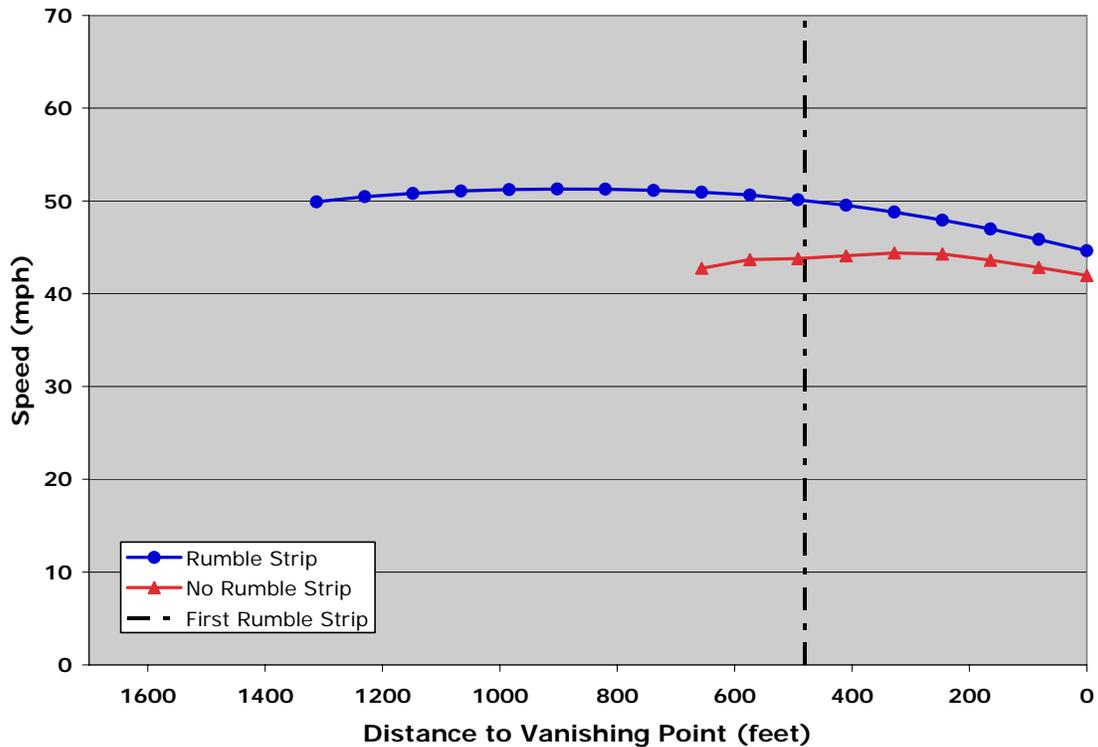


Figure 3.23: Commercial Vehicle/Heavy Truck Category—Mean Speeds on the Approach to Vertical Curve Intersections With Rumble Strips and Without Rumble Strips.

Figure 3.23 shows that the drivers in the Commercial Vehicle/Heavy Truck Category on the approach *With Rumble Strips* were, on average, traveling faster than the drivers on the approach *Without Rumble Strips*—again this was expected because of the difference in the speed limits on the two approaches. In addition, Figure 3.23 shows that, after encountering the first set of rumble strips, the drivers on the approach *With Rumble Strips* begin to reduce speed. It also shows that there was very little difference in average speed between the drivers on the approach *With Rumble Strips* and those on the approach *Without Rumble Strips* at the point where the radar signal dropped out just beyond the crest of the vertical curve.

The effect of rumble strips on the speed of the *individual* drivers of vehicles in the Commercial Vehicle/Heavy Truck Category is explored in the boxplots shown in Figure 3.24.

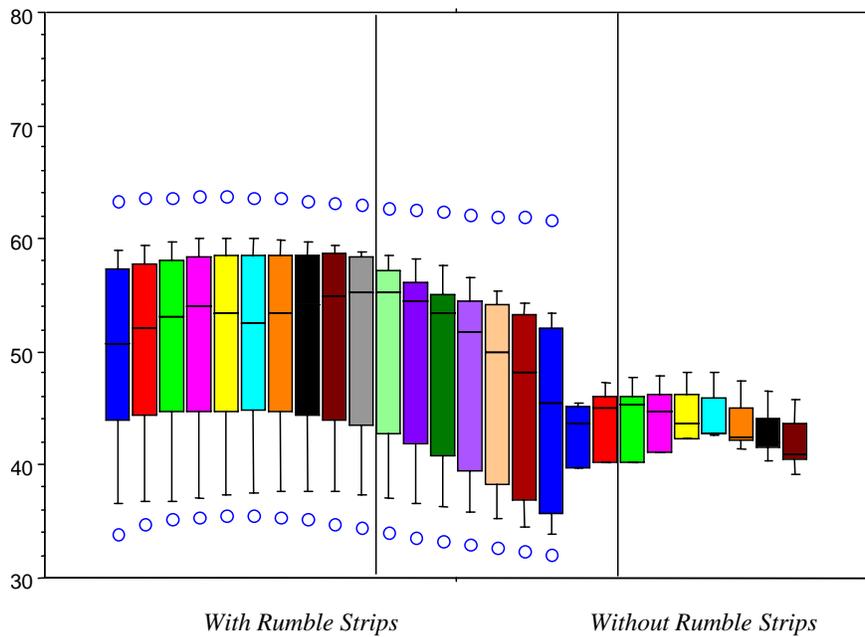


Figure 3.24: Commercial Vehicle/Heavy Truck Category —Boxplots of Individual Mean Speeds in the Segments on the Approach to Vertical Curve Intersections With Rumble Strips and Without Rumble Strips.

Figure 3.24 shows an outlier on the approach *With Rumble Strips* who is an exception to the pattern found in the previous boxplots. In this case, the outlier did not begin to reduce speed after crossing the first set of rumble strips but instead continued at the same speed towards the crest of the hill. Figure 3.24 also shows that there were no outliers on the approach *Without Rumble Strips*.

3.7 Summary of Findings

This was the third in a series of studies investigating various aspects of rumble strips. In this study, to determine the effect of rumble strips on the real-world stopping behavior of drivers, we used a radar gun to collect speed data from over 400 vehicles on the approaches to ten selected intersections. The vehicles approaching the intersections were assigned to one of the following three categories—(1) the SUV/Pick-Up Truck/Van Category; (2) the Passenger Car Category; and (3) the Commercial Vehicle/Heavy Truck category. There were five categories of intersections, with a pair of intersections in each category. The intersection categories were as follows—(1) *Obscure Both* Intersections, with the traffic on *both* sides of the major road *obscured*; (2) *Obscure/Visible* Intersections, with the traffic on one side of the major road *obscured* and the traffic on the other side of the major road *visible*; (3) *Visible Both* Intersections, with the traffic on *both* sides of the major road *visible*; (4) *Horizontal Curve* Intersections, where there is a *horizontal curve* just before the intersection; and (5) *Vertical Curve* Intersections, where there is a *vertical curve* just before the intersection. In each category, one of the pair of intersections was in the *With Rumble Strips* Condition, while the other was in the *Without*

Rumble Strips Condition. The speed data obtained at each pair of intersections can be summarized as follows:

- For the *Obscure Both* Intersections, after drivers encountered the first set of rumble strips, driving speeds were significantly *slower* on the approach *With Rumble Strips*, than they were on the approach *Without Rumble Strips* by, on average, 2.4 mph for drivers in the SUV/Pick-up Truck/Van Category, and 5.0 mph for drivers in the Commercial Vehicle/Heavy Truck Category.
- For the *Obscure/Visible* Intersections, after drivers encountered the first set of rumble strips, on the approach *With Rumble Strips* speeds were significantly *slower* than they were on the approach *Without Rumble Strips* by, on average, 3.3 mph (adjusted) for drivers in the SUV/Pick-up Truck/Van Category, 3.3 mph for drivers in the Passenger Car Category, and 5.5 mph (adjusted) for drivers in the Commercial Vehicle/Heavy Truck Category.
- For the *Visible Both* Intersections, after drivers encountered the first set of rumble strips, on the approach *With Rumble Strips*, speeds were significantly *slower* than they were on the approach *Without Rumble Strips* by, on average, 3.2 mph for drivers in the SUV/Pick-up Truck/Van Category.
- For the *Horizontal Curve* Intersections, after encountering the first set of rumble strips, drivers in the SUV/Pick-up Truck/Van Category and the Commercial Vehicle/Heavy Truck Category, who were on the approach *With Rumble Strips*, *reduced* speed earlier than those who were on the approach *Without Rumble Strips*.
- For the *Vertical Curve* Intersections, after encountering the first set of rumble strips, drivers in the Passenger Car category and the Commercial Vehicle/Heavy Truck Category, *reduced* speed on the approach *With Rumble Strips*, while drivers on the approach *Without Rumble Strips* did not slow down until later in the approach. (However, in this case the difference could be because of the presence of rumble strips *or* it could be because drivers were traveling slower on the approach *Without Rumble Strips*, which had a lower speed limit.)
- For all five Intersection Categories, we found that on the approaches to the intersections *With Rumble Strips* almost all the faster outliers reduced speed after crossing the first set of rumble strips.

3.8 Conclusions

The first two studies in the series investigated the effect of in-lane rumble strips on stopping behavior at simulated rural stop-controlled intersections—the first with *attentive* drivers; the second with *sleep-deprived* drivers. The results of those two studies were similar to the findings of this third study which investigated stopping behavior at real-world rural stop-controlled intersections. In all three studies, drivers reduced speed earlier and to a greater extent at intersections *With Rumble Strips*.

The three studies provide compelling evidence that in-lane rumble strips promote safer stopping behavior on approaches to stop-controlled intersections. Stopping behavior is safer when rumble strips are installed because drivers slow down earlier on the approach

and thus they have more time to respond to an unexpected event (e.g., a slippery road surface).

The findings from the current study confirm and expand the results from the two preceding in-lane rumble strip studies in this series. In the current study, after drivers encountered the first set of in-lane rumble strips, their stopping patterns showed that they slowed down earlier on real-world approaches *With Rumble Strips* than on real-world approaches *Without Rumble Strips*—the difference was, on average, 2.0 mph to 5.0 mph (depending on vehicle category and type of approach). In addition, speeding outliers were more likely to slow down earlier on approaches *With Rumble Strips*.

The effect of the presence of in-lane rumble strips on stopping behavior is greater for approaches where the driver's view of traffic on the major road is *obscured* on one or both sides of the road. And, of the 274 approaches we visited, traffic was *obscured* on both sides of the major road in 89 (32.5%) instances, and it was *obscured* on one side of the major road in 58 (21.2%). Stop-controlled intersections at which cross-traffic is obscured on one or both sides of the minor road would be good candidates for implementing in-lane rumble strips. It would be most beneficial to install in-lane rumble strips on the approaches to intersections at which the cross traffic is obscured by man-made structures and/or vegetation on one or both sides of the intersection.

It would be less beneficial to install rumble strips on the approaches to intersections at which, in normal conditions, the cross traffic is *visible* on both sides of the intersection—we do not believe that rumble strips should be installed at this type of intersection to combat the relatively infrequent cases where the cross-traffic is obscured *only* because of the weather (e.g., fog, driving rain, falling snow). In these cases drivers should take personal responsibility and reduce their speed so that it is appropriate to the driving conditions. In addition, rumble strips are often ineffective on snow-covered roads.

It should be noted that none of the drivers in the three studies ran the stop sign at the intersections *With Rumble Strips* or *Without Rumble Strips*. However, this is not surprising. Incidents involving drivers running (i.e., “blowing”) stop signs are relatively rare, making it extremely unlikely that we would have witnessed such an event while collecting data.

It is also worth noting that while the noise and vibration of in-lane rumble strips warns drivers they are approaching a stop-controlled intersection, the rumble strips themselves cannot actually stop drivers, nor can they give drivers who have stopped better judgment when selecting gaps in cross-traffic. In-lane rumble strips are likely to reduce crashes, but they cannot eliminate them. Some drivers might still run stop signs and others might misjudge gaps.

The results of this study clearly reveal that in-lane rumble strips facilitate safer stopping behavior at various intersection types, though their effect is most pronounced at intersections where cross-traffic is obscured. Consequently, we believe that it would be beneficial to implement in-lane rumble strips at stop-controlled intersections where

drivers on the minor road approaching the intersection cannot see the cross-traffic on one or both sides of the intersection.

References

- Applied Concepts (2004). Internet. *Professional Sports Radar: Owners Manual*. (cited February 15, 2006), http://www.stalkerradar.com/pdf/pro_manual.pdf.
- Emerson, J.D. and Strenio, J. (1987). "Boxplots and Batch Comparison." In: Hoaglin, D.C., Mosteller, F., and Tukey, J.W. (Editors) *Understanding Robust and Exploratory Analysis*. New York, NY: John Wiley & Sons, p58-96.
- Fitzpatrick, K., Brewer, M.A. and Parnham, A.H. (2002). *Left-Turn and Rumble Strip Treatments for Rural Intersections*. Project Summary Report 0-4278-S. Texas Transportation Institute, Texas A&M University System.
- Harder, K. A., Bloomfield, J.R., and Chihak, B. J. (2001). *The Effects of In-Lane Rumble Strips on the Stopping Behavior of Attentive Drivers*. Final Technical Report Number 2002-11 submitted to Minnesota Local Road Research Board, October 2001.
- MUTCD (2001). *Manual on Uniform Traffic Devices (Millennium Edition—Revised December 2001)*. U.S. Department of Transportation, Washington DC: Federal Highway Administration.
- Tukey, J.W. (1977). *Exploratory Data Analysis*. Reading, MA: Addison-Wesley
- Winer, B.J., Brown, D.R., and Michaels, K.M. (1991). *Statistical Principles in Experimental Design: Third Edition*. New York, NY: McGraw-Hill, Inc., p 575-579.

APPENDIX A.1
ILLUSTRATED LIST OF STOP-CONTROLLED INTERSECTIONS:
INTRODUCTION

For this project, 151 one stop-controlled intersections located in 16 Minnesota counties were visited. The intersections were selected with the help of county engineers.

At intersections where rumble strips are installed, at least one photograph was taken just before the point at which a driver approaching the intersections would encounter the first set of rumble strips. At intersections where rumble strips are not installed, at least one photograph was taken close to the point at which the driver would encounter the first set of rumble strips if they were installed at the intersection.

The 151 intersections that were visited are listed in Appendices A.2 through A.17. Each listing includes the photograph taken just before the point at which the first set of rumble strips is encountered, or would be encountered if rumbles strips were installed, for the approaches that are stop-controlled for each of the 151 intersections.

The listing is arranged, by county, in the order in which the intersections were visited. The order is as follows:

Lincoln County
Pipestone County
Rock County
Nobles County
Jackson County
Scott County
Dakota County
Benton County
Kandiyohi County
Wright County
Clay County
Hubbard County
Becker County
Todd County
Washington County
Anoka County

APPENDIX A.2
LINCOLN COUNTY

The intersections in Lincoln County that were visited are listed in this subsection of the appendix. The listing includes the photograph taken just before the point at which the first set of rumble strips is encountered, or would be encountered if rumbles strips were installed, for the approaches that are stop-controlled for each of the intersections.

Intersection #1 (North Side)

Lincoln Co. (Map Page 28)

Condition: **Rumble Strips** on Minor Road

Major Road: County Route 9 (East-West)

Minor Road: County Route 6 (North-South)

On North Side (looking South): traffic on both sides of major road obscured—to West by slight vertical curve and trees; to East by corn and slight vertical curve.



Photograph #1 (Reel #1, 15A) (from North, looking South): first rumble strip and warning sign in view (just *before* crest of vertical curve).

Intersection #1 (South Side)

Lincoln Co. (Map Page 28)

Condition: **Rumble Strips** on Minor Road

Major Road: County Route 9 (East-West)

Minor Road: County Route 6 (North-South)

On South Side (looking North): traffic on both sides of major road obscured by slight depression and uncut corn.



Photograph #3 (Reel #1, 17A) (from North, looking South): first rumble strip and warning sign in view—and hunters with car.

Intersection #2 (South Side)

Lincoln Co. (Map Page 28)

Condition: **No Rumble Strips** on Minor Road

Major Road: U.S. Route 14 (East-West)

Minor Road: County Route 6 (North-South)

On South Side (looking North): to West—corn obscures traffic on major road (and building before road); to East—traffic on major road clear (traffic passes in front of line of trees).



Photograph #5 (Reel #1, 19A) (from South, looking North): taken at approximate distance that rumble strip *would* be installed—warning sign in view.

Intersection #2 (North Side)

Lincoln Co. (Map Page 28)

Condition: **No Rumble Strips** on Minor Road

Major Road: U.S. Route 14 (East-West)

Minor Road: County Route 6 (North-South)

On North Side (looking South): to West—traffic on major road partially obscured by trees (traffic passes in front of building); to East—trees obscure traffic on major road.



Photograph #7 (Reel #1, 21 A) (from North, looking South): taken at approximate distance that rumble strip *would* be installed—warning sign in view; also, vehicle in the intersection.

Intersection #3 (West Side)

Lincoln Co. (Map Page 28)

Condition: **Rumble Strips *only* on this (West) Side** of Minor Road

Major Road: County Route 8 (North-South)

Minor Road: County Route 15 (East-West)

On West Side (looking East): to North—traffic on major road visible; to South—traffic on major road immediately adjacent to intersection visible, but further out view of traffic on major road obscured.



Photograph #8 (Reel #1, 22A) (from West, looking East): first rumble strip and warning sign in view.

Intersection #3 (East Side)

Lincoln Co. (Map Page 28)

Condition: **No Rumble Strips on this (East) Side** of Minor Road

Major Road: County Route 8 (North-South)

Minor Road: County Route 15 (East-West)

On East Side (looking West): both sides of major road—traffic on major road relatively unobstructed.



Photograph #10 (Reel #1, 24A) (from East, looking West): at approximate distance that rumble strip *would* be installed—warning sign in view.

Intersection #4 (East Side)

Lincoln Co. (Map Page 28)

Condition: **Rumble Strips *only on this (East) Side*** of Minor Road

Major Road: County Route 8 (North-South)

Minor Road: County Route 13 (East-West)

On East Side (looking West): intersection itself is partially obscured; to South—traffic on major road obscured by vertical curve and corn; to North—traffic on major road visible.



Photograph #11 (Reel #2, 1A) (from East, looking West): first rumble strip and warning sign in view—truck turning at intersection.

Intersection #4 (West Side)

Lincoln Co. (Map Page 28)

Condition: **No Rumble Strips on this (West) Side** of Minor Road

Major Road: County Route 8 (North-South)

Minor Road: County Route 13 (East-West)

On West Side (looking East): both sides—view of traffic on major road relatively unobstructed (because of slightly elevated position).



Photograph #15 (Reel #2, 5A) (from West, looking East): at approximate distance that rumble strip *would* be installed—warning sign in view.

Intersection #5 (East Side)

Lincoln Co. (Map Page 28)

Curved Approach to T-Junction

Condition: **Rumble Strips on North Side** of Minor Road

Major Road: County Route 8 (North-South, with road curving to West on South side of intersection)

Minor Road: County Route 11 (East-West, with road curving to North at it approaches intersection from East)

On East Side (looking West): Note: vertical curve on the approach to the intersection obscures the fact that the minor road curves to North before reaching the intersection. The vertical curve also obscures the intersection, itself, and the traffic on both sides of the major road.



Photograph #16 (Reel #2, 6A) (from North, looking South): first rumble strip and warning sign in view.

Intersection #6 (West Side)

Lincoln Co. (Map Page 28)

Condition: **No Rumble Strips on this (West) Side** of Minor Road

Major Road: County Route 7 (North-South)

Minor Road: County Route 13 (East-West)

On West Side (looking East): both to North and South—traffic on major road relatively unobstructed.



Photograph #19 (Reel #2, 9A) (from West, looking East): at approximate distance that rumble strip *would* be installed—warning sign in view.

Intersection #6 (East Side)

Lincoln Co. (Map Page 28)

Condition: **Rumble Strips *only* on this (East) Side** of Minor Road

Major Road: County Route 7 (North-South)

Minor Road: County Route 13 (East-West)

On East Side (looking West): to South—vertical curve obscures traffic on major road; to North—buildings obscure traffic on major road.



Photograph #20 (Reel #2, 10A) (from East, looking West): first rumble strip and warning sign in view.

Intersection #7 (East Side)

Lincoln Co. (Map Page 28)

Condition: **Rumble Strips *only* on this (East) Side** of Minor Road

Major Road: U.S Route 75 (North-South)

Minor Road: County Route 13 (East-West, with curve to South just before the intersection)

On East Side (looking West): to South—corn currently largely obscures traffic on major road; to North—trees obscure traffic on major road.



Photograph #23 (Reel #2, 13A) (from East, looking West): first rumble strip in view. [Note, at this intersection, the warning sign, which is barely visible against the bushes, is positioned *after* the second rumble strip (which is cannot be seen in this photograph).]

Intersection #7 (West Side)

Lincoln Co. (Map Page 28)

Condition: **No Rumble Strip on this (West) Side** of Minor Road

Major Road: U.S Route 75 (North-South)

Minor Road: County Route 13 (East-West, with curve to South just before the intersection)

On West Side (looking East): to North—trees obscure traffic on major road; to South—rise and corn largely obscures traffic on major road.



Photograph #25 (Reel #2, 15A) (from West, looking East): at approximate distance that rumble strip *would* be installed—warning sign visible (although it is nearer to intersection than usual for Lincoln County).

Intersection #8 (East Side)

Lincoln Co. (Map Page 28)

Condition: **No Rumble Strips; dirt road on West Side** of Minor Road

[Note: minor road takes jog of about a mile to South—then continues to the West]

Major Road: County Route 1 (North-South)

Minor Road: County Route 13 (East-West)

On East Side (looking West): to South—tree obscures traffic on major road; to North—
corn obscures traffic on major road.



Photograph #27 (Reel #2, 19A) (from East, looking West): at approximate distance that
rumble strip *would* be installed—warning sign in view.

Intersection #9 (West Side)

Lincoln Co. (Map Page 28)

Condition: **Rumble Strips on West Side; dirt road on East Side** of Minor Road

[**Note: minor road takes jog of about a mile to North—then continues to the East**]

Major Road: County Route 1 (North-South)

Minor Road: County Route 13 (East-West)

On West Side (looking East): on both sides—vertical curve obscures intersection and traffic on major road.



Photograph #28 (Reel #2, 20A) (from West, looking East): first rumble strip in view and warning sign in view.

Intersection #10 (West Side)

Lincoln Co. (Map Page 28)

Condition: **No Rumble Strips** on Minor Road

Major Road: U.S. Route 75 (North-South)

Minor Road: County Route 15 (East-West)

On West Side (looking East): on both sides—view of traffic on major road is slightly obscured.



Photograph #30 (Reel #2, 22A) (from West, looking East): at approximate distance that rumble strip *would* be installed—warning sign in view.

Intersection #10 (East Side)

Lincoln Co. (Map Page 28)

Condition: **No Rumble Strips** on Minor Road

Major Road: U.S. Route 75 (North-South)

Minor Road: County Route 15 (East-West)

On East Side (looking West): on both sides—trees and bushes obscure traffic on major road.



Photograph #31 (Reel #2, 23A) (from East, looking West): at approximate distance that rumble strip *would* be installed—warning sign in view.

Intersection #11 (West Side)

Lincoln Co. (Map Page 28)

Condition: **Rumble Strips on North Side; dirt road on South Side** of Minor Road

Major Road: County Route 15 (East-West)

Minor Road: County Route 5 (North-South)

On North Side (looking South): vertical curve obscures intersection; to North—vertical curve obscures traffic on major road; to South—traffic on major road visible.



Photograph #32 (Reel #2, 24A) (from West, looking East): first rumble strip and warning sign in view.

Intersection #12 (North Side)

Lincoln Co. (Map Page 28)

Condition: **Rumble Strips** on Minor Road

Major Road: State Route 19 (East-West)

Minor Road: County Route 7 (North-South)

On North Side (looking South): on both sides—clear view of traffic on major road.



Photograph #35 (Reel #3, 3A) (from North, looking South): first rumble strip and warning sign in view.

Intersection #12 (South Side)

Lincoln Co. (Map Page 28)

Condition: **Rumble Strips** on Minor Road

[Note: there is a guard rail on South Side of minor road.]

Major Road: State Route 19 (East-West)

Minor Road: County Route 7 (North-South)

On South Side (looking North): to East—clear view of traffic on major road; to West—trees partially obscure view of traffic on major road.



Photograph #37 (Reel #3, 5A) (from South, looking North): first rumble strip and warning sign in view.

Intersection #13 (East Side)

Lincoln Co. (Map Page 28)

T-Junction

Condition: **Rumble Strips** on Minor Road

[**Note: minor road takes jog about a mile to South—then continues on to West**]

Major Road: County Route 8 (North-South)

Minor Road: County Route 17 (East-West)

On East Side (looking West): intersection obscured by rise; to South—rise and corn obscure traffic on major road; to North—clear view of traffic on major road.



Photograph #39 (Reel #3, 7A) (from East, looking West): first rumble strip and warning sign in view.

Intersection #14 (West Side)

Lincoln Co. (Map Page 28)

Condition: **No Rumble Strips; dirt road on East Side** on Minor Road

[**Note: minor road takes jog about a mile to North –then continues on to East**]

Major Road: County Route 8 (North-South)

Minor Road: County Route 17 (East-West)

On West Side (looking East): to South—trees obscure traffic on major road; to North—
rise and corn obscure traffic on major road.



Photograph #41 (Reel #3, 9A) (from West, looking East): at approximate distance that
rumble strip *would* be installed—warning sign in view.

Intersection #15 (East Side)

Lincoln Co. (Map Page 28)

Condition: **Rumble Strips** on Minor Road

Major Road: County Route 7 (North-South)

Minor Road: County Route 17 (East-West)

On East Side (looking West): on both sides—clear view of traffic on major road.



Photograph #43 (Reel #3, 11A) (from East, looking West): first rumble strip and warning sign in view. [Note: rumble strip and warning sign at about same distance from intersection.]

Intersection #15 (West Side)

Lincoln Co. (Map Page 28)

Condition: **Rumble Strips** on Minor Road

Major Road: County Route 7 (North-South)

Minor Road: County Route 17 (East-West)

On West Side (looking East): to South—rise and trees obscure traffic on major road; to North—rise and trees obscure traffic on major road.



Photograph #45 (Reel #3, 13A) (from West, looking East): first rumble strip and warning sign in view. [Note: rumble strip and warning sign at about same distance from intersection.]

Intersection #16 (North Side)

Lincoln Co. (Map Page 28)

Condition: *No Rumble Strips* on Minor Road

Major Road: County Route 17 (East-West)

Minor Road: County Route 5 (North-South)

On North Side (looking South): to West—clear view of traffic on major road; to East—
view of traffic on major road slightly obscured.



Photograph #47 (Reel #3, 15A) (from North, looking South): at approximate distance that first rumble strip *would* be installed—warning sign in view.

Intersection #16 (South Side)

Lincoln Co. (Map Page 28)

Condition: *No Rumble Strips* on Minor Road

Major Road: County Route 17 (East-West)

Minor Road: County Route 5 (North-South)

On South Side (looking North): on both sides—clear view of traffic on major road.



Photograph #48 (Reel #3, 16A) (from South, looking North): at approximate distance that first rumble strip *would* be installed—warning sign in view.

Intersection #17 (East Side)

Lincoln Co. (Map Page 28)

Condition: **No Rumble Strips** on Minor Road

Major Road: U.S Route 75 (North-South)

Minor Road: County Route 17 (East-West)

On East Side (looking West): to North—clear view of traffic on major road; to South—
trees obscure traffic on major road.



Photograph #49 (Reel #3, 17A) (from East, looking West): at approximate distance that first rumble strip *would* be installed—warning sign in view.

Intersection #17 (West Side)

Lincoln Co. (Map Page 28)

Condition: **No Rumble Strips** on Minor Road

Major Road: U.S Route 75 (North-South)

Minor Road: County Route 17 (East-West)

On West Side (looking East): on both sides—clear view of traffic on major road (road runs in front of trees to South).



Photograph #50 (Reel #3, 18A) (from East, looking West): at approximate distance that first rumble strip *would* be installed—warning sign in view.

Intersection #18 (East Side)

Lincoln Co. (Map Page 28)

T-Junction

Condition: **Rumble Strips** on Minor Road

Major Road: County Route 1 (North-South)

Minor Road: County Route 5 (East-West)

On East Side (looking West): intersection and view of traffic on major road on both sides obscured by vertical curve.



Photograph #51 (Reel #3, 19A) (from East, looking West): first rumble strip and warning sign in view.

Intersection #19 (North Side)

Lincoln Co. (Map Page 28)

Curved approach to T-Junction

Condition: **Rumble Strips** on Minor Road

Major Road: State Route 271 (from North-West to South)

Minor Road: County Route 1 (from North)

On North Side (looking South): minor road curves to West at intersection; the curve and the intersection are obscured; on both sides—traffic on the major road is obscured.



Photograph #53 (Reel #3, 21A) (from North, looking South): first rumble strip and warning sign in view.

APPENDIX A.3 PIPESTONE COUNTY

The intersections in Pipestone County that were visited are listed in this subsection of the appendix. The listing includes the photograph taken just before the point at which the first set of rumble strips is encountered, or would be encountered if rumble strips were installed, for the approaches that are stop-controlled for each of the intersections.

Intersection #20 (North Side)

Pipestone Co. (Map Page 28)

Condition: **Rumble Strips** on Minor Road

Major Road: County Route 10 (East-West)

Minor Road: County Route 15 (North-South)

On North Side (looking South): on both sides—clear view of traffic on major road.



Photograph #56 (Reel #3, 24A) (from North, looking South): first rumble strip and warning sign in view.

Intersection #20 (South Side)

Pipestone Co. (Map Page 28)

Condition: **Rumble Strips** on Minor Road

Major Road: County Route 10 (East-West)

Minor Road: County Route 15 (North-South)

On South Side (looking North): on both sides—clear view of traffic on major road.



Photograph #57 (Reel #4, 1A) (from South, looking North): first rumble strip and warning sign in view.

Intersection #21 (West Side)

Pipestone Co. (Map Page 28)

Condition: **Rumble Strips** on Minor Road

Major Road: U.S. Route 75 (North-South)

Minor Road: County Route 10 (East-West)

On West Side (looking East): to North—trees obscure view of traffic on major road; to South—clear view of traffic (it travels in front of trees and buildings).



Photograph #59 (Reel #4, 3A) (from West, looking East): first rumble strip in view (in near foreground, but difficult to see because of low angle of the sun)—warning sign also in view.

Intersection #21 (East Side)

Pipestone Co. (Map Page 28)

Condition: **Rumble Strips** on Minor Road

Major Road: U.S. Route 75 (North-South)

Minor Road: County Route 10 (East-West)

On East Side (looking West): on both sides—trees obscure view of traffic on major road.



Photograph #61 (Reel #4, 5A) (from East, looking West): first rumble strip and warning sign in view.

Intersection #22 (East Side)

Pipestone Co. (Map Page 28)

Condition: **Rumble Strips** on Minor Road

Major Road: State Route 23 (North-South)

Minor Road: County Route 10 (East-West)

On East Side (looking West): on both sides—corn obscures view of traffic on major road.



Photograph #63 (Reel #4, 7A) (from East, looking West): first rumble strip and warning sign in view.

Intersection #22 (West Side)

Pipestone Co. (Map Page 28)

Condition: **Rumble Strips** on Minor Road

Major Road: State Route 23 (North-South)

Minor Road: County Route 10 (East-West)

On West Side (looking East): to North—trees obscure view of traffic on major road; to South—clear view of traffic on major road.



Photograph #65 (Reel #4, 9A) (from West, looking East): first rumble strip and warning sign in view.

Intersection #23 (West Side)

Intersection (Oblique angle)

Pipestone Co. (Map Page 19)

Condition: **Rumble Strips** on Minor Road

Major Road: State Route 23 (North/East to South/West)

Minor Road: County Route 8 (East-West)

On West Side (looking East): to North—partial view of traffic on major road; to South—view of traffic unobstructed.



Photograph #68 (Reel #4, 12A) (from West, looking East): first rumble strip and warning sign in view.

Intersection #23 (East Side)

Pipestone Co. (Map Page 19)

Intersection (Oblique angle)

Condition: **Rumble Strips** on Minor Road

Major Road: State Route 23 (North/East to South/West)

Minor Road: County Route 8 (East-West)

On East Side (looking West): to North—vertical curve obscures view of traffic on major road; to South—vertical curve and trees obscure view of traffic on major road.



Photograph #70 (Reel #4, 14A) (from East, looking West): first rumble strip and warning sign in view.

Intersection #24 (East Side)

Pipestone Co. (Map Page 19)

Condition: **Rumble Strips on East Side; dirt road on West Side** of Minor Road

Major Road: County Route 18 (180th) (North-South)

Minor Road: County Route 8 (211th) (East-West)

On East Side (looking West): to North—vertical curve and corn obscure traffic on major road; to South—vertical curve and trees obscure major road.



Photograph #72 (Reel #4, 16A) (from East, looking West): first rumble strip and warning sign in view.

Intersection #25 (aka Diamond Corner) (North Side)

Pipestone Co. (Map Page 19)

Condition: **Rumble Strips** on Minor Road

Major Road: State Route 30 (East-West)

Minor Road: County Route 18 (180th) (North-South)

On North Side (looking South): to East—vertical rise & cemetery obscure traffic on major road; to West—partial view of traffic on major road



Photograph #74 (Reel #4, 18A) (from North, looking South): first rumble strip and warning sign in view. [Note: additional half rumble strip to center of road.]

Intersection #25 (aka Diamond Corner) (South Side)

Pipestone Co. (Map Page 19)

Condition: **Rumble Strips** on Minor Road

Major Road: State Route 30 (East-West)

Minor Road: County Route 18 (180th) (North-South)

On South Side (looking North): to East—corn obscures view of traffic on major road; to West—clear view of traffic on major road.



Photograph #76 (Reel #4, 20A) (from South, looking North): first rumble strip and warning strip in view. [Note: additional half rumble strip to center of road.]

Intersection #26 (South Side)

Pipestone Co. (Map Page 19)

Condition: **Rumble Strips** on Minor Road

Major Road: State Route 30 (East-West)

Minor Road: County Route 13 (North-South)

On South Side (looking North): on both sides—vertical curves obscure traffic on major road.



Photograph #79 (Reel #4, 23A) (from South, looking North): first rumble strip and warning sign in view.

Intersection #26 (North Side)

Pipestone Co. (Map Page 19)

Condition: **Rumble Strips** on Minor Road

Major Road: State Route 30 (East-West)

Minor Road: County Route 13 (North-South)

On North Side (looking South): to East—clear view of traffic on major road; to West—trees obscure traffic on major road.



Photograph #82 (Reel #5, 1A) (from North, looking South): first rumble strip and warning sign in view.

Intersection #27 (North Side)

Pipestone Co. (Map Page 19)

Condition: **Rumble Strips on North Side; dirt road on South Side** of Minor Road

Major Road: County Route 2 (41st) (East-West)

Minor Road: County Route 13 (North-South)

On North Side (looking South): to East—vertical curve partially obscures traffic on major road; to West—trees and buildings obscure traffic on major road.



Photograph #84 (Reel #5, 3A) (from North, looking South): first rumble strip and warning sign in view.

APPENDIX A.4. ROCK COUNTY

The intersections in Rock County that were visited are listed in this subsection of the appendix. The listing includes the photograph taken just before the point at which the first set of rumble strips is encountered, or would be encountered if rumbles strips were installed, for the approaches that are stop-controlled for each of the intersections.

Intersection #28 (West Side)

Rock Co. (Map Page 19)

Condition: **Rumble Strips** on Minor Road

Rumble strips worn

Major Road: State Route 23 (North-South)

Minor Road: County Route 20 (East-West)

On West Side (looking East): to North—corn obscures traffic on major road; to South—clear view of traffic on major road.



Photograph #86 (Reel #5, 5A) (from West, looking East): first rumble strip and warning sign in view.

Intersection #28 (East Side)

Rock Co. (Map Page 19)

Condition: **Rumble Strips** on Minor Road

Rumble strips worn

Major Road: State Route 23 (North-South)

Minor Road: County Route 20 (East-West)

On East Side (looking West): on both sides—clear view of traffic on major road.



Photograph #88 (Reel #5, 7A) (from East, looking West): first rumble strip and warning sign in view.

Intersection #29 (West Side)

Rock Co. (Map Page 19)

Condition: **Rumble Strips** on Minor Road

Major Road: County Route 6 (North-South)

Minor Road: County Route 20 (East-West)

On West Side (looking East): to North—trees and buildings obscure traffic on major road (6); to South—corn obscures traffic on major road.



Photograph #90 (Reel #5, 9A) (from West, looking East): first rumble strip and warning sign in view.

Intersection #29 (East Side)

Rock Co. (Map Page 19)

Condition: **Rumble Strips** on Minor Road

Major Road: County Route 6 (North-South)

Minor Road: County Route 20 (East-West)

On East Side (looking West): to North—corn obscures traffic on major road; to South—
clear view of traffic on major road.



Photograph #92 (Reel #5, 11A) (from East, looking West): first rumble strip and warning sign in view.

Intersection #30 (North Side)

Rock Co. (Map Page 19)

Condition: **Four-way stop with Rumble Strips on all four roads**

Roads: County Route 5 (East-West) & County Route 6 (North-South)

On North Side (looking South): to East—vertical curve & building obscure traffic on cross road; to West—clear view of traffic on cross road.



Photograph #95 (Reel #5, 14A) (from North, looking South): first rumble strip and warning sign in view.

Intersection #30 (South Side)

Rock Co. (Map Page 19)

Condition: **Four-way stop with Rumble Strips on all four roads**

Roads: County Route 5 (East-West) & County Route 6 (North-South)

On South Side (looking North): vertical curve obscures intersection; on both sides—
vertical curve also obscures traffic on cross road.



Photograph #97 (Reel #5, 16A) (from South, looking North): first rumble strip and warning sign (with red center unlike warning signs on other three approaches to the four-way stop) in view.

Intersection #30 (West Side)

Rock Co. (Map Page 19)

Condition: **Four-way stop with Rumble Strips on all four roads**

Roads: County Route 5 (East-West) & County Route 6 (North-South)

On West Side (looking East): to North—clear view of traffic on cross road: to South—
vertical curve obscures traffic on cross road.



Photograph #99 (Reel #5, 18A) (from West, looking East): first rumble strip and warning sign in view.

Intersection #30 (East Side)

Rock Co. (Map Page 19)

Condition: **Four-way stop with Rumble Strips on all four roads**

Roads: County Route 5 (East-West) & County Route 6 (North-South)

On East Side (looking West): vertical curve obscures intersection; on both sides—vertical curve obscures traffic on cross road.



Photograph #101 (Reel #5, 20A) (from East, looking West): first rumble strip, warning sign, and “blind intersection” sign in view.

Intersection #31 (North Side)

Rock Co. (Map Page 19)

Condition: **Rumble Strips** on minor road

Major road: County Route 4 (East-West)

Minor road: County Route 6 (North-South)

On North Side (looking South): intersection obscured by vertical curve; on both sides—
vertical curve obscures traffic on major road.



Photograph #103 (Reel #5, 22A) (from North, looking South): first rumble strip and warning sign in view.

Intersection #31 (South Side)

Rock Co. (Map Page 19)

Condition: **Rumble Strips** on minor road

[Note: there is a rail track running parallel to the major road on its South side.]

Major road: County Route 4 (East-West)

Minor road: County Route 6 (North-South)

On South Side (looking North): to East—clear view of traffic on major road; to West—building and trees partially obscure traffic on major road.



Photograph #105 (Reel #5, 24A) (from South, looking North): first rumble strip and warning sign in view.

Intersection #32 (North Side)

Rock Co. (Map Page 19)

Condition: **Rumble Strips *only* on North side** of minor road

[No picture taken on South side coming out of Hills.]

Major road: State Route 270 (East-West)

Minor road: County Route 6 (North-South)

On North Side (looking South): to East—partial view of traffic on major road; to West—trees obscure traffic on major road.



Photograph #107 (Reel #6, 2A) (from North, looking South): first rumble strip and warning sign in view.

Intersection #33 (South Side)

Rock Co. (Map Page 19)

Condition: **Rumble Strips** on minor road

Major road: State Route 270 (East-West)

Minor road: County Route 11 (North-South)

On South Side (looking North): to East—corn obscures traffic on major road; to West—
corn and buildings obscure traffic on major road.



Photograph #109 (Reel #6, 4A) (from South, looking North): first rumble strip and warning sign in view.

Intersection #33 (North Side)

Rock Co. (Map Page 19)

Condition: **Rumble Strips** on minor road

Major road: State Route 270 (East-West)

Minor road: County Route 11 (North-South)

On North Side (looking South): to East—corn obscures traffic on major road; to West—
corn and vertical curve obscure traffic on major road.



Photograph #111 (Reel #6, 6A) (from North, looking South): first rumble strip and warning sign in view.

Intersection #34 (East Side)

Rock Co. (Map Page 19)

Condition: **Rumble Strips on East Side; dirt road on West Side** of Minor Road

Major road: U.S. Route 75 (East-West)

Minor road: County Route 1 (North-South)

On East Side (looking West): to North—corn obscures traffic on major road; to South—clear view of traffic on major road.



Photograph #113 (Reel #6, 8A) (from East, looking West): first rumble strip and warning sign in view.

Intersection #35 (South Side)

Rock Co. (Map Page 19)

T-Junction, with Rail Crossing

Condition: **Rumble Strips** on Minor Road

Major road: County Route 4 (East-West)

Minor road: County Route 9 (North-South)

On South Side (looking North): to East—vertical curve and trees obscure traffic on major road; to West—trees obscure traffic on major road.



Photographs #116 & 117 (Reel #6, 11A & 12 A) (from South, looking North): first rumble strip and warning in view.

[Note: at this point driver approaching intersection has just crossed railway track.]

Intersection #36 (West Side)

Rock Co. (Map Page 19)

Condition: **Rumble Strips on East Side; dirt road on West Side** of Minor Road

Major road: County Route 3 (North-South)

Minor road: County Route 8 (East-West)

On West Side (looking East): to North—trees and corn obscure traffic on major road; to South—clear view of traffic on major road.



Photograph #119 (Reel #6, 14A) (from East, looking West): first rumble strip and warning sign in view.

**APPENDIX A.5.
NOBLES COUNTY**

The intersections in Nobles County that were visited are listed in this subsection of the appendix. The listing includes the photograph taken just before the point at which the first set of rumble strips is encountered, or would be encountered if rumble strips were installed, for the approaches that are stop-controlled for each of the intersections.

Intersection #37 (South Side)

Nobles Co. (Map Page 19)

Condition: **Rumble Strips** on Minor Road

Major road: County Route 16 (East-West)

Minor road: County Route 19 (North-South)

On South Side (looking North): intersection obscured by vertical curve; on both sides—
vertical curve obscures traffic on major road.



Photograph #121 (Reel #6, 16A) (from South, looking North): first rumble strip and warning sign in view.

Intersection #37 (North Side)

Nobles Co. (Map Page 19)

Condition: **Rumble Strips** on Minor Road

Major road: County Route 16 (East-West)

Minor road: County Route 19 (North-South)

On North Side (looking South): on both sides—clear view of traffic on major road.



Photograph #123 (Reel #6, 18A) (from North, looking South): first rumble strip and warning sign in view.

Intersection #38 (West Side)

Nobles Co. (Map Page 20)

Condition: **Rumble Strips (double sets) on West Side; dirt road on East Side** of Minor Road

Major road: State Route 91 (North-South)

Minor road: County Route 20 (East-West)

On West Side (looking East): to North—trees obscure traffic on major road; to South—clear view of traffic on major road.



Photograph #125 (Reel #6, 20A) (from West, looking East): first set of rumble strips and warning sign in view.

Intersection #39 (West Side)

Nobles Co. (Map Page 20)

Condition: **Rumble Strips on West Side; dirt road on East Side** of Minor Road

Major road: County Route 15 (North-South)

Minor road: County Route 18 (East-West)

On West Side (looking East): to North—buildings and trees obscure traffic on major road; to South—corn obscures traffic on major road.



Photograph #127 (Reel #6, 22A) (from West, looking East): first rumble strip and warning strip in view.

Intersection #40 (West Side)

Nobles Co. (Map Page 20)

Condition: **Rumble Strips** on Minor Road

Major road: County Route 13 (North-South)

Minor road: County Route 18 (East-West)

On West Side (looking East): on both sides—clear view of traffic on major road.



Photograph #129 (Reel #6, 24A) (from West, looking East): first rumble strip and warning sign in view.

Intersection #40 (East Side)

Nobles Co. (Map Page 20)

Condition: **Rumble Strips** on Minor Road

Major road: County Route 13 (North-South)

Minor road: County Route 18 (East-West)

On East Side (looking West): on both sides—clear view of traffic on major road.



Photograph #131 (Reel #7, 2A) (from East, looking West): first rumble strip and warning sign in view.

Intersection #41 (South Side)

Nobles Co. (Map Page 20)

Condition: **Rumble Strips** on Minor Road

Major road: County Route 18 (East-West)

Minor road: County Route 9 (North-South)

On South Side (looking North): on both sides—clear view of traffic on major road.



Photograph #133 (Reel #7, 4A) (from South, looking North): first rumble strip and warning sign in view.

Intersection #41 (North Side)

Nobles Co. (Map Page 20)

Condition: **Rumble Strips** on Minor Road

Major road: County Route 18 (East-West)

Minor road: County Route 9 (North-South)

On North Side (looking South): to East—clear view of traffic on major road; to West—trees (behind which are buildings) obscure traffic on major road.



Photograph #135 (Reel #7, 6A) (from North, looking South): first rumble strip and warning sign in view.

Intersection #42 (North Side)

Nobles Co. (Map Page 20)

Condition: **Rumble Strips** on Minor Road

Major road: County Route 35 (East-West)

Minor road: County Route 9 (North-South)

On North Side (looking South): on both sides—corn obscures traffic on major road.



Photograph #137 (Reel #7, 8A) (from North, looking South): first rumble strip and warning sign in view.

Intersection #42 (South Side)

Nobles Co. (Map Page 20)

Condition: **Rumble Strips** on Minor Road

Major road: County Route 35 (East-West)

Minor road: County Route 9 (North-South)

On South Side (looking North): to East— corn obscures traffic on major road; to West—
clear view of traffic on major road.



Photograph #139 (Reel #7, 10A) (from South, looking North): first rumble strip and warning sign in view.

Intersection #43 (North Side)

Nobles Co. (Map Page 20)

Condition: **Rumble Strips** on Minor Road

Major road: County Route 35 (East-West)

Minor road: County Route 13 (North-South)

On North Side (looking South): intersection obscured by slight vertical curve; on both sides—slight vertical curve, trees and buildings obscure traffic on major road.



Photograph #141 (Reel #7, 12A) (from North, looking South): first rumble strip and warning sign in view.

Intersection #43 (South Side)

Nobles Co. (Map Page 20)

Condition: **Rumble Strips** on Minor Road

Major road: County Route 35 (East-West)

Minor road: County Route 13 (North-South)

On South Side (looking North): to East—clear view of traffic on major road (in front of buildings); to West—buildings obscure traffic on major road.



Photograph #143 (Reel #7, 14A) (from South, looking North): first rumble strip and warning sign in view.

Intersection #44 (East Side)

Nobles Co. (Map Page 20)

Condition: **Rumble Strips** on Minor Road

Major road: County Route 15 (North-South)

Minor road: County Route 6 (East-West)

On East Side (looking West): to North—clear view of traffic on major road; to South—vertical curve and corn obscure traffic on major road.



Photograph #145 (Reel #7, 16A) (from East, looking West): first rumble strip and warning sign in view.

Intersection #44 (West Side)

Nobles Co. (Map Page 20)

Condition: **Rumble Strips** on Minor Road

Major road: County Route 15 (North-South)

Minor road: County Route 6 (East-West)

On West Side (looking East): to both sides—corn obscures traffic on major road.



Photograph #147 (Reel #7, 18A) (from West, looking East): first rumble strip and warning sign in view.

Intersection #45 (West Side)

Nobles Co. (Map Page 20)

Condition: **Rumble Strips** on Minor Road

Major road: County Route 13 (North-South)

Minor road: County Route 6 (East-West)

On West Side (looking East): on both sides—vertical curve obscures traffic on major road.



Photograph #149 (Reel #7, 20A) (from West, looking East): first rumble strip and warning sign in view.

Intersection #45 (East Side)

Nobles Co. (Map Page 20)

Condition: **Rumble Strips** on Minor Road

Major road: County Route 13 (North-South)

Minor road: County Route 6 (East-West)

On East Side (looking West): on both sides—reasonably clear view of traffic on major road (road is in front of buildings on North side).



Photograph #151 (Reel #7, 22A) (from East, looking West): first rumble strip and warning sign in view.

Intersection #46 (West Side)

Nobles Co. (Map Page 20)

Condition: **Rumble Strips on West; dirt road to East** of Minor Road

Major road: County Routes 6 & 4 (North) and County Route 4 (South)

Minor road: County Route 6 (West) and dirt road (East)

On West Side (looking East): rise obscures intersection; on both sides—rise obscures traffic on major road.



Photograph #153 (Reel #7, 24A) (from West, looking East): first rumble strip and warning sign in view.

Intersection #47 (East Side)

Nobles Co. (Map Page 20)

Condition: **Rumble Strips on East; dirt road to West** of Minor road

Major road: County Route 5 (North) and County Route 4 (South)

Minor road: County Route 5 & 4 (East) and dirt road (West)

On East Side (looking West): on both sides—clear view of traffic on major road.



Photograph #155 (Reel #8, 2) (from East, looking West): first rumble strip and warning sign in view.

Intersection #48 (South Side)

Nobles Co. (Map Page 20)

Condition: **Rumble Strips** on Minor Road

Major road: County Route 35 (West-East)

Minor road: County Route 3 (North-South)

On South Side (looking North): to East—corn obscures traffic on major road; to West—buildings and corn obscure traffic on major road.



Photograph #157 (Reel #8, 4) (from South, looking North): first rumble strip and warning sign in view.

Intersection #48 (North Side)

Nobles Co. (Map Page 20)

Condition: **Rumble Strips** on Minor Road

Major road: County Route 35 (West-East)

Minor road: County Route 3 (North-South)

On North Side (looking South): on both sides—corn obscures traffic on major road.



Photograph #159 (Reel #8, 6) (from North, looking South): first rumble strip and warning sign in view.

APPENDIX A.6
JACKSON COUNTY

The intersections in Jackson County that were visited are listed in this subsection of the appendix. At the time these photographs were taken rumble strips had not been installed at stop-controlled intersections in Jackson County. The listing includes the photograph taken just before the point at which the first set of rumble strips would be encountered if rumble strips were installed, for the approaches that are stop-controlled for each of the intersections.

Intersection #49 (West Side)

Jackson Co. (Map Page 21)

Condition: **No Rumble Strips** on Minor Road

Major road: County Route 9 (North-South)

Minor road: County Route 12 (West-East)

On West Side (looking East): on South—clear view of traffic on major road.; on North—
corn obscures traffic on major road.



Photograph #161 (Reel #8,) (from West, looking East): from approximately where first rumble strip would be; warning sign in view.

Intersection #49 (East Side)

Jackson Co. (Map Page 21)

Condition: *No Rumble Strips* on Minor Road

Major road: County Route 9 (North-South)

Minor road: County Route 12 (West-East)

On East Side (looking West): to North—trees obscure traffic on major road; to South—
corn obscures traffic on major road.



Photograph #162 (Reel #8,) (from East, looking West): from approximately where first rumble strip would be; warning sign in view.

Intersection #50 (West Side)

Jackson Co. (Map Page 21)

Condition: **No Rumble Strips; dirt road to East** on Minor Road (County Road 70)

Major road: State Route 86 (North-South)

Minor road: County Route 12 (West) and County Road 70 (East)

On West Side (looking East): to South—clear view of traffic on major road; to North
corn obscures traffic on major road.



Photograph #163 (Reel #8, 11) (from West, looking East): from approximately where first rumble strip would be; warning sign in view.

Intersection #51 (East Side)

Jackson Co. (Map Page 21)

Condition: **No Rumble Strips** on Minor Road

Major road: State Route 86 (North-South)

Minor road: County Route 16 (East) and County Road 71 (West)

On East Side (looking West): to South—corn obscures traffic on major road; to North—
clear view of traffic on major road.



Photograph #165 (Reel #8, 12) (from East, looking West): from approximately where first rumble strip would be; warning sign in view.

Intersection #51 (West Side)

Jackson Co. (Map Page 21)

Condition: *No Rumble Strips* on Minor Road

Major road: State Route 86 (North-South)

Minor road: County Route 16 (East) and County Road 71 (West)

On West Side (looking East): to South—trees obscures traffic on major road; to North—clear view of traffic on major road.



Photograph #166 (Reel #8, 13) (from West, looking East): from approximately where first rumble strip would be; warning sign in view.

Intersection #52 (East Side)

Jackson Co. (Map Page 21)

Condition: *No Rumble Strips* on Minor Road

Major road: State Route 86 (North-South)

Minor road: County Route 24 (West-East)

On East Side (looking West): to South—corn obscures traffic on major road; to North—clear view of traffic on major road.



Photograph #167 (Reel #8, 14) (from East, looking West): from approximately where first rumble strip would be; warning sign in view.

Intersection #52 (West Side)

Jackson Co. (Map Page 21)

Condition: *No Rumble Strips* on Minor Road

Major road: State Route 86 (North-South)

Minor road: County Route 24 (West-East)

On West Side (looking East): to South—trees, buildings and rise obscure traffic on major road; to North—corn and rise obscure traffic on major road.



Photograph #168 (Reel #8, 15) (from West, looking East): from approximately where first rumble strip would be; warning sign in view.

Intersection #53 (West Side)

Jackson Co. (Map Page 21)

Condition: *No Rumble Strips* on Minor Road

Major road: County Route 17 (North-South)

Minor road: County Route 24 (West-East)

On West Side (looking East): rise obscures intersection; on both sides—rise obscures traffic on major road.



Photograph #169 (Reel #8, 16) (from West, looking East): from approximately where first rumble strip would be; warning sign in view.

Intersection #53 (East Side)

Jackson Co. (Map Page 21)

Condition: *No Rumble Strips* on Minor Road

Major road: County Route 17 (North-South)

Minor road: County Route 24 (West-East)

On East Side (looking West): on both sides—clear view of traffic on major road.



Photograph #171 (Reel #8, 18) (from East, looking West): from approximately where first rumble strip would be; warning sign in view.

APPENDIX A.7 SCOTT COUNTY

The intersections in Scott County that were visited are listed in this subsection of the appendix. The listing includes the photograph taken just before the point at which the first set of rumble strips is encountered, or would be encountered if rumbles strips were installed, for the approaches that are stop-controlled for each of the intersections.

[Note: Intersections #58 and #59 are listed in Scott County, although since Judicial Road—the North-South road that is the minor road at both of these intersections—marks the boundary between Scott and Dakota County, they could also both be listed as Dakota County intersections.]

Intersection #54 (North Side)

Scott Co. (Map Page 41)

In town

Condition: **No Rumble Strips** on Minor Road

Major road: County Road 78 (North-South)

Minor road: County Road 79 (West-East)

On North Side (looking South): rise obscures intersection; on both sides—rise obscure traffic on major road.



Photograph #172 (Reel #8, 19) (from North, looking South): from approximately where first rumble strip would be; warning sign in view.

Intersection #55 (West Side)

Scott Co. (Map Page 33)

Condition: **No Rumble Strips** on Minor Road

Major road: County Route 27/Texas Avenue (North-South)

Minor road: County Road 68 (West) and County Route 12 (East)

On West Side (looking East): to North—rise, corn, and building obscure traffic on major road; to South—trees and building obscure traffic on major road.



Photograph #174 (Reel #8, 21) (from West, looking East): from approximately where first rumble strip would be; warning sign in view.

Intersection #55 (East Side)

Scott Co. (Map Page 33)

Condition: *No Rumble Strips* on Minor Road

Major road: County Route 27/Texas Avenue (North-South)

Minor road: County Road 68 (West) and County Route 12 (East)

On East Side (looking West): to South—trees obscure traffic on major road; to North—
rise and buildings obscure traffic on major road.



Photograph #176 (Reel #8, 23) (from East, looking West): from approximately where
first rumble strip would be; warning sign in view.

Intersection #56 (South Side)

Scott Co. (Map Page 33)

Condition: *No Rumble Strips* on Minor Road

Major road: Credit River Boulevard/County Route 12 (East-West)

Minor road: Natchez Avenue (North) and Vernon Avenue (South)

On South Side (looking North): curve and corn obscure intersection; on both sides—corn obscures traffic on major road.



Photograph #178 (Reel #9, 1) (from South, looking North): from approximately where first rumble strip would be; warning sign in view.

Intersection #56 (North Side)

Scott Co. (Map Page 33)

Condition: **No Rumble Strips** on Minor Road

Major road: Credit River Boulevard/County Route 12 (East-West)

Minor road: Natchez Avenue (North) and Vernon Avenue (South)

On North Side (looking South): curve, trees, and rise obscure intersection; to West—rise and trees obscure traffic on major road; to East—trees obscure traffic on major road.



Photograph #180 (Reel #9, 3) (from North, looking South): from approximately where first rumble strip would be; warning sign in view.

Intersection #57 (North Side)

Scott Co. (Map Page 33)

Condition: *No Rumble Strips* on Minor Road

Major road: Eagle Creek Ave SE/185th Street East (East-West)

Minor road: Natchez Avenue (North-South)

On North Side (looking South): to East—trees and buildings partially obscure traffic on major road; to West—trees obscure traffic on major road.



Photograph #182 (Reel #9, 5) (from North, looking South): from approximately where first rumble strip would be; warning sign in view.

Intersection #57 (South Side)

Scott Co. (Map Page 33)

Condition: **No Rumble Strips** on Minor Road

Major road: Eagle Creek Ave SE/185th Street East (East-West)

Minor road: Natchez Avenue (North-South)

On South Side (looking North): to West—trees obscure traffic on major road; to East—close in to intersection, traffic on major road visible, while further away rise obscures traffic.



Photograph #183 (Reel #9, 6) (from South, looking North): from approximately where first rumble strip would be; warning sign in view.

Intersection #58 (South Side)

Located on the Scott Co./Dakota Co. boundary (Map Page 33)

Condition: **No Rumble Strips** on Minor Road

Major road: 185th Street East (East-West)

Minor road: Judicial (North-South)

On South Side (looking North): on both sides—trees obscure traffic on major road.



Photograph #184 (Reel #9, 7) (from South, looking North): from approximately where first rumble strip would be; warning sign in view.

Intersection #58 (North Side)

Located on the Scott Co./Dakota Co. boundary (Map Page 33)

Condition: **No Rumble Strips** on Minor Road

Major road: 185th Street East (East-West)

Minor road: Judicial Road (North-South)

On North Side (looking South): rise obscures intersection; on both sides—hill and trees
obscure traffic on major road.



Photograph #185 (Reel #9, 8) (from North, looking South): from approximately where first rumble strip would be; warning sign in view.

Intersection #59 (North Side)

Located on the Scott Co./Dakota Co. boundary (Map Page 33)

T-junction

Condition: *No Rumble Strips* on Minor Road

Major road: Credit River Boulevard (West) and 205 Street West (East)

Minor road: Judicial Road (North-South)

On North Side (looking South): on both sides—trees obscure traffic on major road.



Photograph #187 (Reel #9, 10) (from North, looking South): from approximately where first rumble strip would be; warning sign in view.

Intersection #60 (South Side)

Scott Co. (Map Page 33)

Condition: *No Rumble Strips* on Minor Road

Major road: County Road 2 (East-West)

Minor road: County Road 91/Natchez Avenue (North-South)

On South Side (looking North): to West—houses obscure traffic on major road; to East—tops of traffic on major road visible.



Photograph #188 (Reel #9, 11) (from South, looking North): from approximately where first rumble strip would be; warning sign in view.

Intersection #60 (North Side)

Scott Co. (Map Page 33)

Condition: **No Rumble Strips** on Minor Road

Major road: County Road 2 (East-West)

Minor road: County Road 91/Natchez Avenue (North-South)

On North Side (looking South): rise partially obscures intersection; on both sides—rise and trees obscure traffic on major road.



Photograph #189 (Reel #9, 12) (from South, looking North): from approximately where first rumble strip would be; warning sign in view.

Intersection #61 (East Side)

Scott Co. (Map Page 33)

4-way stop

Condition: **No Rumble Strips**

Cross Roads: County Route 2 (East-West) and County Route 27 (North-South)

On East Side (looking West): on both sides—rise obscures traffic on cross road.



Photograph #191 (Reel #9, 14) (from East, looking West): from approximately where first rumble strip would be; warning sign in view.

Intersection #61 (West Side)

Scott Co. (Map Page 33)

4-way stop

Condition: *No Rumble Strips*

Cross Roads: County Route 2 (East-West) and County Route 27 (North-South)

On West Side (looking East): to North—rise and corn obscures traffic on major road; to South—clear view of traffic on major road.



Photograph #192 (Reel #9, 15) (from West, looking East): from approximately where first rumble strip would be: warning sign in view.

Intersection #61 (South Side)
Scott Co. (Map Page 33)
4-way stop
Condition: *No Rumble Strips*

Cross Roads: County Route 2 (East-West) and County Route 27 (North-South)

On South Side (looking North): to East—rise partially obscures traffic on major road; to West—clear view of traffic on major road.



Photograph #193 (Reel #9, 16) (from South, looking North): from approximately where first rumble strip would be: warning sign in view.

Intersection #61 (North Side)
Scott Co. (Map Page 33)
4-way stop
Condition: *No Rumble Strips*

Cross: 2 (East-West)

Cross: 27 (North-South)

On North Side (looking South): to East—rise partially obscures traffic on major road; to West—rise obscures traffic on major road.



Photograph #194 (Reel #9,) (from North, looking South): from approx where first rumble strip would be—"Stop Ahead" sign in view.

Intersection #62 (West Side)

Scott Co. (Map Page 33)

Condition: **Rumble strip on West; No Rumble Strips but flash on top of “Stop Ahead” sign to East**

Major road: State Route 13 (North-South)

Minor road: County Route 2 (East-West)

On West Side (looking East): to North—rise obscures traffic on major road; to South—rise and corn obscures traffic on major road.



Photograph #195 (Reel #9, 18) (from West, looking East): first rumble strip and warning sign in view.

Intersection #62 (East Side)

Scott Co. (Map Page 33)

Condition: **Rumble strip on West; No Rumble Strips but flash on top of “Stop Ahead” sign to East**

Major road: State Route 13 (North-South)

Minor road: County Route 2 (East-West)

On East Side (looking West): to South—near to intersection traffic on major road is visible, while further away rise partially obscures traffic; to North—clear view of traffic on major road.



Photograph #197 (Reel #9, 20) (from East, looking West): from approximately where first rumble strip would be; warning sign in view; also, there is a *flasher on top* of the actual STOP sign.

Intersection #63 (East Side)

Scott Co. (Map Page 33)

Condition: *No Rumble Strips* on Minor Road

Major road: 89 (North-South)

Minor road: County Route 2 (East-West)

On East Side (looking West): rise partially obscures intersection; to North—rise obscures traffic on major road: to South—near to intersection rise obscures traffic on major road, while further out traffic is visible.



Photograph #198 (Reel #9, 21) (from East, looking West): from approximately where first rumble strip would be, warning sign in view.

Intersection #63 (West Side)

Scott Co. (Map Page 33)

Condition: **No Rumble Strips** on Minor Road

Major road: 89 (North-South)

Minor road: County Route 2 (East-West)

On West Side (looking East): on both sides—clear view of traffic on major road.



Photograph #200 (Reel #9, 24) (from West, looking East): from approximately where first rumble strip would be; warning sign in view.

Intersection #64 (East Side)

Scott Co. (Map Page 33)

Condition: **No Rumble Strips** on Minor Road

Major road: County Route 15 (North-South)

Minor road: County Route 2 (East-West)

On East Side (looking West): on both sides—rise obscures traffic on major road.



Photograph #201 (Reel #10, 1) (from East, looking West): from approximately where first rumble strip would be; warning sign in view.

Intersection #64 (West Side)

Scott Co. (Map Page 33)

Condition: *No Rumble Strips* on Minor Road

Major road: County Route 15 (North-South)

Minor road: County Route 2 (East-West)

On West Side (looking East): on both sides—clear view of traffic on major road.



Photograph #202 (Reel #10, 2) (from West, looking East): from approximately where first rumble strip would be; warning sign in view.

Intersection #65 (East Side)

Scott Co. (Map Page 32)

Rail (North-South) crossing on East side of major road

Condition: *No Rumble Strips* on Minor Road

Major road: State Route 21 (North-South)

Minor road: County Route 2 (East-West)

On East Side (looking West): to South—rise obscures traffic on major road; to North—clear view of traffic on major road.



Photograph #203 (Reel #10, 3) (from East, looking West): from approximately where first rumble strip would be; warning sign in view.

Intersection #65 (West Side)

Scott Co. (Map Page 32)

Rail (North-South) crossing on East

Condition: **No Rumble Strips** on Minor Road

Major road: State Route 21 (North-South)

Minor road: County Route 2 (East-West)

On West Side (looking East): to South—trees & building obscure traffic on major road;
to North—clear view of traffic on major road.



Photograph #204 (Reel #10, 4) (from West, looking East): from approximately where first rumble strip would be; warning sign in view.

Intersection #141 (East Side)

Scott Co. (Map Page 32)

Condition: **No Rumble Strips** on Minor Road

Major road: County Route 27 (North-South)

Minor road: CR-62/240th Street East (East-West)

On East Side (looking West): to South—trees & building obscure traffic on major road;
to North—rise obscures traffic on major road.



Photograph #474 (Reel #E2, 1) (from East, looking West): *no rumble strip*; warning sign in view.

Intersection #141 (West Side)

Scott Co. (Map Page 32)

Condition: **No Rumble Strips** on Minor Road

Major road: County Route 27 (North-South)

Minor road: CR-62/240th Street East (East-West)

On West Side (looking East): to South—building obscure traffic on major road; to North—clear view of traffic on major road.



Photograph #475 (Reel #E2, 2) (from West, looking East): *no rumble strip*; warning sign in view.

APPENDIX A.8
DAKOTA COUNTY

The intersections in Dakota County that were visited are listed in this subsection of the appendix. The listing includes the photograph taken just before the point at which the first set of rumble strips is encountered, or would be encountered if rumble strips were installed, for the approaches that are stop-controlled for each of the intersections.

Intersection #66 (East Side)

Dakota Co. (Map Page 33)

T-junction

Condition: *No Rumble Strips, but “STOP AHEAD” on road surface* of Minor Road

Major road: County Route 86 (East-West)

Minor road: County Route 23/Galaxie Ave (North-South)

On North Side (looking South): to West—trees obscure traffic on major road; to East—clear view of traffic on major road.



Photograph #201 (Reel #10, 6) (from North, looking South): from approximately where first rumble strip would be; warning sign in view; also, STOP AHEAD on road; and road has very wide shoulder.

Intersection #67 (South Side)

Dakota Co. (Map Page 33)

T-junction

Condition: *No Rumble Strips, but “STOP AHEAD” on road surface* of Minor Road

Major road: County Route 86 (East-West)

Minor road: County Route 23/Foliage Ave (North-South)

On South Side (looking North): to East—buildings and trees obscure traffic on major road; to West—further from intersection on major road corn obscures traffic on major road, nearer in traffic clear.



Photograph #203 (Reel #10, 7) (from South, looking North): from approximately where first rumble strip would be; warning sign in view; also, STOP AHEAD on road.

Intersection #68 (West Side)

Dakota Co. (Map Page 33)

Condition: *No Rumble Strips* on Minor Road

Major road: State Route 3 (North-South)

Minor road: County Route 86 (East-West)

On West Side (looking East): to West—buildings and trees obscure traffic on major road;
to East—partial view of traffic on major road.



Photograph #208 (Reel #10, 8) (from West, looking East): from approx where first rumble strip would be—with “Stop Ahead” in view

Intersection #68 (East Side)

Dakota Co. (Map Page 33)

Condition: **No Rumble Strips** on Minor Road

Major road: State Route 3 (North-South)

Minor road: County Route 86 (East-West)

On East Side (looking West): to North—trees obscure traffic on major road; to South—
rise and trees obscure traffic on major road.



Photograph #209 (Reel #10, 9) (from East, looking West): from approximately where first rumble strip would be; warning sign in view; also, STOP AHEAD on road.

Intersection #69 (West Side)

Dakota Co. (Map Page 33)

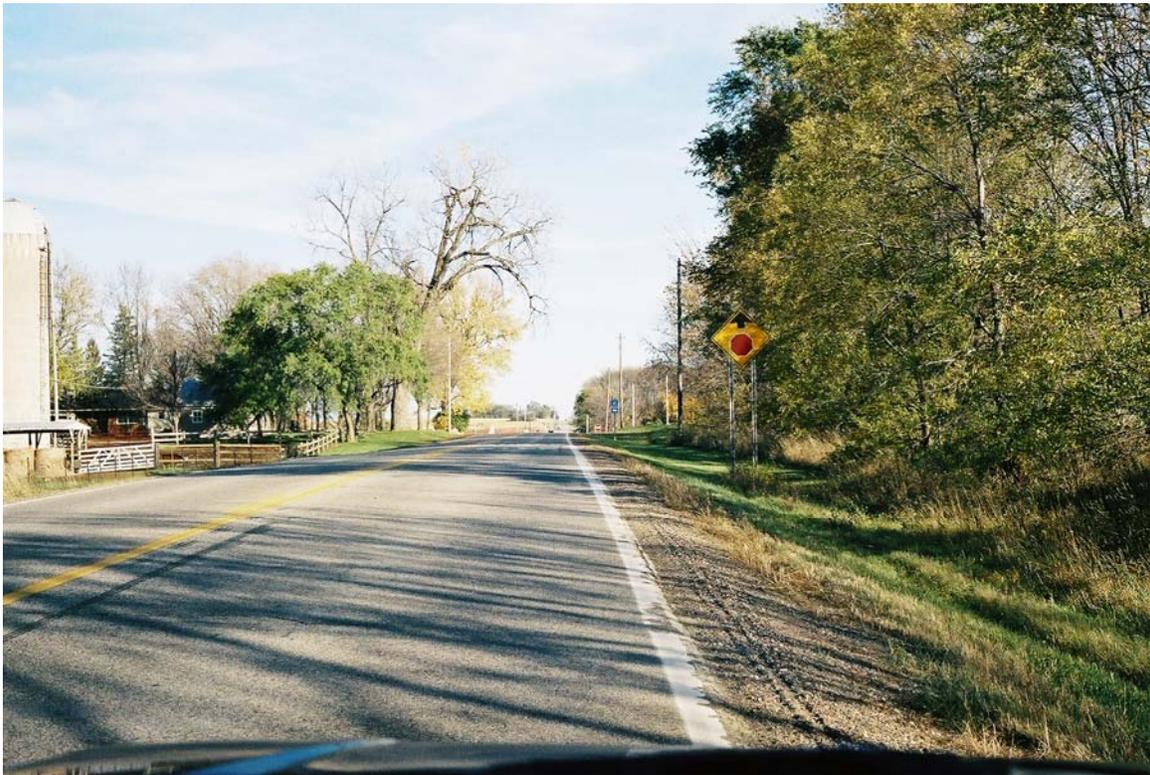
Major road at angle, runs North-East to South-West; also, there is a dirt road connector from East side of minor road to North side of major road

Condition: **No Rumble Strips** on Minor Road

Major road: County Route 47 (North-South)

Minor road: County Route 86 (East-West)

On West Side (looking East): to North—trees and buildings obscure traffic on major road; to South—trees obscure traffic on major road.



Photograph #211 (Reel #10, 11) (from West, looking East): from approximately where first rumble strip would be; warning sign in view; also, STOP AHEAD on road.

Intersection #69 (East Side)

Dakota Co. (Map Page 33)

Major road at angle, runs North-East to South-West; also, there is a dirt road connector from East side of minor road to North side of major road

Condition: **No Rumble Strips** on Minor Road

Major road: County Route 47 (North-South)

Minor road: County Route 86 (East-West)

On East Side (looking West): to South—trees obscure traffic on major road; to North—clear view of traffic on major road (it runs in front of trees).



Photograph #214 (Reel #10, 14) (from East, looking West): from approximately where first rumble strip would be; warning sign in view; also, STOP AHEAD on road; and, dirt road to North arm of major road is immediately before the warning sign.

Intersection #70 (West Side)

Dakota Co. (Map Page 33)

On North side of intersection, major road runs North-South; while on South side, it angles and runs North-East to South-West

Condition: **No Rumble Strips** on Minor Road

Major road: State Route 56 (North-South)

Minor road: County Route 86 (East-West)

On West Side (looking East): on both sides—clear view of traffic on major road (on both sides road runs in front of trees).



Photograph #215 (Reel #10, 15) (from West, looking East): from approximately where first rumble strip would be; warning sign in view; also, STOP AHEAD on road.

Intersection #70 (East Side)

Dakota Co. (Map Page 33)

On North side of intersection, major road runs North-South; while on South side, it angles and runs North-East to South-West

Condition: **No Rumble Strips** on Minor Road

Major road: State Route 56 (North-South)

Minor road: County Route 86 (East-West)

On East Side (looking West): on both sides—trees obscure traffic on major road.



Photograph #216 (Reel #10, 16) (from East, looking West): from approximately where first rumble strip would be; warning sign in view, also, STOP AHEAD on road.

Intersection #71 (North Side)

Dakota Co. (Map Page 34)

Major road at angle, runs North-East to South-West).

Condition: **No Rumble Strips** on Minor Road

Major road: County Route 47 (North-East to South-West)

Minor road: County Road 85/Goodwin Ave (North-South)

On North Side (looking South): on both sides—clear view of traffic on major road.



Photograph #217 (Reel #10, 17) (from North, looking South): from approximately where first rumble strip would be; warning sign in view; also, STOP AHEAD on road; and road has very wide shoulder.

Intersection #71 (South Side)

Dakota Co. (Map Page 34)

Major road at angle, runs North-East to South-West).

Condition: **No Rumble Strips** on Minor Road

Major road: County Route 47 (North-East to South-West)

Minor road: County Road 85/Goodwin Ave (North-South)

On South Side (looking North): on both sides—clear view of traffic on major road



Photograph #218 (Reel #10, 18) (from South, looking North): from approximately where first rumble strip would be; warning sign in view; also, STOP AHEAD on road; and road has very wide shoulder.

Intersection #72 (South Side)

Dakota Co. (Map Page 34)

Condition: **No Rumble Strips** on Minor Road

Major road: County Route 62/190th Street East (East-West)

Minor road: County Road 85/Goodwin Ave (North-South)

On South Side (looking North): to East—corn obscures traffic on major road; to West—clear view of traffic on major road.



Photograph #219 (Reel #10, 19) (from South, looking North): from approximately where first rumble strip would be; warning sign in view; also, STOP AHEAD on road; and road has very wide shoulder.

Intersection #72 (North Side)

Dakota Co. (Map Page 34)

Condition: **No Rumble Strips** on Minor Road

Major road: County Route 62/190th Street East (East-West)

Minor road: County Road 85/Goodwin Ave (North-South)

On North Side (looking South): on both sides—clear view of traffic on major road.



Photograph #219 (Reel #10,) (from North, looking South): from approximately where first rumble strip would be; warning sign in view; also, STOP AHEAD on road; and road has very wide shoulder.

APPENDIX A.9
BENTON COUNTY

The intersections in Benton County that were visited are listed in this subsection of the appendix. The listing includes the photograph taken just before the point at which the first set of rumble strips is encountered, or would be encountered if rumble strips were installed, for the approaches that are stop-controlled for each of the intersections.

Intersection #73 (North Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road

Major Road: State Route 95 (East-West)

Minor Road: County Route 6 (North-South)

On North Side (looking South): to West—slight vertical curve obscures traffic on major road; to East—trees obscure traffic on major road.



Photograph #216 (Reel #11, 2A) (from North, looking South): first rumble strip and warning sign in view—also STOP AHEAD on road.

Intersection #73 (South Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road (1st rumble strip *missing*).

Major Road: State Route 95 (East-West)

Minor Road: County Route 6 (North-South)

On South Side (looking North): on both sides—trees obscure traffic on major road.



Photograph #218 (Reel #11, 4A) (from South, looking North): first rumble strip *missing* (because of new road surface) but warning sign in view and STOP AHEAD visible on road.

Intersection #74 (South Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road

Major Road: County Route 4 (East-West)

Minor Road: County Route 6 (North-South)

On South Side (looking North): to West—clear view of traffic on major road; to East—some obscuration from trees of traffic on major road.



Photograph #220 (Reel #11, 6A) (from South, looking North): first rumble strip *barely visible* in foreground; warning sign in view; STOP AHEAD on road.

Intersection #74 (North Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road

Turn lane to right (West)

Major Road: County Route 4 (East-West)

Minor Road: County Route 6 (North-South)

On North Side (looking South): on both sides—clear view of traffic on major road.



Photograph #222 (Reel #11, 8A) (from North, looking South): first rumble strip and warning sign in view—also, STOP AHEAD on road (just in front of car traveling toward the intersection).

Intersection #75 (South Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road

Major Road: County Route 4 (East-West)

Minor Road: County Route 7 (North-South)

On South Side (looking North): to West—trees obscure traffic on major road; to East—
clear view of traffic on major road.



Photograph #224 (Reel #11, 10A) (from South, looking North): first rumble strip difficult to see—it is just before new construction; warning sign in view; STOP AHEAD on road also difficult to see.

Intersection #75 (North Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road (1st rumble strip *missing*)

Major Road: County Route 4 (East-West)

Minor Road: County Route 7 (North-South)

On North Side (looking South): to West—trees obscure traffic on major road; to East—
clear view of traffic on major road.



Photograph #226 (Reel #11, 12A) (from North, looking South): first rumble strip *missing*;
warning sign in view; STOP AHEAD on road.

Intersection #76 (North Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road

Major Road: County Route 4 (East-West)

Minor Road: County Route 9 (North-South)

On North Side (looking South): to West—trees and buildings obscure traffic on major road; to East—clear view of traffic on major road (in front of trees).



Photograph #228 (Reel #11, 14A) (from North, looking South): first rumble strip and warning sign in view, also STOP AHEAD on road.

Intersection #76 (South Side)

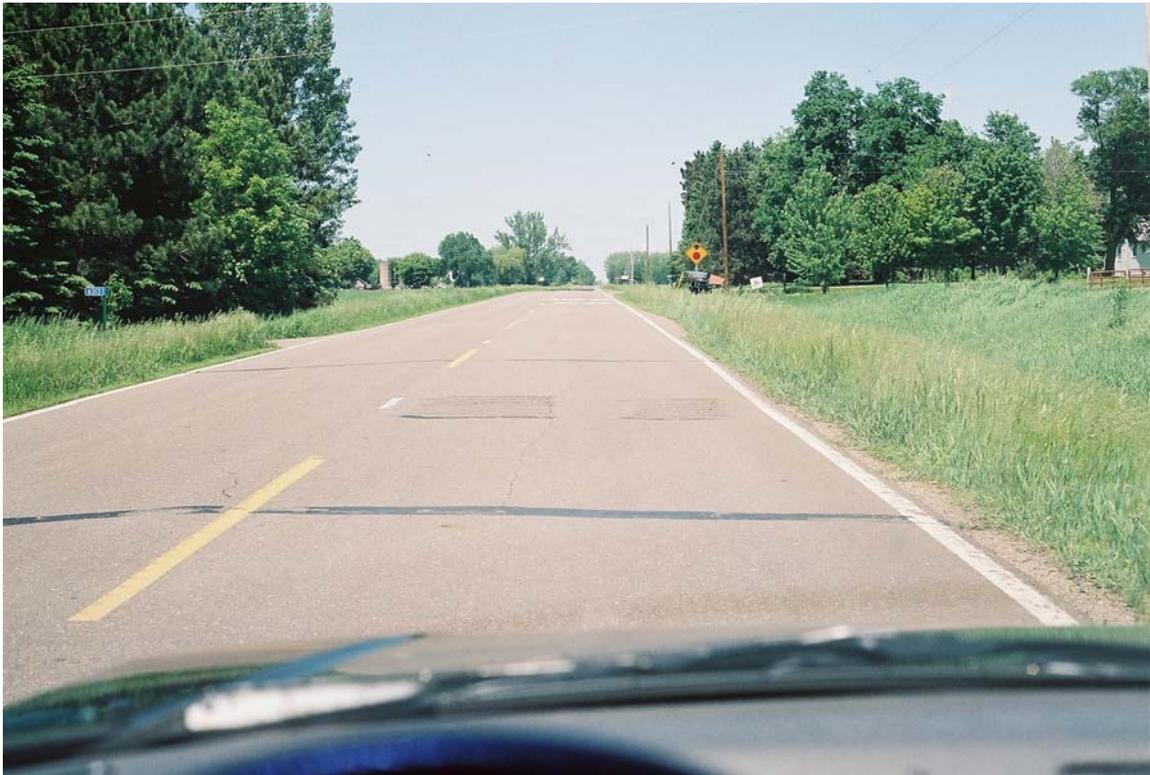
Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road

Major Road: County Route 4 (East-West)

Minor Road: County Route 9 (North-South)

On South Side (looking North): on both sides—trees obscure traffic on major road (more to East than West).



Photograph #230 (Reel #11, 16A) (from South, looking North): first rumble strip and warning sign in view; also, STOP AHEAD on road.

Intersection #77 (South Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road

Major road crosses minor at an angle; it runs from North-East to South-West.

Major Road: State Route 23 (North-East to South-West)

Minor Road: County Route 9 (North-South)

On South Side (looking North): on both sides—view of traffic on major road is clear from further out, but obscured at position of first rumble strip.



Photograph #232 (Reel #11, 18A) (from South, looking North): first rumble strip and warning strip in view—also, STOP AHEAD on road.

Intersection #77 (North Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road

Major road crosses minor at an angle; it runs from North-East to South-West.

Major Road: State Route 23 (North-East to South-West)

Minor Road: County Route 9 (North-South)

On North Side (looking South): on both sides—trees obscure traffic on major road.



Photograph #234 (Reel #11, 20A) (from North, looking South): first rumble strip and warning strip in view; also, faint STOP AHEAD on road.

Intersection #78 (South Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road

Major Road: County Route 5 (East-West)

Minor Road: County Route 9 (North-South)

On South Side (looking North): to West—clear view of traffic on major road; East—trees and buildings obscure traffic on major road.



Photograph #236 (Reel #11, 22A) (from South, looking North): first rumble strip and warning sign in view; also, STOP AHEAD on road.

Intersection #78 (North Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road

Major Road: County Route 5 (East-West)

Minor Road: County Route 9 (North-South)

On North Side (looking South): to West—clear view of traffic on major road; to East—trees partially obscure traffic on major road.



Photograph #238 (Reel #11, 24A) (from North, looking South): first rumble strip and warning sign in view; also, STOP AHEAD on road.

Intersection #79 (South Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road

Major Road: County Route 5 (East-West)

Minor Road: County Route 7 (North-South)

On South Side (looking North): to West—trees and buildings obscure traffic on major road; East—clear view of traffic on major road.



Photograph #240 (Reel #12, 2A) (from South, looking North): first rumble strip and warning sign in view; also, STOP AHEAD on road.

Intersection #79 (North Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road

Major Road: County Route 5 (East-West)

Minor Road: County Route 7 (North-South)

On North Side (looking South): obscured by trees on both sides.



Photograph #242 (Reel #12, 4A) (from North, looking South): first rumble strip in view (though barely visible in photograph), warning sign in view and STOP AHEAD on road.

Intersection #80 (East Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road

Note EXTRA sets of rumble strips on both sides of the intersection—there are *three* sets of rumble strips on the East and *four* sets of rumble strips on the West.

Major Road: County Route 6 (North-South)

Minor Road: County Route 5 (East-West)

On East Side (looking West): to North—clear view of traffic on major road; to South—trees obscure traffic on major road.



Photograph #244 (Reel #12, 6A) (from East, looking West): first of *three* sets of rumble strips and warning sign in view; also STOP AHEAD on road (though not visible in this photograph).

Intersection #80 (West Side)

Benton Co. (Map Page 47)

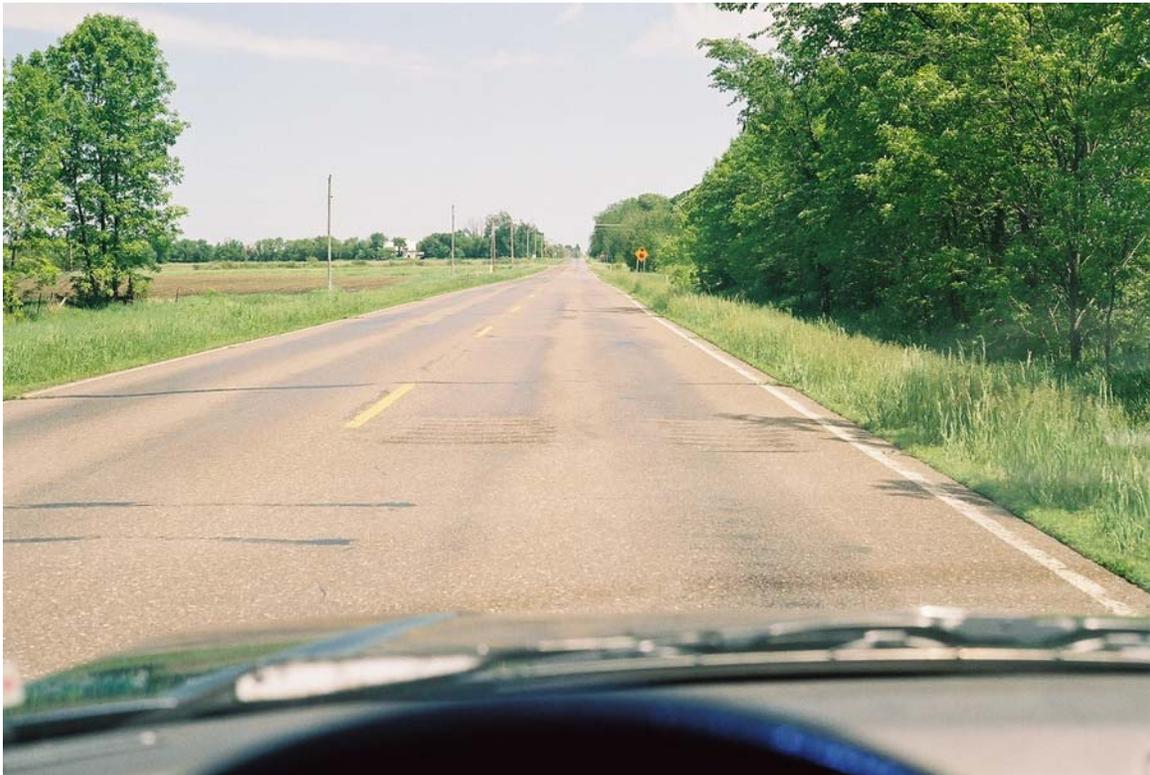
Condition: **Rumble Strips (wheel)** on Minor Road

Note EXTRA sets of rumble strips on both sides of I.

Major Road: 6 (North-South)

Minor Road: 5 (East-West)

On West Side (looking East): to South—trees obscure traffic on major road; to North—
clear view of traffic on major road (except for tree immediately on left).



Photograph #247 (Reel #12, 9A) (from West, looking East): first *of four* sets of rumble strips and warning sign in view; also STOP AHEAD on road (though barely visible in this photograph).

Intersection #81 (North Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road

Minor road angles West to the South of the intersection.

Major Road: County Route 5 (East-West)

Minor Road: County Route 14 (North-South)

On North Side (looking South): to West—slight rise obscures traffic on major road; to East—trees obscure traffic on major road.



Photograph #251 (Reel #12, 13A) (from North, looking South): first rumble strip and warning sign in view; also, STOP AHEAD on road.

Intersection #81 (South Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road

Minor road angles West to the South of the intersection.

Major Road: County Route 5 (East-West)

Minor Road: County Route 14 (North-South)

On South Side (looking North): to West—partially obstructed view of traffic on major road; to East—trees obscure traffic on major road.



Photograph #253 (Reel #12, 15A) (from South, looking North): first rumble strip and warning sign in view; also, STOP AHEAD on road.

Intersection #82 (South Side)

Benton Co. (Map Page 47)

Condition: *No Rumble Strips* on Minor Road

Major Road: County Route 12 (East-West)

Minor Road: County Route 11 (North-South)

On South Side (looking North): on both sides—trees and buildings obscure traffic on major road.



Photograph #255 (Reel #12, 17A) (from South, looking North): warning sign in view; also, STOP AHEAD on road.

Intersection #82 (North Side)

Benton Co. (Map Page 47)

Condition: *No Rumble Strips* on Minor Road

Major Road: County Route 12 (East-West)

Minor Road: County Route 11 (North-South)

On North Side (looking South): on both sides—trees and buildings obscure traffic on major road.



Photograph #256 (Reel #12, 18A) (from North, looking South): warning sign in view; also, STOP AHEAD on road.

Intersection #83 (East Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road (1st rumble strip *missing* on East side).

Major Road: State Route 25 (North-South)

Minor Road: County Route 12 (East-West)

On East Side (looking West): to North—trees partially obscure traffic on major road; to South—trees obscure traffic on major road.



Photograph #257 (Reel #12, 19A) (from East, looking West): first rumble strip *missing* (note second set—a double se—is in place closer to intersection); warning sign in view; also, STOP AHEAD on road.

Intersection #83 (West Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major Road: State Route 25 (North-South)

Minor Road: County Route 12 (East-West)

On West Side (looking East): to North—rise obscures traffic on major road; to South
trees partially obscure traffic on major road.



Photograph #259 (Reel #12, 21A) (from East, looking West): first rumble strip and warning sign in view; also, STOP AHEAD on road.

Intersection #84 (East Side)

Benton Co. (Map Page 46)

Condition: **Rumble Strips (wheel)** on Minor Road, but first rumble strip *has been filled in*.

Major road crosses minor at an angle; it runs from North-West to South-East.

Major road is divided highway

Rail track runs parallel to major road (on Westside)

Major Road: U.S. Route 10 (North-West to South-East)

Minor Road: County Road 40 (East-West)

On East Side (looking West): to North—clear view of traffic on major road; to South rise partially obscures traffic on major road.



Photograph #261 (Reel #12, 23A) (from East, looking West): first rumble strips *filled in* (note second set—a double set—is in place closer to intersection); warning sign in view; also, STOP AHEAD on road.

Intersection #84 (West Side)

Benton Co. (Map Page 46)

Condition: *No Rumble Strips—they are filled in*—on Minor Road.

Major road crosses minor at an angle; it runs from North-West to South-East.

Major road is divided highway

Rail track runs parallel to major road (on Westside)

Also, on West side minor road takes jog to South just before rail crossing and intersection.

Major Road: U.S. Route 10 (North-West to South-East)

Minor Road: County Road 40 (East-West)

On West Side (looking East): to North—rise and trees partially obscure traffic on major road; to South—rise, trees, and buildings partially obscure traffic on major road.



Photograph #263 (Reel #13, 1) (from West, looking East): first rumble strip is filled in (as are second rumble strips; warning sign in view; also, rail crossing sign in view and STOP AHEAD on road.

Intersection #85 (North Side)

Benton Co. (Map Page 47)

Condition: *No Rumble Strips* on North side of Minor Road—but there are **Rumble Strips (wheel)** on the South side.

Major Road: County Road 43 (East-West)

Minor Road: County Road 58 (North-South)

On North Side (looking South): on both sides—clear view of traffic on major road.



Photograph #265 (Reel #13, 3) (from North, looking South): warning sign in view and STOP AHEAD on road [New road surface—No rumble strips].

Intersection #85 (South Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road, but there are *No Rumble Strips* on North side of Minor Road

Major Road: County Road 43 (East-West)

Minor Road: County Road 58 (North-South)

On South Side (looking North): on both sides—clear view of traffic on major road.



Photograph #266 (Reel #13, 4) (from South, looking North): first rumble strips and sign in view; also, STOPAHEAD on road.

Intersection #86 (South Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major Road: County Road 43 (East-West)

Minor Road: County Route 25 (North-South)

On South Side (looking North): on both sides—rise obscures traffic on major road.



Photograph #268 (Reel #13, 6) (from South, looking North): first rumble strips but *No* warning sign.

Intersection #86 (North Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major Road: County Road 43 (East-West)

Minor Road: County Route 25 (North-South)

On North Side (looking South): on both sides—rise obscures traffic on major road.



Photograph #270 (Reel #13, 8) (from North, looking South): first rumble strips and warning sign in view: also, STOP AHEAD on road.

Intersection #87 (West Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road (1st rumble strips *missing*)

Major road at angle, it runs North-East to South-West

Major Road: County Route 3 (North-East to South-West)

Minor Road: County Road 43 (East-West)

On West Side (looking East): both sides obscured close in, by buildings, trees.



Photograph #272 (Reel #13, 10) (from West, looking East): first rumble strips *missing*; warning sign in view; also, STOPAHEAD on road.

Intersection #87 (East Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road (1st rumble strips *filled in*)

Major road at angle, it runs North-East to South-West

Major Road: County Route 3 (North-East to South-West)

Minor Road: County Road 43 (East-West)

On East Side (looking West): on both sides—trees and buildings obscure traffic on major road.



Photograph #274 (Reel #13, 12) (from East, looking West): first rumble strips *filled in*; but, warning sign in view.

Intersection #88 (South Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road

Major Road: County Road 43 (East-West)

Minor Road: County Road 61 (North-South)

On South Side (looking North): to West—trees partially obscure traffic on major road; to East—clear view of traffic on major road (in front of trees).



Photograph #276 (Reel #13, 14) (from South, looking North): first rumble strips and warning sign in view; also, STOP AHEAD on road.

Intersection #88 (North Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road

Major Road: County Road 43 (East-West)

Minor Road: County Road 61 (North-South)

On North Side (looking South): to East—rise and trees obscures traffic on major road; to West—rise obscures traffic on major road.



Photograph #278 (Reel #13, 16) (from North looking South): first rumble strips and warning sign in view; also, STOP AHEAD on road.

Intersection #89 (North Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road (1st rumble strips *missing*)
Major road at angle; it runs North-East to South-West

Major Road: State Route 23 (East/North-West/South)

Minor Road: County Route 25 (North-South)

On North Side (looking South): to East—rise and trees obscure traffic on major road; to
West—rise, trees, and buildings obscure traffic on major road.



Photograph #280 (Reel #13, 18) (from North looking South): first rumble strips *missing*;
warning sign in view.

Intersection #89 (South Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road

Major road at angle; it runs North-East to South-West

On South side Minor road veers to West just before intersection

Major Road: State Route 23 (East/North-West/South)

Minor Road: County Route 25 (North-South)

On South Side (looking North): to West—clear view of traffic on major road; to East—
trees and buildings obscure traffic on major road.



Photograph #282 (Reel #13, 20) (from South looking North): first rumble strips and warning sign in view.

Intersection #90 (North Side)

Benton Co. (Map Page 47)

Condition: **Rumble Strips (wheel)** on Minor Road (right side of 1st rumble strips *missing*)

South side of minor road closed for road construction when photograph taken—because of this there are detour signs for the minor road immediately after the warning sign

Major Road: State Route 95 (East-West)

Minor Road: County Route 25 (North-South)

On North Side (looking South): to East—clear view of traffic on major road; to West—trees obscure traffic on major road.



Photograph #284 (Reel #13, 22) (from North looking South): first rumble strip *with right side missing*; warning sign in view; also, STOP AHEAD on road.

APPENDIX A.10
KANDIYOHI COUNTY

The intersections in Kandiyohi County that were visited are listed in this subsection of the appendix. The listing includes the photograph taken just before the point at which the first set of rumble strips is encountered, or would be encountered if rumbles strips were installed, for the approaches that are stop-controlled for each of the intersections.

Intersection #91 (East Side)

Kandiyohi Co. (Map Page 38)

Condition: **Rumble Strips (full)** on Minor Road

Major Road: U.S. Route 71 (North-South)

Minor Road: County Route 40 (East-West)

On East Side (looking West): to South—rise and trees obscures traffic on major road; to
North—trees obscure traffic on major road.



Photograph #286 (Reel #13, 24) (from East looking West): first rumble strip and warning sign in view.

Intersection #91 (West Side)

Kandiyohi Co. (Map Page 38)

Condition: **Rumble Strips (full)** on Minor Road

Minor road *widens greatly* with a right turn lane at intersection

Major Road: U.S. Route 71 (North-South)

Minor Road: County Route 40 (East-West)

On West Side (looking East): to North—trees obscure traffic on major road; to South—
rise obscures traffic on major road.



Photograph #288 (Reel #14, 2A) (from East looking West): first rumble strip and warning sign in view.

Intersection #92 (South Side)

Kandiyohi Co. (Map Page 38)

Condition: **Rumble Strips (full)** on Minor Road

Minor road widens just before intersection to provide a right turn lane.

Major Road: County Route 40 (East-West)

Minor Road: County Route 5 (North-South)

On South Side (looking North): on both side—clear view of traffic on major road.



Photograph #290 (Reel #14, 4A) (from South looking North): first rumble strip and warning sign in view.

Intersection #92 (North Side)

Kandiyohi Co. (Map Page 38)

Condition: **Rumble Strips (wheel)** on Minor Road

Minor road widens just before intersection to provide a right turn lane.

Major Road: County Route 40 (East-West)

Minor Road: County Route 5 (North-South)

On North Side (looking South): to East—trees obscure traffic on major road; to West—clear view of traffic on major road.



Photograph #292 (Reel #14, 6A) (from North looking South): first rumble strip and warning sign in view.

Intersection #93 (North Side)

Kandiyohi Co. (Map Page 38)

Condition: *No Rumble Strips* on Minor Road

Major Road: County Route 40 (East-West)

Minor Road: County Route 1 (North-South)

On North Side (looking South): rise obscures intersection; on both sides rise obscures traffic on major road.



Photograph #294 (Reel #14, 8A) (from North looking South): from approximately where rumble strips would be; warning sign in view.

Intersection #93 (South Side)

Kandiyohi Co. (Map Page 38)

Condition: *No Rumble Strips* on Minor Road

Major Road: County Route 40 (East-West)

Minor Road: County Route 1 (North-South)

On South Side (looking North): on both sides—rise partially obscures traffic on major road.



Photograph #295 (Reel #14, 9A) (from South looking North): from approximately where rumble strips would be; warning sign in view.

Intersection #94 (West Side)

Kandiyohi Co. (Map Page 38)

Condition: **Rumble Strips (full)** on Minor Road

Major Road: County Route 1 (North-South)

Minor Road: County Route 27 (East-West)

On West Side (looking East): on both sides—nearer in to the intersection on the major road there is a clear view of traffic on major road; while further away, rise obscures traffic.



Photograph #296 (Reel #14, 10A) (from West looking East): first rumble strips and warning sign in view.

Intersection #94 (East Side)

Kandiyohi Co. (Map Page 38)

Condition: **Rumble Strips (full)** on Minor Road

Major Road: County Route 1 (North-South)

Minor Road: County Route 27 (East-West)

On East Side (looking West): on both sides—clear view of traffic on major road.



Photograph #298 (Reel #14, 12A) (from East looking West): first rumble strips warning sign in view.

Intersection #95 (North Side)

Kandiyohi Co. (Map Page 38)

Condition: **Rumble Strips (full)** on Minor Road to South, but *No Rumble Strips* to North (rail crossing instead).

Major road is at angle running North-West to South-East
Railroad on North side of major road

Major Road: U.S. Route 12 (North-West to South-East)

Minor Road: County Route 7 (North-South)

On North Side (looking South): on both sides—traffic on major road visible.



Photograph #300 (Reel #14, 14A) (from North looking South): from approximately where rumble strips would be; warning sign in view.

Intersection #95 (South Side)

Kandiyohi Co. (Map Page 38)

Condition: **Rumble Strips (full)** on Minor Road to South, but *No Rumble Strips* to North (rail crossing instead).

Major road is at angle running North-West to South-East

Railroad on North side of major road

Major Road: U.S. Route 12 (North-West to South-East)

Minor Road: County Route 7 (North-South)

On South Side (looking North): on both sides—clear view of traffic on major road.



Photograph #301 (Reel #14, 15A) (from South looking North): first rumble strips and warning sign in view.

Intersection #96 (North Side)

Kandiyohi Co. (Map Page 38)

Condition: **Rumble Strips (full)** on Minor Road.

Major Road: State Route 40 (East-West)

Minor Road: County Route 7 (North-South)

On North Side (looking South): to West—trees obscure traffic on major road; to East—
clear view of traffic on major road.



Photograph #303 (Reel #14, 17A) (from North looking South): first rumble strips and warning sign in view.

Intersection #96 (South Side)

Kandiyohi Co. (Map Page 38)

Condition: **Rumble Strips (full)** on Minor Road.

Major Road: State Route 40 (East-West)

Minor Road: County Route 7 (North-South)

On South Side (looking North): to West—buildings and trees obscure traffic on major road; to East— power plant partially obscures traffic on major road.



Photograph #305 (Reel #14, 19A) (from South looking North): first rumble strips and warning sign in view.

Intersection #97 (North Side)

Kandiyohi Co. (Map Page 38)

Condition: *No Rumble Strips* on Minor Road.

Major Road: State Route 40 (East-West)

Minor Road: County Route 1 (North-South)

On North Side (looking South): on both sides—clear view of traffic on major road.



Photograph #307 (Reel #14, 21A) (from North looking South): from approximately where rumble strips would be; warning sign in view.

Intersection #97 (South Side)

Kandiyohi Co. (Map Page 38)

Condition: *No Rumble Strips* on Minor Road.

Major Road: State Route 40 (East-West)

Minor Road: County Route 1 (North-South)

On South Side (looking North): to West—clear view of traffic on major road; to East—trees obscure traffic on major road.



Photograph #308 (Reel #14, 22A) (from South looking North): from approximately where rumble strips would be; warning sign in view.

Intersection #98 (North Side)

Kandiyohi Co. (Map Page 38)

Condition: **Rumble Strips (full)** on Minor Road.

Major Road: State Route 40 (East-West)

Minor Road: County Route 5 (North-South)

On North Side (looking South): to West—trees and buildings obscure traffic on major road; to East—trees obscure traffic on major road.



Photograph #309 (Reel #14, 23A) (from North looking South): first rumble strips and warning sign in view.

Intersection #98 (South Side)

Kandiyohi Co. (Map Page 38)

Condition: **Rumble Strips (half-full @ 1st, full @ 2nd)** on Minor Road.

Major Road: State Route 40 (East-West)

Minor Road: County Route 5 (North-South)

On South Side (looking North): to West—trees and buildings obscure traffic on major road; to East—clear view of traffic on major road.



Photograph #311 (Reel #15, 2) (from South looking North): first rumble strips (*but only half-strip—on right side of road*) and warning sign in view.

Intersection #99 (West Side)

Kandiyohi Co. (Map Page 38)

Condition: **Rumble Strips (Full)** on Minor Road.

Major Road: U.S. Route 71 (North-South)

Minor Road: County Route 3 (East-West)

On West Side (looking East): rise obscures intersection; to North—rise, trees, and buildings obscure traffic on major road; to East—close to intersection on major road, rise obscures traffic on major road, while further away traffic is clear.



Photograph #313 (Reel #15, 4) (from West looking East): first rumble strips & warning sign in view.

Intersection #99 (East Side)

Kandiyohi Co. (Map Page 38)

Condition: **Rumble Strips (Full)** on Minor Road.

Major Road: U.S. Route 71 (North-South)

Minor Road: County Route 3 (East-West)

On East Side (looking West): to North—power plant and trees partially obscures traffic on major road; to South—buildings obscure traffic on major road.



Photograph #315 (Reel #15, 6) (from East looking West): first rumble strips and warning sign in view.

Intersection #100 (North Side)

Kandiyohi Co. (Map Page 38)

Condition: **Rumble Strips (full & wheel)** on North side of Minor Road.

Major Road: State Route 7 (East-West)

Minor Road: County Route 7 (North-South)

On North Side (looking South): rise obscures intersection; to East—rise and trees obscure traffic on major road; to West—rise partially obscures traffic on major road.



Photograph #317 (Reel #15, 8) (from East looking West): first rumble strips (*which are both new full and old wheel*) and warning sign in view.

Intersection #100 (South Side)

Kandiyohi Co. (Map Page 38)

Condition: **Rumble Strips (full)** on South side of Minor Road.

Major Road: State Route 7 (East-West)

Minor Road: County Route 7 (North-South)

On South Side (looking North): on both sides—clear view of traffic on major road.



Photograph #320 (Reel #15, 11) (from South looking North): first rumble strips and warning sign in view. [Note, rumble strips and warning sign are preceded by a “Dangerous intersection 1500 feet” sign that is not shown in this photograph.]

Intersection #101 (South Side)

Kandiyohi Co. (Map Page 38)

Condition: **Rumble Strips (full)** on Minor Road.

Major Road: State Route 7 (East-West)

Minor Road: County Route 44 (North-South)

On South Side (looking North): to West—trees obscure traffic on major road; to East—
clear view of traffic on major road.



Photograph #322 (Reel #15, 13) (from South looking North): first rumble strips and warning sign in view.

Intersection #101 (North Side)

Kandiyohi Co. (Map Page 38)

Condition: **Rumble Strips (full)** on Minor Road.

Major Road: State Route 7 (East-West)

Minor Road: County Route 44 (North-South)

On North Side (looking South): on both sides—clear view of traffic on major road.



Photograph #324 (Reel #15, 15) (from North looking South): first rumble strips and warning sign in view.

Intersection #102 (South Side)

Kandiyohi Co. (Map Page 38)

Condition: **Rumble Strips** on Minor Road: **full** on South side; **wheel** on North side.

Major Road: State Route 7 (East-West)

Minor Road: County Route 2 (North-South)

On South Side (looking North): rise partially obscures intersection; on both sides—rise obscures traffic on major road.



Photograph #326 (Reel #15, 17) (from South looking North): first rumble strips and warning sign in view.

Intersection #102 (North Side)

Kandiyohi Co. (Map Page 38)

Condition: **Rumble Strips** on Minor Road: **full** on South side; **wheel** on North side.

Major Road: State Route 7 (East-West)

Minor Road: County Route 2 (North-South)

On North Side (looking South): to East—clear view of traffic on major road; to West—trees partially obscure traffic on major road.



Photograph #328 (Reel #15, 19) (from North looking South): first rumble strips and warning sign in view.

**APPENDIX A.11
WRIGHT COUNTY**

The intersections in Wright County that were visited are listed in this subsection of the appendix. The listing includes the photograph taken just before the point at which the first set of rumble strips is encountered, or would be encountered if rumble strips were installed, for the approaches that are stop-controlled for each of the intersections.

Intersection #103 (East Side)

Wright Co. (Map Page 40)

Condition: ***T-junction; No Rumble Strips*** on Minor Road.

Minor road takes jog to South, then resumes to West at intersection #104

Major Road: County Route 14 (North-South)

Minor Road: County Road 115 (East-West)

On East Side (looking West): to North—rise and trees obscure traffic on major road; to South—trees obscure traffic on major road.



Photograph #330 (Reel #15, 24) (from East looking West): from approximately where rumble strips would be; warning sign in view.

Intersection #104 (West Side)

Wright Co. (Map Page 40)

Condition: ***T-junction; No Rumble Strips*** on Minor Road.

Minor road takes jog to North, then resumes to East at intersection #103

Major Road: County Route 14 (North-South)

Minor Road: County Road 115 (East-West)

On West Side (looking East): to North—relatively clear view of traffic on major road; to South—trees obscure traffic on major road.



Photograph #332 (Reel #16, 0A) (from West looking East): from approximately where rumble strips would be; warning sign in view.

Intersection #105 (South Side)

Wright Co. (Map Page 40)*

Condition: *No Rumble Strips* on Minor Road.

Major Road: County Route 35 (East-West)

Minor Road: 117 (North-South)

[* Note, the road numbers are incorrect on map. Also, according to Mapquest the East-West road is 20th NE, and the North-South road is Edmondson Ave NE.]

On South Side (looking North): to East—trees and building obscure traffic on major road; to West—trees obscure traffic on major road.



Photograph #333 (Reel #16, 1A) (from South looking North): from approximately where rumble strips would be; warning sign in view.

Intersection #105 (North Side)

Wright Co. (Map Page 40)*

Condition: *No Rumble Strips* on Minor Road.

Major Road: County Route 35 (East-West)

Minor Road: 117 (North-South)

[* Note, the road numbers are incorrect on map. Also, according to Mapquest the East-West road is 20th NE, and the North-South road is Edmondson Ave NE.]

On North Side (looking South): rise obscures intersection; on both sides—rise and trees obscure traffic on major road.



Photograph #334 (Reel #16, 2A) (from North looking South): from approximately where rumble strips would be; warning sign in view.

Intersection #106 (South Side)

Wright Co. (Map Page 40)

Condition: **No Rumble Strips** on Minor Road.

Minor road curves to East approaching intersection on North side

Major Road: County Route 37 (East-West)

Minor Road: County Route 15 (North-South)

On South Side (looking South): to West—trees obscure traffic on major road, to East—
clear view of traffic on major road.



Photograph #335 (Reel #16, 3A) (from South looking North): from approximately where rumble strips would be; warning sign in view.

Intersection #106 (North Side)

Wright Co. (Map Page 40)

Condition: **No Rumble Strips** on Minor Road.

Minor road curves to East approaching intersection on North side

Major Road: County Route 37 (East-West)

Minor Road: County Route 15 (North-South)

On North Side (looking South): trees and curve obscure intersection; to East—trees obscure traffic on major road, to West—trees and slight rise partially traffic on major road.



Photograph #336 (Reel #16, 4A) (from North looking South): from approximately where rumble strips would be; warning sign in view.

Intersection #107 (East Side)

Wright Co. (Map Page 40)

Condition: ***Ineffectual Rumble Strips (wheel)*** on Minor Road.

Major Road at angle (North-East to South-West)

Major Road: State Route 25 (North-East to South-West)

Minor Road: County Route 37 (East-West)

On East Side (looking West): on both sides—rise and trees obscure traffic on major road.



Photograph #338 (Reel #16, 6A) (from East looking West): first *ineffectual* rumble present, but not visible; warning sign in view.

Intersection #107 (West Side)

Wright Co. (Map Page 40)

Condition: ***Ineffectual Rumble Strips (wheel)*** on Minor Road.

Major Road at angle (North-East to South-West)

Major Road: State Route 25 (North-East to South-West)

Minor Road: County Route 37 (East-West)

On West Side (looking East): to North—rise and trees obscure traffic on major road; to South—buildings partially obscure traffic on major road.



Photograph #340 (Reel #16, 8A) (from West looking East): first *ineffectual* rumble is visible; warning sign in view; also, very wide shoulder (note parked truck).

Intersection #108 (East Side)

Wright Co. (Map Page 40)

Condition: *4-way stop, No Rumbles.*

East-West Road is County Route 39 to East & County Routes 39 & 7 to West
And North-South Road is County Route 7 to North & County Road 106 to South

On East Side (looking West): to North—rise obscures traffic on cross road; to South—
rise and trees obscure traffic on cross road.



Photograph #342 (Reel #16, 10A) (from East looking West): from approximately where first rumble strips would be; warning sign in view.

Intersection #108 (North Side)

Wright Co. (Map Page 40)

Condition: *4-way stop, No Rumbles.*

East-West Road is County Route 39 to East & County Routes 39 & 7 to West
And North-South Road is County Route 7 to North & County Road 106 to South

On North Side (looking South): rise obscures intersection; to East—rise obscures traffic
on cross road; to West—rise partially obscures traffic on cross road.



Photograph #343 (Reel #16, 12A) (from North looking South): from approximately where first rumble strips would be; warning sign in view; also, STOP AHEAD on road.

Intersection #108 (South Side)

Wright Co. (Map Page 40)

Condition: ***4-way stop, No Rumbles.***

East-West Road is County Route 39 to East & County Routes 39 & 7 to West
And North-South Road is County Route 7 to North & County Road 106 to South

On South Side (looking North): to East—buildings and trees obscure traffic on cross road; to West—clear view of traffic on cross road.



Photograph #344 (Reel #16, 13A) (from South looking North): from approximately where first rumble strips would be; warning sign in view; also, STOP AHEAD on road.

Intersection #108 (West Side)

Wright Co. (Map Page 40)

Condition: *4-way stop, No Rumbles.*

East-West Road is County Route 39 to East & County Routes 39 & 7 to West
And North-South Road is County Route 7 to North & County Road 106 to South

On West Side (looking East): to North—trees obscure traffic on cross road; to South—
clear view of traffic on cross road.



Photograph #345 (Reel #16, 14A) (from West looking East): from approximately where first rumble strips would be; warning sign in view.

Intersection #109 (North Side)

Wright Co. (Map Page 40)

Condition: *No Rumbles* on Minor Road.

Major Road: County Route 39 to West and County Routes 39 & 7 to East

Minor Road: County Route 7 South & County Road 123 North

On North Side (looking South): to East—trees obscure traffic on major road; to West—clear view of traffic on major road.



Photograph #346 (Reel #16, 15A) (from North looking South): from approximately where first rumble strip would be; warning sign in view.

Intersection #109 (South Side)

Wright Co. (Map Page 40)

Condition: *No Rumbles* on Minor Road.

Major Road: County Route 39 to West and County Routes 39 & 7 to East

Minor Road: County Route 7 South & County Road 123 North

On South Side (looking North): to East—trees partially obscure traffic on major road; to West—clear view of traffic on major road.



Photograph #347 (Reel #16, 16A) (from North looking South): from approximately where first rumble strips would be; warning sign in view; also, STOP AHEAD on road.

**APPENDIX A.12
CLAY COUNTY**

The intersections in Clay County that were visited are listed in this subsection of the appendix. The listing includes the photograph taken just before the point at which the first set of rumble strips is encountered, or would be encountered if rumble strips were installed, for the approaches that are stop-controlled for each of the intersections.

Intersection #110 (West Side)

Clay Co. (Map Page 58)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major Road: U.S. Route 71 (North-South)

Minor Road: County Route 12 (East-West)

On West Side (looking East): on both sides—clear view of traffic on major road (when there is no mist).



Photograph #348 (Reel #16, 17A) (from West looking East): first rumble strip and warning sign in view.

Intersection #110 (East Side)

Clay Co. (Map Page 58)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major Road: U.S. Route 71 (North-South)

Minor Road: County Route 12 (East-West)

On East Side (looking West): on both sides—clear view of traffic on major road.



Photograph #350 (Reel #16, 19A) (from East looking West): first rumble strip and warning sign in view.

Intersection #111 (East Side)

Clay Co. (Map Page 58)

Condition: **Rumble Strips (wheel)** on East side; **No Rumble Strips** on West side.

Railroad running parallel with Major Road to West of intersection.

Two lanes going West in minor road on West side.

Major Road: U.S Route 71 (North-South)

Minor Road: County Route 18 (East-West)

On East Side (looking West): to North—clear view of traffic on major road; to South—
rise obscures traffic on major road.



Photograph #352 (Reel #16, 21A) (from East looking West): first rumble strip and warning sign in view.

Intersection #111 (West Side)

Clay Co. (Map Page 58)

Condition: **Rumble Strips (wheel)** on East side; **No Rumble Strips** on West side.

Railroad running parallel with Major Road to West of intersection.

Two lanes going West in minor road on West side.

Major Road: U.S Route 71 (North-South)

Minor Road: County Route 18 (East-West)

On West Side (looking East): to North—clear view of traffic on major road; to South—
rise obscures traffic on major road.



Photograph #355 (Reel #16, 24A) (from West looking East): from approximately where first rumble strips would be; warning sign in view; also, although not in photograph, a Rail Crossing warning precedes the rumble strip and warning sign.

Intersection #112 (East Side)

Clay Co. (Map Page 58)

Condition: **Rumble Strips (wheel)** on Minor Road.

Railroad running parallel with Major Road to West of intersection.

Major Road: U.S. Route 71 (North-South)

Minor Road: County Route 26 (East-West)

On East Side (looking West): to North—power station partially obscures traffic on major road; to South—clear view of traffic on major road.



Photograph #357 (Reel #17, 3) (from East looking West): first rumble strips in view; also, warning signs *on both sides of road*.

Intersection #112 (West Side)

Clay Co. (Map Page 58)

Condition: **Rumble Strips (wheel)** on Minor Road.

Railroad running parallel with Major Road to West of intersection.

Major Road: U.S. Route 71 (North-South)

Minor Road: County Route 26 (East-West)

On West Side (looking East): on both sides—clear view of traffic on major road.



Photograph #361 (Reel #17, 7) (from West looking East): first rumble strips in view. [Note: a rail crossing warning and a warning sign (on the left-hand side of the road) both precede the first rumble strip. In addition, the distance between the “stop ahead” warning and the location of the rumble strips is unusually long.].

Intersection #113 (West Side)

Clay Co. (Map Page 59)

Condition: **Rumble Strips (wheel)** on Minor Road.

South of intersection, the direction of major road changes from North to South to North-East to South-West.

Major Road: State Route 9 (North-South)

Minor Road: County Route 26 (East-West)

On West Side (looking East): on both sides—clear view of traffic on major road.



Photograph #362 (Reel #17, 8) (from West looking East): first rumble strips and warning sign in view.

Intersection #113 (East Side)

Clay Co. (Map Page 59)

Condition: **Rumble Strips (wheel)** on Minor Road.

South of intersection, the direction of major road changes from North to South to North-East to South-West.

Major Road: State Route 9 (North-South)

Minor Road: County Route 26 (East-West)

On East Side (looking West): on both sides—clear view of traffic on major road.



Photograph #364 (Reel #17, 10) (from East looking West): first rumble strips and warning sign in view.

Intersection #114 (North Side)

Clay Co. (Map Page 59)

Condition: *No Rumble Strips* on Minor Road.

Major Road is a divided highway at intersection.

Near intersection on North side there is a bridge over the Buffalo River.

Near intersection of South side a rail bridge goes over minor road.

Major Road: U.S. Route 10 (East-West)

Minor Road: State Route 9 (North-South)

On North Side (looking South): on both sides—trees obscure traffic on major road.



Photograph #367 (Reel #17, 13) (from North looking South): warning sign in view—
further away from intersection than usual (perhaps because of bridge over Buffalo River);
also STOP AHEAD on road nearer to intersection.

Intersection #114 (South Side)

Clay Co. (Map Page 59)

Condition: **No Rumble Strips** on Minor Road.

Major Road is a divided highway at intersection.

Near intersection on North side there is a bridge over the Buffalo River.

Near intersection of South side a rail bridge goes over minor road.

Major Road: U.S. Route 10 (East-West)

Minor Road: State Route 9 (North-South)

On North Side (looking South): on both sides—bridge and trees obscure traffic on major road.



Photograph #369 (Reel #17, 16) (from North looking South): warning sign in view—further away from intersection than usual (perhaps because of rail bridge on minor road); also STOP AHEAD on road nearer to intersection.

Intersection #115 (West Side)

Clay Co. (Map Page 59)

Condition: **Rumble Strips (wheel—reduced number—only 1.5 to West, only 1 to East).**

Major Road is at angle (North-West to South-East).

Major Road: State Route 9 (North-West to South-East).

Minor Road: County Route 10 (East-West)

On West Side (looking East): on both sides—trees and buildings obscure traffic on major road.



Photograph #371 (Reel #17, 17) (from West looking East): rumble strips on old road surface are filled in, then to the right there is an operational *half rumble* strip on old road surface (new surface does *not* have other half rumble strip to left); warning sign in view [note distance between warning sign and rumble strip greater than usual].

Intersection #115 (East Side)

Clay Co. (Map Page 59)

Condition: **Rumble Strips (wheel—reduced number—1.5 to West, 1 to East).**

Major Road is at angle (North-West to South-East).

Major Road: State Route 9 (North-West to South-East).

Minor Road: County Route 10 (East-West)

On East Side (looking West): on both sides—buildings and trees obscure traffic on major road.



Photograph #373 (Reel #17, 19) (from East looking West): *first (& only)* rumble strips and warning sign in view.

Intersection #116 (West Side)

Clay Co. (Map Page 59)

Condition: **4-way stop, No Rumble Strips.**

Roads: County Route 31 (North-South) and County Route 10 (East-West)

On West Side (looking East): to North—rise obscures traffic on cross road; to South—
trees partially obscure traffic on cross road.



Photograph #374 (Reel #17, 20) (from West looking East): warning sign in view.

Intersection #116 (South Side)

Clay Co. (Map Page 59)

Condition: **4-way stop, No Rumble Strips.**

Roads: County Route 31 (North-South) and County Route 10 (East-West)

On South Side (looking North): to East—trees obscure traffic on cross road; to West—
rise bushes obscure traffic on cross road.



Photograph #375 (Reel #17, 21) (from South looking North): warning sign in view.

Intersection #116 (East Side)

Clay Co. (Map Page 59)

Condition: **4-way stop, No Rumble Strips.**

Roads: County Route 31 (North-South) and County Route 10 (East-West)

On East Side (looking West): on both sides—rise obscures traffic on cross road.



Photograph #376 (Reel #17, 22) (from East looking West): warning sign in view.

Intersection #116 (North Side)

Clay Co. (Map Page 59)

Condition: **4-way stop, No Rumble Strips.**

Roads: County Route 31 (North-South) and County Route 10 (East-West)

On North Side (looking South): rise obscures intersection; on both sides—rise obscures traffic on cross road.



Photograph #377 (Reel #17, 23) (from North looking South): warning sign in view.

Intersection #117 (West Side)

Clay Co. (Map Page 59)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major road at angle (North-West to South-East)

[Major Road currently closed to North of I]

Major Road: State Route 32 (North-West to South-East)

Minor Road: County Route 10 (East-West)

On West Side (looking East): to North—trees partial obscure traffic on major road; to South—trees obscure traffic on major road.



Photograph #378 (Reel #17, 24) (from West looking East): first rumble strips and warning sign in view.

**APPENDIX A.13
HUBBARD COUNTY**

The intersections in Hubbard County that were visited are listed in this subsection of the appendix. The listing includes the photograph taken just before the point at which the first set of rumble strips is encountered, or would be encountered if rumbles strips were installed, for the approaches that are stop-controlled for each of the intersections.

Intersection #118 (West Side)

Hubbard Co. (Map Page 61)—actually on Hubbard County/Wadena County boundary

Condition: **Rumble Strips (only *half wheel*)** on Minor Road.

Minor road is dirt track to East.

Major Road: County Route 6 (North-South)

Minor Road: County Route 21 (East-West)

On West Side (looking East): to North—clear view of traffic on major road; to South—
trees obscure traffic on major road.



Photograph #380 (Reel #19, 14A) (from West looking East): first *half* rumble strip and warning sign in view.

Intersection #119 (South Side)

Hubbard Co. (Map Page 61)

Condition: *No Rumble Strips* on Minor Road.

Major Road: State Route 87 (East-West)

Minor Road: County Route 11 (North-South)

On South Side (looking North): to East—trees obscure traffic on major road; to West—
clear view of traffic on major road.



Photograph #382 (Reel #19, 16A) (from West looking East): warning sign in view.

Intersection #119 (North Side)

Hubbard Co. (Map Page 61)

Condition: *No Rumble Strips* on Minor Road.

Major Road: State Route 87 (East-West)

Minor Road: County Route 11 (North-South)

On North Side (looking South): to East—trees obscure traffic on major road; to West—further away from intersection on major road, there is clear view of traffic, while nearer to the intersection on the major road trees obscure view of traffic.



Photograph #383 (Reel #19, 17A) (from North looking South): warning sign in view.

Intersection #120 (East Side)

Hubbard Co. (Map Page 61)

Condition: *No Rumble Strips* on Minor Road.

Major Road: County Route 11 (North-South)

Minor Road: County Route 17 (East-West)

On East Side (looking West): on both sides—trees obscure traffic on major road.



Photograph #384 (Reel #19, 18A) (from East looking West): warning sign in view.

Intersection #120 (West Side)

Hubbard Co. (Map Page 61)

Condition: *No Rumble Strips* on Minor Road.

Major Road: County Route 11 (North-South)

Minor Road: County Route 17 (East-West)

On West Side (looking East): on both sides—trees obscure traffic on major road.



Photograph #385 (Reel #19, 19A) (from East looking West): warning sign in view.

Intersection #121 (South Side)

Hubbard Co. (Map Page 61)

Condition: *No Rumble Strips* on Minor Road.

Major road is 4-lane divided highway at intersection.

Major Road: State Route 34 (East-West)

Minor Road: State Route 266-North & County Route 11-South)

On South Side (looking North): rise obscures intersection; on both sides—trees and rise obscure traffic on major road.



Photograph #386 (Reel #19, 20A) (from South looking North): warning sign in view.

Intersection #121 (North Side)

Hubbard Co. (Map Page 61)

Condition: *No Rumble Strips* on Minor Road.

Major road is 4-lane divided highway at intersection.

Major Road: State Route 34 (East-West)

Minor Road: State Route 266-North & County Route 11-South)

On North Side (looking South): rise obscures intersection; on both sides—trees and rise obscure traffic on major road.



Photograph #387 (Reel #19, 21A) (from South looking North): warning sign in view.

Intersection #122 (North Side)

Hubbard Co. (Map Page 61)

Condition: *T-junction No Rumble Strips* on Minor Road.

Minor Road jogs to West then continues South at intersection #123.

Major Road is 4-lane highway at intersection.

Major Road: State Route 34 (East-West)

Minor Road: County Route 4 (North-South)

On North Side (looking South): on both sides—trees obscure traffic on major road.



Photograph #388 (Reel #19, 22A) (from North looking South): warning sign in view.

Intersection #123 (South Side)

Hubbard Co. (Map Page 61)

Condition: *T-junction No Rumble Strips* on Minor Road.

Minor Road jogs to East then continues North at intersection #122.

Major Road is 4-lane highway at intersection.

Major Road: State Route 34 (East-West)

Minor Road: County Route 4 (North-South)

On South Side (looking North): on both sides—trees and buildings obscure traffic on major road.



Photograph #389 (Reel #19, 23A) (from North looking South): warning sign in view.

Intersection #124 (West Side)

Hubbard Co. (Map Page 61)

Condition: *No Rumble Strips* on Minor Road.

From West, minor road curves to South just before intersection; from East, minor road curves to North just before intersection.

Major Road curves to East as it continues North past intersection.

Major Road: County Route 4 (South to North-East)

Minor Road: County Route 18 (East-West)

On West Side (looking East): intersection obscured by trees and curve; on both sides—curve and trees obscure traffic on major road.



Photograph #390 (Reel #19, 24A) (from West looking East): two warning signs—one indicating road crossing ahead, the other stop sign ahead—in view.

Intersection #124 (East Side)

Hubbard Co. (Map Page 61)

Condition: *No Rumble Strips* on Minor Road.

From West, minor road curves to South just before intersection; from East, minor road curves to North just before intersection.

Major Road curves to East as it continues North past intersection.

Major Road: County Route 4 (South to North-East)

Minor Road: County Route 18 (East-West)

On East Side (looking West): on both sides—trees obscure traffic on major road.



Photograph #392 (Reel #20, 2A) (from East looking West): warning sign in view.

Intersection #125 (East Side)

Hubbard Co. (Map Page 61)

Condition: *T-junction No Rumble Strips* on Minor Road.

Major Road: U.S. Route 71 (North-South)

Minor Road: Argo Township Road 21 (230 Street) (East-West)

On East Side (looking West): on both sides—trees obscure traffic on major road.



Photograph #394 (Reel #20, 4A) (from East looking West): warning sign in view.

**APPENDIX A.14
BECKER COUNTY**

The intersections in Becker County that were visited are listed in this subsection of the appendix. The listing includes the photograph taken just before the point at which the first set of rumble strips is encountered, or would be encountered if rumbles strips were installed, for the approaches that are stop-controlled for each of the intersections.

Intersection #126 (North Side)

Becker Co. (Map Page 61)

Condition: *No Rumble Strips* on Minor Road.

Major Road: State Route 34 (East-West)

Minor Road: County Route 48 (North-South)

On North Side (looking South): to East—trees obscure traffic on major road; to West—trees and building obscure traffic on major road.



Photograph #395 (Reel #20, 5A) (from North looking South): warning sign in view.

Intersection #126 (South Side)

Becker Co. (Map Page 61)

Condition: *No Rumble Strips* on Minor Road.

Major Road: State Route 34 (East-West)

Minor Road: County Route 48 (North-South)

On South Side (looking North): to East—trees obscure traffic on major road; to West—buildings partially obscure traffic on major road.



Photograph #396 (Reel #20, 6A) (from South looking North): warning sign in view.

Intersection #127 (North Side)

Becker Co. (Map Page 61)

Condition: **Rumble strips** on South side of intersection; *No Rumble Strips* on North side of intersection.

Major Road: U.S. Route 34 (East-West)

Minor Road: U.S. Route 225 North & County Route 47 South

On North Side (looking South): to East—clear view of traffic on major road; to West—trees obscure traffic on major road.



Photograph #397 (Reel #20, 7A) (from North looking South): warning sign in view; also STOP AHEAD on road.

Intersection #127 (South Side)

Becker Co. (Map Page 61)

Condition: **Rumble strips** on South side of intersection; **No Rumble Strips** on North side of intersection.

Major Road: U.S. Route 34 (East-West)

Minor Road: U.S. Route 225 North & County Route 47 South

On South Side (looking North): to East—clear view of traffic on major road; to West—power plant partially obscures traffic on major road.



Photograph #399 (Reel #20, 9A) (from South looking North): first rumble strips and warning sign in view.

Intersection #128 (North Side)

Becker Co. (Map Page 61)

Condition: **T-junction; Rumble strips (wheel).**

Major Road: State Route 87 (East-West)

Minor Road: County Route 47 North-South

On North Side (looking South): rise obscures intersection; on both sides—rise and trees obscure traffic on major road.



Photograph #401 (Reel #20, 11A) (from North looking South): first rumble strips and warning sign in view.

**APPENDIX A.15
TODD COUNTY**

The intersections in Todd County that were visited are listed in this subsection of the appendix. The listing includes the photograph taken just before the point at which the first set of rumble strips is encountered, or would be encountered if rumble strips were installed, for the approaches that are stop-controlled for each of the intersections.

Intersection #129 (North Side)

Todd Co. (Map Page 53)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major Road curves to North after intersection.

Major Road: State Route 210 (East to West-North)

Minor Road: County Route 21 (North-South)

On North Side (looking South): to East—trees partially obscure traffic on major road; to West—trees obscure traffic on major road.



Photograph #403 (Reel #19, 2A) (from North looking South): first rumble strips in view, but there is *no warning sign*.

Intersection #129 (South Side)

Todd Co. (Map Page 53)

Condition: **Rumble Strips (wheel)** on Minor Road.

[**Note very shallow rumble strips to South**]

Major Road: State Route 210 (East to West-North)

Minor Road: County Route 21 (North-South)

On North Side (looking South): to East—trees partially obscure traffic on major road; to West—trees obscure traffic on major road.



Photograph #404 (Reel #19, 4A) (from North looking South): first rumble strips and warning sign in view.

Intersection #130 (South Side)

Todd Co. (Map Page 53)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major Road: State Route 210 (East-West)

Minor Road: County Route 11 (North-South)

On South Side (looking North): to East—building partially obscures traffic on major road; to West—trees obscure traffic on major road.



Photograph #407 (Reel #19, 6A) (from South looking North): first rumble strips and warning sign in view.

Intersection #130 (North Side)

Todd Co. (Map Page 53)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major Road: State Route 210 (East-West)

Minor Road: County Route 11 (North-South)

On North Side (looking South): rise obscures intersection; on both sides—rise and trees obscure traffic on major road.



Photograph #409 (Reel #19, 8A) (from North looking South): first rumble strips and warning sign in view.

Intersection #131 (North Side)

Todd Co. (Map Page 53)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major Road: County Route 24 (East to West)

Minor Road: County Route 11 (North-South)

On North Side (looking South): to East—trees obscure traffic on major road; to West—clear view of traffic on major road.



Photograph #411 (Reel #19, 10A) (from North looking South): first rumble strips and warning sign in view.

Intersection #131 (South Side)

Todd Co. (Map Page 53)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major Road: County Route 24 (East to West)

Minor Road: County Route 11 (North-South)

On South Side (looking North): to East—trees and buildings obscure traffic on major road; to West—rise obscures traffic on major road.



Photograph #413 (Reel #19, 12A) (from South looking North): first rumble strips and warning sign in view.

Intersection #132 (North Side)

Todd Co. (Map Page 53)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major Road: County Route 22 (East to West)

Minor Road: County Route 1 (North-South)

On North Side (looking South): on both sides—rise obscures traffic on major road—but by second rumble strips there is clear view of traffic.



Photograph #415 (Reel #20, 13A) (from North looking South): first rumble strips and warning sign in view.

Intersection #132 (South Side)

Todd Co. (Map Page 53)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major Road: County Route 22 (East to West)

Minor Road: County Route 1 (North-South)

On South Side (looking North): to East—trees obscure traffic on major road; to West—buildings and trees obscure traffic on major road.



Photograph #417 (Reel #20, 15A) (from South looking North): first rumble strips and warning sign in view.

Intersection #133 (North Side)

Todd Co. (Map Page 53)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major Road: County Route 14 (East to West)

Minor Road: County Route 1 (North-South)

On North Side (looking South): on both sides—trees obscure traffic on major road by foliage.



Photograph #419 (Reel #20, 17A) (from North looking South): first rumble strips and warning sign in view.

Intersection #133 (South Side)

Todd Co. (Map Page 53)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major Road: County Route 14 (East to West)

Minor Road: County Route 1 (North-South)

On South Side (looking North): to East—trees obscure traffic on major road; to West—
trees partially obscure traffic on major road.



Photograph #421 (Reel #20, 19A) (from South looking North): first rumble strips and warning sign in view.

Intersection #134 (South Side)

Todd Co. (Map Page 53)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major Road: County Route 14 (East-West)

Minor Road: County Route 3 (North-South)

On South Side (looking North): on both sides—clear view of traffic on major road.



Photograph #423 (Reel #20, 21A) (from South looking North): first rumble strips in view, but *no warning sign*.

Intersection #134 (North Side)

Todd Co. (Map Page 53)

Condition: **Rumble Strips (wheel)** on Minor Road.
North side of Minor road currently (June, 05) closed.

Major Road: County Route 14 (East-West)

Minor Road: County Route 3 (North-South)

On North Side (looking South): to East—clear; to West—obscured by trees.



Photograph #426 (Reel #20, 24A) (from North looking South): first rumble strips in view, but *no warning sign* [Note; there is a “No Shoulder” sign in view.]

Intersection #135 (South Side)

Todd Co. (Map Page 53)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major Road: County Route 14 (East to West)

Minor Road: County Route 11 (North-South)

On South Side (looking North): to East—partially obscured by trees; to West—clear.



Photograph #428 (Reel #21, 3) (from South looking North): first rumble strips and warning sign in view.

Intersection #135 (North Side)

Todd Co. (Map Page 53)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major Road: County Route 14 (East to West)

Minor Road: County Route 11 (North-South)

On North Side (looking South): on both sides—trees partially obscure traffic on major road.



Photograph #430 (Reel #21, 5) (from North looking South): first rumble strips and warning sign in view.

Intersection #136 (West Side)

Todd Co. (Map Page 45)

Condition: **Rumble Strips (wheel)** on Minor Road.

Traffic on Major Road is likely to be traveling relatively fast from South—because it is moving down from crest of hill.

Major Road: County Route 11 (North-South)

Minor Road: County Route 38 (East to West)

On West Side (looking East): to North—clear view of traffic on major road; to South—trees obscure traffic on major road.



Photograph #432 (Reel #21, 7) (from West looking East): first rumble strips and warning sign in view.

Intersection #136 (East Side)

Todd Co. (Map Page 45)

Condition: **Rumble Strips (wheel)** on Minor Road.

Traffic on Major Road is likely to be traveling relatively fast from South—because it is moving down from crest of hill.

Major Road: County Route 11 (North-South)

Minor Road: County Route 38 (East to West)

On East Side (looking West): to North—trees obscure traffic on major road at 1st rumble strips but there is a clear view of traffic by 2nd rumble strips; to South—trees obscure traffic on major road.



Photograph #434 (Reel #21, 9) (from East looking West): first rumble strips and warning sign in view.

Intersection #137 (West Side)

Todd Co. (Map Page 45)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major Road: County Route 11 (North-South)

Minor Road: County Route 36 (East to West)

On West Side (looking East): rise obscures intersection; on both sides—trees obscure traffic on major road.



Photograph #436 (Reel #21, 11) (from West looking East): first rumble strips in view, *but no yellow warning sign*. [Note: unusually, warning sign is placed close to second rumble strips.]

Intersection #137 (East Side)

Todd Co. (Map Page 45)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major Road: County Route 11 (North-South)

Minor Road: County Route 36 (East to West)

On East Side (looking West): rise partially obscures intersection; to North—clear view of traffic on major road; to South—trees and building obscure traffic on major road.



Photograph #438 (Reel #21, 13) (from East looking West): first rumble strips and warning sign in view.

Intersection #138 (North Side)

Todd Co. (Map Page 45)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major Road: County Route 10 (East-West)

Minor Road: County Route 11 (North-South)

On North Side (looking South): to East—clear view of traffic on major road (runs in front of trees); to West—trees and buildings obscure traffic on major road.



Photograph #440 (Reel #21, 15) (from North looking South): first rumble strips and warning sign in view (in rain)



Same intersection—No rain (Photograph: DCS00615—from North looking South): first rumble strips and warning sign in view (in rain)

Intersection #138 (South Side)

Todd Co. (Map Page 45)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major Road: County Route 10 (East-West)

Minor Road: County Route 11 (North-South)

On South Side (looking North): on both sides—trees obscure traffic on major road.



Photograph #442 (Reel #21, 17) (from South looking North): first rumble strips and warning sign in view.

Intersection #139 (North Side)

Todd Co. (Map Page 45)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major Road: State Route 27 (East-West)

Minor Road: County Route 11 (North-South)

On South Side (looking North): to East—trees obscure traffic on major road; to West—trees partially obscure traffic on major road at 1st rumble strips, but there is a clear view of traffic by 2nd rumble strips.



Photograph #444 (Reel #21, 19) (from North looking South): first rumble strips and warning sign in view.

Intersection #139 (South Side)

Todd Co. (Map Page 45)

Condition: **Rumble Strips (wheel)** on Minor Road.

Major Road: State Route 27 (East-West)

Minor Road: County Route 11 (North-South)

On South Side (looking North): to East—power plant, building, and trees obscure traffic on major road; to West—clear view of traffic on major road.



Photograph #446 (Reel #21, 21) (from South looking North): first rumble strips and warning sign in view.

Intersection #140 (North Side)

Todd Co. (Map Page 45)

Condition: **Rumble Strips (wheel)** on North side; *No Rumble Strips* on South side

Major Road: County Route 2 (East-West)

Minor Road: County Route 11 (North-South)

On North Side (looking South): rise obscures intersection; on both sides—rise obscures traffic on major road.



Photograph #448 (Reel #21, 23) (from North looking South): first rumble strips and warning sign in view.

Intersection #140 (South Side)

Todd Co. (Map Page 45)

Condition: **Rumble Strips (wheel)** on North side; *No Rumble Strips* on South side

Major Road: County Route 2 (East-West)

Minor Road: County Route 11 (North-South)

On South Side (looking North): on both sides—trees obscure traffic on major road.



Photograph #450 (Reel #21, 25) (from South looking North): “Road crossing” warning sign in view. [Note; unusually, there is no stop ahead warning sign.]

APPENDIX A.16
WASHINGTON COUNTY

The intersections in Washington County that were visited are listed in this subsection of the appendix. The listing includes the photograph taken just before the point at which the first set of rumble strips would be encountered if rumble strips were installed or closer to the intersection when there is no warning sign, for the approaches that are stop-controlled for each of the intersections.

Intersection #142 (North Side)

Washington Co. (Map Page 42)

Condition: *No Rumble Strips* on Minor Road

Major Road: County Route 18 (East-West)

Minor Road: County Road 71 (North-South)

On North Side (looking South): on both sides—traffic on major road obscured by trees.



Photograph #451 (Reel E1, 1) (from North, looking South): warning sign in view; and STOP AHEAD on road.

Intersection #142 (South Side)

Washington Co. (Map Page 42)

Condition: *No Rumble Strips* on Minor Road

Major Road: County Route 18 (East-West)

Minor Road: County Road 71 (North-South)

On South Side (looking North): on both sides—trees obscure traffic on major road.



Photograph #470 (Reel E1, 19) (from South, looking North): warning sign in view; and, STOP AHEAD on road (but barely visible).

Intersection #143 (North Side)

Washington Co. (Map Page 42)

Condition: *No Rumble Strips* on Minor Road

T-junction

Major Road: County Route 18 (East-West)

Minor Road: Oakgreen Ave SE (North-South)

On North Side (looking South): to West—traffic on major road obscured by rise; to East—traffic on major road obscured by rise and trees.



Photograph #453 (Reel E1, 2) (from North, looking South): *no* warning sign—Stop sign and T-junction sign (just) visible at intersection.

Intersection #144 (South Side)

Washington Co. (Map Page 42)

Condition: *No Rumble Strips* on Minor Road; dirt road on North side of intersection.

Major Road: County Route 18 (East-West)

Minor Road: Trading Post Trail S (North-South)

On South Side (looking North): to West—traffic on major road obscured by rise; to East—traffic on major road obscured by rise and trees.



Photograph #454 (Reel E1, 3) (from South, looking North): *no* warning sign—Stop sign barely visible at intersection.

Intersection #145 (East Side)

Washington Co. (Map Page 42)

Condition: *No Rumble Strips* on Minor Road

T-junction

Major Road: County Route 21/St. Croix Trail S (North-South)

Minor Road: County Route 18 (East-West)

On East Side (looking West): on both sides—traffic on major road obscured by trees.



Photograph #455 (Reel E1, 4) (from East, looking West): warning sign in view; and, STOP AHEAD on road (also, side road visible to right—i.e., South).

Intersection #146 (East Side)

Washington Co. (Map Page 42)

Condition: *No Rumble Strips* on Minor Road

Paved road to East till just after crest of hill—then dirt road.

Dirt road to West.

Major Road: County Route 21/St. Croix Trail S (North-South)

Minor Road: 50th Street S (East-West)

On East Side (looking West): on both sides—traffic on major road obscured by vertical rise.



Photograph #456 (Reel E1, 5) (from East, looking West): warning sign in view; and, STOP AHEAD on road surface.

Intersection #147 (North Side)

Washington Co. (Map Page 42)

Condition: *No Rumble Strips* on Minor Road

4-way stop

Roads: County Route 21/St. Croix Trail S (North-South) & County Route 20/70th Street S (East-West)

On North Side (looking South): to East—traffic on major road obscured by trees; to West—traffic on major road partially obscured by trees (& fog).



Photograph #459 (Reel E1, 8) (from North, looking South): warning sign in view.

Intersection #147 (South Side)

Washington Co. (Map Page 42)

Condition: *No Rumble Strips* on Minor Road

4-way stop

Roads: County Route 21/St. Croix Trail S (North-South) & County Route 20/70th Street S (East-West)

On South Side (looking North): on both sides—traffic on major road obscured by rise and trees.



Photograph #460 (Reel E1, 9) (from South, looking North): warning sign in view.

Intersection #147 (West Side)

Washington Co. (Map Page 42)

Condition: *No Rumble Strips* on Minor Road

4-way stop

Roads: County Route 21/St. Croix Trail S (North-South) & County Route 20/70th Street S (East-West)

On West Side (looking East): on both sides—traffic on major road obscured by vertical rise.



Photograph #462 (Reel E1, 11) (from West, looking East): warning sign in view; and, STOP AHEAD on road.

Intersection #147 (East Side)

Washington Co. (Map Page 42)

Condition: *No Rumble Strips* on Minor Road

4-way stop

Roads: County Route 21/St. Croix Trail S (North-South) & County Route 20/70th Street S (East-West)

On East Side (looking West): on both sides—traffic on major road obscured by rise/trees/fog.



Photograph #463 (Reel E1, 12) (from West, looking East): warning sign in view; and, STOP AHEAD on road.

Intersection #148 (South Side)

Washington Co. (Map Page 42)

Condition: *No Rumble Strips* on Minor Road

Major Road: 54th Street S (East-West)

Minor Road: Trading Post Trail S (North-South)

On South Side (looking North): on both sides—traffic on major road obscured by trees
(with more trees to West).



Photograph #465 (Reel E1, 14) (from South, looking North): warning sign in view.

Intersection #148 (North Side)

Washington Co. (Map Page 42)

Condition: *No Rumble Strips* on Minor Road

Major Road: 54th Street S (East-West)

Minor Road: Trading Post Trail S (North-South)

On North Side (looking South): on both sides—traffic on major road obscured by trees
(with more trees to West).



Photograph #467 (Reel E1, 16) (from North, looking South): warning sign in view.

Intersection #149 (West Side)

Washington Co. (Map Page 42)

Condition: *No Rumble Strips* on Minor Road

Dirt on East side of minor road.

Major Road: Neal S (East-West)

Minor Road: 54th Street S (North-South)

On West Side (looking East): on both sides—traffic on major road obscured by trees.



Photograph #469 (Reel E1, 18) (from West, looking East): *no* warning sign on this approach—Stop sign in view.

APPENDIX A.17
ANOKA COUNTY

The intersections in Anoka County that were visited are listed in this subsection of the appendix. The listing includes the photograph taken just before the point at which the first set of rumble strips would be encountered if rumble strips were installed, for the approaches that are stop-controlled for each of the intersections.

Intersection #150 (West Side)

Anoka Co. (Map Page 41)

4-way stop

Condition: *No Rumble Strips*

Cross Roads: County Route 9 (North-South) and County Road 58 (East-West)

On West Side (looking East): rise obscures intersection; on both sides—rise and trees obscure traffic on cross road.



Photograph #470 (Reel #E1, 19) (from North, looking South): *no rumble strip*; warning sign in view (just *before* crest of vertical curve).

Intersection #150 (East Side)
Anoka Co. (Map Page 41)
4-way stop
Condition: *No Rumble Strips*

Cross Roads: County Route 9 (North-South) and County Road 58 (East-West)

On East Side (looking West): on both sides—trees obscure traffic on cross road.



Photograph #472 (Reel #E1, 22) (from North, looking South): *no rumble strip*; warning sign in view.

Intersection #151 (East Side)
Anoka Co. (Map Page 41)
Condition: *No Rumble Strips*
T-junction

Major Road: Lexington Avenue NE (North-South)
Minor Road: W. Broadway Ave/County Road 18 (East-West)

On East Side (looking West): on both sides—trees obscure traffic on major road.



Photograph #473 (Reel #E1, 24) (from North, looking South): *no rumble strip*; warning sign in view.

APPENDIX B
ILLUSTRATED LIST OF SELECTED STOP-CONTROLLED INTERSECTIONS

The intersections selected for this study are shown below.

Obscure Both: *With Rumble Strips*



“Obscure Both”—*With Rumble Strips*:
Pipestone County #26: SR-30 & CR-13
(1st rumble strip visible)

Obscure Both: *Without Rumble Strips*



“Obscure Both”—*Without Rumble Strips*:
Scott County #141: CR-27 & CR-62/240th
(from approximately where 1st rumble strip would be located)

Obscure/Visible: *With Rumble Strips* (Photograph 1—in rain)



“Obscure/Visible”—*With Rumble Strips*:
Todd County #138: CR10 & CR 11
(1st rumble strip visible)
(in rain)

Obscure/Visible: *With Rumble Strips* (Photograph 2—*no rain*)



“Obscure/Visible”—*With Rumble Strips*:
Todd County #138: CR10 & CR 11
(1st rumble strip visible)
(*no rain*)

Obscure/Visible: *Without Rumble Strips*



“Obscure/Visible”—*Without Rumble Strips*:
Wright County #106: CR-37 & CR-15
(from approximately where 1st rumble strip would be located)

Visible Both: *With Rumble Strips*



“Visible Both”—*With Rumble Strips*:
Kandiyohi County #101: SR-7 & CR-44
(1st rumble strip visible):

Visible Both: *Without Rumble Strips*



“Visible Both”—*Without Rumble Strips*:
Kandiyohi County #97: SR-40 & CR-1
(from approximately where 1st rumble strip would be located):

Horizontal Curve: *With Rumble Strips*



“Horizontal Curve”—*With Rumble Strips*:
Lincoln County #7: US-75 & CR-13
(1st rumble strip visible)

Horizontal Curve: *Without Rumble Strips*



“Horizontal Curve”—*Without Rumble Strips*:
Scott County #56: Credit River Boulevard/CR-12 & Natchez Avenue/Vernon Avenue
(from approximately where 1st rumble strip would be located)

Vertical Curve: *With Rumble Strips*



“Vertical Curve”—*With Rumble Strips*:
Lincoln County #9: CR-1 & CR-13
(1st rumble strip visible)

Vertical Curve: *Without Rumble Strips*



“Vertical Curve”—Without Rumble Strips:
Anoka County #150: CR-9 & CR-58
(from approximately where 1st rumble strip would be located)