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DEPARTMENT OF TRANSPORTATION

Minnesota State Highway 23

Road Safety Audit: Technical Report

Foley to Milaca, MN

September 20, 2017

Submitted by:
Bolton & Menk, Inc.
12224 Nicollet Avenue
Burnsville, MN 55337
P: 952-890-0509
F: 952-890-8065

Certification

Road Safety Audit Report

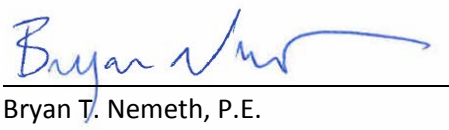
for

Minnesota State Trunk Highway 23
From Foley to Milaca

Minnesota Department of Transportation
T43113923

September 20, 2017

I hereby certify that this plan, specification or report was prepared by me or under my direct supervision, and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

By: 

Bryan T. Nemeth, P.E.
License No. 43354

Date: 09/20/2017

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I. EXECUTIVE SUMMARY

This report discusses the findings of a road safety audit which was completed on a 16 mile corridor of Trunk Highway (Hwy) 23, located from Foley to Milaca, MN. A road safety audit is a formal safety study of the roadway to identify potential road safety issues and identifies safety improvement opportunities.

The road safety audit is performed by an independent and multidisciplinary team and consists of three primary steps including the pre-audit review, the road safety audit field review, and the findings. The pre-audit is used to identify unusual crash trends through a review of the historical crash data while the field review is used to identify deficiencies of the roadway and other safety risks. Safety solutions and recommendations are then identified to improve the safety of the corridor. The need for the road safety audit was triggered by an increase in fatal crashes on the east end of Foley in 2016 and 2017.

Generally crashes have decreased along the corridor over time. Fatal and severe injury crashes have also not been a recurring issue until recently.

Four primary concerns based on community comments and crash data include:

1) High speeds;
2) Safe pedestrian and bicycle connectivity and crossings in urban areas;
3) High speed rear-end crashes in rural areas; and
4) Head-on collisions.

The primary recommended strategies to address the primary concerns include:

1) Develop a 3-lane roadway section in urban areas (Foley, Foreston, Milaca), and plan for the future cross-section and layout of the corridor, to be ready before future MnDOT reconstruction occurs;
2) Improve pedestrian and bicycle crossing amenities in urban areas (curb bumpouts, medians, roundabouts, RRFBs, speed signs);
3) Convert Hwy 23 intersection approach lanes in rural areas from thru-lane/right-turn lane approaches into left turn lane/thru lane approaches, with addition of right turn lanes in the long term; and
4) Develop medians and left turn lanes in urban areas and develop median buffer lanes and centerline rumble strips in rural areas.

Tables 1-1 to 1-4 summarize the safety solution recommendations along the Hwy 23 corridor. These recommendations were developed during the road safety audit review process. Detailed descriptions of the improvements by timeframe are included in Section V. Many of the recommendations as provided in this report are intended to reduce the speed of traffic through communities on a permanent basis. A speed limit change without complementary changes to the roadway environment is likely to only have a temporary or artificial effect of slowing traffic, rather than a permanent change to driver speeding behavior. Additional information on speed limits in provided in Section V and Appendix F.

This report includes the corridor background information, crash trends summary, field process overview, suggested improvement strategies, and an overview of the road safety audit team recommendations. The corridor is divided into seven (7) segments A-G as identified in Figure 1-1. The segments are based on the roadway characteristics, municipal boundaries, and major roadways.

Figure 1-1: Corridor Segments

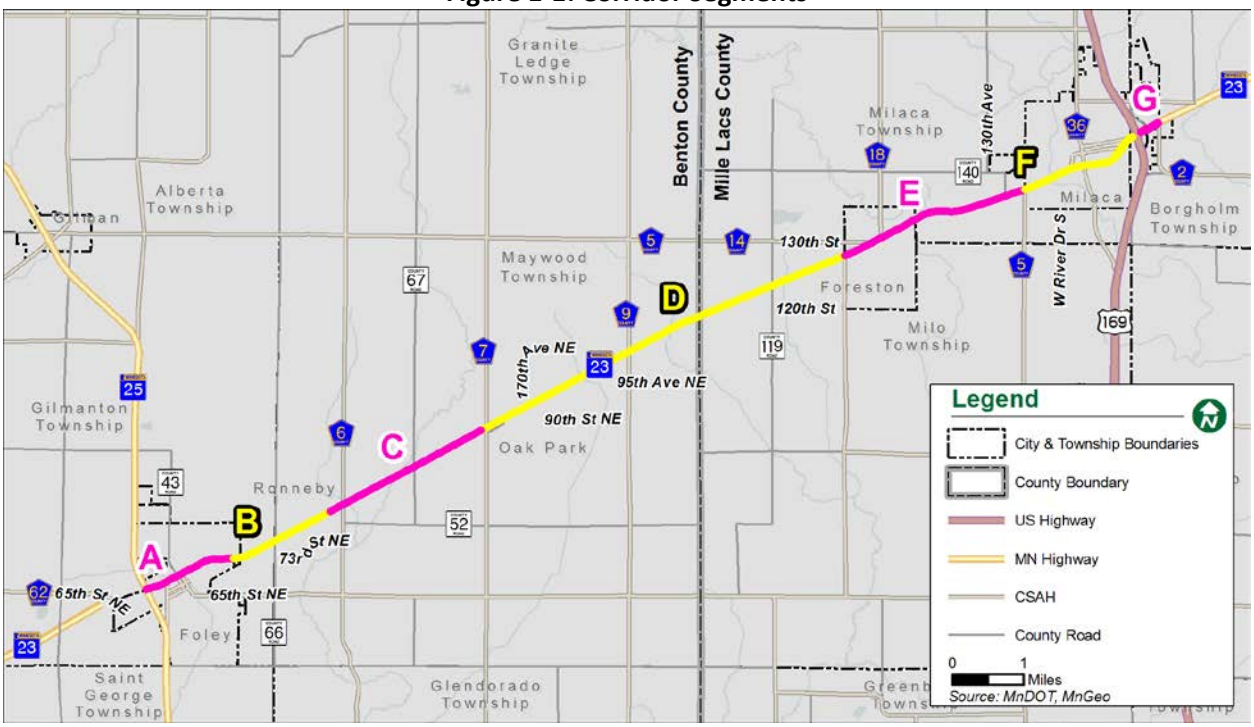


Table 1-1: Summary of Recommended Solutions (1 of 4)

Location	Recommended Solutions
Corridor-Wide	• Schedule and coordinate with the Toward Zero Deaths Region and Local Partners on Education initiatives • Add left turn lanes at identified public street intersections • Improve the pedestrian and bicycle connections along and across Hwy 23 • Develop a community roadway plan • Enhance critical signs for increased impact and visibility • Enhance speed changes with pavement markings • Add centerline buffers, improved edgelines and rumble strips in rural sections • Provide roundabouts as transition features from rural to urban sections

Table 1-2: Summary of Recommended Solutions (2 of 4)

Location	Recommended Solutions

Segment A
Foley
	• Develop a community roadway plan
	  o This is a commitment for the City to lead
	  o Focus on pedestrian and urban characteristics
	  o Helps to guide the future reconstruct by MnDOT
	• Transition corridor to a context sensitive urban roadway from Hwy 25 to 13th Ave
	• Design as a continuous 3-lane urban roadway from 1st Ave to 13th Ave and add a median east of 13th Ave
	• Develop design elements to slow traffic including narrower lanes, curb extensions, and roundabouts as intersection control
	• Explore the feasibility for roundabouts at Hwy 25, Norman Avenue, Broadway Avenue, and 8th Avenue/Penn Street
	• Enhance pedestrian crossing facilities at 8th Ave/Penn St
	• Enhance lighting
	• Enhance speed reduction changes
	• Review speed limits once changes implemented
	• Implement signal enhancements at Hwy 25
	• Implement a constrictor intersection at 13th Ave and at 8th Ave/Penn St in the short term

Segment B	• Extend the urban roadway from Foley to east of 13th Avenue • Review the speed limits and transition locations once changes implemented • Develop roadway vision • Enhance speed reduction changes • Provide centerline improvements including no passing zones, centerline rumble strips, and centerline buffer strip • Add turn lanes at intersections, especially left turn lanes (swap right turn lanes with left turn lanes) • Add or enhance intersection lighting • Improve visibility and sight lines

Table 1-3: Summary of Recommended Solutions (3 of 4)

Location	Recommended Solutions
Segment C	• Develop roadway vision • Provide centerline improvements including no passing zones, centerline rumble strips, and centerline buffer strip • Add turn lanes at intersections, especially left turn lanes (swap right turn lanes with left turn lanes) • Add or enhance intersection lighting • Improve visibility and sight lines
Segment D	• Develop roadway vision • Provide centerline improvements including no passing zones, centerline rumble strips, and centerline buffer strip • Add turn lanes at intersections, especially left turn lanes (swap right turn lanes with left turn lanes) • Add or enhance intersection lighting • Improve visibility and sight lines

Segment E
Foreston
	• Develop a community roadway plan
	  o Focus on pedestrian crossing location at Main Ave
	  o Helps to guide the future intersection improvements and the mill and overlay by MnDOT
	• Transition corridor to a context sensitive rural roadway
	• Design as a continuous 3-lane rural roadway from CR 18 (south leg) to CR 18 (north leg)
	• Develop design elements to slow traffic including narrower lanes
	• Enhance right turn lanes
	• Enhance speed reduction changes
	• Review speed limits once changes implemented

Segment E **Foreston to Milaca**	• Provide centerline improvements including no passing zones, centerline rumble strips, and centerline buffer strip • Add turn lanes at intersections, especially left turn lanes • Add or enhance intersection lighting

Table 1-4: Summary of Recommended Solutions (4 of 4)

Location	Recommended Solutions

Segment F
Milaca West
	• Develop a community roadway plan
	  o This is a commitment for the City to lead
	  o Focus on pedestrian and urban characteristics
	  o Helps to guide the future reconstruct by MnDOT
	• Transition corridor to a context sensitive urban roadway from the Rum River to 3rd St SE
	• Design as a continuous 3-lane section rural roadway west of the Rum River
	• Transition to an urban roadway east of the Rum River
	• Design as a continuous 3-lane urban roadway from Central Ave to 3rd St SE
	• Develop design elements to slow traffic including narrower lanes and curb extensions
	• Add left turn lanes at 3rd Ave and school intersections
	• Enhance pedestrian crossing facilities at 3rd Ave
	• Explore the feasibility of a pedestrian underpass east of 3rd Ave
	• Explore the feasibility for a roundabout at 3rd Ave
	• Add left turn lanes and signal enhancements at Central Ave

Segment G **Milaca East**	• Add left turn lanes at CSAH 2 in short term • Explore the feasibility for a roundabout at either CSAH 2 or at 10th Ave S • Add continuous lighting

II. INTRODUCTION

The Trunk Highway (Hwy) 23 extends from Interstate 90 (I-90) west of Luverne, MN to I-35 south of Hinkley, MN. Hwy 23 extends for approximately 275 miles connecting 36 communities across Minnesota. The Hwy 23 study corridor runs for 16 miles from Foley to Milaca and includes the communities of Foley, Ronneby, Oak Park, Foreston, and Milaca. The study corridor is heavily used by commuters to and from St. Cloud during the peak hours, but is even more heavily used by vacation traffic on the summer weekends.

There have been community concerns with safety on the corridor especially in relation to increased speeds and the weekend summer traffic. Most importantly, there has been a marked increase in fatal crashes in 2016 and 2017 on the east side of the City of Foley that have not occurred on the corridor in the past. MnDOT in coordination with the county sheriff and state patrol has recently increased up efforts to enforce the posted speeds and applicable traffic laws in the area.

To further investigate the corridor issues and community concerns, MnDOT decided to conduct a Road Safety Audit (RSA). A road safety audit is performed to identify and document issues and concerns of the roadway environment and to identify potential solutions to improve the safety of the corridor through short term, mid-term, and long-term improvement strategies. The RSA is completed by an independent and multidisciplinary team and consists of three primary steps including the pre-audit review, the road safety audit field review, and the findings. The pre-audit is used to identify unusual crash trends through a review of the historical crash data while the field review is used to identify deficiencies of the roadway and other safety risks. Safety solutions and recommendations are then identified to improve the safety of the corridor as identified in the findings.

The primary goals of the RSA include:

1. Elimination of fatal and serious injury crashes and
2. Reduction in total crashes.

As stated by the Federal Highway Administration (FHWA), “the aim of an RSA is to answer two primary questions:

1. What elements of the road may present a safety concern: to what extent, to which road users, and under what circumstances?
2. What opportunities exist to eliminate or mitigate identified safety concerns?”

The road safety audit considers a multi-dimensional approach to safety including the 5 Es:

1. Engineering,
2. Enforcement,
3. Education,
4. Emergency Medical and Trauma Services, and
5. Everyone.

A. Study Area

The study corridor runs from Foley to Milaca as identified in Figure 2-1.

Figure 2-1: Study Corridor

B. Road Safety Audit Review Team

A field review team was assembled to review the corridor safety data and the roadway environment and recommend possible safety improvement solutions for the corridor. The team was composed of members of MnDOT and the consultant project team that would provide unbiased views of the issues and develop corridor specific safety solutions. They were chosen to represent different aspects of a safe roadway environment. The team also reviewed public comments to get an understanding of the community views of the issues and concerns.

Table 2-1: Road Safety Audit Team

Name	Agency and Position
Derek Leuer	MnDOT, Traffic Safety Engineer
Jamal Love	MnDOT, Geometrics Engineer
Gwen Mei	MnDOT, Geometrics Engineer
Lars Impola	MnDOT, Traffic Engineer
Ken Hanson	MnDOT, District 3 Assistant Traffic Engineer
Melissa Barnes	MnDOT, Bicycle and Pedestrian Engineer
Michelle Pooler	MnDOT, Transit, Bicycle and Pedestrian Planning Coordinator
Tom Nixon	MnDOT, Central MN TZD Regional Coordinator
Brad Estochen	MnDOT, State Traffic Safety Engineer
Will Stein	FHWA, Safety Engineer (Minnesota Division)
Bryan Nemeth	Bolton & Menk, Project Manager and Traffic Engineer
Marcus Januario	Bolton & Menk, Traffic Engineer

The road safety audit field review was conducted on two different dates: June 20, 2017 and July 19, 2017.

Figure 2-2: Hwy 23 Road Safety Audit Team Members in Foley, MN (June 20, 2017)

C. Key Dates

The following key dates show the development of the Hwy 23 road safety audit process.

Table 2-2: Key Dates

Date	Meeting/Event
May 11, 2017	Field Data Collection: Speeds and Volumes
May 22, 2017	Kickoff Meeting with MnDOT Office of Traffic and Safety
May 30, 2017	Kickoff Meeting with MnDOT District 3
June 15, 2017	Community Meeting at Foley Intermediate School: Issues and Concerns
June 15-June 30, 2017	Public Comments Received
June 20, 2017	Road Safety Audit Field Review 1
July 19, 2017	Road Safety Audit Field Review 2
July 31, 2017	Road Safety Audit Team Draft Recommendations Approved
August 28, 2017	Road Safety Audit Team Review of Draft Report
August 30, 2017	Coalition Meeting to Discuss Findings
September 11, 2017	Community Meeting at Foley Intermediate School: Recommendations

III. PRE-AUDIT

The pre-audit includes the collection and dissemination of existing historical data and public information. This information is used by the Road Safety Audit team to understand the current safety issues and concerns, and provide information about the corridor. The information was composed into a Briefing Book that was reviewed prior to the audit and used during the field audit (see attached "TH 23 Road Safety Audit: Briefing Book, June 20, 2017). Information in the Briefing Book included observations, planned or programmed future improvement projects, roadway characteristics (volume and speed), and historical crash data on a corridor and intersection basis. The information helped to determine key focus areas.

A. Local Concerns

Concerns and recommendations were collected from the community during the Community Meeting on June 15, 2017. Additionally, comments were accepted from the community through email. Some of the primary concerns are noted below. A full summary of the recorded comments are provided in Appendix C: Public Comments.

Corridor-Wide

- High Speeds: need to be reduced, especially in Foley and on east side of Foley, motorists driving in excess of 60 mph between Foley and Milaca
- Lack of safe pedestrian crossings in Foley and Milaca

Foley

- 4th Avenue: pedestrian safety concern, cross street traffic has increased
- Broadway Avenue: traffic and pedestrian safety concern
- 8th Avenue/Penn St: school crossing, need safer options to get students across and stop traffic on Hwy 23, used during summer also
- 13th Avenue: dangerous curve, no turn lane, dangerous bypass lane, right turns into driveways from bypass lane, no shoulder
- East of 13th Avenue: solar glare on curve that can occur during some times of the year
- Numerous fatal crashes on east side of town in 2016/2017
- Numerous speed transitions on the east side of Foley: 35 to 45 to 55 to 60 mph

Between Foley and Milaca

- Lack of left turn lanes: close calls, high speed rear-end crashes
- Bypasses around left turning vehicle in right turn lanes
- CR 66, CR 6: difficulty accessing the highway during peak hours
- Ronneby, CR 6: no right turn lane for WB, minimal shoulder: close calls, rear-end and run-off road crashes
- Lack of safe pedestrian/bike crossing in Ronneby
- Lack of no-passing zones: close calls with passing left turning vehicles
- Speed variation on the roadway due to slow moving vehicles and lack of passing

opportunities

- Right turning traffic onto Hwy 23: conflict with passing vehicles
- Skewed intersections with Hwy 23 result in sight line issues
- Foliage in ditches and along roadway impact sight lines
- No right turn lanes into some streets, narrow shoulder width, rear-end crash close-calls (Foley to Foreston: Railroad Ave, 90th St NE, 170th Ave NE, 180th Ave NE, and 195th Ave NE), (Foreston: WB at 2nd Ave and Main Ave, Golden Rd/135th Ave), (Foreston to Milaca: 130th Ave)

Milaca

- School pedestrian crossing at 3rd Ave SW: eastbound motorists bypass left turning vehicles in right turn lane, narrowly missing pedestrians, no trail/sidewalk from crossing to school through ditch area
- Central Ave: frequent traffic backups due to left turning vehicles
- Pavement in poor condition
- Interchange area can be confusing with so many closely spaced intersections, many vehicle movements and turns
- 10th Ave: busy intersection with lots of traffic, westbound traffic speeds high
- CSAH 2: westbound left turns in through lane, close calls on rear-end crashes, bypass lane starts too late

B. Corridor Characteristics

The following characteristics of the corridor can help define how the corridor is functioning.

B.1 Traffic Volume

The measured daily traffic volume on Hwy 23 ranges from 5,600 to 8,100. This traffic volume was collected in the summer of 2017 outside of the cities of Foley and Milaca. Previous ranges for daily traffic volumes on the corridor, including the cities of Foley and Milaca, from 2014 and 2015 are 5,500 to 9,700. The historical data for the corridor segments in Benton and Mille Lacs County are shown in Tables 3-1 and 3-2. Overall, the volume of traffic on the corridor has stayed level over the past few years with slight decreases outside of the cities of Foley and Milaca.

Table 3-1: Daily Traffic Volume Summary, Benton County

Start	End	2011	2013	2015	3-Year Average
CSAH 4	TH 25	10100	9800	9100	9670
TH 25	8th Ave/Penn St	9700	9300	9700	9570
8th Ave/Penn St	CR 66	7000	7100	7100	7070
CR 66	Railroad Ave (Ronneby)	6500	6300	6600	6470
Railroad Ave (Ronneby)	CSAH 6	6300	6000	6000	6100
CSAH 6	CSAH 14	5600	5300	5500	5470

Measured as Annual Average Daily Traffic (AADT) from MnDOT Traffic Mapping Application

Table 3-2: Daily Traffic Volume Summary, Mille Lacs County

Start	End	2010	2012	2014	3-Year Average
CSAH 14	CSAH 5	7500	6700	6700	6970
CSAH 5	CSAH 32	8400	7600	7900	7970
CSAH 32	CSAH 36	8000	7700	7500	7730
CSAH 36	CSAH 2 (2nd St)	5800	5600	5800	5730
CSAH 2	West Ramp of TH 169	7100	6700	6800	6870
East Ramp of TH 169	CSAH 2 (105th Ave)	5600	5400	6000	5670

Measured as Annual Average Daily Traffic (AADT) from MnDOT Traffic Mapping Application

Traffic volume projections were completed for the corridor to understand the potential growth and capacity needs of the corridor. Based on historical traffic volume data from 1992 to 2015 and employing the MnDOT TDA Least Squares Method and adjusted for county growth rate factors, the growth rates for the corridor range from 0.5 to 1.7% per year. This indicates that the corridor has a projected 2038 daily volume range of 6,650 to 11,650 between Hwy 25 in Foley and Mille Lacs County Highway 2 in Milaca. Higher volume of 12,650 is projected just west of Hwy in the four lane divided high section of Hwy 23. The roadway is appropriate to handle capacity needs with one through lane in each direction based on similar roadways across the District.

Table 3-3: Projected Traffic Growth

Location Description	Start	End	2014	2015	2038
NE of CSAH 4	CSAH 4	TH 25		9100	12650
NE of 2nd Ave in Foley	TH 25	8th Ave/Penn St		9700	11650
E of Lord Ave	8th Ave/Penn St	CR 66		7100	8800
SW of 143rd Ave NE	CR 66	Railroad Ave (Ronneby)		6600	8650
NE of 143rd Ave NE	Railroad Ave (Ronneby)	CSAH 6		6000	6950
SW of CSAH 9	CSAH 6	CSAH 14		5500	6650
W of CSAH 5	CSAH 14	CSAH 5	6700		8100
W of CSAH 32 (3rd Ave SW)	CSAH 5	CSAH 32	7900		8800
W of CSAH 36 (3rd Ave SW)	CSAH 32	CSAH 36	7500		9250
W of 5th Ave SE in Milaca	CSAH 36	CSAH 2 (2nd St)	5800		7050
NE of CSAH 2 (2nd St SE) in Milaca	CSAH 2	West Ramp of TH 169	6800		8300
NE of TH 169	East Ramp of TH 169	CSAH 2 (105th Ave)	6000		7450

Additional information on the traffic volumes on the corridor can be found in the TH 23 Road Safety Audit: Briefing Book.

B.2 Segments

The corridor is segmented to focus the road safety audit and potential solutions. The roadway segments were based on the character of the roadway, specifically focusing on the urban and rural features and municipal boundaries. The vast majority of the corridor is a 2-lane undivided highway through the study area with interspersed right and left turn lanes. Hwy 23 is a 2-lane divided highway on the east side of Milaca, on both sides of the Hwy 169 interchange.

Figure 3-1: Corridor Segments

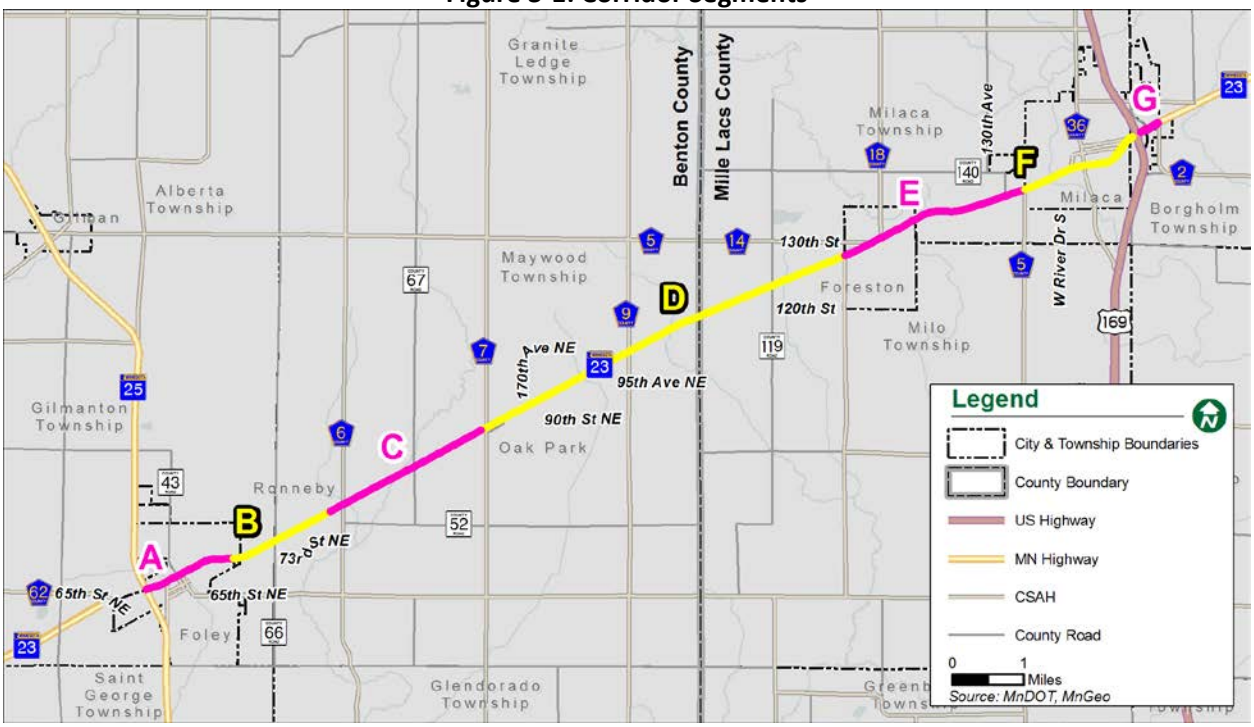


Table 3-4: Segment Characteristics

Segment	From	To	Length (mi)*	Urban / Rural	No. Lanes	Average ADT (2011-2015)**
A	Hwy 25	East of Foley City Line	1.3	Rural to Urban	2	8900
B	East of Foley City Line	West of Ronneby Township Line	1.5	Rural	2	6900
C	West of Ronneby Township Line	West of Oak Park Township Line	2.4	Rural	2	5600
D	West of Oak Park Township Line	West of Foreston City Line	5.7	Rural	2	5500
E	West of Foreston City Line	West of Milaca City Line	2.7	Rural	2	6600
F	West of Milaca City Line	Hwy 169 West Ramp	1.7	Urban	2	7000
G	Hwy 169 East Ramp	CSAH 2 (155th St)	0.3	Urban	3	5800

*Segments include intersections **Weighted average value computed based on segment lengths

B.3 Historic and Planned Road Construction Projects

Discussions with MnDOT has identified past, current, and planned projects on the study corridor and adjacent the study corridor. The construction history of the corridor has also been recorded.

Past Projects:

- 1998 – (0504-15) Thick Overlay – Bituminous over Concrete
- 2003 – (8823-45) Microsurfacing within City of Milaca
- 2004 – (8823-51) Chip Seal – Bituminous over Concrete
- 2011-2012 – (0504-18) Bituminous and concrete surfacing from TH 25/TH 23 intersection to East limits of Foley
- 2012 – (8823-255) Microsurfacing from West limits of Ronneby to CSAH 9/TH 23 intersection
- 2012 – (8823-255) Microsurfacing from West Mille Lacs county line to East of Milaca
- 2012 – Construction of 4-Lane Divided Roadway from TH 95 to TH 25 in Foley

Current Projects:

- TH 25 Resurfacing north and south of TH 23 occurring in 2017
    - Glenn St in Foley to TH 95 (full closure at all times)
    - Foley to Genola (open to traffic at all times)

Planned Projects:

- Intersection improvements along corridor – Short-Term (next summer (2018))
- Urban Reconstruct in Foley: TH 25 to east side of Foley – Mid-Term (± 10 years)
- Urban Reconstruct in Milaca – Mid-Term (± 10 years)
- Mill and Overlay: Ronneby to West of Milaca – Mid-Term (± 10 years)

Source: 10-Year Capital Highway Investment Plan

There are also additional documents that should be considered when planning projects on the corridor. These include statewide, county, and city planning documents.

Known Planning Documents:

- Statewide Bicycle System Plan
- Minnesota Walks (Statewide Pedestrian System Plan)
- Community Vision Plan for Downtown Redevelopment and Pedestrian Connections, City of Foley
- City of Foley and City of Milaca Comprehensive Plans
- Benton County and Mille Lacs County Comprehensive Plans

Table 3-5: Construction History

Year Built	Project No.	Length (mi)	Location	Type	Remarks
2002	8823-36	1.639	TH 25/TH 23 Intersection to East of Foley	Bit Seal Coat	Type FA2
2003	8823-45	0.883	Milaca	Microsurfacing	Type 2
2004	8823-51	6.747	Benton/Mille Lacs County Line to East of Milaca	Bit Seal Coat	Type FA3
2004	8823-51	7.03	West of Ronneby to Benton/Mille Lacs County Line	Bit Seal Coat	Type FA3
2011	0504-18 (0503-75)	1.626	TH 25/TH 23 Intersection to East of Foley	Class 6 Agg Base, Bit Surfacing, Concrete Surfacing	Spec 2360
2012	8823-255	7.03	West of Ronneby to CSAH 9/TH 23 Intersection	Microsurfacing	Spec 2356
2012	0504-18	1.626	TH 25/TH 23 Intersection to East of Foley	Grading, Bit Surfacing, Concrete Surfacing	Spec 2360
2012	4801	4.393	Benton/Mille Lacs County Line to East of Milaca	Control Section Change	Milaca Bypass
2012	8823-255	4.393	Benton/Mille Lacs County Line to East of Milaca	Microsurfacing	Type F2

Information from Benton County and Mille Lacs County Construction Project Logs:
http://www.dot.state.mn.us/roadway/data/const-projlog-bydistrict.html

Most of the corridor has been resurfaced within the past 25 years but none of the corridor has been reconstructed before 1998. The roadway is generally narrow with one lane in each direction and shoulders of 9 to 10 feet in most areas. Most the of roadway surface is a bituminous overlay over concrete. Most the intersections between Foley and Milaca are skewed.

MnDOT had identified that the corridor is due for improvements over the next 10-15 years. The urban portions of the corridor in Foley and Milaca are in need of full reconstruction while the rural portions of the corridor are in need of spot intersection improvements in Foreston and Oak Park, with a mill and overlay of the rest of the corridor. While funding has not been identified, the projects have been identified within the 10-Year Capital Highway Investment Plan. These projects are an opportunity to implement some of the road safety audit recommendations.

B.4 Speed Data

The roadway between Foley and Milaca is signed with a speed limit of 60 mph. Speed limits are set based on national guidance, which sets the speed limit at the speed in which 85% of the traffic travels at that speed or less, identified as the 85th percentile speed. This is in contrast to the average speed which is the speed that 50% of the traffic travels faster and 50% travels slower. For additional information on speed limits, see http://www.dot.state.mn.us/speed/.

Traffic speeds along the corridor were collected at four locations between the cities of Foley and Milaca in locations where the speed limit is signed for 60 mph. The four locations include just east of 13th Avenue in Foley, west of CR 67 (155th Ave), east of CR 119 (160th Ave) near Foreston, and west of CR 112 near Milaca. Average speeds ranged from 53 to 62 mph. 85th percentile speeds ranged from 58 to 67 mph. Lower speeds were closer to Foley and Milaca while higher speeds were more prevalent outside of Foley and Milaca. This indicates that more than 15% of motorists are exceeding the posted speed limit, especially within the straight rural areas of the corridor. Higher speeds are indicated

in the morning and late night hours rather than during the daytime hours.

C. Crash Information

The historical crash data was collected from the Minnesota Crash Mapping Analysis Tool as provided by the Minnesota Department of Transportation (MnDOT) and the Department of Public Safety (MnDPS). The data was used to identify the types of crashes and crash trends that have occurred within the study corridor. This includes all crashes and all severe crashes. Severe crashes encompass crashes that resulted in fatalities and crashes that resulted incapacitating injuries. Due to a system transition at the time of the road safety audit, only the crashes up to 2015 were available. Severe crashes from 2016 and 2017 were also collected on an individual basis as provided by MnDOT. Refer to the TH 23 Road Safety Audit: Briefing Book for additional crash information.

Historical Trends

Crash data from 2006 to 2015 indicates that the number of crashes has generally declined over time, although the crashes started to spike in 2015. This may also be indicative of the increase in severe crashes in 2016 and 2017. Crash rates have also decreased along the corridor.

Figure 3-2: Total Crashes

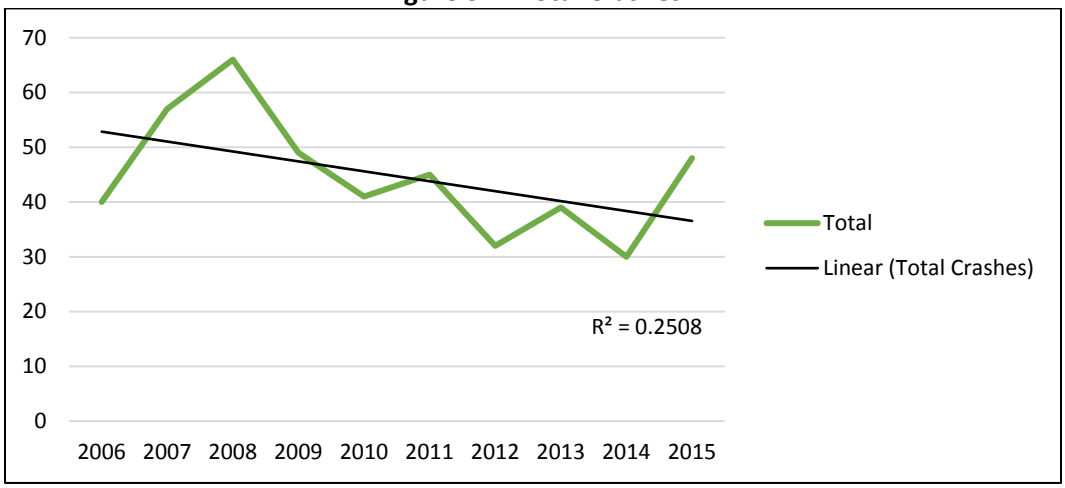
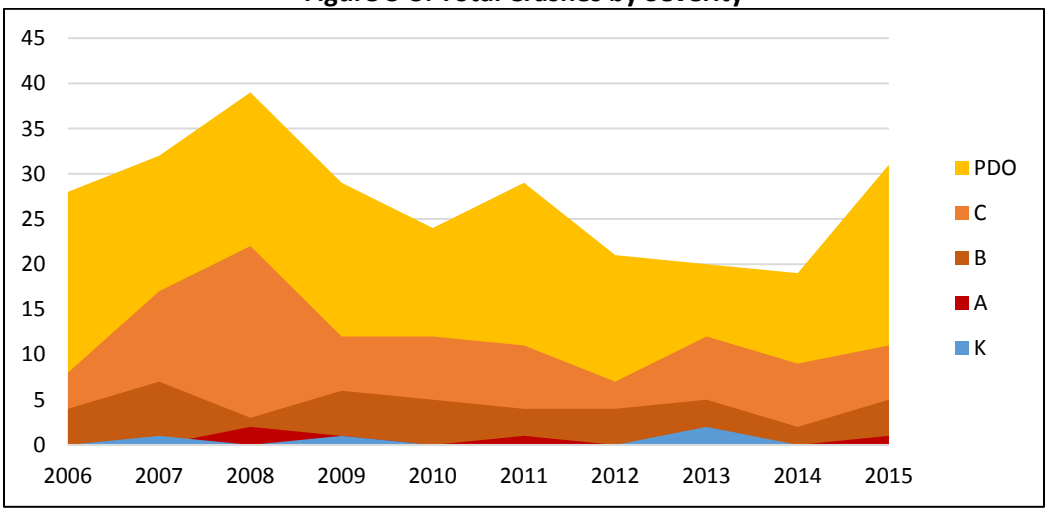


Figure 3-3: Total Crashes by Severity

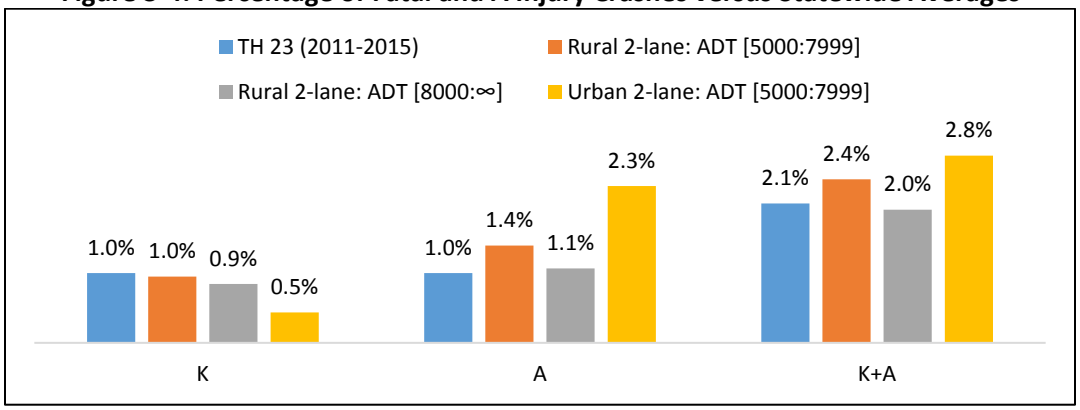


Crash Severity by Type: PDO = Property Damage Only, C= Possible Injury, B=Non-incapacitating Injury, A=Incapacitating Injury, and K = Fatal

Corridor-Wide Trends

The study period for the evaluation of crash records was from 2011 to 2015. Additionally the severe crashes from 2016 and 2017 were also studied to identify trends and safety improvement needs. The five year period provides a recent identification of the locations, types of crashes and conditions on the corridor and long enough to show the trends on a year-by-year basis. Of the 194 crashes from 2011 to 2015, 1% of the crashes were fatal and 1% were incapacitating injury. The corridor is generally about average for severe crashes as compared to other similar corridors in the state. In 2016 and early 2017 there were four fatal crashes and no incapacitating injury crashes. From 2011 to mid-2017, there were a total of eight severe crashes.

Figure 3-4: Percentage of Fatal and A Injury Crashes versus Statewide Averages



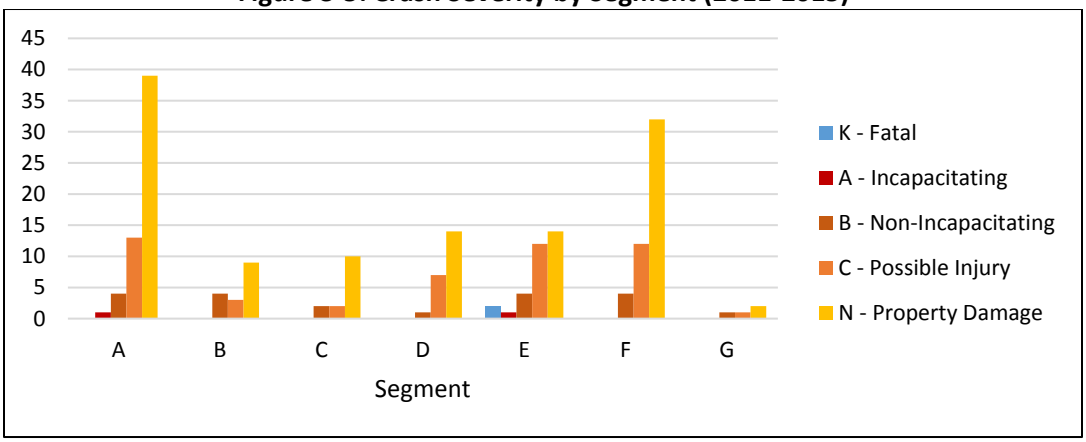
- **Surface Conditions:** 75 percent of the crashes occurred in dry conditions. 100 percent of the severe crashes occurred in dry conditions.
- **Diagram:** 31 percent of the crashes were rear-end while 25 percent were right-angle. Of the severe crashes from 2011 to 2016, 25 percent were rear-end, 25 percent were right-angle, and 50 percent were head-on.

- **Relation to Junction:** 42 percent of the crashes occurred at 4-leg intersections while 27 percent occurred at non-junctions. Of the severe crashes from 2011 to 2016, 50 percent occurred at non-junctions, 25 percent occurred at 3-leg intersections, and 25 percent occurred at 4-leg intersections.
- **Type of Crash:** 73 percent involved another motor vehicle and 2 percent involved a pedestrian. 100 percent of the severe crashes involved another motor vehicle.
- **Location of Crash:** 31 percent of the crashes occurred within the City of Milaca while 18 percent occurred within the City of Foley. 18 percent also occurred within Maywood Township, just east of Foley. Of the severe crashes from 2011 to 2016, 38 percent occurred within Foley, 12 percent occurred in Milo Township just west of Foreston, 25 percent occurred within Foreston, and 25 percent occurred within Milaca.
- **Time of Crash:** The crashes generally occurred throughout the day with spikes in the AM and PM peak hours, consistent with the higher traffic volumes at that time of the day. 25 percent of the severe crashes occurred between 7:00 and 8:00 a.m., 25 percent occurred between 1:00 and 3:00 p.m., and 25 percent occurred between 8:00 and 10:00 p.m.

Segment Trends

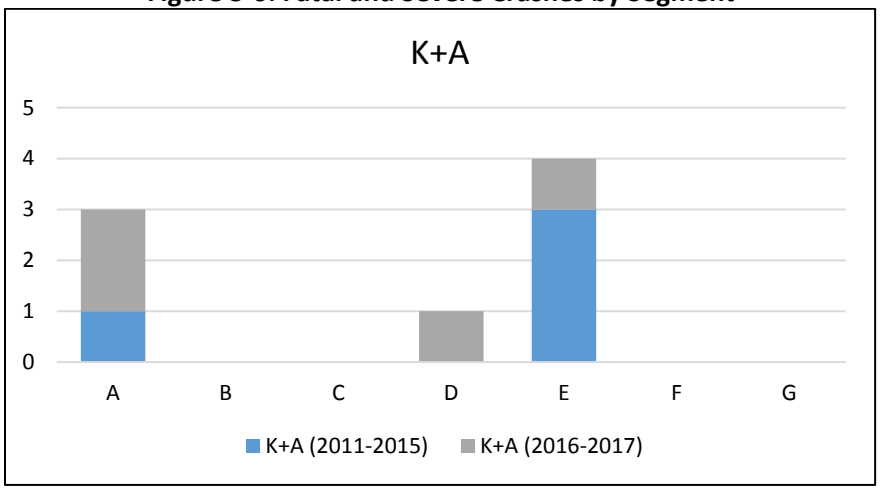
Each of the segments was analyzed as part of the road safety audit. For the segments, most of the crashes occurred in Segments A and F, within the cities of Foley and Milaca, where the roadway has more access points.

Figure 3-5: Crash Severity by Segment (2011-2015)



Most of the fatal and severe injury crashes occurred within Segments A and E, which includes the Cities of Foley and Foreston.

Figure 3-6: Fatal and Severe Crashes by Segment



Crash rates and critical crash rates were calculated based on the formulas in the MnDOT Traffic Safety and Fundamentals Handbook and Green Sheets. The critical crash rate takes into account the confidence range and the type of roadway while the average crash rate does not. The crash index is a measure of the crash rate divided by the critical crash rate. An index above 1 indicates a safety concern as compares to similar types of roadways in the state. The crash rate is measured per million vehicle miles while the Fatal (K) + A injury crash rate (FAR) is measured per 100 million vehicle miles.

The crash rates and FAR for each of the segments was identified. Segments A and E both have crash rates and FAR rates that exceed both the state average and the critical crash rate, with indexes over 1.

Table 3-6: Segment Crash Rates and Severe Crash Rates

Segment	Roadway Type	Crash Rate (2011-2015)				FAR (2006-2017)			
		TH 23	State Average	Calc. Critical Rate	Crash Index	TH 23	State Average	Calc. Critical Rate	Severe Crash Index
A	Rural 2-lane : ADT[8000:]	***1.77***	0.76	1.19	***1.49***	***6.86***	1.98	4.78	***1.44***
B	Rural 2-lane : ADT[5000:7999]	***0.85***	0.60	1.09	0.77	0.00	2.62	6.97	0.00
C	Rural 2-lane : ADT[5000:7999]	0.58	0.60	1.05	0.55	1.82	2.62	6.34	0.29
D	Rural 2-lane : ADT[5000:7999]	0.39	0.60	0.91	0.42	0.77	2.62	4.84	0.16
E	Rural 2-lane : ADT[5000:7999]	***1.02***	0.60	0.99	***1.03***	***6.79***	2.62	5.72	***1.19***
F	Urban 2-lane : ADT[5000:7999]	***2.23***	1.80	2.59	0.86	2.02	3.21	7.48	0.27
G	Urban 2-lane : ADT[5000:7999]	***1.37***	1.80	3.88	0.35	0.00	3.21	19.72	0.00

X.XX	TH 23 Exceeds the State Average Rate
X.XX	TH 23 Exceeds the Critical Rate and the State Average Rate
X.XX	Crash Index or Severity Crash Index exceeds 1

Contributing factors to the crashes have also been identified by segment from the crash data as shown in Table 3-7. The contributing factors help to identify if there is a specific issue that is causing crashes in areas.

Table 3-7: Contributing Factors

Segment	Illegal Speed	Driver Inattention	Chemical Impairment	Improper Lane Use	Improper Maneuver	Other/ Unknown	Total
A	3	7	2	1	23	21	57
B	1	2	1	0	1	11	16
C	1	3	0	0	4	6	14
D	3	2	1	1	2	13	22
E	2	8	2	1	10	10	33
F	0	3	1	1	12	31	48
G	0	0	0	1	1	2	4

The majority of the crashes in the urban areas (segments A, E, and F) are the result of improper maneuvers. This includes failure to yield right of way to vehicles on Hwy 23 from a stop condition or running a red light at a traffic signal.

Intersection Trends

All of the intersections along the corridor were also evaluated using the same measures as the segments. If the crash index is above 1 and either the crash rates (CR) or FARs exceeded state-wide averages or critical rates for the intersection, the intersection was flagged for further evaluation and specific field review. Any intersections with over five (5) crashes from 2011 to 2015 was also flagged. Table 3-8 identifies the flagged intersections. Flagged intersections indicate a potentially higher safety risk based on the historical crash data. The crash rate is measured per million vehicle miles while the Fatal (K) + A injury crash rate (FAR) is measured per 100 million vehicle miles. The majority of the flagged intersections are within Milaca but critical locations also occur within Foley and Foreston.

Table 3-8: Flagged Intersections

Hwy 23 (TH 23) Intersection Cross Street	Type of Intersection	Traffic Control Device	Reasons Studied
MN TH 25	Full Access	Signal	Crash Index >1
1st Ave W/Frontage Rd (Foley)	Full Access	Thru / stop	Crash Index >1
8th Ave/Penn St (Foley)	Full Access	Thru / stop	CR >State Avg CR
Lord Ave (Foley)	T Intersection	Thru / stop	CR >State Avg CR
CR 66/135th Ave NE	Full Access	Thru / stop	CR >State Avg CR
CR 6/Ronneby Rd (Ronneby)	Full Access	Thru / stop	CR >State Avg CR
CR 53/167 1/2 Ave NE (Oak Park)	T Intersection	Thru / stop	CR >State Avg CR
170th Ave NE	T Intersection	Thru / stop	CR >State Avg CR
CSAH 9/185th Ave NE	Full Access	Thru / stop	CR >State Avg CR
CSAH 18 South Leg/150th Ave	T Intersection	Thru / stop	CR >State Avg CR
130th St/1st St/CR 14 (Foreston)	Full Access	Thru / stop	CR >State Avg CR, FAR >State Avg FAR
Main Ave (Foreston)	Full Access	Thru / stop	CR >State Avg CR, FAR >State Avg FAR
CR 112/127th Ave	T Intersection	Thru / stop	CR >State Avg CR, FAR >State Avg FAR
CR 5/125th Ave	Full Access	Thru / stop	CR >State Avg CR
3rd Ave SW (Milaca)	Full Access	Thru / stop	Crash Index >1
2nd Ave SW (Milaca)	Full Access	Thru / stop	CR >State Avg CR
Central Ave S (Milaca)	Full Access	Signal	CR >State Avg CR
2nd Ave SE (Milaca)	T Intersection	Thru / stop	CR >State Avg CR
110th Ave/10th Ave SE (Milaca)	Full Access	Thru / stop	CR >State Avg CR
CSAH 2 (Milaca)	Full Access	Thru / stop	Crash Index >1

Severe Crash Information

Additional detail is provided at the locations in which fatal and A-injury crashes occurred. These locations were also flagged for additional review. The majority of these have occurred within the cities of Foley and Foreston.

Table 3-9: Severe Crash Flagged Locations

Segment	Month/Year of Crash	Location	Type of Intersection	Severity	Crash Diagram	Contributing Factors
A	02/2017	East of 9th Ave (Foley)	On Curve	Fatal	Head-on	Unknown
A	09/2011	West of Lord Ave (Foley)	T Intersection	A-Injury	Rear-end	Driver Inattention
A	01/2017	East of Lord Ave (Foley)	-	Fatal	Head-on	Chemical Impairment
D	07/2016	CR 119/160th Ave	Full Access	Fatal	Rear-end	Driver Inattention
E	06/2016	West of 135th Ave	On Curve	Fatal	Head-on	Unknown
E	05/2015	130th St/1st St/CR 14 (Foreston)	Full Access	A-Injury	Right Angle	Chemical Impairment
E	09/2013	Main Ave (Foreston)	Full Access	Fatal	Pedestrian	Other/ Pedestrian Error
E	11/2013	CR 112/127th Ave	T Intersection	Fatal	Right Angle	Improper Maneuver

IV. AUDIT

On June 20, 2017, a seven hour field review was conducted by the road safety audit team. Additional members of the road safety audit team also conducted a second field review on July 19, 2017. Team members drove the entire study corridor and stopped at flagged intersections and locations as identified through the pre-audit. Additional locations were also reviewed in the field as identified through community comments and to get a review of the entire corridor. This included a majority of the intersections within the communities of Foley, Foreston, and Milaca.

The team took notes an any potential risk factors that could lead to future safety risks. This included noting locations that had a hgher than normal percentage of the crash type and at least two crashes of a single type.

Table 4-1: Crash Types in Relation to Contributing Factors

Crash Type	Possible Contributing Factors	Segments/Intersections/Locations Identified from Crash Data
Rear end collisions	• Sudden change in speed • Queuing (consider presence of congestion, passing lanes, intersection control devices, sight distances) • Road surface • Tailgating • Distracted drivers	Segments: A, B, E Intersections: 1st Ave W (Foley), Lord Ave (Foley), CR 66/135th Ave, Main Ave (Foreston), CR 119/160th Ave, 3rd Ave SW (Milaca), 2nd Ave SW (Milaca), 2nd Ave SE (Milaca) Locations: 9th Ave to Lord Ave (Foley)
Sideswipe collisions	• Distracted drivers • Sudden lane merges	Segment: E
Left turn into traffic	• Inadequate sightline • Lack of gaps in traffic • Distracted drivers	Segments: A, G Intersections: Hwy 25, 1st Ave W (Foley), 8th Ave/Penn St (Foley)
Right angle collisions	• Fail to yield right of way • Inadequate sightlines • Distracted drivers • Poor driver decision	Segments: A, E, F Intersections: Hwy 25, 130th St/1st St/CR 14 (Foreston), CR 6/Ronneby Rd, 130th St/1st St/CR 14 (Foreston), CR 112/127th Ave, CR 5/125th Ave, Central Ave (Milaca) Locations:
Right turn into traffic	• Inadequate sightline • Lack of gaps in traffic • Distracted drivers	Segment: G Intersections: 1st Ave W (Foley)
Head-on collisions	• Lack of centerline rumble strips • Traffic moving in opposite directions have no buffer space • Driver confusion (evaluate lighting, appearance of roadway) • Distracted drivers	Segment: B Locations: Lord Ave to 13th Ave (Foley), West of 135th Ave
Pedestrian related crashes	• Pedestrians have a long crossing distance • Inadequate sightlines • Distracted drivers • Insufficient lighting	Intersections: Main Ave (Foreston)
Speed related crashes	• The character of the area causes drivers to feel like they are on an expressway • Not enough warning to alert drivers of lower speed zones • Distracted drivers	Intersections: CSAH 9/185th Ave
Snow/ Ice related crashes	• Inadequate road maintenance • Road material not textured enough • Not enough warning • Distracted drivers	Segments: G Intersections: Hwy 25
Crashes linked to poor lighting	• Insufficient lighting causing sight issues • Distracted drivers	Segments: A, E, G Intersections: Main Ave (Foreston)

Possible contributing factor information as provided with the US12 Road Safety Audit Final Report

V. POST-AUDIT

The post audit considers the field audit and crash information to develop mitigation strategies for the corridors and intersections to improve safety. All mitigation strategies will need to be evaluated for their justification to be implemented in the locations as identified but serve as a starting point to improve safety based on the field conditions, safety considerations, and mitigating factors.

The implementation timeframe for these strategies have been grouped into short term, mid-term, and long term. Short term strategies can be more easily employed immediately within the current right-of-way and roadway width. Mid-term strategies include more spot location improvements or restriping with the roadway width likely to remain the same and no additional right-of-way needed. Long term strategies require significant reconstruction that alters the roadway width or intersection configuration and may require additional right-of-way.

Many of the strategies recommended along the Hwy 23 corridor have the effect of reducing speed using changes to the roadway environment to modify driver behavior on a permanent basis. A speed limit change without complementary changes to the roadway environment is not recommended as they have been shown to only have a temporary or artificial effect of slowing traffic, rather than a permanent change to driver speeding behavior. Information on how speed limits are set and results of speed studies is provided in Appendix F.

A. Corridor-Wide Strategies

Schedule and Coordinate with the Toward Zero Deaths Region and Local Partners on Education Initiatives

Implementation Schedule: Short Term

Education outreach: Can be utilized to teach current and future drivers about different road safety topics, such as making left turns on 2-lane highways, how to be a bicyclist versus pedestrian and following traffic control devices, school and pedestrian crossing guard training, dangers of distracted driving, the risk of aggressive driving, drinking while driving, seat belt compliance, and knowing how to use different traffic control devices at intersections. Various outreach campaigns are available and can be researched. School and crossing guard training can be provided through the Legionville Summer Training Camp. Additionally, training can be provided on how to educate peers in many of the topics.

The United States Department of Transportation (USDOT), the Minnesota Department of Public Safety, and Minnesota State Patrol provide many great tips and resources about how to start conversations with children and youth, as well as how to use the integrated five-E approach (Engineering, Enforcement, Education, Emergency Medical and Trauma Services, and Everyone) to accomplish safety improvements.

USDOT Education/Outreach Web Link: http://safety.fhwa.dot.gov/ped_bike/education/

Different grants, such as the Toward Zero Deaths (TZD) Safe Roads Grant[22], may be available to help fund action on education outreach and other safety initiatives along the corridor.

TZD Safe Roads Grant Program Web Link: https://dps.mn.gov/divisions/ots/tzd-safe-roads/Pages/default.aspx

Informing drivers of different safety risks may not completely eliminate distraction-related crashes, but it will allow drivers to make more informed decisions when jumping behind the wheel.

Add Left Turn Lanes at Public Street Intersections

Implementation Schedule: Short to Long Term

Add Left Turn Lanes: To reduce the potential for rear-end crashes left turn lanes should be constructed at public street intersections to separate the left turn movements from the through movements. The need for left turn lanes can be more important than right turn lanes, since left turning traffic may be stopped for opposing through vehicles, whereas a right turning vehicle slows down but generally does not stop, except at signalized intersections. These can be added in the short to long term depending on the location. Existing bypass lanes should be eliminated and replaced with left turn lanes. Additionally, where a right turn lane exists but there is no room to incorporate a left turn lane, left turn lanes should be given preference over right turn lanes.

Improve the Multi-Modal Connections along Hwy 23

Planning Schedule: Short to Mid-Term

Implementation Schedule: Mid to Long Term

Hwy 23 is a high priority bicycle link in the Bicycle System Plan. This designation indicates a need for shoulder width to be maintained for bicycles along the corridor and the future consideration of an off-roadway trail.

Sidewalk and Trail Plan: In urban areas of the corridor, a sidewalk network plan should be developed to increase pedestrian safety. In rural areas, a trail network plan should be developed to provide an off-roadway connection between regional centers and cities. Between Foley and Milaca there is an abandoned rail line on the east side of the highway that should be considered for an off-roadway trail.

A sidewalk plan in the cities removes pedestrians off of Hwy 23. A trail plan in the rural areas where speeds are higher removes pedestrian and some bicycle traffic off of Hwy 23 to their own systems. A sidewalk or trail network plan maps out the different sidewalks and trails within a certain boundary and can be used to strategically direct pedestrian traffic to safe crossings. Network plans are developed with the goal of reducing pedestrian risk at crossings, transitions, and also along the sidewalk or trail itself. Additional benefits can be provided because optimized trail connectivity can make sidewalks and trails more accessible and usable.

Sidewalk/trail network plans should be developed in the short-term. To begin, existing sidewalk network plans are first developed to assess current conditions. The corridor is analyzed for consistency, connectivity, and safety of pedestrian crossings. Once key flaws are established and preliminary goals are set, future sidewalk network plans developed. Both public input and engineering analysis are used to create a working plan.

Figure 5-1: Existing Sidewalk in Milaca

In the mid to long-term (whichever is most feasible for a community), these plans should be implemented. Sidewalks should be installed on both sides of the streets to minimize the need for unnecessary crossing. The plan should be coordinated such that pedestrians are routed to safer crossings.

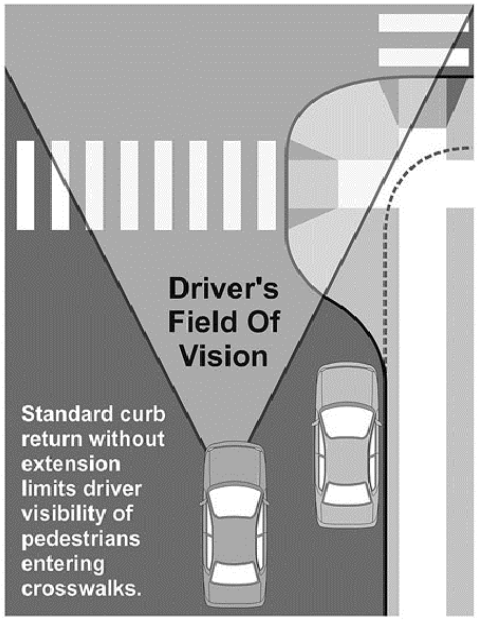
B. Urban Corridor-Wide Strategies

Improve the Safety of Multi-Modal Connections across Hwy 23

Implementation Schedule: Short to Mid-Term

Curb Extensions: At all pedestrian crossings in wide road urban sections, curb extensions are recommended. Curb extensions are installed to narrow the crossing distance over a street and improve pedestrian safety. They allow pedestrians to enter the driver's field of vision before entering the crossing.

Figure 5-2: Curb Extensions



MnDOT/HDR: US 12 Road Safety Audit, September 2015

Because installation can be done on a short schedule, curb extensions should be added in the short or mid-term. Mid-term installation includes permanent curb extensions, which are more effective. However, if it is not possible to install right away, temporary curb extensions can be created using bollards and pavement markings in the short term, as shown in Figure 5-3. Bollards can be implemented in the summer months on a temporary basis while the pavement can also be painted. Although better than nothing, bollards can become a maintenance burden because they may get hit easily and do not create as much physical protection for pedestrians.

Figure 5-3: Temporary Curb Extensions

http://www.minneapolismn.gov/www/groups/public/@publicworks/documents/images/wcms1p-151219.jpg

Rectangular Rapid Flash Beacons (RRFBs): The most critical pedestrian crossings can be enhanced with Rectangular Rapid Flash Beacons, also referred to as RRFBs when the volume of pedestrians is high enough and can be justified based on MnDOT Pedestrian Crossing Facilitation Guidance. Figure 5-4 shows what a typical RRFB installation looks like. They are mounted overhead in higher volume and speed situations. RRFBs provide a visual confirmation to motorists that a pedestrian is crossing when triggered by a pedestrian. RRFBs are installed at unsignalized intersections and mid-block pedestrian crossings to increase driver awareness. Pedestrians are given a button that they can push to trigger a flashing pattern similar to emergency flashers on police vehicles. Solar panels can be used to provide electricity to the devices. Traditionally, local units of government have funded these kinds of safety improvements so funds will need to be pulled aside for these types of improvements.

Figure 5-4: Rectangular Rapid Flashing Beacon (RRFB)

MnDOT: Minnesota's Best Practices for Pedestrian/Bicycle Safety, September 2013

Develop a Community Roadway Plan

Planning Schedule: Short to Mid-Term

Implementation Schedule: Mid to Long Term

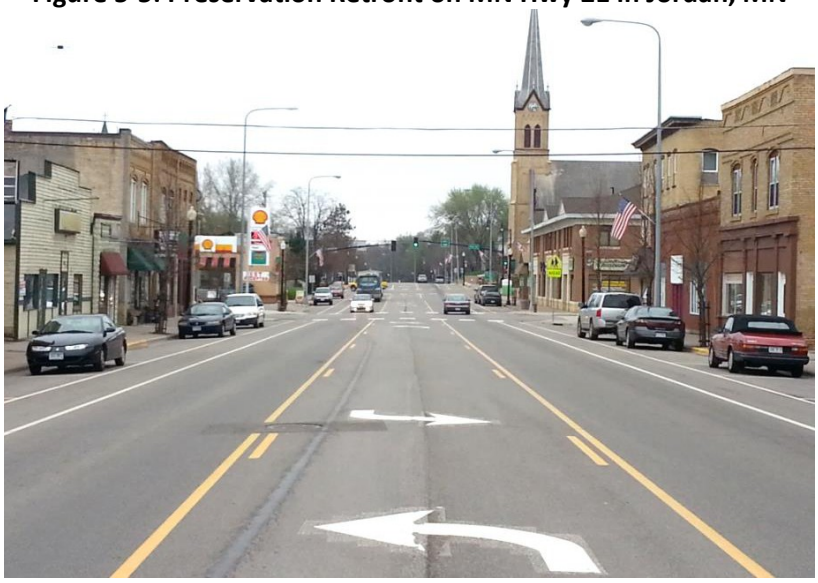
The cities of Foley, Foreston, and Milaca should start a plan now for how the roadway will look in the future. This may include narrow lanes, medians, roundabouts, and specific pedestrian crossing locations. Process should be started soon so when the scoping and planning of urban reconstruction starts within MnDOT, the plan is known and the costs to the city will be known.

3-Lane Roadway: Citizens along the urban segments have expressed concerns related to speeding. The road safety audit team recognized that the road sections were wide through Foley and Milaca. The shoulder widths were often much wider than necessary which resulted in a feel of a higherspeed section, rather than a low speed urban street. Repurposing the cross sectional width is strongly recommended to change the character of the road in Foley, Foreston, and Milaca. This also adds left turn lanes to the roadways. A 3-Lane conversion was accomplished in Jordan, MN as shown in Figure 5-5.

Complete Streets: Depending on the preferences of each city, different methods could be also be employed to change the character of the roadway so that drivers naturally slow down. This can be accomplished by turning urban sections into Complete Streets. Complete Streets are streets that provide for an urban vision of a roadway in which the roadway becomes part of the community versus a separation. They are designed to accommodate all traffic modes including vehicles, pedestrians, and bicyclists. There is no set way to develop a Complete Street layout but designs are most successful when created for specific community needs. Space availability should be considered as well. Public outreach is strongly recommended when considering different ideas. There should be coordination between cities so that urban sections have consistent lane widths and road character.

Various case studies can be used as examples when assessing complete streets ideas. Figure 5-5 shows the results of a retrofit that took place in Jordan, MN. As can be seen in the figure, the presence of bike lanes, parking stalls and narrow lanes gives the road an urban feel. The road was designed to accommodate pedestrians, bicyclists, and vehicles. Parking stalls further separate pedestrians from vehicular traffic as an extra safety measure.

Figure 5-5: Preservation Retrofit on MN Hwy 21 in Jordan, MN



2015 MnDOT Presentation featuring Jordan and Cosmos, MN

There are several resources available for developing Complete Streets solutions. One useful resource is the National Association of City Transportation Officials (NACTO) Urban Street Design Guide. This tool gives a brief overview of the benefits of Complete Streets, provides guidance for designing 21st century streets, provides different case studies from actual projects that have been constructed, and offers trainings and workshops, and more. Recommendations can be found for various intersection and street types.

NACTO's Urban Street Design Guide Web Link: http://nacto.org/publication/urban-street-design-guide/

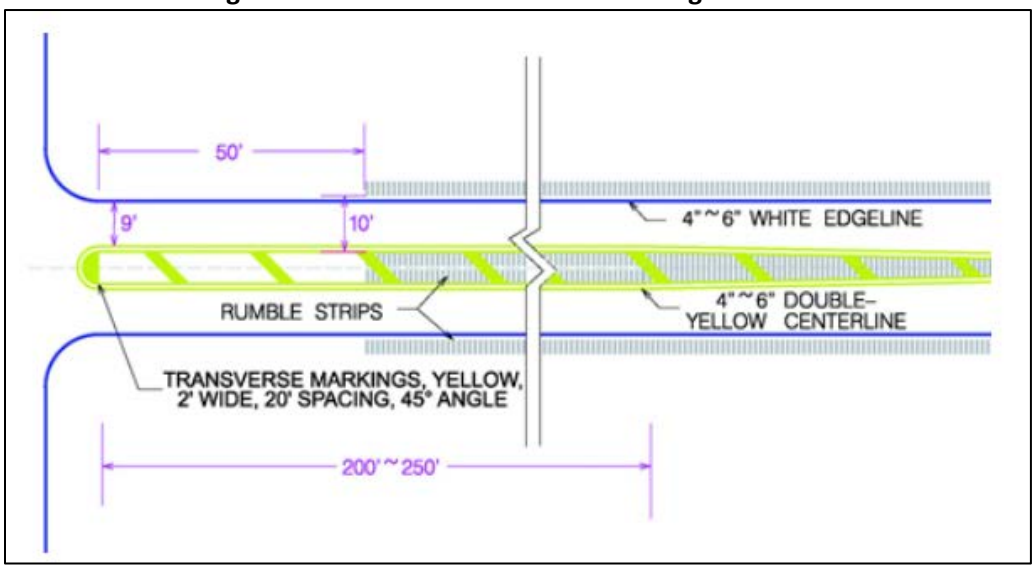
Various elements that can be incorporated into complete streets designs include, but are not limited to: boulevards, bicycle lanes, separation of pedestrians and vehicular traffic, benches, greenery, parking spaces, bus stops, storm water management upgrades, and different traffic calming elements.

Constrictor Intersection

Implementation Schedule: Short to Mid-Term

A wide pavement area at an intersection can be used to implement a striped median to slow down traffic as it enters into an intersection area and to shorten pedestrian crossing distances and exposure time. The Federal Highway Administration (FHWA) has developed and evaluated the narrowing of approach lanes combined with installing rumble strips in the striped median area at two-way stop-controlled (TWSC) intersections on high speed rural roads as a low-cost countermeasure for unsignalized intersections experiencing a high number of crashes. The combination of applied signing and striping with shoulder and median rumble strips increases driver awareness on approach to the intersection, while the lane narrowing acts as a traffic calming measure found to decrease vehicle speeds. These treatments have been proven to be effective while installation can be done in a short amount of time.

Figure 5-6: Constrictor Intersection Design Features



https://www.fhwa.dot.gov/publications/research/safety/10047/

Figure 5-7: Constrictor Lane Narrowing Concept

https://www.fhwa.dot.gov/publications/research/safety/10047/

Roundabouts

Roundabouts can be added at intersections as intersection traffic control and as gateway features upon entering a city. Roundabouts can improve the operations and safety of intersections by slowing down traffic, decreasing delay, decreasing crashes, and decreasing the potential for severe crashes. They can also serve as gateway features to transition from a rural to urban setting and slow traffic as it enters a community. Examples of gateway type roundabouts are shown in Figures 5-8 and 5-9. There are three primary types of roundabouts: compact or mini, single lane, and multi-lane. The roundabouts should be designed as appropriate for the intersection volumes and setting. Any proposed roundabouts on the State Highway system, such as Hwy 23, will also need to be justified through the Intersection Control Evaluation (ICE) process.

Figure 5-8: Roundabouts on MN Hwy 284 in Waconia, MN

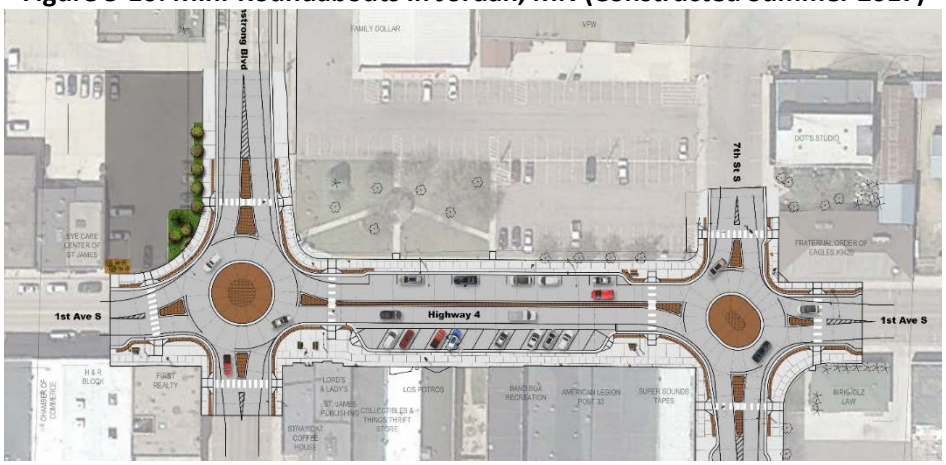
Bing Maps

Figure 5-9: Roundabout at MN Hwy 25/Settlers Parkway in Buffalo, MN

Bing Maps

Compact or Mini Roundabouts: Mini roundabouts operate similar to a larger roundabout but have fully transversable center islands and approach islands to accommodate truck traffic and larger vehicles. They are typically employed in low speed environments with lower volumes. An example of mini-roundabouts can be seen in the City of St. James on Hwy 4 as shown in Figure 5-10.

Figure 5-10: Mini-Roundabouts in Jordan, MN (Constructed Summer 2017)



MnDOT/Bolton & Menk: Hwy 4 Mini-Roundabout Landscape Layout

Single Lane or Multi-Lane Roundabouts: Single and multi-lane roundabouts can be more appropriate for higher speed environments and higher volume intersections. This makes them ideal intersection alternatives when transitioning from a rural to urban environment where speed also changes.

ICE Process: The Intersection Control Evaluation (ICE) process should be used to evaluate intersections in which an investigation of different traffic control measures is needed. ICEs are based on a technical and financial analysis of the intersection and are used to determine the optimum traffic control device for an intersection. The Minnesota Department of Transportation (MnDOT) provides an explanation of ICEs on their Intersection Control Evaluation (ICE) Technical Memorandum (No. 07-07-T-01). When choosing which intersection control types to evaluate, it is important to consider corridor-wide consistency so that driver expectation is maintained. A few scenarios are provided below to explain unique geometries that could be used. Various alternatives are described in depth and can be found in the FHWA's (Federal Highway Administration) April 2010 publication "Alternative Intersections/Interchanges: Informational Report (AIIR)".

C. Rural Corridor-Wide Strategies

Enhance Critical Signs for Increased Impact and Visibility

Implementation Schedule: Short to Mid-Term

Corridor-wide speed limit signing transitions at the cities of Foley, Foreston, and Milaca are inconsistent and may not be readily recognizable to motorists, especially those that driver the corridor infrequently. Additionally, the speed change transitions are extremely short in some areas with multiple speed limit changes. Taking a corridor-wide approach to speed changes would increase consistency across the corridor and would increase driver expectation.

Rural intersections between Foley and Milaca are skewed and results in a need for drivers to turn more than 90 degrees for look for traffic from one of the directions. Providing additional systems at select locations may provide additional notice to drivers that a gap exists in the Hwy 23 traffic. Additionally, a stop may be unexpected as motorists approach Hwy 23, especially with the long straight roadways that approach Hwy 23.

Speed Limit Signing: A short-term solution to this is to start by increasing the size of the speed limit signs where the speed is decreased. An example of this is on the east side of Foley where speeds decrease from 60 mph to 55 mph to 45 mph to 35 mph. A mid-term solution to this is to start by updating the consistency of speed change increments through the cities. An example would be to have 60 mph, 45 mph and 30 mph signing. This would require a speed study to determine the speed change locations to be consistent with the signing.

Intelligent Transportation System (ITS) Speed Technologies: In addition to speed limit signing updates, ITS technology can be used to accent the speed reductions in the mid-term. "Reduced Speed Ahead" flasher systems (see Figure 5-11) have been used and can bring more attention to reduced speed zones. Furthermore, speed detection systems can be installed to alert drivers of their speed (see Figure 5-12).

Figure 5-11: Reduced Speed Limit Ahead Blinker Sign

http://www.tapconet.com/solar-led-division/reduced-speed-limit-led-blinkersign

Figure 5-12: "Your Speed" Sign

MnDOT/HDR: US 12 Road Safety Audit, September 2015

Rural Intersection Conflict Warning System (RICWS): A RICWS is designed to reduce conflicts at rural, thru-stop intersections. They can be deployed to reduce right angle type crashes and have been proven to be successful in Minnesota. The system can be considered if there is limited sight distance or poor gap acceptance for the minor road driver is observed at the site (e.g. actual crashes and/or near misses). The system typically consists of signs and flashing lights alerting motorists on the major and minor approaches of "entering" and "approaching" traffic. Figures 5-13 and 5-14 show the sign configurations for the major and minor legs of the intersection, respectively. This device can also be considered if crashes or crash rates at the intersection are higher than expected over a 5-year period for a region. The intersections where they are deployed should have daily volumes no greater than 12,000 on the major approach and no greater than 3,000 on the minor approach.

Figure 5-13: RICWS Major Approach Sign

CH2M: DPSU Summary Document RICWS, September 2015

Figure 5-14: RICWS Minor Approach Sign

CH2M: DPSU Summary Document RICWS, September 2015

Stop Sign Improvements at Through-Stop Intersections: At through-stop intersections that have a large amount of right angle or turning related crashes due to disregard of traffic control devices, improvements may be made to bring more attention to the stop sign. As shown in Figure 5-15, a "Cross Traffic Does Not Stop" panel can be added beneath the stop sign to bring attention to the fact that mainline traffic does not stop.

Figure 5-15: Example of Cross Traffic Does Not Stop Signage

http://www.southernminn.com/waseca_county_news/news/article_33a7138c-77bc-5304- a48d-f9cfcbd59c1c.html

Improvements can be made to the actual stop sign panel as well to bring further attention. This can mean increasing the panel size or even adding LED red flashers around the perimeter of the stop sign as shown in Figure 5-16.

Figure 5-16: Stop Approach Activated LED Red Flashers on Stop Sign

http://safety.fhwa.dot.gov/intersection/resources/fhwasa11015/sa11015.cfm

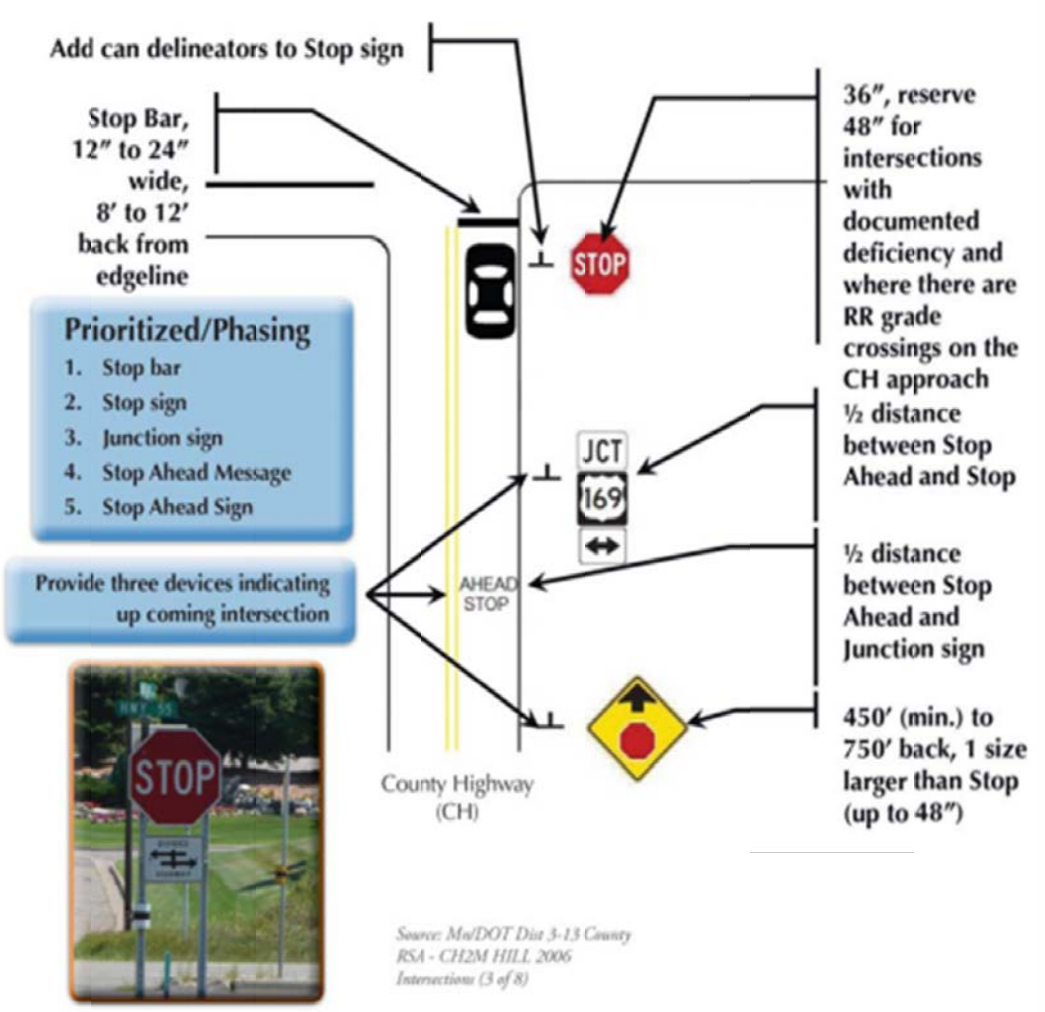
The flashing LED can be a great tool when used appropriately. However, it is not a magic bullet that can stop or even lower the number of severe crashes. Several studies, both local and national, have shown that the majority of intersection crashes are not taking place due to people blowing/rolling through intersections. The numbers vary, but it appears 66 to 75 percent of crashes are the result of poor decision making.

A general practice that MnDOT is trying to implement statewide is the practice of using enhanced signs and markings to help inform drivers that they are approaching a major highway. This methodology can be applied at low cost and can be effective at lowering the number of crashes, especially if the package is done to help people remember that they are coming to a major intersection. With the low cost, this concept can be applied to hundreds or even thousands of intersections.

Figure 5-17 shows MnDOT's standard signing approach that should be used at all stop sign

controlled side streets along the corridor.

Figure 5-17: Intersection Approach Signing



Enhance Speed Changes with Pavement Markings

Implementation Schedule: Short to Mid-Term

There is a concern over driver speeds on many areas of the corridor. Enhancing the pavement marking methods have been used in other areas of the country to reduce speeds in transition zones where speeds are reduced.

Transverse Pavement Markings: Transverse Pavement Markings are stripes that are painted across the roadway surface such that the distance between the stripes decreases as you drive downstream, as shown in Figure 5-18. The markings are placed on the roadway in a converging pattern creates an optical illusion of increasing speed as a driver travels downstream. This is due to the fact that the driver sees the painted bars at an increasing frequency. They have been shown to reduce speeds but must be reapplied when needed to maintain their effectiveness.

Figure 5-18: Transverse Pavement Markings

Virginia Center for Transportation Innovation and Research

Speed Limit Pavement Marking: Speed limits can be marked onto the roadway to give motorists additional information of the speed change as a way to improve motor compliance with the reduced speed limits normally mounted on posts adjacent to the roadway. While it can provide a reminder of the lawful speed limit and catches the attention of drivers, they do require continuous maintenance and are not as effective when faded or during the winter months.

Figure 5-19: Speed Limit Pavement Marking

My35 Central Texas News, TxDOT: My Interstate 35 Speed Limit Study, September 2015

Add centerline buffers, improved edgelines and rumble strips

Implementation Schedule: Mid to Long Term

While the corridor has not had a high proportion of head-on crashes, many of the head-on crashes that do occur are severe or fatal. By preventing lane departure crashes, the total frequency of fatal and severe crashes could be reduced significantly. Various measures can be taken to accomplish this.

Centerline Rumble Strips: Rumble strips are composed of a series of grooves installed in a series across the direction of travel and should be installed on rural segments. When drivers drift from their lanes, a vibration runs through the tires of the cars and warns the driver that they are departing from their lanes. Rumble strips can be used as a counter measure against drifting caused by driver distraction, drowsiness, or impaired visibility caused by poor weather conditions and can be installed at a low cost and on a short time-line. Figure 5-20 shows an example of what centerline rumble strips look like.

Figure 5-20: Centerline Rumble Strips

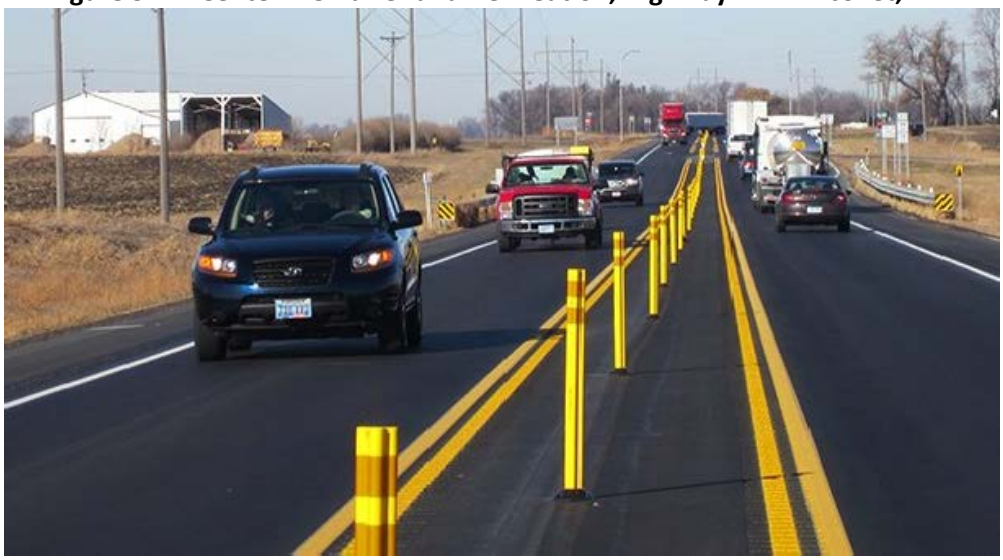
http://safety.fhwa.dot.gov/geometric/pubs/mitigationstrategies/chapter4/4_lane3showidth.cfm#FIGURE_33

Mumble Strips: Mumble strips are similar to rumble strips but are designed to be heard by the motorists in a vehicle traversing them but the sound to anyone else is subdued. They are sinusoidal in shape and are generally implemented in areas near homes or other development where traditional rumble strips can be a sound annoyance to residents. Centerline mumble strips can be used as a counter measure against drifting caused by driver distraction, drowsiness, or impaired visibility caused by poor weather conditions and can be installed at a low cost and on a short time-line.

Centerline Buffer Strip: If lane departure crashes still are prevalent after centerline rumble strips are installed, measures should be taken to separate opposing traffic, such as installing a centerline buffer strip. Centerline buffer strips provide drivers with more room to react to drifting, which further reduces the risk of head-on collisions. In combination with rumble strips, this has been a proven safety measure.

This methodology has been used on US 12 on the bypass through Long Lake and also on the rural, two-lane Highway 14 between Nicollet and Mankato, Minnesota. Figure 5-21 shows the four-foot centerline buffer that was installed on Highway 14 in 2012. To limit passing movements, tubular delineators were installed within the buffer zone. The results were successful. According to an interview with MnDOT engineer Scott Thompson in the Minnesota LTAP (Local Technical Assistance Program) Technology Exchange Spring 2015, Vol. 23 No. 2 Newsletter, fatal and serious injury crashes have been reduced by 100 percent and cross-centerline crashes have been reduced by almost 50 percent.

Figure 5-21: Centerline Buffer and Delineation, Highway 14 in Nicollet, MN



http://finance-commerce.com/2015/05/highway-14-expansion-set-to-begin/

Lane adjustments and widening may have to occur on part of the Hwy 23 Corridor to accommodate a 4-foot buffer width. In some situations, additional pavement is needed to accommodate an increase in cross-sectional width or reinforce shoulders. There should be at least a six-foot shoulder (including gravel portions) provided for enforcement to safely pull over as needed. Tubular delineators are beneficial in that they create more visual cues for drivers. A downside to tubular delineators is that they are susceptible to being hit by vehicles or snow plows and are resultantly a maintenance burden. Consideration should be given for whether tubular delineators are appropriate for Hwy 23 due to maintenance and passing zone concerns.

Figure 5-22: Example Geometry With and Without Four-Foot Buffer

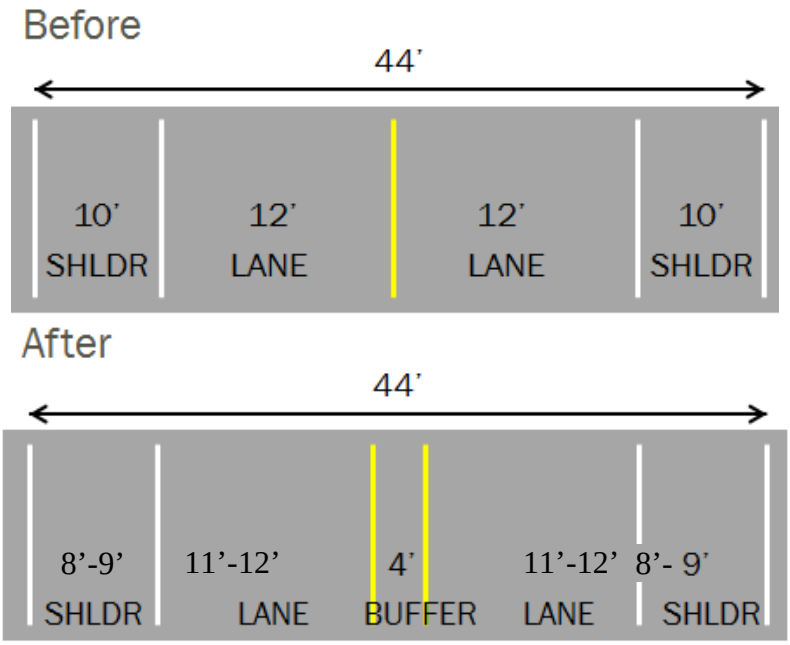


Diagram from TH 8 Road Safety Audit Post Audit Meeting (Presented February 2014, HNTB)

Passing Lanes

2+1 passing lane sections were reviewed to determine whether they are appropriate for the corridor based on their success on other corridors. They are typically installed in rural segments and can reduce crash rates by improving traffic operational efficiency. Passing lanes provide safe opportunities for drivers to pass slower moving traffic while optimizing cross sectional width. Only three lanes need to be paved to fit this configuration.

Passing lane sections are typically provided in one to two mile intervals and alternate between each direction of traffic. This configuration works well with a buffer or other sort of division between traffic because traffic does not need to use the opposing lane to pass slow moving vehicles. When developing a 2+1 section, strategized access management is crucial. The placement of turn lanes will have to be incorporated into the design and some four-way intersections will need to be modified such that through and left-turn movements are restricted at the one to two mile interval. Refer to Figure 5-23 for a visual of a possible 2+1 configuration.

Passing lanes can provide congestion relief when applied correctly. However, even building one passing lane at a time (a quasi-3 lane section), this corridor represents some difficult constraints.

1. Access and city locations are such that it would be difficult to get the minimum one mile needed to have a sufficient passing zone that is worth the effort.
2. Unless access points are properly addressed with turn lanes, passing lanes can lead to increased speeds and increased frequency and severity of crashes. To properly access these access points, excessive widening and cost would need to occur.
3. Travel reduction in this corridor would only amount to about 2 minutes per vehicle. If 50% of the 7,000 vehicles/day benefited by this whole 2 minutes, the benefit to cost

level significantly lower than 1.0. Additional information can be found in Appendix E.

Passing lanes are not a recommended strategy for Hwy 23.

Figure 5-23: 2+1 Passing Lane

http://www.monroemonitor.com/2012/12/27/does-sweden-have-the-answer-for-u-s-2/

Rigid Barrier System

A barrier system was reviewed to determine whether it is appropriate for the corridor based on its success on other corridors. A rigid barrier system is applied down the center of the roadway and would typically be placed within a buffer lane arrangement. This can be applied in coordination with passing lanes. Figure 5-23 shows a cable barrier but this could also be a rigid wall barrier. The placement of the barrier prevents any passing and would reduce access onto Highway 23, making all vehicles turn right, which can reduce crashes. Vehicles would then need to make a u-turn at a designated location, which can be difficult to accomplish on a narrow highway. To this make work, it would be very costly. Each break in the barrier would require end-cap protection, u-turn locations or roundabouts. As with the passing lanes, u-turn locations would be at one to two mile spacing. Additional information can be found in Appendix E on the costs of a rigid barrier system.

Rigid barrier systems are not a recommended strategy for Hwy 23.

D. Segment A (Foley)

Table 5-1: Segment A (Foley) Recommended Strategies Summary

	Proposed Strategy	Concern Addressed
Segment A: Foley	**Short Term**	
	Develop a community roadway plan	Implementation of strategies
	Restripe as 3-lane roadway: 1st Ave to 8th Ave/Penn St	High Speeds Rear-end, left turn, and right angle crashes
	Add temporary curb extensions at 2nd, 3rd, 4th, Broadway, 8th/Penn	High speeds Pedestrian safety
	Improve intersection lighting	Crashes attributed to poor lighting
	Enhance speed reduction changes on east side of the city with signing and striping	High speeds
	Compact or mini roundabouts at Norman and Broadway	High speeds Pedestrian safety
	Constrictor lane narrowing or compact roundabout at 8th/Penn	High speeds Pedestrian safety
	Constrictor lane narrowing at 13th Ave	High speeds Head-on crashes
	Review speed limits once changes implemented	High speeds
	Mid-Term	
	Enhance right turn lanes	Rear-end and right turn crashes
	Enhance speed reduction changes on east side of the city with ITS signing as appropriate	High speeds
	Pedestrian crossing improvements at Hwy 25, 4th, Broadway, 8th/Penn	Pedestrian safety
	3-lane roadway: 8th Ave/Penn St to 13th Ave (west of 13th Ave: extend culvert, flatten slope, remove guardrail)	High Speeds Rear-end, left turn, and right angle crashes
	Signal improvements at Hwy 25	Pedestrian safety Rear-end, left turn and right angle crashes
	Long Term	
	Transition corridor to context sensitive urban roadway	High speeds
	Tight urban 3-lane roadway section (10' thru lane, 11' turn lane, 10' thru lane)	High speeds Rear-end, left turn and right angle crashes Pedestrian safety
	Median east of 13th Ave	High speeds Head-on crashes
	Complete Streets design (crossing locations, sidewalk, street furniture, lighting)	High speeds Pedestrian safety
	Continuous lighting from Norman Ave to Broadway Ave	Crashes attributed to poor lighting
	Gateway features (signing, lane narrowing)	High speeds
	Improve intersection lighting at 9th, 11th, Lord, and 13th	Crashes attributed to poor lighting
	Roundabouts at Norman, 8th/Penn, possibly Hwy 25	High speeds Rear-end, left turn and right angle crashes Snow/ice related crashes
	Review speed limits once changes implemented	High speeds

Develop a Community Roadway Plan through the City of Foley

Short Term

- This is a commitment from the City both financially and politically
- Focus on pedestrian and urban characteristics
- Helps to guide the future reconstruct by MnDOT

Long Term

- Develop design elements to slow traffic including narrower lanes, curb extensions, and roundabouts as intersection control
- Provide for gateway and roadway features that transition to an urban roadway through the city including curbs, median sections, curb extensions, signage, and roundabouts
- Reduce the quantity of traffic conflict points by reducing access at some intersections
- Focus on pedestrian crossing locations

Figure 5-24: Hwy 23 through Foley

Transition Corridor to a Context Sensitive Urban Roadway

Short Term

- Restripe 3-Lane: Potentially restripe 1st Ave to 13th Avenue as 3 lane section (10'-11'-10'). Remove bypass lanes. Once this is complete, re-evaluate speed limits and adjust accordingly.

Long Term

- 3-Lane Roadway: Reconstruct as a 3 lane section (10'-11'-10') with right turn lanes at specific intersections. This 3-Lane roadway to be extended from Hwy 25 to 13th Avenue. This will require widening the bridge and adding sections to the culvert west of 13th Ave. Guardrail should be removed if possible due to the widening and the urban section design. Once this is complete, re-evaluate speed limits and adjust accordingly.
- Add Median: Reconstruct Hwy 23 east of 13th Ave with a median. Design to a lower speed. Once this is complete, re-evaluate speed limits and adjust accordingly.
- Complete Streets Design: Add sign walks, street furniture, lighting, etc., to get the roadway to have a urban feel. This will take a strong commitment from Foley, both financial and political. When MnDOT comes in for reconstruct, the City will need to focus on pedestrian/urban characteristics. A trail/sidewalk along the north side of Hwy 23 from 8th St/Penn Ave to 13th Ave may be acceptable, but trail on both sides of the highway should be considered long term to get students to the crossing at 8th Ave/Penn St.

Enhance Right Turn Lanes

Short Term

- Add Right Turn Lane Arrows: differentiate right turn lanes from bypass lanes

Mid-Term

- Reconstruct Right Turn Lanes: where needed following 3-lane section restriping. Eliminate unneeded right turn lanes to decrease pedestrian crossing distance.

Enhance Lighting

Short Term

- Intersection Lighting: Provide enhanced lighting at critical intersection and pedestrian crossing locations. Provide lighting on both sides of the roadway in advance of the pedestrians so the light shines on them from the direction of traffic.

Long Term

- Continuous Lighting: An overall assessment of corridor lighting should take place. Provide continuous lighting from Norman Ave to Broadway Ave. Having a well-lit corridor can greatly increase driver response time because it allows drivers to better see obstacles and road geometry changes ahead. A corridor lighting plan should be developed to acknowledge light-deficient regions.

Enhance Speed Reduction Changes

Short Term

- Transverse Pavement or Speed Limit Markings: Provide pavement markings to enhance the speed changes on Hwy 23 entering Foley from the east. The speed changes can be unexpected to motorists.
- Speed Limit Signing: Increase the size of the speed limit signs where the speed is decreased on the east side of Foley.

Mid-Term

- Intelligent Transportation System (ITS) Speed Technologies: Implement ITS enhanced signs to alert drivers of changes in speed. These may not be needed if other strategies are employed or speed limits are revised in combination with other roadway features.

Roundabouts

Roundabouts can be added as both intersection traffic control and as gateway features upon entering the City of Foley. Potential gateway roundabout locations include Hwy 25, Norman Ave, and 8th Ave/ Penn St. These can be used to transition to an urban section and slow traffic as it enters the city. The roundabouts will need to be justified through the Intersection Control Evaluation (ICE) process.

Short Term

- Compact or Mini Roundabouts: Possible mini-roundabout locations include Norman Ave/2nd Ave, Broadway Ave, and 8th Ave/Penn St. The ones at Norman/2nd and 8th/Penn may be temporary until single lane roundabouts could be implemented with other projects.

Long Term

- Roundabouts: can be provided at City Limits to trigger drivers to prepare to enter an urban environment. This includes providing single lane roundabouts at Norman Ave and 8th Ave/Penn Ave. A possibility would also be to extend the transition further west to Hwy 25, which would likely necessitate a multi-lane roundabout but would provide a good transition point from a rural high speed 4-lane divided highway to a lower speed undivided urban highway.

Review the speed limit once changes implemented

Short to Long Term

- Speed Limit Review: once changes occur on the corridor, the speed limit transitions and speed limits should be reviewed and updated based on the traffic changes.

E. Segment A Intersections (Foley)

Hwy (TH) 25

The intersection of Hwy 25 was recently reconstructed in 2012 when Hwy 23 was widening to a 4-lane divided highway west of Foley.

Figure 5-25: Hwy 23 at Hwy 25, Foley

Mid-Term

- Update Pedestrian Facilities
    - Update crosswalk pavement markings, add pedestrian push buttons and pedestrian indications
    - Provide ADA compliant connection from shoulder to existing pedestrian facilities: connect the pedestrian facilities to the roadway shoulders
- Signal Enhancements
    - Add reflectorized backplates on signal heads on all approaches, as this is the first signal for a long time in all directions
    - Work with law enforcement on blue enforcement light installation and locations
    - Red Light Running Technology Assistance (in-development by MnDOT)

Long Term

- Roundabout: evaluate potential for a roundabout at the location to provide a gateway feature into Foley and slow traffic on both Hwy 23 and Hwy 25.

Norman Avenue

Short Term

- Compact or Mini Roundabout: Construct a mini roundabout within the intersection.

Mid-Term

- Extend urban section for westbound past intersection

Long Term

- Roundabout: Construct single lane roundabout and connect with Norman Ave north of Hwy 23 – north of 2nd Ave as entryway feature to Foley and reduce speeds

2nd Avenue

Short Term

- Form curb extensions with delineators
- Restripe with narrower thru lanes

Mid-Term

- Connect sidewalk to 3rd Ave and 4th Ave
- Bring curb in and eliminate shoulder
- Make entire section between 2nd Ave and 9th Ave a 3-lane section with a two-way left turn lane instead of dedicated left turn lanes for one direction only
- Install curb extensions where possible

Long Term

- Roundabout (see Norman Ave)
- Dead end 2nd Avenue south of Hwy 23 with roundabout
- Connect frontage road to Norman Ave on north side of TH 23 with pedestrian facility

3rd Avenue

Short Term

- Form curb extensions with delineators

Mid-term:

- Connect sidewalk to 2nd Ave and 4th Ave
- Bring curb in and eliminate shoulder
- Install curb extensions where possible

Long term:

- Reconstruct as tight urban section
- Add street furniture, pedestrian scale lighting

4th Avenue and Broadway Avenue

Short Term

- Trim foliage east of Casey's General Store: foliage impacts the sight lines to crossing at Broadway Ave
- Improve crosswalk markings: zebra or continental blocks
- Rebuild NE corner of Broadway Ave: remove drainage issues
- Add left side approach crosswalk signage
- Form curb extensions with delineators
- Mini-Roundabout at Broadway Ave

Mid-Term

- Eliminate westbound right turn lanes
- Restripe crosswalks on east side of intersections, remove west side crossings
- Bring curb in and eliminate shoulder
- Make entire section between 2nd Ave and 9th Ave a 3-lane section instead of turn lanes
- Install curb extensions where possible
- Add sidewalk on north and south side of Hwy 23 between 2nd and Broadway Ave

Long Term

- Reconstruct as tight urban section
- Add street furniture, pedestrian scale lighting

8th Avenue/Penn Street

Figure 5-26: Hwy 23 at 8th Ave/Penn St, Foley

Short Term:

- Improve crosswalk markings: zebra or continental blocks
- Add lighting to west side
- Add left side approach crosswalk signage
- Constrictor lane narrowing

Mid Term:

- Mini or compact roundabout (short to mid-term)
- Remove eastbound right turn lane
- Install curb extensions where possible
- Add curb extensions on west side of intersection
- Review overhead RRFB potential once speeds reduced and pedestrian demand increased

Long Term

- Roundabout as gateway to the city with smaller roundabouts in town

8th Avenue/Penn Street to 13th Avenue

Short Term

- Extend no passing zone to east of 13th Ave
- Consider removing bypass lanes
- Add Gateway signing into Foley, westbound into Foley

Mid-Term

- Restripe as a 3-lane roadway section (including across bridge)
- Widen roadway at bridge to accommodate 3-lane (west of 13th Ave) – extend culvert, flatten slopes, remove guardrail
- Make entire section between 2nd Ave and 9th Ave a 3-lane section instead of turn lanes
- Install curb extensions where possible
- Add off-road trail between 9th Ave and 8th Ave – north/west side
- Multi-Use trail should be considered out to fringe of town
- Start median curbing back into the horizontal curve, coinciding with gateway signing

Long Term:

- Add trail/sidewalk along Hwy 23 – north/west side from 8th to 13th
- Reconstruct as urban section, add curb and gutter, extend 3-lane section to 13th Ave, add raised median east of 13th Ave
- Provide intersection lighting at 9th Ave, 11th Ave and Lord Ave

13th Avenue

Short Term

- Restripe the left lane as a left turn lane at 13th Ave
- Restripe the bypass lane as the through lane at 13th Ave
- Add intersection lighting at 13th Ave onto Hwy 23
- Constrictor lane narrowing

Mid-Term

- Widen pavement on NE and SW corners for right turns at 13th Ave/driveway

Long Term

- Improved intersection lighting

East of 13th Avenue

Short Term

- Extend no passing zone to east of 13th Ave
- Clear the foliage for sight lines east of 13th and north of Hwy 23

Long Term

- Reconstruct as urban section, add curb and gutter (40 mph design speed)
- Add raised median from 13th Ave to east of the curve (approx. 1,600 ft.), median openings at driveways

F. Segments B, C, and D (Foley to Foreston)

Table 5-2: Segments B, C and D Recommended Strategies Summary

	Proposed Strategy	Concern Addressed
Segments B, C and D: Foley to Foreston	**Short Term**	
	Restripe approach lanes at intersections from through/right lanes to left/through lanes: CR 66, Ronneby Rd, CSAH 7, CR 53, CSAH 9	Head-on, rear-end, and left turn crashes
	Intersection lighting	Crashes attributed to poor lighting
	Enhance speed reduction changes on east side of the city of Foley with signing and striping	High speeds
	Centerline improvements (review no passing zones, rumble strips)	Head-on crashes Driver inattention
	Visibility and sight line improvements for stop approaches	Right angle crashes
	Mid-Term	
	Rural Intersection Conflict Warning System: Ronneby Rd	Right angle crashes
	Enhance speed reduction changes on east side of the city of Foley and west side of Foreston with ITS signing as appropriate	High speeds
	Long Term	
	Roadway widening (left and right turn lanes, centerline buffer strip, rumble strips)	Head-on, rear-end, left turn and right angle crashes
	Curb and raised median east of 13th Ave	High speeds Head-on crashes

Roadway Vision

Long Term

- Roadway Widening: Widen the rural sections of the roadway to have 8' shoulder, 12' lanes, full right and left turn lanes at major/county road intersections, 4-12' buffer/gore areas, centerline and edgeline rumbles.
- Add Median and Curb: Reconstruct Hwy 23 east of 13th Ave as an urban section with curb and a median approximately 1,600 feet east of 13th Ave. Once this is complete, re-evaluate speed limits and adjust accordingly.

Enhance Speed Reduction Changes

Short Term

- Transverse Pavement or Speed Limit Markings: Provide pavement markings to enhance the speed changes on Hwy 23 entering Foley from the east. The speed changes can be unexpected to motorists.
- Speed Limit Signing: Increase the size of the speed limit signs where the speed is decreased on the east side of Foley.

Mid-Term

- Intelligent Transportation System (ITS) Speed Technologies: Implement ITS enhanced signs to alert drivers of changes in speed. These may not be needed if other strategies are employed or speed limits are revised in combination with other roadway features.

Centerline Improvements

Short Term

- No Passing Zones: Extend no-passing zones through rural city centers and areas with safety issues with passing. Employ to reduce passing left turning vehicles. This may include extending through Ronneby and Oak Park as appropriate.
- Add Tube Delineators: In the summer months, tube delineators could be added as an additional enhancement. May become a maintenance issue.
- Centerline Rumble Strips: Employ centerline rumble strips to reduce drifting into oncoming lanes

Long Term

- Centerline Buffer Strip: Provide a median Buffer of 4-12', similar to what was done in Mankato to provide additional space between lanes to allow for more recovery time.

Add Turn Lanes at Public Street Intersections

Short Term

- Restriped Left Turn Lanes: provide for left turn lanes at public street intersections including CR 66, Ronneby Road, CSAH 7, CR 53/Ironwood Rd in Oak Park, and CSAH 9. Left turn lanes provide a refuge for potentially stopped left turning traffic. The through lanes would then be unhindered by the left turning vehicles potentially reducing rear-end crashes and illegal bypassing in the right turn lane. Existing right

turn lanes would be removed. In the short term, the addition of left turn lanes can be accomplished two different ways:

  - Restripe left turn lanes down the center of the roadway: left turns oppose each other and is more expected but there would be grooves where existing pavement markings are located, potentially causing confusion during dark and wet weather conditions. Some roadway widening would be necessary on the both sides of the intersection to move traffic to the right of the left turn lanes. Extend transition (shoulders) as necessary past intersections to bring thru lane back.
  - Restripe the through lanes as left turn lanes and the right turn lanes as through lanes: left turns would not oppose each other potentially causing sight line issues and vehicles could go through the intersection in the left turn lane. Pavement markings would be placed similar to existing pavement markings. Some roadway widening would be necessary on each side of the intersection to move traffic to the right of the left turn lanes. Extend transition (shoulders) as necessary past intersections to bring thru lane back. Due to the additional widening necessary, this may be a mid-term strategy.

- Add Right Turn Arrows: Supplement the right turn lanes with right turn arrows if the proposed left turn lanes provide enough space for right turn lanes or prior to the left turn lane changes to differentiate a right turn lane from a bypass lane.

Long Term

- Add Left and Right Turn Lanes: Reconstruct the public street intersections with left and right turn lanes. This widens the roadway cross section.

Figure 5-27: Hwy 23 at CR 6/Ronneby Road

Bing Maps

Enhance Lighting

Short Term

- Intersection Lighting: Provide enhanced lighting at critical intersection locations.

Visibility and Sight Line Improvements

These improvements could be employed at the more critical intersections along the corridor including CR 66, Ronneby Road, CSAH 7, and CSAH 9 to increase visibility and sight lines.

Short Term

- Pork Chop Islands: On intersections with heavier skew, build small pork chop islands and pull the stop sign in to provide improved sight lines and visibility
- Pull Up the Stop Bars: Place where sight lines open up and give drivers a better, longer view

Mid-Term

- Rural Intersection Conflict Warning System (RICWS): A RICWS is designed to reduce conflicts at rural, thru-stop intersections. They should be selectively deployed to reduce right angle type crashes where there is limited sight distance or poor gap acceptance such as at Ronneby Road.

G. Segment E (Foreston)

Table 5-3: Segment E (Foreston) Recommended Strategies Summary

	Proposed Strategy	Concern Addressed
Segment E: Foreston	**Short Term**	
	Possible no-passing zone and mumble strips	Head-on and sideswipe crashes
	Add turn lane arrows (differentiate from bypass lanes)	Rear end, sideswipe, and right turn crashes
	Enhance speed reduction changes with signing and striping	High speeds
	Review speed limits once changes implemented	High speeds
	Mid-Term	
	Restripe as 3-lane roadway: CR 18 (south leg) to CR 18 (north leg)	High speeds Rear-end, left turn, and right angle crashes
	Continuous lighting: 1st St S to CR 18 (north leg)	Crashes attributed to poor lighting Pedestrian safety
	Enhance speed reduction changes with ITS signing as appropriate	High speeds
	Review speed limits once changes implemented	High speeds
	Long Term	
	3-lane roadway: CR 18 (south leg) to CR 18 (north leg)	High speeds Rear-end, left turn, and right angle crashes
	Median as pedestrian refuge: Main Ave	Pedestrian safety
	Review speed limits once changes implemented	High speeds

Roadway Vision

Short Term

- Focus on pedestrian characteristics
- Helps to guide the future intersection improvements, and mill and overlay by MnDOT

Long Term

- Develop design elements to slow traffic including narrower lanes
- Provide for gateway and roadway features that transition to a suburban roadway through the city including left turn lanes and potential median sections
- Focus on pedestrian crossing locations

Figure 5-28: Hwy 23 through Foreston

Bing Maps

Transition Corridor to a Context Sensitive Rural Roadway

Short Term

- No Passing Zones: Extend no-passing zones through Foreston from CR 18 (south leg) to CR 18 (north leg). Employ to reduce passing left turning vehicles or passing where there are multiple close intersections.
- Centerline Mumble Strips: Employ centerline mumble strips to reduce drifting into oncoming lanes as appropriate.

Mid-Term

- Restripe 3-Lane: Potentially restripe from CR 18 to CR 18 as a 3 lane section (12'-14'-12'). Remove bypass lane at 145th Ave/CR 18. Remove right turn lanes at Main Ave, 1st St and 2nd Ave. Once this is complete, re-evaluate speed limits and adjust accordingly.

Long Term

- 3-Lane Roadway: Reconstruct as a rural 3 lane section (12'-14'-12') with right turn lanes at specific intersections. Once this is complete, re-evaluate speed limits and adjust accordingly.
- Add Median: Add median as needed for a pedestrian refuge area and slow traffic at critical locations. Once this is complete, re-evaluate speed limits and adjust accordingly.

Enhance Right Turn Lanes

Short Term

- Add Right Turn Lane Arrows: differentiate right turn lanes from bypass lanes

Mid-Term

- Reconstruct Right Turn Lanes: where needed following 3-lane section restriping

Enhance Lighting

Long Term

- Continuous Lighting: An overall assessment of corridor lighting should take place. Continuous lighting may be appropriate from 1st St S to CR 18 (north leg). Having a well-lit corridor can greatly increase driver response time because it allows drivers to better see obstacles and road geometry changes ahead. A corridor lighting plan should be developed to acknowledge light-deficient regions.

Enhance Speed Reduction Changes

Short Term

- Transverse Pavement or Speed Limit Markings: Provide pavement markings to enhance the speed changes on Hwy 23 entering Foreston. The speed changes can be unexpected to motorists.
- Speed Limit Signing: Increase the size of the speed limit signs where the speed is decreased.

Mid-Term

- Intelligent Transportation System (ITS) Speed Technologies: Implement ITS enhanced signs to alert drivers of changes in speed. These may not be needed if other strategies are employed or speed limits are revised in combination with other roadway features.

Review the speed limit once changes implemented

Short to Long Term

- Speed Limit Review: once changes occur on the corridor, the speed limit transitions and speed limits should be reviewed and updated based on the traffic changes.

H. Segment E (Foreston to Milaca)

Table 5-4: Segment E Recommended Strategies Summary

	Proposed Strategy	Concern Addressed
Segment E: Foreston to Milaca	**Short Term**	
	Intersection lighting	Crashes attributed to poor lighting
	Enhance speed reduction changes with signing and striping	High speeds
	Centerline improvements (review no passing zones)	Head-on crashes
	Mid-Term	
	Stripe left turn lanes, remove bypass lanes	Head-on, rear-end, and left turn crashes
	Centerline rumble strips	Head-on and sideswipe crashes
	Long Term	
	Roadway widening (left and right turn lanes, centerline buffer strip, rumble strips)	Head-on, sideswipe, rear-end, left turn and right angle crashes
	Rural 3-lane roadway section: CR 112 to CSAH 5	High Speeds Rear-end, left turn, and right angle crashes

Roadway Vision

Long Term

- Roadway Widening: Widen the rural sections of the roadway to have 8' shoulder, 12' lanes, full right and left turn lanes at major/county road intersections, 4-12' buffer/gore areas, centerline and edgeline rumbles.
- 3-Lane Roadway: Reconstruct as a rural 3 lane section (12'-14'-12') from CR 112 to CSAH 5. Add right turn lanes at specific intersections. Once this is complete, re-evaluate speed limits and adjust accordingly.

Enhance Speed Reduction Changes

Short Term

- Transverse Pavement or Speed Limit Markings: Provide pavement markings to enhance the speed changes on Hwy 23 entering Milaca. The speed changes can be unexpected to motorists.
- Speed Limit Signing: Increase the size of the speed limit signs where the speed is decreased.

Centerline Improvements

Short Term

- No Passing Zones: Extend no-passing zones through areas with public street connections with higher volumes or safety issues with passing. Employ to reduce passing left turning vehicles. This includes extending through 130th Ave to CR 112.

Mid-Term

- Centerline Rumble Strips: Employ centerline rumble strips in no-passing zones to

reduce drifting into oncoming lanes

Long Term

- Centerline Buffer Strip: Provide a median Buffer of 4-12', similar to what was done in Mankato to provide additional space between lanes to allow for more recovery time.

Add Turn Lanes at Public Street Intersections

Mid-Term

- Restriped Left Turn Lanes: provide for left turn lane at 130th Ave and CR 112. Left turn lanes provide a refuge for potentially stopped left turning traffic. The through lanes would then be unhindered by the left turning vehicles potentially reducing rear-end crashes and illegal bypassing in the right shoulder. The addition of a left turn lane at 130th can be accomplished through restriping the westbound through lane as a left turn lane and widening the roadway to the north. The left turn lane at CR 112 would require eliminating the bypass lane and widening to the south on each side of the intersection to transition past the left turn lane.

Long Term

- Add Left and Right Turn Lanes: Reconstruct the public street intersections with left and right turn lanes. This widens the roadway cross section.

Enhance Lighting

Short Term

- Intersection Lighting: Provide enhanced lighting at critical intersection locations.

I. Segment F (Milaca West)

Table 5-5: Segment F (Milaca West) Recommended Strategies Summary

	Proposed Strategy	Concern Addressed
Segment F: Milaca West	**Short Term**	
	Develop a community roadway plan	Implementation of strategies
	Stripe left turn lanes: Central, 3rd Ave, School	Head-on, Rear-end, and left turn crashes
	Restripe as 3-lane roadway: Central Ave to 3rd St SE	High Speeds Rear-end, left turn, and right angle crashes
	Pedestrian crossing improvements: 3rd Ave (ramps, landings)	Pedestrian safety
	Mid-Term	
	Pedestrian crossing enhancements: 3rd Ave, Central	Pedestrian safety
	Signal enhancements: Central	Rear-end and left turn crashes
	Long Term	
	Transition corridor to context sensitive urban roadway	High speeds
	Tight urban 3-lane roadway section (10' thru lane, 11' turn lane, 10' thru lane): Rum River to 3rd Ave, Central to 3rd St SE	High speeds Rear-end, left turn and right angle crashes Pedestrian safety
	Construct left turn lanes: Central, 3rd Ave, School	Rear-end and left turn crashes
	Complete Streets design (crossing locations, sidewalk, street furniture, lighting)	High speeds Pedestrian safety
	Gateway features (signing, lane narrowing)	High speeds
	Roundabout: 3rd Ave	High speeds Rear-end, left turn and right angle crashes
	Pedestrian underpass: east of 3rd Ave	Pedestrian safety

Develop a Community Roadway Plan through the City of Milaca

Short Term

- This is a commitment from the City both financially and politically
- Focus on pedestrian and urban characteristics
- Helps to guide the future reconstruct by MnDOT

Long Term

- Develop design elements to slow traffic including narrower lanes, curb extensions, and roundabouts as intersection control
- Provide for gateway and roadway features that transition to an urban roadway through the city including curbs, median sections, curb extensions, signage, and roundabouts
- Reduce the quantity of traffic conflict points by reducing access at some intersections
- Focus on pedestrian crossing locations
- Extend sidewalk along Hwy 23

Figure 5-29: Hwy 23 at Central Avenue, Milaca

Transition Corridor to a Context Sensitive Urban Roadway

Short Term

- Restripe 3-Lane: Potentially restripe from Central Ave to 3rd St SE as 3 lane section (10'-11'-10'). Provide parking on the north side of the highway.

Long Term

- 3-Lane Roadway: Reconstruct as a 3 lane section (10'-11'-10').
- Add Curb: Transition Hwy 23 to an urban section east of the Rum River
- Complete Streets Design: Add sign walks, street furniture, lighting, etc., to get the roadway to have an urban feel. This will take a strong commitment from Milaca, both financial and political. When MnDOT comes in for reconstruct, the city will need to focus on pedestrian/urban characteristics.

Add Left Turn Lanes

Short Term

- Restriped Left Turn Lanes: provide for left turn lanes at the school access, eastbound at 3rd Ave, and at Central Ave. Left turn lanes provide a refuge for potentially stopped left turning traffic. The through lanes would then be unhindered by the left turning vehicles potentially reducing rear-end crashes.
    - 3rd Ave: Restripe the through lanes as a left turn lane and the right turn lane as a through/right lane. Existing right turn lane would be removed. Some roadway widening would be necessary on each side of the intersection to move traffic to the right of the left turn lane. Extend transition (shoulders) as necessary past intersections to bring thru lane back. Due to the additional widening necessary.
    - School Access: Restripe the through lane as the left turn lane and the bypass lane as a through/right lane. Some roadway widening would be necessary on

each side of the intersection to move traffic to the right of the left turn lanes. Extend transition (shoulders) as necessary past intersections to bring thru lane back.

- Central Ave: Restripe the left turn lanes down the center of the roadway: left turns oppose each other and is more expected but there would be grooves where existing pavement markings are located, potentially causing confusion during dark and wet weather conditions.

Long Term

- Add Left Turn Lanes: Reconstruct the school access, 3rd Ave, and Central Ave with left lanes.

Long Term

- Roundabout: Construct single lane roundabout at 3rd Ave

J. Segment F Intersections (Milaca West)

3rd Avenue SW

Short Term

- Move stop bar for westbound to east side of intersection
- Move stop bar for eastbound 20' back from crosswalk due to turn lane
- Improve pedestrian facilities (curb ramps, landing)

Mid-Term

- Restripe eastbound through lane as left turn lane
- Restripe eastbound right turn lane as through lane
- Extend transition (shoulder) as necessary past intersection to bring thru lane back
- Review overhead RRFB potential

Long Term

- Add left turn lanes
- Explore pedestrian underpass east of 3rd Avenue
- Explore feasibility of constructing a roundabout

Central Avenue

Mid-Term

- Restripe with opposing left turn lanes
- Signal Enhancements
  - Add reflectorized backplates on signal heads on all approaches, as this is the first signal for a long time in all directions
  - Add left turn flashing yellow arrows

- Improve pedestrian facilities (APS, truncated domes, landing areas)

Long Term

- Add left turn lanes

K. Segment G (Milaca East)

Table 5-6: Segment G (Milaca East) Recommended Strategies Summary

	Proposed Strategy	Concern Addressed
Segment G: Milaca East	**Short Term**	
	Restripe left turn lane: CSAH 2	Rear-end and left turn crashes
	Enhance right turn lanes (turn arrows)	Rear-end, sideswipe, and right turn crashes
	Long Term	
	Transition to an urban roadway: 10th Ave to CSAH 2	High speeds
	Add trail or sidewalk: 10th Ave to 1st St	Pedestrian safety
	Roundabout: CSAH 2 or 10th Ave	High speeds Rear-end, left turn, and right angle crashes Snow/ice related crashes
	CSAH 2 RA with 10th Ave as ¾ access	
	10th Ave RA with CSAH 2 full access	
	Continuous lighting: Hwy 169 to CSAH 2	Crashes attributed to poor lighting
	Add left turn lane at CSAH 2 (if no roundabout)	Rear-end and left turn crashes

Roadway Vision

Long Term

- Suburban Roadway: Transition roadway from rural to urban. Consider the development of a trail or sidewalk facility to connect 10th Ave to 1st St

Figure 5-30: Hwy 23 at 10th Ave/Milaca Junction

Add Left Turn Lanes

Short Term

- Restriped Left Turn Lane: Left turn lanes provide a refuge for potentially stopped left turning traffic. The through lanes would then be unhindered by the left turning vehicles potentially reducing rear-end crashes. At CSAH 2, restripe the through lane as the left turn lane and the bypass lane as a through lane. Some roadway widening would be necessary on each side of the intersection to move traffic to the right of the left turn lane. Extend transition (shoulders) as necessary past the intersection to bring thru lane back.

Long Term

- Add Left Turn Lane: Reconstruct CSAH 2 with left lanes if not reconstructed as other intersection option.

Enhance Right Turn Lanes

Short Term

- Add Right Turn Lane Arrows: differentiate right turn lanes from bypass lanes

Roundabouts

Long Term

- Roundabout: Can be added as gateway features upon entering the City of Milaca from the east. Potential gateway roundabout locations include either CSAH 2 or 110^{th}/10^{th} Ave SE. These will be used to transition to an urban section and slow traffic as it enters the city. A roundabout at either location will need to be justified through the Intersection Control Evaluation (ICE) process. A roundabout at CSAH 2 should be combined with a 3/4 access at 10^{th} Ave. The wetland and cemetery may impact the feasibility of a roundabout at CSAH 2.

Enhance Lighting

Long Term

- Continuous Lighting: An overall assessment of corridor lighting from the Hwy 169 interchange to CSAH 2 should take place. Having a well-lit corridor can greatly increase driver response time because it allows drivers to better see obstacles and road geometry changes ahead. A corridor lighting plan should be developed to acknowledge light-deficient regions.

Community Meeting

A community meeting was held on September 11, 2017 to present the results of the Road Safety Audit to the public. A summary handout from the meeting and comments received are provided in Appendix G.

VI. CONCLUSION

The primary goals of a road safety audit process is to eliminate fatal and serious injury crashes and reduce the total number of crashes on a roadway. As stated by the Federal Highway Administration (FHWA), "the aim of an RSA is to answer two primary questions:

1. What elements of the road may present a safety concern: to what extent, to which road users, and under what circumstances?
2. What opportunities exist to eliminate or mitigate identified safety concerns?"

The road safety audit process is used to determine if the frequency and severity of crashes is higher than average as compared to similar locations within the state, determine the primary factors for the crashes, and propose short, mid, and long term recommendations on specific strategies to improve the safety of the corridor. All aspects of roadway safety are considered to reduce crash risk.

This report is intended to be used as a tool to provide recommendations and guidance on safety strategies that can be employed at specific locations along Hwy 23. The priorities in each area of the corridor should be continually evaluated to determine when the specific strategies should be deployed given the timing and resources. Short term strategies are usually low-cost, high benefit, and can often be applied corridor-wide and system wide.

Overall, crashes on the corridor have continually decreased over the past 10 years. This is likely a cause of safety improvements that have been implemented over the years. Approximately 30 percent of the crashes on the corridor were rear-end and 25 percent were right angle. There have been eight severe crashes between 2011 and 2017, with a substantial increase in 2016 and the first half of 2017. Half of the severe crashes were head-on. Centerline remedies such as installing rumble strips, adding a buffer between opposing directions of traffic, and the installation of medians can reduce this number of head-on crashes.

63 percent of all crashes on the corridor were junction related and several intersections were flagged as being higher risk based on high crash rates or having a high frequency of crashes. Safety recommendations were made for these intersections on a case- by-case basis. Some low-cost solutions, such as updating sign sizing and spacing on approaches, should be applied to all intersections.

Crash data showed that 31 percent of all crashes occurred in Milaca while 18 percent occurred in both Foley and Maywood Township (east of Foley). The majority of the severe crashes occurred in Foley and Foreston. The high frequency of crashes and severe crashes in those areas is consistent with areas of reduced speed limits as compared to the rest of the corridor. Roadway context strategies including a 3-lane roadway within Foley, Foreston, and Milaca are recommended along with features to enhance the speed limit reductions. Ultimately, the cities of Foley, Foreston and Milaca should plan for context sensitive designs that provide pedestrian safety improvements and decrease speeds. This includes narrowing the roadway section and providing intersection improvements.

Most of the crashes in the rural areas from Foley to Foreston, and from Foreston to Milaca were either rear-end or right angle. Implementing left turn lanes should be a focus of these areas along with intersection improvements to increase sight lines and determine adequate gaps.

A multi-dimensional approach to safety strategies and solutions should include the 5 E's:

1. Engineering,
2. Enforcement,
3. Education,
4. Emergency Medical and Trauma Services, and
5. Everyone

Appendix A: Glossary

Acronym	Meaning	Definition
ICE	Intersection Control Evaluation	From MnDOT's Traffic Engineering Page (August 2015): "The purpose of Intersection Control Evaluation is to determine the optimum traffic control based on a technical and financial analysis as well as political factors."
ITS	Intelligent Transportation System	Wikipedia Definition (August 2015): "Intelligent transportation systems (ITS) are advanced applications which, without embodying intelligence as such, aim to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks."
K+A	Fatal (K) and Incapacitating (A) crashes	The sum of crashes which result in fatality or serious injuries. Also called severe crashes.
LED	Light Emitting Diode	A type of light source which can provide several advantages, such as: high-efficiency, high levels of brightness, low voltage and current requirements, low radiated heat, long life, and can be easily controlled and programmed.
MnDOT	Minnesota Department of Transportation	Wikipedia Definition (August 2015): "The Minnesota Department of Transportation (MnDOT, pronounced "min-dot") oversees transportation by land, water, and air in the U.S. state of Minnesota. The cabinet-level agency is responsible for maintaining the state's trunk highway system (including state highways, U.S. highways, and interstate highways), funding municipal airports and maintaining radio navigation aids, and other activities."
RRFB	Rectangular Rapid Flash Beacon (RRFB)	From FHWA's Safety Website (May 2009): "RRFBs are user-actuated amber LEDs that supplement warning signs at un-signalized intersections or mid-block crosswalks. They can be activated by pedestrians manually by a push button or passively by a pedestrian detection system."
TDA	Transportation Data and Analysis	Analysis and data collection for the development of cartographic maps, GIS data, traffic monitoring programs, and TIS database maintenance for transportation systems.
TH	Trunk Highway	Wikipedia Definition (August 2015): "A trunk road, trunk highway, or strategic road is a major road, usually connecting two or more cities, ports, airports and other places, which is the recommended route for long-distance and freight traffic. Many trunk roads have segregated lanes in a dual carriageway, or are of motorway standard."
TIS	Transportation Information System	From MnDOT's website (September 2015): "An integrated database with roadway and selected bridge, accident, traffic, and pavement data"

Appendix B: Road Safety Audit Information

Goals of a Road Safety Audit (RSA)

#1: Eliminate Fatal and Serious Injuries (K + A)

- State Performance Measures
- Toward Zero Deaths (TZD)

#2: Reduce Total Crashes

- Number
- Severity

Photo Source: "Minnesota's Toward Zero Death Program" – RDC Transportation Planners Meeting (May 16, 2011)

Goals of a Road Safety Audit (RSA)

Multi-dimensional Approach to Safety

- Part of Toward Zero Deaths (TZD)
- 4 E's: Engineering, Enforcement, Education, Emergency Medical and Trauma Services
- 5th E: Everyone

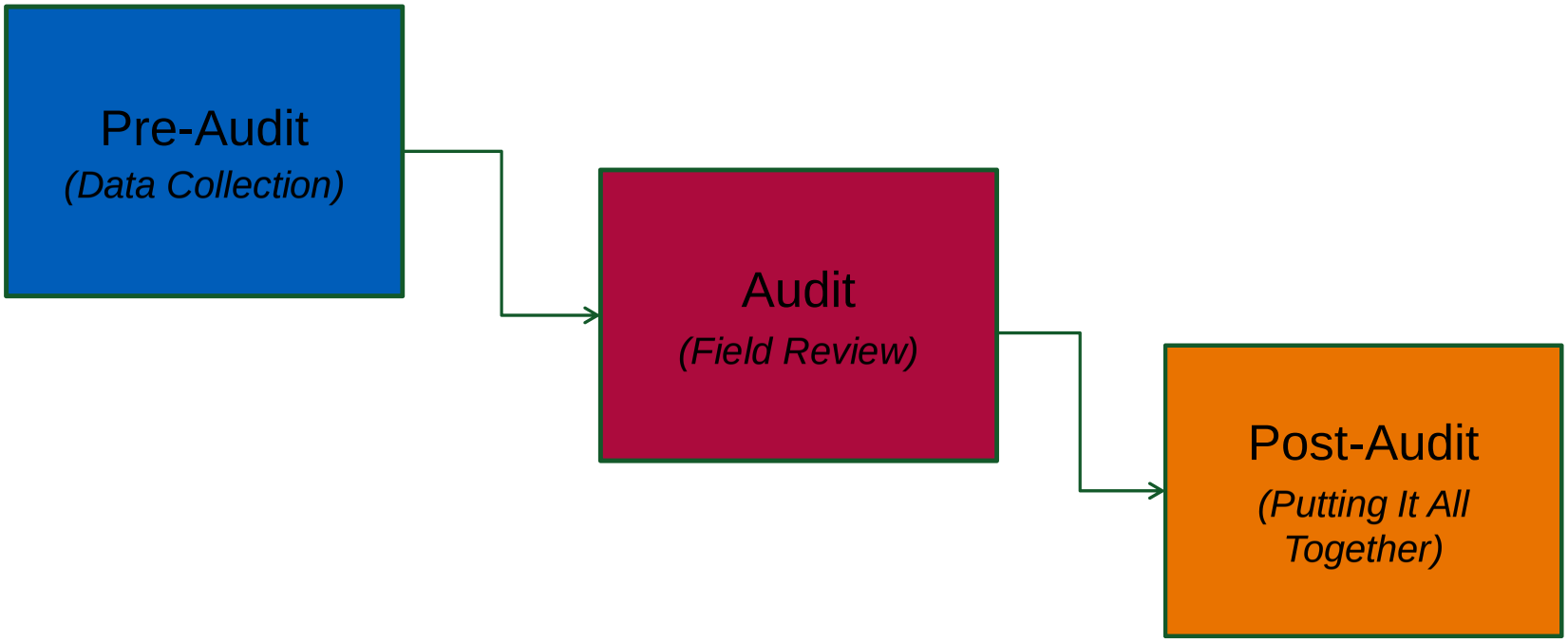
Provide Recommendations

- Short, Medium, and Long-Term Solutions

TOWARD ZERO DEATHS

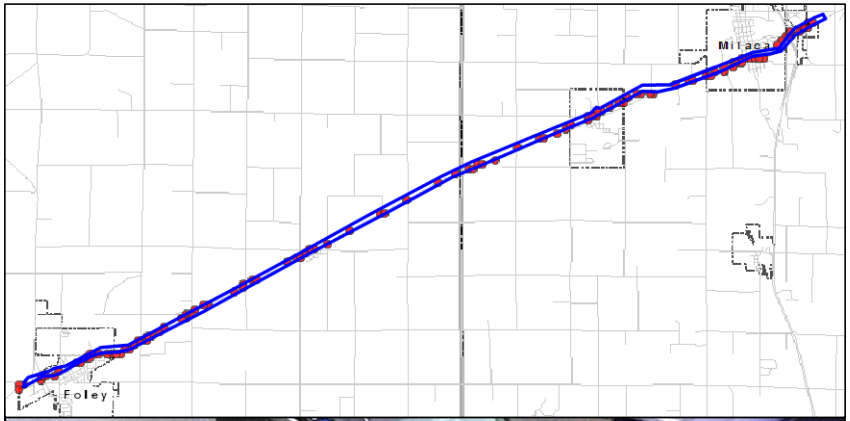
Photo Source: "Minnesota's Toward Zero Death Program" – RDC Transportation Planners Meeting (May 16, 2011)

Process


Pre-Audit
(Data Collection)
Audit
(Field Review)
Post-Audit
(Putting It All Together)

Pre-Audit *- Data Collection -*

- Collect Data
- Determine Logical Segments
  - Traffic Volume
  - Speed
  - Land Use
- Intersections and Entire Corridor
- Analyze Construction History
- Analyze Crash Data
  - 5 Years of Data (2011-2015) along Segments and at Intersections



Audit *- Field Review -*

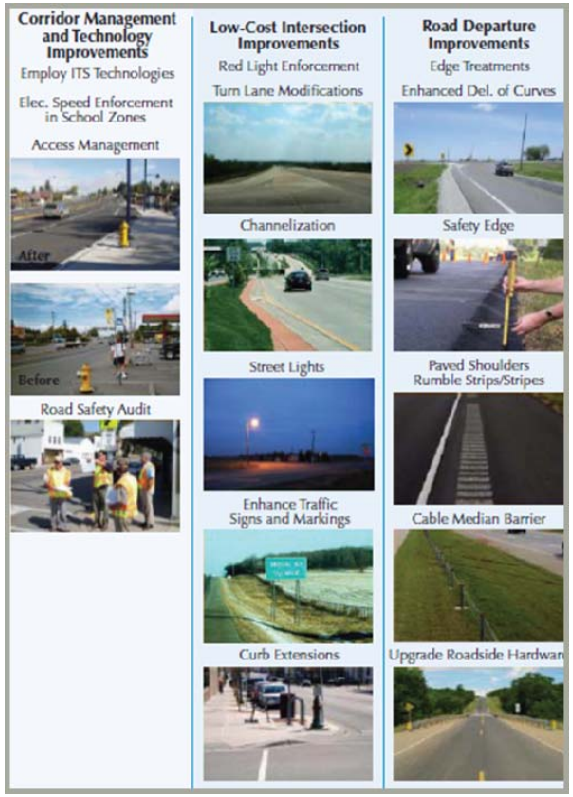
- Onsite Corridor Review on June 20, 2017
  - Record observations
  - Take inventory of existing conditions
- Discussions of Strategies and Applications

Risk Factors - Examples

- Volume
- Road Users
- Intersection Layout
- Traffic Control Devices
- Road Geometry
- Environment
- Development/Access
- Railroad

Post-Audit

- Analysis of pre-audit crash data
- Review of discoveries in the audit
- Develop recommendations
  - short-term (0-5 years)
  - mid-term (5-10 years)
  - long-term (10 + years)
- Intersection Strategies
- Segment Strategies
- Corridor-Wide Strategies
- ***Report Findings to Stakeholders!***



Appendix C: Pre-Audit Community Comments

Meeting Minutes: Foley Town Hall

Date:	6/15/17
Minutes prepared by:	Ken Hansen
Location:	Foley Intermediate School

Attendance

- Derek Leuer, Tom Dumont, Bryan Nemeth, JP Gillach, Ken Hansen
- Most attendees were from the City of Foley and immediate surroundings
- Rep Newberger, Senator Mathews

Meeting Notes

MnDOT with Bolton and Menk presented the past crash history on the TH 23 corridor. This included known problem locations and breakdowns on when, where, and types of crashes that are occurring.

After the presentation, the attendees were given the floor. Their concerns were:

- Presentation
  - Check crash direction with time of day. There is concern with Sun position and increased crashes
  - Check ADT increases in last 5 years
- Audit
  - Suggest watching 7/7:30am and 4/4:30pm times – high volume times
- Speed
  - Speed was the most commented on subject of the meeting – through town
- Pedestrians
  - Many parents in town do not allow children to use the existing crosswalks due to vehicle volume and speeds (drive or bus)
  - City has breakfast/lunch in summer at school and has a municipal pool south of TH23 on 8th
  - Would like a trail to 13th Ave as walkers are not comfortable using the shoulder
  - City and School willing to participate in sidewalk/trail/other crossing metrics (applied for Safe Routes to School)
  - Intersections of Concern
    - 13th Ave (18 or so homes, 38 kids)
    - 8th Ave
    - 4th Ave
- Traffic
  - Left turning traffic feels exposed to high speed rear end crashes
  - Areas of concern are: Norman, CSAH 6, 66th

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Fax: (952) 890-8065
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MEMORANDUM

Date: June 19, 2017

To: Road Safety Audit Study Team

From: Bryan Nemeth

Subject: Highway 23 Road Safety Audit: Community Comments
Minnesota Department of Transportation
Project No.: T43.113923

1. Crossing Hwy 23 at School Crossing: eastbound vehicles must stop but westbound will not…or just the opposite.

2. Multiple comments:
    a. Reduce speed! Norman – 13th to 30 mph.
    b. Hwy 23/13th Ave: curve is dangerous, no turn lane, dangerous bypass lane.
    c. Hwy 23/4th Ave: increase traffic crossing highway, pedestrian and vehicle.
    d. Hwy 23/8th Ave: increase in pedestrians and vehicles during school
    e. Speed Limit between stop lights and Norman: reduce to 40 mph.

3. East of town to turn onto Hwy 66 to go north is a place where I have had many near miss situations as people come close to rear-ending you.

4. Multiple comments:
    a. The speed limit through Foley on Hwy 23 needs to be slowed down from the 25/23 intersection.
    b. Beginning east of Foley right after intersection Hwy 66, start slowing down to 45 mph. This would be before the curve.
    c. Instead of rushing out of town and crossing Hwy 25 at 50 mph (really 65 mph) stay at 35 mph until crossing Hwy 25.
    d. It is dangerous to make a left turn onto 13th Ave without a left turn lane.
    e. Crossing Hwy 23 at the school intersection (8th) is dangerous because even though one car might stop, a vehicle from the opposite direction often doesn't.

5. There is a 50 mph speed sign on Foley near the Xcel power site on Hwy 23. About 200 yards up the Hwy is an entrance to a drive-in-bank and McDonalds. Another 100 yards up the road from there is a four-way stop light. Why is the speed posted at 50 mph? If we are concerned with safety?

6. Multiple comments:
    a. Expedite if possible.
    b. Near misses every day: Hwy 23 and 13th Ave, speed limit concerns, people afraid of getting rear-ended.
    c. Blind intersection: blindly commit to making a right hand turn at 13th

   d. Concern that the crosswalk that exists is not safe.
   e. No way for kids to get around on bikes and walking, e.g. to go to the library.

7. Holdingford population 702, get a Safe Routes to School grant, Foley can't get it due to…?
   a. Difficulty understanding why cannot get crosswalk. Nobody walks because it stinks, so MnDOT says why install where nobody walks?

8. Paint pavement markings and add a lighted sign.
   a. Penn St/8th Ave
   b. 4th Ave

9. Speed from Hwy 66 to stoplights is a problem.

10. Intersections: Help for pedestrians
    a. Morning rush: 7:30-8:30 AM
    b. After school: 3-3:30 PM
    c. Evening rush: 5-6 PM

11. Few pedestrians because it is already not safe.

12. Left turn lanes east of town (Foley)
    a. Manufactured home park
    b. Business area
    c. 13th Ave

13. If could do one thing, reduce speed. If happened, better chance for kids to cross Hwy 23.

14. An increase in traffic speeds in Foley is associated with the change to 4 lanes west of Foley.

15. Reduce speed through town (Foley).

16. Improve pedestrian crossings
    a. Broadway
    b. 6th Ave
    c. 8th Ave and Mr Jims/ Foley Municipal Pool (to south)/Schools (to north)

17. 13th Avenue concerns
    a. Eastbound left turns result in bypasses on the eastbound shoulder/right turn lane
    b. High speed vehicles behind vehicles making eastbound right turn at driveway

18. Ronneby Road
    a. Difficult to go right or left in peak hours
    b. Passing of vehicles occurs within intersection area just to the west
    c. Thru vehicles bypass left turning vehicles in the right turn lane

19. Hwy 66 (CR 66/135th Ave NE)
    a. Difficult to go right or left in peak hours
    b. Thru vehicles bypass left turning vehicles in the right turn lane

20. Multiple Comments

a. Overall speed in town is one of our biggest concerns. Higher speeds make pedestrian and vehicle crossings on the roadway challenging. Times of high volume traffic such as before and after work and school are especially problematic.
b. As discussed in length, Highway 23 safety on the east end of town is particularly concerning for our community for safety of our vehicle traffic and pedestrians.
c. I think it's important for the safety audit team to recognize many locals need to cross Highway 23 between the north and sound ends of our community frequently throughout the day, whether as a pedestrian or in a vehicle.
d. At the end I also mentioned the McDonald's strip mall road. I know the road itself is a privately owned frontage road but the lack of stacking area for traffic getting on to Highway 23 is a safety concern. I'm curious if MNDOT has any suggestions to improve this area.
e. I would be interested in the overall volume of traffic coming through Foley on Highway 23 and how the present traffic volume compares to the last 5-10 years. Has the traffic increased and is it projected to continue to increase?

21. PLEASE improve the quality of life for drivers utilizing Minnesota Highway 23 between 9th Avenue and the east edge of Foley. Two fatal accidents occurred between January 31 and February 6. Help do what should be done to bring about changes NOW!

    There are so many family homes and business establishments between 9th Avenue and the east edge of Foley (less than one-half mile) having no access except via Highway 23. Included are:
    a. Three residential driveways
    b. Two commercial driveways
    c. Four streets containing more than sixty residences
    d. A chiropractic clinic
    e. A commercial child care center serving many families
    f. A tanning salon
    g. An established church, and
    h. A large rental storage center

    All of whom must yield to the hundreds, if not thousands, of vehicles that pass through the half-mile stretch of highway every day.

    Currently MnDOT posts a speed limit too high for the complexity in usage of this half-mile. Can't this speed limit be posted at 35 mph? or 40 mph at the highest? It only makes sense! To say that speed wouldn't make a difference rests in flawed logic. Slower speeds permit drivers to adapt to all of the distractions existing along this particular stretch of highway. 45 mph – 60 mph does not. In addition to posting lower speed limits, create a no-passing zone throughout and reposition the existing bypass-lane signs to reduce the confusion they cause.

    Visit, especially between 7:15 a.m. and 8:30 a.m. or between 3:00 p.m. and 6:00 p.m. on weekdays, to experience what it is like to be a driver in this area. Please place safety for everyone above ALL else. Help do what should be done to make the area safer for all users.

22. As a resident of the area (I live on cty rd 6) I wanted to share a few thoughts:
    a. First, People are just going WAY too fast. There are a lot of roads and drive ways on this stretch of highway. Don't get me wrong…I enjoy a fast speed, but people are going 65-70 or more.
    b. I find it is very dangerous when people are making a left turn on Hwy 23. Often times traffic will go around them in the turn lane or shoulder. I know I have been in the

situation where I am turning left and the lane facing me is turning left then all of a sudden someone pops out on the shoulder. I couldn't see them because the vehicle turning blocked them. Luckily I wasn't going fast or we would've had a huge accident.
    i. This is an issue for turning into driveways on hwy 23 and roads
    ii. This is a huge issue when someone takes the first turn into Ronneby because there is very little shoulder and no turn lane. I have seen multiple people get rear-ended or go into the ditch in this spot.
    iii. I hate riding bike with my son across 23 because people are always swerving out onto the right turn lane. I fear they will hit us. (Problem is his friends live across the highway so we do go across)

c. Another issue is when you are turning right onto Hwy 23 from Ronneby (not Cty Road 6 but the other road), you will look to the west – it's clear, look to the East- clear then get ready to turn, look again and someone is now passing (heading east bound). If someone doesn't give it a second look, they would hit head on.
    i. I believe Hwy 23 from Foley to County road 7 should be "No Passing" or a left turn lane added. If the latter is the solution, I still recommend no passing from Foley to county road 6. There is just too much traffic. Goodfella's in Ronneby drives a lot of people to that area and lots coming in and out.
d. Curve going into Foley and sunlight. I know we cannot do much about the sun but during certain parts of the evening, I find myself in multiple close calls going out of Foley as people come into town. My guess is they are blinded by the sun and don't see how quickly the road curves.
e. I feel that there are too many speed limits from the West side of Foley to the East side of town. I believe in this 1-2 mile stretch there are seven different speeds. Luckily I am from here so I know them, but out of town people I am not sure are paying that close of attention. Maybe we should consider keeping it East side-45 MPH until you get to the 60 and skip the 55, West side- 65 MPH to 45 MPH and eliminate the 50.
f. Ideally, it would be nice to have a flashing crosswalk sign in Foley. I see many children looking to cross the highway and a lot of vehicles who do not stop for them.

23. I am a resident just north of Foley, MN and travel hwy 23 almost daily. We live off Benton County Rd 66, first road east of foley. When leaving Foley going east on hwy 23 we need to turn north on Cty rd 66 (left turn). There has been accidents there before and many close calls. Many people behind you pass you on the shoulder while we wait to turn left, causing issues with other cars behind them not seeing you, or people not paying attention after just getting up to highway speed from the city. People will pass on the right using the right turn lane at highway speeds. That is the one spot we really are very cautious of and I fear we will someday be in an accident there someday. If there was a different tar road to take without a left turn off 23 we would take it. Also, there should be more obvious cross walk signage in Foley for the cross walks in town. (cones in middle of the road, or some sort of crosswalk buttons and lights) Flashing speed limit signs could help people slow down before cross walks also.

24. Problems:
    a. 8th Ave to 13th Ave in the city of Foley. Specifically, the access for motorist and pedestrian safety issues.
    b. Hwy 23 east from 13th Ave running east around the corner. Speed can be a problem at time for motorists making turns to and from Hwy 23.
    c. Hwy 23 between Foley and Foreston. Most secondary cross streets do not come in perpendicular at a 90 degree angle. This is a problem for the cross street driver trying to observe traffic on Hwy 23. It takes more time and with our aging population, it is hard or

impossible for some to rotate their head and neck far enough for an adequate scan of traffic on Hwy 23.

d. Hwy 23 between Foley and Milaca. Many crashes are rear end. Unprotected left turns. Also, too much passing on the right shoulder by impatient drivers.
e. Hwy 23 between Foley and Milaca. Lots of foliage in ditches and near some intersections.

Solutions:

f. Is there some simple solutions from either the Hwy 12 or Hwy 14 two way challenges that could be implement on the east side of Foley to help with the safety concerns?
g. Install center turn lanes at hard surface county roads Foley through Foreston.
h. Improve visual obstructions by clearing ditches and making good clear open zones on both sides of roads.
i. Encourage counties to square off the intersecting roads when they do maintenance or reconstruct.
j. Consider a speed zone drop east of 13 Ave in Foley. I personally don't see a problem with the rest of the existing speed zones in Foley. Maybe advance warning to the east and a little sooner decrease to 45 MPH?
k. I suppose you could consider RICWS at strategic locations along Hwy 23, but generally it doesn't seem like right angle intersection crashes are the problem.
l. My opinion…..8th Ave in the City of Foley doesn't need to be "the" designated pedestrian crossing. Maybe the city should focus more on any one of the crossing at 3, 4, or Broadway Avenues near downtown?

25. I'm not able to make it to the open house tomorrow, but my fiancé and I are concerned citizens who live off this stretch of road and drive Hwy 23 every day. I'm not sure how familiar you are

with the Foley area, but I live north on Benton County Road 66 (135th Ave), which is about 2 miles east of Foley. I've attached a map and color coded some of my concerns. In order to get to work in the morning, we both need to turn west onto Hwy 23 and in order to get home, turn north onto County Road 66 (orange line along 23, to 66).

Our top concern would be people passing right as they come out of Foley (the red circle on the map). As soon as the no passing zone is gone, they are passing. That's caused a few close calls for me, because I am in the process of turning or just about to turn west onto 23 and someone coming out of town heading east, is passing and in the lane I'm about to go in. We believe that the no passing zone should be extended to county road 66.

Our other concern is people passing on the shoulder (purple line on map). The Hwy 23, Cty Rd 66 and Hwy 23, Cty Rd 6 intersections are notorious for this and there have been plenty of accidents to reflect this. If you are trying to take a left and turn off of Hwy 23 in either of these areas, people are constantly passing you on the shoulder. There have been numerous situations where I'm stopped to make a left, another person coming from the east is going to make a left as well, and someone passes me on the shoulder, just about hitting the other person turning. Or I have people stop behind me as I'm making a left turn and the second or third person decides to pass on the shoulder just as I turn and the person right behind me starts to go forward again. Or I'm stopped to make a left and there's a person in the turn lane making a right-hand turn and someone is attempting to pass me on the shoulder. I think this should be more enforced by law enforcement. I know when they've done their speed stings before, both my fiancé and I have seen law enforcement driving on Hwy 23, someone passes on the shoulder and law enforcement keeps going and doesn't even attempt to stop the person that passed on the shoulder.

On the other side of that, people either aren't familiar with or don't know that bypass lanes exist on the outskirts of Foley, by TLC child care and where the accident occurred earlier this year that took the life of Mrs. Cardinal (green line). I've seen and experienced people making left hand turns there and the people behind them are stopped and waiting, instead of utilizing the bypass lanes. The one by the bridge can be a bit tricky, because of the fact of the bridge and there is a mailbox right there as well.

My last concern is the road ditches not being trimmed back far enough at intersections. I know at the intersection I live near (Hwy 23, Cty Rd 66), it can be very difficult to see when you are trying to turn onto Hwy 23. Especially with the cattails in the ditch; they get quite tall and they aren't trimmed back far enough. I know I emailed our County highway department last year to trim them back more and they said they would take a look at it, but nothing was ever done.

26. I won't be able to attend the meeting so I am writing you in hopes to help shed some light on the problem on Highway 23 between Milaca and Foley, MN.

    This road is very dangerous. It scared me every time I have to drive on it. I do think the road needs some improvements BUT I honestly don't think the biggest problem is the road itself. I believe Highway 23 should be extended to a 4 lane Highway like they did between Foley and St. Cloud. It would make it easier and safer to pass. More bypass lanes need to be added (where they can be) because some people are willing to risk their lives and others just to save a few extra seconds passing on the shoulder rather than just staying behind someone waiting for them to turn.

    The BIGGEST problem on that road though is NOT the road itself. It's the people on it. These people are ridiculous. The speed limit is 60 and people are driving 70 or higher. People are in such a big hurry. They are passing even when it's not safe, taking the shoulder to go around people, tailgating and weaving in and out of traffic. Completely driving wreck less and putting everyone's lives in danger. We can sit here and blame the road until we are blue in the face but it's the people that make that road dangerous.

I honestly believe Highway 23 needs to be a 4 lane Highway BUT I believe more that the speed limit needs to be reduced back to 55 MPH and there needs to be WAY more patrol on that road. Everyone is ok with driving crazy on that road because there is hardly ever a cop over there. Just like by my home in Milaca (Highway 23 and County Road 15). People pass on the shoulder there ALL THE TIME. I have watched people almost lose their lives way too many times because of the negligence of others.

27. I am writing as a concerned citizen who travels and makes a left turn off Highway 23 between Foley and Milaca on a daily basis. I have lived north on County road 66 just outside of Foley basically my entire life. One of the biggest issues that has led to the most close calls for me personally is cars flying around me in the turn lane while I am waiting to make a left turn on Benton County road 66. These cars do not slow down and fly around you in the turn lane and because no breaks are applied by these cars if the cars behind them aren't paying close attention suddenly they have my car at a dead stop in front of them and they have make a quick decision. I have also seen accidents over the years caused by this. I do not believe that infraction is being policed to the extent it needs to be. Over my 30 years of living here I have made many left turns there, multiple a day and I would say over 75% of the time someone passes me in the turn lane while I am waiting to turn and I have never seen anyone get pulled over for this.

    I would add that one of the people killed on this stretch of road in the last year was a good friends husband and since his accident I have been much more aware when traveling highway 23 and look in my rear view mirror before making a left turn to see if the car behind me seems to be paying attention and there have been many times that I did not slow down to turn because it seemed as though that car behind me might be distracted so I miss my turn and turn right at the next intersection and "go around the block" to avoid putting myself in danger.

28. I am not able to attend the meeting in Foley tonight but, I definitely wanted to share my opinions as this stretch of road is absolutely terrifying! As someone who commutes between Foley and Milaca I cannot express enough how scary driving on this road can be.

    First of all it does not matter where you are making a left hand turn you ALWAYS have to be paying more attention to your review mirror than anything. The cars come upon you so quickly and then pass on the shoulder going full speed. There truly need to be left turn lanes along this entire stretch to road…at a very minimum at all of the intersections with county roads (personally the ones that I have seen the most close calls at are Benton County Road 6 and 66 but, I travel that stretch of road more than any other).

    My other concern is that there are a few places where there are not right hand turn lanes and really not enough room on the shoulder to move completely over to slow down for your turn (the one I am thinking of is in between Foreston on Milaca and it is a residential dead-end street). This is also terrifying as you really have to watch your review mirror so that you don't get rear ended.

29. I read that there will be a meeting at the Foley Intermediate School on Thursday evening to discuss and let the public voice their concerns on the stretch of Hwy from Foley to Milaca along Hwy 23.

    I will not be able to join you on Thursday evening however, I do personally have a concern that I would like to voice. I head toward Milaca every day. My concern is the left hand turn that I need to make every weekday morning and afternoon into TLC. That spot terrifies every single time that I have to stop and wait for oncoming traffic. I watch the rear view mirror and pray to God

that the car or line of cars see me sitting there at a dead stop with my blinker on waiting to turn left. Most of the cars that come up behind me while I am stopped pass on the right hand shoulder. It is a pretty tight shoulder right in that area, however it's the vehicle that is not paying attention to take the shoulder to pass that I worry about the most.

My sister lives on # 6 and has the same concern about the left hand turn at the intersection.

My voice would be a turning lane located in the center of both lanes, where the car that is turning left can move out of the "main" traffic's road into the turning lane… same as the middle turning lane that runs through Foley now. Extend that all the way to Milaca or at least where the left hand turns are located.

Appendix D: Road Safety Audit Field Notes

BOLTON & MENK
Real People. Real Solutions.

12224 Nicollet Avenue
Burnsville, MN 55337-1649

Ph: (952) 890-0509
Fax: (952) 890-8065
Bolton-Menk.com

Hwy 23 Road Safety Audit
Meeting Minutes
Field Review
June 20, 2017

Meeting Attendees:

- Derek Leuer, MnDOT
- Jamal Love, MnDOT
- Gwen Mei, MnDOT
- Lars Impola, MnDOT
- Ken Hanson, MnDOT D3
- Melissa Barnes, MnDOT
- Michelle Pooler, MnDOT D3
- Tom Nixon, MnDOT D3 TZD
- Brad Estochen, MnDOT
- Will Stein, FHWA
- Bryan Nemeth, Bolton & Menk
- Marcus Januario, Bolton & Menk

The following are draft recommendations as developed through the field review. These draft recommendations will be further refined for the corridor.

I. General Corridor Comments

Speed Limit Signs – increase size at critical locations
Foley – long term 3-lane urban roadway, remove 45 mph zone transition area
Hwy 23 is a high-priority bicycle link in the Bicycle System Plan

- Maintain shoulder width for bicycles
- Future consideration of an off-roadway trail – possibly abandoned rail line on east side of highway in rural sections

Schedule and Coordinate with TZD Region and Local Partners on Education Initiatives:

- Making left turns on 2-lane highways (in some circumstances may be safer to go to next road and come back)
- How to be a bicyclist versus pedestrian with following traffic control devices
- Pedestrian crossing guards at/near school (Legionville summer training camp)
- How to educate peers

Utilize new dynamic speed limit signs for educating on corridor speeds
Education and Enforcement of seat belt compliance
Apply speed limit pavement marking (i.e. 55 MPH painted on the roadway)
Foley: City should start a plan now for how downtown will look in the future. Tight lanes and medians? Roundabouts? Location of crosswalks (limit them to one or two specific locations of importance, consolidate where pedestrians cross so those crossings are used more and pedestrians are expected more)? Process should be started soon so when scoping/planning start within MnDOT, the plan is known and the costs to the city will be known. Essentially, start setting up your long term vision now.

II. TH 25 Intersection (Foley)

Existing condition: traffic signal control, reconstructed in 2012
Observations: no pedestrian indications, no pedestrian push buttons, pedestrians crossing Hwy 23
Potential mitigation discussed:

- Mid-term:
  - Crosswalk pavement markings
  - Pedestrian push buttons
  - Pedestrian indications
  - Provide ADA compliant connection from shoulder to existing pedestrian facilities
  - Add reflectorized backplates on signal heads on all approaches, as this is the first signal for a long time in all directions
- Long term:
  - Roundabout – check volumes

III. Norman Avenue Intersection (Foley)

Existing condition: side street stop control, T-intersection
Observations: speed limit transition west of intersection (35 mph EB, 50 mph WB), urban section starts EB at intersection
Potential mitigation discussed:

- Short term:
  - Restripe with 10 to 11' thru lanes
- Mid-term:
  - Extend urban section for westbound past intersection
- Long term:
  - Roundabout – matched up with Norman Ave north of Hwy 23 – north of 2nd Ave

IV. 2nd Avenue (Intersection)

Existing condition: side street stop control, signed and marked pedestrian crossing
Observations: two way left turn lane between Norman and 2nd, too many marked and signed crosswalk locations within close succession
Potential mitigation discussed:

- Short term:
  - Restripe with 10 to 11' thru lanes
  - Form curb bumpouts with delineators
- Mid-term:
  - Connect sidewalk to 3rd Ave and 4th Ave
  - Bring curb in and eliminate shoulder
  - Make entire section between 2nd Ave and 9th Ave a 3-lane section instead of turn lanes
  - Install curb extensions where possible
- Long term:
  - Roundabout (see Norman Ave)
  - Dead end 2nd Avenue south of Hwy 23 with roundabout
  - Connect frontage road to Norman Ave on north side of TH 23 with pedestrian facility

V. 3rd Avenue Intersection (Foley)

Existing condition: side street stop control, left turn lanes, signed and marked pedestrian crossings (signs on right side only from each direction)
Observations: too many marked and signed crosswalk locations within close succession
Potential mitigation discussed:

- Short term:
  - Restripe with 10 to 11' thru lanes
  - Form curb bumpouts with delineators

- Mid-term:
  - Connect sidewalk to 2nd Ave and 4th Ave
  - Bring curb in and eliminate shoulder
  - Make entire section between 2nd Ave and 9th Ave a 3-lane section instead of turn lanes
  - Install curb extensions where possible
- Long term:
  - Reconstruct as tight urban section
  - Add street furniture, pedestrian scale lighting

VI. 4th Avenue and Broadway Avenue Intersections (Foley)

Existing condition: side street stop control, left turn lanes, right turn lanes at 4th and Broadway, signed and marked pedestrian crossings (signs on right side only from each direction)
Observations: Westbound rights likely light, eastbound rights likely heavier to downtown, drainage issues on NE corner of Broadway, crosswalk on north side of Broadway connects to a residential walkway on NW corner
Potential mitigation discussed:

- Short term:
  - Trim foliage east of Casey's General Store – foliage impacts sight lines to crossing at Broadway
  - Restripe with 10 to 11' thru lanes
  - Improve crosswalk markings: zebra or continental blocks
  - Rebuild NE corner of Broadway Avenue to remove drainage issues
  - Add left side approach crosswalk signage
  - Form curb bumpouts with delineators
- Mid-term:
  - Eliminate westbound right turn lanes
  - Add curb bump-outs on east side
  - Restripe crosswalks on east side of intersections, remove west side crossings
  - Bring curb in and eliminate shoulder
  - Make entire section between 2nd Ave and 9th Ave a 3-lane section instead of turn lanes
  - Install curb extensions where possible
  - Restripe with 11-12' left turn lanes
  - Add sidewalk on north and south side of Hwy 23 between 2nd and Broadway
- Long term:
  - Reconstruct as tight urban section
  - Add street furniture, pedestrian scale lighting

VII. Broadway Avenue to 8th Avenue/Penn Street (Foley)

Existing condition: rural section, left turn lanes, EB right turn lane at 7th, WB right turn lanes to Benton County Courthouse/Offices
Observations: Speed limit transition between 6th and 7th Avenue (45 mph EB, 35 mph WB), rural section starts east of Broadway Ave
Potential mitigation discussed:

- Short term:
  - Restripe with 10 to 11' thru lanes
- Mid-term:
  - Restripe as 3-lane roadway section to reduce sign clutter (change from lane use control signs to two-way left turn signs)

- Make entire section between 2nd Ave and 9th Ave a 3-lane section instead of turn lanes
- Install curb extensions where possible
- Restripe with 11 to 12' left turn lanes
- Re-evaluate speed limit after change – 30 mph?

- Long term:
  - Reconstruct as tight urban section, add curb and gutter
  - Add trail or sidewalk along Hwy 23

VIII. 8th Avenue/Penn Street Intersection (Foley)

Existing condition: side street stop control, lighting on NE corner, pedestrian crosswalk on west side, Foley schools to the north, municipal pool to the south

Observations: large intersection due to presence of turn lanes, skewed intersection, on end of horizontal curve from east, eastbound to southbound is a backward movement for municipal pool destination

Potential mitigation discussed:

- Short term:
  - Improve crosswalk markings: zebra or continental blocks
  - Add lighting to west side
  - Add left side approach crosswalk signage
  - Mini-roundabout done efficiently
  -
- Mid-term:
  - Remove eastbound right turn lane
  - Make entire section between 2nd Ave and 9th Ave a 3-lane section instead of turn lanes
  - Install curb extensions where possible
  - Add curb bump outs on west side of intersection
  - Review overhead RRFB potential once speeds reduced and pedestrian demand increased
- Long term:
  - Roundabout as gateway to the city with smaller roundabouts in town

IX. 8th Avenue/Penn Street to 13th Avenue (Foley)

Existing condition: side street stop control intersections, bridge west of 13th Avenue (44' wide roadway), rural section, eastbound bypass lane at 13th Ave

Observations: Speed limit transition between 9th Avenue and Lloyd Avenue (55 mph EB, 45 mph WB), speed limit transition east of 13th Avenue (60 mph EB, 55 mph WB), numerous speed transitions between 6th and east of 13th Avenue

Potential mitigation discussed:

- Short term:
  - Extend no passing zone to east of 13th Ave
  - Restripe the left lane as a left turn lane at 13th Ave
  - Restripe the bypass lane as the through lane at 13th Ave
  - Add intersection lighting at 13th Ave onto Hwy 23
  - Restripe with 10 to 11' thru lanes
  - Consider removing bypass lanes
  - Add Gateway signing into Foley, westbound into Foley
- Mid-term:
  - Restripe as a 3-lane roadway section (including across bridge)

- Make entire section between 2nd Ave and 9th Ave a 3-lane section instead of turn lanes
- Install curb extensions where possible
- Widen pavement on NE and SW corners for right turns at 13th Ave/driveway
- Add off-road trail between 9th Ave and 8th Ave – north/west side
- Re-evaluate speed limit after change – 40-45 mph?
- Multi-Use trail should be considered out to fringe of town
- Start median curbing back into the horizontal curve, coinciding with gateway signing

- Long term:
  - Add sections to culverts at bridge (west of 13th Ave) – remove guardrail
  - Add trail/sidewalk along Hwy 23 – north/west side from 8th to 13th
  - Reconstruct as urban section, add curb and gutter, add raised median (40 mph design speed)

X. East of 13th Avenue (Foley)

Existing condition: rural section, horizontal curve
Observations: hidden intersections
Potential mitigation discussed:

- Short term:
  - Extend no passing zone to east of 13th Ave
  - Clear the foliage for sight lines east of 13th and north of Hwy 23
- Long term:
  - Reconstruct as urban section, add curb and gutter (40 mph design speed)
  - Add raised median from 13th Ave to east of the curve (approx. 1,600 ft.), median openings at driveways

XI. Foley to Foreston

Existing condition: rural, 60 mph, right turn lanes at County Road intersections
Observations: right turn lanes at intersections used as bypass lanes, bridge east of CR 6 in Ronneby
Potential mitigation discussed:

- Short term:
  - Add intersection lighting
  - No passing zone in Ronneby
  - Add tube delineators in summer
  - Add right turn arrows to right turn lanes
  - On intersections with heavier skew, build small pork chop islands and pull the stop sign in to be more visible
  - Pull up the stop bars to where site lines open up and give drivers a better, longer view
- Mid-term:
  - Restripe through lanes as left turn lanes at intersections with right turn lanes
  - Restripe right turn lanes as through lanes
  - Extend transition (shoulders) as necessary past intersections to bring thru lane back
  - Potentially a RICWS system at select locations (increase in right angle crashes, high risk assessment)
- Long term:
  - Widen and restripe roadway at county road intersections including Ironwood Rd in Oak Park (left turn lanes opposing, through lanes, right turn lanes)

XII. Foreston

Existing condition: rural section, right turn lanes or wide shoulders at each intersection, left turn bypass at CR 18 intersections

Observations: CR 18 south to CR 18 north is primary concern area, pedestrians crossing at Main Ave

Potential mitigation discussed:

- Short term:
  - Increase speed limit sign sizes
  - Add right turn lane arrows at CR 18 intersections
  - No passing zone from CR 18 (south leg) to CR 18 (north leg)
- Mid-term:
  - Restripe as 3-lane roadway from CR 18 (south leg) to CR 18 (north leg)
    - 12' thru lanes, 14-15' TWLTL, narrow shoulders
  - Remove right turn lanes at Main Ave, 1st St, and 2nd Ave
  - Remove ~~left turn lane~~ bypass lane at ~~Main Ave~~ 145th Ave
- Long term:
  - Add pedestrian refuge island at Main Ave
  - Add continuous lighting

XIII. Foreston to Milaca

Existing condition: rural, 60 mph, right turn lanes at County Road intersections

Observations: right turn lanes at intersections used as bypass lanes

Potential mitigation discussed:

- Short term:
  - Add intersection lighting
  - Add right turn arrows to right turn lanes
  - ~~o~~ Add tube delineators in no passing zones in summer
  - On intersections with heavier skew, build small pork chop islands and pull the stop sign in to be more visible
  - Pull up the stop bars to where site lines open up and give drivers a better, longer view
- Mid-term:
  - Restripe through lanes as left turn lanes at intersections with right turn lanes
  - Restripe right turn lanes as through lanes
  - Extend transition (shoulders) as necessary past intersections to bring thru lane back
  - Restripe as three lane section from CR 112 to CSAH 5 (Milaca)
  - Potentially a RICWS system at select locations (increase in right angle crashes, high risk assessment)
- Long term:
  - Widen and restripe roadway at county road intersections (left turn lanes opposing, through lanes, right turn lanes)

XIV. CSAH 5 to 3rd Avenue (Milaca)

Existing condition: rural

Observations: Speed limit transition between CSAH 5 and SW River Drive (45 mph EB, 60 mph WB), pedestrian crossing markings for the cross at 3rd are 2,000 feet from crossing location

Potential mitigation discussed:

- Short term:
  - Reapply turn arrows to turn lanes
  - Add intersection lighting
  - Move pedestrian crossing markings east of Rum River Bridge

- Mid-term:
  - Restripe center lane as a TWLTL between major intersections
  - Restripe through lane as left turn lane at Milaca schools access
  - Restripe bypass lane as the through lane, extend transition (shoulder) as necessary past intersection to bring thru lane back
- Long term:
  - Reconstruct as urban section east of the Rum River Bridge, add curb and gutter

XV. 3rd Avenue SW Intersection (Milaca)

Existing condition: side street stop control, school crossing on west side
Observations: Westbound stop bar from crosswalk west of intersection
Potential mitigation discussed:

- Short term:
  - Move stop bar for westbound to east side of intersection
  - Move stop bar for eastbound 20' back from crosswalk due to turn lane
  - Improve pedestrian facilities (curb ramps, landing)
- Mid-term:
  - Restripe eastbound through lane as left turn lane
  - Restripe eastbound right turn lane as through lane
  - Extend transition (shoulder) as necessary past intersection to bring thru lane back
- Long term:
  - Explore pedestrian underpass east of 3rd Avenue

XVI. Central Avenue Intersection (Milaca)

Existing condition: traffic signal control
Observations: extensive backups from left turning vehicles
Potential mitigation discussed:

- Mid-term:
  - Restripe with opposing left turn lanes
  - Add left turn flashing yellow arrows
  - Improve pedestrian facilities (APS, truncated domes, landing areas)

XVII. Central Avenue to 5th Avenue (Milaca)

Existing condition: urban section, limited sidewalk facilities
Observations: pedestrians and bicyclists on shoulder, on-street parking not used (may be used on weekends with church in area)
Potential mitigation discussed:

- Mid-term:
  - Restripe as 3-lane roadway
  - Possibly maintain parking on one side of roadway
  - Extend sidewalk along Hwy 23

XVIII. West of Hwy 169 to CSAH 2 (Milaca)

Existing condition: side street stop control at intersections
Observations: difficulty in accessing Hwy 23 due to close proximity of Hwy 169 interchange, short left turn bypass lane at CSAH 2, cemetery on SW corner at CSAH 2
Potential mitigation discussed:

- Mid-term:
  - Restripe westbound through lane as left turn lane

  - Restripe westbound bypass lane as through lane
  - Extend transition east (shoulder) as necessary to form left turn lane
- Long term:
  - Roundabout at 10th Ave S
  - Extend median to CSAH 2
  - Consider trail/sidewalk facility to connect 10th Ave to 1st St
  - Alternative Option: Roundabout at CSAH 2 with a ¾ at the intersection to the west at the commercial accesses

XIX. Rejected Options (expand on discussions in the report)

Passing Lanes: additional right of way needed, accesses impacted, promotes high speeds
Center Barrier: head-on crashes minimal, cuts off access to driveways and some streets, have to have turn around locations

Appendix E: Passing Lane and Barrier

The costs versus benefits of passing lanes and rigid barrier systems were calculated as part of the analysis to determine whether they are appropriate for the Hwy 23 corridor.

Passing Lanes:

Travel reduction in this corridor would only amount to about 2 minutes per vehicle. If 50% of the 7,000 vehicles/day benefited by this whole 2 minutes, the benefit to cost level works out to:

- 3,500 vehicles x 2 minutes = 7,000 minutes/day
- 7,000 minutes x 1 hour/60 minutes = 117 hours
- 117 hours x $5/hour = $585 benefit/day
- $585/day x 365 days x 20 years = $4.3 M
- Cost could range, at conservatively $2M per mile = $22-$24M
- B/C = 0.18 – 0.2. This is well below the 1.0 needed to justify a project

Rigid Barrier System:

Barrier system + intersection improvements costs

$500,000 per mile + $1M per intersection (turn lanes) or $2.5M per roundabout

$500,000 per mile x 11 miles = $6.5M

+	$1M x 6 intersections =	$6M (at $2.5 M each = $18M)
	Total	$12.5 M - $25M

Appendix F: Speed Limit Summary

Topic: Speed Limits

Key Points

- MnDOT procedures for establishing speed limits are based on State Statutes and use established best practice performance measures.
- The national research indicates the majority of drivers select a reasonable and safe maximum speed based on their perception of the roadway environment and that the actual posted speed limit has little influence on the speed drivers choose.
- Research does NOT support the notion that urban roads with lower speed limits are safer – safety on urban roads is more a function of access density than speed limit.
- Research does indicate that safety on rural roads is optimized when prevailing speeds are at or near the 85th percentile and the majority of vehicles are in the 10 mile per hour pace.

Background

One of the most challenging issues agency traffic engineers face is responding to local requests to change posted speed limits. Anecdotal evidence suggests that these requests are usually based on two points that seem to be intuitively correct to residents – first, that roadways with lower speed limits are safer and second, that the majority of drivers select their speed based on the posted limit. However, like much of traffic engineering, the facts surrounding this matter appear to be counterintuitive.

Discussions pertaining to speed limits would be enhanced by making sure that all parties understand the process for setting speed limits, the basic premise that underlies the process and the facts based on both local experience and national research.

The basic process for setting speed limits in Minnesota has been in place since the 1930's and is documented in State Statutes (M.S. 169.14, Subdivisions 2, 4 & 5). The law establishes two basic types of speed restrictions: statutory speed limits and established speed zones. Statutory speed limits which are 30 miles per hour in urban areas and 55 miles per hour in rural, apply in areas in which no special hazards exist. The law also recognizes higher statutory limits on expressways and freeways and lower limits on residential roadways if adopted by the road authority. When local authorities believe that the statutory speed limit should be altered in either direction, they may request that the Commissioner of Transportation conduct an engineering and traffic investigation to determine a reasonable and safe speed. The authority to establish speed zones was delegated to the Commissioner as part of the original law so that there would be a high level of consistency across the entire State on all roads with the intention that drivers experiencing similar conditions could expect to find similar speed restrictions.

The process MnDOT has used to conduct the required engineering and traffic investigation is objective and involves measuring a sample of actual vehicle speeds and documenting two particular traffic characteristics on the segment of road in question: the 85th Percentile Speed and the Ten Mile Per Pace. The use of these performance measures is considered to be a best practice and is consistent with the conclusions contained in national research and the guidance in the Minnesota Manual on Uniform Traffic Control Devices. The 85th Percentile Speed is the speed at which 85 percent of drivers are traveling at or below and the Pace is the ten miles per hour that contain the highest fraction of the drivers in the sample.

The use of these performance measures reflects the two basic premises behind the speed law and the speed zoning process:

- The majority of drivers will select a reasonable and safe speed based on their perception of the road environment.
- The more drivers that chose to travel at nearly the same speed, the fewer the number of potential conflicts and the greater the level of safety.

The national research suggests and MnDOT has found that the 85th Percentile Speed approximates what drivers select as a reasonable and safe speed and that where the selected speed limit is in the upper end of the Pace that contains 65 to 75 percent of vehicles, compliance and safety are optimized.

The wisdom and rationale of relying on the users of a segment of roadway to basically select the speed limit is regularly questioned by residents and local authorities. However, the national research and MnDOT's experience is clear and consistent: drivers select reasonable and safe speeds based on their perception of the roadway environment and not based on the speed limit signs posted along the roadway. The most comprehensive national research (Effects of Raising and Lowering Speed Limits on Selected Roadway Sections, FHWA-RD-97-084) looked at 100 sites in 22 states where speed limits were either artificially lowered (59 locations) or raised (41 locations) by 5 to 20 miles per hour. The report concluded that "a review of the before and after speed data at each site revealed that differences in mean speed and 85th percentile speeds were generally less than 2 miles per hour and were not related to amount the posted speed limit was changed". In other words, changing the posted speed limit did not in any of the 100 cases actually change the driver's behavior. Instead they continued to select an operating speed based on their perception of the roadway environment.

MnDOT has conducted similar research at a variety of locations across Minnesota where local authorities disputed the results of their engineering and traffic investigation. In each of these cases, MnDOT agreed to undertake a research project by temporarily changing the speed limit, offering the local authority the opportunity to apply increased levels of enforcement and then regularly documenting the resulting speed profiles. The agreement with the local authorities was that if driver behavior changed sufficiently such that the new speed profiles supported the lower speed limits, the lower limits would remain in place and if they did not the limits would be raised consistent with the results of the engineering and traffic investigation. In each case the limits were either raised or lowered between 5 and 15 miles per hour and the measured 85th percentile speeds changed between zero and three miles per hour (Table 1).

Table 1 – Results of MnDOT Speed Zoning Studies

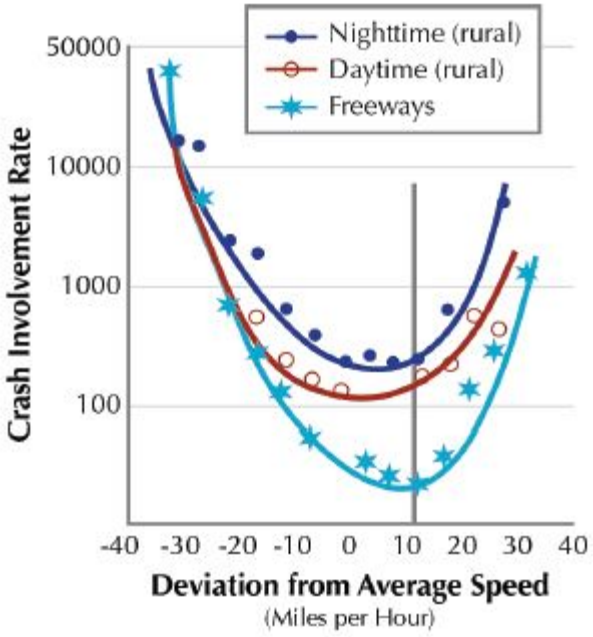
Speed Zoning Studies					
Study Location	Before	After	Sign Change +/- MPH	85% Before After	Change MPH
TH 65	SPEED LIMIT 40	SPEED LIMIT 30	-10	34 34	0
TH 65	SPEED LIMIT 50	SPEED LIMIT 40	-10	44 45	+1
Anoka CSAH 1	SPEED LIMIT 45	SPEED LIMIT 40	-5	48 50	+2
Anoka CSAH 24	SPEED LIMIT 30	SPEED LIMIT 45	+15	49 50	+1
Anoka CSAH 51	SPEED LIMIT 40	SPEED LIMIT 45	+5	45 46	+1
Hennepin CSAH 4	SPEED LIMIT 50	SPEED LIMIT 40	-10	52 51	-1
Noble Ave	SPEED LIMIT 30	SPEED LIMIT 35	+5	37 40	+3
62nd Ave N	SPEED LIMIT 35	SPEED LIMIT 30	-5	37 37	0
Miss. St	SPEED LIMIT 30	SPEED LIMIT 35	+5	39 40	+1

Minnesota Department of Transportation (MnDOT)

The key conclusion from these experiments is consistent with the national research indicating that changing the posted speed limit did not change driver's behavior. Drivers continued to select what they consider to be a reasonable and safe speed based on their perception of the road environment.

The use of the 85th percentile speed as an approximation of reasonable and safe speeds has also been called into question. Research going back as far as 1964 (Accidents on Main Rural Highways, David Solomon) has demonstrated a relationship between vehicle speed and safety. The results of this research (Figure 1) concluded that crash involvement rates were lowest when vehicle speeds were in a range between the median speed and seven miles per hour above the median. It should be noted that 85th percentile speeds are typically five to seven miles per hour greater than the median.

Figure 1 – Average Speed vs. Crash Involvement (Solomon's Curve)



Other research has investigated the notion of changing drivers' speeds by changing their perception of the road environment. A study in Connecticut (Designing Roads that Guide Drivers to Choose Safer Speeds, Connecticut Transportation Institute, 2009) documented the effect on mean speeds along roads in urban areas associated with land development patterns (Figure 2), road features (Figure 3) and on-street parking (Figure 4). The results indicate that the more drivers perceive a road to be urban, the lower a mean speed they select. Small building setbacks, the addition of curb & gutter and sidewalks and the presence of on-street parking reduced mean travel speeds by nine, seven and thirteen miles per hour, respectively. These results clearly support the theory that drivers in fact use visual cues from the road environment to select what they consider to be a reasonable and safe operating speed.

Figure 2 - Comparison of Mean Speed by Building Setback

Mean speed = 33.2 mph
ADT = 5500 veh/day
No parking

Mean speed = 20 mph
ADT = 6900 veh/day
Heavy Parking

Source: "Designing Roads That Guide Drivers to Choose Safer Speeds", Iran, J. & Garrick, N., Connecticut Transportation Institute, 2009

Figure 3 – Comparison of Mean Speed by Presence of Curb & Gutter and Sidewalk

Designing Roads That Guide Drivers to Choose Safety Speeds, Iran, J. & Garrick, N., Connecticut Transportation Institute, 2009

Figure 4 – Comparison of Mean Speed by Presence of On-Street Parking

Mean speed = 42.3 mph
ADT = 3800 veh/day
Setback = large

Mean speed = 32.6 mph
ADT = 7800 veh/day
Setback = small

Source: "Designing Roads That Guide Drivers to Choose Safer Speeds", Iran, J. & Garrick, N., Connecticut Transportation Institute, 2009

A second study focused on changing driver perceptions (Traffic Calming on Main Roads through Rural Communities, FHWA-HRT-08-067) documented the effects of using innovative pavement markings and other low-cost strategies to alter vehicle speeds. The results of this effort (Table 2) indicate that the use of pavement markings by themselves failed to change driver behavior in any consistent and meaningful way. The addition of a vertical element (speed table) had a modest effect, a 4 to 5 mile per hour reduction. However, in Minnesota vertical elements (speed tables, bumps and humps) should only be used on purely local streets (no public transit or primary emergency service routes and cannot be used on any state aided route). The most effective device was the dynamic speed feedback sign, which resulted in speed reductions up to 7 miles per hour in the speed transitions at urban boundaries. It should be noted that subsequent work in Minnesota with the dynamic speed feedback sign has found consistent speed reductions when applied in rural/urban transitions, work zones and school areas but not when the device was used in an effort to call attention to a statutory rural or urban speed limit. These results indicate that pavement markings by themselves have not proven to be sufficient to change drivers perceptions of the road environment and dynamic devices have proven to be moderately effective, but only in speed transition areas.

Table 2 – Summary of Effectiveness of Traffic Calming Treatments

Summary of Impacts and Costs of Rural Traffic Calming Treatments				
Treatment	Change in 85th Percentile Speed (mph)	Cost	Maintenance	Application
Transverse pavement markings [1]	-2 to 0	$	Regular painting	Community entrance
Transverse pavement markings [1] with speed feedback signs	-7 to -3	$$$	Regular painting	Community entrance
Lane narrowing using painted center island and edge marking	-3 to +4	$	Regular painting	Entrance or within community
Converging chevrons [1] and "25 MPH" pavement markings	-4 to 0	$	Regular painting	Community entrance
Lane narrowing using shoulder markings and "25 MPH" pavement legend	-2 to 4	$	Regular painting	Entrance or within community
Speed table	-5 to -4	$$	Regular painting	Within community
Lane narrowing with center island using tubular markers	-3 to 0	$$$	Tubes often struck needing replacement	Within community
Speed feedback sign (3 months after only)	-7	$$$	Troubleshooting electronics	Entrance or within community
"SLOW" pavement legend	-2 to 3	$	Regular painting	Entrance or within community
"35 MPH" pavement legend with red background (1)	-9 to 0	$	Background faded quickly; accelerated repainting cycle	Entrance or within community

[1] Experimental approval required per Section 1A.10 of MUTCD.

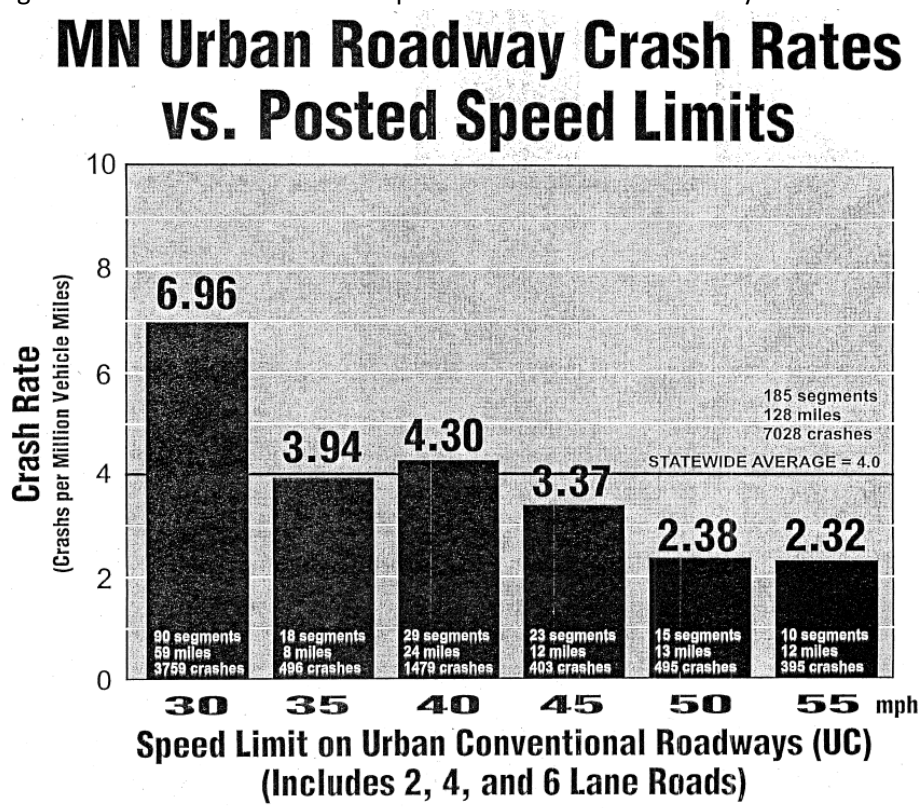
$ = under $2,500
$$ =$2,500 to $5,000
$$$ = $5,000 to $12,000

Traffic Calming on Main Roads Through Rural Communities, FHWA-HRT-08-067, Krammes, R., 2009

Lowering Urban Speed Limits

Most requests from local authorities to lower speed limits in urban areas appear to be based on an intuitive sense that slower speeds are implicitly associated with greater safety. While it is true that urban roadways have fewer severe crashes than rural roadways, a review of the crash data for urban areas indicates that roads with a 30 mile per hour limit have the highest total crash involvement rate and that the rate diminishes with increasing speed limit (Figure 5). The research that produced this chart (Statistical Relationship Between Vehicular Crashes and Highway Access, MN/RC-1998-27) found that the density of access had a greater effect on crash involvement rates than the posted speed limit and that the highest levels of access were found on roadways with lower speed limits. This data suggests that safety on urban roadways is more a function of access density than the posted speed limit.

Figure 5 – Crash Rate vs. Posted Speed Limit on Urban Roadways



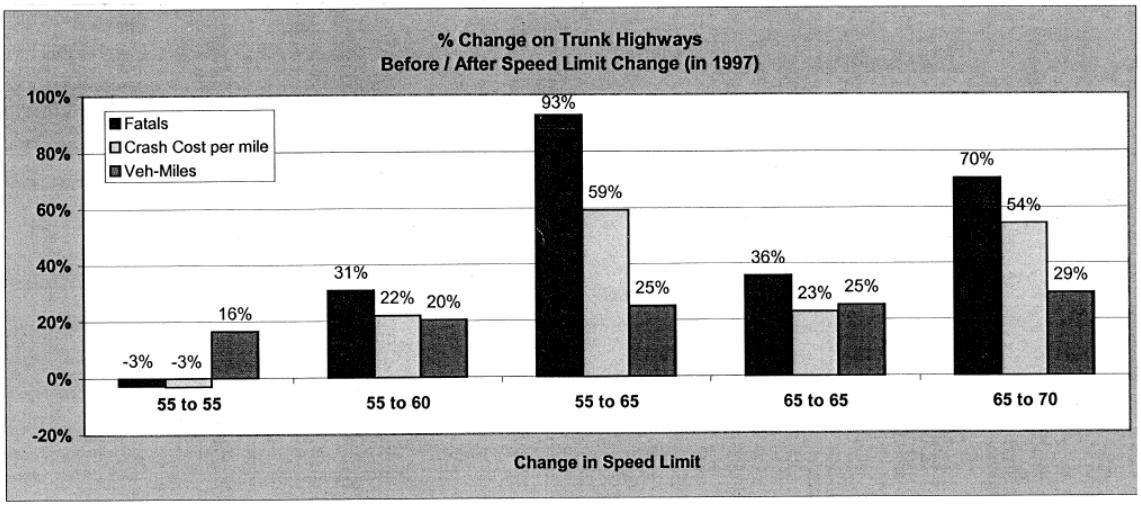
The key conclusion is that in urban areas, there is no information in either the national research or using Minnesota data that supports the theory that lower speed limits are somehow associated with greater safety. The single exception to this statement involves the severity of crashes involving pedestrians – that data is conclusive. Pedestrian involved crashes at 40 miles per hour are fatal 90% of the time whereas crashes at 30 miles per hour are fatal 45% of the time.

Raising Rural Speed Limits

Beginning in 1974, a statutory speed limit of 55 miles per hour applied to rural roads in Minnesota (prior to 1974, the basic rural speed limit was 60 miles per hour daytime and 50 miles per hour nighttime). It was acknowledged that this speed limit was not close to the 85th percentile speed on most roads (the typical 85th percentile speed on two lane roads is closer to 65 miles per hour) but the safety performance of Minnesota's rural roads was very good – the fifth lowest fatality rate in the country. MnDOT participated in raising speed limits along rural and urban, multi-lane divided roadways in 1997 and approximately 61% of rural two-lane state highways in 2012. In each case the initiative appears to have been politically driven and based on three assumptions; that the travel times for residents of Greater Minnesota would decrease, the roads could reasonably and safely accommodate the higher speeds and no harm will result. Subsequent analysis proves that the first assumption regarding travel times is likely always true, however, the travel time differences are modest – 50 seconds for a 10 mile trip and four minutes for a 50 mile trip. The second assumption may be true on some roadways and the third may not be true in any case. An analysis completed by MnDOT following the 1997 speed limit increase along multi-lane roads found that in all cases, higher speed limits were associated with increases in fatal crashes that were substantially greater than what would be expected based on the increase in vehicle-miles traveled

(Figure 6). It should be noted that this data is not considered to be proof that higher rural speed limits cause severe crashes to increase because the original analysis was limited and did not account for factors such as, at the time traffic fatalities were increasing across the State and actual operating speeds only changed marginally. The ongoing update of the District Safety Plans will provide additional insight about the safety characteristics associated with 55 versus 60 mile per hour rural speed limits.

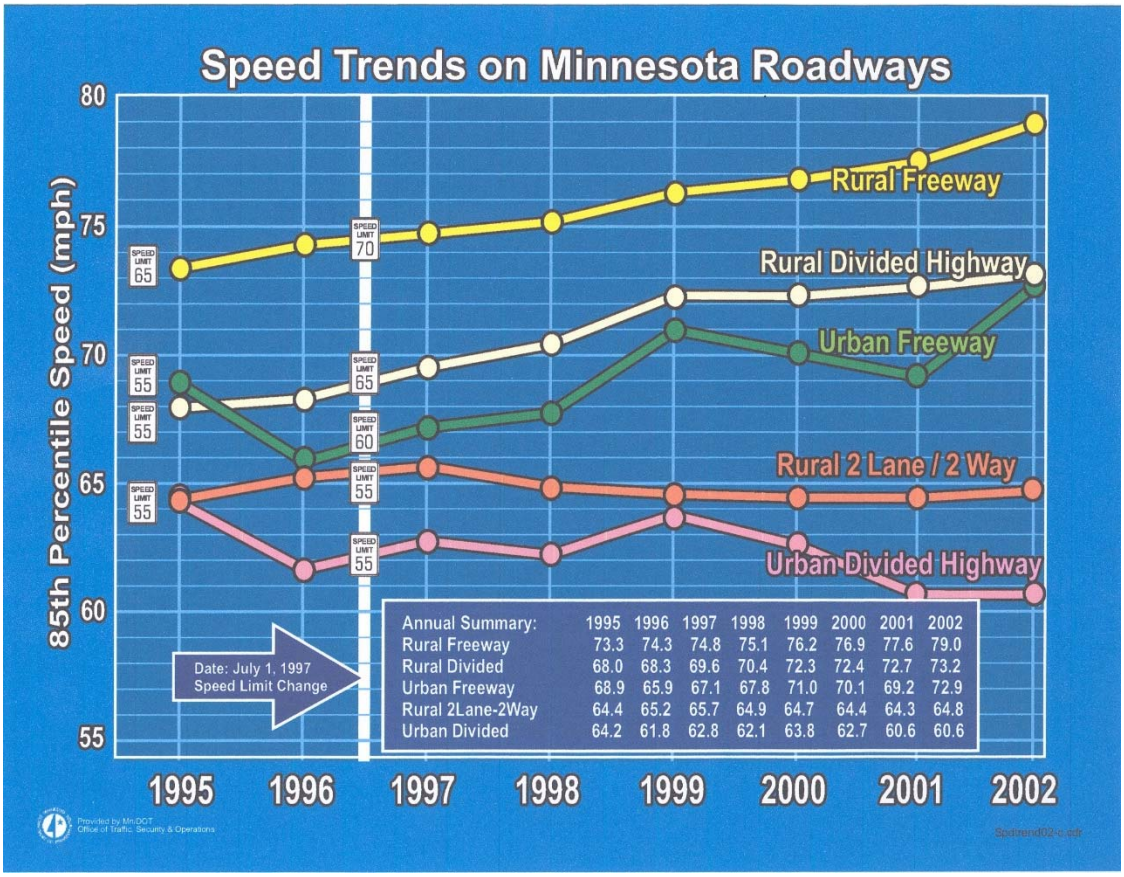
Figure 6 – Fatal Crashes and VMT Following 1997 Speed Limit Change



Effect of Law Enforcement on Vehicle Speeds

Efforts to influence drivers' choices of a reasonable and safe operating speed is a shared responsibility. Road authorities need to consider how to provide drivers with a consistent message with a road environment matching the posted speed limit and law enforcement needs to reinforce the message as to a maximum safe operating speed. The short term effects of applying enforcement at a particular location are well documented demonstrating that the presence of an officer is highly effective at a specific time and place. However, the "halo" effect of spot enforcement has been estimated to be in the range of one hour and one mile. The effect of saturation enforcement campaigns may extend to several months. MnDOT speed trend data (Figure 7) collected at sampling sites around the State indicate that there is only a very limited effect of enforcement across rural systems. The 85th percentile speeds on rural roads are in the range of eight to ten miles per hour over the posted limits and anecdotal information suggests that this is the threshold where enforcement focuses their efforts. It appears to be true that over time the maximum operating speed along rural roads approaches the speed where enforcement begins to hand out tickets.

Figure 7 – Speed Trends on Minnesota Roadways



Wrap-Up

Key points to remember:

- The procedures for establishing speed restrictions along roadways in Minnesota are based on State Statutes, which assigns responsibility to the Commissioner of Transportation.
- There are two types of speed restrictions in Minnesota: statutory limits in rural and urban areas where no special hazards exist and speed zones that are based on the outcome of engineering and traffic investigations.
- The performance measures used in the engineering and traffic investigations used to support the selection of speed limits include the 85th percentile speed and the ten mile per hour pace – both are considered to be best practices in the national research.
- The basic premise behind Minnesota's approach to establishing speed zones is that the majority of drivers will select a reasonable and safe maximum speed based on their perception of the road environment. This approach is consistent with the national research which also concludes that the majority of drivers will not obey a posted limit that is artificially set at a speed inconsistent with the road environment.
- A common opinion held by many residents and locally elected officials is that safety on urban roadways is a function of speed limit with roads with lower posted speed limits having a better safety performance. The available research suggests that this is NOT true and instead that the

safety performance of urban roadways appears to be related to access density and not speed limit.

- Research indicates that safety on rural roads is optimized when the prevailing speeds and posted speed limits are at or near the 85th percentile speed.
- Law enforcement should be a partner in any discussion of changing speed limits. However, there is no evidence in the national literature suggesting any lasting effects on driver behavior associated with short-term spot enforcement.
- If discussions with local authorities fail to reach an agreement on the issue of changing a speed limit, it appears that MnDOT's historic approach of making a temporary adjustment followed by regular monitoring and a return to the previous limit if driver behavior does not change is an effective method for settling disputes.

References

MnDOT, *Methods for Setting Posted Speed Limits*. 2012 [Transportation Research Synthesis 1204]

FHWA, *Procedures for Setting Advisory Speeds on Curves.* [FHWA-SA-11-22]

FWHA, *Effects of Raising and Lowering Speed Limits on Selected Roadway Sections.* 1997 [FHWA-RD-9 7-084]

MnDOT, *Statistical Relationship between Vehicular Crashes and Highway Access, MN/RC-1998-27*

Appendix G: Post-Audit Community Meeting

DEPARTMENT OF TRANSPORTATION

Sept. 11, 2017

Highway 23—Foley to Milaca

Road Safety Audit

The newly completed draft Highway 23 Road Safety Audit and its findings is part of a multi- agency effort to improve safety along 16 miles of Highway 23 from Foley to Milaca in Benton and Mille Lacs counties.

Four Primary Concerns

1. High speeds
2. Safe pedestrian and bicycle connectivity and crossings in urban areas
3. High speed rear-end crashes in rural areas
4. Head-on collisions

Primary Strategies

- Develop a 3-lane roadway section in urban areas.
- Plan for the future cross-section and layout of the corridor. Be ready before any future MnDOT reconstruction occurs.
- Improve pedestrian and bicycle crossing amenities in urban areas
- Convert selected Highway 23 intersection approach lanes in rural areas from thru/right-turn lane into thru/left-turn lane approaches. Right-turn lanes can be added in the long term.
- Develop raised medians and left turn lanes in urban areas.
- Develop median buffer lanes and centerline rumble strips in rural areas.

View the Highway 23 Road Safety Audit online, at mndot.gov/d3/projects/h23foleytomilaca/

Community Action

What we need from you!

- Work with the regional Toward Zero Deaths partners to develop and implement education initiatives
- Develop plans for how you want the Highway through your community to look, operate, and function
- Prepare now before a project is realized and implemented
- Utilize these strategies when opportunities to implement are funded and being realized
- Be prepared to use local funding, and apply for competitive grants and safety funding and coordinate with future MnDOT and County projects

TOWARD ZERO DEATHS

www.minnesotatzd.org

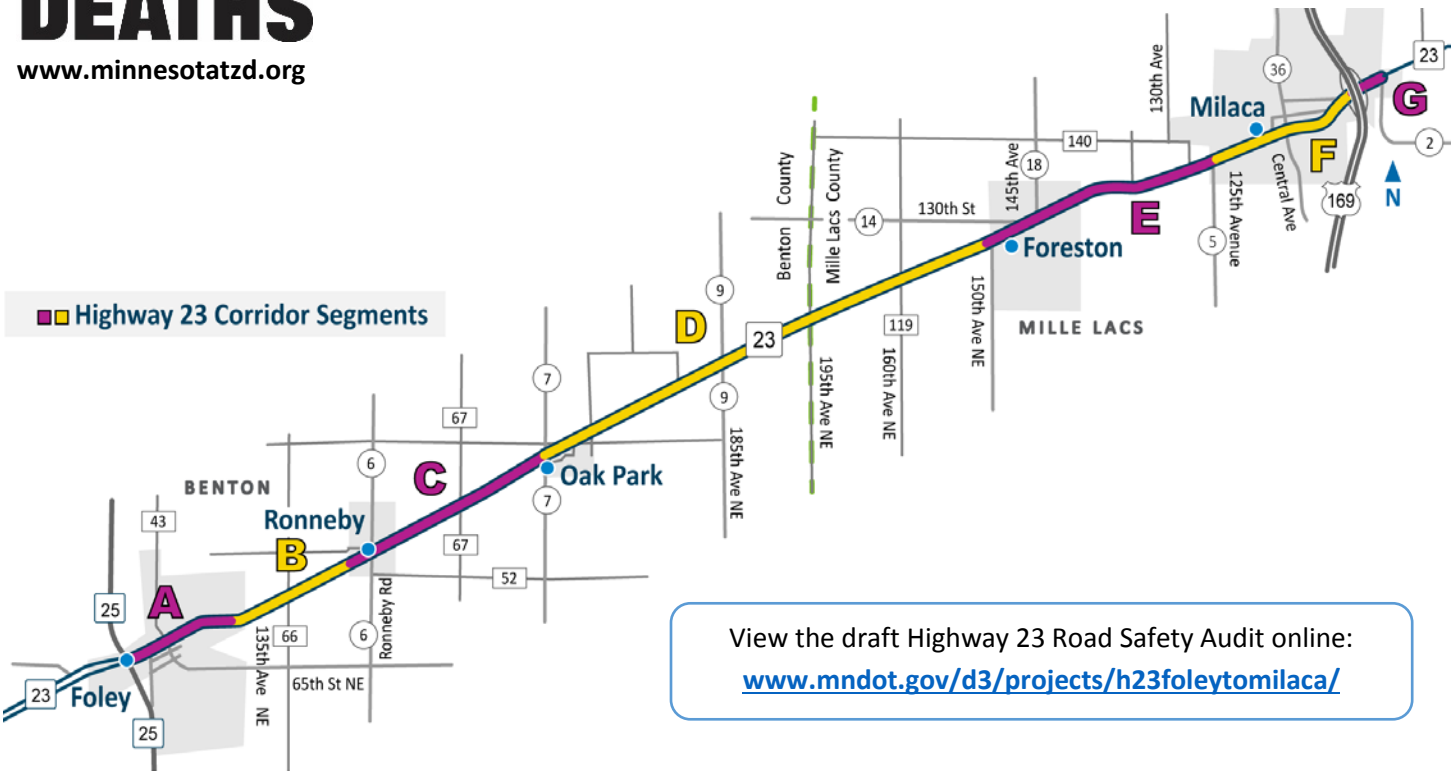
Contact Us

HIGHWAY 23 ROAD SAFETY AUDIT

Derek Leuer, Traffic Safety Engineer, MnDOT Office of Traffic, Safety and Technology
derek.leuer@state.mn.us

Bryan Nemeth, Consultant Project Manager,
Bolton & Menk, Inc.
bryanne@bolton-menk.com

Tom Dumont, District Traffic Engineer, MnDOT District 3
tom.dumont@state.mn.us



View the draft Highway 23 Road Safety Audit online:
www.mndot.gov/d3/projects/h23foleytomilaca/

The Road Safety Audit is one part of a multi-agency effort to improve safety along Highway 23 in Benton and Mille Lacs counties. For more information about the Highway 23 safety improvement effort, or to learn how to get involved with safety efforts along Highway 23, contact Tom Nixon, East Central Minnesota Toward Zero Deaths Coordinator at thomas.nixon@state.mn.us.

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12224 Nicollet Avenue
Burnsville, MN 55337-1649

Ph: (952) 890-0509
Fax: (952) 890-8065
Bolton-Menk.com

MEMORANDUM

Date: September 11, 2017

To: Road Safety Audit Study Team

From: Bryan Nemeth

Subject: Highway 23 Road Safety Audit: Community Comments
Minnesota Department of Transportation
Project No.: T43.113923

A total of 38 people signed in the meeting.

Verbal Comments:

1. Reduce the speed entering into and through the cities
2. Add 11th Avenue in with 9th, Lord, and 13th when discussing recommendations
3. Improve pedestrian crossings with flashing lights near the schools in Foley and Milaca

Written Comments:

4. We need immediate sign/flashing lights, something to get drivers to realize that pedestrians are crossing Hwy 23 at crosswalks.
5. As someone that travels 23 daily from Foley to Mora, I see the benefits of ITS signs in Milaca. I would like to see these up right away with lower speed limits, by the end of 2017.
6. Is 13th in the city limits of Foley? Walking bridge north of 23 by 13th. I was told there was going to be a ped pathway to provide safe access to that neighborhood.
7. This is good!