US 12 Road Safety Audit: Technical Report

Western Wright County Limit to Wayzata, MN

Minnesota Department of Transportation (MnDOT) Metro District and District 3

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Report Prepared By HDR (September 2015)

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1 Executive Summary

This report discusses the findings of a road safety audit which took place on a 38-mile corridor of US 12, located just west of the Minnesota Twin Cities metro region. A road safety audit is a three-step study where a road is observed for unusual crash trends through data analysis, a field visit is conducted to identify deficiencies and other safety risks, then safety solutions and recommendations are provided to increase the safety of a corridor. The need for a road safety audit was triggered in response to a high number of crashes. Fatal and severe crashes are an issue throughout many segments of this corridor.

Table 1-1 and Table 1-2 summarize the recommendations for safety solutions along the US 12 corridor. These recommendations were developed from the road safety audit review process. Please refer to Section 5.2 for more detailed descriptions of solutions for corridor-wide improvements, as well as improvements to specific locations. Please refer to Figure 1-1 to see how the corridor was divided into segments.

This report consists of an evaluation of the corridor background, a summary of crash data trends, an overview of the field review process, suggested improvement strategies, and an overview of the road safety audit team recommendations. Appendix A provides a glossary of commonly referenced acronyms. In addition to this report, please refer to the document "US 12 Road Safety Audit Briefing Book" for background information and crash data on the corridor.

Figure 1-1: Segmentation of the Corridor

Table 1-1: Summary of Recommended Solutions – Corridor-Wide

Location	Recommended Short (0-5 yrs.), Medium (5-10 yrs.), and Long (10+ yrs.) Term Solutions

Corridor-Wide	Short-Term:
	• Develop an Access Management Plan and start implementation of the plan
	• Assess corridor lighting conditions and make improvements as needed
	• Utilize active road maintenance
	  o Signing/striping
	  o Ice/snow removal
	  o Clear zone
	• Implement active enforcement
	• Conduct education outreach
	
	Long-Term:
	• Install roundabouts at city limits to reduce driver speeding through urban segments

Urban Segments ***Segments: B,D,F,J,L***	Short-Term: • Conduct public outreach for Complete Streets solutions (road diet) • Use a consistent approach to speed limit changes • Implement Intelligent Transportation Systems (ITS) speed technologies for speed limit changes • Install pedestrian bump outs/curb extensions • Develop sidewalk network plans • Update pedestrian flashers to be Rectangular Rapid Flash Beacons (RRFBs) • Install “mumble” strips Medium-Term: • Implement Complete Streets solution (road diet) • “Urbanize” streets • Implement sidewalk network plan and Install sidewalks on both sides of the street
Rural Segments ***Segments: A,C,E,G-I,K,M,N***	Short-Term: • Install centerline rumble strips • Install edge line rumble strips Medium-Term: • Install center buffer strip Long-Term: • Develop 2+1 passing lane sections to improve traffic flow • Implement an access management plan into new 2+1 geometry
Various Intersections	Short-Term: • Conduct an Intersection Control Evaluation (ICE) review process • Remove bypass lanes and install left turn lanes • Increase stop sign size and add “Cross Traffic Does Not Stop” signage to minor approaches • Apply MnDOT’s standard Trunk Highway signing approach to stop controlled side streets Medium-Term/Long-Term: • Install traffic control chosen from ICE process

Table 1-2: Summary of Recommended Solutions – By Segment

Location	Recommended Short (0-5yrs), Medium (5-10yrs), and Long (10+yrs) Term Solutions

Segment A
West of Cokato
	Short-Term:
	• Install centerline and edge line rumble strips
	• Monitor ITS ice detection system/utilize active road maintenance
	• Implement active enforcement near Dassel-Cokato High School
	• Evaluate start/end times for schools
	• Conduct an ICE review process at Reardon Avenue intersection
	    o Evaluate: signal with advanced queue detection and warning for mainline traffic, Continuous Green T with dedicated left turn lane, and roundabout configurations
	
	Medium-Term:
	• Install center buffer strip
	• Install wind block (snow/ice reduction)
	    o Use living snow fence
	    o Partner with railroad to use cars
	• Install traffic control chosen from ICE process at intersection with Reardon Avenue
	
	Long-Term:
	• Develop 2+1 passing lane sections (traffic flow improvement/access management)

Segment B
Cokato
	Short-Term:
	• Conduct public outreach for Complete Streets solutions (road diet)
	• Develop Access Management Plan
	• Utilize active road maintenance
	• Install wind block (snow/ice reduction)
	    o Use living snow fence
	    o Partner with railroad to use cars
	• Relocate sign at Jackson Ave (sightline improvement)
	• Update striping at County State Aid Highway (CSAH) 3 (increased width for truck movements)
	• Add retro-reflective back plates at CSAH 3 intersection (increase visibility of signal indications)
	• Re-evaluate pedestrian crossing times at CSAH 3
	• Install overhead pedestrian indications
	
	Medium to Long-Term:
	• Implement Complete Streets solution (road diet)
	• Close access at Sunset Ave, Century Ave, and other regions identified in Access Management Plan
	• Implement 3/4 intersection with Jackson Ave (access consolidation)
	• Install pedestrian bump outs/curb extensions at CSAH 3
	• Move north and south stop bars closer to intersection at CSAH 3 (sightline improvements)

Segment C ***East of Cokato***	Short-Term: • Install centerline and edge line rumble strips Medium-Term: • Install center buffer strip Long-Term: • Develop 2+1 passing lane sections or install concrete or high-tension cable barrier between opposing travel directions in four-lane section (traffic flow improvement/access management)

Location	Recommended Short (0-5yrs), Medium (5-10yrs), and Long (10+yrs) Term Solutions
Segment D ***Howard Lake***	Short-Term: • Conduct public outreach for Complete Streets solutions (road diet) • Develop Access Management Plan • Close south leg of CSAH 6/10th Avenue south approach (access management) • Relocate "1005 Sixth Street Burkstrand Building" sign around north leg of 10th Avenue (sightline improvements) • Add white edge lines (10'-12'-10' Lanes + Bike Lanes) • Update pedestrian flashers to be Rectangular Rapid Flash Beacons (RRFBs) • Install pedestrian bump outs at CSAH 6/10th Ave Medium-Term: • Implement Complete Streets solution (road diet)
Segment E ***East of Howard Lake***	Short-Term: • Install centerline and edge line rumble strips Medium-Term: • Install center buffer strip Long-Term: • Develop 2+1 passing lane sections (traffic flow improvement/access management)
Segment F ***Waverly/ Montrose***	Short-Term: • Conduct public outreach for Complete Streets solutions (road diet) • Develop Access Management Plan • Add additional street light at Clementa Avenue in southwest quadrant • Install westbound advanced warning signs for pedestrian crossing at 4th Street/ CSAH 62 • Install advanced warning signs/flashers to notify eastbound and westbound drivers of signal at Buffalo Avenue/TH 25 • Update pedestrian flashers to be Rectangular Rapid Flash Beacons (RRFBs) Medium-Term: • Implement Complete Streets solution (road diet) • Install pedestrian bump outs at various crossings • Install a High-Intensity Activated crossWalK (HAWK) beacon near 4th Street/ CSAH 62 Long-Term: • Install sidewalks on both sides of the street in Waverly
Segment G ***Eastern Montrose***	Short-Term: • Install centerline and edge line rumble strips • Monitor success of Continuous Green T at Trunk Highway (TH) 25 (determine if can be used at other locations along the corridor) Medium-Term: • Install center buffer strip Long-Term: • Develop 2+1 passing lane sections (traffic flow improvement/access management)

Location	Recommended Short (0-5yrs), Medium (5-10yrs), and Long (10+yrs) Term Solutions
Segment H ***East of Montrose***	Short-Term: • Install centerline and edge line rumble strips Medium-Term: • Install center buffer strip Long-Term: • Develop 2+1 passing lane sections or install concrete or high-tension cable barrier between opposing travel directions in four-lane section (traffic flow improvement/access management)
Segment I ***West of Delano***	Short-Term: • Install centerline and edge line rumble strips • Add more lighting between CSAH 14 and Delano • Add “Cross Traffic Does Not Stop” signage at CSAH 14 north approach and add LED flashers to stop sign perimeter (driver awareness improvements) Medium-Term: • Install center buffer strip Long-Term: • Develop 2+1 passing lane sections (traffic flow improvement/access management)
Segment J ***Delano***	Short-Term: • Conduct public outreach for Complete Streets solutions (road diet) • Develop Access Management Plan • Add warning flashers and relocate beacon prior to the bridge east of the Bridge Avenue Intersection and prior to the curve west of the intersection (driver awareness improvements) • Add “Signal Ahead” warning signs for westbound traffic at the CSAH 30 intersection • Add horizontal curvature warning sign for westbound traffic approaching the CSAH 30 intersection • Perform an intersection capacity analysis to determine if additional lanes needed at Tiger Drive (congestion alleviation) • Evaluate system-wide signal coordination through town (congestion alleviation) • Add flashing yellow arrow for left turns at County Line Road/CSAH 139 (congestion alleviation) • Add pavement markings for pedestrian crossings at County Line Road/ CSAH 139 Medium-Term: • Implement Complete Streets solution (road diet) • Add pedestrian bump outs/curb extensions on US 12 intersections • Look into closing accesses around Babcock Circle, especially on the north side of US 12. • Install signal system interconnect through town (congestion alleviation) • Remove left turn lanes onto Crow River Drive (access consolidation) • Extend right turn lanes at County Line Road/CSAH 139 (congestion alleviation) Long-Term: • Make segment four-lanes with raised center median (access consolidation/congestion alleviation)

<table>
<tr><th>Location</th><th>Recommended Short (0-5yrs), Medium (5-10yrs),
and Long (10+yrs) Term Solutions</th></tr>
<tr><td>Segment K
Independence</td><td>Short-Term:
• Install centerline and edge line rumble strips
• Develop Access Management Plan
• Install warning signs/flashers for the following locations:
  o Add warning signs and flashers by the West Pointe Church to notify drivers of traffic backup from the west
  o Install flashers for approaching traffic at CSAH 90 and CSAH 92 to notify drivers of approaching intersections and traffic backup from the east and west
• Add chevrons to horizontal curve around mile marker 144
• Conduct an ICE review process at CSAH 92 and CSAH 90 intersections
  o Evaluate roundabout or other reduced conflict intersection at CSAH 92 south approach
  o Evaluate right in-right-out configuration for CSAH 92 north approach
  o Evaluate conjoining both 92 intersections using a roundabout
  o Evaluate roundabout at CSAH 90
  o Evaluate adding a reduced conflict intersection configuration to CSAH 92 and CSAH 90 intersections
• Add corridor lighting between CSAH 92 and CSAH 90
• Improve clear zone on westbound shoulder between CSAH 92 and CSAH 90
• Add left turn lanes on CSAH 92 (congestion alleviation)
• Add channelized right turn lane on southern CSAH 92 approach
• Update lane markings on CSAH 90 such that mainline right turn lanes become through lanes and through lanes become left turn lanes (congestion alleviation)

Medium-Term:
• Add pavement to widen shoulders and install center buffer strip (head-on crash reduction)
• Develop 2+1 passing lane sections (traffic flow improvement/access management)
• Close western access for Peterson Produce, access to Hitsman Lane East, and access to Valley Road (access consolidation)
• Realign approaches from CSAH 92 intersections to remove skew
• Install traffic control chosen from ICE process at CSAH 92 and 90 intersections</td></tr>
<tr><td>Segment L
Maple Plain</td><td>Short-Term:
• Conduct public outreach for Complete Streets solutions (road diet)
• Develop Access Management Plan
• Install recoverable attenuator in front of median barrier which protects the rail road bridge and install “mumble” strips leading up to the barrier (driver awareness improvements)
• Create a continuous left turn lane from CSAH 83 to the location east of the nearby median barrier
• Add wayfinding signs to direct pedestrians to High-Intensity Activated crossWalK (HAWK) beacon in town
• Install advanced warning signs to westbound and eastbound traffic approaching the Baker Park Road/TH 25 signal (driver awareness improvements)
• Conduct an ICE review process at Baker Park Road/TH 25 (congestion alleviation)
  o Evaluate signalized Continuous Green T
  o Evaluate reduced Conflict Intersection

Medium-Term:
• Implement Complete Streets solution (road diet)
• Move left turn loop detectors and re-stripe south approach lanes at CSAH 83 (improve detection)</td></tr>
</table>

Location	Recommended Short (0-5yrs), Medium (5-10yrs), and Long (10+yrs) Term Solutions
	• Close south access from Budd Avenue and/or CSAH 19, and close Oak Street access (access consolidation) Long-Term: • Install roundabouts at Maple Avenue and CSAH 29 (congestion alleviation) • Install raised median between Maple Avenue and CSAH 29 (access consolidation) • Install traffic control chosen from ICE process at Baker Park Road/CSAH 29 intersection

Segment M
Orono
	Short-Term:
	• Install centerline and edge line rumble strips
	• Add CSAH 6 ramp metering (congestion alleviation)
	• Implement ITS solutions (driver awareness improvements)
	  o Travel time signing
	  o Congestion ahead
	
	Medium-Term:
	• Install center buffer strip
	• Develop 2+1 passing lane sections (traffic flow improvement/access management)
	
	Long-Term:
	• Create moveable barrier (congestion alleviation)

Segment N
Orono/ Long Lake
	Short-Term:
	• Install flexible delineators along centerline
	• Install centerline median barrier
	• Implement ITS solutions (driver awareness improvements)
	  o Travel time signing
	  o Congestion ahead
	
	Medium-Term:
	• Develop 2+1 passing lane sections (traffic flow improvement/access management)
	• Add dynamic shoulder for eastbound traffic between CSAH 6 and Wayzata (congestion alleviation)
	
	Long-Term:
	• Create moveable barrier (congestion alleviation)

2 Introduction

The corridor of US 12, also known as Trunk Highway (TH) 12, or Highway 12, is bounded by the western Wright County line and Long Lake, MN. The 38-mile corridor runs through nine different cities in two districts and two counties. This stretch of road is heavily used by drivers commuting to and from the Twin Cities metro region. The roadway further connects to South Dakota to the west and Wisconsin to the east. Various concerns have been voiced about safety issues along the corridor.

As a result of the history of crashes and concerns expressed by local residents, Hennepin and Wright County communities and their representatives along Highway 12 formed the Highway 12 Safety Coalition. The Coalition was formed in attempt to work collaboratively with the Minnesota Department of Transportation (MnDOT) to improve the safety of the US 12 corridor.

To further investigate issues along the corridor, MnDOT decided to conduct a road safety audit to determine if the number and severities of crashes is abnormal, determine the primary factors for the crashes, and propose long, medium, and short-term recommendations to improve the safety of the corridor. For more information on what a road safety audit process entails, please refer to Appendix B of this report.

2.1 Study Area

The 38-mile project corridor runs along US 12 from the Western Wright County line to Wayzata Boulevard in Wayzata, MN. The project runs through two different counties (Wright and Hennepin) and is within both District 3 and the Metro District of MnDOT. Nine different cities are included in the corridor: Cokato, Howard Lake, Waverly, Montrose, Delano, Independence, Maple Plain, Orono, and Long Lake. See Figure 2-1 below.

Figure 2-1: Study Limits[1]

[1] *Photo Source: Bing Maps (September 2015)*

2.2 Road Safety Audit Review Team

MnDOT chose HDR to assist in the assembly of a review team and to co-lead US 12 road safety audit efforts. It was crucial to assemble a team that would look at all project aspects and not provide biased views on safety issues. The road safety audit team consisted of team members from various disciplines and backgrounds. Refer to Table 2-1 for a list of the road safety audit team members.

Table 2-1: Road Safety Audit Team

Name	Agency and Position
Derek Leuer	MnDOT, Traffic Safety Engineer
Scott Thompson	MnDOT District 7 (Mankato), Traffic Engineer
Jim Rosenow	MnDOT, State Design Flexibility Engineer
Melissa Barnes	MnDOT, Bicycle and Pedestrian Engineer
Brad Estochen	MnDOT, State Traffic Safety Engineer
Will Stein	FHWA, Safety Engineer (Minnesota Division)
Gary Kroells	West Hennepin Public Safety Department, Director (Leader of the Highway 12 Coalition)
Rick Denneson	West Hennepin Public Safety Department, Sgt.
Brandi Popenhagen	HDR, Project Manager
Natalie Lindsoe	HDR, Project Engineer
Bernie Arseneu	HDR, National Director - Traffic Management Systems

Figure 2-2: US 12 Road Safety Audit team members in Howard Lake, MN (May 28, 2015)[2]

[2] *Photo provided by Gary Kroells*

Figure 2-3: US 12 Road Safety Audit team members at the intersection of Budd Avenue N and US 12 in Maple Plain, MN (May 28, 2015)[3]

Figure 2-4: Chief Gary Kroells (Right) Receiving a Safety Recognition Award on Behalf of the Highway 12 Coalition (June 6, 2015)[4]

2.3 Key Dates

The following dates show the development of the US 12 road safety audit process:

May 04, 2015: Kickoff meeting with MnDOT District 3 and Metro District.
May 07, 2015: Coalition meeting at the Delano City Hall.
May 18, 2015 - May 21, 2015: Wavetronics data collected at two locations. See Appendix F for more information on speed and volume data.
May 21, 2015: Meeting with MnDOT districts to discuss the past, present, and future of the corridor.
May 28, 2015: All day field review of the project corridor.
July 17, 2015: District/road safety audit team review of draft report.
August 6, 2015: Coalition meeting to discuss road safety audit findings.

[3] *Photo provided by Gary Kroells*
[4] *Photo provided by Gary Kroells*

3 Pre-Audit

The main goal of the pre-audit stage was to select key regions to focus on for the field review. In addition, a briefing book was developed so that road safety audit team members could be brought up-to-date on the corridor status on the morning of the field review day (see document “US 12 Road Safety Audit Briefing Book”). Various factors were considered for this, including: observations identified by the coalition, past, present, and future improvement projects planned for the corridor, roadway characteristics (volumes, speeds, AADT), and lastly, crash data.

3.1 Coalition Concerns

Various concerns and recommendations were voiced at the Highway 12 Coalition meeting on May 7, 2015. These concerns are listed below. Any concerns brought up from the cities or residents were noted as well. The topics brought up by these parties were evaluated during the road safety audit process.

Corridor-Wide

<u>Corridor Lighting</u>: *Especially at intersections*

<u>Speeding Issues</u>: *Especially through towns where speed limits are reduced*

Cokato

<u>Ice issues on stretch of Highway 12 between Cokato and Dassel</u>: *Has issues with ice during the winter months. Because there is very little screening, the roadway in between the cities near the school gets very icy with wind blowing snow across the road.*

<u>Access to the school off Highway 12</u>: *There is no signal light or other traffic control device at the intersection by the school. Passenger vehicles and school buses take chances every day trying to exit the school onto Highway 12. As Highway 12 is an open stretch of flat land in either direction, the speed of the oncoming traffic on Highway 12 is also a safety concern. Motorists frequently ignore posted speed limits in this area, and the speed limits are too fast to allow cross traffic from the school to exit safely. Even a flashing light that only stops traffic during peak morning/afternoon drop off times would be helpful.*

<u>Intersection of Highway 12 and CSAH 3</u>*: Often have issues with truck traffic turning to head north on County State Aid Highway (CSAH) 3. Traffic coming south on CSAH 3 are blind to traffic coming from either direction on Highway 12 until they are nearly at the intersection because lines of sight are blocked by two existing buildings. CSAH 3 is not wide enough for large trucks to make the turn from either direction without entering into the left turn lane heading south on CSAH 3. Traffic entering the turn lane south often have to stop far short of the intersection, thus not triggering the sensor for the stoplight, or have been forced to put their vehicle into reverse and back up to avoid being hit by turning trucks. This method has worked, since there weren’t cars behind them in line, but is also a safety risk, as oncoming traffic is not expecting the cars ahead to be coming in reverse.*

Howard Lake

Speed Concerns: *People usually ignore the speed limit drop (55 mph to 30 mph) because the stretch of road is relatively short. This especially creates risk for pedestrians/bicycles because sidewalks are located close to the street.*

Montrose

Speed Concerns: *Particularly around County Rd 14 and TH 25.*

Independence

Redesign/Rebuild: *The Coalition recommends a complete redesign/rebuild of Highway 12 through Independence.*

West Pointe Church at 9090 Highway 12: *The Coalition recommends adding left-hand turn lanes for entering traffic.*

Peterson's Produce: *The Coalition recommends closing off the west driveway to Peterson's Produce.*

County Road 92: *The County Road 92 intersection backs up to Maple Plain during rush hour and drivers will choose to detour away from Highway 12. Sometimes drivers will make less safe decisions regarding left hand turns because of this. Analyze the intersections at Tiger Drive and Crow River Drive. The Coalition also recommends realigning Highway 12 and County Road 92 (north and south), with a controlled intersection.*

County Road 90: *The Coalition recommends installing a roundabout at Highway 12 and County Road 90.*

County Road 83: *The Coalition recommends adding rumble strips west of Highway 83.*

Access Management: *The Coalition recommends the following:*

- *Add frontage road from Nelson Road to County Line Road and cut hill down due to sight line issues.*
- *Close off access to Valley Road and Hitsman Lane East*
- *Realign Hitsman Lane West, Copeland Road, and Lake Haughey Road.*

Maple Plain

Dip in Road: *There is a dip in the road east of Maple Plain where a fatality has occurred.*

Area of Focus: *Focus on the area between Blackwater and Maple Avenue, curve and access points.*

Access Management: *The Coalition recommends allowing businesses on Highway 12 access through Pioneer and Manchester.*

The coalition and public have continued to express their concern for the safety along the corridor. On August 20, 2015 Coalition Leader Gary Kroells wrote a letter expressing the urgency to make safety improvements. In response to recent crashes, an article was published on August 24, 2015 "Time for Action on Highway 12" in several local journals. These public feedback documents can be found in Appendix C: Public Feedback.

3.2 Corridor Characteristics

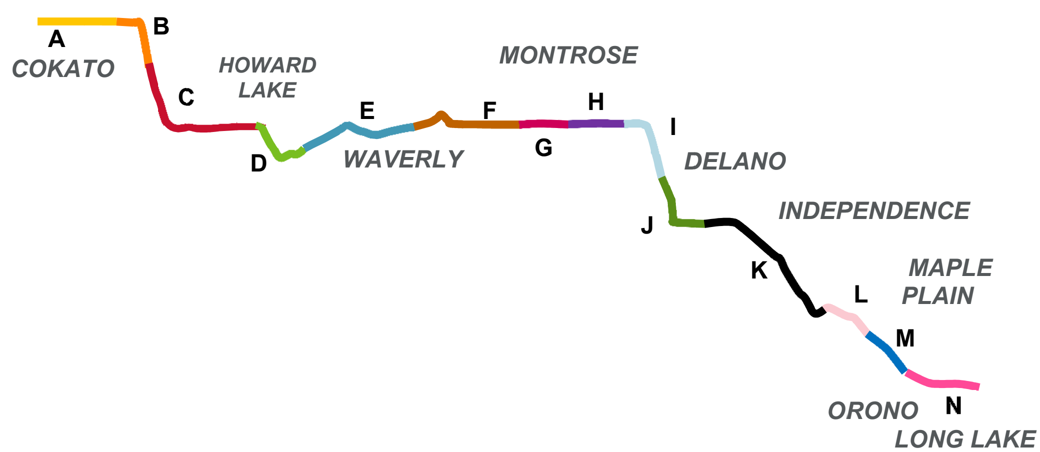
3.2.1 Annual Average Daily Traffic (AADT)

The 2013 annual average daily traffic (AADT) values range between 7,800 at the western project limit and 24,100 at the eastern project limit. In July 2012, the MnDOT Transportation Data and Analysis (TDA) Office prepared future year 2036 projections. State planning-level projections were developed from traffic data in years 1992 to 2011. According to these projections, AADT is projected to range between 9,500 and 25,000 throughout the entire corridor in 2036. Refer to Appendix E, Table E- 2 for projected volume values. It should be noted that this model was unconstrained; meaning that the roadway was assumed to have unlimited capacity. In reality, the roadway does have limited capacity, but it's difficult to predict how the state of the roadway will change over time. For planning level projections, unconstrained models can be good for getting a ball-park estimate. Please refer to pages A-12 to A-17 of the document "US 12 Road Safety Audit Briefing Book" for 2013 AADT maps of the corridor. 2010-2013 AADT values are summarized in Table E- 1, which can be found in Appendix E.

3.2.2 Segments

In order to better perform an analysis, the roadway was divided up into segments. Segment breaks were chosen wherever the road character changed. The corridor alternates primarily between three-lane[5] urban and two-lane rural segments. For the most part, urban segments had reduced speed limits (i.e. around 30mph) while rural segments had speed limits around 50-55mph. Google Earth was used to determine where road geometry and character changes occurred. AADT data was considered in the segmenting process as well. Refer to Figure 3-1 and Table 3-1 for more information about segments.

Figure 3-1: Segmentation of the Corridor



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[5] *Three-lane urban segments in this corridor consisted of one lane for each direction of traffic and a continuous shared left turn lane in the center. This geometry was present in most cities.*

Table 3-1: Segment Notes

Segment	Segment From	Segment To	Length (mi)	Urban/ Rural	# Lanes	Avg. AADT (2010-'13)[6]
Segment A *West of Cokato*	Meeker/Wright County Line	100' West of Sunset Avenue N	2.80	R	2	7,650
Segment B *Cokato*	100' West of Sunset Avenue N	100' East of Oliver Avenue SW	1.34	U	3	8,028
Segment C *East of Cokato*	100' East of Oliver Avenue SW	250' West of Keats Avenue SW	4.16	R	2	7,771
Segment D *Howard Lake*	250' West of Keats Avenue SW	100' East of CSAH 7/ Shoreline Drive	1.83	U	3	9,213
Segment E *East of Howard Lake*	100' East of CSAH 7 /Shoreline Drive	250' West of CSAH 8 LT/ Emerson Avenue SW	3.74	R	2	8,795
Segment F *Waverly/ Montrose*	250' West of CSAH 8 LT/ Emerson Avenue SW	100' East of Arizona Avenue	3.81	U	3	10,029
Segment G *Eastern Montrose*	100' East of Arizona Ave	500' East of TH 25 LT	1.84	R	2	11,748
Segment H *East of Montrose*	500' East of TH 25 LT	1000' West of CSAH 14	1.78	R	3 or 4	11,675
Segment I *West of Delano*	1000' West of CSAH 14	100' West of Ebersole Avenue SE	2.20	R	2	11,675
Segment J *Delano*	100' West of Ebersole Avenue SE	250' East of CSAH 139/ County Line Rd SE	2.25	U	3	15,933
Segment K *Independence*	250' East of CSAH 139 / County Line Rd SE	Maple Plain City Limit	4.94	R	2	14,781
Segment L *Maple Plain*	Maple Plain City Limit	250' East of CSAH 29 / Baker Park Road / Townline Road	1.73	U	3	15,404
Segment M *Orono*	250' East of CSAH 29 / Baker Park Road/ Townline Road	CSAH 6	1.54	R	2	19,425
Segment N *Orono/Long Lake*	CSAH 6	Wayzata Blvd	4.02	U/R	2	22,950

[6] *Average AADT computed based on segment lengths. Refer to the document "US 12 Road Safety Audit Briefing Book" for more information regarding ADA data sources.*

3.3 Historic and Planned Road Construction Projects

Prior to the road safety audit, the road safety audit team met with MnDOT's District 3 and Metro District at a meeting on Thursday, May 21, 2015 to discuss the past, present and future of the project corridor. Specifically, past projects were discussed, along with projects that are programmed. The two districts were also asked to discuss what their future vision is for the project corridor. Table 3-2 and Table 3-3 summarize past, programmed, and planned projects for each district.

Table 3-2: District 3 Past, Programmed, and Planned Projects[7]

Year Built	Location	Description
	District 3 – Past	
1996	West of Cokato	Reconstruction
1997	West limits of Montrose to West limits of Delano	Reconstruction – includes passing lane section
1998	Cokato to Howard Lake	Reconstruction – includes passing lane section
1999	Cokato	Reconstruction
2000	Howard Lake to Montrose	Reconstruction
2008-2009	Delano	Reconstruction – urban section built as three-lane with wide shoulders; could be striped as a four-lane in the future if US 12 capacity increased between Metro and Delano
2014	Dassel/Cokato	Ice sensor warning system installed
	District 3 – Programmed	
2015	1 mile east of Montrose	Reconstruction of the TH 25 north leg and US 12 intersection into a Continuous Green T.
2015	West Cokato city limits to Maple Plain	Complete sign replacement along US 12. Includes side street stop signs and additional side street signs on MnDOT right of way.
Future Year 2018	Cokato to Howard Lake	Resurfacing
Future Year 2019	Meeker County Line to 7th St E in Cokato	Resurfacing and upgrade to Americans with Disabilities Act (ADA) standards
	District 3 – Planned	
Future Year 2021	Howard Lake to Delano	Resurfacing – includes ADA in Howard Lake, Waverly and Montrose.

[7] *Source: District 3 Updates at Past, Present, and Future meeting on May 21, 2015.*

Table 3-3: Metro District Past, Programmed, and Planned Projects[8]

Year Built	Location	Description
	Metro District – Past	
2005	CSAH 90 to Hennepin/Wright County line	Resurfacing
2006	Eastern portion of Maple Plain, west of CSAH 29 to Boundary Avenue	Resurface and install median in
2008	Long Lake and Orono from CSAH 6 to CSAH 15	Construct bypass of Long Lake and Orono
2010	East of CSAH 90 in Maple Plain	Replace BNSF railroad bridge and resurface 0.940 mile stretch of roadway
2010	Wright-Hennepin County boundary to CSAH 90 in Maple Plain	Bituminous seal coat on 4.207 mile stretch
2012	Boundary Avenue to east of BNSF RR bridge location in Maple Plain	Resurface 1.133 mile stretch and add left turn lanes
December 2014	Between CSAH 6 and CSAH 29, and from CSAH 9 to County Line Road	Centerline rumble strips installed (Diamond Surfaces Inc. donation)
	Metro District – Programmed	
2015	CSAH 15/South CSAH 101 to I-494	Add auxiliary lane on eastbound US 12
Fall 2015	East of CSAH 90 to County line. Includes three County Road intersections and four or five city roads.	Install intersection lighting
	Metro District – Planned	
Future Year 2018	CSAH 101 in Wayzata	Re-deck CSAH 101 bridge over US 12
Future Year 2018	CSAH 90 in Independence	Improvement (left turn lane) was planned at CSAH 90; however, this project was placed on hold pending re-scoping after the road safety audit is completed.
TBD	CSAH 6 to CSAH 29 and CSAH 90 to County line	Next pavement project – is undetermined at this time.
TBD	EB lanes between the Super 2 and I-494	Interest in adding an extra auxiliary lane

In general, most of the corridor has either been reconstructed or resurfaced over the last two decades. The exception area is around the City of Independence, which has not been re-constructed in more than 35 years. In general, the roadway through this section is narrow and is notably aged in comparison to the other segments along the corridor. Many of the intersections in the region are skewed. In other words, the cross streets intersect the main street at a non-orthogonal angle. This can lead to a larger amount of right angle and turning-related crashes. Various projects have been planned for this stretch, particularly around CSAH 90, but have been placed on hold, pending the results of the road safety audit study.

In various urban sections, the corridor was built for future four-lane expansion, which resulted in large cross sections. In some situations, wide cross sections can promote speeding above what is acceptable in urban areas. A road diet can be applied to counteract this effect and it is recommended that public outreach is used to develop Complete Streets solutions which can benefit road users according to specific community needs. From Howard Lake to Delano, various Americans with Disabilities Act (ADA) projects are planned. ADA projects are

[8] *Source: Metro District Updates at Past, Present, and Future meeting on May 21, 2015.*

implemented to bring intersections up to standards that accommodate all types of pedestrians. ADA improvements include: adding truncated domes[9] to pedestrian ramps, placing WALK push buttons in accessible locations, adding count down timers and other audio queues to pedestrian signals, and making pedestrian curb ramps less steep. This could be incorporated with Complete Streets solutions and pedestrian safety improvements recommended in this report.

Around the City of Cokato, there is a rural section which contains stretches of passing lanes that are alternated for each direction of traffic. This is commonly referred to as a 2+1 section. 2+1 sections are installed to provide drivers with opportunities to pass slow moving traffic where normally they would have to use the opposing lane to do so. This is a method that could be applied in other rural segments along the corridor.

A Continuous Green T is being constructed at the TH 25 north leg intersection, one mile east of Montrose. Continuous Green T's, also referred to as CGT's, are a type of intersection control installed at T-intersections. They are constructed to allow continuous movement for through traffic on the "top" of the T intersection and provide safer turn movements through channelization. CGT's can reduce right angle crashes attributed to left-turning traffic on the "stem" of the T. Additionally, CGT's can alleviate congestion. Depending on the success of this intersection control device, it is possible that Continuous Green T's could be applied to other regions in this corridor. Further discussion on Continuous Green T's is provided in Section 5.2.4.

A sign replacement project is currently taking place along US 12 from the westerly city limits of Cokato to the City of Maple Plain. This project includes the replacement of side street stop signs and any additional side street signs on MnDOT right of way. At the time of the road safety audit field visit, these sign updates were not yet in place.

Frequent ice issues around the Dassel-Cokato High School have raised safety concerns. In 2014, an ice sensor warning system was installed to inform drivers when ice is present on the roadway. With this detection system, maintenance staff is directly notified when corrective action is needed to clear the roadway. The system performance is being continually evaluated to monitor the effectiveness of this new technology. Further discussion about this project is given in Appendix G: Ice Sensor Warning System.

In response to a large number of head-on collisions, centerline rumble strips were installed between CSAH 6 and CSAH 29, and from CSAH 9 to County Line Road in December 2014. Local officers note that they have noticed a significant reduction in head-on crashes since the installation and intend to install more rumble strips along the corridor.

[9] Truncated domes are textured pieces of material that are placed on edges of curb ramps so that visually impaired people can be alerted that they have entered the interface between the sidewalk and the street crossing.

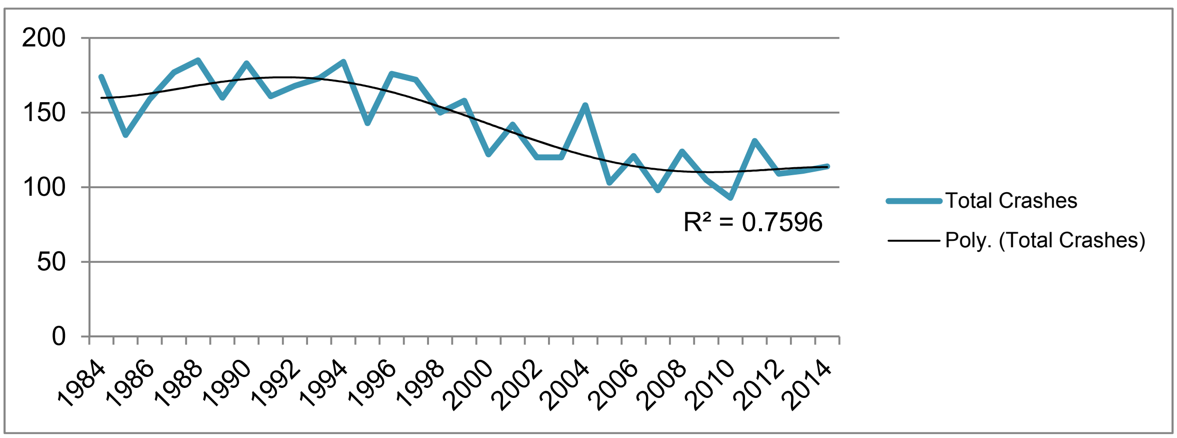
3.4 Crash Data

Crash data was collected from the MnDOT and Minnesota Department of Public Safety (MNDPS) database and was evaluated to identify trends. The corridor history since 1984 was first evaluated on a large scale. Corridor-wide trends from the years 2010-2014 were next assessed in terms of crash severity, surface conditions, diagram, relation to junction, crash type, crash location, and time of crash. To pin-point key risk areas (i.e. “flagged” areas), the corridor was broken down into segments and intersections and were evaluated on a case-by-case basis.

3.4.1 Historical Trends (1984-2014)

Historical crash data was gathered from the years 1984 to 2015. From the years 1984 to 2015, the total amount of crashes that have occurred along the corridor has decreased. As can be seen in Figure 3-2 below, the peak number of crashes within this time period occurred in the early 1990’s. It should be noted that the boundaries used for this data pull were slightly wider than the project boundaries and that traffic data volume was estimated, however, the trends shown still give a general representation of the corridor historical trends.

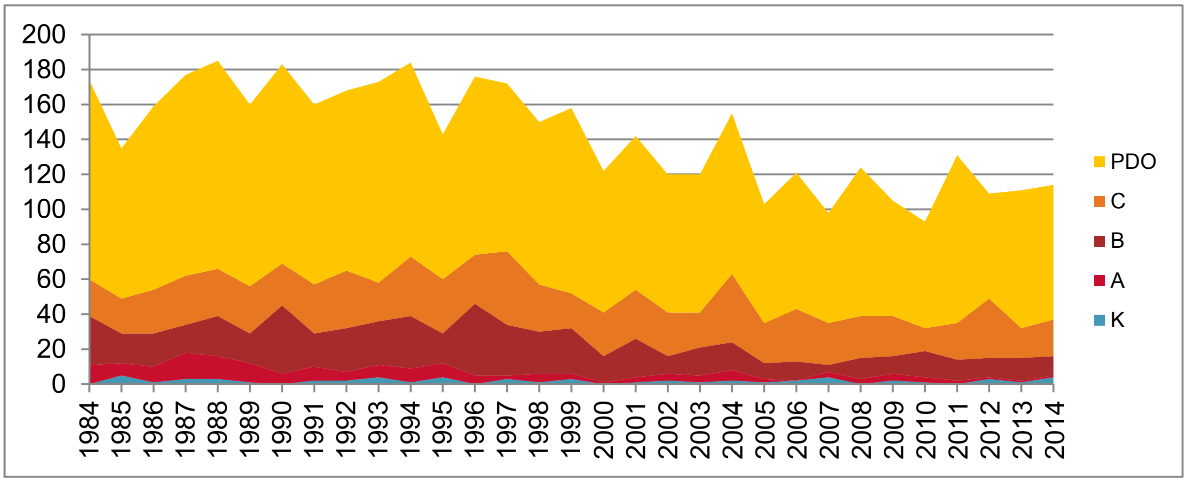
Figure 3-2: Total Crashes (1984-2014)[10]



Throughout this time period, the distribution of crash severities have remained approximately the same, with property damage only (PDO) crashes being the most common, and fatal (type K) crashes being the least frequent. Figure 3-3 demonstrates this.

[10] *US 12 Crash Data Source: 1984-2015 Minnesota TIS Crash Data*

Figure 3-3: Total Crashes, By Severity (1984-2014)[11]



Similarly, crash rates along the corridor have also decreased since 1984. Please refer to pages B1-B4 of the document "US 12 Road Safety Audit Briefing Book" for data figures showing total crash rate trends and fatal and incapacitating rate (FAR) trends.

3.4.2 Corridor-Wide Trends (2010-2014)

The study period chosen for the road safety audit crash data review was from 2010-2014. This five year study period provides data which is recent, yet long enough in duration to more accurately show trends. The bullet points below list the general trends observed along the corridor. Percentages were computed from a total of 558 crashes, with 18 of these crashes being K+A[12]. Please refer to Section C of the document "US 12 Road Safety Audit Briefing Book" for data figures and charts.

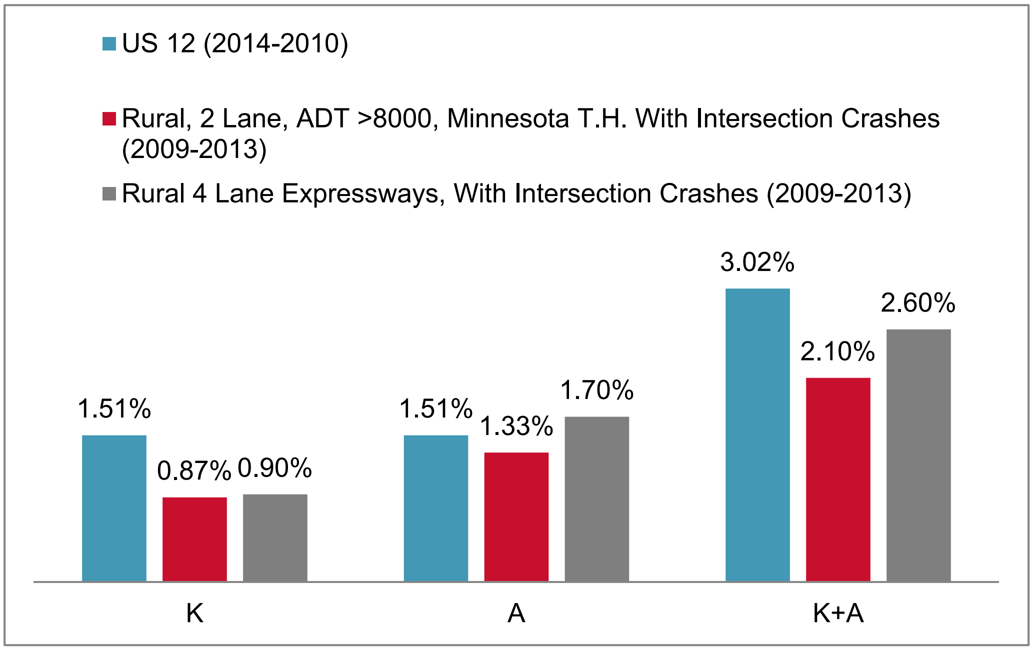
One significant trend observed for this corridor was the high percentage of head-on collisions. Approximately two out of every three fatal or incapacitating crashes were head-on collisions. Based on this trend, the RSA team noted the importance of implementing safety features to reduce lane-departure crashes.

- **Crash Severity:** 65 percent of all crashes were property damage only. Approximately four percent of crashes were fatal or incapacitating (K+A). Refer to Figure 3-4 for a comparison of US 12 K+A severities to state average values.

[11] *US 12 Crash Data Source: 1984-2015 Minnesota TIS Crash Data*

[12] *Note that crash data from Segment N between Brown Road and Wayzata Boulevard was not included in these percentages. This portion of Segment N was included in the analysis on a later timeline in response to public request.*

Figure 3-4: Percentage of Fatal (K) and Severe (A) Crashes - US 12 vs. Statewide Averages[13]



- **Surface Conditions:** 68 percent of all crashes occurred in dry conditions. 61 percent of K+A crashes occurred in dry conditions. 32 percent of K+A crashes occurred in snowy or icy conditions.
- **Diagram:** 38 percent of all crashes were rear end and 16 percent were right angle. **61 percent of K+A crashes were head-on**, 11 percent were rear end.
- **Relation to Junction:** 49 percent of all crashes were non-junction related. 72 percent of K+A crashes were non-junction related. 22 percent of K+A crashes occurred at T-intersections.
- **Type of Crash:** 70 percent of all crashes involved collisions between motor vehicles in transport. 14 percent of all crashes were with fixed objects. 72 percent of K+A crashes involved collisions between motor vehicles in transport.
- **Location of Crash:** 22 percent of all crashes occurred in Independence, 17 percent occurred in Maple Plain, and 15 percent occurred in Delano. 22 percent of K+A crashes occurred in Independence, 17 percent occurred between Waverly and Montrose, and 17 percent occurred in Orono.
- **Time of Crash:** Majority of crashes occurred during AM and PM peak hours.

[13] *US 12 Crash Data Source: 2010-2014 Minnesota TIS Crash Data. Statewide Averages Source: MnDOT 2013 Section Toolkit*

3.4.3 Segment Trends (2010-2014)

Each of the segments shown in Figure 1-1 was individually analyzed as part of the crash study. Crash rates and FARs were computed using formulas from MnDOT's "Traffic Safety and Fundamentals Handbook" (2008). US 12 rates were compared to statewide averages, which came from the MnDOT 2013 Section Toolkit, as well as critical rates, which were computed using formulas from MnDOT's "Traffic Safety and Fundamentals Handbook (2008). Crash rates are summarized in Table 3-4 below. Note that orange cells indicate that the US 12 rate is above Minnesota state average. Red cells indicate that the US 12 rate is over the critical rate and the Minnesota state average. Any segments that are highlighted in yellow were flagged and identified as segments to focus on during the road safety audit. In most cases, the FAR rates were identified as a problem. This signified that fatal and incapacitating crashes play a large role in the corridor safety.

Crash type summaries were developed for each of the highlighted segments in order to determine trends in crash severity, year, light condition, collision type, collision diagram, vehicle type, contributing factors, alcohol/chemical use, time of day, day of week, road surface condition, weather condition, and driver age. Crash frequency and percentages were compared to expected crash data (i.e. Minnesota Statewide Averages) from MnDOT Oracle Business Intelligence (BI) and the MnDOT 2013 Crash Data Toolkit. Please refer to Section D of the document "US 12 Road Safety Audit Briefing Book" to review these data sheets. A summary of segment data sheets is provided in Appendix D of this report.

Table 3-4: Segment Crash Rates (2010-2014)[14]

				Crash Rate			K + A (FAR)		
Seg.	**Roadway Type**	**Total Crashes**	**K+A Crashes**	**US 12**	**State Average**	**Critical**	**US 12**	**State Average**	**Critical**
A	Rural 2-lane: AADT 5000-8000	24	2	0.61	0.61	0.95	*5.12*	2.41	6.86
B	3-lane Undivided	35	0	1.78	2.00	2.85	0.00	2.67	3.17
C	Rural 2-lane: AADT 5000-8000	18	1	0.31	0.61	0.88	1.70	2.41	2.67
D	3-lane Undivided	23	1	0.75	2.00	2.67	*3.25*	2.67	3.07
E	Rural 2-lane: AADT >8000	9	0	0.15	0.73	1.02	0.00	1.57	1.79
F	3-lane Undivided	47	1	0.67	2.00	2.44	1.43	2.67	2.93
G	Rural 2-lane: AADT >8000	24	2	0.61	0.73	1.10	*5.07*	1.57	1.84
H	3-lane Undivided	7	1	0.18	2.00	2.60	2.64	2.67	3.03
I	Rural 2-lane: AADT >8000	15	1	0.32	0.73	1.06	*2.13*	1.57	1.81
J	3-lane Undivided	96	0	1.47	2.00	2.46	0.00	2.67	2.94
K	Rural 2-lane: AADT >8000	110	4	*0.83*	0.73	0.93	*3.00*	1.57	1.71
L	3-lane Undivided	94	1	1.93	2.00	2.53	2.06	2.67	2.98
M	Rural 2-lane: AADT >8000	28	2	0.51	0.73	1.04	*3.66*	1.57	1.80
N	Rural 2-lane: AADT >8000	47	4	0.29	0.73	0.90	*2.27*	1.57	1.69

**Notes:
- Orange cells indicate that the US 12 rate is above Minnesota state average.
- Red cells indicate that the US 12 rate is over the critical rate and the Minnesota state average.
- Any segments that are highlighted in yellow were flagged and identified as segments to focus on during the road safety audit

3.4.4 Intersection Trends (2010-2014)

In addition to evaluating segments, intersections were also evaluated. A similar approach was taken for computing and comparing crash rates. If crash rates or FARs exceeded state averages or critical rates for an intersection, the intersection was further evaluated for crash trends or abnormalities in the field. To ensure that nothing was overlooked, any intersection that had five or more crashes during the five year study period were also observed. Table 3-5 identifies all of the

[14] *All crash rates are in units of crashes per MVM (Million Vehicle Miles). All FARs (Fatal and Incapacitating Rates) are in units of crashes per 100 MVM. US 12 rates were computed via formulas from the Traffic Safety Fundamentals Handbook (2008). Statewide Averages came from the MnDOT 2013 Section Toolkit. Critical rates were computed via formulas from the Traffic Safety Fundamentals Handbook (2008). All segments were taken to be conventional roadways. Segments include intersection crashes. A 99.5% confidence interval was used to compute the critical crash rate. A 90% confidence interval was used to compute the FAR.*

intersections which were flagged as being a higher risk intersection. Please refer to Section C of the document “US 12 Road Safety Audit Briefing Book” for more information on intersection severities and crash rates. Section D contains crash type summaries for each of the flagged intersections. A summary of intersection data sheets is provided in Appendix D of this report.

Table 3-5: Flagged Intersections

Segment	Cross Street	Intersection Type	Reason Studied
Segment A *West of Cokato*	Quimby Avenue SW	Rural Thru/Stop	CR > State Avg.
Segment B *Cokato*	Sunset Avenue N	Urban Thru/Stop	CR > State Avg.
	Johnson Avenue N	Urban Thru/Stop	CR > State Avg.
	Jackson Avenue NW	Urban Thru/Stop	CR > State Avg.
	CSAH 3/ Broadway Avenue N	Low Vol. & Speed Signal	≥ 5 crashes
Segment D *Howard Lake*	CSAH 6 LT/10th Avenue	Urban Thru/Stop	CR > State Avg.
	CSAH 6 RT/7th Avenue	Urban Thru/Stop	CR > State Avg.
Segment F *Waverly/Montrose*	CSAH 8 LT/ Emerson Avenue SW	Urban Thru/Stop	CR > State Avg.
	S 4th Street/CSAH 62	Urban Thru/Stop	CR > State Avg.
	Clementa Avenue SW	Urban Thru/Stop	CR > State Avg.
	Center Avenue S	Urban Thru/Stop	CR > State Avg.
	TH 25 RT/CSAH 12/ Buffalo Avenue S	Low Vol. & Speed Signal	≥ 5 crashes
Segment G *Eastern Montrose*	Zephyr Avenue	Rural Thru/Stop	FAR > State Avg.
	TH 25 LT	Rural Thru/Stop	CR > State Avg.
Segment I *West of Delano*	CSAH 14	Rural Thru/Stop	CR > State Avg.
Segment J *Delano*	Bridge Avenue E	High Vol., Low Speed Signal	≥ 5 crashes
	CSAH 30 RT	High Vol., Low Speed Signal	≥ 5 crashes
	5th Street S	Urban Thru/Stop	≥ 5 crashes
	Babcock Circle	Urban Thru/Stop	≥ 5 crashes
	Tiger Dr	High Vol., Low Speed Signal	≥ 5 crashes
	CSAH 139/ County Line Road SE	High Vol., Low Speed Signal	CR > State Avg.
Segment K *Independence*	Nelson Road	Rural Thru/Stop	≥ 5 crashes
	CSAH 92 RT/Mud Lake Road	Rural Thru/Stop	CR > State Avg.
	CSAH 92 LT/Lake Sarah Road	Rural Thru/Stop	≥ 5 crashes
	Valley Road	Rural Thru/Stop	≥ 5 crashes
	CSAH 90	Rural Thru/Stop	CR > Critical Rate
Segment L *Maple Plain*	CSAH 83/Halgren Road	High Vol., Low Speed Signal	≥ 5 crashes
	Pioneer Avenue	Urban Thru/Stop	CR > State Avg. & FAR > Critical FAR
	Budd Avenue N	Urban Thru/Stop	CR > Critical Rate
	CSAH 19/Main Street E	Urban Thru/Stop	CR > State Avg.
	CSAH 29/Baker Park Road	High Vol. & Speed Signal	≥ 5 crashes

4 Audit

On Thursday, May 28, 2015 a 10-hour field review was conducted by the road safety audit team. Team members drove the entire project corridor and looked for different risk factors that could be used to diagnose the contributing factors of problems identified in the Pre-Audit review.

The road safety audit team focused on the segments and intersections that were deemed higher risk in the Pre-Audit review. Additionally, the team took note of any potential risk factors that could lead to future safety risks. Director Gary Kroells and Sergeant Rick Denneson West Hennepin Public Safety Department were able to provide insight from their own experiences along the corridor.

In addition to feedback provided from the Coalition, crash data was used to inform the road safety audit team about possible reasons for high crash rates. The process is similar to how a doctor will look at different symptoms to determine what is making a patient sick. Often times, there are several ways to make a patient feel better, and it is likely that a doctor will recommend different solutions depending on patient need and preference. Solutions can vary by how invasive they are, how expensive they are, and whether or not they provide a long-term fix. All alternatives should be considered and assessed on a case-by-case basis.

Table 4-1 below demonstrates some examples of crash types (a.k.a. “symptoms”) that the road safety audit team looked for. Also identified in this table are the corresponding factors that could be causing the specific crash types. Higher risk segments/intersections that had crash data values higher than state averages for each crash type are also identified. Refer to crash data sheets in Section D of the document “US 12 Road Safety Audit Briefing Book” for more information on segments and intersection crash data.

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

Crash Type	Possible Contributing Factors(s)	Segments/Intersections 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	<u>Rural Segments</u>: A,G, K,M,N <u>Rural Intersections</u>: Quimby, T.H. 25 LT, CSAH 92 RT, CSAH 92 LT, Valley <u>Urban Intersections</u>: Johnson, Center, T.H. 25 RT, Bridge, 5th St S, Babcock, Tiger, Pioneer, CSAH 29
Sideswipe collisions	• Distracted drivers • Sudden lane merges	<u>Rural Segments</u>: A <u>Rural Intersections</u>: T.H. 25 LT, S 4th St, Tiger, CSAH 83 <u>Urban Intersections</u>: Budd, CSAH 29
Left turn into traffic	• Inadequate sightline • Lack of gaps in traffic • Distracted drivers	<u>Rural Intersections</u>: CSAH 14, CSAH 92 RT <u>Urban Intersections</u>: Jackson, Broadway, CSAH 6 LT, Clementa, Co Rd 30, CSAH 139, CSAH 19
Run off road	• Sharp horizontal curvature (evaluate if have advanced warning signing/delineation, guardrail) • Distracted drivers	<u>Rural Segments</u>: G, N <u>Rural Intersections:</u> T.H. 25 LT, Valley <u>Urban Intersections</u>: Jackson, CSAH 8 LT, Clementa, Bridge, Co Rd 30, Pioneer

Crash Type	Possible Contributing Factors(s)	Segments/Intersections Identified from Crash Data
Right angle collisions	• Fail to yield right of way • Inadequate sightlines • Distracted drivers • Poor driver decision	Rural Segments: I,K Urban Segments: D Rural Intersections: Zephyr, CSAH 14, CSAH 92 RT, CSAH 92 LT, CSAH 90 Urban Intersections: Sunset, Jackson, CSAH 6 RT, CSAH 8 LT, S 4th St, 5th St S, Babcock, Halgren, Budd, CSAH 19
Right turn into traffic	• Inadequate sightline • Lack of gaps in traffic • Distracted drivers	Rural Intersections: CSAH 14 Urban Intersections: Center
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	Rural Segments: A, G, I, K, M, N Urban Segments: D Rural Intersections: Zephyr Urban Intersections: Sunset, CSAH 6 RT, CSAH 8 LT, CSAH 139, Halgren, Pioneer
Overturn/ rollover	• Insufficient edge lines • Distracted drivers • Tight curves • Poor roadside embankment	Rural Intersections: Quimby, Valley Urban Intersections: Co Rd 30, Clementa
Pedestrian related crashes	• Pedestrians have a long crossing distance • Inadequate sightlines • Distracted drivers • Insufficient lighting	Rural Segments: G Urban Intersections: Center
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	Rural Segments: G,I,M Urban Segments: D Rural Intersections: Zephyr, Nelson, Valley Urban Intersections: Sunset, Broadway, CSAH 8 LT, Clementa, Center, TH 25 RT, Bridge, Babcock, Tiger, CSAH 139, Halgren, Pioneer
Snow/Ice related crashes	• Inadequate road maintenance • Road material not textured enough • Not enough warning • Distracted drivers	Rural Segments: A, I, M Rural Intersections: Quimby, CSAH 14, Valley Urban Intersections: Sunset, Jackson, Broadway, CSAH 6 LT, Co Rd 30, Babcock, Tiger, CSAH 139, Budd, CSAH 19
Crashes linked to poor lighting	• Insufficient lighting causing sight issues • Distracted drivers	Rural Segments: I, M, N Rural Intersections: T.H. 25 LT, CSAH 14, CSAH 92 LT, CSAH 90 Urban Intersections: CSAH 3, CSAH 8 LT, Clementa, 5th St S, Babcock, CSAH 139, CSAH 19

5 Post-Audit

5.1 Improvement Strategies

Short-term strategies can be implemented in zero to five years, medium-term strategies can be implemented in five to ten years, and long-term strategies are for ten or more years. It is highly recommended to start with short-term recommendations as they can be implemented quickly and/or at little cost.

There are several advantages of using lower cost, higher benefit strategies. Doing so can allow for changes to be made on a faster timeline and also can be used to spread funding so that the entire system can be fixed strategically.

A general strategy is to establish low-cost/high benefit solutions that can be used as a system-wide approach to corridor wide issues. Where issues are unique, special attention is given on a case-by-case basis.

5.2 Short, Medium, and Long-Term Strategies

The sections below provide explanation of the strategies listed in Table 1-1.

5.2.1 Corridor-Wide

The following paragraphs provide discussion of general safety recommendations given for the US 12 project corridor. Please refer to Table 1-1 for a summary of these recommendations.

Access Management Plans: It is strongly recommended that an access management plan be developed for the entire corridor. According to a publication written by the Federal Highway Administration (FHWA) and the Institute of Transportation Engineers (ITE) in 2004, access management plans are intended to ensure that a roadway "serving a community or region will operate safely and efficiently while adequately meeting the access needs of the abutting land uses of the roadway. The use of access management techniques is designed to increase roadway capacity, manage congestion and reduce crashes."[15]

Access management plans map out current access points in a region and looks at how drivers enter or exit each side street or driveway. Factors that are observed include: access density, presence of turn lanes, use of service and frontage roads, and presence of raised medians. The FHWA provides an overview of key concepts for access management in their "Benefits of Access Management Brochure"[16]. Another resource that can be referenced is the MnDOT Access Management Manual[17]. Some key concepts associated with access management plans are explained in the bullets below:

- <u>Access Density</u>: The more access points (roads or driveways intersecting a corridor) within a given stretch of roadway, the higher the access density. Having high access density can greatly increase the probability of

[15] *Source:* http://library.ite.org/pub/e26c5400-2354-d714-51b2-432d8f3da94d

[16] *Source:* http://ops.fhwa.dot.gov/access_mgmt/docs/benefits_am_trifold.htm

[17] *Source:* http://www.dot.state.mn.us/accessmanagement/pdf/manualchapters/chapter3.pdf

crashes occurring. Limiting access reduces the number of possible conflict zones and can increase capacity. Spacing of access points should also be considered so that drivers have sufficient space to make turns and merges with minimal conflict.

- Raised Medians: Median treatments are an effective way to regulate access because drivers are forced to turn right at minor access points. Instead of crossing traffic to make a left turn or through movement, drivers instead are re-directed to another intersection where they can make safer U-turns.
- Frontage Roads: Local business owners often express concern that that a reduction in access points will cause negative economic impact because accessibility will be reduced. As access points are closed, frontage roads can be used to maintain connectivity from former access points to US 12 mainline. According to the FHWA primer, "Safe Access is Good for Business,"[18] businesses can benefit from access management. This is primarily because managing access on a road can result in better traffic flow, fewer crashes, and an overall better shopping experience for customers.
- Turn Lanes: Exclusive turn lanes should be provided to reduce the frequency of rear end crashes. This is especially important for left-turn lanes because left turns are made from the center of the road way and left turners often have to stop as they wait for an opportunity to cross opposing traffic. The length of turn lanes should also be evaluated based on traffic demands so that queues don't overflow into through lanes.

Access consolidation will be especially beneficial as AADT increases over the years because there will be more drivers on US 12 and, in result, there will be less gaps in traffic for vehicles to make turns to or from side streets. Intersection control methods should be reevaluated for intersections that would carry increased amount of traffic movements. The effects of quality of flow, safety, and effect on intersection capacities throughout the system should be considered.

Corridor Lighting: An overall assessment of corridor lighting 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.

Active Road Maintenance: Road maintenance can play a key role in road safety. There are various measures that can be taken to continually improve safety.

- Signing/Striping: One measure that should be taken is to make sure that signing and striping are in good condition. Signs and pavement markings play a critical role in driver awareness and help a driver stay in the appropriate vehicle path.
- Ice/Snow Removal: Rapid response to ice/snow collection can greatly reduce the number of weather-related crashes. Having an active ice/snow removal plan is strongly recommended.

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[18] *Source:* http://ops.fhwa.dot.gov/publications/amprimer/access_mgmt_primer.htm

- o <u>Clear Zone</u>: Maintaining an open clear zone alleviates the severity of off road crashes and also can improve sightlines at intersections. Clear zones should be cleared of vegetation, fixed objects, debris, or any other objects that could be hazardous.

Enforcement: In regions where speeding was identified as an issue, targeted speed enforcement is an option to modify driver behavior. Having enforcement officers present on the road will motivate drivers to monitor their speed, especially in regions where drivers expect to see officers present.

In addition to reducing speeding, the presence of officers can also increase driver awareness and decrease the amount of distraction related crashes. According to a study by Cohen Children's Medical center "drivers are 23 times more likely to be in a crash if they are texting while driving[19]". State law informational signs can be strategically placed to educate drivers that texting while driving is illegal and unsafe. The state law informational sign shown in Figure 5-1 was installed on Highway 14 in Nicollet, Minnesota to emphasize the importance of wearing a seatbelt and not texting while driving.

Figure 5-1: State Law Informational Sign[20]

Signs can provide some benefits in that they provide a medium for messages to be conveyed. The downside is that the effectiveness may not be very large-scale because drivers may not notice the signs or may choose to ignore them altogether. If too many signs are in place, they won't be as attention grabbing. Sign layout and placement should be planned to strategize information intake.

The enforcement methods mentioned above will only remain effective if enforcement can be maintained. This provides an obstacle in that this most likely will require more availability of officers. Therefore, it is recommended that grant applications are filed to fund extra hours.

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[19] *Source:* http://safety.trw.com/texting-while-driving-now-leading-cause-of-us-teen-deaths/0710/

[20] *Photo taken on TH 14 near Nicollet, MN.*

Education: In addition to driver enforcement, education outreach can be utilized to teach current and future drivers about different road safety topics, such as the dangers of distracted driving, the risk of aggressive driving, drinking while driving, and knowing how to use different traffic control devices at intersections. Various outreach campaigns are available and can be researched.

The United States Department of Transportation (USDOT)[21], 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 four-E approach (Engineering, Enforcement, Education, and Emergency Services) to accomplish safety improvements. 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.

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.

5.2.2 Urban Segments

The following paragraphs provide discussion of safety recommendations given for Urban Segments. Please refer to Table 1-1 for a summary of these recommendations.

Rural to Urban Speed Transitions: Corridor-wide speed limit signing transitions are inconsistent. In some cities, there are speed limit signs reducing the speed in 5 mph increments (i.e. 55 mph to 50 mph to 45 mph to 35 mph to 30 mph), whereas in other cities there are speed limit signs just for 10 or 15 mph increments (i.e. 55 mph, 45 mph and 30 mph). Taking a corridor-wide approach to speed changes would increase consistency across the corridor and would increase driver expectation.

- Speed Limit Signing: A short-term solution to this is to start by updating the speed limit signs across each city. An example would be to have 55mph, 45 mph and 30 mph signing.
- Intelligent Transportation System (ITS) Speed Technologies: In addition to speed limit signing updates, ITS technology can be used to accent the speed reductions. “Reduced Speed Ahead” flasher systems (see Figure 5-2) 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 5-3).

[21] *USDOT Education/Outreach Web Link:* http://safety.fhwa.dot.gov/ped_bike/education/

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

Figure 5-2: Reduced Speed Limit Ahead Blinker Sign[23]

Figure 5-3: "Your Speed" Sign[24]

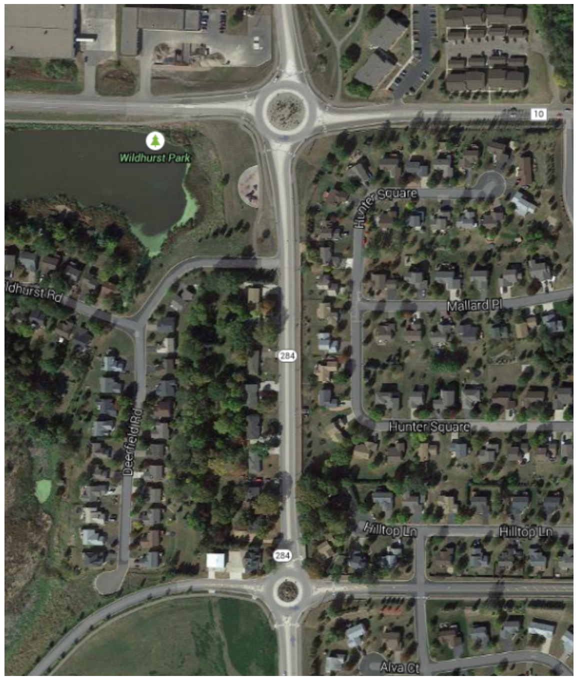
It should be noted that although speed limit signing updates and ITS technologies can provide some benefit, changes to the road cross section from Complete Streets solutions (see discussion in future sections) will likely be much more effective at reducing and managing speed.

- Roundabouts at City Limits: Another option that should be explored as a long-term solution for speeding through cities would be to install roundabouts at bordering intersections. This change in geometry may trigger drivers to prepare to enter an urban environment. This approach has been used on Highway 284 in Waconia, MN. See Figure 5-4 for a visual of this example.

[23] *Photo Source*: http://www.tapconet.com/solar-led-division/reduced-speed-limit-led-blinkersign

[24] *Photo taken on TH 14, near Nicollet, MN.*

Figure 5-4: Roundabouts in Waconia, MN



Maple Plain (Segment L) was identified as a region that could benefit from this type of configuration. In the long-term, other cities could consider taking this approach as well for corridor-wide consistency.

Complete Streets (Road Diet): Citizens along the urban segments have expressed concerns related to speeding. The road safety audit team recognized that the road sections were wide through all of the cities studied. The shoulder widths were often much wider than necessary which resulted in a feel of a higher speed section, rather than a low speed urban street. Repurposing the cross sectional width is strongly recommended to change the character of the road in urban regions.

Depending on the preferences of each city, different methods could be used 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 which are designed to accommodate various road users. 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 5-40 (found in Segment J recommendations section) also provides an example of a complete streets solution from a project in St. Paul, Minnesota.

Figure 5-5: Preservation Retrofit in Jordan, MN[25]

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[26]. 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.

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. Figure 5-6 provides a visual of an info-graphic tool which can be found on NACTO's website.

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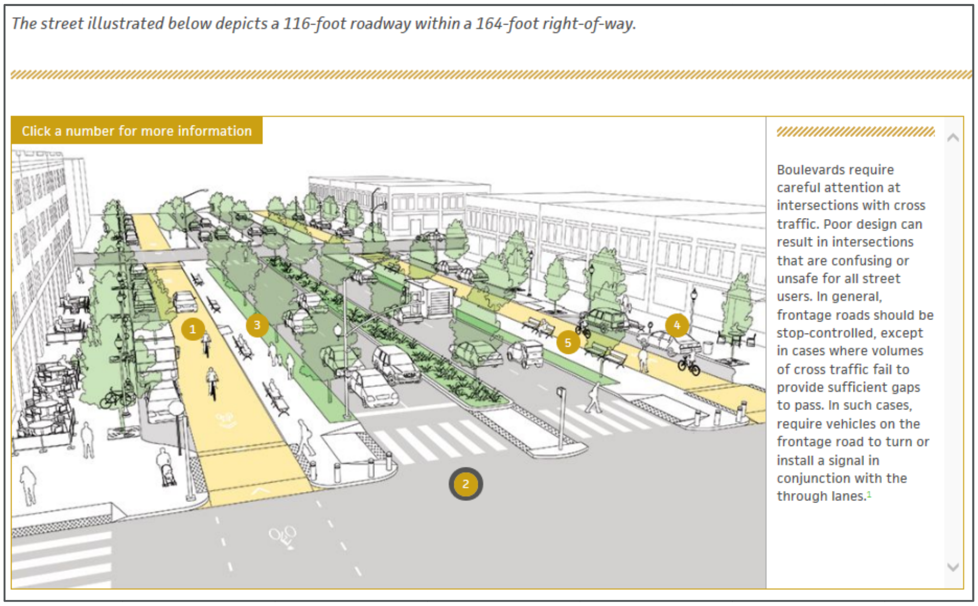
[25] *Photo Source: 2015 MnDOT Presentation featuring Jordan and Cosmos, MN*

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

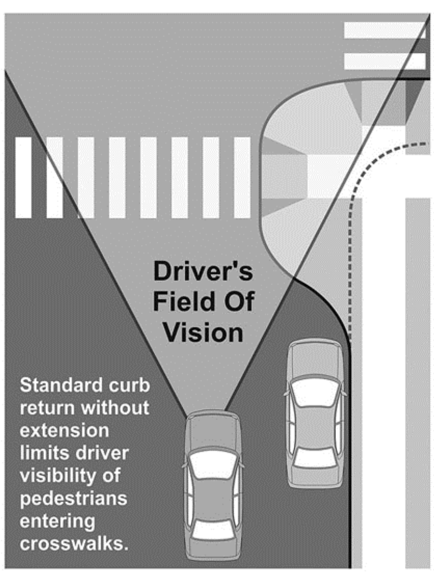
Figure 5-6: National Association of City Transportation Officials (NACTO) Urban Streets Design Guide Info-Graphic Tool on Boulevards



Federal Transportation Investment Generating Economic Recovery (TIGER) grants should be sought out for funding Complete Streets solutions. TIGER grants are awarded on a competitive basis to projects that will have a significant impact on the nation, a region, or a metropolitan area. Multi-modal projects that provide economic benefits are highly encouraged to apply. For more information on TIGER grants, visit the US Department of Transpiration's website at the following link: http://www.transportation.gov/tiger.

Curb Extensions: At all pedestrian crossings in wide road sections, curb extensions are recommended. Curb extensions are installed to narrow the crossing distance over a street and improve pedestrian safety. As can be seen in Figure 5-7, they allow pedestrians to enter the driver's field of vision before entering the crossing.

Figure 5-7: Curb Extensions



Because installation can be done on a short schedule, curb extensions should be added in the short-term. It is much more effective to install permanent curb extensions, however, if it is not possible to install right away, temporary curb extensions can be created using bollards and pavement markings, as shown in Figure 5-8. Although better than nothing, bollards can become a maintenance burden because they get hit easily and do not create as much physical protection for pedestrians.

Figure 5-8: Temporary Curb Extensions[27]

Sidewalk Network Plan: In all urban regions, a sidewalk network plan should be developed to increase pedestrian safety. A sidewalk 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 itself. Additional benefits can be provided because optimized trail connectivity can make sidewalks and trails more accessible and usable.

Sidewalk 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.

In the medium- or 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, such as signalized crossings or RRFBs (Rectangular Rapid Flash Beacons).

Rectangular Rapid Flash Beacons (RRFBs): Existing pedestrian flashers should be updated to Rectangular Rapid Flash Beacons, also referred to as RRFBs. This can be done as a low cost and on a short schedule. Figure 5-9 shows what an

[27] *Photo Source:* http://sf.streetsblog.org/category/san-francisco-neighborhoods/district-6/

RRFB looks like. RRFBs are much more visually apparent than traditional flashers and only flash 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 updates.

Figure 5-9: Rectangular Rapid Flash Beacon (RRFB)

Mumble Strips: In various regions, the risk of drivers drifting out of their lane is present. Traditionally, rumble strips have been installed on the edges of lanes to notify drivers that they are drifting out of their lane. A downside to rumble strips is that they can produce an audible rumbling noise, which is an issue in residential areas. “Mumble” strips, which are rumble strips that produce less external noise, may be an option in areas with higher residential density. Figure 5-10 below gives a visual of what mumble strips look like. For comparison, refer to photos of rumble strips shown in Figure 5-11 and Figure 5-14.

Figure 5-10: Mumble Strips[28]

[28] *Photo Source:* http://mntransportationresearch.org/2014/06/10/rumble-strips-vs-mumble-strips-noise-comparison-video/

5.2.3 Rural Segments

The following paragraphs provide discussion of safety recommendations given for Rural Segments. Please refer to Table 1-1 for a summary of these recommendations.

Centerline Remedies: Approximately 61 percent of fatal and severe crashes in the 2010-2014 study period were head-on collisions. 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.

- In short-term, **centerline rumble strips** should be installed on all rural segments that do not currently have rumble strips. Rumble strips are composed of a series of grooves installed in a series across the direction of travel. 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 5-11 shows an example of what centerline rumble strips look like.

Figure 5-11: Centerline Rumble Strips[29]

- 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.

[29] *Photo Source:* http://safety.fhwa.dot.gov/geometric/pubs/mitigationstrategies/chapter4/4_lane3showidth.cfm#FIGURE_33

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 5-12 shows the four-foot centerline buffer that was installed on Highway 14 in 2012. In spring 2012, Highway 14 underwent a road safety audit process. Similar to US 12, the audit took place in response to a high number of fatal head-on crashes. As a result of the audit, an 8-foot buffer zone was installed along the corridor with double yellow stripes and a set of centerline rumble strips on either side. 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 5-12: Centerline Buffer and Delineation, Highway 14 in Nicollet, MN[30]

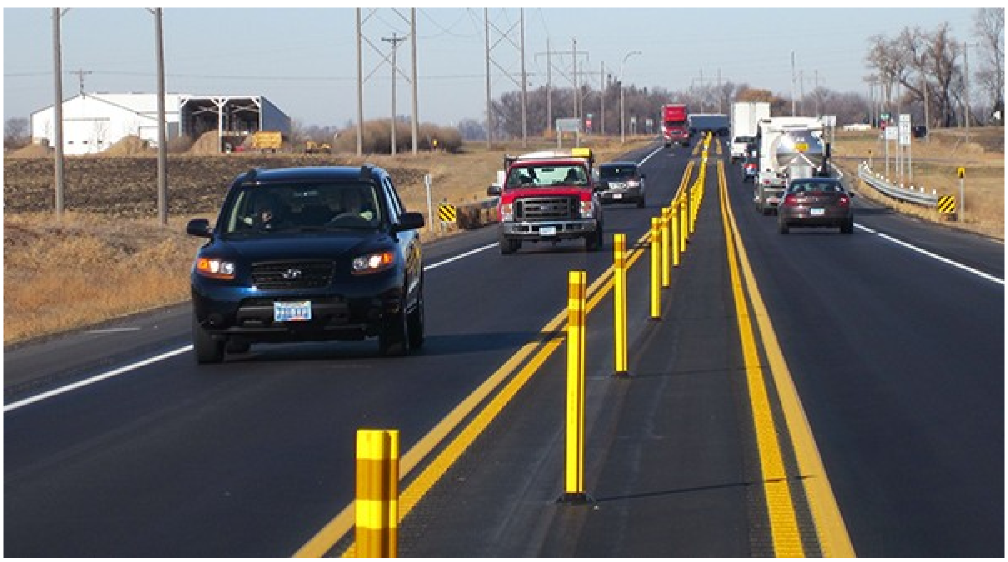
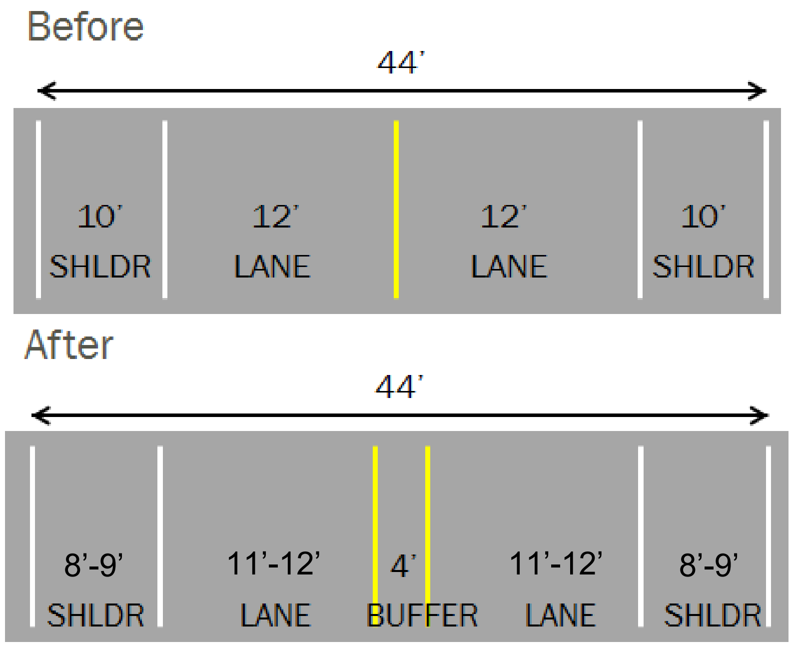


Figure 5-13 demonstrates the lane adjustments that could take place through much of the US 12 Corridor to accommodate a 4-foot buffer width. In some situations, additional pavement may need to be added to accommodate an increase in cross-sectional width or reinforce shoulders. There should be at least a six-foot shoulder (including gravel portions) provided for enforcement to safely pull over as needed. Consideration should be given for whether tubular delineators will be installed. Tubular delineators are beneficial in that they create more visual queues 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.

[30] *Photo Source:* http://finance-commerce.com/2015/05/highway-14-expansion-set-to-begin/

Figure 5-13: Example Geometry With and Without Four-Foot Buffer[31]



Edge Line Rumble Strips: In addition to centerline rumble strips, edge line rumble strips should also be installed or repaired on rural segments to prevent lane departure off the road. Edge line rumble strips are installed on the shoulder at the edge of the travel lane (see Figure 5-14) and alert drivers that they are drifting off the road. These can be installed at a low cost and on a short schedule. If being installed on in place pavement, pavement quality must be sufficient to accept milled rumble strips.

Figure 5-14: Edge Line Rumble Strips[32]

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

[32] *Photo Source:* http://safety.fhwa.dot.gov/geometric/pubs/mitigationstrategies/chapter4/4_lane3showidth.cfm#FIGURE_33

2+1 Passing Lane Section: As a medium- or long-term solution, 2+1 passing lane sections should be installed in rural segments. 2+1 configurations 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 would work well with a buffer or other sort of division between traffic because traffic would not need to use the opposing lane to pass slow moving vehicles. It is strongly recommended that a consistent approach is applied to the entire corridor in order to maintain corridor-wide consistency. Please refer to Figure 5-15 below for a visual of a possible 2+1 configuration.

Figure 5-15: General Schematic of a 2+1 Configuration[33]

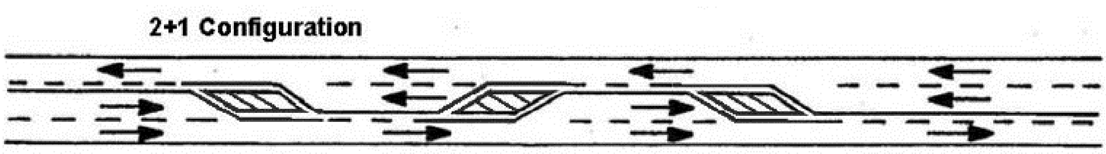


Figure 5-16: 2+1 Passing Lane Section[34]

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 may need to be modified such that through and left-turn movements are restricted. Intersection control methods, such as reduced conflict intersections (RCIs) should be considered. For a description of these methods, please refer to the intersection recommendations section.

[33] *Photo Source:* http://epg.modot.org/index.php?title=232.2_Passing_Lanes

[34] *Photo Source:* http://www.monroemonitor.com/2012/12/27/does-sweden-have-the-answer-for-u-s-2/

5.2.4 Intersections

The following paragraphs provide discussion of general safety recommendations given for various intersections. Please refer to Table 1-1 for a summary of these recommendations.

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)".

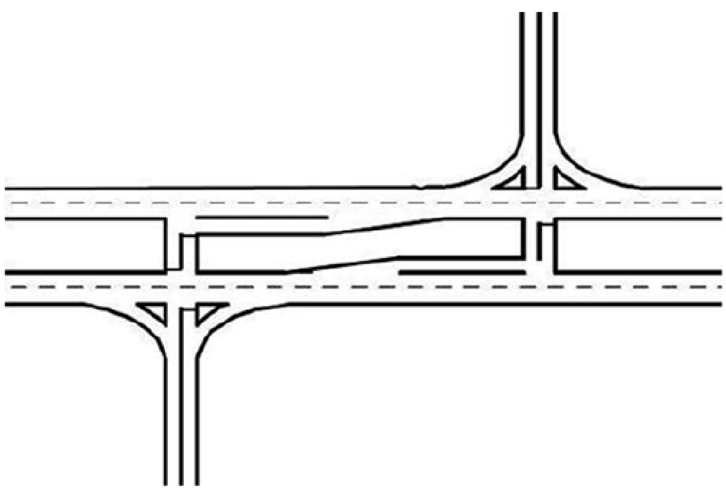
- Continuous Green T: A Continuous Green T is being installed east of Montrose at TH 25 and may be a good option for installation in other regions of the corridor. As indicated by the name, Continuous Green T's allow more continuous movement of traffic via channelization. In situations where through movements are heavy on the "flat" side (i.e. top) of the T-intersection, and turning movements from the stem are a safety concern, this type of configuration may be a good option to consider.

  One downside that should also be considered is that this configuration may promote more speeding. Pedestrians need to be taken into account when deciding whether to install this type of intersection control. If pedestrians need to cross the main road, then a Continuous Green T may not be appropriate. See Figure 5-17 below for further description on Continuous Green T intersections.

Figure 5-17: Aerial View of the Continuous Green T in Grand Junction, Colorado[35]

- Offset T-Intersections: In some cases, it may be beneficial to offset north and south approaches so that the number of conflict points is reduced. This can be especially effective when minor approach volumes are low and existing approaches are skewed and can be retrofitted. Sight distance between approaches should also be considered. Please refer to Figure 5-18 for a visual of offset T-intersections.

Figure 5-18: Typical Geometry of an Offset T-Intersection[36]



[35] *Photo Source:* http://safety.fhwa.dot.gov/intersection/resources/casestudies/fhwasa09016/

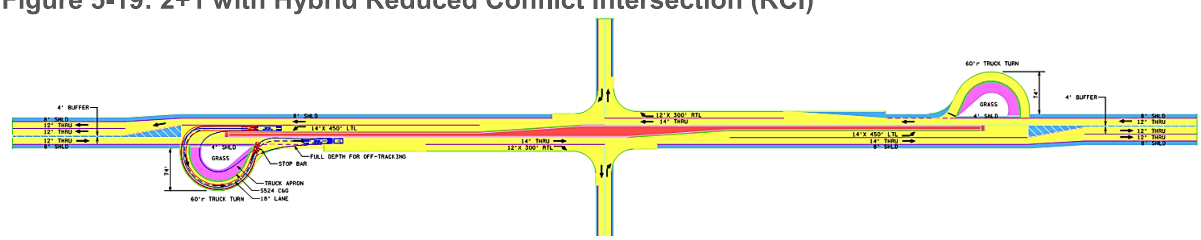
[36] *Photo Source:* http://www.fhwa.dot.gov/publications/research/safety/09060/09060.pdf

- <u>Reduced Conflict Intersections</u>: Reduced conflict intersections (RCIs) would provide great safety benefits to many of the rural intersections along the corridor. RCIs are a fairly new concept in Minnesota. The first RCI was installed in 2010 in the City of Willmar and several have been constructed since then. According to a preliminary crash data from a study performed by MnDOT's Office of Traffic, Safety, and Technology in August 2015, RCI's in Minnesota have shown "a 100 percent reduction in fatal and serious injury crashes, an 89 percent reduction in right angle crashes, and over 60 percent reduction in injury crashes in Minnesota"[37]. Studies have shown that RCI's work best for scenarios where side street traffic makes up less than 20 percent of the intersection traffic volumes. This is true for many rural intersections along US 12.

  The main goal of an RCI is to reduce the number of conflict zones present in an intersection. RCIs usually entail restricting turn movements to be right-in-right-out so that through and turning vehicles don't cross opposing traffic. Pre-specified locations are installed for drivers who need to make U-turn maneuvers. Unlike roundabouts, Continuous Green T's, or standard signals, RCIs do not impede or stop mainline through traffic. An additional benefit provided by this configuration is that issues related to side streets approaching the intersection at an odd angle would be resolved more easily and at lower cost. This is because there is a lot more flexibility in what angle the road can approach the mainline at.

  Approximately 90 percent of traffic on US 12 is through traffic. This makes it difficult for drivers approaching the road from side streets to either turn left or make a through movement. This is because it is difficult to find a gap in traffic for both directions at the same time. When trying to turn left on mainline from rural streets, such as CSAH 92 and CSAH 90, the road safety audit team observed that it was much easier to find opportunities to make right-hand turns than it was to take left-hand turns. Figure 5-19 shows a type of hybrid RCI that could be used with a 2+1 lane configuration. A higher resolution version of this figure (Figure H- 1) is provided in Appendix H.

Figure 5-19: 2+1 with Hybrid Reduced Conflict Intersection (RCI)[38]



When seeking funding for RCIs, help from the Federal Highway Administration's Accelerated Innovation Deployment (AID) program should be sought out. Grants up to one million dollars are available for projects that advance innovation. RCIs are also an Every Day Counts (EDC) initiative, which are encouraged for this funding. The

[37] *Source:* http://www.dot.state.mn.us/roadwork/rci/docs/trafficsafetyatrcistudy.pdf

[38] *Photo Source:* http://safety.fhwa.dot.gov/intersection/resources/casestudies/fhwasa09016/

following link provides information regarding the grant application process: http://www.fhwa.dot.gov/accelerating/grants.

Bypass Lane Replacement with Left Turn Lanes: At various intersections throughout the corridor, bypass lanes are in place to allow through traffic to pass vehicles waiting to make a left turn. This can provide a safety risk because drivers have to change lanes to avoid colliding with the stopped vehicle and driver inattention may lead to rear end collisions. It is recommended that these intersections are re-striped to have designated left turn lanes so that through traffic does not have to change lanes. At narrow intersections, the cross section may need to be widened to accommodate these changes.

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 5-20, 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 5-20: Example of “Cross Traffic Does Not Stop” Signage[39]

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 show in Figure 5-21 below:

[39] *Photo Source:* http://www.southernminn.com/waseca_county_news/news/article_33a7138c-77bc-5304-a48d-f9cfcbd59c1c.html

Figure 5-21: Stop Approach Activated LED Red Flashers on Perimeter of Stop Sign[40]

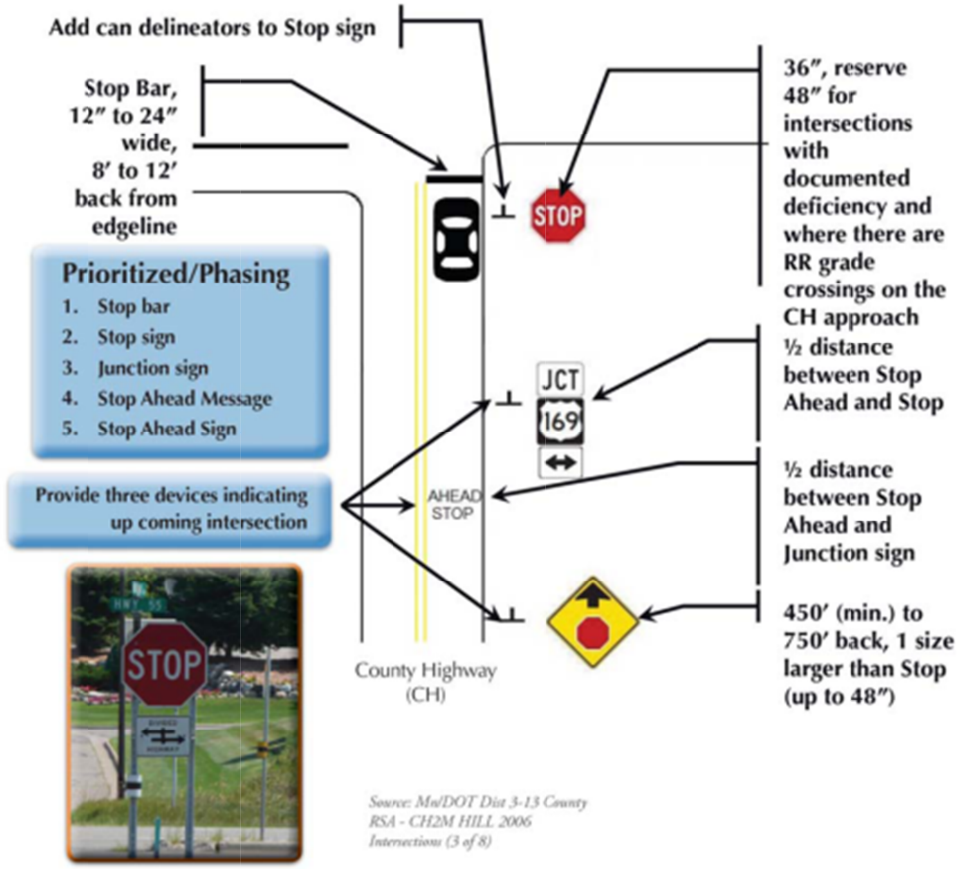
The flashing LED can be a great tool when used appropriately. However, it is not a magic bullet that can stop or even lower the number of severe crashes. Several studies, both local and national, have shown that the majority of intersection crashes are not taking place due to people blowing/rolling through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

South Carolina is in the process of conducting a study on the effectiveness of uniform approach signing at major highways. This technique was tried at over 600 locations at a cost of less than $10,000 per intersection. The before/after analysis showed a reduction of hundreds of crashes in only three years. The total cost of these improvements amounted to the cost of a single interchange or a few roundabouts. Considering the widespread effectiveness of this application, the crash reduction is even more dramatic. Figure 5-22 shows MnDOT's standard signing approach that should be used at all stop sign controlled side streets along the corridor.

[40] *Photo Source:* http://safety.fhwa.dot.gov/intersection/resources/fhwasa11015/sa11015.cfm

Figure 5-22: Intersection Approach Signing

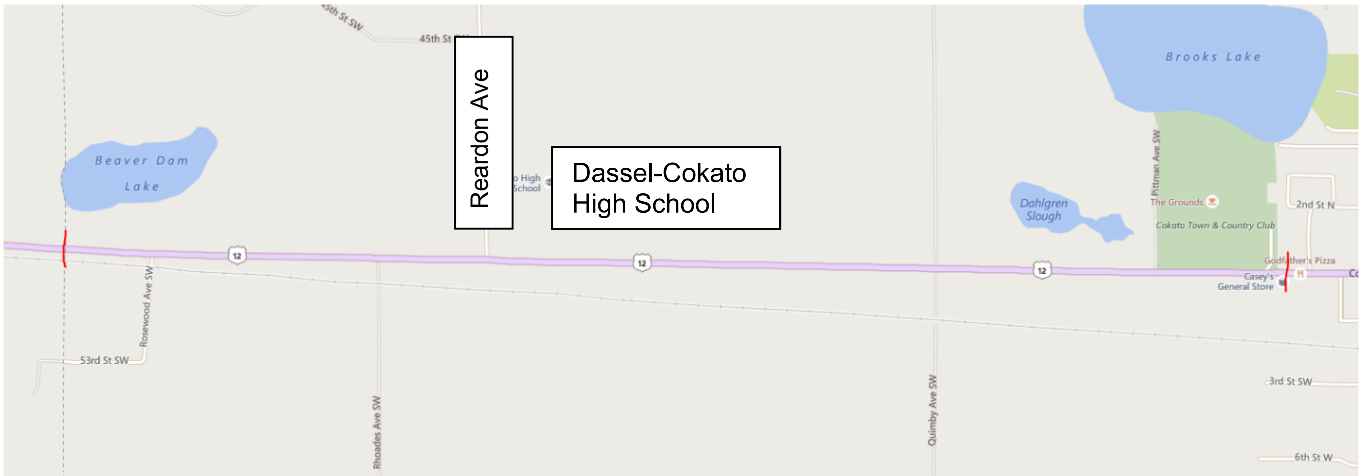


5.2.5 Segment-Specific Improvements

The following sections provide discussions on segment-specific recommendations given in Table 1-2.

Segment A (West of Cokato)

Figure 5-23: Segment A (2.80-Mile Stretch West of Cokato)[41]



Segment A is a rural, two-lane segment that is bordered to the west by the Wright-Meeker County line and runs to the western Cokato city limits (see Figure 5-23 for a map view of the segment). The segment is approximately 2.80-miles long and the Dassel-Cokato High School is located within this segment. In the crash data analysis, the FAR for Segment A was 5.12 crashes per 100 MVM and exceeded the state average of 2.41 crashes per 100 MVM. Head-on crashes were identified as being higher than state average and accounted for half of the segment K+A crashes. All of the K+A crashes occurred in icy conditions. The following paragraphs further explain the recommendations listed in Table 1-2 for Segment A. Refer to corridor-wide and rural segment recommendations listed in previous sections for general recommendations that apply to this segment as well.

Ice Issues: Ice issues were investigated in this region, crash trends did indicate that ice/snow related crashes were above the state average from 2010-2014. Currently an ITS ice detection investigation is in progress. The ITS system is intended to detect and report presence of ice on US 12 to road maintenance staff. Because this study is still taking way, the short-term recommendation would be to track the success of the system and to continue to push for active maintenance to keep the road clear of ice. Refer to Appendix G for more background information on the ice sensor warning system project. A large portion of crashes at Quimby Avenue seemed to be attributed to ice/snow as well.

A medium-term recommendation for this would be to install a wind-block to prevent snow from blowing onto the roadway. There are different alternatives that can be investigated for wind-blocks. One possibility would be to talk to the nearby rail road and investigate if they would be willing to store their unused cars along

[41] *Photo Source: Bing Maps (August 2015)*

the rail road during the winter. Another option is to construct a living snow fence (i.e. plant trees, bushes, or other vegetation to provide a natural barrier). Living snow fences provide more visually appealing results than traditional snow fences and can be installed easily. See Figure 5-24 for a visual of what a living snow fence could look like in practice. It will be important to inform businesses and residents who live along the road to not tamper with the planted vegetation.

Figure 5-24: Living Snow Fences[42]

Reardon Avenue Intersection (Dassel-Cokato High School): In response to congestion-related concerns around the Dassel-Cokato High School, the road safety audit team observed traffic behavior as drivers exited from Reardon Avenue SW onto US 12. The team observed traffic patterns for a 15-minute period around 4:00pm. In attempt to make turns safer, 35 mph speed limit signs with attached flashers were installed. When flashers aren't activated, traffic is allowed to continue at the 55 mph speed limit. A speed detection system which shows "Your Speed" was also installed to make drivers award of their vehicle's speed. Despite this, it appeared that turning left onto US 12 was difficult due to the lack of gaps in traffic. School buses were routed to make only right-hand turns, likely because it is safer and more efficient.

- *Active Enforcement around Dassel-Cokato High School:* According to crash reports, there is a peak in crashes during the morning and evening peak hours. It is recommended that officers are staffed before and after school in the region in attempt to counteract driver distraction, both from students and mainline through traffic.

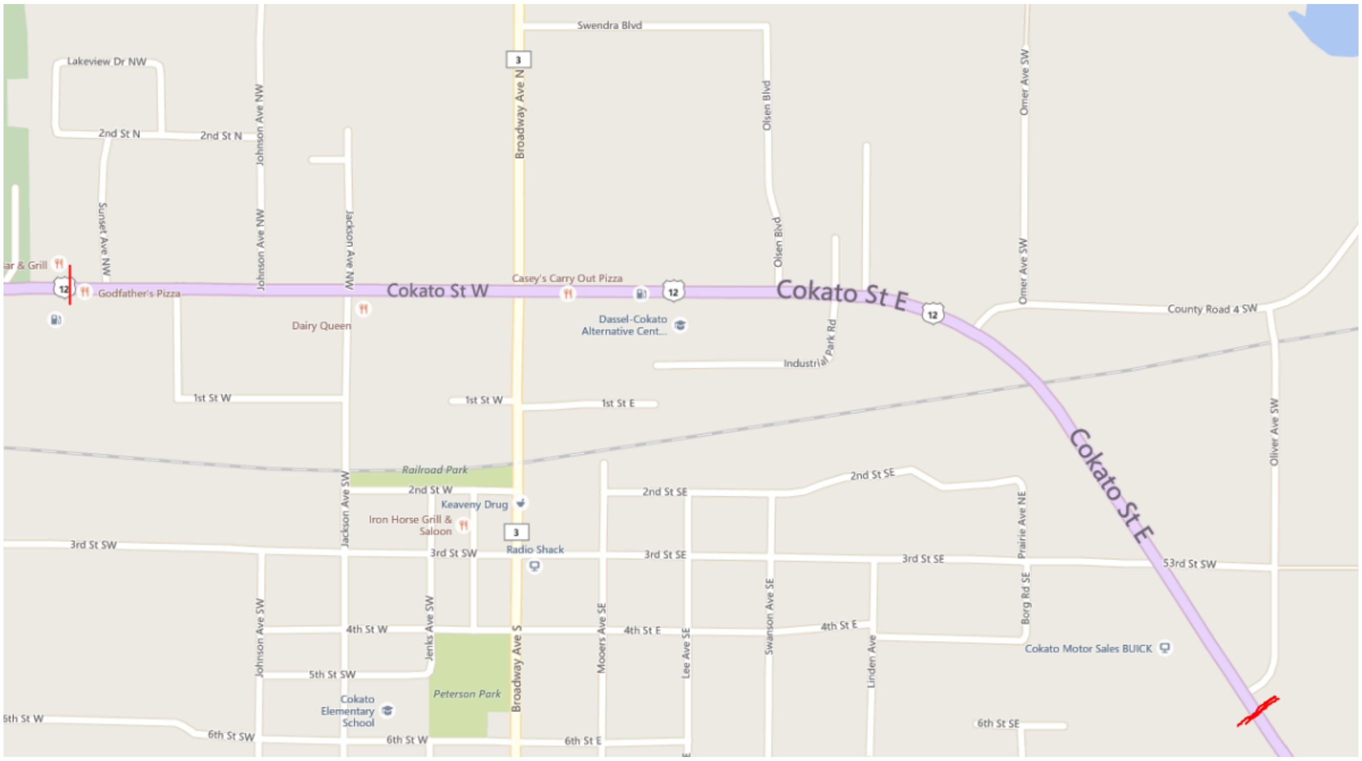
- *Congestion Before/After School:* Because many congestion-related concerns occur during peak hours, start and end times for the Dassel-Cokato High School should be re-evaluated. If moved to a time where traffic volumes aren't as high, many of the safety concerns associated with turn movements would be alleviated. With less traffic on mainline US 12, there would be more gaps in traffic, which would provide more safe opportunities to make turns.

[42] *Photo Source:* https://www.dot.ny.gov/divisions/engineering/design/landscape/trees/rs_liv_sn_fence

- *ICE Process at Reardon Avenue Intersection:* Reardon Avenue SW did not demonstrate high crash rates; however, based on observations from the field visit, there are high safety risks caused by drivers making unsafe turns during rush hour. Several solutions should be explored for this issue, including a re-evaluation of the intersection control. Because turning movements are experiencing the most difficulty, methods to increase gaps in traffic and facilitate turn movements should be prioritized. Key factors to consider in the evaluation would be: this issue usually only occurs during specific time periods before and after school hours and mainline traffic has a much larger volume than the minor leg.
    - Traffic Signal with Queue Detection: A traffic signal could be used to stop mainline traffic so that turns can be made to and from Reardon Avenue during peak hours. Because safety issues occur only during a portion of the day, detectors should be placed to trigger the signal to go off only when needed. Queue detection should also be incorporated so that green time can be modified for longer queues.
    - Continuous Green T: If the Continuous Green T being installed east of Montrose at TH 25 proves to be successful, this type of intersection control may be a good option because it would allow eastbound traffic continuous flow, would channelize turning movements, and would provide more intersection control. It is advised that an Intersection Control Evaluation (ICE) take place to determine the optimum traffic control for the intersection.

Segment B (Cokato)

Figure 5-25: Segment B (1.34-Mile Stretch through Cokato)[43]



Segment B runs 1.34 miles in length through the City of Cokato. Please refer to Figure 5-25 for a map view of the segment. Majority of the segment contains one lane for each travel direction and a center lane reserved for left-turn movements. General corridor-wide and urban segment recommendations (i.e. Complete Streets) should be applied to this segment. The following paragraphs further explain the recommendations listed in Table 1-2 for Segment B.

Complete Streets: When the road safety audit team went through the City of Cokato, the group's driver noted that he felt like he had to actively focus on driving at the speed limit through town. This gave the team insight to the natural tendency for road users to speed as they approach the city. Because the road had a wide cross section and the road character doesn't significantly change, drivers tend to continue driving as if they are still in a rural section.

To change driver habits, a change needs to be made to the road character. A complete streets approach should be taken to do so. The City of Cokato has installed many crosswalks and even has installed flashing pedestrian crossing signs. Given the city's focus on pedestrians and bicyclists, the city could look into striping a bike lane that connects to the trail leading to the Dassel-Cokato High School.

[43] *Photo Source: Bing Maps (August 2015)*

Overhead Pedestrian Indications: Due to excessive road with in Cokato, pedestrian crossing distance is long, which puts pedestrians at high risk when they cross US 12.

- Overhead pedestrian indications should be used to emphasize the presence of wide pedestrian crossings. High Intensity Activated Cross Walk (HAWK) signals are an option for doing this. HAWKs can be coordinated to work with stop and go traffic signals down stream. Refer to Figure 5-26 for a visual of a HAWK that was installed in St. Cloud, Minnesota.

Figure 5-26: HAWK Signal Example[44]

- In situations where pedestrian crossings are more visible, curb extensions and RRFBs may be sufficient in place of an overhead pedestrian indication. Please refer to urban segment recommendations for further discussion on curb extensions and RRFBs.

Ice Issues: Similar to Segment A, ice and snow have been attributed to some crashes in the region. The same general approach should be taken for Segment B.

CSAH 3 Updates: The intersection of US 12 and CSAH 3 is signalized. Large eastbound to northbound driving vehicles have difficulties making left turns because the receiving width is narrow. A short-term solution to this issue is to update pavement markings to make the receiving width wider. Sightline issues were also noted as an issue at this intersection. To push the driver's cone of vision past buildings on the corners, north and south approach stop bars should be pushed closer to the intersection.

During the road safety audit field review, team members observed that the signal indications were difficult to see. This poses a risk to drivers, especially at night time. A short-term recommendation is to install retro-reflective back plates on the signal heads at this intersection. When hit by the light of a vehicle's headlights, these back plates become illuminated and essentially frame the signal head with light. This makes it much easier to see from a distance. Figure 5-27 shows what a retro-reflective back plate looks like.

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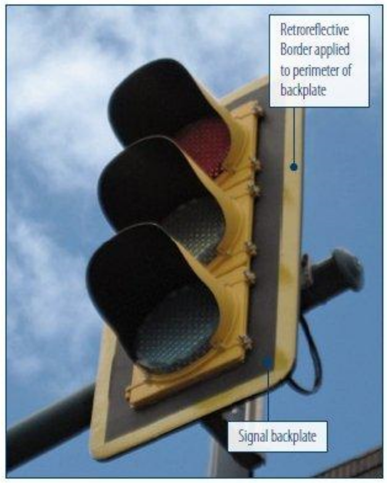
[44] *Photo Source:* http://www.dot.state.mn.us/d3/hottopics/hawk.html

Figure 5-27: Retro-Reflective Back Plate for Signal Heads[45]



Another observation made during the road safety audit field review was that pedestrians did not seem to have enough time to walk across the pedestrian crossing. It is recommended in short-term that crossing-times are re-evaluated in addition to adding curb extensions.

Access Consolidation: There are opportunities for access consolidation in town. A recommendation is to close Century Avenue and Sunset Avenue so that traffic would be re-directed to Johnson Avenue or Jackson Avenue. It was determined during the pre-audit analysis that Sunset Avenue has a higher crash rate (0.21 crashes per MVM) than the state average (0.18 crashes per MVM). Many of the crashes that occurred at this intersection are attributed to turn movements. If Sunset Avenue is not closed, then consideration should be for making turn movements around the intersection more restricted. As an access management plan is developed, look into alternating between north and south approaches to create a positive offset between intersections.

Jackson Avenue Updates: Majority of crashes experienced on Jackson Avenue are tied to the turn movements or northbound/southbound through traffic. Signs located on the corners on the south side of the intersection that cause sightline issues (i.e. the signs for DQ Grill & Chill and Marketplace). It is recommended as a short-term solution that these are relocated to improve sightlines. A medium-term solution would be to restrict turn movements by turning Jackson Avenue into a type of right-in-right-out interseciton, such as a 3/4 intersection. Figure 5-28 below shows what a 3/4 intersection may look like. As you can see, the north and south approaches in this figure are prohibited from making through or left movements. Mainline left turns are channelized using concrete center islands so that the distance needed to cross opposing traffic is minimized.

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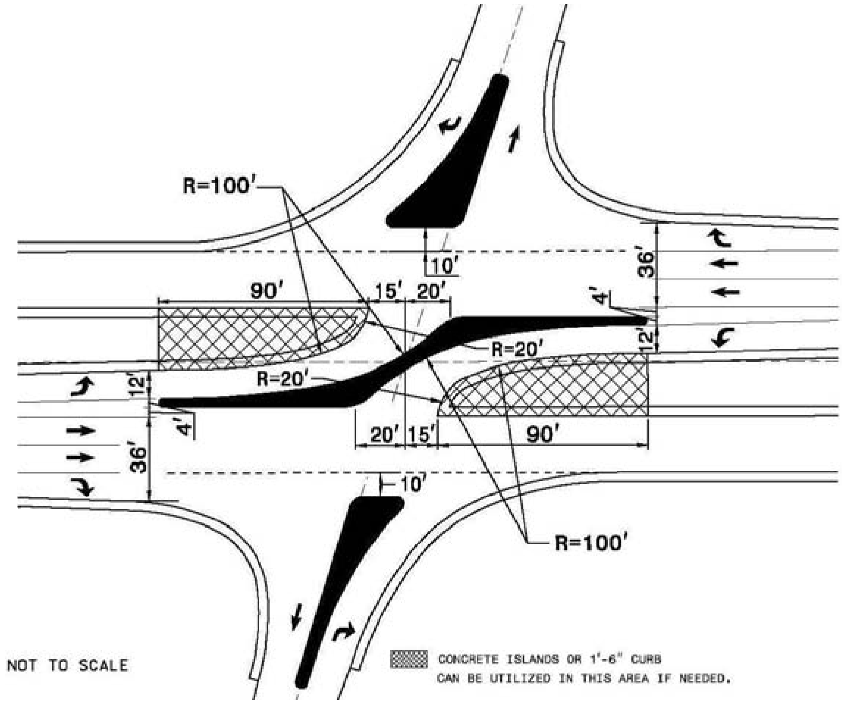
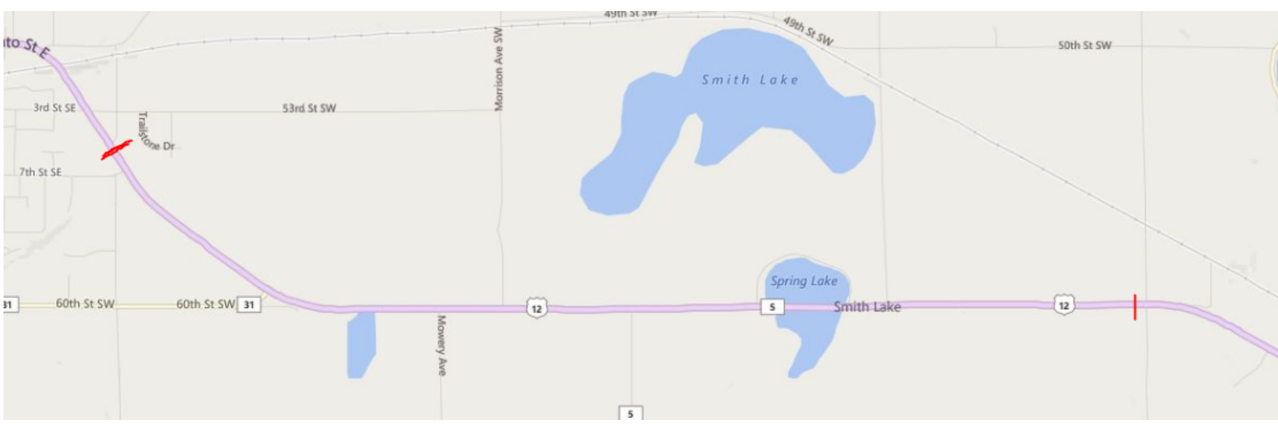
[45] *Photo Source:* http://safety.fhwa.dot.gov/provencountermeasures/fhwa_sa_12_007.htm

Figure 5-28: 3/4 Intersection Example[46]



Segment C (East of Cokato)

Figure 5-29: Segment C (4.16-Mile Stretch East of Cokato)[47]



Segment C is located between the Cities of Cokato and Howard Lake. Refer to Figure 5-29 for a map view of the segment. The segment is 4.16 miles long and is primarily characterized as a two-lane rural highway. There is a 0.8 mile portion of the segment that has four-lanes. General corridor-wide and rural segment recommendations should be applied to this corridor. The following paragraphs further explain the recommendations listed in Table 1-2 for Segment C.

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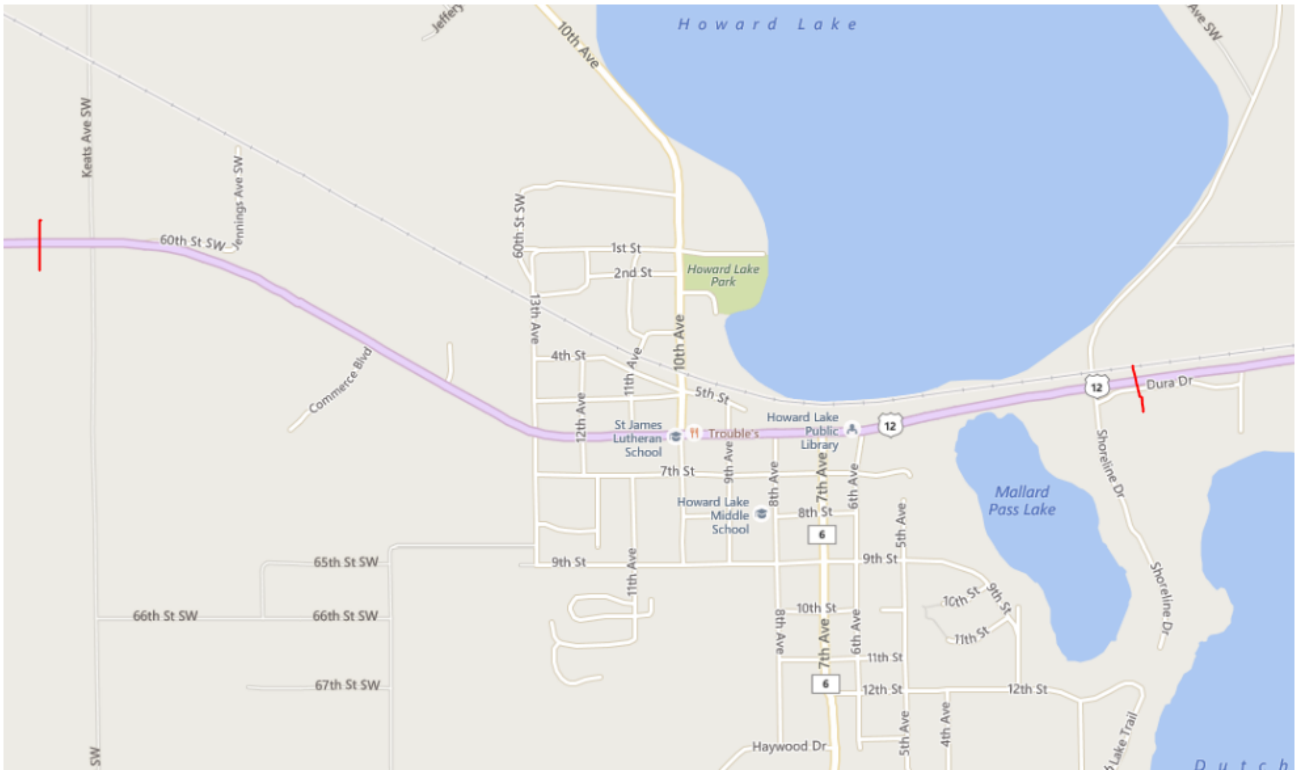
[46] *Photo Source*: https://www.fhwa.dot.gov/publications/research/safety/09060/004.cfm

[47] *Photo Source: Bing Maps (August 2015)*

2+1: As discussed in previous sections, it is highly recommended that all rural segments be converted to have a 2+1 road geometry. This includes Segment C. In the portion of Segment C that already contains four-lanes, some sort of separation should be installed to divide directions of traffic, such as a high-tension cable barrier, tubular delineators, or median barrier.

Segment D (Howard Lake)

Figure 5-30: Segment D (1.83-Mile Stretch through Howard Lake)[48]



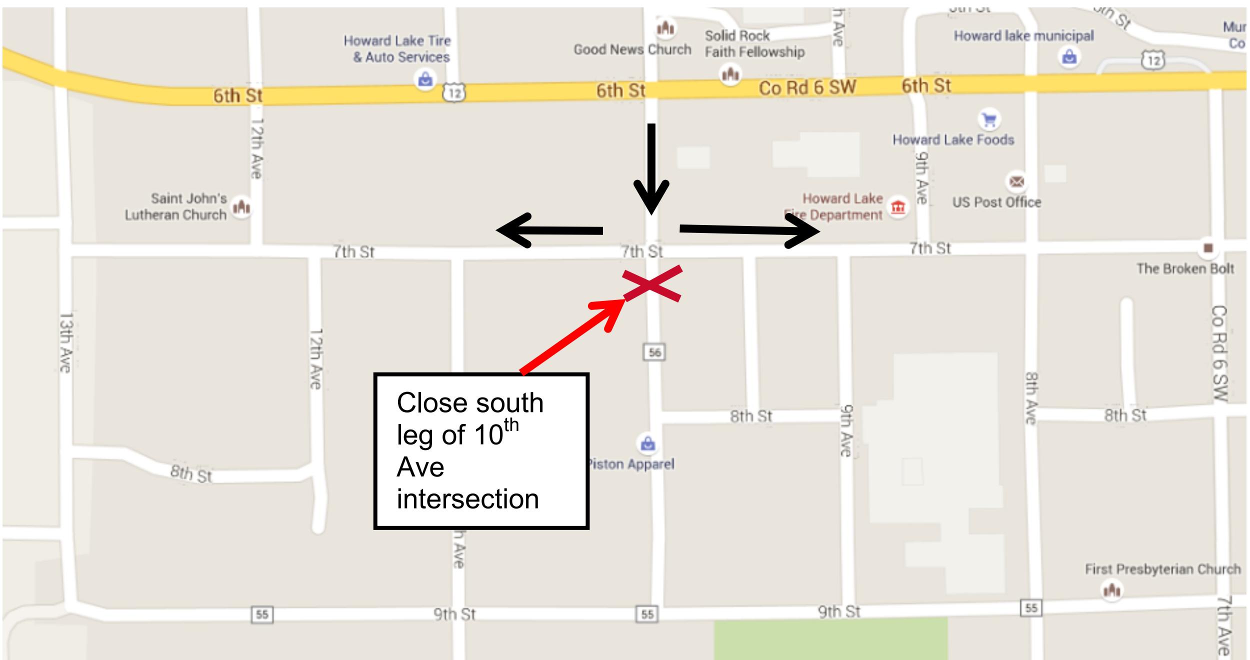
Segment D is primarily classified as a three-lane urban highway. Like Segment B, the center lane is devoted to left-turn movements. The segment runs through the City of Howard Lake and is 1.83 miles in length. See Figure 5-30 for a map view of the segment. The primary concern voiced by the US 12 Coalition was that speeding issues through the city endanger pedestrians. This segment was flagged as having higher risks because the FAR (3.25 crashes per 100 MVM) was higher than both the critical rate (3.07 crashes per 100 MVM) and the state average (2.67 crashes per 100 MVM). General corridor-wide and urban segment recommendations (especially improvements that counter-act speeding concerns, such as Complete Streets solutions) should be applied to this segment. The following paragraphs further explain the recommendations listed in Table 1-2 for Segment D.

[48] *Photo Source: Bing Maps (August 2015)*

Complete Streets: Howard Lake has many regions where there are sight issues caused by buildings. Solutions could be suggested to bring cross street approaches closer to the intersection so that driver sightlines are improved. Additionally, it was observed that sidewalks are fairly narrow and pedestrians are in close range of vehicles. Having some kind of division (such as a boulevard or pedestrian bump outs) between pedestrians and vehicles would provide better protection. ADA improvements could be considered as well. Currently, the through lanes are 18 feet wide and the center lane is 14.5-feet wide. Through lanes could be narrowed to a 10-foot width, the center lane could be narrowed to 12-foot width. This would provide 9.25 feet of extra width on each side of the road to be used for other purposes such as adding bike lanes.

Access Consolidation: There is potential for access consolidation, particularly in situations where a parking lot has access to both US 12 and a side street. See Figure 5-31 for some example access locations that could be closed.

Figure 5-31: Segment D 10th Avenue South Leg Closure[49]



Crash data shows that left turn and right angle collisions are prevalent at the 10th Avenue intersection, majority of these crashes were from northbound traffic failing to yield right of way. The Road Safety Audit team recommends closing the south leg of this intersection as part of the access consolidation plan. By closing this leg, southbound traffic would be re-directed to turn onto mainline and use other streets to access neighborhoods to the south. This would decrease the amount of vehicles making through movements across US 12.

Sightline Improvements: There were a few areas where sightlines were an issue in the corridor. Specifically, it was noted during the road safety audit field review that the sign for “1005 Sixth Street Burkstrand Building” blocks the view for

[49] *Photo Source: Google Maps (August, 2015)*

vehicles coming from the north leg of 10th Avenue. It is recommended that this sign be relocated as a short-term solution.

Figure 5-32: CSAH 6/10th Avenue North Approach[50]

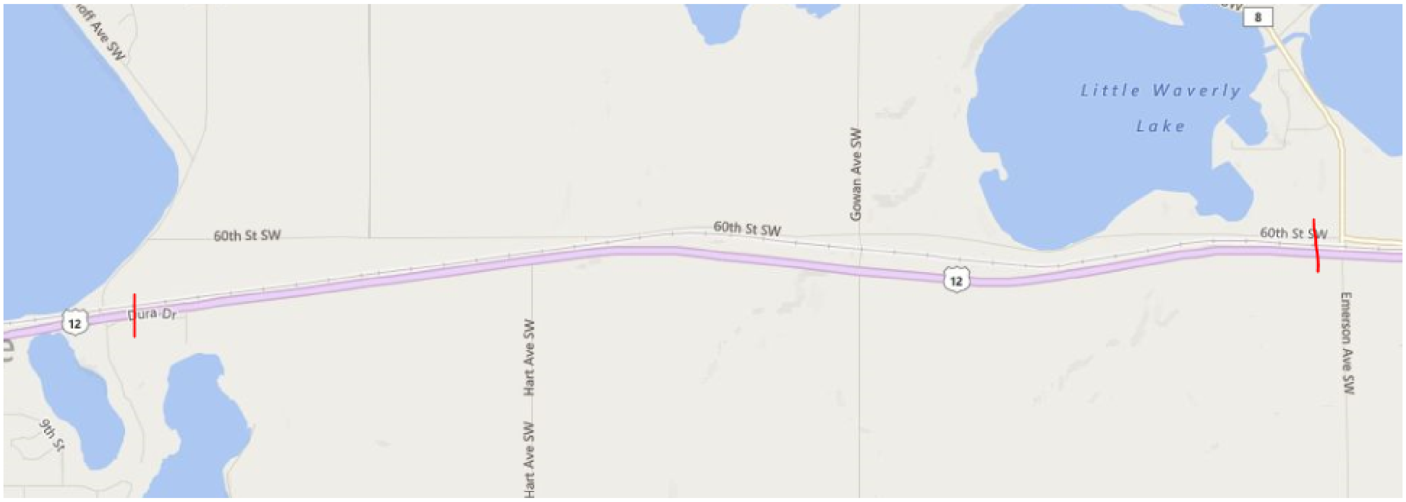
Pedestrian Safety Improvements: The following recommendations are suggested for improving pedestrian safety:

- In response to speeding and pedestrian safety concerns in the City of Howard Lake, it is advised that attention be given to road geometry, especially at intersections. US 12 has a wide cross section throughout Howard Lake, which both promotes higher speeds and creates a long crossing distance for pedestrians. A Complete Streets approach should be taken to counteract these issues.
- In short-term, it is recommended to add pedestrian bump outs (i.e. curb extensions) to narrow the crossing distance. Refer to urban segment recommendations section for further discussion on curb extensions. This is a concept that could potentially be incorporated into upcoming ADA improvement projects in the area.
- Another short-term recommendation is to replace pedestrian flashers with RRFBs. Please refer to urban segment recommendations for a discussion of RRFBs.

[50] *Photo Source: Google Street View (August, 2015)*

Segment E (East of Howard Lake)

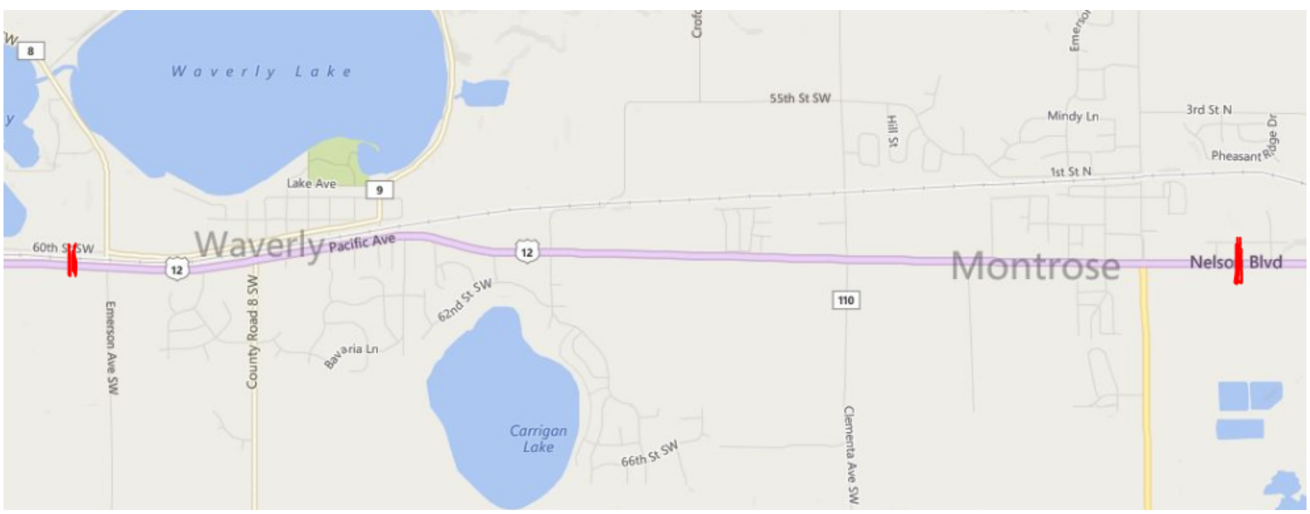
Figure 5-33: Segment E (3.74-Mile Stretch East of Howard Lake)[51]



Segment E is 3.74 miles long and is characterized as being a two-lane rural segment. It is located between the Cities of Howard Lake and Waverly, see Figure 5-33 for a map view of this segment. This segment was not considered a flagged segment based on the crash rates and did not contain any flagged intersections. General corridor-wide and rural segment recommendations should be applied to Segment E as a preventative measure to ensure more safety within the segment safe.

Segment F (Waverly/Montrose)

Figure 5-34: Segment F (3.81-Mile Stretch through Waverly and Montrose)[52]



Segment F runs through both the Cities of Waverly and Montrose. Refer to Figure 5-34 for a map visual of the segment. The segment is 3.81 miles in length and is primarily classified as being a three-lane urban highway, with the center lane being devoted to left turners. In addition to the general corridor-wide and urban

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[51] *Photo Source: Bing Maps (August 2015)*

[52] *Photo Source: Bing Maps (August 2015)*

segment recommendations (i.e. Complete Streets), the following paragraphs further explain the recommendations listed in Table 1-2 for Segment F.

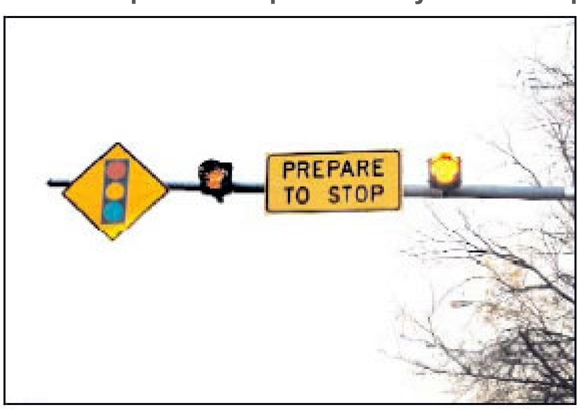
Clementa Avenue Improvements: It was noted during the road safety audit review that Clementa Avenue lighting did not seem adequate. This was also reflected in crash data for the intersection. It is recommended that an additional street light be added in the southwest quadrant of the intersection. In addition to Clementa Avenue, crash data showed a possibility that increasing lighting may help at Emerson Avenue/CSAH 8 LT as well.

Pedestrian Safety Improvements: Various safety improvements are recommended for Segment F:

- The pedestrian crossing at 4th Street is the first crossing seen by westbound traffic upon entering town. This poses a safety risk for pedestrians and it is recommended that advanced warning signs are installed for westbound traffic in short-term. In medium-term, further attention could be brought to the crossing by installing a High Intensity Activated Cross Walk (HAWK) crosswalk. Refer to Segment B recommendations for further discussion on HAWK signals.
- Throughout Montrose and Waverly, pedestrian flashers should be updated to be RRFBs. Please refer to urban segment recommendations for further discussion on RRFBs.
- Throughout Segment F, pedestrian bump outs (i.e. curb extensions) would help reduce crossing distance and could be incorporated as part of a Complete Streets plan. Please refer to urban segment recommendations for further discussion on Complete Streets and curb extensions.

Buffalo Avenue/TH 25: The percentage of rear-end crashes at the Buffalo Avenue/ TH 25 signalized intersection exceeded state averages during the five-year study period. Many crashes were attributed to tailgating or driver distraction. To bring more attention to stopped traffic at the signal, advanced warning signs or flashers could be added for mainline traffic as a short-term solution. A flasher system, such as the one shown in Figure 5-35 below, could be used to bring attention to westbound traffic entering the city.

Figure 5-35: Prepare to Stop Flasher System Example[53]

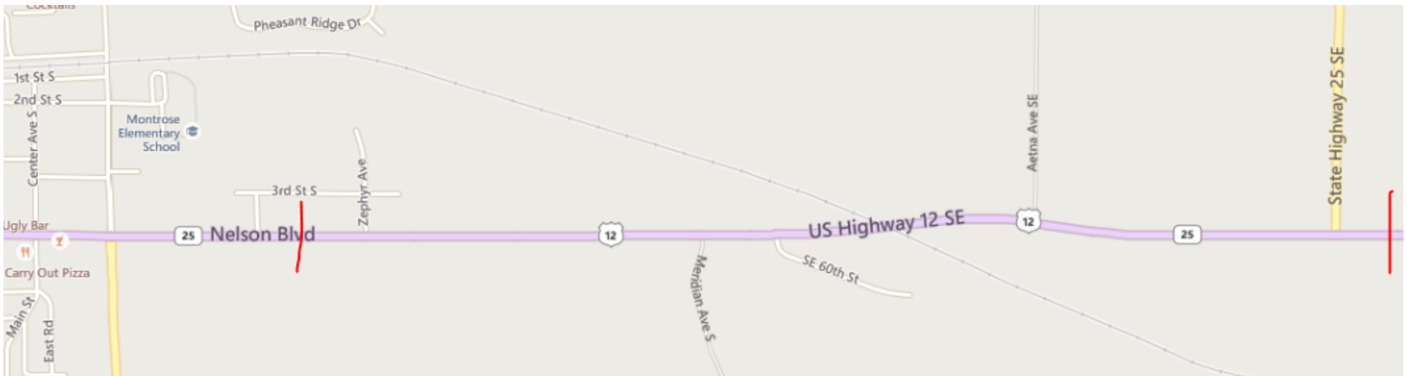


[53] *Photo Source:* http://safety.fhwa.dot.gov/intersection/redlight/cameras/rlr_report/chap3.cfm

The Buffalo Avenue Signal is located near an urban/rural transition point to the east. In addition to tailgating and driver distraction, crash data reflected that speeding is an issue in this region. Speed enforcement and other measures described in previous sections may assist with crash reduction at this intersection.

Segment G (Eastern Montrose)

Figure 5-36: Segment G (1.84-Mile Stretch East of Montrose, MN)[54]



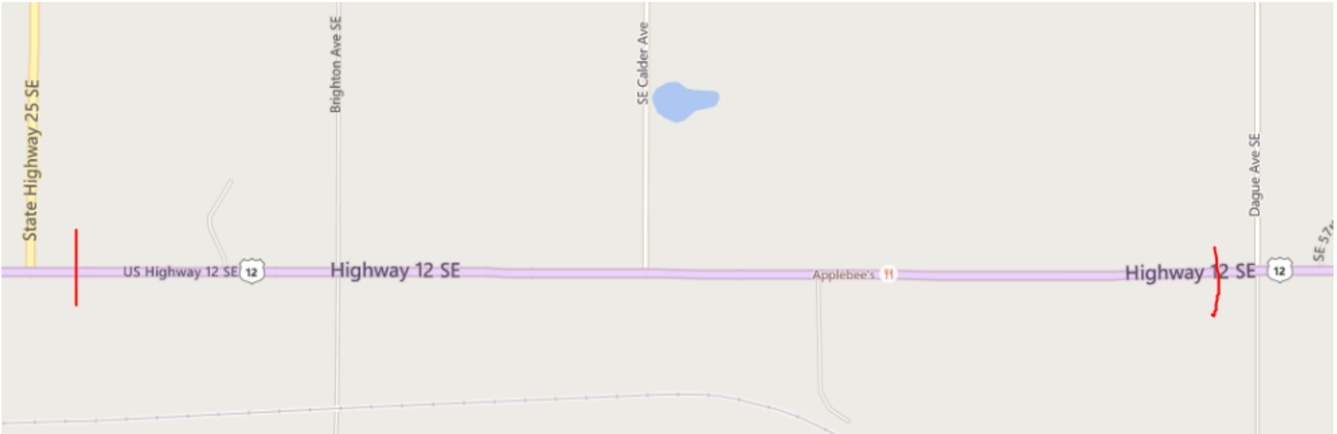
Segment G is 1.84 miles in length and is classified as being a two-lane rural highway. The western limit of the segment starts in eastern Montrose. See Figure 5-36 for a mapped visual of the segment. Segment G was considered a flagged segment during the crash data analysis. The FAR (5.07 crashes per 100 MVM) exceeded both the state average (1.57 crashes per 100 MVM) and the critical rate (1.84 crashes per 100 MVM). Many of the issues in the segment shown in the crash data appeared to occur at the TH 25 north approach. Some examples include a large number of run off road crashes, and crashes related to right turns from the north approach. The current construction project at this intersection for a Continuous Green T installation may help remedy safety concerns. It is advised that the intersection be evaluated post-construction to determine if there are still any safety concerns.

In addition to this, general corridor-wide and rural segment recommendations should be followed for Segment G.

[54] *Photo Source: Bing Maps (August 2015)*

Segment H (East of Montrose)

Figure 5-37: Segment H (1.78-Mile Stretch East of Montrose)[55]

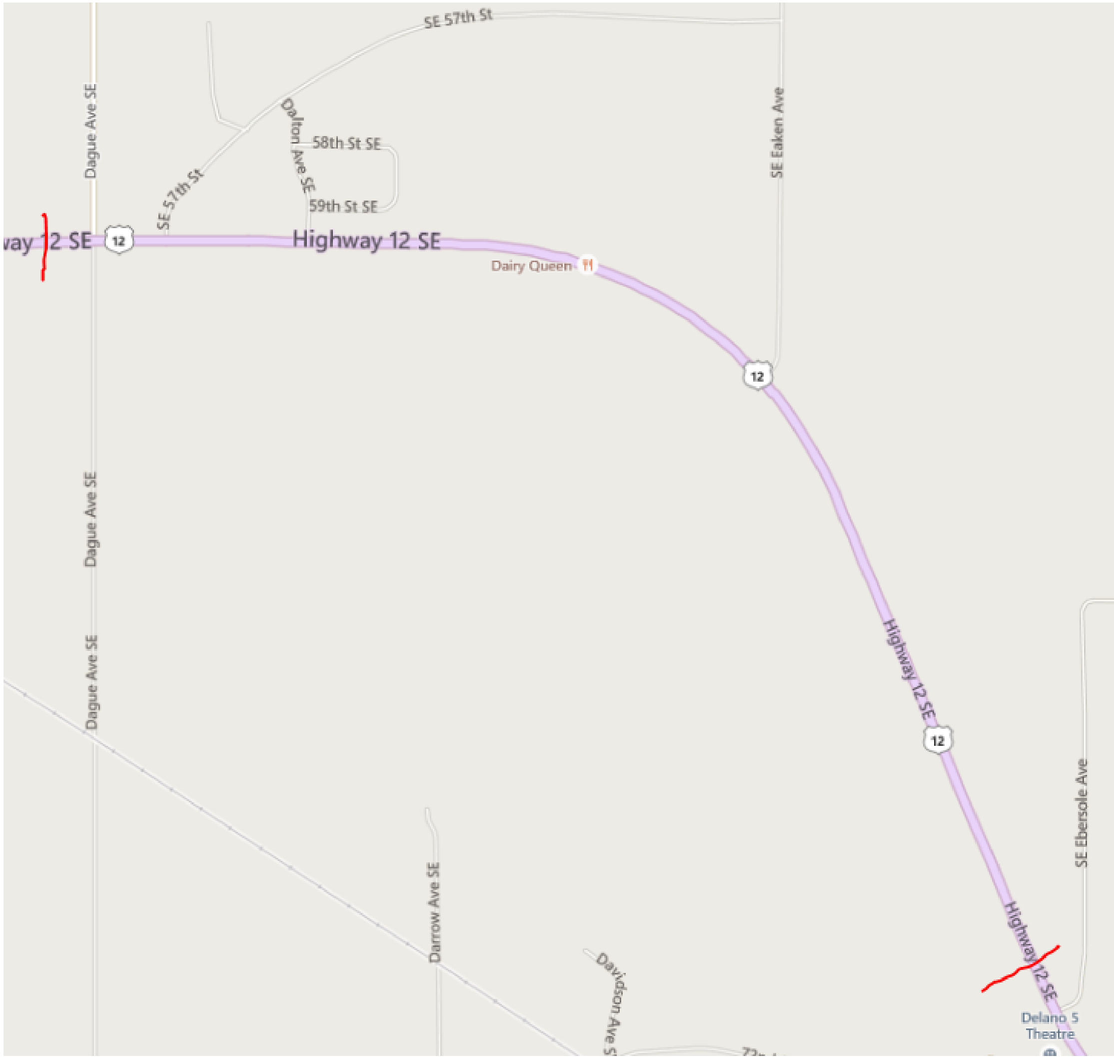


Segment H is 1.78 miles in length and is located just east of Montrose (see Figure 5-37 for a visual of the segment on a map). This rural segment alternates between three and four lane geometries. Based on crash rates, Segment H was not a flagged segment and did not contain any flagged intersections. General corridor-wide and rural segment recommendations should be applied to Segment H. When Segments G and I geometries are updated as part of a long-term solution, all three segments should be designed to have a continuous 2+1 configuration.

[55] *Photo Source: Bing Maps (August 2015)*

Segment I (West of Delano)

Figure 5-38: Segment I (2.20-Mile Stretch West of Delano)[56]



Segment I is located west of Delano and runs 2.20 miles (see Figure 5-38 for a map visual). The segment is classified primarily as being a two-lane, rural highway. The FAR for this segment was found to be 2.13 crashes per 100 MVM, which was higher than the state average (1.57 crashes per 100 MVM) and the critical FAR (1.81 crashes per 100 MVM). Crash data showed that head-on collisions are an issue in this segment. 20 percent of crashes that occurred in the segment were head-on, which is higher than the state average for rural, two-lane segments of nine percent. General corridor-wide and rural segment recommendations (i.e. centerline rumble strips, buffer, etc.) should be applied to this segment. The following paragraphs further explain the recommendations listed in Table 1-2 for Segment I.

Lighting Improvements: Crash data showed a prevalence of crashes occurring in dark conditions between CSAH 14 and Delano. Approximately 30 percent of crashes in the segment occurred during dark conditions. Lighting conditions should be assessed and improved in this region as needed.

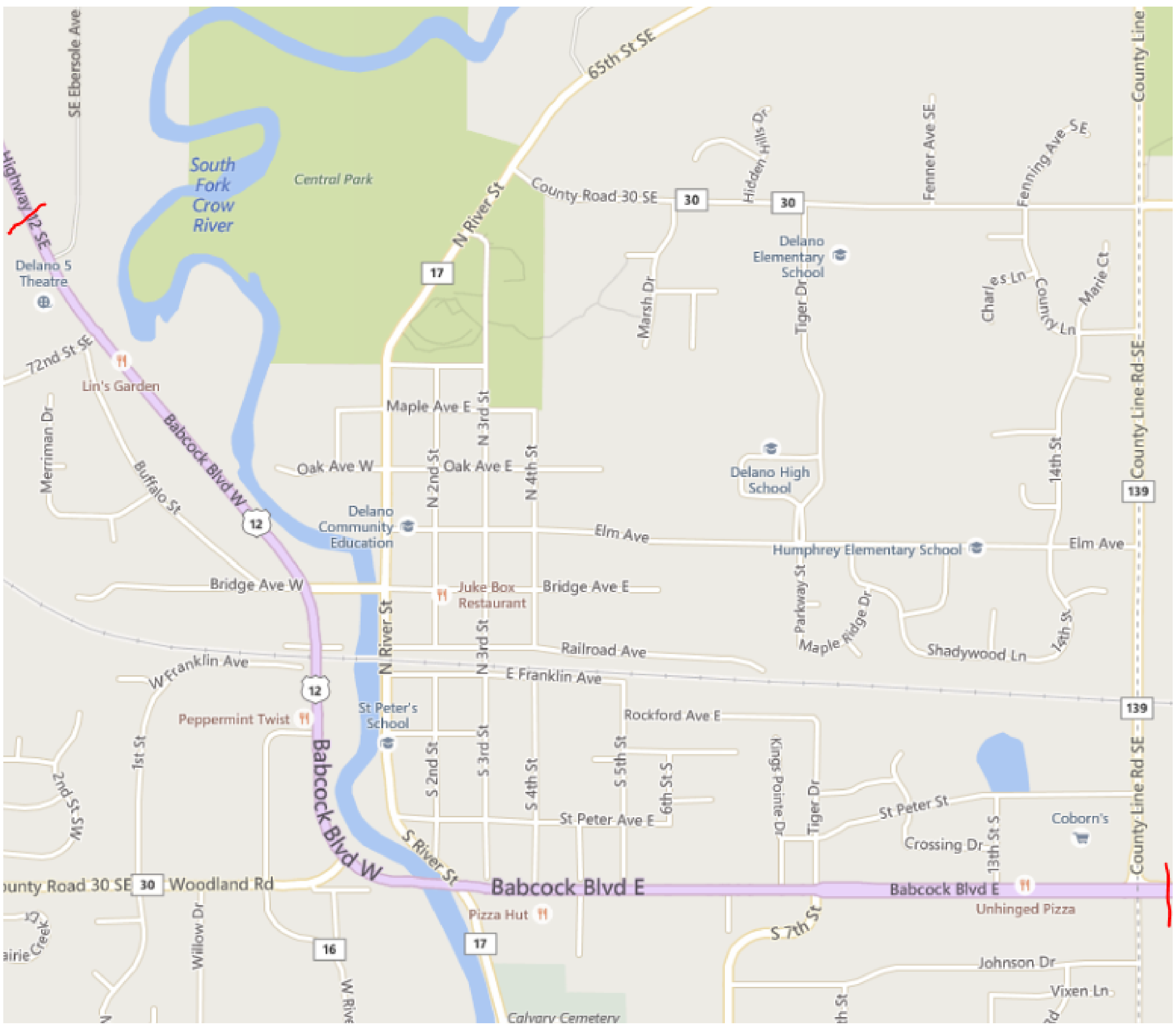
[56] *Photo Source: Bing Maps (August 2015)*

Stop Sign Improvements: Crash data shows that left turn and right angle collisions are prevalent at the CSAH 14 north approach. Majority of these crashes were from southbound traffic failing to yield right of way, and in many cases, driver distraction was noted as being a contributing factor. During the field review, the team didn't observe any abnormalities in the intersection geometry and there weren't any obvious obstructions that could block a driver's cone of vision as they approach the intersection.

A short-term solution would be to increase the size of the stop sign, add LED flashers around the perimeter, and/or add signage showing that cross traffic does not stop as detailed above in the discussion about general intersection remedies. While the effectiveness of LED stop signs is still under discussion, research has confirmed at least some safety benefits to the installation.

Segment J (Delano)

Figure 5-39: Segment J (2.25-Mile Stretch through Delano)[57]



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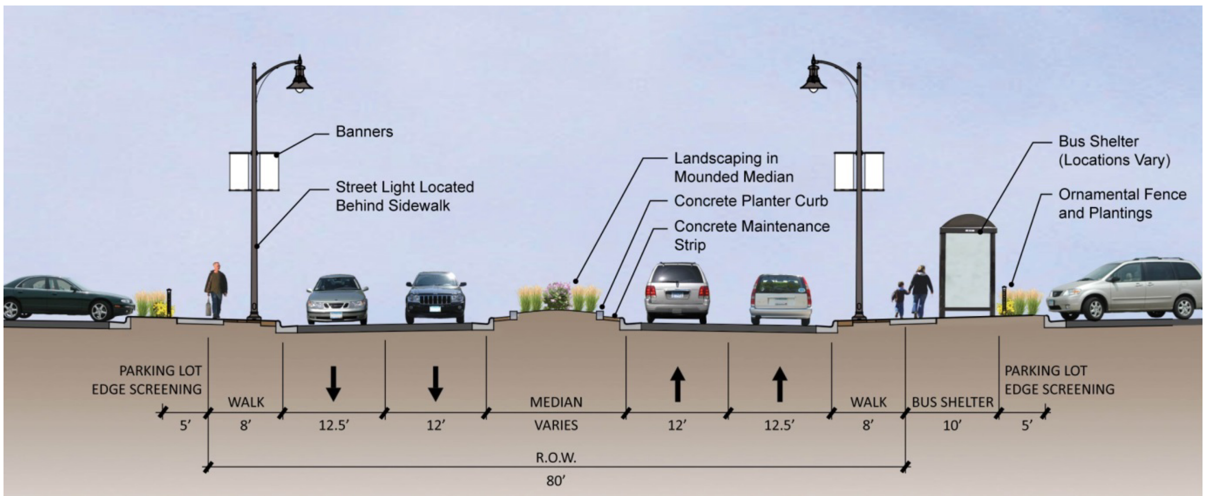
57 *Photo Source: Bing Maps (August 2015)*

Segment J runs through the City of Delano (see Figure 5-39). The segment is 2.25 miles in length and is categorized as being an urban segment with three-lanes (the center lane being devoted to left turns). General corridor-wide and urban segment recommendations (such as Complete Streets) should be applied to this segment. The following paragraphs further explain the recommendations listed in Table 1-2 for Segment J.

Complete Streets: As discussed in future sections of this report, the City of Delano may need to incorporate two lanes in both directions in order to alleviate congestion and queuing issues. Road safety audit team members suggested adding a raised center median and incorporate landscape and other greenery. This would separate traffic, provide additional access management, provide pedestrian refuge at crossings, and would be visually appealing. Other feature could be added as well, such as sidewalks separated from traffic, parking spaces, city banners, and light poles. Figure 5-40 below shows an example of what the final product could look like.

Figure 5-40: Proposed Improvements on Robert Street in St Paul, MN[58]



Congestion Issues through Delano: Locals have voiced concerns regarding safety issues caused by congestion, especially around the Tiger Drive Signal. Crash data reflects a higher than average amount of rear-end crashes due to stopped or slow traffic, and driver distraction/tailgating on US 12 during peak hours. A short-term solution would be to perform an intersection capacity analysis. Intersection capacity is defined by FHWA[59] as the “maximum rate at which vehicles can pass through a given point under prevailing conditions”. As part of this analysis, existing conditions would be assessed to determine if additional lanes are needed at this intersection to carry more vehicles through the intersection, or if more green time is needed for US 12. Improvements should be made to intersection geometry and/or signal timing depending on analysis results.

[58] *Photo Source: Streetscape Features presentation on Robert Street Improvements in St Paul MN. Presentation prepared by SRF Consulting.*

[59] *Source:* http://www.fhwa.dot.gov/publications/research/safety/04091/07.cfm

Signal Coordination: In addition to intersection capacity analyses, system-wide signal coordination should be evaluated throughout town in short-term. Signal coordination means that each traffic signal is synched to be timed to work together. A well-coordinated system can help push heavy traffic through town during peak hours and reduce the frequency of congestion-related crashes.

Traffic coordination can be implemented through installing a traffic signal interconnect system (medium-term solution). With system interconnects, signals can be linked together using underground or over-head cables. The interconnect provides a means for signals to communicate with each other. For example, if signal is turns green, the next signal in the system may be triggered to turn green slightly after so that traffic can move between signals with minimal delay.

Lane Geometry Changes: Intersection capacity analysis results may show that US 12 should be striped for two lanes in each direction through town to improve overall traffic flow. The current cross section was constructed to accommodate up to five lanes and this change should be made once traffic volumes warrant it (i.e. once the AADT surpasses 20,000 vehicles per day). A Complete Streets Approach should be considered in repurposing this space.

Improvements around Tiger Drive/Crow River Drive: Local residents have indicated concerns regarding congestion near the school located north of Tiger Drive and US 12 intersection. In many cases, drivers will take side streets to avoid waiting at the traffic signal. For example, they will use Crow River Drive as an access point from US 12. This poses risk because drivers make unsafe left-turns maneuvers to cross heavy traffic. Restricting turn movements from Crow River Drive to be right-in-right out would help reduce this risk.

Bridge Avenue Intersection Improvements: Driving towards the Bridge Avenue intersection from the east, the road safety audit team observed that there was a lot of visual noise which made the signal less noticeable. This creates sight issues and can increase risk of accidents caused by driver inattention. In addition, the intersection is located on a curve, which creates some horizontal sightline issues. It is advised that warning flashers are added to inform drivers coming from both the east and west of stopped traffic. There are existing beacons located on either side of the intersection; however, it is recommended that they be relocated prior to the curve west of the intersection and prior to the bridge east of the intersection to give drivers more advanced notice.

CSAH 30 Intersection Improvements: Crash data showed a prevalence of speeding related crashes involving westbound traffic approaching the CSAH 30 intersection. Similar to Bridge Avenue, the CSAH 30 intersection is located on a curve, which also causes sightline issues from far away. Signal ahead as well as curve ahead warning signs could help inform drivers of the changes ahead.

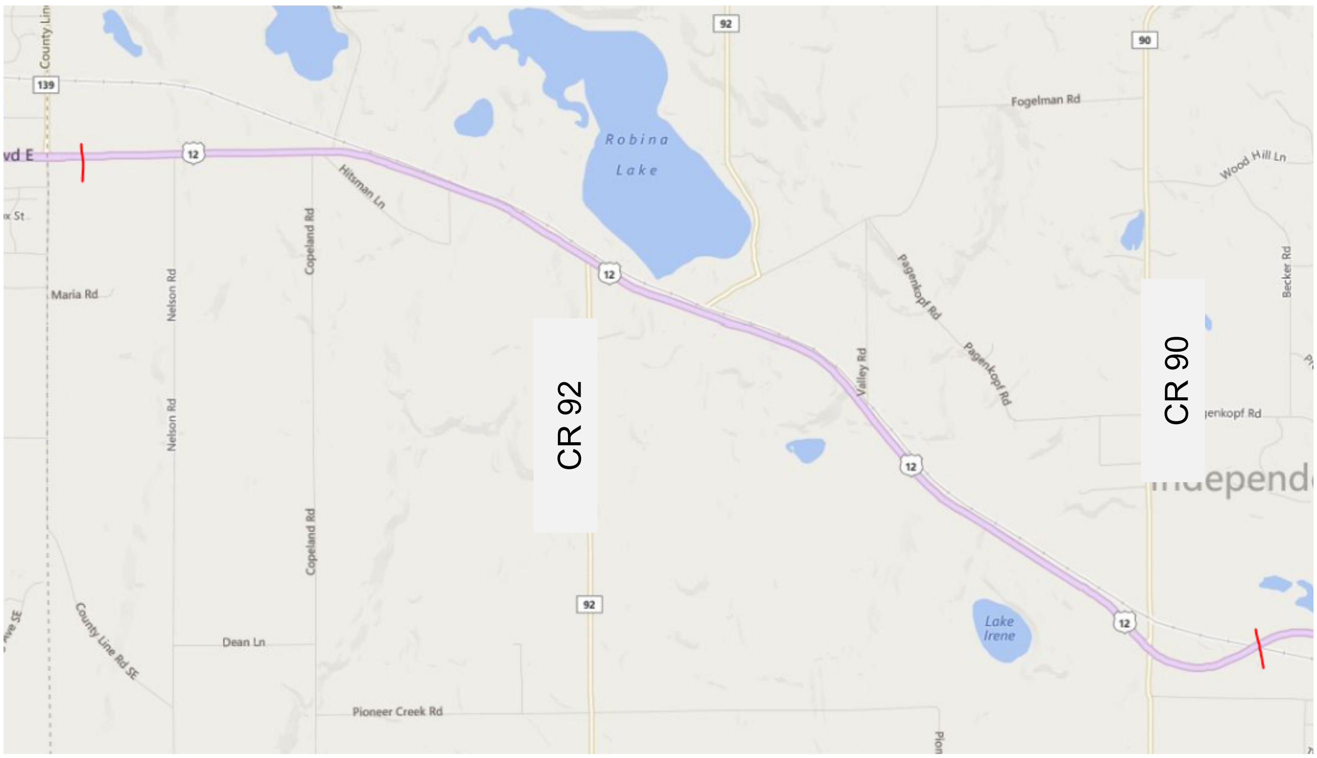
County Line Road/CSAH 139 Improvements: This intersection showed a high frequency of congestion-related crashes. To increase capacity, right turn lanes could be extended. It was observed during the road safety audit field review that the right turn lane from the east approach was not long enough and right turning traffic would drive on the shoulder to get into the right turn bay. Additionally, left-turn movements could be facilitated with the addition of a flashing yellow arrow.

Currently, there are no crosswalk markings to indicate the presence of a crossing. This presents a risk for pedestrian's safety. The addition of these pavement markings would increase driver awareness.

Access Consolidation: There is a high density of access points around the Babcock Circle intersection along the north side of US 12 which provide opportunity for access consolidation improvements.

Segment K (Independence)

Figure 5-41: Segment K (4.94-Mile Stretch through Independence)[60]



Segment K is classified as being a two-lane rural highway. The 4.94-mile segment runs through the city of Independence. During the pre-audit analysis, this segment was flagged as a high-risk segment. The FAR for this segment (3.00 crashes per 100 MVM) was almost double the state average (1.57 crashes per 100 MVM) and also exceeded the critical FAR (1.71). The overall crash rate (0.83 crashes per MVM) exceeded the state average rate (0.73 crashes per MVM).

The cross section through this segment is uncharacteristic to the rest of the corridor. The pavement is visually more aged and the road with is more narrow. Several intersections approach the roadway at an odd angle, which further creates risks for turning vehicles along with a high volume of traffic that passes through this segment every day.

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60 *Photo Source: Bing Maps (August 2015)*

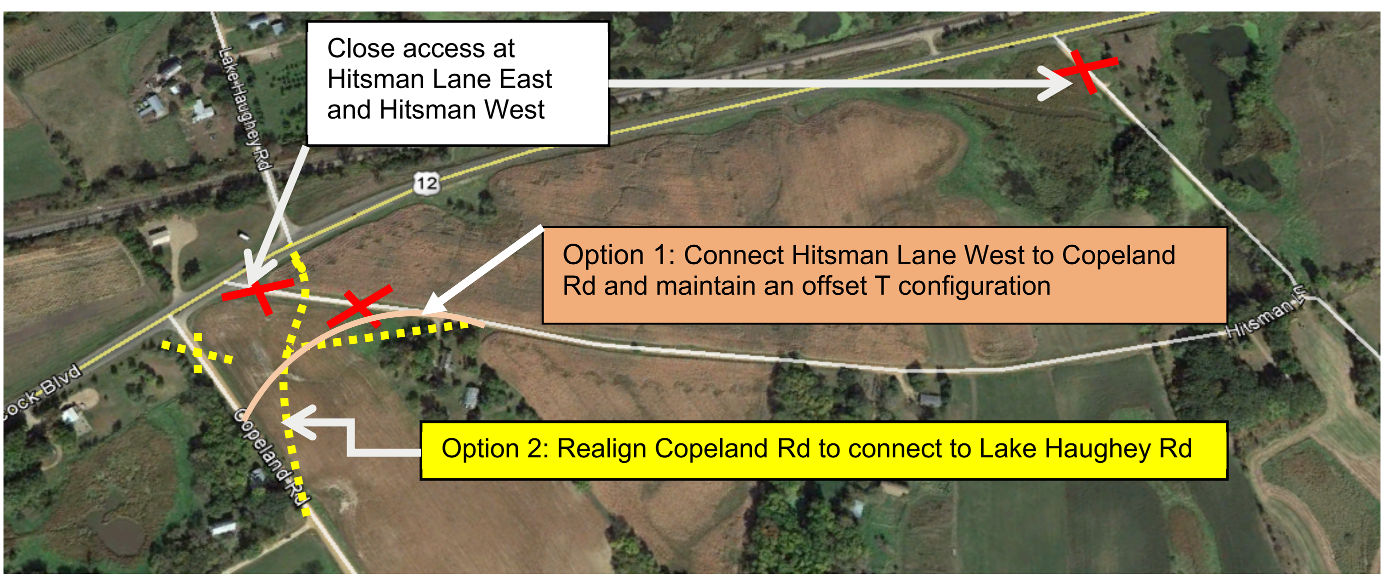
General corridor-wide and rural segment recommendations should be applied to this segment, some solutions should be applied on a tighter time line than suggested for the rest of the corridor. The following paragraphs further explain the recommendations listed in Table 1-2 for Segment K.

Road Improvements: Segment K is visually much older and narrower than the rest of the corridor. It was stated that this stretch of roadway has not been reconstructed in more than 35 years. Crash data trends show a higher concentration of crashes in the segment than in others. Approximately 23 percent of all crashes and 25 percent of fatal and incapacitating crashes took place in the city of Independence during the five-year study period. Similar to other rural segments, it is advised that centerline and edge line rumble strips be immediately added to the roadway in short-term to reduce the frequency of lane departure crashes caused by driver distraction or drowsiness.

In medium-term, the roadway should be planned for reconstruction and converted to a 2+1 lane configuration. Some sort of separation should be included in this re-design to divide opposing directions of traffic (i.e. adding a buffer zone and tubular delineators, high-tension cable barrier, or concrete barrier). By reconstructing this segment, many safety issues could be resolved by improving cross section, as well as horizontal and vertical curvature. It should be noted that if this reconstruction project occurs in near-term, the success of a 2+1 lane configuration and/or buffer zone installation could be tested prior to installation in other segments.

Access Management Plan: Several locations were identified by the Highway 12 Coalition and were verified during the road safety audit field visit for access consolidation. Locations include closing the Western access to Peterson Produce, access to Hitsman Lane East, and access to Valley Road. Alternative routes are available for traffic to use after these closures occur. A summary of suggestions for closures around Hitsman Lane is given in Figure 5-42 below.

Figure 5-42: Summary of Access Management Recommendations around Hitsman Lane[61]



[61] *Photo Source: Google Maps (July 2015).*

The first option would be more preferable because it would involve less road construction. Additionally, this option would provide benefits such as the ones described in discussions on Offset T intersections for intersection recommendations.

Traffic Backup Warning: According to local residents, traffic frequently backs up from Delano to West Pointe Church in the evening peak hour. Traffic data shows a high amount of rear end collisions which are likely attributed to this queuing. Improvements in road capacity and signal coordination in Delano will likely address this issue; however, in short-term a safety solution may be to install warning signs and flashers to notify drivers of oncoming slow or stopped traffic. Please refer to the intersection safety recommendations for further discussion on advanced warning systems and signing.

In addition, CSAH 92 and CSAH 90 minor approaches could benefit from the installation of advanced warning systems.

Horizontal Curve: During the road safety audit review, it was noted that a horizontal curve around Mile 144 could pose some risk to driver safety. As a safety measure, it is recommended that chevrons be added to this curve to raise driver awareness. Refer to Figure 5-43 for an example of chevron signing on a horizontal curve.

Figure 5-43: Chevrons on Horizontal Curve[62]

If not already in place, edge line rumble strips should be added along the curve. Rumble strips can provide further notification to drivers if they are drifting off of the travel lane and that they need to turn their wheels to stay on the road.

Corridor Lighting Improvements: The segment between both the North and South approaches of CSAH 92 was identified to have inadequate lighting. It is recommended that this be investigated and resolved as needed.

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[62] *Photo Source:* http://www.sddc.army.mil/sites/TEA/Functions/SpecialAssistant/TrafficEngineeringBranch/BMTE/calcRoadside/roadsideSafetyTutorials/positiveGuidance/Pages/warningSigns.aspx

Clear Zone Improvements: During the road safety audit field review, it was noted that clear zones needed to be improved (i.e. tree clearing; slope improvements) on the westbound shoulder between the two CSAH 92 approaches. Maintaining a good clear zone will provide drivers with more sight distance as they prepare to approach the south leg from the north leg.

Left Turn Lanes: To alleviate congestion and separate turn movements from through movements, left turn lanes should be added for various intersections in short-term. This is especially true at CSAH 92 and CSAH 90 intersections. All existing bypass lane sections should be eliminated and replaced with left turn lanes. 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.

Channelized Right Turn Lane on CSAH 92: In short-term, there is space available for adding a channelized right turn lane on the CSAH 92 south approach. Channelizing this turn movement gives vehicles a better angle to enter mainline traffic, reduces frequency of right angle crashes, and allows for more continuous turn movements because right turners won't necessarily have to stop before turning.

Pavement Marking Updates on CSAH 90: The current lane configuration has a left-through lane and a right turn lane. Based on similar concepts described above for adding left-turn lanes on mainline, traffic flow would be improved by changing the configuration to instead have a left turn lane and a right-through lane.

CSAH 92 Intersection Improvements: Both CSAH 92 intersections are in need of improvement. These two intersections approach US 12 at a skewed angle. This results in limited sightlines and provides more risk because vehicles have to enter and depart from these approaches at odd angles. Furthermore, US 12 traffic volumes are high, especially during rush hours. Because of this, there aren't many gaps in traffic and vehicles trying to turn onto mainline often take risks to complete their turning maneuver.

In short-term, Intersection control methods should be evaluated via the ICE process. See intersection recommendations for more details on the ICE process. In medium-term, the intersection control method resulting from the ICE process should be installed. At present, additional funding is being sought out by MnDOT to make these updates.

Based on the results of the road safety audit and coalition recommendations, the following scenarios should be evaluated:

- Option #1: Remove the skew for each intersection and create a positive offset. Restrict turn movements to be right-in-right-out configuration at the north approach and add a roundabout at the south approach so that drivers can reverse directions if needed.
- Option #2: Combine the two approaches, but install a roundabout to make turn and through movements safer.
- Option #3: Install reduced conflict intersections (RCI) at these approaches to make turn and side street through movements safer without impacting

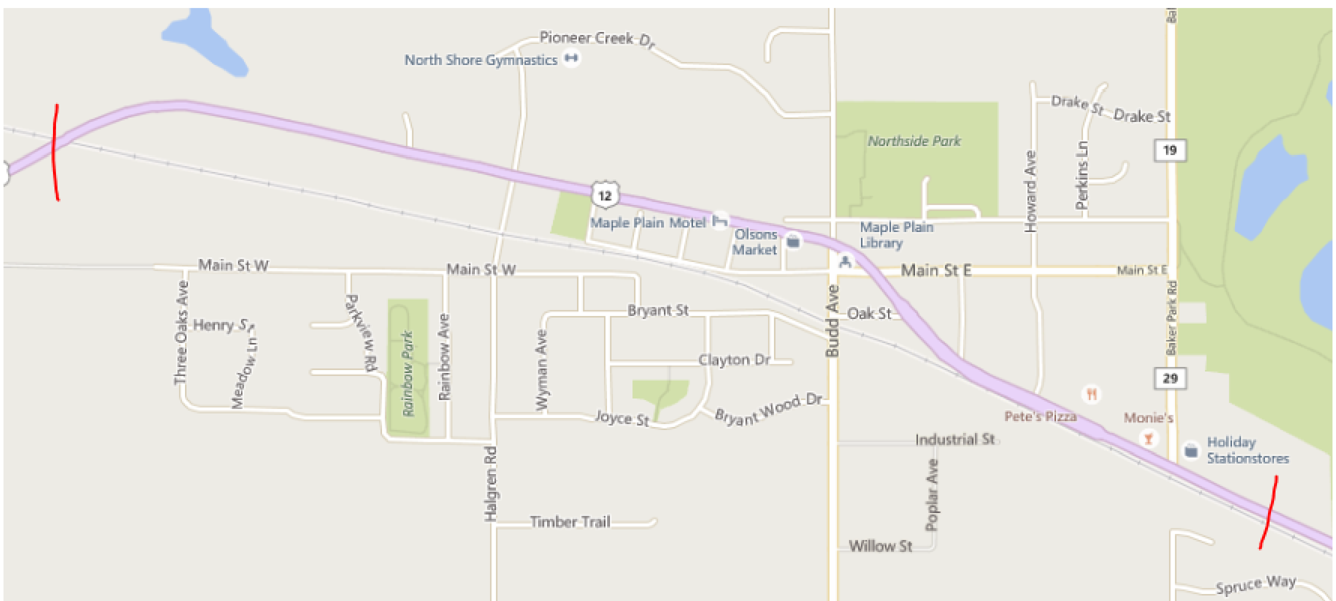
mainline traffic flow. Please refer to discussions on RCIs in the intersection recommendations section.

Although it would be safer, it should be noted that a roundabout may likely negatively impact traffic flow because US 12 traffic volumes can get to be high. Because of this, mainline traffic may over-take the roundabout and side street traffic will have to fight to make their turns. Other options should also be assessed as well, such as installing a Continuous Green T or a Reduced Conflict intersection.

CSAH 90 Intersection Improvements: It was suggested by the Highway 12 Coalition that a roundabout be added to the CSAH 90 intersection. This was in response to a high frequency of junction-related crashes at the intersection. An ICE process should be studied in short-term to establish if a roundabout is the best form of intersection control for the intersection. After the ICE process is completed, the intersection control should be installed. At present, additional funding is being sought out by MnDOT to make these updates.

Segment L (Maple Plain)

Figure 5-44: Segment L (1.73-Mile Stretch through Maple Plain)[63]



Segment L runs though the City of Maple Plain and is 1.73-miles in length (see Figure 5-44 for a visual of the segment on a map). Currently, the roadway is classified as being a three-lane urban segment. The center lane of the roadway is shared by both directions of traffic for left turns. General corridor-wide and urban segment recommendations (i.e. Complete Streets) should be applied to this segment. The following paragraphs further explain the recommendations listed in Table 1-2 for Segment L.

Access Management: Several safety risks are posed from the current intersection configuration in town. The City of Maple Plain currently has plans to buy some

[63] *Photo Source: Bing Maps (August 2015)*

land around the intersections of CSAH 19 and Budd Avenue to develop a city block. With this plan in mind, there are some potential access closures that could align with this future plan.

- Closures at Budd Avenue, CSAH 19, and Oak Street: In the medium-term, it was suggested that the south/west accesses for Budd Avenue and/or CSAH 19, and Oak Street accesses be closed or restricted to right turn movements only. In the current configuration, locals know to avoid crossing US 12 on Budd Avenue because it is difficult to find gaps in traffic large enough to safely cross. To increase safety for road users who are unaware of this, it is advised that the south access be either close or restricted. The CSAH 19 intersection is located on a curve and at a skewed angle and this causes safety risks. To further separate the future city block as a separate region from US 12 mainline, Oak Street could be closed and a cul-de-sac could be added. If CSAH 19, Budd Avenue, and Oak Street south/west accesses are closed, then traffic can be routed to use Maple Avenue to access that part of the city.
- Roundabouts at City Limits: In long-term, it was suggested that roundabouts be added to Maple Avenue and CSAH 29, and that a raised median be added between the two roundabouts. The raised median would further assist with access management. With the addition of roundabouts, drivers would be forced to slow down as they enter town, and the new geometry would allow restricted movements in town to safely make a U-turn if needed. There would also be options to incorporate safer pedestrian crossing locations into this plan. For more information on roundabouts at city limits, refer to discussions on rural to urban speed transitions in the corridor-wide safety solutions recommendations.

Attenuator at Railroad Median Barrier: Local officers indicated that the median barrier which protects a railroad bridge on the western side of Maple Plain frequently gets hit by drivers. A suggestion was made to install a recoverable attenuator in front of the medium barrier to provide some additional protection for the driver. Recoverable attenuators are often placed in front of in place structures that are at risk of getting hit by vehicles. They are intended to reduce damage to structures, vehicles, and motorists resulting from collisions by absorbing the colliding vehicle’s energy and can take repeated impacts without having to be replaced.

Figure 5-45: Recoverable Attenuator[64]

In addition to recoverable attenuators, mumble strips could be installed to prevent drivers from drifting towards the barrier due to distraction or drowsiness. Like rumble strips, mumble strips provide vibration to alert drivers when they drift from their lane, however, they provide significantly less external noise than the traditional design. Figure 5-10 provides a visual of mumble strips.

Continuous Left Turn Lane around CSAH 83: In order to match the character of other urban regions along the corridor, it is recommended that a continuous center left turn lane be added between CSAH 83 and to the east edge of the nearby median barrier.

HAWK Signal Improvements: There is currently a HAWK signal in town between the Budd Avenue N and CSAH 19 intersections. At present, the signal is located on a curve at a location that may be hard for pedestrians to see from different vantage points. It was suggested that way-finding signs be added to help direct pedestrians who want to cross US 12 to this crossing.

Improvements at Baker Park Road/CSAH 29: Crash data trends showed a high number of rear end crashes for eastbound and westbound traffic approaching Baker Park Road/CSAH 29. In short-term, measures such as the ones described for Buffalo Avenue/TH 25 in Segment F, can be taken to try to increase driver awareness of the slowed or stopped traffic ahead.

Additionally, different traffic control devices should be explored using the ICE review process for this intersection. Alternatives suggested by the road safety audit team include:

- Continuous Green T: As discussed in the intersection recommendations section, Continuous Green T's are installed to alleviate mainline flow and improve safety for turning vehicles. A Continuous Green T should be considered because it would help alleviate congestion for mainline traffic, however, it should be noted that this could promote speeding as vehicles enter the City of Maple Plain.

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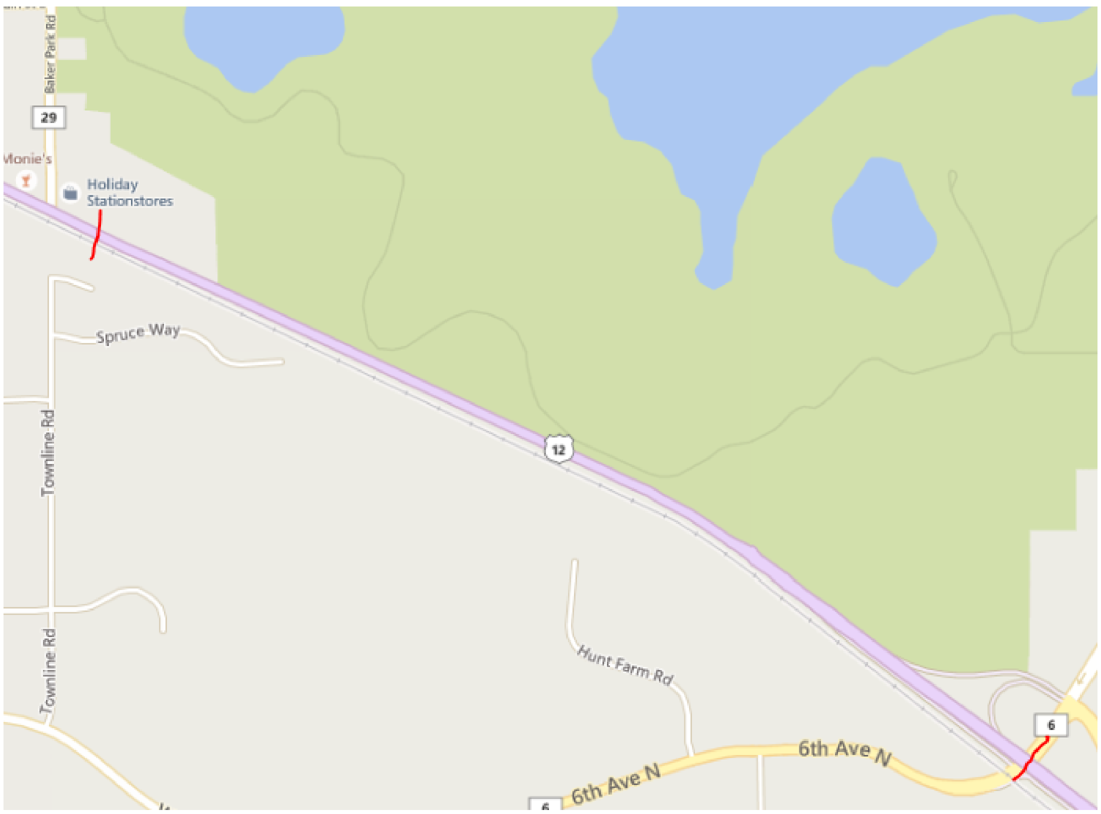
[64] *Photo Source:* http://www.mainstreetmaterials.com/products/safety-equipment/compressor-attenuator/

- Roundabout: As discussed above, a roundabout should be evaluated for this intersection as part of a master plan to provide access control for the City of Maple Plain.

Improvements at CSAH 83: During the road safety audit field review, officers indicated that left turn loop detectors on the south approach for CSAH 83 are frequently triggered by vehicles entering the approach from the west leg of the intersection. This poses a risk in that it can create unnecessary delay for mainline traffic, which could lead to an increase in rear end collisions. This is especially true for drivers entering from the west because it is the first signal encountered upon entering town. It is suggested that the loop detector be re-located to a placement where this issue is less likely to occur. Pavement marking updates should take place as well to assist with this.

Segment M (Orono)

Figure 5-46: Segment M (1.54-Mile Stretch through Orono)[65]



Segment M is 1.54-miles in length and is located between the City of Maple Plain and CSAH 6 (see Figure 5-46 for a visual of the segment). The segment is classified as a two-lane, rural highway. The FAR for Segment M was 3.66 crashes per 100 MVM, which exceed both the state average (1.57 crashes per 100 MVM) and the critical FAR (1.80 crashes per 100 MVM).

In addition to the general corridor-wide and rural segment recommendations, the following paragraphs further explain the recommendations listed in Table 1-2 for

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[65] *Photo Source: Google Maps (August, 2015)*

Segment M. Note, that like Segment K, a 2+1 geometry should be installed on a smaller timeline due to high fatal and incapacitating crash rates.

CSAH 6 Ramp Metering: During peak hours, traffic entering US 12 from CSAH 6 slows down mainline traffic. Ramp meters are signals located at the on ramps, which controls traffic moving onto the highway. Often signals are only active during the peak periods. Ramp metering can help provide gaps in entering traffic so that merging is facilitated. This change could be made in short-term and at a medium range cost.

ITS Solutions: Various ITS solutions could be implemented to help raise driver awareness. One solution would be to install Congestion Ahead signs, such as the one shown in Figure 5-47, to inform drivers to keep their eyes open for slowed or stopped traffic.

Figure 5-47: Congestion Ahead Sign[66]

The use of dynamic travel time signs, such as the one shown in Figure 5-48, could help drivers make informed decisions about the routes that they choose to take. If other routes, such as TH 55, have shorter travel times, this may lead to a decrease in congestion along US 12. These signs could be placed in other regions of the corridor to address congestion from eastbound traffic as well.

Figure 5-48: Travel Time Signing[67]

Moveable Median Barrier: To accommodate peak hour traffic, a moveable median barrier could be utilized as a long-term solution. Moveable median barriers are

[66] *Photo Source:* https://corp.sonic.net/ceo/2014/04/29/net-neutrality-is-dead-long-live-net-neutrality/

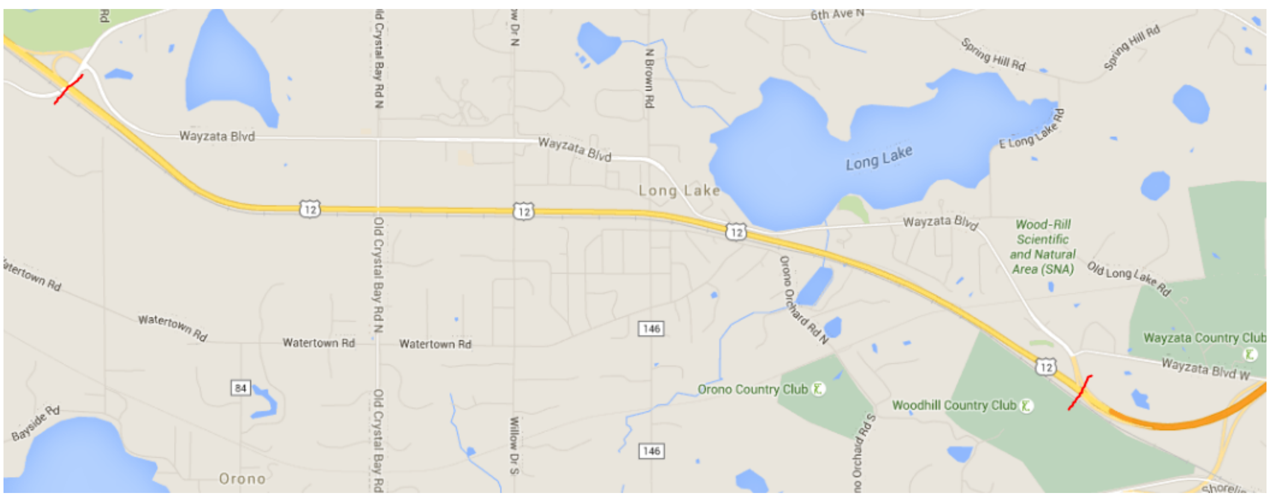
[67] *Photo Source:* http://www.ops.fhwa.dot.gov/publications/fhwahop14022/chapter3.htm

often used for construction staging in regions where space for lanes is limited and heavy traffic directions occur during morning and evening peak hours. Using a "zipping" device, median barrier can be transferred during non-peak hours to provide an extra lane for peak flow traffic. Installing a moveable median barrier requires extra funding for maintenance during week days and will have an upfront equipment cost. These costs should be evaluated against the benefits provided for congestion alleviation along the corridor.

Figure 5-49: Moveable Median Barrier[68]

Segment N (Orono and Long Lake)

Figure 5-50: Segment N (4.02-Mile Stretch through Orono/Long Lake)[69]



Segment N is 4.02-miles in length and is bounded to the west by CSAH 6 (see Figure 5-50 for a visual of the segment). The segment has two-lanes and is mostly classified as being rural, but also has some sections with curb and gutter.

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[68] *Photo Source:* http://www.roadstothefuture.com/Zipper_I95_JRB.html

[69] *Photo Source: Bing Maps (September 2015)*

There is median barrier on the west end of the segment that leads up to the CSAH 6 Bridge. To the east of the median barrier, there is a centerline buffer with rumble strips.

This segment was re-constructed to bypass the City of Long Lake and Orono in 2008 and is in a portion of the road commonly referred to as “the Super Two”. The installation of a centerline buffer and centerline rumble strips resulted from this project to address a high level of head-on collisions.

Over the five year study period for this segment, The FAR for Segment N was 2.27 crashes per 100 MVM, which exceed both the state average (1.57 crashes per 100 MVM) and the critical FAR (1.74 crashes per 100 MVM). 32 percent of all crashes in this segment were rear-end collisions. 50 percent of fatal or incapacitating crashes were from running off the road to the right side. 50 percent of fatal or incapacitating crashes were head-on collisions.

The following paragraphs further explain the recommendations listed in Table 1-2 for Segment N. General corridor-wide and rural segment recommendations should be applied to this segment. Note, that like Segment K, a 2+1 geometry should be installed on a smaller timeline due to high fatal and incapacitating crash rates.

Centerline Improvements: Due to a high concerns related to head-on collisions, flexible delineators should be installed along the centerline of this segment. This should be done in short-term. Another short-term solution is to install a centerline median barrier. Depending on which works best with the road geometry and available funding, a high-tension cable barrier or concrete barrier should be used.

ITS Solutions: Like Segment M, ITS Solutions should be applied for Segment N.

Dynamic Shoulder: A medium-term solution to congestion-related issues would be to introduce a dynamic shoulder for eastbound traffic. Allowing vehicles to drive on the shoulder during peak hours would add an additional lane of capacity as needed and push higher volumes through at a faster rate.

Moveable Median Barrier: Like Segment M, the concept of a moveable median barrier should be applied for Segment N.

6 Conclusion

The goal of a road safety audit process is to determine if the number and severities of crashes is abnormal, determine the primary factors for the crashes, and propose long, medium, and short-term recommendations to improve the safety of the corridor. A focus is given to eliminating severe and fatal crashes and reducing the total number of crashes along the corridor. All aspects of road safety are considered and opportunities to reduce crash risk are sought out.

This report is intended to be used as a tool to provide guidance and recommendations as corridor improvements are made. A hierarchy of priorities should be continually evaluated to make the greatest impact given available time and resources. Short-term solutions are usually low-cost, high benefit, and can often be applied corridor-wide and system wide.

Overall, the amount of crashes on the corridor has continually decreased since the 1980s. This is likely a cause of safety improvements that have happened over the years.

Some improvement projects are currently under way; the success of these improvements should be continually monitored. An example is the Continuous Green T Intersection being installed at TH 25 in Montrose, Minnesota. The intersection was designed to channelize turn movements and allow eastbound through traffic to move through the intersection without stopping. If crash rates and traffic patterns are improved as a result of this project, then this solution could be used elsewhere in the corridor.

The corridor wide fatal and incapacitating crash rates (FARs) are higher than statewide averages for similar roadway types. In most cases, FARs were what flagged segments as being higher risk in the analysis. In many cases, head-on collisions accounted for these severe crashes. Centerline remedies such as installing rumble strips and adding a buffer between opposing directions of traffic can greatly reduce this number.

Although 49 percent of all crashes were non-junction related; several intersections were flagged as being higher risk based on high crash rates or large numbers 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 22 percent of all crashes and 22 percent of fatal and incapacitating crashes occurred in the City of Independence. This is likely because of the high volumes of traffic that travel through this constrained segment. Unlike most other segments, TH 12 in Independence has not been reconstructed in a long time, and this may be contributing to crashes. Due to these factors, centerline rumble strips should be added immediately. This segment should be reconstructed and incorporate the medium-term solution of adding a buffer and 2+1 passing lane configuration.

Speeding issues were prevalent in most urban segments of the corridor. A consistent approach to speed limit signing would help manage driver expectation between rural and urban segments. Additionally, implementing a Complete Streets approach to narrow cross sections in urban regions would change the character of the road to invoke drivers to slow down. In addition to improving speed issues, a Complete Streets design would further benefit the community by repurposing the space for various types of road users. Involving the public in decisions related to Complete Streets improvements would lead to a design based more around the community needs and could help improve the overall usability of the roadway within Cities.

Various ITS methods can be used to increase driver awareness of traffic changes, and even help drivers make informed decisions about their route choice.

The four-E’s (Engineering, Education, Enforcement, and Emergency Services) should be all considered to create a multi-disciplinary approach to safety solutions.

Appendix A. Glossary of Acronyms

Table A- 1: Glossary of Acronyms

Acronym	Meaning	Definition
AADT	Annual Average Daily Traffic	Wikipedia Definition (August 2015): "Annual average daily traffic, abbreviated AADT, is a measure used primarily in transportation planning and transportation engineering. Traditionally, it is the total volume of vehicle traffic of a highway or road for a year divided by 365 days. AADT is a useful and simple measurement of how busy the road is. Newer advances from traffic data providers are now providing AADT by side of the road, by day of week and by time of day."
CGT	Continuous Green T	Continuous Green T's, also referred to as CGT's, are a type of intersection control installed at T-intersections. They are constructed to allow continuous movement for through traffic on the "top" of the T intersection and provide safer turn movements through channelization.
CSAH	County State Aid Highway	Wikipedia Definition (August 2015): "County roads in Minnesota are roads locally maintained by county highway departments in Minnesota. County roads span a wide variety of road types, varying from A-minor arterials that carry large volumes of traffic to an improved road. Most county roads in Minnesota are designated with numbers that are unique only within a county." "Some county routes are designated as County State Aid Highways (CSAH). These routes are constructed and maintained by counties, but they are eligible for funding from the County State Aid Highway Fund."
FAR	Fatal and Incapacitating Crash Rate	A type of crash rate which computes crash frequency of fatal and severe injury crashes per some measure of exposure. This rate allows for road segments of different traffic volumes, lengths, and number of study years to be compared with one another.
FHWA	Federal Highway Administration	From FHWA's website (August 2015): "The Federal Highway Administration (FHWA) provides stewardship over the construction, maintenance and preservation of the Nation's highways, bridges and tunnels. FHWA also conducts research and provides technical assistance to state and local agencies in an effort to improve safety, mobility, and livability, and to encourage innovation."
GIS	Geographic Information System	Wikipedia Definition (September 2015): "A system designed to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data."

Acronym	Meaning	Definition
HAWK	High-Intensity Activated Crosswalk beacon	Wikipedia Definition (August 2015): “A HAWK beacon (High-Intensity Activated crossWalK beacon) is a traffic control device used to stop road traffic and allow pedestrians to cross safely. It is officially known as a Pedestrian Hybrid Beacon (PHB). The purpose of a HAWK beacon is to allow protected pedestrian crossings, stopping road traffic only as needed. Where standard traffic signal 'warrants' prevent the installation of standard three-color traffic signals, the HAWK beacon provides an alternative. A HAWK beacon is used only for marked crosswalks. Similar hybrid beacons are allowed at driveways of emergency service buildings such as fire houses.”
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.
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 (Mn/DOT, 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.”
RCI	Reduced Conflict Intersection	From MnDOT’s Website (August 2015): “Reduced Conflict Intersections are intersections that decrease fatalities and injuries caused by broadside crashes on four-lane divided highways. In some parts of the country, RCIs are sometimes referred to as J-turns or RCUTs.”” In an RCI, drivers always make a right turn, followed by a U-turn.”

Acronym	Meaning	Definition
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"
USDOT	United States Department of Transportation	Wikipedia Definition (August 2015): "The United States Department of Transportation (USDOT or DOT) is a federal Cabinet department of the U.S. government concerned with transportation."

Appendix B. What is a Road Safety Audit?

What is a Road Safety Audit?

In the FHWA's (Federal Highway Safety Administration) *Road Safety Audit Guidelines* 2006 publication, the following definition is provided:

> *A Road Safety Audit is a formal safety performance examination of an existing or future road or intersection by an independent audit team.*
>
> *The road safety audit team considers the safety of all road users, qualitatively estimates and reports on road safety issues and opportunities for safety improvement*

A road safety audit usually is in response to an abnormal frequency or severity of crashes in a region. Road safety audits can also be used to assess potential risk factors as well.

Goals of a Road Safety Audit

The primary goal of a road safety audit is to find ways to make a road safer by identifying potential road safety issues and developing short-, medium-, and long-term solutions. The following fundamental focus areas were identified to help achieve this goal:

Focus #1: Eliminate fatal and serious injuries

Focus #2: Reduce the number and severity of all crashes

Focus #3: Take a multi-dimensional approach

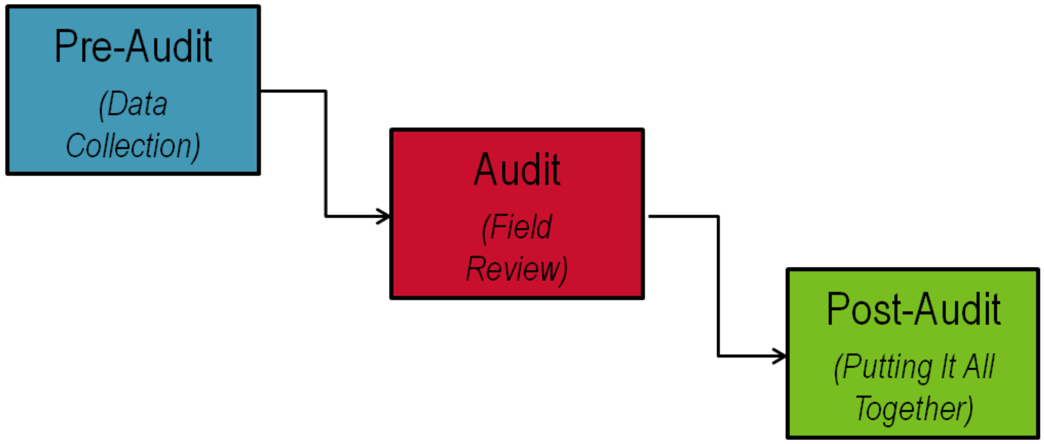
Fatal and incapacitating crashes hold the highest importance. By focusing on fatal and incapacitating crashes, more lives can be saved. This well aligns with Minnesota's "Toward Zero Deaths" (TZD) goal. By next focusing on reducing the total number and severity of crashes, risk factors can be reduced to improve the overall safety of the corridor.

The safety of all road users is important. Semi-trucks, students, daily commuters, pedestrians, bicyclists, road maintenance staff, and emergency vehicles use the road and put their lives at risk. There are many types of road users and different considerations that need to be made to account for them.

Road Safety Audit Review Process

There are three main stages for the road safety audit review process: Pre-audit, audit, and post audit.

Figure B- 1: Road Safety Audit Process



Pre-Audit

The pre-audit stage involves collecting data and background information on the corridor. This includes identifying the roadway characteristics, corridor history, and crash data and trends. Using this information, key focus areas can be determined for the corridor.

Audit

The audit is an onsite corridor review performed by a multi-disciplinary road safety audit team. While in the field, the road safety audit team investigates the project corridor and records observations, takes inventory of existing conditions, and discusses potential strategies and applications that can be used.

Post-Audit

Following the field review, the road safety audit team develops and recommends short-, medium-, and long-term solutions to safety concerns identified in the pre-audit and audit steps. All findings are presented to stakeholders.

Wavetronics devices record the type, speed, and traffic patterns throughout a set number of days. Two locations were chosen along the corridor to collect data from Wavetronics devices. One was placed just west of the Super 2 bypass around Long Lake, near CSAH 6 (see Wavetronics devices were placed at two locations along the corridor (see Figure F- 1 and Figure F- 2). Wavetronics devices are used to collect various data, such as vehicle speeds and traffic counts. Data is collected for each lane of traffic.

Figure F- 1). The second device was placed in Howard Lake in response to speed concerns (see Figure F- 2).

Appendix C. Public Feedback

DOCUMENT 1: A LETTER FROM US 12 COALITION LEADER, GARY KROELLS

From: Gary Kroells
Sent: Thursday, August 20, 2015 1:19 PM
To: Leuer, Derek (DOT)
Subject: RE: US 12 RS Audit

Derek,

I would only stress and I mean really stress Hwy12 through Independence needs to be redesigned and rebuilt in the next three to five years. It is an outdated, unimproved road for over 50 years and it is time to replace it. The crash facts speak for themselves and improvements need to be made now, not later. I don't agree with the time lines in the safety audit in the Independence area. We desperately need traffic control device (stop light or a roundabout) at Hwy12 and County Road 90 and 92 need a in the next three years or less as well. It simply cannot wait five plus year and I will continue to push the improvements on Hwy12 until completed.

I drove Hwy 55 yesterday from Medina to Rockford and you cannot tell me Willow Drive and Arrowhead Drive in Medina warranted a traffic signal to be installed. Very little if any traffic crosses Hwy 55 at either of these local city street roads. I have two major county roads (County Road 92 and Co 90) that are way more dangerous to cross at Hwy 12 than the few cars that cross at Willow and Arrowhead.

Improvements must be made. I know I seem frustrated, but our department, MnDOT, and our cities did this same study 20 plus years ago with the same results. Nothing changed then and now we are back at it. Improvements need to be made and the funding must be discovered for this to be a priority of MnDOT.

I am still waiting for the six foot tall weeks to be cut along Hwy 12 and it has been a month. Now we have to wait until September 1 to even get a tractor out here to get it done. We are forgotten out here by Metro and District 3 and it is time to make some changes.

That is my input.

Chief Gary Kroells
West Hennepin Public Safety
1918 County Road 90
Maple Plain, MN 55359
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Cell: 612 328-1905
Fax: 763-479-0504
westhennepin.com
gkroells@westhennepin.com

DOCUMENT 2: "TIME FOR ACTION ON HIGHWAY 12"

This article was written on August 24, 2015 by Gabe Licht for the Herald Journal/ Dassel-Cokato Enterprise Dispatch/ Delano Herald Journal. Located at this link: http://www.herald-journal.com/archives/2015/columns/gl082415.html

Appendix D. Summary of Segment Crash Data Sheets

Segment Trends

The following trends were observed for segments that had high crash rates or FARs (*observations that apply to fatal crashes are noted with a star). Please refer to section D of the document “US 12 Road Safety Audit Briefing Book” to review these data sheets.

- **Segment A (Rural segment west of Cokato):** Crashes above state averages for: head-on collisions*, driver inattention*, morning peak hours*, ice/snow*, drivers 16-18 years in age*.
- **Segment D (Urban segment in Howard Lake):** Crashes above state averages for: right angle collisions, head-on collisions*, crashes with pickups, speeding, drivers in their 60s*.
- **Segment G (Rural segment in eastern Montrose):** Crashes above state averages for: number of crashes in 2014*****, pedestrian/bicycle collisions*, rear end collisions, run off road collisions*, head-on collisions*, speeding*, hours between 6:00 am and 11:59 am*, drivers 16-18 years in age*, drivers 40 to 49 year in age*.
- **Segment I (Rural segment west of Delano):** Crashes above state averages for: dark lighting*, right angle collisions, head-on collisions*, driver inattention*, hours between 3:00 pm and 5:59 pm*, crashes occurring on a Friday*, ice/snow*, drivers 21-29 years in age*.
- **Segment K (Rural segment in Independence):** Crashes above state averages for: rear end collisions*, right angle collisions*, head-on collisions*, hours between 6:00-8:59 am*, 9:00-11:59 am*, and 3:00-5:59 pm*, drivers aged 19-20* or 40-59* years in age.
- **Segment M (Rural segment in Orono):** Crashes above state averages for: dark lighting*, rear end collisions, head-on collisions*, speeding, alcohol/chemical use, hours between 9:00 and 11:59 pm, crashes occurring on Thursdays and Fridays*, ice/snow*, drivers 21-29* or 50-59* years in age.
- **Segment N (Rural segment in Orono):** Crashes above state averages for: dark lighting*, rear end collisions, run off road collisions*, head-on collisions*, alcohol/chemical use*, hours between 6:00-8:59 am*, ice/snow*, drivers 19-20* or 30-39* years in age.

Intersection Trends

The following trends were observed for the flagged intersections (*observations that apply to fatal crashes are noted with a star). Please refer to Section D of the document “US 12 Road Safety Audit Briefing Book” to review data sheets for these intersections:

- **Quimby Avenue SW:** Crashes above state averages for: overturn/rollover crashes, rear end collisions, driver inattention, crashes occurring on Fridays, ice/snow, and drivers 16-18 or 21-29 years in age.
- **Sunset Avenue N:** Crashes above state averages for: crashes occurring in 2012, right angle collisions, head-on collisions, speeding, hours between 12:00-2:59 pm, ice/snow.
- **Johnson Avenue N:** Crashes above state averages for: rear end collisions, hours between 12:00-2:59 pm, drivers 21-29 years in age.
- **Jackson Avenue NW:** Crashes above state averages for: crashes occurring in 2010, left turn into traffic collisions, run off road crashes, right angle collisions, hours between 6:00-8:59 am, crashes occurring on Thursdays, ice/snow, drivers 16-18 years in age.
- **CSAH 3/Broadway Avenue N:** Crashes above state averages for: crashes occurring in 2012, dark lighting, left turn into traffic collisions, speeding, alcohol/chemical use, hours between 3:00-5:59pm, ice/snow, drivers 16-18 years in age.
- **CSAH 6 LT/10th Avenue:** Crashes above state averages for: crashes occurring in 2011, left turn into traffic collisions, right angle collisions, hours between 6:00-8:59 am and 3:00-5:59 pm, crashes occurring on Fridays, ice/snow, drivers 16-18 years in age.
- **CSAH 6 RT/7th Avenue:** Crashes above state averages for: right angle collisions, head-on collisions, alcohol/chemical use, hours between 12:00-2:59 pm, crashes occurring on Sundays, drivers 16-20 years in age.
- **CSAH 8 LT/Emerson Avenue SW:** Crashes above state averages for: dark lighting, run off road collisions, right angle collisions, speeding, crashes occurring on Fridays and Saturdays, crashes occurring on a wet surface, drivers 21-29 years in age.
- **S 4th Street/CSAH 62:** Crashes above state averages for: sideswipe collisions, right angle collisions, improper lane use, hours between 12:00-2:59 pm, drivers 40-49 years in age.
- **Clementa Avenue SW/ CR 110:** Crashes above state averages for: dark lighting, overturn/rollover crashes, left turn into traffic collisions, run off road collisions, speeding, alcohol/chemical use, hours between 6:00-8:59 pm, drivers 40-49 years in age.
- **Center Avenue S:** Crashes above state averages for: pedestrian and bicycle crashes, rear end collisions, right turn into traffic collisions, speeding, driver inattention, alcohol/chemical use, hours between 12:00-5:59 pm, drivers 30-39 and 50-59 years in age.

- **TH 25 RT/CSAH 12/Buffalo Avenue S:** Crashes above state averages for: crashes occurring in 2012, rear end collisions, speeding, hours between 6:00-8:59 am, drivers 21-29 years in age.
- **Zephyr Avenue:** Crashes above state averages for: right angle collisions, head-on collisions*, speeding, driver inattention*, hours between 9:00-11:59 am*, crashes occurring on a Thursday, drivers 16-18 years in age*.
- **TH 25 LT:** Crashes above state averages for: dark lighting, rear end collisions, sideswipe collisions, run off road collisions, hours between 6:00-8:59 pm, crashes occurring on Thursdays.
- **CSAH 14:** Crashes above state averages for: dark lighting, left turn into traffic collisions, right angle collisions, hours between 3:00-5:59 pm, ice/snow.
- **Bridge Avenue:** Crashes above state averages for: crashes occurring in 2011, rear end collisions, run off road collisions, speeding, alcohol/chemical use, hours between 9:00-11:59 am, crashes occurring on Wednesdays, drivers 30-39 years in age.
- **County Road 30 SE:** Crashes above state averages for: overturn/rollovers, left turn into traffic collisions, run off road collisions, driver inattention, hours between 9:00-11:59 am, ice/snow, drivers 30-39 years in age.
- **5th Street S:** Crashes above state averages for: dark lighting, rear end collisions, right angle collisions, hours between 6:00-8:59 pm, crashes occurring on Thursdays, drivers 40-49 years in age.
- **Babcock Circle:** Crashes above state averages for: dark lighting, rear end collisions, right-angle collisions, speeding, crashes occurring from 9:00-11:59 am and 3:00-5:59 pm, ice/snow.
- **Tiger Drive:** Crashes above state averages for: crashes occurring in 2013, rear end collisions, sideswipe collisions, collisions with semi-trucks, speeding, hours from 3:00-5:59 pm, ice/snow, drivers 30-39 years in age.
- **CSAH 139/County Line Road SE:** Crashes above state averages for: dark lighting, left turn into traffic collisions, head-on collisions, speeding, hours from 6:00-8:59 am and 6:00-8:59pm, ice/snow.
- **Nelson Road:** Crashes above state averages for: speeding, hours between 6:00-8:59 am, 3:00-5:59 pm, drivers 40-49 years in age.
- **CSAH 92 RT/Mud Lake Road:** Crashes above state averages for: crashes occurring in 2011, rear end collisions, left turn into traffic collisions, right angle collisions, hours between 6:00-8:59 am, crashes occurring on Tuesdays.
- **CSAH 92 LT/Lake Sarah Road:** Crashes above state averages for: crashes occurring in 2011, dark lighting, rear end collisions, right angle collisions, hours between 3:00-5:59 pm, wet surface conditions, drivers 21-29 years in age.
- **Valley Road:** Crashes above state averages for: Overturn/rollovers, rear end collisions, run off road collisions, speeding, hours between 6:00-11:59 am, wet road conditions, ice/snow.

- **CSAH 90:** Crashes above state averages for: crashes occurring in 2011, right angle collisions, collisions with semi trucks, hours from 6:00-11:59 am and 6:00-8:59 pm, drivers 21-29 and 50-59 years in age.
- **CSAH 83/Halgren Road:** Crashes above state averages for: crashes occurring in 2014, dark lighting, right angle collisions, head-on collisions, speeding, driver inattention, drivers 21-29 and 50-59 years in age.
- **Pioneer Avenue:** Crashes above state averages for: crashes occurring in 2011, rear end collisions, run off road collisions, head-on collisions*, speeding, driver inattention*, hours from 3:00-5:59 pm*,
- **Budd Avenue:** Crashes above state averages for: sideswipe collisions, right angle collisions, hours between 3:00-5:59 pm, ice/packed snow.
- **CSAH 19/Main Street E:** Crashes above state averages for: crashes occurring in 2013, dark lighting, right angle collisions, alcohol/chemical impairment, crashes occurring on Mondays, ice/snow, drivers 21-29 years in age.
- **CSAH 29:** Crashes above state averages for: crashes occurring in 2011, rear end collisions, sideswipe crashes, hours from 6:00-8:59 am and 3:00-5:59 pm, crashes occurring on Fridays.

Appendix E. Average Annual Daily Traffic (AADT) Data

Table E- 1: 2010-2013 Average Annual Daily Traffic (AADT) Summary

Start	End	2013[70]	2012[71]	2011[72]	2010[73]	Average (2010-2013)
Meeker/Wright County Line	CSAH 3/ Broadway Avenue N	7800	7400	7700	7700	7650
CSAH 3/ Broadway Avenue N	CSAH 4/1st Street NE	9900	9900	7600	7600	8750
CSAH 4/1st Street NE	CSAH 5 RT	7800	7900	7500	7500	7675
CSAH 5 RT	Commerce Boulevard	8330	7600	7800	7800	7882.5
Commerce Boulevard	CSAH 7/Shoreline Drive	10100	9900	9600	9600	9800
CSAH 7/Shoreline Drive	Gowan Avenue SW	8000	8500	8300	8300	8275
Gowan Avenue SW	Clementa Avenue SW	9700	9600	9600	9600	9625
Clementa Avenue SW	TH 25 RT/CSAH 12/ Buffalo Avenue S	11100	10700	10300	10300	10600
TH 25 RT/CSAH 12/ Buffalo Avenue S	TH 25 LT	11000	12000	12000	12000	11750
TH 25 LT	72nd Street SE	11800	11900	11500	11500	11675
72nd Street SE	S River Street	16700	15800	13900	13900	15075
S River Street	CSAH 139/ County Line Road SE	17800	18000	16900	16900	17400
CSAH 139/ County Line Road SE	CSAH 92 RT/ Mud Lake Road	14400	14600	14000	15450	14612.5
CSAH 92 RT/ Mud Lake Road	CSAH 90	16200	15500	14000	14000	14925
CSAH 90	CSAH 19/Main Street E	16600	16100	13100	13100	14725
CSAH 19/Main Street E	CSAH 29/ Baker Park Rd/ Townline Road	17900	16900	16100	16100	16750
CSAH 29/ Baker Park Road/ Townline Road	CSAH 6	24100	20000	16800	16800	19425
CSAH 6		24100	22900	22400	22400	22950

[70] *2013 Draft Values from MnDOT Traffic Mapping Application*

[71] *2012 Values From MnDOT Traffic Mapping Application*

[72] *From 2011 Trunk Highway Traffic Volumes for Metro Street Series*

[73] *From 2010 Trunk Highway Traffic Volumes for Metro Street Series and Wright County*

Table E- 2: US 12 Past and Projected Traffic Volumes (2011 Planning Tool for Wright County)[74]

Location	Begin Mile Point	End Mile Point	1992	1994	1996	…	2006	2008	2010	2011	2036	11 HC	36 HC	AGR	HC AGR
W OF CR100	112+00.641	117+00.628	5200	5400	5400	…	8600	8200	7700	7700	12000	570	890	2.2%	2.2%
W OF JACKSON AVE	117+00.628	117+00.879		8100	8100	…	11800	11400	10800	10700	15500	900	1300	1.8%	1.8%
E OF BROADWAY ST	117+00.879	118+00.323		6100	6100	…	10400	10000	9700	9600	14500	800	1200	2.0%	2.0%
NW OF CSAH31	118+00.323	121+00.102		5700	6200	…	8200	7800	7500	7400	10000	610	820	1.4%	1.4%
0.8 MI E OF CSAH5	121+00.102	123+00.546		6500	7000	…	8500	8100	7800	7700	9500	630	780	0.9%	1.0%
E OF E JCT CSAH6 (7th AV)	123+00.546	124+00.829		7200	7300	…	10600	10100	9600	9500	14000	790	1150	1.9%	1.8%
E OF CSAH7	124+00.829	126+00.970		6500	7000	…	9000	8700	8300	8200	11000	680	910	1.4%	1.4%
W OF CSAH62 (4TH ST)	126+00.970	131+00.104		6700	7600	…	10900	10100	9600	9500	15000	790	1250	2.3%	2.3%
W OF W JCT TH12 &25	131+00.104	132+00.095	7500	8100	8200	…	11000	10200	10300	10200	14000	600	820	1.5%	1.5%
W OF THE E JCT TH12 &25	132+00.095	134+00.152	7100	8300	8400	…	13000	13400	12000	11900	19500	750	1250	2.6%	2.7%
E OF E JCT TH12 &25	134+00.152	138+00.327	6800	7700	7600	…	12200	12200	11500	11400	19000	700	1150	2.7%	2.6%
SE OF CSAH30	138+00.327	139+00.457		11200	11900	…	15900	15900	13900	13800	20000	870	1250	1.8%	1.7%
E OF 5th ST	139+00.457	140+00.464		11200	11900	…	18500	18500	16900	16800	27000	1850	2950	2.4%	2.4%
351 ATR W OF W JCT CSAH92	140+00.464	142+00.904	10900	12200	12200	…	12900		12800	14000	16000	1600	1850	0.6%	0.6%
SE OF CSAH92 (LAKE SARAH RD)	142+00.904	144+00.968		12900	12900	…	15100		14000	13900	15500	1600	1800	0.5%	0.5%
E OF CSAH90	144+00.968	146+00.062			14300	…	13600		13100	13000	14500	1600	1800	0.5%	0.5%
E OF CSAH83 (HALGREN RD)	146+00.062	147+00.150			15500	…	16300		16100	16000	18000	1700	1900	0.5%	0.5%
SE OF CSAH29 (BAKER PARK RD)	147+00.150	148+00.472			18500	…	16800		16800	16700	19000	1750	2000	0.6%	0.6%
E OF CSAH 6	148+00.472	152+00.905				…			22400	22300	25000	1400	1550	0.5%	0.4%
W OF CSAH 15	152+00.905	153+00.605				…			30000	30000	34000	1700	1950	0.5%	0.6%

[74] *Prepared by MnDOT TDA Office on July 17, 2012. Contains built-in county factors that reduce AADT depending on location. Maximum growth set at 3%/year and minimum set at 0.5%/year. Predicted volumes are only intended for planning level use and are based on an unconstrained model.*

Appendix F. Wavetronics Data

Wavetronics devices were placed at two locations along the corridor (see Figure F- 1 and Figure F- 2). Wavetronics devices are used to collect various data, such as vehicle speeds and traffic counts. Data is collected for each lane of traffic.

Figure F- 1: Wavetronics Location #1 (West of the Super 2)

Figure F- 2: Wavetronics Location #2 (West of 6th Ave N in Howard Lake)

The devices recorded data from May 18, 2015 to May 21, 2015. Data from Wednesday, May 20th was chosen to represent data for a typical week day. This representative date was chosen because it was in the middle of the week, and in the middle of the data collection period.

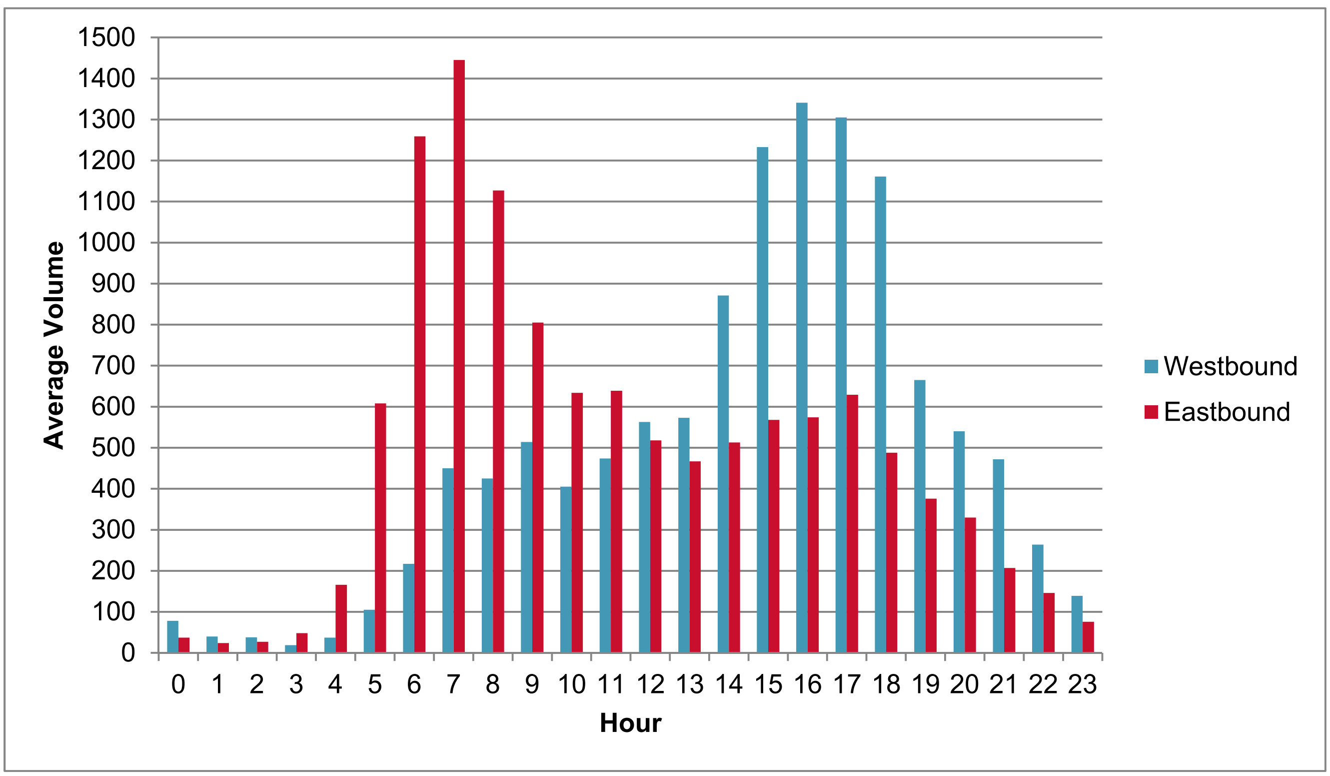
Around the Super 2, vehicles travel at average daily speeds around 57-59mph (see Table F- 1). Maximum speeds occur early in the morning (i.e. before 6:00 AM). From 4:00-6:00 PM, westbound traffic slowed down to speeds around 20-30 mph. Comparing this to hourly volume data shown in Figure F- 3, reduced speeds correlate with PM peak-hour traffic volumes.

Table F- 1: Speed Data (Wednesday, May 20, 2015 at Super 2 Location)

	Eastbound	Westbound
Average Daily Speed	59 mph	57 mph
Maximum Recorded Average Hourly Speed	62 mph (2:00 AM to 2:59 AM)	62 mph (5:00 AM to 5:59 AM)
Minimum Recorded Average Hourly Speed	56 mph (11:00 PM to 11:59 PM)	25 mph (5:00 PM to 5:59 PM)

Data Source: Raw Data Collected from Smart Street Rental

Figure F- 3: Volume vs. Hour (Wednesday, May 20, 2015 at Super 2 Location)



Data Source: Raw Data Collected from Smart Street Rental

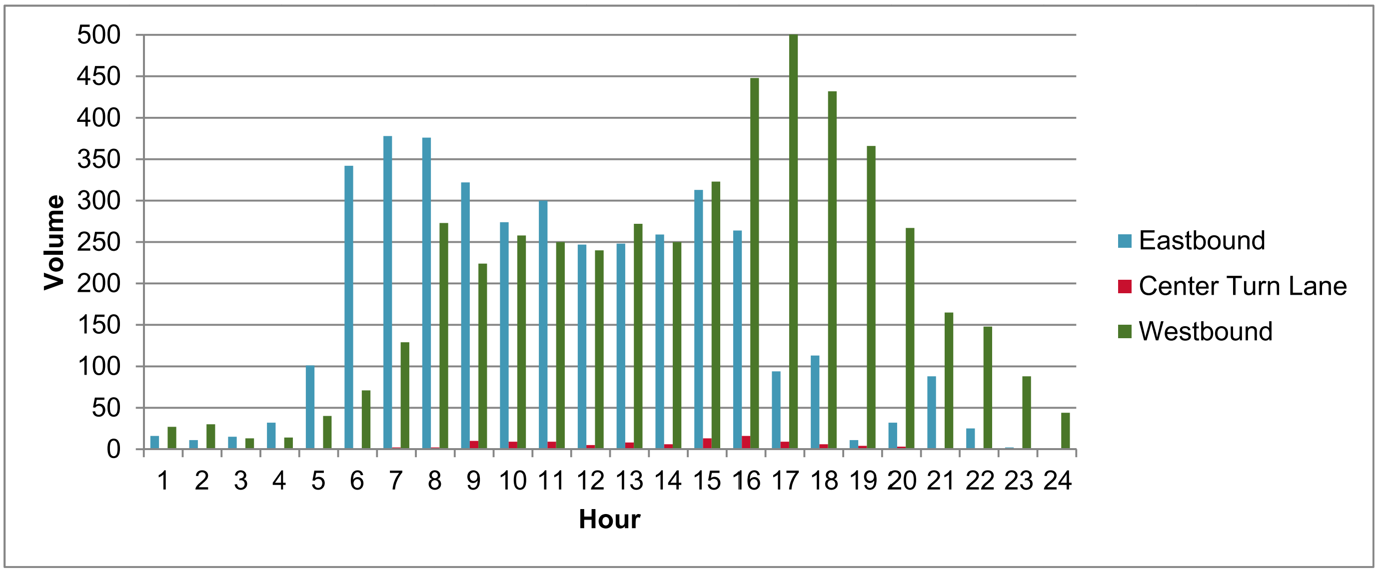
The wavetronics device in Howard Lake showed the speed trends shown in Table F- 2 and volume trends shown in Figure F- 4.

Table F- 2: Speed Data (Wednesday, May 20, 2015 at Howard Lake Location)

	Eastbound	Center Turn Lane	Westbound
Average Daily Speed	31 mph	17 mph	30 mph
Maximum Recorded Average Hourly Speed	34 mph (1:00 AM to 1:59 AM)	30 mph (10:00 PM to 11:59 PM)	32 mph (1:00 AM to 2:59 AM)
Minimum Recorded Average Hourly Speed	26 mph (7:00 PM to 7:59 PM)	10 mph (12:00 AM to 5:59 AM)	28 mph (10:00 AM to 10:59 AM))

Data Source: Raw Data Collected from Smart Street Rental

Figure F- 4: Volume vs. Hour (Wednesday, May 20, 2015 at Howard Lake Location)



Data Source: Raw Data Collected from Smart Street Rental

Appendix G. Ice Sensor Warning System

Ice Sensor Warning System

Background

State Trunk Highway 12 in MnDOT District 8 near Dassel Cokato High School has a history of snow and sleet blowing across the road and creating slippery conditions in a relatively short section when the rest of the highway is clear and dry. Not only does this condition violate driver's expectations increasing risks of crashes and injuries, it also prevents MnDOT from obtaining their goal of clear roadways during the winter months.

This project will provide a design for a dynamic warning to drivers when the pavement becomes icy. District 8 Maintenance will also be informed when these conditions exist so that they may respond to the condition.

Road is to the left. Snow continues to blow over snow fence and onto roadway.

Project Goals

The goal of the project is to provide notification to MnDOT Maintenance forces which will allow appropriate corrective action when these conditions exist.

This project will investigate the use of Commercial off the Shelf traffic components that do not require custom software, are not experimental, are designed for the roadside environment, and are cost effective to provide the detection, processing, communications and display so that all drivers and MnDOT maintenance personnel are aware of slippery conditions that exist on this section of roadway. The warnings will be provided using standard flashing beacons in association with a diamond shaped warning sign displaying the message ICE ON ROAD.

For More Information

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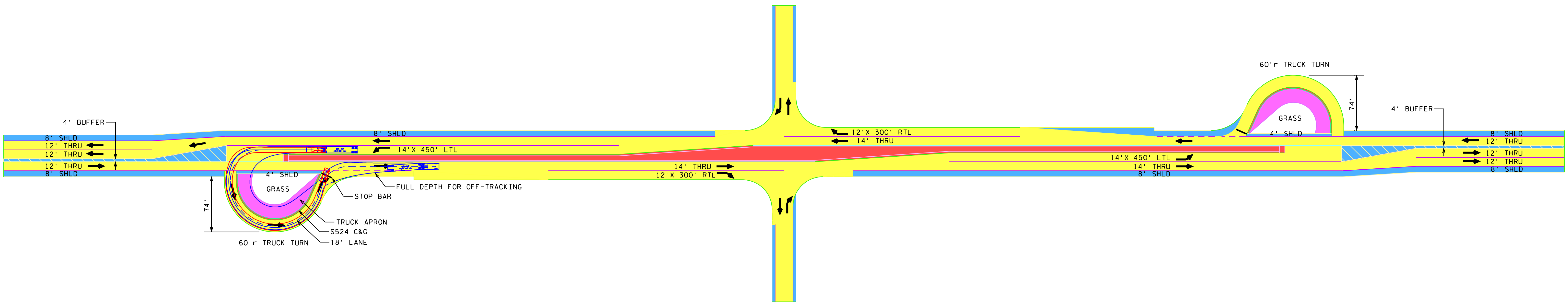
Appendix H. 2+1 Hybrid Reduced Conflict Intersection (RCI)

Figure H-1: Hybrid Reduced Conflict Intersection (RCI)



**This concept was initially designed by the Road Safety Audit Team members and was drawn by Jamal Love, who is a geometrics engineer for the MnDOT Central Office.