Intersection Safety Analysis Update

Final Report

Prepared for

MINNESOTA DEPARTMENT OF TRANSPORTATION

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This report represents the results of research conducted by the authors and does not necessarily represent the views or policies of the Minnesota Department of Transportation. This report does not contain a standard or specified technique.

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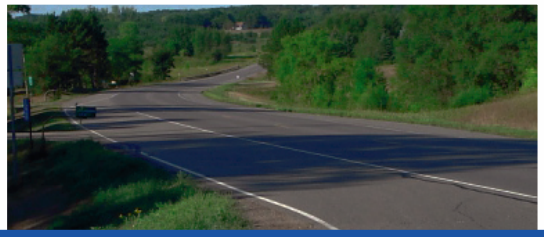


Executive Summary

Executive Summary

Mn/DOT's Strategic Highway Safety Plan (SHSP) identified addressing intersection related crashes as one of the State's Safety Emphasis Areas based on the fact that these crashes account for 33% of statewide fatal crashes. The data driven strategic planning process also documented that 66% of these fatal intersection crashes occurred in Greater Minnesota and that these crashes were approximately equally divided between the State and local highway systems. This over representation of fatal intersection crashes in rural areas combined with very low crash densities – rural intersections average around 1 crash per year and 0.008 fatal crashes per year – began to frame a significant safety planning challenge. How can the most at-risk intersections (for severe crashes) be identified as candidates for safety investment?

Mn/DOT's traditional approach to identifying at-risk intersections focused on finding "Black Spots" – locations with statistically higher than expected numbers of crashes. Mn/DOT would then reactively invest at these high crash locations along the State's system of highways, most of which were signalized intersections along urban/suburban arterials. However, the SHSP acknowledged that this entirely reactive approach had not been successful at reducing fatal crashes because the methodology directed safety investments to locations with relatively low numbers of fatal crashes. The SHSP also concluded that the "Black Spot" method could not be successful at identifying at-risk intersections in rural areas because of the low crash densities. In addition, the SHSP suggested that in order to be successful at achieving interim goals to reduce the number of traffic fatalities and in the long term to move Minnesota Towards Zero Deaths, the State would need to transition to a more proactive approach to identifying and improving at-risk intersections.

This research project was initiated to address three fundamental questions relative to intersection safety:

1. Can factors other than crashes be identified that contribute to the risk of collisions at rural, STOP controlled intersections?
2. Can a methodology be developed to screen systems of rural intersections on both the State and county highway systems to support the effort to identify candidates for the proactive deployment of low-cost safety strategies?
3. Can criteria be developed that would allow a new methodology to be evaluated?

The results of this research suggest that the answer to each of the questions is YES. A review of all of the rural, STOP controlled intersections along the State's expressway and 2-lane highway system and along the county highway system found a number of geometric and traffic volume features that were common among many of the subset of intersections where crashes occurred. The most common features at the intersections with crashes include; skewed minor leg approaches, located in/near horizontal curves and an ADT ratio (minor road ADT/major road ADT) in a fairly narrow band for each category of roadway. A subsequent review of the safety literature identified three other features that appear to be associated with increased risk of intersection crashes – the presence of development at the

intersections, having a railroad crossing on a minor leg approach and (greater) distance from the previous STOP sign on the minor leg approach.

Using the premise that characteristics of the existing highway system (the features of the intersections where crashes did occur) can be used to predict where future crashes are likely to occur resulted in the development of a predictive methodology and a check list type of approach. The methodology was tested by applying it to more than 1,700 rural, STOP controlled intersections along expressways and 2-lane highways around Minnesota and the resulting priority lists identified the top ranked candidates for the proactive deployment of low cost safety improvements. To date, several county engineers have used the priority lists to support development of intersection safety projects and in the State's Highway Safety Improvement Program (HSIP) solicitation process.

The detailed crash analysis conducted in support of this research identified several key crash and roadway environment factors that appear to be contributing to the crashes and points towards a short list of high priority safety strategies. First and foremost, right angle crashes are the type of crash that are over represented at rural, STOP controlled intersections on both the State and county systems. These angle crashes are also the most severe and the fraction of angle crashes approaches 100% at the intersections with multiple severe crashes and at the intersections above the Critical Crash Rate – when these intersections go bad (from a crash/safety perspective) it is almost always because of angle crashes (as opposed to turning crashes, rear end crashes, etc.). The detailed crash analysis also confirmed that the majority of the angle crashes involved a vehicle on the minor road that stopped and then pulled out into the major road (a gap recognition crash), as opposed to the minor road vehicle running the STOP sign. This suggests that at rural intersections, both the reactive and proactive components of the safety program need to focus on safety strategies that effectively address gap recognition type angle crashes. The possible list of safety strategies is also influenced by Benefit/Cost requirements of Minnesota's HSIP – projects on the reactive side may be more costly (even though they need to have a B/C > 1) because the crash costs at these locations are generally high and projects on the proactive side likely need to be relatively low cost because to be effective the strategies need to be widely deployed at a number of locations across a system.

A search of the safety literature found more than fifty potential safety strategies that could be applied to expressway and 2-lane highway intersections. However, a number of these strategies are intended to mitigate turning and rear end crashes and several more are clearly intended for urban locations. The remaining strategies that focus on mitigating angle crashes include improving geometry, traffic control devices, street lights, the use of new technologies and in the case of expressways partial and full grade separations. An overview of a sample of both reactive and proactive intersection safety strategies is illustrated in Figure ES.1

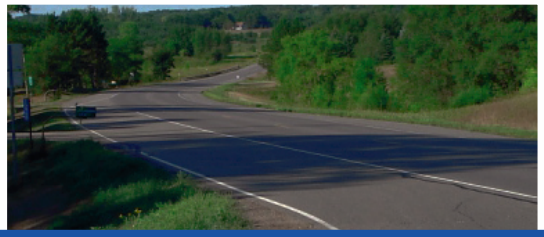
The results of the detailed crash analysis identified a final key point relative to the safety planning process. Consistent with Minnesota's SHSP, there is a need to focus safety planning efforts and safety investment on rural, STOP controlled intersections. These intersections are where the majority of serious intersection related crashes occur – approximately 200 fatal intersection crashes occur each year in Minnesota, 130 of these occur in rural areas, these crashes are scattered across thousands of intersections and no intersection in the data set assembled for this project averaged one fatal crash per year. The

randomness of the fatal crashes clearly supports the notion that selecting intersections for safety improvement by chasing fatal crashes around the system is not an effective strategy.

The final issue to be addressed involves evaluating the effectiveness of the new predictive methodology relative to producing a list of candidate intersections for the proactive deployment of safety strategies. The ultimate performance measure is the reduction of severe crashes, but the crash reduction would need to be measured across the system instead of at individual intersections. As a result, the process of evaluation requires finding agencies to use the new predictive tool to identify candidate intersections, tracking their efforts to develop proactive projects and secure funding to support implementation and then documenting the crash reduction across the system in the years following deployment.

Reactive Component	**Low**	**Medium**	**High**
Enhanced signs and markings on the minor legs (**Figure 4.4**)	$		
Freeway style guide signing (**Figure 4.5**)	$		
Street lighting (**Figure 4.6**)	$		
Close median openings (**Figure 4.7**)	$		
Install splitter islands on minor legs (**Figure 4.8**)	$		
Dynamic mainline warning sign (**Figure 4.9**)	$		
Automated real time system – gap assistant (**Figure 4.10**)		$$	
Indirect left turns (**Figure 4.11**)		$$	
Realign minor legs to eliminate skew (**Figure 4.12**)			$$$
Change vertical/horizontal alignment of major legs			$$$
Partial "T" interchange (**Figure 4.13**)			$$$
One quadrant interchange			$$$
Full Interchange (**Figure 4.14**)			$$$
Proactive Component	**Low**	**Medium**	**High**
Enhanced signs and markings on the minor legs (**Figure 4.4**)	$		
Freeway style guide signing (**Figure 4.5**)	$		
Street lighting (**Figure 4.6**)	$		
Close median openings (**Figure 4.7**)	$		
Install splitter islands on minor legs (**Figure 4.8**)	$		
Dynamic mainline warning sign (**Figure 4.9**)	$		

Figure ES.1 Expressway Intersection Safety Strategy Continuum



Introduction — Problem Definition

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Mn/DOT's Strategic Highway Safety Plan (SHSP) identified addressing intersection related crashes as one of the State's Safety Emphasis Areas based on the fact that these crashes account for 33% of State wide fatal crashes (**Figure 1.1**). The data driven strategic planning process also documented that 66% of these fatal intersection crashes occurred in Greater Minnesota and these crashes were approximately equally divided between the State and local highway systems (**Figure 1.2**). This over representation of fatal intersection crashes in rural areas combined with very low crash densities – rural intersections average around 1 crash per year and 0.008 fatal crashes per year – began to frame a significant safety planning challenge. How will the most at-risk intersections be identified as candidates for safety investment?

Statewide Fatalities (2001-2005)			
Total Vehicle Occupant Fatalities			2,429
Total Nonvehicle Occupant Fatalities (i.e., Pedestrian, Bicyclist)			579
Total Fatalities			3,008
Driver Behavior Based Emphasis Areas	**Number**	**Percentage***	**Rank**
Unbelted (Based on Veh. Occ. Fatalities)	1,271	(52%)	1
Alcohol-Related	1,068	(36%)	2
Speeding-Related	850	(28%)	5
Involved Drivers Under 21	718	(24%)	6
Infrastructure-Based Emphasis Areas	**Number**	**Percentage***	**Rank**
Intersection	1,004	(33%)	3
Single Vehicle Run Off Road	965	(32%)	4
Head-On and Sideswipe	611	(20%)	7

Figure 1.1 Statewide Fatalities (2001-2005)
Source: Minnesota Strategic Highway Safety Plan

		Driver Behavior Based Emphasis Areas				Infrastructure Based Emphasis Areas		
	Total Fatalities	Unbelted	Alcohol-Related	Speeding-Related	Young Driver Involved	Single Vehicle Run Off Road	Intersection	Head-on and Sideswipe
Statewide								
	3,008	1,271 (52%)	1,068 (36%)	850 (28%)	718 (24%)	965 (32%)	1,004 (33%)	611 (20%)
Greater Minnesota Districts (2001-2005 Fatalities)								
State Trunk Highway	1,089 (53%)	476 (49%)	284 (26%)	262 (24%)	224 (21%)	282 (26%)	360 (33%)	295 (27%)
Local Roads	974 (47%)	492 (63%)	460 (47%)	284 (29%)	263 (27%)	459 (47%)	298 (31%)	129 (13%)
Greater Minnesota Districts Total	2,063	968 (55%)	744 (36%)	546 (26%)	487 (24%)	741 (36%)	658 (32%)	424 (21%)
Metro District (2001-2005 Fatalities)								
State Trunk Highway	465 (49%)	162 (45%)	167 (36%)	145 (31%)	103 (22%)	108 (23%)	126 (27%)	112 (24%)
Local Roads	480 (51%)	141 (45%)	157 (33%)	159 (33%)	128 (27%)	116 (24%)	221 (46%)	76 (16%)
Metro District Total	945	303 (45%)	324 (34%)	304 (32%)	231 (24%)	224 (24%)	347 (37%)	188 (20%)

Figure 1.2 State Trunk Highway and Local Road Distribution
Source: Minnesota Strategic Highway Safety Plan

Mn/DOT's traditional approach to identifying at-risk intersections focused on finding "Black Spots" – locations with statistically higher than expected numbers of crashes.

Mn/DOT would then reactively invest at these high crash locations along the State's system of highways, most of which were signalized intersections along urban/suburban arterials. However, the SHSP acknowledged that this entirely reactive approach had not been successful at reducing fatal crashes because the methodology directed safety investments to locations with relatively low numbers of fatal crashes. The SHSP also concluded that the "Black Spot" method could not be successful at identifying at-risk intersections in rural areas because of the low crash densities. In addition, the SHSP suggested that in order to be successful at achieving interim goals to reduce the number of traffic fatalities and in the long term to move Minnesota Towards Zero Deaths, the State would need to transition to a more proactive approach to identifying and improving at-risk intersections.

A key challenge associated with the transition to a more proactive safety program was identified early on. Moving from an established process that primarily relied on the number of crashes to identify candidates for safety improvements to a new process that uses some number of surrogates requires research in order to answer three key questions:

- Can factors other than crashes be identified that contribute to the risk of collisions at intersections?
- Can a methodology be developed to screen systems of rural intersections on both the state and local highway systems in an effort to find candidates for improvement?
- Can criteria be developed that would allow any new methodology to be evaluated – for example, is required data readily available, is the methodology easy to use, do the identified high priority intersections make sense and ultimately did the number of intersection related fatal intersection crashes go down?

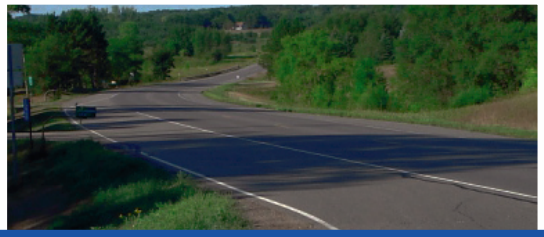
This research project was initiated to provide answers to these questions and ultimately to provide assistance to state and local highway agencies relative to improving the process for evaluating and prioritizing rural intersections based on identifying characteristics that appear to increase risk beyond the traditional crash frequency. The basic approach to this research is founded on the premise that the existing rural road system and its associated environment serve as a powerful tool to predict where future crashes are likely to occur. As a result, this research focused on identifying the characteristics of rural intersections where crashes have occurred and then developing a model methodology to analyze systems of intersections that is based on identifying locations with characteristics similar to those intersections where crashes occurred in the past. This approach results in a process that acknowledges the characteristics of intersections where crashes occurred and then allows an agency to proactively take actions to mitigate the conditions in advance of crashes occurring. Simply put, the goal of this research is to expand the array of available evaluation techniques to provide a foundation for proactively deploying cost-effective strategies at locations with characteristics that indicate they are at-risk but where the actual number of crashes is low.

A quick review of Minnesota's crash records found that approximately 70% of fatal intersection related crashes occurred at rural locations where the minor road traffic was controlled by a STOP sign. As a result, this research only looked at rural, through/STOP

controlled intersections along the State's system of expressways and 2-lane conventional highways and at similar intersections along the county highway system.

The remainder of this report includes sections documenting:

- the initial detailed crash analysis of rural intersections along both the State and local highway systems,
- documentation of a methodology to evaluate and prioritize systems of intersections,
- project development with safety strategies directed towards reactive and proactive implementation, and
- key conclusions including possible policy implications.



Detailed Intersection Crash Analysis

Detailed Intersection Crash Analysis

The initial step in the analytical process involved disaggregating the roughly 80,000 crashes that occur annually in Minnesota to first focus in on only those crashes that are intersection related, to assemble the subset of crashes that resulted in severe crashes (either a fatality or a A-type injury crash) and then to isolate the crashes by facility type – rural expressway, rural conventional 2-lane state highway and county highway. It should be noted that the approach to only consider severe crashes was selected based on Federal Highway and Mn/DOT selecting fatal crashes as the new safety performance measure and Mn/DOT's practice of adding A-type injury crashes to their safety planning efforts because of concerns about statistical reliability of a data set that only considered the very small number of intersection related fatal crashes that occur in Minnesota annually (approximately 200 – 0.25% of all crashes).

The detailed crash analysis used the MnCMAT crash analysis tool and began with a data set that consisted of five years and 429,745 total statewide crashes. In order to address reliability issues, two methods were used to generate the data set of intersection related crashes – the first method sorted the crashes by intersection relationship, intersection control and then crash severity and the second method sorted by crash severity, intersection relationship and then intersection control. Both methods resulted in an identical data set of 9,772 total intersection related crashes at STOP controlled rural intersections along the specified facility types and 866 severe injury crashes (**Figure 2.1**).

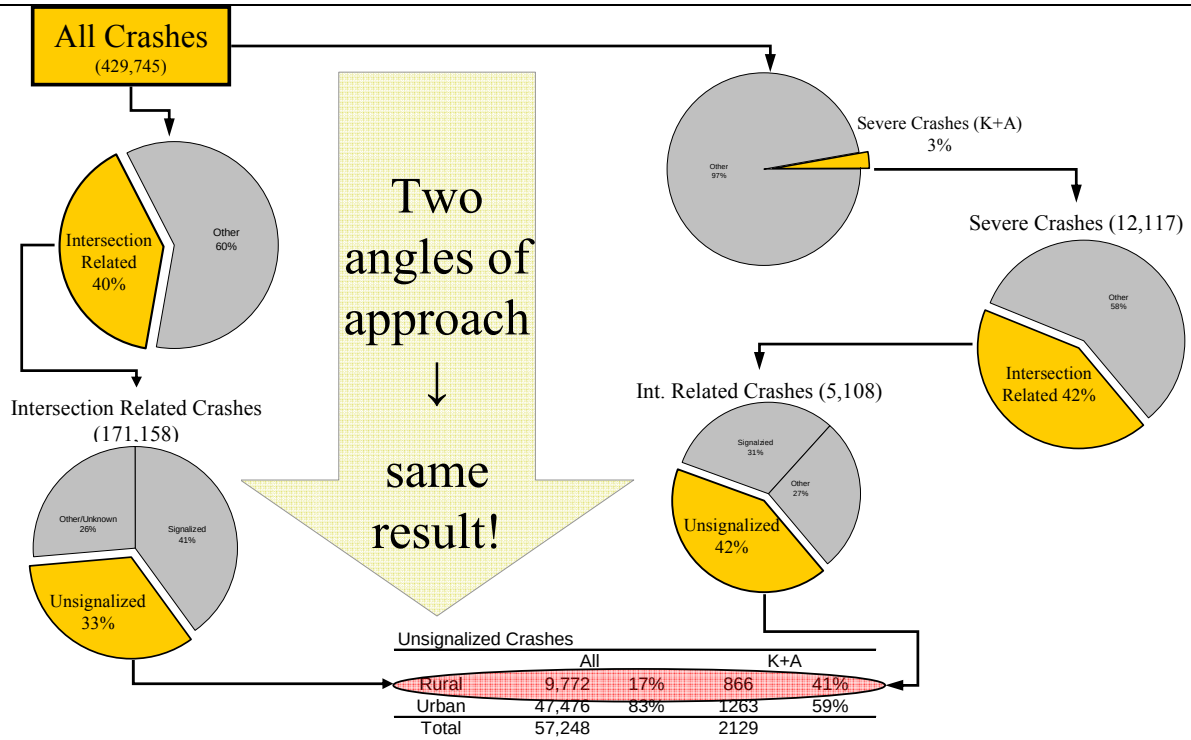


Figure 2.1 Disaggregation of Statewide Crashes
Source: MnCMAT Crash Data, 2002-2006

The initial analysis of the data set of all intersection related crashes revealed the first significant facts **(Figure 2.2**):

- Right angle crashes are the primary crash type at rural STOP controlled intersections – accounting for 50% of all intersection related crashes (this is approximately twice the average frequency for all STOP controlled intersections).
- Right angle crashes at rural intersections are more severe (4% fatal crashes) than the statewide average for other types of crashes at all STOP controlled intersections (1.2% fatal crashes).
- On average, the angle crashes at rural STOP controlled intersections appear to be unrelated to either low light or winter weather conditions.

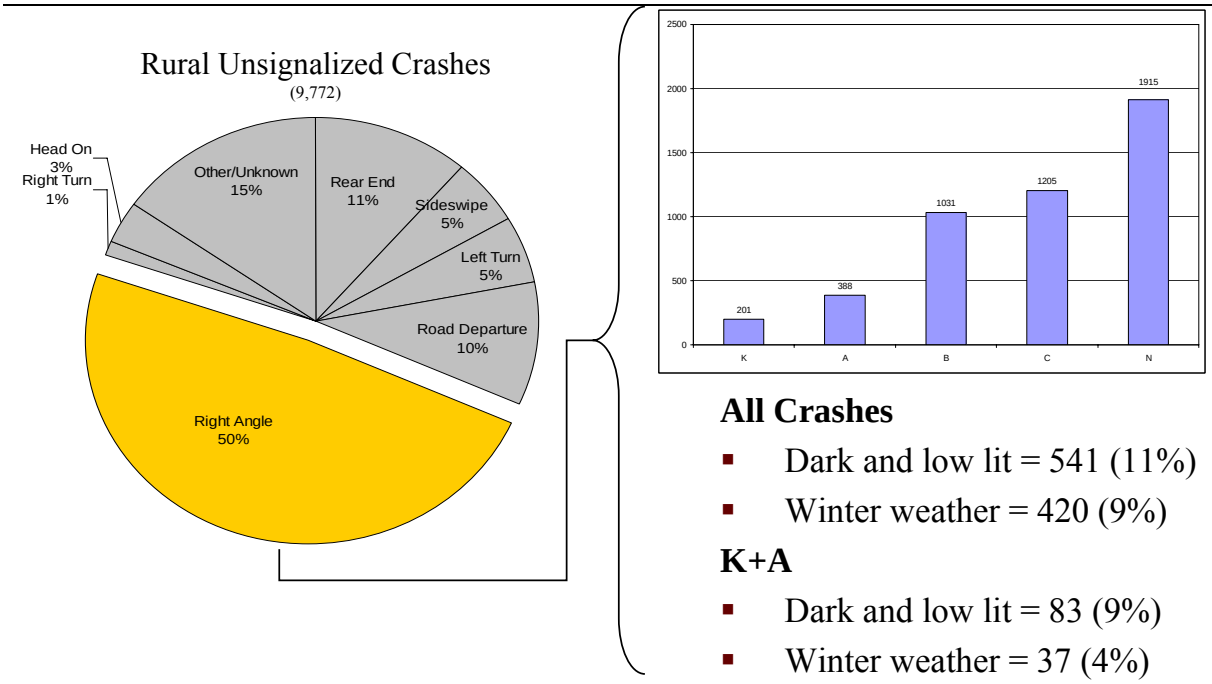


Figure 2.2 Rural STOP Controlled Intersection Crashes
Source: MnCMAT Crash Data, 2002-2006

The over representation of angle crashes suggests that the highest priority safety improvements would be those that have proven to be effective at addressing the factors that contribute to the this particular type of crash, with features aimed at assisting drivers improve both intersection recognition and gap selection. In addition, the high level of severity associated with angle crashes at rural intersections reinforces the importance of finding a way to direct safety investment towards these types of intersections.

The initial crash analysis also documented driver related factors including; age, gender and physical condition. The distribution by age of the driver (**Figure 2.3**) indicates that young drivers (under 21) and older drivers (65 and older) are over represented in intersection

related right angle crashes based on a comparison to State wide averages for all crashes. The data for the distribution by gender and for physical condition of the driver did not reveal any significant differences from the overall State wide averages.

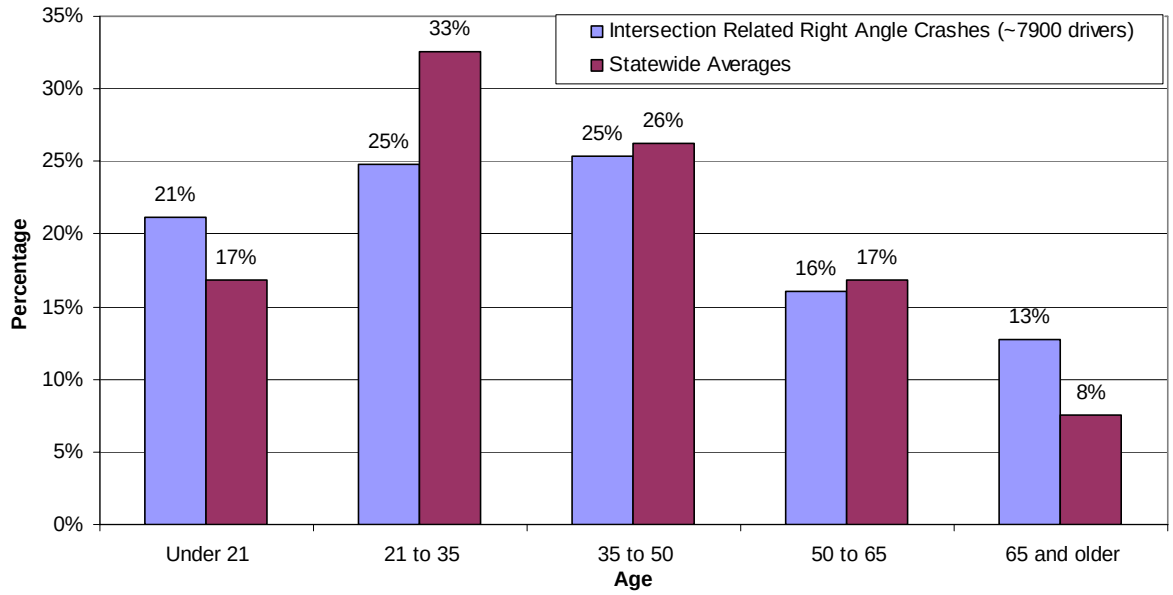


Figure 2.3 Age Distribution of Rural STOP Controlled Intersection Crashes
Source: Mn/DOT Intersection Crash Data, 2002-2007

The next step in the analytical process involved documenting crash characteristics for each of the particular facility types and identifying the key geometric, traffic control and traffic volume characteristics at the subset of intersections where crashes occurred along Expressways, 2-Lane State Highways and 2-Lane County Highways. The initial analysis using the MnCMAT tool identified the type of intersection characteristics (**Figure 2.4**) that could be readily determined from the data contained in the original police crash reports. In addition to crash characteristics, the MnCMAT data includes basic information about the intersection configuration, lighting conditions, road surface characteristics, driver characteristics and vehicle types. It was also determined that this information could be supplemented using existing sources such as; aerial photography and agency files with daily traffic volumes.

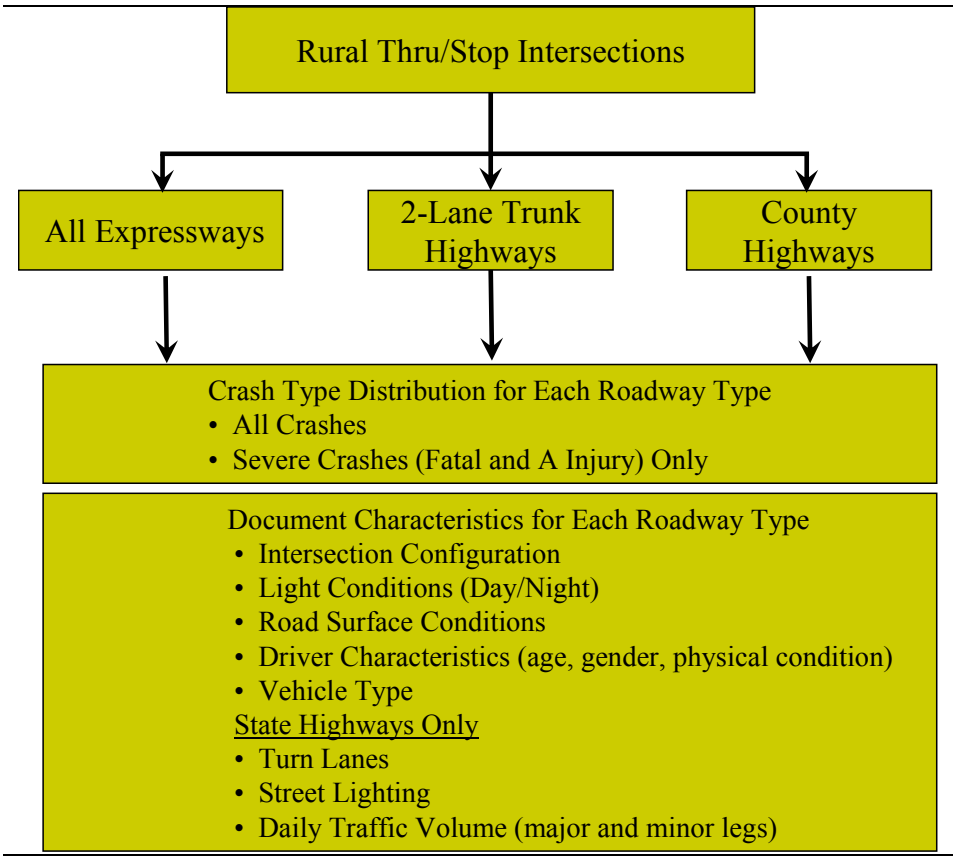


Figure 2.5 Data Gathering Overview

Expressway Intersections

Minnesota has approximately 820 miles of rural expressways, all of which are under Mn/DOT's jurisdiction. These facilities are all four-lane divided roadways with some level of restricted access and occasional grade separations, usually at interchanges with other major state highways. All of these expressways have a 65 MPH speed limit (a statutory limit established by state law) and most have a depressed grass median with grass ditches on the outside of the travel lanes (**Figure 2.5**). It should be noted that the rural designation is based on a determination made by Mn/DOT staff in the respective District Offices and no effort was made to either understand why they made a particular determination or to change any designation. Most expressway segments in Minnesota are easy to designate as rural based on a consistent combination of location, design features, traffic volumes, and speed limit. However, there are a number of miles of rural expressways in metropolitan areas and it appears that the default value is the median and type of drainage system – if the median is grass and if the drainage is in ditches, the segment is considered rural irrespective of volume. As a result, volumes on the rural expressways range from approximately 4,000 vehicles per day (on TH 2 in the northwestern part of the state) to 30,000 vehicles per day (on several segments – TH's 10, 36, 65, 169, etc. – in the Minneapolis/St. Paul Metropolitan Area).

Figure 2.5 US 10 and CSAH 26 in Wadena County

The rural expressways had a total of 494 STOP controlled intersections, of which 227 (46%) experienced at least one crash during the six year study period (following the initial analysis, MnCMAT was updated with an additional year of crash data – all subsequent analysis used the six year data set) . The next step involved a further screening of the expressway intersections in order to identify a short list of priority locations. The effort to identify geometric and traffic volume characteristics would then be limited to this short list of priority intersections. This further screening involved the application of two additional filters - the first filter identified intersections with at least two severe right angle crashes and the second filter identified intersections above the Critical Crash Rate (having a crash rate statistically significantly higher than the statewide average for similar locations). This filtering resulted in the identification of twenty Priority Intersections (with at least two severe right angle crashes) and seven Critical Intersections (with crash rates above the Critical Rate). It should be noted that the seven Critical intersections are a subset of the twenty Priority intersections. These twenty intersections (**Figure 2. 6**) are located all around Minnesota; all Mn/DOT Districts have at least one intersection in the data set, except District 4. The Priority intersections include several locations that have previously been the subject of safety investigations; US 52 at Goodhue CSAH 9 was selected for the deployment of the University of Minnesota's Intersection Decision Support (IDS) technology, a Road Safety Audit was conducted at US 53 and St. Louis CSAH 52 and US 169 at Mille Lacs

CSAH 11 (which has the highest crash and severity rate of any expressway intersection in Minnesota) was considered as a candidate for safety investment.

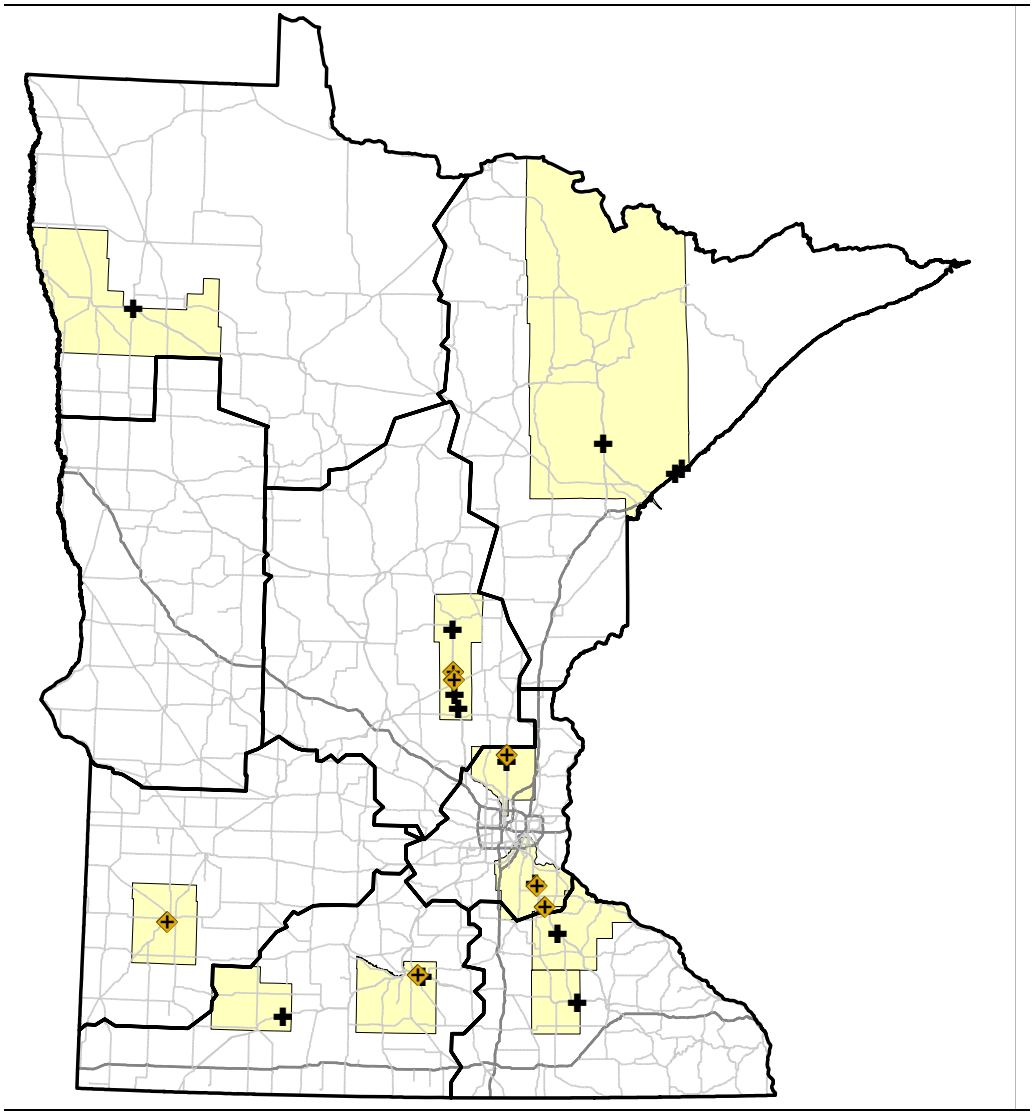


Figure 2.6 Priority and Critical Expressway Intersection Locations

The key results of the detailed crash analysis of STOP controlled rural expressway intersections include:

- Crash Frequency (**Figure 2.7**)
  - The Priority intersections averaged 3 crashes per year, which is three times higher than the State wide average for similar intersections.
  - The average crash rate at the Priority intersections was 0.5 crashes per million entering vehicles, which is 67% higher than the State wide average for similar intersections (0.3). The average crash rate at the Critical intersections was 0.7 and at the individual intersections this rate

is statistically significantly higher (95% confidence level) than the average for similar intersections.

	Priority	Critical
Number of intersections	20	7
Districts	1, 2, 3, M, 6, 7, 8	3, M, 7, 8
Crashes per year	2.9	4.5
Average crash rate (Statewide Avg. 0.3)	0.5	0.7
Severe crashes per year	0.4	0.6
Average Severity Rate	1.5	2.1
Average Entering ADT	16,311	17,799

Figure 2.7 Expressway Intersection Crash Frequency
Source: Mn/DOT Intersection Crash Data, 2002-2007

- Crash Severity (**Figure 2.8**)
  - 70% of the Priority intersections had at least one fatal crash and 85% had at least one A-Injury crash.
  - The Priority and Critical intersections had a higher crash severity (13% K+A) than the other similar intersections in the data set (6% K+A).
  - The average severity rate at the Priority intersections was 1.5, which is three times higher than the State wide average (0.5).
  - Using the presence of one severe angle crash or the Critical Crash Rate appears to be a reliable technique for finding the small subset of intersections with the most severe crashes.

Intersection Number	Intersection	District	County	Intersecting Angle	Major Road Turn Lanes	Street Lights	Total Crashes	Crashes by Year						Entering ADT
								2002	2003	2004	2005	2006	2007	
E1	US 2 & TH 32	2	Polk	Skewed	Right and Left	No	3	0	1	1	0	0	1	4,275
E2	US 14 & CSAH 17	7	Blue Earth	Minimal Skew	Right and Left	Yes	16	1	4	3	4	1	3	16,225
E3	US 14 & CSAH 15	6	Dodge	Skewed	Right and Left	No	15	1	2	4	3	2	3	19,415
E4	TH 23 & CSAH 7	8	Lyon	Minimal Skew	Right and Left	Yes	20	3	3	5	1	3	5	9,800
E5	US 52 & CSAH 9	6	Goodhue	Minimal Skew	Right and Left	No	22	5	1	5	2	5	4	18,150
E6	US 52 & CSAH 86	M	Dakota	Minimal Skew	Right and Left	No	34	6	3	4	3	10	8	20,525
E7	US 52 & CSAH 66	M	Dakota	Skewed	Right and Left	No	30	2	6	8	2	6	6	29,025
E8	US 52 & CSAH 62	M	Dakota	Skewed	Right and Left	No	7	2	0	0	3	1	1	28,440
E9	US 53 & CSAH 52	1	Saint Louis	Minimal Skew	Right and Left	Yes	16	2	2	4	1	2	5	9,680
E10	TH 60 & CSAH 1	7	Cottonwood	Heavy Skew	Right and Left	Yes	9	1	1	4	3	0	0	6,675
E11	TH 61 & CSAH 50	1	Saint Louis	Skewed	Left Only	No	15	4	3	3	2	3	0	10,595
E12	TH 61 & CSAH 42	1	Saint Louis	Skewed	Right and Left	No	10	1	2	3	0	1	3	8,250
E13	US 169 & CSAH 9	3	Mille Lacs	Heavy Skew	Right and Left	No	18	5	3	4	5	0	1	7,965
E14	TH 65 & Klondike Drive	M	Anoka	Perpendicular	Right and Left	No	10	0	1	2	1	2	4	29,898
E15	TH 65 & CSAH 74	M	Anoka	Perpendicular	Right and Left	No	21	1	4	2	5	3	6	27,325
E16	US 169 & CSAH 13	3	Mille Lacs	Skewed	Right and Left	No	21	1	9	7	2	0	2	19,695
E17	US 169 & CSAH 8	3	Mille Lacs	Perpendicular	Right and Left	No	8	1	0	2	3	1	1	19,040
E18	US 169 & CSAH 11	3	Mille Lacs	Minimal Skew	Right and Left	Yes	44	4	13	11	4	4	8	12,750
E19	US 169 & CSAH 22	3	Mille Lacs	Perpendicular	Right and Left	No	5	1	2	0	1	1	0	11,300
E20	US 14 & CR 86	7	Blue Earth	Perpendicular	Right and Left	Yes	22	3	5	4	3	1	6	17,200

Intersection Number	Intersection	Total Crashes	Crash Rate	Expected Crash Rate	Critical Crash Rate	Fatal	Injury A	Severity Rate	Expected Severity Rate	Rear End	Sideswipe Passing	Left Turn	Runoff Road	Right Angle	Head On	Sideswipe Opposing	Other
E1	US 2 & TH 32	3	0.3	0.4	0.8	1	0	1.9	0.7	0	0	0	0	3	0	0	0
E2	US 14 & CSAH 17	16	0.5	0.4	0.6	1	0	1.3	0.6	2	2	2	1	5	1	0	3
E3	US 14 & CSAH 15	15	0.4	0.4	0.6	2	2	1.2	0.7	2	2	0	0	11	0	0	0
E4	TH 23 & CSAH 7	20	0.9	0.4	0.6	1	2	3.6	0.7	0	0	2	0	16	0	0	2
E5	US 52 & CSAH 9	22	0.6	0.4	0.6	2	2	2.0	0.7	1	1	0	0	19	0	0	1
E6	US 52 & CSAH 86	34	0.8	0.2	0.3	0	1	2.4	0.4	1	0	7	1	23	0	0	2
E7	US 52 & CSAH 66	30	0.8	0.2	0.3	1	1	1.4	0.4	1	2	0	0	23	2	0	2
E8	US 52 & CSAH 62	7	0.1	0.2	0.3	1	1	0.4	0.4	0	1	0	0	4	0	0	2
E9	US 53 & CSAH 52	16	0.8	0.5	0.8	1	1	2.5	0.8	0	1	1	1	11	1	0	1
E10	TH 60 & CSAH 1	9	0.6	0.4	0.7	0	1	2.1	0.6	0	0	0	0	8	1	0	0
E11	TH 61 & CSAH 50	15	0.6	0.5	0.8	0	2	1.9	0.8	0	0	0	0	12	0	0	3
E12	TH 61 & CSAH 42	10	0.6	0.5	0.8	0	1	1.3	0.8	0	0	0	1	9	0	0	0
E13	US 169 & CSAH 9	18	1.0	0.4	0.7	1	1	2.8	0.7	1	0	0	2	13	0	0	2
E14	TH 65 & Klondike Drive	10	0.2	0.2	0.3	1	2	0.5	0.4	2	0	1	0	2	2	0	3
E15	TH 65 & CSAH 74	21	0.4	0.2	0.3	1	4	1.2	0.4	1	0	2	2	11	0	0	5
E16	US 169 & CSAH 13	21	0.5	0.4	0.6	0	2	1.5	0.7	1	0	0	1	16	0	0	3
E17	US 169 & CSAH 8	8	0.2	0.4	0.6	0	1	0.4	0.7	0	2	0	1	5	0	0	0
E18	US 169 & CSAH 11	44	1.6	0.4	0.6	1	7	4.7	0.7	1	1	1	5	34	0	0	2
E19	US 169 & CSAH 22	5	0.2	0.4	0.6	1	0	0.8	0.7	0	0	0	0	4	0	0	1
E20	US 14 & CR 86	22	0.6	0.4	0.6	1	2	1.6	0.6	5	0	0	1	13	0	0	3

Figure 2.8 Expressway Intersection Crash Totals

Source: Mn/DOT Intersection Crash Data, 2002-2007

- Crash Type (**Figure 2.9**)
  - Right angle crashes are over represented at the Priority and Critical Intersections.
  - Right angle crashes account for 46% of all expressway intersection crashes, while 71% and 72% of crashes were right angle at the Priority and Critical intersections.
  - Right angle crashes account for even a greater fraction of the severe crashes, 91% and 92% at the Priority and Critical intersections.

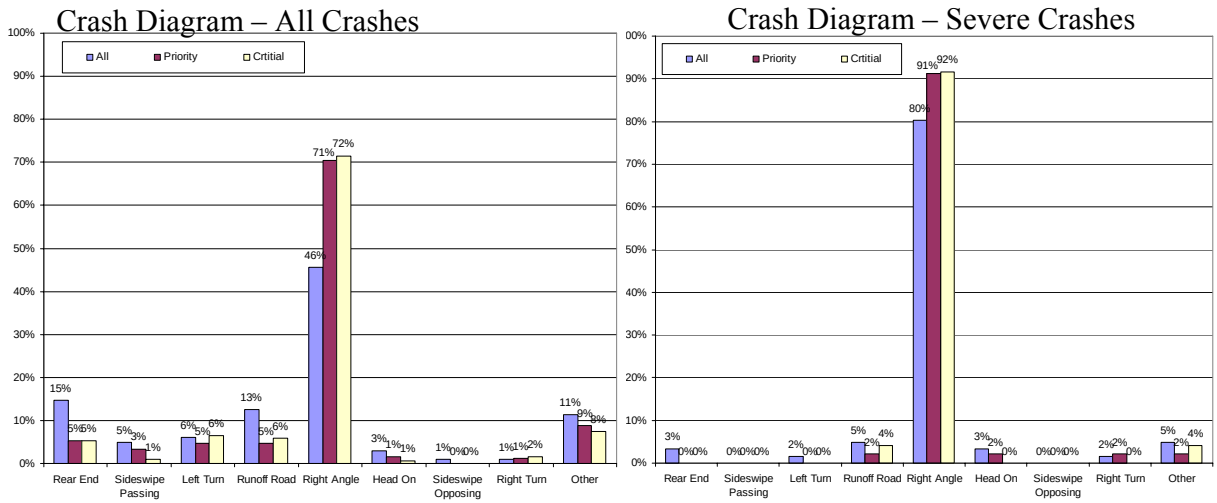


Figure 2.9 Expressway Intersection Crash Type
Source: Mn/DOT Intersection Crash Data, 2002-2007

- Light Conditions (**Figure 2.10**)
  - Approximately 15% of all Expressway intersection crashes occur during periods of darkness and this compares to an average of 11% for all crashes in Minnesota.
  - Severe nighttime crashes (20% – 25%) are also over represented at the Priority and Critical intersections.

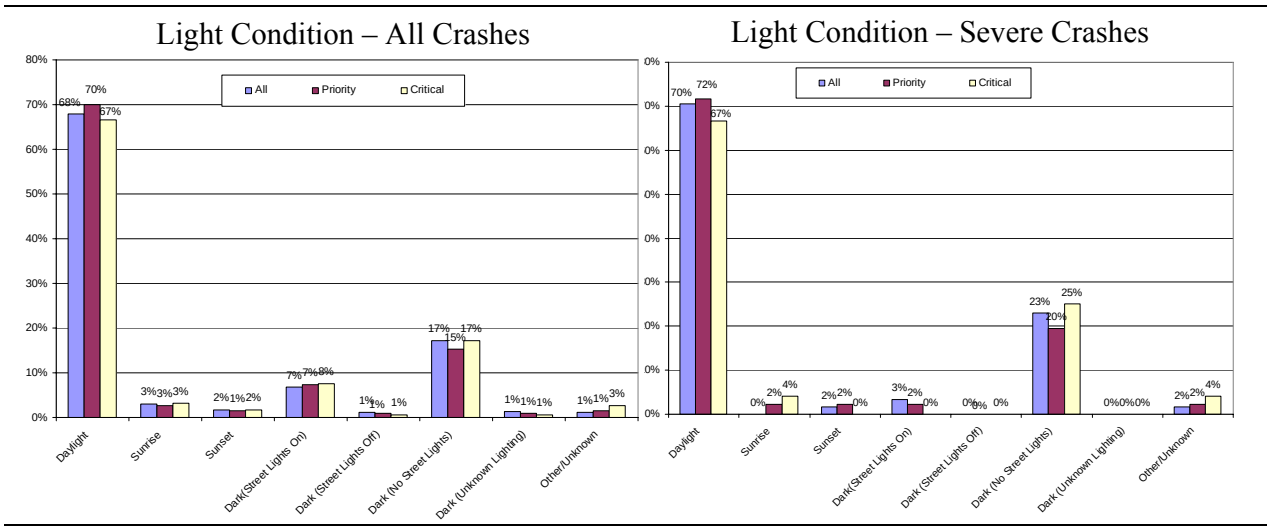


Figure 2.10 Expressway Intersection Crashes – Light Conditions
Source: Mn/DOT Intersection Crash Data, 2002-2007

- Intersection Volume (**Figure 2.11**)
  - Average daily traffic (ADT) volumes on the major (Expressway) legs ranged from approximately 3,500 vehicles per day to 29,000 vehicles per day. The ADT on the minor legs ranged from 350 to 3,500 vehicles per day.
  - 80% of the Priority and Critical intersections had a ratio of minor leg to major leg ADT in the range of 0.03 to 0.12.
  - At the Priority intersections, crash and severity rates were the highest when the sum of the entering volumes was in the mid-range (between 5,000 and 20,000 vehicles per day).

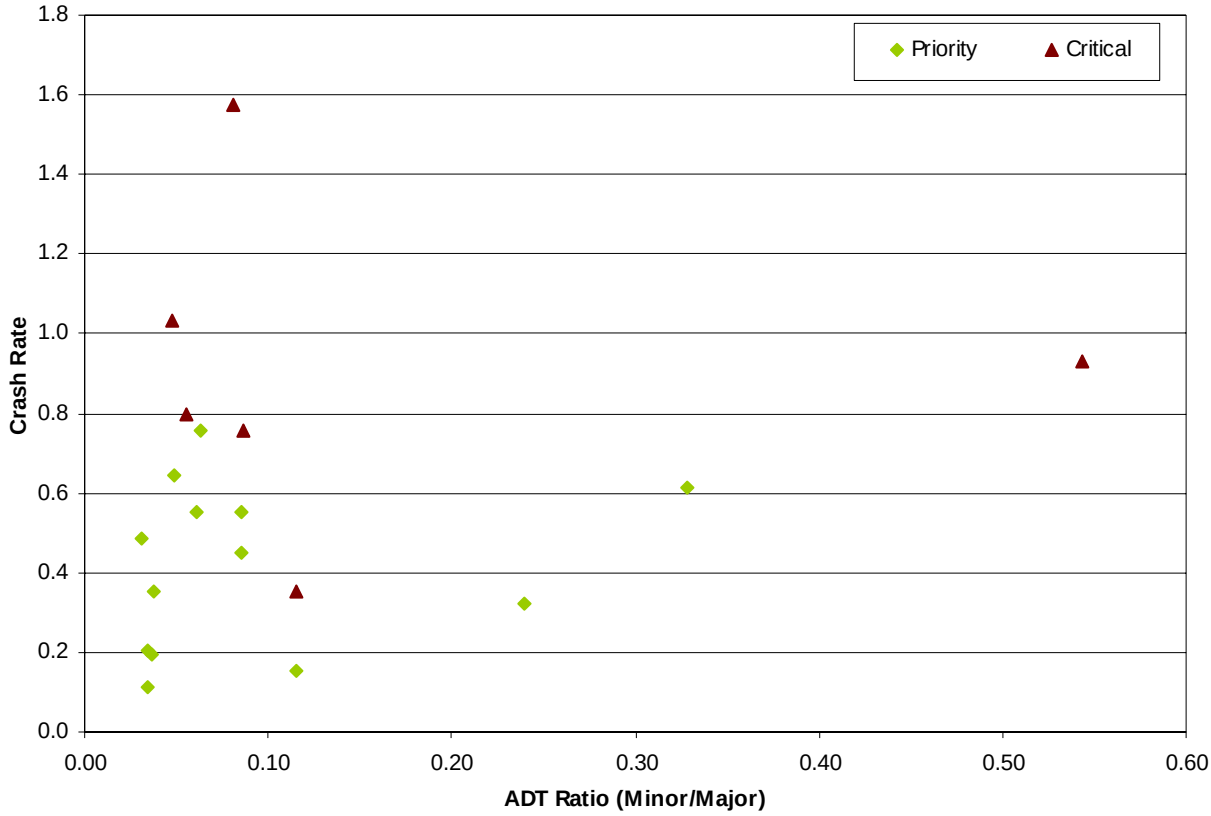


Figure 2.11 Expressway Intersection ADT Ratio
Source: Mn/DOT Intersection Crash Data, 2002-2007

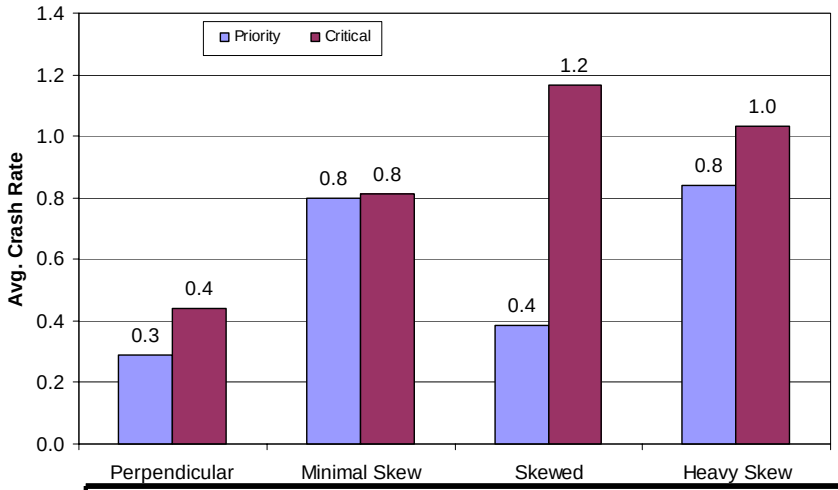
- Intersection Geometry (**Figures 2.12**)
  - 75% of the Priority intersections had minor road approaches that were skewed.*
  - All of the Priority intersections had left turn lanes on the major legs and all but one also had right turn lanes.
  - 35% of the Priority intersections and 71% of the Critical intersections were located on or near either a horizontal or vertical curve.

*Note:

Minimal Skew - Greater than 80°

Skewed - 45° to 80°

Heavy Skew - Less than 45°



	Perpendicular	Minimal Skew	Skewed	Heavy Skew
Priority	5	6	7	2
Critical	2	3	1	1

Number of Intersections

Figure 2.12 Expressway Intersection Geometry
Source: Mn/DOT Intersection Crash Data, 2002-2007

- Land Development
  - A previous safety study of rural expressways in Iowa (Rural Expressway Intersection Synthesis of Practice and Crash Analysis, Iowa State University, CTRE Project 03-157, October, 2004) suggests that the presence of land development has an adverse effect on the safety performance of expressway intersections. As a result, the presence of development was documented for the Priority intersections based on aerial photography. It was determined that commercial development was present at 33% of the Priority intersections.

2-Lane State Highways

Minnesota has approximately 8,800 miles of rural 2-Lane State Highways. These facilities have either a 55 or a 60 mile per hour speed limit and as was the case with the Expressway intersections, the rural designation is based on a determination made by Mn/DOT staff in the District offices. These rural 2-lane highways had a total of 3,721 STOP controlled intersections, of which 1,275 (34%) had at least one crash during the six year study period. In support of the effort to develop a predictive tool for identifying at-risk intersections, the same two filters that were applied to expressway intersections were used to identify the short list of priority locations on the 2-Lane State Highway system. Using the presence of at least two severe right angle crashes resulted in the identification of eighty Priority Intersections and the Critical Crash Rate filter identified 34 intersections (**Figure 2.13**). These eighty intersections are distributed across the State and every Mn/DOT District has at least four intersections in the Priority data set – District 8 has the highest number of intersections (19) and the Metro District has the fewest (4). See **Figure 2.14**.

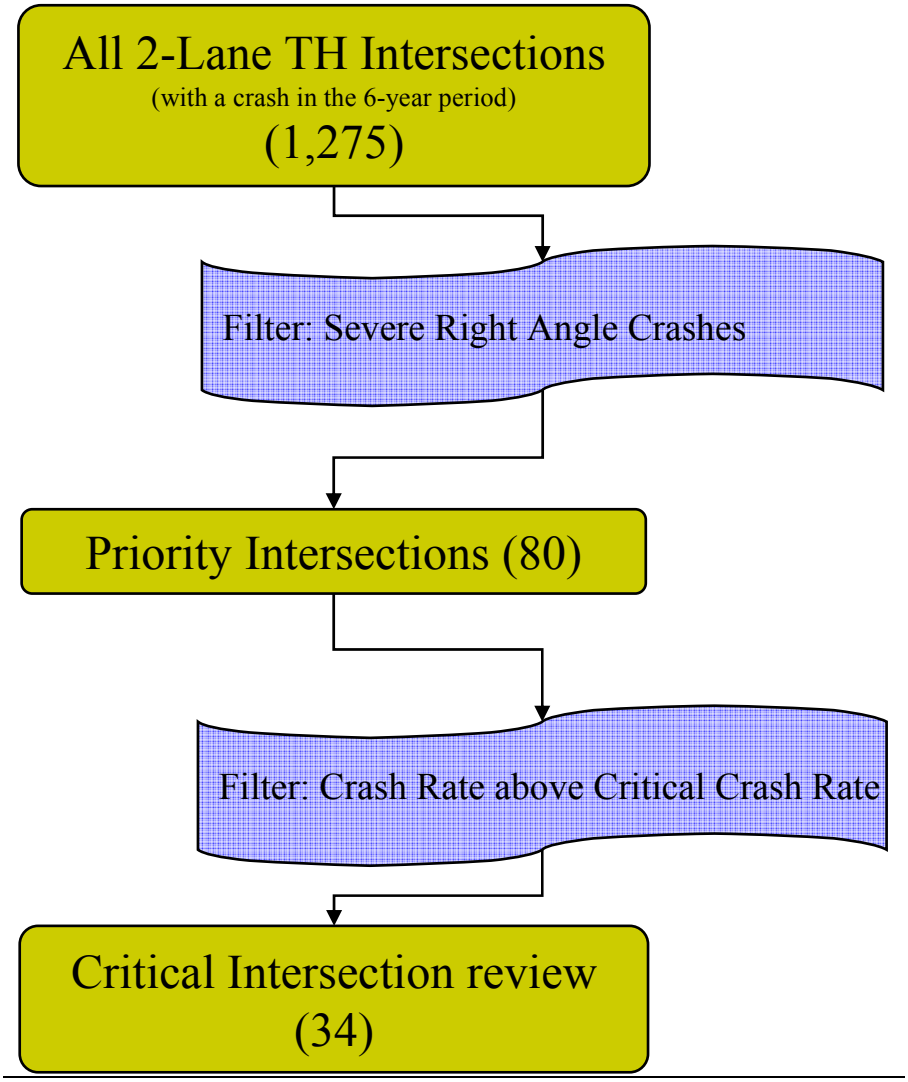


Figure 2.13 2-Lane Intersection Disaggregation
Source: Mn/DOT Intersection Crash Data, 2002-2007

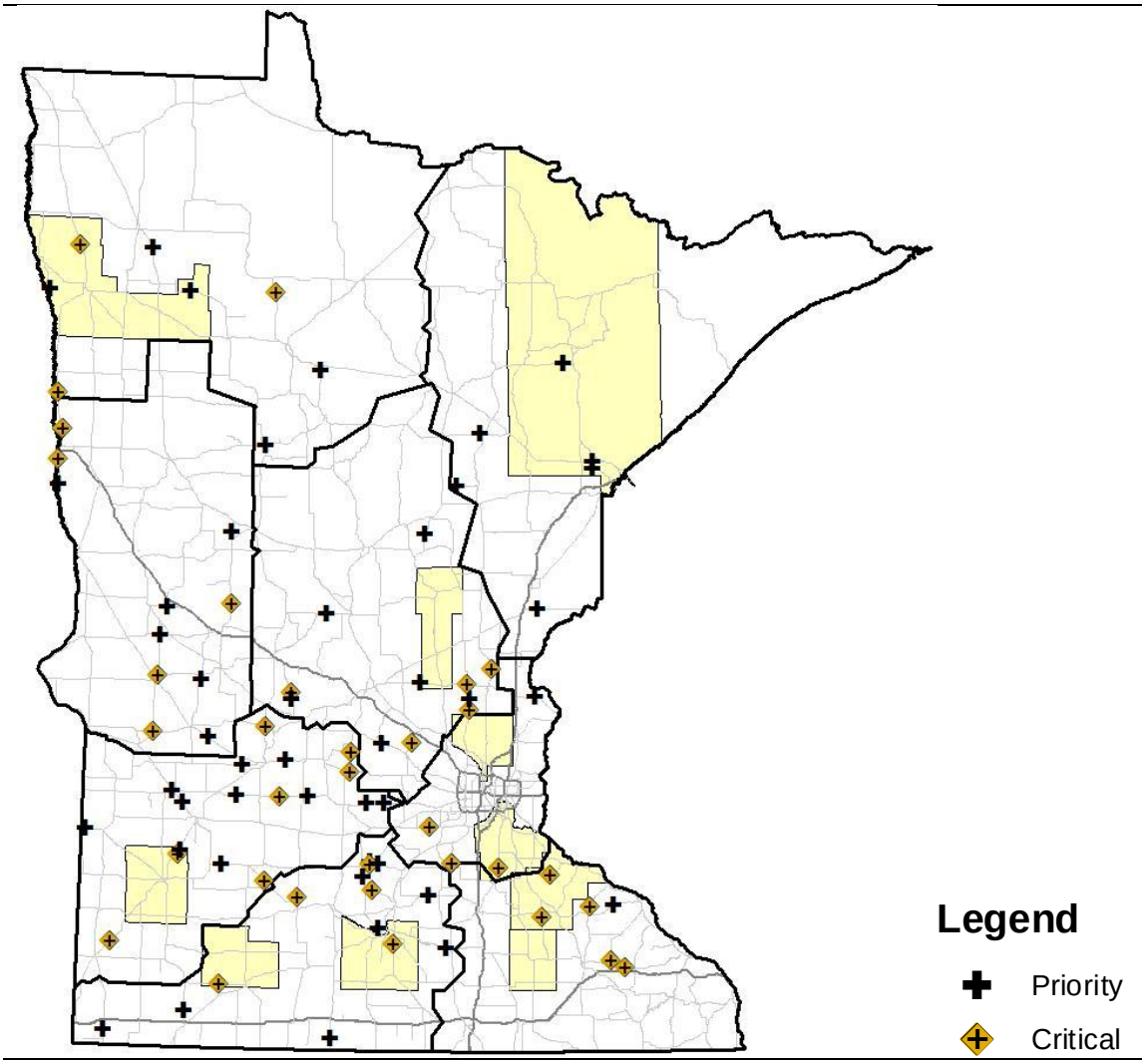


Figure 2.14 2-Lane Intersection Location
Source: Mn/DOT Intersection Crash Data, 2002-2007

The key results of the detailed crash analysis of STOP controlled intersections along 2-Lane State Highways include:

- Crash Frequency (**Figure 2.15**)
  - The Priority intersections averaged 1.3 crashes per year, which is about 30% higher than the State wide average for similar intersections.
  - The average crash rate at the Priority intersections was 0.8 crashes per million entering vehicles, which is more than 2.6 times higher than the State wide average for similar intersections (0.3)

	Priority	Critical
Number of intersections	80	34
Districts	All	2, 3, 4, M, 6, 7, 8
Crashes per year	1.3	2.0
Average crash rate (Statewide Avg. 0.3)	0.8	1.0
Severe crashes per year	0.2	0.3
Average Severity Rate	2.5	3.5
Average Entering ADT	4,582	5,436

Figure 2.15 2-Lane Intersection Crash Frequency
Source: Mn/DOT Intersection Crash Data, 2002-2007

- Crash Severity (**Figure 2.16**)
  - Crashes at the Priority intersections were more severe than at all of the 2-Lane, rural STOP controlled intersections. 19% of the crashes at the Priority intersections involved either a fatality or A injury vs. 7% at all intersections.
  - The average severity rate at the Priority intersections was 2.5, which is five times higher than the State wide average for similar intersections (0.5).

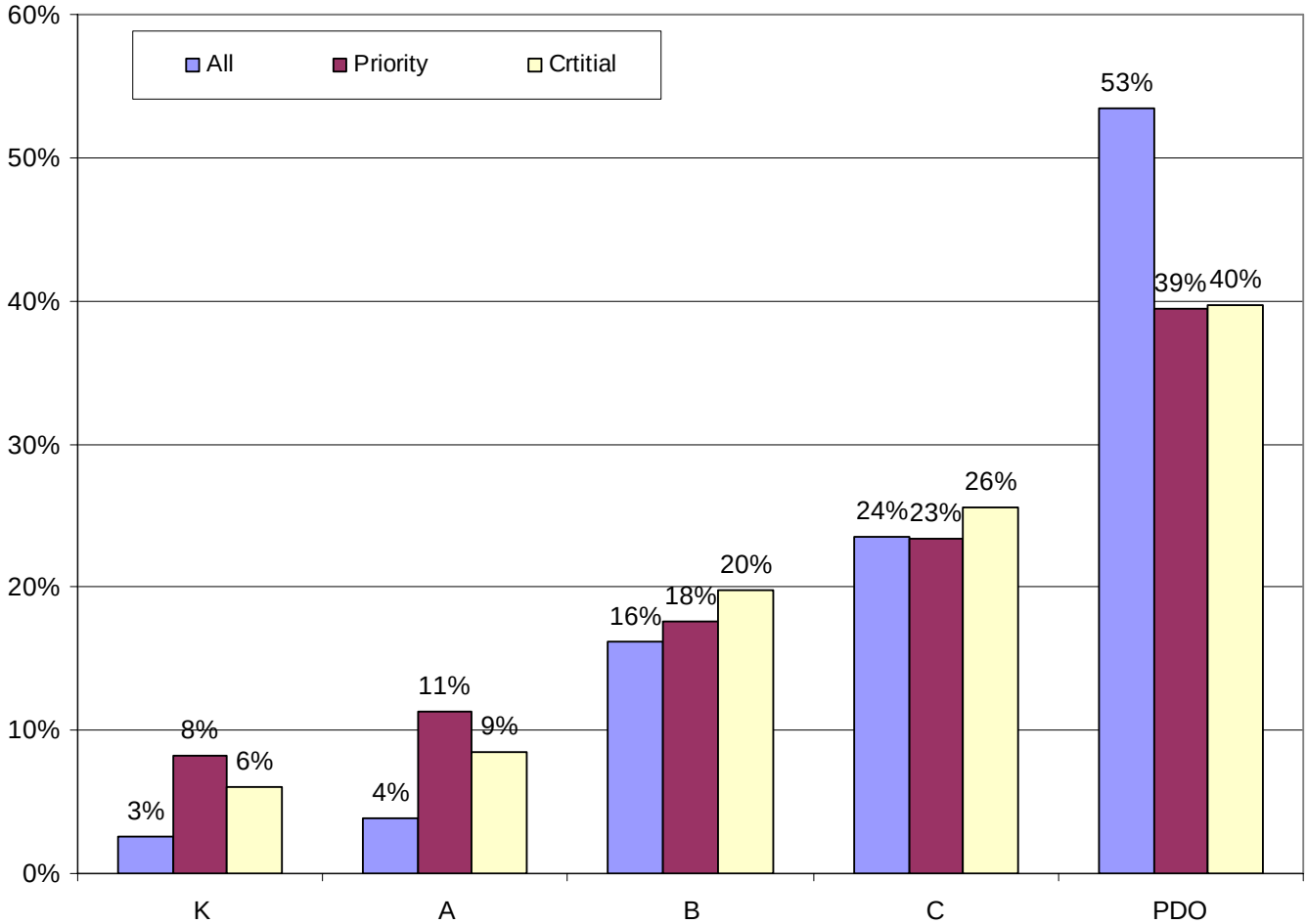


Figure 2.16 2-Lane Intersection Crash Severity
Source: Mn/DOT Intersection Crash Data, 2002-2007

- Crash Type (**Figure 2.17**)
  - Right angle crashes are over represented at the Priority and Critical intersections.
  - Right angle crashes account for 40% of all 2-Lane intersection crashes, while 67% of the crashes were right angle at the Priority intersections.
  - Right angle crashes account for a greater fraction of the severe crashes – 92% at the Priority intersections.

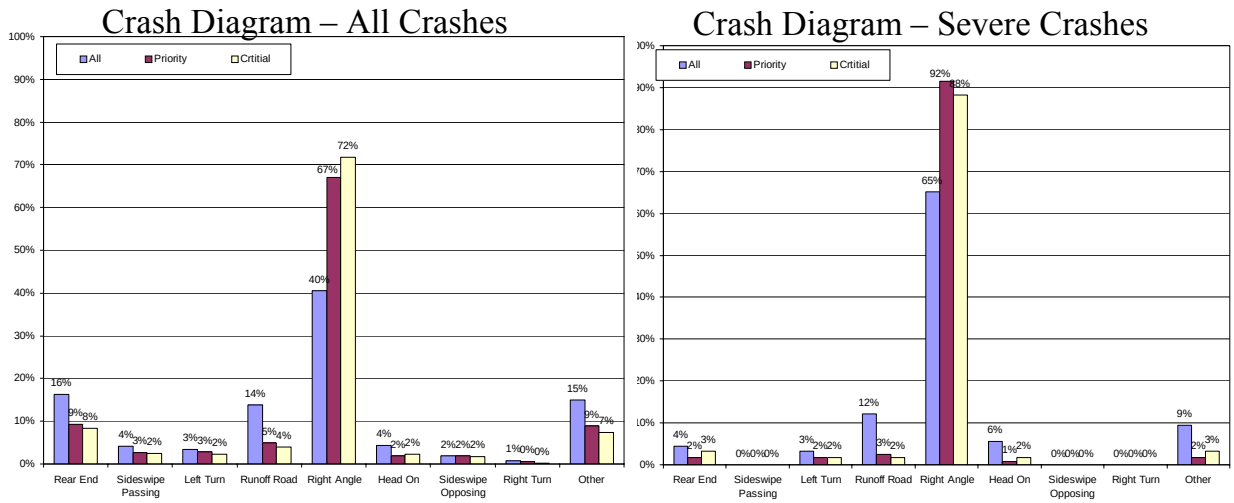


Figure 2.17 2-Lane Intersection Crash Diagram
Source: Mn/DOT Intersection Crash Data, 2002-2007

- Light Conditions
  - Light condition does not appear to be a significant factor – the fraction of night time crashes at the Priority intersections is only one percentage point above the State wide average.
- Intersection Volume (**Figure 2.18**)
  - The ADT on the major (2-Lane Highway) legs ranged from approximately 600 to 19,000 vehicles per day. The ADT on the minor legs ranged from less than 100 to approximately 4,200 vehicles per day.
  - 66% of the Priority intersections had a ratio of minor leg to major leg ADT in the range of 0.1 to 0.5.
  - The Priority intersections in the lower end of the range of entering volumes (less than 10,000 vehicles per day) had the highest crash and severity rates.

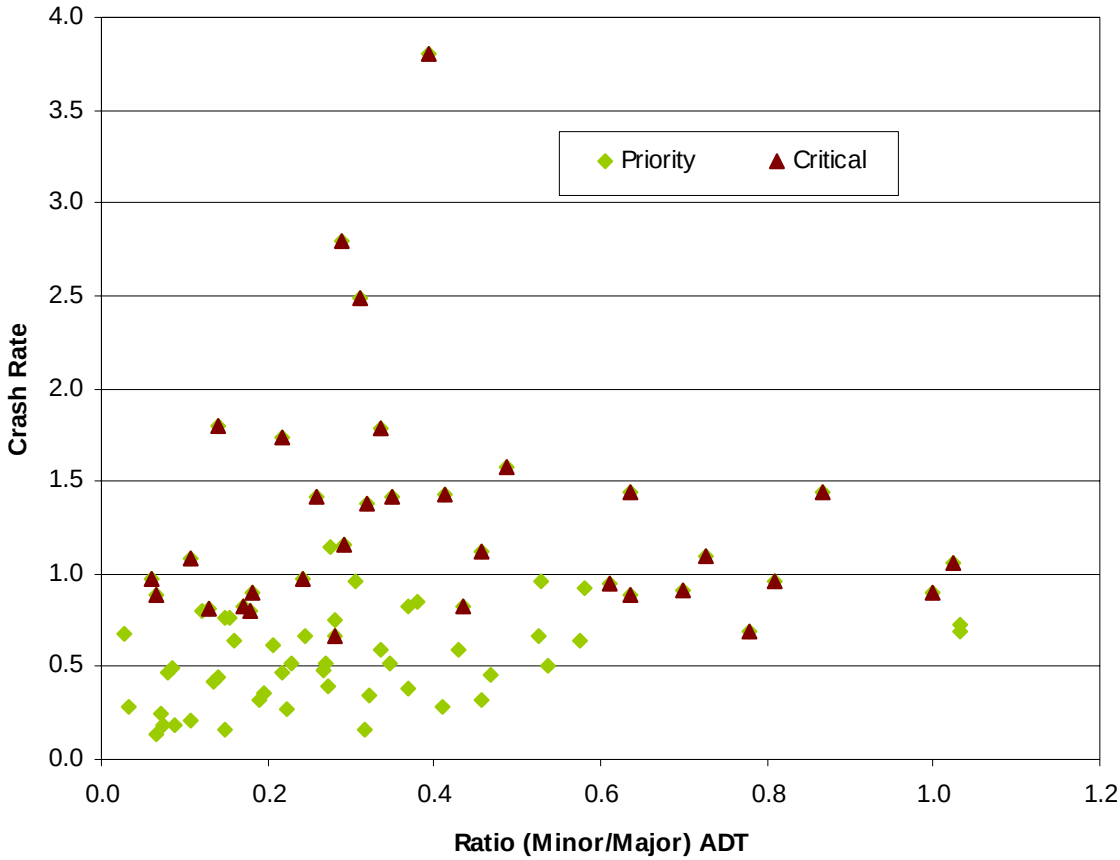
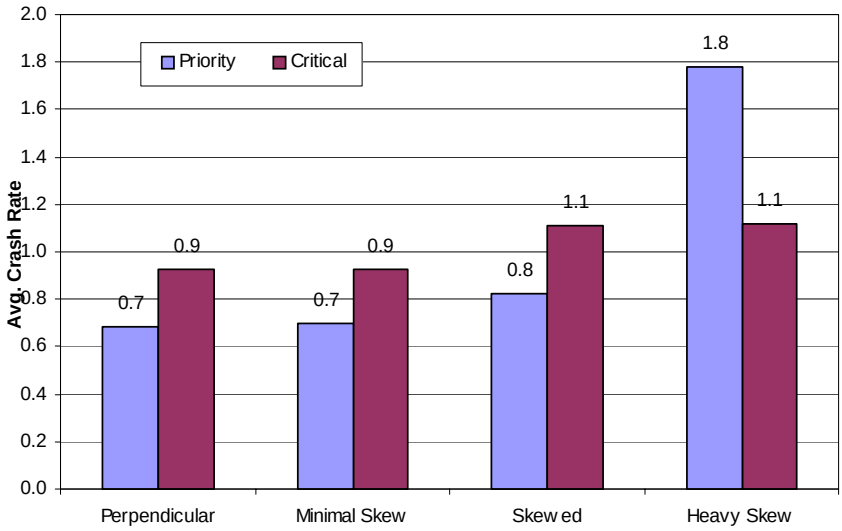


Figure 2.19 2-Lane Intersection Volume Ratio
Source: Mn/DOT Intersection Crash Data, 2002-2007

- Intersection Geometry (**Figure 2.19**)
  - 64% of the Priority intersections had minor road approaches that were skewed.
  - 30% of the Priority intersections and 47% of the Critical intersections were located on or near either a horizontal or vertical curve.



				Number of Intersections
29	28	21	2	Priority
13	8	12	1	Critical

Figure 2.19 2-Lane Intersection Geometry
Source: Mn/DOT Intersection Crash Data, 2002-2007

County Highway Intersections

Minnesota has approximately 45,000 miles of 2-lane highways on the county system. These facilities have a 55 mile per hour speed limit and it was assumed that the vast majority of these miles is in rural areas and is of a rural design (with drainage in ditches); however, there is currently no comprehensive electronic data base that can provide a more accurate accounting. It is estimated (based on extrapolating from a sample of two counties) that there are approximately 12,500 STOP controlled intersections along the county system, of which 3,171 (25%) were found to have had at least one crash during the six year study period. Using the same filters as were applied to rural STOP controlled intersections along the State's system of Expressways and 2-Lane Highways, fifteen Priority intersections were found to have two or more severe right angle crashes and three Critical intersections were found to have crash rates above the Critical Crash Rate. These fifteen intersections (**Figure 2.20**) are located in thirteen counties (only Douglas County has more than one intersection in the data set) and distributed across the State - every Mn/DOT District has at least one intersection in the data set and no District has more than three intersections.

Intersection Number	Intersection	District	County	Intersecting Angle	Total Crashes	Crashes by Year						Entering ADT	Crash Rate	Expected Crash Rate	Critical Crash Rate
						2002	2003	2004	2005	2006	2007				
C01	CSAH 22 & CR 66	M	Anoka	Skewed	4	0	1	0	2	1	0	7,000	0.3	0.2	0.4
C02	CR 60 & CR 149	2	Cass	Minimal Skew	3	1	0	1	0	1	0	2,430	0.6	0.4	0.9
C03	CSAH 23 & CSAH 22	3	Crow Wing	Perpendicular	3	0	0	0	3	0	0	898	1.5	0.4	1.4
C04	CSAH 47 & CSAH 86	M	Dakota	Skewed	13	4	2	2	2	1	2	5,550	1.1	0.2	0.5
C05	CSAH 15 & CSAH 34	6	Dodge	Perpendicular	2	0	0	1	0	1	0	2,320	0.4	0.4	1.0
C06	CSAH 12 & CSAH 5	4	Douglas	Minimal Skew	2	0	1	1	0	0	0	1,063	0.9	0.4	1.3
C07	CSAH 40 $ CSAH 8	4	Douglas	Skewed	7	1	1	0	1	2	2	2,750	0.8	0.4	0.9
C08	CSAH 3 & CSAH 9	8	McLeod	Minimal Skew	2	0	0	1	1	0	0	1,925	0.5	0.4	1.0
C09	CSAH 21 & CSAH 11	6	Olmsted	Perpendicular	4	0	1	0	2	1	0	3,100	0.6	0.4	0.9
C10	CSAH 43 & CSAH 33	1	St. Louis	Perpendicular	3	0	2	0	0	1	0	1,425	1.0	0.5	1.3
C11	CSAH 9 & CR 45	3	Sherburne	Minimal Skew	16	1	1	6	2	4	2	6,300	1.2	0.4	0.7
C12	CSAH 35 & Dague Ave.	3	Wright	Perpendicular	7	1	5	1	0	0	0	8,300	0.4	0.4	0.7
C13	CSAH 4 & CR 87	4	Douglas	Minimal Skew	3	0	0	1	0	1	1	1,570	0.9	0.4	1.1
C14	CSAH 40 & CSAH 5	8	Kandiyohi	Minimal Skew	3	0	2	1	0	0	0	1,775	0.8	0.4	1.1
C15	CSAH 2 & CSAH 27	7	Waseca	Perpendicular	3	0	1	0	0	1	1	6,630	0.2	0.4	0.7

- Green shading – crash rate above expected crash rate but below critical crash rate.
- Pink shading – crash rate above critical crash rate – and included in Critical set.
- All others included in Priority set.

Figure 2.20 2-Lane County Highway Intersections
Source: Mn/DOT Intersection Crash Data, 2002-2007

The key results of the detailed crash analysis of rural, STOP controlled intersections along the County Highway System include:

- Crash Frequency (**Figure 2.21**)
  - The Priority intersections averaged 0.8 crashes per year, which is approximately 100% higher than the average for all intersections along the County system
  - The average crash rate at the Priority intersections was 0.6 crashes per million entering vehicles, which is twice the State wide average for similar intersections (0.3)

	Priority	Critical
Number of intersections	15	3
Districts	All	3 and M
Crashes per year	0.8	1.8
Average crash rate (Statewide Avg. 0.3)	0.6	1.1
Severe crashes per year	0.3	0.4
Average Severity Rate	0.6	1.1
Average Entering ADT	3,536	4,249

Figure 2.21 2-Lane County Highway Intersections Crash Frequency
Source: Mn/DOT Intersection Crash Data, 2002-2007

- Crash Severity (**Figure 2.22**)
  - Crashes at the Priority intersections are more severe than for all intersections along the County system – 42% of the crashes at the Priority intersections involved either a fatality or an A injury vs. 11% at all intersections.
  - The average severity rate at the Priority intersections was 0.6, which is 20% higher than for similar intersections.

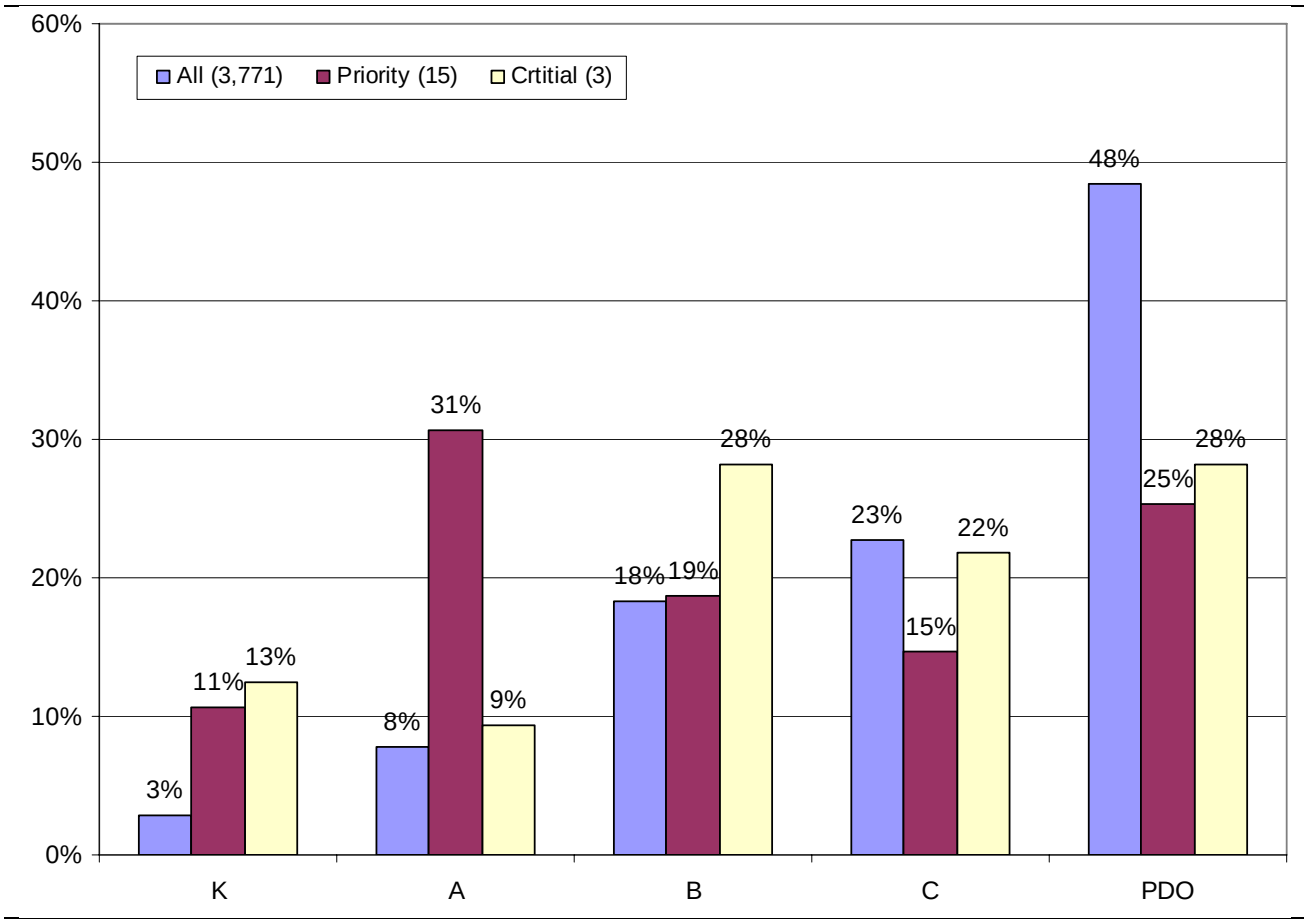


Figure 2.22 2-Lane County Highway Intersections Crash Severity
Source: Mn/DOT Intersection Crash Data, 2002-2007

- Crash Type (**Figure 2.23**)
  - Right angle crashes are over represented at the Priority intersections.
  - Right angle crashes account for 40% of all County Highway intersection crashes, while 79% of crashes were right angle at the Priority intersections.
  - Right angle crashes account for even a greater fraction of the severe crashes, 100% at both the Priority and Critical intersections.

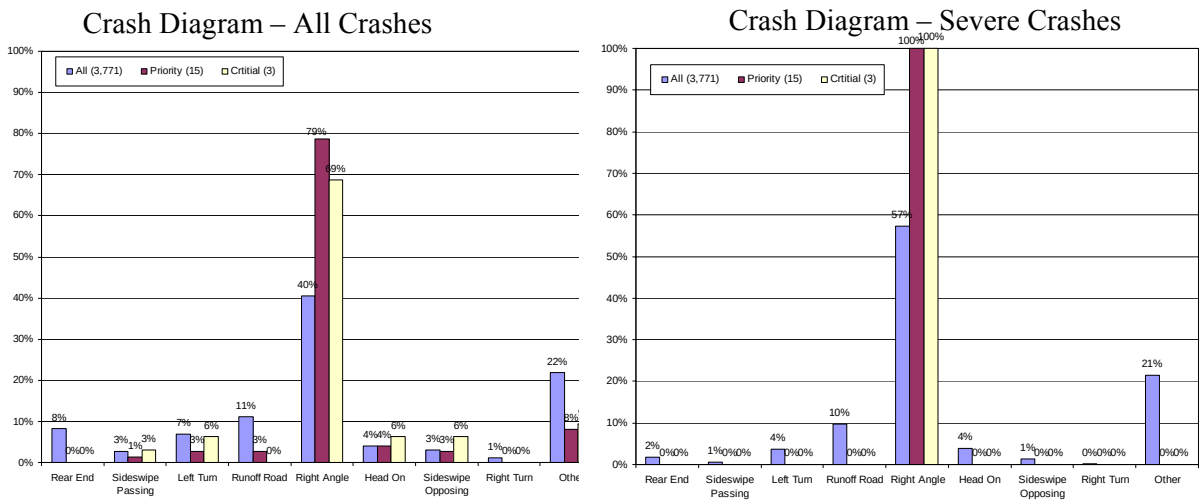


Figure 2.23 2-Lane County Highway Intersections Crash Type
Source: Mn/DOT Intersection Crash Data, 2002-2007

- Light Conditions (**Figure 2.24**)
  - Approximately 18% of all County system intersection crashes occur during periods of darkness and this compares to an average of 11% for all crashes in Minnesota.
  - Severe nighttime crashes (18%) are over represented at the Priority and Critical intersections.

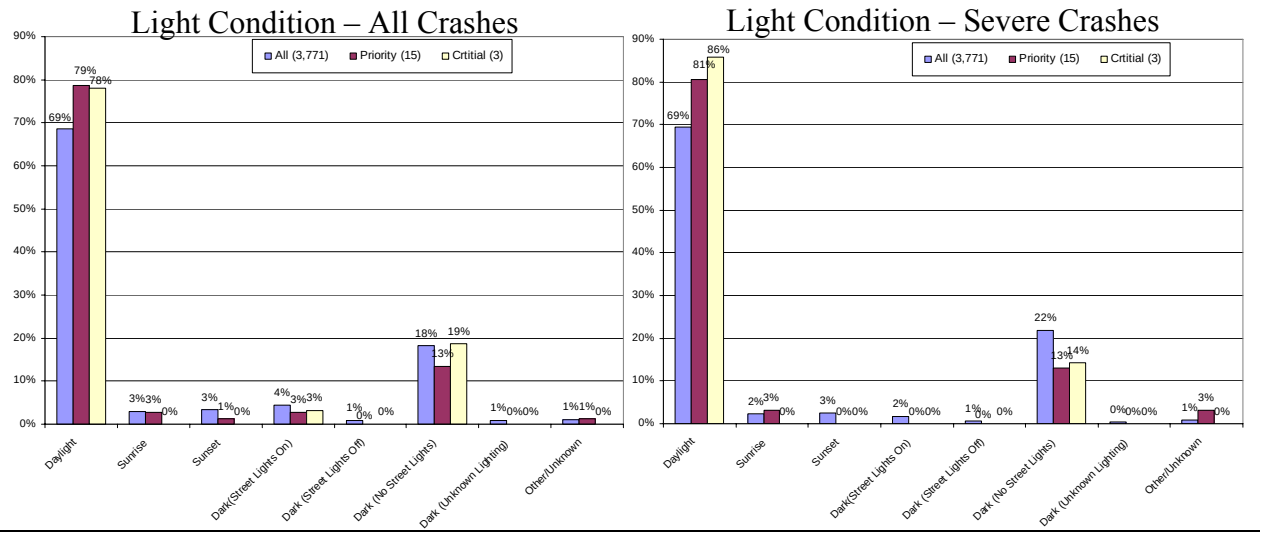


Figure 2.24 2-Lane County Highway Crash Light Conditions
Source: Mn/DOT Intersection Crash Data, 2002-2007

- Intersection Volume (**Figure 2.25**)
  - The ADT entering the Priority intersections ranged from approximately 900 to more than 8,000 vehicles per day.

- 67% of the Priority intersections had a ratio of minor leg to major leg ADT in the range of 0.2 to 0.7

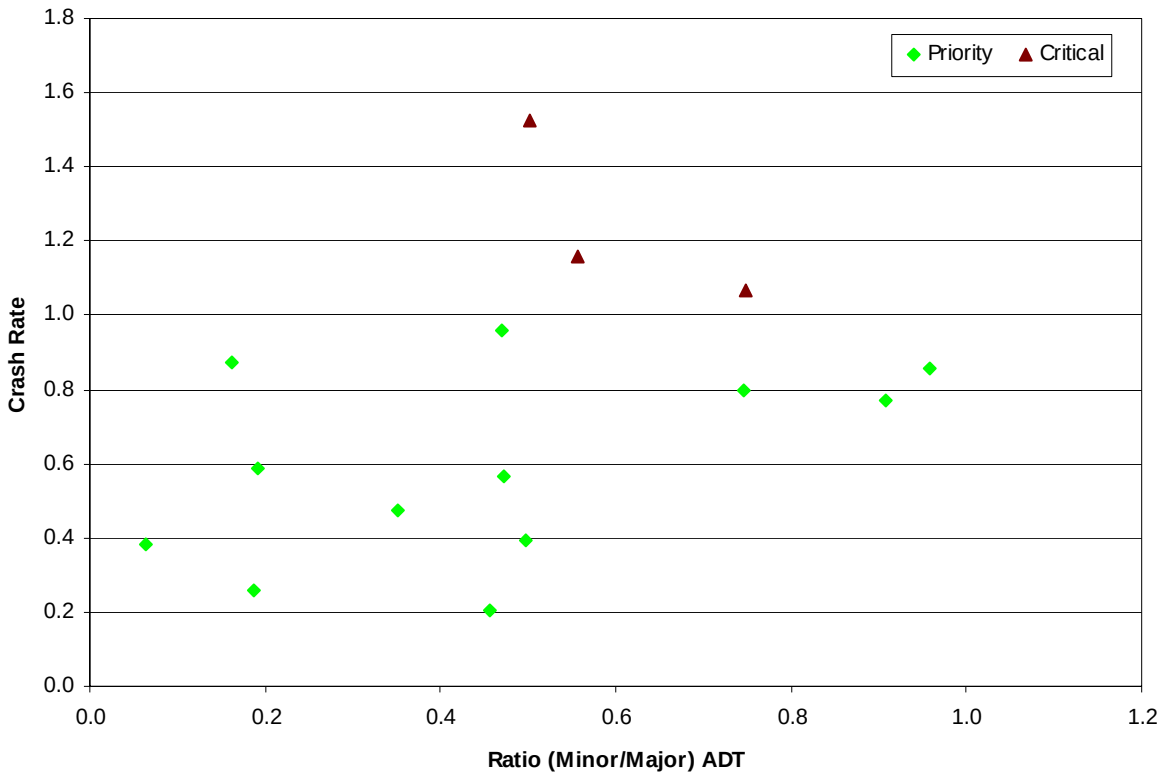
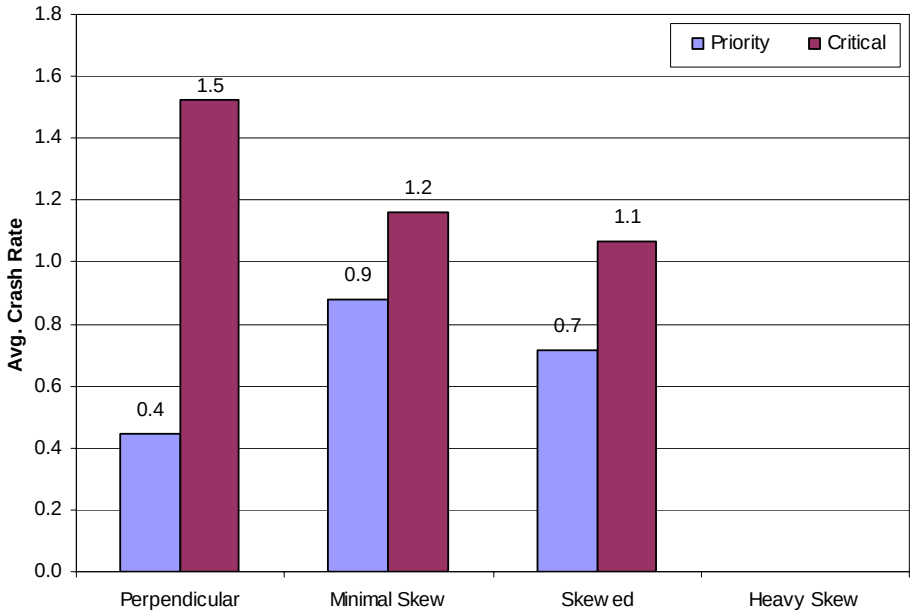


Figure 2.25 2-Lane County Highway Intersections ADT Ratios
Source: Mn/DOT Intersection Crash Data, 2002-2007

- Intersection Geometry (**Figure 2.26**)
  - 60% of the Priority intersections and 67% of the Critical intersections had minor road approaches that were skewed.
  - 33% of the Priority intersections and 100% of the Critical intersections were located on or near either horizontal or vertical curves.



				Number of Intersections
6	6	3	0	Priority
1	1	1	0	Critical

Figure 2.26 2-Lane County Highway Intersection Geometry
Source: Mn/DOT Intersection Crash Data, 2002-2007

Detailed Crash Analysis - Conclusions

The results of the detailed crash analysis (**Figure 2.27**) point to four key conclusions.

1. Addressing angle crashes should be the focus of safety investments at rural intersections. Angle crashes account for 50% of all intersection related crashes, but when intersections go bad from a safety perspective the fraction of angle crashes jumps to 70% at the Priority intersections and to over 90% when only severe crashes are considered.

2. Crashes at rural, STOP controlled intersections are relatively rare events – the majority of these intersections (54% along Expressways, 66% along 2-Lane Highways and 75% along the County system) had no crashes during the six year study period. The occurrence of multiple severe crashes is even rarer – only 4% of the Expressway intersections, 2% of the 2-Lane intersections and 0.1% of the County intersections had two or more severe crashes during the study period.

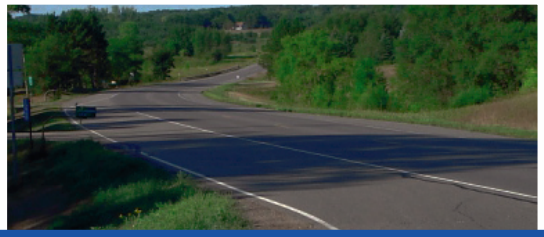
3. The fact that there are so few "Black Spot" intersections along the State's rural systems (by any definition – crash costs, crash frequency, critical crash rate, etc) supports the idea that there is a need to develop a new methodology to screen and prioritize intersections in an effort to identify potential candidates for safety improvement projects.

4. The concept of using the geometric and traffic volume characteristics at intersections with crashes as the basis for the development of a predictive tool is supported by the

results of the detailed crash analysis – 60% to 75% of the Priority intersections with crashes had skewed minor leg approaches, 30% - 35% of the Priority intersections were located in or near horizontal or vertical curves and 66% - 80% of the Priority intersections had ADT volume ratios in a defined range.

	Expressway Intersections		2-Lane Highway Intersections		County Highway Intersections	
	Priority	Critical	Priority	Critical	Priority	Critical
Number of Intersections	20	7	80	24	15	3
Crashes per Year	2.9	4.5	1.3	2.0	0.8	1.8
Average Crash Rate	0.5	0.7	0.8	1.0	0.6	1.1
Severe Crashes per Year	0.4	0.6	0.2	0.3	0.3	0.4
Severity Rate	1.5	2.1	2.5	3.5	0.6	1.1
Average Entering ADT	16,300	17,800	4,600	5,400	3,500	4,200
Angle Crashes	71%	72%	67%	72%	79%	69%
Skewed Approaches	72%	71%	64%	62%	75%	67%
In/Near Horizontal Curve	35%	71%	30%	47%	33%	100%

Figure 2.27 Detailed Crash Analysis Summary
Source: Mn/DOT Intersection Crash Data, 2002-2007



Development of Methodology to Prioritize Intersections

Development of Methodology

The basic objective associated with developing a methodology to evaluate and prioritize rural, STOP controlled intersections using crash surrogates, such as geometric features and traffic volumes, is to support a more comprehensive approach to Statewide and regional safety planning efforts by providing a proactive tool that supplements the reactive analytical techniques that have been in use for more than 30 years (**Figure 3.1**). It is clear that using some combination of crash rates, critical crash rates and crash costs has proven successful at identifying the "Black Spots" along the State's system of highways. This method has historically identified a sufficient number of intersections to allow MnDOT to document locations with the highest crash frequencies and to meet performance objectives relative to addressing a minimum number of these locations each year. It is also very clear that this reactive method has not been able to identify intersections with the most severe crashes – the top 200 intersections by crash cost account for only 25% of the fatal intersection related crashes. This information leads to the key question – other than chasing fatal crashes around the system, how can a subset of the most at-risk rural, STOP controlled intersections (across which the majority of fatal intersection related crashes are randomly distributed) be identified, evaluated and prioritized?

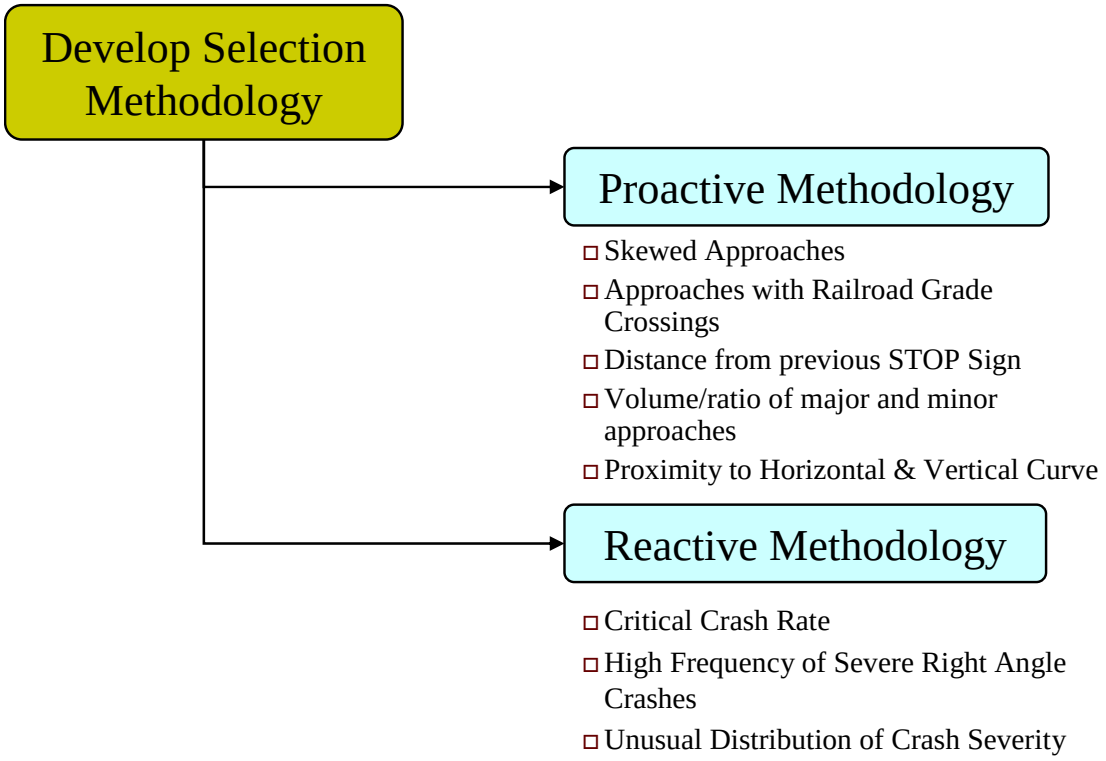


Figure 3.1 Methodology Selection Criteria

The answer, based on the premise of using the characteristics of the existing system to predict where future crashes are likely to occur points to the development of a predictive methodology using the results of the detailed analysis of STOP controlled intersections along rural expressways, 2-lane state and county highways. These results indicate that the locations with at least one crash during a six year study period had a number of common geometric and traffic volume features (**Figure 3.2**) and these features are candidates for including in the initial predictive tool to supplement crash data.

	Expressway		2-Lane TH		County Highways	
	Priority	Critical	Priority	Critical	Priority	Critical
No. of Intersections	20	7	80	34	15	3
Crashes/Year (total)	2.9	4.5	1.3	2.0	0.8	1.8
% Angle Crashes	71%	72%	67%	72%	79%	69%
Crash Rate (0.3 average)	0.5	0.7	0.8	1.0	0.6	1.1
Severe Crashes (K+A) (5% Average)	14%	13%	20%	15%	41%	22%
ADT Ratio	0.03-0.12	0.04-0.11	0.1-0.5	0.1-0.5	0.2-0.8	0.4-0.8
% Skewed Approaches	72%	71%	64%	62%	75%	67%
% On/Near Curve	35%	71%	30%	47%	33%	100%
% Proximity to RR	10%	0%	9%	6%	0%	0%
% Greater than 5 miles from previous STOP	38%		46%		53%	
% Adjacent Development	40%	57%	24%	35%	40%	67%

Figure 3.2 Geometric and Traffic Volume Features of Selected Intersections
Source: Mn/DOT Intersection Crash Data, 2002-2007

Using the crash surrogates from the Priority and Critical intersection subsets to screen the system looking for the locations that are waiting for a crash to happen points to the following features:

- Intersection Geometry – 60% to 75% of the Priority intersections had minor road approaches that were skewed.
- Major Road Alignment – 20% to 35% of the Priority intersections were in or near mainline horizontal curves.
- ADT Ratio – a particular range of minor road to major road ADT ratio was identified for each facility type where crashes were over represented.

In addition to these features, a review of the intersection safety literature suggests consideration of three additional items. First, a previous safety study of rural expressways in Iowa (Rural Expressway Intersection Synthesis of Practice and Crash Analysis, Iowa State University, CTRE Project 03-157, October, 2004) suggests that the presence of land development adjacent to an intersection has an adverse effect on the safety performance of expressway intersections. It was theorized that the development could cause unusual peaking characteristics that resulted in a very high demand for access over a short period of time. As a result, the Priority intersections were reviewed using aerial photography and it was found that development was present at approximately 33% of the intersections. Secondly, a previous safety study of rural intersections in Minnesota (MnDOT Research Report 2003-15, Reducing Crashes at Controlled Rural Intersections, University of Minnesota and CH2M HILL, July, 2003) found that at intersections with angle crashes, the

distance from the previous STOP sign was greater than for intersections where no crashes had occurred. Finally, a review of the results of road safety audit reviews of 130 intersections in MnDOT's District 3 (MnDOT District 3 – 13 County Road Safety Audit Review, Final Technical Report, CH2M HILL, September, 2006) indicates that the presence of a rail road crossing on the minor leg approaches to STOP controlled intersections were pointed out as a concern by a number of the county engineers. The observations by the RSAR Team at these locations noted that in many cases the railroad tracks were constructed at a higher elevation than the main highway, which resulted in a very short crest vertical curve on the minor road approach and this often blocked the line of sight to the intersection. In addition, the rail road warning device (lights or gates) often impaired the line of sight for drivers on the minor road to the STOP sign at the highway intersection (**Figure 3.3**). The Priority intersections were tested for the presence of rail road crossings on the minor legs and it was determined that 10% of the Expressway and 2-Lane highway intersections had rail road crossings on the minor legs (none of the Priority intersections on the county system had minor leg rail crossings). It should be noted that the MnDOT database used to test for the presence of railroad crossings only represents a sample of all intersections along the State's system. As a result, the actual number of minor leg approaches with railroad crossings may be different.

Figure 3.3 Railroad Crossing Near Intersection

The suggested predictive methodology uses a check list type of approach. All of the rural, STOP controlled intersections in a system would be inventoried using aerial photography and other electronic sources for the seven items that were identified as safety risk factors – Geometry (skew & on/near curve), Volume (ADT ratio), Proximity (previous STOP sign & railroad crossing), Development and Crashes. The results would be tabulated in a spread sheet (**Figure 3.4**) with check marks in the columns where the specific features were present at specific intersections. After completing the inventory, the intersections could then be ranked in priority order, based on the number of check marks associated with each

intersection – intersections with greatest number of check marks would be considered to be the most at-risk and therefore the highest priority candidates for safety investment (**Figure 3.5**).

	Geometry		Volume	Proximity			
	Skew	On/Near Curve	ADT Ratio	previous STOP sign	RR Xing	Crashes	Development
Intersection 1	✓	✓	✓	✓			✓
Intersection 2	✓		✓	✓			✓
Intersection 3						✓	
Intersection 4			✓	✓	✓	✓	
Intersection 5		✓		✓			✓
Intersection 6		✓	✓			✓	
Intersection 7	✓	✓	✓	✓		✓	
Intersection 8	✓		✓				

Figure 3.4 Tabulating Intersection Features

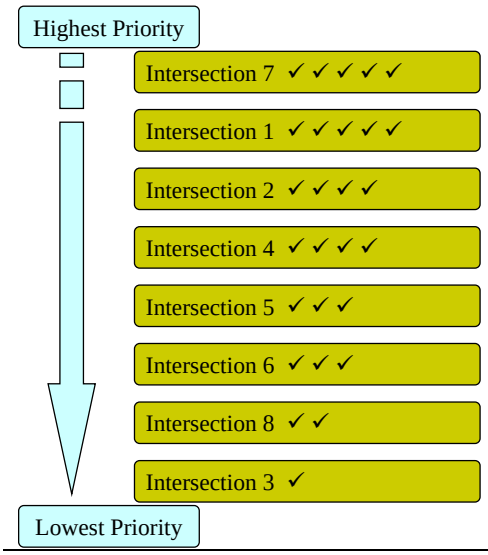


Figure 3.5 Prioritizing Intersections Based Upon At-Risk Features

In order to test the initial predictive methodology, it was applied to a sample of intersections along the MnDOT and county highway systems. The objectives of this testing were to identify the level of effort needed to inventory a system of intersections, document the results of the inventory and to review the prioritized lists with agency staff to get feed back about the value of the information generated relative to providing assistance with the highway safety planning process. The inventory of the systems of intersections took approximately three to five days, depending on the availability of data. The geometric data, presence of development and proximity to railroad crossings was obtained from aerial

photography. The traffic volume data was obtained from various MnDOT data bases. The most challenging part of the inventory was acquiring the information about STOP sign locations – that information was not available electronically and required effort by agency staff. The methodology was applied to intersections along highway systems in District 3, 4 and 7 and in Olmsted, Ottertail and Scott Counties (**Figure 3.6**) to identify intersections of interest – those intersections with characteristics and features that suggest they are more at-risk for severe crashes.

The results of the inventory process, the prioritized ranking of the intersections and observations are documented in the following pages and tables. It should be noted that the tables reporting the prioritization process for each set of intersections also includes the crash cost associated with each intersection in order to provide a comparison to the performance measure that has historically been used by MnDOT to identify candidate intersections for safety investment. The reported crash costs were computed consistent with MnDOT practices and using FHWA crash costs. In addition, the prioritization exercises in Districts 3 and District 7 were limited to six factors – the proximity to previous STOP signs was not provided by the District staff.

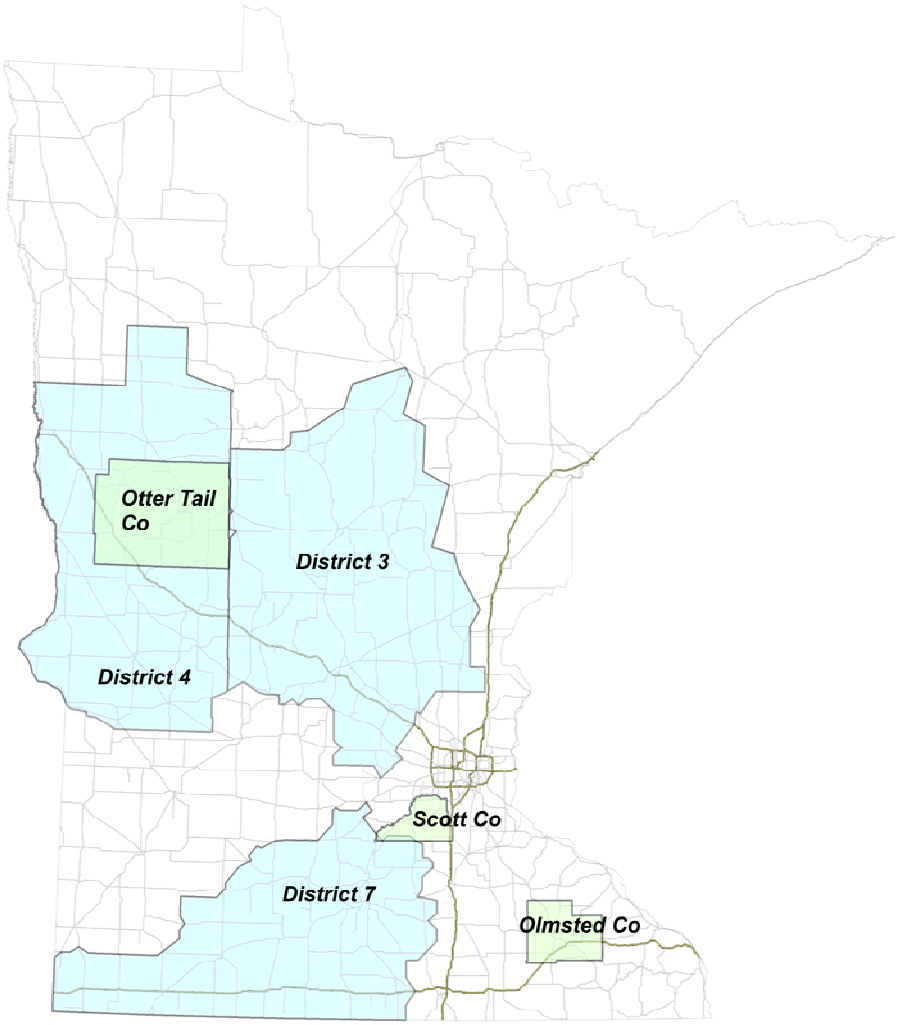


Figure 3.6 Locations of Applied Methodologies

Expressway intersections

- District 3 Expressway Intersections
  - Inventory (**Figure 3.7**) & Priority Ranking (**Figure 3.8**)
  - A total of 82 intersections were inventoried and the top 10 ranked intersections each received four check marks.
  - The common features among the top ranked intersections include; right angle crashes, ADT ratio, in/near curve, skewed approach and presence of development.
  - Four of the top ten intersections had crash rates above the Critical Crash Rate and the highest priority intersection also has the highest crash cost rank.
  - 80 of 82 intersections had crashes.

#	Intersection	Intersection	Geometry Skew (y or n)	Geometry On/Near Curve (within 1/4 mile)	ADT ratio	Proximity Previous STOP sign (approx miles)	Proximity RR Crossing (y or n)	Commercial Area	Crashes	Right Angle Crashes	Crash Rate	K	A	B	C	N	Crash Cost ($)
1	USTH 169 & 190TH ST CSAH11	+	Yes	Yes	0.08	7 miles	No	No	43	30	1.8	1	7	6	11	18	5,277,000
2	USTH 10 & CSAH 14/MORRISON CO	+	Yes	No	0.17	19 miles	No	No	14	11	0.9	2	0	5	2	5	2,375,000
3	USTH 169 & CSAH 13	+	Yes	No	0.04	4 miles	No	No	24	15	0.7	0	2	4	8	10	1,984,000
4	USTH 169 & S JCT MNTH27/ONAMIA	T	No	Yes	0.16	20 miles	No	Yes	16	9	0.6	0	3	3	5	5	1,968,000
5	USTH 169 & CSAH 19 RT/2 MI S ZIMMERMAN	T	No	No	0.04	4 miles	No	No	25	7	0.4	1	0	6	3	15	1,911,000
6	MNTH 371 & CR 125 GULL LKDAMRD LT	+	No	No	0.06	3 miles	No	Yes	26	12	0.6	1	0	3	7	15	1,848,000
7	USTH 10 & MAYHEW LKRD CSAH 13 LT	+	No	Yes	0.02	9 miles	No	No	23	5	0.5	1	1	1	5	15	1,846,000
8	USTH 169 & 280TH ST CSAH20	T	No	No	0.01	16 miles	No	No	6	2	0.3	2	0	0	1	3	1,671,000
9	USTH 10 & CSAH 3 LTT 5RT/SHERBURNE CO	+	Yes	No	0.03	9 miles	No	No	23	3	0.5	0	1	6	3	13	1,497,000
10	USTH 10 & TH 301 RT/ST CLOUD	T	Yes	No	0.05	1 miles	No	No	30	5	0.6	0	1	4	5	20	1,489,000
11	USTH 10 & W JCT TH 25 LTCR 52 RT/BECKER	+	Yes	No	0.14	17 miles	Yes	No	33	12	1.1	0	0	3	8	22	1,227,000
12	USTH 169 & 350TH ST CSAH22/SOF ONAMIA	+	No	No	0.05	8 miles	No	Yes	6	5	0.3	1	0	1	2	2	1,075,000
13	USTH 169 & STEVENS RDCSAH 23/N OFONAMIA	T	Yes	No	0.06	6 miles	No	No	9	3	0.4	1	0	0	2	6	1,002,000
14	MNTH 371 & CR 126 GREEN GBLS RD LTUT617	+	No	Yes	0.05	1 miles	No	No	10	3	0.3	1	0	1	0	8	997,000
15	MNTH 23 & FAIRWAY CIR CR58 LT T 145	+	Yes	No	0.13	2 miles	No	No	5	4	0.3	1	0	0	2	2	954,000
16	MNTH 65 & CSAH 30 T274/N OFCAMBRIDGE	+	Yes	Yes	0.17	1 miles	No	No	22	6	0.9	0	0	4	4	14	952,000
17	USTH 10 & CR 50 RT/3MIW BIGLAKE	T	Yes	No	0.04	2 miles	Yes	No	5	1	0.1	1	0	1	0	3	937,000
18	USTH 10 & CSAH 26 LT/WADENA CO	T	Yes	No	0.04	13 miles	No	No	4	1	0.3	0	2	1	0	1	913,000
19	USTH 10 & CSAH 3 LTT 13RT/SHERBURNECO	+	Yes	No	0.03	1 miles	Yes	No	22	1	0.4	0	0	4	3	15	889,000
20	USTH 10 & LAKESHOREDR MSAS107 LT/BIGLK	T	No	No	0.07	1 miles	No	No	26	5	0.7	0	0	1	7	18	862,000
21	USTH 10 & BISON RD CSAH5 LTCSAH11 RT	+	Yes	Yes	0.06	12 miles	No	No	1	1	0.1	1	0	0	0	0	780,000
22	USTH 10 & CSAH 104 LT M17 RT/RANDALL	+	No	Yes	0.08	1 miles	No	No	1	1	0.1	1	0	0	0	0	780,000
23	USTH 169 & CSAH 25 LT/2 MI S ZIMMERMAN	T	No	No	0.03	2 miles	No	No	23	6	0.4	0	0	2	4	17	746,000
24	MNTH 23 & CSAH 6 RTCSAH138LT/NROCKVL	+	No	Yes	0.07	2 miles	No	Yes	10	2	0.6	0	1	1	2	6	733,000
25	MNTH 23 & CR 46 LT	+	No	Yes	0.02	3 miles	No	Yes	10	2	0.6	0	1	1	2	6	733,000
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78	USTH 10 & CSAH 18 RT	+	No	Yes	0.02	16 miles	No	No	1	0	0.1	0	0	0	0	1	12,000
79	USTH 169 & 250TH ST CSAH19	+	No	No	0.02	5 miles	No	No	1	0	0.0	0	0	0	0	1	12,000
80	MNTH 18 & W JCT TH 309/.2 MIE TH25	T	No	No	0.06	1 miles	No	No	1	0	0.1	0	0	0	0	1	12,000
81	MNTH 923A & CR 140 RT/STEARNS CO	+	Yes	No	0.04	3 miles	No	No	0	0	0.0	0	0	0	0	0	-
82	USTH 169 & PINE ST CSAH 38 LT/S ONAMIA	T	Yes	Yes	0.05	1 miles	No	Yes	0	0	0.0	0	0	0	0	0	-

Figure 3.7 District 3 Expressway Intersection Inventory

Source: Mn/DOT Intersection Crash Data, 2003-2007

Rank	Intersection	Skew 41%	Curve 38%	ADT Ratio 28%	RR Crossing 15%	Right Angle Crashes 71%	Development 11%	Totals	Crash Cost Rank	Crash Rate	Right Angle Crashes	Severe Crashes	Crash Cost	Cumulative Cost
1	USTH 169 & 190TH ST CSAH11	✓	✓	✓		✓		✓✓✓✓	1	1.8	30	8	5,277,000	10.5%
2	USTH 169 & S JCT MNTH27/ONAMIA		✓	✓		✓	✓	✓✓✓✓	4	0.6	9	3	1,968,000	14.4%
3	USTH 10 & W JCT TH 25 LTCR 52 RT/BECKER	✓		✓	✓	✓		✓✓✓✓	11	1.1	12	-	1,227,000	16.9%
4	MNTH 65 & CSAH 30 T274/N OFCAMBRIDGE	✓	✓	✓		✓		✓✓✓✓	16	0.9	6	-	952,000	18.8%
5	USTH 10 & BISON RD CSAH5 LTCSAH11 RT	✓	✓	✓		✓		✓✓✓✓	21	0.1	1	1	780,000	20.3%
6	MNTH 23 & CSAH 6 RTCSAH138LT/NROCKVL		✓	✓		✓	✓	✓✓✓✓	24	0.6	2	1	733,000	21.8%
7	USTH 169 & CSAH 36 LTT 188/2MI STH 23	✓	✓	✓		✓		✓✓✓✓	45	0.2	5	-	336,000	22.5%
8	USTH 10 & CSAH 3 LTT 40RT/MORRISON CO		✓	✓		✓	✓	✓✓✓✓	47	0.5	4	-	307,000	23.1%
9	USTH 10 & TH 115 LTM 26RT/RANDALL		✓	✓		✓	✓	✓✓✓✓	51	0.4	3	-	244,000	23.6%
10	USTH 169 & PINE ST CSAH 38 LT/S ONAMIA	✓	✓	✓			✓	✓✓✓✓	81	0.0	-	-	-	23.6%
11	USTH 10 & CSAH 14/MORRISON CO	✓		✓		✓		✓✓✓	2	0.9	11	2	2,375,000	28.3%
12	MNTH 371 & CR 125 GULL LKDAMRD LT			✓		✓	✓	✓✓✓	6	0.6	12	1	1,848,000	32.0%
13	USTH 10 & TH 301 RT/ST CLOUD	✓		✓		✓		✓✓✓	10	0.6	5	1	1,489,000	34.9%
14	USTH 169 & STEVENS RDCSAH 23/N OFONAMIA	✓		✓		✓		✓✓✓	13	0.4	3	1	1,002,000	36.9%
15	MNTH 371 & CR 126 GREEN GBLS RD LTUT617		✓	✓		✓		✓✓✓	14	0.3	3	1	997,000	38.9%
16	MNTH 23 & FAIRWAY CIR CR58 LT T 145	✓		✓		✓		✓✓✓	15	0.3	4	1	954,000	40.8%
17	USTH 10 & CR 50 RT/3MIW BIGLAKE	✓			✓	✓		✓✓✓	17	0.1	1	1	937,000	42.7%
18	USTH 10 & CSAH 3 LTT 13RT/SHERBURNECO	✓			✓	✓		✓✓✓	19	0.4	1	-	889,000	44.5%
19	USTH 10 & CSAH 104 LT M17 RT/RANDALL		✓	✓		✓		✓✓✓	21	0.1	1	1	780,000	46.0%
20	MNTH 23 & CR 46 LT		✓			✓	✓	✓✓✓	24	0.6	2	1	733,000	47.5%
21	USTH 169 & CSAH 12	✓		✓		✓		✓✓✓	35	0.3	9	-	527,000	48.5%
22	USTH 10 & CR 231 RTT 413 LT/MORRISONCO		✓		✓	✓		✓✓✓	42	0.2	2	-	382,000	49.3%
23	USTH 10 & CR 55/1 MIS CLEARLK		✓		✓	✓		✓✓✓	42	0.3	3	-	382,000	50.0%
24	USTH 10 & CR 65/SHERBURNE CO	✓			✓	✓		✓✓✓	51	0.1	3	-	244,000	50.5%
25	MNTH 371 & CR 115 NASHWAYDR/NOF RND LK	✓	✓			✓		✓✓✓	53	0.3	2	-	241,000	51.0%
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78	USTH 10 & CSAH 35 LT/S OF LITTLE FALLS								36	0.3	-	-	483,000	98.9%
79	USTH 169 & 290TH ST CR 108 T 74								40	0.0	-	1	390,000	99.7%
80	USTH 169 & CSAH 19 RTCR103 LT								64	0.1	-	-	87,000	99.8%
81	USTH 169 & CSAH 16 RTT 99 LT								68	0.0	-	-	75,000	100.0%
82	USTH 169 & 250TH ST CSAH19								78	0.0	-	-	12,000	100.0%

Figure 3.8 District 3 Expressway Intersection Prioritization

Source: Mn/DOT Intersection Crash Data, 2003-2007

- District 4 Expressway Intersections
  - Inventory (**Figure 3.9**) & Priority Ranking (**Figure 3.10**)
  - A total of 29 intersections were inventoried – of the top ranked intersections, 3 received five check marks and 4 received four check marks.
  - The common features among the top ranked intersections include; skewed approach, in/near curve, proximity to STOP signs and railroad crossings, ADT ratio, right angle crashes and presence of development.
  - None of the top seven intersections were above the Critical Crash Rate and the highest crash cost ranked intersection was the number four priority.
  - 6 of 29 intersections had crashes.

#	Intersection	Intersection	Geometry: Skew (y or n)	Geometry: On/Near Curve (within 1/4 mile)	ADT ratio	Proximity: Previous STOP sign (approx miles)	Proximity: RR Crossing (y or n)	Crashes	Severe Right Angle Crashes	Crash Rate	Commercial Area	K	A	B	C	N	Crash Cost ($)	Crash Cost Rank	Notes
1	US 10 & CR 68	+	No	No	0.00	3 miles	No	0	0	0.0	No	0	0	0	0	0	-	24	
2	US 10 & CSAH 17	+	No	No	0.02	4 miles	No	1	0	0.0	Yes	0	0	0	1	0	75,000	14	
3	US 10 & CSAH 44	T	No	No	0.01	1 miles	No	0	0	0.0	No	0	0	0	0	0	-	24	
4	US 10 & CR 86	T	No	No	0.01	3 miles	No	1	0	0.0	Yes	0	0	0	0	1	12,000	18	
5	US 10 & CSAH 23	+	No	No	0.07	7 miles	No	2	0	0.1	No	0	0	1	1	0	196,000	10	
6	US 10 & CSAH 37	+	No	No	0.01	4 miles	No	0	0	0.0	No	0	0	0	0	0	-	24	
7	US 10 & CR 118	T	No	No	0.01	3 miles	No	2	0	0.1	No	0	0	0	0	2	24,000	17	
8	US 10 & CSAH 1	+	No	No	0.03	10 miles	No	1	0	0.0	No	0	0	0	1	0	75,000	14	
9	US 10 & CSAH 5	+	No	No	0.03	10 miles	No	0	0	0.0	Yes	0	0	0	0	0	-	24	
10	US 10 & CR 103	+	Yes	Yes	0.01	6 miles	Yes	2	1	0.1	No	0	1	0	1	0	465,000	4	
11	US 10 & CSAH 51	T	Yes	No	0.01	1 miles	Yes	0	0	0.0	No	0	0	0	0	0	-	24	
12	US 10 & CSAH 13	T	Yes	No	0.08	1 miles	Yes	4	1	0.2	Yes	0	1	1	1	1	598,000	3	
13	US 10 & CSAH 11	+	Yes	No	0.05	6 miles	No	5	0	0.2	Yes	0	0	2	1	2	341,000	6	
14	US 10 & CSAH 15	T	Yes	No	0.03	8 miles	No	4	0	0.2	No	0	0	1	2	1	283,000	8	
15	US 10 & AIRPORT RD	T	Yes	Yes	0.26	2 miles	No	13	1	0.4	Yes	0	1	3	3	6	1,050,000	1	
16	US 10 & CSAH 53	+	Yes	No	0.14	3 miles	Yes	2	0	0.1	Yes	0	0	0	1	1	87,000	12	
17	US 10 & CSAH 10 (W)	+	Yes	Yes	0.15	2 miles	No	4	1	0.2	No	0	2	0	2	0	930,000	2	
18	US 10 & CSAH 10 (E)	T	Yes	Yes	0.08	2 miles	No	1	0	0.1	No	0	0	0	1	0	75,000	14	
19	US 10 & TH 228	+	Yes	Yes	0.10	9 miles	Yes	7	0	0.5	No	0	0	3	0	4	411,000	5	House access
20	US 10 & CSAH 80	T	Yes	Yes	0.24	2 miles	No	1	0	0.1	No	0	0	0	0	1	12,000	18	
21	US 10 & CSAH 53 (2)	+	Yes	Yes	0.02	8 miles	No	3	0	0.3	No	0	0	0	3	0	225,000	9	
22	US 10 & CSAH 137	+	Yes	Yes	0.02	5 miles	Yes	1	0	0.1	No	0	0	0	0	1	12,000	18	
23	US 10 & CSAH 84 (W)	T	No	Yes	0.09	3 miles	No	1	0	0.1	No	0	0	0	0	1	12,000	18	
24	US 10 & CSAH 84 (E)	T	Yes	Yes	0.11	2 miles	No	2	0	0.2	No	0	0	0	1	1	87,000	12	
25	US 10 & CSAH 76	T	Yes	No	0.02	6 miles	No	0	0	0.0	No	0	0	0	0	0	-	24	
26	US 10 & TH 106	+	No	Yes	0.10	7 miles	Yes	4	0	0.3	No	0	0	2	1	1	329,000	7	
27	US 10 & CSAH 143	+	Yes	Yes	0.01	3 miles	Yes	1	0	0.1	No	0	0	0	0	1	12,000	18	
28	US 10 & CSAH 19	T	No	No	0.04	3 miles	No	2	0	0.1	No	0	0	1	0	1	133,000	11	
29	US 10 & CSAH 77	+	No	No	0.05	3 miles	Yes	1	0	0.1	No	0	0	0	0	1	12,000	18	

Figure 3.9 District 4 Expressway Intersection Inventory

Source: Mn/DOT Intersection Crash Data, 2002-2007

Rank	Intersection	Skew 55%	Curve 41%	ADT Ratio 41%	STOP Sign 38%	RR Crossing 31%	Severe Right Angle Crash 14%	Development 24%	Totals	Crash Rate	Crash Cost Rank	Crash Cost	Cumulative Cost
1	US 10 & CSAH 13	✓		✓		✓	✓	✓	✓✓✓✓✓	0.2	3	598,000	11.0%
2	US 10 & CR 103	✓	✓		✓	✓	✓		✓✓✓✓✓	0.1	4	465,000	19.5%
3	US 10 & TH 228	✓	✓	✓	✓	✓			✓✓✓✓✓	0.5	5	411,000	27.0%
4	US 10 & AIRPORT RD	✓	✓				✓	✓	✓✓✓✓	0.4	1	1,050,000	46.3%
5	US 10 & CSAH 11	✓		✓	✓			✓	✓✓✓✓	0.2	6	341,000	52.5%
6	US 10 & TH 106		✓	✓	✓	✓			✓✓✓✓	0.3	7	329,000	58.5%
7	US 10 & CSAH 137	✓	✓		✓	✓			✓✓✓✓	0.1	18	12,000	58.8%
8	US 10 & CSAH 10 (W)	✓	✓				✓		✓✓✓	0.2	2	930,000	75.8%
9	US 10 & CSAH 15	✓		✓	✓				✓✓✓	0.2	8	283,000	81.0%
10	US 10 & CSAH 53 (2)	✓	✓		✓				✓✓✓	0.3	9	225,000	85.1%
11	US 10 & CSAH 53	✓				✓		✓	✓✓✓	0.1	12	87,000	86.7%
12	US 10 & CSAH 84 (E)	✓	✓	✓					✓✓✓	0.2	12	87,000	88.3%
13	US 10 & CSAH 10 (E)	✓	✓	✓					✓✓✓	0.1	14	75,000	89.7%
14	US 10 & CSAH 143	✓	✓			✓			✓✓✓	0.1	18	12,000	89.9%
15	US 10 & CSAH 5			✓	✓			✓	✓✓✓	-	24	-	89.9%
16	US 10 & CSAH 23			✓	✓				✓✓	0.1	10	196,000	93.5%
17	US 10 & CSAH 80	✓	✓						✓✓	0.1	18	12,000	93.7%
18	US 10 & CSAH 84 (W)		✓	✓					✓✓	0.1	18	12,000	93.9%
19	US 10 & CSAH 77			✓		✓			✓✓	0.1	18	12,000	94.2%
20	US 10 & CSAH 51	✓				✓			✓✓	-	24	-	94.2%
21	US 10 & CSAH 76	✓			✓				✓✓	-	24	-	94.2%
22	US 10 & CSAH 19			✓					✓	0.1	11	133,000	96.6%
23	US 10 & CSAH 17							✓	✓	0.0	14	75,000	98.0%
24	US 10 & CSAH 1				✓				✓	0.0	14	75,000	99.3%
25	US 10 & CR 86							✓	✓	0.0	18	12,000	99.6%
26	US 10 & CR 118									0.1	17	24,000	100.0%
27	US 10 & CR 68									-	24	-	100.0%
28	US 10 & CSAH 44									-	24	-	100.0%
29	US 10 & CSAH 37									-	24	-	100.0%

Figure 3.10 District 4 Expressway Intersection Prioritization

Source: Mn/DOT Intersection Crash Data, 2002-2007

- District 7 Expressway Intersections
  - Inventory (**Figure 3.11**) & Priority Ranking (**Figure 3.12**)
  - A total of 57 intersections were inventoried – of the top ranked intersections, 2 received five check marks and 8 received four check marks.
  - The common features among the top ranked intersections include; right angle crashes, skewed approach, in/near curve, ADT ratio, presence of development and proximity to railroad crossing.
  - One of the top ranked intersections was above the Critical Crash Rate and the highest crash cost intersections was not among the top 25 priority intersections.
  - 46 of 57 intersections had crashes.

#	Intersection	Intersection	Geometry Skew (y or n)	Geometry On/Near Curve (within 1/4 mile)	ADT ratio	Proximity Previous STOP sign (approx miles)	Proximity RR Crossing (y or n)	Commercial Area	Crashes	Right Angle Crashes	Crash Rate	K	A	B	C	N	Crash Cost ($)
1	USTH 14 & CSAH 86/W OF EAGLE LAKE	+	No	No	0.05	3 miles	No	No	27	11	0.9	1	2	3	5	16	2,490,000
2	USTH 14 & CSAH 17/EOF EAGLELAKE	+	Yes	No	0.08	6 miles	No	No	18	5	0.6	1	0	3	4	10	1,563,000
3	MNTH 60 & CSAH 50 LTT 373 RT/BLUEE CO	+	No	No	0.01	2 miles	No	No	6	2	0.3	1	0	3	1	1	1,230,000
4	USTH 169 & E JCT CSAH69/2 MIW MANKATO	T	Yes	Yes	0.01	1 miles	No	No	9	2	0.3	1	0	1	1	6	1,048,000
5	MNTH 60 & CSAH 1/MOUNTAIN LAKE	+	No	Yes	0.24	6 miles	No	No	11	7	1.0	0	1	3	3	4	1,026,000
6	USTH 169 & W JCT TH 60/4MI WMANKATO	T	No	No	0.37	10 miles	No	No	20	5	0.5	0	0	2	3	15	647,000
7	USTH 169 & CR 171 RTDAIRY Q CITGOLT	+	No	Yes	0.06	2 miles	No	Yes	12	4	0.4	0	0	2	4	6	614,000
8	MNTH 60 & W JCT CSAH20T 180/LK CRSTL	+	Yes	No	0.12	15 miles	Yes	Yes	11	4	0.6	0	0	3	2	6	585,000
9	USTH 169 & N JCT TH 93 LT/NEARLESUEUR	T	Yes	Yes	0.23	3 miles	No	No	9	1	0.3	0	0	2	4	3	578,000
10	USTH 169 & PEACFULL VLLYRD T16 LT	T	No	No	0.00	3 miles	No	No	9	1	0.3	0	1	0	1	7	549,000
11	USTH 169 & CSAH 33 RT/W SIDE MANKATO	T	Yes	Yes	0.09	1 miles	No	No	12	3	0.3	0	0	3	1	8	534,000
12	USTH 14 & CSAH 48 LT/BLUE EARTH CO	+	Yes	No	0.00	2 miles	No	No	3	1	0.2	0	1	0	1	1	477,000
13	USTH 169 & CSAH 34 LTCR118	+	No	No	0.01	2 miles	No	No	11	1	0.4	0	0	2	1	8	413,000
14	USTH 14 & CSAH 37/COLNSMITHS MILL	+	Yes	Yes	0.06	9 miles	No	No	7	3	0.6	0	0	2	1	4	365,000
15	MNTH 60 & CR 114/2 MI NLAKECRYSTAL	+	Yes	No	0.03	3 miles	Yes	Yes	7	3	0.3	0	0	2	1	4	365,000
16	USTH 14 & CSAH 56 RT/EAGLE LAKE	T	No	Yes	0.09	1 miles	No	No	10	1	0.3	0	0	1	2	7	355,000
17	USTH 169 & W JCT CSAH69LT/4MI WMNKTO	T	Yes	No	0.01	1 miles	No	No	9	1	0.3	0	0	1	2	6	343,000
18	USTH 169 & TH 22 DODDRDPARKRT/STPETER	+	Yes	Yes	0.10	12 miles	No	Yes	16	2	0.5	0	0	1	0	15	301,000
19	USTH 169 & CNTY PARKRT BOAT LANDING LT	+	No	Yes	0.01	1 miles	No	No	5	1	0.2	0	0	1	2	2	295,000
20	USTH 169 & TH 68 LT/WSIDE MANKATO	T	Yes	Yes	0.07	10 miles	No	No	14	3	0.4	0	0	0	2	12	294,000
21	MNTH 60 & CR 115/CRAY CORNER	+	Yes	Yes	0.00	2 miles	Yes	No	12	1	0.6	0	0	0	2	10	270,000
22	MNTH 60 & CSAH 27 LTT 38 RT/MOUNTAINLK	+	No	No	0.23	4 miles	No	No	5	1	0.4	0	0	1	1	3	232,000
23	MNTH 60 & CR 109/W LAKECRYSTAL	+	Yes	No	0.06	2 miles	Yes	No	5	0	0.3	0	0	1	1	3	232,000
24	MNTH 60 & CR 118/BLUE EARTH-WATONCL	+	Yes	No	0.01	2 miles	No	No	10	2	0.7	0	0	1	0	9	229,000
25	MNTH 15 & CSAH 32 LTT 41 RT/N FAIRMONT	+	Yes	Yes	0.04	2 miles	No	Yes	4	2	0.5	0	0	1	1	2	220,000
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54	MNTH 60 & TH 86 RT T156LT/EWILDER	+	Yes	No	0.09	11 miles	Yes	No	0	0	0.0	0	0	0	0	0	-
55	MNTH 60 & CR 47 RT/4MIE BIGHAM LK	T	Yes	No	0.01	4 miles	Yes	No	0	0	0.0	0	0	0	0	0	-
56	MNTH 60 & CSAH 32 RT/3 MI W LK CRYSTAL	T	Yes	No	0.01	3 miles	No	No	0	0	0.0	0	0	0	0	0	-
57	MNTH 960A & 10TH ST CSAH 9/HERON LAKE	+	Yes	Yes	0.21	12 miles	No	No	0	0	0.0	0	0	0	0	0	-

Figure 3.11 District 7 Expressway Intersection Inventory

Source: Mn/DOT Intersection Crash Data, 2003-2007

Rank	Intersection	Skew 56%	Curve 46%	ADT Ratio 37%	RR Crossing 32%	Right Angle Crashes 56%	Development 14%	Totals	Crash Cost Rank	Crash Rate	Right Angle Crashes	Severe Crashes	Crash Cost	Cumulative Cost
1	MNTH 60 & W JCT CSAH20T 180/LK CRSTL	✓		✓	✓	✓	✓	✓✓✓✓✓	8	0.6	4	-	585,000	3.4%
2	USTH 169 & TH 22 DODDRDPARKRT/STPETER	✓	✓	✓		✓	✓	✓✓✓✓✓	18	0.5	2	-	301,000	5.2%
3	USTH 169 & CR 171 RTDAIRY Q CITGOLT		✓	✓		✓	✓	✓✓✓✓	7	0.4	4	-	614,000	8.7%
4	USTH 169 & N JCT TH 93 LT/NEARLESUEUR	✓	✓	✓		✓		✓✓✓✓	9	0.3	1	-	578,000	12.1%
5	USTH 169 & CSAH 33 RT/W SIDE MANKATO	✓	✓	✓		✓		✓✓✓✓	11	0.3	3	-	534,000	15.2%
6	USTH 14 & CSAH 37/COLNSMITHS MILL	✓	✓	✓		✓		✓✓✓✓	14	0.6	3	-	365,000	17.3%
7	MNTH 60 & CR 114/2 MI NLAKECRYSTAL	✓			✓	✓	✓	✓✓✓✓	14	0.3	3	-	365,000	19.4%
8	USTH 169 & TH 68 LT/WSIDE MANKATO	✓	✓	✓		✓		✓✓✓✓	20	0.4	3	-	294,000	21.1%
9	MNTH 60 & CR 115/CRAY CORNER	✓	✓		✓	✓		✓✓✓✓	21	0.6	1	-	270,000	22.7%
10	MNTH 15 & CSAH 32 LTT 41 RT/N FAIRMONT	✓	✓			✓	✓	✓✓✓✓	25	0.5	2	-	220,000	24.0%
11	USTH 14 & CSAH 17/EOF EAGLELAKE	✓		✓		✓		✓✓✓	2	0.6	5	1.0	1,563,000	33.1%
12	USTH 169 & E JCT CSAH69/2 MIW MANKATO	✓	✓			✓		✓✓✓	4	0.3	2	1.0	1,048,000	39.2%
13	MNTH 60 & CSAH 1/MOUNTAIN LAKE		✓	✓		✓		✓✓✓	5	1.0	7	1.0	1,026,000	45.1%
14	USTH 14 & CSAH 56 RT/EAGLE LAKE		✓	✓		✓		✓✓✓	16	0.3	1	-	355,000	47.2%
15	MNTH 60 & CR 109/W LAKECRYSTAL	✓		✓	✓			✓✓✓	22	0.3	-	-	232,000	48.5%
16	USTH 169 & HAPPY CHEFXOVR/MANKATON CL	✓				✓	✓	✓✓✓	27	0.3	1	-	159,000	49.5%
17	MNTH 60 & CSAH 30/5MI SLAKECRYSTAL	✓			✓	✓		✓✓✓	28	0.5	1	-	147,000	50.3%
18	MNTH 15 & CSAH 3/N OF MADELA	✓	✓	✓				✓✓✓	29	0.6	-	-	145,000	51.2%
19	MNTH 60 & CR 112 LTT 530 RT/N LKCRSTL	✓			✓	✓		✓✓✓	37	0.3	3	-	84,000	51.7%
20	MNTH 60 & CSAH 27 LT/MOUNTAINLAKE		✓	✓		✓		✓✓✓	38	0.1	1	-	75,000	52.1%
21	MNTH 60 & CR 119 LTT 151 RT	✓			✓	✓		✓✓✓	40	0.4	1	-	60,000	52.4%
22	MNTH 15 & TH 68/NEWULM		✓	✓			✓	✓✓✓	42	0.5	-	-	48,000	52.7%
23	MNTH 960A & 10TH ST CSAH 9/HERON LAKE	✓	✓	✓				✓✓✓	47	-	-	-	-	52.7%
24	MNTH 60 & TH 86 RT T156LT/EWILDER	✓		✓	✓			✓✓✓	47	-	-	-	-	52.7%
25	USTH 169 & W JCT TH 60/4MI WMANKATO			✓		✓		✓✓	6	0.5	5	-	647,000	56.5%
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54	MNTH 60 & CR 103 RTT 103 LT/E STJAMES					✓		✓	40	0.5	1	-	60,000	99.7%
55	MNTH 60 & CSAH 32 RT/3 MI W LK CRYSTAL	✓						✓	47	-	-	-	-	99.7%
56	MNTH 60 & CR 109/2 MI SS JCTTH 15								42	0.4	-	-	48,000	99.9%
57	MNTH 60 & CR 117 RTT94LT/SS JCTTH15								46	0.1	-	-	12,000	100.0%

Figure 3.12 District 7 Expressway Intersection Prioritization

Source: Mn/DOT Intersection Crash Data, 2003-2007

2-Lane State Highway intersections

- District 3 2-Lane Intersections
  - Inventory (**Figure 3.13**) & Priority Ranking (**Figure 3.14**)
  - A total of 464 intersections were inventoried – of the top ranked intersections, 2 received six check marks and 12 received five check marks.
  - The common features among the top ranked intersections include; in/near curve, ADT ratio, skewed approach, right angle crashes and presence of development.
  - One of the top ranked intersections was above the Critical Crash Rate and the highest crash cost intersection was not among the top 25 priority intersections.
  - 87 of 464 intersections had crashes.

#	Intersection	Intersection	Geometry Skew (y or n)	Geometry On/Near Curve (within 1/4 mile)	ADT ratio	Proximity Previous STOP sign (approx miles)	Proximity RR Crossing (y or n)	Commercial Area	Crashes	Right Angle Crashes	Crash Rate	K	A	B	C	N	Crash Cost ($)
1	MNTH 47 & CSAH 8/S OF BRADFORD	+	No	No	0.49	13 miles	No	No	25	16	1.6	2	0	8	6	9	3,086,000
2	MNTH 25 & FOREST CITY RDCSAH37/NEBUFLO	+	Yes	No	0.20	8 miles	No	No	43	24	1.1	1	2	3	10	27	2,997,000
3	MNTH 65 & CSAH 3	+	No	No	0.10	11 miles	No	No	25	8	1.2	0	3	8	3	11	2,495,000
4	MNTH 15 & CSAH 47 CSAH 136/STAUGUSTA	+	No	No	0.24	6 miles	No	Yes	33	13	1.7	0	0	7	14	12	2,041,000
5	MNTH 55 & CSAH 12/.3MIW BUFFALO	+	Yes	No	0.36	3 miles	Yes	No	48	28	1.6	0	0	7	11	30	2,032,000
6	MNTH 55 & CALDER AVCR 134 LTT 282 RT/B	T	Yes	No	0.12	1 miles	No	No	29	16	1.0	0	2	3	9	15	1,998,000
7	MNTH 47 & TH 95	+	No	No	0.00	8 miles	No	No	26	21	1.7	0	1	10	3	12	1,969,000
8	MNTH 95 & CSAH 7	+	No	No	0.16	5 miles	No	No	12	6	1.3	2	0	1	1	8	1,852,000
9	MNTH 371 & CSAH 16 RTT 133/JENKINSS LIM	+	Yes	No	0.16	13 miles	No	No	14	4	0.7	1	0	4	5	4	1,687,000
10	MNTH 25 & CR 106 & T225	+	Yes	No	0.07	7 miles	No	No	28	12	0.8	0	0	7	8	13	1,603,000
11	MNTH 23 & CSAH 12	+	Yes	Yes	0.16	6 miles	No	No	10	4	0.9	1	0	4	3	2	1,513,000
12	USTH 12 & E JCT TH 239935MI EMONTROSE	T	No	No	0.19	7 miles	No	No	9	5	0.3	1	1	1	1	5	1,426,000
13	MNTH 55 & CSAH 14 RT	T	Yes	Yes	0.06	5 miles	Yes	No	14	7	0.4	1	0	2	2	9	1,280,000
14	MNTH 23 & CSAH 7	+	Yes	No	0.07	3 miles	Yes	No	7	2	0.6	1	0	2	3	1	1,259,000
15	USTH 12 & CR 90 LT CSAH90 RT/INDEPENDNC	+	Yes	Yes	0.09	2 miles	Yes	Yes	17	5	0.5	0	1	3	4	9	1,161,000
16	MNTH 4 & CSAH 32	+	Yes	No	0.31	8 miles	No	No	10	9	3.0	0	1	2	6	1	1,094,000
17	MNTH 55 & BRADSHAW AV DIVISION ST/BUFFAL	+	Yes	No	0.11	1 miles	Yes	No	20	5	0.7	0	1	3	2	14	1,071,000
18	MNTH 371 & S JCT TH 87 LTCR 117 RT	+	No	No	0.30	1 miles	No	Yes	6	4	0.5	0	2	1	2	1	1,063,000
19	MNTH 47 & CR 53 & T193	+	No	No	0.05	2 miles	No	No	6	4	0.5	1	0	2	0	3	1,058,000
20	MNTH 24 & CP COURAGERDCSAH39/NEANDALE	T	Yes	Yes	0.16	2 miles	No	No	8	0	0.6	1	0	0	3	4	1,053,000
21	MNTH 18 & CSAH 10 RTT 713 LT	+	No	Yes	0.03	3 miles	No	No	5	2	0.4	1	0	2	0	2	1,046,000
22	MNTH 18 & CSAH 25 LTCR144 RT/E BRAINERD	+	No	No	0.08	5 miles	No	No	7	3	0.5	1	0	0	3	3	1,041,000
23	MNTH 24 & CSAH 8/NEOF CLEARWATER	+	No	No	0.11	9 miles	No	No	14	0	0.4	0	2	1	0	11	1,033,000
24	MNTH 47 & CSAH 5	+	No	No	0.37	12 miles	No	No	5	3	0.5	1	0	1	1	2	1,000,000
25	MNTH 210 & TH 64/CASSCO	T	Yes	Yes	0.26	34 miles	No	No	14	3	1.1	0	1	3	2	8	999,000
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460	USTH 71 & CR 175 & T774	+	Yes	No	0.06	5 miles	No	No	0	0	0.0	0	0	0	0	0	-
461	USTH 71 & CSAH 2B	T	Yes	No	0.05	9 miles	No	No	0	0	0.0	0	0	0	0	0	-
462	USTH 71 & CSAH 48 &T 517	+	Yes	No	0.05	4 miles	Yes	No	0	0	0.0	0	0	0	0	0	-
463	USTH 71 & CSAH 50 LT	T	Yes	No	0.02	1 miles	No	No	0	0	0.0	0	0	0	0	0	-
464	USTH 71 & CSAH 6 (2)	+	No	No	0.07	4 miles	No	No	0	0	0.0	0	0	0	0	0	-

Figure 3.13 District 3 2-Lane State Highway Intersection Inventory

Source: Mn/DOT Intersection Crash Data, 2003-2007

Rank	Intersection	Skew 50%	Curve 39%	ADT Ratio 65%	RR Crossing 11%	Right Angle Crashes 40%	Development 6%	Totals	Crash Cost Rank	Crash Rate	Right Angle Crashes	Severe Crashes	Crash Cost	Cumulative Cost
1	USTH 12 & CR 90 LT CSAH90 RT/INDEPENDNC	✓	✓	✓	✓	✓	✓	✓✓✓✓✓✓	15	0.5	5	1	1,161,000	0.9%
2	USTH 12 & CSAH 7 LTSHORELINEDR/HOW LK	✓	✓	✓	✓	✓	✓	✓✓✓✓✓✓	77	0.2	1	1	552,000	1.4%
3	MNTH 55 & CSAH 14 RT	✓	✓	✓	✓	✓		✓✓✓✓✓	13	0.4	7	1	1,280,000	2.4%
4	MNTH 55 & CSAH 3 & CR 136	✓	✓	✓	✓	✓		✓✓✓✓✓	51	1.0	9	-	788,000	3.0%
5	MNTH 55 & CSAH 6/3 MI WMAPLELK	✓	✓	✓	✓	✓		✓✓✓✓✓	68	0.5	4	1	636,000	3.5%
6	MNTH 210 & CSAH 36 HRDY LK RDRT T197LT	✓	✓	✓	✓	✓		✓✓✓✓✓	71	0.5	3	-	624,000	4.0%
7	MNTH 55 & CSAH 37 RTCSAH 7 CAMP RD LT	✓	✓	✓	✓	✓		✓✓✓✓✓	112	0.3	5	-	353,000	4.3%
8	USTH 12 & E JCT CSAH92 LAKE SARAHLT/IND	✓	✓	✓	✓	✓		✓✓✓✓✓	112	0.2	1	-	353,000	4.6%
9	MNTH 210 & CSAH 12 RTCR83 LT/E AITKIN		✓	✓	✓	✓	✓	✓✓✓✓✓	122	0.4	2	-	319,000	4.8%
10	MNTH 55 & CR 138 & T311	✓	✓	✓	✓	✓		✓✓✓✓✓	128	0.3	3	-	261,000	5.0%
11	MNTH 23 & CR 214 RTCSAH24 LT	✓	✓	✓	✓	✓		✓✓✓✓✓	205	0.6	2	-	135,000	5.1%
12	MNTH 55 & CSAH 7 & M31	✓	✓	✓	✓	✓		✓✓✓✓✓	276	0.4	3	-	84,000	5.2%
13	MNTH 238 & CSAH 9	✓	✓	✓	✓		✓	✓✓✓✓✓	330	0.4	-	-	12,000	5.2%
14	MNTH 55 & CSAH 56	✓	✓	✓	✓		✓	✓✓✓✓✓	388	-	-	-	-	5.2%
15	MNTH 55 & CSAH 12/.3MIW BUFFALO	✓		✓	✓	✓		✓✓✓✓	5	1.6	28	-	2,032,000	6.8%
16	MNTH 23 & CSAH 12	✓	✓	✓		✓		✓✓✓✓	11	0.9	4	1	1,513,000	8.0%
17	MNTH 23 & CSAH 7	✓		✓	✓	✓		✓✓✓✓	14	0.6	2	1	1,259,000	9.0%
18	MNTH 55 & BRADSHAW AV DIVISION ST/BUFFAL	✓		✓	✓	✓		✓✓✓✓	17	0.7	5	1	1,071,000	9.9%
19	MNTH 210 & TH 64/CASSCO	✓	✓	✓		✓		✓✓✓✓	25	1.1	3	1	999,000	10.7%
20	USTH 12 & CSAH 92 RTMUDLAKERD M20 LT	✓	✓	✓		✓		✓✓✓✓	28	0.4	3	1	963,000	11.4%
21	MNTH 25 & CSAH 11 LTCSAH 14RT/NOF MON	✓	✓	✓		✓		✓✓✓✓	40	0.3	1	1	858,000	12.1%
22	MNTH 371 & CSAH 29 LTCR107 RT/N NISSWA	✓	✓	✓		✓		✓✓✓✓	45	0.5	2	1	820,000	12.8%
23	MNTH 25 & NORMAN AVCSAH32 RT/S FOLEY	✓	✓	✓		✓		✓✓✓✓	48	0.3	1	1	804,000	13.4%
24	MNTH 23 & CSAH 6	✓		✓	✓	✓		✓✓✓✓	56	1.0	2	1	740,000	14.0%
25	MNTH 65 & S JCT CSAH6 RT/3 MI N CAMBRG	✓		✓	✓	✓		✓✓✓✓	60	0.5	5	1	694,000	14.6%
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460	MNTH 65 & CSAH 25								388	-	-	-	-	100.0%
461	MNTH 87 & CSAH 41 LTT 406 RT/CASSCO								388	-	-	-	-	100.0%
462	MNTH 95 & CR 67								388	-	-	-	-	100.0%
463	USTH 71 & CR 132								388	-	-	-	-	100.0%
464	USTH 71 & CR 142 & T77								388	-	-	-	-	100.0%

Figure 3.14 District 3 2-Lane State Highway Intersection Prioritization

Source: Mn/DOT Intersection Crash Data, 2003-2007

- District 4 2-Lane Intersections
  - Inventory (**Figure 3.15**) & Priority Ranking (**Figure 3.16**)
  - A total of 311 intersections were inventoried – of the top ranked intersections, 1 received seven check marks, 1 received six check marks and 18 received five check marks.
  - The common features among the top ranked intersections include; ADT ratio, skewed approach, in/near curve proximity to STOP sign, right angle crashes, presence of development and proximity to railroad crossing.
  - Five of the top ranked intersections were above the Critical Crash Rate and the highest crash cost intersection was not among the top 25 priority intersections.
  - 185 of 311 intersections had crashes.

#	Intersection	Intersection	Geometry Skew (y or n)	Geometry On/Near Curve (within 1/4 mile)	ADT ratio	Proximity Previous STOP sign (approx miles)	Proximity RR Crossing (y or n)	Crashes	Right Angle Crashes	Crash Rate	Commercial Area	K	A	B	C	N	Crash Cost ($)
1	US 10 & CSAH 75	+	Yes	No	0.12	12 miles	Yes	0	0	0.0	Yes	0	0	0	0	0	-
2	US 12 & CR 67	+	No	No	0.04	10 miles	No	0	0	0.0	No	0	0	0	0	0	-
3	US 12 & CSAH 21	+	No	No	0.20	7 miles	No	2	2	1.0	No	0	0	0	1	1	87,000
4	US 12 & CR 77	+	No	No	0.03	5 miles	No	0	0	0.0	No	0	0	0	0	0	-
5	US 12 & CSAH 23	+	No	No	0.06	5 miles	No	0	0	0.0	No	0	0	0	0	0	-
6	US 12 & CR 75	+	No	No	0.01	5 miles	No	0	0	0.0	No	0	0	0	0	0	-
7	US 12 & CSAH 25	+	No	No	0.21	7 miles	No	1	1	0.6	No	0	0	0	0	1	12,000
8	US 12 & CR 80	+	No	No	0.03	6 miles	No	0	0	0.0	No	0	0	0	0	0	-
9	US 12 & CSAH 1	+	No	No	0.23	6 miles	No	1	0	0.6	No	0	0	0	0	1	12,000
10	US 12 & CR 55	+	No	Yes	0.06	8 miles	No	0	0	0.0	No	0	0	0	0	0	-
11	US 12 & TH 119	+	No	Yes	0.36	9 miles	No	0	0	0.0	No	0	0	0	0	0	-
12	US 12 & CSAH 20	+	No	No	0.07	10 miles	No	0	0	0.0	No	0	0	0	0	0	-
13	US 12 & TH 59	+	No	No	1.02	10 miles	No	7	5	1.5	No	1	0	1	3	2	1,150,000
14	US 12 & CR 63	+	No	No	0.01	5 miles	No	0	0	0.0	No	0	0	0	0	0	-
15	US 12 & CSAH 13	+	No	No	0.07	4 miles	No	0	0	0.0	No	0	0	0	0	0	-
16	US 12 & CSAH 17	T	No	Yes	0.12	7 miles	No	1	0	0.3	Yes	0	0	0	1	0	75,000
17	US 12 & CSAH 107 (West)	T	Yes	Yes	0.06	1 miles	No	0	0	0.0	No	0	0	0	0	0	-
18	US 12 & CSAH 15	+	No	Yes	0.08	4 miles	No	0	0	0.0	No	0	0	0	0	0	-
19	US 12 & CSAH 107 (East)	T	Yes	Yes	0.05	3 miles	No	0	0	0.0	No	0	0	0	0	0	-
20	US 12 & CR 73	+	Yes	No	0.01	2 miles	Yes	0	0	0.0	No	0	0	0	0	0	-
21	US 12 & CR 76 (West)	T	Yes	Yes	0.02	1 miles	No	0	0	0.0	No	0	0	0	0	0	-
22	US 12 & CR 76 (East)	T	Yes	Yes	0.02	1 miles	No	0	0	0.0	No	0	0	0	0	0	-
23	US 12 & CSAH 3	T	No	No	0.23	1 miles	No	1	0	0.2	No	0	0	0	1	0	75,000
24	US 12 & CSAH 25	T	Yes	Yes	0.07	2 miles	No	1	0	0.1	No	0	0	0	0	1	12,000
25	US 12 & CR 72	+	Yes	No	0.09	1 miles	Yes	0	0	0.0	Yes	0	0	0	0	0	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
307	MNTH 228 & CSAH 36	+	No	Yes	0.16	6 miles	No	0	0	0.0	No	0	0	0	0	0	-
308	MNTH 235 & CSAH 63	T	No	Yes	0.24	4 miles	No	0	0	0.0	No	0	0	0	0	0	-
309	MNTH 235 & CR 129	T	Yes	Yes	0.17	2 miles	No	2	1	1.9	No	0	0	1	0	1	133,000
310	MNTH 235 & CSAH 79	T	No	Yes	0.49	4 miles	No	0	0	0.0	No	0	0	0	0	0	-
311	MNTH 336 & CSAH 14	T	No	No	0.06	4 miles	No	1	0	0.1	No	0	0	0	0	1	12,000

Figure 3.15 District 4 2-Lane State Highway Intersection Inventory

Source: Mn/DOT Intersection Crash Data, 2002-2007

Rank	Intersection	Skew 52%	Curve 34%	ADT Ratio 66%	Sign 51%	RR Crossing 18%	Right Angle Crash 21%	Development 9%	Totals	Overall Rank	Crash Rate	Right Angle Crashes	Crash Cost	Cumulative Cost
1	MNTH 09 & CSAH 20 (Benson)	✓	✓	✓	✓	✓	✓	✓	✓✓✓✓✓✓✓	74	0.2	1	75,000	0.2%
2	MNTH 210 & CSAH 5 (South)	✓	✓	✓	✓		✓	✓	✓✓✓✓✓✓	33	0.6	1	254,000	1.1%
3	US 59 & TH 28	✓	✓	✓			✓	✓	✓✓✓✓✓	2	1.0	5	1,758,000	6.9%
4	US 59 & CSAH 22	✓	✓	✓	✓		✓		✓✓✓✓✓	15	1.0	7	529,000	8.7%
5	US 75 & CSAH 26	✓	✓		✓	✓	✓		✓✓✓✓✓	23	0.8	5	428,000	10.1%
6	MNTH 29 & TH 55	✓		✓	✓	✓	✓		✓✓✓✓✓	27	0.6	2	319,000	11.2%
7	MNTH 210 & CSAH 35	✓		✓	✓		✓	✓	✓✓✓✓✓	38	0.4	3	208,000	11.9%
8	MNTH 78 & CSAH 10	✓	✓	✓	✓		✓		✓✓✓✓✓	93	0.4	1	12,000	11.9%
9	US 59 & CSAH 17 (Detroit Lakes)	✓	✓	✓	✓		✓		✓✓✓✓✓	47	0.3	1	145,000	12.4%
10	MNTH 210 & CSAH 40		✓	✓	✓		✓	✓	✓✓✓✓✓	93	0.3	1	12,000	12.5%
11	US 59 & CSAH 21	✓	✓	✓			✓	✓	✓✓✓✓✓	93	0.3	1	12,000	12.5%
12	US 59 & CSAH 9	✓	✓	✓	✓			✓	✓✓✓✓✓	93	0.1	-	12,000	12.5%
13	US 10 & CSAH 75	✓		✓	✓	✓		✓	✓✓✓✓✓	127	-	-	-	12.5%
14	US 59 & TH 34	✓	✓	✓	✓			✓	✓✓✓✓✓	127	-	-	-	12.5%
15	US 75 & CSAH 5	✓	✓	✓	✓	✓			✓✓✓✓✓	127	-	-	-	12.5%
16	MNTH 07 & TH 28 CSAH 1	✓	✓	✓	✓	✓			✓✓✓✓✓	127	-	-	-	12.5%
17	MNTH 09 & INDSTL B	✓	✓	✓		✓		✓	✓✓✓✓✓	127	-	-	-	12.5%
18	MNTH 55 & CSAH 5	✓	✓	✓	✓	✓			✓✓✓✓✓	127	-	-	-	12.5%
19	MNTH 210 & CSAH 29	✓	✓	✓	✓			✓	✓✓✓✓✓	127	-	-	-	12.5%
20	MNTH 210 & CSAH 47	✓	✓	✓	✓	✓			✓✓✓✓✓	127	-	-	-	12.5%
21	MNTH 235 & CR 129	✓	✓	✓			✓		✓✓✓✓	51	1.9	1	133,000	13.0%
22	MNTH 27 & TH 28		✓	✓	✓		✓		✓✓✓✓	30	1.7	1	278,000	13.9%
23	MNTH 32 & CSAH 10	✓	✓		✓		✓		✓✓✓✓	24	1.6	8	406,000	15.3%
24	US 75 & TH 55	✓			✓	✓	✓		✓✓✓✓	43	1.6	1	174,000	15.8%
25	MNTH 09 & TH 55	✓			✓	✓	✓		✓✓✓✓	40	1.2	2	196,000	16.5%
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
307	US 75 & CR 67 (South)									127	-	-	-	100.0%
308	US 75 & CR 67 (North)									127	-	-	-	100.0%
309	US 75 & CSAH 22 (South)									127	-	-	-	100.0%
310	MNTH 210 & CR 161									127	-	-	-	100.0%
311	MNTH 210 & CSAH 17									127	-	-	-	100.0%

Figure 3.16 District 4 2-Lane State Highway Intersection Prioritization

Source: Mn/DOT Intersection Crash Data, 2002-2007

- District 7 2-Lane Intersections
  - Inventory (**Figure 3.17**) & Priority Ranking (**Figure 3.18**)
  - A total of 480 intersections were inventoried – the seven top ranked intersections received five check marks (27 additional intersections received four check marks).
  - The common features among the top ranked intersections include; right angle crashes, skewed approach, ADT ratio, in/near curve, proximity to railroad crossing and presence of development.
  - One of the top ranked intersections was above the Critical Crash Rate and the highest crash cost intersection was not among the top 25 priority intersections.
  - 327 of 480 intersections had crashes.

#	Intersection	Intersection	Geometry Skew (y or n)	Geometry On/Near Curve (within 1/4 mile)	ADT ratio	Proximity Previous STOP sign (approx miles)	Proximity RR Crossing (y or n)	Commercial Area	Crashes	Right Angle Crashes	Crash Rate	K	A	B	C	N	Crash Cost ($)
1	MNTH 22 & CSAH 90/SOF MANKATO	+	No	No	0.28	8 miles	No	No	20	13	1.0	1	0	5	4	10	1,805,000
2	MNTH 4 & CSAH 29/NSLEPY EYE	+	No	No	0.00	14 miles	No	No	6	6	1.0	0	4	1	1	0	1,756,000
3	USTH 14 & E JCT TH 15/EOF NEW ULM	+	Yes	Yes	0.34	8 miles	No	Yes	27	9	1.5	0	0	7	5	15	1,402,000
4	MNTH 60 & CSAH 3 RTREEDST LT/WATERVLE	+	Yes	Yes	0.08	4 miles	No	Yes	9	0	1.0	1	1	0	2	5	1,380,000
5	USTH 75 & CSAH 15/SOF LUVERNE	+	No	No	0.08	3 miles	No	No	2	2	0.6	1	1	0	0	0	1,170,000
6	MNTH 21 & TH 99 LT	T	Yes	Yes	0.23	8 miles	No	No	11	2	1.7	1	0	1	1	8	1,072,000
7	MNTH 19 & CSAH 13	+	No	No	0.34	5 miles	No	No	6	2	2.0	0	2	1	1	2	1,000,000
8	USTH 14 & CSAH 27/WEDGEWASECA	+	No	Yes	0.49	6 miles	Yes	No	10	5	0.8	1	0	0	1	8	951,000
9	MNTH 22 & CSAH 3/W OF NORSELAND	+	No	No	0.41	2 miles	No	No	4	2	2.1	1	0	0	2	1	942,000
10	MNTH 19 & CSAH 34 RTT 2LT/EHENDERSON	T	Yes	Yes	0.10	2 miles	No	No	9	3	2.5	0	2	0	1	6	927,000
11	MNTH 4 & S JCT CSAH10LT T120/LONGLK	T	Yes	Yes	0.07	3 miles	No	No	5	1	1.6	1	0	0	1	3	891,000
12	MNTH 62 & CSAH 5	+	No	Yes	0.85	12 miles	No	No	4	3	1.7	1	0	0	1	2	879,000
13	USTH 59 & CSAH 14/4MI NWORTHINGTON	+	No	No	0.22	6 miles	No	No	2	2	0.3	1	0	0	1	0	855,000
14	USTH 14 & CSAH 17 LTCR77 RT/W NMNKTO	+	Yes	Yes	0.02	5 miles	No	No	5	0	0.3	1	0	0	0	4	828,000
15	MNTH 60 & CSAH 44 RT	+	Yes	Yes	0.04	2 miles	No	No	4	1	0.3	1	0	0	0	3	816,000
16	MNTH 19 & CSAH 9 NEWROME	+	No	No	0.57	6 miles	No	No	4	3	1.2	0	2	0	0	2	804,000
17	MNTH 99 & CSAH 5/2 MI ELE CENTER	+	No	No	0.08	4 miles	No	No	2	1	0.3	1	0	0	0	1	792,000
18	USTH 71 & CSAH 25 LT/WINDOM	T	Yes	Yes	0.29	9 miles	Yes	No	2	1	0.4	1	0	0	0	1	792,000
19	MNTH 15 & CSAH 12/4.5 MIN IOWA/MINN SL	+	No	No	0.15	5 miles	No	No	1	1	0.2	1	0	0	0	0	780,000
20	MNTH 68 & CSAH 8 LT	+	No	No	0.03	2 miles	No	No	1	1	0.4	1	0	0	0	0	780,000
21	MNTH 83 & CSAH 15/STCLAIR	+	Yes	No	0.21	4 miles	No	No	4	0	0.7	0	1	3	0	0	753,000
22	MNTH 22 & CSAH 8/4.5MIS GAYLORD	+	No	No	0.39	14 miles	No	No	6	4	1.2	0	1	2	1	2	731,000
23	USTH 59 & S JCT TH 60	T	Yes	No	0.00	4 miles	No	No	5	0	0.6	0	1	2	1	1	719,000
24	MNTH 5 & CSAH 9/ARLINGTON	+	Yes	No	0.34	12 miles	Yes	No	4	2	0.5	0	1	1	2	0	661,000
25	MNTH 60 & CSAH 2 CR102	+	No	No	0.03	3 miles	No	No	4	1	0.5	0	1	2	0	1	644,000
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476	USTH 75 & T 149 LT/3MIS LUVERNE	T	No	No	0.02	3 miles	No	No	0	0	0.0	0	0	0	0	0	-
477	USTH 75 & T 18/4 MIS I90	+	No	No	0.03	2 miles	No	No	0	0	0.0	0	0	0	0	0	-
478	USTH 914A & CR 52 LT T159RT/WOF WASECA	+	Yes	No	0.01	2 miles	Yes	No	0	0	0.0	0	0	0	0	0	-
479	USTH 914A & CSAH 17/4MI EJANESVILLE	+	Yes	No	0.04	4 miles	Yes	No	0	0	0.0	0	0	0	0	0	-
480	USTH 914A & CSAH 33 RTCR68 LT/E JANESVLL	+	Yes	No	0.02	6 miles	Yes	No	0	0	0.0	0	0	0	0	0	-

Figure 3.17 District 7 2-Lane State Highway Intersection Inventory

Source: Mn/DOT Intersection Crash Data, 2003-2007

Rank	Intersection	Skew 37%	Curve 26%	ADT Ratio 65%	RR Crossing 9%	Right Angle Crashes 25%	Development 4%	Totals	Crash Cost Rank	Crash Rate	Right Angle Crashes	Severe Crashes	Crash Cost	Cumulative Cost
1	USTH 14 & E JCT TH 15/EOF NEW ULM	✓	✓	✓		✓	✓	✓✓✓✓✓	3	1.5	9.0	-	1,402,000	2.2%
2	USTH 71 & CSAH 25 LT/WINDOM	✓	✓	✓	✓	✓		✓✓✓✓✓	17	0.4	1.0	1.0	792,000	3.5%
3	USTH 14 & CSAH 27 RT/E SLPY EYE	✓	✓	✓		✓	✓	✓✓✓✓✓	29	0.3	3.0	1.0	535,000	4.3%
4	MNTH 5 & CSAH 34 RTCR69 LT/N ARLNGTN	✓		✓	✓	✓	✓	✓✓✓✓✓	88	0.5	3.0	-	186,000	4.6%
5	USTH 169 & S JCT TH 30 RTT 22LT/AMBOY	✓	✓	✓		✓	✓	✓✓✓✓✓	135	0.7	2.0	-	123,000	4.8%
6	USTH 71 & CENTRAL STCSAH 15M 21/SANBRN	✓	✓	✓	✓	✓		✓✓✓✓✓	138	0.2	1.0	-	121,000	5.0%
7	MNTH 60 & CSAH 2 LTT 194 RT/E BUTTERFLD	✓	✓	✓	✓	✓		✓✓✓✓✓	236	0.2	1.0	-	24,000	5.1%
8	MNTH 60 & CSAH 3 RTREEDST LT/WATERVLE	✓	✓	✓			✓	✓✓✓✓	4	1.0	-	2.0	1,380,000	7.3%
9	MNTH 21 & TH 99 LT	✓	✓	✓		✓		✓✓✓✓	6	1.7	2.0	1.0	1,072,000	9.0%
10	USTH 14 & CSAH 27/WEDGEWASECA		✓	✓	✓	✓		✓✓✓✓	8	0.8	5.0	1.0	951,000	10.5%
11	MNTH 19 & CSAH 34 RTT 2LT/EHENDERSON	✓	✓	✓		✓		✓✓✓✓	10	2.5	3.0	2.0	927,000	12.0%
12	MNTH 4 & S JCT CSAH10LT T120/LONGLK	✓	✓	✓		✓		✓✓✓✓	11	1.6	1.0	1.0	891,000	13.4%
13	MNTH 5 & CSAH 9/ARLINGTON	✓		✓	✓	✓		✓✓✓✓	24	0.5	2.0	1.0	661,000	14.4%
14	MNTH 5 & CSAH 13/EOF GAYLRD	✓		✓	✓	✓		✓✓✓✓	28	0.7	1.0	1.0	564,000	15.3%
15	MNTH 22 & CSAH 21 KASOTARD	✓	✓	✓		✓		✓✓✓✓	41	0.4	4.0	-	406,000	16.0%
16	MNTH 5 & E JCT TH 19/EOF GAYLRD	✓		✓	✓		✓	✓✓✓✓	43	0.5	-	-	404,000	16.6%
17	MNTH 5 & CSAH 15 LT/S EDGE GREENISLE	✓	✓	✓		✓		✓✓✓✓	44	0.3	1.0	1.0	402,000	17.3%
18	USTH 14 & CSAH 10/3MI ESLEEPY EYE	✓		✓	✓	✓		✓✓✓✓	56	0.5	4.0	-	329,000	17.8%
19	MNTH 60 & CSAH 2/BIGELOW	✓		✓	✓	✓		✓✓✓✓	59	1.6	2.0	-	304,000	18.3%
20	USTH 14 & TH 99 LT/NICOLLET	✓	✓	✓		✓		✓✓✓✓	60	1.6	2.0	-	303,000	18.7%
21	MNTH 13 & MAIN ST CSAH 14 LT/WATERVILLE	✓		✓		✓	✓	✓✓✓✓	61	0.6	2.0	-	295,000	19.2%
22	USTH 169 & CSAH 38 LT/GARDEN CITY	✓	✓	✓		✓		✓✓✓✓	63	0.7	1.0	-	283,000	19.7%
23	MNTH 99 & CR 102 RT	✓	✓	✓		✓		✓✓✓✓	85	0.5	1.0	-	198,000	20.0%
24	MNTH 13 & CSAH 28/TOHDLBERG		✓	✓	✓	✓		✓✓✓✓	90	0.5	2.0	-	181,000	20.3%
25	MNTH 15 & CSAH 38 LT	✓	✓	✓		✓		✓✓✓✓	93	0.5	1.0	-	174,000	20.5%
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476	USTH 71 & CR 53 LT T89RT/1MI NTH 30								328	-	-	-	-	100.0%
477	USTH 71 & CSAH 22 RTCR76 LT/N JACKSON								328	-	-	-	-	100.0%
478	USTH 71 & CTNWD CSAH41LT/RDWD COLN								328	-	-	-	-	100.0%
479	USTH 75 & T 149 LT/3MIS LUVERNE								328	-	-	-	-	100.0%
480	USTH 75 & T 18/4 MIS I90								328	-	-	-	-	100.0%

Figure 3.18 District 7 2-Lane State Highway Intersection Prioritization

Source: Mn/DOT Intersection Crash Data, 2003-2007

County Highway intersections

- Olmsted County Highway Intersections
  - Inventory (**Figure 3.19**) & Priority Ranking (**Figure 3.20**)
  - A total of 71 intersections were inventoried – of the top ranked intersections, 2 received five check marks and 8 received four check marks.
  - The common features among the top ranked intersections include; right angle crashes, in/near curve, skewed approach, ADT ratio and proximity to a STOP sign.
  - Five of the top ranked intersections were above the Critical Crash Rate and the highest crash cost intersection was not among the top 25 priority intersections.
  - 45 of 71 intersections had crashes.

#	Intersection	Type	ADT Ratio	Geometry Skew (y or n)	Geometry On/Near Curve (within 1/4 mile)	Proximity Previous STOP (approx miles)	Proximity RR Crossing (y or n)	Commercial Area	Crashes	Right Angle Crashes	Crash Rate	K	A	B	C	N	Crash Cost ($)
1	CSAH 11 & CSAH 21	+	0.19	No	No	5	No	No	7	5	1.2	2	1	1	1	2	2,170,000
2	US 63 & CSAH 14	+	0.51	Yes	No	5	No	No	20	13	1.1	0	1	2	6	11	1,214,000
3	US 63 & CSAH 21	+	0.25	Yes	No	9	No	No	7	3	0.5	1	0	2	1	3	1,133,000
4	TH 42 & CSAH 9	+	0.70	No	No	7	No	No	7	3	0.9	1	0	0	1	5	915,000
5	CSAH 8 & CSAH 16	T	0.18	No	No	4	No	No	4	1	0.9	0	1	3	0	0	753,000
6	CSAH 3 & CSAH 34	+	0.49	No	No	3	No	No	9	8	1.6	0	0	5	1	3	716,000
7	TH 14 & CR 104	+	0.10	Yes	No	1	Yes	No	15	8	0.4	0	0	4	1	10	679,000
8	CSAH 11 & CSAH 9	+	0.47	Yes	Yes	3	No	No	4	3	0.5	0	1	2	0	1	644,000
9	US 63 & CSAH 12/TH 247	+	0.47	No	No	11	No	No	13	9	1.0	0	0	3	2	8	609,000
10	CSAH 3 & CSAH 12	T	0.43	Yes	Yes	4	No	No	3	1	1.2	0	1	1	0	1	523,000
11	CSAH 14 & CR 112	+	0.80	No	No	3	No	No	3	1	0.2	0	0	1	2	0	271,000
12	US 52 & CSAH 19 (east)	+	0.05	No	Yes	2	No	No	3	0	0.3	0	0	2	0	1	254,000
13	TH 30 & CSAH 8	+	0.68	No	No	8	No	No	4	4	0.5	0	0	0	3	1	237,000
14	CSAH 3 & CSAH 5	T	0.45	No	Yes	10	No	No	3	0	0.7	0	0	0	3	0	225,000
15	CSAH 10 & CSAH 9	+	0.81	No	No	6	No	No	3	2	0.9	0	0	1	0	2	145,000
16	US 52 & CSAH 7 (west)	T	0.02	Yes	Yes	4	No	No	3	0	0.3	0	0	1	0	2	145,000
17	US 52 & CSAH 16	+	0.06	Yes	Yes	4	No	No	3	2	0.2	0	0	1	0	2	145,000
18	CSAH 23 & CSAH 19 (east)	T	0.47	Yes	Yes	2	No	No	2	0	2.5	0	0	1	0	1	133,000
19	TH 30 & CSAH 20	+	0.16	No	No	4	No	No	2	0	0.6	0	0	1	0	1	133,000
20	TH 30 & CSAH 15	+	0.10	No	No	6	No	No	2	0	0.4	0	0	1	0	1	133,000
21	CSAH 2 & CSAH 11 (south)	T	0.23	Yes	Yes	4	No	No	2	0	0.3	0	0	1	0	1	133,000
22	CSAH 11 & CSAH 14	T	0.63	No	No	3	No	No	1	0	0.5	0	0	1	0	0	121,000
23	CSAH 25 & CSAH 15	T	0.19	No	No	3	No	No	1	0	0.3	0	0	1	0	0	121,000
24	CSAH 4 & CR 104	T	0.23	Yes	Yes	2	No	No	1	0	0.1	0	0	1	0	0	121,000
25	TH 42 & CSAH 23	+	0.08	No	No	6	No	No	3	2	0.4	0	0	0	1	2	99,000
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67	TH 30 & CSAH 3	+	0.16	No	No	11	No	No	0	0	0.0	0	0	0	0	0	-
68	TH 30 & CSAH 7	T	0.14	No	Yes	2	No	No	0	0	0.0	0	0	0	0	0	-
69	US 14 & CSAH 10	+	0.26	Yes	Yes	12	No	No	0	0	0.0	0	0	0	0	0	-
70	US 14 & CSAH 19	+	0.10	Yes	No	4	Yes	Yes	0	0	0.0	0	0	0	0	0	-
71	US 14 & CSAH 32	+	0.03	Yes	Yes	3	Yes	No	0	0	0.0	0	0	0	0	0	-

Figure 3.19 Olmsted County Highway Intersection Inventory

Source: MnCMAT Crash Data, 2003-2007

Rank	Intersection	Skew 41%	Curve 42%	ADT Ratio 32%	STOP Sign 39%	RR Crossing 6%	Crash 63%	Development 4%	Totals	Overall Rank	Crash Rate	Right Angle Crashes	Severe Crashes	Crash Cost	Cumulative Cost
1	CSAH 3 & CSAH 26	✓	✓		✓		✓	✓	✓✓✓✓✓	27	0.7	1	-	75,000	0.6%
2	CSAH 5 & CSAH 4	✓	✓	✓	✓		✓		✓✓✓✓✓	43	0.2	-	-	12,000	0.7%
3	CSAH 3 & CSAH 12	✓	✓	✓			✓		✓✓✓✓	10	1.2	1	1	523,000	4.9%
4	CSAH 11 & CSAH 9	✓	✓	✓			✓		✓✓✓✓	8	0.5	3	1	644,000	10.0%
5	CSAH 23 & CSAH 19 (east)	✓	✓	✓			✓		✓✓✓✓	18	2.5	-	-	133,000	11.0%
6	US 63 & CSAH 14	✓		✓	✓		✓		✓✓✓✓	2	1.1	13	1	1,214,000	20.7%
7	CSAH 3 & CSAH 5		✓	✓	✓		✓		✓✓✓✓	14	0.7	-	-	225,000	22.5%
8	TH 30 & CSAH 1		✓	✓	✓		✓		✓✓✓✓	34	0.6	1	-	36,000	22.8%
9	CSAH 16 (West) & CSAH 20	✓	✓	✓			✓		✓✓✓✓	39	0.4	-	-	12,000	22.9%
10	US 52 & CSAH 19 (west)	✓	✓		✓		✓		✓✓✓✓	32	0.1	1	-	75,000	23.4%
11	TH 42 & CSAH 9			✓	✓		✓		✓✓✓	4	0.9	3	1	915,000	30.7%
12	US 63 & CSAH 21	✓			✓		✓		✓✓✓	3	0.5	3	1	1,133,000	39.7%
13	US 63 & CSAH 12/TH 247			✓	✓		✓		✓✓✓	9	1.0	9	-	609,000	44.6%
14	CSAH 10 & CSAH 32	✓	✓				✓		✓✓✓	37	0.9	-	-	12,000	44.7%
15	TH 30 & CSAH 8			✓	✓		✓		✓✓✓	13	0.5	4	-	237,000	46.6%
16	TH 14 & CR 104	✓				✓	✓		✓✓✓	7	0.4	8	-	679,000	52.0%
17	CSAH 14 & CSAH 3 (west)			✓	✓		✓		✓✓✓	40	0.4	1	-	12,000	52.1%
18	CSAH 6 & CSAH 8 (west)			✓	✓		✓		✓✓✓	41	0.4	-	-	12,000	52.1%
19	CSAH 4 & CSAH 3 (east)	✓	✓				✓		✓✓✓	26	0.4	-	-	87,000	52.8%
20	TH 42 & CSAH 2 (north)	✓	✓				✓		✓✓✓	35	0.3	-	-	24,000	53.0%
21	CSAH 2 & CSAH 11 (south)	✓	✓				✓		✓✓✓	21	0.3	-	-	133,000	54.1%
22	CSAH 1 & CSAH 16 (south)	✓	✓				✓		✓✓✓	42	0.3	-	-	12,000	54.2%
23	US 52 & CSAH 7 (west)	✓	✓				✓		✓✓✓	16	0.3	-	-	145,000	55.3%
24	US 52 & CSAH 16	✓	✓				✓		✓✓✓	17	0.2	2	-	145,000	56.5%
25	CSAH 34 & CR 104		✓	✓			✓		✓✓✓	29	0.2	1	-	75,000	57.1%
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67	CSAH 1 & CSAH 16 (north)									46	-	-	-	-	100.0%
68	CSAH 10 & CSAH 29									48	-	-	-	-	100.0%
69	CSAH 3 & CSAH 6									60	-	-	-	-	100.0%
70	CSAH 9 & CSAH 7 (east)									63	-	-	-	-	100.0%
71	CSAH 9 & CSAH 7 (west)									64	-	-	-	-	100.0%

Figure 3.20 Olmsted County Highway Intersection Prioritization

Source: MnCMAT Crash Data, 2003-2007

- Ottertail County Highway Intersections
  - Inventory (**Figure 3.21**) & Priority Ranking (**Figure 3.22**)
  - A total of 148 intersections were inventoried – of the top ranked intersections, 5 received five check marks and 11 received four check marks.
  - The common features among the top ranked included; skewed approach, in/near curve, proximity to a STOP sign, right angle crashes and ADT ratio.
  - Seven of the top ranked intersections were above the Critical Crash Rate and the highest crash cost intersection was not among the top 25 priority intersections.
  - 47 of the 148 intersections had crashes.

#	Intersection	Intersection	Geometry Skew (y or n)	Geometry On/Near Curve (within 1/4 mile)	ADT ratio	Proximity Previous STOP sign (approx miles)	Proximity RR Crossing (y or n)	Crashes	Right Angle Crashes	Crash Rate	Commercial Area	K	A	B	C	N	Crash Cost ($)	Crash Cost Rank
1	CSAH 34 & CR 125	+	No	No	0.2	3	No	2	0	0.6	No	2	0	0	0	0	1,560,000	1
2	CSAH 1 & CSAH 35	+	No	No	0.5	16	No	5	3	0.9	No	0	2	1	1	1	988,000	2
3	CSAH 52 & CSAH 67	+	No	No	0.5	7	No	2	1	0.9	No	0	1	1	0	0	511,000	3
4	CSAH 10 & CSAH 21	+	No	No	0.6	3	No	2	2	1.9	No	0	1	0	1	0	465,000	4
5	CSAH 13 & CSAH 60	T	No	No	0.3	5	No	1	0	0.6	No	0	1	0	0	0	390,000	5
6	CSAH 14 & CSAH 67	T	Yes	Yes	0.3	8	No	1	0	0.5	No	0	1	0	0	0	390,000	5
7	CSAH 5 & CSAH 16	T	No	Yes	0.4	6	No	1	0	0.8	No	0	1	0	0	0	390,000	5
8	CSAH 16 & CSAH 61	+	No	No	0.1	6	No	1	0	0.6	No	0	1	0	0	0	390,000	5
9	CSAH 40 & CSAH 65	+	Yes	Yes	0.7	6	No	1	1	0.8	No	0	1	0	0	0	390,000	5
10	CSAH 1 & CSAH 14	T	Yes	Yes	0.2	3	No	1	0	0.3	No	0	1	0	0	0	390,000	5
11	CSAH 34 & CSAH 35	T	No	Yes	0.5	3	No	1	0	0.6	No	0	1	0	0	0	390,000	5
12	CSAH 46 & CSAH 69	T	No	No	0.3	3	No	2	0	2.3	No	0	0	2	0	0	242,000	12
13	CSAH 20 & CSAH 31	T	No	Yes	0.4	3	No	2	0	0.8	No	0	0	1	1	0	196,000	13
14	CSAH 72 & CSAH 83	T	No	No	0.4	1	No	2	2	1.6	No	0	0	0	2	0	150,000	14
15	CSAH 10 & CSAH 27	+	No	No	0.5	4	No	2	2	0.3	No	0	0	1	0	1	133,000	15
16	CSAH 9 & CSAH 23	+	No	No	0.1	5	No	2	1	0.8	No	0	0	1	0	1	133,000	15
17	CSAH 33 & CR 120	T	Yes	Yes	0.9	2	No	1	0	1.0	No	0	0	1	0	0	121,000	17
18	CSAH 8 & CSAH 13	T	Yes	Yes	0.3	5	No	1	0	0.3	No	0	0	1	0	0	121,000	17
19	CSAH 22 & CSAH 27	+	Yes	Yes	0.4	6	No	1	0	0.2	No	0	0	1	0	0	121,000	17
20	CSAH 21 & CSAH 88	+	Yes	No	0.4	7	Yes	1	0	0.8	No	0	0	1	0	0	121,000	17
21	CSAH 1 & CSAH 26	+	No	No	0.4	11	No	4	1	2.2	No	0	0	0	1	3	111,000	21
22	CSAH 8 & CSAH 53	+	No	No	0.4	7	No	2	1	0.9	No	0	0	0	1	1	87,000	22
23	CSAH 24 & CSAH 27	T	No	Yes	0.2	12	No	2	2	1.7	No	0	0	0	1	1	87,000	22
24	CSAH 1 & CSAH 18	T	No	No	0.1	7	No	1	0	0.2	No	0	0	0	1	0	75,000	24
25	CSAH 1 & CR 110	+	No	No	0.1	2	No	1	1	0.7	No	0	0	0	1	0	75,000	24
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
144	CSAH 21 7 CSAH 28	+	No	No	0.6	7	No	0	0	0.0	No	0	0	0	0	0	-	46
145	CSAH 11 & CSAH 28	+	No	No	0.3	3	No	0	0	0.0	No	0	0	0	0	0	-	46
146	CSAH 23 & CR 113	T	Yes	Yes	0.4	3	No	0	0	0.0	No	0	0	0	0	0	-	46
147	CSAH 21 & CR 118	+	No	No	0.2	3	No	0	0	0.0	No	0	0	0	0	0	-	46
148	CSAH 21 & CSAH 30	+	Yes	Yes	0.8	4	No	0	0	0.0	No	0	0	0	0	0	-	46

Figure 3.21 Otter Tail County Highway Intersection Inventory

Source: MnCMAT Crash Data, 2003-2007

Rank	Intersection	Skew 34%	Curve 43%	ADT Ratio 29%	STOP Sign 53%	RR Crossing 3%	Crash 30%	Development 5%	Totals	Crash Rate	Right Angle Crashes	Crash Cost	Cumulative Cost
1	CSAH 40 & CSAH 65	✓	✓	✓	✓		✓		✓✓✓✓✓	0.8	1	390,000	4.5%
2	CSAH 21 & CSAH 88	✓		✓	✓	✓	✓		✓✓✓✓✓	0.8	1	121,000	5.9%
3	CSAH 83 & CR 122	✓	✓	✓	✓		✓		✓✓✓✓✓	0.7	1	12,000	6.0%
4	CSAH 22 & CSAH 27	✓	✓	✓	✓		✓		✓✓✓✓✓	0.2	1	121,000	7.4%
5	CSAH 9 & CSAH 20	✓	✓	✓	✓			✓	✓✓✓✓✓	-	-	-	7.4%
6	CSAH 38 & CSAH 81	✓	✓		✓		✓		✓✓✓✓	1.3	1	75,000	8.3%
7	CSAH 5 & CSAH 16		✓	✓	✓		✓		✓✓✓✓	0.8	1	390,000	12.8%
8	CSAH 10 & CSAH 88	✓		✓		✓	✓		✓✓✓✓	0.7	1	12,000	12.9%
9	CSAH 35 & CSAH 41	✓	✓		✓		✓		✓✓✓✓	0.6	1	12,000	13.1%
10	CSAH 14 & CSAH 67	✓	✓		✓		✓		✓✓✓✓	0.5	1	390,000	17.6%
11	CSAH 4 & CSAH 31	✓	✓		✓		✓		✓✓✓✓	0.3	1	12,000	17.7%
12	CSAH 8 & CSAH 13	✓	✓		✓		✓		✓✓✓✓	0.3	1	121,000	19.1%
13	CSAH 3 & CSAH 22	✓	✓	✓	✓				✓✓✓✓	-	-	-	19.1%
14	CSAH 32 & CSAH 74	✓	✓	✓	✓				✓✓✓✓	-	-	-	19.1%
15	CSAH 1 & CSAH 15	✓	✓		✓			✓	✓✓✓✓	-	-	-	19.1%
16	CSAH 53 & CR 157	✓	✓	✓	✓				✓✓✓✓	-	-	-	19.1%
17	CSAH 24 & CSAH 27		✓		✓		✓		✓✓✓	1.7	2	87,000	20.1%
18	CSAH 40 & CSAH 75	✓	✓				✓		✓✓✓	1.5	1	12,000	20.3%
19	CSAH 33 & CR 120	✓	✓				✓		✓✓✓	1.0	1	121,000	21.7%
20	CSAH 8 & CSAH 53			✓	✓		✓		✓✓✓	0.9	2	87,000	22.7%
21	CSAH 1 & CSAH 35			✓	✓		✓		✓✓✓	0.9	5	988,000	34.1%
22	CSAH 52 & CSAH 67			✓	✓		✓		✓✓✓	0.9	2	511,000	40.0%
23	CSAH 51 & CSAH 60			✓	✓		✓		✓✓✓	0.7	1	75,000	40.9%
24	CSAH 34 & CSAH 35		✓	✓			✓		✓✓✓	0.6	1	390,000	45.4%
25	CSAH 4 & CSAH 41	✓			✓		✓		✓✓✓	0.4	1	12,000	45.5%
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-	-	-	-	-	-	-	-	-	-	-	-	-	-
144	CSAH 19 & CR 144									-	-	-	100.0%
145	CR 135 & CR 142									-	-	-	100.0%
146	CSAH 52 & CR 143									-	-	-	100.0%
147	CSAH 42 & CSAH 48									-	-	-	100.0%
148	CR 138 & CR 139									-	-	-	100.0%

Figure 3.22 Otter Tail County Highway Intersection Prioritization

Source: MnCMAT Crash Data, 2003-2007

- Scott County Highway Intersections
  - Inventory (**Figure 3.23**) & Priority Ranking (**Figure 3.24**)
  - A total of 96 intersections were included in the inventory – of the top ranked intersections, 2 received five check marks and 7 received four check marks.
  - The common features among the top ranked intersections included; skewed approach, in/near curve, right angle crashes, ADT ratio and proximity to a STOP sign.
  - Three of the top ranked intersections were above the Critical Crash Rate and the highest crash cost intersections was ranked 10th on the priority list.
  - 64 of the 96 intersections had crashes.

#	Intersection	Intersection	ADT Ratio	Geometry Skew (y or n)	Geometry On/Near Curve (within 1/4 mile)	Proximity Previous STOP (approx miles)	Proximity RR Crossing (y or n)	Commercial Area	Crashes	Right Angle Crashes	Crash Rate	K	A	B	C	N	Crash Cost ($)
1	CSAH 2 & CSAH 46	+	0.70	No	Yes	3	No	No	14	6	1.21	-	5	-	5	4	2,373,000
2	CR 69 & CSAH 78	+	0.20	No	No	2	No	No	20	13	1.63	1	1	6	3	9	2,229,000
3	CSAH 68 & CR 91	+	0.60	Yes	Yes	4	No	No	9	6	1.01	2	-	3	2	2	2,097,000
4	CSAH 2 & CR 89	+	0.15	No	No	4	No	No	13	9	2.26	1	-	5	2	5	1,595,000
5	CSAH 29 & CSAH 46	+	0.06	No	No	2	No	No	7	2	0.68	1	-	5	1	-	1,460,000
6	Hwy 13 & CSAH 2	+	0.63	Yes	No	8	No	No	19	13	1.37	-	-	7	6	6	1,369,000
7	CSAH 46 & CSAH 86	+	0.97	No	No	9	No	No	10	2	0.99	-	2	3	1	4	1,266,000
8	CSAH 2 & CSAH 91	+	0.31	No	No	5	No	No	15	5	0.91	-	1	4	4	6	1,246,000
9	Hwy 13 & CSAH 8	+	0.34	No	No	6	No	No	10	5	0.59	1	-	2	2	5	1,232,000
10	CSAH 23 & CSAH 86	T	0.17	No	No	2	No	No	7	1	0.75	-	2	-	1	4	903,000
11	CSAH 8 & CR 91	+	0.22	No	Yes	5	No	No	9	3	0.64	-	1	2	3	3	893,000
12	Hwy 13 & CR 64	+	0.10	No	No	3	No	No	4	1	0.38	1	-	-	-	3	816,000
13	CSAH 27 & CSAH 68	+	0.66	No	No	3	No	No	7	2	0.56	-	1	1	2	3	697,000
14	CSAH 12 & CSAH 17	T	0.12	Yes	Yes	3	No	No	3	2	0.23	-	1	1	-	1	523,000
15	Hwy 19 & CSAH 3	+	0.57	No	No	5	No	No	4	3	0.71	-	1	-	1	2	489,000
16	Hwy 13 & CR 89	+	0.02	No	No	2	No	Yes	8	0	0.47	-	-	2	2	4	440,000
17	CSAH 4 & CSAH 7	T	0.16	No	Yes	2	No	No	3	0	1.18	-	1	-	-	2	414,000
18	CSAH 27 & CR 62	+	0.14	No	No	2	No	No	3	0	0.55	-	1	-	-	2	414,000
19	CSAH 59 & CR 64 (North)	T	0.28	Yes	No	4	No	No	1	0	0.58	-	1	-	-	-	390,000
20	Hwy 19 & CSAH 11	+	0.28	Yes	Yes	7	No	No	8	0	1.00	-	-	-	2	6	222,000
21	Hwy 13 & CSAH 10	+	0.11	Yes	Yes	6	No	No	4	1	0.24	-	-	1	1	2	220,000
22	CSAH 10 & CSAH 23	+	0.27	No	No	1	No	No	3	0	0.47	-	-	1	1	1	208,000
23	CSAH 14 & CSAH 15	+	0.56	No	No	3	No	No	3	1	0.44	-	-	1	1	1	208,000
24	CR 77 & CSAH 78	T	0.09	No	No	1	No	No	2	1	0.23	-	-	1	1	-	196,000
25	CSAH 15 & CSAH 78	+	0.69	No	No	2	No	No	5	2	0.38	-	-	-	2	3	186,000
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92	CSAH 27 & CR 84	T	0.01	Yes	No	2	No	No	0	0	0.00	-	-	-	-	-	-
93	CSAH 27 & CR 75	T	0.03	Yes	No	1	No	No	0	0	0.00	-	-	-	-	-	-
94	CSAH 68 & CR 87 (East)	T	0.18	No	No	2	No	No	0	0	0.00	-	-	-	-	-	-
95	CR 70 & CR 79	+	0.12	No	No	2	No	No	0	0	0.00	-	-	-	-	-	-
96	CR 73 & CSAH 78	T	0.01	No	No	2	No	No	0	0	0.00	-	-	-	-	-	-

Figure 3.23 Scott County Highway Intersection Inventory

Source: MnCMAT Crash Data, 2003-2007

Rank	Intersection	Skew 29%	Curve 30%	ADT Ratio 34%	STOP Sign 19%	RR Crossing 1%	Crash 67%	Development 4%	Totals	Overall Rank	Crash Rate	Right Angle Crashes	Crash Cost	Cumulative Cost
1	Hwy 19 & CSAH 86	✓	✓	✓	✓		✓		✓✓✓✓✓	29	0.2	-	150,000	0.6%
2	CSAH 8 & CSAH 23 (North)	✓	✓	✓			✓	✓	✓✓✓✓✓	41	0.6	-	111,000	1.0%
3	CSAH 68 & CR 91	✓	✓	✓			✓		✓✓✓✓	3	1.0	6	2,097,000	9.3%
4	Hwy 13 & CSAH 2	✓		✓	✓		✓		✓✓✓✓	6	1.4	13	1,369,000	14.7%
5	Hwy 19 & CSAH 11	✓	✓		✓		✓		✓✓✓✓	20	1.0	-	222,000	15.6%
6	Hwy 13 & CSAH 10	✓	✓		✓		✓		✓✓✓✓	21	0.2	1	220,000	16.4%
7	CSAH 8 & CSAH 23 (South)		✓	✓			✓	✓	✓✓✓✓	33	0.3	-	133,000	17.0%
8	CSAH 46 & CR 62	✓	✓	✓			✓		✓✓✓✓	46	0.3	1	87,000	17.3%
9	CSAH 1 & CR 51	✓	✓	✓	✓				✓✓✓✓	65	-	-	-	17.3%
10	CSAH 2 & CSAH 46		✓	✓			✓		✓✓✓	1	1.2	6	2,373,000	26.7%
11	CSAH 2 & CSAH 91			✓	✓		✓		✓✓✓	8	0.9	5	1,246,000	31.6%
12	Hwy 13 & CSAH 8			✓	✓		✓		✓✓✓	9	0.6	5	1,232,000	36.4%
13	CSAH 8 & CR 91		✓		✓		✓		✓✓✓	11	0.6	3	893,000	39.9%
14	CSAH 12 & CSAH 17	✓	✓				✓		✓✓✓	14	0.2	2	523,000	42.0%
15	Hwy 19 & CSAH 3			✓	✓		✓		✓✓✓	15	0.7	3	489,000	43.9%
16	Hwy 21 & CSAH 2		✓			✓	✓		✓✓✓	30	0.7	5	147,000	44.5%
17	CSAH 10 & CR 79	✓		✓			✓		✓✓✓	31	0.8	-	133,000	45.0%
18	Hwy 19 & CSAH 5	✓			✓		✓		✓✓✓	36	0.2	-	121,000	45.5%
19	Hwy 13 & CR 56	✓	✓				✓		✓✓✓	37	0.1	-	121,000	46.0%
20	CSAH 8 & CSAH 27		✓	✓			✓		✓✓✓	40	0.3	-	111,000	46.4%
21	Hwy 21 & CSAH 8	✓			✓		✓		✓✓✓	42	0.3	1	99,000	46.8%
22	CSAH 2 & CSAH 27			✓	✓		✓		✓✓✓	43	0.3	-	99,000	47.2%
23	CSAH 1 & CSAH 6		✓	✓			✓		✓✓✓	47	0.5	1	75,000	47.5%
24	Hwy 19 & CSAH 7				✓		✓	✓	✓✓✓	52	0.5	-	36,000	47.6%
25	CSAH 59 & CR 66	✓	✓	✓					✓✓✓	69	-	-	-	47.6%
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92	CR 62 & CSAH 91 (South)									86	-	-	-	100.0%
93	CR 62 & CSAH 91 (North)									87	-	-	-	100.0%
94	CSAH 68 & CR 87 (East)									94	-	-	-	100.0%
95	CR 70 & CR 79									95	-	-	-	100.0%
96	CR 73 & CSAH 78									96	-	-	-	100.0%

Figure 3.24 Scott County Highway Intersection Prioritization

Source: MnCMAT Crash Data, 2003-2007

Urban 2-Lane Highway Intersections

- Scott County Urban 2-Lane Highway Intersections
  - An opportunity presented it self to test the methodology in an urban setting in Scott County, as part of their safety plan development. The criteria was modified to reflect that horizontal curves are less of an issue in urban areas with a grid pattern of streets and proximity to driveways and traffic signals were more of an issue.
  - Inventory (**Figure 3.25**) & Priority Ranking (**Figure 3.26**)
  - A total of 20 intersections were included in the inventory – of the top ranked intersections, 4 received three check marks.
  - The common features among the top ranked intersections included; skewed approaches, ADT ratio, angle crashes and proximity to a traffic signal (note, for urban locations the criteria was modified – in/near curve was dropped, proximity to signals was added).
  - Two of the top ranked intersections were above the Critical Crash Rate and the two highest crash cost intersections were also the highest priority intersections.

					Main Road															
					Geometry			Spacing												
#	Intersection	Intersection	ADT Ratio	Skew	Lanes	Divided or Undivided	Near Residental Driveways	Nearest Intersection	Nearest Sig. Intersection	Left Turn Lanes	Commercial Area	Crashes	Severe Angle Crashes	Crash Rate	K	A	B	C	N	Crash Cost ($)
1	CSAH 17 & CR 42	+	0.39	Yes	2	Undivided	No	0.4	1.1	No	No	44	3	1.73	1	2	10	11	20	3,835,000
2	US 169 & CSAH 3	+	0.29	Yes	4	Divided	No	0.8		Yes	No	61	1	1.53	1	-	4	19	37	3,133,000
3	CSAH 16 & CSAH 18 (South)	T	0.23	Yes	4	Divided	No	0.3	0.9	Yes	No	29	2	0.86	-	2	2	3	22	1,511,000
4	CSAH 17 & CSAH 82	T	0.43	Yes	2	Undivided	No	0.2	2.5	No	No	20	0	1.09	-	1	4	2	13	1,180,000
5	CSAH 78 & CR 79	+	0.53	No	2	Undivided	Yes	0.3	0.7	No	No	11	0	0.77	-	1	-	4	6	762,000
6	CSAH 81 & CSAH 82	T	0.02	Yes	4	Divided	No	0.3	2.0	Yes	No	4	0	0.34	-	1	2	-	1	644,000
7	CSAH 14 & CSAH 17	T	0.20	No	2	Undivided	No	0.2	2.0	No	No	8	0	0.48	-	-	3	1	4	486,000
8	CSAH 27 & CSAH 44	T	0.34	Yes	2	Undivided	No	0.5	0.6	No	No	15	0	0.59	-	-	1	2	12	415,000
9	Hwy 13 & CSAH 12	T	0.21	Yes	2	Divided	No	0.2	0.3	No	No	7	0	0.32	-	-	3	-	4	411,000
10	CSAH 5 & CSAH 7	+	0.82	No	2	Undivided	No	0.1		No	No	11	0	1.16	-	-	1	2	8	367,000
11	Hwy 13 & CSAH 15	+	0.15	No	2	Undivided	No	0.1	0.6	No	Yes	8	0	0.39	-	-	-	2	6	222,000
12	CSAH 16 & CSAH 18 (North)	T	0.10	Yes	4	Divided	No	0.2	0.6	Yes	No	13	0	0.36	-	-	-	1	12	219,000
13	Hwy 21 & CR 61	+	0.25	No	2	Undivided	No	0.1	0.7	Yes	No	4	0	0.23	-	-	-	1	3	111,000
14	CSAH 15 & CSAH 37	+	0.63	No	2	Undivided	No	0.2		No	No	6	0	0.35	-	-	-	-	6	72,000
15	Hwy 25 & CSAH 6 (North)	+	0.07	No	2	Undivided	Yes	0.1		No	No	1	0	0.08	-	-	-	-	1	12,000
16	Hwy 21 & CSAH 37	T	0.29	No	2	Undivided	No	0.02		No	Yes	1	0	0.07	-	-	-	-	1	12,000
17	Hwy 282 & CSAH 10	T	0.15	Yes	2	Undivided	No	0.2	0.6	No	No	1	0	0.08	-	-	-	-	1	12,000
18	CSAH 12 & CSAH 81	T	0.05	Yes	2	Undivided	Yes	0.1		No	No	1	0	0.23	-	-	-	-	1	12,000
19	CSAH 15 & CSAH 16	T	0.70	No	2	Undivided	Yes	0.2		No	No	1	0	0.09	-	-	-	-	1	12,000
20	CR 61 & CR 66	+	0.60	No	2	Undivided	No	0.2		No	No	0	0	0.00	-	-	-	-	-	-

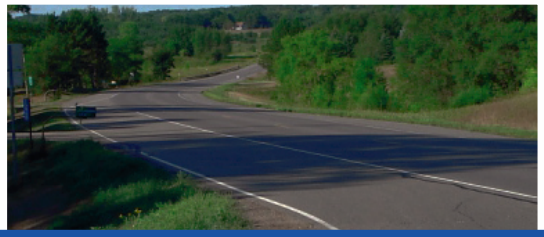
Figure 3.25 Scott County Highway Urban Intersection Inventory

Source: MnCMAT Crash Data, 2003-2007

Rank	Intersection	Skew 50%	Driveways 20%	ADT Ratio 55%	STOP Sign 30%	Severe Angle 15%	Commercial 10%	Totals	Overall Rank	Crash Rate	Crash Cost	Cumulative Cost
1	CSAH 17 & CR 42	✓		✓		✓		✓✓✓	1	1.7	3,835,000	28.6%
2	US 169 & CSAH 3	✓		✓		✓		✓✓✓	2	1.5	3,133,000	51.9%
3	Hwy 21 & CSAH 37			✓	✓		✓	✓✓✓	16	0.1	12,000	52.0%
4	CSAH 12 & CSAH 81	✓	✓		✓			✓✓✓	14	0.2	12,000	52.1%
5	CSAH 16 & CSAH 18 (South)	✓				✓		✓✓	2	0.9	1,511,000	63.3%
6	CSAH 17 & CSAH 82	✓		✓				✓✓	3	1.1	1,180,000	72.1%
7	CSAH 78 & CR 79		✓	✓				✓✓	4	0.8	762,000	77.8%
8	CSAH 27 & CSAH 44	✓		✓				✓✓	6	0.6	415,000	80.9%
9	CSAH 5 & CSAH 7			✓	✓			✓✓	10	1.2	367,000	83.6%
10	Hwy 13 & CSAH 15				✓		✓	✓✓	8	0.4	222,000	85.3%
11	Hwy 21 & CR 61			✓	✓			✓✓	10	0.2	111,000	86.1%
12	Hwy 25 & CSAH 6 (North)		✓		✓			✓✓	12	0.1	12,000	86.2%
13	CSAH 15 & CSAH 16		✓	✓				✓✓	15	0.1	12,000	86.3%
14	CSAH 81 & CSAH 82	✓						✓	6	0.3	644,000	91.1%
15	Hwy 13 & CSAH 12	✓						✓	7	0.3	411,000	94.1%
16	CSAH 16 & CSAH 18 (North)	✓						✓	9	0.4	219,000	95.8%
17	CSAH 15 & CSAH 37			✓				✓	11	0.3	72,000	96.3%
18	Hwy 282 & CSAH 10	✓						✓	13	0.1	12,000	96.4%
19	CR 61 & CR 66			✓				✓	16	-	-	96.4%
20	CSAH 14 & CSAH 17								5	0.5	486,000	100.0%

Figure 3.26 Scott County Highway Urban Intersection Prioritization

Source: MnCMAT Crash Data, 2003-2007



Project Development

Project Development

The objective of this research effort is to provide a new tool to assist agency staff to create a comprehensive list of intersection candidates for safety investment that includes both a reactive and proactive component. The approach to identifying the reactive component is well established – use some combination of crash frequency, crash rate and crash costs to identify "Black Spot" locations where the occurrence of crashes is much higher than for similar locations. The approach to identifying the proactive component has never existed, at least not to the point where a uniform or consistent process was adopted by agencies across Minnesota – the questions always came back to two points; how can at-risk intersections be identified and are there really any low-cost strategies that we can rely on to reduce crashes across our system?

The previous Chapter identified a number of geometric, traffic volume and traffic control criteria and a check list methodology that could be used to identify at-risk intersections and the initial testing suggests that this approach is feasible (it only required a modest level of effort and the necessary data was generally available) and produces a reasonable list of candidates. This section focuses the discussion on the second question – can the approach help identify a reasonable list of possible safety improvement strategies?

The detailed crash analysis conducted in support of this research identified several key crash and roadway environment factors that appear to be contributing to the crashes and point towards a short list of potential safety strategies. First and foremost, right angle crashes are the type of crash that are over represented at rural, STOP controlled intersections on both the State and county systems (**Figure 4.1**). These angle crashes are also the most severe and the fraction of angle crashes approaches 100% at the intersections with multiple severe crashes and at the intersections above the Critical crash rate – when these intersections go bad (from a crash/safety perspective) it is almost always because of angle crashes (as opposed to turning crashes, rear end crashes, etc).

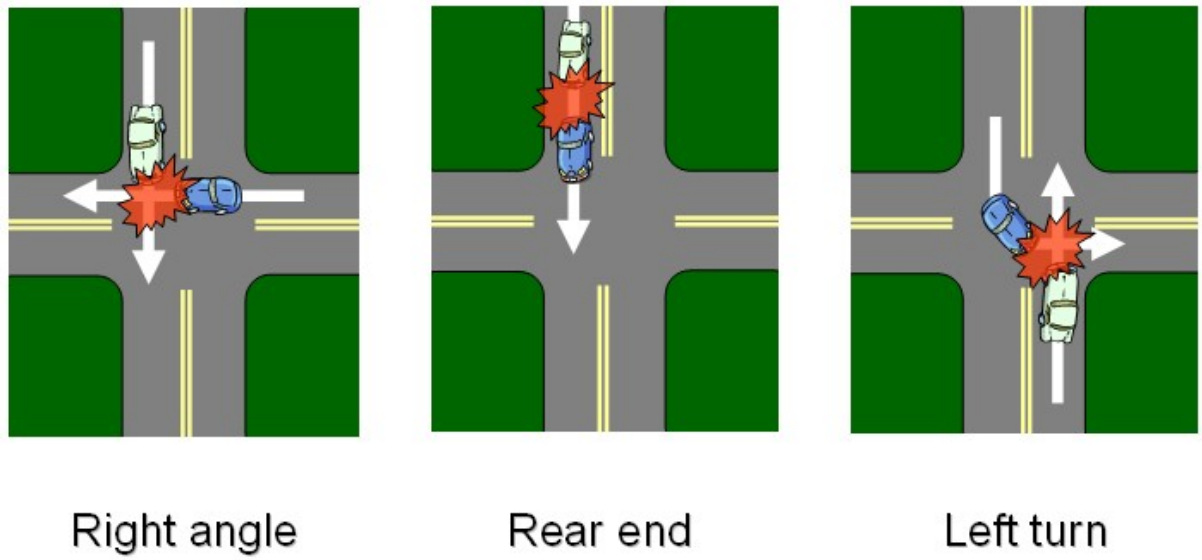


Figure 4.1 Crash Types
Source: FHWA

The detailed crash analysis also confirmed that the majority of the angle crashes involved a vehicle on the minor road that stopped and then pulled out into the major road (a gap recognition crash), as opposed to the minor road vehicle running the STOP sign. This suggests that at rural intersections, both the reactive and proactive components of the safety program need to focus on safety strategies that effectively address gap recognition angle crashes. The possible list of safety strategies is also influenced by Benefit/Cost requirements of Minnesota's Highway Safety Improvement Program – projects on the reactive side are likely to be more costly (even thought they need to have a B/C > 1) because the crash costs at these locations are generally high and projects on the proactive side are likely to be relatively low-cost because to be effective the strategies need to be widely deployed at a number of locations.

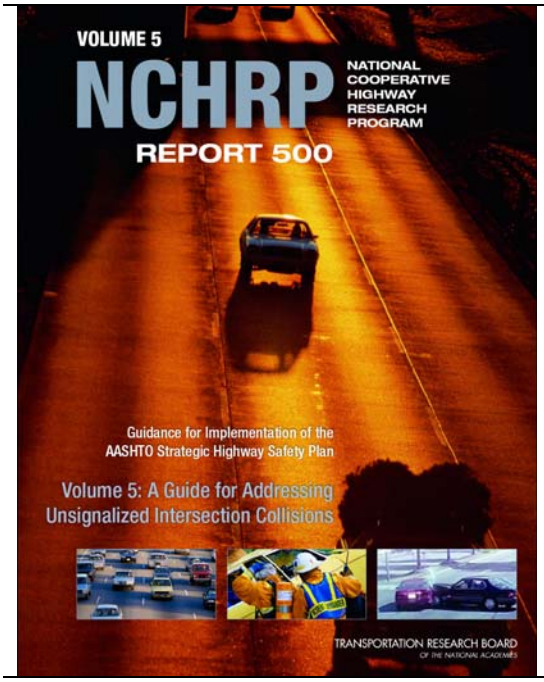


Figure 4.2 NCHRP 500 Report Cover

A search of the safety literature (Volume 5, NCHRP Report 500, A Guide for Addressing Unsignalized Intersection Collisions (**Figure 4.2**); NCHRP 15-30, Median Intersection Design for Rural High-Speed Divided Highways and Low-Cost Safety Concepts for Two-Way STOP Controlled Rural Intersections, FHWA-HRT-08-063) found more than fifty potential safety strategies that could be applied at expressway and 2-lane highway intersections. However, a number of these strategies are intended to mitigate turning and rear end crashes and several more are clearly intended for urban locations. The remaining strategies that focus on mitigating

angle crashes at rural locations include improving geometry, traffic control devices, new technologies, street lighting and in the case of expressways median restrictions, partial and full grade separations. An overview of a sample of both reactive and proactive intersection safety strategies is provided below.

Expressway Intersection Safety Strategies

Reactive Component	**Low**	**Medium**	**High**
Enhanced signs and markings on the minor legs (**Figure 4.4**)	$		
Freeway style guide signing (**Figure 4.5**)	$		
Street lighting (**Figure 4.6**)	$		
Close median openings (**Figure 4.7**)	$		
Install splitter islands on minor legs (**Figure 4.8**)	$		
Dynamic mainline warning sign (**Figure 4.9**)	$		
Automated real time system – gap assistant (**Figure 4.10**)		$$	
Indirect left turns (**Figure 4.11**)		$$	
Realign minor legs to eliminate skew (**Figure 4.12**)			$$$
Change vertical/horizontal alignment of major legs			$$$
Partial "T" interchange (**Figure 4.13**)			$$$
One quadrant interchange			$$$
Full Interchange (**Figure 4.14**)			$$$
Proactive Component	**Low**	**Medium**	**High**
Enhanced signs and markings on the minor legs (**Figure 4.4**)	$		
Freeway style guide signing (**Figure 4.5**)	$		
Street lighting (**Figure 4.6**)	$		
Close median openings (**Figure 4.7**)	$		
Install splitter islands on minor legs (**Figure 4.8**)	$		
Dynamic mainline warning sign (**Figure 4.9**)	$		

Figure 4.3 Expressway Intersection Safety Strategy Continuum

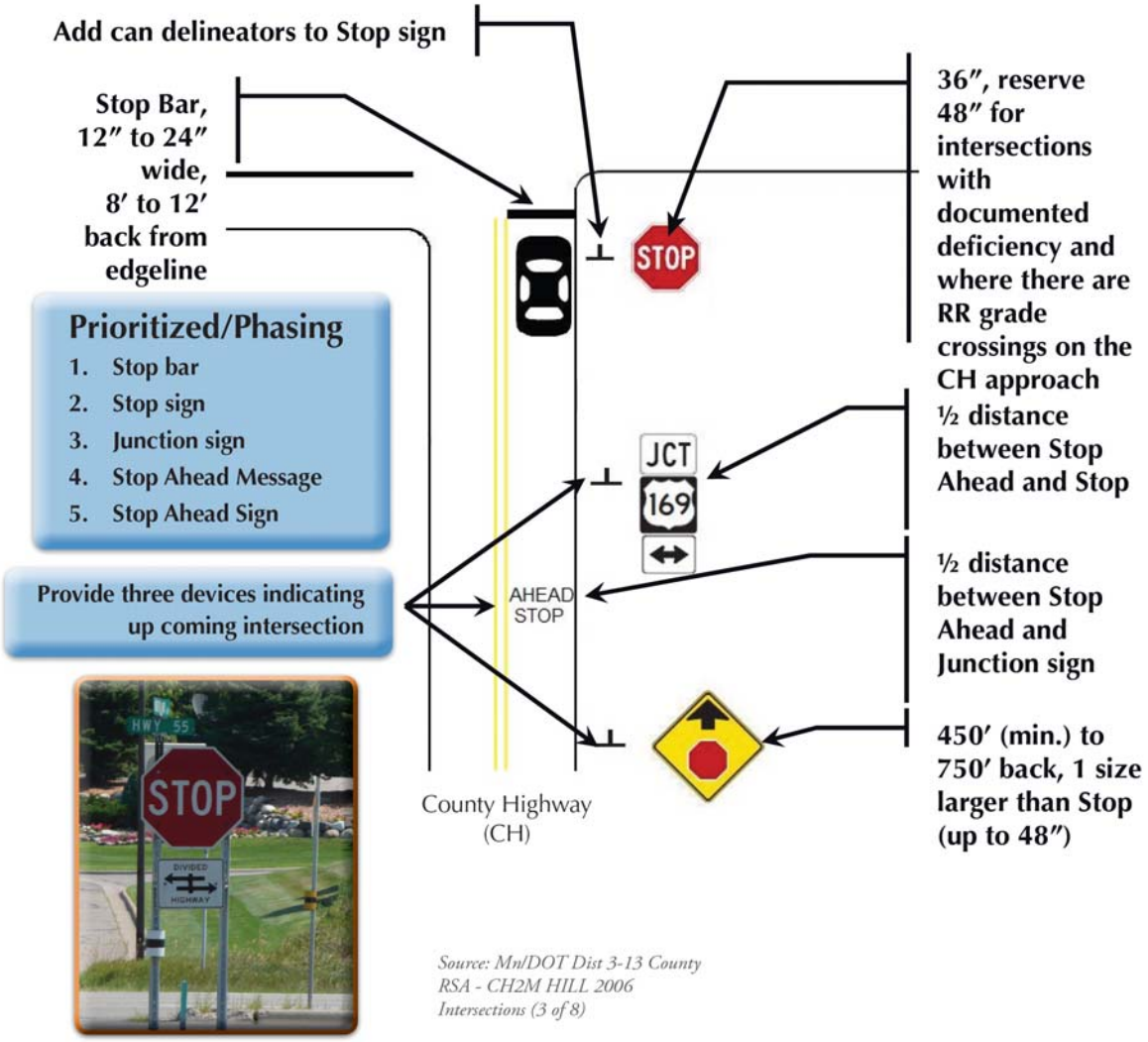


Figure 4.4 Enhanced Signs and Marking on the Minor Legs
Source: Mn/DOT Traffic Safety Fundamentals Handbook, 2008

Figure 4.5 Freeway Style Guide Signing

Figure 4.6 Street Lighting

Figure 4.7 Examples of Closed Median Openings
Source: Google Maps

Figure 4.8 Install Splitter Islands on Minor Legs
Source: FHWA Publication No.: FHWA-HRT-08-063

Figure 4.9 Dynamic Mainline Warning Signs

Figure 4.10 Automated Real Time System – Gap Assistant

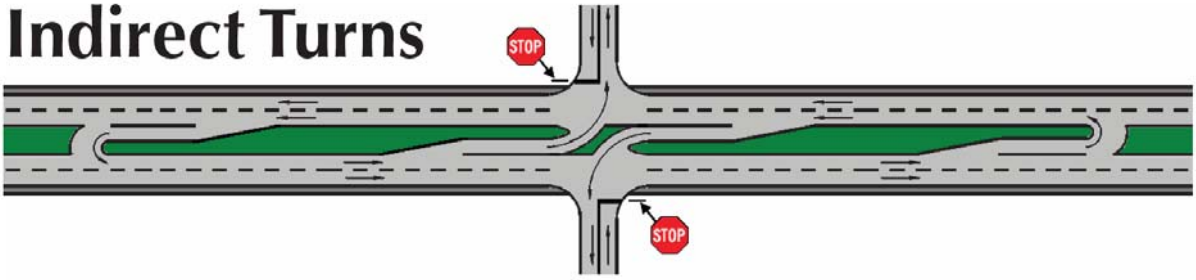


Figure 4.11 Indirect Turns
Source: NCHRP 15-30

Figure 4.12 Realign Minor Legs to Eliminate Skew
Source: District 3 13 County Road Safety Audits

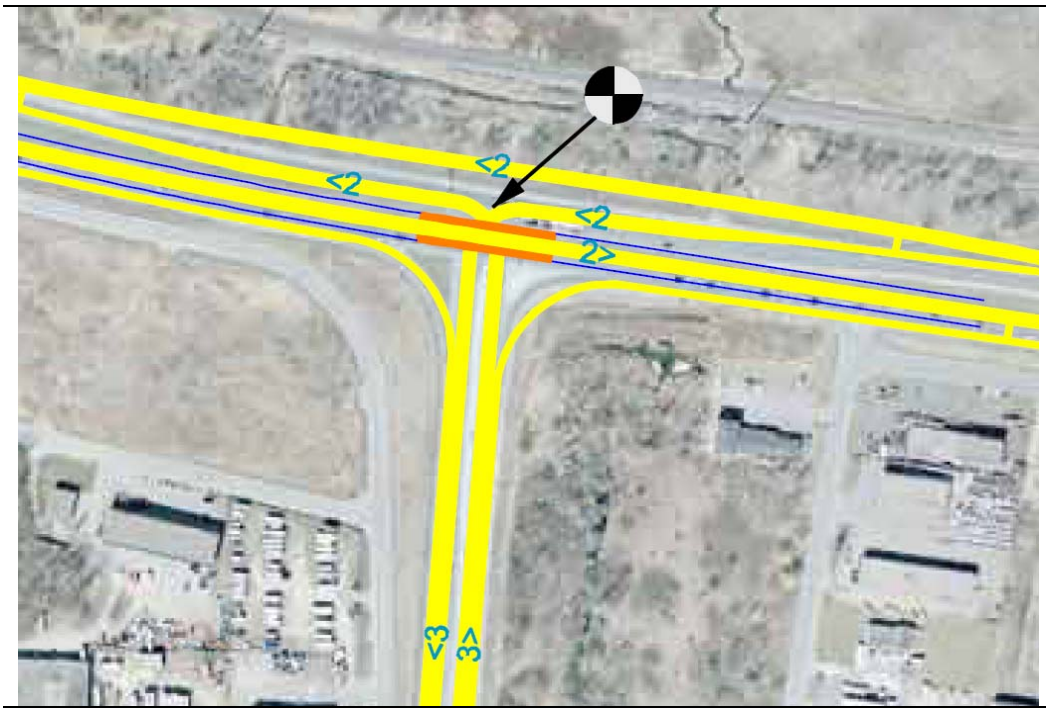


Figure 4.13 Partial "T" Interchange

Figure 4.14 Full Interchange
Source: Google Maps, US 14 West of Mankato

2-Lane Intersections (State and County System) Safety Strategies

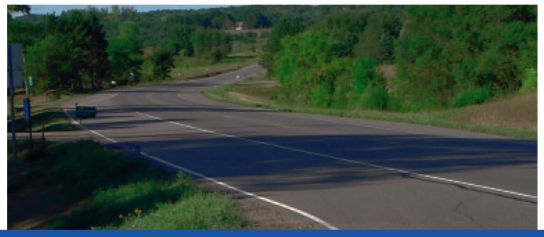
Reactive Component	Low	Medium	High

Enhanced signs and markings on the minor legs (**Figure 4.4**)	$			
Street lighting (**Figure 4.6**)	$			
Install splitter islands on minor legs (**Figure 4.8**)		$		
Dynamic mainline warning sign (**Figure 4.9**)		$		
Automated real time system – gap assistant (**Figure 4.10**)			$$	
Realign minor legs to eliminate skew (**Figure 4.12**)				$$$
Change vertical/horizontal alignment of major legs				$$$
Roundabouts (**Figure 4.16**)				$$$
Proactive Component	**Low**		**Medium**	**High**
Enhanced signs and markings on the minor legs (**Figure 4.4**)	$			
Street lighting (**Figure 4.6**)	$			
Install splitter islands on minor legs (**Figure 4.8**)		$		
Dynamic mainline warning sign (**Figure 4.9**)		$		

Figure 4.15 2-Lane Intersection Safety Strategy Continuum

Figure 4.16 Roundabout
Source: Mn/DOT Traffic Safety Fundamentals Handbook, 2008

The final issue to be addressed involves evaluating the effectiveness of the new predictive methodology relative to producing a list of candidate intersections for the proactive deployment of safety strategies. It is suggested that the ultimate performance measure is the reduction of severe crashes, but the crash reduction would need to be measured across the system instead of at individual intersections. As a result, the process of evaluation requires finding agencies to use the new predictive tool to identify candidate intersections, tracking their efforts to develop proactive projects and secure funding to support implementation and then documenting the crash reduction across their system in the years following deployment.



Conclusions

Conclusions

This research project was initiated to address three fundamental questions relative to intersection safety:

1) Can factors other than crashes be identified that contribute to the risk of collisions at rural, STOP controlled intersections?

2) Can a methodology be developed to screen systems of rural intersections on both the State and county highway systems to support the effort to identify candidates for the proactive deployment of low-cost safety strategies?

3) Can criteria be developed that would allow a new methodology to be evaluated?

The results of this research suggest that the answer to both of these questions is YES. A review of all of the rural, STOP controlled intersections along the State's expressway and 2-lane highway system and along the county highway system found a number of geometric and traffic volume features that were common among many of the subset of intersections where crashes occurred. The most common features at the intersections with crashes include; skewed minor leg approaches, located in/near horizontal curves and an ADT ratio (minor road ADT/major road ADT) in a fairly narrow band for each category of roadway. A subsequent review of the safety literature identified three other features that appear to be associated with increased risk of intersection crashes – the presence of development at the intersection, having a railroad crossing on a minor leg approach and (greater) distance from the previous STOP sign on the minor leg approach.

Using the premise that characteristics of the existing highway system (the features of the intersections where crashes did occur) can be used to predict where future crashes are likely to occur resulted in the development of a predictive methodology and a check list type of approach. The methodology was tested by applying it to more than 1,700 intersections along expressways and 2-lane highways around Minnesota and the resulting priority lists identified the top ranked candidates for proactive deployment of low cost safety improvements. To date, several county engineers have used their priority lists to support development of safety projects and in the HSIP solicitation process. The predictive process has proven to be relatively easy to use – the inventories of the State and county systems were completed in three to five days using data that was available in existing data bases. Beyond asking agency staff for feedback relative to the use of the methodology, it appears that an evaluation of the process will take time – time to find agencies willing to use the process, time to get the resulting projects funded and implemented and time to accumulate several years of crash data following deployment across a system of intersections.

Several other key points were identified during the course of this research, including:

- Consistent with Minnesota's SHSP – there is a need to focus safety planning efforts and safety investment on rural, STOP controlled intersections. These intersections are where the majority of serious intersection related crashes occur. Approximately

200 fatal intersection crashes occur each year in Minnesota and 130 of these occur in rural areas, but these crashes are scattered over thousands of intersections.

- No intersection in Minnesota averages one fatal crash per year. The worst 200 intersections in Minnesota based on crash cost average 0.1 fatal crashes per year and the remaining 8,000 intersections on the State system average less than 0.01 fatal crashes per year.
- The randomness of the fatal crashes clearly supports the notion that selecting intersections for safety improvement by chasing fatal crashes around the system is not an effective strategy and it is also clear that using historic "Black Spot" methods also does not work at identifying rural intersections with low numbers of severe crashes. In a typical year, 60% of the "Black Spot" intersections are located in the Metropolitan District, but only 25% of the intersection related fatal crashes are in the Metropolitan Area.
- Angle crashes are over represented at intersections with severe crashes and at intersections over the Critical Crash Rate – when intersections go bad (from a safety perspective) it is because of right angle crashes (as opposed to turning or rear end crashes). This suggests that the focus of intersection safety planning and investment should be developing and implementing safety projects that are effective at mitigating the causes of angle crashes.

The final issue to be addressed involves evaluating the effectiveness of the new predictive methodology relative to producing a list of candidate intersections for the proactive deployment of safety strategies. The ultimate performance measure is the reduction of severe crashes, but the crash reduction would need to be measured across the system instead of at individual intersections, tracking their efforts to develop proactive projects and secure funding to support implementation and then documenting the crash reduction across the system in the years following deployment.

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