DRAFT

5. Detailed Crash Analysis

The initial County wide analysis of crashes found that of the almost 1,300 crashes that occur on Olmsted County highways annually, approximately 83% occur in urban areas. However, when severe crashes were considered (fatal + A-injury) there was an almost even distribution with 24 severe crashes per year in urban areas and 21 severe crashes per year in rural areas. A more detailed review of the crash data found that four elements of the County system account for the majority (60%) of these severe crashes:

1) Rural highway segments (20%)

2) Urban STOP controlled intersections (16%)

3) Rural STOP controlled intersections (13%)

4) Urban signalized intersections (11%)

The following sections document the results of detailed crash analysis of these four elements of Olmsted County's highway system and describe the characteristics and factors that contribute to the crashes that occur at these locations. This information was then used in a series of prioritization exercises that identified specific locations that are considered to be at-risk and therefore, candidates for safety investments.

5.1 Rural Highway Segments

There are 324 miles of rural highway in Olmsted County's system and the predominant type of crash is a single vehicle running off the road. These single vehicle crashes account for almost 40% of all rural crashes and 46% of the severe rural crashes. Given that the desired end product is a list of safety projects – the deployment of specific mitigation strategies at specific locations, a series of questions need to be answered. First, are all rural segments equally at risk? If so, any approach to implementation would be equally effective. However, if some segments are more at-risk than others, the most cost-effective approach to implementation would involve a screening exercise to identify the subset of the most at-risk segments.

The first step of the detailed analysis of crashes along rural road segments consisted of disaggregating the 324 miles of rural highways into volume categories and then determining the distribution for each category of miles, vehicle miles of travel (VMT) and road departure crashes. The results of this analysis are illustrated in **Figure 5.1** and suggest that the approximately one-half of the system mileage with daily traffic volumes between 500 and 2,000 vehicles per day (VPD) is most at-risk based on the fact that the fraction of road departure crashes on these segments exceeds the fraction of VMT, these segments have the highest rate of road departure crashes (0.5 road departure crashes per million vehicle miles of travel) and this rate is 60% to 100% higher than for any of the other volume categories.

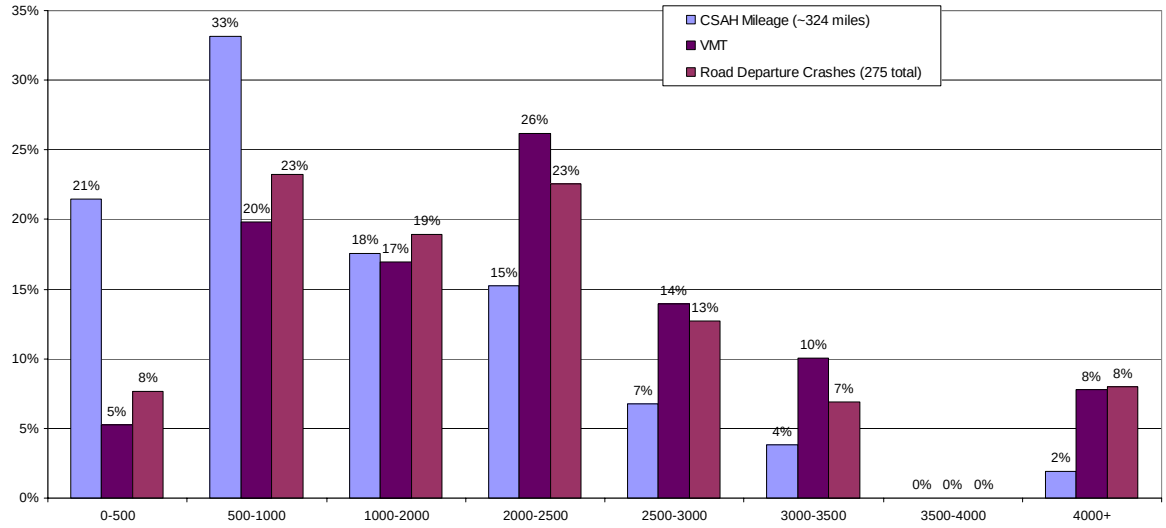

Figure 5.1 CSAH Mileage and Road Departure Crashes By ADT
Source: MnCMAT Crash Data, 2002-2006.

The second step in the detailed analysis consisted of ranking the 38 segments in the 500 to 2,000 VPD volume category based on the number of road departure crashes, total crashes and severe crashes. The results of this analysis are illustrated in **Figure 5.2** and indicate a suggested priority that has the 3.4 mile segment of CSAH 36 (between US 52 and CR 143) ranked highest as a result of 12 road departure crashes, 3 severe crashes and 25 total crashes and the 1.9 mile segment of CSAH 18 (between CSAH 12 and the Wabasha County line) ranked 38th with no crashes during the study period. The data also indicate that these 38 segments contain almost one-half of the road departure crashes that occur on Olmsted County's rural highways and almost 70% of all severe crashes.

Route	From	To	ADT	Length	RoR Crashes	Crashes K	A	Total
CSAH 36	US 52	CR 143	1050	3.4	12	2	1	25
CSAH 3	CSAH 6	CSAH 4	884	17.5	10	1	4	21
CSAH 3	CSAH 14	CSAH 13	1072	8.2	10		3	15
CSAH 14	Dodge County	CSAH 3 (west)	600	5.3	6		1	8
CSAH 13	Dodge County	Goodhue County	760	1.7	6		2	7
CR 112	CSAH 14	US 52	1070	4.4	6		1	17
CR 104	CR 117	CSAH 4	1100	6.6	6			8
CSAH 10	US 14	Wabasha County	1070	10.2	5		1	12
CSAH 15	TH 30	CSAH 25	552	6.6	4			6
CSAH 5	CSAH 25	US 14	680	5	4			8
CSAH 24	CSAH 2	Wabasha County	820	4.7	4			5
CSAH 6	CSAH 3	US 63	875	7.6	4			8
CSAH 10	Chatfield city limit	I-90	569	8.2	3		1	3
CR 142	CSAH 7	Sheek Street N	770	5	3	1		3
CR 117	CSAH 15	CSAH 8	980	3.4	3		1	4
CSAH 8	CSAH 6	CSAH 35	1150	1.8	3	1	1	4
CSAH 5	Dodge County CSAH 22	CSAH 3	1450	5	3			5
CR 133	55th Street NW	CSAH 14	1600	2.4	3			7
CR 114	CSAH 12	Wabasha County	600	2.1	2			4
CSAH 11	CSAH 2	TH 247	668	7.5	2	1	1	8
CSAH 3	CSAH 4	CSAH 14	800	0.25	2			2
CSAH 12	CSAH 3	US 52	810	3.5	2			3
CR 111	CSAH 1	US 52	820	2.6	2		1	3
CSAH 20	TH 30	CSAH 16	500	4.6	1	1		4
CSAH 7	US 52	I-90	790	2.3	1			4
CSAH 16	CSAH 8	CSAH 20	793	3.8	1		1	5
CSAH 16	CSAH 20	CSAH 1	800	1.4	1			1
CSAH 9	CSAH 10	Winona County	820	3	1			6
CSAH 14	US 63	CSAH 11	850	3.2	1		1	2
CSAH 20	CSAH 16 (west)	US 63	940	4.4	1			2
CR 143	CSAH 36	CSAH 11	1104	2.4	1			3
CSAH 14	CSAH 3	US 52	1450	2.9	1		1	11
CSAH 8	Mower County	CSAH 6	1500	0.5	1			2
CSAH 25	CSAH 3	CSAH 22	1720	5.5	1	1	1	10
CSAH 27	CSAH 12	Wabasha County	900	1.7	0			2
CSAH 19	CSAH 23	US 14	940	1.9	0		1	1
CSAH 10	I-90	US 14	1200	1.7	0			0
CSAH 18	CSAH 12	Wabasha County	1200	1.9	0			0
			Total	164.2	116	8	23	239
		Countywide Rural Corridor Total		323.5	275	15	40	539

Figure 5.2 Prioritizing Rural Segments with ADT between 500 and 2,000

The detailed crash analysis also identified a subset of the rural highway system that appears to be a factor that contributes to the overall frequency of road departure crashes – horizontal curves (**Figure 5.3**). The 324 miles of rural County highways contains 239 horizontal curves and the total length of these curves is approximately 31 miles, or slightly less than 10% of the system mileage. However, 40% of both total road and severe road departure crashes occur in horizontal curves. As a result, it was concluded that horizontal curves are an at-risk element of the County's rural highway system and as was the case with the rural highway segments, an analysis was completed to prioritize the curves based on the relative degree of risk. The results of this analysis documented the following crash characteristics:

- Almost 75% of the curves had no crashes during the five year study period.

- Four of the curves had 1 fatal crash – none had 2 fatal crashes.
- One curve had 2 A injury crashes and nine more curves had 1 A injury crash.
- One curve averaged 1 crash per year and the average annual number of crashes per curve was 0.08.

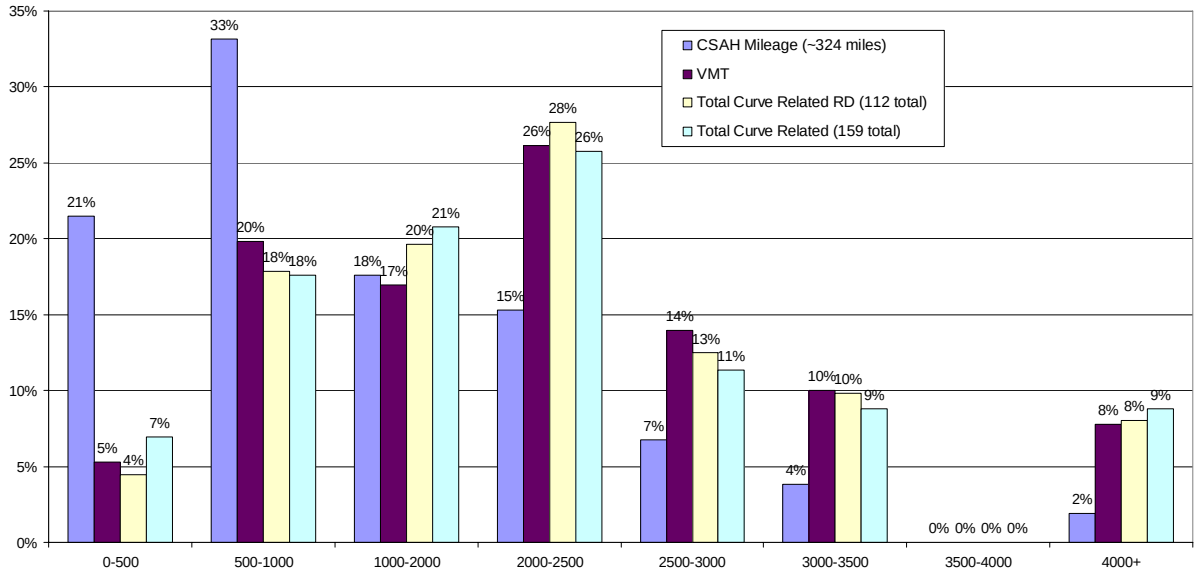

Figure 5.3 CSAH Mileage and Curve Related Crashes By ADT
Source: MnCMAT Crash Data, 2002-2006.

All of this information supports the notion that traditional methods of assigning safety risk based on the number of crashes could not be effective if applied to horizontal curves – there are simply too few crashes in curves to be a reliable indicator of the relative degree of risk. As a result, a new technique was developed for Olmsted County that was based on combining an understanding of the characteristics of the curves in Olmsted County where crashes did occur with the results of similar efforts in other counties in Minnesota and with the results of recently published research by the Minnesota Department of Transportation (Cost-Benefit-Analysis of In-Vehicle Technologies and Infrastructure Changes to Avoid Crashes Along Curves and Shoulders, University of Minnesota and CH2M HILL, June 2009). This detailed crash analysis of curve related crashes suggest that in addition to crashes, four features increase the level of risk at individual curves:

- Curve radius – shorter curve radii result in higher crash rates (**Figure 5.4**). In Olmsted County, curves with radii less than 1,500 feet have crash rates two to three times greater than curves with longer radii. This relationship is similar to that found in the Minnesota and national research, but in these documents the radii/safety relationship is even more pronounced.
- Traffic volumes – there is a range of volumes in each system that is over represented relative to the frequency of curve related crashes. In Olmsted County the curves in the volume range between 1,000 and 2,500 VPD accounted for 32% of the mileage, 39% of the VMT and 43% of the curve related crashes

(**Figure 5.3**). The fraction of the curve related crashes in each of the other volume categories was less than or equal to the fraction of VMT.

- Intersection in the curve – the presence of an intersection in the curve increased the level of risk.
- Visual trap – the presence of a visual trap (a situation that occurs when a crest vertical curve is ahead of the beginning of the horizontal curve of when there is a minor road continuing on the tangent – **Figure 5.5**) increased the level of risk.

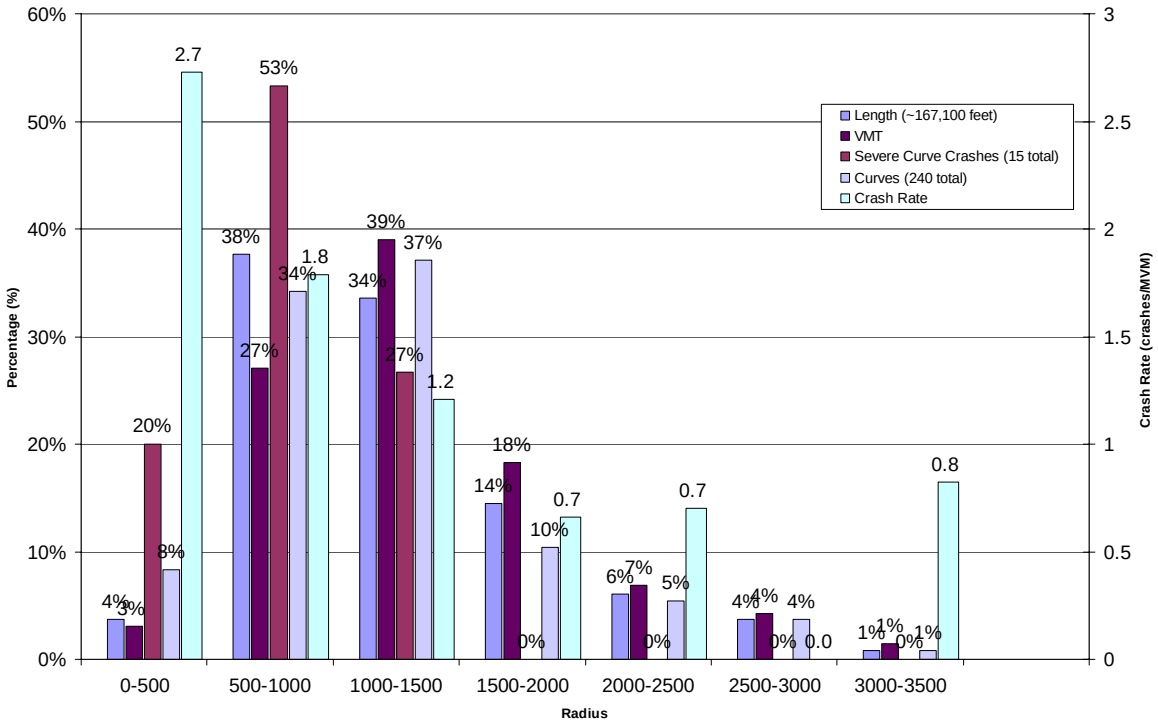

Figure 5.4 Curve Crashes Disaggregated by Radius
Source: MnCMAT Crash Data, 2002-2006.

Figure 5.5 CSAH Visual Trap

This information resulted in the development of a prioritization process that documented these five factors at each of the 239 curves. An example of the application of these factors to a sample of the horizontal curves is illustrated in **Figure 5.6** and the results of applying the process, a ranking of the twenty-two most at-risk curves, is documented in **Figure 5.7**. These twenty-three curves represent under 10% of all curves in Olmsted County's system, but 50% of the curve related fatal crashes and 64% of the severe curve related crashes. In addition, these curves include one where all five factors were present, six curves where four factors were present and sixteen curves where three factors were present.

Corridor	Segment	Description	Curve	Corridor Weighted ADT	Crashes K	A	B	C	PDO	Severe RoR K	A	Radius	Length Curve	Intersection on Curve	Chevrons	Visual Trap	Rank
7	CSAH 3	Mower Co - CSAH 6	1	295	1	0	0	0	0	1	0	800	1,250			Yes	xxx
8	CSAH 8	Mower Co - CSAH 6	1	1,500	0	0	0	0	1	0	0	1,300	425				x
			2	1,500	None					0	0	150	125				x
9	CSAH 4	CSAH 5 - CSAH 22	1	1,950	None					0	0	1,250	700				xx
			2	1,950	0	0	1	0	0	0	0	1,150	650				xx
			3	2,650	None					0	0	3,000	600				
			4	2,650	0	0	0	0	1	0	0	3,000	725	Yes			x
			5	2,650	0	0	0	0	3	0	0	1,150	1,225	Yes			xx
			6	3,075	1	0	1	1	1	1	0	1,150	1,875	Yes			xxx
10	CR 154	US 52 - CR 112	No Curves														
11	CSAH 8	CSAH 6 - CSAH 35	1	1,150	None					0	0	2,500	650	Yes			xx
			2	1,150	None					0	0	2,200	600				x
			3	1,150	None					0	0	1,150	1,050	Yes		Yes	xxxx
			4	1,150	None					0	0	1,600	775	Yes			xx
12	CSAH 8	CSAH 35 - Meadow Crossing Rd	1	2,100	0	0	0	0	1	0	0	600	875	Yes	Yes	Yes	xxx
			2	2,100	0	1	0	0	2	0	1	600	875	Yes	Yes		xxx
			3	3,500	0	0	0	1	0	0	0	1,100	325				x
			4	3,500	0	0	1	0	0	0	0	1,150	850				x
			5	3,500	0	0	0	0	1	0	0	850	1,000				x
			6	3,500	0	0	1	1	2	0	0	1,450	825				

Figure 5.6 Curve Prioritization
Source: MnCMAT Crash Data, 2002-2006.

Corridor	Segment	Description	Curve	Corridor Weighted ADT	Crashes K	A	B	C	PDO	Severe RoR K	A	Radius	Length Curve	Intersection on Curve	Chevrons	Visual Trap	Rank
7	CSAH 3	Mower Co - CSAH 6	1	295	1	0	0	0	0	1	0	800	1,250			Yes	xxx
9	CSAH 4	CSAH 5 - CSAH 22	6	3,075	1	0	1	1	1	1	0	1,150	1,875	Yes			xxx
11	CSAH 8	CSAH 6 - CSAH 35	3	1,150	None					0	0	1,150	1,050	Yes		Yes	xxxx
18	CSAH 11	CSAH 36 - CSAH 2	2	1,500	None					0	0	900	725	Yes		Yes	xxxx
20	CSAH 2	36th Ave NE - TH 42	4	3,200	None					0	0	1,050	1,500	Yes		Yes	xxx
21	CR 133	55th St NW - CSAH 14	6	1,600	0	0	1	0	0	0	0	800	1,100	Yes			xxx
22	CSAH 3	CSAH 14 - CSAH 13	9	1,200	0	1	0	0	0	0	0	800	500				xxx
24	CSAH 12	US 52 - US 63	2	3,650	0	1	0	2	0	0	1	1,000	725	Yes			xxx
26	CSAH 5	Byron City Limits - Dodge Co (CSAH 17)	5	2,150	0	0	1	0	0	0	0	1,100	1,025			Yes	xxx
			6	2,150	0	0	0	0	1	0	0	1,150	325	Yes			xxx
41	CSAH 34	US 14 - CSAH 3	3	2,100	None					0	0	1,850	800	Yes		Yes	xxx
42	CSAH 3	CSAH 6 - CSAH 4	5	1,000	0	1	0	0	2	0	1	850	1,350	Yes		Yes	xxxxx
			6	1,150	None					0	0	850	1,250	Yes		Yes	xxxx
44	CSAH 6	CSAH 3 - US 63	1	1,250	0	0	1	0	0	0	0	850	1,225	Yes		Yes	xxxx
			2	1,250	None					0	0	800	1,250	Yes		Yes	xxxx
52	CSAH 10	Chatfield City Limits - I-90	4	480	None					0	0	800	1,250	Yes		Yes	xxx
63	CSAH 25	CSAH 3 - CSAH 22	1	1,900	0	0	2	0	0	0	0	1,050	975	Yes			xxx
			3	1,900	0	0	1	0	0	0	0	1,150	1,075	Yes		Yes	xxxx
64	CSAH 23	CSAH 19 - TH 42	4	295	None					0	0	800	1,250	Yes		Yes	xxx
			5	295	None					0	0	800	1,200	Yes		Yes	xxx
65	CR 143	CSAH 11 - CSAH 19	3	350	0	2	0	0	0	0	1	1,000	375	Yes			xxx
71	CSAH 16	CSAH 1 - US 52	3	400	None					0	0	850	1,275	Yes		Yes	xxx
75	CSAH 18	CSAH 12 - Wabasha Co	4	1,200	0	0	0	1	0	0	0	1,300	600	Yes		Yes	xxx

Figure 5.7 High Priority Curves

5.2 Urban STOP Controlled Intersections

Approximately 30% of the severe crashes that occur along Olmsted County's urban system of highways occur at STOP controlled intersections and the most common type of crash at these intersections is a right angle collision (60%). The detailed analysis found that over 80% of these severe crashes occurred in Rochester and the remainder occurred in Oronoco and Stewartville. The analysis also found:

- The intersections with severe crashes in Oronoco have already been improved as a result of the various upgrading projects along TH 52.
- The intersections in Stewartville are along a segment of TH 63 that is 30 miles per hour and the officers that investigated the crashes could not identify any contributing factors.

As a result, the detailed analysis focused in on the 80% of the crashes that occurred at STOP controlled intersections in Rochester.

The next step in the analytical process involved identifying locations with multiple crashes and in this case all crashes (not just severe) were considered in order to increase the size of the data set. This helps in the identification of factors contributing to the types of crashes which are of most interest – right angle collisions. A total of five intersections in Rochester were identified as having more than five crashes (**Figure 5.8**) and two items stand out – right angle collisions (48%) are the type most over represented in the sample and two of the multiple crash intersections are located along Circle Drive (NE , NW and SW). Circle Drive is in fact the only road with more than one intersection with multiple crashes.

	Crash Severity				
Intersection	K	A	B	C	PDO
US 14 & CSAH 7			3	3	10
US 63 & CSAH 6		1	2	2	13
CSAH 25 & CR 125				4	11
CSAH 9 & CR 155			4	1	4
CSAH 22 & CSAH 25 (west)		1	2		4
CSAH 22 & 9th St NW			2	3	11

Figure 5.8 Urban STOP Controlled Intersections with more than five crashes
Source: MnCMAT Crash Data, 2002-2006.

5.3 Rural STOP Controlled Intersections

Approximately 30% of the severe crashes along Olmsted County's rural system of highways occur at STOP controlled intersections and the most common type of crash at these intersections is a right angle collision (52%). Given that there are approximately 350 of these intersections across the County, it was determined that the analysis would focus on the subset of intersections where the probability of conflicts was greatest – at the highest volume intersections. A further review of the County's system found that these high volume intersections can be identified by the jurisdiction of the entering legs – as a result, the subset of STOP controlled intersections included in the detailed analysis were defined by having at least one leg on the County State Aid Highway system and the remaining legs on either the County State Aid or the State Trunk Highway system. This subset was found to include a total of 71 intersections and this group of intersections was found to account for almost one-third of both total and the severe intersection related crashes in the County.

In order to further prioritize the Stop controlled rural intersections, additional analysis found that a particular group of intersections had on average the highest crash rates – intersections with a ratio of Minor Leg Average Daily Traffic/Major Leg Average Daily Traffic between 0.3 and 0.5 (**Figure 5.9**). The twenty-five intersections in this range of ADT's have crash rates that average more than 0.6 crashes per million entering vehicles and this rate is 50% greater than the Countywide average and more than twice the average in any other volume category.

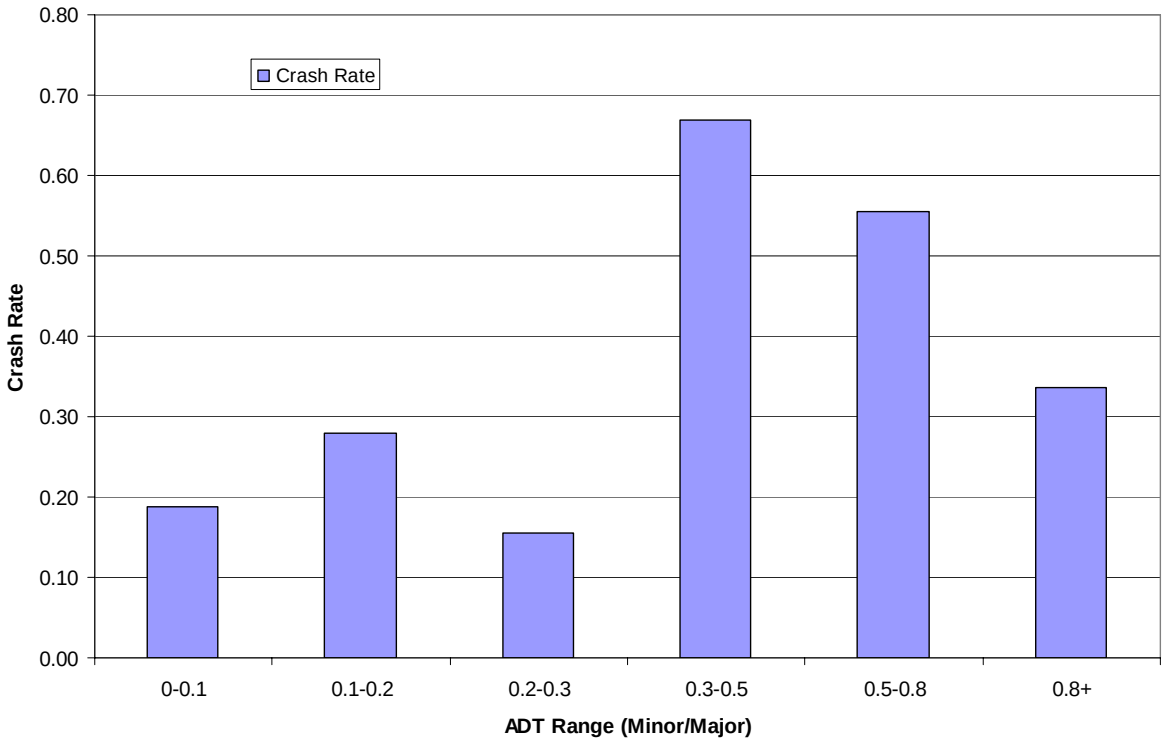

Figure 5.9 Rural STOP Intersections Crash Rate by ADT Range
Source: MnCMAT Crash Data, 2002-2006.

Finally, these intersections were prioritized by their crash rate, with the resulting ranking identified in **Figure 5.10**. It should be noted that these twenty-five intersections account for around 5% of all rural STOP controlled intersections but they account for 19% of total rural intersection crashes and 13% of severe intersection related crashes.

Number	Intersection	ADT Ratio	Actual Crash Rate	Critical Crash Rate	Approaches	Crashes K	A	Total
1	CSAH 23 & CSAH 19 (East)	0.47	2.52	2.20	1			2
2	CSAH 3 & CSAH 34	0.49	1.57	0.92	2			9
3	CSAH 3 & CSAH 12	0.43	1.22	1.27	1		1	3
4	US 63 & CSAH 14	0.51	1.11	0.67	2		1	20
5	US 63 & CSAH 12/TH 247	0.47	1.02	0.73	2			13
6	TH 42 & CSAH 9	0.70	0.85	0.82	2	1		7
7	CSAH 3 & CSAH 5	0.45	0.70	1.02	1			3
8	TH 30 & CSAH 1	0.72	0.56	0.94	2			3
9	TH 30 & CSAH 8	0.68	0.54	0.85	2			4
10	CSAH 11 & CSAH 14	0.63	0.50	1.38	1			1
11	CSAH 20 & CSAH 16	0.56	0.49	1.37	1			1
12	CSAH 11 & CSAH 9	0.47	0.47	0.81	2		1	4
13	CSAH 16 & CSAH 20	0.46	0.40	1.26	1			1
14	CSAH 14 & CSAH 3 (west)	0.39	0.38	1.24	1			1
15	CSAH 6 & CSAH 8 (west)	0.64	0.37	1.22	1			1
16	CSAH 14 & CR 112	0.80	0.19	0.69	2			3
17	CSAH 34 & CR 104	0.41	0.19	0.94	2			1
18	CSAH 5 & CSAH 4	0.46	0.18	0.93	1			1
19	CSAH 4 & CSAH 3 (west)	0.35	0.18	0.93	2			1
20	CSAH 36 & CSAH 11	0.30	0.09	0.75	2			1
21	US 14 & CSAH 11	0.30	0.05	0.65	2			1
22	CSAH 8 & CSAH 35	0.73	0.00	0.97	2			0
23	CSAH 6 & CSAH 8 (east)	0.60	0.00	1.08	1			0
24	CSAH 25 & CSAH 5	0.55	0.00	1.47	1			0
25	CSAH 3 & CSAH 17	0.41	0.00	1.43	2			0

Figure 5.10 Prioritization of Rural STOP Controlled Intersections
Source: MnCMAT Crash Data, 2002-2006.

5.4 Urban Signalized Intersections

Approximately 20% of the severe crashes in urban areas in Olmsted County occur at signalized intersections. The most common type of severe crash at the signals along the County's system in and around Rochester is a right angle collision (41%). The detailed analysis of the crash data found three corridors – CSAH 22 East, CSAH 22 West and TH 14 (the South Beltway where many of the cross streets are County highways) - with the greatest concentration of both total crashes and angle crashes. The twenty-eight signalized intersections along these corridors account for approximately 20% of the signalized intersections in Olmsted County, but they account for 28% of all crashes and 37% of all right angle crashes. In addition, right angle crashes at these twenty-eight signals accounted for 64% of the severe crashes – clearly, crashes, angle crashes and severe angle crashes are over represented at these intersections.

The twenty-eight signalized intersections along these high priority corridors are identified in **Figure 5.11**.

US 14 from US 52 to CSAH 11

- US 14 and Memorial Pkwy SW (+)
- US 14 and 12th St SW (T)
- US 14 and TH 63 (+)
- *US 14 and CR 146 (3rd Ave SE) (+)*
- US 14 and 8th Ave SE (+)
- *US 14 and CSAH 1 (11th Ave SE) (+)*
- *US 14 and CSAH 36 (15th Ave SE) (+)*
- *US 14 and CSAH 22 (T)*
- US 14 and CSAH 11 (+)

CSAH 22 (West) from US 52 to US 52/14

- *CSAH 22 and West Frontage Rd (+)*
- *CSAH 22 and Chateau Rd NW (+)*
- *CSAH 22 and 55th St NW (+)*
- *CSAH 22 and 41st St. NW (T)*
- *CSAH 22 and CSAH 4 (Valley High Dr NW) (+)*
- *CSAH 22 and 19th St NW (+)*
- *CSAH 22 and 7th St NW (North) (+)*
- *CSAH 22 and 7th St NW (South) (+)*
- *CSAH 22 and CSAH 34 (Country Club Rd SW) (+)*
- *CSAH 22 and CSAH 8 (Bamber Valley Rd SW) (T)*
- *CSAH 22 and CSAH 25 (16th St SW) (T)*
- *CSAH 22 and Fox Valley Dr SW (+)*

CSAH 22 (East) from US 14 to US 52

- *CSAH 22 and CSAH 9 (Collegeview Rd E) (+)*
- *CSAH 22 and CSAH 2 (Viola Rd NE) (+)*
- *CSAH 22 and TH 63 (+)*
- *CSAH 22 and East River Rd NE (+)*
- *CSAH 22 and West River Pkwy NW (+)*
- *CSAH 22 and 18th Ave NW (+)*
- *CSAH 22 and 22nd Ave NW (+)*

Figure 5.11 Signalized Intersections along High Priority Corridors
Note: Italics indicate signals under County Jurisdiction. (+)-Four-leg intersection, (T)-Three-leg intersection