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Final Report

Review of Wisconsin's Rural Intersection Crashes: Application of Methodology for Identifying Intersections for Intersection Decision Support (IDS)

Report #1 in the Series: Toward a Multi-State Consensus on Rural Intersection Decision Support

Minnesota Department of Transportation

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The Intersection Decision Support (IDS) research project is sponsored by a consortium of states (Minnesota, California, and Virginia) and the Federal Highway Administration (FHWA) whose objective is to improve intersection safety. The Minnesota team's focus is to develop a better understanding of the causes of crashes at rural unsignalized intersections and then develop a technology solution to address the cause(s).

In the original study, a review of Minnesota's rural crash records and of past research identified poor driver gap selection as a major contributing cause of rural intersection crashes. Consequently, the design of the rural IDS technology has focused on enhancing the driver's ability to successfully negotiate rural intersections by communicating information about the available gaps in the traffic stream to the driver.

In order to develop an IDS technology that has the potential to be nationally deployed, the regional differences at rural intersections must first be understood. Only then can a universal solution be designed and evaluated. To achieve this goal of national consensus and deployment, the University of Minnesota and the Minnesota Department of Transportation initiated a State Pooled Fund study, in which nine states are cooperating in intersection-crash research. This report documents the crash analysis phase of the pooled fund study for the State of Wisconsin.

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Final Report

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- California
- Georgia
- Iowa
- Michigan
- Minnesota
- Nevada
- New Hampshire
- North Carolina
- Wisconsin

We would also like to especially acknowledge several individuals at the Wisconsin Department of Transportation (WisDOT) who played key roles in the analysis of Wisconsin intersections and development of this report. We would like to thank Richard Lange, State Safety Engineer with WisDOT, who provided the crash record information, supplied technical direction for the crash reviews, and participated in the intersection field reviews. The research team would also wish to acknowledge Marc Bowker, WisDOT District Traffic Engineer, who participated in the field reviews and was able to provide additional information and background on each of the intersections reviewed. Wisconsin's participation in the pool reflects the support of the study by John Corbin, Wisconsin's State Traffic Engineer.

Finally, we wish to acknowledge the assistance provided by Ray Starr of the Minnesota Department of Transportation (Mn/DOT) who served as technical manager of the pooled fund project and Jim Klessig of Mn/DOT who served as administrative liaison of the pooled fund.

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Executive Summary

The Intersection Decision Support (IDS) research project is sponsored by a consortium of states (Minnesota, California, and Virginia) and the Federal Highway Administration (FHWA) whose objective is to improve intersection safety. The Minnesota team's focus is to develop a better understanding of the causes of crashes at rural unsignalized intersections and then develop a technology solution to address the cause(s).

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Based on the Minnesota crash analysis, one intersection was identified for instrumentation (collection of driver behavior information) and deployment of the IDS technology under development. Also underway, alternative Driver Infrastructure Interfaces (DII) designs are being tested in a driving simulator at the University of Minnesota.

In order to develop an IDS technology that has the potential to be nationally deployed, the regional differences at rural intersections must first be understood. Only then can a universal solution be designed and evaluated. To achieve this goal of national consensus and deployment, the University of Minnesota and the Minnesota Department of Transportation initiated a State Pooled Fund study, in which nine states are cooperating in intersection-crash research. The participating states are:

- California
- Georgia
- Iowa
- Michigan
- Minnesota
- Nevada
- New Hampshire
- North Carolina
- Wisconsin

The first facet of this pooled fund project is a review of intersection crash data from each participating state, applying methods developed in previous IDS research. The crash data will be used to understand rural intersection crashes on a national basis, and to identify candidate intersections for subsequent instrumentation and study. The second facet is a participatory design process to design and refine candidate intersection Driver Infrastructure Interfaces. The third facet is to instrument candidate intersections in participating states, as a means to acquire data regarding the behavior of drivers at rural intersections over a wide geographical base. States choosing to instrument intersections will be well positioned to participate in the second phase of the IDS program, a proposed Field Operational Test designed to evaluate the performance of these systems.

Review of Wisconsin's Intersections

This report documents the initial phase of the pooled fund study for the State of Wisconsin. The crash analysis focused on the U.S. 53 corridor from Rice Lake to Superior. During the 6.5 year study period (January 1, 1998 through June 30, 2004), there were 74 intersections that had at least one crash. Of these 74, six intersections stood out as having an unusually high number of crossing path crashes and crash severity:

- **CTH V** (Barron County),
- **CTH B** (Washburn County),
- **CTH E** (Washburn County),
- **U.S. 63, N. Jct.** (Washburn County),
- **STH 77** (Washburn County), and
- **CTH B** (Douglas County).

A field visit revealed that the Wisconsin Department of Transportation had deployed a wide variety of strategies at each intersection, including some or all of the following: DANGEROUS INTERSECTION sign, STOP AHEAD sign with red flasher and rumble strips on minor street approaches; oversized STOP sign with red flasher; second STOP sign placed on left side of roadway; intersection lighting; CROSS ROAD AHEAD sign with flasher on U.S. 53 approaches; and rumble strips, painted YIELD message and painted YIELD bar in the median. However, all of these strategies are most effective at addressing crashes where the driver fails to recognize he/she is approaching the intersection and runs the STOP sign and will provide a driver with no assistance in gap recognition and selection.

Looking at the crash data, these strategies did prove effective at reducing run-the-STOP crashes since there were few of these crash types. Instead, the crossing path crashes at the six candidate intersections were predominately associated with a driver's poor gap identification and selection.

Using the crash factors of at-fault driver age, crash severity, driver's contributing factor along with several other factors, the intersection selected as the best candidate for test deployment of the IDS technology was U.S. 53 and State Trunk Highway (STH) 77 (Washburn County). The STH 77 intersection has one of the worst crash experiences, including the highest crash rate, the most fatal crashes, and the greatest number of older at-fault drivers (i.e., over the age of 64). Further, the design of the intersection (i.e., wide median with STOP control in the median as opposed to YIELD control), presents a unique situation where researchers can observe driver behavior.

1. Introduction

The Intersection Decision Support (IDS) research project is sponsored by a consortium of states (Minnesota, California, and Virginia) and the Federal Highway Administration (FHWA) whose objective is to improve intersection safety. The Minnesota team's focus is to develop a better understanding of the causes of crashes at rural unsignalized intersections and then develop a technology solution to address the cause(s).

In the original study, a review of Minnesota's rural crash records and of past research identified poor driver gap selection as a major contributing cause of rural intersection crashes (*1,2,3*). Consequently, the design of the rural IDS technology has focused on enhancing the driver's ability to successfully negotiate rural intersections by communicating information about the available gaps in the traffic stream to the driver.

Based on the Minnesota crash analysis, one intersection was identified for instrumentation (collection of driver behavior information) and deployment of the IDS technology under development. Also underway, alternative Driver Infrastructure Interface (DII) designs are being tested in a driving simulator at the University of Minnesota.

In order to develop an IDS technology that has the potential to be nationally deployed, the regional differences at rural intersections must first be understood. Only then can a universal solution be designed and evaluated. To achieve this goal of national consensus and deployment, the University of Minnesota and the Minnesota Department of Transportation initiated a State Pooled Fund study, in which nine states are cooperating in intersection-crash research. The participating states are:

- California
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The first facet of this pooled fund project is a review of intersection crash data from each participating state, applying methods developed in previous IDS research. The crash data will be used to understand rural intersection crashes on a national basis, and to identify candidate intersections for subsequent instrumentation and study. The second facet is a participatory design process to refine candidate intersection Driver Infrastructure Interfaces. The third facet is to instrument candidate intersections in participating states, as a means to acquire data regarding the behavior of drivers at rural intersections over a wide geographical base. States choosing to instrument intersections will be well positioned to participate in the second phase of the IDS program, a proposed Field Operational Test designed to evaluate the performance of these systems.

This report documents the initial phase of the pooled fund study for the State of Wisconsin. Following is a description of the crash analysis performed for Wisconsin and a recommendation of an intersection for design of an IDS system for possible deployment.

1.1. Typical Countermeasures for Rural Intersections

A typical right-angle crash at a rural unsignalized intersection is most often caused by the driver's (on a minor street approach) inability to recognize the intersection (which consequently results in a run the STOP sign violation) or his/her inability to recognize and select a safe gap in the major street traffic stream.

Traditional safety countermeasures deployed at rural high-crash intersections include:

- Upgrading traffic control devices
  - Larger STOP signs
  - Multiple STOP signs
  - Advance warning signs and pavement markings
- Minor geometric improvements
  - Free right turn islands
  - Center splitter islands
  - Off-set right turn lanes
- Installing supplementary devices
  - Flashing beacons mounted on the STOP signs
  - Overhead flashing beacons
  - Street lighting
  - Transverse rumble strips

All of these countermeasures are relatively low-cost and easy to deploy, but are typically designed to assist drivers with intersection recognition and have not exhibited an ability to address gap recognition problems. Yet, up to 80% of crossing path crashes are related to selection of an insufficient gap (*1*). In addition, a Minnesota study of rural thru-STOP intersections for rural two-lane roadways found only one-quarter of right-angle crashes were caused by the driver on the minor street failing to stop because they did not recognize they were approaching an intersection (*2*). At the same set of intersections, 56% of the right-angle crashes were related to selecting an unsafe gap while 17% were classified as other or unknown.

The concept of gap recognition being a key factor contributing to rural intersection safety appears to be a recent idea. As a result, there are relatively few devices in the traffic engineer's safety toolbox to assist drivers with gap recognition and they mainly consist of a few high cost geometric improvements and a variety of lower cost strategies that are considered to be experimental because they have not been widely used in rural applications. **Figure 1-1** illustrates the range of strategies currently available to address safety deficiencies associated with gap recognition problems, organized in order of the estimated cost to deploy (based on Minnesota conditions and typical implementation costs). The strategies include:

- The use of supplemental devices such as street light poles to mark the threshold between safe and unsafe gaps
- Minor geometric improvements to reduce conflicts at intersection such as inside acceleration lanes, channelized median openings to eliminate certain maneuvers (sometimes referred to as a Michigan Left-turn), or revising a four-legged intersection to create off-set T's
- Installing a traffic signal to assign right-of-way to the minor street

- Major geometric improvements such as roundabout or grade separated interchanges to eliminate or reduce crossing conflicts. (Refer to *Rural Expressway Intersection Synthesis of Practice and Crash Analysis* for a review of various alternatives [*4*].)

The use of these strategies may not be appropriate, warranted or effective in all situations. Also, the construction cost or right-of-way may prove to be prohibitive at some locations. All of this combined with a recommendation in American Association of State Highway and Transportation Official (AASHTO) Strategic Highway Safety Plan to investigate the use of technology to address rural intersection safety led to the ongoing research to develop a cost-effective Intersection Decision Support (IDS) system, including a new driver interface. The IDS system is intended to be a relatively low cost strategy (similar to the cost of a traffic signal), but at the same time is technologically advanced, using roadside sensors and computers to track vehicles on the major road approaches, computers to process the tracking data and measure available gaps and the driver interface to provide minor road traffic with real-time information.

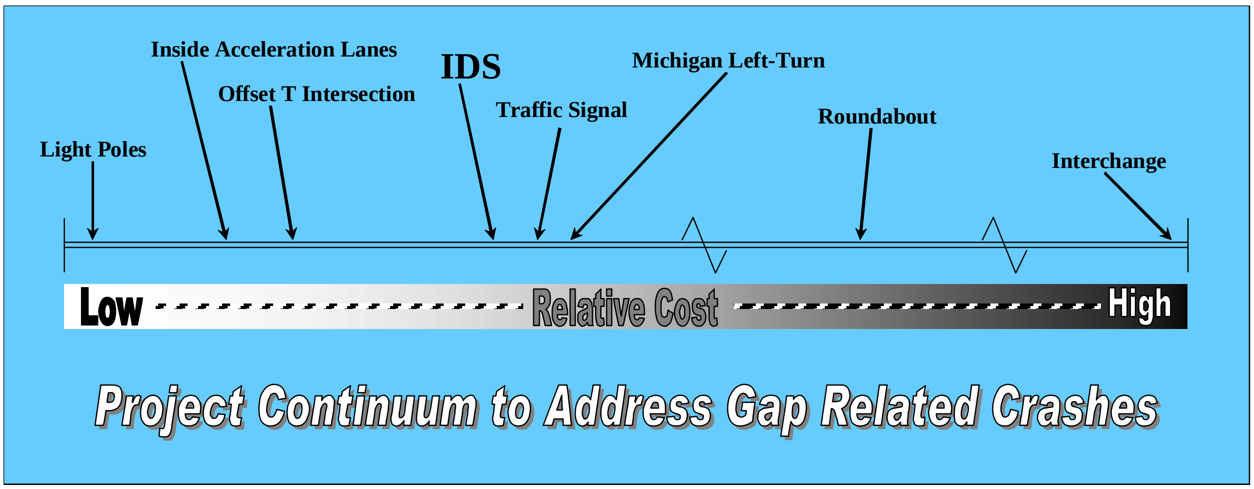


FIGURE 1-1
Gap Selection Related Safety Strategies

2. Crash Analysis Methods for Candidate Intersection Identification

A comprehensive method for intersection identification was developed using Minnesota's crash record system (see **Figure 2-1**). The method was applied to all rural, thru-STOP intersections in Minnesota, as this is the most frequent intersection situation in Minnesota. This intersection type is also the most likely where a driver will have to judge and select a gap at a rural intersection (i.e., stopped vehicle on the minor approach). The approach to identify the intersection selected for a potential field test of the technology used the three screens described in the following:

- **Critical Crash Rate –** The first screen was to identify the rural thru-STOP intersections that have a crash rate greater than the critical crash rate. The critical crash rate is a statistically significant rate higher than the statewide intersection crash rate. Therefore, any intersection with a crash rate equal to or above the critical crash rate can be identified as an intersection with a crash problem due to an existing safety deficiency.
- **Number and Severity of Correctable Crashes –** Once the list of intersections meeting the first criteria was identified, this second screen was performed to identify intersections where a relatively high number and percentage of crashes were potentially correctable by the IDS technologies being developed. In Minnesota's crash record system, right angle crashes were the crash type most often related to poor gap selection. Therefore the ideal candidate intersections had a high number and percentage of right-angle collisions and tended to have more severe crashes. This screen was used to identify the top three candidate intersections for the final screen.
- **Crash Conditions and At-Fault Driver Characteristics –** The IDS technology is believed to have the greatest benefit for older drivers. Therefore, the at-fault driver age was reviewed to identify intersections where older drivers were over represented. Other aspects of the crashes that were reviewed include whether the crashes were typically a problem with intersection recognition or gap recognition and the crash location (near lanes or far lanes).

In Wisconsin, application of the preferred process was not feasible due to the DOT's current crash record system. Therefore, the Wisconsin Department of Transportation (WisDOT) selected a portion of U.S. 53 through northwest Wisconsin because of known safety issues (see **Figure 2-2**). **Table 2-1** is a summary of the screening process used in Wisconsin and also lists the problems faced in the Wisconsin analysis, the solutions, and resulting compromises that were used to overcome the limitations of the State's crash record system.

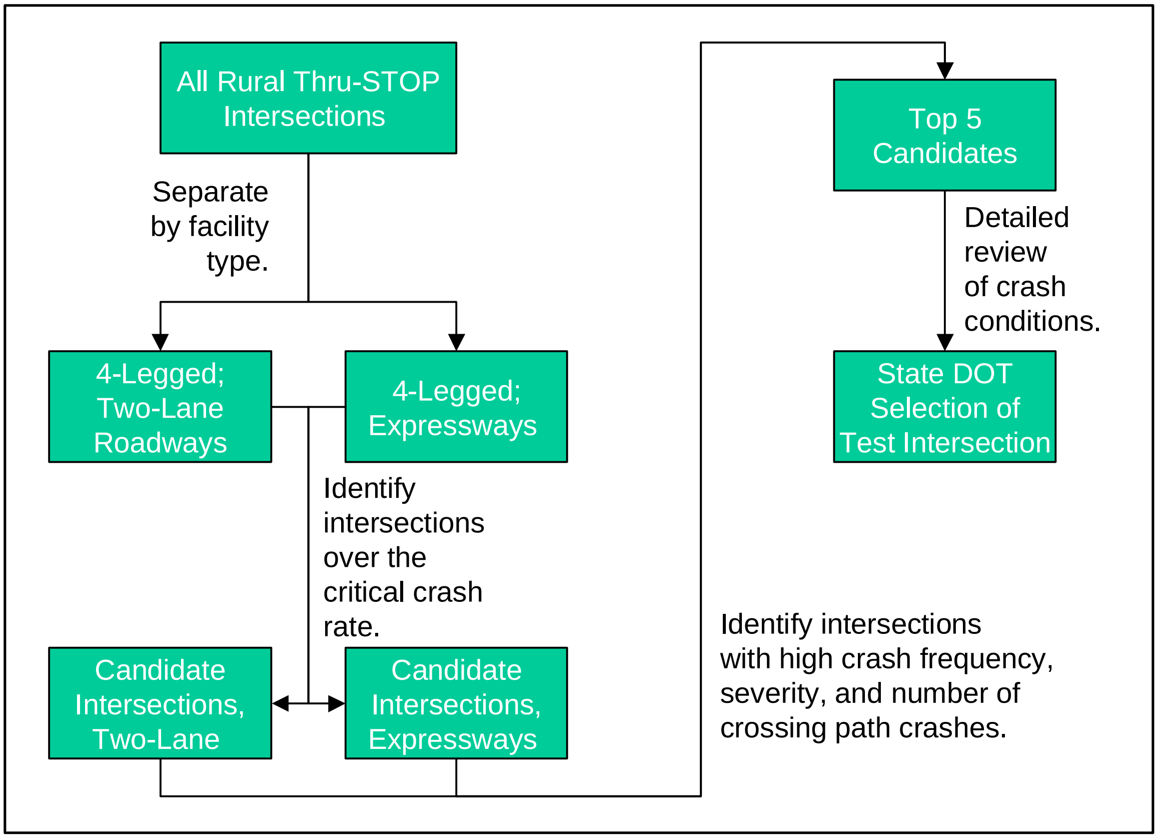


FIGURE 2-1
Preferred Crash Analysis Process

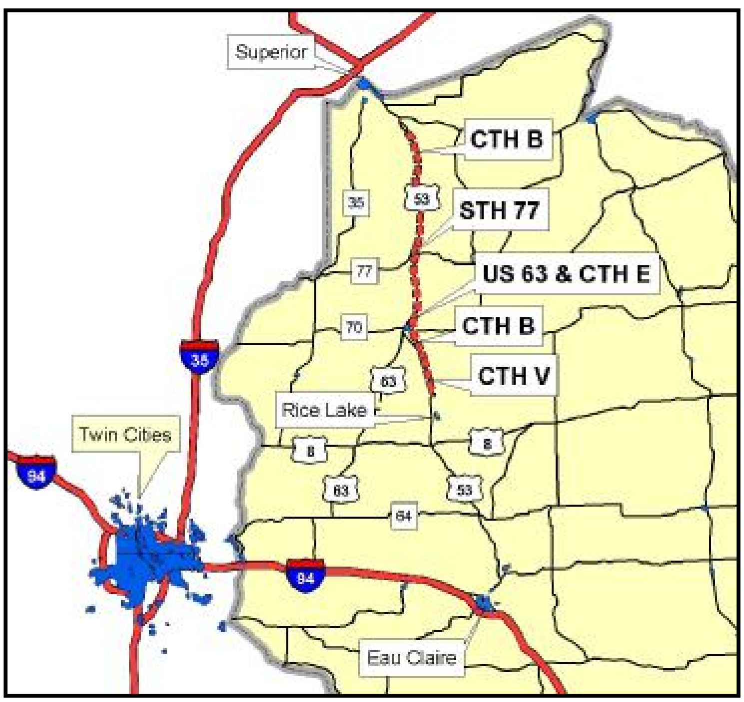


FIGURE 2-2
Wisconsin Study Corridor (U.S. 53 from Rice Lake to Superior)

TABLE 2-1
Wisconsin Crash Analysis

Problem	Solution	Effect on Analysis
Identifying Intersection Locations	Wis/DOT is limited in their ability to automatically identify groups of crashes that occurred at an intersection; crash records have to be manually reviewed to identify intersection crashes. Therefore, the task of identifying all rural unsignalized intersections in Wisconsin is impractical.	Candidate intersections were selected from a 70-mile portion of U.S. 53 (Rice Lake to Superior). This corridor was selected by WisDOT staff because it was known that it included several intersections with right angle crash problems.
Calculating a Crash Rate for Local Street Intersections	Of the local roadways, Wis/DOT maintains daily traffic volumes for only the County Trunk Highways. Volumes for local streets were unavailable.	If a local street did not have a daily volume, then an estimated volume was assumed (200 vehicles per day [vpd]). Because of the relatively high daily volumes on U.S. 53 (4,500 vpd to 10,000 vpd), the intersection crash rate tended to be very insensitive to the assumed minor street volumes.
Computing a Critical Crash Rate	An expected crash rate is necessary in order to compute a critical crash rate for an intersection. Wis/DOT is limited in their ability to compute an average crash rate for all rural, thru-STOP intersections.	An average crash rate was computed for thru-STOP intersections along the portion of U.S. 53 studied. Due to data limitation, the average crash rate was not computed using all intersections along the corridor. Instead, the average crash was based on all intersections that had at least one crash during the 6.5 year study period. This potentially yields a higher average rate than if all intersections in the corridor were included. Also, the typical procedure used by WisDOT is to remove all animal/deer crashes at intersections, which will lower the expected crash rate.

3. Identification of Candidate Intersections

Review of the U.S. 53 corridor (Rice Lake, Wis. to Superior, Wis.) began with crash records from January 1, 1998 through June 30, 2004 (6.5 years). Along this stretch of U.S. 53, there were 376 intersection crashes (any intersection collision involving an animal was removed) that occurred at 74 different intersections. With the WisDOT system, only the intersections that had at least one crash during the study period were identified and any intersection that had no crashes was not identifiable using the crash record summaries. Using the 74 identified intersections, the average crash rate was computed for the corridor, which is 0.3 crashes per 100 million entering vehicles.

To identify the top candidate intersections, several screens were applied. The first criteria used to screen the intersections was to remove all intersections that had four or fewer crashes in the 6.5 year period. This narrowed the list of intersections from 74 down to 20 intersections (see **Table 3-1**). Even though four crashes in the 6.5 year study period was arbitrarily set, an intersection with this few crashes is unlikely to be a quality candidate for a field test of a new safety device, yet this value significantly reduced the number of intersections to be reviewed.

Because the IDS technology is being developed to address high crash locations, the second screen was to identify the intersections that have a crash rate above the critical crash rate. To compute the critical crash rate, the corridor's average crash rate was used as the expected value. For seven of the 20 intersections, the minor street approach volume was not available. At these intersections, the average daily traffic (ADT) was estimated at 150 to 250 vehicles per day (vpd). This screen identified nine intersections as "dangerous" locations. The nine intersections (i.e., cross streets) with a crash rate above the critical crash rate are:

- **County Trunk Highway (CTH) V** (Barron County),
- **CTH B** (Washburn County),
- **CTH E** (Washburn County),
- **U.S. 63, N. Jct.** (Washburn County),
- **State Trunk Highway (STH) 77** (Washburn County),
- CTH Y (Douglas County),
- Baldwin Avenue (Douglas County),
- CTH A (Douglas County), and
- **CTH B** (Douglas County).

The final screen was a subjective review of crash frequency, crash severity and crash-type distribution in order to identify the top candidates. For crash frequency, three intersections (CTH Y, Baldwin Avenue, and CTH A) had only 13 crashes while the next highest crash frequency was 19 (U.S. 63). The same three intersections also had fewer fatal crashes except for one of the remaining six intersections (Note: CTH E also had no fatal crashes, but still had 19 angle crashes.). Finally, the percentage of angle crashes at CTH Y (38%) and CTH A (46%) was below the statewide distribution for angle crashes (47.6%). Therefore, six of the nine intersections were identified as candidates (intersections in bold in above list). For these six intersections, a detailed crash review and field review was performed.

TABLE 3-1
U.S. 53 Intersection Summary Table

County	Township / City	Cross Street	Total Crashes	Crashes by Year							Years of Accident Data	Entering ADT
				1998	1999	2000	2001	2002	2003	2004		
Barron	Oak Grove	CTH V	23	4	4	2	5	2	2	4	6.5	10,570
	Oak Grove	26th Avenue	8	0	2	1	2	2	0	1	6.5	10,250
Washburn	Sarona	CTH D	10	0	1	0	2	2	2	3	6.5	10,835
	Sarona	Pierce Road	5	3	0	1	1	0	0	0	6.5	10,200
	Beaver Brook	Cranberry Drive	6	0	2	0	0	4	0	0	6.5	10,300
	Beaver Brook	Wild Cat Road	8	0	1	0	1	2	1	3	6.5	10,300
	Beaver Brook	CTH B	22	5	2	4	2	3	5	1	6.5	10,720
	Spooner	State Highway 70	5	1	0	0	0	2	1	1	6.5	12,000
	Spooner	US 63 (South Jct)	8	0	0	0	1	4	3	0	6.5	10,300
	Trego	CTH E	30	5	7	6	3	2	7	0	6.5	9,000
	Trego	US 63 (North Jct)	19	3	4	2	3	5	1	1	6.5	10,400
	Minong	State Highway 77	30	4	1	2	9	3	11	0	6.5	6,800
Douglas	Gordon	CTH Y	13	3	2	2	2	2	2	0	6.5	7,180
	Solon Springs	Baldwin Avenue	13	0	3	2	2	3	3		6.5	6,500
	Solon Springs	CTH E	5	1	2	1	0	1	0	0	6.5	6,900
	Solon Springs (city)	CTH A	13	6	2	1	2	1	0	1	6.5	7,810
	Bennett	CTH L	5	0	1	0	0	0	3	1	6.5	7,240
	Hawthorne	CTH B	20	7	3	0	4	2	2	2	6.5	7,700
	Amnicon	US 2	12	2	1	0	3	3	3	0	6.5	14,500
	Amnicon	Middle River Road	8	0	2	2	0	1	1	2	6.5	7,900

TABLE 3-1 (continued)
U.S. 53 Intersection Summary Table

County	Township / City	Cross Street	Rate			Severity		
			Crash Rate	Expected Crash	Critical Crash	Fatal	Injury	PDO
		Distribution for Intersections in Corridor				6.4%	47.1%	46.5%
		Statewide Distribution				0.6%	30.7%	68.7%
Barron	Oak Grove	CTH V	0.9	0.3	0.5	4 17%	15 65%	4 17%
	Oak Grove	26th Avenue	0.3	0.3	0.5	0 0%	2 25%	6 75%
Washburn	Sarona	CTH D	0.4	0.3	0.5	1 10%	6 60%	3 30%
	Sarona	Pierce Road	0.2	0.3	0.5	0 0%	3 60%	2 40%
	Beaver Brook	Cranberry Drive	0.2	0.3	0.5	0 0%	1 17%	5 83%
	Beaver Brook	Wild Cat Road	0.3	0.3	0.5	0 0%	2 25%	6 75%
	Beaver Brook	CTH B	0.9	0.3	0.5	3 14%	13 59%	6 27%
	Spooner	State Highway 70	0.2	0.3	0.5	0 0%	3 60%	2 40%
	Spooner	US 63 (South Jct)	0.3	0.3	0.5	0 0%	1 13%	7 88%
	Trego	CTH E	1.4	0.3	0.5	0 0%	18 60%	12 40%
	Trego	US 63 (North Jct)	0.8	0.3	0.5	3 16%	6 32%	10 53%
	Minong	State Highway 77	1.9	0.3	0.6	5 17%	15 50%	10 33%
Douglas	Gordon	CTH Y	0.8	0.3	0.5	0 0%	8 62%	5 38%
	Solon Springs	Baldwin Avenue	0.8	0.3	0.6	1 8%	9 69%	3 23%
	Solon Springs	CTH E	0.3	0.3	0.6	0 0%	2 40%	3 60%
	Solon Springs (city)	CTH A	0.7	0.3	0.5	0 0%	8 62%	5 38%
	Bennett	CTH L	0.3	0.3	0.5	1 20%	1 20%	3 60%
	Hawthorne	CTH B	11.0	0.3	0.5	3 15%	10 50%	7 35%
	Amnicon	US 2	0.3	0.3	0.5	0 0%	7 58%	5 42%
	Amnicon	Middle River Road	0.4	0.3	0.5	0 0%	2 25%	6 75%

TABLE 3-1 (continued)
U.S. 53 Intersection Summary Table

County	Township / City	Cross Street	Crash Type						
			Angle	Head On	Rear End	No Collision*	Sideswipe - Opposing	Sideswipe - Same	Unknown
			47.6%	1.6%	8.8%	31.4%	1.6%	5.1%	4.0%
Barron	Oak Grove	CTH V	20		1	1	1		
			87%	0%	4%	4%	4%	0%	0%
	Oak Grove	26th Avenue	1		1	5		1	
			13%	0%	13%	63%	0%	13%	0%
Washburn	Sarona	CTH D	3		3	3		1	
			30%	0%	30%	30%	0%	10%	0%
	Sarona	Pierce Road				5			
			0%	0%	0%	100%	0%	0%	0%
	Beaver Brook	Cranberry Drive			1	5			
			0%	0%	17%	83%	0%	0%	0%
	Beaver Brook	Wild Cat Road	1			7			
			13%	0%	0%	88%	0%	0%	0%
	Beaver Brook	CTH B	19	1		2			
			86%	5%	0%	9%	0%	0%	0%
	Spooner	State Highway 70	1			3			1
			20%	0%	0%	60%	0%	0%	20%
	Spooner	US 63 (South Jct)				7		1	
			0%	0%	0%	88%	0%	13%	0%
	Trego	CTH E	19	2	1	4	2	1	1
			63%	7%	3%	13%	7%	3%	3%
	Trego	US 63 (North Jct)	10		5	1		1	2
			53%	0%	26%	5%	0%	5%	11%
	Minong	State Highway 77	21	1	1	6		1	
			70%	3%	3%	20%	0%	3%	0%
Douglas	Gordon	CTH Y	5		1	4	2		1
			38%	0%	8%	31%	15%	0%	8%
	Solon Springs	Baldwin Avenue	13						
			100%	0%	0%	0%	0%	0%	0%
	Solon Springs	CTH E	3			1		1	
			60%	0%	0%	20%	0%	20%	0%
	Solon Springs (city)	CTH A	6		2	2		2	1
			46%	0%	15%	15%	0%	15%	8%
	Bennett	CTH L	5						
			100%	0%	0%	0%	0%	0%	0%
	Hawthorne	CTH B	17		1			1	1
			85%	0%	5%	0%	0%	5%	5%
	Amnicon	US 2	1			7		2	2
			8%	0%	0%	58%	0%	17%	17%
	Amnicon	Middle River Road	6			2			
			75%	0%	0%	25%	0%	0%	0%

Source: Wisconsin Crash Records; January 1, 1998 to June 30, 2004.

Highlighted rows are intersections where the crash rate was greater than the critical crash rate.

* An example of a "No Collision" crash is a run-off the road or an overturn crash.

4. Crash Record Review of Candidate Intersections

It was already known that the six candidate intersections had high crash rates, high crash frequencies, and a high number of angle crashes, but the decision was made to investigate each intersection further for specific information pertinent to the IDS technology and also to learn of any unusual circumstances at the intersections. At the candidate intersections, the factors reviewed included at-fault driver age, crash severity, crash location, contributing factors, and the effects of weather. For all of these summaries, the focus is on correctable crossing path crashes only (see following section for definition), which are the crash types with the greatest potential to be corrected by the IDS device.

4.1. Correctable Crash Types

The General Estimates System (GES) crash database is a national sample of police-reported crashes used in many safety studies. In the GES, five crossing path crash types have been identified (see **Figure 4-1**), they are:

- Left Turn Across Path – Opposite Direction (LTAP/OD),
- Left Turn Across Path – Lateral Direction (LTAP/LD),
- Left Turn Into Path – Merge (LTIP),
- Right Turn Into Path – Merge (RTIP), and
- Straight Crossing Path (SCP).

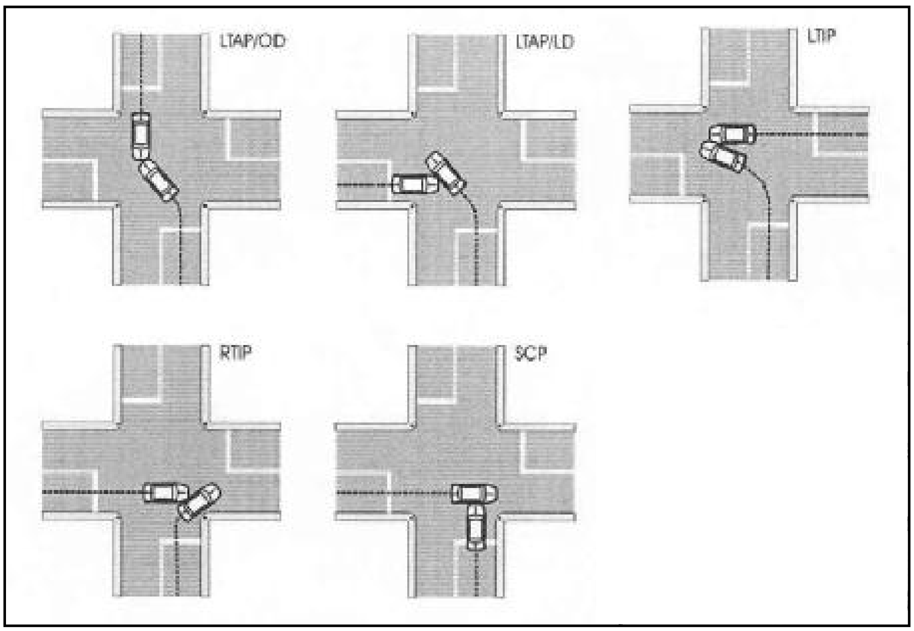


FIGURE 4-1
GES Crossing Path Crash Types

At this time, the IDS system under development is intended to address the crash types involving at least one vehicle from the major and minor street, which includes all five GES crash types except for LTAP/OD. This research has not focused on the LTAP/OD crash type at unsignalized rural intersections because they are expected to be a relatively small problem. However, it is believed the system could be adapted to address LTAO/OD crashes if an intersection had a significant number of these crashes. For example, LTAP/OD crashes involving two vehicles from the major street may be reduced if the DII is placed so that it is visible from the median (NOTE: more research is still needed before conclusions can be drawn about the importance of the placement).

At the candidate intersections, the number and percent of correctable crashes is summarized in **Table 4-1**. As listed in **Table 4-1**, all six intersections have approximately 60% or more of the crashes as a potentially correctable crash type. The intersections of CTH V and STH 77 had the most correctable crashes during the study period with 22 crashes each, while the U.S. 63 intersection had the fewest correctable crashes at 11.

4.2. At-Fault Drivers

For each candidate intersection, all crash reports from January 1, 1998 to June 30, 2004 were reviewed to identify the driver whose action caused the accident, also known as the at-fault driver. The age of the at-fault driver is important since the IDS technology may have its greatest benefit in assisting older drivers in particular (see **Figure 4-2**). From the 2002 Wisconsin Traffic Crash Facts, 17.9% of involved drivers were under the age of 21, 66.3% between the age of 21 and 64, and 7.4% over the age of 64 (Note: For 8.4% of involved drivers, the age was unknown. Wisconsin Traffic Crash Facts lists involved drivers and not specifically at-fault drivers. Comparisons between statewide involvement rates and the at-fault age distributions at the six candidate intersections must be carefully considered.)

Based on the statewide age distributions, only the intersection of CTH B and U.S. 53 (Douglas County) has an older driver involvement rate close to the expected value. All other intersections are at least 14 percentage points above the expected rate. Three of the intersections (CTH V, CTH E, and STH 77) have involvement rates of older drivers that is six-to-seven times greater than expected. For the young drivers, two intersections have an over-representation. At U.S. 63, young drivers are over-represented by 10 percentage points, while CTH B (Douglas County) has young drivers over-represented by 35 percentage points, which is nearly three times the expected value.

To assess whether the at-fault drivers are likely to be familiar with the intersection and enter it routinely, the distance from the crash location to their residence was examined (see **Table 4-2**). This can be an important factor if simulation testing reveals that drivers have a difficult time understanding the DII their first time through the intersection. If at-fault drivers are generally local residents, an educational program might be necessary and could be focused on the local population. However, if many of the at-fault drivers were not from the area and also did not have a high understanding of the DII, it is likely the IDS device would not have helped the driver avoid the crash.

A general trend among the intersections is that the U.S. and State route highways have a much higher median and average distance between the crash location and the at-fault driver’s residence when compared to the county intersections. The one noticeable difference is CTH V, where the average distance is the highest at 113 miles. However, there was one crash where the driver was from Florida, which skewed the average distance. Dismissing the Florida driver, the average distance is lowered to 47 miles, which is much closer to the other county intersections.

Typically, fewer than half of the at-fault drivers lived within 10 miles of the crash location, while 65% or more lived within 30 miles. However, it was common for each intersection (except for CTH B in Douglas County) to have at least two at-fault drivers who clearly did not live in the local area (i.e., lived more than 100 miles away). Therefore, it is important for the DII to be easy for a driver to understand the first time they see it, especially if deployed at U.S. 63 or STH 77 where fewer than 40% of the at-fault drivers lived within 30 miles of the crash location.

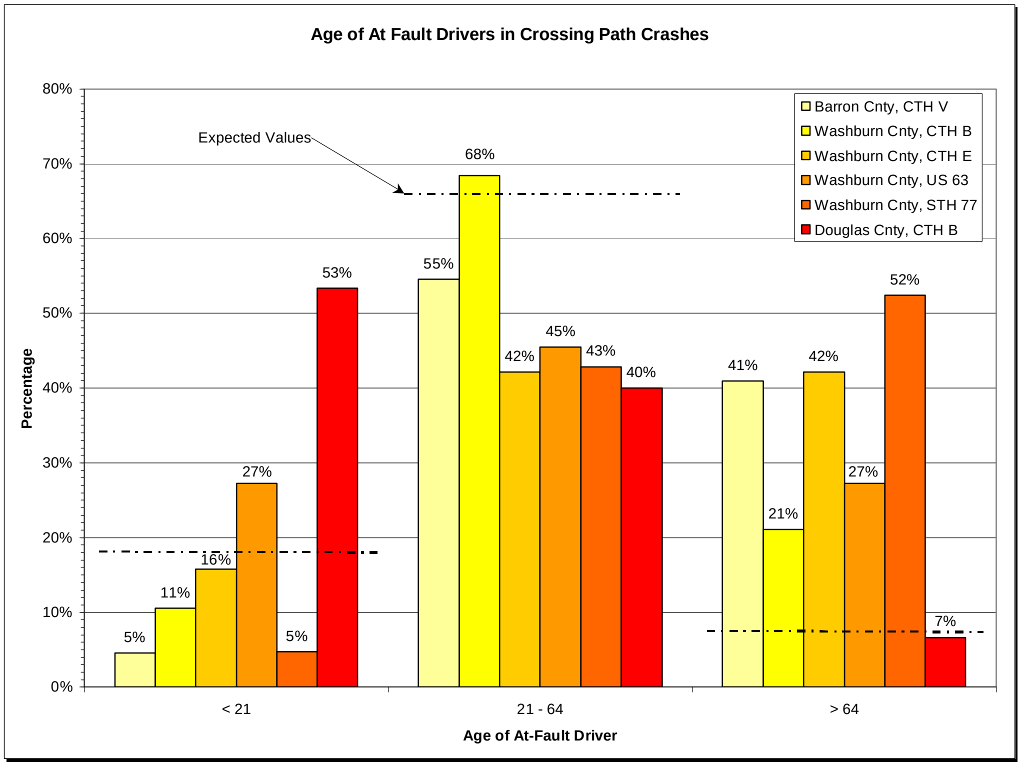


FIGURE 4-2

At-Fault Driver Age of Correctable Crash Types at Candidate Intersections

NOTE: Expected values based on involved driver age of all crashes reported in 2002 Wisconsin Traffic Crash Facts

4.3. Crash Severity

Another goal of the IDS technology is to address the most serious intersections crashes, especially fatal crashes. Therefore, the best candidate intersection would have a high distribution of fatal and severe injury crashes. Since the Wisconsin crash records do not separate injuries by level of severity (i.e., severe, moderate, and minor were used in the Minnesota analysis), all injury crashes were kept as a single group. Of Wisconsin's 2002 crashes, fatal crashes represented approximately 0.6% of all of crashes, with injury crashes at 30.7% and property damage (PD) crashes representing 68.7 % of all crashes (Source: 2002 Wisconsin Traffic Crash Facts). **Figure 4-3** shows that all intersections except for CTH E have a much higher distribution of fatal crashes than expected. Even though CTH E had no fatal crossing path crashes, this intersection does have the highest percentage of injury crashes, closely followed by CTH V and CTH B (Washburn County). Further, the U.S. 63 intersection has fewer injury crashes than expected, but the total of fatal and injury crashes is still higher than the statewide average.

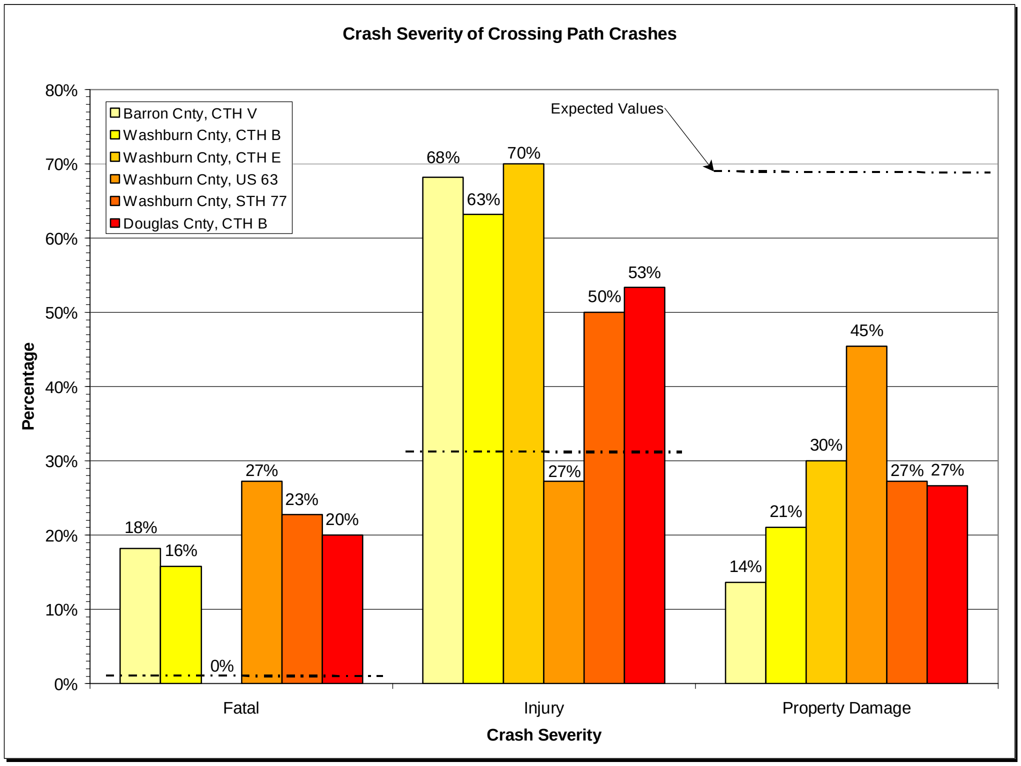


FIGURE 4-3

Crash Severity of Correctable Crash Types at Candidate Intersections

NOTE: Expected values based on crash severity of all crashes reported in 2002 Wisconsin Traffic Crash Facts

4.4. Crash Location and Contributing Factors

From the initial review of Minnesota's crash records (*3*), it was observed that crossing path crashes at the candidate intersections were predominately on the far side of the intersection. [NOTE: A farside crash occurs when the stopped vehicle safely negotiates the first two lanes it crosses, but is involved in a crash when leaving the median to either cross or merge into traffic in the second set of lanes.] The primary cause of the high number of farside crashes was not evident from review of the crash records. However, it was speculated that drivers used a one-step process for crossing rather than a two-step process. When a driver enters the median, rather than stopping to reevaluate whether the gap is still safe (a two-step process), it is believed that drivers simply proceed into the far lanes without stopping (a one-step process). At the selected intersection in Minnesota (U.S. 52 and Goodhue County 9), vehicle detection equipment has already been installed along with video cameras. The information recorded at the intersection will be used to quantify how drivers typically cross this and similar intersections. Even though it is still unknown how this may affect the device's final design, the decision was made to still document this crash characteristic.

At the intersections of CTH V, CTH B (Washburn County) and CTH B (Douglas County), approximately three-quarters or more of the crashes were classified as farside (see **Figure 4-4**), similar to what was observed in Minnesota. However, STH 77 had only 55% farside crashes while CTH E and U.S. 63 had over half of the crashes occurring on the nearside, 65% and 73% respectively. At STH 77, the likely reason the crashes are almost equally split is because of the median design, which is wider than typical and includes a STOP sign rather than a YIELD sign (see **Section 5.4** for more information). At CTH E and U.S. 63, the high percentage of nearside crashes is believed to be attributed to the land use. These two intersections are located on the edge of Trego, WI and the land use around the intersections is more suburban than rural in nature (see **Section 5.3** for more information).

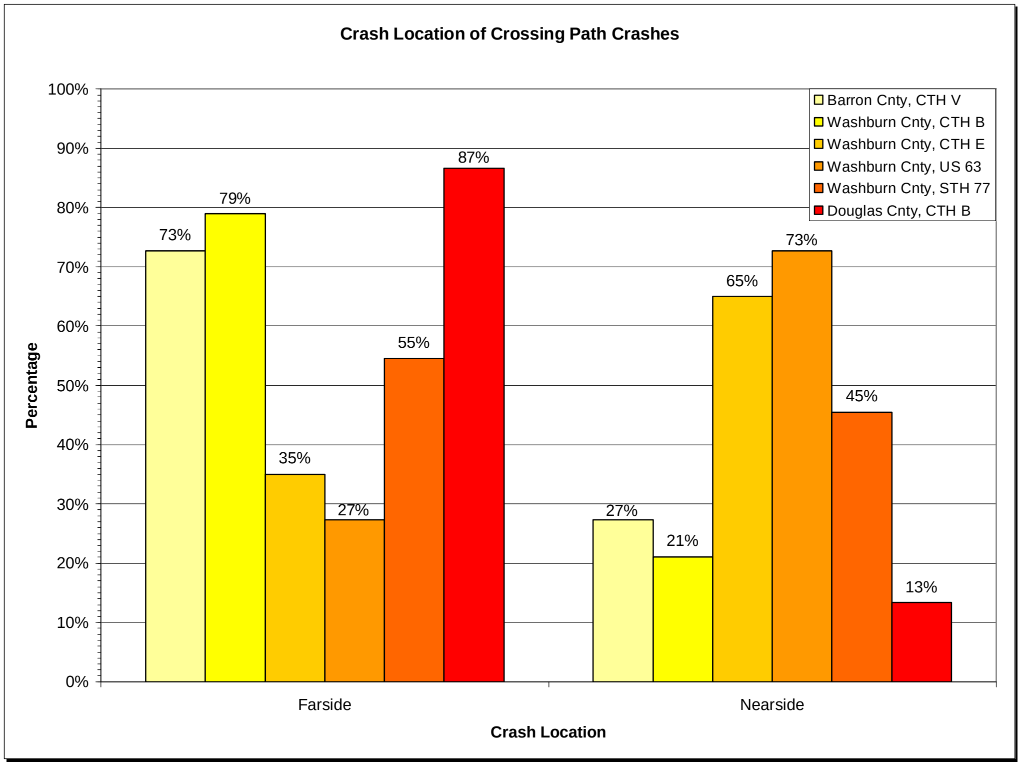


FIGURE 4-4
Crash Location of Correctable Crash Types at Candidate Intersections

Another important crash characteristic is whether the at-fault driver failed to recognize the intersection (i.e., ran-the-STOP) or failed to select a safe gap (i.e., stopped, pulled out). Since the IDS device is intended to help drivers with selecting safe gaps, crashes where the driver ran the STOP may not be correctable. To classify the crashes as either intersection recognition or gap recognition, the narratives on the officer reports were reviewed. However, some officer reports were not legible or did not include a narrative. For these crashes, the contributing factor was classified as "unknown." Also, some narratives did not specifically state whether the driver stopped at the STOP sign. However, for most of these situations, the officer's narrative provided enough information to make a determination as to whether or not the driver recognized the intersection. For example, the officer may have reported that the driver slowed for the YIELD sign in the median but did not come to a complete stop. In this example, even though the driver did not come to a complete stop, the driver obviously recognized the intersection but was unable to select a safe gap and the crashes was classified as gap recognition.

A predominate number of the crossing path crashes was drivers selecting gaps that were too small or not seeing the cross traffic before entering the intersection and very few crashes were drivers running the STOP sign (see **Figure 4-5**). The only intersection where intersection recognition was a noticeable problem was U.S. 63, otherwise the problem at the candidate intersections was overwhelmingly gap recognition.

4.5. Effect of Weather, Road Condition, and Light Condition

The final factors reviewed for the crossing path crashes at each candidate intersection were the weather, road, and light conditions. If the crashes tended to occur during adverse weather conditions (i.e., snow, rain, dark), then deployment of a new technology may not have a significant benefit unless coordinated with a local road weather information system station. In **Tables 4-3** thru **4-5**, all candidate intersections had a higher than expected number of crossing path crashes occurring during clear/cloudy conditions, on dry pavement and during the day. Therefore, weather was determined not to be a significant cause of crossing path crashes at any of the six intersections.

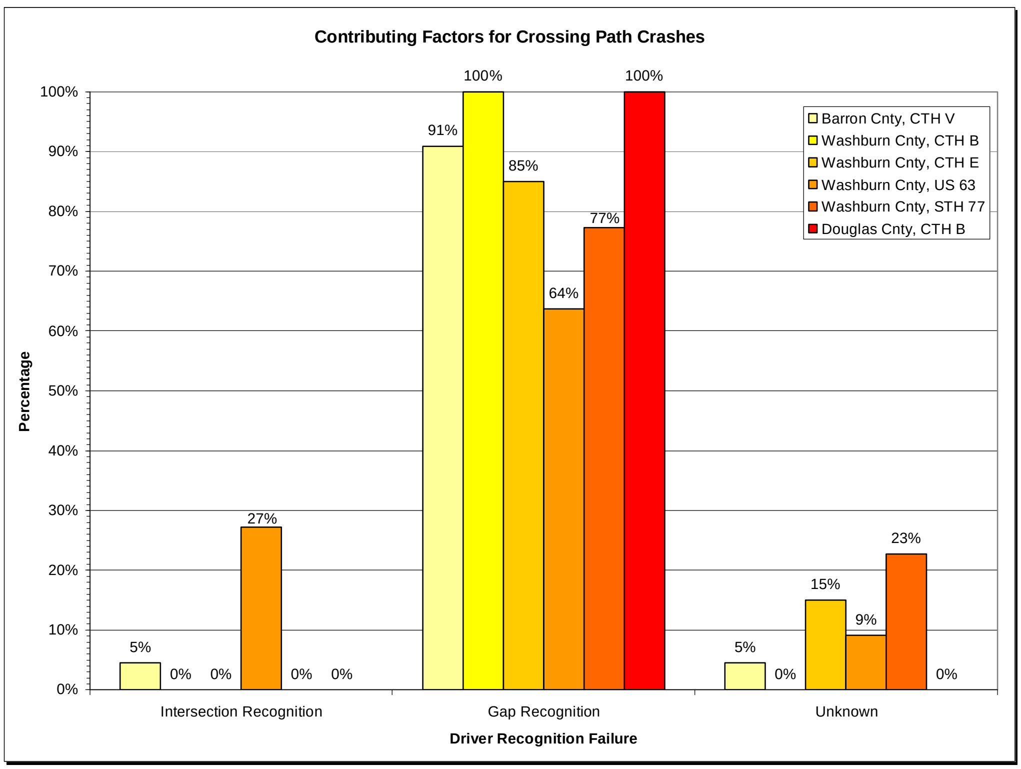


FIGURE 4-5
Contributing Factors of Correctable Crash Types at Candidate Intersections

TABLE 4-1
Potential Correctable Crashes for IDS Technology at Candidate Intersections

	CTH V Barron County	CTH B Washburn County	CTH E Washburn County	U.S. 63 (N. Jct.) Washburn County	STH 77 Washburn County	CTH B Douglas County
Number of Crashes	23	22	30	19	30	20
Number of Correctable Crashes	22	19	20	11	22	15
Percent of Crashes that are Correctable	96%	86%	67%	58%	73%	75%

NOTE: Correctable crashes have been defined as SCP, LTAP/LD, LTIP, and RTIP.

TABLE 4-2
Distance from Crash Location to At-Fault Driver's Residence

	CTH V Barron County	CTH B Washburn County	CTH E Washburn County	U.S. 63 (N. Jct.) Washburn County	STH 77 Washburn County	CTH B Douglas County
Median Distance	18 miles	6 miles	14 miles	47 miles	93 miles	11 miles
Average Distance	113 miles	26 miles	33 miles	98 miles	112 miles	13 miles
Minimum Distance	3 miles	3 miles	1 miles	8 miles	2 miles	1 miles
Maximum Distance	1,508 miles	128 miles	127 miles	413 miles	445 miles	27 miles
Percent of Distances ≤ 10 miles	32%	63%	45%	27%	23%	47%
Percent of Distances ≤ 30 miles	64%	79%	65%	36%	27%	100%

TABLE 4-3
Weather Condition Distribution for Crossing Path Crashes at Candidate Intersections

	Expected	CTH V Barron County	CTH B Washburn County	CTH E Washburn County	U.S. 63 (N. Jct.) Washburn County	STH 77 Washburn County	CTH B Douglas County
Clear or Cloudy	70%	91%	95%	95%	82%	86%	93%
Rain	6%	9%	5%	5%	18%	9%	7%
Snow or Sleet	7%	0%	0%	0%	0%	0%	0%
Unknown	16%	0%	0%	0%	0%	5%	0%

TABLE 4-4
Roadway Surface Condition Distribution for Crossing Path Crashes at Candidate Intersections

	Expected	CTH V Barron County	CTH B Washburn County	CTH E Washburn County	U.S. 63 (N. Jct.) Washburn County	STH 77 Washburn County	CTH B Douglas County
Dry	60%	91%	89%	90%	82%	77%	87%
Wet	12%	9%	11%	10%	18%	14%	6.5%
Snow or Ice	11%	0%	0%	0%	0%	0%	0%
Unknown	17%	0%	0%	0%	0%	9%	6.5%

TABLE 4-5
Light Condition Distribution for Crossing Path Crashes at Candidate Intersections

	Expected	CTH V Barron County	CTH B Washburn County	CTH E Washburn County	U.S. 63 (N. Jct.) Washburn County	STH 77 Washburn County	CTH B Douglas County
Daylight	56%	86%	95%	80%	82%	91%	87%
Dawn or Dusk	3%	5%	0%	10%	0%	0%	0%
Dark	26%	9%	5%	10%	18%	9%	13%

5. Field Review

On November 15, 2004, a field review of the six candidate intersections was performed. Some of the general observations made during the field review include:

- A majority of the intersections already have multiple low-cost improvements implemented that were intended to address the crash problem. However, all of the improvements are designed to help drivers recognize the intersection and do not assist the driver in selecting a safe gap. As was documented in **Chapter 5**, the crash problem is primarily related to gap recognition and not intersection recognition. (Note: Low-cost improvement deployed at the intersections included some or all of the following: DANGEROUS INTERSECTION sign, STOP AHEAD sign with red flasher and rumble strips on minor street approaches; oversized STOP sign with red flasher; second STOP sign placed on left side of roadway; street lights; and CROSS ROAD AHEAD sign with flasher on U.S. 53 approaches.)
- Additional strategies were used in the median to encourage drivers to stop. These improvements in the median include a YIELD pavement marking, rumble strips, and painted yield bar. **Figure 5-1** is the median at CHT B (Douglas County), which is a typical median design along the corridor.
- Power is readily available at all intersections to operate an IDS system.
- Intersections are typically located on or near a horizontal or vertical curve. However, at least 10 or more seconds of sight distance is available for the stopped vehicles.
- All medians are wide enough to store one or two passenger vehicles. Except for the median at STH 77, none of the intersections is wide enough to store a bus or semi-truck. At STH 77, the median can store a bus or semi with a 55’ trailer, but an oversized semi may still not be able to stop safely in the median.

FIGURE 5-1
Typical Intersection Median for U.S. 53 Corridor

Following is a brief description of each of the intersections. For each intersection, crash diagrams are included in **Appendix A** and available aerial photos are in **Appendix B**.

5.1. CTH V, Barron County

The intersection of CTH V and U.S. 53 is located approximately one mile to the east of Haugen, Wis. (pop. less than 500). A small pool cue manufacturing company and a farm home are located nearby, but the land use is predominantly agricultural (see **Figure 5-2**). The north approach of U.S. 53 is a crest vertical curve, but the available sight distance is still 12 to 15 seconds for a vehicle stopped in either the median or at the west approach (see **Figure 5-3**).

FIGURE 5-2
General Area at CTH V Intersection (west approach)

FIGURE 5-3
Crest Vertical Curve to North of CTH V Intersection (looking north from west approach)

5.2. CTH B, Washburn County

The intersection of U.S. 53 and CTH B is an isolated rural intersection with only farm homes nearby. The intersection is located on a horizontal curve, but available sight distance is still greater than 10 seconds (see **Figure 5-4**).

FIGURE 5-4
Horizontal Curve at CTH B (looking north from east approach)
NOTE: During the field visit, a temporary work zone was in place due to routine maintenance.

5.3. CTH E and U.S. 63 (North Jct.), Washburn County

These two intersections are located approximately 0.5 mile from each other and on the edge of Trego, Wis. Even though the area is not fully developed, both intersections have several businesses located nearby visible from U.S. 53 (see **Figure 5-5**). Therefore, the intersections are not considered to be typical isolated rural intersection. Also at these intersections, the right-turn lanes on U.S. 53 have been offset in order to help improve the sight line for vehicles stopped on the minor street approaches (see **Figure 5-6**). Finally, the U.S. 63 intersection is not a true four-legged intersection. The west approach is a driveway to several small businesses and a frontage road.

5.4. STH 77, Washburn County

STH 77 is located on the edge of Minong, Wis., and does have a gas station and several houses located nearby. However, U.S. 53 is a typical by-pass around Minong and the highway design, posted speed limit, and traffic volumes are typical for a rural highway. As is common for most of the candidate intersections, STH 77 intersects U.S. 53 along a horizontal curve, but still has plenty of available sight distance for a driver to safely cross U.S. 53 (see **Figure 5-7**). STH 77 does differ from the other five intersections because of its wider median. The median is approximately 100’ wide (from edge of travel lane to edge of travel lane). Rather than using the typical median design (see **Figure 5-1**) with this wider median, a new approach was used (see

Figure 5-8). This new design is a STOP sign, STOP pavement marking, stop bar, and double yellow centerline in the median.

FIGURE 5-5
Example Development at CTH E and U.S. 63 (area east of CTH E)

FIGURE 5-6
Example Offset Right Turn Lane at CTH E and U.S. 63 (looking south from east approach)

FIGURE 5-7
Horizontal Curve at STH 77 (looking north from west approach)

FIGURE 5-8
Median at STH 77

5.5. CTH B, Douglas County

The CTH B intersection is located approximately one mile west of Hawthorne, Wis. Several gas stations are located at the intersection, yet the intersection is predominately in a rural area. Similar to most intersections, CTH B is located just to the north of a horizontal curve on U.S. 53, but still has adequate sight distance for stopped vehicles (see **Figure 5-9**). In **Figure 5-9**, it can also be seen that this intersection is located just to the north of a portion of U.S. 53 that has independent vertical profiles. However, the location of the separate profiles does not restrict the line of sight for vehicles on the minor approach.

FIGURE 5-9
Horizontal Curve and Grade Separation at CTH B (looking south from east approach)

6. Summary and Intersection Recommendation

An overview of the pertinent crash statistics has been summarized in **Table 6-1** for the six candidate intersections. Following is a set of general observations from the analysis of U.S 53 from Rice Lake to Superior, Wisconsin.

- WisDOT has applied the standard traffic safety toolbox at each of these intersections. Generally, these strategies (minor street improvements such as DANGEROUS INTERSECTION sign, STOP AHEAD sign with red flasher, rumble strips, oversized STOP sign with red flasher, second STOP sign placed on left side of roadway, and street lights) have been very effective at reducing intersection recognition crashes (see **Figure 4-5**)
- These strategies have not been effective at addressing gap-related crashes – these types of crashes are over-represented at the highest crash frequency intersections along U.S. 53.
- The intersections have a crash rate greater than the critical crash rate (statistically significantly different than the expected value), the distribution of crash types skewed to angle crashes (predominately on the farside of the intersection), gap related, more severe than expected, and typically not caused by weather and/or light conditions.
- The predominance of farside angle crashes suggests the need for some additional control in the median. However, the U.S. 53 and STH 77 intersection has a STOP sign in the median (compared to the typical YIELD sign) but still has the highest frequency of crashes, the highest crash rate, and the most fatal crashes.
- The intersections with crash rates over the critical rate are different than "typical" intersections, but not just from the perspective of more crashes. The distribution of severity is higher and the distribution of crash type is skewed towards angle crashes (the fraction of angle crashes is more than twice the expected value at a "typical" intersection).
- There is a complicating geometric or traffic pattern at each of the intersections – vertical curve, horizontal curve, high volume of turning vehicles, etc. However, the actual intersection sight distance at each intersection is consistent with AASHTO guidelines.
- Overall, many at-fault drivers are local to the area (live within 30 miles of crash location), but the U.S. 63 and STH 77 intersections have few at-fault drivers that were considered local.

6.1. Recommended Intersection for Deployment

U.S. 63 and CTH E are not considered the best candidates for deployment of the IDS system because they are not isolated rural intersections. With the development on the edge of Minong, the land use is more suburban/urban. For the remaining four intersections, the pros and cons of each is summarized in **Table 6-2**.

The major drawback of the CTH V and CTH B (Washburn County) intersections is that they are too similar to the intersection selected in Minnesota. Deploying at these intersections will not increase the confidence that the device can work in many types of situations. For the CTH B (Douglas County) intersection, this intersection is again very similar to the Minnesota intersection in every aspect except for the age distribution of the at-fault drivers. With the high rate of young drivers, it is believed there is another factor at this intersection which has not be accounted for. Therefore, the intersection of U.S. 53 and STH 77 is recommended for deployment of the IDS device. This intersection has the highest crash rate, greatest number of fatalities and the crash statistics match closely to the Minnesota intersection. However, the unique design of the median provides for an opportunity to test the IDS device at an intersection that would provide an added perspective on how the proposed IDS system may function across a variety of intersection characteristics.

6.2. Other Recommendations

The University of Minnesota could design an IDS system for any of the remaining candidate intersections if WisDOT wished to implement additional intersections. If so, the second preferred intersection is CTH V because of how similar it is to the Minnesota intersection. Testing at this intersection will help increase the confidence of the results of the Minnesota test. If the IDS system was deployed at CTH V, comparing the results to a traditional geometric improvement (see following) deployed at CTH B (Washburn County) could be conducted since the intersections are very similar in design and crash statistics. The third preference is either the U.S. 63 or CTH E intersection. Since, these intersections are significantly different from the Minnesota intersection, it is likely that a redesign of the sensing equipment would be required. Yet, testing at either intersection would again increase the knowledge of how the system will operate in various situations.

If the IDS system is deployed only at STH 77, the remaining five candidate intersections also could benefit from traditional mitigation strategies to address the high number of crossing path crashes (especially those related to gap recognition). The following recommendations are presented for WisDOT's consideration. However, further investigation is required to determine if these recommendations are feasible solutions or if another strategy may be optimal.

- CTH V – Create offset T intersection by closing west approach and using either CTH SS or 27th Avenue to provide access. Consider constructing inside acceleration lanes as left-turn volumes are expected to increase.

- CTH B – Close the median cross-over and create a Michigan Left-Turn to accommodate left turn and crossing maneuvers.

- CTH E and U.S. 63 – Create an offset T intersection by closing west approach (driveway) of the U.S. 63 intersection and east approach at CTH E. Consider constructing inside acceleration lanes as left-turn volumes are expected to increase. Continue to provide access to adjacent business using a frontage road system and right-in/right-out intersections located between CTH E and U.S. 63.

- CTH B – Create an offset T intersection by closing the east approach of CTH B. Use the local street located approximately one mile to the north, which connects diagonally to CTH B east of U.S. 53 to provide access. Consider constructing inside acceleration lanes as left-turn volumes are expected to increase.

Our final recommendation is that WisDOT may benefit from an electronic database that has key intersection attributes (i.e., roadway design, posted speed limit, area type, traffic control device, etc.) which can be queried and is also linked to the crash record database. Development of a tool would allow the State to quickly screen through hundreds of similar intersections in order to determine expected rates and identify high crash locations.

TABLE 6-1
Candidate Intersection Summary

Performance Measure		CTH V Barron County	CTH B Washburn County	CTH E Washburn County	U.S. 63 (N. Jct.) Washburn County	STH 77 Washburn County	CTH B Douglas County
Crash Frequency		23	22	30	19	30	20
CrashSeverity	Fat	4 (17%)	3 (14%)	0 (0%)	3 (16%)	5 (17%)	3 (15%)
	Inj	15 (65%)	13 (59%)	18 (60%)	6 (32%)	15 (50%)	10 (50%)
	PD	4 (17%)	6 (27%)	12 (40%)	10 (53%)	10 (33%)	7 (35%)
Daily Entering ADT		10,570	10,720	9,000	10,400	6,800	7,700
Crash Rate		0.9	0.9	1.4	0.8	1.9	1.1
Expected Rate		0.3	0.3	0.3	0.3	0.3	0.3
Critical Crash Rate		0.5	0.5	0.5	0.5	0.6	0.5
Correctable Crash Type		22 (96%)	19 (86%)	20 (67%)	11 (58%)	22 (73%)	15 (75%)
Crash Severity	Fat	4 (18%)	3 (16%)	0 (0%)	3 (27%)	5 (23%)	3 (20%)
	Inj	15 (68%)	12 (63%)	14 (70%)	3 (27%)	11 (50%)	8 (53%)
	PD	3 (14%)	4 (21%)	6 (30%)	5 (45%)	6 (27%)	4 (27%)
At-Fault Driver							
	< 21	1 (5%)	2 (11%)	3 (16%)	3 (27%)	1 (5%)	8 (53%)
	21 – 64	12 (55%)	13 (68%)	8 (42%)	5 (45%)	9 (43%)	6 (40%)
	> 64	9 (41%)	4 (21%)	8 (42%)	3 (27%)	11 (52%)	1 (7%)
Crash Location							
	Farside	16 (73%)	15 (79%)	7 (35%)	3 (27%)	12 (55%)	13 (87%)
	Nearside	6 (27%)	4 (21%)	13 (65%)	8 (73%)	10 (45%)	2 (13%)
Contributing Factors							
	Int Recg	1 (5%)	0 (0%)	0 (0%)	3 (27%)	0 (0%)	0 (0%)
	Gap Recg	20 (91%)	19 (100%)	17 (85%)	7 (64%)	17 (77%)	15 (100%)
	Unknown	1 (5%)	0 (0%)	3 (15%)	1 (9%)	5 (23%)	0 (0%)

TABLE 6-2
Pros and Cons of Candidate Intersections

Candidate Intersection	Pros	Cons
CTH V - Barron County	Tied with STH 77 for the greatest number of correctable crash types. Of correctable crash types, has highest percentage of fatal and injury crashes. Older drivers are over-represented. High percentage of farside crashes. High percentage of gap related crashes, including the highest number of gap related crashes.	Very similar to existing Minnesota site, thus does not provide for testing in different situations. WisDOT has considered as a candidate for constructing an offset T intersection.
CTH B - Washburn County	High percentage of correctable crash types. Fatal and injury crashes are over-represented. Older drivers are over-represented. High percentage of farside crashes. Tied with CTH B (Douglas County) for highest percentage of gap related crashes.	Intersection does not have the highest number of correctable crashes, fatal crashes, older driver crashes, or farside crashes
STH 77 - Washburn County	Highest intersection crash rate. Tied with CTH V for the greatest number of correctable crash types. Of correctable crash types, has highest number of fatal crashes. Has the highest involvement of older drivers. High percentage of gap related crashes.	Unlike other intersections, has a near equal split in farside/nearside crashes. Not known how DII being developed will perform in wider median that includes a STOP sign.
CTH B - Douglas County	High percentage of correctable crash types. Fatal and injury crashes are over-represented. Has the highest percentage of farside crashes. Tied with CTH B (Washburn County) for highest percentage of gap related crashes.	Older drivers are not over-represented. However, young drivers are over represented and more investigation is required before an IDS system could be properly designed.

Note: "Correctable crash type" implies that the crash was potentially correctable by the IDS technology.

References

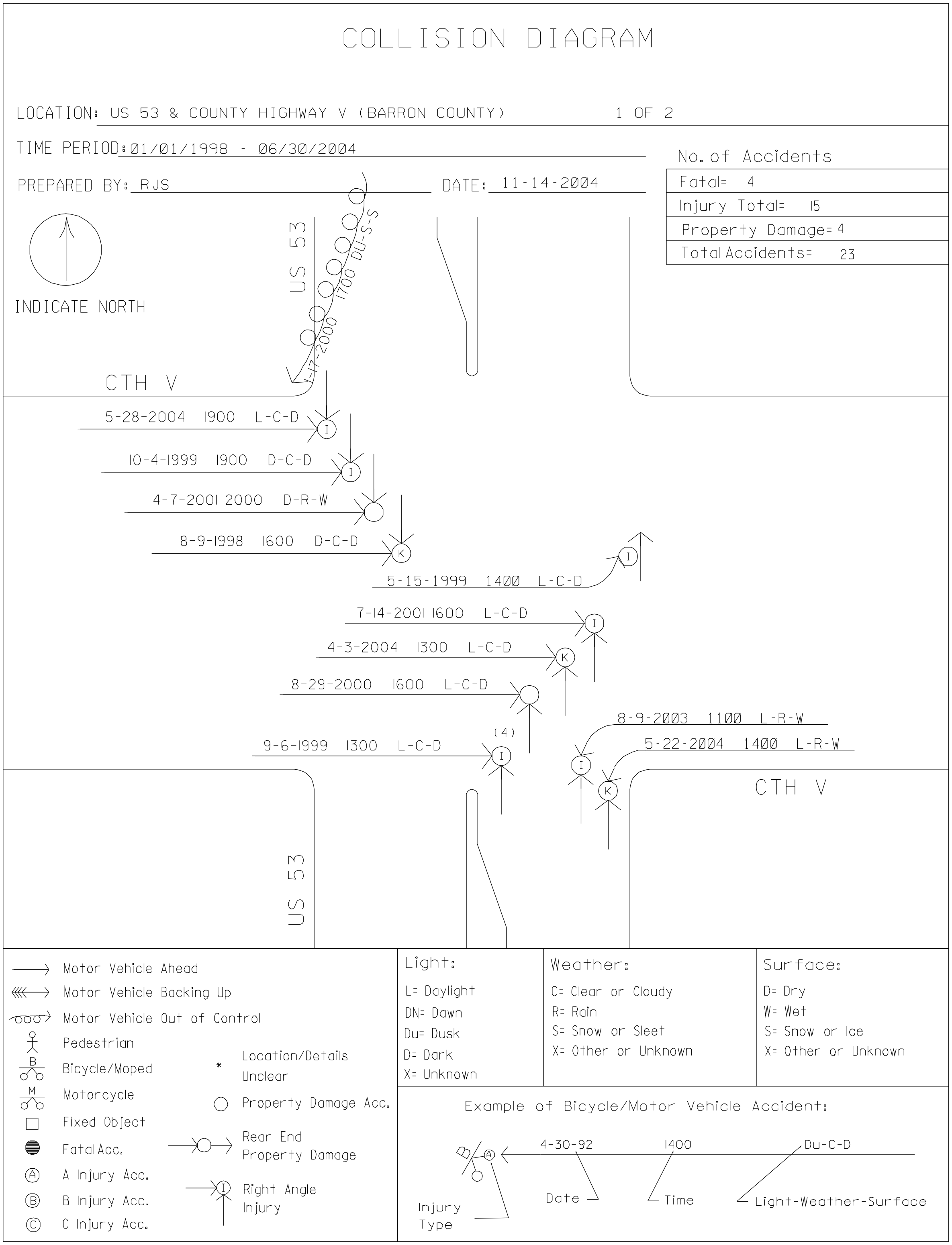
1. Najm, W.J., J.A. Koopmann and D.L. Smith. “Analysis of Crossing Path Crash Countermeasure Systems.” Proceedings of the 17th International Technical Conference on the Enhanced Safety of Vehicles, Amsterdam, The Netherlands. June 2001.

2. Harder, K.A., J. Bloomfield, B.J. Chihak. *Crashes at Controlled Rural Intersection.* Report MN/RC-2003-15. Local Road Research Board, Minnesota Department of Transportation. July 2003.

3. Preston, H., R. Storm, M. Donath, C. Shankwitz. *Review of Minnesota’s Rural Intersection Crashes: Methodology for Identifying Intersections for Intersection Decision Support.* Report MN/RC-2004-31. Minnesota Department of Transportation. May 2004.

Appendix A

Intersection Crash Diagrams



COLLISION DIAGRAM
LOCATION: US 53 & COUNTY HIGHWAY V (BARRON COUNTY)
1 OF 2
TIME PERIOD: 01/01/1998 - 06/30/2004
PREPARED BY: RJS
DATE: 11-14-2004
No. of Accidents
Fatal= 4
Injury Total= 15
Property Damage= 4
Total Accidents= 23
INDICATE NORTH
US 53
CTH V
1-17-2000 1700 DU-S-S
5-28-2004 1900 L-C-D
10-4-1999 1900 D-C-D
4-7-2001 2000 D-R-W
8-9-1998 1600 D-C-D
5-15-1999 1400 L-C-D
7-14-2001 1600 L-C-D
4-3-2004 1300 L-C-D
8-29-2000 1600 L-C-D
(4)
9-6-1999 1300 L-C-D
8-9-2003 1100 L-R-W
5-22-2004 1400 L-R-W
CTH V
US 53
Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
A Injury Acc.
B Injury Acc.
C Injury Acc.
* Location/Details Unclear
Property Damage Acc.
Rear End Property Damage
Right Angle Injury
Light:
L= Daylight
DN= Dawn
Du= Dusk
D= Dark
X= Unknown
Weather:
C= Clear or Cloudy
R= Rain
S= Snow or Sleet
X= Other or Unknown
Surface:
D= Dry
W= Wet
S= Snow or Ice
X= Other or Unknown
Example of Bicycle/Motor Vehicle Accident:
4-30-92
1400
Du-C-D
Injury Type
Date
Time
Light-Weather-Surface

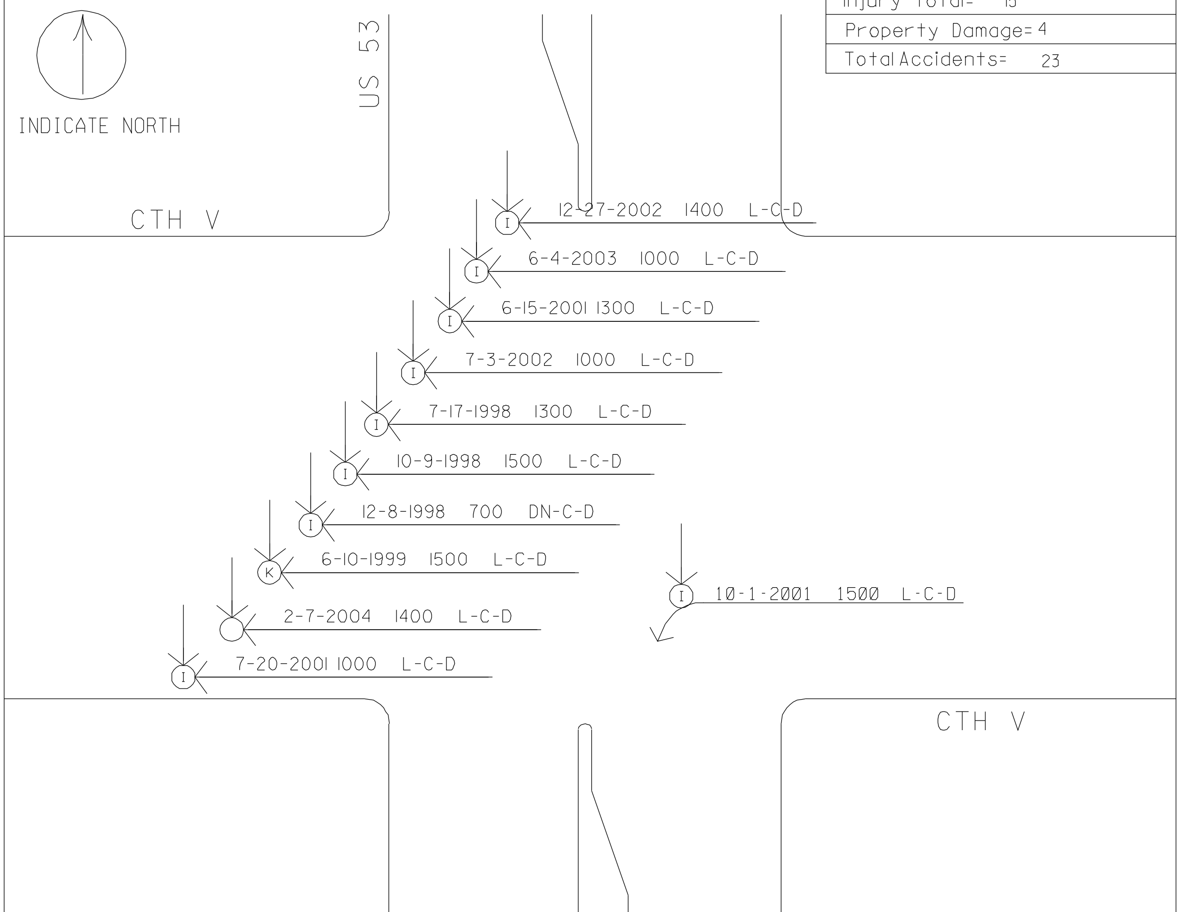
COLLISION DIAGRAM

LOCATION: US 53 & COUNTY HIGHWAY V (BARRON COUNTY) 2 OF 2

TIME PERIOD: 01/01/1998 - 06/30/2004

PREPARED BY: RJS DATE: 11-14-2004

No. of Accidents	
Fatal=	4
Injury Total=	15
Property Damage=	4
Total Accidents=	23



Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
Ⓐ A Injury Acc.
Ⓑ B Injury Acc.
Ⓒ C Injury Acc.

* Location/Details Unclear
○ Property Damage Acc.
Rear End Property Damage
Right Angle Injury

Light:	Weather:	Surface:
L= Daylight	C= Clear or Cloudy	D= Dry
DN= Dawn	R= Rain	W= Wet
Du= Dusk	S= Snow or Sleet	S= Snow or Ice
D= Dark	X= Other or Unknown	X= Other or Unknown
X= Unknown		

Example of Bicycle/Motor Vehicle Accident:

4-30-92 1400 Du-C-D

Injury Type — Date — Time — Light-Weather-Surface

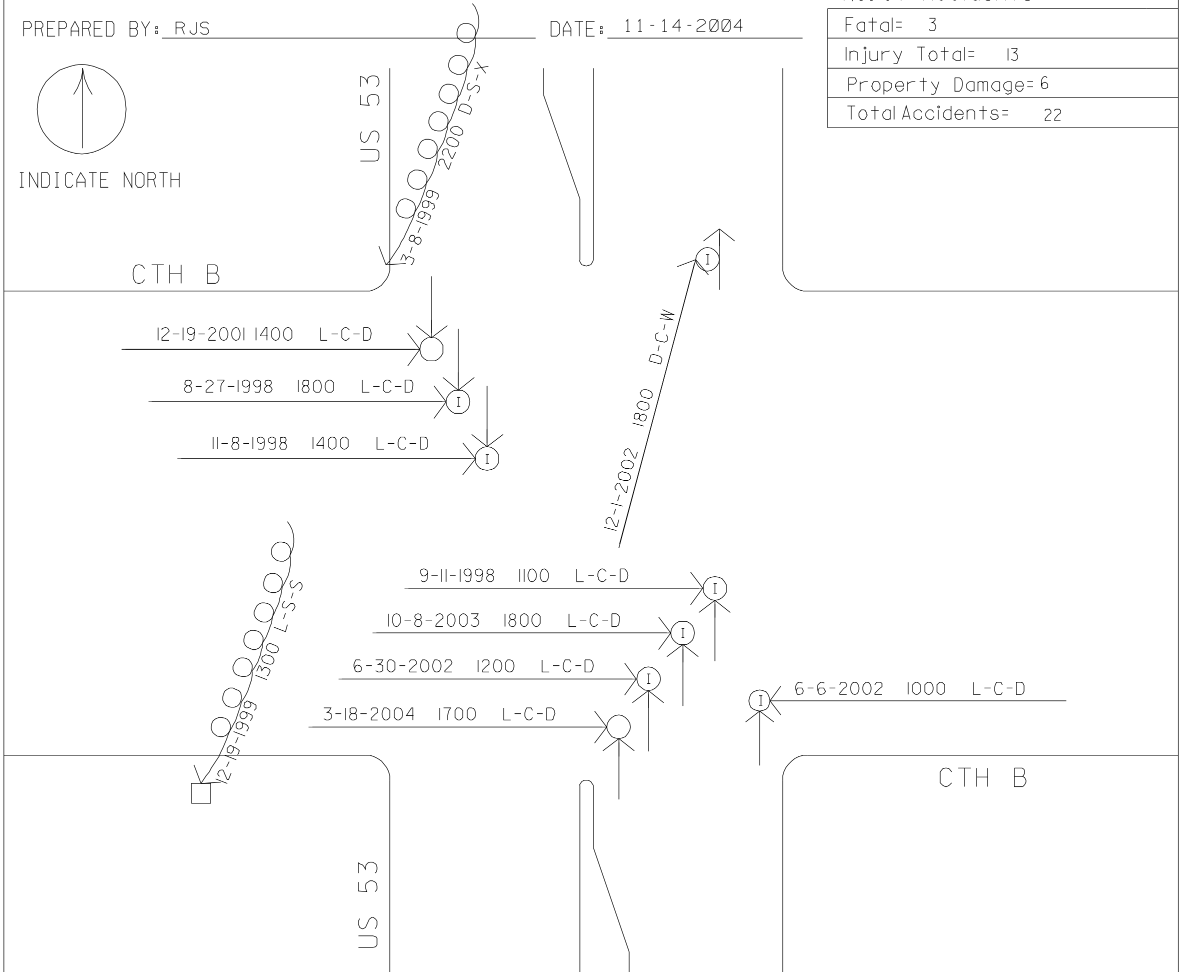
COLLISION DIAGRAM

LOCATION: US 53 & COUNTY HIGHWAY B (WASHBURN COUNTY) 1 OF 2

TIME PERIOD: 01/01/1998 - 06/30/2004

PREPARED BY: RJS DATE: 11-14-2004

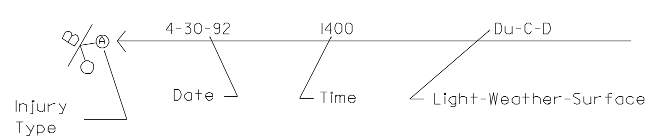
No. of Accidents	
Fatal=	3
Injury Total=	13
Property Damage=	6
Total Accidents=	22



Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
Ⓐ A Injury Acc.
Ⓑ B Injury Acc.
Ⓒ C Injury Acc.
* Location/Details Unclear
Property Damage Acc.
Rear End Property Damage
Right Angle Injury

Light:	Weather:	Surface:
L= Daylight	C= Clear or Cloudy	D= Dry
DN= Dawn	R= Rain	W= Wet
Du= Dusk	S= Snow or Sleet	S= Snow or Ice
D= Dark	X= Other or Unknown	X= Other or Unknown
X= Unknown		

Example of Bicycle/Motor Vehicle Accident:



COLLISION DIAGRAM

LOCATION: US 53 & COUNTY HIGHWAY B (WASHBURN COUNTY) 2 OF 2

TIME PERIOD: 01/01/1998 - 06/30/2004

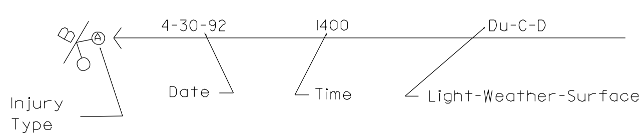
PREPARED BY: RJS DATE: 11-14-2004

No. of Accidents
Fatal= 3
Injury Total= 13
Property Damage= 6
Total Accidents= 22

- Motor Vehicle Ahead
- Motor Vehicle Backing Up
- Motor Vehicle Out of Control
- Pedestrian
- Bicycle/Moped
- Motorcycle
- Fixed Object
- Fatal Acc.
- A Injury Acc.
- B Injury Acc.
- C Injury Acc.
- * Location/Details Unclear
- Property Damage Acc.
- Rear End Property Damage
- Right Angle Injury

Light:	Weather:	Surface:
L= Daylight	C= Clear or Cloudy	D= Dry
DN= Dawn	R= Rain	W= Wet
Du= Dusk	S= Snow or Sleet	S= Snow or Ice
D= Dark	X= Other or Unknown	X= Other or Unknown
X= Unknown		

Example of Bicycle/Motor Vehicle Accident:



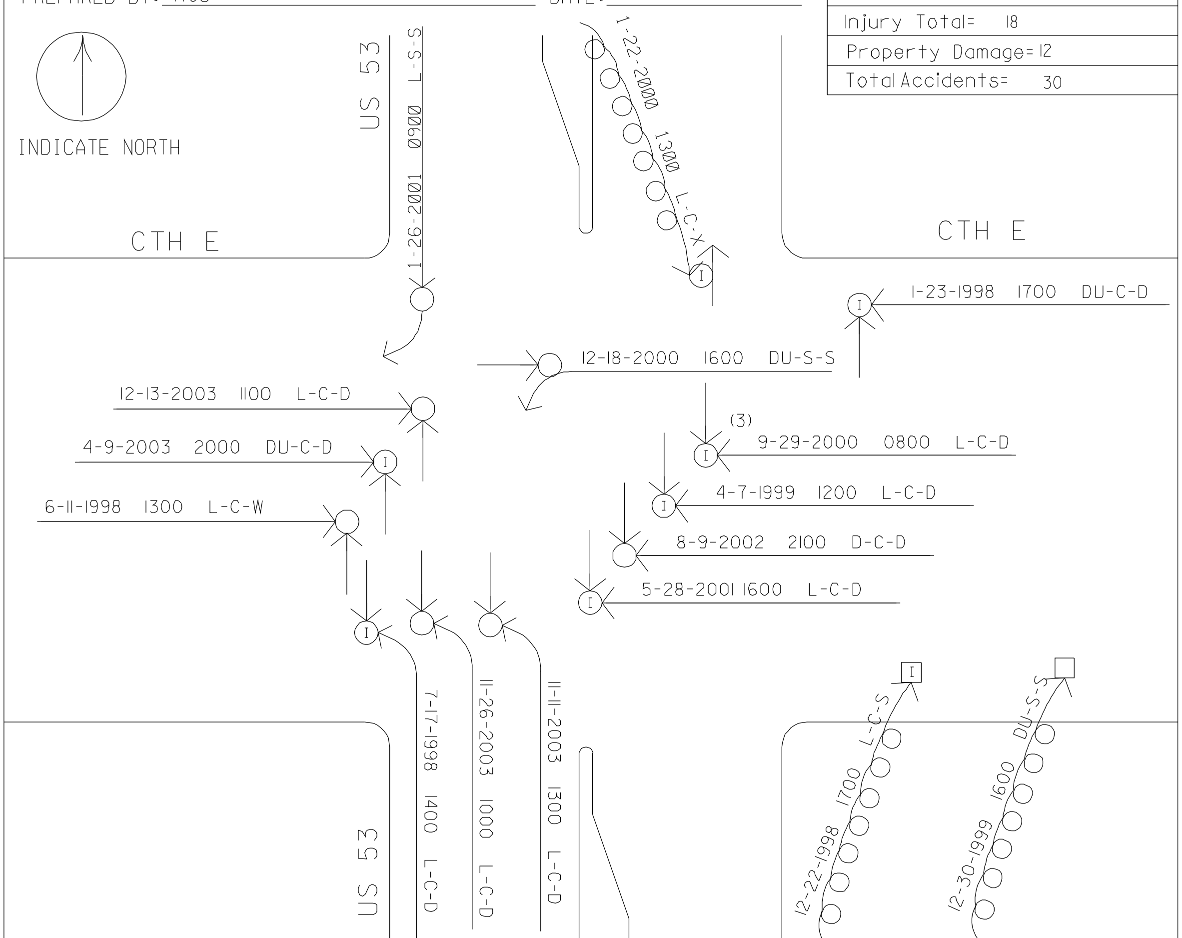
COLLISION DIAGRAM

LOCATION: US 53 & COUNTY HIGHWAY E (WASHBURN COUNTY) 1 OF 2

TIME PERIOD: 01/01/1998 - 06/30/2004

PREPARED BY: RJS DATE: 11-14-2004

No. of Accidents	
Fatal=	0
Injury Total=	18
Property Damage=	12
Total Accidents=	30



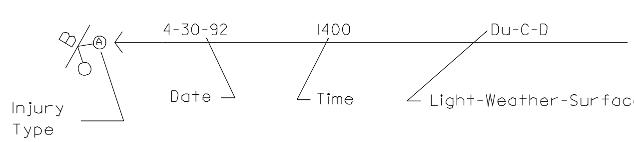
- → Motor Vehicle Ahead
- Motor Vehicle Backing Up
- Motor Vehicle Out of Control
- Pedestrian
- Bicycle/Moped
- Motorcycle
- Fixed Object
- Fatal Acc.
- Ⓐ A Injury Acc.
- Ⓑ B Injury Acc.
- Ⓒ C Injury Acc.
- * Location/Details Unclear
- ○ Property Damage Acc.
- Rear End Property Damage
- Right Angle Injury

Light:
L= Daylight
DN= Dawn
Du= Dusk
D= Dark
X= Unknown

Weather:
C= Clear or Cloudy
R= Rain
S= Snow or Sleet
X= Other or Unknown

Surface:
D= Dry
W= Wet
S= Snow or Ice
X= Other or Unknown

Example of Bicycle/Motor Vehicle Accident:



COLLISION DIAGRAM

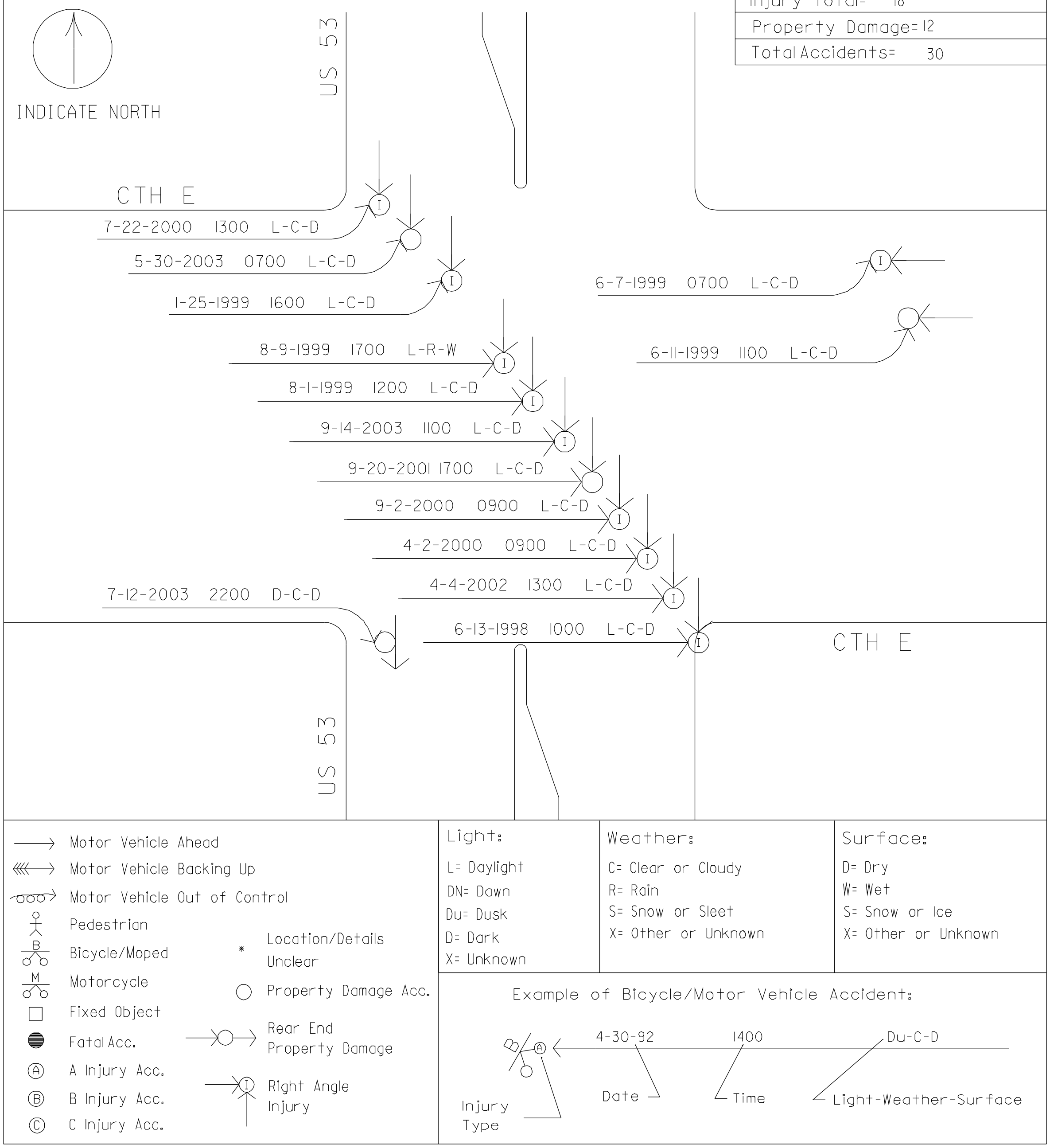
LOCATION: US 53 & COUNTY HIGHWAY E (WASHBURN COUNTY)

TIME PERIOD: 01/01/1998 - 06/30/2004

PREPARED BY: RJS

DATE: 11-14-2004

No. of Accidents	
Fatal=	0
Injury Total=	18
Property Damage=	12
Total Accidents=	30



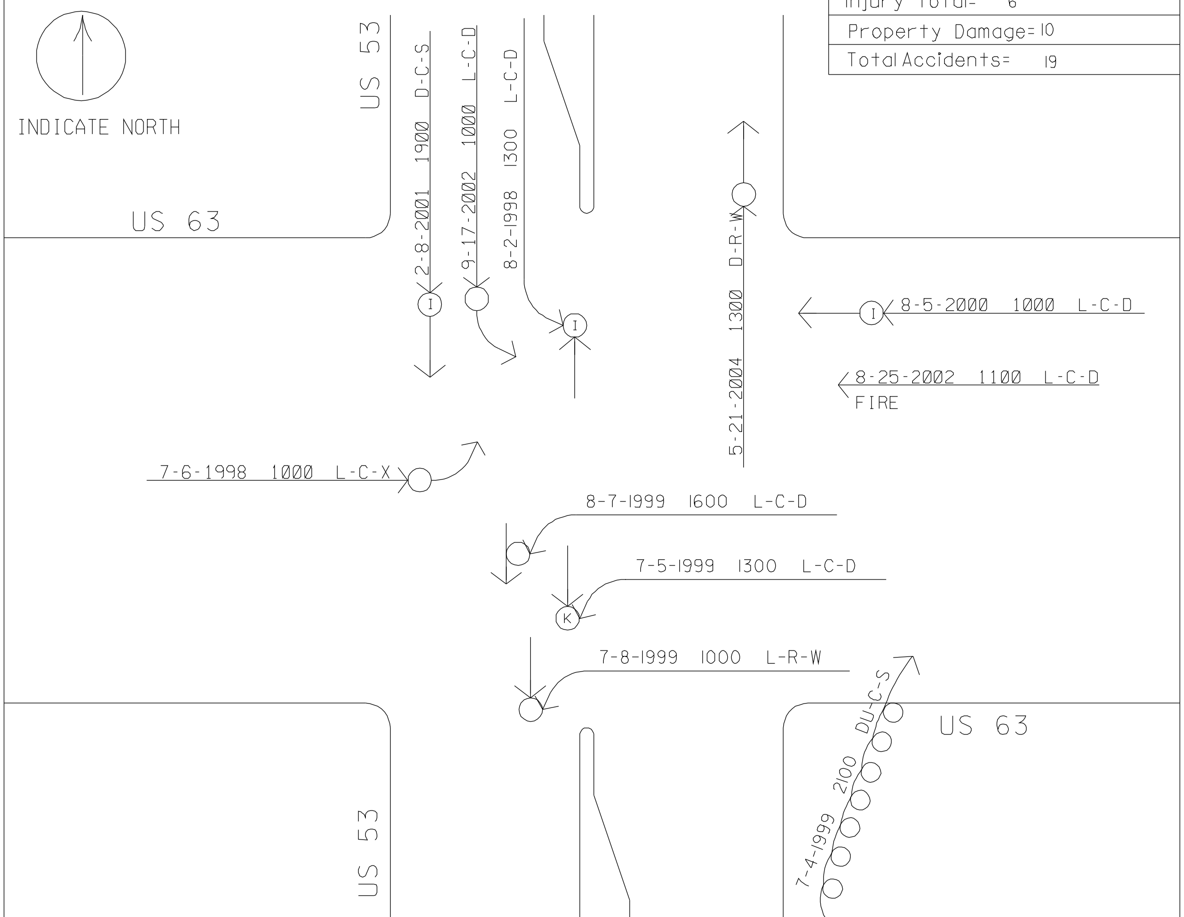
COLLISION DIAGRAM

LOCATION: US 53 & US 63 (WASHBURN COUNTY) 1 OF 2

TIME PERIOD: 01/01/1998 - 06/30/2004

PREPARED BY: RJS DATE: 11-14-2004

No. of Accidents	
Fatal=	3
Injury Total=	6
Property Damage=	10
Total Accidents=	19



Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
A Injury Acc.
B Injury Acc.
C Injury Acc.
* Location/Details Unclear
Property Damage Acc.
Rear End Property Damage
Right Angle Injury

Light:
L= Daylight
DN= Dawn
Du= Dusk
D= Dark
X= Unknown

Weather:
C= Clear or Cloudy
R= Rain
S= Snow or Sleet
X= Other or Unknown

Surface:
D= Dry
W= Wet
S= Snow or Ice
X= Other or Unknown

Example of Bicycle/Motor Vehicle Accident:

4-30-92 1400 Du-C-D

Injury Type — Date — Time — Light-Weather-Surface

COLLISION DIAGRAM

LOCATION: US 53 & US 63 (WASHBURN COUNTY) 2 OF 2

TIME PERIOD: 01/01/1998 - 06/30/2004

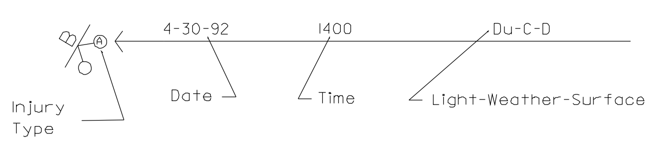
PREPARED BY: RJS DATE: 11-14-2004

No. of Accidents
Fatal= 3
Injury Total= 6
Property Damage= 10
Total Accidents= 19

Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
A Injury Acc.
B Injury Acc.
C Injury Acc.
* Location/Details Unclear
Property Damage Acc.
Rear End Property Damage
Right Angle Injury

Light:	Weather:	Surface:
L= Daylight	C= Clear or Cloudy	D= Dry
DN= Dawn	R= Rain	W= Wet
Du= Dusk	S= Snow or Sleet	S= Snow or Ice
D= Dark	X= Other or Unknown	X= Other or Unknown
X= Unknown		

Example of Bicycle/Motor Vehicle Accident:



COLLISION DIAGRAM

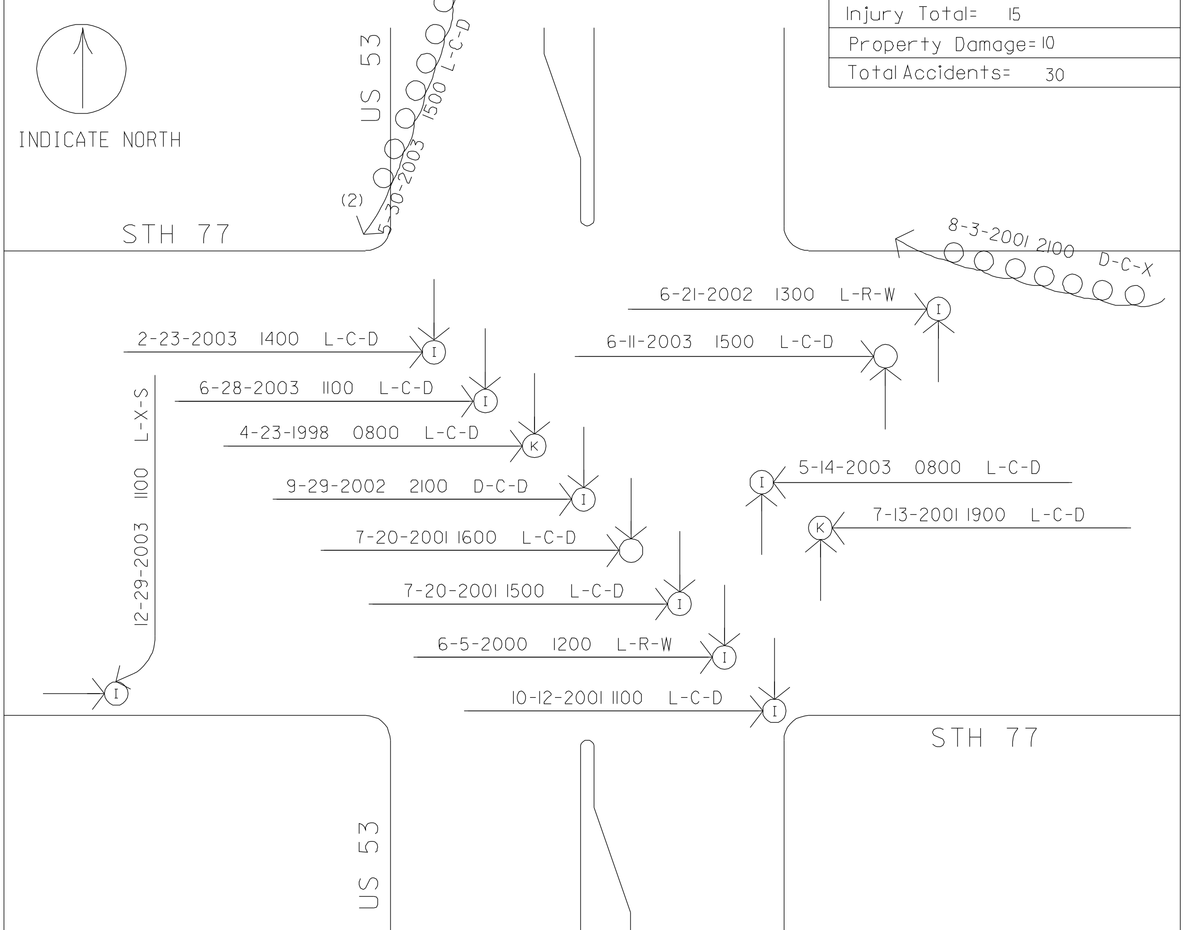
LOCATION: US 53 & STATE HIGHWAY 77 (WASHBURN COUNTY) 1 OF 2

TIME PERIOD: 01/01/1998 - 06/30/2004

PREPARED BY: RJS DATE: 11-14-2004

No. of Accidents

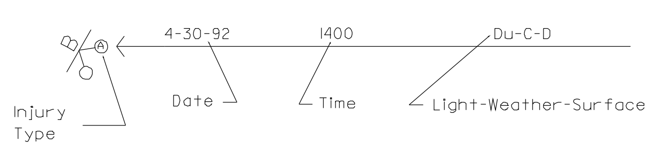
Fatal=	5
Injury Total=	15
Property Damage=	10
Total Accidents=	30



Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
A Injury Acc.
B Injury Acc.
C Injury Acc.
* Location/Details Unclear
Property Damage Acc.
Rear End Property Damage
Right Angle Injury

Light:	Weather:	Surface:
L= Daylight	C= Clear or Cloudy	D= Dry
DN= Dawn	R= Rain	W= Wet
Du= Dusk	S= Snow or Sleet	S= Snow or Ice
D= Dark	X= Other or Unknown	X= Other or Unknown
X= Unknown		

Example of Bicycle/Motor Vehicle Accident:



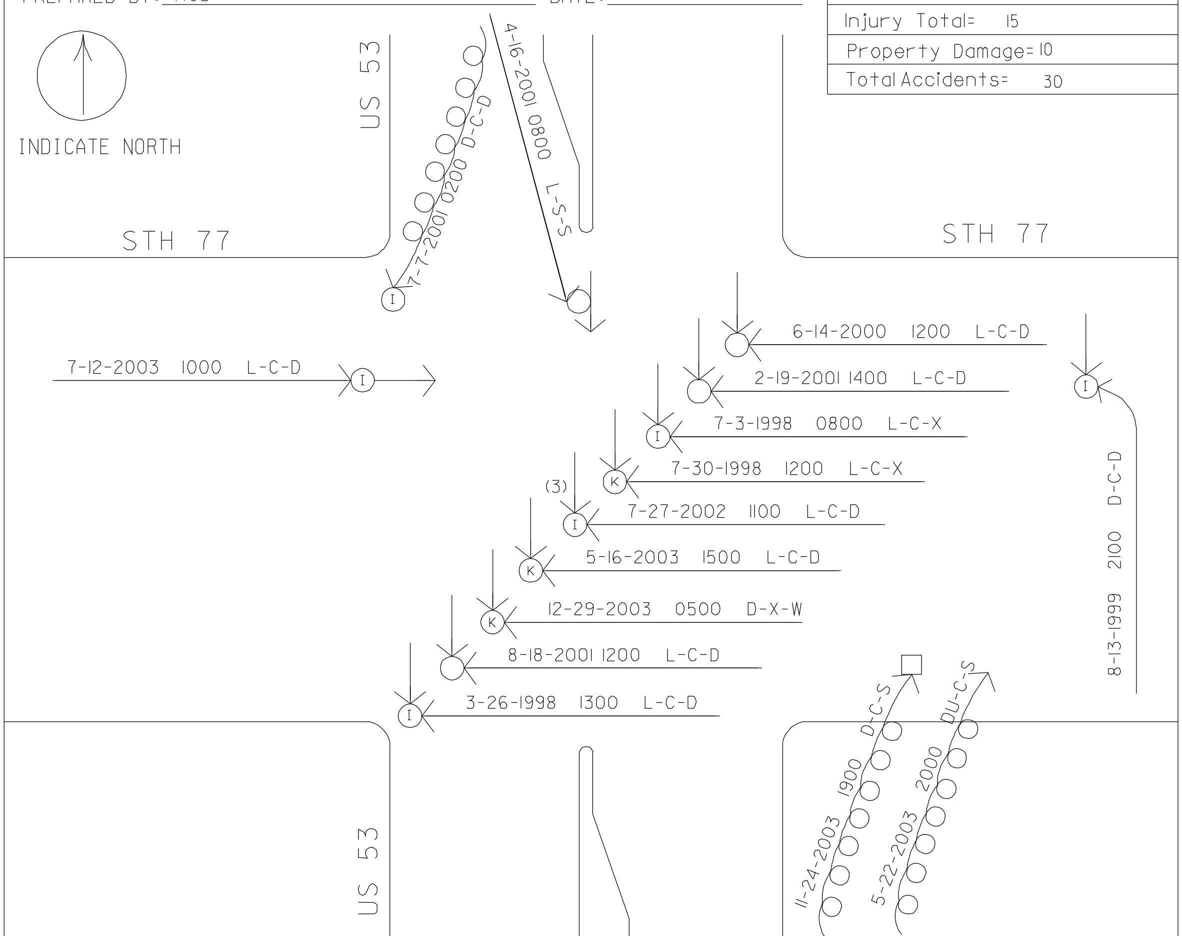
COLLISION DIAGRAM

LOCATION: US 53 & STATE HIGHWAY 77 (WASHBURN COUNTY) 2 OF 2

TIME PERIOD: 01/01/1998 - 06/30/2004

PREPARED BY: RJS DATE: 11-14-2004

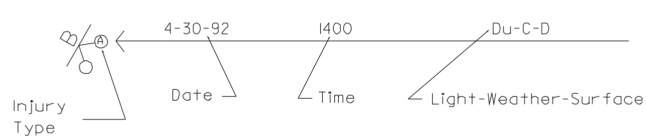
No. of Accidents	
Fatal=	5
Injury Total=	15
Property Damage=	10
Total Accidents=	30



Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
A Injury Acc.
B Injury Acc.
C Injury Acc.
* Location/Details Unclear
Property Damage Acc.
Rear End Property Damage
Right Angle Injury

Light:	Weather:	Surface:
L= Daylight	C= Clear or Cloudy	D= Dry
DN= Dawn	R= Rain	W= Wet
Du= Dusk	S= Snow or Sleet	S= Snow or Ice
D= Dark	X= Other or Unknown	X= Other or Unknown
X= Unknown		

Example of Bicycle/Motor Vehicle Accident:



COLLISION DIAGRAM

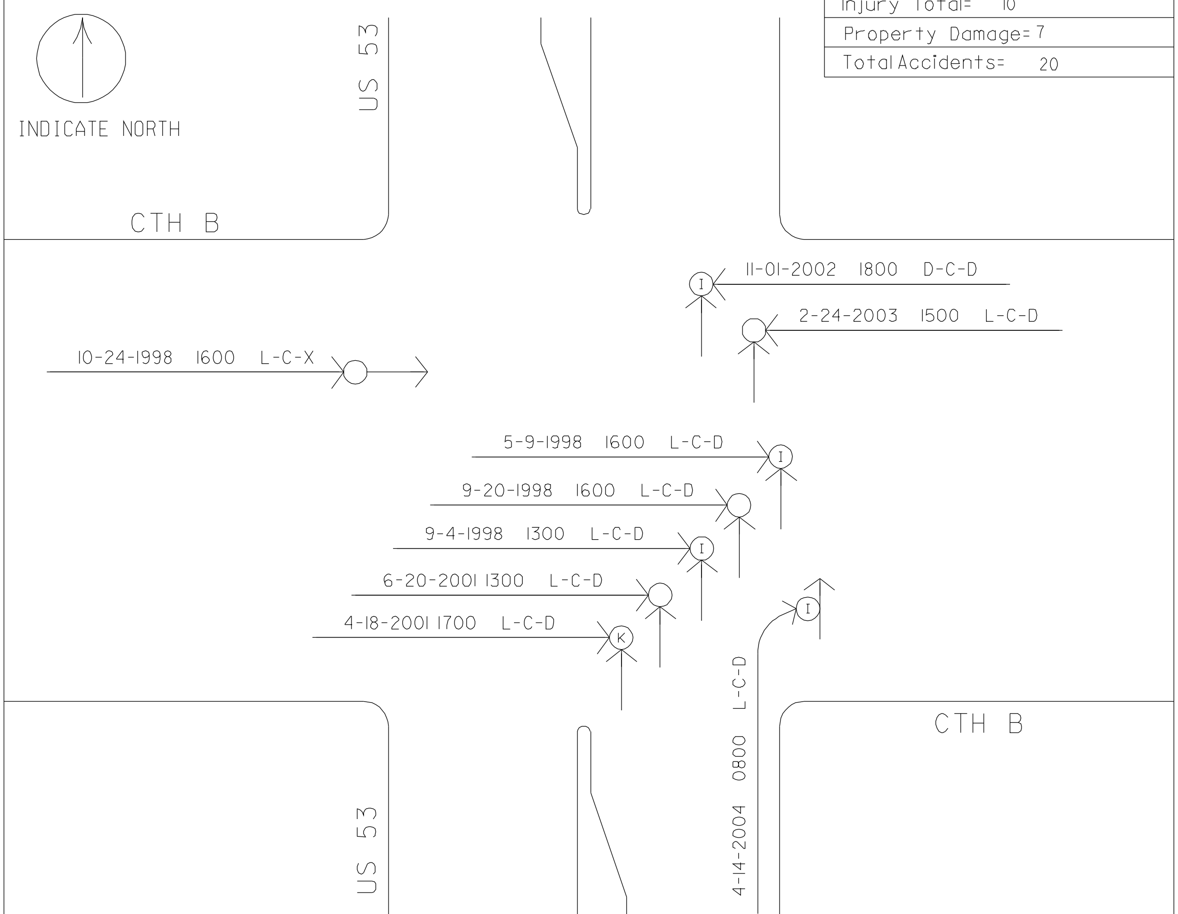
LOCATION: US 53 & COUNTY HIGHWAY B (DOUGLAS COUNTY) 1 OF 2

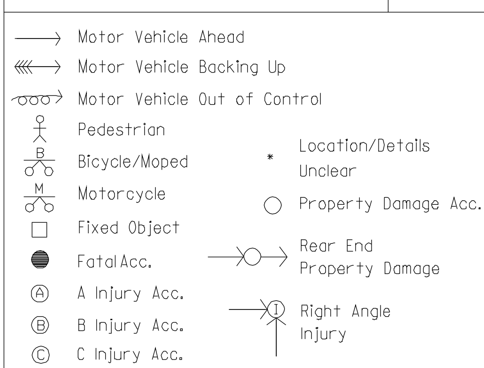
TIME PERIOD: 01/01/1998 - 06/30/2004

PREPARED BY: RJS DATE: 11-14-2004

No. of Accidents

Fatal=	3
Injury Total=	10
Property Damage=	7
Total Accidents=	20



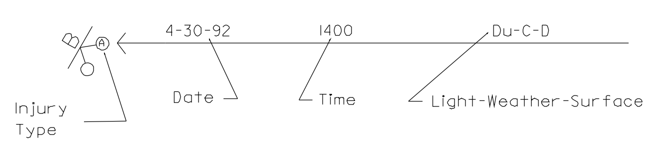


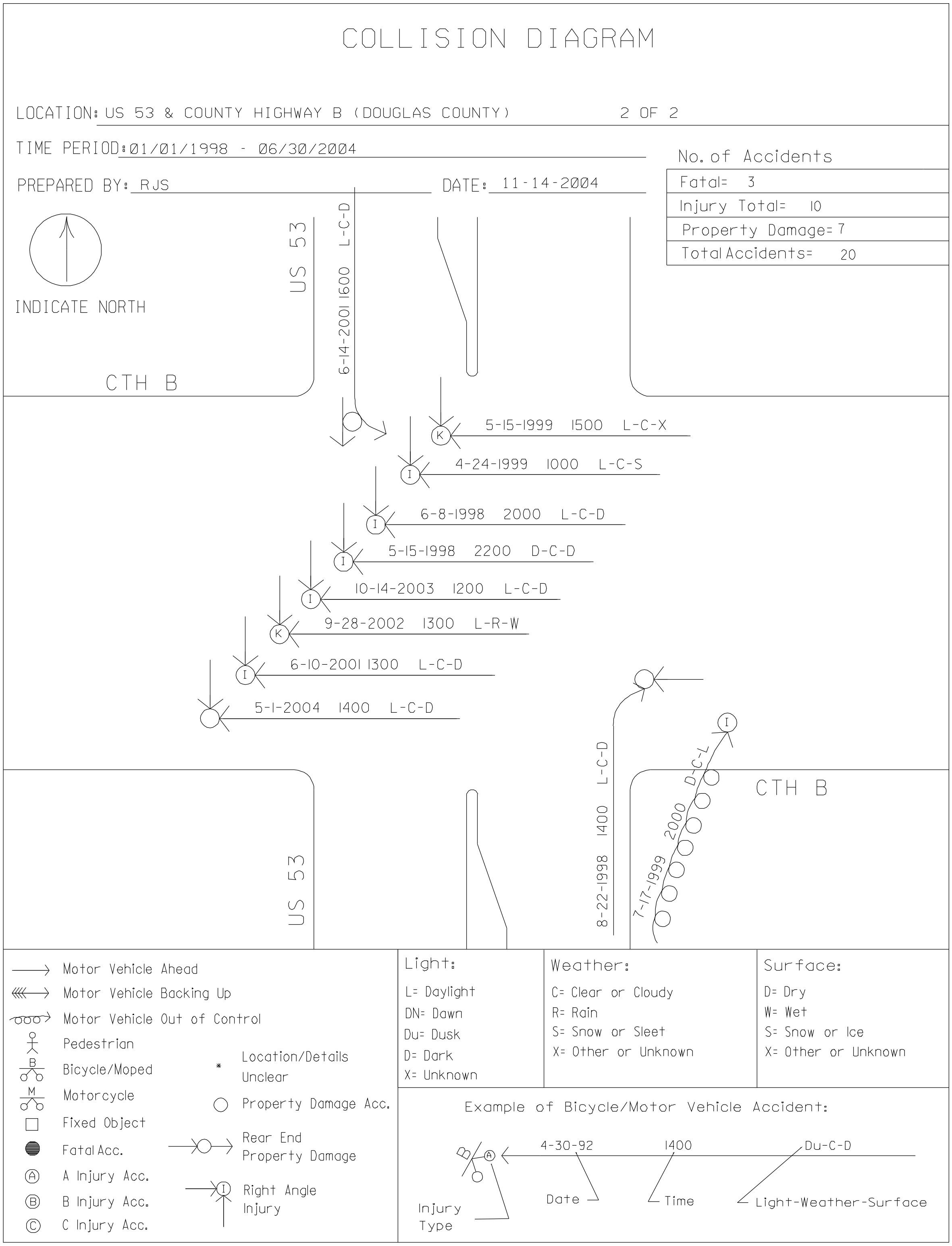
Light:
L= Daylight
DN= Dawn
Du= Dusk
D= Dark
X= Unknown

Weather:
C= Clear or Cloudy
R= Rain
S= Snow or Sleet
X= Other or Unknown

Surface:
D= Dry
W= Wet
S= Snow or Ice
X= Other or Unknown

Example of Bicycle/Motor Vehicle Accident:




COLLISION DIAGRAM
LOCATION: US 53 & COUNTY HIGHWAY B (DOUGLAS COUNTY)
2 OF 2
TIME PERIOD: 01/01/1998 - 06/30/2004
PREPARED BY: RJS
DATE: 11-14-2004
No. of Accidents
Fatal= 3
Injury Total= 10
Property Damage= 7
Total Accidents= 20
INDICATE NORTH
US 53
CTH B
6-14-2001 1600 L-C-D
5-15-1999 1500 L-C-X
4-24-1999 1000 L-C-S
6-8-1998 2000 L-C-D
5-15-1998 2200 D-C-D
10-14-2003 1200 L-C-D
9-28-2002 1300 L-R-W
6-10-2001 1300 L-C-D
5-1-2004 1400 L-C-D
8-22-1998 1400 L-C-D
7-17-1999 2000 D-C-L
CTH B
US 53
Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
A Injury Acc.
B Injury Acc.
C Injury Acc.
Location/Details Unclear
Property Damage Acc.
Rear End Property Damage
Right Angle Injury
Light:
L= Daylight
DN= Dawn
Du= Dusk
D= Dark
X= Unknown
Weather:
C= Clear or Cloudy
R= Rain
S= Snow or Sleet
X= Other or Unknown
Surface:
D= Dry
W= Wet
S= Snow or Ice
X= Other or Unknown
Example of Bicycle/Motor Vehicle Accident:
4-30-92
1400
Du-C-D
Injury Type
Date
Time
Light-Weather-Surface

Appendix B

Aerial Photographs

FIGURE B-1
Aerial Photo of U.S. 53 and CTH V (Barron County)
Source: www.terraserver.com

FIGURE B-2
Aerial Photo of U.S. 53 and CTH B (Washburn County)
Source: Wisconsin Department of Transportation

FIGURE B-3
Aerial Photo of U.S. 53 and CTH E (Washburn County)
Source: Wisconsin Department of Transportation

FIGURE B-4
Aerial Photo of U.S. 53 and U.S. 63 (Washburn County)
Source: Wisconsin Department of Transportation

FIGURE B-5
Aerial Photo of U.S. 53 and STH 77 (Washburn County)
Source: Wisconsin Department of Transportation

FIGURE B-6
Aerial Photo of U.S. 53 and CTH B (Douglas County)
Source: www.terraserver.com