DEPARTMENT OF TRANSPORTATION

Evaluation of Major Street Speeds for Minnesota Intersection Collision Warning Systems

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June 2018

Research Project
Final Report 2017-38S

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Technical Report Documentation Page

1. Report No.	2.	3. Recipients Accession No.
MN/RC 2017-38S		

4. Title and Subtitle	5. Report Date
Evaluation of Major Street Speeds for Minnesota Intersection Collision Warning Systems	June 2018
	6.

7. Author(s)	8. Performing Organization Report No.
Shauna L. Hallmark, Raju Thapa, Milagros Pinto-Nunez, Skylar Knickerbocker, Neal Hawkins, and Anna Bilek	

9. Performing Organization Name and Address	10. Project/Task/Work Unit No.
Center for Transportation Research and Education Iowa State University 2711 S. Loop Drive, Suite 4700 Ames, IA 50010	11. Contract (C) or Grant (G) No. (C) 99004 (WO) 16

12. Sponsoring Organization Name and Address	13. Type of Report and Period Covered
Minnesota Department of Transportation Research Services & Library 395 John Ireland Boulevard, MS 330 St. Paul, Minnesota 55155-1899	Final Report
	14. Sponsoring Agency Code

15. Supplementary Notes

http://dot.state.mn.us/research/reports/2017/201738S.pdf
http://dot.state.mn.us/research/reports/2017/201738.pdf

16. Abstract (Limit: 250 words)

This study is a complement to Evaluation of Intersection Collision Warning Systems in Minnesota (2017-18), which was published in October 2017. That project evaluated behaviors such as type of stop for drivers on the minor approach in the presence of intersection collision warning systems (ICWS). This project was a follow-up to that study and compared speeds along the major street approaches at ICWS treatment sites after installation of the system to determine whether the ICWS provided any measurable impact on speed when drivers on the major street were presented with a message from the system (activated) versus when drivers were not presented with a message (not activated).

The study found that mean and 85th percentile speeds were lower on the major approach when the ICWS was activated compared to when it was not activated. However, the differences were minor. As a result, the system is expected to reduce speeds, but only a modest impact is expected in terms of mainline drivers.

17. Document Analysis/Descriptors	18. Availability Statement
Warning systems, Crash avoidance systems, Traffic safety, Unsignalized intersections, Traffic conflicts	No restrictions. Document available from: National Technical Information Services, Alexandria, Virginia 22312

19. Security Class (this report)	20. Security Class (this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	37	

EVALUATION OF MAJOR STREET SPEEDS FOR MINNESOTA INTERSECTION COLLISION WARNING SYSTEMS

FINAL REPORT

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June 2018

Published by:

Minnesota Department of Transportation
Research Services & Library
395 John Ireland Boulevard, MS 330
St. Paul, Minnesota 55155-1899

ACKNOWLEDGMENTS

The team wishes to thank the Minnesota Department of Transportation (MnDOT) for its assistance in collecting the data used in this work and for funding the project. We would also like to thank the members of the Technical Advisory Panel for helping guide this project. Special thanks are also due to the participating agencies for allowing us to collect data.

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BACKGROUND

This study is a complement to *Evaluation of Intersection Collision Warning Systems in Minnesota* (http://dot.state.mn.us/research/reports/2017/201738.pdf). That project evaluated behaviors such as type of stop for drivers on the minor approach (ICWS). Information about site selection, data collection, and data reduction is provided in that report.

This project was a follow-up to that study and compared speeds along the major street approaches at ICWS treatment sites after installation of the system to determine whether the ICWS provided any measurable impact on speed when drivers on the major street were presented with a message from the system (activated) versus when drivers were not presented with a message (not activated).

SUMMARY

Speed and other metrics were compared at the periods 1 month and 12 months after installation. Speed data were collected in the original study using Wavetronix devices. Whether an individual vehicle would have approached the intersection when the system was “activated” versus “not activated” was determined, and metrics were compared for the two scenarios. It was assumed that reductions in speed would allow drivers on the mainline additional time to react if a vehicle on the side street failed to yield.

Differences were first compared for each individual site. Decreases in mean speed ranged from 0.8 to 1.5 mph at 1 month and 1.8 to 2.7 mph at 12 months. Three sites experienced no change in 85th percentile speed at 1 month, while two sites experienced decreases of 1 mph. At 12 months, decreases in 85th percentile speed ranged from 1 to 4 mph.

When data for all sites were combined, mean speed when the systems were activated was 3.7 mph lower at 1 month and 1.6 mph lower at 12 months than when the systems were not activated. The difference in 85th percentile speed was 2 mph lower at 1 month and 1 mph lower at 12 months.

Overall, speeds were lower when drivers encountered an activated system. However, differences were minor in most cases (typically around 1 mph), although differences up to 4 mph were noted. This suggests that the system does alter driver behavior, but no major impact was noted.

CHAPTER 1: INTRODUCTION

This study is a complement to *Evaluation of Intersection Collision Warning Systems in Minnesota* (http://dot.state.mn.us/research/reports/2017/201738.pdf). That project evaluated behaviors such as type of stop for drivers on the minor approach in the presence of intersection collision warning systems (ICWS). Information about site selection, data collection, and data reduction is provided in that report and is not duplicated here.

This project was a follow-up to that study and compared speeds along the major street approaches at ICWS treatment sites after installation of the system to determine whether the ICWS provided any measurable impact on speed when drivers on the major street were presented with a message from the system (activated) versus when drivers were not presented with a message (not activated). The term "activated" indicates that a major approach driver was approaching the intersection within the timeframe when a driver was approaching or stopped on the minor approach. The major street driver received a message that vehicles were approaching on the minor street.

The intent of the message for the major street drivers was to alert them in case the minor street driver entered the intersection inappropriately. No response was required from the major street driver. However, a reduction in speed would suggest that drivers made some action to be prepared. When the ICWS was activated, both the major and minor street driver would have received the corresponding message. The major street driver would have been presented with the sign in Figure 1.1.

Not active (© 2017 Google from Google Street View)

Active (© 2017 Google from Google Street View)

Figure 1.1 Message for major street driver at east approach of McLeod County site

The static text was “Entering Traffic When Flashing.” The dynamic portion of the sign was a flashing beacon that activated when a minor street vehicle was present. The minor street driver would have seen the sign configuration shown in Figure 1.2 when a vehicle was present on the major approach.

Figure 1.2 Message for minor street driver

The sign board displayed the dynamic message “Traffic Approaching” and an alternating flashing pattern was shown between the two top beacons. A static sign below displayed “When Flashing.” When no vehicles were present on the major approach, the minor street driver would have seen the static message and a blank message board.

The term “not activated” indicates that the ICWS was present and functioning at the corresponding intersection. In this scenario, no vehicle was approaching or stopped on the minor street. As a result, the major street driver would have viewed the static message shown in Figure 1.1 but no flashing beacon.

CHAPTER 2: DESCRIPTION OF DATA

Data were collected in three different timeframes: before the installation of ICWS, at one to three months after the installation of the system (identified as "1 month"), and about one year after the installation of the ICWS (identified as "12 months"), as described in the previous report. Data were collected using a video data collection array and Wavetronix devices (additional information is provided in Hallmark et al. 2017).

Table 2.1 shows different timeframes of data collection at each of the five treatment sites. Because data collected before installation were not used for this analysis, this time period is not shown in the table.

Table 2.1 Data collection timeline after installation of the ICWS system at treatment sites

Intersections (Treatment only)	ICWS installation date	1 month	12 months
Chippewa County	11/13/2014	4/28/2015 to 5/5/2015	9/15/2015 to 9/21/2015
Cottonwood County	11/19/2014	4/18/2015 to 4/23/2015	9/8/2015 to 9/14/2015
Isanti County	12/4/2014	5/6/2015 to 5/13/2015	10/13/2015 to 10/19/2015
McLeod County	9/23/2015	10/20/2015 to 10/26/2015	7/21/2016 to 7/26/2016
Pipestone County	9/30/2015	10/28/2015 to 11/3/2015	7/28/2016 to 8/2/2016

Speed data were collected by Wavetronix devices at a location just upstream of each intersection along the major street. Figure 2.1 shows the setup of the devices in the field. Each device was attached to a trailer set up to collect video of the movement of both major and minor approach traffic within the intersection. Each trailer was installed at around 100 to 200 feet upstream of the intersection, with slight variation among the different sites. The location of each trailer was the same during the different timeframes of data collection. The Wavetronix device measured the speed of vehicles passing through its detection zone. Based on its setup, the device either measured speed data in both the far and near lanes or in the near lane only. As shown in Figure 2.1, vehicles moving in the near lane were approaching the intersection, while vehicles in the far lane had already passed the intersection. For this study, only vehicles travelling in the near lane, i.e., approaching the intersection, were considered.

Figure 2.1 Location of Wavetronix device at treatment site

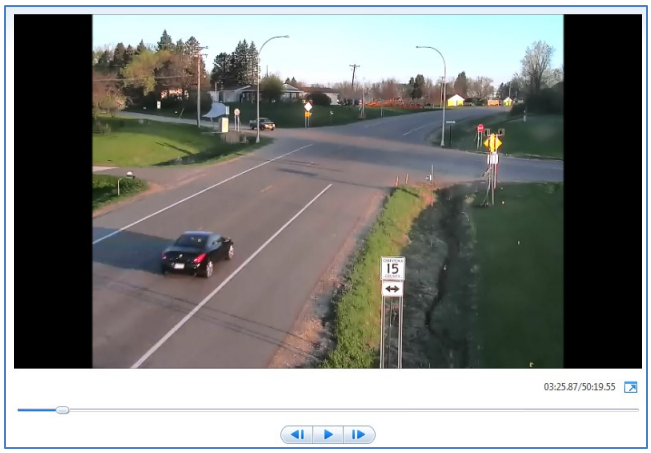
2.1 DATA REDUCTION

Data were only reduced for weekdays from 6 am until 8 pm. Nighttime data were not reduced due to poor visibility. Only free-flow vehicles approaching the intersection on the major approach were considered for the reduction.

The Wavetronix device collects data using radar. As a result, speed data for individual vehicles are provided in a text file. In order to determine whether a vehicle on the mainline approach had been presented with an activated or not activated message sign, it was necessary to match the vehicles in the Wavetronix data to the same vehicles in the video data. Vehicle speed was extracted from the Wavetronix file by comparing the time at which the vehicle appeared in the video to the time at which the speed was recorded by the device. Timestamps in the Wavetronix files were synchronized with

timestamps in the video files. This was accomplished by matching gaps and required manual processing of both the speed and video data sets.

Figure 2.2 shows a snapshot of the Wavetronix and video data and demonstrates how the arrival times of vehicles were matched to extract the speed data.



Video file

Arrival Time (Video)	Speed	Time to travel from flashing ligh to intersection	Code	Major street vehicle at Flashing light
0:03:24	55	0:00:07	0:03:27	0:03:20
0:04:16	54.6	0:00:07	0:04:19	0:04:12
0:09:39	43.3	0:00:09	0:09:42	0:09:33
0:13:33	55.5	0:00:07	0:13:36	0:13:29
0:14:14	55.5	0:00:07	0:14:17	0:14:10
0:16:20	49	0:00:08	0:16:23	0:16:15
0:18:47	57	0:00:07	0:18:51	0:18:44
0:19:14	50.3	0:00:08	0:19:17	0:19:09
0:19:42	49.7	0:00:08	0:19:45	0:19:37
0:20:34	50.5	0:00:08	0:20:37	0:20:29
0:22:07	53.5	0:00:07	0:22:10	0:22:03
0:27:54	57.9	0:00:07	0:27:57	0:27:50
0:28:33	39.8	0:00:10	0:28:35	0:28:25
0:29:12	46.2	0:00:09	0:29:15	0:29:06
0:32:23	55.7	0:00:07	0:32:25	0:32:18
0:33:03	49.5	0:00:08	0:33:05	0:32:57
0:35:24	47.3	0:00:08	0:35:27	0:35:19
0:36:20	54	0:00:07	0:36:22	0:36:15
0:39:51	53.4	0:00:07	0:39:54	0:39:47
0:40:44	47	0:00:08	0:40:46	0:40:38

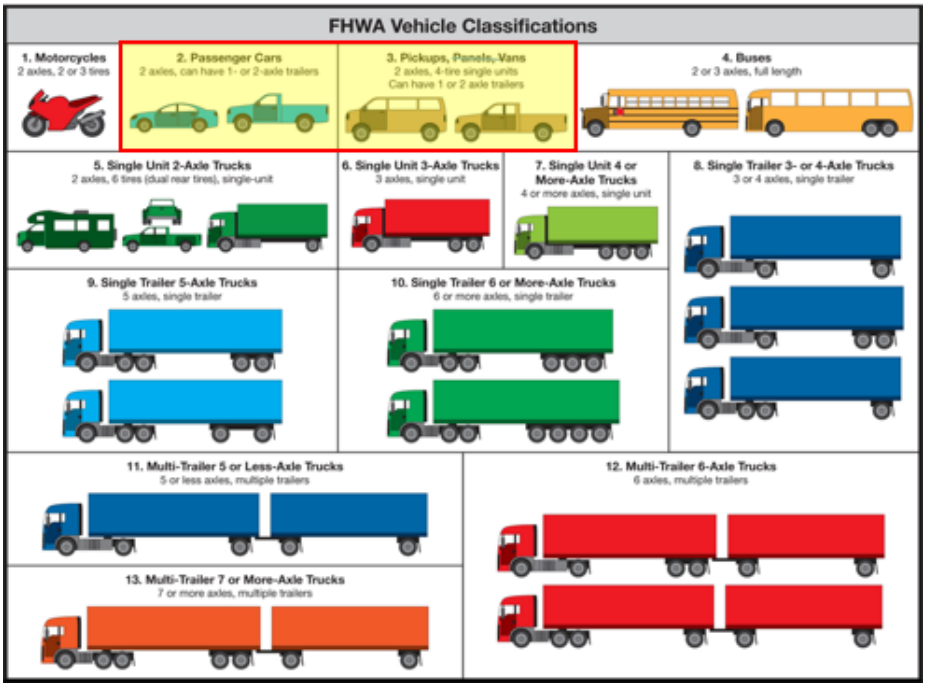
Wavetronix data in Excel file

Figure 2.2 Snapshot of video and Wavetronix files used to extract speed data

All types of turning vehicles (both left and right) and vehicles following with gap size of ≤ 3 seconds were removed. The status of the flashing light at the major approach was also coded for each vehicle. Because the trailer was installed upstream from the flashing light, the available video file only covered the intersection area. Thus, a criterion was developed to determine system status based on the arrival of minor approach vehicles at a stop bar and the arrival of major approach vehicles at the point of the message board.

Because daily traffic volume ranges in the thousands, it was not possible to code all vehicles. Therefore, a random sample of vehicles was coded from the video. The first five vehicles for which the system was

activated and the first five vehicles for which the system was not activated were coded for each hour. Due to the inconsistency in the vehicle types on the major approach, only vehicles smaller than or of an equivalent size to pickup trucks (excluding motorcycles) were considered for reduction. The shaded area in Figure 2.3 shows the types of vehicle used for the reduction.



Source: http://onlinemanuals.txdot.gov/txdotmanuals/tri/images/FHWA_Classification_Chart_FINAL.png

Figure 2.3 Types of vehicles used for reduction

Due to the limited coverage of the collected video, it was not possible to reduce the system status of the major approach flashing light at the time a vehicle passed through it. As a result, system status had to be inferred base on a set of assumptions and calculations. Possible system status configurations are shown in Table 2.2.

Table 2.2 Different conditions when major road alert (flashing light) is active

SN	Conditions
1	Any vehicle on the minor approach is waiting at the stop or yield sign
2	Any vehicle from the minor approach is within the intersection
3	Any vehicle on the minor approach is waiting at the median yield sign
4	Any vehicle on the minor approach is approaching less than time “t” away from the intersection

The first three conditions in Table 2.2 could be reduced from the available video file, but the video camera was not set to cover the minor approach at the point when they would activated the system designated as time “t”. The previous study defined “t” as the lag time from 2.5 seconds in advance of the major approach warning sign to the intersection at the posted speed limit and was used at the minor approach as a range for detecting vehicles that would be expected to activate the major approach alert.

2.2 DESCRIPTION OF THE DATA REDUCTION CRITERIA

Due to the location of the detectors at the minor approaches and the unknown braking behavior of the minor approach vehicles, the study used an assumed safety threshold to ensure that the system status of the flashing light or the ICWS alert at the major approach was correctly estimated. All vehicles not satisfying the criteria were removed. Figure 2.4 shows the details of the criteria.

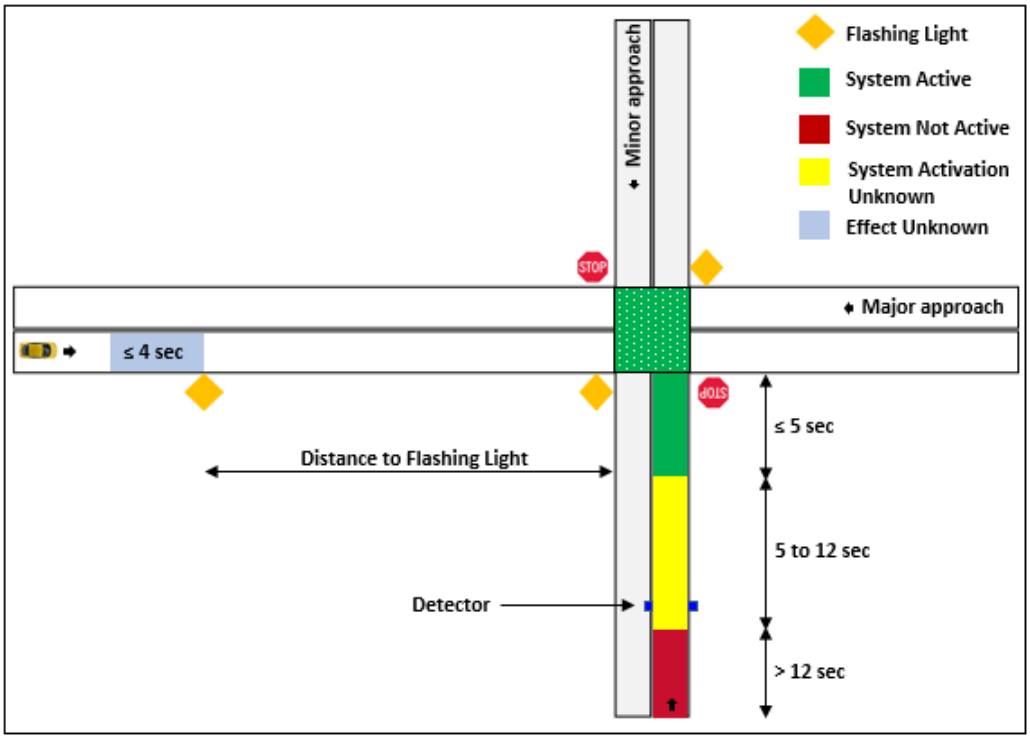


Figure 2.4 Details of the criteria developed for determining the system status at the major approach

2.2.1 Location of Major Approach Vehicle at Flashing Light (in Seconds)

The time at which each major approach vehicle arrived at the flashing light was defined based on the arrival time of the vehicle at the intersection minus the time required for that vehicle to travel the distance from the flashing light to the intersection at a given speed.

2.2.2 Detailed Procedure of Activation of Major Approach Flashing Light due to Minor Approach Vehicle

Figure 2.4 only shows the criteria developed for one side of the minor approach, but the criteria are similar for the other minor approach too. The research team was able to reduce information from the video file regarding the first three conditions listed in Table 2.2. Regarding time "t," which is another criterion for system activation, the research team estimated the travel time of the major approach vehicles from the message board to the intersection and the braking distances of the minor approach vehicles at various deceleration rates. Based on the estimated numbers and engineering judgement, it

was assumed that if any vehicle on the minor approaches was within 5 seconds from the intersection, the ICWS would have been activated. When a vehicle was beyond 12 seconds from the intersection, the system was assumed to be not activated. Because it was difficult to determine system status when a vehicle on a minor approach was between 5 and 12 seconds from the intersection due to variations in braking behavior after the vehicle passed the detector location, the system status during this period was assumed to be unknown, and vehicles within this interval were not included.

Data reduction also included minor approach vehicle arrival time at the stop bar and departure time, which were used to determine position from the stop bar in terms of time.

2.2.3 Status of Flashing Light When Major Approach Vehicle Was Approaching the Sign

The arrival time of the major approach vehicle at the flashing light was compared to the system activation status based on minor approach street vehicle activity as defined in the previous section. Assuming that a vehicle at the major approach requires sufficient time (a reaction time greater than 2.5 seconds) to perceive the system status, any changes occurring during the time interval of 4 seconds, such as the light beginning or ceasing to flash, was skipped under the assumption that the effect of the changes occurring within that timeframe was not known. Therefore, if any major approach vehicle was within that interval (≤ 4 seconds from the flashing light) and changes occurred due to any minor approach vehicle, the vehicle was removed from consideration.

2.2.4 Summary

Overall, if the system status for any major vehicle was coded as “activated,” there was a high probability that the major street driver was at a point along the major street where he/she was able to see the activated message board. Similarly, if the system status was coded as “not active,” the vehicle was positioned such that the driver would not have seen the message board activated.

A formula was created in an Excel file that calculated system status for each major street vehicle based on all of the information reduced from the major and minor approach vehicles.

Due to the similar locations of the flashing lights at the major approaches and the placement of the detectors at the minor approaches, the criteria developed, as discussed above, were applied for the Chippewa, Cottonwood, McLeod, and Pipestone County treatment sites. However, due to the different location of the flashing light and detector at the Isanti County treatment site, the system activation due to minor road vehicles was used as follows: ≤ 3 seconds for active, 3 to 12 seconds for not known, and > 12 seconds for not active. Due to the closer location of the detector at the minor approach, 3 seconds was used instead of 5 seconds. Table 2.3 shows the location of the flashing light at the major approaches and the detector placement at the minor approaches.

Table 2.3 Location of flashing light and detector at major and minor approaches, respectively

Treatment site	Major approach	Location of flashing light (ft)	Minor approach	Location of detector (ft)
Chippewa County	North	580	East	391
	South	580	West	322
Cottonwood County	East	720	North	421
	West	720	South	421
Isanti County	North	1,075	East	185
	South	1,075	West	185
McLeod County	East	810	North	620
	West	810	South	620
Pipestone County	East	775	North	391
	West	775	South	391

2.3 AVAILABLE DATA

Table 2.4 shows the summary of the available data.

Table 2.4 Overview of the available data

Treatment site	1 month (number of days / total vehicles / active system)	12 months (number of days / total vehicles / active system)
Chippewa County	4 / 382/166	3 / 253
Cottonwood County	4 / 287	3 / 282
Isanti County	4 / 464	3 / 233
McLeod County	3 / 276	4 /414
Pipestone County	3 / 217	NA

For instance, at the Chippewa County treatment site, four days of video were reduced with a total of 383 vehicles; the system was active at the major approach for 166 of these vehicles and was not active for the remaining 216 vehicles. Since there were occasional malfunctions with the Wavetronix devices, in some cases a full day of video was not available. In addition, due to variations in the traffic volumes at the major and minor approaches, the sampling method had to be adjusted in some cases.

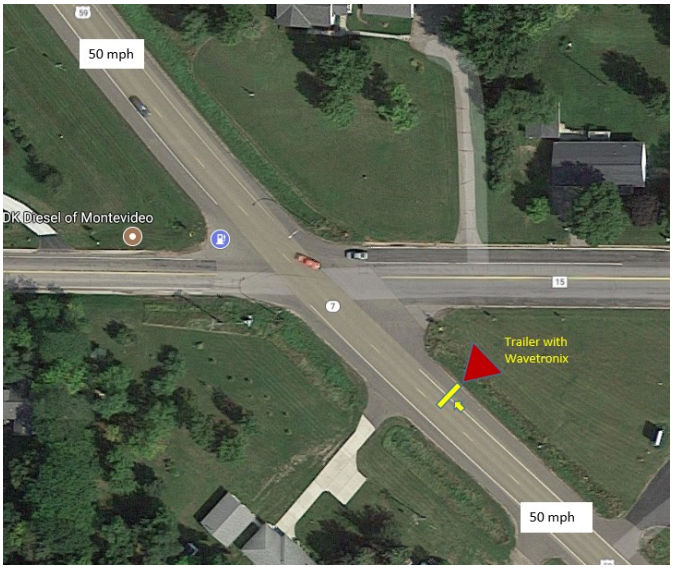
CHAPTER 3: ANALYSIS

The study used minimum, maximum, standard deviation, mean, and 85th percentile of the reduced speed data as different metrics to compare the 1-month and 12-month data. To check the statistical significance of the mean difference between the two time periods, an independent sample t-test was conducted. The Levene test was conducted prior to the t-test to check the equality of the variances between the two data sets. Based on the outcome, an independent sample t-test based on either equal or unequal variance was conducted to check the equality of the mean speed. For the purpose of this research, an alpha level of 5% was used for all statistical tests.

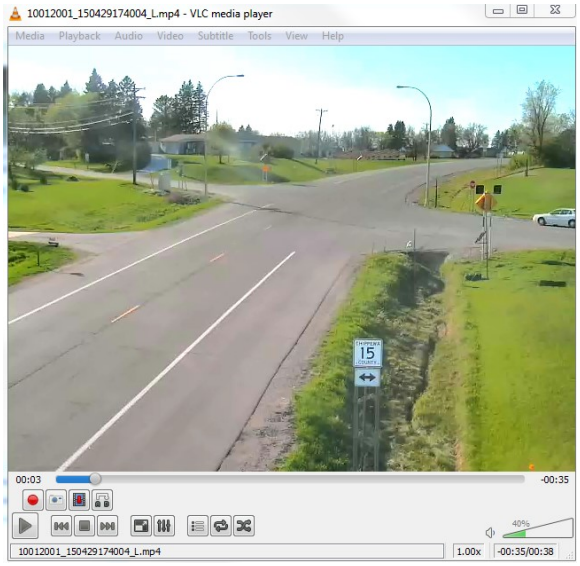
Only speed data of through-moving vehicles approaching the intersection were used for the analysis.

3.1 RESULTS FOR CHIPPEWA COUNTY TREATMENT SITE

The treatment site consisted of a two-lane undivided highway with a speed limit of 50 mph on both the major approaches. The message sign for the major approach was installed at a distance of 580 feet from the intersection on both approaches. A Wavetronix device was installed as shown in Figure 3.1. Only speed data of through-moving vehicles approaching the intersection were used for the analysis. Figure 3.1 (top) shows the location of the trailer and Figure 3.1 (bottom) shows the view from the trailer where the Wavetronix device was attached.



Tentative location of trailer with Wavetronix (© 2017 Google)



Snapshot of video collected from the trailer

Figure 3.1 Intersection configuration for Chippewa County site

Table 3.1 shows a summary of the data collected at the Chippewa County treatment site.

Table 3.1 Comparison of speed when ICWS is activated/not activated at Chippewa County site

Speed metrics in mph	1 month			12 months		
	Active	Not Active	Diff	Active	Not Active	Diff
Days used for analysis	4			3		
Minimum	30.4	35.1	-4.7	24.8	38.9	-14.1
Maximum	68.0	66.5	1.5	64.8	64.1	0.7
Std. Deviation (SD)	6.0	5.0		5.5	4.9	
Mean (M)	49.8	50.7	-0.9 (p = 0.109)	48.8	50.5	-1.7 (p=0.010)
85th percentile	55	55	0	53	57	-4 (p=0.008)
Sample Size	166	216		108	145	

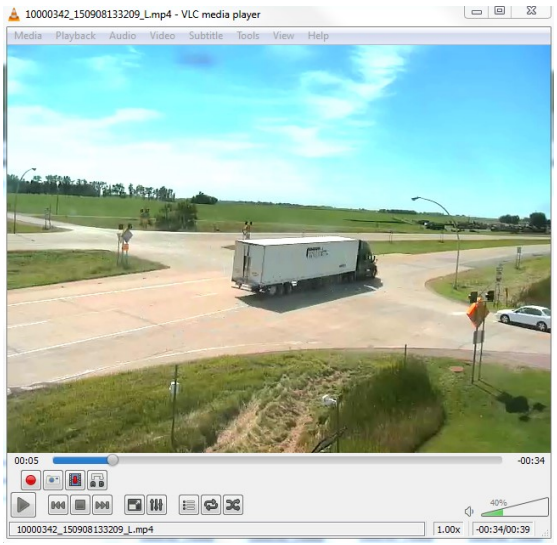
As noted, at the period 1 month after the ICWS was installed, drivers averaged a roughly 1 mph lower mean speed when the warning system was activated than when the system was not activated. The 85th percentile speed was 55 mph for both scenarios. Neither difference was statistically significant.

At the period 12 months after installation of the system, significantly lower mean speeds were present when the ICWS was activated than when the system was not activated (difference = 1.71 mph). The 85th percentile speed was 4 mph lower (53 versus 57 mph) when the system was activated versus not activated. The differences in both cases were statistically significant.

3.2 RESULTS FOR COTTONWOOD COUNTY TREATMENT SITE

The Cottonwood County treatment site consisted of a four-lane divided highway with a speed limit of 60 mph on both major approaches and with a two-lane minor approach. The major road message sign was installed at a distance of 720 feet from the intersection on both approaches. A Wavetronix device was placed west of the intersection during data collection, as shown in Figure 3.2 (top).

Location of trailer with Wavetronix (© 2017 Google)



Snapshot of video collected from trailer

Figure 3.2 Intersection configuration for Cottonwood County site

As shown in Table 3.2, at the 1-month period after installation of the ICWS, mean speeds were around 1 mph lower when the system was activated compared to not activated, but the difference was not statistically significant (p = 0.120).

Table 3.2 Comparison of speed when ICWS is activated/not activated at Cottonwood County site

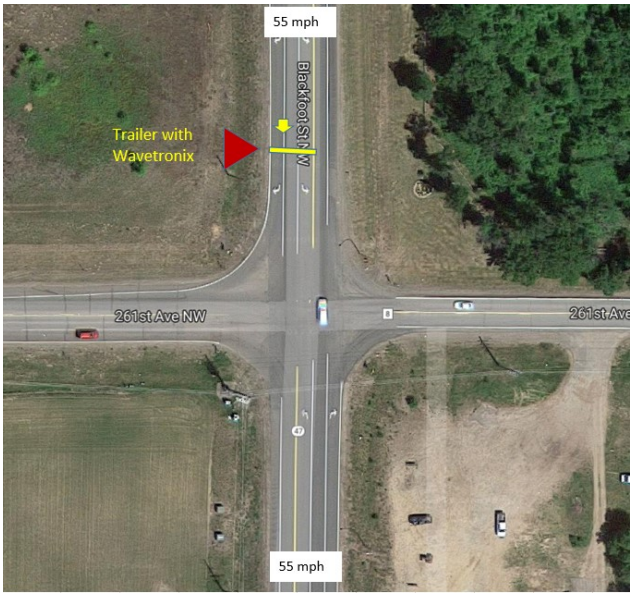
Speed metrics in mph	1 month			12 months		
	Active	Not Active	Diff	Active	Not Active	Diff
Days used for analysis	4			3		
Minimum	48.1	51.3	-3.2	51.1	53.5	-2.4
Maximum	83.6	78.2	5.4	74.3	80.2	-5.9
Std. Deviation	4.5	4.2		5.0	4.8	
Mean	62.6	63.4	-0.8 (p = 0.120)	61.7	64.4	-2.7 (p << 0)
85th percentile	67	68	-1 (p = 0.107)	67	69	-2 (p = 0.009)
Sample Size	135	152		141	141	

The 85th percentile speed was 1 mph lower when the system was activated versus not activated (67 versus 68 mph), and the difference was also not statistically significant.

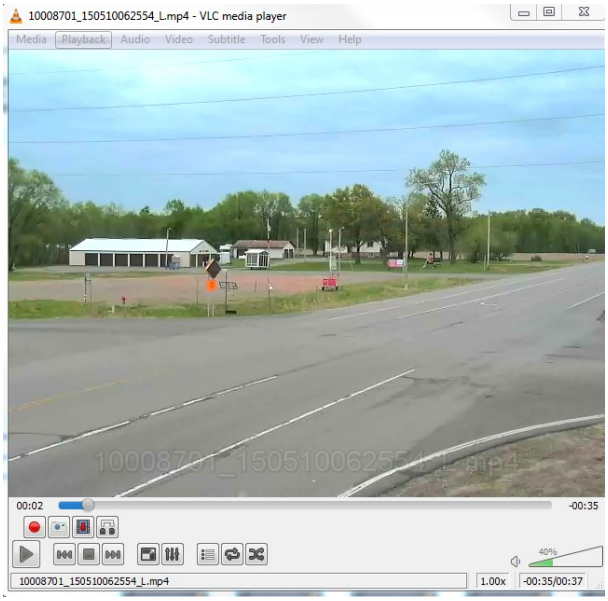
At 12 months after installation, mean speeds were around 3 mph lower when the ICWS was activated compared to when the system was not activated. Eighty fifth percentile speeds were 2 mph lower when the system was activated versus not activated (67 versus 69 mph). Both differences were statistically significant.

3.3 RESULTS FOR ISANTI COUNTY TREATMENT SITE

The Isanti County treatment site consisted of a two-lane undivided highway with a speed limit of 55 mph on the major approach and with a two-lane undivided minor street approach. The message boards were installed at a distance of 1,075 feet from the intersection on both approaches. The Wavetronix data collection equipment was installed north of the intersection, as shown in Figure 3.3 (top).



Tentative location of trailer with Wavetronix (© 2017 Google)



Snapshot of video collected from trailer

Figure 3.3 Intersection configuration for Isanti County site

As noted in Table 3.3, at 1 month after installation of the ICWS, mean speeds were 1.5 mph lower when the ICWS system was activated than when not activated.

Table 3.3 Comparison of speed when ICWS is activated/not activated at Isanti County site

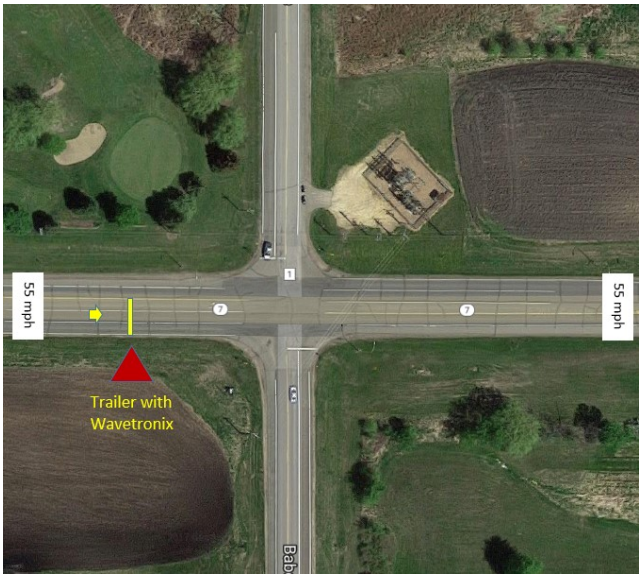
Speed metrics in mph	1 month			12 months		
	Active	Not Active	Diff	Active	Not Active	Diff
Days used for analysis	4			3		
Minimum	44.8	49.2	-4.4	41.6	46.6	-5.0
Maximum	69.6	74.8	-5.2	69.4	67.3	2.1
Std. Deviation	4.0	3.7		4.5	3.4	
Mean	59.0	60.5	-1.5 (p << - 0)	59.4	61.2	-1.8 (p = 0.001)
85th percentile	63	64	-1 (p = 0.56)	64	65	-1 (p =0.55)
Sample Size	230	234		117	116	

The 85th percentile speed was 1 mph lower when the system was activated versus not activated (63 versus 64 mph). Both differences were statistically different.

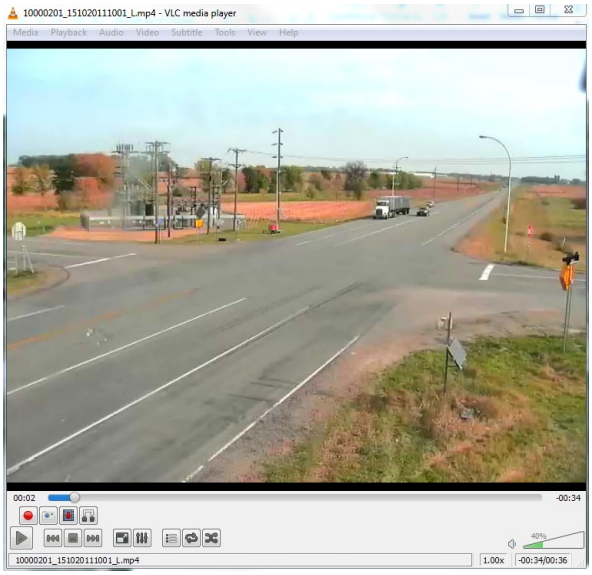
Similarly, at 12 months after installation, mean speeds were 1.8 mph lower when the ICWS was activated than when not activated. The difference in mean speeds was statistically significant. The 85th percentile speed was 1 mph lower (64 versus 65 mph) when the system was activated compared to when it was not activated. The difference in 85th percentile speeds was not statistically significant.

3.4 RESULTS FOR MCLEOD COUNTY TREATMENT SITE

The McLeod County treatment site consisted of a two-lane undivided highway with speed limit of 55 mph on the major approach and with a two-lane undivided minor approach. The ICWS message signs for the major approach were installed at a distance of 810 feet from the intersection on both approaches. The Wavetronix data collection equipment was installed west of the intersection, as shown in Figure 3.4 (top).



Tentative location of trailer with Wavetronix (© 2017 Google)



Snapshot of video collected from trailer

Figure 3.4 Intersection configuration for McLeod County site

Table 3.4 shows speed metrics for the McLeod County intersection.

Table 3.4 Comparison of speed when ICWS is activated/not activated at McLeod County site

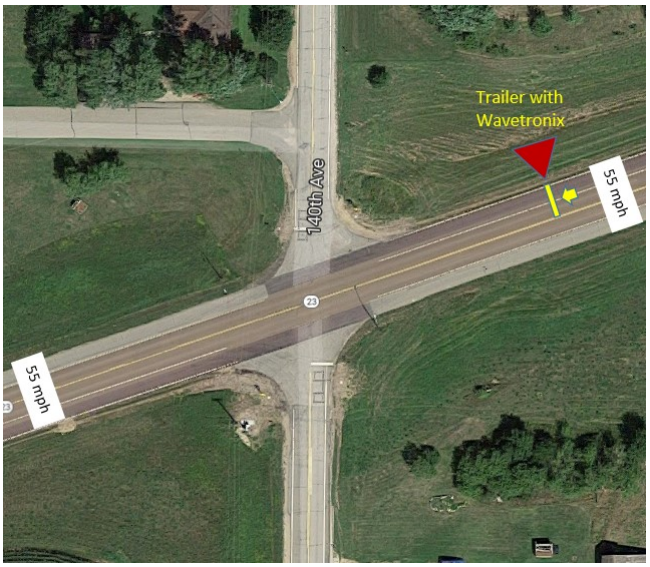
Speed in mph, T63	1 month			12 months		
	Active	Not Active	Diff	Active	Not Active	Diff
Days used for analysis	3			4		
Minimum	46.1	51.8	-5.7	37.0	43.3	-6.3
Maximum	70.4	73.2	-2.8	71.9	75.3	-3.4
Std. Deviation	4.4	3.8		5.2	4.6	
Mean	61.4	62.7	-1.4 (p = 0.007)	61.4	63.8	-2.4 (p << 0)
85th percentile	66	66	0	66	68	-2 (p =0.005)
Sample Size	140	136		205	213	

As noted, at 1 month after installation of the ICWS, mean speeds were around 1 mph lower when the ICWS was activated compared to when it was not activated, and the difference was statistically significant. The 85th percentile speed was the same for both scenarios (66 mph).

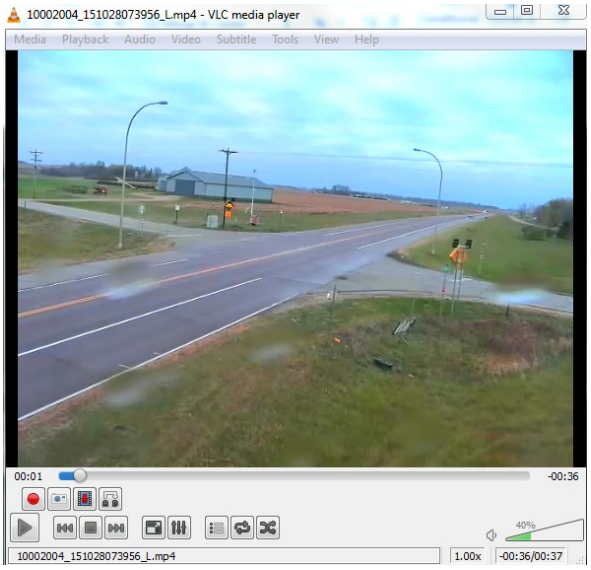
At 12 months after installation, the mean speed was more than 2 mph lower when the ICWS was activated versus not activated. The 85th percentile speed was also 2 mph lower when the system was activated versus not activated (66 versus 68 mph). In both cases, the difference was statistically significant.

3.5 RESULTS FOR PIPESTONE COUNTY TREATMENT SITE

The Pipestone County treatment site consisted of a two-lane undivided highway with speed limit of 55 mph on the major approach and with a two-lane undivided minor approach. The ICWS message boards for the major street were installed at a distance of 775 feet from the intersection on both approaches. The Wavetronix data collection array was installed east of the intersection, as shown in Figure 3.5 (top).



Tentative location of trailer with Wavetronix (© 2017 Google)



Snapshot of video collected from trailer

Figure 3.5 Intersection configuration for Pipestone County site

Speed metrics are provided in Table 3.5.

Table 3.5 Comparison of speed when ICWS is activated/not activated at Pipestone County site

Speed metrics in mph	1 month		
	Active	Not Active	Diff
Days used for analysis	3		
Minimum	46.4	45.9	0.5
Maximum	73.8	73.3	0.5
Std. Deviation	4.6	3.9	
Mean	62.0	62.7	-0.7 (p = 0.24)
85th percentile	66	66	0
Sample Size	77	140	

At 1 month after installation of the ICWS, mean speed was around 1 mph lower when a driver on the major approach was presented with an activated ICWS sign compared to when a driver saw a blank ICWS sign, but the difference was not statistically different. No difference was noted in 85th percentile speeds.

Results are not provided for the 12-month after period because some technical issues occurred with the Wavetronix device that affected the data collected during that time period.

3.6 RESULTS FOR ALL SITES COMBINED

Data for all locations were combined. Although an attempt was made to code a similar number of observations for each site and each time period, some had more observations than others. A disparity in sample sizes can result in skewing the averages of the results towards sites with more observations. As a result, a sampling method was used to winnow the sites with more samples. For instance, at 1 month, the McCleod site had around 140 samples for which the ICWS system was not activated and had the smallest number of observations of any of the sites. The Chippewa, Cottonwood, Isanti, and Pipestone County sites were sorted, and around 140 observations for which the ICWS was not activated were extracted.

The next step was to combine the data and compare speed metrics. Table 3.6 provides the results for the 1-month and 12-month after periods for all sites.

Table 3.6 Comparison of speed when ICWS was activated/not activated for all sites

	1 month			12 months		
	Active	Not Active	Diff	Active	Not Active	Diff
Minimum	30.4	35.1	-4.7	24.8	38.9	-14.1
Maximum	73.8	63.1	10.7	74.3	80.2	-5.9
Std. Deviation	7.5	6.43		7.1	7.3	
Mean	56.1	59.8	-3.7 (p = 0.0001)	58.3	59.9	-1.6 (p = 0.0001)
85th percentile	64	66	-2 (p << 0)	65	66	-1 (p = 0.0024)

The 1-month data include McCleod, Chippewa, Pipestone, Cottonwood, and Isanti County sites. Wavetronix data were not available for the 12-month after period for the Pipestone County site, so the combined data for the 12-month after period does not include Pipestone data.

Results for one month after installation of the ICWS demonstrate that mean speed is 3.7 mph lower when the ICWS system is activated than when the system is not activated. The 85th percentile speed is 2 mph lower for activated versus not activated. In both cases, the differences are statistically significant.

Results for one year after installation indicate a 1.6 mph decrease in mean speed when the system is activated versus not activated. A 1 mph decrease in 85th percentile speed was also noted. Both differences are statistically significant.

CHAPTER 4: SUMMARY AND CONCLUSIONS

This study is a complement to *Evaluation of Intersection Collision Warning Systems in Minnesota* (http://dot.state.mn.us/research/reports/2017/201738.pdf). That project evaluated behaviors such as type of stop for drivers on the minor approach in the presence of intersection collision warning systems. Information about site selection, data collection, and data reduction is provided in that report.

This project was a follow-up to that study and compared speeds along the major street approaches at ICWS treatment sites after installation of the systems. The objective was to determine whether the ICWS provided any measurable impact on speed when drivers on the major street were presented with a message from the system (activated) versus when drivers were not presented with a message (not activated).

This study compared major street speeds when the system was "activated" versus "not activated." The term "activated" indicated that a major approach driver was approaching the intersection within the timeframe when a driver was approaching or stopped at the minor approach. The major street driver received a message that vehicles were approaching on the minor street. The intent of the message for the major street drivers was to alert them in case the minor street driver entered the intersection inappropriately. No response was required from the major street driver. However, a reduction in speed would suggest that drivers made some action to be prepared. It was assumed that reductions in speed would allow drivers on the mainline additional time to react if a vehicle on the side street failed to yield. When the ICWS was activated, both the major and minor street drivers would have received a corresponding message. Speed and other metrics were compared at 1 month and 12 month after installation.

Speed data were collected in the original study using Wavetronix devices. Whether an individual vehicle would have approached the intersection when the system was "activated" versus "not activated" was determined, and metrics were compared for the two scenarios.

Differences were first compared for each individual site. Decreases in mean speed ranged from 0.8 to 1.5 mph at 1 month and 1.8 to 2.7 mph at 12 months. Three sites experienced no change in 85th percentile speed at 1 month, while two sites experienced decreases of 1 mph. At 12 months, decreases in 85th percentile speed ranged from 1 to 4 mph.

When data for all sites were combined, the mean speed when the system was activated was 3.7 mph lower at 1 month and 1.6 mph lower at 12 months than when the system was not activated. The difference in 85th percentile speed was 2 mph lower at 1 month and 1 mph lower at 12 months.

Overall, speeds were lower when drivers encountered an activated system. However, differences were minor in most cases (typically around 1 mph), although differences up to 4 mph were noted. This suggests that the system does alter driver behavior, but the impact is modest.

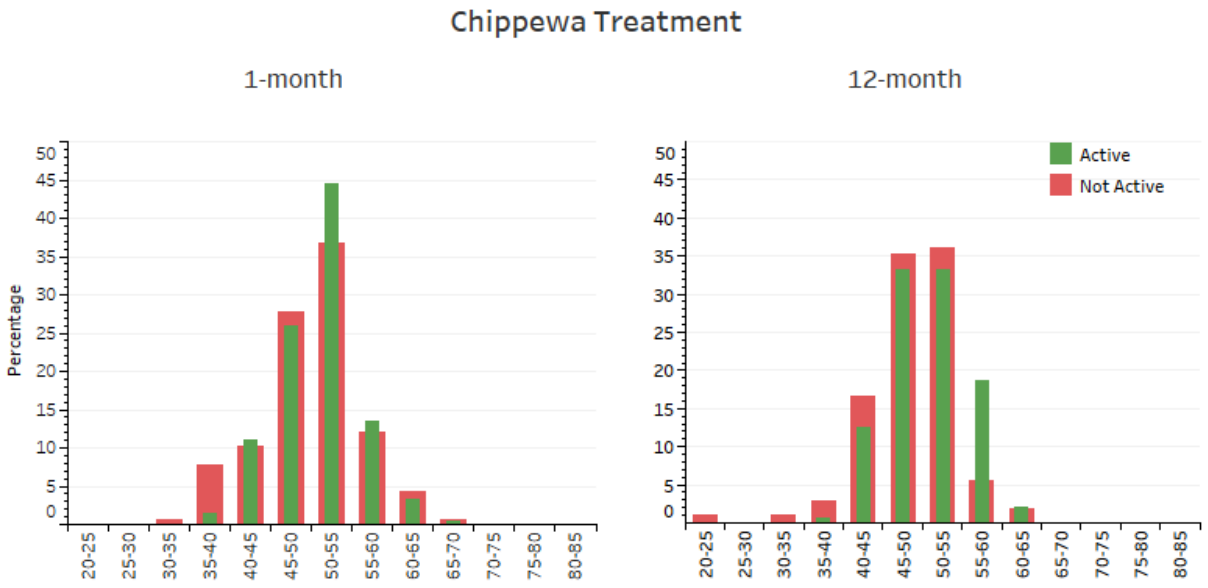
REFERENCES

Hallmark, S. L., N. Hawkins, R. Thapa, S. Knickerbocker, J. Gaspar. 2017. *Evaluation of Intersection Collision Warning Systems in Minnesota*. Minnesota Department of Transportation, Saint Paul, MN. http://dot.state.mn.us/research/reports/2017/201738.pdf.

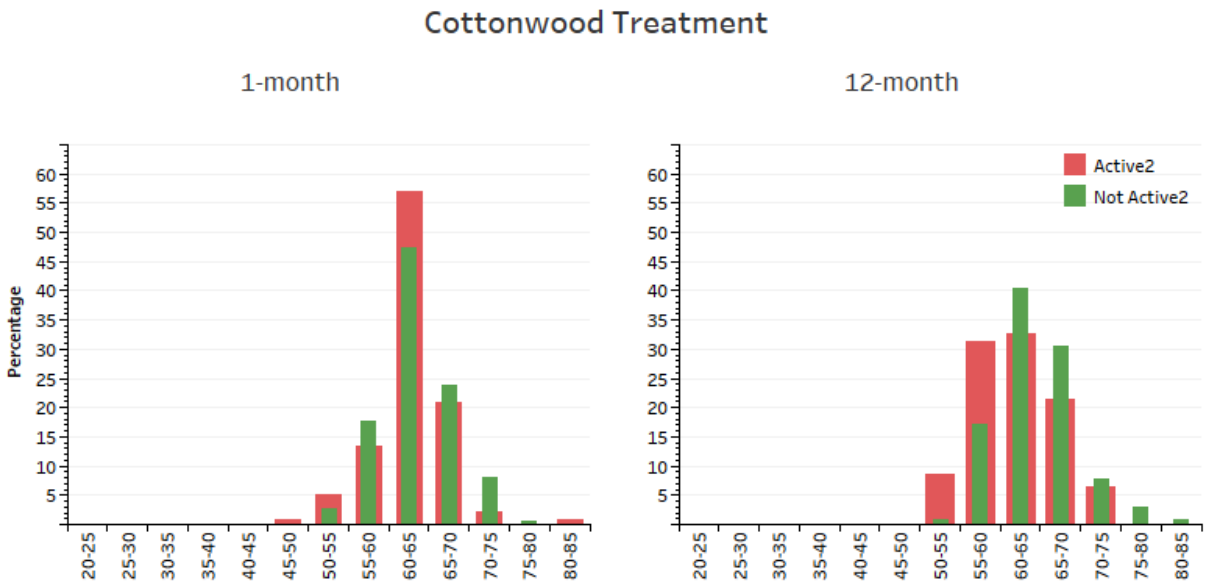
APPENDIX A:
DISTRIBUTION OF SPEED DATA AT TREATMENT SITES

This appendix shows the distribution of speed data at each treatment site. In each plot, the x-axis shows bin size for speed in miles per hour, and the y-axis shows the percentage of total vehicles reduced with speed in a certain bin size. For instance, at the Chippewa County treatment site during the 1-month after period, around 45% of the vehicles travelled with speeds between 50 to < 55 miles per hour when the system was active on the major approach.

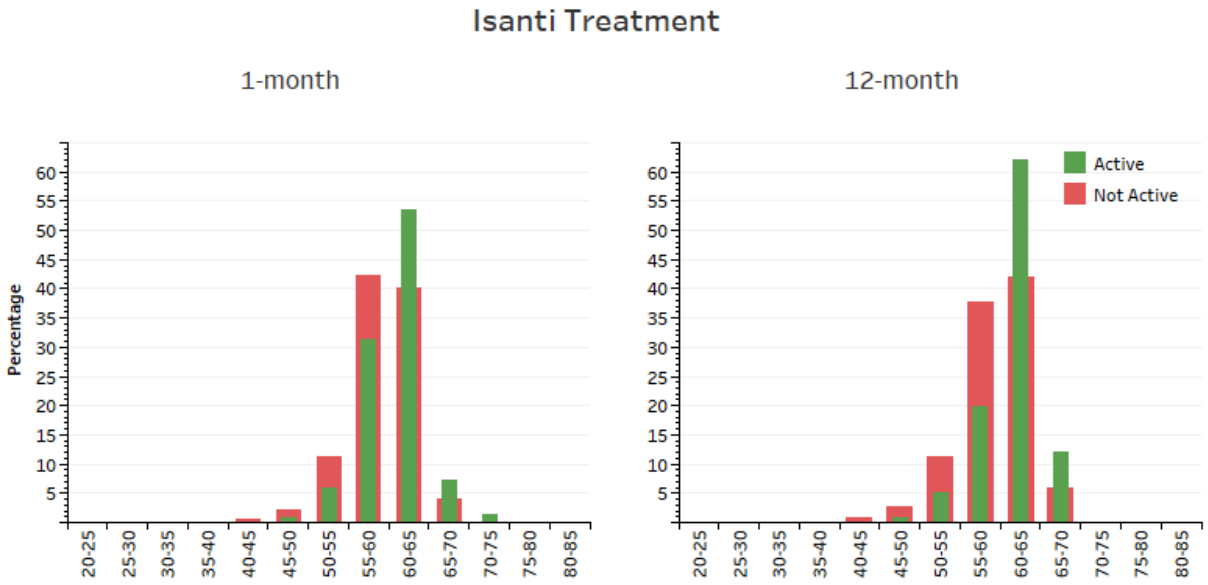
CHIPPEWA COUNTY TREATMENT



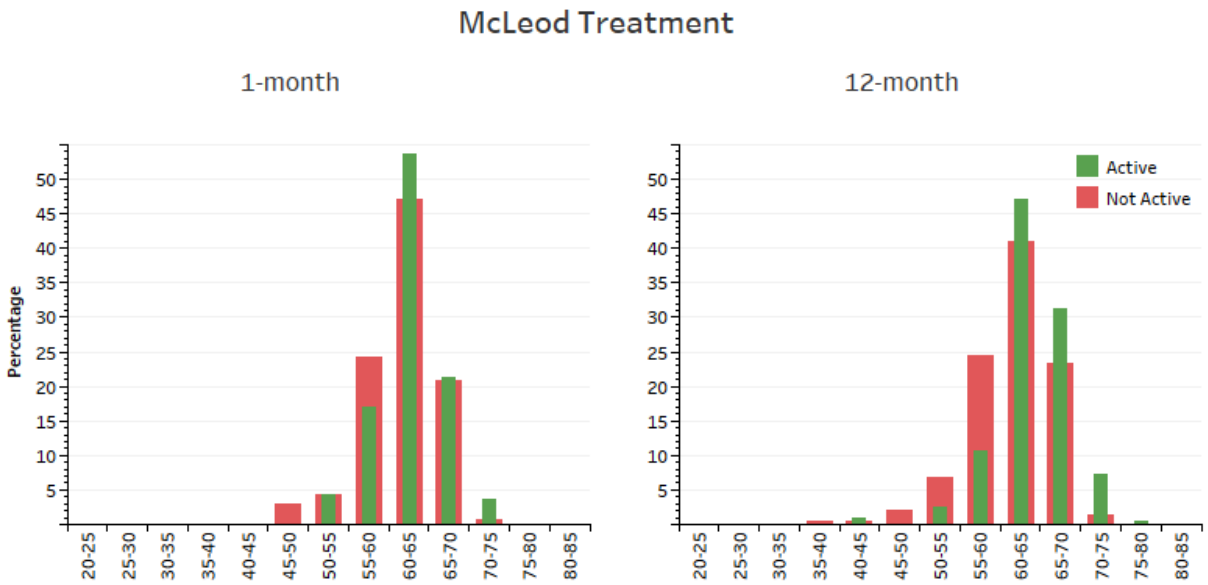
COTTONWOOD COUNTY TREATMENT



ISANTI COUNTY TREATMENT



MCLEOD COUNTY TREATMENT



PIPESTONE COUNTY TREATMENT