DEPARTMENT OF TRANSPORTATION

COVID-19 Impacts on Speed and Safety for Minnesota Roads and Work Zones

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AUGUST 2021

Research Report
Final Report 2021-21

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Technical Report Documentation Page

1. Report No.	2.	3. Recipients Accession No.	
MN 2021-21			
4. Title and Subtitle COVID-19 Impacts on Speed and Safety for Minnesota Roads and Work Zones		5. Report Date August 2021 6.	
7. Author(s) Neal Hawkins, Shauna Hallmark, Skylar Knickerbocker, and Theresa Litteral		8. Performing Organization Report No.	
9. Performing Organization Name and Address Institute for Transportation Iowa State University 2711 S. Loop Drive, Suite 4700 Ames, Iowa 50010		10. Project/Task/Work Unit No. 11. Contract (C) or Grant (G) No. (c) 1036334 (wo) 5	
12. Sponsoring Organization Name and Address Minnesota Local Road Research Board Minnesota Department of Transportation Office of Research & Innovation 395 John Ireland Boulevard, MS 330 St. Paul, Minnesota 55155-1899		13. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code	
15. Supplementary Notes https://www.mndot.gov/research/reports/2021/202121.pdf			

16. Abstract (Limit: 250 words)

Reduced traffic volumes resulting from COVID-19, along with the strain on enforcement during the pandemic, are thought to have produced higher speeds and more aggressive driving. Understanding the magnitude of speeding and other driver behaviors requires measurement and contrast. This project quantifies reductions in volume and the resulting differences in travel speeds across Minnesota along regular roads and within two work zones prior to and during the novel COVID-19 pandemic. The work includes a review of total crashes as well as fatal and serious injury crashes and includes a survey of law enforcement opinions. Findings based on 125 Automatic Traffic Recorders (ATR) and traffic Sensors quantify volume reductions, which, of course, were lower in 2020 but which varied considerably by location and month. Average speeds overall along with both the number and percentage of vehicles traveling greater than 15 mph over the posted speed limit increased in 2020. This information supports benchmarking and agency decision making.

17. Document Analysis/Descriptors	18. Availability Statement		
Traffic volume, Speeding, Average travel speed, Law enforcement, Traffic crashes, COVID-19	No restrictions. Document available from: National Technical Information Services, Alexandria, Virginia 22312		
19. Security Class (this report) Unclassified	20. Security Class (this page) Unclassified	21. No. of Pages 63	22. Price

COVID-19 IMPACTS ON SPEED AND SAFETY FOR MINNESOTA ROADS AND WORK ZONES

FINAL REPORT

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AUGUST 2021

Published by:

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

ACKNOWLEDGMENTS

Special thanks to the Minnesota Department of Transportation (MnDOT) for funding this research along with the excellent Technical Advisory Panel members, which included Derek Leuer and Brent Rusco (MnDOT) and Vic Lund (St. Louis County, Minnesota). The authors recognize the various districts of the Minnesota State Patrol (Districts 2100, 2200, 2300, 2400, 2800, and 3200) for their time and survey input on enforcement as well as Ian Vaagenes (MnDOT) for assisting with Automatic Traffic Recorder (ATR) data.

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LIST OF ABBREVIATIONS

A list of common abbreviations used within this report follows.

AASHTO	American Association of State Highway and Transportation Officials
ATR	Automated Traffic Recorder
COVID-19	Coronavirus disease
GHSA	Governors Highway Safety Association
MnDOT	Minnesota Department of Transportation
MnPASS	High occupancy toll lanes in Minneapolis-St. Paul Metro Area
MPH	Miles per hour
Sensor	Traffic Sensor
TAP	Technical Advisory Panel

EXECUTIVE SUMMARY

This study quantifies how drivers responded to the reduced traffic volumes that resulted from the novel COVID-19 pandemic, which impacted travel in Minnesota from March through December 2020. At question was whether drivers were taking advantage of the lack of traffic on the roadway, and perhaps a perception of less enforcement, and in turn driving at higher speeds. Understanding the magnitude of speeding and other driver behaviors requires measurement and contrast, which for the majority of this report included comparing 2020 against 2019 from March through December.

Analytical Tools

The research team developed interactive analysis tools per data source that provide both analytics and visualizations built into a "story" format. The user can choose to see the results per individual site or any combination of multiple sites. Table 3-1 identifies the information generated and clicking on the column titles opens each tool online.

Lower Traffic Volumes and Higher Average Speeds

Figure 6-1 is a summary of all 27 ATR sites (upper) and 98 Sensor sites (lower) together, beginning with a map (left), volume (middle), and average speed (right) visualizations. As shown, volumes were down across all sites, with maximum reductions seen in April 2020 of 38% (ATR) and 47% (Sensor). The comparison of average speed indicates higher speeds in 2020 by varying degrees each month and with maximum monthly increases of 2.9% in July (ATR) and 3.0% in April (Sensor).

Increased High Speeds

The ATR data alone provides the opportunity to compare higher speeds, which are defined as greater than 15 mph over the posted speed limit. These types of comparisons are done on a site-by-site basis. Comparing 2020 to 2019, 69% of the ATR sites showed an increase in the number of high-speed vehicles and 88% showed an increase in the percent of vehicles travelling at high speeds.

Crash and Enforcement

Crash and enforcement data from each of the 6 Minnesota State Patrol districts were evaluated to assess the impact of the COVID-19 pandemic and a survey was distributed to record officer impressions in 2020. The findings showed that total speeding-related crashes in 2020 were 2-5% higher in 5 districts and 1% lower in 1 district compared to 2019. Also speeding-related fatal and serious injury crashes in 2020 were 4-13% higher in 4 districts and 1-4% lower in 2 districts compared to 2019.

Overall

This analysis, and the tools developed, serve to support benchmarking and decision making by both MnDOT and the Minnesota State Patrol. Future opportunities to expand these efforts and build a near real-time dashboard will be discussed with the project Technical Advisory Panel.

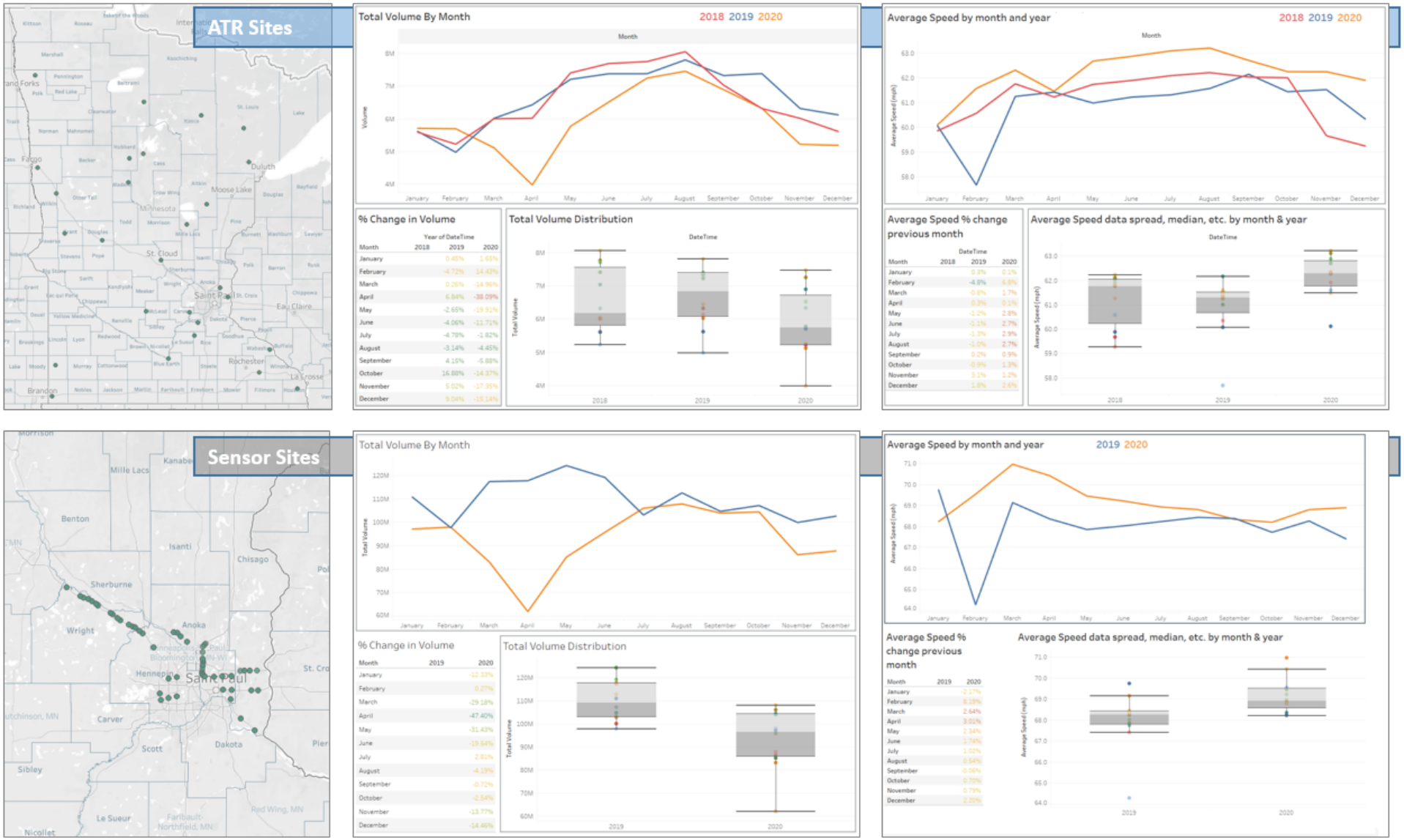

Figure ES-1. ATR and Sensor comparison of volume and average speed

CHAPTER 1: INTRODUCTION

Over the last decade, Minnesota has made impressive targeted efforts to reduce traffic fatalities through its multi-agency Toward Zero Deaths initiative. These efforts are showing that traffic crashes are preventable when the right traffic safety strategies are applied. Unfortunately, reduced traffic volumes resulting from COVID-19, along with the strain on enforcement during the pandemic, is thought to have produced higher speeds and more aggressive driving. Understanding the magnitude of speeding and other driver behaviors requires measurement and contrast.

The term "before" within this report refers to all times prior to 2020 and "during" reflects the period from January 1 through December 31, 2020. This project quantifies the reductions in volume and resulting differences in travel speeds across the state and within two work zones prior to and during the novel COVID-19 pandemic. The quantified results include both crash consideration and input from enforcement all of which support agency benchmarking and decision making.

1.1 BACKGROUND

The first confirmed case of COVID-19 in Minnesota was on March 6, 2020, followed by various closures and then issuance of a stay-at-home order on March 27 (MnDOT, 2020). Figure 1-1 illustrates these announcements in contrast to reductions in travel to and from the MSP airport in 2020 compared to previous years (2017 through 2019).

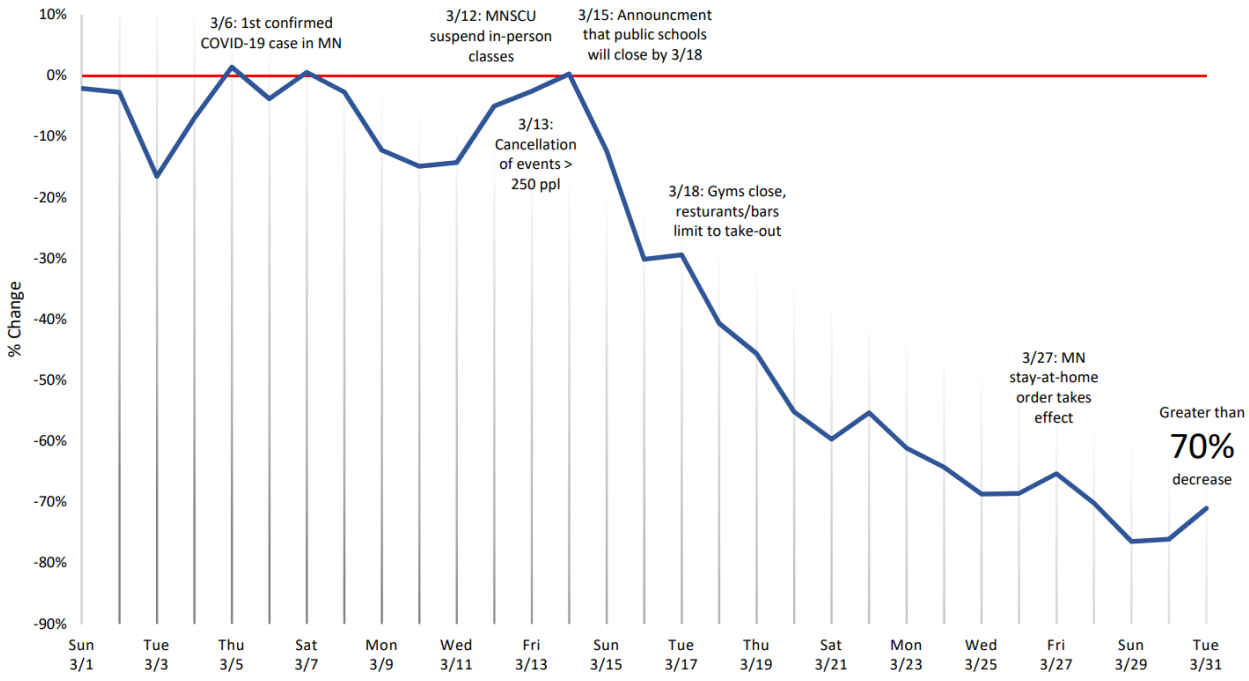

Figure 1-1. COVID-19 March impacts to travel at the MSP Airport (Source: MnDOT 2020)

The novel reduction in traffic volume led to expectations of less crash and injury, yet by June 2020, it became clear that some drivers were taking advantage of empty streets and travelling at excessive speeds. For instance, the Iowa State Patrol found a 65% increase in drivers exceeding the speed limit by 25 mph or more from January to June 2020 compared to the previous 4-year average. The highest rate of noncompliance occurred on Saturday afternoons, with nearly one-third of citations during that period issued for speeds as high as 121 to 155 mph (Rose, 2020), with an example shown on the left side of Figure 1-2.

Unfortunately, higher speeds increase the risk of injury crashes. Virginia experienced a 45% decrease in total crashes during the state's approximately 3-month lockdown, but the number of fatalities involving speed and the lack of seat belt use increased by 78% compared to a similar period in 2019, (AASHTO, 2020). The state found that 50% of its fatalities were speed related from March 13 to May 21 compared to 42% in the same period in 2019. "We are urging all motorists to drive the posted speed limit and wear seat belts," noted Shannon Valentine, Virginia's secretary of transportation (see messaging shown on the right in Figure 1-2).

Figure 1-2. Iowa State Patrol speed recorded at 124 mph (left), Virginia speed messaging (right). Image sources: Iowa State Patrol Facebook page; and AASHTO 2020.

The California Highway Patrol issued 15,000 tickets for speeds exceeding 100 mph from mid-March to mid-Aug 2020, which was more than a 100% increase from the same period in 2019 (CBS News, 2020). Overall, California experienced a 97% spike in speeding citations for speeds in excess of 100 mph. In Ohio, traffic volumes decreased by 15% from February to July 2020, but the number of people driving at speeds exceeding 80 mph increased by 30%. State troopers issued 61% more citations for drivers traveling more than 100 mph as compared to 2019, with the highest ticketed speed being 147 mph in Cincinnati. Utah reported a 23% increase in tickets for drivers going 20 mph, or more, over the speed limit from March through August 2020 compared to 2019 (CBS News, 2020). The Nebraska DOT noted 100 speeding citations statewide for speeds in excess of 100 mph between March 18 and mid-April compared to 61 citations for the same time period in 2019 (AASHTO, 2020). Traffic was down by 45% in Atlanta, Georgia, in April 2020, but 140 speeding citations were issued for speeds of 100 mph or more, a

63% increase from the previous year. One motorcyclist was clocked at 172 mph in Sandy Springs (Wickert, 2020).

The Governors Highway Safety Association (GHSA, 2020) reported on early impacts due to the pandemic including New York City issuing 24,765 daily speeding tickets from automated enforcement cameras in March 2020 compared to 12,672 tickets issued daily in February 2020. An increase in fatalities was also noted. In 2020, Ohio experienced the highest number of traffic fatalities (154) since 2007 (CBS News, 2020). The Missouri DOT (2020) noted that as of June 2020, despite a 50% decrease in traffic volumes, a 12% rise in fatalities had occurred, compared to 2019, with 70 percent of the fatalities not wearing a seatbelt. One psychologist interviewed by the *Washington Post* noted that drivers may find speeding an emotional release to counteract some of the negative and stressed feelings due to the pandemic and lifestyle changes (Lazo, 2020).

1.2 STUDY APPROACH

The original project intent was to select a maximum of 10 rural locations for analysis and 5 work zone locations. However, a larger number of locations where traffic data (speed and volume) were available for both the "before" and "during" COVID-19 analysis periods. As a result, the scope was expanded to evaluate all 92 statewide Automated Traffic Recording (ATR) stations, of which 27 sites were found to have sufficient data completeness for this analysis. In addition, data from 98 Traffic Sensor stations (Sensor) were also included in this analysis, of which 68 had sufficient data completeness. Figure 1-3 illustrates the spatial locations of all ATR and Sensor stations across the state.

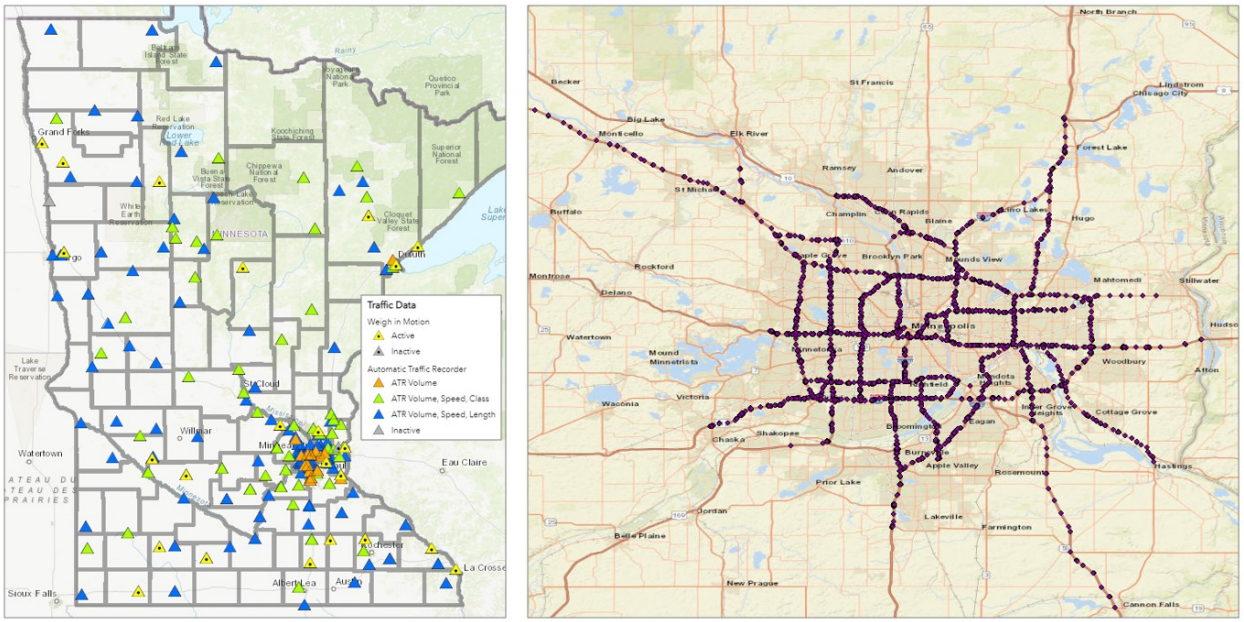

Figure 1-3. MnDOT Statewide ATR Locations (left) and Minneapolis-St. Paul metro area Traffic Sensors (right)

CHAPTER 2: DATA COLLECTION

This analysis is based on the following MnDOT data and sources:

- Automated Traffic Recording (ATR) stations distributed across the state
- Traffic Sensor stations (Sensor) primarily concentrated around the Minneapolis-St. Paul area
- Work Zone Information using the Minnesota State Highway Construction Projects list

ATR sites were the primary data source for this analysis given the statewide coverage, the fact that the data support an analysis of high-end and 85th percentile speeds, and since MnDOT can deliver these data in batch downloads with quality control for the years 2018 through 2020. Traffic Sensor data were also used to supplement ATR sites and to consider trends along critical corridors emanating out of the Twin Cities and at two known work zones. However, the sensor data only provide average speeds and require individual site downloads. The ClearGuide HERE data were not included based on being well beyond the required 10 site analysis and more so due to the fact that the data are averaged averages. A discussion on data completeness along with information per data source follows.

2.1 DATA COMPLETENESS

Surface transportation travel demands vary over time by hour, day of week, and month due to a variety of factors so measurement is critical and unfortunately, the equipment and communications used are not constantly reliable. An effective analysis of speed trends begins by understanding the completeness of the data per potential site used and understanding the temporal data gaps over the entire analysis period. This was accomplished for both the ATR and Sensor data separately using specific analytic and visualization tools developed for this analysis.

Data completeness per site was defined on a scale of 0% (no data) to 100% (site data reported for the entire analysis period). Completeness was considered by year, month, and hour. This analysis tools developed provide opportunities to review completeness as follows:

- Only 1 year of data (A specific hour of data for a given year)
- 2 years of data per hour (Any hour of the day must have data for at least two years, otherwise, the hour of data is filtered out)
- 3 years of data per hour (Any hour of the day must have data for all three years, otherwise, the hour of data is filtered out)

A discussion on completeness is included within the ATR and Sensor sections below.

2.2 AUTOMATED TRAFFIC RECORDING (ATR) DATA

The team coordinated with Mr. Ian Vaagenes (MnDOT) to obtain 2018, 2019, and 2020 raw speed data for the ATR stations. The data fields include: Site, Date and Time (by hour increments), Speed bins start at 0 mph and go by 5 mph increments up to the final bin >95 mph. Based on a review of these data

some adjustments to speed bins as well as quality control (by MnDOT) was completed. This resulted in the following files and file sizes:

Table 2-1. ATR data obtained from MnDOT

File Name	Size (MB)
QCd_2018_atr_speed.csv	52.38
QCd_2018_wavetronix_speed.csv	17.34
QCd_2019_atr_speed.csv	43.15
QCd_2019_wavetronix_speed.csv	22.38
QCd_2020_atr_speed.csv	40.43
QCd_2020_wavetronix_speed.csv	56.53

2.2.1 ATR Data Completeness

Of the 92 ATR sites, 70 are identified as rural and 22 are within an urban setting. The left side of Figure 2-1 shows all 92 sites using a circle which is thematically colored by completeness using a scale from red (low) to green (high completeness score). The right side of Figure 2-1 illustrates the data completeness by site for some of the sites along with the rural and urban count.

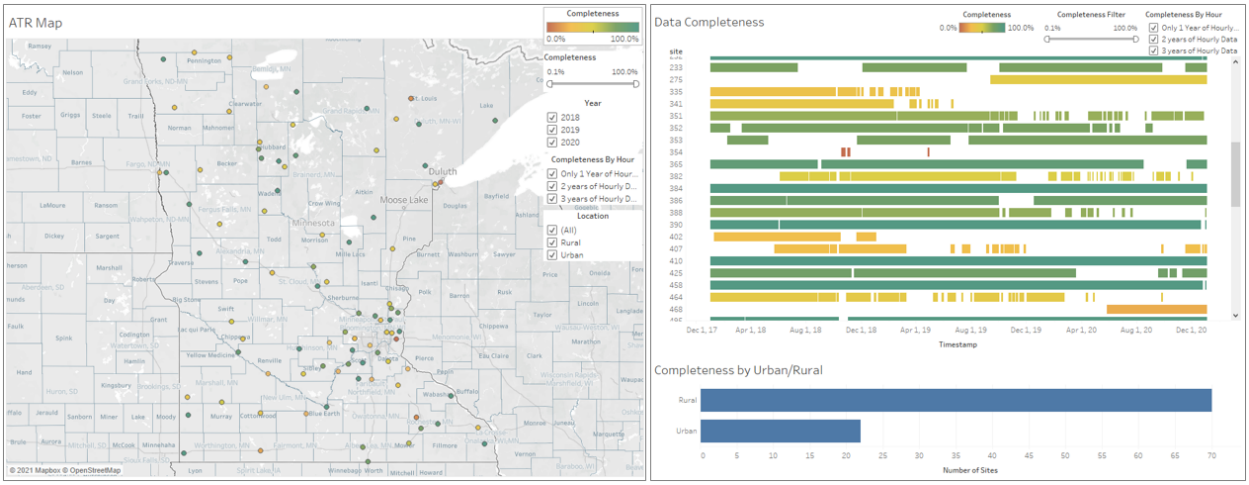

Figure 2-1. ATR site data spatially (left) and completeness by site (right)

2.2.2 ATR Sites Selected for Analysis

In order to provide a robust examination of speeds before and during COVID-19, this analysis is based on all sites that meet or exceed a data completeness score of 90.3 percent. Table 2-2 shows a map of the 27 ATR sites meeting the 90.3 percent data completeness criteria.

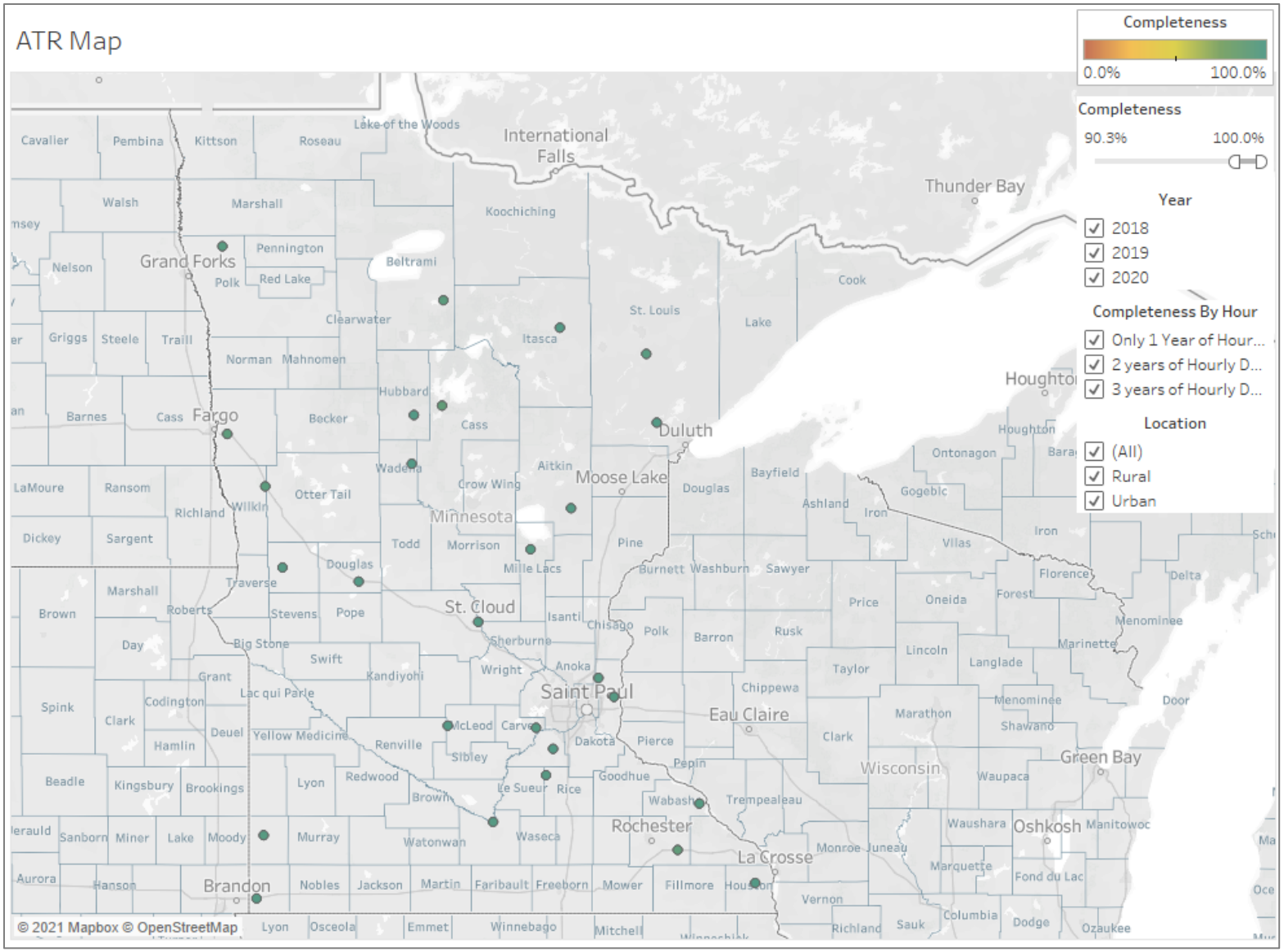

Figure 2-2. Map showing 27 ATR sites selected for the analysis

Figure 2-3 illustrates the data completeness for a portion of the 27 ATR sites meeting the 90.3 percent or greater completeness criteria and shows the count of 20 rural and 7 urban locations.

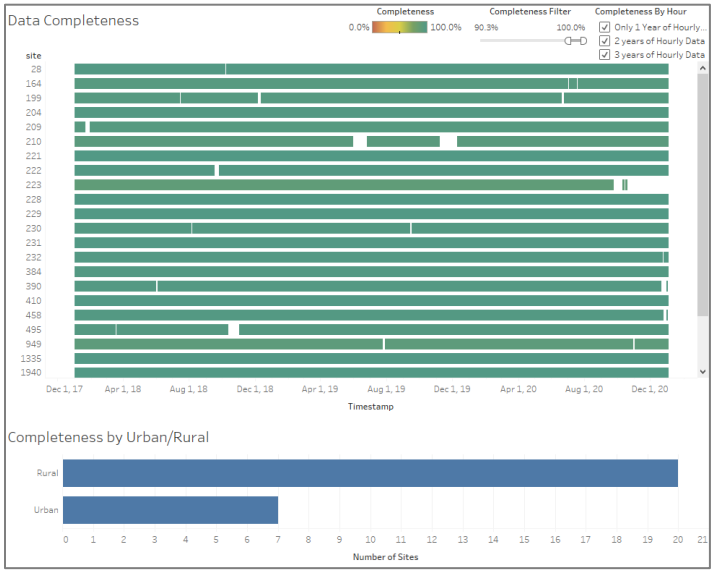

Figure 2-3. ATR sites with a data completeness score of 90.3% or greater

Table 2-2 provides a descriptive summary per ATR site with the site name providing a hyperlink to view the roadway setting per location. The selected include a variety of roadway settings, which provides a robust cross-sectional analysis. Posted speed limit information was needed in for the ATR high-speed analysis and the information was obtained through visual inspection of on-line imagery.

Table 2-2. ATR sites selected for analysis

Site	Urban Rural	Speed Limit (mph)	ROUTE	COUNTY
28	Urban	30	MSAS 114	Stearns
164	Rural	65	US 53	Saint Louis
199	Rural	55	US 75	Pipestone
204	Rural	65	US 169	Mille Lacs
209	Rural	55	US 75	Polk
210	Rural	60	US 71	Beltrami
221	Rural	60	MN 34	Hubbard
222	Rural	55	MN 65	Aitkin
223	Rural	55	MN 371	Cass
228	Rural	55	CSAH 7	Itasca
229	Rural	55	CSAH 18	McLeod
230	Rural	55	CSAH 2	Rice
231	Rural	55	CSAH 12	Wadena
232	Rural	55	CSAH 11	Grant

Site	Urban Rural	Speed Limit (mph)	ROUTE	COUNTY
384	Urban	50	MN 36	Washington
390	Urban	45	US 61	Washington
410	Rural	50	CSAH 23	Scott
458	Urban	40	MSAS 108	Carver
495	Urban	50	US 169	Blue Earth
949	Urban	70	I 94	Clay
1335	Urban	70	I 94	Douglas
1940	Rural	55	MN 44	Houston
3801	Rural	70	I 90	Ramsey
4820	Rural	70	I 90	Rock
4910	Rural	65	US 53	Saint Louis
5984	Rural	65	US 61	Wabasha
6224	Rural	70	I 94	Wilkin

2.3 TRAFFIC SENSOR STATION (SENSOR) DATA

Data from the MnDOT Traffic Mapping Application interactive web tool, along with a shape file, enabled sensor data to be identified and acquired for 2019 and 2020. The files include average speed and volume by 15-minute increments. To simplify use, the raw data were transposed for each record to represent a specific 15-minute period.

2.3.1 Sensor Sites included within the Analysis

Traffic sensors around the metro area were identified to supplement the ATR sites and to provide data within two known work zone locations (I-35W North MnPASS from Roseville to Blaine/Lino Lakes and I-94 Maple Grove to Clearwater). The data for each sensor is by travel direction and was also chosen where the data completeness score is 90.4 percent or higher. Figure 2-4 identifies the 98 sensor locations downloaded. A further review of data quality resulted in a final list of only 68 sites for the comparative analysis. These 68 sites are identified by name and location Table 2-3.

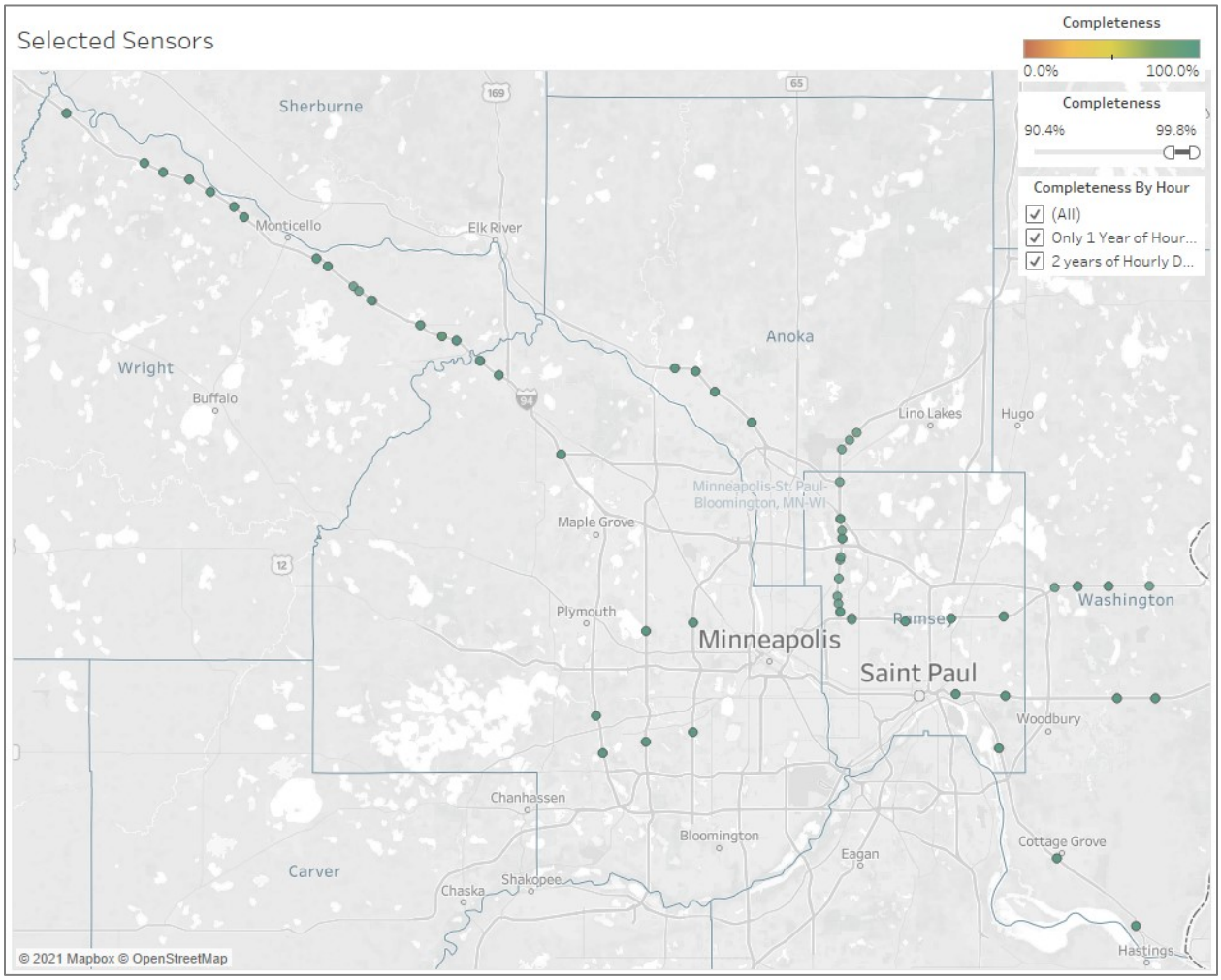

Figure 2-4. Map showing the location of 98 sensor sites

Table 2-3. Sensor site name and location (68 sites)

Sensor	Location
1904	U.S.169 NB @ Lincoln Dr
1995	U.S.169 SB @ Lincoln Dr
7290	T.H.36 EB @ Hilton Tr
7575	T.H.36 EB @ McKnight Rd
7587	T.H.36 WB @ McKnight Rd
S1045	I-94 EB @ McKnight Rd
S1059	I-94 WB @ Co Rd 17B
S1066	I-94 WB @ McKnight Rd
S1107	I-94 WB @ 101st Ave
S1229	I-94 EB W of T.H.25
S1356	I-94 EB @ Co Rd 71
S1361	I-94 WB @ Co Rd 71
S1598	T.H.61 SB S of T.H.95
S1724	I-94 EB E of T.H.24
S1727	I-94 EB E of Co Rd 8
S1728	I-94 EB E of Co Rd 8
S1729	I-94 EB @ Enfield RA
S1730	I-94 EB W of T.H.25
S1731	I-94 EB W of T.H.25
S1735	I-94 EB E of Co Rd 18
S1737	I-94 EB E of Co Rd 18
S1738	I-94 EB E of Co Rd 18
S1741	I-94 EB E of T.H.241

Sensor	Location
S1743	I-94 WB E of T.H.241
S1746	I-94 WB E of Co Rd 18
S1749	I-94 WB E of Co Rd 18
S1750	I-94 WB @ Co Rd 18
S1753	I-94 WB W of T.H.25
S1754	I-94 WB W of T.H.25
S1755	I-94 WB W of T.H.25
S1756	I-94 WB E of Co Rd 8
S1757	I-94 WB E of Co Rd 8
S1758	I-94 WB E of Co Rd 8
S1761	I-94 WB E of T.H.24
S1848	T.H.36 EB E of Demontreville Tr
S1850	T.H.36 EB E of Keats Ave
S1852	T.H.36 EB @ Stillwater Blvd
S1855	T.H.36 WB E of Keats Ave
S1857	T.H.36 WB E of Demontreville Tr
S1881	I-94 EB W of T.H.101
S1882	I-94 WB W of T.H.101
S1889	T.H.61 SB S of Highwood Ave
S1901	T.H.61 SB @ Point Douglas Ct
S1917	T.H.61 NB S of T.H.95
S1927	T.H.61 NB @ Point Douglas Ct
S1938	T.H.61 NB S of Highwood Ave

Sensor	Location
S1945	I-94 EB E of Mounds Blvd
S1948	I-94 WB E of Mounds Blvd
S1962	I-35W NB @ Round Lake Rd
S297	I-494 SB @ Orchard Rd
S382	T.H.100 NB @ Vernon Ave
S402	T.H.100 SB N of Westbrooke Rd
S406	T.H.100 NB N of Westbrooke Rd
S414	T.H.100 SB @ Vernon Ave
S470	I-494 SB @ Baker Rd
S488	I-494 NB @ Baker Rd
S513	I-494 NB @ Orchard Rd
S611	T.H.36 WB @ Western Ave
S652	I-35W NB @ Oakcrest Ave
S697	I-35W SB @ Oakcrest Ave
S738	U.S.169 SB @ 21st Ave
S769	U.S.169 NB @ 21st Ave
S942	T.H.10 EB E of 7th Ave
S947	T.H.10 EB W of Hanson Blvd
S952	T.H.10 EB @ Egret Blvd
S980	T.H.10 WB @ Egret Blvd
S985	T.H.10 WB W of Hanson Blvd
S990	T.H.10 WB E of 7th Ave

2.4 WORK ZONES

The research team worked with MnDOT staff to identify potential construction projects from the Minnesota State Highway Construction Projects to consider speed impacts during the analysis period within work zones. The list was filtered by projects starting before 2020 and considering the types of work that impacted lanes of travel. Next, the list was filtered by locations that have sensor data available within the work zone. Only two construction projects met the criteria and had sufficient sensor data as noted below. Figure 2-5 shows project limits.

- I-35W North MnPASS from Roseville to Blaine/Lino Lakes – Includes constructing MnPASS lane, repaving, and bridge replacements on a 12 mile section (March 2019 to Fall 2021).
- I-94 Maple Grove to Clearwater – Includes constructing bridges, paving, and access work on a 39 mile section (2019 to 2022

Table 2-4 identifies the 48 work zone sensors including 14 sensors along the I-35W corridor and 34 sensors along the I-94 corridor.

Table 2-4. Sensor sites selected within work zones

Work Zone: **I-35W North MnPASS from Roseville to Blaine/Lino Lakes**	
Sensor	Location
S653	I-35W NB @ Co Rd C
S654	I-35W NB @ Iona Ln
S656	I-35W NB @ T.H.88
S691	I-35W SB @ Co Rd E2
S658	I-35W NB @ Co Rd E2
S1962	I-35W NB @ Round Lake Rd
S1880	I-35W SB S of Co Rd 96
S1879	I-35W SB @ Co Rd 96
S666	I-35W NB @ Co Rd 10
S683	I-35W SB @ Co Rd 10
S1861	I-35W NB @ T.H.10
S1864	I-35W NB @ 95th Ave
S1865	I-35W NB N of 95th Ave
S1866	I-35W NB S of Lexington Ave

Work Zone: **I-94 Maple Grove to Clearwater**							
Sensor	Location	Sensor	Location	Sensor	Location	Sensor	Location
S1107	I-94 WB @ 101st Ave	S1737	I-94 EB E of Co Rd 18	S1728	I-94 EB E of Co Rd 8		
S1120	I-94 EB @ T.H.610	S1747	I-94 WB E of Co Rd 18	S1757	I-94 WB E of Co Rd 8		
S1881	I-94 EB W of T.H.101	S1735	I-94 EB E of Co Rd 18	S1727	I-94 EB E of Co Rd 8		
S1882	I-94 WB W of T.H.101	S1749	I-94 WB E of Co Rd 18	S1758	I-94 WB E of Co Rd 8		
S1741	I-94 EB E of T.H.241	S1734	I-94 EB @ Co Rd 18	S1724	I-94 EB E of T.H.24		
S1743	I-94 WB E of T.H.241	S1750	I-94 WB @ Co Rd 18	S1761	I-94 WB E of T.H.24		
S1220	I-94 WB W of T.H.241	S1731	I-94 EB W of T.H.25				
S1221	I-94 EB W of T.H.241	S1753	I-94 WB W of T.H.25				
S1740	I-94 EB W of T.H.241	S1229	I-94 EB W of T.H.25				
S1744	I-94 WB W of T.H.241	S1754	I-94 WB W of T.H.25				
S1745	I-94 WB @ Co Rd 37	S1730	I-94 EB W of T.H.25				
S1739	I-94 EB @ Co Rd 37	S1755	I-94 WB W of T.H.25				
S1738	I-94 EB E of Co Rd 18	S1729	I-94 EB @ Enfield RA				
S1746	I-94 WB E of Co Rd 18	S1756	I-94 WB E of Co Rd 8				

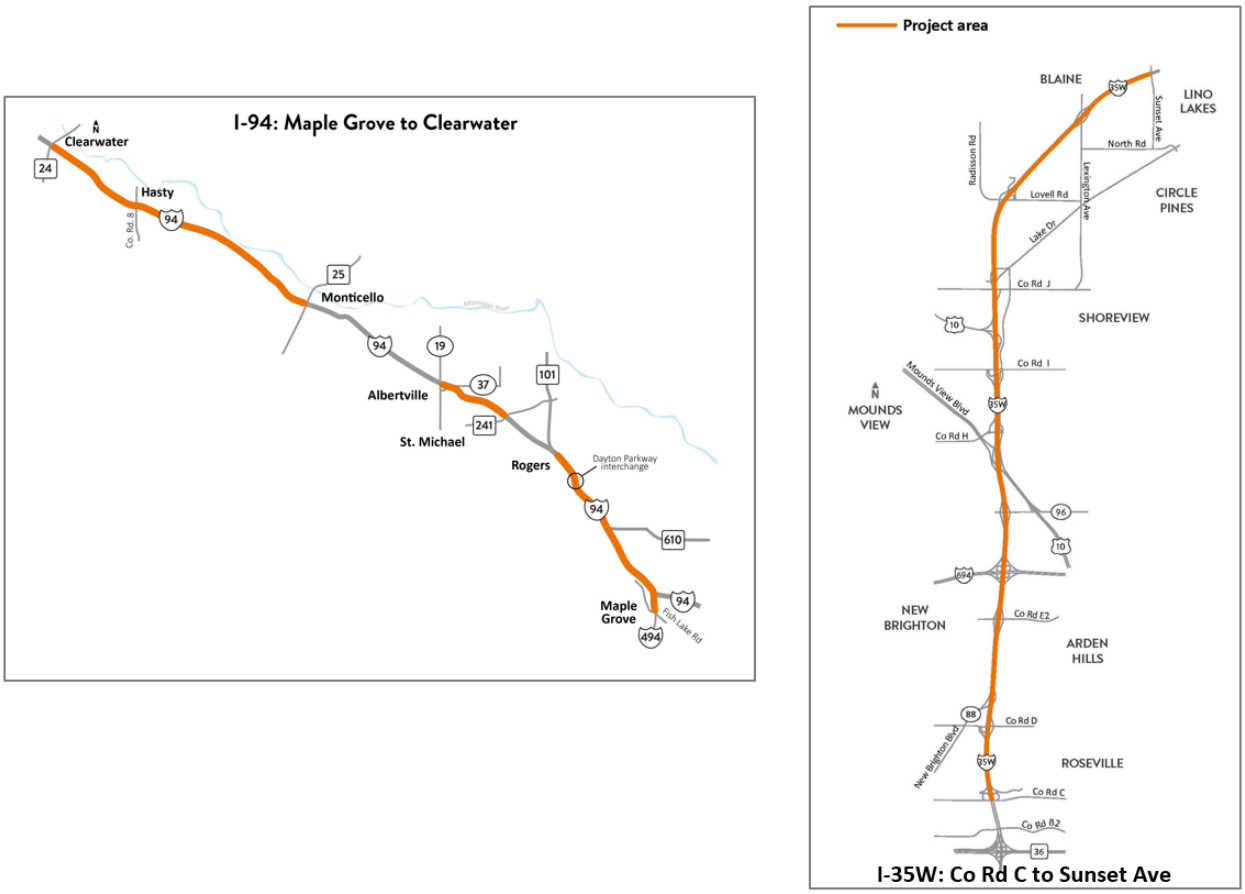

Figure 2-5. Work zones with sensor sites identified for analysis

CHAPTER 3: DATA ANALYSIS

This descriptive research analysis is focused on identifying traffic speed and volume characteristics before and during the COVID-19 influenced months in 2020. This analysis is based on two sources of data covering: ATR (3 years of data from 2018 through 2020) and Sensor (2 years of data from 2019 through 2020).

3.1 ANALYSIS METHODOLOGY

Based on the need to analyze large data sets, the methodology began with development of analytical tools and visualizations of the data. Once complete, the analysis results were further explored by site in terms of Volume, Average Speed, and in the case of ATR data by the number and percentages of High Speed Vehicles. High speeds were defined as any vehicles traveling 15 mph over the posted speed limit.

3.2 ANALYTICAL TOOLS

The research team developed interactive analysis tools per data source, which provide both analytics and visualizations built into a "story" format. The user can choose to see the results per individual site or any combination of multiple sites. Table 3-1 identifies the information generated and clicking on the column titles opens up each tool online.

Table 3-1. Interactive analytical tool visualizations

ATR DATA - Analytics Tool	SENSOR DATA - Analytics Tool
Raw Volume	Raw Volume
Volume over time	Volume over time
Raw Average Speed	Raw Average Speed
Average Speed over time	Average Speed over time
Volume and Average Speed Box and Whisker Chart	Volume and Average Speed Box and Whisker Chart
High Speed Volume, Percent High Speed Vehicles, and Number of High Speed Vehicles	
Distribution of Average Speeds by Year and Percent of Vehicles by Speed Class	
High Average Speeds by Month, Day, and Hour	
85th Percentile Speeds by Month, Day, and Hour	

These tools allow the user to download the story information in a report. Links showing two examples can be viewed here ATR Story for Site 209, and here Sensor Story for Site S402. Figure 3-1 illustrates a box and whisker diagram where the upper portion shows that volumes for Site 209 trended down in 2020 and at the same time average speeds (lower portion of chart) were higher. Each colored dot reflects a specific month. Each chart identifies data point position relative to other values in each set by a lower whisker (lowest value), lower hinge (25th percentile, the data median (dark grey to light grey line which is the 50th percentile), upper hinge (75th percentile), and upper whisker (maximum data extent). The hinges are formed due to the data being split into 4 pieces. As an example, the April 2020 Average Speed is 64.3 mph, slightly above the median of 64.2 mph. In contrast, the average speed for October 2020 (green dot at the upper whisker) is the highest value at 65.4 mph.

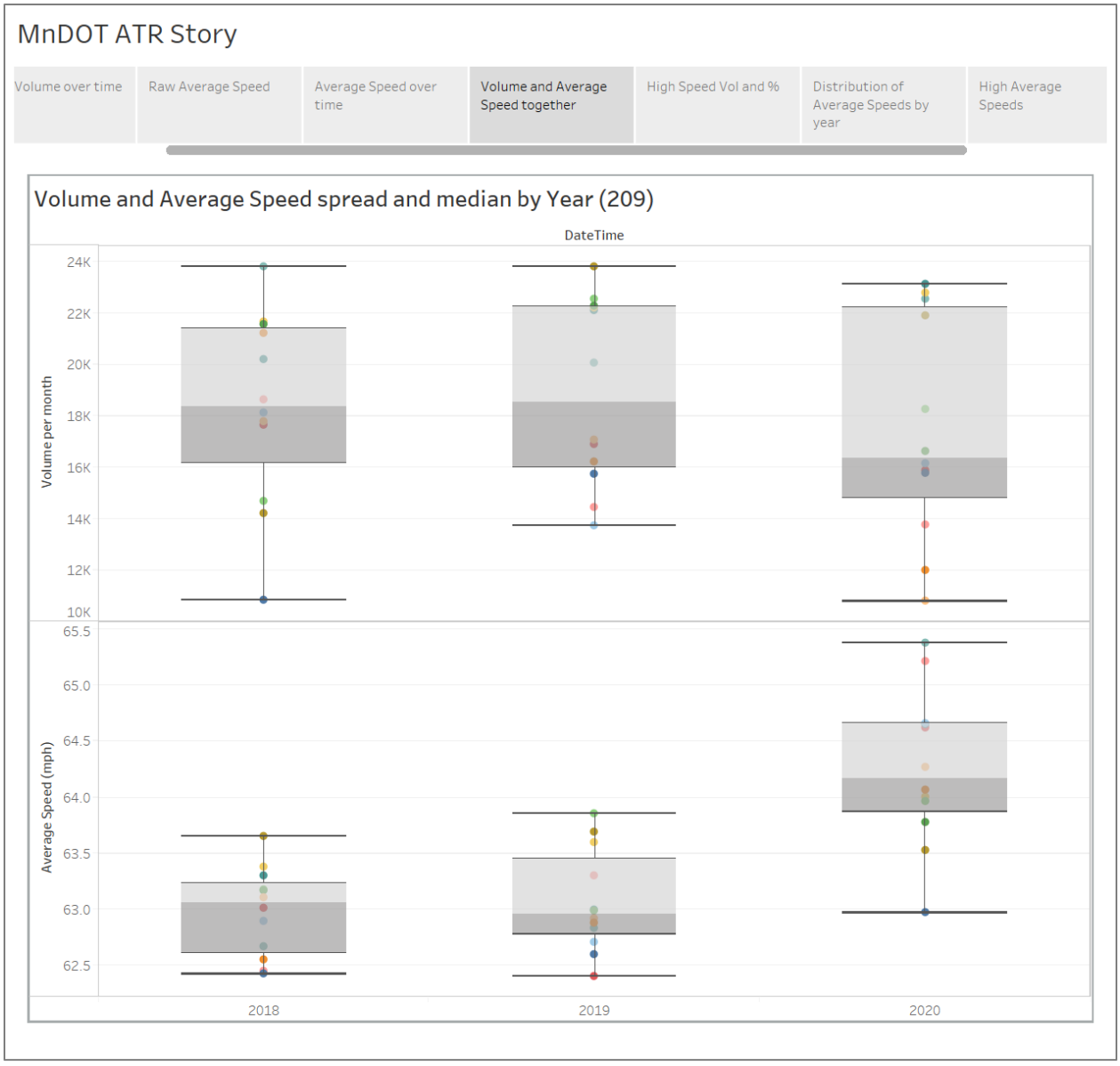

Figure 3-1. Volume and Average Speed together for Site 209

CHAPTER 4: ANALYSIS RESULTS

The analysis findings are summarized below by ATR and Sensor data source with one of the key deliverables being the interactive tools developed which support an endless number of queries and site comparisons.

4.1 ATR RESULTS

4.1.1 Interactive Tool

The ATR Interactive tool is used to characterize speed, volume, and other factors noted in Table 3-1 on a per site basis both before and throughout 2020.

4.1.2 Monthly Comparison

The ATR Interactive tool data were also used to compare all of the ATR sites by monthly characteristics (Volume, Average Speeds, and the Number and Percent of High Speed Vehicles). A portion of the ATR Monthly Comparison table is illustrated in Table 4-1 with monthly volumes and average speeds shown for ATR Site 164. As shown, volumes are thematically colored with high values in red and lower values in green. The percentage change (2020 versus 2019) is shown using a horizontal bar chart. Similarly, the average speeds are shown as well as the difference in average speeds in terms of miles per hour (mph). For ATR Site 164, volumes are lower in March of 2020 (-22.2%) and continue to decline further with July having the highest percent reduction (-57.3%). Average speeds are shown thematically with the last column which shows the difference in average speed in 2020 versus 2019, provides perspective in that although average speeds are higher for some months, the maximum difference for any one month, March through December 2020, is only 1.1 mph.

Table 4-1. ATR monthly comparison

Site	Month	2018 Volume	2019 Volume	2020 Volume	%change Volume '20 v '19	Posted Speed Limit	2018 Avg. Speed	2019 Avg. Speed	2020 Avg. Speed	Difference in Avg. Speed (mph) '20 v '19
164	**January**	222,591	216,584	225,001	3.9%	65	65.6	66.5	66.9	0.4
164	**February**	212,834	208,249	227,751	9.4%	65	67.0	65.7	68.1	2.5
164	**March**	248,309	242,701	188,799	-22.2%	65	68.0	68.1	68.3	0.3
164	**April**	236,365	241,820	136,625	-43.5%	65	67.9	68.2	68.3	0.2
164	**May**	302,792	318,965	208,251	-34.7%	65	68.6	68.7	68.7	(0.0)
164	**June**	351,737	356,517	157,248	-55.9%	65	67.8	68.5	68.6	0.1
164	**July**	369,801	383,299	163,734	-57.3%	65	67.2	67.8	68.9	1.1
164	**August**	366,319	382,299	236,791	-38.1%	65	67.1	67.9	69.0	1.1
164	**September**	309,073	320,704	236,505	-26.3%	65	66.9	68.3	69.0	0.7
164	**October**	285,158	291,875	224,005	-23.3%	65	67.5	68.7	68.4	(0.3)
164	**November**	249,928	241,873	183,694	-24.1%	65	66.7	67.3	68.3	1.0
164	**December**	241,650	233,445	198,377	-15.0%	65	65.8	66.4	67.0	0.5

Table 4-2 illustrates the right half of this wide table where High Speed is defined as 15 mph greater than the posted speed limit. The number of vehicles exceeding this High Speed limit is also shown as is the percent of vehicles exceeding the high-speed threshold for this site. In this example, ATR Site 164 had a maximum of 2,185 vehicles exceeding 80 mph in June of 2020, which was actually a lower percentage than found in 2019 by -0.3 percent.

Table 4-2. ATR site high-speed characteristics

Site	Setting	Month	High Speed is 15 mph > Posted	Number of High Speed Vehicles 2018	Number of High Speed Vehicles 2019	Number of High Speed Vehicles 2020	% change in Number of High Speed Vehicles '20 v '19	#High Speed Veh '20 v '19	% Veh at High Speed 2018	% Veh at High Speed 2019	% Veh at High Speed 2020	Difference in % High Speed Veh '20 v '19
164	Rural	**January**	80	760	819	1,003	22.5%	184	0.3%	0.4%	0.5%	0.1%
164	Rural	**February**	80	895	798	1,460	83.0%	662	0.4%	0.4%	0.6%	0.3%
164	Rural	**March**	80	1,663	2,194	1,642	-25.2%	(552)	0.7%	0.9%	0.9%	0.0%
164	Rural	**April**	80	1,528	1,950	940	-51.8%	(1,010)	0.7%	0.8%	0.7%	-0.1%
164	Rural	**May**	80	2,390	2,694	1,219	-54.8%	(1,475)	0.8%	0.8%	0.6%	-0.3%
164	Rural	**June**	80	1,859	2,997	812	-72.9%	(2,185)	0.5%	0.8%	0.5%	-0.3%
164	Rural	**July**	80	1,882	2,811	1,108	-60.6%	(1,703)	0.5%	0.7%	0.7%	-0.1%
164	Rural	**August**	80	1,784	2,899	1,982	-31.6%	(917)	0.5%	0.8%	0.8%	0.1%
164	Rural	**September**	80	1,283	2,531	1,836	-27.5%	(695)	0.4%	0.8%	0.8%	0.0%
164	Rural	**October**	80	1,398	2,721	1,681	-38.2%	(1,040)	0.5%	0.9%	0.8%	-0.2%
164	Rural	**November**	80	1,171	1,521	1,260	-17.2%	(261)	0.5%	0.6%	0.7%	0.1%
164	Rural	**December**	80	858	1,074	867	-19.3%	(207)	0.4%	0.5%	0.4%	0.0%

4.1.3 Annual Comparison

The ATR Monthly Comparison data were further reduced to an annual basis, see the ATR Annual Comparison. Table 4-3 shows Volume, Average Speed, and High-Speed comparisons and only includes the months of March through December 2020, given that the reduced COVID-19 influenced volumes began in March 2020. This annual comparison averages monthly values for 2018 and 2019 and compares this average to 2020 Volumes, Average Speeds, and High Speed values. April was by far the most common month experiencing the highest monthly traffic volume reduction.

4.1.4 Qualitative Comparison

The ATR Summary table provides a qualitative description across all ATR sites over the analysis period. This table is based off the ATR Annual Comparison information. Of the 27 ATR sites, one was excluded (Site 223) given that speeds average 70 mph and the roadway was posted at 55 mph, two-lane rural, and near a curve. As a result, data from this site appeared to be an outlier. Figure 4-1 provides a qualitative overview of for the ATR sites.

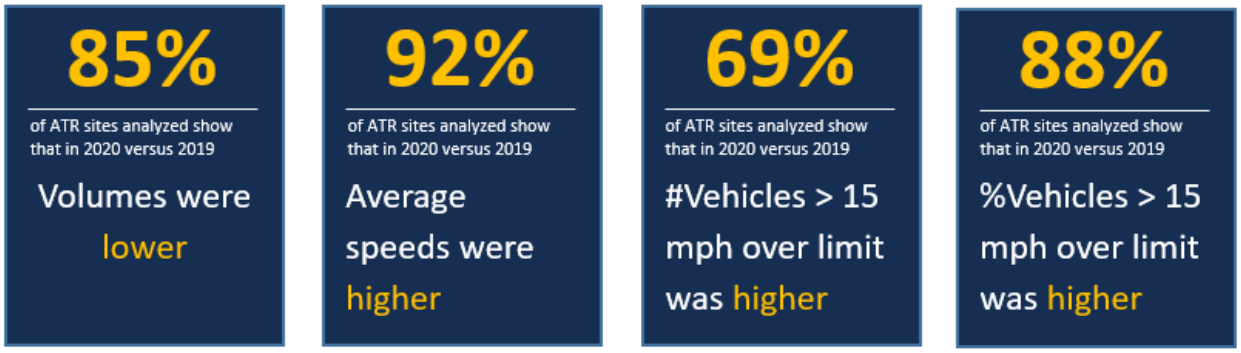

Figure 4-1. ATR qualitative overview summary

Table 4-3. ATR Annual Comparison

	VOLUME (Mar-Dec)			AVERAGE SPEED (Mar-Dec)				HIGH SPEEDS (Mar-Dec)			
Site	Volume percent difference '20 v '19	Max percentatge reduction '20 monthly volumes?	Max monthly volume reduction occurred in	Posted speed limit (mph)	Average Speed percent difference '20 v '19	Max increase in Avg. Speed for a given month '20 v '19 (mph)	Month monthly increase in average speed occurred in '20	"High Speed" (>15 mph over posted)	Difference in the number of vehicles travelling at high speed in '20 v '19	% Vehicles travelling at high speed 2020	Difference in % of vehicles travelling at high speed '20 v '19
28	-15%	-41%	April	30	2%	1.1	March	45	2,614	0.4%	0.2%
164	-34%	-57%	July	65	1%	1.1	July	80	-10,045	0.7%	-0.1%
199	-24%	-44%	May	55	0%	1.3	March	70	-925	2.7%	0.5%
204	-7%	-31%	April	65	1%	2.1	December	80	12,269	1.4%	0.4%
209	-11%	-37%	April	55	2%	2.5	October	70	4,938	9.7%	3.5%
210	19%	-22%	April	60	2%	6.6	June	75	979	1.5%	0.2%
221	-13%	-37%	April	60	1%	0.8	November	75	516	1.1%	0.2%
222	4%	-11%	April	55	1%	2.1	May	70	1,978	8.6%	2.6%
223	-18%	-40%	April	55	1%	1.0	March	70	-1,754	4.4%	0.6%
228	-1%	-10%	April	55	2%	3.5	October	70	2,806	5.2%	1.3%
229	-12%	-20%	September	55	1%	1.7	April	70	1,103	3.7%	0.8%
230	-13%	-25%	April	55	1%	1.4	March	70	4,610	3.6%	1.0%
231	4%	-17%	April	55	1%	2.6	December	70	1,119	6.4%	0.7%
232	4%	-42%	November	55	0%	4.3	March	70	3,222	13.7%	3.6%
384	-18%	-38%	April	50	3%	2.8	April	65	54,624	2.5%	0.9%
390	-23%	-46%	December	45	2%	2.0	December	60	235	0.0%	0.0%
410	-13%	-21%	November	50	1%	1.2	March	65	8,296	4.8%	1.4%
458	-25%	-46%	December	40	1%	1.5	December	55	349	0.1%	0.0%

495	-14%	-31%	April	50	1%	3.4	October	65	-27,480	3.7%	0.2%
949	-13%	-42%	April	70	0%	1.6	December	85	-8,707	1.3%	0.1%
1335	-20%	-45%	April	70	4%	9.3	August	85	2,283	5.6%	0.7%
1940	-13%	-36%	April	55	1%	2.5	March	70	7,531	2.5%	0.9%
3801	-8%	-41%	April	70	0%	0.6	December	85	-2,335	0.2%	-0.1%
4820	10%	-46%	April	70	2%	6.8	August	85	7,732	1.7%	0.2%
4910	-19%	-42%	April	65	1%	2.8	December	80	-49,777	13.8%	0.5%
5984	-19%	-40%	April	65	1%	1.4	December	80	3,699	2.5%	0.7%
6224	-19%	-45%	April	70	-1%	0.4	December	85	-2,446	4.4%	0.5%

4.1.5 Quantitative Comparisons

Change across each ATR site in terms of Volume, Average Speeds, and the Number and Percent of High Speed Vehicles was quantified for this analysis.

4.1.5.1 Traffic Volumes

Table 4-4 is sorted by rural and urban sites to illustrate the wide range of traffic volumes measured across the 27 ATR sites. In 2019, the total traffic counted across all sites was 68.7 million vehicles (March through December) which, in 2020 was reduced to 9.6 million vehicles, a 14 percent reduction. Four sites had higher volumes (overall) in 2020.

Volumes at the 20 rural ATR sites varied from 4 million to less than 100,000 vehicles per year with the percent reduction in volume ranging from -37% to 44%. Volumes at the 7 urban ATR sites varied from 11.8 million to 2.3 million vehicles per year with the percent reduction in volume ranging from -25% to -13%.

4.1.5.2 Average Speeds

Figure 4-2 contrasts average speeds per site, March through December, in terms of roadway setting (rural/urban), year, and posted speed limit. The chart supports understanding average speeds relative to posted speed limit and year. For example, ATR Site 28, with a posted speed limit of 30 mph, recorded average speeds for each of the 3 years within 2 to 3 mph of this value.

Scanning from left to right helps to identify anomalies like ATR Site 232 where average speeds are over 70 mph, the posted speed limit is only 55 mph, and on further review, the ATR site is between two horizontal curves, which brings these values into question. ATR Site 6224 also stands out as the 81 mph average speeds are higher than any other roadways that have a 70 mph speed limit.

For 2020, we know that traffic volumes overall were 14 percent lower with individual sites having individual monthly reductions as low as 57 percent. Of interest is understanding that when these large drops in monthly volumes occur what was happening with the corresponding average speeds. Table 4-5 lists each ATR site by setting and includes both volume and average speed changes measured between 2020 and 2019. The information includes percent change overall as well as by the largest difference measured for any one month in terms of volume and average speed. As shown, there are no consistent trends between the volume reductions and changes in average speeds.

4.1.5.3 High Speeds

Although 15 mph, or greater, over the posted speed limit is considered high speed in this analysis, the ATR Interactive Tool provides a dynamic option to change this threshold for further examination at any given ATR site. This is particularly useful when viewing the raw speed data and applying different threshold values.

Table 4-6 shows the high-speed threshold per site, the difference (2020 versus 2019) in the number of vehicles travelling at high speeds, and the difference in the percent of vehicles travelling at high speeds. As show, the number of vehicles at high speed varies, however when sorted by the difference in percentage of vehicles travelling at high speed we see that the five highest increases occur at rural sites (209, 222, 410, 228, and 230). Based on MnDOT field verification, the speed measurements from Site 6224 are omitted due to speed measurement error.

Table 4-4. ATR Volume comparison (March through December)

Site	Setting	2019 Total Annual Volume	2020 Total Annual Volume	Difference in Total Volume	Percent change in Total Volume
6224	Rural	4,042,973	3,262,593	(780,380)	-19%
4820	Rural	3,517,065	3,451,820	(65,245)	-2%
204	Rural	3,443,903	3,262,777	(181,126)	-5%
3801	Rural	3,357,932	4,486,870	1,128,938	34%
164	Rural	3,013,498	1,934,029	(1,079,469)	-36%
4910	Rural	2,167,901	1,764,564	(403,337)	-19%
5984	Rural	1,364,560	1,103,764	(260,796)	-19%
223	Rural	1,360,007	858,881	(501,126)	-37%
1940	Rural	1,294,423	1,124,412	(170,011)	-13%
410	Rural	1,181,702	1,027,262	(154,440)	-13%
221	Rural	1,053,892	926,369	(127,523)	-12%
230	Rural	912,146	795,257	(116,889)	-13%
199	Rural	471,545	353,549	(117,996)	-25%
229	Rural	361,120	316,379	(44,741)	-12%
210	Rural	281,015	405,612	124,597	44%
228	Rural	261,653	261,800	147	0%
209	Rural	197,778	177,785	(19,993)	-10%
232	Rural	122,026	104,425	(17,601)	-14%
231	Rural	97,841	102,457	4,616	5%

222	Rural	64,410	67,749	3,339	5%
384	Urban	11,798,107	9,655,858	(2,142,249)	-18%
949	Urban	9,161,786	7,993,241	(1,168,545)	-13%
495	Urban	7,450,376	6,414,492	(1,035,884)	-14%
390	Urban	3,647,059	2,815,899	(831,160)	-23%
1335	Urban	2,906,894	2,321,495	(585,399)	-20%
458	Urban	2,846,059	2,136,179	(709,880)	-25%
28	Urban	2,334,732	1,965,949	(368,783)	-16%

Overall Total	68,712,403	59,091,467	(9,620,936)	-14%

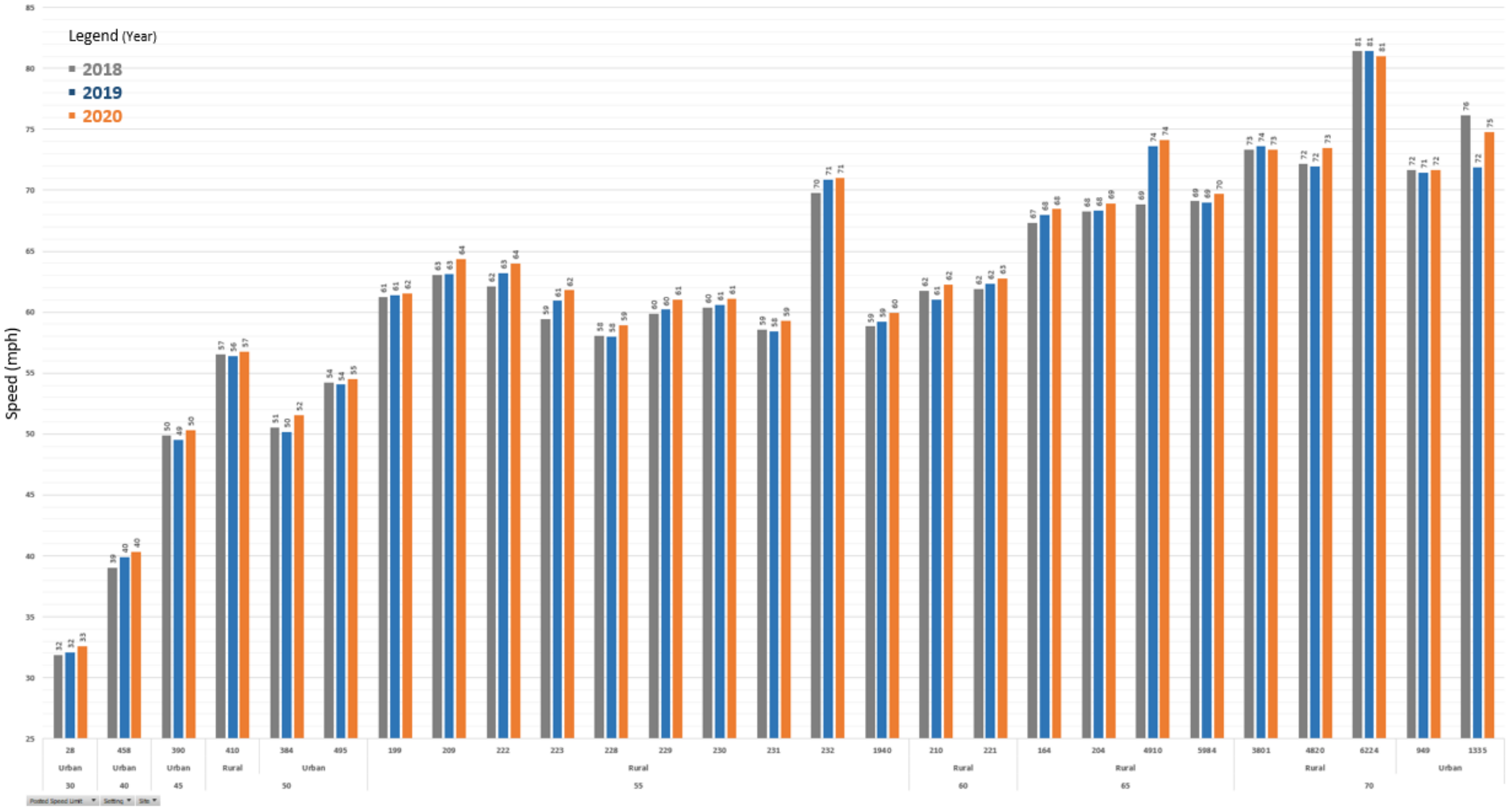

Figure 4-2. ATR average speeds by year and posted speed limit

Table 4-5. ATR volume and average speed comparisons (March through December)

Site	Setting	Percent change in Total Volume	Percent change in Average Speed	Maximum percent reduction in Volume by month		Maximum increase in Average Speed by month (mph)	
6224	Rural	-19%	-1%	-45%	April	0.4	December
4820	Rural	-2%	2%	-46%	April	6.8	August
204	Rural	-5%	1%	-31%	April	2.1	December
3801	Rural	34%	0%	-41%	April	0.6	December
164	Rural	-36%	1%	-57%	July	1.1	July
4910	Rural	-19%	1%	-42%	April	2.8	December
5984	Rural	-19%	1%	-40%	April	1.4	December
223	Rural	-37%	1%	-40%	April	1.0	March
1940	Rural	-13%	1%	-36%	April	2.5	March
410	Rural	-13%	1%	-21%	November	1.2	March
221	Rural	-12%	1%	-37%	April	0.8	November
230	Rural	-13%	1%	-25%	April	1.4	March
199	Rural	-25%	0%	-44%	May	1.3	March
229	Rural	-12%	1%	-20%	September	1.7	April
210	Rural	44%	2%	-22%	April	6.6	June
228	Rural	0%	2%	-10%	April	3.5	October
209	Rural	-10%	2%	-37%	April	2.5	October
232	Rural	-14%	0%	-42%	November	4.3	March
231	Rural	5%	1%	-17%	April	2.6	December
222	Rural	5%	1%	-11%	April	2.1	May
384	Urban	-18%	3%	-38%	April	2.8	April
949	Urban	-13%	0%	-42%	April	1.6	December
495	Urban	-14%	1%	-31%	April	3.4	October
390	Urban	-23%	2%	-46%	December	2.0	December

1335	Urban	-20%	4%	-45%	April	9.3	August
458	Urban	-25%	1%	-46%	December	1.5	December
28	Urban	-16%	2%	-41%	April	1.1	March

Table 4-6. ATR high speed comparison (March through December)

Site	Setting	"High Speed" (>15 mph over posted)	Number of vehicles at high speed in 2020	Difference in number of vehicles at high speed in '20 v '19	Percentage of Vehicles at high speed in 2020	Difference in percentage of vehicles at high speed '20 v '19
209	Rural	70	17,076	4,938	9.7%	3.5%
222	Rural	70	5,894	1,978	8.6%	2.6%
410	Rural	65	48,059	8,296	4.8%	1.4%
228	Rural	70	13,233	2,806	5.2%	1.3%
230	Rural	70	28,501	4,610	3.6%	1.0%
384	Urban	65	237,735	54,624	2.5%	0.9%
1940	Rural	70	27,526	7,531	2.5%	0.9%
229	Rural	70	11,963	1,103	3.7%	0.8%
1335	Urban	85	133,358	2,283	5.6%	0.7%
231	Rural	70	6,788	1,119	6.4%	0.7%
5984	Rural	80	28,149	3,699	2.5%	0.7%
223	Rural	70	33,217	-1,754	4.4%	0.6%
199	Rural	70	9,256	-925	2.7%	0.5%
4910	Rural	80	243,955	-49,777	13.8%	0.5%
204	Rural	80	50,290	12,269	1.4%	0.4%
210	Rural	75	5,971	979	1.5%	0.2%
4820	Rural	85	58,363	7,732	1.7%	0.2%
221	Rural	75	10,217	516	1.1%	0.2%
28	Urban	45	8,164	2,614	0.4%	0.2%
495	Urban	65	240,853	-27,480	3.7%	0.2%
949	Urban	85	103,633	-8,707	1.3%	0.1%
458	Urban	55	2,608	349	0.1%	0.0%
390	Urban	60	1,213	235	0.0%	0.0%
3801	Rural	85	10,503	-2,335	0.2%	-0.1%
164	Rural	80	13,347	-10,045	0.7%	-0.1%

4.2 SENSOR RESULTS

4.2.1 Interactive Tool

The SENSOR DATA - Analytics tool is used to characterize the speed and volume on a per site basis for the years 2019 and 2020 across all 98 sensor sites. Selecting a site from the map auto populates the site story from raw data to volume and average speed visualizations.

4.2.2 Monthly Comparison

Data from the 98 sensor locations were compared by site, month, and percent change in volume for each month, March through December 2020 as compared to 2019. The results highlighted a number of sites where unusual volume data result in extreme high and low percent change values, from 23,766% to -100%. The validity of data per site was considered using the Sensor Data Analytics tool. Common issues found include unusual, missing, or unreasonable data values in either 2019 or 2020. In all, data from 30 sites were not included in the Sensor Monthly Comparison of 68 sensor sites. Table 4-7 shows the sensor percent change in volume for each month in 2020 by max, average, and minimum values. Table 4-8 shows the sensor difference in average speed in 2020 by max, average, and minimum values.

Table 4-7. Sensor percent change in volume by month for all 68 sites

	March	April	May	June	July	August	September	October	November	December
Max	-16%	-32%	-8%	-12%	23%	2%	8%	6%	-4%	-10%
Average	-20%	-44%	-33%	-24%	-8%	-17%	-13%	-17%	-21%	-20%
Min	-29%	-58%	-46%	-38%	-30%	-28%	-29%	-28%	-31%	-37%

Table 4-8. Sensor difference in average speed (mph) by month for all 68 sites

	March	April	May	June	July	August	September	October	November	December
Max	18.4	11.6	10.7	10.3	10.8	11.7	12.1	10.3	10.3	8.5
Average	2.4	1.6	1.3	1.2	1.5	1.2	1.0	1.2	1.2	1.8
Min	-2.8	-5.8	-5.4	-5.0	-4.1	-3.7	-4.3	-5.3	-5.3	-1.4

4.2.3 Annual Comparison

The Sensor Monthly Comparison data, for 68 sites, were used to summarize annual values.

Table 4-9 shows a portion of the Sensor Annual Comparison table, which includes volume and average speed comparison for each sensor site, March through December, percent difference in volume and difference in average speed. As shown, the range of total volume per site varies considerably from a 2019 high of 20.6 million (Sensor S1945) down to less than 1 million vehicles per year (Sensor 1995).

Table 4-10 summarizes the Sensor Annual Comparison by providing the maximum, average, minimum, and total volume per year. The total 2019 volume for all sites was 680.3 million vehicles. The total 2020 volume for all sites was 585.5 million vehicles, which was a 22 percent reduction. Average speeds in 2020 were 1.4 mph higher with a maximum average speed increase of 7.8 mph (Sensor S1962).

4.2.4 Qualitative Comparison

A qualitative description across each sensor site based on the Sensor Annual Comparison information is summarized in Figure 4-3.

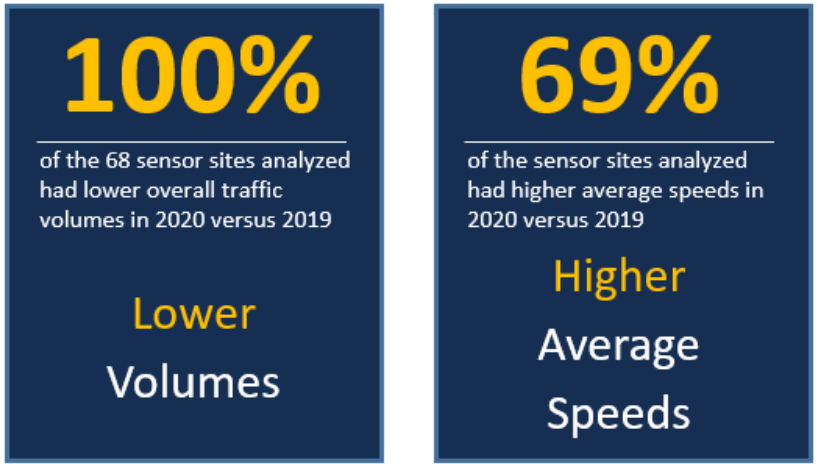

Figure 4-3. Sensor qualitative overview summary

Table 4-9. Sensor annual comparison (March through December and partial list shown)

Sensor	Total Volume 2019	Total Volume 2020	Percent Difference in Volume	Average Speed 2019	Average Speed 2020	Difference in Average Speed (mph)
S1945	20,652,097	15,453,054	-25%	61.3	65.3	4.0
S1948	20,512,972	15,625,301	-24%	61.8	66.8	5.0
S414	20,185,262	13,755,841	-31%	60.2	66.1	5.9
S382	18,402,797	13,131,612	-28%	60.3	65.5	5.2
S297	18,093,313	12,595,898	-30%	70.6	72.4	1.8
S513	17,892,478	12,696,430	-29%	66.8	72.5	5.7
S470	16,236,249	11,143,700	-31%	74.9	74.5	-0.5
S488	16,196,421	11,343,138	-30%	67.4	71.7	4.3
S402	15,977,605	11,886,063	-26%	62.9	68.7	5.7
S406	15,555,389	11,593,955	-25%	70.8	74.9	4.0
S1107	14,524,368	12,384,353	-15%	62.1	66.9	4.7
S1059	13,699,177	10,674,735	-22%	77.3	77.1	-0.3
S769	13,587,438	10,875,528	-20%	59.2	62.2	3.0
S611	13,310,211	9,866,276	-26%	63.1	68.5	5.3
S738	13,213,703	10,855,459	-18%	58.9	63.9	5.0
S1962	13,068,655	9,655,024	-26%	58.0	65.9	7.8
S1881	12,996,771	10,140,350	-22%	68.3	66.4	-1.9
S1361	12,980,283	10,177,128	-22%	74.7	74.0	-0.7
S1741	12,955,476	10,207,920	-21%	69.9	71.4	1.5
S1356	12,863,047	9,907,501	-23%	79.2	79.6	0.4
S1882	12,705,197	9,900,286	-22%	70.0	69.6	-0.4
S1045	12,651,463	9,019,385	-29%	63.2	64.9	1.7
S1743	12,481,156	9,897,850	-20%	68.3	68.7	0.4
S1066	12,414,901	8,940,434	-28%	64.9	67.7	2.7
S947	12,058,311	9,892,894	-18%	72.5	76.1	3.5
S652	11,959,553	10,099,264	-16%	55.4	63.1	7.7
S985	11,551,625	9,601,171	-17%	76.3	78.5	2.2
S942	11,550,927	9,745,952	-16%	74.3	75.1	0.8
S990	11,142,318	9,340,217	-16%	78.2	79.8	1.6
S697	9,934,003	7,728,457	-22%	64.5	69.2	4.7
S1746	9,909,987	7,657,056	-23%	72.3	72.4	0.1
S980	9,672,030	8,001,237	-17%	74.6	77.5	2.8
S1749	9,662,258	7,624,515	-21%	71.8	71.8	0.0

Table 4-10. Sensor annual comparison summary (March through December)

	Total Volume 2019	Total Volume 2020	Percent Difference	Average Speed 2019	Average Speed 2020	Difference (mph)
Max	20,652,097	15,625,301	-10%	79.2	79.8	7.8
Average	10,005,125	7,740,721	-22%	67.3	68.7	1.4
Min	731,932	585,539	-31%	36.0	37.2	-3.3
Total	680,348,472	526,369,051				

As noted, 47 (69%) of the 68 sensor sites measured overall increased average speeds in 2020. Table 4-11 shows the Sensor Annual Comparison Sorted by increase in average speed from 7.8 mph (S1962) down to a decrease of 3.3 mph (S1729). Site location along with posted speed limit is noted with speed limits obtained from web-based images (not official data from MnDOT).

Table 4-11. Sensor site comparison sorted by increase in average speed (March through December and partial list shown)

Sensor	Location	Total Volume 2019	Total Volume 2020	Percent Difference in Volume	Speed Limit	Average Speed 2019	Average Speed 2020	Difference in Average Speed (mph)
S1962	I-35W NB @ Round Lake Rd	13,068,655	9,655,024	-26%	60	58.0	65.9	7.8
S652	I-35W NB @ Oakcrest Ave	11,959,553	10,099,264	-16%	60	55.4	63.1	7.7
1904	U.S.169 NB @ Lincoln Dr	736,294	605,379	-18%	60	51.4	58.7	7.3
S414	T.H.100 SB @ Vernon Ave	20,185,262	13,755,841	-31%	55	60.2	66.1	5.9
S402	T.H.100 SB N of Westbrooke Rd	15,977,605	11,886,063	-26%	60	62.9	68.7	5.7
S513	I-494 NB @ Orchard Rd	17,892,478	12,696,430	-29%	60	66.8	72.5	5.7
S611	T.H.36 WB @ Western Ave	13,310,211	9,866,276	-26%	55	63.1	68.5	5.3
S382	T.H.100 NB @ Vernon Ave	18,402,797	13,131,612	-28%	55	60.3	65.5	5.2
S738	U.S.169 SB @ 21st Ave	13,213,703	10,855,459	-18%	60	58.9	63.9	5.0
S1948	I-94 WB E of Mounds Blvd	20,512,972	15,625,301	-24%	55	61.8	66.8	5.0
S1107	I-94 WB @ 101st Ave	14,524,368	12,384,353	-15%	70	62.1	66.9	4.7
S697	I-35W SB @ Oakcrest Ave	9,934,003	7,728,457	-22%	60	64.5	69.2	4.7
S488	I-494 NB @ Baker Rd	16,196,421	11,343,138	-30%	60	67.4	71.7	4.3
S406	T.H.100 NB N of Westbrooke Rd	15,555,389	11,593,955	-25%	60	70.8	74.9	4.0
S1945	I-94 EB E of Mounds Blvd	20,652,097	15,453,054	-25%	55	61.3	65.3	4.0

4.3 WORK ZONES

Data from 48 sensors within two known work zones were downloaded and reviewed for quality. Table 2-4 identified these 14 sensors along the I-35W and 34 sensors along I-94. Based on a review of the raw data, only 12 of the 48 sensors were used in the comparative analysis. Table 4-12 identifies the 12 sites which includes none of the sensors for I-35W and 12 out of the 34 sensors for I-94.

Table 4-12. Sensors identified for analysis within the I-94 work zone

Sensor	Location
S1107	I-94 WB @ 101st Ave
S1882	I-94 WB W of T.H.101
S1743	I-94 WB E of T.H.241
S1746	I-94 WB E of Co Rd 18
S1749	I-94 WB E of Co Rd 18
S1750	I-94 WB @ Co Rd 18

Sensor	Location
S1754	I-94 WB W of T.H.25
S1755	I-94 WB W of T.H.25
S1757	I-94 WB E of Co Rd 8
S1761	I-94 WB E of T.H.24
S1741	I-94 EB E of T.H.241
S1881	I-94 EB W of T.H.101

The Sensor Data Analytics tool was used to review raw volume data for each of the 48 sensors identified within work zones. From this, only 12 sensors were used for a comparative analysis given the observed anomalies in 2019 volumes. Figure 4-4, shows the anomalies in 2019 volume data in blue (left), and missing 2020 data (right) each of which prohibit a meaningful comparison of volumes and speeds for each site. Figure 4-5 shows the similar S653 issue for all of the I-35W sensor sites.

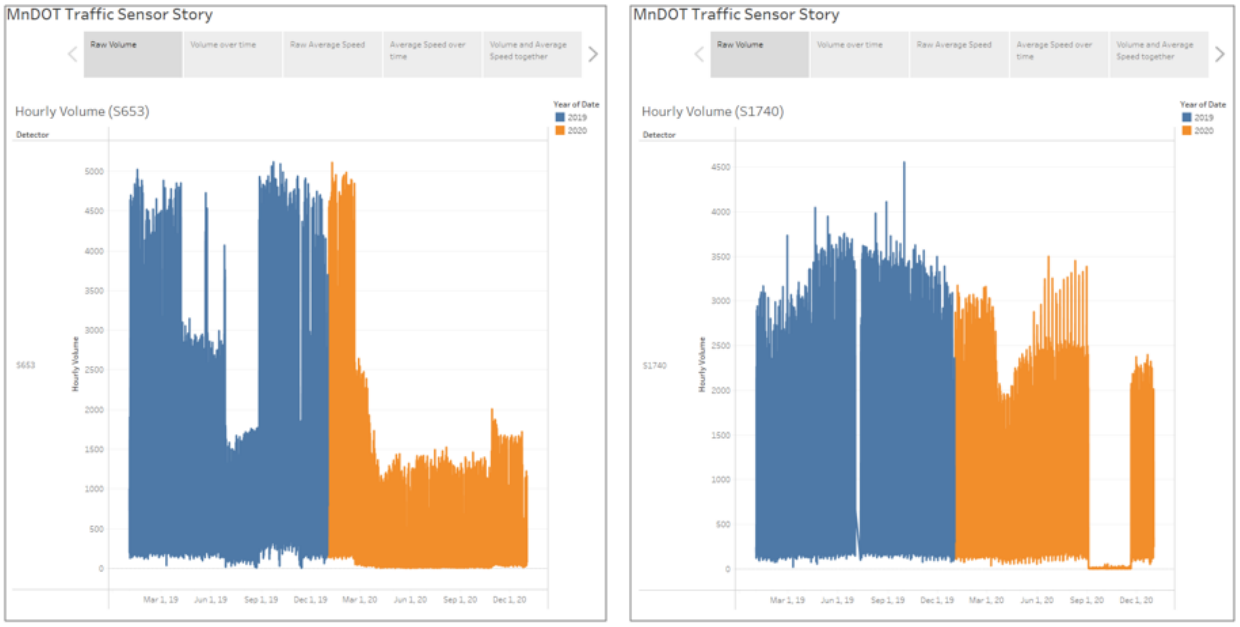

Figure 4-4. Sensor S653 on I-35W (left) shows erratic 2019 volumes and S1740 (right) on I-94 shows missing 2020 volume data

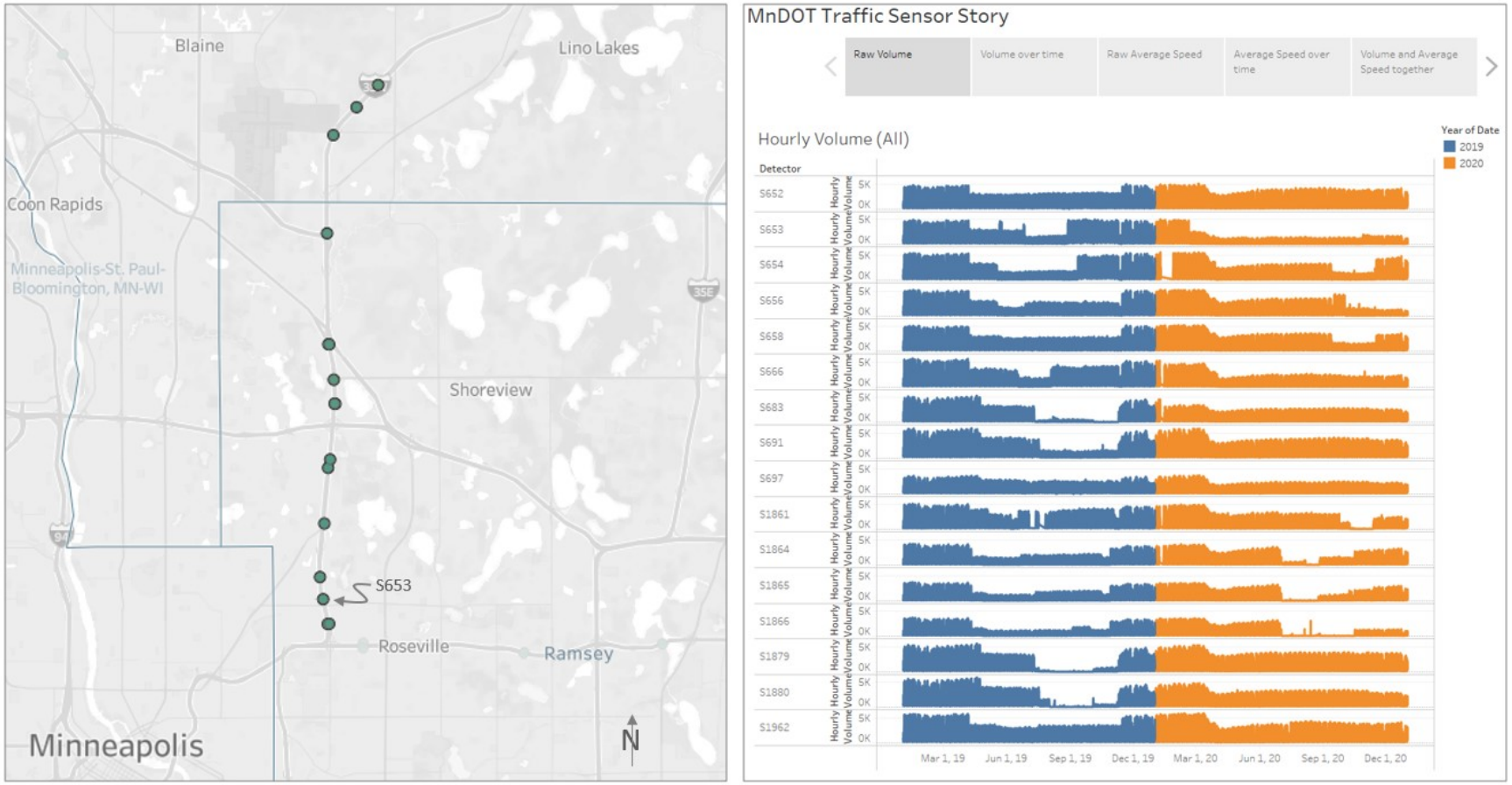

Figure 4-5. Sensors along I-35W map (left) and raw volumes (right)

4.3.1 Annual Comparison

The overall comparison of sensors along I-94 is shown in Table 4-13 which is arranged by direction of travel and includes volume, percent difference in volume, average speed, and the difference in average speed 2020 versus 2019. As shown, the total volume, in 2019 for these sites ranged from 14.5 million to 7.3 million vehicles annually. The percent difference in volume is -15% at sensor S1107 which has the highest volumes and is the closest to the metro area. The percent difference in volume is the highest at -30% at sensor S1750. Average speeds ranged from 62.1 to 76.7 mph over the 2020 and 2019 period. The difference in average speed varied across sites from a high value of 4.7 mph at sensor S1107 to a low of -1.9 mph, an actual speed increase in 2020, at sensor S1881 which measures eastbound travel.

Table 4-13. Sensor comparison along the I-94 work zone area (March through December)

Location	Sensor	Total Volume 2019	Total Volume 2020	Percent Difference in Volume	Average Speed 2019	Average Speed 2020	Difference in Average Speed (mph)
I-94 WB @ 101st Ave	S1107	14,524,368	12,384,353	-15%	62.1	66.9	4.7
I-94 WB W of T.H.101	S1882	12,705,197	9,900,286	-22%	70.0	69.6	-0.4
I-94 WB E of T.H.241	S1743	12,481,156	9,897,850	-20%	68.3	68.7	0.4
I-94 WB E of Co Rd 18	S1746	9,909,987	7,657,056	-23%	72.3	72.4	0.1
I-94 WB E of Co Rd 18	S1749	9,662,258	7,624,515	-21%	71.8	71.8	0.0
I-94 WB @ Co Rd 18	S1750	9,178,407	6,383,592	-30%	71.3	70.3	-1.0
I-94 WB W of T.H.25	S1754	7,370,071	5,532,123	-25%	74.7	73.4	-1.3
I-94 WB W of T.H.25	S1755	7,430,752	5,740,187	-23%	67.7	67.8	0.1
I-94 WB E of Co Rd 8	S1757	7,335,768	5,533,611	-25%	76.7	75.7	-1.0
I-94 WB E of T.H.24	S1761	7,317,705	5,548,866	-24%	75.1	74.5	-0.5
I-94 EB E of T.H.241	S1741	12,955,476	10,207,920	-21%	69.9	71.4	1.5
I-94 EB W of T.H.101	S1881	12,996,771	10,140,350	-22%	68.3	66.4	-1.9

4.4 SUMMARY

Both the ATR and Sensor analysis quantify the 2020 (March through December) reductions in volume and in most cases the increase in speeds. Figure 4-6 highlights the five ATR locations which had the highest percentage of vehicles travelling at high speeds (left column) as well as the top 5 sensor locations when comparing the change in average speed between 2019 and 2020.

Figure 4-6. Top 5 ATR (left) and Sensor (right) locations experiencing changes in speed (Image Source: Street View, 2020)

CHAPTER 5: EVALUATION OF CRASH AND ENFORCEMENT

Crash and enforcement data were obtained from the Minnesota State Patrol and used to evaluate and assess the impact of the COVID-19 pandemic.

5.1 CRASH AND ENFORCEMENT DATA ACQUISITION

Information was gathered from law enforcement to assess the impact of COVID 19 on travel behavior based on crash data and the perspective of law enforcement. Contact information for the Minnesota State Patrol Districts was provided by the TAP. Emails were sent with a survey and request for any crash or enforcement data, which were available. The survey is provided in Appendix A.

Six captains either responded to the survey via email or provided information through a phone interview. This includes District's 2100, 2200, 2300, 2400, 2800, and 3200, see Figure 5-1. Crash data (including speeding related, time of day, and crash rate) and speed citation data were requested and then provided for each district.

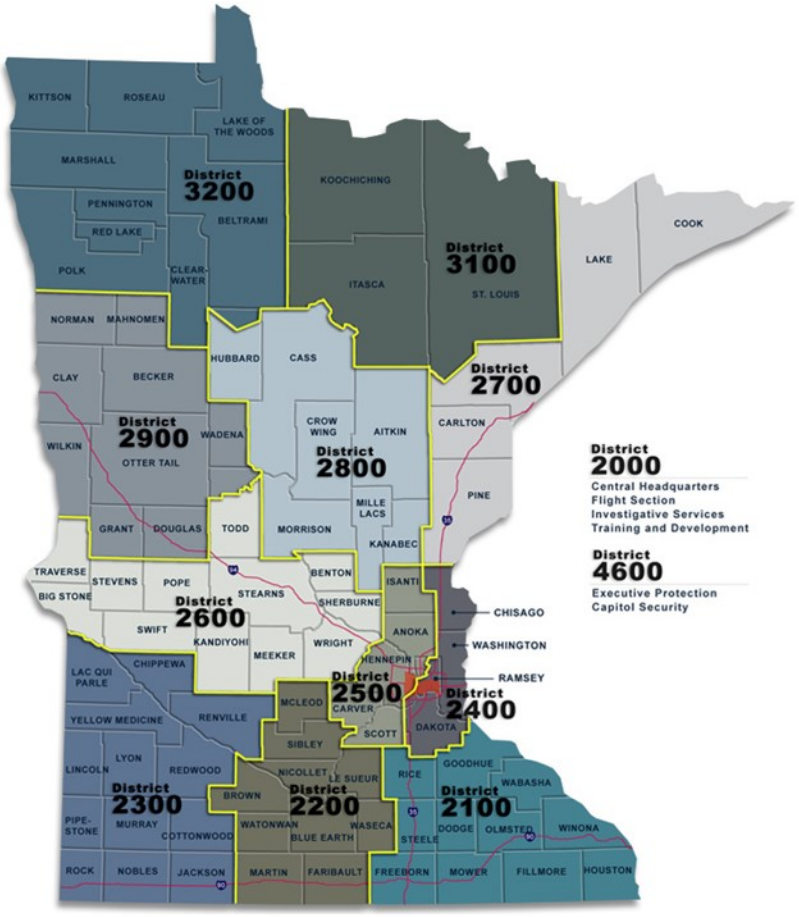

Figure 5-1. Minnesota State Patrol Districts (Image source: Minnesota State Patrol)

5.2 SURVEY RESULTS

The survey asked for impressions on speeding and enforcement during the COVID-19 pandemic. As shown in Table 5-1, all officers felt speeds in general had increased. When asked about their impression of excessive speeding, 83% thought excessive speeding had increased overall while 17% did not observe much change. One officer clocked a speed of 153 in October 2020 and another officer noted that speeds over 100 mph were up considerably. Another officer observed that when stopped, drivers commented that they did not think anyone was going to stop them. One officer reported that due to protests, which occurred in Minneapolis over the summer, the ability to conduct enforcement was limited leading to some people not following the rules. An officer also commented that motorcycles were one of the highest offenders for speeding behavior.

Table 5-1. Survey responses

Survey Response	More	Same	Less	Varies
Speeding in General	100%	0%	0%	0%
Excessive Speeding	83%	17%	0%	0%
Other Problem Behaviors	67%	33%	0%	0%
Work Zone Speeding	50%	50%	0%	0%

Officers were asked about their impression of problematic driver behaviors such as distraction, inattention, aggression, etc. of which 67% indicated they thought there had been an overall increase in these behaviors. Half of the responses indicated that there was more speeding within work zones during COVID-19 with the remaining answers citing speeds were about the same.

Officers were also asked about whether they thought enforcement had increased during COVID-19. In general, 17% of respondents indicated enforcement was less, 67% found enforcement was reduced at times, while 17% indicated no change in enforcement had occurred. None indicated enforcement had increased.

5.3 CITATIONS AND CRASHES OVERALL

Crash and citation data were provided for the 5-year period (2015 to 2019) and for the year 2020. It should be noted that 2020 crashes were not yet finalized when the data were provided so the official annual numbers could vary.

Figure 5-2 shows the data by district with both crash and the number of citations being flat if not lower in 2020 relative to previous years. There has been speculation that due to speeding and other behaviors during COVID-19, crashes would increase. Additionally, when citations are lower, it is generally expected that crashes are likely to increase if drivers feel there is less enforcement. On the other hand, volumes were down and as a result exposure decreased.

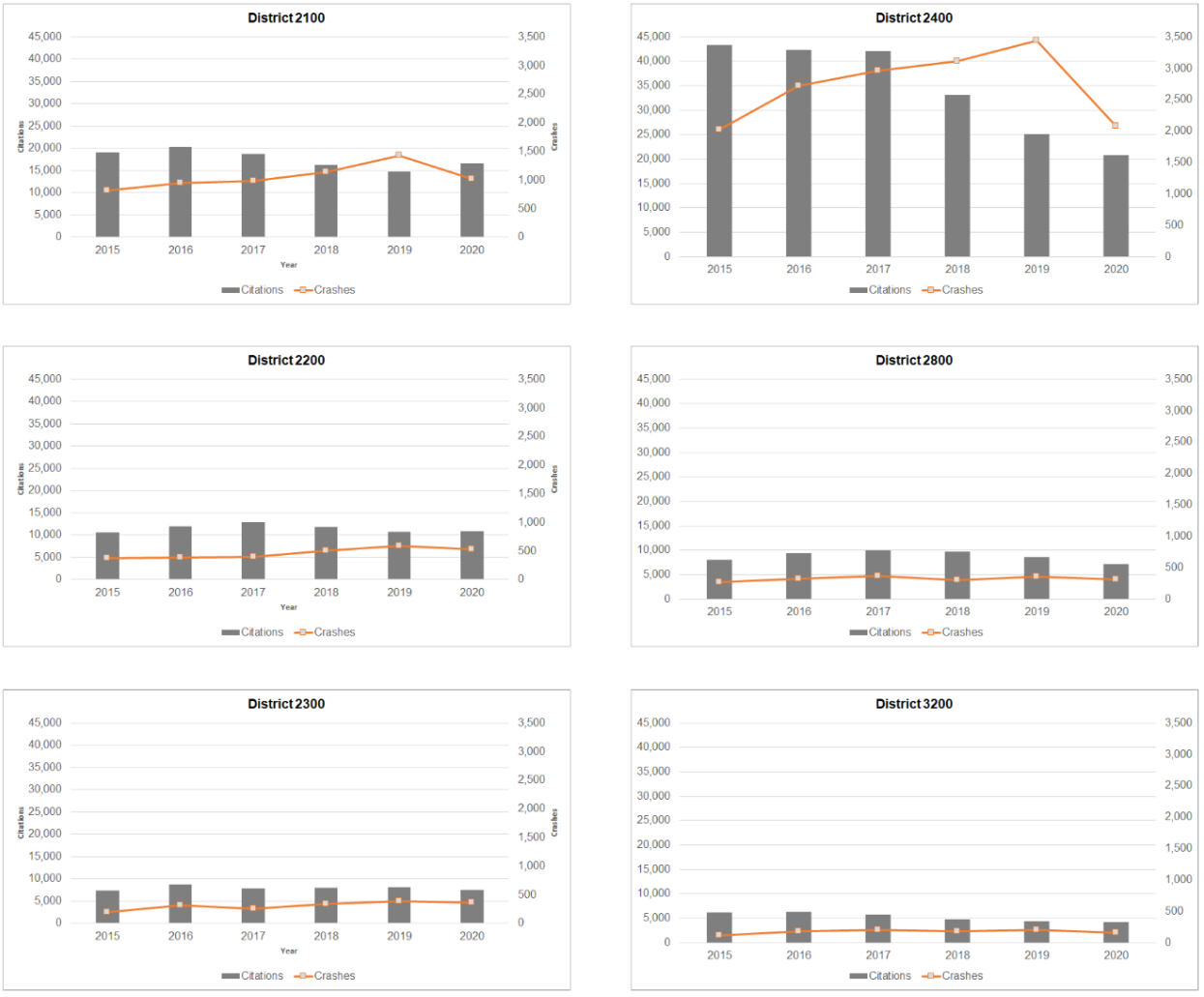

Figure 5-2. Citation versus crash frequency 2015 to 2020

5.4 SPEED RELATED CRASH

The crash data includes both severity and an indication of whether or not the crash was speed related. Speeding related crashes for 2020 were compared to 2019 as well as average crashes over the last 5 years (2015 to 2019).

Table 5-2 shows the percentage of all speeding related crashes per Minnesota State Patrol district. These values were calculated by dividing the number of all speeding related crashes by the total number of all crashes. The statistical significance was evaluated using a test of proportions. These comparisons are simple number comparisons, for instance, in District 2100, crashes in 2020 increased 2% from 2019 to 2020 (20% - 18%). The statistical increase could be calculated by comparing the proportion of change from the before to after period. In District 2100, crashes increased 11.7% using the following calculation: (20% - 18%)/18%. The simple difference is easier to infer from observing the tables and was therefore the metric provided.

As shown, speeding related crashes were 2 to 5 percent higher in 2020 compared to 2019 for all districts except 2400 which was 1% lower. Speeding related crashes were 2 to 7% higher in 2020 compared to the 5-year average which reflects an increase for each districts. All differences were statistically significant at the 90% level of significance.

Table 5-2. Percent speed related versus total crashes by District

Percent Speeding Related Total Crashes	Minnesota State Patrol District #					
	2100	2200	2300	2800	2400	3200
5-yr Average (2015 to 2019)	16%	13%	19%	16%	14%	17%
2019	18%	15%	22%	16%	17%	18%
2020	20%	20%	26%	18%	16%	20%
Change 2019 to 2020	2%*	5%*	4%*	2%^	-1%*	2%*
Change 5-yr Avg. to 2020	4%*	7%*	7%*	2%^	2%*	3%*

*Statistically significant at 95% level of significance
^Statistically significant at 90% level of significance

Table 5-3 shows the percent of speeding related fatal and injury crashes compared to all fatal and serious injury crashes. As shown, crashes in 2020 were from 4 to 13% higher in 4 districts and two districts experienced 1 to 4% less speed related fatal and injury crashes.

When compared to the 5-year average, speeding related fatal and injury crashes in 2020 were 4 to 14% higher in five districts with one district showing a 4% decrease in crashes.

Table 5-3. Percent speed related versus all fatal and injury crashes by District

Percent Speed Related Fatal & Injury Crashes	Minnesota State Patrol District #					
	2100	2200	2300	2800	2400	3200
5-yr Average (2015 to 2019)	19%	20%	20%	26%	23%	24%
2019	20%	14%	21%	26%	26%	29%
2020	25%	25%	34%	22%	30%	28%
Change 2019 to 2020	5%	11%*	13%*	-4%	4%	-1%
Change 5-yr Avg. to 2020	6%	5%	14%*	-4%	7%*	4%

*Statistically significant at 95% level of significance

5.5 SUMMARY FOR CRASH AND ENFORCEMENT

Crash and enforcement data from each of the six Minnesota State Patrol districts were evaluated to assess the impact of the COVID-19 pandemic and a survey was distributed to record officer impressions during 2020. The majority of responses noted that speeding and other problem behaviors, such as distraction and aggressive driving had increased. Citations and total crashes, in most cases, were lower in 2020 compared to previous years.

The percentage of speeding related crashes in 2020 was compared to two previous periods including 2019 alone, and the average of 2015 to 2019. In general, the proportion of speeding related crashes in 2020 were higher with the comparisons to 2019 noted below and in Figure 5-3.

- Speeding related total crashes in 2020 were 2 to 5% higher in 5 districts and 1% lower in 1 district compared to 2019. When compared to the average from 2015 to 2019, speeding related total crash numbers were 2 to 7% higher across all districts.

- Speeding related fatal and serious injury crashes in 2020 were 4 to 13% higher in 4 districts and 1 to 4% lower in 2 districts compared to 2019. When compared to the average from 2015 to 2019, speed related fatal and serious injury crash numbers were 4 to 14% higher in 5 districts and 4% lower in 1 district.

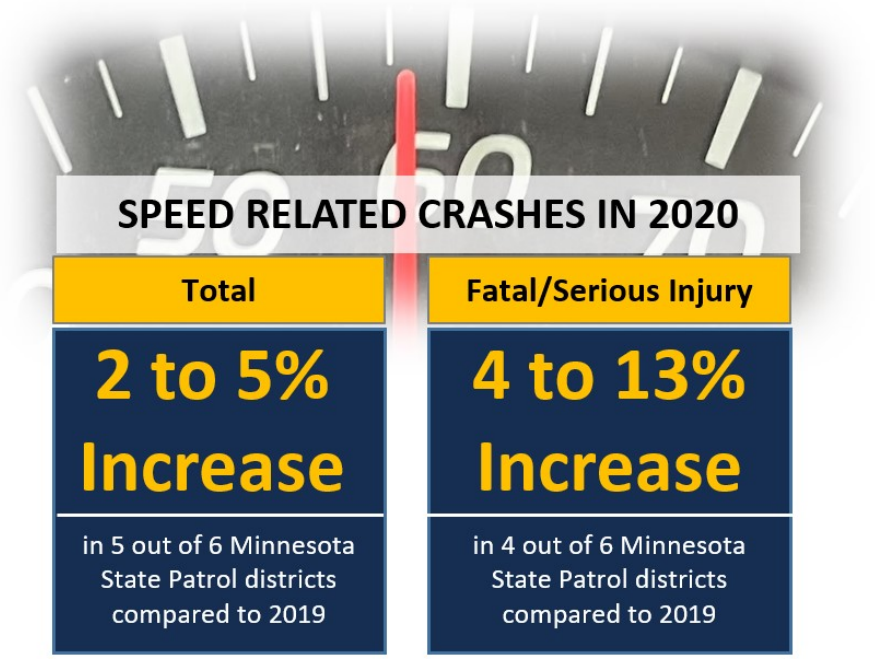

Figure 5-3. Speed related crash findings when comparing 2020 to 2019fff

CHAPTER 6: CONCLUSION

This study quantifies how drivers responded to the reduction in traffic volumes that resulted from the novel COVID-19 pandemic, which impacted travel in Minnesota from March through December 2020. At question was whether drivers were taking advantage of the lack of traffic on the roadway, and perhaps a perception of less enforcement, and in turn driving at higher speeds. Understanding the magnitude of speeding and other driver behaviors requires measurement and contrast, which for the majority of this report, included comparing 2020 against 2019 from March through December.

Analytical Tools

The research team developed interactive analysis tools per data source, which provide both analytics and visualizations built into a "story" format. The user can choose to see the results per individual site or any combination of multiple sites. Table 3-1 identifies the information generated, and clicking on the column titles opens each tool online.

Lower Traffic Volumes and Higher Average Speeds

Figure 6-1 is a summary of all 27 ATR sites (upper) and 98 Sensor sites (lower) together, beginning with a map (left), volume (middle), and average speed (right) visualizations. As shown, volumes were down across all sites, with maximum reductions seen in April 2020 of 38% (ATR) and 47% (Sensor). The comparison of average speed indicates higher speeds in 2020 that varied by degree each month, with maximum monthly increases of 2.9% in July (ATR) and 3.0% in April (Sensor).

Increased High Speeds

The ATR data alone provide the opportunity to compare higher speeds, which are defined as greater than 15 mph over the posted speed limit. These types of comparisons were done on a site-by-site basis. Comparing 2020 to 2019, 69% of the ATR sites showed an increase in the number of high-speed vehicles and 88% showed an increase in the percent of vehicles travelling at high speeds.

Crash and Enforcement

Crash and enforcement data from each of the 6 Minnesota State Patrol districts were evaluated to assess the impact of the COVID-19 pandemic and a survey was distributed to record officers' impressions in 2020. The findings show that speeding-related total crashes in 2020 were 2-5% higher in 5 districts and 1% lower in 1 district compared to 2019. Speeding-related fatal and serious injury crashes in 2020 were 4-14% higher in 4 districts and 1-3% lower in 2 districts compared to 2019.

Overall

This analysis and the tools developed serve to support benchmarking and decision making by both MnDOT and the Minnesota State Patrol. Future opportunities to expand these efforts and build a near real-time dashboard will be discussed with the project Technical Advisory Panel.

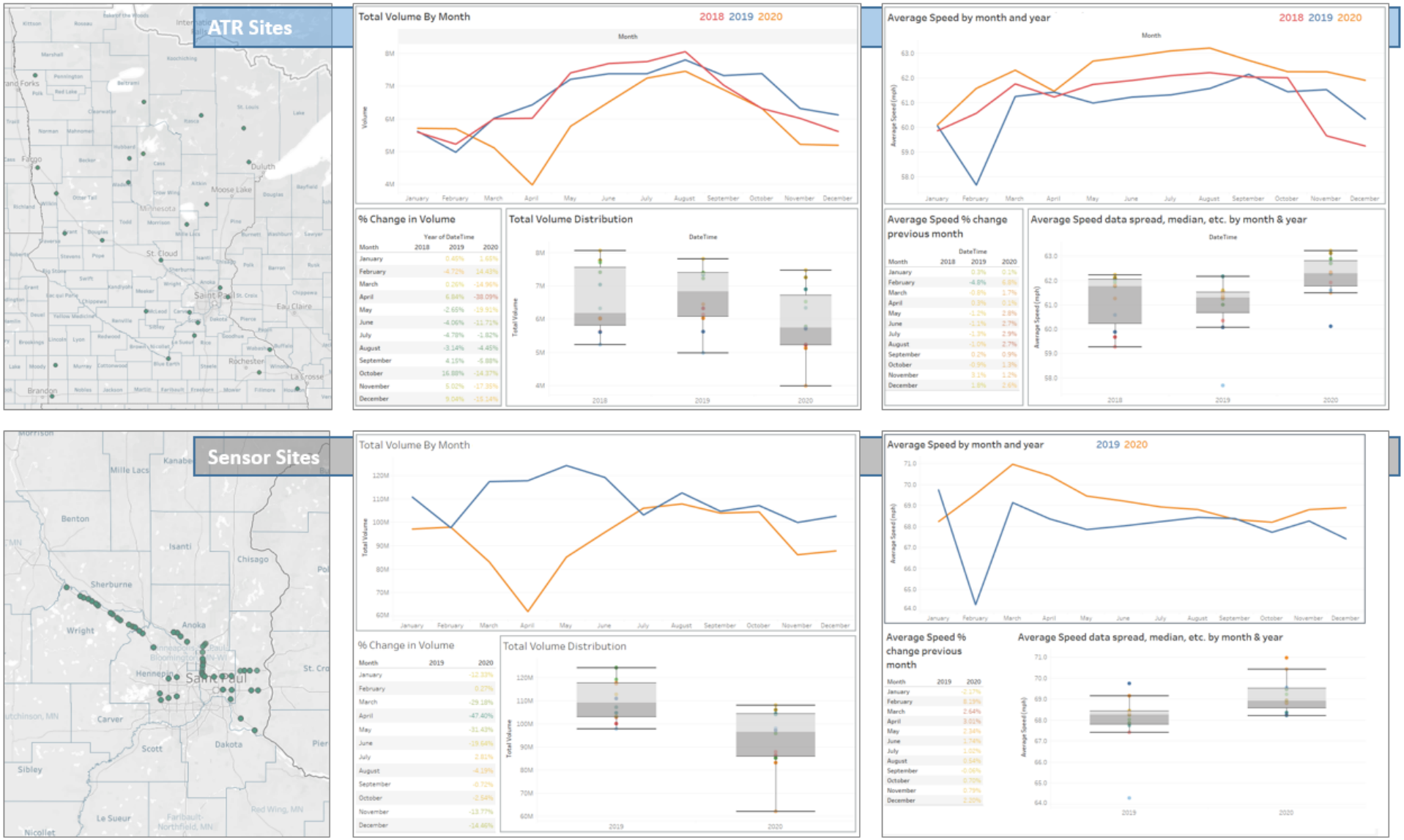

Figure 6-1. ATR and Sensor comparison of volume and average speed

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APPENDIX A
SURVEY QUESTIONS FOR LAW ENFORCEMENT

Survey Questions for Law Enforcement

1. Typical traffic volumes are down due to COVID-19 and so since March 2020 what has been your impression with regards to drivers and speeding?
   a) More people are speeding
   b) Seems about the same
   c) Less people are speeding
   d) Certain months had more speeding, but this has not been consistent each month since March 2020

2. For the same time period, what is your impression on excessive speeding? For example, the change in folks driving 10, 15, or 20 mph or more over the posted speed limit?
   a) Increase in excessive speeding is common
   b) Increase in excessive speeding is occasional but not that different from normal
   c) No observable change
   d) Other

3. As we try to characterize the degree of speeding during this time period do you have information on how many citations include excessively speeding? For example, before COVID typically found that 15% were ticketed at 10 or more miles over the posted and during COVID this changed to XX%.
   a) Yes, we have this and can share the information
   b) Not something we can share at this time
   c) Perhaps but someone else (name, email, or phone) might be a better resource for this question
   d) Other

4. What is your impression on other problematic behaviors like distracted drivers, aggressive drivers, lane departure crashes, driver inattention, etc. since COVID-19?
   a) Increase in these types of behaviors
   b) Increase is occasional but not that different from normal
   c) No observable change
   d) Perhaps but someone else (name, email, or phone) might be a better resource for this question
   e) Other

5. Have you noticed a difference in speeding or problem behaviors within work zones since COVID-19?
   a) Increase in these types of behaviors
   b) Increase is occasional but not that different from normal
   c) No observable change
   d) Perhaps but someone else (name, email, or phone) might be a better resource for this question
   e) Other

6. Do you track any of the above with data that you could share?
   a) Yes
   b) No
   c) Perhaps but someone else (name, email, or phone) might be a better resource for this question

7. Given the health and safety issues faced with COVID-19, how has this impacted your ability to do enforcement across the state?
   a) Enforcement was less than pre-COVID
   b) Enforcement was reduced for some months but not every month since March 2020
   c) Enforcement was about the same
   d) Enforcement actually increased

8. Do you track enforcement actions to provide numbers on the above? For example, citations were down by 20% over the March to July time period but have steadily increased since…etc.
   a) Yes, we have this and can share the information
   b) Not something we can share at this time
   c) Perhaps but someone else (name, email, or phone) might be a better resource for this question
   d) Other

9. We might have missed something that you feel has been a big change that impacts safety during COVID-19. If you would, please note any other important changes that you have observed below.