DEPARTMENT OF TRANSPORTATION

Impact of Speed Limit Changes on Urban Streets

Gary Davis, Principal Investigator
Civil, Environmental, and Geo- Engineering
University of Minnesota

JUNE 2023

Research Project
Final Report 2023-22

LRRB
LOCAL ROAD RESEARCH BOARD

To request this document in an alternative format, such as braille or large print, call 651-366-4718 or 1-800-657-3774 (Greater Minnesota) or email your request to ADArequest.dot@state.mn.us. Please request at least one week in advance.

Technical Report Documentation Page

1. Report No.	2.	3. Recipients Accession No.
MN 2023-22		

4. Title and Subtitle	5. Report Date
Impact of Speed Limit Changes on Urban Streets	June 2023
	6.

7. Author(s)	8. Performing Organization Report No.
Gary A. Davis	

9. Performing Organization Name and Address	10. Project/Task/Work Unit No.
Dept. of Civil, Environmental, and Geo-Engineering University of Minnesota 500 Pillsbury Drive SE Minneapolis, MN 55455	CTS #2021007
	11. Contract (C) or Grant (G) No. (c) 1036213

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

15. Supplementary Notes

http://mdl.mndot.gov/

16. Abstract (Limit: 250 words)

In 2019 the Minnesota Legislature amended that state's statutes to allow cities to set speed limits on city-owned streets. In February 2021 we surveyed 33 cities within the Twin Cities metro area and identified the city of St. Louis Park as planning to implement a city-wide change in speed limits, with a default speed limit of 20 mph but with selected roads being signed for limits ranging from 25 mph to 35 mph. Speed data was collected using road tube traffic recorders in the summer of 2021, 2-4 months before the speed limit change, and in the summer of 2022, 6-8 months after the change. There was considerable variability regarding what was seen at individual locations, with before/after differences in mean speed ranging from a decrease of 7 mph to an increase of 2.4 mph. On average, mean speeds were slightly lower (1-2 mph) in the after period, both on streets where the speed limit was lowered and on streets where the limit was unchanged. This pattern, modest reductions in mean speeds following a reduction in speed limit, with possible spillover, was consistent with what has been seen in other cities in North America and Great Britain.

17. Document Analysis/Descriptors	18. Availability Statement
Speed limits, Traffic speed, Streets	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	44	

Impact of Speed Limit Changes on Urban Streets

FINAL REPORT

Prepared by:

Gary A. Davis
Department of Civil, Environmental, and Geo- Engineering
University of Minnesota

June 2023

Published by:

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

ACKNOWLEDGMENTS

The author would like to thank the engineering staff at the city of St. Louis Park for their assistance. He would also like to thank graduate student Christopher Cheong and undergraduate student Josh Klavins for their assistance in collecting and processing the speed data. Finally, he would like to acknowledge the project's technical advisory panel: Victor Lund (TL), Joe Gustafson, Kent Exner, Brad Estochen, Tracey Von Bargen, Chelsea Palmateer, John Hourdos, Tim Plath, Derek Lauer, Kristi Sebastian, Taryn Erickson, Randy Newton, and Marcus Berkele (AP).

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

In 2019, the Minnesota Legislature amended that state's statutes to allow cities to set speed limits on city-owned streets and in February 2021, we surveyed 33 cities within the Twin Cities metro area to see if any were planning to take advantage of this change. From this survey, we identified the city of St. Louis Park as planning to implement a city-wide change in speed limits and as willing to partner with us to investigate the effect of this change on free-flow vehicle speeds. St. Louis Park planned to implement a default speed limit of 20 mph, with selected roads being signed for limits ranging from 25 mph to 35 mph. After obtaining information on the city's current and proposed speed limits, we designed a study plan aimed at collecting speed data on a sample of 28 streets in St. Louis Park and adjacent cities, all being two-lane, two-way roads. Speed data was then collected using road tube traffic recorders in the summer of 2021, 2-4 months before the speed limit change, and in the summer of 2022, 6-8 months after the change. Ultimately, it was possible to obtain complete before and after data for 24 of the streets.

We found considerable variability in what was seen at individual locations, with before/after differences in mean speed ranging from a decrease of 7 mph to an increase of 2.4 mph. On average, mean speeds were slightly lower (1-2 mph) in the after period, both on streets where the speed limit was lowered and on streets where the limit was unchanged. This pattern, modest reductions in mean speeds following a reduction in speed limit, with possible spillover, was consistent with what has been reported for other cities in North America and Great Britain.

We note that, for many of us, driving is an overlearned, habitual, behavior, and it might be that in the absence of physical changes in a roadway, or strict enforcement, a driver's adaptation to a lowered speed limit takes place over a longer time horizon than has been typically investigated. We recommend that, in subsequent years, comparable data be collected on at least a subset of our sample streets to track this adaptation process.

CHAPTER 1: INTRODUCTION

In Minnesota before 2019, the statutory speed limit in urban districts was 30 mph, but a limit of 25 mph could be applied on a "…residential roadway if adopted by the road authority having jurisdiction." Variances from the statutory limits were at the discretion of the Commissioner of Transportation, with consideration given to a road's 85th percentile speed along with other factors as determined by an "engineering and traffic investigation" (MnDOT 2015, p. 14-18). In 2019, however, the Minnesota legislature added the following paragraph to Section 169 of the Minnesota statutes:

> Subd. 5h. Speed limits on city streets. A city may establish speed limits for city streets under the city's jurisdiction other than the limits provided in subdivision 2 without conducting an engineering and traffic investigation. This subdivision does not apply to town roads, county highways, or trunk highways in the city. A city that establishes speed limits pursuant to this section must implement speed limit changes in a consistent and understandable manner. The city must erect appropriate signs to display the speed limit. A city that uses the authority under this subdivision must develop procedures to set speed limits based on the city's safety, engineering, and traffic analysis. At a minimum, the safety, engineering, and traffic analysis must consider national urban speed limit guidance and studies, local traffic crashes, and methods to effectively communicate the change to the public.

That is, a city could now establish speed limits on certain streets within the city's jurisdiction without going through the Commissioner of Transportation, provided the city had developed appropriate procedures for setting and implementing the limits. During summer 2020, MnDOT and Minnesota's Local Road Research Board issued Research Needs Statement 580, which stated: "Further study should be completed to examine the relationship between changing the posted speed limit sign and the change in vehicle speeds when there is no change in the roadway environment." This report describes research addressing this request.

Although it is widely recognized that, given one has been involved in a road crash, the chances of serious injury increase as the speeds of the involved vehicles increase, the relationship between vehicles' speeds and the chance of being involved in crashes in the first place, especially on urban roads, has been more difficult to pin down. "The relationship between speed and road safety is controversial. Although it is widely accepted that impact speed exerts a decisive influence on injury severity, there is more controversy about the relationship between speed and the probability of accident occurrence" (Elvik 2005, p. 68). This is due at least in part to the variety of ways that crashes can occur and the need to distinguish the different mechanisms underlying crash occurrences. "Driving slowly in congested urban traffic is associated with many fender benders and very few severe crashes, whereas driving fast on expressways is associated with very few fender benders and a small but significant number of severe crashes. On the basis of these two situations, if all crashes are counted, it appears that speed is inversely related to crashes. However, if only severe crashes are examined, the relationship between speed and crashes is direct" (Shinar 1998, p. 225). Because controlled experiments are rarely feasible in road

safety, reliance is placed on observational studies that can identify correlations between, for example, speeds and crash incidence, but are of limited value in identifying causal relationships. One especially provocative set of findings concerns observed correlations between aggregated measures of crash risk, such as roads' estimated crash rates, and measures of the variability of vehicle speeds on the roads. Such correlations were given prominence by Lave (1985, 1989), but similar results have been reported by, for example, Garber and Ehrhart (2000) and recently by Park et al. (2021). Shortly after Lave's original publication, Gaber and Gadiraju (1988) reported correlations between speed variance and differences between roads' speed limits and their design speeds, leading to the conjecture that setting speed limits below a road's design speed might actually increase crash risk by increasing the variability in vehicle speeds. This conjecture remains a conjecture, however, because the causal connection between speed variability and crash risk has yet to be established. In fact, it can be shown (Rodriguez 1990; Davis 2002) that positive correlations between crash rate measures and speed variance can be expected when an individual's crash risk increases with speed, when it decreases with speed, or when it takes a U-shaped form, even in situations where there is never more than one vehicle on a road at a time. That is, positive correlations between estimated crash rates and speed variance can appear as mathematical consequences of data aggregation and so do not, of themselves, have implications regarding safety.

Given it has been decided that livability or other social goals might be reached by reducing vehicle speeds on a road, the question of how to accomplish that reduction is also a subject for debate. Physical modifications to a roadway, such as speed humps, or strict police enforcement of a reduced speed limit tend to be effective, but the effectiveness of simply changing a speed limit is open to question. For example, Minnesota's *Traffic Safety Fundamentals Handbook* reports results from several roads where changes in speed limits, both increases and decreases, had marginal effects on observed 85th percentile speeds (Preston et al, 2015, p. C-45). In a review of studies published prior to 2012, Islam et al. (2014) reported that drivers often treated posted speed limits as recommended speeds, rather than maximum speeds, and that reductions of posted speed limits on roads where the original speed limits were in the range of 31 mph – 36 mph (50 kph-60 kph) resulted in modest (1 mph – 3 mph) reductions in mean speeds.

This trend also appears in more recent studies focusing on urban streets. Heydari et al (2014) investigated the effect of lowering speed limits in Montreal from 50 kph to 40 kph (31 mph to 25 mph) as part of a program aimed at improving safety for pedestrians. The authors identified 19 road sections where speed limits were reduced (treatment sites) and 9 similar sites where limits were not reduced (comparison sites). Individual vehicle speed measurements were collected using sensors placed on the pavement for five-day periods in 2009 (before) and 2011 (after). The authors then applied sophisticated statistical methods to determine if the changed speed limits affected the fractions of vehicle speeds exceeding 40 kph, exceeding 50 kph, and exceeding 80 kph (50 mph). Probably the most striking finding in this study was that on both the treatment and comparison sites, the fractions of speeds exceeding the three thresholds (40 kph, 50, kph, 80 kph) increased substantially on both the treatment and comparison sites. After controlling for this trend, the authors reported modest decreases in the fractions exceeding 40 kph and 50 kph but no change in the fraction exceeding 80 kph.

In 2009, the city of Bristol, in the United Kingdom, initiated a phased city-wide reduction of speed limits from 30 mph to 20 mph (Bornioli et al. 2018). The city was divided into seven clusters, with reductions being implemented for the first cluster in 2010 and for the last two clusters midway through 2015. Using automatic radar equipment, speeds were monitored for two-week periods, twice a year, at 106 sites. The only physical changes in the roadways were changes in speed limit signs; no traffic calming measures were used. The study's authors had access to data obtained between the start of the last half of 2014 and the end of the first half of 2017, with two clusters providing 6 months of before data, two clusters providing 1 year of before data, and three clusters providing only after data, for a total of almost 37,000,000 individual vehicle speed measurements. Overall, after adjusting for differences in location, time-of-day, day-of-week, year, and season, the authors reported a 2.6-mph reduction in mean speed that could be attributed to the change in speed limit signs, with indications that the effect was stronger at those locations where the change had been in place longer.

Islan et al. (2014) investigated the effect of a similar change (lowering speed limits from 50 kph to 40 kph) implemented in Edmonton, Canada. Six communities within Edmonton were selected for implementation of the speed-reduction program where, in addition to changes in posted speed limits, "a variety of educational and enforcement measures were taken" (p. 485), including a limited use of photo enforcement. Three additional communities that did not experience changes in speed limits were selected as controls. At 65 locations within the nine communities, traffic data was collected continuously from April 1 to October 31, 2010, with data from April being used to characterize the "before" condition. To capture the effect of free-flow speeds, vehicles with headways less than 2.0 seconds were removed from the analysis. Overall, the authors found reductions in mean speeds in the range of 3.2 – 6.9 kph (1.9 – 4.1 mph) depending on vehicle type, roadway type (collector vs local), and time of day.

Finally, in 2017, the city of Boston, Massachusetts, reduced the default speed limit of city streets from 30 mph to 25 mph, and an evaluation of the effect of this change was conducted by researchers at the Insurance Institute for Highway Safety (Hu and Cicchino 2019). Fifty sites within Boston were selected for data collection, and 50 similar sites in nearby Providence, Rhode Island were selected as control sites. At each site, road tube traffic recorders were used to collect speed data on two weekdays having dry weather, during a before period running from October to December 2016 and an after period running from September to November 2017. Only data collected during a daytime off-peak period from 10 AM to 3 PM was used in the analyses. In Boston, the overall off-peak mean speed was 24.8 mph before the speed limit change and 24.8 mph after the change, while 85th percentile speeds were 31 mph both before and after. The authors also reported that the percent of vehicles travelling above 35 mph changed from 4.9% to 3.8%.

Overall then, research to date indicates that, on urban streets, changes in posted speed limits unaccompanied by either physical changes in roads or vigorous enforcement are associated with, at best, statistically significant but practically modest reductions of mean speeds. At this point, it is helpful to consider how drivers might respond to a change in a road's speed limit. As has been suggested elsewhere (Lave 1985), one effect of an "artificially" low speed limit, such as the old National Maximum Speed Limit of 55 mph, could be to divide drivers into subgroups depending on how closely they follow

the new limit. Arguably, the simplest model for this effect would be one where, after a speed limit change, the population of drivers on a road divides into two subgroups, one where the drivers continue as they did before the change and another where the drivers attempt to comply with the new limit. Over time, one might then expect to see a gradual increase in the fraction of drivers in the compliance group. More formally, if we let μ_0, σ_0^2 denote the mean speed and speed variance on the road before the speed limit change, μ_1, σ_1^2 denote the mean speed and speed variance for the complying drivers after the change, and *p* denote the fraction of complying drivers, then the overall mean speed after the change would be

$$\tilde{\mu} = p\mu_1 + (1-p)\mu_0 = \mu_0 + p(\mu_1 - \mu_0) \qquad (1.1)$$

and the overall speed variance after the change would be

$$\tilde{\sigma}^2 = p\sigma_1^2 + (1-p)\sigma_0^2 + p(1-p)(\mu_1 - \mu_0)^2 = \sigma_0^2 + p(\sigma_1^2 - \sigma_0^2) + p(1-p)(\mu_1 - \mu_0)^2 \qquad (1.2)$$

If $\mu_1 < \mu_0$, then equation (1.1) implies that the overall mean after the change will be lower than the mean before, with the magnitude of the change depending both on the fraction of complying drivers and on the difference between the mean speeds for the two groups. The overall speed variance could possibly increase or decrease, depending on *p* and the difference between the variances in the compliant and non-compliant groups, but the term $p(1-p)(\mu_1-\mu_0)^2$ indicates that any change in mean speeds will tend to increase overall variance. For the case where both groups have the same variance, $\sigma_0^2=\sigma_1^2$, and whenever $\mu_1 \neq \mu_0$, equation (1.2) shows that the overall variance will increase, and this seems like a more likely outcome. Based on this model, we would predict that, after a speed limit reduction, we should see a decrease in mean speed and, unless the fraction of complying drivers is large and the variance for the complying group substantially less than that of the non-compliers, an increase in speed variance.

CHAPTER 2: STUDY DESIGN

In February 2020, after being notified that our proposed project had been selected for support, we compiled a list of municipalities within the Twin Cities region:

Vadnais Heights, Shoreview, Saint Paul, Medina, Brooklyn Center, Edina, Eden Prairie, St. Louis Park, Maple Wood, Roseville, Arden Hills, Little Canada, New Brighton, White Bear Lake, North Saint Paul, Minnetonka, Bloomington, Maple Grove, Brooklyn Park, Golden Valley, Plymouth , Richfield, Hopkins, Dayton, Greenfield, Independence, Minnetrista, Orono, Wayzata, Deephaven, Crystal, Shorewood, Tonka Bay, Mound

We then contacted the city engineers for each of these cities by email and asked (1) if their city was planning to change speed limits and, (2) if so, were they interested in partnering with our team to evaluate the speed-related impacts of the change. A copy of our cover letter can be found in Appendix A. Eight cities, Vadnais Heights, Shoreview, St. Paul, Medina, Brooklyn Center, Edina, Eden Prairie, and St. Louis Park, responded to our query. The City of Minneapolis had earlier expressed interest in our study but it turned out that both Minneapolis and St. Paul both planned to implement speed limit changes early in Fall 2020, which was too soon for us to collect before-implementation data. Of the remaining seven respondents three, Edina, Eden Prairie, and St. Louis Park indicated an interest in participating in our study. Staff at St. Louis Park also indicated that they were preparing a proposed city-wide speed limit policy for presentation to the City Council later in the year. This initial proposal was presented to the City Council at study sessions in August 2020 and January 2021. In June 2021, the St. Louis Park City Council passed an ordinance, to take effect on July 16, 2021, calling for the City's Engineering Department to establish speed limits "in accordance with the provisions set forth at Minnesota Statutes Section 169.14." A process of installing or replacing speed limit signs and retiming traffic signals was begun during the Fall of 2021 and completed in December 2021.

Figure 2.1 shows the speed limits on St. Louis Park's streets prior to the city-wide speed limit change. Most streets followed the statutory 30 mph limit for urban areas, but with some notable exceptions:

(1) Several primarily residential streets had had their speed limits lowered to 25 mph.

(2) Cedar Lake Rd, a city street, and Minnetonka and Excelsior Blvds, both county roads, had speed limits of 35 mph.

(3) A short section of the service road east of MNTH 100 had a 40 mph speed limit.

Figure 2.2 shows the speed limits on St. Louis Park streets after implementation of the city-wide change. The default speed limit is now set at 20 mph, with the following exceptions:

(1) The speed limit on Cedar Lake Rd was changed from 35 mph to 30 mph

(2) Speed limits on Louisiana Ave and several roads on the edges of the city, such as Ford Rd and Park Place Blvd, were left at 30 mph

(3) Several roads, such as Texas Ave, Walker St, Lake St. and France Ave had speed limits reduced from 30 mph to 25 mph.

(4) The speed limit on the section of MNTH 100 service road was reduced from 40 mph to 35 mph.

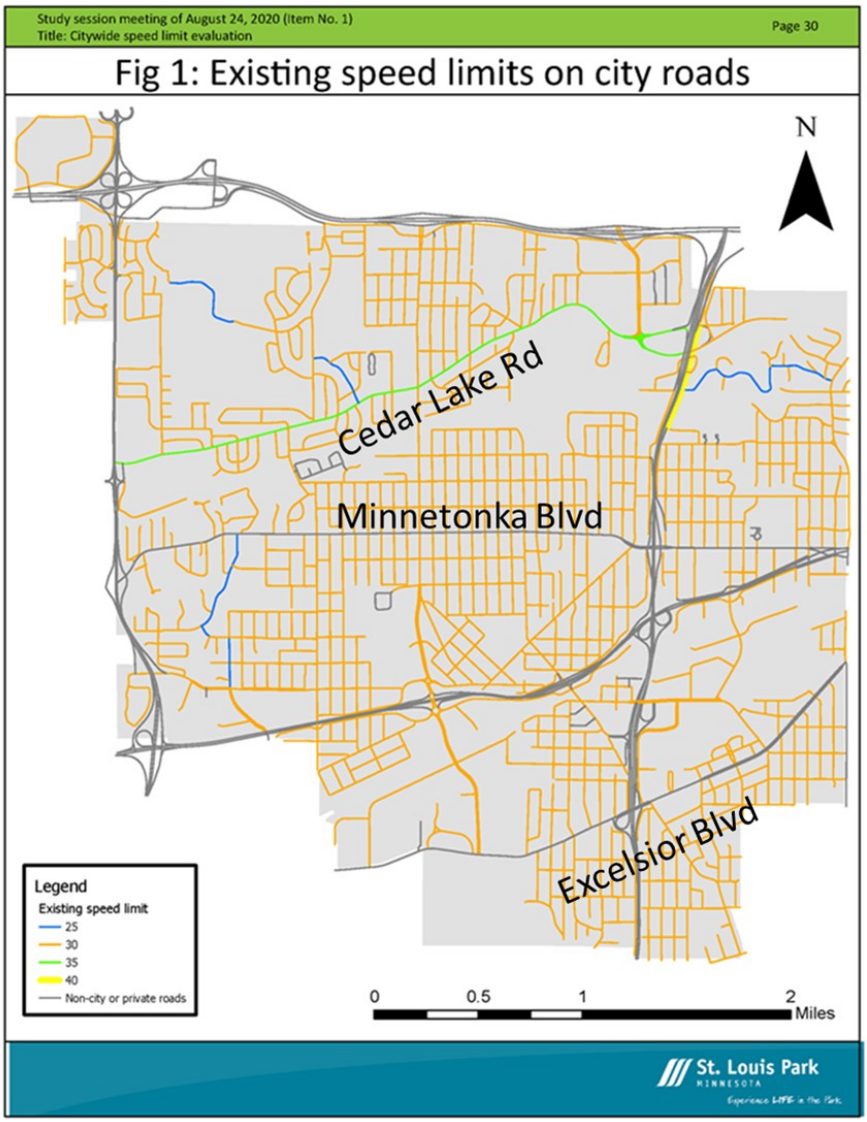


Figure 2.1: Speed limits in St. Louis Park prior to city-wide change. Courtesy of the City of St. Louis Park.

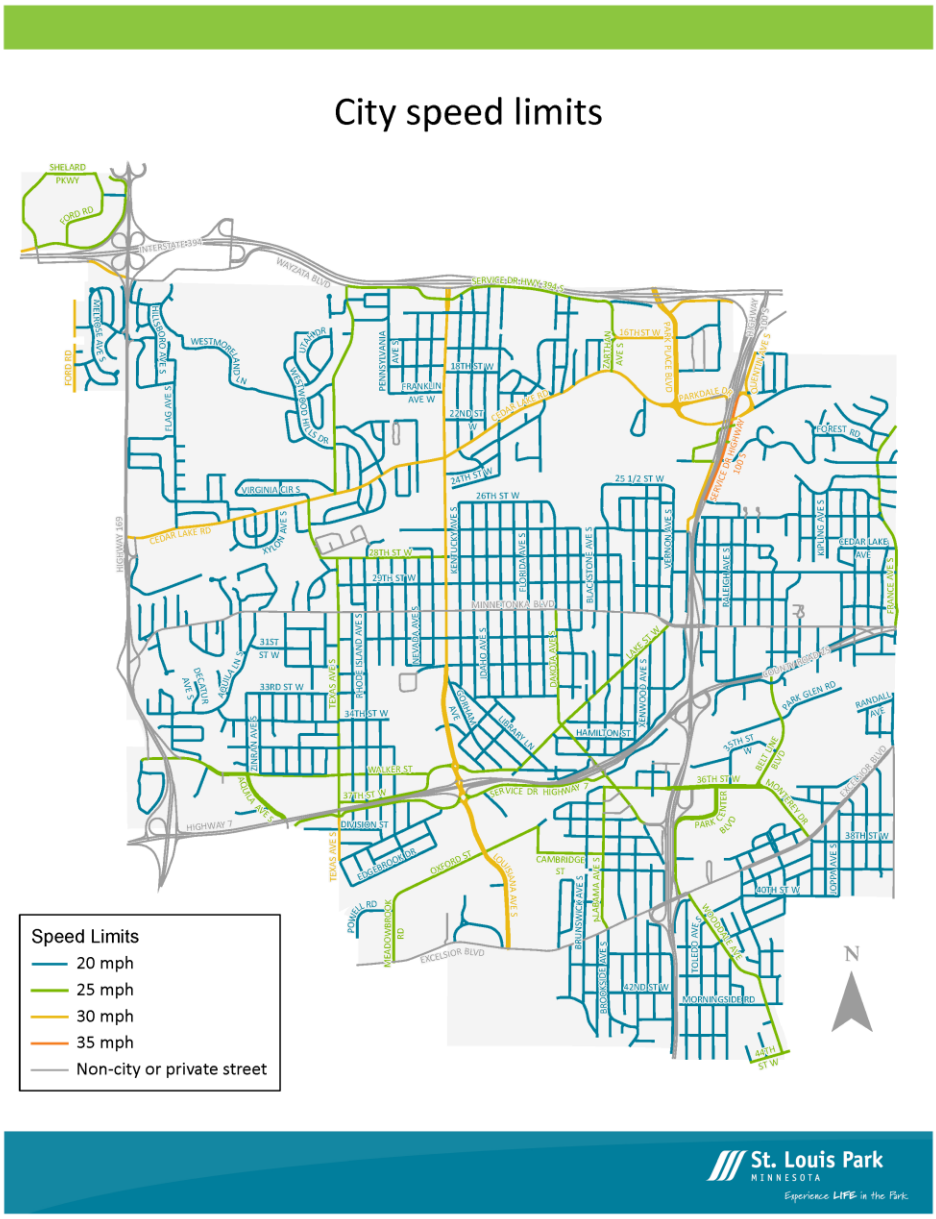


Figure 2.2: Speed limits in St. Louis Park following the city-wide change. Courtesy of the City of St. Louis Park.

During Spring 2021 the City of St. Louis Park provided project staff with the map shown in Figure 2.1 along with a second map showing the initial proposed speed limit changes. Using these maps we developed an initial sampling plan with three components:

(1) A set of treatment/comparison pairs. These were roads scheduled for speed limit changes, where each was paired with a roughly similar road where the speed limit was not scheduled to change.

(2) One site in the Westwood Hills neighborhood scheduled for a change in speed limit from 30 mph to 20 mph, paired with a similar road scheduled for a change of from 25 mph to 20 mph.

(3) Additional unpaired sites scheduled for changes from 30 mph to either 25 mph or 20 mph.

During the initial data collection phase, from June 2021-August 2021, each proposed site was visited by the project's PI to assess its suitability for data collection using our road tube equipment. In cases where the pavement surface was unsuited to anchoring the road tubes, or where a suitable fixed object was not available for securing the traffic recorder, the initial placement was modified or, in some cases, deleted. The final sampling scheme consisted of four treatment-comparison pairs for component (1) (eight sites), one pair for component (2) (2 sites), and 18 sites for component (3), for a total of 28 sites. These, along with their locations were our equipment was placed, are listed in Tables 2.1 and 2.2.

Table 2.1: Treatment/Comparison pairs in final sample. The speed limit change was implemented during November-December 2021.

Street	Latitude	Longitude	Speed Limit	
			Before Change	After Change
Cedar Lake Rd	44°57'31.25"N	93°22'35.22"W	35	30
Minnetonka Blvd	44°56'57.95"N	93°22'39.54"W	35	35
Cedar Lake Rd	44°57'45.11"N	93°21'53.57"W	35	30
Minnetonka Blvd	44°56'58.63"N	93°21'50.94"W	35	35
Texas Ave S	44°58'0.48"N	93°22'48.11"W	30	25
Louisiana Ave S,	44°57'59.22"N	93°22'15.60"W	30	30
Lake St	44°56'7.62"N	93°22'24.53"W	30	20
Lake St	44°55'54.23"N	93°23'04.20"W	30	30
Morningside Rd	44°55'24.60"N	93°20'38.51"W	30	20
Morningside Rd	44°55'24.06"N	93°19'59.45"W	30	30
Franklin Ave	44°57'49.97"N	93°23'13.20"W	30	20
Westmoreland Dr	44°57'51.41"N	93°23'20.76"W	25	20

Table 2.2: Additional treatment sites. The speed limit change was implemented during November-December 2021.

Street	Longitude	Latitude	Speed Limit	
			Before Change	After Change
Jersey Ave	44°57'59.11"N	93°22'05.95"W	30	20
W 18th Street	44°57'55.26"N	93°22'00.96"W	30	20
1st Street	44°56'26.09"N	93°22'01.13"W	30	20
Library Ln	44°56'28.07"N	93°21'52.81"W	30	20
33rd	44° 56’ 48.8” N	93° 23’ 16.4” W	30	20
Xylon Ave	44°56'34.01"N	93°23'09.06"W	30	20
I394 S Frontage	44°58'13.51"N	93°21'36.90"W	30	25
Zarthan Ave S	44°58'8.58"N	93°21'18.6"W	30	30
W 28th Street	44°57'10.80"N	93°22'44.11"W	30	25
W 28th Street	44°57'11.05"N	93°22'9.66"W	30	20
Louisiana Ave S,	44°57'59.22"N	93°22'15.60"W	30	30
Texas Ave S	44°58'0.48"N	93°22'48.11"W	30	25
France Ave S	44°57'32.04"N	93°19'49.91"W	30	25
W 26th street	44°57'20.63"N	93°20'31.02"W	30	25
Walker Street	44°56'19.86"N	93°22'30.18"W	30	25
W 36th Street	44°56'19.07"N	93°23'6.83"W	30	25
Alabama Ave S	44°56'5.82"N	93°21'22.25"W	30	25
Brookside Ave	44°55'29.39"N	93°21'20.59"W	30	20

CHAPTER 3: DATA COLLECTION

Early in 2021 we acquired two Timemark Delta NT traffic recorders, along with associated hardware, and in July 2021 we acquired additional recorders. The Timemark recorders use pneumatic tubes placed across the road to identify times when vehicle axles cross the tube. Parallel tubes placed a known distance apart can then in principle give speed measurements, but in practice different types of axle configurations, and vehicles travelling in different directions, must also be accounted for. Timemark provides proprietary software that takes a raw file of tube strike times as input and gives estimates vehicles' speeds, headways and classifications as outputs. June 10, 2021 we conducted an initial test to verify the accuracy of the recorder/software system's speed estimates. One of our recorders was set up on Pillsbury Drive, next the Civil Engineering building at the University of Minnesota, while a member of our research team was located in an unobtrusive position with a Falcon radar gun and a watch synchronized with the traffic recorder's clock. This observer recorded speeds and times at which vehicle crossed the road tubes, and these were later compared to speed estimates from the recorder. 30 radar speed measurements could be reliably matched with speeds from the recorder, and Figure 3.1 shows a scatterplot of the radar and recorder speeds, along with a best-fit line relating the two sets of speed measurements. The scatterplot suggests that one observation, highlighted by the box, was an outlier and, after removing this from the data, linear regression was used to estimate the intercept and slope of a line relating the recorder speed to the radar speed. The results of this exercise are shown in Table 3.1.

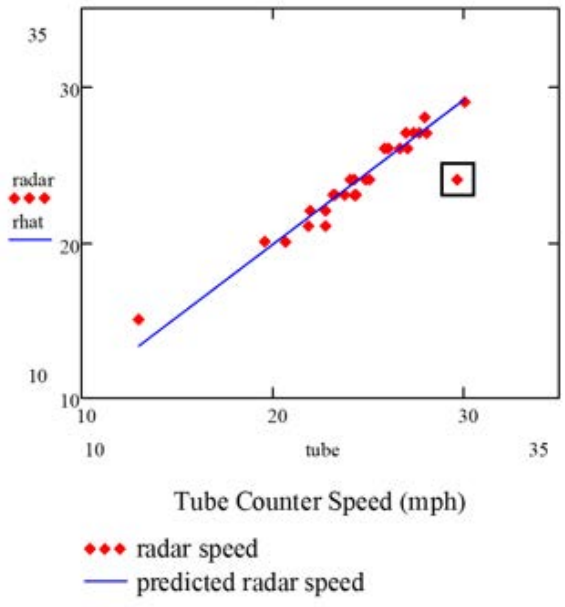


Figure 3.1: Scatterplot showing radar and traffic recorder speed measurements, along with the fitted regression line.

Table 3.1: Results from fitting a regression line, with traffic recorder speed as the independent variable and radar speed as the dependent variable.

Coefficient	Estimate	Standard Error	T-statistic	p-value
Intercept	1.22	1.59	0.77	0.45
Slope	0.9288	0.0649	14.3	0.00

If the traffic recorder and the radar were giving essentially similar speed measurements one would expect (a) the estimated intercept to be not different from zero, (b) the estimated slope to be not different from 1.0, and (c) the standard deviation of the differences between predicted and measured speeds to be approximately 1.0, the resolution of the radar gun. The T-statistic column in Table 3.1 indicates that the estimated intercept was not significantly different from 0, while a T-statistic comparing the estimated slope to 1.0 was T=-1.097, with a p-value of 0.14, indicating that the estimated slope was not significantly different from 1.0. The estimated error variance was 1.073 and a test for whether or not this was significantly different from 1.0 yielded a p-value of 0.59. Overall then, for this sample, the traffic recorder and the radar gave statistically indistinguishable speed measurements.

The initial expectation was that St. Louis Park would implement the speed limit change in late Summer/early Fall of 2021, so starting in June 2021 we began collecting "Before" data, with the goal of completing data collection by early August 2021. The following procedure was used:

(1) Several days prior to setting out the traffic recorders the project's PI scouted proposed locations and adjacent areas, to identify placement sites. An acceptable location was somewhere near midblock, where a recorder's road tubes could be placed so as to not interfere with a resident's driveway or cross a sidewalk, and where a road sign or utility pole was available to secure the recorder. Depending on the outcome of this reconnaissance, an initial proposed site might be changed or deleted.

(2) On the scheduled day the project team setup and initialized the recorders.

(3) 1-2 days later the team downloaded the data from the recorders and removed them.

Figure 3.2: Setting up a traffic recorder

Table 3.2: Dates and locations for speed data collection. The speed limit change was implemented during November-December 2021.

Counter Locations				Speed Limit		Data Collection Dates	
Code	**Street**	**Longitude**	**Latitude**	**Before**	**After**	**Before (2021)**	**After (2022)**
1A	Franklin Ave	44°57'49.97"N	93°23'13.20"W	30	20	6/17-18	6/21-23
1B	Westmoreland	44°57'51.41"N	93°23'20.76"W	25	20	6/17-18	6/21-23
2A	Jersey Ave	44°57'59.11"N	93°22'05.95"W	30	20	6/22-23	6/21-23
2B	W 18th Street	44°57'55.26"N	93°22'00.96"W	30	20	6/22-23	6/21-23
3A	1st Street	44°56'26.09"N	93°22'01.13"W	30	20	6/23-24	6/29-7/1
3B	Library Ln	44°56'28.07"N	93°21'52.81"W	30	20	6/23-24	6/29-7/1
4A	33rd	44° 56’ 48.8” N	93° 23’ 16.4” W	30	20	6/24-25	6/29-7/1
4B	Xylon Ave	44°56'34.01"N	93°23'09.06"W	30	20	6/24-25	6/29-7/1
5A	Lake St	44°56'7.62"N	93°22'24.53"W	30	20	6/29-30	7/13-15
5B	Lake St (Hopkins)	44°55'54.23"N	93°23'04.20"W	30	30	6/29-30	7/13-15
6A	I394 S Frontage	44°58'13.51"N	93°21'36.90"W	30	25	7/7-8	7/6-8
6B	Zarthan Ave S	44°58'8.58"N	93°21'18.6"W	30	30	7/7-8	7/6-8
7A	Morningside Rd	44°55'24.60"N	93°20'38.51"W	30	20	7/8-9	---
7B	Morningside Rd	44°55'24.06"N	93°19'59.45"W	30	30	7/8-9	---

8A	W 28th Street	44°57'10.80"N	93°22'44.11"W	30	25	7/13-14	7/26-28
8B	W 28th Street	44°57'11.05"N	93°22'9.66"W	30	20	7/13-14	7/26-28
9A	Louisiana Ave S,	44°57'59.22"N	93°22'15.60"W	30	30	7/14-15	6/1-2
9B	Texas Ave S	44°58'0.48"N	93°22'48.11"W	30	25	7/14-15	6/1-2
10A	France Ave S	44°57'32.04"N	93°19'49.91"W	30	25	7/20-21	7/26-28
10B	W 26th street	44°57'20.63"N	93°20'31.02"W	30	25	7/20-21	7/26-28
11A	Walker Street	44°56'19.86"N	93°22'30.18"W	30	25	7/21-22	7/13-15
11B	W 36th Street	44°56'19.07"N	93°23'6.83"W	30	25	7/21-22	7/13-15
11C	Alabama Ave S	44°56'5.82"N	93°21'22.25"W	30	25	7/21-22	7/20-22
11D	Brookside Ave	44°55'29.39"N	93°21'20.59"W	30	20	7/21-22	7/20-22
12A	Cedar Lake Rd	44°57'31.25"N	93°22'35.22"W	35	30	8/3-5	6/7-9
12B	Cedar Lake Rd	44°57'45.11"N	93°21'53.57"W	35	30	8/3-5	6/7-9
12C	Minnetonka Blvd	44°56'57.95"N	93°22'39.54"W	35	35	8/3-5	---
12D	Minnetonka Blvd	44°56'58.63"N	93°21'50.94"W	35	35	8/3-5	6/7-9

Our object was to collect data on typical weekdays, mainly Tuesday-Thursday, but on occasion data was also collected on a Friday morning. Holidays such as the Fourth of July were avoided, as were weekends. Days with heavy rain were also avoided but on a few occasions very light rain was observed during data collection. Table 3.2 lists the locations and dates where data was collected for the “Before” period in 2021, and the “After” period in 2022, while Figures 3.3 and 3.4 show Google Earth views depicting the locations of our data collections sites. All sites were on two-lane, two-way, roads.

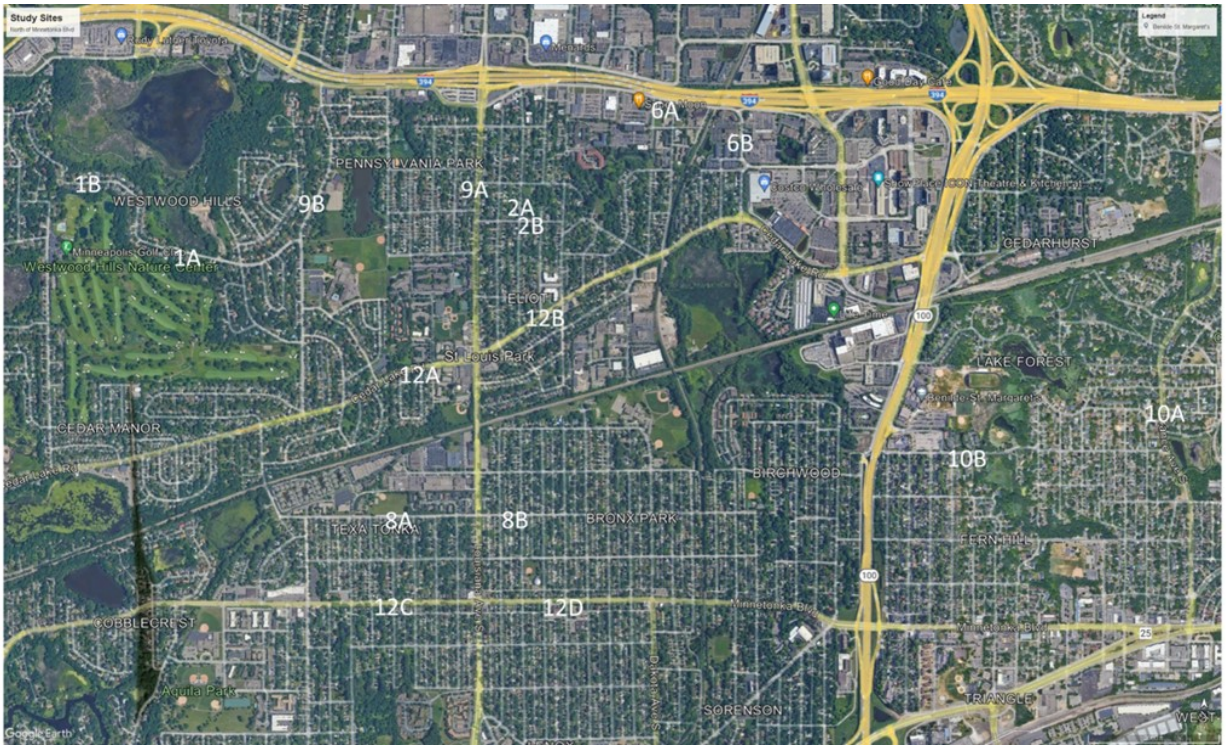


Figure 3.3: Data collection sites north of Minnetonka Boulevard.

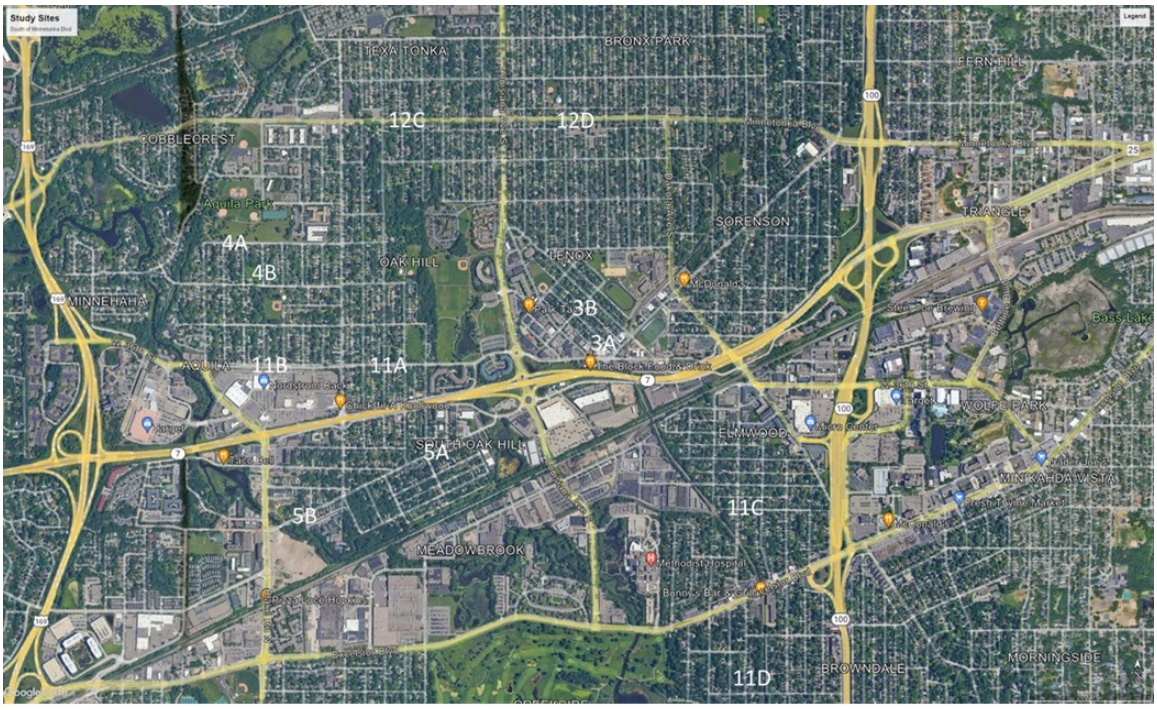


Figure 3.4: Data collection sites on, and south of, Minnetonka Boulevard.

Some comments are in order:

1. Our goal generally was to set the recorders out between 9 AM and noon, and to remove them roughly 24 or 48 hours later.

2. As noted above, we started out with two recorders, each set out for about 24 hours at a site. After we acquired additional recorders we began setting them out for about 48 hours at a time.

3. We initially expected the speed limit change to be in place by early Fall 2021, which would allow for a limited “After” data collection in 2021 before winter weather. Since the speed limit change was not implemented until November-December 2021 data collection was suspended until June 2022.

4. Sites 7A and 7B were originally selected as a treatment/comparison pair. However, the City of Edina also implemented a speed limit change that applied to site 7B, so “After” data collection at 7A and 7B was scrapped.

5. We originally planned to collect “After” data at site 12C on June 7-9, 2022, but emergency work on water mains was underway that week. We revisited the site on both August 8 and 9, but maintenance activities were again taking place and data collection was not possible.

CHAPTER 4: DATA ANALYSIS

After downloading data from the recorders, Timemark's VIAS 2 software was used to compute individual vehicle speeds and headways, classified by direction, from the raw tube strike data. In order to obtain samples more likely to represent drivers' freely chosen speeds, rather than speeds governed by car-following or congested conditions, vehicles with following headways less than 4 seconds were removed from our samples. No additional filtering of the speed data, for example to identify trucks or buses, was done. This produced, for each site and each data collection period, samples of individual, unhindered, speeds classified by direction. For each site, each data collection period, and each direction, summary statistics describing the distributions of speeds were then computed, and these are presented in two tables displayed in Appendix B.

The statistical summary Tables B2 and B3 show a substantial amount of information and to help understand the trends in these results several figures were constructed. Figure 4.1 shows the estimated mean speeds for each site and direction, 90% confidence intervals bracketing the estimated means, and the roads' speed limits, during both the "Before" and "After" periods. A 90% confidence interval is a range computed using a rule that will contain an unknown true value in 9 out of 10 samples. Figure 4.2 shows similar information for the estimated 85th percentile speeds, while Figure 4.3 shows how the 10-mph pace (the 10 mph range containing the greatest fraction of sample values) varied across the sites, both "Before" and "After". (The entries in the "On Graph" columns in Tables B2 and B3 correspond to the site/direction plotting positions in Figures 4.1-4.3.)

Looking first at Figure 4.1, before the speed limit change the mean speeds on all our sampled local streets were below the streets' speed limits, while on our sampled collectors mean speeds could be above or below the speed limits, with a tendency toward being above. After the speed limit change, however, mean speeds tended to be higher than the speed limits on the local roads, and this trend was even more pronounced on the collectors. Looking next at Figure 4.2, which shows the relation between 85th percentile speeds and speed limits, only the local roads before the speed limit change showed cases where the 85th percentile speeds were below speed limits, while after the speed limit change the 85th percentile speeds exceeded the speed limits at all our data collection locations. Figure 4.3, which compares the 10-mph pace to speed limits, confirms what we have seen in Figures 4.1 and 4.2, with vehicle speeds on a road being more likely to exceed the road's speed limit after the speed limit change.

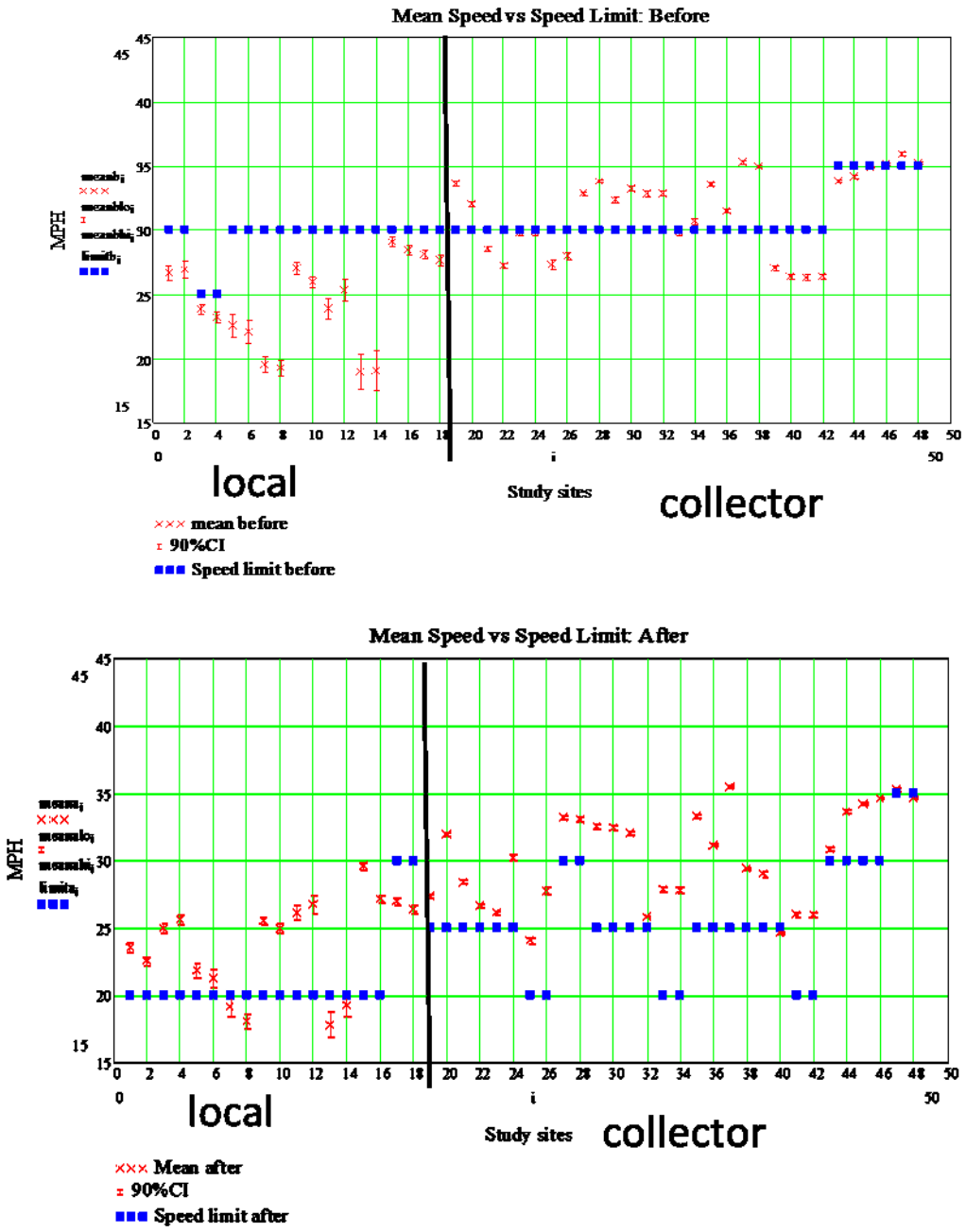


Figure 4.1: Estimated mean speeds, 90% confidence intervals for the estimated means, and speed limits, both before and after the speed limit changes.

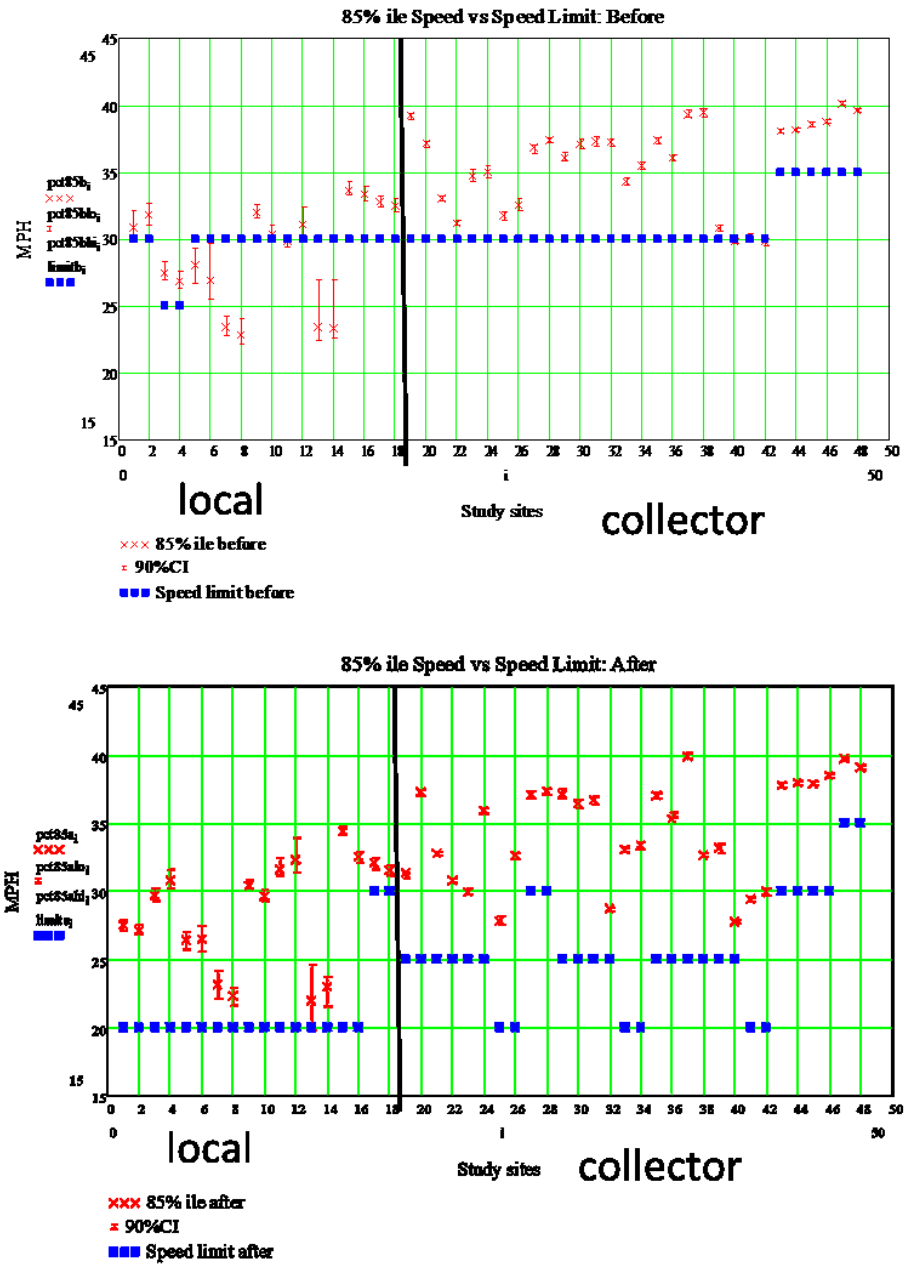
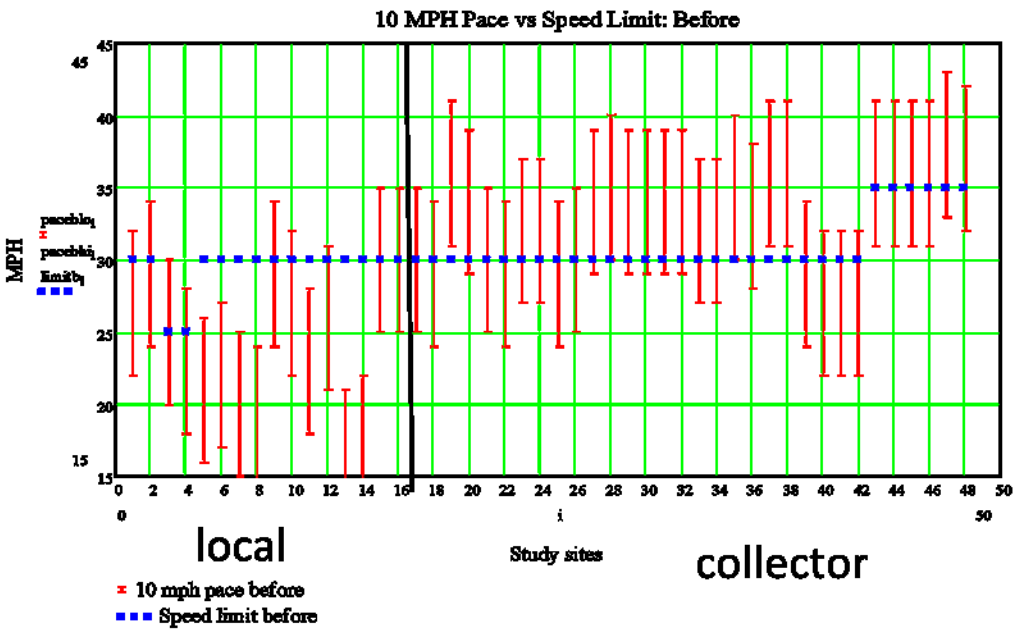


Figure 4.2: Estimated 85th percentile speeds, 90% confidence intervals for the estimates, and speed limits, both before and after the speed limit changes.



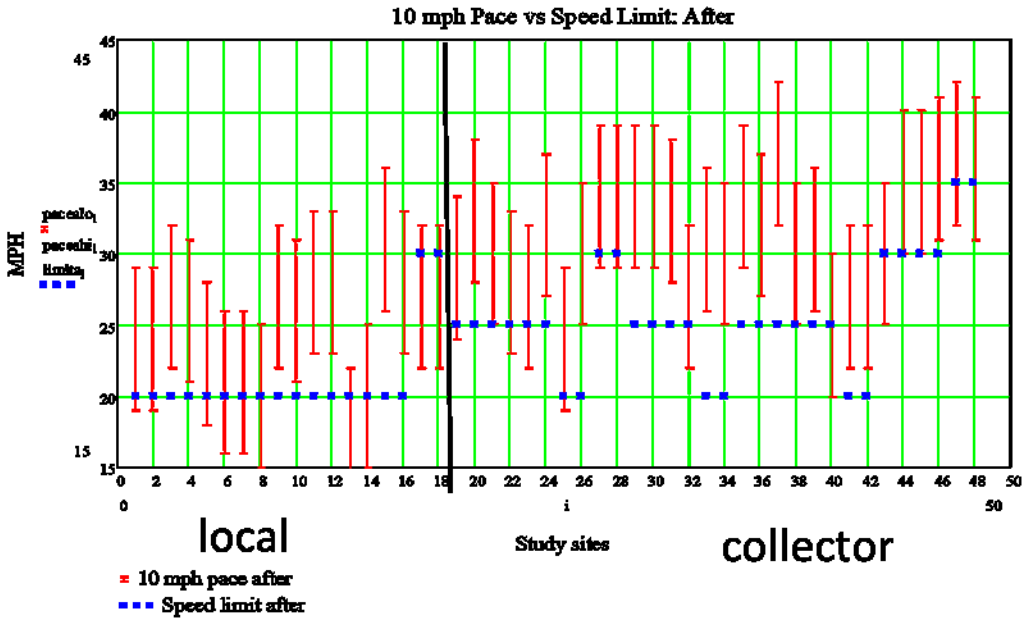


Figure 4.3: Estimated 10 mph pace for each site and direction, both before and after the speed limit changes.

Table 4.1, below, summarizes the trends shown in Figures 4.1-4.3. Overall, it is reasonable to conclude that during Summer 2021 drivers' free-flow speeds were, on average, roughly consistent with the existing speed limits, but with considerable variability across the sites. Before the speed limits were changed in 2021 the 85th percentile speeds tended to be higher than the existing speed limits, while the 10 mph pace tended to contain the existing speed limits. During Summer 2022, after many speed limits had been reduced, drivers on average tended to exceed the new speed limits, especially on roads with

the 20 mph limit. The tendency for the 85th percentile speeds to be higher than the speed limits was exacerbated, and there were frequent instances where the new speed limit fell below the 10 mph pace.

Table 4.1: Counts for numbers of sites where speed summaries fell above, at, or below the site's speed limit, both before and after the speed limit changes.

Relation between Mean Speeds and Speed Limits				
Road Class	**Time Period**	**Below Limit**	**No Difference**	**Above Limit**
Local	**Before**	18	0	0
	After	6	0	12
Collector	**Before**	10	3	17
	After	2	0	28
Relation between 85th Percentile Speeds and Speed Limits				
Road Class	**Time Period**	**Below Limit**	**No Difference**	**Above Limit**
Local	**Before**	6	4	8
	After	0	0	18
Collector	**Before**	0	3	27
	After	0	0	30
Relation between 10-mph Pace and Speed Limits				
		Below	**Within**	**Above**
Local	**Before**	6	12	0
	After	0	10	8
Collector	**Before**	0	25	3
	After	0	15	15

A major objective of this research is to quantify changes in speed behavior attributable to the changes in speed limits. This issue has two components: (1) quantifying the differences, if any, between the Before vs After periods, and (2) determining to what extent any reliable differences can be said to have been caused by the speed limit changes.

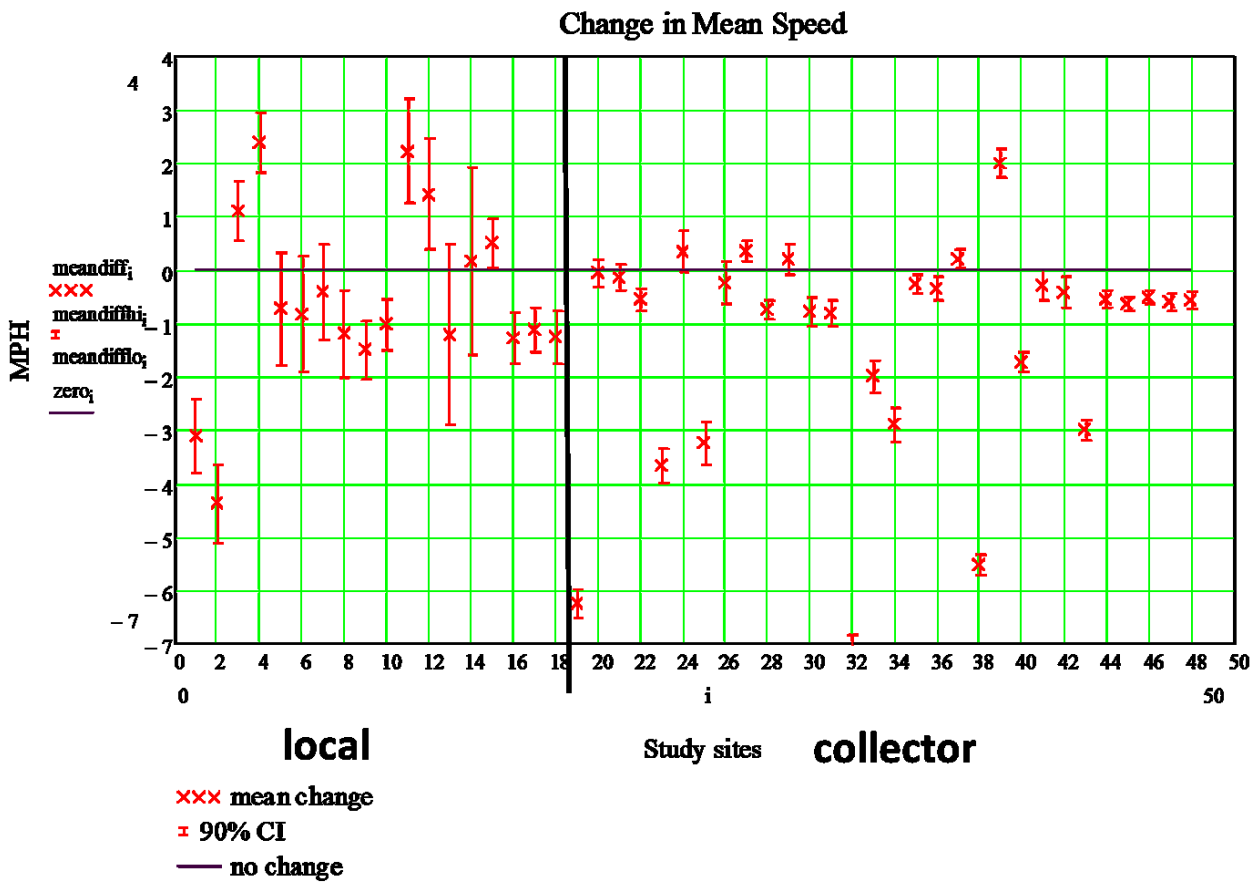


Figure 4.4: Differences in mean speeds after vs before the speed limit changes. A positive difference corresponds to the mean speed being higher after the speed limit change, a negative difference corresponds to a decrease in mean speed.

Figure 4.4 shows the estimated changes in mean speed for each site and direction in our sample, along with approximate 90% confidence intervals for the estimated changes. A positive difference corresponds to an increase in mean speed after the speed limit change, a negative difference corresponds to a decrease. Figure 4.4 shows cases where the mean speed was higher after the speed limit change, cases where the change in mean speed was not significantly different from zero, and cases where the mean speed was lower after the speed limit change. Overall though there appears to be tendency for negative instances, where mean speeds decreased, to be more frequent than positive instances, where means speeds increased.

Finally, as we noted in our Introduction, there is an ongoing concern that when the speed limit on a road is set at an "artificially" low value there can be an increase in the speed variability, and that since some research has reported correlations between aggregate crash risk and measures of speed variability, this leads to a concern that lowering speed limits might make a road less safe. As we pointed in the Introduction, however, correlations between speed variance and aggregated measures of crash risk can be expected even when speed variability has no causal effect on an individual's crash risk. If, when a speed limit is lowered, there is tendency for drivers to divide into those who attempt to comply with the

new limit and those who do not there is likely to be an increase in speed variability. To look into this possibility Figure 4.5 shows the estimated variance ratios for our sample, along with approximate 90% confidence intervals for these estimates. A variance ratio greater than 1.0 indicates that speed variance was higher after the speed limit change, a ratio less than 1.0 indicates that a speeds variance was lower after the change. As with the other summary statistics there is considerable variation across the sites, with instances of increase, decrease, and no change in variance. Table 4.2 tabulates the numbers of sites/directions showing increases, decreases, and no change in mean speed and in speed variance following the speed limit change.

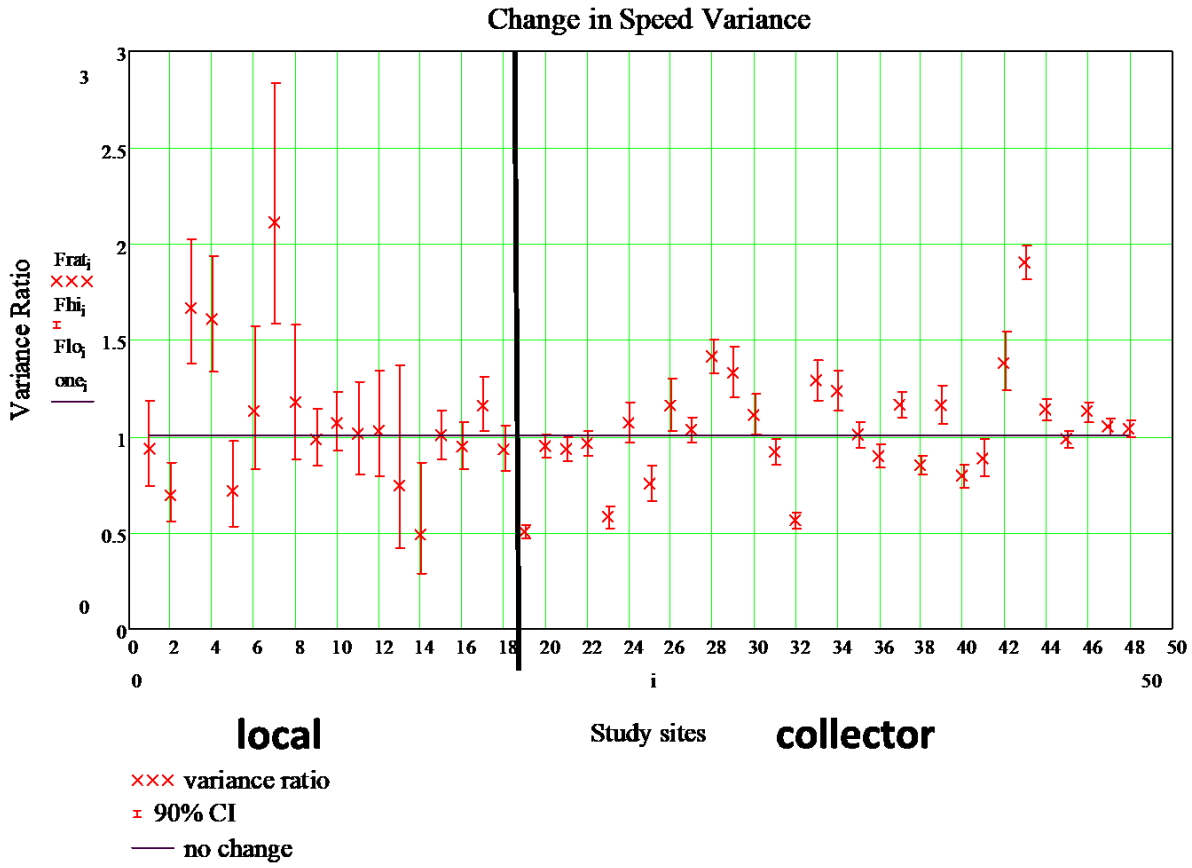


Figure 4.5: Estimated variance ratios and approximate 90% confidence intervals for all sites/directions. A variance ratio greater than 1.0 indicates that variance was greater after the speed limit change, a ratio less than 1.0 indicates that variance was smaller after the change.

Table 4.2: Numbers of sites/directions showing decreases, increases, or no change in mean speed and in speed variance following the speed limit change.

	Mean Speed		
	Decrease	**No Change**	**Increase**
Local	8	5	5
Collector	21	6	3
	Speed Variance		
	Decrease	**No Change**	**Increase**
Local	3	12	3
Collector	11	6	13

Table 4.3: Average changes in mean speed and speed variance for different road types and speed limit changes.

	Speed Limit Before	Speed Limit After	Instances	Average Mean Difference (mph)	Average Variance Ratio
Local	30	20	14	-0.81	1.32
	25	20	2	1.75	1.985
	30	30	2	-1.19	1.185
Collector	30	20	6	-1.52	1.235
	30	25	16	-1.53	1.00
	35	30	4	-1.18	1.35
	30	30	2	-0.19	1.30
	35	35	2	-0.59	1.085

Table 4.3 shows the differences in mean speeds and in the variance ratios averaged over those sites/directions having similar changes in speed limit. For example, on local roads where the speed limit was reduced from 30 mph to 20 mph, we had 14 instances (7 sites with 2 directions/site) and the average change in mean speed was a reduction of 0.81 mph, while the variance increased by about 32% (i.e. the standard deviation increased by about 5.7%). At our local road site where the speed limit was 30 mph both before and after, the mean speed was about 1.19 mph lower and the variance was about 18.5 percent higher.

Overall, a case can be made that mean speeds were, on average, around 1-2 mph lower in summer 2022 compared to 2021, but with substantial variability over different sites and directions. The next question is to determine to what extent the speed limit changes can be said to have caused these reductions. As

noted previously, our sample of sites included several treatment/comparison pairs, where a road due for a speed limit reduction was paired with a similar road where the speed limit did not change. Originally, these were to be sites 5A/5B, 7A/7B, 9A/9B, 12A/12C and 12B/12D. However, comparison site 7B, in Edina, also had its speed limit reduced when the City of Edina implemented speed limit reductions, while comparison site 12C, on Minnetonka Blvd, was undergoing repairs on the three occasions we visited it. This left us with three treatment comparison pairs, 5A/5B, 9A/9B, and 12B/12D. Figures 4.6, 4.7, and 4.8 show the estimated mean speeds before and after the speed limit change for the treatment/comparison pairs.

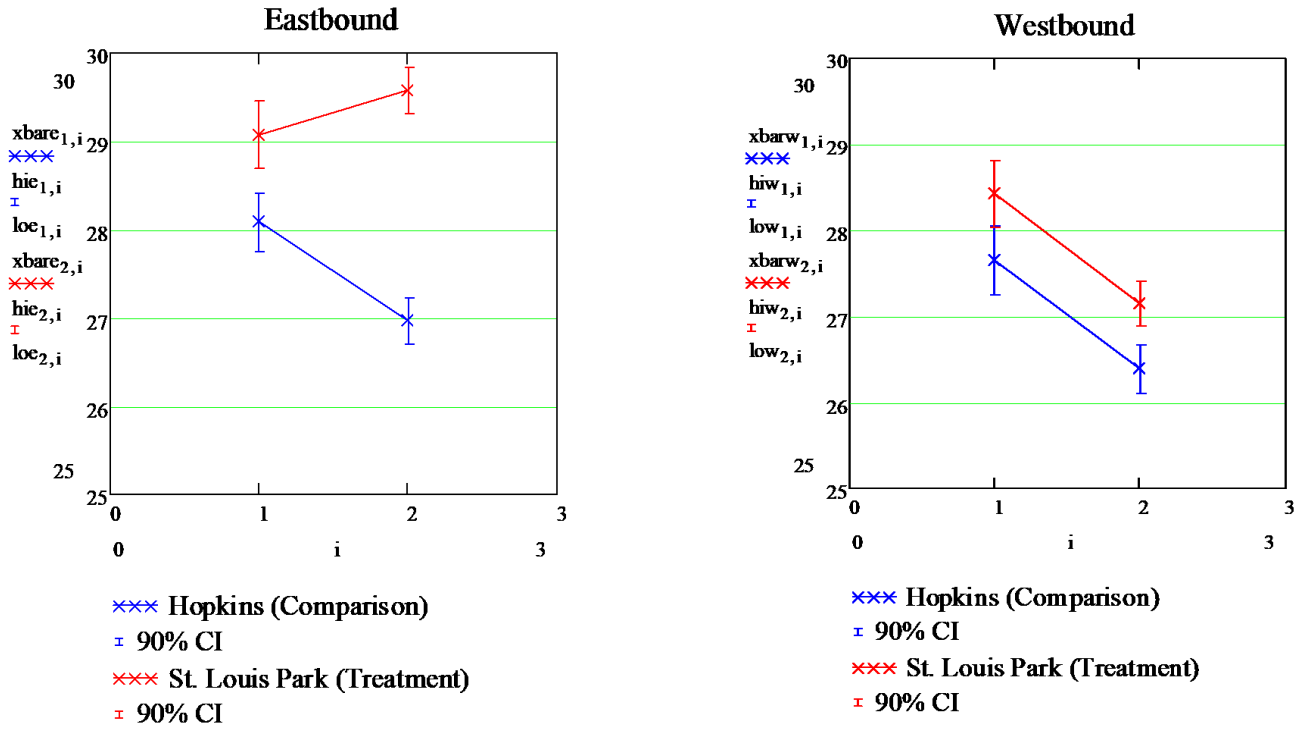


Figure 4.6: Changes in mean speed for the Lake Street treatment/comparison pair, sites 5A and 5B. The speed limit was changed from 30 mph to 25 mph on the St. Louis Park section but stayed at 30 mph on the Hopkins section.

Figure 4.6 shows the changes in estimated mean speed observed on Lake Street, sites 5A and 5B. The speed limit was changed from 30 mph to 25 mph on the St. Louis Park section of Lake Street but stayed at 30 mph on the Hopkins section. For the eastbound direction, the treatment site showed an increase in mean speed after the speed limit change while the comparison site showed a decrease. For the westbound direction, both the treatment and comparison sites showed decreases. Figure 4.7 shows the changes in estimated mean speed observed on Texas and Louisiana Avenues, sites 9A and 9B. The speed limit was reduced from 30 mph to 25 mph on Texas but stayed at 30 mph on Louisiana. For the northbound direction, both the treatment and comparison sites showed increases in mean speed, while for the southbound direction both the treatment and comparison sites showed decreases. Finally, Figure

4.8 shows the changes in mean speed for the Cedar Lake Rd/Minnetonka Blvd treatment/comparison pair, sites 12B and 12D. The speed limit was reduced from 35 mph to 30 mph on Cedar Lake Rd but stayed at 35 mph on Minnetonka. Here, both the eastbound and westbound directions, and both the treatment and comparison sites, showed decreases in mean speed.

Overall, the results from our detailed analyses of the treatment/comparison pairs were consistent with our more aggregated analyses. There was a general tendency for mean speeds to be slightly lower in summer 2022 compared to summer 2021, but with noticeable between-site variability, and this pattern was seen both for sites where the speed limit was changed and for sites were it was not changed.

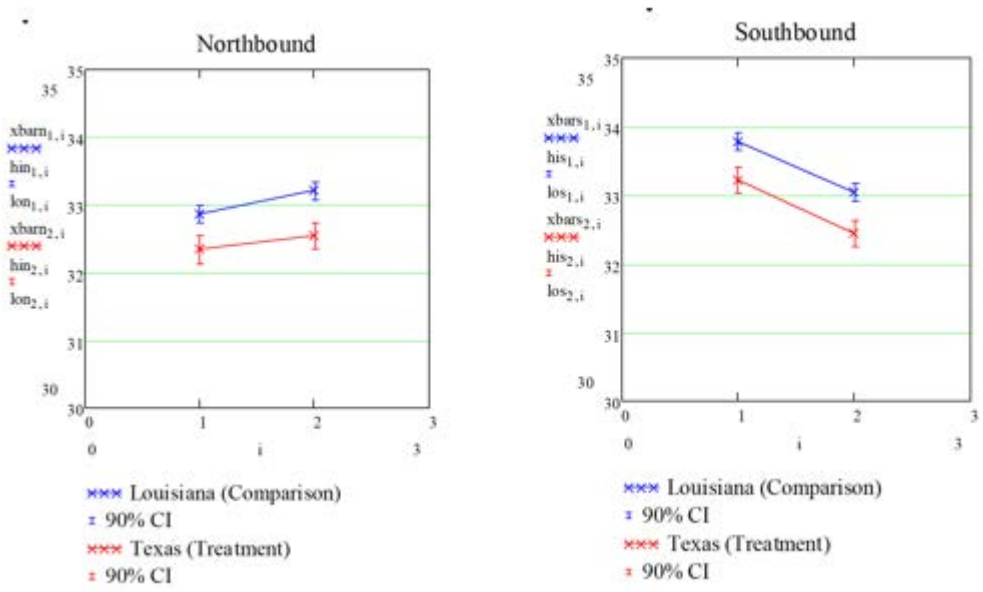


Figure 4.7: Changes in mean speed for the Louisiana/Texas treatment/comparison pair, sites 9A and 9B. The speed limit was reduced from 30 mph to 25 mph on Texas but stayed at 30 mph on Louisiana.

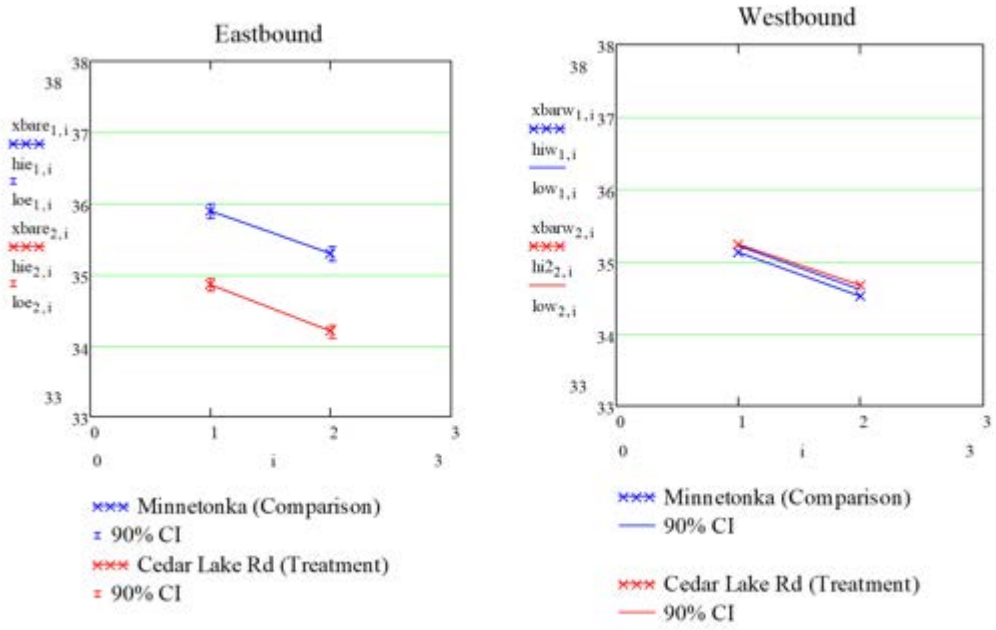


Figure 4.8: Changes in mean speed for the Cedar Lake Rd/Minnetonka Blvd treatment/comparison pair sites 12B and 12D. The speed limit was reduced from 35 mph to 30 mph on Cedar Lake Rd but stayed at 35 mph on Minnetonka Blvd.

Finally, if we define a "practically significant" reduction in mean speed as one of 2 mph or more, Table 4.4 displays the sites and directions showing such deceases after their speed limits were reduced. Also shown are the changes for the companion directions, and if drivers on a road are attempting to comply with the changed speed limit one would expect to see similar effects in both directions. Of the eight sites listed in Table 4.4, however, only two, Franklin Ave and 26th St, showed similar reductions for both directions. Since the 26th St results were compromised by road construction taking place about two block west of the site during the "After" data collection, which could account for the observed reduction in mean speed at this site, we have only one site out of 24 showing consistent, practically significant, reductions in both directions.

Table 4.4: Sites/Directions with largest decreases in mean speed. Bold face font highlights those sites, 1A and 10B, where both directions showed consistent decreases.

Site ID	Street	Direction	Mean Difference	Comments
10A	France Ave.	SB	-7.0	Reduction in SB direction but little change for NB direction
		NB	-0.8	
6A	I 394 Frontage Rd	EB	-6.3	Reduction in EB direction but little change in WB direction
		WB	-0.1	
11B	W 36th St	WB	-5.5	Reduction in WB, but little change in EB
		EB	0.2	
1A	**Franklin Ave**	**WB**	**-4.4**	Reduction in both EB and WB directions
		EB	**-3.1**	
8A	W 28 St	EB	-3.7	Reduction in EB but little change in WB
		WB	0.3	
8B	W 28 St	EB	-3.2	Reduction in EB but little change in WB
		WB	-0.3	
12A	Cedar Lake Rd west of Louisiana	EB	-3.0	Reduction in EB but little change in WB
		EB	-0.6	
10B	**W 26th St**	**WB**	**-2.9**	Reduction in both directions, but road construction during "After"
		EB	**-2.0**	

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

In 2021, the city of St. Louis Park lowered the default speed limit on city streets from 30 mph to 20 mph, with certain streets being given posted limits of 25 mph, 30 mph, and in one case, 35 mph. In the summer of 2021, before this change went into effect, we collected speed data on a sample of these streets, and then in the summer of 2022, we again collected speed data on these sample streets. At our study sites, the mean free-flow speeds in the summer of 2022 appeared to be, on average, slightly lower than those seen on the same roads during the summer of 2021, while speed variances were, on average, slightly higher. This pattern was what one would expect if some, but not all, drivers were making at least limited efforts to comply with the new limits. This pattern was seen, on average, on both local streets and collectors and at both treatment and comparison sites. The observed reductions in mean speed were, on average, considerably less than the reductions in the speed limits, but roughly consistent with reports by researchers in other cities. Regarding our treatment/comparison pairs, if there was a clear, straightforward, causal effect due to the speed limit change, we would expect to see no changes on roads where speed limits were not reduced, and similar reductions for the different directions at the treatment sites, but this did not occur. Overall, this study found no evidence that the changes in posted speed limits led to decreases in mean speeds roughly equal in magnitude to the changes in the speed limit, and the modest decreases that were seen tended to occur at both treatment and comparison sites.

So what, if any, effect did the speed limit change have on driver behavior? One assumption underlying our analysis is that if drivers intend to comply with the reduced speed limits, they will do so quickly and completely after the reduction is in place. But driving is largely an overlearned, habitual, activity, and it is reasonable to assume that many of the drivers on our sample roads drive these roads on a regular basis. The assumption of quick and complete compliance then might not be accurate, and a driver who has been in the habit of travelling at a given speed on a road might need a period of consciously recalling and choosing to follow the lower speed limit before a new habit develops. Under this hypothesis, speeds observed fairly soon after a speed limit change would tend to underestimate the long-run effect of the change. We recommend then that comparable speed samples be collected in subsequent years, on at least a subset of our sampled sites to track any development of new habits.

REFERENCES

Bornioli, A., Bray, I., Pilkington, P., & Bird, E. (2008). The effectiveness of a 20 mph speed limit intervention on vehicle speeds in Bristol, UK: A non-randomized stepped wedge design. *Journal of Transport and Health*, *11,* 47-55.

Davis, G. (2002). Is the claim that 'variance kills' an ecological fallacy? *Accident Analysis and Prevention*, *34*, 343-346.

Elvik, R. (2005). Speed and safety: Synthesis of evidence from evaluation studies. *Transportation Research Record*, *1908*, 59-69.

Garber, N., & Gadariju, R. (1990). Factors affecting speed variance and its influence on accidents. *Transportation Research Record*, *1213,* 64-71.

Garber, N., & Ehrhart, A. (2000). Effects of speed, flow, and geometric characteristics on crash frequency on two-lane highways, *Transportation Research Record*, *1717,* 76-83.

Heydari, S., Miranda-Moreno, L., & Fu., L. (2014). Speed limit reduction in urban areas: A before-after study using Bayesian generalized mixed linear models. *Accident Analysis and Prevention*, *73,* 252-261.

Hu, W., & Cicchino, J. (2020). Lowering the speed limit from 30 mph to 25 mph in Boston: Effects on vehicle speeds. *Injury Prevention*, *26*(2), 99-104.

Islam, M., El-Basyouny, K., & Ibrahim, S. (2014). The impact of lowered residential speed limits on vehicle speed behavior. *Safety Science*, *62,* 483-494.

Lave, C. (1985). Speeding, coordination, and the 55 mph limit. *American Economic Review,* 75, 1159-1164.

Lave, C. (1989). Speeding, coordination, and the 55 mph limit: A reply. *American Economic Review, 79*(4), 926-931.

McCarthy, P. (1998). Effect of speed limits on speed distributions and highway safety: A survey of the literature. In *Managing speed: Review of current practice for setting and enforcing speed limits* (Special Report 254). Washington, DC: Transportation Research Board.

MnDOT. (2015). *Traffic engineering manual*, chapter 14. St. Paul, MN: Minnesota Dept. of Transportation.

Park, E., Fitzpatrick, K., Das, S., & Avelar, R. (2021). Exploration of the relationship among roadway characteristics, operating speed, and crashes for city streets using path analysis. *Accident Analysis, and Prevention*, *150,* 105896.

Preston, H., Richfield, V., & Farmington, N. (2015). *Traffic safety fundamentals handbook*. St. Paul, MN: Minnesota Dept. of Transportation.

Rodriguez, R. (1990). Speed, speed dispersion and the highway fatality rate. *Southern Economic Journal*, *57*(2), 249-356.

Shinar, D. (1998). Speed and crashes: A controversial topic and an elusive relationship. In *Managing speed: Review of current practice for setting and enforcing speed limits* (Special Report 254). Washington, DC: Transportation Research Board

APPENDIX A

LETTER SENT TO METRO-AREA TRAFFIC ENGINEERS

UNIVERSITY OF MINNESOTA

Twin Cities Campus

Department of Civil, Environmental, and Geo- Engineering
College of Science and Engineering

500 Pillsbury Drive SE
Minneapolis, MN 55455
Office: 612-625-5522
Fax: 612-626-7750
www.cege.umn.edu

February 5, 2020

To Whom It May Concern:

As you probably know, last year the Minnesota Legislature changed our speed limit law to allow cities increased freedom in setting speed limits. As part of a research project sponsored by the Local Road Research Board we are investigating how changes in speed limits on roads affect the speeds chosen by drivers. Our study design calls for identifying a sample of roads where speed limits will be changed and then collecting speed data both before and after the changes. To help identify roads for possible inclusion in our sample we would like to know if your city is planning on taking advantage of the new law and, if so, if you are interested in partnering with us. More particularly, we would like to know:

(1) Does your city plan on changing speed limits on some of your roads?
(2) If the answer to (1) is yes, is your city interested in partnering with us?
(3) If the answers to (1) and (2) are yes, on what roads do you plan to change speed limits and when do you expect that these changes will be made?

This information can be sent electronically to Mr. Christopher Cheong at cheon028@umn.edu, or by regular mail to

Christopher Cheong
Dept. of Civil, Environmental, and Geo-Engineering
University of Minnesota
122 CivE
500 Pillsbury Drive SE
Minneapolis, MN 55455

If you have any questions or comments feel free to contact Mr. Cheong or me. My email address is drtrips@umn.edu and my office phone is 612 625 2598.

Thank you for your time.

Sincerely

Gary A. Davis

Gary A. Davis
Professor
Principal Investigator

APPENDIX B

SUMMARY TABLES SHOWING SPEED STATISTICS

Table B1. Definitions of summary statistics computed for each site and direction and listed in Tables B2 and B3.

Column Heading	Description
Street	Name of street
locID	Location identifier
Dir	Direction of travel
Class	Local or collector
On Graph	Plotting position of site/direction on report figures
Limit0	Speed limit during " before" period
N0	Sample size for "before" data
Mean0	Estimated mean speed for "before" data
SD0	Standard deviation for "before" speeds
Lower0	Lower and upper bounds of 90% confidence interval for "before" mean speed
Upper0	
Limit1	Speed limit during "after" period
N1	Sample size for "after" data
Mean1	Estimated mean speed for "after" data
SD1	Standard deviation for "after" speeds
Lower1	Lower and upper bounds of 90% confidence interval for "after" mean speed
Upper1	
Meandiff	Difference between "before" and "after" mean speeds
DiffSE	Standard error for mean difference
Difflower	Lower and upper bounds of 90% confidence interval for mean difference
Diffupper	
Fratio	F ratio statistic comparing "before" and "after" variances
Fratlo	Lower and upper bound of 90% confidence interval for F ratio
Frathi	
Median0	Median speed for "before" data
85%ile0	85th percentile speed for "before" data
85%low0	Lower and upper bounds of 90% confidence interval around the 85th percentile speed, "before" data
85%hi0	
Pacelo0	Lower and upper bounds of 10 mph pace, "before" data
Paceup0	
Median1	Median speed for "after" data
85%ile1	85th percentile speed for "after" data
85%low1	Lower and upper bounds of 90% confidence interval around the 85th percentile speed, "after" data
85%hi1	
Pacelo1	Lower and upper bounds of 10 mph pace, "after" data
Paceup1	

Table B2. Summary statistics part 1

Street	locID	Class	dir	On Graph	Limit0	N0	mean0	SD0	Lower0	Upper0	Limit1	N1	mean1	SD1	Lower1	Upper1	meanDiff	DiffSE	diffLower	diffUpper	Fratio	Fratlo	Frathi
Franklin Ave	1A	local	EB	1	30	136	26.63	4.26	26.03	27.23	20	419	23.52	4.11	23.19	23.85	-3.11	0.42	-3.80	-2.43	0.93	0.75	1.18
	1A	local	WB	2	30	164	26.91	5.11	26.25	27.56	20	411	22.53	4.24	22.19	22.88	-4.38	0.45	-5.12	-3.63	0.69	0.56	0.86
Westmoreland Dr	1B	local	EB	3	25	209	23.84	3.70	23.42	24.26	20	471	24.95	4.77	24.59	25.31	1.11	0.34	0.55	1.66	1.66	1.38	2.03
	1B	local	WB	4	25	241	23.21	3.85	22.80	23.62	20	456	25.60	4.87	25.23	25.98	2.39	0.34	1.84	2.95	1.60	1.34	1.94
Jersey Ave	2A	local	NB	5	30	88	22.55	5.20	21.64	23.46	20	180	21.83	4.40	21.29	22.37	-0.72	0.64	-1.78	0.34	0.71	0.53	0.98
	2A	local	SB	6	30	82	22.08	4.77	21.21	22.94	20	156	21.24	5.07	20.57	21.91	-0.83	0.66	-1.93	0.26	1.13	0.83	1.57
1st St	3A	local	NB	7	30	105	19.51	3.71	18.92	20.11	20	176	19.11	5.39	18.44	19.78	-0.40	0.54	-1.30	0.49	2.11	1.59	2.83
	3A	local	SB	8	30	105	19.26	3.86	18.64	19.88	20	175	18.06	4.19	17.54	18.58	-1.19	0.49	-2.00	-0.38	1.17	0.89	1.58
Library Ln	3B	local	EB	9	30	384	27.01	5.10	26.58	27.44	20	645	25.52	5.05	25.19	25.85	-1.49	0.33	-2.03	-0.95	0.98	0.85	1.14
	3B	local	WB	10	30	427	25.95	4.80	25.57	26.34	20	697	24.94	4.95	24.63	25.25	-1.02	0.30	-1.51	-0.52	1.06	0.92	1.23
33rd St.	4Ar	local	EB	11	30	156	23.89	5.95	23.11	24.67	20	289	26.10	5.98	25.53	26.68	2.21	0.59	1.24	3.19	1.01	0.80	1.28
	4Ar	local	WB	12	30	119	25.32	5.57	24.48	26.16	20	225	26.73	5.64	26.11	27.35	1.41	0.63	0.37	2.46	1.03	0.79	1.35
Xylon Ave	4B	local	NB	13	30	27	18.96	4.38	17.58	20.35	20	42	17.75	3.77	16.80	18.71	-1.21	1.02	-2.90	0.47	0.74	0.42	1.37
	4B	local	SB	14	30	29	19.05	5.12	17.49	20.62	20	57	19.21	3.57	18.44	19.99	0.16	1.06	-1.59	1.91	0.49	0.29	0.86
Lake St (SLP)	5A	local	EB	15	30	509	29.07	5.21	28.69	29.45	20	1059	29.58	5.22	29.32	29.85	0.51	0.28	0.05	0.97	1.00	0.89	1.14
	5A	local	WB	16	30	484	28.43	5.20	28.04	28.82	20	952	27.15	5.05	26.88	27.42	-1.28	0.29	-1.75	-0.81	0.94	0.83	1.08
Lake St (Hopkins)	5B	local	EB	17	30	571	28.09	4.81	27.76	28.42	30	1041	26.97	5.17	26.71	27.24	-1.12	0.26	-1.54	-0.70	1.16	1.03	1.31
	5B	local	WB	18	30	501	27.65	5.51	27.24	28.05	30	948	26.39	5.32	26.11	26.67	-1.26	0.30	-1.75	-0.76	0.93	0.82	1.06
I394 Frontage	6A	collector	EB	19	30	1660	33.60	6.07	33.36	33.85	25	3834	27.34	4.30	27.23	27.46	-6.26	0.16	-6.53	-5.99	0.50	0.47	0.54
	6A	collector	WB	20	30	1787	32.00	5.46	31.79	32.22	25	4098	31.95	5.31	31.82	32.09	-0.05	0.15	-0.30	0.20	0.95	0.89	1.01
Zarthan Ave	6B	collector	NB	21	30	1779	28.51	4.86	28.32	28.70	25	3946	28.37	4.69	28.25	28.49	-0.14	0.14	-0.37	0.09	0.93	0.87	1.00
	6B	collector	SB	22	30	1674	27.20	4.38	27.03	27.38	25	3728	26.65	4.30	26.54	26.77	-0.55	0.13	-0.76	-0.34	0.96	0.90	1.03
W 28th St west	8A	collector	EB	23	30	891	29.81	5.15	29.52	30.09	25	1825	26.13	3.91	25.98	26.28	-3.68	0.20	-4.00	-3.36	0.58	0.53	0.64
	8A	collector	WB	24	30	839	29.85	5.51	29.53	30.16	25	1699	30.19	5.69	29.96	30.42	0.34	0.23	-0.04	0.73	1.07	0.97	1.18
W28th St east	8B	collector	EB	25	30	539	27.29	4.86	26.95	27.64	20	1172	24.05	4.21	23.84	24.25	-3.24	0.24	-3.64	-2.85	0.75	0.67	0.85
	8B	collector	WB	26	30	601	27.97	4.77	27.65	28.29	20	1239	27.72	5.13	27.48	27.96	-0.25	0.24	-0.65	0.15	1.16	1.03	1.30
Louisiana Ave	9A	collector	NB	27	30	2628	32.86	4.14	32.73	32.99	30	2773	33.21	4.20	33.08	33.34	0.35	0.11	0.17	0.54	1.03	0.97	1.10
	9A	collector	SB	28	30	2880	33.79	3.87	33.67	33.90	30	2898	33.04	4.60	32.90	33.18	-0.74	0.11	-0.93	-0.56	1.41	1.33	1.50
Texas Ave	9B	collector	NB	29	30	915	32.34	3.89	32.13	32.55	25	1409	32.54	4.48	32.34	32.74	0.20	0.18	-0.09	0.49	1.33	1.20	1.47
	9B	collector	SB	30	30	1075	33.22	3.98	33.02	33.42	25	1358	32.44	4.19	32.25	32.62	-0.78	0.17	-1.06	-0.51	1.11	1.01	1.22
France Ave	10A	collector	NB	31	30	1561	32.85	4.86	32.65	33.05	25	3348	32.03	4.65	31.90	32.16	-0.82	0.15	-1.06	-0.57	0.92	0.85	0.98
	10A	collector	SB	32	30	1739	32.84	4.48	32.66	33.02	25	3956	25.81	3.35	25.72	25.90	-7.03	0.12	-7.23	-6.83	0.56	0.52	0.60
W 26th St	10B	collector	EB	33	30	1224	29.83	4.98	29.59	30.06	20	2315	27.84	5.65	27.65	28.03	-1.99	0.18	-2.29	-1.68	1.29	1.19	1.40
	10B	collector	WB	34	30	1253	30.67	5.18	30.43	30.91	20	2129	27.77	5.75	27.57	27.98	-2.90	0.19	-3.22	-2.58	1.23	1.13	1.34
Walker St	11A	collector	EB	35	30	1949	33.54	3.85	33.40	33.68	25	3971	33.27	3.86	33.17	33.37	-0.27	0.11	-0.44	-0.09	1.01	0.94	1.07
	11A	collector	WB	36	30	1585	31.48	4.73	31.28	31.67	25	3423	31.13	4.47	31.00	31.26	-0.35	0.14	-0.58	-0.12	0.89	0.83	0.96
W 36th St	11Br	collector	EB	37	30	2361	35.27	4.10	35.14	35.41	25	4729	35.48	4.41	35.37	35.58	0.20	0.11	0.03	0.38	1.16	1.09	1.23
	11Br	collector	WB	38	30	2288	34.93	4.62	34.77	35.09	25	4658	29.39	4.25	29.29	29.50	-5.53	0.11	-5.72	-5.35	0.85	0.80	0.90
Alabama Ave	11C	collector	NB	39	30	1656	27.03	4.05	26.87	27.19	25	1167	29.03	4.36	28.82	29.24	2.00	0.16	1.73	2.26	1.16	1.06	1.27
	11C	collector	SB	40	30	1314	26.35	3.63	26.18	26.51	25	2598	24.61	3.23	24.51	24.71	-1.74	0.12	-1.93	-1.54	0.79	0.73	0.86
Brookside Ave	11D	collector	NB	41	30	685	26.28	3.90	26.04	26.53	20	1434	25.99	3.66	25.83	26.15	-0.29	0.18	-0.58	0.00	0.88	0.79	0.98
	11D	collector	SB	42	30	650	26.40	3.46	26.17	26.62	20	1388	25.97	4.06	25.79	26.15	-0.43	0.17	-0.71	-0.14	1.38	1.23	1.54
Cedar Lake Rd west	12Ar	collector	EB	43	35	4808	33.80	4.65	33.69	33.91	30	5087	30.80	6.41	30.66	30.95	-3.00	0.11	-3.18	-2.81	1.90	1.81	1.99
	12Ar	collector	WB	44	35	4269	34.16	4.51	34.04	34.27	30	4453	33.61	4.80	33.49	33.73	-0.55	0.10	-0.71	-0.38	1.14	1.08	1.19
Cedar Lake Rd east	12B	collector	EB	45	35	5082	34.85	3.99	34.75	34.94	30	5242	34.20	3.96	34.11	34.29	-0.64	0.08	-0.77	-0.51	0.98	0.94	1.03
	12B	collector	WB	46	35	5025	35.12	3.94	35.03	35.22	30	5478	34.60	4.18	34.51	34.70	-0.52	0.08	-0.65	-0.39	1.13	1.08	1.18
Minnetonka Blvd ea	12D	collector	EB	47	35	6157	35.89	5.06	35.79	36.00	35	6116	35.29	5.18	35.18	35.39	-0.61	0.09	-0.76	-0.45	1.05	1.01	1.09
	12D	collector	WB	48	35	6376	35.22	5.12	35.12	35.33	35	6112	34.66	5.22	34.55	34.77	-0.57	0.09	-0.72	-0.42	1.04	0.99	1.08

Table B3. Summary statistics part 2

Street	locID	dir	Class	On Graph	Limit0	N0	mean0	SD0	median0	85%ile0	85%low0	85%up0	pacelow0	paceup0	Limit1	N1	mean1	SD1	median1	85%ile1	85%low1	85%up1	pacelow1	paceup1
Franklin Ave	1A	EB	local	1	30	136	26.63	4.26	26.92	30.85	29.82	32.20	22.00	32.00	20	419	23.52	4.11	23.65	27.52	27.09	27.93	19.00	29.00
	1A	WB	local	2	30	164	26.91	5.11	27.44	31.77	31.02	32.67	24.00	34.00	20	411	22.53	4.24	22.59	27.08	26.82	27.60	19.00	29.00
Westmoreland Dr	1B	EB	local	3	25	209	23.84	3.70	23.85	27.44	26.97	28.31	20.00	30.00	20	471	24.95	4.77	24.95	29.68	29.34	30.18	22.00	32.00
	1B	WB	local	4	25	241	23.21	3.85	23.47	26.81	26.38	27.53	18.00	28.00	20	456	25.60	4.87	25.54	30.76	30.21	31.59	21.00	31.00
Jersey Ave	2A	NB	local	5	30	88	22.55	5.20	22.17	28.04	26.72	29.34	16.00	26.00	20	180	21.83	4.40	21.47	26.37	25.73	27.02	18.00	28.00
	2A	SB	local	6	30	82	22.08	4.77	22.06	26.90	25.54	29.62	17.00	27.00	20	156	21.24	5.07	21.14	26.46	25.53	27.47	16.00	26.00
1st St	3A	NB	local	7	30	105	19.51	3.71	19.74	23.39	22.75	24.23	15.00	25.00	20	176	19.11	5.39	19.19	23.11	22.19	24.17	16.00	26.00
	3A	SB	local	8	30	105	19.26	3.86	19.59	22.79	22.14	24.07	14.00	24.00	20	175	18.06	4.19	18.30	22.28	21.64	22.95	15.00	25.00
Library Ln	3B	EB	local	9	30	384	27.01	5.10	27.70	32.01	31.54	32.59	24.00	34.00	20	645	25.52	5.05	25.49	30.37	30.18	30.81	22.00	32.00
	3B	WB	local	10	30	427	25.95	4.80	26.11	30.33	29.98	31.05	22.00	32.00	20	697	24.94	4.95	25.16	29.63	29.29	30.13	21.00	31.00
33rd St	4Ar	EB	local	11	30	156	23.89	5.95	24.01	29.84	29.40	30.39	18.00	28.00	20	289	26.10	5.98	26.70	31.58	31.12	32.40	23.00	33.00
	4Ar	WB	local	12	30	119	25.32	5.57	25.07	31.05	29.89	32.40	21.00	31.00	20	225	26.73	5.64	26.44	32.27	31.43	33.96	23.00	33.00
Xylon Ave	4B	NB	local	13	30	27	18.96	4.38	18.64	23.38	22.41	26.95	11.00	21.00	20	42	17.75	3.77	16.95	21.94	19.77	24.58	12.00	22.00
	4B	SB	local	14	30	29	19.05	5.12	18.13	23.27	22.61	26.97	12.00	22.00	20	57	19.21	3.57	19.45	22.94	21.52	23.68	15.00	25.00
Lake St (SLP)	5A	EB	local	15	30	509	29.07	5.21	29.45	33.63	33.31	34.23	25.00	35.00	20	1059	29.58	5.22	29.92	34.37	34.18	34.69	26.00	36.00
	5A	WB	local	16	30	484	28.43	5.20	28.47	33.31	32.84	33.89	25.00	35.00	20	952	27.15	5.05	27.12	32.49	32.08	32.84	23.00	33.00
Lake St (Hopkins)	5B	EB	local	17	30	571	28.09	4.81	28.44	32.78	32.40	33.21	25.00	35.00	30	1041	26.97	5.17	27.07	32.07	31.59	32.42	22.00	32.00
	5B	WB	local	18	30	501	27.65	5.51	27.93	32.46	32.07	33.07	24.00	34.00	30	948	26.39	5.32	26.45	31.49	31.10	31.96	22.00	32.00
I394 Frontage	6A	EB	collector	19	30	1660	33.60	6.07	34.39	39.25	38.95	39.44	31.00	41.00	25	3834	27.34	4.30	27.65	31.33	30.98	31.33	24.00	34.00
	6A	WB	collector	20	30	1787	32.00	5.46	32.40	37.16	36.87	37.36	29.00	39.00	25	4098	31.95	5.31	32.21	37.24	37.01	37.41	28.00	38.00
Zarthan Ave	6B	NB	collector	21	30	1779	28.51	4.86	29.00	33.03	32.84	33.23	25.00	35.00	25	3946	28.37	4.69	28.85	32.72	32.59	32.92	25.00	35.00
	6B	SB	collector	22	30	1674	27.20	4.38	27.52	31.19	31.02	31.43	24.00	34.00	25	3728	26.65	4.30	26.92	30.76	30.59	30.93	23.00	33.00
W 28th St	8A	EB	collector	23	30	891	29.81	5.15	30.31	34.72	34.31	35.22	27.00	37.00	25	1825	26.13	3.91	26.29	29.90	29.73	30.15	22.00	32.00
	8A	WB	collector	24	30	839	29.85	5.51	30.56	34.98	34.59	35.49	27.00	37.00	25	1699	30.19	5.69	30.61	35.87	35.64	36.13	27.00	37.00
W28th St	8B	EB	collector	25	30	539	27.29	4.86	27.95	31.76	31.38	32.08	24.00	34.00	20	1172	24.05	4.21	23.87	27.78	27.53	28.13	19.00	29.00
	8B	WB	collector	26	30	601	27.97	4.77	28.33	32.51	32.14	33.05	25.00	35.00	20	1239	27.72	5.13	28.02	32.59	32.34	32.82	25.00	35.00
Louisiana Ave	9A	NB	collector	27	30	2628	32.86	4.14	32.76	36.87	36.37	37.06	29.00	39.00	30	2773	33.21	4.20	33.09	37.04	36.82	37.29	29.00	39.00
	9A	SB	collector	28	30	2880	33.79	3.87	33.69	37.39	37.24	37.56	30.00	40.00	30	2898	33.04	4.60	33.05	37.34	37.06	37.54	29.00	39.00
Texas Ave	9B	NB	collector	29	30	915	32.34	3.89	32.61	36.06	35.80	36.41	29.00	39.00	25	1409	32.54	4.48	33.25	37.09	36.82	37.54	29.00	39.00
	9B	SB	collector	30	30	1075	33.22	3.98	33.25	37.09	36.82	37.54	29.00	39.00	25	1358	32.44	4.19	32.44	36.41	36.13	36.72	29.00	39.00
France Ave	10A	NB	collector	31	30	1561	32.85	4.86	32.88	37.31	36.99	37.64	29.00	39.00	25	3348	32.03	4.65	31.99	36.65	36.39	36.92	28.00	38.00
	10A	SB	collector	32	30	1739	32.84	4.48	32.95	37.24	36.97	37.49	29.00	39.00	25	3956	25.81	3.35	25.79	28.70	28.56	28.81	22.00	32.00
W 26th St	10B	EB	collector	33	30	1224	29.83	4.98	30.26	34.27	33.98	34.59	27.00	37.00	20	2315	27.84	5.65	28.84	33.03	32.88	33.25	26.00	36.00
	10B	WB	collector	34	30	1253	30.67	5.18	31.05	35.46	35.20	35.76	27.00	37.00	20	2129	27.77	5.75	28.52	33.33	33.09	33.59	25.00	35.00
Walker St	11A	EB	collector	35	30	1949	33.54	3.85	33.53	37.39	37.14	37.61	30.00	40.00	25	3971	33.27	3.86	33.27	36.97	36.84	37.11	29.00	39.00
	11A	WB	collector	36	30	1585	31.48	4.73	31.58	36.08	35.83	36.32	28.00	38.00	25	3423	31.13	4.47	30.98	35.28	35.37	35.76	27.00	37.00
W 36th St	11Br	EB	collector	37	30	2361	35.27	4.10	35.11	39.30	39.14	39.67	31.00	41.00	25	4729	35.48	4.41	35.37	39.87	39.67	40.09	32.00	42.00
	11Br	WB	collector	38	30	2288	34.93	4.62	34.72	39.47	39.17	39.78	31.00	41.00	25	4658	29.39	4.25	29.00	32.61	32.49	32.78	25.00	35.00
Alabama Ave	11C	NB	collector	39	30	1656	27.03	4.05	27.10	30.80	30.62	31.03	24.00	34.00	25	1167	29.03	4.36	29.19	33.17	32.82	33.51	26.00	36.00
	11C	SB	collector	40	30	1314	26.35	3.63	26.48	29.80	29.62	30.05	22.00	32.00	25	2598	24.61	3.23	24.67	27.74	27.63	27.89	20.00	30.00
Brookside Ave	11D	NB	collector	41	30	685	26.28	3.90	26.31	30.02	29.75	30.44	22.00	32.00	20	1434	25.99	3.66	26.17	29.39	29.23	29.60	22.00	32.00
	11D	SB	collector	42	30	650	26.40	3.46	26.54	29.76	29.45	30.13	22.00	32.00	20	1388	25.97	4.06	26.29	29.95	29.63	30.21	22.00	32.00
Cedar Lake west	12Ar	EB	collector	43	35	4808	33.80	4.65	34.16	38.07	37.92	38.18	31.00	41.00	30	5087	30.80	6.41	30.07	37.74	37.56	37.92	25.00	35.00
	12Ar	WB	collector	44	35	4269	34.16	4.51	34.42	38.15	38.05	38.31	31.00	41.00	30	4453	33.61	4.80	33.96	37.92	37.76	38.12	30.00	40.00
Cedar Lake Rd east	12B	EB	collector	45	35	5082	34.85	3.99	34.91	38.57	38.41	38.68	31.00	41.00	30	5242	34.20	3.96	34.21	37.87	37.74	38.02	30.00	40.00
	12B	WB	collector	46	35	5025	35.12	3.94	35.20	38.76	38.60	38.95	31.00	41.00	30	5478	34.60	4.18	34.61	38.47	38.31	38.63	31.00	41.00
Minnetonka Blvd w	12D	EB	collector	47	35	6157	35.89	5.06	36.20	40.12	40.01	40.30	33.00	43.00	35	6116	35.29	5.18	35.76	39.70	39.59	39.84	32.00	42.00
	12D	WB	collector	48	35	6376	35.22	5.12	35.69	39.61	39.50	39.75	32.00	42.00	35	6112	34.66	5.22	35.13	39.06	38.92	39.25	31.00	41.00