Project Benefit Report

2019 Rochester TH 14 and 19th Street Signal Optimization

Minnesota Department of Transportation – District 6

SRF Consulting Group, Inc. | Engineers Planners Designers

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SRF No. 12176

Project Benefit Report

2019 Rochester TH 14 and 19th Street Signal Optimization

Report Certification:

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

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Signature	Date

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Project Summary

SRF Consulting Group, Inc. was tasked by the Minnesota Department of Transportation (MnDOT) with providing updated signal timing for two corridors in Rochester. The project involved developing and implementing new optimized coordinated signal timing plans for 11 intersections across three corridors, including:

- **Group 1**: TH 52 interchange with 19th St, including the interchange and frontage roads to the east and west (3 intersections)
- **Group 2**: TH 14 from Memorial Pkwy to 15th Ave, plus the Crossroads Dr access to Hy-Vee (8 intersections)

While the signal at the Crossroads Rd access to Hy-Vee was not included in the original scope of work, additional benefit was expected to be achieved by evaluating coordination at this intersection. Therefore, it was included in the implemented timing plans and is included for evaluation in this report.

The goal of this project was to improve mainline progression and travel times while minimizing stops and side street delay.

Throughout this report, the phrase "Before" describes traffic conditions with the signal timing plans in place along the corridor prior to this project. The phrase "After" describes traffic operations with the new signal timing plans implemented and field fine-tuned.

Table 1 summarizes the project benefit based on Synchro/SimTraffic modeling results. The optimized timing plans resulted in a reduction in delay, stops and fuel consumption. Comparing these benefits to the cost of implementation, the project delivered a one-year benefit-cost ratio of 72:1. Signal timing plans have a shelf life of three to five years, after which point the need for coordination updates should be evaluated.

Table 1. One-Year Project Benefit Summary

MOE	Before	After	Change	% Change
Delay (hours)	657,641	508,899	-148,742	-23%
Stops	52,168,594	45,480,494	-6,688,100	-13%
Fuel Consumption (gal.)	1,535,522	1,400,547	-134,975	-9%
Emissions (kg)	391,149	371,037	-20,112	-5%

Background

Trunk Highway (TH) 52 is a principal arterial connecting Rochester to the Twin Cities metro area to the north, and Interstate 90 to the south. The TH 52 interchange with 19th Street is configured as a Single-Point Urban Interchange (SPUI).

TH 14 is a principal arterial which connects Rochester regionally to areas to the east and west. Within the project area, TH 14 is a four-lane divided roadway, with turn lanes at intersections. TH 14 contains an urban cross-section from the west end of the project throughout most of the corridor, but transitions to a rural cross-section east of 11th Ave.

The project included the signalized intersections at and adjacent to the 19th St SPUI, as well as along TH 14 from Memorial Pkwy to 15th Ave. The signalized project intersections are listed in Table 2 and Table 3.

Table 2. Signalized Intersections – TH 52 & 19th Street

No.	Intersection
1	19th Street and West Frontage Road
2	TH 52 and 19th Street SPUI
3	19th Street and East Frontage Road

Table 3. Signalized Intersections – TH 14

No.	Intersection
1	TH 14 and Memorial Pkwy
2	TH 14 and Crossroads Rd
3	Crossroads Rd and Hy-Vee Driveway
4	TH 14 and Broadway
5	TH 14 and 3rd Ave
6	TH 14 & 8th Ave
7	TH 14 & 11th Ave
8	TH 14 & 15th Ave

"Before" Conditions

Turning Movement Counts

Associated Consulting Services, LLC collected turning movement counts at all project intersections on Tuesday, October 23, 2018. Counts were collected from 6:00 a.m. to 6:00 p.m. Heavy vehicle volumes, in addition to pedestrian and bicycle volumes, were collected as part of the counts.

Daily Volume Profiles

Associated Consulting Services, LLC also collected continuous roadway volume data at one location on each corridor. These data identified directional volumes in 15-minute intervals for a weekday and Saturday. The weekday counts were collected on October 23 while the Saturday counts were collected November 10, 2018.

Signal Timing Data

Existing signal timing data for the project intersections were provided by MnDOT, primarily in a scanned PDF format. Existing timings were verified by uploading controller databases prior to implementation.

Table 4 and Table 5 provide a summary of the signal operation of each intersection under the before conditions. The table notes whether each signal operated in coordination (or Free) and where there are special operating considerations, such as Flashing Yellow Arrow (FYA) left turn operations.

Table 4. Existing Signal Operation Summary – TH 52 & 19th Street

No.	Intersection	Existing Operation	Operation Notes
1	19th Street and West Frontage Road	Coord	
2	TH 52 and 19th Street SPUI	Coord	
3	19th Street and East Frontage Road	Coord	

Table 5. Existing Signal Operation Summary – TH 14

No.	Intersection	Existing Operation	Operation Notes
1	TH 14 and Memorial Pkwy	Free	
2	TH 14 and Crossroads Rd	Free	
3	Crossroads Rd and Hy-Vee Driveway	Free	
4	TH 14 and Broadway	Coord	Coord w/ Broadway Corridor
5	TH 14 and 3rd Ave	Free	FYA
6	TH 14 & 8th Ave	Free	FYA
7	TH 14 & 11th Ave	Free	FYA
8	TH 14 & 15th Ave	Free	FYA

Synchro/SimTraffic Model Setup

Synchro/SimTraffic, version 9, was used to model Before conditions. Models were created by SRF Consulting Group and included observed geometry, volumes and timings under the Before conditions. One Synchro model was created for each of the three coordinated timing plans in use at the TH 52/19th St interchange, concurrent with AM, Midday, and PM peak hour volumes. One model was created for each of the AM, Midday and PM peak hours along TH 14, where the Before conditions consisted primarily of free operations.

These Synchro/SimTraffic models were used in developing the new optimized signal timing plans. They also were used to establish a baseline in determining the benefit of the project in terms of reduced delay, stops, and fuel consumption.

Modeled Traffic Volumes

The set of turning movement volumes used for the peak hour Synchro/SimTraffic models were developed using the following process:

1. For each corridor, the AM, Midday and PM peak hour periods were identified.
2. Peak Hour Factors and Heavy Vehicle Percentages were identified for each movement at each intersection during each peak hour.

3. Volumes were adjusted to address volume imbalances between intersections. The primary adjustment was to mainline volumes, with secondary adjustments applied to turning movements where appropriate. The goal with the balancing process was to identify locations where vehicular queuing may be impacting balance and to adjust the counts to reflect true demand as opposed to vehicles served. Unsignalized intersections with large source/sink volumes were included in the models as needed. Specifically, the unsignalized intersection of TH 14 and the TH 52 NB On Ramp was included to improve the ability of the model to properly model imbalanced lane usage on the westbound approach to the Memorial Pkwy intersection.

"After" Conditions

YARP Updates

Although the development of new Yellow, All Red, Walk and Don't Walk signal timing parameters (collectively referred to as YARP timing, for **Y**ellow, **A**ll-**R**ed, and **P**edestrian) was not included in the scope of services for this project, observation of existing conditions led to one recommendation: to increase the All-Red intervals at the TH 52/19th St SPUI to align with the recommended practices from ITE and MnDOT. The updated All-Red intervals were included in the final timing plans and implemented concurrently.

Optimized Timing Plan Development

Number of Timing Plans

The first step in developing the proposed timing plans was to determine the total number of plans needed. Based on a review of the turning movement count data, 24-hour count data and field observations of the corridors, a menu of timing plans was devised for each corridor to handle the typical range of traffic patterns experienced.

The timing plans were numbered per the following MnDOT standard numbering scheme:

Table 6. Standard Timing Plan Numbering Scheme

Pattern	Timing Plan / Peak Period
1	Free
2	AM Off Peak
3	AM Peak
4	Midday/Balanced Off Peak
5	Midday/Balanced Peak
6	PM Off Peak (Mid)
7	PM Peak
8	PM Off Peak (Low)

For the TH 52/19th St corridor, three timing plans (Plans 3, 5, and 7) were recommended. On TH 14, four plans (Plans 3, 4, 5, and 7) were identified to manage traffic throughout the course of a typical week.

Synchro/SimTraffic 9, along with proprietary spreadsheet tools and engineering experience and judgement were then used to develop and optimize the proposed signal timing plans for each corridor and each time period as described in detail below.

3+2n Splits

Synchro tends to balance overall network delay by assigning more split time to side streets when optimizing phase splits. Therefore, initial green time splits (used in the determination of cycle lengths) were developed using MnDOT's critical lane analysis (3+2n) procedure adapted from the Highway Capacity Manual. In general, the 3+2n procedure initially gives minimum required split time (after accounting for lost time, number of lanes, vehicle headways, and other factors) to non-coordinated phases and any resulting extra time to the coordinated phases.

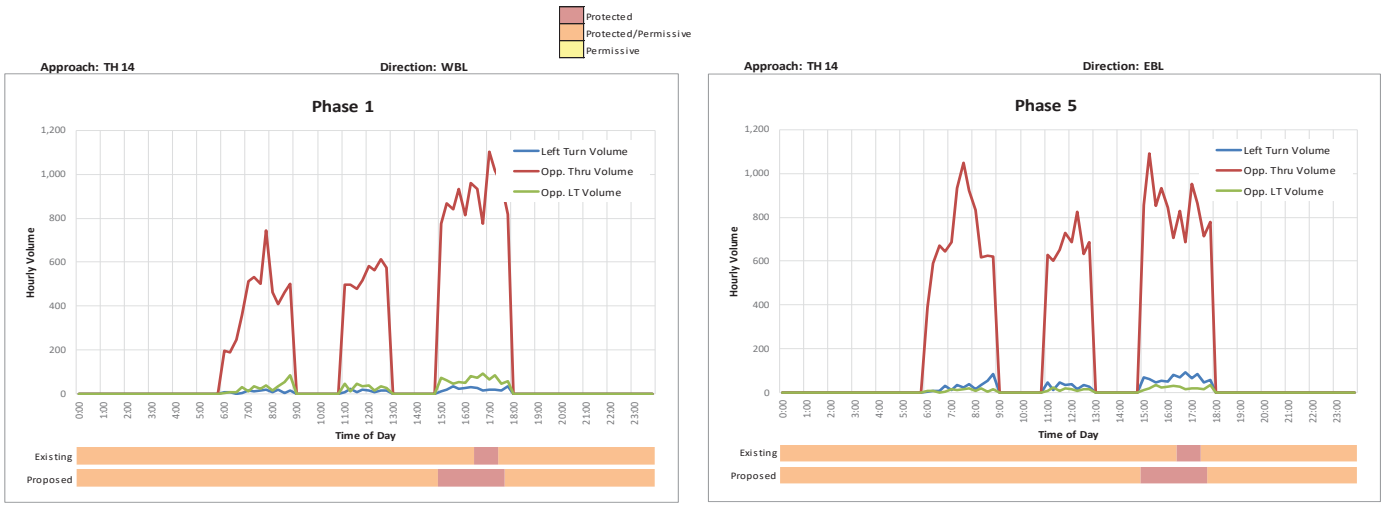
Flashing Yellow Arrow Left Turn Phasing Mode Evaluation

For each of the project intersections with Flashing Yellow Arrow (FYA) indications, the collected traffic volume data, along with the posted speed limit, number of turn lanes, available sight distance, and operational observations, were analyzed to determine which left turn phasing mode would be most appropriate for each of the proposed timing plans. The evaluation was completed to eliminate phases that were not warranted, allowing for shorter cycle lengths and reduced delay. The analysis was performed in accordance with Exhibits 4-6 and 4-7 of the 2015 MnDOT Signal Timing and Coordination Manual.

For this project, the intersections and movements where left turn phasing was evaluated, along with the resulting phasing decisions implemented, are shown on Figure 1 (parts a – b). On Figure 1, each chart corresponds to one FYA left turn movement. The line graphs at the top show hourly volumes for the left turn movement, opposing through movement, and opposing left turn movement over the course of an average weekday. The shaded bars at the bottom show the previous and current FYA decisions.

TH 14 & 3rd Ave

TH 14 & 8th Ave



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SRF

FYA Decisions

2019 Rochester TH 14 and TH 52 Signal Optimization

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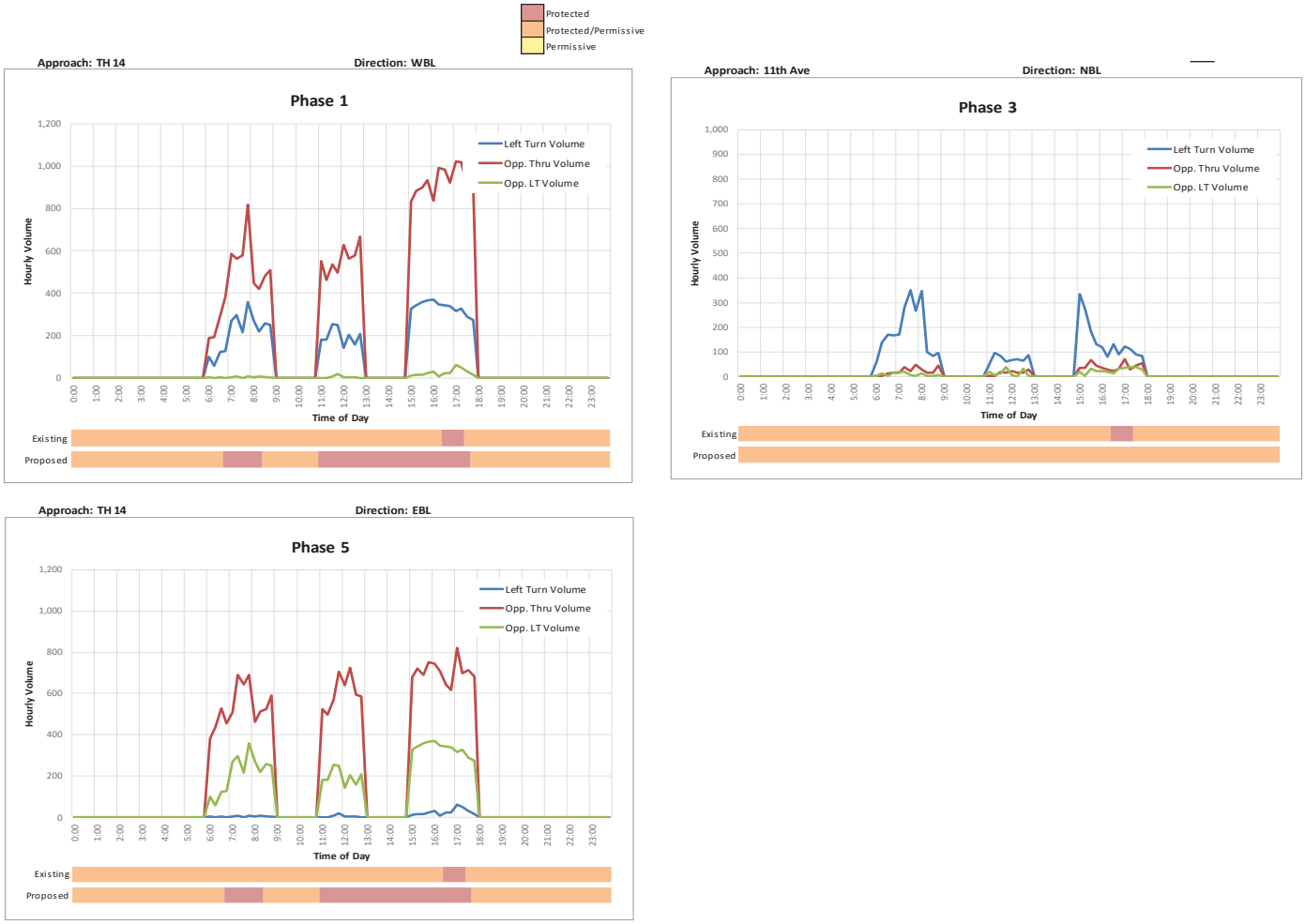
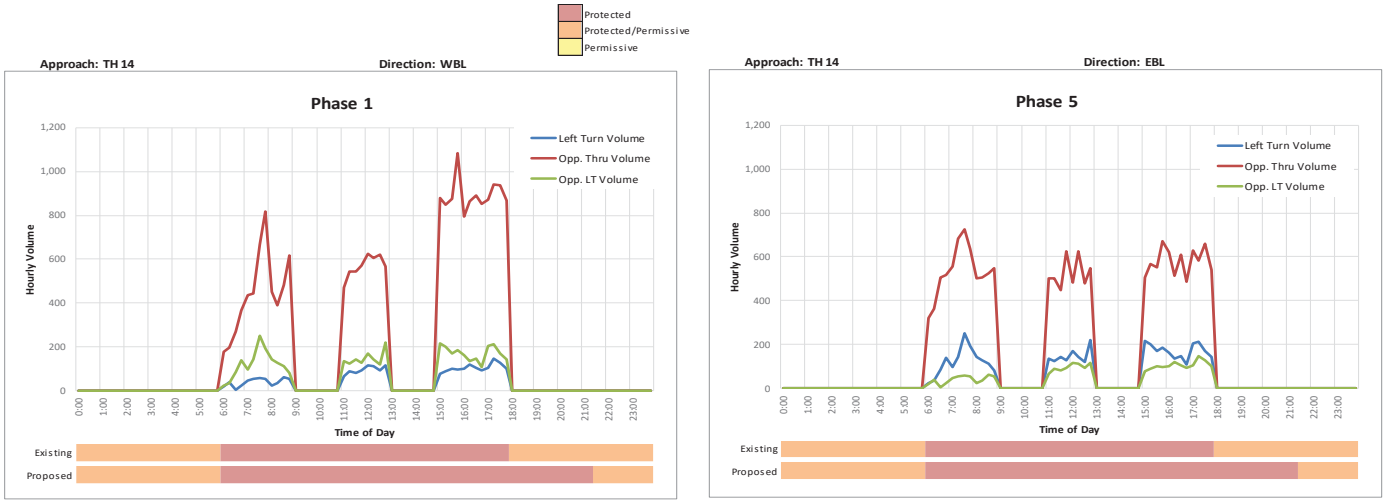
Figure 1a

TH 14 & 11th Ave



TH 14 & 15th Ave



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SRF

FYA Decisions

2019 Rochester TH 14 and TH 52 Signal Optimization

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Figure 1b

Cycle Lengths

After a plan for left-turn phasing for FYA movement by time of day was devised, cycle lengths for each timing plan were determined. Multiple cycle lengths (including half-cycles) were evaluated for each timing plan. The cycle lengths chosen for evaluation were based on field observations of the existing timing plans. The process for evaluation of the cycle length options was as follows:

1. A Synchro model was developed for each cycle length. Cross coordinated was ignored for this step.
2. 3+2n splits were calculated for each intersection. The use of 3+2n splits improves the ability to identify the optimal cycle for two-way progression.
3. At overcapacity intersections, splits were assigned to minimize delay and queuing.
4. Two-way progression was optimized in Synchro, using primarily manual methods to adjust offsets and phase sequences.
5. Synchro and SimTraffic MOEs (MOEs including delay, stops, and fuel consumption) were reviewed, and an optimization of time-space diagrams was performed (manually, with review of initial input from Synchro) to determine which cycle length would provide optimal performance, especially in terms of two-way mainline progression. Each timing plan was also reviewed to determine if splitting the corridor into two or more parts with different cycle lengths would be optimal.
6. Once a mainline cycle length(s) was selected, cross coord intersections were reviewed to determine appropriate cycle length. Full and half cycles were reviewed, and Free operation was also evaluated.

The cycle lengths chosen for each plan are shown in Table 7.

Table 7. Cycle Lengths

Corridor	Plan 2	Plan 3	Plan 4	Plan 5	Plan 6	Plan 7	Plan 8
TH 52 & 19th Street	-	100	-	90	-	100	-
TH 14	-	110	90	110	-	140	-

Offsets, Phase Order

After a final set of mainline and cross-coord cycle lengths was chosen for each timing plan, further optimization of phase order and offsets was performed through manual inspection of the time-space diagram in Synchro. The Phase order selections utilized full functionality of FYA intersections, including lead-lead, lag-lag, and lead-lag phasing.

Revised Splits

After identifying optimal progression patterns (offsets and phase order) with 3+2n splits, splits were re-adjusted to provide additional (spare/cushion) split time to the non-coordinated movements where providing that time would not interfere with progression.

Splits and Pedestrians

Where split times are less than the required minimum to accommodate pedestrian phases, a pedestrian call placed via pushbutton will result in longer than programmed green time splits to cover the required Walk and Flashing Don't Walk times, followed by a period of transition where splits are shortened in order to return to coordinated operation.

At intersections with considerable pedestrian volumes, splits were increased to more fully accommodate pedestrian requirements if possible. Although most splits were not extended to fully cover the pedestrian need, providing some additional split time does help to reduce the amount of time spent in transition after a pedestrian call, in turn reducing delay due to mainline.

Time-Of-Day Schedules

After the timing plans were complete, time-of-day (TOD) schedules were developed for each corridor. The process for developing the schedules was as follows:

1. Determine the time periods for which the AM and PM peak timing plans (if applicable) are required, by comparing peak hour and peak 15-minute volumes to volumes just outside the peak hours, and by considering field observations of existing timing plans.
2. Determine the time periods for which the short cycle plans can operate by considering field observations and by evaluating performance in Synchro with varying growth factors.
3. Fill in any gaps with the remaining timing plans. Require each timing plan to run for at least 30 minutes to reduce the impact of transition between plans. Consider the rate at which volumes are changing. For example, in the AM peak, traffic volumes increase quickly, making it more difficult to use multiple timing plans.
4. Review TOD schedule decisions with volume data from multiple locations along the corridor. Revise as needed for each segment of the corridor.

The resulting TOD schedules for each corridor, shown as colored columns for each timing plan and overlaid with the daily traffic volume line graphs, are shown in Figure 2 and Figure 3.

Figure 2. Weekday Time of Day Schedule – TH 52 & 19th Street

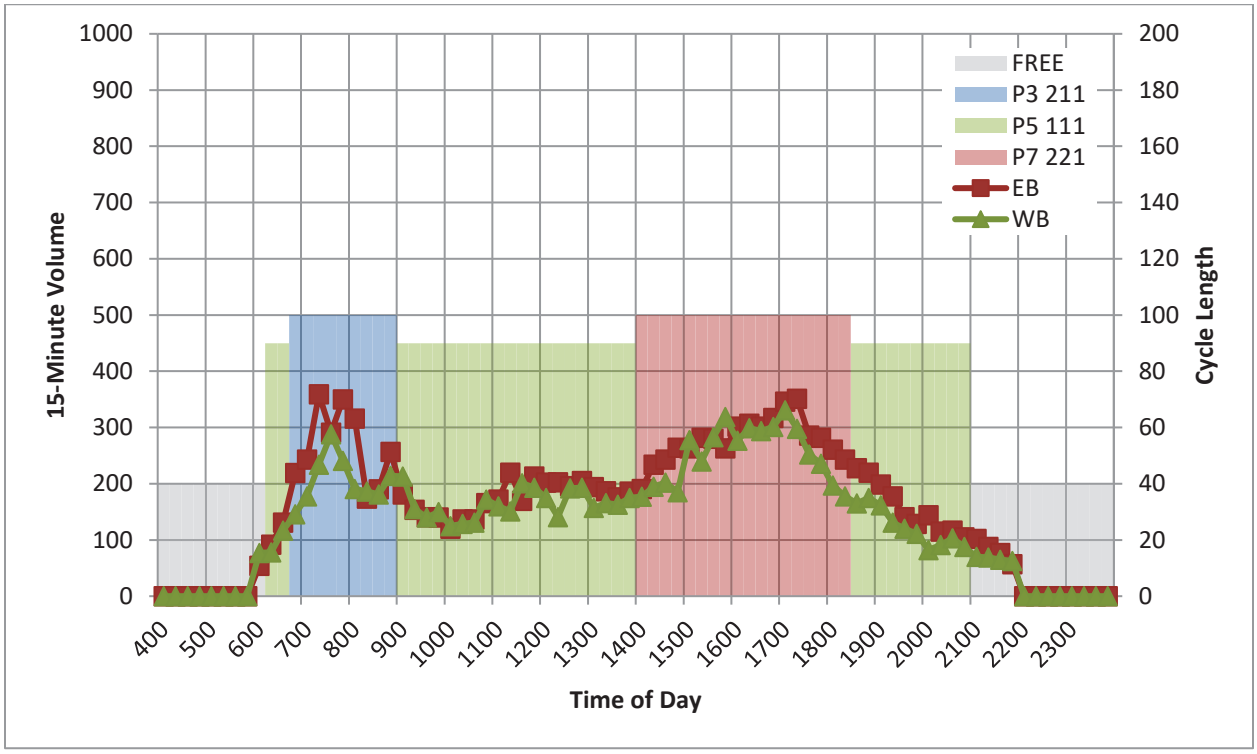
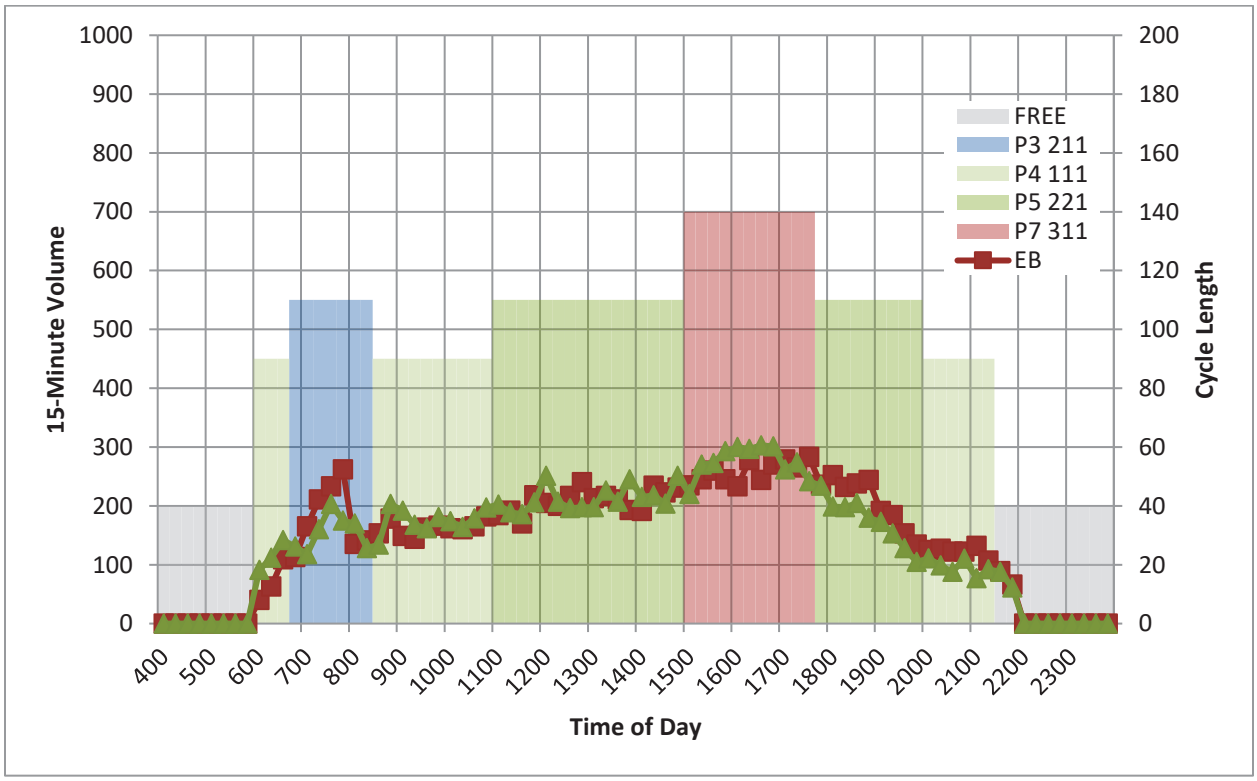


Figure 3. Weekday Time of Day Schedule – TH 14



Timing Plan Implementation

The optimized signal timing plans were implemented and field fine-tuned by SRF on May 14, 15, and 16, 2019. The fine-tuning effort consisted of verifying correct operation and performing additional observations to determine where split, offset or phase order changes could be made to further improve operations based on observed traffic flows. Initial timing plans were entered and downloaded via TACTICS software at the City of Rochester Public Works office. Fine-tuning changes were input via a mix of controller front panel entry in the field and TACTICS entry at the Public Works office. Observations gathered and adjustments made during implementation included:

TH 52 & 19th Street

- A very short and very steep 15-minute traffic volume spike was observed during the AM peak. Split time was increased for the southbound off ramp for AM plan to better accommodate the observed flows.
- The 90-second Midday plan works well for most of the day outside the peak hour in the AM and the peak two hours in the PM.
- Several small split changes were made during the PM peak.

TH 14

- Most cycle lengths worked well across the corridor. The 90-second cycle (Plan 4) worked well except at TH 14/Broadway where traffic was near capacity with this short cycle. TOD schedules were adjusted to reduce the amount of time this plan is in effect. Utilization of this plan could be reduced further if issues are observed.
- The TOD schedule was adjusted to start the PM peak plan at 3:00 p.m. in order to be fully transitioned before the onset outbound traffic from Mayo High School.
- Storage becomes an issue for the northbound approach at Crossroads as cycle lengths increase beyond 120 seconds. The PM 140-second cycle works well, but some queues back to Hy-Vee signal were observed. The Hy-Vee signal runs at a half cycle length with Phase 4 (SB) as the coordinated phase to minimize issues caused by blocking and to prevent increased blocking. The offset at the Hy-Vee signal is configured so that the eastbound left turn at Hy-Vee starts at the same time or slightly later than the northbound left turn starts at the main Crossroads intersection, allowing eastbound traffic at Hy-Vee to progress through both signals.
- Additional revisions to the flashing yellow arrow time-of-day schedule were made as part of a separate trip the week of June 23. The changes involved changing from Protected Only to Protected-Permissive operation for some of the shoulder time periods to make left turn operation less restrictive. The changes were prompted based on MnDOT observations of the corridor.

The final field implemented signal timing plans (Signal Timing Settings Book) can be found in the Appendix. This reference includes complete detail on final coordinated timing plan parameters and time of day schedule.

Before/After Comparison

Level of Service

A capacity analysis was completed in Synchro/SimTraffic for the relevant peak hours on each corridor. The results identify a Level of Service (LOS), which indicates the quality of traffic flow through an intersection. Intersections are given a ranking from LOS A through LOS F. The LOS results are based on average delay per vehicle, which correspond to the delay threshold values shown in Table 8. LOS A indicates the best traffic operation, with vehicles experiencing minimal delays. LOS F indicates an intersection where demand exceeds capacity, or a breakdown of traffic flow. An overall LOS A through D is generally considered acceptable by drivers on facilities similar to those included in this project.

Table 8. Level of Service Criteria for Signalized Intersections

Level of Service	Average Delay/Vehicle (sec.)
A	≤ 10
B	> 10 – 20
C	> 20 – 35
D	> 35 – 55
E	> 55 – 80
F	> 80

Source: Highway Capacity Manual, 2010 Edition.

Table 9 and Table 10 summarize the results of the Before vs. After Level of Service analysis. All study intersections operate at LOS D or better throughout the day. In most cases, the Before and After LOS are either the same or separated by a single letter grade, indicating that the optimized timing plans provided incremental improvement. At no location was the LOS worse in the After conditions than the Before conditions.

Table 9. Before/After Level of Service Comparison – TH 52 &19th Street

No.	Intersection Name	AM Peak	Midday Peak	PM Peak
1	19th Street and West Frontage Road	B/B	B/B	C/C
2	TH 52 and 19th Street SPUI	C/C	B/B	C/C
3	19th Street and East Frontage Road	C/C	C/C	C/C

Key:
Before LOS/After LOS.
Changes in LOS are **bolded**.

Table 10. Before/After Level of Service Comparison – TH 14

No.	Intersection Name	AM Peak	Midday Peak	PM Peak
1	TH 14 and Memorial Pkwy	**C/B**	C/C	C/C
2	TH 14 and Crossroads Rd	A/A	B/B	B/B
3	Crossroads Rd and Hy-Vee Driveway	B/B	**B/A**	**B/A**
4	TH 14 and Broadway	**D/C**	D/D	D/D
5	TH 14 and 3rd Ave	C/C	C/C	**D/C**
6	TH 14 & 8th Ave	B/B	**B/A**	C/C
7	TH 14 & 11th Ave	C/C	B/B	**D/C**
8	TH 14 & 15th Ave	**D/C**	C/C	D/D

Key:
Before LOS/After LOS.
Changes in LOS are **bolded**.

Coordination Performance Measures

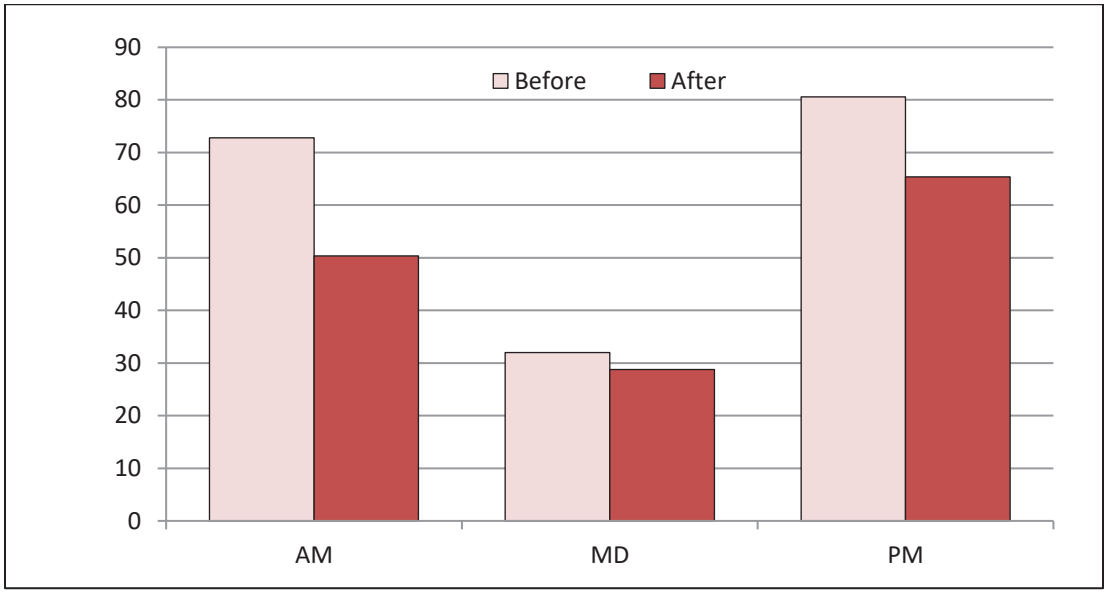
The Before and After Synchro/SimTraffic models for each of the timing plans were compared to determine the impact the project had on delay, stops, fuel consumption and emissions. For the AM and PM peak timing plans (Plans 3 and 7), SimTraffic was used to account for unbalanced lane usage, overcapacity movements, long queues, and upstream queue impacts. Five runs were averaged for each SimTraffic analysis. The daily Synchro/SimTraffic results comparisons are illustrated in Figure 4 - Figure 11.

Volume factors were developed to convert the results of the Synchro/SimTraffic hourly models to a daily value. These factors were developed by dividing the total daily volume served by the timing plan by the volume served during the Synchro/SimTraffic analysis periods.

Annual measures of effectiveness were derived from the daily results by multiplying by 250, or the approximate number of weekdays in a year. The resulting annual measures of effectiveness reported should therefore be considered conservative because they do not account for benefits accrued during weekday off-peak times and on weekends.

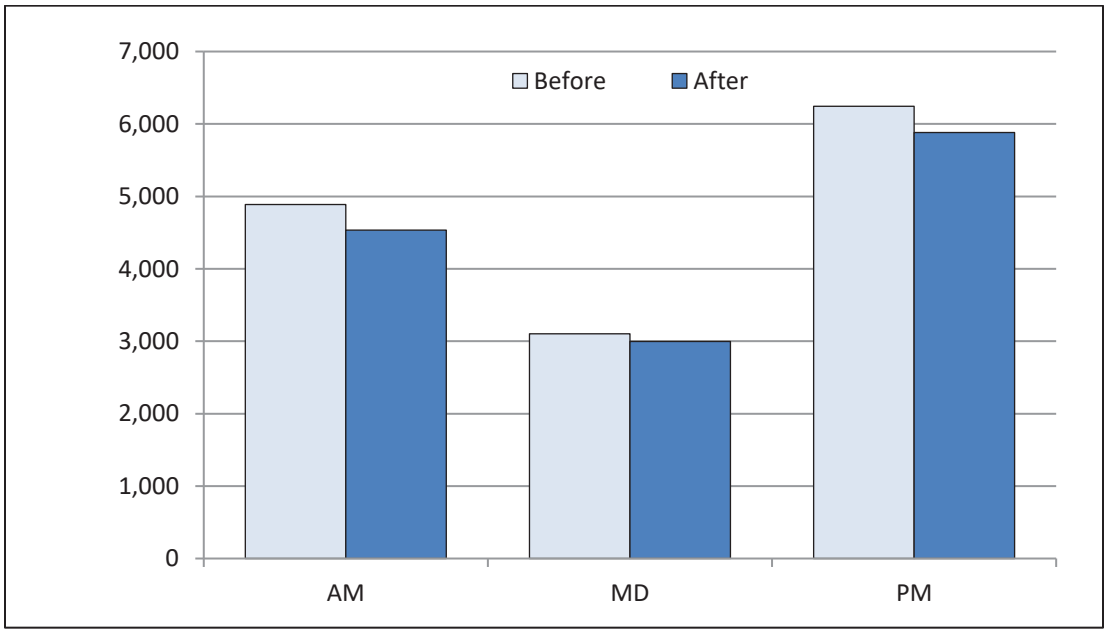
Daily and annual before/after summaries are shown in Table11 and Table 12 below.

Figure 4. Before/After Delay Comparison – TH 52 & 19th Street



Delay (in hours), per weekday, by peak hour.

Figure 5. Before/After Stops Comparison – TH 52 & 19th Street

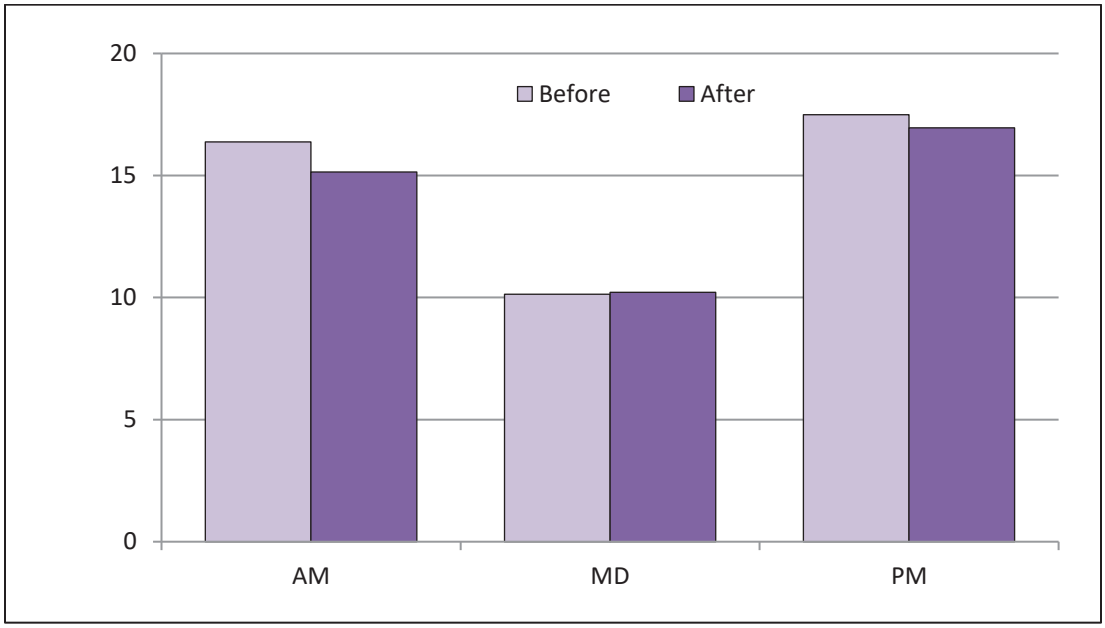


Stops, per weekday, by peak hour.

Figure 6. Before/After Fuel Consumption Comparison – TH 52 & 19th Street

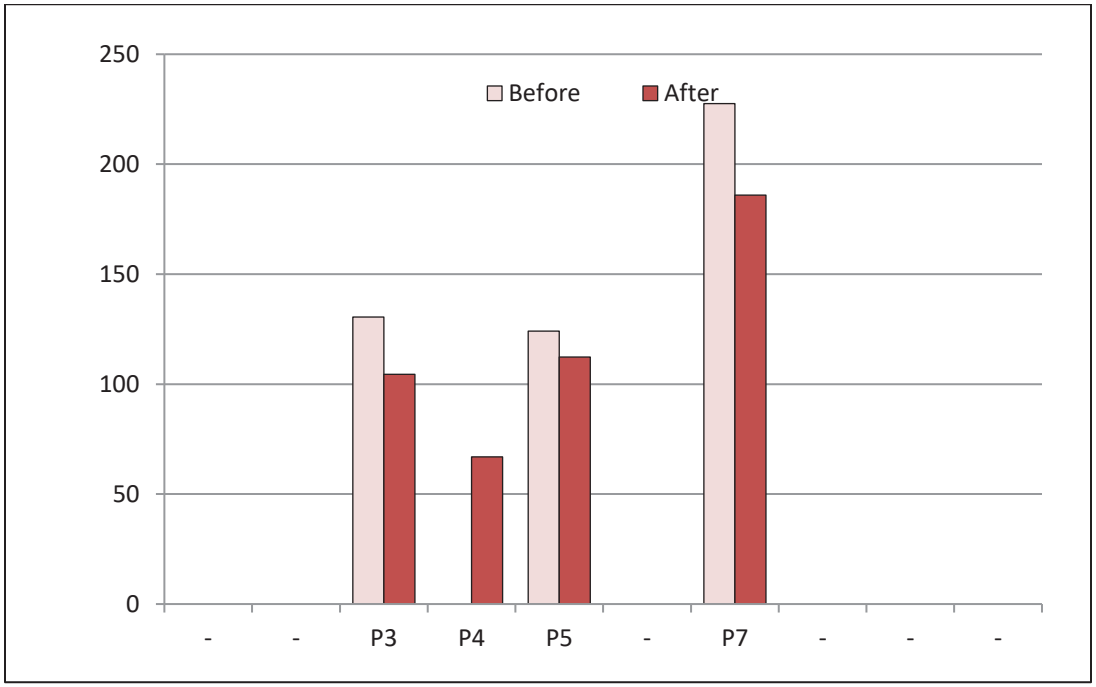
Fuel consumption (in gallons), per weekday, by peak hour.

Figure 7. Before/After Emissions Comparison – TH 52 & 19th Street



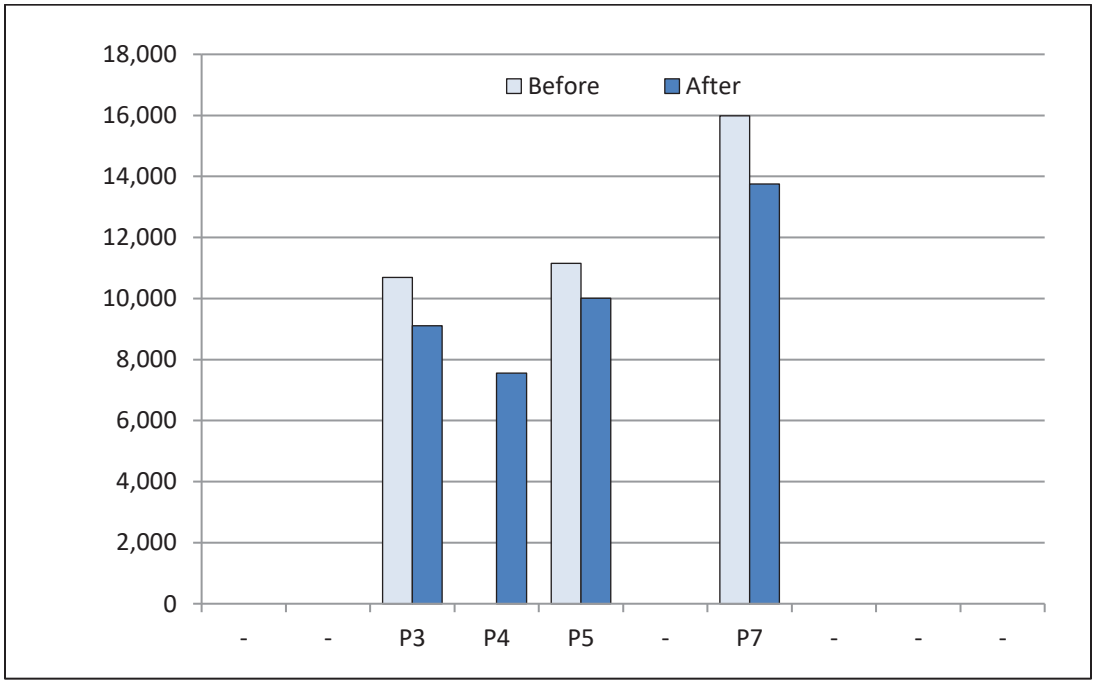
Fuel consumption (in gallons), per weekday, by peak hour.

Figure 8. Before/After Delay Comparison – TH 14



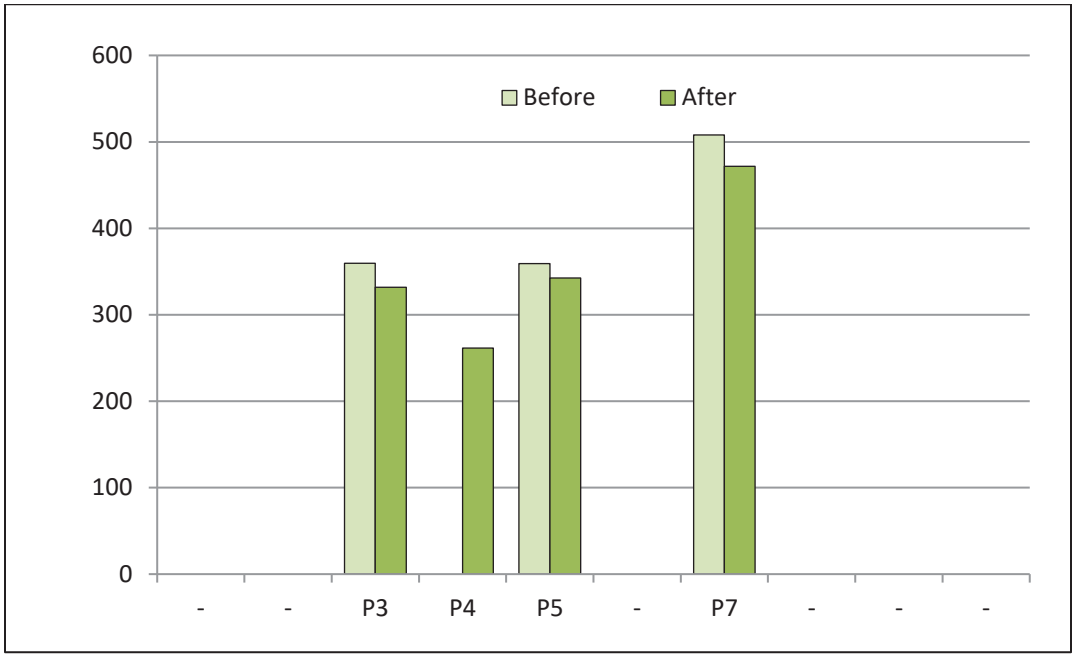
Delay (in hours), per weekday, by peak hour.

Figure 9. Before/After Stops Comparison – TH 14



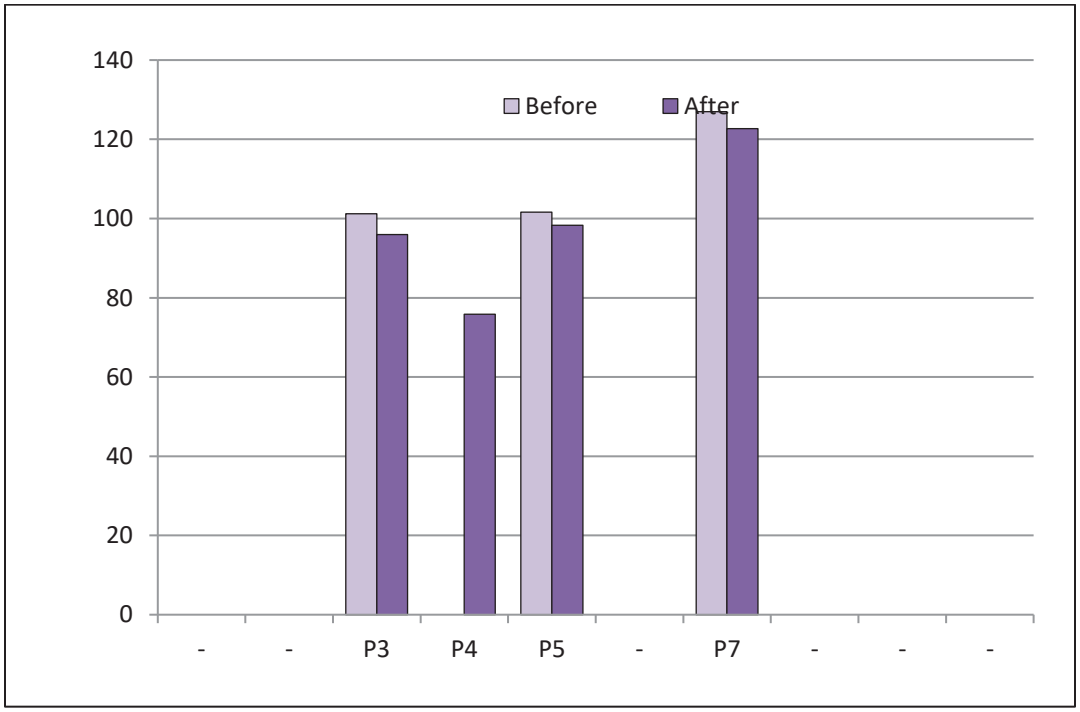
Stops, per weekday, by peak hour.

Figure 10. Before/After Fuel Consumption Comparison – TH 14



Fuel consumption (in gallons), per weekday, by peak hour.

Figure 11. Before/After Emissions Comparison – TH 14



Fuel consumption (in gallons), per weekday, by peak hour.

Table 11. Synchro/SimTraffic Before/After Comparison – TH 52 & 19th Street

		Before	After	Change	% Change
Weekday	Delay (hours)	568	455	-114	-20%
	Stops	45,300	42,850	-2,450	-5%
	Fuel (gal.)	853	796	-56	-7%
	Emissions (kg)	139	135	-4	-3%
Annual	Delay (hours)	142,119	113,643	-28,476	-20%
	Stops	11,325,123	10,712,605	-612,518	-5%
	Fuel (gal.)	213,190	199,122	-14,067	-7%
	Emissions (kg)	34,717	33,714	-1,003	-3%

Table 12. Synchro/SimTraffic Before/After Comparison – TH 14

		Before	After	Change	% Change
Weekday	Delay (hours)	2,062	1,581	-481	-23%
	Stops	163,374	139,072	-24,302	-15%
	Fuel (gal.)	5,289	4,806	-484	-9%
	Emissions (kg)	1,426	1,349	-77	-5%
Annual	Delay (hours)	515,521	395,256	-120,266	-23%
	Stops	40,843,471	34,767,889	-6,075,582	-15%
	Fuel (gal.)	1,322,333	1,201,425	-120,908	-9%
	Emissions (kg)	356,432	337,323	-19,109	-5%

Benefit/Cost Analysis

Benefits

The reduction in delay, stops, fuel consumption, and emissions calculated from Synchro/SimTraffic were converted to dollar benefits in order to derive an overall project benefit/cost ratio. The dollar values used for each measure of effectiveness were as follows:

- The cost per hour of delay was obtained from the Benefit-Cost Analysis Standard Value Tables, 2019[1].
- The cost per stop was obtained from FHWA's Life-Cycle Cost Analysis in Pavement Design, published as NCHRP Report 133[2], adjusted for inflation[3].
- The cost per gallon of gasoline was obtained from the Retail Gasoline Historical Prices[4] for Minnesota for 2018.
- The cost per kilogram of emissions was based on data published in FHWA's Highway Economic Requirements System[5], adjusted for inflation.

Summaries of each corridor's annual project benefit are shown in Table 13 and Table 14 below. The entire project benefit is shown in Table 15.

[1] MnDOT Office of Capital Programs and Performance Measures. Benefit-Cost Analysis Standard Value Tables. http://www.dot.state.mn.us/planning/program/appendix_a.html
[2] Federal Highway Administration. Life-Cycle Cost Analysis in Pavement Design Interim Technical Bulletin, September 1998. https://www.fhwa.dot.gov/infrastructure/asstmgmt/013017.pdf
[3] United States Department of Labor. Bureau of Labor Statistics CPI Inflation Calculator. http://www.bls.gov/data/inflation_calculator.htm
[4] Energy Information Administration. Retail Gasoline Historical Prices. https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_smn_w.htm
[5] FHWA Highway Economic Requirements System – State Version, August 2005, pg F-9.

Table 13. Annual Project Benefits – TH 52 & 19th Street

	Annual Reduction	Unit Cost	Benefit
Delay	-120,266 hours	$19.13 / hour	$2,300,680
Stops	-6,075,582 stops	$0.110 / stop	$668,314
Fuel	-120,908 gal.	$2.61 / gallon	$315,569
CO Emissions	-15,373 kg	$0.16 / kg	$2,460
NOx Emissions	-1,998 kg	$8.93 / kg	$17,845
VOC Emissions	-1,738 kg	$6.78 / kg	$11,784
Total Annual Benefit			$3,316,652

Table 14. Annual Project Benefits – TH 14

	Annual Reduction	Unit Cost	Benefit
Delay	-28,476 hours	$19.13 / hour	$544,753
Stops	-612,518 stops	$0.110 / stop	$67,377
Fuel	-14,067 gal.	$2.61 / gallon	$36,716
CO Emissions	-725 kg	$0.16 / kg	$116
NOx Emissions	-104 kg	$8.93 / kg	$931
VOC Emissions	-174 kg	$6.78 / kg	$1,178
Total Annual Benefit			$651,070

Table 15. Annual Project Benefits – Project-Wide

	Annual Reduction	Unit Cost	Benefit
Delay	-148,742 hours	$19.13 / hour	2,845,432
Stops	-6,688,100 stops	$0.110 / stop	735,691
Fuel	-134,975 gal.	$2.61 / gallon	352,285
CO Emissions	-16,098 kg	$0.16 / kg	2,576
NOx Emissions	-2,103 kg	$8.93 / kg	18,776
VOC Emissions	-1,912 kg	$6.78 / kg	12,962
Total Annual Benefit			$3,967,722

Costs

The project cost to complete this signal timing optimization project was $(45,000+$10,000). This figure includes both consultant fees and an estimated cost of MnDOT staff time. Costs involved included collecting turning movement counts, Synchro/SimTraffic modeling, controller database data input, field implementation, field observations and fine-tuning, and preparation of this project benefit report. A summary of the project costs is shown in Table 16.

Table 16. Project Costs

	Amount
MnDOT (est.)	$ 10,000
Consultant Costs	$ 45,000
Total Project Cost	$ 55,000

Benefit/Cost Ratio

The one-year benefit-cost ratio was calculated to be 72:1, as shown in Table 17. Signal timing plans typically operate for 3-5 years before needing adjustment and retiming so the benefit-cost ratio over the life of the timing plans is even higher. Based on the benefit-cost analysis results, the project was successful with the project benefits outweighing the project costs.

Table 17. One-Year Project Benefit/Cost Ratio

	Amount
Project Benefits (1 Year)	$3,967,722
Project Costs	$ 55,000
One-Year Benefit/Cost Ratio	72:1

Recommendations

Specific recommendations to enhance ongoing corridor operations and safety, based on both field observations and Synchro/SimTraffic analysis, are as follows:

General Recommendations

- Upgrade to latest TACTICS version (v5.x) from current version (v3.2).
- Until TACTICS software is updated to the latest version, work to address TACTICS glitch that causes incompatibility between TACTICS TOD command and local TOD command. Currently, TACTICS is set to "standby" for both zones to allow coord to be commanded from local controller TOD schedules.
- Consider using local TOD schedules, rather than using TACTICS TOD scheduler. As the number of signals in Rochester grows, as communication links improve, and as need for zone changes throughout the day/week increases, having individual intersection TOD schedules may simplify management/operations oversight.
- Where using local TOD schedules, plan to update holiday dates yearly.
- Update YARPs. (Yellow, All Red, Walk, FDW). In particular, consider using consistent method to determine pedestrian crossing times network-wide.

TH 52 & 19th Street Interchange

- Consider adding 19th Ave signal (located 3 blocks west of W Frontage Road) to AM and PM peak timing plans.
- Check video detection operation on the northbound approach at the West Frontage Rd intersection to minimize falls calls observed during the AM peak.
- Consider adding signal indications for a northbound right turn overlap at the SPUI. Investigate the signal indications to be used to maximize capacity. In particular, consider keeping the ability to make rolling right turns when competing phases are on if no conflicting traffic is present. A standard 5-section overlap may not necessarily provide capacity benefit.
- Check video detection at SPUI for northbound and southbound TH 52 off-ramps. If detection is functioning properly, remove min recall for the off-ramp phases.
- Lane imbalance was observed for the eastbound approach at East Frontage Road. Consider adding pavement markings or signage to advertise that two eastbound through lanes exist.

- If possible as part of a geometric revision project, look for opportunities for a longer storage distance for the westbound left turn at East Frontage Rd. Even if only one of the two left turn lanes is extended, it would provide benefit especially during the AM peak.

TH 14 Corridor

- The pedestrian push button station for the north leg crosswalk in the NE corner of TH 14/15th Ave had been taken out due, possibly due to construction in the area. Verify that the button has been replaced and ensure that the pedestrian phase for the north leg is no longer in recall.

- Set up the southbound right (SBR) turn movement at Hy-Vee as a 3-way overlap (Phase 4 + Phase 5 – Phase 4 Ped). This will require a controller upgrade. A 3-way overlap will provide efficiency and safety benefits by allowing traffic to flow continuously without a clearance interval between the included phases. When a pedestrian is present, the arrow will not be displayed, providing a cue for drivers to increase their awareness.

- Set up NBR at 11th Street as 3-way overlap (Phase 8 + Phase 1 – Phase 8 Ped). This will require a controller upgrade.

- Upgrade signal controllers to provide enhanced FYA operating functionality and provide compatibility for 3-way overlaps.

- Add FYA for SBL at 11thStreet. After SBL FYA is in place, consider changing NBL to lagging operation to eliminate "hiccup" period between leading protected and lagging permissive (when opposing through traffic is not present) to improve capacity and safety.

- Matching cycle lengths on northbound Broadway in the AM and southbound Broadway in the PM should be pursued as part of the City of Rochester's upcoming retiming project to maximize throughput at TH 14/Broadway intersection.

- Consider alternate intersection geometries for TH 14/Broadway intersection. Potential ideas are displaced lefts and a multi-lane roundabout. For the roundabout, consider a design that would allow for 3-lane approaches spiraling down to 2-lane exits. Having a RAB at this location might work out well from a network perspective since cycle length demand at this intersection is very high, but cycle length demands are lower at adjacent intersections, especially to west, east and north.

- In the future, if a signal stays in place at the TH 14 & Broadway intersection, retime Broadway and TH 14 corridors at the same time to maximize network benefit.

Appendix

A. Post Fine-Tuning Signal Timing Settings – TH 52 & 19th Street
B. Post Fine-Tuning Signal Timing Settings – TH 14