Project Benefit Report

2019 St Peter TH 169 Signal Optimization

Minnesota Department of Transportation – District 7

SRF Consulting Group, Inc. | Engineers Planners Designers

June 27, 2019

SRF No. 12487

Project Benefit Report

2019 St Peter TH 169 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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Project Summary

SRF Consulting Group, Inc. was tasked by the Minnesota Department of Transportation (MnDOT) to provide updated signal timing for a signalized corridor in St Peter, Minnesota. The project involved developing and field implementing new optimized coordinated signal timing plans for five intersections on TH 169.

The goal of this project was to improve mainline progression and travel times while minimizing stops and side street delay. These project intersections were operating in Free prior to this project, except for TH 169/Nassau Street and TH 169/Mulberry Street that operated as a two-intersection coordinated zone.

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 resulted in a reduction in delay, stops, fuel consumption, and emissions. Comparing these benefits to the cost of implementation, the project delivered a one-year benefit-cost ratio of 33:1. 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)	118,106	95,081	-23,025	-19%
Stops	14,551,962	9,674,666	-4,877,295	-34%
Fuel Consumption (gal.)	418,475	368,689	-49,786	-12%
Emissions (kg)	150,909	134,207	-16,702	-11%

Background

Trunk Highway (TH) 169 is a principal arterial connecting St Peter and Mankato to the Twin Cities metro area to the north. Within the project area, TH 169 is a four-lane divided urban roadway, with left-turn lanes on TH 169 at all intersections, but right-turn lanes only at certain intersections. The posted speed limit along the corridor is 30 mph on the north end and 35 mph on the south end.

The signalized project intersections are listed in Table 2.

Table 2. Signalized Intersections

No.	Intersection
1	Broadway Ave (TH 99)
2	Nassau St
3	Mulberry St
4	Jefferson Ave
5	TH 22

“Before” Conditions

Turning Movement Counts

Associated Consulting Services, LLC collected turning movement counts at all project intersections on Tuesday, March 12, 2019 and Thursday, March 28, 2019. Counts were collected from 6:00 a.m. to 9:00 a.m., 11:00 a.m. to 1:00 p.m., and 3:00 p.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 the TH 169/TH 22 intersection on a Thursday, March 28, 2019 and Saturday, March 30, 2019 to gain an understanding of volume fluctuations throughout the day. These volume profiles were used to develop the time of day (TOD) of the coordination patterns.

Signal Timing Data

Existing signal timing data for the project intersections was obtained by direct connecting to the signal controllers in the field and uploading the databases.

Table 3 provides a summary of the signal operation of each intersection under the before conditions. The table notes whether the signal operated in coordination (or Free) and where there are special operating considerations, such as Flashing Yellow Arrow (FYA) left turn operations.

Table 3. Existing Signal Operation Summary

No.	Intersection	Existing Operation	Operation Notes
1	Broadway Ave (TH 99)	Free	FYA
2	Nassau St	Coord	
3	Mulberry St	Coord	
4	Jefferson Ave	Free	
5	TH 22	Free	AWF in northbound direction

Synchro/SimTraffic Model Setup

Synchro/SimTraffic, version 9, was used to model Before conditions. Existing models were created by SRF Consulting Group and included observed geometry, volumes and timings under the before conditions. The models incorporated the one coordination pattern that was in place at the Nassau St and Mulberry St intersections. This pattern ran during the AM and Midday time periods, so multiple Synchro models were developed with the same timing, but different volume sets. There was a plan in place for the PM peak and overnight time period, but the split time for Phases 1 and Phases 5 were

not long enough to accommodate the Min Green plus clearance time; therefore, these intersections were not running the programmed coordination patterns correctly. The Broadway Ave (TH 99), Jefferson Ave, and TH 22 intersections were coded as Free in all Synchro models.

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

Modeled Traffic Volumes

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

1. AM, Midday and PM network-wide 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. Volume imbalances where there are access points were left in place if the imbalance seemed reasonable based on the surrounding land uses.

"After" Conditions

YARP Updates

MnDOT District 7 provided 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) for all but one intersection. SRF Consulting Group prepared recommended YARP timings for the TH 22 intersection. SRF's YARP recommendations were based on current published ITE guidelines and MnDOT practices.

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, daily 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 to conform to the following MnDOT standard numbering scheme:

Table 4. 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)

Five plans (Plans 3, 4, 5, 6, and 7) were developed to manage traffic throughout the course of a typical week. Plan 9 was also developed to accommodate event traffic for the Minnesota Air Spectacular event; the 2019 edition was held June 15/16, 2019.

Synchro/SimTraffic 9, along with proprietary spreadsheet tools and engineering 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.

Flashing Yellow Arrow Left Turn Phasing Mode Evaluation

For the TH 169/Broadway Ave intersection, 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. Recommendations were reviewed by MnDOT staff.

The northbound and southbound left-turn phases were recommended to run protected-only during the p.m. peak (Plan 7) based on the higher left-turning and conflicting volumes. This is a change from the existing operations where these two movements always ran protected-permissive. The westbound and eastbound left-turn phases were recommended to run protected-permissive during the same time based on the higher volumes. These two left-turn phases previously ran permissive-only throughout the day.

During Free operations, all left-turn phases have been updated to run protected-permissive with lagging left-turn phases. The left-turn phases will generally operate as permissive-only because vehicles will generally typically be able to make the left-turn during the permissive phase. However, this setup will allow the left-turn phase to come up if someone is unable to make a permissive left-turn. This setup also eliminates the clearance interval that runs between the protected and permissive phases when leading the protected phase.

Volumes for each left-turn movement at the TH 169/Broadway Ave intersection, along with the resulting phasing decisions implemented, are shown in Figures 1 through 4. 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. For the shaded bars indicating FYA decisions, yellow represents permissive-only, orange represents protected-permissive, and red represents protected-only.

Figure 1. Phase 1 (Southbound Left) Volumes

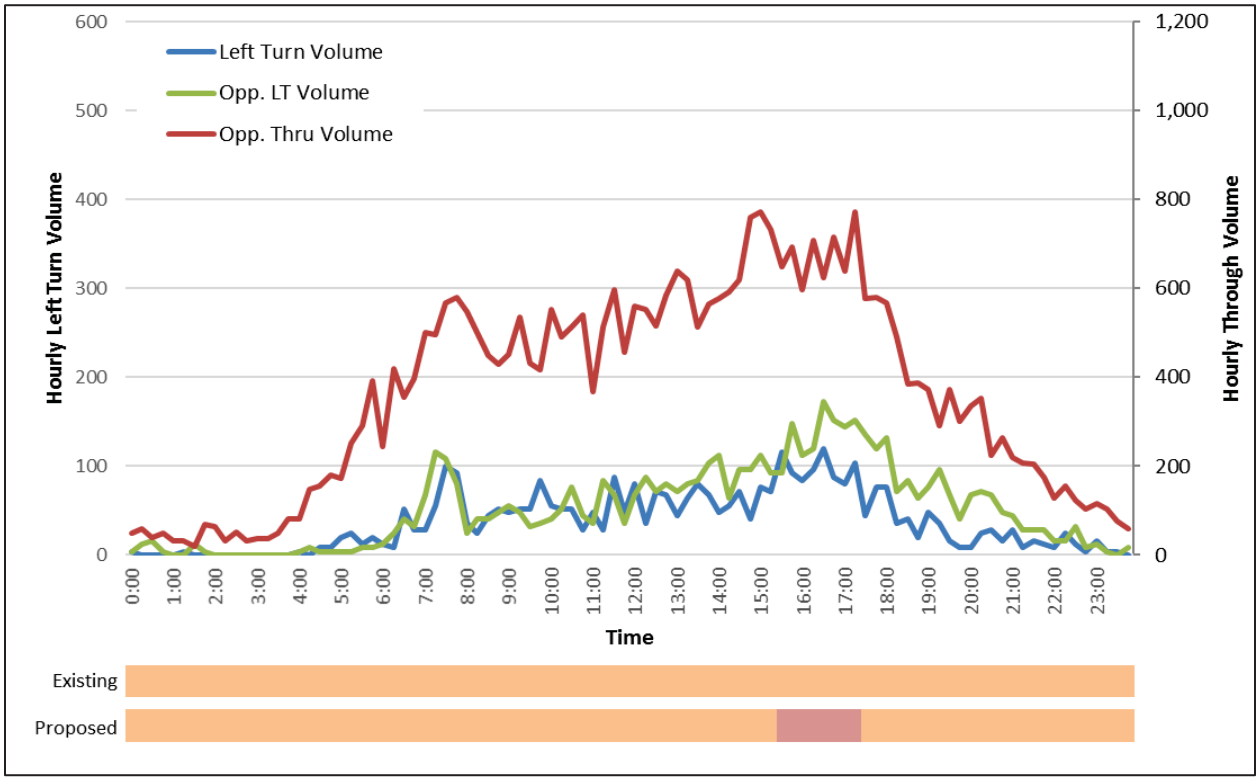


Figure 2. Phase 5 (Northbound Left) Volumes

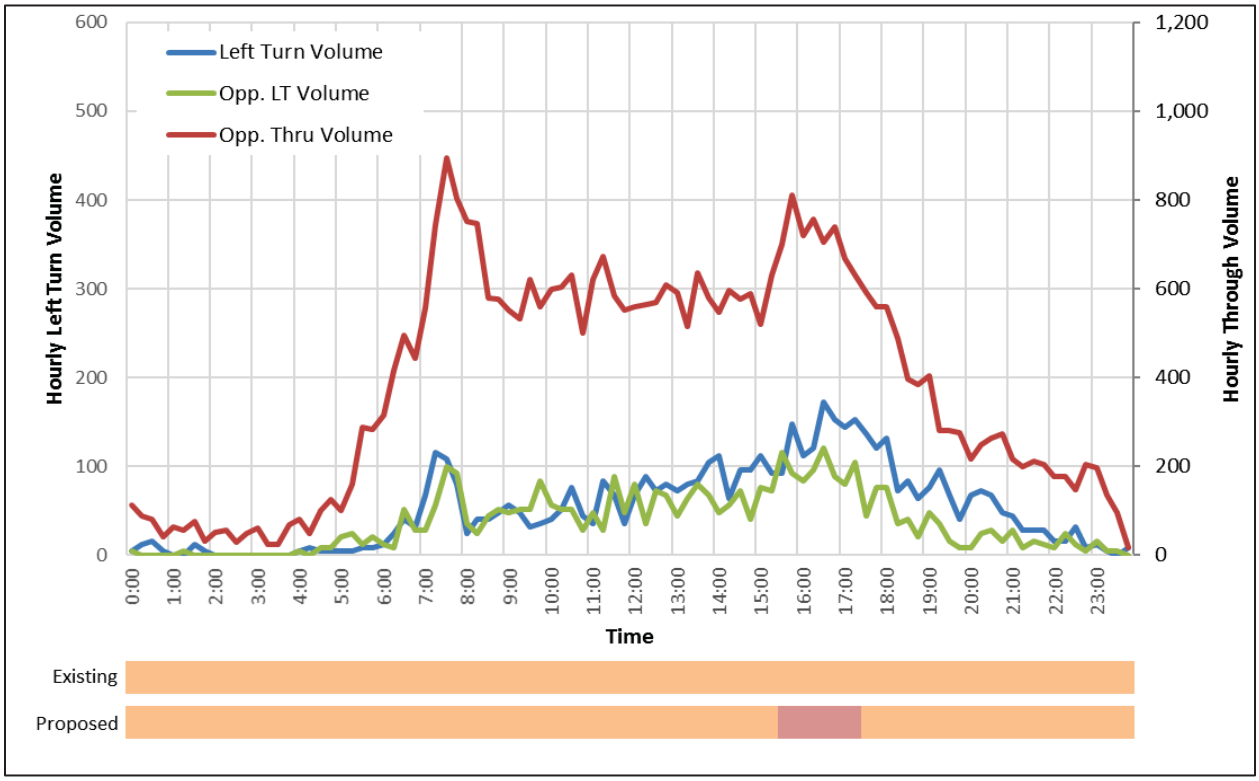


Figure 3. Phase 3 (Westbound Left) Volumes

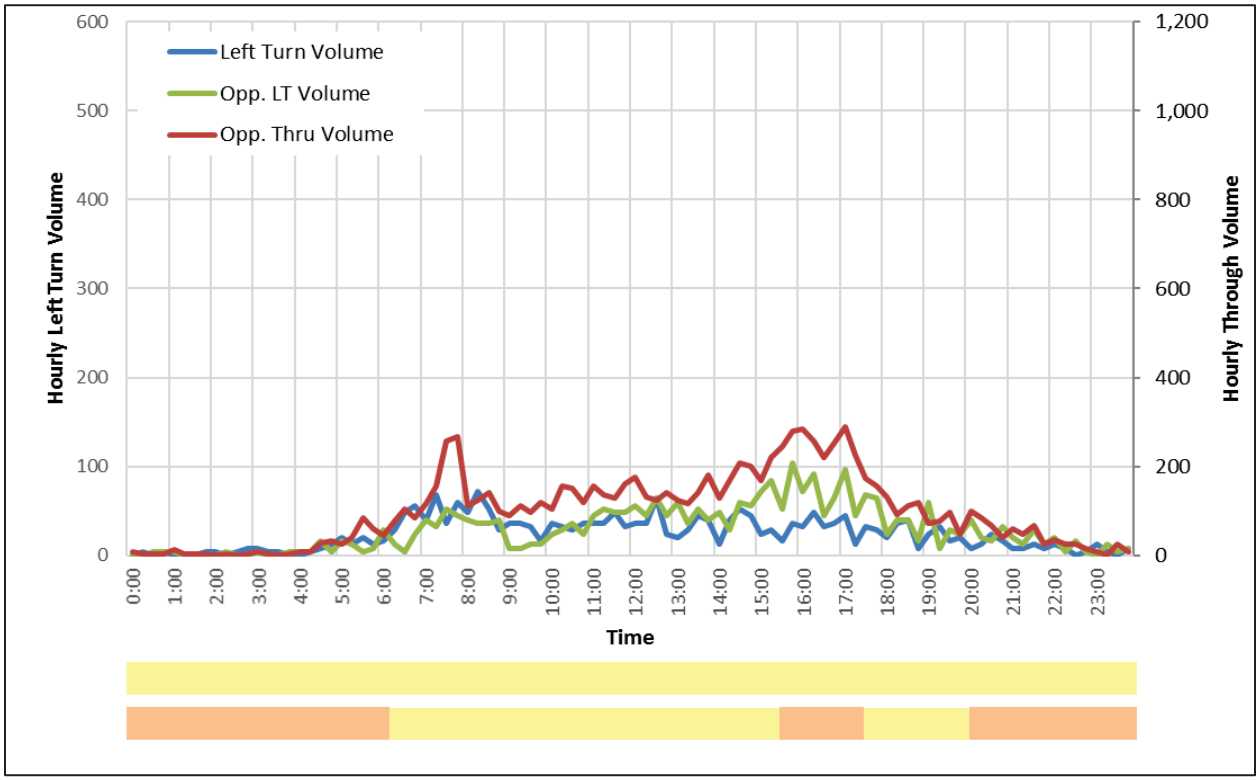
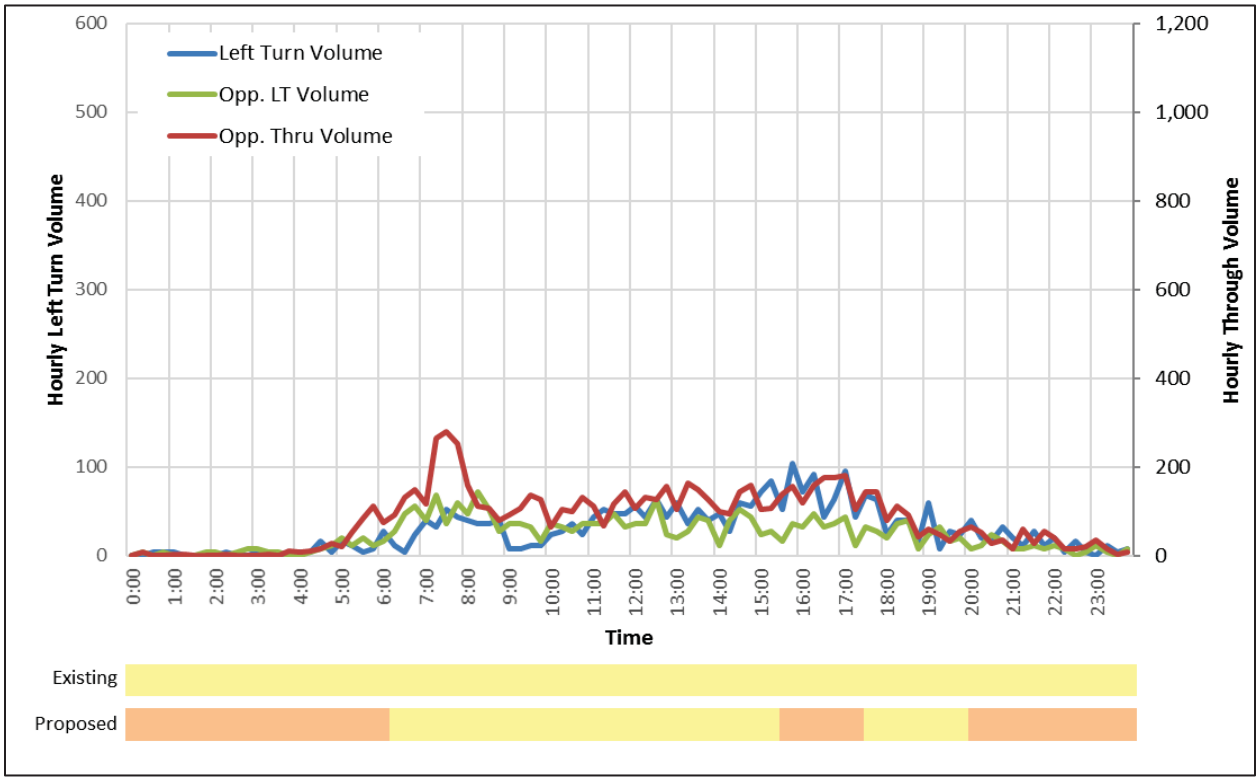


Figure 4. Phase 7 (Eastbound Left) Volumes



Cycle Lengths

After a plan for left-turn phasing for FYA movements by time of day was devised, cycle lengths for each timing plan were evaluated and selected through an iterative process. Multiple cycle lengths (including half-cycles) were evaluated for each timing plan. The cycle lengths chosen for evaluation were based on field observations and the Synchro/SimTraffic model. The process for evaluation of the cycle length options was as follows:

1. A Synchro model was developed for each potential cycle length by time of day.
2. At intersections with movements operating at or near capacity, splits were assigned to minimize delay and queuing.
3. The corridor has fairly well balanced flows in both northbound and southbound directions, so two-way progression was optimized in Synchro, using primarily manual methods to adjust offsets and phase sequences.
4. 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 parts with different cycle lengths would be optimal.

Cycle lengths were chosen to optimize throughput on TH 169, while minimizing delay on the side streets as much as possible and allowing side-street queues to clear. The cycle lengths chosen for each plan are shown in Table 7. The analysis showed it would be beneficial to run the corridor as one zone and maintain a consistent cycle length from the south to north end throughout the day.

Table 5. Cycle Lengths

Plan 3	110
Plan 4	80
Plan 5	100
Plan 6	110
Plan 7	130
Plan 9	140

These cycle lengths will run continuously throughout the time each plan is programmed to run, with each phase being served every cycle. However, the cycle lengths and splits can be impacted by an Emergency Vehicle Preemption (EVP) event, transitioning from one coord plan to another, or a side-street pedestrian call. An EVP event on TH 169 will result in the signal immediately transitioning to Phases 2 and 6 (i.e. TH 169 mainline phases) after any conflicting ped phases have terminated and will hold in these phases until the emergency vehicle has progressed through the intersection; this is typically under 30 seconds, but the preempt could potentially hold for two to three minutes. The signal controller will start to transition back into coordination once the emergency vehicle has cleared the

intersection. During the EVP event and transition back to coordination, side-street phases might have longer delays and appear to be skipped.

During the transition from one coord pattern to another, the signal controller may lengthen (i.e. ADD) or shorten (i.e. SUBTRACT) phases in order to get into coordination as quickly as possible. The controller will determine to lengthen or shorten based on where the signal is currently at in its cycle when the transition period begins.

Similar to transitioning from one coord plan to another, the signal controller will go into a period of transition after a side-street ped phase runs longer than the programmed split for the side-street phases. This is described in more detail in the Splits and Pedestrians section below.

Offsets, Phase Order

After a final set of 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 selection at TH 169/Broadway Ave included evaluating all sequences, including lead-lead, lag-lag, and lead-lag phasing. It was determined that leading the southbound left-turn phase and lagging the northbound left-turn phase provided the best two-way progression for all coord patterns.

Previously the southbound protected-permissive left-turn at the TH 169/TH 22 could only run leading even though it is a T intersection due to the Advanced Warning Flasher (AWF) in the northbound direction. Based on the proposed timing plans it was determined to be beneficial to lag the southbound left-turn in all timing plans. It would also be beneficial to run the southbound left-turn phase twice-per-cycle during the p.m. peak due to the high volume making this movement that can fill up the turn lane and queue back into the southbound through lanes.

Changes to the setup of the intersection were required to lag the southbound left-turn phase and run the phase twice-per-cycle. The cabinet is a TS-2, so the change could be made via controller output and no rewiring was needed. The first load switch previously was setup to output Phase 1; this was updated in the Load Switch Assignment (MM 1-3) of the controller to output Overlap D instead of Phase 1. Overlap D was setup to include Phases 1 and 9, with Lag X Phase checked for Phase 9 and Lag Green time was coded. The Lag X Phase and Lag Green time were setup due to the AWF in the northbound direction; the overlap will continue to output Green to the southbound left-turn arrow during the time the AWF is active.

Splits and Pedestrians

Splits for all coord patterns were setup to be flexible and accommodate a wide range of traffic conditions for each pattern. Splits for the side-streets were setup to be long enough to clear the queues each cycle and minimize the occurrence of split failures. The offsets for each intersection were set to accommodate the longer side-street splits and account for the early return to mainline green when volumes on the side-streets are lighter and the phases gap out.

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. This transition period will generally be short and the signal will be back into coordination within one cycle.

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. Pedestrians were particularly given attention at the TH 169/Nassau St intersection due to the large number of pedestrians crossing TH 169.

Time-Of-Day Schedules

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

1. Determine the time periods for which the AM and PM peak timing plans are required, by comparing peak hour and peak 15-minute volumes to volumes just outside the peak hours.
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.

Based on input from MnDOT and observations made during the final turn on of the timing plans on a Friday, it was determined to develop a separate Friday TOD to accommodate higher volumes. The resulting TOD schedules, shown as colored columns for each timing plan and overlaid with the daily traffic volume line graphs, are shown in Figure 5 through Figure 7.

Figure 5. Weekday (Monday – Thursday) Time of Day Schedule

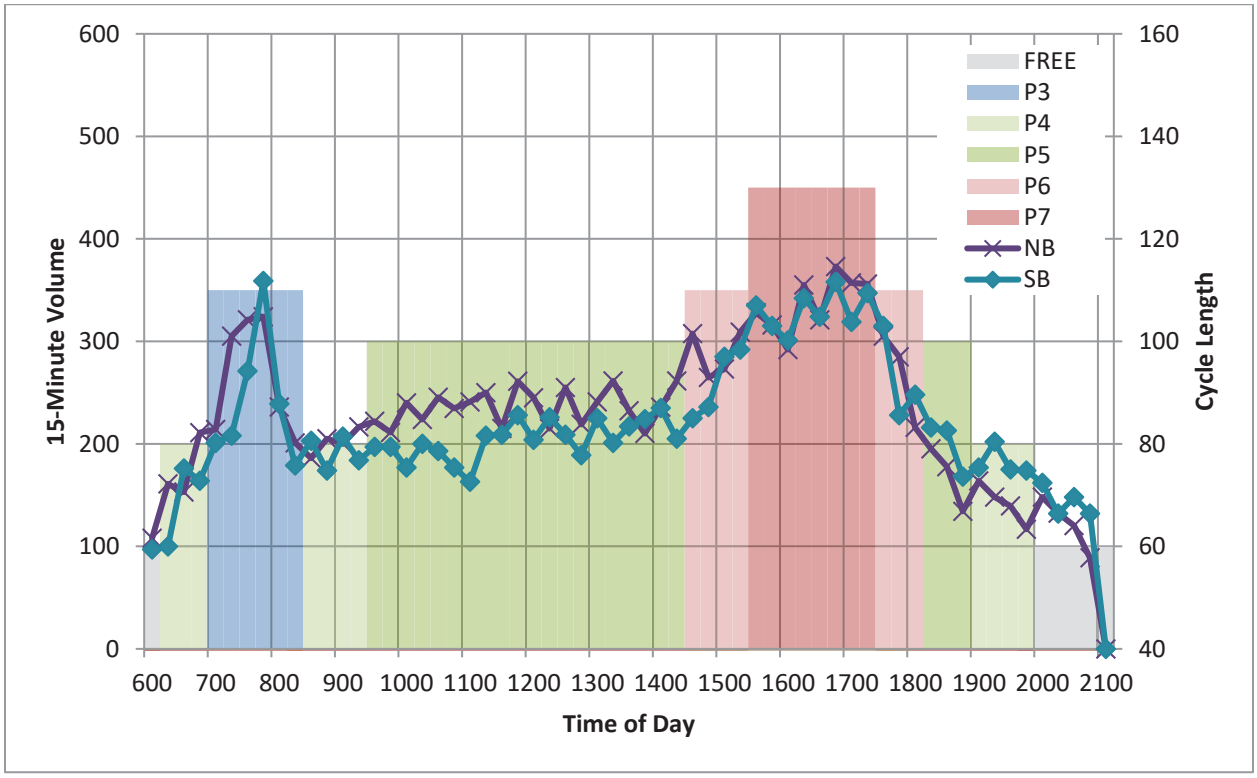


Figure 6. Friday Time of Day Schedule

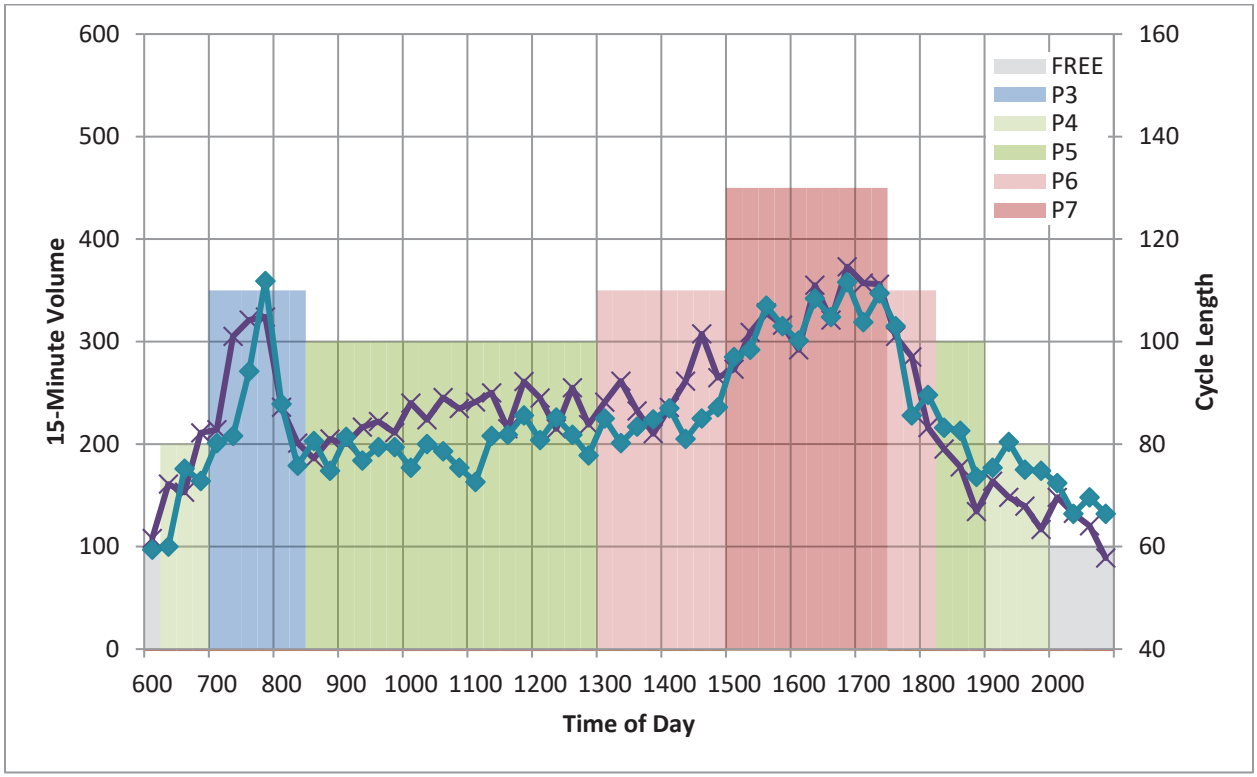
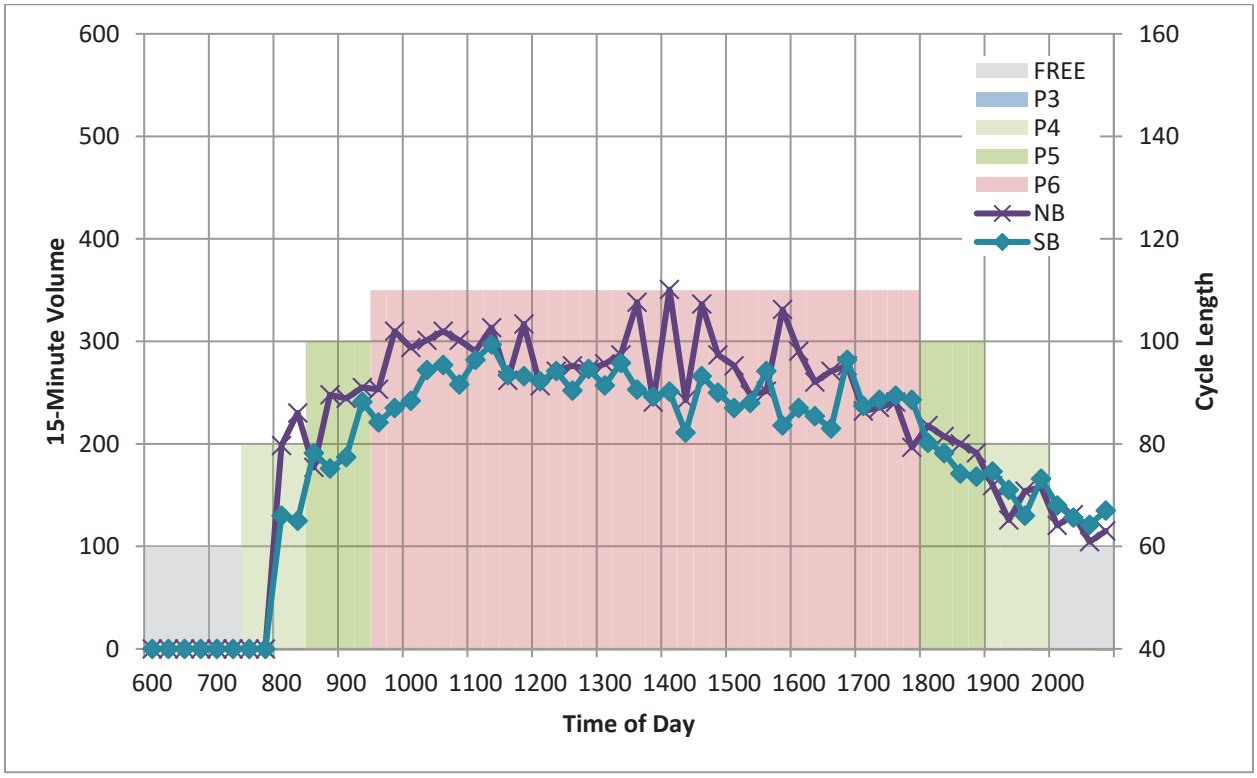


Figure 7. Weekend Time of Day Schedule



Timing Plan Implementation

The optimized signal timing plans were field fine-tuned by SRF and MnDOT on May 21 and 22, 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 downloaded and fine-tuning changes were input via direct connection to signal controllers. The signal controllers were set to Free after fine-turning because they were not on MaxView yet and the clocks were drifting several seconds a day. The signals were all put on MaxView in early June and another site visit was made on June 14, 2019 to perform additional fine tuning, confirm the southbound left-turn twice-per-cycle at the TH 169/TH 22 intersection worked as designed, and permanently switch the signals to coordinated operation.

Observations gathered and adjustments made during implementation included:

- Running the corridor as one zone and maintaining a consistent cycle length worked well. The platoons remained together throughout the corridor, so the number of stops was significantly reduced by running one cycle length from the south to north end.
- Truck traffic is heavy along the corridor, so having timing plans that reduced mainline stops proved especially beneficial.
- Plan 4 (Balanced Low – 80 seconds) worked for a shorter period of time in the morning than originally planned. Northbound traffic volumes increased and Plan 5 (Balanced – 90 seconds)

worked better to accommodate the additional traffic. Plan 4 is also most impacted from pedestrian calls at the TH 169/Nassau St and TH 169/Mulberry St intersections.

- The a.m. and p.m. peak plans (Plans 3 and 7) worked well and traffic was able to progress from one end of the corridor to the other end without stopping.
- The southbound left-turn twice-per-cycle at TH 169/TH 22 in the p.m. peak worked well. This allowed the southbound left-turn lane to clear out at the beginning and end of the cycle. This also delayed northbound vehicles from departing early and hitting the back of the queue at Jefferson Ave.
- Side-street phases cleared each cycle at all intersections and vehicles were not having to wait multiple cycles.
- The Minnesota Air Spectacular event plan (Plan 9) accommodated the additional event traffic on Saturday and Sunday. No significant queueing or operational issues were reported. The event plan is Day Plan 4 in the controllers and is currently turned off, but can be set to run in future years as needed.

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 6. 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 6. 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 7 summarizes the results of the Before vs. After Level of Service analysis. All study intersections operate at LOS D or better throughout the day. LOS remained the same or improved at all locations with the after timings.

Table 7. Before/After Level of Service Comparison

No.	Intersection Name	AM Peak	Midday Peak	PM Peak
1	Broadway Ave (TH 99)	C/C	**C/B**	C/C
2	Nassau St	**B/A**	**B/A**	**B/A**
3	Mulberry St	A/A	A/A	**B/A**
4	Jefferson Ave	**C/B**	B/B	**C/B**
5	TH 22	B/B	B/B	B/B

Key:
LOS measures reported from Synchro.
Before LOS/After LOS.
Changes in LOS are **bolded**.

Coordination Performance Measures

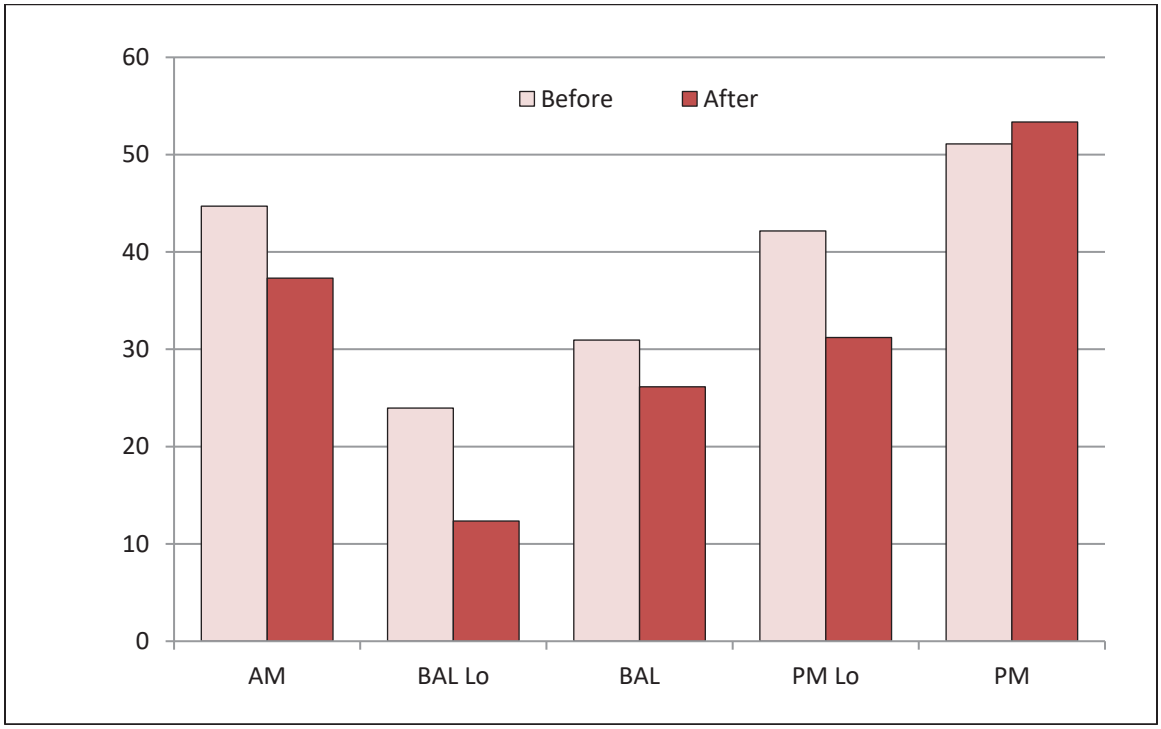
The Before and After Synchro/SimTraffic models for each of the timing plans were compared to determine the impact the project had on delay, stops, fuel consumption and emissions. Five runs were averaged for each SimTraffic analysis. The daily Synchro/SimTraffic results comparisons are illustrated in Figure 8 through 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 throughout the weekends.

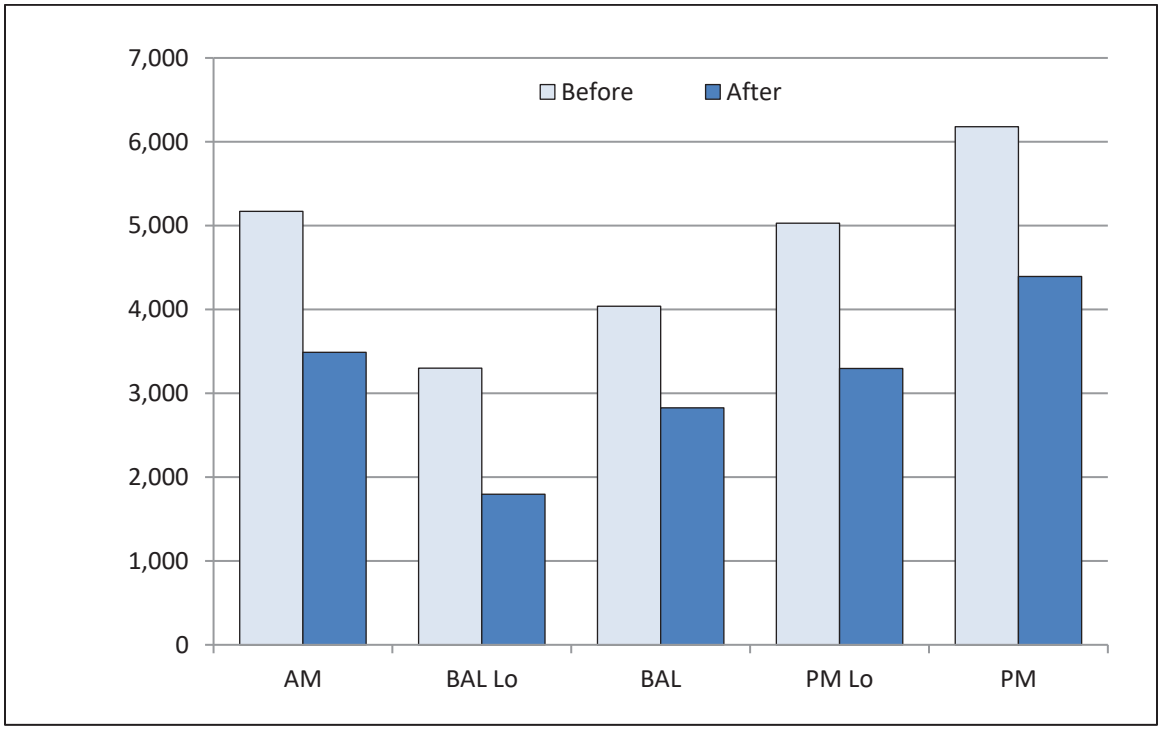
Daily and annual before/after summaries are shown in Table 8 below.

Figure 8. Before/After Delay Comparison



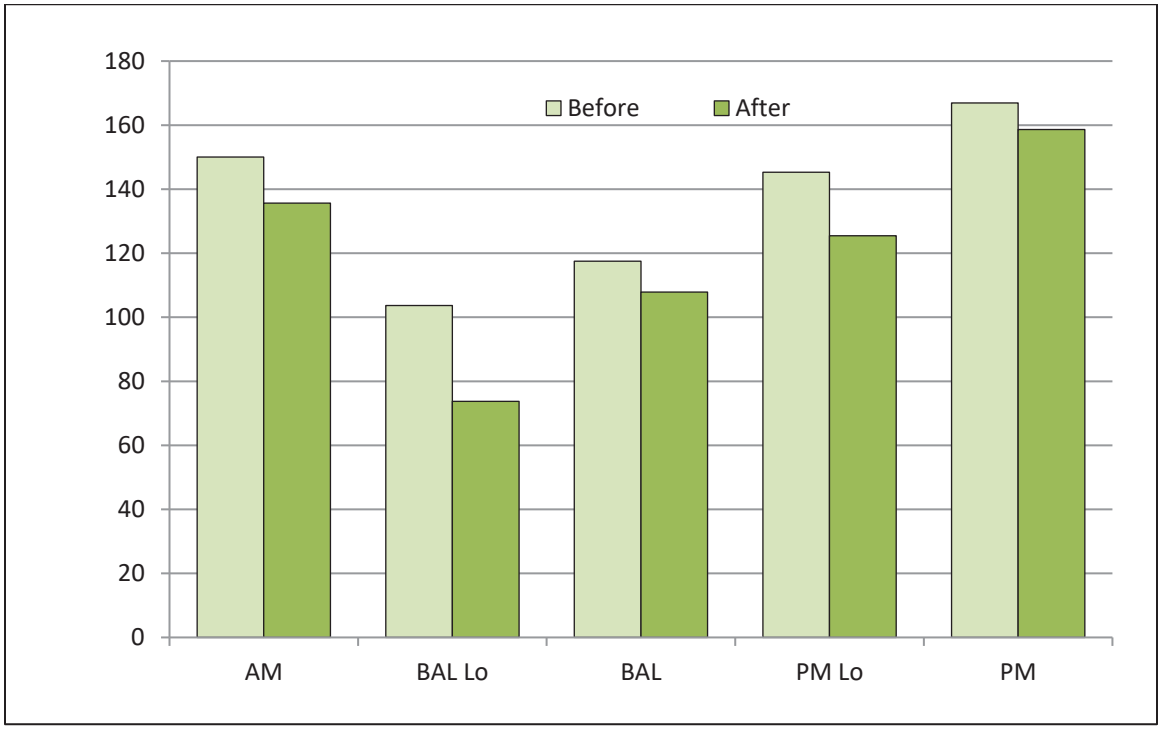
Delay (in hours), per weekday, by peak hour.

Figure 9. Before/After Stops Comparison



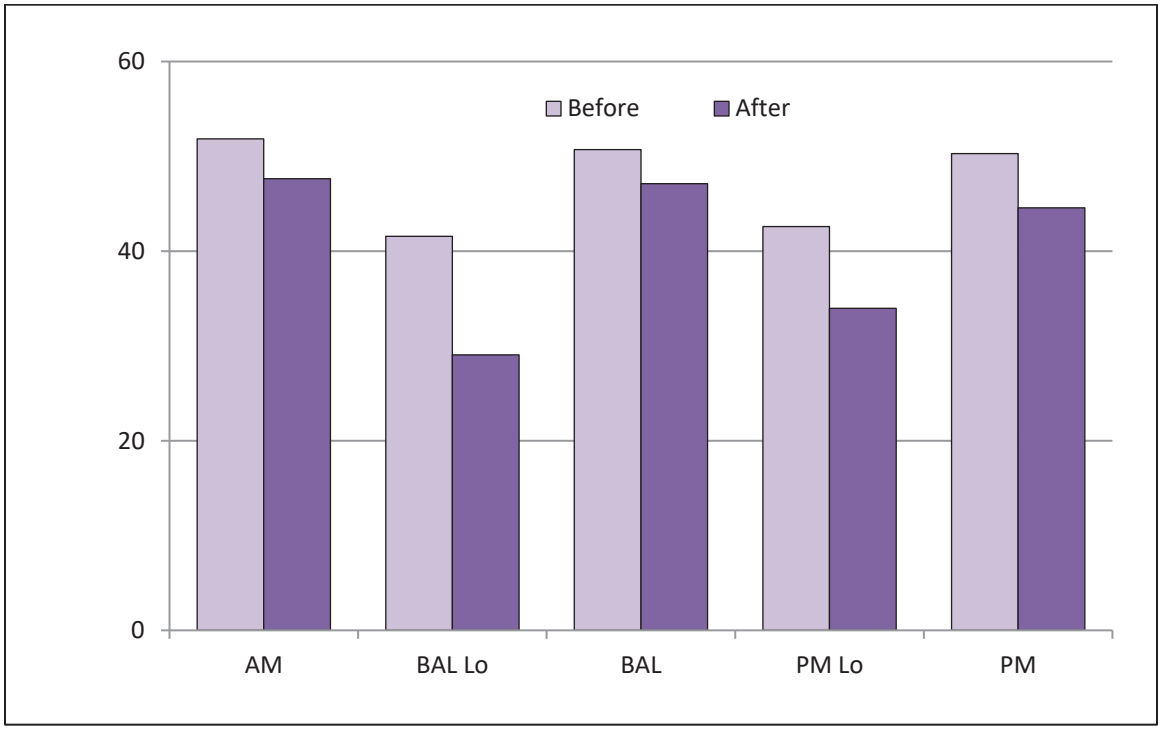
Stops, per weekday, by peak hour.

Figure 10. Before/After Fuel Consumption Comparison



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

Figure 11. Before/After Emissions Comparison



Total emissions (in kilograms), per weekday, by peak hour.

Table 8. Synchro/SimTraffic Before/After Comparison

		Before	After	Change	% Change
Weekday	Delay (hours)	472	380	-92	-19%
	Stops	58,208	38,699	-19,509	-34%
	Fuel (gal.)	1,674	1,475	-199	-12%
	Emissions (kg)	604	537	-67	-11%
Annual	Delay (hours)	118,106	95,081	-23,025	-19%
	Stops	14,551,962	9,674,666	-4,877,295	-34%
	Fuel (gal.)	418,475	368,689	-49,786	-12%
	Emissions (kg)	150,909	134,207	-16,702	-11%

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.

A summary of the annual project benefits is shown in Table 9 below. The entire project benefit is shown in Table 11.

[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 9. Annual Project Benefits

	Annual Reduction	Unit Cost	Benefit
Delay	-21,342	$19.13 / hour	$ 440,461
Stops	-4,858,842	$0.110 / stop	$ 536,502
Fuel	-50,448	$2.61 / gallon	$ 129,942
CO Emissions	-3,525	$0.16 / kg	$ 2,232
NOx Emissions	-95	$8.93 / kg	$ 15,666
VOC Emissions	-360	$6.78 / kg	$ 6,771
Total Annual Benefit			$ 1,131,573

Costs

The project cost to complete this signal timing optimization project was $33,958. 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 10.

Table 10. Project Costs

	Amount
MnDOT (est.)	$ 4,000
Consultant Costs	$ 29,958
Total Project Cost	$ 33,958

Benefit/Cost Ratio

The one-year benefit-cost ratio was calculated to be 33:1, as shown in Table 11. 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 11. One-Year Project Benefit/Cost Ratio

	Amount
Project Benefits (1 Year)	$ 1,131,573
Project Costs	$ 33,958
One-Year Benefit/Cost Ratio	33:1

Recommendations

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

General Recommendations

- Add FYA to the TH 169/Jefferson Ave intersection. Having the ability to provide lead/lag left turn phasing on mainline would help improve two-way progression on the corridor.
- Consider using Traffic Responsive operations for the corridor. This is an isolated corridor without any cross coordination, so the time of day schedule could vary dynamically without impacting other corridors.
- Add detection in the westbound right-turn lanes at TH 169/TH 22 so the westbound right-turn can extend Phases 1, 3, and 9, as needed. Put delays on these detectors so they do not unnecessarily call Phase 3.
- Evaluate changing the traffic control and/or the geometrics of the TH 169/TH 22 intersection to better accommodate the heavy southbound left-turn and westbound right-turn movements.
- Correct stuck northbound ped push-button at TH 169/Mulberry St. and install Flashing Don't Walk heads at this intersection.
- For years when the Minnesota Air Spectacular occurs, schedule Day Plan 4 to run over the weekend of the event.
- Upgrade to MaxView 2.0 when it becomes available, which will allow for more efficient pulling of signal controller data logs for analysis.

Appendix

Post Fine-Tuning Signal Timing Settings

Signal Timing Summary

St Peter TH 169 Timing
Fined Tuned

Prepared For:

MnDOT D7

Prepared By:

June 27, 2019

St Peter TH 169 Timing
Fined Tuned

Time of Day Schedule

Days	Step	Program Day Plan	Start Time	Pattern	COS	Override	Peak	Cycle	PLANID
Mon-Thurs	1	1	0 0	1	FREE	-	-	FREE	FREE
Mon-Thurs	2	1	6 15	4	111	-	BAL LOW	80	P4
Mon-Thurs	3	1	7 0	3	322	-	AM	110	P3
Mon-Thurs	4	1	8 30	4	111	-	BAL LOW	80	P4
Mon-Thurs	5	1	9 30	5	211	-	BAL	100	P5
Mon-Thurs	6	1	14 30	6	311	-	PM LOW	110	P6
Mon-Thurs	7	1	15 30	7	411	-	PM	130	P7
Mon-Thurs	8	1	17 30	6	311	-	PM LOW	110	P6
Mon-Thurs	9	1	18 15	5	211	-	BAL	100	P5
Mon-Thurs	10	1	19 0	4	111	-	BAL LOW	80	P4
Mon-Thurs	11	1	20 0	1	FREE	-	-	FREE	FREE
Friday	1	3	0 0	1	FREE	-	-	FREE	FREE
Friday	2	3	6 15	4	111	-	BAL LOW	80	P4
Friday	3	3	7 0	3	322	-	AM	110	P3
Friday	4	3	8 30	5	211	-	BAL	100	P5
Friday	5	3	1 0	6	311	-	PM LOW	110	P6
Friday	6	3	3 0	7	411	-	PM	130	P7
Friday	7	3	17 30	6	311	-	PM LOW	110	P6
Friday	8	3	18 15	5	211	-	BAL	100	P5
Friday	9	3	19 0	4	111	-	BAL LOW	80	P4
Friday	10	3	20 0	1	FREE	-	-	FREE	FREE
Sat-Sun	1	2	0 0	1	FREE	-	-	FREE	FREE
Sat-Sun	2	2	7 30	4	111	-	BAL LOW	80	P4
Sat-Sun	3	2	8 30	5	211	-	BAL	100	P5
Sat-Sun	4	2	9 30	6	311	-	PM LOW	110	P6
Sat-Sun	5	2	18 0	5	211	-	BAL	100	P5
Sat-Sun	6	2	19 0	4	111	-	BAL LOW	80	P4
Sat-Sun	7	2	20 0	1	FREE	-	-	FREE	FREE
Air Show Event	1	4	0 0	1	FREE	-	-	FREE	FREE
Air Show Event	2	4	7 0	4	111	-	BAL LOW	80	P4
Air Show Event	3	4	8 0	5	211	-	BAL	100	P5
Air Show Event	4	4	9 0	3	322	-	AM	110	P3
Air Show Event	5	4	10 0	9	511	-	Event	140	P9
Air Show Event	6	4	11 30	3	322	-	AM	110	P3
Air Show Event	7	4	13 0	7	411	-	PM	130	P7
Air Show Event	8	4	16 0	9	511	-	Event	140	P9
Air Show Event	9	4	18 30	7	411	-	PM	130	P7
Air Show Event	10	4	19 15	6	311	-	PM LOW	110	P6
Air Show Event	11	4	20 0	5	211	-	BAL	100	P5
Air Show Event	12	4	20 45	1	FREE	-	-	FREE	FREE

Notes:

St Peter TH 169 Timing
Fined Tuned

INTID: **100** **TH 169/TH 22** **COMM ID:** **1**

Phase	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Front Page Timing									
Direction	SBL	NBT	WBL			SBT			SBL
Left Turn Type	P/P								P/P
Min Green	7	15	7	-	-	15	-	-	7
Max Green	45	80	40	-	-	80	-	-	45
Walk	-	-	-	-	-	-	-	-	-
Flash. Don't Walk	-	-	-	-	-	-	-	-	-
Yellow	3.3	3.6	3.6	-	-	3.6	-	-	3.3
All Red	2.2	2.6	2.0	-	-	2.6	-	-	2.2
Vehicle Extension	3.5	4.0	3.5	-	-	4.0	-	-	3.5
Time Before	10.0	20.0	10.0	-	-	20.0	-	-	10.0
Time to Reduce	10.0	10.0	10.0	-	-	10.0	-	-	10.0
Min Gap	2.0	2.5	2.5	-	-	2.5	-	-	2.0
Recall Mode	-	Min	-	-	-	Min	-	-	-
Min Split Synchro	15	23	15	-	-	23	-	-	15
Min Split Ped	-	-	-	-	-	-	-	-	-
Min Split Veh	15	23	15	-	-	23	-	-	15
Min Split Phasing	13	18	15	-	-	18	-	-	13

Pattern	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Peak	**-**	**-**	**AM**	**BAL LOW**	**BAL**	**PM LOW**	**PM**	**-**	**Event**
Cycle	**FREE**	**-**	**110**	**80**	**100**	**110**	**130**	**-**	**140**
Coord Timing									
Cycle	-	-	110	80	100	110	130	-	140
COS	-	-	322	111	211	311	411	-	511
Offset	-	-	20	49	28	72	50	-	48
Phase 1 SBL	-	-	-	-	-	-	15	-	45
Phase 2 NBT	-	-	35	34	41	45	48	-	42
Phase 3 WBL	-	-	25	21	21	20	20	-	23
Phase 4	-	-	-	-	-	-	-	-	-
Phase 5	-	-	-	-	-	-	-	-	-
Phase 6 SBT	-	-	85	59	79	90	110	-	117
Phase 7	-	-	-	-	-	-	-	-	-
Phase 8	-	-	-	-	-	-	-	-	-
Phase 9 SBL	-	-	50	25	38	45	47	-	30
Coord Phase(s)	-	-	26+	26+	26+	26+	26+	-	26+
Lag Left Phase(s)	-	-	-	-	-	-	-	-	-
ASC/3 Sequence	-	-	1	1	1	1	1	-	1
Omitted Phase(s)	-	-	1	1	1	1	-	-	-
Recalls			Phase 9 Min	Phase 9 Min	Phase 9 Min	Phase 9 Min	Phase 9 Min		P1 Max P9 Min

Notes:
Twice Per Cycle SBL (Phases 1 and 9)

St Peter TH 169 Timing
Fined Tuned

INTID: **110** **TH 169/Jefferson Ave** **COMM ID:** **2**

Phase	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Front Page Timing								
Direction	SBL	NBT		EBT	NBL	SBT		WBT
Left Turn Type	P/P				P/P			
Min Green	7	15	-	7	7	15	-	7
Max Green	30	80	-	40	30	80	-	40
Walk	-	7	-	7	-	7	-	7
Flash. Don't Walk	-	18	-	23	-	18	-	23
Yellow	3.0	3.6	-	3.3	3.0	3.6	-	3.3
All Red	2.2	2.2	-	2.9	2.2	2.2	-	2.9
Vehicle Extension	3.5	4.0	-	3.5	3.5	4.0	-	3.5
Time Before	10.0	20.0	-	10.0	10.0	20.0	-	10.0
Time to Reduce	10.0	10.0	-	10.0	10.0	10.0	-	10.0
Min Gap	2.0	2.5	-	2.5	2.0	2.5	-	2.5
Recall Mode	-	Min	-	-	-	Min	-	-
Min Split Synchro	15	23	-	15	15	23	-	15
Min Split Ped	-	32	-	37	-	32	-	37
Min Split Veh	15	23	-	15	15	23	-	15
Min Split Phasing	13	18	-	15	13	18	-	15

Pattern	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**9**
Peak	**-**	**-**	**AM**	**BAL LOW**	**BAL**	**PM LOW**	**PM**	**Event**
Cycle	**FREE**	**-**	**110**	**80**	**100**	**110**	**130**	**140**
Coord Timing								
Cycle	-	-	110	80	100	110	130	140
COS	-	-	322	111	211	311	411	511
Offset	-	-	32	56	41	93	75	74
Phase 1 SBL	-	-	15	15	17	15	15	15
Phase 2 NBT	-	-	57	37	48	54	66	77
Phase 3	-	-	-	-	-	-	-	-
Phase 4 EBT	-	-	38	28	35	41	49	48
Phase 5 NBL	-	-	19	17	17	16	17	16
Phase 6 SBT	-	-	53	35	48	53	64	76
Phase 7	-	-	-	-	-	-	-	-
Phase 8 WBT	-	-	38	28	35	41	49	48
Coord Phase(s)	-	-	26+	26+	26+	26+	26+	26+
Lag Left Phase(s)	-	-	-	-	-	-	-	-
ASC/3 Sequence	-	-	1	1	1	1	1	1
Omitted Phase(s)	-	-	-	-	-	-	-	-
Recalls								

Notes:

St Peter TH 169 Timing
Fined Tuned

INTID: 120 **TH 169/Mulberry St** **COMM ID:** 3

Phase	1	2	3	4	5	6	7	8
Front Page Timing								
Direction	SBL	NBT		EBT	NBL	SBT		WBT
Left Turn Type	P/P				P/P			
Min Green	7	15	-	7	7	15	-	7
Max Green	30	80	-	40	30	60	-	40
Walk	-	7	-	7	-	7	-	7
Flash. Don't Walk	-	14	-	23	-	18	-	23
Yellow	3.0	3.7	-	3.3	3.0	3.7	-	3.3
All Red	1.8	1.8	-	2.8	1.8	1.8	-	2.8
Vehicle Extension	3.5	4.0	-	3.5	3.5	4.0	-	3.5
Time Before	10.0	20.0	-	10.0	10.0	20.0	-	10.0
Time to Reduce	10.0	10.0	-	10.0	10.0	10.0	-	10.0
Min Gap	2.0	2.5	-	2.5	2.0	2.5	-	2.5
Recall Mode	-	Min	-	-	-	Min	-	-
Min Split Synchro	15	23	-	15	15	23	-	15
Min Split Ped	-	27	-	37	-	31	-	37
Min Split Veh	15	23	-	15	15	23	-	15
Min Split Phasing	13	18	-	15	13	18	-	15

Pattern	1	2	3	4	5	6	7	9
Peak	-	-	AM	BAL LOW	BAL	PM LOW	PM	Event
Cycle	FREE	-	110	80	100	110	130	140
Coord Timing								
Cycle	-	-	110	80	100	110	130	140
COS	-	-	322	111	211	311	411	511
Offset	-	-	99	55	97	42	4	134
Phase 1 SBL	-	-	17	-	18	17	17	17
Phase 2 NBT	-	-	63	50	52	63	83	93
Phase 3	-	-	-	-	-	-	-	-
Phase 4 EBT	-	-	30	30	30	30	30	30
Phase 5 NBL	-	-	18	17	21	19	19	17
Phase 6 SBT	-	-	62	33	49	61	81	93
Phase 7	-	-	-	-	-	-	-	-
Phase 8 WBT	-	-	30	30	30	30	30	30
Coord Phase(s)	-	-	26+	26+	26+	26+	26+	26+
Lag Left Phase(s)	-	-	-	-	-	-	-	-
ASC/3 Sequence	-	-	1	1	1	1	1	1
Omitted Phase(s)	-	-	-	1	-	-	-	-
Recalls								

Notes:

St Peter TH 169 Timing
Fined Tuned

INTID: 130 **TH 169/Nassau St** **COMM ID:** 4

Phase	1	2	3	4	5	6	7	8
Front Page Timing								
Direction	SBL	NBT		EBT	NBL	SBT		WBT
Left Turn Type	P/P				P/P			
Min Green	7	15	-	7	7	15	-	7
Max Green	30	80	-	40	30	80	-	40
Walk	-	7	-	7	-	7	-	7
Flash. Don't Walk	-	18	-	23	-	18	-	23
Yellow	3.0	3.6	-	3.3	3.0	3.6	-	3.3
All Red	1.8	1.8	-	2.8	1.8	1.8	-	2.8
Vehicle Extension	3.5	4.0	-	3.5	3.5	4.0	-	3.5
Time Before	10.0	20.0	-	10.0	10.0	20.0	-	10.0
Time to Reduce	10.0	10.0	-	10.0	10.0	10.0	-	10.0
Min Gap	2.0	2.5	-	2.5	2.0	2.5	-	2.5
Recall Mode	-	Min	-	-	-	Min	-	-
Min Split Synchro	15	23	-	15	15	23	-	15
Min Split Ped	-	31	-	37	-	31	-	37
Min Split Veh	15	23	-	15	15	23	-	15
Min Split Phasing	13	18	-	15	13	18	-	15

Pattern	1	2	3	4	5	6	7	9
Peak	-	-	AM	BAL LOW	BAL	PM LOW	PM	Event
Cycle	FREE	-	110	80	100	110	130	140
Coord Timing								
Cycle	-	-	110	80	100	110	130	140
COS	-	-	322	111	211	311	411	511
Offset	-	-	100	63	93	35	118	133
Phase 1 SBL	-	-	17	17	18	17	18	15
Phase 2 NBT	-	-	63	33	52	63	82	96
Phase 3	-	-	-	-	-	-	-	-
Phase 4 EBT	-	-	30	30	30	30	30	29
Phase 5 NBL	-	-	17	17	18	17	19	17
Phase 6 SBT	-	-	63	33	52	63	81	94
Phase 7	-	-	-	-	-	-	-	-
Phase 8 WBT	-	-	30	30	30	30	30	29
Coord Phase(s)	-	-	26+	26+	26+	26+	26+	26+
Lag Left Phase(s)	-	-	-	-	-	-	-	-
ASC/3 Sequence	-	-	1	1	1	1	1	1
Omitted Phase(s)	-	-	-	-	-	-	-	-
Recalls								

Notes:

St Peter TH 169 Timing
Fined Tuned

INTID: 140 **TH 169/Broadway Ave** **COMM ID:** 5

Phase	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Front Page Timing								
Direction	SBL	NBT	WBL	EBT	NBL	SBT	EBL	WBT
Left Turn Type	FYA		FYA		FYA		FYA	
Min Green	7	15	7	7	7	15	7	7
Max Green	30	80	30	50	30	80	30	50
Walk	-	7	-	7	-	7	-	7
Flash. Don't Walk	-	18	-	23	-	18	-	23
Yellow	3.0	3.6	3.0	3.3	3.0	3.6	3.0	3.3
All Red	2.6	2.7	2.5	2.8	2.6	2.7	2.5	2.8
Vehicle Extension	3.0	4.0	3.0	3.0	3.0	4.0	3.0	3.0
Time Before	10.0	20.0	10.0	10.0	10.0	20.0	10.0	10.0
Time to Reduce	5.0	10.0	5.0	5.0	5.0	5.0	10.0	5.0
Min Gap	2.0	2.5	2.0	2.0	2.0	2.5	2.0	2.0
Recall Mode	-	Min	-	-	-	Min	-	-
Min Split Synchro	15	23	15	15	15	23	15	15
Min Split Ped	-	32	-	37	-	32	-	37
Min Split Veh	15	23	15	15	15	23	15	15
Min Split Phasing	13	18	13	15	13	18	13	15

Pattern	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**9**
Peak	**-**	**-**	**AM**	**BAL LOW**	**BAL**	**PM LOW**	**PM**	**Event**
Cycle	**FREE**	**-**	**110**	**80**	**100**	**110**	**130**	**140**
Coord Timing								
Cycle	-	-	110	80	100	110	130	140
COS	-	-	322	111	211	311	411	511
Offset	-	-	77	48	76	28	3	3
Phase 1 SBL	-	-	17	18	19	17	23	25
Phase 2 NBT	-	-	54	36	50	56	58	76
Phase 3 WBL	-	-	-	-	-	-	15	-
Phase 4 EBT	-	-	39	26	31	37	34	39
Phase 5 NBL	-	-	17	18	21	23	25	38
Phase 6 SBT	-	-	54	36	48	50	56	63
Phase 7 EBL	-	-	-	-	-	-	15	-
Phase 8 WBT	-	-	39	26	31	37	34	39
Coord Phase(s)	-	-	26+	26+	26+	26+	26+	26+
Lag Left Phase(s)	-	-	5	5	5	5	5	5
ASC/3 Sequence	-	-	5	5	5	5	5	5
Omitted Phase(s)	-	-	37	37	37	37	-	37
Recalls								
Phase 1 SBL	-	-	P/P	P/P	P/P	P/P	Prot	Prot
Phase 3 WBL	-	-	Perm	Perm	Perm	Perm	P/P	Perm
Phase 5 NBL	-	-	P/P	P/P	P/P	P/P	Prot	Prot
Phase 7 EBL	-	-	Perm	Perm	Perm	Perm	P/P	Perm
AP Spec. Func. Bits	-	-	-	-	-	-	1,5	1,5
Detector Plan	-	-	2	2	2	2	3	3

Notes:
Pattern 59 for FREE (Lagging left-turns)