AGENDA ITEM #9.2

REPORT TO CITY COUNCIL

Report Prepared by: Tim Houle

Date: September 3, 2019

Subject: Traffic Study Report

Report: As previously approved and directed by the City Council, we have prepared the attached Traffic Study Report for several intersections within the core downtown area of Pequot Lakes. At the Council Meeting, I will review several pages from the Report regarding recommendations for the various intersections with the understanding that any approval from the Council will not be setting final designs for each intersection. Should specific improvements at the various intersections move forward in the future, the Council would have an opportunity at that time to approve, or not, those specific designs.

The approval of the Traffic Study is acknowledgment that the work was done with interaction by the Committee and that the general concepts in the Report are in alignment with the present outlook of the Council.

Council Action Requested: Council motion accepting the Traffic Study Report from Spack Consulting and Widseth Smith Nolting.

Spack CONSULTING
ENGINEERING TRAFFIC FORWARD

Traffic Study

Pequot Lakes, Minnesota

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

By: _____
Max Moreland, P.E.
License No. 52665

Date: August 8, 2019

Executive Summary

Background:

In 2017, Highway 371 underwent an expansion to a four-lane section from Nisswa to the south side of Jenkins. As a part of this, the highway was re-routed through the City of Pequot Lakes. Before the expansion, Highway 371 ran along Patriot Avenue. Now Highway 371 has an interchange located east of the downtown Pequot Lakes area. With this change, traffic patterns in the City of Pequot Lakes have changed. The purpose of this study is to be able to understand the magnitude and impacts of these changes and review the need or feasibility of making modifications to existing downtown intersections and roadways.

Results & Recommendations:

The traffic of the study network was thoroughly studied, and it was found that the study intersections and corridors are forecast to operate acceptably through the 2024 and 2039 scenarios.

The following recommendations are made for the study network:

- 2nd Street/Main Street: stripe narrower lanes around the curve and restrict on-street parking on the west side of the curve.
- Patriot Avenue/Main Street: remove the northbound and southbound right turn lanes and restrict on-street parking on the south side of Main Street west of Patriot Avenue for at least 100 feet from the crosswalk.
- Rasmussen Road/Main Street: add seasonal curb bump outs.
- Patriot Avenue/Woodman Street: add a pedestrian crossing with a median on the northern side of the intersection across Patriot Avenue. Extend the existing sidewalk on the west side of the intersection to this crossing.
- Patriot Avenue/West Lake Street: no changes.
- Patriot Avenue/Front Street: complete a test closure of the Front Street approaches utilizing temporary barriers.
- Main Street/Paul Bunyan Trail: add a seasonal bump out on south side of Main Street, restrict parking on the south side of Main Street on that block and stripe eastbound Main Street to have one 12-foot lane.

TABLE OF CONTENTS

1. Introduction 1
2. Existing Conditions Summary 3
3. City Goals 4
4. Forecasted Traffic 5
5. Operational Analyses 6
6. Alternative Intersection Analyses 10
7. Alternative Corridor Analyses 22
8. Conclusions and Recommendations 24
9. Appendix 25

LIST OF TABLES & CHARTS

Chart 1 – Study Corridor Volume to Capacity 6
Chart 2 – Peak Hour Delays: Signal Controlled Intersection 7
Chart 3 – Peak Hour Delays: All-Way Stop Sign Controlled Intersection 8
Chart 6 – A.M. Peak Hour Queues: Side Street Stop Sign Controlled Intersections 9
Chart 7 – P.M. Peak Hour Queues: Side Street Stop Sign Controlled Intersections 9
Figure 1 – Patriot Avenue/Main Street Alternatives 13
Chart 8 – Patriot Avenue & Main Street Alternative Peak Hour Delays: Signal Control ... 14
Chart 9 – Patriot Avenue & Main Street Alternative Peak Hour Delays: All-Way Stop and Roundabout Control 14
Figure 2 – Seasonal Curb Bump Out Example 16
Figure 3 – Patriot Avenue/Woodman Street Pedestrian Recommendations 18
Table 1 – Potential Intersection Alternative Comparisons 20
Figure 4 – Main Street Trail Crossing Improvements 23

1. Introduction

a. *Purpose of Study*

In 2017, Highway 371 underwent an expansion to a four-lane section from Nisswa to the south side of Jenkins. As a part of this expansion, the highway was re-routed around the City of Pequot Lakes. Where before the expansion Highway 371 ran along Patriot Avenue through downtown, the new highway bypasses the City on its east side and is accessible via interchanges. As expected, the new bypass has altered travel patterns and changed driving routes associated with the City. The purpose of this study is to be able to understand the magnitude and impacts of these changes and review the need or feasibility of making modifications to existing downtown intersections and roadways.

For those not familiar with the general concepts and terms associated with traffic engineering, *The Language of Traffic Engineering* guide is included in the Appendix.

Spack Consulting completed an "Existing Conditions" memorandum as a part of this study in June 2019. That document is included for review in the Appendix.

b. *Study Objectives*

This study aims to answer three primary sets of questions:

i. What are the current volumes through the City now that the new Highway is in place and drivers have acclimated to new travel patterns? How do these compare to past information such as the traffic forecasts when the new Highway was being designed?
ii. Can Patriot Avenue from roughly West Lake Street on the south to Front Street on the north be narrowed, reduced in number of lanes, or reconfigured to allow parallel or diagonal parking, etc.?
iii. Does the traffic (vehicle and non-vehicle) at any of the studied intersections necessitate geometric or traffic control modifications at those intersections (now and into the future) – with special consideration on the existing traffic signal system at Patriot Avenue / Main Street and the existing all-way Stop at Main Street / Rasmussen Road?

The first set of primary questions is addressed in the Existing Conditions memorandum. The other two sets of questions will be addressed in this study. The objectives of this study are:

i. Review how the study intersections and roadways currently operate.
ii. Forecast the amount of traffic growth expected in the study network.
iii. Determine how the study intersections and roadways will operate in the future years 2024 and 2039.
iv. Recommend appropriate mitigation measures if poor operations are identified including answering the second and third sets of primary questions.

For the purposes of this traffic study, the study intersections chosen for review include:

i. 2nd Street & Main Street
ii. Patriot Avenue & Main Street

iii. Rasmussen Road & Main Street
iv. Patriot Avenue & Woodman Street
v. Patriot Avenue & West Lake Street
vi. Patriot Avenue & Front Street

It should be noted traffic expected from future growth will have impacts on other corridors and intersections beyond those studied here. Furthermore, this study does not account for the existing roadway conditions such as pavement quality or appropriate drainage.

2. Existing Conditions Summary

As mentioned, Spack Consulting previously complete an Existing Conditions memorandum, which can be referenced in the Appendix for further details about the existing network.

The primary conclusions from the Existing Conditions analysis are:

- Study peak hours of operations occurred from 7:30 – 8:30 a.m. and 3:00 – 4:00 p.m. and correspond to the peak times for the high school
- Volumes counted in May 2019 for this study are generally lower than 2015 traffic counts with the biggest decreases along Patriot Avenue. Main Street east of Rasmussen Road is the only roadway segment that did not experience a decrease in daily volumes.
- Before the Highway 371 expansion, forecasts at Patriot Avenue/Main Street were made to estimate traffic volumes after the expansion. Compared to the actual traffic counts taken, those forecasts were rather close with the westbound volumes being overestimated.
- Seasonal variations in traffic volumes can occur in this area with the peak traffic volumes being in July. The traffic volumes from May are likely higher than the annual average traffic volumes.
- Acceptable operations at the study intersections with no areas of excessive delays or vehicle stacking outside of normal expectations for the area.
- At the signal there are some long maximum queues, but they always clear in one green phase.
- At the all-way stop at Main Street/Rasmussen Road, the eastbound approach sees the longest queues of approximately seven vehicles during the p.m. peak hour, due to school traffic. The westbound approach has its longest queues in the a.m. peak hour of approximately five vehicles. Northbound and southbound have low queues throughout the day. All queues clear rather quickly.
- Larger eastbound queues occur on West Lake Street and Woodman Street at Patriot Avenue during the p.m. peak hour due to the school letting out at that time. These queues are generally cleared within 10 to 15 minutes.

In general, current operations were deemed acceptable without major issues or concerns. This information was presented at a Traffic Study Meeting in June 2019, attended by members of the City of Pequot Lakes staff. Those in attendance agreed with the findings of the memorandum.

3. City Goals

Both the *2014 Pequot Lakes Downtown Plan* and the *2018 Pequot Lakes Comprehensive Plan* were reviewed to gain an understanding of the key goals for the City of Pequot Lakes within the study area. Comments from the June 2019 meeting were taken to gain a further understanding.

From these sources, the transportation goals include:

- Increasing focus on serving all modes of transportation.
- Providing safe, convenient access to the surrounding region.
- Allowing for heavy vehicle access through the City while avoiding residential areas.
- Shifting from auto oriented roadways to establish a greater sense of place.

4. Forecasted Traffic

Any changes to the transportation system must be able to accommodate existing as well as projected future traffic. Two future year scenarios are analyzed; 2024 and 2039 representing five year and 20-year forecasts. To forecast future traffic volumes in the study the general growth in traffic is considered first.

Previously collected traffic volumes along study roadways were gathered from the period of 2001 to 2015, before the Highway 371 bypass project. Growth rates could then be developed for the study roadways during that period and averaged to determine the general overall growth. The growth along Patriot Avenue (previously Highway 371) was not included in this average since that growth may have been due to factors outside of Pequot Lakes. This average growth rate was found to be approximately 1% per year and is assumed to continue through the 20-year forecasts for this study. This rate then covers expected development and continued growth of the City into the future.

A second type of growth is based on the high school adjacent to several of the study intersections. Based on discussion with the Pequot Lakes School District, the student population of the school district is anticipated to increase by about 5% total in the next three years with no significant growth anticipated for the long term. A separate growth rate of 5% (total, not per year) for both the 2024 and 2039 scenarios is therefore conservatively applied to traffic related to the school.

For the sake of this analysis, it is assumed most of the trips on the south leg of 2nd Street & Main Street and the west legs of Patriot Avenue & Woodman Street and Patriot Avenue & West Lake Street are related to school traffic. Those volumes are then proportionally carried through the study network.

To summarize, a background growth rate of 1% per year was applied to the existing non-school traffic volumes with a total 5% applied to school related traffic to establish the 2024 and 2039 forecasts. The average daily traffic volume forecasts developed through this process as well as the resultant 2024 and 2039 peak hour forecasts are shown in the Appendix.

5. Operational Analyses

a. *Corridor Vehicular Analysis*

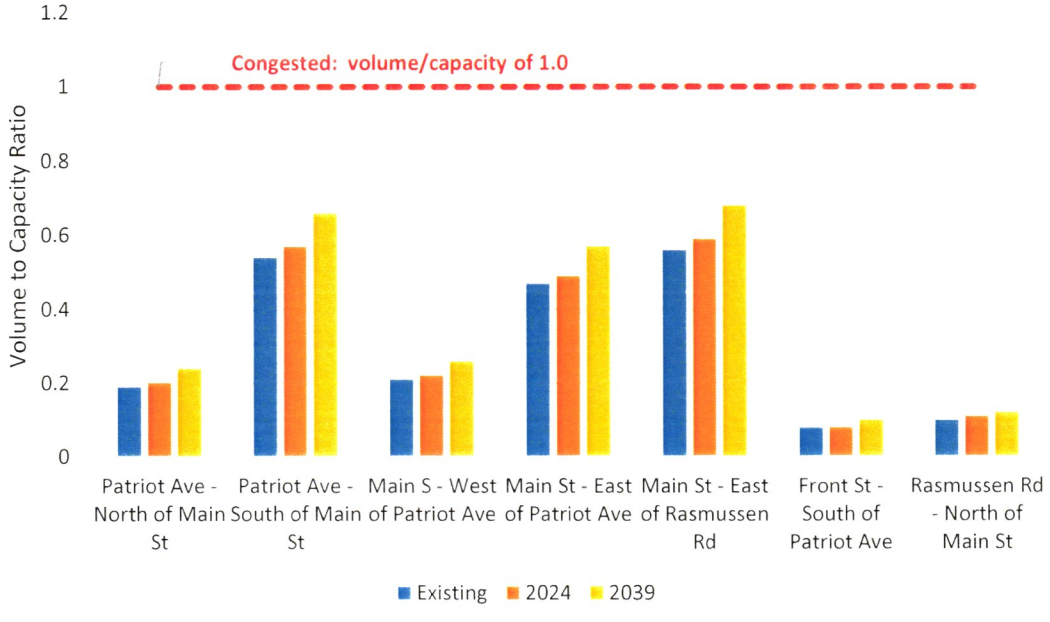
While many factors contribute to a road feeling congested, the two biggest factors are volume, how many vehicles are using the road, and capacity, how many vehicles the road can accommodate a day. Transportation professionals use these pieces of information to create a ratio of volume to capacity. For example, a road with a volume to capacity ratio of 1.0, where the traffic demand is nearly equal to the traffic supply, will feel congested to motorists.

Below is a rough guide of the daily traffic volumes different types of roads can accommodate based on standards for counties in the area. If the Average Daily Traffic (ADT) volume on a roadway is below the threshold, then it is considered un-congested. If the daily volume falls inside the range, the road is almost congested, and if the daily volume is over the threshold the road is congested.

- 2-lane undivided, urban street (one lane in each direction): 10,000 vehicles per day.
- 3-lane undivided, urban street (one lane in each direction with center left turn lanes): 15,000 vehicles per day.

To provide an initial planning level screening, Chart 1 provides volume to capacity ratios of the study corridors during each of the study years to determine if any of the roadway corridors are candidates for additional through lanes. This type of planning-level screening does not account for lane widths. As shown, the existing roadway corridors provide for acceptable operations with their current geometry.

Chart 1 – Study Corridor Volume to Capacity



b. *Intersection Vehicular Analysis*

Individual intersections can perform poorly during peak periods while the overall roadway corridor is operating with an uncongested daily volume to capacity ratio lower than 1.0. Therefore, capacity analyses are performed for the study intersections to determine if they need improvements such as turn lanes or an upgrade in traffic control.

The existing and forecasted turning movement volumes along with the existing intersection configurations and traffic control were used to develop the average delay per intersection in each study scenario. The delay calculations were done in accordance with the *Highway Capacity Manual, 6th Edition* using the Vistro software package. The full calculations for each study scenario, including Level of Service (LOS) grades and queue lengths, are included in the Appendix. Also, included in the Appendix is a guide explaining the Level of Service grade concept.

Chart 2 shows the average peak hour delay per traffic signal-controlled intersection for each study scenario. The LOS D/E boundary of 55 seconds of delay per vehicle is considered the threshold between acceptable and unacceptable traffic signal operation in Minnesota. In peak hours, the optimal range for an intersection to be in would be LOS C or LOS D. Operations of LOS A or LOS B in a peak hour signify an intersection may have excess, unneeded capacity.

Based on the Institute of Transportation Engineers' (ITE) recommendation of updating traffic signal timing plans every three to five years, the signal timing plans used in the future year analyses were optimized to best accommodate the forecasted traffic volumes. That optimization actually results in a decrease in intersection delay in the a.m. peak hour for future scenarios compared to the existing scenario.

Chart 2 – Peak Hour Delays: Signal Controlled Intersection

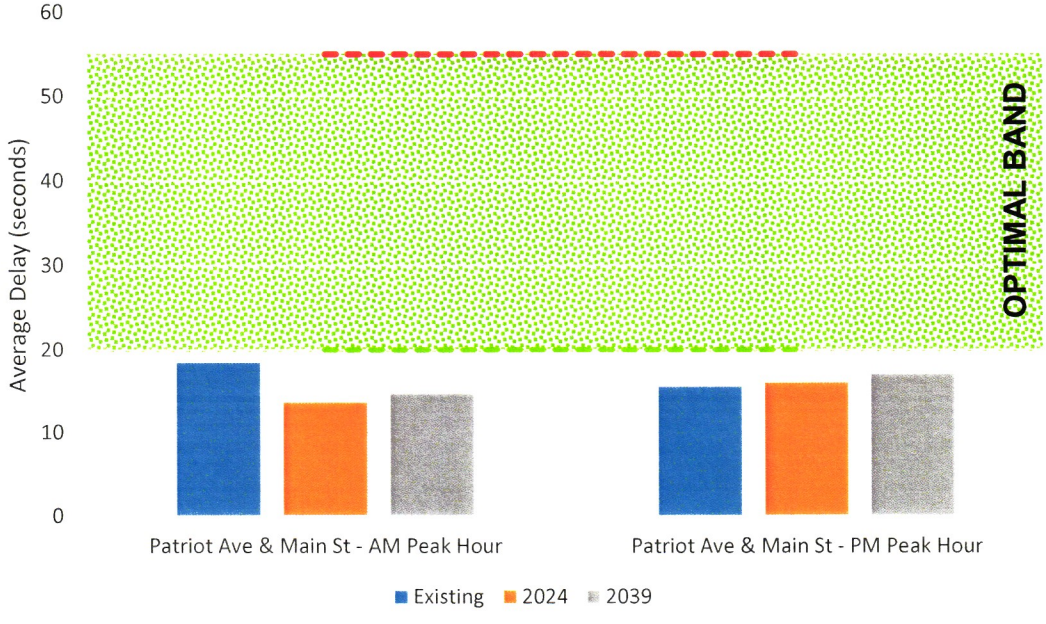


Chart 3 shows the average peak hour delay per the all way stop sign controlled intersection for each study scenario. The LOS D/E boundary of 35 seconds of delay per vehicle is considered the threshold between acceptable and unacceptable all-way stop and roundabout operation in Minnesota. The *Highway Capacity Manual* sets the threshold lower at all-way stop signs and roundabouts then at traffic signal-controlled intersections based on the theory motorists have more patience at traffic signal-controlled intersections and accept longer delays at a red light.

Chart 3 – Peak Hour Delays: All-Way Stop Sign Controlled Intersection

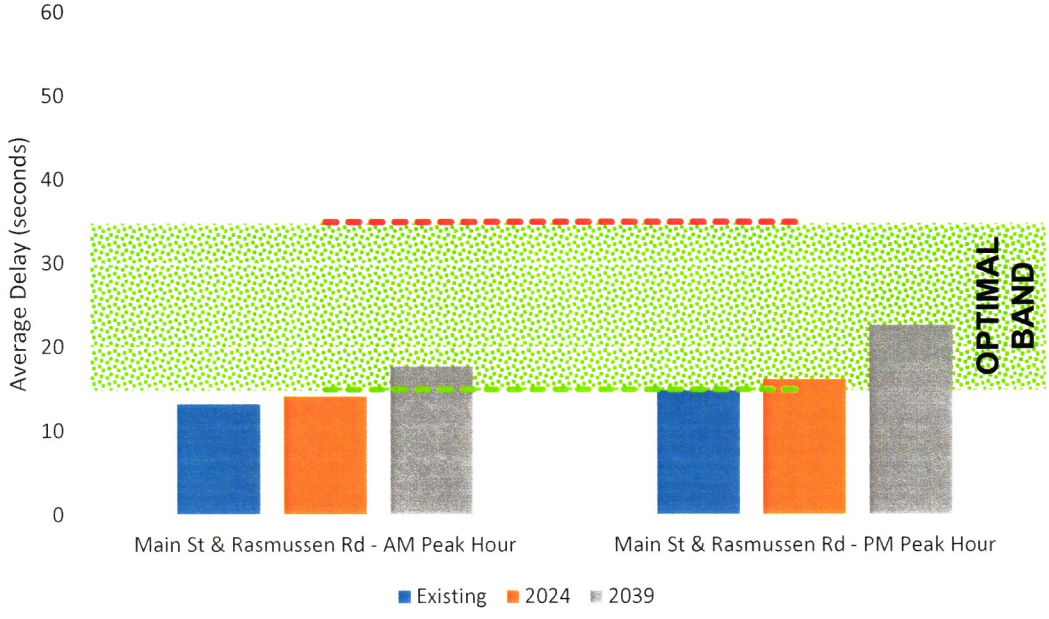


Chart 4 (a.m. peak hour) and Chart 5 (p.m. peak hour) show the 95th percentile queue lengths on the busiest stop sign controlled approach at intersections with side street stop sign control. Average delays are not shown for intersections with side street stop sign control because the vast majority of vehicles going through the intersection are on the main roadway and have zero delay, which leads to low overall average delays. At side street stop sign controlled approaches to busy roadways, the average delay for all the vehicles on the approach often exceeds 60 seconds. This can be the case for a few vehicles waiting at the stop sign where improvements would not be justified for the low traffic volume.

Based on our experience, improvements are not warranted at these types of intersections until the 95th percentile queue at a stop sign is at least five vehicles. More often than not, mitigation can wait until these queues are over ten vehicles.

Chart 6 – A.M. Peak Hour Queues: Side Street Stop Sign Controlled Intersections

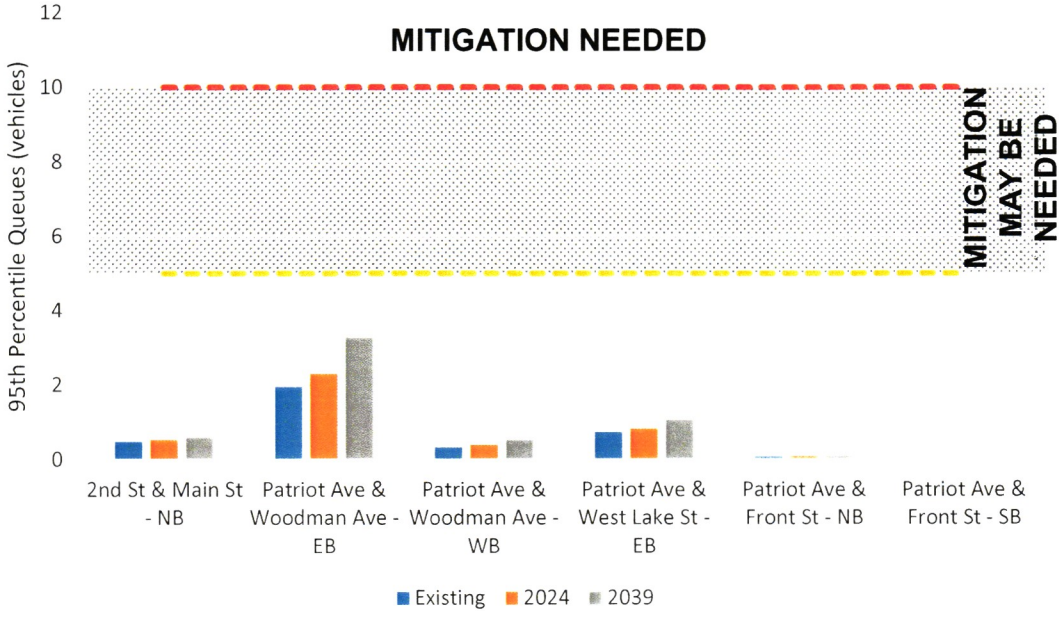
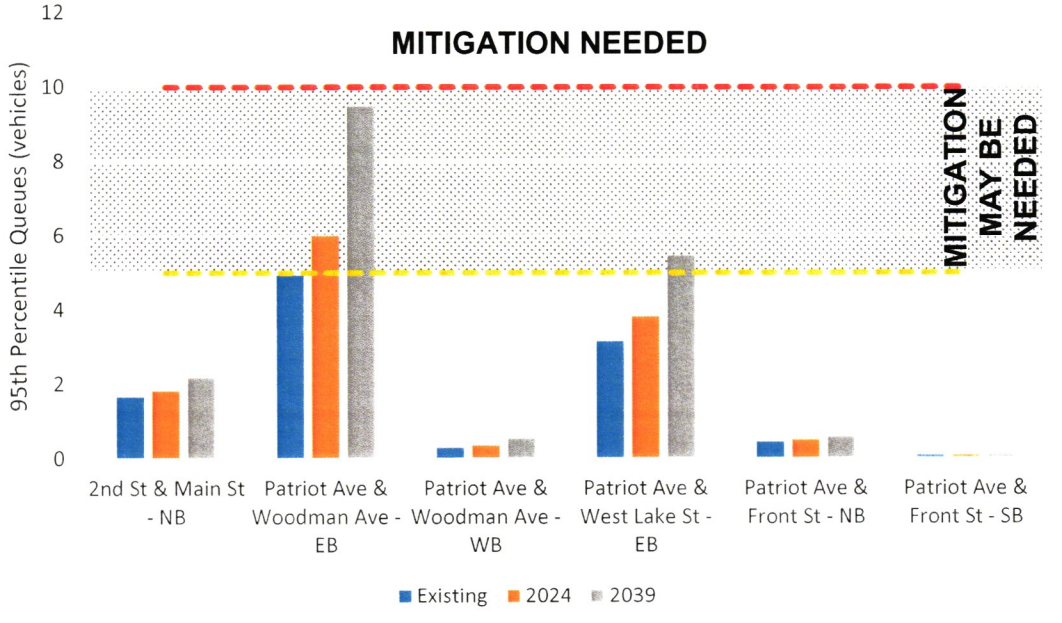


Chart 7 – P.M. Peak Hour Queues: Side Street Stop Sign Controlled Intersections



6. Alternative Intersection Analyses

a. *Current & Future Intersection Operations*

As seen in Charts 2 through 7, most of the study intersections currently experience, and are forecast to continue to experience, acceptable operations during peak hours.

The signalized and all-way stop controlled intersections are well within the levels of acceptable average delay during peak hours.

At the side-street stop-controlled intersections, the 95th percentile queues are within acceptable ranges with the exception of eastbound queues on Woodman Avenue and West Lake Street during the p.m. peak hour. As discussed in the Existing Conditions memorandum, those large queues are due to traffic leaving the high school. Though these queues are longer than desired, the period of high traffic volumes is short lived before queue lengths return to acceptable levels.

Based on this evaluation, no improvements are necessary to bring operations to acceptable levels. In addition, some study intersections may have excess capacity that could allow for changes in geometry or traffic control.

b. *Alternative Intersection Layouts & Control Types*

As mentioned above, either keeping the current configuration and traffic control at the study intersections or reducing the number of lanes and lowering the level of traffic control may be appropriate. To determine what level of change would be acceptable at the study intersections, each study intersection is considered individually below.

2nd Street & Main Street

This intersection is currently under side street stop control with no exclusive turn lanes designated. Outside of the school periods, traffic volumes are generally light at this intersection.

The main issue with this intersection is the west leg has a 90-degree curve very close to the intersection. Vehicles on the northbound leg at the stop sign have decent sight lines for both approaches, but westbound vehicles have poor sight lines making it potentially dangerous to turn left onto 2nd Street. This issue is exacerbated when vehicles coming from the north/west travel at higher speeds around the curve. It was observed that a number of vehicles coming from the north/west cross over the centerline as they head southeast around the curve.

The two best solutions for this issue would be to either realign 2nd Street and Front Street so they are a continuous road or to remove the buildings on the north side of Main Street east of Front Street to allow for better sight lines. Both of these options would be significant undertakings and may not be feasible.

The next best option would be to slow traffic coming from the north/west into this intersection to allow more time for vehicles on other approaches to recognize a potential

conflict. Converting this intersection to an all-way stop is not recommended because the volumes are significantly lower than desired for an all-way stop; volumes do not meet Manual on Uniform Traffic Control Devices (MUTCD) warrants for multi-way stop control. Additionally, the angle for vehicles approaching a stop sign from the north/west may lead to some drivers missing the sign.

To slow traffic, the lanes on Main Street/Front Street around the curve could be narrowed. When a lane is narrower, drivers tend to drive slower than if they were on a wider roadway. With a number of buses travelling through this intersection, the lane width would still need to remain wide enough for those large vehicles. Therefore, painting white edge lines will give the effect of a narrower lane. The road is currently over 20 feet wide at the ends of the curve. Painting 12-foot lanes will give drivers the feel that they should not take the curve fast and wide. Buses and large vehicles will still be able to traverse over the painted lines when needed to maneuver the curve.

Another issue at this location is drivers crossing over the centerline when travelling southbound around the curve. One factor contributing to this is the presence of parking on the west side of 2nd Street along the curve. If a no parking zone were extended on the west side from the intersection to the north end of the curve, vehicles travelling south around the curve may not feel the need to cross the center line.

An additional measure to keep drivers from crossing over the centerline as they travel around the corner would be placing flexible bollards along the centerline to guide drivers and enforce lane consistency. The bollards could be removed in the winter to accommodate snowplows. Turning movements were analyzed for school buses and full length semi-trailer trucks around this curve. With the addition of bollards, school buses would be able to navigate the curve without issue. Full sized semi-trailer trucks would not quite be able to do so as they currently need to cross over the centerline to make that turn.

Though not seen during our observations, westbound vehicles traveling around the curve may also possibly cross over the centerline. Restricting parking on the north/east side of the curve may also be a consideration.

A curve warning sign with an advisory speed plaque indicating a speed less than 30 mph may be appropriate. A speed study for the curve would be needed to determine the advisory speed limit.

Patriot Avenue & Main Street

This intersection is under signalized control with left turn lanes on all approaches and right turn lanes on the northbound and southbound approaches. The acceptable operation results with these lanes suggest an opportunity to change the traffic control, reduce the number of approach lanes, or do both.

When considering a reduction in approach lanes, impacts to be considered include:

- Vehicle delays. Removing turn lanes causes those turning movements to share a lane with through traffic and will increase delay time.
- Encouragement of alternative routes. A more confined intersection, particularly if paired with higher delays, may cause some drivers to rethink their travel paths and adjust to other areas.
- Truck movements. Any adjustments need to ensure heavy vehicle traffic is still able to easily maneuver through the intersection.
- Safer pedestrian crossings. Removal of turn lanes reduces the crossing distance and the exposure time of pedestrians to vehicle traffic.
- Less pavement to manage. Less pavement at an intersection leads to less management issues associated with the roads (while outside of the scope of this study, still an important impact to mention).

Considering the volumes at the study intersection (indirectly considering the impact on vehicle delays first), the northbound right turn is the highest movement volume over the course a day at the intersection. However, the northbound through movement volume is low. Additionally, the southbound right turning volume is similarly low throughout the day. Because of these volumes, removing the northbound and southbound right turn lanes is a viable option.

For left turn lanes, only the westbound approach has significant enough peak hour left turning volume to warrant an exclusive left turn lane. For symmetry reasons, the eastbound approach should also have a left turn lane to match the geometry of the westbound approach. Therefore, removal of the northbound and southbound left turn lanes is a viable option.

The existing turning movement volumes through the Patriot Avenue/Main Street intersection do not meet MUTCD warrants for signal installation. These warrants are standard guidance that suggest when a traffic signal may be justified for an intersection. Since the warrants are not satisfied, a traffic signal may not be needed and other options could be explored. The two options for traffic control at this location other than a traffic signal are all-way stop control and roundabout control. Traffic volumes at this intersection are too high and balanced to consider side-street stop control; 57% of approach traffic is northbound-southbound and 43% is eastbound-westbound.

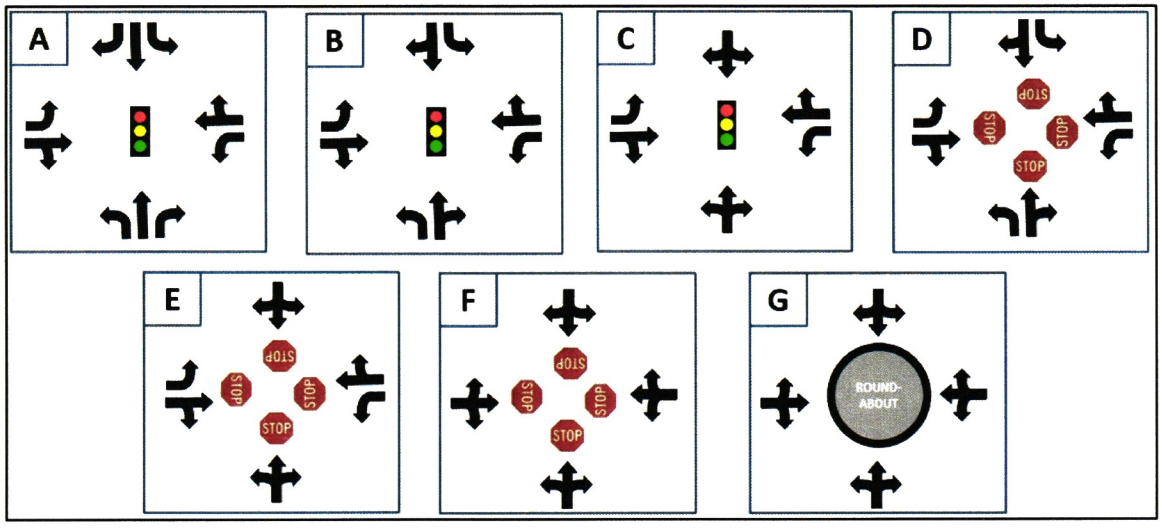
With an all-way stop, as the name implies, every vehicle on every approach stops at the intersection. The benefits of all-way stop over a signal is usually seen during off-peak times when vehicle volumes are lower. For example, a car approaching the intersection at 5:00 a.m. may have to stop at a red signal for many seconds even if there are no other vehicles around. With an all-way stop, this vehicle would only have to make a brief stop and then continue on. Another benefit is that pedestrians do not need to wait for a signal change and can proceed through the intersection. Conversely, all-way stop intersections cannot handle as high of traffic volumes as a signal.

Similarly, off-peak operations at a roundabout can be better than those of a signal since vehicles do not need to wait for a change in the signal phase. Pedestrians also do not

need to wait for a signal to cross. Roundabouts can handle higher traffic volumes than all-way stops. Roundabouts have been proven safer than traditional intersections, preventing most serious injury and fatal crashes.

Using the review above, Figure 1 shows the different traffic control and turn lane option alternatives for this intersection. Note that Option A represents the existing layout.

Figure 1 – Patriot Avenue/Main Street Alternatives



Using the forecast 2039 volumes for the a.m. and p.m. peak hours, intersection operations were analyzed for each of the seven scenarios from Figure 1. Once again, these calculations were done in accordance with the *Highway Capacity Manual, 6th Edition* using the Vistro software package. The results of these analyses are shown in Charts 8 and 9. Chart 8 shows results for the signalized options while Chart 9 shows results for the all-way stop and roundabout options.

Chart 8 – Patriot Avenue & Main Street Alternative Peak Hour Delays: Signal Control

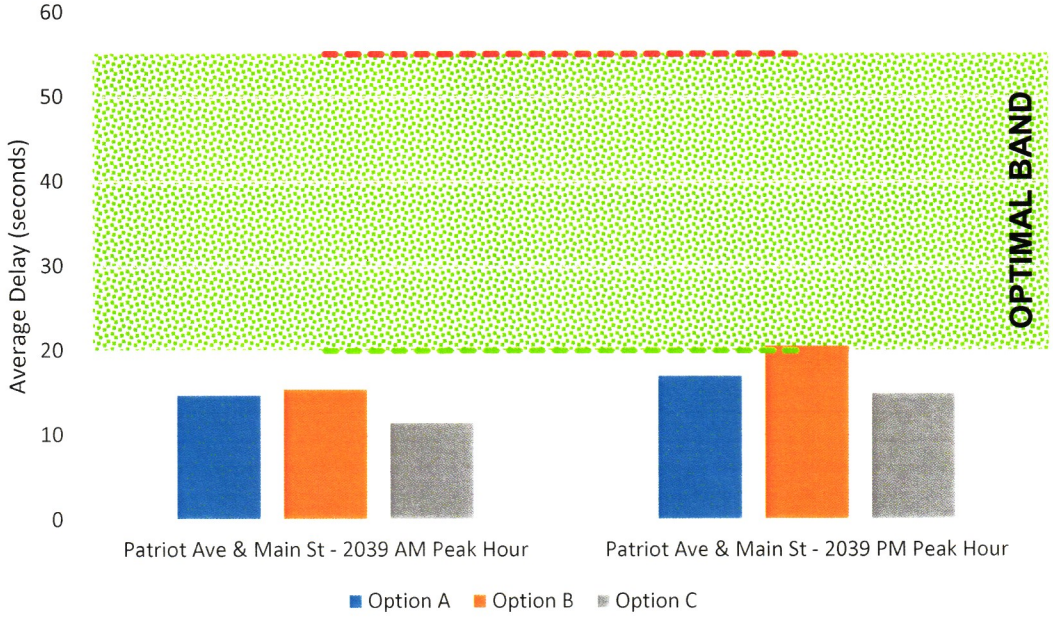
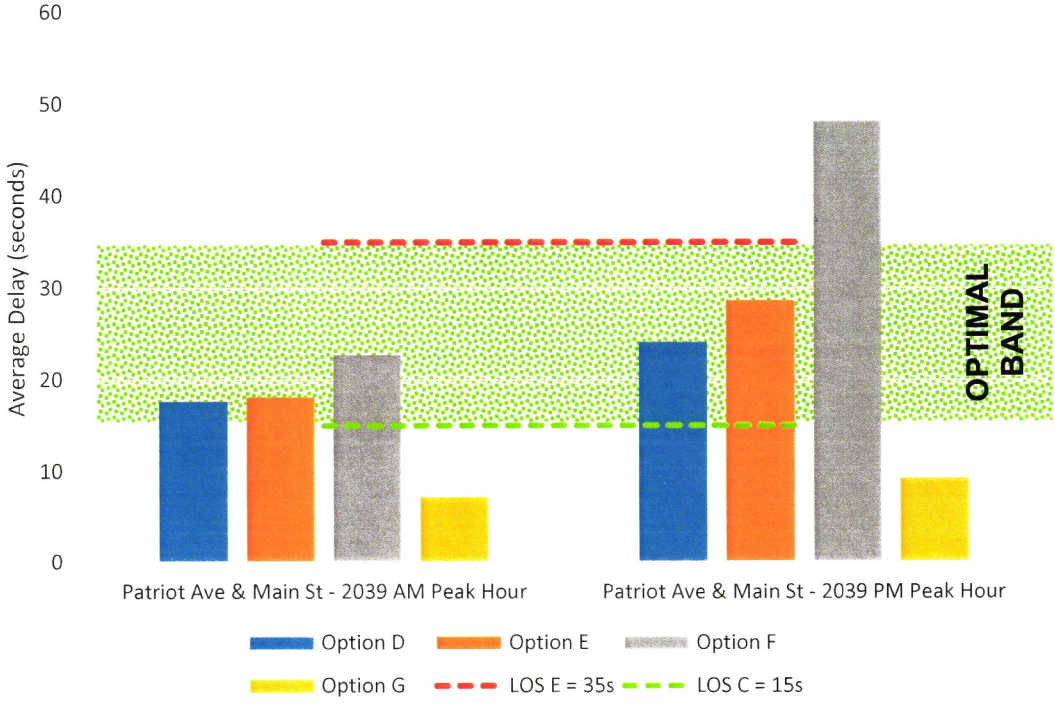


Chart 9 – Patriot Avenue & Main Street Alternative Peak Hour Delays: All-Way Stop and Roundabout Control



As can be seen in Charts 8 & 9, all alternative options are forecast to keep Patriot Avenue/Main Street operating acceptably through the 2039 forecasts except for Option E. For the signalized options, it is noted that Option C actually sees a slight overall improvement in intersection delays since the northbound and southbound protected left turn phases are removed. Overall, each of the signalized options show similar operations suggesting lane removal can be considered for the intersection. Turning radii of the corners could be kept wide enough to accommodate heavy vehicle turns. In any case, if the signal is kept at this intersection, timing plans should be updated every three to five years to reflect current intersection use.

For the unsignalized options, converting the intersection to an all-way stop and keeping left turn lanes or converting to a single lane roundabout both show acceptable peak hour operations with the 2039 forecasts. Not reflected in Chart 9 is the change in individual approach delays between scenarios. With a roundabout, all approaches see an improvement in approach delay. With the stop, the westbound approach in the a.m. peak hour and the northbound approach in the p.m. peak hour see increases in approach delay with the northbound p.m. peak hour approach in the LOS E or F range.

With the all-way stop layouts, Options D and E both have more than one lane on at least some of the approaches. This type of layout will likely lead to confusion/uncertainty for some drivers causing the average delays to be higher than shown in Chart 9.

For a roundabout, the intersection would need to be designed in a way to accommodate heavy vehicle turns because the City of Pequot Lakes does not want to divert heavy vehicle traffic onto other routes through the city. An education campaign may also be necessary depending upon how familiar drivers are with roundabouts.

On the west leg of this intersection, there is less than 60 feet between the crosswalk and on-street parking on the south side of Main Street. Vehicles parked on-street here effectively block the shared through/right turn lane allowing for little stacking room at the intersection. If this layout remains, it is recommended that on-street parking availability on the south side of Main Street be removed for at least 100 feet west of the crosswalk to allow for better operations with less weaving at the intersection.

Rasmussen Road & Main Street

This intersection is under all-way stop control with one lane on each approach. Chart 3 shows this intersection is to operate acceptably through 2039. The two other control types available for this intersection would be either a single-lane roundabout or a side-street stop-controlled intersection.

Roundabouts have a larger footprint than all-way stop controlled intersections. A roundabout at this location would need to take significantly more space than the current intersection. For that reason, a roundabout may not be a good option at this location.

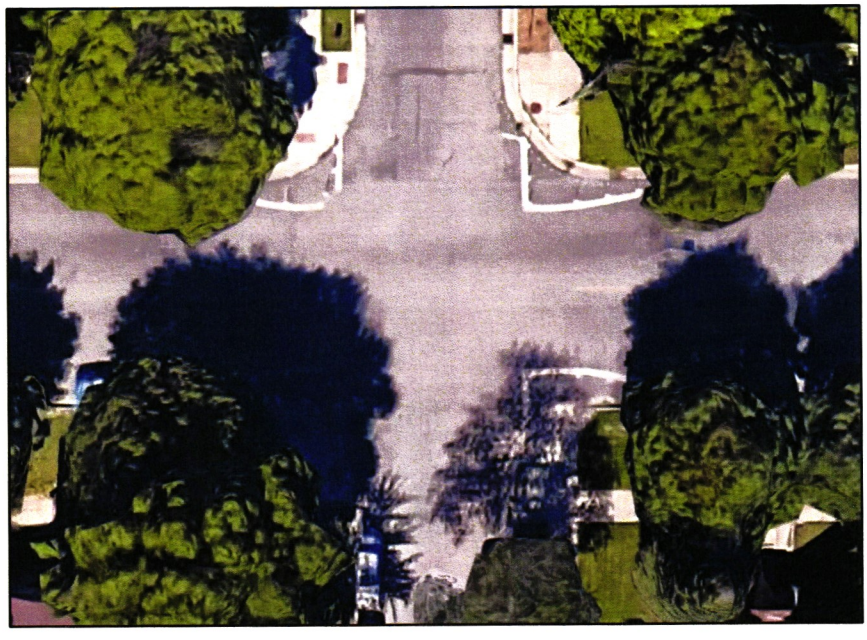
With a side-street stop-controlled intersection, the stop signs along Main Street would be removed since that is the roadway with higher volumes. Vehicles along Main Street

would no longer need to stop at this intersection meaning speeds will be increased through this intersection. With pedestrian crossings on all sides of this intersection, higher speeds would not be desired and would make crossing more difficult and likely less safe. Therefore, changing the traffic control at this intersection may not be appropriate.

Two previously mentioned goals of the City are to accommodate pedestrians/bicycles as well as keep heavy vehicle traffic on main routes. One way to aid in these goals at this intersection is to install bump outs. Curb bump outs extend the curb and tighten up the turning radius. These extensions make the crossing distance lower for pedestrians, lowering their exposure time. However, bump outs also make it more challenging for large vehicles to turn. Turning movements were analyzed for school buses and full length semi-trailer trucks at this intersection. School buses would be able to make all turns and not cross over any centerlines with the addition of curb bump outs. Semi-trailer trucks would be unable to navigate around bump outs as they currently cannot make these turns without crossing over centerlines.

Curb bump outs could either be constructed out of concrete as a physical extension of the sidewalk or outlined with paint and pylons. To aid in accommodating snow plowing operations, pylons can be used and removed in the winter. Figure 2 shows an example of a seasonal curb bump out using paint and pylons.

Figure 2 – Seasonal Curb Bump Out Example



Patriot Avenue & Woodman Street

This intersection is under side-street stop control with Patriot Avenue free-flowing. Two-way left turn lanes are provided on Patriot Avenue at this intersection. From Charts 6 and 7 it can be seen that there are some longer eastbound queues in the p.m. peak hour. These queues are generally not long lasting as they due to traffic coming from

the school as the school lets out for the day. Over 10% of the daily eastbound traffic on this eastbound approach occurs in one 15-minute period in the p.m. peak hour. Once the school traffic passes the queues on Woodman Street are relatively short. Therefore, no mitigation measures would be recommended to accommodate the vehicle traffic on Woodman Street.

Being near the school, there are pedestrians that cross Patriot Avenue at this intersection. While the pedestrian crossing volumes are moderate, about 40 crossing Patriot Avenue per day, the proximity to the high school makes this location a desirable place to cross and pedestrian crossing improvements would be beneficial. This location is approximately 680 feet south of the pedestrian crossing at the signal at Patriot Avenue/Main Street.

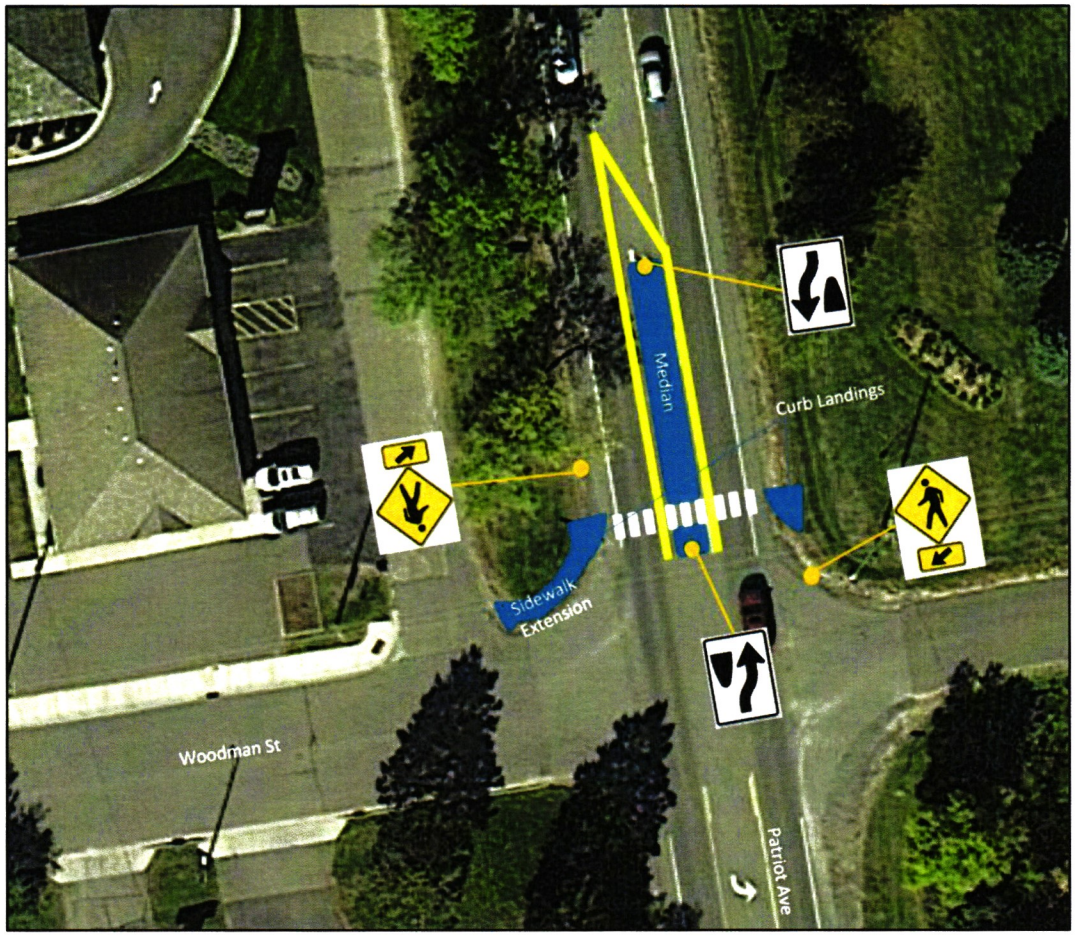
With a sidewalk on the north side of Woodman Street west of Patriot Avenue, a crossing across Patriot Avenue on the north side of this intersection would be the appropriate location. Pedestrian crossing signage and striping would be recommended to communicate to drivers and pedestrians the location of the crossing. In-road pedestrian crossing signs placed on the lane lines would further communicate to drivers on Patriot Avenue that they may need to stop in a location they previously may not have anticipated stopping. Curb landings with ADA compliant ramps are recommended on either side of the crossing with a sidewalk extension on the west side to connect to the existing sidewalk.

The two-way left turn lane on Patriot Avenue increases the distance pedestrians would need to cross. Looking at the Patriot Avenue left turning volumes at this intersection, the highest hourly volume is northbound left turns in the a.m. peak hour where there are 73 vehicles turning left. With this level of left turning traffic, the northbound left turn lane provides enough benefit to remain.

For southbound Patriot Avenue, the highest hourly left turning movement only contains eight left turns. That level of left turning traffic does not need an exclusive left turn lane. With a pedestrian crossing on the northern portion of this intersection, the southbound left turn lane could be removed and a median could be placed for a pedestrian refuge. This median could either be concrete or striped. This means the two-way left turn lane would start at Woodman Street and extend south. North of Woodman Street, there could still be exclusive left turn lanes for Butler Street and Main Street but not a two-way left turn lane.

Figure 3 shows a sketch of these recommendations.

Figure 3 – Patriot Avenue/Woodman Street Pedestrian Recommendations



Patriot Avenue & West Lake Street

This intersection is also under side-street stop control with Patriot Avenue free-flowing. Two-way left turn lanes are provided on Patriot Avenue at this intersection. Charts 6 and 7 show some larger queues in the p.m. peak hour, but those are also related to school traffic. No mitigation measures are recommended to accommodate the vehicle traffic at this intersection.

Though some pedestrians were observed to cross Patriot Avenue and cut through the wooded area to the east, without a defined destination on the east side of Patriot Avenue a pedestrian crossing is not recommended here. Additionally, if a pedestrian crossing were included at Woodman Street, pedestrians would be encouraged to route one block north to cross.

The maximum hourly northbound left turn volume was observed to be 83 vehicles. It is reasonable with those volumes to keep the left turn lane at this intersection.

Patriot Avenue & Front Street

This intersection is also under side-street stop control with Patriot Avenue free-flowing with a two-way left turn lane. This intersection is skewed with left turns off of Patriot Avenue and right turns off of Front Street being at very tight angles. Conversely, right turns off of Patriot Avenue and left turns off of Front Street are at very shallow angles. Vehicles turning right off of Patriot Avenue are able to make that turn without much speed reduction.

The volumes on Front Street at this intersection are very low throughout the day. Because this intersection is not highly utilized and the angles lead to challenging or high-speed turns, it could be considered for closure. Both the north and the south legs have alternative routes within approximately 300 feet that could be taken, so there would be little impact to travel times. Sight line improvements may be needed at the Sibley Street intersection with Patriot Avenue as more vehicles would be pushed to this intersection with a closure of Front Street.

It is recommended that a temporary closure of the Front Street legs at this intersection be conducted. Using barriers, the legs of Front Street can be temporarily closed, and operations be monitored to determine how drivers adapt to the change.

Table 1 lists the potential intersection alternatives with benefits and drawbacks of each.

Table 1 – Potential Intersection Alternative Comparisons

Intersection	Potential Alternative	Benefits		Drawbacks	
2nd St & Main St	Stripe narrower lanes	Reduce speeds around curve	--	--	--
2nd St & Main St	Remove on-street parking	Reduce centerline crossovers	--	Reduced parking availability	--
2nd St & Main St	Centerline bollards	Reduce centerline crossover	--	Large truck conflicts	--
Patriot Ave & Main St	Remove NB/SB right turn lanes	Reduce ped/bike exposure	--	Added delay for NB/SB right turns	--
Patriot Ave & Main St	Remove all NB/SB turn lanes	Reduce ped/bike exposure	--	Added delay for NB/SB turns	--
Patriot Ave & Main St	Convert to all-way stop	Reduce ped/bike exposure	Improve off-peak operations	Increased delays on some approaches	Multi-lane all-way stops can be confusing for drivers
Patriot Ave & Main St	Convert to roundabout	Reduce ped/bike exposure & multi-stage crossings	Improve off-peak operations	Large construction costs	--
Patriot Ave & Main St	Remove on-street parking	Improve eastbound approach operations	--	Reduced parking availability	--
Rasmussen Rd & Main St	Curb Bump Out	Reduce ped/bike exposure	Discourage heavy vehicle turns	Large truck conflicts	--
Patriot Ave & Woodman St	Ped Crossing & sidewalk extension	Increase driver awareness of peds	--	--	--
Patriot Ave & Woodman St	Remove SB left turn lane	Allow for pedestrian refuge	--	Minor impacts to southbound vehicle delays	--
Patriot Ave & Front St	Close intersection	Remove high speed turns	Remove sharp angle turns	Moderately increase travel times	--

Based on the previous analysis, our recommendations include the following:

- 2nd Street/Main Street: stripe narrower lanes around the curve and restrict on-street parking on the west side of the curve.
- Patriot Avenue/Main Street: remove the northbound and southbound right turn lanes and restrict on-street parking on the south side of Main Street west of Patriot Avenue for at least 100 feet from the crosswalk.
- Rasmussen Road/Main Street: add seasonal curb bump outs.
- Patriot Avenue/Woodman Street: add a pedestrian crossing with a median on the northern side of the intersection across Patriot Avenue. Extend the existing sidewalk on the west side of the intersection to this crossing.
- Patriot Avenue/West Lake Street: no changes.
- Patriot Avenue/Front Street: complete a test closure of the Front Street approaches utilizing temporary barriers.

7. Alternative Corridor Analyses

a. *Current & Future Corridor Operations*

As shown in Chart 1, all roadways are forecast to continue to operate within their capacity through 2039. No expansions to the study roadways are anticipated to be needed.

b. *Alternative Corridor Layouts*

All of the roadways in the study network are two-lane, undivided roads with the exception of Patriot Avenue. As discussed, it is recommended that the right turn lanes on Patriot Avenue at Main Street be removed, allowing Patriot Avenue to be narrowed in the area around Main Street. Left turn lanes are recommended to remain in some areas. With the desire to keep heavy vehicle traffic on Patriot Avenue and not use alternate routes through Pequot Lakes, adding on-street parking on Patriot Avenue is not recommended. Parking would cause more interruptions in the traffic flow and create a confined feel, negatively impacting how truck drivers view the corridor.

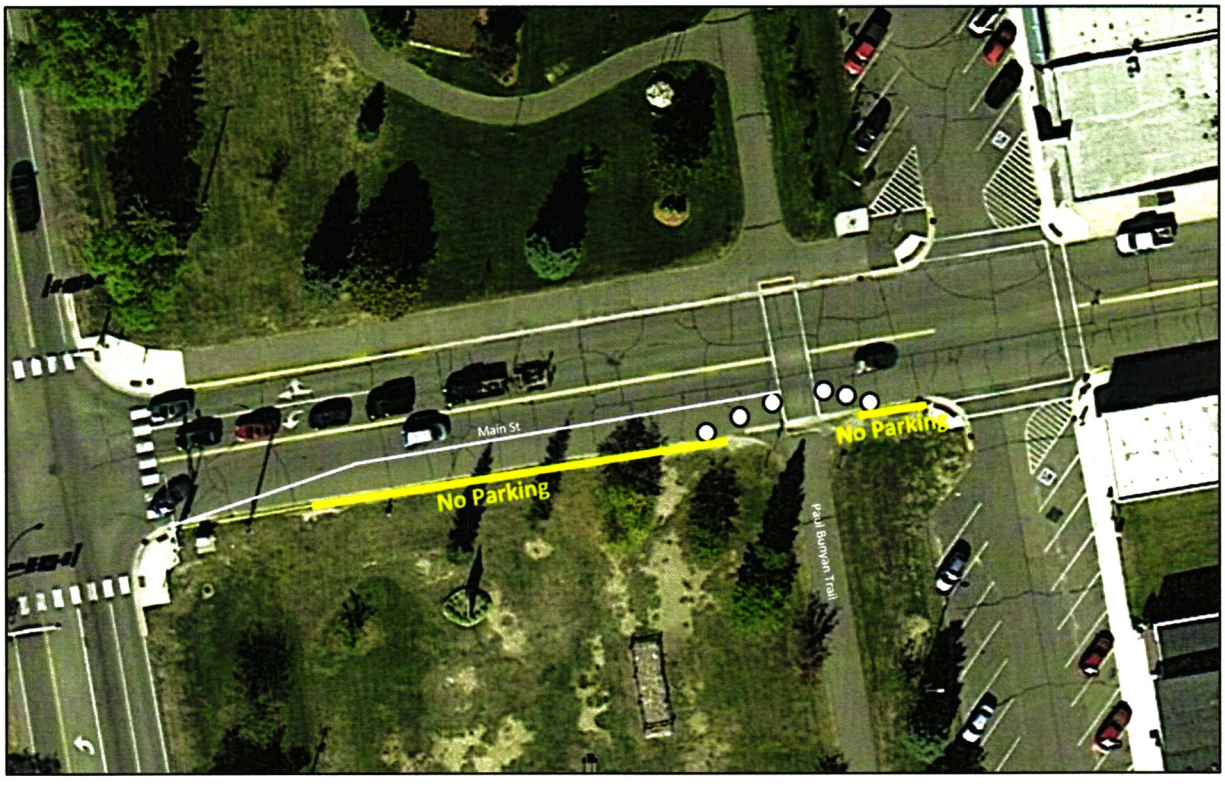
Main Street east of Patriot Avenue is approximately 45 feet wide. With two westbound lanes and one eastbound lane on this block, this road could be reduced in width. With the Paul Bunyan Trail crossing on this block, reducing the width of the roadway would reduce pedestrian and bicycle exposure time at this location. One way to achieve this would be to add a bump out on the south side of Main Street at the trail crossing reducing the eastbound through lane to be closer to 12 feet wide rather than over 20 feet wide. This could be done using pylons which could be removed in the winter to aid snow plowing operations. Pedestrian and bicycle crossing movements are anticipated to be lower in the winter so having only seasonal pylons would likely be all that is needed.

Additionally, the eastbound approach on Main Street is over 20 feet wide. This wide lane can lead to higher vehicle speeds as well as vehicles potentially using this stretch as two lanes rather than one, especially if going around a left turning vehicle. If the eastbound lane was striped as a 12-foot wide lane, driver expectations would be better set and it may reduce any excessive speeds.

Another step that could be made at this trail crossing location to improve pedestrian and bicycle crossings would be to remove on-street parking. On-street parking on the south side of Main Street can block the view of approaching traffic for both pedestrians/bicyclists as well as motorists. If parking were prohibited on this block, there would be an unobstructed view for all of those approaching the crossing.

Figure 4 shows a sketch of the trail crossing improvements.

Figure 4 – Main Street Trail Crossing Improvements



8. Conclusions and Recommendations

The traffic of the study network was thoroughly studied, and it was found that the study intersections and corridors are forecast to operate acceptably through the 2024 and 2039 scenarios.

The following recommendations are made for the study network:

- 2nd Street/Main Street: stripe narrower lanes around the curve and restrict on-street parking on the west side of the curve.
- Patriot Avenue/Main Street: remove the northbound and southbound right turn lanes and restrict on-street parking on the south side of Main Street west of Patriot Avenue for at least 100 feet from the crosswalk.
- Rasmussen Road/Main Street: add seasonal curb bump outs.
- Patriot Avenue/Woodman Street: add a pedestrian crossing with a median on the northern side of the intersection across Patriot Avenue. Extend the existing sidewalk on the west side of the intersection to this crossing.
- Patriot Avenue/West Lake Street: no changes.
- Patriot Avenue/Front Street: complete a test closure of the Front Street approaches utilizing temporary barriers.
- Main Street/Paul Bunyan Trail: add a seasonal bump out on south side of Main Street, restrict parking on the south side of Main Street on that block and stripe eastbound Main Street to have one 12-foot lane.

A sketch showing all recommendations is included in the Appendix.

9. Appendix

A. Recommendations Sketch

B. Existing Conditions Memorandum

C. Volume Forecasts

D. The Language of Traffic Engineering

E. Level of Service (LOS)

F. Capacity Analysis Backup

- AM Existing
- PM Existing
- AM 2024
- PM 2024
- AM 2039
- PM 2039