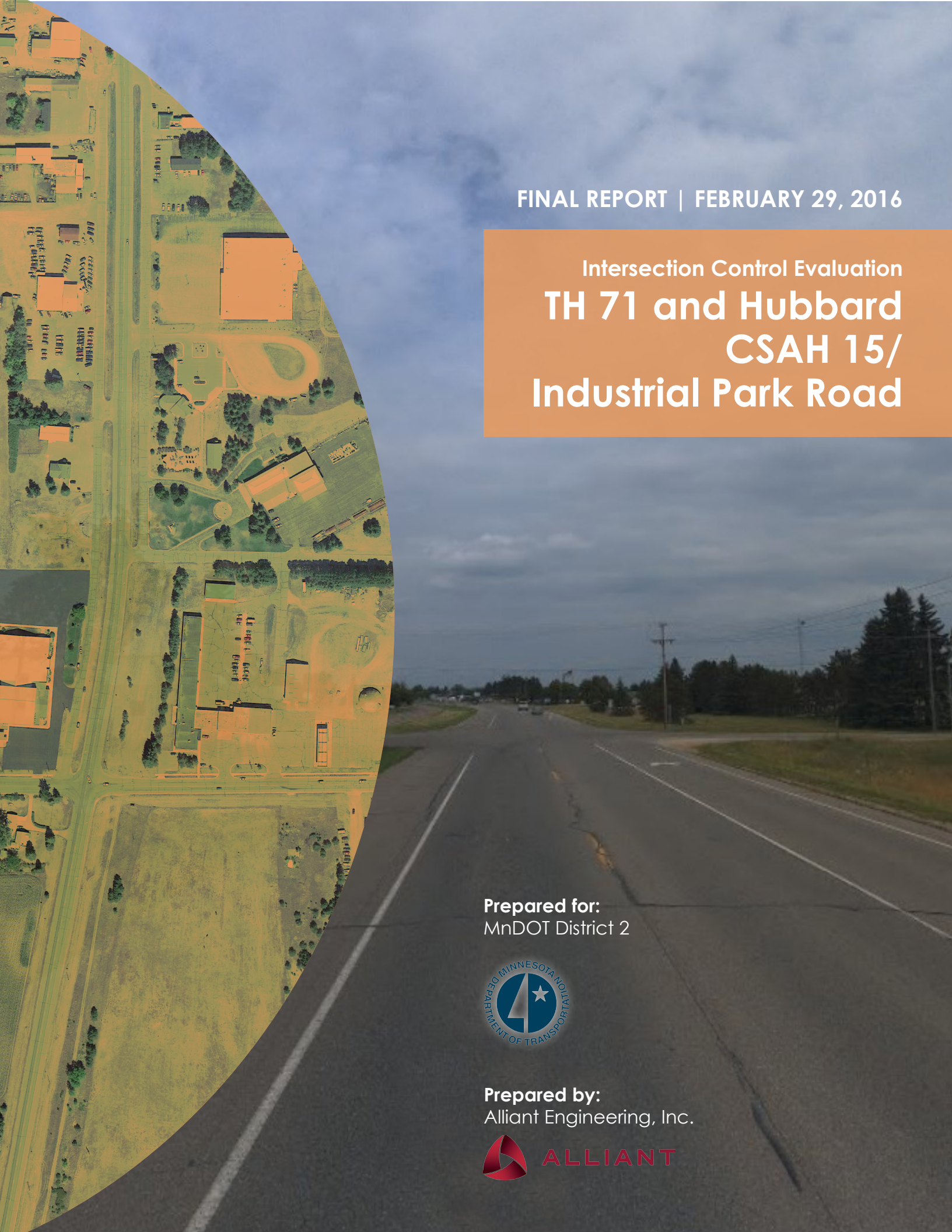

FINAL REPORT | FEBRUARY 29, 2016

Intersection Control Evaluation

TH 71 and Hubbard CSAH 15/ Industrial Park Road

Prepared for:
MnDOT District 2

Prepared by:
Alliant Engineering, Inc.

MINNESOTA DEPARTMENT OF TRANSPORTATION

INTERSECTION CONTROL EVALUATION

for

S.P. 2904-15
TH 71 and Hubbard County State Aid Highway 15 / Industrial Park Road

In Park Rapids, Hubbard County

Program: Safety Capacity **Funding:** Trunk Highway

Projected Letting Date: Estimated Letting 2018

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.

Michael R. Anderson	42828 Reg. No.	**02/29/2016** Date

APPROVED:

MnDOT District 2 Traffic Engineer	Date
Hubbard County Engineer	Date
Park Rapids City Engineer	Date

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1.0 Introduction

The Minnesota Department of Transportation (MnDOT) has identified a need to conduct an Intersection Traffic Control Evaluation (ICE) study for the Trunk Highway (TH) 71 and Industrial Park Road/County State Aid Highway 15 (CSAH 15) intersection.

1.1 Purpose and Need

Over the past ten years, the TH 71 and CSAH 15 intersection has experienced a noticeable crash history. The overall intersection crash rate is over 1.5 times the average statewide rate, but slightly under the critical crash rate. The intersection severity rate is nearly twice the statewide average rate. MnDOT recently completed a reclamation project along TH 71 where left and right turn lanes were constructed at major intersections. Left turn lanes were not added at CSAH 15 due to a greater need to identify the appropriate lane geometrics and traffic control device. As a result, passing on the right maneuvers is prevalent at this location; along with a high percentage of right angle crashes. In addition, the community has expressed concern regarding the delay incurred waiting at the stop sign, particularly during the peak hours.

MnDOT has identified 1.6 million in funding for construction of intersection improvements in 2018 to address motorist safety and delay concerns. The goal is to implement cost-effective safety improvements that can begin to address deficiencies in the near and long term. Understanding the combined nature of the intersection safety problem, and the need to address future traffic operation deficiencies, MnDOT desires an intersection improvement solution that accomplishes the following goals:

- Significantly reduces the frequency of severe crashes; and
- Improves the intersection level of service into the future.

To support MnDOT in identifying the appropriate intersection and traffic control improvements that meet the above stated goals, the ICE study will accomplish the following:

- Document the existing geometric, traffic operation and safety characteristics.
- Document opening year 2018 and design year 2038 traffic forecasts based upon expected employment and population growth projections surrounding the study area.
- Develop and evaluate at a high level conceptual alternatives that will to a varying degree improve the intersection safety characteristics.
- Conduct a traffic operation and safety analysis of each alternative.

- Develop a matrix comparing preliminary cost estimates, right of way and other factors to help determine the most optimal intersection lane geometrics and appropriate level of traffic control.
- Identify the preferred alternative.

1.2 Description of Location

The proposed roadway geometric and traffic control revisions are located at the intersection of TH 71 and CSAH 15, on the southern limits of Park Rapids, Hubbard County, Minnesota. Figure 1 illustrates the study intersection as well as its proximity to major roadways. The year 2014 population of Park Rapids is 3,727.

1.3 Technical Advisory Committee

The project was guided by a Technical Advisory Committee (TAC) including representation from Engineering and Planning Divisions of MnDOT District 2, Hubbard County and the City of Park Rapids. The role of the TAC was to assist in identifying the project issues, identification of alternatives, provide input on the alternatives analysis and to provide input regarding the preliminary alternatives and recommendations. Three TAC meetings were held over the course of the project.

1.4 Public Involvement

A public open house was held on February 2, 2016 to encourage citizen participation in the study. The goal of the public open house was to provide a forum that allowed interested citizens the opportunity to:

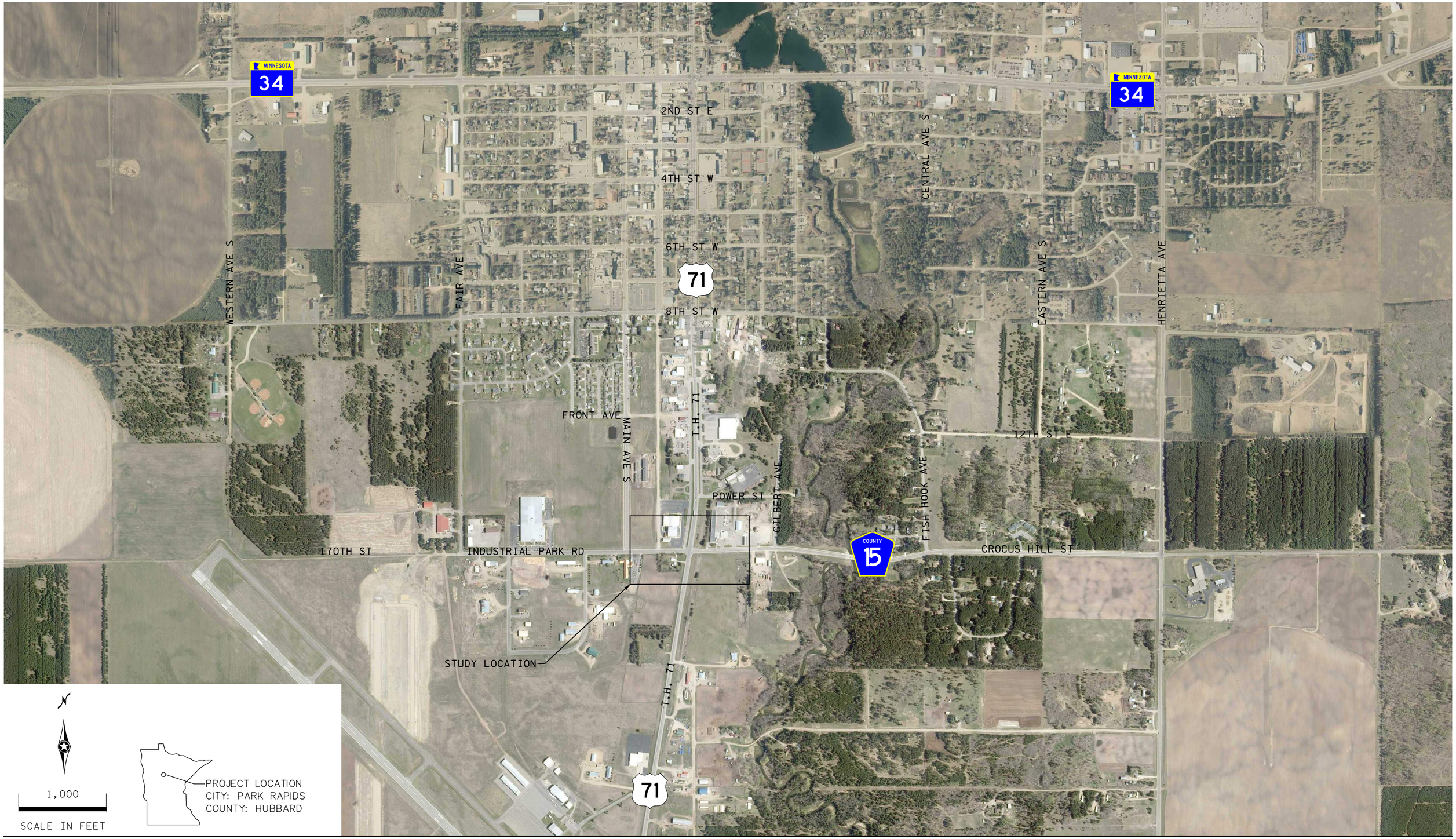
- Be actively engaged in the planning process;
- Provide comment and express ideas;
- Obtain education on the alternative traffic control devices; and
- Receive information on the project.

Two alternatives were presented for feedback (two-way stop control with left turn lanes and a single lane roundabout). The study conclusions and recommendations for the segment of TH 71 between CSAH 15 and 8th Street were also illustrated.

1.5 Elements of Study

The following elements are included in the ICE Study:

- Existing Conditions (Section 2.0)
- Future Conditions (Section 3.0)
- Alternatives Analysis (Section 4.0)
- Access Management Alternatives (Section 5.0)
- Preferred Alternative (Section 6.0)



TH 71 at CSAH 15/Industrial Park Road Intersection Control Evaluation

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Figure 1
Project Location Map

2.0 Existing Conditions

The following sections document the existing conditions analysis completed for the TH 71/CSAH 15/Industrial Park Road intersection.

2.1 Existing Roadway and Traffic Control Characteristics

The existing roadway characteristics are summarized below:

- **TH 71**: TH 71 serves as a principal arterial and generally consists of an undivided two lane section with exclusive turn lanes at major intersections. TH 71 has a rural roadway design with an approximate 10 foot paved shoulder. At CSAH 15, TH 71 has exclusive right turn lanes. The posted speed limit is 40 miles per hour (mph). Approximately 1,000 feet south of CSAH 15, TH 71 becomes a posted 60 mph roadway.
- **CSAH 15/Industrial Park Road:** CSAH 15/Industrial Park Road is a two-lane undivided county road with an urban roadway design and a posted speed limit of 30 mph. CSAH 15 serves primarily residential neighborhood streets east of Gilbert Ave and manufacturing land uses to the west.

Currently, the TH 71/CSAH 15 intersection is controlled by stop signs facing the eastbound and westbound approaches. Key features of the existing intersection characteristics, including lane geometrics and traffic control are illustrated in Figure 2.

2.2 Right of Way

Approximate right of way and parcel property mapping information was provided by MnDOT. The purpose of the right of way is to document the cross-sectional width available for infrastructure related improvements. To the extent feasible, future design alternatives and conceptual layouts will be developed within the right of way to minimize environmental, land acquisition and access impacts. However, where this is not possible, the comparison of the right of way needs between each alternative may serve as a useful decision factor.

TH 71 at CSAH 15/Industrial Park Road Intersection Control Evaluation

Figure 2
Existing Intersection Characteristics

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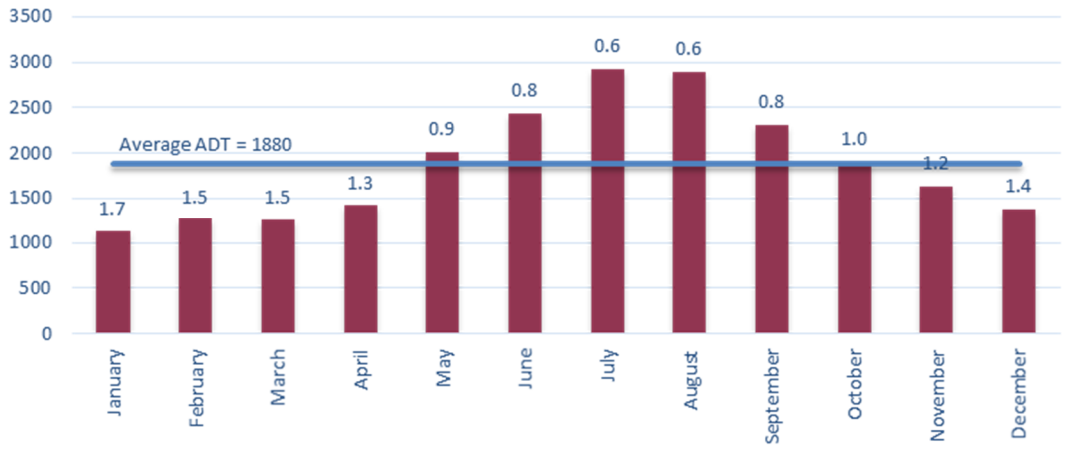
2.3 Existing Traffic Volumes

MnDOT provided 12-hour (7 a.m. to 7 p.m.) intersection turning movement counts collected in May 2009 at the TH 71/CSAH 15 intersection. In addition, April 2013 turning movement counts were provided for the 7 a.m. to 12:45 p.m. time period. A comparison of the 2009 to 2013 intersection counts was conducted to estimate the remainder of the year 2013 traffic volumes. The comparison found the 2009 traffic volumes were approximately 25% higher than those collected in 2013. It was determined that the volume difference is largely due to the seasonal nature of the traffic volume levels along TH 71. To determine the estimated seasonal variation along TH 71, daily and monthly traffic data collected at the Automatic Traffic Recorder (ATR) Station 220 (TH 71 at CR 89, located approximately 8 miles north of Park Rapids) was reviewed. The average daily traffic data by month, obtained from ATR Station 220 is plotted in Table 1. Table 1 also indicates the average annual daily traffic (AADT) and the monthly adjustment factors. Depending on the month in which traffic data is collected, the adjustment factors are used to either increase or decrease the collected volumes to arrive at an average normalized level. As shown, data collected in April is approximately 30% less than the average annual volume and data collected in May is typically 10% higher than the average annual volume. The seasonal variation between April and May is consistent with the volume difference found between the 2009 and 2013 traffic counts.

Table 1. TH 71 – Seasonal Adjustment Factor



Source: MnDOT ATR Station 220 – TH 71 (located just south of CR 89)

Based on the seasonal characteristics of TH 71, the 2013 traffic volumes (collected in April) were adjusted by a factor of 1.3 to normalize the turning movement data to reflect an average day.

Table 2 details the 2013 existing Average Annual Daily Traffic (AADT) as a function of the turning movement counts at the TH 71/CSAH 15 intersection and Figure 3 illustrates

the daily traffic volume profile along TH 71. Figure 4, on page 8, illustrates the existing year 2013 a.m. and p.m. peak hour seasonally adjusted turning movement volumes.

Table 2. Existing Year 2013 AADT Volumes

Roadway	Segment	Existing 2013
TH 71	North of CSAH 15	7,700
TH 71	South of CSAH 15	7,600
CSAH 15	West of TH 71	2,100
CSAH 15	East of TH 71	2,500

Source: 13 hour turning movement count collected in April 2013.
The 13-hour volume is assumed to be 80% of the daily. A 1.3 seasonal adjustment factor is applied to estimate the annual average daily traffic volume.

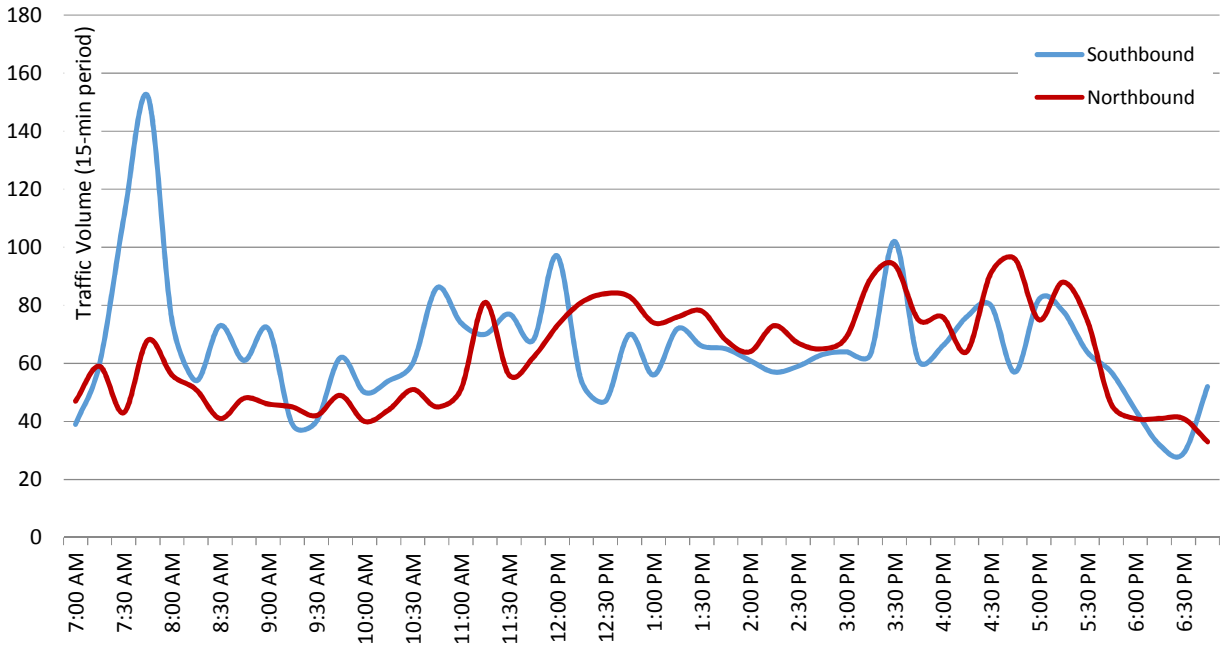


Figure 3. Daily Traffic Volume Profile – TH 71

TH 71 at CSAH 15/Industrial Park Road Intersection Control Evaluation

Figure 4
2013 AM and PM Peak Hour Turning Movement Volumes

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2.4 Existing Crash Experience

MnDOT provided crash data for the dates between 2005 and 2014. Based on the crash data provided there have been 15 reported crashes at the TH 71/CSAH 15 intersection. The crash diagram detailing the crash type and contributing factors is provided in Appendix A.

A key factor in the safety analysis is the crash rate. The crash rate for any intersection is defined as the number of crashes occurring per million entering vehicles (MEV). Table 3 summarizes the existing crash rate for each intersection compared to the statewide average for similar traffic control types.

Crash occurrence is somewhat random by nature. Identifying every intersection with a crash rate above the statewide average value in an analysis would produce a large amount of data that may not be statistically relevant with respect to safety deficiencies. The critical crash rate identifies those locations that have a crash rate higher than similar facilities by a statistically significant amount. The critical crash rate is calculated by adjusting the system wide average based on the amount of exposure and a statistical constant indicating level of confidence[1]. At locations where the actual crash rate exceeds the critical crash rate, it is 95 percent certain that an intersection design deficiency exists, or there are hazardous characteristics present at the location.

Crash severity quantifies how severe the crashes are at a particular location. In the crash information database maintained by MnDOT, crashes are categorized into three major categories of severity; property damage – no injuries occurred, type A, B and C injury crashes and fatal crashes. The purpose for analyzing this statistic is to identify locations that experience a low crash rate but have a high percentage of injury or fatal crashes. Conversely, locations which have high crash rates with a large proportion of property damage crashes may not warrant as much priority when deficiencies are being addressed.

The review of the existing crash rate, critical crash rate and severity rate finds the TH 71/CSAH 15 intersection is experiencing more crashes and a higher severity rate than the statewide average for similar intersections. The intersection crash rate was found to be slightly less than the critical crash rate.

[1] MnDOT Traffic Safety Fundamentals Handbook, August 2015.

Table 3. Crash Rate Summary (2005 – 2014)

Intersection	Traffic Control	Total Crashes[4]	Total Entering Volume[6]	Crash Rate	State Average Crash Rate[1]	Critical Crash Rate[2, 3]	Crash Severity Rate[5]	State Average Severity Rate[1]
TH 71 & CSAH 15/Industrial Park Road	Thru-Stop	15	36,098,500	0.42	0.28	0.44	0.83	0.47

[1] MnDOT's 2013 Green Sheets were used to determine the State average crash rate. Intersection is categorized as a Rural Thru-Stop.

[2] The critical crash rate is a statistically adjusted crash rate to account for random nature of crashes and is dictated by the follwing equation:

$$C = A + K\left(\frac{A}{m}\right)^2 - \frac{0.5}{m}$$

Where C= Critical Crash Rate, A=State Average Critical Crash Rate, K= 95% Confidence interval, m=(Years of Data)*(ADT)*(365/1 million)

[3] A 95% confidence level was assumed.

[4] Crash Data obtained from MNDoT's Crash Mapping Analysis Tool (CMAT)

[5] Severity rate factors: 5 for Fatal Crashes, 4 for A type, 3 for B type, 2 for C type, and 1 for Property Damage Crashes

[6] AADT for Years 2014, 2012, 2010, 2008, and 2006 (MnDOT Traffic Flow Maps). Total Entering volume is based on the sum total of 10 years multiplied by 365 days per year.

Crash type Distribution

Figure 5 documents the crash type distribution. The crash type distribution was compared to the typical values compiled from data throughout Minnesota.

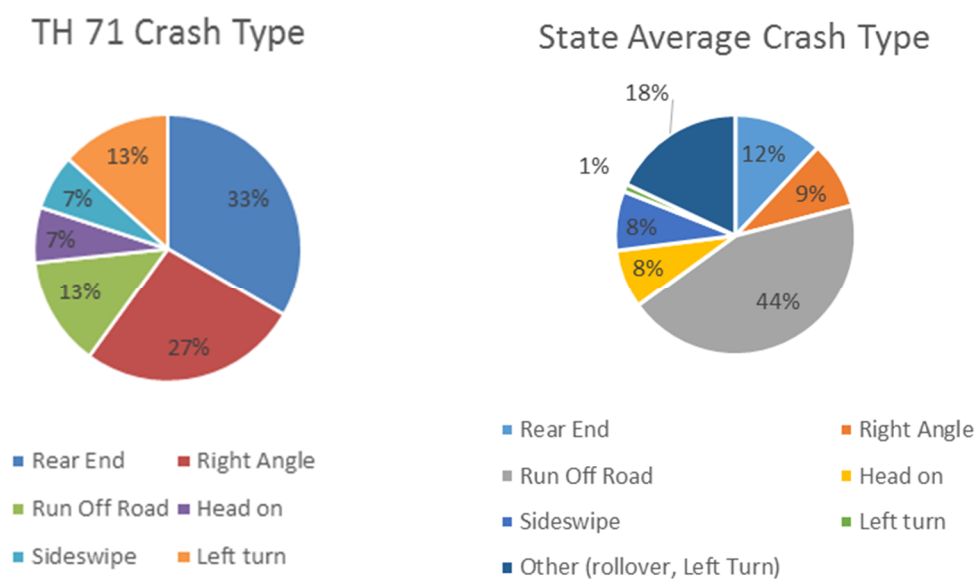


Figure 5. Crash Type Distribution

Contributing Factors

Figure 6 documents the crash type distribution versus the lighting conditions and is compared against the statewide average.

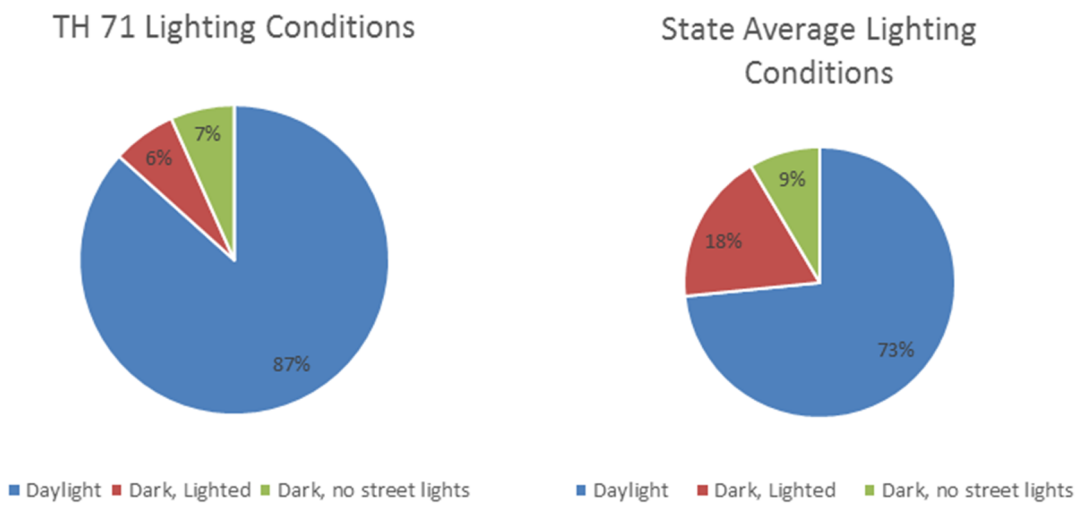


Figure 6. Crash Type Distribution versus Lighting Conditions

Figure 7 documents the crash type distribution versus weather conditions and is compared against the statewide average.

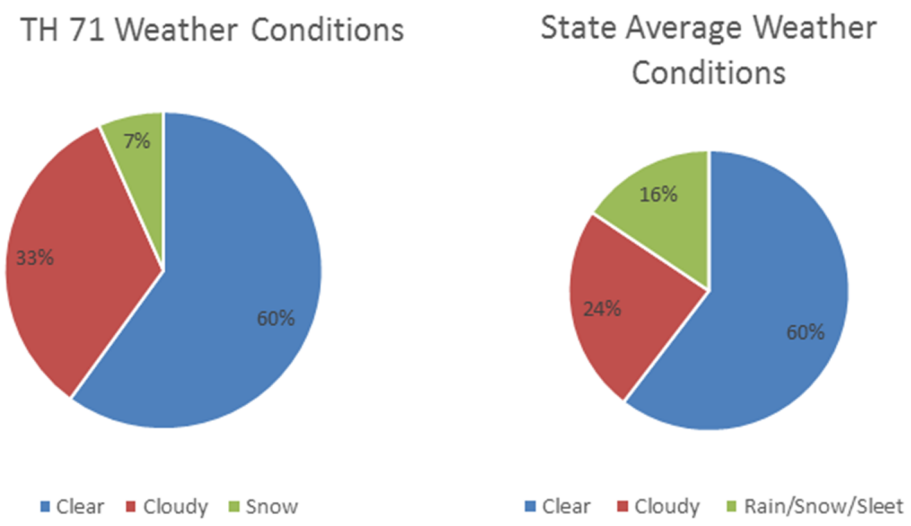


Figure 7. Crash Type Distribution versus Weather Conditions

Figure 8 documents the crash type distribution versus age of the motorist listed as the at fault driver.

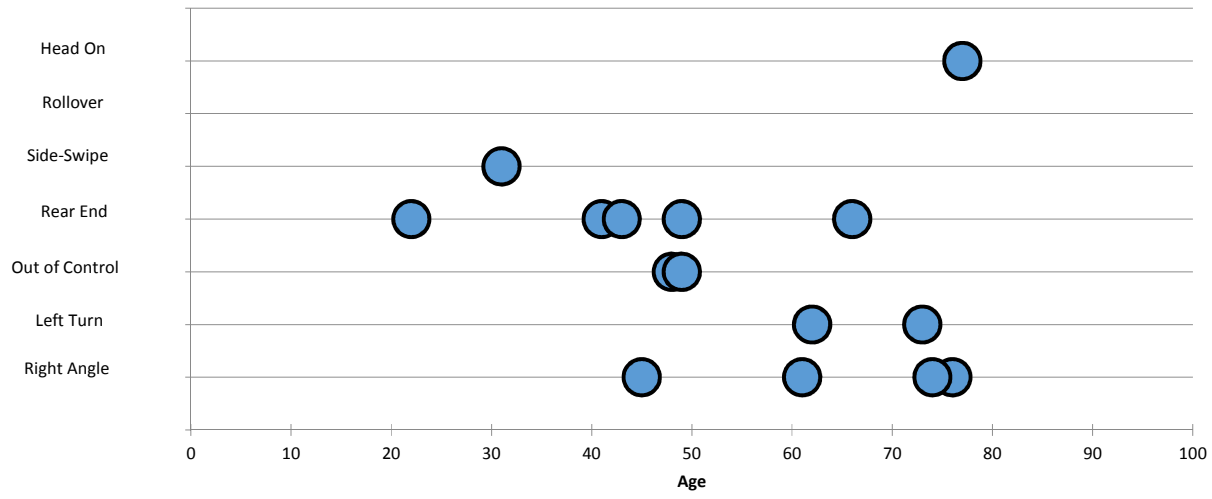


Figure 8. Crash Type Distribution versus At Fault Motorist Age

Figure 9 documents the crash type distribution versus the time of day of the crash occurrence.

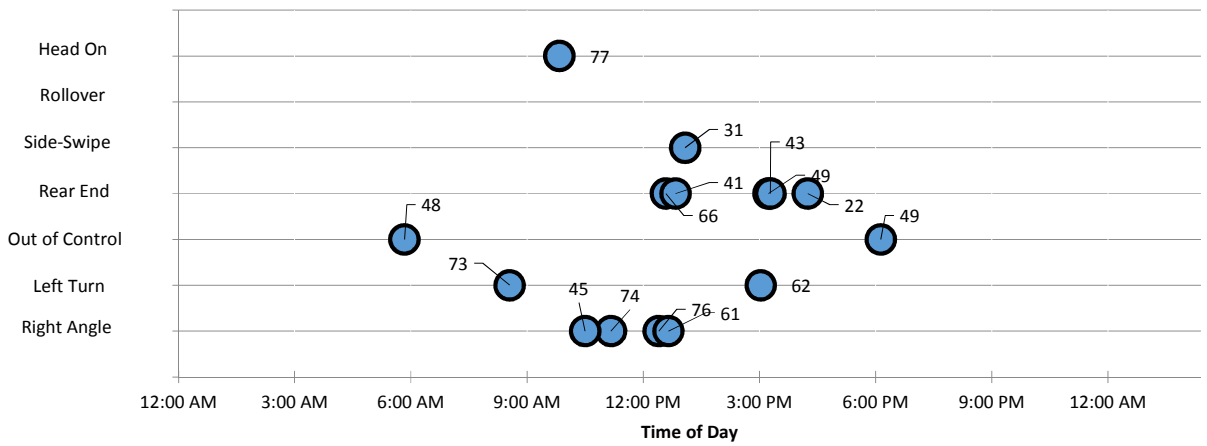


Figure 9. Crash Type Distribution versus Time of Day and Motorist Age

2.5 Existing Conditions Safety Analysis Conclusions

Based on the analysis of the existing intersection characteristics and crash experience, the following preliminary conclusions are made:

- The TH 71/CSAH 15 intersection experienced 15 crashes over the past ten years. Out of these crashes, there were zero fatalities, five property damage crashes, and 11 injuries. The overall intersection crash rate is about one and a half times the average state rate, but slightly less than the critical crash rate. Based on this data,

the crashes experienced at this intersection may be indicative of a safety deficiency.

- The most common type of crash was rear end, accounting for 5 of the 15 crashes. This is two and a half times the state average of 12% for rear end crashes at unsignalized intersections. Nearly all of them occurred in the northbound and southbound direction. In addition, all five rear end crashes occurred while the second motorist was distracted or following too close and the first motorist either stopped or was slowing in the roadway, which may be indicative of no left turn lanes on TH 71.
- The second most common type of crash was right angle crashes with a total of 4 of the 15 crashes. This is two times the number of expected crashes (27% at TH 71, and 9% state average). Three of the four right angle crashes occurred in the northbound and westbound approaches. The sight lines for westbound motorists looking to the south is unobstructed. Most of the crashes occurred in dry conditions with only 2 of the 15 being icy or snow related crashes. Therefore, weather does not appear to be a significant factor.
- The majority of the crashes have occurred during the midday (periods of lower traffic volume conditions). Therefore, motorist impatience or risky driver behavior associated with longer delays or higher traffic volumes do not seem to be a primary factor.
- The two leading contributing factors to most of the crashes are “Failure to Yield” and “Distraction”, which combined account for 9 of the 15 crashes.

Based on a review of the crash patterns and observations at the intersection, potential contributing factors include:

- **Approaching motorist speed**. One factor may be that motorists are having difficulty in perceiving the approaching motorist speed and not making the appropriate gap acceptance decision. Motorists approaching speed may be highly variable with the 60 mph to 40 mph posted speed change just south of CSAH 15.
- **Passing on the right maneuvers**. It is also a common observation that northbound/southbound motorists are using the right turn lane to bypass left turn vehicles. This motorist behavior may contribute to rear end and right angle related crashes since the cross-street stopped motorist may be making an assumption that the approaching vehicle is turning right. Although this behavior is common, the crash reports did not specifically identify passing on the right as a contributing factor.

3.0 Forecast Conditions

The increase in vehicle traffic resulting from regional infrastructure, regional connectivity and demographic changes will influence the long term operation of the existing TH 71/CSAH 15 intersection. The ICE study will evaluate intersection geometric and traffic control needs based upon the forecast year 2018 and 2038 design horizons.

The following sections document the future no-build conditions analysis completed for the intersection of TH 71 at CSAH 15.

3.1 Planned Infrastructure and Development

Planned roadway infrastructure or land development within the study area could result in direct changes in traffic characteristics at the TH 71/CSAH 15 intersection. The following planned infrastructure and development is expected:

- Hubbard County has planned for 2016 construction of a truck bypass route. The bypass route will provide a connection between TH 34 and TH 71 via CSAH 28 (129th Avenue). The connection to TH 71 is expected to occur just north of 150th Street. Trucks through the TH 71/CSAH 15 study intersection are expected to be considerably reduced. Based on the daily truck volume information provided by MnDOT through the bypass planning process an estimated 2 percent reduction in northbound and southbound through traffic along TH 71 is expected as a result of truck traffic moving over to use the bypass.
- There are no known planned developments within the immediate study area.

3.2 ADT and Background Traffic Forecasts

Traffic on the roadway system is expected to change (typically increases) over time due to other regional changes in employment, regional connectivity, population and land uses. Table 4 shows the historical ADT's for the TH 71 and CSAH 15 roadway segments.

Table 4. Historical ADT

Roadway	Segment	1994	1996	1997	1998	2000	2001	2002	2003	2004	2005	2006	2008	2010	2012	2014	Average (1994-2014)
TH 71	North of 4th St	9,700	10,200		9,900	11,000		9,700		10,300		11,000	10,100	10,100	9,700	8,300	10,000
TH 71	South of CSAH 15	7,700	8,900		6,500	6,500		6,900		7,400		8,100	6,900	7,200	7,400	7,000	7,318
CSAH 15	West of TH 71										750		1,950		1,900		1,925
CSAH 15	East of TH 71			100			340				2,750		3,300		3,350		3,133

A regression analysis was completed to determine the estimated future ADT for the 2038 design year based upon the historical data. Figure 10 illustrates the projected volume

trend line for each roadway segment. The forecast 2038 ADT was smoothed to balance the traffic volume inflow/outflow at TH 71/CSAH 15 then compared against the year 2013 existing ADT to develop an annual growth rate. The historical volume along TH 71 shows periods of highs and lows, with the 20 year average volume only slightly less than the existing 2013 ADT. In evaluation of 1998 to 2010 (a period of time when traffic growth along TH 71 was occurring), the growth trend was consistent with a 1% per year rate.

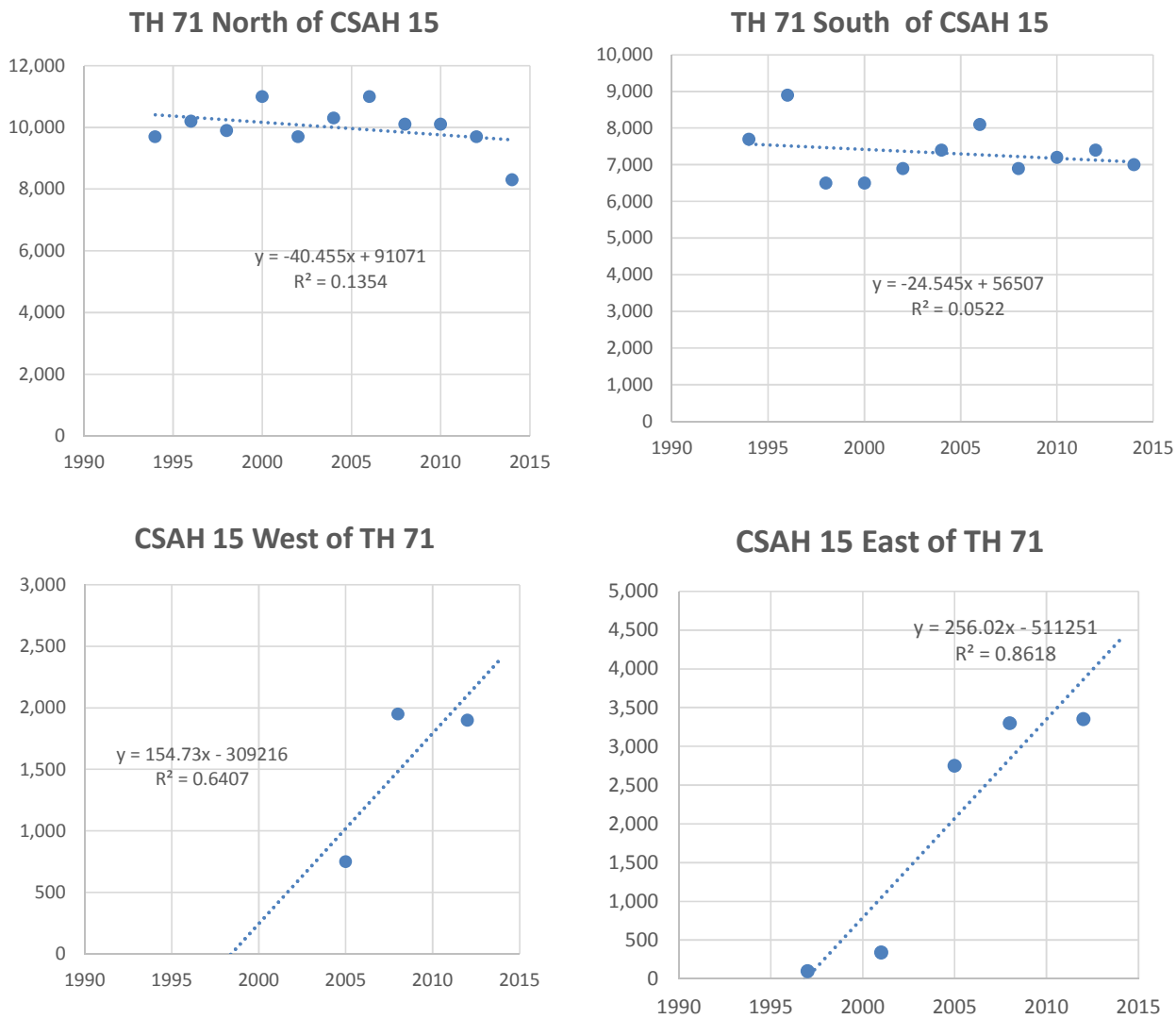


Figure 10. Forecast ADT Trend Line Regression Analysis

In addition, a separate forecast 2038 ADT was developed based upon the State Aid Project Factor of 1.5 for Hubbard County (annualized growth rate of 1.64 percent per year). Table 5 provides a comparison of the forecast year 2038 ADT using both the

historical growth rate (1998 to 2010) and the State Aid Projection Factor. Based on a review of the historical traffic volumes, historical growth rate trend, and the state aid projection factor an annual background growth rate of 1.5 percent per year is developed. This is slightly lower than the projected State Aid annual growth rate of 1.64 percent per year (1.5 factor), but exceeds the historical growth trend observed resulting in a conservative analysis.

Table 5. Forecast ADT

Roadway	Segment	Existing[1]	Forecast[2] (State Aid Factor)	Forecast[3] (Historical Growth)	MnDOT State Aid 20 Year Projection Factor	Annual Growth Rate[4] (Historical)	Annual Growth Rate[2] (State Aid Factor)
		2013	2038	2038			
TH 71	South of CSAH 15	7,600	11,400	9,561	1.5	0.92%	1.64%
CSAH 15	West of TH 71	2,100	3,150	1,575	1.5	-1.14%	1.64%
CSAH 15	East of TH 71	2,500	3,750	5,559	1.5	3.25%	1.64%

[1]Derived from year 2013 intersection turning movement counts.
[2]Year 2035 adt based upon 1.5 Project Factor from MnDOT 2011 Traffic Factor Projection by County
[3]Year 2035 ADT based upon regression analysis completed for histroical years 1998 to 2010
[4]Background growth rate derived based upon the regression analysis estimated 2038 forecast compared to the 2013 existing ADT

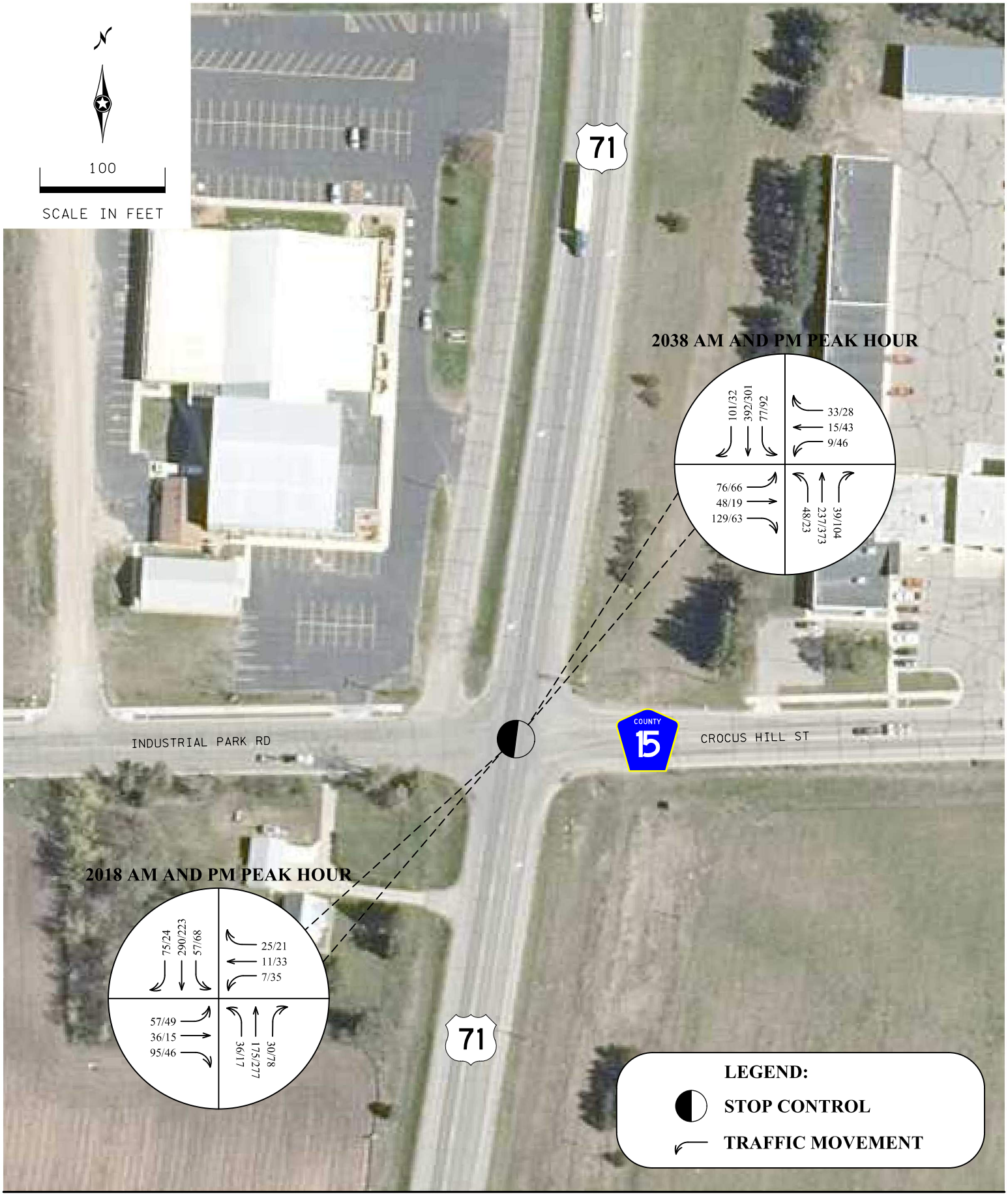
3.3 Forecast Peak Hour Traffic Volumes

Forecasted a.m. and p.m. peak hour intersection turning movement volumes were developed with a growth rate of 1.5 percent per year. The forecasted year 2018 and 2038 a.m. and p.m. intersection turning movement volumes used in the traffic operation analysis are illustrated in Figure 11. Table 6 illustrates the forecast year 2018 and 2038 ADT volumes.

The 15-minute volume distribution (peak hour factor) observed in the existing conditions traffic counts is assumed constant and applied to the forecast 2018 and 2038 traffic volumes used in the traffic operation analysis.

Table 6. 2018 and 2038 Forecast ADT

Roadway	Segment	Existing	Forecast	Forecast
		2013	2018	2038
TH 71	North of CSAH 15	7,700	8,300	11,200
TH 71	South of CSAH 15	7,600	8,200	11,100
CSAH 15	West of TH 71	2,100	2,300	3,100
CSAH 15	East of TH 71	2,500	2,700	3,700



TH 71 at CSAH 15/Industrial Park Road Intersection Control Evaluation

Figure 11
Year 2018 and 2038 AM and PM Peak Hour Turning Movement Volumes

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3.4 Signal Warrant Analysis

A traffic signal warrant analysis was completed for the TH 71/CSAH 15 intersection under existing geometric (no-build conditions) and forecast 2018 and 2038 volumes. The warrant analysis is conducted in accordance with the *Minnesota Manual on Uniform Traffic Control Devices (MMUTCD)*[2]. The following are the eight MMUTCD traffic signal warrants:

- Warrant 1 – Eight Hour Vehicle Volume
- Warrant 2 – Four-hour Vehicle Volume
- Warrant 3 – Peak Hour Volume
- Warrant 4 – Pedestrian Volume
- Warrant 5 – School Crossing
- Warrant 6 – Coordinated Signal System
- Warrant 7 – Crash Experience
- Warrant 8 – Roadway Network

Warrant 1, Warrant 2, Warrant 3 and Warrant 7 were reviewed using the existing 2013, forecast 2018 and forecast 2038 hourly approach volumes. The remaining traffic signal warrants were not reviewed or do not apply to the TH 71/CSAH 15 intersection. Table 7 presents a summary of the MMUTCD warrant analysis results. The right turn volumes were factored out on minor street approaches with exclusive right turn lanes based upon the recommended procedures documented in *Mn/DOT Technical Memorandum 07-02-T-01*[3]. Reductions were made to the hourly volumes by applying the respective a.m. or p.m. peak hour right turn movement volume. The detailed signal warrant analysis results are included in Appendix B.

Table 7. Signal Warrant Analysis Result Summary

Scenario	All Way Stop Control			Warrant 1 - Eight Hour Vehicle Volume				Warrant 2 - Four Hour Volume		Warrant 3 - Peak Hour Volume		Warrant 6 - School Crossing			Warrant 7 - Crash Experience
	Cond. C (Hours)	Cond. D (80%) (Hours)	Warrant Met / Not Met	1A (Hours)	1B (Hours)	1C (Hours)	Warrant Met / Not Met	Hours	Warrant Met / Not Met	3B (Hours)	Warrant Met / Not Met	No. School Children	Primary School Crossing	Warrant Met / Not Met	Warrant Met / Not Met
Year 2013 Existing	0 Hours	0 Hours	**Not Met**	0 Hours	0 Hours	0 Hours	**Not Met**	0 Hours	**Not Met**	0 Hours	**Not Met**	--	**No**	**Not Met**	**Not Met**
Year 2018 Forecast	0 Hours	1 Hours	**Not Met**	0 Hours	2 Hours	1 Hour	**Not Met**	0 Hours	**Not Met**	0 Hour	**Not Met**	--	**No**	**Not Met**	**Not Met**
Year 2038 Forecast	1 Hours	5 Hours	**Not Met**	6 Hours	9 Hours	8 Hour	**Met**	4 Hours	**Met**	0 Hour	**Not Met**	--	**No**	**Not Met**	**Not Met**

Source: 2011 Minnesota Manual on Uniform Traffic Control Devices

As shown above, the existing year 2013 and forecast year 2018 warrants are not met. Warrant 1 and Warrant 2 are met under the year 2038 forecast volumes (estimated to be met in year 2029). Although signal warrants are met under the forecast 2038 approach

[2] Minnesota Manual on Uniform Traffic Control Devices, December 2011.
[3] Technical Memorandum 07-02-T-01, Mn/DOT Engineering Services Division, Intersection Control Evaluation, March 2007

volumes, this alone may not justify the installation of a traffic signal system. Other considerations, including a capacity analysis, will be made to determine the appropriate control device and the estimated year a traffic signal installation would be required.

3.5 Traffic Operation Analysis

A traffic operation analysis was conducted to evaluate the operational performance of the TH 71/CSAH 15 intersection under the existing geometric conditions (no-build) and forecast year 2018 and 2038 traffic volumes. An adjustment was made to the northbound and southbound thru movement to account for the Hubbard County truck bypass route, which is planned for construction in 2016.

3.5.1 Analysis Tool

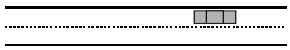
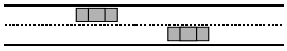
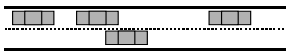
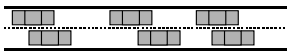
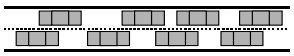
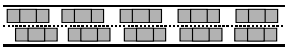
The traffic operation analysis performed for the existing and forecast no-build conditions was conducted using SimTraffic8.0. SimTraffic8.0 is a microscopic simulation tool and was used to evaluate the operational performance of the stop controlled intersection. SimTraffic8.0 was selected based upon its ability to better replicate the traffic peaking behavior, and the operation of the unsignalized intersection configuration.

3.5.2 Level of Service Definition

The term level of service (LOS), as taken from the *Highway Capacity Manual (HCM)*[4], refers to the ability of an intersection to process traffic volumes. It is defined as the delay to vehicles caused by the traffic control at the intersection. The results of this measure of effectiveness (MOE) are typically presented in the form of a letter grade (A-F) that provides a qualitative indication of the operational efficiency or effectiveness. By definition, LOS A conditions represents high-quality operations and LOS F conditions represent very poor operations. The general relationship between delay and LOS are graphically displayed in Table 8. The LOS C/D boundary is considered acceptable operating conditions for Outstate Minnesota. Although traffic simulation models arrive at the seconds of delay per vehicle differently than the HCM procedures, the thresholds presented in Table 8 are applicable.

[4] Highway Capacity Manual, 2010 Edition, Transportation Research Board

Table 8. LOS Definition

Level of Service		Description	Intersection Delay (Seconds / Vehicle)	
			Signalized Intersection	Un-Signalized Intersection
A		**Free Flow.** Low volumes and no delays.	0 - 10	0 - 10
B		**Stable Flow.** Speeds restricted by travel conditions, minor delays.	>10 - 20	>10 - 15
C		**Stable Flow.** Speeds and maneuverability closely controlled due to higher volumes.	>20 - 35	>15 - 25
D		**Stable Flow.** Speeds considerably affected by change in operating conditions. High density traffic restricts maneuverability, volume near capacity.	>35 - 55	>25 - 35
E		**Unstable Flow.** Low speeds, considerable delay, volume at or slightly over capacity.	>55 - 80	>35 - 50
F		**Forced Flow.** Very low speeds, volumes exceed capacity, long delays with stop and go traffic.	> 80	> 50

Source: Highway Capacity Manual, 2010 Edition, Transportation Research Board, Exhibit 18-4 for Signalized Intersections, Exhibit 19-1 for Unsignalized Intersections

3.5.3 Future No-Build Analysis Results

The traffic operation analysis was completed for the existing, year 2018 and year 2038 no-build conditions and is assumes the existing thru-stop traffic control device and existing lane geometrics. The purpose of this analysis is to provide a baseline condition, which future improvement alternatives can be compared. In addition, the analysis provides context to the need for intersection improvements on the basis of intersection capacity. The key measure of effectiveness (MOE) evaluated include movement delay, overall intersection delay, 95th percentile queue length and LOS. Table 9 provides the traffic operation analysis summary for the existing 2013, forecast 2018 and forecast 2038 time periods. The detailed MOE are attached for reference in Appendix C.

The traffic operation analysis indicates by year 2038, the existing stop controlled intersection of TH 71/CSAH 15 is expected to experience higher stop control approach delay. Motorists will experience a longer wait to enter TH 71, which may lead to impatience or risky driver behavior. However, the longer wait is not necessarily an indication of a capacity deficiency.

Table 9. Traffic Operation Analysis – Existing and Future No-Build Conditions

AM Peak Hour

Intersection	MOE	Year 2015 Existing Conditions	Year 2018 Forecast (1.5% Growth Rate)	Year 2038 Forecast (1.5% Growth Rate)
TH 71 & CSAH 15	LOS	A / C	A / C	A / E
	Delay (sec/veh)	4.0 / 20.0	4.3 / 21.1	9.0 / 42.4
	Total Delay (hr)	0.9 / 0.2	1.1 / 0.2	3.1 / 0.9
	Total Intersection Volume (vph)	830	893	1223

PM Peak Hour

Intersection	MOE	Year 2015 Existing Conditions	Year 2018 Forecast (1.5% Growth Rate)	Year 2038 Forecast (1.5% Growth Rate)
TH 71 & CSAH 15	LOS	A / B	A / B	A / E
	Delay (sec/veh)	3.3 / 12.2	3.7 / 14.1	7.6 / 42.0
	Total Delay (hr)	0.7 / 0.1	0.9 / 0.2	2.6 / 0.7
	Total Intersection Volume (vph)	763	895	1191

3.6 Future Conditions Analysis Conclusions

Based on the forecasted 2038 safety and traffic conditions analysis, the TH 71/CSAH 15 intersection is currently experiencing higher than expected intersection crashes and a severity rate twice the statewide average. In addition, long motorist delays can be currently observed during the peak hours, with much longer delays expected to occur by year 2038. With longer delays expected into the future, the safety performance of the intersection could be expected to degrade further. A review of the forecast hourly approach volumes indicate the TH 71/CSAH 15 intersection will not meet the minimum provisions of Warrant 1 and Warrant 2 for traffic signal installation until year 2029. Although a traffic signal may be a potential option for consideration, other potential geometric and/or traffic control devices are warranted and will be explored in great detail through the alternatives analysis process.

4.0 Alternatives Analysis

To address the existing intersection safety issues and to preserve traffic mobility, a high level alternatives analysis was completed. The goal of the alternatives analysis is to define the engineering considerations, the impacts of each alternative, and the expected traffic operation and safety benefits. In addition, an economic analysis is completed for each preliminary alternative to help identify the most cost-beneficial solution. Key elements include:

- Development of concept sketches
- Identification of preliminary alternatives
- Conducting a traffic operation analysis to assess the performance of each alternative
- Documentation of safety benefit
- Development of construction costs
- Comparison evaluation of alternatives
- Conducting a benefit to cost analysis

4.1 Traffic Control Devices

The three primary traffic control devices considered for installation include a two-way stop (existing conditions), traffic signal system and a roundabout. Table 10 and the following summarizes the high level pros and cons comparison and safety considerations of each traffic control device:

- A two-way stop control maintains the existing traffic control device. The addition of left turn lanes onto TH 71 is expected to achieve a safety improvement and minimal operation benefit. However, the existing crash characteristics and crash severity experience will remain largely the same. A reduction in rear-end and left turn crash types is expected with the exclusive left turn lanes.
- The installation of signalized intersection control is compatible with the addition of left turn lanes onto TH 71 and can be implemented with no impact to right of way. The traffic signal is not expected to be warranted until year 2029; therefore, funding is a consideration. An increase in overall intersection crashes is expected; however, the severity rate is expected to be reduced. A traffic signal system is expected to increase the overall intersection delay during all periods of the day.
- A roundabout would require full intersection reconstruction, and the higher initial construction cost may be a consideration. In addition, a small portion of right of way acquisition is expected necessary. Overall, the roundabout is expected to provide the greatest intersection safety performance (significant reduction in severe crashes) and most efficient traffic operations with least motorist delay during all time periods of the day.

Table 10. Traffic Control Devices Matrix

Two-Way Stop Intersection

Description

Through/Stop intersections is an uncontrolled intersection with stop control on the minor street. The stop-controlled approaches are referred to as the minor street approaches. The intersection approaches that are not controlled by stop signs are referred to as the major street approaches.

Pros and Cons

Pros
1. Low installation cost
2. Continuous traffic flow for major approaches
3. Low maintenance cost

Cons
1. Does not address the higher intersection crash severity rate
2. Difficult to enforce stop control compliance
3. Could result in drivers speeding across the intersection to make gaps
4. Motorist must be able to detect the presence of the intersection and then detect, recognize, and respond to the drivers crossing.
5. Higher stop control motorist delay during peak periods

Safety Considerations

Crash Types
- Most common crash types are rear end and right angle

Average Crash Rate
- 0.42 Crashes/MEV (Existing Conditions)
- 0.28 Crashes/MEV (Statewide Average - Rural Thru/Stop)

Crash Severity
- Injury related crashes represent approximately 67% of the total reported intersection crashes

Traffic Signal System

Description

Traffic signals assign right-of-way to various traffic movements at intersections. Signal design has typically focused on the operating characteristics of motorized vehicles, but do provide some added protection for pedestrians.

Pros and Cons

Pros
1. Generally Can Be Designed with Minor Impact to Street Width/Curbs
2. Compatible with the Lane Geometrics of the Stop Controlled Intersection and Could be Easily Installed at a Later Date.
3. Improves Left Turn Access onto CR 15
4. Provides for Controlled Movement of Traffic
5. Reduces the Frequency and Severity of Certain Types of Right-Angle Collisions
6. Familiarity

Cons
1. Traffic Signal is Not Warranted. Expected Date Meeting MMUTCD Warrants is 2029
2. Traffic Signals That Do Not Meet MMUTCD Warrants are Ineligible for Federal Funding. City, State or County Cost Burden or Wait Until Warranted.
3. Ongoing Operation, Maintenance, Electricity Costs
4. Increased Crashes, Particularly Rear-end, Right Angle
5. Increased Motor Vehicle Delay and can be Inefficient During Off Peak Periods

Safety Considerations

Crash Types
- Predominant crash types are rear end, right angle and left turn collisions

Average Crash Rate
- 0.6 Crashes/MEV (Low Volume / Low Speed)

Crash Severity
- Injury related crashes represent approximately 29% of the total reported intersection crashes

Roundabout

Description

Roundabouts are a design technique intended to control traffic and reduce conflicts between traffic movements on the major and minor legs approaching an intersection. Roundabouts, which provide an alternative to traffic signal control at an intersection, are usually built with a circular raised island and splitter medians on all approaches to help slow vehicles and direct traffic into the counterclockwise flow around the center island.

Pros and Cons

Pros
1. Provides Continuous Flow of Traffic.
2. Provides Traffic Calming – Designed for 15 mph Speed.
3. Improves Pedestrian Crossing – Reduced Exposure, Improved Sightline with Refuge Island
4. Overall Number of Crashes May be Reduced and Roundabouts Greatly Reduce the Crash Severity
5. Aesthetics

Cons
1. More Expensive than Signal, But May be Less in Long Run.
2. Requires More Space at Intersection, but Less Space along Road.
3. Special Attention Required in Design for Trucks/Buses
4. Familiarity

Safety Considerations

Crash Types
Most common crash types include failure to yield at entry, improper lane use and single-vehicle run off road.

Average Crash Rate
0.48 Crashes/MEV (Single Lane)

Crash Severity
Injury related crashes represent approximately 24% of the total reported intersection crashes

4.2 Intersection Concept Sketches

A total of 8 conceptual alternatives were sketched and discussed with the Technical Advisory Committee (TAC). The improvement alternatives include the following general strategies:

- Exclusive left turn lanes (no right turn lanes) on TH 71
- Addition of left turn lanes onto TH 71
- Exclusive left turn lanes (no right turn lanes) on CSAH 15
- Exclusive left and right turn lanes on all approaches
- Two way stop control
- Traffic signal
- Single lane roundabout
- Single lane roundabout with frontage road connection

4.3 Preliminary Intersection Alternatives

Based on high level concept sketches and discussion with the TAC, four alternatives were selected for detailed evaluation and comparison.

4.3.1 Concept Layouts

The concept layouts for each alternative identified are described below:

- **Alternative 2: Two-Way Stop Control**. Preferred Alternative 2 would maintain a two-way stop control system and reconstruct existing intersection lane geometrics to add exclusive left turn lanes on TH 71. The CSAH 15 roadway geometrics would remain unchanged. Alternative 2 is illustrated in Figure 12.
- **Alternative 4: Traffic Signal System.** Preferred Alternative 4 would employ a traffic signal system. The lane geometrics will remain the same as Alternative 2. Under signalized intersection control, protected/permissive left turn phasing is assumed for northbound and southbound approaches. Alternative 2 is illustrated in Figure 13.
- **Alternative 2a/4a: Two-Way Stop Control or Traffic Signal System with Raised Median.** Preferred Alternative 2a/4a adds a raised center median on TH 71 as illustrated in Figure 14. The two-way stop control and traffic signal system evaluated in 2a/4a is consistent with Alternative 2 and 4, respectively.
- **Alternative 7: Roundabout.** Preferred Alternative 7 reconstructs the intersection to provide a 130 foot diameter single lane roundabout. Alternative 7 is illustrated in Figure 15.

Under all alternatives evaluated, the frontage road access to CSAH 15 is assumed to be closed and the driveway access to the church property is relocated to the west. The

existing disconnected sidewalk facility along the north side of CSAH 15 is extended through the intersection.

4.3.2 Design Assumptions

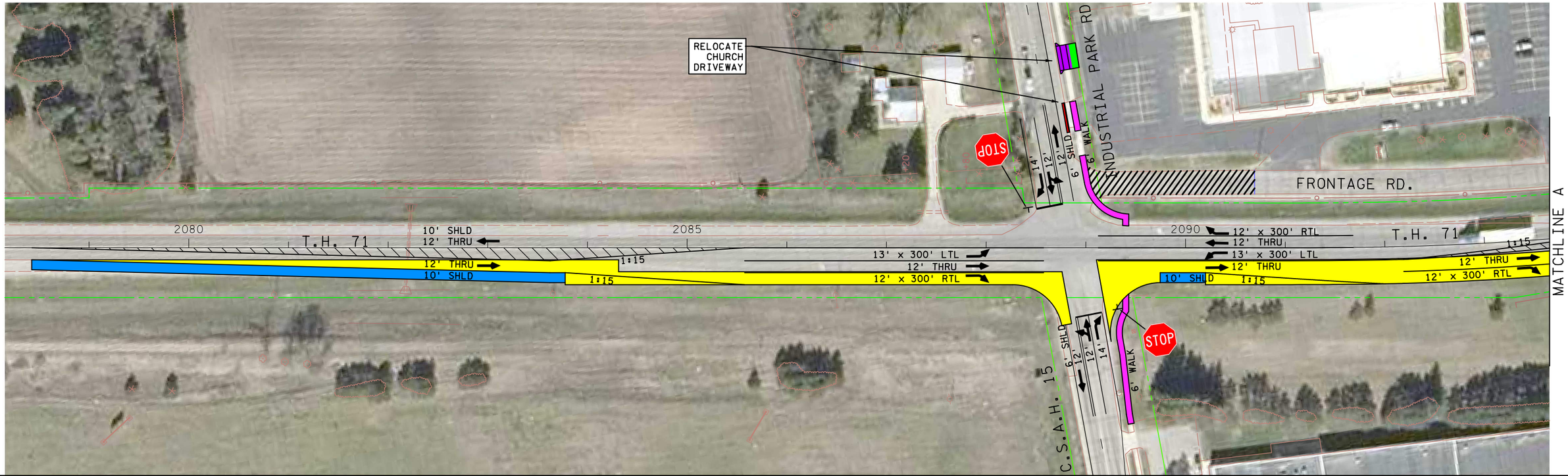
A detailed concept layout for each preferred alternative was preliminary engineered in accordance with the requirements and guidelines specified in the *MnDOT Road Design Manual*[5]. In developing the conceptual layouts a number of key general considerations were made:

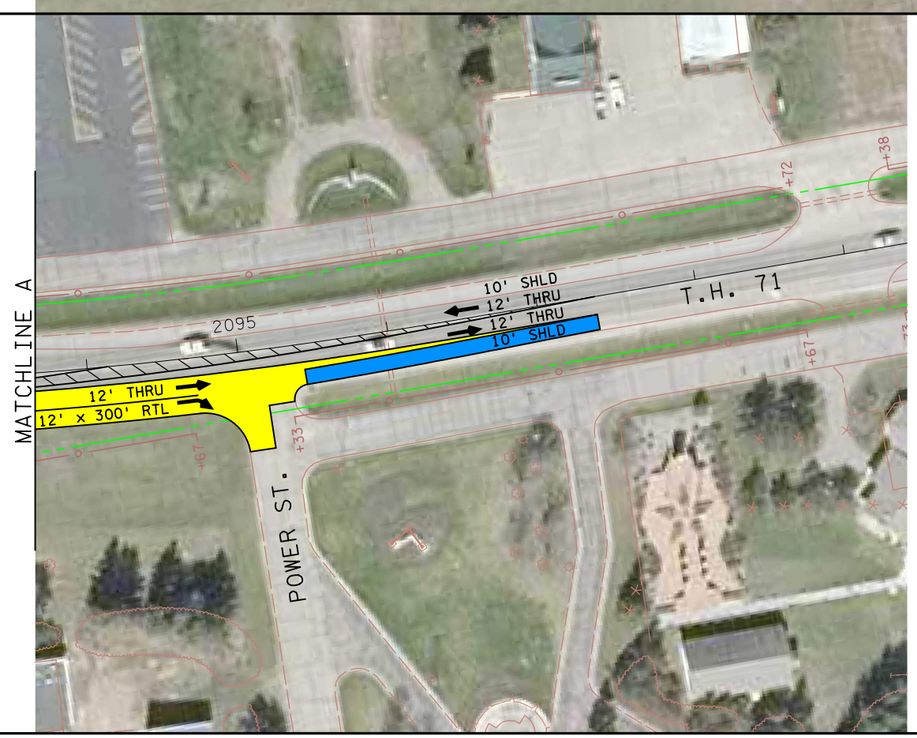
- The following design parameters were used:
  - Design Vehicle: WB-62
  - Design Speed on TH 71: 40 mph
  - Design Speed on CSAH 15: 30 mph
  - Turn lane deceleration taper rates are 1:15.
- Left turn lane deceleration lengths of 300 feet were used and are consistent with MnDOT rural intersection design standards for 40 mph roadways.
- No changes to right turn deceleration lanes on TH 71 were made unless the geometric changes resulted in modification to the existing curbs.
- The two-way stop control and traffic signal alternatives are assumed to be implemented through retrofit construction; whereas, the roundabout alternative is full depth reconstruction.
- AutoTURN truck turning templates were evaluated for the WB-62 design vehicle.

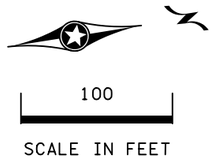
4.4 Traffic Operation Analysis

A traffic operation analysis for each alternative was completed to evaluate the performance of the TH 71/CSAH 15 intersection. A summary comparison of the overall intersection delay and level of service is shown in Table 11, on page 30. The detailed intersection delay and level of service by movement are provided for reference in Appendix C.

[5] MnDOT Road Design Manual, Part I and Part II







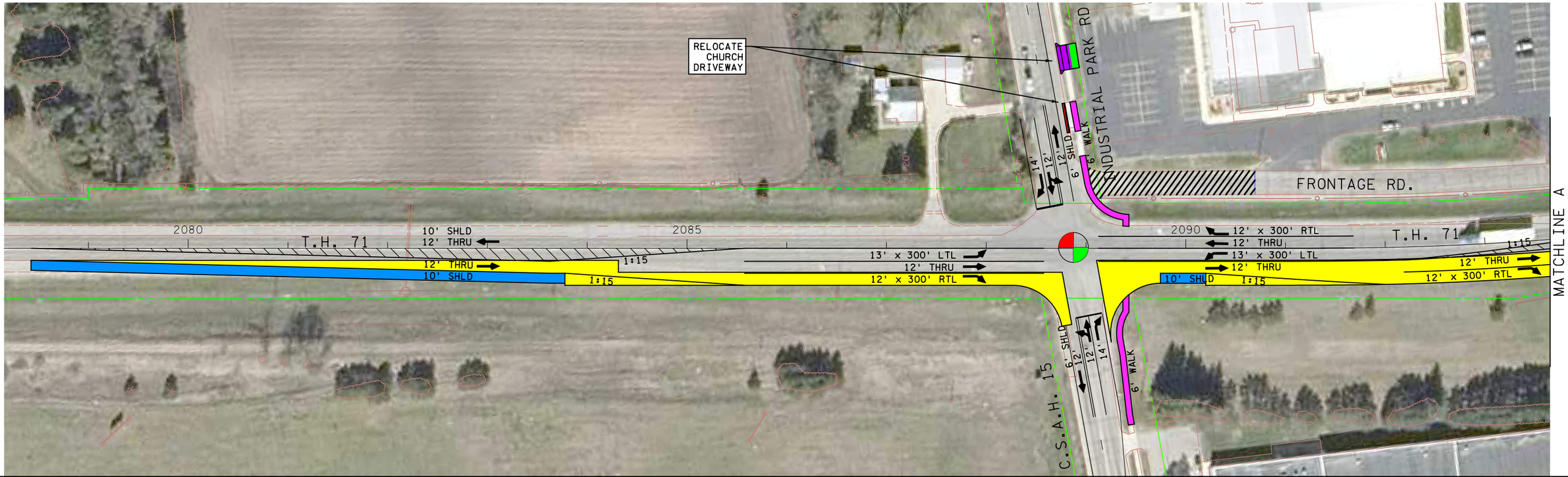
LEGEND

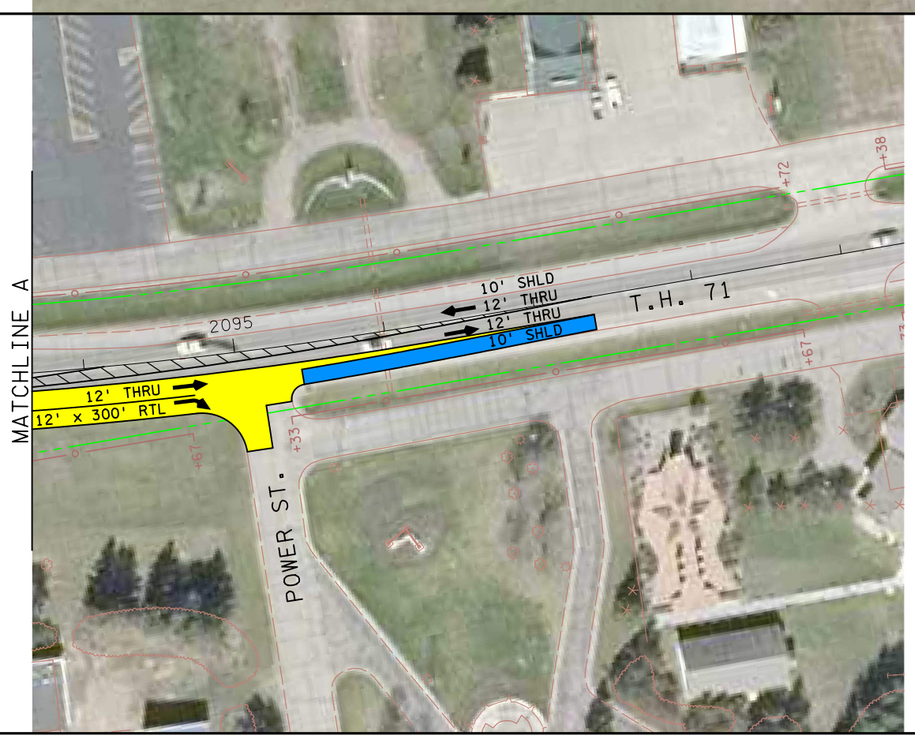
- ROADWAY
- CONCRETE CURB & GUTTER AND RAISED CONCRETE MEDIAN
- PAVED SHOULDER
- CONCRETE SIDEWALK
- CONCRETE DRIVEWAY
- BITUMINOUS DRIVEWAY
- LANDSCAPED AREA
- PAVEMENT REMOVAL
- EXISTING RIGHT-OF-WAY
- PROPOSED RIGHT-OF-WAY

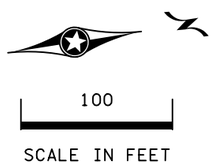
TH 71 at CSAH 15/Industrial Park Road Intersection Control Evaluation

ALLIANT ENGINEERING

Figure 12
Alternative 2 - Two Way Stop Controlled with Left Turn Lanes







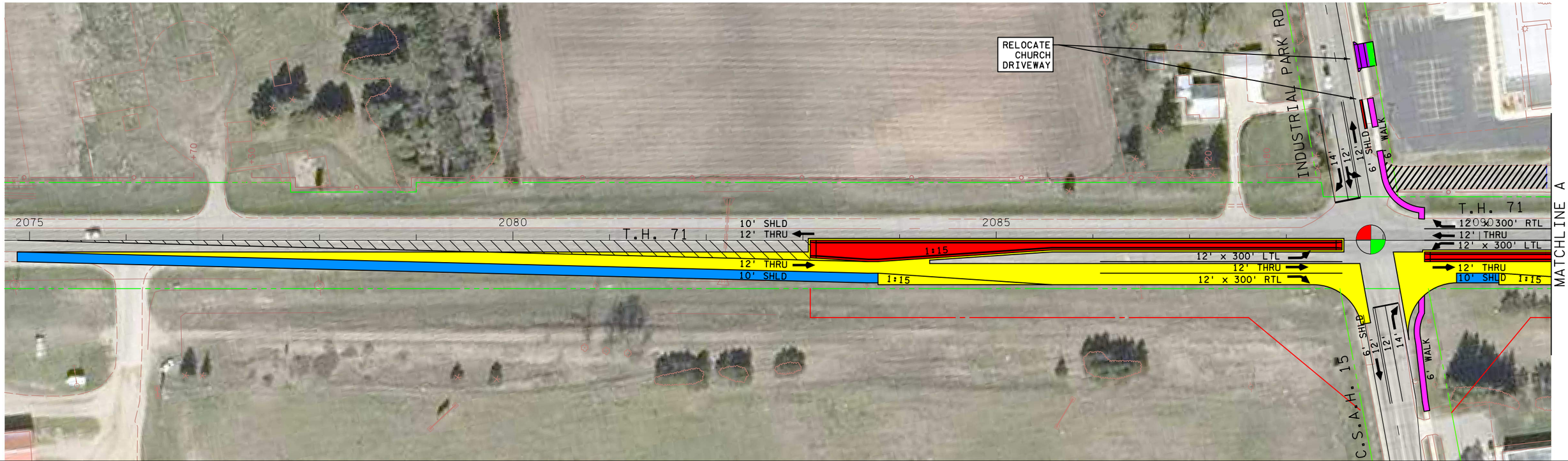
LEGEND

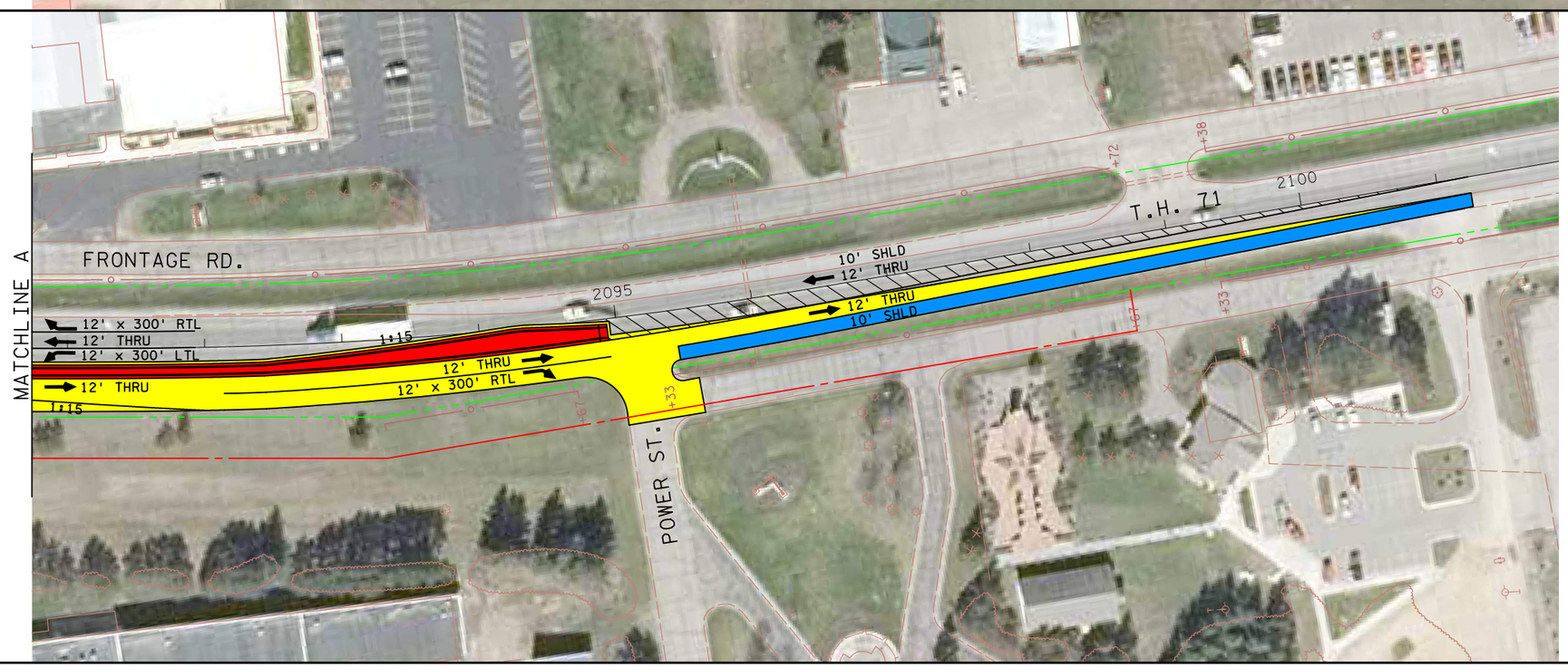
- ROADWAY
- CONCRETE CURB & GUTTER AND RAISED CONCRETE MEDIAN
- PAVED SHOULDER
- CONCRETE SIDEWALK
- CONCRETE DRIVEWAY
- BITUMINOUS DRIVEWAY
- LANDSCAPED AREA
- PAVEMENT REMOVAL
- EXISTING RIGHT-OF-WAY
- PROPOSED RIGHT-OF-WAY
- SIGNALIZED INTERSECTION

TH 71 at CSAH 15/Industrial Park Road Intersection Control Evaluation

ALLIANT ENGINEERING

Figure 13
Alternative 4 -Traffic Signal System with Left Turn Lanes





100

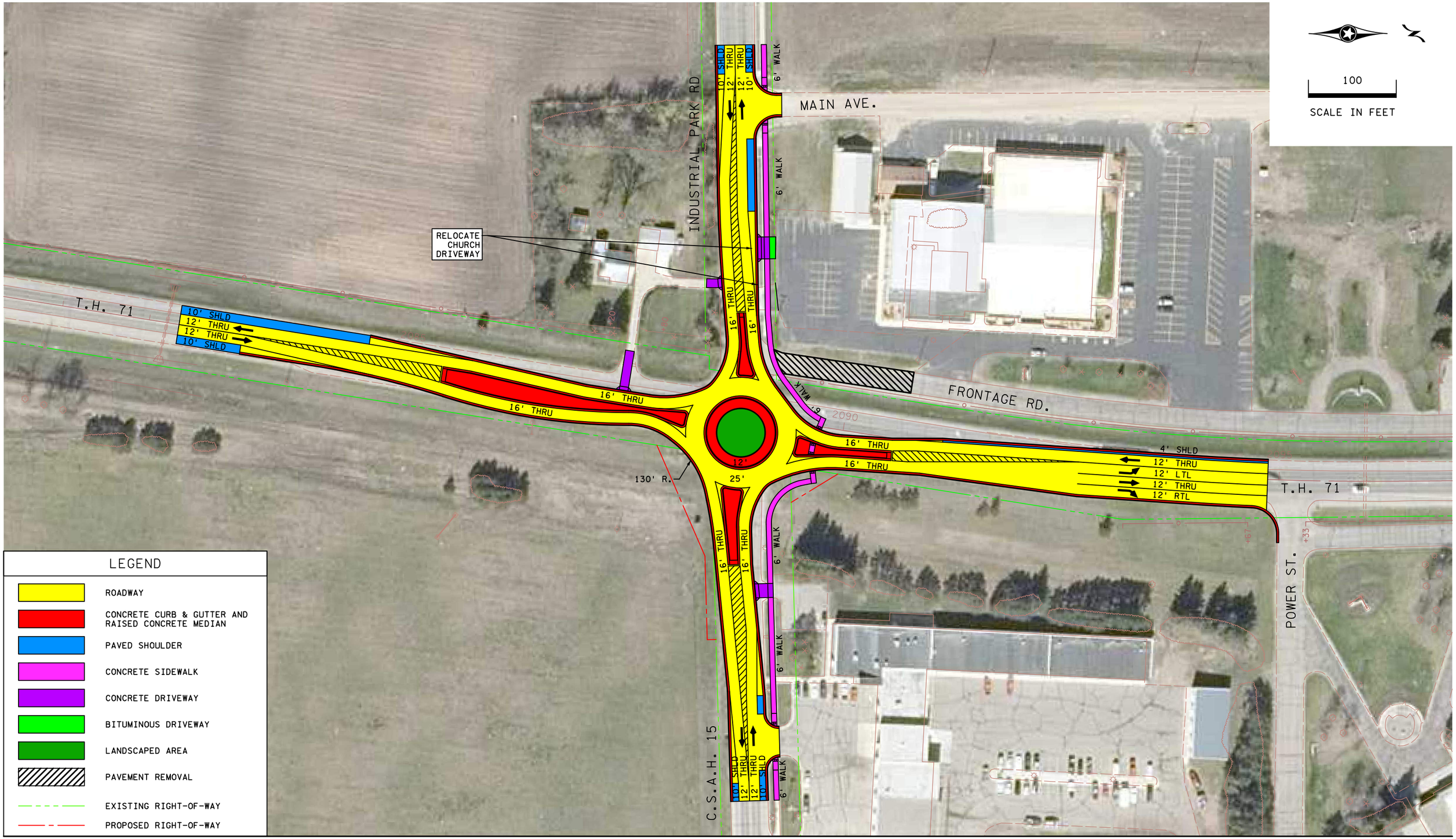
SCALE IN FEET

LEGEND

- ROADWAY
- CONCRETE CURB & GUTTER AND RAISED CONCRETE MEDIAN
- PAVED SHOULDER
- CONCRETE SIDEWALK
- CONCRETE DRIVEWAY
- BITUMINOUS DRIVEWAY
- LANDSCAPED AREA
- PAVEMENT REMOVAL
- EXISTING RIGHT-OF-WAY
- PROPOSED RIGHT-OF-WAY
- SIGNALIZED INTERSECTION

ALLIANT ENGINEERING

Figure 14
Alternative 2a/4a - Two Way Stop or Traffic Signal with Raised Median



TH 71 at CSAH 15/Industrial Park Road Intersection Control Evaluation

ALLIANT ENGINEERING

Figure 15
Alternative 7 - Single Lane Roundabout

Table 11. Traffic Operation Analysis – Preliminary Alternatives

AM Peak Hour		No Build	ALT 2 - Two Way Stop	ALT 4 - Traffic Signal	ALT 7 - Roundabout	No Build	ALT 2 - Two Way Stop	ALT 4 - Traffic Signal	ALT 7 - Roundabout
Intersection	**MOE**	**Year 2018 Forecast**	**Year 2018 Forecast**	**Year 2018 Forecast**	**Year 2018 Forecast**	**Year 2038 Forecast**	**Year 2038 Forecast**	**Year 2038 Forecast**	**Year 2038 Forecast**
TH 71 & CSAH 15	LOS	A / C	A / C	A / B	A / A	A / **E**	A / D	B / B	A / B
	Delay (sec/veh)	4.3 / 21.1	3.9 / 22.3	7.6 / 13.8	3.7 / 4.8	9.0 / 42.4	6.9 / 31.0	10.4 / 20.0	6.3 / 13.5
	Total Delay (hr)	1.1	1.0	1.9	0.9	3.1	2.4	3.6	2.1
	Total Intersection Volume	893	893	893	889	1223	1223	1223	1197

PM Peak Hour		No Build	ALT 2 - Two Way Stop	ALT 4 - Traffic Signal	ALT 7 - Roundabout	No Build	ALT 2 - Two Way Stop	ALT 4 - Traffic Signal	ALT 7 - Roundabout
Intersection	**MOE**	**Year 2018 Forecast**	**Year 2018 Forecast**	**Year 2018 Forecast**	**Year 2018 Forecast**	**Year 2038 Forecast**	**Year 2038 Forecast**	**Year 2038 Forecast**	**Year 2038 Forecast**
TH 71 & CSAH 15	LOS	A / B	A / **B**	A / B	A / A	A / **E**	A / **E**	B / B	A / A
	Delay (sec/veh)	3.7 / 14.1	3.4 / 14.0	7.6 / 15.8	3.6 / 4.4	7.6 / 42.0	6.5 / 36.9	10.1 / 18.7	4.7 / 5.7
	Total Delay (hr)	0.9	0.8	1.9	0.9	2.6	2.2	3.4	1.5
	Total Intersection Volume	895	893	893	883	1191	1191	1191	1185

XX / XX = Overall Intersection Delay (LOS) / Worst Performing Movement Delay (LOS)

Key conclusions from the operation analysis are summarized in the following:

- All alternatives are expected to provide acceptable traffic operations under the forecast 2018 traffic volumes.
- The two way stop control is expected to degrade to a LOS E (stopped approach) under both the 2038 no-build and 2038 Alternative 2 and 2a scenarios.
- Although a traffic signal is expected to provide acceptable traffic operations, the overall intersection delay is expected to be the highest of all the alternatives evaluated.
- In both the short and long term analysis, Alternative 7 is expected to provide the most efficient intersection operations.

To quantify the traffic operation benefit, the overall total network vehicle delay is also computed. The total vehicle delay, measured in hours, provides a useful measure in comparing traffic operation performance between alternatives and computing motorist travel time benefit (vehicle hours traveled). This approach also accounts for change in traffic patterns and volume levels as the result of access control changes, access closures or rerouting of vehicle movements. The a.m. and p.m. vehicle hour delay computed for each scenario was extrapolated to the remaining 22 hours of the day (based on existing hourly traffic volume percentage profile), to obtain total daily vehicle hours traveled. Table 12 summarizes the a.m. and p.m. peak hour network delay and the 20-year present worth value for each alternative. The detailed analysis and computation of the daily and annual vehicle hours traveled is provided for reference in Appendix D.

Table 12. Estimated Traffic Operation Benefit – Network Wide Vehicle Hours Traveled

Scenario	Improvement	AM Peak Hour (VHT)	PM Peak Hour (VHT)	Total Annual Delay (VHT)	Percent Change (Compared to No-Build)	20-Year Present Worth Benefit (Alternative 2) ($)	20-Year Present Worth Benefit (Alternative 2a) ($)	20-Year Present Worth Benefit (Alternative 4) ($)	20-Year Present Worth Benefit (Alternative 4a) ($)	20-Year Present Worth Benefit (Alternative 7) ($)
2018 No Build	Thru Stop	1.1	0.9	**4,233**	--	--	--	--	--	--
2018 ALT 2	Thru Stop	1.0	0.8	**3,804**	**10%**					
2018 ALT 4	Signalized	1.9	1.9	**8,153**	**-93%**					
2018 ALT 7	Roundabout	0.9	0.9	**3,873**	**9%**					
2038 No Build	Thru Stop	3.1	2.6	**12,103**	--	$ 508,545	$ 508,545	$ (1,322,461)	$ (1,322,461)	$ 877,336
2038 ALT 2	Thru Stop	2.4	2.2	**9,797**	**19%**					
2038 ALT 4	Signalized	3.6	3.4	**14,925**	**-23%**					
2038 ALT 7	Roundabout	2.1	1.5	**7,695**	**36%**					

Notes:

1. Total annual delay is based upon estimated daily delay over 365 days.
2. Office of Investment Management, Cost Benefit Analysis, Appendix A - Fiscal year 2015 standard values: Value of time for Auto is $17.00/hour and Truck is $27.90/hour
3. Assumed auto occupancy rate is 1.35 passengers per vehicle
4. Discount rate of 1.7%
5. Network truck percent is assumed to be 7%

4.5 Safety Analysis

The primary goal of improving the TH 71/CSAH 15 intersection is to reduce the intersection crash rate and significantly reduce the frequency of severe crashes. A detailed safety benefit analysis was completed to help understand expected level of improvement with each alternative. The safety benefit review includes investigating the change in crash types and/or the elimination in certain types of crashes, and computing a monetary benefit.

The intersection safety benefit analysis computes the estimated 20-year present worth value for each alternative and forecast growth rate scenario. Key analysis assumptions include:

- The existing 10-year crash rate and crash severity distribution experienced at the TH 71 and CSAH 15 intersection is assumed for both the existing and forecast year 2038 no-build safety analyses.
- For addition of left turn lanes and/or the addition of a raised median, the intersection crash reductions and severity distributions are based on the U.S. Department of Transportation Federal Highway Administration Crash Reduction Factors.[6] The crash reduction factors are applied to only relevant crash occurrences that could be expected to reduce.
- It is assumed the traffic signal alternative will perform at the statewide average crash rate and severity rate distribution.

[6] Desktop Reference for Crash Reduction Factors, FHWA Report No. FHWA-SA-08-011, September 2008

- For Alternative 7, the intersection crash reductions and severity distribution is based on the Office of Traffic, Safety, and Technology MnDOT Single Lane Roundabouts Study[7].

Table 13 documents the estimated 20-year, present worth safety benefit of each alternative. The detailed amortized safety benefit worksheets and estimated change in total intersection crashes by severity type are provided in Appendix E.

Table 13. Estimated Safety Benefit

	Alternative 2 Two-Way Stop (Left Turn Lanes)	Alternative 2a Two-Way Stop (Left Turn Lanes and Raised Median)	Alternative 4 Traffic Signal (Install 2018) (Left Turn Lanes)	Alternative 4 Traffic Signal (Install 2029) (Left Turn Lanes)	Alternative 4a Traffic Signal (Install 2018) (Left Turn Lanes and Raised Median)	Alternative 7 Roundabout (Single Lane)
20-year Present Worth Benefit	$694,089	$922,294	$1,602,189	$1,111,923	$1,759,372	$2,240,322

Notes:
1. 20 year analysis period with 1.7%

4.6 Construction Cost Estimate

Estimated construction costs were developed for the preliminary alternatives based upon the concept layouts. The preliminary construction cost estimates are shown in Table 14. The detailed construction cost estimate for each alternative is provided for reference in Appendix F. It should be noted that the cost estimates are based upon a 15 percent conceptual layout; therefore, a consistent 20 percent contingency was assumed for all alternatives to account for risk or any unknowns that may not be identified without more detailed engineering.

Table 14. Preliminary Construction Cost Estimate

Description	TH 71 at CSAH 15 / Industrial Park Road			
	Two-Way Stop Layout 2 (Estimated Cost Year 2015 Dollar)	Traffic Signal Layout 4 (Estimated Cost Year 2015 Dollar)	Roundabout Layout 7 (Estimated Cost Year 2015 Dollar)	Traffic Signal Raised Median Layout 4a (Estimated Cost Year 2015 Dollar)
Roadway	$ 264,476	$ 324,476	$ 1,676,762	$ 824,763
Traffic Signal / Lighting (Year 2029)	$ -	$ 300,000	$ -	$ 300,000
Right of Way	$ -	$ -	$ 718	$ 6,239
Contingency (20%)	$ 44,079	$ 104,079	$ 279,460	$ 187,460
Total	**$ 308,556**	**$ 728,556**	**$ 1,956,941**	**$ 1,318,462**

Note: Refer to Appendix F for SEQ and basis of estimated quantities.

[7] A Study of the Traffic Safety at Single Lane Roundabouts in Minnesota, MnDOT Office of Traffic, Safety and Technology, December 16, 2014

4.7 Alternatives Evaluation Summary

A comparison matrix summarizing the key decision factors and evaluation of the pros and cons with respect to the key objectives is provided in Table 15. The key decision factors include:

- **Traffic Operations**. Documentation of the expected traffic operations.
- **Safety**. Assessment of expected impact on motorist safety and to the degree to which the existing safety deficiency is improved.
- **Design Considerations**. Qualitative assessment of design issues, considerations or other impacts.
- **Right of Way**. Qualitative, order of magnitude, assessment of property and right of way impacts.
- **Cost**. Order of magnitude construction cost.
- **Pros and Cons**. Qualitative assessment of key advantages and disadvantages of the alternatives.

4.8 Benefit to Cost Analysis

An economic analysis was completed in accordance with the MnDOT Office of Investment Management, Benefit to Cost Analysis for Transportation Projects procedures, and assumes a 20 year analysis period (year 2018 to 2038) with construction expenditures assumed to occur in year 2018. The economic analysis for each alternative and forecast growth rate are provided in Appendix G.

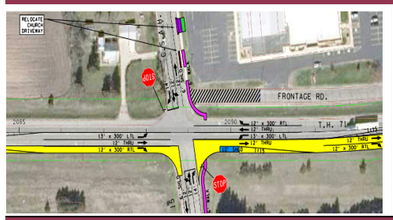
The monetary benefit of the project is quantified in terms of reduced (or increased) vehicle hours traveled (VHT) or less delay (or added delay) at the intersection and the reduced number and/or severity of estimated crashes over the analysis period between the existing conditions and the proposed alternatives as previously presented. The monetary costs include the construction and contingency costs. Design, administration and inspection costs are not included in the cost analysis. Remaining capital values of the roadway features at the end of the analysis period are also subtracted from the total cost of the project. Key assumptions and fiscal year 2015 economic values are provided in Appendix G.

Table 15. Alternatives Analysis Comparison Matrix

No Build - Dedicated Right Turn Lane/Thru Left on TH 71 and CSAH 15

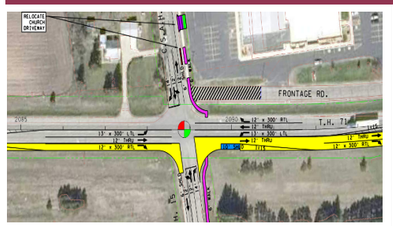
Description	Safety	2038 Traffic Operations	Right of Way	Construction Cost Estimate	Design Considerations	Pros and Cons
No Geometric Changes	-Will not eliminate safety concerns	**1.5% Growth** AM Peak: A/E (9.0 / 42.4) PM Peak: A/E (7.6 / 42.0)	No Right of Way acquisition expected	$ -		**Pros:** -No cost **Cons:** -Does not address operation or safety deficiencies

Alternative 2 - Two Way Stop Control (Provide Left Turn and Right Turn Lanes on TH 71)



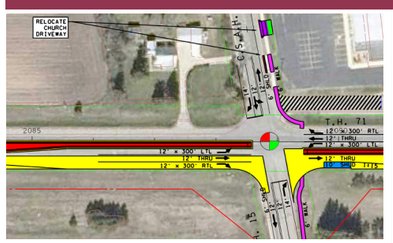
Description	Safety	2038 Traffic Operations	Right of Way	Construction Cost Estimate	Design Considerations	Pros and Cons
Maintain Two-Way Stop. Reconfigure the northbound and southbound approaches to include an exclusive left turn lane and right turn lane. CSAH 15 lane geometrics remain the same as existing.	May reduce the instances of rear end crashes with the provision of left and right turn lanes. Based on the FHWA Crash Reduction Factors, an estimated 50% reduction in relevant crashes may be expected.	AM Peak: A/D (6.9 / 31.0) PM Peak: A/E (6.5 / 36.9)	No Right of Way acquisition expected	$ 310,000.00	-Roadway widening required. May consider shifting all widening to the east to avoid encroaching into the frontage road or residential property. -Consider closing the residential driveway to TH 71. -Extend the sidewalk to the intersection and provide pedestrian ramps and crossing of the north leg. -Consider closing the frontage road intersection. -Consider relocating the church driveway to the west and restripe the parking lot.	**Pros:** -Provides optimal lane geometry on TH 71 -Improves the left turn and right turn lane operation and safety on TH 71 **Cons:** -Does not address operation deficiencies (stop delay) -Does not address right angle or left turn related crashes -Does not provide protection for pedestrian crossings.

Alternative 4 - Traffic Signal (Provide Left and Right Turn Lanes on TH 71)



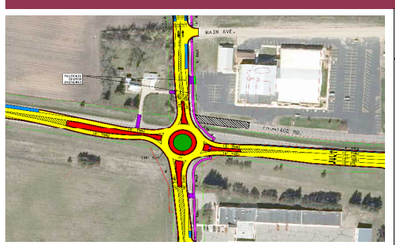
Description	Safety	2038 Traffic Operations	Right of Way	Construction Cost Estimate	Design Considerations	Pros and Cons
Install Traffic Signal. Reconfigure the northbound and southbound approaches to include an exclusive left turn lane and right turn lane. CSAH 15 lane geometrics remain the same as existing.	-May Reduce Volume & Gap Acceptance Related Right Angle Crash -Will Not Eliminate Right Angle Crashes -May Increase Rear End Crashes -May Reduce Left Turn Crashes -Construction of exclusive left turn lanes and protected/permissive signal phasing will provide positive safety benefit.	AM Peak: B/B (10.4 / 20.0) PM Peak: B/B (10.1 / 18.7)	No Right of Way acquisition expected	$ 730,000.00	-Roadway widening required. May consider shifting all widening to the east to avoid encroaching into the frontage road or residential property. -Consider closing the residential driveway to TH 71. -Extend the sidewalk to the intersection and provide pedestrian ramps and crossing of the north leg. -Consider closing the frontage road intersection. -Consider relocating the church driveway to the west and restripe the parking lot. -Signal operation should provide for protected/permissive left turn operation on TH 71 and permissive only operation on CSAH 15.	**Pros**: -Can be designed with minor impacts to street width. -Improves left turn access onto CSAH 15 and TH 71. -Provides a more protected pedestrian crossing of TH 71 with continuous sidewalk -Familiarity **Cons:** -Traffic Signal does not meet MMUTCD Warrants -Overall delay is greater than two-way stop or a roundabout -Likely to result in increased crashes (rear end and right angle)

Alternative 2a/4a - Two-Way Stop or Traffic Signal (Provide Left and Right Turn Lanes on TH 71 with Raised Median)



Description	Safety	2038 Traffic Operations	Right of Way	Construction Cost Estimate	Design Considerations	Pros and Cons
Reconfigure the northbound and southbound approaches to include an exclusive left turn lane and right turn lane, and a raised median on TH 71. This alternative is compatible with either the two-way stop control and the traffic signal system control devices.	May reduce the instances of rear end crashes with the provision of left and right turn lanes. Based on the FHWA Crash Reduction Factors, an estimated 50% reduction in relevant crashes may be expected with the left turn lanes and an additional 25% reduction in relevant crashes with the raised median. The median also provides improved crossing for pedestrians.	Two Way Stop: AM Peak: A/D (6.9 / 31.0) PM Peak: A/E (6.5 / 36.9) Traffic Signal: AM Peak: B/B (10.4 / 20.0) PM Peak: B/B (10.1 / 18.7)	Right of Way acquisition along the east side of TH 71 is expected. Approximately 1.2 acres.	$ 1,320,000.00	-Roadway widening required. May consider shifting all widening to the east to avoid encroaching into the frontage road or residential property. -Consider closing the residential driveway to TH 71. -Extend the sidewalk to the intersection and provide pedestrian ramps and crossing of the north leg. -Consider closing the frontage road intersection. -Consider relocating the church driveway to the west and restripe the parking lot.	**Pros:** -Can be designed with minor impacts to CSAH 15. -Provides separation between oncoming traffic flows. -Provides an improved pedestrian crossing of TH 71 with continuous sidewalk and median refuge for two stage crossing -Provides physical separation for access control along TH 71. **Cons:** -Requires right of way acquisition -High cost for little additional motor vehicle safety or traffic operation benefit

Alternative 7 - Single Lane Roundabout



Description	Safety	2038 Traffic Operations	Right of Way	Construction Cost Estimate	Design Considerations	Pros and Cons
Construct 130 foot diameter single lane roundabout.	-Will significantly reduce right angle and left turn related crashes -May result in run off road and failure to yield crashes -Will reduce severity and injury related crashes -May create sideswipe property damage crashes -Based on MnDOT Safety Study of Single Lane Roundabouts, the study found a 30% reduction in crash rates and a 65% reduction in injury crashes.	AM Peak: A/B (6.3 / 13.5) PM Peak: A/A (4.7 / 5.7)	- Right of Way acquisition expected. Approximately 0.14 acres.	$ 1,960,000.00	-Roadway widening at the intersection is required. May requiring shifting the center and TH 71 alignment to the east to avoid encroaching into the frontage road or residential property. -Extend the sidewalk to the intersection and provide pedestrian ramps and crossing of the north leg. -Consider closing the frontage road intersection. -Consider relocating the church driveway to the west and restripe the parking lot. -Provide full access to the residential property driveway on CSAH 15	**Pros:** -Maintains continuous traffic flow -Single lane entry reduces complexity and provides optimum 24 hour intersection operation -Provides the least overall intersection delay of all traffic control strategies -Expected to significantly reduces right angle conflicts and improves intersection safety. -Provides positive speed control and opportunity for aesthetics. **Cons:** -Most expensive traffic control device. -Requires full reconstruction of the intersection. -Unfamiliar and may be viewed negatively by the public.

The benefit to cost ratio shown in Table 16 is a comparison between the estimated traffic operation and safety benefit for each preliminary alternative and the estimated 20-year construction cost. The highest benefit to cost ratio represents the most economical solution. Benefit to cost ratios less than 1.0 might not be considered an economically viable alternative. To more accurately reflect the implementation plan for each alternative, the year 2015 construction costs were adjusted (discount rate of 1.7 percent) to account for the expected present worth value of when the expenditures are expected to be made (for purposes of analysis are assumed to be 2018). At the end of the analysis period (2038) there is remaining capital value with each infrastructure component, which is also accounted for in the total cost. With respect to the signalized intersection Alternative 4, two implementation plan scenarios were evaluated – install the traffic signal in 2018 with the left turn lanes or install the signal in year 2029 once warranted). The 20-year traffic operation and safety benefit is influenced by this decision and reflected in the benefit to cost ratio.

Table 16. Benefit to Cost Ratio

	Alternative 2 Two-Way Stop (Left Turn Lanes)	Alternative 2a Two-Way Stop (Left Turn Lanes with Raised Median)	Alternative 4 Traffic Signal (Install in 2018) (Left Turn Lanes)	Alternative 4 Traffic Signal (Install in 2029) (Left Turn Lanes)	Alternative 4a Traffic Signal (Install in 2018) (Left Turn Lanes with Raised Median)	Alternative 7 Roundabout (Single Lane)
Total Traffic Operation Benefit	$ 508,545	$ 508,545	$ (1,322,461)	$ (309,685)	$ (1,322,461)	$ 877,336
Total Safety Benefit	$ 694,089	$ 922,294	$ 1,602,189	$ 1,111,923	$ 1,759,372	$ 2,240,322
Total Cost[1]	$ 241,236	$ 700,044	$ 633,748	$ 666,536	$ 1,092,556	$ 1,529,706
Benefit to Cost Ratio	**5.0**	**2.0**	**0.4**	**1.2**	**0.4**	**2.0**

[1] Total cost is a 20 year estimate (based on a year 2015 cost estimate) that includes the discounted construction cost plus the remaining capital value at the end of the analysis period.

4.9 Intersection Analysis Summary

Figure 16 compares the expected intersection traffic operations and safety performance for each traffic control device, and concept layout, against the no-build scenario. Figure 17 graphically illustrates the economic analysis. As shown, the provision of left turn lanes and maintaining the through-stop control (Alternative 2) is expected to result in both intersection efficiency gained and some safety improvement. However, there is no expected reduction in the crash severity rate. A traffic signal (Alternative 4 or 4a) is expected to increase the overall intersection delay, provide some tangible safety improvement through reduction in the crash severity rate; however, will result in the greatest amount of intersection crashes. Based on the characteristics of TH 71/CSAH 15 intersection, the roundabout is expected to result in the least overall intersection delay and greatest severity rate reduction.

The analysis indicates that Alternative 2 may be the most economical solution in the short term (positive traffic operation and safety benefit for a low construction cost); however, Alternative 7 is expected to provide the greatest safety benefit and traffic operation efficiency with the second best benefit to cost ratio. The traffic signal alternative is only

an economically viable alternative if the control device is installed at a future date when warranted.

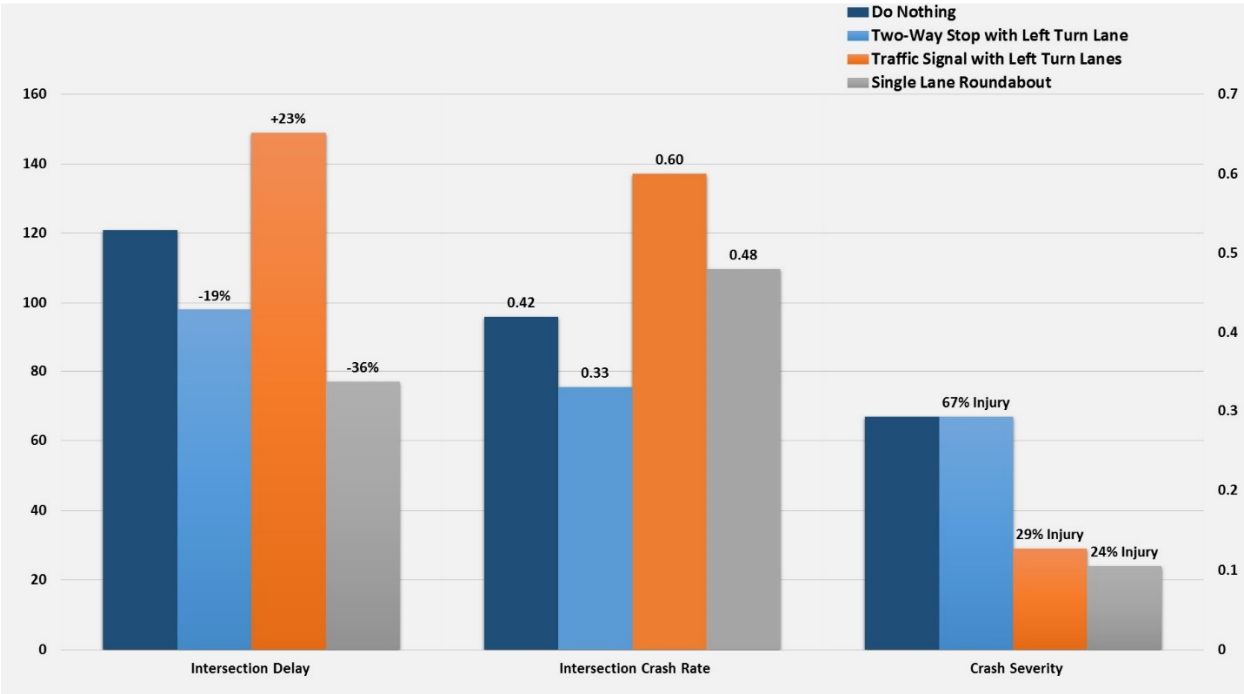


Figure 16. Intersection Delay and Safety Comparison

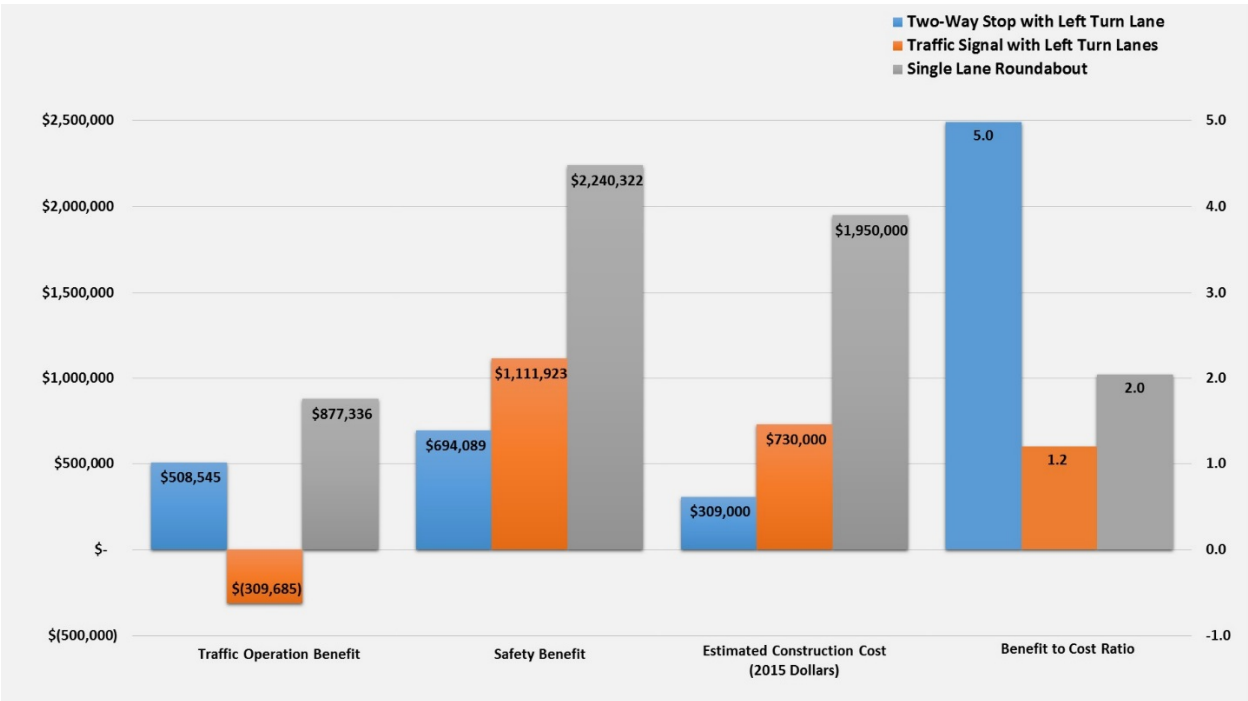


Figure 17. Benefit Analysis Comparison

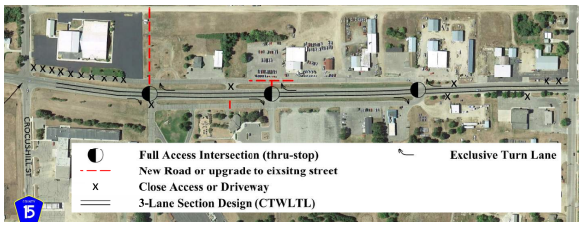
5.0 Access Management Alternatives

Access Management is the planning, design, and implementation of land use and transportation strategies between the road and surrounding land. Appropriate spacing and design of public street intersections and private access is key to this strategy. The segment of TH 71 between CSAH 15 and 8th Street was reviewed for opportunity to consolidate driveways, reconfigure primary intersections, establish frontage road connections, and to provide additional supporting street network. The five primary alternatives identified are illustrated and summarized in Table 16.

The access management alternatives were discussed with the TAC and the preferred configuration is to establish a three lane cross-section with three primary intersections. The preferred alternative and potential driveway closures are illustrated in Figure 18. Historically there has not been a documented safety hazard along this segment of TH 71, so the options that minimize property impact and are most consistent with the northerly segments of TH 71 is preferred. All recommendations do take a proactive approach to addressing future safety concerns. The three lane configuration is compatible with any of the intersection alternatives and could be constructed concurrent with or separate from the 2018 project as funding may allow. It is recommended MnDOT and the City work with the affected property owners to discuss the driveway closures and action be taken as agreements are made.

Table 17. Access Management Alternatives

Alternative A



Description

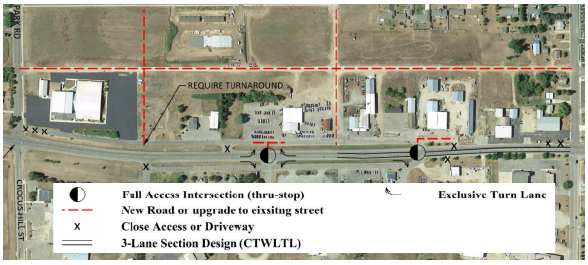
Three lane roadway design with a center left turn lane. Three primary intersection accesses to the frontage roads with exclusive right turn lanes provided. Establish new city street (Powers Street) connection to Main Avenue. Consolidate access driveways.

Pros and Cons

Pros
1. Least amount of impact to business and property owners
2. Provides uniform spacing of primary accesses along TH 71.
3. Provides good balance between access control and driveway consolidation given there has not been a crash history.
4. Compatible with all CR 15 intersection design alternatives and is consistent in design with TH 71 to the north.
5. Lower Cost

Cons
1. Three lane roadway may require urban street section due to proximity to the frontage roads.
2. Least amount of access control

Alternative B



Description

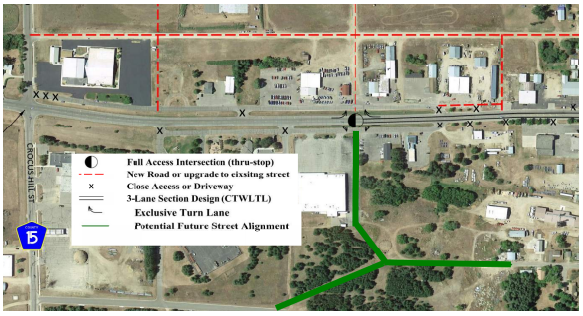
Three lane roadway design with center left turn lane beginning about Front Avenue. Provide two primary intersection accesses to the frontage roads with exclusive left and right turn lanes. Establish upgraded city street supporting network along Main Avenue, Powers Street and Front Avenue. Consolidate access driveways.

Pros and Cons

Pros
1. Provides uniform spacing of primary accesses along TH 71.
2. Provides good balance between access control and driveway consolidation given there has not been a crash history.
3. Compatible with all CR 15 intersection design alternatives and is consistent in design with TH 71 to the north.
4. Lower Cost

Cons
1. Three lane roadway may require urban street section due to proximity to the frontage roads.
2. Disconnects Powers Street access
3. West Frontage Road will require a turnaround design if access to TH 71 or the Powers Street roadway segment is not provided.

Alternative C



Description

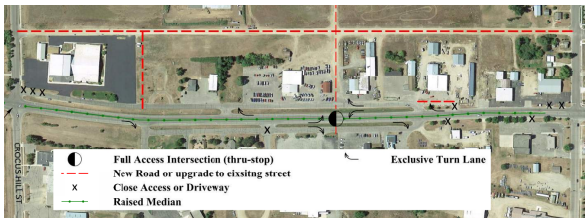
Three lane roadway design with center left turn lane beginning at Front Avenue. Provide only one primary intersection at Front Avenue. Establish a new east/west road (Front Avenue) connection between Pleasant Avenue and Gilbert Avenue. Gilbert Avenue would also be connected between CSAH 15 at 8th Avenue. Establish upgraded city street supporting network along Main Avenue, Powers Street and Front Avenue. Consolidate access driveways.

Pros and Cons

Pros
1. Provides uniform spacing of primary accesses along TH 71.
2. Provides greatest amount of access control
3. Establishes a supporting street network to allow circulation to occur off of TH 71.
4. Compatible with all CR 15 intersection design alternatives and is consistent in design with TH 71 to the north.

Cons
1. Three lane roadway may require urban street section due to proximity to the frontage roads.
2. Right of way acquisition
3. Disconnects Powers Street access
4. Perception that this alternative has the greatest impact to the business and property owners due to reduced access.
5. West Frontage Road will require a turnaround design if access to TH 71 or the Powers Street roadway segment is not provided.

Alternative D



Description

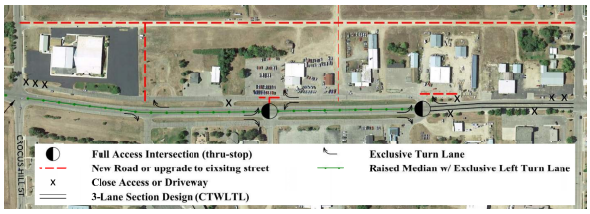
Two lane roadway design with a raised center median ending approximately 300' short of 8th Street. Provide only one primary intersection at Front Avenue with left and right turn lanes. Establish a new east/west road (Front Avenue) connection between Pleasant Avenue and TH 71. Establish upgraded city street supporting network along Main Avenue, Powers Street and Front Avenue. Consolidate access driveways.

Pros and Cons

Pros
1. Provides uniform spacing of primary accesses along TH 71.
2. Provides greatest amount of access control
3. Establishes a supporting street network to allow circulation to occur off of TH 71.
4. Allows right in/right out access at existing street connections.
5. Can be compatible with all CR 15 intersection design alternatives.

Cons
1. Will require urban street section due to proximity to the frontage roads.
2. Perception that this alternative has the greatest impact to the business and property owners due to reduced access.
3. Raised median design is not consistent with the rest of TH 71.

Alternative E



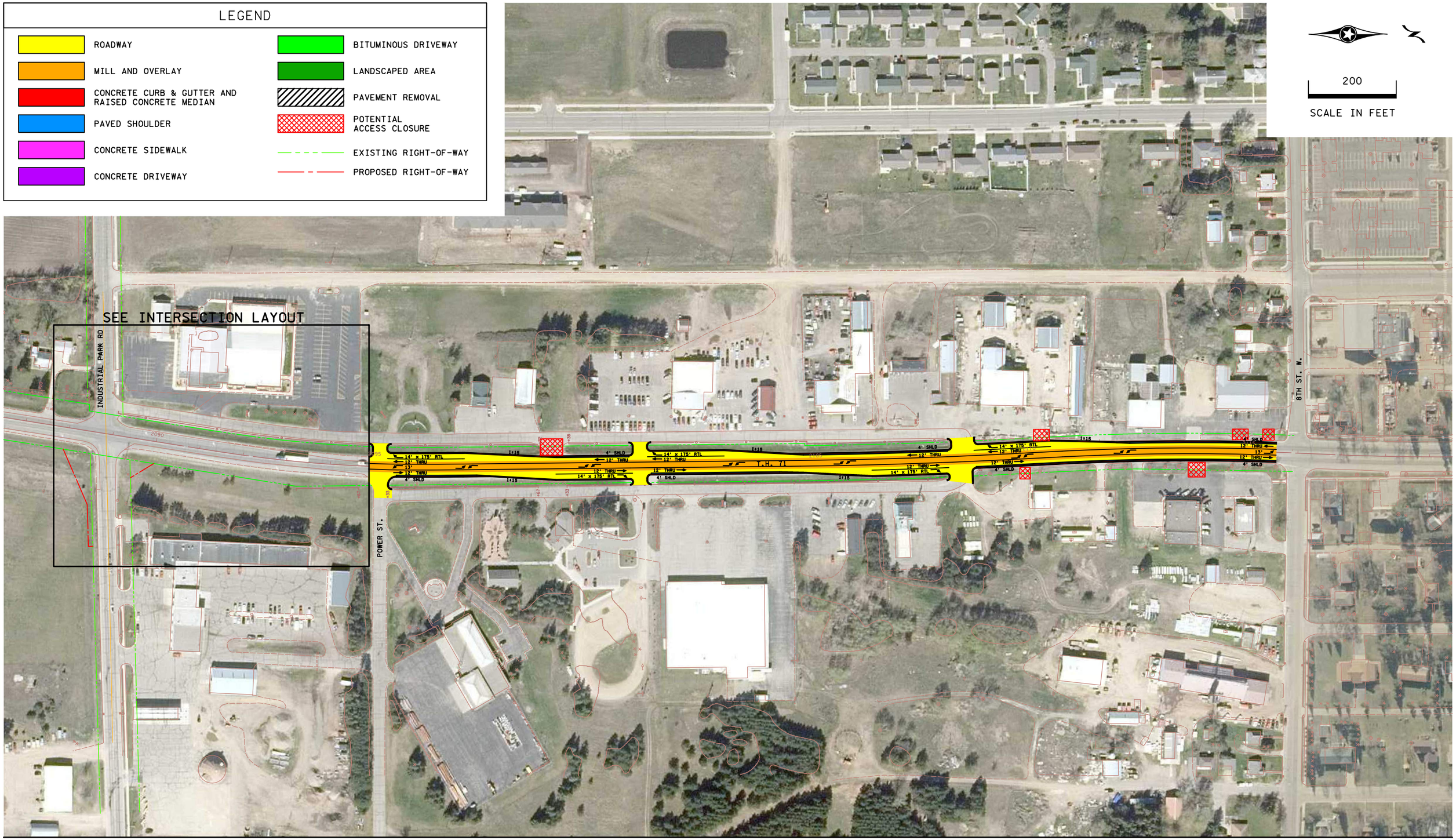
Description

Two lane roadway design with a raised center median ending at northerly end of the frontage road limits. Begin three lane section with center turn lane. Provide two one primary intersections with left and right turn lanes. Establish a new east/west road (Front Avenue) connection between Pleasant Avenue and TH 71. Establish upgraded city street supporting network along Main Avenue, Powers Street and Front Avenue. Consolidate access driveways.

Pros and Cons

Pros
1. Provides uniform spacing of primary accesses along TH 71.
2. Provides good balance between access control and local access consolidation.
3. Establishes a supporting street network to allow circulation to occur off of TH 71.
4. Allows right in/right out access at existing street connections.
5. Can be compatible with all CR 15 intersection design alternatives.

Cons
1. Will require urban street section due to proximity to the frontage roads.
2. Raised median design is not consistent with the rest of TH 71.
3. High Cost.



TH 71 at CSAH 15/Industrial Park Road Intersection Control Evaluation

ALLIANT ENGINEERING

Figure 18
Preferred Alternative Roadway
Cross-Section - CSAH 15 to 8th Street

6.0 Preferred Alternative

The selection of the preferred alternative and recommendations made for the TH 71 and CSAH 15 intersection are made based upon; discussions with the TAC, results of the safety analysis, the benefit to cost analysis, and consideration of the key decision factors evaluated in the comparison matrix. Based on the information presented in this ICE study, Alternative 7 (roundabout), is the preferred alternative (See Figure 15). In addition, it is recommended the segment of TH 71 between CSAH 15 and 8th Street be reconstructed to a three lane roadway with left and right turn lanes at the primary accesses (See Figure 18).

Key conclusions and findings of the ICE study that lead to the study recommendations include:

- The TH 71 and CSAH 15 intersection has experienced 15 crashes. The overall intersection crash rate is 1.5 times the statewide average crash rate, and is nearly twice the average severity rate. Based on these statistics, the crash experience at this intersection is indicative of a safety concern. The need to address both the existing safety deficiency and future traffic operation deficiency is warranted.
- The most prevalent crashes occurring at TH 71 and CSAH 15 are right angle and rear end crashes, which amount to over 60 percent (9 of the 15 crashes) of the total intersection crashes.
- The roundabout design is expected to provide the greatest safety benefit (highest reduction in severe crashes) and the greatest traffic operation benefit (least amount of delay to all motorists).
- The roundabout will immediately address the operation and safety concerns. Whereas, a traffic signal system is not expected warranted until year 2029, when severity rate reduction benefit would begin. The provision of left turn lanes would immediately provide some minimal traffic operation benefit and a safety benefit under two way stop control (reduction in crashes); however, the crash severity would not be expected to change.
- The roundabout is expected to provide positive speed control as motorists enter and leave Park Rapids. The roundabout will be designed for a 15-20 mph circulatory speed. Currently motorist speeds can be variable, being this intersection is on the edge of town and 60 mph posted limit exists just to the south of CSAH 15.
- Although the initial construction cost is much higher than the other alternatives, the roundabout is expected to have a 2.0 benefit to cost ratio, which is an economically viable solution.
- The roundabout is expected to be the most adaptable and efficient form of traffic control device in consideration of the high monthly and season variable traffic volume levels.

Once the project moves into preliminary engineering, a few design considerations include:

- The specific footprint of the roundabout should be fine-tuned. Based on feedback from the public open house, the appropriate design vehicle should be identified and the roundabout size, truck apron diameter and entry and exit approach geometrics be optimized. However, the parallel Hubbard County truck bypass is expected to minimize the need for oversized vehicles to navigate the roundabout.
- Intersection street lighting should be provided.
- The frontage road access to CSAH 15 should be closed and the existing church driveway access to CSAH 15 be moved to the west.

Appendix A:
Collision Diagram

Mn/DOT 2942 (rev 9-11-92)

COLLISION DIAGRAM

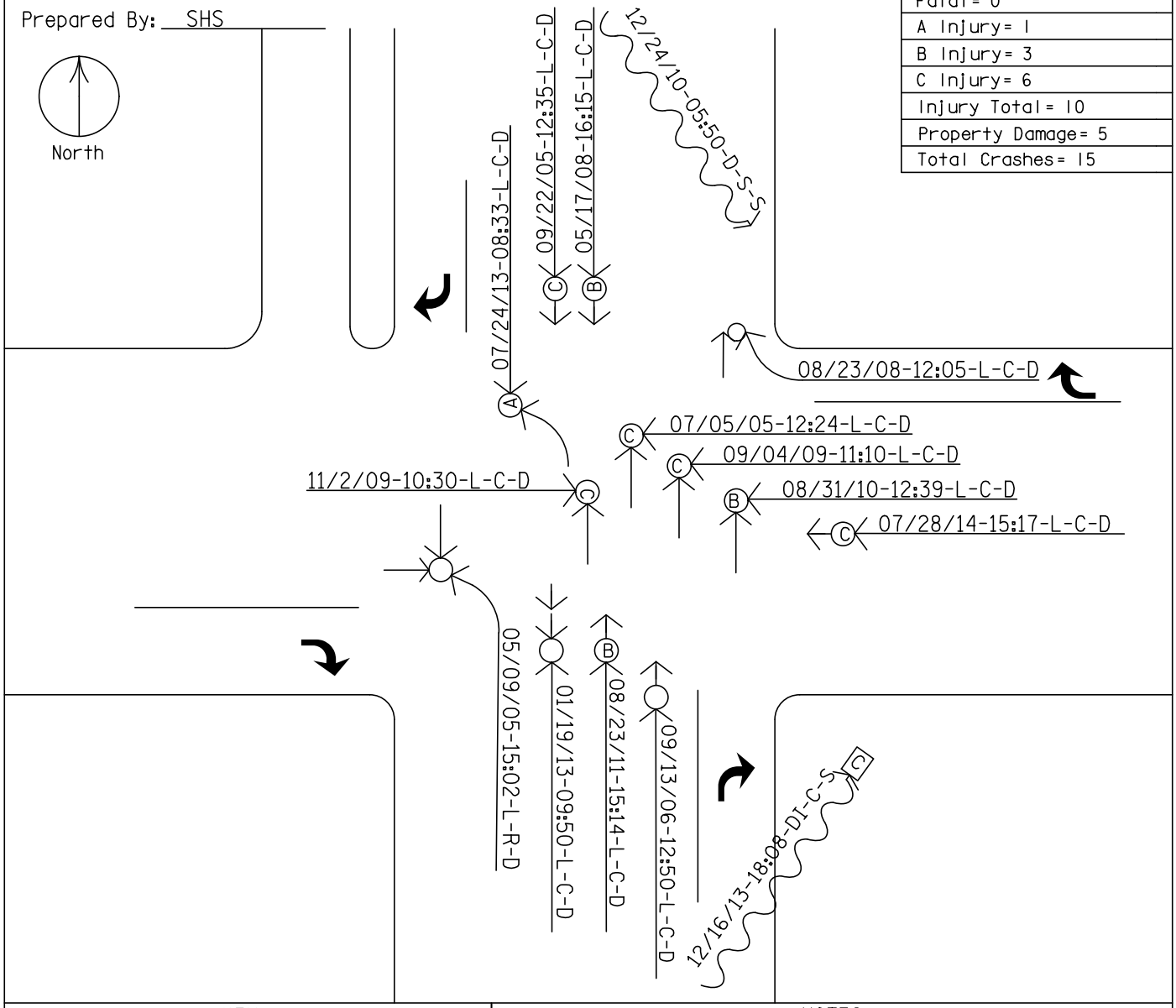
Minnesota Department of Transportation

Location: TH 71 & CSAH 15/INDUSTRIAL PARK ROAD

Time Period: 2004-2013 Date: 10/21/2015

Prepared By: SHS

No. of Crashes
Fatal = 0
A Injury = 1
B Injury = 3
C Injury = 6
Injury Total = 10
Property Damage = 5
Total Crashes = 15



KEY

- Motor Vehicle Out of Control
- Motor Vehicle Backing Up
- Motor Vehicle Rollover
- Motor Vehicle Sideswipe
- Fixed Object
- Fatal Crash
- A Injury Crash
- B Injury Crash
- C Injury Crash
- Property Damage Crash
- Pedestrian
- Bicycle
- Motorcycle
- Parked Vehicle
- Rear End Property Damage
- Right Angle B Injury

NOTES

[1]
[2]
[3]

Light:	Weather:	Surface:
L = Daylight (1)	C = Clear or Cloudy (1 or 2)	D = Dry (1)
DN = Dawn (2)	R = Rain (3)	W = Wet (2)
Du = Dusk (3)	S = Snow or Sleet (4 or 5)	S = Snow or Ice (3 or 4)
Dl = Dark, Lighted (4)	F = Fog, Smog, Smoke (6)	M = Muddy (5)
Do = Dark, Lights Off (5)	B = Blowing Sand/Dust (7)	Db = Debris (6)
D = Dark, Unlighted (6)	W = Severe Crosswinds (8)	O = Oily (7)
X = Unknown (99)	X = Other or Unknown (99)	X = Other or Unknown (99)

(X) = Number of Vehicles in Crash (X) Other Vehicle Injury Type [Date]—[Time (hrs)]—[Light-Weather-Surface]

Appendix B:
Signal Warrant Analysis

TABLE B-1
SIGNAL WARRANT ANALYSIS
WARRANT 1
LOCATION: **TH 71 AT CSAH 15**

Count Date:	**Year 2013**
Source:	See Footnote
Factor:	1.00
Population < 10,000?	NO
Speed over 40 mph?	Yes

APPROACH	DESCRIPTION	NUMBER OF LANES	SPEED (MPH)
Major Approach 1	TH 71 Northbound	2	40
Major Approach 3	TH 71 Southbound	2	40
Minor Approach 2	CSAH 15 Westbound	1	30
Minor Approach 4	Industrial Park Road Eastbound	1	30

If population is less than 10,000; or the major street speed is over 40 mph, seventy percent factor can be applied. Apply seventy percent factor? yes

	MAJOR STREET							MINOR STREET										WARRANT MET SAME HOURS ON MAJOR AND MINOR STREETS				WARRANT MET ALL WAY STOP CONTROL							
	APPROACH VOLUME			WARRANT MET *				APPROACH VOLUME		WARRANT MET APPROACH 2 *				WARRANT MET APPROACH 4 *								Major	Minor	Major	Minor				
				Cond. A	Cond. B	7 & (A&B) Comb.				Cond. A	Cond. B	7 & (A&B) Comb.		Cond. A	Cond. B	7 & (A&B) Comb.				7 & (A&B) Comb.		Cond. C1	Cond. C2	80% of C1	80% of C2	Warrant Met Same Hour			
			TOTAL			80% of A	80% of B					80% of A	80% of B			80% of A	80% of B												
HOUR	1	3	1 + 3	420	630	336	504	2	4	105	53	84	42.4	105	53	84	42.4	Cond. A	Cond. B	80% of A	80% of B	300	200	240	160	Cond. C	Cond. D	Cond. C	Cond. D
12 - 1 AM	0	0	0					0	0																				
1 - 2 AM	0	0	0					0	0																				
2 - 3 AM	0	0	0					0	0																				
3 - 4 AM	0	0	0					0	0																				
4 - 5 AM	0	0	0					0	0																				
5 - 6 AM	0	0	0					0	0																				
6 - 7 AM	0	0	0					0	0																				
7 - 8 AM	217	361	578	X		X	X	51	32				X								X	X		X					
8 - 9 AM	196	263	459	X		X		61	18		X		X									X		X					
9 - 10 AM	182	213	395			X		42	10													X		X					
10 - 11 AM	180	250	430	X		X		32	19													X		X					
11 - Noon	250	289	539	X		X	X	28	59						X		X				X	X		X					
12 - 1 PM	321	268	589	X		X	X	54	35		X		X								X	X		X					
1 - 2 PM	296	259	555	X		X	X	71	35		X		X								X	X		X					
2 - 3 PM	269	240	509	X		X	X	72	33		X		X								X	X		X					
3 - 4 PM	327	290	617	X		X	X	68	52		X		X				X				X	X		X					
4 - 5 PM	327	279	606	X		X	X	73	77		X		X		X		X				X	X		X					
5 - 6 PM	284	281	565	X		X	X	41	48								X				X	X		X					
6 - 7 PM	156	157	313					30	17													X		X					
7 - 8 PM	0	0	0					0	0																				
8 - 9 PM	0	0	0					0	0																				
9 - 10 PM	0	0	0					0	0																				
10 - 11 PM	0	0	0					0	0																				
11 - Midnight	0	0	0					0	0																				

SUMMARY OF RESULTS:

Warrant 1 - Cond. A was	not met:	0	hours satisfied requirements
Warrant 1 - Cond. B was	not met:	0	hours satisfied requirements
Warrant 1 - Combine A & B was	not met:	0	hours satisfied requirements
All Way Stop Warrant Cond. C was	not met:	0	hours satisfied requirements
All Way Stop Warrant Cond. D was	not met:	0	hours satisfied requirements

Note:
* Warrant volume requirements are from the 2011 Minnesota Manual on Uniform Traffic Control Devices.

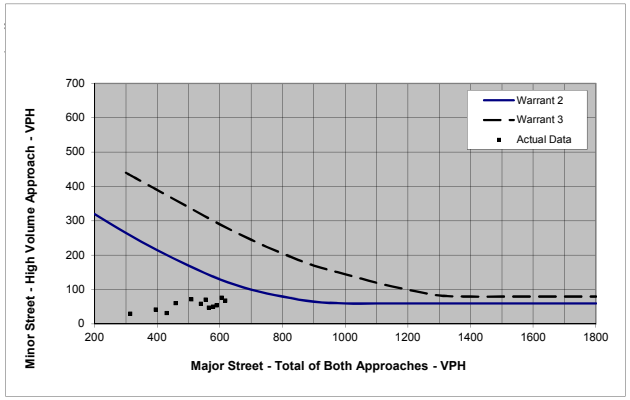


TABLE B-2
SIGNAL WARRANT ANALYSIS
WARRANT 1
LOCATION: **TH 71 AT CSAH 15**

Count Date:	Year 2018
Source:	See Footnote
Factor:	1.00
Population < 10,000?	NO
Speed over 40 mph?	Yes

APPROACH	DESCRIPTION	NUMBER OF LANES	SPEED (MPH)
Major Approach 1	TH 71 Northbound	2	40
Major Approach 3	TH 71 Southbound	2	40
Minor Approach 2	CSAH 15 Westbound	1	30
Minor Approach 4	Industrial Park Road Eastbound	1	30

If population is less than 10,000; or the major street speed is over 40 mph, seventy percent factor can be applied. Apply seventy percent factor? YES

	MAJOR STREET							MINOR STREET										WARRANT MET SAME HOURS ON MAJOR AND MINOR STREETS				WARRANT MET ALL WAY STOP CONTROL							
	APPROACH VOLUME			WARRANT MET *				APPROACH VOLUME		WARRANT MET APPROACH 2 *				WARRANT MET APPROACH 4 *								Major	Minor	Major	Minor				
				Cond. A	Cond. B	7 & (A&B) Comb.				Cond. A	Cond. B	7 & (A&B) Comb.		Cond. A	Cond. B	7 & (A&B) Comb.				7 & (A&B) Comb.		Cond. C1	Cond. C2	80% of C1	80% of C2	Warrant Met Same Hour			
						80% of A	80% of B					80% of A	80% of B			80% of A	80% of B												
HOUR	1	3	TOTAL 1 + 3	420	630	336	504	2	4	105	53	84	42.4	105	53	84	42.4	Cond. A	Cond. B	80% of A	80% of B	300	200	240	160	Cond. C	Cond. D	Cond. C	Cond. D
12 - 1 AM	0	0	0					0	0																				
1 - 2 AM	0	0	0					0	0																				
2 - 3 AM	0	0	0					0	0																				
3 - 4 AM	0	0	0					0	0																				
4 - 5 AM	0	0	0					0	0																				
5 - 6 AM	0	0	0					0	0																				
6 - 7 AM	0	0	0					0	0																				
7 - 8 AM	230	383	613	X		X	X	61	36		X		X								X	X		X					
8 - 9 AM	208	280	488	X		X		68	20		X		X									X		X					
9 - 10 AM	191	225	416			X		46	12				X									X		X					
10 - 11 AM	190	265	455	X		X		37	19													X		X					
11 - Noon	267	305	572	X		X	X	34	63						X		X				X	X		X					
12 - 1 PM	342	285	627	X		X	X	62	36		X		X								X	X		X					
1 - 2 PM	315	276	591	X		X	X	78	36		X		X								X	X		X					
2 - 3 PM	285	256	541	X		X	X	80	34		X		X								X	X		X					
3 - 4 PM	345	308	653	X	X	X	X	76	56		X		X		X		X		X		X	X		X					
4 - 5 PM	347	296	643	X	X	X	X	82	84		X		X		X	X	X		X	X	X	X		X	X		X		1
5 - 6 PM	301	298	599	X		X	X	48	52				X				X				X	X		X					
6 - 7 PM	166	167	333					35	17													X		X					
7 - 8 PM	0	0	0					0	0																				
8 - 9 PM	0	0	0					0	0																				
9 - 10 PM	0	0	0					0	0																				
10 - 11 PM	0	0	0					0	0																				
11 - Midnight	0	0	0					0	0																				

SUMMARY OF RESULTS:

Warrant 1 - Cond. A was	not met:	0	hours satisfied requirements
Warrant 1 - Cond. B was	not met:	2	hours satisfied requirements
Warrant 1 - Combine A & B was	not met:	1	hours satisfied requirements
All Way Stop Warrant Cond. C was	not met:	0	hours satisfied requirements
All Way Stop Warrant Cond. D was	not met:	1	hours satisfied requirements

Note:
* Warrant volume requirements are from the 2011 Minnesota Manual on Uniform Traffic Control Devices.

Source: Hourly approch volumes provided by Dakota County Transportation Department.

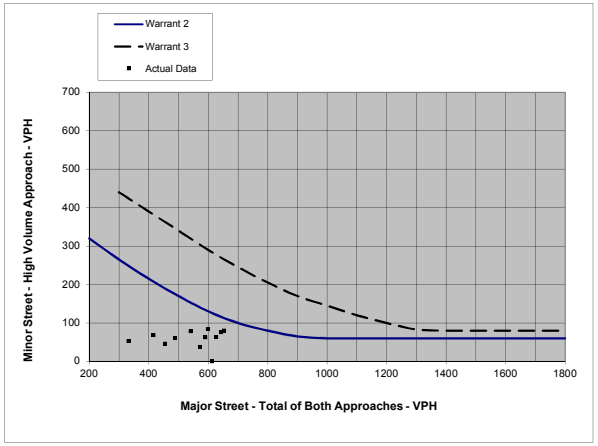


TABLE B-3
SIGNAL WARRANT ANALYSIS
WARRANT 1
LOCATION: **TH 71 AT CSAH 15**

Count Date:	**Year 2038**
Source:	See Footnote
Factor:	1.00
Population < 10,000?	NO
Speed over 40 mph?	Yes

APPROACH	DESCRIPTION	NUMBER OF LANES	SPEED (MPH)
Major Approach 1	TH 71 Northbound	2	40
Major Approach 3	TH 71 Southbound	2	40
Minor Approach 2	CSAH 15 Westbound	1	30
Minor Approach 4	Industrial Park Road Eastbound	1	30

If population is less than 10,000; or the major street speed is over 40 mph, seventy percent factor can be applied. Apply seventy percent factor? YES

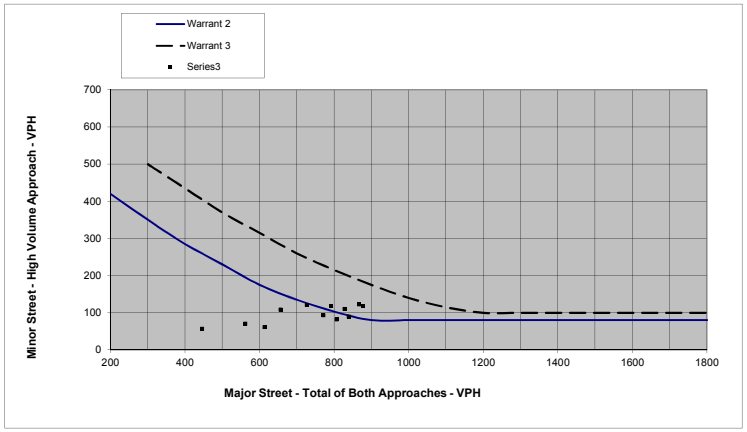
	MAJOR STREET							MINOR STREET										WARRANT MET SAME HOURS ON MAJOR AND MINOR STREETS				WARRANT MET ALL WAY STOP CONTROL							
	APPROACH VOLUME			WARRANT MET *				APPROACH VOLUME		WARRANT MET APPROACH 2 *				WARRANT MET APPROACH 4 *								Major	Minor	Major	Minor				
				Cond. A	Cond. B	7 & (A&B) Comb.				Cond. A	Cond. B	7 & (A&B) Comb.		Cond. A	Cond. B	7 & (A&B) Comb.				7 & (A&B) Comb.		Cond. C1	Cond. C2	80% of C1	80% of C2	Warrant Met Same Hour			
			TOTAL			80% of A	80% of B					80% of A	80% of B			80% of A	80% of B												
HOUR	1	3	1 + 3	420	630	336	504	2	4	105	53	84	42.4	105	53	84	42.4	Cond. A	Cond. B	80% of A	80% of B	300	200	240	160	Cond. C	Cond. D	Cond. C	Cond. D
12 - 1 AM	0	0	0					0	0																				
1 - 2 AM	0	0	0					0	0																				
2 - 3 AM	0	0	0					0	0																				
3 - 4 AM	0	0	0					0	0																				
4 - 5 AM	0	0	0					0	0																				
5 - 6 AM	0	0	0					0	0																				
6 - 7 AM	0	0	0					0	0																				
7 - 8 AM	311	517	828	X	X	X	X	110	56	X	X	X	X		X		X	X	X	X	X	X		X	X		X		1
8 - 9 AM	279	377	656	X	X	X	X	109	35	X	X	X	X					X	X	X	X	X		X					
9 - 10 AM	258	304	562	X		X	X	71	23		X		X								X	X		X					
10 - 11 AM	256	357	613	X		X	X	61	30		X		X								X	X		X					
11 - Noon	358	413	771	X	X	X	X	62	93		X		X		X	X	X		X	X	X	X		X					
12 - 1 PM	457	382	839	X	X	X	X	90	54		X	X	X		X		X		X	X	X	X		X					
1 - 2 PM	422	370	792	X	X	X	X	118	51	X	X	X	X				X	X	X	X	X	X		X	X		X		1
2 - 3 PM	383	343	726	X	X	X	X	121	52	X	X	X	X				X	X	X	X	X	X		X	X		X		1
3 - 4 PM	464	413	877	X	X	X	X	118	79	X	X	X	X		X		X	X	X	X	X	X		X	X		X		1
4 - 5 PM	466	400	866	X	X	X	X	122	114	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	1
5 - 6 PM	405	401	806	X	X	X	X	82	73		X		X		X		X		X		X	X		X					
6 - 7 PM	222	224	446	X		X		57	25		X		X									X		X					
7 - 8 PM	0	0	0					0	0																				
8 - 9 PM	0	0	0					0	0																				
9 - 10 PM	0	0	0					0	0																				
10 - 11 PM	0	0	0					0	0																				
11 - Midnight	0	0	0					0	0																				

SUMMARY OF RESULTS:

Warrant 1 - Cond. A was	not met:	6	hours satisfied requirements
Warrant 1 - Cond. B was	met:	9	hours satisfied requirements
Warrant 1 - Combine A & B was	met:	8	hours satisfied requirements
All Way Stop Warrant Cond. C was	not met:	1	hours satisfied requirements
All Way Stop Warrant Cond. D was	not met:	5	hours satisfied requirements

Note:
* Warrant volume requirements are from the 2011 Minnesota Manual on Uniform Traffic Control Devices.

Source: Hourly approch volumes provided by Dakota County Transportation Department.



Appendix C:
Intersection Delay and Level of Service

Table 1. 2013 Existing MOE Summary by Movement

AM Peak Hour

Node	Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
			EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
101	TH 7 1 & CSAH 15	LOS	B	B	A	C	B	A	A	A	A	A	A	A	A
		Delay (sec/veh)	13.2	12.2	6.1	20	14.4	4.3	3.2	1.5	0.4	3.2	2.4	1.1	4.0
		Total Delay (hr)	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.9
		Volume	51	39	87	9	11	25	32	167	31	48	262	68	830.0
		95th Queue (ft)	81		62	42		50	41		0	38		2	
		Storage Length (ft)			N/A			150			330			330	

PM Peak Hour

Node	Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
			EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
101	TH 7 1 & CSAH 15	LOS	B	B	A	B	B	A	A	A	A	A	A	A	A
		Delay (sec/veh)	11.4	10.3	4	12.2	11.6	4.9	2.4	1.5	0.8	3.2	2.2	0.7	3.3
		Total Delay (hr)	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.7
		Volume	39	13	37	27	25	18	15	235	76	61	197	20	763.0
		95th Queue (ft)	58		49	62		42	23		2	53		0	
		Storage Length (ft)			N/A			150			330			330	

Table 2. 2018 No Build (1.5% Growth Rate) MOE Summary by Movement

AM Peak Hour

Node	Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
			EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
101	TH 7 1 & CSAH 15	LOS	B	B	A	C	B	A	A	A	A	A	A	A	A
		Delay (sec/veh)	14.4	14.2	6.2	21.1	14.6	4.2	3.5	1.7	0.4	3.1	2.7	1.2	4.3
		Total Delay (hr)	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.0	1.1
		Volume	55	42	89	8	10	31	38	179	31	56	282	72	893.0
		95th Queue (ft)	74		66	45		47	36		0	34		2	
		Storage Length (ft)			N/A			150			330			330	

PM Peak Hour

Node	Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
			EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
101	TH 7 1 & CSAH 15	LOS	B	B	A	B	B	A	A	A	A	A	A	A	A
		Delay (sec/veh)	14.1	10.7	4.6	13.1	12.3	5	2.3	1.5	0.9	3.8	2.4	0.8	3.7
		Total Delay (hr)	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.9
		Volume	45	15	45	33	31	22	18	281	83	75	225	22	895.0
		95th Queue (ft)	63		55	66		42	26		4	55		0	
		Storage Length (ft)			N/A			150			330			330	

Table 3. 2038 No Build (1.5% Growth Rate) MOE Summary by Movement

AM Peak Hour

Node	Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
			EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
101	TH 7 1 & CSAH 15	LOS	E	E	B	E	D	A	A	A	A	A	A	A	A
		Delay (sec/veh)	42.4	39	11.9	37.4	32.3	5.9	5.4	2.5	0.5	5	4.3	1.8	9.0
		Total Delay (hr)	0.9	0.6	0.4	0.1	0.1	0.1	0.1	0.2	0.0	0.1	0.5	0.1	3.1
		Volume	79	53	129	7	14	36	47	241	41	81	392	103	1223.0
		95th Queue (ft)	166		106	54		50	71		0	71		3	
		Storage Length (ft)			N/A			150			330			330	

PM Peak Hour

Node	Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
			EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
101	TH 7 1 & CSAH 15	LOS	D	E	A	D	D	A	A	A	A	A	A	A	A
		Delay (sec/veh)	35	42	6.1	31.1	31.4	7.4	3.6	2.3	1.1	5.3	3.7	1.1	7.6
		Total Delay (hr)	0.7	0.2	0.1	0.4	0.3	0.1	0.0	0.2	0.0	0.1	0.3	0.0	2.6
		Volume	66	19	63	48	37	30	21	377	104	97	300	29	1191.0
		95th Queue (ft)	128		56	101		55	47		5	79		0	
		Storage Length (ft)			N/A			150			330			330	

Table 4. Alternative 2 2018 1.5% Growth Rate MOE Summary by Movement

AM Peak Hour

Node	Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
			EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
101	TH 71 & CSAH 15	LOS	B	B	A	C	B	A	A	A	A	A	A	A	A
		Delay (sec/veh)	13.5	12.9	7.2	22.3	12.6	4.2	2.8	1	0.4	3	1.9	1.1	3.9
		Total Delay (hr)	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	1.0
		Volume	55	42	89	8	10	31	38	179	31	56	282	72	893
		95th Queue (ft)	78		68	43		50	29		2	28		1	
		Storage Length (ft)			N/A			150	330		330			330	

PM Peak Hour

Node	Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
			EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
101	TH 71 & CSAH 15	LOS	B	B	A	B	B	A	A	A	A	A	A	A	A
		Delay (sec/veh)	14	11.6	4.5	13.4	12.9	4.7	2.4	1.3	0.9	3.7	1.4	0.8	3.4
		Total Delay (hr)	0.2	0.0	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.8
		Volume	45	14	46	33	30	23	18	280	83	74	225	22	893
		95th Queue (ft)	64		55	68		42	20		3	40		2	
		Storage Length (ft)			N/A			150	330		330	330		330	

Table 5. Alternative 2 2038 1.5% Growth Rate MOE Summary by Movement

AM Peak Hour

Node	Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
			EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
101	TH 71 & CSAH 15	LOS	D	D	B	D	C	A	A	A	A	A	A	A	A
		Delay (sec/veh)	31	27.1	13.7	26	23.2	5.9	4.4	1.3	0.5	4	2.6	1.6	6.9
		Total Delay (hr)	0.7	0.4	0.5	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.3	0.0	2.4
		Volume	79	53	129	7	14	36	47	241	41	81	392	103	1223
		95th Queue (ft)	129		112	49		49	39		0	38		3	
		Storage Length (ft)			N/A			150	330		330			330	

PM Peak Hour

Node	Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
			EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
101	TH 71 & CSAH 15	LOS	D	E	A	D	D	A	A	A	A	A	A	A	A
		Delay (sec/veh)	31.9	36.9	5.6	28.9	28.6	7.1	3.7	1.8	1	4.9	1.8	1	6.5
		Total Delay (hr)	0.6	0.2	0.1	0.4	0.3	0.1	0.0	0.2	0.0	0.1	0.2	0.0	2.2
		Volume	66	19	63	48	37	30	21	377	104	97	300	29	1191
		95th Queue (ft)	118		55	96		54	24		5	45		2	
		Storage Length (ft)			N/A			150	330		330	330		330	

Table 6. Alternative 4 2018 1.5% Growth Rate MOE Summary by Movement

AM Peak Hour

Node	Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
			EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
101	TH 71 & CSAH 15	LOS	B	B	A	B	B	A	A	A	A	A	A	A	A
		Delay (sec/veh)	12.6	13.8	6.1	13.6	11.2	3.4	7.1	7.2	1.8	8.2	8.5	2.4	7.6
		Total Delay (hr)	0.2	0.2	0.2	0.0	0.0	0.0	0.1	0.4	0.0	0.1	0.7	0.0	1.9
		Volume	55	42	89	8	10	31	38	179	31	56	282	72	893
		95th Queue (ft)	87		64	34		43	40	73	19	45	113	30	
		Storage Length (ft)			N/A			150			330			330	

PM Peak Hour

Node	Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
			EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
101	TH 71 & CSAH 15	LOS	B	B	A	B	B	A	A	A	A	A	A	A	A
		Delay (sec/veh)	15.8	15.2	4.7	15.3	15	5.6	7.6	8.3	2.8	7.8	5.7	1.8	7.6
		Total Delay (hr)	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.7	0.1	0.2	0.4	0.0	1.9
		Volume	45	14	46	33	30	23	18	280	83	74	225	22	893
		95th Queue (ft)	64		57	72		41	28	103	42	49	72	13	
		Storage Length (ft)			N/A			150			330			330	

Table 7. Alternative 4 2038 1.5% Growth Rate MOE Summary by Movement

AM Peak Hour

Node	Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
			EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
101	TH 71 & CSAH 15	LOS	B	B	A	B	B	A	A	A	A	B	B	A	B
		Delay (sec/veh)	14.9	15.3	8.6	20	14.6	4.2	10	9.8	1.9	10.2	13	3.3	10.4
		Total Delay (hr)	0.3	0.2	0.3	0.0	0.1	0.0	0.1	0.7	0.0	0.2	1.4	0.1	3.6
		Volume	79	53	129	7	14	36	47	241	41	81	392	103	1223
		95th Queue (ft)	103		93	44		46	44	122		66	186	40	
		Storage Length (ft)			N/A			150			330			330	

PM Peak Hour

Node	Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
			EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
101	TH 71 & CSAH 15	LOS	B	B	A	B	B	A	A	B	A	B	A	A	B
		Delay (sec/veh)	18.2	18.7	5.1	17.3	18.1	6.6	8.6	11.9	3.2	10.1	8.1	2.1	10.1
		Total Delay (hr)	0.3	0.1	0.1	0.2	0.2	0.1	0.1	1.3	0.1	0.3	0.7	0.0	3.4
		Volume	66	19	63	48	37	30	21	377	104	97	300	29	1191
		95th Queue (ft)	94	57	82			50	34	173	45	58	106	19	
		Storage Length (ft)			N/A			150			330			330	

Table 8. Alternative 7 2018 1.5% Growth Rate MOE Summary by Movement

AM Peak Hour

Node	Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
			EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
101	TH 71 & CSAH 15	LOS	A	A	A	A	A	A	A	A	A	A	A	A	A
		Delay (sec/veh)	4.0	4.0	4.8	3.3	1.9	2.1	3.9	3.2	2.4	4.5	4.0	3.2	3.7
		Total Delay (hr)	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.3	0.1	0.9
		Volume	58	33	94	7	12	23	37	174	30	57	287	77	889
		Max Queue (ft)		131			47			97			114		

PM Peak Hour

Node	Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
			EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
101	TH 71 & CSAH 15	LOS	A	A	A	A	A	A	A	A	A	A	A	A	A
		Delay (sec/veh)	3.1	3.3	3.0	3.8	3.6	3.0	4.2	4.4	3.9	3.1	3.2	2.3	3.6
		Total Delay (hr)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.1	0.2	0.0	0.9
		Volume	49	16	44	35	33	21	17	273	80	67	222	26	883
		95th Queue (ft)		66			77			124			78		

Table 9. Alternative 7 2038 1.5% Growth Rate MOE Summary by Movement

AM Peak Hour

Node	Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
			EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
101	TH 71 & CSAH 15	LOS	A	A	B	A	A	A	A	A	A	A	A	A	A
		Delay (sec/veh)	8.1	8.8	13.5	4.2	2.4	3.7	4.5	4.3	3.6	6.4	5.8	4.8	6.3
		Total Delay (hr)	0.2	0.1	0.5	0.0	0.0	0.0	0.1	0.3	0.0	0.1	0.6	0.1	2.1
		Volume	81	44	124	9	15	34	47	237	39	72	393	102	1197
		Max Queue (ft)		289			67			142			224		

PM Peak Hour

Node	Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
			EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
101	TH 71 & CSAH 15	LOS	A	A	A	A	A	A	A	A	A	A	A	A	A
		Delay (sec/veh)	4.6	5.3	3.8	5.2	4.4	4.3	5.7	5.6	5.0	4.0	4.0	3.4	4.7
		Total Delay (hr)	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.6	0.2	0.1	0.3	0.0	1.5
		Volume	63	19	64	45	42	30	22	367	108	90	301	34	1185
		95th Queue (ft)		92			102			181			118		

Appendix D:
Traffic Operation Benefit Analysis (VHT)

Daily and Annual Vehicle Hours Traveled

2015 Vehicle Hours Traveled (VHT)

Time Period	Grouping	Percent of Grouping by Volume	2015 No Build (Veh-Hr)
12:00 AM	AM	2.8%	0.03
1:00 AM	AM	1.1%	0.01
2:00 AM	AM	2.2%	0.02
3:00 AM	AM	5.6%	0.05
4:00 AM	AM	11.2%	0.10
5:00 AM	AM	33.6%	0.30
6:00 AM	AM	76.1%	0.68
7:00 AM	**AM**	**100.0%**	**0.90**
8:00 AM	AM	71.9%	0.65
9:00 AM	AM	58.5%	0.53
10:00 AM	AM	62.6%	0.56
11:00 AM	AM	82.4%	0.74
12:00 PM	PM	86.0%	0.60
1:00 PM	PM	83.6%	0.58
2:00 PM	PM	79.5%	0.56
3:00 PM	PM	94.4%	0.66
4:00 PM	**PM**	**100.0%**	**0.70**
5:00 PM	PM	86.4%	0.60
6:00 PM	PM	48.2%	0.34
7:00 PM	PM	41.7%	0.29
8:00 PM	PM	28.2%	0.20
9:00 PM	PM	11.3%	0.08
10:00 PM	PM	5.6%	0.04
11:00 PM	PM	2.8%	0.02
2015 Daily Vehicle Hours Traveled (VHT)			**9.2**
2015 Annual Vehicle Hours Traveled (VHT)			**3374.6**

2018 Vehicle Hours Traveled (VHT)

Time Period	Grouping	Percent of Grouping by Volume	2018 No Build (Veh-Hr)	2018 ALT 2 Total Delay (Veh-Hr)	2018 ALT 4 Total Delay (Veh-Hr)	2018 ALT 7 Total Delay (Veh-Hr)
12:00 AM	AM	2.8%	0.03	0.03	0.05	0.03
1:00 AM	AM	1.1%	0.01	0.01	0.02	0.01
2:00 AM	AM	2.2%	0.02	0.02	0.04	0.02
3:00 AM	AM	5.6%	0.06	0.06	0.11	0.05
4:00 AM	AM	11.2%	0.12	0.11	0.21	0.10
5:00 AM	AM	33.6%	0.37	0.34	0.64	0.31
6:00 AM	AM	76.1%	0.84	0.76	1.45	0.70
7:00 AM	**AM**	**100.0%**	**1.10**	**1.00**	**1.90**	**0.92**
8:00 AM	AM	71.9%	0.79	0.72	1.37	0.67
9:00 AM	AM	58.5%	0.64	0.59	1.11	0.54
10:00 AM	AM	62.6%	0.69	0.63	1.19	0.58
11:00 AM	AM	82.4%	0.91	0.82	1.57	0.76
12:00 PM	PM	86.0%	0.77	0.69	1.63	0.76
1:00 PM	PM	83.6%	0.75	0.67	1.59	0.74
2:00 PM	PM	79.5%	0.72	0.64	1.51	0.70
3:00 PM	PM	94.4%	0.85	0.75	1.79	0.84
4:00 PM	**PM**	**100.0%**	**0.90**	**0.80**	**1.90**	**0.89**
5:00 PM	PM	86.4%	0.78	0.69	1.64	0.76
6:00 PM	PM	48.2%	0.43	0.39	0.92	0.43
7:00 PM	PM	41.7%	0.38	0.33	0.79	0.37
8:00 PM	PM	28.2%	0.25	0.23	0.53	0.25
9:00 PM	PM	11.3%	0.10	0.09	0.21	0.10
10:00 PM	PM	5.6%	0.05	0.05	0.11	0.05
11:00 PM	PM	2.8%	0.03	0.02	0.05	0.02
2018 Daily Vehicle Hours Traveled (VHT)			**11.6**	**10.4**	**22.3**	**10.6**
2018 Annual Vehicle Hours Traveled (VHT)			**4232.8**	**3803.7**	**8152.9**	**3872.9**

2038 Vehicle Hours Traveled (VHT)

Time Period	Grouping	Percent of Grouping by Volume	2038 No Build (Veh-Hr)	2038 ALT 2 Total Delay (Veh-Hr)	2038 ALT 4 Total Delay (Veh-Hr)	2038 ALT 7 Total Delay (Veh-Hr)
12:00 AM	AM	2.6%	0.08	0.06	0.10	0.06
1:00 AM	AM	1.1%	0.03	0.03	0.04	0.02
2:00 AM	AM	2.1%	0.07	0.05	0.08	0.04
3:00 AM	AM	5.3%	0.16	0.13	0.19	0.11
4:00 AM	AM	10.6%	0.33	0.25	0.38	0.22
5:00 AM	AM	31.8%	0.99	0.76	1.14	0.66
6:00 AM	AM	71.8%	2.23	1.72	2.59	1.50
7:00 AM	**AM**	**100.0%**	**3.10**	**2.40**	**3.60**	**2.09**
8:00 AM	AM	78.4%	2.43	1.88	2.82	1.64
9:00 AM	AM	78.3%	2.43	1.88	2.82	1.64
10:00 AM	AM	81.4%	2.52	1.95	2.93	1.70
11:00 AM	AM	81.1%	2.52	1.95	2.92	1.70
12:00 PM	PM	62.0%	1.61	1.36	2.11	0.96
1:00 PM	PM	66.4%	1.73	1.46	2.26	1.03
2:00 PM	PM	78.7%	2.05	1.73	2.67	1.22
3:00 PM	PM	83.9%	2.18	1.85	2.85	1.30
4:00 PM	**PM**	**100.0%**	**2.60**	**2.20**	**3.40**	**1.55**
5:00 PM	PM	92.9%	2.41	2.04	3.16	1.44
6:00 PM	PM	77.7%	2.02	1.71	2.64	1.20
7:00 PM	PM	40.6%	1.05	0.89	1.38	0.63
8:00 PM	PM	8.1%	0.21	0.18	0.28	0.13
9:00 PM	PM	9.7%	0.25	0.21	0.33	0.15
10:00 PM	PM	4.1%	0.11	0.09	0.14	0.06
11:00 PM	PM	2.0%	0.05	0.04	0.07	0.03
2038 Daily Vehicle Hours Traveled (VHT)			**33.2**	**26.8**	**40.9**	**21.1**
2038 Annual Vehicle Hours Traveled (VHT)			**12102.8**	**9797.5**	**14924.7**	**7695.3**

Appendix E:
Safety Benefit Analysis

TH 71 Intersection Crash Rate Analysis - Alt 2 (Two-Way Stop with Left Turn Lanes)

	Rear End	Right Angle	Run Off	Head On	Sideswipe	Left Turn	Total
Existing Crashes[1]	5	4	2	1	1	2	15.0
Reduction Factors	-60.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Crash Reduction*	-3	0	0	0	0	0	-3.0
Expected Crashes	2.0	4.0	2.0	1.0	1.0	2.0	12.0

*Desktop Reference for Crash Reduction Factors, September 2008, Install left-turn lane - 4-leg (2 app), FHWA-SA-08-011

2015 Annual Crash Cost

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	ADT (Entering Vehicles - 2015)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
No Build	Thru Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.105	$ 570,000	$ 59,850.0
		B	20.0%			0.300	$ 170,000	$ 51,000.0
		C	40.0%			0.600	$ 83,000	$ 49,800.0
		PD	33.0%			0.495	$ 7,600	$ 3,762.0
		Total	**100.0%**	**0.42**	**9,930**	**1.500**	**$ -**	**$ 164,412.0**
Scenario	**Traffic Control**	**Severity**	**Severity Proportion**	**Crash Rate**	**ADT (Entering Vehicles - 2015)**	**Average Crashes / Year (No.)**	**Cost / Crash ($)**	**Cost / Year ($)**
Alt 1	Thru Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.084	$ 570,000	$ 47,880.0
		B	20.0%			0.240	$ 170,000	$ 40,800.0
		C	40.0%			0.480	$ 83,000	$ 39,840.0
		PD	33.0%			0.396	$ 7,600	$ 3,009.6
		Total	**100.0%**	**0.33**	**9,930**	**1.200**	**$ -**	**$ 131,529.6**

2018 Annual Crash Cost (1.5% Growth)

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	ADT (Entering Vehicles - 2018)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
No Build	Thru Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.111	$ 570,000	$ 63,317.5
		B	20.0%			0.317	$ 170,000	$ 53,954.8
		C	40.0%			0.635	$ 83,000	$ 52,685.3
		PD	33.0%			0.524	$ 7,600	$ 3,980.0
		Total	**100.0%**	**0.42**	**10,463**	**1.587**	**$ -**	**$ 173,937.6**
Alt 1	Two-Way Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.089	$ 570,000	$ 50,450.0
		B	20.0%			0.253	$ 170,000	$ 42,990.0
		C	40.0%			0.506	$ 83,000	$ 41,978.4
		PD	33.0%			0.417	$ 7,600	$ 3,171.1
		Total	**100.0%**	**0.33**	**10,463**	**1.264**	**$ -**	**$ 138,589.5**

2038 Annual Crash Cost (1.5% Growth)

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	ADT (Entering Vehicles - 2038)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
No Build	Thru Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.149	$ 570,000	$ 85,145.6
		B	20.0%			0.427	$ 170,000	$ 72,555.1
		C	40.0%			0.854	$ 83,000	$ 70,847.9
		PD	33.0%			0.704	$ 7,600	$ 5,352.0
		Total	**100.0%**	**0.42**	**14,070**	**2.134**	**$ -**	**$ 233,900.6**
Alt 1	Two-Way Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.119	$ 570,000	$ 67,842.1
		B	20.0%			0.340	$ 170,000	$ 57,810.3
		C	40.0%			0.680	$ 83,000	$ 56,450.0
		PD	33.0%			0.561	$ 7,600	$ 4,264.4
		Total	**100.0%**	**0.33**	**14,070**	**1.700**	**$ -**	**$ 186,366.7**

Note: Severity propostions are based on the existing crash history.

TH 71 Intersection Present Value Crash Benefit - 2038 Forecast - Alt 2 (Two Way Stop with Left Turn Lanes)

Year	Annual Crash Cost		Crash Benefit		Present Value Crash Benefit	
	No Build (1.5% Growth)	Two-Way (1.5% Growth)	No Build (1.5% Growth)	Two-Way (1.5% Growth)	No Build (1.5% Growth)	Two-Way (1.5% Growth)
			$ -	$ -	$ -	$ -
			$ -	$ -	$ -	$ -
			$ -	$ -	$ -	$ -
2015	$ 164,412	$ -	$ -	$ -	$ -	$ -
2016	$ 167,433	$ -	$ -	$ -	$ -	$ -
2017	$ 170,454	$ -	$ -	$ -	$ -	$ -
2018	$ 173,476	$ 138,590	$ -	$ 34,886	$ -	$ 34,886
2019	$ 176,497	$ 140,978	$ -	$ 35,519	$ -	$ 34,925
2020	$ 179,518	$ 143,367	$ -	$ 36,151	$ -	$ 34,952
2021	$ 182,539	$ 145,756	$ -	$ 36,783	$ -	$ 34,969
2022	$ 185,561	$ 148,145	$ -	$ 37,416	$ -	$ 34,976
2023	$ 188,582	$ 150,534	$ -	$ 38,048	$ -	$ 34,973
2024	$ 191,603	$ 152,923	$ -	$ 38,680	$ -	$ 34,960
2025	$ 194,624	$ 155,312	$ -	$ 39,313	$ -	$ 34,937
2026	$ 197,646	$ 157,700	$ -	$ 39,945	$ -	$ 34,906
2027	$ 200,667	$ 160,089	$ -	$ 40,578	$ -	$ 34,866
2028	$ 203,688	$ 162,478	$ -	$ 41,210	$ -	$ 34,817
2029	$ 206,709	$ 164,867	$ -	$ 41,842	$ -	$ 34,761
2030	$ 209,731	$ 167,256	$ -	$ 42,475	$ -	$ 34,696
2031	$ 212,752	$ 169,645	$ -	$ 43,107	$ -	$ 34,624
2032	$ 215,773	$ 172,034	$ -	$ 43,740	$ -	$ 34,545
2033	$ 218,794	$ 174,422	$ -	$ 44,372	$ -	$ 34,458
2034	$ 221,816	$ 176,811	$ -	$ 45,004	$ -	$ 34,365
2035	$ 224,837	$ 179,200	$ -	$ 45,637	$ -	$ 34,266
2036	$ 227,858	$ 181,589	$ -	$ 46,269	$ -	$ 34,160
2037	$ 230,879	$ 183,978	$ -	$ 46,901	$ -	$ 34,048
2038	$ 233,901	$ 186,367	$ -	$ 47,534	$ -	$ 33,930
	$ 4,779,751	**$ 3,412,041**	**$ -**	**$ 865,411**	**$ -**	**$ 694,089**

TH 71 Intersection Crash Rate Analysis - Alt 2a (Two Way Stop with Left Turn Lanes and Raised Median)

	Rear End	Right Angle	Run Off	Head On	Sideswipe	Left Turn	Total
Existing Crashes[1]	5	4	2	1	1	2	15.0
Reduction Factors*	-60.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Crash Reduction	-3	0	0	0	0	0	-3.0
Expected Crashes	2.0	4.0	2.0	1.0	1.0	2.0	12.0
Reduction Factors**	-25.0%	0.0%	0.0%	0.0%	0.0%	-25.0%	
Crash Reduction	-0.5	0	0	0	0	-0.5	-1.0
Expected Crashes	1.5	4.0	2.0	1.0	1.0	1.5	11.0

*Desktop Reference for Crash Reduction Factors, September 2008, Install left-turn lane - 4-leg (2 app), FHWA-SA-08-011
**Desktop Reference for Crash Reduction Factors, September 2008, Install Raised Median, FHWA-SA-08-011

2015 Annual Crash Cost

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	ADT (Entering Vehicles - 2015)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
No Build	Thru Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.105	$ 570,000	$ 59,850.0
		B	20.0%			0.300	$ 170,000	$ 51,000.0
		C	40.0%			0.600	$ 83,000	$ 49,800.0
		PD	33.0%			0.495	$ 7,600	$ 3,762.0
		Total	**100.0%**	**0.42**	**9,930**	**1.500**	**$ -**	**$ 164,412.0**
Scenario	**Traffic Control**	**Severity**	**Severity Proportion**	**Crash Rate**	**ADT (Entering Vehicles - 2015)**	**Average Crashes / Year (No.)**	**Cost / Crash ($)**	**Cost / Year ($)**
Alt 2a	Thru Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.077	$ 570,000	$ 43,890.0
		B	20.0%			0.220	$ 170,000	$ 37,400.0
		C	40.0%			0.440	$ 83,000	$ 36,520.0
		PD	33.0%			0.363	$ 7,600	$ 2,758.8
		Total	**100.0%**	**0.30**	**9,930**	**1.100**	**$ -**	**$ 120,568.8**

2018 Annual Crash Cost (1.5% Growth)

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	ADT (Entering Vehicles - 2018)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
No Build	Thru Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.111	$ 570,000	$ 63,317.5
		B	20.0%			0.317	$ 170,000	$ 53,954.8
		C	40.0%			0.635	$ 83,000	$ 52,685.3
		PD	33.0%			0.524	$ 7,600	$ 3,980.0
		Total	**100.0%**	**0.42**	**10,463**	**1.587**	**$ -**	**$ 173,937.6**
Alt 2a	Two-Way Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.081	$ 570,000	$ 46,245.8
		B	20.0%			0.232	$ 170,000	$ 39,407.5
		C	40.0%			0.464	$ 83,000	$ 38,480.2
		PD	33.0%			0.382	$ 7,600	$ 2,906.9
		Total	**100.0%**	**0.30**	**10,463**	**1.159**	**$ -**	**$ 127,040.4**

2038 Annual Crash Cost (1.5% Growth)

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	ADT (Entering Vehicles - 2038)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
No Build	Thru Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.149	$ 570,000	$ 85,145.6
		B	20.0%			0.427	$ 170,000	$ 72,555.1
		C	40.0%			0.854	$ 83,000	$ 70,847.9
		PD	33.0%			0.704	$ 7,600	$ 5,352.0
		Total	**100.0%**	**0.42**	**14,070**	**2.134**	**$ -**	**$ 233,900.6**
Alt 2a	Two-Way Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.109	$ 570,000	$ 62,188.5
		B	20.0%			0.312	$ 170,000	$ 52,992.7
		C	40.0%			0.623	$ 83,000	$ 51,745.9
		PD	33.0%			0.514	$ 7,600	$ 3,909.0
		Total	**100.0%**	**0.30**	**14,070**	**1.559**	**$ -**	**$ 170,836.2**

Note: Severity propostions came from 2011 Green sheets, 2013 data did not differentiate between severities

TH 71 Intersection Present Value Crash Benefit - 2038 Forecast -Alt 2a (Two Way Stop with Left Turn Lanes & Raised Median)

Year	Annual Crash Cost		Crash Benefit		Present Value Crash Benefit	
	No Build (1.5% Growth)	Two-Way (1.5% Growth)	No Build (1.5% Growth)	Two-Way (1.5% Growth)	No Build (1.5% Growth)	Two-Way (1.5% Growth)
			$ -	$ -	$ -	$ -
			$ -	$ -	$ -	$ -
			$ -	$ -	$ -	$ -
2015	$ 164,412	$ -	$ -	$ -	$ -	$ -
2016	$ 167,433	$ -	$ -	$ -	$ -	$ -
2017	$ 170,454	$ -	$ -	$ -	$ -	$ -
2018	$ 173,476	$ 127,040	$ -	$ 46,435	$ -	$ 46,435
2019	$ 176,497	$ 129,230	$ -	$ 47,267	$ -	$ 46,477
2020	$ 179,518	$ 131,420	$ -	$ 48,098	$ -	$ 46,504
2021	$ 182,539	$ 133,610	$ -	$ 48,930	$ -	$ 46,517
2022	$ 185,561	$ 135,800	$ -	$ 49,761	$ -	$ 46,516
2023	$ 188,582	$ 137,989	$ -	$ 50,593	$ -	$ 46,503
2024	$ 191,603	$ 140,179	$ -	$ 51,424	$ -	$ 46,477
2025	$ 194,624	$ 142,369	$ -	$ 52,256	$ -	$ 46,439
2026	$ 197,646	$ 144,559	$ -	$ 53,087	$ -	$ 46,390
2027	$ 200,667	$ 146,748	$ -	$ 53,918	$ -	$ 46,329
2028	$ 203,688	$ 148,938	$ -	$ 54,750	$ -	$ 46,257
2029	$ 206,709	$ 151,128	$ -	$ 55,581	$ -	$ 46,174
2030	$ 209,731	$ 153,318	$ -	$ 56,413	$ -	$ 46,081
2031	$ 212,752	$ 155,508	$ -	$ 57,244	$ -	$ 45,979
2032	$ 215,773	$ 157,697	$ -	$ 58,076	$ -	$ 45,867
2033	$ 218,794	$ 159,887	$ -	$ 58,907	$ -	$ 45,746
2034	$ 221,816	$ 162,077	$ -	$ 59,739	$ -	$ 45,616
2035	$ 224,837	$ 164,267	$ -	$ 60,570	$ -	$ 45,478
2036	$ 227,858	$ 166,457	$ -	$ 61,402	$ -	$ 45,332
2037	$ 230,879	$ 168,646	$ -	$ 62,233	$ -	$ 45,178
2038	$ 233,901	$ 170,836	$ -	$ 63,064	$ -	$ 45,016
	$ 4,779,751	**$ 3,127,704**	**$ -**	**$ 1,149,747**	**$ -**	**$ 922,294**

TH 71 Intersection Crash Rate Analysis - Alt 4 (Traffic Signal with Left Turn Lanes)

2015 Annual Crash Cost

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	ADT (Entering Vehicles - 2015)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
No Build	Thru Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.105	$ 570,000	$ 59,850.0
		B	20.0%			0.300	$ 170,000	$ 51,000.0
		C	40.0%			0.600	$ 83,000	$ 49,800.0
		PD	33.0%			0.495	$ 7,600	$ 3,762.0
		Total	**100.0%**	**0.42**	**9,930**	**1.500**	**$ -**	**$ 164,412.0**

2018 Annual Crash Cost (1.5% Growth)

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	ADT (Entering Vehicles - 2018)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
No Build	Thru Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.111	$ 570,000	$ 63,317.5
		B	20.0%			0.317	$ 170,000	$ 53,954.8
		C	40.0%			0.635	$ 83,000	$ 52,685.3
		PD	33.0%			0.524	$ 7,600	$ 3,980.0
		Total	**100.0%**	**0.42**	**10,463**	**1.587**	**$ -**	**$ 173,937.6**
Alt 4	Signalized	K	0.0%			0.000	$ 1,140,000	$ -
		A	1.0%			0.023	$ 570,000	$ 13,061.0
		B	7.0%			0.160	$ 170,000	$ 27,267.6
		C	21.0%			0.481	$ 83,000	$ 39,939.0
		PD	71.0%			1.627	$ 7,600	$ 12,364.4
		Total	**100.0%**	**0.60**	**10,463**	**2.291**	**$ -**	**$ 92,632.0**

2038 Annual Crash Cost (1.5% Growth)

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	ADT (Entering Vehicles - 2038)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
No Build	Thru Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.149	$ 570,000	$ 85,145.6
		B	20.0%			0.427	$ 170,000	$ 72,555.1
		C	40.0%			0.854	$ 83,000	$ 70,847.9
		PD	33.0%			0.704	$ 7,600	$ 5,352.0
		Total	**100.0%**	**0.42**	**14,070**	**2.134**	**$ -**	**$ 233,900.6**
Alt 4	Signalized	K	0.0%			0.000	$ 1,140,000	$ -
		A	1.0%			0.031	$ 570,000	$ 17,563.6
		B	7.0%			0.216	$ 170,000	$ 36,667.8
		C	21.0%			0.647	$ 83,000	$ 53,707.6
		PD	71.0%			2.188	$ 7,600	$ 16,626.9
		Total	**100.0%**	**0.60**	**14,070**	**3.081**	**$ -**	**$ 124,565.8**

Note: Severity propostions came from 2011 Green sheets, 2013 data did not differentiate between severities

TH 71 Intersection Present Value Crash Benefit - 2038 Forecast - Alt 4 (Traffic Signal with Left Turn Lanes)

Year	Annual Crash Cost		Crash Benefit		Present Value Crash Benefit	
	No Build (1.5% Growth)	Signalized (1.5% Growth)	No Build (1.5% Growth)	Signalized (1.5% Growth)	No Build (1.5% Growth)	Signalized (1.5% Growth)
			$ -	$ -	$ -	$ -
			$ -	$ -	$ -	$ -
			$ -	$ -	$ -	$ -
2015	$ 164,412	$ -	$ -	$ -	$ -	$ -
2016	$ 167,433	$ -	$ -	$ -	$ -	$ -
2017	$ 170,454	$ -	$ -	$ -	$ -	$ -
2018	$ 173,476	$ 92,632	$ -	$ 80,844	$ -	$ 80,844
2019	$ 176,497	$ 94,229	$ -	$ 82,268	$ -	$ 80,893
2020	$ 179,518	$ 95,825	$ -	$ 83,693	$ -	$ 80,918
2021	$ 182,539	$ 97,422	$ -	$ 85,117	$ -	$ 80,920
2022	$ 185,561	$ 99,019	$ -	$ 86,542	$ -	$ 80,899
2023	$ 188,582	$ 100,615	$ -	$ 87,966	$ -	$ 80,856
2024	$ 191,603	$ 102,212	$ -	$ 89,391	$ -	$ 80,792
2025	$ 194,624	$ 103,809	$ -	$ 90,816	$ -	$ 80,707
2026	$ 197,646	$ 105,406	$ -	$ 92,240	$ -	$ 80,603
2027	$ 200,667	$ 107,002	$ -	$ 93,665	$ -	$ 80,480
2028	$ 203,688	$ 108,599	$ -	$ 95,089	$ -	$ 80,338
2029	$ 206,709	$ 110,196	$ -	$ 96,514	$ -	$ 80,179
2030	$ 209,731	$ 111,792	$ -	$ 97,938	$ -	$ 80,002
2031	$ 212,752	$ 113,389	$ -	$ 99,363	$ -	$ 79,809
2032	$ 215,773	$ 114,986	$ -	$ 100,787	$ -	$ 79,600
2033	$ 218,794	$ 116,582	$ -	$ 102,212	$ -	$ 79,376
2034	$ 221,816	$ 118,179	$ -	$ 103,637	$ -	$ 79,137
2035	$ 224,837	$ 119,776	$ -	$ 105,061	$ -	$ 78,883
2036	$ 227,858	$ 121,372	$ -	$ 106,486	$ -	$ 78,617
2037	$ 230,879	$ 122,969	$ -	$ 107,910	$ -	$ 78,337
2038	$ 233,901	$ 124,566	$ -	$ 109,335	$ -	$ 78,044
	$ 4,779,751	**$ 2,280,578**	**$ -**	**$ 1,996,874**	**$ -**	**$ 1,602,189**

TH 71 Intersection Crash Rate Analysis - Alt 4 (2029 Install Traffic Signal)

	Rear End	Right Angle	Run Off	Head On	Sideswipe	Left Turn	Total
Existing Crashes[1]	5	4	2	1	1	2	15.0
Reduction Factors	-60.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Crash Reduction*	-3	0	0	0	0	0	-3.0
Expected Crashes	2.0	4.0	2.0	1.0	1.0	2.0	12.0

*Desktop Reference for Crash Reduction Factors, September 2008, Install left-turn lane - 4-leg (2 app), FHWA-SA-08-011

2015 Annual Crash Cost

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	ADT (Entering Vehicles - 2015)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
No Build	Thru Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.105	$ 570,000	$ 59,850.0
		B	20.0%			0.300	$ 170,000	$ 51,000.0
		C	40.0%			0.600	$ 83,000	$ 49,800.0
		PD	33.0%			0.495	$ 7,600	$ 3,762.0
		Total	**100.0%**	**0.42**	**9,930**	**1.500**	**$ -**	**$ 164,412.0**
Scenario	**Traffic Control**	**Severity**	**Severity Proportion**	**Crash Rate**	**ADT (Entering Vehicles - 2015)**	**Average Crashes / Year (No.)**	**Cost / Crash ($)**	**Cost / Year ($)**
Alt 2	Thru Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.084	$ 570,000	$ 47,880.0
		B	20.0%			0.240	$ 170,000	$ 40,800.0
		C	40.0%			0.480	$ 83,000	$ 39,840.0
		PD	33.0%			0.396	$ 7,600	$ 3,009.6
		Total	**100.0%**	**0.33**	**9,930**	**1.200**	**$ -**	**$ 131,529.6**

2018 Annual Crash Cost (1.5% Growth)

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	ADT (Entering Vehicles - 2018)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
No Build	Thru Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.111	$ 570,000	$ 63,317.5
		B	20.0%			0.317	$ 170,000	$ 53,954.8
		C	40.0%			0.635	$ 83,000	$ 52,685.3
		PD	33.0%			0.524	$ 7,600	$ 3,980.0
		Total	**100.0%**	**0.42**	**10,463**	**1.587**	**$ -**	**$ 173,937.6**
Alt 2	Two-Way Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.089	$ 570,000	$ 50,450.0
		B	20.0%			0.253	$ 170,000	$ 42,990.0
		C	40.0%			0.506	$ 83,000	$ 41,978.4
		PD	33.0%			0.417	$ 7,600	$ 3,171.1
		Total	**100.0%**	**0.33**	**10,463**	**1.264**	**$ -**	**$ 138,589.5**

2029 Annual Crash Cost (1.5% Growth)

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	ADT (Entering Vehicles - 2038)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
No Build	Thru Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.149	$ 570,000	$ 85,145.6
		B	20.0%			0.427	$ 170,000	$ 72,555.1
		C	40.0%			0.854	$ 83,000	$ 70,847.9
		PD	33.0%			0.704	$ 7,600	$ 5,352.0
		Total	**100.0%**	**0.42**	**12,300**	**1.866**	**$ -**	**$ 233,900.6**
Alt 2	Two-Way Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.104	$ 570,000	$ 59,307.6
		B	20.0%			0.297	$ 170,000	$ 50,537.8
		C	40.0%			0.595	$ 83,000	$ 49,348.6
		PD	33.0%			0.491	$ 7,600	$ 3,727.9
		Total	**100.0%**	**0.33**	**12,300**	**1.486**	**$ -**	**$ 162,921.9**
Alt 4	Signalized Intersection	K	0.0%			0.000	$ 1,140,000	$ -
		A	1.0%			0.027	$ 570,000	$ 15,354.1
		B	7.0%			0.189	$ 170,000	$ 32,055.0
		C	21.0%			0.566	$ 83,000	$ 46,951.2
		PD	71.0%			1.913	$ 7,600	$ 14,535.2
		Total	**100.0%**	**0.60**	**12,300**	**2.694**	**$ -**	**$ 108,895.5**

2038 Annual Crash Cost (1.5% Growth)

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	ADT (Entering Vehicles - 2038)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
No Build	Thru Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.149	$ 570,000	$ 85,145.6
		B	20.0%			0.427	$ 170,000	$ 72,555.1
		C	40.0%			0.854	$ 83,000	$ 70,847.9
		PD	33.0%			0.704	$ 7,600	$ 5,352.0
		Total	**100.0%**	**0.42**	**14,070**	**2.134**	**$ -**	**$ 233,900.6**
Alt 4	Signalized Intersection	K	0.0%			0.000	$ 1,140,000	$ -
		A	1.0%			0.031	$ 570,000	$ 17,563.6
		B	7.0%			0.216	$ 170,000	$ 36,667.8
		C	21.0%			0.647	$ 83,000	$ 53,707.6
		PD	71.0%			2.188	$ 7,600	$ 16,626.9
		Total	**100.0%**	**0.60**	**14,070**	**3.081**	**$ -**	**$ 124,565.8**

Note: Severity propostions are based on the existing crash history.

TH 71 Intersection Present Value Crash Benefit - 2038 Forecast - Alt 4 (2029 Install of Traffic Signal)

Year	Annual Crash Cost		Crash Benefit		Present Value Crash Benefit	
	No Build (1.5% Growth)	Two-Way (1.5% Growth)	No Build (1.5% Growth)	Two-Way (1.5% Growth)	No Build (1.5% Growth)	Two-Way (1.5% Growth)
			$ -	$ -	$ -	$ -
			$ -	$ -	$ -	$ -
			$ -	$ -	$ -	$ -
2015	$ 164,412	$ -	$ -	$ -	$ -	$ -
2016	$ 167,433	$ -	$ -	$ -	$ -	$ -
2017	$ 170,454	$ -	$ -	$ -	$ -	$ -
2018	$ 173,476	$ 138,590	$ -	$ 34,886	$ -	$ 34,886
2019	$ 176,497	$ 140,802	$ -	$ 35,695	$ -	$ 35,099
2020	$ 179,518	$ 143,014	$ -	$ 36,505	$ -	$ 35,294
2021	$ 182,539	$ 145,226	$ -	$ 37,314	$ -	$ 35,474
2022	$ 185,561	$ 147,438	$ -	$ 38,123	$ -	$ 35,637
2023	$ 188,582	$ 149,650	$ -	$ 38,932	$ -	$ 35,785
2024	$ 191,603	$ 151,862	$ -	$ 39,741	$ -	$ 35,919
2025	$ 194,624	$ 154,074	$ -	$ 40,551	$ -	$ 36,037
2026	$ 197,646	$ 156,286	$ -	$ 41,360	$ -	$ 36,142
2027	$ 200,667	$ 158,498	$ -	$ 42,169	$ -	$ 36,233
2028	$ 203,688	$ 160,710	$ -	$ 42,978	$ -	$ 36,311
2029	$ 206,709	$ 108,896	$ -	$ 97,814	$ -	$ 81,259
2030	$ 209,731	$ 110,637	$ -	$ 99,094	$ -	$ 80,946
2031	$ 212,752	$ 112,378	$ -	$ 100,374	$ -	$ 80,621
2032	$ 215,773	$ 114,119	$ -	$ 101,654	$ -	$ 80,285
2033	$ 218,794	$ 115,860	$ -	$ 102,934	$ -	$ 79,937
2034	$ 221,816	$ 117,601	$ -	$ 104,214	$ -	$ 79,578
2035	$ 224,837	$ 119,342	$ -	$ 105,494	$ -	$ 79,209
2036	$ 227,858	$ 121,084	$ -	$ 106,775	$ -	$ 78,830
2037	$ 230,879	$ 122,825	$ -	$ 108,055	$ -	$ 78,441
2038	$ 233,901	$ 124,566	$ -	$ 109,335	$ -	$ 78,044
	$ 4,779,751	**$ 2,813,453**	**$ -**	**$ 1,463,998**	**$ -**	**$ 1,111,923**

TH 71 Intersection Crash Rate Analysis - Alt 4a (Traffic Signal with Left Turn Lanes and Raised Median)

	Rear End	Right Angle	Run Off	Head On	Sideswipe	Left Turn	Reducable Crashes (Median)	Other Crashes	Total
Existing Crashes[1]	5	4	2	1	1	2			15.0
Signal Total Expected Crashes							7.5	14.3	21.7
Reduction Factors*	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-25.0%		
Crash Reduction	0	0	0	0	0	0	-1.9		-1.9
Expected Crashes	0.0	0.0	0.0	0.0	0.0	0.0	5.6	14.3	19.9

*Desktop Reference for Crash Reduction Factors, September 2008, Install Raised Median, FHWA-SA-08-011

2015 Annual Crash Cost

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	ADT (Entering Vehicles - 2015)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
No Build	Thru Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.105	$ 570,000	$ 59,850.0
		B	20.0%			0.300	$ 170,000	$ 51,000.0
		C	40.0%			0.600	$ 83,000	$ 49,800.0
		PD	33.0%			0.495	$ 7,600	$ 3,762.0
		Total	**100.0%**	**0.42**	**9,930**	**1.500**	**$ -**	**$ 164,412.0**
Alt 4a	Signalized	K	0.0%			0.000	$ 1,140,000	$ -
		A	1.0%			0.023	$ 570,000	$ 13,061.0
		B	7.0%			0.183	$ 170,000	$ 31,163.0
		C	21.0%			0.412	$ 83,000	$ 34,233.5
		PD	71.0%			1.673	$ 7,600	$ 12,712.7
		Total	**100.0%**	**0.55**	**9,930**	**1.988**	**$ -**	**$ 91,170.1**

2018 Annual Crash Cost (1.5% Growth)

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	ADT (Entering Vehicles - 2018)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
No Build	Thru Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.111	$ 570,000	$ 63,317.5
		B	20.0%			0.317	$ 170,000	$ 53,954.8
		C	40.0%			0.635	$ 83,000	$ 52,685.3
		PD	33.0%			0.524	$ 7,600	$ 3,980.0
		Total	**100.0%**	**0.42**	**10,463**	**1.587**	**$ -**	**$ 173,937.6**
Alt 4a	Signalized	K	0.0%			0.000	$ 1,140,000	$ -
		A	1.0%			0.021	$ 570,000	$ 11,939.4
		B	7.0%			0.147	$ 170,000	$ 24,926.0
		C	21.0%			0.440	$ 83,000	$ 36,509.3
		PD	71.0%			1.487	$ 7,600	$ 11,302.6
		Total	**100.0%**	**0.55**	**10,463**	**2.095**	**$ -**	**$ 84,677.2**

2038 Annual Crash Cost (1.5% Growth)

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	ADT (Entering Vehicles - 2038)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
No Build	Thru Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.149	$ 570,000	$ 85,145.6
		B	20.0%			0.427	$ 170,000	$ 72,555.1
		C	40.0%			0.854	$ 83,000	$ 70,847.9
		PD	33.0%			0.704	$ 7,600	$ 5,352.0
		Total	**100.0%**	**0.42**	**14,070**	**2.134**	**$ -**	**$ 233,900.6**
Alt 4a	Signalized	K	0.0%			0.000	$ 1,140,000	$ -
		A	1.0%			0.028	$ 570,000	$ 16,055.3
		B	7.0%			0.197	$ 170,000	$ 33,519.0
		C	21.0%			0.592	$ 83,000	$ 49,095.4
		PD	71.0%			2.000	$ 7,600	$ 15,199.0
		Total	**100.0%**	**0.55**	**14,070**	**2.817**	**$ -**	**$ 113,868.8**

Note: Severity propostions came from 2011 Green sheets, 2013 data did not differentiate between severities

TH 71 Intersection Present Value Crash Benefit - 2038 Forecast - Alt 4a (Traffic Signal with Left Turn Lanes & Raised Median)

Year	Annual Crash Cost		Crash Benefit		Present Value Crash Benefit	
	No Build (1.5% Growth)	Signalized (1.5% Growth)	No Build (1.5% Growth)	Signalized (1.5% Growth)	No Build (1.5% Growth)	Signalized (1.5% Growth)
			$ -	$ -	$ -	$ -
			$ -	$ -	$ -	$ -
			$ -	$ -	$ -	$ -
2015	$ 164,412	$ -	$ -	$ -	$ -	$ -
2016	$ 167,433	$ -	$ -	$ -	$ -	$ -
2017	$ 170,454	$ -	$ -	$ -	$ -	$ -
2018	$ 173,476	$ 84,677	$ -	$ 88,798	$ -	$ 88,798
2019	$ 176,497	$ 86,137	$ -	$ 90,360	$ -	$ 88,850
2020	$ 179,518	$ 87,596	$ -	$ 91,922	$ -	$ 88,874
2021	$ 182,539	$ 89,056	$ -	$ 93,483	$ -	$ 88,873
2022	$ 185,561	$ 90,516	$ -	$ 95,045	$ -	$ 88,848
2023	$ 188,582	$ 91,975	$ -	$ 96,607	$ -	$ 88,798
2024	$ 191,603	$ 93,435	$ -	$ 98,168	$ -	$ 88,725
2025	$ 194,624	$ 94,894	$ -	$ 99,730	$ -	$ 88,630
2026	$ 197,646	$ 96,354	$ -	$ 101,292	$ -	$ 88,513
2027	$ 200,667	$ 97,813	$ -	$ 102,853	$ -	$ 88,375
2028	$ 203,688	$ 99,273	$ -	$ 104,415	$ -	$ 88,217
2029	$ 206,709	$ 100,733	$ -	$ 105,977	$ -	$ 88,040
2030	$ 209,731	$ 102,192	$ -	$ 107,538	$ -	$ 87,844
2031	$ 212,752	$ 103,652	$ -	$ 109,100	$ -	$ 87,630
2032	$ 215,773	$ 105,111	$ -	$ 110,662	$ -	$ 87,399
2033	$ 218,794	$ 106,571	$ -	$ 112,223	$ -	$ 87,150
2034	$ 221,816	$ 108,030	$ -	$ 113,785	$ -	$ 86,886
2035	$ 224,837	$ 109,490	$ -	$ 115,347	$ -	$ 86,606
2036	$ 227,858	$ 110,950	$ -	$ 116,909	$ -	$ 86,312
2037	$ 230,879	$ 112,409	$ -	$ 118,470	$ -	$ 86,002
2038	$ 233,901	$ 113,869	$ -	$ 120,032	$ -	$ 85,680
	$ 4,779,751	**$ 2,084,733**	**$ -**	**$ 2,192,718**	**$ -**	**$ 1,759,372**

TH 71 Intersection Crash Rate Analysis - Alt 7 (Roundabout)

2015 Annual Crash Cost

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	ADT (Entering Vehicles - 2015)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
No Build	Thru Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.105	$ 570,000	$ 59,850.0
		B	20.0%			0.300	$ 170,000	$ 51,000.0
		C	40.0%			0.600	$ 83,000	$ 49,800.0
		PD	33.0%			0.495	$ 7,600	$ 3,762.0
		Total	**100.0%**	**0.42**	**9,930**	**1.500**	**$ -**	**$ 164,412.0**

2018 Annual Crash Cost (1.5% Growth)

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	ADT (Entering Vehicles - 2018)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
No Build	Thru Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.111	$ 570,000	$ 63,317.5
		B	20.0%			0.317	$ 170,000	$ 53,954.8
		C	40.0%			0.635	$ 83,000	$ 52,685.3
		PD	33.0%			0.524	$ 7,600	$ 3,980.0
		Total	**100.0%**	**0.42**	**10,463**	**1.587**	**$ -**	**$ 173,937.6**
Alt 7	Roundabout	K	0.0%			0.000	$ 1,140,000	$ -
		A	1.0%			0.018	$ 570,000	$ 10,448.8
		B	6.0%			0.110	$ 170,000	$ 18,697.8
		C	17.0%			0.312	$ 83,000	$ 25,865.3
		PD	76.0%			1.393	$ 7,600	$ 10,588.1
		Total	**100.0%**	**0.48**	**10,463**	**1.833**	**$ -**	**$ 65,599.9**

2038 Annual Crash Cost (1.5% Growth)

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	ADT (Entering Vehicles - 2038)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
No Build	Thru Stop	K	0.0%			0.000	$ 1,140,000	$ -
		A	7.0%			0.149	$ 570,000	$ 85,145.6
		B	20.0%			0.427	$ 170,000	$ 72,555.1
		C	40.0%			0.854	$ 83,000	$ 70,847.9
		PD	33.0%			0.704	$ 7,600	$ 5,352.0
		Total	**100.0%**	**0.42**	**14,070**	**2.134**	**$ -**	**$ 233,900.6**
Alt 7	Roundabout	K	0.0%			0.000	$ 1,140,000	$ -
		A	1.0%			0.025	$ 570,000	$ 14,050.9
		B	6.0%			0.148	$ 170,000	$ 25,143.7
		C	17.0%			0.419	$ 83,000	$ 34,782.1
		PD	76.0%			1.873	$ 7,600	$ 14,238.2
		Total	**100.0%**	**0.48**	**14,070**	**2.465**	**$ -**	**$ 88,214.8**

Note: Severity propostions came from 2011 Green sheets, 2013 data did not differentiate between severities

TH 71 Intersection Present Value Crash Benefit - 2038 Forecast - Alt 7 (Roundabout)

Year	Annual Crash Cost		Crash Benefit		Present Value Crash Benefit	
	No Build (1.5% Growth)	Roundabout (1.5% Growth)	No Build (1.5% Growth)	Roundabout (1.5% Growth)	No Build (1.5% Growth)	Roundabout (1.5% Growth)
			$ -	$ -	$ -	$ -
			$ -	$ -	$ -	$ -
			$ -	$ -	$ -	$ -
2015	$ 164,412	$ -	$ -	$ -	$ -	$ -
2016	$ 167,433	$ -	$ -	$ -	$ -	$ -
2017	$ 170,454	$ -	$ -	$ -	$ -	$ -
2018	$ 173,476	$ 65,600	$ -	$ 107,876	$ -	$ 107,876
2019	$ 176,497	$ 66,731	$ -	$ 109,766	$ -	$ 107,931
2020	$ 179,518	$ 67,861	$ -	$ 111,657	$ -	$ 107,955
2021	$ 182,539	$ 68,992	$ -	$ 113,547	$ -	$ 107,948
2022	$ 185,561	$ 70,123	$ -	$ 115,438	$ -	$ 107,911
2023	$ 188,582	$ 71,254	$ -	$ 117,328	$ -	$ 107,844
2024	$ 191,603	$ 72,384	$ -	$ 119,219	$ -	$ 107,750
2025	$ 194,624	$ 73,515	$ -	$ 121,109	$ -	$ 107,629
2026	$ 197,646	$ 74,646	$ -	$ 123,000	$ -	$ 107,482
2027	$ 200,667	$ 75,777	$ -	$ 124,890	$ -	$ 107,310
2028	$ 203,688	$ 76,907	$ -	$ 126,781	$ -	$ 107,113
2029	$ 206,709	$ 78,038	$ -	$ 128,671	$ -	$ 106,893
2030	$ 209,731	$ 79,169	$ -	$ 130,562	$ -	$ 106,651
2031	$ 212,752	$ 80,300	$ -	$ 132,452	$ -	$ 106,387
2032	$ 215,773	$ 81,430	$ -	$ 134,343	$ -	$ 106,101
2033	$ 218,794	$ 82,561	$ -	$ 136,233	$ -	$ 105,796
2034	$ 221,816	$ 83,692	$ -	$ 138,124	$ -	$ 105,471
2035	$ 224,837	$ 84,823	$ -	$ 140,014	$ -	$ 105,127
2036	$ 227,858	$ 85,953	$ -	$ 141,905	$ -	$ 104,766
2037	$ 230,879	$ 87,084	$ -	$ 143,795	$ -	$ 104,387
2038	$ 233,901	$ 88,215	$ -	$ 145,686	$ -	$ 103,992
	$ 4,779,751	**$ 1,615,055**	**$ -**	**$ 2,662,397**	**$ -**	**$ 2,240,322**

Appendix F:
Preliminary Construction Cost Estimate

ESTIMATED QUANTITIES TABULATION - ROADWAY CONSTRUCTION ELEMENTS

ITEM NO.	DESCRIPTION		UNITS	ALTERNATIVE 2	ALTERNATIVE 4	ALTERNATIVE 4A	ALTERNATIVE 7 - ROUNDABOUT	UNIT COST	ALTERNATIVE 2	ALTERNATIVE 4	ALTERNATIVE 4A	ALTERNATIVE 7 - ROUNDABOUT
	PROPOSED RIGHT OF WAY	(14)	SQ FT			54,355	6,256					
2106.501	EXCAVATION - COMMON	(EV) (P)	CU YD	1,232	1,232	2,570	3,811	$6.00	$7,393.14	$7,393.14	$15,422.42	$22,868.22
2106.507	EXCAVATION - SUBGRADE	(EV) (P)	CU YD	5,377	5,377	11,216	16,631	$8.00	$43,014.65	$43,014.65	$89,730.47	$133,051.47
2106.521	GRANULAR EMBANKMENT (CV)	'(3)	CU YD	2,688	2,688	5,608	8,316	$5.00	$13,442.08	$13,442.08	$28,040.77	$41,578.59
2106.607	SELECT GRANULAR EMBANKMENT (CV)	(3)	CU YD	2,688	2,688	5,608	8,316	$14.00	$37,637.82	$37,637.82	$78,514.16	$116,420.04
2211.503	AGGREGATE BASE (CV) CLASS 5	(4)	CU YD	672	672	1,402	2,189	$25.00	$16,802.60	$16,802.60	$35,050.96	$54,719.19
2231.604	BITUMINOUS PATCH SPECIAL	(13)	SQ YD				19	$52.00	$0.00	$0.00	$0.00	$1,006.35
2301.504	CONCRETE PAVEMENT 8"	(8)	SQ YD				258	$32.00	$0.00	$0.00	$0.00	$8,256.00
2357.502	BITUMINOUS MATERIAL FOR TACK COAT	(2)	GALLON	121	121	206	528	$3.00	$362.94	$362.94	$618.65	$1,584.82
2360.501	TYPE SP 12.5 WEARING COURSE MIXTURE (3,C)	(1)	TON	1,139	1,139	1,942	2,487	$65.00	$74,049.04	$74,049.04	$126,222.55	$161,673.50
2503.541	18" RC PIPE SEWER DES 3006 CL III	(6)	LIN FT			1,116	2,634	$40.00	$0.00	$0.00	$44,640.00	$105,340.00
2503.541	36" RC PIPE SEWER DES 3006 CL III	(5)	LIN FT			1,116	2,634	$80.00	$0.00	$0.00	$89,280.00	$210,680.00
2506.502	CONSTRUCT DRAINAGE STRUCTURE DESIGN 48-4020	(7)	EACH			6	13	$2,500.00	$0.00	$0.00	$13,950.00	$32,918.75
2521.501	4" CONCRETE WALK	(9)	SQ FT	1,510	1,510	15,287	4,013	$4.00	$6,038.61	$6,038.61	$61,146.43	$16,052.00
2521.501	6" CONCRETE WALK	(10)	SQ FT	120	120	120	6,418	$5.00	$600.00	$600.00	$600.00	$32,090.00
2531.501	CONCRETE CURB & GUTTER DESIGN B624		LIN FT	30	30	2232	4,840	$15.00	$450.00	$450.00	$33,480.00	$72,600.00
2531.501	CONCRETE CURB & GUTTER DESIGN S524		LIN FT				251	$17.00	$0.00	$0.00	$0.00	$4,267.00
2531.502	CONCRETE CURB DESIGN B6		LIN FT				176	$19.00	$0.00	$0.00	$0.00	$3,344.00
2531.507	6" CONCRETE DRIVEWAY PAVEMENT	(12)	SQ YD				73	$52.00	$0.00	$0.00	$0.00	$3,796.00
2531.507	8" CONCRETE DRIVEWAY PAVEMENT	(11)	SQ YD	332	332	332	77	$58.00	$19,256.00	$19,256.00	$19,256.00	$4,466.00
2531.618	TRUNCATED DOMES		SQ FT	30	30	30	96	$45.00	$1,350.00	$1,350.00	$1,350.00	$4,320.00
2565.616	TRAFFIC SIGNAL SYSTEM		LS		1	1		$300,000.00	$0.00	$300,000.00	$300,000.00	$0.00
	LANDSCAPING		LS				1	$50,000.00	$0.00	$0.00	$0.00	$50,000.00
	LIGHTING SYSTEM		LS				1	$30,000.00	$0.00	$0.00	$0.00	$30,000.00
								SUBTOTAL	$220,396.87	$520,396.87	$937,302.41	$1,397,301.89
2021.501	MOBILIZATION		LUMP SUM	1	1	1	1	5%	*$11,019.84*	*$26,019.84*	*$46,865.12*	*$69,865.09*
2563.601	TRAFFIC CONTROL		LUMP SUM	1	1	1	1	10%	*$22,039.69*	*$52,039.69*	*$93,730.24*	*$139,730.19*
	RIGHT OF WAY/EASEMENT		LUMP SUM					2%	*$4,407.94*	*$10,407.94*	*$18,746.05*	*$27,946.04*
	PAVEMENT MARKINGS AND SIGNING		LUMP SUM	1	1	1	1	3%	*$6,611.91*	*$15,611.91*	*$28,119.07*	*$41,919.06*
	CONTIGENCY		LUMP SUM	1	1	1	1	20%	*$44,079.37*	*$104,079.37*	*$187,460.48*	*$279,460.38*
								CONSTRUCTION COST	**$308,555.61**	**$728,555.61**	**$1,312,223.37**	**$1,956,222.65**
	RIGHT OF WAY		**ACRE**	**0.00**	**0.00**	**1.25**	**0.14**	**$ 5,000.00**	**$0.00**	**$0.00**	**$6,239.10**	**$718.14**
								GRAND TOTAL	**$308,555.61**	**$728,555.61**	**$1,318,462.47**	**$1,956,940.79**

BASIS OF QUANTITIES:
(1) Pavement section was assumed to be 5" of bituminous wear course, place as two 1.5" lifts and a 2.0" final lift for the roadways. Density was assumed to be 113 lbs/sq in. Assumed shoulder and turn lane sections are the same as mainline section.
(2) Application of tack coat assumed to be 0.03 gallons per square yard.
(3) Layer assumed to be 24" in depth for roadway area only.
(4) Layer assumed to be 6" in depth.
(5) Size assumed to be 36" for trunk. Length was assumed to be half the curb & gutter quantity.
(6) Size assumed to be 18" for lateral crossings. Length was assumed to be half of the curb & gutter quantity.
(7) Number of structures estimated based on 400' spacing along curb & gutter quantity.
(8) Assumed pay item for concrete truck apron.
(9) 4" Concrete Walk item used for sidewalk along north side of C.S.A.H. 15.
(10) 6" Concrete Walk item used for initial pedestrian ramp and landing area and raised roundabout splitter islands.
(11) 8" Concrete Driveway Pavement item used for commercial driveways.
(12) 6" Concrete Driveway Pavement item used for residential driveways.

Appendix G:
Benefit to Cost Analysis

Benefit Cost Assumptions

Analysis Timeframe		
Existing Year		2015
Duration of Benefit Cost Analysis (years)		17
Year of Opening		2018
Design Year		2038
Days Per Year		365.25

Crash Costs		
Fatal Type K	$	1,140,000
Injury Type A	$	570,000
Injury Type B	$	170,000
Injury Type C	$	83,000
Property Damage Only	$	7,600

Time Costs		
Vehicles Miles of Travel (Auto)	$	17.00
Vehicles Miles of Travel (Truck)	$	27.90

Vehicle Occupancy	
All Auto Trips (7 County Metro Area - Daily)	1.35
Percentage Auto	93%
Percentage Trucks	7%

Traffic Control Device		
Average Annual Maintenance/Operation Cost of Traffic Signal	$	2,500.00

Component Service Life	Years	20 Year Analysis Capital Value Factor
Preliminary Engineering	0	0.00
Right of Way	100	0.91
Major Structures (Bridges)	60	0.77
Roadway	30	0.39
Traffic Signals / Lighting	30	0.39

Depreciation	
Discount Rate	1.7%

Source: MnDOT Office of Investment Management, Cost Benefit Analysis for Transportation Projects, Appendix A, FY2014 Standard Values.

TH 71 & CR 15/Industrial Park Road --- Benefit / Cost Analysis for Alternative 2- Two-Stop - 2038 Forecast

BASE 2015	Total
DELAY (Stop)	3,375

2038 No Improvement	Total	2018 No Improvement	Total
DELAY (Stop)	12,103	DELAY (Stop)	4,233

2038 Improvement	Total	2018 Improvement	Total
DELAY (Alt)	9,797	DELAY (Alt)	3,804

2038 Changes:	Total	
DELAY	(2,305)	-19.0%

	COST ITEM				
	1	2	3	4	5
Category	Roadway	Bridge	Traffic Signal Lighting	Contingency Construciton Costs	ROW
Capital Value ($)	264,476	$0	$0	$ 44,079	$0
Remaining Life (%)-20yr	39%	77%	39%	39%	91%
Remaining Life (%)-5yr	0%	0%	0%	0%	0%
Remaining Cap. Value	$ 103,146	$ -	$ -	$ 17,191	$ -

Note: Assume Expected Life of 30 Years. Analysis Period is 20 years (assume 20 year capital value, remaining life values).

B/C Analysis Summary

BENEFITS		Value(Discounted)
1. Travel Time Savings:	$	508,545
TOTAL	$	508,545

COSTS		Value(Discounted)
1. Roadway/Interchange	$	282,924
2. Bridges	$	-
3. Traffic Signal/Lighting	$	-
4. Contingency Costs	$	47,154
5. Right-of-way (ROW)	$	-
Remaining Capital	$	88,842
TOTAL	$	241,236

Benefit/Cost Analysis Results		
20-Yr Operation Benefit	$	508,545
20-Yr Safety Benefit	$	694,089
COSTS	$	241,236
B/C Ratio*:		4.985

Cost Category	Improvement Description	Estimated NA	Estimated Layout (Alt 2)	Estimated NA
1		$0	$0	$0
1	Ramps/Interchange	$0	$0	$0
1	Roadway Paving	$0	$264,476	$0
2	Bridge	$0	$0	$0
2				
3	Traffic Signal/Lighting	$0	$0	$0
4				
4				
	Total Estimated Construction Co	$0	$264,476	$0
4	Indirect Costs & Contingency	$0	$44,079	$0
5	Right-of-Way/Easement Costs	$0	$0	$0
4	Urban Enhancements	$0	$0	$0
	Total Project Costs	$0	$308,555	$0

BENEFIT 1: Travel Time Savings (VHT)

	YEAR	Daily 2038 No Improvement	Daily 2038 Improvement	Annualized Savings Improvement w/ VHT Savings	Annualized Savings '00 cost per hour* $ 17.00	Discounted Value (1.7%)
ay Stop	2012	-	-	-	-	-
	2013	-	-	-	-	-
	2014	-	-	-	-	-
	2015	3,375	3,375	-	-	-
	2016	3,661	3,661	-	-	-
	2017	3,947	3,947	-	-	-
	2018	4,233	3,804	429	9,997	9,345
	2019	4,626	4,103	523	12,182	11,197
	2020	5,020	4,403	617	14,367	12,985
	2021	5,413	4,703	711	16,553	14,711
	2022	5,807	5,002	804	18,738	16,374
	2023	6,200	5,302	898	20,924	17,978
	2024	6,594	5,602	992	23,109	19,524
	2025	6,987	5,902	1,086	25,295	21,014
	2026	7,381	6,201	1,180	27,480	22,447
	2027	7,774	6,501	1,273	29,666	23,828
	2028	8,168	6,801	1,367	31,851	25,155
	2029	8,561	7,100	1,461	34,036	26,432
	2030	8,955	7,400	1,555	36,222	27,659
	2031	9,348	7,700	1,649	38,407	28,838
	2032	9,742	7,999	1,742	40,593	29,969
	2033	10,135	8,299	1,836	42,778	31,055
	2034	10,529	8,599	1,930	44,964	32,095
	2035	10,922	8,898	2,024	47,149	33,093
	2036	11,316	9,198	2,118	49,335	34,048
	2037	11,709	9,498	2,211	51,520	34,962
	2038	12,103	9,797	2,305	53,706	35,836
	2039	-	-	-	-	-
	TOTAL				$ 668,872	$ 508,545

Note: Trucks on average account for approximately 7% of network traffic . Passenger vehicle occupancy assumed to be 1.35

MnDOT Office of Investment Management, Benefit Cost Analysis Trucks (Value of Time) $ 27.90

COST 1: Roadways/Interchange Construction

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	-	-
2016	$ -	-
2017	$ -	-
2018	$ (264,476)	(282,924)
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ (264,476)	$ (282,924)

COST 2: Bridge

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ -	-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ -	$ -

Standard Values, Appendix A, Fiscal Year 2015

COST 3: Traffic Signal / Maintenance & Operation

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ -	-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ -	$ -

COST 4: Contingency Construction Costs

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ (44,079)	(47,154)
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ (44,079)	$ (47,154)

COST 5: Right of Way (ROW)

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ -	-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ -	$ -

Note: Assume operation, power and maintenance cost of the traffic signal and lighting system to be $1,000 per year.

Remaining Capital Value

YEAR	Remaining Capital Value	Discounted Value (1.7%)
2012	$ -	-
2013	$ -	-
2014	$ -	-
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ -	-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ 120,336	88,842
TOTAL	$ 120,336	$ 88,842

S:\2015\150116\COST-BEN\[ALT 2_Two-Way Stop.xls]Two-Way Stop

TH 71 & CR 15/Industrial Park Road --- Benefit / Cost Analysis for Alternative 2a- Two-Stop with Raised Median- 2038 Forecast

BASE 2015	Total
DELAY (Stop)	3,375

2038 No Improvement	Total	2018 No Improvement	Total
DELAY (Stop)	12,103	DELAY (Stop)	4,233

2038 Improvement	Total	2018 Improvement	Total
DELAY (Alt)	9,797	DELAY (Alt)	3,804

2038 Changes:	Total	
DELAY	(2,305)	-19.0%

	COST ITEM				
	1	2	3	4	5
Category	Roadway	Bridge	Traffic Signal Lighting	Contingency Construciton Costs	ROW
Capital Value ($)	764,763	$0	$0	$ 127,460	$6,239
Remaining Life (%)-20yr	39%	77%	39%	39%	91%
Remaining Life (%)-5yr	0%	0%	0%	0%	0%
Remaining Cap. Value	$ 298,258	$ -	$ -	$ 49,710	$ 5,678

Note: Assume Expected Life of 30 Years. Analysis Period is 20 years (assume 20 year capital value, remaining life values).

B/C Analysis Summary

BENEFITS		Value(Discounted)
1. Travel Time Savings:	$	508,545
TOTAL	$	508,545

COSTS		Value(Discounted)
1. Roadway/Interchange	$	818,108
2. Bridges	$	-
3. Traffic Signal/Lighting	$	-
4. Contingency Costs	$	136,351
5. Right-of-way (ROW)	$	6,674
Remaining Capital	$	261,090
TOTAL	$	700,044

Benefit/Cost Analysis Results		
20-Yr Operation Benefit	$	508,545
20-Yr Safety Benefit	$	922,294
COSTS	$	700,044
B/C Ratio*:		2.044

Cost Category	Improvement Description	Estimated NA	Estimated Layout (Alt 2a)	Estimated NA
1		$0	$0	$0
1	Ramps/Interchange	$0	$0	$0
1	Roadway Paving	$0	$764,763	$0
2	Bridge	$0	$0	$0
2				
3	Traffic Signal/Lighting	$0	$0	$0
4				
4				
	Total Estimated Construction Co	$0	$764,763	$0
4	Indirect Costs & Contingency	$0	$127,460	$0
5	Right-of-Way/Easement Costs	$0	$6,239	$0
4	Urban Enhancements	$0	$0	$0
	Total Project Costs	$0	$898,462	$0

BENEFIT 1: Travel Time Savings (VHT)

	Daily		Annualized Savings		
YEAR	2038 No Improvement	2038 Improvement	Improvement w/ VHT Savings	'00 cost per hour* $ 17.00	Discounted Value (1.7%)
2012	-	-	-	-	-
2013	-	-	-	-	-
2014	-	-	-	-	-
2015	3,375	3,375	-	-	-
2016	3,661	3,661	-	-	-
2017	3,947	3,947	-	-	-
2018	4,233	3,804	429	9,997	9,345
2019	4,626	4,103	523	12,182	11,197
2020	5,020	4,403	617	14,367	12,985
2021	5,413	4,703	711	16,553	14,711
2022	5,807	5,002	804	18,738	16,374
2023	6,200	5,302	898	20,924	17,978
2024	6,594	5,602	992	23,109	19,524
2025	6,987	5,902	1,086	25,295	21,014
2026	7,381	6,201	1,180	27,480	22,447
2027	7,774	6,501	1,273	29,666	23,828
2028	8,168	6,801	1,367	31,851	25,155
2029	8,561	7,100	1,461	34,036	26,432
2030	8,955	7,400	1,555	36,222	27,659
2031	9,348	7,700	1,649	38,407	28,838
2032	9,742	7,999	1,742	40,593	29,969
2033	10,135	8,299	1,836	42,778	31,055
2034	10,529	8,599	1,930	44,964	32,095
2035	10,922	8,898	2,024	47,149	33,093
2036	11,316	9,198	2,118	49,335	34,048
2037	11,709	9,498	2,211	51,520	34,962
2038	12,103	9,797	2,305	53,706	35,836
2039	-	-	-	-	-
TOTAL				$ 668,872	$ 508,545

Note: Trucks on average account for approximately 7% of network traffic . Passenger vehicle occupancy assumed to be 1.35

COST 1: Roadways/Interchange Construction

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	-	-
2016	$ -	-
2017	$ -	-
2018	$ (764,763)	(818,108)
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ (764,763)	$ (818,108)

COST 2: Bridge

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ -	-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ -	$ -

Trucks (Value of Time) $ 27.90

Standard Values, Appendix A, Fiscal Year 2015

COST 3: Traffic Signal / Maintenance & Operation

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ -	-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ -	$ -

COST 4: Contingency Construction Costs

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ (127,460)	(136,351)
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ (127,460)	$ (136,351)

COST 5: Right of Way (ROW)

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ (6,239)	(6,674)
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ (6,239)	$ (6,674)

Note: Assume operation, power and maintenance cost of the traffic signal and lighting system to be $1,000 per year.

Remaining Capital Value

YEAR	Remaining Capital Value	Discounted Value (1.7%)
2012	$ -	-
2013	$ -	-
2014	$ -	-
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ -	-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ 353,645	261,090
TOTAL	$ 353,645	$ 261,090

S:\2015\150116\COST-BEN\[ALT 2a_Two-Way Stop.xls]Two-Way Stop with Median

TH 71 & CR 15/Industrial Park Road --- Benefit / Cost Analysis for Alternative 4 - Signalized Intersection - 2038 Forecast

BASE 2015	Total
DELAY (Stop)	3,375

2038 No Improvement	Total	2018 No Improvement	Total
DELAY (Stop)	12,103	DELAY (Stop)	4,233

2038 Improvement	Total	2018 Improvement	Total
DELAY (Alt)	14,925	DELAY (Alt)	8,153

2038 Changes:	Total	
DELAY	2,822	23.3%

	COST ITEM				
	1	2	3	4	5
Category	Roadway	Bridge	Traffic Signal Lighting	Contingency Construciton Costs	ROW
Capital Value ($)	324,476	$0	$300,000	$ 104,079	$0
Remaining Life (%)-20yr	39%	77%	39%	39%	91%
Remaining Life (%)-5yr	0%	0%	0%	0%	0%
Remaining Cap. Value	$ 126,546	$ -	$ 117,000	$ 40,591	$ -

Note: Assume Expected Life of 30 Years. Analysis Period is 20 years (assume 20 year capital value, remaining life values).

B/C Analysis Summary

BENEFITS		Value(Discounted)
1. Travel Time Savings:	$	(1,322,461)
TOTAL	$	(1,322,461)

COSTS		Value(Discounted)
1. Roadway/Interchange	$	347,109
2. Bridges	$	-
3. Traffic Signal/Lighting	$	385,073
4. Contingency Costs	$	111,339
5. Right-of-way (ROW)	$	-
Remaining Capital	$	209,773
TOTAL	$	633,748

Benefit/Cost Analysis Results		
20-Yr Operation Benefit	$	(1,322,461)
20-Yr Safety Benefit	$	1,602,189
COSTS	$	633,748
B/C Ratio*:		0.441

Cost Category	Improvement Description	Estimated NA	Estimated Layout (Alt 4)	Estimated NA
1		$0	$0	$0
1	Ramps/Interchange	$0	$0	$0
1	Roadway Paving	$0	$324,476	$0
2	Bridge	$0	$0	$0
2				
3	Traffic Signal/Lighting	$0	$300,000	$0
4				
4				
	Total Estimated Construction Co	$0	$624,476	$0
4	Indirect Costs & Contingency	$0	$104,079	$0
5	Right-of-Way/Easement Costs	$0	$0	$0
4	Urban Enhancements	$0	$0	$0
	Total Project Costs	$0	$728,555	$0

BENEFIT 1: Travel Time Savings (VHT)

	Daily		Annualized Savings		
YEAR	2038 No Improvement	2038 Improvement	Improvement w/ VHT Savings	'00 cost per hour* $ 17.00	Discounted Value (1.7%)
2012	-	-	-	-	-
2013	-	-	-	-	-
2014	-	-	-	-	-
2015	3,375	3,375	-	-	-
2016	3,661	3,661	-	-	-
2017	3,947	3,947	-	-	-
2018	4,233	8,153	(3,920)	(91,326)	(85,371)
2019	4,626	8,492	(3,865)	(90,046)	(82,768)
2020	5,020	8,830	(3,810)	(88,767)	(80,228)
2021	5,413	9,169	(3,755)	(87,488)	(77,750)
2022	5,807	9,507	(3,701)	(86,209)	(75,333)
2023	6,200	9,846	(3,646)	(84,930)	(72,974)
2024	6,594	10,184	(3,591)	(83,650)	(70,674)
2025	6,987	10,523	(3,536)	(82,371)	(68,430)
2026	7,381	10,862	(3,481)	(81,092)	(66,241)
2027	7,774	11,200	(3,426)	(79,813)	(64,106)
2028	8,168	11,539	(3,371)	(78,534)	(62,024)
2029	8,561	11,877	(3,316)	(77,254)	(59,994)
2030	8,955	12,216	(3,261)	(75,975)	(58,014)
2031	9,348	12,555	(3,206)	(74,696)	(56,084)
2032	9,742	12,893	(3,151)	(73,417)	(54,202)
2033	10,135	13,232	(3,096)	(72,138)	(52,368)
2034	10,529	13,570	(3,042)	(70,858)	(50,579)
2035	10,922	13,909	(2,987)	(69,579)	(48,836)
2036	11,316	14,248	(2,932)	(68,300)	(47,137)
2037	11,709	14,586	(2,877)	(67,021)	(45,481)
2038	12,103	14,925	(2,822)	(65,742)	(43,867)
2039	-	-	-	-	-
TOTAL				$ (1,649,205)	$ (1,322,461)

Note: Trucks on average account for approximately 7% of network traffic . Passenger vehicle occupancy assumed to be 1.35

MnDOT Office of Investment Management, Benefit Cost Analysis Trucks (Value of Time) $ 27.90

COST 1: Roadways/Interchange Construction

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	-	-
2016	$ -	-
2017	$ -	-
2018	$ (324,476)	(347,109)
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ (324,476)	$ (347,109)

COST 2: Bridge

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ -	-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ -	$ -

Standard Values, Appendix A, Fiscal Year 2015

COST 3: Traffic Signal / Maintenance & Operation

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ (300,000)	(320,926)
2019	$ (2,500)	(2,720)
2020	$ (2,500)	(2,766)
2021	$ (2,500)	(2,813)
2022	$ (2,500)	(2,861)
2023	$ (2,500)	(2,910)
2024	$ (2,500)	(2,959)
2025	$ (2,500)	(3,009)
2026	$ (2,500)	(3,060)
2027	$ (2,500)	(3,113)
2028	$ (2,500)	(3,165)
2029	$ (2,500)	(3,219)
2030	$ (2,500)	(3,274)
2031	$ (2,500)	(3,330)
2032	$ (2,500)	(3,386)
2033	$ (2,500)	(3,444)
2034	$ (2,500)	(3,502)
2035	$ (2,500)	(3,562)
2036	$ (2,500)	(3,622)
2037	$ (2,500)	(3,684)
2038	$ (2,500)	(3,747)
2039	$ -	-
TOTAL	$ (350,000)	$ (385,073)

COST 4: Contingency Construction Costs

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ (104,079)	(111,339)
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ (104,079)	$ (111,339)

COST 5: Right of Way (ROW)

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ -	-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ -	$ -

Remaining Capital Value

YEAR	Remaining Capital Value	Discounted Value (1.7%)
2012	$ -	-
2013	$ -	-
2014	$ -	-
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ -	-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ 284,136	209,773
TOTAL	$ 284,136	$ 209,773

Note: Assume operation, power and maintenance cost of the traffic signal and lighting system to be $1,000 per year.

S:\2015\150116\COST-BEN\[ALT 4_Signalized Intersection.xls]Signalized Intersection

TH 71 & CR 15/Industrial Park Road --- Benefit / Cost Analysis for Alternative 4 - 2029 Install Signalized Intersection - 2038 Forecast

BASE 2015	Total
DELAY (Stop)	3,375

2038 No Improvement	Total	2018 No Improvement	Total
DELAY (Stop)	12,103	DELAY (Stop)	4,233

2038 Improvement	Total	2029 Improvement	Total
DELAY (Alt)	14,925	DELAY (Alt)	11,735

2038 Changes:	Total	
DELAY	2,822	23.3%

	COST ITEM				
	1	2	3	4	5
Category	Roadway	Bridge	Traffic Signal Lighting	Contingency Construciton Costs	ROW
Capital Value ($)	324,476	$0	$300,000	$ 104,079	$0
Remaining Life (%)-20yr	39%	77%	39%	39%	91%
Remaining Life (%)-5yr	0%	0%	0%	0%	0%
Remaining Cap. Value	$ 126,546	$ -	$ 117,000	$ 40,591	$ -

Note: Assume Expected Life of 30 Years. Analysis Period is 20 years (assume 20 year capital value, remaining life values).

B/C Analysis Summary

BENEFITS		Value(Discounted)
1. Travel Time Savings:	$	(309,685)
TOTAL	$	(309,685)

COSTS		Value(Discounted)
1. Roadway/Interchange	$	347,109
2. Bridges	$	-
3. Traffic Signal/Lighting	$	417,861
4. Contingency Costs	$	111,339
5. Right-of-way (ROW)	$	-
Remaining Capital	$	209,773
TOTAL	$	666,536

Benefit/Cost Analysis Results		
20-Yr Operation Benefit	$	(309,685)
20-Yr Safety Benefit	$	1,111,923
COSTS	$	666,536
B/C Ratio*:		1.204

Cost Category	Improvement Description	Estimated NA	Estimated Layout (Alt 4)	Estimated NA
1		$0	$0	$0
1	Ramps/Interchange	$0	$0	$0
1	Roadway Paving	$0	$324,476	$0
2	Bridge	$0	$0	$0
2				
3	Traffic Signal/Lighting	$0	$300,000	$0
4				
4				
	Total Estimated Construction Co	$0	$624,476	$0
4	Indirect Costs & Contingency	$0	$104,079	$0
5	Right-of-Way/Easement Costs	$0	$0	$0
4	Urban Enhancements	$0	$0	$0
	Total Project Costs	$0	$728,555	$0

BENEFIT 1: Travel Time Savings (VHT)

YEAR	Daily 2038 No Improvement	Daily 2038 Improvement	Annualized Savings Improvement w/ VHT Savings	Annualized Savings '00 cost per hour* $ 17.00	Discounted Value (1.7%)
2012	-	-	-	-	-
2013	-	-	-	-	-
2014	-	-	-	-	-
2015	3,375	3,375	-	-	-
2016	3,661	3,661	-	-	-
2017	3,947	3,947	-	-	-
2018	4,233	3,804	429	9,997	9,345
2019	4,626	4,103	523	12,182	11,197
2020	5,020	4,403	617	14,367	12,985
2021	5,413	4,703	711	16,553	14,711
2022	5,807	5,002	804	18,738	16,374
2023	6,200	5,302	898	20,924	17,978
2024	6,594	5,602	992	23,109	19,524
2025	6,987	5,902	1,086	25,295	21,014
2026	7,381	6,201	1,180	27,480	22,447
2027	7,774	6,501	1,273	29,666	23,828
2028	8,168	6,801	1,367	31,851	25,155
2029	8,561	11,735	(3,174)	(73,938)	(57,419)
2030	8,955	12,089	(3,135)	(73,028)	(55,764)
2031	9,348	12,444	(3,096)	(72,117)	(54,148)
2032	9,742	12,798	(3,057)	(71,206)	(52,570)
2033	10,135	13,153	(3,017)	(70,295)	(51,030)
2034	10,529	13,507	(2,978)	(69,385)	(49,527)
2035	10,922	13,861	(2,939)	(68,474)	(48,060)
2036	11,316	14,216	(2,900)	(67,563)	(46,628)
2037	11,709	14,570	(2,861)	(66,652)	(45,231)
2038	12,103	14,925	(2,822)	(65,742)	(43,867)
2039	-	-	-	-	-
TOTAL				$ (468,238)	$ (309,685)

Note: Trucks on average account for approximately 7% of network traffic . Passenger vehicle occupancy assumed to be 1.35

MnDOT Office of Investment Management, Benefit Cost Analysis Trucks (Value of Time) $ 27.90

COST 1: Roadways/Interchange Construction

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	-	-
2016	$ -	-
2017	$ -	-
2018	$ (324,476)	(347,109)
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ (324,476)	$ (347,109)

COST 2: Bridge

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ -	-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ -	$ -

Standard Values, Appendix A, Fiscal Year 2015

COST 3: Traffic Signal / Maintenance & Operation

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ -	-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ (300,000)	(386,310)
2030	$ (2,500)	(3,274)
2031	$ (2,500)	(3,330)
2032	$ (2,500)	(3,386)
2033	$ (2,500)	(3,444)
2034	$ (2,500)	(3,502)
2035	$ (2,500)	(3,562)
2036	$ (2,500)	(3,622)
2037	$ (2,500)	(3,684)
2038	$ (2,500)	(3,747)
2039	$ -	-
TOTAL	$ (322,500)	$ (417,861)

COST 4: Contingency Construction Costs

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ (104,079)	(111,339)
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ (104,079)	$ (111,339)

COST 5: Right of Way (ROW)

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ -	-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ -	$ -

Note: Assume operation, power and maintenance cost of the traffic signal and lighting system to be $1,000 per year.

Remaining Capital Value

YEAR	Remaining Capital Value	Discounted Value (1.7%)
2012	$ -	-
2013	$ -	-
2014	$ -	-
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ -	-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ 284,136	209,773
TOTAL	$ 284,136	$ 209,773

S:\2015\150116\COST-BEN\[ALT 4_2029 Install_Signalized Intersection.xls]Signalized Intersection

TH 71 & CR 15/Industrial Park Road --- Benefit / Cost Analysis for Alternative 4a - Signalized Intersection - 2038 Forecast

BASE 2015	Total
DELAY (Stop)	3,375

2038 No Improvement	Total	2018 No Improvement	Total
DELAY (Stop)	12,103	DELAY (Stop)	4,233

2038 Improvement	Total	2018 Improvement	Total
DELAY (Alt)	14,925	DELAY (Alt)	8,153

2038 Changes:	Total	
DELAY	2,822	23.3%

	COST ITEM				
	1	2	3	4	5
Category	Roadway	Bridge	Traffic Signal Lighting	Contingency Construciton Costs	ROW
Capital Value ($)	824,763	$0	$300,000	$ 187,460	$6,239
Remaining Life (%)-20yr	39%	77%	39%	39%	91%
Remaining Life (%)-5yr	0%	0%	0%	0%	0%
Remaining Cap. Value	$ 321,658	$ -	$ 117,000	$ 73,109	$ 5,677

Note: Assume Expected Life of 30 Years. Analysis Period is 20 years (assume 20 year capital value, remaining life values).

B/C Analysis Summary

BENEFITS		Value(Discounted)
1. Travel Time Savings:	$	(1,322,461)
TOTAL	$	(1,322,461)

COSTS		Value(Discounted)
1. Roadway/Interchange	$	882,293
2. Bridges	$	-
3. Traffic Signal/Lighting	$	385,073
4. Contingency Costs	$	200,536
5. Right-of-way (ROW)	$	6,674
Remaining Capital	$	382,020
TOTAL	$	1,092,556

Benefit/Cost Analysis Results		
20-Yr Operation Benefit	$	(1,322,461)
20-Yr Safety Benefit	$	1,759,372
COSTS	$	1,092,556
B/C Ratio*:		0.400

Cost Category	Improvement Description	Estimated NA	Estimated Layout (Alt 4a)	Estimated NA
1		$0	$0	$0
1	Ramps/Interchange	$0	$0	$0
1	Roadway Paving	$0	$824,763	$0
2	Bridge	$0	$0	$0
2				
3	Traffic Signal/Lighting	$0	$300,000	$0
4				
4				
	Total Estimated Construction Co	$0	$1,124,763	$0
4	Indirect Costs & Contingency	$0	$187,460	$0
5	Right-of-Way/Easement Costs	$0	$6,239	$0
4	Urban Enhancements	$0	$0	$0
	Total Project Costs	$0	$1,318,462	$0

BENEFIT 1: Travel Time Savings (VHT)

	Daily		Annualized Savings		
YEAR	2038 No Improvement	2038 Improvement	Improvement w/ VHT Savings	'00 cost per hour* $ 17.00	Discounted Value (1.7%)
2012	-	-	-	-	-
2013	-	-	-	-	-
2014	-	-	-	-	-
2015	3,375	3,375	-	-	-
2016	3,661	3,661	-	-	-
2017	3,947	3,947	-	-	-
2018	4,233	8,153	(3,920)	(91,326)	(85,371)
2019	4,626	8,492	(3,865)	(90,046)	(82,768)
2020	5,020	8,830	(3,810)	(88,767)	(80,228)
2021	5,413	9,169	(3,755)	(87,488)	(77,750)
2022	5,807	9,507	(3,701)	(86,209)	(75,333)
2023	6,200	9,846	(3,646)	(84,930)	(72,974)
2024	6,594	10,184	(3,591)	(83,650)	(70,674)
2025	6,987	10,523	(3,536)	(82,371)	(68,430)
2026	7,381	10,862	(3,481)	(81,092)	(66,241)
2027	7,774	11,200	(3,426)	(79,813)	(64,106)
2028	8,168	11,539	(3,371)	(78,534)	(62,024)
2029	8,561	11,877	(3,316)	(77,254)	(59,994)
2030	8,955	12,216	(3,261)	(75,975)	(58,014)
2031	9,348	12,555	(3,206)	(74,696)	(56,084)
2032	9,742	12,893	(3,151)	(73,417)	(54,202)
2033	10,135	13,232	(3,096)	(72,138)	(52,368)
2034	10,529	13,570	(3,042)	(70,858)	(50,579)
2035	10,922	13,909	(2,987)	(69,579)	(48,836)
2036	11,316	14,248	(2,932)	(68,300)	(47,137)
2037	11,709	14,586	(2,877)	(67,021)	(45,481)
2038	12,103	14,925	(2,822)	(65,742)	(43,867)
2039	-	-	-	-	-
TOTAL				$ (1,649,205)	$ (1,322,461)

Note: Trucks on average account for approximately 7% of network traffic . Passenger vehicle occupancy assumed to be 1.35

MnDOT Office of Investment Management, Benefit Cost Analysis Trucks (Value of Time) $ 27.90

COST 1: Roadways/Interchange Construction

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	-	-
2016	$ -	-
2017	$ -	-
2018	$ (824,763)	(882,293)
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ (824,763)	$ (882,293)

COST 2: Bridge

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ -	-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ -	$ -

Standard Values, Appendix A, Fiscal Year 2015

COST 3: Traffic Signal / Maintenance & Operation

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ (300,000)	(320,926)
2019	$ (2,500)	(2,720)
2020	$ (2,500)	(2,766)
2021	$ (2,500)	(2,813)
2022	$ (2,500)	(2,861)
2023	$ (2,500)	(2,910)
2024	$ (2,500)	(2,959)
2025	$ (2,500)	(3,009)
2026	$ (2,500)	(3,060)
2027	$ (2,500)	(3,113)
2028	$ (2,500)	(3,165)
2029	$ (2,500)	(3,219)
2030	$ (2,500)	(3,274)
2031	$ (2,500)	(3,330)
2032	$ (2,500)	(3,386)
2033	$ (2,500)	(3,444)
2034	$ (2,500)	(3,502)
2035	$ (2,500)	(3,562)
2036	$ (2,500)	(3,622)
2037	$ (2,500)	(3,684)
2038	$ (2,500)	(3,747)
2039	$ -	-
TOTAL	$ (350,000)	$ (385,073)

COST 4: Contingency Construction Costs

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ (187,460)	(200,536)
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ (187,460)	$ (200,536)

COST 5: Right of Way (ROW)

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ (6,239)	(6,674)
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ (6,239)	$ (6,674)

Note: Assume operation, power and maintenance cost of the traffic signal and lighting system to be $1,000 per year.

Remaining Capital Value

YEAR	Remaining Capital Value	Discounted Value (1.7%)
2012	$ -	-
2013	$ -	-
2014	$ -	-
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ -	-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ 517,444	382,020
TOTAL	$ 517,444	$ 382,020

S:\2015\150116\COST-BEN\[ALT 4a__Signalized Intersection.xls]Signalized Intersection

TH 71 & CR 15/Industrial Park Road --- Benefit / Cost Analysis for Alternative 7 - Roundabout - 2038 Forecast

BASE 2015	Total
DELAY (Stop)	3,375

2038 No Improvement	Total	2018 No Improvement	Total
DELAY (Stop)	12,103	DELAY (Stop)	4,233

2038 Improvement	Total	2018 Improvement	Total
DELAY (Alt)	7,695	DELAY (Alt)	3,873

2038 Changes:	Total	
DELAY	(4,407)	-36.4%

	COST ITEM				
	1	2	3	4	5
Category	Roadway	Bridge	Traffic Signal Lighting	Contingency Construciton Costs	ROW
Capital Value ($)	1,676,762	$0	$0	$ 279,460	$718
Remaining Life (%)-20yr	39%	77%	39%	39%	91%
Remaining Life (%)-5yr	0%	0%	0%	0%	0%
Remaining Cap. Value	$ 653,937	$ -	$ -	$ 108,989	$ 653

Note: Assume Expected Life of 30 Years. Analysis Period is 20 years (assume 20 year capital value, remaining life values).

B/C Analysis Summary

BENEFITS		Value(Discounted)
1. Travel Time Savings:	$	877,336
TOTAL	$	877,336

COSTS		Value(Discounted)
1. Roadway/Interchange	$	1,793,722
2. Bridges	$	-
3. Traffic Signal/Lighting	$	-
4. Contingency Costs	$	298,953
5. Right-of-way (ROW)	$	768
Remaining Capital	$	563,738
TOTAL	$	1,529,706

Benefit/Cost Analysis Results		
20-Yr Operation Benefit	$	877,336
20-Yr Safety Benefit	$	2,240,322
COSTS	$	1,529,706
B/C Ratio*:		**2.038**

Cost Category	Improvement Description	Estimated NA	Estimated Layout (Alt 7)	Estimated NA
1		$0	$0	$0
1	Ramps/Interchange	$0	$0	$0
1	Roadway Paving	$0	$1,676,762	$0
2	Bridge	$0	$0	$0
2				
3	Traffic Signal/Lighting	$0	$0	$0
4				
4				
	Total Estimated Construction Co	$0	$1,676,762	$0
4	Indirect Costs & Contingency	$0	$279,460	$0
5	Right-of-Way/Easement Costs	$0	$718	$0
4	Urban Enhancements	$0	$0	$0
	Total Project Costs	$0	$1,956,940	$0

BENEFIT 1: Travel Time Savings (VHT)

YEAR	Daily 2038 No Improvement	Daily 2038 Improvement	Annualized Savings Improvement w/ VHT Savings	Annualized Savings '00 cost per hour* $ 17.00	Discounted Value (1.7%)
2012	-	-	-	-	-
2013	-	-	-	-	-
2014	-	-	-	-	-
2015	3,375	3,375	-	-	-
2016	3,661	3,661	-	-	-
2017	3,947	3,947	-	-	-
2018	4,233	3,873	360	8,385	7,838
2019	4,626	4,064	562	13,100	12,041
2020	5,020	4,255	765	17,814	16,101
2021	5,413	4,446	967	22,529	20,021
2022	5,807	4,637	1,169	27,244	23,807
2023	6,200	4,828	1,372	31,958	27,460
2024	6,594	5,020	1,574	36,673	30,984
2025	6,987	5,211	1,777	41,388	34,383
2026	7,381	5,402	1,979	46,102	37,659
2027	7,774	5,593	2,181	50,817	40,816
2028	8,168	5,784	2,384	55,532	43,858
2029	8,561	5,975	2,586	60,246	46,786
2030	8,955	6,166	2,788	64,961	49,604
2031	9,348	6,357	2,991	69,675	52,315
2032	9,742	6,549	3,193	74,390	54,921
2033	10,135	6,740	3,396	79,105	57,425
2034	10,529	6,931	3,598	83,819	59,831
2035	10,922	7,122	3,800	88,534	62,140
2036	11,316	7,313	4,003	93,249	64,355
2037	11,709	7,504	4,205	97,963	66,479
2038	12,103	7,695	4,407	102,678	68,513
2039	-	-	-	-	-
TOTAL				$ 1,166,162	$ 877,336

Note: Trucks on average account for approximately 7% of network traffic . Passenger vehicle occupancy assumed to be 1.35

MnDOT Office of Investment Management, Benefit Cost Analysis Trucks (Value of Time) $ 27.90

COST 1: Roadways/Interchange Construction

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	-	-
2016	$ -	-
2017	$ -	-
2018	$ (1,676,762)	(1,793,722)
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ (1,676,762)	$ (1,793,722)

COST 2: Bridge

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ -	-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ -	$ -

Standard Values, Appendix A, Fiscal Year 2015

COST 3: Traffic Signal / Maintenance & Operation

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ -	-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ -	$ -

COST 4: Contingency Construction Costs

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ (279,460)	(298,953)
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ (279,460)	$ (298,953)

COST 5: Right of Way (ROW)

YEAR	CHANGE with Improvement	Discounted Value (1.7%)
2012		
2013		
2014		
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ (718)	(768)
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ (718)	$ (768)

Note: Assume operation, power and maintenance cost of the traffic signal and lighting system to be $1,000 per year.

Remaining Capital Value

YEAR	Remaining Capital Value	Discounted Value (1.7%)
2012	$ -	-
2013	$ -	-
2014	$ -	-
2015	$ -	-
2016	$ -	-
2017	$ -	-
2018	$ -	-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ 763,580	563,738
TOTAL	$ 763,580	$ 563,738

S:\2015\150116\COST-BEN\[ALT 7_Roundabout.xls]Roundabout