CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road) Intersection Control Evaluation

Mankato, MN

Prepared For:

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Final Report
December 7, 2021

INTERSECTION CONTROL EVALUATION

for

CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road)

Mankato, Blue Earth County

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.

Scott C. Poska	47068	12/7/2021
	Reg. No.	Date

APPROVED:

Jeffrey E Johnson Digitally signed by Jeffrey E Johnson Date: 2021.12.14 12:47:42 -06'00'

City of Mankato Engineer	12/14/21
	Date

Ryan Thilges Digitally signed by Ryan Thilges DN: cn=Ryan Thilges, o=Blue Earth County, ou=Public Works, email=ryan.thilges@blueearthcountymn.gov, c=US Date: 2021.12.14 14:25:40 -06'00'

Blue Earth County Engineer	12/14/21
	Date

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1.0 Introduction

The Mankato Area Planning Organization (MAPO) in conjunction with Blue Earth County and the City of Mankato have identified the need to conduct an Intersection Control Evaluation (ICE) for the CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road) intersection in Mankato, MN. The purpose of this study is to identify the appropriate traffic control and optimal geometrics for existing and forecast conditions that is consistent with the County and City's transportation systems and MAPO Long Range Transportation Plan (LRTP).

1.1 Description of Location

The intersection of CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road) is located in the City of Mankato, MN (see **Figure 1**: Project Location). The area to the east of the intersection is primarily residential, with the Minnesota State University, Mankato campus located approximately 0.5 miles east of the intersection. Land use surrounding the intersection is a mix of parkland, residential, and light commercial.

1.2 Project Management Team

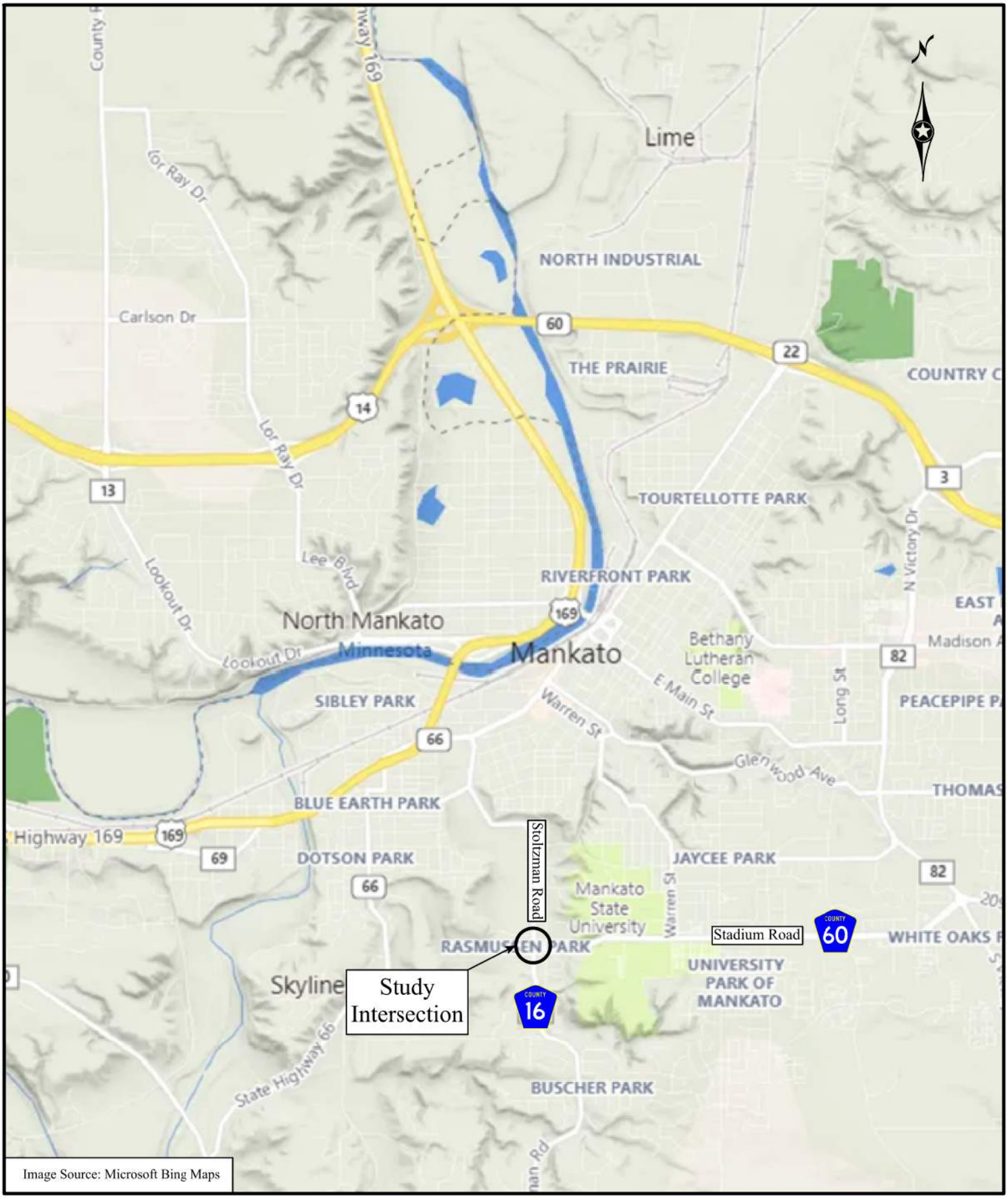
The Project Management Team (PMT) met a total of four times throughout the duration of the project to present and discuss progress of the study. PMT meetings occurred on May 26th, October 11th, November 1st, and November 29th of 2021. The PMT included members from MAPO, Blue Earth County, the City of Mankato, and the consultant team, Alliant Engineering, Inc. The PMT consisted of the following members:

- Charles Androsky, Mankato/North Mankato Area Planning Organization (MAPO)
- Ryan Thilges, County Engineer, Blue Earth County
- Stefan Gantert, Assistant County Engineer, Blue Earth County
- Jon Nelson, Associate Civil Engineer, City of Mankato
- Scott Poska, Alliant Engineering

1.3 Elements of Evaluation

The following elements are included in this ICE:

- Existing Conditions (Section 2.0)
- Traffic Volumes (Section 3.0)
- Alternatives Analysis (Section 4.0)
- Recommendations (Section 5.0)



CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road) - Mankato

Figure 1
Project Location

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2.0 Existing Conditions

The following sections document the existing conditions analysis completed for the CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road) intersection.

2.1 Roadway and Traffic Control Characteristics

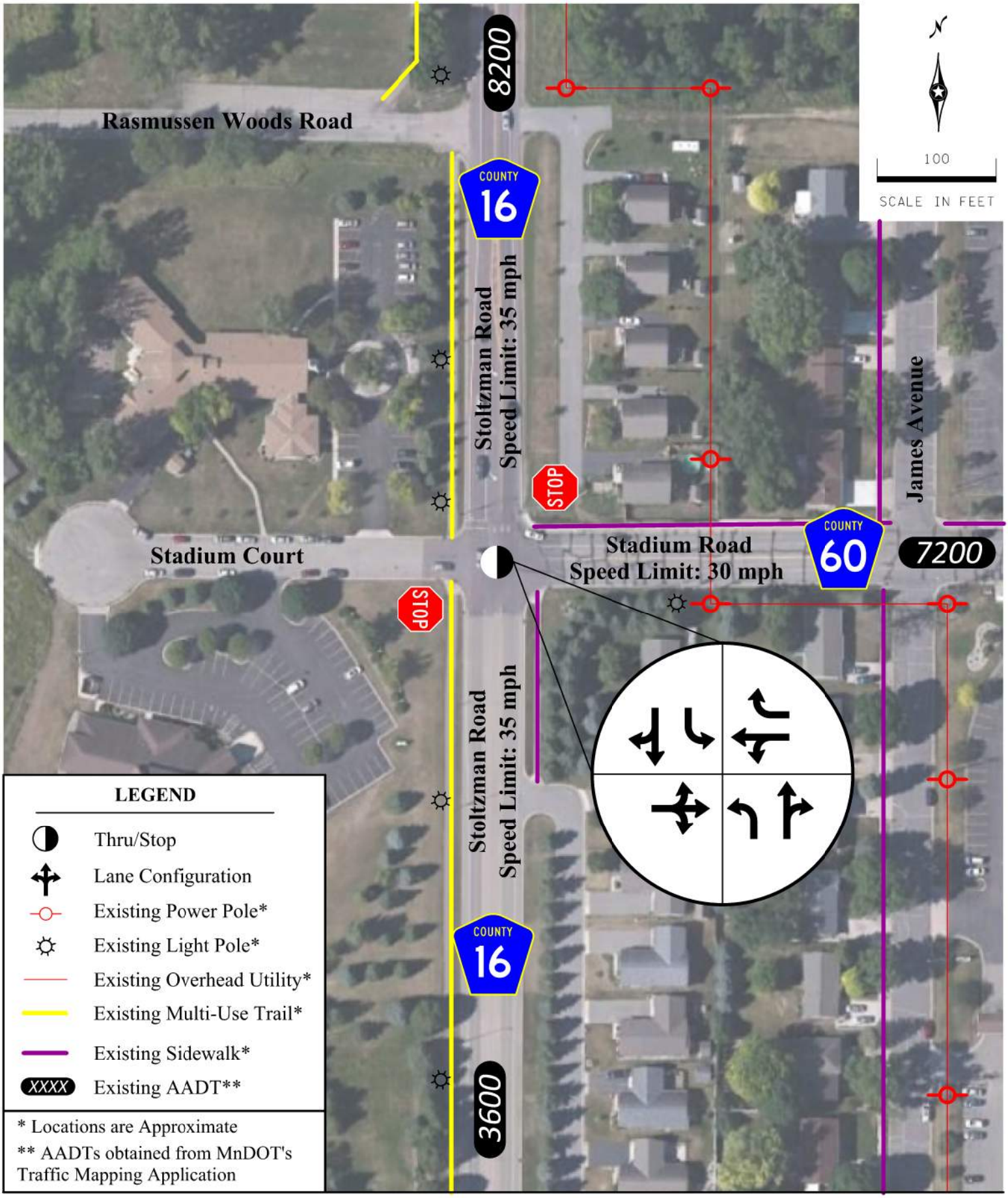
The intersection is currently controlled by thru/stop. The existing roadway characteristics are summarized below:

- **CSAH 16 (Stoltzman Road):** The north leg of CSAH 16 (Stoltzman Road) serves as a *Minor Arterial* roadway and the south leg serves as a *Major Collector* roadway. The north leg consists of a two-lane roadway with paved shoulders and a dedicated southbound left-turn lane at the intersection. The south leg consists of a two-lane roadway with a Center Two-Way Left-Turn Lane (CTWLTL). A multi-use trail runs along the west side of CSAH 16, providing connections to the Rasmussen Woods Park and Mankato West High School to the north of the intersection. The posted speed limit is 35 miles per hour (MPH).

- **CSAH 60 (Stadium Road)**: CSAH 60 (Stadium Road) is the east leg of the intersection and is classified as a *Minor Arterial* roadway, consisting of a four-lane undivided cross-section with a dedicated right-turn lane and shared through/left-turn lane at the intersection. Sidewalk facilities are located at the back of curb on the north side of the road. CSAH 60 (Stadium Road) provides a key connection to the Minnesota State University – Mankato campus, located approximately 0.5 miles east of the intersection. The posted speed limit is 30 MPH.

- **CSAH 60 (Stadium Court)**: CSAH 60 (Stadium Court) is the west leg of the intersection and consists of a two-lane cross section with parking lanes. CSAH 60 (Stadium Court) terminates approximately 300 feet west of the intersection at a cul-de-sac.

Key intersection characteristics, including lane configuration and traffic control, are depicted in **Figure 2**.



CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road) - Mankato

Figure 2
Existing Conditions

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2.2 Crash Experience

Historical crash data from the most recent ten years of data available, 2011 through 2020, was obtained from MnDOT's Crash Mapping Analysis Tool (MnCMAT2) platform. Included narratives provided by law enforcement were reviewed to ensure data accuracy. Based on the crash data provided, there were 10 reported crashes at the intersection during the 10-year analysis period (see **Figure 3**: Collision Diagram). The crashes are classified into the following types:

- 2 of 10 Crashes (20 percent) – Left Turn
- 2 of 10 Crashes (20 percent) – Bicycle
- 2 of 10 Crashes (20 percent) – Ran-off-road
- 2 of 10 Crashes (20 percent) – Other
- 1 of 10 Crashes (10 percent) – Angle
- 1 of 10 Crashes (10 percent) – Right Turn

The primary crash types for this intersection are left turn crashes and bicycle crashes. Both left turn crashes occurred between a southbound left-turning vehicle and a northbound through vehicle. One bicycle crash involved a bicyclist crossing the north leg of CSAH 16 (Stoltzman Road), and one involved a bicyclist crossing the west leg of CSAH 60 (Stadium Road).

2.2.1 Crash Rate

History has proven that crashes are a function of exposure. Roadways with higher traffic volumes experience more crashes than similar roadways with lower volumes. Rather than simply documenting the number of crashes that occur at an intersection, the crash rate must be considered. Crash rates normalize different locations with varying traffic volumes, providing a useful tool in comparing the locations with respect to safety. Actual crash rates at specific locations can also be compared to average or typical values for similar intersection types. Intersection crash rates are defined as the number of crashes occurring per million entering vehicles (MEV). **Table 1** summarizes the observed intersection crash rates compared to the statewide average for similar traffic control and roadway types.

Crash occurrence is somewhat random by nature. Identifying every intersection with a crash rate above the statewide average 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 locations that have a crash rate higher than similar facilities by a statistically significant amount. The critical crash rate is calculated by adjusting the systemwide average based on the amount of exposure and a statistical constant indicating level of confidence. At locations where the observed crash rate exceeds the critical crash rate, it is 99 percent certain that an intersection or roadway segment could be improved through the modification of the existing traffic control, the configuration of the intersection, or the configuration of the roadway.

The observed 10-year crash rate at the CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road) intersection (0.25 crashes / MEV) is higher than the statewide average for an urban through/stop intersection (0.09 crashes / MEV) as well as the calculated critical crash rate (0.22 crashes / MEV) resulting in a critical crash rate index of 1.14. Therefore, the number of reported crashes would be considered statistically significant.

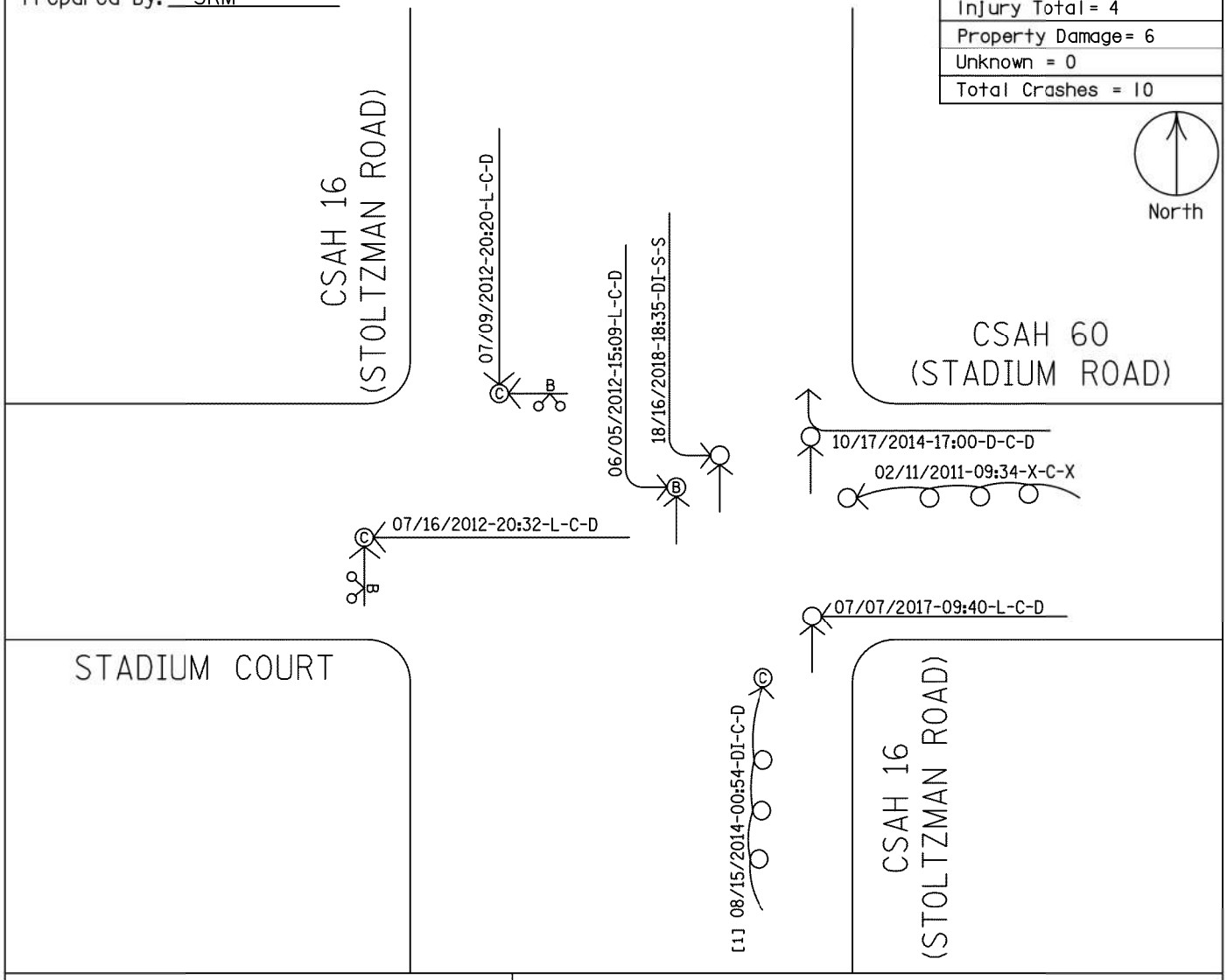
Collision Diagram

Location: CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road)

Time Period: 2011-2020 Date: 09/21/2021

Prepared By: SRM

Crash Severity [2]
Fatal = 0
A Injury = 0
B Injury = 1
C Injury = 3
Injury Total = 4
Property Damage = 6
Unknown = 0
Total Crashes = 10



KEY

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

NOTES

[1] Driver under the influence of alcohol.

[2] Crash reports for two crashes that occurred at the intersection were not thorough enough to identify crash types, so they are not included on the collision diagram, but are included in the crash severity table.

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]

CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road) - Mankato

Figure 3
Collision Diagram

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Table 1. Crash Rate Summary

10-Year Crash Analysis (2011-2020)		Rate Category	Crash	K/A
Traffic Control	Thru/Stop *Urban*	Intersection	0.25	0.00
Total Crashes[1]	10	State Average[3]	0.09	0.22
Total Entering Volume[2]	40,180,417	Critical[4,5]	0.22	2.41
K/A Crashes	0	Critical Index	1.14	0.00

[1] Crash Data obtained from MnCMAT and detailed police crash reports.

[2] Calculated from AADT obtained from MnDOT Traffic Data Map

[3] MnDOT's 2015-2019 Intersection Toolkit was used to determine the State average crash rates.

[4] The critical rate is a statistically adjusted crash rate to account for random nature of crashes

[5] A 99.5% confidence level was assumed for critical crash rate and an 80% confidence level was assumed for critical severity and K/A rate.

2.2.2 Intersection Crash Severity

In the 10-year analysis period (2011-2020) one of the 10 total crashes resulted in a minor injury (Type B), three resulted in a possible injury (Type C), and six resulted in a property damage only crash (Type O). Crash severities reported at the intersection are depicted in **Figure 4**.

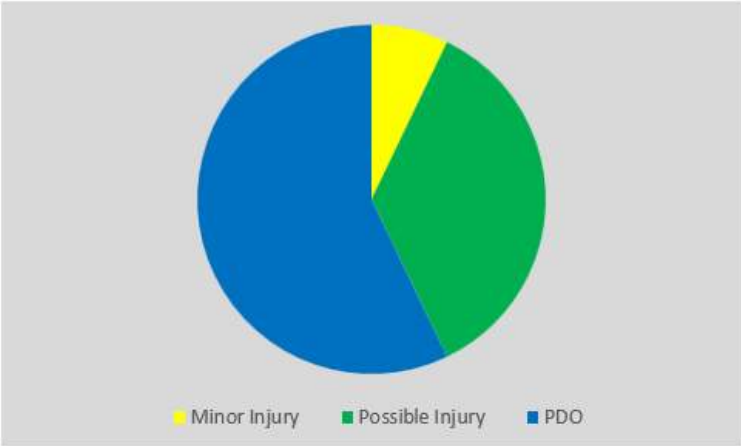


Figure 4. Intersection Crash Severities

With no fatal or serious injury crashes reported, the observed 10-year intersection K/A rate was 0.00. The observed 10-year K/A rate for the intersection is lower than the statewide average K/A rate for urban through/stop intersections (0.22), and lower than the K/A critical rate (2.41) resulting in a critical K/A rate index of 0.00. Therefore, the number of reported K/A crashes is not considered statistically significant. Crash types reported at the intersection are summarized by crash severity in **Figure 5**. A detailed trend analysis is located in **Appendix A**.

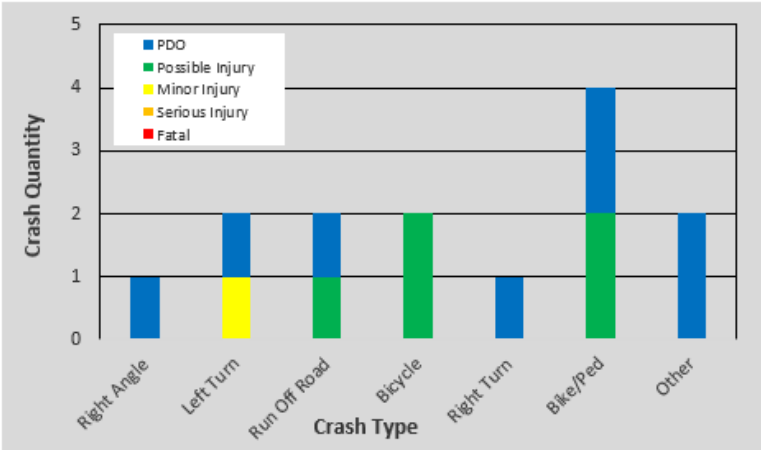


Figure 5. Intersection Crash Types by Severity

3.0 Traffic Volumes

Without a known project construction year, this ICE evaluated intersection geometric and traffic control needs based on the existing year (2021), forecast year 2022, and the 10-year (2032) and 20-year (2042) forecasts.

3.1 Existing Traffic Volumes

Turning movement counts were obtained using video collection completed by Alliant Engineering, Inc. in September of 2021. To account for any loss of traffic volume due to the ongoing COVID-19 pandemic, StreetLight data was used to determine a COVID-19 adjustment factor in September 2021. StreetLight average hourly volume data was obtained for weekdays (Monday – Thursday) for the month of June 2019 (Pre-COVID) and June 2021 (during COVID) and is shown in **Figure 6**. June was used for comparison purposes because at the time of analysis, StreetLight data was not available for the fall 2021. Pre-COVID volumes were on average 15% higher than during COVID, so an adjustment factor of 1.15 was applied. The existing 2021 peak hour adjusted traffic volumes are shown in **Figure 7**.

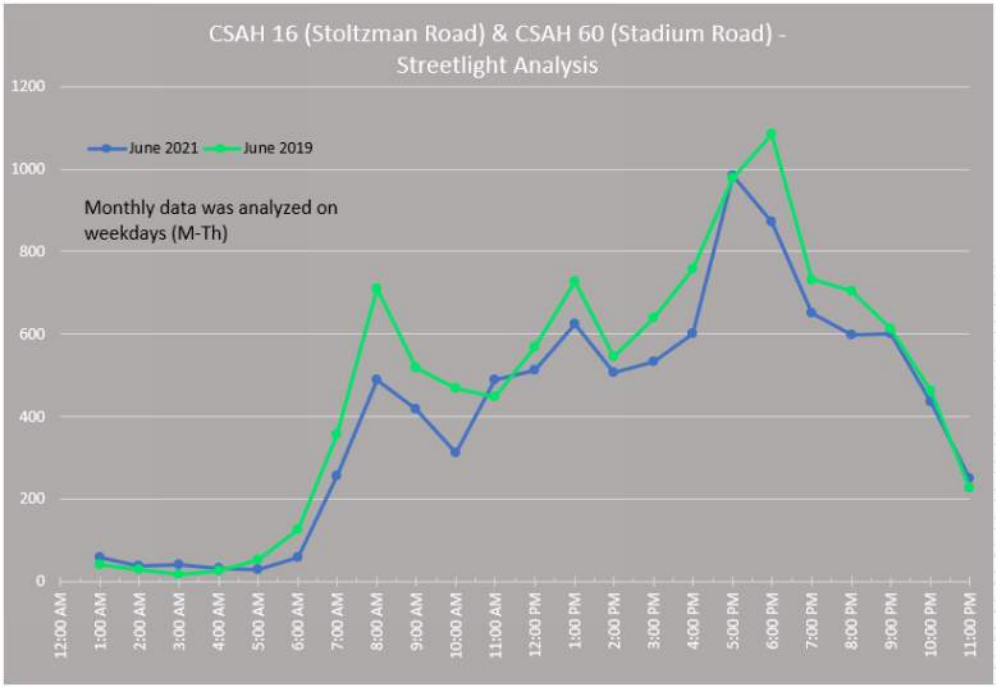
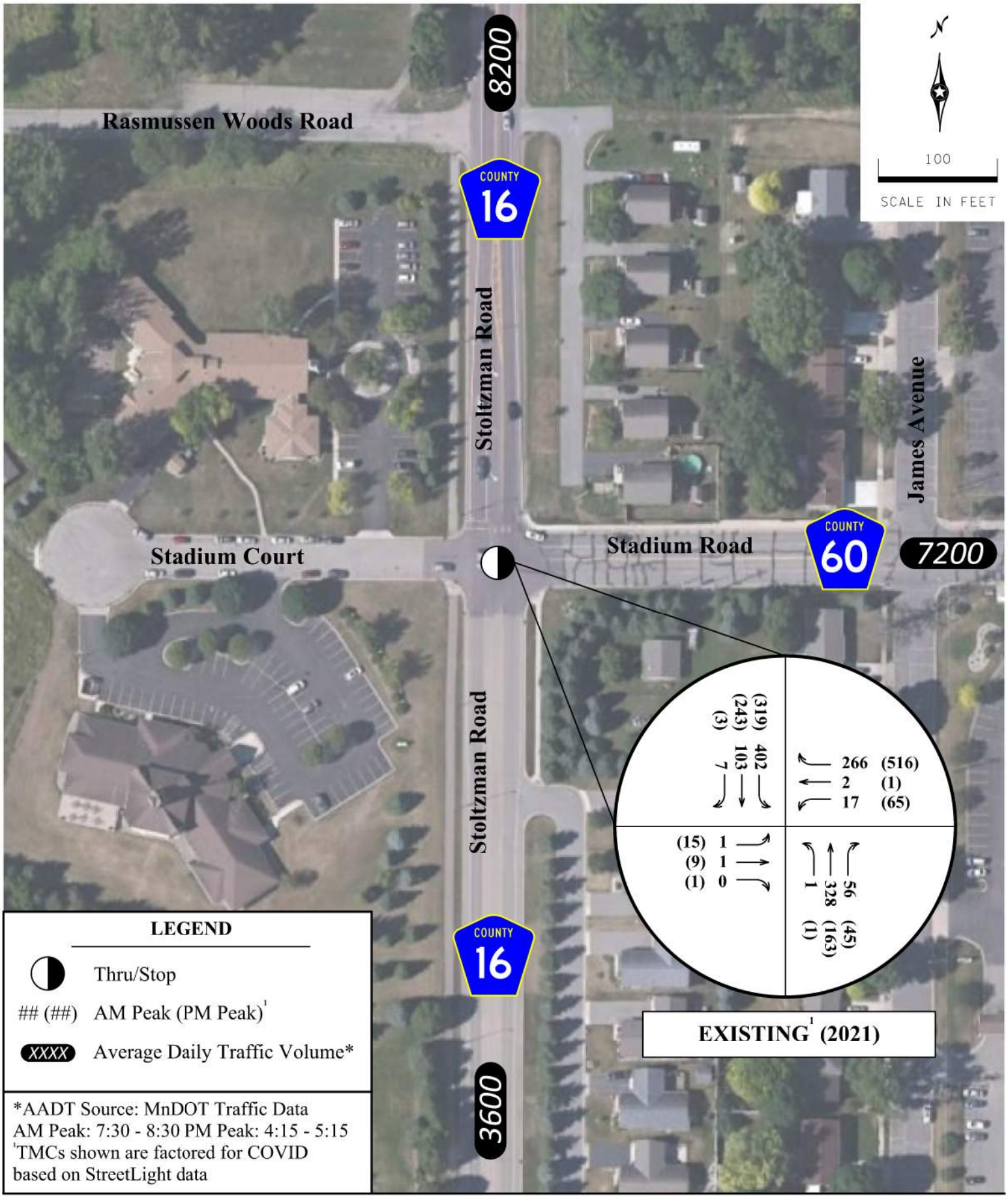


Figure 6. COVID-19 Average Volume Profiles



CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road) - Mankato

Figure 7
Existing[1] Traffic Volumes

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3.2 Traffic Growth Rates

Historical AADT was obtained from MnDOT's Traffic Mapping Application. Historical AADT data shows traffic volumes increasing slightly on the north leg of CSAH 16 (Stoltzman Road) and east leg of CSAH 60 (Stadium Road) and decreasing slightly on the south leg of CSAH 16 (Stoltzman Road). No historical AADT data was available for the west leg of CSAH 60 (Stadium Court).

Historical AADT data was compared to projected growth rates for the intersection identified in MAPO's 2045 Long Range Transportation Plan (LRTP). The LRTP identified project growth rates for each leg of the intersection ranging from 1.0% to 2.6%. Based on a review of the historical volumes, and with no planned developments in the area, it was determined that a 0.5% growth rate would be utilized for the CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road) intersection. The growth rate and historical volume analysis for the north leg of CSAH 16 (Stoltzman Road) is shown in **Figure 8** below.

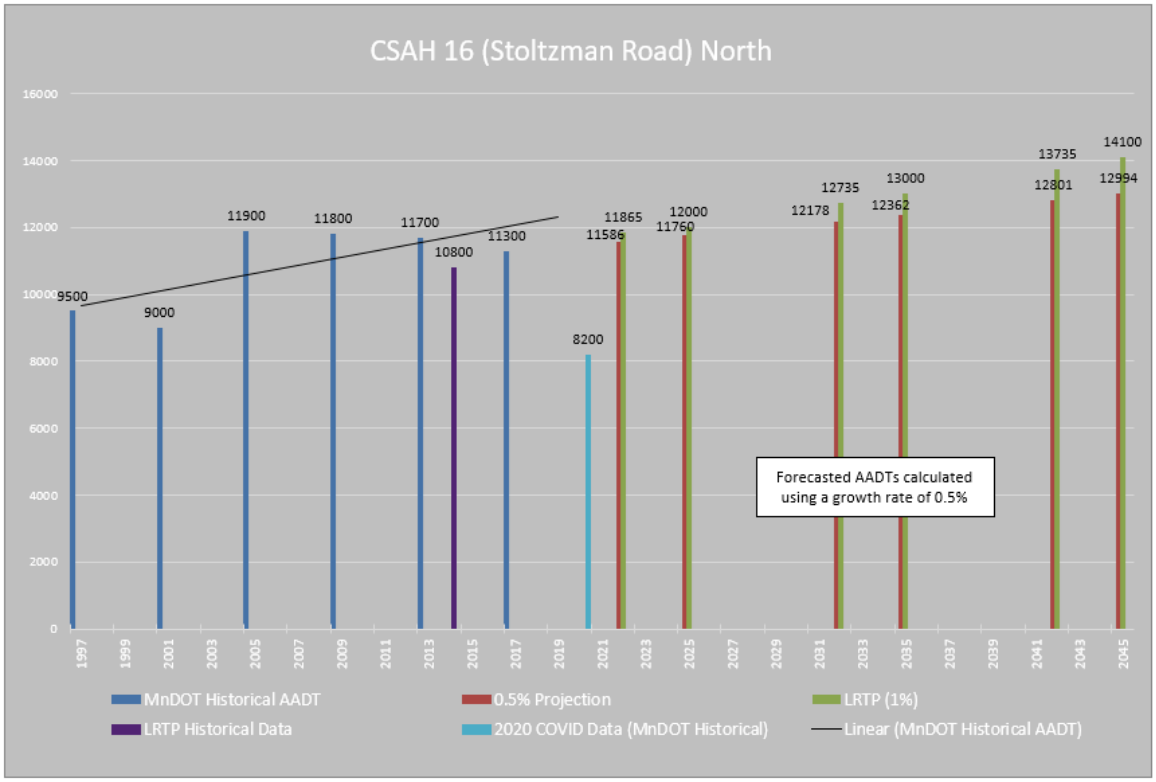
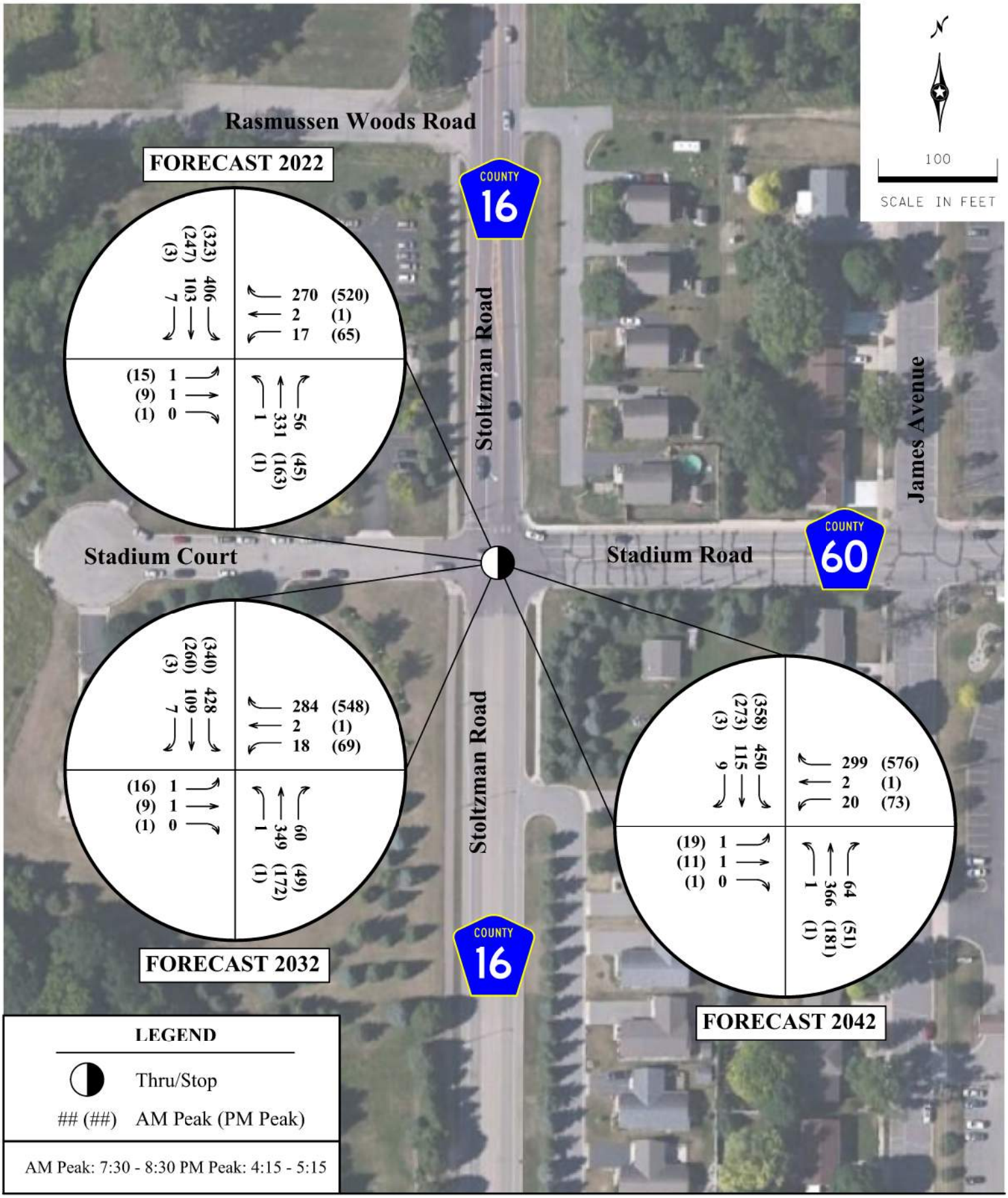


Figure 8. Traffic Growth Rate

3.3 Forecast Peak Hour Traffic Volumes

Forecast AM and PM peak hour turning movement volumes for the CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road) intersection were obtained using a 0.5% growth rate. The resultant forecast year 2022, 2032 and 2042 peak hour traffic volumes are shown in **Figure 9**.



CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road) - Mankato

Figure 9
Forecast Traffic Volumes

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4.0 Alternatives Analysis

The goals of the alternatives analysis were to identify engineering considerations, expected traffic operations and safety impacts, and alternative pros and cons to ultimately determine a recommended alternative for the intersection.

4.1 Traffic Control Devices

Four forms of traffic control were preliminarily identified for analysis for the CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road) intersection. Listed below are descriptions of each traffic control alternative.

- **Through/Stop** – Continuation of the existing through/stop control.
- **All-Way Stop** – This alternative would convert the existing through/stop control to an all-way stop control.
- **Traffic Signal –** This alternative would construct a traffic signal system at the intersection with the existing lane configuration.
- **Urban Compact Roundabout –** This alternative would construct a roundabout at the intersection

In addition to traffic control modifications, changes to the lane configurations on the east leg were explored. Because existing traffic volumes on CSAH 60 (Stadium Road) do not exceed the capacity of a two-lane roadway, it could be converted from a four-lane section to a three-lane section with a Center Two Way Left Turn Lane (CTWLTL). This would improve safety by removing the multiple lane threat for crossing pedestrians at CSAH 16 (Stolzman Road) and James Avenue with little operational impact. The CTWLTL would become a dedicated left turn lane and a shared through/right turn lane or a shared through/left turn lane and dedicated right turn lane at the CSAH 16 (Stoltzman Road) intersection.

4.2 Warrant Analysis

An all-way stop and traffic signal warrant analysis were completed for the CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road) intersection in accordance with the Minnesota Manual on Uniform Traffic Control Devices (MnMUTCD). The MnMUTCD contains specific engineering standards, or warrants, that define the minimum conditions under which further consideration of an all-way stop and traffic signal is appropriate. These warrants are important for applying consistency in traffic control across intersections throughout the transportation system.

4.2.1 All-Way Stop Warrant Analysis

An all-way stop analysis was completed for the CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road) intersection under forecast years 2022 and 2042. The warrant analysis was conducted in accordance with the Minnesota Manual of Uniform Traffic Control Devices (MnMUTCD). In order for an all-way stop control to be considered, one of the following warrant criteria should be met:

- Warrant Criteria A – Signal Justified
- Warrant Criteria B – Crash Experience
- Warrant Criteria C – Minimum Volumes and Minor Approach Maximum Delay
- Warrant Criteria D – 80% Rule

Traffic volumes were reviewed under existing and forecast traffic volumes and crash experience was reviewed using historical crash data from MnCMAT. **Table 2** presents a summary of the MnMUTCD all-way stop warrant analysis results. Results of the all-way stop warrant analysis indicate that none of the warrant criteria are met for the CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road) intersection. The detailed all-way stop warrant analysis results are included in **Appendix B**.

Table 2. All-Way Stop Warrant Analysis Summary

Forecast Year	Criteria A - Signal Justified	Criteria B - Crash Experience		Criteria C - Minimum Volumes and Minor Approach Maximum Delay			Criteria D - 80% Rule			
	Met?	Crashes	Met?	C1	C2	Met?	B	C1	C2	Met?
2022	No	1	No	13	11	No	1	13	11	No
2032	No	1	No	14	15	No	1	14	15	No
2042	No	1	No	14	15	No	1	14	15	No

Note: Analysis includes 100% of right-turn movements on both minor street approaches

4.2.2 Signal Warrant Analysis

A signal warrant analysis was completed for the CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road) intersection under forecast year 2022 and forecast year 2042 traffic volumes. The warrant analysis was conducted in accordance with the MnMUTCD. In order for a traffic signal to be considered for implementation at the intersection, at least one of the following warrant criteria must be met:

- W1 – Eight-Hour Vehicular Volume
- W2 – Four-Hour Vehicular Volume
- W3 – Peak Hour
- W4 – Pedestrian Volume
- W5 – School Crossing
- W6 – Coordinated Signal System
- W7 – Crash Experience
- W8 – Roadway Network
- W9 – Intersection Near a Grade Crossing

Warrant 1, Warrant 2, and Warrant 3 were reviewed under the forecast traffic volumes. Warrant 7 was reviewed using historical crash data. The remaining traffic signal warrants were not applicable at the CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road) intersection, or minimum warrant standards were not met. **Table 3** presents a summary of the MnMUTCD signal warrant analysis results. The right-turn volumes on the minor street approaches were omitted from the warrant analysis based on the recommendations in MnDOT Technical Memorandum 13-05-T-02. Results of the signal warrant analysis indicate that none of the warrants are met for forecast years 2022 or 2042. Detailed signal warrant analysis results are included in **Appendix C**.

Table 3. Signal Warrant Analysis Summary

Forecast Year	Warrant 1 - Eight-Hour Vehicular Volumes				Warrant 2 - Four-Hour Vehicular Volumes		Warrant 3 - Peak Hour		Warrant 7 - Crash Experience	
	1A	1B	1C	Met?	Hours	Met?	3B	Met?	Crashes	Met?
2022	0	0	0	No	0	No	0	No	1	No
2032	0	0	0	No	0	No	0	No	1	No
2042	0	0	0	No	0	No	0	No	1	No

4.3 Roundabout Capacity Analysis

A planning-level roundabout capacity analysis was completed for the CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road) intersection under forecast year 2022, 2032, and 2042 traffic volumes for peak hour conditions and was conducted in accordance with the Highway Capacity Manual (HCM 2016). The purpose of this analysis was to determine whether a single-lane or multi-lane roundabout would be needed for the intersection under existing and forecast year traffic volumes.

Results of the roundabout capacity analysis for the forecast year 2042 are shown in **Figure 10**. Results indicate that a single-lane roundabout is expected to accommodate peak hour traffic volumes in forecast years 2022, 2032, and 2042. Planning-level roundabout capacity analysis results are located in **Appendix D**.

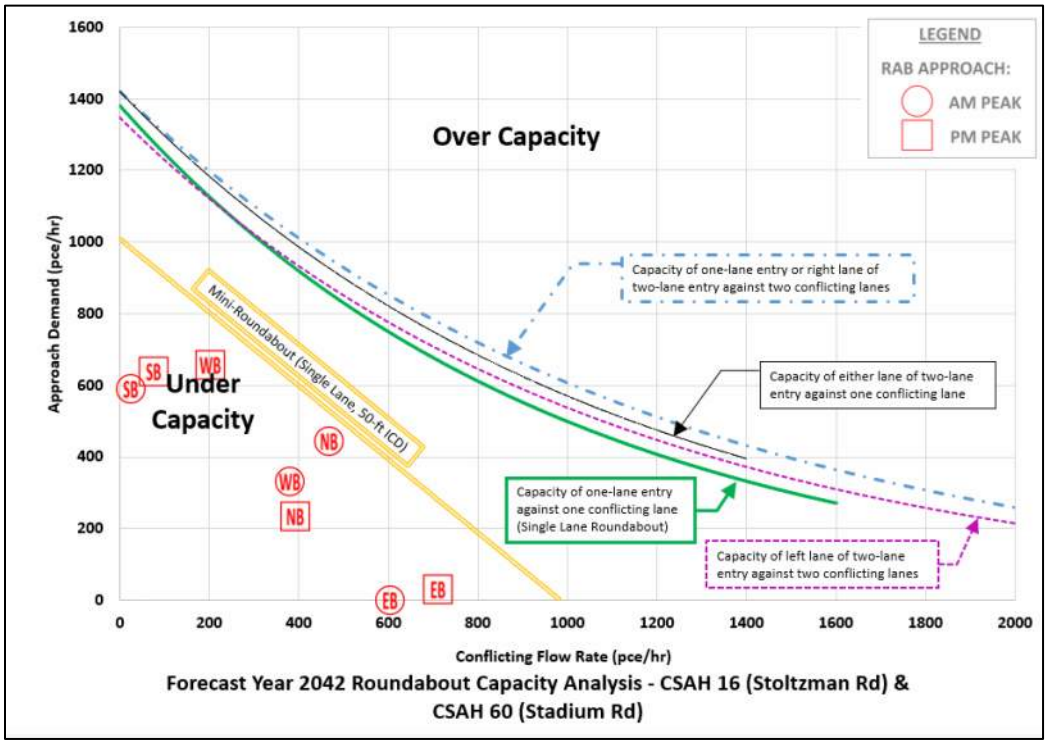


Figure 10. 2042 Planning-Level Roundabout Capacity Analysis

4.4 Detailed Alternatives Analysis

Based on the results of the preliminary alternatives analysis and discussions with the PMT, the following alternatives were identified for detailed evaluation, with Alternative 0 serving as the baseline No Build condition:

- **Alternative 0 (No Build) –** Under this alternative, the existing through/stop traffic control and existing lane configurations would remain unchanged.
- **Alternative 1 – Through/Stop with Pedestrian Refuges:** The existing through/stop traffic control and lane configurations would remain the same as existing. A 6-foot-wide pedestrian refuge island would be constructed at the north leg of CSAH 16 (Stoltzman Road) by restriping the north leg of the intersection.
- **Alternative 2 – Through/Stop with Rapid Rectangular Flashing Beacon (RRFB):** The existing through/stop traffic control and lane configurations would remain the same as existing. An RRFB would be installed at the north leg of CSAH 16 (Stoltzman Road).
- **Alternative 3 – Through/Stop with Pedestrian Refuges and RRFB:** The existing through/stop traffic control and lane configurations would remain the same as existing. A 6-foot-wide pedestrian refuge island would be constructed and an RRFB system would be installed at the north leg of CSAH 16 (Stoltzman Road).
- **Alternative 4 – Compact Roundabout:** This alternative would construct an urban compact single-lane roundabout at the intersection with a westbound lane drop prior to James Avenue and a pedestrian refuge on the west leg of the CSAH 60 (Stadium Road) and James Avenue intersection.

4.5 Safety Analysis

A detailed safety analysis was completed to help understand the anticipated safety improvement with each alternative. The safety analysis investigates the expected change in or elimination of crash types, evaluates the anticipated injury rate distribution, and computes a monetary annual crash cost for each alternative.

Future crashes for Alternative 1, Alternative 2, and Alternative 3 were estimated using Crash Modification Factors (CMFs) from the CMF Clearinghouse website. CMF ID 9120[1] for median treatments was applied to Alternative 1 and Alternative 3. CMF ID 9024[2] for installation of an RRFB was applied to Alternative 2 and Alternative 3. Further information on CMF ID 9120 and CMF ID 9024 can be found in **Appendix E** and **Appendix F**, respectively.

Future crashes for the roundabout alternative, Alternative 4, were estimated using values given in a 2017 MnDOT Roundabout Study. The crash rate and injury rate distributions for a single-lane roundabout were applied to crash values for Alternative 4. Further information on the 2017 MnDOT Roundabout study can be found in **Appendix G**. **Table 4** summarizes the results of the safety analysis.

Table 4. Safety Analysis Summary

Alternative	Traffic Control	Estimated Crash Rate per MEV	Estimated Injury Rate	Estimated Crash Cost Per Year	Estimated 20-Year Safety Benefit
Alternative 0: No Build	Thru/Stop	0.25	40%	$73,066	-
Alternative 1: Ped Refuge	Thru/Stop	0.22	40%	$64,904	$184,847
Alternative 2: RRFB	Thru/Stop	0.23	34%	$60,434	$305,519
Alternative 3: Ped Refuge & RRFB	Thru/Stop	0.21	36%	$57,202	$392,411
Alternative 4: Compact RAB	Roundabout	0.32	25%	$71,947	$320,581

Key conclusions of the safety analysis include the following:

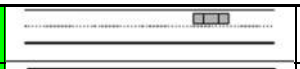
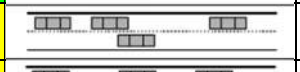
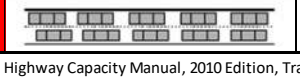
- All of the alternatives provide a reduction in injury rate from the No Build. The roundabout alternative (Alternative 4) is expected to have the lowest injury rate of the build alternatives.
- Alternatives 1-3 will result in a reduced crash rate compared to the No Build. Alternative 3 will have the lowest crash rate of the build alternatives.
- Although roundabouts have been proven to decrease the number of injury crashes at an intersection, statewide averages show that single-lane roundabouts increase lower severity crashes, and therefore the total number of crashes at the intersection.

4.6 Traffic Operations Analysis

A traffic operations analysis was completed for each alternative using the forecast year 2022, 2032, and 2042 peak hour traffic volumes. All alternatives were analyzed using Synchro/SimTraffic with the exception of Alternative 4 (Compact Roundabout), which was analyzed using VISSIM. The purpose of this analysis is to evaluate and compare the performance of each alternative. In addition, the traffic operations analysis provides context to the need for intersection improvements based on intersection capacity.

Operations analysis results identify a Level of Service (LOS), which indicates the quality of traffic flow through an intersection. Intersections are given a ranking from LOS A through LOS F. The LOS results are based on average delay per vehicle, which correspond to the delay threshold values shown in **Table 5**.

Table 5. Level of Service Criteria

Level of Service		Description	Delay per Vehicle (seconds)	
			Signalized Intersection	Unsignalized 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, volume exceed capacity, long delays with stop and go traffic.	> 80	> 50

Source: Highway Capacity Manual, 2010 Edition, Transportation Research Board, Exhibits 18-4 & 19-1.

LOS A indicates the best traffic operation, with vehicles experiencing minimal delays. LOS F indicates an intersection where demand exceeds capacity, or a breakdown of traffic flow. Although traffic simulation models arrive at the average seconds of delay per vehicle slightly differently than HCM procedures, the thresholds presented are still applicable. The LOS C/D/E/ boundary for overall operations is generally considered an acceptable threshold for operating conditions in greater Minnesota. For side-street stop-controlled intersections, a key measure of operational effectiveness is the side-street LOS. Long delays and poor LOS can occur on side-street approaches even if the overall intersection is functioning well, making side-street LOS a valuable design criterion.

After LOS, the second component of the operations analysis is a study of vehicular queuing, or the lineup of vehicles waiting to pass through an intersection. An intersection can operate with an acceptable LOS, but if queues from the intersection block entrances to turn lanes or adjacent driveways, unsafe operation conditions could result. The 95th percentile queue, or the length of queue with only a five percent probability of being exceeded during an analysis period, is considered the standard for design purposes.

Results of the existing traffic operations analysis are show in **Table 6**. During the AM peak, the westbound through and left-turn movements operate at LOS F, but is a very low volume movement with multiple gaps in conflicting volume on Stoltzman Road during the peak hour. Results of the operations analysis indicate that the CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road) intersection is expected to operate at an overall LOS B or better for the No Build and each of the alternatives under forecast year 2022, 2032, and 2042 traffic volumes. Results for each alternative under forecast year 2022, 2032, and 2042 are shown in **Tables 7, 8,** and **9** respectively. Detailed Measures of Effectiveness (MOE) can be found in **Appendix H.**

Table 6. Measure of Effectiveness Summary - Existing Conditions (2021)

Alternative	AM Peak Hour		PM Peak Hour	
	LOS	Delay (s)	LOS	Delay (s)
Existing Conditions (2021)	A / B	6.4 / 14.3	A / B	6.8 / 13.2

Overall Intersection LOS / Worst Approach LOS
Overall Intersection Delay / Worst Approach Delay

Table 7. Measures of Effectiveness Summary - Forecast Year 2022

Alternative	AM Peak Hour		PM Peak Hour	
	LOS	Delay (s)	LOS	Delay (s)
Alt 0 (No Build)	A / B	6.4 / 13.9	A / B	6.9 / 14.5
Alt 1: Through/Stop with Pedestrian Refuges	A / B	6.4 / 13.9	A / B	6.9 / 14.5
Alt 2: Through/Stop with RRFB	A / B	6.4 / 13.9	A / B	6.9 / 14.5
Alt 3: Through/Stop with Ped Refuges and RRFB	A / B	6.4 / 13.9	A / B	6.9 / 14.5
Alt 4: Compact Roundabout	A / B	5.9 / 12.2	A / A	3.5 / 5.1

Overall Intersection LOS / Worst Approach LOS
Overall Intersection Delay / Worst Approach Delay

Table 8. Measures of Effectiveness Summary - Forecast Year 2032

Intersection	AM Peak Hour		PM Peak Hour	
	LOS	Delay (s)	LOS	Delay (s)
Alt 0 (No Build)	A / C	7.9 / 15.4	A / B	7.7 / 15.0
Alt 1: Through/Stop with Pedestrian Refuges	A / C	7.9 / 15.4	A / B	7.7 / 15.0
Alt 2: Through/Stop with RRFB	A / C	7.9 / 15.4	A / B	7.7 / 15.0
Alt 3: Through/Stop with Ped Refuges and RRFB	A / C	7.9 / 15.4	A / B	7.7 / 15.0
Alt 4: Compact Roundabout	A / C	7.7 / 16.6	A / A	3.8 / 5.8

Overall Intersection LOS / Worst Approach LOS
Overall Intersection Delay / Worst Approach Delay

Table 9. Measures of Effectiveness Summary - Forecast Year 2042

Intersection	AM Peak Hour		PM Peak Hour	
	LOS	Delay (s)	LOS	Delay (s)
Alt 0 (No Build)	A / C	9.1 / 16.9	A / C	8.5 / 15.9
Alt 1: Through/Stop with Pedestrian Refuges	A / C	9.1 / 16.9	A / C	8.5 / 15.9
Alt 2: Through/Stop with RRFB	A / C	9.1 / 16.9	A / C	8.5 / 15.9
Alt 3: Through/Stop with Ped Refuges and RRFB	A / C	9.1 / 16.9	A / C	8.5 / 15.9
Alt 4: Compact Roundabout	B / D	12.3 / 30.0	A / A	4.2 / 6.6

Overall Intersection LOS / Worst Approach LOS

Overall Intersection Delay / Worst Approach Delay

With no changes to traffic control type or lane configuration, Alternative 1, Alternative 2, and Alternative 3 are anticipated to perform the same as the No Build for the forecast years. Results of the traffic operations analysis show that Alternative 1, Alternative 2, and Alternative 3 will perform at an overall intersection LOS A and worst approach LOS C in the forecast year 2042. It should be noted that although the worst approach has LOS C, the westbound through and left-turn movements do experience LOS F in the 2032 and 2042 AM peak hours, as shown in the Detailed Measures of Effectiveness (MOE), located in **Appendix H**. Although these movements perform at LOS F, the movement volumes are so low that the intersection still performs at an overall LOS A and worst approach LOS C.

Alternative 4: Compact Roundabout is expected to perform better than the No Build in the PM peak for each of the forecast years, resulting in an overall intersection and worst approach LOS A. However, results of the analysis show that Alternative 4 does not perform as well in the AM peak hour, resulting in overall intersection LOS A and worst approach LOS D in the forecast year 2042. These levels of service are slightly worse than the 2042 forecast AM peak hour results for the No Build, which are overall intersection LOS A and worst approach LOS C. The compact roundabout alternative performs worse in the AM peak because of the high volumes on CSAH 16 (Stoltzman Road). This can also be seen in the No Build and for Alternative 1, Alternative 2, and Alternative 3.

4.7 Construction Cost Estimates

High-level construction cost estimates were generated for the intersection alternatives based on a review of the site, previous project experience, and concept-level preliminary layouts. Conceptual layouts for Alternative 1, Alternative 2, Alternative 3 and Alternative 4 are shown in **Figure 11, Figure 12,** and **Figure 13,** and **Figure 14** respectively. Construction cost estimates are summarized in **Table 11.** These include a relatively high 30% contingency to account for risk or any unknowns that may not be identified without more detailed engineering. Professional fees for design and construction services as well as potential right of way costs were not included in the construction cost estimates.

Further preliminary engineering is necessary to refine the construction cost estimate to accurately account for actual construction limits, grading, wetland impacts, drainage, and other design considerations. The cost estimates shown are only intended to be used for the purpose of relative comparison within this ICE report.

Table 10. Construction Cost Estimate Summary

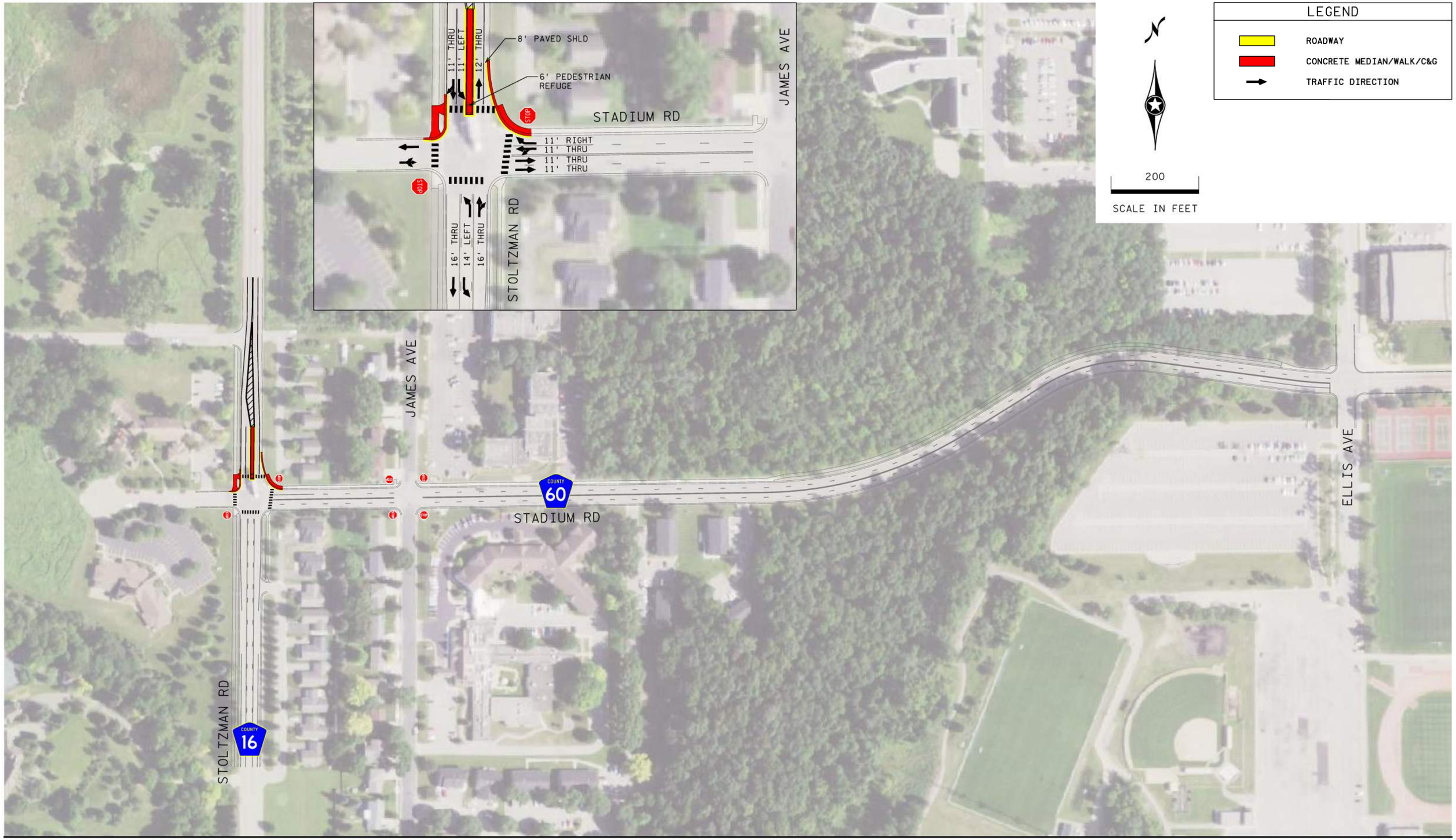
Alternative	Construction Cost Estimate (2022 Dollars)
Alternative 0: No Build	-
Alternative 1: Ped Refuge	$72,150
Alternative 2: RRFB	$30,700
Alternative 3: Ped Refuge & RRFB	$94,450
Alternative 4: Compact RAB	$750,000

4.8 Benefit/Cost Analysis

An economic benefit/cost analysis was completed in accordance with the MnDOT Office of Investment Management, Benefit/Cost Analysis for Transportation Projects procedures, and assumes a 20-year analysis period. The benefit/cost ratio is a comparison between the estimated traffic operations and safety benefit for the intersection alternatives, the estimated construction cost, and any expected operational and maintenance cost over this period (e.g., lighting, street signs). The highest benefit/cost ratio represents the most economically reactive solution. Benefit/cost ratios less than 1.0 may not be considered an economically viable alternative; however, they may be worth considering as a proactive long-term solution. The economic benefit/cost analyses for the intersection alternatives are summarized in **Table 12** and provided in detail in **Appendix I**.

Table 11. Benefit/Cost Analysis Summary

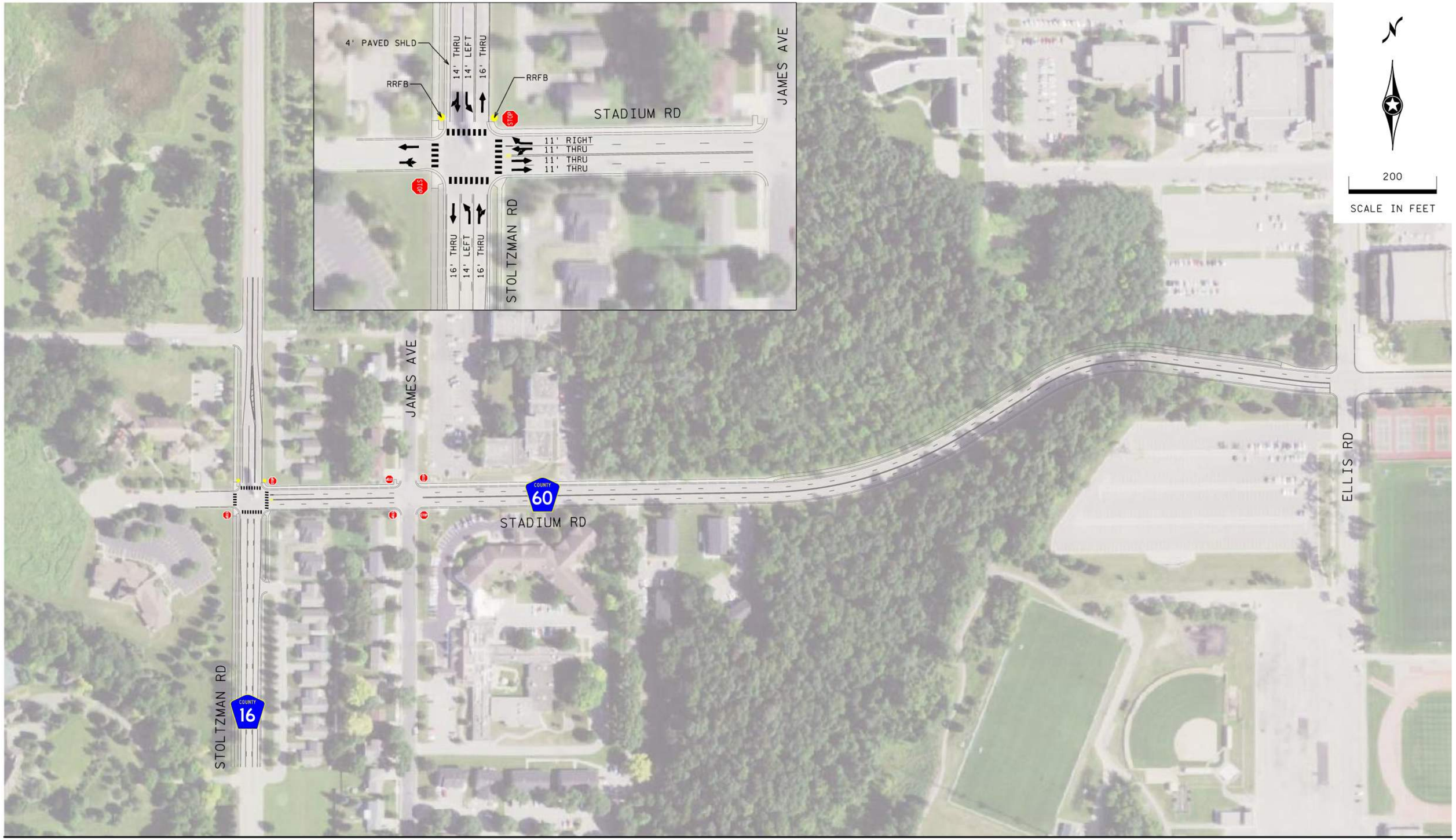
Alternative	Estimated 20-Year Safety Benefit	Estimated 20-Year Operational Benefit	Construction Cost Estimate (2022 Dollars)	B/C Ratio
Alternative 0: No Build	-	-	-	-
Alternative 1: Ped Refuge	$184,847	-	$72,150	4.64
Alternative 2: RRFB	$305,519	-	$30,700	4.90
Alternative 3: Ped Refuge & RRFB	$392,411	-	$94,450	3.08
Alternative 4: Compact RAB	$320,581	$2,042,460	$750,000	3.61



CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road) - Mankato

ALLIANT

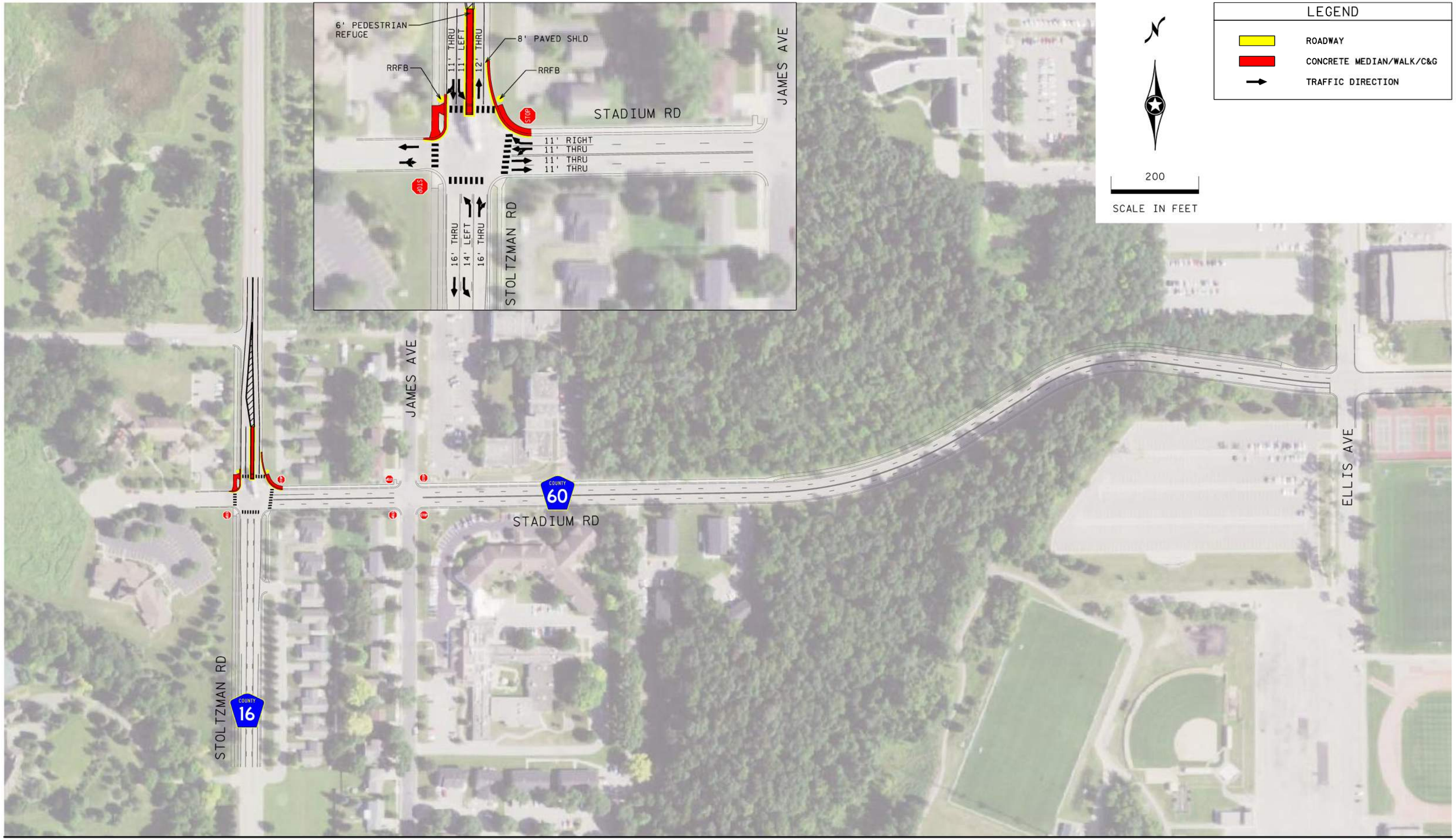
Figure 11
Conceptual Layout
Alternative 1



CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road) - Mankato

ALLIANT

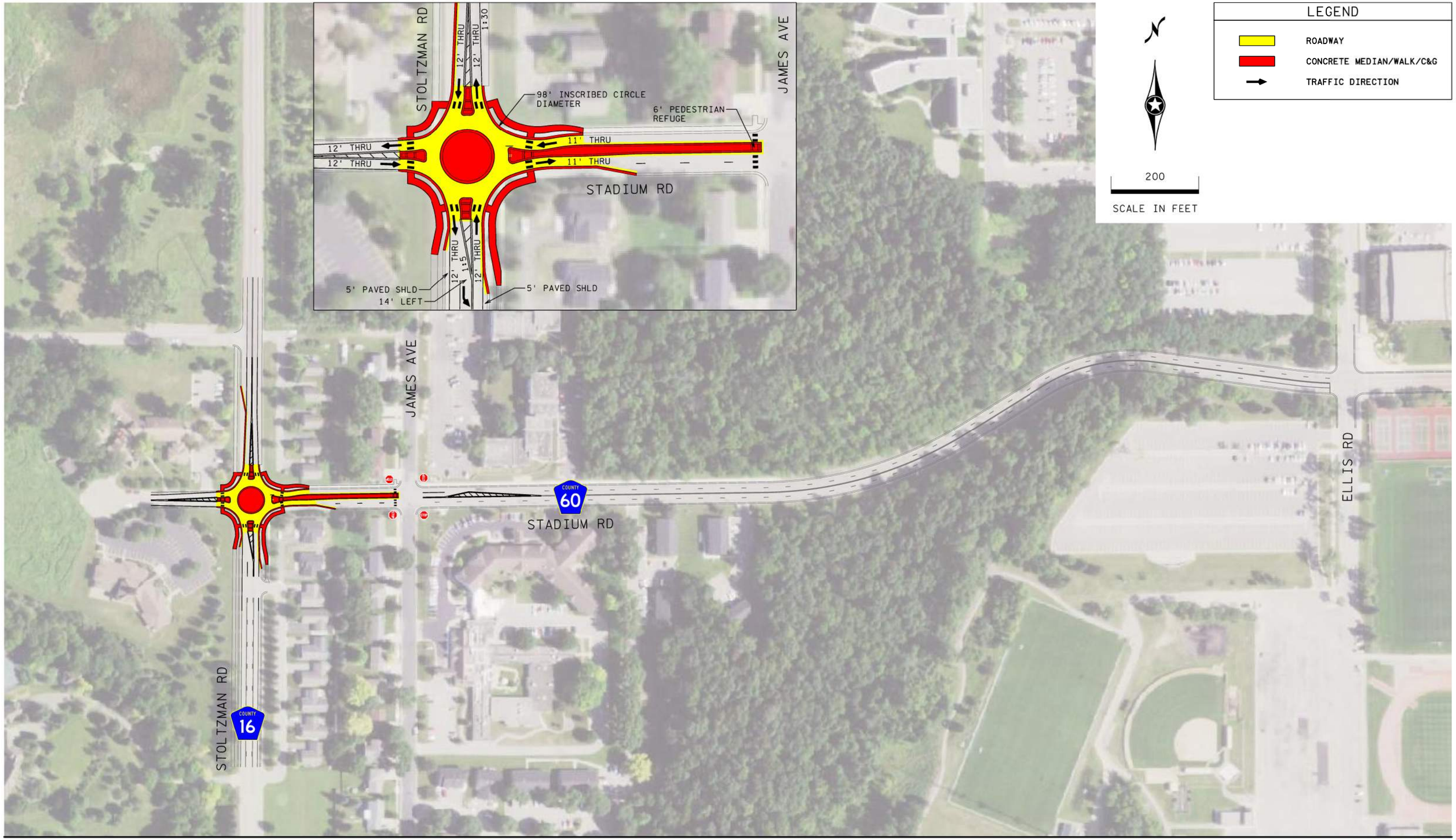
Figure 12
Conceptual Layout
Alternative 2



CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road) - Mankato

ALLIANT

Figure 13
Conceptual Layout
Alternative 3



CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road) - Mankato

ALLIANT

Figure 14
Conceptual Layout
Alternative 4

4.9 Stakeholder Information Meetings

Keeping key stakeholders informed throughout the study process was an important element of this ICE. The PMT met with several key stakeholders throughout the duration of the project to give an overview of the study, the ICE process, and to present preliminary alternatives. The meetings and their dates are listed below.

- County Board Meeting – Blue Earth County – November 23rd, 2021
- MAPO Technical Advisory Committee Meeting – Mankato Area Planning Organization – December 8th, 2021
- City Council Meeting – City of Mankato – December 13th, 2021
- MAPO Policy Board Meeting – Mankato Area Planning Organization – December 13th, 2021

The PMT also met with facilities staff from Minnesota State University, Mankato to collect input on the intersection's existing operational conditions. Input collected from this meeting was taken into consideration as the PMT made project decisions throughout the duration of the study. The date of this meeting is listed below.

- Minnesota State University, Mankato – May 26th, 2021

4.10 Alternative Evaluation Matrix

A comparison matrix summarizing the key decision factors with respect to the project goals is provided in **Table 12**. The key decision factors include:

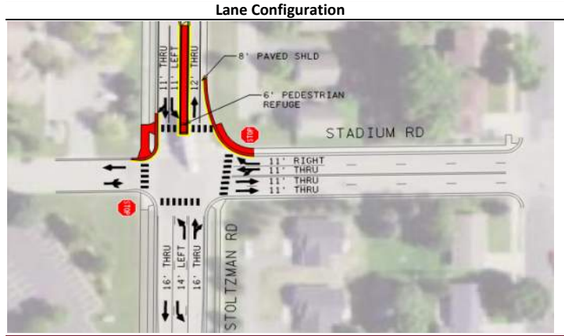
- **Pros and Cons** – Qualitative assessment of key advantages and disadvantages of the intersection alternatives
- **Safety Evaluation** – Assessment of expected impact on motorist safety and the degree to which existing safety deficiency is improved
- **Traffic Operations Evaluation** – Documentation of anticipated future traffic operations
- **Economic Evaluation** – Construction cost estimates and benefit/cost ratios

Table 12. Alternatives Evaluation Matrix

Alternative 0: No Build

Lane Configuration	Characteristics	Pros and Cons	Traffic Operations Analysis	Safety Analysis	Benefit Summary
	The "No Build" alternative carries the current geometry and traffic control (through/stop) forward. This alternative could be combined with the lane configurations sub-alternative A, B, or C.	**Pros:** 1. No construction cost 2. Familiar traffic control for the intersection 3. No R/W acquisition needed **Cons:** 1. No improvement to traffic safety or traffic operations 2. No improvement to non-motorized user facilities or safety	**Existing Operations:** **2022 Intersection/Worst Approach:** AM: 6.4 (A) / 13.9 (B) PM: 6.9 (A) / 14.5 (B) **2032 Intersection/Worst Approach:** AM: 7.9 (A) / 15.4 (B) PM: 7.7 (A) / 15.0 (B) **2042 Intersection/Worst Approach:** AM: 9.1 (A) / 16.9 (C) PM: 8.5 (A) / 15.9 (C)	**Fully or partially addressed known safety issues:** None **Unaddressed known safety issues:** 1. Left-turn crashes (2 of 10 crashes) 2. Bicycle/Pedestrian crashes (2 of 10 crashes) **Potential new safety issues:** None	**20-Year Operational Benefit:** N/A **20-Year Safety Benefit:** N/A **Estimated Construction Cost:** N/A **Benefit/Cost Ratio:** N/A

Alternative 1: Through/Stop with Pedestrian Refuge

Lane Configuration	Characteristics	Pros and Cons	Traffic Operations Analysis	Safety Analysis	Benefit Summary
	Lane configurations remain the same as existing. A pedestrian refuge island is constructed at the north leg of CSAH 16 (Stoltzman Road).	**Pros:** 1. Two-stage pedestrian crossing allows pedestrians to focus on crossing one direction of vehicular travel at a time 2. May reduce vehicle speeds on CSAH 16 (Stoltzman Road) approaches **Cons:** 1. Would require reconstructing a portion of CSAH 16 (Stoltzman Road) which would have moderate construction costs	**Expected Operations:** **2022 Intersection/Worst Approach:** AM: 6.4 (A) / 13.9 (B) PM: 6.9 (A) / 14.5 (B) **2032 Intersection/Worst Approach:** AM: 7.9 (A) / 15.4 (C) PM: 7.7 (A) / 15.0 (B) **2042 Intersection/Worst Approach:** AM: 9.1 (A) / 16.9 (C) PM: 8.5 (A) / 15.9 (C)	**Fully or partially addressed known safety issues:** 1. Bicycle/Pedestrian crashes (2 of 10 crashes) **Unaddressed known safety issues:** 1. Left-turn crashes (2 of 10 crashes) **Potential new safety issues:**	**20-Year Operational Benefit:** **$0** **20-Year Safety Benefit:** **$184,847** **Estimated Construction Cost:** **$72,150** **Benefit/Cost Ratio:** **4.64**

Alternative 2: Through/Stop with RRFB

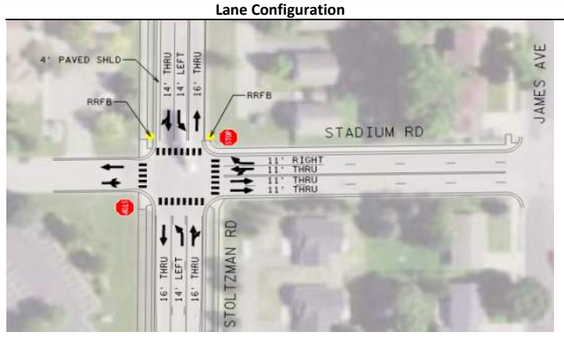
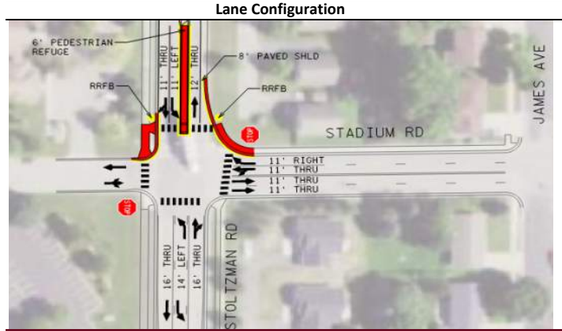
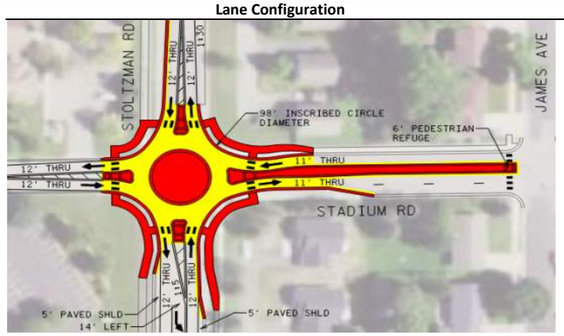
Lane Configuration	Characteristics	Pros and Cons	Traffic Operations Analysis	Safety Analysis	Benefit Summary
	Lane configurations remain the same as existing. An RRFB is installed at the north leg of CSAH 16 (Stoltzman Road).	**Pros:** 1. The RRFB will provide a high visibility crossing for pedestrians. RRFBs have been proven to increase yield rate for pedestrian crossings **Cons:** 1. Long pedestrian crossing distance	**Expected Operations:** **2022 Intersection/Worst Approach:** AM: 6.4 (A) / 13.9 (B) PM: 6.9 (A) / 14.5 (B) **2032 Intersection/Worst Approach:** AM: 7.9 (A) / 15.4 (C) PM: 7.7 (A) / 15.0 (B) **2042 Intersection/Worst Approach:** AM: 9.1 (A) / 16.9 (C) PM: 8.5 (A) / 15.9 (C)	**Fully or partially addressed known safety issues:** 1. Bicycle/Pedestrian crashes (2 of 10 crashes) **Unaddressed known safety issues:** 1. Left-turn crashes (2 of 10 crashes) **Potential new safety issues:**	**20-Year Operational Benefit:** **$0** **20-Year Safety Benefit:** **$305,519** **Estimated Construction Cost:** **$30,700** **Benefit/Cost Ratio:** **4.90**

Table 12. Alternatives Evaluation Matrix

Alternative 3: Through/Stop with Pedestrian Refuge and RRFB

Lane Configuration	Characteristics	Pros and Cons	Traffic Operations Analysis	Safety Analysis	Benefit Summary
	Lane configurations remain the same as existing. A pedestrian refuge island is constructed at the north leg of CSAH 16 (Stoltzman Road). An RRFB is installed at the north leg of CSAH 16 (Stoltzman Road).	**Pros:** 1. Two-stage pedestrian crossing allows pedestrians to focus on crossing one direction of vehicular travel at a time 2. May reduce vehicle speeds on CSAH 16 (Stoltzman Road) approaches 3. The RRFB will provide a high visibility crossing for pedestrians. RRFBs have been proven to increase yield rate for pedestrian crossings **Cons:** 1. Would require reconstructing a portion of CSAH 16 (Stoltzman Road) which would have moderate Construction costs	**Expected Operations:** **2022 Intersection/Worst Approach:** AM: 6.4 (A) / 13.9 (B) PM: 6.9 (A) / 14.5 (B) **2032 Intersection/Worst Approach:** AM: 7.9 (A) / 15.4 (C) PM: 7.7 (A) / 15.0 (B) **2042 Intersection/Worst Approach:** AM: 9.1 (A) / 16.9 (C) PM: 8.5 (A) / 15.9 (C)	**Fully or partially addressed known safety issues:** 1. Bicycle/Pedestrian crashes (2 of 10 crashes) **Unaddressed known safety issues:** 1. Left-turn crashes (2 of 10 crashes) **Potential new safety issues:**	**20-Year Operational Benefit:** **$0** **20-Year Safety Benefit:** **$392,411** **Estimated Construction Cost:** **$94,450** **Benefit/Cost Ratio:** **3.08**

Alternative 4: Compact Roundabout

Lane Configuration	Characteristics	Pros and Cons	Traffic Operations Analysis	Safety Analysis	Benefit Summary
	This alternative constructs an urban compact roundabout at the intersection with a WB lane drop prior to James Avenue and a pedestrian refuge on the west leg of the CSAH 60 (Stadium Road) and James Avenue intersection.	**Pros:** 1. Provides operational benefit and reduced delay 2. Provides traffic calming - designed for 15 mph speed 3. Allows bicyclists/pedestrians to cross one lane of traffic at a time 4. Driver familiarity with single-lane roundabouts located at the intersection of Stadium Road and Pohl Road to the east **Cons:** 1. High construction cost 2. Non-balanced approach volumes 3. May increase rear-end and sideswipe-same crashes 4. Special attention required in design for trucks	**Expected Operations:** **2022 Intersection/Worst Approach:** AM: 5.9 (A) / 12.2 (B) PM: 3.5 (A) / 5.1 (A) **2032 Intersection/Worst Approach:** AM: 7.7 (A) / 16.6 (C) PM: 3.8 (A) / 5.8 (A) **2042 Intersection/Worst Approach:** AM: 12.3 (B) / 30.0 (D) PM: 4.2 (A) / 6.6 (A)	**Fully or partially addressed known safety issues:** 1. Left-turn crashes (2 of 10 crashes) 2. Bicycle/Pedestrian crashes (2 of 10 crashes) **Unaddressed known safety issues:** None **Potential new safety issues:** 1. May increase rear-end and/or sideswipe crashes	**20-Year Operational Benefit:** **$2,042,460** **20-Year Safety Benefit:** **$320,581** **Estimated Construction Cost:** **$750,000** **Benefit/Cost Ratio:** **3.61**

5.0 Recommendations

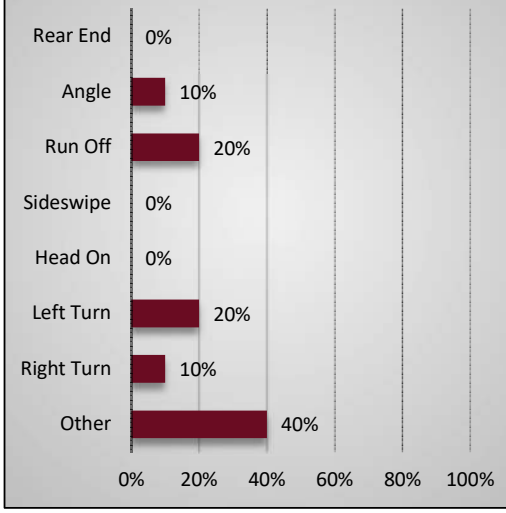
The selection of the recommended alternative for the CSAH 16 (Stoltzman Road) and CSAH 60 (Stadium Road) intersection is made based upon discussions with the PMT, results of the intersection operations and safety analyses, results of the benefit/cost analysis, Minnesota State University, Mankato input, and consideration of the key decision factors presented in the evaluation matrix. Based on the information presented in this ICE, Alternative 2: Rapid Rectangular Flashing Beacon (RRFB) is recommended to be installed at the intersection.

Alternative 2: RRFB does not result in any improvement to traffic operations at the intersection, however it does result in the highest benefit-cost ratio with the lowest overall construction cost. Preliminary alternatives of an all-way stop and traffic signal would both address the existing high delay for the westbound through and left turn movements at the expense of northbound/southbound through movements, but neither alternative meets MnMUTCD warrants and the traffic signal would come at a significant cost. Alternative 4: Compact Roundabout would also address high delay for the westbound through and left turn movements but comes at a significantly higher cost than any other alternative.

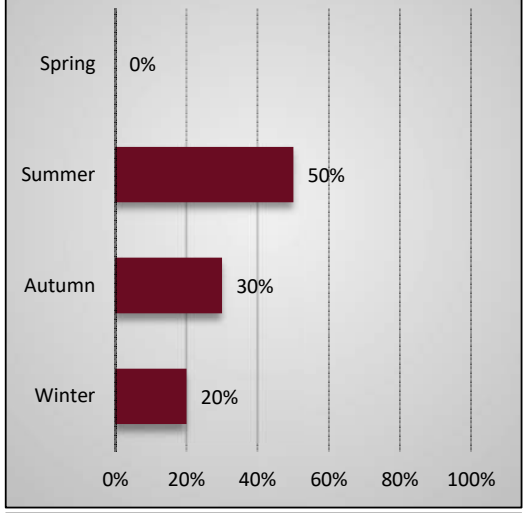
Installing an RRFB will provide a high visibility crossing for pedestrians and will likely increase the vehicle yield rate. Alternative 3: Pedestrian Refuges and RRFB could be implemented at the intersection in future years as it comes at a higher construction cost than Alternative 2. The addition of a pedestrian refuge would provide pedestrians with a two-stage crossing, allowing them to focus on crossing one direction of vehicular travel at a time. Additionally, the pedestrian refuge and narrow lanes would provide traffic calming through the intersection.

Appendix A: Detailed Crash Trend Analysis

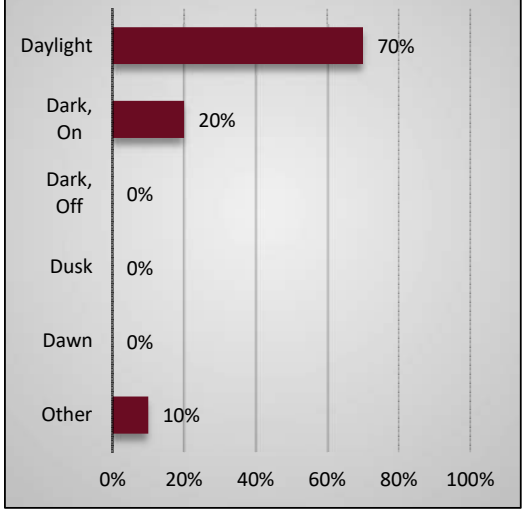
Crash Type[1]



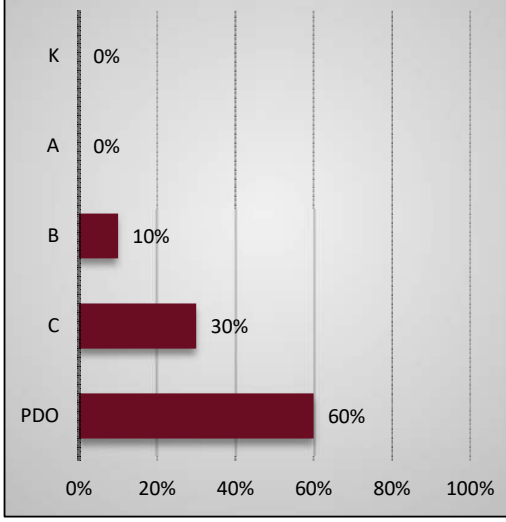
Seasonal Variation



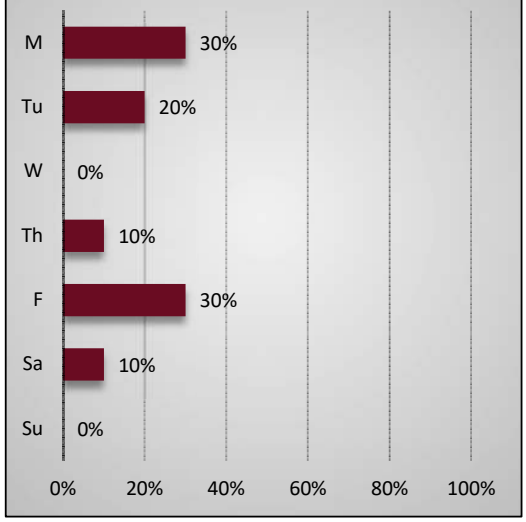
Lighting Conditions



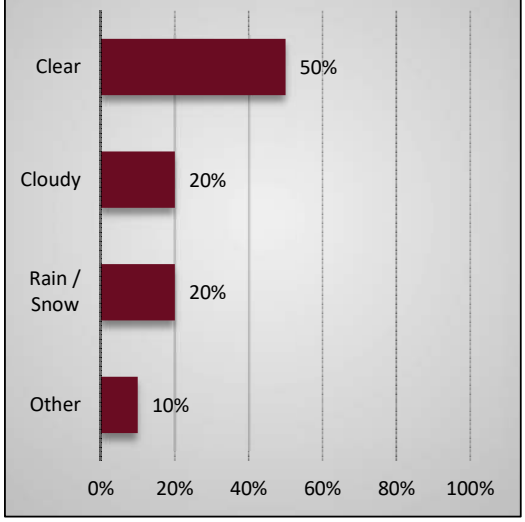
Crash Severity[2]



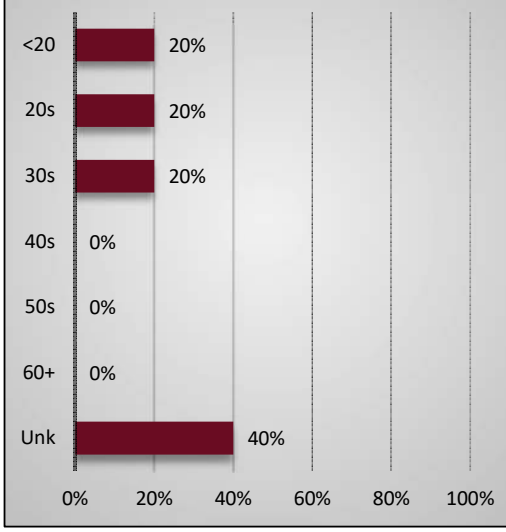
Day of Week



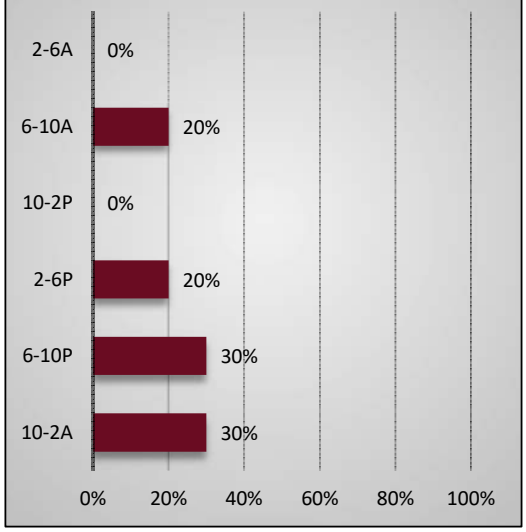
Weather Conditions



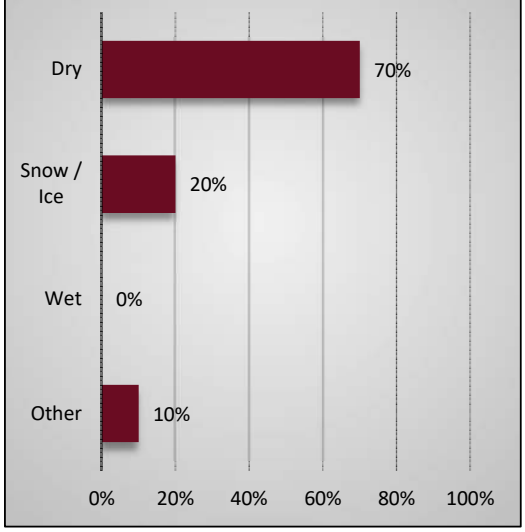
Age Group[3]



Time of Day



Surface Conditions



[1] Baseline Crash Type values were calculated using 2004-2015 data as recorded categories changed starting in 2016.

[2] Definitions for Crash Severity were changed starting in 2016, all years (2004-2019) were utilized for baseline values.

[3] Baseline Age Groups include all drivers involved in crashes, whereas intersection-specific ages are listed for at-fault drivers only.

Appendix B: Detailed All-Way-Stop Warrant Analysis

AWS WARRANT ANALYSIS - 2022
WARRANT 1
LOCATION: **CSAH 16 (Stoltzman Rd) & CSAH 60 (Stadium Rd)**

Count Date:
Source:
Factor: 1.00

Population < 10,000?	NO
Speed over 40 mph?	NO
VOLUME REQ AT 70%	NO

APPROACH	DESCRIPTION	NUMBER OF LANES	SPEED (MPH)
Major Approach 1	CSAH 16 (Stoltzman Rd) NB	2	35
Major Approach 3	CSAH 16 (Stoltzman Rd) SB	2	35
Minor Approach 2	Stadium Court EB	1	30
Minor Approach 4	CSAH 60 (Stadium Rd) WB	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? **NO**

	MAJOR STREET										MINOR STREET												WARRANT MET SAME HOURS ON MAJOR AND MINOR STREETS						WARRANT MET SAME HOURS ON MAJOR AND MINOR STREETS						
	APPROACH VOLUME			WARRANT MET *							APPROACH VOLUME		WARRANT MET APPROACH 2 *						WARRANT MET APPROACH 4 *																	
				Cond. A	Cond. B	(A&B) Comb.		Existing Signal					Cond. A	Cond. B	(A&B) Comb.		Existing Signal		Cond. A	Cond. B	(A&B) Comb.		Existing Signal				(A&B) Comb.		Existing Signal				(A&B) Comb.		Existing Signal	
						80% of A	80% of B	60% of A	60% of B						80% of A	80% of B	60% of A	60% of B			80% of A	80% of B	60% of A	60% of B												
HOUR	1	3	1 + 3	600	900	480	720	360	540	2	4	150	75	120	60	90	45	150	75	120	60	90	45	Cond. A	Cond. B					Cond. A	Cond. B				
12 - 1 AM	35	2	37							39	5																								
1 - 2 AM	14	0	14							13	2																								
2 - 3 AM	22	0	22							18	7																								
3 - 4 AM	23	0	23							19	1																								
4 - 5 AM	22	0	22							8	17																								
5 - 6 AM	70	0	70							47	58						X						X												
6 - 7 AM	126	0	126							121	123		X	X	X	X	X		X	X	X	X	X												
7 - 8 AM	275	0	275							430	397	X	X	X	X	X	X	X	X	X	X	X	X												
8 - 9 AM	259	3	262							456	242	X	X	X	X	X	X	X	X	X	X	X	X												
9 - 10 AM	187	4	191							298	137	X	X	X	X	X	X		X	X	X	X	X												
10 - 11 AM	235	9	244							248	121	X	X	X	X	X	X		X	X	X	X	X												
11 - Noon	327	6	333							353	128	X	X	X	X	X	X		X	X	X	X	X												
12 - 1 PM	343	6	349							398	152	X	X	X	X	X	X	X	X	X	X	X	X												
1 - 2 PM	316	3	319							395	158	X	X	X	X	X	X	X	X	X	X	X	X												
2 - 3 PM	362	5	367					X		395	161	X	X	X	X	X	X	X	X	X	X	X	X					X					1		
3 - 4 PM	420	5	425					X		519	145	X	X	X	X	X	X		X	X	X	X	X					X					1		
4 - 5 PM	583	22	605	X		X		X	X	549	197	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X	X	1		1	1	1	1
5 - 6 PM	498	13	511			X		X		590	184	X	X	X	X	X	X	X	X	X	X	X	X			X		X				1	1	1	1
6 - 7 PM	418	13	431					X		468	120	X	X	X	X	X	X		X	X	X	X	X					X					1		
7 - 8 PM	280	23	303							374	114	X	X	X	X	X	X		X		X	X	X												
8 - 9 PM	219	0	219							286	72	X	X	X	X	X	X				X		X												
9 - 10 PM	165	3	168							180	38	X	X	X	X	X	X																		
10 - 11 PM	110	0	110							132	15		X	X	X	X	X																		
11 - Midnight	64	4	68							73	8				X		X																		

SUMMARY OF RESULTS:

Warrant 1 - Cond. A was	not met:	1	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
Existing Signal Warrant A	not met:	5	hours satisfied requirements
Existing Signal Warrant B	not met:	1	hours satisfied requirements

AWS WARRANT ANALYSIS - 2042
WARRANT 1
LOCATION: **CSAH 16 (Stoltzman Rd) & CSAH 60 (Stadium Rd)**

Count Date:
Source:
Factor: 1.00

Population < 10,000?	NO
Speed over 40 mph?	NO
VOLUME REQ AT 70%	NO

APPROACH	DESCRIPTION	NUMBER OF LANES	SPEED (MPH)
Major Approach 1	CSAH 16 (Stoltzman Rd) NB	2	35
Major Approach 3	CSAH 16 (Stoltzman Rd) SB	2	35
Minor Approach 2	Stadium Court EB	1	30
Minor Approach 4	CSAH 60 (Stadium Rd) WB	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? **NO**

	MAJOR STREET										MINOR STREET												WARRANT MET SAME HOURS ON MAJOR AND MINOR STREETS						WARRANT MET SAME HOURS ON MAJOR AND MINOR STREETS						
	APPROACH VOLUME			WARRANT MET *						APPROACH VOLUME		WARRANT MET APPROACH 2 *						WARRANT MET APPROACH 4 *																	
				Cond. A	Cond. B	(A&B) Comb.		Existing Signal				Cond. A	Cond. B	(A&B) Comb.		Existing Signal		Cond. A	Cond. B	(A&B) Comb.		Existing Signal				(A&B) Comb.		Existing Signal				(A&B) Comb.		Existing Signal	
						80% of A	80% of B	60% of A	60% of B					80% of A	80% of B	60% of A	60% of B			80% of A	80% of B	60% of A	60% of B												
HOUR	1	3	TOTAL 1 + 3	600	900	480	720	360	540	2	4	150	75	120	60	90	45	150	75	120	60	90	45	Cond. A	Cond. B	80% of A	80% of B	60% of A	60% of B	Cond. A	Cond. B	80% of A or B	80% of A	80% of B	60% of A	60% of B
12 - 1 AM	40	2	42							45	6						X																		
1 - 2 AM	17	0	17							16	2																								
2 - 3 AM	26	0	26							23	9																								
3 - 4 AM	27	0	27							23	1																								
4 - 5 AM	25	0	25							9	20																								
5 - 6 AM	78	0	78							54	66						X				X		X												
6 - 7 AM	142	0	142							135	138		X	X	X	X	X		X	X	X	X	X												
7 - 8 AM	305	0	305							477	442	X	X	X	X	X	X	X	X	X	X	X	X												
8 - 9 AM	290	3	293							507	269	X	X	X	X	X	X	X	X	X	X	X	X												
9 - 10 AM	210	5	215							333	154	X	X	X	X	X	X	X	X	X	X	X	X												
10 - 11 AM	262	12	274							277	137	X	X	X	X	X	X		X	X	X	X	X												
11 - Noon	363	7	370					X		392	144	X	X	X	X	X	X		X	X	X	X	X					X					1	
12 - 1 PM	379	6	385					X		442	170	X	X	X	X	X	X	X	X	X	X	X	X					X					1	
1 - 2 PM	352	3	355							439	176	X	X	X	X	X	X	X	X	X	X	X	X												
2 - 3 PM	401	5	406					X		439	180	X	X	X	X	X	X	X	X	X	X	X	X					X					1	
3 - 4 PM	467	5	472					X		576	163	X	X	X	X	X	X	X	X	X	X	X	X					X					1	
4 - 5 PM	647	27	674	X		X		X	X	607	219	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X	X	1		1	1		1	1
5 - 6 PM	554	15	569			X		X	X	655	205	X	X	X	X	X	X	X	X	X	X	X	X			X		X	X			1	1		1	1
6 - 7 PM	464	16	480			X		X		521	135	X	X	X	X	X	X		X	X	X	X	X			X		X				1	1		1	
7 - 8 PM	313	28	341							415	127	X	X	X	X	X	X		X	X	X	X	X												
8 - 9 PM	245	0	245							319	82	X	X	X	X	X	X		X		X		X												
9 - 10 PM	185	3	188							200	45	X	X	X	X	X	X						X												
10 - 11 PM	123	0	123							148	19		X	X	X	X	X																		
11 - Midnight	71	5	76							82	10		X		X		X																		

SUMMARY OF RESULTS:

Warrant 1 - Cond. A was	not met:	1	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
Existing Signal Warrant A	not met:	7	hours satisfied requirements
Existing Signal Warrant B	not met:	2	hours satisfied requirements

Appendix C: Detailed Signal Warrant Analysis

TRAFFIC SIGNAL WARRANTS ANALYSIS - FORECAST 2022

120-0105_MAPO, CSAH 16 (Stoltzman Rd) & CSAH 60 (Stadium Rd)

ALLIANT

Background

Project Data		Analysis	Volumes	Direction	Analysis Approach	Roadway	Speed	Lanes	RT %
Project: 120-0105_MAPO		***Date:***	***Scenario:***	NB	Major Approach 1	CSAH 16 (Stoltzman Rd)	35	2	100%
Intersection: CSAH 16 (Stoltzman Rd) & CSAH 60 (Stadi		9/28/2021	2022	SB	Major Approach 3	CSAH 16 (Stoltzman Rd)	35	2	100%
Population < 10,000?	NO	***Analysis:***	***Format:***	EB	Minor Approach 2	Stadium Court	30	1	0%
70% Factor Used:	NO	SRM	15 MIN	WB	Minor Approach 4	CSAH 60 (Stadium Rd)	30	1	0%

Warrant Analysis

Hour	Major Approaches			Volumes Met		Minor Approaches			Volumes Met		Traffic Signal Warrants							Volumes Met		AWS Warrants	
	Major	Major	Total	A	B	Minor	Minor	Max	A	B	Same Hours		80% A	80% B	4-HR	Peak	Existing 60%		C1	C2	Same	80%
	1	3		600	900	2	4		150	75	1A	1B	1C		2	3B	1A	1B	300	200	C	D
12 - 1 AM	5	39	44			2	2	2														
1 - 2 AM	2	13	15			0	0	0														
2 - 3 AM	7	18	25			0	1	1														
3 - 4 AM	1	19	20			0	0	0														
4 - 5 AM	17	8	25			0	0	0														
5 - 6 AM	58	47	105			0	1	1														
6 - 7 AM	123	121	244			0	8	8														
7 - 8 AM	397	430	827	X		0	23	23											X			
8 - 9 AM	242	456	698	X		3	37	37											X			
9 - 10 AM	137	298	435			3	22	22											X			
10 - 11 AM	121	248	369			9	19	19											X			
11 - Noon	128	353	481			6	36	36											X			
12 - 1 PM	152	398	550			4	41	41											X			
1 - 2 PM	158	395	553			3	24	24											X			
2 - 3 PM	161	395	556			5	40	40											X			
3 - 4 PM	145	519	664	X		4	44	44											X			
4 - 5 PM	197	549	746	X		21	76	76		X				X				X	X			
5 - 6 PM	184	590	774	X		13	62	62						X				X	X			
6 - 7 PM	120	468	588			13	49	49										X	X			
7 - 8 PM	114	374	488			20	46	46											X			
8 - 9 PM	72	286	358			0	26	26											X			
9 - 10 PM	38	180	218			2	17	17														
10 - 11 PM	15	132	147			0	9	9														
11 - 12 AM	8	73	81			4	2	4														

Warrant Summary

Warrant & Description	Met	Req'd.	Warrant Met?	Warrant & Description	Met	Req'd.	Warrant Met?
Warrant 1A: Eight-Hour (Minimum Vehicular Volume)	0	8	NOT MET	**Existing Signal Justification:** Condition A	0	8	NOT MET
Warrant 1B: Eight-Hour (Interruption of Continuous Traffic)	0	8	NOT MET	**Existing Signal Justification:** Condition B	3	8	NOT MET
Warrant 1C: Eight-Hour (Combination of Warrants)	0	8	NOT MET	**All-Way Stop:** Criteria A (Signal Justified)	-	-	NOT MET
Warrant 2: Four-Hour	0	4	NOT MET	**All-Way Stop:** Criteria B (Crash History - 12 Months)	1	5	NOT MET
Warrant 3B: Peak Hour	0	1	NOT MET	**All-Way Stop:** Criteria C1 (Minimum Volumes)	13	8	MET
Warrant 7B: Crash History - 12 Months	1	5	NOT MET	**All-Way Stop:** Criteria C2 (Minor Approach - Maximum Delay)	10.6	30	NOT MET
Warrant 7C: Condition A or Condition B (80%)	2	8	NOT MET	**All-Way Stop:** Criteria D (80% of Criteria B, C1, & C2)	14	8	NOT MET

Source: *U.S. Department of Transportation FHWA Manual on Uniform Traffic Control Devices (2009 Edition)*

Prepared by Alliant Engineering, 10/1/2021

TRAFFIC SIGNAL WARRANTS ANALYSIS

120-0105_MAPO, CSAH 16 (Stoltzman Rd) & CSAH 60 (Stadium Rd)

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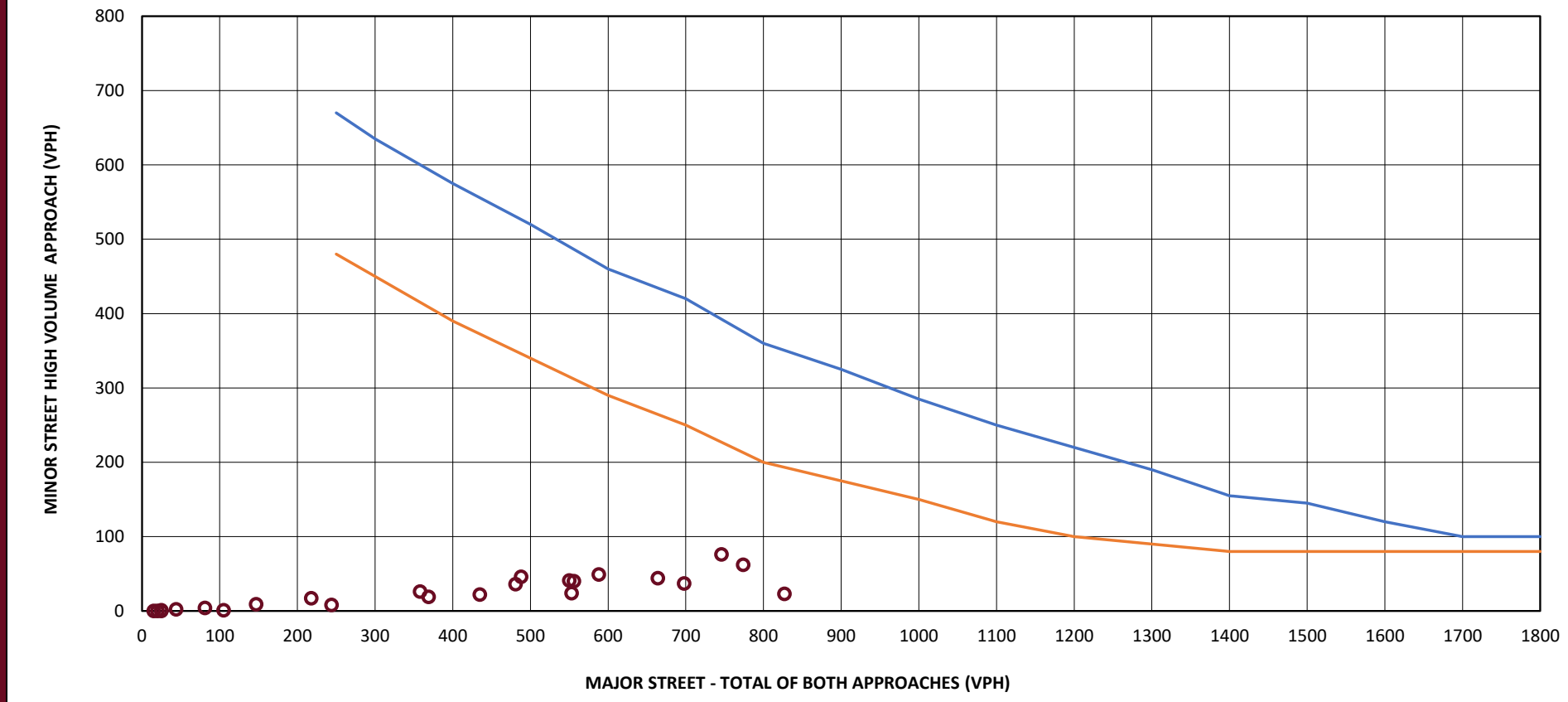
Warrant 2 & Warrant 3B



Scenario:	Major: 2	Minor: 1								
2022	70% Factor:	NO	Warrant 2 (Four-Hour)	Lower Threshold:	80	Hours Met:	0	Hours Req'd:	4	Met? NOT MET
			Warrant 3B (Peak Hour)		100		0		1	NOT MET

Source: *U.S. Department of Transportation FHWA Manual on Uniform Traffic Control Devices (2009 Edition)*

Warrant 2 (Four-Hour) Notes:

100%: 115 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 80 vph applies as the lower threshold volume for a minor-street approach with one lane.
70%: 80 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 60 vph applies as the lower threshold volume for a minor-street approach with one lane.

Warrant 3B (Peak Hour) Notes:

100%: 150 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 100 vph applies as the lower threshold volume for a minor-street approach with one lane.
70%: 100 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 75 vph applies as the lower threshold volume for a minor-street approach with one lane.

TRAFFIC SIGNAL WARRANTS ANALYSIS - FORECAST 2032

120-0105_MAPO, CSAH 16 (Stoltzman Rd) & CSAH 60 (Stadium Rd)

ALLIANT

Background

Project Data		Analysis	Volumes	Direction	Analysis Approach	Roadway	Speed	Lanes	RT %
Project: 120-0105_MAPO		***Date:***	***Scenario:***	NB	Major Approach 1	CSAH 16 (Stoltzman Rd)	35	2	100%
Intersection: CSAH 16 (Stoltzman Rd) & CSAH 60 (Stadi		9/28/2021	2032	SB	Major Approach 3	CSAH 16 (Stoltzman Rd)	35	2	100%
Population < 10,000?	NO	***Analysis:***	***Format:***	EB	Minor Approach 2	Stadium Court	30	1	0%
70% Factor Used:	NO	SRM	15 MIN	WB	Minor Approach 4	CSAH 60 (Stadium Rd)	30	1	0%

Warrant Analysis

Hour	Major Approaches			Volumes Met		Minor Approaches			Volumes Met		Traffic Signal Warrants							Volumes Met		AWS Warrants	
	Major	Major	Total	A	B	Minor	Minor	Max	A	B	Same Hours		80% A	80% B	4-HR	Peak	Existing 60%		C1	C2	Same	80%
	1	3		600	900	2	4		150	75	1A	1B	1C		2	3B	1A	1B	300	200	C	D
12 - 1 AM	5	42	47			2	2	2														
1 - 2 AM	2	14	16			0	0	0														
2 - 3 AM	7	18	25			0	1	1														
3 - 4 AM	1	20	21			0	0	0														
4 - 5 AM	18	8	26			0	0	0														
5 - 6 AM	62	51	113			0	1	1														
6 - 7 AM	131	130	261			0	8	8														
7 - 8 AM	419	454	873	X		0	26	26											X			
8 - 9 AM	257	481	738	X		3	39	39											X			
9 - 10 AM	148	315	463			3	24	24											X			
10 - 11 AM	129	262	391			9	21	21											X			
11 - Noon	137	372	509			6	40	40											X			
12 - 1 PM	162	420	582			4	45	45										X	X			
1 - 2 PM	170	417	587			3	26	26											X			
2 - 3 PM	172	416	588			5	44	44											X			
3 - 4 PM	155	547	702	X		4	48	48										X	X			
4 - 5 PM	210	578	788	X		22	80	80		X				X				X	X			
5 - 6 PM	196	623	819	X		13	66	66						X				X	X			
6 - 7 PM	129	494	623	X		13	54	54										X	X			
7 - 8 PM	123	394	517			22	50	50											X			
8 - 9 PM	79	302	381			0	29	29											X			
9 - 10 PM	41	192	233			2	19	19														
10 - 11 PM	15	142	157			0	9	9														
11 - 12 AM	8	77	85			4	2	4														

Warrant Summary

Warrant & Description	Met	Req'd.	Warrant Met?	Warrant & Description	Met	Req'd.	Warrant Met?
Warrant 1A: Eight-Hour (Minimum Vehicular Volume)	0	8	NOT MET	**Existing Signal Justification:** Condition A	0	8	NOT MET
Warrant 1B: Eight-Hour (Interruption of Continuous Traffic)	0	8	NOT MET	**Existing Signal Justification:** Condition B	5	8	NOT MET
Warrant 1C: Eight-Hour (Combination of Warrants)	0	8	NOT MET	**All-Way Stop:** Criteria A (Signal Justified)	-	-	NOT MET
Warrant 2: Four-Hour	0	4	NOT MET	**All-Way Stop:** Criteria B (Crash History - 12 Months)	1	5	NOT MET
Warrant 3B: Peak Hour	0	1	NOT MET	**All-Way Stop:** Criteria C1 (Minimum Volumes)	14	8	MET
Warrant 7B: Crash History - 12 Months	1	5	NOT MET	**All-Way Stop:** Criteria C2 (Minor Approach - Maximum Delay)	15.3	30	NOT MET
Warrant 7C: Condition A or Condition B (80%)	2	8	NOT MET	**All-Way Stop:** Criteria D (80% of Criteria B, C1, & C2)	15	8	NOT MET

Source: *U.S. Department of Transportation FHWA Manual on Uniform Traffic Control Devices (2009 Edition)*

Prepared by Alliant Engineering, 10/1/2021

TRAFFIC SIGNAL WARRANTS ANALYSIS

120-0105_MAPO, CSAH 16 (Stoltzman Rd) & CSAH 60 (Stadium Rd)

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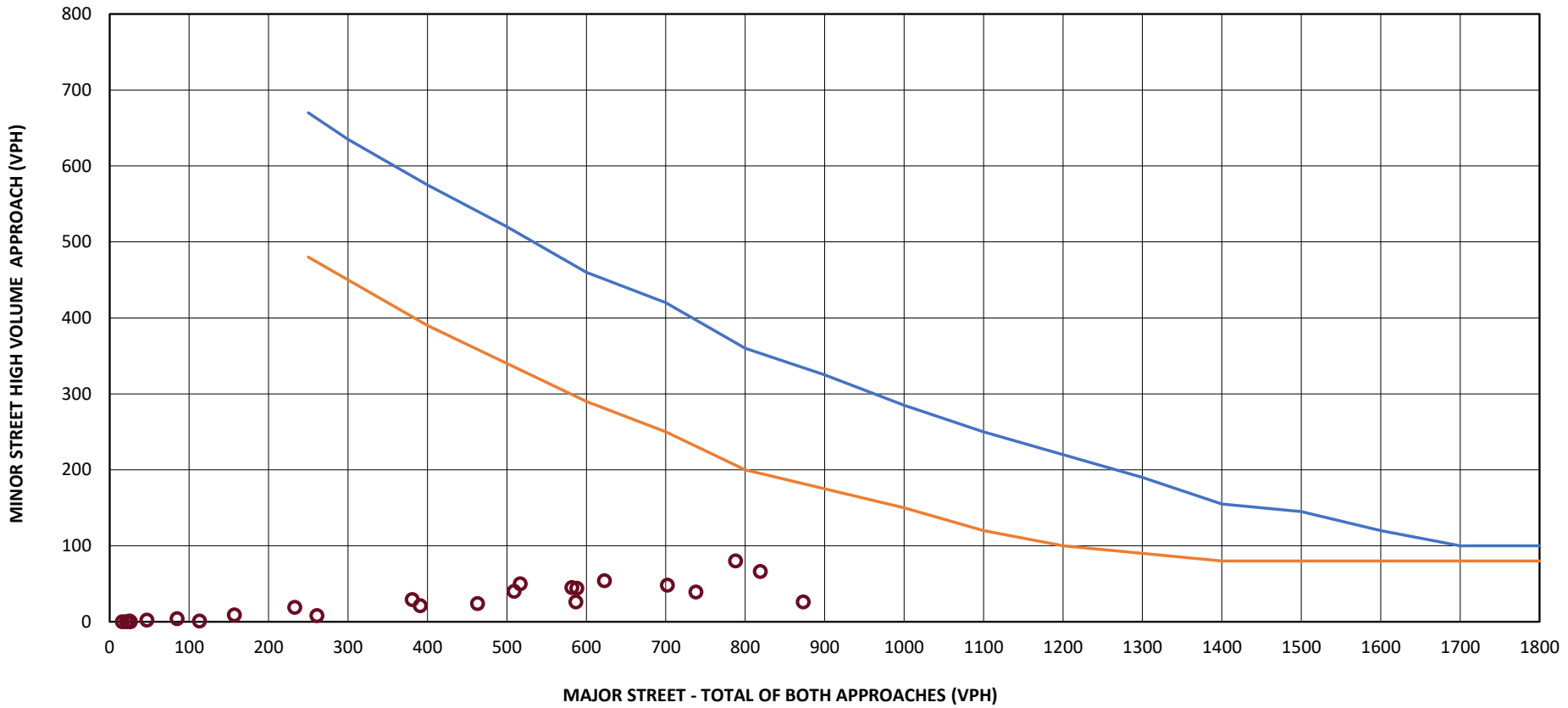
Warrant 2 & Warrant 3B



Scenario:	Major: 2	Minor: 1								
2032	70% Factor:	NO	Warrant 2 (Four-Hour)	Lower Threshold:	80	Hours Met:	0	Hours Req'd:	4	Met? NOT MET
			Warrant 3B (Peak Hour)		100		0		1	NOT MET

Source: *U.S. Department of Transportation FHWA Manual on Uniform Traffic Control Devices (2009 Edition)*

Warrant 2 (Four-Hour) Notes:

100%: 115 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 80 vph applies as the lower threshold volume for a minor-street approach with one lane.
70%: 80 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 60 vph applies as the lower threshold volume for a minor-street approach with one lane.

Warrant 3B (Peak Hour) Notes:

100%: 150 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 100 vph applies as the lower threshold volume for a minor-street approach with one lane.
70%: 100 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 75 vph applies as the lower threshold volume for a minor-street approach with one lane.

TRAFFIC SIGNAL WARRANTS ANALYSIS - FORECAST 2042

120-0105_MAPO, CSAH 16 (Stoltzman Rd) & CSAH 60 (Stadium Rd)

ALLIANT

Background

Project Data		Analysis	Volumes	Direction	Analysis Approach	Roadway	Speed	Lanes	RT %
Project: 120-0105_MAPO		***Date:***	***Scenario:***	NB	Major Approach 1	CSAH 16 (Stoltzman Rd)	35	2	100%
Intersection: CSAH 16 (Stoltzman Rd) & CSAH 60 (Stadi		9/28/2021	2042	SB	Major Approach 3	CSAH 16 (Stoltzman Rd)	35	2	100%
Population < 10,000?	NO	***Analysis:***	***Format:***	EB	Minor Approach 2	Stadium Court	30	1	0%
70% Factor Used:	NO	SRM	15 MIN	WB	Minor Approach 4	CSAH 60 (Stadium Rd)	30	1	0%

Warrant Analysis

Hour	Major Approaches			Volumes Met		Minor Approaches			Volumes Met		Traffic Signal Warrants							Volumes Met		AWS Warrants	
	Major 1	Major 3	Total	A 600	B 900	Minor 2	Minor 4	Max	A 150	B 75	Same Hours 1A	Same Hours 1B	80% A 1C	80% B 1C	4-HR 2	Peak 3B	Existing 60% 1A	Existing 60% 1B	C1 300	C2 200	Same C	80% D
12 - 1 AM	6	45	51			2	2	2														
1 - 2 AM	2	16	18			0	0	0														
2 - 3 AM	9	23	32			0	1	1														
3 - 4 AM	1	23	24			0	0	0														
4 - 5 AM	20	9	29			0	0	0														
5 - 6 AM	66	54	120			0	1	1														
6 - 7 AM	138	135	273			0	10	10														
7 - 8 AM	442	477	919	X	X	0	26	26											X			
8 - 9 AM	269	507	776	X		3	44	44											X			
9 - 10 AM	154	333	487			4	26	26											X			
10 - 11 AM	137	277	414			12	23	23											X			
11 - Noon	144	392	536			7	41	41											X			
12 - 1 PM	170	442	612	X		4	45	45										X	X			
1 - 2 PM	176	439	615	X		3	28	28											X			
2 - 3 PM	180	439	619	X		5	45	45										X	X			
3 - 4 PM	163	576	739	X		4	50	50										X	X			
4 - 5 PM	219	607	826	X		26	85	85		X				X				X	X			
5 - 6 PM	205	655	860	X		15	71	71						X				X	X			
6 - 7 PM	135	521	656	X		16	56	56										X	X			
7 - 8 PM	127	415	542			24	53	53										X	X			
8 - 9 PM	82	319	401			0	30	30											X			
9 - 10 PM	45	200	245			2	20	20														
10 - 11 PM	19	148	167			0	11	11														
11 - 12 AM	10	82	92			5	2	5														

Warrant Summary

Warrant & Description	Met	Req'd.	Warrant Met?	Warrant & Description	Met	Req'd.	Warrant Met?
Warrant 1A: Eight-Hour (Minimum Vehicular Volume)	0	8	NOT MET	**Existing Signal Justification:** Condition A	0	8	NOT MET
Warrant 1B: Eight-Hour (Interruption of Continuous Traffic)	0	8	NOT MET	**Existing Signal Justification:** Condition B	7	8	NOT MET
Warrant 1C: Eight-Hour (Combination of Warrants)	0	8	NOT MET	**All-Way Stop:** Criteria A (Signal Justified)	-	-	NOT MET
Warrant 2: Four-Hour	0	4	NOT MET	**All-Way Stop:** Criteria B (Crash History - 12 Months)	1	5	NOT MET
Warrant 3B: Peak Hour	0	1	NOT MET	**All-Way Stop:** Criteria C1 (Minimum Volumes)	14	8	MET
Warrant 7B: Crash History - 12 Months	1	5	NOT MET	**All-Way Stop:** Criteria C2 (Minor Approach - Maximum Delay)	15.3	30	NOT MET
Warrant 7C: Condition A or Condition B (80%)	2	8	NOT MET	**All-Way Stop:** Criteria D (80% of Criteria B, C1, & C2)	15	8	NOT MET

Source: *U.S. Department of Transportation FHWA Manual on Uniform Traffic Control Devices (2009 Edition)*

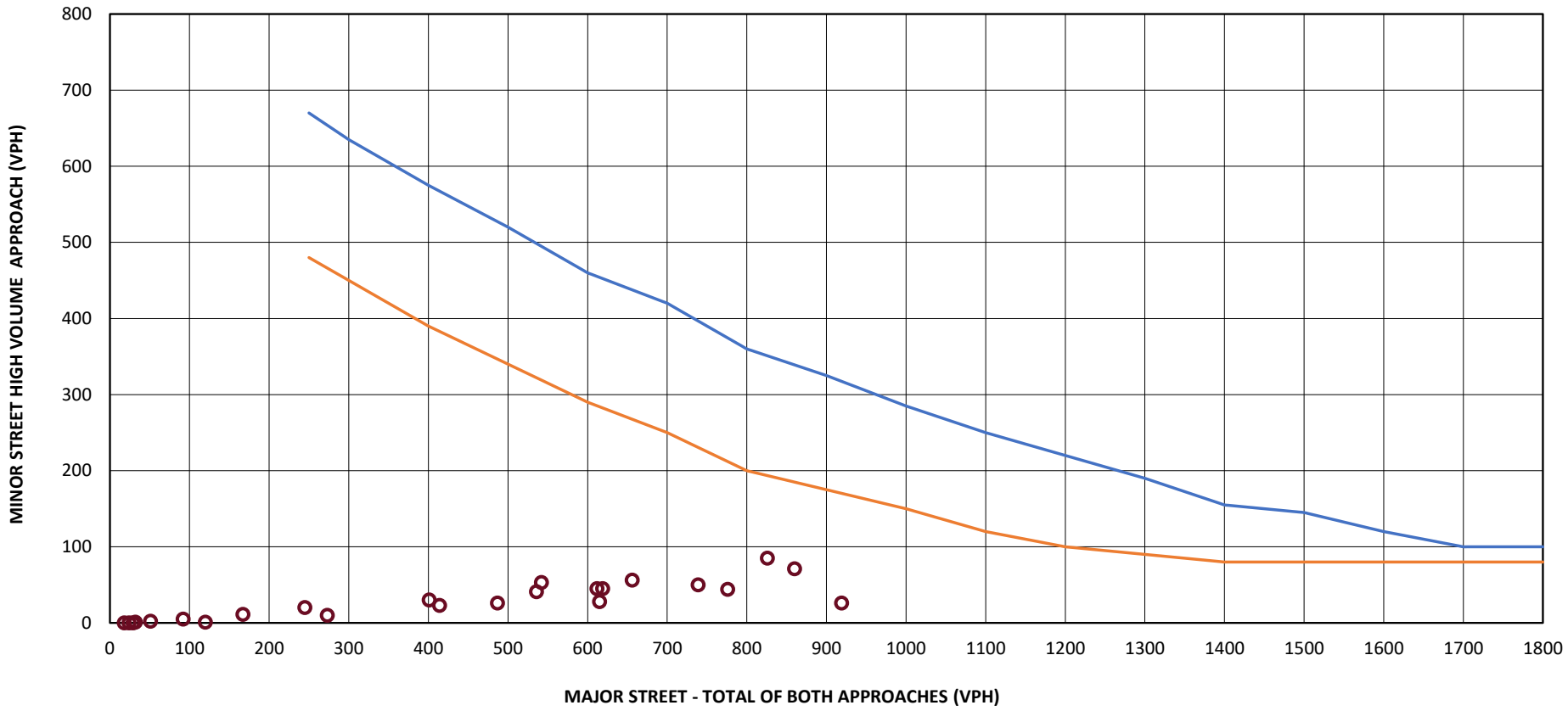
Prepared by Alliant Engineering, 10/1/2021

TRAFFIC SIGNAL WARRANTS ANALYSIS

120-0105_MAPO, CSAH 16 (Stoltzman Rd) & CSAH 60 (Stadium Rd)

ALLIANT

Warrant 2 & Warrant 3B



Scenario:	Major: 2	Minor: 1								
2042	70% Factor:	NO	Warrant 2 (Four-Hour)	Lower Threshold:	80	Hours Met:	0	Hours Req'd:	4	Met? NOT MET
			Warrant 3B (Peak Hour)		100		0		1	NOT MET

Source: *U.S. Department of Transportation FHWA Manual on Uniform Traffic Control Devices (2009 Edition)*

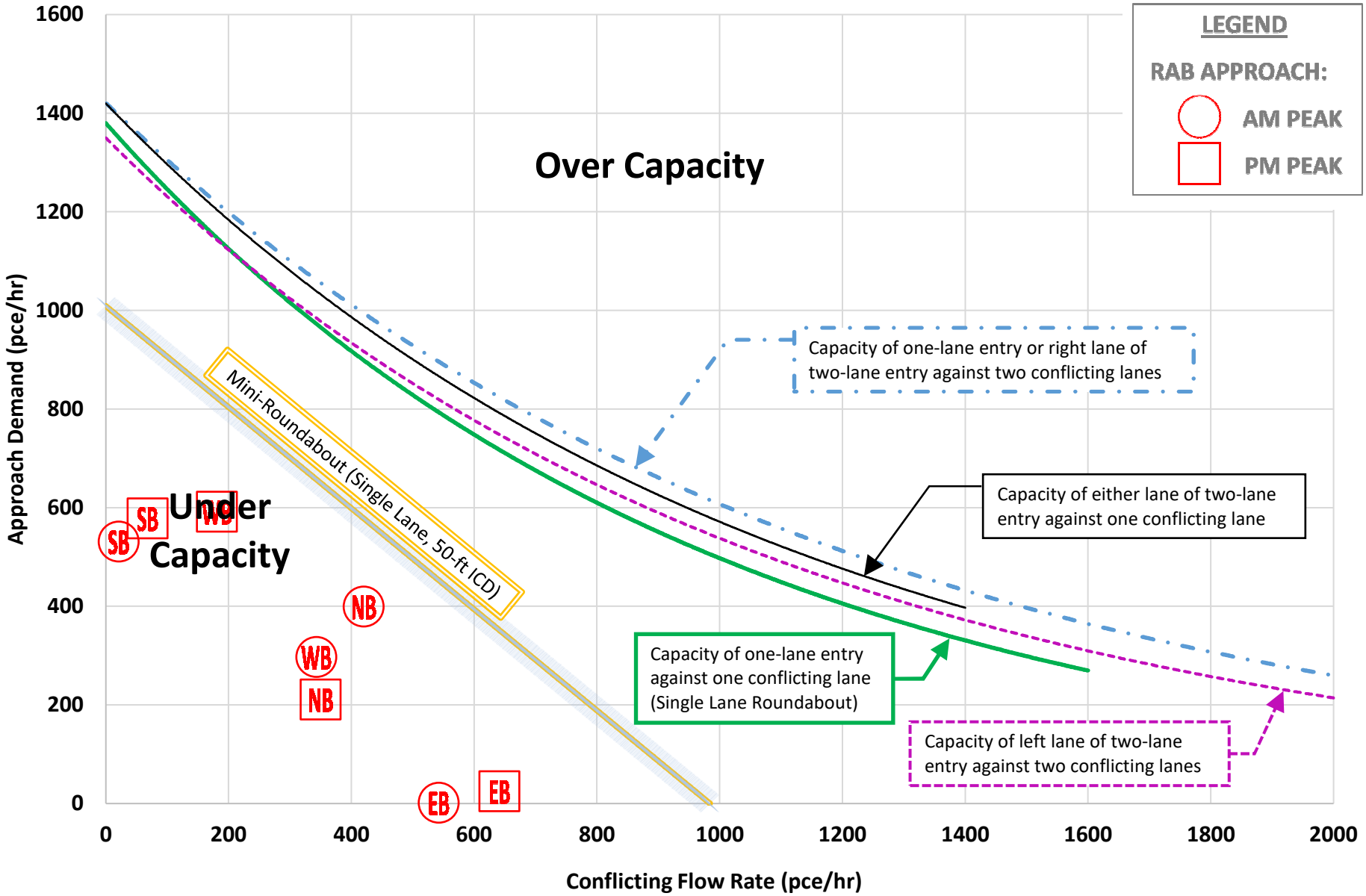
Warrant 2 (Four-Hour) Notes:

100%: 115 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 80 vph applies as the lower threshold volume for a minor-street approach with one lane.
70%: 80 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 60 vph applies as the lower threshold volume for a minor-street approach with one lane.

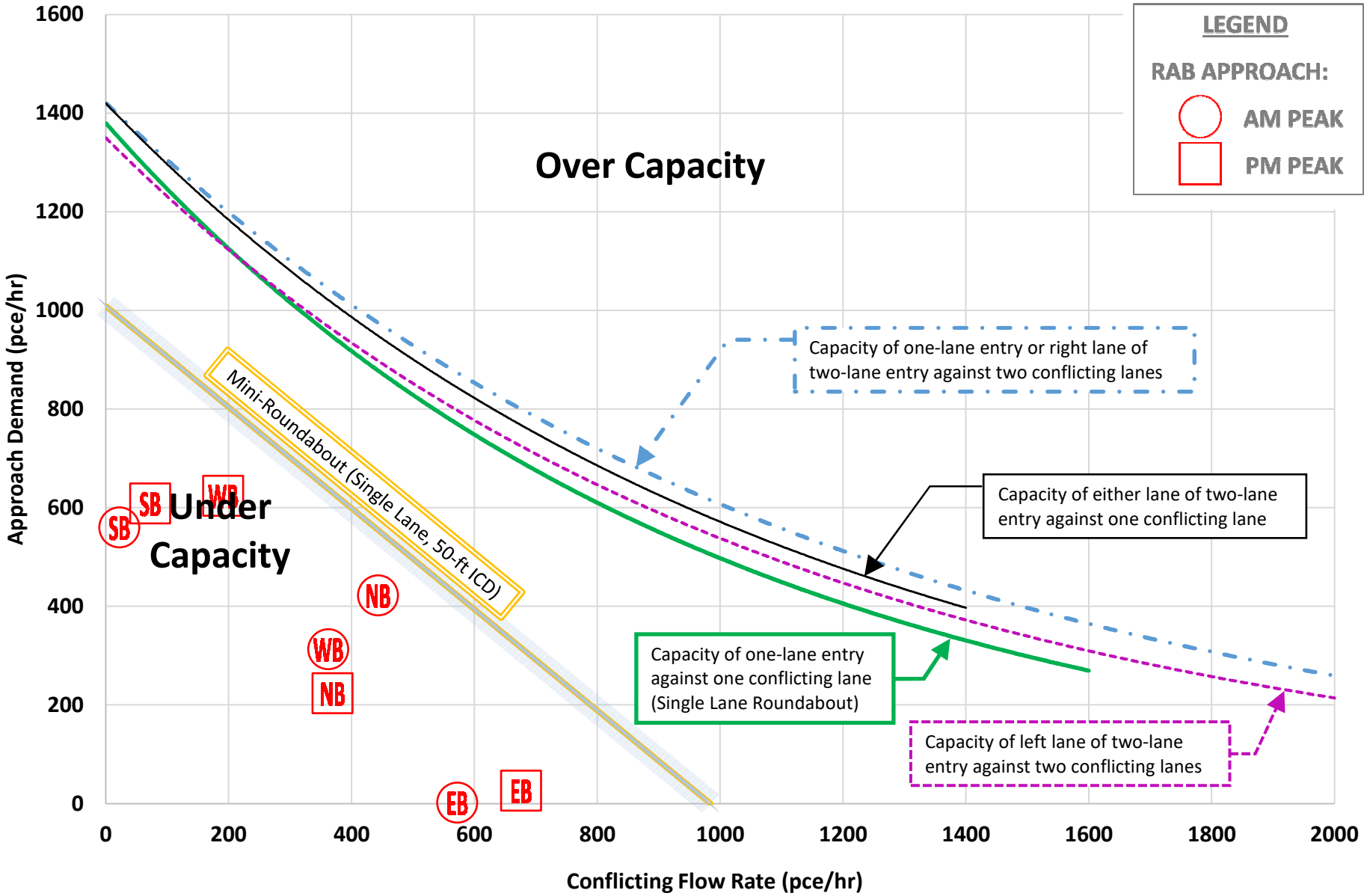
Warrant 3B (Peak Hour) Notes:

100%: 150 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 100 vph applies as the lower threshold volume for a minor-street approach with one lane.
70%: 100 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 75 vph applies as the lower threshold volume for a minor-street approach with one lane.

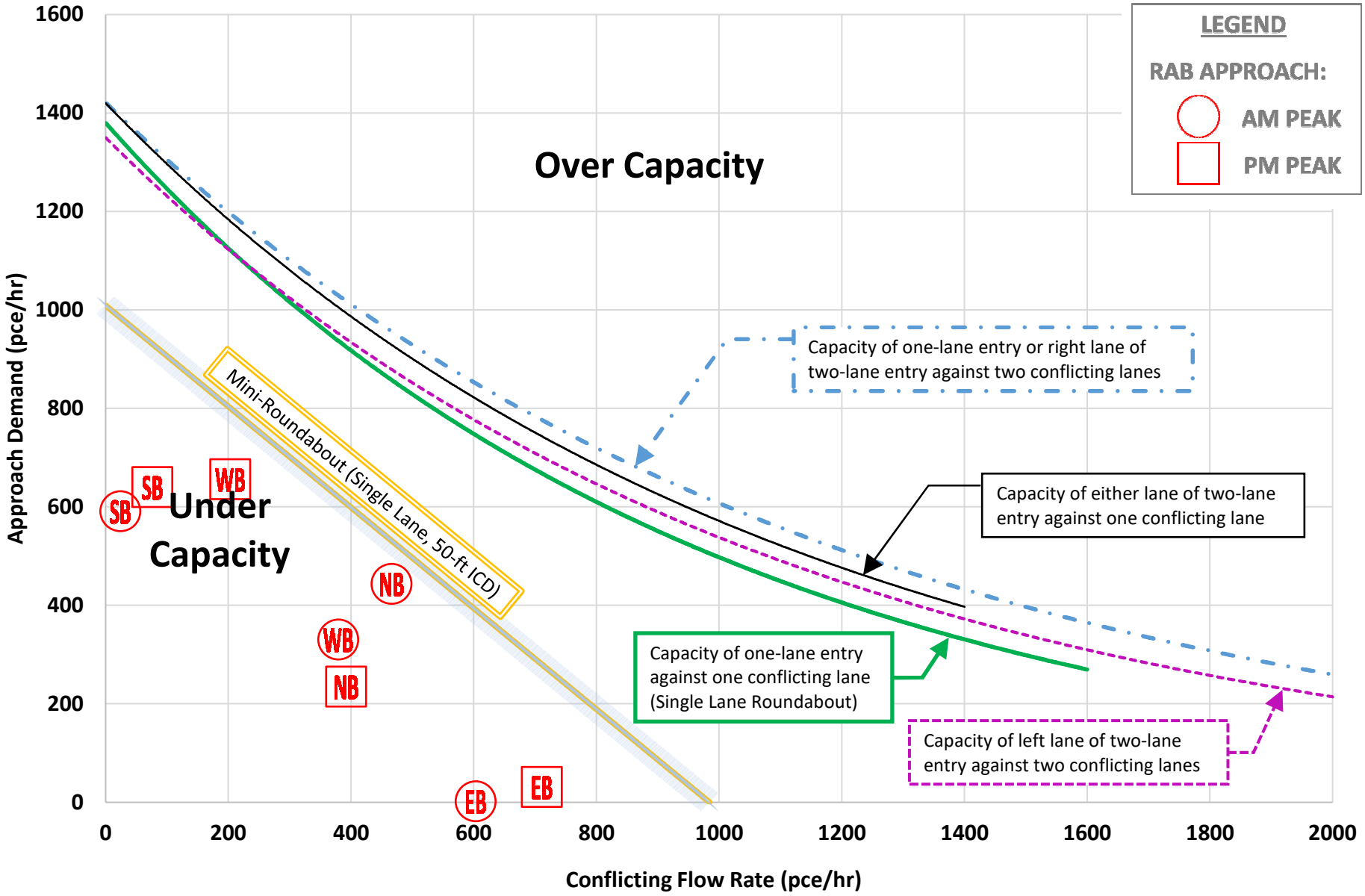
Appendix D: Planning-Level Roundabout Capacity Analysis



Forecast Year 2022 Roundabout Capacity Analysis - CSAH 16 (Stoltzman Rd) & CSAH 60 (Stadium Rd)



Forecast Year 2032 Roundabout Capacity Analysis - CSAH 16 (Stoltzman Rd) & CSAH 60 (Stadium Rd)



Forecast Year 2042 Roundabout Capacity Analysis - CSAH 16 (Stoltzman Rd) & CSAH 60 (Stadium Rd)

Appendix E: CMF ID 9120

CRASH MODIFICATION FACTORS CLEARINGHOUSE

CMF / CRF Details

CMF ID: 9120

Median treatment for ped/bike safety

Description: Install various median treatment: median fencing, sidewalk fencing, median brick planters, pedestrian islands

Prior Condition: ***No Prior Condition(s)***

Category: Roadside

Study: ***Analyzing the Impact of Median Treatments on Pedestrian/Bicyclist Safety, Zhang et al., 2017***

Star Quality Rating:	★★★☆☆ [View score details]

Crash Modification Factor (CMF)	
Value:	0.86
Adjusted Standard Error:	
Unadjusted Standard Error:	0.04

Crash Reduction Factor (CRF)	
Value:	14 *(This value indicates a **decrease** in crashes)*
Adjusted Standard Error:	

Unadjusted Standard Error:	4

Applicability

Crash Type:	All
Crash Severity:	All
Roadway Types:	Not specified
Number of Lanes:	
Road Division Type:	Divided by Median
Speed Limit:	
Area Type:	Urban
Traffic Volume:	
Time of Day:	All

If countermeasure is intersection-based

Intersection Type:	
Intersection Geometry:	
Traffic Control:	
Major Road Traffic Volume:	
Minor Road Traffic Volume:	

Development Details

Date Range of Data Used:	1998 to 2016
Municipality:	
State:	MD

Country:	USA
Type of Methodology Used:	2
Sample Size Used:	

Other Details

Included in Highway Safety Manual?	No
Date Added to Clearinghouse:	Jan-17-2018
Comments:	For all crashes, not just ped/bike related.

This site is funded by the U.S. Department of Transportation Federal Highway Administration and maintained by the University of North Carolina Highway Safety Research Center

Appendix F: CMF ID 9024

CMF / CRF Details

CMF ID: 9024

Install rectangular rapid flashing beacon (RRFB)

Description: Install rectangular rapid flashing beacon (RRFB)

Prior Condition: No RRFB

Category: Pedestrians

Study: *Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments*, Zegeer et al., 2017

Star Quality Rating:	[View score details]

Crash Modification Factor (CMF)	
Value:	0.526
Adjusted Standard Error:	
Unadjusted Standard Error:	0.377

Crash Reduction Factor (CRF)	
Value:	47.4 *(This value indicates a **decrease** in crashes)*
Adjusted Standard Error:	

Unadjusted Standard Error:	37.7

Applicability

Crash Type:	Vehicle/pedestrian
Crash Severity:	All
Roadway Types:	Minor Arterial
Number of Lanes:	2 to 8
Road Division Type:	
Speed Limit:	
Area Type:	Urban and suburban
Traffic Volume:	533 to 49402 *Annual Average Daily Traffic (AADT)*
Time of Day:	All

If countermeasure is intersection-based

Intersection Type:	
Intersection Geometry:	
Traffic Control:	
Major Road Traffic Volume:	
Minor Road Traffic Volume:	

Development Details

Date Range of Data Used:	2004 to 2013
Municipality:	
State:	AZ, FL, IL, MA, NY, NC, OR, VA, WI

Country:	USA
Type of Methodology Used:	7
Sample Size Used:	

Other Details

Included in Highway Safety Manual?	No
Date Added to Clearinghouse:	Nov-17-2017
Comments:	

This site is funded by the U.S. Department of Transportation Federal Highway Administration and maintained by the University of North Carolina Highway Safety Research Center

Appendix G: Excerpt from 2017 MnDOT Roundabout Study

Single Lane Roundabouts

Single lane roundabouts were the first roundabouts built in Minnesota. They tend to be considered the basic roundabout and likely the default option for most engineers and transportation officials. Only as traffic volumes increase are more complex and multi-lane roundabouts considered.

Based on the before-after analysis shown here, single lane roundabouts are showing a remarkable performance and decrease in the number of fatal, serious, and injury-related crashes. In fact, the total crash reduction at single lane roundabouts comes completely from the reduction in injury crashes, as property damage crashes remain at the same rate.

Table 12: Crash data from Single Lane Roundabouts with before construction and after construction crash data based on Severity

Description	Vehicles Entering	Total Crashes	K	A	B	C	PDO
Before Crashes	1,129,275,675	499	7	17	61	140	274
Before Crash Rate	NA	0.442	0.0062	0.015	0.054	0.124	0.243
After Crashes	1,604,841,825	518	1	4	35	87	391
After Crash Rate	NA	0.323	0.001	0.0025	0.022	0.054	0.244
Percent Increase/Decrease (By Rate)	**+42.1%**	**-27.0%**	**-89.9%**	**-83.4%**	**-60.9%**	**-56.3%**	**+0.4%**

Table 13: Crash data from Single Lane Roundabouts with before construction and after construction crash data based on the crash diagram

Description	Rear End	Sideswipe Same Dir	Left Turn	Ran-off-Road Left	Right Angle	Ran-off-Road Rt.	Head On	Sideswipe Opp
Before Crashes	137	15	45	10	197	14	19	13
Before Rate	0.121	0.013	0.040	0.009	0.174	0.012	0.017	0.012
After Crashes	132	42	11	31	89	69	28	5
After Rate	0.082	0.026	0.007	0.019	0.055	0.043	0.017	0.003
Percent Increase/Decr	**-32.2%**	**+97.0%**	**-82.8%**	**+118.1%**	**-68.2%**	**+246.8%**	**+3.7%**	**-72.9%**

Table 14: Crash data from Single Lane Roundabouts with before construction and after construction crash data based on the crash diagram/type

Description	Other	Not Applicable	Unknown	Blank/Right-Turn	Multi-Vehicle	Ped Crash	Bike Crash
Before Crashes	38	2	3	6	455	6	1
Before Crash Rate	0.034	0.002	0.003	0.005	0.403	0.005	0.001
After Crashes	73	18	2	18	313	10	3
After Crash Rate	0.045	0.011	0.001	0.011	0.195	0.006	0.002
Percent Increase/ Decrease	**+35.2%**	**+533.3%**	**-53.1%**	**+111.1%**	**-51.6%**	**+17.3%**	**+111.1%**

Appendix H: Detailed Measures of Effectiveness Results

Existing Year 2021 Conditions - AM Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road)	Movement Delay (sec/veh)	14.3	0.0	0.0	57.0	29.8	7.6	0.0	2.2	0.9	8.1	2.1	2.0	6.4
	Total Delay (hr)	0.0	0.0	0.0	0.3	0.0	0.6	0.0	0.2	0.0	1.0	0.1	0.0	2.2
	Movement LOS	B	A	A	F	D	A	A	A	A	A	A	A	A
	Movement Volume	1	0	0	20	2	259	0	315	57	420	106	8	1188
	Movement 95th Queue (ft)	14	14	14	71	71	111	0	7	7	140	33	33	
	Storage Bay Distance (ft)	0	0	0	0	0	0	0	0	0	130	0	0	
	Approach Delay (sec/veh)	14.3			11.3			2.0			6.8			
	Approach LOS	B			B			A			A			

Existing Year 2021 Conditions - PM Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road)	Movement Delay (sec/veh)	14.4	12.2	3.1	18.2	16.2	11.4	2.5	1.7	0.5	4.0	1.7	1.5	6.8
	Total Delay (hr)	0.1	0.0	0.0	0.3	0.0	1.6	0.0	0.1	0.0	0.3	0.1	0.0	2.5
	Movement LOS	B	B	A	C	C	B	A	A	A	A	A	A	A
	Movement Volume	16	10	1	61	2	508	1	156	48	308	240	4	1355
	Movement 95th Queue (ft)	47	47	47	72	72	199	3	5	5	65	0	0	
	Storage Bay Distance (ft)	0	0	0	0	0	0	0	0	0	130	0	0	
	Approach Delay (sec/veh)	13.2			12.1			1.4			3.0			
	Approach LOS	B			B			A			A			

Alternative 0 (No Build), Forecast Year 2022 - AM Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road)	Movement Delay (sec/veh)	13.9	0.0	0.0	57.8	26.1	7.8	0.0	2.2	0.9	8.2	2.2	1.9	6.4
	Total Delay (hr)	0.0	0.0	0.0	0.3	0.0	0.6	0.0	0.2	0.0	1.0	0.1	0.0	2.2
	Movement LOS	B	A	A	F	D	A	A	A	A	A	A	A	A
	Movement Volume	1	0	0	19	2	263	0	318	57	423	106	8	1197
	Movement 95th Queue (ft)	14	14	14	71	71	112	0	7	7	139	0	0	
	Storage Bay Distance (ft)	0	0	0	0	0	0	0	0	0	130	0	0	
	Approach Delay (sec/veh)	13.9			11.3			2.0			6.9			
	Approach LOS	B			B			A			A			

Alternative 0 (No Build), Forecast Year 2022 - PM Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road)	Movement Delay (sec/veh)	16.3	13.0	2.2	17.7	17.5	11.6	2.3	1.7	0.5	4.0	1.7	1.5	6.9
	Total Delay (hr)	0.1	0.0	0.0	0.3	0.0	1.7	0.0	0.1	0.0	0.4	0.1	0.0	2.7
	Movement LOS	C	B	A	C	C	B	A	A	A	A	A	A	A
	Movement Volume	15	9	1	62	1	517	1	158	46	311	247	4	1372
	Movement 95th Queue (ft)	46	46	46	75	75	203	3	6	6	62	0	0	
	Storage Bay Distance (ft)	0	0	0	0	0	0	0	0	0	130	0	0	
	Approach Delay (sec/veh)	14.5			12.3			1.4			3.0			
	Approach LOS	B			B			A			A			

Alternative 1, 2, & 3, Forecast Year 2022 - AM Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road)	Movement Delay (sec/veh)	13.9	0.0	0.0	57.8	26.1	7.8	0.0	2.2	0.9	8.2	2.2	1.9	6.4
	Total Delay (hr)	0.0	0.0	0.0	0.3	0.0	0.6	0.0	0.2	0.0	1.0	0.1	0.0	2.2
	Movement LOS	B	A	A	F	D	A	A	A	A	A	A	A	A
	Movement Volume	1	0	0	19	2	263	0	318	57	423	106	8	1197
	Movement 95th Queue (ft)	14	14	14	71	71	112	0	7	7	139	0	0	
	Storage Bay Distance (ft)	0	0	0	0	0	0	0	0	0	130	0	0	
	Approach Delay (sec/veh)	13.9			11.3			2.0			6.9			
	Approach LOS	B			B			A			A			

Alternative 1, 2, & 3, Forecast Year 2022 - PM Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road)	Movement Delay (sec/veh)	16.3	13.0	2.2	17.7	17.5	11.6	2.3	1.7	0.5	4.0	1.7	1.5	6.9
	Total Delay (hr)	0.1	0.0	0.0	0.3	0.0	1.7	0.0	0.1	0.0	0.4	0.1	0.0	2.7
	Movement LOS	C	B	A	C	C	B	A	A	A	A	A	A	A
	Movement Volume	15	9	1	62	1	517	1	158	46	311	247	4	1372
	Movement 95th Queue (ft)	46	46	46	75	75	203	3	6	6	62	0	0	
	Storage Bay Distance (ft)	0	0	0	0	0	0	0	0	0	130	0	0	
	Approach Delay (sec/veh)	14.5			12.3			1.4			3.0			
	Approach LOS	B			B			A			A			

Alternative 0 (No Build), Forecast Year 2032 - AM Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road)	Movement Delay (sec/veh)	15.4	0.0	0.0	90.3	79.3	8.9	0.9	2.3	1.0	10.1	2.4	2.4	7.9
	Total Delay (hr)	0.0	0.0	0.0	0.5	0.0	0.7	0.0	0.2	0.0	1.2	0.1	0.0	2.7
	Movement LOS	C	A	A	F	F	A	A	A	A	B	A	A	A
	Movement Volume	1	0	0	20	2	281	1	345	62	439	112	8	1271
	Movement 95th Queue (ft)	13	13	13	92	92	121	0	10	10	165	87	87	
	Storage Bay Distance (ft)	0	0	0	0	0	0	0	0	0	130	0	0	
	Approach Delay (sec/veh)	15.4			14.7			2.1			8.4			
	Approach LOS	C			B			A			A			

Alternative 0 (No Build), Forecast Year 2032 - PM Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road)	Movement Delay (sec/veh)	16.9	12.9	3.0	19.0	26.3	13.6	1.2	1.8	0.5	4.3	2.0	1.8	7.7
	Total Delay (hr)	0.1	0.0	0.0	0.3	0.0	2.0	0.0	0.1	0.0	0.4	0.1	0.0	3.0
	Movement LOS	C	B	A	C	D	B	A	A	A	A	A	A	A
	Movement Volume	17	10	1	64	1	531	1	166	49	335	268	3	1446
	Movement 95th Queue (ft)	47	47	47	75	75	240	0	5	5	69	0	0	
	Storage Bay Distance (ft)	0	0	0	0	0	0	0	0	0	130	0	0	
	Approach Delay (sec/veh)	15.0			14.2			1.5			3.3			
	Approach LOS	B			B			A			A			

Alternative 1, 2, & 3 Forecast Year 2032 - AM Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road)	Movement Delay (sec/veh)	15.4	0.0	0.0	90.3	79.3	8.9	0.9	2.3	1.0	10.1	2.4	2.4	7.9
	Total Delay (hr)	0.0	0.0	0.0	0.5	0.0	0.7	0.0	0.2	0.0	1.2	0.1	0.0	2.7
	Movement LOS	C	A	A	F	F	A	A	A	A	B	A	A	A
	Movement Volume	1	0	0	20	2	281	1	345	62	439	112	8	1271
	Movement 95th Queue (ft)	13	13	13	92	92	121	0	10	10	165	87	87	
	Storage Bay Distance (ft)	0	0	0	0	0	0	0	0	0	130	0	0	
	Approach Delay (sec/veh)	15.4			14.7			2.1			8.4			
	Approach LOS	C			B			A			A			

Alternative 1, 2, & 3 Forecast Year 2032 - PM Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road)	Movement Delay (sec/veh)	16.9	12.9	3.0	19.0	26.3	13.6	1.2	1.8	0.5	4.3	2.0	1.8	7.7
	Total Delay (hr)	0.1	0.0	0.0	0.3	0.0	2.0	0.0	0.1	0.0	0.4	0.1	0.0	3.0
	Movement LOS	C	B	A	C	D	B	A	A	A	A	A	A	A
	Movement Volume	17	10	1	64	1	531	1	166	49	335	268	3	1446
	Movement 95th Queue (ft)	47	47	47	75	75	240	0	5	5	69	0	0	
	Storage Bay Distance (ft)	0	0	0	0	0	0	0	0	0	130	0	0	
	Approach Delay (sec/veh)	15.0			14.2			1.5			3.3			
	Approach LOS	B			B			A			A			

Alternative 0 (No Build), Forecast Year 2042 - AM Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL*	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road)	Movement Delay (sec/veh)	8.0	20.9	0.0	103.7	115.9	10.9	1.3	2.4	0.9	11.3	2.5	3.0	8.7
	Total Delay (hr)	0.0	0.0	0.0	0.5	0.1	0.9	0.0	0.3	0.0	1.4	0.1	0.0	3.3
	Movement LOS	A	C	A	F	F	B	A	A	A	B	A	A	A
	Movement Volume	1	1	0	18	2	297	1	377	65	445	120	10	1337
	Movement 95th Queue (ft)	12	12	12	92	92	141	0	8	8	172	124	124	
	Storage Bay Distance (ft)	0	0	0	0	0	0	0	0	0	130	0	0	
	Approach Delay (sec/veh)		14.5			16.8			2.2			9.3		
	Approach LOS		B			C			A			A		

Alternative 0 (No Build), Forecast Year 2042 - PM Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road)	Movement Delay (sec/veh)	16.5	15.1	5.7	20.5	34.2	15.3	1.0	1.9	0.5	4.5	2.1	1.8	8.5
	Total Delay (hr)	0.1	0.1	0.0	0.4	0.0	2.4	0.0	0.1	0.0	0.4	0.2	0.0	3.7
	Movement LOS	C	C	A	C	D	C	A	A	A	A	A	A	A
	Movement Volume	17	12	1	70	1	556	1	179	51	349	279	4	1520
	Movement 95th Queue (ft)	52	52	52	77	77	260	0	4	4	75	0	0	
	Storage Bay Distance (ft)	0	0	0	0	0	0	0	0	0	130	0	0	
	Approach Delay (sec/veh)		15.6			15.9			1.6			3.4		
	Approach LOS		C			C			A			A		

*Due to the random nature of traffic modeling, and the extremely low volume of the EBL movement, the original five model runs for the 2042 AM peak hour reported a movement volume of 0 for the EBL movement. With a movement volume of zero, the delay for that movement was therefore also zero. In an attempt to get a non-zero delay, the model was run 10 total times. Between the original five runs and the second round of ten runs, an aggregate five runs was chosen and averaged to obtain a non-zero EBL movement volume. This results in delay for the EBL movement in the 2042 AM being lower than the 2022 and 2032 AM. Typically the delay would be expected to increase over time with growing volumes. However, the EBL movement volume is so low that it will not significantly impact overall or worst approach LOS, or benefit/cost ratios.

Alternative 1, 2, & 3, Forecast Year 2042 - AM Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL*	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road)	Movement Delay (sec/veh)	8.0	20.9	0.0	103.7	115.9	10.9	1.3	2.4	0.9	11.3	2.5	3.0	8.7
	Total Delay (hr)	0.0	0.0	0.0	0.5	0.1	0.9	0.0	0.3	0.0	1.4	0.1	0.0	3.3
	Movement LOS	A	C	A	F	F	B	A	A	A	B	A	A	A
	Movement Volume	1	1	0	18	2	297	1	377	65	445	120	10	1337
	Movement 95th Queue (ft)	12	12	12	92	92	141	0	8	8	172	124	124	
	Storage Bay Distance (ft)	0	0	0	0	0	0	0	0	0	130	0	0	
	Approach Delay (sec/veh)	14.5			16.8			2.2			9.3			
	Approach LOS	B			C			A			A			

Alternative 1, 2, & 3, Forecast Year 2042 - PM Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road)	Movement Delay (sec/veh)	16.5	15.1	5.7	20.5	34.2	15.3	1.0	1.9	0.5	4.5	2.1	1.8	8.5
	Total Delay (hr)	0.1	0.1	0.0	0.4	0.0	2.4	0.0	0.1	0.0	0.4	0.2	0.0	3.7
	Movement LOS	C	C	A	C	D	C	A	A	A	A	A	A	A
	Movement Volume	17	12	1	70	1	556	1	179	51	349	279	4	1520
	Movement 95th Queue (ft)	52	52	52	77	77	260	0	4	4	75	0	0	
	Storage Bay Distance (ft)	0	0	0	0	0	0	0	0	0	130	0	0	
	Approach Delay (sec/veh)	15.6			15.9			1.6			3.4			
	Approach LOS	C			C			A			A			

*Due to the random nature of traffic modeling, and the extremely low volume of the EBL movement, the original five model runs for the 2042 AM peak hour reported a movement volume of 0 for the EBL movement. With a movement volume of zero, the delay for that movement was therefore also zero. In an attempt to get a non-zero delay, the model was run 10 total times. Between the original five runs and the second round of ten runs, an aggregate five runs was chosen and averaged to obtain a non-zero EBL movement volume. This results in delay for the EBL movement in the 2042 AM being lower than the 2022 and 2032 AM. Typically the delay would be expected to increase over time with growing volumes. However, the EBL movement volume is so low that it will not significantly impact overall or worst approach LOS, or benefit/cost ratios.

Appendix I: Detailed Benefit/Cost Analysis

CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road) - Mankato

Crash Cost Analysis

	Right Angle	Left Turn	Rear End	Sideswipe	Run Off Road	Head On	Right Turn	Pedestrian Crash Other	Total
All Crashes	1	2	0	0	2	0	1	4	10
Fatal									
A Injury									
B Injury		1							8
C Injury					1			1	
PDO	1	1					1	2	
Cross-Street Crashes									0
Fatal									
A Injury									
B Injury									2
C Injury								1	
PDO					1				
Alternative 0 No Build									
Total Crashes	1.0	2.0	0.0	0.0	2.0	0.0	1.0	4.0	10.0
Fatal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A Injury	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B Injury	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
C Injury	0.0	0.0	0.0	0.0	1.0	0.0	0.0	2.0	3.0
PDO	1.0	1.0	0.0	0.0	1.0	0.0	1.0	2.0	6.0
								Crash Rate =	**0.25**
Alternative 1 Through/Stop with Pedestrian Refuges									
CMF = 0.86	CMF ID 9120 (1)								
Total Crashes	0.9	1.7	0.0	0.0	1.9	0.0	0.9	3.6	8.9
Fatal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A Injury	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B Injury	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.9
C Injury	0.0	0.0	0.0	0.0	0.9	0.0	0.0	1.9	2.7
PDO	0.9	0.9	0.0	0.0	1.0	0.0	0.9	1.7	5.3
								Crash Rate =	**0.22**
Alternative 4 Compact Roundabout									
	2017 MnDOT RAB Study (2)								
Total Crashes									
Fatal	0.00								
A Injury	0.01								
B Injury	0.07								
C Injury	0.17								
PDO	0.75							Crash Rate =	**0.32**

(1) CMF ID 9120: Median treatment for ped/bike safety
(2) 2017 MnDOT RAB Study: *A Study of the Traffic Safety at Roundabouts in Minnesota*

2021 Annual Crash Cost

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	Total Entering Volume	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
Alternative 0 No Build	Thru/Stop	K	0.0%	0.25	4,018,042	0.000	$ 12,800,000	$ -
		A	0.0%			0.000	$ 720,000	$ -
		B	10.0%			0.200	$ 220,000	$ 44,000.00
		C	30.0%			0.600	$ 120,000	$ 72,000.00
		PDO	60.0%			1.200	$ 13,000	$ 15,600.00
		Total	**100%**			**2.000**		**$ 131,600.00**
Scenario	**Traffic Control**	**Severity**	**Severity Proportion**	**Crash Rate**	**Total Entering Volume**	**Average Crashes / Year (No.)**	**Cost / Crash ($)**	**Cost / Year ($)**
Alternative 1 Through/Stop with Pedestrian Refuges	Thru/Stop	K	0.0%	0.22	4,018,042	0.000	$ 12,800,000	$ -
		A	0.0%			0.000	$ 720,000	$ -
		B	9.7%			0.172	$ 220,000	$ 37,840.00
		C	30.6%			0.544	$ 120,000	$ 65,280.00
		PDO	59.7%			1.060	$ 13,000	$ 13,780.00
		Total	**100%**			**1.776**		**$ 116,900.00**
Scenario	**Traffic Control**	**Severity**	**Severity Proportion**	**Crash Rate**	**Total Entering Volume**	**Average Crashes / Year (No.)**	**Cost / Crash ($)**	**Cost / Year ($)**
Alternative 4 Compact Roundabout	Roundabout	K	0.2%	0.32	4,018,042	0.002	$ 12,800,000	$ 31,772.01
		A	0.8%			0.010	$ 720,000	$ 7,148.70
		B	6.8%			0.087	$ 220,000	$ 19,112.85
		C	16.8%			0.216	$ 120,000	$ 25,914.04
		PDO	75.5%			0.971	$ 13,000	$ 12,616.96
		Total	**100%**			**1.286**		**$ 96,564.56**

Cost/Crash reflects MnDOT's Cost-Effectiveness & Benefit-Cost Analysis for Transportation Projects Appendix A, published July 2020. (http://www.dot.state.mn.us/planning/program/appendix_a.html)

2042 Annual Crash Cost

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	Total Entering Volume	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)	
Alternative 0 No Build	Thru/Stop	K	0.0%	0.25	4,461,714	0.000	$ 12,800,000	N/A	40.0%
		A	0.0%			0.000	$ 720,000	$ -	
		B	10.0%			0.111	$ 220,000	$ 24,429.24	
		C	30.0%			0.333	$ 120,000	$ 39,975.12	
		PDO	60.0%			0.666	$ 13,000	$ 8,661.28	
		Total	**100%**			**1.110**		**$ 73,065.64**	
Scenario	**Traffic Control**	**Severity**	**Severity Proportion**	**Crash Rate**	**Total Entering Volume**	**Average Crashes / Year (No.)**	**Cost / Crash ($)**	**Cost / Year ($)**	
Alternative 1 Through/Stop with Pedestrian Refuges	Thru/Stop	K	0.0%	0.22	4,461,714	0.000	$ 12,800,000	N/A	
		A	0.0%			0.000	$ 720,000	$ -	
		B	9.7%			0.095	$ 220,000	$ 21,009.15	
		C	30.6%			0.302	$ 120,000	$ 36,244.11	
		PDO	59.7%			0.589	$ 13,000	$ 7,650.79	
		Total	**100%**			**0.986**		**$ 64,904.05**	
Scenario	**Traffic Control**	**Severity**	**Severity Proportion**	**Crash Rate**	**Total Entering Volume**	**Average Crashes / Year (No.)**	**Cost / Crash ($)**	**Cost / Year ($)**	
Alternative 4 Compact Roundabout	Roundabout	K	0.2%	0.32	4,461,714	0.003	$ 12,800,000	N/A	24.5%
		A	0.8%			0.011	$ 720,000	$ 7,938.06	
		B	6.8%			0.096	$ 220,000	$ 21,223.29	
		C	16.8%			0.240	$ 120,000	$ 28,775.47	
		PDO	75.5%			1.078	$ 13,000	$ 14,010.13	
		Total	**100%**			**1.428**		**$ 71,946.95**	

Cost/Crash reflects MnDOT's Cost-Effectiveness & Benefit-Cost Analysis for Transportation Projects Appendix A, published July 2020. (http://www.dot.state.mn.us/planning/program/appendix_a.html)

CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road) - Mankato

Crash Cost Analysis

	Right Angle	Left Turn	Rear End	Sideswipe	Run Off Road	Head On	Right Turn	Pedestrian Crash Other	Total
All Crashes	1	2	0	0	2	0	1	4	10
Fatal									
A Injury									
B Injury		1							8
C Injury					1			1	
PDO	1	1					1	2	
Cross-Street Crashes									0
Fatal									
A Injury									
B Injury									2
C Injury								1	
PDO					1				
Alternative 0 No Build									
Total Crashes	1.0	2.0	0.0	0.0	2.0	0.0	1.0	4.0	10.0
Fatal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A Injury	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B Injury	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
C Injury	0.0	0.0	0.0	0.0	1.0	0.0	0.0	2.0	3.0
PDO	1.0	1.0	0.0	0.0	1.0	0.0	1.0	2.0	6.0
								Crash Rate =	**0.25**
Alternative 2 Through/Stop with RRFB									
CMF = 0.526	CMF ID 9024 (3)								
Total Crashes	1.0	2.0	0.0	0.0	2.0	0.0	1.0	3.1	9.1
Fatal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A Injury	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B Injury	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
C Injury	0.0	0.0	0.0	0.0	1.0	0.0	0.0	**1.1**	2.1
PDO	1.0	1.0	0.0	0.0	1.0	0.0	1.0	2.0	6.0
								Crash Rate =	**0.23**
Alternative 3 Through/Stop with Ped Refuges, RRFB									
CMF = 0.86, 0.526	CMF ID 9120 (1), CMF ID 9024 (3)								
Total Crashes	0.9	1.7	0.0	0.0	1.9	0.0	0.9	3.0	8.3
Fatal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A Injury	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B Injury	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.9
C Injury	0.0	0.0	0.0	0.0	0.9	0.0	0.0	**1.3**	2.1
PDO	0.9	0.9	0.0	0.0	1.0	0.0	0.9	1.7	5.3
								Crash Rate =	**0.21**

(1) CMF ID 9120: Median treatment for ped/bike safety
(3) CMF ID 9024: Install Rectangular rapid flashing beacon (RRFB)

2021 Annual Crash Cost

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	Total Entering Volume	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
Alternative 0 No Build	Thru/Stop	K	0.0%	0.25	4,018,042	0.000	$ 12,800,000	$ -
		A	0.0%			0.000	$ 720,000	$ -
		B	10.0%			0.200	$ 220,000	$ 44,000.00
		C	30.0%			0.600	$ 120,000	$ 72,000.00
		PDO	60.0%			1.200	$ 13,000	$ 15,600.00
		Total	**100%**			**2.000**		**$ 131,600.00**
Scenario	**Traffic Control**	**Severity**	**Severity Proportion**	**Crash Rate**	**Total Entering Volume**	**Average Crashes / Year (No.)**	**Cost / Crash ($)**	**Cost / Year ($)**
Alternative 2 Through/Stop with RRFB	Thru/Stop	K	0.0%	0.23	4,018,042	0.000	$ 12,800,000	$ -
		A	0.0%			0.000	$ 720,000	$ -
		B	11.0%			0.200	$ 220,000	$ 44,000.00
		C	22.7%			0.410	$ 120,000	$ 49,248.00
		PDO	66.3%			1.200	$ 13,000	$ 15,600.00
		Total	**100%**			**1.810**		**$ 108,848.00**
Scenario	**Traffic Control**	**Severity**	**Severity Proportion**	**Crash Rate**	**Total Entering Volume**	**Average Crashes / Year (No.)**	**Cost / Crash ($)**	**Cost / Year ($)**
Alternative 3 Through/Stop with Ped Refuges, RRFB	Thru/Stop	K	0.0%	0.21	4,018,042	0.000	$ 12,800,000	$ -
		A	0.0%			0.000	$ 720,000	$ -
		B	10.4%			0.172	$ 220,000	$ 37,840.00
		C	25.8%			0.428	$ 120,000	$ 51,408.00
		PDO	63.8%			1.060	$ 13,000	$ 13,780.00
		Total	**100%**			**1.660**		**$ 103,028.00**

Cost/Crash reflects MnDOT's Cost-Effectiveness & Benefit-Cost Analysis for Transportation Projects Appendix A, published July 2020. (http://www.dot.state.mn.us/planning/program/appendix_a.html)

2042 Annual Crash Cost

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	Total Entering Volume	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)	
Alternative 0 No Build	Thru/Stop	K	0.0%	0.25	4,461,714	0.000	$ 12,800,000	N/A	40.0%
		A	0.0%			0.000	$ 720,000	$ -	
		B	10.0%			0.111	$ 220,000	$ 24,429.24	
		C	30.0%			0.333	$ 120,000	$ 39,975.12	
		PDO	60.0%			0.666	$ 13,000	$ 8,661.28	
		Total	**100%**			**1.110**		**$ 73,065.64**	
Scenario	**Traffic Control**	**Severity**	**Severity Proportion**	**Crash Rate**	**Total Entering Volume**	**Average Crashes / Year (No.)**	**Cost / Crash ($)**	**Cost / Year ($)**	
Alternative 2 Through/Stop with RRFB	Thru/Stop	K	0.0%	0.23	4,461,714	0.000	$ 12,800,000	N/A	33.7%
		A	0.0%			0.000	$ 720,000	$ -	
		B	11.0%			0.111	$ 220,000	$ 24,429.24	
		C	22.7%			0.228	$ 120,000	$ 27,342.98	
		PDO	66.3%			0.666	$ 13,000	$ 8,661.28	
		Total	**100%**			**1.005**		**$ 60,433.50**	
Scenario	**Traffic Control**	**Severity**	**Severity Proportion**	**Crash Rate**	**Total Entering Volume**	**Average Crashes / Year (No.)**	**Cost / Crash ($)**	**Cost / Year ($)**	
Alternative 3 Through/Stop with Ped Refuges, RRFB	Thru/Stop	K	0.0%	0.21	4,461,714	0.000	$ 12,800,000	N/A	36.2%
		A	0.0%			0.000	$ 720,000	$ -	
		B	10.4%			0.095	$ 220,000	$ 21,009.15	
		C	25.8%			0.238	$ 120,000	$ 28,542.24	
		PDO	63.8%			0.589	$ 13,000	$ 7,650.79	
		Total	**100%**			**0.922**		**$ 57,202.18**	

Cost/Crash reflects MnDOT's Cost-Effectiveness & Benefit-Cost Analysis for Transportation Projects Appendix A, published July 2020. (http://www.dot.state.mn.us/planning/program/appendix_a.html)

CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road) - Present Value Crash Benefit - 2042 Forecast

Year	Annual Crash Cost			Crash Benefit			Present Value Crash Benefit		
	No Build (0.5% Growth)	Alt 1 (0.5% Growth)	Alt 4 (0.5% Growth)	No Build (0.5% Growth)	Alt 1 (0.5% Growth)	Alt 4 (0.5% Growth)	No Build (0.5% Growth)	Alt 1 (0.5% Growth)	Alt 4 (0.5% Growth)
2021	$ 131,600	$ 131,600	$ 131,600	$ -	$ -	$ -	$ -	$ -	$ -
2022	$ 128,813	$ 117,485	$ 97,047	$ -	$ 11,328	$ 31,765	$ -	$ 11,216	$ 31,451
2023	$ 126,025	$ 114,855	$ 95,792	$ -	$ 11,170	$ 30,233	$ -	$ 10,950	$ 29,637
2024	$ 123,238	$ 112,226	$ 94,537	$ -	$ 11,011	$ 28,701	$ -	$ 10,688	$ 27,857
2025	$ 120,451	$ 109,597	$ 93,282	$ -	$ 10,853	$ 27,168	$ -	$ 10,430	$ 26,108
2026	$ 117,663	$ 106,968	$ 92,027	$ -	$ 10,695	$ 25,636	$ -	$ 10,176	$ 24,392
2027	$ 114,876	$ 104,339	$ 90,772	$ -	$ 10,537	$ 24,104	$ -	$ 9,926	$ 22,707
2028	$ 112,089	$ 101,710	$ 89,517	$ -	$ 10,378	$ 22,571	$ -	$ 9,680	$ 21,053
2029	$ 109,301	$ 99,081	$ 88,262	$ -	$ 10,220	$ 21,039	$ -	$ 9,438	$ 19,429
2030	$ 106,514	$ 96,452	$ 87,007	$ -	$ 10,062	$ 19,507	$ -	$ 9,200	$ 17,836
2031	$ 103,726	$ 93,823	$ 85,752	$ -	$ 9,903	$ 17,974	$ -	$ 8,965	$ 16,272
2032	$ 100,939	$ 91,194	$ 84,497	$ -	$ 9,745	$ 16,442	$ -	$ 8,735	$ 14,737
2033	$ 98,152	$ 88,565	$ 83,242	$ -	$ 9,587	$ 14,910	$ -	$ 8,508	$ 13,232
2034	$ 95,364	$ 85,936	$ 81,987	$ -	$ 9,428	$ 13,377	$ -	$ 8,284	$ 11,754
2035	$ 92,577	$ 83,307	$ 80,732	$ -	$ 9,270	$ 11,845	$ -	$ 8,064	$ 10,305
2036	$ 89,790	$ 80,678	$ 79,477	$ -	$ 9,112	$ 10,313	$ -	$ 7,848	$ 8,883
2037	$ 87,002	$ 78,049	$ 78,222	$ -	$ 8,953	$ 8,780	$ -	$ 7,636	$ 7,488
2038	$ 84,215	$ 75,420	$ 76,967	$ -	$ 8,795	$ 7,248	$ -	$ 7,426	$ 6,120
2039	$ 81,428	$ 72,791	$ 75,712	$ -	$ 8,637	$ 5,716	$ -	$ 7,220	$ 4,778
2040	$ 78,640	$ 70,162	$ 74,457	$ -	$ 8,478	$ 4,183	$ -	$ 7,018	$ 3,463
2041	$ 75,853	$ 67,533	$ 73,202	$ -	$ 8,320	$ 2,651	$ -	$ 6,819	$ 2,173
2042	$ 73,066	$ 64,904	$ 71,947	$ -	$ 8,162	$ 1,119	$ -	$ 6,623	$ 908
	$ 2,119,722	**$ 1,915,080**	**$ 1,774,440**	**$ -**	**$ 204,642**	**$ 345,282**	**$ -**	**$ 184,847**	**$ 320,581**

Discount Rate	1.0%
Current Year	2021

CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road) - Present Value Crash Benefit - 2042 Forecast

Year	Annual Crash Cost			Crash Benefit			Present Value Crash Benefit		
	No Build (0.5% Growth)	Alt 2 (0.5% Growth)	Alt 3 (0.5% Growth)	No Build (1.0% Growth)	Alt 2 (0.5% Growth)	Alt 3 (0.5% Growth)	No Build (1.0% Growth)	Alt 2 (0.5% Growth)	Alt 3 (0.5% Growth)
2021	$ 131,600	$ 131,600	$ 131,600	$ -	$ -	$ -	$ -	$ -	$ -
2022	$ 128,813	$ 109,392	$ 103,543	$ -	$ 19,420	$ 25,270	$ -	$ 19,228	$ 25,019
2023	$ 126,025	$ 106,944	$ 101,226	$ -	$ 19,081	$ 24,799	$ -	$ 18,705	$ 24,311
2024	$ 123,238	$ 104,496	$ 98,909	$ -	$ 18,742	$ 24,329	$ -	$ 18,190	$ 23,613
2025	$ 120,451	$ 102,048	$ 96,592	$ -	$ 19,420	$ 25,270	$ -	$ 18,663	$ 24,284
2026	$ 117,663	$ 99,600	$ 94,275	$ -	$ 18,063	$ 23,388	$ -	$ 17,186	$ 22,253
2027	$ 114,876	$ 97,153	$ 91,958	$ -	$ 17,723	$ 22,918	$ -	$ 16,696	$ 21,590
2028	$ 112,089	$ 94,705	$ 89,641	$ -	$ 17,384	$ 22,448	$ -	$ 16,214	$ 20,937
2029	$ 109,301	$ 92,257	$ 87,324	$ -	$ 17,045	$ 21,977	$ -	$ 15,740	$ 20,296
2030	$ 106,514	$ 89,809	$ 85,007	$ -	$ 16,705	$ 21,507	$ -	$ 15,274	$ 19,665
2031	$ 103,726	$ 87,361	$ 82,690	$ -	$ 16,366	$ 21,037	$ -	$ 14,816	$ 19,044
2032	$ 100,939	$ 84,913	$ 80,373	$ -	$ 16,026	$ 20,566	$ -	$ 14,365	$ 18,434
2033	$ 98,152	$ 82,465	$ 78,056	$ -	$ 15,687	$ 20,096	$ -	$ 13,921	$ 17,834
2034	$ 95,364	$ 80,017	$ 75,739	$ -	$ 15,347	$ 19,626	$ -	$ 13,485	$ 17,245
2035	$ 92,577	$ 77,569	$ 73,422	$ -	$ 15,008	$ 19,156	$ -	$ 13,056	$ 16,665
2036	$ 89,790	$ 75,121	$ 71,104	$ -	$ 14,669	$ 18,685	$ -	$ 12,635	$ 16,095
2037	$ 87,002	$ 72,673	$ 68,787	$ -	$ 14,329	$ 18,215	$ -	$ 12,220	$ 15,534
2038	$ 84,215	$ 70,225	$ 66,470	$ -	$ 13,990	$ 17,745	$ -	$ 11,813	$ 14,983
2039	$ 81,428	$ 67,777	$ 64,153	$ -	$ 13,650	$ 17,274	$ -	$ 11,412	$ 14,442
2040	$ 78,640	$ 65,329	$ 61,836	$ -	$ 13,311	$ 16,804	$ -	$ 11,018	$ 13,909
2041	$ 75,853	$ 62,881	$ 59,519	$ -	$ 12,972	$ 16,334	$ -	$ 10,631	$ 13,386
2042	$ 73,066	$ 60,434	$ 57,202	$ -	$ 12,632	$ 15,863	$ -	$ 10,250	$ 12,872
	$ 2,119,722	**$ 1,783,170**	**$ 1,687,826**	**$ -**	**$ 337,570**	**$ 433,307**	**$ -**	**$ 305,519**	**$ 392,411**

Discount Rate	1.0%
Current Year	2021

Daily and Annual Vehicle Hours Traveled

2021 Delay (hr)

Time Period	Grouping	Percent of Grouping by Volume	2021 No Build Delay (hr)
12:00 AM	AM OFF	6.8%	0.14
1:00 AM	AM OFF	2.4%	0.05
2:00 AM	AM OFF	4.0%	0.08
3:00 AM	AM OFF	3.6%	0.08
4:00 AM	AM OFF	4.0%	0.08
5:00 AM	AM OFF	14.8%	0.31
6:00 AM	AM	31.3%	0.66
7:00 AM	**AM**	**100.0%**	**2.10**
8:00 AM	AM	80.3%	1.69
9:00 AM	OFF	52.7%	1.11
10:00 AM	OFF	44.2%	1.15
11:00 AM	OFF	58.4%	1.52
12:00 PM	OFF	64.5%	1.68
1:00 PM	OFF	62.6%	1.63
2:00 PM	OFF	66.3%	1.72
3:00 PM	PM	78.1%	2.03
4:00 PM	**PM**	**100.0%**	**2.60**
5:00 PM	PM	92.3%	2.40
6:00 PM	PM	73.2%	1.90
7:00 PM	PM OFF	56.8%	1.48
8:00 PM	PM OFF	41.5%	1.08
9:00 PM	PM OFF	28.0%	0.73
10:00 PM	PM OFF	18.6%	0.48
11:00 PM	PM OFF	10.8%	0.28
2021 Daily Delay (hr)			**27.0**
2021 Annual Delay (hr)			**9852.2**

2022 Delay (hr)

Time Period	Grouping	Percent of Grouping by Volume	2022 No Build Delay (hr)	2022 ALT 1 Delay (hr)	2022 ALT 4 Delay (hr)
12:00 AM	AM OFF	6.8%	0.14	0.14	0.13
1:00 AM	AM OFF	2.4%	0.05	0.05	0.05
2:00 AM	AM OFF	3.9%	0.08	0.08	0.08
3:00 AM	AM OFF	3.6%	0.08	0.08	0.07
4:00 AM	AM OFF	3.9%	0.08	0.08	0.08
5:00 AM	AM OFF	14.6%	0.31	0.31	0.29
6:00 AM	AM	31.0%	0.65	0.65	0.61
7:00 AM	**AM**	**100.0%**	**2.10**	**2.10**	**1.96**
8:00 AM	AM	80.3%	1.69	1.69	1.57
9:00 AM	OFF	52.4%	1.10	1.10	1.03
10:00 AM	OFF	44.0%	1.19	1.19	0.60
11:00 AM	OFF	58.4%	1.58	1.58	0.79
12:00 PM	OFF	64.5%	1.74	1.74	0.87
1:00 PM	OFF	62.6%	1.69	1.69	0.85
2:00 PM	OFF	66.3%	1.79	1.79	0.90
3:00 PM	PM	78.2%	2.11	2.11	1.06
4:00 PM	**PM**	**100.0%**	**2.70**	**2.70**	**1.35**
5:00 PM	PM	92.2%	2.49	2.49	1.25
6:00 PM	PM	73.2%	1.98	1.98	0.99
7:00 PM	PM OFF	56.8%	1.53	1.53	0.77
8:00 PM	PM OFF	41.4%	1.12	1.12	0.56
9:00 PM	PM OFF	27.7%	0.75	0.75	0.38
10:00 PM	PM OFF	18.4%	0.50	0.50	0.25
11:00 PM	PM OFF	10.7%	0.29	0.29	0.14
2022 Daily Delay (hr)			**27.7**	**27.7**	**16.6**
2022 Annual Delay (hr)			**10128.3**	**10128.3**	**6068.8**

2032 Delay (Hr)

Time Period	Grouping	Percent of Grouping by Volume	2032 No Build Delay (hr)	2032 ALT 1 Delay (hr)	2032 ALT 4 Delay (hr)
12:00 AM	AM OFF	6.9%	0.19	0.19	0.19
1:00 AM	AM OFF	2.5%	0.07	0.07	0.07
2:00 AM	AM OFF	4.0%	0.11	0.11	0.11
3:00 AM	AM OFF	3.8%	0.11	0.11	0.10
4:00 AM	AM OFF	4.0%	0.11	0.11	0.11
5:00 AM	AM OFF	14.9%	0.42	0.42	0.40
6:00 AM	AM	31.2%	0.87	0.87	0.84
7:00 AM	**AM**	**100.0%**	**2.80**	**2.80**	**2.70**
8:00 AM	AM	80.5%	2.25	2.25	2.17
9:00 AM	OFF	52.7%	1.48	1.48	1.42
10:00 AM	OFF	44.2%	1.37	1.37	0.69
11:00 AM	OFF	58.6%	1.82	1.82	0.91
12:00 PM	OFF	64.7%	2.01	2.01	1.00
1:00 PM	OFF	62.9%	1.95	1.95	0.98
2:00 PM	OFF	66.5%	2.06	2.06	1.03
3:00 PM	PM	78.3%	2.43	2.43	1.21
4:00 PM	**PM**	**100.0%**	**3.10**	**3.10**	**1.55**
5:00 PM	PM	92.4%	2.86	2.86	1.43
6:00 PM	PM	73.5%	2.28	2.28	1.14
7:00 PM	PM OFF	57.1%	1.77	1.77	0.89
8:00 PM	PM OFF	41.8%	1.30	1.30	0.65
9:00 PM	PM OFF	28.0%	0.87	0.87	0.43
10:00 PM	PM OFF	18.7%	0.58	0.58	0.29
11:00 PM	PM OFF	10.7%	0.33	0.33	0.17
2032 Daily Delay (hr)			**33.1**	**33.1**	**20.5**
2032 Annual Delay (hr)			**12101.9**	**12101.9**	**7474.4**

2042 Delay (hr)

Time Period	Grouping	Percent of Grouping by Volume	2042 No Build Delay (hr)	2042 ALT 1 Delay (hr)	2042 ALT 4 Delay (hr)
12:00 AM	AM OFF	7.0%	0.24	0.24	0.32
1:00 AM	AM OFF	2.6%	0.09	0.09	0.12
2:00 AM	AM OFF	4.4%	0.15	0.15	0.20
3:00 AM	AM OFF	3.8%	0.13	0.13	0.17
4:00 AM	AM OFF	4.1%	0.14	0.14	0.18
5:00 AM	AM OFF	14.9%	0.51	0.51	0.68
6:00 AM	AM	31.3%	1.06	1.06	1.42
7:00 AM	**AM**	**100.0%**	**3.40**	**3.40**	**4.54**
8:00 AM	AM	80.5%	2.74	2.74	3.65
9:00 AM	OFF	52.9%	1.80	1.80	2.40
10:00 AM	OFF	44.4%	1.60	1.60	0.80
11:00 AM	OFF	58.5%	2.11	2.11	1.06
12:00 PM	OFF	64.4%	2.32	2.32	1.16
1:00 PM	OFF	62.7%	2.26	2.26	1.13
2:00 PM	OFF	66.2%	2.38	2.38	1.20
3:00 PM	PM	78.2%	2.82	2.82	1.41
4:00 PM	**PM**	**100.0%**	**3.60**	**3.60**	**1.81**
5:00 PM	PM	92.3%	3.32	3.32	1.67
6:00 PM	PM	73.4%	2.64	2.64	1.33
7:00 PM	PM OFF	57.0%	2.05	2.05	1.03
8:00 PM	PM OFF	41.7%	1.50	1.50	0.75
9:00 PM	PM OFF	28.0%	1.01	1.01	0.51
10:00 PM	PM OFF	18.7%	0.67	0.67	0.34
11:00 PM	PM OFF	10.9%	0.39	0.39	0.20
2042 Daily Delay (hr)			**38.9**	**38.9**	**28.1**
2042 Annual Delay (hr)			**14216.6**	**14216.6**	**10249.6**

Daily and Annual Vehicle Hours Traveled

2021 Delay (hr)

Time Period	Grouping	Percent of Grouping by Volume	2021 No Build Delay (hr)
12:00 AM	AM OFF	6.8%	0.14
1:00 AM	AM OFF	2.4%	0.05
2:00 AM	AM OFF	4.0%	0.08
3:00 AM	AM OFF	3.6%	0.08
4:00 AM	AM OFF	4.0%	0.08
5:00 AM	AM OFF	14.8%	0.31
6:00 AM	AM	31.3%	0.66
7:00 AM	**AM**	**100.0%**	**2.10**
8:00 AM	AM	80.3%	1.69
9:00 AM	OFF	52.7%	1.11
10:00 AM	OFF	44.2%	1.15
11:00 AM	OFF	58.4%	1.52
12:00 PM	OFF	64.5%	1.68
1:00 PM	OFF	62.6%	1.63
2:00 PM	OFF	66.3%	1.72
3:00 PM	PM	78.1%	2.03
4:00 PM	**PM**	**100.0%**	**2.60**
5:00 PM	PM	92.3%	2.40
6:00 PM	PM	73.2%	1.90
7:00 PM	PM OFF	56.8%	1.48
8:00 PM	PM OFF	41.5%	1.08
9:00 PM	PM OFF	28.0%	0.73
10:00 PM	PM OFF	18.6%	0.48
11:00 PM	PM OFF	10.8%	0.28
2021 Daily Delay (hr)			**27.0**
2021 Annual Delay (hr)			**9852.2**

2022 Delay (hr)

Time Period	Grouping	Percent of Grouping by Volume	2022 No Build Delay (hr)	2022 ALT 2 Delay (hr)	2022 ALT 3 Delay (hr)
12:00 AM	AM OFF	6.8%	0.14	0.14	0.14
1:00 AM	AM OFF	2.4%	0.05	0.05	0.05
2:00 AM	AM OFF	3.9%	0.08	0.08	0.08
3:00 AM	AM OFF	3.6%	0.08	0.08	0.08
4:00 AM	AM OFF	3.9%	0.08	0.08	0.08
5:00 AM	AM OFF	14.6%	0.31	0.31	0.31
6:00 AM	AM	31.0%	0.65	0.65	0.65
7:00 AM	**AM**	**100.0%**	**2.10**	**2.10**	**2.10**
8:00 AM	AM	80.3%	1.69	1.69	1.69
9:00 AM	OFF	52.4%	1.10	1.10	1.10
10:00 AM	OFF	44.0%	1.19	1.19	1.19
11:00 AM	OFF	58.4%	1.58	1.58	1.58
12:00 PM	OFF	64.5%	1.74	1.74	1.74
1:00 PM	OFF	62.6%	1.69	1.69	1.69
2:00 PM	OFF	66.3%	1.79	1.79	1.79
3:00 PM	PM	78.2%	2.11	2.11	2.11
4:00 PM	**PM**	**100.0%**	**2.70**	**2.70**	**2.70**
5:00 PM	PM	92.2%	2.49	2.49	2.49
6:00 PM	PM	73.2%	1.98	1.98	1.98
7:00 PM	PM OFF	56.8%	1.53	1.53	1.53
8:00 PM	PM OFF	41.4%	1.12	1.12	1.12
9:00 PM	PM OFF	27.7%	0.75	0.75	0.75
10:00 PM	PM OFF	18.4%	0.50	0.50	0.50
11:00 PM	PM OFF	10.7%	0.29	0.29	0.29
2022 Daily Delay (hr)			**27.7**	**27.7**	**27.7**
2022 Annual Delay (hr)			**10128.3**	**10128.3**	**10128.3**

2032 Delay (Hr)

Time Period	Grouping	Percent of Grouping by Volume	2032 No Build Delay (hr)	2032 ALT 2 Delay (hr)	2032 ALT 3 Delay (hr)
12:00 AM	AM OFF	6.9%	0.19	0.19	0.19
1:00 AM	AM OFF	2.5%	0.07	0.07	0.07
2:00 AM	AM OFF	4.0%	0.11	0.11	0.11
3:00 AM	AM OFF	3.8%	0.11	0.11	0.11
4:00 AM	AM OFF	4.0%	0.11	0.11	0.11
5:00 AM	AM OFF	14.9%	0.42	0.42	0.42
6:00 AM	AM	31.2%	0.87	0.87	0.87
7:00 AM	**AM**	**100.0%**	**2.80**	**2.80**	**2.80**
8:00 AM	AM	80.5%	2.25	2.25	2.25
9:00 AM	OFF	52.7%	1.48	1.48	1.48
10:00 AM	OFF	44.2%	1.37	1.37	1.37
11:00 AM	OFF	58.6%	1.82	1.82	1.82
12:00 PM	OFF	64.7%	2.01	2.01	2.01
1:00 PM	OFF	62.9%	1.95	1.95	1.95
2:00 PM	OFF	66.5%	2.06	2.06	2.06
3:00 PM	PM	78.3%	2.43	2.43	2.43
4:00 PM	**PM**	**100.0%**	**3.10**	**3.10**	**3.10**
5:00 PM	PM	92.4%	2.86	2.86	2.86
6:00 PM	PM	73.5%	2.28	2.28	2.28
7:00 PM	PM OFF	57.1%	1.77	1.77	1.77
8:00 PM	PM OFF	41.8%	1.30	1.30	1.30
9:00 PM	PM OFF	28.0%	0.87	0.87	0.87
10:00 PM	PM OFF	18.7%	0.58	0.58	0.58
11:00 PM	PM OFF	10.7%	0.33	0.33	0.33
2035 Daily Delay (hr)			**33.1**	**33.1**	**33.1**
2035 Annual Delay (hr)			**12101.9**	**12101.9**	**12101.9**

2042 Delay (hr)

Time Period	Grouping	Percent of Grouping by Volume	2042 No Build Delay (hr)	2042 ALT 2 Delay (hr)	2042 ALT 3 Delay (hr)
12:00 AM	AM OFF	7.0%	0.24	0.24	0.24
1:00 AM	AM OFF	2.6%	0.09	0.09	0.09
2:00 AM	AM OFF	4.4%	0.15	0.15	0.15
3:00 AM	AM OFF	3.8%	0.13	0.13	0.13
4:00 AM	AM OFF	4.1%	0.14	0.14	0.14
5:00 AM	AM OFF	14.9%	0.51	0.51	0.51
6:00 AM	AM	31.3%	1.06	1.06	1.06
7:00 AM	**AM**	**100.0%**	**3.40**	**3.40**	**3.40**
8:00 AM	AM	80.5%	2.74	2.74	2.74
9:00 AM	OFF	52.9%	1.80	1.80	1.80
10:00 AM	OFF	44.4%	1.60	1.60	1.60
11:00 AM	OFF	58.5%	2.11	2.11	2.11
12:00 PM	OFF	64.4%	2.32	2.32	2.32
1:00 PM	OFF	62.7%	2.26	2.26	2.26
2:00 PM	OFF	66.2%	2.38	2.38	2.38
3:00 PM	PM	78.2%	2.82	2.82	2.82
4:00 PM	**PM**	**100.0%**	**3.60**	**3.60**	**3.60**
5:00 PM	PM	92.3%	3.32	3.32	3.32
6:00 PM	PM	73.4%	2.64	2.64	2.64
7:00 PM	PM OFF	57.0%	2.05	2.05	2.05
8:00 PM	PM OFF	41.7%	1.50	1.50	1.50
9:00 PM	PM OFF	28.0%	1.01	1.01	1.01
10:00 PM	PM OFF	18.7%	0.67	0.67	0.67
11:00 PM	PM OFF	10.9%	0.39	0.39	0.39
2042 Daily Delay (hr)			**38.9**	**38.9**	**38.9**
2042 Annual Delay (hr)			**14216.6**	**14216.6**	**14216.6**

CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road) --- Benefit / Cost Analysis for ALT 1 - 2042 Forecast

BASE 2021	Total
DELAY (Stop)	9,852

2042 No Improvement	Total	2022 No Improvement	Total
DELAY (Stop)	14,217	DELAY (Stop)	10,128

2042 Improvement	Total	2022 Improvement	Total
DELAY (Alt)	14,217	DELAY (Alt)	10,128

2042 Changes:	Total	
DELAY	-	0.0%

	COST ITEM				
	1	2	3	4	5
Category	Roadway	Bridge	Traffic Signal Lighting	Contingency Construciton Costs	ROW
Capital Value ($)	36,950	$0	$11,000	$ 38,800	$0
Remaining Life (%)-20yr	37%	73%	22%	37%	87%
Remaining Life (%)-5yr	0%	0%	0%	0%	0%
Remaining Cap. Value	$ 13,672	$ -	$ 2,420	$ 14,356	$ -

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:	$ -
TOTAL	$ -

COSTS	Value(Discounted)
1. Roadway/Interchange	$ (36,950)
2. Bridges	$ -
3. Traffic Signal/Lighting	$ 11,000
4. Contingency Costs	$ (38,800)
5. Right-of-way (ROW)	$ -
Remaining Capital	$ 24,953
TOTAL	$ (39,797)

Benefit/Cost Analysis Results		
20-Yr Operation Benefit	$	-
20-Yr Safety Benefit	$	184,847
COSTS	$	39,797
B/C Ratio*:		**4.645**

Cost Category	Improvement Description	Estimated NA	Estimated NA
1	Roadway Paving	$0	$34,050
1	Drainage and Erosion	$0	$2,900
1	Misc	$0	$0
2	Bridge	$0	$0
2			
3	Traffic Signal/Lighting	$0	$11,000
4			
4			
	Total Estimated Construction Cost	$0	$47,950
4	Indirect Costs & Contingency	$0	$24,200
5	Right-of-Way/Easement Costs	$0	$0
4	Professional Services	$0	$14,600
	Total Project Costs	$0	$86,750

BENEFIT 1: Travel Time Savings (VHT)

	Annual VHT		Annualized Savings		
YEAR	2042 No Improvement	2042 Improvement	Improvement w/ VHT Savings	'00 cost per hour $ 20.30	Discounted Value (1.0%)
2021	9,852	9,852			
2022	10,128	10,128	$ -	$ -	$ -
2023	10,333	10,333	$ -	$ -	$ -
2024	10,537	10,537	$ -	$ -	$ -
2025	10,742	10,742	$ -	$ -	$ -
2026	10,946	10,946	$ -	$ -	$ -
2027	11,150	11,150	$ -	$ -	$ -
2028	11,355	11,355	$ -	$ -	$ -
2029	11,559	11,559	$ -	$ -	$ -
2030	11,764	11,764	$ -	$ -	$ -
2031	11,968	11,968	$ -	$ -	$ -
2032	12,172	12,172	$ -	$ -	$ -
2033	12,377	12,377	$ -	$ -	$ -
2034	12,581	12,581	$ -	$ -	$ -
2035	12,786	12,786	$ -	$ -	$ -
2036	12,990	12,990	$ -	$ -	$ -
2037	13,195	13,195	$ -	$ -	$ -
2038	13,399	13,399	$ -	$ -	$ -
2039	13,603	13,603	$ -	$ -	$ -
2040	13,808	13,808	$ -	$ -	$ -
2041	14,012	14,012	$ -	$ -	$ -
2042	14,217	14,217	$ -	$ -	$ -
TOTAL				$ -	$ -

Note: Trucks on average account for approximately 5% of network traffic . Passenger vehicle occupancy assumed to be 1.31

MnDOT Office of Investment Management, Benefit Cost Analysis — Trucks (Value of Time) $ 33.00

Standard Values, Appendix A, Fiscal Year 2015

COST 1: Roadways/Interchange Construction

YEAR	CHANGE with Improvement	Discounted Value (1.0%)
2021		
2022	$ (36,950)	(36,950)
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
2040	$ -	-
2041	$ -	-
2042	$ -	-
TOTAL	$ (36,950)	$ (36,950)

COST 2: Bridge

YEAR	CHANGE with Improvement	Discounted Value (1.0%)
TOTAL	$ -	$ -

COST 3: Traffic Signal / Maintenance & Operation

YEAR	CHANGE with Improvement	Discounted Value (1.0%)
2021		
2022	$ 11,000	11,000
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
2040	$ -	-
2041	$ -	-
2042	$ -	-
TOTAL	$ 11,000	$ 11,000

COST 4: Contingency Construction Costs

YEAR	CHANGE with Improvement	Discounted Value (1.0%)
2021		
2022	$ (38,800)	(38,800)
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
2040	$ -	-
2041	$ -	-
2042	$ -	-
TOTAL	$ (38,800)	$ (38,800)

COST 5: Right of Way (ROW)

YEAR	CHANGE with Improvement	Discounted Value (1.0%)
TOTAL	$ -	$ -

Remaining Capital Value

YEAR	Remaining Capital Value	Discounted Value (1.0%)
2021		
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
2040	$ -	-
2041	$ -	-
2042	$ 30,448	24,953
TOTAL	$ 30,448	$ 24,953

CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road) --- Benefit / Cost Analysis for ALT 2 - 2042 Forecast

BASE 2021	Total
DELAY (Stop)	9,852

2042 No Improvement	Total	2022 No Improvement	Total
DELAY (Stop)	14,217	DELAY (Stop)	10,128

2042 Improvement	Total	2022 Improvement	Total
DELAY (Alt)	14,217	DELAY (Alt)	10,128

2042 Changes:	Total	
DELAY	-	0.0%

	COST ITEM				
	1	2	3	4	5
Category	Roadway	Bridge	Traffic Signal Lighting	Contingency Construciton Costs	ROW
Capital Value ($)	-	$0	$20,500	$ -	$0
Remaining Life (%)-20yr	37%	73%	22%	37%	87%
Remaining Life (%)-5yr	0%	0%	0%	0%	0%
Remaining Cap. Value	$ -	$ -	$ 4,510	$ -	$ -

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:	$ -
TOTAL	$ -

COSTS	Value(Discounted)
1. Roadway/Interchange	$ -
2. Bridges	$ -
3. Traffic Signal/Lighting	$ (66,065)
4. Contingency Costs	$ -
5. Right-of-way (ROW)	$ -
Remaining Capital	$ 3,696
TOTAL	$ (62,369)

Benefit/Cost Analysis Results		
20-Yr Operation Benefit	$	-
20-Yr Safety Benefit	$	305,519
COSTS	$	62,369
B/C Ratio*:		**4.899**

Cost		Estimated	Estimated	Estimated
Category	Improvement Description	NA	NA	NA
1	Roadway Paving	$0	$0	$0
1	Drainage and Erosion	$0	$0	$0
1	Misc	$0	$0	$0
2	Bridge	$0	$0	$0
2				
3	Traffic Signal/Lighting	$0	$20,500	$0
4				
4				
	Total Estimated Construction Cost	$0	$20,500	$0
4	Indirect Costs & Contingency	$0	$10,200	$0
5	Right-of-Way/Easement Costs	$0	$0	$0
4	Professional Services	$0	$6,200	$0
	Total Project Costs	$0	$36,900	$0

BENEFIT 1: Travel Time Savings (VHT)

	Annual VHT		Annualized Savings		
YEAR	2042 No Improvement	2042 Improvement	Improvement w/ VHT Savings	'00 cost per hour $ 20.30	Discounted Value (1.0%)
2021	9,852	9,852			
2022	10,128	10,128	$ -	$ -	$ -
2023	10,333	10,333	$ -	$ -	$ -
2024	10,537	10,537	$ -	$ -	$ -
2025	10,742	10,742	$ -	$ -	$ -
2026	10,946	10,946	$ -	$ -	$ -
2027	11,150	11,150	$ -	$ -	$ -
2028	11,355	11,355	$ -	$ -	$ -
2029	11,559	11,559	$ -	$ -	$ -
2030	11,764	11,764	$ -	$ -	$ -
2031	11,968	11,968	$ -	$ -	$ -
2032	12,172	12,172	$ -	$ -	$ -
2033	12,377	12,377	$ -	$ -	$ -
2034	12,581	12,581	$ -	$ -	$ -
2035	12,786	12,786	$ -	$ -	$ -
2036	12,990	12,990	$ -	$ -	$ -
2037	13,195	13,195	$ -	$ -	$ -
2038	13,399	13,399	$ -	$ -	$ -
2039	13,603	13,603	$ -	$ -	$ -
2040	13,808	13,808	$ -	$ -	$ -
2041	14,012	14,012	$ -	$ -	$ -
2042	14,217	14,217	$ -	$ -	$ -
TOTAL				$ -	$ -

Note: Trucks on average account for approximately 5% of network traffic . Passenger vehicle occupancy assumed to be 1.31

MnDOT Office of Investment Management, Benefit Cost Analysis

Standard Values, Appendix A, Fiscal Year 2015

Trucks (Value of Time) $ 33.00

COST 1: Roadways/Interchange Construction

YEAR	CHANGE with Improvement	Discounted Value (1.0%)
2021		
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
2040	$ -	-
2041	$ -	-
2042	$ -	-
TOTAL	$ -	$ -

COST 2: Bridge

YEAR	CHANGE with Improvement	Discounted Value (1.0%)
TOTAL	$ -	$ -

COST 3: Traffic Signal / Maintenance & Operation

YEAR	CHANGE with Improvement	Discounted Value (1.0%)
2021		
2022	$ (20,500)	(20,500)
2023	$ (2,500)	(2,500)
2024	$ (2,500)	(2,475)
2025	$ (2,500)	(2,451)
2026	$ (2,500)	(2,426)
2027	$ (2,500)	(2,402)
2028	$ (2,500)	(2,379)
2029	$ (2,500)	(2,355)
2030	$ (2,500)	(2,332)
2031	$ (2,500)	(2,309)
2032	$ (2,500)	(2,286)
2033	$ (2,500)	(2,263)
2034	$ (2,500)	(2,241)
2035	$ (2,500)	(2,219)
2036	$ (2,500)	(2,197)
2037	$ (2,500)	(2,175)
2038	$ (2,500)	(2,153)
2039	$ (2,500)	(2,132)
2040	$ (2,500)	(2,111)
2041	$ (2,500)	(2,090)
2042	$ (2,500)	(2,069)
TOTAL	$ (70,500)	$ (66,065)

COST 4: Contingency Construction Costs

YEAR	CHANGE with Improvement	Discounted Value (1.0%)
2021		
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
2040	$ -	-
2041	$ -	-
2042	$ -	-
TOTAL	$ -	$ -

COST 5: Right of Way (ROW)

YEAR	CHANGE with Improvement	Discounted Value (1.0%)
TOTAL	$ -	$ -

Remaining Capital Value

YEAR	Remaining Capital Value	Discounted Value (1.0%)
2021		
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
2040	$ -	-
2041	$ -	-
2042	$ 4,510	3,696
TOTAL	$ 4,510	$ 3,696

CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road) --- Benefit / Cost Analysis for ALT 3 - 2042 Forecast

BASE 2021	Total
DELAY (Stop)	9,852

2042 No Improvement	Total	2022 No Improvement	Total
DELAY (Stop)	14,217	DELAY (Stop)	10,128

2042 Improvement	Total	2022 Improvement	Total
DELAY (Alt)	14,217	DELAY (Alt)	10,128

2042 Changes:	Total	
DELAY	-	0.0%

	COST ITEM				
	1	2	3	4	5
Category	Roadway	Bridge	Traffic Signal Lighting	Contingency Construciton Costs	ROW
Capital Value ($)	36,950	$0	$26,000	$ 50,500	$0
Remaining Life (%)-20yr	37%	73%	22%	37%	87%
Remaining Life (%)-5yr	0%	0%	0%	0%	0%
Remaining Cap. Value	$ 13,672	$ -	$ 5,720	$ 18,685	$ -

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:	$ -
TOTAL	$ -

COSTS	*Value(Discounted)*
1. Roadway/Interchange	$ (36,950)
2. Bridges	$ -
3. Traffic Signal/Lighting	$ (71,114)
4. Contingency Costs	$ (50,500)
5. Right-of-way (ROW)	$ -
Remaining Capital	$ 31,205
TOTAL	$ (127,358)

Benefit/Cost Analysis Results	
20-Yr Operation Benefit	$ -
20-Yr Safety Benefit	$ 392,411
COSTS	$ 127,358
B/C Ratio*:	**3.081**

Cost Category	Improvement Description	Estimated NA	Estimated NA
1	Roadway Paving	$0	$34,050
1	Drainage and Erosion	$0	$2,900
1	Misc	$0	$0
2	Bridge	$0	$0
2			
3	Traffic Signal/Lighting	$0	$26,000
4			
4			
	Total Estimated Construction Cost	$0	$62,950
4	Indirect Costs & Contingency	$0	$31,500
5	Right-of-Way/Easement Costs	$0	$0
4	Professional Services	$0	$19,000
	Total Project Costs	$0	$113,450

BENEFIT 1: Travel Time Savings (VHT)

	Annual VHT		Annualized Savings		
YEAR	2042 No Improvement	2042 Improvement	Improvement w/ VHT Savings	'00 cost per hour $ 20.30	Discounted Value (1.0%)
2021	9,852	9,852	$ -	$ -	$ -
2022	10,128	10,128	$ -	$ -	$ -
2023	10,333	10,333	$ -	$ -	$ -
2024	10,537	10,537	$ -	$ -	$ -
2025	10,742	10,742	$ -	$ -	$ -
2026	10,946	10,946	$ -	$ -	$ -
2027	11,150	11,150	$ -	$ -	$ -
2028	11,355	11,355	$ -	$ -	$ -
2029	11,559	11,559	$ -	$ -	$ -
2030	11,764	11,764	$ -	$ -	$ -
2031	11,968	11,968	$ -	$ -	$ -
2032	12,172	12,172	$ -	$ -	$ -
2033	12,377	12,377	$ -	$ -	$ -
2034	12,581	12,581	$ -	$ -	$ -
2035	12,786	12,786	$ -	$ -	$ -
2036	12,990	12,990	$ -	$ -	$ -
2037	13,195	13,195	$ -	$ -	$ -
2038	13,399	13,399	$ -	$ -	$ -
2039	13,603	13,603	$ -	$ -	$ -
2040	13,808	13,808	$ -	$ -	$ -
2041	14,012	14,012	$ -	$ -	$ -
2042	14,217	14,217	$ -	$ -	$ -
TOTAL				$ -	$ -

Note: Trucks on average account for approximately 5% of network traffic . Passenger vehicle occupancy assumed to be 1.31

MnDOT Office of Investment Management, Benefit Cost Analysis — Trucks (Value of Time) $ 33.00

Standard Values, Appendix A, Fiscal Year 2015

COST 1: Roadways/Interchange Construction

YEAR	CHANGE with Improvement	Discounted Value (1.0%)
2021		
2022	$ (36,950)	(36,950)
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
2040	$ -	-
2041	$ -	-
2042	$ -	-
TOTAL	$ (36,950)	$ (36,950)

COST 2: Bridge

YEAR	CHANGE with Improvement	Discounted Value (1.0%)
TOTAL	$ -	$ -

COST 3: Traffic Signal / Maintenance & Operation

YEAR	CHANGE with Improvement	Discounted Value (1.0%)
2021		
2022	$ (26,000)	(26,000)
2023	$ (2,500)	(2,475)
2024	$ (2,500)	(2,451)
2025	$ (2,500)	(2,426)
2026	$ (2,500)	(2,402)
2027	$ (2,500)	(2,379)
2028	$ (2,500)	(2,355)
2029	$ (2,500)	(2,332)
2030	$ (2,500)	(2,309)
2031	$ (2,500)	(2,286)
2032	$ (2,500)	(2,263)
2033	$ (2,500)	(2,241)
2034	$ (2,500)	(2,219)
2035	$ (2,500)	(2,197)
2036	$ (2,500)	(2,175)
2037	$ (2,500)	(2,153)
2038	$ (2,500)	(2,132)
2039	$ (2,500)	(2,111)
2040	$ (2,500)	(2,090)
2041	$ (2,500)	(2,069)
2042	$ (2,500)	(2,049)
TOTAL	$ (76,000)	$ (71,114)

COST 4: Contingency Construction Costs

YEAR	CHANGE with Improvement	Discounted Value (1.0%)
2021		
2022	$ (50,500)	(50,500)
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
2040	$ -	-
2041	$ -	-
2042	$ -	-
TOTAL	$ (50,500)	$ (50,500)

COST 5: Right of Way (ROW)

YEAR	CHANGE with Improvement	Discounted Value (1.0%)
		-
		-
		-
		-
		-
		-
		-
		-
		-
		-
		-
		-
		-
		-
		-
		-
		-
		-
		-
		-
TOTAL	$ -	$ -

Remaining Capital Value

YEAR	Remaining Capital Value	Discounted Value (1.0%)
2021		
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
2040	$ -	-
2041	$ -	-
2042	$ 38,077	31,205
TOTAL	$ 38,077	$ 31,205

CSAH 16 (Stoltzman Road) & CSAH 60 (Stadium Road) --- Benefit / Cost Analysis for ALT 4 - 2042 Forecast

BASE 2021	Total
DELAY (Stop)	9,852

2042 No Improvement	Total	2022 No Improvement	Total
DELAY (Stop)	14,217	DELAY (Stop)	10,128

2042 Improvement	Total	2022 Improvement	Total
DELAY (Alt)	10,250	DELAY (Alt)	6,069

2042 Changes:	Total	
DELAY	(3,967)	-27.9%

	COST ITEM				
	1	2	3	4	5
Category	Roadway	Bridge	Traffic Signal Lighting	Contingency Construciton Costs	ROW
Capital Value ($)	420,463	$0	$80,703	$ 398,834	$0
Remaining Life (%)-20yr	37%	73%	22%	37%	87%
Remaining Life (%)-5yr	0%	0%	0%	0%	0%
Remaining Cap. Value	$ 155,571	$ -	$ 17,755	$ 147,569	$ -

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:	$	2,042,460
TOTAL	$	2,042,460

COSTS	*Value(Discounted)*	
1. Roadway/Interchange	$	(420,463)
2. Bridges	$	-
3. Traffic Signal/Lighting	$	(98,749)
4. Contingency Costs	$	(398,834)
5. Right-of-way (ROW)	$	-
Remaining Capital	$	262,987
TOTAL	$	(655,058)

Benefit/Cost Analysis Results		
20-Yr Operation Benefit	$	2,042,460
20-Yr Safety Benefit	$	320,581
COSTS	$	655,058
B/C Ratio*:		**3.607**

Cost Category	Improvement Description	Estimated NA	Estimated NA
1	Roadway Paving	$0	$352,538
1	Drainage and Erosion	$0	$67,925
1	Misc	$0	$0
2	Bridge	$0	$0
2			
3	Traffic Signal/Lighting	$0	$80,703
4			
4			
	Total Estimated Construction Cost	$0	$501,166
4	Indirect Costs & Contingency	$0	$248,834
5	Right-of-Way/Easement Costs	$0	$0
4	Professional Services	$0	$150,000
	Total Project Costs	$0	$900,000

BENEFIT 1: Travel Time Savings (VHT)

	Annual VHT		Annualized Savings		
YEAR	2042 No Improvement	2042 Improvement	Improvement w/ VHT Savings	'00 cost per hour $ 20.30	Discounted Value (1.0%)
2020					
2021	9,852	9,852	$ -	$ -	$ -
2022	10,128	6,069	$ 4,059.51	$ 109,515.11	$ 108,430.80
2023	10,333	6,278	$ 4,054.89	$ 109,390.37	$ 107,234.94
2024	10,537	6,487	$ 4,050.26	$ 109,265.63	$ 106,052.14
2025	10,742	6,696	$ 4,045.64	$ 109,140.89	$ 104,882.25
2026	10,946	6,905	$ 4,041.01	$ 109,016.15	$ 103,725.13
2027	11,150	7,114	$ 4,036.39	$ 108,891.41	$ 102,580.64
2028	11,355	7,323	$ 4,031.77	$ 108,766.67	$ 101,448.64
2029	11,559	7,532	$ 4,027.14	$ 108,641.94	$ 100,329.01
2030	11,764	7,741	$ 4,022.52	$ 108,517.20	$ 99,221.60
2031	11,968	7,950	$ 4,017.90	$ 108,392.46	$ 98,126.28
2032	12,172	8,159	$ 4,013.27	$ 108,267.72	$ 97,042.93
2033	12,377	8,368	$ 4,008.65	$ 108,142.98	$ 95,971.41
2034	12,581	8,577	$ 4,004.02	$ 108,018.24	$ 94,911.59
2035	12,786	8,786	$ 3,999.40	$ 107,893.51	$ 93,863.35
2036	12,990	8,995	$ 3,994.78	$ 107,768.77	$ 92,826.57
2037	13,195	9,204	$ 3,990.15	$ 107,644.03	$ 91,801.12
2038	13,399	9,413	$ 3,985.53	$ 107,519.29	$ 90,786.87
2039	13,603	9,622	$ 3,980.91	$ 107,394.55	$ 89,783.70
2040	13,808	9,832	$ 3,976.28	$ 107,269.81	$ 88,791.51
2041	14,012	10,041	$ 3,971.66	$ 107,145.07	$ 87,810.15
2042	14,217	10,250	$ 3,967.03	$ 107,020.34	$ 86,839.53
TOTAL				$ 2,273,622	$ 2,042,460

Note: Trucks on average account for approximately 5% of network traffic . Passenger vehicle occupancy assumed to be 1.31

MnDOT Office of Investment Management, Benefit Cost Analysis — Trucks (Value of Time) $ 33.00

Standard Values, Appendix A, Fiscal Year 2015

COST 1: Roadways/Interchange Construction

YEAR	CHANGE with Improvement	Discounted Value (1.0%)
2020		
2021		
2022	$ (420,463)	(420,463)
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
2040	$ -	-
2041	$ -	-
2042	$ -	-
TOTAL	$ (420,463)	$ (420,463)

COST 2: Bridge

YEAR	CHANGE with Improvement	Discounted Value (1.0%)
TOTAL	$ -	$ -

COST 3: Traffic Signal / Maintenance & Operation

YEAR	CHANGE with Improvement	Discounted Value (1.0%)
2021		
2022	$ (80,703)	(80,703)
2023	$ (1,000)	(990)
2024	$ (1,000)	(980)
2025	$ (1,000)	(971)
2026	$ (1,000)	(961)
2027	$ (1,000)	(951)
2028	$ (1,000)	(942)
2029	$ (1,000)	(933)
2030	$ (1,000)	(923)
2031	$ (1,000)	(914)
2032	$ (1,000)	(905)
2033	$ (1,000)	(896)
2034	$ (1,000)	(887)
2035	$ (1,000)	(879)
2036	$ (1,000)	(870)
2037	$ (1,000)	(861)
2038	$ (1,000)	(853)
2039	$ (1,000)	(844)
2040	$ (1,000)	(836)
2041	$ (1,000)	(828)
2042	$ (1,000)	(820)
TOTAL	$ (100,703)	$ (98,749)

COST 4: Contingency Construction Costs

YEAR	CHANGE with Improvement	Discounted Value (1.0%)
2021		
2022	$ (398,834)	(398,834)
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
2040	$ -	-
2041	$ -	-
2042	$ -	-
TOTAL	$ (398,834)	$ (398,834)

COST 5: Right of Way (ROW)

YEAR	CHANGE with Improvement	Discounted Value (1.0%)
TOTAL	$ -	$ -

Remaining Capital Value

YEAR	Remaining Capital Value	Discounted Value (1.0%)
2021		
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
2040	$ -	-
2041	$ -	-
2042	$ 320,895	262,987
TOTAL	$ 320,895	$ 262,987