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ROUNDABOUT JUSTIFICATION REPORT

for

SAP 074-634-029, SAP 074-645-040, SAP 123-020-050, SAP 123-020-051

CSAH 34 (NW 26th Street) at CSAH 45 (State Ave)

in

City of Owatonna, Steele County, Minnesota

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.

Ross B. Tillman, P.E.	51692	2/10/2021
	License. No.	Date

REVIEWED BY:

Kyle Skov

Owatonna City Engineer — Feb 11, 2021 — Date

Gregory M. Ilkka
Gregory M. Ilkka (Feb 11, 2021 09:28 CST)

Steele County Engineer — Feb 11, 2021 — Date

APPROVED BY:

Fausto Cabral

MnDOT District 6 State Aid Engineer — 2021.03.11 09:07:38 -06'00' — Date

Review for participation
State Aid eligible

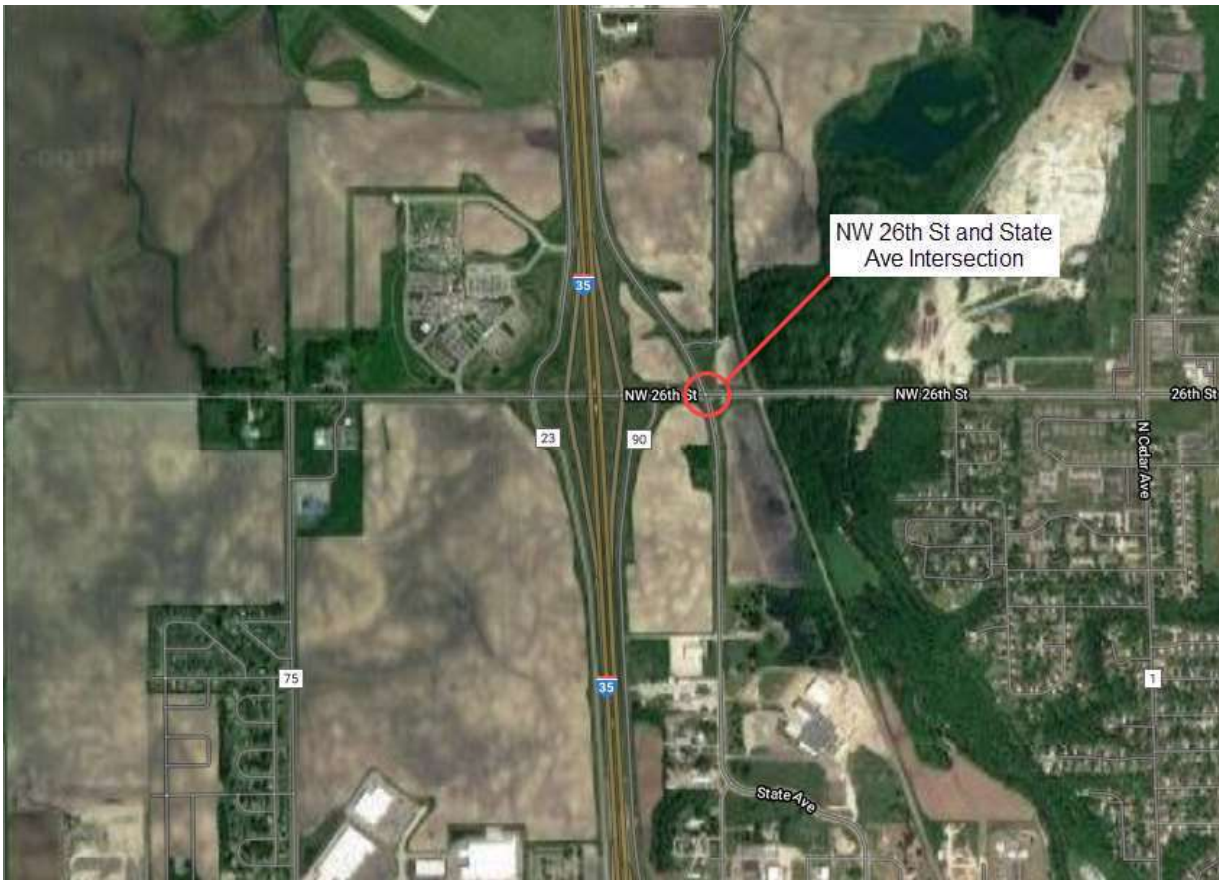
Introduction

An analysis of the intersection of CSAH 34 (NW 26th St) and CSAH 45 (State St) was completed. Due to issues with the existing signal, Steele County is working to construct improvements at the intersection.

Existing Conditions

The CSAH 34 at CSAH 45 intersection consists of a two-lane roadway on CSAH 34 and a two-lane roadway on CSAH 45. See **Figure 1** below for the project location map. The intersection is currently signalized. The speed limit on CSAH 34 is 45 mph and the roadway is classified as a Minor Arterial. The speed limit on CSAH 45 is 55 mph and the roadway is classified as a Major Collector. The intersection is located less than 700 ft east of the NB I-35 ramp, 375 ft east of the E Frontage Rd/CR 90 intersection and 400 ft west of a railroad crossing.

Figure 1: Project Location Map



Data Collection

Turning movement count data was collected in January 2020. The AM peak hour was found to be from 7:15 to 8:15 AM and the PM peak hour was found to be from 4:30 to 5:30 PM. Each peak period was used to analyze traffic operations at the study location. The existing peak hour turning movement counts are shown in **Figure 1** of the **Appendix**.

Warrant Analysis

A warrant analysis was completed for the intersection with the 2020 traffic volumes. A roundabout is considered to be justified if the intersection meets warrants for either a traffic signal or an all-way stop.

Traffic Control Signal Warrant Analysis

The MnMUTCD (chapter 4C) states that the investigation of the need for a traffic control signal shall include an analysis of the applicable factors contained in the following traffic signal warrants:

- Warrant 1: Eight-Hour Vehicular Volume
- Warrant 2: Four-Hour Vehicular Volume
- Warrant 3: Peak Hour
- Warrant 4: Pedestrian Volume
- Warrant 5: School Crossing
- Warrant 6: Coordinated Signal System
- Warrant 7: Crash Experience
- Warrant 8: Roadway Network
- Warrant 9: Intersection Near a Grade Crossing

A traffic control signal should not be installed unless one or more of the warrants can be met, however the satisfaction of a traffic signal warrant or warrants shall not in itself require the installation of a traffic signal. Furthermore, a traffic control signal should not be installed unless an engineering study indicates that the traffic control signal will improve the overall safety and operation of the intersection. Finally, the signal should not disrupt the progressive flow of traffic.

The warrant analysis was completed assuming the geometry of a single lane roundabout so only one lane was assumed along each approach. Warrants 1B, 2, and 3 are met at the study location with the existing volumes.

All-Way Stop Control Warrant Analysis

All-way stop control can be useful as a safety measure at intersections if safety concerns exist because of high traffic volumes in multiple directions or if there is an insufficient sight distance available to see conflicting traffic on an approach to an intersection. The MnMUTCD states that the need for an all-way stop control shall be considered if one of the following conditions is met:

- Condition A: Where traffic control signals are justified, an all-way stop can be installed as an interim measure.
- Condition B: Five or more crashes are reported in a 12-month period that are susceptible to correction by an all-way stop installation.
- Condition C: The volume of either vehicles or a combination of vehicles, pedestrians and bicycles entering the intersection from all approaches for any eight hours of an average day meets the minimum volume requirements set forth in section 2B.7 of the 2020 MnMUTCD.

Condition A is met as a signal is justified and Condition C is met with traffic volumes meeting the volume requirements in the MnMUTCD. Condition B is not met. The detailed warrant analysis can be found in the **Appendix**.

Safety Analysis

A crash review was completed for the intersection for the previous five years (2015-2019). MnDOT uses a comparison of the crash rate and the critical rate when determining whether or not there is a safety issue at an intersection. The crash rate is the number of crashes per million entering vehicles (MEV). The critical rate is a statistical comparison based on similar intersections statewide. An observed crash rate greater than the critical rate indicates that the intersection operates outside of the expected, normal range.

The critical index reports the magnitude of this difference and a critical index of less than one shows that the intersection is operating within the normal range.

The study intersection is operating with a critical index of 1.21, which shows that this intersection is operating outside the normal range. The observed crash rate was found to be 0.966 where the statewide average is 0.42. This shows that the observed crash rate for this intersection is over two times higher than the statewide average. **Table 1** summarizes the crashes reported at this intersection. The crashes were analyzed to determine if the correct crash type was reported. One crash was labeled as "unknown". This crash consisted of a semi-truck that damaged powerlines and the temporary signal and is indicated below as a collision with object that resulted in property damage.

Table 1. Crash Type and Severity (2015-2019)

Crash Type	Crash Severity			
	Serious Injury	Minor Injury	Possible Injury	Property Damage
Rear End	-	3	2	6
Right Angle	-	2	1	4
Left Turn	1	-	-	2
Sideswipe	-	-	-	1
Collision with Object	-	-	-	1
Head On	-	-	-	1

Table 1 shows that rear end crashes were the most common type of crash that occurred at the intersection accounting for 9 of the 22 total crashes. Right angle crashes were the next most common crash type accounting for 7 of the 22 total crashes. See the **Appendix** for a crash summary sheet.

Alternatives

Two alternatives were considered at this location: Do Nothing/Existing Geometry and a Single Lane Roundabout. Both alternatives are summarized below. See the **Appendix** for the concept drawing of the roundabout along with design criteria utilized.

Do Nothing: This leaves the existing geometry in place along with a signal at the intersection.
Single Lane Roundabout: Converts the intersection to a roundabout. All four legs would have one shared left-thru-right lane.

Operations Analysis

An operational analysis was completed for the AM and PM peak hours using the existing turning movement counts. The operation analysis for the intersection included an evaluation of intersection delay and Level of Service (LOS). LOS results are described using letters ranging from A to F. These letters serve to describe a range of operating conditions for different types of facilities. Levels of Service are calculated based on the Highway Capacity Manual (HCM) 6th Edition, which defines the LOS, based on control delay. Control delay is the delay experienced by vehicles slowing down as they are approaching the intersection, the wait time at the intersection, and the time for the vehicle to speed up through the intersection and enter into the traffic stream. The average intersection control delay is a volume weighted average of delay experienced by all motorists entering the intersection on all intersection approaches. The control delay is modeled within the analysis software. LOS D is commonly taken as an acceptable design year LOS.

The existing/do nothing analysis was completed using SimTraffic. The alternative analysis was completed using VISSIM. **Table 2** shows a summary of the results. The queues shown were rounded up to the nearest 25 feet, which is the typical length of a passenger car. The full results can be found in the **Appendix**.

Table 2. 2020 Traffic Operational Analysis

Option	Peak Hour	Intersection Delay (sec/veh)		Aprch	Movement Delay (sec/veh)		Queue Length (ft)	
							Avg	Max
Signalized Intersection	AM	11	B	EB	8	A	50	125
				WB	11	B	100	225
				NB	16	B	50	125
				SB	13	B	25	100
	PM	10	B	EB	10	B	100	225
				WB	8	A	50	125
				NB	12	B	50	125
				SB	14	B	50	100
Single Lane Roundabout	AM	3	A	EB	2	A	25	125
				WB	3	A	25	175
				NB	2	A	25	75
				SB	7	A	25	100
	PM	3	A	EB	3	A	25	250
				WB	1	A	25	100
				NB	4	A	25	100
				SB	3	A	25	100

With existing traffic control and volumes, the intersection operates with an LOS B on average for both peak hours. The maximum westbound through queue extends beyond the turn lanes during the AM peak hour and the maximum eastbound through queue extends beyond the right turn lane during the PM peak hour. The single lane roundabout operates with LOS A overall and along each approach. All queues are anticipated to be acceptable with a single lane roundabout.

In Vissim, a train can be modeled crossing the railroad tracks approximately 400 ft to the east of the intersection. Video footage of the railroad crossing indicated that CSAH 34 is blocked for approximately two minutes when a train is passing through. Only one train was recorded passing through the project area during the AM peak hour, but a train was also modeled passing through during the PM peak hour to see how it impacts operations. **Table 3** shows the 2020 traffic operations with a single lane roundabout when a train is present to show the impact a train passing through has on the intersection operations.

Table 3. 2020 Alternative Traffic Operational Analysis (With Train)

Option	Peak Hour	Intersection Delay (sec/veh)		Aprch	Movement Delay (sec/veh)		Queue Length (ft)	
							Avg	Max
Single Lane Roundabout	AM	4	A	EB	2	A	25	125
				WB	4	A	25	650
				NB	2	A	25	75
				SB	9	A	25	100
	PM	3	A	EB	3	A	50	250
				WB	2	A	25	225
				NB	5	B	25	100
				SB	4	B	25	100

Table 3 shows that a single lane roundabout is anticipated to continue to operate with acceptable delay when a train is present. The long max queue for westbound traffic occurs immediately after the train clears, as all vehicles queued at the railroad gate arrive at the roundabout in a large platoon. The average westbound queue is only 25 ft, which implies this long queue clears quickly.

Traffic Forecasting – Baseline Growth

Traffic volumes were projected to 2041 to analyze future operations. A previous study of CSAH 34 forecasted traffic volumes based on the average annual population growth rate for the City of Owatonna and potential development scenarios in the area. The population growth rate was updated with the latest US census data available. Additionally, historic growth rates near the study intersection were analyzed and it was found that since the previous study was completed in 2014, growth rates along CSAH 34 have decreased.

The updated annual population growth rate was found to be 0.96%. This growth rate was rounded up to an even 1% and used to calculate the baseline growth anticipated at the study intersection. The 2041 forecasted turning movement counts are shown in the **Figure 2** of the **Appendix**.

Traffic Operations – 2041 Baseline Growth

The 2041 baseline AM and PM peak hours were analyzed with the single lane roundabout in Vissim. **Table 4** shows the results with and without the train present. The full results can be found in the **Appendix**.

Table 4. 2041 Alternative Traffic Operational Analysis – Baseline Growth

Option	Peak Hour	Intersection Delay (sec/veh)		Aprch	Movement Delay (sec/veh)		Queue Length (ft)	
							Avg	Max
Signalized Intersection	AM	12	B	EB	9	A	50	125
				WB	11	B	100	225
				NB	20	C	75	150
				SB	16	B	50	125
	PM	12	B	EB	11	B	125	250
				WB	10	B	75	150
				NB	15	B	50	125
				SB	17	B	50	125
Single Lane Roundabout (Without Train)	AM	6	A	EB	3	A	25	150
				WB	5	A	25	375
				NB	2	A	25	100
				SB	21	C	25	175
	PM	4	A	EB	4	A	25	450
				WB	2	A	25	125
				NB	7	A	25	125
				SB	5	A	25	125
Single Lane Roundabout (With Train)	AM	7	A	EB	2	A	25	125
				WB	7	A	75	1100
				NB	2	A	25	100
				SB	26	D	25	200
	PM	6	A	EB	6	A	25	575
				WB	3	A	25	375
				NB	10	B	25	175
				SB	7	A	25	125

Table 4 indicates that the signalized intersection is expected to operate with LOS B for both peak hours with 2041 volumes. The maximum westbound through queue extends beyond the turn lanes during the AM peak hour and the maximum eastbound through queue extends beyond the right turn lane during the PM peak hour. A roundabout is expected to operate acceptably overall with LOS A during both peak hours. With the baseline traffic the southbound approach is anticipated to operate with LOS C or D during the AM peak hour. All other approaches are anticipated to operate with LOS A or B during both peak hours. The maximum eastbound approach queue is anticipated to extend beyond the E Frontage Rd during the PM peak hour (located approximately 375 ft away). With the train included in the traffic modeling, the maximum westbound approach queue is anticipated to be 1,100 ft in length. This is because when the train comes through vehicles queue along westbound CSAH 34 and when the gate arms rise all of the vehicles are queued up at the roundabout at the same time.

Traffic Forecasting – Development Driven

Potential development in the area was also considered. The previous study analyzed three potential growth scenarios

- Low Growth - 42 acres to develop in the southwest quadrant of the I-35 interchange
- Medium/Anticipated Growth – 104 acres to develop in the southwest quadrant of the I-35 interchange
- High Growth/Full Build – 300 acres to develop surrounding the I-35 interchange

All three growth scenarios also assumed further development of the Landmark Dr area and a new high school along CSAH 34 to the east of the study intersection.

The low growth scenario was assumed for further analysis with the current study in addition to the potential development near Landmark Dr. The following updates were made to the growth assumptions from the previous study:

- A newer version (10th Edition) of the ITE Trip Generation Manual was released since the previous study so the analysis was updated with the latest rates.
- The high school was removed from the potential growth as it is no longer planned to be located on the north side of town.
- A gas station was removed from the potential growth near Landmark Dr as it has been built since the previous study
- The number of potential single family detached homes north of Landmark Dr was updated as ten homes have been built since the previous study.

The new trips from the low growth scenario and growth near Landmark Dr were distributed along the roadway network based on the existing volumes. The growth near Landmark Dr is only assumed to increase peak hour traffic volumes at the intersection by about 40-50 vehicles. However, developing 42 acres in the southwest quadrant of the I-35 interchange could add about 450-560 vehicles to the intersection during the peak hours.

The estimated peak hour 2041 forecasted turning movement counts with development are shown in **Figure 3** of the **Appendix**. This shows that development could greatly increase the peak hour traffic at the intersection with volumes along CSAH 34 nearly doubling from the baseline growth.

The capacity of a roundabout was analyzed with the 2041 forecasted turning movement counts including the development. This analysis is included in the **Appendix**. The analysis indicates that based on the assumptions made for the potential development, the capacity of a single lane roundabout is expected to be reached. However, the exact growth will depend on the development type and proximity to the CSAH 34 at CSAH 45 intersection. Further analysis is recommended once development type and location are known to determine what improvements are required.

Railroad Crossing Analysis

Queues at the railroad gate arms were also analyzed in Vissim. **Table 5** shows the eastbound queue lengths from the railroad crossing gate arm when a train is passing through. The railroad crossing is located approximately 400 ft to the east of the intersection.

Table 5. Peak Hour Queues from Railroad Crossing Gate Arms

Year	Peak Hour	Queue Length (ft)	
		EB Gate Arm (1)	
		Average	Maximum
2020	AM	25	200
	PM	25	800
2040 *(Baseline Growth)*	AM	25	275
	PM	50	1050

(1) 400 ft between roundabout and railroad tracks

Table 5 shows that the maximum queue from the eastbound gate arm extends past the intersection during the 2020 PM peak hour and beyond the E Frontage Rd during the 2040 PM peak hour with baseline growth. This queuing would occur regardless of intersection control. Future mitigation may be required.

Roundabout Safety Analysis

An analysis was completed to determine how the roundabout design could reduce the crash rate at the intersection. The existing intersection is operating with a critical index of 1.21, which shows that this intersection is operating outside the normal range. The observed crash rate was found to be 0.966 where the statewide average is 0.42.

Crash reduction factors for converting a signalized intersection to a roundabout were taken from the CMF Clearinghouse. CMF ID 225 and 226 were used to estimate the change in crashes expected after implementing a roundabout. CMF ID 226 applies to crashes of all type that result in serious injury, minor injury, or possible injury. CMF ID 225 applies to crashes of all type and all severity. CMF ID 226 estimates a 78% reduction in crashes and CMF ID 225 estimates a 48% reduction in crashes. Applying CMF ID 226 to the injury crashes and CMF ID 225 to the property damage only crashes is anticipated to reduce the observed crash rate from 0.966 to 0.414. The CMF detail sheets can be found in the **Appendix**.

Conclusion

A single lane roundabout is recommended at the intersection of CSAH 34 at CSAH 45 for the following reasons:

1. Both signal and all-way stop warrants are met for the intersection with existing volumes, justifying a single lane roundabout.
2. The five-year crash review indicates that there is a safety concern at the intersection with the current traffic control. The existing observed crash rate is over two time higher than the statewide average for low volume signals. Implementing a roundabout at this intersection is anticipated to reduce injury crashes by 78% and all other crashes by 48%.
3. The operational analysis shows that a single lane roundabout at this location operates with minimal delay and queuing with existing and 2041 baseline growth traffic volumes.

As development occurs, impacts to the adjacent roadway network should be evaluated based on exact land uses and locations in the general area. These impact analyses will need to determine what improvements along the public roadways are required to manage traffic safely and effectively. Depending on development scale, type and location, capacity of the single lane roundabout and 2-lane roadway along CSAH 34 in this area may be exceeded. Additionally, Steele County has long term plans to grade separate CSAH 34 over the railroad, which would include potential capacity improvements and would require further intersection modifications at that time.

Appendix

CSAH 34/CSAH 45 Roundabout

Steele County, Minnesota

Figure 1. Existing Turning Movement Counts

November 2020

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Map Document: \\arcserver\GIS\STCO\T42\120387\ESRI\Maps\120387_Existing_TMC_8x11P.mxd | Date Saved: 11/9/2020 12:07:53 PM

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SIGNAL WARRANTS ANALYSIS
FOR
CSAH 34 at CSAH 45
Existing (2020) Volumes [Roundabout Geometry]

LOCATION: CSAH 34 at CSAH 45
COUNTY: Steele
REF. POINT:
DATE: 1/14/2020
OPERATOR: KR

Speed	Approach Description		Lanes
45	Major App1:	EASTBOUND - CSAH 34	1
45	Major App3:	WESTBOUND - CSAH 34	1
55	Minor App2:	NORTHBOUND - CSAH 45	1
55	Minor App4:	SOUTHBOUND - CSAH 45	1

0.70 FACTOR USED? YES
POPULATION < 10,000? No
N/A No

THRESHOLDS 1A/1B: 350/525 105/52 105/52

HOUR	MAJOR APP. 1	MAJOR APP. 3	TOTAL 1+3	MAJOR 1A/1B	MINOR APP. 2	MINOR 2 1A/1B	MINOR APP. 4	MINOR 4 (	MET SAME 1A/1B
0:00 - 1:00			0	/		/		/	/
1:00 - 2:00			0	/		/		/	/
2:00 - 3:00			0	/		/		/	/
3:00 - 4:00			0	/		/		/	/
4:00 - 5:00			0	/		/		/	/
5:00 - 6:00			0	/		/		/	/
6:00 - 7:00	95	315	410	X/	44	/	49	/	/
7:00 - 8:00	173	489	662	X/X	75	/X	68	/X	/X
8:00 - 9:00	163	347	510	X/	91	/X	57	/X	/
9:00 - 10:00	153	226	379	X/	87	/X	63	/X	/
10:00 - 11:00	213	219	432	X/	85	/X	61	/X	/
11:00 - 12:00	256	241	497	X/	90	/X	55	/X	/
12:00 - 13:00	308	282	590	X/X	124	X/X	86	/X	X/X
13:00 - 14:00	274	284	558	X/X	90	/X	67	/X	/X
14:00 - 15:00	333	266	599	X/X	106	X/X	77	/X	X/X
15:00 - 16:00	390	370	760	X/X	121	X/X	82	/X	X/X
16:00 - 17:00	475	350	825	X/X	140	X/X	122	X/X	X/X
17:00 - 18:00	456	362	818	X/X	116	X/X	111	X/X	X/X
18:00 - 19:00	369	274	643	X/X	59	/X	54	/X	/X
19:00 - 20:00			0	/		/		/	/
20:00 - 21:00			0	/		/		/	/
21:00 - 22:00			0	/		/		/	/
22:00 - 23:00			0	/		/		/	/
23:00 - 24:00			0	/		/		/	/

	Met (Hr)	Required (Hr)	
Warrant 1A	5	8	Not satisfied
Warrant 1B	**8**	8	**Satisfied**
Warrant 2	5	4	**Satisfied**
Warrant 3	2	1	**Satisfied**
Warrant 7	**12**	8	**Satisfied, check accident record**

LOCATION: CSAH 34 at CSAH 45
COUNTY: Steele
REF. POINT:
DATE: 1/14/2020
OPERATOR: KR

Speed	Approach Description	Lanes
45	Major App1: EASTBOUND - CSAH 34	1
45	Major App3: WESTBOUND - CSAH 34	1
55	Minor App2: NORTHBOUND - CSAH 45	1
55	Minor App4: SOUTHBOUND - CSAH 45	1

0.70 FACTOR USED?	YES
POPULATION < 10,000?	No
EXISTING SIGNAL ?	No

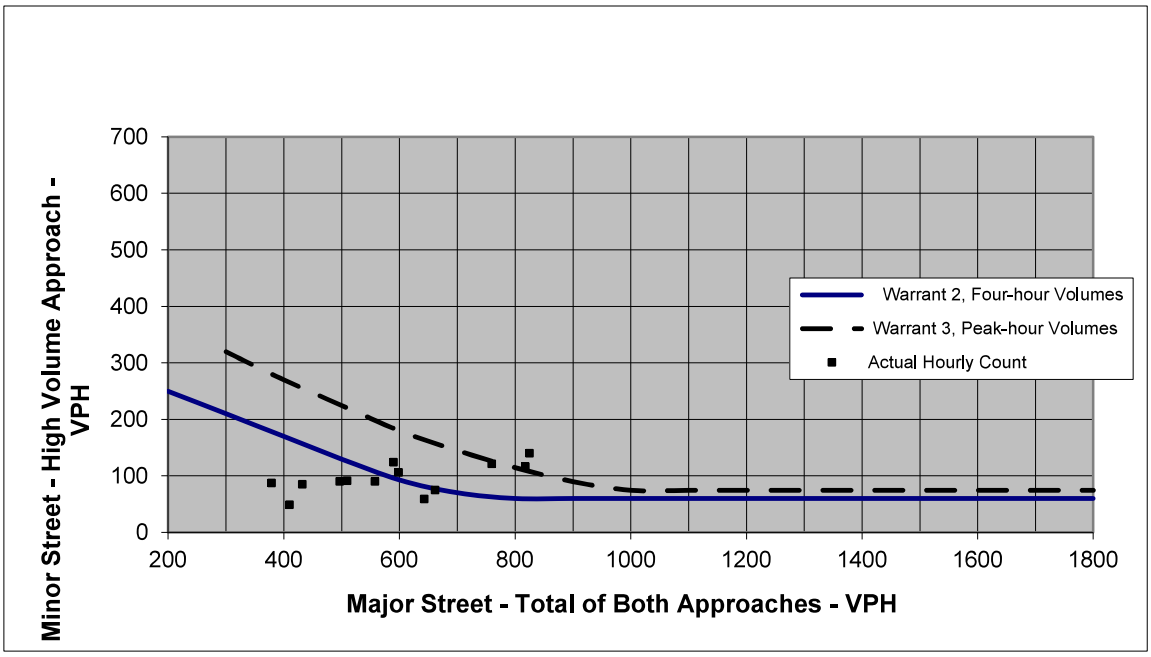

Figure 1. Four Hour and Peak Hour Warrant Analysis

Note: For data points outside the graph range, check the minor street volume against the lower thresholds

Warrant Criteria			Actual Hourly Count	
Major	Warrant 2,	Warrant 3, Pe	Major	Actual Hourly Count
200	250		0	0
300	210	320	0	0
400	170	270	0	0
500	130	225	0	0
600	93	180	0	0
700	70	145	0	0
800	60	115	410	49
900	60	90	662	75
1000	60	75	510	91
1100	60	75	379	87
1200	60	75	432	85
1300	60	75	497	90
1400	60	75	590	124
1500	60	75	558	90
1600	60	75	599	106
1700	60	75	760	121
1800	60	75	825	140
			818	116
			643	59
			0	0
			0	0
			0	0
			0	0
			0	0

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ALL WAY STOP WARRANT ANALYSIS
FOR
CSAH 34 at CSAH 45
Existing (2020) Volumes [Roundabout Geometry]

LOCATION: CSAH 34 at CSAH 45
COUNTY: Steele
REF. POINT:
DATE: 1/14/2020
OPERATOR: KR

Speed	Approach Description	Lanes
45	Major App1: EASTBOUND - CSAH 34	1
45	Major App3: WESTBOUND - CSAH 34	1
55	Minor App2: NORTHBOUND - CSAH 45	1
55	Minor App4: SOUTHBOUND - CSAH 45	1

0.70 FACTOR USED? Yes

					210	140	
HOUR	MAJOR	MAJOR	MINOR	MINOR	MAJOR TOTAL Σ (APP. 1 & APP. 3)	MINOR TOTAL APP. 2 + APP. 4	WARRANT MET
0:00 - 1:00							
1:00 - 2:00							
2:00 - 3:00							
3:00 - 4:00							
4:00 - 5:00							
5:00 - 6:00							
6:00 - 7:00	95	315	44	49	410	93	X/
7:00 - 8:00	173	489	75	68	662	143	X/X
8:00 - 9:00	163	347	91	57	510	148	X/X
9:00 - 10:00	153	226	87	63	379	150	X/X
10:00 - 11:00	213	219	85	61	432	146	X/X
11:00 - 12:00	256	241	90	55	497	145	X/X
12:00 - 13:00	308	282	124	86	590	210	X/X
13:00 - 14:00	274	284	90	67	558	157	X/X
14:00 - 15:00	333	266	106	77	599	183	X/X
15:00 - 16:00	390	370	121	82	760	203	X/X
16:00 - 17:00	475	350	140	122	825	262	X/X
17:00 - 18:00	456	362	116	111	818	227	X/X
18:00 - 19:00	369	274	59	54	643	113	X/
19:00 - 20:00							
20:00 - 21:00							
21:00 - 22:00							
22:00 - 23:00							
23:00 - 24:00							

	Met (Hr)	Required (Hr)	
Allway Stop Warrant:	11	8	Satisfied

REMARKS:

Intersection Safety Screening

Intersection: CSAH 34 at CSAH 45

Statewide Averages based on 2015-2019 crashes

Crashes by Crash Severity	
Fatal	0
Incapacitating Injury	1
Minor Injury	3
Possible Injury	3
Property Damage	14
Total Crashes	21

Intersection Characteristics	
Entering Volume	11,900
Environment	Rural
Lighting	Lit
Traffic Control	Signal

Annual crash cost = $384,400

Statewide comparison = Signal, Low Volume (<=20K)

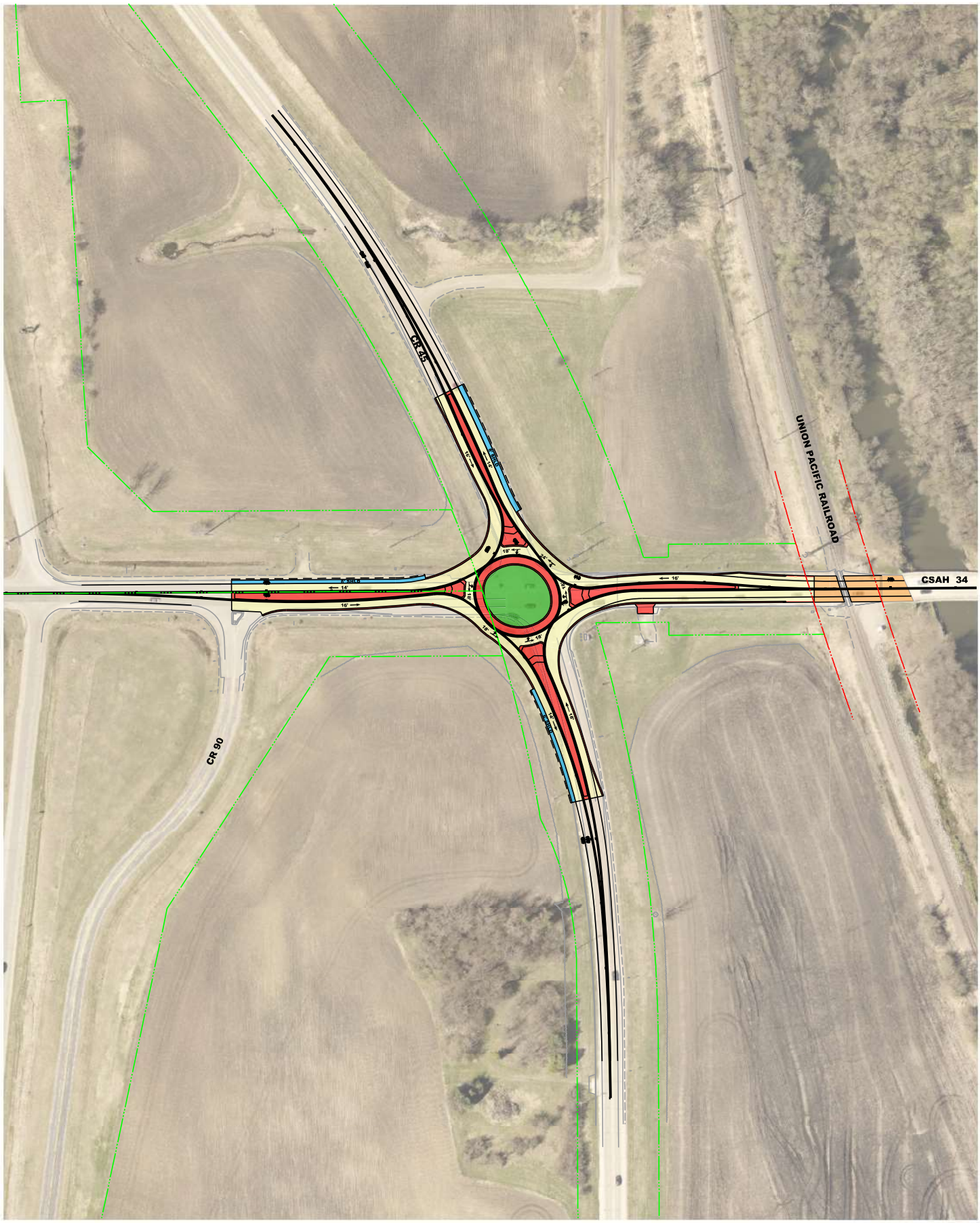
Total Crash Rate	
Observed	0.966
Statewide Average	0.420
Critical Rate	0.800
Critical Index	**1.21**

Fatal & Serious Injury Crash Rate	
Observed	4.602
Statewide Average	0.635
Critical Rate	5.130
Critical Index	**0.90**

The observed crash rate is the number of crashes per million entering vehicles (MEV). The critical rate is a statistical comparison based on similar intersections statewide. An observed crash rate greater than the critical rate indicates that the intersection operates outside the expected, normal range. The critical index reports the magnitude of this difference.

The observed total crash rate for this period is 0.97 per MEV; this is 1.2 times the critical rate. If crashes were reduced by 4 over five years, this intersection would perform within normal range.

The observed fatal and serious injury crash rate for this period is 4.60 per 100 MEV; this is 10% below the critical rate. The intersection operates within the normal range.



BOLTON & MENK

GENERAL LAYOUT

CSAH 34 & CSAH 45 ROUNDABOUT PROJECT

BOLTON & MENK, INC. ROUNDABOUT DESIGN CRITERIA

General Design Criteria

CSAH 34 (26th St)

Design Speed	= 45 mph
Stopping Sight Distance	= 365 ft.
Braking Distance	= 195 ft.
Lane Width	= 16 ft.
Design Vehicle	= WB-62

CSAH 45 (State Ave)

Design Speed	= 55 mph
Stopping Sight Distance	= 500 ft.
Braking Distance	= 290 ft.
Lane Width	= 16 ft.
Design Vehicle	= WB-62

Roundabout Design Criteria

Inscribed Diameter (ICD) = 184 ft. (Major Circle)
158 ft. (Minor Circle)

	-North Leg-	-South Leg-	-East Leg-	-West Leg-
Speed Limit	55 mph	55 mph	45 mph	45 mph
Design Speed	55 mph	55 mph	45 mph	45 mph
Splitter Island Length(min)	265 (250) ft	250 (250) ft	255 (250) ft	355 (250) ft
Entry Width	22 ft	22 ft	19 ft	20 ft
Approach Width	16 ft	16 ft	16 ft	16 ft
Entry Angle	27°	28°	28°	28°
Shoulder Width	N/A	N/A	N/A	N/A
Sidewalk Width*	10 ft	10 ft	10 ft	10 ft
Boulevard Width*	10 ft	10 ft	10 ft	10 ft
R-Values	-Southbound-	-Northbound-	-Westbound-	-Eastbound-
R1	100	150	150	125
R2	75	100	100	75
R3	200	200	200	200
R4	73	73	73	73
R5	109	108	160	205

***Graded for future facility**

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Table A1: Existing Traffic Operations Analysis

Intersection	Peak Hour	Intersection Delay (1.)		Movement Delay (sec/veh)																					
				NBL		NBT		NBR		SBL		SBT		SBR		EBL		EBT		EBR		WBL		WBT		WBR	
CSAH 34 at CSAH 45 *Signalized Intersection*	AM	11	B	16	B	18	B	4	A	14	B	15	B	6	A	12	B	9	A	2	A	11	B	11	B	3	A
	PM	10	B	15	B	17	B	6	A	14	B	19	B	4	A	9	A	11	B	3	A	11	B	8	A	2	A

1. Delay in seconds per vehicle

Table A2: Existing Peak Hour Queues By Movement

Intersection	Peak Hour	Queue Lengths (ft)																							
		EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
		Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max
CSAH 34 at CSAH 45 *Signalized Intersection*	AM	25	50	50	125	25	25	25	100	100	225	25	25	50	125	50	125	25	50	25	100	25	100	25	50
	PM	25	25	100	225	25	50	25	50	50	125	25	25	50	125	50	125	25	75	50	100	50	100	25	50

Table A3. 2020 AM - Single Lane Roundabout (No Train)
7:15-8:15 AM

Location	Aprch	Demand volumes				Modeled Volumes				Model - Demand					Total Delay by Movement (sec/veh)			Level of Service by Movement			LOS by Approach		LOS		Queuing (feet)		
		L	T	R	Total	L	T	R	Total	L	T	R	Total	%	L	T	R	L	T	R	Delay	LOS	Delay	LOS	Storage	Avg	Max
	EB	22	191	32	245	19	188	39	246	-3	-3	7	1	0%	2	2	3	A	A	A	2	A			375	25	125
CSAH 34 at CSAH 45	WB	62	447	25	534	62	448	24	534	0	1	-1	0	0%	3	3	2	A	A	A	3	A	3	A	400	25	175
Single Lane Roundabout	NB	70	34	10	114	71	33	11	115	1	-1	1	1	1%	2	2	1	A	A	A	2	A				25	75
	SB	18	50	22	90	21	47	23	91	3	-3	1	1	1%	8	9	4	A	A	A	7	A				25	100

Table A4. 2020 PM - Single Lane Roundabout (No Train)
4:30-5:30 PM

Location	Aprch	Demand volumes				Modeled Volumes				Model - Demand					Total Delay by			Level of Service by			LOS by		LOS		Queuing (feet)		
		L	T	R	Total	L	T	R	Total	L	T	R	Total	%	L	T	R	L	T	R	Delay	LOS	Delay	LOS	Storage	Avg	Max
	EB	12	473	69	554	15	467	74	556	3	-6	5	2	0%	3	3	3	A	A	A	3	A			375	25	250
CSAH 34 at CSAH 45	WB	18	246	16	280	16	248	16	280	-2	2	0	0	0%	1	1	1	A	A	A	1	A	3	A	400	25	100
Single Lane Roundabout	NB	35	56	56	147	33	56	57	146	-2	0	1	-1	-1%	4	3	4	A	A	A	4	A				25	100
	SB	41	49	21	111	46	47	18	111	5	-2	-3	0	0%	3	4	1	A	A	A	3	A				25	100

Table A5. 2020 AM - Single Lane Roundabout (with Train)
7:15-8:15 AM

Location	Aprch	Demand volumes				Modeled Volumes				Model - Demand					Total Delay by Movement (sec/veh)			Level of Service by Movement			LOS by Approach		LOS		Queuing (feet)		
		L	T	R	Total	L	T	R	Total	L	T	R	Total	%	L	T	R	L	T	R	Delay	LOS	Delay	LOS	Storage	Avg	Max
CSAH 34 at CSAH 45	EB	22	191	32	245	19	188	39	246	-3	-3	7	1	0%	2	2	3	A	A	A	2	A	4	A	375	25	125
	WB	62	447	25	534	62	448	24	534	0	1	-1	0	0%	5	4	4	A	A	A	4	A			400	25	650
Single Lane Roundabout	NB	70	34	10	114	71	33	11	115	1	-1	1	1	1%	2	1	1	A	A	A	2	A				25	75
	SB	18	50	22	90	21	47	23	91	3	-3	1	1	1%	14	9	6	B	A	A	9	A				25	100

Table A6. 2020 PM - Single Lane Roundabout (with Train)
4:30-5:30 PM

Location	Aprch	Demand volumes				Modeled Volumes				Model - Demand					Total Delay by			Level of Service by			LOS by		LOS		Queuing (feet)		
		L	T	R	Total	L	T	R	Total	L	T	R	Total	%	L	T	R	L	T	R	Delay	LOS	Delay	LOS	Storage	Avg	Max
CSAH 34 at CSAH 45	EB	12	473	69	554	15	467	74	556	3	-6	5	2	0%	5	3	3	A	A	A	3	A	3	A	375	25	250
	WB	18	246	16	280	16	248	16	280	-2	2	0	0	0%	2	2	2	A	A	A	2	A			400	25	225
Single Lane Roundabout	NB	35	56	56	147	33	56	57	146	-2	0	1	-1	-1%	5	5	5	A	A	A	5	A				25	100
	SB	41	49	21	111	46	47	18	111	5	-2	-3	0	0%	5	4	2	A	A	A	4	A				25	100

Figure 2. 2041 Forecasted Turning Movement Counts Baseline

CSAH 34/CSAH 45 Roundabout

Steele County, Minnesota

November 2020

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Map Document: \\arcserver1\GIS\STCO\T4212038\ESRI\Maps\120387_204C_Baseline_TMC_8x11P.mxd | Date Saved: 11/9/2020 12:34:31 PM

Table A7: 2041 Baseline Growth – Traffic Operations Analysis

Intersection	Peak Hour	Intersection Delay (1.)		Movement Delay (sec/veh)																					
				NBL		NBT		NBR		SBL		SBT		SBR		EBL		EBT		EBR		WBL		WBT		WBR	
CSAH 34 at CSAH 45 *Signalized Intersection*	AM	12	B	21	C	24	C	4	A	20	C	19	B	7	A	13	B	10	B	2	A	11	B	12	B	3	A
	PM	12	B	17	B	19	B	9	A	18	B	21	C	5	A	11	B	12	B	3	A	13	B	10	B	2	A

1. Delay in seconds per vehicle

Table A8: 2041 Baseline Growth – Peak Hour Queues By Movement

Intersection	Peak Hour	Queue Lengths (ft)																							
		EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
		Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max
CSAH 34 at CSAH 45 *Signalized Intersection*	AM	25	50	50	125	25	50	25	125	100	225	25	50	75	150	75	150	25	50	50	125	50	125	25	50
	PM	25	50	125	250	25	50	25	50	75	150	25	25	50	125	50	125	50	100	50	125	50	125	25	75

Table A9. 2041 AM - Baseline Growth - Single Lane Roundabout (No Train)
7:15-8:15 AM

Location	Aprch	Demand volumes				Modeled Volumes				Model - Demand					Total Delay by Movement (sec/veh)			Level of Service by Movement			LOS by Approach		LOS		Queuing (feet)		
		L	T	R	Total	L	T	R	Total	L	T	R	Total	%	L	T	R	L	T	R	Delay	LOS	Delay	LOS	Storage	Avg	Max
CSAH 34 at CSAH 45	EB	24	229	36	289	24	228	40	292	0	-1	4	3	1%	2	3	2	A	A	A	3	A	6	A	375	25	150
	WB	78	543	30	651	77	543	29	649	-1	0	-1	-2	0%	6	5	5	A	A	A	5	A			400	25	375
Single Lane Roundabout	NB	85	42	13	140	87	40	13	140	2	-2	0	0	0%	3	2	1	A	A	A	2	A				25	100
	SB	23	61	26	110	26	58	25	109	3	-3	-1	-1	-1%	30	20	13	D	C	B	21	C				25	175

Table A10. 2041 PM - Baseline Growth - Single Lane Roundabout (No Train)
4:30-5:30 PM

Location	Aprch	Demand volumes				Modeled Volumes				Model - Demand					Total Delay by Movement (sec/veh)			Level of Service by Movement			LOS by Approach		LOS		Queuing (feet)		
		L	T	R	Total	L	T	R	Total	L	T	R	Total	%	L	T	R	L	T	R	Delay	LOS	Delay	LOS	Storage	Avg	Max
CSAH 34 at CSAH 45	EB	14	576	85	675	16	574	88	678	2	-2	3	3	0%	4	4	5	A	A	A	4	A	4	A	375	25	450
	WB	22	300	19	341	20	304	16	340	-2	4	-3	-1	0%	3	2	2	A	A	A	2	A			400	25	125
Single Lane Roundabout	NB	43	68	69	180	42	69	69	180	-1	1	0	0	0%	7	7	7	A	A	A	7	A				25	125
	SB	49	60	25	134	52	58	24	134	3	-2	-1	0	0%	6	5	2	A	A	A	5	A				25	125

Table A11. 2041 AM - Baseline Growth - Single Lane Roundabout (with Train)
7:15-8:15 AM

Location	Aprch	Demand volumes				Modeled Volumes				Model - Demand					Total Delay by Movement (sec/veh)			Level of Service by Movement			LOS by Approach		LOS		Queuing (feet)		
		L	T	R	Total	L	T	R	Total	L	T	R	Total	%	L	T	R	L	T	R	Delay	LOS	Delay	LOS	Storage	Avg	Max
CSAH 34 at CSAH 45	EB	24	229	36	289	24	228	40	292	0	-1	4	3	1%	2	2	2	A	A	A	2	A	7	A	375	25	125
	WB	78	543	30	651	77	543	29	649	-1	0	-1	-2	0%	9	7	8	A	A	A	7	A			400	75	1100
Single Lane Roundabout	NB	85	42	13	140	87	40	13	140	2	-2	0	0	0%	3	2	1	A	A	A	2	A				25	100
	SB	23	61	26	110	26	58	25	109	3	-3	-1	-1	-1%	36	25	17	E	C	C	26	D				25	200

Table A12. 2041 PM - Baseline Growth - Single Lane Roundabout (with Train)
4:30-5:30 PM

Location	Aprch	Demand volumes				Modeled Volumes				Model - Demand					Total Delay by Movement (sec/veh)			Level of Service by Movement			LOS by Approach		LOS		Queuing (feet)		
		L	T	R	Total	L	T	R	Total	L	T	R	Total	%	L	T	R	L	T	R	Delay	LOS	Delay	LOS	Storage	Avg	Max
CSAH 34 at CSAH 45	EB	14	576	85	675	16	574	88	678	2	-2	3	3	0%	8	6	6	A	A	A	6	A	6	A	375	25	575
	WB	22	300	19	341	20	304	16	340	-2	4	-3	-1	0%	4	3	5	A	A	A	3	A			400	25	375
Single Lane Roundabout	NB	43	68	69	180	42	69	69	180	-1	1	0	0	0%	10	11	9	B	B	A	10	B				25	175
	SB	49	60	25	134	52	58	24	134	3	-2	-1	0	0%	8	7	3	A	A	A	7	A				25	125

Figure 3. 2041 Forecasted Turning Movement Counts
Baseline with Development

CSAH 34/CSAH 45 Roundabout

Steele County, Minnesota

November 2020

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Legend

Turning Movement Counts

AM (PM)

0 300 Foot

Source: Steele County, MnDOT

Note

Forecast volumes depicted assume a confidence level of approximately plus or minus 15 percent.

Map Document: \\arcserver1\GIS\STCO\T4212038\ESRI\Maps\120387_204C_Baseline_Dev_TMC_8x11_P.mxd | Date Saved: 11/9/2020 12:34:22 PM

ROUNDABOUT CAPACITY

The 2041 (with development) peak hour traffic volumes at the intersection were analyzed compared to the capacity for a single lane roundabout. The Highway Capacity Manual (6th Edition) provides an estimated capacity per approach based on the conflicting volume. **Tables A13** and **A14** show the 2041 (with development) traffic volumes compared to the capacity of a single lane roundabout.

Table A13. 2041 Volume to Capacity Analysis – AM Peak Hour

Approach	Entering Volume	Conflicting Volume	Roundabout Capacity*	Percent of Capacity (Entering/Capacity)
EB	628	170	1160	54%
WB	913	281	1036	88%
NB	231	540	796	29%
SB	161	1052	472	34%

*Capacity for a single lane roundabout according to the Highway Capacity Manual (6th Edition)

Table A14. 2041 Volume to Capacity Analysis – PM Peak Hour

Approach	Entering Volume	Conflicting Volume	Roundabout Capacity*	Percent of Capacity (Entering/Capacity)
EB	1135	141	1195	95%
WB	637	283	1034	62%
NB	287	1000	498	58%
SB	194	758	637	30%

*Capacity for a single lane roundabout according to the Highway Capacity Manual (6th Edition)

The 2041 capacity analysis with development indicates that with a single lane roundabout the westbound approach is nearly at capacity during the AM peak hour and the eastbound approach is nearly at capacity during the PM peak hour. This analysis indicates that the eastbound and westbound approaches are anticipated to have excessive delay and queuing during the peak hours.

The capacity of a 2x1 roundabout with two through lanes along the CSAH 34 was also analyzed. **Tables A15** and **A16** show the 2041 (with development) traffic volumes compared to the capacity of a 2x1 roundabout.

Table A15. 2041 Volume to Capacity Analysis – AM Peak Hour

Approach	Entering Volume	Conflicting Volume	Roundabout Capacity*	Percent of Capacity (Entering/Capacity)
EB	628	170	2433	26%
WB	913	281	2199	42%
NB	231	540	796	29%
SB	161	1052	472	34%

*Capacity for a 2x1 roundabout according to the Highway Capacity Manual (6th Edition)

Table A16. 2041 Volume to Capacity Analysis – PM Peak Hour

Approach	Entering Volume	Conflicting Volume	Roundabout Capacity*	Percent of Capacity (Entering/Capacity)
EB	1135	141	2498	45%
WB	637	283	2195	29%
NB	287	1000	498	58%
SB	194	758	637	30%

*Capacity for a 2x1roundabout according to the Highway Capacity Manual (6th Edition)

Tables A15 and A16 show that a 2x1 roundabout is anticipated to operate well with volumes only reaching 42-45% the capacity along CSAH 34 and at most 58% of capacity along CSAH 45.

CRASH MODIFICATION FACTORS CLEARINGHOUSE

CMF / CRF Details

CMF ID: 225

Convert signalized intersection to modern roundabout

Description:

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

Category: Intersection geometry

Study: ***NCHRP Report 572: Applying Roundabouts in the United States,*** **Rodegerdts et al., 2007**

Star Quality Rating:	★★★★☆

Crash Modification Factor (CMF)	
Value:	0.52
Adjusted Standard Error:	0.06
Unadjusted Standard Error:	0.05

Crash Reduction Factor (CRF)	
Value:	48 *(This value indicates a* ***decrease*** *in crashes)*
Adjusted Standard Error:	6

Unadjusted Standard Error:	5

Applicability

Crash Type:	All
Crash Severity:	All
Roadway Types:	Not Specified
Number of Lanes:	1 or 2
Road Division Type:	
Speed Limit:	
Area Type:	All
Traffic Volume:	
Time of Day:	

If countermeasure is intersection-based

Intersection Type:	Roadway/roadway (not interchange related)
Intersection Geometry:	Not Specified
Traffic Control:	Signalized
Major Road Traffic Volume:	
Minor Road Traffic Volume:	

Development Details

Date Range of Data Used:	
Municipality:	
State:	

Country:	
Type of Methodology Used:	Before/after using empirical Bayes or full Bayes
Sample Size Used:	

Other Details

Included in Highway Safety Manual?	Yes. HSM lists this CMF in **bold** font to indicate that it has the highest reliability since it has an adjusted standard error of 0.1 or less.
Date Added to Clearinghouse:	Dec-01-2009
Comments:	Countermeasure name changed to match HSM

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

CRASH MODIFICATION FACTORS CLEARINGHOUSE

CMF / CRF Details

CMF ID: 226

Convert signalized intersection to modern roundabout

Description:

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

Category: Intersection geometry

Study: ***NCHRP Report 572: Applying Roundabouts in the United States,*** **Rodegerdts et al., 2007**

Star Quality Rating:	★★★★☆

Crash Modification Factor (CMF)	
Value:	0.22
Adjusted Standard Error:	0.07
Unadjusted Standard Error:	0.06

Crash Reduction Factor (CRF)	
Value:	78 *(This value indicates a* ***decrease*** *in crashes)*
Adjusted Standard Error:	7

Unadjusted Standard Error:	6

Applicability

Crash Type:	All
Crash Severity:	A (serious injury),B (minor injury),C (possible injury)
Roadway Types:	Not Specified
Number of Lanes:	1 or 2
Road Division Type:	
Speed Limit:	
Area Type:	All
Traffic Volume:	
Time of Day:	

If countermeasure is intersection-based

Intersection Type:	Roadway/roadway (not interchange related)
Intersection Geometry:	Not Specified
Traffic Control:	Signalized
Major Road Traffic Volume:	
Minor Road Traffic Volume:	

Development Details

Date Range of Data Used:	
Municipality:	
State:	

Country:	
Type of Methodology Used:	Before/after using empirical Bayes or full Bayes
Sample Size Used:	

Other Details

Included in Highway Safety Manual?	Yes. HSM lists this CMF in **bold** font to indicate that it has the highest reliability since it has an adjusted standard error of 0.1 or less.
Date Added to Clearinghouse:	Dec-01-2009
Comments:	Countermeasure name changed to match HSM

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