

Technical Memo

Date: Monday, June 10, 2019

Project: US14-US14 Bypass Corridor Study

To: Study Advisory Team

From: HDR

Subject: Existing Conditions Traffic Operations

Introduction

This memorandum presents the traffic operations analysis along the US14B corridor from the US14 junction west of Brookings to the US14 junction east of Brookings, and the US 14 corridor from the south/east junction with US81 to the US14Bypass junction west of Brookings. The analysis period evaluated in this memorandum is for Existing Conditions (Year 2019).

The purpose of this memorandum is to identify traffic operational needs along the study corridor. This analysis also serves as a baseline for the development and evaluation of corridor concepts that will be carried into conceptual design. Methods and assumptions used for this analysis are further described in the US14-US14 Bypass Corridor Study Methods and Assumptions Documentation.

Traffic Data

Traffic data used to develop the 2019 Existing Conditions volume sets is summarized as follows:

24-hour intersection turning movement counts:

- Includes pedestrian/bicycle crosswalk data
- Collected by Traffic Data Inc. (TDI) on Wednesday, April 24, 2019.
 - Exception: US 14 Bypass / 32nd Avenue counts were collected on May 23, 2019

24-hour roadway segment counts:

- Includes vehicle speeds
- Collected by the South Dakota Department of Transportation (SDDOT) for at least a 24 hour period within from April 23 to 29, 2019.

Heavy vehicle percentages and peak hour factors (PHF) used in the analysis were obtained from the peak hour intersection turning movement counts.

Traffic Volume Development

Daily segment volumes and AM and PM peak hour intersection volumes were developed for the 2019 Existing Conditions scenario.

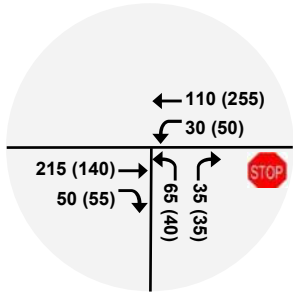


The 2019 Existing Conditions volume set was developed for the existing corridor using the 2019 segment and peak hour counts, factored to a design season to account for seasonal fluctuations. Intersection turning movement volumes were balanced and smoothed across the corridor. Additional background on traffic volume development is provided in the Methods and Assumptions Document.

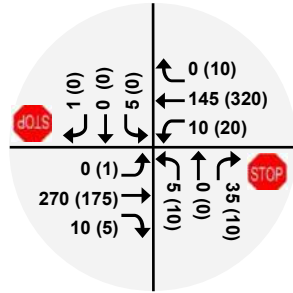
A summary of traffic volumes for 2019 Existing Conditions is provided in **Figure 1** and **Figure 2**.



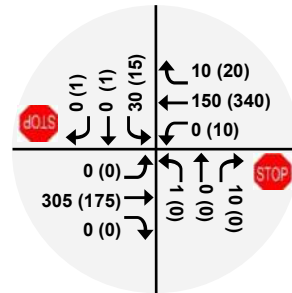
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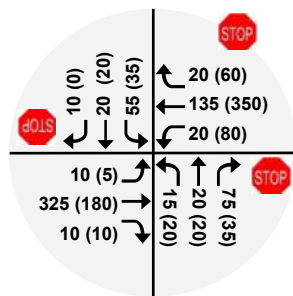
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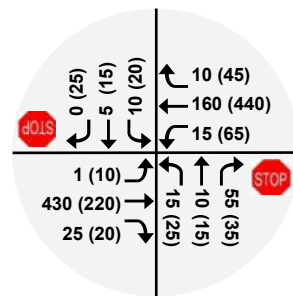
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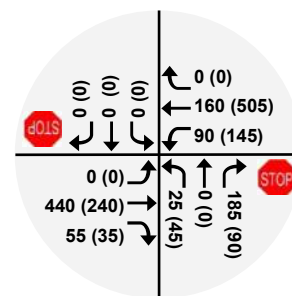
4 US 14 & Brookings Co. 5 / 464th Ave



5 US 14 & Kasan Ave



6 US 14 & Hansina Ave



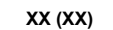
LEGEND



Study Intersection



Daily Traffic Volumes



Peak Hour Traffic Volumes: AM (PM)



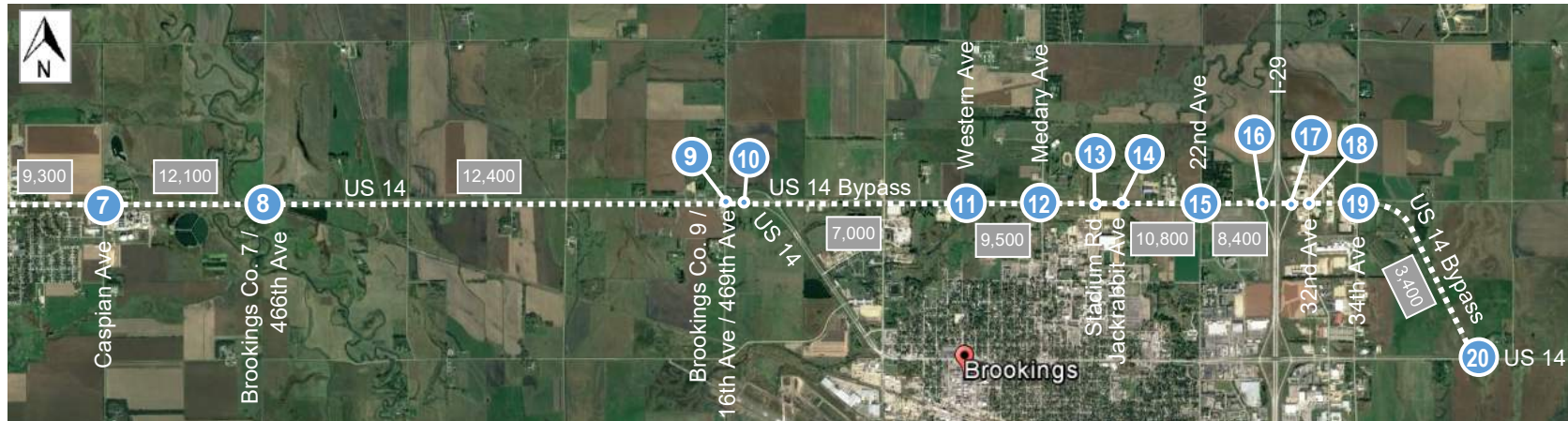
Traffic Movement



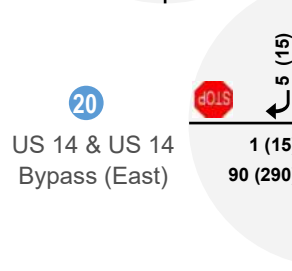
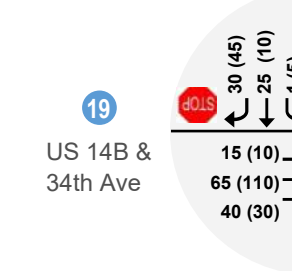
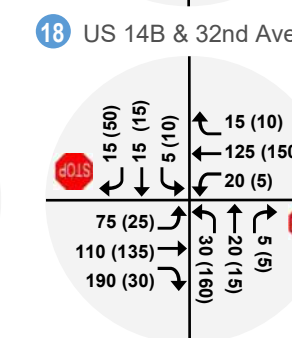
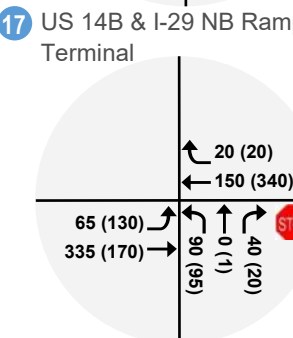
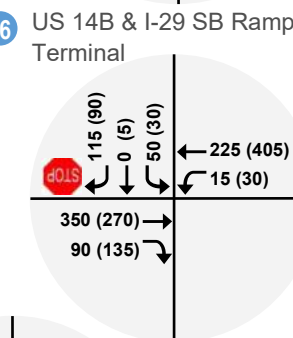
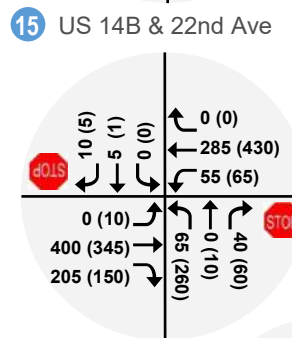
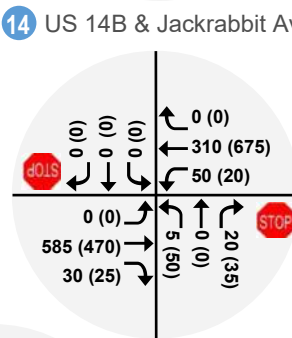
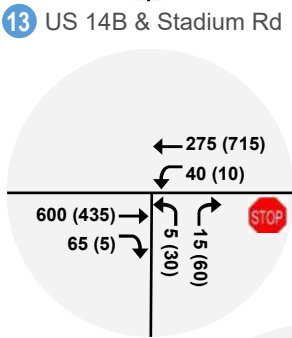
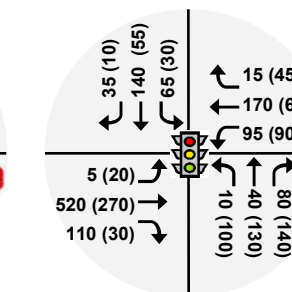
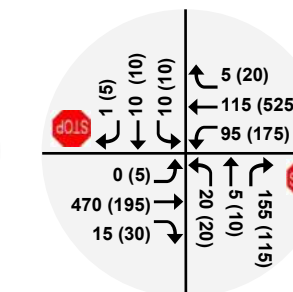
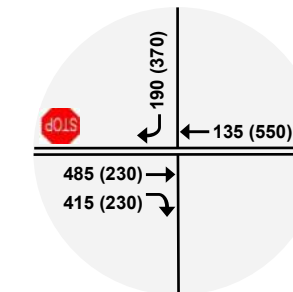
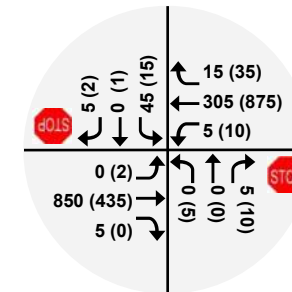
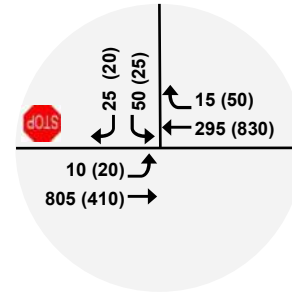
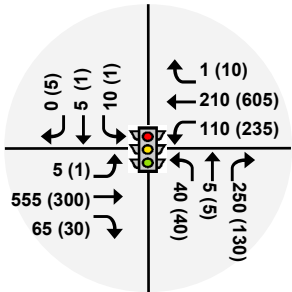
Existing Traffic Control

NOTES

- AM peak hour is from 7:15 to 8:15
AM and PM peak hour is from 4:30 to 5:30 PM.



- 7** US 14 & Caspian Ave
- 8** US 14 & Brookings Co. 7 / 466th Ave
- 9** US 14 & Brookings Co. 9 / 16th Ave W / 469th Ave
- 10** US 14 & US 14 Bypass (West)
- 11** US 14B & Western Ave
- 12** US 14B & Medary Ave
- 13** US 14B & Stadium Rd
- 14** US 14B & Jackrabbit Ave
- 15** US 14B & 22nd Ave
- 16** US 14B & I-29 SB Ramp Terminal
- 17** US 14B & I-29 NB Ramp Terminal
- 18** US 14B & 32nd Ave
- 19** US 14B & 34th Ave
- 20** US 14 & US 14 Bypass (East)



*See Figure 1 for legend and notes



2019 Existing Conditions Traffic Volumes: Caspian Ave to US 14 & US 14 Bypass (East) (2 of 2)

US14-US14 Bypass Corridor Study



Free Flow Speed Measurements

Measured free flow speeds and posted speed limits for each of the study highway segments are summarized in **Table 1**.

Table 1: Highway Segment Speeds

Seg. No.	Mainline	From	To	Posted Speed (mph)	Measured Free Flow Speed (mph)	
					EB	WB
1	US 14	Project Beginning MP MRM 402.94	US 81	65	*	*
2	US 14	US 81	Brookings CR 11 / 458th Ave	65	*	*
3	US 14	Brookings CR 11 / 458th Ave	Brookings CR 1 / 459th Ave	65	*	*
4	US 14	Brookings CR 1 / 459th Ave	Brookings CR 5 / 464th Ave	65	65	60
5	US 14	Brookings CR 5 / 464th Ave	Kasan Ave	35	*	*
6	US 14	Kasan Ave	Hansina Ave	35	*	*
7	US 14	Hansina Ave	Caspian Ave	35 to 50	*	*
8	US 14	Caspian Ave	Brookings CR 7 / 466th Ave	Mostly 65	*	*
9	US 14	Brookings CR 7 / 466th Ave	Brookings CR 9 / 16th Ave W / 469th Ave	Mostly 65	60	60
10	US 14	Brookings CR 9 / 16th Ave W / 469th Ave	US 14 B (west)	55	*	*
11	US 14	US 14 B (west)	Western Ave	55	50	55
12	US 14 B	Western Ave	Medary Ave	55	*	*
13	US 14 B	Medary Ave	Jackrabbit Ave	55	*	*
14	US 14 B	Jackrabbit Ave	22nd Ave	55	50	50
15	US 14 B	22nd Ave	I-29 SB Ramp Terminal	55	45	45
16	US 14 B	I-29 SB Ramp Terminal	I-29 NB Ramp Terminal	55	*	*
17	US 14 B	I-29 NB Ramp Terminal	32nd Ave	55	*	*
18	US 14 B	32nd Ave	34th Ave	55	*	*
19	US 14 B	34th Ave	US 14 B (east) MRM 423.24	65	55	55

*No measurement taken in this segment. Assume 5 mph below posted for free flow speed. Or 45mph if posted speed is less than 45mph.

Traffic Operations - Methodology

Peak hour level of service (LOS) was calculated for the 20 analysis intersections and 19 analysis segments using Highway Capacity Software, Version 7 (HCS7) and methodology described in the 6th Edition of the Highway Capacity Manual (HCM6).



Level of Service Thresholds for Intersections

HCM6 analysis methods measure intersection average control delay in terms of seconds of delay per vehicle (sec/veh) and applies a LOS value in accordance with thresholds presented in **Table 2**.

Table 2: Intersection Level of Service Thresholds

LOS	Intersection Delay per Vehicle (sec/veh)	
	Signalized Intersections	Two-Way Stop-Control*, All-Way Stop-Control, and Roundabouts
A	≤ 10	≤ 10
B	> 10 – 20	> 10 – 15
C	> 20 - 35	> 15 - 25
D	> 35 – 55	> 25 – 35
E	> 55 – 80	> 35 – 50
F	Demand exceeds capacity; > 80	Demand exceeds capacity; > 50

Source: Transportation Research Board, HCM6.

* Two-way stop-control LOS reflects worst-case stop-controlled approach.

Weighted intersection delay was also calculated to present a second average delay measure for intersections. This method accounts for the operational benefits afforded to the major, high volume through movements that are not stop or signal-controlled at intersections. HCM6 reporting in HCS provides an average approach delay value that reflects the weighted average delay of all vehicles entering each approach. A LOS measure is applied to this average intersection delay value using HCM6 All-Way Stop-Control LOS thresholds.

Level of Service Thresholds for Highway Segments

For two-lane highway segments designated as Class I¹, HCM6 analysis methods measure average travel speed in terms of miles per hour (mph), as well as percent time spent following and applies a LOS value in accordance with thresholds presented in **Table 3**.

Table 3: Level of Service Criteria for Two-Lane Highway Segments (Class I Highways)

LOS	Average Travel Speed (mph)	Percent Time Spent Following (%)
A	>55	≤35
B	>50-55	>35-50
C	>45-50	>50-65
D	>40-45	>65-80
E	≤40	>80
F	Demand exceeds capacity	

Source: Transportation Research Board, HCM6.

¹ Class I two-lane highways are those where motorists are expected to travel at relatively high speeds. See Chapter 15 of HCM6 for additional information.



For multi-lane highway segments, HCM6 analysis methods measure lane density in terms of passenger cars per mile per lane (pc/mi/ln) and applies a LOS value in accordance with thresholds presented in **Table 4**.

Table 4: Level of Service Criteria for Multilane Highway Segments

LOS	Density (pc/mi/ln)
A	≥11
B	>11-18
C	>18-26
D	>26-35
E	>35-45
F	Demand exceeds capacity OR density >45

Source: Transportation Research Board, HCM6.

Level of Service Goals for Study

Minimum allowable LOS thresholds established for this study are shown in **Table 5**.

Table 5: Level of Service Goals by Facility and Area Type

Facility Type	Rural Areas	Urban Areas	General Notes
Signalized Intersections	Minimum allowable LOS: B	Minimum allowable LOS: D	Individual movements allowed to operate at LOS E, but the overall intersection shall be LOS D or better.
Two-Way Stop Controlled Intersections	Minimum allowable LOS: B	Minimum allowable LOS: C	Intersection LOS is based on weighted average intersection delay; the worst case stop-controlled approach delay and LOS may be lower than the minimum allowable LOS.
Ramp Terminal Intersections	Minimum allowable LOS: B	Minimum allowable LOS: C	Individual movements allowed to operate at LOS D, but the overall intersection shall be LOS C or better.
Two-Lane Highways	Minimum allowable LOS: B	Minimum allowable LOS: C, LOS B or better is desirable	
Multi-Lane Highways	Minimum allowable LOS: B	Minimum allowable LOS: C, LOS B or better is desirable	

These LOS thresholds will be used to identify areas of operational needs along the corridor. In Future Build Conditions operational analysis memoranda, these thresholds will be used to guide the development of potential improvements and subsequent evaluation of concepts.



Study Intersections and Segments

This study focuses on the traffic operations at the following 20 intersections, two of which are signalized and the remainder are two-way stop controlled (TWSC):

1. US 14 & US 81
2. US 14 & Brookings County 11 / 458th Avenue
3. US 14 & Brookings County 1 / 459th Avenue
4. US 14 & Brookings County 5 / 464th Avenue
5. US 14 & Kasan Avenue
6. US 14 & Hansina Avenue
7. US 14 & Caspian Avenue - **Signalized**
8. US 14 & Brookings County 7 / 466th Avenue
9. US 14 & Brookings County 9 / 16th Avenue W / 469th Avenue
10. US 14 & US 14B (West of Brookings)
11. US 14B & Western Avenue
12. US 14B & Medary Avenue - **Signalized**
13. US 14B & Stadium Road
14. US 14B & Jackrabbit Avenue
15. US 14B & 22nd Avenue
16. US 14B & I-29 SB Ramp Terminal
17. US 14B & I-29 NB Ramp Terminal
18. US 14B & 32nd Avenue
19. US 14B & 34th Avenue
20. US 14 & US 14B (East of Brookings)

In addition, 19 mainline road segments between each of the study intersections were analyzed.

Existing Conditions Traffic Operations Analysis

The Existing Conditions traffic operations analysis reflects a scenario that analyzes the current network, using recently collected traffic counts (2019) and existing roadway conditions such as number of lanes, intersection traffic control, speed limits, signal timings, etc.

Intersection Operations

The 2019 Existing Conditions intersection operations are summarized in the following table. HCS analysis reports are provided in **Appendix A**.

Table 6: Intersections – Existing Conditions

Intersection	Approach*	AM			PM		
		Control Delay (s/veh)	LOS	95th% Queue (Veh)	Control Delay (s/veh)	LOS	95th% Queue (Veh)
1. US 14 & US 81 <i>(Stop Controlled, Rural)</i>	Overall	2.6	A	0.4	2.1	A	0.2
	EB	0	A	0	0	A	0
	WB	1.8	A	0.1	1.4	A	0.1
	NB	10.6	B	0.4	10.1	B	0.2
2. US 14 & Brookings County 11 / 458th Avenue <i>(Stop Controlled, Rural)</i>	Overall	1.3	A	0.2	0.8	A	0.1
	EB	0	A	0	0	A	0
	WB	0.6	A	0	0.6	A	0
	NB	11	B	0.2	11.3	B	0.1
	SB	12.9	B	0	5	A	0



Intersection	Approach*	AM			PM		
		Control Delay (s/veh)	LOS	95th% Queue (Veh)	Control Delay (s/veh)	LOS	95th% Queue (Veh)
3. US 14 & Brookings County 1 / 459th Avenue (Stop Controlled, Rural)	Overall	8.2	A	0.3	0.6	A	0.1
	EB	7.6	A	0	0	A	0
	WB	8	A	0	0.3	A	0
	NB	10.6	B	0.1	5	A	0
	SB	13.9	B	0.3	13.2	B	0.1
4. US 14 & Brookings County 5 / 464th Avenue (Stop Controlled, Rural)	Overall	4.6	A	1	4.1	A	1
	EB	0.2	A	0	0.3	A	0
	WB	1	A	0.1	1.3	A	0.2
	NB	13.2	B	0.8	16	C	0.7
	SB	18.4	C	1	25.7	D	1
5. US 14 & Kasan Avenue (Stop Controlled, Rural)	Overall	1.8	A	0.5	2.8	A	0.6
	EB	0	A	0	0.3	A	0
	WB	0.7	A	0	0.9	A	0.2
	NB	12.1	B	0.5	14.3	B	0.6
	SB	13	B	0.1	16	C	0.6
6. US 14 & Hasina Avenue (Stop Controlled, Rural)	Overall	3.6	A	1.4	2.9	A	1.1
	EB	0	A	0	0	A	0
	WB	3.2	A	0.3	1.9	A	0.5
	NB	12.7	B	1.4	13.4	B	1.1
	SB	5	A	0	5	A	0
7. US 14 & Caspian Avenue (Signalized, Rural)	Overall	21.1	C	10.6	23.7	C	10.7
	EB	19.3	B	8	23.7	C	8.9
	WB	11.8	B	1.9	13.1	B	2
	NB	34.9	C	10.6	35.3	D	10.7
	SB	22.2	C	0.4	20.9	C	0.4
8. US 14 & Brookings County 7 / 466th Avenue (Stop Controlled, Rural)	Overall	0.9	A	0.6	0.7	A	0.4
	EB	0.1	A	0	0.5	A	0.1
	WB	0	A	0	0	A	0
	NB	0	A	0	0	A	0
	SB	12.7	B	0.6	15.7	C	0.4
9. US 14 & Brookings County 9 / 469th Avenue (Stop Controlled, Rural)	Overall	0.7	A	0.5	0.5	A	0.3
	EB	0	A	0	0.1	A	0
	WB	0.2	A	0	0.1	A	0
	NB	12.6	B	0	11.6	B	0.1
	SB	15.4	C	0.5	20.9	C	0.3
	Overall	1.6	A	1.1	5	A	4.4



Intersection	Approach*	AM			PM		
		Control Delay (s/veh)	LOS	95th% Queue (Veh)	Control Delay (s/veh)	LOS	95th% Queue (Veh)
10. US 14 & US 14 Bypass - West (Stop Controlled, Rural)	EB	0	A	0	0	A	0
	WB	0	A	0	0	A	0
	SB	10.3	B	1.1	18.6	C	4.4
11. US 14 Bypass & Western Avenue (Stop Controlled, Urban)	Overall	7.3	A	3.9	4.2	A	1.7
	EB	0	A	0	0.2	A	0
	WB	4.3	A	0.5	2	A	0.5
	NB	26.5	D	3.9	17.5	C	1.7
	SB	39.6	E	0.8	28.2	D	0.5
12. US 14 Bypass & Medary Avenue (Signalized, Urban)	Overall	12.9	B	3.7	10	A	4.2
	EB	8.5	A	3.7	6.8	A	1.4
	WB	8.7	A	2	6.7	A	0.6
	NB	21.8	C	2.2	20.5	C	4.2
	SB	24.5	C	2.5	21	C	0.1
13. US 14 Bypass & Stadium Road (Stop Controlled, Urban)	Overall	0.7	A	0.2	1.1	A	0.8
	EB	0	A	0	0	A	0
	WB	1.3	A	0.2	0.1	A	0
	NB	15.3	C	0.2	15	C	0.8
14. US 14 Bypass & Jackrabbit Avenue (Stop Controlled, Urban)	Overall	0.9	A	0.3	1.3	A	1
	EB	0	A	0	0	A	0
	WB	1.3	A	0.2	0.2	A	0.1
	NB	15.3	C	0.3	17.8	C	1
	SB	5	A	0	5	A	0
15. US 14 Bypass & 22nd Avenue (Stop Controlled, Urban)	Overall	2.6	A	1.4	32.5	F	15.2
	EB	0	A	0	0.2	A	0
	WB	1.6	A	0.3	1.2	A	0.2
	NB	18.7	C	1.4	129.1	F	15.2
	SB	14.1	B	0.1	12.9	B	0
16. US 14 Bypass & I-29 SB Ramp Terminal (Stop Controlled, Urban)	Overall	3.1	A	1.6	3	A	1.8
	EB	0	A	0	0	A	0
	WB	0.7	A	0.1	1.1	A	0.1
	SB	14.7	B	1.6	19.7	C	1.8
17. US 14 Bypass & I-29 NB Ramp Terminal	Overall	4.6	A	1.7	5.9	A	2.5
	EB	1.8	A	0.2	4.6	A	0.5
	WB	0	A	0	0	A	0



Intersection	Approach*	AM			PM		
		Control Delay (s/veh)	LOS	95th% Queue (Veh)	Control Delay (s/veh)	LOS	95th% Queue (Veh)
<i>(Stop Controlled, Urban)</i>	NB	19	C	1.7	27.7	D	2.5
18. US 14 Bypass & 32nd Avenue <i>(Stop Controlled, Urban)</i>	Overall	3.4	A	0.5	8.7	A	3.4
	EB	1.6	A	0.2	1	A	0.1
	WB	1	A	0.1	0.2	A	0
	NB	16.4	C	0.5	23.4	C	3.4
	SB	13.8	B	0.4	11.7	B	0.6
19. US 14 Bypass & 34th Avenue <i>(Stop Controlled, Urban)</i>	Overall	3.4	A	0.3	4.6	A	0.5
	EB	1	A	0	0.5	A	0
	WB	0	A	0	0.4	A	0
	NB	11.6	B	0.1	11.1	B	0.5
	SB	10.7	B	0.3	9.8	A	0.3
20. US 14 & US 14 Bypass - East <i>(Stop Controlled, Rural)</i>	Overall	1.6	A	0.7	3.9	A	1.6
	EB	0.1	A	0	0.4	A	0
	WB	0	A	0	0	A	0
	SB	14.6	B	0.7	15.5	C	1.6

*Overall intersection control delay results represent the weighted average of each approach and overall intersection 95th% queues reported are the maximum of the approaches.

Highway Segment Operations

The 2019 Existing Conditions highway segment operations are summarized in the following table. HCS analysis reports are provided in **Appendix B**.

Table 7: Highway Segments – Existing Conditions

Seg. No.	Mainline	From	To	Length (miles)	Type	Segment LOS			
						AM		PM	
						EB	WB	EB	WB
1	US 14	Project Beginning MP MRM 402.94	US 81	0.15	4-Ln, Divided	A	A	A	A
2	US 14	US 81	Brookings CR 11 / 458th Ave	3.96	Mostly 4-Ln, Divided	A	A	A	A
3	US 14	Brookings CR 11 / 458th Ave	Brookings CR 1 / 459th Ave	1.04	2-lane Undivided	B	B	A	B



Seg. No.	Mainline	From	To	Length (miles)	Type	Segment LOS			
						AM		PM	
						EB	WB	EB	WB
4	US 14	Brookings CR 1 / 459th Ave	Brookings CR 5 / 464th Ave	4.90	2-lane Undivided	B	A	A	B
5	US 14	Brookings CR 5 / 464th Ave	Kasan Ave	0.09	5-lane Undivided	A	A	A	A
6	US 14	Kasan Ave	Hansina Ave	0.27	5-lane Undivided	A	A	A	A
7	US 14	Hansina Ave	Caspian Ave	0.63	5-lane Undivided	A	A	A	A
8	US 14	Caspian Ave	Brookings CR 7 / 466th Ave	1.19	Mostly 4-Ln, Divided	A	A	A	A
9	US 14	Brookings CR 7 / 466th Ave	Brookings CR 9 / 16th Ave W / 469th Ave	2.93	4-Ln, Divided	A	A	A	A
10	US 14	Brookings CR 9 / 16th Ave W / 469th Ave	US 14 B (west)	0.09	4-Ln, Divided	B	A	A	A
11	US 14	US 14 B (west)	Western Ave	0.77	2-Ln, Undivided	E	C	D	D
12	US 14 B	Western Ave	Medary Ave	0.97	2-Ln, Undivided	E	D	D	E
13	US 14 B	Medary Ave	Jackrabbit Ave	0.49	2-Ln, Undivided	E	E	D	E
14	US 14 B	Jackrabbit Ave	22nd Ave	0.41	2-Ln, Undivided	E	E	E	E
15	US 14 B	22nd Ave	I-29 SB Ramp Terminal	0.39	2-Ln, Undivided	E	E	E	E
16	US 14 B	I-29 SB Ramp Terminal	I-29 NB Ramp Terminal	0.19	2-Ln, Undivided	D	D	D	E
17	US 14 B	I-29 NB Ramp Terminal	32nd Ave	0.20	2-Ln, Undivided	D	D	D	D
18	US 14 B	32nd Ave	34th Ave	0.22	2-Ln, Undivided	C	C	C	C



Seg. No.	Mainline	From	To	Length (miles)	Type	Segment LOS			
						AM		PM	
						EB	WB	EB	WB
19	US 14 B	34th Ave	US 14 B (east) MRM 423.24	1.41	2-Ln, Undivided	C	C	C	C

Summary and Conclusions

Traffic operations at intersections in the 2019 Existing Conditions scenario all result in delay within acceptable LOS thresholds for this study, with the exceptions being noted below:

- **US 14 & Caspian Avenue** operates at an overall LOS C in both the AM and PM peak hours. This is mostly due to delay occurring in the northbound and southbound approaches. This is worse than the minimum allowable threshold for signalized rural intersections (LOS B).
- **US 14 Bypass & 22nd Avenue** operates at an overall LOS F in the PM peak hour, this is largely due to excessive delay (129 seconds) and queue lengths (15 vehicles) in the northbound approach. This is worse than the minimum allowable threshold for two-way stop controlled urban intersections (LOS C).

Some intersections experience approach LOS D or worse, but the overall weighted delay is such that overall intersection operations are acceptable. Queue lengths at most intersections are fairly short (typically zero to five vehicles long).

West of the US 14 and US 14 Bypass split (west of Brookings), segment LOS is LOS B or better in both the eastbound and westbound directions in both the AM and PM peak hours, indicating acceptable operations. In this region, the corridor varies in cross section and generally has higher free flow speeds (60 to 65 mph), with the exception being reduced speeds within the City of Volga.

East of the split, all segments operate at LOS C or worse in both directions and in both AM and PM peak hours, indicating operations outside of the acceptable threshold. In the AM peak hour, LOS is generally worse for eastbound travel, and in the PM, the reverse is true. In this region, the corridor becomes two-lane, undivided, and more urban in character.



Appendix

- A. Existing Conditions HCS Reports - Intersections
- B. Existing Conditions HCS Reports – Highway Segments