



MEMORANDUM

PAGE 1 OF 9

DATE: September 17, 2021

TO: Dan Sanayi, Montgomery County Department of Transportation

FROM: Kristen Haas, P.E., PTOE, STV

SUBJECT: White Flint Intersection Concept Designs – Tower Oaks Boulevard at Montrose Road

Introduction

A Critical Lane Volume (CLV) analysis was previously conducted for the intersection of Tower Oaks Boulevard at Montrose Road, which concluded that the intersection currently operates at a LOS F during the AM peak hour and LOS D during the PM peak hour and future traffic growth is projected to further exacerbate intersection capacity. The failing operation at this intersection can be mainly attributed to high eastbound through volumes, and as such, it is recommended that additional capacity be provided for this movement. There are geometric limitations to adding capacity on the eastbound approach due to the location of the I-270 off ramp to eastbound Montrose Road. As such, STV has developed two concept alternatives to convert this intersection into a Continuous Green-T intersection so that eastbound through traffic is free flowing rather than controlled by the traffic signal. The purpose of this memorandum is to document the results of queuing and safety analyses conducted for the intersection to determine the impacts associated with the recommended improvement, as well as verify the necessary acceleration lane length for the southbound left turn.

Existing Conditions

The existing lane use and traffic control for the study intersection are shown in **Figure 1**. Weekday peak period turning movement counts were conducted in May 2021 during the COVID-19 pandemic. Due to the pandemic and its effect on traffic volumes, the 2021 peak hour volumes were compared to a count conducted in 2018. The comparison showed a 34% reduction in AM volumes and a 25% reduction in PM volumes. As such, the 2018 volumes were used as a base for this study to reflect a more conservative analysis. The 2018 and 2021 turning movement counts, as well as a comparison of the two, are provided in **Attachment A**.

The 2018 volumes were updated to include trips associated with the Tower Oaks development currently under construction north of the study intersection. The development is expected to generate 202 and 269 new trips during the AM and PM peak hours, respectively, according to projections provided by the City of Rockville. The resultant existing intersection volumes are shown in **Figure 2**.

MEMORANDUM

PAGE 2 OF 9

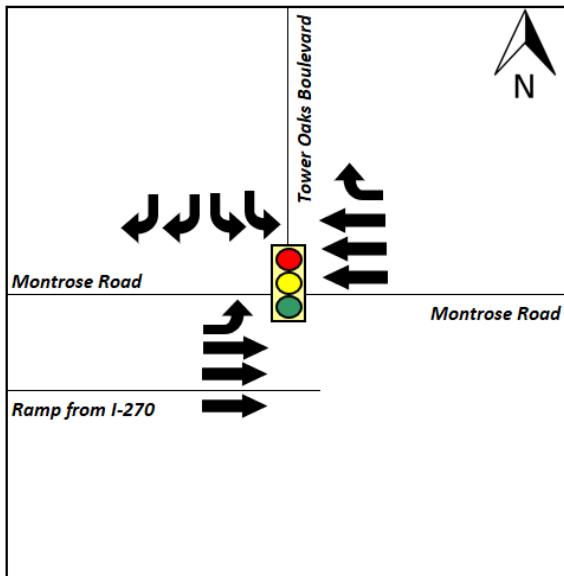


Figure 1: Existing Lane Use and Traffic Control

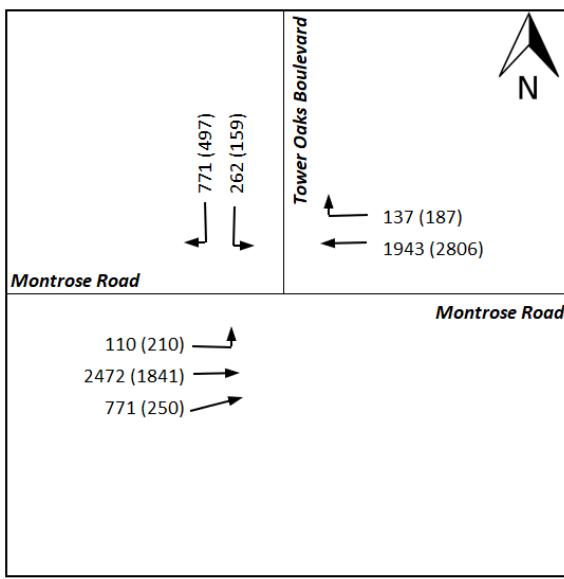


Figure 2: Existing Intersection Volumes

CLV Analysis

Existing and proposed intersection capacity was analyzed using the Critical Lane Volume (CLV) methodology. Volume to capacity (v/c) ratios, expressed in the results table as a percent of congestion, were calculated based on a comparison of the calculated CLV to the Maryland-National Capital Park and Planning Commission (M-

MEMORANDUM

PAGE 3 OF 9

NCPCC) policy area CLV thresholds listed in the 2016 *Local Area Transportation Review* (LATR). Intersection Level of Service (LOS) was determined based on guidance from the Federal Highway Administration's *Signalized Intersections Informal Guide* publication on signalized intersection analysis as shown in **Table 1**.

Table 1: LOS Thresholds

Intersection v/c	LOS
< 0.65	A
0.65 to < 0.75	B
0.75 to < 0.85	C
0.85 to < 0.95	D
0.95 to <= 1.00	E
> 1.00	F

As previously indicated, a concept has been developed to convert this intersection into a Continuous Green-T intersection. This improvement would allow eastbound through vehicles to operate freely rather than be controlled by the traffic signal. This improvement would also require one of the southbound left turn lanes to be removed as well as portions of the medians on the east and west leg. The proposed lane use is shown in **Figure 3**. Two concept plans have been prepared showing the Continuous Green-T intersection configuration and are provided in **Attachment B**. In both alternatives, the Montrose Road at Tower Oaks Boulevard intersection configuration is the same; however, the alternatives differ in pavement markings provided at the Tower Oaks Boulevard at North Farm Lane unsignalized intersection.

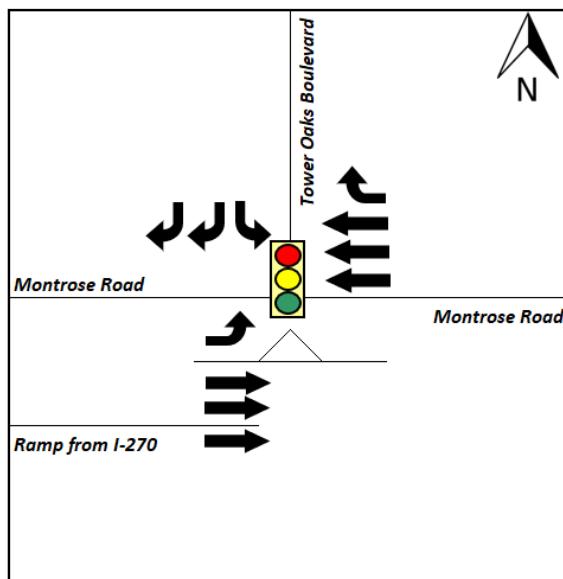


Figure 3: Proposed Lane Use and Traffic Control

MEMORANDUM

PAGE 4 OF 9

The AM and PM peak hour results of the CLV analysis for existing and proposed conditions are summarized in **Table 2**, and the CLV calculation sheets are provided in **Attachment C**.

Table 2: CLV Analysis

Policy Area Threshold	AM Peak Hour			PM Peak Hour		
	% of Congestion	CLV	LOS	% of Congestion	CLV	LOS
2018 Existing Conditions						
1,550	111%	1,723	F	96%	1,490	E
2018 Proposed Conditions						
1,550	81%	1,251	C	96%	1,491	E
2042 Future Conditions						
1,550	143%	2,210	F	123%	1,909	F
2042 Proposed Conditions						
1,550	103%	1,604	E	123%	1,909	F

The results of the CLV analysis indicate that the intersection currently operates at LOS F during the AM peak hour and LOS E during the PM peak hour. Constructing a Continuous Green-T intersection at this location does not significantly affect the intersection LOS during the PM peak hour but improves the AM peak hour from LOS F to LOS C. Under 2042 future conditions, the intersection is projected to operate at LOS F during both peak hours. The intersection improvement is projected to improve intersection LOS to LOS E during the AM peak hour.

Speed Data Analysis

Seven day speed data was collected along east- and westbound Montrose Road in May and June of 2021. The weekday speed data indicates that the average and 85th percentile speeds are 42 and 48 MPH, respectively in the eastbound direction and 43 and 49 MPH in the westbound direction.

Data was collected to the east and west of the intersection and the weekday average and 85th percentile speeds are summarized in Table 3. The speed data is provided in **Attachment D**.

Table 3: Weekday Speed Data

Speed Data Location	Average Speed (MPH)	85 th Percentile Speed (MPH)
Eastbound (45 MPH Speed Limit)		
West of Tower Oaks Boulevard	45	51
East of North Farm Lane	41	46
Westbound (40 MPH Speed Limit)		
West of Tower Oaks Boulevard	45	51
East of North Farm Lane	41	47

MEMORANDUM

PAGE 5 OF 9

The weekday speed data indicates that speeds are generally higher to the west of the intersection, near the I-270 interchange. Based on the existing location of speed limit signs, the speed limit on eastbound Montrose Road is 45 MPH through the study intersection and becomes 40 MPH east of North Farm Lane, whereas the posted speed limit along westbound Montrose Road is 40 MPH through the study area. Speeding is typically considered an issue if the 85th percentile speed is at least 8 MPH greater than the posted speed limit. As such, speeding is only considered an issue in the westbound direction west of the intersection. It should also be noted that speeds are lower during the AM and PM peak hours, where 85th percentile speeds are 43 MPH and 44 MPH in the east- and westbound directions, respectively, during the AM peak hour and 43 MPH in both directions during the PM peak hour.

Queuing Analysis

A queuing analysis using SimTraffic software was also conducted to determine the impacts of reconstructing the intersection into a Continuous Green-T intersection and to determine an appropriate length for the southbound left turn acceleration lane. Based on guidance provided in the *American Association of State Highway and Transportation Officials (AASHTO) A Policy on Geometric Design of Highways and Streets (2011 Edition)*, a minimum acceleration length of 360 feet is recommended to allow a vehicle from a stop condition to accelerate to a 40 miles per hour speed limit. This distance of 360 feet was used in the SimTraffic model as a basis for this analysis. SimTraffic driving parameters were also updated to reflect the speed data collected for Montrose Road to calibrate the queuing model.

Signal phasing at the Tower Oaks Boulevard and Montrose Road intersection was updated to reflect the free flowing eastbound through movement and signal timings were optimized. In addition to modeling the study intersection, the pedestrian signal at the intersection of Montrose Road at North Farm Lane was included in the model so that any queuing associated with the pedestrian signal would be reflected. Volumes on Montrose Road were balanced from the study intersection volumes, and 5 and 20 pedestrian calls per hour were assumed for the AM and PM peak hours, respectively, based on input from Montgomery County Department of Transportation Traffic Management Center. As previously noted, the alternative options operate are the same at the Tower Oaks Boulevard at Montrose Road intersection as well as along Montrose Road; therefore, the concepts were not modeled separately.

The results of the queuing analysis for the affected movements, i.e. the southbound left turn and eastbound through at Tower Oaks Boulevard at Montrose Road and the eastbound through at the pedestrian signal at North Farm Lane, are shown in **Table 4**. SimTraffic worksheets are provided in **Attachment E**.



MEMORANDUM

PAGE 6 OF 9

Table 4: 2018 Queuing Analysis

Intersection	Movement	Storage Distance ² (ft)	AM Peak Hour		PM Peak Hour	
			Average Q ¹ (ft)	95 th % Q ¹ (ft)	Average Q ¹ (ft)	95 th % Q ¹ (ft)
Existing Conditions						
Tower Oaks Blvd at Montrose Rd	SBL	375/1,225	300	875	100	150
	SBR	250/1,225	750	1,175	250	325
	EBT	3,365	225	375	125	225
Pedestrian Signal	EBT	625	75	300	100	275
Proposed Conditions						
Tower Oaks Blvd at Montrose Rd	SBL	1,225	150	250	125	200
	SBR	250/1,225	275	400	225	325
	EBT	3,365	25	150	-	-
Pedestrian Signal	EBT	625	75	500	175	425

1- Queues rounded to the nearest 25 feet

2- Storage distance measured from upstream signalized intersection

The results of the queuing analysis indicate that significant southbound left turn queues occur during the AM peak hour as a result of the additional southbound traffic added to the intersection from the Tower Oaks development. It should be noted, however, that this left turn queue reflects vehicles in the left turn lane being blocked by vehicles trying to get into the adjacent right turn lane. The southbound right turn queues during the AM peak hour under existing conditions are extensive and block the adjacent lanes as well as impede traffic trying to turn from North Farm Lane onto southbound Tower Oaks Boulevard.

Under the proposed conditions, queues are significantly reduced on the southbound approach during the AM peak hour as a result of reallocated green time given to the southbound approach made possible by implementing the Continuous Green-T intersection configuration. It should be noted, however, that the projected 95th percentile queues for the southbound left turn of 250 feet and 200 feet during the AM and PM peak hour, respectively, indicate that North Farm Lane, which is approximately 165 feet north of the Montrose Road, may occasionally be blocked. This blockage is not anticipated to occur throughout the peak hour and thus not anticipated to effect traffic patterns within the North Farm community. In order to further provide relief to the North Farm community, "Do Not Block Intersection" pavement markings are recommended under both alternative options.

MEMORANDUM

PAGE 7 OF 9

Additionally, the higher projected 95th percentile queue for the southbound left turn is 250 feet, indicating that the AASHTO recommended acceleration length of 360 feet on eastbound Montrose Road to North Farm Lane is sufficient. While the 95th percentile queue for the eastbound through at the pedestrian signal increases during both peak hours, this queue does not extend to Tower Oaks Boulevard.

Safety Analysis

Available crash data was obtained from the County for the study intersection and crash data by type for the 5-year period of 2016 through 2020 is shown in **Figure 4**. The crash data is provided in **Attachment F**.



Figure 4: Crash Types at Montrose Road at Tower Oaks Boulevard (2016-2020)

As shown in Figure 4, fifty crashes were reported at the intersection between 2016 and 2020. The fifty crashes consisted of 28 rear end crashes, seven angle crashes, four left turn crashes, four single vehicle crashes, three sideswipe crashes, two right turn crashes, and two crashes identified as other. It should be noted that of the four left turn crashes, three were identified as same direction left turn crashes while only one was identified as a head on left turn crash, indicating that left turn crashes from eastbound Montrose Road to northbound Tower Oaks Boulevard are not predominant at the intersection. Sixteen of the 50 crashes resulted in an injury, while the remaining 34 crashes were identified as property damage only.

Vision Zero

MCDOT's Vision Zero policy seeks to reduce transportation-related injuries and fatalities. As noted, there were no pedestrian or bicycle crashes in the 5-year period of 2016 through 2020 at the Montrose Road at Tower

MEMORANDUM

PAGE 8 OF 9

Oaks Boulevard intersection or at the North Farm Lane signalized pedestrian crossing. Additionally, the proposed design seeks to improve pedestrian safety at the Montrose Road at Tower Oaks Boulevard intersection by shortening the pedestrian crosswalk across Tower Oaks Boulevard, reducing the amount of time that pedestrians are in the roadway.

At the Montrose Road at North Farm Lane signalized pedestrian crossing, the proposed design increases the pedestrian crossing distance by a maximum of three feet. Based on the MUTCD standard pedestrian walking speed of 3.5 feet per second, the maximum three feet of widening equates to less than 1 additional second in the roadway. Additionally, the signal timings for the North Farm Lane intersection were reviewed and the existing timings meet MUTCD standards for adequate Flashing Don't Walk time to cross Montrose Road. Since the signal is timed for a pedestrian to fully cross both east- and westbound Montrose Road, the proposed design would not impact signal timings as the maximum three feet of widening cuts into the existing median. The FHWA Crash Modification Factors Clearinghouse website provides Crash Modification Factors (CMFs) to project how different intersection treatments will impact the quantity, type, and severity of crashes. It should be noted that there were no applicable CMFs associated with installing an acceleration lane in the vicinity of a signalized pedestrian crossing.

In addition to an expected improvement to traffic operations, converting the study intersection to a Continuous Green-T intersection is expected to improve safety and reduce the number of expected crashes, particularly those that result in injury. The FHWA Crash Modification Factors Clearinghouse website indicates that the CMF associated with converting a conventional signalized intersection into a Continuous Green-T intersection is 0.958 for all crashes, meaning that a 4.2 percent reduction of all crashes can be estimated. Further, the CMF for fatal, serious, minor, and possible injury crashes is 0.846, resulting in an estimated 15.4 percent reduction in injury crashes. Details from the CMF website are provided in **Attachment G**. It should also be noted that more than half of the reported crashes between 2016 and 2020 were rear end crashes, seven of which occurred in the eastbound direction. The Continuous Green-T intersection would likely result in a reduction of rear end crashes due to the decreased congestion, particularly in the eastbound direction where vehicles would no longer need to stop at the intersection.

Conclusion

The purpose of this memorandum is to document the results of CLV and queuing analyses conducted for the intersection of Tower Oaks Boulevard at Montrose Road. Based on the existing CLV analysis, the intersection operates at LOS F during AM peak hour and LOS E during the PM peak hour. The failing operation can be partially attributed to the high volume of eastbound throughs at this location. Two concepts were developed to reconstruct the intersection into a Continuous Green-T intersection to allow the eastbound throughs to operate freely from the traffic signal. The results of the CLV analysis indicate that the intersection LOS will improve during the AM peak hour with the proposed improvements and will remain the same during the PM peak hour. The results of the queuing analysis indicate that queues are significantly reduced on the southbound approach during the AM peak hour as a result of reallocated green time given to the southbound approach made possible by implementing the Continuous Green-T intersection configuration. The reduction in southbound queuing will also reduce the amount of time that southbound vehicles block the unsignalized intersection of North Farm Lane at Tower Oaks Boulevard. In order to further provide relief to the North Farm community, "Do Not Block Intersection" pavement markings are recommended under both alternative options. Additionally, the AAHSTO



MEMORANDUM

PAGE 9 OF 9

recommended acceleration length of 360 feet along eastbound Montrose Road is sufficient and queues are not projected to exceed available storage capacity under existing or proposed conditions.

The safety analysis indicates that the conversion to a Continuous Green-T intersection is projected to reduce fatal, serious, minor, and possibly injury crashes by 15.4 percent, consistent with MCDOT's Vision Zero policy. Additionally, the proposed design improves pedestrian safety at the Montrose Road at Tower Oaks Boulevard intersection by shortening the pedestrian crosswalk across Tower Oaks Boulevard, reducing the amount of time that pedestrians are in the roadway. The proposed concept alternatives improve traffic operations while enhancing pedestrian and vehicular safety at the Montrose Road at Tower Oaks Boulevard intersection. The proposed improvements are projected to decrease congestion on eastbound Montrose Road and are not expected to adversely impact traffic operations at downstream signalized intersections on the corridor.

ATTACHMENT

A

Turning Movement Count Data

Start Date: 1/11/2018

Start Time: 6:00:00 AM

Site Code: TOWER OAKS BLVD @ MONTROSE RD

VEHS

Start Time	TOWER OAKS BLVD From North				MONTROSE RD From East				TOWER OAKS BLVD From South				MONTROSE RD From West			
	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds
06:00	3	0	88	0	0	110	2	0	0	0	0	0	4	213	0	0
06:15	8	0	102	0	0	124	3	0	0	0	0	0	11	257	0	0
06:30	10	0	123	0	0	138	2	0	0	0	0	0	10	340	0	0
06:45	14	0	152	0	0	171	11	0	0	0	0	0	15	385	0	0
07:00	23	0	140	0	0	219	8	0	0	0	0	0	10	379	0	0
07:15	24	0	142	0	0	268	10	0	0	0	0	0	11	366	0	0
07:30	48	0	151	0	0	340	16	0	0	0	0	0	7	522	0	0
07:45	80	0	167	0	0	417	22	0	0	0	0	0	12	573	0	0
08:00	64	0	154	0	0	515	38	0	0	0	0	0	16	673	0	0
08:15	58	0	188	0	0	551	41	0	0	0	0	0	11	601	0	0
08:30	47	0	156	0	0	403	21	0	0	0	0	0	14	568	0	0
08:45	48	0	167	0	0	474	22	0	0	0	0	0	30	630	0	0
	427	0	1730	0	0	3730	196	0	0	0	0	0	151	5507	0	0
15:30	19	0	106	0	0	582	20	0	0	0	0	0	21	459	0	0
15:45	15	0	82	0	0	581	32	0	0	0	0	0	22	453	0	0
16:00	17	0	77	0	0	571	30	0	0	0	0	0	24	408	0	0
16:15	21	0	98	0	0	684	31	1	0	0	0	0	17	415	0	0
16:30	35	0	102	0	0	642	34	1	0	0	0	0	16	378	0	0
16:45	20	0	92	1	0	741	31	0	0	0	0	0	23	460	0	0
17:00	39	0	107	0	0	631	37	0	0	0	0	0	24	422	0	0
17:15	33	0	113	1	0	724	30	0	0	0	0	0	23	471	0	0
17:30	37	0	115	0	0	710	38	0	0	0	0	0	19	488	0	0
17:45	33	0	97	0	0	633	67	0	0	0	0	0	24	500	0	0
18:00	23	0	83	0	0	532	64	1	0	0	0	0	25	413	0	0
18:15	21	0	86	0	0	561	75	0	0	0	0	0	22	426	0	0
	313	0	1158	2	0	7592	489	3	0	0	0	0	260	5293	0	0

Start Date: 1/11/2018

Start Time: 6:00:00 AM

Site Code: TOWER OAKS BLVD @ MONTROSE RD

UTURNS

Start Time	TOWER OAKS BLVD From North				MONTROSE RD From East				TOWER OAKS BLVD From South				MONTROSE RD From West			
	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds
06:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06:15	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
06:30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06:45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07:15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07:30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07:45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08:15	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
08:30	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
08:45	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0
15:30	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
15:45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:00	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
16:15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:30	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
16:45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17:00	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
17:15	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
17:30	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
17:45	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
18:00	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
18:15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0

Start Date: 1/11/2018

Start Time: 6:00:00 AM

Site Code: TOWER OAKS BLVD @ MONTROSE RD

BIKES

Start Date: 5/11/2021

Start Time: 6:00:00 AM

Site Code: MONTROSE RD @ TOWER OAKS BLVD TMC

Start Time	TOWER OAKS BLVD From North		MONTROSE RD From East		From South		MONTROSE RD From West		UTURNS
	U-TURNS		U-TURNS		U-TURNS		U-TURNS		
6:00:00 AM	0		0						0
6:15:00 AM	0		0						0
6:30:00 AM	0		0						0
6:45:00 AM	0		0						0
7:00:00 AM	0		0						0
7:15:00 AM	0		0						0
7:30:00 AM	0		0						0
7:45:00 AM	0		0						0
8:00:00 AM	0		0						1
8:15:00 AM	0		0						1
8:30:00 AM	0		0						0
8:45:00 AM	0		0						1
9:00:00 AM	0		0						1
9:15:00 AM	0		0						0
9:30:00 AM	0		0						1
9:45:00 AM	0		0						2
10:00:00 AM	0		0						1
10:15:00 AM	0		0						0
10:30:00 AM	0		0						0
10:45:00 AM	0		0						0
11:00:00 AM	0		0						4
11:15:00 AM	0		0						1
11:30:00 AM	0		0						1
11:45:00 AM	0		0						2
12:00:00 PM	0		0						2
12:15:00 PM	0		0						4
12:30:00 PM	0		0						3
12:45:00 PM	0		0						0
1:00:00 PM	0		0						4
1:15:00 PM	0		0						0
1:30:00 PM	0		0						0
1:45:00 PM	0		0						1
2:00:00 PM	0		0						2
2:15:00 PM	0		0						3
2:30:00 PM	0		0						3
2:45:00 PM	0		0						1
3:00:00 PM	0		0						2
3:15:00 PM	0		0						1
3:30:00 PM	0		0						0
3:45:00 PM	0		0						2
4:00:00 PM	0		0						1
4:15:00 PM	0		0						1
4:30:00 PM	0		0						1
4:45:00 PM	0		0						1
5:00:00 PM	0		0						1
5:15:00 PM	0		0						1
5:30:00 PM	0		0						1
5:45:00 PM	0		0						2
6:00:00 PM	0		0						3
6:15:00 PM	0		0						3
6:30:00 PM	0		0						0
6:45:00 PM	0		0						1

60

Table IA

Montrose Road at Tower Oaks Blvd

Traffic Count Comparison

AM Peak Hour

Approach/ Movement/ Link	January 2018		May 2021		Difference	
					Count	Percent
	Count	Percent	Count	Percent	Count	Percent
Approach/ Movement						
SBR	665		387		(278)	-42%
SBL	217		66		(151)	-70%
Subtotal	882	16%	453	13%	(429)	-49%
VWR	122		71		(51)	-42%
WB	1,943		1,490		(453)	-23%
Subtotal	2,065	38%	1,561	43%	(504)	-24%
EBT	2,472		1,525		(947)	-38%
EBL	71		79		8	11%
Subtotal	2,543	46%	1,604	44%	(939)	-37%
Total	5,490	100%	3,618	100%	(1,872)	-34%

Link

North	Count	Percent	Count	Percent	Count	Percent
NB	193	18%	150	25%	(43)	-22%
SB	882	82%	453	75%	(429)	-49%
Subtotal	1,075	100%	603	100%	(472)	-44%
East	Count	Percent	Count	Percent	Count	Percent
EB	2,689	57%	1,591	50%	(1,098)	-41%
WB	2,065	43%	1,561	50%	(504)	-24%
Subtotal	4,754	100%	3,152	100%	(1,602)	-34%
West	Count	Percent	Count	Percent	Count	Percent
EB	2,543	49%	1,604	46%	(939)	-37%
WB	2,608	51%	1,877	54%	(731)	-28%
Subtotal	5,151	100%	3,481	100%	(1,670)	-32%
Total	10,980		7,236		(3,744)	

Table IB

Montrose Road at Tower Oaks Blvd

Traffic Count Comparison

PM Peak Hour

Approach/ Movement/ Link	January 2018		May 2021		Difference	
					Count	Percent
	Count	Percent	Count	Percent	Count	Percent
Approach/ Movement						
SBR	427		289		(138)	-32%
SBL	129		75		(54)	-42%
Subtotal	556	10%	364	9%	(192)	-35%
VWR	136		70		(66)	-49%
WB	2,806		2,141		(665)	-24%
Subtotal	2,942	54%	2,211	54%	(731)	-25%
EBT	1,841		1,431		(410)	-22%
EBL	89		64		(25)	-28%
Subtotal	1,930	36%	1,495	37%	(435)	-23%
Total	5,428	100%	4,070	100%	(1,358)	-25%

Link

North	Count	Percent	Count	Percent	Count	Percent
NB	225	29%	134	27%	(91)	-40%
SB	556	71%	364	73%	(192)	-35%
Subtotal	781	100%	498	100%	(283)	-36%
East						
EB	1,970	40%	1,506	41%	(464)	-24%
WB	2,942	60%	2,211	59%	(731)	-25%
Subtotal	4,912	100%	3,717	100%	(1,195)	-24%
West						
EB	1,930	37%	1,495	38%	(435)	-23%
WB	3,233	63%	2,430	62%	(803)	-25%
Subtotal	5,163	100%	3,925	100%	(1,238)	-24%
Total	10,856		8,140		(2,716)	

ATTACHMENT

B

Concept Plan of Recommended Improvement



ROADWAY LEGEND		
	PAVEMENT REMOVAL	
	FULL DEPTH ASPHALT PAVEMENT	
	CONCRETE SIDEWALK/CURB & GUTTER/MEDIAN	

I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND.
LICENSE NO. 21350
EXPIRATION DATE SEPTEMBER 20, 2022
Designed By JNS Drawn By JNS Checked By SRH

NO.	REVISION	BY	DATE

DEPARTMENT OF TRANSPORTATION
DIVISION OF TRAFFIC ENGINEERING & OPERATIONS
MONTGOMERY COUNTY, MARYLAND

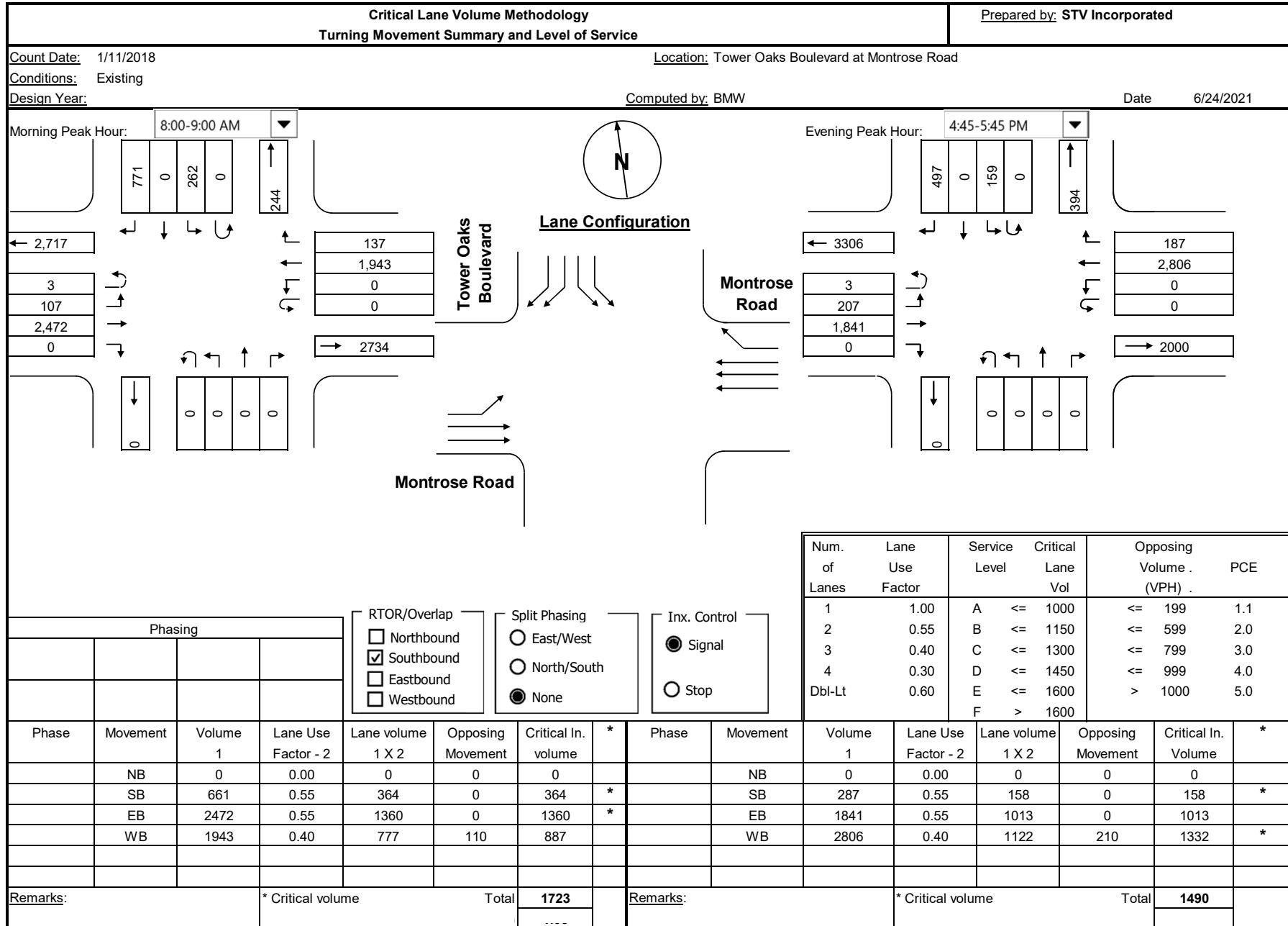
CONCEPT PLAN
OPTION I
MD 927 (MONTROSE ROAD)
AT TOWER OAKS BOULEVARD
INTERSECTION IMPROVEMENTS

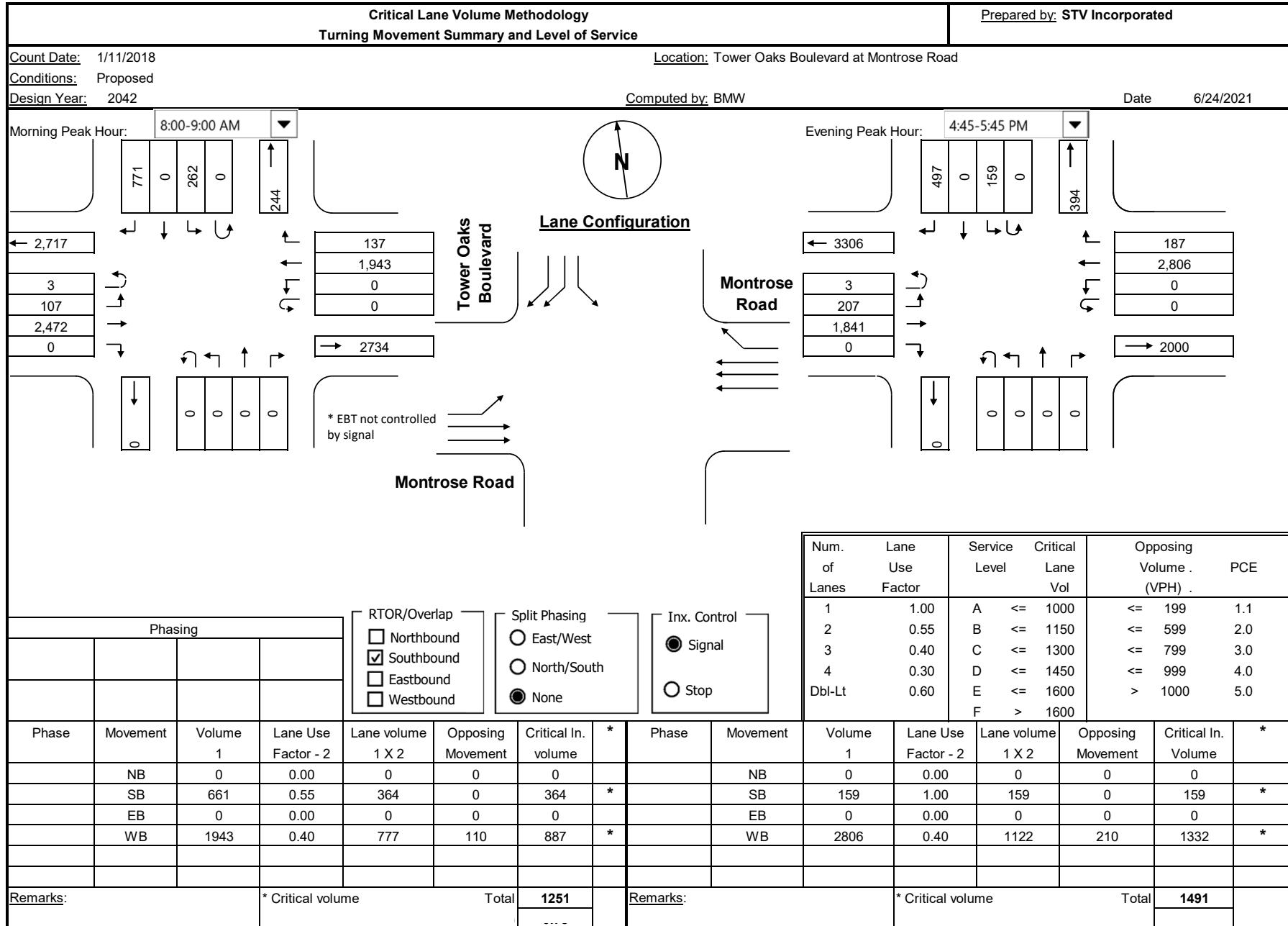
SCALE: 1" = 50'

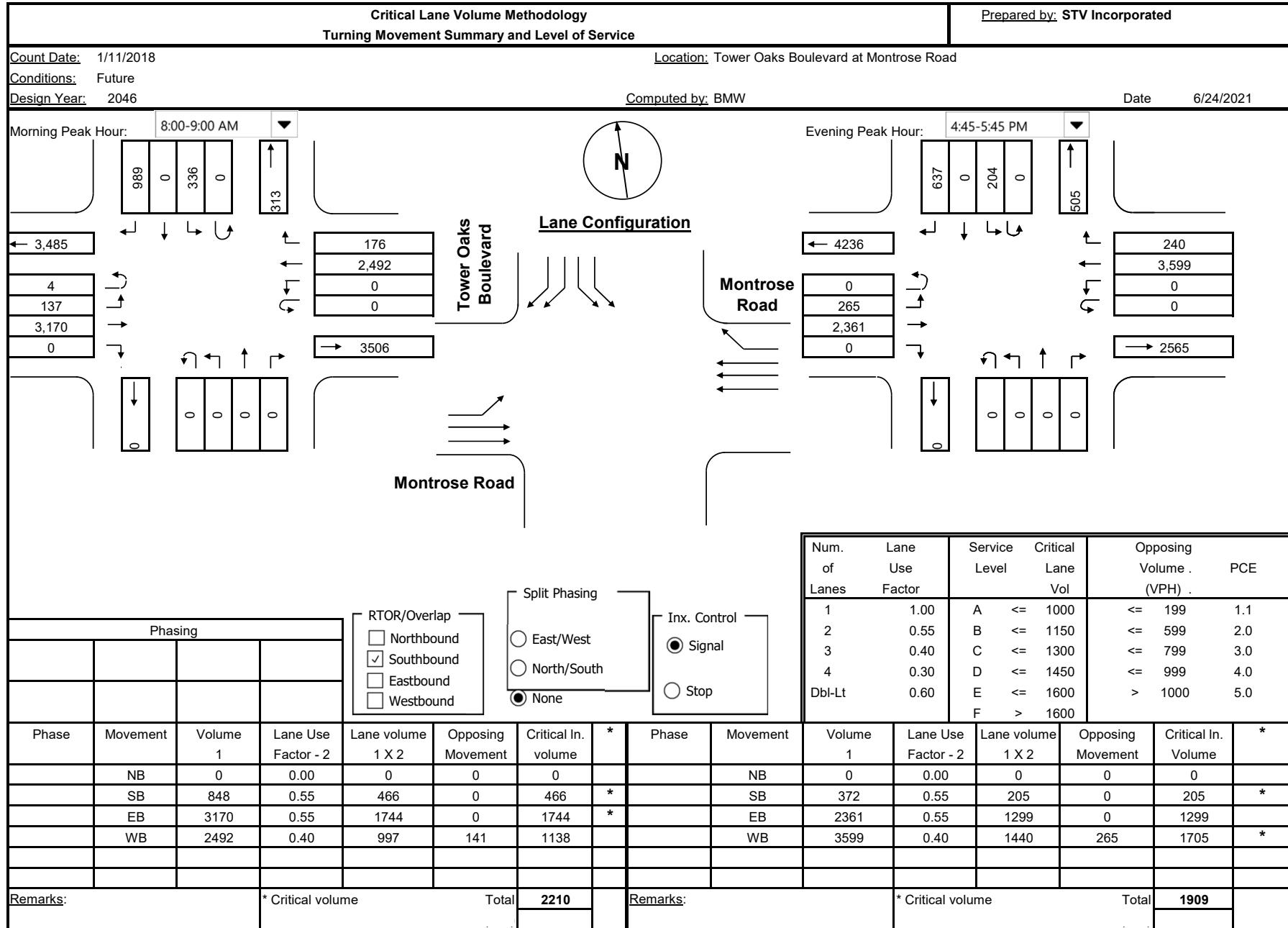
ATTACHMENT

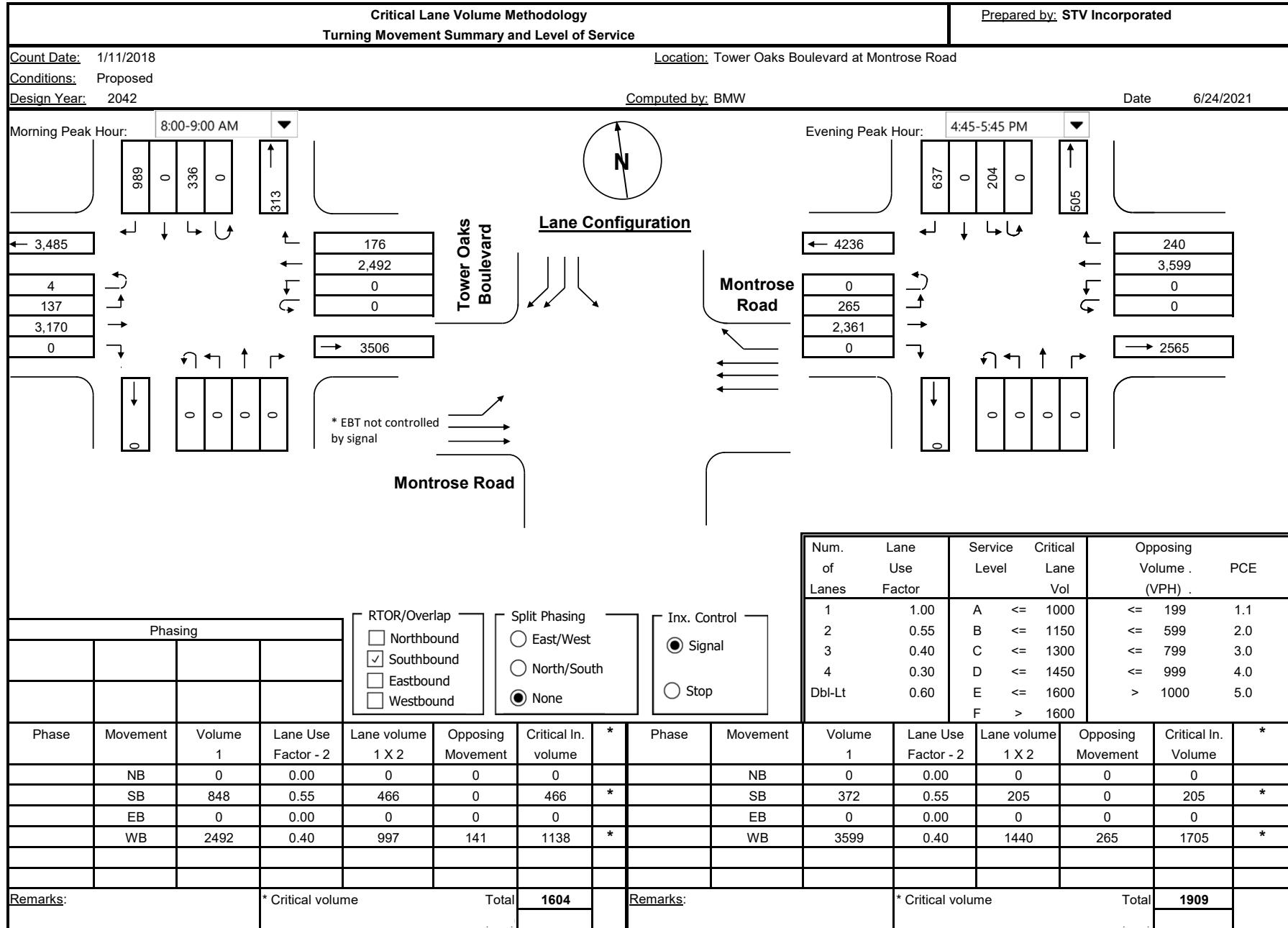
C

CLV Calculation Sheets









ATTACHMENT

D

Speed Data

Time [--]	Vbin 6 12	Vbin 12 19	Vbin 19 25	Vbin 25 31	Vbin 31 37	Vbin 37 43	Vbin 43 50	Vbin 50 56	Vbin 56 62	Vbin 62 68	Vbin 68 75	Vbin 75 81	Vbin 81 87	Vbin 87 93	Vbin 93 99	Vpp 85]PSL 40
0000	0	0	0	2	35	46	11	1	0	0	0	0	0	0	0	43.3	36
0100	0	0	0	3	23	20	20	4	1	0	0	0	0	0	0	47	32
0200	0	0	0	2	13	26	11	2	0	0	0	0	0	0	0	46.6	25
0300	0	0	0	6	13	35	12	3	2	0	0	0	0	0	0	45.1	34
0400	0	0	0	4	26	50	52	15	2	0	0	0	0	0	0	49	102
0500	0	0	0	1	39	163	167	67	10	2	0	0	0	0	0	50.7	342
0600	0	0	0	1	30	261	261	113	25	1	0	0	0	0	0	50.9	580
0700	0	2	7	14	135	510	406	112	12	3	0	0	0	0	0	48.3	853
0800	1	13	12	62	401	856	475	99	9	3	0	0	0	0	0	46.8	1078
0900	0	0	1	15	292	745	495	84	8	0	0	0	0	0	0	47.1	1036
1000	0	0	5	20	311	714	339	70	10	0	0	0	0	0	0	46.1	818
1100	0	0	0	48	340	820	333	51	9	0	0	0	0	0	0	45.5	853
1200	0	0	1	18	335	817	387	69	8	1	0	0	0	0	0	46	928
1300	0	0	3	50	282	842	386	68	11	2	0	0	0	0	0	46	973
1400	0	0	1	19	339	840	380	77	14	0	0	0	0	0	0	46	970
1500	0	3	4	22	401	886	465	68	6	0	0	0	0	0	0	45.7	1028
1600	0	4	29	81	421	977	472	82	14	2	0	0	0	0	0	45.7	1098
1700	1	8	22	62	450	959	493	81	11	0	0	0	0	0	0	45.9	1139
1800	0	0	1	21	236	906	524	86	10	2	1	0	1	0	0	46.5	1172
1900	0	0	1	34	245	704	367	69	9	1	0	0	0	0	0	46.4	857
2000	0	0	0	12	148	522	234	52	8	3	0	0	0	0	0	46.4	595
2100	0	0	0	17	206	333	116	29	4	2	0	0	0	0	0	45.4	317
2200	0	0	0	8	117	201	88	25	6	0	0	0	1	0	0	46.6	222
2300	0	1	0	12	56	108	72	16	6	0	1	0	0	0	0	48	157
00-00	2	31	87	534	4894	12341	6566	1343	195	22	2	0	2	0	0	46.5	15245

Vehicles = 26019

Posted speed limit = 40 mph, Exceeding = 15245 (58.59%), Mean Exceeding = 44.69 mph

Maximum = 85.5 mph, Minimum = 10.2 mph, Mean = 41.2 mph

85% Speed = 46.53 mph, 95% Speed = 50.33 mph, Median = 41.05 mph

12 mph Pace = 35 - 47, Number in Pace = 19801 (76.10%)

Variance = 29.87, Standard Deviation = 5.47 mph

Grand Total

Time [--]	Vbin 6 12	Vbin 12 19	Vbin 19 25	Vbin 25 31	Vbin 31 37	Vbin 37 43	Vbin 43 50	Vbin 50 56	Vbin 56 62	Vbin 62 68	Vbin 68 75	Vbin 75 81	Vbin 81 87	Vbin 87 93	Vbin 93 99	Vpp 85]PSL 40
--	62	234	773	5572	39718	84050	39360	7311	1131	200	48	7	6	1	8	45.9	94833

Vehicles = 178481

Posted speed limit = 40 mph, Exceeding = 94833 (53.13%), Mean Exceeding = 44.48 mph

Maximum = 98.9 mph, Minimum = 7.0 mph, Mean = 40.5 mph

85% Speed = 45.86 mph, 95% Speed = 49.66 mph, Median = 40.38 mph

12 mph Pace = 34 - 46, Number in Pace = 135072 (75.68%)

Variance = 31.23, Standard Deviation = 5.59 mph

ATTACHMENT

E

SimTraffic Worksheets

Queuing and Blocking Report
Existing Conditions - AM Peak Hour

06/18/2021

Intersection: 1: I-270 Ramp/Tower Oaks Boulevard & Montrose Road

Movement	EB	EB	EB	WB	WB	WB	WB	SB	SB	SB	SB
Directions Served	L	T	T	T	T	T	R	L	L	R	R
Maximum Queue (ft)	131	370	445	380	352	285	57	199	971	1200	275
Average Queue (ft)	50	208	217	234	180	90	22	88	303	760	273
95th Queue (ft)	103	334	367	350	316	190	49	184	874	1187	281
Link Distance (ft)		3316	3316	598	598	598			1226	1226	
Upstream Blk Time (%)									4	7	
Queuing Penalty (veh)									0	0	
Storage Bay Dist (ft)	425						400	375			250
Storage Blk Time (%)		0							0	55	52
Queuing Penalty (veh)		0							0	214	201

Intersection: 2: Montrose Road & North Farm Lane

Movement	EB	EB	EB	WB	WB	WB
Directions Served	T	T	T	T	T	TR
Maximum Queue (ft)	398	391	403	263	226	142
Average Queue (ft)	64	69	70	43	35	20
95th Queue (ft)	275	290	290	182	152	91
Link Distance (ft)	598	598	598	671	671	671
Upstream Blk Time (%)						
Queuing Penalty (veh)						
Storage Bay Dist (ft)						
Storage Blk Time (%)						
Queuing Penalty (veh)						

Network Summary

Network wide Queuing Penalty: 415

Queuing and Blocking Report
Existing Conditions - PM Peak Hour

06/18/2021

Intersection: 1: I-270 Ramp/Tower Oaks Boulevard & Montrose Road

Movement	EB	EB	EB	WB	WB	WB	WB	SB	SB	SB	SB
Directions Served	L	T	T	T	T	T	R	L	L	R	R
Maximum Queue (ft)	211	246	273	602	590	574	423	138	155	339	275
Average Queue (ft)	119	128	135	335	314	279	81	41	94	243	180
95th Queue (ft)	194	223	232	577	563	529	298	104	144	329	354
Link Distance (ft)		3309	3309	598	598	598			1236	1236	
Upstream Blk Time (%)				0	0	1					
Queuing Penalty (veh)				2	1	8					
Storage Bay Dist (ft)	425						400	375			250
Storage Blk Time (%)							3	0		6	1
Queuing Penalty (veh)							5	0		14	3

Intersection: 2: Montrose Road & North Farm Lane

Movement	EB	EB	EB	WB	WB	WB
Directions Served	T	T	T	T	T	TR
Maximum Queue (ft)	301	310	306	561	493	445
Average Queue (ft)	86	93	96	195	171	135
95th Queue (ft)	246	259	264	510	458	385
Link Distance (ft)	598	598	598	671	671	671
Upstream Blk Time (%)				1	0	0
Queuing Penalty (veh)				0	0	0
Storage Bay Dist (ft)						
Storage Blk Time (%)						
Queuing Penalty (veh)						

Network Summary

Network wide Queuing Penalty: 34

Queuing and Blocking Report
Proposed Conditions - AM Peak Hour

06/18/2021

Intersection: 1: I-270 Ramp/Tower Oaks Boulevard & Montrose Road

Movement	EB	EB	EB	WB	WB	WB	WB	NB	SB	SB	SB
Directions Served	L	T	T	T	T	T	R	R	L	R	R
Maximum Queue (ft)	121	197	229	381	366	354	269	17	298	441	275
Average Queue (ft)	60	29	36	319	286	208	44	1	161	281	222
95th Queue (ft)	107	121	139	406	385	336	149	12	262	393	370
Link Distance (ft)		3325	3325	322	322	322		309	1237	1237	
Upstream Blk Time (%)				8	3	1	0				
Queuing Penalty (veh)				56	18	5	0				
Storage Bay Dist (ft)	425						400				250
Storage Blk Time (%)							1	0		11	3
Queuing Penalty (veh)							1	0		42	10

Intersection: 2: Montrose Road & North Farm Lane

Movement	EB	EB	EB	WB	WB	WB
Directions Served	T	T	T	T	T	TR
Maximum Queue (ft)	302	298	311	273	256	176
Average Queue (ft)	52	63	69	45	34	18
95th Queue (ft)	225	258	273	189	151	90
Link Distance (ft)	244	244	244	671	671	671
Upstream Blk Time (%)	2	3	5			
Queuing Penalty (veh)	19	39	59			
Storage Bay Dist (ft)						
Storage Blk Time (%)						
Queuing Penalty (veh)						

Intersection: 8: Montrose Road

Movement	EB	EB	EB	EB	WB	WB	WB
Directions Served	T	T	T	T	T	T	T
Maximum Queue (ft)	201	245	274	295	156	95	40
Average Queue (ft)	18	52	92	102	17	6	2
95th Queue (ft)	107	180	207	226	91	61	29
Link Distance (ft)	322	322	322	322	244	244	244
Upstream Blk Time (%)	0	0	0	0	0	0	
Queuing Penalty (veh)	0	1	1	4	1	0	
Storage Bay Dist (ft)							
Storage Blk Time (%)							
Queuing Penalty (veh)							

Network Summary

Network wide Queuing Penalty: 254

Queuing and Blocking Report
Proposed Conditions - PM Peak Hour

06/18/2021

Intersection: 1: I-270 Ramp/Tower Oaks Boulevard & Montrose Road

Movement	EB	EB	WB	WB	WB	WB	SB	SB	SB
Directions Served	L	T	T	T	T	R	L	R	R
Maximum Queue (ft)	239	4	408	386	395	322	232	329	275
Average Queue (ft)	129	0	335	324	298	109	129	236	143
95th Queue (ft)	211	3	459	455	439	319	207	321	337
Link Distance (ft)		3322	322	322	322		1238	1238	
Upstream Blk Time (%)			19	14	10	0			
Queuing Penalty (veh)			187	143	98	0			
Storage Bay Dist (ft)	425				400		250		
Storage Blk Time (%)					10	0	4	0	
Queuing Penalty (veh)					18	3	9	1	

Intersection: 2: Montrose Road & North Farm Lane

Movement	EB	EB	EB	WB	WB	WB
Directions Served	T	T	T	T	T	TR
Maximum Queue (ft)	248	270	303	551	518	402
Average Queue (ft)	82	128	164	256	226	167
95th Queue (ft)	210	306	373	571	518	396
Link Distance (ft)	244	244	244	671	671	671
Upstream Blk Time (%)	0	1	5	0	0	
Queuing Penalty (veh)	0	6	39	0	0	
Storage Bay Dist (ft)						
Storage Blk Time (%)						
Queuing Penalty (veh)						

Intersection: 8: Montrose Road

Movement	EB	EB	EB	EB	WB	WB	WB
Directions Served	T	T	T	T	T	T	T
Maximum Queue (ft)	10	15	93	81	311	309	294
Average Queue (ft)	0	1	15	15	99	85	62
95th Queue (ft)	7	11	57	53	281	267	228
Link Distance (ft)	322	322	322	322	244	244	244
Upstream Blk Time (%)					4	2	2
Queuing Penalty (veh)					40	24	19
Storage Bay Dist (ft)							
Storage Blk Time (%)							
Queuing Penalty (veh)							

Network Summary

Network wide Queuing Penalty: 588

ATTACHMENT

F

Crash Data

ATTACHMENT

G

Crash Modification Factors



CMF / CRF DETAILS

CMF ID: 8655

CONVERT A T INTERSECTION INTO A CONTINUOUS GREEN T INTERSECTION

DESCRIPTION: THE CONTINUOUS GREEN T INTERSECTION IS CHARACTERIZED BY A CHANNELIZED LEFT-TURN MOVEMENT FROM THE MINOR STREET APPROACH ONTO THE MAJOR STREET, ALONG WITH A CONTINUOUS THROUGH MOVEMENT ON THE MAJOR STREET. THE CONTINUOUS FLOW THROUGH MOVEMENT IS NOT CONTROLLED BY THE THREE-PHASE TRAFFIC SIGNAL THAT IS USED TO SEPARATE ALL OTHER MOVEMENTS AT THE INTERSECTION. RATHER, THE CONTINUOUS THROUGH MOVEMENT HAS A GREEN THROUGH ARROW INDICATOR TO INFORM DRIVERS THAT THEY DO NOT HAVE TO STOP.

PRIOR CONDITION: SIGNALIZED T INTERSECTION

CATEGORY: INTERSECTION GEOMETRY

STUDY: SAFETY EVALUATION OF CONTINUOUS GREEN T INTERSECTIONS: A PROPENSITY SCORES-GENETIC MATCHING-POTENTIAL OUTCOMES APPROACH, WOOD AND DONN

Star Quality Rating:		[VIEW SCORE DETAILS]
Rating Points Total:	105	

Crash Modification Factor (CMF)

Value:	0.958
Adjusted Standard Error:	
Unadjusted Standard Error:	0.106

Crash Reduction Factor (CRF)

Value:	4.2 (This value indicates a <i>decrease</i> in crashes)
Adjusted Standard Error:	
Unadjusted Standard Error:	10.6

Applicability

Crash Type:	All
Crash Severity:	All
Roadway Types:	Not specified
Number of Lanes:	2-8
Road Division Type:	
Speed Limit:	15-60
Area Type:	
Traffic Volume:	
Average Traffic Volume:	

Time of Day: All

If countermeasure is intersection-based

Intersection Type:	Roadway/roadway (not interchange related)
Intersection Geometry:	3-leg
Traffic Control:	Signalized
Major Road Traffic Volume:	Minimum of 8300 to Maximum of 59000 Annual Average Daily Traffic (AADT)
Minor Road Traffic Volume:	Minimum of 500 to Maximum of 40000 Annual Average Daily Traffic (AADT)
Average Major Road Volume :	30951 Annual Average Daily Traffic (AADT)
Average Minor Road Volume :	9421 Annual Average Daily Traffic (AADT)

Development Details

Date Range of Data Used:	2008 to 2013
Municipality:	
State:	FL, SC
Country:	USA
Type of Methodology Used:	7
Sample Size (crashes):	2339 crashes
Sample Size (sites):	60 sites
Sample Size (site-years):	297 site-years

Other Details

Included in Highway Safety Manual?	No
Date Added to Clearinghouse:	Nov-06-2017
Comments:	The study used weighted negative binomial regression with the genetic matched data.

[VIEW THE FULL STUDY DATA](#)[EXPORT DETAIL PAGE AS A PDF](#)

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

For more information, contact Karen Scurry at karen.scurry@dot.gov

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CMF / CRF DETAILS

CMF ID: 8656

CONVERT A T INTERSECTION INTO A CONTINUOUS GREEN T INTERSECTION

DESCRIPTION: THE CONTINUOUS GREEN T INTERSECTION IS CHARACTERIZED BY A CHANNELIZED LEFT-TURN MOVEMENT FROM THE MINOR STREET APPROACH ONTO THE MAJOR STREET, ALONG WITH A CONTINUOUS THROUGH MOVEMENT ON THE MAJOR STREET. THE CONTINUOUS FLOW THROUGH MOVEMENT IS NOT CONTROLLED BY THE THREE-PHASE TRAFFIC SIGNAL THAT IS USED TO SEPARATE ALL OTHER MOVEMENTS AT THE INTERSECTION. RATHER, THE CONTINUOUS THROUGH MOVEMENT HAS A GREEN THROUGH ARROW INDICATOR TO INFORM DRIVERS THAT THEY DO NOT HAVE TO STOP.

PRIOR CONDITION: SIGNALIZED T INTERSECTION

CATEGORY: INTERSECTION GEOMETRY

STUDY: SAFETY EVALUATION OF CONTINUOUS GREEN T INTERSECTIONS: A PROPENSITY SCORES-GENETIC MATCHING-POTENTIAL OUTCOMES APPROACH, WOOD AND DONN

Star Quality Rating:		[VIEW SCORE DETAILS]
Rating Points Total:	95	

Crash Modification Factor (CMF)

Value:	0.846
Adjusted Standard Error:	
Unadjusted Standard Error:	0.114

Crash Reduction Factor (CRF)

Value:	15.4 (This value indicates a decrease in crashes)
Adjusted Standard Error:	
Unadjusted Standard Error:	11.4

Applicability

Crash Type:	All
Crash Severity:	K (fatal),A (serious injury),B (minor injury),C (possible injury)
Roadway Types:	Not specified
Number of Lanes:	2-8
Road Division Type:	
Speed Limit:	15-60
Area Type:	
Traffic Volume:	
Average Traffic Volume:	

Time of Day: All

If countermeasure is intersection-based

Intersection Type:	Roadway/roadway (not interchange related)
Intersection Geometry:	3-leg
Traffic Control:	Signalized
Major Road Traffic Volume:	Minimum of 8300 to Maximum of 59000 Annual Average Daily Traffic (AADT)
Minor Road Traffic Volume:	Minimum of 500 to Maximum of 40000 Annual Average Daily Traffic (AADT)
Average Major Road Volume :	30951 Annual Average Daily Traffic (AADT)
Average Minor Road Volume :	9421 Annual Average Daily Traffic (AADT)

Development Details

Date Range of Data Used:	2008 to 2013
Municipality:	
State:	FL, SC
Country:	USA
Type of Methodology Used:	7
Sample Size (crashes):	848 crashes
Sample Size (sites):	60 sites
Sample Size (site-years):	297 site-years

Other Details

Included in Highway Safety Manual?	No
Date Added to Clearinghouse:	Nov-06-2017
Comments:	The study used weighted negative binomial regression with the genetic matched data.

[VIEW THE FULL STUDY DATA](#)[EXPORT DETAIL PAGE AS A PDF](#)

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