Appendix IV. Traffic Study

228TH AVENUE SE ROUNDABOUT FEASIBILTY TRAFFIC ANALYSIS REPORT

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COSA0000-0010

May 2011

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1.0 PROJECT OVERVIEW

The City of Sammamish, Washington (CITY) desires to evaluate the feasibility of roundabouts at SE 8th Street/228th Avenue SE and SE 10th Street/228th Avenue SE in conjunction with a potential community center located at and accessing 228th Avenue SE between the two intersections.

This report presents the methodology, findings, and conclusions regarding the traffic operational analysis for both signal and roundabout control options at SE 8th Street/228th Avenue SE and SE 10th Street/228th Avenue SE. The following Town Center scenarios (which include the proposed community center) were included in the analysis for both locations. All scenarios include the recently-completed annexations adopted in 2009 and 2010.

- 2016 (current concurrency model) with anticipated initial Town Center development application and Community Center
- 2020 with Adopted Town Center Plan and Community Center
- 2030 with Adopted Town Center Plan and Community Center

The proposed new Sammamish Community Center consists of 80,000 square feet of building area, and is located just immediately west of the Sammamish Library. The current access intersection to/from 228th Avenue SE to the Sammamish Library operates with a right-in/right-out control.

The intersections at SE 8th Street/228th Avenue SE and SE 10th Street/228th Avenue SE are currently under signal control.

2.0 METHODOLOGY AND ASSUMPTIONS

The proposed new Sammamish Community Center consisting of 80,000 square feet of building area was added to the available citywide 2016 with anticipated initial Town Center travel demand model, 2020 with adopted town center plan travel demand model, and 2030 with adopted town center plan travel demand model for trip distribution and assignment in the PM peak hour. The intersection forecast volumes at SE 8th Street/228th Avenue SE and SE 10th Street/228th Avenue SE for 2016, 2020, and 2030 were obtained from the travel demand model for operational analysis.

Both signal and roundabout control options were evaluated at the intersections at SE 8th Street and SE 10th Street on 228th Avenue SE. The level of service (LOS) of the signal option was evaluated using the SYNCHRO program (version 7) and the LOS of the roundabout option was evaluated using the aaSIDRA program (version 5.1) that incorporates the latest HCM 2010 LOS method.

The forecast volumes in the PM peak hour at SE 8th Street/228th Avenue SE and SE 10th Street/228th Avenue SE for all scenarios in 2016, 2020, and 2030 were obtained from the citywide travel demand model. The PM peak hour factor and heavy vehicle percentage obtained from the latest counts were applied to all future scenarios.

The signal timings were optimized for all scenarios at the intersections at SE 8th Street and SE 10th Street on 228th Avenue SE.

3.0 INTERSECTION LOS DEFINITION AND STANDARDS

The 2010 Highway Capacity Manual (HCM 2000) methodology prepared by the Transportation Research Board (TRB) was used to calculate the LOS at the intersections within the study area. LOS is a

qualitative measure describing operational conditions within a traffic stream and the perception thereof by road users. For signalized intersections, roundabouts, and sign control intersections, LOS is defined in terms of delay, which is a measure of driver discomfort and frustration, fuel consumption, and lost travel time. There are six LOS levels ranging from LOS A to LOS F, with LOS A representing the best operating conditions and LOS F the worst. Specifically, LOS criteria are stated in terms of the average vehicle control delay for a peak 15-minute analysis period, factored to a full hour, for the intersection or roundabout as a whole. Based on the new HCM 2010 LOS method, the LOS definition for roundabouts is the same as that for sign control intersections. **Table 1** provides LOS definitions for signalized intersections, roundabouts, and sign control intersections.

Table 1. Level of Service Definitions (HCM 2010)

Level of Service (LOS)	Average control delay per vehicle in seconds (d)			Expected Delays
	Signalized Intersections	Roundabouts	Sign Control Intersections	
A	$d \leq 10$	$d \leq 10$	$d \leq 10$	Little or no delay
B	$10 < d \leq 20$	$10 < d \leq 15$	$10 < d \leq 15$	Short traffic delays
C	$20 < d \leq 35$	$15 < d \leq 25$	$15 < d \leq 25$	Average traffic delays
D	$35 < d \leq 55$	$25 < d \leq 35$	$25 < d \leq 35$	Long traffic delays
E	$55 < d \leq 80$	$35 < d \leq 50$	$35 < d \leq 50$	Very long traffic delays
F	$80 < d$	$50 < d$	$50 < d$	(1)

(1) When demand volume exceeds the capacity of the movement, extreme delays will be encountered with queuing, which may cause severe congestion affecting other traffic movements in the intersection.

SOURCE: 2010 Highway Capacity Manual (TRB 2010)

In the City's transportation comprehensive plan, the City has developed a level of service standard to measure the overall transportation system's ability to move people and goods. LOS D is the level of service standard for the 228th Avenue SE corridor.

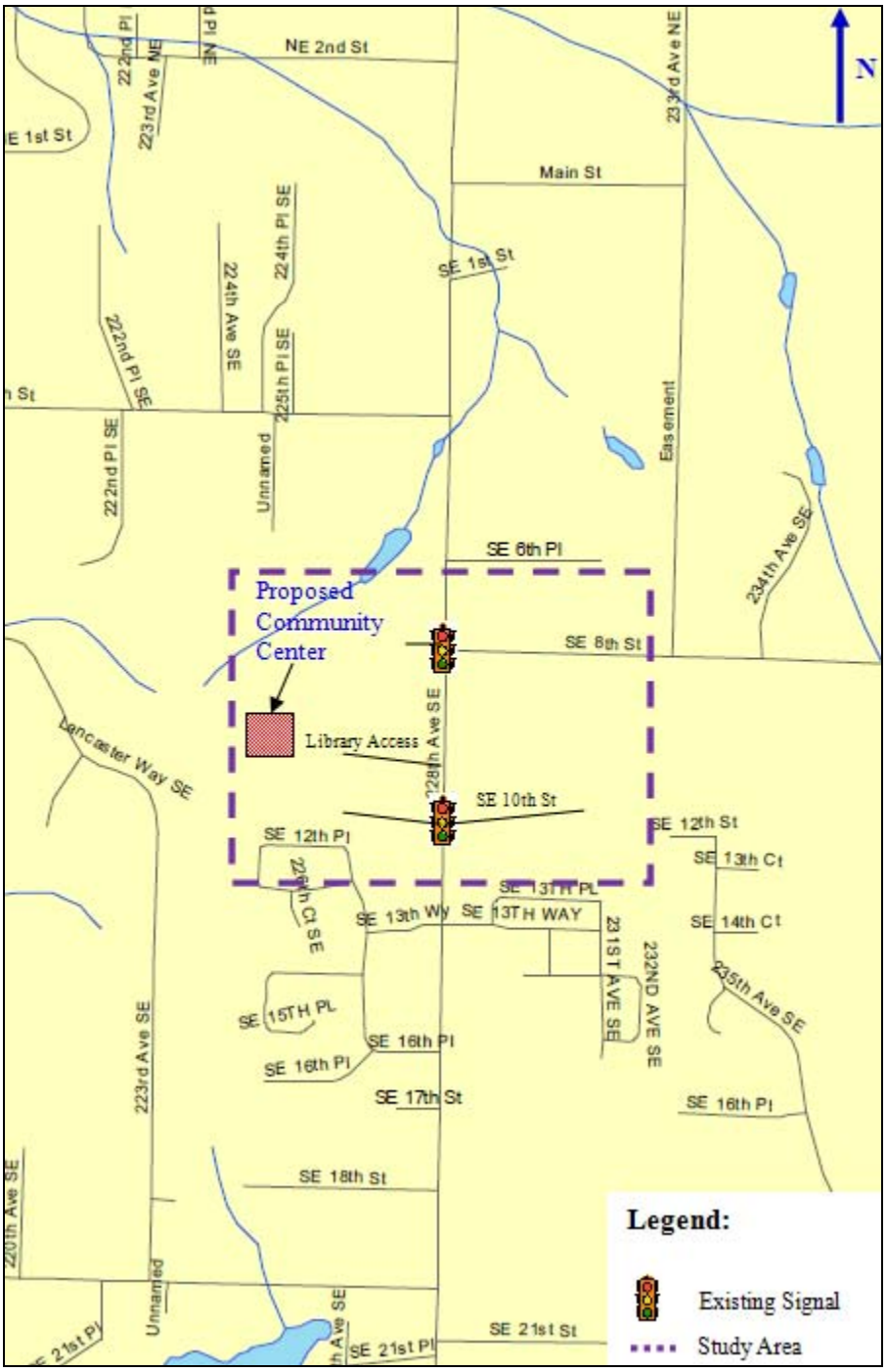
4.0 STUDY AREA

The focus of this study is to assess the intersection traffic control options for two intersections:

- SE 8th Street/228th Avenue SE
- SE 10th Street/228th Avenue SE

The intersection of Library Access/228th Avenue SE will maintain as a right-in/right-out control intersection. The study area intersections are shown in **Figure 1**.

Figure 1. Study Area and Key Intersections



The following three intersections were identified for evaluation within the study area:

- **SE 8th Street/228th Avenue SE**: This is a signalized intersection. Right-turn pockets and one through and left-turn shared lane are provided on the eastbound and westbound approaches. Left-turn pockets and two though and right-turn shared lanes are provided on the northbound and southbound approaches. U-turns are allowed on both the northbound and southbound approaches.

- **Library Access/228th Avenue SE**: This is a right-in and right out control intersection with a stop sign on the eastbound approach. The existing access is a two-lane roadway with one entering lane and one exiting lane. Two through lanes are provided on the northbound and southbound approaches, and northbound left-turning traffic to the access is blocked by the median.

- **SE 10th Street/228th Avenue SE**: This is a signalized intersection. A right-turn pocket and one through and left-turn shared lane are provided on the westbound approach, and a left-turn pocket and one through and right-turn shared lane are provided on the eastbound approach. Left-turn pockets and two though and right-turn shared lanes are provided on the northbound and southbound approaches. U-turns are allowed on both the northbound and southbound approaches.

The following roads were inventoried as part of this study:

- **228th Avenue SE:** This is a north-south principal arterial with a 5-lane roadway in the study area. Curb, gutter, and sidewalks exist along both sides of 228th Avenue NE. The posted speed limit is 40 miles per hour (mph). The alignment is straight with small grade, and the pavement is in good condition.

- **SE 8th Street:** This is an east-west minor arterial with a 3-lane roadway (a two-way, left-turn lane in the median) in the study area. Curb, gutter, and sidewalks exist along both sides of SE 8th Street. The posted speed limit is 30 mph. The alignment is straight and the pavement is in good condition.

- **SE 10th Street:** This is an east-west access to Skyline High School with a 2-lane roadway in the study area. Curb, gutter, and sidewalks exist along both sides of SE 10th Street. The alignment is slightly curved and the pavement is in good condition.

The existing configuration of the intersections and roadway segments within the study area is shown in **Figure 2**.

Figure 2. Existing Configuration of the Intersections and Roadway Segments

5.0 INTERSECTION LEVEL OF SERVICE

Both signal and roundabout options are evaluated at the intersections at SE 8th Street and SE 10th Street on 228th Avenue SE. The LOS of the signal control option was evaluated using the SYNCHRO program (version 7) and the LOS of the roundabout option was evaluated using the aaSIDRA program (version 5.1) that incorporates the latest HCM 2010 LOS method. The new HCM 2010 changes the roundabout LOS definition, and roundabout LOS delay threshold is set the same as un-signalized intersections.

The forecast volumes for all scenarios in 2016, 2020, and 2030 were obtained from the citywide travel demand model. The PM peak hour factor and heavy vehicle percentage obtained from the latest counts were applied to all future scenarios. The signal timings were optimized for all scenarios at the intersections at SE 8th Street and SE 10th Street on 228th Avenue SE.

The existing configuration at the intersections of SE 8th Street/228th Avenue SE and SE 10th Street/228th Avenue SE was applied to the signal control option in the 2016, 2020, and 2030 scenarios. The conceptual layouts of the roundabout option are shown in **Appendix A**.

Table 2 summarizes the LOS for both the signal and roundabout options. Overall, both the signal and roundabout control options in all scenarios in 2016, 2020, and 2030 meet the City's LOS standard. For the roundabout option in the 2030 scenario, the eastbound approach at SE 10th Street/228th Avenue SE has a delay of 50.9 seconds which is defined as LOS F based on the new HCM 2010 roundabout LOS definition, but the delay is less than 55 seconds which is comparable to LOS D for a signal.

Overall the roundabout option has less intersection-wide delay and better LOS compared to the signal option. The detailed LOS calculations for the signal and roundabout options are shown in **Appendices B** and **D**, respectively.

Table 2. Intersection LOS and Delay

Intersection/Approach	**LOS[1] (Delay[2]) with Signal**			**LOS[1] (Delay[2]) with Roundabout**		
	2016	**2020**	**2030**	**2016**	**2020**	**2030**
SE 8th St/228th Ave SE	**C (22.2)**	**C (21.4)**	**C (24.0)**	**B (14.8)**	**B (14.7)**	**C (16.6)**
Eastbound	C (31.0)	C (23.6)	C (21.3)	B (12.5)	B (11.4)	B (13.1)
Westbound	C (34.7)	C (23.5)	C (21.9)	B (11.9)	B (12.4)	B (13.0)
Northbound	B (14.8)	B (14.2)	B (16.3)	C (15.3)	C (16.9)	C (18.3)
Southbound	C (24.0)	C (30.4)	D (35.8)	C (15.9)	B (13.4)	C (16.7)
SE 10th St/228th Ave SE	**B (19.2)**	**C (20.6)**	**C (28.6)**	**B (13.5)**	**B (13.7)**	**C (24.4)**
Eastbound	D (47.6)	D (42.1)	D (44.0)	B (10.4)	A (9.7)	F (50.9)[3]
Westbound	C (32.3)	C (30.2)	C (25.7)	C (16.7)	C (18.5)	C (23.3)
Northbound	C (21.8)	C (23.5)	C (27.6)	B (12.9)	B (14.3)	C (22.0)
Southbound	B (12.1)	B (14.0)	C (24.5)	C (13.5)	B (12.3)	C (17.0)
Library Access/228th Ave SE **- Right-in/Right-out control**	B (13.0)	B (13.7)	B (13.1)	-	-	-

[1]LOS – Level of Service
[2]Delay – Control Delay, seconds/vehicle
[3]New LOS criteria for roundabouts results in LOS F, but the delay is less than 55 seconds, which is comparable to LOS D for a signal.

6.0 INTERSECTION 95TH PERCENTILE QUEUES

The 95th percentile queues were obtained from SYNCHRO and aaSIDRA models. The aaSIDRA program only provides 95th percentile queues for each approach; in other words, all movements in that approach have the same approach queues. The maximum approach 95th percentile queues for the signal option were obtained from SYNCHRO so that the queues of the signal option are comparable to the approach queues of the roundabout option.

The approach 95th percentile queues are shown in **Table 3**. Overall, both signal and roundabout options do not result in substantially long queues, and the roundabout option generally has shorter approach queues compared to the signal option. The detailed queue calculations for the signal and roundabout options are shown in **Appendices C** and **D**, respectively. For the signal option at the signalized intersections of SE 8th Street/228th Avenue SE and SE 10th Street/228th Avenue SE, the maximum northbound and southbound approach queues are longer than the available pocket lengths, which would result in the left-turn traffic being blocked by the approach queues.

Table 3. Maximum Approach 95th Percentile Queues

Intersection/Approach	95th Queue[1] (feet) with Signal				95th Queue[2] (feet) with Roundabout		
	Pocket length	2016	2020	2030	2016	2020	2030
SE 8th St/228th Ave SE							
Eastbound	50 (RT)	82*	82*	86*	28	25	27
Westbound	270 (RT)	147	96	120	30	24	31
Northbound	175 (LT)	232*	244*	243*	139	165	176
Southbound	150 (LT)	343*	310*	379*	116	88	117
SE 10th St/228th Ave SE							
Eastbound	150 (LT)	24	15	88	11	10	171
Westbound	150 (LT)	142	136	123	44	47	55
Northbound	150 (LT)	368*	366*	357*	105	127	182
Southbound	150 (LT)	235*	271*	266*	119	98	151

[1]Signalized intersection queues are measured for the approach pocket.
[2]Roundabout queues are measured for the entire approach.
*Approach queue lengths are longer than pocket lengths.

7.0 SAFETY ANALYSIS

The collision data for the study area is not available at this point, so a safety analysis of the existing roadway system and intersections was not conducted. Instead, qualitative analyses of the future safety benefits of the proposed roundabout were conducted.

Roundabouts have inherent safety benefits associated with their design where roundabout circulating speeds are low and conflict movements are reduced compared to signalized intersections. A national Cooperative Highway Research Program 2007 report, "Roundabout in United States", concluded that crashes reduced from 1,122 crashes per year to 426 crashes per year (reduced by 35 percent) after 55 traditional intersections were replaced with roundabouts. In addition, the study also found that the number of severe injury-related crashes was reduced significantly, as much as 60 to 80 percent.

Roundabouts, including multi-lane roundabouts, have positive safety records for both pedestrians and bicycles. Multi-lane roundabouts have higher crash rates than single-lane roundabouts, but are comparable to multi-lane signalized intersections. Signalized intersections with right-turn by-pass lanes are very similar to roundabouts, requiring an uncontrolled pedestrian crossing at the right-turn lanes, combined with a signalized crossing.

The lower operating speeds of roundabouts (entering and exiting speeds typically under 25 mph vs. entering and exit speeds of signals on 228th of over 35 mph) significantly reduce the risk of fatalities caused by inattentive drivers or pedestrians.

Vehicle crash severity is significantly reduced with roundabouts compared to signals. Fatal crashes are nearly eliminated (most are a result of impaired drivers) and injury crashes are reduced by 75 percent. Multi-lane roundabouts have higher crash rates than singl- lane roundabouts (typically side-swipe crashes in the circulating roadway). Good geometric design can reduce multi-lane crashes as well.

8.0 CONCLUSIONS

Both signal and roundabout control options were evaluated for SE 8th Street/228th Avenue SE and SE 10th Street/228th Avenue SE for three scenarios: 2016 with initial town center and community center, 2020 with town center and community center, and 2030 with town center and community center.

The traffic analysis showed that roundabout option is feasible for the two intersections. The overall intersection-wide average delay per vehicle and overall queue lengths were less when designed as roundabouts versus signals. In addition, roundabouts would be preferable over signals because traffic entering and exiting the Sammamish Library and the proposed community center can conveniently make U-turns at the two intersections at SE 8th Street and SE 10th Street on 228th Avenue SE while the access intersection still maintains right-in/right-out control. Furthermore, roundabouts would be safer due to their low circulating speeds that would accommodate the high pedestrian and bike activity expected near the study area when the town center and community center are completed.

The proposed conceptual roundabout layout would include two circulating lanes on the northbound and southbound approaches and one circulating lane on the eastbound and westbound approach at the two locations.

Future federal actions related to accommodation of the disabled or public rights-of-way may require that accessible pedestrian signals and detectors be installed on all roundabout approaches to assist pedestrians who have visual disabilities in safely crossing streets at roundabouts. Other options, including rapid flashing beacons (RBF), are being tested.

APPENDIX A – CONCEPTUAL ROUNDABOUT LAYOUTS


228th Avenue SE
SE 10th Street
SE 8th Street


228th Avenue SE
SE 10th Street
SE 8th Street

APPENDIX B – 2016, 2020, AND 2030 SIGNALIZED INTERSECTION LOS CALCULATIONS

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR
Lane Configurations														
Volume (vph)	82	14	137	154	13	125	87	78	699	267	1	107	715	96
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Grade (%)		2%			-2%				-2%				2%	
Total Lost time (s)		2.0	4.0		3.0	3.0		3.0	3.0			3.5	3.0	
Lane Util. Factor		1.00	1.00		1.00	1.00		1.00	0.95			1.00	0.95	
Frt		1.00	0.85		1.00	0.85		1.00	0.96			1.00	0.98	
Flt Protected		0.96	1.00		0.96	1.00		0.95	1.00			0.95	1.00	
Satd. Flow (prot)		1744	1546		1739	1546		1745	3345			1710	3360	
Flt Permitted		0.58	1.00		0.58	1.00		0.95	1.00			0.95	1.00	
Satd. Flow (perm)		1056	1546		1056	1546		1745	3345			1710	3360	
Peak-hour factor, PHF	0.78	0.78	0.78	0.82	0.82	0.82	0.96	0.96	0.96	0.96	0.94	0.94	0.94	0.94
Adj. Flow (vph)	105	18	176	188	16	152	91	81	728	278	1	114	761	102
RTOR Reduction (vph)	0	0	87	0	0	108	0	0	26	0	0	0	7	0
Lane Group Flow (vph)	0	123	89	0	204	44	0	172	980	0	0	115	856	0
Heavy Vehicles (%)	0%	0%	0%	2%	2%	2%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm		Perm	Perm		Perm	Prot	Prot			Prot	Prot		
Protected Phases		8			4		5	5	2		1	1	6	
Permitted Phases	8		8	4		4								
Actuated Green, G (s)		29.7	29.7		29.7	29.7		11.0	55.3			8.0	52.3	
Effective Green, g (s)		32.7	30.7		31.7	31.7		14.0	58.3			10.5	55.3	
Actuated g/C Ratio		0.30	0.28		0.29	0.29		0.13	0.53			0.10	0.50	
Clearance Time (s)		5.0	5.0		5.0	5.0		6.0	6.0			6.0	6.0	
Vehicle Extension (s)		3.0	3.0		2.0	2.0		3.0	2.0			2.0	2.0	
Lane Grp Cap (vph)		314	431		304	446		222	1773			163	1689	
v/s Ratio Prot								c0.10	c0.29			0.07	0.25	
v/s Ratio Perm		0.12	0.06		c0.19	0.03								
v/c Ratio		0.39	0.21		0.67	0.10		0.77	0.55			0.71	0.51	
Uniform Delay, d1		30.7	30.3		34.5	28.7		46.5	17.2			48.3	18.3	
Progression Factor		1.00	1.00		1.00	1.00		0.85	0.41			1.00	1.00	
Incremental Delay, d2		0.8	0.2		4.5	0.0		13.8	1.1			10.8	1.1	
Delay (s)		31.5	30.6		39.1	28.7		53.2	8.2			59.0	19.3	
Level of Service		C	C		D	C		D	A			E	B	
Approach Delay (s)		31.0			34.7				14.8				24.0	
Approach LOS		C			C				B				C	

Intersection Summary			
HCM Average Control Delay	22.2	HCM Level of Service	C
HCM Volume to Capacity ratio	0.62		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	9.0
Intersection Capacity Utilization	63.0%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR
Lane Configurations														
Volume (vph)	12	0	22	140	1	50	2	12	924	96	145	35	862	47
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	3.0		3.0	3.0			3.0	3.0			3.0	3.0	
Lane Util. Factor	1.00	1.00		1.00	1.00			1.00	0.95			1.00	0.95	
Frt	1.00	0.85		1.00	0.85			1.00	0.99			1.00	0.99	
Flt Protected	0.95	1.00		0.95	1.00			0.95	1.00			0.95	1.00	
Satd. Flow (prot)	1745	1561		1728	1550			1728	3406			1728	3428	
Flt Permitted	0.71	1.00		0.54	1.00			0.22	1.00			0.17	1.00	
Satd. Flow (perm)	1313	1561		982	1550			392	3406			304	3428	
Peak-hour factor, PHF	0.47	0.47	0.47	0.78	0.78	0.78	0.96	0.96	0.96	0.96	0.94	0.94	0.94	0.94
Adj. Flow (vph)	26	0	47	179	1	64	2	12	962	100	154	37	917	50
RTOR Reduction (vph)	0	43	0	0	47	0	0	0	7	0	0	0	3	0
Lane Group Flow (vph)	26	4	0	179	18	0	0	14	1055	0	0	191	964	0
Heavy Vehicles (%)	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm			pm+pt			pm+pt	pm+pt			pm+pt	pm+pt		
Protected Phases		8		7	4		5	5	2		1	1	6	
Permitted Phases	8			4			2	2			6	6		
Actuated Green, G (s)	5.7	5.7		27.0	27.0			55.3	51.8			71.1	61.7	
Effective Green, g (s)	8.7	8.7		30.0	30.0			61.1	54.7			74.0	64.6	
Actuated g/C Ratio	0.08	0.08		0.27	0.27			0.56	0.50			0.67	0.59	
Clearance Time (s)	6.0	6.0		6.0	6.0			5.9	5.9			5.9	5.9	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			2.0	2.0			2.0	2.0	
Lane Grp Cap (vph)	104	123		392	423			295	1694			416	2013	
v/s Ratio Prot		0.00		c0.08	0.01			0.00	c0.31			c0.07	c0.28	
v/s Ratio Perm	0.02			c0.05				0.02				0.24		
v/c Ratio	0.25	0.03		0.46	0.04			0.05	0.62			0.46	0.48	
Uniform Delay, d1	47.6	46.8		32.5	29.4			19.0	20.1			24.8	13.0	
Progression Factor	1.00	1.00		1.00	1.00			1.00	1.00			0.75	0.76	
Incremental Delay, d2	1.3	0.1		0.8	0.0			0.0	1.7			0.3	0.8	
Delay (s)	48.8	46.9		33.3	29.5			19.0	21.9			19.0	10.7	
Level of Service	D	D		C	C			B	C			B	B	
Approach Delay (s)		47.6			32.3				21.8				12.1	
Approach LOS		D			C				C				B	

Intersection Summary			
HCM Average Control Delay	19.2	HCM Level of Service	B
HCM Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	63.0%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (veh/h)	0	261	0	1130	828	266
Sign Control	Stop			Free	Free	
Grade	0%			-2%	0%	
Peak Hour Factor	0.90	0.90	0.98	0.98	0.97	0.97
Hourly flow rate (vph)	0	290	0	1153	854	274
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage veh)						
Upstream signal (ft)				369	590	
pX, platoon unblocked	0.86	0.86	0.86			
vC, conflicting volume	1567	564	1128			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	577	161	818			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	61	100			
cM capacity (veh/h)	386	740	697			

Direction, Lane #	EB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	290	577	577	569	559
Volume Left	0	0	0	0	0
Volume Right	290	0	0	0	274
cSH	740	1700	1700	1700	1700
Volume to Capacity	0.39	0.34	0.34	0.33	0.33
Queue Length 95th (ft)	47	0	0	0	0
Control Delay (s)	13.0	0.0	0.0	0.0	0.0
Lane LOS	B				
Approach Delay (s)	13.0	0.0		0.0	
Approach LOS	B				

Intersection Summary			
Average Delay	1.5		
Intersection Capacity Utilization	54.2%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR
Lane Configurations														
Volume (vph)	100	14	138	118	9	103	131	74	799	202	1	79	626	111
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Grade (%)		2%			-2%				-2%				2%	
Total Lost time (s)		2.0	4.0		3.0	3.0		3.0	3.0			3.5	3.0	
Lane Util. Factor		1.00	1.00		1.00	1.00		1.00	0.95			1.00	0.95	
Frt		1.00	0.85		1.00	0.85		1.00	0.97			1.00	0.98	
Flt Protected		0.96	1.00		0.96	1.00		0.95	1.00			0.95	1.00	
Satd. Flow (prot)		1742	1546		1738	1546		1745	3384			1710	3343	
Flt Permitted		0.67	1.00		0.61	1.00		0.95	1.00			0.95	1.00	
Satd. Flow (perm)		1221	1546		1106	1546		1745	3384			1710	3343	
Peak-hour factor, PHF	0.78	0.78	0.78	0.82	0.82	0.82	0.96	0.96	0.96	0.96	0.94	0.94	0.94	0.94
Adj. Flow (vph)	128	18	177	144	11	126	136	77	832	210	1	84	666	118
RTOR Reduction (vph)	0	0	77	0	0	82	0	0	18	0	0	0	12	0
Lane Group Flow (vph)	0	146	100	0	155	44	0	213	1024	0	0	85	772	0
Heavy Vehicles (%)	0%	0%	0%	2%	2%	2%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm		Perm	Perm		Perm	Prot	Prot			Prot	Prot		
Protected Phases		8			4		5	5	2		1	1	6	
Permitted Phases	8		8	4		4								
Actuated Green, G (s)		33.0	33.0		33.0	33.0		13.9	46.0			4.0	36.1	
Effective Green, g (s)		36.0	34.0		35.0	35.0		16.9	49.0			6.5	39.1	
Actuated g/C Ratio		0.36	0.34		0.35	0.35		0.17	0.49			0.06	0.39	
Clearance Time (s)		5.0	5.0		5.0	5.0		6.0	6.0			6.0	6.0	
Vehicle Extension (s)		3.0	3.0		2.0	2.0		3.0	2.0			2.0	2.0	
Lane Grp Cap (vph)		440	526		387	541		295	1658			111	1307	
v/s Ratio Prot								c0.12	c0.30			0.05	0.23	
v/s Ratio Perm		0.12	0.06		c0.14	0.03								
v/c Ratio		0.33	0.19		0.40	0.08		0.72	0.62			0.77	0.59	
Uniform Delay, d1		23.3	23.3		24.6	21.7		39.3	18.6			46.0	24.1	
Progression Factor		1.00	1.00		1.00	1.00		0.77	0.43			1.00	1.00	
Incremental Delay, d2		0.4	0.2		0.2	0.0		7.1	1.4			24.2	2.0	
Delay (s)		23.7	23.5		24.8	21.8		37.5	9.4			70.2	26.1	
Level of Service		C	C		C	C		D	A			E	C	
Approach Delay (s)		23.6			23.5				14.2				30.4	
Approach LOS		C			C				B				C	

Intersection Summary			
HCM Average Control Delay	21.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	100.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	61.1%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR
Lane Configurations														
Volume (vph)	7	0	26	144	1	45	2	15	990	103	164	27	769	43
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	3.0		3.0	3.0			3.0	3.0			3.0	3.0	
Lane Util. Factor	1.00	1.00		1.00	1.00			1.00	0.95			1.00	0.95	
Frt	1.00	0.85		1.00	0.85			1.00	0.99			1.00	0.99	
Flt Protected	0.95	1.00		0.95	1.00			0.95	1.00			0.95	1.00	
Satd. Flow (prot)	1745	1561		1728	1550			1728	3406			1728	3428	
Flt Permitted	0.72	1.00		0.54	1.00			0.25	1.00			0.13	1.00	
Satd. Flow (perm)	1320	1561		975	1550			454	3406			242	3428	
Peak-hour factor, PHF	0.47	0.47	0.47	0.78	0.78	0.78	0.96	0.96	0.96	0.96	0.94	0.94	0.94	0.94
Adj. Flow (vph)	15	0	55	185	1	58	2	16	1031	107	174	29	818	46
RTOR Reduction (vph)	0	50	0	0	43	0	0	0	7	0	0	0	4	0
Lane Group Flow (vph)	15	5	0	185	16	0	0	18	1131	0	0	203	860	0
Heavy Vehicles (%)	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm			pm+pt			pm+pt	pm+pt			pm+pt	pm+pt		
Protected Phases		8		7	4		5	5	2		1	1	6	
Permitted Phases	8			4			2	2			6	6		
Actuated Green, G (s)	5.7	5.7		23.7	23.7			47.8	44.2			64.4	54.9	
Effective Green, g (s)	8.7	8.7		26.7	26.7			53.6	47.1			67.3	57.8	
Actuated g/C Ratio	0.09	0.09		0.27	0.27			0.54	0.47			0.67	0.58	
Clearance Time (s)	6.0	6.0		6.0	6.0			5.9	5.9			5.9	5.9	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			2.0	2.0			2.0	2.0	
Lane Grp Cap (vph)	115	136		373	414			326	1604			418	1981	
v/s Ratio Prot		0.00		c0.07	0.01			0.00	c0.33			c0.08	c0.25	
v/s Ratio Perm	0.01			c0.06				0.03				0.24		
v/c Ratio	0.13	0.04		0.50	0.04			0.06	0.70			0.49	0.43	
Uniform Delay, d1	42.2	41.8		30.1	27.2			17.1	20.9			23.7	11.9	
Progression Factor	1.00	1.00		1.00	1.00			1.00	1.00			0.78	1.03	
Incremental Delay, d2	0.5	0.1		1.0	0.0			0.0	2.6			0.3	0.7	
Delay (s)	42.7	41.9		31.2	27.2			17.2	23.6			18.7	12.9	
Level of Service	D	D		C	C			B	C			B	B	
Approach Delay (s)		42.1			30.2				23.5				14.0	
Approach LOS		D			C				C				B	

Intersection Summary			
HCM Average Control Delay	20.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	100.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	65.9%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (veh/h)	0	357	0	1206	648	365
Sign Control	Stop			Free	Free	
Grade	0%			-2%	0%	
Peak Hour Factor	0.90	0.90	0.98	0.98	0.97	0.97
Hourly flow rate (vph)	0	397	0	1231	668	376
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage veh)						
Upstream signal (ft)				369	590	
pX, platoon unblocked	0.82	0.85	0.85			
vC, conflicting volume	1471	522	1044			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	330	97	709			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	51	100			
cM capacity (veh/h)	528	808	762			

Direction, Lane #	EB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	397	615	615	445	599
Volume Left	0	0	0	0	0
Volume Right	397	0	0	0	376
cSH	808	1700	1700	1700	1700
Volume to Capacity	0.49	0.36	0.36	0.26	0.35
Queue Length 95th (ft)	69	0	0	0	0
Control Delay (s)	13.7	0.0	0.0	0.0	0.0
Lane LOS	B				
Approach Delay (s)	13.7	0.0		0.0	
Approach LOS	B				

Intersection Summary				
Average Delay	2.0			
Intersection Capacity Utilization	58.4%	ICU Level of Service	B	
Analysis Period (min)	15			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR
Lane Configurations														
Volume (vph)	98	24	133	147	13	108	135	73	754	238	1	101	686	110
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Grade (%)		2%			-2%				-2%				2%	
Total Lost time (s)		2.0	4.0		3.0	3.0		3.0	3.0			3.5	3.0	
Lane Util. Factor		1.00	1.00		1.00	1.00		1.00	0.95			1.00	0.95	
Frt		1.00	0.85		1.00	0.85		1.00	0.96			1.00	0.98	
Flt Protected		0.96	1.00		0.96	1.00		0.95	1.00			0.95	1.00	
Satd. Flow (prot)		1748	1546		1739	1546		1745	3364			1710	3350	
Flt Permitted		0.66	1.00		0.59	1.00		0.95	1.00			0.95	1.00	
Satd. Flow (perm)		1200	1546		1064	1546		1745	3364			1710	3350	
Peak-hour factor, PHF	0.78	0.78	0.78	0.82	0.82	0.82	0.96	0.96	0.96	0.96	0.94	0.94	0.94	0.94
Adj. Flow (vph)	126	31	171	179	16	132	141	76	785	248	1	107	730	117
RTOR Reduction (vph)	0	0	63	0	0	81	0	0	26	0	0	0	11	0
Lane Group Flow (vph)	0	157	108	0	195	51	0	217	1007	0	0	108	836	0
Heavy Vehicles (%)	0%	0%	0%	2%	2%	2%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm		Perm	Perm		Perm	Prot	Prot			Prot	Prot		
Protected Phases		8			4		5	5	2		1	1	6	
Permitted Phases	8		8	4		4								
Actuated Green, G (s)		36.5	36.5		36.5	36.5		13.0	41.5			5.0	33.5	
Effective Green, g (s)		39.5	37.5		38.5	38.5		16.0	44.5			7.5	36.5	
Actuated g/C Ratio		0.40	0.38		0.38	0.38		0.16	0.44			0.08	0.36	
Clearance Time (s)		5.0	5.0		5.0	5.0		6.0	6.0			6.0	6.0	
Vehicle Extension (s)		3.0	3.0		2.0	2.0		3.0	2.0			2.0	2.0	
Lane Grp Cap (vph)		474	580		410	595		279	1497			128	1223	
v/s Ratio Prot								c0.12	c0.30			0.06	c0.25	
v/s Ratio Perm		0.13	0.07		c0.18	0.03								
v/c Ratio		0.33	0.19		0.48	0.09		0.78	0.67			0.84	0.68	
Uniform Delay, d1		21.1	21.0		23.2	19.6		40.3	22.0			45.7	26.9	
Progression Factor		1.00	1.00		1.00	1.00		0.72	0.44			1.00	1.00	
Incremental Delay, d2		0.4	0.2		0.3	0.0		10.0	1.9			35.8	3.1	
Delay (s)		21.5	21.2		23.5	19.6		39.2	11.4			81.5	30.0	
Level of Service		C	C		C	B		D	B			F	C	
Approach Delay (s)		21.3			21.9				16.3				35.8	
Approach LOS		C			C				B				D	

Intersection Summary			
HCM Average Control Delay	24.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	100.0	Sum of lost time (s)	6.0
Intersection Capacity Utilization	64.4%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR
Lane Configurations														
Volume (vph)	84	0	118	142	1	48	2	101	905	101	162	30	773	126
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	3.0		3.0	3.0			3.0	3.0			3.0	3.0	
Lane Util. Factor	1.00	1.00		1.00	1.00			1.00	0.95			1.00	0.95	
Frt	1.00	0.85		1.00	0.85			1.00	0.98			1.00	0.98	
Flt Protected	0.95	1.00		0.95	1.00			0.95	1.00			0.95	1.00	
Satd. Flow (prot)	1745	1561		1728	1550			1728	3403			1728	3382	
Flt Permitted	0.72	1.00		0.21	1.00			0.16	1.00			0.13	1.00	
Satd. Flow (perm)	1315	1561		373	1550			299	3403			238	3382	
Peak-hour factor, PHF	0.47	0.47	0.47	0.78	0.78	0.78	0.96	0.96	0.96	0.96	0.94	0.94	0.94	0.94
Adj. Flow (vph)	179	0	251	182	1	62	2	105	943	105	172	32	822	134
RTOR Reduction (vph)	0	208	0	0	40	0	0	0	9	0	0	0	15	0
Lane Group Flow (vph)	179	43	0	182	23	0	0	107	1039	0	0	204	941	0
Heavy Vehicles (%)	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Turn Type	Perm			pm+pt			pm+pt	pm+pt			pm+pt	pm+pt		
Protected Phases		8		7	4		5	5	2		1	1	6	
Permitted Phases	8			4			2	2			6	6		
Actuated Green, G (s)	14.3	14.3		31.7	31.7			48.7	38.9			52.3	40.7	
Effective Green, g (s)	17.3	17.3		34.7	34.7			54.5	41.8			58.1	43.6	
Actuated g/C Ratio	0.17	0.17		0.35	0.35			0.54	0.42			0.58	0.44	
Clearance Time (s)	6.0	6.0		6.0	6.0			5.9	5.9			5.9	5.9	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			2.0	2.0			2.0	2.0	
Lane Grp Cap (vph)	227	270		325	538			344	1422			354	1475	
v/s Ratio Prot		0.03		c0.08	0.01			0.04	c0.31			c0.08	0.28	
v/s Ratio Perm	c0.14			0.11				0.13				0.25		
v/c Ratio	0.79	0.16		0.56	0.04			0.31	0.73			0.58	0.64	
Uniform Delay, d1	39.6	35.2		24.9	21.6			25.8	24.4			28.5	22.0	
Progression Factor	1.00	1.00		1.00	1.00			1.00	1.00			0.77	1.03	
Incremental Delay, d2	16.4	0.3		2.2	0.0			0.2	3.3			1.3	2.0	
Delay (s)	56.0	35.5		27.1	21.7			26.0	27.7			23.3	24.7	
Level of Service	E	D		C	C			C	C			C	C	
Approach Delay (s)		44.0			25.7				27.6				24.5	
Approach LOS		D			C				C				C	

Intersection Summary			
HCM Average Control Delay	28.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.69		
Actuated Cycle Length (s)	100.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	63.4%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (veh/h)	0	362	0	1199	731	370
Sign Control	Stop			Free	Free	
Grade	0%			-2%	0%	
Peak Hour Factor	0.90	0.90	0.98	0.98	0.97	0.97
Hourly flow rate (vph)	0	402	0	1223	754	381
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage veh)						
Upstream signal (ft)				369	590	
pX, platoon unblocked	0.85	0.82	0.82			
vC, conflicting volume	1556	568	1135			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	358	40	731			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	52	100			
cM capacity (veh/h)	526	846	720			

Direction, Lane #	EB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	402	612	612	502	633
Volume Left	0	0	0	0	0
Volume Right	402	0	0	0	381
cSH	846	1700	1700	1700	1700
Volume to Capacity	0.48	0.36	0.36	0.30	0.37
Queue Length 95th (ft)	65	0	0	0	0
Control Delay (s)	13.1	0.0	0.0	0.0	0.0
Lane LOS	B				
Approach Delay (s)	13.1	0.0		0.0	
Approach LOS	B				

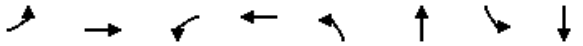
Intersection Summary			
Average Delay	1.9		
Intersection Capacity Utilization	61.1%	ICU Level of Service	B
Analysis Period (min)	15		

APPENDIX C – 2016, 2020, AND 2030 SIGNALIZED INTERSECTION QUEUE CALCULATIONS

Lane Group	EBT	EBR	WBT	WBR	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	123	176	204	152	172	1006	115	863
v/c Ratio	0.39	0.34	0.67	0.27	0.77	0.56	0.71	0.51
Control Delay	31.6	10.7	43.5	4.6	61.3	8.9	72.0	21.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	31.6	10.7	43.5	4.6	61.3	8.9	72.0	21.6
Queue Length 50th (ft)	69	30	127	0	130	20	80	201
Queue Length 95th (ft)	82	50	147	28	#232	146	#166	343
Internal Link Dist (ft)	203		1235			510		601
Turn Bay Length (ft)		25		520	180		150	
Base Capacity (vph)	518	794	319	572	222	1800	163	1696
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.24	0.22	0.64	0.27	0.77	0.56	0.71	0.51

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.



Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	26	47	179	65	14	1062	191	967
v/c Ratio	0.22	0.13	0.47	0.15	0.04	0.56	0.54	0.44
Control Delay	51.2	0.7	36.4	8.3	9.2	19.4	20.2	10.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	51.2	0.7	36.4	8.3	9.2	19.4	20.2	10.1
Queue Length 50th (ft)	17	0	98	1	4	247	38	123
Queue Length 95th (ft)	24	0	142	24	9	368	m85	235
Internal Link Dist (ft)		263		1025		593		289
Turn Bay Length (ft)	150		200		150		150	
Base Capacity (vph)	119	367	392	495	377	1929	463	2279
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.22	0.13	0.46	0.13	0.04	0.55	0.41	0.42

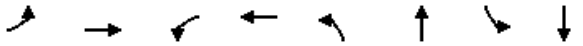
Intersection Summary

m Volume for 95th percentile queue is metered by upstream signal.

Lane Group	EBT	EBR	WBT	WBR	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	146	177	155	126	213	1042	85	784
v/c Ratio	0.33	0.29	0.40	0.20	0.77	0.61	0.66	0.58
Control Delay	22.9	8.4	25.4	3.7	48.9	10.3	70.4	27.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	22.9	8.4	25.4	3.7	48.9	10.3	70.4	27.3
Queue Length 50th (ft)	64	25	71	0	136	41	54	205
Queue Length 95th (ft)	82	46	96	24	#244	162	#125	310
Internal Link Dist (ft)	203		1235			510		601
Turn Bay Length (ft)		25		520	180		150	
Base Capacity (vph)	574	760	387	623	279	1718	128	1358
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.25	0.23	0.40	0.20	0.76	0.61	0.66	0.58

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.



Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	15	55	185	59	18	1138	203	864
v/c Ratio	0.12	0.14	0.51	0.14	0.04	0.63	0.59	0.39
Control Delay	42.6	0.8	35.7	8.7	9.8	19.9	23.8	11.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	42.6	0.8	35.7	8.7	9.8	19.9	23.8	11.9
Queue Length 50th (ft)	9	0	89	0	6	283	45	116
Queue Length 95th (ft)	15	0	136	23	10	366	m103	271
Internal Link Dist (ft)		263		1025		593		289
Turn Bay Length (ft)	150		200		150		150	
Base Capacity (vph)	185	442	361	499	405	1817	429	2262
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.08	0.12	0.51	0.12	0.04	0.63	0.47	0.38

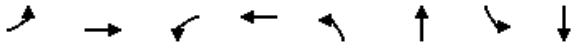
Intersection Summary

m Volume for 95th percentile queue is metered by upstream signal.

Lane Group	EBT	EBR	WBT	WBR	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	157	171	195	132	217	1033	108	847
v/c Ratio	0.33	0.27	0.48	0.20	0.78	0.68	0.84	0.69
Control Delay	21.0	8.6	25.4	3.4	45.8	12.4	93.5	32.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	21.0	8.6	25.4	3.4	45.8	12.4	93.5	32.3
Queue Length 50th (ft)	64	27	86	0	141	102	69	247
Queue Length 95th (ft)	86	49	120	24	m#232	243	#168	#379
Internal Link Dist (ft)	203		1235			510		601
Turn Bay Length (ft)		25		520	180		150	
Base Capacity (vph)	576	766	409	676	279	1524	128	1235
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.27	0.22	0.48	0.20	0.78	0.68	0.84	0.69

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.
m Volume for 95th percentile queue is metered by upstream signal.



Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	179	251	182	63	107	1048	204	956
v/c Ratio	0.79	0.53	0.59	0.12	0.29	0.71	0.61	0.62
Control Delay	64.6	9.2	34.2	7.2	17.6	26.9	28.0	24.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	64.6	9.2	34.2	7.2	17.6	26.9	28.0	24.6
Queue Length 50th (ft)	111	0	80	0	30	301	52	231
Queue Length 95th (ft)	88	0	123	21	47	357	m99	266
Internal Link Dist (ft)		263		1025		593		289
Turn Bay Length (ft)	150		200		150		150	
Base Capacity (vph)	232	482	310	579	370	1519	388	1783
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.77	0.52	0.59	0.11	0.29	0.69	0.53	0.54

Intersection Summary

m Volume for 95th percentile queue is metered by upstream signal.

APPENDIX D – 2016, 2020, AND 2030 ROUNDABOUT LOS AND QUEUE CALCULATIONS

MOVEMENT SUMMARY

Site: 228th Ave SE and SE 8th St-2016PM

228th Ave SE and SE 8th St
Year 2016 PM Peak Period
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: 228th Ave SE (NB)											
3L	L	172	1.0	0.670	15.3	LOS C	5.5	139.4	0.67	0.93	18.3
8T	T	728	1.0	0.670	15.3	LOS C	5.5	139.4	0.67	0.76	19.7
8R	R	278	1.0	0.670	15.3	LOS C	5.5	139.4	0.67	0.81	19.4
Approach		1178	1.0	0.670	15.3	LOS C	5.5	139.4	0.67	0.80	19.4
East: SE 8th St (WB)											
1L	L	188	2.0	0.374	12.4	LOS B	1.2	30.1	0.62	0.91	11.7
6T	T	16	2.0	0.374	12.4	LOS B	1.2	30.1	0.62	0.73	21.6
6R	R	152	2.0	0.295	11.3	LOS B	0.9	22.6	0.62	0.79	13.3
Approach		356	2.0	0.374	11.9	LOS B	1.2	30.1	0.62	0.85	13.1
North: 228th Ave SE (SB)											
7L	L	115	1.0	0.640	15.9	LOS C	4.6	115.7	0.72	1.05	14.2
4T	T	761	1.0	0.640	15.9	LOS C	4.6	115.7	0.72	0.91	18.0
4R	R	102	1.0	0.640	15.9	LOS C	4.6	115.7	0.72	0.95	17.7
Approach		978	1.0	0.640	15.9	LOS C	4.6	115.7	0.72	0.93	17.5
West: SE 8th St (EB)											
5L	L	105	1.0	0.264	11.8	LOS B	0.8	19.3	0.65	0.91	13.0
2T	T	18	1.0	0.264	11.8	LOS B	0.8	19.3	0.65	0.74	12.0
2R	R	176	1.0	0.355	13.0	LOS B	1.1	27.6	0.66	0.83	12.7
Approach		299	1.0	0.355	12.5	LOS B	1.1	27.6	0.66	0.85	12.8
All Vehicles		2811	1.1	0.670	14.8	LOS B	5.5	139.4	0.68	0.86	17.5

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used.

MOVEMENT SUMMARY

Site: 228th Ave SE and SE 8th St-2020PM

228th Ave SE and SE 8th St
Year 2020 PM Peak Period
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: 228th Ave SE (NB)											
3L	L	214	1.0	0.709	16.9	LOS C	6.5	164.8	0.71	0.93	17.8
8T	T	832	1.0	0.709	16.9	LOS C	6.5	164.8	0.71	0.79	19.0
8R	R	210	1.0	0.709	16.9	LOS C	6.5	164.8	0.71	0.83	18.7
Approach		1256	1.0	0.709	16.9	LOS C	6.5	164.8	0.71	0.82	18.7
East: SE 8th St (WB)											
1L	L	144	2.0	0.321	12.5	LOS B	0.9	23.9	0.65	0.91	11.7
6T	T	11	2.0	0.321	12.5	LOS B	0.9	23.9	0.65	0.75	21.5
6R	R	126	2.0	0.276	12.3	LOS B	0.8	20.4	0.66	0.82	12.9
Approach		280	2.0	0.321	12.4	LOS B	0.9	23.9	0.66	0.86	12.8
North: 228th Ave SE (SB)											
7L	L	85	1.0	0.564	13.4	LOS B	3.5	88.1	0.65	1.01	15.1
4T	T	666	1.0	0.564	13.4	LOS B	3.5	88.1	0.65	0.84	19.2
4R	R	118	1.0	0.564	13.4	LOS B	3.5	88.1	0.65	0.89	18.9
Approach		869	1.0	0.564	13.4	LOS B	3.5	88.1	0.65	0.86	18.8
West: SE 8th St (EB)											
5L	L	128	1.0	0.286	11.3	LOS B	0.9	21.6	0.62	0.90	13.2
2T	T	18	1.0	0.286	11.3	LOS B	0.9	21.6	0.62	0.72	12.2
2R	R	177	1.0	0.328	11.5	LOS B	1.0	25.1	0.61	0.79	13.4
Approach		323	1.0	0.328	11.4	LOS B	1.0	25.1	0.62	0.83	13.2
All Vehicles		2729	1.1	0.709	14.7	LOS B	6.5	164.8	0.68	0.84	17.7

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used.

MOVEMENT SUMMARY

Site: 228th Ave SE and SE 8th St-2030PM

228th Ave SE and SE 8th St
Year 2030 PM Peak Period
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: 228th Ave SE (NB)											
3L	L	217	1.0	0.730	18.3	LOS C	7.0	176.3	0.76	0.98	17.3
8T	T	785	1.0	0.730	18.3	LOS C	7.0	176.3	0.76	0.86	18.4
8R	R	248	1.0	0.730	18.3	LOS C	7.0	176.3	0.76	0.90	18.1
Approach		1250	1.0	0.730	18.3	LOS C	7.0	176.3	0.76	0.89	18.1
East: SE 8th St (WB)											
1L	L	179	2.0	0.391	13.7	LOS B	1.2	31.4	0.66	0.93	11.3
6T	T	16	2.0	0.391	13.7	LOS B	1.2	31.4	0.66	0.78	21.1
6R	R	132	2.0	0.280	12.0	LOS B	0.8	20.8	0.65	0.81	13.0
Approach		327	2.0	0.391	13.0	LOS B	1.2	31.4	0.66	0.88	12.7
North: 228th Ave SE (SB)											
7L	L	109	1.0	0.648	16.7	LOS C	4.6	116.8	0.74	1.06	14.0
4T	T	730	1.0	0.648	16.7	LOS C	4.6	116.8	0.74	0.93	17.6
4R	R	117	1.0	0.648	16.7	LOS C	4.6	116.8	0.74	0.97	17.4
Approach		955	1.0	0.648	16.7	LOS C	4.6	116.8	0.74	0.95	17.2
West: SE 8th St (EB)											
5L	L	126	1.0	0.337	13.3	LOS B	1.1	26.5	0.68	0.94	12.5
2T	T	31	1.0	0.337	13.3	LOS B	1.1	26.5	0.68	0.78	11.3
2R	R	171	1.0	0.346	12.9	LOS B	1.1	26.6	0.66	0.83	12.7
Approach		327	1.0	0.346	13.1	LOS B	1.1	26.6	0.67	0.87	12.5
All Vehicles		2859	1.1	0.730	16.6	LOS C	7.0	176.3	0.73	0.90	16.8

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used.

MOVEMENT SUMMARY

Site: 228th Ave SE and SE 10th St-2016PM

228th Ave SE and SE 10th St
Year 2016 PM Peak Period
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: 228th Ave SE (NB)											
3L	L	15	1.0	0.601	12.9	LOS B	4.2	105.1	0.59	0.92	18.0
8T	T	962	1.0	0.601	12.9	LOS B	4.2	105.1	0.59	0.69	17.7
8R	R	100	1.0	0.601	12.9	LOS B	4.2	105.1	0.59	0.75	17.1
Approach		1077	1.0	0.601	12.9	LOS B	4.2	105.1	0.59	0.70	17.6
East: SE 10th St (WB)											
1L	L	179	1.0	0.496	16.7	LOS C	1.8	44.4	0.71	0.85	7.8
6T	T	1	1.0	0.496	16.7	LOS C	1.8	44.4	0.71	0.84	12.3
6R	R	64	1.0	0.496	16.7	LOS C	1.8	44.4	0.71	0.84	7.4
Approach		245	1.0	0.496	16.7	LOS C	1.8	44.4	0.71	0.84	7.8
North: 228th Ave SE (SB)											
7L	L	191	1.0	0.631	13.5	LOS B	4.7	118.7	0.60	0.88	18.9
4T	T	917	1.0	0.631	13.5	LOS B	4.7	118.7	0.60	0.67	20.7
4R	R	50	1.0	0.631	13.5	LOS B	4.7	118.7	0.60	0.74	20.3
Approach		1159	1.0	0.631	13.5	LOS B	4.7	118.7	0.60	0.71	20.3
West: SE 10th St (EB)											
5L	L	26	1.0	0.166	10.4	LOS B	0.4	10.8	0.64	0.65	10.3
2T	T	2	1.0	0.166	10.4	LOS B	0.4	10.8	0.64	0.64	8.2
2R	R	47	1.0	0.166	10.4	LOS B	0.4	10.8	0.64	0.64	9.1
Approach		74	1.0	0.166	10.4	LOS B	0.4	10.8	0.64	0.64	9.6
All Vehicles		2555	1.0	0.631	13.5	LOS B	4.7	118.7	0.61	0.71	17.9

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used.

MOVEMENT SUMMARY

Site: 228th Ave SE and SE 10th St-2020PM

228th Ave SE and SE 10th St
Year 2020 PM Peak Period
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: 228th Ave SE (NB)											
3L	L	18	1.0	0.645	14.3	LOS B	5.0	126.7	0.63	0.93	17.2
8T	T	1031	1.0	0.645	14.3	LOS B	5.0	126.7	0.63	0.72	16.9
8R	R	107	1.0	0.645	14.3	LOS B	5.0	126.7	0.63	0.78	16.5
Approach		1156	1.0	0.645	14.3	LOS B	5.0	126.7	0.63	0.73	16.9
East: SE 10th St (WB)											
1L	L	185	1.0	0.523	18.5	LOS C	1.9	47.2	0.74	0.89	7.4
6T	T	1	1.0	0.523	18.5	LOS C	1.9	47.2	0.74	0.89	12.1
6R	R	58	1.0	0.523	18.5	LOS C	1.9	47.2	0.74	0.89	7.0
Approach		244	1.0	0.523	18.5	LOS C	1.9	47.2	0.74	0.89	7.4
North: 228th Ave SE (SB)											
7L	L	203	1.0	0.586	12.3	LOS B	3.9	98.2	0.56	0.87	19.3
4T	T	818	1.0	0.586	12.3	LOS B	3.9	98.2	0.56	0.66	21.3
4R	R	46	1.0	0.586	12.3	LOS B	3.9	98.2	0.56	0.73	20.9
Approach		1067	1.0	0.586	12.3	LOS B	3.9	98.2	0.56	0.70	20.8
West: SE 10th St (EB)											
5L	L	15	1.0	0.152	9.7	LOS A	0.4	9.9	0.61	0.62	10.5
2T	T	2	1.0	0.152	9.7	LOS A	0.4	9.9	0.61	0.61	8.5
2R	R	55	1.0	0.152	9.7	LOS A	0.4	9.9	0.61	0.61	9.4
Approach		72	1.0	0.152	9.7	LOS A	0.4	9.9	0.61	0.62	9.7
All Vehicles		2539	1.0	0.645	13.7	LOS B	5.0	126.7	0.61	0.73	17.7

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used.

MOVEMENT SUMMARY

228th Ave SE and SE 10th St
Year 2030 PM Peak Period
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: 228th Ave SE (NB)											
3L	L	107	1.0	0.762	22.0	LOS C	7.2	181.8	0.84	1.12	13.7
8T	T	943	1.0	0.762	22.0	LOS C	7.2	181.8	0.84	1.03	13.7
8R	R	105	1.0	0.762	22.0	LOS C	7.2	181.8	0.84	1.06	13.5
Approach		1155	1.0	0.762	22.0	LOS C	7.2	181.8	0.84	1.04	13.7
East: SE 10th St (WB)											
1L	L	182	1.0	0.589	23.3	LOS C	2.2	55.0	0.80	1.00	6.6
6T	T	1	1.0	0.589	23.3	LOS C	2.2	55.0	0.80	0.99	11.5
6R	R	62	1.0	0.589	23.3	LOS C	2.2	55.0	0.80	0.99	6.1
Approach		245	1.0	0.589	23.3	LOS C	2.2	55.0	0.80	0.99	6.5
North: 228th Ave SE (SB)											
7L	L	204	1.0	0.696	17.0	LOS C	6.0	150.8	0.73	1.00	17.7
4T	T	822	1.0	0.696	17.0	LOS C	6.0	150.8	0.73	0.86	18.9
4R	R	134	1.0	0.696	17.0	LOS C	6.0	150.8	0.73	0.90	18.7
Approach		1161	1.0	0.696	17.0	LOS C	6.0	150.8	0.73	0.89	18.6
West: SE 10th St (EB)											
5L	L	179	1.0	0.909	50.9	LOS F	6.8	170.7	0.93	1.68	4.6
2T	T	2	1.0	0.909	50.9	LOS F	6.8	170.7	0.93	1.68	3.0
2R	R	251	1.0	0.909	50.9	LOS F	6.8	170.7	0.93	1.68	3.6
Approach		432	1.0	0.909	50.9	LOS F	6.8	170.7	0.93	1.68	4.1
All Vehicles		2993	1.0	0.909	24.4	LOS C	7.2	181.8	0.81	1.07	13.0

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used.

center. These are based on the community center being constructed at the Kellman site right here behind City Hall.

16. Which of the following three payment/membership fee models would you prefer?

17. Based on the information presented in the slides, would you be more likely to pay daily fees to use the community center or membership fees?

18. Would you be more likely to purchase a three month or annual pass? (Some explanation needed here that shorter term passes or daily passes may increase the subsidy required). Would be nice to know if that would impact their recommendation overall, although I'd still like to know their personal preference.)

19. Having now seen the influence certain spaces of the community center have on revenue, would you be likely to change your priorities from earlier in the discussion?

POTENTIAL COSTS

20. What are your initial reactions to the two preliminary options (levy or utility tax) for paying for the potential community center (i.e. are they too expensive, not expensive, about right)? (May need to explain the difference between the two funding options).

21. Which range do you prefer for the cost of the potential community center (i.e. $30 to $40 million)?

22. Having now seen the cost for each space of the community center, which spaces do you believe are less important that the potential community center could do without?

23. Has the price ranged changed now that you've seen the costs for the spaces?