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# Appendix

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**Level of Service Descriptions**

**Commercial St./Ratcliff Dr. Analysis**

**Commercial St./Madrona Ave. Analysis**

**Commercial St./Alive Ave./Fairview Ave. Analysis**

**Bicycle Crossing Analysis**

**Qualitative Assessment of Walkability and Bikeability**



## **Level of Service Descriptions**

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favorable or the cycle length is very short. If it is due to favorable progression, most vehicles arrive during the green indication and travel through the intersection without stopping.

LOS B describes operations with control delay between 10 and 20 s/veh and a volume-to-capacity ratio no greater than 1.0. This level is typically assigned when the volume-to-capacity ratio is low and either progression is highly favorable or the cycle length is short. More vehicles stop than with LOS A.

LOS C describes operations with control delay between 20 and 35 s/veh and a volume-to-capacity ratio no greater than 1.0. This level is typically assigned when progression is favorable or the cycle length is moderate. Individual *cycle failures* (i.e., one or more queued vehicles are not able to depart as a result of insufficient capacity during the cycle) may begin to appear at this level. The number of vehicles stopping is significant, although many vehicles still pass through the intersection without stopping.

LOS D describes operations with control delay between 35 and 55 s/veh and a volume-to-capacity ratio no greater than 1.0. This level is typically assigned when the volume-to-capacity ratio is high and either progression is ineffective or the cycle length is long. Many vehicles stop and individual cycle failures are noticeable.

LOS E describes operations with control delay between 55 and 80 s/veh and a volume-to-capacity ratio no greater than 1.0. This level is typically assigned when the volume-to-capacity ratio is high, progression is unfavorable, and the cycle length is long. Individual cycle failures are frequent.

LOS F describes operations with control delay exceeding 80 s/veh or a volume-to-capacity ratio greater than 1.0. This level is typically assigned when the volume-to-capacity ratio is very high, progression is very poor, and the cycle length is long. Most cycles fail to clear the queue.

A lane group can incur a delay less than 80 s/veh when the volume-to-capacity ratio exceeds 1.0. This condition typically occurs when the cycle length is short, the signal progression is favorable, or both. As a result, both the delay and volume-to-capacity ratio are considered when lane group LOS is established. A ratio of 1.0 or more indicates that cycle capacity is fully utilized and represents failure from a capacity perspective (just as delay in excess of 80 s/veh represents failure from a delay perspective).

Exhibit 18-4 lists the LOS thresholds established for the automobile mode at a signalized intersection.

**Exhibit 18-4**  
LOS Criteria: Automobile Mode

Control Delay (s/veh)	LOS by Volume-to-Capacity Ratio <sup>a</sup>	
	≤1.0	>1.0
≤10	A	F
>10-20	B	F
>20-35	C	F
>35-55	D	F
>55-80	E	F
>80	F	F

Note: <sup>a</sup> For approach-based and intersectionwide assessments, LOS is defined solely by control delay.

**Exhibit 19-1**  
Level-of-Service Criteria:  
Automobile Mode

present greater delay than an unsignalized intersection. Unsignalized intersections are also associated with more uncertainty for users, as delays are less predictable than they are at signals, which can reduce users' delay tolerance.

Control Delay (s/vehicle)	LOS by Volume-to-Capacity Ratio	
	$v/c \leq 1.0$	$v/c > 1.0$
0-10	A	F
>10-15	B	F
>15-25	C	F
>25-35	D	F
>35-50	E	F
>50	F	F

Note: The LOS criteria apply to each lane on a given approach and to each approach on the minor street. LOS is not calculated for major-street approaches or for the intersection as a whole.

Pedestrian LOS at TWSC intersections is defined for pedestrians crossing a traffic stream not controlled by a STOP sign; it also applies to midblock pedestrian crossings. LOS criteria for pedestrians are given in Exhibit 19-2.

**Exhibit 19-2**  
Level-of-Service Criteria:  
Pedestrian Mode

LOS	Control Delay (s/pedestrian)	Comments
A	0-5	Usually no conflicting traffic
B	5-10	Occasionally some delay due to conflicting traffic
C	10-20	Delay noticeable to pedestrians, but not inconveniencing
D	20-30	Delay noticeable and irritating, increased likelihood of risk taking
E	30-45	Delay approaches tolerance level, risk-taking behavior likely
F	>45	Delay exceeds tolerance level, high likelihood of pedestrian risk taking

Note: Control delay may be interpreted as s/pedestrian group if groups of pedestrians were counted as opposed to individual pedestrians.

LOS F for pedestrians occurs when there are not enough gaps of suitable size to allow waiting pedestrians to cross through traffic on the major street safely. This situation is typically evident from extremely long control delays. The method is based on a constant critical headway. In the field, however, LOS F may also appear in the form of crossing pedestrians selecting smaller-than-usual gaps. In such cases, safety could be a concern that warrants further study.

**REQUIRED INPUT DATA**

Analysis of a TWSC intersection requires the following data:

1. Number and configuration of lanes on each approach;
2. Percentage of heavy vehicles for each movement;
3. Either of the following:
  - a. Demand flow rate for each entering vehicular movement and each pedestrian crossing movement during the peak 15 min, or
  - b. Demand flow rate for each entering vehicular movement and each pedestrian crossing movement during the peak hour and a peak hour factor for the hour;
4. Special geometric factors such as
  - a. Unique channelization aspects,
  - b. Existence of a two-way left-turn lane or raised or striped median storage (or both),

Control Delay (s/veh)	LOS by Volume-to-Capacity Ratio*	
	$v/c \leq 1.0$	$v/c > 1.0$
0–10	A	F
>10–15	B	F
>15–25	C	F
>25–35	D	F
>35–50	E	F
>50	F	F

Note: \* For approaches and intersectionwide assessment, LOS is defined solely by control delay.

Exhibit 20-2  
LOS Criteria: Automobile Mode

### REQUIRED INPUT DATA

Analysis of an AWSC intersection requires the following data:

1. Number and configuration of lanes on each approach;
2. Percentage of heavy vehicles;
3. Turning movement demand flow rate for each entering lane or, alternatively, hourly demand volume and peak hour factor; and
4. Length of analysis period—generally a peak 15-min period within the peak hour, although any 15-min period can be analyzed.

### SCOPE OF THE METHODOLOGY

This chapter focuses on the operation of AWSC intersections. This version of the AWSC intersection analysis procedures is primarily a result of studies conducted by National Cooperative Highway Research Program Project 3-46 (1).

### LIMITATIONS OF THE METHODOLOGY

#### Automobile Mode

The methodologies in this chapter apply to isolated AWSC intersections with up to three lanes on each approach. They do not account for interaction effects with other intersections. The methodologies do not apply to AWSC intersections with more than four approaches. In addition, the effect of conflicting pedestrians on automobiles is not considered in this procedure. Conflicting pedestrian movements are likely to increase the saturation headway of affected vehicular movements, but the magnitude of this effect is unknown as of the publication of this edition of the HCM.

#### Pedestrian and Bicycle Modes

The current methodologies for analyzing LOS and delay at AWSC intersections do not extend to pedestrians and apply to bicycles only in limited situations that are not supported by research at the time of publication of this edition. As such, there are no set LOS standards that apply to pedestrians or bicycles at AWSC intersections, nor can pedestrian or bicycle delay, capacity, or quality of service be quantitatively assessed by using the procedures described in this chapter. Additional research on pedestrian and bicyclist behavior and operations at AWSC intersections needs to be done before procedures can be developed that adequately address these issues. A discussion of qualitative effects is included in the methodology section of this chapter.
























## **Commercial St./Ratcliff Dr. Analysis**

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HCM Signalized Intersection Capacity Analysis  
 3: Commercial Street & Salem Heights Ave SE/Ratcliff Dr SE





















2035 PM\_Ratcliff Signal No NBR  
 Commercial-Vista Corridor Study

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	5	115	35	10	80	145	1320	55	40	1715	50
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	0.95		1.00	0.95	
Frbp, ped/bikes	1.00	0.99		1.00	1.00		1.00	1.00		1.00	1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	0.86		1.00	0.87		1.00	0.99		1.00	1.00	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1710	1506		1708	1521		1693	3329		1710	3337	
Flt Permitted	0.51	1.00		0.40	1.00		0.07	1.00		0.17	1.00	
Satd. Flow (perm)	916	1506		719	1521		126	3329		301	3337	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	11	5	121	37	11	84	153	1389	58	42	1805	53
RTOR Reduction (vph)	0	108	0	0	78	0	0	1	0	0	1	0
Lane Group Flow (vph)	11	18	0	37	17	0	153	1446	0	42	1857	0
Confl. Peds. (#/hr)			1	1			3		2	2		3
Confl. Bikes (#/hr)									8			9
Heavy Vehicles (%)	0%	0%	1%	0%	0%	3%	1%	2%	2%	0%	2%	0%
Turn Type	Perm	NA		Perm	NA		pm+pt	NA		pm+pt	NA	
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)	10.0	10.0		10.0	10.0		112.0	103.1		100.4	95.5	
Effective Green, g (s)	10.0	10.0		10.0	10.0		112.0	103.1		100.4	95.5	
Actuated g/C Ratio	0.08	0.08		0.08	0.08		0.86	0.79		0.77	0.73	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	70	115		55	117		259	2640		285	2451	
v/s Ratio Prot		0.01			0.01		c0.06	0.43		0.01	c0.56	
v/s Ratio Perm	0.01			c0.05			0.45			0.11		
v/c Ratio	0.16	0.16		0.67	0.15		0.59	0.55		0.15	0.76	
Uniform Delay, d1	56.1	56.1		58.4	56.0		23.8	4.9		3.7	10.3	
Progression Factor	0.94	0.92		1.00	1.00		1.38	2.28		0.95	0.69	
Incremental Delay, d2	1.0	0.6		27.8	0.6		2.0	0.5		0.2	1.7	
Delay (s)	53.7	52.0		86.2	56.6		34.9	11.7		3.7	8.8	
Level of Service	D	D		F	E		C	B		A	A	
Approach Delay (s)		52.1			64.9			13.9			8.7	
Approach LOS		D			E			B			A	
<b>Intersection Summary</b>												
HCM 2000 Control Delay			14.5				HCM 2000 Level of Service			B		
HCM 2000 Volume to Capacity ratio			0.73									
Actuated Cycle Length (s)			130.0				Sum of lost time (s)			12.0		
Intersection Capacity Utilization			78.9%				ICU Level of Service			D		
Analysis Period (min)			15									

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis  
 3: Commercial Street & Salem Heights Ave SE/Ratcliff Dr SE

Commercial-Vista Corridor Study  
 2035 AM\_Ratcliff Signal

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	30	5	85	20	5	35	30	1420	45	30	695	10
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	1.00			1.00		1.00	0.95		1.00	0.95	
Frbp, ped/bikes	1.00	1.00			1.00		1.00	1.00		1.00	1.00	
Flpb, ped/bikes	1.00	1.00			1.00		1.00	1.00		1.00	1.00	
Frt	1.00	0.86			0.92		1.00	1.00		1.00	1.00	
Flt Protected	0.95	1.00			0.98		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1710	1544			1575		1613	3330		1613	3313	
Flt Permitted	0.50	1.00			0.85		0.35	1.00		0.13	1.00	
Satd. Flow (perm)	898	1544			1367		594	3330		215	3313	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	32	5	89	21	5	37	32	1495	47	32	732	11
RTOR Reduction (vph)	0	77	0	0	35	0	0	1	0	0	1	0
Lane Group Flow (vph)	32	17	0	0	28	0	32	1541	0	32	742	0
Confl. Peds. (#/hr)							1					1
Confl. Bikes (#/hr)									2			1
Heavy Vehicles (%)	0%	0%	0%	0%	0%	6%	6%	2%	7%	6%	3%	0%
Turn Type	pm+pt	NA		pm+pt	NA		pm+pt	NA		pm+pt	NA	
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)	17.2	17.2			8.4		100.8	96.9		100.8	96.9	
Effective Green, g (s)	17.2	17.2			8.4		100.8	96.9		100.8	96.9	
Actuated g/C Ratio	0.13	0.13			0.06		0.78	0.75		0.78	0.75	
Clearance Time (s)	4.0	4.0			4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	148	204			88		491	2482		208	2469	
v/s Ratio Prot	c0.01	0.01					0.00	c0.46		c0.00	0.22	
v/s Ratio Perm	0.02				c0.02		0.05			0.11		
v/c Ratio	0.22	0.08			0.32		0.07	0.62		0.15	0.30	
Uniform Delay, d1	50.1	49.5			58.1		3.5	7.8		5.7	5.4	
Progression Factor	0.93	1.04			1.00		0.18	1.24		0.73	0.44	
Incremental Delay, d2	0.7	0.2			2.1		0.0	0.8		0.3	0.3	
Delay (s)	47.4	51.6			60.2		0.6	10.5		4.5	2.7	
Level of Service	D	D			E		A	B		A	A	
Approach Delay (s)		50.5			60.2			10.3			2.7	
Approach LOS		D			E			B			A	
<b>Intersection Summary</b>												
HCM 2000 Control Delay			11.2				HCM 2000 Level of Service				B	
HCM 2000 Volume to Capacity ratio			0.57									
Actuated Cycle Length (s)			130.0				Sum of lost time (s)			16.0		
Intersection Capacity Utilization			60.0%				ICU Level of Service			B		
Analysis Period (min)			15									

c Critical Lane Group

































# **Commercial St./Madrona Ave. Analysis**

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HCM Signalized Intersection Capacity Analysis  
5: Commercial Street & Madrona Ave SE

2035 PM\_Madrona Improvements  
Commercial-Vista Corridor Study

													
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
Lane Configurations	 			 				 			 		
Volume (vph)	145	185	140	245	360	100	165	1290	120	120	1645	80	
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	
Total Lost time (s)	4.0	5.0	4.0	4.0	5.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	
Lane Util. Factor	0.97	1.00	1.00	0.97	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Frpb, ped/bikes	1.00	1.00	0.99	1.00	1.00	0.97	1.00	1.00	0.96	1.00	1.00	0.97	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (prot)	3190	1800	1453	3285	1850	1468	1676	3450	1416	1693	3386	1436	
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.06	1.00	1.00	0.11	1.00	1.00	
Satd. Flow (perm)	3190	1800	1453	3285	1850	1468	100	3450	1416	188	3386	1436	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	
Adj. Flow (vph)	153	195	147	258	379	105	174	1358	126	126	1732	84	
RTOR Reduction (vph)	0	0	31	0	0	31	0	0	23	0	0	23	
Lane Group Flow (vph)	153	195	116	258	379	74	174	1358	103	126	1732	61	
Confl. Peds. (#/hr)	25		4	4		25	5		7	7		5	
Confl. Bikes (#/hr)									2			6	
Heavy Vehicles (%)	4%	0%	4%	1%	1%	1%	2%	1%	4%	1%	1%	3%	
Turn Type	Prot	NA	pm+ov	Prot	NA	pm+ov	pm+pt	NA	pm+ov	pm+pt	NA	pm+ov	
Protected Phases	3	8	1	7	4	5	1	6	7	5	2	3	
Permitted Phases			8			4	6		6	2		2	
Actuated Green, G (s)	7.6	25.1	35.0	10.9	28.4	34.9	80.4	70.5	81.4	73.6	67.1	74.7	
Effective Green, g (s)	7.6	25.1	35.0	10.9	28.4	34.9	80.4	70.5	81.4	73.6	67.1	74.7	
Actuated g/C Ratio	0.06	0.19	0.27	0.08	0.22	0.27	0.62	0.54	0.63	0.57	0.52	0.57	
Clearance Time (s)	4.0	5.0	4.0	4.0	5.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	
Vehicle Extension (s)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
Lane Grp Cap (vph)	186	347	391	275	404	394	181	1870	930	181	1747	869	
v/s Ratio Prot	0.05	0.11	0.02	c0.08	c0.20	0.01	c0.07	0.39	0.01	0.03	0.51	0.00	
v/s Ratio Perm			0.06			0.04	c0.52		0.06	0.36		0.04	
v/c Ratio	0.82	0.56	0.30	0.94	0.94	0.19	0.96	0.73	0.11	0.70	0.99	0.07	
Uniform Delay, d1	60.5	47.5	37.7	59.2	49.9	36.6	41.8	22.5	9.8	19.2	31.2	12.3	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.63	0.71	0.63	
Incremental Delay, d2	23.4	1.2	0.2	37.2	28.9	0.1	55.1	2.5	0.0	7.5	17.6	0.0	
Delay (s)	84.0	48.7	37.9	96.4	78.9	36.7	96.9	25.0	9.8	38.8	39.8	7.7	
Level of Service	F	D	D	F	E	D	F	C	A	D	D	A	
Approach Delay (s)		56.4			79.0			31.4			38.3		
Approach LOS		E			E			C			D		
<b>Intersection Summary</b>													
HCM 2000 Control Delay			44.0					HCM 2000 Level of Service	D				
HCM 2000 Volume to Capacity ratio			0.98										
Actuated Cycle Length (s)			130.0					Sum of lost time (s)	17.0				
Intersection Capacity Utilization			102.3%					ICU Level of Service	G				
Analysis Period (min)			15										

c Critical Lane Group























# **Commercial St./Alive Ave./Fairview Ave. Analysis**

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HCM Signalized Intersection Capacity Analysis  
 1: Commercial Street & Alice Avenue/Farview Avenue





















2035 PM\_Alice Open NBR  
 Commercial-Vista Corridor Study

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	40	0	40	465	0	75	55	1540	60	0	2200	45
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0		4.0	4.0	4.0		5.0	5.0			5.0	
Lane Util. Factor	1.00		1.00	0.95	0.95		1.00	0.95			0.91	
Frbp, ped/bikes	1.00		1.00	1.00	0.99		1.00	1.00			1.00	
Flpb, ped/bikes	0.99		1.00	1.00	1.00		1.00	1.00			1.00	
Frt	1.00		0.85	1.00	0.96		1.00	0.99			1.00	
Flt Protected	0.95		1.00	0.95	0.97		0.95	1.00			1.00	
Satd. Flow (prot)	1650		1485	1608	1549		1710	3329			3900	
Flt Permitted	0.23		1.00	0.95	0.97		0.05	1.00			1.00	
Satd. Flow (perm)	399		1485	1608	1549		95	3329			3900	
Peak-hour factor, PHF	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Adj. Flow (vph)	40	0	40	470	0	76	56	1556	61	0	2222	45
RTOR Reduction (vph)	0	0	14	0	14	0	0	2	0	0	1	0
Lane Group Flow (vph)	40	0	26	277	255	0	56	1615	0	0	2266	0
Confl. Peds. (#/hr)	9					9	9		12	12		9
Confl. Bikes (#/hr)						2			7			5
Heavy Vehicles (%)	3%	0%	3%	1%	0%	2%	0%	2%	0%	0%	1%	4%
Turn Type	custom		custom	Perm	NA		Perm	NA			NA	
Protected Phases					8			2			6	
Permitted Phases	4		4	8			2					
Actuated Green, G (s)	25.5		25.5	25.5	25.5		95.5	95.5			95.5	
Effective Green, g (s)	25.5		25.5	25.5	25.5		95.5	95.5			95.5	
Actuated g/C Ratio	0.20		0.20	0.20	0.20		0.73	0.73			0.73	
Clearance Time (s)	4.0		4.0	4.0	4.0		5.0	5.0			5.0	
Vehicle Extension (s)	0.5		0.5	0.5	0.5		0.5	0.5			0.5	
Lane Grp Cap (vph)	78		291	315	303		69	2445			2865	
v/s Ratio Prot								0.49			0.58	
v/s Ratio Perm	0.10		0.02	c0.17	0.16		c0.59					
v/c Ratio	0.51		0.09	0.88	0.84		0.81	0.66			0.79	
Uniform Delay, d1	46.7		42.8	50.8	50.3		11.3	8.9			10.9	
Progression Factor	1.00		1.00	1.00	1.00		0.39	0.34			1.00	
Incremental Delay, d2	2.4		0.0	22.5	18.1		55.6	1.2			2.3	
Delay (s)	49.1		42.8	73.3	68.4		60.0	4.2			13.2	
Level of Service	D		D	E	E		E	A			B	
Approach Delay (s)		45.9			70.9			6.0			13.2	
Approach LOS		D			E			A			B	
<b>Intersection Summary</b>												
HCM 2000 Control Delay			18.1				HCM 2000 Level of Service				B	
HCM 2000 Volume to Capacity ratio			0.82									
Actuated Cycle Length (s)			130.0				Sum of lost time (s)				9.0	
Intersection Capacity Utilization			78.6%				ICU Level of Service				D	
Analysis Period (min)			15									

c Critical Lane Group





















HCM Signalized Intersection Capacity Analysis  
 1: Commercial Street & Alice Avenue/Farview Avenue

2035 PM\_Alice Prot+Perm Phasing  
 Commercial-Vista Corridor Study

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	40	0	40	465	0	75	55	1540	5	0	2200	45
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0		4.0	4.0	4.0		4.0	5.0			5.0	
Lane Util. Factor	1.00		1.00	0.95	0.95		1.00	0.95			0.91	
Frpb, ped/bikes	1.00		1.00	1.00	0.99		1.00	1.00			1.00	
Flpb, ped/bikes	0.99		1.00	1.00	1.00		1.00	1.00			1.00	
Frt	1.00		0.85	1.00	0.96		1.00	1.00			1.00	
Flt Protected	0.95		1.00	0.95	0.97		0.95	1.00			1.00	
Satd. Flow (prot)	1650		1485	1608	1548		1710	3351			3900	
Flt Permitted	0.21		1.00	0.95	0.97		0.05	1.00			1.00	
Satd. Flow (perm)	373		1485	1608	1548		81	3351			3900	
Peak-hour factor, PHF	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Adj. Flow (vph)	40	0	40	470	0	76	56	1556	5	0	2222	45
RTOR Reduction (vph)	0	0	32	0	48	0	0	0	0	0	1	0
Lane Group Flow (vph)	40	0	8	277	221	0	56	1561	0	0	2266	0
Confl. Peds. (#/hr)	9					9	9		12	12		9
Confl. Bikes (#/hr)						2			7			5
Heavy Vehicles (%)	3%	0%	3%	1%	0%	2%	0%	2%	0%	0%	1%	4%
Turn Type	custom		custom	Perm	NA		pm+pt	NA			NA	
Protected Phases					8		5	2			6	
Permitted Phases	4		4	8			2					
Actuated Green, G (s)	24.7		24.7	24.7	24.7		97.3	96.3			85.9	
Effective Green, g (s)	24.7		24.7	24.7	24.7		97.3	96.3			85.9	
Actuated g/C Ratio	0.19		0.19	0.19	0.19		0.75	0.74			0.66	
Clearance Time (s)	4.0		4.0	4.0	4.0		4.0	5.0			5.0	
Vehicle Extension (s)	0.5		0.5	0.5	0.5		3.0	0.5			0.5	
Lane Grp Cap (vph)	70		282	305	294		140	2482			2577	
v/s Ratio Prot							0.02	c0.47			c0.58	
v/s Ratio Perm	0.11		0.01	c0.17	0.14		0.28					
v/c Ratio	0.57		0.03	0.91	0.75		0.40	0.63			0.88	
Uniform Delay, d1	47.8		42.9	51.5	49.8		29.4	8.2			17.8	
Progression Factor	1.00		1.00	1.00	1.00		1.19	1.58			1.00	
Incremental Delay, d2	6.8		0.0	28.4	9.3		1.5	1.0			4.7	
Delay (s)	54.7		42.9	79.9	59.0		36.4	13.9			22.5	
Level of Service	D		D	E	E		D	B			C	
Approach Delay (s)		48.8			69.6			14.7			22.5	
Approach LOS		D			E			B			C	
<b>Intersection Summary</b>												
HCM 2000 Control Delay			25.9				HCM 2000 Level of Service				C	
HCM 2000 Volume to Capacity ratio			0.88									
Actuated Cycle Length (s)			130.0				Sum of lost time (s)			13.0		
Intersection Capacity Utilization			78.6%				ICU Level of Service			D		
Analysis Period (min)			15									

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis 2015 PM\_Alice Prot+Perm Phasing and Open NBR  
 1: Commercial Street & Alice Avenue/Farview Avenue Commercial-Vista Corridor Study

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	40	0	40	465	0	75	55	1540	60	0	2200	45
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0		4.0	4.0	4.0		4.0	5.0			5.0	
Lane Util. Factor	1.00		1.00	0.95	0.95		1.00	0.95			0.91	
Frbp, ped/bikes	1.00		1.00	1.00	0.99		1.00	1.00			1.00	
Flpb, ped/bikes	0.99		1.00	1.00	1.00		1.00	1.00			1.00	
Frt	1.00		0.85	1.00	0.96		1.00	0.99			1.00	
Flt Protected	0.95		1.00	0.95	0.97		0.95	1.00			1.00	
Satd. Flow (prot)	1650		1485	1608	1548		1710	3329			3900	
Flt Permitted	0.21		1.00	0.95	0.97		0.05	1.00			1.00	
Satd. Flow (perm)	373		1485	1608	1548		81	3329			3900	
Peak-hour factor, PHF	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Adj. Flow (vph)	40	0	40	470	0	76	56	1556	61	0	2222	45
RTOR Reduction (vph)	0	0	32	0	48	0	0	2	0	0	1	0
Lane Group Flow (vph)	40	0	8	277	221	0	56	1615	0	0	2266	0
Confl. Peds. (#/hr)	9						9	9		12	12	9
Confl. Bikes (#/hr)							2			7		5
Heavy Vehicles (%)	3%	0%	3%	1%	0%	2%	0%	2%	0%	0%	1%	4%
Turn Type	custom		custom	Perm	NA		pm+pt	NA			NA	
Protected Phases					8		5	2			6	
Permitted Phases	4		4	8			2					
Actuated Green, G (s)	24.7		24.7	24.7	24.7		97.3	96.3			85.9	
Effective Green, g (s)	24.7		24.7	24.7	24.7		97.3	96.3			85.9	
Actuated g/C Ratio	0.19		0.19	0.19	0.19		0.75	0.74			0.66	
Clearance Time (s)	4.0		4.0	4.0	4.0		4.0	5.0			5.0	
Vehicle Extension (s)	0.5		0.5	0.5	0.5		3.0	0.5			0.5	
Lane Grp Cap (vph)	70		282	305	294		140	2466			2577	
v/s Ratio Prot							0.02	c0.49			c0.58	
v/s Ratio Perm	0.11		0.01	c0.17	0.14		0.28					
v/c Ratio	0.57		0.03	0.91	0.75		0.40	0.65			0.88	
Uniform Delay, d1	47.8		42.9	51.5	49.8		29.4	8.5			17.8	
Progression Factor	1.00		1.00	1.00	1.00		1.19	1.55			1.00	
Incremental Delay, d2	6.8		0.0	28.4	9.3		1.5	1.1			4.7	
Delay (s)	54.7		42.9	79.9	59.0		36.4	14.3			22.5	
Level of Service	D		D	E	E		D	B			C	
Approach Delay (s)		48.8			69.6			15.0			22.5	
Approach LOS		D			E			B			C	
<b>Intersection Summary</b>												
HCM 2000 Control Delay			25.9				HCM 2000 Level of Service				C	
HCM 2000 Volume to Capacity ratio			0.88									
Actuated Cycle Length (s)			130.0			Sum of lost time (s)				13.0		
Intersection Capacity Utilization			78.6%			ICU Level of Service				D		
Analysis Period (min)			15									

c Critical Lane Group























# **Bicycle Crossing Analysis**

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# HCM Signalized Intersection Capacity Analysis 2035 PM\_Bike Signal\_Alice Prot+Perm Phasing

## 1: Commercial Street & Alice Avenue/Farview Avenue

Commercial-Vista Corridor Study

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	40	0	40	465	0	75	55	1540	5	0	2200	45
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0		4.0	4.0	4.0		4.0	5.0			10.0	
Lane Util. Factor	1.00		1.00	0.95	0.95		1.00	0.95			0.91	
Frbp, ped/bikes	1.00		1.00	1.00	0.99		1.00	1.00			1.00	
Flpb, ped/bikes	0.99		1.00	1.00	1.00		1.00	1.00			1.00	
Frt	1.00		0.85	1.00	0.96		1.00	1.00			1.00	
Flt Protected	0.95		1.00	0.95	0.97		0.95	1.00			1.00	
Satd. Flow (prot)	1485		1337	1448	1394		1539	3016			3900	
Flt Permitted	0.24		1.00	0.95	0.97		0.04	1.00			1.00	
Satd. Flow (perm)	381		1337	1448	1394		73	3016			3900	
Peak-hour factor, PHF	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Adj. Flow (vph)	40	0	40	470	0	76	56	1556	5	0	2222	45
RTOR Reduction (vph)	0	0	0	0	81	0	0	0	0	0	2	0
Lane Group Flow (vph)	40	0	40	277	188	0	56	1561	0	0	2265	0
Confl. Peds. (#/hr)	9					9	9		12	12		9
Confl. Bikes (#/hr)						2			7			5
Heavy Vehicles (%)	3%	0%	3%	1%	0%	2%	0%	2%	0%	0%	1%	4%
Turn Type	custom		custom	Perm	NA		pm+pt	NA			NA	
Protected Phases					8		5	2			6	
Permitted Phases	4		4	8			2					
Actuated Green, G (s)	26.3		26.3	26.3	26.3		95.7	94.7			79.3	
Effective Green, g (s)	26.3		26.3	26.3	26.3		95.7	94.7			79.3	
Actuated g/C Ratio	0.20		0.20	0.20	0.20		0.74	0.73			0.61	
Clearance Time (s)	4.0		4.0	4.0	4.0		4.0	5.0			10.0	
Vehicle Extension (s)	0.5		0.5	0.5	0.5		3.0	0.5			0.5	
Lane Grp Cap (vph)	77		270	292	282		125	2197			2379	
v/s Ratio Prot							0.02	c0.52			c0.58	
v/s Ratio Perm	0.10		0.03	c0.19	0.14		0.31					
v/c Ratio	0.52		0.15	0.95	0.67		0.45	0.71			0.95	
Uniform Delay, d1	46.2		42.6	51.2	47.8		32.4	9.9			23.6	
Progression Factor	1.00		1.00	1.00	1.00		0.93	1.04			1.00	
Incremental Delay, d2	2.4		0.1	38.3	4.6		2.0	1.6			10.2	
Delay (s)	48.7		42.7	89.4	52.4		32.3	11.9			33.8	
Level of Service	D		D	F	D		C	B			C	
Approach Delay (s)		45.7			71.2			12.6			33.8	
Approach LOS		D			E			B			C	
<b>Intersection Summary</b>												
HCM 2000 Control Delay			31.0				HCM 2000 Level of Service				C	
HCM 2000 Volume to Capacity ratio			0.95									
Actuated Cycle Length (s)			130.0				Sum of lost time (s)			18.0		
Intersection Capacity Utilization			89.0%				ICU Level of Service			E		
Analysis Period (min)			15									

c Critical Lane Group



# **Qualitative Assessment of Walkability and Bikeability**

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## Qualitative Assessment of Intersection Walkability

Intersection	Traffic Control		Largest Crossing Width		Presence of Cross Walks		Lighting		Total Pedestrian	
	Score	Comment	Score	Comment	Score	Comment	Score	Comment	Score	Comment
Commercial/Madrona	3	Signalized with Countdown timers, right-turn yield with island	1	84'	3	Pedestrians can make all movements - Right – turn Yield with island	3	Lighting to Standard	2.5	Good
Commercial/Triangle	2	Unsignalized, stop on Triangle	1.5	72' with 18' devoted to buffered bike lanes	2	Marked Crosswalk with Raised Median Island-missing crosswalk south leg	3	Lighting to Standard	2.13	Fair
Commercial/Ratcliff	2.5	Signalized with Countdown timers, right turn lane eliminated	1.5	72'	3	Marked Crosswalks with Countdown Timers	3	Lighting to Standard	2.5	Good
Commercial/Vista	2.5	Signalized with Countdown timers	1.5	72'	2	Missing North Crosswalk	3	Lighting to Standard	2.25	Fair
Commercial/Alice/Fairview	2.5	Signalized with Countdown timers	1	84'	2	Missing South Crosswalk	3	Lighting to Standard	2.13	Fair
Liberty/Salem Heights Alternative 3A	2.5	Signalized with Countdown timers	2	55'	3	Marked Crosswalks	3	Lighting to Standard	2.63	Good
Liberty/Salem Heights Alternative 4	2.5	Signalized with Countdown timers	2	68'	3	Marked Crosswalks	3	Lighting to Standard	2.63	Good
Liberty/Triangle/Missouri Alternative 3A	2.5	RRFB + stop on Missouri and Triangle	2	55'	2	Marked Crosswalk on south side	3	Lighting to Standard	2.28	Fair
Liberty/Triangle/Missouri Alternative 4	2.5	RRFB + stop on Missouri and Triangle	2	68'	2	Marked Crosswalk on south side	3	Lighting to Standard	2.28	Fair
Liberty/Vista Alternative 3A	3	Signalized with Countdown timers and ped lead off, double left	2	55'	2	Missing east Crosswalk	3	Lighting to Standard	2.5	Good
Liberty/Vista Alternative 4	3	Signalized with Countdown timers and ped lead off, double left	2	68'	2	Missing east Crosswalk	3	Lighting to Standard	2.5	Good
Pedestrian Score for Important Facilities										Fair

(3.5 and above = Excellent) (2.5 to 3.4 = Good) (1.5 to 2.4 = Fair) (1.4 and below = Poor)

## Qualitative Assessment of Intersection Bikeability

Intersection	Traffic Control		Crossing Width		Lighting		Bike Facilities		Bike Lane Width		Total Bicycle	
	Score	Comment	Score	Comment	Score	Comment	Score	Comment	Score	Comment	Score	Comment
Commercial/Madrona	3	Signalized	1	84'	3	Lighting to Standard	3	Bike Lanes – painted bike lane but, still LT movement difficult	3	9' (with buffer)	2.6	Good
Commercial/Triangle	2	Unsignalized and stop on Triangle but added crossing with raised island	2	72' with 18' devoted to buffered bike lanes	3	Lighting to Standard	1.5	Raised median with ped crossing on north side of Triangle	3	9' (with buffer)	2.88	Good
Commercial/Ratcliff	3	Signalized	2	72'	3	Lighting to Standard	2	Bike Lanes (potential for bike box)	3	9' (with buffer)	2.6	Good
Commercial/Vista	3	Signalized with bike boxes for NB LT movement	2	72'	3	Lighting to Standard	2.5	Bike Lanes –LT movement onto Vista difficult but bike boxes for NT turn	3	9' (with buffer)	2.7	Good
Commercial/Alice/Fairview	2.5	Signalized but double lefts and RT	2	30'	3	Lighting to Standard	2.75	Bike Lanes – new light for SB bikes on Commercial	3	9' (with buffer)	2.65	Good
Liberty/Salem Heights Alt. 3A	2	Signalized	2	55'	3	Lighting to Standard	1.5	Yes- bikes would need to stop at cross street	1.5	Shared-use Path	2	Fair
Liberty/Salem Heights Alt. 4	3	Signalized	2	68'	3	Lighting to Standard	2	Yes-Bike Lanes	2	6'	2.4	Fair
Liberty/Triangle Alt. 3A	2	Unsignalized + Stop on Triangle	2	55'	3	Lighting to Standard	1.5	Yes- bikes would need to stop at cross street	1.5	Shared-use Path	2	Fair
Liberty/Triangle Alt. 4	2	Unsignalized + Stop on Triangle	2	68'	3	Lighting to Standard	2	Yes-Bike Lanes	2	6'	2.2	Fair
Liberty/Vista Alt. 3A	2	Signalized	2	55'	3	Lighting to Standard	1.5	Yes- bikes would need to stop at cross street	1.5	Shared-use Path	2	Fair
Liberty/Vista Alt. 4	3	Signalized	2	68'	3	Lighting to Standard	2	Yes-Bike Lanes	2	6'	2.4	Fair
Qualitative Assessment for Bicycles at Important Intersections											Fair	

(3.5 and above = Excellent) (2.5 to 3.4 = Good) (1.5 to 2.4 = Fair) (1.4 and below = Poor)

## Qualitative Assessment of Segment Walkability

Segment	Volume of Adjacent Travel Lane		Type and Speed of Traffic		Outside Travel Lane Width		Sidewalk/Path Presence		Pedestrian Buffers		Lighting		Total Pedestrian	
	Score	Comment	Score	Comment	Score	Comment	Score	Comment	Score	Comment	Score	Comment	Score	Comment
Commercial Street	1	>37,300 ADT	3	Buffered Bike Lane	3	11' , bike lane	3	Yes, additional crossings	3.25	Furnishing Zone with Street Trees	3	Lighting to Standard	2.7	Good
Liberty Road Alternative 3A	1	>18,000 ADT	2	No	1	11'	3	Yes-curb tight multi-use path shared with bikes, additional crossing	2.75	No-Shared Multi-use Path	3	Lighting to Standard	2.1	Fair
Liberty Road Alternative 4	1	>18,000 ADT	2.5	6' Bike Lane	3	11', bike lane	3	Yes, additional crossing	3.25	Furnishing Zone with Street Trees	3	Lighting to Standard	2.7	Good
Salem Heights/Ratcliff Avenue Bike Lanes	3	250 Peak Hour	3	6' Bike Lane	3	11' bike lane	3	Yes	2.75	Furnishing Zone with Street Trees on one side	3	Lighting to Standard	3	Good
Salem Heights/Ratcliff Avenue with Parking on both sides	3	250 Peak Hour	3	No	3	12'	3	Yes	2.75	Parallel Parking	3	Lighting to Standard	3	Good
Triangle Drive TSP Local	3	150 Peak Hour	-	n/a	3	15'	3	Yes	3	Furnishing Zone with Street Trees	3	Lighting to Standard	3	Good
Triangle Drive Angled Parking	3	150 Peak Hour	-	n/a	2	11'	3	Yes	2.75	Angled Parking	3	Lighting to Standard	2.8	Good
Neef	-	n/a	-	n/a - Traffic Calming	3	10'	1	No sidewalks	1	No sidewalk	3	Lighting to Standard	1.6	Fair
Pedestrian Score for Important Facilities													Good	

(3.5 and above = Excellent) (2.5 to 3.4 = Good) (1.5 to 2.4 = Fair) (1.4 and below = Poor)

Qualitative Assessment of Segment Bikeability																
Segment	Volume in Adjacent Travel Lane		Type and Speed Traffic		Outside Travel Lane Width		Shoulder Width		Bike Lane Width		Grade		Pavement Condition		Total Bike	
	Score	Comment	Score	Comment	Score	Comment	Score	Comment	Score	Comment	Score	Comment	Score	Comment	Score	Comment
Commercial Street	1	>37,300 ADT	3	Major Arterial – Street Trees ,	3	11' , buffer	-	Bike Lanes	4	6 with 2' buffer	2	Mild Grade	3	Good	2.7	Good
Liberty Road Alternative 3A	1	>18,000 ADT	2	Major Arterial	1	11'	-	Bike Lanes	2.75	Multi-use path	2	Mild Grade	3	Fair	2.0	Fair
Liberty Road Alternative 4	1	>18,000 ADT	3	Major Arterial- Street Trees	1	11'	-	Bike Lanes	3	6'	2	Mild Grade	3	Good	2.17	Fair
Salem Heights/Ratcliff Avenue Bike Lanes	3	250 Peak Hour	3	Collector- Street Trees	2	11'	-	Bike Lanes	2.5	6' and 5'	2	Mild Grade	3	Good	2.58	Good
Salem Heights/Ratcliff Avenue with Parking on both sides	3	250 Peak Hour	3	Collector – Street Trees, parking	3	12'	2.5	Narrower lanes better for sharing road on lower volume streets	-	No bike lanes	2	Mild Grade	3	Good	2.75	Good
Triangle Drive TSP Local	3	150 Peak Hour	3	Local	3	15'	-	n/a	-	n/a	2	Mild Grade	3	Good	2.8	Good
Triangle Drive Angled Parking	3	150 Peak Hour	3	Local	3	11' narrower lanes better on lower volume streets	-	n/a	-	n/a	2	Mild Grade	3	Good	2.8	Good
Neef Avenue	3		3	Local	3	10'	1	none	-	n/a	2	Mild Grade	2	Fair	2.3	Fair
Biking Score for Important Segments															Good	

(3.5 and above = Excellent) (2.5 to 3.4 = Good) (1.5 to 2.4 = Fair) (1.4 and below = Poor)