

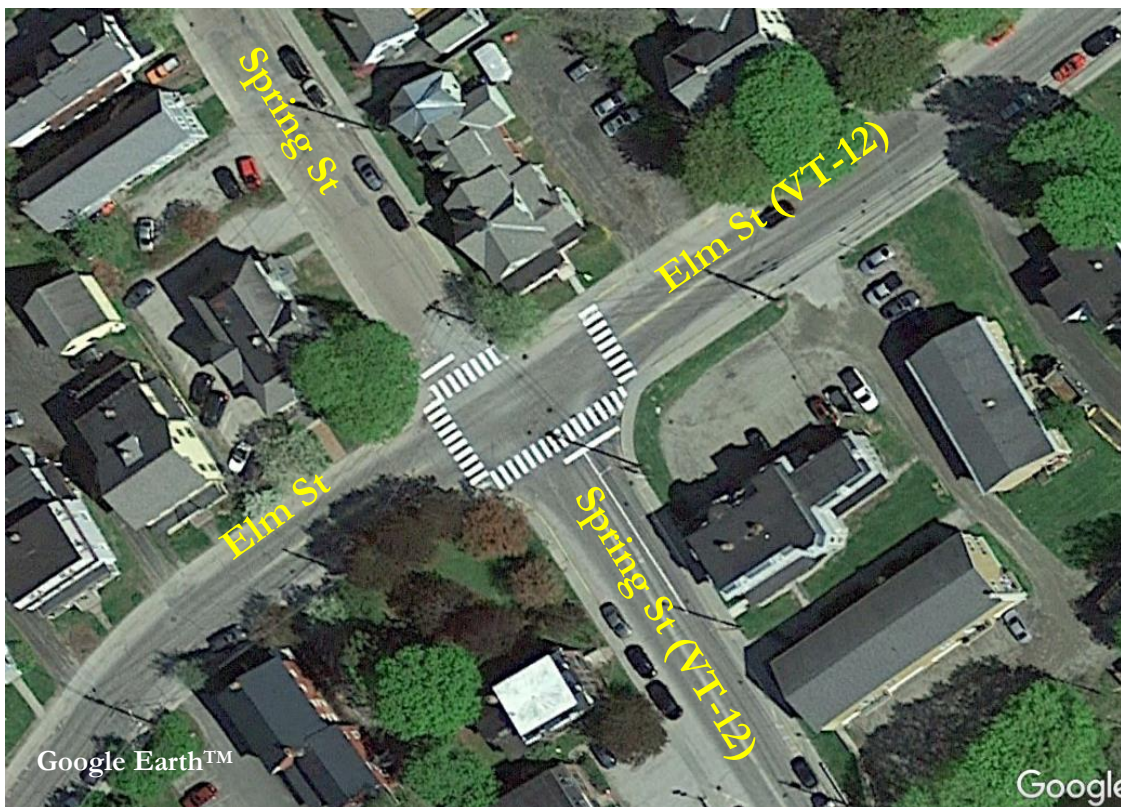
MEMO

TO: Corey Line, City of Montpelier DPW
FROM: Ben Swanson, RSG
DATE: January 19, 2017
SUBJECT: Elm Street & Spring Street Traffic Control Assessment

On behalf of the City of Montpelier, RSG has assessed traffic control alternatives for the Elm Street & Spring Street intersection.

As currently configured (shown in Figure 1), the eastbound and westbound Spring Street approaches are both stop controlled while the northbound and southbound Elm Street approaches are not controlled. All intersection approaches except for the westbound Spring Street approach, are single shared left/through/right-turn lanes. The Westbound Spring Street approach consists of a shared left/through lane and a dedicated right-turn lane. Pedestrian crosswalks are striped across all four approaches.

FIGURE 1: STUDY INTERSECTION



ANALYSIS SCENARIOS

To assess potential alternative traffic control configurations for the study intersection, the following scenarios were examined:

1. Existing Conditions,
2. All-way Stop Control,
3. Signal Control.

In all scenarios the existing lane configurations and intersection footprint are retained.

ANALYSIS TRAFFIC VOLUMES

Intersection turning movement counts were conducted by VTrans on Thursday May 23rd 2013 and Friday May 24th 2013. Following VTrans traffic study guidelines, weekday AM and PM peak hour traffic volumes from these counts were adjusted to reflect design hour conditions¹ using two adjustment factors:

1. Design hour adjustment factors are based on VTrans permanent count station W024, which is located on US-2 in Montpelier, VT. Design hour volume (DHV) adjustments increase AM peak hour counts by 6% and PM peak hour counts by 8%.
2. An annual adjustment factor, which represents general background traffic growth, is based on historic count data at VTrans permanent count stations. As presented in the 2015 VTrans Red Book, the growth factor from 2016 to 2017 increases traffic volumes by 1%.

CONGESTION AND QUEUING ANALYSIS

Level-of-service (LOS) is a qualitative measure describing the operating conditions as perceived by motorists driving in a traffic stream. LOS is calculated using the procedures outlined in the 2000 and 2010 Highway Capacity Manuals.² In addition to traffic volumes, key inputs include the number of lanes at each intersection, traffic control type (signalized or unsignalized), and the traffic signal timing plans.

The 2010 Highway Capacity Manual defines six qualitative grades to describe the level of service at an intersection. Level-of-Service is based on the average control delay per vehicle. **Error! Reference source not found.** shows the various LOS grades and descriptions for signalized and unsignalized intersections.

¹ The DHV is the 30th highest hour of traffic for the year and is used as the design standard in Vermont.

² The HCM 2010 does not provide methodologies for calculating intersection delays at certain intersection types including signalized intersections with exclusive pedestrian phases and signalized intersections with non NEMA-standard phasing. Because of these limitations, HCM 2000 methodologies are employed where necessary.



FIGURE 2: LEVEL-OF-SERVICE CRITERIA FOR SIGNALIZED AND UNSIGNALIZED INTERSECTIONS

LOS	CHARACTERISTICS	UNSIGNALIZED	SIGNALIZED
		TOTAL DELAY (SEC)	TOTAL DELAY (SEC)
A	Little or no delay	≤ 10.0	≤ 10.0
B	Short delays	10.1-15.0	10.1-20.0
C	Average delays	15.1-25.0	20.1-35.0
D	Long delays	25.1-35.0	35.1-55.0
E	Very long delays	35.1-50.0	55.1-80.0
F	Extreme delays	> 50.0	> 80.0

The delay thresholds for LOS at signalized and unsignalized intersections differ because of the driver’s expectations of the operating efficiency for the respective traffic control conditions. According to HCM procedures, an overall LOS cannot be calculated for two-way stop-controlled intersections because not all movements experience delay. In signalized and all-way stop-controlled intersections, all movements experience delay and an overall LOS can be calculated.

The VTrans policy on level of service for **Signalized and All-Way Stop Intersections** is:

- Overall LOS C should be maintained for state-maintained highways and other streets accessing the state’s facilities
- Reduced LOS may be acceptable on a case-by-case basis when considering, at minimum, current and future traffic volumes, delays, volume to capacity ratios, crash rates, and negative impacts as a result of improvement necessary to achieve LOS C.

The VTrans policy on level of service for **Two-Way and One-Way Stop Intersections** is:

LOS D should be maintained for side roads with volumes exceeding 100 vehicles/hour for a single lane approach (150 vehicles/hour for a two-lane approach) at two-way stop-controlled intersections. No LOS criteria are in effect for volumes less than these.

In addition to vehicle delays and levels of service, average and 95th percentile queues were obtained for all scenarios. Queues results were obtained from the SimTraffic simulation software, from Trafficware.³ Figure 3 through Figure 5 present the delay, LOS, and Queue results for this analysis.

Calculated and simulated existing condition delays and queue results appear consistent with conditions observed in the field during the AM peak hour on Thursday January 19, 2017. During this site visit, queues of 2 to 4 vehicles were typically seen on the westbound Spring Street approach. However, at one point a queue was observed on this approach extending temporarily back to approximately the Main Street & Spring Street roundabout. While a free movement, southbound Elm Street traffic is periodically forced to yield to northbound through and right-turning traffic, which resulted in observed queues of 2 to 10 vehicles. However, the during the majority of the peak hour, the southbound movement was observed to operate with minimal delays and queueing. Just before 8:00 AM there were several pedestrian crossings observed with either parents and elementary

³ Five hour-long simulations were averaged together to calculate delays and queue lengths for each scenario.

school aged children crossing southbound Elm Street together or schoolchildren crossing on their own.

As can be seen below, long delays and LOS F/E conditions currently exist for stop controlled westbound Spring Street traffic during the AM and PM peak hours. Converting the intersection to an all-way stop-controlled intersection, results in a more even distribution of delay across the various approaches and results in all approaches operating at LOS C or better. Moderate queueing is projected on average but 95th percentile queues increase from approximately 2 vehicles in length to approximately 9 vehicles in length for the northbound Elm Street approach, which is currently not controlled.

Converting the study intersection to a signal with permitted left-turn phasing is projected to result in LOS B or better conditions but results in increased queues for the southbound Elm Street approach, which is currently not controlled. Signalization is examined with both an exclusive pedestrian phase and with a leading pedestrian interval, in which pedestrians are given a 5 second protected phase to establish their presence, followed by a concurrent pedestrian phase to finish crossing. Shorter queues are projected with a leading pedestrian interval, as compared with an exclusive pedestrian phase

FIGURE 3: DELAY AND LEVEL-OF-SERVICE RESULTS

Intersections	Elm Street & Spring Street											
	Existing Condition			All-Way Stop			Signal - Exclusive			Signal - LPI		
	LOS	Delay	v/c	LOS	Delay	v/c	LOS	Delay	v/c	LOS	Delay	v/c
AM Peak Hour												
Overall	B	13	-	B	13	-	B	17	0.58	B	13	0.67
EB Spring Street (left/through/right)	C	18	0.12	A	9	0.06	B	18	0.06	B	15	0.08
WB Spring Street (left/through)	F	57	0.68	B	12	0.26	B	20	0.48	B	20	0.60
WB Spring Street (right)	A	10	0.16	A	10	0.21	B	18	0.09	B	15	0.09
NB Elm Street (left/through/right)	A	<1	0.01	A	10	0.25	B	10	0.17	A	7	0.16
SB Elm Street (left/through/right)	A	5	0.18	C	16	0.62	B	19	0.75	B	13	0.71
PM Peak Hour												
Overall	A	10	-	C	16	-	B	13	0.54	B	13	0.60
EB Spring Street (left/through/right)	C	17	0.09	B	10	0.05	B	17	0.04	B	15	0.05
WB Spring Street (left/through)	E	48	0.56	B	12	0.21	B	19	0.39	B	16	0.40
WB Spring Street (right)	B	14	0.41	B	14	0.45	B	18	0.17	B	15	0.18
NB Elm Street (left/through/right)	A	<1	0.01	C	20	0.68	A	10	0.52	A	10	0.56
SB Elm Street (left/through/right)	A	6	0.19	C	16	0.52	B	13	0.65	B	14	0.70

FIGURE 4: AVERAGE QUEUE RESULTS (VEHICLES)

	Existing Condition	All-Way Stop	Signal - Exclusive	Signal - LPI
AM Peak Hour				
EB, along Spring St	1	1	1	1
WB, along Spring St	3	2	3	3
NB, along Elm St	0	2	2	2
SB, along Elm St	2	4	6	5
PM Peak Hour				
EB, along Spring St	1	1	1	1
WB, along Spring St	3	3	3	3
NB, along Elm St	1	5	5	4
SB, along Elm St	3	3	6	5

FIGURE 5: 95TH PERCENTILE QUEUE RESULTS (VEHICLES)

		Existing Condition	All-Way Stop	Signal - Exclusive	Signal - LPI
AM Peak Hour					
	EB, along Spring St	2	2	3	2
	WB, along Spring St	5	4	6	5
	NB, along Elm St	1	3	4	4
	SB, along Elm St	4	7	11	8
PM Peak Hour					
	EB, along Spring St	2	2	2	2
	WB, along Spring St	8	5	6	5
	NB, along Elm St	2	9	10	7
	SB, along Elm St	6	5	12	9

RECOMMENDATIONS

Analysis indicates that an all-way stop-controlled intersection would operate with a more even distribution of delay across the various approaches and results in all approaches operating at LOS C or better. Requiring Elm Street traffic to stop at this location would also improve the pedestrian crossings on the southbound and northbound Elm Street approaches.

Due to the high volume of southbound Elm Street left-turns (over 200 vehicles per hour during both the AM and PM peak hours), a simple traffic signal is not projected to operate better than all-way stop control, and would require a significantly larger investment to implement. Given the current LOS F/LOS E conditions for westbound Elm Street traffic, we recommend the City consider implementing an all-way stop controlled intersection.

Please feel free to contact us with any questions.



Attachments



Elm Street & Spring Street
 Montpelier, VT
 AM: 5/24/2013
 PM: 5/23/2013
 AM: 4th Friday
 PM: 4th Thursday

note:

Source: VTrans

	Eastbound Spring Street				Westbound Spring Street				Northbound Elm Street				Southbound VT-12				Pedestrians				15 Min Total	Hour Total								
	L	(t)	T	(t)	L	(t)	T	(t)	L	(t)	T	(t)	L	(t)	T	(t)	EB	WB	NB	SB										
6:00 AM	0	0	1	0	0	0	3	0	3	0	3	2	2	0	4	1	5	0	21	0	13	0	3	0	4	0	0	0	61	
6:15 AM	0	0	0	0	1	0	4	1	1	0	8	1	0	0	8	0	2	0	29	0	25	1	0	0	1	0	0	0	81	
6:30 AM	0	0	0	0	1	0	8	0	1	0	5	1	2	0	9	0	7	0	23	0	18	0	0	0	0	0	0	0	75	
6:45 AM	0	0	1	0	1	0	9	0	0	0	18	2	0	0	8	4	5	0	37	0	33	1	0	0	0	0	0	0	119	336
7:00 AM	0	0	1	0	5	0	11	0	1	0	21	2	1	0	6	1	7	0	32	1	25	0	0	0	1	0	0	0	114	389
7:15 AM	0	0	5	0	2	0	19	0	0	0	39	4	1	0	8	1	17	1	46	6	32	0	0	0	0	0	1	1	181	489
7:30 AM	0	0	4	0	0	0	16	0	3	0	31	3	1	0	17	1	26	0	67	4	58	1	4	0	1	0	1	1	236	650
7:45 AM	0	0	2	0	6	0	26	1	2	0	27	5	2	0	9	1	25	0	62	0	49	0	0	0	1	1	1	6	217	748
8:00 AM	1	0	11	0	5	0	33	0	14	0	22	3	10	0	8	0	31	1	40	5	33	0	1	0	12	2	0	9	218	852
8:15 AM	0	0	1	0	4	0	27	0	9	0	35	2	4	0	9	1	21	0	44	4	32	0	0	0	2	2	0	4	193	864
8:30 AM	0	1	1	0	3	0	21	1	4	0	46	1	3	0	15	0	13	0	48	3	32	0	0	0	1	3	3	0	192	820
8:45 AM	0	0	0	0	2	0	19	0	2	0	25	5	1	0	20	0	20	0	35	4	29	1	0	0	0	1	1	0	163	766
9:00 AM	0	0	0	0	1	0	22	0	1	0	26	3	2	0	9	1	18	1	44	8	29	1	0	1	0	0	0	0	167	715
9:15 AM	0	0	1	1	4	0	14	0	0	0	41	3	0	1	11	0	18	1	38	6	28	0	0	0	1	0	1	1	167	689
9:30 AM	0	0	1	0	0	0	15	0	3	0	22	2	1	0	15	0	16	0	41	2	13	1	0	0	0	0	0	1	132	629
9:45 AM	0	0	4	0	4	0	11	0	1	0	35	3	0	0	12	1	12	0	31	1	25	0	2	0	2	1	1	3	142	608
10:00 AM	6	0	7	0	1	0	6	3	2	0	22	3	0	0	4	0	9	0	20	2	15	0	4	2	1	1	0	0	106	547
10:15 AM	0	0	0	0	2	0	18	0	1	0	26	1	1	0	14	1	14	0	42	2	17	1	0	0	0	2	2	2	140	520
10:30 AM	0	0	0	0	1	0	12	0	2	1	41	2	0	0	9	4	11	2	29	9	18	0	0	0	0	1	0	1	141	529
10:45 AM	0	0	2	0	3	0	13	1	1	0	33	3	4	0	10	0	9	1	22	0	21	1	0	0	1	1	1	0	124	511
11:00 AM	0	0	1	0	1	0	21	0	1	0	30	3	2	0	19	1	11	0	27	3	20	0	0	0	1	2	0	3	144	549
11:15 AM	0	0	3	0	2	0	16	0	2	0	28	4	1	0	11	0	12	2	27	3	13	1	0	0	1	0	1	2	125	534
11:30 AM	0	0	1	0	4	0	16	0	1	0	21	2	3	0	18	0	14	0	41	3	30	0	1	0	2	0	2	0	155	548
11:45 AM	0	0	4	0	2	0	19	0	8	0	21	1	2	0	15	1	18	0	23	5	27	0	1	0	0	0	0	0	147	571
12:00 PM	0	0	2	0	1	0	15	0	2	0	36	2	2	0	16	2	25	1	52	1	32	0	0	0	6	1	6	5	189	616
12:15 PM	0	0	2	0	4	0	9	1	2	0	43	1	1	0	19	0	27	0	31	2	22	0	1	0	4	2	5	5	165	656
12:30 PM	0	0	1	0	3	0	7	0	1	0	40	0	3	0	19	0	20	1	35	3	22	2	1	0	1	1	1	0	158	659
12:45 PM	0	0	0	0	5	0	11	0	0	0	31	6	2	0	14	0	17	1	27	0	13	0	0	0	4	5	0	1	127	639
1:00 PM	0	0	2	0	1	0	12	1	0	0	32	2	3	0	22	2	20	0	26	2	20	0	2	0	6	2	2	3	147	597
1:15 PM	1	0	2	0	1	0	15	1	3	0	36	6	0	0	20	2	22	0	29	5	19	0	0	0	1	2	1	2	162	594
1:30 PM	1	0	1	0	3	0	15	0	2	0	34	2	4	0	22	0	21	2	30	4	21	0	2	0	1	0	0	1	164	600
1:45 PM	0	0	1	0	3	0	12	1	1	0	45	1	1	0	21	0	13	0	38	1	21	0	0	0	1	2	2	1	159	632
2:00 PM	0	0	2	0	2	0	18	0	1	0	33	1	4	0	23	0	20	0	34	3	18	2	0	0	2	0	3	0	161	646
2:15 PM	0	0	0	0	4	0	9	0	2	0	37	3	1	0	17	1	17	0	38	2	24	0	0	0	0	1	3	0	155	639
2:30 PM	0	0	1	0	0	0	12	2	2	0	41	4	2	0	17	1	16	2	35	3	16	2	0	0	0	0	0	3	156	631
2:45 PM	0	0	2	0	3	0	18	4	4	0	42	5	5	0	30	1	23	0	33	4	17	3	0	0	4	0	8	4	194	666
3:00 PM	1	0	4	0	2	0	19	1	1	0	51	1	1	0	33	2	37	0	36	3	10	2	1	0	12	4	14	2	205	710
3:15 PM	0	0	5	0	4	0	22	0	1	0	64	0	0	0	39	3	28	0	36	1	28	0	0	0	2	2	6	3	231	786
3:30 PM	1	0	0	0	5	0	11	0	2	0	53	4	4	0	43	1	29	2	32	5	24	2	1	0	3	0	4	1	219	849
3:45 PM	10	0	8	0	2	0	13	0	7	0	39	0	1	0	22	1	16	1	34	0	26	0	9	0	2	0	1	0	189	844
4:00 PM	0	0	8	0	7	0	20	1	6	0	58	0	5	0	30	0	42	1	32	3	32	0	0	0	2	3	3	0	245	884
4:15 PM	0	0	1	0	3	0	24	2	1	0	75	1	3	0	44	2	31	1	37	3	21	1	0	0	0	0	1	6	250	903
4:30 PM	0	0	2	0	3	0	16	0	4	0	51	3	10	0	61	0	72	0	66	1	26	0	0	2	1	4	1	315	999	
4:45 PM	0	0	4	0	4	0	17	1	4	0	59	2	3	0	41	1	47	0	47	2	21	0	2	0	1	0	3	4	255	1065
5:00 PM	0	0	2	0	0	0	21	1	6	0	59	1	3	0	46	0	45	0	36	2	21	0	2	0	6	0	7	1	245	1065
5:15 PM	0	0	3	0	7	0	20	0	6	0	73	2	3	0	50	0	41	1	36	4	24	0	0	0	3	3	2	0	270	1085
5:30 PM	0	0	0	0	2	0	18	0	1	0	69	1	2	0	46	0	38	0	40	1	27	0	0	0	4	0	1	0	245	1015
5:45 PM	0	0	2	0	4	0	11	1	5	0	63	1	7	0	41	1	36	0	45	0	32	0	1	0	6	3	3	5	250	1010

AM (6AM-12PM) Peak 864
 PM (12PM-6PM) Peak 1085

01/19/17 11:08 AM

Raw Count Data

DHV & Annual Adjustments (3) to

Adjusted Raw Counts

2017

2017

Synchro
Node

2016 DHV at W024 on US 2 in Montpelier 1365

1 Elm Street & Spring Street
Montpelier, VT
5/24/2013
4th Friday

	EB	WB	NB	SB	
LT	1	103	17	226	
TH	18	28	46	173	
RT	15	128	104	5	864
Enter	34	259	167	404	864
Exit	348	50	175	291	864
% Trucks	0.0%	5.4%	2.4%	3.5%	
Peds	15	5	2	20	PHF
Peak Hour	7:30 AM - 8:30 AM Peak				0.92

	EB	WB	NB	SB	
L	1	110	18	241	
T	19	30	49	184	
R	16	136	111	5	921
Enter	36	276	178	431	921
Exit	371	53	187	310	921

W024 Peak on count date	1293
DHV Adjustment	1.06
2016-2017 growth	1.01
Total Adjustment	1.07

1.07

01/19/17 11:09 AM

Raw Count Data

DHV & Annual Adjustments (3) to

Adjusted Raw Counts

2017

2017

Synchro
Node

2016 DHV at W024 on US 2 in Montpelier 1365

1 Elm Street & Spring Street
Montpelier, VT
5/23/2013
4th Thursday

	EB	WB	NB	SB	
LT	0	76	19	194	
TH	11	20	199	92	
RT	14	250	206	4	1085
Enter	25	346	424	290	1085
Exit	411	43	449	182	1085
% Trucks	0.0%	2.9%	0.5%	3.1%	
Peds	12	4	16	6	PHF
Peak Hour	4:30 PM - 5:30 PM Peak				0.86

	EB	WB	NB	SB	
L	0	83	21	211	
T	12	22	217	100	
R	15	272	224	4	1181
Enter	27	376	461	316	1181
Exit	447	47	489	198	1181

W024 Peak on count date	1267
DHV Adjustment	1.08
2016-2017 growth	1.01
Total Adjustment	1.09

HCM Signalized Intersection Capacity Analysis
1: Elm Street & Spring Street

2017 AM Peak Hour
Signal - LPI

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	1	19	16	110	30	136	18	49	111	241	184	5
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0											
Lane Util. Factor	1.00											
Frpb, ped/bikes	0.99											
Flpb, ped/bikes	1.00											
Frt	0.94											
Flt Protected	1.00											
Satd. Flow (prot)	1762											
Flt Permitted	0.99											
Satd. Flow (perm)	1741											
Peak-hour factor, PHF	1.00											
Adj. Flow (vph)	1											
RTOR Reduction (vph)	0											
Lane Group Flow (vph)	0											
Conf. Peds. (#/hr)	20											
Heavy Vehicles (%)	0%											
Turn Type	Perm NA Perm NA Perm NA Perm NA Perm NA Perm NA											
Protected Phases	6 6 2 2 4 4 8 8											
Actuated Green, G (s)	7.6 7.6 7.6 7.6 19.9 19.9											
Effective Green, g (s)	7.6 7.6 7.6 7.6 19.9 19.9											
Actuated g/C Ratio	0.17 0.17 0.17 0.17 0.45 0.45											
Clearance Time (s)	6.0 6.0 6.0 6.0 6.0 6.0											
Vehicle Extension (s)	1.5 1.5 1.5 1.5 1.5 1.5											
Lane Grp Cap (vph)	300 232 248 710 604											
v/s Ratio Prot	0.01											
v/s Ratio Perm	0.08											
v/c Ratio	15.3											
Uniform Delay, d1	1.00											
Progression Factor	0.0											
Incremental Delay, d2	15.3											
Delay (s)	15.3											
Level of Service	B											
Approach Delay (s)	15.3											
Approach LOS	B											
Intersection Summary												
HCM 2000 Control Delay	13.4											
HCM 2000 Volume to Capacity ratio	0.67											
Actuated Cycle Length (s)	44.1											
Intersection Capacity Utilization	63.9%											
Analysis Period (min)	60											
c Critical Lane Group												

2017 AM Peak Hour 12/21/2016 Signal - LPI

Synchro 8 Report
Page 1

HCM 2010 TWSC
1: Elm Street & Spring Street

2017 PM Peak Hour
Existing Condition

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR												
Intersection	9.7																							
Int Delay, s/veh	9.7																							
Vol, veh/h	0	12	15	83	22	272	21	217	224	211	100	4												
Conflicting Peds. #/hr	6	0	16	16	0	6	12	0	4	4	0	12												
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free												
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None												
Storage Length	-	-	-	-	-	100	-	-	-	-	-	-												
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-												
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-												
Peak Hour Factor	100	100	100	100	100	100	100	100	100	100	100	100												
Heavy Vehicles, %	0	0	0	3	3	3	1	1	1	3	3	3												
Mvmt Flow	0	12	15	83	22	272	21	217	224	211	100	4												
Major/Minor																								
Conflicting Flow All	938	1039	130	941	929	357	120	0	0	457	0	0												
Stage 1	540	540	-	387	387	-	-	-	-	-	-	-												
Stage 2	398	499	-	554	542	-	-	-	-	-	-	-												
Critical Hdwy	7.1	6.5	6.2	7.13	6.53	6.23	4.11	-	-	4.13	-	-												
Critical Hdwy Slg 1	6.1	5.5	-	6.13	5.53	-	-	-	-	-	-	-												
Critical Hdwy Slg 2	6.1	5.5	-	6.13	5.53	-	-	-	-	-	-	-												
Follow-up Hdwy	3.5	4	3.3	3.527	4.027	3.327	2.209	-	-	2.227	-	-												
Pot Cap-1 Maneuver	247	232	925	242	267	685	1474	-	-	1099	-	-												
Stage 1	530	524	-	635	608	-	-	-	-	-	-	-												
Stage 2	632	547	-	515	519	-	-	-	-	-	-	-												
Platoon blocked, %	-																							
Mov Cap-1 Maneuver	109	176	904	183	202	669	1459	-	-	1088	-	-												
Mov Cap-2 Maneuver	109	176	-	183	202	-	-	-	-	-	-	-												
Stage 1	512	411	-	614	588	-	-	-	-	-	-	-												
Stage 2	350	529	-	386	407	-	-	-	-	-	-	-												
Approach																								
HCM Control Delay, s	EB			WB			NB			SB														
HCM LOS	C			C			0.3			6.1														
Minor Lane/Major Mvmt																								
Capacity (veh/h)	1459			-			318			187			669			1088			-			-		
HCM Lane V/C Ratio	0.014			-			0.085			0.561			0.407			0.194			-			-		
HCM Control Delay (s)	7.5			0			-			17.4			48.2			14.1			9.1			0		
HCM Lane LOS	A			A			-			C			E			B			A			A		
HCM 95th %ile Q(veh)	0			-			-			0.3			3.5			2			0.7			-		

2017 PM Peak Hour 12/21/2016 Existing Condition

Synchro 8 Report
Page 1

HCM 2010 AWSC
1: Elm Street & Spring Street

2017 PM Peak Hour
All Way Stop

Movement	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR			
Intersection	16.4														
Intersection Delay, s/veh	16.4														
Intersection LOS	C														
Vol, veh/h	0	0	12	15	0	83	22	272	0	21	217	224			
Peak Hour Factor	100	100	100	100	100	100	100	100	100	100	100	100			
Heavy Vehicles, %	2	0	0	0	2	3	3	3	2	1	1	1			
Mvmt Flow	0	0	12	15	0	83	22	272	0	21	217	224			
Number of Lanes	0	0	1	0	0	0	1	1	0	0	1	2			
Approach															
Opposing Approach	WB			EB			SB			-					
Opposing Lanes	2			1			1			-					
Conflicting Approach Left	SB			NB			EB			-					
Conflicting Lanes Left	1			1			1			-					
Conflicting Approach Right	NB			SB			WB			-					
Conflicting Lanes Right	1			1			2			-					
HCM Control Delay	10.1			13.1			19.9			-					
HCM LOS	B			B			C			-					
Lane															
Vol Left, %	5%			0%			79%			0%			67%		
Vol Thru, %	47%			44%			21%			0%			32%		
Vol Right, %	48%			56%			0%			100%			1%		
Sign Control	Stop			Stop			Stop			Stop			-		
Traffic Vol by Lane	462			27			105			272			315		
LT Vol	21			0			83			0			211		
Through Vol	217			12			22			0			100		
RT Vol	224			15			0			272			4		
Lane Flow Rate	462			27			105			272			315		
Geometry Grp	2			5			7			7			2		
Degree of Util (X)	0.684			0.051			0.207			0.451			0.522		
Departure Headway (Hd)	5.333			6.753			7.09			5.972			5.961		
Convergence, Y/N	Yes			Yes			Yes			Yes			Yes		
Cap	675			534			504			601			602		
Service Time	3.4			4.753			4.86			3.742			4.034		
HCM Lane V/C Ratio	0.684			0.051			0.208			0.453			0.523		
HCM Control Delay	19.9			10.1			11.7			13.7			15.6		
HCM Lane LOS	C			B			B			B			C		
HCM 95th %ile Q	6.1			0.2			0.8			2.4			3.2		

2017 PM Peak Hour 12/21/2016 All Way Stop

Synchro 8 Report
Page 1

HCM 2010 AWSC
1: Elm Street & Spring Street

2017 PM Peak Hour
All Way Stop

Movement	SBU	SBL	SBT	SBR
Intersection	15.6			
Intersection Delay, s/veh	15.6			
Intersection LOS	C			
Vol, veh/h	0	211	100	4
Peak Hour Factor	100	100	100	100
Heavy Vehicles, %	2	3	3	3
Mvmt Flow	0	211	100	4
Number of Lanes	0	0	1	0
Approach				
Opposing Approach	NB			
Opposing Lanes	1			
Conflicting Approach Left	WB			
Conflicting Lanes Left	2			
Conflicting Approach Right	EB			
Conflicting Lanes Right	1			
HCM Control Delay	15.6			
HCM LOS	C			
Lane				

2017 PM Peak Hour 12/21/2016 All Way Stop

Synchro 8 Report
Page 2

HCM Signalized Intersection Capacity Analysis
1: Elm Street & Spring Street

2017 PM Peak Hour
Signal

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔
Volume (vph)	0	12	15	83	22	272	21	217	224	211	100	4
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		6.0		6.0	6.0	6.0		6.0		6.0		6.0
Lane Util. Factor		1.00		1.00	1.00	1.00		1.00		1.00		1.00
Frt		0.93		1.00	0.85	0.93		1.00		1.00		1.00
Flt Protected		1.00		0.96	1.00	1.00		1.00		0.97		1.00
Satd. Flow (prot)		1758		1775	1568	1754		1782		1782		1782
Flt Permitted		1.00		0.75	1.00	0.98		0.55		0.55		0.55
Satd. Flow (perm)		1758		1389	1568	1718		1016		1016		1016
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	0	12	15	83	22	272	21	217	224	211	100	4
RTOR Reduction (vph)	0	12	0	0	0	220	0	35	0	0	1	0
Lane Group Flow (vph)	0	15	0	0	105	52	0	427	0	0	314	0
Heavy Vehicles (%)	0%	0%	0%	3%	3%	3%	1%	1%	1%	3%	3%	3%
Turn Type	NA		Perm	NA	Perm	Perm	NA		Perm	NA		NA
Protected Phases	6			2			4					8
Permitted Phases	6			2			4					8
Actuated Green, G (s)		10.0		10.0	10.0		25.0					25.0
Effective Green, g (s)		10.0		10.0	10.0		25.0					25.0
Actuated g/C Ratio		0.19		0.19	0.19		0.48					0.48
Clearance Time (s)		6.0		6.0	6.0		6.0					6.0
Vehicle Extension (s)		2.0		2.0	2.0		2.0					2.0
Lane Grp Cap (vph)		336		266	300		822					486
v/s Ratio Prot		0.01										
v/s Ratio Perm				c0.08	0.03		0.25					c0.31
w/c Ratio		0.04		0.39	0.17		0.52					0.65
Uniform Delay, d1		17.2		18.5	17.6		9.4					10.3
Progression Factor		1.00		1.00	1.00		1.00					1.00
Incremental Delay, d2		0.0		0.4	0.1		0.2					2.2
Delay (s)		17.2		18.8	17.7		9.7					12.5
Level of Service		B		B	B		A					B
Approach Delay (s)		17.2		18.0			9.7					12.5
Approach LOS		B		B			A					B

Intersection Summary			
HCM 2000 Control Delay	13.3	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	52.2	Sum of lost time (s)	15.0
Intersection Capacity Utilization	70.9%	ICU Level of Service	C
Analysis Period (min)	60		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis
1: Elm Street & Spring Street

2017 PM Peak Hour
Signal - LPI

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔
Volume (vph)	0	12	15	83	22	272	21	217	224	211	100	4
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		6.0		6.0	6.0	6.0		6.0		6.0		6.0
Lane Util. Factor		1.00		1.00	1.00	1.00		1.00		1.00		1.00
Frt		0.97		1.00	0.97	0.99		1.00		1.00		1.00
Flt Protected		1.00		0.97	1.00	1.00		1.00		0.97		1.00
Satd. Flow (prot)		1704		1726	1516	1732		1778		1778		1778
Flt Permitted		1.00		0.75	1.00	0.98		0.56		0.56		0.56
Satd. Flow (perm)		1704		1351	1516	1693		1027		1027		1027
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	0	12	15	83	22	272	21	217	224	211	100	4
RTOR Reduction (vph)	0	12	0	0	0	219	0	48	0	0	1	0
Lane Group Flow (vph)	0	15	0	0	105	53	0	414	0	0	314	0
Heavy Vehicles (%)	0%	0%	0%	3%	3%	3%	1%	1%	1%	3%	3%	3%
Turn Type	NA		Perm	NA	Perm	Perm	NA		Perm	NA		NA
Protected Phases	6			2			4					8
Permitted Phases	6			2			4					8
Actuated Green, G (s)		8.7		8.7	8.7		19.7					19.7
Effective Green, g (s)		8.7		8.7	8.7		19.7					19.7
Actuated g/C Ratio		0.19		0.19	0.19		0.44					0.44
Clearance Time (s)		6.0		6.0	6.0		6.0					6.0
Vehicle Extension (s)		1.5		1.5	1.5		2.0					2.0
Lane Grp Cap (vph)		329		261	293		741					449
v/s Ratio Prot		0.01										
v/s Ratio Perm				c0.08	0.03		0.24					c0.31
w/c Ratio		0.05		0.40	0.18		0.56					0.70
Uniform Delay, d1		14.8		15.9	15.2		9.4					10.3
Progression Factor		1.00		1.00	1.00		1.00					1.00
Incremental Delay, d2		0.0		0.4	0.1		0.5					4.1
Delay (s)		14.8		16.2	15.3		9.9					14.3
Level of Service		B		B	B		A					B
Approach Delay (s)		14.8		15.5			9.9					14.3
Approach LOS		B		B			A					B

Intersection Summary			
HCM 2000 Control Delay	13.0	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	71.1%	ICU Level of Service	C
Analysis Period (min)	60		

c Critical Lane Group

Queuing and Blocking Report
Existing Condition

2017 AM Peak Hour
Existing Condition

Intersection: 1: Elm Street & Spring Street

Movement	EB	WB	WB	NB	SB
Directions Served	LTR	LT	R	LTR	LTR
Maximum Queue (ft)	44	116	96	55	123
Average Queue (ft)	22	57	39	5	38
95th Queue (ft)	45	101	69	28	89
Link Distance (ft)	331	358		431	527
Upstream Blk Time (%)					
Queuing Penalty (veh)					
Storage Bay Dist (ft)		100			
Storage Blk Time (%)		1	0		
Queuing Penalty (veh)		2	0		

Network Summary

Network wide Queuing Penalty: 2

Queuing and Blocking Report
All Way Stop

2017 AM Peak Hour
All Way Stop

Intersection: 1: Elm Street & Spring Street

Movement	EB	WB	WB	NB	SB
Directions Served	LTR	LT	R	LTR	LTR
Maximum Queue (ft)	44	86	78	77	199
Average Queue (ft)	21	44	39	42	79
95th Queue (ft)	46	71	61	66	140
Link Distance (ft)	331	358		431	527
Upstream Blk Time (%)					
Queuing Penalty (veh)					
Storage Bay Dist (ft)		100			
Storage Blk Time (%)		0	0		
Queuing Penalty (veh)		0	0		

Network Summary

Network wide Queuing Penalty: 0

Queuing and Blocking Report
Signal

2017 AM Peak Hour
Signal

Intersection: 1: Elm Street & Spring Street

Movement	EB	WB	WB	NB	SB
Directions Served	LTR	LT	R	LTR	LTR
Maximum Queue (ft)	72	167	122	113	267
Average Queue (ft)	20	66	45	44	118
95th Queue (ft)	52	122	89	89	214
Link Distance (ft)	331	358		431	527
Upstream Blk Time (%)					
Queuing Penalty (veh)					
Storage Bay Dist (ft)			100		
Storage Blk Time (%)		2	0		
Queuing Penalty (veh)		2	0		

Network Summary

Network wide Queuing Penalty: 3

Queuing and Blocking Report
Signal - LPI

2017 AM Peak Hour
Signal - LPI

Intersection: 1: Elm Street & Spring Street

Movement	EB	WB	WB	NB	SB
Directions Served	LTR	LT	R	LTR	LTR
Maximum Queue (ft)	49	136	106	92	198
Average Queue (ft)	16	53	40	43	98
95th Queue (ft)	43	102	73	76	165
Link Distance (ft)	331	358		431	527
Upstream Blk Time (%)					
Queuing Penalty (veh)					
Storage Bay Dist (ft)			100		
Storage Blk Time (%)		1	0		
Queuing Penalty (veh)		1	0		

Network Summary

Network wide Queuing Penalty: 1

Queuing and Blocking Report
Existing Condition

2017 PM Peak Hour
Existing Condition

Intersection: 1: Elm Street & Spring Street

Movement	EB	WB	WB	NB	SB
Directions Served	LTR	LT	R	LTR	LTR
Maximum Queue (ft)	44	249	124	69	149
Average Queue (ft)	19	66	64	13	59
95th Queue (ft)	45	169	113	45	114
Link Distance (ft)	331	358		431	527
Upstream Blk Time (%)		1			
Queuing Penalty (veh)		0			
Storage Bay Dist (ft)			100		
Storage Blk Time (%)		5	1		
Queuing Penalty (veh)		14	1		

Network Summary

Network wide Queuing Penalty: 15

Queuing and Blocking Report
All Way Stop

2017 PM Peak Hour
All Way Stop

Intersection: 1: Elm Street & Spring Street

Movement	EB	WB	WB	NB	SB
Directions Served	LTR	LT	R	LTR	LTR
Maximum Queue (ft)	40	148	116	238	137
Average Queue (ft)	19	42	58	98	62
95th Queue (ft)	44	92	99	177	108
Link Distance (ft)	331	358		431	527
Upstream Blk Time (%)					
Queuing Penalty (veh)					
Storage Bay Dist (ft)			100		
Storage Blk Time (%)		0	1		
Queuing Penalty (veh)		0	1		

Network Summary

Network wide Queuing Penalty: 1

Queuing and Blocking Report
Signal

2017 PM Peak Hour
Signal

Intersection: 1: Elm Street & Spring Street

Movement	EB	WB	WB	NB	SB
Directions Served	LTR	LT	R	LTR	LTR
Maximum Queue (ft)	44	174	123	265	303
Average Queue (ft)	16	61	66	105	127
95th Queue (ft)	42	127	111	193	242
Link Distance (ft)	331	358		431	527
Upstream Blk Time (%)					
Queuing Penalty (veh)					
Storage Bay Dist (ft)			100		
Storage Blk Time (%)		2	1		
Queuing Penalty (veh)		5	2		

Network Summary

Network wide Queuing Penalty: 7

Queuing and Blocking Report
Signal - LPI

2017 PM Peak Hour
Signal - LPI

Intersection: 1: Elm Street & Spring Street

Movement	EB	WB	WB	NB	SB
Directions Served	LTR	LT	R	LTR	LTR
Maximum Queue (ft)	49	142	121	176	212
Average Queue (ft)	17	52	63	87	98
95th Queue (ft)	44	105	106	149	173
Link Distance (ft)	331	358		431	527
Upstream Blk Time (%)					
Queuing Penalty (veh)					
Storage Bay Dist (ft)			100		
Storage Blk Time (%)		1	1		
Queuing Penalty (veh)		1	1		

Network Summary

Network wide Queuing Penalty: 3