

To: Jason Guillot
Westhampton, LLC
350 Pembroke Lane
Richmond, VA 23238

Date: May 23, 2016

Project #: 34149.00

From: Diane Linderman
Ahmed Amer
VHB

Re: Traffic Impact Analysis for the Westhampton on
Grove Redevelopment Project

Introduction

This memo is to summarize the analysis made of the intersections in the vicinity of the proposed new development at the Westhampton on Grove redevelopment project in Richmond, VA. The objective is to study the impacts of the proposed new development on the traffic operations at the following three adjacent intersections.

- 1) Grove Avenue and Libbie Avenue (Signalized).
- 2) Grove Avenue and Granite Avenue (two-way stop control (TWSC) on Granite Avenue).
- 3) Libbie Avenue and York Road (TWSC on York Road).

As shown in Figure 1, the development is located on the north side of Grove Avenue at the corner of Grove and Granite Avenues in the City of Richmond. The current uses on the property include a two screen movie theater, a real estate office, and parking. The redevelopment site plan indicates the following proposed land uses.



Figure 1: Aerial Image of the Study Area and the Subject Intersections (Source: Google Earth®)

- Restaurant.
- Salon.
- Food store/sandwich shop.

115 South 15th Street
Suite 200
Richmond, VA 23219-4209
P 804.343.7100

- Office.
- Residential.

Due to the location of the project within the City of Richmond, it has been assumed that VDOT Traffic Impact Analysis Regulations (Chapter 527) will not apply in this case.

Existing Conditions

Traffic and Pedestrian/Bicycle Counts

Based on our scoping meeting with City staff, the operational analysis was conducted for PM peak hour conditions. Vehicular turning movement counts (TMCs) as well as pedestrian/bicycle crossings during midday and PM peak periods were recently collected from the three subject intersections in March 2016. Figure 2, Figure 3 and Figure 4 summarize the existing conditions traffic counts during the evening peak hour (5:00 – 6:00 PM).

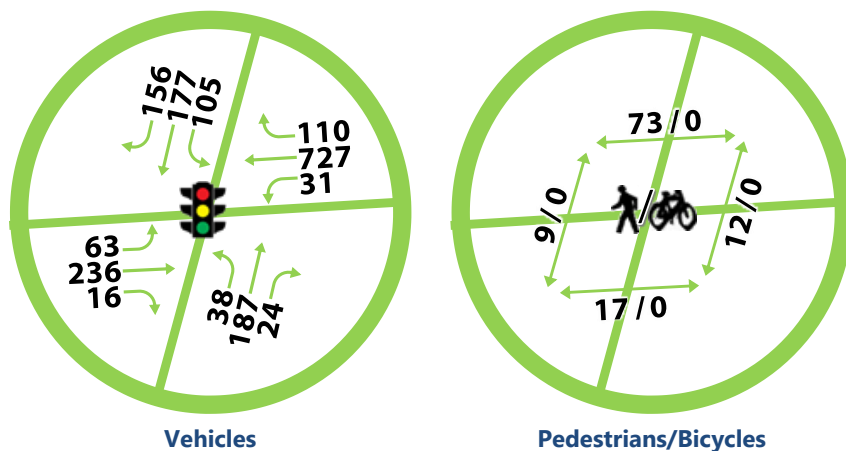


Figure 2: Existing Conditions - Evening Peak Vehicular, Pedestrian and Bicycle Counts at Grove Ave and Libbie Ave

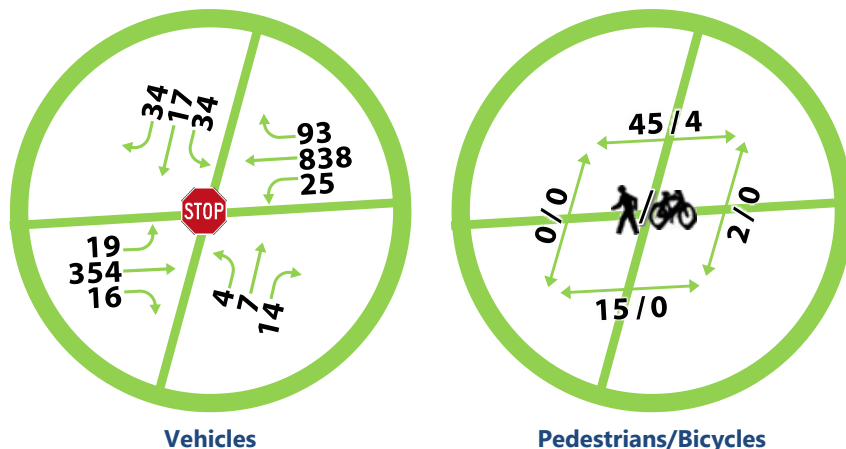


Figure 3: Existing Conditions - Evening Peak Vehicular, Pedestrian and Bicycle Counts at Grove Ave and Granite Ave

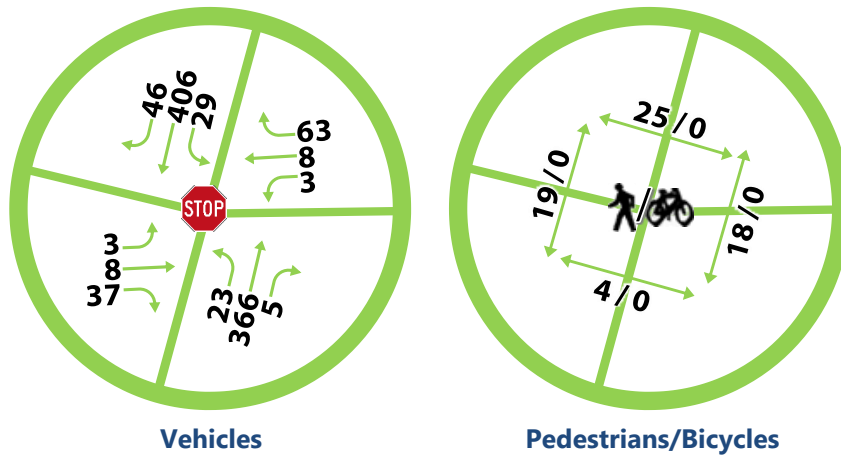


Figure 4: Existing Conditions - Evening Peak Vehicular, Pedestrian and Bicycle Counts at Libbie Ave and York Rd

This neighborhood is influenced by vehicle and pedestrian traffic due to the proximity of the three schools. Vehicular turning movement counts (TMCs) as well as pedestrian/bicycle crossings for the midday peak are shown in Figure 5, Figure 6 and Figure 7.

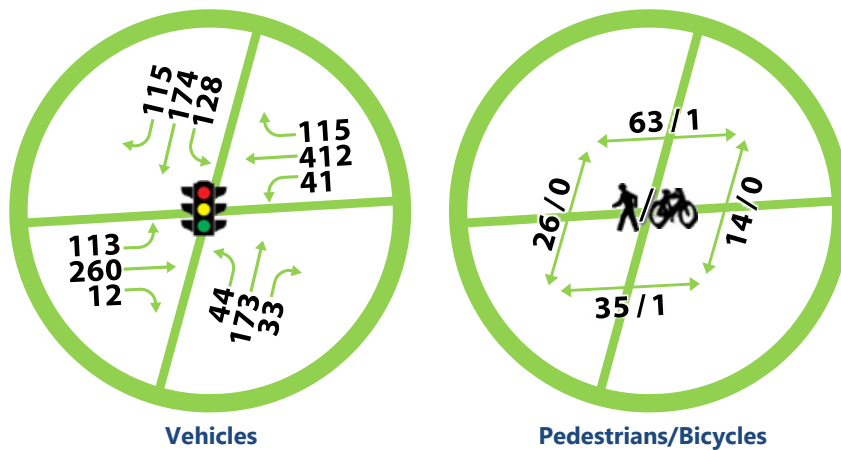
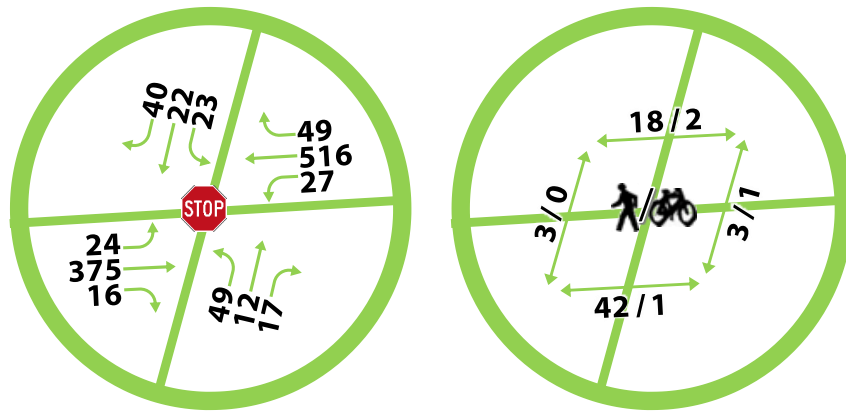


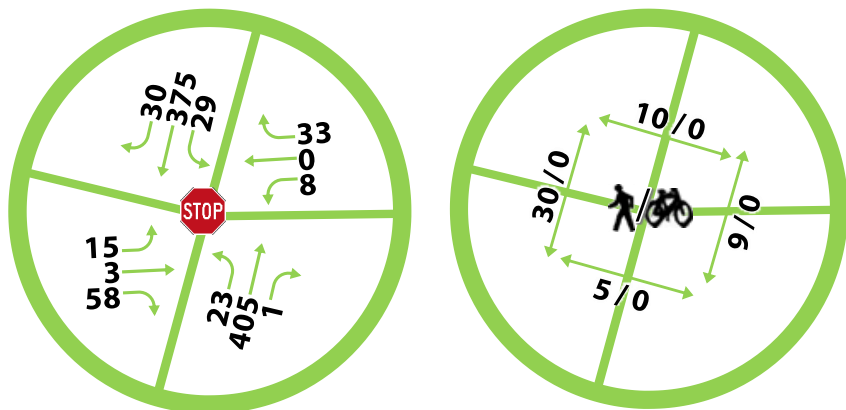
Figure 5: Existing Conditions - Midday Peak Vehicular, Pedestrian and Bicycle Counts at Grove Ave and Libbie Ave



Vehicles

Pedestrians/Bicycles

Figure 6: Existing Conditions – Midday Peak Vehicular, Pedestrian and Bicycle Counts at Grove Ave and Granite Ave



Vehicles

Pedestrians/Bicycles

Figure 7: Existing Conditions - Midday Peak Vehicular, Pedestrian and Bicycle Counts at Libbie Ave and York Rd

Signal Phasing and Timings

Existing phasing and timings at the signalized intersection of Grove Ave and Libbie Ave were obtained from City of Richmond, as shown in Figure 8. It is worth mentioning that the split phasing operation on Grove Ave has phase numbers 1 and 2. Nevertheless, in order for Synchro to be able to run HCM 2010 analyses, the phase number for WB approach is changed from phase 1 to phase 6. Signal timing splits are based on a PM cycle length of 110 seconds.

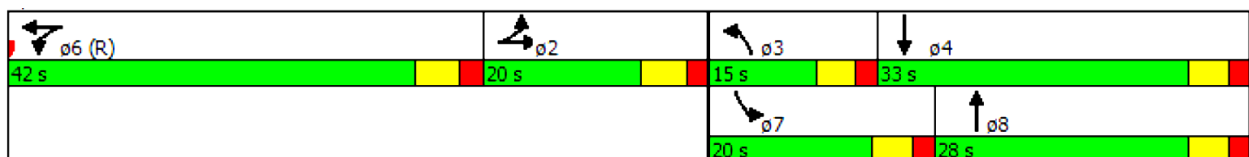


Figure 8: Existing Signal Phasing at Grove Ave and Libbie Ave (Weekday PM)

Proposed Developments

The redevelopment of this site includes land uses that are allowed under the current zoning. The site plan prepared by Stewart/HG and dated May 2016 is included as Figure 9. This plan proposed a reconfiguration of the parking lot behind the buildings with an entrance only at Granite Avenue and exit only on York Road. The parking lot will have controlled access and be available for use by the retail and residential uses in this development. The site plan improves the access management on York Road by consolidating the current access in and out of the existing parking lot to one driveway. The improvements along Grove Avenue will greatly enhance the pedestrian environment by the elimination of two existing driveways. A new sidewalk will be constructed along the west side Granite Avenue to the driveway entrance and along the property boundary on York Road.

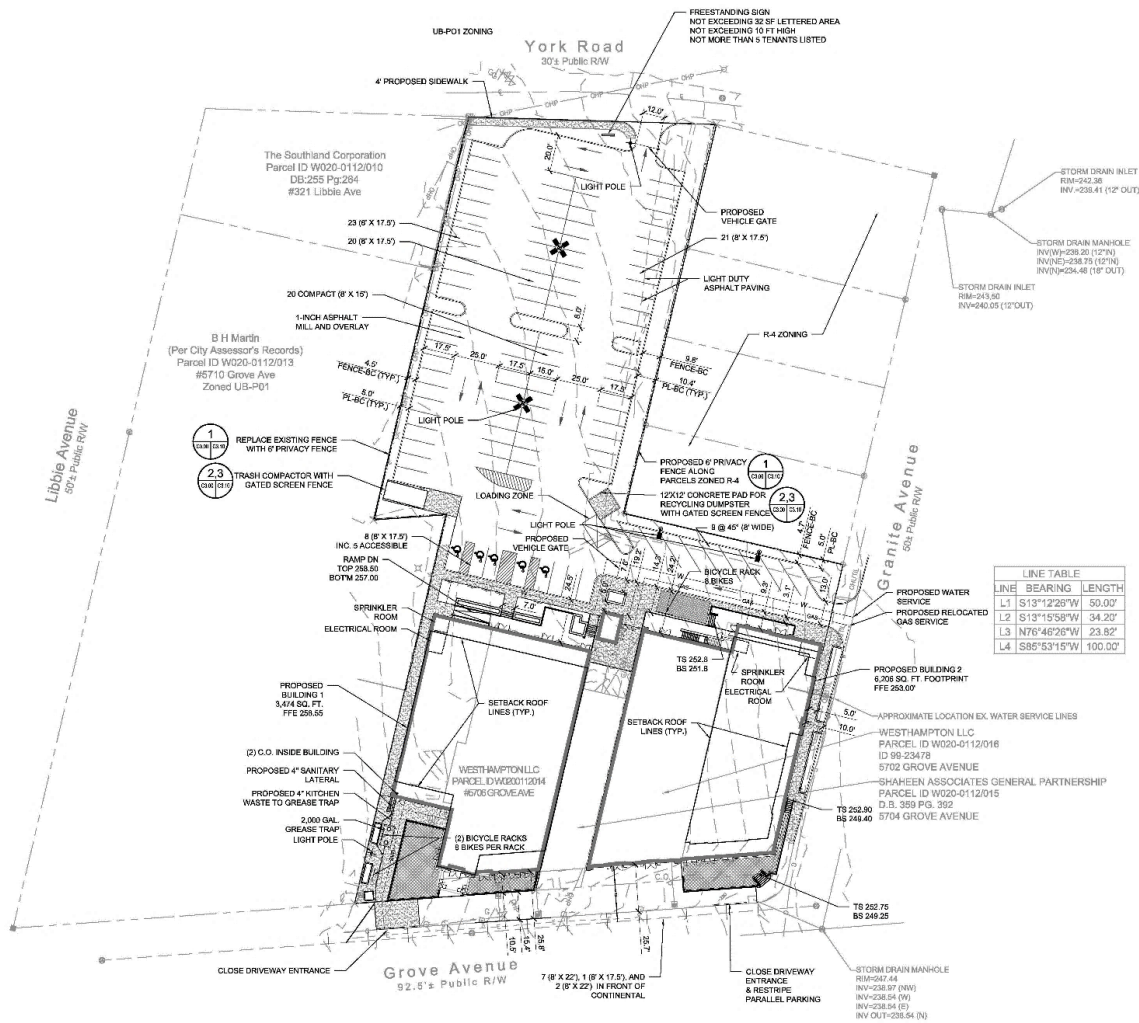


Figure 9: Proposed Plan View (Source: Stewart/HG, May 2016)

Proposed Land Uses and Trip Generation

In addition to the existing land uses, the new proposed land uses are listed hereinafter along with the assumed ITE land use codes (LUCs) for each land use type. Using the assumed LUCs, Table 1 includes the total daily and PM peak hour trip generation for the proposed land uses and Table 2 summarizes the trip generation results for the PM peak hour.

Existing Land Uses

- Movie Theater with Matinee (LUC 444): 2 screens.
- General Office (LUC 710): 5,800 sf.

Proposed Land Uses

- Residential (LUC 230): 12 units.
- General Office (LUC 710): 20,182 sf.
- Hair Salon (LUC 918): 3,053 sf.
- High-Turnover (Sit-Down) Restaurant (LUC 932): 4,736 sf.
- Quality Restaurant (LUC 931): 4,576 sf.

Table 1: Future PM Peak Trip Generation

ITE Land Use Code	Use	Units	ITE MANUAL RATES*			
			ADT	PM Enter	PM Exit	PM Total
230	Condominiums	12 units	70	4	2	6
710	General Office	20,182 sf	389	17	84	101
918	Hair Salon	3,053 sf	60	2	4	6
932	High-Turnover (Sit-Down) Restaurant	4,736 sf	602	48	40	88
931	Quality Restaurant	4,576 sf	412	23	11	34
<i>Total Trips</i>			<i>1,533</i>	<i>94</i>	<i>141</i>	<i>235</i>

Table 2: Summary of PM Peak Trip Generation Results

Scenario	Daily	PM Peak		
		In	Out	Total
Existing Total	591	42	43	85
Future Total	1,533	94	141	235
Existing Internal Capture	30	2	2	4
Future Internal Capture	127	5	5	10
Existing Pass-By	-	-	-	-
Future Pass-By	-	19	19	38
Existing Non-Pass-By	561	40	41	81
Future Non-Pass-By	1,406	70	117	187
Net New Non-Pass-By	845	30	76	106

Background Traffic

Using the VDOT traffic count data, the average daily traffic volumes were reviewed over the last five years. The volumes on Grove Avenue (counts both east and west of Libbie Avenue) and on Libbie Avenue north of Grove Avenue show no growth. Grove Avenue, between Libbie Avenue and Thompson Street, has a volume of approximately 9,400 daily trips and between Three Chopt Road and Libbie Avenue, approximately 10,000 trips per day. Libbie Avenue, north of Grove Avenue carries approximately 10,000 daily trips. Accordingly, a zero percent annual background traffic growth rate is assumed for the study area.

Trip Distribution and Assignment

The trip distribution uses percentages based on the current volume counts at the three subject intersections are shown on Figure 10 (22% north, 11% south, 45% east, and 22% west).



Figure 10: Proposed Trip Distribution Percentages

Based on these assumptions, entering and exiting final generated trips are assigned at the subject intersection as shown in Figure 11 and Figure 12, respectively. The PM Peak generated trips as assigned to the road network are shown on Figure 13.

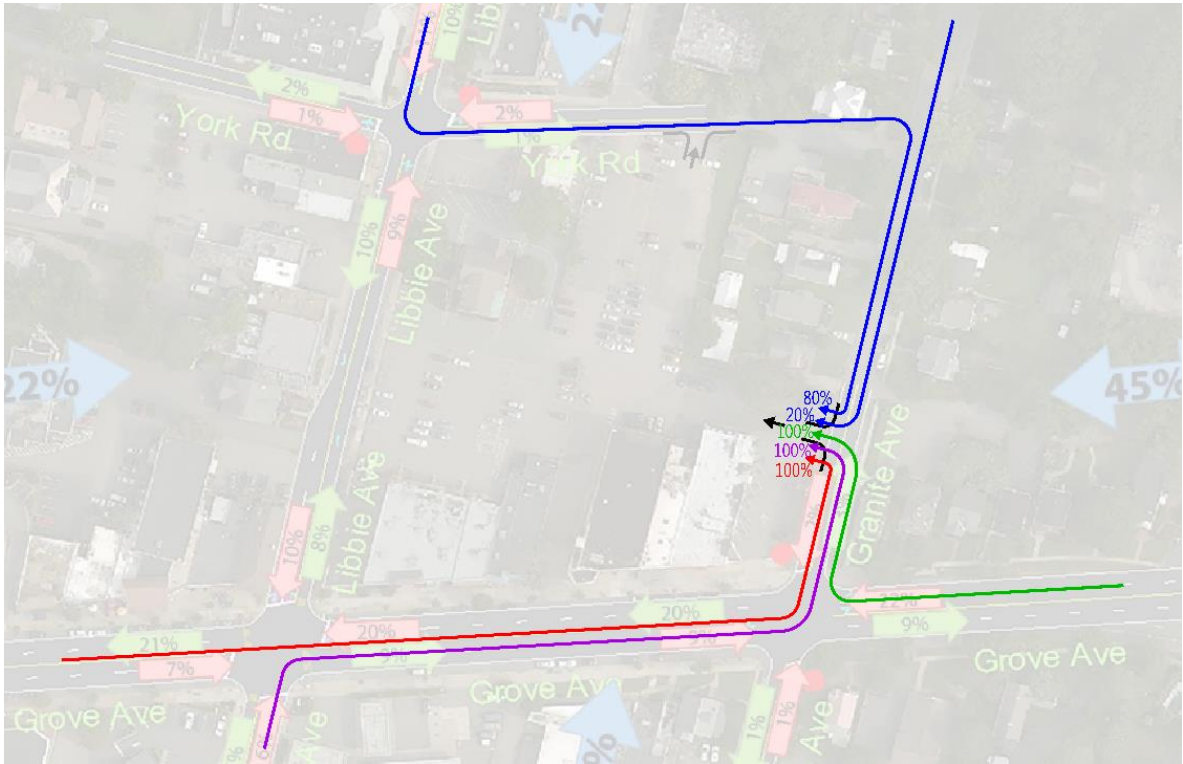


Figure 11: Percentage Assignment of Entering Final Generated Trips

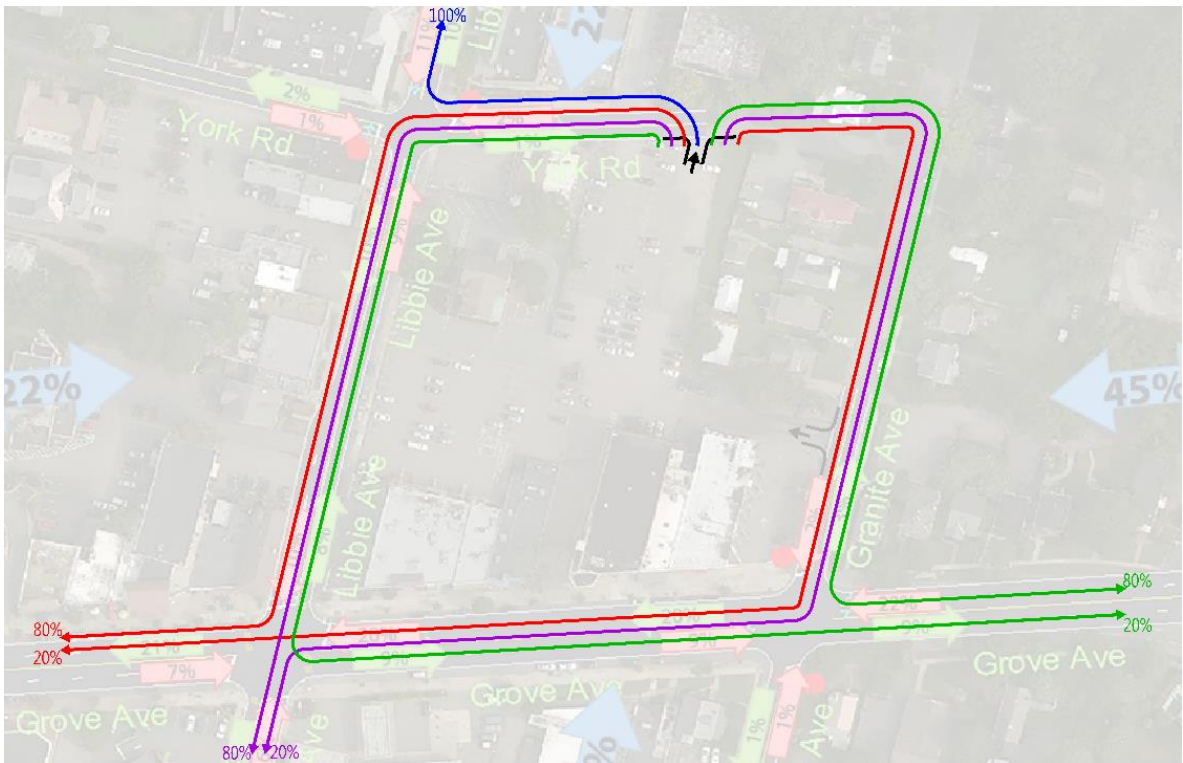


Figure 12: Percentage Assignment of Exiting Final Generated Trips

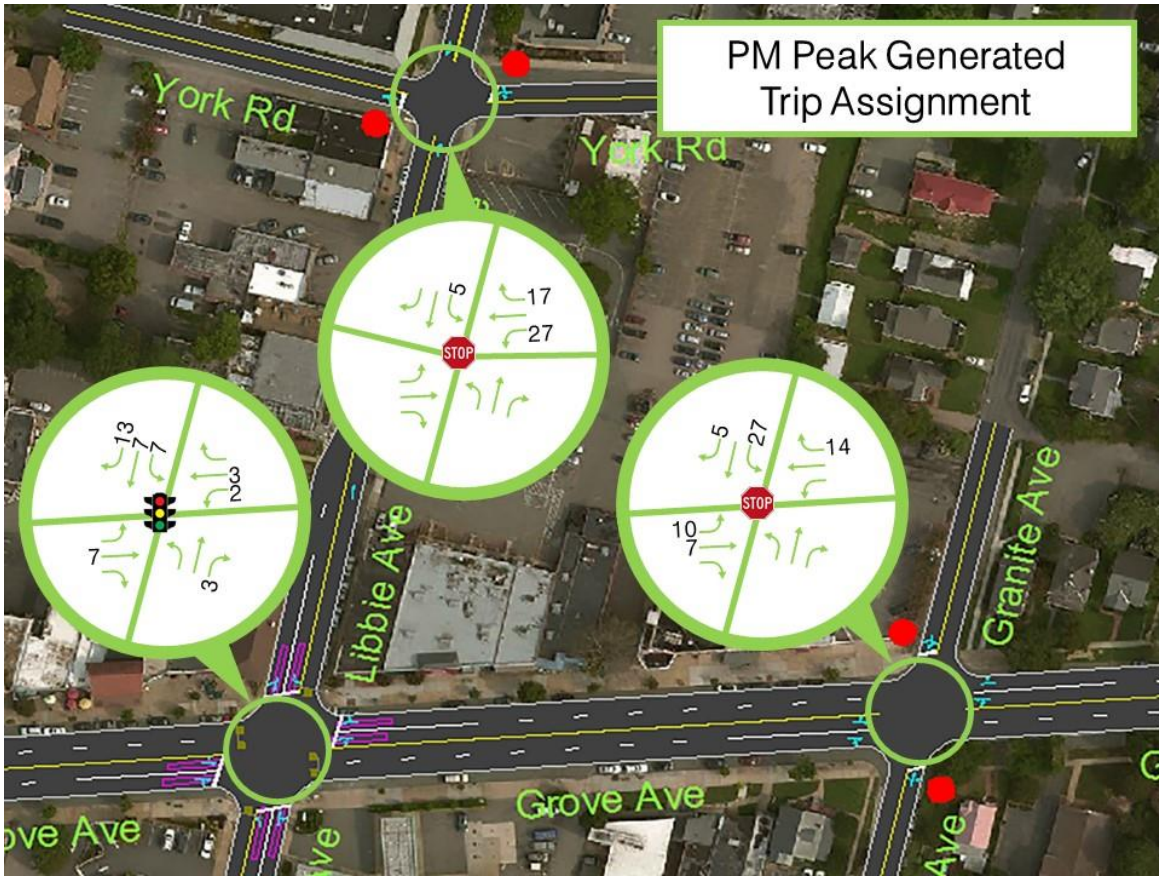


Figure 13: PM Peak Trip Assignment

Proposed Traffic Volumes

Based on the above trip generation, distribution and assignment, the final future vehicular volumes, based on the proposed land use developments, during evening peak hour are summarized Figure 14.

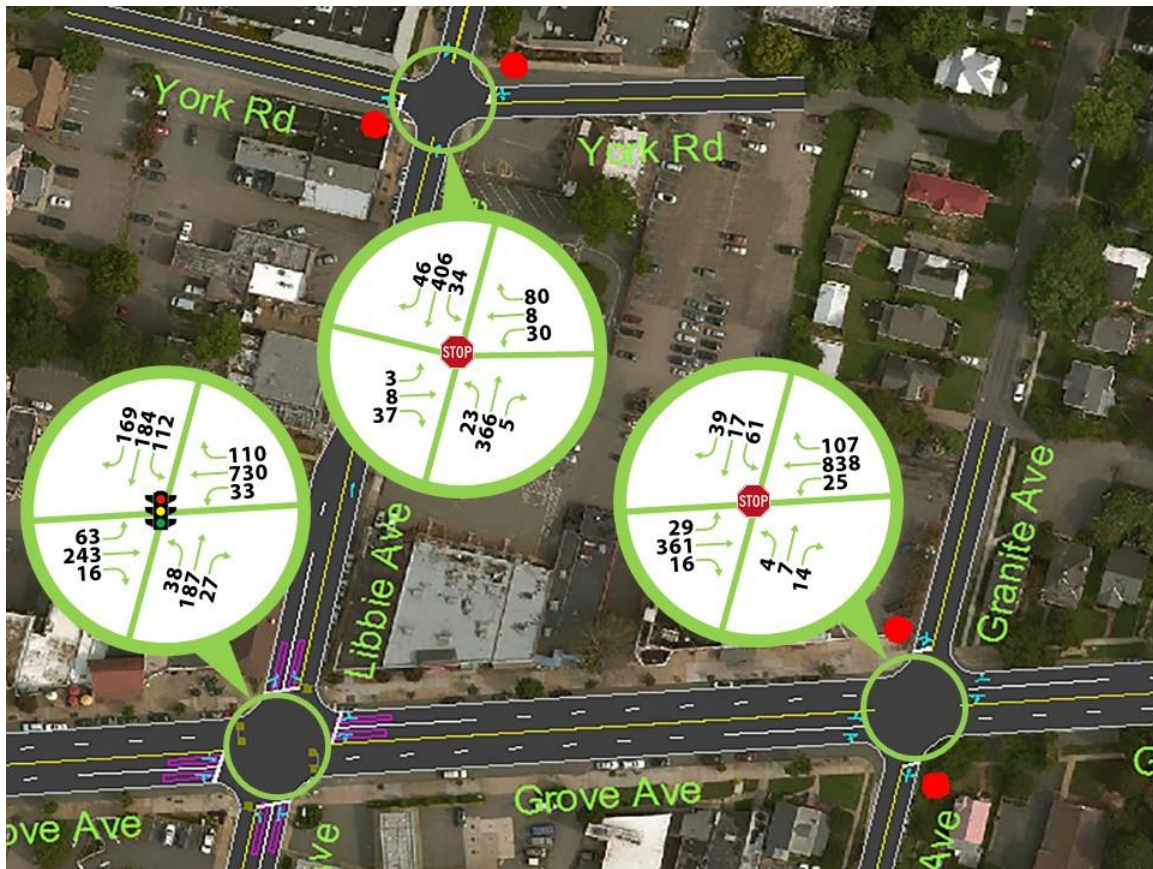


Figure 14: Proposed Conditions - Evening Peak Vehicular, Pedestrian and Bicycle Volumes

Results and Conclusions

Analysis Results

A Synchro model was used to code the study area, and HCM 2010 used to run the analyses at the three subject intersections, using fixed PM cycle lengths (110 seconds), phasing and splits. The model is used to obtain the measures of effectiveness (MOEs) and level of service (LOS) at the subject intersection. The model is run for the evening peak and evaluates the delay/LOS as well as 95th percentile queue lengths for the three intersections, based on two different scenarios listed hereinafter.

- No-build (existing) conditions
- Build (proposed) conditions

Figure 15 and Figure 16 summarize the delay and level of service (LOS) of the intersection approaches of each of the two scenarios, respectively. In addition, Figure 17 and Figure 18 summarize the 95th percentile queue lengths of the intersection approaches of each of the two scenarios, respectively. The detailed HCM 2010 Synchro outputs can be found in Appendix A.

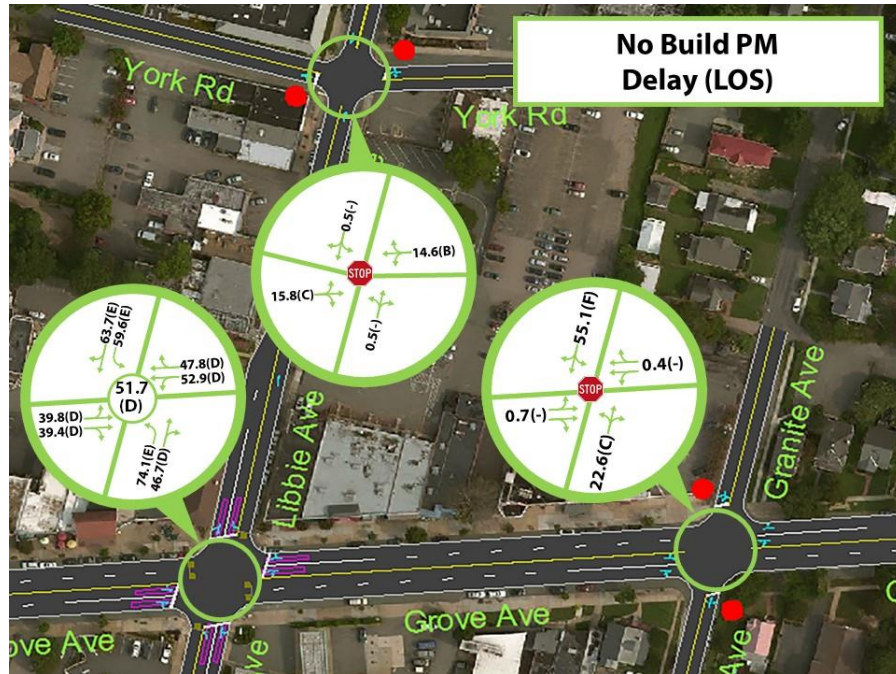


Figure 15: Delay (s) and Level of Service – No Build PM Peak

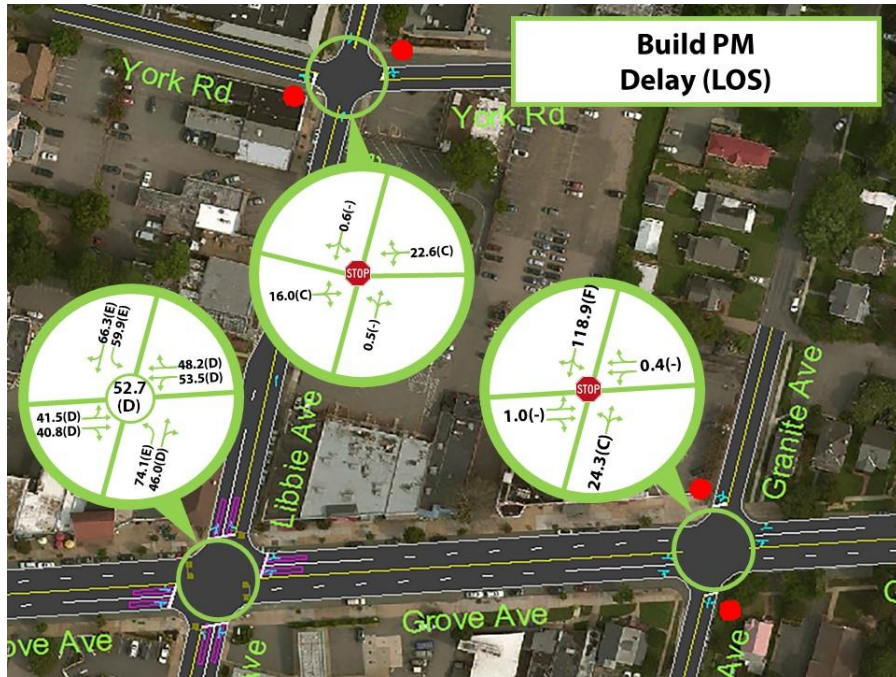


Figure 16: Delay (s) and Level of Service – Build PM Peak

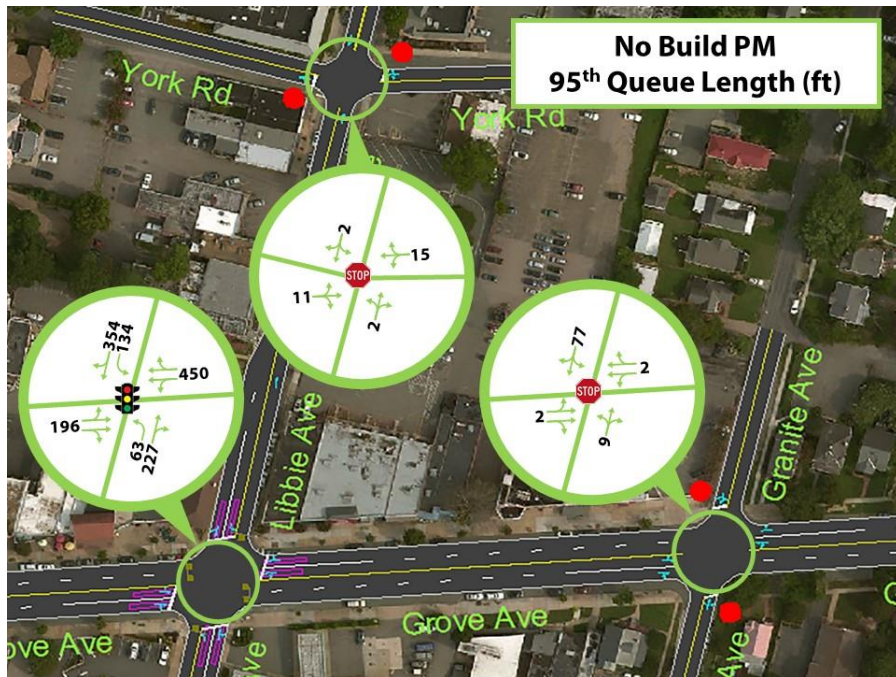


Figure 17: 95th % Queue Length (ft) – No Build PM Peak

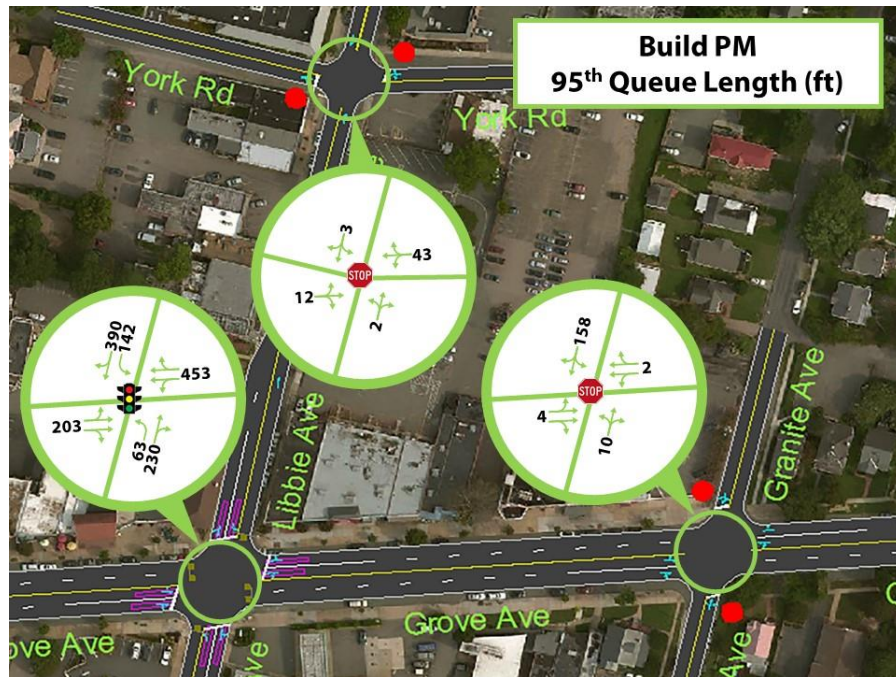


Figure 18: 95th % Queue Length (ft) – Build PM Peak

Conclusions

It can be seen from both the delay/LOS figures as well as the 95th percentile queue length figures that the added trips generated from the proposed development plan have minimal impact on the operations at the three intersections. For the signalized intersection of Grove Ave and Libbie Ave, none of the approaches experienced a deterioration in the level of service in the build case compared by the no-build. With the respect to the TWSC intersection of Libbie Ave and York Rd, the operations on the mainline as well as the EB approach was not impacted by the proposed developments. However, the WB approach of York Rd shows a change in the LOS from "B" to "C", as well as increase in the 95th % queue length from 15 ft to 43 ft, due to the proposed development. Such change in the approach MOE is still considered acceptable.

Similarly, for the TWSC intersection of Grove Ave and Granite Ave, the proposed development does not have any observed impacts on the mainline (Grove Ave) nor the NB approach of Granite Ave. Nevertheless, the SB approach of the intersection currently has an existing LOS "F" with 55 seconds of delay and 77 ft 95th % queue length. These deteriorated MOEs already exist without the proposed development. Such deteriorated performance on that approach can be attributed to the extended queues from the adjacent signalized intersection (450 ft on WB approach at Grove Ave and Libbie Ave). That long queue extends further than the spacing between the two intersections (~410 ft), spills back and impedes approaching SB traffic from proceeding through the STOP sign.

Looking at the build scenario, it can be found that the SB approach experienced increased delay and queue length, those can still be attributed to the currently deteriorated condition discussed earlier. It is anticipated that over time,

drivers will choose other options than sitting in a long queue – more may exit at York Road and Libbie Avenue or go north on Granite Avenue to Patterson Avenue.

With the installation of a signal at Maple and Grove Avenues, it is anticipated that some volume may divert to Maple Avenue from Libbie Avenue, reducing the volume on Libbie Avenue and improving the LOS at Libbie and Grove Avenues. This diversion has not been considered in this analysis and is therefore considered a conservative analysis.

In conclusion, it can be clearly seen from the results and the above discussions that the proposed new land use development at the Westhampton on Grove does not show any considerable impact on the traffic operations at the three adjacent intersections.

Recommendations

Due to the character of the neighborhood and the focus on pedestrians, the following recommendations are made:

- Install crosswalk across York Road, westbound approach
- Install crosswalk across Granite Avenue, southbound approach
- Provide the City with the signal retiming to maximize the efficiency of the signal at Libbie and Grove Avenues
- Evaluate advance signage on Grove Avenue, east of Granite Avenue to warn drivers of the change of road character, for example "Do not block intersection", enhanced speed limit reduction signage



















Appendix A:

Synchro Model HCM 2010 Outputs

HCM 2010 Signalized Intersection Summary

1: Libbie Ave & Grove Ave

5/25/2016

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	63	236	16	31	727	110	38	187	24	105	177	156
Number	5	2	12	1	6	16	3	8	18	7	4	14
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		0.82	1.00		0.89	1.00		0.98	1.00		0.99
Parking Bus, Adj	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1891	1900
Adj Flow Rate, veh/h	68	257	17	34	790	120	41	203	26	114	192	170
Adj No. of Lanes	0	2	0	0	2	0	1	1	0	1	1	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	0	0	0	0	0	0	0	0	0	0	0	0
Cap, veh/h	134	530	36	38	915	148	53	295	38	143	210	186
Arrive On Green	0.21	0.21	0.21	0.33	0.33	0.33	0.03	0.18	0.18	0.08	0.23	0.23
Sat Flow, veh/h	653	2576	177	116	2795	451	1810	1647	211	1810	921	815
Grp Volume(v), veh/h	194	0	148	553	0	391	41	0	229	114	0	362
Grp Sat Flow(s),veh/h/ln	1867	0	1539	1894	0	1469	1810	0	1858	1810	0	1736
Q Serve(g_s), s	10.1	0.0	9.3	30.5	0.0	26.8	2.5	0.0	12.7	6.8	0.0	22.4
Cycle Q Clear(g_c), s	10.1	0.0	9.3	30.5	0.0	26.8	2.5	0.0	12.7	6.8	0.0	22.4
Prop In Lane	0.35		0.12	0.06		0.31	1.00		0.11	1.00		0.47
Lane Grp Cap(c), veh/h	384	0	317	620	0	481	53	0	332	143	0	397
V/C Ratio(X)	0.51	0.00	0.47	0.89	0.00	0.81	0.78	0.00	0.69	0.80	0.00	0.91
Avail Cap(c_a), veh/h	384	0	317	620	0	481	156	0	380	239	0	434
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	38.7	0.0	38.4	35.2	0.0	33.9	53.0	0.0	42.3	49.8	0.0	41.4
Incr Delay (d2), s/veh	1.1	0.0	1.1	17.7	0.0	13.9	21.0	0.0	4.4	9.8	0.0	22.3
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	5.4	0.0	4.0	19.0	0.0	12.7	1.6	0.0	6.9	3.8	0.0	13.2
LnGrp Delay(d),s/veh	39.8	0.0	39.4	52.9	0.0	47.8	74.1	0.0	46.7	59.6	0.0	63.7
LnGrp LOS	D		D	D		D	E		D	E		E
Approach Vol, veh/h		342			944			270			476	
Approach Delay, s/veh		39.6			50.8			50.8			62.7	
Approach LOS		D			D			D			E	
Timer	1	2	3	4	5	6	7	8				
Assigned Phs		2	3	4		6	7	8				
Phs Duration (G+Y+Rc), s		28.6	8.7	30.6		42.0	14.2	25.2				
Change Period (Y+Rc), s		6.0	5.5	5.5		6.0	5.5	5.5				
Max Green Setting (Gmax), s		14.0	9.5	27.5		36.0	14.5	22.5				
Max Q Clear Time (g_c+I1), s		12.1	4.5	24.4		32.5	8.8	14.7				
Green Ext Time (p_c), s		0.2	0.0	0.8		1.4	0.1	1.5				
Intersection Summary												
HCM 2010 Ctrl Delay			51.7									
HCM 2010 LOS			D									
Notes												
User approved pedestrian interval to be less than phase max green.												

HCM 2010 TWSC
2: Granite Ave & Grove Ave

5/25/2016

Intersection

Int Delay, s/veh 4.1

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	19	354	16	25	838	93	4	7	14	34	17	34
Conflicting Peds, #/hr	45	0	15	15	0	45	0	0	2	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	92	92	92	92	92	92	92	92	92	92	92	92
Heavy Vehicles, %	0	1	0	0	1	0	0	0	0	0	0	0
Mvmt Flow	21	385	17	27	911	101	4	8	15	37	18	37

Major/Minor	Major1	Major2	Minor1	Minor2								
Conflicting Flow All	1012	0	0	404	0	0	956	1503	248	1256	1461	551
Stage 1	-	-	-	-	-	-	437	437	-	1016	1016	-
Stage 2	-	-	-	-	-	-	519	1066	-	240	445	-
Critical Hdwy	4.1	-	-	4.1	-	-	7.5	6.5	6.9	7.5	6.5	6.9
Critical Hdwy Stg 1	-	-	-	-	-	-	6.5	5.5	-	6.5	5.5	-
Critical Hdwy Stg 2	-	-	-	-	-	-	6.5	5.5	-	6.5	5.5	-
Follow-up Hdwy	2.2	-	-	2.2	-	-	3.5	4	3.3	3.5	4	3.3
Pot Cap-1 Maneuver	693	-	-	1166	-	-	216	123	758	130	130	483
Stage 1	-	-	-	-	-	-	574	583	-	259	318	-
Stage 2	-	-	-	-	-	-	513	301	-	748	578	-
Platoon blocked, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Cap-1 Maneuver	667	-	-	1122	-	-	156	111	728	108	117	465
Mov Cap-2 Maneuver	-	-	-	-	-	-	156	111	-	108	117	-
Stage 1	-	-	-	-	-	-	550	558	-	248	300	-
Stage 2	-	-	-	-	-	-	403	284	-	667	553	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0.7	0.4	22.6	55.1
HCM LOS			C	F

Minor Lane/Major Mvmt	NBLn1	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1
Capacity (veh/h)	232	667	-	-	1122	-	-	159
HCM Lane V/C Ratio	0.117	0.031	-	-	0.024	-	-	0.581
HCM Control Delay (s)	22.6	10.6	0.2	-	8.3	0.2	-	55.1
HCM Lane LOS	C	B	A	-	A	A	-	F
HCM 95th %tile Q(veh)	0.4	0.1	-	-	0.1	-	-	3

Intersection

Int Delay, s/veh 2.3

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	3	8	37	3	8	63	23	366	5	29	406	46
Conflicting Peds, #/hr	25	0	4	4	0	25	0	0	18	0	0	19
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	92	92	92	92	92	92	92	92	92	92	92	92
Heavy Vehicles, %	0	0	0	0	0	0	0	0	0	0	0	0
Mvmt Flow	3	9	40	3	9	68	25	398	5	32	441	50

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	1068	1032	509	1055	1055	445	516	0	0	428	0	0
Stage 1	554	554	-	476	476	-	-	-	-	-	-	-
Stage 2	514	478	-	579	579	-	-	-	-	-	-	-
Critical Hdwy	7.1	6.5	6.2	7.1	6.5	6.2	4.1	-	-	4.1	-	-
Critical Hdwy Stg 1	6.1	5.5	-	6.1	5.5	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.1	5.5	-	6.1	5.5	-	-	-	-	-	-	-
Follow-up Hdwy	3.5	4	3.3	3.5	4	3.3	2.2	-	-	2.2	-	-
Pot Cap-1 Maneuver	201	235	568	205	227	617	1060	-	-	1142	-	-
Stage 1	520	517	-	574	560	-	-	-	-	-	-	-
Stage 2	547	559	-	504	504	-	-	-	-	-	-	-
Platoon blocked, %												
Mov Cap-1 Maneuver	157	210	548	168	203	595	1044	-	-	1124	-	-
Mov Cap-2 Maneuver	157	210	-	168	203	-	-	-	-	-	-	-
Stage 1	493	486	-	545	531	-	-	-	-	-	-	-
Stage 2	454	530	-	434	474	-	-	-	-	-	-	-



















Approach	EB	WB	NB	SB
HCM Control Delay, s	15.8	14.6	0.5	0.5
HCM LOS	C	B		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	1044	-	-	385	454	1124	-	-
HCM Lane V/C Ratio	0.024	-	-	0.136	0.177	0.028	-	-
HCM Control Delay (s)	8.5	0	-	15.8	14.6	8.3	0	-
HCM Lane LOS	A	A	-	C	B	A	A	-
HCM 95th %tile Q(veh)	0.1	-	-	0.5	0.6	0.1	-	-

HCM 2010 Signalized Intersection Summary

1: Libbie Ave & Grove Ave

5/25/2016

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	63	243	16	33	730	110	38	187	27	112	184	169
Number	5	2	12	1	6	16	3	8	18	7	4	14
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		0.81	1.00		0.89	1.00		0.98	1.00		0.99
Parking Bus, Adj	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1891	1900
Adj Flow Rate, veh/h	68	264	17	36	793	120	41	203	29	122	200	184
Adj No. of Lanes	0	2	0	0	2	0	1	1	0	1	1	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	0	0	0	0	0	0	0	0	0	0	0	0
Cap, veh/h	125	506	34	40	914	147	53	300	43	151	216	199
Arrive On Green	0.20	0.20	0.20	0.33	0.33	0.33	0.03	0.18	0.18	0.08	0.24	0.24
Sat Flow, veh/h	640	2592	174	123	2792	449	1810	1622	232	1810	903	831
Grp Volume(v), veh/h	198	0	151	556	0	393	41	0	232	122	0	384
Grp Sat Flow(s),veh/h/ln	1868	0	1537	1894	0	1469	1810	0	1854	1810	0	1733
Q Serve(g_s), s	10.5	0.0	9.6	30.8	0.0	27.0	2.5	0.0	12.8	7.3	0.0	23.8
Cycle Q Clear(g_c), s	10.5	0.0	9.6	30.8	0.0	27.0	2.5	0.0	12.8	7.3	0.0	23.8
Prop In Lane	0.34		0.11	0.06		0.31	1.00		0.13	1.00		0.48
Lane Grp Cap(c), veh/h	365	0	300	620	0	481	53	0	342	151	0	414
V/C Ratio(X)	0.54	0.00	0.50	0.90	0.00	0.82	0.78	0.00	0.68	0.81	0.00	0.93
Avail Cap(c_a), veh/h	365	0	300	620	0	481	156	0	379	239	0	433
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	39.8	0.0	39.5	35.2	0.0	34.0	53.0	0.0	41.8	49.5	0.0	40.9
Incr Delay (d2), s/veh	1.7	0.0	1.3	18.2	0.0	14.2	21.0	0.0	4.2	10.3	0.0	25.4
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	5.6	0.0	4.2	19.2	0.0	12.8	1.6	0.0	7.0	4.1	0.0	14.3
LnGrp Delay(d),s/veh	41.5	0.0	40.8	53.5	0.0	48.2	74.1	0.0	46.0	59.9	0.0	66.3
LnGrp LOS	D		D	D		D	E		D	E		E
Approach Vol, veh/h		349			949			273				506
Approach Delay, s/veh		41.2			51.3			50.2				64.8
Approach LOS		D			D			D				E
Timer	1	2	3	4	5	6	7	8				
Assigned Phs		2	3	4		6	7	8				
Phs Duration (G+Y+Rc), s		27.5	8.7	31.8		42.0	14.7	25.8				
Change Period (Y+Rc), s		6.0	5.5	5.5		6.0	5.5	5.5				
Max Green Setting (Gmax), s		14.0	9.5	27.5		36.0	14.5	22.5				
Max Q Clear Time (g_c+I1), s		12.5	4.5	25.8		32.8	9.3	14.8				
Green Ext Time (p_c), s		0.2	0.0	0.5		1.3	0.1	1.6				
Intersection Summary												
HCM 2010 Ctrl Delay			52.7									
HCM 2010 LOS			D									
Notes												
User approved pedestrian interval to be less than phase max green.												

HCM 2010 TWSC
2: Granite Ave & Grove Ave

5/25/2016

Intersection												
Int Delay, s/veh	10.1											

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	29	361	16	25	838	107	4	7	14	61	17	39
Conflicting Peds, #/hr	45	0	15	15	0	45	0	0	2	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	92	92	92	92	92	92	92	92	92	92	92	92
Heavy Vehicles, %	0	1	0	0	1	0	0	0	0	0	0	0
Mvmt Flow	32	392	17	27	911	116	4	8	15	66	18	42

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	1027	0	0	412	0	0	985	1548	252	1288	1498	559
Stage 1	-	-	-	-	-	-	466	466	-	1023	1023	-
Stage 2	-	-	-	-	-	-	519	1082	-	265	475	-
Critical Hdwy	4.1	-	-	4.1	-	-	7.5	6.5	6.9	7.5	6.5	6.9
Critical Hdwy Stg 1	-	-	-	-	-	-	6.5	5.5	-	6.5	5.5	-
Critical Hdwy Stg 2	-	-	-	-	-	-	6.5	5.5	-	6.5	5.5	-
Follow-up Hdwy	2.2	-	-	2.2	-	-	3.5	4	3.3	3.5	4	3.3
Pot Cap-1 Maneuver	684	-	-	1158	-	-	205	115	754	123	124	478
Stage 1	-	-	-	-	-	-	551	566	-	256	316	-
Stage 2	-	-	-	-	-	-	513	296	-	723	561	-
Platoon blocked, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Cap-1 Maneuver	658	-	-	1115	-	-	142	101	725	100	109	460
Mov Cap-2 Maneuver	-	-	-	-	-	-	142	101	-	100	109	-
Stage 1	-	-	-	-	-	-	515	529	-	240	298	-
Stage 2	-	-	-	-	-	-	396	279	-	629	525	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	1	0.4	24.3	118.9
HCM LOS			C	F

Minor Lane/Major Mvmt	NBLn1	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1
Capacity (veh/h)	214	658	-	-	1115	-	-	138
HCM Lane V/C Ratio	0.127	0.048	-	-	0.024	-	-	0.922
HCM Control Delay (s)	24.3	10.7	0.3	-	8.3	0.2	-	118.9
HCM Lane LOS	C	B	A	-	A	A	-	F
HCM 95th %tile Q(veh)	0.4	0.2	-	-	0.1	-	-	6.3

Intersection

Int Delay, s/veh 3.8

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	3	8	37	30	8	80	23	366	5	34	406	46
Conflicting Peds, #/hr	25	0	4	4	0	25	0	0	18	0	0	19
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	92	92	92	92	92	92	92	92	92	92	92	92
Heavy Vehicles, %	0	0	0	0	0	0	0	0	0	0	0	0
Mvmt Flow	3	9	40	33	9	87	25	398	5	37	441	50

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	1088	1043	509	1066	1066	445	516	0	0	428	0	0
Stage 1	565	565	-	476	476	-	-	-	-	-	-	-
Stage 2	523	478	-	590	590	-	-	-	-	-	-	-
Critical Hdwy	7.1	6.5	6.2	7.1	6.5	6.2	4.1	-	-	4.1	-	-
Critical Hdwy Stg 1	6.1	5.5	-	6.1	5.5	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.1	5.5	-	6.1	5.5	-	-	-	-	-	-	-
Follow-up Hdwy	3.5	4	3.3	3.5	4	3.3	2.2	-	-	2.2	-	-
Pot Cap-1 Maneuver	195	231	568	202	224	617	1060	-	-	1142	-	-
Stage 1	513	511	-	574	560	-	-	-	-	-	-	-
Stage 2	541	559	-	497	498	-	-	-	-	-	-	-
Platoon blocked, %												
Mov Cap-1 Maneuver	146	205	548	165	199	595	1044	-	-	1124	-	-
Mov Cap-2 Maneuver	146	205	-	165	199	-	-	-	-	-	-	-
Stage 1	487	477	-	545	531	-	-	-	-	-	-	-
Stage 2	433	530	-	425	465	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	16	22.6	0.5	0.6
HCM LOS	C	C		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1WBLn1	SBL	SBT	SBR
Capacity (veh/h)	1044	-	-	378	331	1124	-
HCM Lane V/C Ratio	0.024	-	-	0.138	0.387	0.033	-
HCM Control Delay (s)	8.5	0	-	16	22.6	8.3	0
HCM Lane LOS	A	A	-	C	C	A	A
HCM 95th %tile Q(veh)	0.1	-	-	0.5	1.8	0.1	-

Queues

1: Libbie Ave & Grove Ave

5/25/2016



Lane Group	EBT	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	342	944	41	229	114	362
v/c Ratio	0.83	0.77	0.32	0.70	0.59	0.77
Control Delay	64.4	35.7	54.7	53.0	58.9	46.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	64.4	35.7	54.7	53.0	58.9	46.5
Queue Length 50th (ft)	124	316	28	145	77	217
Queue Length 95th (ft)	#196	#450	63	227	134	#354
Internal Link Dist (ft)	408	392		134		164
Turn Bay Length (ft)						
Base Capacity (vph)	419	1232	155	385	237	477
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.82	0.77	0.26	0.59	0.48	0.76

Intersection Summary

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

HCM Unsignalized Intersection Capacity Analysis

2: Granite Ave & Grove Ave

5/25/2016



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕↕			↕↕			↕			↕	
Volume (veh/h)	19	354	16	25	838	93	4	7	14	34	17	34
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	21	385	17	27	911	101	4	8	15	37	18	37
Pedestrians					2			15			45	
Lane Width (ft)					12.0			12.0			12.0	
Walking Speed (ft/s)					4.0			4.0			4.0	
Percent Blockage					0			1			4	
Right turn flare (veh)												
Median type		None			None							
Median storage (veh)												
Upstream signal (ft)		472										
pX, platoon unblocked				0.95			0.95	0.95	0.95	0.95	0.95	
vC, conflicting volume	1057			417			1006	1561	218	1315	1519	551
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1057			282			901	1486	72	1227	1442	551
tC, single (s)	4.1			4.1			7.5	6.5	6.9	7.5	6.5	6.9
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	97			98			97	93	98	66	84	92
cM capacity (veh/h)	642			1213			165	107	920	107	114	465

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	213	210	483	557	27	92
Volume Left	21	0	27	0	4	37
Volume Right	0	17	0	101	15	37
cSH	642	1700	1213	1700	239	158
Volume to Capacity	0.03	0.12	0.02	0.33	0.11	0.59
Queue Length 95th (ft)	2	0	2	0	9	77
Control Delay (s)	1.4	0.0	0.7	0.0	22.0	55.9
Lane LOS	A		A		C	F
Approach Delay (s)	0.7		0.3		22.0	55.9
Approach LOS					C	F

Intersection Summary

Average Delay	4.0
Intersection Capacity Utilization	59.2%
ICU Level of Service	B
Analysis Period (min)	15

HCM Unsignalized Intersection Capacity Analysis

3: Libbie Ave & York Rd

5/25/2016



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↔			↔			↔			↔	
Volume (veh/h)	3	8	37	3	8	63	23	366	5	29	406	46
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	3	9	40	3	9	68	25	398	5	32	441	50
Pedestrians		19			18			4			25	
Lane Width (ft)		12.0			12.0			12.0			12.0	
Walking Speed (ft/s)		4.0			4.0			4.0			4.0	
Percent Blockage		2			1			0			2	
Right turn flare (veh)												
Median type								None			None	
Median storage (veh)												
Upstream signal (ft)								512				
pX, platoon unblocked	0.90	0.90		0.90	0.90	0.90				0.90		
vC, conflicting volume	1097	1020	489	1046	1042	444	510			421		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1054	968	489	998	993	331	510			306		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	98	96	93	98	96	89	98			97		
cM capacity (veh/h)	145	213	572	168	206	623	1048			1127		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	52	80	428	523
Volume Left	3	3	25	32
Volume Right	40	68	5	50
cSH	390	469	1048	1127
Volume to Capacity	0.13	0.17	0.02	0.03
Queue Length 95th (ft)	11	15	2	2
Control Delay (s)	15.6	14.3	0.7	0.8
Lane LOS	C	B	A	A
Approach Delay (s)	15.6	14.3	0.7	0.8
Approach LOS	C	B		

Intersection Summary			
Average Delay		2.5	
Intersection Capacity Utilization	50.8%	ICU Level of Service	A
Analysis Period (min)		15	

Queues

1: Libbie Ave & Grove Ave

5/25/2016



Lane Group	EBT	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	349	949	41	232	122	384
v/c Ratio	0.85	0.78	0.32	0.70	0.62	0.81
Control Delay	65.7	36.7	54.7	52.7	59.8	48.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	65.7	36.7	54.7	52.7	59.8	48.8
Queue Length 50th (ft)	126	326	28	144	83	230
Queue Length 95th (ft)	#203	#453	63	230	142	#390
Internal Link Dist (ft)	408	392		134		164
Turn Bay Length (ft)						
Base Capacity (vph)	419	1215	155	387	237	481
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.83	0.78	0.26	0.60	0.51	0.80

Intersection Summary

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

HCM Unsignalized Intersection Capacity Analysis

2: Granite Ave & Grove Ave

5/25/2016



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↔↔			↔↔			↔			↔	
Volume (veh/h)	29	361	16	25	838	107	4	7	14	61	17	39
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	32	392	17	27	911	116	4	8	15	66	18	42
Pedestrians					2			15			45	
Lane Width (ft)					12.0			12.0			12.0	
Walking Speed (ft/s)					4.0			4.0			4.0	
Percent Blockage					0			1			4	
Right turn flare (veh)												
Median type		None			None							
Median storage (veh)												
Upstream signal (ft)		472										
pX, platoon unblocked				0.95			0.95	0.95	0.95	0.95	0.95	
vC, conflicting volume	1072			425			1041	1606	222	1349	1556	559
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1072			279			930	1527	65	1255	1475	559
tC, single (s)	4.1			4.1			7.5	6.5	6.9	7.5	6.5	6.9
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	95			98			97	92	98	34	83	91
cM capacity (veh/h)	633			1210			151	99	926	100	107	460

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	228	214	483	572	27	127
Volume Left	32	0	27	0	4	66
Volume Right	0	17	0	116	15	42
cSH	633	1700	1210	1700	223	137
Volume to Capacity	0.05	0.13	0.02	0.34	0.12	0.93
Queue Length 95th (ft)	4	0	2	0	10	158
Control Delay (s)	2.1	0.0	0.7	0.0	23.4	121.2
Lane LOS	A		A		C	F
Approach Delay (s)	1.1		0.3		23.4	121.2
Approach LOS					C	F

Intersection Summary

Average Delay	10.2
Intersection Capacity Utilization	63.2%
ICU Level of Service	B
Analysis Period (min)	15

HCM Unsignalized Intersection Capacity Analysis

3: Libbie Ave & York Rd

5/25/2016



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↔			↔			↔			↔	
Volume (veh/h)	3	8	37	30	8	80	23	366	5	34	406	46
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	3	9	40	33	9	87	25	398	5	37	441	50
Pedestrians		19			18			4			25	
Lane Width (ft)		12.0			12.0			12.0			12.0	
Walking Speed (ft/s)		4.0			4.0			4.0			4.0	
Percent Blockage		2			1			0			2	
Right turn flare (veh)												
Median type								None			None	
Median storage (veh)												
Upstream signal (ft)								512				
pX, platoon unblocked	0.90	0.90		0.90	0.90	0.90				0.90		
vC, conflicting volume	1126	1030	489	1057	1053	444	510			421		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1086	980	489	1010	1005	331	510			306		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	98	96	93	80	96	86	98			97		
cM capacity (veh/h)	133	208	572	165	201	624	1048			1127		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	52	128	428	528
Volume Left	3	33	25	37
Volume Right	40	87	5	50
cSH	382	337	1048	1127
Volume to Capacity	0.14	0.38	0.02	0.03
Queue Length 95th (ft)	12	43	2	3
Control Delay (s)	15.9	22.1	0.7	0.9
Lane LOS	C	C	A	A
Approach Delay (s)	15.9	22.1	0.7	0.9
Approach LOS	C	C		

Intersection Summary			
Average Delay		3.9	
Intersection Capacity Utilization	57.0%		ICU Level of Service
Analysis Period (min)		15	B