PRE-MEETING AGENDA
MOUNTAIN BROOK CITY COUNCIL

PRE-COUNCIL ROOM (A106) CITY HALL
56 CHURCH STREET
MOUNTAIN BROOK, AL 35213

TUESDAY, MAY 26, 2015, 6:30 P. M.

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1. Traffic improvement recommendations for Church Street/Montevallo Road/Montrose Road intersection – Richard Caudle, Skipper Consultants.

From: Richard Caudle [mailto:richard@skipperinc.com]
Sent: Tuesday, May 12, 2015 3:01 PM
To: gastons@mtnbrook.org; Ronald Vaughn; Ted Cook; Robert Ezekiel (ezekielr@mtnbrook.org); Dana Hazen
Cc: Mike Kaczorowski
Subject: Montevallo at Church/Montrose

OK ladies and gentlemen. I have a great idea for the intersection of Church at Montevallo that I want to get your input on before I go any further.

The attached pdf file is a sketch which helps explain my idea (montevallo at church signal 051215.pdf).

Background Information – The existing signal operates with three phases – Montevallo Road NB+SB, then Church Street EB, then Montrose Rd WB. See the top half of the pdf file. The side streets run what is called "split phase". Looking at the traffic counts, the left turns from Church Street and Montrose Road onto Montevallo Road are both very small compared to the through movements. Therefore, the signal would be much more efficient if the left turns from Church and Montrose ran together and then the through movements ran together. But it is not possible for the left turns to run together since they occupy the same paving in the middle of the intersection.

We could reconstruct and restripe the intersection such that there would be separation between the left turns. But we could also phase the signal such that the left turn from Church Street leads and the left turn from Montrose Road lags (or vice versa). See the bottom half of the pdf file. The left turns can be given all the green time they need, the side street through movements get more time, and Montevallo Road get the same amount of time. The cycle length would be shorter by around 20 seconds, which would help Montevallo.

I have analyzed the a.m. peak hour. Currently, the overall intersection is experiencing a level of service F with an average delay per vehicle of 180 seconds with long queues on several movements. This is in line with what I have observed in the field. The proposed improvements yield a level of service D with an average delay of 40 seconds per vehicle with a corresponding significant reduction in most of the queues.

A quick estimate of the cost to perform this work would be around $5,000 in engineering and $30,000 in signal construction. The signal construction would be a new cabinet, two new signal heads and signs, and getting the vehicle detector loops working and assigned to right phases.

I have attached the capacity worksheets in case you want to look at them. (am peak los and queue worksheets 051215.pdf).

I have looked at the counts for the afternoon school peak and p.m. peak, and this solution is applicable for these time periods as well and should have similar improvements.

Please let me know your thoughts about this. If we need to meet in the field and look at it first hand, let me know. If you think someone else needs to look at this idea, feel free to forward this email onto them.

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From: Richard Caudle [mailto:richard@skipperinc.com]
Sent: Wednesday, May 20, 2015 9:18 AM
To: gastons@mtnbrook.org; Ronald Vaughn
Subject: Overbrook Road at Mountain Brook Parkway/Pine Ridge Road

Attached is the signal modification plan for the intersection of Overbrook Road at Mountain Brook Parkway/Pine Ridge Road. I have calculated the estimated cost of this work to be approximately $34,000. I am going to send this plan over to Stone and Sons Electrical to see if they would be willing to provide a price, and if it is less than $50,000, to get them to send a contract to the City for the work.

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Received 5/22/2015

Montevallo Road at Church Street/Montrose Road

The intersection of Montevallo Road at Church Street/Montrose Road was examined to determine the scope of both non-widening and widening projects which could alleviate existing traffic congestion experienced at the intersection. The general study area for the analysis is shown in Figure 1.

Figure 1. Site Location Map

In the vicinity of the intersection, Montevallo Road is a two lane urban minor arterial roadway with a posted speed limit of 30 miles per hour. Church Street is a three lane local roadway with a posted speed limit of 20 miles per hour. Montrose Road is a two lane local roadway with a posted speed limit of 30 miles per hour. The intersection of Montevallo Road at Church Street/Montrose Road is controlled by a traffic signal. Traffic conditions at the intersection are significantly influenced by the presence of Crestline Elementary School, located on Church Street immediately west of Montevallo Road.

Existing Intersection Turning Movement Traffic Counts

An existing intersection turning movement traffic count was performed at the intersection of Montevallo Road at Church Street/Montrose Road on Wednesday to Thursday, May 14 to 15, 2014, during the hours of 7:00 to 9:00 a.m., 2:30 to 3:30 p.m., and 4:00 to 6:00 p.m., by Traffic Data, LLC on behalf of Skipper Consulting, Inc. The traffic count data is included in Appendix A. Peak hour turning movement traffic volumes are illustrated in Figure 2.

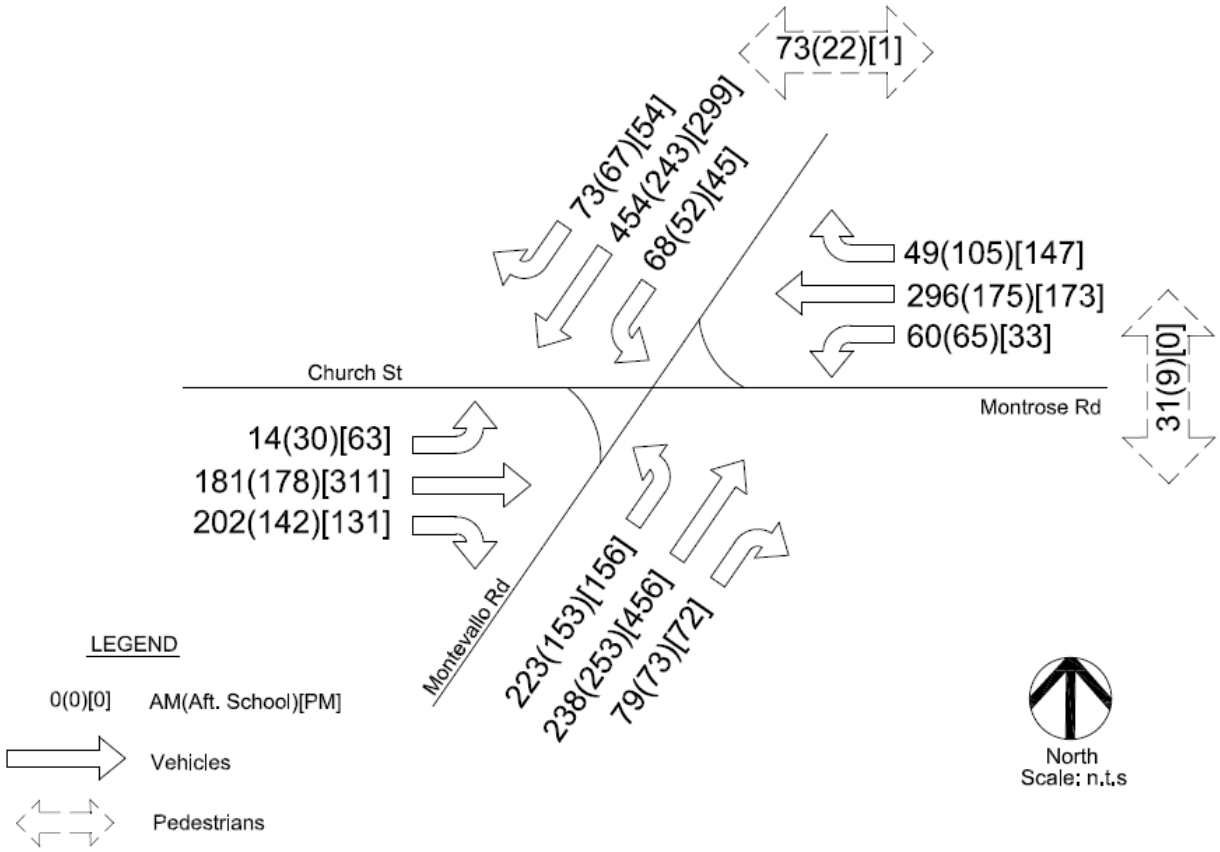


Figure 2. Existing Intersection Turning Movement Traffic Counts

Existing Traffic Signal Phasing and Timing

The existing traffic signal operates with a single phase Montevallo Road northbound and southbound (Phase 2), and split phase side street movements (Church Street = Phase 3 and Montrose Road = Phase 4). There is a pedestrian phase associated with Phases 2 and 4 for pedestrian crossings of Montrose Road and Montevallo Road. The existing traffic signal operating plan is shown in Figure 3. The existing traffic signal programming chart is shown in Table 1.

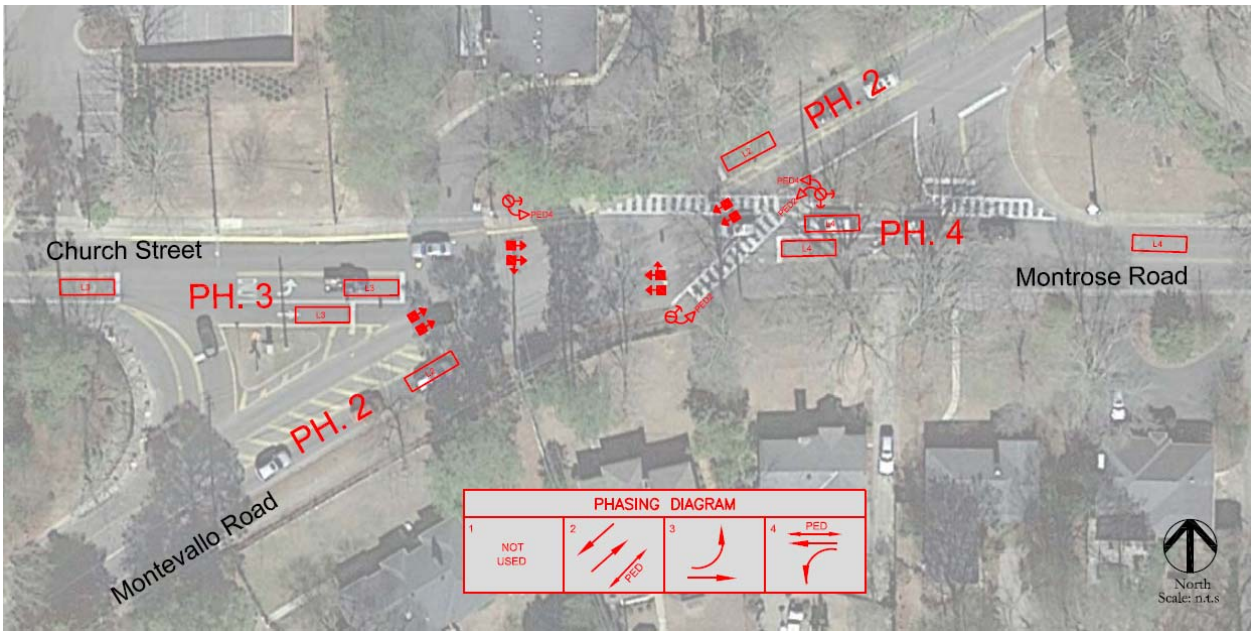


Figure 3. Existing Traffic Signal Operating Plan

Table 1. Existing Traffic Signal Controller Programming

	1	***2***	***3***	***4***
Min. Green		15	8	8
Passage		5	4	5
Max. Green 1		40	30	30
Max. Green 2		50	30	50
Yellow		4	4	4
All Red		1	1	1
Walk		10		10
Don't Walk		10		10
Recall		Max		
Non-Lock			X	X

<u>Existing Intersection Capacity Analysis and Queue Calculations</u>

Existing peak hour intersection capacity analyses and queue calculations were performed for the intersection of Montevallo Road at Church Street/Montrose Road using the methods of analysis contained in the 2010 *Highway Capacity Manual*, published by the Transportation Research Board. Capacities are expressed as levels of service, and range from a level of service "A" (highest quality of service) to a level of service "F" (jammed conditions). As a general rule, operation at a level of service "C" or better is desirable, with a level of service "D" considered acceptable during the peak hours of traffic flow. The results of the intersection capacity analyses and queue calculations are included in Appendix B and are summarized in Table 2.

Table 2. Existing Intersection Capacity Analysis and Queue Calculations

Approach	Movement	AM Peak			Aft. School Peak			PM Peak		
		LOS	Delay	Queue	LOS	Delay	Queue	LOS	Delay	Queue
Church Street Eastbound	Left	C	30	25’	C	30	40’	C	30	75’
	Through/Right	F	93	420’	E	65	345’	F	142	550’
	Overall approach	*F*	*90*		*E*	*62*		*F*	*128*	
Montrose Road Westbound	Left	C	33	75’	C	32	75’	C	33	45’
	Through/Right	E	60	400’	D	47	270’	D	55	325’
	Overall approach	E	56		D	44		D	52	
Montevallo Road Northbound	Left	F	399	405’	D	37	175’	E	59	215’
	Through/Right	D	35	285’	C	28	270’	F	81	585’
	Overall approach	*F*	*200*		*C*	*31*		*E*	*76*	
Montevallo Road Southbound	Left-Through-Right	F	323	935’	D	36	435’	F	878	665’
	Overall intersection	***F***	***180***		***D***	***43***		***F***	***228***	

Note: Delay is expressed in average seconds per vehicle

Crash History

Crash information for the intersection of Montevallo Road at Church Street/Montrose Road was provided by the City of Mountain Brook Police Department for 2012, 2013, and 2014. During the period, there were 22 crashes related to the intersection of Montevallo Road at Church Street/Montrose Road. A crash diagram is provided in Figure 4.

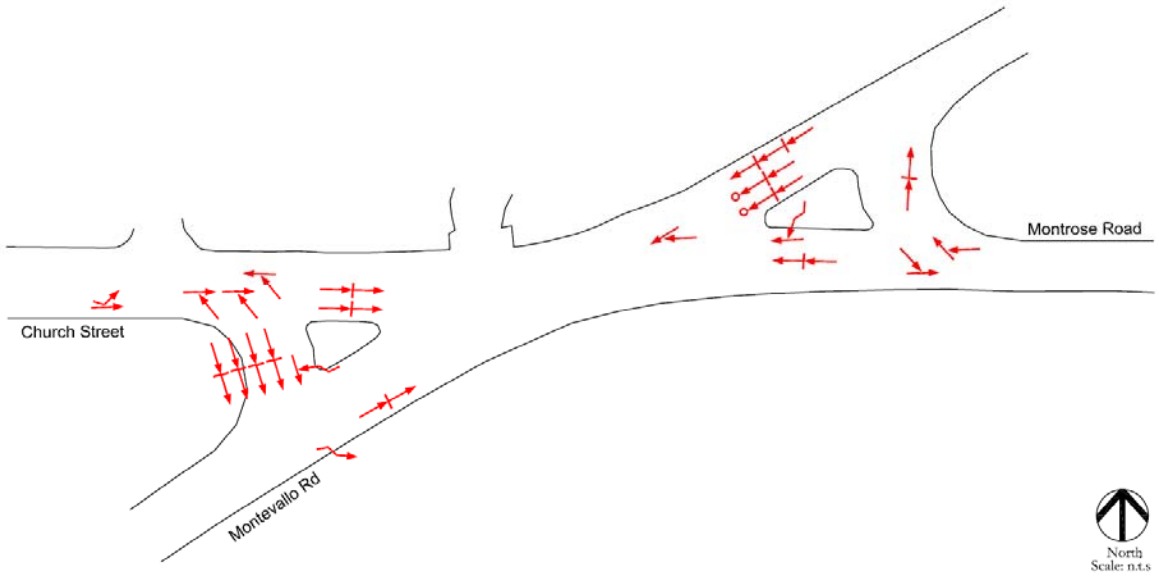


Figure 4. Crash History

Observations

Observations of traffic flow at the intersection of Montevallo Road at Church Street/Montrose Road were performed on Wednesday to Thursday, May 6 to 7, 2015 by Skipper Consulting, Inc. Observations were conducted from 7:20 to 8:00 a.m., 2:40 to 3:05 p.m., and 4:25 to 5:30 p.m. The findings of the observations are discussed below.

AM Peak Period Observations

- The Montevallo Road southbound queue did not clear during any signal cycle from 7:28 a.m. until 8:00 a.m. The extent of the queue was beyond sight from 7:42 a.m. to 7:53 a.m.
- The northbound left turn queue on Montevallo Road turning onto Church Street exceeded the queue storage repeatedly from 7:35 a.m. to 7:48 a.m.
- The Montrose Road westbound queue did not clear on any signal cycle from 7:37 a.m. to 7:53 a.m. The queue was backed beyond sight from 7:39 a.m. to 7:48 a.m.
- There were several instances where southbound left turning vehicles on Montevallo Road turning onto Montrose Road caused congestion and delay on Montevallo Road southbound

Afternoon School Peak Period Observations

- The Montrose Road westbound queue did not clear from 2:50 p.m. to 2:59 p.m.

PM Peak Period Observations

- There were repeated instances where the eastbound queue on Church Street did not clear between 4:28 p.m. to 5:14 p.m. The queue extended past Oak Street from 5:08 p.m. to 5:14 p.m.
- Beginning at 4:31 p.m., Montevallo Road northbound exhibited a continuous stream of moving vehicles with the end of the queue backed beyond sight. The queue of vehicles extended south beyond Overbrook Road.

Short-Term Improvements

The existing traffic signal at the intersection of Montevallo Road at Church Street/Montrose Road operates with three phases – Montevallo Road northbound + southbound, then Church Street eastbound, then Montrose Rd westbound (see Figure 3 previous in this report). The side streets run what in what is called "split phase" mode. Based on the traffic counts, the left turn volumes from Church Street and Montrose Road onto Montevallo Road are both small compared to the through movement volumes. Therefore, the signal would be more efficient if the left turns from Church Street and Montrose Road ran together and then the through movements on Church Street and Montrose Road ran together. But it is not possible for the left turns to run together since they occupy the same paving in the middle of the intersection, as shown in Figure 5.

Figure 5. Side Street Left Turn Overlap

The intersection could be reconstructed and restriped such that there would be sufficient separation between the left turns. But the traffic signal could also be phased such that the left turn from Church Street leads and the left turn from Montrose Road lags (or vice versa), thereby avoiding reconstruction and restriping. The proposed traffic signal phasing diagram is shown in Figure 6.

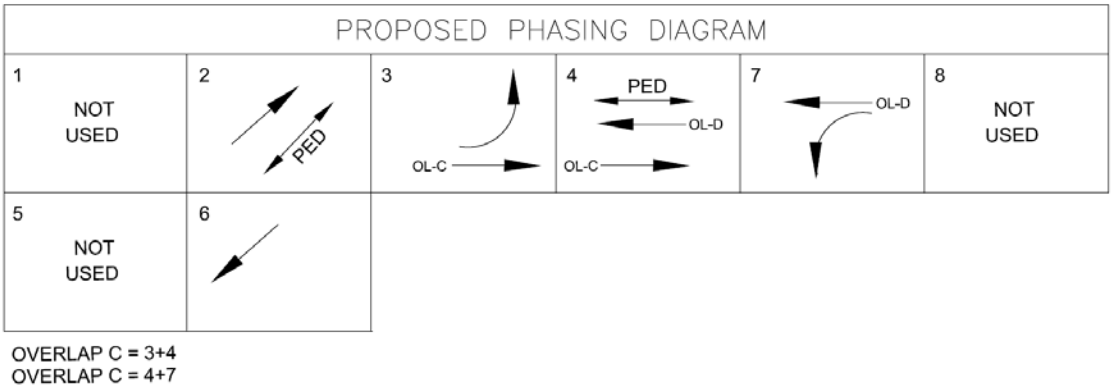


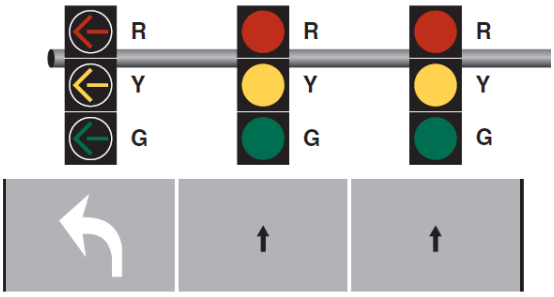
Figure 6. Proposed Traffic Signal Phasing Diagram

The proposed improvements would require modification to the traffic signal, including the following:

- Installation of a new traffic signal controller cabinet
- Installation of four new traffic signal heads and related signing
- Installation and wiring of vehicle loop detectors

The traffic signal indications facing Church Street and Montrose Road will be altered. The existing signal indications have a four section head with a green left turn arrow and a three section signal head facing both Church Street Montrose Road. The proposed signal indications will have a three section head with arrows for the left turn lane and two three section heads for the through movements. The left turn signal indications are illustrated in Figure 7.

Existing Left Turn Signal Indications



Proposed Left Turn Signal Indications

Figure 7. Side Street Left Turn Signal Indications

The proposed short-term improvement plan is shown in Figure 8. The proposed traffic signal timing chart is shown in Table 3.

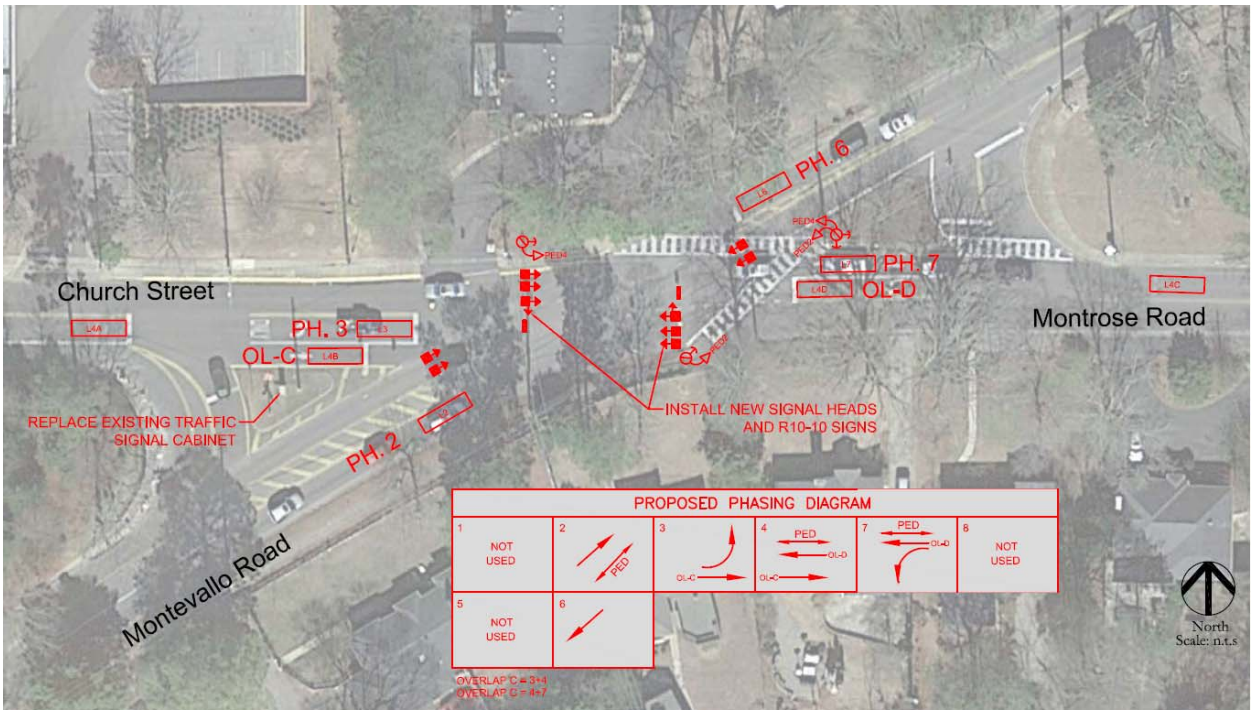


Figure 8. Proposed Short-Term Improvement Plan

Table 3. Proposed Traffic Signal Controller Programming

	1	***2***	***3***	***4***	***5***	***6***	***7***	***8***
Min. Green		15	4	8		15	4	
Passage		4	4	4		4	4	
Max. Green 1		45	15	35		45	15	
Max. Green 2		45	15	35		45	15	
Yellow		4	3.5	4		4	3.5	
All Red		1	1	1		1	1	
Walk		10		10				
Don't Walk		10		10				
Recall		Min				Min		
Non-Lock			X	X			X	

Overlap C = 3+4 Overlap D = 4+7

Operational Analysis of Short-Term Improvements

An operational assessment of the proposed short-term improvements was performed by determining the resultant levels of service, delay, and queues for the intersection of Montevallo Road at Church Street/Montrose Road with the proposed improvements in place. The results of these analyses are included in Appendix C and are summarized in Table 4.

Table 4. Intersection Capacity Analysis and Queue Calculations with Short-Term Improvements

Approach	***Movement***	***AM Peak***			***Aft. School Peak***			***PM Peak***		
		LOS	***Delay***	***Queue***	***LOS***	***Delay***	***Queue***	***LOS***	***Delay***	***Queue***
Church Street Eastbound	Left	D	42	25'	D	38	50'	D	40	75'
	Through/Right	D	45	290'	C	28	240'	D	41	335'
	Overall approach	*D*	*45*		*C*	*28*		*D*	*41*	
Montrose Road Westbound	Left	D	54	100'	D	36	80'	D	44	55'
	Through/Right	C	32	290'	C	22	185'	C	29	245'
	Overall approach	D	35		C	25		C	31	
Montevallo Road Northbound	Left	E	76	260'	D	44	195'	C	29	135'
	Through/Right	B	18	180'	C	30	280'	D	39	395'
	Overall approach	*D*	*42*		*C*	*35*		*D*	*37*	
Montevallo Road Southbound	Left-Through-Right	C	34	565'	D	47	460'	F	123	505'
Overall intersection		***D***	***39***		***C***	***33***		***D***	***52***	

Note: Delay is expressed in average seconds per vehicle

Cost Estimate of Short-Term Improvements

The cost estimate to implement the short-term improvement proposal is shown in Table 5.

Table 5. Cost Estimate – Short-Term Improvements

Intersection: Montevallo Road at Church Street/Montrose Road
Location: Mountain Brook, Alabama

Quantity	Unit	Description	Installed Unit Price	Installed Total Price
		Cabinets and Controllers		
1	ea	traffic signal controller, 8 phase and 12 channel conflict monitor, in base mounted	$10,900.00	$10,900
1	ea	controller and cabinet removal	$1,500.00	$1,500
		Vehicle Detection Devices and Cameras		
8	ea	single channel loop detector amplifier	$180.00	$1,440
		Signal Heads		
4	ea	traffic signal head, one way, three section, 12", red, yellow, green, all LED	$700.00	$2,800
2	ea	signal head removal	$150.00	$300
2	ea	signal head relocation\	$250.00	$500
		Cables and Wiring		
500	lf	4c#14 signal cable	$0.50	$250
2500	lf	#12 loop wire	$2.00	$5,000
1600	lf	2c#12 with ground shielded loop home run cable	$0.90	$1,440
		Signing and Traffic Control		
2	ea	sign, 30"x36", with mounting hardware	$150.00	$300
250	sf	construction signs	$12.00	$3,000
25	ea	drums	$75.00	$1,875
8	hour	off duty police officer	$43.00	$344
		subtotal		**$29,649**
		+15% contingencies		**$4,447**
		subtotal construction		**$34,096**
		engineering		**$5,000**
		grand total		**$39,096**

Funding Sources for Short-Term Improvements

The only reasonable source of funding for the proposed short-term improvements to the intersection of Montevallo Road at Church Street/Montrose Road is local funding.

Long-Term Improvements

The operational analysis of short-term improvements indicates that there will continue to be a capacity deficiency for the southbound through movement on Montevallo Road during the p.m. peak hour. The deficiency is due, at least in part, to the lack of an exclusive left turn lane on Montevallo Road southbound turning left onto Montrose Road. In order to determine if a left turn lane is warranted on Montevallo Road westbound, the existing p.m. peak hour traffic volumes were analyzed using the left turn warrant analysis methodology contained in the National Cooperative Highway Research Project (NCHRP) Report 457. The results of this analysis are depicted in Figure 9, and indicate a left turn lane is warranted on Montevallo Road southbound.

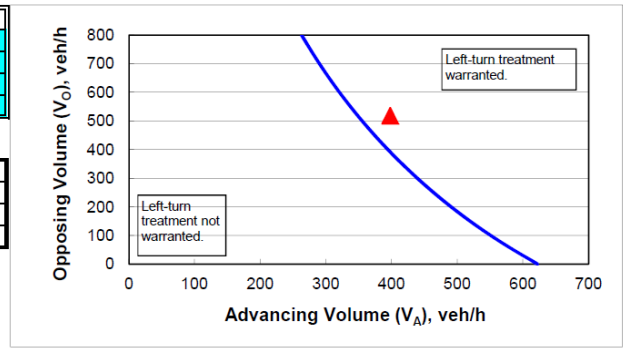
2-lane roadway (English)

INPUT

Variable	Value
85th percentile speed, mph:	30
Percent of left-turns in advancing volume (V_A), %:	11%
Advancing volume (V_A), veh/h:	398
Opposing volume (V_O), veh/h:	519

OUTPUT

Variable	Value
Limiting advancing volume (V_A), veh/h:	348
Guidance for determining the need for a major-road left-turn bay:	
Left-turn treatment warranted.	



CALIBRATION CONSTANTS

Variable	Value
Average time for making left-turn, s:	3.0
Critical headway, s:	5.0
Average time for left-turn vehicle to clear the advancing lane , s:	1.9

Figure 9. Left Turn Lane Warrant Analysis

A conceptual design was prepared for the proposed left turn. In addition, the proposed widening also allows for the separation of the side street left turns so that they can run together. The proposed long-term improvement plan is depicted in Figure 10.

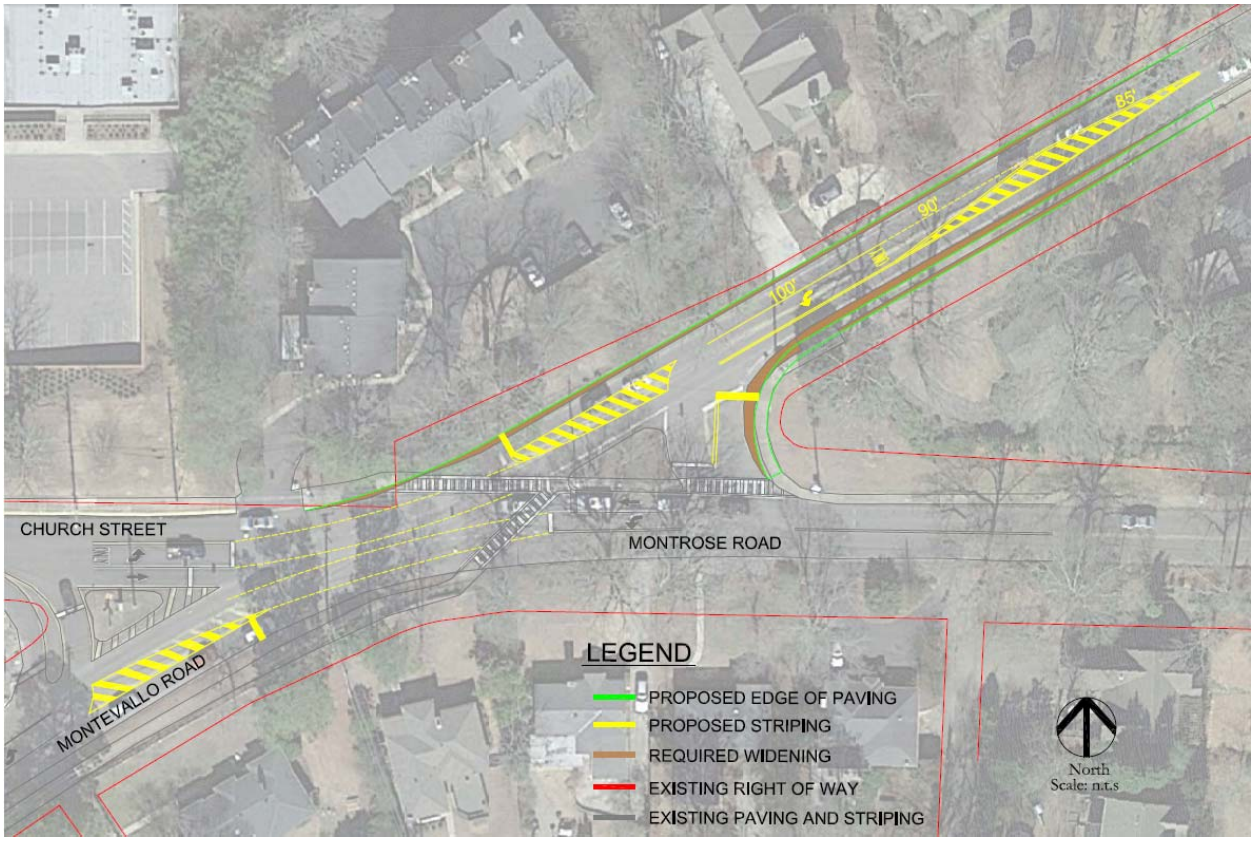


Figure 10. Proposed Long-Term Improvement Plan

The proposed long-term improvements can be accomplished within the existing right-of-way; however, there are improvements within the existing right-of-way which would be impacted by the proposed widening. The most significant of these impacts include:

- a stone wall and fence along the frontage of Church Court Condominiums
- five driveway connections to Montevallo Road
- three utility poles

Pictures of affected areas are included on the following page.

Operational Analysis of Long-Term Improvements

An operational assessment of the proposed long-term improvements was performed by determining the resultant levels of service, delay, and queues for the intersection of Montevallo Road at Church Street/Montrose Road with the proposed improvements in place. The results of these analyses are included in Appendix D and are summarized in Table 6.

Table 6. Intersection Capacity Analysis and Queue Calculations with Short-Term Improvements

Approach	Movement	AM Peak			Aft. School Peak			PM Peak		
		LOS	Delay	Queue	LOS	Delay	Queue	LOS	Delay	Queue
Church Street Eastbound	Left	C	23	15’	C	20	20’	B	16	40’
	Through/Right	D	53	310’	C	34	250’	C	35	295’
	Overall approach	*D*	*52*		*C*	*33*		*C*	*32*	
Montrose Road Westbound	Left	C	27	55’	B	17	40’	C	22	25’
	Through/Right	C	33	305’	C	22	170’	C	28	235’
	Overall approach	C	32		C	21		C	27	
Montevallo Road Northbound	Left	E	76	255’	C	22	180’	C	25	150’
	Through/Right	B	15	160’	B	19	290’	C	31	420’
	Overall approach	*D*	*40*		*B*	*20*		*C*	*30*	
Montevallo Road Southbound	Left	B	13	50’	B	15	65’	C	29	85’
	Through/Right	B	18	325’	B	17	280’	B	18	255’
	Overall approach	B	18		B	17		B	19	
	Overall intersection	***D***	***35***		***C***	***23***		***C***	***28***	

Note: Delay is expressed in average seconds per vehicle

Cost Estimate of Long-Term Improvements

The cost estimate to implement the long-term improvement proposal is shown in Table 7.

Funding Sources for Long-Term Improvements

There are two possible funding sources for the proposed long-term projects: federal funding and local funding. Since Montevallo Road is a classified urban minor arterial roadway, it would qualify for the use of Federal transportation funding. The most likely source of Federal transportation would be through the Birmingham area Metropolitan Planning Organization as a Surface Transportation Program (STP) Birmingham Attributable (BH) project. If the project was pursued as an STPBH project, the funding split would be 80% Federal/20% City. The allocation of funds would be:

Preliminary Engineering

Federal share		$36,300
City share		$ 9,100
	Total	$45,400

Construction

Federal share		$242,100
City share		$ 60,500
	Total	$302,600

Table 7. Cost Estimate – Long-Term Improvements

	Quantity	Unit	Unit Cost	Extended Cost
REMOVALS/RELOCATIONS				
Removal of existing traffic control markings	500	sq.ft.	$ 2.60	$ 1,300.00
Removal of existing traffic signal (partial)	1	lump sum	$ 5,000.00	$ 5,000.00
Removal of curb and gutter/valley gutter	750	lf	$ 12.00	$ 9,000.00
Removal of exisitng driveway apron	160	sq.yd.	$ 12.00	$ 1,920.00
Removal of existing sidewalk	110	sq.yd.	$ 12.00	$ 1,320.00
Relocation of existing utility pole	3	each	$16,000.00	$ 48,000.00
subtotal - removals				*$ 66,540.00*
INSTALLATIONS				
Unclassified excavation	165	cu.yd.	$ 25.00	$ 4,125.00
Sawcut existing paving	1000	lf	$ 3.00	$ 3,000.00
Base and pave	165	sq.yd.	$ 30.00	$ 4,950.00
Overlay	2630	sq.yd.	$ 13.00	$ 34,190.00
Sidewalk, 4'	222	sq.yd.	$ 35.00	$ 7,770.00
Curb and gutter	1000	lf	$ 25.00	$ 25,000.00
ADA ramp	22	sq.yd.	$ 70.00	$ 1,540.00
Driveway apron	160	sq.yd.	$ 60.00	$ 9,600.00
Traffic control markings	500	sq.ft.	$ 4.00	$ 2,000.00
Traffic signal modifications	1	lump sum	$30,000.00	$ 30,000.00
Water meter reset	3	each	$ 660.00	$ 1,980.00
subtotal - installations				*$ 124,155.00*
total construction cost without overhead				*$ 190,695.00*
OVERHEAD				
Mobilization (9%)				$ 17,162.55
Geometric controls (1%)				$ 1,906.95
Eroison control (2%)				$ 3,813.90
Traffic handling (5%)				$ 9,534.75
Clearing and grubbing (2%)				$ 5,720.85
Landscaping (2%)				$ 3,813.90
Construciton fuel (1%)				$ 1,906.95
Construction engineering and inspection (15%)				$ 28,604.25
total construction cost estimate without contingencies				*$ 263,159.10*
Contingencies (15%)				$ 39,473.87
total construction cost estimate with contingencies				***$ 302,632.97***
PRELIMINARY ENGINEERING				
Survey (5%)				$ 15,131.65
Preliminary engineering (10%)				$ 30,263.30
total - preliminary engineering				***$ 45,394.94***
TOTAL PROJECT COST				**$ 348,027.91**

Appendix A

Intersection Turning Movement Traffic Counts

TRAFFIC DATA, LLC

1409 Turnham Lane
Birmingham, AL 35216
205-824-0125

Mountain Brook, AL

File Name : mtnbrook02
Site Code : 00000000
Start Date : 05/14/2014
Page No : 1

Groups Printed- Unshifted

	MONTEVALLO RD Southbound				MONTOSE RD Westbound				MONTEVALLO RD Northbound				CHURCH ST Eastbound				
Start Time	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Int. Total
02:30 PM	6	55	21	0	19	53	21	0	47	52	15	0	5	26	28	0	348
02:45 PM	11	44	16	14	12	38	35	7	42	69	5	0	4	35	22	0	354
Total	17	99	37	14	31	91	56	7	89	121	20	0	9	61	50	0	702
03:00 PM	17	91	20	8	19	41	16	2	14	48	10	0	10	65	54	0	415
03:15 PM	18	53	10	0	15	43	33	0	53	84	43	0	11	52	38	0	453
Total	35	144	30	8	34	84	49	2	67	132	53	0	21	117	92	0	868
04:00 PM	5	45	9	1	10	41	17	1	36	98	10	0	11	36	43	0	363
04:15 PM	6	62	10	0	8	39	30	0	33	112	9	0	11	47	46	0	413
04:30 PM	12	77	8	0	4	31	19	0	36	116	18	0	13	48	38	0	420
04:45 PM	14	50	14	1	14	43	23	0	34	101	14	0	11	70	30	0	419
Total	37	234	41	2	36	154	89	1	139	427	51	0	46	201	157	0	1615
05:00 PM	19	76	11	0	10	45	30	0	43	109	20	0	17	65	42	0	487
05:15 PM	4	74	11	0	11	39	46	0	28	99	26	0	14	82	43	0	477
05:30 PM	11	78	22	1	5	42	40	0	45	131	18	0	15	75	23	0	506
05:45 PM	11	71	10	0	7	47	31	0	40	117	8	0	17	89	23	0	471
Total	45	299	54	1	33	173	147	0	156	456	72	0	63	311	131	0	1941
07:00 AM	19	89	10	3	12	36	11	0	32	41	8	0	5	27	31	0	324
07:15 AM	17	124	22	2	8	63	12	1	53	49	18	0	5	41	37	0	452
07:30 AM	12	109	10	50	9	65	3	28	64	53	11	0	1	69	66	0	550
07:45 AM	22	102	20	14	25	82	19	2	69	86	27	0	2	42	67	0	579
Total	70	424	62	69	54	246	45	31	218	229	64	0	13	179	201	0	1905
08:00 AM	17	119	21	7	18	86	15	0	37	50	23	0	6	29	32	0	460
08:15 AM	17	110	9	4	18	50	17	0	40	33	10	0	5	37	22	0	372
08:30 AM	17	110	14	4	10	35	8	2	47	51	5	0	5	30	29	0	367
08:45 AM	14	114	15	2	14	44	16	5	61	60	16	0	8	24	33	0	426
Total	65	453	59	17	60	215	56	7	185	194	54	0	24	120	116	0	1625
Grand Total	269	1653	283	111	248	963	442	48	854	1559	314	0	176	989	747	0	8656
Apprch %	11.6	71.4	12.2	4.8	14.6	56.6	26.0	2.8	31.3	57.2	11.5	0.0	9.2	51.7	39.1	0.0	
Total %	3.1	19.1	3.3	1.3	2.9	11.1	5.1	0.6	9.9	18.0	3.6	0.0	2.0	11.4	8.6	0.0	

	MONTEVALLO RD Southbound					MONTOSE RD Westbound					MONTEVALLO RD Northbound					CHURCH ST Eastbound					
Start Time	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Int. Total
Peak Hour From 04:00 PM to 05:45 PM - Peak 1 of 1																					
Intersection	05:00 PM																				
Volume	45	299	54	1	399	33	173	147	0	353	156	456	72	0	684	63	311	131	0	505	1941
Percent	11.3	74.9	13.5	0.3		9.3	49.0	41.6	0.0		22.8	66.7	10.5	0.0		12.5	61.6	25.9	0.0		
05:30 Volume	11	78	22	1	112	5	42	40	0	87	45	131	18	0	194	15	75	23	0	113	506
Peak Factor																					0.959
High Int.	05:30 PM					05:15 PM					05:30 PM					05:15 PM					
Volume	11	78	22	1	112	11	39	46	0	96	45	131	18	0	194	14	82	43	0	139	
Peak Factor					0.891					0.919					0.881					0.908	

TRAFFIC DATA, LLC

1409 Turnham Lane
Birmingham, AL 35216
205-824-0125

File Name : mtnbrook02
Site Code : 00000000
Start Date : 05/14/2014
Page No : 2

	MONTEVALLO RD Southbound					MONTOSE RD Westbound					MONTEVALLO RD Northbound					CHURCH ST Eastbound					
Start Time	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Int. Total
Peak Hour From 04:00 PM to 05:45 PM - Peak 1 of 1																					
By Approach	05:00 PM					05:00 PM					05:00 PM					05:00 PM					
Volume	45	299	54	1	399	33	173	147	0	353	156	456	72	0	684	63	311	131	0	505	
Percent	11.3	74.9	13.5	0.3		9.3	49.0	41.6	0.0		22.8	66.7	10.5	0.0		12.5	61.6	25.9	0.0		
High Int.	05:30 PM					05:15 PM					05:30 PM					05:15 PM					
Volume	11	78	22	1	112	11	39	46	0	96	45	131	18	0	194	14	82	43	0	139	
Peak Factor					0.891					0.919					0.881					0.908	
Peak Hour From 07:00 AM to 08:45 AM - Peak 1 of 1																					
Intersection	07:15 AM																				
Volume	68	454	73	73	668	60	296	49	31	436	223	238	79	0	540	14	181	202	0	397	2041
Percent	10.2	68.0	10.9	10.9		13.8	67.9	11.2	7.1		41.3	44.1	14.6	0.0		3.5	45.6	50.9	0.0		
07:45 Volume	22	102	20	14	158	25	82	19	2	128	69	86	27	0	182	2	42	67	0	111	579
Peak Factor																					0.881
High Int.	07:30 AM					07:45 AM					07:45 AM					07:30 AM					
Volume	12	109	10	50	181	25	82	19	2	128	69	86	27	0	182	1	69	66	0	136	
Peak Factor					0.923					0.852					0.742					0.730	
Peak Hour From 07:00 AM to 08:45 AM - Peak 1 of 1																					
By Approach	07:15 AM					07:30 AM					07:15 AM					07:15 AM					
Volume	68	454	73	73	668	70	283	54	30	437	223	238	79	0	540	14	181	202	0	397	
Percent	10.2	68.0	10.9	10.9		16.0	64.8	12.4	6.9		41.3	44.1	14.6	0.0		3.5	45.6	50.9	0.0		
High Int.	07:30 AM					07:45 AM					07:45 AM					07:30 AM					
Volume	12	109	10	50	181	25	82	19	2	128	69	86	27	0	182	1	69	66	0	136	
Peak Factor					0.923					0.854					0.742					0.730	

Appendix B

Intersection Capacity Analysis Worksheets
Existing

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
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		1.00	1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	0.97		1.00	0.97			0.97	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frt	1.00	0.92		1.00	0.98		1.00	0.96			0.98	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.99	
Satd. Flow (prot)	1770	1715		1770	1765		1770	1746			1767	
Flt Permitted	0.95	1.00		0.95	1.00		0.24	1.00			0.62	
Satd. Flow (perm)	1770	1715		1770	1765		452	1746			1095	
Volume (vph)	14	181	202	60	296	49	223	238	79	68	454	73
Peak-hour factor, PHF	0.73	0.73	0.73	0.85	0.85	0.85	0.74	0.74	0.74	0.92	0.92	0.92
Adj. Flow (vph)	19	248	277	71	348	58	301	322	107	74	493	79
RTOR Reduction (vph)	0	35	0	0	5	0	0	10	0	0	4	0
Lane Group Flow (vph)	19	490	0	71	401	0	301	419	0	0	642	0
Confl. Peds. (#/hr)	73			31		73			31	31		73
Turn Type	Split			Split			Perm			Perm		
Protected Phases	3	3		4	4			2			2	
Permitted Phases							2			2		
Actuated Green, G (s)	30.0	30.0		27.7	27.7		40.0	40.0			40.0	
Effective Green, g (s)	31.0	31.0		28.7	28.7		41.0	41.0			41.0	
Actuated g/C Ratio	0.28	0.28		0.25	0.25		0.36	0.36			0.36	
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0			5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)	487	472		451	449		164	635			398	
v/s Ratio Prot	0.01	c0.29		0.04	c0.23			0.24				
v/s Ratio Perm							c0.67				0.59	
v/c Ratio	0.04	1.04		0.16	0.89		1.84	0.66			1.61	
Uniform Delay, d1	29.9	40.9		32.6	40.5		35.9	30.0			35.9	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2	0.0	51.8		0.2	19.5		398.7	5.3			286.8	
Delay (s)	30.0	92.6		32.8	60.1		434.5	35.3			322.7	
Level of Service	C	F		C	E		F	D			F	
Approach Delay (s)		90.4			56.0			199.9			322.7	
Approach LOS		F			E			F			F	

Intersection Summary			
HCM Average Control Delay	179.5	HCM Level of Service	F
HCM Volume to Capacity ratio	1.32		
Actuated Cycle Length (s)	112.7	Sum of lost time (s)	12.0
Intersection Capacity Utilization	92.6%	ICU Level of Service	F
Analysis Period (min)	15		

c Critical Lane Group

Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBT
Lane Group Flow (vph)	19	525	71	406	301	429	646
v/c Ratio	0.04	1.04	0.16	0.89	1.88	0.67	1.66
Control Delay	31.4	87.0	33.2	56.8	443.3	35.5	334.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	31.4	87.0	33.2	56.8	443.3	35.5	334.9
Queue Length 50th (ft)	10	~399	40	280	~343	258	~706
Queue Length 95th (ft)	24	#418	74	#400	#405	283	#935
Internal Link Dist (ft)		220		420		420	420
Turn Bay Length (ft)	215		65		140		
Base Capacity (vph)	487	507	477	481	160	645	389
Starvation Cap Reductn	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	0.04	1.04	0.15	0.84	1.88	0.67	1.66

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

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

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
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		1.00	1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	0.97		1.00	0.99			0.99	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frt	1.00	0.93		1.00	0.94		1.00	0.97			0.97	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.99	
Satd. Flow (prot)	1770	1739		1770	1708		1770	1783			1776	
Flt Permitted	0.95	1.00		0.95	1.00		0.42	1.00			0.73	
Satd. Flow (perm)	1770	1739		1770	1708		784	1783			1299	
Volume (vph)	30	178	142	65	175	105	156	253	73	52	243	67
Peak-hour factor, PHF	0.73	0.73	0.73	0.85	0.85	0.85	0.74	0.74	0.74	0.92	0.92	0.92
Adj. Flow (vph)	41	244	195	76	206	124	211	342	99	57	264	73
RTOR Reduction (vph)	0	25	0	0	21	0	0	9	0	0	7	0
Lane Group Flow (vph)	41	414	0	76	309	0	211	432	0	0	387	0
Confl. Peds. (#/hr)	22			9		22			9	9		22
Turn Type	Split			Split			Perm			Perm		
Protected Phases	3	3		4	4			2			2	
Permitted Phases							2			2		
Actuated Green, G (s)	25.1	25.1		22.8	22.8		40.1	40.1			40.1	
Effective Green, g (s)	26.1	26.1		23.8	23.8		41.1	41.1			41.1	
Actuated g/C Ratio	0.25	0.25		0.23	0.23		0.40	0.40			0.40	
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0			5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)	449	441		409	395		313	711			518	
v/s Ratio Prot	0.02	c0.24		0.04	c0.18			0.24				
v/s Ratio Perm							0.27				c0.30	
v/c Ratio	0.09	0.94		0.19	0.78		0.67	0.61			0.75	
Uniform Delay, d1	29.4	37.7		31.8	37.2		25.4	24.6			26.5	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2	0.1	27.6		0.2	9.7		11.1	3.8			9.5	
Delay (s)	29.5	65.2		32.0	46.9		36.5	28.4			36.0	
Level of Service	C	E		C	D		D	C			D	
Approach Delay (s)		62.2			44.1			31.0			36.0	
Approach LOS		E			D			C			D	

Intersection Summary			
HCM Average Control Delay	42.5	HCM Level of Service	D
HCM Volume to Capacity ratio	0.81		
Actuated Cycle Length (s)	103.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	76.1%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBT
Lane Group Flow (vph)	41	439	76	330	211	441	394
v/c Ratio	0.09	0.94	0.19	0.80	0.71	0.61	0.82
Control Delay	32.3	66.5	31.8	40.8	42.8	29.3	44.2
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	32.3	66.5	31.8	40.8	42.8	29.3	44.2
Queue Length 50th (ft)	21	268	40	189	116	222	225
Queue Length 95th (ft)	42	#343	73	268	173	272	#436
Internal Link Dist (ft)		220		420		420	420
Turn Bay Length (ft)	215		65		140		
Base Capacity (vph)	448	466	499	500	298	720	479
Starvation Cap Reductn	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	0.09	0.94	0.15	0.66	0.71	0.61	0.82

Intersection Summary

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

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
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		1.00	1.00			1.00	
Frt	1.00	0.96		1.00	0.93		1.00	0.98			0.98	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.99	
Satd. Flow (prot)	1770	1780		1770	1735		1770	1825			1818	
Flt Permitted	0.95	1.00		0.95	1.00		0.37	1.00			0.22	
Satd. Flow (perm)	1770	1780		1770	1735		680	1825			408	
Volume (vph)	63	311	131	33	173	147	156	456	72	45	299	54
Peak-hour factor, PHF	0.73	0.73	0.73	0.85	0.85	0.85	0.74	0.74	0.74	0.92	0.92	0.92
Adj. Flow (vph)	86	426	179	39	204	173	211	616	97	49	325	59
RTOR Reduction (vph)	0	13	0	0	27	0	0	5	0	0	5	0
Lane Group Flow (vph)	86	592	0	39	350	0	211	708	0	0	428	0
Turn Type	Split			Split			Perm			Perm		
Protected Phases	3	3		4	4			2			2	
Permitted Phases							2			2		
Actuated Green, G (s)	30.1	30.1		25.5	25.5		40.1	40.1			40.1	
Effective Green, g (s)	31.1	31.1		26.5	26.5		41.1	41.1			41.1	
Actuated g/C Ratio	0.28	0.28		0.24	0.24		0.37	0.37			0.37	
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0			5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)	497	500		424	415		252	678			151	
v/s Ratio Prot	0.05	c0.33		0.02	c0.20			0.39				
v/s Ratio Perm							0.31				c1.05	
v/c Ratio	0.17	1.18		0.09	0.84		0.84	1.04			2.83	
Uniform Delay, d1	30.1	39.8		32.7	40.1		31.7	34.8			34.8	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2	0.2	101.7		0.1	14.4		26.9	46.6			843.4	
Delay (s)	30.2	141.5		32.8	54.5		58.6	81.4			878.2	
Level of Service	C	F		C	D		E	F			F	
Approach Delay (s)		127.7			52.4			76.2			878.2	
Approach LOS		F			D			E			F	

Intersection Summary			
HCM Average Control Delay	227.6	HCM Level of Service	F
HCM Volume to Capacity ratio	1.78		
Actuated Cycle Length (s)	110.7	Sum of lost time (s)	12.0
Intersection Capacity Utilization	94.2%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			

Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBT
Lane Group Flow (vph)	86	605	39	377	211	713	433
v/c Ratio	0.17	1.18	0.09	0.85	0.87	1.04	2.89
Control Delay	32.6	135.4	32.4	47.2	67.2	81.7	881.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	32.6	135.4	32.4	47.2	67.2	81.7	881.1
Queue Length 50th (ft)	48	~528	22	234	142	~571	~447
Queue Length 95th (ft)	73	#549	47	324	#213	#587	#664
Internal Link Dist (ft)		220		420		420	420
Turn Bay Length (ft)	215		65		140		
Base Capacity (vph)	497	513	477	494	243	683	150
Starvation Cap Reductn	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	0.17	1.18	0.08	0.76	0.87	1.04	2.89

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

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

Appendix C

Intersection Capacity Analysis Worksheets
Short-Term

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
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		1.00	1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	0.97		1.00	0.98			0.98	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frt	1.00	0.92		1.00	0.98		1.00	0.96			0.98	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.99	
Satd. Flow (prot)	1770	1715		1770	1774		1770	1752			1774	
Flt Permitted	0.95	1.00		0.95	1.00		0.33	1.00			0.85	
Satd. Flow (perm)	1770	1715		1770	1774		616	1752			1516	
Volume (vph)	14	181	202	60	296	49	223	238	79	68	454	73
Peak-hour factor, PHF	0.73	0.73	0.73	0.85	0.85	0.85	0.74	0.74	0.74	0.92	0.92	0.92
Adj. Flow (vph)	19	248	277	71	348	58	301	322	107	74	493	79
RTOR Reduction (vph)	0	43	0	0	6	0	0	12	0	0	5	0
Lane Group Flow (vph)	19	482	0	71	400	0	301	417	0	0	641	0
Confl. Peds. (#/hr)	73			31		73			31	31		73
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	3	3 4		7	4 7			2			2	
Permitted Phases							2			2		
Actuated Green, G (s)	5.0	29.2		5.0	29.2		45.0	45.0			45.0	
Effective Green, g (s)	6.0	30.2		6.0	30.2		46.0	46.0			46.0	
Actuated g/C Ratio	0.06	0.32		0.06	0.32		0.49	0.49			0.49	
Clearance Time (s)	5.0			5.0			5.0	5.0			5.0	
Vehicle Extension (s)	3.0			3.0			3.0	3.0			3.0	
Lane Grp Cap (vph)	113	550		113	569		301	856			740	
v/s Ratio Prot	0.01	c0.28		0.04	c0.23			0.24				
v/s Ratio Perm							c0.49				0.42	
v/c Ratio	0.17	0.88		0.63	0.70		1.00	0.49			0.87	
Uniform Delay, d1	41.7	30.2		43.0	28.1		24.1	16.2			21.4	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2	0.7	14.6		10.4	3.9		51.9	2.0			12.9	
Delay (s)	42.4	44.8		53.5	32.0		76.0	18.2			34.3	
Level of Service	D	D		D	C		E	B			C	
Approach Delay (s)		44.8			35.2			42.0			34.3	
Approach LOS		D			D			D			C	

Intersection Summary			
HCM Average Control Delay	39.2	HCM Level of Service	D
HCM Volume to Capacity ratio	0.91		
Actuated Cycle Length (s)	94.2	Sum of lost time (s)	8.0
Intersection Capacity Utilization	89.3%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBT
Lane Group Flow (vph)	19	525	71	406	301	429	646
v/c Ratio	0.17	0.89	0.63	0.71	1.01	0.49	0.87
Control Delay	45.8	43.7	68.8	34.7	82.0	17.9	36.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	45.8	43.7	68.8	34.7	82.0	17.9	36.5
Queue Length 50th (ft)	11	265	43	207	~184	159	332
Queue Length 95th (ft)	27	288	#98	290	#259	182	#563
Internal Link Dist (ft)		220		420		420	420
Turn Bay Length (ft)	215		65		140		
Base Capacity (vph)	113	602	113	585	298	868	739
Starvation Cap Reductn	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	0.17	0.87	0.63	0.69	1.01	0.49	0.87

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

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

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
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		1.00	1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	0.97		1.00	0.99			0.99	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Frt	1.00	0.93		1.00	0.94		1.00	0.97			0.97	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.99	
Satd. Flow (prot)	1770	1739		1770	1711		1770	1784			1778	
Flt Permitted	0.95	1.00		0.95	1.00		0.40	1.00			0.68	
Satd. Flow (perm)	1770	1739		1770	1711		751	1784			1222	
Volume (vph)	30	178	142	65	175	105	156	253	73	52	243	67
Peak-hour factor, PHF	0.73	0.73	0.73	0.85	0.85	0.85	0.74	0.74	0.74	0.92	0.92	0.92
Adj. Flow (vph)	41	244	195	76	206	124	211	342	99	57	264	73
RTOR Reduction (vph)	0	32	0	0	23	0	0	11	0	0	8	0
Lane Group Flow (vph)	41	407	0	76	307	0	211	430	0	0	386	0
Confl. Peds. (#/hr)	22			9		22			9	9		22
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	3	3 4		7	4 7			2			2	
Permitted Phases							2			2		
Actuated Green, G (s)	10.1	32.6		12.6	35.1		33.3	33.3			33.3	
Effective Green, g (s)	11.1	33.6		13.6	36.1		34.3	34.3			34.3	
Actuated g/C Ratio	0.12	0.36		0.15	0.39		0.37	0.37			0.37	
Clearance Time (s)	5.0			5.0			5.0	5.0			5.0	
Vehicle Extension (s)	3.0			3.0			3.0	3.0			3.0	
Lane Grp Cap (vph)	210	625		257	661		276	654			448	
v/s Ratio Prot	0.02	c0.23		0.04	c0.18			0.24				
v/s Ratio Perm							0.28				c0.32	
v/c Ratio	0.20	0.65		0.30	0.46		0.76	0.66			0.86	
Uniform Delay, d1	37.2	25.0		35.7	21.5		26.0	24.7			27.4	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2	0.5	2.4		0.6	0.5		18.1	5.1			19.1	
Delay (s)	37.6	27.5		36.3	22.0		44.1	29.8			46.5	
Level of Service	D	C		D	C		D	C			D	
Approach Delay (s)		28.3			24.7			34.5			46.5	
Approach LOS		C			C			C			D	

Intersection Summary			
HCM Average Control Delay	33.3	HCM Level of Service	C
HCM Volume to Capacity ratio	0.69		
Actuated Cycle Length (s)	93.5	Sum of lost time (s)	8.0
Intersection Capacity Utilization	76.1%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBT
Lane Group Flow (vph)	41	439	76	330	211	441	394
v/c Ratio	0.20	0.67	0.30	0.48	0.78	0.66	0.89
Control Delay	43.5	27.4	38.8	20.4	51.3	31.8	54.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	43.5	27.4	38.8	20.4	51.3	31.8	54.0
Queue Length 50th (ft)	22	179	41	126	104	197	201
Queue Length 95th (ft)	48	240	80	183	#197	282	#462
Internal Link Dist (ft)		220		420		420	420
Turn Bay Length (ft)	215		65		140		
Base Capacity (vph)	210	707	275	745	271	664	441
Starvation Cap Reductn	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	0.20	0.62	0.28	0.44	0.78	0.66	0.89

Intersection Summary

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

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
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		1.00	1.00			1.00	
Frt	1.00	0.96		1.00	0.93		1.00	0.98			0.98	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.99	
Satd. Flow (prot)	1770	1780		1770	1735		1770	1825			1818	
Flt Permitted	0.95	1.00		0.95	1.00		0.41	1.00			0.46	
Satd. Flow (perm)	1770	1780		1770	1735		770	1825			847	
Volume (vph)	63	311	131	33	173	147	156	456	72	45	299	54
Peak-hour factor, PHF	0.73	0.73	0.73	0.85	0.85	0.85	0.74	0.74	0.74	0.92	0.92	0.92
Adj. Flow (vph)	86	426	179	39	204	173	211	616	97	49	325	59
RTOR Reduction (vph)	0	16	0	0	33	0	0	6	0	0	6	0
Lane Group Flow (vph)	86	589	0	39	344	0	211	707	0	0	427	0
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	3	3 4		7	4 7			2			2	
Permitted Phases							2			2		
Actuated Green, G (s)	10.0	34.2		6.0	30.2		40.0	40.0			40.0	
Effective Green, g (s)	11.0	35.2		6.0	30.2		41.0	41.0			41.0	
Actuated g/C Ratio	0.12	0.37		0.06	0.32		0.44	0.44			0.44	
Clearance Time (s)	5.0			4.0			5.0	5.0			5.0	
Vehicle Extension (s)	3.0			3.0			3.0	3.0			3.0	
Lane Grp Cap (vph)	207	665		113	556		335	794			369	
v/s Ratio Prot	0.05	c0.33		0.02	c0.20			0.39				
v/s Ratio Perm							0.27				c0.50	
v/c Ratio	0.42	0.89		0.35	0.62		0.63	0.89			1.16	
Uniform Delay, d1	38.6	27.6		42.2	27.1		20.7	24.5			26.6	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00			1.00	
Incremental Delay, d2	1.4	13.4		1.8	2.1		8.7	14.3			96.7	
Delay (s)	40.0	41.0		44.1	29.2		29.4	38.9			123.3	
Level of Service	D	D		D	C		C	D			F	
Approach Delay (s)		40.9			30.6			36.7			123.3	
Approach LOS		D			C			D			F	

Intersection Summary			
HCM Average Control Delay	52.1	HCM Level of Service	D
HCM Volume to Capacity ratio	0.97		
Actuated Cycle Length (s)	94.2	Sum of lost time (s)	8.0
Intersection Capacity Utilization	90.9%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBT
Lane Group Flow (vph)	86	605	39	377	211	713	433
v/c Ratio	0.42	0.89	0.35	0.64	0.63	0.89	1.19
Control Delay	45.7	42.1	51.4	29.2	31.4	40.0	135.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	45.7	42.1	51.4	29.2	31.4	40.0	135.4
Queue Length 50th (ft)	49	321	23	167	97	384	~316
Queue Length 95th (ft)	77	337	53	244	135	397	#506
Internal Link Dist (ft)		220		420		420	420
Turn Bay Length (ft)	215		65		140		
Base Capacity (vph)	207	691	113	598	334	800	365
Starvation Cap Reductn	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	0.42	0.88	0.35	0.63	0.63	0.89	1.19

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

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

Appendix D

Intersection Capacity Analysis Worksheets
Long-Term

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
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	1.00		1.00	1.00	
Frpb, ped/bikes	1.00	1.00		1.00	0.97		1.00	0.98		1.00	0.97	
Flpb, ped/bikes	0.98	1.00		1.00	1.00		1.00	1.00		0.97	1.00	
Frt	1.00	0.92		1.00	0.98		1.00	0.96		1.00	0.98	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1742	1715		1770	1773		1770	1752		1715	1776	
Flt Permitted	0.28	1.00		0.13	1.00		0.30	1.00		0.41	1.00	
Satd. Flow (perm)	507	1715		243	1773		561	1752		744	1776	
Volume (vph)	14	181	202	60	296	49	223	238	79	68	454	73
Peak-hour factor, PHF	0.73	0.73	0.73	0.85	0.85	0.85	0.74	0.74	0.74	0.92	0.92	0.92
Adj. Flow (vph)	19	248	277	71	348	58	301	322	107	74	493	79
RTOR Reduction (vph)	0	42	0	0	6	0	0	13	0	0	6	0
Lane Group Flow (vph)	19	483	0	71	400	0	301	416	0	74	566	0
Confl. Peds. (#/hr)	73			31		73			31	31		73
Turn Type	pm+pt			pm+pt			Perm			Perm		
Protected Phases	3	8		7	4			6			2	
Permitted Phases	8			4			6			2		
Actuated Green, G (s)	29.7	28.5		31.9	29.6		50.1	50.1		50.1	50.1	
Effective Green, g (s)	31.7	29.5		33.9	30.6		51.1	51.1		51.1	51.1	
Actuated g/C Ratio	0.33	0.31		0.35	0.32		0.53	0.53		0.53	0.53	
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0		5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	196	528		138	566		299	934		396	946	
v/s Ratio Prot	0.00	c0.28		c0.02	0.23			0.24			0.32	
v/s Ratio Perm	0.03			0.16			c0.54			0.10		
v/c Ratio	0.10	0.92		0.51	0.71		1.01	0.45		0.19	0.60	
Uniform Delay, d1	22.8	32.0		24.2	28.7		22.4	13.7		11.6	15.4	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.2	20.5		3.2	4.0		53.7	1.5		1.0	2.8	
Delay (s)	23.0	52.6		27.4	32.7		76.1	15.3		12.7	18.2	
Level of Service	C	D		C	C		E	B		B	B	
Approach Delay (s)		51.5			31.9			40.4			17.5	
Approach LOS		D			C			D			B	

Intersection Summary			
HCM Average Control Delay	35.1	HCM Level of Service	D
HCM Volume to Capacity ratio	0.96		
Actuated Cycle Length (s)	95.9	Sum of lost time (s)	12.0
Intersection Capacity Utilization	84.2%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	19	525	71	406	301	429	74	572
v/c Ratio	0.10	0.95	0.46	0.69	0.96	0.44	0.18	0.58
Control Delay	20.7	56.6	29.8	34.1	67.6	13.8	12.8	17.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	20.7	56.6	29.8	34.1	67.6	13.8	12.8	17.0
Queue Length 50th (ft)	7	280	27	189	170	139	22	217
Queue Length 95th (ft)	17	#310	53	305	#254	160	48	323
Internal Link Dist (ft)		220		420		420		420
Turn Bay Length (ft)	215		65		140		100	
Base Capacity (vph)	184	557	154	598	312	978	412	983
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.10	0.94	0.46	0.68	0.96	0.44	0.18	0.58

Intersection Summary

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

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
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	1.00		1.00	1.00	
Frpb, ped/bikes	1.00	1.00		1.00	0.97		1.00	0.99		1.00	0.99	
Flpb, ped/bikes	0.99	1.00		1.00	1.00		1.00	1.00		0.99	1.00	
Frt	1.00	0.93		1.00	0.94		1.00	0.97		1.00	0.97	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1745	1739		1768	1714		1770	1784		1756	1776	
Flt Permitted	0.51	1.00		0.18	1.00		0.46	1.00		0.37	1.00	
Satd. Flow (perm)	940	1739		329	1714		864	1784		677	1776	
Volume (vph)	30	178	142	65	175	105	156	253	73	52	243	67
Peak-hour factor, PHF	0.73	0.73	0.73	0.85	0.85	0.85	0.74	0.74	0.74	0.92	0.92	0.92
Adj. Flow (vph)	41	244	195	76	206	124	211	342	99	57	264	73
RTOR Reduction (vph)	0	37	0	0	25	0	0	10	0	0	9	0
Lane Group Flow (vph)	41	402	0	76	305	0	211	431	0	57	328	0
Confl. Peds. (#/hr)	22			9		22			9	9		22
Turn Type	pm+pt			pm+pt			Perm			Perm		
Protected Phases	3	8		7	4			6			2	
Permitted Phases	8			4			6			2		
Actuated Green, G (s)	26.7	25.1		37.7	31.1		39.2	39.2		39.2	39.2	
Effective Green, g (s)	28.7	26.1		38.7	32.1		40.2	40.2		40.2	40.2	
Actuated g/C Ratio	0.33	0.30		0.45	0.37		0.46	0.46		0.46	0.46	
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0		5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	335	522		289	633		400	825		313	822	
v/s Ratio Prot	0.00	c0.23		c0.03	c0.18			0.24			0.18	
v/s Ratio Perm	0.04			0.09			c0.24			0.08		
v/c Ratio	0.12	0.77		0.26	0.48		0.53	0.52		0.18	0.40	
Uniform Delay, d1	20.0	27.7		16.4	21.0		16.6	16.6		13.7	15.4	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.2	6.8		0.5	0.6		4.9	2.4		1.3	1.4	
Delay (s)	20.2	34.4		16.9	21.6		21.5	18.9		15.0	16.8	
Level of Service	C	C		B	C		C	B		B	B	
Approach Delay (s)		33.2			20.7			19.8			16.6	
Approach LOS		C			C			B			B	

Intersection Summary			
HCM Average Control Delay	22.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.62		
Actuated Cycle Length (s)	86.9	Sum of lost time (s)	16.0
Intersection Capacity Utilization	72.7%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	41	439	76	330	211	441	57	337
v/c Ratio	0.13	0.80	0.20	0.49	0.57	0.52	0.21	0.40
Control Delay	14.1	28.3	12.9	17.6	31.6	23.5	24.2	21.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	14.1	28.3	12.9	17.6	31.6	23.5	24.2	21.1
Queue Length 50th (ft)	12	169	22	118	67	130	15	91
Queue Length 95th (ft)	21	249	40	168	179	290	67	279
Internal Link Dist (ft)		220		420		420		420
Turn Bay Length (ft)	215		65		140		100	
Base Capacity (vph)	304	749	387	834	373	852	275	848
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.13	0.59	0.20	0.40	0.57	0.52	0.21	0.40

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
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	1.00		1.00	1.00	
Frt	1.00	0.96		1.00	0.93		1.00	0.98		1.00	0.98	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	1780		1770	1735		1770	1825		1770	1820	
Flt Permitted	0.27	1.00		0.17	1.00		0.42	1.00		0.13	1.00	
Satd. Flow (perm)	497	1780		309	1735		776	1825		235	1820	
Volume (vph)	63	311	131	33	173	147	156	456	72	45	299	54
Peak-hour factor, PHF	0.73	0.73	0.73	0.85	0.85	0.85	0.74	0.74	0.74	0.92	0.92	0.92
Adj. Flow (vph)	86	426	179	39	204	173	211	616	97	49	325	59
RTOR Reduction (vph)	0	18	0	0	32	0	0	5	0	0	6	0
Lane Group Flow (vph)	86	587	0	39	345	0	211	708	0	49	378	0
Turn Type	pm+pt			pm+pt			Perm			Perm		
Protected Phases	3	8		7	4			6			2	
Permitted Phases	8			4			6			2		
Actuated Green, G (s)	37.3	31.7		27.3	25.7		37.8	37.8		37.8	37.8	
Effective Green, g (s)	38.3	32.7		28.3	26.7		38.8	38.8		38.8	38.8	
Actuated g/C Ratio	0.45	0.38		0.33	0.31		0.46	0.46		0.46	0.46	
Clearance Time (s)	5.0	5.0		4.0	5.0		5.0	5.0		5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	337	684		130	544		354	832		107	830	
v/s Ratio Prot	c0.02	c0.33		0.01	0.20			c0.39			0.21	
v/s Ratio Perm	0.09			0.09			0.27			0.21		
v/c Ratio	0.26	0.86		0.30	0.63		0.60	0.85		0.46	0.46	
Uniform Delay, d1	15.1	24.1		21.1	25.0		17.3	20.6		15.9	15.9	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.4	10.4		1.3	2.4		7.2	10.6		13.5	1.8	
Delay (s)	15.5	34.5		22.4	27.5		24.5	31.2		29.4	17.7	
Level of Service	B	C		C	C		C	C		C	B	
Approach Delay (s)		32.1			27.0			29.7			19.0	
Approach LOS		C			C			C			B	

Intersection Summary			
HCM Average Control Delay	28.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.85		
Actuated Cycle Length (s)	85.1	Sum of lost time (s)	12.0
Intersection Capacity Utilization	86.0%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	86	605	39	377	211	713	49	384
v/c Ratio	0.25	0.84	0.18	0.66	0.65	0.84	0.54	0.45
Control Delay	13.8	27.8	14.8	26.0	33.6	33.5	48.4	19.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	13.8	27.8	14.8	26.0	33.6	33.5	48.4	19.6
Queue Length 50th (ft)	25	283	11	153	91	345	20	141
Queue Length 95th (ft)	39	296	25	233	152	422	#87	255
Internal Link Dist (ft)		220		420		420		420
Turn Bay Length (ft)	215		65		140		100	
Base Capacity (vph)	414	828	221	644	323	853	91	852
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.21	0.73	0.18	0.59	0.65	0.84	0.54	0.45

Intersection Summary

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