

## **MEMORANDUM**

TO: Cindy Petkac, AICP  
Director  
Department of Planning and Zoning  
Town of Vienna, Virginia

FROM: David Samba, P.E., PTOE

DATE: February 22, 2018

SUBJECT: Mill Street Public Parking Condominium  
Traffic and Intersection Analysis

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### **Introduction**

The Town of Vienna is reviewing the potential to purchase one floor within a proposed building for use as public parking. The proposed building is a commercial/self-storage development with integrated parking levels. Overall, the building is anticipated to accommodate approximately 300 parking spaces. The parking floor under review by the Town includes approximately 127 spaces. As the Town reviews the project, they have asked Kimley-Horn for ongoing engineering and planning support related to this project.

Based on the proposed locations of the site entrances and the likely routes that would be used to access the site, Town staff directed Kimley-Horn to conduct a traffic and intersection analysis at the intersection of Mill Street and Church Street, including a signal warrant evaluation. The purpose of the evaluation is to determine if the additional traffic generated by the proposed building results in total traffic volumes that exceed the typical amounts that trigger the consideration of a traffic signal.

Town staff also directed Kimley-Horn to provide some guidance on the potential queue spillback to the intersection of Mill Street and Park Street that may result from implementation of a traffic signal at this location.

The analyses described herein were conducted in accordance with Chapter 4C of the Manual on Uniform Traffic Control Devices (MUTCD), 2009 Edition published by the Federal Highway Administration (FHWA).

**Existing Conditions**

The proposed site will be located at 223 to 241 Mill Street in the Town of Vienna, Virginia. The site is located in the northern quadrant of the intersection of Mill Street and Church Street. Mill Street is classified as a local street with one lane in each direction and with no posted speed limits. In the vicinity of the proposed site, Church Street is classified as a collector street with one travel lane and one on-street parking lane in each direction and a posted 25 miles per hour speed limit.

The intersection of Mill Street and Church Street currently operates as an all-way stop controlled intersection and has crosswalks on all approaches. Immediately adjacent intersections are all unsignalized and are located 600 feet to the west (Ayr Hill Avenue NE), 450 feet to the east (Maple Avenue), 215 feet to the south (Dominion Road), and 260 feet to the north (Park Street).

The subject study area shown in **Figure 1**.



Figure 1: Study Area

Traffic counts were conducted on Tuesday, February 13, 2018 at the intersection of Mill Street and Church Street between the hours 6:00 AM and 7:00 PM. The peak hours of traffic were identified as 7:45 AM to 8:45 AM in the morning and 4:45 to 5:45 PM in the evening. Hourly traffic counts at the intersection of Mill Street and Church Street are presented in **Table 1**.

Traffic counts were also conducted on February 13, 2018 at the intersection of Park Street and Church Street between the hours 6:00 AM and 9:00 AM and between the hours of 3:30 PM and 6:30 PM. The peak hours of traffic were identified as 7:45 AM to 8:45 AM in the morning and 5:00 PM to 6:00 PM in the evening. The full 6-hour peak period traffic counts are presented in **Table 2**.

Table 1: Hourly Traffic Counts at Intersection of Church Street and Mill Street

Hour Start Time	Church Street								Mill Street							
	NORTHBOUND				SOUTHBOUND				EASTBOUND				WESTBOUND			
	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R	U
6:45 AM	6	246	5	0	21	106	36	0	218	6	4	0	12	50	10	0
7:45 AM	7	343	16	0	43	218	70	0	343	16	5	0	12	31	10	0
8:45 AM	14	317	26	0	26	148	70	0	266	34	12	0	16	33	23	0
9:45 AM	17	210	15	1	9	127	54	0	127	18	13	0	6	47	6	0
10:45 AM	15	205	8	0	12	184	58	0	119	28	17	0	18	63	11	0
11:45 AM	15	204	22	0	17	210	74	0	128	24	20	0	21	45	21	0
12:45 PM	16	225	10	0	11	227	79	0	107	25	16	0	31	42	13	0
1:45 PM	18	216	18	0	16	220	91	0	94	29	13	0	30	66	15	0
2:45 PM	15	261	7	0	15	265	130	0	141	29	20	0	24	88	6	0
3:45 PM	15	232	12	0	13	330	215	0	147	19	18	0	35	65	16	0
4:45 PM	19	234	19	0	27	421	357	0	182	31	30	0	44	88	9	0
5:45 PM	21	230	14	0	18	394	343	0	155	26	25	0	43	76	8	0

Peak Hour: L- Left, T- Through, R- Right, U- U-turn

Table 2: Hourly Peak Period Traffic Count at Church Street and Park Street

Hour Start Time	Church Street								Mill Street							
	NORTHBOUND				SOUTHBOUND				EASTBOUND				WESTBOUND			
	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R	U
6:45 AM	37	261	165	0	12	54	1	0	3	35	66	0	46	10	9	0
7:45 AM	69	482	142	0	26	121	1	0	1	70	165	0	50	17	25	0
8:45 AM	28	350	48	0	23	144	53	1	190	53	28	0	27	32	31	0
4:00 PM	74	204	119	0	38	355	2	0	0	61	134	0	139	42	32	1
5:00 PM	60	215	114	0	25	396	1	0	2	119	265	0	167	50	29	0
6:00 PM*	20	107	74	0	14	168	2	0	3	38	140	0	93	21	14	0

Peak Hour: L- Left, T- Through, R- Right, U- U-turn; \*indicates counts are from 6:00 - 6:30 PM

**Warrant Analysis Methodology**

The MUTCD provides the following standard, among others, regarding justification for traffic control signals:

**“The satisfaction of a traffic signal warrant or warrants shall not in itself require the installation of a traffic control signal.” (Source: MUTCD 2009, Section 4C.01, Paragraph 03)**

According to the MUTCD, the investigation of the need for a traffic control signal shall include an analysis of the applicable factors contained in the following traffic signal warrants and other factors related to existing operation and safety at the study location:

- Warrant 1, Eight-Hour Vehicular Volume
- Warrant 2, Four-Hour Vehicular Volume
- Warrant 3, Peak Hour
- Warrant 4, Pedestrian Volume
- Warrant 5, School Crossing
- Warrant 6, Coordinated Signal System
- Warrant 7, Crash Experience
- Warrant 8, Roadway Network
- Warrant 9, Intersection Near a Grade Crossing

For the purposed this analysis, Warrants 1, 2, and 3 were evaluated.

**Warrant 1 (Eight Hour Vehicular Volume)** Condition 1A is intended for application at locations where a large volume of intersecting traffic is the principal reason to consider installing a traffic signal. Warrant 1 Condition 1B is intended for application where Condition 1A is not satisfied and where the traffic volume on a major street is so heavy that traffic on a minor intersecting street suffers excessive delay or conflict in entering or crossing the major street. If both Condition 1A and Condition 1B are 80% satisfied, Warrant 1C would be satisfied. The criteria thresholds for Warrant 1 are shown in **Table 3**.

Table 3: Warrant 1, 8 Hour Vehicular Volume Traffic Signal Warrant Thresholds

Intersection	Condition A		Condition B		Combination Condition			
	Major Street (vph)	Minor Street (vph)	Major Street (vph)	Minor Street (vph)	Condition A		Condition B	
					Major Street (vph)	Minor Street (vph)	Major Street (vph)	Minor Street (vph)
Mill Street and Church Street	500	150	750	75	400	120	600	60

vph – vehicles per hour

**Warrant 2 (Four Hour Vehicular Volume)** is intended to be applied at locations where the volume of intersecting traffic is the principal reason to consider installing a traffic signal.

**Figure 2** shows the threshold chart for the four-hour vehicle volume warrant, based on traffic volume and street configuration.

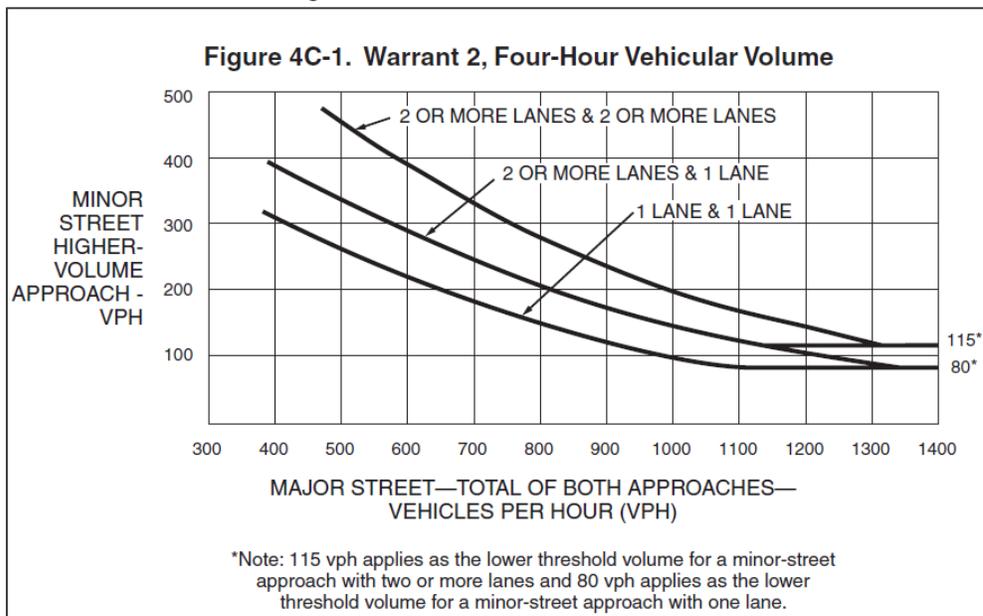


Figure 2: Warrant 2, 4 Hour Vehicular Volume Traffic Signal Warrant Thresholds

**Warrant 3 (Peak Hour)** is intended for use at locations where traffic conditions are such that for a minimum of 1 hour of an average day, the minor-street traffic suffers undue delay when entering or crossing the major street. **Figure 3** shows the thresholds for the peak hour vehicle volume warrant, based on traffic volume and street configuration.

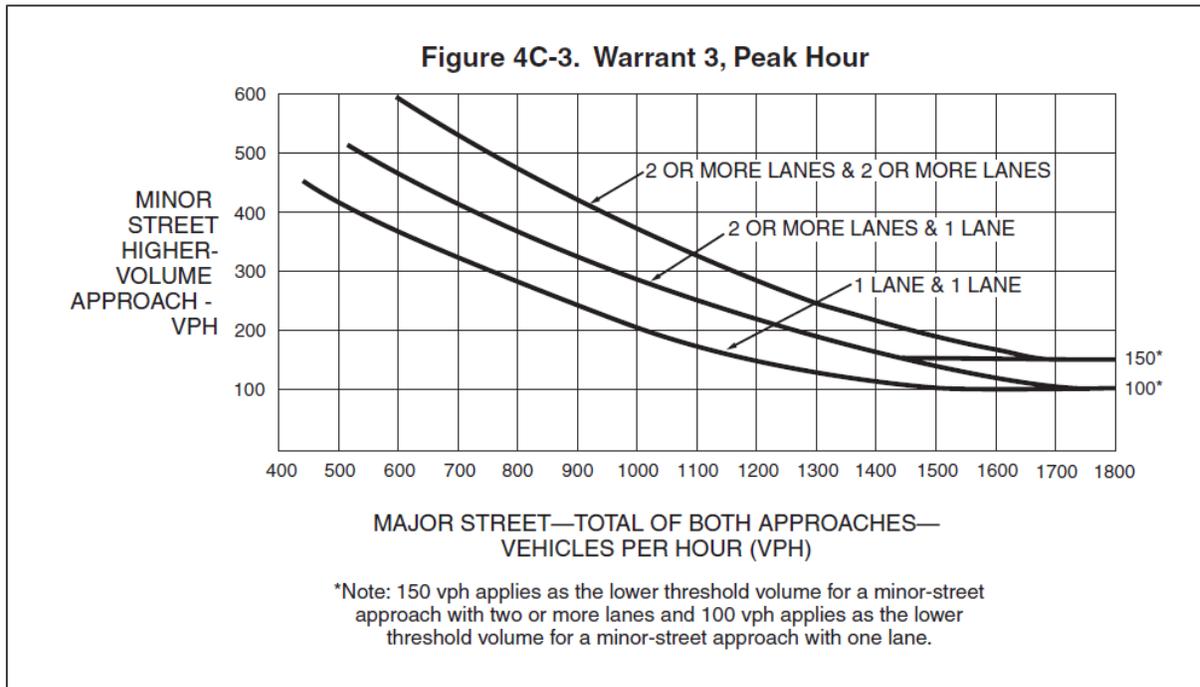


Figure 3: Warrant 3, Peak Hour Traffic Signal Warrant Thresholds

**Warrant Analysis Results**

The existing turning movement counts were summarized as major and minor street approach volumes. Based on the observed traffic volumes, Church Street is the major street and Mill Street is the minor street.

The major street traffic volumes, given as the sum of both approaches, and the minor street traffic volumes, given for the highest approach, at the intersection of Mill street and Church Street are shown in **Table 4**.

Table 4: Existing Hourly Major and Minor Street Approach Volumes at Intersection of Church Street and Mill Street

Time	Major Street (Church Street)	Minor Street (Mill Street)
6:45 AM	420	228
7:45 AM	697	364
8:45 AM	601	312
9:45 AM	433	158
10:45 AM	482	164
11:45 AM	542	172
12:45 PM	568	148
1:45 PM	579	136
2:45 PM	693	190
3:45 PM	817	184
4:45 PM	1077	243
5:45 PM	1020	206

The existing conditions warrant results for the traffic analysis and approach lane combinations at the study intersection is shown in **Table 5**.

Table 5: Existing Hourly Major and Minor Street Approach Volumes at Intersection of Church Street and Mill Street

Time	Major Street (Church Street)	Minor Street (Mill Street)	Warrant 1 Condition A Met	Warrant 1 Condition B Met	Warrant 1 Combination Condition Met	Warrant 2 Met	Warrant 3 Met
6:45 AM	420	228	No	No	No	<u>Yes</u>	No
7:45 AM	697	364	<u>Yes</u>	No	<u>Yes</u>	<u>Yes</u>	No
8:45 AM	601	312	<u>Yes</u>	No	<u>Yes</u>	<u>Yes</u>	No
9:45 AM	433	158	No	No	No	No	No
10:45 AM	482	164	No	No	No	No	No
11:45 AM	542	172	<u>Yes</u>	No	No	No	No
12:45 PM	568	148	No	No	No	No	No
1:45 PM	579	136	No	No	No	No	No
2:45 PM	693	190	<u>Yes</u>	No	<u>Yes</u>	<u>Yes</u>	<u>Yes</u>
3:45 PM	817	184	<u>Yes</u>	<u>Yes</u>	<u>Yes</u>	<u>Yes</u>	No
4:45 PM	1077	243	<u>Yes</u>	<u>Yes</u>	<u>Yes</u>	No	No
5:45 PM	1020	206	<u>Yes</u>	<u>Yes</u>	<u>Yes</u>	No	No
<b>Hours Met</b>			<b><u>7</u></b>	<b><u>3</u></b>	<b><u>6</u></b>	<b><u>5</u></b>	<b><u>1</u></b>
<b>Hours Needed to Meet Warrant</b>			8	8	8	5	1
<b>Warrant Met?</b>			No	No	No	<u>Yes</u>	<u>Yes</u>

A trip generation analysis for the proposed commercial development and parking activity was prepared by Gorove/Slade. The estimate of trips generated by the proposed site is shown as **Figure 4**.

Land Use	ITE Code	Size	Units	----- Week day -----						
				AM Peak Hour			PM Peak Hour			Weekday Total
				In	Out	Total	In	Out	Total	
<b>Current Use</b>										
Specialty Retail	826	28.0	kSF	10	12	22	40	49	89	1,236
<b>Total Current Use Trips</b>				<b>10</b>	<b>12</b>	<b>22</b>	<b>40</b>	<b>49</b>	<b>89</b>	<b>1,236</b>
<b>Proposed Uses</b>										
Specialty Retail*	826	25.7	kSF	9	12	21	37	47	84	1,137
Self-Storage	151	116.5	kSF	9	7	16	16	15	31	292
Garage**	N/A	130	Spaces	9	12	21	37	47	84	1,150
<b>Total Proposed Uses Trips</b>				<b>27</b>	<b>31</b>	<b>58</b>	<b>90</b>	<b>109</b>	<b>199</b>	<b>2,579</b>
<b>Difference (Proposed Uses - Current Use)</b>				<b>17</b>	<b>19</b>	<b>36</b>	<b>50</b>	<b>60</b>	<b>110</b>	<b>1,343</b>
* The AM peak hour trip generation rates for the Specialty Retail use (ITE Code: 826) are not provided in the ITE Trip Generation Manual. Hence, a trip generation rate equal to 25% of the PM peak hour rate was used.										
** The trip generation for the garage use was calculated using the rates for Specialty Retail use. Since approximately 130 spaces will be provided in the parking garage for visitors to the Town of Vienna for shopping, the trip generation was calculated based on a 26,000 square foot specialty retail center (1 parking space per 200 square foot retail).										

Figure 4: Proposed Trip Generation (Source: Trip Generation Comparison Memorandum, Gorove/Slade)

The peak hour trips associated with the specialty retail and self-storage portions of the development and with 50 percent of the town’s proposed parking spaces were used to estimate hourly commercial trips per recommended *ITE Trip Generation* methodology. The 50 percent figure represents parking activity of visitors to the Town and additional retail patrons.

The trips associated with the remaining 50 percent of the town’s proposed parking spaces represents parking activity in parking spaces designated for commuters per the proposed NVT A funding request. These trips were assigned to the hour directly before or after the AM and PM peak hour, respectively, to represent commuter parking.

The resulting hourly trips associated with the proposed development and town parking spaces, assigned to the major and minor street, are shown in **Table 6**. The resulting future major and minor street approach volumes are shown in **Table 7**.

Table 6: Hourly Traffic Associated with the Retail and Commuter Activity of the Proposed Development Along Major and Minor Street Approaches at Intersection of Church Street and Mill Street

Time	Major Street (Church Street)	Minor Street (Mill Street)
6:45 AM	31	6
7:45 AM	9	13
8:45 AM	16	22
9:45 AM	21	37
10:45 AM	29	55
11:45 AM	47	71
12:45 PM	23	38
1:45 PM	20	36
2:45 PM	19	34
3:45 PM	24	35
4:45 PM	27	37
5:45 PM	24	97

Table 7: Future Hourly Major and Minor Street Approach Volumes at Intersection of Church Street and Mill Street

Time	Major Street (Church Street)	Minor Street (Mill Street)
6:45 AM	451	234
7:45 AM	706	377
8:45 AM	617	334
9:45 AM	454	195
10:45 AM	511	219
11:45 AM	589	243
12:45 PM	591	186
1:45 PM	599	172
2:45 PM	712	224
3:45 PM	841	219
4:45 PM	1104	280
5:45 PM	1044	303

The future conditions traffic signal warrant results for the traffic volumes and approach lane combinations at the study intersection is shown in **Table 8**.

Table 8: Future Hourly Major and Minor Street Approach Volumes at Intersection of Church Street and Mill Street

Time	Major Street (Church Street)	Minor Street (Mill Street)	Warrant 1 Condition A Met	Warrant 1 Condition B Met	Warrant 1 Combination Condition Met	Warrant 2 Met	Warrant 3 Met
6:45 AM	451	234	No	No	No	<u>Yes</u>	No
7:45 AM	706	377	<u>Yes</u>	No	<u>Yes</u>	<u>Yes</u>	<u>Yes</u>
8:45 AM	617	334	<u>Yes</u>	No	<u>Yes</u>	<u>Yes</u>	No
9:45 AM	454	195	No	No	No	No	No
10:45 AM	511	219	<u>Yes</u>	No	No	No	No
11:45 AM	589	243	<u>Yes</u>	No	No	<u>Yes</u>	No
12:45 PM	591	186	<u>Yes</u>	No	No	<u>Yes</u>	No
1:45 PM	599	172	<u>Yes</u>	No	No	<u>Yes</u>	No
2:45 PM	712	224	<u>Yes</u>	No	<u>Yes</u>	<u>Yes</u>	<u>Yes</u>
3:45 PM	841	219	<u>Yes</u>	<u>Yes</u>	<u>Yes</u>	<u>Yes</u>	<u>Yes</u>
4:45 PM	1104	280	<u>Yes</u>	<u>Yes</u>	<u>Yes</u>	No	No
5:45 PM	1044	303	<u>Yes</u>	<u>Yes</u>	<u>Yes</u>	No	No
<b>Hours Met</b>			<u>10</u>	<u>3</u>	<u>6</u>	<u>8</u>	<u>3</u>
<b>Hours Needed to meet Warrant</b>			8	8	8	5	1
<b>Warrant Met?</b>			<u>Yes</u>	No	No	<u>Yes</u>	<u>Yes</u>

**Table 9** summarizes the traffic signal warrant analysis for the existing and future conditions. The Appendix of this memorandum contains summary worksheets of the traffic volume thresholds and warrant analysis results.

Table 9: Signal Warrant Analysis Summary

Warrants		Existing Conditions	Future Conditions
Warrant 1	Condition A	No	Yes
	Condition B	No	No
	Combination	No	No
Warrant 2		Yes	Yes
Warrant 3		Yes	Yes

Warrant 1 (Condition A) is met under future conditions based on the 8-hour volumes at the study intersection. Warrant 2 is met under both existing and future conditions based on the 4-hour volumes at the study intersection. Warrant 3 is met under both existing and future conditions based on the peak hour volumes at the study intersection.

Traffic signal warrants are not additive, triggering the criteria for multiple warrants does not suggest that there is a higher need for a traffic signal. What the analysis suggest is that, under existing conditions and with the current level of traffic that passes through the intersection on a typical day, a traffic signal is warranted. The addition of traffic related to the development and to the parking activity will result in some amount of additional delay and queuing at the intersection, but does not justify the need for a traffic signal any more than the current traffic does.

It is critical to consider additional factors beyond the results of a warrant analysis when considering the implementation of a traffic signal; a warrant analysis can be part of the *justification* for a signal, but should not be sole reason for one.

Church Street is envisioned as a pedestrian corridor and thus, the pedestrian experience is essential. A traffic signal could potentially increase the delays for pedestrians waiting crossing at the intersection of Church Street and Mill Street, which is antithetical to the pedestrian experience.

Similarly, the compatibility of a traffic signal at this location with a surrounding transportation network of closely spaced all- or two-way stop controlled intersections along Church Street must be closely evaluated. The true effectiveness of the traffic signal may be directly related to the overall compatibility of the entire street.

### **Alternative Intersection Analysis**

In addition to the signal warrant analysis, an alternative intersection analysis was considered at the intersection of Mill Street and Church Street, using the Virginia Department of Transportation's (VDOT's) Junction Screen Tool (VJust). The tool analyzes, at planning-level, the potential suitability of alternative intersection treatments based on approach lane configuration and peak hour traffic volumes. Based on the geometric constraints of the intersection the following intersection types were considered: conventional (i.e. traffic signal), 50' mini roundabout, 75' mini roundabout, roundabout, and two-way stop control.

The results of the tool are presented in **Figure 5**. Based on the planning level alternatives analysis, it is anticipated that a conventional intersection or a roundabout treatment would operate with acceptable levels of congestion. A two-way stop control intersection would be over-capacity and likely offer no better service than the current all-way stop control. The roundabouts have a potential safety advantage over the conventional intersection due to a reduced number of vehicular conflict points.

VDOT Junction Screening Tool			
Results Worksheet			
<b>General Information</b>			
Project Title:	Town Of Vienna Parking Garage		
EW Facility:	Mill Street		
NS Facility:	Church Street		
Date:			
<b>Volumes (veh/hr)</b>	<b>U-Turn / Left</b>	<b>Through</b>	<b>Right</b>
Eastbound	343	16	5
Westbound	12	31	10
Northbound	7	343	16
Southbound	43	218	70
<b>General Instructions:</b> All intersection and interchange configurations have a default assumption of one exclusive lane per movement. No results shall be interpreted until the user has verified the lane configurations on each worksheet.			

Intersection Results					
		Congestion	Pedestrian	Safety	Notes
Type	Dir	Maximum V/C	Accommodation Compared to Conventional	Weighted Total Conflict Points	
Conventional	-	0.47		48	
50 Mini Roundabout	-	0.62		8	
75 Mini Roundabout	-	0.58		8	
Roundabout	-	0.49		8	
Two-Way Stop Control	-	1.46		48	

Figure 5: Alternative Junction Screening at Mill Street and Church Street

### Traffic Analysis

A traffic analysis of the intersection of Mill Street and Church Street and the intersection of Church Street and Park Street was conducted to determine the impacts (vehicle delay/Level of Service and queuing) of a proposed signal. The analysis was conducted using Synchro 9.2 traffic software. The peak hour traffic impact results for the two study intersections are provided in Table 10 (existing conditions), 11 (future conditions), and 12 (future conditions with a traffic signal).

Table 10: Existing Traffic Operations at Study Intersections

Intersection	Approach	Mvmnt	Vehicle Delay (seconds) AM / PM	Level of Service AM / PM	95 Percentile Queuing (feet) AM / PM
Mill Street and Church Street	Northbound	TL	26.1 / 27.2	D / D	145 / 127.5
		R	9.3 / 10.5	A / B	2.5 / 2.5
	Southbound	TLR	32.0 / 300.3	D / F	200 / 1242.5
	Eastbound	TLR	27.1 / 22.4	D / C	155 / 85
	Westbound	TLR	12.2 / 17.1	B / C	12.5 / 37.5
		<b>Overall</b>	<b>27.6 / 170.4</b>	<b>D / F</b>	-
Park Street and Church Street	Northbound	TLR	98.1 / 99.0	F / F	560 / 367.5
	Southbound	TLR	13.3 / 107.5	B / F	37.5 / 385
	Eastbound	TLR	15.9 / 69.7	C / F	70 / 282.5
	Westbound	TLR	12.6 / 38.7	B / E	22.5 / 147.5
			<b>Overall</b>	<b>60.2 / 83.0</b>	<b>F / F</b>

Table 11: Future Traffic Operations at Study Intersections (Intersection of Church Street and Mill Street unsignalized)

Intersection	Approach	Mvmnt	Vehicle Delay (seconds) AM / PM	Level of Service AM / PM	95 Percentile Queuing (feet) AM / PM
Mill Street and Church Street	Northbound	TL	28.4 / 31.8	D / D	155 / 142.5
		R	9.6 / 11.1	A / B	2.5 / 5.0
	Southbound	TLR	40.8 / 357.1	E / F	247.5 / 1385.0
	Eastbound	TLR	31.3 / 28.5	D / D	177.5 / 115
	Westbound	TLR	12.8 / 18.8	B / C	12.5 / 42.5
		<b>Overall</b>	<b>32.8 / 200.2</b>	<b>D / F</b>	-
Park Street and Church Street	Northbound	TLR	109.9 / 124.1	F / F	605 / 427.5
	Southbound	TLR	13.5 / 128.5	B / F	40 / 432.5
	Eastbound	TLR	16.5 / 71.8	C / F	75 / 280
	Westbound	TLR	12.8 / 40.1	B / E	22.5 / 147.5
			<b>Overall</b>	<b>67.0 / 97.7</b>	<b>F / F</b>

Table 12: Future Traffic Operations at Study Intersections (Intersection of Church Street and Mill Street signalized)

Intersection	Approach	Mvmnt	Vehicle Delay (seconds) AM / PM	Level of Service AM / PM	95 Percentile Queuing (feet) AM / PM
Mill Street and Church Street	Northbound	TL	9.6 / 6.7	A / A	157 / 88.0
		R	0 / 0	A / B	6.0 / 5.0
	Southbound	TLR	11.1 / 22.6	B / C	160 / #523
	Eastbound	TLR	12.6 / 21.3	B / C	#249 / #217
	Westbound	TLR	8.9 / 17.4	A / B	30 / 87
		<b>Overall</b>	<b>11.0 / 18.8</b>	<b>B / B</b>	-
Park Street and Church Street	Northbound	TLR	109.9 / 124.1	F / F	605 / 427.5
	Southbound	TLR	13.5 / 128.5	B / F	40 / 432.5
	Eastbound	TLR	16.5 / 71.8	C / F	75 / 280
	Westbound	TLR	12.8 / 40.1	B / E	22.5 / 147.5
			<b>Overall</b>	<b>67.0 / 97.7</b>	<b>F / F</b>

# – 95<sup>TH</sup> percentile queue volume exceeds capacity, queue may be longer. Queue shown is maximum after two cycles.

Based on the analysis, the intersections currently operate with significant delays. In the future, with the addition of traffic generated by the proposed retail development and parking activity, both intersections will operate with the same level of service as existing conditions but with additional vehicle delays and queuing.

The analysis also demonstrates that the intersection of Mill Street and Church Street can operate with significantly improved level of service with the implementation of a traffic signal. This also significantly reduces the queuing along Church Street, reducing the likelihood of queue spillback to Park Street.

It is noted that while a traffic signal may improve some of the traffic operations at the intersection, the implementation of a traffic signal or of an alternate intersection treatment should consider additional factors such as cost-effectiveness, pedestrian and vehicular safety, geometric impacts, and compatibility with the existing transportation network.

**Close**

Thank you for the opportunity to be of service on this important project for the Town of Vienna.

Please do not hesitate to contact us with any further questions.

## Intersection TRAFFIC SIGNAL VOLUME WARRANT ANALYSIS

Based on 2003 MUTCD

INTERSECTION NAME: Church Street and Mill Street

COUNT DATE:

INTERSECTION CONDITION: Existing

MAJOR STREET: Church Street

MINOR STREET: Mill Street

# OF APPROACH LANES: 1

# OF APPROACH LANES: 1

ISOLATED COMMUNITY WITH POPULATION LESS THAN 10,000 (Y OR N): N

85TH PERCENTILE SPEED GREATER THAN 40 MPH ON MAJOR STREET (Y OR N): N

			MAJOR ST BOTH APPROACHES	MINOR ST HIGHEST APPROACH	WARRANT 1, Condition A			WARRANT 1, Condition B			WARRANT 1, Combination Warrant						WARRANT 2	WARRANT 3
					MAJOR STREET	MINOR STREET	BOTH MET	MAJOR STREET	MINOR STREET	BOTH MET	CONDITION A			CONDITION B				
											MAJOR STREET	MINOR STREET	BOTH MET	MAJOR STREET	MINOR STREET	BOTH MET		
THRESHOLD VALUES					500	150		750	75		400	120		600	60			
6:45 AM	TO	7:45 AM	420	228		Y		Y			Y	Y	Y		Y			
7:45 AM	TO	8:45 AM	697	364	Y	Y	Y		Y		Y	Y	Y	Y	Y	Y		
8:45 AM	TO	9:45 AM	601	312	Y	Y	Y		Y		Y	Y	Y	Y	Y	Y		
9:45 AM	TO	10:45 AM	433	158		Y		Y			Y	Y	Y		Y			
10:45 AM	TO	11:45 AM	482	164		Y		Y			Y	Y	Y		Y			
11:45 AM	TO	12:45 PM	542	172	Y	Y	Y		Y		Y	Y	Y		Y			
12:45 PM	TO	1:45 PM	568	148	Y			Y			Y	Y	Y		Y			
1:45 PM	TO	2:45 PM	579	136	Y			Y			Y	Y	Y		Y			
2:45 PM	TO	3:45 PM	693	190	Y	Y	Y		Y		Y	Y	Y	Y	Y	Y	Y	
3:45 PM	TO	4:45 PM	817	184	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		
4:45 PM	TO	5:45 PM	1077	243	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		
5:45 PM	TO	06:45 PM	1020	206	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		
			7,929	2,505	7			3			12			6			5	1
					<b>8 HOURS NEEDED NOT SATISFIED</b>			<b>8 HOURS NEEDED NOT SATISFIED</b>			<b>8 HOURS OF BOTH COND. A AND COND. B NEEDED NOT SATISFIED</b>						<b>4 HRS NEEDED SATISFIED</b>	<b>1 HR NEEDED SATISFIED</b>

WARRANT 1 -- Eight-Hour Vehicular Volume Warrant  
 Condition A : Minimum Vehicular Volume  
 Condition B : Interruption of Continuous Traffic  
 Combination : Combination of Condition A and Condition B

WARRANT 2 -- Four-Hour Vehicular Volume Warrant

WARRANT 3 -- Peak Hour Warrant

## Intersection TRAFFIC SIGNAL VOLUME WARRANT ANALYSIS

Based on 2003 MUTCD

INTERSECTION NAME: Church Street and Mill Street

COUNT DATE:  

INTERSECTION CONDITION: Future

MAJOR STREET: Church Street

MINOR STREET: Mill Street

# OF APPROACH LANES: 1

# OF APPROACH LANES: 1

ISOLATED COMMUNITY WITH POPULATION LESS THAN 10,000 (Y OR N): N

85TH PERCENTILE SPEED GREATER THAN 40 MPH ON MAJOR STREET (Y OR N): N

			MAJOR ST BOTH APPROACHES	MINOR ST HIGHEST APPROACH	WARRANT 1, Condition A			WARRANT 1, Condition B			WARRANT 1, Combination Warrant						WARRANT 2	WARRANT 3
					MAJOR STREET	MINOR STREET	BOTH MET	MAJOR STREET	MINOR STREET	BOTH MET	CONDITION A			CONDITION B				
											MAJOR STREET	MINOR STREET	BOTH MET	MAJOR STREET	MINOR STREET	BOTH MET		
THRESHOLD VALUES					500	150		750	75		400	120		600	60			
6:45 AM	TO	7:45 AM	451	234		Y		Y			Y	Y	Y		Y			
7:45 AM	TO	8:45 AM	706	377	Y	Y	Y		Y		Y	Y	Y	Y	Y	Y		
8:45 AM	TO	9:45 AM	617	334	Y	Y	Y		Y		Y	Y	Y	Y	Y	Y		
9:45 AM	TO	10:45 AM	454	195		Y		Y			Y	Y	Y		Y			
10:45 AM	TO	11:45 AM	511	219	Y	Y	Y		Y		Y	Y	Y		Y			
11:45 AM	TO	12:45 PM	589	243	Y	Y	Y		Y		Y	Y	Y		Y			
12:45 PM	TO	1:45 PM	591	186	Y	Y	Y		Y		Y	Y	Y		Y			
1:45 PM	TO	2:45 PM	599	172	Y	Y	Y		Y		Y	Y	Y		Y			
2:45 PM	TO	3:45 PM	712	224	Y	Y	Y		Y		Y	Y	Y	Y	Y	Y		
3:45 PM	TO	4:45 PM	841	219	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		
4:45 PM	TO	5:45 PM	1104	280	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		
5:45 PM	TO	6:45 PM	1044	303	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		
			8,219	2,986	<b>10</b>			<b>3</b>			<b>12</b>			<b>6</b>			<b>8</b>	<b>3</b>
					<b>8 HOURS NEEDED SATISFIED</b>			<b>8 HOURS NEEDED NOT SATISFIED</b>			<b>8 HOURS OF BOTH COND. A AND COND. B NEEDED NOT SATISFIED</b>						<b>4 HRS NEEDED SATISFIED</b>	<b>1 HR NEEDED SATISFIED</b>

WARRANT 1 -- Eight-Hour Vehicular Volume Warrant  
 Condition A : Minimum Vehicular Volume  
 Condition B : Interruption of Continuous Traffic  
 Combination : Combination of Condition A and Condition B

WARRANT 2 -- Four-Hour Vehicular Volume Warrant

WARRANT 3 -- Peak Hour Warrant

Intersection	
Intersection Delay, s/veh	27.6
Intersection LOS	D

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕	↕		↕	
Traffic Vol, veh/h	343	16	5	12	31	10	7	343	16	43	218	70
Future Vol, veh/h	343	16	5	12	31	10	7	343	16	43	218	70
Peak Hour Factor	0.95	0.95	0.95	0.88	0.88	0.88	0.96	0.96	0.96	0.73	0.73	0.73
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	361	17	5	14	35	11	7	357	17	59	299	96
Number of Lanes	0	1	0	0	1	0	0	1	1	0	1	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	1	1	1	2
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	1	2	1	1
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	2	1	1	1
HCM Control Delay	27.1	12.2	25.4	32
HCM LOS	D	B	D	D

Lane	NBLn1	NBLn2	EBLn1	WBLn1	SBLn1
Vol Left, %	2%	0%	94%	23%	13%
Vol Thru, %	98%	0%	4%	58%	66%
Vol Right, %	0%	100%	1%	19%	21%
Sign Control	Stop	Stop	Stop	Stop	Stop
Traffic Vol by Lane	350	16	364	53	331
LT Vol	7	0	343	12	43
Through Vol	343	0	16	31	218
RT Vol	0	16	5	10	70
Lane Flow Rate	365	17	383	60	453
Geometry Grp	7	7	2	2	5
Degree of Util (X)	0.718	0.029	0.737	0.134	0.813
Departure Headway (Hd)	7.086	6.358	6.924	8.001	6.456
Convergence, Y/N	Yes	Yes	Yes	Yes	Yes
Cap	507	560	521	451	558
Service Time	4.867	4.138	4.998	6.001	4.534
HCM Lane V/C Ratio	0.72	0.03	0.735	0.133	0.812
HCM Control Delay	26.1	9.3	27.1	12.2	32
HCM Lane LOS	D	A	D	B	D
HCM 95th-tile Q	5.8	0.1	6.2	0.5	8

Intersection	
Intersection Delay, s/veh	60.2
Intersection LOS	F

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Traffic Vol, veh/h	1	70	165	50	17	25	69	482	142	26	121	1
Future Vol, veh/h	1	70	165	50	17	25	69	482	142	26	121	1
Peak Hour Factor	0.81	0.81	0.81	0.79	0.79	0.79	0.95	0.95	0.95	0.76	0.76	0.76
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	1	86	204	63	22	32	73	507	149	34	159	1
Number of Lanes	0	1	0	0	1	0	0	1	0	0	1	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	1	1	1	1
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	1	1	1	1
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	1	1	1	1
HCM Control Delay	15.9	12.6	98.1	13.3
HCM LOS	C	B	F	B

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	10%	0%	54%	18%
Vol Thru, %	70%	30%	18%	82%
Vol Right, %	20%	70%	27%	1%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	693	236	92	148
LT Vol	69	1	50	26
Through Vol	482	70	17	121
RT Vol	142	165	25	1
Lane Flow Rate	729	291	116	195
Geometry Grp	1	1	1	1
Degree of Util (X)	1.128	0.5	0.226	0.348
Departure Headway (Hd)	5.566	6.545	7.427	6.731
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	649	554	487	537
Service Time	3.613	4.545	5.427	4.731
HCM Lane V/C Ratio	1.123	0.525	0.238	0.363
HCM Control Delay	98.1	15.9	12.6	13.3
HCM Lane LOS	F	C	B	B
HCM 95th-tile Q	22.4	2.8	0.9	1.5

Intersection	
Intersection Delay, s/veh	170.4
Intersection LOS	F

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕	↕		↕	
Traffic Vol, veh/h	182	31	30	44	88	9	19	234	19	27	421	357
Future Vol, veh/h	182	31	30	44	88	9	19	234	19	27	421	357
Peak Hour Factor	0.89	0.89	0.89	0.90	0.90	0.90	0.74	0.74	0.74	0.89	0.89	0.89
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	204	35	34	49	98	10	26	316	26	30	473	401
Number of Lanes	0	1	0	0	1	0	0	1	1	0	1	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	1	1	1	2
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	1	2	1	1
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	2	1	1	1
HCM Control Delay	22.4	17.1	26	300.3
HCM LOS	C	C	D	F

Lane	NBLn1	NBLn2	EBLn1	WBLn1	SBLn1
Vol Left, %	8%	0%	75%	31%	3%
Vol Thru, %	92%	0%	13%	62%	52%
Vol Right, %	0%	100%	12%	6%	44%
Sign Control	Stop	Stop	Stop	Stop	Stop
Traffic Vol by Lane	253	19	243	141	805
LT Vol	19	0	182	44	27
Through Vol	234	0	31	88	421
RT Vol	0	19	30	9	357
Lane Flow Rate	342	26	273	157	904
Geometry Grp	7	7	2	2	5
Degree of Util (X)	0.689	0.046	0.562	0.341	1.611
Departure Headway (Hd)	8.212	7.447	8.768	9.366	6.412
Convergence, Y/N	Yes	Yes	Yes	Yes	Yes
Cap	444	484	415	387	579
Service Time	5.912	5.147	6.768	7.366	4.412
HCM Lane V/C Ratio	0.77	0.054	0.658	0.406	1.561
HCM Control Delay	27.2	10.5	22.4	17.1	300.3
HCM Lane LOS	D	B	C	C	F
HCM 95th-tile Q	5.1	0.1	3.4	1.5	49.7

Intersection	
Intersection Delay, s/veh	83
Intersection LOS	F

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Traffic Vol, veh/h	2	119	265	167	50	29	60	215	114	25	396	1
Future Vol, veh/h	2	119	265	167	50	29	60	215	114	25	396	1
Peak Hour Factor	0.94	0.94	0.94	0.87	0.87	0.87	0.88	0.88	0.88	0.95	0.95	0.95
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	2	127	282	192	57	33	68	244	130	26	417	1
Number of Lanes	0	1	0	0	1	0	0	1	0	0	1	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	1	1	1	1
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	1	1	1	1
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	1	1	1	1
HCM Control Delay	69.7	38.7	99	107.5
HCM LOS	F	E	F	F

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	15%	1%	68%	6%
Vol Thru, %	55%	31%	20%	94%
Vol Right, %	29%	69%	12%	0%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	389	386	246	422
LT Vol	60	2	167	25
Through Vol	215	119	50	396
RT Vol	114	265	29	1
Lane Flow Rate	442	411	283	444
Geometry Grp	1	1	1	1
Degree of Util (X)	1.079	0.973	0.751	1.104
Departure Headway (Hd)	9.18	9.158	10.305	9.285
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	398	398	353	395
Service Time	7.18	7.158	8.305	7.285
HCM Lane V/C Ratio	1.111	1.033	0.802	1.124
HCM Control Delay	99	69.7	38.7	107.5
HCM Lane LOS	F	F	E	F
HCM 95th-tile Q	14.7	11.3	5.9	15.4

Intersection	
Intersection Delay, s/veh	32.8
Intersection LOS	D

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕	↕		↕	
Traffic Vol, veh/h	356	16	5	12	35	10	8	343	16	54	218	78
Future Vol, veh/h	356	16	5	12	35	10	8	343	16	54	218	78
Peak Hour Factor	0.95	0.95	0.95	0.88	0.88	0.88	0.96	0.96	0.96	0.73	0.73	0.73
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	375	17	5	14	40	11	8	357	17	74	299	107
Number of Lanes	0	1	0	0	1	0	0	1	1	0	1	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	1	1	1	2
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	1	2	1	1
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	2	1	1	1
HCM Control Delay	31.3	12.8	27.6	40.8
HCM LOS	D	B	D	E

Lane	NBLn1	NBLn2	EBLn1	WBLn1	SBLn1
Vol Left, %	2%	0%	94%	21%	15%
Vol Thru, %	98%	0%	4%	61%	62%
Vol Right, %	0%	100%	1%	18%	22%
Sign Control	Stop	Stop	Stop	Stop	Stop
Traffic Vol by Lane	351	16	377	57	350
LT Vol	8	0	356	12	54
Through Vol	343	0	16	35	218
RT Vol	0	16	5	10	78
Lane Flow Rate	366	17	397	65	479
Geometry Grp	7	7	2	2	5
Degree of Util (X)	0.741	0.03	0.781	0.149	0.88
Departure Headway (Hd)	7.295	6.564	7.085	8.309	6.605
Convergence, Y/N	Yes	Yes	Yes	Yes	Yes
Cap	494	541	508	434	547
Service Time	5.094	4.362	5.175	6.309	4.698
HCM Lane V/C Ratio	0.741	0.031	0.781	0.15	0.876
HCM Control Delay	28.4	9.6	31.3	12.8	40.8
HCM Lane LOS	D	A	D	B	E
HCM 95th-tile Q	6.2	0.1	7.1	0.5	9.9

Intersection	
Intersection Delay, s/veh	67
Intersection LOS	F

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Traffic Vol, veh/h	1	70	173	50	17	25	69	495	142	26	121	1
Future Vol, veh/h	1	70	173	50	17	25	69	495	142	26	121	1
Peak Hour Factor	0.81	0.81	0.81	0.79	0.79	0.79	0.95	0.95	0.95	0.76	0.76	0.76
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	1	86	214	63	22	32	73	521	149	34	159	1
Number of Lanes	0	1	0	0	1	0	0	1	0	0	1	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	1	1	1	1
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	1	1	1	1
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	1	1	1	1
HCM Control Delay	16.5	12.8	109.9	13.5
HCM LOS	C	B	F	B

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	10%	0%	54%	18%
Vol Thru, %	70%	29%	18%	82%
Vol Right, %	20%	71%	27%	1%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	706	244	92	148
LT Vol	69	1	50	26
Through Vol	495	70	17	121
RT Vol	142	173	25	1
Lane Flow Rate	743	301	116	195
Geometry Grp	1	1	1	1
Degree of Util (X)	1.16	0.52	0.228	0.351
Departure Headway (Hd)	5.619	6.608	7.538	6.828
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	647	548	480	530
Service Time	3.663	4.608	5.538	4.828
HCM Lane V/C Ratio	1.148	0.549	0.242	0.368
HCM Control Delay	109.9	16.5	12.8	13.5
HCM Lane LOS	F	C	B	B
HCM 95th-tile Q	24.2	3	0.9	1.6

Intersection	
Intersection Delay, s/veh	200.2
Intersection LOS	F

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕	↕		↕	
Traffic Vol, veh/h	210	36	34	44	93	9	21	234	19	27	421	382
Future Vol, veh/h	210	36	34	44	93	9	21	234	19	27	421	382
Peak Hour Factor	0.89	0.89	0.89	0.90	0.90	0.90	0.74	0.74	0.74	0.89	0.89	0.89
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	236	40	38	49	103	10	28	316	26	30	473	429
Number of Lanes	0	1	0	0	1	0	0	1	1	0	1	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	1	1	1	2
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	1	2	1	1
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	2	1	1	1
HCM Control Delay	28.5	18.8	30.4	357.1
HCM LOS	D	C	D	F

Lane	NBLn1	NBLn2	EBLn1	WBLn1	SBLn1
Vol Left, %	8%	0%	75%	30%	3%
Vol Thru, %	92%	0%	13%	64%	51%
Vol Right, %	0%	100%	12%	6%	46%
Sign Control	Stop	Stop	Stop	Stop	Stop
Traffic Vol by Lane	255	19	280	146	830
LT Vol	21	0	210	44	27
Through Vol	234	0	36	93	421
RT Vol	0	19	34	9	382
Lane Flow Rate	345	26	315	162	933
Geometry Grp	7	7	2	2	5
Degree of Util (X)	0.73	0.049	0.665	0.369	1.738
Departure Headway (Hd)	8.776	8.004	9.156	10.038	6.711
Convergence, Y/N	Yes	Yes	Yes	Yes	Yes
Cap	417	450	396	362	550
Service Time	6.476	5.704	7.156	8.038	4.76
HCM Lane V/C Ratio	0.827	0.058	0.795	0.448	1.696
HCM Control Delay	31.8	11.1	28.5	18.8	357.1
HCM Lane LOS	D	B	D	C	F
HCM 95th-tile Q	5.7	0.2	4.6	1.7	55.4

Intersection	
Intersection Delay, s/veh	97.7
Intersection LOS	F

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Traffic Vol, veh/h	2	119	265	167	50	29	60	243	114	25	421	1
Future Vol, veh/h	2	119	265	167	50	29	60	243	114	25	421	1
Peak Hour Factor	0.94	0.94	0.94	0.87	0.87	0.87	0.88	0.88	0.88	0.95	0.95	0.95
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	2	127	282	192	57	33	68	276	130	26	443	1
Number of Lanes	0	1	0	0	1	0	0	1	0	0	1	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	1	1	1	1
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	1	1	1	1
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	1	1	1	1
HCM Control Delay	71.8	40.1	124.1	128.5
HCM LOS	F	E	F	F

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	14%	1%	68%	6%
Vol Thru, %	58%	31%	20%	94%
Vol Right, %	27%	69%	12%	0%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	417	386	246	447
LT Vol	60	2	167	25
Through Vol	243	119	50	421
RT Vol	114	265	29	1
Lane Flow Rate	474	411	283	471
Geometry Grp	1	1	1	1
Degree of Util (X)	1.152	0.976	0.754	1.163
Departure Headway (Hd)	9.342	9.473	10.665	9.468
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	393	386	342	386
Service Time	7.342	7.473	8.665	7.468
HCM Lane V/C Ratio	1.206	1.065	0.827	1.22
HCM Control Delay	124.1	71.8	40.1	128.5
HCM Lane LOS	F	F	E	F
HCM 95th-tile Q	17.1	11.2	5.9	17.3

# Queues

## 3: Church Street & Mill Street

02/22/2018



Lane Group	EBT	WBT	NBT	NBR	SBT
Lane Group Flow (vph)	397	65	365	17	480
v/c Ratio	0.78	0.10	0.52	0.03	0.76
Control Delay	26.6	9.4	15.2	2.2	21.8
Queue Delay	0.0	0.0	0.0	0.0	0.0
Total Delay	26.6	9.4	15.2	2.2	21.8
Queue Length 50th (ft)	99	10	81	0	113
Queue Length 95th (ft)	#249	30	157	6	160
Internal Link Dist (ft)	308	303	224		251
Turn Bay Length (ft)					
Base Capacity (vph)	703	903	1006	882	890
Starvation Cap Reductn	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0
Reduced v/c Ratio	0.56	0.07	0.36	0.02	0.54

### Intersection Summary

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

HCM 2010 Signalized Intersection Summary  
 3: Church Street & Mill Street

02/22/2018

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	356	16	5	12	35	10	8	343	16	54	218	78
Future Volume (veh/h)	356	16	5	12	35	10	8	343	16	54	218	78
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1900	1863	1900	1900	1863	1900	1900	1863	1863	1900	1863	1900
Adj Flow Rate, veh/h	375	17	5	14	40	11	8	357	0	74	299	107
Adj No. of Lanes	0	1	0	0	1	0	0	1	1	0	1	0
Peak Hour Factor	0.95	0.95	0.95	0.88	0.88	0.88	0.96	0.96	0.96	0.73	0.73	0.73
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	642	21	6	186	451	108	93	736	632	166	453	149
Arrive On Green	0.36	0.36	0.36	0.36	0.36	0.36	0.40	0.40	0.00	0.40	0.40	0.40
Sat Flow, veh/h	1317	60	18	224	1257	302	11	1842	1583	164	1134	372
Grp Volume(v), veh/h	397	0	0	65	0	0	365	0	0	480	0	0
Grp Sat Flow(s),veh/h/ln	1394	0	0	1783	0	0	1853	0	1583	1670	0	0
Q Serve(g_s), s	9.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0
Cycle Q Clear(g_c), s	10.4	0.0	0.0	1.0	0.0	0.0	6.0	0.0	0.0	9.6	0.0	0.0
Prop In Lane	0.94		0.01	0.22		0.17	0.02		1.00	0.15		0.22
Lane Grp Cap(c), veh/h	669	0	0	745	0	0	829	0	632	768	0	0
V/C Ratio(X)	0.59	0.00	0.00	0.09	0.00	0.00	0.44	0.00	0.00	0.63	0.00	0.00
Avail Cap(c_a), veh/h	1006	0	0	1161	0	0	1204	0	958	1096	0	0
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	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	11.7	0.0	0.0	8.8	0.0	0.0	9.3	0.0	0.0	10.2	0.0	0.0
Incr Delay (d2), s/veh	0.8	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.8	0.0	0.0
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	4.1	0.0	0.0	0.5	0.0	0.0	3.1	0.0	0.0	4.7	0.0	0.0
LnGrp Delay(d),s/veh	12.6	0.0	0.0	8.9	0.0	0.0	9.6	0.0	0.0	11.1	0.0	0.0
LnGrp LOS	B			A			A			B		
Approach Vol, veh/h		397			65			365			480	
Approach Delay, s/veh		12.6			8.9			9.6			11.1	
Approach LOS		B			A			A			B	
Timer	1	2	3	4	5	6	7	8				
Assigned Phs		2		4		6		8				
Phs Duration (G+Y+Rc), s		21.5		19.8		21.5		19.8				
Change Period (Y+Rc), s		5.0		5.0		5.0		5.0				
Max Green Setting (Gmax), s		25.0		25.0		25.0		25.0				
Max Q Clear Time (g_c+I1), s		8.0		12.4		11.6		3.0				
Green Ext Time (p_c), s		5.6		2.5		4.9		3.1				
<b>Intersection Summary</b>												
HCM 2010 Ctrl Delay				11.0								
HCM 2010 LOS				B								

Intersection	
Intersection Delay, s/veh	67
Intersection LOS	F

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Traffic Vol, veh/h	1	70	173	50	17	25	69	495	142	26	121	1
Future Vol, veh/h	1	70	173	50	17	25	69	495	142	26	121	1
Peak Hour Factor	0.81	0.81	0.81	0.79	0.79	0.79	0.95	0.95	0.95	0.76	0.76	0.76
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	1	86	214	63	22	32	73	521	149	34	159	1
Number of Lanes	0	1	0	0	1	0	0	1	0	0	1	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	1	1	1	1
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	1	1	1	1
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	1	1	1	1
HCM Control Delay	16.5	12.8	109.9	13.5
HCM LOS	C	B	F	B

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	10%	0%	54%	18%
Vol Thru, %	70%	29%	18%	82%
Vol Right, %	20%	71%	27%	1%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	706	244	92	148
LT Vol	69	1	50	26
Through Vol	495	70	17	121
RT Vol	142	173	25	1
Lane Flow Rate	743	301	116	195
Geometry Grp	1	1	1	1
Degree of Util (X)	1.16	0.52	0.228	0.351
Departure Headway (Hd)	5.619	6.608	7.538	6.828
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	647	548	480	530
Service Time	3.663	4.608	5.538	4.828
HCM Lane V/C Ratio	1.148	0.549	0.242	0.368
HCM Control Delay	109.9	16.5	12.8	13.5
HCM Lane LOS	F	C	B	B
HCM 95th-tile Q	24.2	3	0.9	1.6

# Queues

## 3: Church Street & Mill Street

02/22/2018



Lane Group	EBT	WBT	NBT	NBR	SBT
Lane Group Flow (vph)	314	162	344	26	932
v/c Ratio	0.83	0.36	0.38	0.03	0.95
Control Delay	39.9	18.5	9.5	2.3	33.0
Queue Delay	0.0	0.0	0.0	0.0	0.0
Total Delay	39.9	18.5	9.5	2.3	33.0
Queue Length 50th (ft)	99	43	66	0	265
Queue Length 95th (ft)	#217	87	88	5	#523
Internal Link Dist (ft)	308	303	224		251
Turn Bay Length (ft)					
Base Capacity (vph)	414	496	931	890	998
Starvation Cap Reductn	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0
Reduced v/c Ratio	0.76	0.33	0.37	0.03	0.93

### Intersection Summary

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

HCM 2010 Signalized Intersection Summary  
 3: Church Street & Mill Street

02/22/2018

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	210	36	34	44	93	9	21	234	19	27	421	382
Future Volume (veh/h)	210	36	34	44	93	9	21	234	19	27	421	382
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1900	1863	1900	1900	1863	1900	1900	1863	1863	1900	1863	1900
Adj Flow Rate, veh/h	236	40	38	49	103	10	28	316	0	30	473	429
Adj No. of Lanes	0	1	0	0	1	0	0	1	1	0	1	0
Peak Hour Factor	0.89	0.89	0.89	0.90	0.90	0.90	0.74	0.74	0.74	0.89	0.89	0.89
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	394	49	46	176	327	28	103	941	897	81	506	444
Arrive On Green	0.26	0.26	0.26	0.26	0.26	0.26	0.57	0.57	0.00	0.57	0.57	0.57
Sat Flow, veh/h	1100	191	178	363	1275	108	61	1662	1583	26	894	785
Grp Volume(v), veh/h	314	0	0	162	0	0	344	0	0	932	0	0
Grp Sat Flow(s),veh/h/ln	1469	0	0	1747	0	0	1722	0	1583	1705	0	0
Q Serve(g_s), s	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.7	0.0	0.0
Cycle Q Clear(g_c), s	11.1	0.0	0.0	4.0	0.0	0.0	5.5	0.0	0.0	29.4	0.0	0.0
Prop In Lane	0.75		0.12	0.30		0.06	0.08		1.00	0.03		0.46
Lane Grp Cap(c), veh/h	488	0	0	531	0	0	1045	0	897	1031	0	0
V/C Ratio(X)	0.64	0.00	0.00	0.31	0.00	0.00	0.33	0.00	0.00	0.90	0.00	0.00
Avail Cap(c_a), veh/h	575	0	0	635	0	0	1048	0	900	1035	0	0
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	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	19.4	0.0	0.0	17.1	0.0	0.0	6.5	0.0	0.0	11.6	0.0	0.0
Incr Delay (d2), s/veh	1.9	0.0	0.0	0.3	0.0	0.0	0.2	0.0	0.0	11.0	0.0	0.0
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	4.8	0.0	0.0	2.1	0.0	0.0	2.8	0.0	0.0	16.6	0.0	0.0
LnGrp Delay(d),s/veh	21.3	0.0	0.0	17.4	0.0	0.0	6.7	0.0	0.0	22.6	0.0	0.0
LnGrp LOS	C			B			A			C		
Approach Vol, veh/h		314			162			344			932	
Approach Delay, s/veh		21.3			17.4			6.7			22.6	
Approach LOS		C			B			A			C	
Timer	1	2	3	4	5	6	7	8				
Assigned Phs		2		4		6		8				
Phs Duration (G+Y+Rc), s		36.9		19.4		36.9		19.4				
Change Period (Y+Rc), s		5.0		5.0		5.0		5.0				
Max Green Setting (Gmax), s		32.0		18.0		32.0		18.0				
Max Q Clear Time (g_c+I1), s		7.5		13.1		31.4		6.0				
Green Ext Time (p_c), s		12.1		1.4		0.5		2.5				
<b>Intersection Summary</b>												
HCM 2010 Ctrl Delay				18.8								
HCM 2010 LOS				B								

Intersection	
Intersection Delay, s/veh	97.7
Intersection LOS	F

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Traffic Vol, veh/h	2	119	265	167	50	29	60	243	114	25	421	1
Future Vol, veh/h	2	119	265	167	50	29	60	243	114	25	421	1
Peak Hour Factor	0.94	0.94	0.94	0.87	0.87	0.87	0.88	0.88	0.88	0.95	0.95	0.95
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	2	127	282	192	57	33	68	276	130	26	443	1
Number of Lanes	0	1	0	0	1	0	0	1	0	0	1	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	1	1	1	1
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	1	1	1	1
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	1	1	1	1
HCM Control Delay	71.8	40.1	124.1	128.5
HCM LOS	F	E	F	F

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	14%	1%	68%	6%
Vol Thru, %	58%	31%	20%	94%
Vol Right, %	27%	69%	12%	0%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	417	386	246	447
LT Vol	60	2	167	25
Through Vol	243	119	50	421
RT Vol	114	265	29	1
Lane Flow Rate	474	411	283	471
Geometry Grp	1	1	1	1
Degree of Util (X)	1.152	0.976	0.754	1.163
Departure Headway (Hd)	9.342	9.473	10.665	9.468
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	393	386	342	386
Service Time	7.342	7.473	8.665	7.468
HCM Lane V/C Ratio	1.206	1.065	0.827	1.22
HCM Control Delay	124.1	71.8	40.1	128.5
HCM Lane LOS	F	F	E	F
HCM 95th-tile Q	17.1	11.2	5.9	17.3