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Take 5 Oil Change



16912 E. 23rd Street Independence, Missouri

TRAFFIC IMPACT STUDY

September 2021



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Take 5 Oil Change

Traffic Impact Study

September 2021

I HEREBY CERTIFY THAT THIS REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION, AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER EXISTING UNDER THE LAWS OF THE STATE OF MISSOURI



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BHC Project Number 031990.00.01

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1 Introduction

The purpose of this study is to assess the impact of the development on the adjacent street network related to traffic operations and safety. Three (3) conditions will be evaluated. Two analysis periods (AM and PM peak hours of traffic) will be considered for each condition.

- 1. Existing
- 2. Existing + Take 5 Oil Change + Fast Food with Drive Thru
- 3. Existing + Take 5 Oil Change + Convenience Store with Gas

The proposed site is Take 5 Oil Change located at 16912 East 23rd Street South, Independence, MO. Site traffic will be determined using trip generation and trip distribution.

2 Existing Condition

Land Use

The existing property is comprised of three parcels and zoned as Neighborhood Commercial (C-1). One parcel is occupied by a LendNation, which provides loans (installment, payday, and title). See <u>Figure 1</u> - Site Location Map.

Site Plan Access

The existing property has two access points in the northeast quadrant of the E. 23rd Street and M-291 intersection. The access along E. 23rd Street is 60' wide and its center is 160' east of the center of the intersection. The access along M-291 is 50' wide and its center is 160' north of the center of the intersection. See Figure 1 - Site Location Map.

Street Network and Traffic Control

- M-291 is a north-south divided 4-lane roadway with a posted speed of 45 mph south of the intersection and 50 mph north of the intersection. The intersection is signalized. There are two 200' left-turn lanes, two through lanes, and a yield-controlled right turn lane in both the northbound (225' storage) and southbound (320' storage) directions.
- East 23rd Street South / M-78 is an east-west divided 4-lane roadway with a posted speed of 40 mph east and west of the intersection. The intersection is signalized. There are two left-turn lanes, two through lanes, a yield-controlled right turn lane in the eastbound (210' storage) direction, and a signal-controlled right turn lane in the westbound (160' storage) direction.

Existing Traffic Volumes

Existing turning movement count data was collected during the peak hours, 7-9am and 4-6pm, using Miovision on Wednesday, August 18, 2021. Pedestrians and bicyclists were also counted. Vehicles were classified into Lights, Articulated Trucks, Buses and Single-Unit Trucks. Peak hours were determined to be 7:15am to 8:15am and 4:45pm to 5:45pm. See both <u>Appendix A</u> – Traffic Count Data and <u>Figure 3</u> – Existing Traffic Volumes. The existing Signal Phasing and Timing Plan, provided by MoDOT, is shown in <u>Appendix C</u>. The existing turning movement count data was analyzed using Synchro traffic software.

As shown in <u>Appendix D</u> the AM Peak Hour operates at a level of service (LOS) D or 45.9s Delay. As shown in <u>Appendix E</u> the PM Peak Hour operates at a LOS E or 59.3s Delay.

3 Proposed Condition

Land Use

Two land use scenarios will be analyzed.

Scenario A

- 1,415 SF, 3-bay Quick Lubrication Vehicle Shop (Take 5) [ITE land use code 941]
- 3,751 SF Fast-Food Restaurant with Drive-Through Window [934]

Scenario B

- 1,415 SF, 3-bay Quick Lubrication Vehicle Shop (Take 5) [941]
- 4,200 SF, 6-pump Convenience Market with Gasoline Pumps [853]

See <u>Figure 2</u> - Site Plan (for Scenario A). It is understood that the Convenience Market occupies a similar footprint as the Fast-Food Restaurant.

Site Plan Access

The two existing access points will be removed. An access point along E. 23rd Street and another along M-291 are proposed. The access point along E. 23rd Street is a 24-foot wide right in-right out and located 260' east of the intersection. The access point along M-291 is a 24-foot wide right in-right out and located 315' north of the intersection. A northbound right turn lane with a 55' taper and 93' of storage is proposed. See <u>Figure 2</u> - Site Plan.

4 Proposed Access vs. Design Criteria

Driveway Geometrics

Low Volume Commercial Driveway

As per MoDOT's Engineering Policy Guide (EPG) Table 940.16.4, driveways with no more than 150 peak hour vehicles in both directions classify "Low Volume Commercial / Industrial" driveway. As shown in Figure 4A and Figure 4B, the M-291 and E. 23rd Street entrances in the AM and PM peak hours in both scenarios are under the 150-vehicle guideline, except the PM peak hour for Scenario B (160 vehicles).

Right-Turn (Approach) Radius

As per MoDOT's EPG Table 940.16.3, the right-turn radius for a commercial driveway in an urban area is 25 feet. Both the M-291 and E. 23rd Street entrances meet that guideline.

Width

As per MoDOT's EPG Table 940.16.4, the minimum driveway width for a two-way access striped for two lanes is 28 feet. The Site Plan in Figure 2 shows 24-foot driveway widths at M-291 and E. 23rd Street. It is recommended that these driveways be widened to 28 feet at least for a 20-foot throat length.

Throat

As per MoDOT's EPG 940.16.8, the driveway throat length for a low traffic volume commercial driveway is 20 feet. As shown in the Site Plan in Figure 2, the M-291 and E. 23rd Street entrances exceed that throat length.

Minimum Sight Distance

The required intersection sight distance at the proposed M-291 entrance (looking south to make a NB right turn) for 50mph is 555 feet (as per MoDOT's EPG Table 233.2.1). There is roughly 600 feet of sight distance from the M-291 entrance looking south. The required intersection sight distance at the E. 23rd Street entrance (looking east to make a SB right turn) for 40mph is 445 feet (as per MoDOT's EPG Table 233.2.1). There is roughly 550 feet of sight distance from the E. 23rd Street entrance looking east. Vegetation will not be proposed within the intersection sight triangles at the M-291 and E. 23rd Street entrances.

Spacing between other Driveways and Streets

MoDOT's EPG 940.14 provides guidance on driveway spacing from a major street. As shown in the Site Plan in <u>Figure 2</u>, the M-291 entrance is proposed to be located along the north property line. As shown in the Site Plan in <u>Figure 2</u>, the E. 23rd Street entrance is proposed to be located at the end of the westbound right-turn turn lane and 108 feet from an existing residential driveway. No exception is taken for the location of these driveways.

Westbound Approach Signalization

The westbound approach signalization does not impact the northbound right tun lane. Westbound vehicles will merge with the northbound through vehicles before the taper of the northbound right turn lane.

Southbound U-turn

As shown in <u>Figure 4A</u> and <u>Figure 4B</u>, there are only four to six vehicles making this movement in the peak hour to access the site. However, a 15-foot inside radius or 25-foot outside radius is assumed for an automobile making a U-turn as per AASHTO's <u>A Policy on Geometric Design of Highways and Streets</u>, Figure 2-1. At this location, there is about a 20-foot inside radius. No improvements to the site are necessary.

5 Trip Generation and Distribution

Trip Generation

The expected trip generation for the development was estimated using the 10th Edition of the <u>Trip Generation Handbook</u> published by the Institute of Transportation Engineers (ITE). For purposes of this study, the businesses will be classified with the ITE land use code and independent variables indicated previously in the "Land Use" section.

The Average Trip Generation Rate was used to estimate trip generation. There were no Fitted Curved Equations given. The square foot variable (versus Vehicle Fueling Positions) was used for ITE land use code 853 as this provided more conservative trip ends. Also, "Servicing Positions" was used for ITE land use code 941 as there were more studies for this variable. <u>Table 1A</u> and <u>Table 1B</u> summarize the trip ends produced for the AM and PM peak hours for

		т	able 1	A - Trip Gei	neratio	n		
Peak	Land			Ava. Trip	Dir.		Trip End	S
Hour	Use	Variable	Value	Gen. Rate	Dist.	Total	Entering	Exiting
	941	Serv. Pos.	3	3.00	67/33	9	6	3
AM	934	1000 SF	3.75	40.19	51/49	151	77	74
					Total	160	83	77
	941	Serv. Pos.	3	4.85	56/44	15	8	7
PM	934	1000 SF	3.75	32.67	52/48	123	64	59
1					Total	138	72	66

Scenarios A and B, respectively. The detailed trip generation data plots are shown in <u>Appendix B</u>.

		т	able 1	B - Trip Gei	neratio	n		
Peak	Land			Ava. Trip	Dir.		Trip Ends	5
Hour	Use	Variable	Value	Gen. Rate	Dist.	Total	Entering	Exiting
	941	Serv. Pos.	3	3.00	67/33	9	6	3
AM	853	1000 SF	4.20	40.59	50/50	170	85	85
					Total	179	91	88
	941	Serv. Pos.	3	4.85	56/44	15	8	7
PM	853	1000 SF	4.20	49.29	50/50	207	104	103
					Total	222	112	110

Trip Distribution

Trips to the proposed site were distributed based on the existing directional traffic pattern of the peak periods and a general analysis of the surrounding area.

Southbound Vehicles consist of 34% and 32% of the intersection traffic in the AM and PM, respectively. However, to enter the site a southbound U-turn would be necessary. For this reason, the entering southbound U-turn movement at the intersection was set at 5%.

Eastbound Vehicles consist of 15% and 22% of the intersection traffic in the AM and PM, respectively. These vehicles can access the site with a northbound left at the intersection. However, when these vehicles leave the site (from the 23rd Street entrance) a restricted westbound U-turn movement at the 23rd Street / M-291 intersection would require them to travel an additional 600 feet west to Hub Drive to make a U-turn to continue eastbound. For this reason, the entering eastbound left movement at the intersection was set at 5%.

Detailed trip distribution is shown below in <u>Table 2</u>. <u>Figure 4A</u> and <u>Figure 4B</u> show the Site Generated Traffic Volumes for the AM and PM peak hours for Scenarios A and B, respectively.

						Ta	able	2 -	• T I	rip l	Dis	strib	utic	on					
	Trip Intersection Site																		
		En	ds			23	rd St	treet	& N	1-291				23rd	St.	M-291	23rd St.	M-2	91
						Enteri	ng				E	kiting			Enter	ing	E	kiting	
	Pk.			SB U-	Turn	NB	Т	EB	L	WB	L^	WB	T*	WB	R	NBR	SBR	WB	R"
Sc.	Hr.	Ent.	Ex.	%	#	%	#	%	#	%	#	%	#	%	#	#	#	%	#
	AM	83	77	5 %	4	60%	57	5 %	4	5%	4	26%	20	210/	18	65	24	60%	53
	PM	72	66	5%	4	0970	49	5%	4	570	3	20 /0	18	21/0	15	57	21	0970	45
Ь	AM	91	88	F 0/	5	670/	61	E 0/	5	5 0/	4	2/10/	25	020/	20	71	29	670/	59
	PM	112	110	5%	6	07 %	75	5%	6	5%	6	34 %	31	23%	25	87	37	07 %	73
^WE	^WBL accommodates SB Traffic.																		
*WE	BT acc	commo	odate	s both	WB	and E	B Tra	affic.											
"WE	"WBR (at M-291 Entrance) accommodates NB Traffic.																		

6 Capacity Analysis

The capacity analysis for the study intersections was completed using the methodology outlined in the <u>Highway Capacity Manual</u>, 6th Edition. The capacity analysis was completed using Synchro 10 software by Trafficware. The criteria for determining Level of Service (LOS) of signalized and unsignalized intersections is based on the average vehicle delay and is outlined in <u>Table 3</u>. The intersection of M-291 and E. 23rd Street is signalized. The entrances off M-291 and E. 23rd Street are not signalized. Level of Service is defined as the measure of the quality of traffic flow and is graded from "A" to "F". "A" is the best situation and "F" is the worst situation.

Table 3 - Intersection LOS											
LOS	Average Veh (sec/v	iicle Delay reh)									
	Unsignalized Signalized										
Α	< 10	< 10									
В	< 15	< 20									
С	< 25	< 35									
D	< 35	< 55									
E	< 50 < 80										
F	≥ 50 ≥ 80										

LOS ratings of A to D are typically considered acceptable during peak hours of traffic.

7 Existing + Site Condition

Scenario B is a more conservative as it generates more trips. <u>Figure 5B</u> shows the Scenario B Site Generated Traffic Volumes for the AM and PM peak hours from <u>Figure 4B</u> plus the existing traffic volumes from <u>Figure 3</u>.

Level of Service (LOS) and the 95th Percentile Queue for vehicles exiting the site was calculated using Synchro traffic software. The AM and PM Peak Hour analysis is shown in <u>Appendix F</u> and <u>Appendix G</u>, respectively. <u>Table 4</u> summarizes the Level of Service and Exiting Queue.

Table 4 – LOS & Exiting Queue									
Int.	Peak Hour	Cond.	Delay (s)	LOS	Q (veh)				
	A N A	Ex.	45.9	D					
M-291	AIVI	Ex. + Site	46.7	D					
23rd St		Ex.	59.3	E					
	PIVI	Ex. + Site	61.4	E					
M-291	AM	Ex. + Site	16.2	С	0.6				
Ent.	PM	Ex. + Site	28.4	D	1.4				
23rd St.	AM	Ex. + Site	10.2	В	0.1				
Ent.	PM	Ex. + Site	11.0	В	0.2				

With the addition of the Scenario B site generated traffic, the AM peak hour delay increased by 0.8s and the PM peak hour increased by 2.1s. The LOS of both the AM and PM peak hours remained unchanged.

8 Queuing Analysis

There are two proposed access point for the site. One along M-291 and another along E. 23^{rd} Street. See <u>Figure 2</u> – Site Plan (for Scenario A). As shown in Tables 1A and 1B, the "Future Development" comprises of 90-95% of the trip ends. The queuing analysis will focus on the trips generated by the "Future Development", which will either be a Convenience Market with Gas (Scenario A) or a Fast-Food Restaurant (Scenario B).

The Take 5 Oil Change produced 6 trips in the AM and 8 trips in the PM. This is one vehicle every 7.5 to 10 minutes for three service bays and 5 parking spaces.

M-291 Entrance

The throat length off M-291 is 164 feet. This will hold over 6 vehicles. The two-lane drive-thru lane is 75 feet. This will hold another 6 vehicles. In addition to queuing for 12 vehicles, there are 40 parking spaces.

In *Scenario A*, there are 65 and 57 vehicles entering in the AM and PM peak hours, respectively. This one vehicle every minute.

In *Scenario B*, there are 71 and 87 vehicles entering in the AM and PM peak hours, respectively. This 1 to 1.5 vehicles every minute.

E. 23rd Street Entrance

The southern access point to the "Future Development" has been changed by the developer to an "Exit Only". This allows a throat length of 186 feet off E. 23rd Street to the "Future Development" site. This will hold over 7 vehicles. The two-lane drive-thru lane is 75 feet. This will hold another 6 vehicles. In addition to queuing for 13 vehicles, there are 40 parking spaces.

In *Scenario A*, there are 18 and 15 vehicles entering in the AM and PM peak hours, respectively. This one vehicle every 3 to 4 minutes.

In *Scenario B*, there are 20 and 25 vehicles entering in the AM and PM peak hours, respectively. This one vehicle every 2 to 3 minutes.

The number of vehicles expected to access the proposed site from northbound M-291 or westbound E. 23rd Street is low enough that the throat length will be sufficient to handle peak hour traffic and no adverse effects on the adjacent roadways.

9 Conclusion and Recommendations

Conclusion

Using trip generation, trip distribution, and capacity analysis software, this study assessed the impact of the development on the adjacent street network related to traffic operations and safety.

As calculated from <u>Table 1A</u> and <u>Table 1B</u>, Scenario B produces about 13% more trips in the AM peak hour and about 68% more trips in the PM peak hour than Scenario A.

As shown in <u>Table 2</u>, roughly 70% of the vehicles entering the site are northbound and 20% are westbound vehicles.

With the addition of the Scenario B site generated traffic, the AM peak hour delay increased by 0.8s and the PM peak hour increased by 2.1s. The LOS of both the AM and PM peak hours remained unchanged.

In addition, the number of vehicles expected to access the proposed site from northbound M-291 or westbound E. 23rd Street is low enough that the throat length will be sufficient to handle peak hour traffic and no adverse effects on the adjacent roadways.

Recommendations

• It is recommended that the M-291 and E. 23rd Street driveways be widened to 28 feet at least for a 20-foot throat length.

Figures









Volume Legend

(##) = AM Peak Hour (PM Peak Hour)

Entering

Exiting



Volume Legend

(##) = AM Peak Hour (PM Peak Hour)

Entering

Exiting



Appendices

E. 23rd Street & M-291, Independece, MO - TMC Wed Aug 18, 2021 Full Length (7 AM-9 AM, 4 PM-6 PM) All Classes (Lights, Articulated Trucks, Buses and Single-Unit Tr

All Classes (Lights, Articulated Trucks, Buses and Single-Unit Trucks, Pedestrians, Bicycles on Crosswalk)

All Movements

ID: 863357, Location: 39.077833, -94.379162



Leg	M-291						23rd St						M-291						23rd St						
Direction	Southb	ound					Westbo	und					Northbo	ound					Eastbou	ind					
Time	R	Т	L	U	Арр	Ped*	R	Т	L	U	Арр	Ped*	R	Т	L	U	App	Ped*	R	Т	L	U	App P	ed*	Int
2021-08-18 7:00AM	48	245	17	0	310	0	7	45	34	0	86	0	19	188	51	0	258	0	47	36	33	0	116	0	770
7:15AM	44	297	18	1	360	0	10	63	53	0	126	0	24	271	74	0	369	0	54	37	34	0	125	0	980
7:30AM	55	231	19	0	305	0	5	78	49	0	132	0	28	270	89	0	387	0	77	55	51	0	183	0	1007
7:45AM	59	290	32	0	381	0	18	62	36	0	116	0	34	311	91	0	436	0	63	66	38	0	167	0	1100
Hourly Total	206	1063	86	1	1356	0	40	248	172	0	460	0	105	1040	305	0	1450	0	241	194	156	0	591	0	3857
8:00AM	45	233	14	1	293	0	6	50	42	0	98	0	26	228	69	0	323	0	41	45	39	0	125	0	839
8:15AM	31	241	20	0	292	0	8	38	33	0	79	0	16	213	63	0	292	0	48	40	40	0	128	0	791
8:30AM	56	231	11	0	298	0	9	40	32	0	81	0	24	194	62	0	280	0	54	66	42	0	162	0	821
8:45AM	51	269	18	1	339	0	12	46	36	0	94	0	18	197	78	0	293	0	55	44	35	0	134	0	860
Hourly Total	183	974	63	2	1222	0	35	174	143	0	352	0	84	832	272	0	1188	0	198	195	156	0	549	0	3311
4:00PM	66	336	23	0	425	0	20	69	38	0	127	0	29	330	69	0	428	0	79	102	70	0	251	0	1231
4:15PM	47	335	18	0	400	1	28	86	47	0	161	0	29	313	111	0	453	0	85	117	106	0	308	0	1322
4:30PM	66	335	20	0	421	0	26	81	67	0	174	0	21	298	93	0	412	0	94	138	85	0	317	0	1324
4:45PM	58	324	24	0	406	0	20	74	42	0	136	0	26	335	86	0	447	0	66	118	106	0	290	0	1279
Hourly Total	237	1330	85	0	1652	1	94	310	194	0	598	0	105	1276	359	0	1740	0	324	475	367	0	1166	0	5156
5:00PM	76	369	29	2	476	0	26	79	53	0	158	0	25	342	80	0	447	0	87	118	93	0	298	0	1379
5:15PM	67	361	27	0	455	0	31	65	58	0	154	0	19	357	81	0	457	0	95	126	93	0	314	0	1380
5:30PM	52	346	19	0	417	1	32	92	60	0	184	1	11	364	89	0	464	0	78	135	91	0	304	0	1369
5:45PM	62	332	25	0	419	0	20	77	51	0	148	0	20	284	95	0	399	0	76	92	73	0	241	0	1207
Hourly Total	257	1408	100	2	1767	1	109	313	222	0	644	1	75	1347	345	0	1767	0	336	471	350	0	1157	0	5335
Total	883	4775	334	5	5997	2	278	1045	731	0	2054	1	369	4495	1281	0	6145	0	1099	1335	1029	0	3463	0	17659
% Approach	14.7%	79.6%	5.6%	0.1%	-	-	13.5%	50.9%	35.6%	0%	-	-	6.0%	73.1%	20.8%	0%	-	-	31.7%	38.6%	29.7%	0%	-	-	-
% Total	5.0%	27.0%	1.9%	0%3	34.0%	-	1.6%	5.9%	4.1%	0% 1	1.6%	-	2.1%	25.5%	7.3%	0%:	34.8%	-	6.2%	7.6%	5.8%	0% 1	19.6%	-	-
Lights	851	4516	331	5	5703	-	271	1024	723	0	2018	-	361	4211	1261	0	5833	-	1075	1319	1005	0	3399	-	16953
% Lights	96.4%	94.6%	99.1%	100% 9	95.1%	-	97.5%	98.0%	98.9%	0% 9	8.2%	-	97.8%	93.7%	98.4%	0% 9	94.9%	-	97.8%	98.8%	97.7%	0% 9	98.2%	-	96.0%
Articulated Trucks	10	124	1	0	135	-	1	3	2	0	6	-	4	145	2	0	151	-	5	2	7	0	14	-	306
% Articulated Trucks	1.1%	2.6%	0.3%	0%	2.3%	-	0.4%	0.3%	0.3%	0%	0.3%	-	1.1%	3.2%	0.2%	0%	2.5%	-	0.5%	0.1%	0.7%	0%	0.4%	-	1.7%
Buses and Single-Unit																									
Trucks	22	135	2	0	159	-	6	18	6	0	30	-	4	139	18	0	161	-	19	14	17	0	50	-	400
% Buses and Single-Unit																									
Trucks	2.5%	2.8%	0.6%	0%	2.7%	-	2.2%	1.7%	0.8%	0%	1.5%	-	1.1%	3.1%	1.4%	0%	2.6%	-	1.7%	1.0%	1.7%	0%	1.4%	-	2.3%
Pedestrians	-	-	-	-	-	2	-	-	-	-	-	1	-	-	-	-	-	0	-	-	-	-	-	0	L
% Pedestrians	-	-	-	-	-	100%	-	-	-	-	-	100%	-	-	-	-	-	-	-	-	-	-	-	-	-
Bicycles on Crosswalk	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	0	L
% Bicycles on Crosswalk	-	-	-	-	-	0%	-	-	-	-	-	0%	-	-	-	-	-	-	-	-	-	-	-	-	- 1

^{*}Pedestrians and Bicycles on Crosswalk. L: Left, R: Right, T: Thru, U: U-Turn

E. 23rd Street & M-291, Independece, MO - TMC Wed Aug 18, 2021 Full Length (7 AM-9 AM, 4 PM-6 PM) All Classes (Lights, Articulated Trucks, Buses and Single-Unit Trucks, Pedestrians, Bicycles on Crosswalk) All Movements ID: 863357, Location: 39.077833, -94.379162





E. 23rd Street & M-291, Independece, MO - TMC Wed Aug 18, 2021 AM Peak (7:15 AM - 8:15 AM) All Classes (Lights, Articulated Trucks, Buses and Single-Unit Trucks, Pedestrians, Bicycles on Crosswalk) All Movements ID: 863357, Location: 39.077833, -94.379162



625 Forest Edge Drive, Vernon Hills, IL, 60061, US

Leg	M-291					23rd 3	St					M-291						23rd St						
Direction	Southb	ound				Westl	oound					Northb	ound					Eastbo	und					
Time	R	Т	L	U	App Ped*	R	Т	L	U	Арр	Ped*	R	Т	L	U	Арр	Ped*	R	Т	L	U	App I	'ed*	Int
2021-08-18 7:15AM	44	297	18	1	360 0	10	63	53	0	126	0	24	271	74	0	369	0	54	37	34	0	125	0	980
7:30AM	55	231	19	0	305 0	5	78	49	0	132	0	28	270	89	0	387	0	77	55	51	0	183	0	1007
7:45AM	59	290	32	0	381 0	18	62	36	0	116	0	34	311	91	0	436	0	63	66	38	0	167	0	1100
8:00AM	45	233	14	1	293 0	6	50	42	0	98	0	26	228	69	0	323	0	41	45	39	0	125	0	839
Total	203	1051	83	2	1339 0	39	253	180	0	472	0	112	1080	323	0	1515	0	235	203	162	0	600	0	3926
% Approach	15.2%	78.5%	6.2%	0.1%		- 8.3%	53.6%	38.1%	0%	-	-	7.4%	71.3%	21.3%	0%	-	-	39.2%	33.8%	27.0%	0%	-	-	-
% Total	5.2%	26.8%	2.1%	0.1%	34.1%	- 1.0%	6.4%	4.6%	0%	12.0%	-	2.9%	27.5%	8.2%	0%	38.6%	-	6.0%	5.2%	4.1%	0%1	15.3%	-	-
PHF	0.860	0.885	0.648	0.500	0.879	0.542	0.811	0.849	-	0.894	-	0.824	0.868	0.887	-	0.869	-	0.763	0.769	0.794	-	0.820	-	0.892
Lights	191	959	83	2	1235	- 39	244	176	0	459	-	110	999	317	0	1426	-	231	199	154	0	584	-	3704
% Lights	94.1%	91.2%	100%	100%	92.2%	- 100%	96.4%	97.8%	0% !	97.2%	-	98.2%	92.5%	98.1%	0%	94.1%	-	98.3%	98.0%	95.1%	0% S	97.3%	-	94.3%
Articulated Trucks	2	40	0	0	42 ·	- 0	2	1	0	3	-	1	43	1	0	45	-	0	0	3	0	3	-	93
% Articulated Trucks	1.0%	3.8%	0%	0%	3.1%	- 0%	0.8%	0.6%	0%	0.6%	-	0.9%	4.0%	0.3%	0%	3.0%	-	0%	0%	1.9%	0%	0.5%	-	2.4%
Buses and Single-Unit Trucks	10	52	0	0	62	- 0	7	3	0	10	-	1	38	5	0	44	-	4	4	5	0	13	-	129
% Buses and Single-Unit																								
Trucks	4.9%	4.9%	0%	0%	4.6%	- 0%	2.8%	1.7%	0%	2.1%	-	0.9%	3.5%	1.5%	0%	2.9%	-	1.7%	2.0%	3.1%	0%	2.2%	-	3.3%
Pedestrians	-	-	-	-	- 0) -	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	0	
% Pedestrians	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bicycles on Crosswalk	-	-	-	-	- 0) -	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	0	
% Bicycles on Crosswalk	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

^{*}Pedestrians and Bicycles on Crosswalk. L: Left, R: Right, T: Thru, U: U-Turn

E. 23rd Street & M-291, Independece, MO - TMC Wed Aug 18, 2021 AM Peak (7:15 AM - 8:15 AM) All Classes (Lights, Articulated Trucks, Buses and Single-Unit Trucks, Pedestrians, Bicycles on Crosswalk) All Movements ID: 863357, Location: 39.077833, -94.379162





E. 23rd Street & M-291, Independece, MO - TMC Wed Aug 18, 2021 PM Peak (4:45 PM - 5:45 PM) - Overall Peak Hour

All Classes (Lights, Articulated Trucks, Buses and Single-Unit Trucks, Pedestrians, Bicycles on Crosswalk)

All Movements

ID: 863357, Location: 39.077833, -94.379162



625 Forest Edge Drive, Vernon Hills, IL, 60061, US

Leg	M-291						23rd St						M-291						23rd St						
Direction	Southb	ound					Westbo	ound					Northb	ound					Eastbo	und					
Time	R	Т	L	U	Арр	Ped*	R	Т	L	U	Арр	Ped*	R	Т	L	U	App P	ed*	R	Т	L	U	App I	Ped*	Int
2021-08-18 4:45PM	58	324	24	0	406	0	20	74	42	0	136	0	26	335	86	0	447	0	66	118	106	0	290	0	1279
5:00PM	76	369	29	2	476	0	26	79	53	0	158	0	25	342	80	0	447	0	87	118	93	0	298	0	1379
5:15PM	67	361	27	0	455	0	31	65	58	0	154	0	19	357	81	0	457	0	95	126	93	0	314	0	1380
5:30PM	52	346	19	0	417	1	32	92	60	0	184	1	11	364	89	0	464	0	78	135	91	0	304	0	1369
Total	253	1400	99	2	1754	1	109	310	213	0	632	1	81	1398	336	0	1815	0	326	497	383	0	1206	0	5407
% Approach	14.4%	79.8%	5.6%	0.1%	-	-	17.2%	49.1%	33.7%	0%	-	-	4.5%	77.0%	18.5%	0%	-	-	27.0%	41.2%	31.8%	0%	-	-	-
% Total	4.7%	25.9%	1.8%	0%	32.4%	-	2.0%	5.7%	3.9%	0% 1	1.7%	-	1.5%	25.9%	6.2%	0%:	33.6%	-	6.0%	9.2%	7.1%	0%	22.3%	-	-
PHF	0.832	0.949	0.853	0.250	0.921	-	0.852	0.842	0.888	-	0.859	-	0.779	0.960	0.944	-	0.978	-	0.858	0.920	0.903	-	0.960	-	0.980
Lights	248	1365	98	2	1713	-	105	309	213	0	627	-	80	1343	332	0	1755	-	321	495	381	0	1197	-	5292
% Lights	98.0%	97.5%	99.0%	100%	97.7%	-	96.3%	99.7%	100%	0% 9	9.2%	-	98.8%	96.1%	98.8%	0% 9	96.7%	-	98.5%	99.6%	99.5%	0%	99.3%	-	97.9%
Articulated Trucks	2	20	0	0	22	-	1	0	0	0	1	-	0	33	0	0	33	-	2	0	0	0	2	-	58
% Articulated Trucks	0.8%	1.4%	0%	0%	1.3%	-	0.9%	0%	0%	0%	0.2%	-	0%	2.4%	0%	0%	1.8%	-	0.6%	0%	0%	0%	0.2%	-	1.1%
Buses and Single-Unit Trucks	3	15	1	0	19	-	3	1	0	0	4	-	1	22	4	0	27	-	3	2	2	0	7	_	57
% Buses and Single-Unit Trucks	1.2%	1.1%	1.0%	0%	1.1%	-	2.8%	0.3%	0%	0%	0.6%	-	1.2%	1.6%	1.2%	0%	1.5%	-	0.9%	0.4%	0.5%	0%	0.6%	-	1.1%
Pedestrians	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	0	-	-	-	-	-	0	
% Pedestrians	-	-	-	-	-	100%	-	-	-	-	-	100%	-	-	-	-	-	-	-	-	-	-	-	-	-
Bicycles on Crosswalk	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	0	
% Bicycles on Crosswalk	-	-	-	-	-	0%	-	-	-	-	-	0%	-	-	-	-	-	-	-	-	-	-	-	-	-

*Pedestrians and Bicycles on Crosswalk. L: Left, R: Right, T: Thru, U: U-Turn

E. 23rd Street & M-291, Independece, MO - TMC Wed Aug 18, 2021 PM Peak (4:45 PM - 5:45 PM) - Overall Peak Hour All Classes (Lights, Articulated Trucks, Buses and Single-Unit Trucks, Pedestrians, Bicycles on Crosswalk) All Movements ID: 863357, Location: 39.077833, -94.379162





Vehicle Trip Ends vs: On a:	1000 Sq. Ft. GFA Weekday, Peak Hour of Adjacent Street Traffic, One Hour Between 7 and 9 a.m.
Setting/Location:	General Urban/Suburban
Number of Studies:	57
Avg. 1000 Sq. Ft. GFA:	3
Directional Distribution:	50% entering, 50% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
40.59	6.30 - 104.76	19.18



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Vehicle Trip Ends vs: On a:	1000 Sq. Ft. GFA Weekday, Peak Hour of Adjacent Street Traffic, One Hour Between 4 and 6 p.m.
Setting/Location:	General Urban/Suburban
Number of Studies:	67
Avg. 1000 Sq. Ft. GFA:	3
Directional Distribution:	50% entering, 50% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
49.29	9.66 - 115.71	22.49



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Vehicle Trip Ends vs: On a:	Vehicle Fueling Positions Weekday, Peak Hour of Adjacent Street Traffic, One Hour Between 7 and 9 a.m.
Setting/Location:	General Urban/Suburban
Number of Studies:	59
Avg. Num. of Vehicle Fueling Positions:	6
Directional Distribution:	50% entering, 50% exiting

Vehicle Trip Generation per Vehicle Fueling Position

Average Rate	Range of Rates	Standard Deviation
20.76	3.75 - 50.00	9.88



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Vehicle Fueling Positions Weekday, Peak Hour of Adjacent Street Traffic, One Hour Between 4 and 6 p.m.
General Urban/Suburban
69
6
50% entering, 50% exiting

Vehicle Trip Generation per Vehicle Fueling Position

Average Rate	Range of Rates	Standard Deviation
23.04	5.75 - 57.80	11.91



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Fast-Food Restaurant with Drive-Through Window (934)

Vehicle Trip Ends vs: On a:	1000 Sq. Ft. GFA Weekday, Peak Hour of Adjacent Street Traffic, One Hour Between 7 and 9 a.m.
Setting/Location:	General Urban/Suburban
Number of Studies:	111
Avg. 1000 Sq. Ft. GFA:	4
Directional Distribution:	51% entering, 49% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
40.19	0.38 - 164.25	28.78



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Fast-Food Restaurant with Drive-Through Window (934)

Vehicle Trip Ends vs: On a:	1000 Sq. Ft. GFA Weekday, Peak Hour of Adjacent Street Traffic, One Hour Between 4 and 6 p.m.
Setting/Location:	General Urban/Suburban
Number of Studies:	185
Avg. 1000 Sq. Ft. GFA:	3
Directional Distribution:	52% entering, 48% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
32.67	8.17 - 117.22	17.87



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(941)	
Vehicle Trip Ends vs: On a:	Servicing Positions Weekday, Peak Hour of Adjacent Street Traffic, One Hour Between 7 and 9 a.m.
Setting/Location:	General Urban/Suburban
Number of Studies:	1
Avg. Num. of Servicing Positions:	2
Directional Distribution:	67% entering, 33% exiting

Valstala Ck .

Vehicle Trip Generation per Servicing Position

Average Rate	Range of Rates	Standard Deviation
3.00	3.00 - 3.00	*

Data Plot and Equation

Caution – Small Sample Size



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(941)										
Vehicle Trip Ends vs:	Servicing Positions									
On a:	Weekday,									
	Peak Hour of Adjacent Street Traffic,									
	One Hour Between 4 and 6 p.m.									
Setting/Location:	General Urban/Suburban									
Number of Studies:	10									
Avg. Num. of Servicing Positions:	3									
Directional Distribution:	56% entering, 44% exiting									

uick Lubrication Vehicle Shop ſ

Vehicle Trip Generation per Servicing Position

Average Rate	Range of Rates	Standard Deviation
4.85	2.67 - 10.00	2.25



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Appendix C - Signal Phasing and Timing Plan

Image of the second s					SIGNAI	PHASING AND	TIMING - ACT	UATED / COOR	DINATED OPE	RATION			
NO 291 & MO 78 BY : Image: constraint of the second		c		T							TIMING DATE	8/31/2021	
CITY Macro Macro Mo ACTUATED PLAN ACTUATED PLAN <th cols<="" td=""><td></td><td>°↓ (_</td><td></td><td>IN</td><td>ROUTE</td><td></td><td>MO 291</td><td>& MO 78</td><td></td><td>BY:</td><td></td><td></td></th>	<td></td> <td>°↓ (_</td> <td></td> <td>IN</td> <td>ROUTE</td> <td></td> <td>MO 291</td> <td>& MO 78</td> <td></td> <td>BY:</td> <td></td> <td></td>		°↓ (_		IN	ROUTE		MO 291	& MO 78		BY:		
ACTUATED FLAN ACTUATED FLAN <td></td> <td></td> <td>· •</td> <td>4</td> <td>СІТҮ</td> <td></td> <td>Ir</td> <td>ndependence M</td> <td>0</td> <td></td> <td></td> <td></td>			· •	4	СІТҮ		Ir	ndependence M	0				
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RING 1 1 1 1 1 1 1 2 2 2 2 MIN. INITAL / GREEN model 5 7 7 5 8 7 7 5 VELLOW CLEARANCE 1.3 1.7 2.4 4.4 3.9 4.1 4.4 4.2 4.1 3.9 VEL OP CLEARANCE 1.3 1.7 2.4 2.				DE11111E.	PHASE 1	PHASE 2	PHASE 3	PHASE 4	PHASE 5	PHASE 6	PHASE 7	PHASE 8	
NRN STALL OR EAR series 5 7 7 5 8 7 7 5 7 7 5 7 7 7 7 7 7	DINK				1	1	1	1	2	2	2	2	
UNIT EXTENSION/PASSAGE (non-) 3.0 3.		SEQU)	5	7	7	5	8	7	7	5	
VELUO CLEARANCE 42 44 39 4.1 4.4 4.2 4.1 3.9 MAX. 1 Motion 30		ENSION		2-1)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
RED CLEARANCE 1.9 1.7 2.4 2.4 1.7 1.9 2.4 2.4 2.4 MAX.1 max 30	YELLOW CLEA	RANCE		(00012-1)	4.2	4.4	3.9	4.1	4.4	4.2	4.1	3.9	
MAX.1 watch 30	RED CLEARAN	CE			1.9	1.7	2.4	2.4	1.7	1.9	2.4	2.4	
MAX.2 Description VPN-LOCK MEMORY (YES / NO) seen. MIN PED KALL (MIN / MAX / SOFT) seen. MIN PED WALK seen. X X X DUAL ENTRY searce. X X X X PED WALK searce. X X X X X PED WALK GLEARANCE ONES: DETECTOR SSIGNMENT Searce. Image: Constraint Searce. Image: Constraint Searce. Image: Constraint Searce. Image: Constraint Searce. VEH. DET. DELAY TIME Searce. PP LT. DETECTOR SWITCH Searce. Image: Constraint Searce. Image: Constraint Searce. Image: Constraint Searce. Image: Constraint Searce. ADVANCE DETECTION Image: Constraint Searce. Image: Constraint Searce. Image: Constraint Searce. Image: Constraint Searce. Image: Constraint Searce. Image: Constraint Searce. Image: Constraint Searce. Image: Constraint Searce. Image: Constraint Searce. ACTION PLAN = 1 CYCLE = 100 SECONDS OFFSET = 1. SECONDS SEC : 13 Image: Constraint Searce.		MAX. 1	(MM-2-1)		30	30	30	30	30	30	30	30	
NOM-CUCK MEMORY (TEST K0) mice MIN MIN MIN PED RECALL make MIN X X X X X DUAL ENTRY makes X X X X X X X PED WALK CLEARANCE smooth X X X X X X X PED WALK CLEARANCE smooth X X X X X X X PED WALK CLEARANCE smooth X X X X X X X PED WALK CLEARANCE smooth X X X X X X IDECOTA SSIGNMENT make-out-makes X X X X X X IDENTIME STATE makes ACTION PLAN = 1 CYCLE = 100 SECONDS OFFSET = 82 SECONDS SEC : 4 DAY PLN EVIT ACT. PLN TIME 14 45 18 23 20 3 18 23 1 1 Free 0:01 17 55 18		MAX. 2	2 (MM-2-1)										
Then Nordown Dor () find min min min PED RECALL pairs X X X X X X PDUAL ENTRY match Min X X X X X X PED WALK watch Min X X X X X X PED WALK CLEARANCE motion DETECTOR SSIGNMENT makes Image: Comparison of the state	VEH RECA		AY (YES/NO) (MM-2-8) T) (MM-2-8)		MIN				MIN			
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PED WALK subject PED WALK Subject<	D	UAL ENT	RY (MM-2-6-1)			Х		Х		Х		Х	
PED WALK CLEARANCE ##2:0 Image: Control of the i		PED WA	LK (MM-2-1)										
DETECTOR DETECTOR States VEH. DELAY TIME Second Second <t< td=""><td>PED W</td><td>ALK CLE</td><td></td><td>1-2-1)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></t<>	PED W	ALK CLE		1-2-1)									
VERT. DET. DELIVENT IN DETAIL AT THE 2000 PP I. T. DETECTOR SWITCH associated and the second and the seco	DETEC	TOR ASS		IM-6-1)									
ADVANCE DETECTION ADVANCE DETECTION INITIALIZATION STATE MADE CABINET FLASH MADE DAY PLN EVEN FOR GERESCOORDINATION TIME ON LAW ACTION PLAN = 1 CYCLE = 100 SECONDS OFFSET = 82 SECONDS SEQ : 4 DAY PLN EVEN ACT. PLN TIME 14 45 18 23 20 39 18 23 1 1 Free 0.01 17 55 18 30 24 48 25 23 1 1 1845 1 10 17 55 18 30 24 48 25 23 1 5 Free 23:00	P/P LT. D			(MM-6-2)									
INITIALIZATION STATE (MAX) CABINET FLASH (MAX) ACTION PLAN = 1 CYCLE = 100 SECONDS OFFSET = 82 SECONDS SEQ : 4 DAY PLN EVENT ACTION PLAN = 1 CYCLE = 100 SECONDS OFFSET = 82 SECONDS SEQ : 4 DAY PLN EVENT ACTION PLAN = 2 CYCLE = 120 SECONDS OFFSET = 62 SECONDS SEQ : 7 1 2 1 18:45 30 24 48 25 23 1 4 1 18:45 1 2 1 5 Free 2300 - <t< td=""><td>AD</td><td>ANCE D</td><td>ETECTION</td><td>(1111 0 2)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></t<>	AD	ANCE D	ETECTION	(1111 0 2)									
CABINET FLASH MALGE BROW OF MARCH MALGE - AUTION PLAN = 1 CYCLE = 100 SECONDS OFFSET = 82 SECONDS SEQ : 4 DAY PLN EVNT ACTION PLAN = 1 CYCLE = 100 SECONDS OFFSET = 62 SECONDS SEQ : 7 1 1 Free 0.01 I I I I I I I I I I I I I I I I I I I	INITIA	LIZATIO	N STATE (MM-	2-5)									
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I S Pree 23:00 ACTION PLAN = 4 CYCLE = 145 SECONDS OFFSET = 1 SECONDS SEC : 13 I <thi< th=""> <thi< th=""> <thi< th=""> I <</thi<></thi<></thi<>	CA BEGIN OF GRE DAY PLN 1 1 1	EVNT EVNT 1 2 3	ATION TIMING - DIA ACT. PLN Free 1 2	I PLAN TIME 0:01 8:00 11:00	ACTI 14 ACTIO 17	ON PLAN = 1 45 ON PLAN = 2 55	CYCLE = 18	100 SECONDS 23 120 SECOND 30	S OFFS 20 S OFFS 24	ET = <u>82</u> SECC 39 SET = <u>62</u> SECC 48	DNDS SE 18 DNDS SE 25	EQ : 4 23 EQ : <u>7</u> 23	
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2 11 Free 23:00 DAY PLAN # S M T W T F S DAY PLAN 1 S M T W T F S CLEARANCE FORMULAS (EPG Section 902.5.36.2) DAY PLAN 2 S M T W T F S Yellow = 1.5+((1.47*Speed)/(20+(64.4*Grade)))) DAY PLAN 2 S M T W T F S Red = ((Width+20)/(1.47*Speed)) Change Period: CP = t + V V Red = ((Width+20)/(1.47*Speed)) Change Period: TE Equation Yellow 3 s <= YELLOW <= 6 s	CA BEGIN OF GRE DAY PLN 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2	BINET F EEN-COORDIN EVNT 1 2 3 4 5 - 1 2 3 4 5 - 6 7 8 9	LASH (MM-2-5) ATTON TIMING - DIA ACT. PLN Free 1 2 1 Free 1 2 1 2 1 2 1 4 4 4 4 4 4 4 4	Image: Plan 0:01 8:00 11:00 18:45 23:00 0:01 5:45 6:20 9:00 11:00 13:00 14:35 15:15 15:45	ACTI 14 ACTI 17 ACTI 13 ACTIC 13 Seq 4 2, 1 4, 3	ON PLAN = 1 45 DN PLAN = 2 55 ON PLAN = 4 86 DN PLAN = <u>14</u> 78 Seq 7 1, 2 4, 3	CYCLE = 18 CYCLE = 18 CYCLE = 24 CYCLE 24 Seq 13 1, 2 3,4	100 SECONDS 23 120 SECOND 30 145 SECONDS 22 = 145 SECONDS 30 COMM	S OFFS 20 S OFFS 24 S OFFS 26 DS OFFS 26 IENTS	ET = $\underline{82}$ SEC(39 SET = $\underline{62}$ SEC(48 ET = $\underline{1}$ SEC(73 SET = $\underline{1}$ SEC(65	DNDS SE 18 DNDS SE 25 NDS SE 17 DNDS SE 25 25	EQ : 4 23 EQ : <u>7</u> 23 Q : <u>13</u> 29 EQ : <u>13</u> 29	
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$\frac{CP = t + \frac{v}{2a + 64.4g} + \frac{w + L}{V}}{\frac{13 \text{ s} \text{ c} \text{Fellulov-sb} \text{ s}}{\frac{17 \text{ E} \text{ guation Red}}{\text{ Change Period Sum}}}$ $\frac{STARTUP \text{ OPERATION}}{\text{CONTROLLER MAKE/MODEL}}$ $\frac{MASTER CONTROLLER @}{DISTRIBUTION : CABINET SHOP DISTRICT OFFICE (FILE / BOOK)}$	CA BEGIN OF GRE DAY PLN 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2	BINET F EN-COORDIN EVNT 1 2 3 4 5 5 4 5 5 6 7 7 8 9 10 11 11 # 1 2 2 3 4 4 5 5 6 6 7 7 8 9 10 11	LASH (MM-25) ATTON TIMING - DIA ACT. PLN Free 1 2 1 Free 1 2 1 4 4 4 4 4 4 4 4 4 4 4 5 1 8 1 4 4 4 4 5 1 8 1 7 7 8 1 8 1 8 1 8 1 8 1 8 1 8 1 8	Image: Plan 0:01 8:00 11:00 18:45 23:00 0:01 5:45 6:20 9:00 11:00 13:00 14:35 15:15 15:45 18:45 23:00 ITIFIS ITIFIS ITIFIS	ACTI 14 ACTIC 17 ACTIC 13 ACTIC 13 Seq 4 2, 1 4, 3 5, 6 7, 8 Yellow = 1.5+ Red = ((Width	ON PLAN = 1 45 ON PLAN = 2 55 ON PLAN = 4 86 ON PLAN = 14 78 Seq 7 1, 2 4, 3 6, 5 7, 8 ((1.47*Speed)/ h+20)/(1.47*Sp	CYCLE = 18 CYCLE = 18 CYCLE = 24 CYCLE = 24 CYCLE 24 CYCLE 24 CYCLE 24 CYCLE 24 CYCLE (20+(64.4*Gra eed))	100 SECONDS 23 120 SECOND 30 145 SECONDS 22 = 145 SECONE 30 COMM E FORMULAS de)))	S OFFS 20 S OFFS 24 S OFFS 26 DS OFFS 26 DS OFFS 26 IENTS	ET = <u>82</u> SECC <u>39</u> SET = <u>62</u> SECC <u>48</u> SET = <u>1</u> SECO <u>65</u> <u>65</u> <u>65</u> <u>65</u> <u>65</u> <u>65</u> <u>65</u> <u>65</u>	DNDS SE 18 DNDS SE 25 NDS SE 17 DNDS SE 25 25	EQ : 4 23 EQ : 7 23 Q : 13 29 EQ : 13 29	
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STARTUP OPERATION MASTER CONTROLLER @ CONTROLLER MAKE/MODEL MASTER CONTROLLER @ DISTRIBUTION : CABINET SHOP DISTRICT OFFICE (FILE / BOOK)	CAA BEGIN OF GRE DAY PLN 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2	BINET F EEN-COORDIN EVNT 1 2 3 4 5 6 7 8 9 10 11 $\frac{1}{2}$ 3 4 5 6 7 8 9 10 11 $\frac{1}{2}$ 3 4 5 6 7 8 9 10 11 2 3 4 5 6 7 8 9 10 11 2 3 4 5 6 7 8 9 10 10 10 10 10 10 10 10 10 10	LASH (MM-2-5) ATTON TIMING - DIA ACT. PLN Free 1 2 1 Free 1 2 1 4 4 4 4 4 4 4 4 4 14 4 4 5 M T W S M T W	Image: PLAN N TIME 0:01 8:00 11:00 18:45 23:00 - 0:01 5:45 6:20 9:00 11:00 13:00 14:35 15:15 15:45 23:00 ITIFIS 23:00 ITIFIS 15:45 18:45 23:00 ITIFIS IFIS ITIFIS IFIS ITIFIS IFIS ITIFIS IFIS ITIFIS ITIFIS ITIFIS ITIFIS ITIFIS ITIFIS ITIFIS ITIFIS ITIFIS ITIFIS	ACTI 14 ACTIC 17 ACTIC 13 ACTIC 13 Seq 4 2, 1 4, 3 5, 6 7, 8 Yellow = 1.5+ Red = ((Width	ON PLAN = 1 45 DN PLAN = 2 55 ON PLAN = 4 86 PN PLAN = 14 78 Seq 7 1, 2 4, 3 6, 5 7, 8 ((1.47*Speed)/ h+20)/(1.47*Speed)/	CYCLE = 18 CYCLE = 18 CYCLE = 24 CYCLE = 24 CYCLE = 24 Seq 13 1, 2 3,4 6, 5 8, 7 CLEARANC (20+(64.4*Gra eed))	100 SECONDS 23 120 SECOND 30 145 SECOND 22 = 145 SECONE 30 COMM E FORMULAS de)))	S OFFS 20 S OFFS 24 S OFFS 26 DS OFFS 26 IENTS	ET = $\underline{82}$ SEC(39 SET = $\underline{62}$ SEC(48 ET = $\underline{1}$ SECO 73 SET = $\underline{1}$ SECO 65 0 0 0 0 0 0 0 0 0 0 0 0 0	DNDS SE 18 DNDS SE 25 NDS SE 17 DNDS SE 25 25 0 0 0 0 0 0 0 0 0 0 0 0 0	EQ : 4 23 EQ : 7 23 Q : 13 29 EQ : 13 29	
CONTROLLER MAKE/MODEL MASTER CONTROLLER @ DISTRIBUTION : CABINET SHOP DISTRICT OFFICE (FILE / BOOK)	CA BEGIN OF GRE DAY PLN 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2	BINE I F EEN-COORDIN EVNT 1 2 3 4 5 5 1 2 3 4 5 5 6 7 8 9 10 11 2 3 4 5 6 7 8 9 9 10 11 1 2 2 3 4 4 5 5 6 7 8 9 9 10 11 2 5 5 5 7 8 9 9 10 10 10 10 10 10 10 10 10 10 10 10 10	LASH (MM-2-5) ATTON TIMING - DIA ACT. PLN Free 1 2 1 Free 1 2 1 4 4 4 4 4 4 4 4 1 Free S M T W S M T W	Image: PLAN N TIME 0:01 8:00 11:00 18:45 23:00	ACTI 14 ACTIC 17 ACTIC 13 ACTIC 13 Seq 4 2, 1 4, 3 5, 6 7, 8 Yellow = 1.5+ Red = ((Width	ON PLAN = 1 45 ON PLAN = 2 55 ON PLAN = 4 86 ON PLAN = 14 78 Seq 7 1, 2 4, 3 6, 5 7, 8 ((1.47*Speed)/ h+20)/(1.47*Sp	CYCLE = 18 CYCLE = 18 CYCLE = 24 CYCLE = 24 CYCLE = 24 Seq 13 1, 2 3,4 6, 5 8, 7 CLEARANC (20+(64.4*Gra eed))	100 SECONDS 23 120 SECOND 30 145 SECONDS 22 = 145 SECONE 30 COMM E FORMULAS de)))	S OFFS 20 S OFFS 24 S OFFS 26 DS OFFS 26 IENTS	ET = $\underline{82}$ SEC(39 BET = $\underline{62}$ SEC(48 ET = $\underline{1}$ SECO 73 SET = $\underline{1}$ SECO 65	DNDS SE 18 DNDS SE 25 NDS SE 17 DNDS SE 25 25 25	EQ : 4 23 EQ : 7 23 Q : 13 29 EQ : 13 29 EQ : 13 29	
DISTRIBUTION : CABINET SHOP DISTRICT OFFICE (FILE / BOOK)	CA BEGIN OF GRE DAY PLN 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2	BINE I F EEN-COORDIN EVNT 1 2 3 4 5 6 1 2 3 4 5 6 7 8 9 10 11 $\frac{1}{2}$ 3 4 5 6 7 8 9 10 11 $\frac{1}{2}$ 6 7 8 9 10 11 $\frac{1}{2}$ 6 6 7 8 9 10 11 $\frac{1}{2}$ 6 6 7 8 9 10 11 $\frac{1}{2}$ 6 6 7 8 9 10 10 11 $\frac{1}{2}$ 6 6 7 8 9 10 10 10 10 10 10 10 10 10 10	LASH (MM-25) ATTON TIMING - DIA ACT. PLN Free 1 2 1 Free 1 2 1 4 4 4 4 4 4 4 1 Free S M T W S M T W	L PLAN N TIME 0:01 8:00 11:00 18:45 23:00 0:01 5:45 6:20 9:00 11:00 13:00 14:35 15:15 15:45 15:45 23:00 (T F S 23:00 (T F S T F S	ACTI 14 ACTIC 17 ACTIC 13 ACTIC 13 Seq 4 2, 1 4, 3 5, 6 7, 8 Yellow = 1.5+ Red = ((Width	ON PLAN = 1 45 ON PLAN = 2 55 ON PLAN = 4 86 ON PLAN = 14 78 Seq 7 1, 2 4, 3 6, 5 7, 8 ((1.47*Speed)/ n+20)/(1.47*Sp	CYCLE = 18 CYCLE = 18 CYCLE = 24 CYCLE = 24 CYCLE = 24 Seq 13 1, 2 3,4 6, 5 8,7 CLEARANC (20+(64.4*Gra eed))	100 SECONDS 23 120 SECOND 30 145 SECONDS 22 = 145 SECOND 30 COMM E FORMULAS ide)))	S OFFS 20 S OFFS 24 S OFFS 26 DS OFFS 26 IENTS (EPG Section	ET = $\underline{82}$ SEC(39 SET = $\underline{62}$ SEC(48 SET = $\underline{1}$ SECO 73 SET = $\underline{1}$ SECO 65	DNDS SE 18 DNDS SE 25 NDS SE 17 DNDS SE 25 25	EQ : 4 23 EQ : 7 23 Q : 13 29 EQ : 13 29	
	CAA BEGIN OF GRE DAY PLN 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2	BINE I F EEN-COORDIN EVNT 1 2 3 4 5 1 2 3 4 5 6 7 8 9 10 11 # 1 2 3 4 5 6 7 8 9 10 11 # 10 11 # 6 6 7 8 9 10 10 10 10 10 10 10 10 10 10	LASH (MM-25) ATTON TIMING - DIA ACT. PLN Free 1 2 1 Free 1 2 1 4 4 4 4 4 1 4 4 1 5 M T I W S M T W	L PLAN N TIME 0:01 8:00 11:00 18:45 23:00 0:01 5:45 6:20 9:00 11:00 13:00 11:00 14:35 15:15 15:15 15:45 23:00 11:05 15:45	ACTI 14 ACTIC 17 ACTIC 13 ACTIC 13 Seq 4 2, 1 4, 3 5, 6 7, 8 Yellow = 1.5+ Red = ((Width	ON PLAN = 1 45 ON PLAN = 2 55 ON PLAN = 2 55 ON PLAN = 4 86 ON PLAN = 14 78 Seq 7 1, 2 4, 3 6, 5 7, 8 ((1.47*Speed)/ h+20)/(1.47*Sp	CYCLE = 18 CYCLE = 18 CYCLE = 24 CYCLE	100 SECONDS 23 120 SECOND 30 145 SECOND 22 = 145 SECOND 30 COMM E FORMULAS de))))	S OFFS 20 S OFFS 24 S OFFS 26 DS OFFS 26 IENTS (EPG Section (EPG Section	ET = $\underline{82}$ SEC(39 SET = $\underline{62}$ SEC(48 SET = $\underline{1}$ SECO 73 SET = $\underline{1}$ SECO 65 n 902.5.36.2)	DNDS SE 18 DNDS SE 25 NDS SE 17 DNDS SE 25 25 25	EQ : 4 23 EQ : 7 23 Q : 13 29 EQ : 13 29	

Appendix D - HCM 6th Ed. LOS [Existing AM]

HCM 6th Signalized Intersection Summary 1: M-291 & E. 23rd St.

	٠	-	7	*	•	*	1	t	1	1	ŧ	~
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	ሻሻ	^	1	ሻሻ	^	1	ሻሻ	^	1	ሻሻ	^	7
Traffic Volume (veh/h)	162	203	235	180	253	39	323	1080	112	83	1051	203
Future Volume (veh/h)	162	203	235	180	253	39	323	1080	112	83	1051	203
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
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	176	221	0	196	275	42	351	1174	0	90	1142	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	337	495		533	696	310	515	1448		314	1241	
Arrive On Green	0.10	0.14	0.00	0.15	0.20	0.20	0.15	0.41	0.00	0.09	0.35	0.00
Sat Flow, veh/h	3456	3554	1585	3456	3554	1585	3456	3554	1585	3456	3554	1585
Grp Volume(v), veh/h	176	221	0	196	275	42	351	1174	0	90	1142	0
Grp Sat Flow(s),veh/h/ln	1728	1777	1585	1728	1777	1585	1728	1777	1585	1728	1777	1585
Q Serve(g_s), s	5.8	6.9	0.0	6.1	8.1	2.6	11.5	35.1	0.0	2.9	37.0	0.0
Cycle Q Clear(g_c), s	5.8	6.9	0.0	6.1	8.1	2.6	11.5	35.1	0.0	2.9	37.0	0.0
Prop In Lane	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	337	495		533	696	310	515	1448		314	1241	
V/C Ratio(X)	0.52	0.45		0.37	0.40	0.14	0.68	0.81		0.29	0.92	
Avail Cap(c_a), veh/h	337	495		533	696	310	515	1448		314	1241	
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	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00
Uniform Delay (d), s/veh	51.5	47.4	0.0	45.5	42.1	39.9	48.3	31.5	0.0	50.9	37.4	0.0
Incr Delay (d2), s/veh	5.7	2.9	0.0	2.0	1.7	0.9	7.1	5.0	0.0	2.3	12.4	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/In	2.7	3.2	0.0	2.7	3.7	1.1	5.3	15.2	0.0	1.3	17.2	0.0
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	57.2	50.3	0.0	47.5	43.7	40.8	55.4	36.5	0.0	53.2	49.9	0.0
LnGrp LOS	E	D		D	D	D	E	D		D	D	
Approach Vol, veh/h		397	А		513			1525	А		1232	A
Approach Delay, s/veh		53.4			44.9			40.8			50.1	
Approach LOS		D			D			D			D	
Timer - Assigned Phs	1	2	3	4	5	6	7	8				
Phs Duration (G+Y+Rc), s	17.0	55.0	18.0	30.0	24.0	48.0	25.0	23.0				
Change Period (Y+Rc), s	* 6.1	* 6.1	6.3	6.5	* 6.1	* 6.1	6.5	6.3				
Max Green Setting (Gmax), s	* 11	* 49	11.7	23.5	* 18	* 42	18.5	16.7				
Max Q Clear Time (g_c+I1), s	4.9	37.1	7.8	10.1	13.5	39.0	8.1	8.9				
Green Ext Time (p_c), s	0.1	5.9	0.2	1.4	0.5	1.9	0.4	0.7				
Intersection Summary												
HCM 6th Ctrl Delay			45.9									
HCM 6th LOS			D									

Notes

* HCM 6th computational engine requires equal clearance times for the phases crossing the barrier. Unsignalized Delay for [NBR, EBR, SBR] is excluded from calculations of the approach delay and intersection delay.

Appendix E - HCM 6th Ed. LOS [Existing PM]

HCM 6th Signalized Intersection Summary 1: M-291 & E. 23rd St.

	٠	-	7	*	←	*	1	t	1	4	Ŧ	~
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	ካካ	**	1	ካካ	^	1	ሻሻ	^	1	ሻሻ	**	1
Traffic Volume (veh/h)	383	497	326	213	310	109	336	1398	81	99	1400	253
Future Volume (veh/h)	383	497	326	213	310	109	336	1398	81	99	1400	253
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
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	416	540	0	232	337	118	365	1520	0	108	1522	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	422	556		250	380	169	474	1958		164	1640	
Arrive On Green	0.12	0.16	0.00	0.07	0.11	0.11	0.14	0.55	0.00	0.05	0.46	0.00
Sat Flow, veh/h	3456	3554	1585	3456	3554	1585	3456	3554	1585	3456	3554	1585
Grp Volume(v), veh/h	416	540	0	232	337	118	365	1520	0	108	1522	0
Grp Sat Flow(s),veh/h/ln	1728	1777	1585	1728	1777	1585	1728	1777	1585	1728	1777	1585
Q Serve(g_s), s	17.4	21.9	0.0	9.7	13.6	7.8	14.8	48.7	0.0	4.5	58.5	0.0
Cycle Q Clear(g_c), s	17.4	21.9	0.0	9.7	13.6	7.8	14.8	48.7	0.0	4.5	58.5	0.0
Prop In Lane	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	422	556		250	380	169	474	1958		164	1640	
V/C Ratio(X)	0.99	0.97		0.93	0.89	0.70	0.77	0.78		0.66	0.93	
Avail Cap(c_a), veh/h	422	556		250	380	169	474	1958		164	1640	
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	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00
Uniform Delay (d), s/veh	63.5	60.8	0.0	66.9	63.9	35.1	60.3	25.5	0.0	67.9	36.8	0.0
Incr Delay (d2), s/veh	40.5	31.6	0.0	40.8	25.0	21.1	11.4	3.1	0.0	18.7	10.7	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/In	9.9	12.2	0.0	5.6	7.4	4.0	7.1	20.1	0.0	2.4	26.3	0.0
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	104.0	92.4	0.0	107.7	88.9	56.2	71.8	28.6	0.0	86.6	47.5	0.0
LnGrp LOS	F	F		F	F	E	E	С		F	D	
Approach Vol, veh/h		956	А		687			1885	А		1630	A
Approach Delay, s/veh		97.5			89.6			37.0			50.1	
Approach LOS		F			F			D			D	
Timer - Assigned Phs	1	2	3	4	5	6	7	8				
Phs Duration (G+Y+Rc), s	13.0	86.0	24.0	22.0	26.0	73.0	17.0	29.0				
Change Period (Y+Rc), s	* 6.1	* 6.1	6.3	6.5	* 6.1	* 6.1	6.5	6.3				
Max Green Setting (Gmax), s	* 6.9	* 80	17.7	15.5	* 20	* 67	10.5	22.7				
Max Q Clear Time (g_c+l1), s	6.5	50.7	19.4	15.6	16.8	60.5	11.7	23.9				
Green Ext Time (p_c), s	0.0	13.2	0.0	0.0	0.4	4.6	0.0	0.0				
Intersection Summary												
HCM 6th Ctrl Delay			59.3									
HCM 6th LOS			E									

Notes

* HCM 6th computational engine requires equal clearance times for the phases crossing the barrier.

Unsignalized Delay for [NBR, EBR, SBR] is excluded from calculations of the approach delay and intersection delay.

Appendix F - HCM 6th Ed. LOS [Existing+Site AM]

HCM 6th Signalized Intersection Summary 1: M-291 & E. 23rd St.

Movement EBL EBT EBR WBL WBT WBR NBL NBT NBR SBL SBT SBR Lane Configurations 11
Lane Configurations 1
Traffic Volume (veh/h) 167 203 235 184 278 39 323 1141 112 83 1051 203 Future Volume (veh/h) 167 203 235 184 278 39 323 1141 112 83 1051 203 Initial Q (Qb), veh 0 <
Future Volume (veh/h) 167 203 235 184 278 39 323 1141 112 83 1051 203 Initial Q (Qb), veh 0
Initial Q (Qb), veh 0
Ped-Bike Adj(A_pbT) 1.00
Parking Bus, Adj 1.00
Work Zone On Approach No No No No Adj Sat Flow, veh/h/ln 1870 142 0 1
Adj Sat Flow, veh/h/ln1870<
Adj Flow Rate, veh/h182221020030242351124009011420Peak Hour Factor0.92
Peak Hour Factor0.92 <th0.92< th="">0.920.920.92</th0.92<>
Percent Heavy Veh, % 2
Cap, veh/h33749553369631051514483141241Arrive On Green0.100.140.000.150.200.200.150.410.000.090.350.00Sat Flow, veh/h345635541585345635541585345635541585345635541585Grp Volume(v), veh/h182221020030242351124009011420Grp Sat Flow(s),veh/h/ln172817771585172817771585172817771585Q Serve(g_s), s6.06.90.06.29.02.611.538.10.02.937.00.0
Arrive On Green0.100.140.000.150.200.200.150.410.000.090.350.00Sat Flow, veh/h345635541585345635541585345635541585345635541585Grp Volume(v), veh/h182221020030242351124009011420Grp Sat Flow(s),veh/h/ln172817771585172817771585172817771585Q Serve(g_s), s6.06.90.06.29.02.611.538.10.02.937.00.0
Sat Flow, veh/h345635541585345635541585345635541585Grp Volume(v), veh/h182221020030242351124009011420Grp Sat Flow(s),veh/h/ln172817771585172817771585172817771585172817771585Q Serve(g_s), s6.06.90.06.29.02.611.538.10.02.937.00.0
Grp Volume(v), veh/h 182 221 0 200 302 42 351 1240 0 90 1142 0 Grp Sat Flow(s),veh/h/ln 1728 1777 1585 1728 1777 1585 1728 1777 1585 1728 1777 1585 1728 1777 1585 Q Serve(g_s), s 6.0 6.9 0.0 6.2 9.0 2.6 11.5 38.1 0.0 2.9 37.0 0.0
Grp Sat Flow(s),veh/h/ln 1728 1777 1585 1728 1777 1585 1728 1777 1585 1728 1777 1585 Q Serve(g_s), s 6.0 6.9 0.0 6.2 9.0 2.6 11.5 38.1 0.0 2.9 37.0 0.0
Q Serve(g_s), s 6.0 6.9 0.0 6.2 9.0 2.6 11.5 38.1 0.0 2.9 37.0 0.0
Cycle Q Clear(g c), s 6.0 6.9 0.0 6.2 9.0 2.6 11.5 38.1 0.0 2.9 37.0 0.0
Prop In Lane 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.0
Lane Grp Cap(c), veh/h 337 495 533 696 310 515 1448 314 1241
V/C Ratio(X) 0.54 0.45 0.38 0.43 0.14 0.68 0.86 0.29 0.92
Avail Cap(c_a), veh/h 337 495 533 696 310 515 1448 314 1241
HCM Platoon Ratio 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.0
Upstream Filter(I) 1.00 1.00 0.00 1.00 1.00 1.00 1.00 1.0
Uniform Delay (d), s/veh 51.6 47.4 0.0 45.6 42.4 39.9 48.3 32.4 0.0 50.9 37.4 0.0
ncr Delay (d2), s/veh 6.1 2.9 0.0 2.0 2.0 0.9 7.1 6.7 0.0 2.3 12.4 0.0
nitial Q Delay(d3),s/veh 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.
%ile BackOfQ(50%),veh/ln 2.9 3.2 0.0 2.8 4.1 1.1 5.3 16.7 0.0 1.3 17.2 0.0
Unsig. Movement Delay, s/veh
∟nGrp Delay(d),s/veh 57.7 50.3 0.0 47.6 44.4 40.8 55.4 39.1 0.0 53.2 49.9 0.0
LnGrp LOS E D D D D E D D D
Approach Vol, veh/h 403 A 544 1591 A 1232 A
Approach Delay, s/veh 53.6 45.3 42.7 50.1
Approach LOS D D D D
Fimer - Assigned Phs 1 2 3 4 5 6 7 8
Phs Duration (G+Y+Rc), s 17.0 55.0 18.0 30.0 24.0 48.0 25.0 23.0
Change Period (Y+Rc), s * 6.1 * 6.1 6.3 6.5 * 6.1 * 6.1 6.5 6.3
Max Green Setting (Gmax), s * 11 * 49 11.7 23.5 * 18 * 42 18.5 16.7
Max Q Clear Time (g_c+l1), s 4.9 40.1 8.0 11.0 13.5 39.0 8.2 8.9
Green Ext Time (p_c), s 0.1 5.1 0.2 1.5 0.5 1.9 0.4 0.7
Intersection Summary
HCM 6th Ctrl Delay 46.7
HCM 6th LOS D

Notes

* HCM 6th computational engine requires equal clearance times for the phases crossing the barrier. Unsignalized Delay for [NBR, EBR, SBR] is excluded from calculations of the approach delay and intersection delay.

Synchro 10 Report

Appendix F - HCM 6th Ed. LOS [Existing+Site AM]

HCM 6th TWSC 2: M-291 & M-291 Ent.

Intersection						
Int Delay, s/veh	0.4					
N 4			NDT			ODT
Novement	WBL	WBR	INR I	NRK	SBL	SBI
Lane Configurations			- † †	1		- † †
Traffic Vol, veh/h	0	59	1281	71	0	1051
Future Vol, veh/h	0	59	1281	71	0	1051
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	-	0	-	93	-	-
Veh in Median Storage	e, # 0	-	0	-	-	0
Grade, %	0	-	0	-	-	0
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	0	64	1392	77	0	1142

Major/Minor	Minor1	Μ	lajor1	Maj	or2					
Conflicting Flow All	-	696	0	0	-	-				
Stage 1	-	-	-	-	-	-				
Stage 2	-	-	-	-	-	-				
Critical Hdwy	-	6.94	-	-	-	-				
Critical Hdwy Stg 1	-	-	-	-	-	-				
Critical Hdwy Stg 2	-	-	-	-	-	-				
Follow-up Hdwy	-	3.32	-	-	-	-				
Pot Cap-1 Maneuver	0	384	-	-	0	-				
Stage 1	0	-	-	-	0	-				
Stage 2	0	-	-	-	0	-				
Platoon blocked, %			-	-		-				
Mov Cap-1 Maneuver	· -	384	-	-	-	-				
Mov Cap-2 Maneuver	-	-	-	-	-	-				
Stage 1	-	-	-	-	-	-				
Stage 2	-	-	-	-	-	-				
Approach	WB		NB		SB					
HCM Control Delay, s	16.2		0		0					

HCM LOS C

Minor Lane/Major Mvmt	NBT	NBRWBLn1	SBT
Capacity (veh/h)	-	- 384	-
HCM Lane V/C Ratio	-	- 0.167	-
HCM Control Delay (s)	-	- 16.2	-
HCM Lane LOS	-	- C	-
HCM 95th %tile Q(veh)	-	- 0.6	-

Appendix F - HCM 6th Ed. LOS [Existing+Site AM]

HCM 6th TWSC 3: E. 23rd St. & 23rd St. Ent.

Intersection						
Int Delay, s/veh	0.4					
Maxamant		ГРТ			CDI	CDD
wovernent	EDL	EDI	VVDI	VVDR	SDL	SDK
Lane Configurations			≜ î,			1
Traffic Vol, veh/h	0	203	472	20	0	29
Future Vol, veh/h	0	203	472	20	0	29
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	-	-	-	0
Veh in Median Storage	e, # -	0	0	-	0	-
Grade, %	-	0	0	-	0	-
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
	-	004	= 10	~~	•	00

Major/Minor	Major1	l	Major2	Ν	Minor2		
Conflicting Flow All	-	0	-	0	-	268	
Stage 1	-	-	-	-	-	-	
Stage 2	-	-	-	-	-	-	
Critical Hdwy	-	-	-	-	-	6.94	
Critical Hdwy Stg 1	-	-	-	-	-	-	
Critical Hdwy Stg 2	-	-	-	-	-	-	
Follow-up Hdwy	-	-	-	-	-	3.32	
Pot Cap-1 Maneuver	0	-	-	-	0	730	
Stage 1	0	-	-	-	0	-	
Stage 2	0	-	-	-	0	-	
Platoon blocked, %		-	-	-			
Mov Cap-1 Maneuver	-	-	-	-	-	730	
Mov Cap-2 Maneuver	-	-	-	-	-	-	
Stage 1	-	-	-	-	-	-	
Stage 2	-	-	-	-	-	-	
Approach	EB		WB		SB		
HCM Control Delay, s	0		0		10.2		
HCM LOS					В		
Minor Lane/Major Mvn	nt	EBT	WBT	WBR	SBLn1		
Capacity (veh/h)		-	-	-	730		
HCM Lane V/C Ratio		-	-	-	0.043		
HCM Control Delay (s))	-	-	-	10.2		
HCM Lane LOS		-	-	-	В		
HCM 95th %tile Q(veh)	-	-	-	0.1		

Appendix G - HCM 6th Ed. LOS [Existing+Site PM]

HCM 6th Signalized Intersection Summary 1: M-291 & E. 23rd St.

	٠	→	7	1	+	*	1	t	1	1	ŧ	~
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	ሻሻ	^	1	ሻሻ	44	1	ሻሻ	**	1	ሻሻ	**	1
Traffic Volume (veh/h)	389	497	326	219	341	109	336	1473	81	99	1400	253
Future Volume (veh/h)	389	497	326	219	341	109	336	1473	81	99	1400	253
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
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	423	540	0	238	371	118	365	1601	0	108	1522	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	422	556		250	380	169	474	1958		164	1640	
Arrive On Green	0.12	0.16	0.00	0.07	0.11	0.11	0.14	0.55	0.00	0.05	0.46	0.00
Sat Flow, veh/h	3456	3554	1585	3456	3554	1585	3456	3554	1585	3456	3554	1585
Grp Volume(v), veh/h	423	540	0	238	371	118	365	1601	0	108	1522	0
Grp Sat Flow(s),veh/h/ln	1728	1777	1585	1728	1777	1585	1728	1777	1585	1728	1777	1585
Q Serve(g_s), s	17.7	21.9	0.0	9.9	15.1	7.8	14.8	53.4	0.0	4.5	58.5	0.0
Cycle Q Clear(g_c), s	17.7	21.9	0.0	9.9	15.1	7.8	14.8	53.4	0.0	4.5	58.5	0.0
Prop In Lane	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	422	556		250	380	169	474	1958		164	1640	
V/C Ratio(X)	1.00	0.97		0.95	0.98	0.70	0.77	0.82		0.66	0.93	
Avail Cap(c_a), veh/h	422	556		250	380	169	474	1958		164	1640	
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	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00
Uniform Delay (d), s/veh	63.7	60.8	0.0	67.0	64.6	35.1	60.3	26.6	0.0	67.9	36.8	0.0
Incr Delay (d2), s/veh	44.5	31.6	0.0	45.6	40.7	21.1	11.4	3.9	0.0	18.7	10.7	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/In	10.3	12.2	0.0	5.9	8.9	4.0	7.1	22.2	0.0	2.4	26.3	0.0
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	108.2	92.4	0.0	112.6	105.2	56.2	71.8	30.5	0.0	86.6	47.5	0.0
LnGrp LOS	F	F		F	F	E	E	С		F	D	
Approach Vol, veh/h		963	А		727			1966	А		1630	A
Approach Delay, s/veh		99.3			99.7			38.2			50.1	
Approach LOS		F			F			D			D	
Timer - Assigned Phs	1	2	3	4	5	6	7	8				
Phs Duration (G+Y+Rc), s	13.0	86.0	24.0	22.0	26.0	73.0	17.0	29.0				
Change Period (Y+Rc), s	* 6.1	* 6.1	6.3	6.5	* 6.1	* 6.1	6.5	6.3				
Max Green Setting (Gmax), s	* 6.9	* 80	17.7	15.5	* 20	* 67	10.5	22.7				
Max Q Clear Time (g_c+I1), s	6.5	55.4	19.7	17.1	16.8	60.5	11.9	23.9				
Green Ext Time (p_c), s	0.0	12.9	0.0	0.0	0.4	4.6	0.0	0.0				
Intersection Summary												
HCM 6th Ctrl Delay			61.4									
HCM 6th LOS			Е									

Notes

* HCM 6th computational engine requires equal clearance times for the phases crossing the barrier.

Unsignalized Delay for [NBR, EBR, SBR] is excluded from calculations of the approach delay and intersection delay.

Appendix G - HCM 6th Ed. LOS [Existing+Site PM]

HCM 6th TWSC 2: M-291 & M-291 Ent.

Intersection						
Int Delay, s/veh	0.6					
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations		1	- 11	1		t.
Traffic Vol, veh/h	0	73	1890	87	0	1400
Future Vol, veh/h	0	73	1890	87	0	1400
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	-	0	-	93	-	-
Veh in Median Storage	,# 0	-	0	-	-	0
Grade, %	0	-	0	-	-	0
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	0	79	2054	95	0	1522

Major/Minor	Minor1	or1 Major1		Major2		
Conflicting Flow All	-	1027	0	0	-	-
Stage 1	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-
Critical Hdwy	-	6.94	-	-	-	-
Critical Hdwy Stg 1	-	-	-	-	-	-
Critical Hdwy Stg 2	-	-	-	-	-	-
Follow-up Hdwy	-	3.32	-	-	-	-
Pot Cap-1 Maneuver	0	232	-	-	0	-
Stage 1	0	-	-	-	0	-
Stage 2	0	-	-	-	0	-
Platoon blocked, %			-	-		-
Mov Cap-1 Maneuver	-	232	-	-	-	-
Mov Cap-2 Maneuver	-	-	-	-	-	-
Stage 1	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-
Approach	WB		NB		SB	
HCM Control Delay, s	28.4		0		0	

HCM LOS D

Minor Lane/Major Mvmt	NBT	NBRWBLn1	SBT
Capacity (veh/h)	-	- 232	-
HCM Lane V/C Ratio	-	- 0.342	-
HCM Control Delay (s)	-	- 28.4	-
HCM Lane LOS	-	- D	-
HCM 95th %tile Q(veh)	-	- 1.4	-

Appendix G - HCM 6th Ed. LOS [Existing+Site PM]

HCM 6th TWSC 3: E. 23rd St. & 23rd St. Ent.

Intersection						
Int Delay, s/veh	0.3					
14	EDI	FDT			0.01	000
Movement	EBL	ERI	WRI	WBR	SBL	SBR
Lane Configurations		- 11	≜ î,			1
Traffic Vol, veh/h	0	497	632	25	0	37
Future Vol, veh/h	0	497	632	25	0	37
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	-	-	-	0
Veh in Median Storage	, # -	0	0	-	0	-
Grade, %	-	0	0	-	0	-
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mymt Flow	٥	540	687	27	٥	40

Major/Minor	Major1	1	Major2	N	linor2	
Conflicting Flow All	-	0	-	0	-	357
Stage 1	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-
Critical Hdwy	-	-	-	-	-	6.94
Critical Hdwy Stg 1	-	-	-	-	-	-
Critical Hdwy Stg 2	-	-	-	-	-	-
Follow-up Hdwy	-	-	-	-	-	3.32
Pot Cap-1 Maneuver	0	-	-	-	0	639
Stage 1	0	-	-	-	0	-
Stage 2	0	-	-	-	0	-
Platoon blocked, %		-	-	-		
Mov Cap-1 Maneuver	• -	-	-	-	-	639
Mov Cap-2 Maneuver	· -	-	-	-	-	-
Stage 1	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-
Approach	EB		WB		SB	
HCM Control Delay, s	0		0		11	
HCM LOS					В	
Minor Lane/Maior My	mt	FBT	WBT	WBR S	SBI n1	
Canacity (veh/h)				-	639	
HCM Lane V/C Ratio		_	_	_	0.063	
HCM Control Delay (s	;)	_	_	-	11	
HCM Lane LOS	,	-	-	-	B	
HCM 95th %tile Q(veh	า)	-	-	-	0.2	