CIVIL ENGINEERING / SURVEYING / UTILITIES

7101 College Blvd., Suite 400
Overland Park, KS 66210
913.663.1900
www.ibhc.com

TRAFFIC IMPACT STUDY

# Take 5 Oil Change


**16912 E. 23rd Street**
**Independence, Missouri**

September
2021

BHC Project Number 031990.00.01

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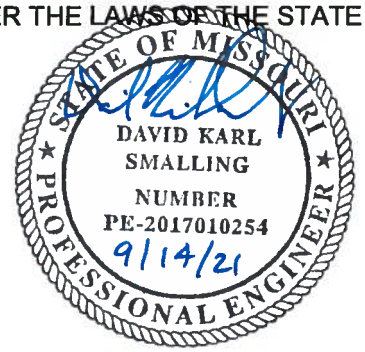
# Take 5 Oil Change

# 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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Missouri Professional Engineer PE-2017010254

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 Figure 1 - 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 Appendix A – Traffic Count Data and Figure 3 – Existing Traffic Volumes. The existing Signal Phasing and Timing Plan, provided by MoDOT, is shown in Appendix C. The existing turning movement count data was analyzed using Synchro traffic software.

As shown in Appendix D the AM Peak Hour operates at a level of service (LOS) D or 45.9s Delay. As shown in Appendix E 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 Figure 2 - 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 Figure 2 - 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 Figure 2, the M-291 entrance is proposed to be located along the north property line. As shown in the Site Plan in Figure 2, 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 Figure 4A and Figure 4B, 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 A Policy on Geometric Design of Highways and Streets, 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 Trip Generation Handbook 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. Table 1A and Table 1B summarize the trip ends produced for the AM and PM peak hours for

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

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

| Table 1B - Trip Generation | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Peak Hour | Land Use | Variable | Value | Avg. Trip Gen. Rate | Dir. Dist. | Trip Ends | | |
| | | | | | | Total | Entering | Exiting |
| AM | 941 | Serv. Pos. | 3 | 3.00 | 67/33 | 9 | 6 | 3 |
| | 853 | 1000 SF | 4.20 | 40.59 | 50/50 | 170 | 85 | 85 |
| | | | | | **Total** | **179** | **91** | **88** |
| PM | 941 | Serv. Pos. | 3 | 4.85 | 56/44 | 15 | 8 | 7 |
| | 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 Table 2. Figure 4A and Figure 4B show the Site Generated Traffic Volumes for the AM and PM peak hours for Scenarios A and B, respectively.

| Table 2 - Trip Distribution | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Trip Ends | | Intersection | | | | | | | | | | Site | | | | | |
| | | | | 23rd Street & M-291 | | | | | | | | | | 23rd St. | | M-291 | | 23rd St. | M-291 |
| | | | | Entering | | | | | | Exiting | | | | Entering | | | | Exiting | |
| | | | | SB U-Turn | | NBT | | EBL | | WBL^ | | WBT* | | WBR | | NBR | | SBR | WBR" |
| Sc. | Pk. Hr. | Ent. | Ex. | % | # | % | # | % | # | % | # | % | # | % | # | # | | # | % | # |
| A | AM | 83 | 77 | 5% | 4 | 69% | 57 | 5% | 4 | 5% | 4 | 26% | 20 | 21% | 18 | 65 | | 24 | 69% | 53 |
| | PM | 72 | 66 | | 4 | | 49 | | 4 | | 3 | | 18 | | 15 | 57 | | 21 | | 45 |
| B | AM | 91 | 88 | 5% | 5 | 67% | 61 | 5% | 5 | 5% | 4 | 34% | 25 | 23% | 20 | 71 | | 29 | 67% | 59 |
| | PM | 112 | 110 | | 6 | | 75 | | 6 | | 6 | | 31 | | 25 | 87 | | 37 | | 73 |

^WBL accommodates SB Traffic.
*WBT accommodates both WB and EB Traffic.
"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 Highway Capacity Manual, 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 Table 3. 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 Vehicle Delay (sec/veh) | |
| | Unsignalized | Signalized |
| A | < 10 | < 10 |
| B | < 15 | < 20 |
| C | < 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. Figure 5B shows the Scenario B Site Generated Traffic Volumes for the AM and PM peak hours from Figure 4B plus the existing traffic volumes from Figure 3.

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 Appendix F and Appendix G, respectively. Table 4 summarizes the Level of Service and Exiting Queue.

**Table 4 – LOS & Exiting Queue**

| Int. | Peak Hour | Cond. | Delay (s) | LOS | Q (veh) |
|---|---|---|---|---|---|
| M-291 & 23rd St. | AM | Ex. | 45.9 | D | |
| | | Ex. + Site | 46.7 | D | |
| | PM | Ex. | 59.3 | E | |
| | | Ex. + Site | 61.4 | E | |
| M-291 Ent. | AM | Ex. + Site | 16.2 | C | 0.6 |
| | PM | Ex. + Site | 28.4 | D | 1.4 |
| 23rd St. Ent. | AM | Ex. + Site | 10.2 | B | 0.1 |
| | PM | Ex. + Site | 11.0 | B | 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. 23rd Street. See Figure 2 – 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 Table 1A and Table 1B, 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 Table 2, 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.

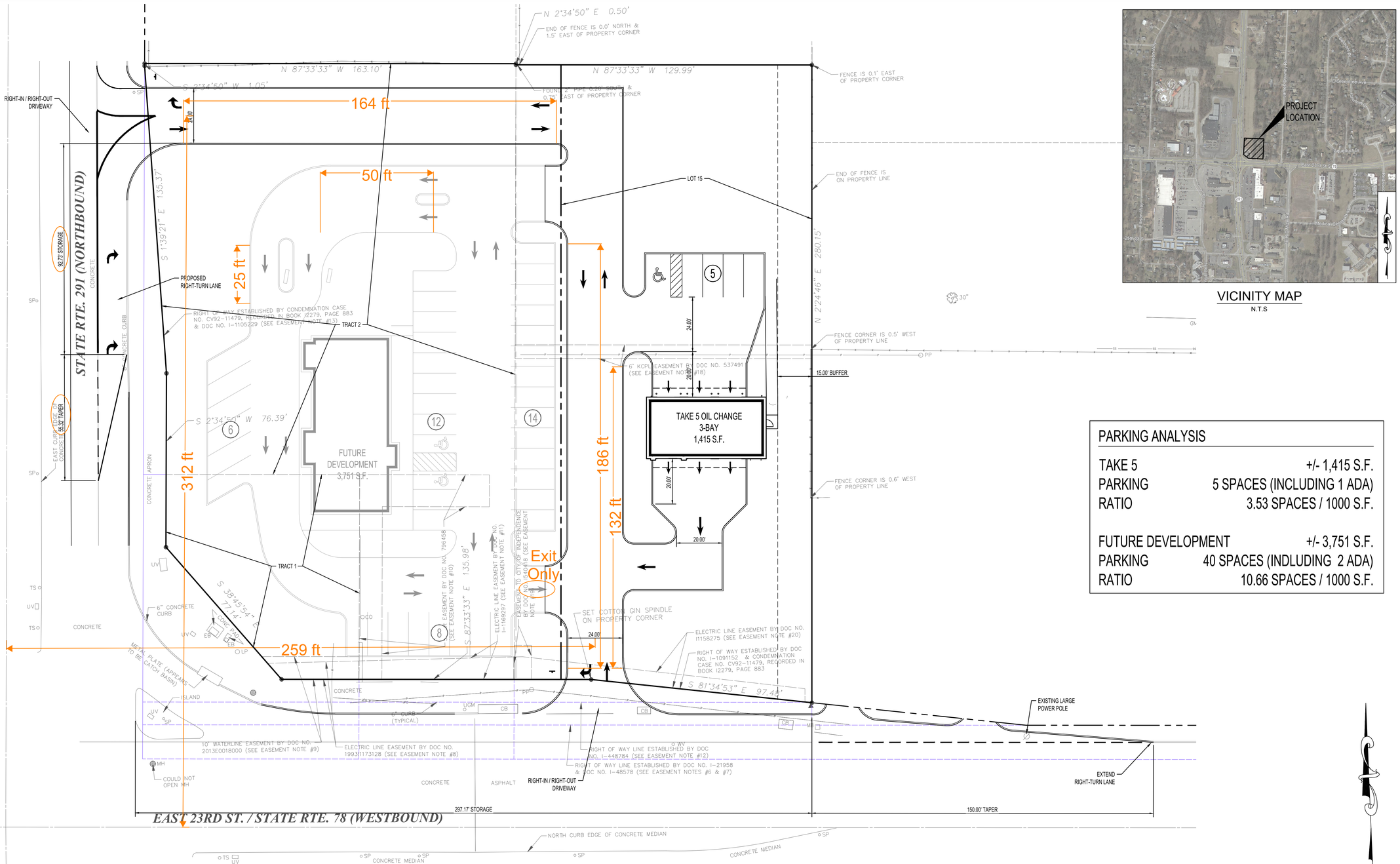
In addition, the number of vehicles expected to access the proposed site from northbound M-291 or westbound E. 23rd Street is low enough that the throat length will be sufficient to handle peak hour traffic and no adverse effects on the adjacent roadways.

## 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


**Figure 1 – Site Location Map**







VICINITY MAP
N.T.S

## PARKING ANALYSIS

| | |
|---|---|
| TAKE 5 | +/- 1,415 S.F. |
| PARKING | 5 SPACES (INCLUDING 1 ADA) |
| RATIO | 3.53 SPACES / 1000 S.F. |
| FUTURE DEVELOPMENT | +/- 3,751 S.F. |
| PARKING | 40 SPACES (INDLUDING 2 ADA) |
| RATIO | 10.66 SPACES / 1000 S.F. |

Not For Construction

# SITE PLAN

| REVISION | BY |
|---|---|
| | |

HIGH TIDE CONSULTANTS LLC
700 CANAL BOULEVARD
THIBODAUX, LA 70301
www.hightidela.com

SIGNATURE:

DATE:

STAMP

PROPOSED TAKE 5 OIL CHANGE
E 23RD STREET @ STATE ROAD 291
INDEPENDENCE, MISSOURI

DRIVEN ASSETS, LLC

| |
|---|
| DRAWN JPH |
| CHECKED RCG |
| ISSUED DATE 7-13-21 |
| ISSUED FOR REVIEW |
| PROJECT NO. 21-120 |
| FILE 21-114 SITE |
| SHEET C-1 |

**Figure 2 - Site Plan**

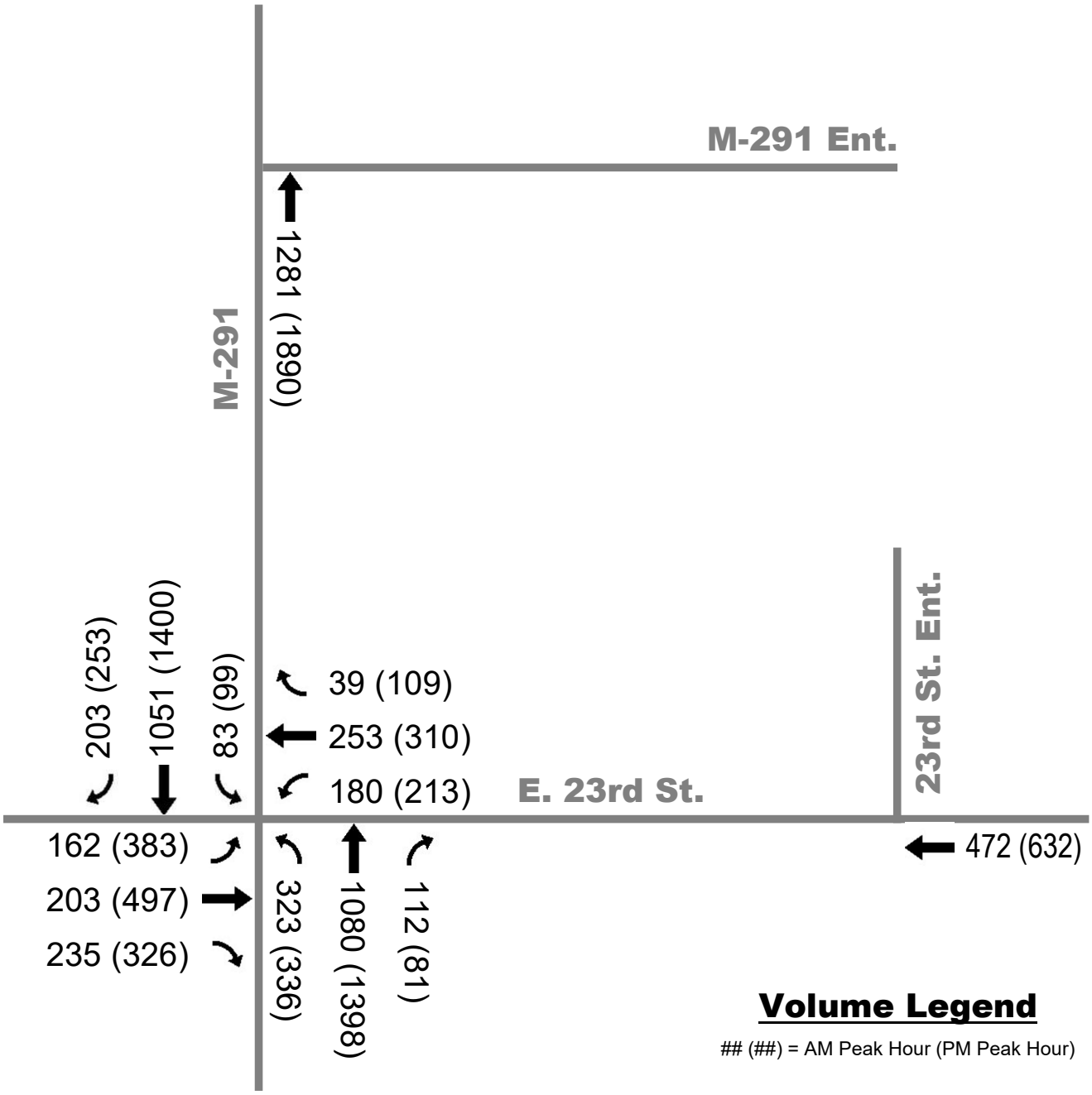
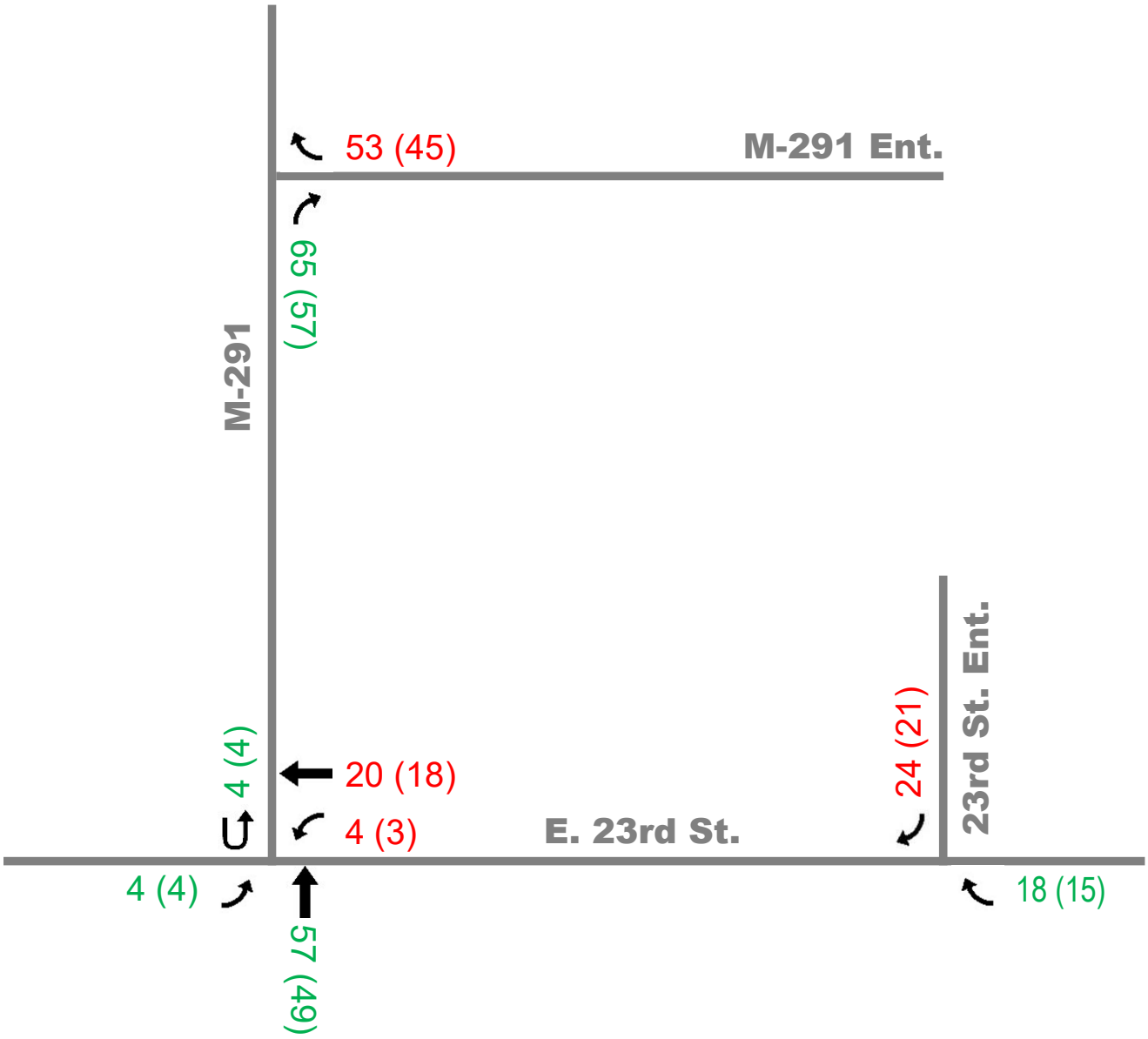



**Figure 3 - Existing Traffic Volumes**



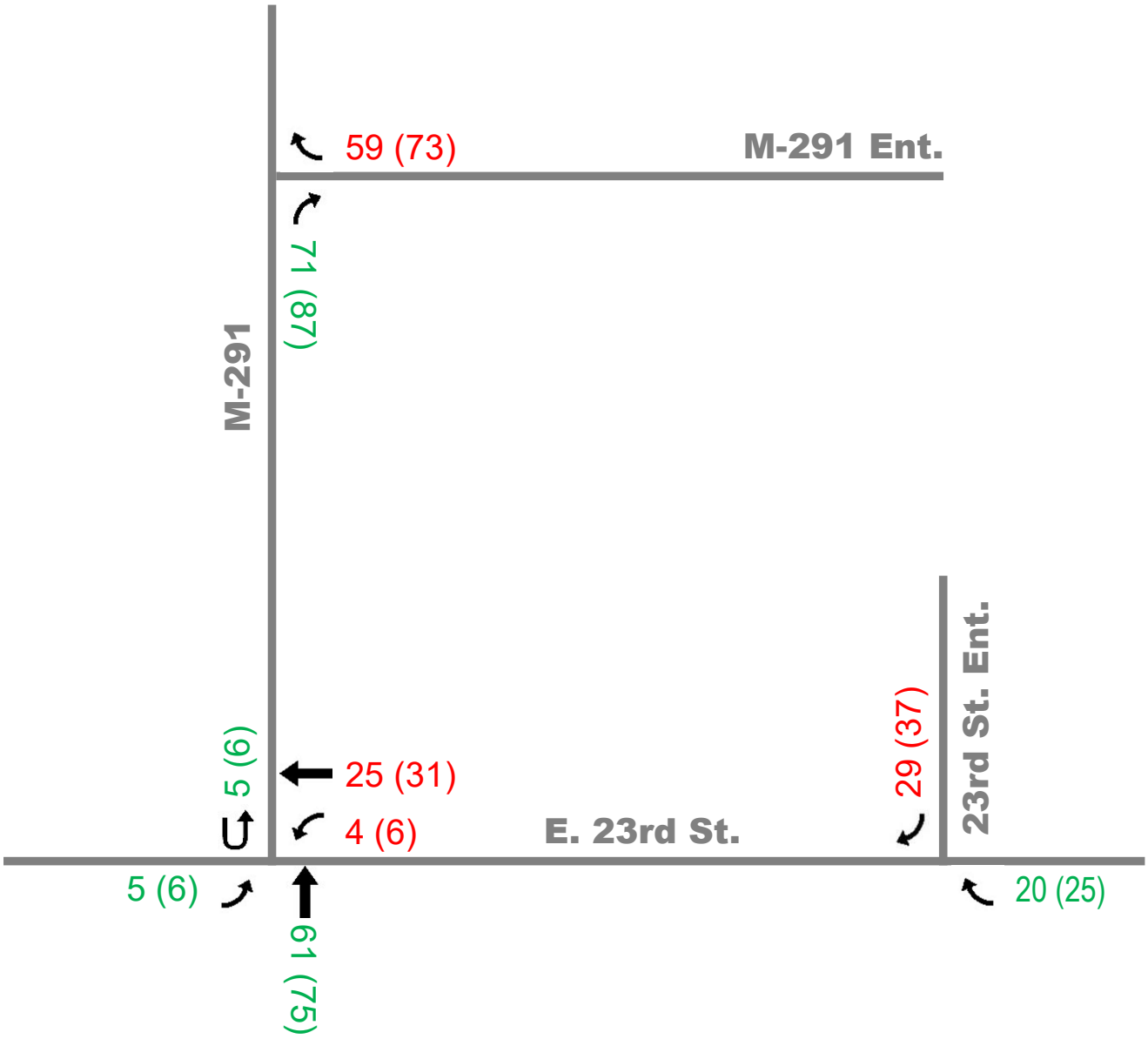

**Volume Legend**

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

Entering

Exiting

**Figure 4A - Site Generated Traffic Volumes**




**Volume Legend**

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

Entering

Exiting

**Figure 4B - Site Generated Traffic Volumes**

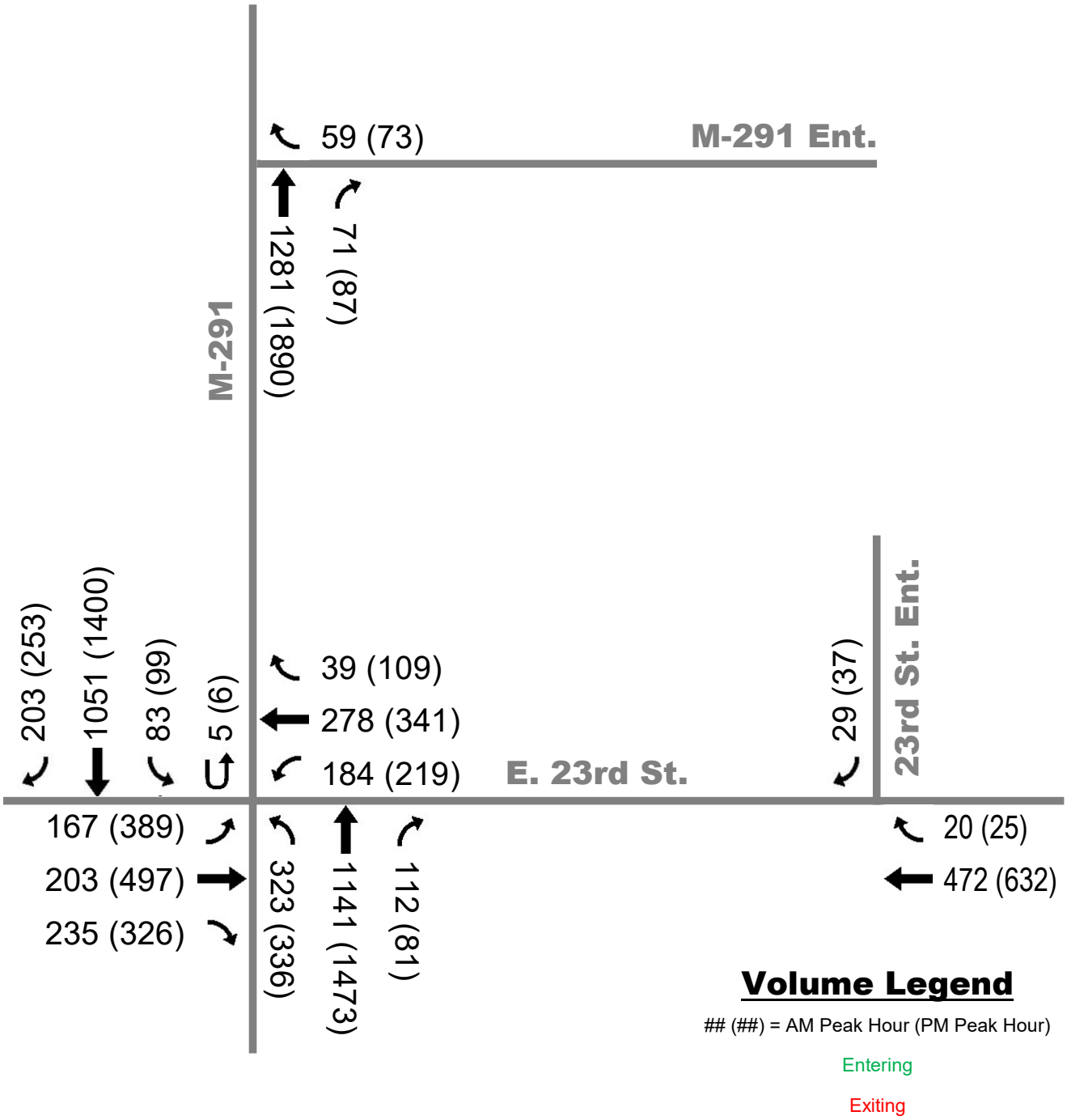



**Figure 5B - Existing + Site (Scenario B) Traffic Volumes**

# Appendices

# Appendix A - Traffic Count Data

## 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

Provided by: Gewalt Hamilton Associates Inc.
625 Forest Edge Drive, Vernon Hills, IL, 60061, US

| Leg | M-291 | | | | | | 23rd St | | | | | | M-291 | | | | | | 23rd St | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Direction | Southbound | | | | | | Westbound | | | | | | Northbound | | | | | | Eastbound | | | | | | |
| Time | R | T | L | U | App | Ped* | R | T | L | U | App | Ped* | R | T | L | U | App | Ped* | R | T | L | U | App | Ped* | 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% | **34.0%** | - | 1.6% | 5.9% | 4.1% | 0% | **11.6%** | - | 2.1% | 25.5% | 7.3% | 0% | **34.8%** | - | 6.2% | 7.6% | 5.8% | 0% | **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% | **95.1%** | - | 97.5% | 98.0% | 98.9% | 0% | **98.2%** | - | 97.8% | 93.7% | 98.4% | 0% | **94.9%** | - | 97.8% | 98.8% | 97.7% | 0% | **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 | |
| % Pedestrians | - | - | - | - | - | 100% | - | - | - | - | - | 100% | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Bicycles on Crosswalk | - | - | - | - | - | 0 | - | - | - | - | - | 0 | - | - | - | - | - | 0 | - | - | - | - | - | 0 | |
| % Bicycles on Crosswalk | - | - | - | - | - | 0% | - | - | - | - | - | 0% | - | - | - | - | - | - | - | - | - | - | - | - | - |

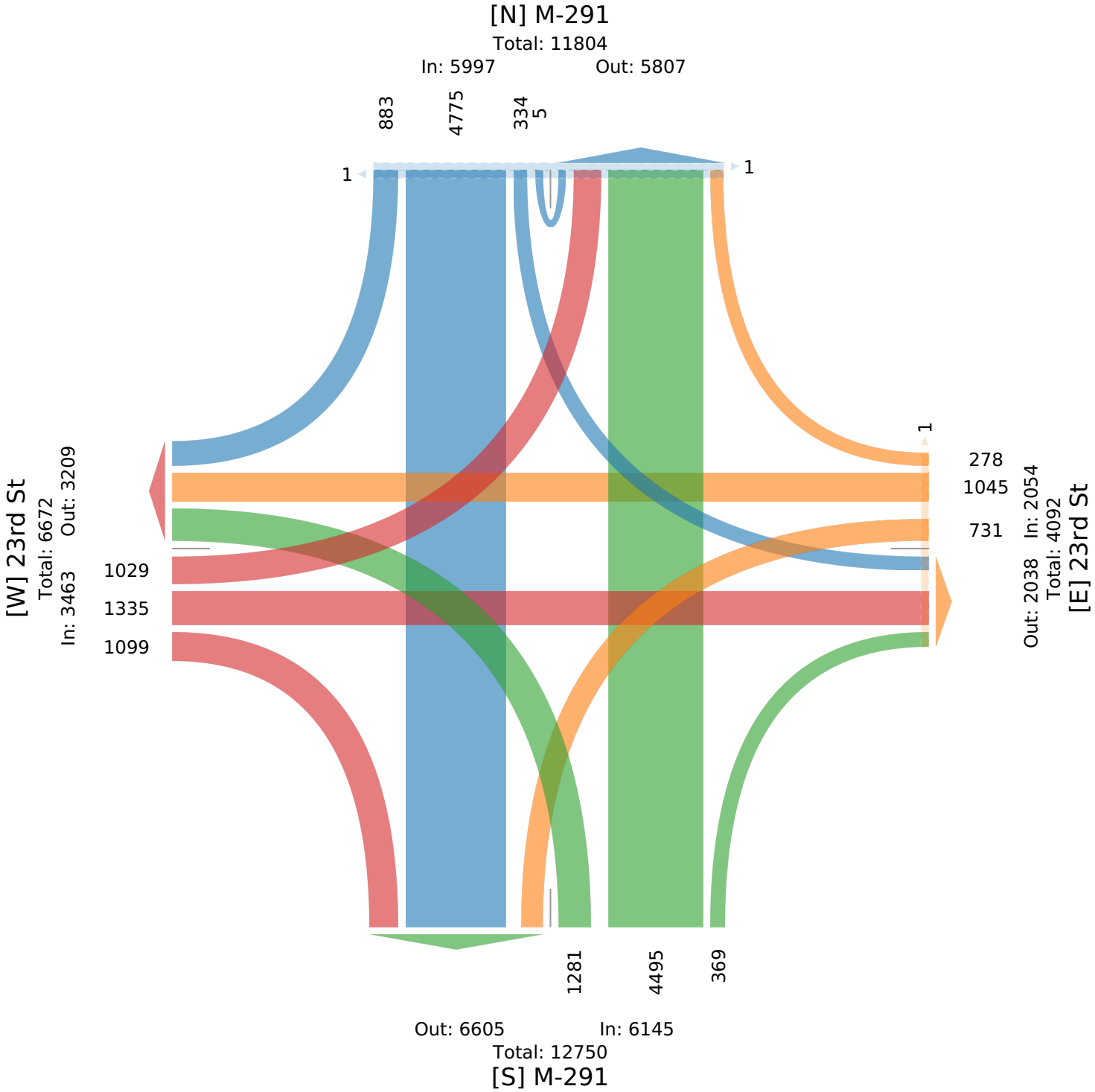
*Pedestrians and Bicycles on Crosswalk. L: Left, R: Right, T: Thru, U: U-Turn

# Appendix A - Traffic Count Data

## 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

Provided by: Gewalt Hamilton Associates Inc.
625 Forest Edge Drive, Vernon Hills, IL, 60061, US



# Appendix A - Traffic Count Data

## 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

Provided by: Gewalt Hamilton Associates Inc.
625 Forest Edge Drive, Vernon Hills, IL, 60061, US

| Leg | M-291 | | | | | | 23rd St | | | | | | M-291 | | | | | | 23rd St | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Direction | Southbound | | | | | | Westbound | | | | | | Northbound | | | | | | Eastbound | | | | | | |
| Time | R | T | L | U | **App** | Ped* | R | T | L | U | **App** | Ped* | R | T | L | U | **App** | Ped* | R | T | L | U | **App** | Ped* | **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% | **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% | **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 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

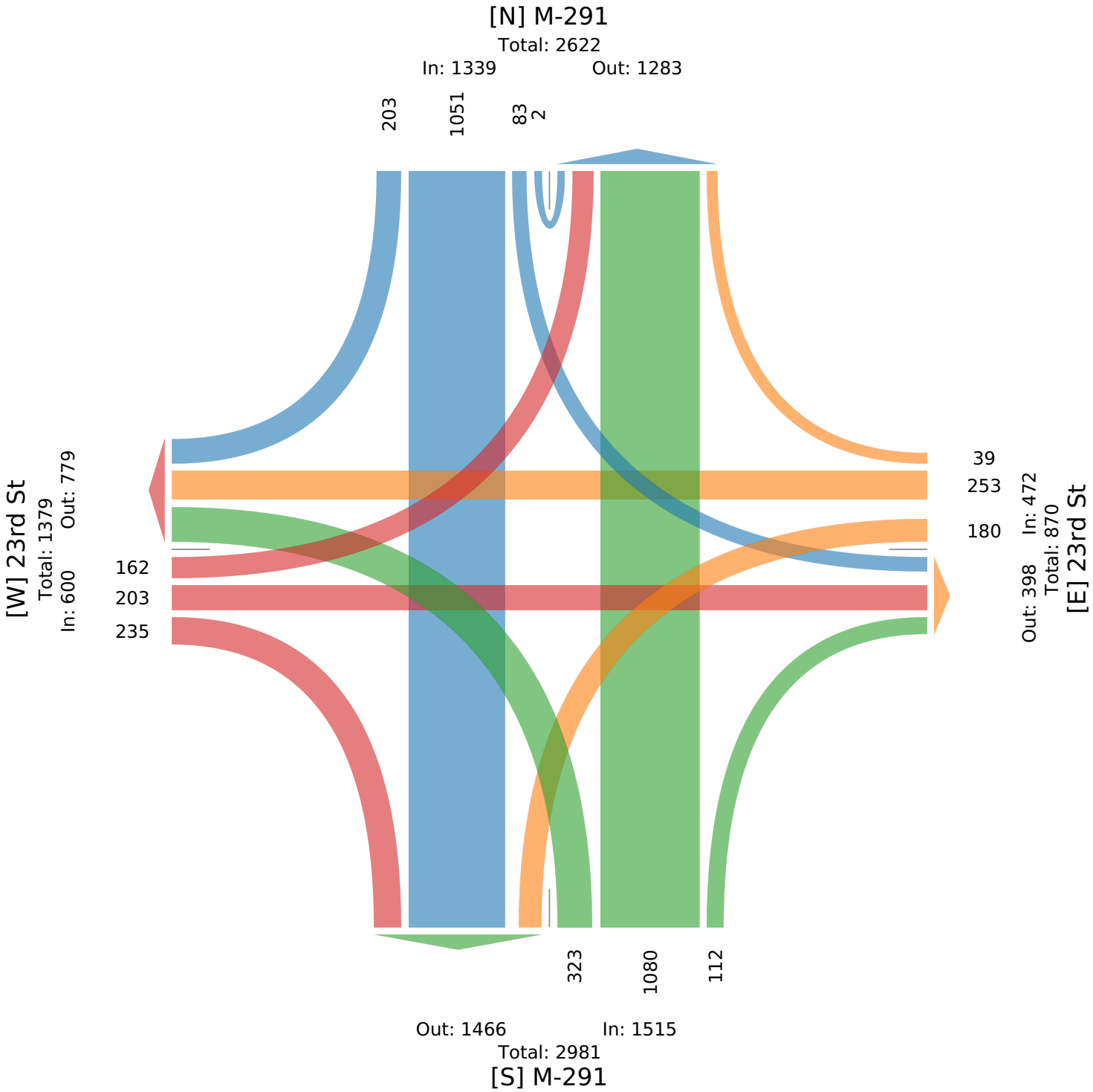
*Pedestrians and Bicycles on Crosswalk. L: Left, R: Right, T: Thru, U: U-Turn

# Appendix A - Traffic Count Data

## 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

Provided by: Gewalt Hamilton Associates Inc.
625 Forest Edge Drive, Vernon Hills, IL, 60061, US



# Appendix A - Traffic Count Data

## 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

Provided by: Gewalt Hamilton Associates Inc.
625 Forest Edge Drive, Vernon Hills, IL, 60061, US

| Leg | M-291 | | | | | | 23rd St | | | | | | M-291 | | | | | | 23rd St | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Direction | Southbound | | | | | | Westbound | | | | | | Northbound | | | | | | Eastbound | | | | | | |
| Time | R | T | L | U | App | Ped* | R | T | L | U | App | Ped* | R | T | L | U | App | Ped* | R | T | L | U | App | 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% | **11.7%** | - | 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% | **99.2%** | - | 98.8% | 96.1% | 98.8% | 0% | **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% | - | - | - | - | - | - | - | - | - | - | - | - | - |

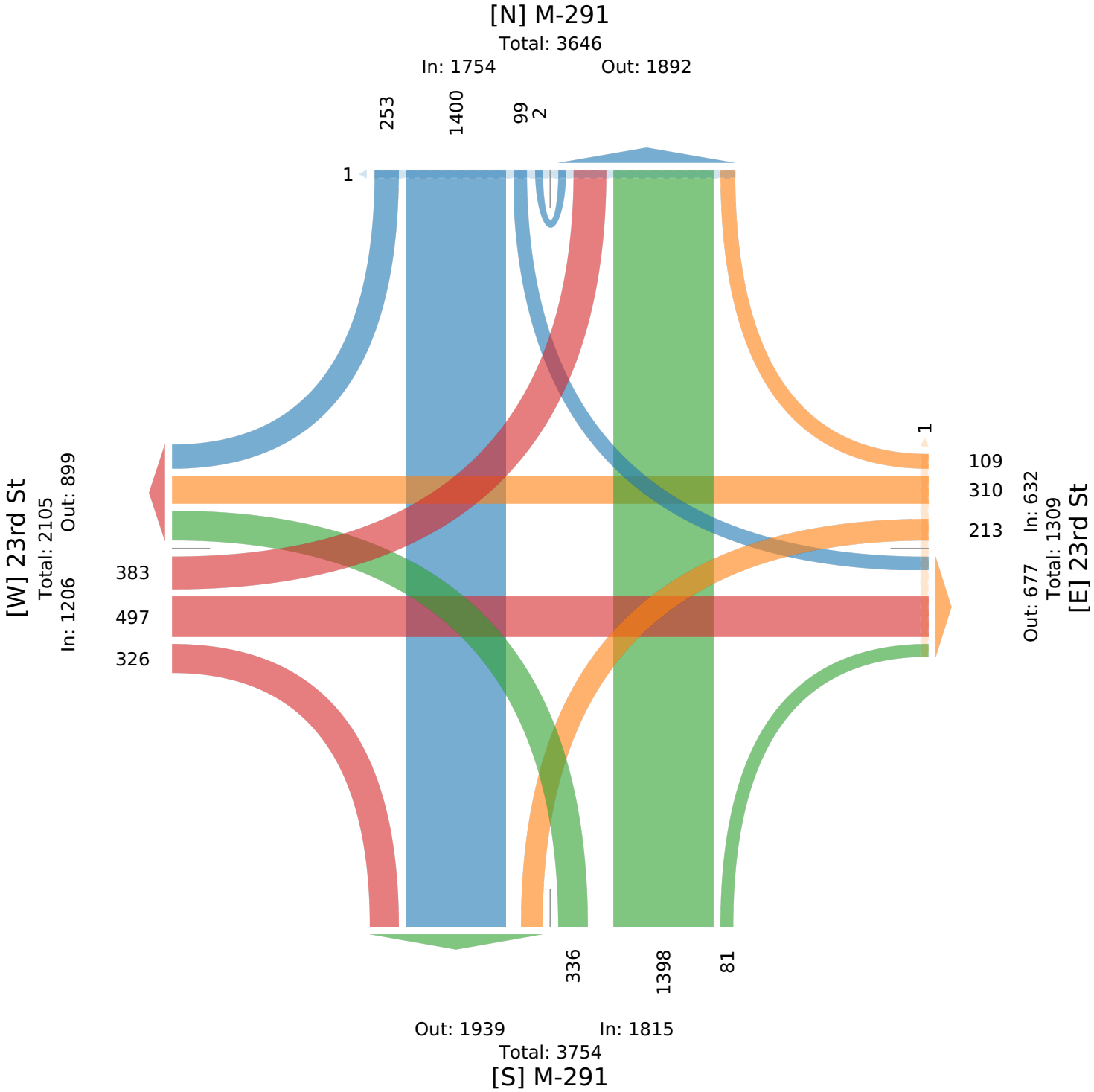
*Pedestrians and Bicycles on Crosswalk. L: Left, R: Right, T: Thru, U: U-Turn

# Appendix A - Traffic Count Data

## 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

GEWALT HAMILTON ASSOCIATES, INC.
Provided by: Gewalt Hamilton Associates Inc.
625 Forest Edge Drive, Vernon Hills, IL, 60061, US



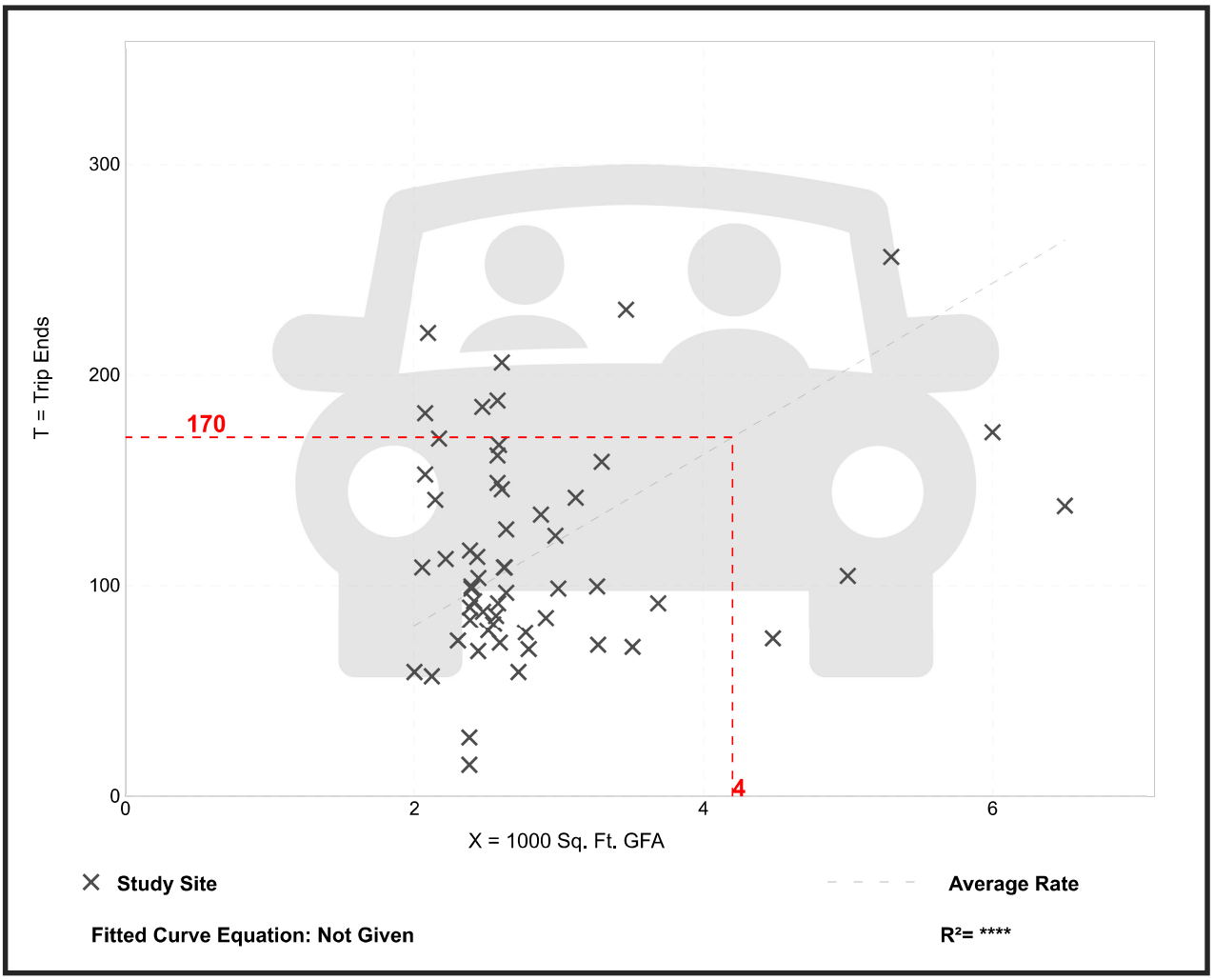
# Convenience Market with Gasoline Pumps
(853)

| | |
|---|---|
| **Vehicle Trip Ends vs:** | **1000 Sq. Ft. GFA** |
| **On a:** | **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 |

## Data Plot and Equation



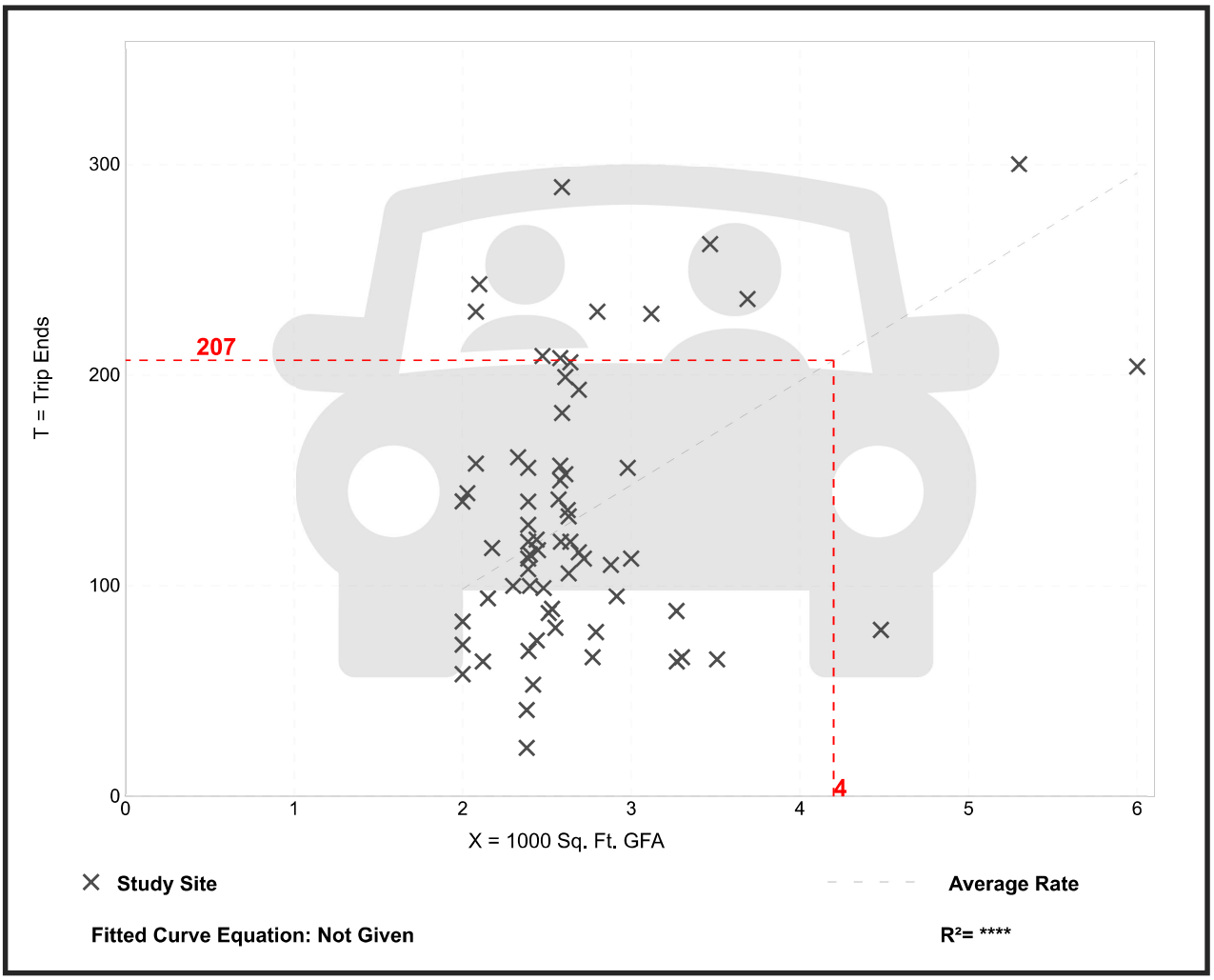
# Convenience Market with Gasoline Pumps
(853)

| | |
|---|---|
| **Vehicle Trip Ends vs:** | **1000 Sq. Ft. GFA** |
| **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: | 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 |

## Data Plot and Equation



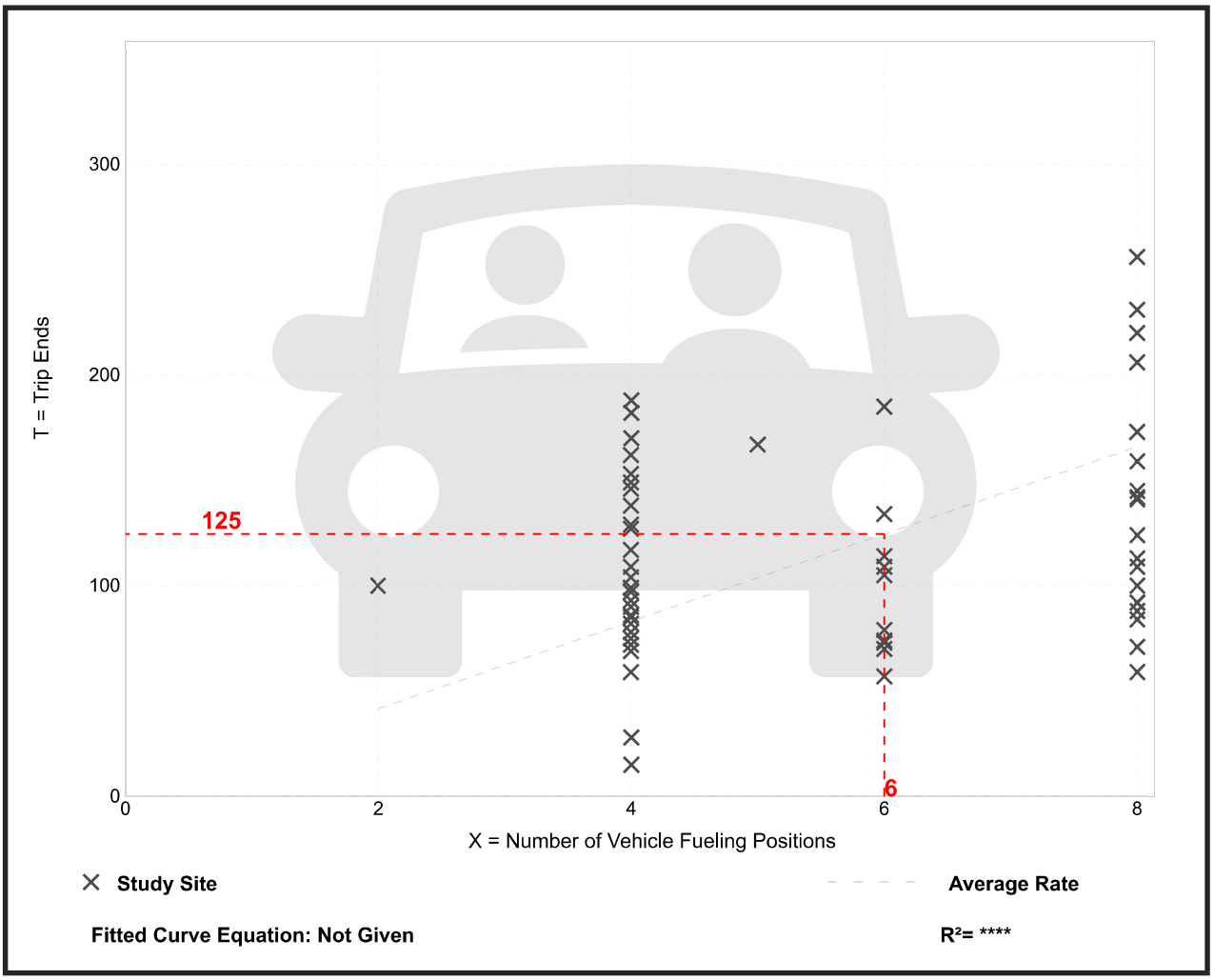
# Convenience Market with Gasoline Pumps
(853)

| | |
|---|---|
| **Vehicle Trip Ends vs:** | **Vehicle Fueling Positions** |
| **On a:** | **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 |

## Data Plot and Equation



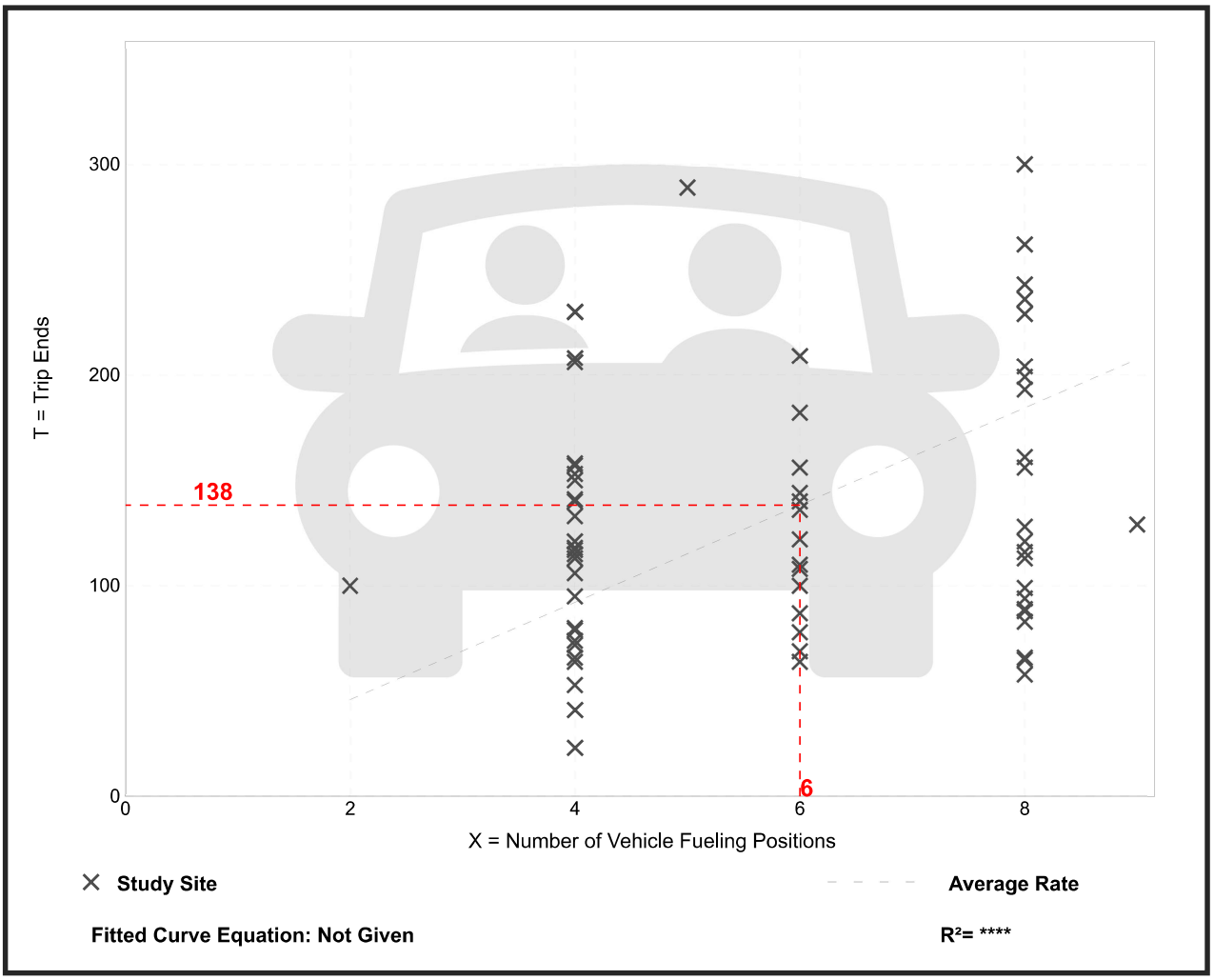
# Convenience Market with Gasoline Pumps
(853)

| | |
|---|---|
| **Vehicle Trip Ends vs:** | **Vehicle Fueling Positions** |
| **On a:** | **Weekday,**<br>**Peak Hour of Adjacent Street Traffic,**<br>**One Hour Between 4 and 6 p.m.** |
| **Setting/Location:** | **General Urban/Suburban** |
| Number of Studies: | 69 |
| 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 |
|---|---|---|
| 23.04 | 5.75 - 57.80 | 11.91 |

## Data Plot and Equation



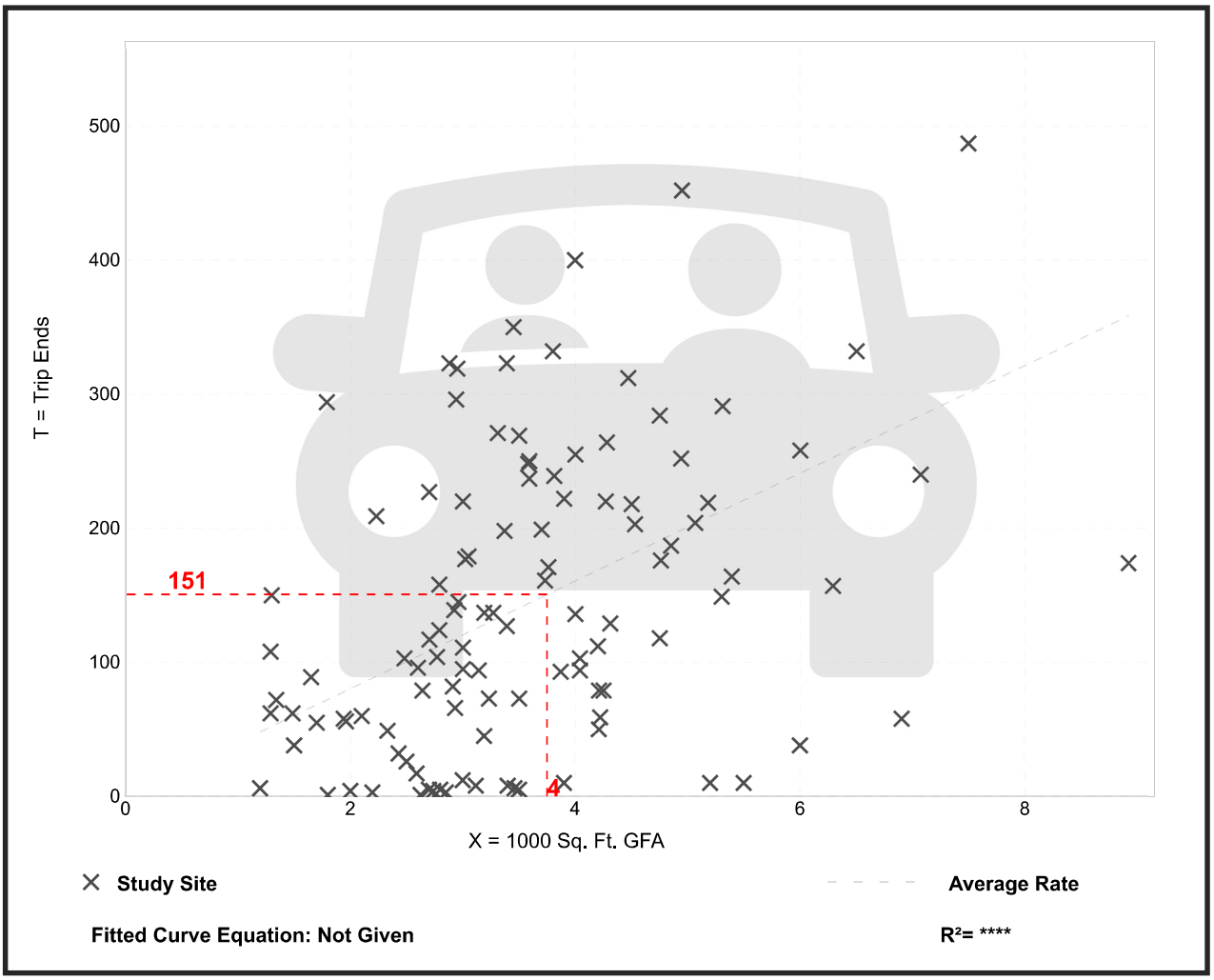
# Fast-Food Restaurant with Drive-Through Window
(934)

| | |
|---|---|
| **Vehicle Trip Ends vs:** | **1000 Sq. Ft. GFA** |
| **On a:** | **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 |

## Data Plot and Equation



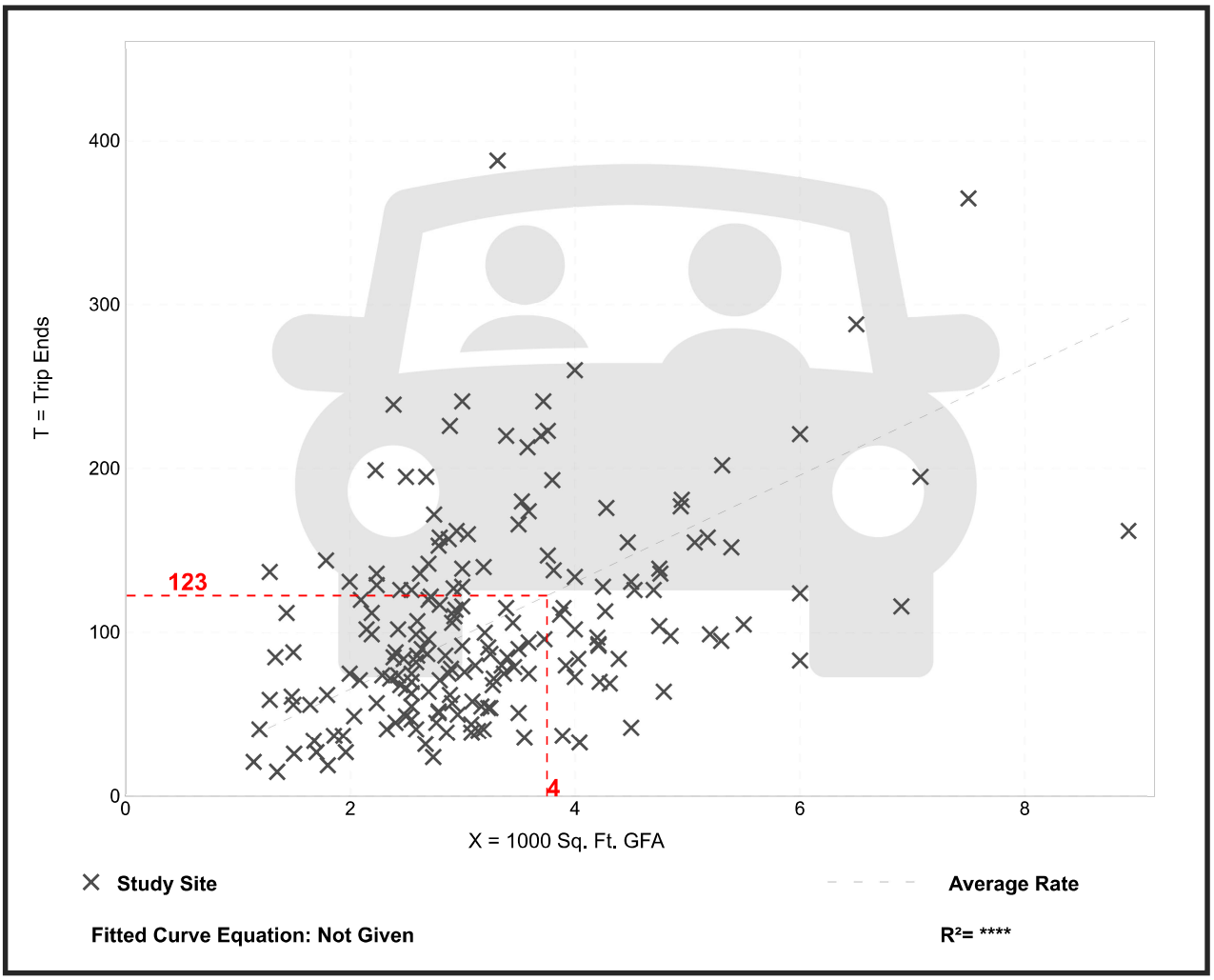
# Fast-Food Restaurant with Drive-Through Window
(934)

| | |
|---|---|
| **Vehicle Trip Ends vs:** | **1000 Sq. Ft. GFA** |
| **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: | 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 |

## Data Plot and Equation



# Quick Lubrication Vehicle Shop
(941)

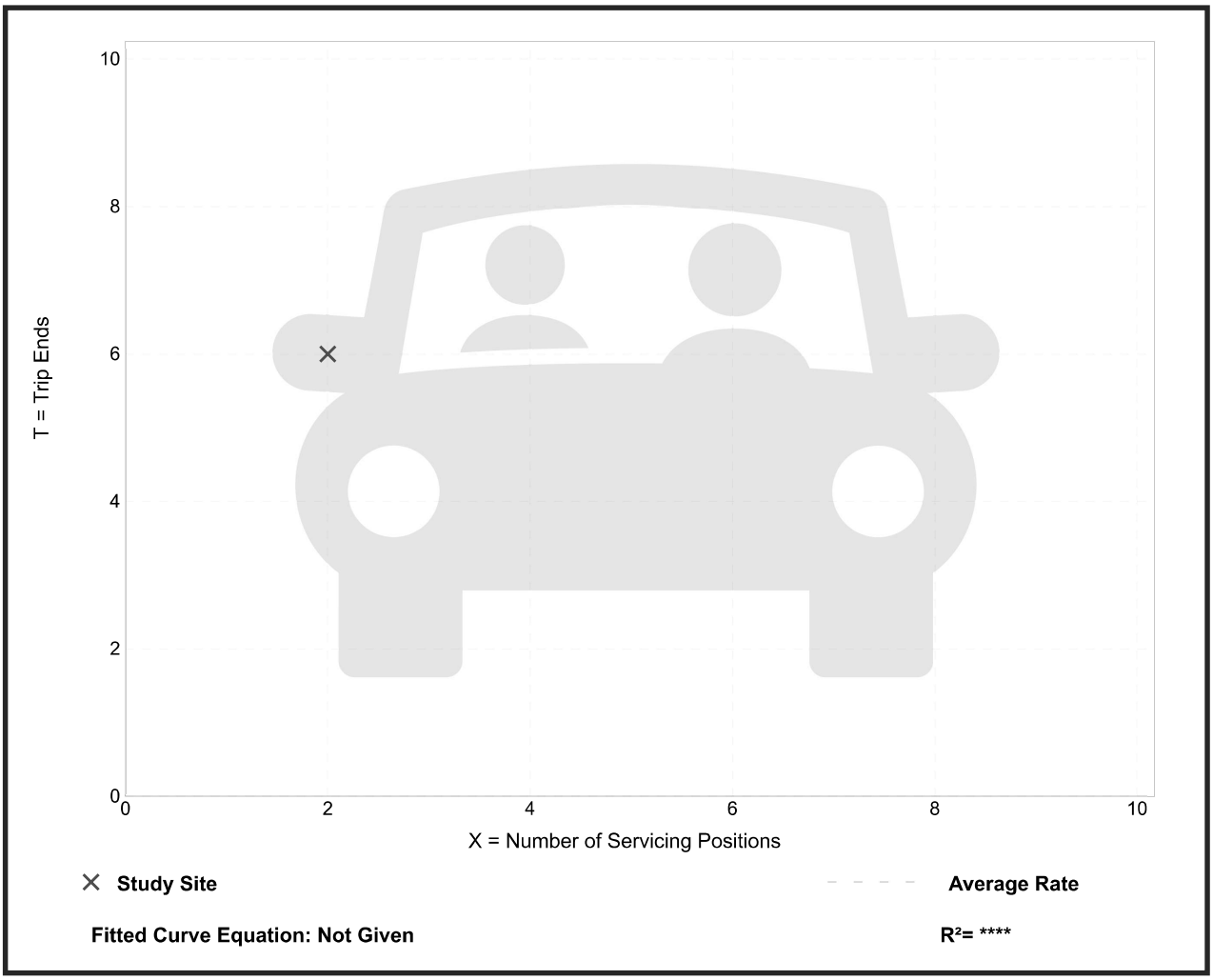
**Vehicle Trip Ends vs:** **Servicing Positions**
**On a:** **Weekday,**
**Peak Hour of Adjacent Street Traffic,**
**One Hour Between 7 and 9 a.m.**
**Setting/Location:** **General Urban/Suburban**
Number of Studies: 1
Avg. Num. of Servicing Positions: 2
Directional Distribution: 67% entering, 33% exiting

## 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***



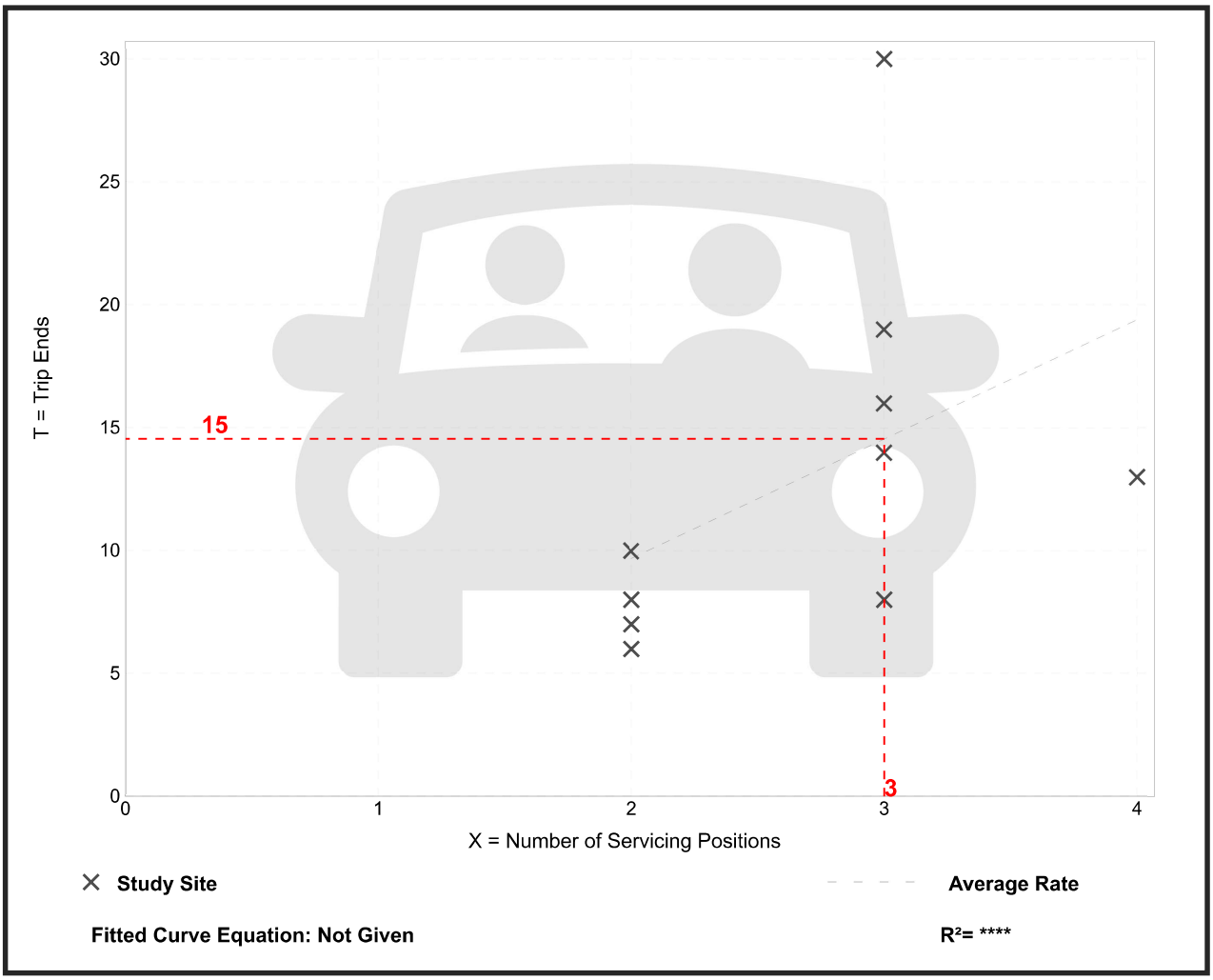
# Quick Lubrication Vehicle Shop
(941)

| | |
|---|---|
| **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 |

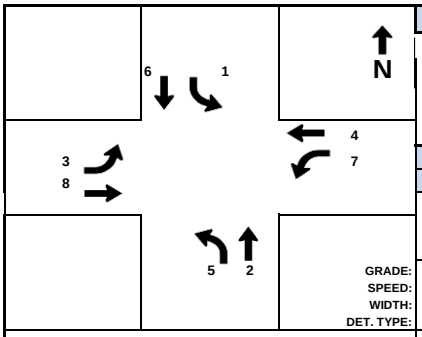
## Vehicle Trip Generation per Servicing Position

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

## Data Plot and Equation



# Appendix C - Signal Phasing and Timing Plan




**SIGNAL PHASING AND TIMING - ACTUATED / COORDINATED OPERATION**

TIMING DATE 8/31/2021

ROUTE MO 291 & MO 78 BY :

CITY Independence MO

*ACTUATED PLAN*

| | PHASE 1 | PHASE 2 | PHASE 3 | PHASE 4 | PHASE 5 | PHASE 6 | PHASE 7 | PHASE 8 |
|---|---|---|---|---|---|---|---|---|
| GRADE: | – | – | – | – | – | – | – | – |
| SPEED: | – | – | – | – | – | – | – | – |
| WIDTH: | – | – | – | – | – | – | – | – |
| DET. TYPE: | – | – | – | – | – | – | – | – |
| RING | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| RING SEQUENCE (MM-1-1-1) | | | | | | | | |
| MIN. INITIAL / GREEN (MM-2-1) | *5* | *7* | *7* | *5* | *8* | *7* | *7* | *5* |
| UNIT EXTENSION/PASSAGE (MM-2-1) | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* |
| YELLOW CLEARANCE | *4.2* | *4.4* | *3.9* | *4.1* | *4.4* | *4.2* | *4.1* | *3.9* |
| RED CLEARANCE | 1.9 | 1.7 | 2.4 | 2.4 | 1.7 | 1.9 | 2.4 | 2.4 |
| MAX. 1 (MM-2-1) | *30* | *30* | *30* | *30* | *30* | *30* | *30* | *30* |
| MAX. 2 (MM-2-1) | | | | | | | | |
| NON-LOCK MEMORY (YES / NO) (MM-2-8) | | | | | | | | |
| VEH. RECALL (MIN / MAX / SOFT) (MM-2-8) | | *MIN* | | | | *MIN* | | |
| PED RECALL (MM-2-8) | | | | | | | | |
| DUAL ENTRY (MM-2-6-1) | | X | | X | | X | | X |
| PED WALK (MM-2-1) | | | | | | | | |
| PED WALK CLEARANCE (MM-2-1) | | | | | | | | |
| DETECTOR ASSIGNMENT (MM-6-1) | | | | | | | | |
| VEH. DET. DELAY TIME (MM-6-2) | | | | | | | | |
| P/P LT. DETECTOR SWITCH (MM-6-2) | | | | | | | | |
| ADVANCE DETECTION | | | | | | | | |
| INITIALIZATION STATE (MM-2-5) | | | | | | | | |
| CABINET FLASH (MM-2-5) | | | | | | | | |

| BEGIN OF GREEN-COORDINATION TIMING - DIAL PLAN | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| DAY PLN | EVNT | ACT. PLN | TIME | ACTION PLAN = 1 \| CYCLE = 100 SECONDS \| OFFSET = 82 SECONDS \| SEQ : 4 | | | | | |
| | | | | *14* | *45* | *18* | *23* | *20* | *39* | *18* | *23* |
| 1 | 1 | Free | 0:01 | | | | | | | | |
| 1 | 2 | 1 | 8:00 | ACTION PLAN = 2 \| CYCLE = 120 SECONDS \| OFFSET = 62 SECONDS \| SEQ : 7 | | | | | |
| 1 | 3 | 2 | 11:00 | *17* | *55* | *18* | *30* | *24* | *48* | *25* | *23* |
| 1 | 4 | 1 | 18:45 | | | | | | | | |
| 1 | 5 | Free | 23:00 | | | | | | | | |
| | | | | ACTION PLAN = 4 \| CYCLE = 145 SECONDS \| OFFSET = 1 SECONDS \| SEQ : 13 | | | | | |
| | | | | *13* | *86* | *24* | *22* | *26* | *73* | *17* | *29* |
| 2 | 1 | Free | 0:01 | | | | | | | | |
| 2 | 2 | 1 | 5:45 | | | | | | | | |
| 2 | 3 | 2 | 6:20 | ACTION PLAN = 14 \| CYCLE = 145 SECONDS \| OFFSET = 1 SECONDS \| SEQ : 13 | | | | | |
| 2 | 4 | 1 | 9:00 | *13* | *78* | *24* | *30* | *26* | *65* | *25* | *29* |
| 2 | 5 | 4 | 11:00 | | | | | | | | |
| 2 | 6 | 4 | 13:00 | | | | | | | | |
| 2 | 7 | 4 | 14:35 | | | | | | | | |
| 2 | 8 | 14 | 15:15 | | | | | | | | |
| 2 | 9 | 4 | 15:45 | | | | | | | | |
| 2 | 10 | 1 | 18:45 | | | | | | | | |
| 2 | 11 | Free | 23:00 | | | | | | | | |

**COMMENTS**

| seq 4 | Seq 7 | Seq 13 |
|---|---|---|
| 2, 1 I 4, 3 | 1, 2 I 4, 3 | 1, 2 I 3,4 |
| 5, 6 I 7, 8 | 6, 5 I 7, 8 | 6, 5 I 8, 7 |

| DAY PLAN | # | S \| M \| T \| W \| T \| F \| S |
|---|---|---|
| DAY PLAN | 1 | S \| M \| T \| W \| T \| F \| S |
| DAY PLAN | 2 | S \| M \| T \| W \| T \| F \| S |
| DAY PLAN | _ | S \| M \| T \| W \| T \| F \| S |

**CLEARANCE FORMULAS (EPG Section 902.5.36.2)**

Yellow = 1.5+((1.47*Speed)/(20+(64.4*Grade)))

Red = ((Width+20)/(1.47*Speed))

Change Period: $CP = t + \frac{V}{2a + 64.4g} + \frac{W + L}{V}$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ITE Equation Yellow | | | | | | | | |
| 3 s <=YELLOW<=6 s | | | | | | | | |
| ITE Equation Red | | | | | | | | |
| Change Period Sum | | | | | | | | |

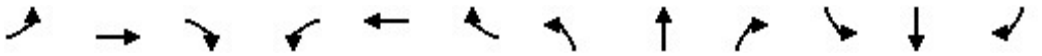
| STARTUP OPERATION | | | | | | | | |
|---|---|---|---|---|---|---|---|---|

CONTROLLER MAKE/MODEL | MASTER CONTROLLER @

DISTRIBUTION : CABINET SHOP DISTRICT OFFICE (FILE / BOOK)

# Appendix D - HCM 6th Ed. LOS [Existing 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 | | | | | | | | | | | | |
| 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/ln | 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 | A | | 513 | | | 1525 | A | | 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.

| Movement | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| 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/ln | 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 | C | | F | D | |
| Approach Vol, veh/h | | 956 | A | | 687 | | | 1885 | A | | 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+I1), 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 |

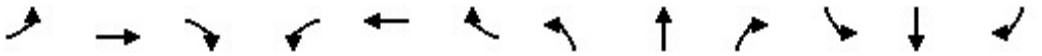
Notes

* 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 | | | | | | | | | | | | |
| 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 | 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 | 182 | 221 | 0 | 200 | 302 | 42 | 351 | 1240 | 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 | 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 |
| 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 | | 1.00 |
| 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 | 1.00 | 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 | 51.6 | 47.4 | 0.0 | 45.6 | 42.4 | 39.9 | 48.3 | 32.4 | 0.0 | 50.9 | 37.4 | 0.0 |
| Incr 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 |
| 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 | 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 | | | | | | | | | | | | |
| LnGrp 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 | |

| 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 | 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.

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

| Intersection | |
|---|---|
| Int Delay, s/veh | 0.4 |

| Movement | WBL | WBR | NBT | NBR | SBL | SBT |
|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | |
| 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, # | 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 | | Major1 | | Major2 | |
|---|---|---|---|---|---|---|
| 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 | NBR | WBLn1 | 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 | - |

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

| Intersection | |
|---|---|
| Int Delay, s/veh | 0.4 |

| Movement | EBL | EBT | WBT | WBR | SBL | SBR |
|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | |
| 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, # | - | 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 | 221 | 513 | 22 | 0 | 32 |

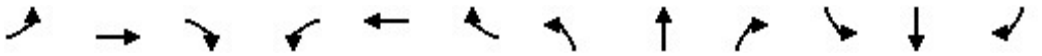
| Major/Minor | Major1 | | Major2 | | Minor2 | |
|---|---|---|---|---|---|---|
| Conflicting Flow All | - | 0 | - | 0 | - | 268 |
| Stage 1 | - | - | - | - | - | - |
| Stage 2 | - | - | - | - | - | - |
| Critical Hdwy | - | - | - | - | - | 6.94 |
| Critical Hdwy Stg 1 | - | - | - | - | - | - |
| Critical 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 | | | B |

| Minor Lane/Major Mvmt | EBT | WBT | WBR | SBLn1 |
|---|---|---|---|---|
| Capacity (veh/h) | - | - | - | 730 |
| HCM Lane V/C Ratio | - | - | - | 0.043 |
| HCM Control Delay (s) | - | - | - | 10.2 |
| HCM Lane LOS | - | - | - | B |
| 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.



| Movement | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| 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/ln | 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 | C | | F | D | |
| Approach Vol, veh/h | | 963 | A | | 727 | | | 1966 | A | | 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 | 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.

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 | | | | | | |
| 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 | | 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 | NBR | WBLn1 | 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 | - |

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

| Intersection | |
|---|---|
| Int Delay, s/veh | 0.3 |

| Movement | EBL | EBT | WBT | WBR | SBL | SBR |
|---|---|---|---|---|---|---|
| Lane Configurations | | ↑↑ | ↑↑ | | | ↱ |
| 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 |
| Mvmt Flow | 0 | 540 | 687 | 27 | 0 | 40 |

| Major/Minor | Major1 | | Major2 | | Minor2 | |
|---|---|---|---|---|---|---|
| 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 | | | B |

| Minor Lane/Major Mvmt | EBT | WBT | WBR | SBLn1 |
|---|---|---|---|---|
| Capacity (veh/h) | - | - | - | 639 |
| HCM Lane V/C Ratio | - | - | - | 0.063 |
| HCM Control Delay (s) | - | - | - | 11 |
| HCM Lane LOS | - | - | - | B |
| HCM 95th %tile Q(veh) | - | - | - | 0.2 |