# FINAL REPORT

for

# METRA PARK EGRESS IMPROVEMENTS

## YELLOWSTONE COUNTY, MT

Prepared for

## YELLOWSTONE COUNTY COMMISSIONERS

Prepared by


MARVIN & ASSOCIATES
1300 North Transtech Way
Billings, MT 59102


April 2013

# FINAL REPORT

for

# METRA PARK EGRESS IMPROVEMENTS

## YELLOWSTONE COUNTY, MT

Prepared for

## YELLOWSTONE COUNTY COMMISSIONERS

Prepared by

MARVIN & ASSOCIATES
1300 North Transtech Way
Billings, MT 59102


April 2013
P.T.O.E. # 259

## TABLE OF CONTENTS

## *LIST OF FIGURES*

## *LIST OF FIGURES Continued*



## *LIST OF TABLES*

Marvin & Associates

# METRA PARK
# EGRESS TRAFFIC STUDY

## INTRODUCTION

This report summarizes the findings of the METRA Park Egress Traffic Study completed for Yellowstone County. Marvin & Associates was retained by the Yellowstone County Commissioners to perform this study primarily because of extreme traffic congestion that occurred during the November 2012 election-day event. Numerous complaints from the public underscored the problem that has plagued METRA Park in the past. The intent of this study is to answer the basic question: "How do we empty the parking lots in a timely manner so that visitors want to return for future events?" Thus, the scope of this study was based upon development of concepts that have the lowest cost while providing the most benefit in terms of clearing traffic from METRA parking lots in the least amount of time. It was the intent of this study to propose improvements that could be considered interim solutions that deal with today's problems.

A committee consisting of representative of METRA Park operations, City and County law enforcement, Yellowstone County Public Works, and the Montana Department of Transportation (MDT) was formed by Commissioner Reno and a number of comments were received from committee members. All of the concepts proposed in the initial meeting were evaluated within the framework of this study. Other concepts were developed during the course of the study as quantitative data was developed for analysis. The report narratives, figures, and appendix data within this report are intended to support the conclusions and recommendations herein.

Since the draft report presentation at a public meeting confirmed a desire to investigate the recommended alternative further, the study was expanded to include an analysis of improvement impacts during METRA Park events' ingress traffic. Subsequent to the public meeting and additional meetings with the commissioners the study resulted in definitive improvement concepts that will be pursued in the future.

## EXISTING CONDITIONS

No previous studies have been performed that directly relate to METRA Park traffic operations. Therefore, the initial phase of this study was dedicated to documenting and quantifying the number of parking spaces in each lot area, determining the number of vehicles that each access is capable of accommodating at various times of the day, and determining what direction drivers want to go when they leave the METRA Park area. The following report sections provide the answers to these questions and identify the existing supply and demand conditions that basically control egress service time. In addition, operational observations and calculations contained herein are aimed at identifying inefficiencies that may be contributing to excessive egress service time.

### Parking Supply

METRA Park operations personnel were able to provide actual parking space counts for the METRA Park lots shown in Figure 1. There are five separate parking lot areas identified as: the Upper Parking Lot, which is on an elevated bench northeast of the Rimrock Auto Arena; the Front Lot, which is reserved for official and handicap spaces at the main entrance to the arena: an unmarked Special parking area, northwest of Bench Boulevard; the Lower Parking Lot, northwest of the Montana Pavilion building; and the Midway Parking area that is used for the carnival rides and exhibits during the fair. The number of parking spaces available for use in each parking area is noted in Figure 1. The total number of parking spaces is approximately 3,750. It should be noted that the special parking area on the north side of Bench Boulevard can, and frequently does, accommodate more than the 100 spaces shown in Figure 1. However, parking volumes of more than 100 vehicles usually occurs during daylight hours due to steep grades and perilous conditions.

MIDWAY PARKING
593 Total Spaces
LOWER LOT
545 Total Spaces
300 Spaces
245 Spaces
FRONT LOT
141 Total Spaces
51 Spaces
90 Spaces
Special Parking
About 100 Spaces
UPPER LOT – 2367 Total Spaces
355 Spaces
693 Spaces
615 Spaces
702 Spaces
Total Parking Capacity = Approximately 3,750 Vehicles
Figure 1. METRA Parking Lot Available Spaces

## METRA Park Accesses

METRA Park is accessed by Main Street and by Bench Boulevard. Main Street is also designated as US 87 and is a principal NHS route maintained by MDT. Bench Boulevard is a principal arterial roadway in Billings and is an urban route also maintained by MDT. There is one public access on Main Street and four accesses on Bench Boulevard. The Main Street access only allows ingress movements from the public street system. Access to and from the lower lot allows egress movements to and from the Main Street – Bench Boulevard intersection. Access to and from the, Upper Lot is coincident with the intersection of Bench Boulevard and Airport Road, another principal arterial street and an MDT urban route that connects to Main Street west of Bench Boulevard. The remaining METRA Park accesses on Bench Boulevard are relatively minor accesses and traffic movements at those accesses can essentially be considered circulation traffic within the METRA parking lot system. Because Bench Boulevard is an integral roadway to the METRA parking circulation pattern, there are only three access points that provide access to the external street system. METRA Park traffic can enter the property at three locations: Main Street and 4$^{th}$ Avenue North; Bench Boulevard and the Lower Lot access; and Bench Boulevard and Airport Road. However, there are only two of those access points that can accommodate egress movements.

## Egress Capacity

Typically the vehicles that leave METRA Park at the end of an event (egress traffic) would have substantially different characteristics than traffic that enters the property prior to an event (ingress traffic). Ingress traffic demand would be very low one hour prior to an event, increase exponentially as the event time nears, and dwindle substantially after the schedule event begins. Egress traffic begins as soon as the event patrons reach their parked vehicles, whereupon the egress demand is essentially 100% of the parking lot occupancy. Thus, drivers are more in control of their arrival time, while their departure time is totally

dependent upon the capacity of traffic facilities available to handle the egress maneuvers.

There are only 2 intersections that accommodate all of the METRA Park egress demand: Main Street and Bench Boulevard and Bench Boulevard and Airport Road. Since capacity of the intersection of Airport Road and Main Street is directly down-stream from the Bench Boulevard-Airport Road intersection, egress capacity at that intersection directly influences the number of METRA Park egress vehicles that can be served.

Extensive 24 hour traffic volume counts were taken by MDT in 2012 at the intersections of: 4th Avenue, 6th Avenue North and Airport Road with Main Street. From these counts, hourly turning movements were available for any hour of the average day. Peak hour counts were taken at the intersection of Bench Boulevard and Airport Road and 24 hour turning movement volumes were synthesized based upon 24 hour counts at the adjacent intersections. These counts are summarized in Appendix A of this report. These counts were considered to be background traffic and were used in the study analysis to determine METRA Park egress capacity.

Capacity calculations for two different time periods were performed to determine the number of vehicles that could leave METRA Park after typical events. An iterative capacity calculation process was used at three intersections, where egress traffic was added to critical directional movements during the two different time periods. When the capacity of movements on the public streets (Main Street and Bench Boulevard) was just above level of service “E”, the number of egress vehicles added to the background traffic was considered to be the ultimate egress “service volume”.

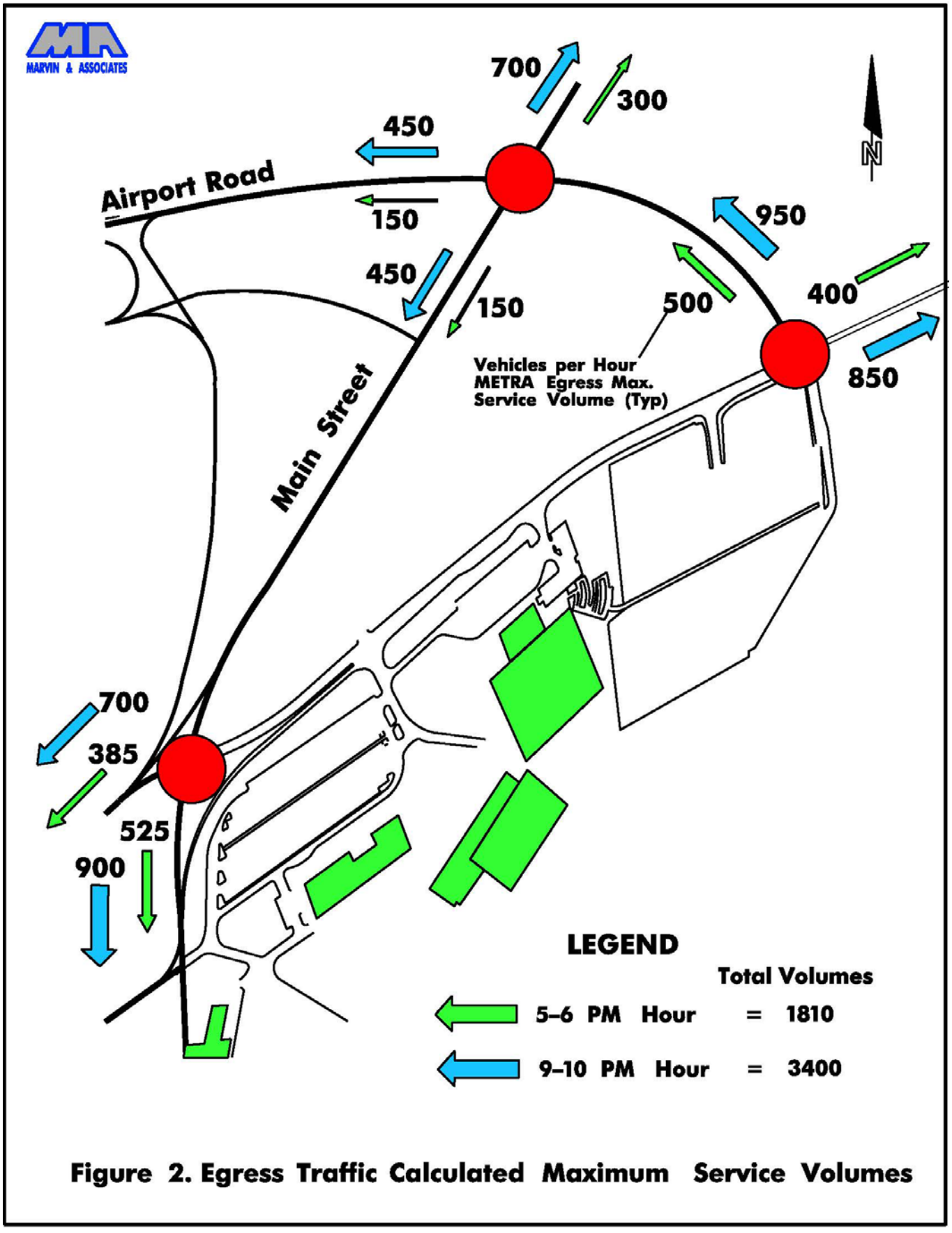



**Figure 2. Egress Traffic Calculated Maximum Service Volumes**

Figure 2 illustrates the ultimate egress service volumes at the control intersections for both the 5:00 pm peak hour and the 9:00 pm evening event hour and shows the maximum service volumes that can be accommodated in different directions on the public roadway system. As an example, at the intersection of Bench Boulevard and Main Street, 385 vehicles can go straight onto 6th Avenue North and 525 vehicles can turn left onto Main Street at the 5:00 pm event time and 700 and 900 vehicles can be served for the same respective movements during the 9:00 pm event. The total egress service volume at 5:00 pm is 1,810 and it is 3,400 vehicles during the 9:00 pm event. When comparing the total egress service volumes to the maximum number of parking lot spaces (3,750), it can be seen that not all of the maximum number of parked vehicles could leave the METRA Park property within a one hour period during the evening event. If the maximum number of parked vehicles were to leave the METRA Park property during the 5:00 pm hour period, it would take more than 2 hours to empty the lots.

**Egress Travel Desires**

The forgoing report section quantified the directional egress service volumes available for events during two different events time periods. However, it is also important to know the directional travel desires of the motorists to determine if improvement concepts would actually enhance the egress experience. The method used to determine the theoretical travel desires was based on street facility service areas. Lines radiating outward from METRA Park on either side of each major street facility were drawn. The lines represent a series of equal travel time points and the resultant areas created by the lines and outer limits of urban development were calculated. Land uses and density within the areas were examined and area adjustments made to account for potential egress destinations. As an example, large areas of industrial developments were excluded and a proportionate area encompassing smaller communities accessed by the road facility were added into defined areas (Laurel, Huntley, Lockwood,

etc.). The resultant areas associated with each street facility were totaled and the percent distribution was determined by dividing each area by the total.

Figure 3, on the following page, illustrates the relative percentage distribution of egress trips from METRA Park. These percentages represent the calculated (theoretical) travel desires. This figure indicates that 28% of the travel desires would be directed toward Billings Heights and outlying areas north of METRA Park. Checks of current population figures indicate that the Billings Heights area contains approximately 27% of the urbanized area population. Thus, the travel desire method used seem to be consistent with population figures, at least for that direction of travel. It should be noted that the relative percentage of egress travel desires at the two intersections which control egress service volumes are 38% for the Bench Boulevard – Airport Road intersection and 62% for the Bench Boulevard – Airport Road intersection. This travel desire split between north and west can be a significant consideration when evaluating overall improvement concepts.

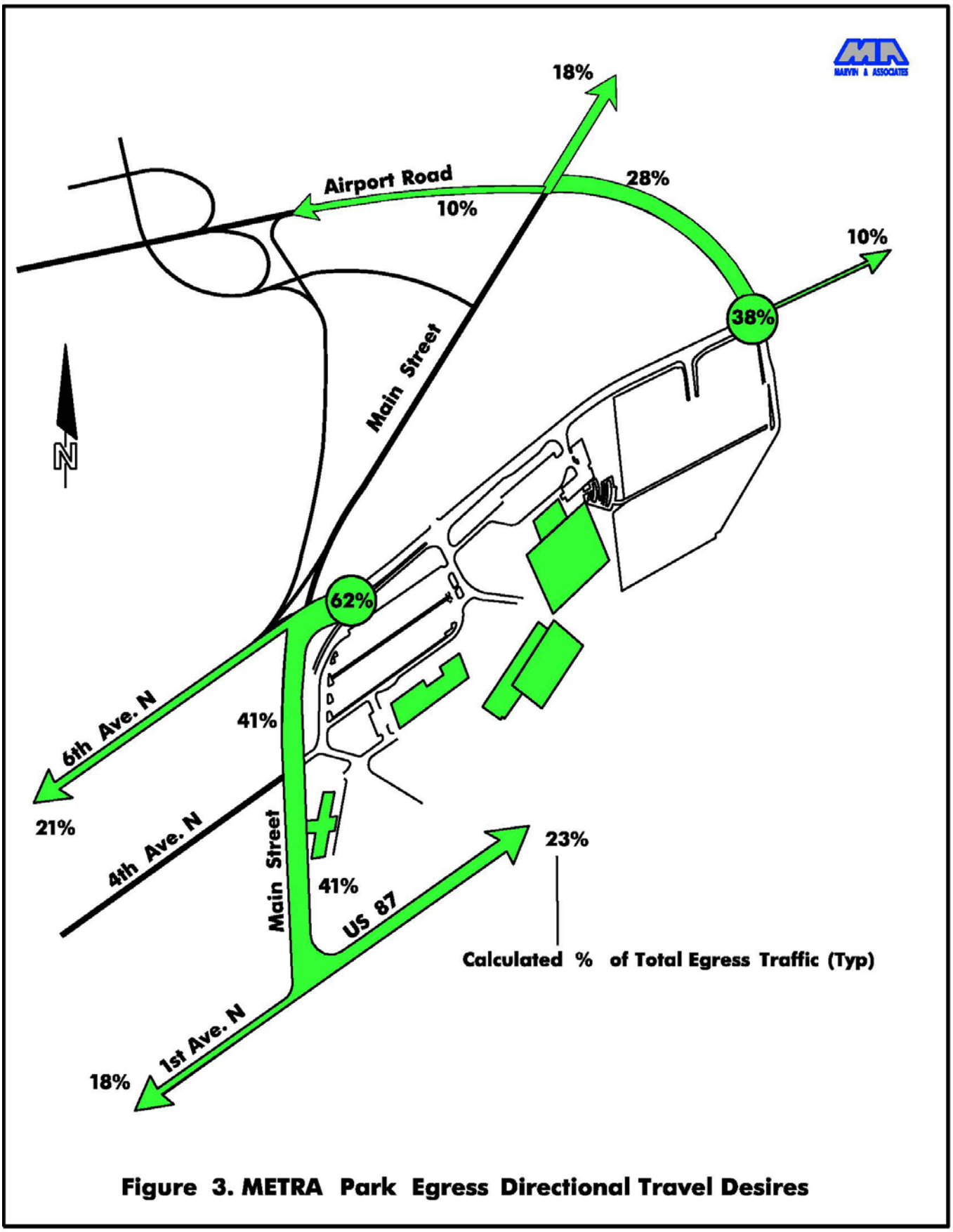



**Figure 3. METRA Park Egress Directional Travel Desires**

## TRAFFIC CHARACTERISTICS- CHASE HAWKS RODEO

This study included documentation of operations at an evening event held at the Rimrock Auto Arena on December 22, 2012. The subject event was the Chase Hawks Rodeo which had a documented attendance of approximately 5,200 persons. The event ended at approximately 9:30 pm and the entire egress process was recorded using a digital camera from a position on the Rimrocks at an elevation approximately 200 feet above the lower parking lot. From that position, the video recording included all of the METRA Park accesses and parking lot activities. The following data and observations provided invaluable information in evaluating existing operations and potential improvements.

### Traffic Volumes

Traffic volumes associated with METRA Park egress operations were derived from the video recordings. While the recording includes close-up views of individual intersections and panning of parking lot operations, the egress demand at each lot was relatively constant and therefore a spreadsheet was developed to estimate total traffic flows based upon the proportionate amount of time that each access or intersection was visible on the video. Additional volumes were added for vehicles remaining in the lots after uniform traffic flows dwindled.

Figure 4, on the following page, presents a summary of traffic volumes associated with the Chase Hawks event. Directional distribution of traffic was calculated based on the traffic counts and can be compared with the travel desires shown in Figure 3. That comparison indicates that the calculated travel desires are very close to the directional distribution documented at the Chase Hawks Rodeo. The largest deviations traffic destined to Billings Heights, which was documented at 31% during this event and was calculated to be 28%, and traffic using Airport Road to the west, was calculated to be 10%, but documented to be 6%.

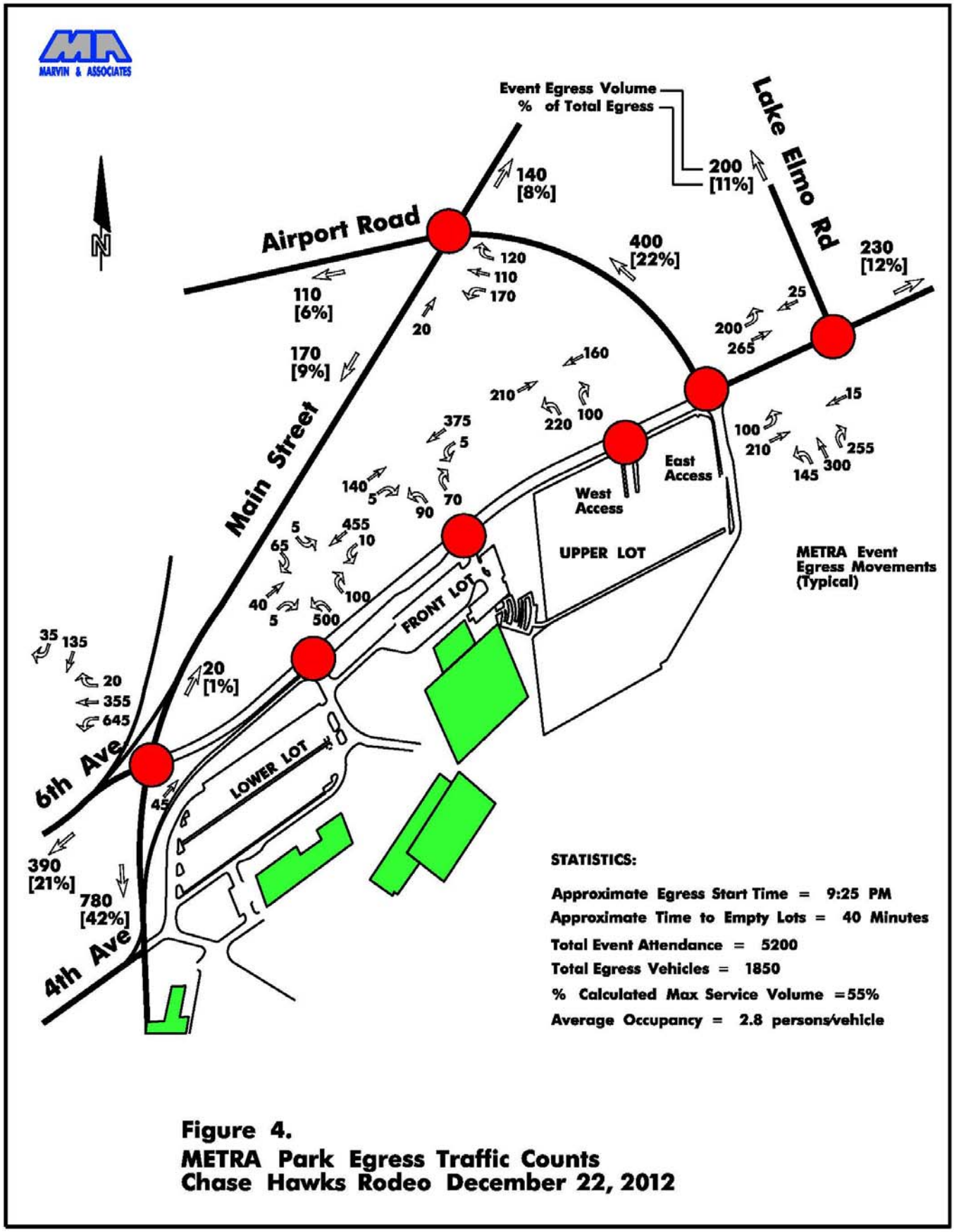



**Figure 4.**
**METRA Park Egress Traffic Counts**
**Chase Hawks Rodeo December 22, 2012**

Some of that discrepancy could also be involved with 11% of the traffic that used Lake Elmo Road to access Main Street. It is not known how much of that traffic actually turned left onto Main and then turned right onto Airport Road, south of Lake Elmo Drive.

**Parking & Occupancy**

The total number of parked vehicles at the event was estimated to be approximately 1,850. Thus, the average vehicle occupancy was estimated to be 2.8 persons/vehicle (5200/1850). This level of occupancy may vary by the type of event and the time of year, but serves as an average rate that can be used for estimation of future traffic demand based on expected attendance figures.

The approximate time to vacate the majority of parking spaces in the lower lot was approximately 40 minutes. The upper lot was vacated within approximately 25 minutes. There were approximately 70 vehicles remaining in each lot when the constant traffic flow sharply dropped-off. This event represented approximately 55% of the maximum service volumes at the two key intersections.

**Signal Operations**

Signal timing at the Bench Boulevard - Main Street intersection appeared to be fairly responsive to traffic demands on Bench Boulevard. The maximum green time for the Bench Boulevard approach was approximately 40 seconds and the entire queue of vehicles cleared the intersection on almost every cycle. Queue lengths on that approach did not back-up more than 400 feet and did not impede operations at the lower lot access. It appeared that gaps in traffic created by limitations at the up-stream accesses did not create a constant demand at the Main Street signal and additional green time would have been available if westbound traffic flow would have been more uniform.

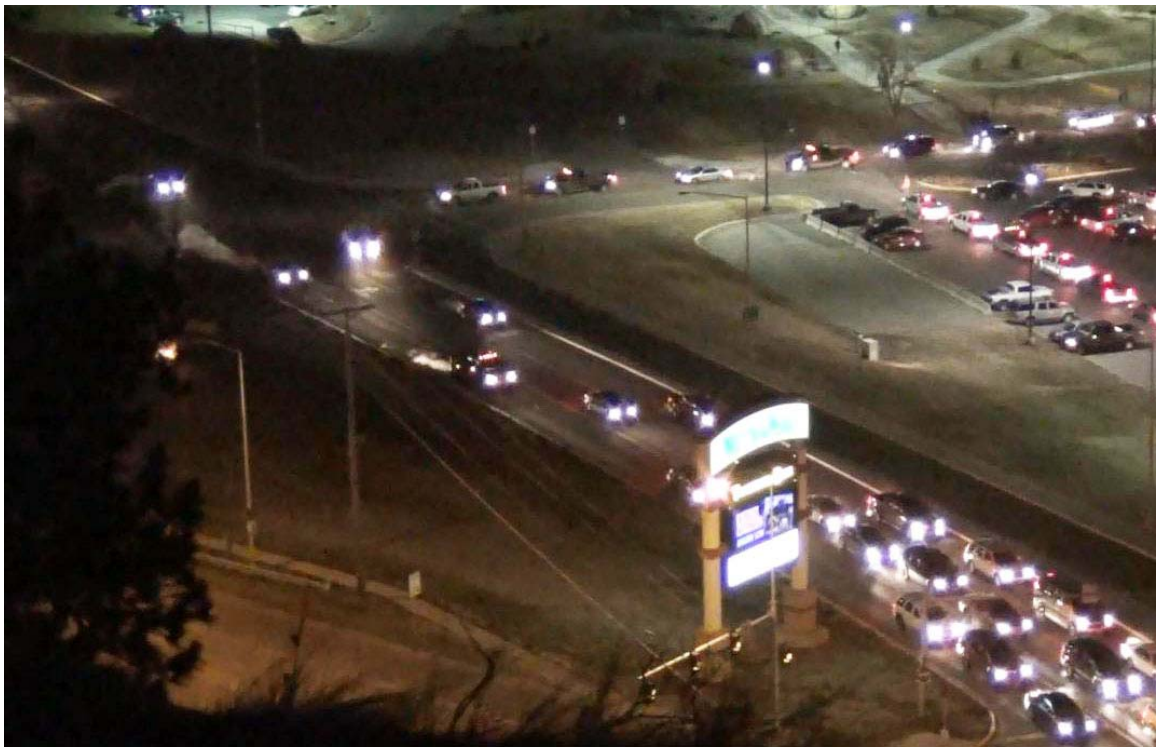
The Bench Boulevard – Airport Road traffic signal appeared to function well in response to traffic demand, but there were a number of circumstances which were an impediment to maximum efficiency. Airport Road traffic backed-up from Main Street into the Bench Boulevard intersection creating momentary grid- lock conditions. The photo below shows the Airport Road Traffic completely blocking traffic on Bench Boulevard even though Bench Boulevard has a green light.

Observations indicate that vehicles will abruptly change lanes when these conditions occur and proceed in a different direction. Because the northbound (northwest) left-turn bay is so short, vehicles will proceed straight through the intersection and then turn left onto Lake Elmo Drive. U-turns from the left-turn lane were also noticed.

**Flagging Operations**

Flagging operations were confined to the lower parking lot at two locations where multiple traffic streams meet. The interior lot layout has a number of curbed islands that divide traffic in such a manner that there are two locations where flag persons are required to split time between three different lines of vehicles. The first flag person is so close to the actual lot access at Bench Boulevard that only 3 to 4 vehicles are in the access queue and prepared to enter Bench Boulevard

when gaps are available. This creates a situation where motorists are either unprepared to judge gaps and delay their departure or they are overly aggressive from the delays and enter Bench Boulevard whether there are adequate gaps or not. It was noted that, the existing number and alignment of approach lanes on Bench Boulevard, at its intersection with the lower lot, combined with a very low volume of traffic approaching from the west, allows vehicles to turn left from the lower lot approach alongside westbound through traffic on Bench (see photo below).



**Safety Considerations**

Three of the four Bench Boulevard parking lot accesses have line of sight issues that caused potential conflicts during the event observation period. There is marginal sight distance from the Front Lot access for motorists turning left (to the east) and relatively unlimited sight distance to the west. At the West Upper Lot access, sight distance is limited to the west and at the Upper Lot access

approach to the Bench Boulevard – Airport road intersection; sight distance is also limited to the west, which creates conflicts for right-turning vehicles. At the West Upper Lot access, the number of conflicts requiring through vehicles on Bench Boulevard to apply their brakes to avoid collisions was counted at it was determined that approximately 22% of all vehicles exiting the lot at that location triggered braking maneuvers (4% in the westbound direction and 18% in the eastbound direction). The photo below illustrates the level of conflicts at that approach.

To determine the existing sight distance limitations a test vehicle was positioned in each of the three Bench Boulevard accesses such that the front wheel was on the front of the crosswalk line with the vehicle straddling the crosswalk and the driver's position just on the back side of the crosswalk. Gap times from first sight of oncoming vehicles until the vehicles reached the center of the access were timed for a significant number of trials. The following average measurements were calculated:

| | Gap Time (sec) Looking to | |
|---|---|---|
| | The East | The West |
| Front Lot | 5.4 | > 7 |
| West Upper Lot | 3.1 | >7 |
| Upper Lot at Airport Rd | > 7 | 4.5 |

ASHTO design guidelines indicate that the required intersection sight distance for a vehicle making a left-turn from the minor street should have a minimum gap of 7.5 seconds. Thus, left-turns from the Front Lot were 2.1 seconds too short and from the West Upper Lot were less than half of the require distance at 3.1 seconds. For right-turns from the minor street, AASHTO recommends a 6.5 second gap. The Upper Lot approach to the Bench Boulevard- Airport Road intersection was 2.0 seconds short of the recommendations. In addition, the AASHTO measurements indicate that the minor street observation point should be from a driver's position where the front of the vehicle is at the stop bar. Thus, the above noted gap times over-estimate the available sight distance and the current approach geometry requires drivers to block the pedestrian crossings just to gain a little more sight distance.

In addition to drivers' sight distance restrictions, it was noted during the observation period that pedestrian conflicts also exist. A number of instances occurred where pedestrians dashed out into Bench Boulevard between either stopped or slow moving vehicles rather than crossing at signalized crossings.

**Access Efficiency**

The Lower Lot had the highest egress demand of all Bench Boulevard accesses during the observed event. A combination of factors including: low eastbound volumes on Bench Boulevard, the signal at Bench and Airport Road metering traffic from the east, and the willingness of more aggressive drivers to merge with eastbound through vehicles on Bench resulted in more efficient operations for left-turn egress vehicles than would have been expected. Even so, egress traffic was very erratic, and depended upon the aggressiveness of drivers, and the driver's ability to process information and react to traffic gaps.

Left-turn movements from the West Upper Lot access were also aided by gaps created by the signal at Airport Road. There were twice as many left-turns as right-turns from that access due to the signals presence.

It was noted that traffic exiting the Front Lot experienced more delay than any of the approaches due to limited sight distance to the east and slightly heavier traffic approaching from the left. Many of the vehicles at that access initially signaled to turn left and then turned right after waiting for a variable period of time.

Overall traffic operation at the Bench Boulevard accesses involved interaction with egress site traffic rather than conflicts with background traffic that would normally be on the street. In fact, background traffic on Bench Boulevard was substantially less than normal, probably because drivers detoured to parallel facilities in order to avoid conflicts with METRA Park egress traffic.

## DESIGN EVENT TRAFFIC

### Maximum Egress Demand

In order to gauge the efficiency of existing METRA Park egress conditions, the Chase Hawks traffic distribution numbers were applied to a maximum situation where every available parking space in METRA Park was occupied. This would represent an evening event where 3,750 spaces were occupied and 10,500 people were in attendance. The METRA Park egress traffic distribution was added to background traffic and turning movement volumes were calculated. Figure 5, on the following page, illustrates the resultant turning movement volumes at the critical intersections and accesses. In addition, the relative percentage of maximum service volumes (see Figure 2) associated with each departure movement under these conditions is noted.

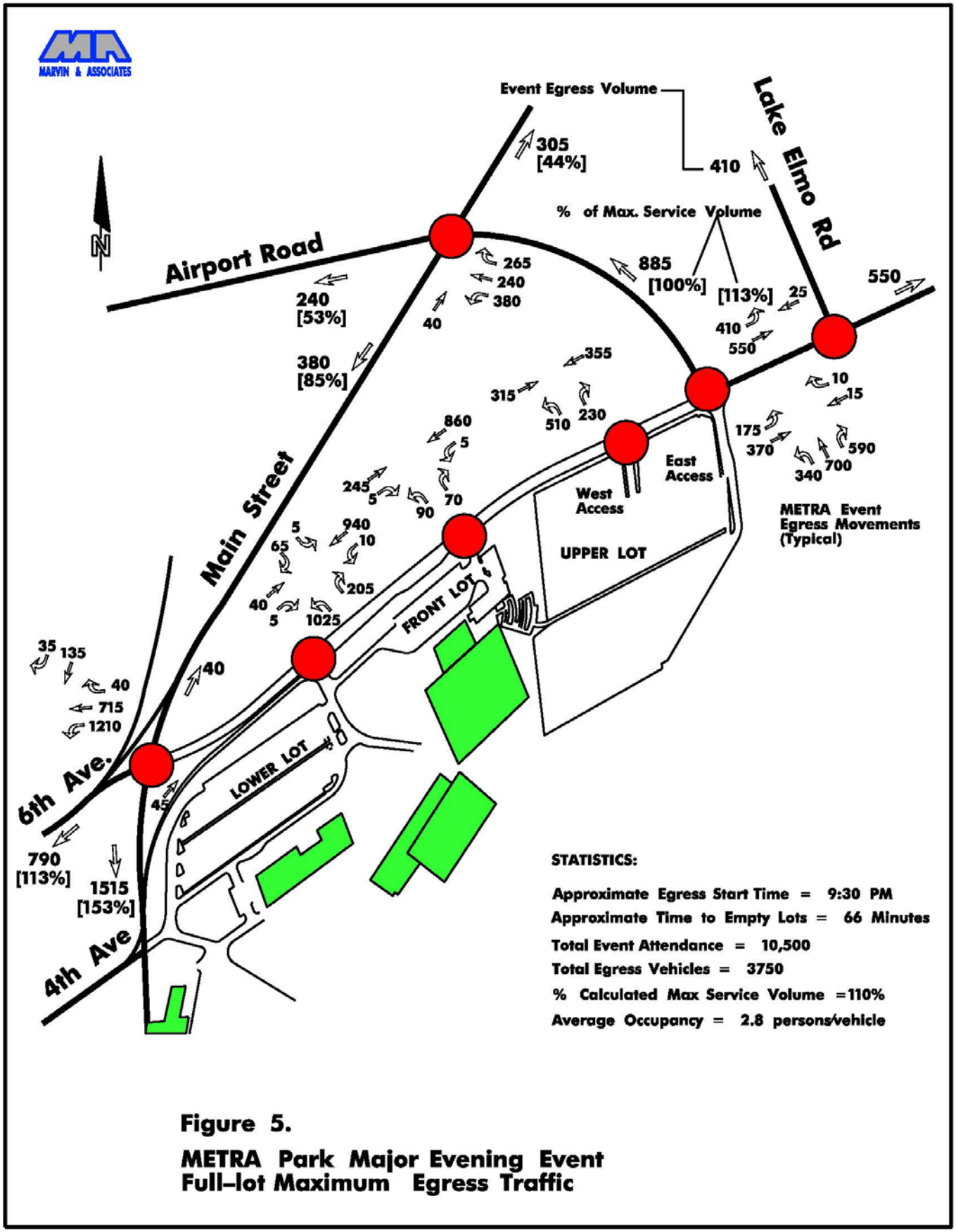



**Figure 5.**

**METRA Park Major Evening Event**
**Full–lot Maximum Egress Traffic**

It can be seen that the Airport Road and Bench Boulevard facilities at the Upper Lot would be close to 100% of the maximum service volumes, while traffic at the Main Street and 6th Avenue facilities would be substantially more than the maximum service volumes. This exercise illustrates that the egress routes to the west and the Lower Lot, in particular, is less able to accommodate major event egress traffic. In addition, diversion of traffic to the east rather than the west would only result in less efficient operations at the Airport Road intersections and the resultant recirculation of traffic south on Main Street would further impede egress movements at the Bench and Main intersection. It should be recognized that the entire system relies on dynamic traffic balancing, since diversion of traffic from one over-saturated flow condition results in over-saturation at another.

**METRA Park Attendance History**

Since there very few events that would create a condition where all of the parking spaces are occupied and all of the vehicles leave at the same time, it is necessary to determine design hour events that would handle the vast majority of events. In an effort to determine what level of traffic demand should be used in design hour events, METRA Park operations provided extremely detailed records of events at METRA Park from 2001 through 2012. These records indicated that METRA Park has had events that ranged from 300 people to 8900 in the evening and from 6 people to 42,000 for daytime or all day events. Frequently having multiple events on the same day, most years have seen the same number of events as there are days in the year. After examining the attendance figures, it was determined that the average annual attendance at events in METRA Park was approximately 753,000 during the 12 year period. Attendance in the year 2008 was almost exactly the same as the 12 year average at 752,000. It also appeared to be the most recent year with highest evening event attendance. Still recovering from the hurricane, attendance in 2012 was approximately 640,000 and it appears that evening event attendance is on an upswing. Thus it was decided to use data from the year 2008 to determine design hour traffic demand.

Table 1, below, presents a statistical summary of year 2008 METRA Park attendance for both single evening events and all-day or daytime events. Because of the upswing in evening event attendance and the fact that there were evening events in the past that attendance ranged as high as 8,900 people, it was decided that the maximum event in 2008 of 7,500 would be a desirable design attendance figure for evening events.

**TABLE 1. METRA PARK 2008 EVENTS**

**SINGLE EVENING EVENTS**

| Event Type | Average Attendance | Attendance Range | Number of Events |
|---|---|---|---|
| Concerts | 5818 | 2481 - 7524 | 5 |
| Graduation Ceremonies | 4344 | 3500 - 4800 | 4 |
| Rodeos | 3703 | 500 - 6720 | 16 |
| Special Shows | 3000 | 297 - 6163 | 12 |
| Special Sporting Events | 3051 | 1088 - 5208 | 16 |
| Sports Tournaments | 3500 | 300 - 4000 | 6 |
| **Averages =** | **3585** | **297 - 7524** | **59 Total Events** |

**ALL-DAY or DAYTIME EVENTS**

| Event Type | Average Attendance | Attendance Range | Number of Events |
|---|---|---|---|
| Fair | 39000 | 36000 - 42000 | 7 |
| Conventions | 6840 | 1966 - 10046 | 7 |
| Exhibitions | 4056 | 550 - 15000 | 30 |
| Special Events | 5989 | 1000 - 7400 | 9 |
| Sporting Events | 2937 | 1068 - 7137 | 15 |
| Miscellaneous Recurring Events | 148 | 6 - 1500 | 131 |
| **Averages =** | **2813** | **6 - 42000** | **199 Total Events** |

**DESIGN EVENTS:**

| | | |
|---|---|---|
| **Single Evening maximum Attendance =** | **7500** | |
| **Approximate Number of Veh @ 2.8 per/veh =** | **2700** | |
| **Peak Afternoon Hour maximum attendance =** | **4050** | (39000/12 hrs phf=1.2) |
| **Approximate Number of Veh @ 2.8 per/veh =** | **1450** | |

Since it is very difficult to determine an ideal design hour attendance figure because of the vast number of combinations that could occur, it was decided to use the annual fair's average daily attendance of 39,000 as a potential design

figure. Since this attendance mark is spread out over a 12 hour day, the average hourly volume would be approximately 3250. If it could be assumed that the peak hour of activity would be 120% of the average, the peak hour attendance would then be 4,050 people. The final assumption would be that all 4,050 people would want to leave at the same time. While some of these assumption may not be valid for the fair, it allow for other events such as conventions that may have the majority of attendees exit METRA Park at or near the peak pm hour between 5:00 and 6:00.

The METRA Park attendance records and above noted assumptions have resulted in two design hour periods that are used to investigate potential egress improvements within this study. The peak 5:00 pm design hour egress volume would be 1,450 vehicles and the evening design hour would be 2,700 vehicles, as indicated in Table 1.

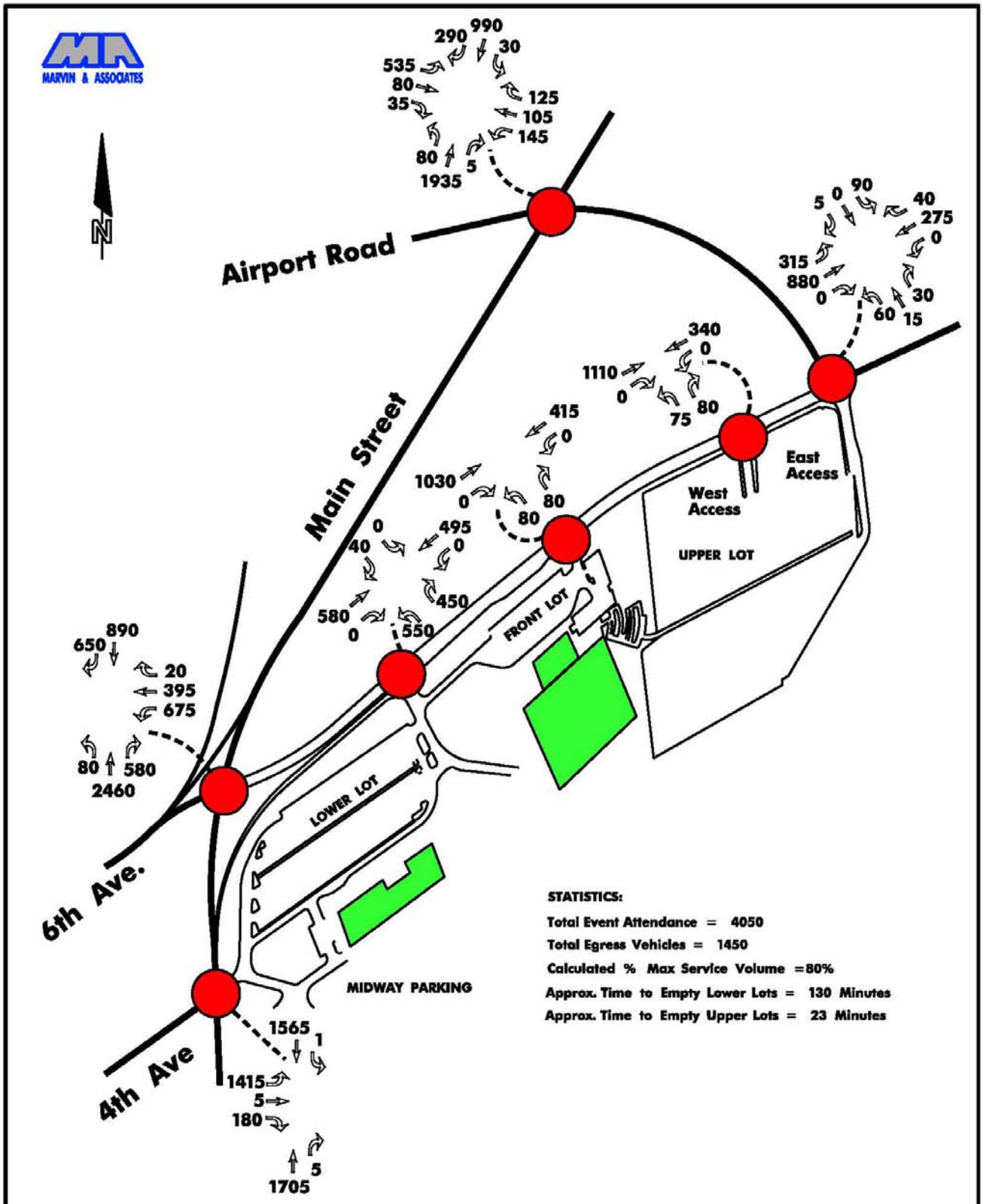



**Figure 6. METRA Design Event Peak 5:00 PM Hour Plus Background Traffic**

## METRA Park Daytime Event Design Hour Traffic

Figure 6 illustrates the assignment of METRA Park event traffic associated with the design hour daytime event plus existing background traffic on the surrounding street system between the hours of 5:00 pm and 6:00 pm. The assignment of traffic from the METRA parking lots assumes that the Lower Lot and the Midway Lots would be full prior to vehicles parking in the Upper Lots. Total egress traffic of 1,450 vehicles represents approximately 80% of the maximum service volume available at the key intersections. Capacity calculations at the key intersections and accesses were completed and summaries can be found in Appendix B. From those calculations it was determined that the approximate time to empty the Lower Lots would be approximately 2 hrs and 10 minutes, while the upper lot would empty in approximately 23 minutes.

## METRA Park Single Evening Event Design Hour Traffic

A similar distribution of egress traffic and volume assignments at key intersections was completed for the evening design event hour. The existing 9:00 pm to 10:00 pm background traffic was combined with the egress traffic assignment and Figure 7 illustrates the resultant traffic at critical intersections and accesses. Similar to the daytime design event, the Lower Lots would be full, but the majority of the Upper Lot would also be full. Total egress traffic of 2,700 vehicles also represents approximately 80% of the maximum service volume available at the key intersections. Capacity calculations at the key intersections and accesses were completed (Appendix B), and from those calculations it was determined that the approximate time to empty the Lower Lots would be approximately 1 hrs and 18 minutes, while the upper lot would empty in approximately 57 minutes.

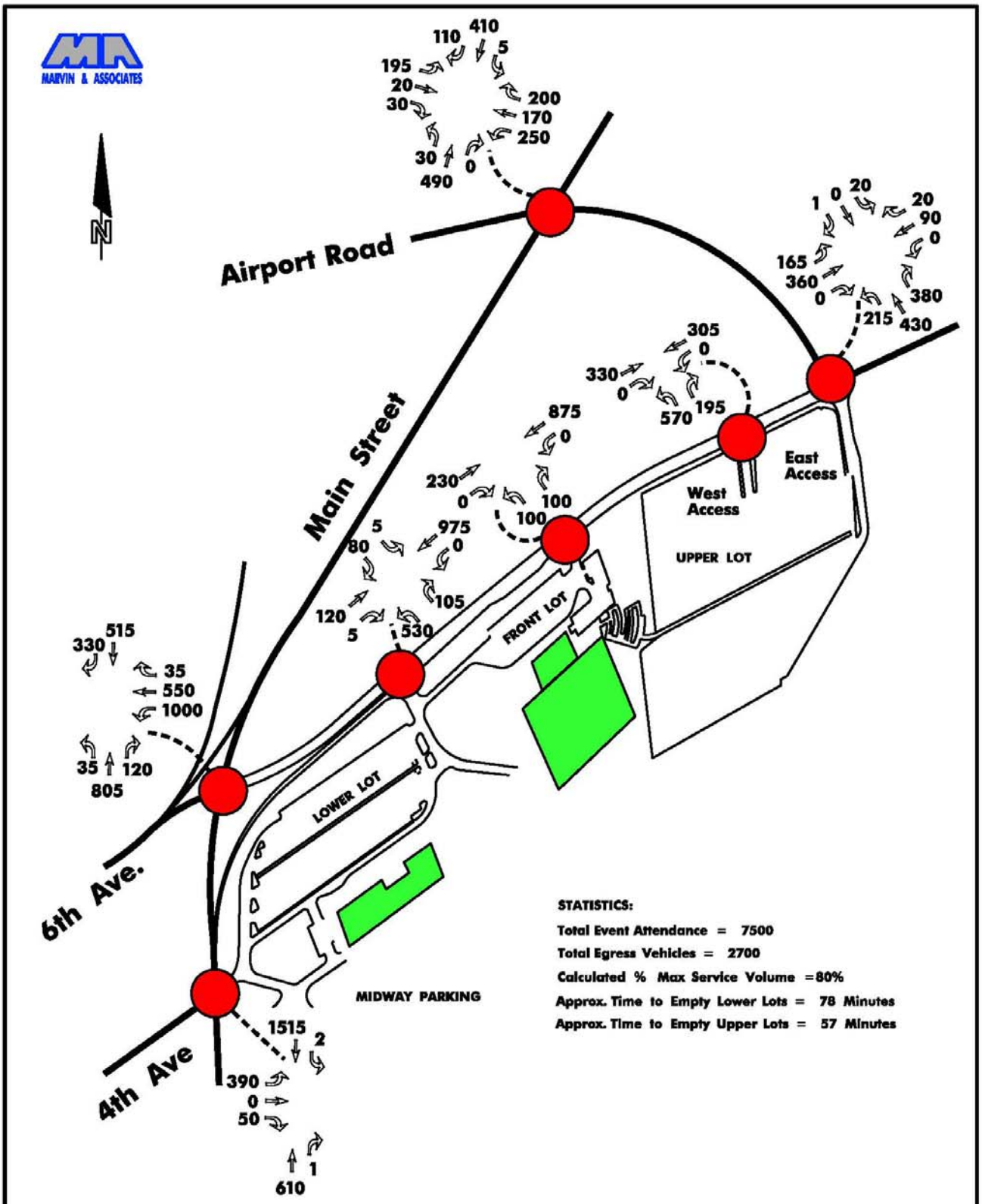



**Figure 7. METRA Design Single Event 9:30 PM Hour Plus Background Traffic**

## ALTERNATIVE IMPROVEMENT CONCEPTS

The following report sections discuss the analysis and evaluation of ideas set forth by the study committee and other concepts developed during the course of this study. Some of the concepts were not explored in great detail, when it was determined that no overall benefits could be achieved based on the operational condition of the street system or would be impractical due to physical restrictions and other practical limitations. Concepts with potential for significant benefits were analyzed in sufficient detail to be advanced for further consideration by the study committee.

### Signing Improvements

One of the principal findings of this study was the fact that the Lower Lot has the longest egress times and it is over-utilized in comparison to the Upper Lot. If a portion of the Lower Lot traffic could be directed to the Upper Lot prior to events, more balanced egress traffic flows could result. Since signs are typically invisible to most motorists, especially over a period of time, it was felt that changeable message or blank-out signing would be required to have any impact. Electronic signing would also need to be placed in very conspicuous locations. Advanced overhead signing locations would be available for use on the 4$^{th}$ Avenue North approach, the Airport Road approach, and on the northbound Main Street approach, south of 4$^{th}$ Avenue North. Use of the signs would be confined to very specific events for which the attendance figures could be reliably predicted and a cut-off point for parking in the Lower Lot could be determined. Just prior to the cut-off point being reached the dynamic signs would be activated. The signs would indicate that the Lower Lot is full and that the Upper Lot should be used.

This concept would require a very formal operational structure to determine the need for signing for each event, an estimate of the cut-off point for parking in the lower lots, and authorization for energizing the signing. Jurisdictional control of

this system would need to be established to install and maintain these signs. There would also be challenges in the design and operation of these signs at three remote locations. The entire system of signing could range in cost from $50,000 to $100,000 and there would be ongoing energy and maintenance costs. Actual benefits related to this concept cannot be quantified.

**Right-turn Only Egress Lower Lot**

The concept of only allowing right-turns from the Lower Lot access was explored and it was determined that it would not be feasible for the following reasons:

- Design hour traffic volumes shown in Figures 6 and 7 indicate that an additional 500 vehicles would be directed to the northeast instead of turning left onto Bench. That would result in approximately 1,250 egress vehicles entering the intersection of Bench and Airport Road during the peak pm hour where only 900 vehicles can be serviced. It would also result in 1,950 vehicles entering that intersection during the evening deign hour when it can only serve 1,600 vehicles.
- Traffic egress from the Front Lot and the West Upper Lot would be severely impacted by an addition 500 vehicles on Bench Boulevard and sight distance restrictions at those intersections could result in crashes.

Because of the safety and efficiency issues associated with this concept, it would not be a feasible alternative for improving egress traffic operations.

**Directional Control – Flagging Coordination**

Coordination of flagging operations could be used to improve the overall efficiency of METRA Park egress operations. Existing flagging operations in the lower lot consists of flagmen at two locations and both flag persons alternate

right-of-way between three separate traffic streams. Each time the flag person stops one direction of traffic and motions another direction to proceed, approximately 12 seconds of time is essentially dead-time. If modifications to the feeder aisles were made to allow only two directions of travel, 50% of the directional change dead-time could be eliminated. Proposed modifications to the feeder aisles are discussed further within this section of the report.

Coordination between the two flag persons in the lower lot could also be improved by having the upstream flag person control or meter traffic so that is arrives downstream without having to be stopped by the second flag person. Additional coordination could be achieved by setting up a communication link with an additional personnel stationed at the Upper Lot. At some point in time when traffic demand has tapered off at the intersection of Bench Boulevard and Airport Road, flagging operations at the lower lot could direct traffic to the northeast thus taking advantage of unused capacity at that intersection. This would require a great deal of communications to ensure that the decision to divert traffic does not disrupt the balance of traffic flows. In addition, forcing traffic out of direction after all previous traffic was allowed to turn left may not possible without having flag persons encroach on Bench Boulevard operations since a number of drivers will attempt the left-turn after they pass the flagging station. Police presence would almost be necessary to enforce the traffic diversion.

### 4th Avenue N Entry Ramp Closure

It was felt by some committee members that many people enter the Lower Lot at 4th Avenue North during the egress period and use the outer ramp which contributes to congestion at Lower Lot access to Bench. During the Chase Hawks Rodeo event this movement was not observed. It appeared that all traffic that approached the flagging station on that ramp was actually parked in the adjacent spaces. Therefore, closure of the ramp would probably not benefit the

overall egress operations. Since the subject ramp is actually a remnant of the parking lot circulation system prior to the construction of Bench boulevard, future improvement project should consider reconfiguration of the parking lot to maximize parking and minimize conflicts.

### Upper Lot Directional Division

It was suggested that the Upper Lot should be divided and that one section of the lot should be forced to exit in one direction and the other section forced to exit in the other. Logically, the West Upper Lot Approach would be required to accommodate left-turns to the west and the Airport Road – Bench intersection would handle through and right-turn movements to the north and east or else the traffic streams would cross paths. If this scheme were implemented, the demand for left-turns from the West Upper Lot access would be 135 vehicles in the peak pm design hour and 985 in the evening design hour. However the capacities of the left-turn movements during those events time periods are only 100 vph and 400 vph respectively. If these movements were forced by physical barriers, the overall time to empty the Upper Lot would actually increase. Thus, this concept does not appear to be feasible.

### Additional Bench Access

It was suggested that an additional access from Bench Boulevard to the Lower Lot could be used as an entrance at the beginning of an event and then switch to an exit at the end of the event. The addition of another access to accommodate entering vehicles would be feasible and would relieve some pressure from the 4$^{th}$ Avenue North entry. However, from observations and experience it appears that the existing Lower Lot access is about as close to the Main and Bench intersection as can be tolerated without having overlapping areas of operational influence. In addition, the grade differential between Bench Boulevard and the Lower Lot is substantial and an exit onto to Bench Boulevard from the Lower Lot

would require fairly shallow grades and a landing area that would extend for a substantial distance into the peaking lot. Right-in only entrance geometry would not infringe upon the parking lot to the same degree. Thus, it appears that only the entrance portion of this concept may be feasible and is discussed further in the forgoing concept narratives.

**Signal Timing Improvements**

After observing peak pm traffic and evening event operations, it appeared that the existing signal system is fairly responsive to event egress demands and appears to provide an optimum balance between moving traffic on the public streets and serving egress vehicle queues. Some questionable operations were observed at the Airport Road – Bench Boulevard signal during the peak pm hour between 4:45 and 5:15 pm where the controller was not skipping left-turn phases when there were no calls. This situation rectified itself and was not observed again. In discussions with local MDT personnel they indicated that they would check the signal controller and video detection equipment to see if there is a problem or whether it was merely an anomaly.

During the Chase Hawks Rodeo event there was a brief period of time when traffic from Airport Road and Main Street backed-up into the Airport Road intersection with Bench Boulevard. Capacity calculations indicate that the signal at Main should have a higher service volume than the service volume entering Airport Road from the Bench Boulevard intersection. Operations at the Airport Road and Main Street intersection were observed again during the egress event at the Rascal Flats concert and it appeared that the signal was providing up to 60 seconds of green time for METRA Park egress traffic and there were very few cycles that did not clear the approach queues. The incidence at the Chase Hawks Rodeo could have been the result of an accident or an emergency preemption. In any case, it doesn't appear that signal changes would increase the efficiency of METRA Park egress to any significant degree.

**Reversible Lanes**

The concept of reversible lanes on the section of Airport Road between Main Street and Bench Boulevard was actually developed when the existing signal bridge at Airport and Main was designed and constructed in the 1990s. Reversible center lanes are commonly employed in large metropolitan areas on commuter routes that limited room to widen roadway facilities. In this case, the Airport Road approach to Main Street was wedged between commercial buildings and only one entrance and two departure lanes could be squeezed between the buildings. Recently the building on the north side of the approach was demolished and a new building was constructed. Sadly, the new building is just as close to the road as the previous building. Therefore, there is still no room to add another traffic lane. The minimum number of lanes needed to provide a facility with three lanes in-bound at the beginning of an event and three lane outbound at the end is four.

**Convert 4th Avenue North Entrance into an Exit**

When this concept was first proposed it seemed to be an unworkable since a previous study briefly investigated the possibility of moving Bench Boulevard to the 4th Avenue North location and found it to be counterproductive. However, when this concept was viewed as a conversion from an entrance to an exit rather than adding a movement to the intersection, it not only appeared to be feasible it could potentially enhance operations on the surrounding street system.

The original suggestions was also accompanied by an idea that the entrance and exit could be designed to reverse directions providing both ingress and egress to events, which at first glance also appeared to be feasible. Dynamic signs installed on the advance lane control signs on 4th Avenue North could be used to inform drivers that the 4th Avenue North entrance was closed and additional signing at the entrance would direct traffic to use the Bench Boulevard ramp to

access METRA Park. Further investigation into the reverse flow concept reveled a number of challenges, not least among them, would be jurisdictional control of the signal system and dynamic signing systems. An entire hierarchy of event coordination and technical personnel from MDT would be required to operate the system on a continuing basis. Even then, processing the information and performing the required movement would probably be too much for the typical drivers' abilities. Thus, the reversible entrance/exit concept was abandoned.

Figures 8, 9 and 10, on the following pages illustrate the same basic concept of converting the 4th Avenue entrance into a left-turn only exit for the Lower Lot at METRA Park. These concept drawings illustrate various option of controlling traffic at the 4th Avenue North and Main Street intersection while maintain the Main Street pedestrian crossing. Figures 8 and 9 illustrate the controls necessary for a three phase signal and are labeled Alternative A, Options 1 and 2 respectively. Figure 10 illustrates the ultimate alignment and control features that would allow two phase signal operations with a Main Street pedestrian crossing located between the opposing left-turn movements.

Figure 8, Alternative A Option 1, illustrates minor realignment of the METRA Park approach to avoid overlapping left-turn movements paths. Since the base map aerial photo is an oblique, the actual geometry of the approach would need to be located more precisely during design. The existing Main Street pedestrian crossing would be rotated to the south and new median configurations north and south of the intersection would need to be constructed. This Option would require a new signal pole in the southwest corner, replacement of one signal head for the 4th Avenue North approach signal, new pedestrian signal indications, replacements of lane control signs, and new pavement markings.

**Figure 8. Alternative A – Option 1**

**Figure 9. Alternative A – Option 2**

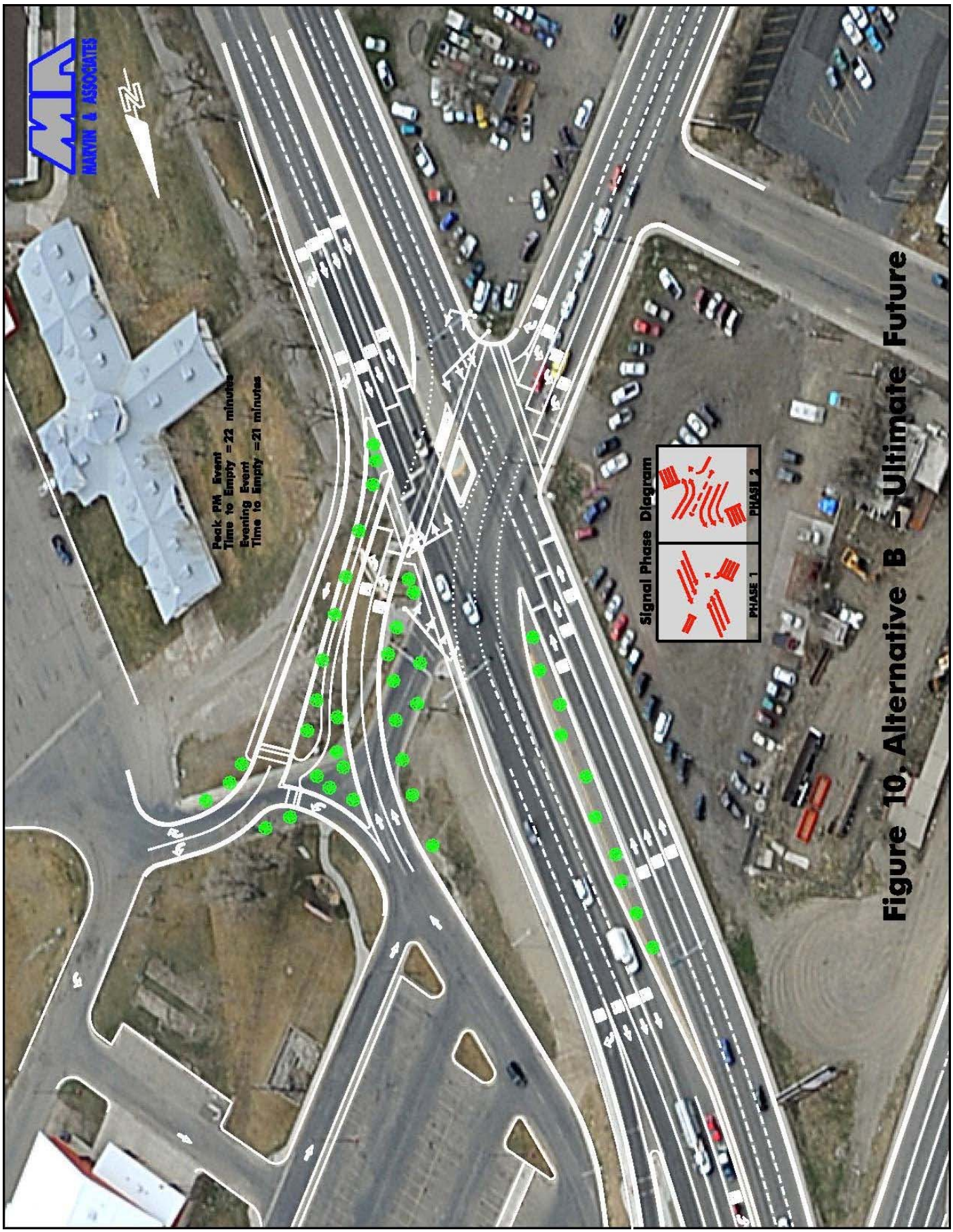



Figure 10, Alternative B – Ultimate Future

The signal would operate with the following phases: Phase 1 would be north and south thru traffic, Phase 2 would be eastbound 4th Avenue North protected left-turn traffic, permissive right-turn movements, and pedestrian crossing, and Phase 3 would be 4th Avenue North and METRA Park exit left-turns, and a permissive 4th Avenue North right-turn. The second phase would be a skip phase that would only be actuated by pedestrian push-buttons.

Figure 9, Alternative A Option 2, would have similar features as Option 1 except that the existing METRA Park access alignment would not need to be changed. Traffic signal operations would be markedly different than Option 1 and would be substantially less efficient. The signal would operate with the following phases: Phase 1 would be north and south thru traffic, Phase 2 would be eastbound 4th Avenue North protected left-turn traffic, permissive right-turn movements, and pedestrian crossing, and Phase 3 would be METRA Park exit left-turns, and a permissive 4th Avenue North right-turn. This phasing scheme is commonly know a split phasing.

Figure 10, Alternative B, represent the ultimate or possible future improvements required to allow a 4th Avenue North METRA Park egress access. This alternative would require major realignment of the METRA Park approach so that it would enter the intersection further to the south. This would allow the Main Street pedestrian crossing to be located between the opposing left-turn lanes for METRA Park and 4th Avenue North. Included in this alternative would be a ramp for northbound traffic which would be used as an alternate entrance to the Midway and Lower Lot parking areas. This would relieve a substantial portion of the entry traffic that would otherwise take the Bench Boulevard Ramp to the Lower Lot entrance. Signals, signing, and pavement marking improvements would be more substantial than what would be involved with Alternative A options.

The signal operations would only require two phases: Phase 1 would be north and south thru-traffic with a permissive 4th Avenue North right-turn, and Phase 2 would be opposing left-turn movements from METRA Park and 4th Avenue North with a concurrent pedestrian crossing of main Street, and the permissive right-turn on 4th Avenue North.

As with all of these alternatives there are some concerns that the Bench Boulevard and Lower Lot access intersection would be able to accommodate the entrance demand. The northbound Main Street ramp to the Midway Parking area shown in Figure 10 would alleviate a lot of the demand and should be considered for Alternative A options as well. However, it is not known if the ingress demand on 4th Avenue North can be accommodated satisfactorily, without performing an ingress count during a large event. If the demand is too great for the lane assignments, it may be necessary to construct an additional lane on the Bench Boulevard ramp and provide another right-in entrance to the Lower Lot, as previously discussed in this report.

The concept of using the 4th Avenue North entrance as an exit has a number of other benefits and possibilities. Motorists forced to use the Bench Boulevard ramp will be able to visually see the extent of parking in the lower lot and then be able to decide if it is worth fighting over a space or continuing on Bench Boulevard to the Upper Lot. If a Main Street – Midway parking ramp is built, METRA Park would be able to place an illuminated sign on their property that indicates that the lower lots are full. That sign could be activated manually or remotely by METRA Park personnel. Because this concept would dramatically change traffic flow during the egress periods, additional traffic assignment analysis was completed for Alternative A Option 1 (representative of all options). Figures 11 and 12 on the following pages illustrate the design hour volumes for pm peak and evening egress hour events.

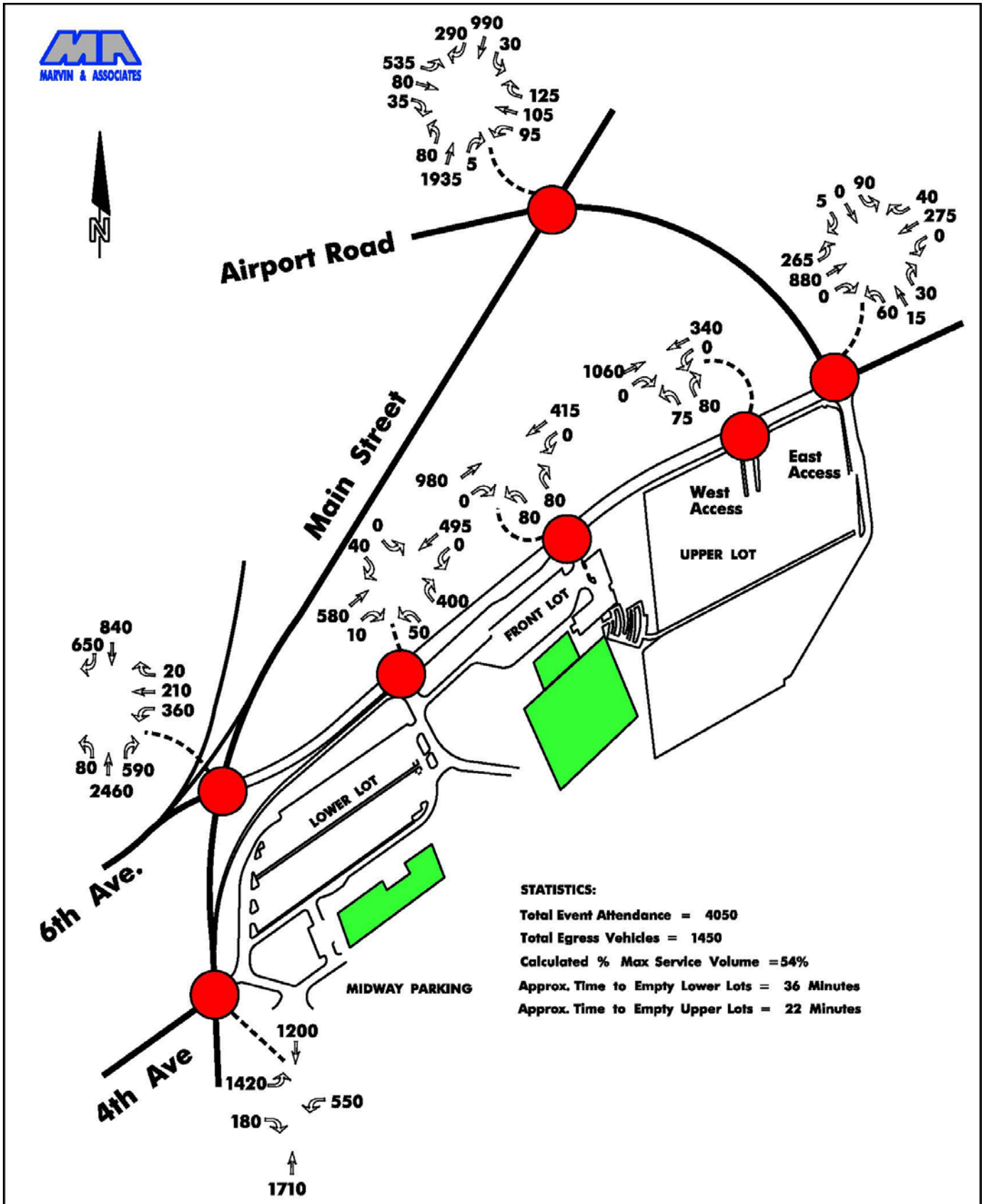



**Figure 11. METRA Design Event 5:00 PM Hour – 4th Ave Exit Alt. A Option 1**

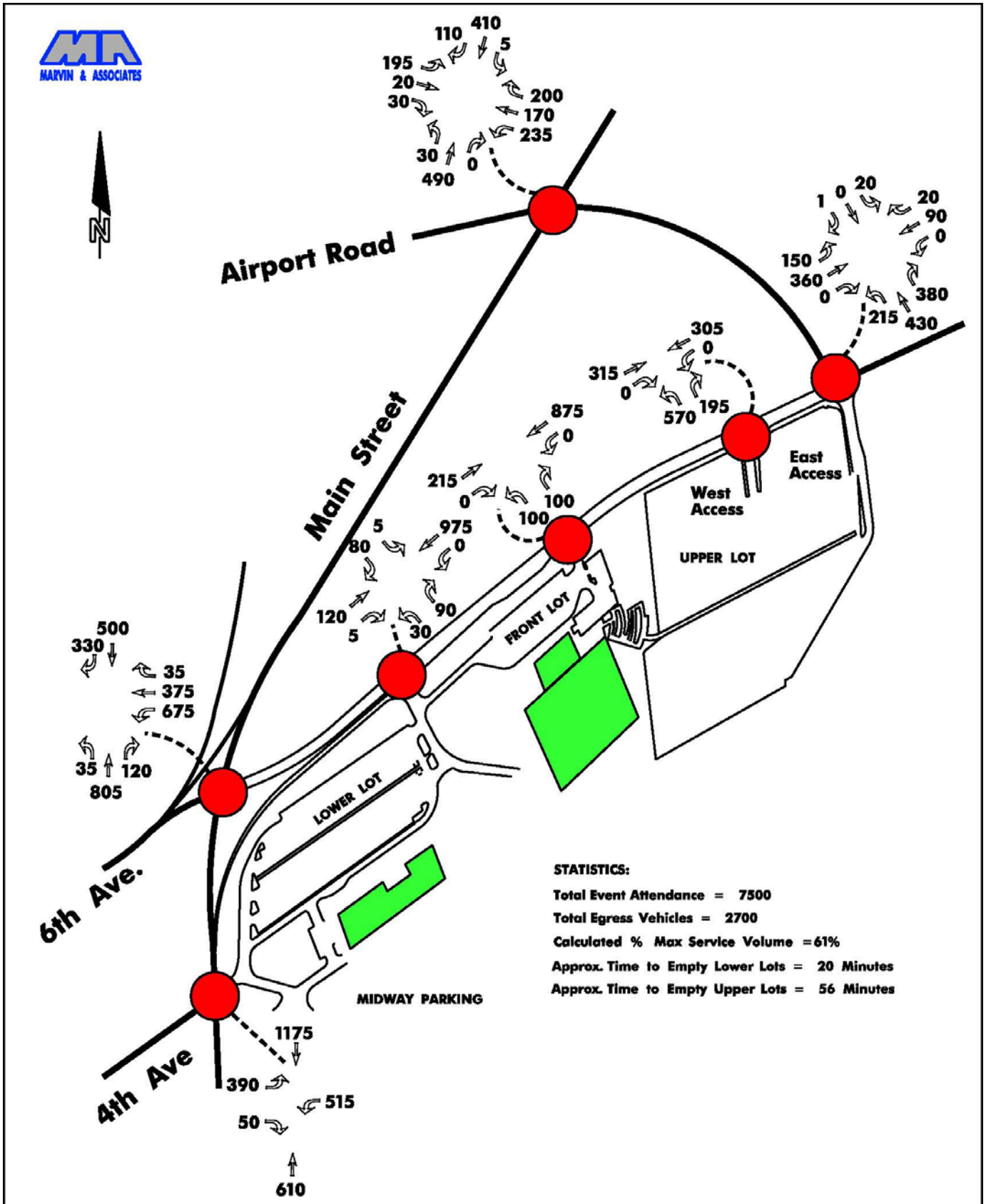



**Figure 12. METRA Design Single Event 9:30 PM Hour – 4th Ave Exit Alt A Option1**

Capacity calculations were completed for the 4th Avenue North exit alternative (see Appendix B) and it was determined that significant improvements would be made at the Main Street and Bench intersection and at the Bench Boulevard accesses. It comparing the overall performance to existing design hour measures shown in Figures 5 and 6, it can be seen that in the peak pm hour period the overall percentage of maximum service volume went from 80% to 54% with this alternative, and the time to empty the lower lot went from 130 minutes to 36 minutes. For the evening hour event the percentage of maximum service volume went from 80% to 61% with this alternative, and the time to empty the lower lot went from 78 minutes to 20 minutes.

**Event Traffic Control Devices at Lower Lot**

A concept was set forth to establish temporary traffic control devices at the intersection of Bench Boulevard and Lower Lot access which would utilize the wide pavement section at that location and allow almost uninterrupted left-turn traffic flow from the METRA Park access. Observations during the evening event in December indicated that many of the more aggressive drivers were already using the intersection in a similar manner without the benefit of traffic control devices. Figure 13, on the following page, illustrates the level of traffic control devices that would be required to initiate this operation.

The Lower Lot access to Bench Boulevard is located directly opposite the unimproved Special Lot located on the north side of Bench Boulevard and the lane marking on the lower lot access allows for a right-turn turn lane and a thru/left movement from the other lane. There should be no reason for a vehicle to cross Bench Boulevard to the lot north of Bench. Therefore, the marking should be changed to left and right turn lanes. With this designation, permanent markings can be installed as indicated in Figure 13. The dashed lines would serve as markers for the installation of special traffic control devices such and barrels and candles.

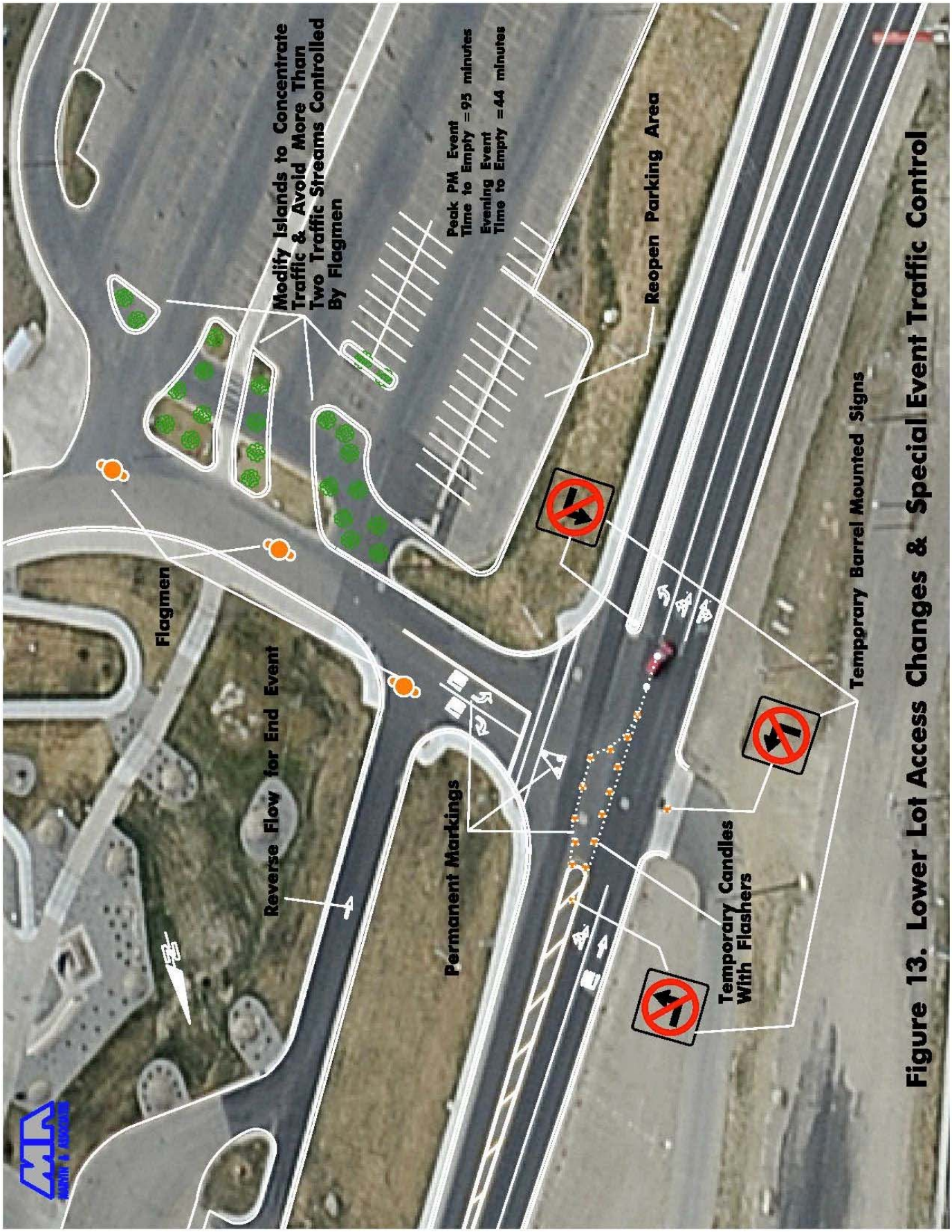



**Figure 13. Lower Lot Access Changes & Special Event Traffic Control**

Turn prohibitions signs would limit conflicts with the Lower Lot left-turn traffic. The left-turn traffic would then only need to yield to thru traffic approaching from the west. This layout indicates that the candle delineation would end at the median nose, but it may be necessary to extend the cones all of the way to the intersection of Main Street to eliminate weaving conflicts. The left-hand lane would then be forced to turn left at Main Street. The middle lane would still be able to handle all of the left turning traffic that originates east of the Lower Lot access.

Other changes that would be necessary to implement this alternative would be modifications to the internal traffic islands so that flagging operations can effectively feed traffic into the Bench Boulevard access. The layout shown in Figure 13 should be considered for any of the improvements that are implemented since the changes would drastically improve the efficiency of egress traffic. Those improvements are necessary for implementation of this alternative. The one-way access road from the Lower Lot to the Front Lot would not be able to accommodate any circulating traffic that needs to turn left in front in egress traffic. Thus, reversal of the one-way street should be considered as a part of this concept. This reversal would also allow vehicle from the Front Lot to access Bench Boulevard more safely than at the Front Lot access.

Capacity calculations were completed for this alternative (Appendix B) and it was determined that this alternative would have a measured increased in maximum service volumes. The time to empty the full lots would be 95 minutes in the peak pm design hour and 44 minutes in the evening design hour. This represents at 27% decrease in the peak pm hour and a 43% decrease during the evening design hour from existing conditions.

**New Traffic Signal at Lower Lot Access**

Another concept was developed during the course of the study which involves a traffic signal installation at the Lower Lot access on Bench Boulevard. A roundabout was initially considered, however it was determined that the constant flow of traffic on some movements, especially as background traffic increase on Bench Boulevard, would periodically block access for other traffic and possibly create congestion at adjacent intersections. A traffic signal installation as illustrated in Figure 14, on the following page, would greatly improve egress movements from the Lower Lot. In order to maximize egress service volumes, it would be desirable to incorporate dual left-turn movements. This would require construction of another egress lane for right-turn movements. As with the previous alternative concept it would be imperative that the internal traffic islands be modified to provide more efficient flagging operations to avoid under-utilized signal operations. Also, it would be extremely desirable to reverse flow on the one-way access to the Front Lot. The signal would also allow protected pedestrian crossing of Bench Boulevard which would vastly improve safety.

Capacity calculations (Appendix B) indicate that there would be substantial increases in service volumes for the Lower Lot access. Those calculations indicate that the signal would operate on the same background cycle length as Main Street and could be tied into the Main Street signal system. Properly timed the progression could ensure that the maximum number of vehicle on Bench Boulevard could be served and the Bench Boulevard signal interval would not be underserved. If this concept should be selected for further consideration, a more sophisticated system software will be used prior to production of the final report to ensure that the signal would function within the system parameters; preliminary calculations indicate that in the peak pm hour period the time to empty the lower lot would go from 130 minutes to 50 minutes. For the evening hour event, the time to empty the lower lot would be reduced from 78 minutes to 28 minutes.

Figure 14. Lower Lot Access Changes & New Traffic Signal Control

## DRAFT REPORT COST ESTIMATES

Definitive cost estimates were not completed for the draft study report, since there may have been be a number of modifications that would be suggested once the committee has had a chance to review the information contained within the draft report. The following alternative costs represented a wide range of costs that may be associated with each alternative and were presented at the public meeting to illustrate the approximate levels of magnitude associated with each of the alternatives.

| | |
|---|---|
| 4th Avenue North Exist Alternative A Option 1 | - $90,000 to $100,000 |
| 4th Avenue North Exist Alternative A Option 2 | - $60,000 to $80,000 |
| 4th Avenue North Exist Alternative A Option 1 | - $200,000 to $250,000 |
| Temporary Traffic Control Lower Lot | - $35,000 to $45,000 |
| Traffic Signal at Lower Lot & Bench Blvd. | - $190,000 to 230,000 |

Costs for the Lower Lot access alternatives also included the internal traffic island modifications. Not included in the temporary traffic control alternative was the long term per event costs associated with setup, retrieval, storage, and replacement costs associated with the cones, barrels, and signs.

## ALTERNATIVE COMPARISONS

Of all the concepts evaluated within this study, it was determined that a number of concepts were either not feasible or did not provided measurable improvements to egress operations. The remaining concepts and alternatives are compared in Table 2, on the following page.

## Table 2. METRA Egress Concepts Screening Matrix

| Criteria | METRA Egress Improvement Concepts | | | | |
|---|---|---|---|---|---|
| | 4th Ave. N. Exit Alt. A Concept 1 | 4th Ave. N. Exit Alt. A Concept 2 | 4th Ave. N. Exit Alt. B | Temporary Traffic Control Lower Lot | Traffic Signal Lower Lot |
| **Operations 5:00 - 6:00 PM** | | | | | |
| % Max. Service Volumes | 54% | 54% | 54% | 80% | 80% |
| Time to Empty Lower Lot | 36 Minutes | 47 Minutes | 22 Minutes | 95 Minutes | 50 Minutes |
| Time to Empty Upper Lot | 22 Minutes | 22 Minutes | 22 Minutes | 23 Minutes | 23 Minutes |
| | | | | | |
| **Operations 9:00 - 10:00 PM** | | | | | |
| % Max. Service Volumes | 61% | 61% | 61% | 80% | 80% |
| Time to Empty Lower Lot | 30 Minutes | 35 Minutes | 21 Minutes | 44 Minutes | 28 Minutes |
| Time to Empty Upper Lot | 56 Minutes | 56 Minutes | 56 Minutes | 57 Minutes | 57 Minutes |
| | | | | | |
| **Costs** | | | | | |
| Construction | $90,000 to $110,000 | | $200,000 to $250,000 | $35,000 to $45,000 | $190,000 to $230,000 |
| METRA Operations/Event | Flagging | Flagging | Flagging | Flagging & TC Setup/Removal | Flagging |
| Maximum Construction Cost/Minute Time Savings | $765 | $625 | $1,497 | $652 | $1,770 |
| | | | | | |
| **Summary for Discussion** | **Second best in terms of time savings. Could invovle more costs depending on unknown design factors. Could require construction of additional ingress ramps.** | **Best in terms of construction costs for each minute of time savings. Could involve construction of ingress ramps.** | **Best overall operations. Construction cost are the highest and could be considered the best alterntive for future considerations.** | **Lowest construction costs and second lowest in terms of costs per minute of time savings. Setup and removal of temporary traffic control devices and replacement cost would be ongoing costs born by METRA.** | **Highest cost per minute of time savings. Operations dependent upon coordination with Main Street signal system. Continued operation into future years not insured.** |

## DRAFT REPORT RECOMMENDATIONS

Based on the overall improvements to egress operations; sustainability in terms of consistency and reliability; and overall operational aspects, it was recommended that the 4th Avenue North conversion from an entrance to an exit would be the most desirable alternative to implement. It was anticipated that the alternative option that is adopted will most likely be dependent upon the level of funding that could be dedicated to the immediate improvements. However, at the public meeting the Yellowstone County Commissioners indicated that the recommended alternative be explored further and subsequently approved a contract supplement to investigate associated impacts that the alternative may have during METRA Park ingress events. Thus the following sections of this report summarize additional study that was directed toward ingress traffic operations related to conversion of the 4th Avenue North entrance to an exit.

## EXISTING INGRESS OPERATIONS

Two events were scheduled at METRA Park in March that had potential for different peaking characteristics. The following sections focus on traffic operations for the two events at the two existing entrances to the Lower and Midway parking lots. Unlike traffic observations that documented egress operations, the ingress study focused on the parking areas west of the arena.

### State A Basketball Tournament, Friday March 8, 2013

The Friday March 8, 2013 event was the State A Basketball tournament, which involved 2 games in the afternoon and 2 games in the evening. The 6:30 pm game was the target event since traffic would begin arriving for that game at the end of the 4:30 to 5:30 pm peak hour traffic period on Main Street. Turning movement count boards were used at each entrance and video recordings were made of the entire ingress event at the intersection of 4th Avenue North and Main Street. Appendix C contains traffic count information and statistics for the entire

count period. Counts were taken in 5 minute increments between 5:30 pm and 6:40 pm. The peak hour volume for both total traffic and ingress traffic was between 5:30 and 6:30 pm. At the beginning of the counts, the Lower Lot was approximately 30% full. During the counting period, approximately 646 vehicles entered the lower lot. Since the lower lot only has a capacity of 545 vehicles, approximately 250 vehicles circulated thru the lot and either accessed the Front Lots or exited onto to Bench to access the upper lots. Appendix C ingress data indicates that ingress demand was relatively constant between 5:30 and 6:25 pm, which would not typically be expected. However, the facts that there were a number of consecutive games, and the signal at 4th Avenue north tends to meter traffic would account for this type of demand distribution.

Figure 15 illustrates traffic movements at both entrances during the 5:30 to 6:30 pm peak hour period. In addition to intersection traffic counts, Figure 15 shows individual lane volumes and the number of vehicles in each lane that separate destinations. This information was considered to be necessary in order to reassign traffic for evaluation of ingress impacts associated with the 4th Avenue North exit conversion alternative. In this case, through movements entering METRA Park from 4th Avenue North were evenly split between the third and fourth lanes. Of the 301 left-turn vehicles using the third lane on 4th Avenue North, 225 turned right onto Bench Boulevard at the 6th Avenue North intersection. Approximately 360 vehicles in the outside northbound lane on Main Street also turned right onto Bench Boulevard, which resulted in 585 vehicles using the northbound right-turn ramp onto Bench Boulevard. Only 36 of those vehicles entered the Lower Parking lot at the Bench Boulevard access.

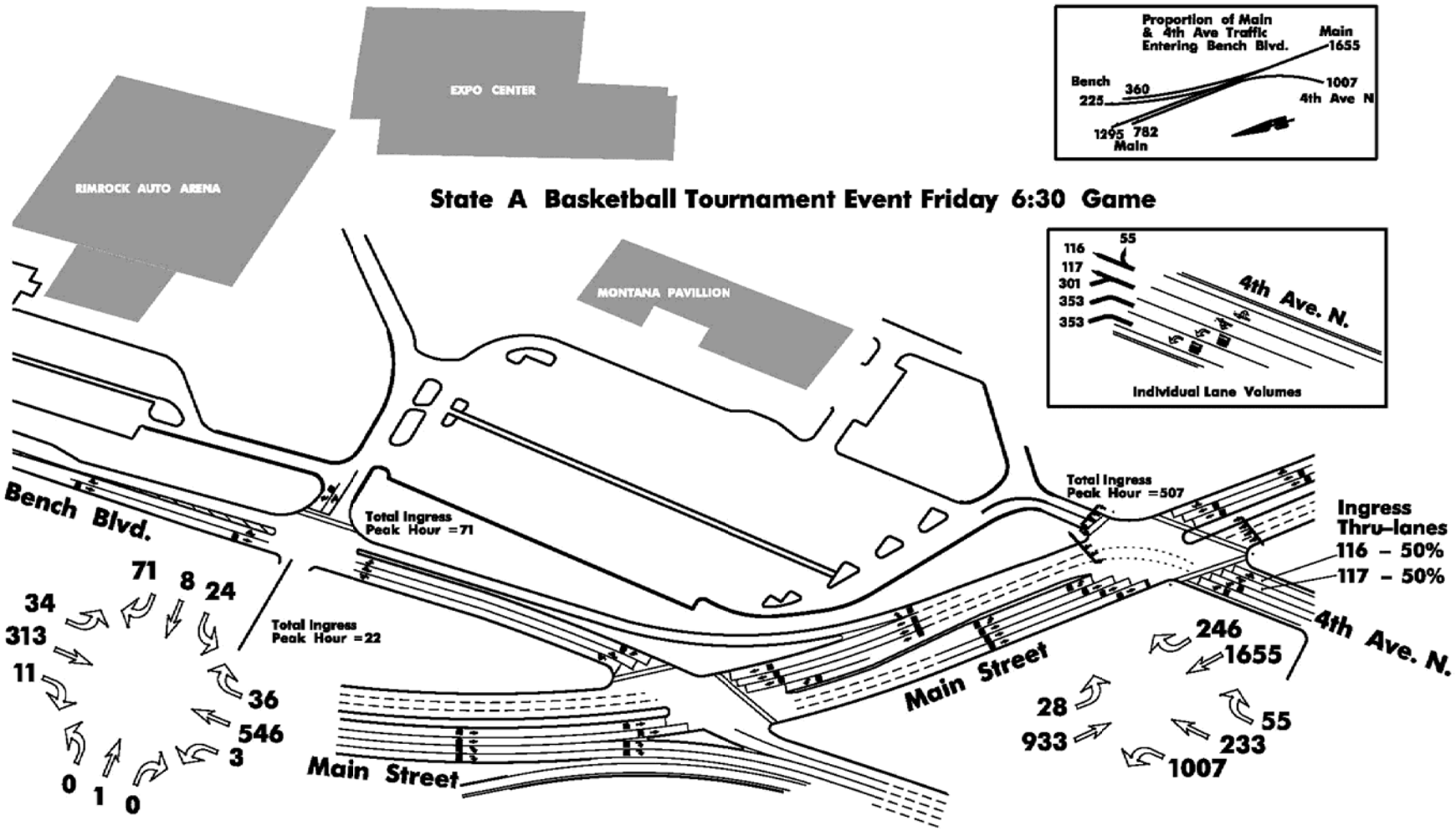



**Figure 15. March 8, 2013 Peak Hour Ingress Traffic Counts 5:30 to 6:30 PM**

**Monster Truck Event, Saturday March 16, 2013**

The Monster Truck event was observed since it would be a typical evening event starting at 7:30 pm and ending near 10:00 pm on a Saturday. Since there was also a 6:00 pm pre-event scheduled as part of the evening event, traffic counts began at 6:00 pm at the Bench Boulevard entrance and at 6:20 pm at the 4th Avenue North entrance. Detailed 5 minute interval counts and statistics can be found in Appendix C of this report. Video recordings of the 4th Avenue North entrance were also made at this event to document lane usage and directional distributions. During the counting period, approximately 967 vehicles entered the lower lot. Again, the lower lot only has a capacity of 545 vehicles and approximately 400 vehicles circulated thru the lot and either accessed the Front Lots or exited onto to Bench to access the upper lots. One building in the Midway had a separate event that attracted approximately 30 vehicles. It is interesting to note that the Lower Lot was full by 6:40 pm, a full 50 minutes before the event began, yet vehicles continued to enter at 4th Avenue North until 15 minutes after the event started. Appendix C ingress data indicates that ingress demand was relatively constant between 6:05 and 7:05 pm and then gradually tapered-off. This rate of arrival was somewhat different than the March 8, 2013 event however; the majority of vehicles did arrive at a steady rate for a one hour period.

Figure 16 illustrates traffic movements at both entrances during the 6:20 to 7:20 pm peak hour period. As with Figure 15, Figure 16 shows individual lane volumes and the number of vehicles in each lane that separate destinations. In this case, through movements entering METRA Park from 4th Avenue North were split 63%/37% between the third and fourth lanes. Of the 307 left-turn vehicles using the third lane on 4th Avenue North, 115 turned right onto Bench Boulevard at the 6th Avenue North intersection. Approximately 215 vehicles in the outside northbound lane on Main Street turned right onto Bench Boulevard resulting in 330 vehicles using the northbound right-turn ramp onto Bench Boulevard.

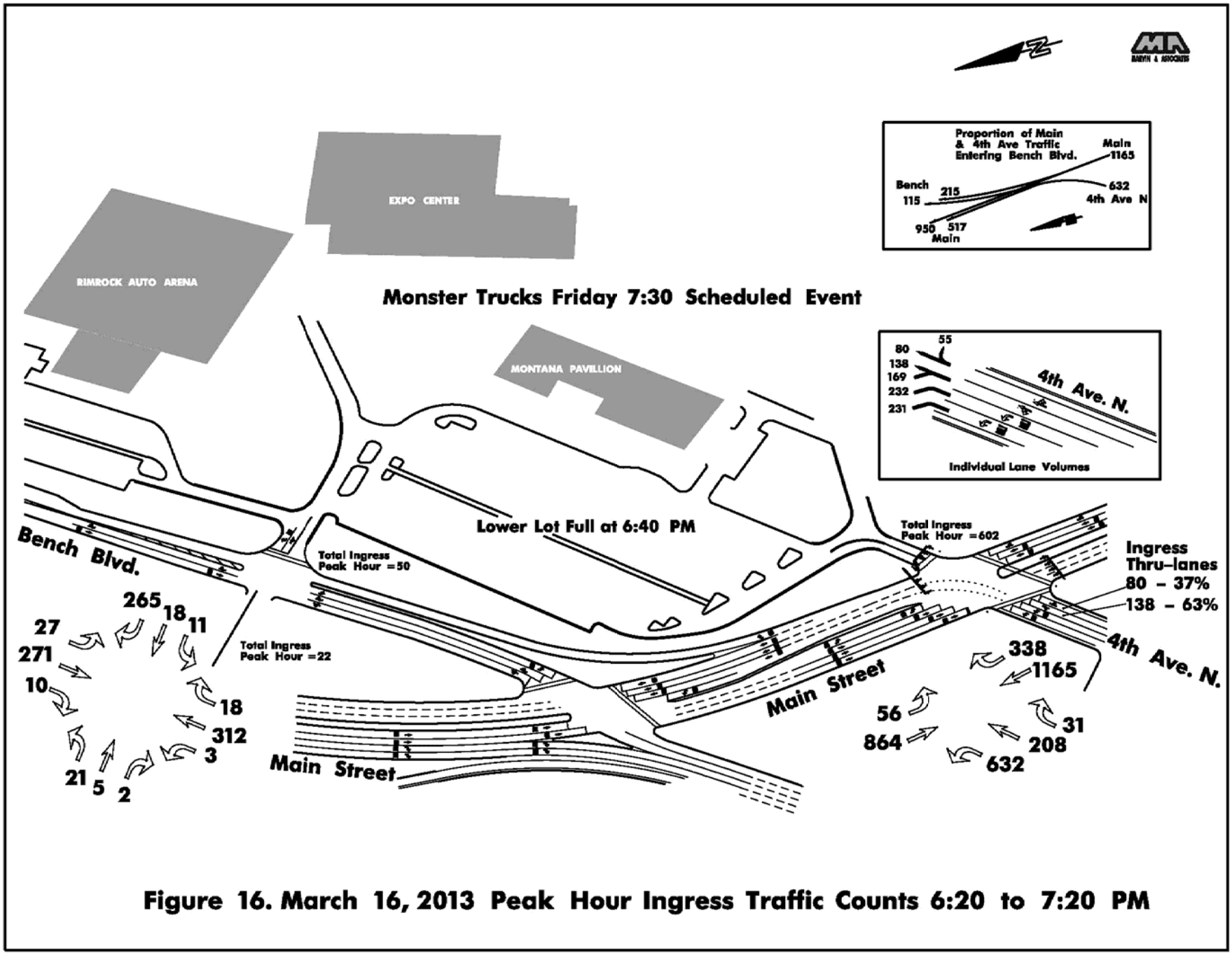



**Figure 16. March 16, 2013 Peak Hour Ingress Traffic Counts 6:20 to 7:20 PM**

## INGRESS DESIGN HOURS

Ingress design hour traffic was calculated in a similar manner as the egress design traffic. The same number of vehicles used for the daytime and evening hour events are used, except the ingress design vehicles would occur between 5:30 and 6:30 pm (1,450 vehicles) for the daytime event and between 6:30 and 7:30 pm (2,700vehicles) for the late evening event. Ingress for daytime events would typically occur in mid-afternoon, so a measure of conservatism would be introduced by having higher volumes of background traffic included in the event's design hour volumes. These higher numbers would replicate the election day events in 2012 and sporting events that draw bigger attendance than the State A Basketball Tournament.

### Design Event Ingress Traffic – Existing Conditions

Definitive impacts related to the 4th Avenue North conversion from an entrance to an exit can only be determined by calculating measures of efficiency based upon existing operational controls. This also requires some assumptions regarding parking usage related to the Lower Lot and the Midway Lot. Therefore, it was assumed that the Lower Lot would be full for both events (550 vehicles) and during the early event there would be less than 50 vehicles in the Midway Lot. During the late evening event it was assumed that approximately 300 vehicles would park in the Midway Lot. It was also assumed that a proportionate number of vehicles would still enter at 4th Avenue North even when the lots were full.

***Traffic Volumes.*** Figure 17 illustrates traffic movements that would occur during the two event design hours. Lane assignments and turning movement distribution calculations were based upon the same proportions observed and measured during the March 2013 events. Both design events have higher traffic volumes than the observed events, while the evening design event is substantially higher than the observed event.

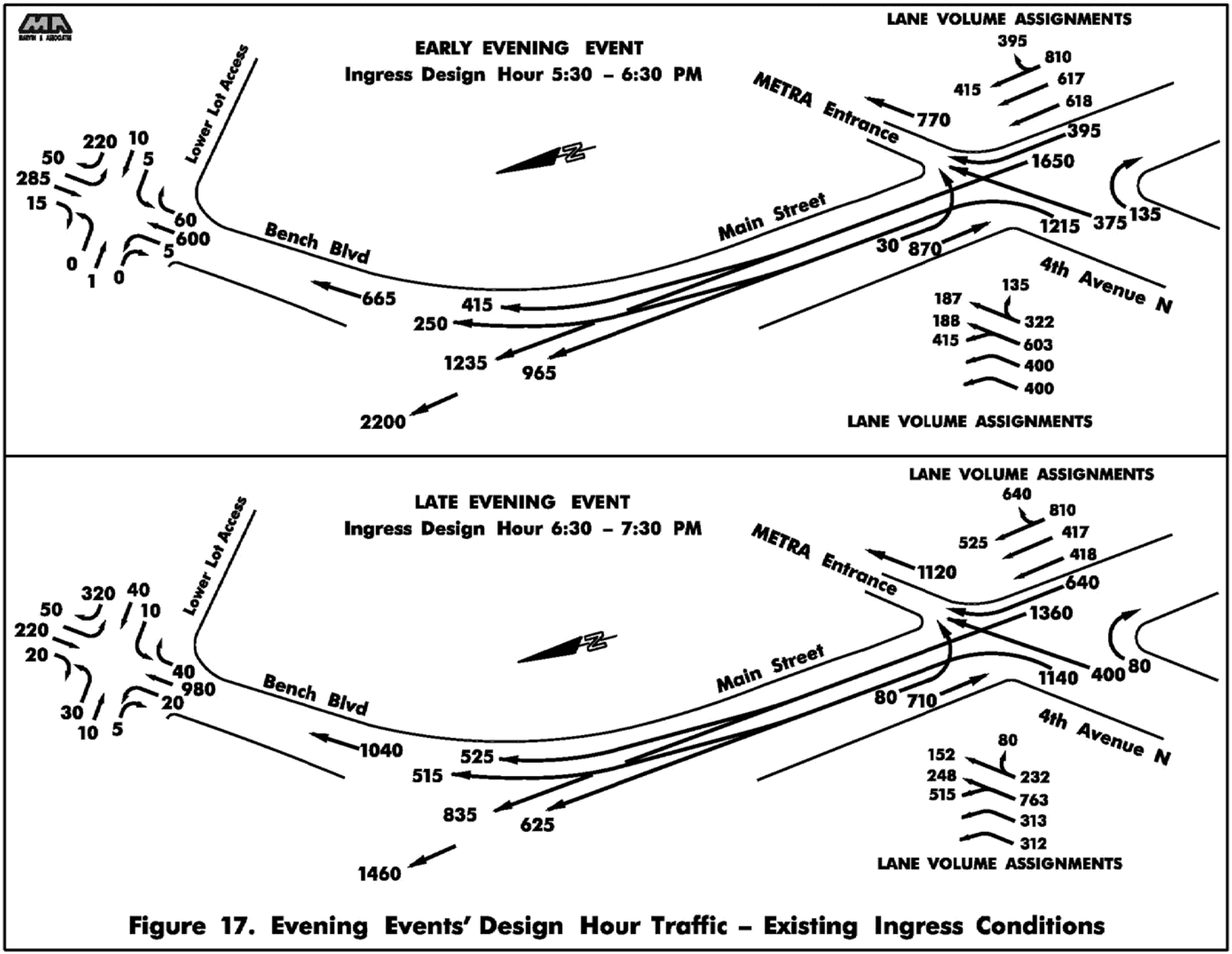



**Figure 17. Evening Events' Design Hour Traffic – Existing Ingress Conditions**

***Capacity.*** Baseline capacity calculations for the design ingress events and existing traffic control conditions were completed and can be found in Appendix D of this report. It was determined that the overall intersection LOS for 4th Avenue North and Main would be "C" for the 5:30 to 6:30 ingress hour with the 4th Avenue North approach operating at LOS "D", During the 6:30 to 7:30 ingress design hou,r the overall intersection LOS would be "D" with the 4th Avenue North approach operating at LOS "C". In both cases, the southbound left-turn movement on Main Street would suffer excessive delay, as was observed during the March 2013 events. At the Lower Lot access, on Bench Boulevard, the intersection would operate at LOS "C" during the 5:30 to 6:30 pm ingress design hour, but both the northbound and southbound approaches would operate at LOS "F" during the 6:30 to 7:30 pm ingress design hour.

**Design Event Ingress Traffic – 4th Avenue North Exit**

***Traffic Volumes.*** Redistribution of traffic shown in Figure 17 was completed under the assumption that the METRA Park entrance would be converted to an exit without provisions for a slip-ramp for northbound traffic on Main Street south of 4th Avenue North. Figure 18 illustrates the traffic redistribution for both event design hours and includes the relative lane loadings at the 4th Avenue North intersection as well as the distribution of traffic onto the Bench Boulevard right-turn ramp from Main Street. It can be seen that the third lane on the 4th Avenue North approach would have three times the number of vehicles that would be in lanes 1 and 2 during the late evening event ingress period.

***Capacity.*** Capacity calculations were completed at both intersections for both events (Appendix D) and it was determined that if the 4th Avenue North Exit Alternative Option 2 was constructed (no geometric changes and split phase signal) both of the ingress design events would have a LOS "D" for the 4th Avenue North and Main Street intersection. During the 5:30 to 6:30 period, both 4th Avenue North approaches would operate at LOS "E". During the 6:30 to 7:30 pm period the eastbound approach would operate at LOS "D".

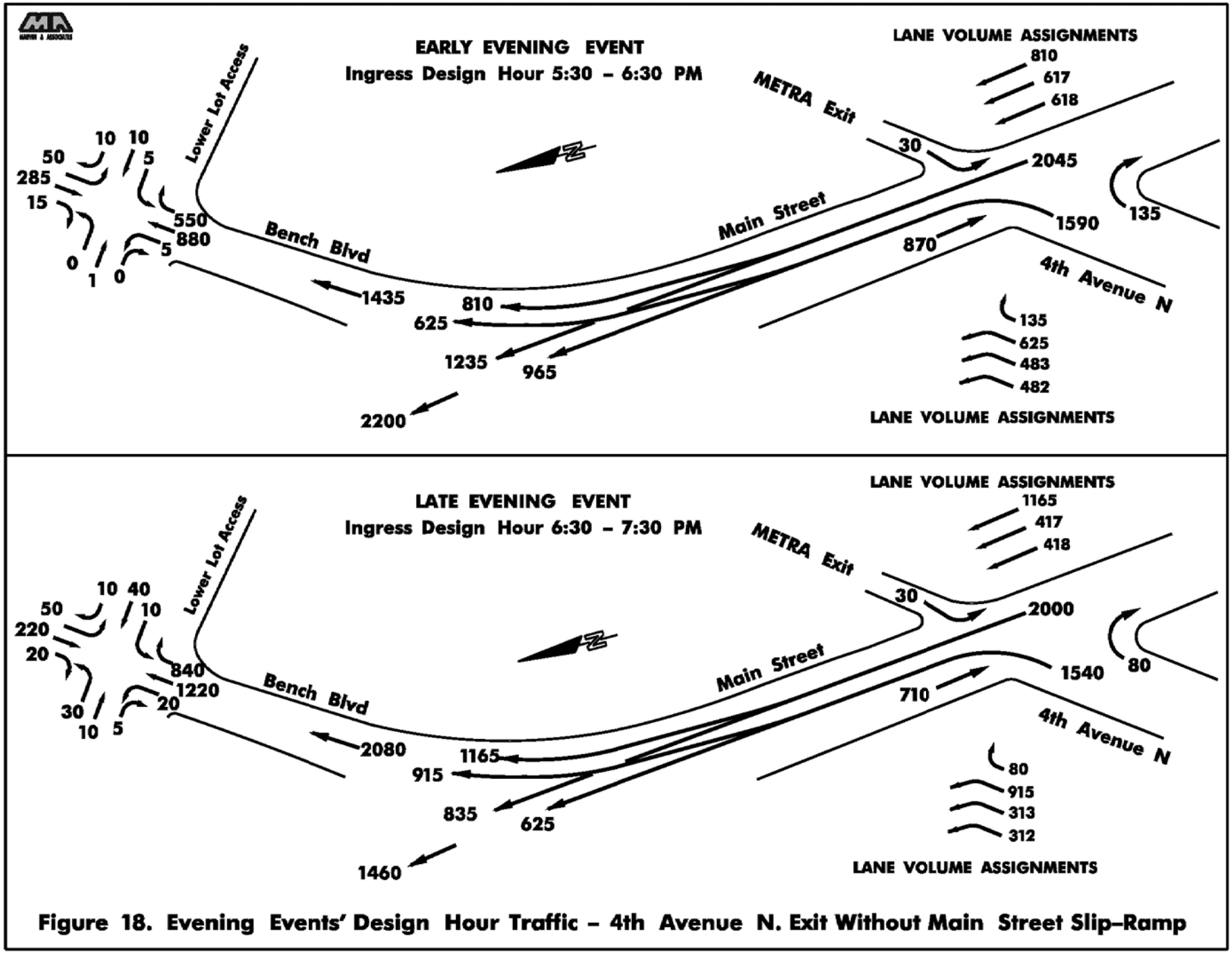



**Figure 18. Evening Events' Design Hour Traffic – 4th Avenue N. Exit Without Main Street Slip–Ramp**

In addition, the vehicles queues on 4th avenue North would increase by over 50 percent to a maximum of 26 vehicles during the 5:30 to 6:30 period. The capacity program did not consider the full extent of forced lane utilization. When third lane utilization is considered, the queues in than lane could exceed 35 vehicles or about 900 feet. Increased queues on Main Street would also occur, but more importantly the averages delays for Main Street traffic would increase by a factor greater than 2. At the Lower Lot access on Bench Boulevard there would be substantially fewer vehicles exiting, but the LOS would still remain in the "F" category with delays up to a minute for the Lower lot approach right-turn movements.

At this point in the ingress analysis process it has become apparent that Alternative A -Option B would have negative impacts on Main Street traffic operations, primarily due to green time requirements that require split phasing for eastbound and westbound traffic on 4th Avenue North. Thus, further consideration of Alternative A – Option 2 as a viable alternative was not given.

Subsequent analysis of Alternative B, which would operate with a two phase signal cycle and pedestrian crossing occurring simultaneously with the 4th Avenue North green phase was completed (Appendix D) and it was determined that all approaches would operate at a LOS "C" or better during both design ingress periods. In fact, Alternative B would provide substantial improvements over the existing baseline operations at the Main Street intersection for both ingress design hours.

Since the design hour volumes on the Main Street to Bench Boulevard ramp during both ingress design hours exceed 1,400 vph, which is the maximum capacity of the ramp at LOS "C", it can also be concluded that a slip-lane into METRA Park from Main Street south of 4th Avenue North will be required for ingress operations. This also requires the geometric changes associated with Alternative B.

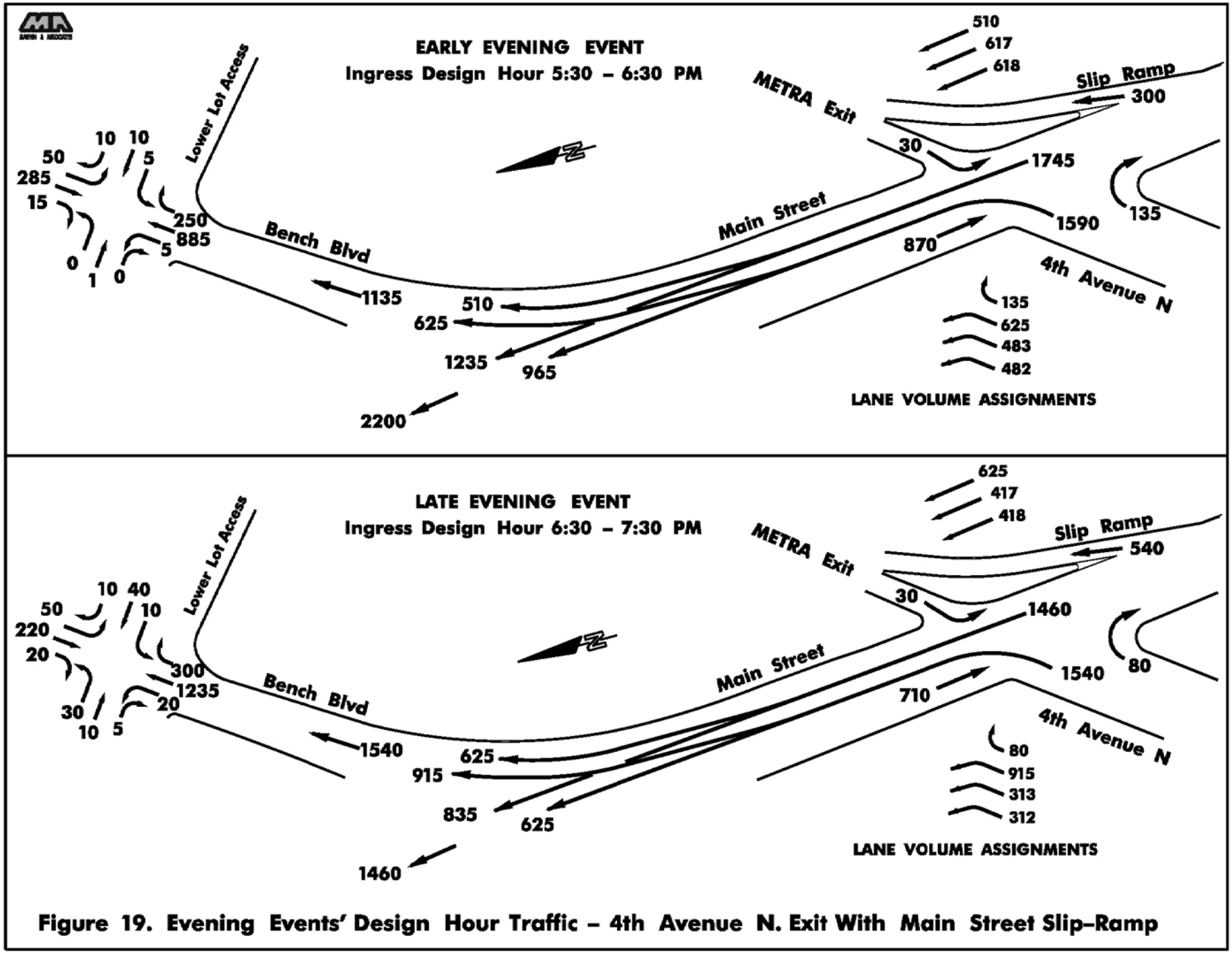



**Figure 19. Evening Events' Design Hour Traffic – 4th Avenue N. Exit With Main Street Slip–Ramp**

**Design Event Ingress Traffic – 4th Avenue North Exit**
**With Main Street Slip-Ramp**

***Traffic Volumes.*** Figure 19 illustrates the traffic assignment associated with a Main Street Slip-ramp for both event design hours and includes the relative lane loadings at the 4th Avenue North intersection. The traffic assignment calculations assumed that there would be mechanisms in-place that would warn drivers when the parking lots were full and/or prevent entrances after capacity was reached. For the early event design hour it was assumed that 300 vehicles would use the slip-ramp to access the Lower Lot before the lot was full and in the late evening ingress event it would accommodate approximately 540 vehicles. The remaining vehicles would enter the Lower Lot access on Bench Boulevard and the majority of those vehicles would have originated on the 4th Avenue North Approach. Because the capacity of this intersection is excellent within the timing limitations of the Main Street coordination system, additional calculations using Synchro software was not considered necessary to evaluate Main Street system impacts.

***Capacity.*** Capacity calculations were completed at both intersections for both events (Appendix D) and it was determined both of the ingress design events would have a LOS "C" or better for all movements at the 4th Avenue North and Main Street intersection. During both the 5:30 to 6:30 and the 6:30 to 7:30 pm periods the eastbound approach would have an approximate 30% increase in queues lengths and the third lane would most likely be less than a maximum of 30 vehicles or approximately 750' in length.

The intersection of Bench Boulevard and the Lower Lot access operate at LOS "D" during the 5:30 to 6:30 pm period, but would still be at LOS "F" during the 6:30 7:30 pm design ingress period. The Main Street to Bench Boulevard ramp would have a maximum volume of 1540 vehicles during the late evening ingress event and would operate at LOS "D". In addition, the single lane eastbound on Bench Boulevard at the Lower Lot access would be backed-up by vehicles turning right from Bench Boulevard into the Lower Lot such that vehicles queues

could certainly impact traffic on Main Street. An auxiliary right–turn would prevent the traffic back-up and would substantially improve delay for vehicle exiting the Lower Lot access (see Appendix D).

**Bench Boulevard Auxiliary Right-turn Lane**

The MDT Traffic Manual indicates that right-turn traffic volumes in excess of 60 vph on facilities with design speeds less than 50 mph warrant a right-turn lane. Thus, in order to avoid impacts related to traffic backing-up on the Bench Boulevard Ramp onto Main Street during ingress periods, an auxiliary right-turn lane would be required. The turn lane would need to have a minimum full-width length of 400' and a 15:1 transition taper would be required prior to beginning the turn lane. The right-turn entry speed at the Lower Lot access should be approximately 15 mph and entering traffic must be free of traffic conflicts for a minimum distance of at least 100' within the intersection throat area. This would require restructuring of the internal islands and construction of an 8' wide raised median to avoid conflicts with traffic movements related to the Front Lot connection road. The Front Lot connection Road could then be converted to accommodate two-way traffic, which would allow ingress access from the Lower Lot and egress access from the Front Lot to the Lower Lot access onto Bench Boulevard.


**Figure 20. Recommended Access Improvements at METRA Park**

## RECCOMENDED ACCESS IMPROVEMENTS

Figure 20, on the preceding page, is a schematic showing all of the improvements that would be necessary to accommodate METRA ingress and egress traffic demands at the highest level of efficiency. The following are major features of the concept improvements that are critical to successful implementation of this concept:

1. The existing METRA Park entrance road geometry at 4th Avenue North and Main Street must be realigned to provide two exit lanes south of its present location. Concurrent left-turn movements from METRA Park and from 4th Avenue North must be separated far enough apart to allow construction of a pedestrian crosswalk and pedestrian refuge in the median on Main Street. The median on Main Street must be reconstructed north of the 4th Avenue North intersection to eliminate the southbound left-turn lane and south of the intersection to allow the left-turn movements exiting METRA Park.
2. A Main Street northbound Slip-Ramp must be constructed to allow a minimum distance of 600' of full length ramp within the METRA Park property. Existing fencing will need to be modified and the ramp could have the option of being gated, if necessary. Access to the ramp must be controlled by changeable message or blank-out signs that can alert motorists that the ramp is either closed or that the parking areas are full. Coordination with MDT will be required during design to ensure that the signing matches the operational protocol.
3. The internal roadway and parking isles intersections on the west end of the Lower Lot will need to be revised to allow bi-directional movements. Figure 20 indicates that the internal roadway would be marked for two-way traffic and the north side of the Lower Lot can exit using the right exit lane at 4th Avenue North and the south side of the Lower Lot can use the left exit lane. Vehicles entering on the slip-ramp will be able to access both the north and south halves of the lower lot using the internal roadway.

4. The signal at the intersection of 4th Avenue North and Main Street will need to be modified to accommodate the new movements. Three existing signal standards will need to be relocated and one new signal standard installed. 6 new pedestrian signal poles, pedestrian push buttons, and count-down pedestrian indications would be required to upgrade to the latest accessibility guidelines. All of the signal indications would need to be upgrade to new LED standards. An additional video or radar detector would be needed for the new METRA Park exit lanes. Additional lighting of the intersection and internal Slip-Ramp junction may also be required.
5. There are numerous signs and pavement markings that will need to be removed, replaced, or relocated at or near the intersection of 4th Avenue North and Main Street.
6. An auxiliary right-turn lane must be constructed on Bench Boulevard that provides a full-width lane at least 400' long and a transition taper of at least 15:1. Changeable message or blank-out signs will be needed to alert motorists that the Lower Lots are full.
7. An 8' wide raised median island at least 120' long must be constructed within the Lower Lot access throat to separate ingress and egress movements to prevent vehicle conflicts with traffic movements to and from the connection road to the Front Lot parking area.
8. The internal parking channelization must be reconfigured to minimize conflicts along the Lower Lot access road. The first internal parking isle access point should be a minimum distance of 200' from the southern curb-line on Bench Boulevard.
9. The Front Lot connection road can be converted to two-way operation with right-in and right-out control at its intersection with the Lower Lot access. This will allow buses to enter the Lower Lot using the Main Street Slip-Ramp and drop-off passengers, curbside, in front of the Arena.
10. The island in the Front Parking lot must be modified to allow busses that enter from Bench Boulevard the opportunity to turn within the lot so that passengers can be dropped-off at the Arena's front doors.

## ACCESS IMPROVEMENT COSTS

Appendix E contains detailed itemized cost estimates for implementing the above noted improvements. These costs are based on measurements and information extracted from aerial photos along with recent unit bid prices for similar construction in the Billings area. Contingencies of 10% were added to the construction estimates, but limitations related to actual design information would probably warrant a much higher contingency.

The following costs were identified in Appendix E:

| | |
|---|---|
| 4th Avenue North – Main Street Intersection Area | = $531,000.00 |
| Lower Lot – Bench Blvd Intersection Area | = $209,000.00 |
| Total Construction Costs | = $890,000.00 |
| Engineering & Surveying Design Costs | = $ 90,000.00 |
| Construction Management & Inspection Costs | = $ 60,000.00 |
| | |
| TOTAL IMPROVEMENT PROJECT COSTS | = 890,000.00 |

## INTERIM EGRESS IMPROVEMENTS

Since the scope of recommended improvements would require sufficient time to coordinate with MDT and the City of Billings, develop funding sources, and design the project, interim egress improvements would be necessary. It is recommended that all or at least a portion of the improvements outlined in Figure 13 of this report be considered to improve egress conditions in the lower lot on an interim basis. While it would be desirable to modify the internal islands to limit conflicts, some measure of improvement could be gained with using just the traffic control devices. Implementation of the traffic control devices and flagging procedures would need to be reviewed by MDT and the City of Billings. It is anticipated that the interim measures would only be used during late evening events when conflicting traffic on Bench Boulevard is low.

# APPENDIX A – TRAFFIC VOLUMES

# Main & 4th Avenue North Intersection Traffic

July 11, 2012

| | Main Street North of 4th Ave | | | | | Main Street South of 4th Ave | | | | | 4th Ave. N. west of Main | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Begin Hour | Southbound T | L | SB App | NB Depart | Total Both Direct | Northbound T | R | NB App | SB Depart | Total Both Direct | Eastbound T | L | R | EB Total | Total Entering |
| Midnight | 101 | 0 | 102 | 209 | 311 | 105 | 1 | 106 | 113 | 219 | 1 | 104 | 12 | 117 | 325 |
| 1.00 | 64 | 0 | 64 | 142 | 206 | 78 | 0 | 78 | 65 | 143 | 0 | 64 | 1 | 65 | 207 |
| 2.00 | 52 | 0 | 52 | 123 | 175 | 67 | 0 | 67 | 55 | 122 | 1 | 56 | 3 | 60 | 179 |
| 3.00 | 83 | 0 | 83 | 75 | 158 | 52 | 0 | 52 | 88 | 140 | 0 | 23 | 5 | 28 | 163 |
| 4.00 | 164 | 0 | 164 | 119 | 283 | 89 | 0 | 89 | 175 | 264 | 0 | 30 | 11 | 41 | 294 |
| 5.00 | 494 | 1 | 495 | 305 | 800 | 220 | 4 | 224 | 523 | 747 | 1 | 85 | 29 | 115 | 834 |
| 6.00 | 1040 | 1 | 1041 | 653 | 1694 | 473 | 6 | 479 | 1090 | 1569 | 1 | 180 | 50 | 231 | 1751 |
| 7.00 | 1536 | 1 | 1538 | 1027 | 2565 | 726 | 10 | 736 | 1612 | 2348 | 4 | 301 | 76 | 381 | 2655 |
| 8.00 | 905 | 5 | 912 | 1091 | 2003 | 696 | 11 | 707 | 989 | 1696 | 8 | 395 | 84 | 487 | 2106 |
| 9.00 | 758 | 1 | 760 | 1170 | 1930 | 695 | 10 | 705 | 845 | 1550 | 5 | 475 | 87 | 567 | 2032 |
| 10.00 | 867 | 3 | 871 | 1382 | 2253 | 776 | 12 | 788 | 969 | 1757 | 6 | 606 | 102 | 714 | 2373 |
| 11.00 | 880 | 2 | 882 | 1813 | 2695 | 933 | 11 | 944 | 970 | 1914 | 13 | 880 | 90 | 983 | 2809 |
| 12.00 | 1090 | 4 | 1096 | 1985 | 3081 | 992 | 11 | 1003 | 1173 | 2176 | 13 | 993 | 83 | 1089 | 3188 |
| 13.00 | 967 | 7 | 974 | 1884 | 2858 | 980 | 11 | 991 | 1066 | 2057 | 4 | 904 | 99 | 1007 | 2972 |
| 14.00 | 887 | 4 | 893 | 1974 | 2867 | 1046 | 4 | 1050 | 1006 | 2056 | 13 | 928 | 119 | 1060 | 3003 |
| 15.00 | 977 | 4 | 984 | 2382 | 3366 | 1286 | 10 | 1296 | 1123 | 2419 | 3 | 1096 | 146 | 1245 | 3525 |
| 16.00 | 916 | 4 | 921 | 2969 | 3890 | 1670 | 1 | 1671 | 1092 | 2763 | 4 | 1299 | 176 | 1479 | 4071 |
| 17.00 | 950 | 1 | 951 | 3217 | 4168 | 1803 | 4 | 1807 | 1132 | 2939 | 4 | 1414 | 182 | 1600 | 4358 |
| 18.00 | 793 | 3 | 796 | 2081 | 2877 | 1196 | 2 | 1198 | 883 | 2081 | 4 | 885 | 90 | 979 | 2973 |
| 19.00 | 625 | 1 | 626 | 1389 | 2015 | 809 | 1 | 810 | 700 | 1510 | 2 | 580 | 75 | 657 | 2093 |
| 20.00 | 476 | 3 | 480 | 1212 | 1692 | 717 | 2 | 719 | 531 | 1250 | 0 | 495 | 55 | 550 | 1749 |
| 21.00 | 360 | 2 | 363 | 941 | 1304 | 552 | 1 | 553 | 413 | 966 | 0 | 389 | 53 | 442 | 1358 |
| 22.00 | 232 | 2 | 235 | 626 | 861 | 340 | 0 | 340 | 263 | 603 | 2 | 286 | 31 | 319 | 894 |
| 23.00 | 143 | 0 | 143 | 378 | 521 | 217 | 0 | 217 | 163 | 380 | 0 | 161 | 20 | 181 | 541 |
| **24 Hour Totals** | **15360** | **49** | **15426** | **29147** | **44573** | **16518** | **112** | **16630** | **17039** | **33669** | **89** | **12629** | **1679** | **14397** | **46453** |

## Main/Bench & 6th Avenue North Intersection Traffic

July 11, 2012

| | Main N of Bench | | | | | Bench E of Main | | | | | | Main S of Bench | | | | | | 6th Ave N | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Begin Hour | Southbound R | Southbound T | SB App | NB Depart | Total Both Direct | Westbound R | Westbound T | Westbound L | WB App | EB Depart | Total Both Direct | Northbound R | Northbound T | Northbound L | NB App | SB Depart | Total Both Direct | WB Total | Total Entering |
| Midnight | 51 | 88 | 139 | 185 | 324 | 0 | 6 | 14 | 20 | 23 | 43 | 23 | 185 | 11 | 220 | 102 | 322 | 68 | 379 |
| 1.00 | 46 | 62 | 108 | 116 | 224 | 1 | 10 | 5 | 16 | 16 | 32 | 16 | 115 | 11 | 142 | 67 | 209 | 67 | 266 |
| 2.00 | 37 | 43 | 80 | 95 | 175 | 0 | 2 | 5 | 7 | 25 | 32 | 25 | 95 | 6 | 126 | 48 | 174 | 45 | 213 |
| 3.00 | 35 | 76 | 111 | 60 | 171 | 0 | 4 | 7 | 11 | 8 | 19 | 8 | 60 | 10 | 78 | 83 | 161 | 49 | 200 |
| 4.00 | 92 | 140 | 232 | 83 | 315 | 0 | 3 | 23 | 26 | 12 | 38 | 12 | 83 | 14 | 109 | 163 | 272 | 109 | 367 |
| 5.00 | 272 | 413 | 685 | 225 | 910 | 0 | 43 | 87 | 130 | 34 | 164 | 34 | 225 | 43 | 302 | 500 | 802 | 358 | 1117 |
| 6.00 | 768 | 781 | 1549 | 439 | 1988 | 1 | 113 | 185 | 299 | 63 | 362 | 63 | 438 | 123 | 624 | 966 | 1590 | 1004 | 2472 |
| 7.00 | 1395 | 1292 | 2687 | 723 | 3410 | 2 | 277 | 348 | 627 | 120 | 747 | 120 | 721 | 176 | 1017 | 1640 | 2657 | 1848 | 4331 |
| 8.00 | 956 | 825 | 1781 | 825 | 2606 | 0 | 149 | 173 | 322 | 97 | 419 | 97 | 825 | 168 | 1090 | 998 | 2088 | 1273 | 3193 |
| 9.00 | 734 | 708 | 1442 | 914 | 2356 | 1 | 124 | 129 | 254 | 147 | 401 | 147 | 913 | 97 | 1157 | 837 | 1994 | 955 | 2853 |
| 10.00 | 676 | 786 | 1462 | 1099 | 2561 | 6 | 106 | 157 | 269 | 163 | 432 | 163 | 1093 | 123 | 1379 | 943 | 2322 | 905 | 3110 |
| 11.00 | 678 | 759 | 1437 | 1443 | 2880 | 4 | 155 | 155 | 314 | 212 | 526 | 212 | 1439 | 95 | 1747 | 914 | 2661 | 928 | 3498 |
| 12.00 | 803 | 868 | 1672 | 1623 | 3295 | 3 | 130 | 191 | 324 | 252 | 576 | 252 | 1620 | 112 | 1985 | 1059 | 3044 | 1045 | 3981 |
| 13.00 | 733 | 815 | 1548 | 1549 | 3097 | 0 | 140 | 181 | 321 | 243 | 564 | 243 | 1549 | 101 | 1896 | 996 | 2892 | 974 | 3765 |
| 14.00 | 675 | 779 | 1454 | 1574 | 3028 | 2 | 122 | 163 | 287 | 257 | 544 | 257 | 1572 | 98 | 1927 | 942 | 2869 | 895 | 3668 |
| 15.00 | 591 | 833 | 1424 | 1901 | 3325 | 9 | 106 | 175 | 290 | 334 | 624 | 334 | 1892 | 102 | 2328 | 1008 | 3336 | 799 | 4042 |
| 16.00 | 659 | 794 | 1453 | 2290 | 3743 | 0 | 115 | 171 | 286 | 490 | 776 | 490 | 2290 | 100 | 2880 | 965 | 3845 | 874 | 4619 |
| 17.00 | 621 | 792 | 1413 | 2465 | 3878 | 4 | 115 | 164 | 283 | 581 | 864 | 581 | 2461 | 79 | 3123 | 956 | 4079 | 815 | 4819 |
| 18.00 | 627 | 666 | 1293 | 1654 | 2947 | 2 | 124 | 155 | 281 | 328 | 609 | 328 | 1652 | 99 | 2080 | 821 | 2901 | 850 | 3654 |
| 19.00 | 384 | 523 | 907 | 1115 | 2022 | 2 | 63 | 92 | 157 | 214 | 371 | 214 | 1113 | 66 | 1393 | 615 | 2008 | 513 | 2457 |
| 20.00 | 295 | 422 | 717 | 1005 | 1722 | 3 | 58 | 80 | 141 | 181 | 322 | 181 | 1002 | 57 | 1240 | 502 | 1742 | 410 | 2098 |
| 21.00 | 275 | 325 | 600 | 805 | 1405 | 2 | 35 | 53 | 90 | 119 | 209 | 119 | 803 | 36 | 958 | 378 | 1336 | 346 | 1648 |
| 22.00 | 167 | 206 | 373 | 524 | 897 | 0 | 17 | 39 | 56 | 84 | 140 | 84 | 524 | 24 | 632 | 245 | 877 | 208 | 1061 |
| 23.00 | 103 | 133 | 236 | 297 | 533 | 0 | 10 | 18 | 28 | 51 | 79 | 51 | 297 | 23 | 372 | 151 | 523 | 136 | 636 |
| **24 Hour Totals** | **11673** | **13129** | **24803** | **23009** | **47812** | **42** | **2027** | **2770** | **4839** | **4054** | **8893** | **4054** | **22967** | **1774** | **28805** | **15899** | **44704** | **15474** | **58447** |

## Main Street & Airport Road Intersection Traffic

April 3, 2012

| | Main Street North of Airport | | | | | | Airport Rd East of Main* | | | | | | Main Street South of Airport | | | | | | Airport Road West of Main | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Begin | Southbound | | | | | Total | Westbound | | | | | Total | Northbound | | | | | Total | Eastbound | | | | | Total | Total |
| Hour | R | T | L | SB App | NB Depart | Both Direct | R | T | L | WB App | EB Depart | Both Direct | R | T | L | NB App | SB Depart | Both Direct | R | T | L | EB App | WB Depart | Both Direct | Entering |
| Midnight | 9 | 75 | 3 | 87 | 150 | 237 | 4 | 1 | 4 | 9 | 3 | 12 | 0 | 113 | 4 | 117 | 91 | 208 | 12 | 0 | 33 | 45 | 14 | 59 | 258 |
| 1.00 | 11 | 63 | 1 | 75 | 95 | 170 | 1 | 0 | 1 | 2 | 3 | 5 | 0 | 78 | 0 | 78 | 68 | 146 | 4 | 2 | 16 | 22 | 11 | 33 | 177 |
| 2.00 | 14 | 50 | 1 | 65 | 60 | 125 | 3 | 2 | 2 | 7 | 1 | 8 | 0 | 43 | 4 | 47 | 56 | 103 | 4 | 0 | 14 | 18 | 20 | 38 | 137 |
| 3.00 | 15 | 88 | 0 | 103 | 58 | 161 | 0 | 2 | 1 | 3 | 0 | 3 | 0 | 52 | 7 | 59 | 93 | 152 | 4 | 0 | 6 | 10 | 24 | 34 | 175 |
| 4.00 | 24 | 199 | 1 | 224 | 98 | 322 | 3 | 1 | 1 | 5 | 2 | 7 | 0 | 71 | 17 | 88 | 206 | 294 | 6 | 1 | 24 | 31 | 42 | 73 | 348 |
| 5.00 | 61 | 502 | 4 | 567 | 266 | 833 | 2 | 1 | 2 | 5 | 7 | 12 | 0 | 207 | 16 | 223 | 515 | 738 | 11 | 3 | 57 | 71 | 78 | 149 | 866 |
| 6.00 | 181 | 1315 | 10 | 1506 | 522 | 2028 | 2 | 26 | 7 | 35 | 21 | 56 | 2 | 387 | 41 | 430 | 1350 | 1780 | 28 | 9 | 133 | 170 | 248 | 418 | 2141 |
| 7.00 | 333 | 1872 | 21 | 2226 | 928 | 3154 | 13 | 42 | 17 | 72 | 60 | 132 | 3 | 675 | 65 | 743 | 1932 | 2675 | 43 | 36 | 240 | 319 | 440 | 759 | 3360 |
| 8.00 | 250 | 1204 | 18 | 1472 | 1038 | 2510 | 21 | 46 | 9 | 76 | 43 | 119 | 3 | 762 | 53 | 818 | 1263 | 2081 | 50 | 22 | 255 | 327 | 349 | 676 | 2693 |
| 9.00 | 230 | 1125 | 15 | 1370 | 1079 | 2449 | 15 | 16 | 5 | 36 | 34 | 70 | 2 | 822 | 39 | 863 | 1157 | 2020 | 27 | 17 | 242 | 286 | 285 | 571 | 2555 |
| 10.00 | 220 | 1062 | 20 | 1302 | 1315 | 2617 | 17 | 26 | 12 | 55 | 45 | 100 | 5 | 981 | 47 | 1033 | 1103 | 2136 | 29 | 20 | 317 | 366 | 293 | 659 | 2756 |
| 11.00 | 276 | 1258 | 22 | 1556 | 1722 | 3278 | 31 | 27 | 19 | 77 | 66 | 143 | 5 | 1339 | 60 | 1404 | 1316 | 2720 | 39 | 39 | 352 | 430 | 363 | 793 | 3467 |
| 12.00 | 266 | 1410 | 50 | 1726 | 1711 | 3437 | 30 | 26 | 19 | 75 | 86 | 161 | 3 | 1288 | 75 | 1366 | 1458 | 2824 | 29 | 48 | 393 | 470 | 367 | 837 | 3657 |
| 13.00 | 229 | 1232 | 21 | 1482 | 1640 | 3122 | 23 | 22 | 8 | 53 | 55 | 108 | 1 | 1267 | 54 | 1322 | 1291 | 2613 | 51 | 43 | 350 | 444 | 305 | 749 | 3301 |
| 14.00 | 220 | 1101 | 22 | 1343 | 1742 | 3085 | 29 | 25 | 18 | 72 | 65 | 137 | 6 | 1304 | 62 | 1372 | 1160 | 2532 | 41 | 49 | 409 | 499 | 307 | 806 | 3302 |
| 15.00 | 286 | 1211 | 20 | 1517 | 2078 | 3595 | 29 | 21 | 19 | 69 | 71 | 140 | 5 | 1572 | 62 | 1639 | 1279 | 2918 | 49 | 59 | 477 | 585 | 369 | 954 | 3842 |
| 16.00 | 318 | 1234 | 20 | 1572 | 2507 | 4079 | 25 | 20 | 15 | 60 | 66 | 126 | 2 | 1888 | 71 | 1961 | 1307 | 3268 | 58 | 56 | 594 | 708 | 409 | 1117 | 4330 |
| 17.00 | 288 | 988 | 27 | 1303 | 2500 | 3803 | 24 | 20 | 15 | 59 | 96 | 155 | 5 | 1920 | 79 | 2004 | 1036 | 3040 | 33 | 81 | 556 | 670 | 387 | 1057 | 4089 |
| 18.00 | 264 | 934 | 16 | 1214 | 1599 | 2813 | 20 | 18 | 14 | 52 | 57 | 109 | 7 | 1208 | 60 | 1275 | 986 | 2261 | 38 | 44 | 371 | 453 | 342 | 795 | 3018 |
| 19.00 | 210 | 708 | 16 | 934 | 1353 | 2287 | 19 | 20 | 10 | 49 | 49 | 98 | 1 | 987 | 50 | 1038 | 745 | 1783 | 27 | 41 | 347 | 415 | 280 | 695 | 2443 |
| 20.00 | 173 | 548 | 18 | 739 | 1009 | 1748 | 19 | 20 | 9 | 48 | 35 | 83 | 3 | 758 | 31 | 792 | 583 | 1375 | 26 | 14 | 232 | 272 | 224 | 496 | 1851 |
| 21.00 | 108 | 410 | 6 | 524 | 669 | 1193 | 13 | 8 | 4 | 25 | 23 | 48 | 0 | 462 | 28 | 490 | 442 | 932 | 28 | 17 | 194 | 239 | 144 | 383 | 1278 |
| 22.00 | 62 | 240 | 5 | 307 | 379 | 686 | 8 | 3 | 0 | 11 | 19 | 30 | 3 | 284 | 22 | 309 | 252 | 561 | 12 | 11 | 87 | 110 | 87 | 197 | 737 |
| 23.00 | 40 | 137 | 1 | 178 | 247 | 425 | 5 | 3 | 2 | 10 | 5 | 15 | 0 | 180 | 15 | 195 | 144 | 339 | 5 | 4 | 62 | 71 | 58 | 129 | 454 |
| **24 Hour Totals** | **4088** | **18966** | **338** | **23392** | **24765** | **48157** | **356** | **396** | **213** | **965** | **912** | **1877** | **56** | **18648** | **962** | **19666** | **19833** | **39499** | **654** | **616** | **5761** | **7031** | **5446** | **12477** | **51235** |

* April Counts Modified to Deduct METRA Event Traffic on this date.

# Bench Blvd. & Airport Road Intersection Traffic

**2012 Calculated**

| | Bench Blvd North of Airport Rd | | | | | Bench Blvd South of Airport Rd | | | | | Airport Road West of Bench | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Begin Hour** | **T** | **R** | **SB App** | **NB Depart** | **Total Both Direct** | **T** | **L** | **NB App** | **SB Depart** | **Total Both Direct** | **L** | **R** | **EB App** | **WB Depart** | **Total Both Direct** | **Total Entering** |
| Midnight | 20 | 7 | 27 | 26 | 53 | 23 | 0 | 23 | 20 | 43 | 3 | 0 | 3 | 7 | 10 | 53 |
| 1.00 | 16 | 2 | 18 | 19 | 37 | 16 | 0 | 16 | 16 | 32 | 3 | 0 | 3 | 2 | 5 | 37 |
| 2.00 | 7 | 6 | 13 | 26 | 39 | 25 | 0 | 25 | 7 | 32 | 1 | 0 | 1 | 6 | 7 | 39 |
| 3.00 | 11 | 2 | 13 | 8 | 21 | 8 | 0 | 8 | 11 | 19 | 0 | 0 | 0 | 2 | 2 | 21 |
| 4.00 | 25 | 4 | 29 | 14 | 43 | 12 | 0 | 12 | 25 | 37 | 2 | 0 | 2 | 4 | 6 | 43 |
| 5.00 | 127 | 4 | 131 | 41 | 172 | 33 | 1 | 34 | 127 | 161 | 7 | 0 | 7 | 5 | 12 | 172 |
| 6.00 | 293 | 28 | 321 | 83 | 404 | 62 | 1 | 63 | 294 | 357 | 20 | 1 | 21 | 29 | 50 | 405 |
| 7.00 | 614 | 57 | 671 | 176 | 847 | 118 | 2 | 120 | 618 | 738 | 56 | 4 | 60 | 59 | 119 | 851 |
| 8.00 | 316 | 60 | 376 | 137 | 513 | 95 | 2 | 97 | 319 | 416 | 40 | 3 | 43 | 62 | 105 | 516 |
| 9.00 | 249 | 28 | 277 | 179 | 456 | 144 | 3 | 147 | 251 | 398 | 32 | 2 | 34 | 31 | 65 | 458 |
| 10.00 | 264 | 43 | 307 | 205 | 512 | 160 | 3 | 163 | 267 | 430 | 42 | 3 | 45 | 46 | 91 | 515 |
| 11.00 | 308 | 61 | 369 | 274 | 643 | 208 | 4 | 212 | 312 | 524 | 62 | 4 | 66 | 65 | 131 | 647 |
| 12.00 | 318 | 59 | 377 | 333 | 710 | 247 | 5 | 252 | 323 | 575 | 81 | 5 | 86 | 64 | 150 | 715 |
| 13.00 | 315 | 42 | 357 | 295 | 652 | 238 | 5 | 243 | 318 | 561 | 52 | 3 | 55 | 47 | 102 | 655 |
| 14.00 | 281 | 57 | 338 | 318 | 656 | 252 | 5 | 257 | 285 | 542 | 61 | 4 | 65 | 62 | 127 | 660 |
| 15.00 | 284 | 55 | 339 | 401 | 740 | 327 | 7 | 334 | 288 | 622 | 67 | 4 | 71 | 62 | 133 | 744 |
| 16.00 | 280 | 47 | 327 | 552 | 879 | 480 | 10 | 490 | 284 | 774 | 62 | 4 | 66 | 57 | 123 | 883 |
| 17.00 | 277 | 47 | 324 | 671 | 995 | 569 | 12 | 581 | 283 | 864 | 90 | 6 | 96 | 59 | 155 | 1001 |
| 18.00 | 275 | 41 | 316 | 382 | 698 | 321 | 7 | 328 | 278 | 606 | 54 | 3 | 57 | 48 | 105 | 701 |
| 19.00 | 154 | 39 | 193 | 260 | 453 | 210 | 4 | 214 | 157 | 371 | 46 | 3 | 49 | 43 | 92 | 456 |
| 20.00 | 138 | 38 | 176 | 214 | 390 | 177 | 4 | 181 | 140 | 321 | 33 | 2 | 35 | 42 | 77 | 392 |
| 21.00 | 88 | 20 | 108 | 141 | 249 | 117 | 2 | 119 | 89 | 208 | 22 | 1 | 23 | 22 | 45 | 250 |
| 22.00 | 55 | 9 | 64 | 102 | 166 | 82 | 2 | 84 | 56 | 140 | 18 | 1 | 19 | 11 | 30 | 167 |
| 23.00 | 27 | 8 | 35 | 56 | 91 | 50 | 1 | 51 | 27 | 78 | 5 | 0 | 5 | 9 | 14 | 91 |
| **24 Hour Totals** | **4742** | **764** | **5506** | **4913** | **10419** | **3974** | **80** | **4054** | **4795** | **8849** | **859** | **53** | **912** | **844** | **1756** | **10472** |

# APPENDIX B – EGRESS CAPACITY CALCULATIONS

# Appendix B – Capacity Calculations

## Maximum Egress Service Volumes

# HCM Analysis Summary

METRA Egress Capacity /Main Area Type: Non CBD
R Marvin 01/05/2013 Analysis Duration: 15 mins.
Peak PM 5-6 Case: Bench at Main 5PM Max Cap

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 0 | 1 | | | | | | | | | | | | |
| WB | 3 | 3 | L | 12.0 | LT | 12.0 | TR | 12.0 | | | | | | |
| NB | 4 | 3 | L | 12.0 | T | 12.0 | T | 12.0 | T | 12.0 | | | | |
| SB | 2 | 3 | T | 12.0 | T | 12.0 | | | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 0 | 0 | 0 | 690 | 500 | 10 | 79 | 2461 | 0 | 0 | 792 | 0 |
| PHF | 0.90 | 0.90 | 0.90 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.90 | 0.90 | 0.92 | 0.90 |
| % Heavy Vehicles | 2 | 2 | 2 | 1 | 1 | 0 | 1 | 4 | 2 | 2 | 4 | 2 |
| Lane Groups | | | | L | LTR | | L | T | | | T | |
| Arrival Type | | | | 3 | 3 | | 4 | 4 | | | 4 | |
| RTOR Vol (vph) | | 0 | | | 0 | | | 0 | | | 0 | |
| Peds/Hour | | 5 | | | 0 | | | 5 | | | 0 | |
| % Grade | | 0 | | | 0 | | | 0 | | | 0 | |
| Buses/Hour | | 0 | | | 0 | | | 0 | | | 0 | |
| Parkers/Hour (Left\|Right) | --- | --- | | --- | --- | | --- | --- | | --- | --- | |

Signal Settings: Actuated Operational Analysis Cycle Length: 130.0 Sec Lost Time Per Cycle: 10.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | | | | | | | | | | | | | | | | | |
| WB | | LTR | | | | | | | | | | | | | | | | |
| NB | | | | LT | | T | | | | | | | | | | | | |
| SB | | | | | | T | | | | | | | | | | | | |
| Green | | 50.0 | | 12.0 | | 54.0 | | | | | | | | | | | | 0 |
| Yellow | All Red | 3.5 | 1.5 | 3.0 | 1.0 | 3.5 | 1.5 | | | | | | | | | | | |

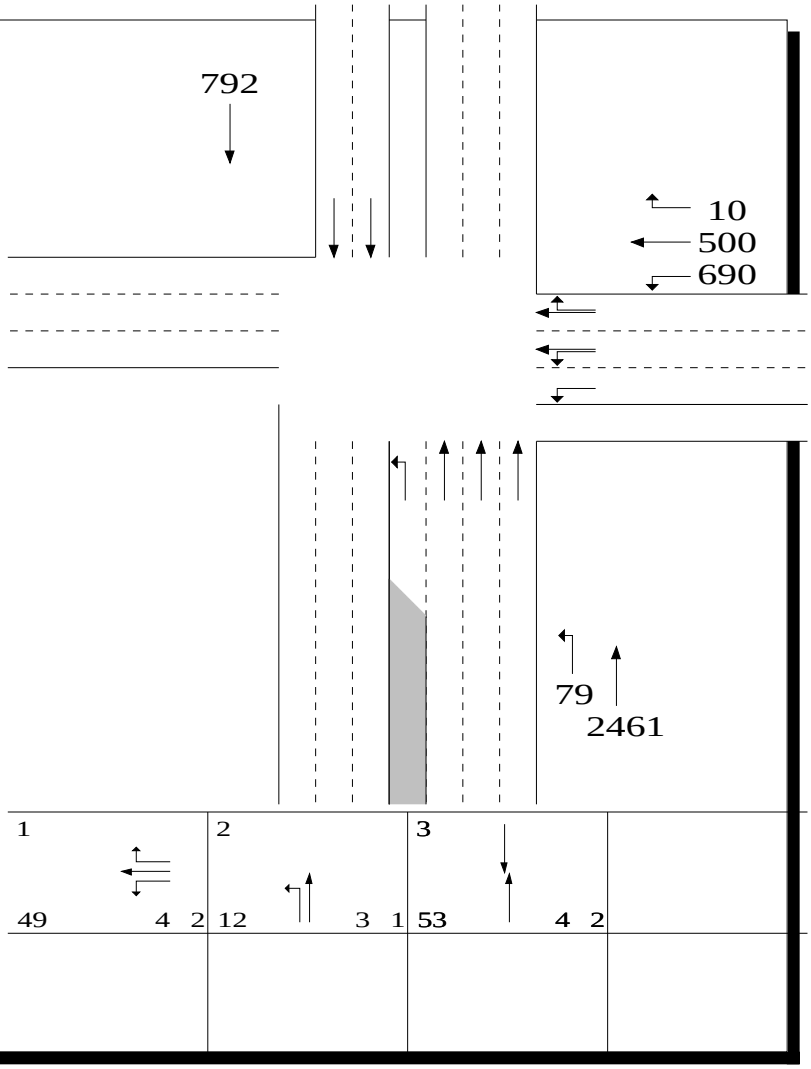
| Capacity Analysis Results | | | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| WB | | | | | | | | | | |
| | * L | 685 | 0.337 | 0.385 | L | 0.876 | 48.9 | D | 39.2 | D |
| | LTR | 1356 | 0.200 | 0.385 | LTR | 0.519 | 30.9 | C | | |
| NB | | | | | | | | | | |
| | L | 165 | 0.048 | 0.092 | L | 0.521 | 67.5 | E | 38.4 | D |
| | * T | 2686 | 0.536 | 0.538 | T | 0.996 | 37.4 | D | | |
| SB | | | | | | | | | | |
| | T | 1442 | 0.248 | 0.415 | T | 0.597 | 27.8 | C | 27.8 | C |

Intersection: Delay = 36.7 sec/veh Int. LOS=D $X_c$= 0.95 * Critical Lane Group $\Sigma$(v/s)Crit= 0.87

# NETSIM Summary Results

METRA Egress Capacity /Main
R Marvin 01/05/2013
Peak PM 5-6 Case: Bench at Main 5PM Max Cap

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | All | | 8.4 | 0.0 |
| WB | L | 13 / 16 | 6.4 | 0.0 |
| | LTR | 10 / 12 | 9.5 | 0.0 |
| | | | | |
| | All | | 8.9 | 0.0 |
| NB | L | 5 / 7 | 2.4 | 0.0 |
| | T | 18 / 22 | 9.4 | 0.0 |
| | | | | |
| | All | | 13.0 | 0.0 |
| | | | | |
| SB | T | 4 / 6 | 13.0 | 0.0 |
| | | | | |
| | | | | |
| Intersect. | | | 9.2 | |



# HCM Analysis Summary

METRA Egress Capacity /Main Area Type: Non CBD
R Marvin 01/05/2013 Analysis Duration: 15 mins.
9 PM Event Case: Bench at Main 9PM Max Cap

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 0 | 1 | | | | | | | | | | | | |
| WB | 3 | 3 | L | 12.0 | LT | 12.0 | TR | 12.0 | | | | | | |
| NB | 4 | 3 | L | 12.0 | T | 12.0 | T | 12.0 | T | 12.0 | | | | |
| SB | 2 | 3 | T | 12.0 | T | 12.0 | | | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 0 | 0 | 0 | 1040 | 740 | 20 | 36 | 803 | 0 | 0 | 325 | 0 |
| PHF | 0.90 | 0.90 | 0.90 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.90 | 0.90 | 0.92 | 0.90 |
| % Heavy Vehicles | 2 | 2 | 2 | 1 | 1 | 0 | 1 | 4 | 2 | 2 | 4 | 2 |
| Lane Groups | | | | L | LTR | | L | T | | | T | |
| Arrival Type | | | | 3 | 3 | | 4 | 4 | | | 4 | |
| RTOR Vol (vph) | 0 | | | 0 | | | 0 | | | 0 | | |
| Peds/Hour | 5 | | | 0 | | | 5 | | | 0 | | |
| % Grade | 0 | | | 0 | | | 0 | | | 0 | | |
| Buses/Hour | 0 | | | 0 | | | 0 | | | 0 | | |
| Parkers/Hour (Left\|Right) | --- | --- | | --- | --- | | --- | --- | | --- | --- | |

Signal Settings: Actuated Operational Analysis Cycle Length: 130.0 Sec Lost Time Per Cycle: 10.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | | | | | | | | | | | | | | | | | |
| WB | | LTR | | | | | | | | | | | | | | | | |
| NB | | | | LT | | T | | | | | | | | | | | | |
| SB | | | | | | T | | | | | | | | | | | | |
| Green | | 70.0 | | 16.0 | | 30.0 | | | | | | | | | | | | 0 |
| Yellow | All Red | 3.5 | 1.5 | 3.0 | 1.0 | 3.5 | 1.5 | | | | | | | | | | | |

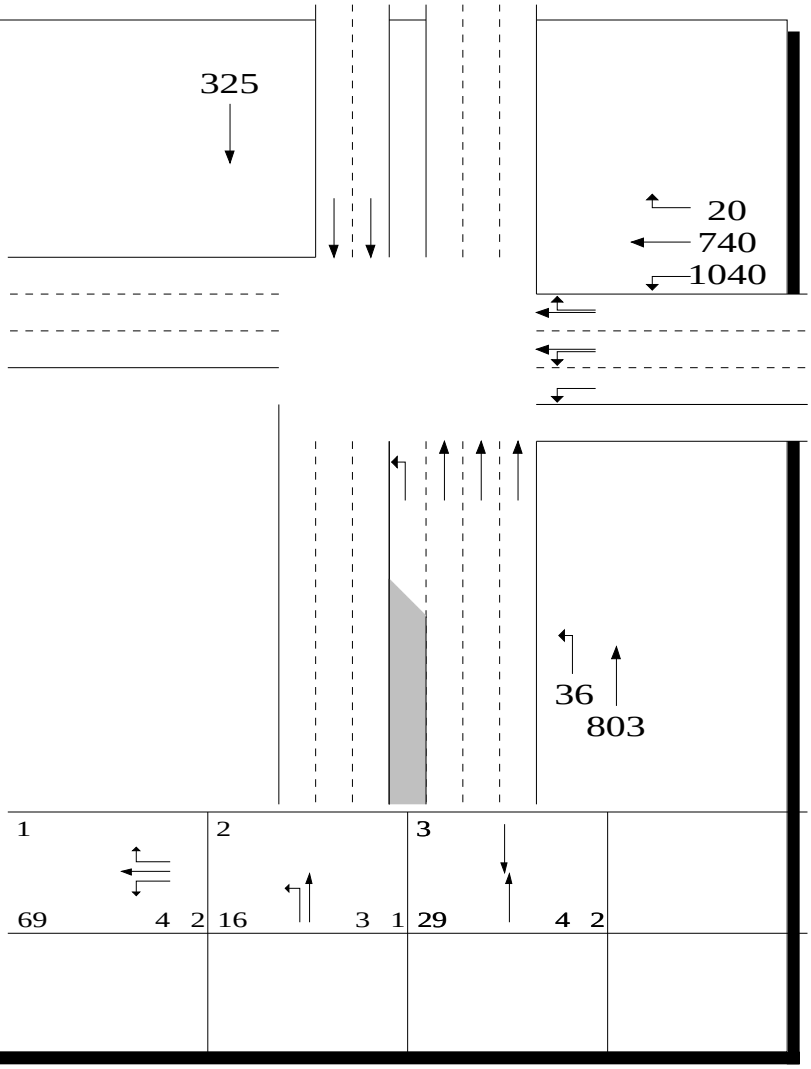
| Capacity Analysis Results | | | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| WB | | | | | | | | | | |
| | * L | 960 | 0.507 | 0.538 | L | 0.942 | 44.7 | D | 31.4 | C |
| | LTR | 1897 | 0.299 | 0.538 | LTR | 0.555 | 20.0 | B | | |
| NB | | | | | | | | | | |
| | L | 220 | 0.022 | 0.123 | L | 0.177 | 52.9 | D | 29.0 | C |
| | * T | 1918 | 0.175 | 0.385 | T | 0.455 | 28.0 | C | | |
| SB | | | | | | | | | | |
| | T | 801 | 0.102 | 0.231 | T | 0.441 | 44.6 | D | 44.6 | D |

Intersection: Delay = 32.2 sec/veh Int. LOS=C $X_c$= 0.74 * Critical Lane Group $\Sigma$(v/s)Crit= 0.68

# NETSIM Summary Results

METRA Egress Capacity /Main
R Marvin 01/05/2013
9 PM Event Case: Bench at Main 9PM Max Cap

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | All | | 10.5 | 0.0 |
| WB | L | 15 / 18 | 8.7 | 0.0 |
| | LTR | 12 / 14 | 11.6 | 0.0 |
| | | | | |
| | All | | 6.0 | 0.0 |
| NB | L | 2 / 3 | 4.4 | 0.0 |
| | T | 10 / 12 | 6.0 | 0.0 |
| | | | | |
| | All | | 17.7 | 0.0 |
| | | | | |
| SB | T | 1 / 1 | 17.7 | 0.0 |
| | | | | |
| | | | | |
| Intersect. | | | 8.9 | |



# HCM Analysis Summary

| | | |
|---|---|---|
| METRA Egress Event | Airport Rd/Bench | Area Type: Non CBD |
| R Marvin | 01/07/2013 | Analysis Duration: 15 mins. |
| Peak PM 5-6 | Case: Bench Airport 5 PM | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 2 | 1 | L | 12.0 | TR | 12.0 | | | | | | | | |
| WB | 3 | 2 | L | 12.0 | T | 12.0 | TR | 12.0 | | | | | | |
| NB | 2 | 1 | L | 12.0 | TR | 12.0 | | | | | | | | |
| SB | 2 | 1 | L | 12.0 | TR | 12.0 | | | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 90 | 1 | 6 | 10 | 400 | 300 | 112 | 669 | 0 | 1 | 277 | 47 |
| PHF | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| % Heavy Vehicles | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 0 |
| Lane Groups | L | TR | | L | TR | | L | TR | | L | TR | |
| Arrival Type | 3 | 3 | | 3 | 3 | | 3 | 3 | | 3 | 3 | |
| RTOR Vol (vph) | 0 | | | 100 | | | 0 | | | 10 | | |
| Peds/Hour | 5 | | | 5 | | | 5 | | | 5 | | |
| % Grade | 0 | | | 0 | | | 0 | | | 0 | | |
| Buses/Hour | 0 | | | 0 | | | 0 | | | 0 | | |
| Parkers/Hour (Left\|Right) | --- | --- | | --- | --- | | --- | --- | | --- | --- | |

Signal Settings: Actuated  Operational Analysis  Cycle Length: 110.0 Sec  Lost Time Per Cycle: 18.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | 6 | 7 | 8 | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | L | | TP | | | | | | | | | | |
| WB | | L | | TP | | | | | | | | | | |
| NB | | | | | | L | | TP | | | | | | |
| SB | | | | | | L | | TP | | | | | | |
| Green | | 8.0 | | 20.0 | | 15.0 | | 49.0 | | | | | | 0 |
| Yellow | All Red | 3.0 | 1.0 | 3.5 | 1.5 | 3.0 | 1.0 | 3.5 | 1.5 | | | | | |

| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | * L | 131 | 0.054 | 0.073 | L | 0.748 | 68.8 | E | 66.4 | E |
| | TR | 297 | 0.005 | 0.182 | TR | 0.027 | 37.0 | D | | |
| WB | | | | | | | | | | |
| | L | 131 | 0.006 | 0.073 | L | 0.084 | 47.7 | D | 94.1 | F |
| | * TR | 621 | 0.191 | 0.182 | TR | 1.050 | 94.9 | F | | |
| NB | | | | | | | | | | |
| | * L | 246 | 0.068 | 0.136 | L | 0.496 | 44.6 | D | 40.9 | D |
| | * TR | 830 | 0.390 | 0.445 | TR | 0.876 | 40.2 | D | | |
| SB | | | | | | | | | | |
| | L | 246 | 0.001 | 0.136 | L | 0.004 | 41.0 | D | 22.4 | C |
| | TR | 815 | 0.186 | 0.445 | TR | 0.418 | 22.4 | C | | |

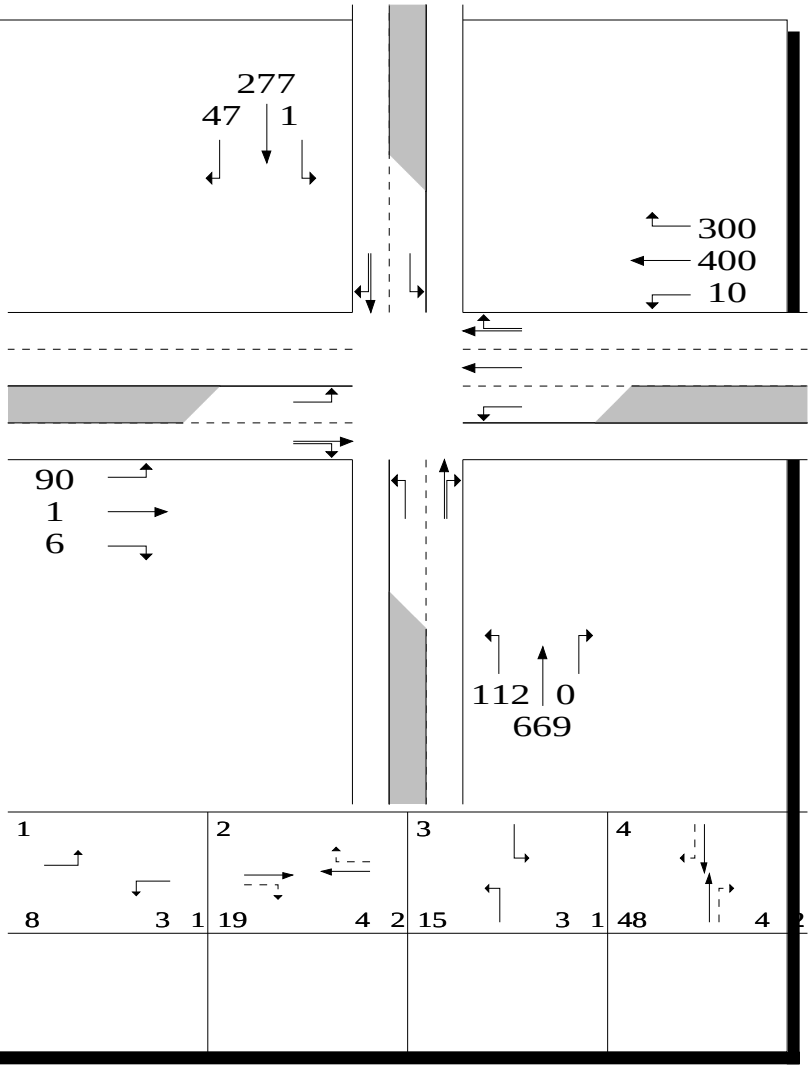
Intersection: Delay = 57.0 sec/veh  Int. LOS=E  $X_c$= 0.84  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.70

# NETSIM Summary Results

METRA Egress Event
R Marvin
Peak PM 5-6

Airport Rd/Bench
01/07/2013
Case: Bench Airport 5 PM

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 3 / 3 | 3.7 | 0.0 |
| | TR | 0 / 1 | 22.3 | 0.0 |
| | | | | |
| | All | | 6.3 | 0.0 |
| WB | L | 1 / 3 | 3.0 | 0.0 |
| | TR | 10 / 12 | 6.9 | 0.0 |
| | | | | |
| | All | | 6.8 | 0.0 |
| NB | L | 5 / 6 | 4.2 | 0.0 |
| | TR | 13 / 16 | 9.6 | 0.0 |
| | | | | |
| | All | | 8.7 | 0.0 |
| SB | L | 0 / 0 | 0.0 | 0.0 |
| | TR | 6 / 7 | 12.0 | 0.0 |
| | | | | |
| | All | | 12.0 | 0.0 |
| Intersect. | | | 8.1 | |



# HCM Analysis Summary

| | | |
|---|---|---|
| METRA Egress Event | Airport Rd/Bench | Area Type: Non CBD |
| R Marvin | 01/07/2013 | Analysis Duration: 15 mins. |
| Peak 9 PM | Case: BENCH AIRPORT 9 PM | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 2 | 1 | L | 12.0 | TR | 12.0 | | | | | | | | |
| WB | 3 | 2 | L | 12.0 | T | 12.0 | TR | 12.0 | | | | | | |
| NB | 2 | 1 | L | 12.0 | TR | 12.0 | | | | | | | | |
| SB | 2 | 1 | L | 12.0 | TR | 12.0 | | | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 22 | 1 | 1 | 10 | 850 | 450 | 102 | 417 | 0 | 1 | 88 | 20 |
| PHF | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| % Heavy Vehicles | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 0 |
| Lane Groups | L | TR | | L | TR | | L | TR | | L | TR | |
| Arrival Type | 3 | 3 | | 3 | 3 | | 3 | 3 | | 3 | 3 | |
| RTOR Vol (vph) | 0 | | | 200 | | | 0 | | | 0 | | |
| Peds/Hour | 5 | | | 5 | | | 5 | | | 5 | | |
| % Grade | 0 | | | 0 | | | 0 | | | 0 | | |
| Buses/Hour | 0 | | | 0 | | | 0 | | | 0 | | |
| Parkers/Hour (Left\|Right) | --- | --- | | --- | --- | | --- | --- | | --- | --- | |

Signal Settings: Actuated  Operational Analysis  Cycle Length: 120.0 Sec  Lost Time Per Cycle: 18.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | L | | TP | | | | | | | | | | | | | | |
| WB | | L | | TP | | | | | | | | | | | | | | |
| NB | | | | | | L | | TP | | | | | | | | | | |
| SB | | | | | | L | | TP | | | | | | | | | | |
| Green | | 8.0 | | 44.0 | | 15.0 | | 35.0 | | | | | | | | | | 0 |
| Yellow | All Red | 3.0 | 1.0 | 3.5 | 1.5 | 3.0 | 1.0 | 3.5 | 1.5 | | | | | | | | | |

| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | * L | 120 | 0.013 | 0.067 | L | 0.200 | 53.3 | D | 51.0 | D |
| | TR | 642 | 0.001 | 0.367 | TR | 0.003 | 24.1 | C | | |
| WB | | | | | | | | | | |
| | L | 120 | 0.006 | 0.067 | L | 0.092 | 52.7 | D | 49.5 | D |
| | * TR | 1276 | 0.344 | 0.367 | TR | 0.937 | 49.5 | D | | |
| NB | | | | | | | | | | |
| | * L | 226 | 0.061 | 0.125 | L | 0.491 | 49.6 | D | 53.0 | D |
| | * TR | 543 | 0.243 | 0.292 | TR | 0.834 | 53.8 | D | | |
| SB | | | | | | | | | | |
| | L | 226 | 0.001 | 0.125 | L | 0.004 | 46.0 | D | 33.3 | C |
| | TR | 528 | 0.065 | 0.292 | TR | 0.223 | 33.2 | C | | |

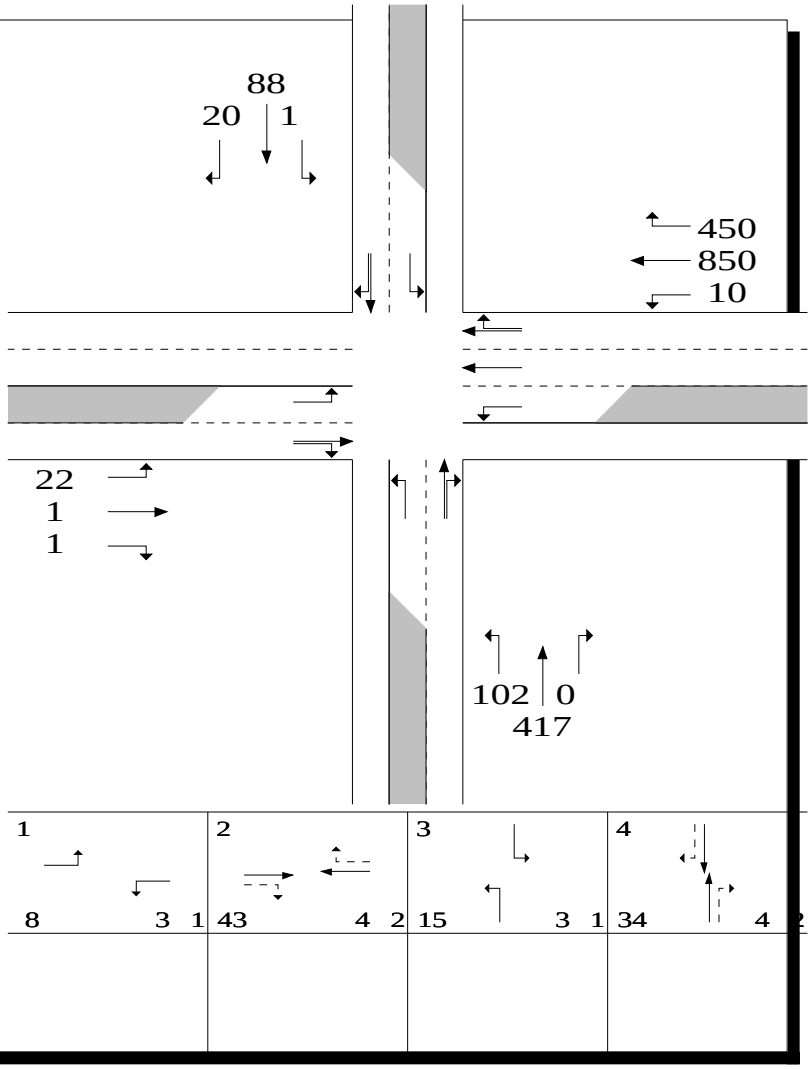
Intersection: Delay = 49.6 sec/veh  Int. LOS=D  $X_c$= 0.78  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.66

# NETSIM Summary Results

METRA Egress Event
R Marvin
Peak 9 PM

Airport Rd/Bench
01/07/2013
Case: BENCH AIRPORT 9 PM

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 1 / 1 | 3.3 | 0.0 |
| | TR | 0 / 0 | 28.0 | 0.0 |
| | | | | |
| | All | | 5.6 | 0.0 |
| WB | L | 1 / 3 | 2.6 | 0.0 |
| | TR | 20 / 26 | 5.1 | 2.0 |
| | | | | |
| | All | | 5.0 | 2.0 |
| NB | L | 4 / 7 | 3.9 | 0.0 |
| | TR | 11 / 13 | 7.8 | 0.0 |
| | | | | |
| | All | | 6.9 | 0.0 |
| SB | L | 0 / 0 | 0.0 | 0.0 |
| | TR | 3 / 3 | 8.1 | 0.0 |
| | | | | |
| | All | | 8.1 | 0.0 |
| Intersect. | | | 5.6 | |



# HCM Analysis Summary

| | | |
|---|---|---|
| METRA Egress Study | Airport Road/Main Street | Area Type: Non CBD |
| R Marvin | 10/12/2011 | Analysis Duration: 15 mins. |
| Peak 5 PM Hour | Case: Airport Main 5 PM | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 3 | 1 | L | 12.0 | LT | 12.0 | R | 12.0 | | | | | | |
| WB | 2 | 2 | LT | 12.0 | R | 12.0 | | | | | | | | |
| NB | 4 | 3 | L | 12.0 | T | 12.0 | T | 12.0 | TR | 12.0 | | | | |
| SB | 4 | 3 | L | 12.0 | T | 12.0 | T | 12.0 | TR | 12.0 | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 556 | 81 | 33 | 15 | 320 | 300 | 79 | 1920 | 5 | 27 | 988 | 288 |
| PHF | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 |
| % Heavy Vehicles | 2 | 0 | 4 | 1 | 1 | 1 | 2 | 2 | 0 | 0 | 2 | 1 |
| Lane Groups | L | LT | R | | LT | R | L | TR | | L | TR | |
| Arrival Type | 3 | 3 | 3 | | 3 | 3 | 5 | 5 | | 5 | 5 | |
| RTOR Vol (vph) | 20 | | | 50 | | | 0 | | | 80 | | |
| Peds/Hour | 5 | | | 0 | | | 5 | | | 5 | | |
| % Grade | 0 | | | 0 | | | 0 | | | 0 | | |
| Buses/Hour | 0 | | | 0 | | | 0 | | | 0 | | |
| Parkers/Hour (Left\|Right) | --- | --- | | --- | --- | | --- | --- | | --- | --- | |

Signal Settings: Actuated | Operational Analysis | Cycle Length: 150.0 Sec | Lost Time Per Cycle: 20.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | LTP | | | | R | | | | | | | | | | | | |
| WB | | | | LTP | | | | | | | | | | | | | | |
| NB | | | | | | LTP | | TP | | | | | | | | | | |
| SB | | | | | | | | TP | | LTR | | | | | | | | |
| Green | | 30.0 | | 25.0 | | 10.0 | | 55.0 | | 7.0 | | | | | | | | 0 |
| Yellow | All Red | 3.5 | 1.5 | 3.5 | 1.5 | 3.0 | 0.0 | 3.5 | 1.5 | 3.5 | 1.5 | | | | | | | |

| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | * L | 354 | 0.231 | 0.200 | L | 1.153 | 156.1 | F | 117.9 | F |
| | LT | 360 | 0.154 | 0.200 | LT | 0.769 | 65.6 | E | | |
| | R | 443 | 0.009 | 0.287 | R | 0.032 | 38.5 | D | | |
| | | | | | | | | | | |
| WB | | | | | | | | | | |
| | | | | | | | | | | |
| | * LT | 313 | 0.192 | 0.167 | LT | 1.150 | 160.5 | F | 142.9 | F |
| | R | 267 | 0.168 | 0.167 | R | 1.007 | 119.5 | F | | |
| | | | | | | | | | | |
| NB | | | | | | | | | | |
| | L | 118 | 0.048 | 0.067 | L | 0.720 | 96.8 | F | 25.9 | C |
| | * TR | 2304 | 0.407 | 0.453 | TR | 0.898 | 23.0 | C | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| SB | | | | | | | | | | |
| | * L | 84 | 0.016 | 0.047 | L | 0.345 | 77.9 | E | 16.8 | B |
| | TR | 2211 | 0.260 | 0.447 | TR | 0.582 | 15.4 | B | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

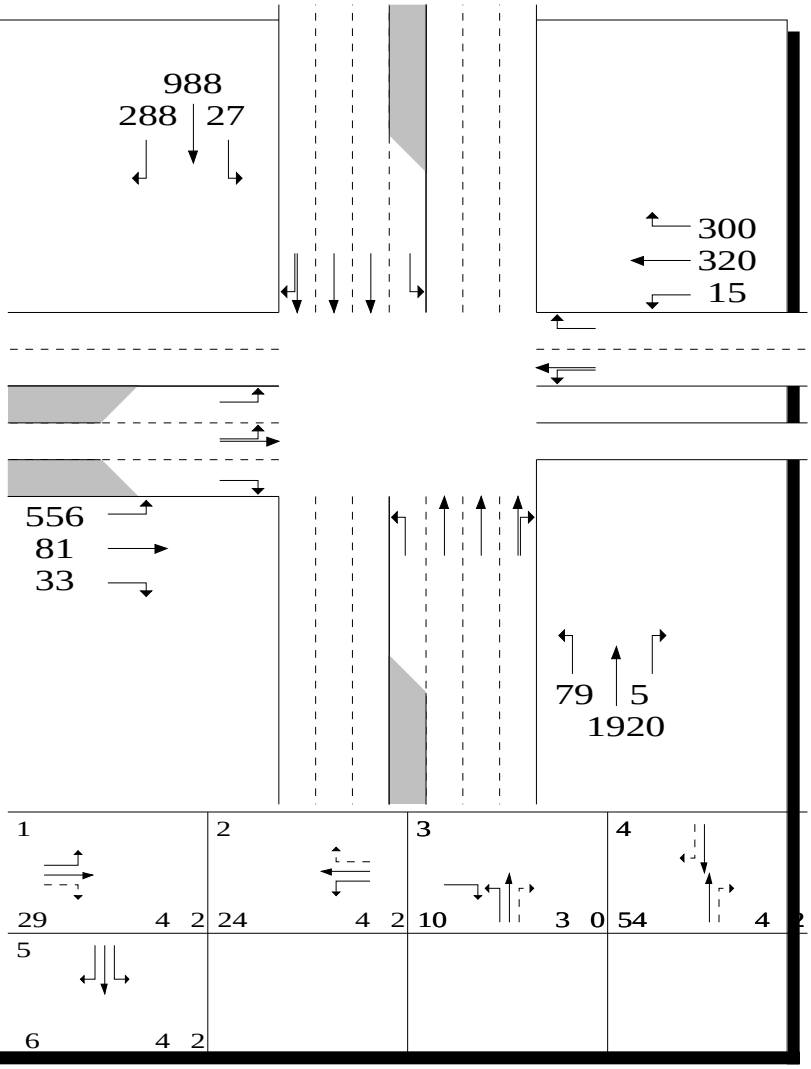
Intersection: Delay = 52.2 sec/veh  Int. LOS=D  $X_c$= 0.98  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.85

# NETSIM Summary Results

METRA Egress Study
R Marvin
Peak 5 PM Hour

Airport Road/Main Street
10/12/2011
Case: Airport Main 5 PM

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 12 / 13 | 4.7 | 0.0 |
| | LT | 12 / 13 | 5.9 | 0.0 |
| | R | 1 / 1 | 20.0 | 0.0 |
| | All | | 5.5 | 0.0 |
| | | | | |
| WB | LT | 16 / 19 | 3.6 | 0.0 |
| | R | 6 / 10 | 12.1 | 0.0 |
| | All | | 5.5 | 0.0 |
| NB | L | 4 / 5 | 3.3 | 0.0 |
| | TR | 6 / 8 | 13.4 | 0.0 |
| | | | | |
| | All | | 12.0 | 0.0 |
| SB | L | 2 / 4 | 6.2 | 0.0 |
| | TR | 0 / 2 | 24.3 | 0.0 |
| | | | | |
| | All | | 22.3 | 0.0 |
| Intersect. | | | 10.0 | |



# HCM Analysis Summary

| | | |
|---|---|---|
| METRA Egress Study | Airport Road/Main Street | Area Type: Non CBD |
| R Marvin | 10/12/2011 | Analysis Duration: 15 mins. |
| Peak 9 PM Hour | Case: Airport Main 9 PM | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 3 | 1 | L | 12.0 | LT | 12.0 | R | 12.0 | | | | | | |
| WB | 2 | 2 | LT | 12.0 | R | 12.0 | | | | | | | | |
| NB | 4 | 3 | L | 12.0 | T | 12.0 | T | 12.0 | TR | 12.0 | | | | |
| SB | 4 | 3 | L | 12.0 | T | 12.0 | T | 12.0 | TR | 12.0 | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 194 | 17 | 28 | 4 | 900 | 700 | 28 | 470 | 0 | 6 | 410 | 110 |
| PHF | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 |
| % Heavy Vehicles | 2 | 0 | 4 | 1 | 1 | 1 | 2 | 2 | 0 | 0 | 2 | 1 |
| Lane Groups | L | LT | R | | LT | R | L | TR | | L | TR | |
| Arrival Type | 3 | 3 | 3 | | 3 | 3 | 5 | 5 | | 5 | 5 | |
| RTOR Vol (vph) | 20 | | | 200 | | | 0 | | | 80 | | |
| Peds/Hour | 5 | | | 0 | | | 5 | | | 5 | | |
| % Grade | 0 | | | 0 | | | 0 | | | 0 | | |
| Buses/Hour | 0 | | | 0 | | | 0 | | | 0 | | |
| Parkers/Hour (Left\|Right) | --- | --- | | --- | --- | | --- | --- | | --- | --- | |

Signal Settings: Actuated  Operational Analysis  Cycle Length: 150.0 Sec  Lost Time Per Cycle: 18.0 Sec

| Phase: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Ped Only |
|---|---|---|---|---|---|---|---|---|---|
| EB | LTP | | R | | | | | | |
| WB | | LTP | | | | | | | |
| NB | | | LTP | TP | | | | | |
| SB | | | | TP | LTR | | | | |
| Green | 15.0 | 75.0 | 10.0 | 20.0 | 7.0 | | | | 0 |
| Yellow / All Red | 3.5 / 1.5 | 3.5 / 1.5 | 3.0 / 0.0 | 3.5 / 1.5 | 3.5 / 1.5 | | | | |

| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | * L | 177 | 0.094 | 0.100 | L | 0.944 | 117.9 | F | 101.4 | F |
| | LT | 180 | 0.033 | 0.100 | LT | 0.333 | 63.2 | E | | |
| | R | 287 | 0.006 | 0.187 | R | 0.031 | 49.9 | D | | |
| WB | | | | | | | | | | |
| | * LT | 941 | 0.517 | 0.500 | LT | 1.033 | 75.6 | E | 59.4 | E |
| | R | 800 | 0.336 | 0.500 | R | 0.673 | 30.1 | C | | |
| NB | | | | | | | | | | |
| | * L | 118 | 0.017 | 0.067 | L | 0.254 | 68.4 | E | 43.9 | D |
| | TR | 1119 | 0.099 | 0.220 | TR | 0.451 | 42.4 | D | | |
| SB | | | | | | | | | | |
| | L | 84 | 0.003 | 0.047 | L | 0.071 | 67.8 | E | 43.6 | D |
| | * TR | 1073 | 0.094 | 0.213 | TR | 0.441 | 43.3 | D | | |

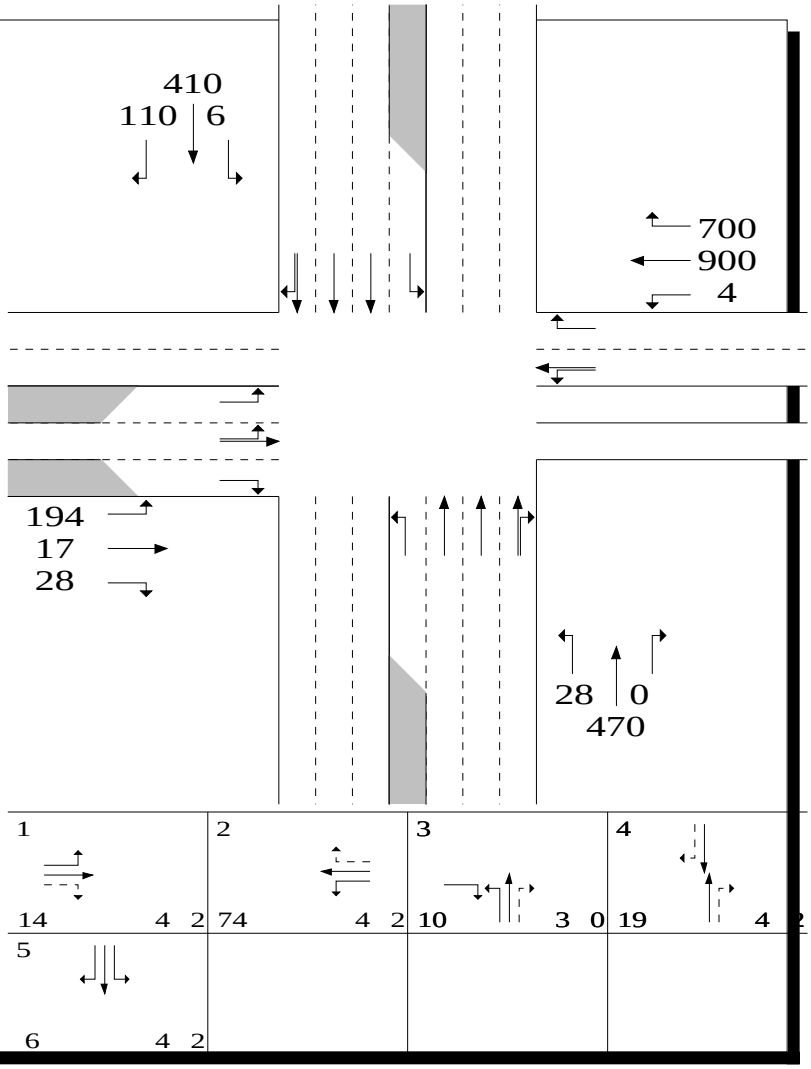
Intersection: Delay = 57.2 sec/veh  Int. LOS=E  $X_c$= 0.82  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.72

# NETSIM Summary Results

METRA Egress Study
R Marvin
Peak 9 PM Hour

Airport Road/Main Street
10/12/2011
Case: Airport Main 9 PM

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 5 / 5 | 4.3 | 0.0 |
| | LT | 4 / 5 | 6.6 | 0.0 |
| | R | 1 / 1 | 21.5 | 0.0 |
| | All | | 6.0 | 0.0 |
| | | | | |
| WB | LT | 29 / 30 | 5.0 | 36.4 |
| | R | 4 / 6 | 20.1 | 0.0 |
| | All | | 7.2 | 36.4 |
| NB | L | 1 / 2 | 5.1 | 0.0 |
| | TR | 0 / 1 | 24.3 | 0.0 |
| | | | | |
| | All | | 18.7 | 0.0 |
| SB | L | 1 / 1 | 8.6 | 0.0 |
| | TR | 1 / 2 | 23.1 | 0.0 |
| | | | | |
| | All | | 22.5 | 0.0 |
| Intersect. | | | 9.3 | |



# TWO-WAY STOP CONTROL SUMMARY

## General Information

| | |
|---|---|
| Analyst | *R Marvin* |
| Agency/Co. | *Marvin & Associates* |
| Date Performed | *1/18/2013* |
| Analysis Time Period | *Maximum Event Late PM* |

## Site Information

| | |
|---|---|
| Intersection | *Lower Lot Access & Bench* |
| Jurisdiction | *Yelloewstone County* |
| Analysis Year | *2013* |
| | |

Project Description *METRA Egress Study*

East/West Street: *Bench Boulevard* | North/South Street: *Lower Lot Access*

Intersection Orientation: *East-West* | Study Period (hrs): *0.25*

## Vehicle Volumes and Adjustments

| **Major Street** | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| Movement | 1 | 2 | 3 | 4 | 5 | 6 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *0* | *40* | *5* | *10* | *940* | *0* |
| Peak-Hour Factor, PHF | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* |
| Hourly Flow Rate, HFR (veh/h) | *0* | *40* | *5* | *10* | *940* | *0* |
| Percent Heavy Vehicles | *0* | -- | -- | *0* | -- | -- |
| Median Type | *Undivided* | | | | | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *0* | *1* | *0* | *1* | *2* | *0* |
| Configuration | *LTR* | | | *L* | *T* | *TR* |
| Upstream Signal | | *0* | | | *1* | |

| **Minor Street** | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| Movement | 7 | 8 | 9 | 10 | 11 | 12 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *1025* | | *205* | *5* | | *65* |
| Peak-Hour Factor, PHF | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* |
| Hourly Flow Rate, HFR (veh/h) | *1025* | *0* | *205* | *5* | *0* | *65* |
| Percent Heavy Vehicles | *0* | *0* | *0* | *0* | *0* | *0* |
| Percent Grade (%) | | *0* | | | *0* | |
| Flared Approach | | *N* | | | *N* | |
| Storage | | *0* | | | *0* | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *1* | *0* | *1* | *1* | *0* | *1* |
| Configuration | *L* | | *R* | *L* | | *R* |

## Delay, Queue Length, and Level of Service

| Approach | Eastbound | Westbound | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|---|---|
| Movement | 1 | 4 | 7 | 8 | 9 | 10 | 11 | 12 |
| Lane Configuration | *LTR* | *L* | *L* | | *R* | *L* | | *R* |
| v (veh/h) | *0* | *10* | *1025* | | *205* | *5* | | *65* |
| C (m) (veh/h) | *706* | *1576* | *359* | | *1034* | *131* | | *524* |
| v/c | *0.00* | *0.01* | *2.86* | | *0.20* | *0.04* | | *0.12* |
| 95% queue length | *0.00* | *0.02* | *87.64* | | *0.74* | *0.12* | | *0.42* |
| Control Delay (s/veh) | *10.1* | *7.3* | *865.0* | | *9.3* | *33.6* | | *12.8* |
| LOS | *B* | *A* | *F* | | *A* | *D* | | *B* |
| Approach Delay (s/veh) | -- | -- | *722.4* | | | *14.3* | | |
| Approach LOS | -- | -- | *F* | | | *B* | | |



*HCS+*™ Version 5.6

Generated: 1/18/2013 3:17 PM

# Appendix B – Capacity Calculations

## Peak PM Egress Design Hour Conditions

# HCM Analysis Summary

| | | |
|---|---|---|
| METRA Egress Capacity | /Main | Area Type: Non CBD |
| R Marvin | 01/05/2013 | Analysis Duration: 15 mins. |
| Peak PM 5-6 Design Event | Case: Main & 6th Exist PM Design Event | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 0 | 1 | | | | | | | | | | | | |
| WB | 3 | 3 | L | 12.0 | LT | 12.0 | TR | 12.0 | | | | | | |
| NB | 4 | 3 | L | 12.0 | T | 12.0 | T | 12.0 | T | 12.0 | | | | |
| SB | 2 | 3 | T | 12.0 | T | 12.0 | | | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 0 | 0 | 0 | 675 | 395 | 20 | 80 | 2460 | 0 | 0 | 890 | 0 |
| PHF | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 |
| % Heavy Vehicles | 2 | 2 | 2 | 1 | 1 | 0 | 1 | 4 | 2 | 2 | 4 | 2 |
| Lane Groups | | | | L | LTR | | L | T | | | T | |
| Arrival Type | | | | 3 | 3 | | 4 | 4 | | | 4 | |
| RTOR Vol (vph) | 0 | | | 0 | | | 0 | | | 0 | | |
| Peds/Hour | 5 | | | 0 | | | 5 | | | 0 | | |
| % Grade | 0 | | | 0 | | | 0 | | | 0 | | |
| Buses/Hour | 0 | | | 0 | | | 0 | | | 0 | | |
| Parkers/Hour (Left\|Right) | --- | --- | | --- | --- | | --- | --- | | --- | --- | |

Signal Settings: Actuated  Operational Analysis  Cycle Length: 150.0 Sec  Lost Time Per Cycle: 10.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | | | | | | | | | | | | | | | | | |
| WB | | LTR | | | | | | | | | | | | | | | | |
| NB | | | | LT | | T | | | | | | | | | | | | |
| SB | | | | | | T | | | | | | | | | | | | |
| Green | | 50.0 | | 16.0 | | 70.0 | | | | | | | | | | | | 0 |
| Yellow | All Red | 3.5 | 1.5 | 3.0 | 1.0 | 3.5 | 1.5 | | | | | | | | | | | |

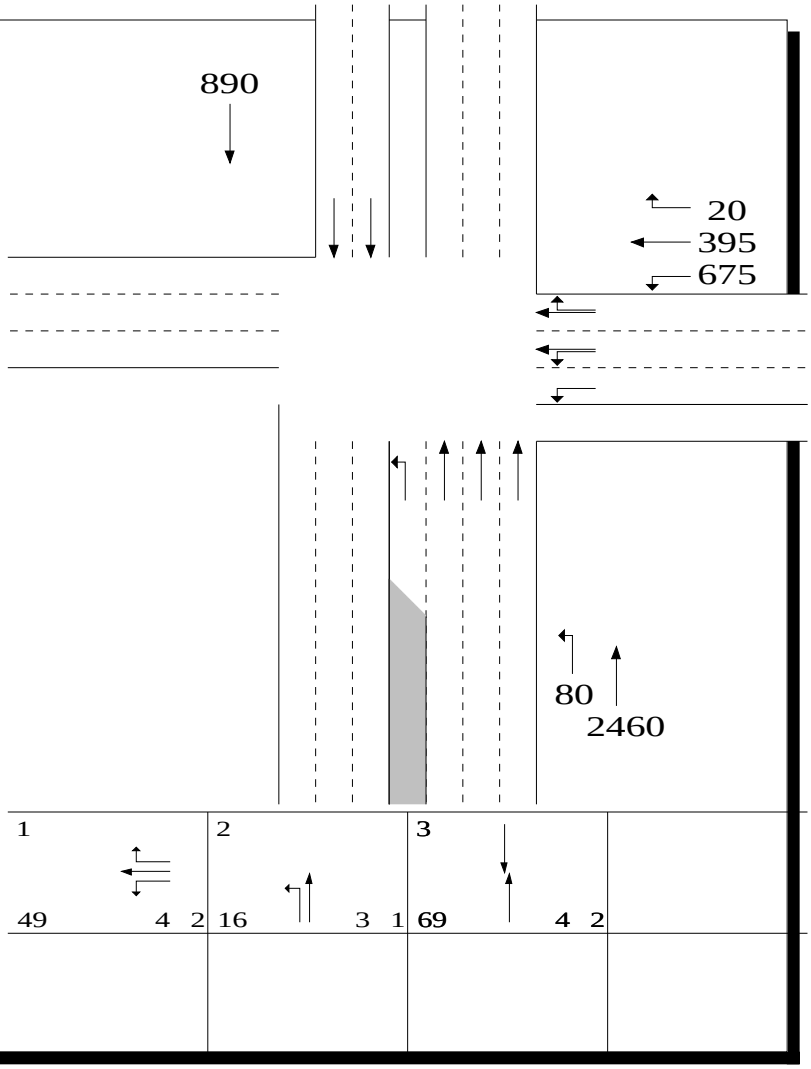
| | Capacity Analysis Results | | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| WB | | | | | | | | | | |
| | * L | 593 | 0.253 | 0.333 | L | 0.759 | 49.7 | D | 45.9 | D |
| | LTR | 1161 | 0.218 | 0.333 | LTR | 0.655 | 43.7 | D | | |
| NB | | | | | | | | | | |
| | L | 191 | 0.050 | 0.107 | L | 0.466 | 70.9 | E | 22.4 | C |
| | * T | 2993 | 0.548 | 0.600 | T | 0.913 | 20.8 | C | | |
| SB | | | | | | | | | | |
| | T | 1620 | 0.285 | 0.467 | T | 0.610 | 26.0 | C | 26.0 | C |

Intersection: Delay = 28.8 sec/veh  Int. LOS=C  $X_c$= 0.86  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.80

# NETSIM Summary Results

METRA Egress Capacity /Main
R Marvin 01/05/2013
Peak PM 5-6 Design Event Case: Main & 6th Exist PM Design Event

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | All | | 7.2 | 0.0 |
| WB | L | 15 / 15 | 6.1 | 0.0 |
| | LTR | 11 / 12 | 7.8 | 0.0 |
| | | | | |
| | All | | 9.6 | 0.0 |
| NB | L | 6 / 7 | 2.0 | 0.0 |
| | T | 18 / 22 | 10.4 | 0.0 |
| | | | | |
| | All | | 11.4 | 0.0 |
| | | | | |
| SB | T | 6 / 8 | 11.4 | 0.0 |
| | | | | |
| | | | | |
| Intersect. | | | 9.2 | |



# HCM Analysis Summary

| | | |
|---|---|---|
| METRA Egress Study | Airport Road/Main Street | Area Type: Non CBD |
| R Marvin | 10/12/2011 | Analysis Duration: 15 mins. |
| Peak 5 PM Design Event Hour | Case: Airport Main PM Design Event | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 3 | 1 | L | 12.0 | LT | 12.0 | R | 12.0 | | | | | | |
| WB | 2 | 2 | LT | 12.0 | R | 12.0 | | | | | | | | |
| NB | 4 | 3 | L | 12.0 | T | 12.0 | T | 12.0 | TR | 12.0 | | | | |
| SB | 4 | 3 | L | 12.0 | T | 12.0 | T | 12.0 | TR | 12.0 | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 535 | 80 | 35 | 145 | 105 | 125 | 80 | 1935 | 5 | 30 | 990 | 290 |
| PHF | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 |
| % Heavy Vehicles | 2 | 0 | 4 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 2 | 1 |
| Lane Groups | L | LT | R | | LT | R | L | TR | | L | TR | |
| Arrival Type | 3 | 3 | 3 | | 3 | 3 | 5 | 5 | | 5 | 5 | |
| RTOR Vol (vph) | | 20 | | | 30 | | | 0 | | | 80 | |
| Peds/Hour | | 5 | | | 0 | | | 5 | | | 5 | |
| % Grade | | 0 | | | 0 | | | 0 | | | 0 | |
| Buses/Hour | | 0 | | | 0 | | | 0 | | | 0 | |
| Parkers/Hour (Left\|Right) | --- | --- | | --- | --- | | --- | --- | | --- | --- | |

Signal Settings: Actuated | Operational Analysis | Cycle Length: 150.0 Sec | Lost Time Per Cycle: 20.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | LTP | | | | R | | | | | | | | | | | | |
| WB | | | | LTP | | | | | | | | | | | | | | |
| NB | | | | | | LTP | | TP | | | | | | | | | | |
| SB | | | | | | | | TP | | LTR | | | | | | | | |
| Green | | 30.0 | | 24.0 | | 12.0 | | 55.0 | | 6.0 | | | | | | | | 0 |
| Yellow | All Red | 3.5 | 1.5 | 3.5 | 1.5 | 3.0 | 0.0 | 3.5 | 1.5 | 3.5 | 1.5 | | | | | | | |

| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | * L | 354 | 0.231 | 0.200 | L | 1.153 | 156.1 | F | 117.7 | F |
| | LT | 361 | 0.140 | 0.200 | LT | 0.701 | 60.9 | E | | |
| | R | 464 | 0.010 | 0.300 | R | 0.034 | 37.1 | D | | |
| | | | | | | | | | | |
| WB | | | | | | | | | | |
| | | | | | | | | | | |
| | * LT | 295 | 0.146 | 0.160 | LT | 0.912 | 92.0 | F | 82.4 | F |
| | R | 258 | 0.063 | 0.160 | R | 0.395 | 56.9 | E | | |
| | | | | | | | | | | |
| NB | | | | | | | | | | |
| | L | 142 | 0.049 | 0.080 | L | 0.606 | 80.5 | F | 22.5 | C |
| | * TR | 2372 | 0.410 | 0.467 | TR | 0.879 | 20.1 | C | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| SB | | | | | | | | | | |
| | * L | 72 | 0.018 | 0.040 | L | 0.444 | 87.0 | F | 18.0 | B |
| | TR | 2178 | 0.261 | 0.440 | TR | 0.593 | 16.3 | B | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

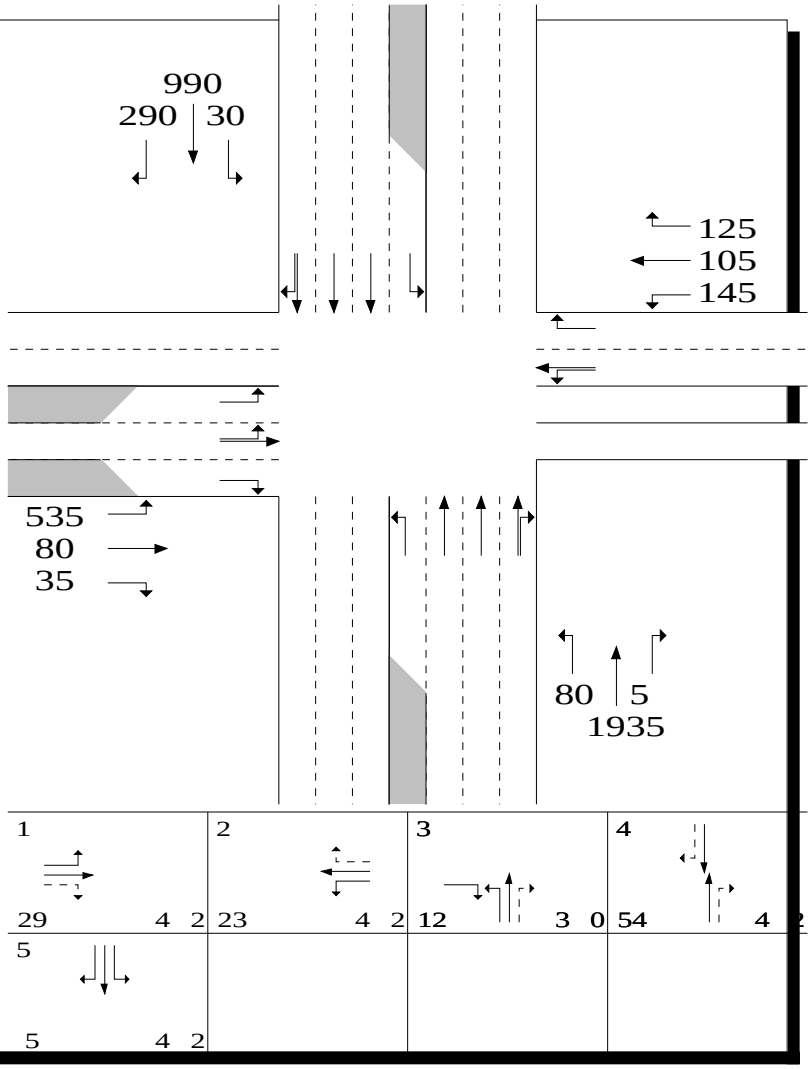
Intersection: Delay = 40.3 sec/veh  Int. LOS=D  $X_c$= 0.93  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.80

# NETSIM Summary Results

METRA Egress Study
R Marvin
Peak 5 PM Design Event Hour

Airport Road/Main Street
10/12/2011
Case: Airport Main PM Design Event

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 12 / 13 | 4.6 | 0.0 |
| | LT | 11 / 12 | 6.5 | 0.0 |
| | R | 1 / 1 | 23.3 | 0.0 |
| | All | | 5.7 | 0.0 |
| | | | | |
| WB | LT | 9 / 14 | 5.4 | 0.0 |
| | R | 4 / 7 | 10.4 | 0.0 |
| | All | | 6.6 | 0.0 |
| NB | L | 4 / 6 | 3.7 | 0.0 |
| | TR | 5 / 10 | 14.1 | 0.0 |
| | | | | |
| | All | | 12.8 | 0.0 |
| SB | L | 3 / 4 | 5.8 | 0.0 |
| | TR | 0 / 3 | 24.8 | 0.0 |
| | | | | |
| | All | | 22.6 | 0.0 |
| Intersect. | | | 11.3 | |



# HCM Analysis Summary

| | | |
|---|---|---|
| 4th Ave N & Main Existing | 4th Ave N/Main St | Area Type: Non CBD |
| R Marvin | 01/23/2013 | Analysis Duration: 15 mins. |
| Peak PM Design | Case: 4th Avenue Existing Peak PM Design | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 4 | 2 | L | 12.0 | L | 12.0 | LT | 12.0 | R | 12.0 | | | | |
| WB | 0 | 0 | | | | | | | | | | | | |
| NB | 3 | 3 | T | 12.0 | T | 12.0 | TR | 12.0 | | | | | | |
| SB | 4 | 3 | L | 12.0 | T | 12.0 | T | 12.0 | T | 12.0 | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 1415 | 5 | 180 | 0 | 0 | 0 | 0 | 1705 | 5 | 1 | 1565 | 0 |
| PHF | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 |
| % Heavy Vehicles | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 4 | 1 | 2 | 4 | 2 |
| Lane Groups | L | LT | R | | | | | TR | | L | T | |
| Arrival Type | 3 | 3 | 3 | | | | | 4 | | 3 | 4 | |
| RTOR Vol (vph) | | 80 | | | 0 | | | 0 | | | 0 | |
| Peds/Hour | | 5 | | | 0 | | | 5 | | | 5 | |
| % Grade | | 0 | | | 0 | | | 0 | | | 0 | |
| Buses/Hour | | 0 | | | 0 | | | 0 | | | 0 | |
| Parkers/Hour (Left\|Right) | --- | --- | | --- | --- | | --- | --- | | --- | --- | |

Signal Settings: Actuated | Operational Analysis | Cycle Length: 150.0 Sec | Lost Time Per Cycle: 11.0 Sec

| Phase: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Ped Only |
|---|---|---|---|---|---|---|---|---|---|
| EB | LTP | | | | | | | | |
| WB | | | | | | | | | |
| NB | | TP | | | | | | | |
| SB | | LT | | | | | | | |
| Green | 75.0 | 64.0 | | | | | | | 0 |
| Yellow / All Red | 4.0 / 1.5 | 4.0 / 1.5 | | | | | | | |

| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | L | 1717 | 0.229 | 0.500 | L | 0.458 | 24.4 | C | 33.7 | C |
| | * LT | 888 | 0.446 | 0.500 | LT | 0.892 | 44.8 | D | | |
| | R | 797 | 0.070 | 0.500 | R | 0.139 | 20.2 | C | | |
| NB | | | | | | | | | | |
| | * TR | 2127 | 0.381 | 0.427 | TR | 0.893 | 40.7 | D | 40.7 | D |
| SB | | | | | | | | | | |
| | L | 49 | 0.009 | 0.427 | L | 0.020 | 24.9 | C | 36.4 | D |
| | T | 2128 | 0.349 | 0.427 | T | 0.817 | 36.4 | D | | |

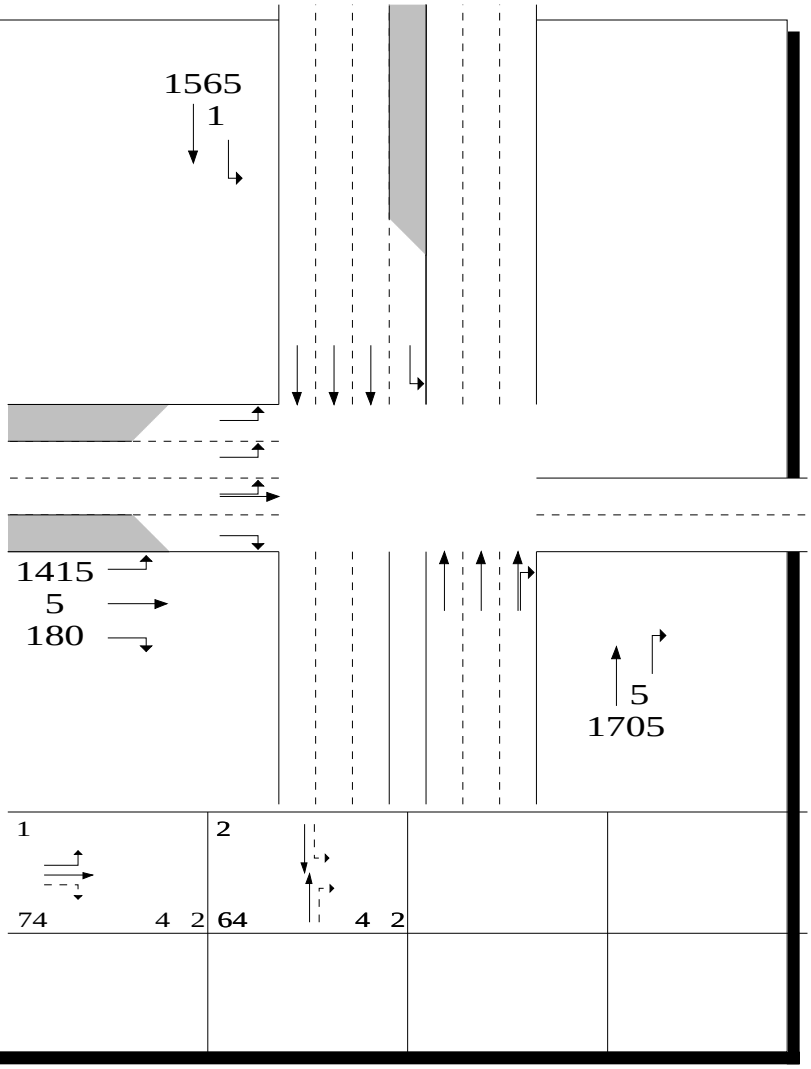
Intersection: Delay = 37.1 sec/veh  Int. LOS=D  $X_c$= 0.89  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.83

# NETSIM Summary Results

4th Ave N & Main Existing
R Marvin
Peak PM Design

4th Ave N/Main St
01/23/2013
Case: 4th Avenue Existing Peak PM Design

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 14 / 14 | 8.3 | 0.0 |
| | LT | 12 / 14 | 12.4 | 0.0 |
| | R | 3 / 5 | 12.0 | 0.0 |
| | All | | 9.8 | 0.0 |
| | | | | |
| | | | | |
| | | | | |
| | All | | 7.9 | 0.0 |
| | | | | |
| NB | TR | 12 / 16 | 7.9 | 0.0 |
| | | | | |
| | All | | 5.7 | 0.0 |
| SB | L | 0 / 0 | 0.0 | 0.0 |
| | T | 24 / 27 | 5.7 | 0.0 |
| | | | | |
| | | | | |
| Intersect. | | | 7.4 | |



# HCM Analysis Summary

| | | |
|---|---|---|
| METRA Egress Event | Airport Rd/Bench | Area Type: Non CBD |
| R Marvin | 01/07/2013 | Analysis Duration: 15 mins. |
| Peak PM Design | Case: Bench Airport Peak MPM Design | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 2 | 1 | L | 12.0 | TR | 12.0 | | | | | | | | |
| WB | 3 | 2 | L | 12.0 | T | 12.0 | TR | 12.0 | | | | | | |
| NB | 2 | 1 | L | 12.0 | TR | 12.0 | | | | | | | | |
| SB | 2 | 1 | L | 12.0 | TR | 12.0 | | | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 90 | 0 | 5 | 60 | 15 | 30 | 315 | 880 | 0 | 0 | 275 | 40 |
| PHF | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| % Heavy Vehicles | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 0 |
| Lane Groups | L | TR | | L | TR | | L | TR | | L | TR | |
| Arrival Type | 3 | 3 | | 3 | 3 | | 3 | 3 | | 3 | 3 | |
| RTOR Vol (vph) | 0 | | | 5 | | | 0 | | | 0 | | |
| Peds/Hour | 5 | | | 5 | | | 5 | | | 5 | | |
| % Grade | 0 | | | 0 | | | 0 | | | 0 | | |
| Buses/Hour | 0 | | | 0 | | | 0 | | | 0 | | |
| Parkers/Hour (Left\|Right) | --- | --- | | --- | --- | | --- | --- | | --- | --- | |

Signal Settings: Actuated | Operational Analysis | Cycle Length: 110.0 Sec | Lost Time Per Cycle: 14.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | L | | TP | | | | | | | | | | | | | | |
| WB | | L | | TP | | | | | | | | | | | | | | |
| NB | | | | | | LTP | | LTP | | | | | | | | | | |
| SB | | | | | | | | LTP | | | | | | | | | | |
| Green | | 12.0 | | 12.0 | | 20.0 | | 48.0 | | | | | | | | | | 0 |
| Yellow | All Red | 3.0 | 1.0 | 3.5 | 1.5 | 3.0 | 1.0 | 3.5 | 1.5 | | | | | | | | | |

| | Capacity Analysis Results | | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | * L | 197 | 0.054 | 0.109 | L | 0.497 | 46.9 | D | 46.7 | D |
| | TR | 172 | 0.003 | 0.109 | TR | 0.029 | 43.8 | D | | |
| WB | | | | | | | | | | |
| | L | 197 | 0.036 | 0.109 | L | 0.330 | 45.6 | D | 45.1 | D |
| | * TR | 352 | 0.013 | 0.109 | TR | 0.122 | 44.3 | D | | |
| NB | Lper | 369 | 0.018 | 0.482 | | | | | 16.8 | B |
| | Lpro | 328 | 0.182 | 0.182 | L | 0.491 | 11.6 | B | | |
| | * TR | 1219 | 0.514 | 0.655 | TR | 0.785 | 18.6 | B | | |
| SB | | | | | | | | | | |
| | L | 829 | 0.000 | 0.436 | L | 0.000 | 0.0 | A | 23.2 | C |
| | TR | 797 | 0.187 | 0.436 | TR | 0.429 | 23.2 | C | | |

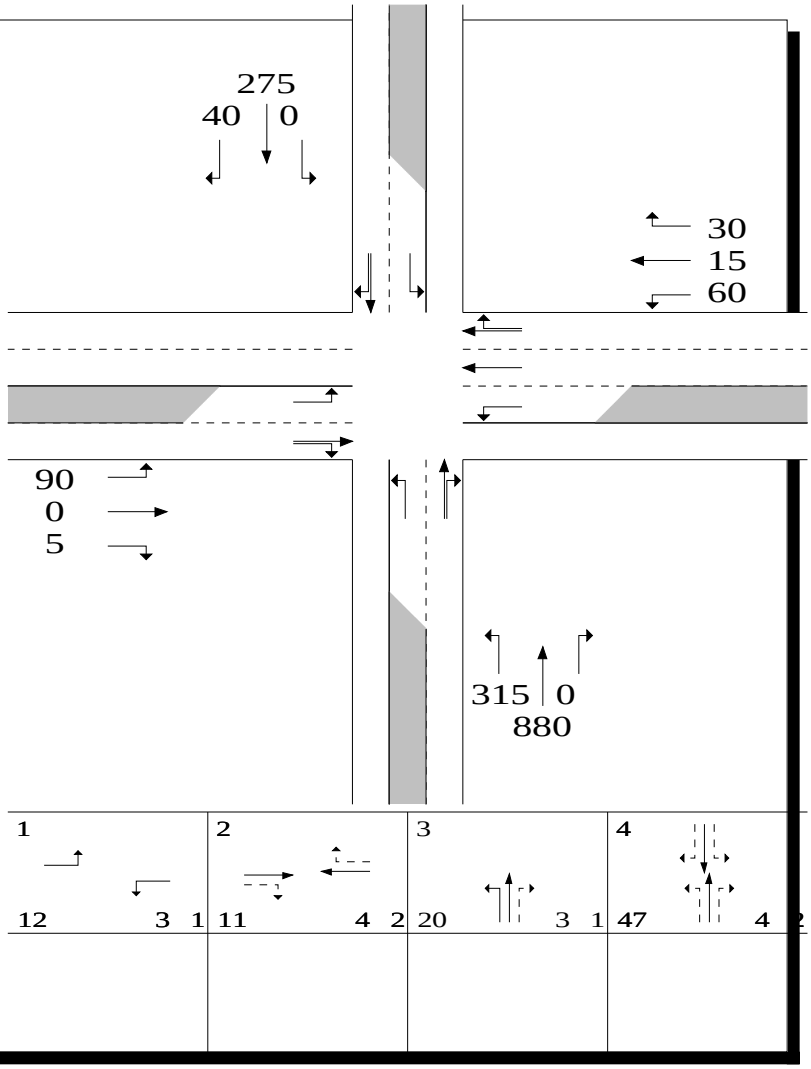
Intersection: Delay = 21.3 sec/veh  Int. LOS=C  $X_c$= 0.67  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.58

# NETSIM Summary Results

METRA Egress Event
R Marvin
Peak PM Design

Airport Rd/Bench
01/07/2013
Case: Bench Airport Peak MPM Design

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 3 / 3 | 4.2 | 0.0 |
| | TR | 0 / 0 | 26.6 | 0.0 |
| | | | | |
| | All | | 6.9 | 0.0 |
| WB | L | 2 / 3 | 4.0 | 0.0 |
| | TR | 1 / 2 | 18.0 | 0.0 |
| | | | | |
| | All | | 8.0 | 0.0 |
| NB | L | 5 / 7 | 9.1 | 0.0 |
| | TR | 12 / 17 | 13.5 | 0.0 |
| | | | | |
| | All | | 12.6 | 0.0 |
| SB | L | 0 / 0 | 0.0 | 0.0 |
| | TR | 6 / 7 | 11.5 | 0.0 |
| | | | | |
| | All | | 11.5 | 0.0 |
| Intersect. | | | 11.5 | |



# TWO-WAY STOP CONTROL SUMMARY

## General Information

| | |
|---|---|
| Analyst | *R Marvin* |
| Agency/Co. | *Marvin Associates* |
| Date Performed | *1/31/2013* |
| Analysis Time Period | *PM Design* |

## Site Information

| | |
|---|---|
| Intersection | *Bench & West Upper Access* |
| Jurisdiction | *Yellowstone* |
| Analysis Year | *2012 Design* |
| | |

Project Description *METRA Egress Study*

East/West Street: *West Upper Access* | North/South Street: *Bench Blvd*

Intersection Orientation: *North-South* | Study Period (hrs): *0.25*

## Vehicle Volumes and Adjustments

| **Major Street** | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| Movement | 1 | 2 | 3 | 4 | 5 | 6 |
| | L | T | R | L | T | R |
| Volume (veh/h) | | *1110* | *0* | *0* | *340* | |
| Peak-Hour Factor, PHF | *1.00* | *0.95* | *0.95* | *0.95* | *0.95* | *1.00* |
| Hourly Flow Rate, HFR (veh/h) | *0* | *1168* | *0* | *0* | *357* | *0* |
| Percent Heavy Vehicles | *0* | -- | -- | *0* | -- | -- |
| Median Type | *Undivided* | | | | | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *0* | *1* | *0* | *1* | *1* | *0* |
| Configuration | | | *TR* | *L* | *T* | |
| Upstream Signal | | *0* | | | *1* | |

| **Minor Street** | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| Movement | 7 | 8 | 9 | 10 | 11 | 12 |
| | L | T | R | L | T | R |
| Volume (veh/h) | | | | *75* | | *80* |
| Peak-Hour Factor, PHF | *1.00* | *1.00* | *1.00* | *0.95* | *1.00* | *0.95* |
| Hourly Flow Rate, HFR (veh/h) | *0* | *0* | *0* | *78* | *0* | *84* |
| Percent Heavy Vehicles | *0* | *0* | *0* | *0* | *0* | *0* |
| Percent Grade (%) | | *0* | | | *0* | |
| Flared Approach | | *N* | | | *N* | |
| Storage | | *0* | | | *0* | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *0* | *0* | *0* | *1* | *0* | *1* |
| Configuration | | | | *L* | | *R* |

## Delay, Queue Length, and Level of Service

| Approach | Northbound | Southbound | Westbound | | | Eastbound | | |
|---|---|---|---|---|---|---|---|---|
| Movement | 1 | 4 | 7 | 8 | 9 | 10 | 11 | 12 |
| Lane Configuration | | *L* | *L* | | *R* | | | |
| v (veh/h) | | *0* | *78* | | *84* | | | |
| C (m) (veh/h) | | *600* | *108* | | *235* | | | |
| v/c | | *0.00* | *0.72* | | *0.36* | | | |
| 95% queue length | | *0.00* | *3.85* | | *1.54* | | | |
| Control Delay (s/veh) | | *11.0* | *97.2* | | *28.6* | | | |
| LOS | | *B* | *F* | | *D* | | | |
| Approach Delay (s/veh) | -- | -- | *61.7* | | | | | |
| Approach LOS | -- | -- | *F* | | | | | |



*HCS+*™ Version 5.6

Generated: 1/31/2013 4:26 PM

# TWO-WAY STOP CONTROL SUMMARY

## General Information

| | |
|---|---|
| Analyst | *R Marvin* |
| Agency/Co. | *Marvin & Associates* |
| Date Performed | *1/18/2013* |
| Analysis Time Period | *Peak PM Hour Event* |

## Site Information

| | |
|---|---|
| Intersection | *Lower Lot Access & Bench* |
| Jurisdiction | *Yelloewstone County* |
| Analysis Year | *2013* |
| | |

Project Description *METRA Egress Study*

East/West Street: *Bench Boulevard* | North/South Street: *Lower Lot Access*

Intersection Orientation: *East-West* | Study Period (hrs): *0.25*

## Vehicle Volumes and Adjustments

| **Major Street** | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| Movement | 1 | 2 | 3 | 4 | 5 | 6 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *0* | *580* | *0* | *0* | *495* | *0* |
| Peak-Hour Factor, PHF | *1.00* | *0.95* | *1.00* | *1.00* | *1.00* | *1.00* |
| Hourly Flow Rate, HFR (veh/h) | *0* | *610* | *0* | *0* | *495* | *0* |
| Percent Heavy Vehicles | *0* | -- | -- | *0* | -- | -- |
| Median Type | *Undivided* | | | | | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *0* | *1* | *0* | *1* | *2* | *0* |
| Configuration | *LTR* | | | *L* | *T* | *TR* |
| Upstream Signal | | *0* | | | *1* | |

| **Minor Street** | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| Movement | 7 | 8 | 9 | 10 | 11 | 12 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *550* | | *450* | *0* | | *40* |
| Peak-Hour Factor, PHF | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* |
| Hourly Flow Rate, HFR (veh/h) | *550* | *0* | *450* | *0* | *0* | *40* |
| Percent Heavy Vehicles | *0* | *0* | *0* | *0* | *0* | *0* |
| Percent Grade (%) | | *0* | | | *0* | |
| Flared Approach | | *N* | | | *N* | |
| Storage | | *0* | | | *0* | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *1* | *0* | *1* | *1* | *0* | *1* |
| Configuration | *L* | | *R* | *L* | | *R* |

## Delay, Queue Length, and Level of Service

| Approach | Eastbound | Westbound | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|---|---|
| Movement | 1 | 4 | 7 | 8 | 9 | 10 | 11 | 12 |
| Lane Configuration | *LTR* | *L* | *L* | | *R* | *L* | | *R* |
| v (veh/h) | *0* | *0* | *550* | | *450* | *0* | | *40* |
| C (m) (veh/h) | *1013* | *979* | *230* | | *498* | *11* | | *689* |
| v/c | *0.00* | *0.00* | *2.39* | | *0.90* | *0.00* | | *0.06* |
| 95% queue length | *0.00* | *0.00* | *44.62* | | *10.33* | *0.00* | | *0.18* |
| Control Delay (s/veh) | *8.6* | *8.7* | *672.6* | | *48.9* | *332.3* | | *10.5* |
| LOS | *A* | *A* | *F* | | *E* | *F* | | *B* |
| Approach Delay (s/veh) | -- | -- | *391.9* | | | *10.5* | | |
| Approach LOS | -- | -- | *F* | | | *B* | | |



*HCS+*™ Version 5.6

Generated: 1/31/2013 3:08 PM

# Appendix B - Capacity Calculations

## Evening Event Egress Design Hour Conditions

# HCM Analysis Summary

| | | |
|---|---|---|
| METRA Egress Capacity | /Main | Area Type: Non CBD |
| R Marvin | 01/05/2013 | Analysis Duration: 15 mins. |
| Evening Design Event | Case: Main & 6th Exist Evening Design Event | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 0 | 1 | | | | | | | | | | | | |
| WB | 3 | 3 | L | 12.0 | LT | 12.0 | TR | 12.0 | | | | | | |
| NB | 4 | 3 | L | 12.0 | T | 12.0 | T | 12.0 | T | 12.0 | | | | |
| SB | 2 | 3 | T | 12.0 | T | 12.0 | | | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 0 | 0 | 0 | 1000 | 550 | 35 | 35 | 805 | 0 | 0 | 515 | 0 |
| PHF | 0.90 | 0.90 | 0.90 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.90 | 0.90 | 0.92 | 0.90 |
| % Heavy Vehicles | 2 | 2 | 2 | 1 | 1 | 0 | 1 | 4 | 2 | 2 | 4 | 2 |
| Lane Groups | | | | L | LTR | | L | T | | | T | |
| Arrival Type | | | | 3 | 3 | | 4 | 4 | | | 4 | |
| RTOR Vol (vph) | | 0 | | | 15 | | | 0 | | | 0 | |
| Peds/Hour | | 5 | | | 0 | | | 5 | | | 0 | |
| % Grade | | 0 | | | 0 | | | 0 | | | 0 | |
| Buses/Hour | | 0 | | | 0 | | | 0 | | | 0 | |
| Parkers/Hour (Left\|Right) | --- | --- | | --- | --- | | --- | --- | | --- | --- | |

Signal Settings: Actuated  Operational Analysis  Cycle Length: 120.0 Sec  Lost Time Per Cycle: 14.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | | | | | | | | | | | | | | | | | |
| WB | | LTR | | | | | | | | | | | | | | | | |
| NB | | | | LT | | T | | | | | | | | | | | | |
| SB | | | | | | T | | | | | | | | | | | | |
| Green | | 54.0 | | 12.0 | | 40.0 | | | | | | | | | | | | 0 |
| Yellow | All Red | 3.5 | 1.5 | 3.0 | 1.0 | 3.5 | 1.5 | | | | | | | | | | | |

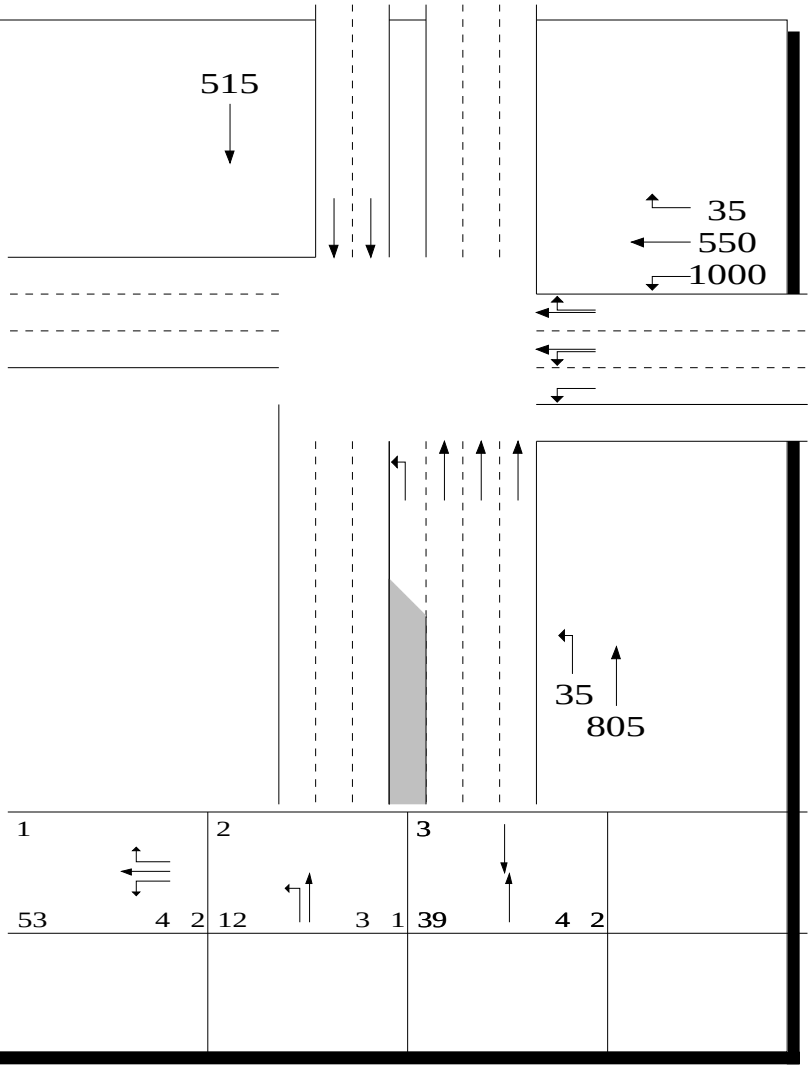
| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| WB | | | | | | | | | | |
| | * L | 801 | 0.427 | 0.450 | L | 0.950 | 52.1 | D | 37.3 | D |
| | LTR | 1574 | 0.271 | 0.450 | LTR | 0.601 | 25.3 | C | | |
| NB | | | | | | | | | | |
| | * L | 179 | 0.021 | 0.100 | L | 0.212 | 52.3 | D | 18.8 | B |
| | T | 2328 | 0.175 | 0.467 | T | 0.376 | 17.3 | B | | |
| SB | | | | | | | | | | |
| | * T | 1157 | 0.161 | 0.333 | T | 0.484 | 31.9 | C | 31.9 | C |

Intersection: Delay = 31.0 sec/veh  Int. LOS=C  $X_c$= 0.69  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.61

# NETSIM Summary Results

METRA Egress Capacity /Main
R Marvin 01/05/2013
Evening Design Event Case: Main & 6th Exist Evening Design Event

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | All | | 9.3 | 0.0 |
| WB | L | 15 / 18 | 7.8 | 0.0 |
| | LTR | 12 / 13 | 10.2 | 0.0 |
| | | | | |
| | All | | 7.6 | 0.0 |
| NB | L | 2 / 4 | 6.6 | 0.0 |
| | T | 10 / 11 | 7.6 | 0.0 |
| | | | | |
| | All | | 15.2 | 0.0 |
| | | | | |
| SB | T | 2 / 3 | 15.2 | 0.0 |
| | | | | |
| | | | | |
| Intersect. | | | 9.2 | |



# HCM Analysis Summary

| | | |
|---|---|---|
| 4th Ave N & Main Existing | 4th Ave N/Main St | Area Type: Non CBD |
| R Marvin | 01/23/2013 | Analysis Duration: 15 mins. |
| Evening Event Design | Case: 4th Avenue Existing Evening Design | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 4 | 2 | L | 12.0 | L | 12.0 | LT | 12.0 | R | 12.0 | | | | |
| WB | 0 | 0 | | | | | | | | | | | | |
| NB | 3 | 3 | T | 12.0 | T | 12.0 | TR | 12.0 | | | | | | |
| SB | 4 | 3 | L | 12.0 | T | 12.0 | T | 12.0 | T | 12.0 | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 390 | 0 | 50 | 0 | 0 | 0 | 0 | 610 | 1 | 2 | 1515 | 0 |
| PHF | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 |
| % Heavy Vehicles | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 4 | 1 | 2 | 4 | 2 |
| Lane Groups | L | LT | R | | | | | TR | | L | T | |
| Arrival Type | 3 | 3 | 3 | | | | | 4 | | 3 | 4 | |
| RTOR Vol (vph) | | 30 | | | 0 | | | 0 | | | 0 | |
| Peds/Hour | | 5 | | | 0 | | | 5 | | | 5 | |
| % Grade | | 0 | | | 0 | | | 0 | | | 0 | |
| Buses/Hour | | 0 | | | 0 | | | 0 | | | 0 | |
| Parkers/Hour (Left\|Right) | --- | --- | | --- | --- | | --- | --- | | --- | --- | |

Signal Settings: Actuated | Operational Analysis | Cycle Length: 110.0 Sec | Lost Time Per Cycle: 11.0 Sec

| Phase: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Ped Only |
|---|---|---|---|---|---|---|---|---|---|
| EB | LTP | | | | | | | | |
| WB | | | | | | | | | |
| NB | | TP | | | | | | | |
| SB | | LT | | | | | | | |
| Green | 35.0 | 64.0 | | | | | | | 0 |
| Yellow / All Red | 4.0 / 1.5 | 4.0 / 1.5 | | | | | | | |

| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | L | 1092 | 0.063 | 0.318 | L | 0.198 | 27.3 | C | 28.2 | C |
| | * LT | 564 | 0.122 | 0.318 | LT | 0.385 | 29.3 | C | | |
| | R | 506 | 0.014 | 0.318 | R | 0.043 | 25.9 | C | | |
| NB | | | | | | | | | | |
| | TR | 2901 | 0.136 | 0.582 | TR | 0.234 | 7.1 | A | 7.1 | A |
| SB | | | | | | | | | | |
| | L | 414 | 0.003 | 0.582 | L | 0.005 | 9.6 | A | 9.8 | A |
| | * T | 2902 | 0.337 | 0.582 | T | 0.580 | 9.8 | A | | |

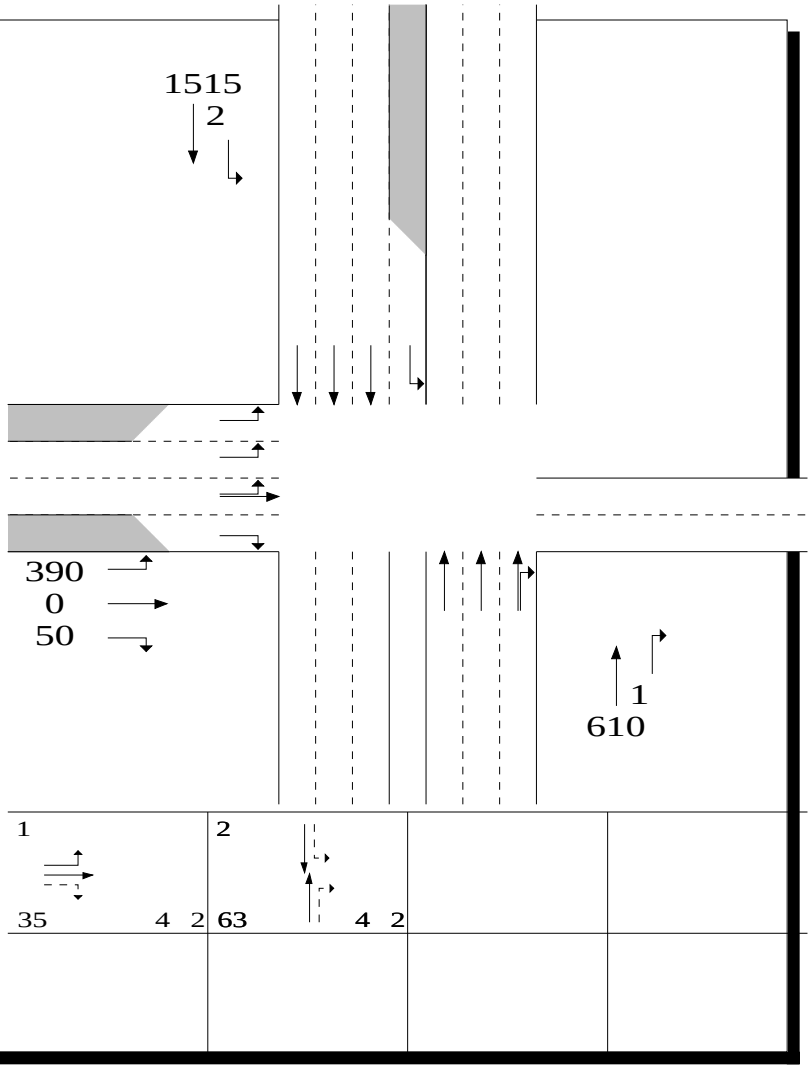
Intersection: Delay = 12.1 sec/veh  Int. LOS=B  $X_c$= 0.51  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.46

# NETSIM Summary Results

4th Ave N & Main Existing
R Marvin
Evening Event Design

4th Ave N/Main St
01/23/2013
Case: 4th Avenue Existing Evening Design

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 4 / 4 | 7.2 | 0.0 |
| | LT | 3 / 3 | 16.3 | 0.0 |
| | R | 1 / 2 | 13.2 | 0.0 |
| | All | | 10.3 | 0.0 |
| | | | | |
| | | | | |
| | | | | |
| | All | | 25.5 | 0.0 |
| | | | | |
| NB | TR | 0 / 0 | 25.5 | 0.0 |
| | | | | |
| | All | | 12.1 | 0.0 |
| SB | L | 0 / 0 | 0.0 | 0.0 |
| | T | 11 / 13 | 12.1 | 0.0 |
| | | | | |
| | | | | |
| Intersect. | | | 13.4 | |



# HCM Analysis Summary

| | | |
|---|---|---|
| METRA Egress Study | Airport Road/Main Street | Area Type: Non CBD |
| R Marvin | 10/12/2011 | Analysis Duration: 15 mins. |
| Evening Design Hour | Case: Airport Main Evening Design | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 3 | 1 | L | 12.0 | LT | 12.0 | R | 12.0 | | | | | | |
| WB | 2 | 2 | LT | 12.0 | R | 12.0 | | | | | | | | |
| NB | 4 | 3 | L | 12.0 | T | 12.0 | T | 12.0 | TR | 12.0 | | | | |
| SB | 4 | 3 | L | 12.0 | T | 12.0 | T | 12.0 | TR | 12.0 | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 195 | 20 | 30 | 250 | 170 | 200 | 30 | 495 | 0 | 5 | 410 | 110 |
| PHF | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| % Heavy Vehicles | 2 | 0 | 4 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 2 | 1 |
| Lane Groups | L | LT | R | | LT | R | L | TR | | L | TR | |
| Arrival Type | 3 | 3 | 3 | | 3 | 3 | 5 | 5 | | 5 | 5 | |
| RTOR Vol (vph) | | 20 | | | 50 | | | 0 | | | 20 | |
| Peds/Hour | | 5 | | | 0 | | | 5 | | | 5 | |
| % Grade | | 0 | | | 0 | | | 0 | | | 0 | |
| Buses/Hour | | 0 | | | 0 | | | 0 | | | 0 | |
| Parkers/Hour (Left\|Right) | --- | --- | | --- | --- | | --- | --- | | --- | --- | |

Signal Settings: Actuated  Operational Analysis  Cycle Length: 120.0 Sec  Lost Time Per Cycle: 18.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | LTP | | | | R | | | | | | | | | | | | |
| WB | | | | LTP | | | | | | | | | | | | | | |
| NB | | | | | | LTP | | TP | | | | | | | | | | |
| SB | | | | | | | | TP | | LTR | | | | | | | | |
| Green | | 23.0 | | 40.0 | | 8.0 | | 20.0 | | 6.0 | | | | | | | | 0 |
| Yellow | All Red | 3.5 | 1.5 | 3.5 | 1.5 | 3.0 | 0.0 | 3.5 | 1.5 | 3.5 | 1.5 | | | | | | | |

| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | L | 339 | 0.058 | 0.192 | L | 0.301 | 41.8 | D | 41.6 | D |
| | * LT | 343 | 0.069 | 0.192 | LT | 0.362 | 42.4 | D | | |
| | R | 438 | 0.007 | 0.283 | R | 0.025 | 31.0 | C | | |
| WB | | | | | | | | | | |
| | * LT | 615 | 0.240 | 0.333 | LT | 0.719 | 38.6 | D | 36.2 | D |
| | R | 538 | 0.098 | 0.333 | R | 0.294 | 29.7 | C | | |
| NB | | | | | | | | | | |
| | * L | 118 | 0.018 | 0.067 | L | 0.271 | 56.3 | E | 30.7 | C |
| | TR | 1314 | 0.102 | 0.258 | TR | 0.396 | 29.1 | C | | |
| SB | | | | | | | | | | |
| | L | 90 | 0.003 | 0.050 | L | 0.056 | 53.6 | D | 29.6 | C |
| | * TR | 1277 | 0.107 | 0.258 | TR | 0.413 | 29.3 | C | | |

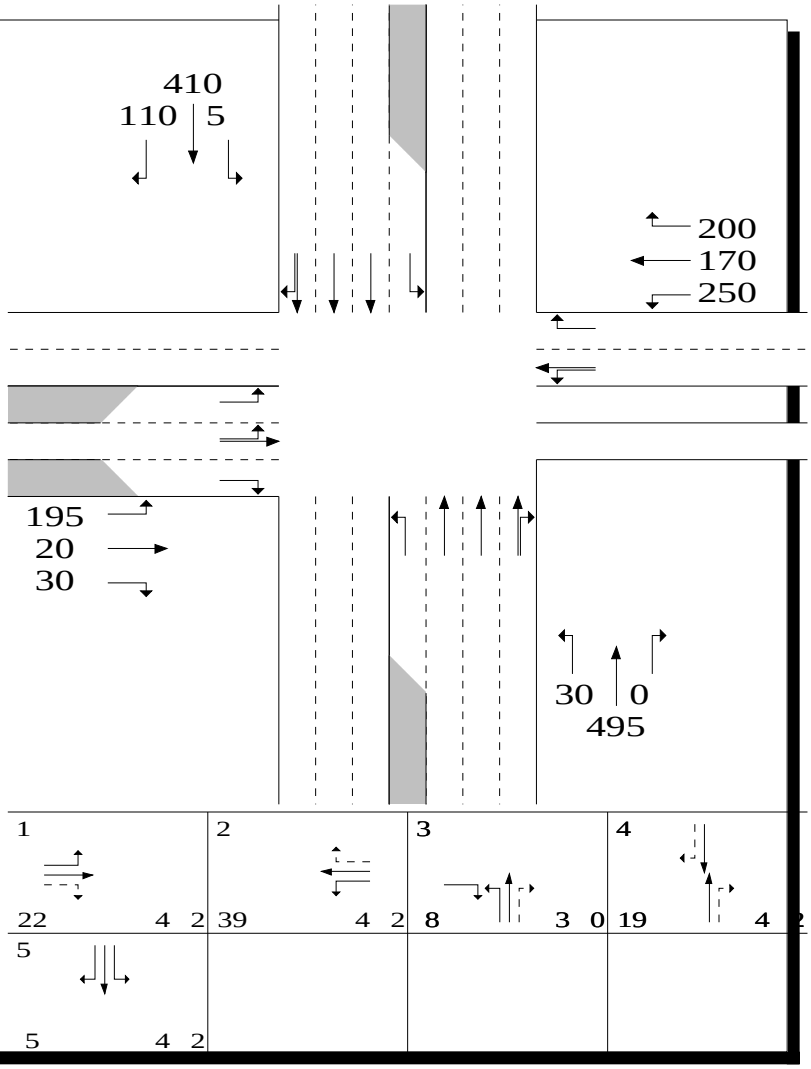
Intersection: Delay = 33.5 sec/veh  Int. LOS=C  $X_c$= 0.51  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.43

# NETSIM Summary Results

METRA Egress Study
R Marvin
Evening Design Hour

Airport Road/Main Street
10/12/2011
Case: Airport Main Evening Design

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 3 / 4 | 6.4 | 0.0 |
| | LT | 3 / 3 | 9.1 | 0.0 |
| | R | 1 / 1 | 22.4 | 0.0 |
| | All | | 8.3 | 0.0 |
| | | | | |
| WB | LT | 11 / 13 | 7.3 | 0.0 |
| | R | 1 / 2 | 21.7 | 0.0 |
| | All | | 9.2 | 0.0 |
| NB | L | 1 / 2 | 7.0 | 0.0 |
| | TR | 0 / 2 | 24.5 | 0.0 |
| | | | | |
| | All | | 20.3 | 0.0 |
| SB | L | 0 / 1 | 7.7 | 0.0 |
| | TR | 0 / 1 | 23.4 | 0.0 |
| | | | | |
| | All | | 22.7 | 0.0 |
| Intersect. | | | 13.3 | |



# HCM Analysis Summary

| | | |
|---|---|---|
| METRA Egress Event | Airport Rd/Bench | Area Type: Non CBD |
| R Marvin | 01/07/2013 | Analysis Duration: 15 mins. |
| Evening Hour Design | Case: Bench Airport Evening Design | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 2 | 1 | L | 12.0 | TR | 12.0 | | | | | | | | |
| WB | 3 | 2 | L | 12.0 | T | 12.0 | TR | 12.0 | | | | | | |
| NB | 2 | 1 | L | 12.0 | TR | 12.0 | | | | | | | | |
| SB | 2 | 1 | L | 12.0 | TR | 12.0 | | | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 20 | 0 | 1 | 215 | 430 | 380 | 165 | 360 | 0 | 0 | 90 | 20 |
| PHF | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| % Heavy Vehicles | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 0 |
| Lane Groups | L | TR | | L | TR | | L | TR | | L | TR | |
| Arrival Type | 3 | 3 | | 3 | 3 | | 3 | 3 | | 3 | 3 | |
| RTOR Vol (vph) | 0 | | | 70 | | | 0 | | | 0 | | |
| Peds/Hour | 5 | | | 5 | | | 5 | | | 5 | | |
| % Grade | 0 | | | 0 | | | 0 | | | 0 | | |
| Buses/Hour | 0 | | | 0 | | | 0 | | | 0 | | |
| Parkers/Hour (Left\|Right) | --- | --- | | --- | --- | | --- | --- | | --- | --- | |

Signal Settings: Actuated  Operational Analysis  Cycle Length: 110.0 Sec  Lost Time Per Cycle: 14.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | L | | TP | | | | | | | | | | | | | | |
| WB | | L | | TP | | | | | | | | | | | | | | |
| NB | | | | | | LTP | | LTP | | | | | | | | | | |
| SB | | | | | | | | LTP | | | | | | | | | | |
| Green | | 20.0 | | 30.0 | | 12.0 | | 30.0 | | | | | | | | | | 0 |
| Yellow | All Red | 3.0 | 1.0 | 3.5 | 1.5 | 3.0 | 1.0 | 3.5 | 1.5 | | | | | | | | | |

| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | L | 328 | 0.012 | 0.182 | L | 0.067 | 37.3 | D | 36.9 | D |
| | TR | 436 | 0.001 | 0.273 | TR | 0.002 | 29.1 | C | | |
| WB | | | | | | | | | | |
| | * L | 328 | 0.130 | 0.182 | L | 0.713 | 48.5 | D | 47.6 | D |
| | * TR | 919 | 0.239 | 0.273 | TR | 0.875 | 47.3 | D | | |
| NB | Lper | 343 | 0.000 | 0.318 | | | | | 24.6 | C |
| | Lpro | 197 | 0.099 | 0.109 | L | 0.331 | 21.8 | C | | |
| | * TR | 779 | 0.210 | 0.418 | TR | 0.502 | 25.9 | C | | |
| SB | | | | | | | | | | |
| | L | 518 | 0.000 | 0.273 | L | 0.000 | 0.0 | A | 32.3 | C |
| | TR | 494 | 0.066 | 0.273 | TR | 0.243 | 32.3 | C | | |

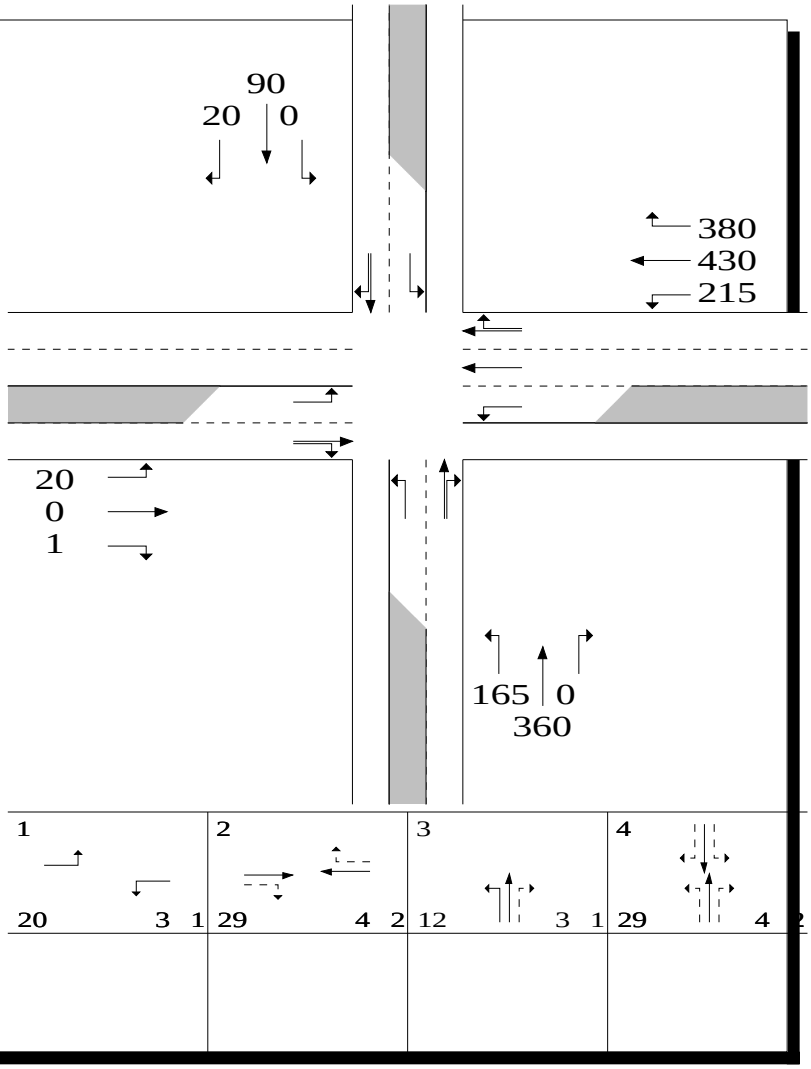
Intersection: Delay = 38.9 sec/veh  Int. LOS=D  $X_c$= 0.66  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.58

# NETSIM Summary Results

METRA Egress Event
R Marvin
Evening Hour Design

Airport Rd/Bench
01/07/2013
Case: Bench Airport Evening Design

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 1 / 1 | 5.8 | 0.0 |
| | TR | 0 / 0 | 28.7 | 0.0 |
| | | | | |
| | All | | 9.4 | 0.0 |
| WB | L | 6 / 7 | 4.7 | 0.0 |
| | TR | 9 / 14 | 8.7 | 0.0 |
| | | | | |
| | All | | 8.0 | 0.0 |
| NB | L | 3 / 8 | 6.0 | 0.0 |
| | TR | 7 / 11 | 12.4 | 0.0 |
| | | | | |
| | All | | 10.6 | 0.0 |
| SB | L | 0 / 0 | 0.0 | 0.0 |
| | TR | 2 / 3 | 10.5 | 0.0 |
| | | | | |
| | All | | 10.5 | 0.0 |
| Intersect. | | | 8.8 | |



# TWO-WAY STOP CONTROL SUMMARY

## General Information

| | |
|---|---|
| Analyst | *R Marvin* |
| Agency/Co. | *Marvin & Associates* |
| Date Performed | *1/18/2013* |
| Analysis Time Period | *Evening Hour Event* |

## Site Information

| | |
|---|---|
| Intersection | *Lower Lot Access & Bench* |
| Jurisdiction | *Yelloewstone County* |
| Analysis Year | *2013* |
| | |

Project Description *METRA Egress Study*

East/West Street: *Bench Boulevard* | North/South Street: *Lower Lot Access*

Intersection Orientation: *East-West* | Study Period (hrs): *0.25*

## Vehicle Volumes and Adjustments

| **Major Street** | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| Movement | 1 | 2 | 3 | 4 | 5 | 6 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *0* | *120* | *5* | *0* | *975* | *0* |
| Peak-Hour Factor, PHF | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* |
| Hourly Flow Rate, HFR (veh/h) | *0* | *120* | *5* | *0* | *975* | *0* |
| Percent Heavy Vehicles | *0* | -- | -- | *0* | -- | -- |
| Median Type | *Undivided* | | | | | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *0* | *1* | *0* | *1* | *2* | *0* |
| Configuration | *LTR* | | | *L* | *T* | *TR* |
| Upstream Signal | | *0* | | | *1* | |

| **Minor Street** | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| Movement | 7 | 8 | 9 | 10 | 11 | 12 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *530* | | *105* | *5* | | *80* |
| Peak-Hour Factor, PHF | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* |
| Hourly Flow Rate, HFR (veh/h) | *530* | *0* | *105* | *5* | *0* | *80* |
| Percent Heavy Vehicles | *0* | *0* | *0* | *0* | *0* | *0* |
| Percent Grade (%) | | *0* | | | *0* | |
| Flared Approach | | *N* | | | *N* | |
| Storage | | *0* | | | *0* | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *1* | *0* | *1* | *1* | *0* | *1* |
| Configuration | *L* | | *R* | *L* | | *R* |

## Delay, Queue Length, and Level of Service

| Approach | Eastbound | Westbound | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|---|---|
| Movement | 1 | 4 | 7 | 8 | 9 | 10 | 11 | 12 |
| Lane Configuration | *LTR* | *L* | *L* | | *R* | *L* | | *R* |
| v (veh/h) | *0* | *0* | *530* | | *105* | *5* | | *80* |
| C (m) (veh/h) | *687* | *1474* | *308* | | *935* | *134* | | *513* |
| v/c | *0.00* | *0.00* | *1.72* | | *0.11* | *0.04* | | *0.16* |
| 95% queue length | *0.00* | *0.00* | *33.66* | | *0.38* | *0.12* | | *0.55* |
| Control Delay (s/veh) | *10.2* | *7.4* | *366.9* | | *9.3* | *32.9* | | *13.3* |
| LOS | *B* | *A* | *F* | | *A* | *D* | | *B* |
| Approach Delay (s/veh) | -- | -- | *307.8* | | | *14.5* | | |
| Approach LOS | -- | -- | *F* | | | *B* | | |

# TWO-WAY STOP CONTROL SUMMARY

## General Information

| | |
|---|---|
| Analyst | *R Marvin* |
| Agency/Co. | *Marvin Associates* |
| Date Performed | *1/31/2013* |
| Analysis Time Period | *Evening Event Design* |

## Site Information

| | |
|---|---|
| Intersection | *Bench & West Upper Access* |
| Jurisdiction | *Yellowstone* |
| Analysis Year | *2012 Design* |
| | |

Project Description *METRA Egress Study*

East/West Street: *West Upper Access* | North/South Street: *Bench Blvd*

Intersection Orientation: *North-South* | Study Period (hrs): *0.25*

## Vehicle Volumes and Adjustments

| **Major Street** | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| Movement | 1 | 2 | 3 | 4 | 5 | 6 |
| | L | T | R | L | T | R |
| Volume (veh/h) | | *330* | *0* | *0* | *305* | |
| Peak-Hour Factor, PHF | *1.00* | *0.95* | *0.95* | *0.95* | *0.95* | *1.00* |
| Hourly Flow Rate, HFR (veh/h) | *0* | *347* | *0* | *0* | *321* | *0* |
| Percent Heavy Vehicles | *0* | -- | -- | *0* | -- | -- |
| Median Type | *Undivided* | | | | | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *0* | *1* | *0* | *1* | *1* | *0* |
| Configuration | | | *TR* | *L* | *T* | |
| Upstream Signal | | *0* | | | *1* | |

| **Minor Street** | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| Movement | 7 | 8 | 9 | 10 | 11 | 12 |
| | L | T | R | L | T | R |
| Volume (veh/h) | | | | *571* | | *195* |
| Peak-Hour Factor, PHF | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* |
| Hourly Flow Rate, HFR (veh/h) | *0* | *0* | *0* | *571* | *0* | *195* |
| Percent Heavy Vehicles | *0* | *0* | *0* | *0* | *0* | *0* |
| Percent Grade (%) | | *0* | | | *0* | |
| Flared Approach | | *N* | | | *N* | |
| Storage | | *0* | | | *0* | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *0* | *0* | *0* | *1* | *0* | *1* |
| Configuration | | | | *L* | | *R* |

## Delay, Queue Length, and Level of Service

| Approach | Northbound | Southbound | Westbound | | | Eastbound | | |
|---|---|---|---|---|---|---|---|---|
| Movement | 1 | 4 | 7 | 8 | 9 | 10 | 11 | 12 |
| Lane Configuration | | *L* | *L* | | *R* | | | |
| v (veh/h) | | *0* | *571* | | *195* | | | |
| C (m) (veh/h) | | *1213* | *434* | | *693* | | | |
| v/c | | *0.00* | *1.32* | | *0.28* | | | |
| 95% queue length | | *0.00* | *25.52* | | *1.15* | | | |
| Control Delay (s/veh) | | *8.0* | *184.1* | | *12.2* | | | |
| LOS | | *A* | *F* | | *B* | | | |
| Approach Delay (s/veh) | -- | -- | *140.3* | | | | | |
| Approach LOS | -- | -- | *F* | | | | | |



*HCS+*™ Version 5.6

Generated: 1/31/2013 4:28 PM

# Appendix B – Capacity Calculations

## Peak PM Egress Design Hour with 4th Avenue N Exit

# HCM Analysis Summary

| | | |
|---|---|---|
| 4th Ave N Exit From METRA Opt 1 | 4th Ave N/Main St | Area Type: Non CBD |
| R Marvin | 01/23/2013 | Analysis Duration: 15 mins. |
| Peak PM Design | Case: 4TH EXIT ALT A OPT1 PM Design | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 4 | 0 | L | 12.0 | L | 12.0 | L | 12.0 | R | 12.0 | | | | |
| WB | 2 | 0 | L | 12.0 | L | 12.0 | | | | | | | | |
| NB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |
| SB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 1420 | 0 | 180 | 550 | 0 | 0 | 0 | 1710 | 0 | 0 | 1200 | 0 |
| PHF | 0.95 | 0.90 | 0.95 | 0.95 | 0.90 | 0.90 | 0.90 | 0.95 | 0.90 | 0.90 | 0.95 | 0.90 |
| % Heavy Vehicles | 1 | 2 | 1 | 0 | 2 | 2 | 2 | 4 | 2 | 2 | 4 | 2 |
| Lane Groups | L | | R | L | | | | T | | | T | |
| Arrival Type | 3 | | 3 | 3 | | | | 4 | | | 4 | |
| RTOR Vol (vph) | 80 | | | 0 | | | 0 | | | 0 | | |
| Peds/Hour | 5 | | | 0 | | | 5 | | | 5 | | |
| % Grade | 0 | | | 0 | | | 0 | | | 0 | | |
| Buses/Hour | 0 | | | 0 | | | 0 | | | 0 | | |
| Parkers/Hour (Left\|Right) | --- | --- | | --- | --- | | --- | --- | | --- | --- | |

Signal Settings: Actuated  Operational Analysis  Cycle Length: 150.0 Sec  Lost Time Per Cycle: 10.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | L P | | L | | | | | | | | | | | | | | |
| WB | | | | L | | | | | | | | | | | | | | |
| NB | | | | | | T | | | | | | | | | | | | |
| SB | | | | | | T | | | | | | | | | | | | |
| Green | | 35.0 | | 40.0 | | 60.0 | | | | | | | | | | | | 0 |
| Yellow | All Red | 3.5 | 1.5 | 3.5 | 1.5 | 3.5 | 1.5 | | | | | | | | | | | |

| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | * L | 2774 | 0.287 | 0.533 | L | 0.539 | 23.0 | C | 24.6 | C |
| | R | 371 | 0.066 | 0.233 | R | 0.283 | 47.4 | D | | |
| WB | | | | | | | | | | |
| | L | 934 | 0.165 | 0.267 | L | 0.620 | 49.3 | D | 49.3 | D |
| NB | | | | | | | | | | |
| | * T | 1995 | 0.361 | 0.400 | T | 0.902 | 45.0 | D | 45.0 | D |
| SB | | | | | | | | | | |
| | T | 1995 | 0.253 | 0.400 | T | 0.633 | 33.9 | C | 33.9 | C |

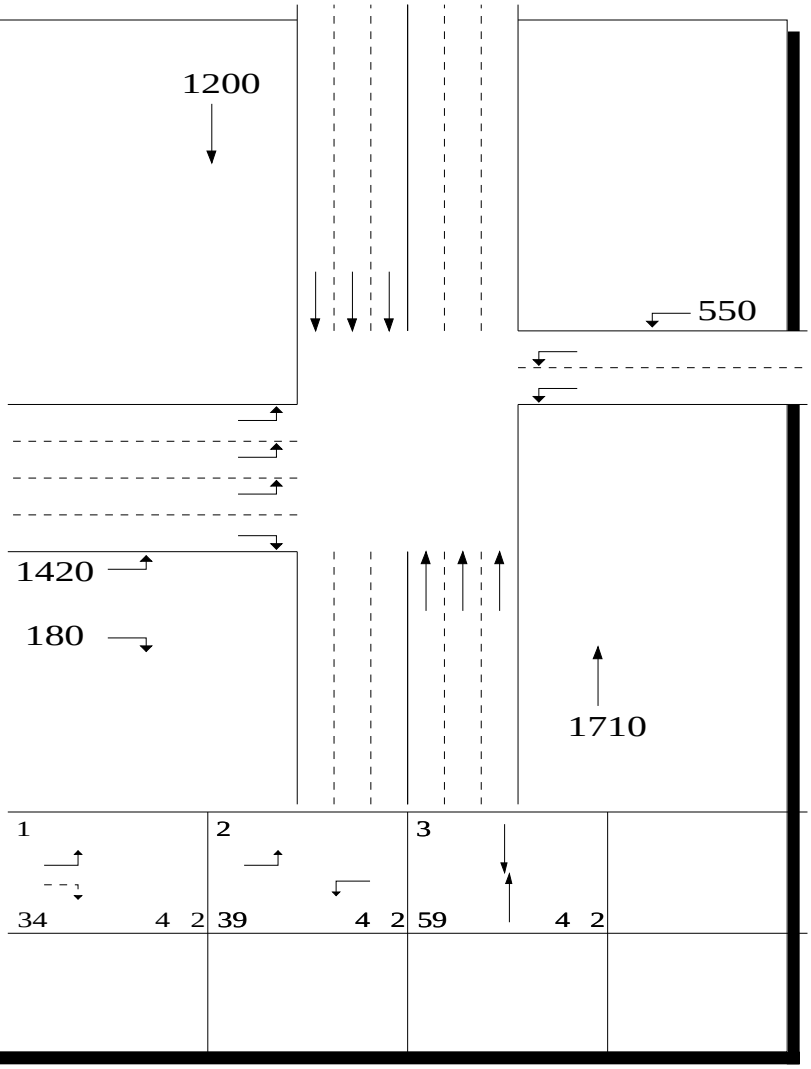
Intersection: Delay = 36.6 sec/veh  Int. LOS=D  $X_c$= 0.69  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.65

# NETSIM Summary Results

4th Ave N Exit From METRA Opt 1
R Marvin
Peak PM Design

4th Ave N/Main St
01/23/2013
Case: 4TH EXIT ALT A OPT1 PM Design

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 11 / 19 | 10.2 | 0.0 |
| | | | | |
| | R | 3 / 4 | 18.7 | 0.0 |
| | All | | 10.8 | 0.0 |
| WB | L | 9 / 12 | 6.4 | 0.0 |
| | | | | |
| | | | | |
| | All | | 6.4 | 0.0 |
| | | | | |
| NB | T | 12 / 15 | 7.3 | 0.0 |
| | | | | |
| | All | | 7.3 | 0.0 |
| | | | | |
| SB | T | 5 / 7 | 10.7 | 0.0 |
| | | | | |
| | All | | 10.7 | 0.0 |
| Intersect. | | | 8.7 | |



# HCM Analysis Summary

| | | |
|---|---|---|
| 4th Ave N Exit From METRA Opt 2 | 4th Ave N/Main St | Area Type: Non CBD |
| R Marvin | 01/23/2013 | Analysis Duration: 15 mins. |
| Peak PM Design Hour | Case: 4TH EXIT ALT A OPT2 PM Design | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 4 | 0 | L | 12.0 | L | 12.0 | L | 12.0 | R | 12.0 | | | | |
| WB | 2 | 0 | L | 12.0 | L | 12.0 | | | | | | | | |
| NB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |
| SB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 1420 | 0 | 180 | 550 | 0 | 0 | 0 | 1710 | 0 | 0 | 1200 | 0 |
| PHF | 0.95 | 0.90 | 0.95 | 0.95 | 0.90 | 0.90 | 0.90 | 0.95 | 0.90 | 0.90 | 0.95 | 0.90 |
| % Heavy Vehicles | 1 | 2 | 1 | 0 | 2 | 2 | 2 | 4 | 2 | 2 | 4 | 2 |
| Lane Groups | L | | R | L | | | | T | | | T | |
| Arrival Type | 3 | | 3 | 3 | | | | 4 | | | 4 | |
| RTOR Vol (vph) | 80 | | | 0 | | | 0 | | | 0 | | |
| Peds/Hour | 5 | | | 0 | | | 5 | | | 5 | | |
| % Grade | 0 | | | 0 | | | 0 | | | 0 | | |
| Buses/Hour | 0 | | | 0 | | | 0 | | | 0 | | |
| Parkers/Hour (Left\|Right) | --- | | --- | --- | | --- | --- | | --- | --- | | --- |

Signal Settings: Actuated  Operational Analysis  Cycle Length: 150.0 Sec  Lost Time Per Cycle: 15.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | L P | | | | | | | | | | | | | | | | |
| WB | | | | L | | | | | | | | | | | | | | |
| NB | | | | | | T | | | | | | | | | | | | |
| SB | | | | | | T | | | | | | | | | | | | |
| Green | | 45.0 | | 30.0 | | 60.0 | | | | | | | | | | | | 0 |
| Yellow | All Red | 3.5 | 1.5 | 3.5 | 1.5 | 3.5 | 1.5 | | | | | | | | | | | |

| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | * L | 1560 | 0.287 | 0.300 | L | 0.958 | 65.6 | E | 63.9 | E |
| | R | 477 | 0.066 | 0.300 | R | 0.220 | 39.4 | D | | |
| WB | | | | | | | | | | |
| | * L | 700 | 0.165 | 0.200 | L | 0.827 | 65.2 | E | 65.2 | E |
| NB | | | | | | | | | | |
| | * T | 1995 | 0.361 | 0.400 | T | 0.902 | 45.0 | D | 45.0 | D |
| SB | | | | | | | | | | |
| | T | 1995 | 0.253 | 0.400 | T | 0.633 | 33.9 | C | 33.9 | C |

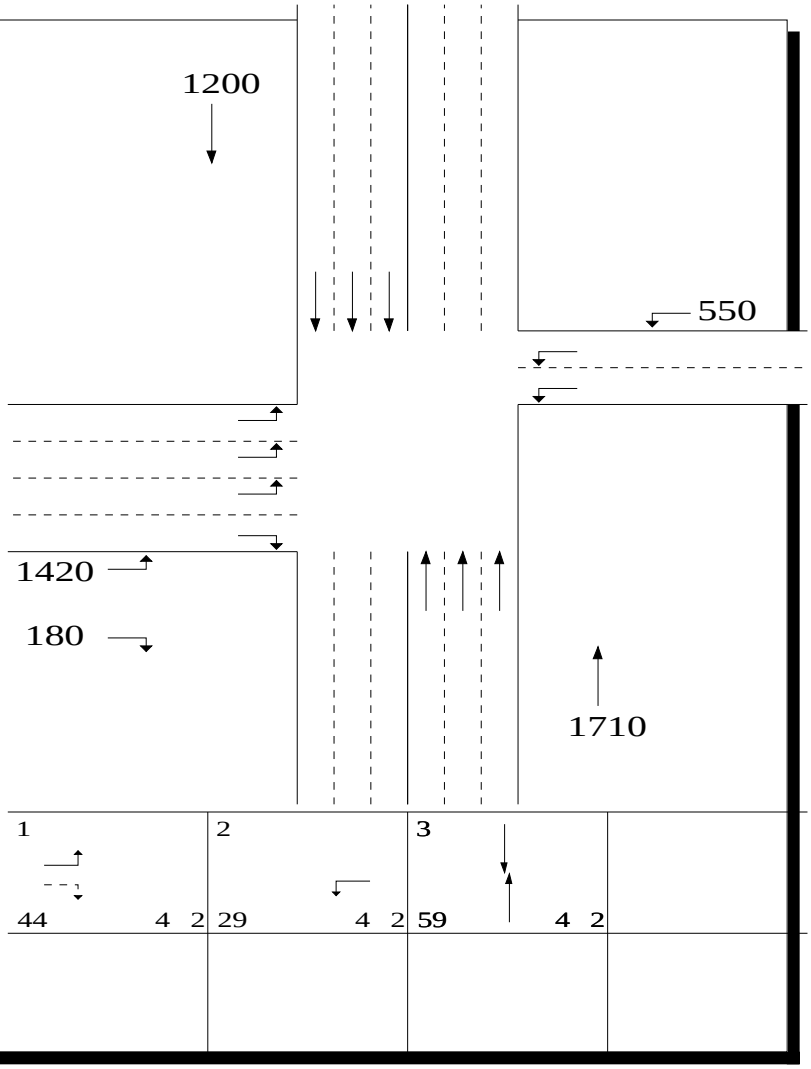
Intersection: Delay = 50.3 sec/veh  Int. LOS=D  $X_c$= 0.90  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.81

# NETSIM Summary Results

4th Ave N Exit From METRA Opt 2
R Marvin
Peak PM Design Hour

4th Ave N/Main St
01/23/2013
Case: 4TH EXIT ALT A OPT2 PM Design

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 18 / 24 | 4.8 | 0.0 |
| | | | | |
| | R | 3 / 4 | 19.0 | 0.0 |
| | All | | 5.3 | 0.0 |
| WB | L | 10 / 14 | 5.6 | 0.0 |
| | | | | |
| | | | | |
| | All | | 5.6 | 0.0 |
| | | | | |
| NB | T | 12 / 15 | 7.2 | 0.0 |
| | | | | |
| | All | | 7.2 | 0.0 |
| | | | | |
| SB | T | 4 / 7 | 11.0 | 0.0 |
| | | | | |
| | All | | 11.0 | 0.0 |
| Intersect. | | | 6.8 | |



# HCM Analysis Summary

| | | |
|---|---|---|
| 4th Ave N Exit From METRA Alt B | 4th Ave N/Main St | Area Type: Non CBD |
| R Marvin | 01/23/2013 | Analysis Duration: 15 mins. |
| Peak PM Design | Case: 4TH EXIT ALT B PM Design | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 4 | 0 | L | 12.0 | L | 12.0 | L | 12.0 | R | 12.0 | | | | |
| WB | 2 | 0 | L | 12.0 | L | 12.0 | | | | | | | | |
| NB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |
| SB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 1420 | 0 | 180 | 550 | 0 | 0 | 0 | 1710 | 0 | 0 | 1200 | 0 |
| PHF | 0.95 | 0.90 | 0.95 | 0.95 | 0.90 | 0.90 | 0.90 | 0.95 | 0.90 | 0.90 | 0.95 | 0.90 |
| % Heavy Vehicles | 1 | 2 | 1 | 0 | 2 | 2 | 2 | 4 | 2 | 2 | 4 | 2 |
| Lane Groups | L | | R | L | | | | T | | | T | |
| Arrival Type | 3 | | 3 | 3 | | | | 4 | | | 4 | |
| RTOR Vol (vph) | 80 | | | 0 | | | 0 | | | 0 | | |
| Peds/Hour | 5 | | | 0 | | | 5 | | | 5 | | |
| % Grade | 0 | | | 0 | | | 0 | | | 0 | | |
| Buses/Hour | 0 | | | 0 | | | 0 | | | 0 | | |
| Parkers/Hour (Left\|Right) | --- | | --- | --- | | --- | --- | | --- | --- | | --- |

Signal Settings: Actuated  Operational Analysis  Cycle Length: 150.0 Sec  Lost Time Per Cycle: 10.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | L P | | | | | | | | | | | | | | | | |
| WB | | L | | | | | | | | | | | | | | | | |
| NB | | | | T | | | | | | | | | | | | | | |
| SB | | | | T | | | | | | | | | | | | | | |
| Green | | 65.0 | | 75.0 | | | | | | | | | | | | | | 0 |
| Yellow | All Red | 3.5 | 1.5 | 3.5 | 1.5 | | | | | | | | | | | | | |

| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | * L | 2254 | 0.287 | 0.433 | L | 0.663 | 34.4 | C | 33.8 | C |
| | R | 690 | 0.066 | 0.433 | R | 0.152 | 25.8 | C | | |
| WB | | | | | | | | | | |
| | L | 1518 | 0.165 | 0.433 | L | 0.381 | 28.9 | C | 28.9 | C |
| NB | | | | | | | | | | |
| | * T | 2494 | 0.361 | 0.500 | T | 0.722 | 24.3 | C | 24.3 | C |
| SB | | | | | | | | | | |
| | T | 2494 | 0.253 | 0.500 | T | 0.506 | 20.0 | B | 20.0 | B |

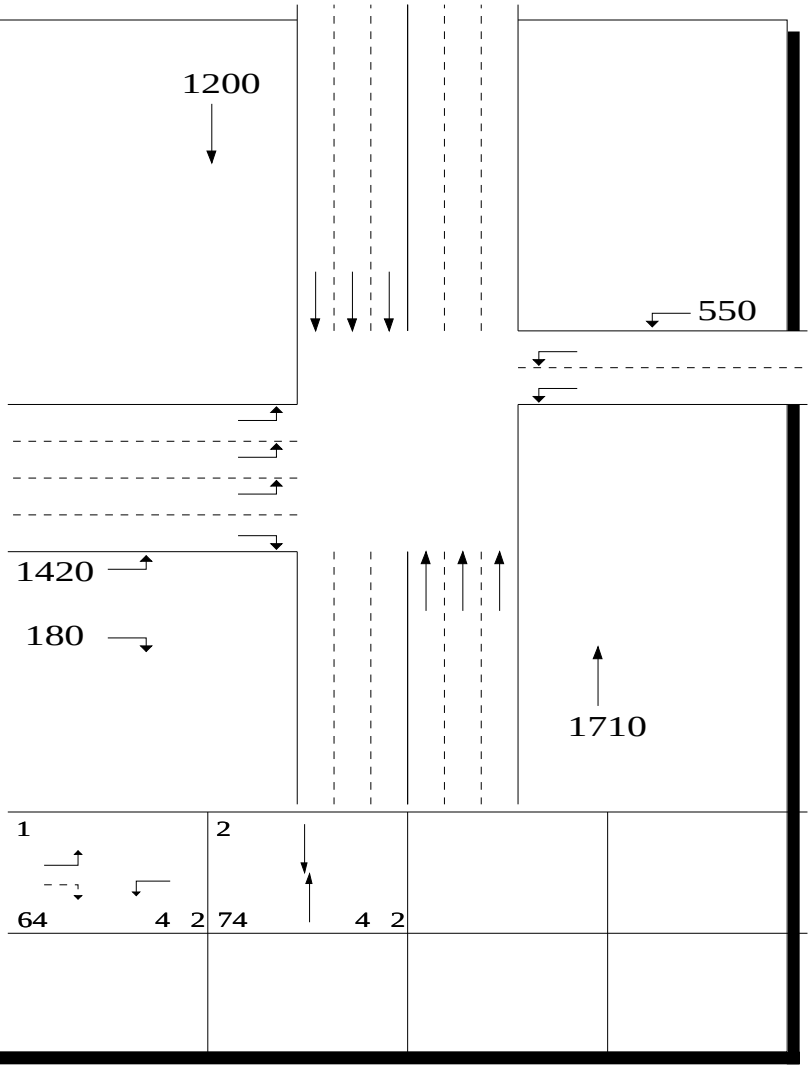
Intersection: Delay = 26.7 sec/veh  Int. LOS=C  $X_c$= 0.69  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.65

# NETSIM Summary Results

4th Ave N Exit From METRA Alt B
R Marvin
Peak PM Design

4th Ave N/Main St
01/23/2013
Case: 4TH EXIT ALT B PM Design

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 13 / 20 | 8.2 | 0.0 |
| | | | | |
| | R | 3 / 4 | 16.1 | 0.0 |
| | All | | 8.7 | 0.0 |
| WB | L | 8 / 13 | 9.4 | 0.0 |
| | | | | |
| | | | | |
| | All | | 9.4 | 0.0 |
| | | | | |
| NB | T | 10 / 14 | 9.3 | 0.0 |
| | | | | |
| | All | | 9.3 | 0.0 |
| | | | | |
| SB | T | 3 / 5 | 15.4 | 0.0 |
| | | | | |
| | All | | 15.4 | 0.0 |
| Intersect. | | | 10.0 | |



# HCM Analysis Summary

| | | |
|---|---|---|
| METRA Capacity with 4th Exit Alt | /Main | Area Type: Non CBD |
| R Marvin | 01/05/2013 | Analysis Duration: 15 mins. |
| Peak PM 5-6 Design Event | Case: Main & 6th PM Design Event w 4th Exit Alt | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 0 | 1 | | | | | | | | | | | | |
| WB | 3 | 3 | L | 12.0 | LT | 12.0 | TR | 12.0 | | | | | | |
| NB | 4 | 3 | L | 12.0 | T | 12.0 | T | 12.0 | T | 12.0 | | | | |
| SB | 2 | 3 | T | 12.0 | T | 12.0 | | | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 0 | 0 | 0 | 360 | 210 | 20 | 80 | 2460 | 0 | 0 | 840 | 0 |
| PHF | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 |
| % Heavy Vehicles | 2 | 2 | 2 | 1 | 1 | 0 | 1 | 4 | 2 | 2 | 4 | 2 |
| Lane Groups | | | | L | LTR | | L | T | | | T | |
| Arrival Type | | | | 3 | 3 | | 4 | 4 | | | 4 | |
| RTOR Vol (vph) | | 0 | | | 0 | | | 0 | | | 0 | |
| Peds/Hour | | 5 | | | 0 | | | 5 | | | 0 | |
| % Grade | | 0 | | | 0 | | | 0 | | | 0 | |
| Buses/Hour | | 0 | | | 0 | | | 0 | | | 0 | |
| Parkers/Hour (Left\|Right) | --- | --- | | --- | --- | | --- | --- | | --- | --- | |

Signal Settings: Actuated  Operational Analysis  Cycle Length: 150.0 Sec  Lost Time Per Cycle: 10.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | | | | | | | | | | | | | | | | | |
| WB | | LTR | | | | | | | | | | | | | | | | |
| NB | | | | LT | | T | | | | | | | | | | | | |
| SB | | | | | | T | | | | | | | | | | | | |
| Green | | 45.0 | | 20.0 | | 71.0 | | | | | | | | | | | | 0 |
| Yellow | All Red | 3.5 | 1.5 | 3.0 | 1.0 | 3.5 | 1.5 | | | | | | | | | | | |

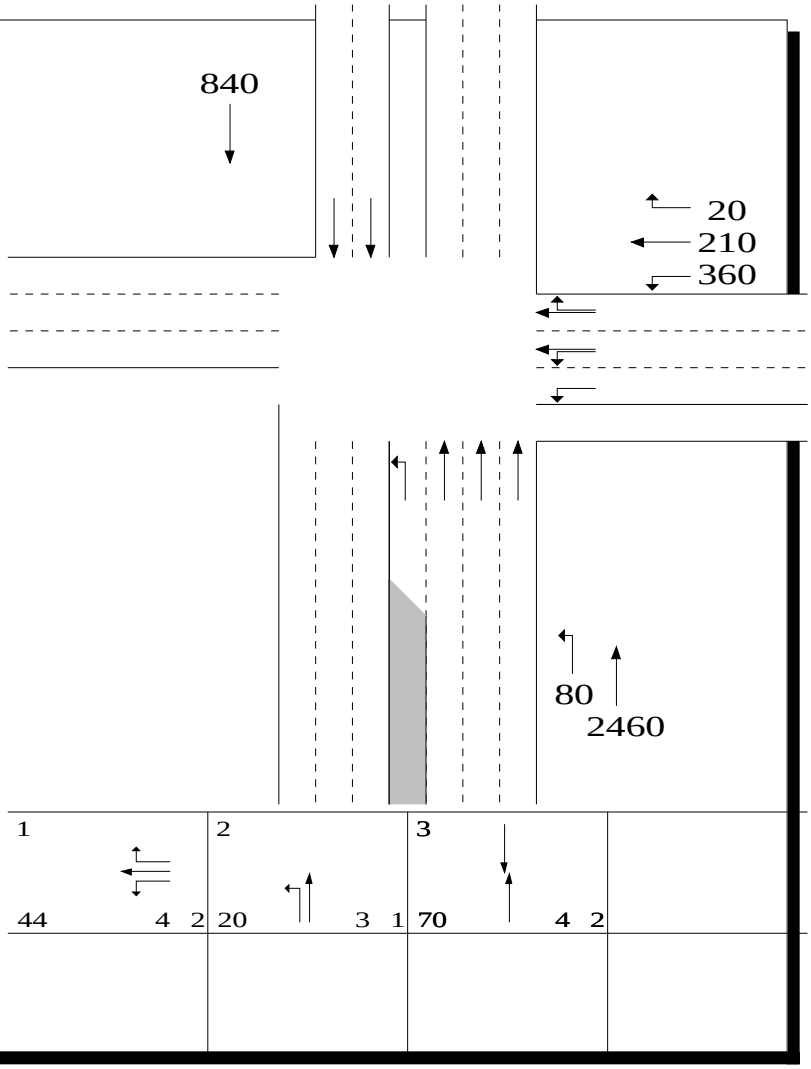
| Capacity Analysis Results | | | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| WB | | | | | | | | | | |
| | * L | 533 | 0.180 | 0.300 | L | 0.600 | 46.2 | D | 43.4 | D |
| | LTR | 1048 | 0.096 | 0.300 | LTR | 0.320 | 40.7 | D | | |
| NB | | | | | | | | | | |
| | L | 238 | 0.050 | 0.133 | L | 0.374 | 63.7 | E | 15.9 | B |
| | * T | 3159 | 0.548 | 0.633 | T | 0.865 | 14.4 | B | | |
| SB | | | | | | | | | | |
| | T | 1643 | 0.269 | 0.473 | T | 0.568 | 24.4 | C | 24.4 | C |

Intersection: Delay = 21.8 sec/veh  Int. LOS=C  $X_c$= 0.78  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.73

# NETSIM Summary Results

METRA Capacity with 4th Exit Alt /Main
R Marvin 01/05/2013
Peak PM 5-6 Design Event Case: Main & 6th PM Design Event w 4th Exit Alt

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | All | | 7.1 | 0.0 |
| WB | L | 8 / 8 | 5.7 | 0.0 |
| | LTR | 7 / 8 | 8.0 | 0.0 |
| | | | | |
| | All | | 10.6 | 0.0 |
| NB | L | 6 / 6 | 2.0 | 0.0 |
| | T | 17 / 19 | 11.5 | 0.0 |
| | | | | |
| | All | | 12.6 | 0.0 |
| | | | | |
| SB | T | 5 / 6 | 12.6 | 0.0 |
| | | | | |
| | | | | |
| Intersect. | | | 10.2 | |



# TWO-WAY STOP CONTROL SUMMARY

## General Information

| | |
|---|---|
| Analyst | *R Marvin* |
| Agency/Co. | *Marvin & Associates* |
| Date Performed | *1/18/2013* |
| Analysis Time Period | *PM Hour Event* |

## Site Information

| | |
|---|---|
| Intersection | *Lower Lot Bench 4th Exit Alt* |
| Jurisdiction | *Yellowstone County* |
| Analysis Year | *2013* |
| | |

Project Description *METRA Egress Study*

East/West Street: *Bench Boulevard* | North/South Street: *Lower Lot Access*

Intersection Orientation: *East-West* | Study Period (hrs): *0.25*

## Vehicle Volumes and Adjustments

| **Major Street** | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| Movement | 1 | 2 | 3 | 4 | 5 | 6 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *0* | *580* | *10* | *0* | *495* | *0* |
| Peak-Hour Factor, PHF | *1.00* | *0.95* | *1.00* | *1.00* | *1.00* | *1.00* |
| Hourly Flow Rate, HFR (veh/h) | *0* | *610* | *10* | *0* | *495* | *0* |
| Percent Heavy Vehicles | *0* | -- | -- | *0* | -- | -- |
| Median Type | *Undivided* | | | | | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *0* | *1* | *0* | *1* | *2* | *0* |
| Configuration | *LTR* | | | *L* | *T* | *TR* |
| Upstream Signal | | *0* | | | *1* | |

| **Minor Street** | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| Movement | 7 | 8 | 9 | 10 | 11 | 12 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *50* | | *400* | *0* | | *40* |
| Peak-Hour Factor, PHF | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* |
| Hourly Flow Rate, HFR (veh/h) | *50* | *0* | *400* | *0* | *0* | *40* |
| Percent Heavy Vehicles | *0* | *0* | *0* | *0* | *0* | *0* |
| Percent Grade (%) | | *0* | | | *0* | |
| Flared Approach | | *N* | | | *N* | |
| Storage | | *0* | | | *0* | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *1* | *0* | *1* | *1* | *0* | *1* |
| Configuration | *L* | | *R* | *L* | | *R* |

## Delay, Queue Length, and Level of Service

| Approach | Eastbound | Westbound | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|---|---|
| Movement | 1 | 4 | 7 | 8 | 9 | 10 | 11 | 12 |
| Lane Configuration | *LTR* | *L* | *L* | | *R* | *L* | | *R* |
| v (veh/h) | *0* | *0* | *50* | | *400* | *0* | | *40* |
| C (m) (veh/h) | *1013* | *970* | *229* | | *495* | *22* | | *689* |
| v/c | *0.00* | *0.00* | *0.22* | | *0.81* | *0.00* | | *0.06* |
| 95% queue length | *0.00* | *0.00* | *0.81* | | *7.67* | *0.00* | | *0.18* |
| Control Delay (s/veh) | *8.6* | *8.7* | *25.1* | | *36.2* | *168.6* | | *10.5* |
| LOS | *A* | *A* | *D* | | *E* | *F* | | *B* |
| Approach Delay (s/veh) | -- | -- | *35.0* | | | *10.5* | | |
| Approach LOS | -- | -- | *D* | | | *B* | | |



*HCS+*™ Version 5.6

Generated: 1/31/2013 4:49 PM

# Appendix B – Capacity Calculations

## Evening Event Egress Design Hour with 4th Avenue N Exit

# HCM Analysis Summary

| | | |
|---|---|---|
| 4th Ave N Exit From METRA Opt 1 | 4th Ave N/Main St | Area Type: Non CBD |
| R Marvin | 01/23/2013 | Analysis Duration: 15 mins. |
| Evening Design | Case: 4TH EXIT ALT A OPT1 Eveneing DESIGN | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 4 | 0 | L | 12.0 | L | 12.0 | L | 12.0 | R | 12.0 | | | | |
| WB | 2 | 0 | L | 12.0 | L | 12.0 | | | | | | | | |
| NB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |
| SB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 390 | 0 | 50 | 550 | 0 | 0 | 0 | 610 | 0 | 0 | 515 | 0 |
| PHF | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 |
| % Heavy Vehicles | 1 | 2 | 1 | 0 | 2 | 2 | 2 | 4 | 2 | 2 | 4 | 2 |
| Lane Groups | L | | R | L | | | | T | | | T | |
| Arrival Type | 3 | | 3 | 3 | | | | 4 | | | 4 | |
| RTOR Vol (vph) | 30 | | | 0 | | | 0 | | | 0 | | |
| Peds/Hour | 5 | | | 0 | | | 5 | | | 5 | | |
| % Grade | 0 | | | 0 | | | 0 | | | 0 | | |
| Buses/Hour | 0 | | | 0 | | | 0 | | | 0 | | |
| Parkers/Hour (Left\|Right) | --- | | --- | --- | | --- | --- | | --- | --- | | --- |

Signal Settings: Actuated  Operational Analysis  Cycle Length: 120.0 Sec  Lost Time Per Cycle: 15.0 Sec

| Phase: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Ped Only |
|---|---|---|---|---|---|---|---|---|---|
| EB | L P | L | | | | | | | |
| WB | | L | | | | | | | |
| NB | | | T | | | | | | |
| SB | | | T | | | | | | |
| Green | 35.0 | 35.0 | 35.0 | | | | | | 0 |
| Yellow / All Red | 3.5 / 1.5 | 3.5 / 1.5 | 3.5 / 1.5 | | | | | | |

| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | L | 3251 | 0.083 | 0.625 | L | 0.133 | 9.2 | A | 10.2 | B |
| | * R | 464 | 0.014 | 0.292 | R | 0.047 | 30.5 | C | | |
| WB | | | | | | | | | | |
| | * L | 1021 | 0.174 | 0.292 | L | 0.598 | 37.2 | D | 37.2 | D |
| NB | | | | | | | | | | |
| | * T | 1455 | 0.136 | 0.292 | T | 0.466 | 35.6 | D | 35.6 | D |
| SB | | | | | | | | | | |
| | T | 1455 | 0.115 | 0.292 | T | 0.393 | 34.5 | C | 34.5 | C |

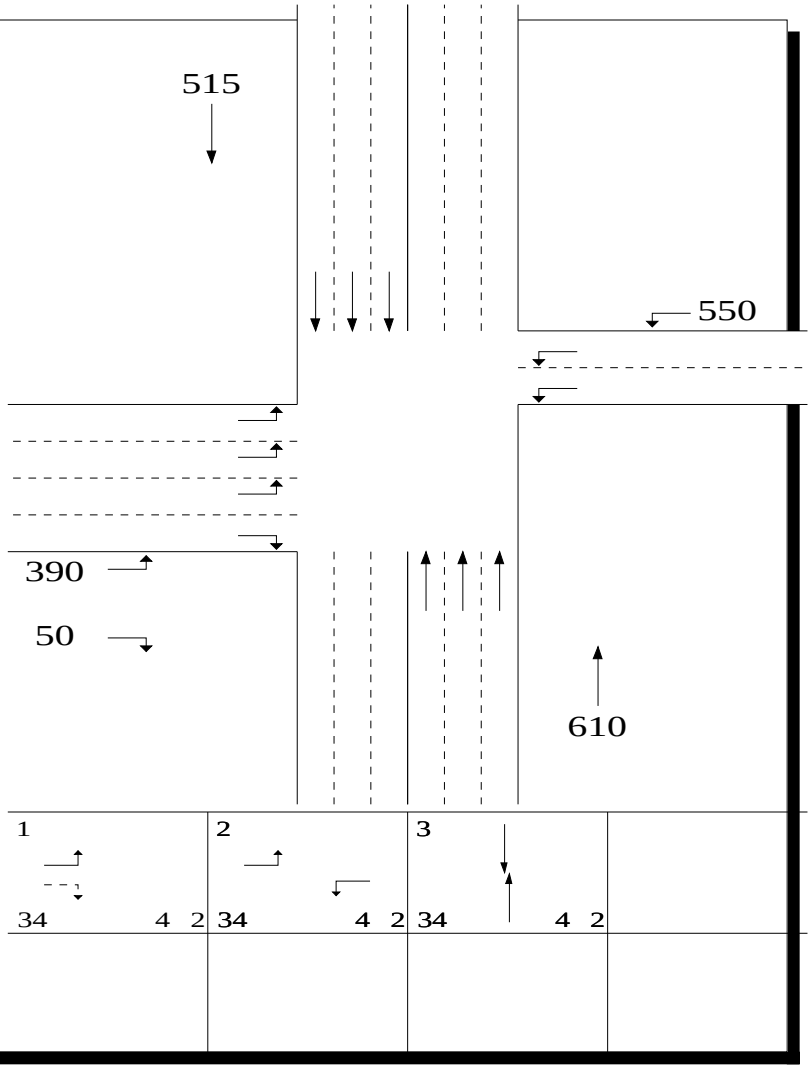
Intersection: Delay = 30.8 sec/veh  Int. LOS=C  $X_c$= 0.37  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.32

# NETSIM Summary Results

4th Ave N Exit From METRA Opt 1
R Marvin
Evening Design

4th Ave N/Main St
01/23/2013
Case: 4TH EXIT ALT A OPT1 Eveneing DESIGN

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 2 / 4 | 16.8 | 0.0 |
| | | | | |
| | R | 1 / 2 | 20.3 | 0.0 |
| | All | | 17.0 | 0.0 |
| WB | L | 8 / 10 | 7.7 | 0.0 |
| | | | | |
| | | | | |
| | All | | 7.7 | 0.0 |
| | | | | |
| NB | T | 1 / 2 | 14.7 | 0.0 |
| | | | | |
| | All | | 14.7 | 0.0 |
| | | | | |
| SB | T | 0 / 1 | 21.4 | 0.0 |
| | | | | |
| | All | | 21.4 | 0.0 |
| Intersect. | | | 12.9 | |



# HCM Analysis Summary

| | | |
|---|---|---|
| 4th Ave N Exit From METRA Opt 2 | 4th Ave N/Main St | Area Type: Non CBD |
| R Marvin | 01/23/2013 | Analysis Duration: 15 mins. |
| Evening Design Hour | Case: 4TH EXIT ALT A OPT2 Evening Design | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 4 | 0 | L | 12.0 | L | 12.0 | L | 12.0 | R | 12.0 | | | | |
| WB | 2 | 0 | L | 12.0 | L | 12.0 | | | | | | | | |
| NB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |
| SB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 390 | 0 | 50 | 515 | 0 | 0 | 0 | 610 | 0 | 0 | 1175 | 0 |
| PHF | 0.95 | 0.90 | 0.95 | 0.95 | 0.90 | 0.90 | 0.90 | 0.95 | 0.90 | 0.90 | 0.95 | 0.90 |
| % Heavy Vehicles | 1 | 2 | 1 | 0 | 2 | 2 | 2 | 4 | 2 | 2 | 4 | 2 |
| Lane Groups | L | | R | L | | | | T | | | T | |
| Arrival Type | 3 | | 3 | 3 | | | | 4 | | | 4 | |
| RTOR Vol (vph) | 20 | | | 0 | | | 0 | | | 0 | | |
| Peds/Hour | 5 | | | 0 | | | 5 | | | 5 | | |
| % Grade | 0 | | | 0 | | | 0 | | | 0 | | |
| Buses/Hour | 0 | | | 0 | | | 0 | | | 0 | | |
| Parkers/Hour (Left\|Right) | --- | | --- | --- | | --- | --- | | --- | --- | | --- |

Signal Settings: Actuated | Operational Analysis | Cycle Length: 120.0 Sec | Lost Time Per Cycle: 15.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | L P | | | | | | | | | | | | | | | | |
| WB | | | | L | | | | | | | | | | | | | | |
| NB | | | | | | T | | | | | | | | | | | | |
| SB | | | | | | T | | | | | | | | | | | | |
| Green | | 35.0 | | 30.0 | | 40.0 | | | | | | | | | | | | 0 |
| Yellow | All Red | 3.5 | 1.5 | 3.5 | 1.5 | 3.5 | 1.5 | | | | | | | | | | | |

| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | * L | 1517 | 0.079 | 0.292 | L | 0.271 | 32.7 | C | 32.6 | C |
| | R | 464 | 0.020 | 0.292 | R | 0.069 | 30.7 | C | | |
| WB | | | | | | | | | | |
| | * L | 876 | 0.155 | 0.250 | L | 0.619 | 40.9 | D | 40.9 | D |
| NB | | | | | | | | | | |
| | T | 1663 | 0.129 | 0.333 | T | 0.386 | 30.0 | C | 30.0 | C |
| SB | | | | | | | | | | |
| | * T | 1663 | 0.248 | 0.333 | T | 0.744 | 37.0 | D | 37.0 | D |

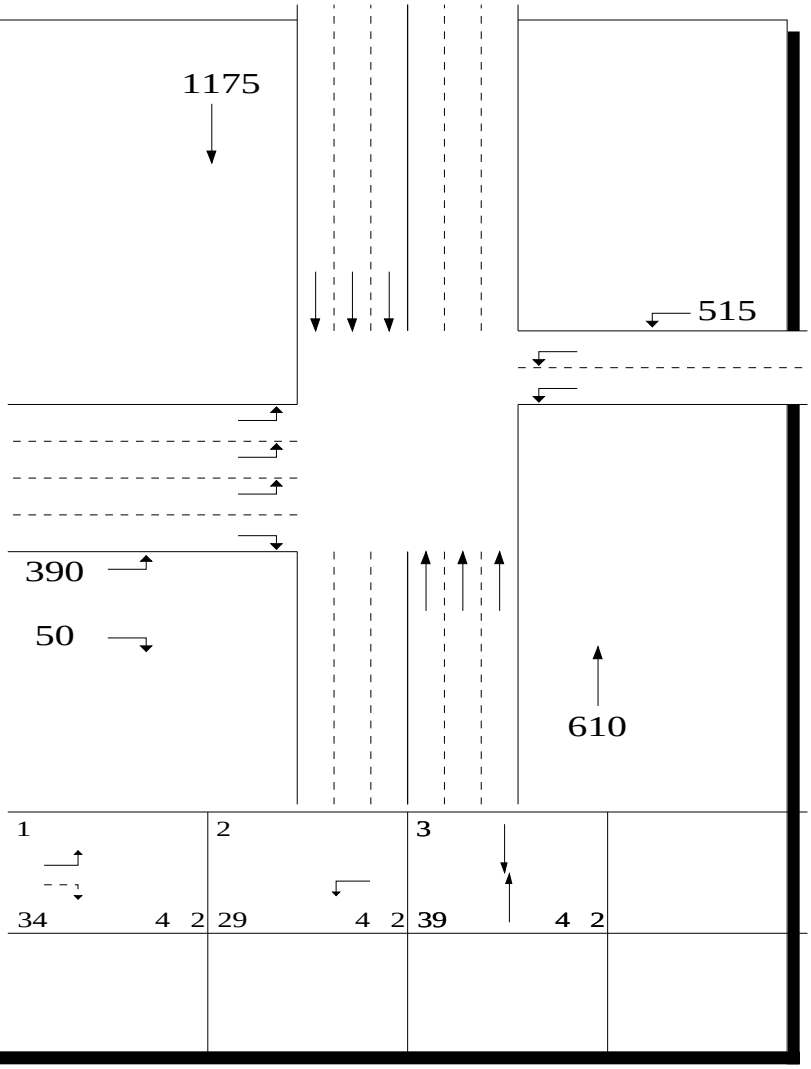
Intersection: Delay = 35.5 sec/veh  Int. LOS=D  $X_c$= 0.55  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.48

# NETSIM Summary Results

4th Ave N Exit From METRA Opt 2
R Marvin
Evening Design Hour

4th Ave N/Main St
01/23/2013
Case: 4TH EXIT ALT A OPT2 Evening Design

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 4 / 10 | 8.2 | 0.0 |
| | | | | |
| | R | 1 / 1 | 19.7 | 0.0 |
| | All | | 8.6 | 0.0 |
| WB | L | 7 / 11 | 7.4 | 0.0 |
| | | | | |
| | | | | |
| | All | | 7.4 | 0.0 |
| | | | | |
| NB | T | 1 / 2 | 18.8 | 0.0 |
| | | | | |
| | All | | 18.8 | 0.0 |
| | | | | |
| SB | T | 6 / 7 | 9.3 | 0.0 |
| | | | | |
| | All | | 9.3 | 0.0 |
| Intersect. | | | 9.9 | |



# HCM Analysis Summary

| | | |
|---|---|---|
| 4th Ave N Exit From METRA Alt B | 4th Ave N/Main St | Area Type: Non CBD |
| R Marvin | 01/23/2013 | Analysis Duration: 15 mins. |
| Evening Hour Design | Case: 4TH EXIT ALT B Evening Design | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 4 | 0 | L | 12.0 | L | 12.0 | L | 12.0 | R | 12.0 | | | | |
| WB | 2 | 0 | L | 12.0 | L | 12.0 | | | | | | | | |
| NB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |
| SB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 390 | 0 | 50 | 515 | 0 | 0 | 0 | 610 | 0 | 0 | 1175 | 0 |
| PHF | 0.95 | 0.90 | 0.95 | 0.95 | 0.90 | 0.90 | 0.90 | 0.95 | 0.90 | 0.90 | 0.95 | 0.90 |
| % Heavy Vehicles | 1 | 2 | 1 | 0 | 2 | 2 | 2 | 4 | 2 | 2 | 4 | 2 |
| Lane Groups | L | | R | L | | | | T | | | T | |
| Arrival Type | 3 | | 3 | 3 | | | | 4 | | | 4 | |
| RTOR Vol (vph) | 20 | | | 0 | | | 0 | | | 0 | | |
| Peds/Hour | 5 | | | 0 | | | 5 | | | 5 | | |
| % Grade | 0 | | | 0 | | | 0 | | | 0 | | |
| Buses/Hour | 0 | | | 0 | | | 0 | | | 0 | | |
| Parkers/Hour (Left\|Right) | --- | | --- | --- | | --- | --- | | --- | --- | | --- |

Signal Settings: Actuated  Operational Analysis  Cycle Length: 120.0 Sec  Lost Time Per Cycle: 10.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | L P | | | | | | | | | | | | | | | | |
| WB | | L | | | | | | | | | | | | | | | | |
| NB | | | | T | | | | | | | | | | | | | | |
| SB | | | | T | | | | | | | | | | | | | | |
| Green | | 50.0 | | 60.0 | | | | | | | | | | | | | | 0 |
| Yellow | All Red | 3.5 | 1.5 | 3.5 | 1.5 | | | | | | | | | | | | | |

| Capacity Analysis Results | | | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | L | 2167 | 0.079 | 0.417 | L | 0.190 | 22.2 | C | 22.1 | C |
| | R | 664 | 0.020 | 0.417 | R | 0.048 | 20.8 | C | | |
| WB | | | | | | | | | | |
| | * L | 1459 | 0.155 | 0.417 | L | 0.371 | 24.2 | C | 24.2 | C |
| NB | | | | | | | | | | |
| | T | 2494 | 0.129 | 0.500 | T | 0.257 | 13.5 | B | 13.5 | B |
| SB | | | | | | | | | | |
| | * T | 2494 | 0.248 | 0.500 | T | 0.496 | 16.0 | B | 16.0 | B |

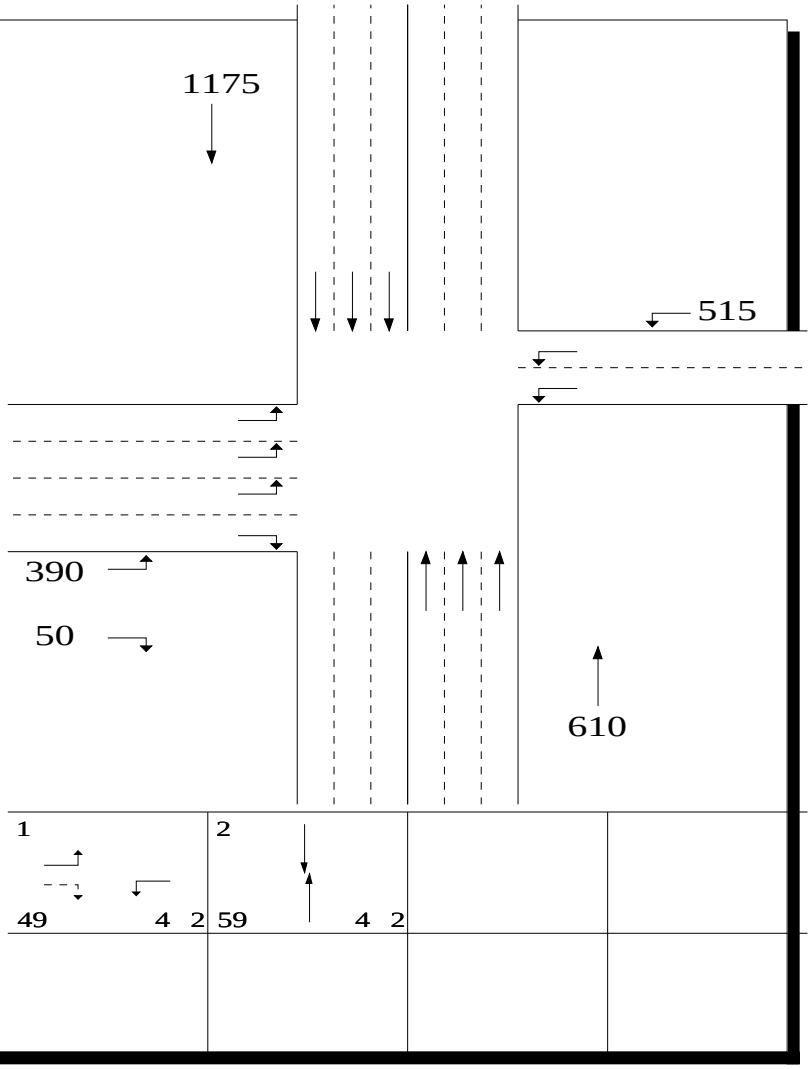
Intersection: Delay = 17.9 sec/veh  Int. LOS=B  $X_c$= 0.44  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.40

# NETSIM Summary Results

4th Ave N Exit From METRA Alt B
R Marvin
Evening Hour Design

4th Ave N/Main St
01/23/2013
Case: 4TH EXIT ALT B Evening Design

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 3 / 5 | 11.0 | 0.0 |
| | | | | |
| | R | 1 / 1 | 19.5 | 0.0 |
| | All | | 11.4 | 0.0 |
| WB | L | 6 / 9 | 10.4 | 0.0 |
| | | | | |
| | | | | |
| | All | | 10.4 | 0.0 |
| | | | | |
| NB | T | 0 / 0 | 25.0 | 0.0 |
| | | | | |
| | All | | 25.0 | 0.0 |
| | | | | |
| SB | T | 3 / 5 | 15.7 | 0.0 |
| | | | | |
| | All | | 15.7 | 0.0 |
| Intersect. | | | 14.7 | |



# HCM Analysis Summary

| | | |
|---|---|---|
| METRA Capacity w 4th Exit Alt | /Main | Area Type: Non CBD |
| R Marvin | 01/05/2013 | Analysis Duration: 15 mins. |
| Peak Evening Design Event | Case: Main & 6th Exist Evening Design w 4th Exit Alt | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 0 | 1 | | | | | | | | | | | | |
| WB | 3 | 3 | L | 12.0 | LT | 12.0 | TR | 12.0 | | | | | | |
| NB | 4 | 3 | L | 12.0 | T | 12.0 | T | 12.0 | T | 12.0 | | | | |
| SB | 2 | 3 | T | 12.0 | T | 12.0 | | | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 0 | 0 | 0 | 675 | 375 | 35 | 35 | 805 | 0 | 0 | 500 | 0 |
| PHF | 0.90 | 0.90 | 0.90 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.90 | 0.90 | 0.92 | 0.90 |
| % Heavy Vehicles | 2 | 2 | 2 | 1 | 1 | 0 | 1 | 4 | 2 | 2 | 4 | 2 |
| Lane Groups | | | | L | LTR | | L | T | | | T | |
| Arrival Type | | | | 3 | 3 | | 4 | 4 | | | 4 | |
| RTOR Vol (vph) | | 0 | | | 15 | | | 0 | | | 0 | |
| Peds/Hour | | 5 | | | 0 | | | 5 | | | 0 | |
| % Grade | | 0 | | | 0 | | | 0 | | | 0 | |
| Buses/Hour | | 0 | | | 0 | | | 0 | | | 0 | |
| Parkers/Hour (Left\|Right) | --- | --- | | --- | --- | | --- | --- | | --- | --- | |

Signal Settings: Actuated | Operational Analysis | Cycle Length: 121.0 Sec | Lost Time Per Cycle: 14.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | | | | | | | | | | | | | | | | | |
| WB | | LTR | | | | | | | | | | | | | | | | |
| NB | | | | LT | | T | | | | | | | | | | | | |
| SB | | | | | | T | | | | | | | | | | | | |
| Green | | 55.0 | | 12.0 | | 40.0 | | | | | | | | | | | | 0 |
| Yellow | All Red | 3.5 | 1.5 | 3.0 | 1.0 | 3.5 | 1.5 | | | | | | | | | | | |

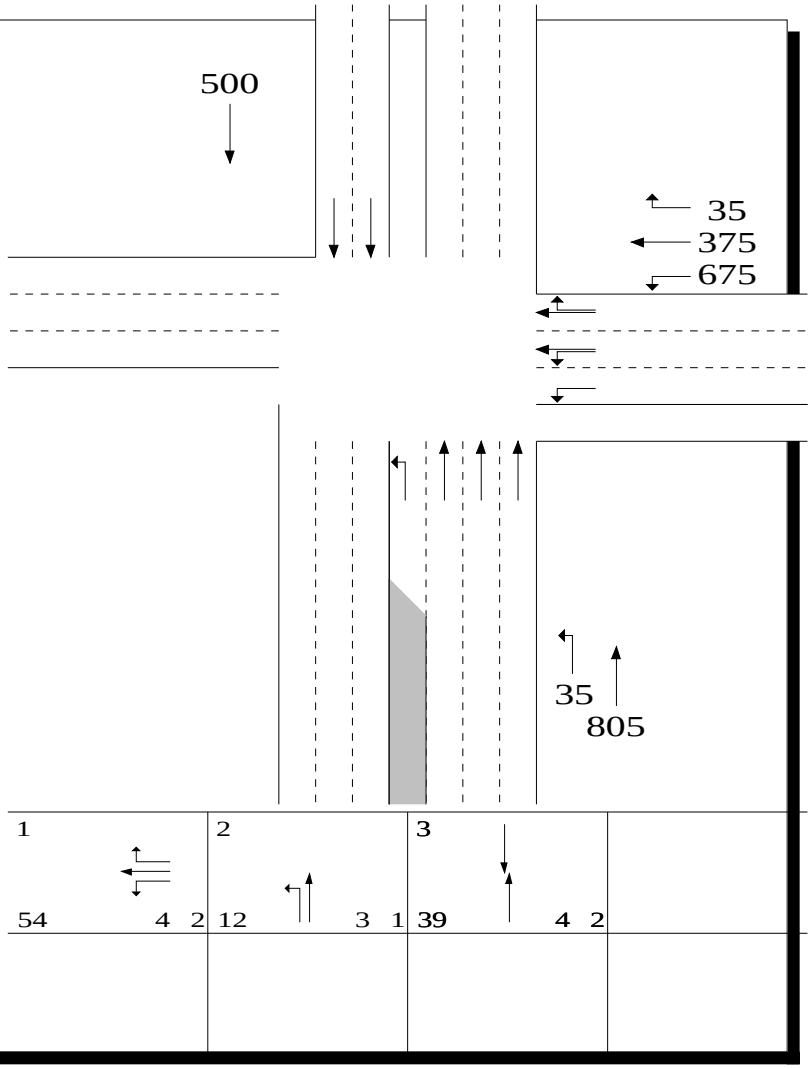
| Capacity Analysis Results | | | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| WB | | | | | | | | | | |
| | L | 810 | 0.206 | 0.455 | L | 0.453 | 22.8 | C | 23.3 | C |
| | * LTR | 1579 | 0.229 | 0.455 | LTR | 0.505 | 23.5 | C | | |
| NB | | | | | | | | | | |
| | * L | 177 | 0.021 | 0.099 | L | 0.215 | 52.9 | D | 19.3 | B |
| | T | 2308 | 0.175 | 0.463 | T | 0.379 | 17.8 | B | | |
| SB | | | | | | | | | | |
| | * T | 1147 | 0.156 | 0.331 | T | 0.473 | 32.3 | C | 32.3 | C |

Intersection: Delay = 23.8 sec/veh  Int. LOS=C  $X_c$= 0.46  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.41

# NETSIM Summary Results

METRA Capacity w 4th Exit Alt /Main
R Marvin 01/05/2013
Peak Evening Design Event Case: Main & 6th Exist Evening Design w 4th Exit Alt

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | All | | 10.9 | 0.0 |
| WB | L | 9 / 10 | 8.4 | 0.0 |
| | LTR | 8 / 9 | 12.3 | 0.0 |
| | | | | |
| | All | | 7.5 | 0.0 |
| NB | L | 2 / 4 | 6.3 | 0.0 |
| | T | 10 / 14 | 7.6 | 0.0 |
| | | | | |
| | All | | 16.9 | 0.0 |
| | | | | |
| SB | T | 1 / 3 | 16.9 | 0.0 |
| | | | | |
| | | | | |
| Intersect. | | | 10.0 | |



# TWO-WAY STOP CONTROL SUMMARY

## General Information

| | |
|---|---|
| Analyst | *R Marvin* |
| Agency/Co. | *Marvin & Associates* |
| Date Performed | *1/18/2013* |
| Analysis Time Period | *Evening Hour Event* |

## Site Information

| | |
|---|---|
| Intersection | *Lower Lot Bench 4th Exit Alt* |
| Jurisdiction | *Yelloewstone County* |
| Analysis Year | *2013* |
| | |

Project Description *METRA Egress Study*

East/West Street: *Bench Boulevard* | North/South Street: *Lower Lot Access*

Intersection Orientation: *East-West* | Study Period (hrs): *0.25*

## Vehicle Volumes and Adjustments

| **Major Street** | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| Movement | 1 | 2 | 3 | 4 | 5 | 6 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *0* | *120* | *5* | *0* | *975* | *0* |
| Peak-Hour Factor, PHF | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* |
| Hourly Flow Rate, HFR (veh/h) | *0* | *120* | *5* | *0* | *975* | *0* |
| Percent Heavy Vehicles | *0* | -- | -- | *0* | -- | -- |
| Median Type | *Undivided* | | | | | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *0* | *1* | *0* | *1* | *2* | *0* |
| Configuration | *LTR* | | | *L* | *T* | *TR* |
| Upstream Signal | | *0* | | | *1* | |

| **Minor Street** | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| Movement | 7 | 8 | 9 | 10 | 11 | 12 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *30* | | *90* | *5* | | *80* |
| Peak-Hour Factor, PHF | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* |
| Hourly Flow Rate, HFR (veh/h) | *30* | *0* | *90* | *5* | *0* | *80* |
| Percent Heavy Vehicles | *0* | *0* | *0* | *0* | *0* | *0* |
| Percent Grade (%) | | *0* | | | *0* | |
| Flared Approach | | *N* | | | *N* | |
| Storage | | *0* | | | *0* | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *1* | *0* | *1* | *1* | *0* | *1* |
| Configuration | *L* | | *R* | *L* | | *R* |

## Delay, Queue Length, and Level of Service

| Approach | Eastbound | Westbound | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|---|---|
| Movement | 1 | 4 | 7 | 8 | 9 | 10 | 11 | 12 |
| Lane Configuration | *LTR* | *L* | *L* | | *R* | *L* | | *R* |
| v (veh/h) | *0* | *0* | *30* | | *90* | *5* | | *80* |
| C (m) (veh/h) | *687* | *1474* | *308* | | *935* | *139* | | *513* |
| v/c | *0.00* | *0.00* | *0.10* | | *0.10* | *0.04* | | *0.16* |
| 95% queue length | *0.00* | *0.00* | *0.32* | | *0.32* | *0.11* | | *0.55* |
| Control Delay (s/veh) | *10.2* | *7.4* | *17.9* | | *9.3* | *31.9* | | *13.3* |
| LOS | *B* | *A* | *C* | | *A* | *D* | | *B* |
| Approach Delay (s/veh) | -- | -- | *11.4* | | | *14.4* | | |
| Approach LOS | -- | -- | *B* | | | *B* | | |



*HCS+*™ Version 5.6

Generated: 1/31/2013 4:51 PM

# Appendix B - Capacity Calculations

## Lower Lot Access Design Hour Conditions

# TWO-WAY STOP CONTROL SUMMARY

## General Information

| | |
|---|---|
| Analyst | *R Marvin* |
| Agency/Co. | *Marvin & Associates* |
| Date Performed | *1/18/2013* |
| Analysis Time Period | *Peak PM Design Hour Event* |

## Site Information

| | |
|---|---|
| Intersection | *Lower Lot - Bench Left Merge* |
| Jurisdiction | *Yelloewstone County* |
| Analysis Year | *2013* |
| | |

Project Description *METRA Egress Study*

East/West Street: *Bench Boulevard* | North/South Street: *Lower Lot Access*

Intersection Orientation: *East-West* | Study Period (hrs): *0.25*

## Vehicle Volumes and Adjustments

| **Major Street** | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| Movement | 1 | 2 | 3 | 4 | 5 | 6 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *0* | *580* | *0* | *0* | *5* | *0* |
| Peak-Hour Factor, PHF | *1.00* | *0.95* | *1.00* | *1.00* | *1.00* | *1.00* |
| Hourly Flow Rate, HFR (veh/h) | *0* | *610* | *0* | *0* | *5* | *0* |
| Percent Heavy Vehicles | *0* | -- | -- | *0* | -- | -- |
| Median Type | *Undivided* | | | | | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *0* | *1* | *0* | *1* | *2* | *0* |
| Configuration | *LTR* | | | *L* | *T* | *TR* |
| Upstream Signal | | *0* | | | *1* | |

| **Minor Street** | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| Movement | 7 | 8 | 9 | 10 | 11 | 12 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *550* | | *450* | *0* | | *40* |
| Peak-Hour Factor, PHF | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* |
| Hourly Flow Rate, HFR (veh/h) | *550* | *0* | *450* | *0* | *0* | *40* |
| Percent Heavy Vehicles | *0* | *0* | *0* | *0* | *0* | *0* |
| Percent Grade (%) | | *0* | | | *0* | |
| Flared Approach | | *N* | | | *N* | |
| Storage | | *0* | | | *0* | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *1* | *0* | *1* | *1* | *0* | *1* |
| Configuration | *L* | | *R* | *L* | | *R* |

## Delay, Queue Length, and Level of Service

| Approach | Eastbound | Westbound | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|---|---|
| Movement | 1 | 4 | 7 | 8 | 9 | 10 | 11 | 12 |
| Lane Configuration | *LTR* | *L* | *L* | | *R* | *L* | | *R* |
| v (veh/h) | *0* | *0* | *550* | | *450* | *0* | | *40* |
| C (m) (veh/h) | *1497* | *979* | *347* | | *498* | *24* | | *927* |
| v/c | *0.00* | *0.00* | *1.59* | | *0.90* | *0.00* | | *0.04* |
| 95% queue length | *0.00* | *0.00* | *31.85* | | *10.33* | *0.00* | | *0.14* |
| Control Delay (s/veh) | *7.4* | *8.7* | *304.2* | | *48.9* | *155.0* | | *9.1* |
| LOS | *A* | *A* | *F* | | *E* | *F* | | *A* |
| Approach Delay (s/veh) | -- | -- | *189.4* | | | *9.1* | | |
| Approach LOS | -- | -- | *F* | | | *A* | | |



*HCS+*™ Version 5.6

Generated: 2/1/2013 12:26 PM

# TWO-WAY STOP CONTROL SUMMARY

## General Information

| | |
|---|---|
| Analyst | *R Marvin* |
| Agency/Co. | *Marvin & Associates* |
| Date Performed | *1/18/2013* |
| Analysis Time Period | *Evening Design Event* |

## Site Information

| | |
|---|---|
| Intersection | *Lower Lot - Bench Left Merge* |
| Jurisdiction | *Yelloewstone County* |
| Analysis Year | *2013* |
| | |

Project Description *METRA Egress Study*

East/West Street: *Bench Boulevard* | North/South Street: *Lower Lot Access*

Intersection Orientation: *East-West* | Study Period (hrs): *0.25*

## Vehicle Volumes and Adjustments

| **Major Street** | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| Movement | 1 | 2 | 3 | 4 | 5 | 6 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *0* | *120* | *5* | *0* | *5* | *0* |
| Peak-Hour Factor, PHF | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* |
| Hourly Flow Rate, HFR (veh/h) | *0* | *120* | *5* | *0* | *5* | *0* |
| Percent Heavy Vehicles | *0* | -- | -- | *0* | -- | -- |
| Median Type | *Undivided* | | | | | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *0* | *1* | *0* | *1* | *2* | *0* |
| Configuration | *LTR* | | | *L* | *T* | *TR* |
| Upstream Signal | | *0* | | | *1* | |

| **Minor Street** | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| Movement | 7 | 8 | 9 | 10 | 11 | 12 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *530* | | *105* | *5* | | *80* |
| Peak-Hour Factor, PHF | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* |
| Hourly Flow Rate, HFR (veh/h) | *530* | *0* | *105* | *5* | *0* | *80* |
| Percent Heavy Vehicles | *0* | *0* | *0* | *0* | *0* | *0* |
| Percent Grade (%) | | *0* | | | *0* | |
| Flared Approach | | *N* | | | *N* | |
| Storage | | *0* | | | *0* | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *1* | *0* | *1* | *1* | *0* | *1* |
| Configuration | *L* | | *R* | *L* | | *R* |

## Delay, Queue Length, and Level of Service

| Approach | Eastbound | Westbound | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|---|---|
| Movement | 1 | 4 | 7 | 8 | 9 | 10 | 11 | 12 |
| Lane Configuration | *LTR* | *L* | *L* | | *R* | *L* | | *R* |
| v (veh/h) | *0* | *0* | *530* | | *105* | *5* | | *80* |
| C (m) (veh/h) | *1497* | *1474* | *717* | | *935* | *638* | | *927* |
| v/c | *0.00* | *0.00* | *0.74* | | *0.11* | *0.01* | | *0.09* |
| 95% queue length | *0.00* | *0.00* | *6.62* | | *0.38* | *0.02* | | *0.28* |
| Control Delay (s/veh) | *7.4* | *7.4* | *22.8* | | *9.3* | *10.7* | | *9.2* |
| LOS | *A* | *A* | *C* | | *A* | *B* | | *A* |
| Approach Delay (s/veh) | -- | -- | *20.6* | | | *9.3* | | |
| Approach LOS | -- | -- | *C* | | | *A* | | |



*HCS+*™ Version 5.6

Generated: 2/1/2013 12:31 PM

# HCM Analysis Summary

| | | |
|---|---|---|
| METRA Lower Lot Signal Alt | Bench/Lower Lot Acc | Area Type: Non CBD |
| R Marvin | 02/07/2013 | Analysis Duration: 15 mins. |
| PM Design Hour | Case: Lower Lot Signal PM Design | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 1 | 1 | LTR | 12.0 | | | | | | | | | | |
| WB | 2 | 3 | LT | 12.0 | TR | 12.0 | | | | | | | | |
| NB | 3 | 1 | L | 12.0 | LT | 12.0 | R | 12.0 | | | | | | |
| SB | 1 | 1 | LTR | 12.0 | | | | | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 0 | 580 | 5 | 5 | 495 | 0 | 550 | 0 | 450 | 0 | 0 | 40 |
| PHF | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| % Heavy Vehicles | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lane Groups | | LTR | | | LTR | | L | LT | R | | LTR | |
| Arrival Type | | 4 | | | 3 | | 3 | 3 | 3 | | 3 | |
| RTOR Vol (vph) | | 0 | | | 0 | | | 250 | | | 10 | |
| Peds/Hour | | 5 | | | 0 | | | 5 | | | 0 | |
| % Grade | | 0 | | | 0 | | | 0 | | | 0 | |
| Buses/Hour | | 0 | | | 0 | | | 0 | | | 0 | |
| Parkers/Hour (Left\|Right) | --- | --- | | --- | --- | | --- | --- | | --- | --- | |

Signal Settings: Actuated  Operational Analysis  Cycle Length: 150.0 Sec  Lost Time Per Cycle: 10.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | LTP | | | | | | | | | | | | | | | | |
| WB | | LTP | | | | | | | | | | | | | | | | |
| NB | | | | LTP | | | | | | | | | | | | | | |
| SB | | | | LTP | | | | | | | | | | | | | | |
| Green | | 90.0 | | 50.0 | | | | | | | | | | | | | | 0 |
| Yellow | All Red | 3.5 | 1.5 | 3.5 | 1.5 | | | | | | | | | | | | | |

| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | * LTR | 1127 | 0.346 | 0.600 | LTR | 0.577 | 12.7 | B | 12.7 | B |
| WB | | | | | | | | | | |
| | LTR | 2035 | 0.164 | 0.600 | LTR | 0.273 | 14.7 | B | 14.7 | B |
| NB | | | | | | | | | | |
| | * L | 466 | 0.248 | 0.333 | L | 0.745 | 50.0 | D | 44.1 | D |
| | LT | 466 | 0.166 | 0.333 | LT | 0.498 | 40.3 | D | | |
| | R | 534 | 0.132 | 0.333 | R | 0.395 | 38.6 | D | | |
| SB | | | | | | | | | | |
| | LTR | 548 | 0.019 | 0.333 | LTR | 0.058 | 34.0 | C | 34.0 | C |

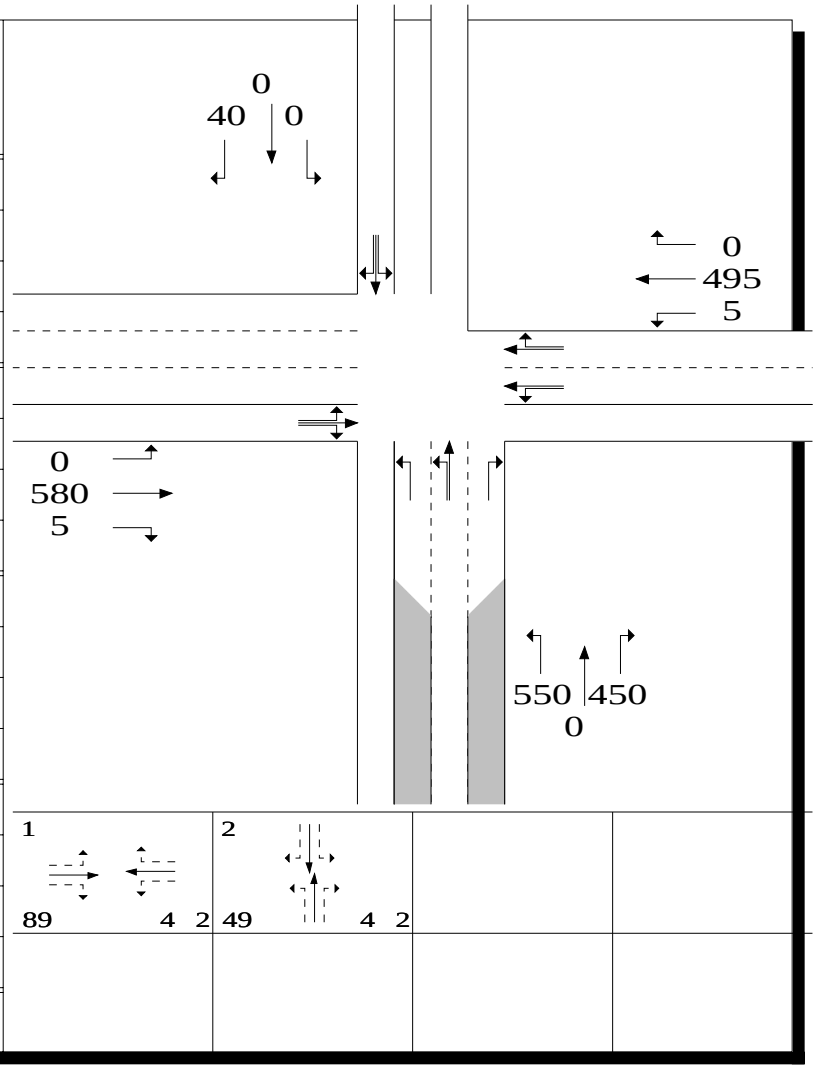
Intersection: Delay = 25.8 sec/veh  Int. LOS=C  $X_c$= 0.64  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.59

# NETSIM Summary Results

METRA Lower Lot Signal Alt
R Marvin
PM Design Hour

Bench/Lower Lot Acc
02/07/2013
Case: Lower Lot Signal PM Design

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| | | | | |
| EB | LTR | 8 / 8 | 14.3 | 0.0 |
| | | | | |
| | All | | 14.3 | 0.0 |
| | | | | |
| WB | LTR | 6 / 6 | 13.6 | 0.0 |
| | | | | |
| | All | | 13.6 | 0.0 |
| NB | L | 9 / 10 | 4.2 | 0.0 |
| | LT | 8 / 9 | 12.7 | 0.0 |
| | R | 7 / 11 | 8.6 | 0.0 |
| | All | | 9.0 | 0.0 |
| | | | | |
| SB | LTR | 1 / 1 | 25.3 | 0.0 |
| | | | | |
| | All | | 25.3 | 0.0 |
| Intersect. | | | 11.2 | |



# HCM Analysis Summary

| | | |
|---|---|---|
| METRA Lower Lot Signal Alt | Bench/Lower Lot Acc | Area Type: Non CBD |
| R Marvin | 02/07/2013 | Analysis Duration: 15 mins. |
| Evening Event Design Hour | Case: Lower Lot Signal Evening Design | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 1 | 1 | LTR | 12.0 | | | | | | | | | | |
| WB | 2 | 3 | LT | 12.0 | TR | 12.0 | | | | | | | | |
| NB | 3 | 1 | L | 12.0 | LT | 12.0 | R | 12.0 | | | | | | |
| SB | 1 | 1 | LTR | 12.0 | | | | | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 0 | 120 | 5 | 5 | 975 | 0 | 530 | 0 | 105 | 5 | 0 | 80 |
| PHF | 0.85 | 0.85 | 0.85 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| % Heavy Vehicles | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lane Groups | | LTR | | | LTR | | L | LT | R | | LTR | |
| Arrival Type | | 4 | | | 3 | | 3 | 3 | 3 | | 3 | |
| RTOR Vol (vph) | | 0 | | | 0 | | | 55 | | | 40 | |
| Peds/Hour | | 5 | | | 0 | | | 5 | | | 0 | |
| % Grade | | 0 | | | 0 | | | 0 | | | 0 | |
| Buses/Hour | | 0 | | | 0 | | | 0 | | | 0 | |
| Parkers/Hour (Left\|Right) | --- | --- | | --- | --- | | --- | --- | | --- | --- | |

Signal Settings: Actuated  Operational Analysis  Cycle Length: 120.0 Sec  Lost Time Per Cycle: 10.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | LTP | | | | | | | | | | | | | | | | |
| WB | | LTP | | | | | | | | | | | | | | | | |
| NB | | | | LTP | | | | | | | | | | | | | | |
| SB | | | | LTP | | | | | | | | | | | | | | |
| Green | | 60.0 | | 50.0 | | | | | | | | | | | | | | 0 |
| Yellow | All Red | 3.5 | 1.5 | 3.5 | 1.5 | | | | | | | | | | | | | |

| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | LTR | 935 | 0.079 | 0.500 | LTR | 0.157 | 12.8 | B | 12.8 | B |
| WB | | | | | | | | | | |
| | * LTR | 1705 | 0.302 | 0.500 | LTR | 0.605 | 23.1 | C | 23.1 | C |
| NB | | | | | | | | | | |
| | * L | 575 | 0.243 | 0.417 | L | 0.583 | 28.0 | C | 26.1 | C |
| | LT | 575 | 0.162 | 0.417 | LT | 0.388 | 24.5 | C | | |
| | R | 669 | 0.033 | 0.417 | R | 0.079 | 21.1 | C | | |
| SB | | | | | | | | | | |
| | LTR | 678 | 0.029 | 0.417 | LTR | 0.069 | 21.0 | C | 21.0 | C |

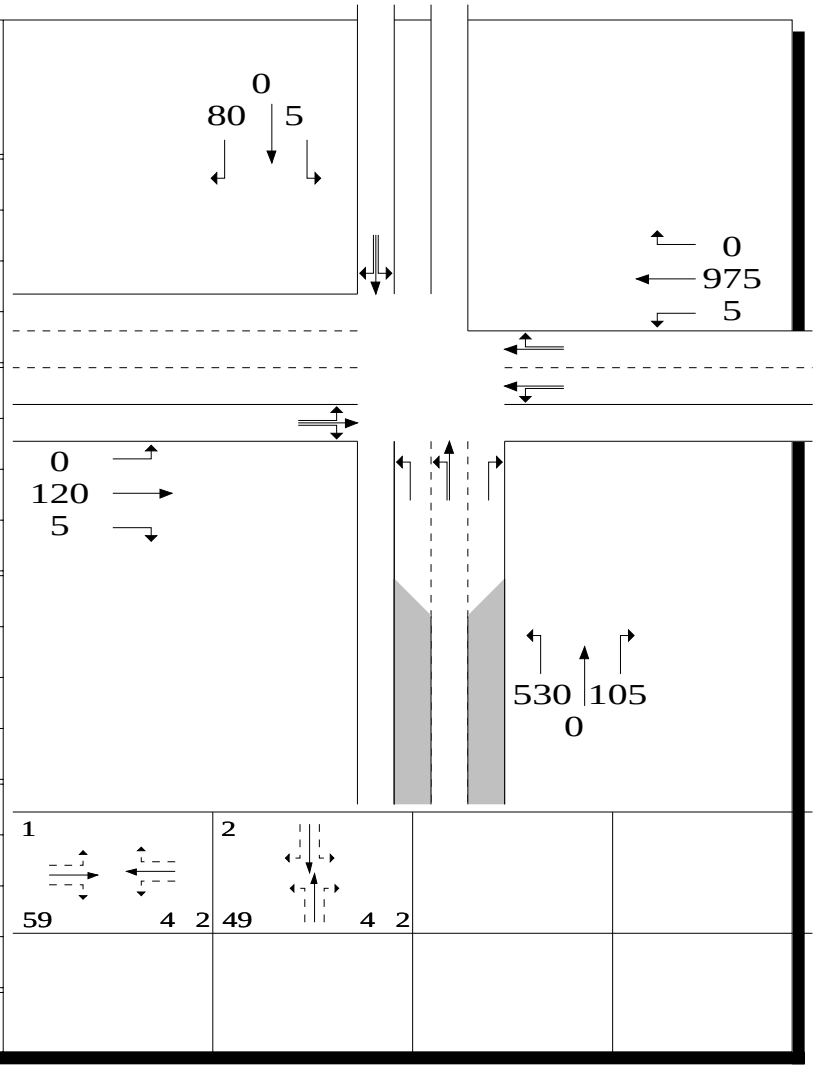
Intersection: Delay = 23.2 sec/veh  Int. LOS=C  $X_c$= 0.59  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.55

# NETSIM Summary Results

METRA Lower Lot Signal Alt
R Marvin
Evening Event Design Hour

Bench/Lower Lot Acc
02/07/2013
Case: Lower Lot Signal Evening Design

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| | | | | |
| EB | LTR | 0 / 0 | 25.3 | 0.0 |
| | | | | |
| | All | | 25.3 | 0.0 |
| | | | | |
| WB | LTR | 10 / 11 | 10.9 | 0.0 |
| | | | | |
| | All | | 10.9 | 0.0 |
| NB | L | 5 / 6 | 6.4 | 0.0 |
| | LT | 5 / 6 | 14.8 | 0.0 |
| | R | 1 / 2 | 18.5 | 0.0 |
| | All | | 11.7 | 0.0 |
| | | | | |
| SB | LTR | 1 / 1 | 25.6 | 0.0 |
| | | | | |
| | All | | 25.6 | 0.0 |
| Intersect. | | | 12.0 | |



# APPENDIX C – INGRESS EVENT TRAFFIC VOLUMES

## March 8, 2013 State A Basketball Tournament
## Ingress Counts Lower Lot 6:30 PM Game

| Ingress | | Begin Time | Main Street North of 4th Ave Southbound T | L | SB App | NB Depart | Total Both Direct | Main Street South of 4th Ave Northbound T | R | NB App | SB Depart | Total Both Direct | 4th Ave. N. west of Main Eastbound T | L | R | EB Total | Total Entering | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 33 | | **5:30** | 65 | 1 | 66 | 243 | 309 | 134 | 15 | 149 | 69 | 218 | 17 | 109 | 4 | 130 | 345 | | |
| 51 | | **5:35** | 73 | 2 | 75 | 236 | 311 | 170 | 20 | 190 | 79 | 269 | 29 | 66 | 6 | 101 | 366 | | |
| 45 | 129 | **5:40** | 89 | 5 | 94 | 231 | 325 | 142 | 14 | 156 | 92 | 248 | 26 | 89 | 3 | 118 | 368 | | |
| 26 | 122 | **5:45** | 97 | 2 | 99 | 240 | 339 | 147 | 12 | 159 | 98 | 257 | 12 | 93 | 1 | 106 | 364 | 1098 | peak 15 Min |
| 50 | 121 | **5:50** | 89 | 1 | 90 | 233 | 323 | 152 | 33 | 185 | 90 | 275 | 16 | 81 | 1 | 98 | 373 | | |
| 50 | 126 | **5:55** | 82 | 2 | 84 | 201 | 285 | 124 | 28 | 152 | 88 | 240 | 20 | 77 | 6 | 103 | 339 | | |
| 48 | 148 | **6:00** | 81 | 3 | 84 | 212 | 296 | 115 | 24 | 139 | 91 | 230 | 21 | 97 | 10 | 128 | 351 | PHF = | 0.95 |
| 48 | 146 | **6:05** | 68 | 1 | 69 | 227 | 296 | 145 | 19 | 164 | 73 | 237 | 28 | 82 | 5 | 115 | 348 | | |
| 46 | 142 | **6:10** | 70 | 4 | 74 | 201 | 275 | 130 | 23 | 153 | 72 | 225 | 19 | 71 | 2 | 92 | 319 | | |
| 48 | 142 | **6:15** | 87 | 3 | 90 | 228 | 318 | 157 | 27 | 184 | 95 | 279 | 18 | 71 | 8 | 97 | 371 | | |
| 31 | 125 | **6:20** | 66 | 2 | 68 | 209 | 277 | 131 | 19 | 150 | 74 | 224 | 10 | 78 | 8 | 96 | 314 | | |
| 31 | 110 | **6:25** | 66 | 2 | 68 | 201 | 269 | 108 | 12 | 120 | 67 | 187 | 17 | 93 | 1 | 111 | 299 | 4157 | Peak Hour |
| | | **Total PH** | **933** | **28** | **961** | **2662** | **3623** | **1655** | **246** | **1901** | **988** | **2889** | **233** | **1007** | **55** | **1295** | **4157** | | |
| 22 | | **6:30** | 67 | 1 | 68 | 167 | 235 | 117 | 16 | 133 | 74 | 207 | 5 | 50 | 7 | 62 | 263 | | |
| 17 | | **6:35** | 64 | 1 | 65 | 176 | 241 | 109 | 8 | 117 | 69 | 186 | 8 | 67 | 5 | 80 | 262 | | |
| 24 | | **6:40** | 71 | 0 | 71 | 174 | 245 | 103 | 15 | 118 | 80 | 198 | 9 | 71 | 9 | 89 | 278 | | |

148 15 min
507
PHF = 0.86

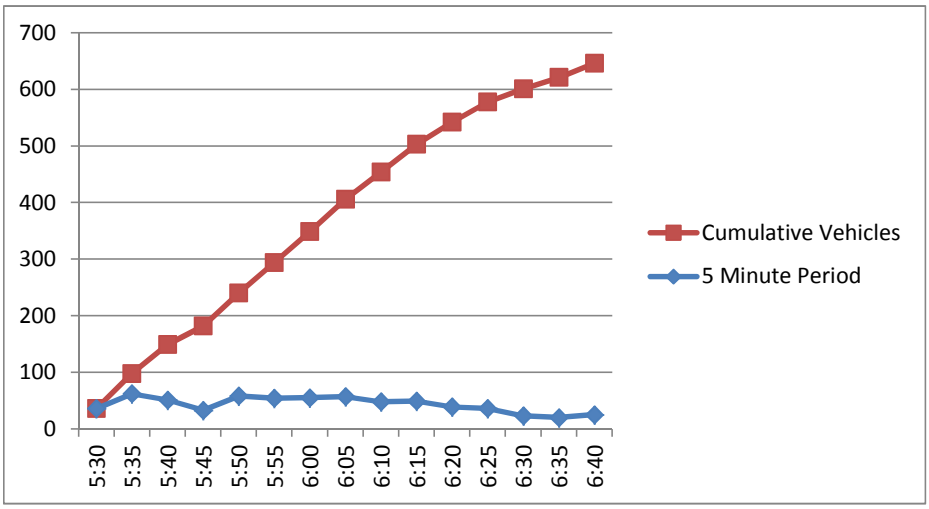
| Ingress | | Begin Time | Bench West of Lower Lot Eastbound L | T | R | EB Total | Bench East of Lower Lot Westbound L | T | R | WB Total | Lower Lot South of Bench Northbound L | T | R | NB Total | Special Lot North of Bench Southbound L | T | R | SB Total | Total Entering | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | | **5:30** | 0 | 57 | 2 | **59** | 1 | 25 | 0 | 26 | 0 | 0 | 4 | **4** | 0 | 0 | 0 | **0** | **89** | | |
| 12 | | **5:35** | 0 | 40 | 4 | **44** | 7 | 27 | 1 | 35 | 3 | 0 | 4 | **7** | 0 | 0 | 0 | **0** | **86** | | |
| 8 | | **5:40** | 1 | 45 | 3 | **49** | 3 | 33 | 1 | 37 | 2 | 0 | 3 | **5** | 0 | 0 | 0 | **0** | **91** | | |
| 8 | 28 | **5:45** | 0 | 51 | 5 | **56** | 2 | 30 | 1 | 33 | 3 | 0 | 3 | **6** | 0 | 0 | 0 | **0** | **95** | | |
| 10 | | **5:50** | 1 | 44 | 3 | **48** | 4 | 24 | 1 | 29 | 6 | 0 | 8 | **14** | 0 | 1 | 0 | **1** | **92** | 278 | peak 15 Mi |
| 7 | | **5:55** | 1 | 41 | 1 | **43** | 3 | 34 | 1 | 38 | 1 | 1 | 4 | **6** | 0 | 0 | 0 | **0** | **87** | | |
| 8 | | **6:00** | 0 | 50 | 5 | **55** | 2 | 16 | 1 | 19 | 2 | 0 | 3 | **5** | 0 | 0 | 0 | **0** | **79** | | |
| 11 | | **6:05** | 0 | 47 | 3 | **50** | 6 | 28 | 0 | 34 | 3 | 2 | 4 | **9** | 0 | 0 | 0 | **0** | **93** | PHF = | 0.94 |
| 8 | | **6:10** | 0 | 39 | 2 | **41** | 0 | 32 | 3 | 35 | 2 | 3 | 4 | **9** | 0 | 0 | 0 | **0** | **85** | | |
| 2 | | **6:15** | 0 | 54 | 1 | **55** | 0 | 22 | 0 | 22 | 1 | 1 | 12 | **14** | 0 | 0 | 0 | **0** | **91** | | |
| 8 | | **6:20** | 0 | 42 | 3 | **45** | 5 | 21 | 0 | 26 | 1 | 0 | 12 | **13** | 0 | 0 | 0 | **0** | **84** | | |
| 8 | | **6:25** | 0 | 36 | 4 | **40** | 1 | 21 | 2 | 24 | 0 | 1 | 10 | **11** | 0 | 0 | 0 | **0** | **75** | 1047 | Peak Hour |
| | | **Total PH** | **3** | **546** | **36** | **585** | **34** | **313** | **11** | **358** | **24** | **8** | **71** | **103** | **0** | **1** | **0** | **1** | **1047** | | |
| 6 | | **6:30** | 0 | 33 | 0 | **33** | 1 | 17 | 1 | 19 | 1 | 4 | 8 | **13** | 0 | 0 | 0 | **0** | **65** | | |
| 5 | | **6:35** | 0 | 34 | 1 | **35** | 2 | 23 | 0 | 25 | 1 | 2 | 9 | **12** | 1 | 0 | 0 | **1** | **73** | | |
| 6 | | **6:40** | 0 | 26 | 0 | **26** | 0 | 33 | 1 | 34 | 0 | 4 | 11 | **15** | 1 | 1 | 0 | **2** | **77** | | |

110

PHF = 0.98

## March 8, 2013 State A Basketball Tournament
## Ingress Counts Lower Lot 6:30 PM Game

| | Main St @ 4th Ave. N. | | | | | Lower Lot @ Bench Boulevard | | | | | Both Entrances | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Begin Time PM | SB LT | NB RT | EB Thru | Total | Cumulative Totals | EB RT | WB LT | SB Thru | Total | Cumulative Totals | Total | Cumulative Totals |
| **5:30** | 1 | 15 | 17 | **33** | **33** | 2 | 1 | 0 | **3** | **3** | **36** | **36** |
| **5:35** | 2 | 20 | 29 | **51** | **84** | 4 | 7 | 0 | **11** | **14** | **62** | **98** |
| **5:40** | 5 | 14 | 26 | **45** | **129** | 3 | 3 | 0 | **6** | **20** | **51** | **149** |
| **5:45** | 2 | 12 | 12 | **26** | **155** | 5 | 2 | 0 | **7** | **27** | **33** | **182** |
| **5:50** | 1 | 33 | 16 | **50** | **205** | 3 | 4 | 1 | **8** | **35** | **58** | **240** |
| **5:55** | 2 | 28 | 20 | **50** | **255** | 1 | 3 | 0 | **4** | **39** | **54** | **294** |
| **6:00** | 3 | 24 | 21 | **48** | **303** | 5 | 2 | 0 | **7** | **46** | **55** | **349** |
| **6:05** | 1 | 19 | 28 | **48** | **351** | 3 | 6 | 0 | **9** | **55** | **57** | **406** |
| **6:10** | 4 | 23 | 19 | **46** | **397** | 2 | 0 | 0 | **2** | **57** | **48** | **454** |
| **6:15** | 3 | 27 | 18 | **48** | **445** | 1 | 0 | 0 | **1** | **58** | **49** | **503** |
| **6:20** | 2 | 19 | 10 | **31** | **476** | 3 | 5 | 0 | **8** | **66** | **39** | **542** |
| **6:25** | 2 | 12 | 17 | **31** | **507** | 4 | 1 | 0 | **5** | **71** | **36** | **578** |
| **6:30** | 1 | 16 | 5 | **22** | **529** | 0 | 1 | 0 | **1** | **72** | **23** | **601** |
| **6:35** | 1 | 8 | 8 | **17** | **546** | 1 | 2 | 0 | **3** | **75** | **20** | **621** |
| **6:40** | 0 | 15 | 9 | **24** | **570** | 0 | 0 | 1 | **1** | **76** | **25** | **646** |
| **Totals** | **30** | **285** | **255** | **570** | | **37** | **37** | **2** | **76** | | **646** | |
| **% Totals** | **5.3%** | **50.0%** | **44.7%** | **1** | | **48.7%** | **48.7%** | **2.6%** | **1** | | | |



## March 16, 2013 Monster Trucks
## Ingress Counts Lower Lot Gates open 6:00 PM & 7:30 Performance

| | | | Main Street North of 4th Ave | | | | | Main Street South of 4th Ave | | | | | 4th Ave. N. west of Main | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ingress | | Begin Time | Southbound T | L | SB App | NB Depart | Total Both Direct | Northbound T | R | NB App | SB Depart | Total Both Direct | Eastbound T | L | R | EB Total | Total Entering | | |
| 71 | | 6:20 | 69 | 5 | 74 | 134 | 208 | 65 | 41 | 106 | 69 | 175 | 25 | 69 | 0 | 94 | 274 | | |
| 59 | | 6:25 | 72 | 10 | 82 | 161 | 243 | 111 | 30 | 141 | 78 | 219 | 19 | 50 | 6 | 75 | 298 | | |
| 52 | 182 | 6:30 | 77 | 4 | 81 | 153 | 234 | 96 | 32 | 128 | 81 | 209 | 16 | 57 | 4 | 77 | 286 | | |
| 61 | 172 | 6:35 | 80 | 5 | 85 | 158 | 243 | 108 | 41 | 149 | 85 | 234 | 15 | 50 | 5 | 70 | 304 | | |
| 52 | 165 | 6:40 | 96 | 5 | 101 | 162 | 263 | 110 | 38 | 148 | 99 | 247 | 9 | 52 | 3 | 64 | 313 | 903 | peak 15 Min |
| 56 | 169 | 6:45 | 64 | 3 | 67 | 144 | 211 | 98 | 36 | 134 | 64 | 198 | 17 | 46 | 0 | 63 | 264 | | |
| 49 | 157 | 6:50 | 85 | 1 | 86 | 148 | 234 | 93 | 27 | 120 | 87 | 207 | 21 | 55 | 2 | 78 | 284 | PHF = | 0.91 |
| 48 | 153 | 6:55 | 69 | 10 | 79 | 139 | 218 | 95 | 20 | 115 | 71 | 186 | 18 | 44 | 2 | 64 | 258 | | |
| 45 | 142 | 7:00 | 60 | 1 | 61 | 153 | 214 | 84 | 23 | 107 | 66 | 173 | 21 | 69 | 6 | 96 | 264 | | |
| 45 | 138 | 7:05 | 81 | 4 | 85 | 115 | 200 | 89 | 19 | 108 | 81 | 189 | 22 | 26 | 0 | 48 | 241 | | |
| 38 | 128 | 7:10 | 62 | 5 | 67 | 177 | 244 | 107 | 17 | 124 | 63 | 187 | 16 | 70 | 1 | 87 | 278 | | |
| 26 | 109 | 7:15 | 49 | 3 | 52 | 153 | 205 | 109 | 14 | 123 | 51 | 174 | 9 | 44 | 2 | 55 | 230 | | |
| **602** | | **Peak Hour** | **864** | **56** | **920** | **1797** | **2717** | **1165** | **338** | **1503** | **895** | **2398** | **208** | **632** | **31** | **871** | **3294** | 3294 | Peak Hour |
| 21 | 85 | 7:20 | 43 | 2 | 45 | 134 | 179 | 82 | 7 | 89 | 44 | 133 | 12 | 52 | 1 | 65 | 199 | | |
| 12 | 59 | 7:25 | 64 | 4 | 68 | 90 | 158 | 73 | 7 | 80 | 69 | 149 | 1 | 17 | 5 | 23 | 171 | | |
| 17 | 50 | 7:30 | 59 | 2 | 61 | 155 | 216 | 91 | 12 | 103 | 64 | 167 | 3 | 64 | 5 | 72 | 236 | | |

182 15 min
602
PHF = 0.83

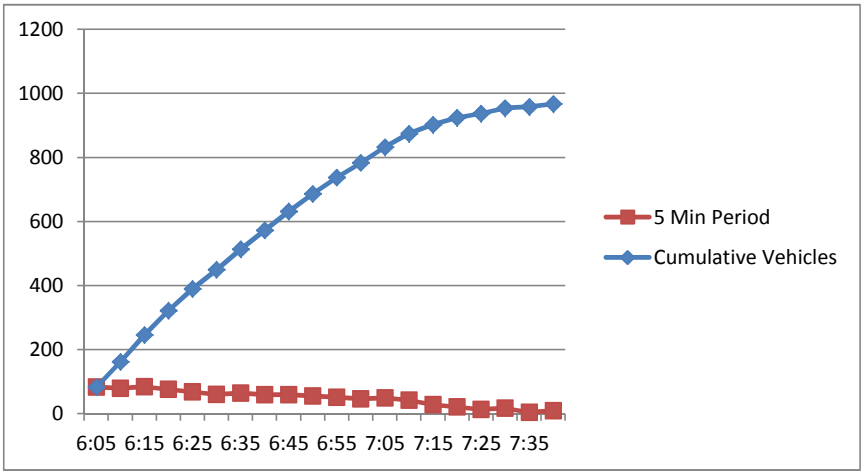
| | | | Bench West of Lower Lot | | | | Bench East of Lower Lot | | | | Lower Lot South of Bench | | | | Special Lot North of Bench | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ingress | | Begin Time | Eastbound L | T | R | EB Total | Westbound L | T | R | WB Total | Northbound L | T | R | NB Total | Southbound L | T | R | SB Total | Total Entering | | |
| 13 | | 6:05 | 2 | 30 | 1 | **33** | 8 | 22 | 2 | 32 | 1 | 0 | 5 | **6** | 0 | 0 | 0 | **0** | **71** | | |
| 11 | | 6:10 | 0 | 23 | 6 | **29** | 1 | 26 | 1 | 28 | 4 | 1 | 5 | **10** | 0 | 2 | 0 | **2** | **69** | | |
| 15 | 39 | 6:15 | 0 | 23 | 4 | **27** | 5 | 29 | 4 | 38 | 2 | 1 | 7 | **10** | 4 | 1 | 1 | **6** | **81** | | |
| 7 | 33 | 6:20 | 1 | 20 | 1 | **22** | 3 | 20 | 1 | 24 | 3 | 0 | 5 | **8** | 0 | 1 | 0 | **1** | **55** | | |
| 9 | 31 | 6:25 | 0 | 21 | 4 | **25** | 5 | 24 | 0 | 29 | 1 | 0 | 5 | **6** | 0 | 0 | 0 | **0** | **60** | | |
| 11 | 27 | 6:30 | 1 | 25 | 3 | **29** | 3 | 20 | 1 | 24 | 3 | 1 | 6 | **10** | 0 | 2 | 0 | **2** | **65** | | |
| 3 | 23 | 6:35 | 0 | 33 | 2 | **35** | 1 | 39 | 0 | 40 | 1 | 0 | 9 | **10** | 0 | 0 | 0 | **0** | **85** | | |
| 8 | 22 | 6:40 | 0 | 30 | 0 | **30** | 6 | 31 | 1 | 38 | 0 | 0 | 8 | **8** | 0 | 1 | 0 | **1** | **77** | | |
| 7 | 18 | 6:45 | 0 | 31 | 2 | **33** | 0 | 13 | 1 | 14 | 0 | 3 | 22 | **25** | 1 | 1 | 0 | **2** | **74** | | |
| 10 | 25 | 6:50 | 0 | 24 | 0 | **24** | 6 | 28 | 1 | 35 | 0 | 3 | 39 | **42** | 3 | 0 | 1 | **4** | **105** | | |
| 6 | 23 | 6:55 | 0 | 31 | 0 | **31** | 2 | 25 | 2 | 29 | 3 | 1 | 43 | **47** | 0 | 1 | 1 | **2** | **109** | | |
| 5 | 21 | 7:00 | 1 | 24 | 1 | **26** | 0 | 14 | 0 | 14 | 0 | 3 | 40 | **43** | 4 | 0 | 0 | **4** | **87** | 301 | peak 15 Mi |
| 6 | 17 | 7:05 | 0 | 17 | 3 | **20** | 1 | 22 | 1 | 24 | 2 | 1 | 22 | **25** | 3 | 0 | 0 | **3** | **72** | | |
| 5 | 16 | 7:10 | 1 | 29 | 2 | **32** | 2 | 20 | 0 | 22 | 0 | 0 | 33 | **33** | 1 | 0 | 0 | **1** | **88** | PHF = | 0.80 |
| 8 | 19 | 7:15 | 0 | 26 | 1 | **27** | 1 | 21 | 1 | 23 | 0 | 5 | 22 | **27** | 4 | 0 | 0 | **4** | **81** | | |
| 3 | 16 | 7:20 | 0 | 21 | 0 | **21** | 0 | 14 | 2 | 16 | 1 | 1 | 16 | **18** | 5 | 0 | 0 | **5** | **60** | | |
| **81** | | **Peak Hour** | 3 | 312 | 18 | **333** | 27 | 271 | 10 | 308 | 11 | 18 | 265 | **294** | 21 | 5 | 2 | **28** | **963** | 963 | Peak Hour |
| 3 | 14 | 7:25 | 1 | 23 | 1 | **25** | 0 | 14 | 0 | 14 | 1 | 1 | 12 | **14** | 2 | 0 | 0 | **2** | **55** | | |
| 0 | 6 | 7:30 | 0 | 15 | 0 | **15** | 0 | 17 | 0 | 17 | 0 | 0 | 8 | **8** | 0 | 0 | 0 | **0** | **40** | | |
| 4 | 7 | 7:35 | 0 | 13 | 0 | **13** | 0 | 21 | 0 | 21 | 0 | 4 | 4 | **8** | 4 | 0 | 0 | **4** | **46** | | |
| 2 | 6 | 7:40 | 0 | 16 | 0 | **16** | 0 | 28 | 1 | 29 | 2 | 1 | 9 | **12** | 1 | 0 | 0 | **1** | **58** | | |

39 15 min
105
PHF = 0.67

**465** Circulated thru Lower Lot & Parked in Upper Lot

## March 16, 2013 Monster Trucks
## Ingress Counts Lower Lot Gates open 6:00 PM & 7:30 Performance

| | Main St @ 4th Ave. N. | | | | | Lower Lot @ Bench Boulevard | | | | | Both Entrances | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Begin Time PM | SB LT | NB RT | EB Thru | Total | Cumulative Totals | EB RT | WB LT | SB Thru | Total | Cumulative Totals | Total | Cumulative Totals |
| **6:05** | 6 | 42 | 26 | **74** | **74** | 1 | 8 | 0 | **9** | **9** | **83** | **83** |
| **6:10** | 5 | 40 | 25 | **70** | **144** | 6 | 1 | 2 | **9** | **18** | **79** | **162** |
| **6:15** | 6 | 42 | 26 | **74** | **218** | 4 | 5 | 1 | **10** | **28** | **84** | **246** |
| **6:20** | 5 | 41 | 25 | **71** | **289** | 1 | 3 | 1 | **5** | **33** | **76** | **322** |
| **6:25** | 10 | 30 | 19 | **59** | **348** | 4 | 5 | 0 | **9** | **42** | **68** | **390** |
| **6:30** | 4 | 32 | 16 | **52** | **400** | 3 | 3 | 2 | **8** | **50** | **60** | **450** |
| **6:35** | 5 | 41 | 15 | **61** | **461** | 2 | 1 | 0 | **3** | **53** | **64** | **514** |
| **6:40** | 5 | 38 | 9 | **52** | **513** | 0 | 6 | 1 | **7** | **60** | **59** | **573** |
| **6:45** | 3 | 36 | 17 | **56** | **569** | 2 | 0 | 1 | **3** | **63** | **59** | **632** |
| **6:50** | 1 | 27 | 21 | **49** | **618** | 0 | 6 | 0 | **6** | **69** | **55** | **687** |
| **6:55** | 10 | 20 | 18 | **48** | **666** | 0 | 2 | 1 | **3** | **72** | **51** | **738** |
| **7:00** | 1 | 23 | 21 | **45** | **711** | 1 | 0 | 0 | **1** | **73** | **46** | **784** |
| **7:05** | 4 | 19 | 22 | **45** | **756** | 3 | 1 | 0 | **4** | **77** | **49** | **833** |
| **7:10** | 5 | 17 | 16 | **38** | **794** | 2 | 2 | 0 | **4** | **81** | **42** | **875** |
| **7:15** | 3 | 14 | 9 | **26** | **820** | 1 | 1 | 0 | **2** | **83** | **28** | **903** |
| **7:20** | 2 | 7 | 12 | **21** | **841** | 0 | 0 | 0 | **0** | **83** | **21** | **924** |
| **7:25** | 4 | 7 | 1 | **12** | **853** | 1 | 0 | 0 | **1** | **84** | **13** | **937** |
| **7:30** | 2 | 12 | 3 | **17** | **870** | 0 | 0 | 0 | **0** | **84** | **17** | **954** |
| **7:35** | 0 | 3 | 1 | **4** | **874** | 0 | 0 | 0 | **0** | **84** | **4** | **958** |
| **7:40** | 0 | 5 | 4 | **9** | **883** | 0 | 0 | 0 | **0** | **84** | **9** | **967** |
| **Totals** | **81** | **496** | **306** | **883** | | **31** | **44** | **9** | **84** | | **967** | |
| **% Totals** | **9.2%** | **56.2%** | **34.7%** | **1** | | **36.9%** | **52.4%** | **10.7%** | **1** | | | |



# APPENDIX D – INGRESS CAPACITY CALCULATIONS

# Appendix D – Ingress Capacity Calculations

## Design Hour Ingress Existing Conditions

# HCM Analysis Summary

| | | |
|---|---|---|
| 4th Ave N & Main Existing Condition | 4th Ave N/Main St | Area Type: Non CBD |
| R Marvin | 3/28/13 | Analysis Duration: 15 mins. |
| 5:30 to 6:30 PM Design Event | Case: 4TH AVE 530_630 Event Ingress Exist Cond | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 4 | 2 | L | 12.0 | L | 12.0 | LT | 12.0 | R | 12.0 | | | | |
| WB | 0 | 0 | | | | | | | | | | | | |
| NB | 3 | 3 | T | 12.0 | T | 12.0 | TR | 12.0 | | | | | | |
| SB | 4 | 3 | L | 12.0 | T | 12.0 | T | 12.0 | T | 12.0 | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 1215 | 375 | 135 | 0 | 0 | 0 | 0 | 1650 | 395 | 30 | 870 | 0 |
| PHF | 0.95 | 0.95 | 0.95 | 0.90 | 0.90 | 0.90 | 0.90 | 0.95 | 0.95 | 0.95 | 0.95 | 0.90 |
| % Heavy Vehicles | 1 | 0 | 1 | 2 | 2 | 2 | 2 | 4 | 0 | 0 | 4 | 2 |
| Lane Groups | L | LT | R | | | | | TR | | L | T | |
| Arrival Type | 3 | 3 | 3 | | | | | 4 | | 3 | 4 | |
| RTOR Vol (vph) | | 80 | | | 0 | | | 150 | | | 0 | |
| Peds/Hour | | 5 | | | 0 | | | 5 | | | 5 | |
| % Grade | | 0 | | | 0 | | | 0 | | | 0 | |
| Buses/Hour | | 0 | | | 0 | | | 0 | | | 0 | |
| Parkers/Hour (Left\|Right) | --- | --- | | --- | --- | | --- | --- | | --- | --- | |

Signal Settings: Actuated | Operational Analysis | Cycle Length: 150.0 Sec | Lost Time Per Cycle: 11.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | LTP | | | | | | | | | | | | | | | | |
| WB | | | | | | | | | | | | | | | | | | |
| NB | | | | TP | | | | | | | | | | | | | | |
| SB | | | | LT | | | | | | | | | | | | | | |
| Green | | 64.0 | | 75.0 | | | | | | | | | | | | | | 0 |
| Yellow | All Red | 4.0 | 1.5 | 4.0 | 1.5 | | | | | | | | | | | | | |

| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | L | 1557 | 0.284 | 0.427 | L | 0.665 | 35.3 | D | 38.0 | D |
| | * LT | 788 | 0.346 | 0.427 | LT | 0.810 | 43.6 | D | | |
| | R | 680 | 0.036 | 0.427 | R | 0.085 | 25.6 | C | | |
| | | | | | | | | | | |
| NB | | | | | | | | | | |
| | | | | | | | | | | |
| | * TR | 2468 | 0.404 | 0.500 | TR | 0.808 | 27.1 | C | 27.1 | C |
| | | | | | | | | | | |
| | | | | | | | | | | |
| SB | | | | | | | | | | |
| | L | 51 | 0.317 | 0.500 | L | 0.627 | 44.3 | D | 18.9 | B |
| | T | 2494 | 0.184 | 0.500 | T | 0.367 | 18.0 | B | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

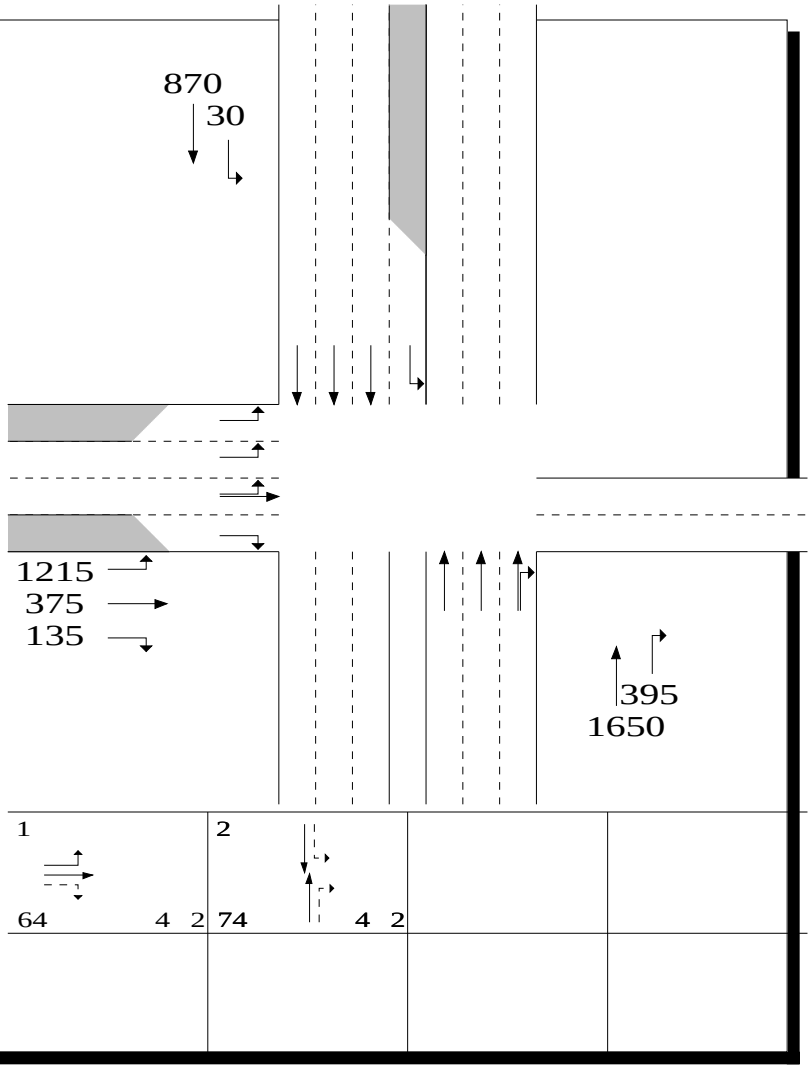
Intersection: Delay = 29.5 sec/veh  Int. LOS=C  $X_c$= 0.81  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.75

# NETSIM Summary Results

4th Ave N & Main Existing Condition
R Marvin
5:30 to 6:30 PM Design Event

4th Ave N/Main St
3/28/13
Case: 4TH AVE 530_630 Event Ingress Exist Cond

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 13 / 14 | 7.1 | 0.0 |
| | LT | 13 / 16 | 10.3 | 0.0 |
| | R | 2 / 4 | 14.3 | 0.0 |
| | All | | 8.6 | 0.0 |
| | | | | |
| | | | | |
| | | | | |
| | All | | 7.3 | 0.0 |
| | | | | |
| NB | TR | 17 / 23 | 7.3 | 0.0 |
| | | | | |
| | All | | 6.0 | 0.0 |
| SB | L | 2 / 4 | 1.5 | 0.0 |
| | T | 13 / 15 | 6.5 | 0.0 |
| | | | | |
| | | | | |
| Intersect. | | | 7.4 | |



# HCM Analysis Summary

| | | |
|---|---|---|
| 4th Ave N & Main Existing Condition | 4th Ave N/Main St | Area Type: Non CBD |
| R Marvin | 3/28/13 | Analysis Duration: 15 mins. |
| 6:30 to 7:30 PM Design Event | Case: 4TH AVE 630_730 Event Ingress Exist Cond | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 4 | 2 | L | 12.0 | L | 12.0 | LT | 12.0 | R | 12.0 | | | | |
| WB | 0 | 0 | | | | | | | | | | | | |
| NB | 3 | 3 | T | 12.0 | T | 12.0 | TR | 12.0 | | | | | | |
| SB | 4 | 3 | L | 12.0 | T | 12.0 | T | 12.0 | T | 12.0 | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 1140 | 400 | 80 | 0 | 0 | 0 | 0 | 1360 | 640 | 80 | 710 | 0 |
| PHF | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 |
| % Heavy Vehicles | 1 | 0 | 1 | 2 | 2 | 2 | 2 | 2 | 0 | 0 | 2 | 2 |
| Lane Groups | L | LT | R | | | | | TR | | L | T | |
| Arrival Type | 3 | 3 | 3 | | | | | 4 | | 3 | 4 | |
| RTOR Vol (vph) | | 60 | | | 0 | | | 250 | | | 0 | |
| Peds/Hour | | 5 | | | 0 | | | 5 | | | 5 | |
| % Grade | | 0 | | | 0 | | | 0 | | | 0 | |
| Buses/Hour | | 0 | | | 0 | | | 0 | | | 0 | |
| Parkers/Hour (Left\|Right) | --- | --- | | --- | --- | | --- | --- | | --- | --- | |

Signal Settings: Actuated | Operational Analysis | Cycle Length: 150.0 Sec | Lost Time Per Cycle: 11.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | LTP | | | | | | | | | | | | | | | | |
| WB | | | | | | | | | | | | | | | | | | |
| NB | | | | TP | | | | | | | | | | | | | | |
| SB | | | | LT | | | | | | | | | | | | | | |
| Green | | 70.0 | | 69.0 | | | | | | | | | | | | | | 0 |
| Yellow | All Red | 4.0 | 1.5 | 4.0 | 1.5 | | | | | | | | | | | | | |

| Capacity Analysis Results | | | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | L | 1703 | 0.271 | 0.467 | L | 0.580 | 29.6 | C | 34.7 | C |
| | * LT | 861 | 0.392 | 0.467 | LT | 0.840 | 42.1 | D | | |
| | R | 744 | 0.014 | 0.467 | R | 0.030 | 21.6 | C | | |
| | | | | | | | | | | |
| NB | | | | | | | | | | |
| | | | | | | | | | | |
| | TR | 2282 | 0.392 | 0.460 | TR | 0.852 | 33.9 | C | 33.9 | C |
| | | | | | | | | | | |
| | | | | | | | | | | |
| SB | | | | | | | | | | |
| | * L | 51 | 0.809 | 0.460 | L | 1.745 | 444.4 | F | 64.6 | E |
| | T | 2339 | 0.155 | 0.460 | T | 0.337 | 21.7 | C | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

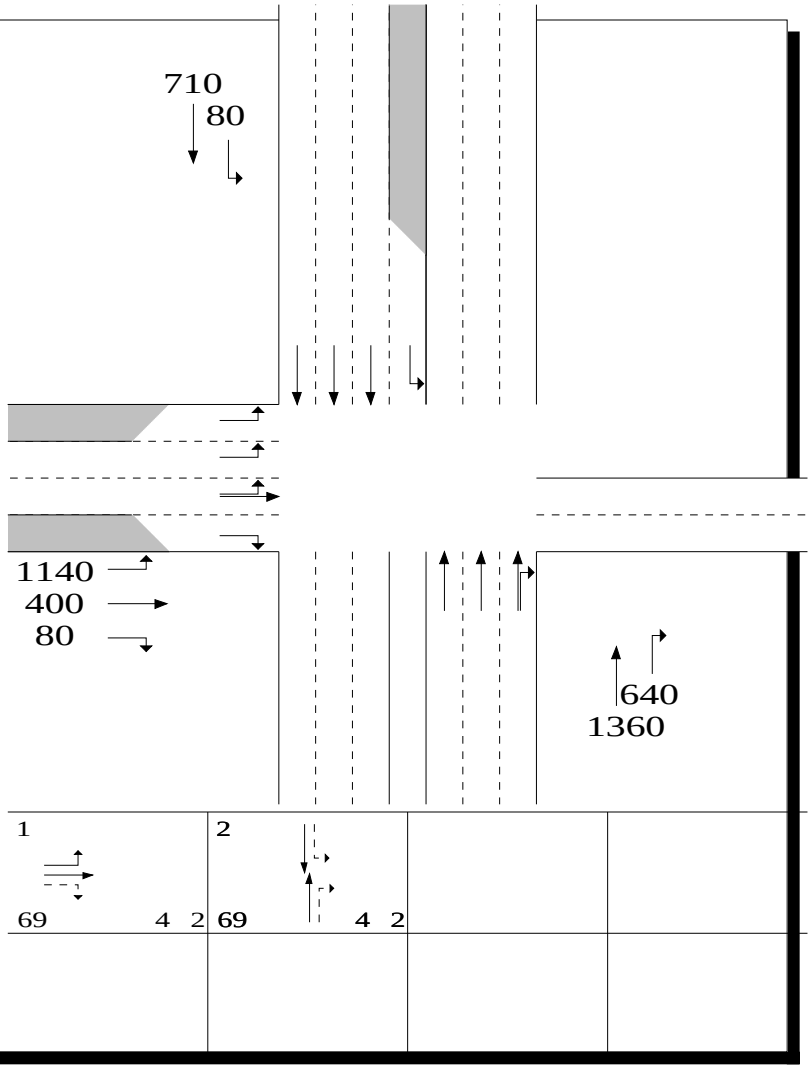
Intersection: Delay = 40.1 sec/veh Int. LOS=D $X_c$= 1.30 * Critical Lane Group $\Sigma$(v/s)Crit= 1.20

# NETSIM Summary Results

4th Ave N & Main Existing Condition
R Marvin
6:30 to 7:30 PM Design Event

4th Ave N/Main St
3/28/13
Case: 4TH AVE 630_730 Event Ingress Exist Cond

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 13 / 19 | 7.5 | 0.0 |
| | LT | 15 / 19 | 10.1 | 0.0 |
| | R | 2 / 2 | 14.2 | 0.0 |
| | All | | 8.7 | 0.0 |
| | | | | |
| | | | | |
| | | | | |
| | All | | 6.0 | 7.3 |
| | | | | |
| NB | TR | 20 / 30 | 6.0 | 7.3 |
| | | | | |
| | All | | 3.7 | 37.1 |
| SB | L | 11 / 18 | 0.3 | 37.1 |
| | T | 11 / 15 | 5.9 | 0.0 |
| | | | | |
| | | | | |
| Intersect. | | | 6.1 | |



# TWO-WAY STOP CONTROL SUMMARY

## General Information

| | |
|---|---|
| Analyst | *R Marvin* |
| Agency/Co. | *Marvin & Associates* |
| Date Performed | *3/29/13* |
| Analysis Time Period | *5:30 to 6:30 Design Ingress* |

## Site Information

| | |
|---|---|
| Intersection | *Lower Lot & Bench* |
| Jurisdiction | *Yellowstone County* |
| Analysis Year | *2013 Existing Conditions* |
| | |

Project Description *METRA Egress Study*

East/West Street: *Bench Boulevard* | North/South Street: *Lower Lot Access*

Intersection Orientation: *East-West* | Study Period (hrs): *0.25*

## Vehicle Volumes and Adjustments

| **Major Street** | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| Movement | 1 | 2 | 3 | 4 | 5 | 6 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *5* | *600* | *60* | *50* | *285* | *15* |
| Peak-Hour Factor, PHF | *0.95* | *0.95* | *0.95* | *0.90* | *0.90* | *0.90* |
| Hourly Flow Rate, HFR (veh/h) | *5* | *631* | *63* | *55* | *316* | *16* |
| Percent Heavy Vehicles | *0* | -- | -- | *0* | -- | -- |
| Median Type | *Undivided* | | | | | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *0* | *1* | *0* | *1* | *2* | *0* |
| Configuration | *LTR* | | | *L* | *T* | *TR* |
| Upstream Signal | | *1* | | | *1* | |

| **Minor Street** | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| Movement | 7 | 8 | 9 | 10 | 11 | 12 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *5* | *10* | *220* | *0* | *1* | *0* |
| Peak-Hour Factor, PHF | *0.90* | *0.90* | *0.90* | *0.50* | *0.50* | *0.50* |
| Hourly Flow Rate, HFR (veh/h) | *5* | *11* | *244* | *0* | *2* | *0* |
| Percent Heavy Vehicles | *0* | *0* | *0* | *0* | *0* | *0* |
| Percent Grade (%) | | *0* | | | *0* | |
| Flared Approach | | *N* | | | *N* | |
| Storage | | *0* | | | *0* | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *1* | *1* | *0* | *0* | *1* | *0* |
| Configuration | *L* | | *TR* | | *LTR* | |

## Delay, Queue Length, and Level of Service

| Approach | Eastbound | Westbound | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|---|---|
| Movement | 1 | 4 | 7 | 8 | 9 | 10 | 11 | 12 |
| Lane Configuration | *LTR* | *L* | *L* | | *TR* | | *LTR* | |
| v (veh/h) | *5* | *55* | *5* | | *255* | | *2* | |
| C (m) (veh/h) | *1306* | *882* | *250* | | *450* | | *206* | |
| v/c | *0.00* | *0.06* | *0.02* | | *0.57* | | *0.01* | |
| 95% queue length | *0.01* | *0.20* | *0.06* | | *3.44* | | *0.03* | |
| Control Delay (s/veh) | *7.8* | *9.4* | *19.7* | | *23.0* | | *22.6* | |
| LOS | *A* | *A* | *C* | | *C* | | *C* | |
| Approach Delay (s/veh) | -- | -- | *22.9* | | | *22.6* | | |
| Approach LOS | -- | -- | *C* | | | *C* | | |



*HCS+*™ Version 5.6

Generated: 3/29/2013 5:40 PM

# TWO-WAY STOP CONTROL SUMMARY

## General Information

| | |
|---|---|
| Analyst | *R Marvin* |
| Agency/Co. | *Marvin & Associates* |
| Date Performed | *3/29/13* |
| Analysis Time Period | *6:30 to 7:30 Design Ingress* |

## Site Information

| | |
|---|---|
| Intersection | *Lower Lot & Bench* |
| Jurisdiction | *Yellowstone County* |
| Analysis Year | *2013 Existing Conditions* |
| | |

Project Description *METRA Egress Study*

East/West Street: *Bench Boulevard* | North/South Street: *Lower Lot Access*

Intersection Orientation: *East-West* | Study Period (hrs): *0.25*

## Vehicle Volumes and Adjustments

| **Major Street** | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| Movement | 1 | 2 | 3 | 4 | 5 | 6 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *20* | *980* | *40* | *50* | *220* | *20* |
| Peak-Hour Factor, PHF | *0.98* | *0.98* | *0.98* | *0.90* | *0.90* | *0.90* |
| Hourly Flow Rate, HFR (veh/h) | *20* | *999* | *40* | *55* | *244* | *22* |
| Percent Heavy Vehicles | *0* | -- | -- | *0* | -- | -- |
| Median Type | *Undivided* | | | | | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *0* | *1* | *0* | *1* | *2* | *0* |
| Configuration | *LTR* | | | *L* | *T* | *TR* |
| Upstream Signal | | *1* | | | *1* | |

| **Minor Street** | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| Movement | 7 | 8 | 9 | 10 | 11 | 12 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *10* | *40* | *320* | *30* | *10* | *5* |
| Peak-Hour Factor, PHF | *0.95* | *0.95* | *0.95* | *0.50* | *0.50* | *0.50* |
| Hourly Flow Rate, HFR (veh/h) | *10* | *42* | *336* | *60* | *20* | *10* |
| Percent Heavy Vehicles | *0* | *0* | *0* | *0* | *0* | *0* |
| Percent Grade (%) | | *0* | | | *0* | |
| Flared Approach | | *N* | | | *N* | |
| Storage | | *0* | | | *0* | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *1* | *1* | *0* | *0* | *1* | *0* |
| Configuration | *L* | | *TR* | | *LTR* | |

## Delay, Queue Length, and Level of Service

| Approach | Eastbound | Westbound | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|---|---|
| Movement | 1 | 4 | 7 | 8 | 9 | 10 | 11 | 12 |
| Lane Configuration | *LTR* | *L* | *L* | | *TR* | | *LTR* | |
| v (veh/h) | *20* | *55* | *10* | | *378* | | *90* | |
| C (m) (veh/h) | *1378* | *646* | *113* | | *248* | | *0* | |
| v/c | *0.01* | *0.09* | *0.09* | | *1.52* | | | |
| 95% queue length | *0.04* | *0.28* | *0.28* | | *22.54* | | | |
| Control Delay (s/veh) | *7.7* | *11.1* | *39.9* | | *291.9* | | | |
| LOS | *A* | *B* | *E* | | *F* | | *F* | |
| Approach Delay (s/veh) | -- | -- | *285.5* | | | | | |
| Approach LOS | -- | -- | *F* | | | | | |



*HCS+*™ Version 5.6

Generated: 3/29/2013 5:12 PM

# Appendix D – Ingress Capacity Calculations

# 4th Avenue North Exit Alternative A Option 2

# HCM Analysis Summary

| | | |
|---|---|---|
| 4th Ave N Exit From METRA Opt 2 | 4th Ave N/Main St | Area Type: Non CBD |
| R Marvin | 01/23/2013 | Analysis Duration: 15 mins. |
| 5:30 6:30 Ingress Design No | Case: 4TH AVE EXIT OPTION A2 INGRESS 530 TO 630 NO RAMP | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 4 | 0 | L | 12.0 | L | 12.0 | L | 12.0 | R | 12.0 | | | | |
| WB | 2 | 0 | L | 12.0 | L | 12.0 | | | | | | | | |
| NB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |
| SB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 1590 | 0 | 135 | 30 | 0 | 0 | 0 | 2045 | 0 | 0 | 870 | 0 |
| PHF | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 |
| % Heavy Vehicles | 1 | 2 | 1 | 0 | 2 | 2 | 2 | 4 | 2 | 2 | 4 | 2 |
| Lane Groups | L | | R | L | | | | T | | | T | |
| Arrival Type | 3 | | 3 | 3 | | | | 4 | | | 4 | |
| RTOR Vol (vph) | 80 | | | 0 | | | 0 | | | 0 | | |
| Peds/Hour | 20 | | | 0 | | | 5 | | | 5 | | |
| % Grade | 0 | | | 0 | | | 0 | | | 0 | | |
| Buses/Hour | 0 | | | 0 | | | 0 | | | 0 | | |
| Parkers/Hour (Left\|Right) | --- | --- | | --- | --- | | --- | --- | | --- | --- | |

Signal Settings: Actuated | Operational Analysis | Cycle Length: 150.0 Sec | Lost Time Per Cycle: 15.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | L P | | | | | | | | | | | | | | | | |
| WB | | | | L | | | | | | | | | | | | | | |
| NB | | | | | | T | | | | | | | | | | | | |
| SB | | | | | | T | | | | | | | | | | | | |
| Green | | 53.0 | | 12.0 | | 70.0 | | | | | | | | | | | | 0 |
| Yellow | All Red | 3.5 | 1.5 | 3.5 | 1.5 | 3.5 | 1.5 | | | | | | | | | | | |

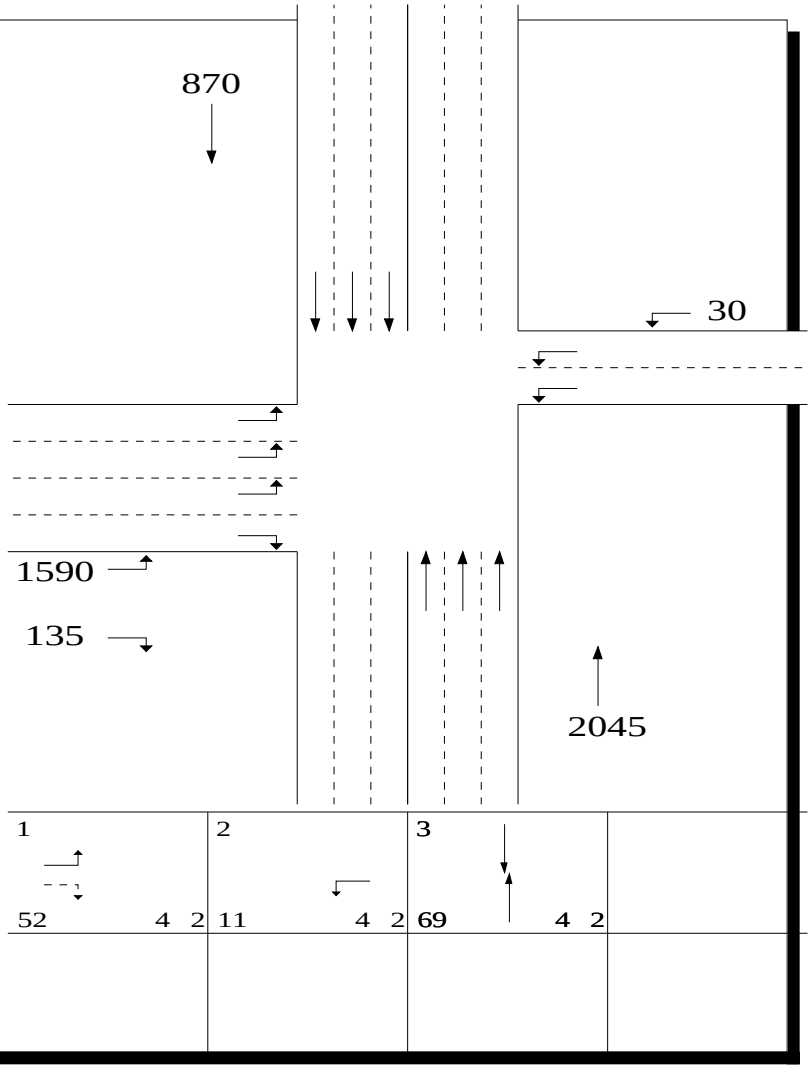
| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | * L | 1838 | 0.340 | 0.353 | L | 0.961 | 60.5 | E | 59.5 | E |
| | R | 555 | 0.039 | 0.353 | R | 0.110 | 32.7 | C | | |
| WB | | | | | | | | | | |
| | * L | 280 | 0.009 | 0.080 | L | 0.118 | 64.2 | E | 64.2 | E |
| NB | | | | | | | | | | |
| | * T | 2328 | 0.455 | 0.467 | T | 0.976 | 45.7 | D | 45.7 | D |
| SB | | | | | | | | | | |
| | T | 2328 | 0.194 | 0.467 | T | 0.415 | 22.1 | C | 22.1 | C |

Intersection: Delay = 46.3 sec/veh  Int. LOS=D  $X_c$= 0.89  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.80

# NETSIM Summary Results

4th Ave N Exit From METRA Opt 2 — 4th Ave N/Main St
R Marvin — 01/23/2013
5:30 6:30 Ingress Design No — Case: 4TH AVE EXIT OPTION A2 INGRESS 530 TO 630 N

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 20 / 26 | 5.2 | 3.0 |
| | | | | |
| | R | 1 / 2 | 18.6 | 0.0 |
| | All | | 5.5 | 3.0 |
| WB | L | 1 / 1 | 5.3 | 0.0 |
| | | | | |
| | | | | |
| | All | | 5.3 | 0.0 |
| | | | | |
| NB | T | 17 / 19 | 7.4 | 0.0 |
| | | | | |
| | All | | 7.4 | 0.0 |
| | | | | |
| SB | T | 1 / 3 | 18.1 | 0.0 |
| | | | | |
| | All | | 18.1 | 0.0 |
| Intersect. | | | 7.2 | |



# HCM Analysis Summary

| | | |
|---|---|---|
| 4th Exit w/ Ramp Early Event Des | 4th Avenu North/Main Street | Area Type: Non CBD |
| R Marvin | 03/28/2013 | Analysis Duration: 15 mins. |
| 5:30 to 6:30 PM | Case: 4th Ave Exit Option A2 Ingress 530 to 630 With Ramp | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 4 | 0 | L | 12.0 | L | 12.0 | L | 12.0 | R | 12.0 | | | | |
| WB | 2 | 0 | L | 12.0 | L | 12.0 | | | | | | | | |
| NB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |
| SB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 1590 | 0 | 135 | 30 | 0 | 0 | 0 | 1745 | 0 | 0 | 870 | 0 |
| PHF | 0.95 | 0.90 | 0.95 | 0.95 | 0.90 | 0.90 | 0.90 | 0.95 | 0.90 | 0.90 | 0.95 | 0.90 |
| % Heavy Vehicles | 1 | 2 | 2 | 0 | 2 | 2 | 2 | 4 | 2 | 2 | 4 | 2 |
| Lane Groups | L | | R | L | | | | T | | | T | |
| Arrival Type | 3 | | 3 | 3 | | | | 4 | | | 4 | |
| RTOR Vol (vph) | 70 | | | 0 | | | 0 | | | 0 | | |
| Peds/Hour | 5 | | | 0 | | | 5 | | | 5 | | |
| % Grade | 0 | | | 0 | | | 0 | | | 0 | | |
| Buses/Hour | 0 | | | 0 | | | 0 | | | 0 | | |
| Parkers/Hour (Left\|Right) | --- | | --- | --- | | --- | --- | | --- | --- | | --- |

Signal Settings: Actuated  Operational Analysis  Cycle Length: 150.0 Sec  Lost Time Per Cycle: 13.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | L P | | | | | | | | | | | | | | | | |
| WB | | | | L | | | | | | | | | | | | | | |
| NB | | | | | | T | | | | | | | | | | | | |
| SB | | | | | | T | | | | | | | | | | | | |
| Green | | 65.0 | | 10.0 | | 62.0 | | | | | | | | | | | | 0 |
| Yellow | All Red | 3.0 | 0.0 | 3.5 | 1.5 | 3.5 | 1.5 | | | | | | | | | | | |

| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | * L | 2254 | 0.322 | 0.433 | L | 0.743 | 36.7 | D | 36.3 | D |
| | R | 684 | 0.043 | 0.433 | R | 0.099 | 25.2 | C | | |
| WB | | | | | | | | | | |
| | * L | 233 | 0.009 | 0.067 | L | 0.137 | 66.0 | E | 66.0 | E |
| NB | | | | | | | | | | |
| | * T | 2062 | 0.368 | 0.413 | T | 0.891 | 42.3 | D | 42.3 | D |
| SB | | | | | | | | | | |
| | T | 2062 | 0.184 | 0.413 | T | 0.444 | 28.5 | C | 28.5 | C |

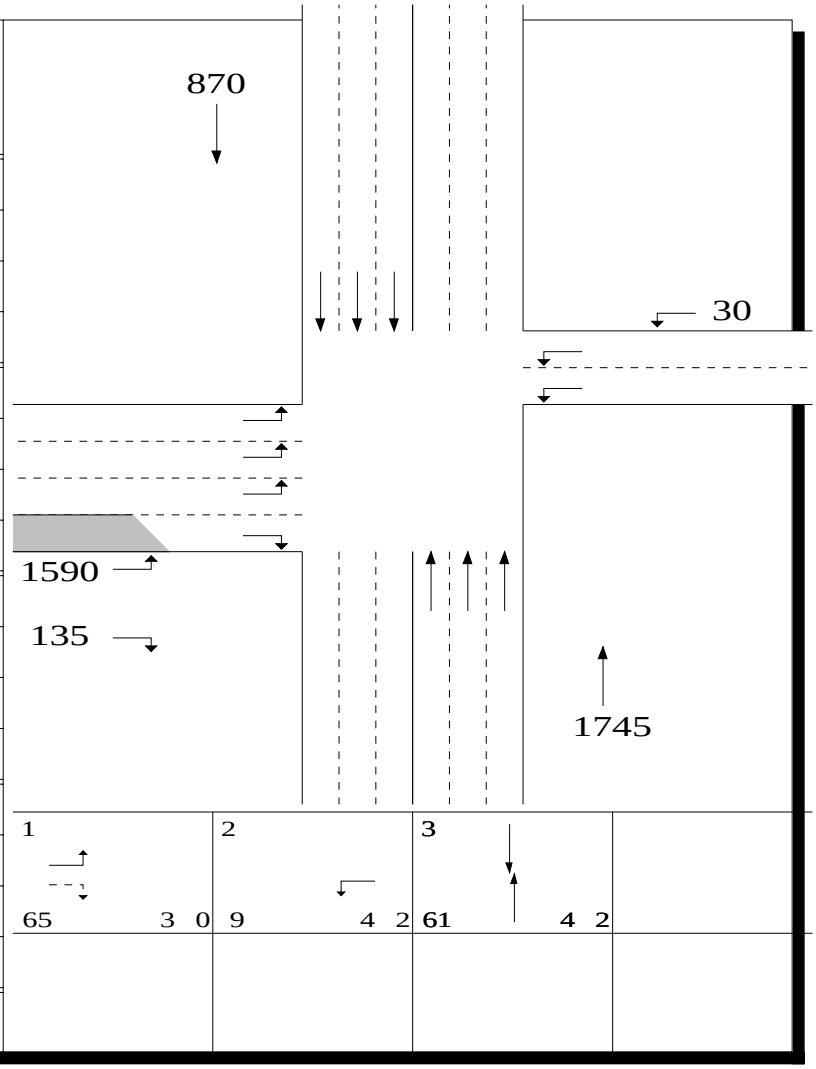
Intersection: Delay = 37.3 sec/veh  Int. LOS=D  $X_c$= 0.77  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.70

# NETSIM Summary Results

4th Exit w/ Ramp Early Event Des
R Marvin
5:30 to 6:30 PM

4th Avenu North/Main Street
03/28/2013
Case: 4th Ave Exit Option A2 Ingress 530 to 630 With Ramp

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 16 / 21 | 7.2 | 0.0 |
| | | | | |
| | R | 2 / 2 | 17.3 | 0.0 |
| | All | | 7.5 | 0.0 |
| WB | L | 1 / 1 | 5.7 | 0.0 |
| | | | | |
| | | | | |
| | All | | 5.7 | 0.0 |
| | | | | |
| NB | T | 12 / 16 | 7.9 | 0.0 |
| | | | | |
| | All | | 7.9 | 0.0 |
| | | | | |
| SB | T | 1 / 1 | 21.9 | 0.0 |
| | | | | |
| | All | | 21.9 | 0.0 |
| Intersect. | | | 8.8 | |



# TWO-WAY STOP CONTROL SUMMARY

## General Information

| | |
|---|---|
| Analyst | *R Marvin* |
| Agency/Co. | *Marvin & Associates* |
| Date Performed | *3/29/13* |
| Analysis Time Period | *5:30 to 6:30 Design Ingress* |

## Site Information

| | |
|---|---|
| Intersection | *Lower Lot & Bench* |
| Jurisdiction | *Yellowstone County* |
| Analysis Year | *2013 4th Ave Exit No Ramp* |
| | |

Project Description *METRA Egress Study*

East/West Street: *Bench Boulevard* | North/South Street: *Lower Lot Access*

Intersection Orientation: *East-West* | Study Period (hrs): *0.25*

## Vehicle Volumes and Adjustments

| **Major Street** | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| Movement | 1 | 2 | 3 | 4 | 5 | 6 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *5* | *880* | *550* | *50* | *285* | *15* |
| Peak-Hour Factor, PHF | *0.98* | *0.98* | *0.98* | *0.90* | *0.90* | *0.90* |
| Hourly Flow Rate, HFR (veh/h) | *5* | *897* | *561* | *55* | *316* | *16* |
| Percent Heavy Vehicles | *0* | -- | -- | *0* | -- | -- |
| Median Type | *Undivided* | | | | | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *0* | *1* | *0* | *1* | *2* | *0* |
| Configuration | *LTR* | | | *L* | *T* | *TR* |
| Upstream Signal | | *1* | | | *1* | |

| **Minor Street** | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| Movement | 7 | 8 | 9 | 10 | 11 | 12 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *5* | *10* | *10* | *0* | *1* | *0* |
| Peak-Hour Factor, PHF | *0.50* | *0.50* | *0.50* | *0.50* | *0.50* | *0.50* |
| Hourly Flow Rate, HFR (veh/h) | *10* | *20* | *20* | *0* | *2* | *0* |
| Percent Heavy Vehicles | *0* | *0* | *0* | *0* | *0* | *0* |
| Percent Grade (%) | | *0* | | | *0* | |
| Flared Approach | | *N* | | | *N* | |
| Storage | | *0* | | | *0* | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *1* | *1* | *0* | *0* | *1* | *0* |
| Configuration | *L* | | *TR* | | *LTR* | |

## Delay, Queue Length, and Level of Service

| Approach | Eastbound | Westbound | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|---|---|
| Movement | 1 | 4 | 7 | 8 | 9 | 10 | 11 | 12 |
| Lane Configuration | *LTR* | *L* | *L* | | *TR* | | *LTR* | |
| v (veh/h) | *5* | *55* | *10* | | *40* | | *2* | |
| C (m) (veh/h) | *1185* | *421* | *103* | | *127* | | *51* | |
| v/c | *0.00* | *0.13* | *0.10* | | *0.31* | | *0.04* | |
| 95% queue length | *0.01* | *0.45* | *0.31* | | *1.24* | | *0.12* | |
| Control Delay (s/veh) | *8.1* | *14.8* | *43.7* | | *45.9* | | *78.5* | |
| LOS | *A* | *B* | *E* | | *E* | | *F* | |
| Approach Delay (s/veh) | -- | -- | *45.4* | | | *78.5* | | |
| Approach LOS | -- | -- | *E* | | | *F* | | |



*HCS+*™ Version 5.6

Generated: 3/29/2013 5:19 PM

# TWO-WAY STOP CONTROL SUMMARY

## General Information

| | |
|---|---|
| Analyst | *R Marvin* |
| Agency/Co. | *Marvin & Associates* |
| Date Performed | *3/29/13* |
| Analysis Time Period | *6:30 to 7:30 Design Ingress* |

## Site Information

| | |
|---|---|
| Intersection | *Lower Lot & Bench* |
| Jurisdiction | *Yellowstone County* |
| Analysis Year | *2013 4th Ave Exit No Ramp* |
| | |

Project Description *METRA Egress Study*

East/West Street: *Bench Boulevard* | North/South Street: *Lower Lot Access*

Intersection Orientation: *East-West* | Study Period (hrs): *0.25*

## Vehicle Volumes and Adjustments

| **Major Street** | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| Movement | 1 | 2 | 3 | 4 | 5 | 6 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *20* | *1220* | *840* | *50* | *220* | *20* |
| Peak-Hour Factor, PHF | *0.98* | *0.98* | *0.98* | *0.90* | *0.90* | *0.90* |
| Hourly Flow Rate, HFR (veh/h) | *20* | *1244* | *857* | *55* | *244* | *22* |
| Percent Heavy Vehicles | *0* | -- | -- | *0* | -- | -- |
| Median Type | *Undivided* | | | | | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *0* | *1* | *0* | *1* | *2* | *0* |
| Configuration | *LTR* | | | *L* | *T* | *TR* |
| Upstream Signal | | *1* | | | *1* | |

| **Minor Street** | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| Movement | 7 | 8 | 9 | 10 | 11 | 12 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *10* | *40* | *10* | *30* | *10* | *5* |
| Peak-Hour Factor, PHF | *0.95* | *0.95* | *0.95* | *0.50* | *0.50* | *0.50* |
| Hourly Flow Rate, HFR (veh/h) | *10* | *42* | *10* | *60* | *20* | *10* |
| Percent Heavy Vehicles | *0* | *0* | *0* | *0* | *0* | *0* |
| Percent Grade (%) | | *0* | | | *0* | |
| Flared Approach | | *N* | | | *N* | |
| Storage | | *0* | | | *0* | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *1* | *1* | *0* | *0* | *1* | *0* |
| Configuration | *L* | | *TR* | | *LTR* | |

## Delay, Queue Length, and Level of Service

| Approach | Eastbound | Westbound | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|---|---|
| Movement | 1 | 4 | 7 | 8 | 9 | 10 | 11 | 12 |
| Lane Configuration | *LTR* | *L* | *L* | | *TR* | | *LTR* | |
| v (veh/h) | *20* | *55* | *10* | | *52* | | *90* | |
| C (m) (veh/h) | *819* | *234* | | | *0* | | | |
| v/c | *0.02* | *0.24* | | | | | | |
| 95% queue length | *0.08* | *0.89* | | | | | | |
| Control Delay (s/veh) | *9.5* | *25.0* | | | | | | |
| LOS | *A* | *D* | | | *F* | | | |
| Approach Delay (s/veh) | -- | -- | | | | | | |
| Approach LOS | -- | -- | | | | | | |



*HCS+*™ Version 5.6

Generated: 3/29/2013 5:25 PM

# Appendix D – Ingress Capacity Calculations

## 4th Avenue North Exit Alternative B No Slip Ramp

# HCM Analysis Summary

| | | |
|---|---|---|
| 4th Ave Ingress No Ramp Opt B | 4th Avenu North/Main Street | Area Type: Non CBD |
| R Marvin | 03/28/2013 | Analysis Duration: 15 mins. |
| 5:30 to 6:30 PM | Case: 4TH Ave Alt B 530_630 Ingress Design No Ramp | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 4 | 0 | L | 12.0 | L | 12.0 | L | 12.0 | R | 12.0 | | | | |
| WB | 2 | 0 | L | 12.0 | L | 12.0 | | | | | | | | |
| NB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |
| SB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 1590 | 0 | 135 | 30 | 0 | 0 | 0 | 2045 | 0 | 0 | 870 | 0 |
| PHF | 0.95 | 0.90 | 0.95 | 0.95 | 0.90 | 0.90 | 0.90 | 0.95 | 0.90 | 0.90 | 0.95 | 0.90 |
| % Heavy Vehicles | 1 | 2 | 1 | 0 | 2 | 2 | 2 | 4 | 2 | 2 | 4 | 2 |
| Lane Groups | L | | R | L | | | | T | | | T | |
| Arrival Type | 3 | | 3 | 3 | | | | 4 | | | 4 | |
| RTOR Vol (vph) | 70 | | | 0 | | | 0 | | | 0 | | |
| Peds/Hour | 1 | | | 0 | | | 5 | | | 5 | | |
| % Grade | 0 | | | 0 | | | 0 | | | 0 | | |
| Buses/Hour | 0 | | | 0 | | | 0 | | | 0 | | |
| Parkers/Hour (Left\|Right) | --- | | --- | --- | | --- | --- | | --- | --- | | --- |

Signal Settings: Actuated  Operational Analysis  Cycle Length: 150.0 Sec  Lost Time Per Cycle: 8.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | L P | | | | | | | | | | | | | | | | |
| WB | | L | | | | | | | | | | | | | | | | |
| NB | | | | T | | | | | | | | | | | | | | |
| SB | | | | T | | | | | | | | | | | | | | |
| Green | | 70.0 | | 72.0 | | | | | | | | | | | | | | 0 |
| Yellow | All Red | 3.0 | 0.0 | 3.5 | 1.5 | | | | | | | | | | | | | |

| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | * L | 2427 | 0.322 | 0.467 | L | 0.690 | 32.2 | C | 31.8 | C |
| | R | 746 | 0.043 | 0.467 | R | 0.091 | 22.3 | C | | |
| WB | | | | | | | | | | |
| | L | 1634 | 0.009 | 0.467 | L | 0.020 | 21.5 | C | 21.5 | C |
| NB | | | | | | | | | | |
| | * T | 2394 | 0.432 | 0.480 | T | 0.899 | 34.4 | C | 34.4 | C |
| SB | | | | | | | | | | |
| | T | 2394 | 0.184 | 0.480 | T | 0.383 | 20.3 | C | 20.3 | C |

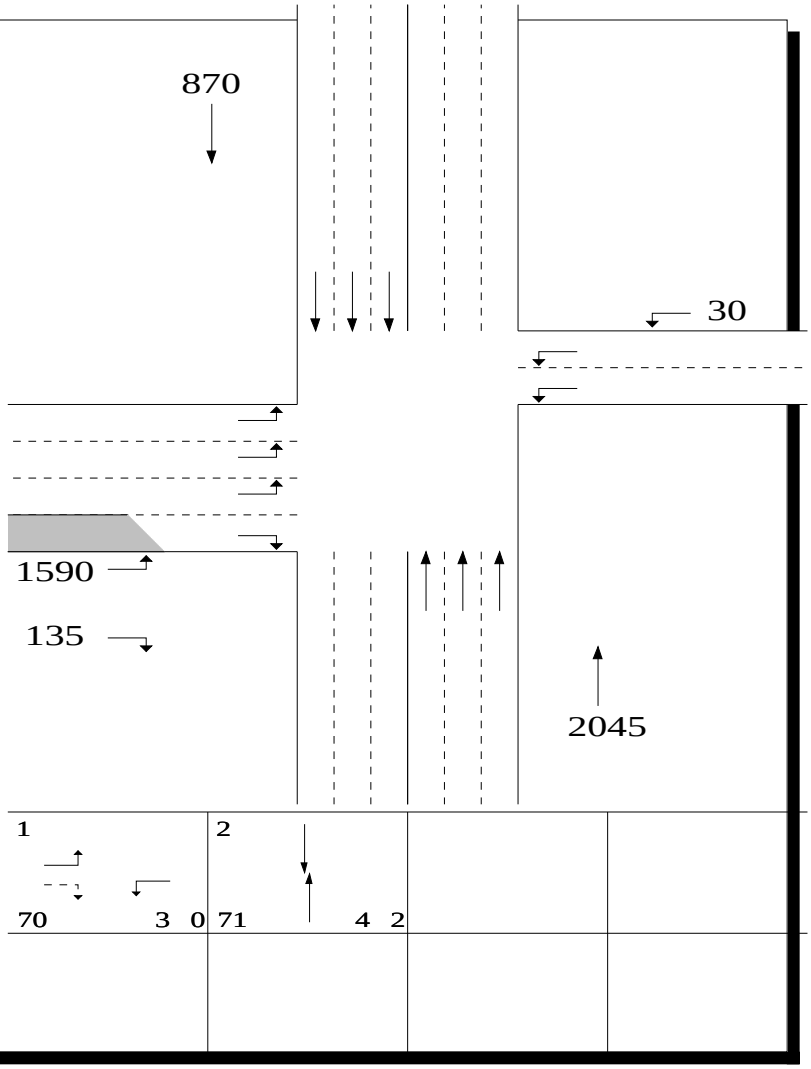
Intersection: Delay = 30.7 sec/veh  Int. LOS=C  $X_c$= 0.80  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.75

# NETSIM Summary Results

4th Ave Ingress No Ramp Opt B
R Marvin
5:30 to 6:30 PM

4th Avenu North/Main Street
03/28/2013
Case: 4TH Ave Alt B 530_630 Ingress Design No Ramp

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 14 / 19 | 8.4 | 0.0 |
| | | | | |
| | R | 1 / 2 | 19.4 | 0.0 |
| | All | | 8.7 | 0.0 |
| WB | L | 1 / 1 | 13.6 | 0.0 |
| | | | | |
| | | | | |
| | All | | 13.6 | 0.0 |
| | | | | |
| NB | T | 15 / 16 | 8.1 | 0.0 |
| | | | | |
| | All | | 8.1 | 0.0 |
| | | | | |
| SB | T | 0 / 1 | 23.9 | 0.0 |
| | | | | |
| | All | | 23.9 | 0.0 |
| Intersect. | | | 9.6 | |



# HCM Analysis Summary

| | | |
|---|---|---|
| 4th Ave Ingress No Ramp Opt B | 4th Avenu North/Main Street | Area Type: Non CBD |
| R Marvin | 03/28/2013 | Analysis Duration: 15 mins. |
| 6:30 to 7:30 PM | Case: 4TH Ave Alt B 630_730 Ingress Design No Ramp | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 4 | 0 | L | 12.0 | L | 12.0 | L | 12.0 | R | 12.0 | | | | |
| WB | 2 | 0 | L | 12.0 | L | 12.0 | | | | | | | | |
| NB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |
| SB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 1540 | 0 | 135 | 30 | 0 | 0 | 0 | 2000 | 0 | 0 | 710 | 0 |
| PHF | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 |
| % Heavy Vehicles | 1 | 2 | 1 | 0 | 2 | 2 | 2 | 4 | 2 | 2 | 4 | 2 |
| Lane Groups | L | | R | L | | | | T | | | T | |
| Arrival Type | 3 | | 3 | 3 | | | | 4 | | | 4 | |
| RTOR Vol (vph) | 80 | | | 0 | | | 0 | | | 0 | | |
| Peds/Hour | 1 | | | 0 | | | 5 | | | 5 | | |
| % Grade | 0 | | | 0 | | | 0 | | | 0 | | |
| Buses/Hour | 0 | | | 0 | | | 0 | | | 0 | | |
| Parkers/Hour (Left\|Right) | --- | | --- | --- | | --- | --- | | --- | --- | | --- |

Signal Settings: Actuated  Operational Analysis  Cycle Length: 150.0 Sec  Lost Time Per Cycle: 8.0 Sec

| Phase: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Ped Only |
|---|---|---|---|---|---|---|---|---|---|
| EB | L P | | | | | | | | |
| WB | L | | | | | | | | |
| NB | | T | | | | | | | |
| SB | | T | | | | | | | |
| Green | 68.0 | 74.0 | | | | | | | 0 |
| Yellow / All Red | 3.0 / 0.0 | 3.5 / 1.5 | | | | | | | |

| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | * L | 2358 | 0.329 | 0.453 | L | 0.726 | 34.4 | C | 34.0 | C |
| | R | 724 | 0.038 | 0.453 | R | 0.084 | 23.3 | C | | |
| WB | | | | | | | | | | |
| | L | 1588 | 0.009 | 0.453 | L | 0.021 | 22.6 | C | 22.6 | C |
| NB | | | | | | | | | | |
| | * T | 2461 | 0.445 | 0.493 | T | 0.903 | 33.0 | C | 33.0 | C |
| SB | | | | | | | | | | |
| | T | 2461 | 0.158 | 0.493 | T | 0.321 | 18.1 | B | 18.1 | B |

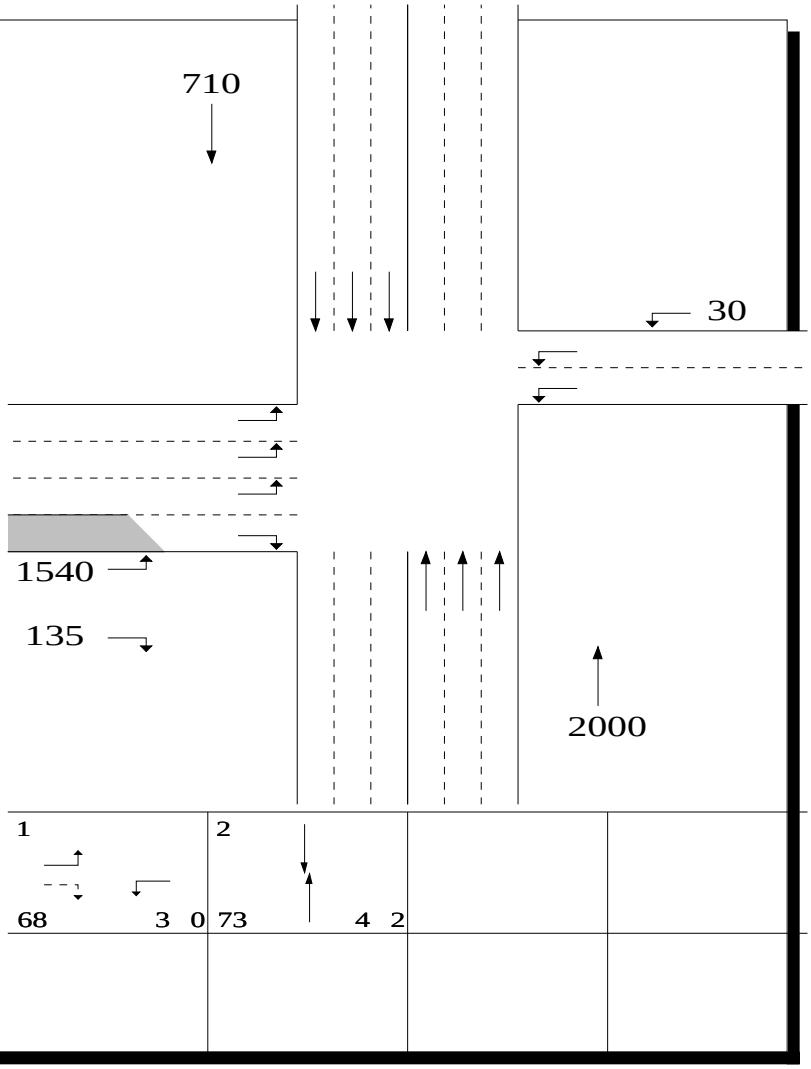
Intersection: Delay = 30.8 sec/veh  Int. LOS=C  $X_c$= 0.82  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.77

# NETSIM Summary Results

4th Ave Ingress No Ramp Opt B
R Marvin
6:30 to 7:30 PM

4th Avenu North/Main Street
03/28/2013
Case: 4TH Ave Alt B 630_730 Ingress Design No Ramp

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 14 / 19 | 8.5 | 0.0 |
| | | | | |
| | R | 2 / 4 | 16.9 | 0.0 |
| | All | | 8.8 | 0.0 |
| WB | L | 1 / 1 | 12.6 | 0.0 |
| | | | | |
| | | | | |
| | All | | 12.6 | 0.0 |
| | | | | |
| NB | T | 14 / 18 | 8.6 | 0.0 |
| | | | | |
| | All | | 8.6 | 0.0 |
| | | | | |
| SB | T | 0 / 2 | 24.7 | 0.0 |
| | | | | |
| | All | | 24.7 | 0.0 |
| Intersect. | | | 9.7 | |



# Appendix D – Ingress Capacity Calculations

## 4th Avenue North Exit – With Main Street Slip Ramp

# HCM Analysis Summary

| | | |
|---|---|---|
| 4th Ave Ingress With Ramp Opt B | 4th Avenu North/Main Street | Area Type: Non CBD |
| R Marvin | 03/28/2013 | Analysis Duration: 15 mins. |
| 5:30 to 6:30 PM | Case: 4TH Ave Alt B 530_630 Ingress Design With Ramp | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 4 | 0 | L | 12.0 | L | 12.0 | L | 12.0 | R | 12.0 | | | | |
| WB | 2 | 0 | L | 12.0 | L | 12.0 | | | | | | | | |
| NB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |
| SB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 1590 | 0 | 135 | 30 | 0 | 0 | 0 | 1745 | 0 | 0 | 870 | 0 |
| PHF | 0.95 | 0.90 | 0.95 | 0.95 | 0.90 | 0.90 | 0.90 | 0.95 | 0.90 | 0.90 | 0.95 | 0.90 |
| % Heavy Vehicles | 1 | 2 | 1 | 0 | 2 | 2 | 2 | 4 | 2 | 2 | 4 | 2 |
| Lane Groups | L | | R | L | | | | T | | | T | |
| Arrival Type | 3 | | 3 | 3 | | | | 4 | | | 4 | |
| RTOR Vol (vph) | 70 | | | 0 | | | 0 | | | 0 | | |
| Peds/Hour | 1 | | | 0 | | | 5 | | | 5 | | |
| % Grade | 0 | | | 0 | | | 0 | | | 0 | | |
| Buses/Hour | 0 | | | 0 | | | 0 | | | 0 | | |
| Parkers/Hour (Left\|Right) | --- | | --- | --- | | --- | --- | | --- | --- | | --- |

Signal Settings: Actuated  Operational Analysis  Cycle Length: 150.0 Sec  Lost Time Per Cycle: 8.0 Sec

| Phase: | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Ped Only |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EB | | L P | | | | | | | | | | | | | | | | |
| WB | | L | | | | | | | | | | | | | | | | |
| NB | | | | T | | | | | | | | | | | | | | |
| SB | | | | T | | | | | | | | | | | | | | |
| Green | | 75.0 | | 67.0 | | | | | | | | | | | | | | 0 |
| Yellow | All Red | 3.0 | 0.0 | 3.5 | 1.5 | | | | | | | | | | | | | |

| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | * L | 2601 | 0.322 | 0.500 | L | 0.644 | 28.1 | C | 27.7 | C |
| | R | 799 | 0.043 | 0.500 | R | 0.085 | 19.6 | B | | |
| WB | | | | | | | | | | |
| | L | 1751 | 0.009 | 0.500 | L | 0.018 | 18.9 | B | 18.9 | B |
| NB | | | | | | | | | | |
| | * T | 2228 | 0.368 | 0.447 | T | 0.825 | 34.2 | C | 34.2 | C |
| SB | | | | | | | | | | |
| | T | 2228 | 0.184 | 0.447 | T | 0.411 | 24.2 | C | 24.2 | C |

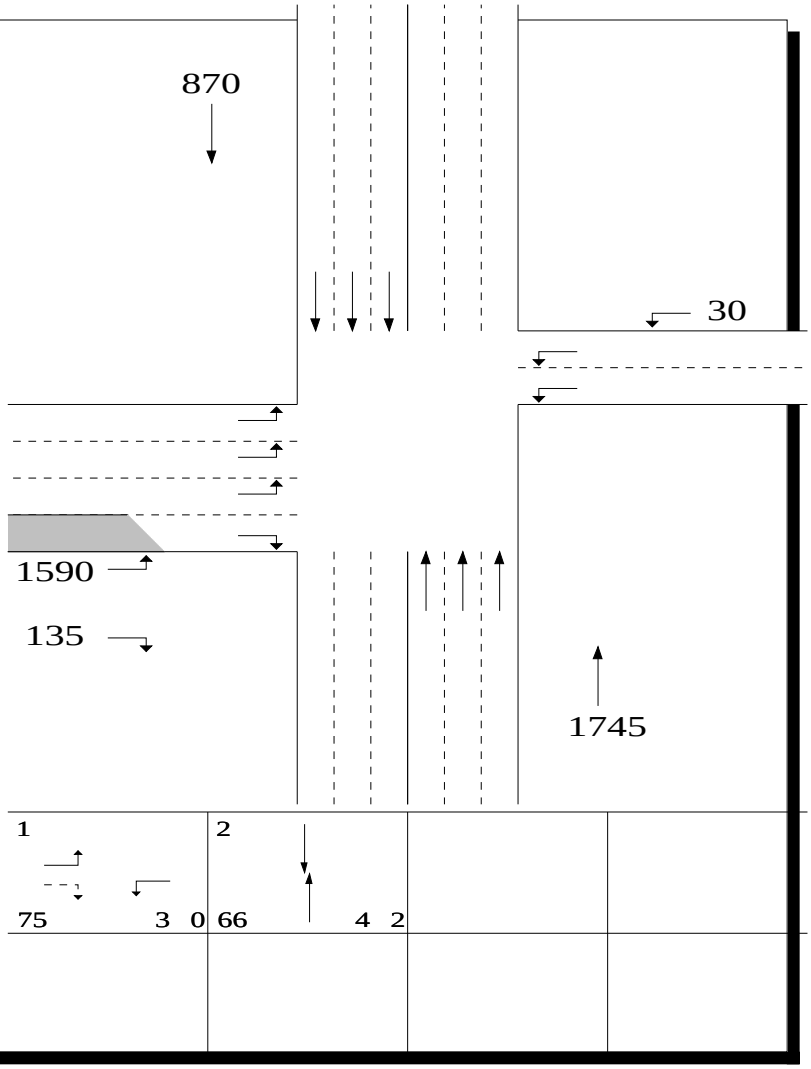
Intersection: Delay = 29.6 sec/veh  Int. LOS=C  $X_c$= 0.73  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.69

# NETSIM Summary Results

4th Ave Ingress With Ramp Opt B
R Marvin
5:30 to 6:30 PM

4th Avenu North/Main Street
03/28/2013
Case: 4TH Ave Alt B 530_630 Ingress Design With Ramp

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 13 / 21 | 9.5 | 0.0 |
| | | | | |
| | R | 1 / 2 | 19.6 | 0.0 |
| | All | | 9.8 | 0.0 |
| WB | L | 1 / 1 | 13.9 | 0.0 |
| | | | | |
| | | | | |
| | All | | 13.9 | 0.0 |
| | | | | |
| NB | T | 11 / 14 | 8.7 | 0.0 |
| | | | | |
| | All | | 8.7 | 0.0 |
| | | | | |
| SB | T | 1 / 4 | 20.5 | 0.0 |
| | | | | |
| | All | | 20.5 | 0.0 |
| Intersect. | | | 10.3 | |



# HCM Analysis Summary

| | | |
|---|---|---|
| 4th Ave Ingress With Ramp Opt B | 4th Avenu North/Main Street | Area Type: Non CBD |
| R Marvin | 03/28/2013 | Analysis Duration: 15 mins. |
| 6:30 to 7:30 PM | Case: 4TH Ave Alt B 630_730 Ingress Design With Ramp | |

| Lanes | | | Geometry: Movements Serviced by Lane and Lane Widths (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | Outbound | Lane 1 | | Lane 2 | | Lane 3 | | Lane 4 | | Lane 5 | | Lane 6 | |
| EB | 4 | 0 | L | 12.0 | L | 12.0 | L | 12.0 | R | 12.0 | | | | |
| WB | 2 | 0 | L | 12.0 | L | 12.0 | | | | | | | | |
| NB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |
| SB | 3 | 3 | T | 12.0 | T | 12.0 | T | 12.0 | | | | | | |

| | East | | | West | | | North | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data | L | T | R | L | T | R | L | T | R | L | T | R |
| Movement Volume (vph) | 1540 | 0 | 135 | 30 | 0 | 0 | 0 | 1460 | 0 | 0 | 710 | 0 |
| PHF | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 |
| % Heavy Vehicles | 1 | 2 | 1 | 0 | 2 | 2 | 2 | 4 | 2 | 2 | 4 | 2 |
| Lane Groups | L | | R | L | | | | T | | | T | |
| Arrival Type | 3 | | 3 | 3 | | | | 4 | | | 4 | |
| RTOR Vol (vph) | 80 | | | 0 | | | 0 | | | 0 | | |
| Peds/Hour | 1 | | | 0 | | | 5 | | | 5 | | |
| % Grade | 0 | | | 0 | | | 0 | | | 0 | | |
| Buses/Hour | 0 | | | 0 | | | 0 | | | 0 | | |
| Parkers/Hour (Left\|Right) | --- | | --- | --- | | --- | --- | | --- | --- | | --- |

Signal Settings: Actuated  Operational Analysis  Cycle Length: 150.0 Sec  Lost Time Per Cycle: 8.0 Sec

| Phase: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Ped Only |
|---|---|---|---|---|---|---|---|---|---|
| EB | L P | | | | | | | | |
| WB | L | | | | | | | | |
| NB | | T | | | | | | | |
| SB | | T | | | | | | | |
| Green | 78.0 | 64.0 | | | | | | | 0 |
| Yellow / All Red | 3.0 / 0.0 | 3.5 / 1.5 | | | | | | | |

| | | Capacity Analysis Results | | | | | | | Approach: | |
|---|---|---|---|---|---|---|---|---|---|---|
| App | Lane Group | Cap (vph) | v/s Ratio | g/C Ratio | Lane Group | v/c Ratio | Delay (sec/veh) | LOS | Delay (sec/veh) | LOS |
| EB | | | | | | | | | | |
| | * L | 2705 | 0.329 | 0.520 | L | 0.633 | 26.1 | C | 25.8 | C |
| | R | 831 | 0.038 | 0.520 | R | 0.073 | 18.0 | B | | |
| WB | | | | | | | | | | |
| | L | 1821 | 0.009 | 0.520 | L | 0.018 | 17.4 | B | 17.4 | B |
| NB | | | | | | | | | | |
| | * T | 2128 | 0.325 | 0.427 | T | 0.762 | 34.2 | C | 34.2 | C |
| SB | | | | | | | | | | |
| | T | 2128 | 0.158 | 0.427 | T | 0.371 | 25.8 | C | 25.8 | C |

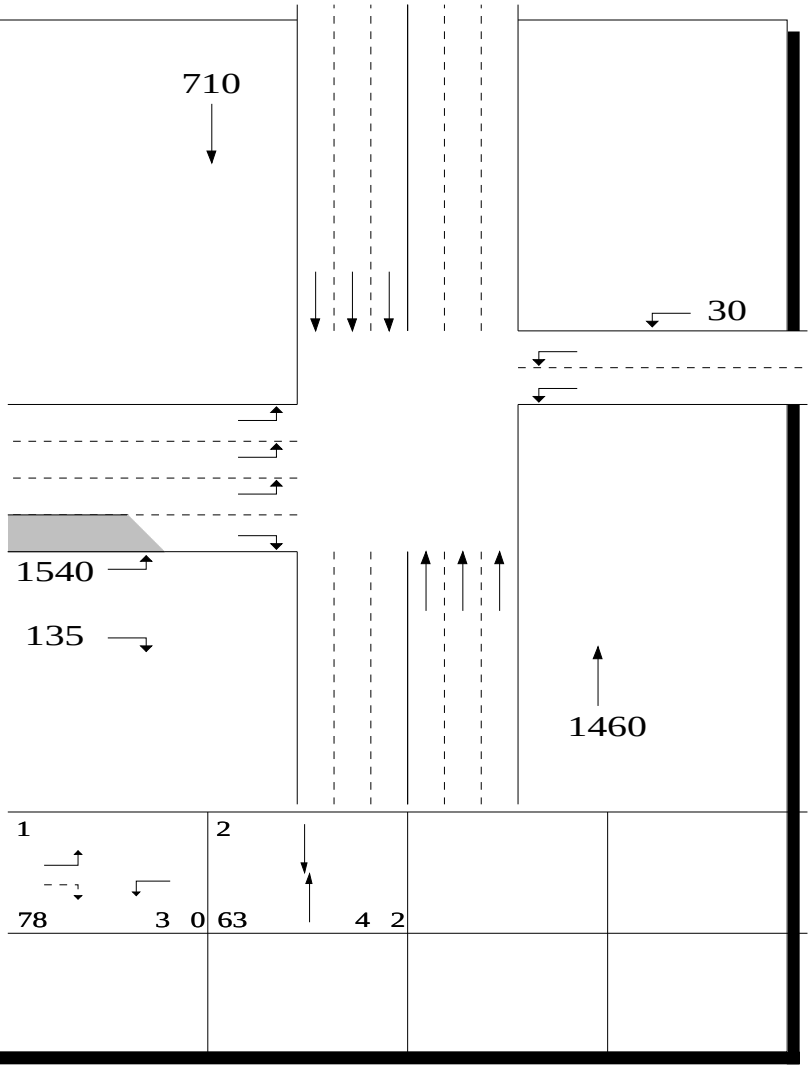
Intersection: Delay = 29.0 sec/veh  Int. LOS=C  $X_c$= 0.69  * Critical Lane Group  $\Sigma$(v/s)Crit= 0.65

# NETSIM Summary Results

4th Ave Ingress With Ramp Opt B
R Marvin
6:30 to 7:30 PM

4th Avenu North/Main Street
03/28/2013
Case: 4TH Ave Alt B 630_730 Ingress Design With Ramp

| App | Lane Group | Queues Per Lane Avg/Max (veh) | Average Speed (mph) | Spillback in Worst Lane (% of Peak Period) |
|---|---|---|---|---|
| EB | L | 13 / 20 | 9.7 | 0.0 |
| | | | | |
| | R | 2 / 4 | 17.8 | 0.0 |
| | All | | 10.0 | 0.0 |
| WB | L | 1 / 1 | 11.3 | 0.0 |
| | | | | |
| | | | | |
| | All | | 11.3 | 0.0 |
| | | | | |
| NB | T | 9 / 10 | 9.0 | 0.0 |
| | | | | |
| | All | | 9.0 | 0.0 |
| | | | | |
| SB | T | 0 / 4 | 21.5 | 0.0 |
| | | | | |
| | All | | 21.5 | 0.0 |
| Intersect. | | | 10.6 | |



# TWO-WAY STOP CONTROL SUMMARY

## General Information

| | |
|---|---|
| Analyst | *R Marvin* |
| Agency/Co. | *Marvin & Associates* |
| Date Performed | *3/29/13* |
| Analysis Time Period | *5:30 to 6:30 Design Ingress* |

## Site Information

| | |
|---|---|
| Intersection | *Lower Lot & Bench* |
| Jurisdiction | *Yellowstone County* |
| Analysis Year | *2013 4th Ave Exit With Ramp* |
| | |

Project Description *METRA Egress Study*

East/West Street: *Bench Boulevard* | North/South Street: *Lower Lot Access*

Intersection Orientation: *East-West* | Study Period (hrs): *0.25*

## Vehicle Volumes and Adjustments

| **Major Street** | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| Movement | 1 | 2 | 3 | 4 | 5 | 6 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *5* | *885* | *250* | *50* | *285* | *15* |
| Peak-Hour Factor, PHF | *0.98* | *0.98* | *0.98* | *0.90* | *0.90* | *0.90* |
| Hourly Flow Rate, HFR (veh/h) | *5* | *903* | *255* | *55* | *316* | *16* |
| Percent Heavy Vehicles | *0* | -- | -- | *0* | -- | -- |
| Median Type | *Undivided* | | | | | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *0* | *1* | *0* | *1* | *2* | *0* |
| Configuration | *LTR* | | | *L* | *T* | *TR* |
| Upstream Signal | | *1* | | | *1* | |

| **Minor Street** | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| Movement | 7 | 8 | 9 | 10 | 11 | 12 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *5* | *10* | *10* | *0* | *1* | *0* |
| Peak-Hour Factor, PHF | *0.50* | *0.50* | *0.50* | *0.50* | *0.50* | *0.50* |
| Hourly Flow Rate, HFR (veh/h) | *10* | *20* | *20* | *0* | *2* | *0* |
| Percent Heavy Vehicles | *0* | *0* | *0* | *0* | *0* | *0* |
| Percent Grade (%) | | *0* | | | *0* | |
| Flared Approach | | *N* | | | *N* | |
| Storage | | *0* | | | *0* | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *1* | *1* | *0* | *0* | *1* | *0* |
| Configuration | *L* | | *TR* | | *LTR* | |

## Delay, Queue Length, and Level of Service

| Approach | Eastbound | Westbound | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|---|---|
| Movement | 1 | 4 | 7 | 8 | 9 | 10 | 11 | 12 |
| Lane Configuration | *LTR* | *L* | *L* | | *TR* | | *LTR* | |
| v (veh/h) | *5* | *55* | *10* | | *40* | | *2* | |
| C (m) (veh/h) | *1330* | *564* | *135* | | *167* | | *96* | |
| v/c | *0.00* | *0.10* | *0.07* | | *0.24* | | *0.02* | |
| 95% queue length | *0.01* | *0.32* | *0.24* | | *0.89* | | *0.06* | |
| Control Delay (s/veh) | *7.7* | *12.1* | *33.8* | | *33.2* | | *43.3* | |
| LOS | *A* | *B* | *D* | | *D* | | *E* | |
| Approach Delay (s/veh) | -- | -- | *33.3* | | | *43.3* | | |
| Approach LOS | -- | -- | *D* | | | *E* | | |



*HCS+*™ Version 5.6

Generated: 3/29/2013 5:44 PM

# TWO-WAY STOP CONTROL SUMMARY

## General Information

| | |
|---|---|
| Analyst | *R Marvin* |
| Agency/Co. | *Marvin & Associates* |
| Date Performed | *3/29/13* |
| Analysis Time Period | *6:30 to 7:30 Design Ingress* |

## Site Information

| | |
|---|---|
| Intersection | *Lower Lot & Bench* |
| Jurisdiction | *Yellowstone County* |
| Analysis Year | *2013 4th Ave Exit With Ramp* |
| | |

Project Description *METRA Egress Study*

East/West Street: *Bench Boulevard* | North/South Street: *Lower Lot Access*

Intersection Orientation: *East-West* | Study Period (hrs): *0.25*

## Vehicle Volumes and Adjustments

| **Major Street** | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| Movement | 1 | 2 | 3 | 4 | 5 | 6 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *20* | *1235* | *300* | *50* | *220* | *20* |
| Peak-Hour Factor, PHF | *0.98* | *0.98* | *0.98* | *0.90* | *0.90* | *0.90* |
| Hourly Flow Rate, HFR (veh/h) | *20* | *1260* | *306* | *55* | *244* | *22* |
| Percent Heavy Vehicles | *0* | -- | -- | *0* | -- | -- |
| Median Type | *Undivided* | | | | | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *0* | *1* | *0* | *1* | *2* | *0* |
| Configuration | *LTR* | | | *L* | *T* | *TR* |
| Upstream Signal | | *1* | | | *1* | |

| **Minor Street** | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| Movement | 7 | 8 | 9 | 10 | 11 | 12 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *10* | *40* | *10* | *30* | *10* | *5* |
| Peak-Hour Factor, PHF | *0.50* | *0.50* | *0.50* | *0.50* | *0.50* | *0.50* |
| Hourly Flow Rate, HFR (veh/h) | *20* | *80* | *20* | *60* | *20* | *10* |
| Percent Heavy Vehicles | *0* | *0* | *0* | *0* | *0* | *0* |
| Percent Grade (%) | | *0* | | | *0* | |
| Flared Approach | | *N* | | | *N* | |
| Storage | | *0* | | | *0* | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *1* | *1* | *0* | *0* | *1* | *0* |
| Configuration | *L* | | *TR* | | *LTR* | |

## Delay, Queue Length, and Level of Service

| Approach | Eastbound | Westbound | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|---|---|
| Movement | 1 | 4 | 7 | 8 | 9 | 10 | 11 | 12 |
| Lane Configuration | *LTR* | *L* | *L* | | *TR* | | *LTR* | |
| v (veh/h) | *20* | *55* | *20* | | *100* | | *90* | |
| C (m) (veh/h) | *1116* | *392* | *27* | | *54* | | *0* | |
| v/c | *0.02* | *0.14* | *0.74* | | *1.85* | | | |
| 95% queue length | *0.05* | *0.48* | *2.34* | | *9.64* | | | |
| Control Delay (s/veh) | *8.3* | *15.7* | *298.7* | | *567.1* | | | |
| LOS | *A* | *C* | *F* | | *F* | | *F* | |
| Approach Delay (s/veh) | -- | -- | *522.4* | | | | | |
| Approach LOS | -- | -- | *F* | | | | | |



*HCS+*™ Version 5.6

Generated: 3/29/2013 5:46 PM

# TWO-WAY STOP CONTROL SUMMARY

## General Information

| | |
|---|---|
| Analyst | *R Marvin* |
| Agency/Co. | *Marvin & Associates* |
| Date Performed | *3/29/13* |
| Analysis Time Period | *5:30 to 6:30 Design Ingress* |

## Site Information

| | |
|---|---|
| Intersection | *Lower Lot & Bench* |
| Jurisdiction | *Yellowstone County* |
| Analysis Year | *2013 4th Ave Exit Ramp & RT LN* |
| | |

Project Description *METRA Egress Study*

East/West Street: *Bench Boulevard* | North/South Street: *Lower Lot Access*

Intersection Orientation: *East-West* | Study Period (hrs): *0.25*

## Vehicle Volumes and Adjustments

| **Major Street** | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| Movement | 1 | 2 | 3 | 4 | 5 | 6 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *5* | *885* | *250* | *50* | *285* | *15* |
| Peak-Hour Factor, PHF | *0.98* | *0.98* | *0.98* | *0.90* | *0.90* | *0.90* |
| Hourly Flow Rate, HFR (veh/h) | *5* | *903* | *255* | *55* | *316* | *16* |
| Percent Heavy Vehicles | *0* | -- | -- | *0* | -- | -- |
| Median Type | *Undivided* | | | | | |
| RT Channelized | | | *1* | | | *0* |
| Lanes | *0* | *1* | *1* | *1* | *2* | *0* |
| Configuration | *LT* | | *R* | *L* | *T* | *TR* |
| Upstream Signal | | *1* | | | *1* | |

| **Minor Street** | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| Movement | 7 | 8 | 9 | 10 | 11 | 12 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *5* | *10* | *10* | *0* | *1* | *0* |
| Peak-Hour Factor, PHF | *0.50* | *0.50* | *0.50* | *0.50* | *0.50* | *0.50* |
| Hourly Flow Rate, HFR (veh/h) | *10* | *20* | *20* | *0* | *2* | *0* |
| Percent Heavy Vehicles | *0* | *0* | *0* | *0* | *0* | *0* |
| Percent Grade (%) | *0* | | | *0* | | |
| Flared Approach | | *N* | | | *N* | |
| Storage | | *0* | | | *0* | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *1* | *1* | *0* | *0* | *1* | *0* |
| Configuration | *L* | | *TR* | | *LTR* | |

## Delay, Queue Length, and Level of Service

| Approach | Eastbound | Westbound | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|---|---|
| Movement | 1 | 4 | 7 | 8 | 9 | 10 | 11 | 12 |
| Lane Configuration | *LT* | *L* | *L* | | *TR* | | *LTR* | |
| v (veh/h) | *5* | *55* | *10* | | *40* | | *2* | |
| C (m) (veh/h) | *1330* | *723* | *184* | | *211* | | *157* | |
| v/c | *0.00* | *0.08* | *0.05* | | *0.19* | | *0.01* | |
| 95% queue length | *0.01* | *0.25* | *0.17* | | *0.68* | | *0.04* | |
| Control Delay (s/veh) | *7.7* | *10.4* | *25.7* | | *26.0* | | *28.2* | |
| LOS | *A* | *B* | *D* | | *D* | | *D* | |
| Approach Delay (s/veh) | -- | -- | *25.9* | | | *28.2* | | |
| Approach LOS | -- | -- | *D* | | | *D* | | |



*HCS+*™ Version 5.6

Generated: 4/8/2013 3:26 PM

# TWO-WAY STOP CONTROL SUMMARY

## General Information

| | |
|---|---|
| Analyst | *R Marvin* |
| Agency/Co. | *Marvin & Associates* |
| Date Performed | *3/29/13* |
| Analysis Time Period | *6:30 to 7:30 Design Ingress* |

## Site Information

| | |
|---|---|
| Intersection | *Lower Lot & Bench* |
| Jurisdiction | *Yellowstone County* |
| Analysis Year | *2013 4th Ave Exit Ramp & RT LN* |
| | |

Project Description *METRA Egress Study*

East/West Street: *Bench Boulevard* | North/South Street: *Lower Lot Access*

Intersection Orientation: *East-West* | Study Period (hrs): *0.25*

## Vehicle Volumes and Adjustments

| **Major Street** | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| Movement | 1 | 2 | 3 | 4 | 5 | 6 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *20* | *1235* | *300* | *50* | *220* | *20* |
| Peak-Hour Factor, PHF | *0.98* | *0.98* | *0.98* | *0.90* | *0.90* | *0.90* |
| Hourly Flow Rate, HFR (veh/h) | *20* | *1260* | *306* | *55* | *244* | *22* |
| Percent Heavy Vehicles | *0* | -- | -- | *0* | -- | -- |
| Median Type | *Undivided* | | | | | |
| RT Channelized | | | *1* | | | *0* |
| Lanes | *0* | *1* | *1* | *1* | *2* | *0* |
| Configuration | *LT* | | *R* | *L* | *T* | *TR* |
| Upstream Signal | | *1* | | | *1* | |

| **Minor Street** | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| Movement | 7 | 8 | 9 | 10 | 11 | 12 |
| | L | T | R | L | T | R |
| Volume (veh/h) | *10* | *40* | *10* | *30* | *10* | *5* |
| Peak-Hour Factor, PHF | *0.50* | *0.50* | *0.50* | *0.50* | *0.50* | *0.50* |
| Hourly Flow Rate, HFR (veh/h) | *20* | *80* | *20* | *60* | *20* | *10* |
| Percent Heavy Vehicles | *0* | *0* | *0* | *0* | *0* | *0* |
| Percent Grade (%) | | *0* | | | *0* | |
| Flared Approach | | *N* | | | *N* | |
| Storage | | *0* | | | *0* | |
| RT Channelized | | | *0* | | | *0* |
| Lanes | *1* | *1* | *0* | *0* | *1* | *0* |
| Configuration | *L* | | *TR* | | *LTR* | |

## Delay, Queue Length, and Level of Service

| Approach | Eastbound | Westbound | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|---|---|
| Movement | 1 | 4 | 7 | 8 | 9 | 10 | 11 | 12 |
| Lane Configuration | *LT* | *L* | *L* | | *TR* | | *LTR* | |
| v (veh/h) | *20* | *55* | *20* | | *100* | | *90* | |
| C (m) (veh/h) | *1116* | *525* | *70* | | *92* | | *3* | |
| v/c | *0.02* | *0.10* | *0.29* | | *1.09* | | *30.00* | |
| 95% queue length | *0.05* | *0.35* | *1.03* | | *6.64* | | *13.39* | |
| Control Delay (s/veh) | *8.3* | *12.7* | *75.8* | | *203.4* | | *15397* | |
| LOS | *A* | *B* | *F* | | *F* | | *F* | |
| Approach Delay (s/veh) | -- | -- | *182.2* | | | *15397* | | |
| Approach LOS | -- | -- | *F* | | | *F* | | |



*HCS+*™ Version 5.6

Generated: 4/8/2013 3:28 PM

# APPENDIX E – IMPROVEMENT COST ESTIMATES

## Construction Estimate - 4th Avenue North Entrance to Exist Conversion w/ Slip-Ramp

4/12/2013

| Item No. | Est. Qty. | Unit | Description | Unit Price | Total Price |
|---|---|---|---|---|---|
| 101 | 1 | LS | Mobilization & Insurance | $ 24,000.00 | $ 24,000.00 |
| 102 | 1800 | LF | Remove & Dispose Curb & Gutter | $ 11.00 | $ 19,800.00 |
| 103 | 4900 | SF | Remove & Dispose Concrete Sidewalk | $ 2.50 | $ 12,250.00 |
| 104 | 17250 | SF | Remove & Dispose Asphalt | $ 2.00 | $ 34,500.00 |
| 105 | 2600 | CY | Unclassified Excavation | $ 10.00 | $ 26,000.00 |
| 106 | 1000 | CY | 1.5" Base Course Gravel | $ 18.00 | $ 18,000.00 |
| 107 | 3880 | LF | Concrete Curb & Gutter | $ 12.00 | $ 46,560.00 |
| 108 | 200 | SF | Concrete Double Gutter | $ 8.00 | $ 1,600.00 |
| 109 | 1180 | SF | Concrete Median Cap (3" Conc. & 3" Base) | $ 4.00 | $ 4,720.00 |
| 110 | 100 | SF | Concrete Accessibility Walk-Thru Median | $ 9.00 | $ 900.00 |
| 111 | 320 | SF | Concrete Accessibility Ramp (includes base) | $ 8.00 | $ 2,560.00 |
| 112 | 8 | EA | Truncated Dome Panel | $ 140.00 | $ 1,120.00 |
| 113 | 5600 | SF | Concrete Sidewalk - 4" Thick | $ 4.00 | $ 22,400.00 |
| 114 | 4600 | SY | Asphalt Surface Course (4' Section) | $ 15.00 | $ 69,000.00 |
| 115 | 170 | SY | Asphalt Surface Course (6" Section) | $ 30.00 | $ 5,100.00 |
| 116 | 1 | LS | Utility Adjustments | $ 6,000.00 | $ 6,000.00 |
| 117 | 1 | LS | Miscellaneous Removals | $ 4,000.00 | $ 4,000.00 |
| 118 | 1 | LS | New Landscaping | $ 10,000.00 | $ 10,000.00 |
| 119 | 54 | GL | Epoxy Pavement Markings | $ 200.00 | $ 10,800.00 |
| 120 | 30 | GL | Curb Paint (Yellow) | $ 115.00 | $ 3,450.00 |
| 121 | 250 | SF | Obliterate Pavement Markings | $ 4.00 | $ 1,000.00 |
| 122 | 40 | EA | New Ground Mount Regulatory Sign | $ 450.00 | $ 18,000.00 |
| 123 | 10 | EA | New Overhead Signs | $ 300.00 | $ 3,000.00 |
| 124 | 2 | EA | Changeable Message Signs | $ 4,000.00 | $ 8,000.00 |
| 125 | 30 | EA | Remove Signs | $ 75.00 | $ 2,250.00 |
| 126 | 8 | EA | Surface Mount Flexible Delineators | $ 100.00 | $ 800.00 |
| 127 | 15 | CY | Structural Concrete Pole Foundations | $ 1,000.00 | $ 15,000.00 |
| 128 | 200 | LF | Conduit - Var Sizes - Push | $ 15.00 | $ 3,000.00 |
| 129 | 500 | LF | Conduit - Var Sizes - Trench | $ 12.00 | $ 6,000.00 |
| 130 | 700 | LF | Cable #14 AWG Var Sizes | $ 3.00 | $ 2,100.00 |
| 131 | 600 | LF | Conductors - Var Sizes | $ 1.50 | $ 900.00 |
| 132 | 1 | EA | New Signal Standard - 20' Mast & Lum Extension | $ 7,500.00 | $ 7,500.00 |
| 133 | 4 | EA | New Pedestrain Standard | $ 1,500.00 | $ 6,000.00 |
| 134 | 2 | EA | New 40' Luminiare Standards | $ 2,000.00 | $ 4,000.00 |
| 135 | 2 | EA | New HPS Luminaires | $ 450.00 | $ 900.00 |
| 136 | 15 | EA | New Signal Indications (12x12x12) | $ 1,000.00 | $ 15,000.00 |
| 137 | 6 | EA | New Count-down Pedestrian Signals | $ 1,000.00 | $ 6,000.00 |
| 138 | 6 | EA | New Tactile Push Buttons | $ 600.00 | $ 3,600.00 |
| 139 | 3 | EA | Relocate Existing Signal Standards | $ 1,500.00 | $ 4,500.00 |
| 140 | 1 | EA | Relocate Existing Luminare Standards | $ 400.00 | $ 400.00 |
| 141 | 1 | LS | Remove & Salvage Electrical Equipment | $ 1,500.00 | $ 1,500.00 |
| 142 | 1 | LS | Modify Existing Electrical Service | $ 500.00 | $ 500.00 |
| 143 | 1 | LS | Traffic Control | $ 50,000.00 | $ 50,000.00 |
| | | | **Total Prices =** | | **$ 482,710.00** |
| | | | **Contingency @ 10% =** | | **$ 48,271.00** |
| | | | **Total Estimated Construction Cost =** | | **$ 530,981.00** |

## Construction Estimate - Lower Lot Entrance Improvements and Bench Right-turn Lane

4/12/2013

| Item No. | Est. Qty. | Unit | Description | Unit Price | Total Price |
|---|---|---|---|---|---|
| 201 | 1 | LS | Mobilization & Insurance | $ 10,000.00 | $ 10,000.00 |
| 202 | 1150 | LF | Remove & Dispose Curb & Gutter | $ 11.00 | $ 12,650.00 |
| 203 | 4000 | SF | Remove & Dispose Concrete Sidewalk | $ 2.00 | $ 8,000.00 |
| 204 | 470 | SF | Remove & Dispose Asphalt | $ 1.50 | $ 705.00 |
| 205 | 700 | CY | Unclassified Excavation | $ 9.00 | $ 6,300.00 |
| 206 | 700 | CY | 1.5" Base Course Gravel | $ 18.00 | $ 12,600.00 |
| 207 | 1830 | LF | Concrete Curb & Gutter | $ 11.00 | $ 20,130.00 |
| 208 | 1 | LS | Relocate Storm Drain Inlet | $ 4,000.00 | $ 4,000.00 |
| 209 | 1 | LS | Miscellaneous Removals | $ 3,000.00 | $ 3,000.00 |
| 210 | 160 | SF | Concrete Accessibility Ramp (includes base) | $ 7.50 | $ 1,200.00 |
| 211 | 3 | EA | Truncated Dome Panel | $ 140.00 | $ 420.00 |
| 212 | 4850 | SF | Concrete Sidewalk - 4" Thick | $ 4.00 | $ 19,400.00 |
| 213 | 400 | SY | Asphalt Surface Course (4' Section) | $ 15.00 | $ 6,000.00 |
| 214 | 600 | SY | Asphalt Surface Course (6" Section) | $ 24.00 | $ 14,400.00 |
| 215 | 1 | LS | Utility Adjustments | $ 4,000.00 | $ 4,000.00 |
| 216 | 1 | LS | New Landscaping & Irrigation Modifications | $ 8,000.00 | $ 8,000.00 |
| 217 | 51 | GL | Epoxy Pavement Markings | $ 200.00 | $ 10,200.00 |
| 218 | 18 | GL | Curb Paint (Yellow) | $ 115.00 | $ 2,070.00 |
| 219 | 180 | SF | Obliterate Pavement Markings | $ 4.00 | $ 720.00 |
| 220 | 15 | EA | New Ground Mount Regulatory Sign | $ 450.00 | $ 6,750.00 |
| 221 | 1 | EA | Changeable Message Signs | $ 4,000.00 | $ 4,000.00 |
| 222 | 12 | EA | Remove Signs | $ 75.00 | $ 900.00 |
| 223 | 8 | EA | Surface Mount Flexible Delineators | $ 100.00 | $ 800.00 |
| 224 | 3 | CY | Structural Concrete Pole Foundations | $ 1,000.00 | $ 3,000.00 |
| 225 | 500 | LF | Conduit - 1.5" PVC - Trench | $ 9.00 | $ 4,500.00 |
| 226 | 3000 | LF | Conductors - Var Sizes | $ 1.00 | $ 3,000.00 |
| 227 | 3 | EA | Relocate Existing Luminare Standards | $ 300.00 | $ 900.00 |
| 228 | 1 | LS | Remove & Salvage Electrical Equipment | $ 200.00 | $ 200.00 |
| 229 | 1 | LS | Relocate Existing Lighting Service | $ 2,000.00 | $ 2,000.00 |
| 230 | 1 | LS | Traffic Control | $ 20,000.00 | $ 20,000.00 |
| | | | **Total Prices =** | | **$ 189,845.00** |
| | | | **Contingency @ 10% =** | | **$ 18,984.50** |
| | | | **Total Estimated Construction Cost =** | | **$ 208,829.50** |

## Total Cost for Access Improvements - METRA Park

### Construction Costs:

| | |
|---|---|
| 4th Avenue North Area Improvements = | $ 531,000.00 |
| Lower Lot Bech Access Improvements = | $ 209,000.00 |
| **Subtotal Construction Costs =** | **$ 740,000.00** |
| Engineering Design Costs = | $ 90,000.00 |
| Construction Coordination & Inspection Costs = | $ 60,000.00 |
| **Total Project Costs =** | **$ 890,000.00** |