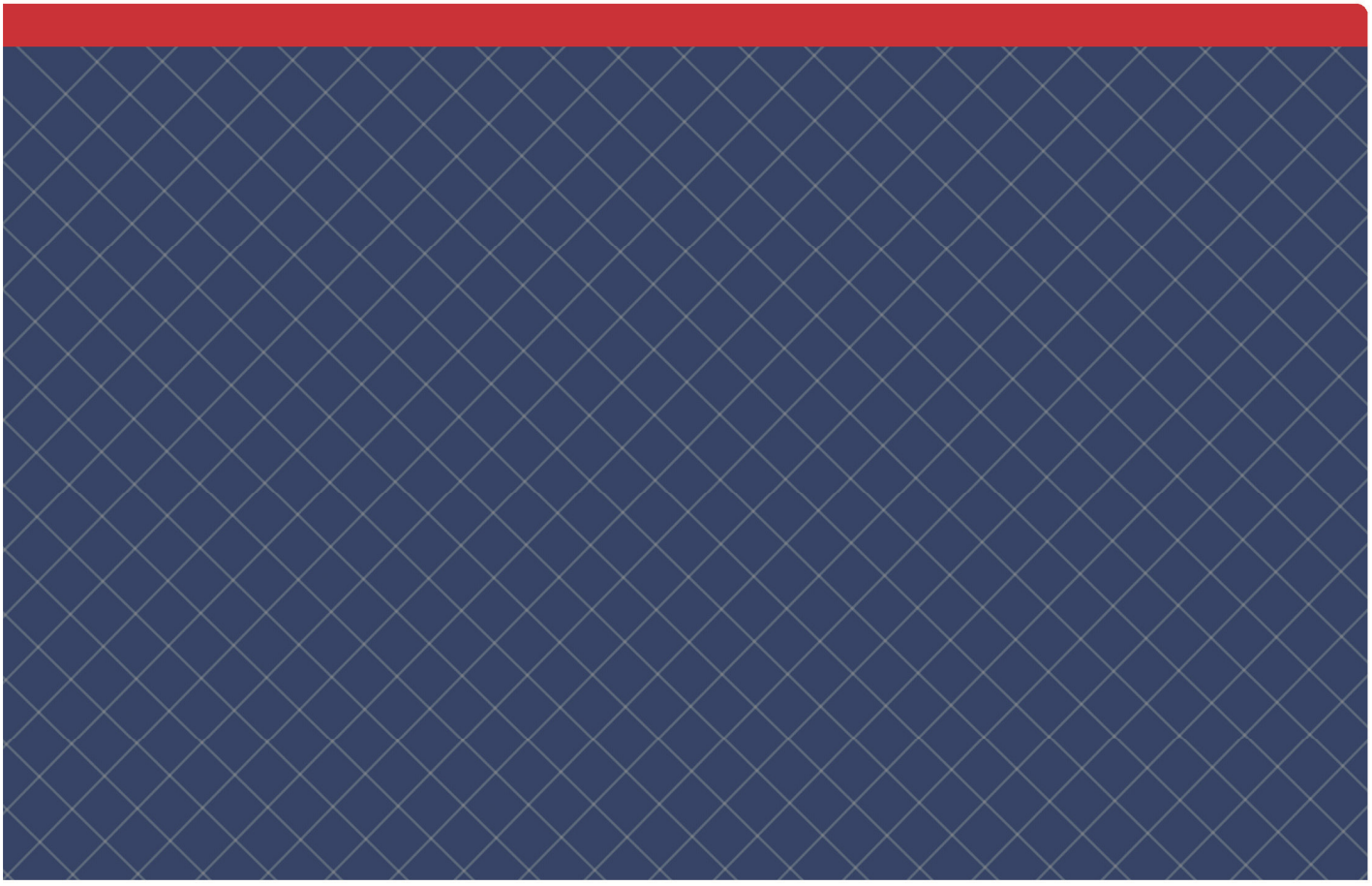
CUY-480-14.10/14.40 SAFETY STUDY
STATE ROAD (SR-94) TO SR176

ODOT DISTRICT 12
URBAN FREEWAY RANKING #67

September 11, 2015



PREPARED FOR:

Ohio Department of Transportation
District 12

5500 Transportation Boulevard
Garfield Heights, OH 44125-5396

PREPARED BY:

LJB Inc.

2500 Newmark Drive
Miamisburg, OH 45342
(937) 259-5000

TABLE OF CONTENTS

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EXECUTIVE SUMMARY

PURPOSE AND NEED

The purpose of the safety study is to evaluate existing safety performance and identify potential countermeasures to reduce congestion and traffic crashes at the I-480 interchange with State Route 94 (State Road) and ramps to State Route 176 (Jennings Freeway) in Cleveland, Ohio.

BACKGROUND

A review of the crash data provided by the Ohio Department of Transportation (ODOT) yielded a total of 384 crashes within the study area during a 3-year period between 2011 and 2013. A thorough review of crash patterns showed that certain crash trends were higher than the statewide averages for similar facilities.

The segment of I- 480 between the State Road interchange ramps (SLM 14.27 to 14.37) was ranked 67 on the ODOT 2013 Urban Freeway Peak Searching Excess Locations list.

BRIEF OVERVIEW OF POSSIBLE CAUSES

Higher than statewide average statistics of rear-end crashes are a sign of congestion. The AM and PM peak hour time periods contribute to a majority (47 percent) of crashes indicate that congestion during peak hours is the primary contributing factor.

Additional contributing factors include:

1. Insufficient capacity of the I-480 EB to SR 176 NB ramp that contributes to queue spillback onto mainline I-480 through the State Road interchange during the AM peak hour,
2. Insufficient storage on State Road between Brookpark Road and I-480 ramp intersections and
3. Poor signal coordination on State Road result in queueing that sometimes spills back onto mainline I-480.

RECOMMENDED COUNTERMEASURES

This safety study has identified short, medium and long term countermeasures to mitigate crashes within the study area.

Short and medium term improvements for State Road corridor and mainline I-480 and I-480/SR 176 interchange include:

Short term countermeasures

- Perform signal timing improvements on State Road for improved progression and optimized timings at the signalized intersections. Upgrade interchange phasing to a diamond phasing sequence.
- Perform traffic control improvements along State Road for improved lane channelization within the existing section.
- Provide a TWLTL or exclusive left turn lanes on State Road at Wetzel/Springdale intersection and Ralph/Burger intersection.

Medium term countermeasures

- Provide a dedicated right turn lane on the westbound approach of State Road/Brookpark Road intersection
- Reconfigure the northbound ramp entrance connection to Jennings Freeway/SR 176 to one lane each from Brookpark Road, I-480 EB and I-480 WB.

- Increase storage of turn lanes on the I-480 WB exit ramp approach to State Road from the existing 200 feet to 600 feet.

Long term countermeasures for the study area include:

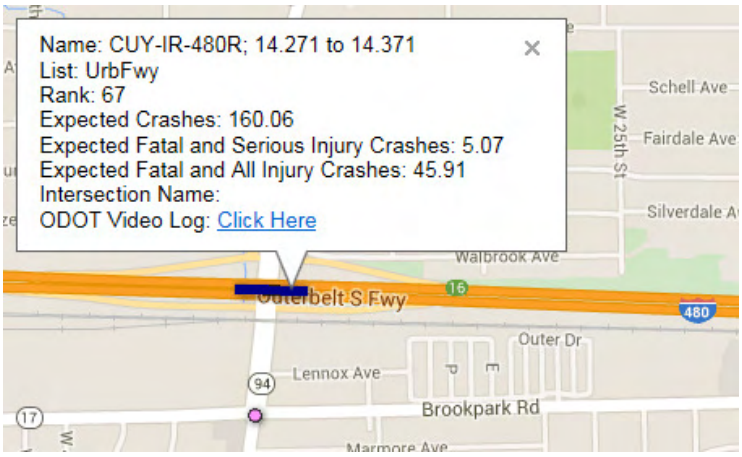
- Widen I-480 EB exit ramp to SR 176 NB from a single to two lane configuration. Merge the entrance ramp from SR 17/Brookpark Road with the two lane entrance ramp from I-480 EB.
- Convert the I-480 WB exit ramp to SR 176 NB from two lanes to a single lane configuration.
- Add a fifth travel lane (auxiliary lane) on I-480 WB from SR 176 SB entrance ramp to State Road exit ramp.
- Evaluate reconfiguration of the State Road/I-480 interchange to a Diverging Diamond Interchange (DDI) or a Single Point Urban Interchange (SPUI).

PURPOSE AND BACKGROUND

PURPOSE AND NEED

The purpose of the safety study is to evaluate existing safety performance and identify potential countermeasures to reduce congestion and traffic crashes on Interstate Route 480 (I-480) between State Route 94 (State Road) and the State Route 176 (Jennings Freeway) interchanges in Cleveland, Ohio. A project location map is provided in **Figure 1** with a more detailed study area map shown in **Figure 2**.

FIGURE 1: ODOT SAFETY PRIORITY DATA



The segment of I- 480 between the State Road interchange ramps (SLM 14.27 to 14.37) was ranked #67 on the 2013 Urban Freeway Peak Searching Excess Locations list. The study area was expanded to identify the contributing factors associated with the hot spot location shown in Figure 3. The Brookpark (SR17) and State Route intersection also is ranked #87 on the Urban Intersection Peak Searching Excess Locations list.A review of the ODOT crash data yielded a total of 375 crashes within the study area during a 3-year period between 2011 and 2013. The following crash types and conditions are overrepresented in the study area compared to statewide averages for state system, freeway locations (statewide averages shown in parenthesis). Note the statewide crash averages are based on 2008-2012 data whereas the project data encompasses years 2011 to 2013.

I-480 and SR176 ramps (Total crashes – 195)

- Injury: 57 crashes or 29.2 percent (23.8 percent)
- Fixed Object: 74 crashes or 37.9 percent (27.1 percent)
- Rear end: 66 crashes or 33.8 percent (29.3 percent)
- Sideswipe-passing: 45 crashes or 23.1 percent (18.7 percent)

State Route 94 (Total crashes – 189)

- Injury: 60 crashes or 31.7 percent (25.4 percent)
- Rear end: 94 crashes or 49.7 percent (30.9 percent)
- Angle: 42 crashes or 22.2 percent (15.6 percent)
- Sideswipe-passing: 24 crashes or 12.7 percent (8.7 percent)
- Left turn: 14 crashes or 7.4 percent (5.2 percent)

FIGURE 2: PROJECT LOCATION MAP

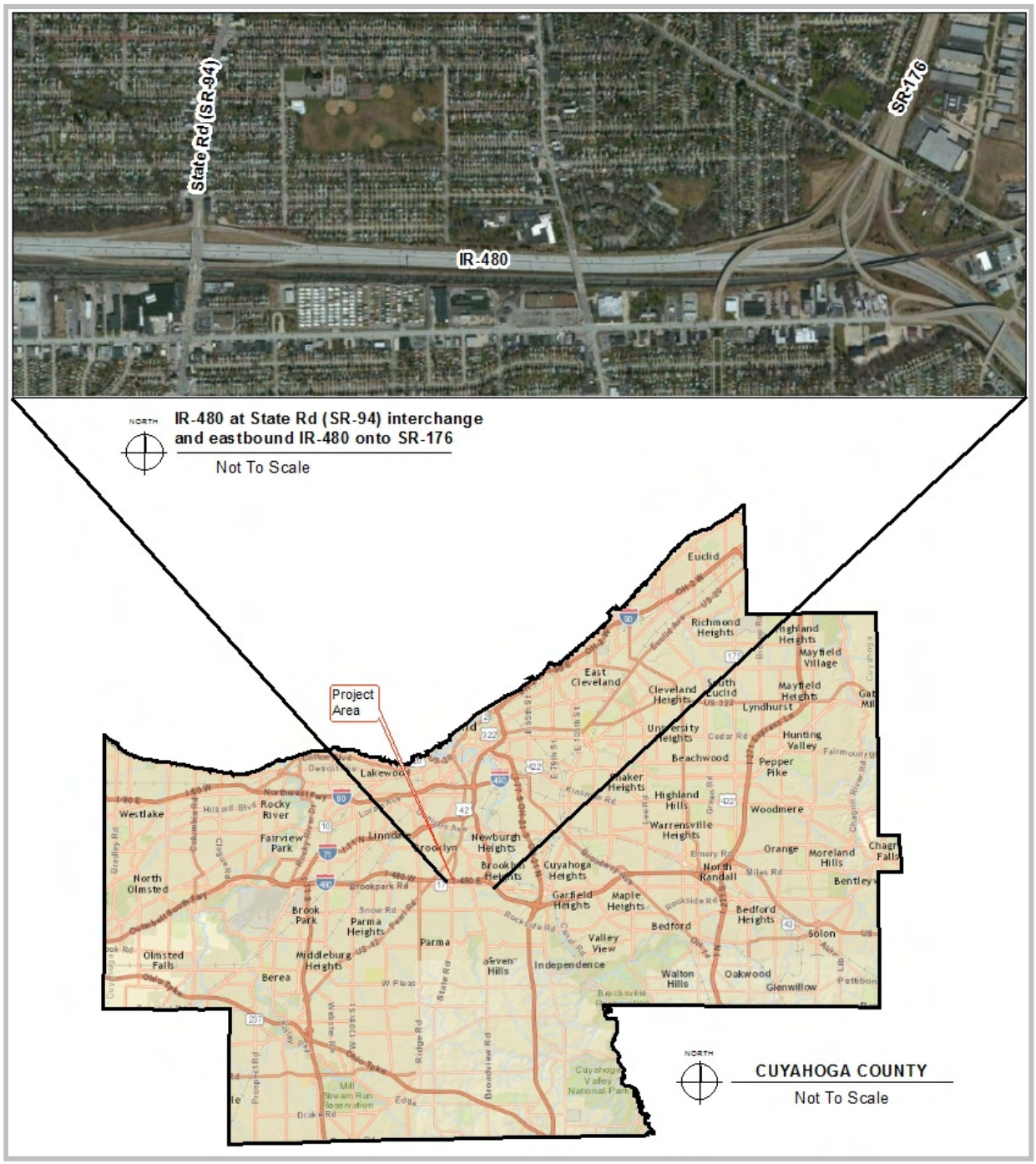


FIGURE 3: STUDY AREA MAP

BACKGROUND

I-480 is a 42 mile long auxiliary interstate highway that begins at I-80 interchange in Lorain County and reconnects with I-80 in Portage County. I-480 crosses interstates I-71, I-77 and I-271 in addition to Jennings Freeway (SR 176).

State Route 94 (State Road) is a north-south roadway that begins in the City of North Royalton and continues north where it terminates in Cleveland after intersecting with SR 17, I- 480, and US Route 42. The I-480 and State Road interchange has a diamond configuration with ramp terminal intersections controlled by traffic signals.

A number of safety studies adjacent to the study area were completed over the past three years. Excerpts from the safety studies are provided in **Appendix A**. The safety studies and their recommendations and recent safety improvements are briefly described below.

1. **SR 176 SB ramp to I-480 EB:** In 2011, the SR 176 SB ramp to I-480 EB was restriped from two lanes to a single lane ramp. This safety improvement would reduce excess traveling speeds and mitigate crashes on the ramp and improve the operation of the downstream SR17 ramp merge.
2. **Brookpark Road/ State Road safety study:** A safety study was conducted in October 2012 for the State Road and Brookpark Road intersection. This intersection was ranked #35 on the 2010 Safety Analyst Fatal and Serious Injury, Non-Freeway list. The following countermeasures were recommended from this safety study::
   - Review the feasibility of coordinating traffic signals along State Road from Brookpark Road to Burger Avenue /Ralph Avenue, including the I- 480 interchange signals.
   - Reconfigure the intersection to provide southbound dual left turn lanes.
   - Add an exclusive right turn lane on the westbound approach of Brookpark Road.

   Traffic signal improvements at the Brookpark/State Road intersection converted the southbound left turn phase from a protected only phase to an actuated phase (protected/permissive). Other improvements included the addition of detection of left turn movements and the addition of signal heads on the southbound approach.
3. **CUY-176/17-10.13/10.43 safety study**. A safety study was completed January 2012 on SR176 which included the Brookpark Road (SR 17) and SR176 intersection. This segment was ranked #12 on the 2010 Non-Freeway high crash location list. The following countermeasures were recommended from this study:
   - Install rumble strips and warning signs on SR176 approaching the signalized intersection
   - Perform ball bank study to establish the advisory speed for curves
   - Revise the alignment of the southbound right turn lane on SR176 at Brookpark Road to improve intersection sight distance.
4. **CUY-480-15.30-15.40 safety study**: A safety study was completed January 2015 for the I-480/SR 176 interchange (SLM 15.30 to 15.40). This location was ranked #74 on the 2012 Urban Freeway Peak Searching Excess Locations list. The proposed countermeasures include an auxiliary lane on westbound I- 480 between the SR 176 SB entrance ramp and the State Road (SR 94) interchange. Additional studies were recommended to determine if the proposed fifth westbound lane on I-480 should be extended west of the SR 94 interchange.

EXISTING CONDITIONS

LAND USE AND PROPERTY ACCESS

Land uses in proximity to the study area include residential neighborhoods, neighborhood shopping centers, and industrial facilities. The study area is located within the City of Cleveland limits. The City of Parma is located south of Brookpark Road.

ROADWAY/INTERCHANGE CONDITIONS

The Interstate Route 480 is also referenced as John Glenn Highway or the Outerbelt South Freeway. I-480 is comprised of an eight lane section within the study area; an auxiliary lane is provided in the eastbound direction between the State Road (SR 94) and the Jennings Freeway (SR 176) interchanges.

I-480 serves commuter traffic and experiences significant inbound (eastbound) traffic during the AM peak and outbound (westbound) traffic during the PM peak. Similarly, SR 176 (Jennings Freeway) experiences heavy inbound (northbound) traffic during the AM peak and outbound (southbound) traffic during the PM peak.

I-480/State Road interchange: The I-480/State Road interchange is a diamond interchange and provides access to the cities of Parma and Cleveland. All entrance and exit ramps at the I-480/State Road interchange are single lane ramps. Additional turn lanes are provided on the State Road approaches.

State Road is a variable width roadway with a lane configuration that varies between 4 and 8 lanes within the study area. Existing roadway conditions are summarized in **Table 1**. An existing conditions diagram is provided in **Appendix B**.

TABLE 1: EXISTING ROADWAY CONDITIONS

	I-480 (WEST OF STATE RD)	I-480 (EAST OF STATE RD)	STATE RD (N. OF I-480)	STATE RD (S. OF I-480)	SR-176/JENNINGS FWY (N. OF I-480)
ODOT Functional Classification	Urban Interstate	Urban Interstate	Urban Minor Arterial	Urban Minor Arterial	Urban Other Freeway and Expressway
Posted speed limit	60 MPH	60 MPH	35 MPH	35 MPH	60 MPH
Roadway section	5 lanes EB 5 lanes WB	5 lanes EB 4 lanes WB	4-5 lane typical section	7 lane typical section	3 lanes NB 3 lanes SB
2012 ADT (TIMS)	137,400	136,300	18,400	34,900	74,300

I-480/SR 176 (Jennings Freeway) interchange The I-480/SR 176 interchange is a system interchange. SR 176/ Jennings Freeway connects I-480 to I-71 and provides access to downtown Cleveland via I-71 and I-90.

SR 176 is a six lane divided urban expressway. The SR 176 northbound section at I-480 is formed by three ramps. Single lane entrance ramps from SR 17/Brookpark Road and I-480 EB merge into a single northbound lane. A 2-lane ramp from I-480 WB adds to form the three-lane section. Note the combined ramp volume in the single lane (22,600 vpd) is greater than the 2-lane ramp from I-480 WB (16,700 vpd) as shown in Table 2.

TABLE 2: SR 176/I-480 INTERCHANGE RAMP VOLUME DATA

	I-480 EB TO SR 176 NB RAMP	SR 17 TO SR 176 NB RAMP	I-480 WB TO SR 176 NB RAMP	SR 176 SB TO I-480 WB RAMP
2014 ADT[1]	17,070	5,550	16,720	16,170

Note 1: Source: Raw counts from the Office of Traffic Information Services (OTS), seasonally adjusted and projected to 2014.

The AM peak is the critical peak for the I-480 EB ramp to SR 176 NB. The existing ramp roadway pavement is in poor condition. (**Photo 1 and 2**). A single curve warning sign with an advisory speed plaque of 45 MPH exists on the ramp.

SR 176 southbound is also a three-lane section. The lane adjacent to the barrier is an exit only lane to SR 17 (Brookpark Road). The center lane is channelized to form a ramp to I-480 EB. The third lane forms a ramp to I-480 WB.

The length of the existing taper for the SR 176 SB ramp to I-480 WB is 875 feet, less than the ODOT L&D manual (Figure 503-2cE) suggests a preferred length of 1,250 feet.

PHOTO 1 – I-480 EB RAMP TO SR 176 NB

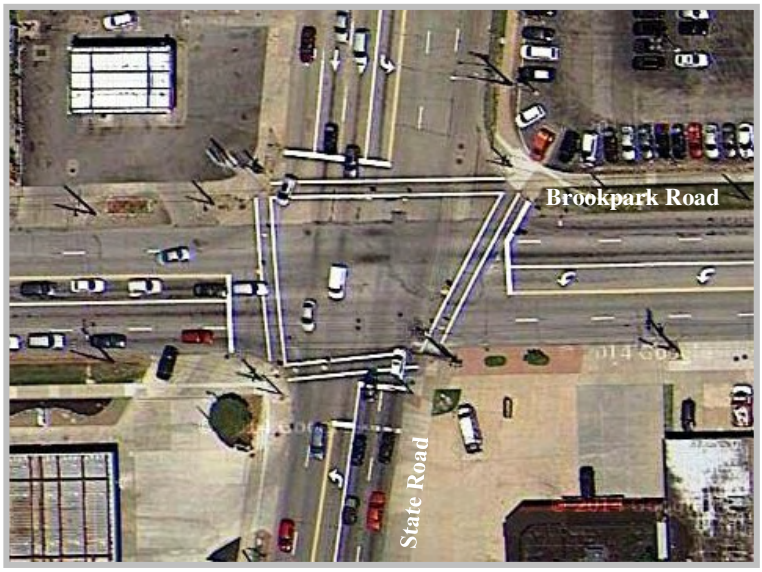
INTERSECTION CONDITIONS

The overall study area also includes the State Road corridor from Brookpark Road to Burger Avenue/Ralph Avenue. Four signalized intersections exist within this section. All four signals are maintained by the City of Cleveland. A description of existing conditions and traffic operations at these intersections are summarized below.

State Road and Brookpark Road intersection

This intersection is the southern terminus of the study area and is located 650 feet south of the I-480 EB ramps intersection. The intersection operates on a four phase sequence: southbound/ northbound left turn phase (protected/permissive), northbound/southbound State Road, eastbound/westbound left turn phase (protected/permissive), and eastbound/westbound Brookpark Road. Pedestrian phases are recalled for all pedestrian crossings.

PHOTO 3: SR 94 AND SR 17 INTERSECTION



The traffic operations related to congestion that was observed in the field are summarized below:

- Site observations showed that the east/west through phases on Brookpark Road served all vehicles while multi-cycle backup occurred on the State Road approaches in the AM peak period.

  The southbound left turn queue extends through the I-480 EB ramp intersection (650 feet) in the AM peak period (7:30 to 8:15 AM). The queue spillback in the AM peak is

attributed to the insufficient capacity of the southbound left turn movement. Queues in the PM peak are attributed to southbound through traffic blocking access to the left turn lane (270 ft length).

> Brookpark Road through and left turn movements operate with acceptable delay (LOS D or better).

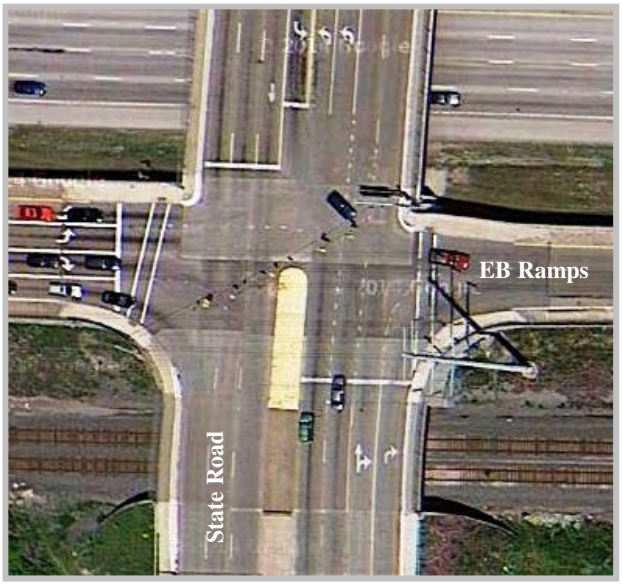
> The curbside through-right lane on the westbound approach operates as a defacto right turn lane during peak hours.

See **Appendix A** for a signal plan showing recent signal upgrades to the address recommendations from a 2012 safety study. See **Appendix C** for a detailed operations review of the State Road corridor.

State Road and I-480 EB ramp intersection

The intersection provides access from the exit ramp and to the entrance ramp of the eastbound I-480 lanes. This signalized intersection operates on a 3-phase sequence with pedestrian recall: northbound/ southbound State Road, lagging southbound left turn (protected only), and the I-480 EB ramp.

PHOTO 4: SR 94 AND I-480 EB RAMP INTERSECTION



Lane imbalances were noted as part of the field observations. The lane imbalances are attributed to the proximity of adjacent signalized intersections, heavy demand of turning movements exceeding available storage, and/or changes of lane continuity (through lane transitions). Video from a nearby ITS camera was provided by ODOT District 12 from the following dates:October 30, 2014 (AM and PM peaks) October 15, 2014 (PM peak only). The videos were used to document the lane utilization of major movements that are serviced with two or more travel lanes. **Table 3** summarizes the lane utilization by movement.

TABLE 3 – LANE UTILIZATION ANALYSIS

INTERSECTION	MOVEMENT	PEAK TIME PERIOD	LANE 1 VOLUME	LANE 2 VOLUME	LANE 3 VOLUME	LANE UTILIZATION FACTOR (F_{LU})	CONTRIBUTING FACTORS
I-480 EB RAMPS	NB THROUGH	AM	128	78	24	0.60	Vehicles destined to WB Entrance ramp
		PM	115	80	14	0.61	
	NB RIGHT	AM	3	128		0.51	Dedicated RT lane is favored to avoid queueing behind a through veh in TR shared lane
		PM	0	112		0.50	
	EB RIGHT	AM	94	75		0.90	Vehicles destined to EB Brookpark
		PM	98	95		0.98	
I-480 WB RAMPS	NB LEFT	AM	80	92		0.93	Two lane to single lane merge prior to the gore
		PM	138	160		0.93	
	WB LEFT	AM	18	65		0.64	
		PM	217	225		0.98	

The default lane utilization factor applied by the Highway Capacity Manual (HCM) is 0.97. The lane utilization of multiple through lanes and dual turn lanes within the study area are lower than the default values, adversely affecting intersection capacity.

The lane utilization factor (F_{LU}) is calculated using the following equation:

$$f_{LU} = \frac{\text{Total Approach Volume}}{\text{(No. of Lanes) x (High Lane Vol)}}$$

Other factors affect the capacity of the signalized intersection. These factors should be taken into account when analyzing intersection capacity.

- **Eastbound:** The eastbound right turn traffic from the exit ramp is constrained by the southbound queues at the Brookpark Road intersection. Queues extend from the southbound left turn lane at Brookpark Road intersection during the AM peak period (see **Photo 5**). Queues extend from the southbound through lanes at the Brookpark Road intersection during the PM peak period, indicating the need for better progression in the southbound direction during the PM peak.

PHOTO 5: SOUTHBOUND LEFT TURN QUEUE AT STATE/BROOKPARK INTERSECTION – AM PEAK

- **Northbound:** Northbound left turn queues from the downstream westbound ramp intersection exceed available storage and extend into the inside northbound through lane at the I-480 EB exit ramp intersection (see **Photo 6**). This queue also causes a startup delay for the SB left turn movements that operate on a protected-only lagging left turn phase.

PHOTO 6: NORTHBOUND QUEUE AT STATE/EB RAMPS INTERSECTION

The radius of the northbound right turn movement at the EB ramp intersection does not accommodate a dual right turn movement, requiring trucks to straddle both lanes. Trucks require a larger turning radius that blocks the second right turn lane.

SR 94 and I-480 WB ramp intersection

The intersection is located 370 feet north of the I-480 eastbound ramps intersection. This signalized intersection operates on a 3-phase sequence: northbound/southbound through, lagging northbound left turn (protected only), and the I-480 westbound ramp.

The lane configuration at the intersection is comprised of four northbound lanes (L-L-T-T), three southbound lanes (T-T-TR), and three westbound lanes (L-L-R).

The traffic operations related to congestion that was observed in the field are summarized below:

- The entrance ramp receiving lanes include one for the southbound right movement and two for the northbound left turn movement. The southbound right movement onto the I-480 westbound entrance ramp has a yield sign to merge with the two receiving lanes from the northbound left movement. All three receiving lanes merge to a single lane within 400 feet of the intersection.

PHOTO 7: SR 94 AND I-480 WB RAMP INTERSECTION

- The traffic volume of 865 vph for the westbound left turn movement during PM peak results in queues exceeding 1,200 feet. The queue extends to the gore area on the I-480 mainline (**Photo 8**) due, in part, to the short length of the dual left-turn lanes (200 feet).
- Vehicles turning left from the exit ramp are stored on the State Road bridge deck between the two ramp intersections. By the end of the exit ramp green phase, the available storage on the bridge deck is full and any residual vehicles remain behind the stop bar to avoid blocking the intersection. This queue blockage often results in a startup delay for the southbound through phase approaching the bridge.

PHOTO 8: I-480 WB EXIT RAMP QUEUE TO STATE RD

SR 94 and Burger Avenue / Ralph Avenue Intersection

The State Road at Burger/Ralph intersection is located 550 feet north of the I-480 WB ramp intersection. The signalized intersection operates a 2-phase sequence: northbound/southbound through followed by the eastbound/westbound phase.

Traffic operations observed in the field are documented below:

- East/west phases are on a max recall (30 seconds) to accommodate peds. This green time is longer than required for vehicular traffic, causing unnecessary vehicle delays on State Road.
- Drivers on the Burger/Ralph Avenue approaches were observed to be stopping forward of the stop lines -- left, through, and right turn movements. Stop lines on the side streets are setback 25 feet from the State Road edge of pavement.
- Mid-block turns occur on State Road between the WB ramps and Burger Avenue/Ralph Avenue.

PHOTO 9: SR 94 AND BURGER / RALPH INTERSECTION

DATA COLLECTION

Turning movement counts were collected for the State Road corridor on Thursday, October 30, 2014 from 6:00 AM to 10:00 AM and from 2:00 PM to 6:00 PM. Turning movement data for the Brookpark Road/State Road intersection were obtained from the CUY-17-10.78 safety study that was collected on Wednesday, March 21, 2012 from 7:00 AM to 11:00 AM and from 2:00 PM to 6:00 PM.

The ADT volumes for the I-480 ramps and mainline were obtained from the ODOT's Office of Technical Services. The mainline I-480 volume is established from the permanent count station at SLM 12.21 and the I-480 ramp volume data for the section between the Ridge Road and SR 176/SR 17 interchanges. Weaving exists on the eastbound lanes of I-480 between the State Road and Jennings Freeway. LJB documented the number of vehicles weaving on I-480 eastbound on January 20, 2015 (PM peak hour) and on January 29, 2015 (AM peak hour) based on field observations.

Traffic volumes for the design year 2034 were calculated using growth rates obtained from the NOACA's regional model. No growth is projected for traffic on the State Road corridor, ramps of the I-480/State Road interchange west of State Road, and all ramps at the SR 176/I-480 interchange. The annual growth rate for I-480 west of SR 176 is 0.20%, while the growth rate for the I-480/State Road interchange east of State Road is 0.02%.

The traffic count data, growth rates from NOACA and traffic volume plates for the base year (2014) and design year (2034) are provided in **Appendix D**.

CRASH ANALYSIS

CRASH DATA

Crash data was obtained from the ODOT for the study limits, encompassing a three-year period between 2011 and 2013. The OH-1 crash report for each documented crash was reviewed to confirm accuracy and to locate crashes properly within the study limits. A summary of crashes by location for the I-480/SR 176 interchange ramps and the I-480 mainline and are shown in **Figures 4 and 5**, respectively.

A total of 384 crashes were reported within the study limits during the three-year analysis period. The following crash types and conditions are overrepresented in the study area compared to statewide averages for state system. Crash percentages for I-480, Jennings Freeway and ramps are compared to the freeway statistics while the State Road (SR 94) statistics are compared to the non-freeway location statistics (statewide averages shown in parenthesis). Note that the statewide crash averages are based on 2008-2012 data whereas the project data encompasses years 2011 to 2013.

I-480 and SR176 ramps (Total crashes – 195)

- Fatal: 1 crash or 0.5 percent (0.3 percent)
- Injury: 57 crashes or 29.2 percent (23.8 percent)
- Fixed object: 74 crashes or 37.9 percent (27.1 percent)
- Rear end: 66 crashes or 33.8 percent (29.3 percent)
- Sideswipe-passing: 45 crashes or 23.1 percent (18.7 percent)

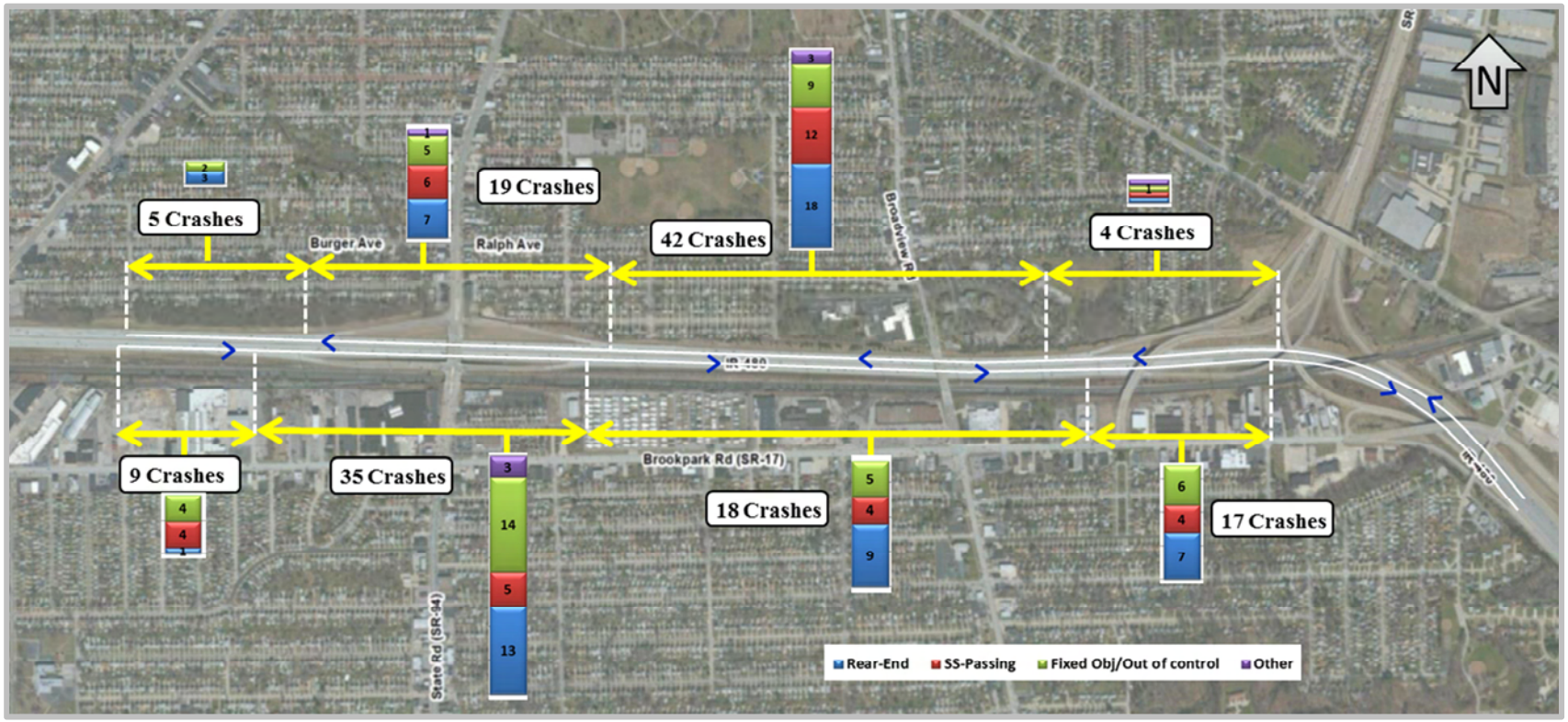
State Route 94 (Total crashes – 189)

- Injury: 60 crashes or 31.7 percent (25.4 percent)
- Rear end: 94 crashes or 49.7 percent (30.9 percent)
- Angle: 42 crashes or 22.2 percent (15.6 percent)
- Sideswipe-passing: 24 crashes or 12.7 percent (8.7 percent)
- Left turn: 14 crashes or 7.4 percent (5.2 percent)

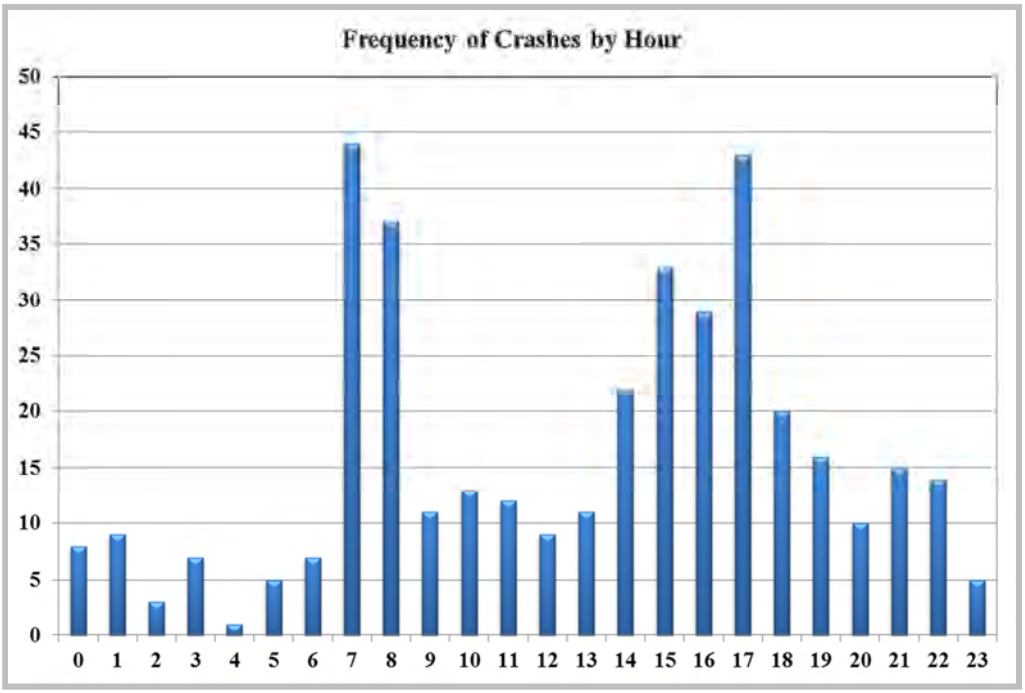
The crash frequency suggests that congestion is a contributing factor to the safety performance of the study area. The AM peak (6-9 am) and PM peak (3-6 pm) periods account for 47 percent of all crashes within the study area as shown in **Graph 1**. Additional analyses by time of day and by location are summarized later in this section.

FIGURE 4 – I-480/SR 176 INTERCHANGE RAMPS CRASH SUMMARY

FIGURE 5 – I-480 MAINLINE CRASH SUMMARY

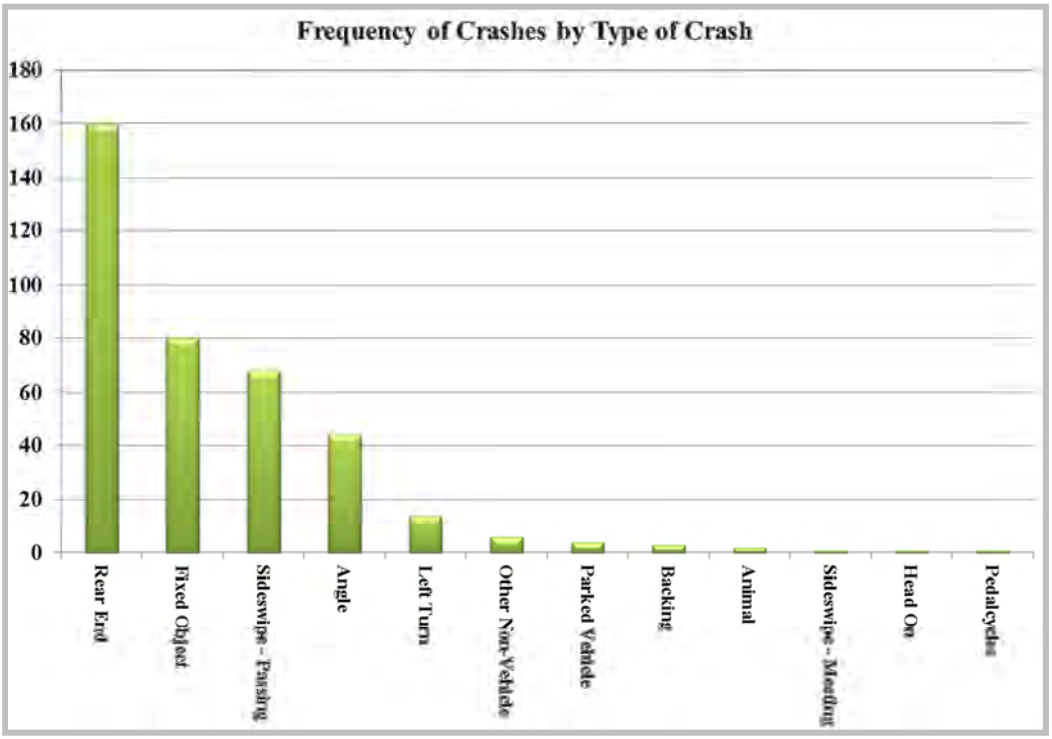


GRAPH 1 – CRASH FREQUENCY BY TIME OF DAY



Rear end, fixed object, sideswipe-passing and angle crashes are the primary crash types accounting for 92 percent of all crashes (**Graph 2**). A contributing factor to the fixed object crashes on the interstate network is vehicles attempting to avoid slowing or stopped traffic in a travel lane.

GRAPH 2 – CRASH FREQUENCY BY CRASH TYPE



Detailed crash diagrams for the study area are provided in **Appendix E**.

CRASH SUMMARY BY LOCATION

A summary of crashes by location are provided in **Table 4.** Focus areas are highlighted and further discussed below**.**

TABLE 4: CRASH SUMMARY BY LOCATION

INTERSECTION	TOTAL	REAR END (30.9%)[1]	ANGLE / LT (20.8%)[1]	FIXED OBJECT (14.6%)[1]	SIDESWIPE PASSING (8.7%)[1]	TOD (6-9AM)[2]	TOD (3-6PM)[2]	ODOT RSI[5]
SR 94/Brookpark	76	42 (55.3%)	13 (17.1%)	5 (6.6%)	6 (7.9%)	19.7%	32.9%	22,820
SR94/I-480 EB Ramps[3]	43	24 (55.8%)	9 (20.9%)	2 (4.7%)	7 (16.3%)	18.6%	18.6%	20,795
SR94/IR-480 WB Ramps[3]	36	19 (52.8%)	11 (30.6%)		6 (16.6%)	8.3%	27.8%	22,356
SR94/Ralph/ Burger[3]	17	6 (35.3%)	8 (47.1%)		1 (5.9%)	11.8%	29.4%	20,884
INTERSTATE	**TOTAL**	**REAR END (30.9%)[1]**	**ANGLE / LT (20.8%)[1]**	**FIXED OBJECT (14.6%)[1]**	**SIDESWIPE PASSING (8.7%)[1]**	**TOD (6-9AM)[2]**	**TOD (3-6PM)[2]**	**ODOT RSI[5]**
I-480 EB[3] (SR94 to SR 176)	66	23 (34.8%)	-	29 (43.9%)	9 (13.6%)	42.4%	12.1%	25,413
I-480 WB[3] (SR 176 to SR94)	46	19 (41.3%)	-	10 (21.7%)	13 (28.3%)	13.0%	45.7%	23,380
		(29.3%)[4]		(27.1%)[4]	(18.7%)[4]			

1 – Statewide averages for crashes on state system, non-freeway locations shown in parenthesis
2 – Time of Day (TOD) crashes stated as percentage of total at each location
3 – Crash statistics reference total number of crashes and percentage of total at each location
4 – Statewide averages for crashes on the state system, freeway locations shown in parenthesis
5 – Relative Safety Index (Source: ODOT CAM Tool – Severity Calc Sheet Tab)

SR 94 and I-480 EB ramp intersection crashes

The most prevalent crash type at this intersection was rear end crashes (24 crashes). The crashes are distributed on all legs of the intersection – 11 crashes occurred on the northbound approach and 7 crashes occurred on the eastbound approach.

The second most prevalent crash type was angle or turning angle crashes (9 crashes) of which 5 crashes involved an eastbound left/southbound through vehicles. Of these 5 crashes, 3 crashes were the result of eastbound left turn drivers running red light. Overall, red light running was a contributing factor in 8 of the 9 crashes. The frequency of red light running crashes at the intersection is attributed to the limited sight distance between eastbound traffic on State Road and southbound traffic on the EB ramp approach. Research conducted by Dr. Timothy Gates of Wayne State University indicate that a driver's tendency to run a red light increases when conflicting movements are not apparent such as an opposing left turn movement or traffic on the side street. The sight distance at the subject intersection is limited by the bridge parapet in the northwest quadrant of the intersection.

SR 94 and I-480 WB ramp intersection crashes

The most prevalent crash type at this intersection was rear end crashes. Of the 19 total rear end crashes at this intersection, eleven occurred on the westbound approach and six crashes occurred on the northbound approach. The rear-end crashes on the WB ramp approach extend to the I-480 mainline/ exit ramp diverge area during the PM peak period.

Two crash types involved the northbound left turning movement:

- Four sideswipe crashes involved dual northbound left turning vehicles. The small radius on the southwest quadrant and the raised island on the north leg of State Road that extends into the intersection cause vehicles to favor the dotted channelizing line separating the dual left turn lanes. Turning vehicles in both turning lanes avoid the obstruction (raised median adjacent to the right lane) or constraint (small radius adjacent to the left lane) thus increasing the frequency of sideswipe crashes.
- Seven left turn crashes occurred at this intersection. All left turn crashes involved a northbound left turning vehicle and an opposing southbound through vehicle with southbound drivers running a red light in six of the crashes. Southbound vehicles in the curb lane are able to travel through the signalized intersection at the end of the phase whereas traffic in the adjacent lanes are a part of a queue that extends from the left turn lane to access I-480 EB. Southbound vehicles in the curb lane push the clearance interval and do not expect the opposing left turn movement (lagging) to turn through the queue in the adjacent lane.

SR 94 and Ralph Avenue / Burger Avenue intersection crashes

Seven angle crashes occurred at this intersection. Of these, six crashes involved State Road through vehicles and eastbound/westbound vehicles. Five of the seven total angle crashes resulted in injury. Red light running was a contributing factor in three of these crashes. The approach speed on Burger/Ralph Avenue is lower than 25 miles per hour.

I-480 eastbound crashes

Fifty three (53) crashes occurred on the eastbound I-480 between the SR 94 exit ramp gore and the SR 176 NB exit ramp gore; an additional 13 crashes were recorded on the SR 176 NB entrance ramp from I-480 EB. These crashes include 23 rear end crashes, 29 fixed object/out-of-control crashes and 9 sideswipe-passing crashes. Twenty nine of those crashes occurred during wet, snowy, or icy road conditions.

Of the 66 crashes, 28 crashes (42 percent) occurred during AM peak (6-9 am). This crash pattern is consistent with the queueing observed on I-480 EB during the AM peak hour conditions.

A fatal crash occurred on Saturday May 19, 2012 at 2:25 PM on eastbound IR-480, east of the SR 176 NB exit ramp gore. The driver was a 66 year old male. The vehicle was operating in the third lane from the left and for unknown reasons swerved to the left and hit the barrier wall. The vehicle proceeded to crossed all lanes of traffic and hit the impact attenuator between mainline and the ramp to SR-176 north.

I-480 westbound crashes

Forty six (46) crashes were recorded on westbound I-480, 1,000 feet east of SR 176 SB entrance ramp gore (SLM 15.44) to State Road exit ramp gore (SLM 14.55). Of these, the most prevalent crash types are rear end (19 crashes), sideswipe-passing (13 crashes) and fixed object/out-of-control (10 crashes).

The majority of crashes (46 percent) occurred during the PM peak hour (3-6 pm). This crash pattern is consistent with the westbound direction experiencing congestion during the PM peak hour.

Fourteen crashes (30 percent) were recorded near the SR 176 SB entrance ramp area, whereas the remaining 32 crashes (70 percent) were recorded downstream of the SR 176 SB ramp merge to the State Road exit ramp.

COUNTERMEASURES

The following section addresses contributing factors associated with the prevalent crash types by identifying countermeasures for the study subsections. Additional countermeasures may be suggested to minimize potential safety issues that may not be directly attributable to historical crash patterns.

SHORT TERM COUNTERMEASURES -- STATE ROAD (56 CRASHES)

The State Road (SR 94) corridor experiences congestion during peak periods. The frequency of angle crashes at the study area intersections is higher than the statewide averages for similar roadway types and is attributed to queues extending through adjacent intersections. The following short term countermeasures are proposed on the State Road corridor to improve safety performance. Capacity analysis of the existing and recommended improvements is included in **Appendix H**.

Medium and long term countermeasures to mitigate crashes at the Brookpark Road (SR 17) and State Road (SR 94) intersection have been identified as part of a separate safety study.

1. **Signal timing improvements.** Updates to the signal timing are recommended to address angle and rear end crash types. Both crash types represent 78% or more of the total crashes at the 3 signalized intersections within the study area.

    a. ***Upgrade clearance intervals***: Modify the yellow clearance and all red clearance times per ODOT Traffic Engineering Manual and ODOT District 12 preferences. Recommended clearance intervals are based on posted speeds (35 MPH) and actual crossing distances. NCHRP Report 731 dated July 2012 confirms that the ITE clearance interval guidelines are used by the highest percentage of state and local agencies resulting in a total crash reduction of 8 to 14 percent – an injury reduction of 12 percent also can be expected.

    The NCHRP Report 731 also recommends using a design speed of 20 MPH for left turning vehicles. This finding is consistent with research conducted by the North Carolina Department of Transportation published by the ITE Journal which determined that the average operating speed for left turning traffic is 17 miles per hour. This methodology helps provide adequate all-red clearance times based on operating speeds and avoids excessively long clearance intervals (yellow + AR).

    b. ***Improve Signal Progression*:** The four signals on State Road are closely spaced within a distance of 1,700 feet. The traffic signals are operating different cycle lengths depending upon the time of day. A signal progression study is recommended to optimize traffic progression during the AM and PM peaks and reduce queue lengths.

    c. ***Intersection optimization***. The Brookpark Road (SR 17) and State Road (SR 94) intersection is the critical intersection of the corridor. Capacity improvements that increase throughput in the southbound direction at the I-480 interchange will have limited benefits unless the SB split is increased at the Brookpark Road intersection especially during the PM peak hour.

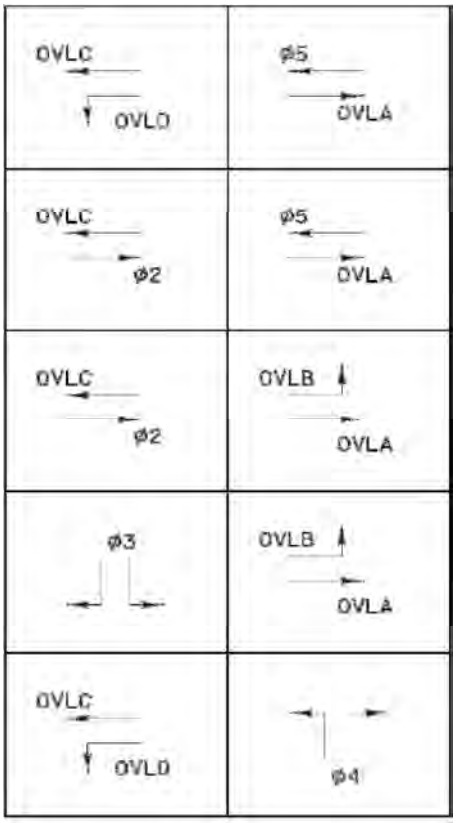
    d. ***Interchange phasing*:** Queues extending from the left turn lanes on State Road between the ramp intersections often block the adjacent intersection. The effective split time programmed in the controller to deliver left turning volumes at the interchange therefore is reduced due to the queue lengths blocking adjacent intersections. Left turn crashes are mitigated by reducing congestion within the intersection boundaries which may contribute to the frequency of red light running.

An alternate signal phasing plan of the EB and WB I-480 ramp intersections is proposed to operate a 4 or 5 phase sequence for a diamond interchange. Features of a diamond phasing sequence include a single controller that operates both ramp intersections, a limited number of vehicles being stored between the ramp intersections, progression of heavy ramp volumes, and ramp spacing less than 400 feet (360 e actual).

Signal phasing for a diamond interchange was first developed by the Texas DOT and refined by TTI. A modified phasing sequence is shown in **Figure 6** that enables a short interval for simultaneous arterial green phases. The WB ramp is assigned Phase 3 and the EB ramp is assigned Phase 4 for the sample phase diagram. **Appendix F** shows a sample signal plan and detection scheme used at another tight diamond intersection.

Another phasing change proposed at the EB ramp intersection is to convert the NB right turn movement to be an overlap with the EB ramp phase. Nearly all vehicles turning right are destine to EB I-480 and are in the exclusive right turn lane – few right turning vehicles use the existing shared through-right turn lane due in part to the small turning radius in the SE quadrant of the intersection. Allowing the right turn movement to overlap with the EB ramp phase will reduce the length of the queue extending from the NB right turn lane during the AM peak period.

FIGURE 6: DIAMOND PHASING



2. **Traffic control improvements.** Minor changes are proposed to the lane configuration, stop line locations, and raised medians to improve safety performance. See **Figure 7** for a conceptual plan of the proposed improvements.

   a. ***EB I-480 intersection.*** Revise the lane configuration of the northbound approach from the existing T(L)-T-TR-R configuration to a T(L)-T(L)-T-R configuration. The T(L) lane designation represents a through lane on the northbound approach of the EB I-480 intersection that is aligned with the northbound left turn lanes at the WB I-480 intersection. The lane configuration change is proposed for 3 reasons:

      > Over 70% of the approach traffic in the through lanes on the northbound approach are destine to the dual NB left turn lanes at the WB ramp intersection – 621 vehicles in the AM peak and 571 vehicles in the PM peak.

      > The remaining vehicles in the through lane can be serviced by a single through lane – 191 vehicles in the AM peak and 230 vehicles in the PM peak.

      > The radius in the SE quadrant can only accommodate a single right turning vehicle. The shared through-right turn lane is challenging if 2 vehicles turn at the same time.

The three (3) northbound lanes originating from the Brookpark Road intersection are to be configured as a 2-lane section. The two NB through lanes are to transition and align with the T(L) and the through (T) lane at the EB I-480 intersection. Revise the overhead lane use signs on the State Road approaches to match the proposed lane changes.

Revise the stop line location on the southbound approach to increase the start up time for vehicles in the through lanes and increase the storage length of the left turn lane. Angle crashes involving EB vehicles on the ramp approach are to be mitigated with the adjustments to the stop line locations.

b. ***WB I-480 intersection***. Revise the lane configuration of the southbound approach from the existing T-T-TR configuration to a T(L)-T-T-R configuration. The T(L) lane designation represents a through lane on the southbound approach of the WB I-480 intersection that is aligned with the southbound left turn lane at the EB I-480 intersection.

PHOTO 7: DAMAGED CURB IN SW QUADRANT

Two changes are proposed that improve the safety performance of the dual NB left turn lanes:

- Revise the radius in the SW quadrant. The existing curb is damaged and rutting of the tree lawn indicates that vehicles are hitting the curb as they negotiate the NB left turn (see **Photo 7**).
- Adjust stop line locations. The relocation of the stop lines will increase left turn lane storage and reduce the all-red clearance time.

Revise the stop line location on the westbound approach to increase the start up time for vehicles in the dual left turn lanes. Angle crashes involving WB vehicles on the ramp approach are to be mitigated with the adjustments to the stop line location.

c. ***Ralph/Burger intersection***. Signal warrant analysis indicates that the signal does not meet the 8-hour, 4-hour or peak hour warrant. Sight distance issues are not anticipated as the available sight distance meets the intersection sight distance criteria for a 35 mile per hour design speed on State Road. If the city is to consider signal removal, note that the Burger/Ralph Avenue approaches are expected to experience delays up to 220 seconds with stop control (**Appendix H**). If the signal is removed, periodic review of delays and crash patterns is recommended. **Appendix G** includes detailed signal warrant analysis.

If the signal remains, install push buttons for pedestrians to cross State Road and vehicle detection on the minor street approached to eliminate the need for max/ped recall

d. ***Wetzel/Springdale intersection***. The existing typical section does not include turn lanes on State Road at intersections although pavement width is adequate to accommodate a center turn lane. Crash patterns indicate angle crashes at Wetzel/Springdale intersections and access to the commercial development on the west side between Wetzel Avenue and Burger Avenue. A two way left turn lane (TWLTL) or exclusive left turn lanes at the Ralph/Burger intersection will provide storage for left turning vehicles that would otherwise block through vehicles.

CUY-480-14.10-14.40
SAFETY STUDY

FIGURE 7
STATE ROAD CORRIDOR

CALCULATED VM
CHECKED VM

0 30 60 120
HORIZONTAL SCALE IN FEET

N

MEDIUM TERM COUNTERMEASURES

Many components of the interstate system (merge, diverge, basic freeway section) are shown to operate at acceptable levels of service within the study area as shown in **Appendix I**. The methodology applied to develop the volumes is documented in **Appendix D.**

The medium term countermeasures defined herein are based on existing geometric and/or capacity constraints. Capacity related improvements due to a change of traffic volumes attributed to seasonal fluctuations, maintenance of traffic (MOT) plans implemented on the surrounding interstate network in the Cleveland region or the increase of future traffic volumes that cause merge/diverges to fail or operate at unacceptable levels of service (LOS E or worse) are deferred as long term countermeasures.

1. **Brookpark Road (SR 17) at State Road (SR 94) intersection (76 crashes).** The October 2012 safety study recommended the construction of a westbound right turn lane to reduce vehicle delays at the subject intersection. The addition of a WB right turn lane is expected to improve the intersection level of service from an LOS E to LOS D.

   The construction of dual southbound left turn lanes were identified as a potential countermeasure but are deferred as a future improvement as part this study. The levels of service expected with the addition of only the WB right turn lane is sufficient to achieve acceptable levels of services (LOS D or better). Signal improvements were already installed as part of a separate construction project in 2014. See **Figure 7** for a conceptual plan of the proposed improvements.

2. **I-480 EB ramp to SR 176 NB (66 crashes).** Field observations confirmed that slow or stopped vehicles exist between the State Road interchange and the SR 176 NB ramp. Crashes were documented within this segment of I-480 that was consistent with congestion on mainline I-480.

   Capacity analysis of the merge/diverge, the weaving section, and the basic freeway section showed that all performed at acceptable levels of service (LOS D or better). A capacity constraint does exist on SR 176 at the northbound merge of 2 single lane ramps:

   - I-480 EB ramp to SR 176 NB – 1,630 vehicles in the AM peak hour
   - Brookpark Road ramp to SR 176 NB – 530 vehicles in the AM peak hour

   The combined volumes of these ramps result in a total volume of 2,160 vehicles in the AM peak hour. In comparison, the existing 2-lane ramp volume of the I-480 WB ramp to SR 176 NB has 1,310 vehicles in the AM peak hour. The northbound ramp configuration of SR 176 is proposed to be revised to balance ramp volumes especially in the AM peak hour:

   a. One lane ramp from Brookpark Road to SR 176 NB (530 vehicles)
   b. One lane ramp from I-480 EB to SR 176 NB (1,630 vehicles). Ramp capacity is assumed to be 2,100 vehicles under ideal conditions. The volume/capacity (VC) ratio with this change is expected to be 0.78 which is better than the VC ratio of 1.03 for the existing condition.
   c. One lane ramp from I-480 WB to SR 176 NB (1,310 vehicles). A VC ratio of 0.31 was calculated for the existing 2-lane ramp configuration. The proposed VC ration of 0.62 as a single lane ramp is more compatible with other ramps on the network. Note that the complementary movement (SR 176 SB to I-480 EB) was converted from a 2-lane ramp to a single lane ramp in 2011.

The proposed countermeasure is intended to be limited to pavement markings and signing changes. The lane transition on SR 176 is proposed to start about 150 feet north of the Schaaf Road bridge and meet the existing 3-lane section with a 900 ft taper. Existing trench drains and catch basins are to be avoided in the existing median. The lane reduction on the I-480 EB ramp to SR 176 NB should begin in advance of the Tuxedo Drive/Granger Road bridges.

Other signing improvements on the I-480 EB ramp include a left side mounted curve warning sign (45 MPH advisory plaque) and additional chevron signs on the outside of the horizontal curve to provide positive guidance.

See **Figure 8** for a conceptual plan of the proposed improvements.

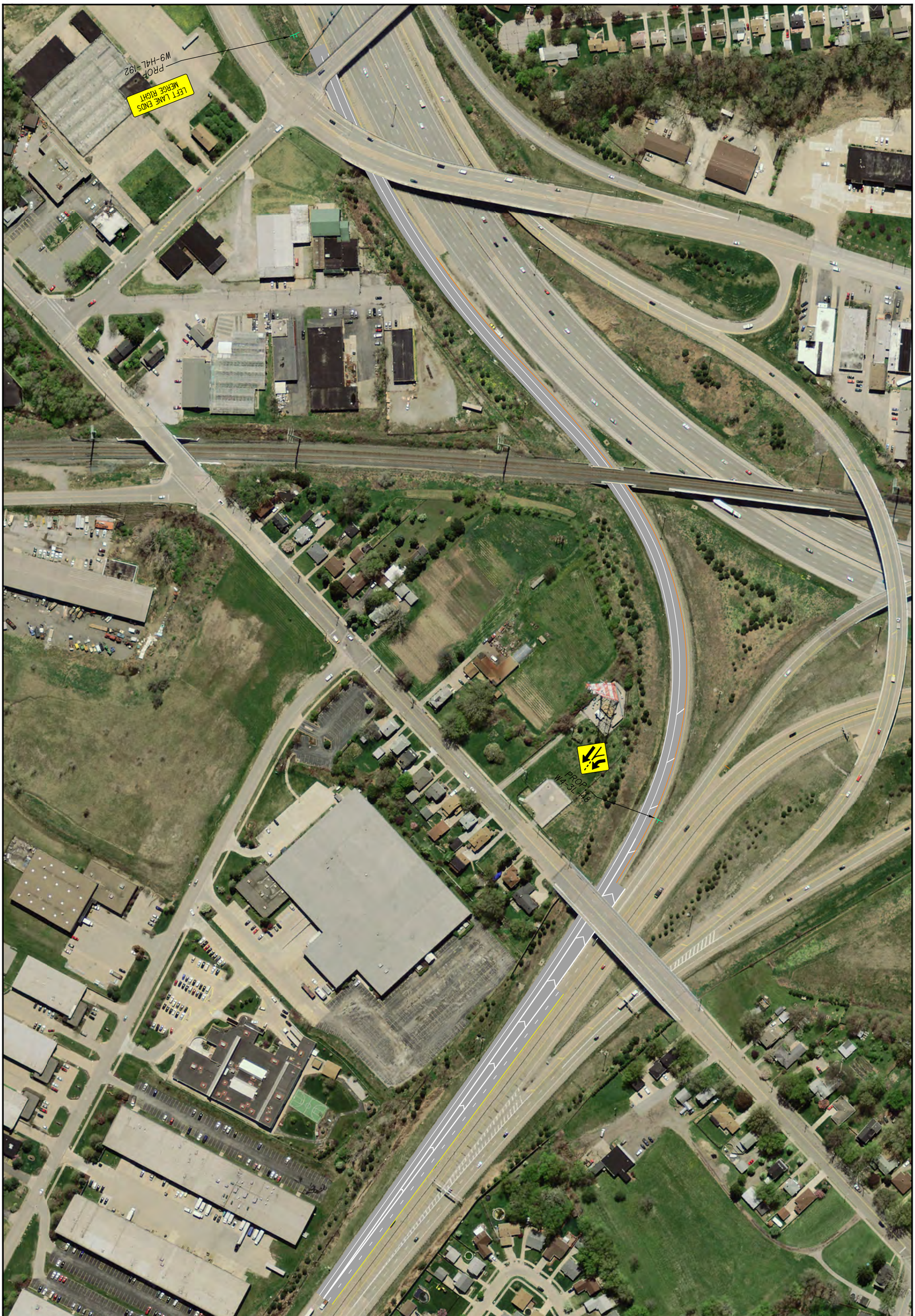
3. **SR 176 SB ramp to I-480 WB (46 crashes).** Two countermeasures are proposed to mitigate crashes on I-480 westbound within the study area:

    a. ***Storage lane lengths***. The existing turn lanes at the WB ramp intersection and State Road (SR 94) are 200 feet long. Queues extend beyond the gore of the exit ramp during peak periods and contribute to congestion on mainline I-480. Calculated storage lane lengths of 600 feet are proposed to minimize queues on the exit ramp affecting traffic operations on I-480. Lane sizing calculations are included in **Appendix J**. See **Figure 7** for a conceptual plan of the proposed improvements.

    b. ***Ramp geometry***. Analysis of the ramp merge for the SR 176 SB ramp to I-480 WB is shown to operate at acceptable levels of service. A previous safety study has shown the merge to operate at unacceptable levels of service (LOS E). Differences of traffic volumes used for the 2 studies could be attributed to seasonal fluctuations or variable traffic volumes associated with MOT for the Innerbelt project.

    Slow traffic was observed on SR 176 in advance of the I-480 interchange and was attributed to the weaving between the Spring Road and the I-480 interchanges. The crash pattern indicates that most crashes are focused at the merge point of the ramp and west of the SR 176 interchange. The concentration of crashes at the merge point suggests that a contributing factor may be a geometric issue in addition to a capacity related issue.

    The length of the existing taper is 875 feet whereas the ODOT L&D manual (Figure 503-2cE) suggests a preferred length of 1,250 feet. Sight distance is also restricted by the Brookpark Road ramp flyover structure upstream of the ramp merge. The preferred length would extend pavement widening west of the Broadview Road bridge. Pavement widening should be designed to accommodate a future auxiliary lane between the SR 176 interchange and the State Road (SR 94) interchange.



22	CUY-480-14.10-14.40 SAFETY STUDY	FIGURE 8 SR 176 NORTHBOUND - MEDIUM TERM	CALCULATED VM CHECKED VM	0 100 50 200 HORIZONTAL SCALE IN FEET

LONG TERM COUNTERMEASURES

The CUY-480 corridor has both safety and capacity issues – these factors are related with the lack of capacity serving as the primary cause for the crashes along I-480. A recent Transportation Research Board study, *Development of Relationships Between Safety and Congestion for Urban Freeways*, listed in the Journal of the Transportation Research Board, No. 2398, documents this safety-congestion relationship. The countermeasures on I-480 were developed from identifying existing capacity constraints and comparing these locations to the documented crashes within the study area.

The following long-term capacity-related improvements are deemed necessary to mitigate an increase of traffic volumes. The traffic volume increases that justify improvements are attributed to three conditions: 1) seasonal fluctuations, 2) diverted traffic associated with the maintenance-of-traffic (MOT) for the Innerbelt project, and 3) future traffic growth. . Capacity related improvements are proposed to improve merge/diverges that fail or operate at unacceptable levels of service (LOS E or worse).

1. **I-480 EB ramp to SR 176 NB (66 crashes).** Field observations confirmed that slow or stopped vehicles exist on I-480 EB between the State Road interchange and the SR 176 NB entrance ramp. Crashes were documented within this segment of I-480 that was consistent with congestion on mainline I-480. Capacity improvements to the I-480 EB ramp to SR 176 NB include the conversion of a single lane ramp to a 2-lane ramp. Two options were evaluated to implement a 2-lane ramp:

    a. **Option A – Retrofit within the existing section:** The existing pavement width on the ramp is 28 feet whereas the bridge width (toe of parapet to toe of parapet) is 30 feet. Retrofitting a two lane section (24 feet wide) results in shoulder widths of 3 feet on the existing bridge deck.

    This ramp configuration requires four design exceptions for paved shoulder width, bridge width and lateral clearance to the guardrail. **This countermeasure is not recommended for further consideration due to the extent of design exceptions required to implement.** Additional details on the design exception and conceptual plan are included in **Appendix K**.

    b. **Option B – Reconstruct Ramp**: Reconstruct the existing I-480 EB exit ramp to northbound SR 176 NB including the bridge over I-480 mainline per ODOT's L&D manual design criteria.

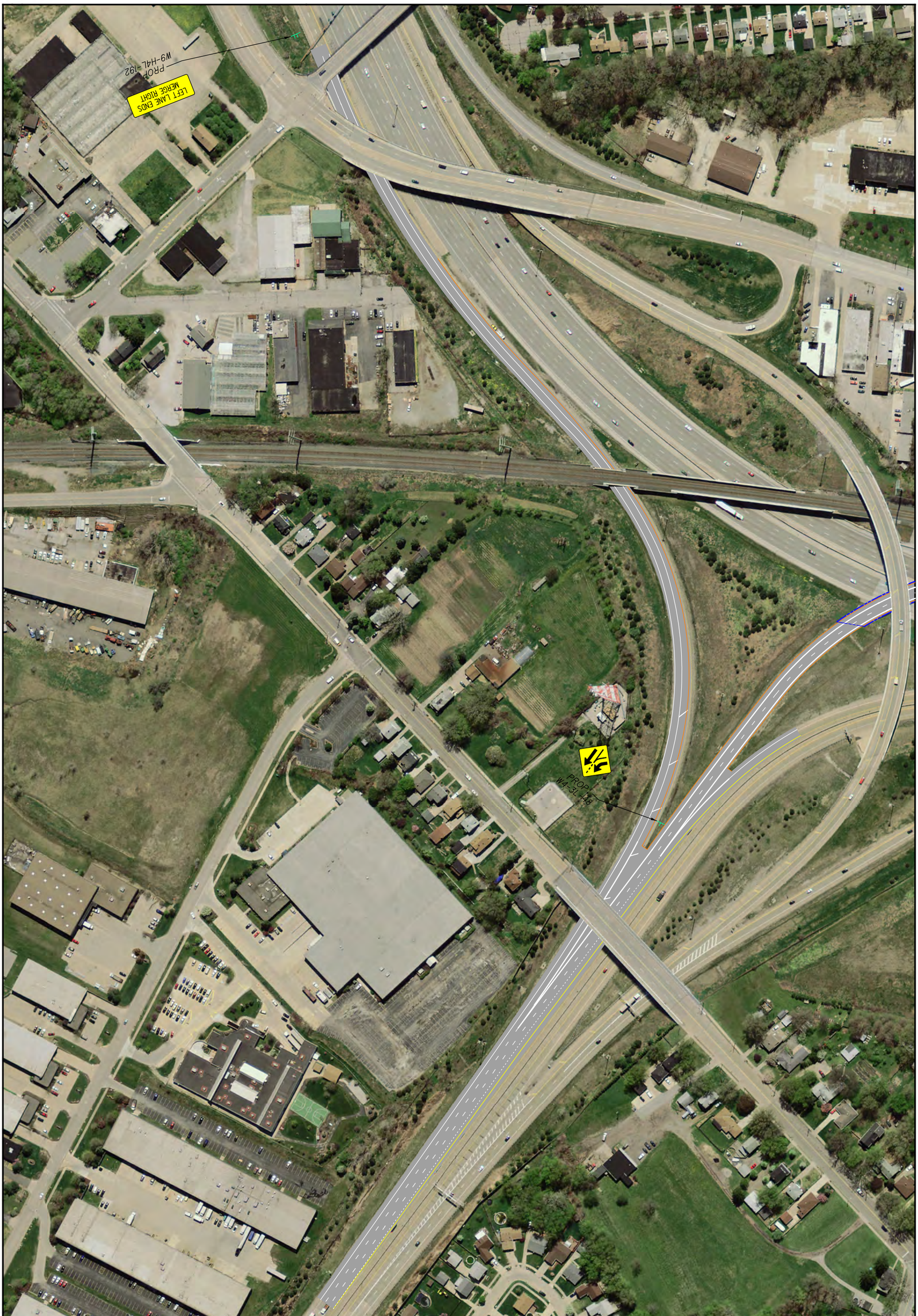
    For both options, to maintain the two lanes from I-480 EB to northbound SR 176 on the receiving end, the following lane configuration (**Figure 9**) is recommended.

    > Merge the SR 176 entrance ramp from Brookpark Road with the two lane ramp from I-480 EB.

    > Convert the existing I-480 WB exit ramp from 2 lanes to a single lane configuration. The inside (left) lane is proposed to be merged prior to the RR overpass. The single lane SR 176 NB exit ramp from I-480 EB will be consistent with the complimentary movement (single lane exit ramp) from SR 176 SB to I-480 EB that was implemented in 2011.

    The construction cost of Option B is $11.2 million in 2015 dollars. The detailed cost estimates for Option B is included in **Appendix L**.

CUY-480-14.10-14.40 SAFETY STUDY	FIGURE 9 I-480 EB TO SR 176 NB TWO LANE RAMP - LONG TERM	CALCULATED VM / CHECKED VM	0 50 100 200 HORIZONTAL SCALE IN FEET	

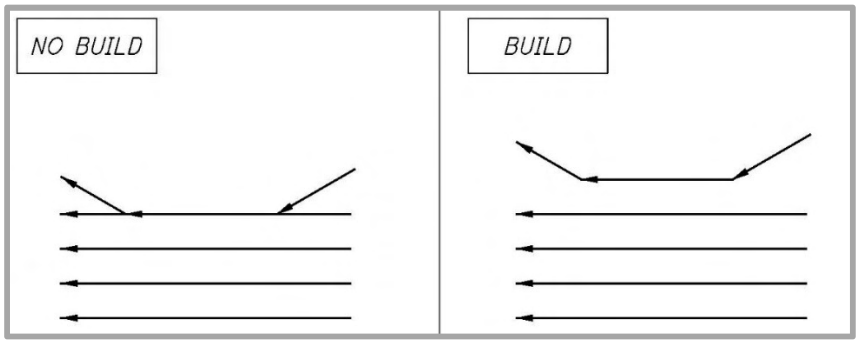


22	CUY-480-14.10-14.40 SAFETY STUDY	FIGURE 9 I-480 EB TO SR 176 NB TWO LANE RAMP - LONG TERM	CALCULATED VM CHECKED VM	0 100 50 200 HORIZONTAL SCALE IN FEET

2. **I-480 WB mainline (42 crashes)**. Add an auxiliary lane on westbound I-480 from the SR 176 SB entrance ramp for a distance of 2,800 feet (**Figure 10**). This countermeasure will improve the available distance to merge as intended with the medium term countermeasure. This countermeasure also provides additional capacity for the merge condition that was identified as having poor level of service (LOS E) in a previous safety study.

   The cost of this countermeasure is $3.3 million in 2015 dollars. The detailed cost estimates are included in **Appendix L**.

FIGURE 10: I-480 WB AUXILIARY LANE



The medium and long term countermeasures proposed above are considered to be effective solutions to mitigate safety issues experienced on the interstate and the arterial roadway network within the study area. Additional long term countermeasures that involve the reconstruction of the State Road interchange considered but not evaluated as part of this study are noted below.

1. Convert the I-480/State Road interchange from a diamond configuration to a **Diverging Diamond Interchange (DDI) configuration**. A DDI simplifies the interaction of turn movements at interchange ramp terminals by crossing side street through movements over each other at each of the ramp intersections. Crossing these through movements to the opposite side of the road replaces left turn crossing conflicts with merge/diverge movements and removes signal phases for traffic destined to entrance ramps.

   This configuration will provide following benefits:

   - Reduce delays through more efficient signal operation and fewer phases. Left turn movements entering I-480 will be free flow movements on the bridge.
   - Improves safety by reducing conflict points at the ramp intersections.

2. Convert the I-480/State Road interchange from a diamond configuration to a **Single point urban interchange (SPUI) configuration**. This configuration will provide following benefits:

   - Eliminates the need to store vehicles on the bridge deck and minimize overall delay
   - Reduce ramp intersections/signals from two to one. Allows for right turn overlap with cross street left turns, i.e., right turns from the EB exit ramp overlap with NB left (WB entrance ramp) movements and NB right turn (EB entrance ramp) movement with WB exit ramp left turn.
   - Increase storage on SR 94 between I-480 ramps and Brookpark Road intersection.

Both changes to the existing interchange configuration are deferred as future improvements. Note that the existing railroad on the south side of I-480 could be a major constraint to ramp realignments on the south side of the interchange.

IMPLEMENTATION PLAN

The Relative Safety Index (RSI) was calculated for the subsections of the study area to help prioritize safety improvements by location. The RSI values shown in parenthesis from **Table 4** suggest the following safety ranking starting with the highest priority location:

1. I-480 EB from SR 94 to SR 176 (25,413)
2. I-480 WB from SR 176 to SR 94 (23,380)
3. SR 94 at Brookpark Road intersection (22,820)
4. SR 94/I-480 WB ramp intersection (22,356)
5. SR 94/ Ralph/Burger intersection (20,884)
6. SR 94/I-480 EB ramp intersection (20,795)

A revised ranking of countermeasures by location is proposed to provide the greatest opportunity to improve the safety performance within the study area. The countermeasures are grouped into categories due to different operational characteristics and of different funding sources.

1. Service interchange (arterial) countermeasures (65,971)
   - SR 94 at Brookpark Road intersection (22,820)
   - SR 94/I-480 WB ramp intersection (22,356)
   - SR 94/I-480 EB ramp intersection (20,795)
2. Interstate system countermeasures (48,793)
   - I-480 EB from SR 94 to SR 176 (25,413)
   - I-480 WB from SR 176 to SR 94 (23,380)

SERVICE INTERCHANGE PLAN

ODOT's Ramp Clear program was created to reduce congestion on interchange ramps that experience bottleneck and where traffic frequently backs up onto the freeway. The safety improvements to be eligible under this program are expected to be low cost, with minimum or no right of way acquisition and utilities, constructible in one construction season and capable of design build development.

The State Road (SR 94) interchange experiences daily congestion resulting in queue spillback onto the mainline and safety issues at the Brookpark Road (SR 17) intersection. The countermeasures recommended in this safety study are eligible for ODOT's Ramp Clear Program. The following combination of improvements is recommended for the Ramp Clear Program.

- Revised signal timing, Buckeye diamond phasing, and lane configuration changes at the I-480 ramp intersections. These countermeasures include concrete median reconstruction, pavement joint repair, and minor radii improvements as described in the Short Term countermeasure section.
- Auxiliary turn lane installation at the Wetzel/Springdale intersection.
- Extending storage lane lengths on the I-480 WB ramp at the State Road (SR 94) intersection. Queue blocking of the existing right turn lane results in longer ramp queues that affect mainline I-480 operations.

The study area meets the eligibility criteria of recurring congestion and queue spillback onto the freeway and above improvements can be constructed within the existing Right of way for less than $2 million. **Table 5** lists the total estimated project cost, crash reduction factors and resulting benefit cost for the countermeasures eligible for the Ramp Clear program.

Additional information about the cost estimates and benefit cost calculations for the improvements are addressed in the Benefit Cost Analysis section of the report**.**

SYSTEM INTERCHANGE PLAN

Safety funding is proposed to construct improvements to the I-480 and Jennings Freeway (SR 176) interchange. The following combination of improvements is recommended for improve the safety performance of I-480 within the study area:

- The northbound ramp configuration of SR 176 is proposed to be modified to balance ramp volumes especially in the AM peak hour. The proposed countermeasure is intended to be limited to pavement markings and signing changes. The lane transition on SR 176 is proposed to start about 150 feet north of the Schaaf Road bridge and meet the existing 3-lane section with a 900 ft taper. The lane reduction on the I-480 EB ramp to SR 176 NB should begin in advance of the Tuxedo Drive/Granger Road bridges.

- Add an auxiliary lane on westbound I-480 from the SR 176 SB entrance ramp for a distance of 2,800 feet. This countermeasure will improve the available distance to merge as intended with the medium term countermeasure (i.e., increase ramp taper length). This countermeasure also provides additional capacity for the merge condition that was identified as having poor level of service (LOS E) as part of a previous safety study (CUY-480-15.30/ 15.40).

Additional information about the cost estimates and benefit cost calculations for the improvements are addressed in the Benefit Cost Analysis section of the report**.**

BENEFIT COST ANALYSIS

Benefit cost analysis is a tool to determine the financial benefits of a project by comparing the net present value (NPV) of a project to NPV of the safety benefit provided by that project. Benefit cost values greater than one indicate a positive return on the original investment. Preferred countermeasures are those having the highest NPV of safety benefits.

BENEFIT COST FOR SR 94 IMPROVEMENTS

A benefit cost analysis for short term countermeasures was prepared using the ODOT ECAT analysis tool. Crash modification factors were applied for the following improvements. This does not account for all recommended improvements, rather only those countermeasures that have CMF values.

- Install right turn lane on a major street approach
- Four lane to five lane conversion
- Update clearance intervals to the ITE recommended values
- Provide left turn lane on one major road approach – CMF value – 0.94 (This CMF was applied to the SR 94/I-480 WB ramps intersection to replicate the safety benefit of the proposed widening of the existing turn lanes)
- Add a through lane – CMF value - 0.74 (This CMF was applied to both ramp intersections to replicate the safety benefit of lane channelization improvements on State Road that also increase storage for the downstream left turn lanes. This CMF was only applied to 33 percent of crashes as the improvements are applicable to one approach of a 3-leg intersection)

Project costs were estimated for short term countermeasures including signal timing and traffic control improvements, medium term countermeasures including adding WB right turn lane at SR 94/Brookpark intersection and increasing storage on the WB exit ramp approach. Construction cost estimates assume the following:

- 10 percent engineering design
- 35 percent design risk
- 12.9 percent inflation rate for an estimated 2018 construction year.
- Right of way impacts are anticipated for the WB right turn lane improvement at Brookpark.

Cost estimates and benefit cost analysis reports from the ECAT tool are included in **Appendix L**. **Table 5** provides summarizes the benefit cost analysis results.

TABLE 5: BENEFIT COST ANALYSIS FOR STATE ROAD IMPROVEMENTS

Countermeasures with CMF values used in ECAT Tool	• Install right turn lane on one major street approach • 4 lane to 5 lane conversion • Update clearance intervals • Provide (extend) left turn lane • Add a through lane (improve lane channelization)
Expected annual crash adjustment	4.61
Net present value of project	$1,595,300
Net present value of safety benefit	$2,475,400
Benefit / Cost Ratio	**1.55**

APPENDIX A
PROJECT INFORMATION

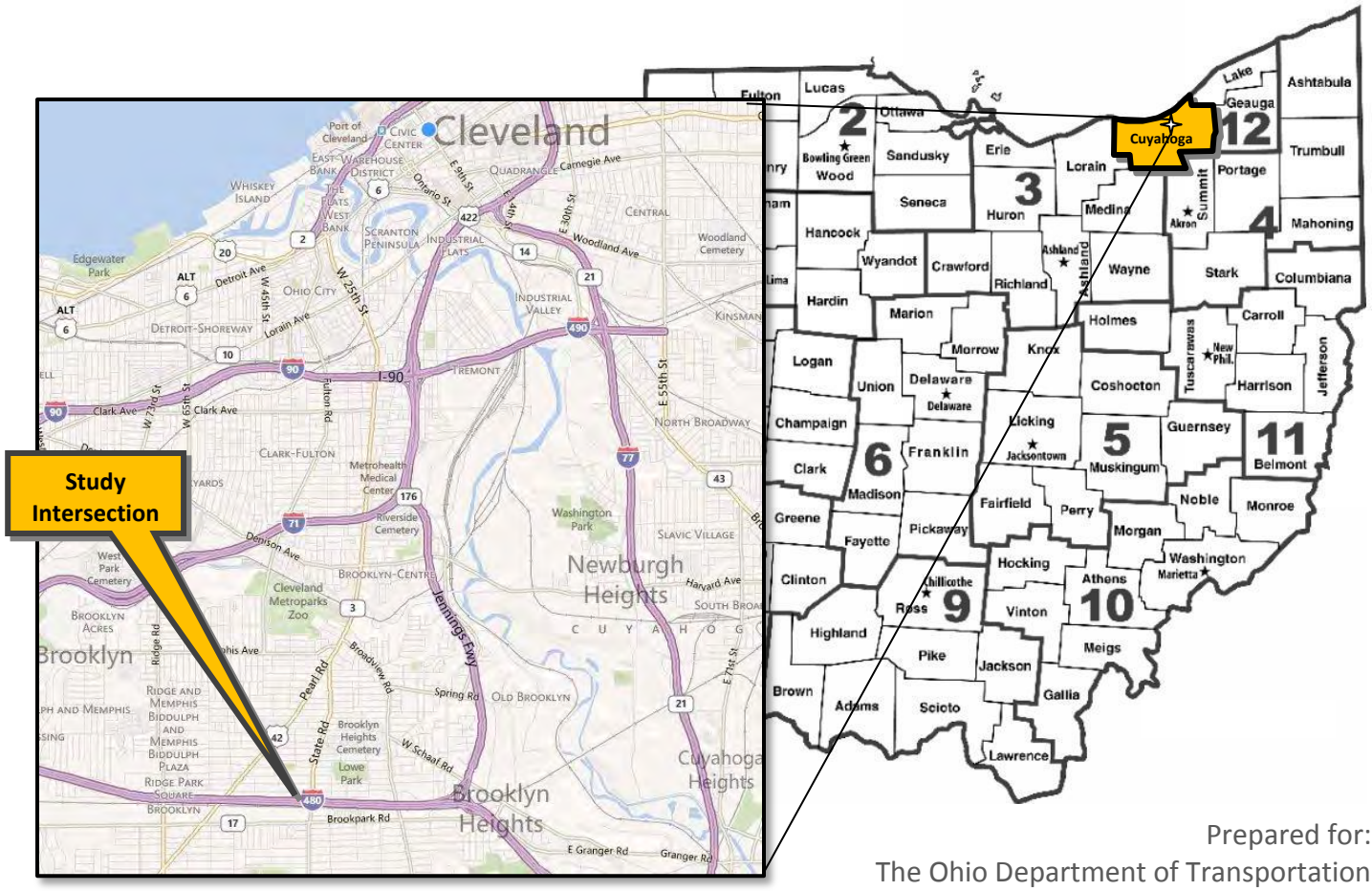
FINAL REPORT
OCTOBER 2012

DLZ OHIO, INC.

CUY-17-10.78 | SAFETY STUDY

BROOKPARK ROAD AT STATE ROAD

#35 ODOT SAFETYANALYST FATAL & SERIOUS INJURY



Prepared for:
The Ohio Department of Transportation
District 12
5500 Transportation Boulevard
Garfield Heights, OH 44125
216.581.2100

Prepared by:
DLZ Ohio, Inc.
614 West Superior Avenue
Suite 1000
Cleveland, OH 44113-1397
216.771.1090

DLZ Job No.: 1021-1008-16

1.0 Executive Summary

Purpose and Need & Background

The purpose of this Safety Study is to identify crash problems, determine site-specific countermeasures, and set up reasonable time periods to implement the proposed countermeasures at the intersection of Brookpark Road (SR-17) and State Road (SR 94). More specifically, this report is setup to address the recent crash history (46 crashes between 2008 and 2010) and provide recommendations to items associated with the crash history such as alleviating heavy peak hour congestions.

The Ohio Department of Transportation (ODOT) utilizes SafetyAnalyst which is a highway safety management software program developed in conjunction with the Highway Safety Manual through the American Association of State Highway and Transportation Officials (AASHTO) to flag and rank intersections and segments that have higher than predicted crash frequencies. The most recent three years of available crash data (2008 – 2010) were used to compile the SafetyAnalyst rankings and will be used for this report.

The intersection of Brookpark Road and State Road ranked #35 statewide on the 2010 ODOT SafetyAnalyst *Fatal and Serious Injury, Non-Freeway* list for "*higher than predicted crash frequency involving fatal or serious injuries*."

Brookpark Road and State Road are both classified as minor urban arterials. All approaches contain exclusive left turn lanes while the southbound approach on State Road also contains an exclusive right turn lane. The posted speed limit on Brookpark Road is 35 MPH. On State Road, the posted speed limit is 35 MPH just north of Brookpark Road and 25 MPH just south of Brookpark Road.

Possible Causes

Based on crash data obtained from ODOT, the most common types of crashes in the study area are left turn and rear end crashes. The majority of left turn crashes are occurring within the intersection in the eastbound and westbound directions along Brookpark Road. Rear end crashes are also occurring primarily in the eastbound and westbound directions.

Both types of crashes can be attributed to congestion and driver frustration/impatience caused by poor level of service and long delays. Observations revealed no visible vehicle detection and an apparent pretimed signal operation. The lack a vehicle actuation is contributing to an inefficient signal operation.

Recommended Countermeasures and Costs

The proposed improvement phases for this study can be categorized into short-term and medium-term phases. General countermeasures are also listed. These recommendations are proven countermeasures that can be applied to the study intersection. See section 8.0 Recommendations for more detailed recommendations.

General recommendations include:

- upgrading all pedestrian signals to countdown LED signals with pushbuttons for all approaches (short term),
- upgrading signs with highly reflective sheeting (short term),

The short-term recommendations include:

- upgrading the traffic controller to add left turn lane stop bar detection,
- adding lane control signs for the northbound approach,
- adding two signal heads for the southbound approach,
- studying the feasibility of coordinating traffic signals along State Road from Burger Avenue, north of I-480, to Brookpark Road.

DLZ estimated construction costs for year 2012 and included a 20% contingency. For the short-term improvements, the estimated cost is $79,800.

The medium-term recommendations include:

- access management strategies such as eliminating, relocating, or restricting movements for the drives at the northwest and southwest corners,
- reconfiguring the intersection to provide southbound dual left turn lanes and two northbound receiving lanes,
- upgrading the entire intersection with additional signal heads, new mast arms, LED indications, and backplates,
- adding an exclusive right turn lane to Brookpark Road for the westbound approach.

For medium-term improvements, the estimated construction cost is $485,100 with a 35% rate of return. This includes a 35% contingency. Right of way costs are included in this estimate as are public utility relocation (notably waterwork which includes relocating hydrants). Private utility relocation is not included but several utility poles along the north side of Brookpark Road present an obstacle to widening for a westbound exclusive right lane.

2012 Safety Analyst Safety Study
CUY-480-15.30-15.40
Cuyahoga County, Ohio

2012 Urban Freeway Rank # 74; CUY-480 (15.30-15.40)

Final Report

Submitted To:

Ohio Department of Transportation – District 12
5500 Transportation Boulevard
Garfield Heights, Ohio 44125

Prepared By:

Parsons Brinckerhoff
1660 West Second Street, Suite 820
Cleveland, Ohio 44113
&
Hatch Mott MacDonald
18013 Cleveland Parkway Drive
Suite 200
Cleveland, Ohio 44135

January 2015

1.0 Executive Summary

1.1 Purpose and Background

ODOT initiated a Formal Safety Engineering Study to assess crashes and capacity on I-480 at the SR 176 interchange and to recommend countermeasures. Over 100 crashes were reviewed that occurred at the study interchange between 2010 and 2012. Crashes identified occurred on I-480, SR 176, and the interchange ramps.

Raw crashes were supplied by ODOT in CAMTool format. OH-1 police reports were retrieved for each crash. Crashes were then reviewed and analyzed as follows:

1) Limits were verified for influence error.
2) Crashes captured by spatial query but outside of influence area were removed.
3) Each crash report was reviewed to ensure crash details are correct and corrections were made per ODOT "Hand Logged Revisions" instructions for submission to ODOT.

The purpose of this study is to identify high crash locations to assist ODOT in the planning of future construction projects and to determine potential short-term, low-cost improvements at critical crash locations. Locations on the 2012 Safety Priority List are as follows:

- #74 Urban Freeway, CUY-480-15.306-15.406
- #64 Urban Freeway, CUY-480-14.271-14.371 (just west of project area at SR 94)
- #15 Urban Non-Freeway, CUY-176-10.13-10.20 (Southern-most section of SR 176 SB ramp to SR 17 (Brookpark Road)

1.2 Location

The study area is the I-480/SR 176 interchange which is located in the City of Cleveland and the Village of Brooklyn Heights.

The interstate segments under this study are:

- I-480 from approximately 15.30 to 15.40

The interchange under this study is:

- I-480 at SR 176

The merge/diverge areas included within the study limits are:

- *Merge:* SR 176 SB to I-480 WB

To properly analyze the study segments, ramps, and merges, actual limits of the study area on I-480 were from SR 94 (State Road) to the SR 176 SB merge with I-480 EB (approximately logpoint 14.30 to 17.00).

The Build Condition presents a weave condition on I-480 WB from SR 176 to SR 94 (State Road). Traffic impacts given this weave are not covered in this report and should be studied further.

The entire study area was considered an area of interest.

1.3 Results

Crash data for the three year period from 2010-2012 indicates a total of 108 crashes occurred at the I-480/SR 176 interchange. The most common crash type in the interchange area was the rear end crash (38% of all crashes) followed by fixed object crashes (36%).

To determine if the existing gore spacing is sufficient, a capacity analysis for all elements is required. Further study with inclusive traffic data is required to determine the relationship between capacity and geometrics at this location.

Lane Widths: All lane widths within the interchange meet current L&D design criteria.

3.4 Existing Crash Data

Based on a crash analysis from 2010 through 2012, there were 15 crashes that occurred on the SR 176 SB to I-480 EB systems interchange ramp. This includes both merges with the westbound SR 17 ramp and with the I-480 EB merge. The majority of these crashes occurred near the SR 176 SB split to I-480 EB/WB, north of the SR 17 merge areas. Eleven of the 15 crashes were fixed object, three were sideswipe-passing, and one was a rear end crash.

3.5 Alternatives

The following alternatives were reviewed to improve traffic operations at the I-480 EB / SR 176 SB / SR 17 interchange area:

1. Eliminating the SR 17 EB to I-480 EB entrance ramp and combining both SR 17 eastbound and westbound entrance movements to I-480 EB via a reconfiguration of the existing SR 17 WB ramp.
2. Eliminating the SR 17 WB to I-480 EB entrance ramp and combining both SR 17 eastbound and westbound entrance movements to I-480 EB via a reconfiguration of the existing SR 17 EB ramp.
3. Given option 1 or 2, separate SR 176 from the SR 17 entrance ramp and merge SR 176 SB into I-480 EB first then merge SR 17 into I-480 EB after to improve spacing between the SR 176 merge and the I-77 interchange (see Figure 5)

Based on geometrics and site constraints, we recommend combining movements from SR 17 to I-480 EB by eliminating the SR 17 EB to I-480 EB entrance ramp and then separating the SR 176 SB ramp from the SR 17 ramp to allow SR 176 SB to merge onto I-480 EB further upstream from existing conditions.

To address crashes, the SR 176 SB to I-480 EB system ramp was restriped by ODOT in 2011 from two lanes to a single lane. Crash data does not currently support the need to implement geometric changes at the I-480/SR 17 interchange for safety purposes. We recommend waiting for more up to date crash data in this area to determine whether or not improvements are needed to address safety. Given additional crash and traffic data, we suggest that ODOT

consider further study on the recommended alternative with consideration given to the following:

- If widening or realignment of SR 17 or any of the ramps is needed, the pier locations at the SR 17 Bridge, Tuxedo Avenue Bridge and the overhead sanitary pipe need to be considered as existing piers are located on both sides of the SR 176 SB/SR 17 WB to I-480 EB system ramp.
- If alternative 1 is studied further, the need for a signal as well as a dedicated EB left turn lane should be studied at the SR 17 and I-480 entrance ramp intersection.
- If suggestion 2 is studied further, consider options to accommodate the elimination of this ramp including a signalized loon/bulb-out or a two-lane roundabout on SR 17 (Brookpark Road) to accommodate a U-turn movement for SR 17 WB traffic as well as a widening SR 17 to accommodate a WB left turn lane.
- If suggestion 3 is studied further, perform a capacity and geometric review to determine appropriate spacing between merge points. Also note that this alternative will require modifications to the existing concrete median and drainage system to accommodate a quicker merge.

Note that any alteration to the ramps will require operational analysis in accordance with the Highway Capacity Manual (HCM) and ODOT's guidelines for an Interchange Modification Study (IMS).

Figure 5 - SR 176 SB to I-480 EB Build Alternative

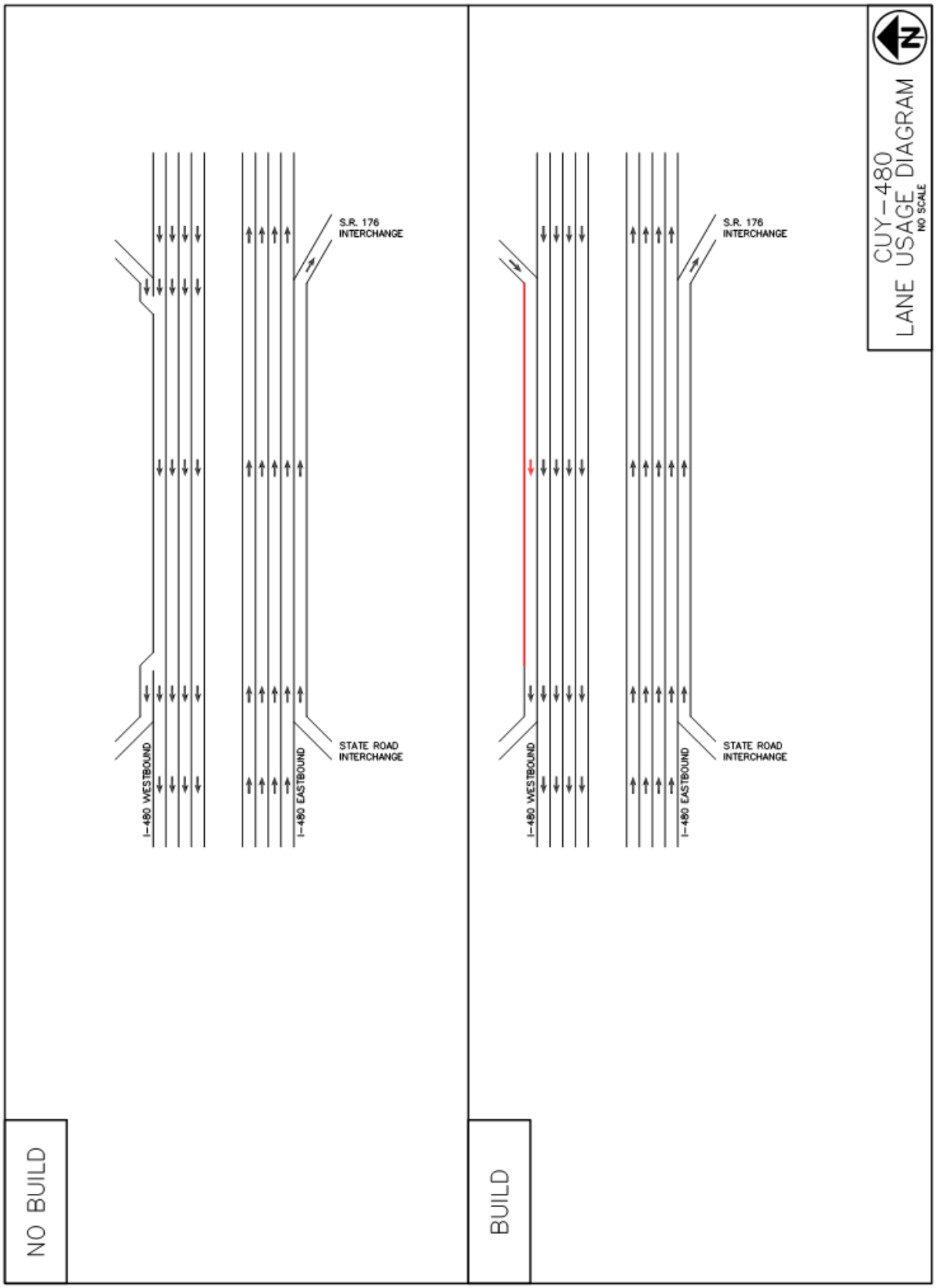


Figure 14 – I-480 Proposed Countermeasure

Programmed EPAC Data

3/17/2015
7:44:45AM

Intersection Name: State & Brookpark **Intersection Alias: State & Broo**

Access Code: 9999 Channel: 1 Address: 3 Revision: 3.34g
IP:

Access Data

:1200 Baud
:9600 Baud

Phase Data

Vehical Basic Timings

Phase	Min_Grn	Passage	Max1	Max2	Yellow	All Red
SB 1 LTA	7	3.0	20	0	3.0	2.0
NB 2	27	0.0	27	0	4.0	2.0
EB 3 LTA & 7 SB RTA	7	3.0	20	0	3.0	2.0
WB 4	7	0.0	40	0	4.0	2.0
NB 5 LTA	7	3.0	20	0	3.0	2.0
SB 6	27	0.0	27	0	4.0	2.0
WB 7 LTA	7	3.0	20	0	3.0	2.0
EB 8	7	0.0	40	0	4.0	2.0

Vehical Density Timings

Added Initial	Max_Initial	Time B4 Reduction	Cars Before	Time To Reduce	Min_Gap
0.0	0	0	0	0	0.0
0.0	0	0	0	0	0.0
0.0	0	0	0	0	0.0
0.0	0	0	0	0	0.0
0.0	0	0	0	0	0.0
0.0	0	0	0	0	0.0
0.0	0	0	0	0	0.0
0.0	0	0	0	0	0.0

Pedestrian Timing

Phase	Walk	Ped Clear	Flashing Walk	Extended Actuated Ped Clear	Extended Actuated Rest in Walk
1	0	0	No	0	No
2	7	20	No	0	Yes
3	0	0	No	0	No
4	7	29	No	0	No
5	0	0	No	0	No
6	7	20	No	0	Yes
7	0	0	No	0	No
8	7	29	No	0	No

General Control

Initialize	Non-Act Response	Veh Recall	Ped Recall	Recall Delay
Inactive	None	None	None	0
Inactive	NonActI	Min	Ped	0
Inactive	None	None	None	0
Green	None	Max	Ped	0
Inactive	None	None	None	0
Inactive	NonActI	Min	Ped	0
Inactive	None	None	None	0
Green	None	Max	Ped	0

Miscellaneous

Non Lock	Dual Entry	Last Car Passage	Conditional Service	No Simultaneous Gap Out
Yes	No	No	No	No
No	Yes	No	No	No
Yes	No	No	No	No
No	Yes	No	No	No
Yes	No	No	No	No
No	Yes	No	No	No
Yes	No	No	No	No
No	Yes	No	No	No

Special Sequence

Phase	Phase Omit	Minus Yellow Phase	Omit Call
1	2	0	0
2	0	0	0
3	4	0	0
4	0	0	0
5	6	0	0
6	0	0	0
7	8	0	0
8	0	0	0

Vehical Detector Phase Assignment

	Assigned Phase	Mode	Switched Phase	Extend	Delay
Vehical Detector Channel :1	5	Veh	0	0.0	0
Vehical Detector Channel :2	5	Veh	0	0.0	0
Vehical Detector Channel :3	1	Veh	0	0.0	0
Vehical Detector Channel :4	1	Veh	0	0.0	0
Vehical Detector Channel :5	3	Veh	0	0.0	0
Vehical Detector Channel :6	3	Veh	0	0.0	0
Vehical Detector Channel :8	7	Veh	0	0.0	0

Pedestrian Detector

	Assign Phase	Mode	Switched Phase	Extend	Delay
Pedestrian Detector Channel :1	2	Ped	0	0.0	0
Pedestrian Detector Channel :3	4	Ped	0	0.0	0
Pedestrian Detector Channel :5	6	Ped	0	0.0	0
Pedestrian Detector Channel :7	8	Ped	0	0.0	0

Default Data

Special Detector Phase Assignment

	Assign Phase	Mode	Switched Phase	Extend	Delay

:

Default Data

Unit Data

General Control

Startup Time: 0sec Startup State: Flash Red Revert: 4.0sec
Auto Ped Clear: No Stop Time Reset: No Alternate Sequence: 0
Aux Switch Func: 0:NoFunction
ABC connector Input Modes: 0
ABC connector Output Modes: 0
D connector Input Modes: 0
D connector Output Modes: 0

Ring	Input Response	Output Selection
1	Ring 1	Ring 1
2	Ring 2	Ring 2
3	None	None
4	None	None

Remote Flash
Test A = Flash

Phase	Flash Entry Phase	Flash Exit Phase

Default Data - No Flash

Channel	Flash Color	Flash Alternat

Default Data - No Flash

Overlaps

Phase(s)	Overlaps A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Green	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellow	4.0	2.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Red	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Stop Grn/Yel Phase	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Strat Green Phase	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Ring

Phase	Ring	Next Phase
1	1	2
2	1	3
3	1	4
4	1	1
5	2	6
6	2	7
7	2	8
8	2	5

Concurrent Phases	Phase(s) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	1	2	3	4	1	1	3	3	9	10	11	12	13	14	15	16
	5	5	7	7	2	2	4	4								
	6	6	8	8	5	6	7	8								

Alternate Sequences

No Alternate Sequences Programmed

Port 1 Data

BIU Addr	Port Status	Message 40
1	Used	No
2	Used	No
9	Used	No
17	Used	No
19	Used	No

Control	Channel	Hardware Pins	Control	Channel	Hardware Pins

Coordination Data

General Coordination Data

Operation Mode: 1=Auto
Coordination Mode: 0=Permissive
Maximun Mode: 0=Inhibit
Correction Mode: 3=Short Way Plus
Offset Mode: 1=End Grn
Force Mode: 0=Plan
Max Dwell Time: 20
Yield Period: 10
Manual Dial: 1
Manual Split: 1
Manual Offset: 1

Dial/Split	Cycle
1/1	120
2/2	150
3/3	150

Split Times and Phase Mode

Dial 1 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	20	0=Actuated	2	42	1=Coordinate	3	15	0=Actuated	4	43	5=Ped & Max
5	20	0=Actuated	6	42	1=Coordinate	7	15	0=Actuated	8	43	5=Ped & Max

Dial 2 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	25	0=Actuated	2	57	1=Coordinate	3	25	0=Actuated	4	43	5=Ped & Max
5	25	0=Actuated	6	57	1=Coordinate	7	25	0=Actuated	8	43	5=Ped & Max

Dial 3 / Split 3

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	25	0=Actuated	2	57	1=Coordinate	3	25	0=Actuated	4	43	5=Ped & Max
5	25	0=Actuated	6	57	1=Coordinate	7	25	0=Actuated	8	43	5=Ped & Max

Traffic Plan Data

Local TBC Data

Start of Daylight Saving Month: 3 Week: 2 Cycle Zero ReferenceHours: 24 Min: 0

End of Daylight Saving Month: 11 Week: 1

Source Day	Equate Days 1	2	3	4	5	6	7
	1	2	3	4	5	6	7 0

Traffic Data

Event	Day	Time	D/S/O	flash	PHASE FUNCTION 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1	0:0	1/1/1		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2	1	7:0	2/2/2		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3	1	9:0	1/1/1		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4	1	15:30	3/3/3		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
5	1	18:0	1/1/1		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

AUX. Events

Event	Program Day	Hour	Min.	Aux Ouputs 1	2	3	Det. Diag. D1	Det. Rpt. D2	Det. Mult100 D3	Dimming	Special Function Outputs 1	2	3	4	5	6	7	8
				☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Default Data - No Special Day(s) or Week(s) Programmed

Special Functions

Function	SF1	SF2	SF3	SF4	SF5	SF6	SF7	SF8
Special Function 1	X							
Special Function 2		X						
Special Function 3			X					
Special Function 4				X				
Special Function 5					X			
Special Function 6						X		
Special Function 7							X	
Special Function 8								X

Phase Function

Phase Function Map	PF1	PF2	PF3	PF4	PF5	PF6	PF7	PF8	PF9	PF10	PF11	PF12	PF13	PF14	PF15	PF16
Phase 1 Max2	X															
Phase 2 Max2		X														
Phase 3 Max2			X													
Phase 4 Max2				X												
Phase 5 Max2					X											
Phase 6 Max2						X										
Phase 7 Max2							X									
Phase 8 Max2								X								
Phase 1 Phase Omit									X							
Phase 2 Phase Omit										X						
Phase 3 Phase Omit											X					
Phase 4 Phase Omit												X				
Phase 5 Phase Omit													X			
Phase 6 Phase Omit														X		
Phase 7 Phase Omit															X	
Phase 8 Phase Omit																X

Dimming Data

Channel	Red	Yellow	Green	Alternate

Default Data - No Dimming Programmed

Preemption Data

General Preemption Data

Flash > Preepmt 1, Preepmt 1 > Preempt 2, Preepmt 2 > Preempt 3, Preepmt 3 > Preempt 4, Preepmt 4 > Preempt 5, Preepmt 5 > Preempt 6

Ring 1 Min GRN/WLK = 10 Ring 2 Min GRN/WLK = 10 Ring 3 Min GRN/WLK = 10 Ring 4 Min GRN/WLK = 10

Preempt	Preempt Timers									Select			Track				D well	Return		
	Non-Locking	Link to Prmpt	Delay	Extend	Duration	MaxCall	Lck-Out	GateExt	Debounce	Ped Clr	Yel	Red	Grn	Ped	Yel	Red	Grn	Ped Clr	Yel	Red
1	No	0	0	0	0	0	0	0	0.0	8	40	20	10	8	40	20	10	8	40	20
2	No	0	0	0	0	0	0	0	0.0	8	40	20	10	8	40	20	10	8	40	20
3	No	0	0	0	0	0	0	0	0.0	8	40	20	10	8	40	20	10	8	40	20
4	No	0	0	0	0	0	0	0	0.0	8	40	20	10	8	40	20	10	8	40	20
5	No	0	0	0	0	0	0	0	0.0	8	40	20	10	8	40	20	10	8	40	20
6	No	0	0	0	0	0	0	0	0.0	8	40	20	10	8	40	20	10	8	40	20

Preempt 1			Preempt 2			Preempt 3			Preempt 4			Preempt 5			Preempt 6		
Phase	Exit Phase	Exit Calls	Phase	Exit Phase	Exit Calls	Phase	Exit Phase	Exit Calls	Phase	Exit Phase	Exit Calls	Phase	Exit Phase	Exit Calls	Phase	Exit Phase	Exit Calls

Programmed EPAC Data

3/17/2015
7:45:42AM

Intersection Name: STATE & I 480 S RAMP **Intersection Alias: STATE I480 S**

Access Code: 9999 Channel: 1 Address: 2 Revision: 3.32h
IP:

Access Data :1200 Baud

Phase Data

Vehical Basic Timings

Phase	Min_Grn	Passage	Max1	Max2	Yellow	All Red
NB2 & NB21 RTA	0.0	21	0	4.0	2.0
SB3 LTA	7	0.0	25	0	3.0	2.0
EB4 RAMP	7	0.0	30	0	4.0	2.0

Vehical Density Timings

Added Initial	Max_Initial	Time B4 Reduction	Cars Before	Time To Reduce	Min_Gap
0.0	0	0	0	0	0.0
0.0	0	0	0	0	0.0
0.0	0	0	0	0	0.0

Pedestrian Timing

Phase	Walk	Ped Clear	Flashing Walk	Extended Actuated Ped Clear	Extended Actuated Rest in Walk
2	0	0	No	0	Yes
3	0	0	No	0	No
4	7	20	No	0	No

General Control

Initialize	Non-Act Response	Veh Recall	Ped Recall	Recall Delay
Green	NonActI	Min	None	0
Inactive	None	Max	None	0
Inactive	None	Max	Ped	0

Miscellaneous

Non Lock	Dual Entry	Last Car Passage	Conditional Service	No Simultaneous Gap Out
No	No	No	No	No
No	No	No	No	No
No	No	No	No	No

Special Sequence
Default Data

Vehical Detector Phase Assignment

Assigned Phase	Mode	Switched Phase	Extend	Delay

Default Data

Pedestrian Detector
Default Data

Special Detector Phase Assignment

Assign Phase	Mode	Switched Phase	Extend	Delay

:
Default Data

Unit Data

General Control

Startup Time: 0sec Startup State: Flash Red Revert: 4.0sec
Auto Ped Clear: No Stop Time Reset: No Alternate Sequence: 0
Aux Switch Func: 0:NoFunction
ABC connector Input Modes: 0
ABC connector Output Modes: 0
D connector Input Modes: 0
D connector Output Modes: 0

Ring	Input Response	Output Selection
1	Ring 1	Ring 1
2	Ring 2	Ring 2
3	None	None
4	None	None

Remote Flash
Test A = Flash

Phase	Flash Entry Phase	Flash Exit Phase

Default Data - No Flash

Channel	Flash Color	Flash Alternat

Default Data - No Flash

Overlaps

SB

Overlaps	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Phase(s)	2															
	3															
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Green	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellow	4.0	2.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Red	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Stop Grn/Yel Phase	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Strat Green Phase	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Ring Phase	Ring	Next Phase
2	1	3
3	1	4
4	1	1

Concurrent Phases	Phase(s) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	1	2	3	4	1	1	3	3	9	10	11	12	13	14	15	16
	5	5	7	7	2	2	4	4								
	6	6	8	8	5	6	7	8								

Alternate Sequences

Alternate Sequences

Phase Pair(s)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1 2	3 4	1 2	5 6	1 2	3 4	1 2	7 8	1 2	3 4	1 2	5 6	1 2	3 4	1 2
2	0 0	0 0	3 4	0 0	5 6	5 6	3 4	0 0	7 8	7 8	3 4	7 8	5 6	5 6	3 4
3	0 0	0 0	0 0	0 0	0 0	0 0	5 6	0 0	0 0	0 0	7 8	0 0	7 8	7 8	5 6
4	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	7 8

Port 1 Data

BIU Addr	Port Status	Message 40

Default Data

Control	Channel	Hardware Pins	Control	Channel	Hardware Pins
1 - Veh Phase 1	1	1 - Phase 1 RYG	2 - Veh Phase 2	2	2 - Phase 2 RYG
3 - Veh Phase 3	3	3 - Phase 3 RYG	4 - Veh Phase 4	4	4 - Phase 4 RYG
5 - Veh Phase 5	5	5 - Phase 5 RYG	6 - Veh Phase 6	6	6 - Phase 6 RYG
7 - Veh Phase 7	7	7 - Phase 7 RYG	8 - Veh Phase 8	8	8 - Phase 8 RYG
18 - Ped Phase 2	9	10 - Phase 2 DPW	20 - Ped Phase 4	10	12 - Phase 4 DPW
22 - Ped Phase 6	11	14 - Phase 6 DPW	24 - Ped Phase 8	12	16 - Phase 8 DPW
33 - Overlap A	13	17 - Overlap A RYG	34 - Overlap B	14	18 - Overlap B RYG
35 - Overlap C	15	19 - Overlap C RYG	36 - Overlap D	16	20 - Overlap D RYG
17 - Ped Phase 1	17	9 - Phase 1 DPW	19 - Ped Phase 3	18	11 - Phase 3 DPW
21 - Ped Phase 5	19	13 - Phase 5 DPW	23 - Ped Phase 7	20	15 - Phase 7 DPW

Coordination Data

General Coordination Data

Operation Mode: 1=Auto
Coordination Mode: 0=Permissive
Maximun Mode: 0=Inhibit
Correction Mode: 3=Short Way Plus

Offset Mode: 1=End Grn
Force Mode: 0=Plan
Max Dwell Time: 25
Yield Period: 10

Manual Dial: 1
Manual Split: 1
Manual Offset: 1

Dial/Split	Cycle
1/1	100
2/2	100
3/3	100

Split Times and Phase Mode

Dial 1 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
2	40	1=Coordinate	3	26	3=Max Recall	4	34	3=Max Recall			

Dial 2 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
2	40	1=Coordinate	3	26	3=Max Recall	4	34	3=Max Recall			

Dial 3 / Split 3

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
2	40	1=Coordinate	3	26	3=Max Recall	4	34	3=Max Recall			

Traffic Plan Data

Local TBC Data

Start of Daylight Saving Month: 3 Week: 2
End of Daylight Saving Month: 11 Week: 1

Cycle Zero ReferenceHours: 24 Min: 0

Source Day	Equate Days 1	2	3	4	5	6	7
	1	2	3	4	5	6	7	0

Traffic Data

Event	Day	Time	D/S/O	flash	PHASE FUNCTION 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1	0:0	1/1/1		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2	1	7:0	2/2/2		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3	1	9:0	1/1/1		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4	1	15:30	3/3/3		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
5	1	18:0	1/1/1		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

AUX. Events

Event	Program Day	Hour	Min.	Aux Ouputs 1	2	3	Det. Diag. D1	Det. Rpt. D2	Det. Mult100 D3	Dimming	Special Function Outputs 1	2	3	4	5	6	7	8
				☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Default Data - No Special Day(s) or Week(s) Programmed

Special Functions

Function	SF1	SF2	SF3	SF4	SF5	SF6	SF7	SF8
Special Function 1	X							
Special Function 2		X						
Special Function 3			X					
Special Function 4				X				
Special Function 5					X			
Special Function 6						X		
Special Function 7							X	
Special Function 8								X

Phase Function

Phase Function Map	PF1	PF2	PF3	PF4	PF5	PF6	PF7	PF8	PF9	PF10	PF11	PF12	PF13	PF14	PF15	PF16
Phase 1 Max2	X															
Phase 2 Max2		X														
Phase 3 Max2			X													
Phase 4 Max2				X												
Phase 5 Max2					X											
Phase 6 Max2						X										
Phase 7 Max2							X									
Phase 8 Max2								X								
Phase 1 Phase Omit									X							
Phase 2 Phase Omit										X						
Phase 3 Phase Omit											X					
Phase 4 Phase Omit												X				
Phase 5 Phase Omit													X			
Phase 6 Phase Omit														X		
Phase 7 Phase Omit															X	
Phase 8 Phase Omit																X

Dimming Data

Channel	Red	Yellow	Green	Alternate

Default Data - No Dimming Programmed

Preemption Data

General Preemption Data

Flash > Preepmt 1, Preepmt 1 > Preempt 2, Preepmt 2 > Preempt 3, Preepmt 3 > Preempt 4, Preepmt 4 > Preempt 5, Preepmt 5 > Preempt 6

Ring 1 Min GRN/WLK = 10 Ring 2 Min GRN/WLK = 10 Ring 3 Min GRN/WLK = 10 Ring 4 Min GRN/WLK = 10

Preempt	Preempt Timers									Select			Track				D	Return		
	Non-Locking	Link to Prmpt	Delay	Extend	Duration	MaxCall	Lck-Out	GateExt	Debounce	Ped Clr	Yel	Red	Grn	Ped	Yel	Red	well Grn	Ped Clr	Yel	Red
1	No	0	0	0	0	0	0	0	0.0	8	40	20	10	8	40	20	10	8	40	20
2	No	0	0	0	0	0	0	0	0.0	8	40	20	10	8	40	20	10	8	40	20
3	No	0	0	0	0	0	0	0	0.0	8	40	20	10	8	40	20	10	8	40	20
4	No	0	0	0	0	0	0	0	0.0	8	40	20	10	8	40	20	10	8	40	20
5	No	0	0	0	0	0	0	0	0.0	8	40	20	10	8	40	20	10	8	40	20
6	No	0	0	0	0	0	0	0	0.0	8	40	20	10	8	40	20	10	8	40	20

Programmed EPAC Data

3/17/2015
7:46:34AM

Intersection Name: STATE & I 480 N RAMP **Intersection Alias: STATE I 480N**

Access Code: 9999 Channel: 1 Address: 1 Revision: 3.32d
IP:

Access Data
:1200 Baud
:9600 Baud

Phase Data

Vehical Basic Timings

Phase	Min_Grn	Passage	Max1	Max2	Yellow	All Red
SB 2	21	0.0	21	0	4.0	2.0
NB 3 CTA	7	0.0	25	0	3.0	2.0
WB 4 RAMP	7	0.0	30	0	4.0	2.0

Vehical Density Timings

Added Initial	Max_Initial	Time B4 Reduction	Cars Before	Time To Reduce	Min_Gap
0.0	0	0	0	0	0.0
0.0	0	0	0	0	0.0
0.0	0	0	0	0	0.0

Pedestrian Timing

Phase	Walk	Ped Clear	Flashing Walk	Extended Actuated Ped Clear	Rest in Walk
2	7	14	No	0	Yes
3	0	0	No	0	No
4	0	0	No	0	No

General Control

Initialize	Non-Act Response	Veh Recall	Ped Recall	Recall Delay
Green	NonActI	Min	Ped	0
Inactive	None	Max	None	0
Inactive	None	Max	None	0

Miscellaneous

Non Lock	Dual Entry	Last Car Passage	Conditional Service	No Simultaneous Gap Out
No	No	No	No	No
No	No	No	No	No
No	No	No	No	No

Special Sequence
Default Data

Vehical Detector Phase Assignment

Assigned Phase	Mode	Switched Phase	Extend	Delay

Default Data

Pedestrian Detector
Default Data

Special Detector Phase Assignment

Assign Phase	Mode	Switched Phase	Extend	Delay

:
Default Data

Unit Data

General Control

Startup Time: 0sec Startup State: Flash Red Revert: 4.0sec
Auto Ped Clear: No Stop Time Reset: No Alternate Sequence: 0
Aux Switch Func: 0:NoFunction
ABC connector Input Modes: 0
ABC connector Output Modes: 0
D connector Input Modes: 0
D connector Output Modes: 0

Ring	Input Response	Output Selection
1	Ring 1	Ring 1
2	Ring 2	Ring 2
3	None	None
4	None	None

Remote Flash
Test A = Flash

Phase	Flash Entry Phase	Flash Exit Phase

Default Data - No Flash

Channel	Flash Color	Flash Alternat

Default Data - No Flash

Overlaps

NB

Overlaps	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Phase(s)	2															
	3															
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Green	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellow	4.0	2.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Red	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Stop Grn/Yel Phase	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Strat Green Phase	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Ring Phase	Ring	Next Phase
2	1	3
3	1	4
4	1	1

Concurrent Phases	Phase(s) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	1	2	3	4	1	1	3	3	9	10	11	12	13	14	15	16
	5	5	7	7	2	2	4	4								
	6	6	8	8	5	6	7	8								

Alternate Sequences

Alternate Sequences

Phase Pair(s)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	**1 2**	**3 4**	**1 2**	**5 6**	**1 2**	**3 4**	**1 2**	**7 8**	**1 2**	**3 4**	**1 2**	**5 6**	**1 2**	**3 4**	**1 2**
2	**0 0**	**0 0**	**3 4**	**0 0**	**5 6**	**5 6**	**3 4**	**0 0**	**7 8**	**7 8**	**3 4**	**7 8**	**5 6**	**5 6**	**3 4**
3	**0 0**	**0 0**	**0 0**	**0 0**	**0 0**	**0 0**	**5 6**	**0 0**	**0 0**	**0 0**	**7 8**	**0 0**	**7 8**	**7 8**	**5 6**
4	**0 0**	**0 0**	**0 0**	**0 0**	**0 0**	**0 0**	**0 0**	**0 0**	**0 0**	**0 0**	**0 0**	**0 0**	**0 0**	**0 0**	**7 8**

Port 1 Data

BIU Addr	Port Status	Message 40

Default Data

Control	Channel	Hardware Pins	Control	Channel	Hardware Pins
1 - Veh Phase 1	**1**	1 - Phase 1 RYG	2 - Veh Phase 2	**2**	2 - Phase 2 RYG
3 - Veh Phase 3	**3**	3 - Phase 3 RYG	4 - Veh Phase 4	**4**	4 - Phase 4 RYG
33 - Overlap A	**5**	5 - Phase 5 RYG	6 - Veh Phase 6	**6**	6 - Phase 6 RYG
7 - Veh Phase 7	**7**	7 - Phase 7 RYG	8 - Veh Phase 8	**8**	8 - Phase 8 RYG
18 - Ped Phase 2	**9**	10 - Phase 2 DPW	20 - Ped Phase 4	**10**	12 - Phase 4 DPW
22 - Ped Phase 6	**11**	14 - Phase 6 DPW	24 - Ped Phase 8	**12**	16 - Phase 8 DPW
33 - Overlap A	**13**	17 - Overlap A RYG	34 - Overlap B	**14**	18 - Overlap B RYG
35 - Overlap C	**15**	19 - Overlap C RYG	36 - Overlap D	**16**	20 - Overlap D RYG
17 - Ped Phase 1	**17**	9 - Phase 1 DPW	19 - Ped Phase 3	**18**	11 - Phase 3 DPW
21 - Ped Phase 5	**19**	13 - Phase 5 DPW	23 - Ped Phase 7	**20**	15 - Phase 7 DPW

Coordination Data

General Coordination Data

Operation Mode: 1=Auto
Coordination Mode: 0=Permissive
Maximun Mode: 0=Inhibit
Correction Mode: 3=Short Way Plus

Offset Mode: 1=End Grn
Force Mode: 0=Plan
Max Dwell Time: 25
Yield Period: 10

Manual Dial: 1
Manual Split: 1
Manual Offset: 1

Dial/Split	Cycle
1/1	100
2/2	100
3/3	100

Split Times and Phase Mode

Dial 1 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
2	40	1=Coordinate	3	26	3=Max Recall	4	34	3=Max Recall			

Dial 2 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
2	40	1=Coordinate	3	26	3=Max Recall	4	34	3=Max Recall			

Dial 3 / Split 3

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
2	40	1=Coordinate	3	26	3=Max Recall	4	34	3=Max Recall			

Traffic Plan Data

Local TBC Data

Start of Daylight Saving Month: 3 Week: 2
End of Daylight Saving Month: 11 Week: 1

Cycle Zero ReferenceHours: 24 Min: 0

Source Day	Equate Days 1	2	3	4	5	6	7
	1	2	3	4	5	6	7	0

Traffic Data

Event	Day	Time	D/S/O	flash	PHASE FUNCTION 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1	0:0	1/1/1		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2	1	7:0	2/2/2		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3	1	9:0	1/1/1		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4	1	15:30	3/3/3		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
5	1	18:0	1/1/1		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

AUX. Events

Event	Program Day	Hour	Min.	Aux Ouputs 1	2	3	Det. Diag. D1	Det. Rpt. D2	Det. Mult100 D3	Dimming	Special Function Outputs 1	2	3	4	5	6	7	8
				☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Default Data - No Special Day(s) or Week(s) Programmed

Special Functions

Function	SF1	SF2	SF3	SF4	SF5	SF6	SF7	SF8
Special Function 1	X							
Special Function 2		X						
Special Function 3			X					
Special Function 4				X				
Special Function 5					X			
Special Function 6						X		
Special Function 7							X	
Special Function 8								X

Phase Function

Phase Function Map	PF1	PF2	PF3	PF4	PF5	PF6	PF7	PF8	PF9	PF10	PF11	PF12	PF13	PF14	PF15	PF16
Phase 1 Max2	X															
Phase 2 Max2		X														
Phase 3 Max2			X													
Phase 4 Max2				X												
Phase 5 Max2					X											
Phase 6 Max2						X										
Phase 7 Max2							X									
Phase 8 Max2								X								
Phase 1 Phase Omit									X							
Phase 2 Phase Omit										X						
Phase 3 Phase Omit											X					
Phase 4 Phase Omit												X				
Phase 5 Phase Omit													X			
Phase 6 Phase Omit														X		
Phase 7 Phase Omit															X	
Phase 8 Phase Omit																X

Dimming Data

Channel	Red	Yellow	Green	Alternate

Default Data - No Dimming Programmed

Preemption Data

General Preemption Data

Flash > Preepmt 1, Preepmt 1 > Preempt 2, Preepmt 2 > Preempt 3, Preepmt 3 > Preempt 4, Preepmt 4 > Preempt 5, Preepmt 5 > Preempt 6

Ring 1 Min GRN/WLK = 10 Ring 2 Min GRN/WLK = 10 Ring 3 Min GRN/WLK = 10 Ring 4 Min GRN/WLK = 10

Preempt	Preempt Timers									Select			Track				D well	Return		
	Non-Locking	Link to Prmpt	Delay	Extend	Duration	MaxCall	Lck-Out	GateExt	Debounce	Ped Clr	Yel	Red	Grn	Ped	Yel	Red	Grn	Ped Clr	Yel	Red
1	No	0	0	0	0	0	0	0	0.0	8	40	20	10	8	40	20	10	8	40	20
2	No	0	0	0	0	0	0	0	0.0	8	40	20	10	8	40	20	10	8	40	20
3	No	0	0	0	0	0	0	0	0.0	8	40	20	10	8	40	20	10	8	40	20
4	No	0	0	0	0	0	0	0	0.0	8	40	20	10	8	40	20	10	8	40	20
5	No	0	0	0	0	0	0	0	0.0	8	40	20	10	8	40	20	10	8	40	20
6	No	0	0	0	0	0	0	0	0.0	8	40	20	10	8	40	20	10	8	40	20

Programmed EPAC Data

3/17/2015
7:47:17AM

Intersection Name: State & Ralph Burger **Intersection Alias: State & Ralp**

Access Code: 9999 Channel: 1 Address: 4 Revision: 2.30
IP:

Access Data :1200 Baud :9600 Baud

Phase Data

Vehical Basic Timings

Phase	Min_Grn	Passage	Max1	Max2	Yellow	All Red
NB 2 SB	30	0.0	30	0	4.0	2.0
EB 4 WB	7	0.0	30	0	3.0	2.0

Vehical Density Timings

Added Initial	Max_Initial	Time B4 Reduction	Cars Before	Time To Reduce	Min_Gap
0.0	0	0	0	0	0.0
0.0	0	0	0	0	0.0

Pedestrian Timing

Phase	Walk	Ped Clear	Flashing Walk	Extended Actuated Ped Clear	Rest in Walk
2	0	0	No	0	No
4	0	0	No	0	No

General Control

Initialize	Non-Act Response	Veh Recall	Ped Recall	Recall Delay
Green	NonActI	Min	None	0
Inactive	None	Max	None	0

Miscellaneous

Non Lock	Dual Entry	Last Car Passage	Conditional Service	No Simultaneous Gap Out
No	No	No	No	No
No	No	No	No	No

Special Sequence
Default Data

Vehical Detector Phase Assignment

Assigned Phase	Mode	Switched Phase	Extend	Delay

Default Data

Pedestrian Detector
Default Data

Special Detector Phase Assignment

Assign Phase	Mode	Switched Phase	Extend	Delay

:
Default Data

Unit Data

General Control

Startup Time: 7sec Startup State: Flash Red Revert: 2.0sec
Auto Ped Clear: No Stop Time Reset: No Alternate Sequence: 0
Aux Switch Func: 0:NoFunction
ABC connector Input Modes: 0
ABC connector Output Modes: 0
D connector Input Modes: 0
D connector Output Modes: 0

Ring	Input Response	Output Selection
1	Ring 1	Ring 1
2	Ring 2	Ring 2
3	None	None
4	None	Ring 2

Remote Flash
Test A = Flash Yes

Phase	Flash Entry Phase	Flash Exit Phase
2	No	Yes
4	Yes	No

Channel	Flash Color	Flash Alternat

Default Data - No Flash

Overlaps

Phase(s)	Overlaps A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Green	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellow	4.0	2.0	4.0	4.0	4.0	4.0	4.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Red	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stop Grn/Yel Phase	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Strat Green Phase	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Ring

Phase	Ring	Next Phase
2	1	3
4	1	1

Phase(s)

Concurrent Phases	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	1	2	3	4	1	1	3	3	9	10	11	12	13	14	15	16
	5	5	7	7	2	2	4	4								
	6	6	8	8	5	6	7	8								

Alternate Sequences

Alternate Sequences

Phase Pair(s)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1 2	3 4	1 2	5 6	1 2	3 4	1 2	7 8	1 2	3 4	1 2	5 6	1 2	3 4	1 2
2	0 0	0 0	3 4	0 0	5 6	5 6	3 4	0 0	7 8	7 8	3 4	7 8	5 6	5 6	3 4
3	0 0	0 0	0 0	0 0	0 0	0 0	5 6	0 0	0 0	0 0	7 8	0 0	7 8	7 8	5 6
4	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	7 8

Port 1 Data

BIU Addr: Port Status: Message: 40

Default Data

Control	Channel	Hardware Pins	Control	Channel	Hardware Pins
1 - Veh Phase 1	1	1 - Phase 1 RYG	2 - Veh Phase 2	2	2 - Phase 2 RYG
3 - Veh Phase 3	3	3 - Phase 3 RYG	4 - Veh Phase 4	4	4 - Phase 4 RYG
5 - Veh Phase 5	5	5 - Phase 5 RYG	6 - Veh Phase 6	6	6 - Phase 6 RYG
7 - Veh Phase 7	7	7 - Phase 7 RYG	8 - Veh Phase 8	8	8 - Phase 8 RYG
18 - Ped Phase 2	9	10 - Phase 2 DPW	20 - Ped Phase 4	10	12 - Phase 4 DPW
22 - Ped Phase 6	11	14 - Phase 6 DPW	24 - Ped Phase 8	12	16 - Phase 8 DPW
33 - Overlap A	13	17 - Overlap A RYG	34 - Overlap B	14	18 - Overlap B RYG
35 - Overlap C	15	19 - Overlap C RYG	36 - Overlap D	16	20 - Overlap D RYG
17 - Ped Phase 1	17	9 - Phase 1 DPW	19 - Ped Phase 3	18	11 - Phase 3 DPW
21 - Ped Phase 5	19	13 - Phase 5 DPW	23 - Ped Phase 7	20	15 - Phase 7 DPW
37 - Overlap E	21	21 - Phase 1 ONC	38 - Overlap F	22	22 - Phase 2 ONC
39 - Overlap G	23	23 - Phase 3 ONC	40 - Overlap H	24	24 - Phase 4 ONC

Coordination Data

General Coordination Data

Operation Mode: 1=Auto
Coordination Mode: 0=Permissive
Maximun Mode: 0=Inhibit
Correction Mode: 3=Short Way Plus

Offset Mode: 1=End Grn
Force Mode: 0=Plan
Max Dwell Time: 25
Yield Period: 10

Manual Dial: 1
Manual Split: 1
Manual Offset: 1

Dial/Split	Cycle
1/1	90
2/2	120
3/3	120
3/4	100
4/1	100
4/2	100
4/3	100
4/4	100

Split Times and Phase Mode:

Dial 1 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
2	60	1=Coordinate	4	30	3=Max Recall						

Dial 2 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
2	90	1=Coordinate	4	30	3=Max Recall						

Dial 3 / Split 3

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
2	90	1=Coordinate	4	30	3=Max Recall						

Dial 3 / Split 4

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	25	0=Actuated	2	25	1=Coordinate	3	25	0=Actuated	4	25	0=Actuated
5	25	0=Actuated	6	25	1=Coordinate	7	25	0=Actuated	8	25	0=Actuated

Dial 4 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	25	0=Actuated	2	25	1=Coordinate	3	25	0=Actuated	4	25	0=Actuated
5	25	0=Actuated	6	25	1=Coordinate	7	25	0=Actuated	8	25	0=Actuated

Dial 4 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	25	0=Actuated	2	25	1=Coordinate	3	25	0=Actuated	4	25	0=Actuated
5	25	0=Actuated	6	25	1=Coordinate	7	25	0=Actuated	8	25	0=Actuated

Dial 4 / Split 3

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	25	0=Actuated	2	25	1=Coordinate	3	25	0=Actuated	4	25	0=Actuated
5	25	0=Actuated	6	25	1=Coordinate	7	25	0=Actuated	8	25	0=Actuated

Dial 4 / Split 4

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	25	0=Actuated	2	25	1=Coordinate	3	25	0=Actuated	4	25	0=Actuated
5	25	0=Actuated	6	25	1=Coordinate	7	25	0=Actuated	8	25	0=Actuated

Traffic Plan Data

Local TBC Data

Start of Daylight Saving Month: 3 Week: 2 Cycle Zero ReferenceHours: 24 Min: 0

End of Daylight Saving Month: 11 Week: 1

Source Day	Equate Days 1	2	3	4	5	6	7
1	7	0	0	0	0	0	0
2	3	4	5	6	0	0	0

Traffic Data

Event	Day	Time	D/S/O	flash	PHASE FUNCTION 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1	0:0	1/1/1		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2	2	0:0	1/1/1		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3	2	7:0	2/2/2		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4	2	9:0	1/1/1		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
5	2	15:30	3/3/3		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
6	2	18:0	1/1/1		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

AUX. Events

Event	Program Day	Hour	Min.	Aux Ouputs 1	2	3	Det. Diag. D1	Det. Rpt. D2	Det. Mult100 D3	Dimming	Special Function Outputs 1	2	3	4	5	6	7	8
				☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Default Data - No Special Day(s) or Week(s) Programmed

Special Functions

Function	SF1	SF2	SF3	SF4	SF5	SF6	SF7	SF8
Special Function 1	X							
Special Function 2		X						
Special Function 3			X					
Special Function 4				X				
Special Function 5					X			
Special Function 6						X		
Special Function 7							X	
Special Function 8								X

Phase Function

Phase Function Map	PF1	PF2	PF3	PF4	PF5	PF6	PF7	PF8	PF9	PF10	PF11	PF12	PF13	PF14	PF15	PF16
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Dimming Data

Channel	Red	Yellow	Green	Alternate
	☐	☐	☐	☐

Default Data - No Dimming Programmed

Preemption Data

General Preemption Data

Flash > Preepmt 1, Preepmt 1 = Preempt 2, Preepmt 2 = Preempt 3, Preepmt 3 = Preempt 4, Preepmt 4 = Preempt 5, Preepmt 5 = Preempt 6
Ring 1 Min GRN/WLK = 5 Ring 2 Min GRN/WLK = 5 Ring 3 Min GRN/WLK = 5 Ring 4 Min GRN/WLK = 5

Preempt Timers

Preempt	Non-Locking	Link to Prmpt	Delay	Extend	Duration	MaxCall	Lck-Out	GateExt	Debounce	Select			Track				D well	Return		
										Ped Clr	Yel	Red	Grn	Ped	Yel	Red	Grn	Ped Clr	Yel	Red
1	No	0	0	0	0	0	0	0	0.0	8	40	20	5	0	40	20	5	0	40	20
2	No	0	0	0	0	0	0	0	0.0	8	40	20	5	0	40	20	5	0	40	20
3	No	0	0	0	0	0	0	0	0.0	8	40	20	5	0	40	20	5	0	40	20
4	No	0	0	0	0	0	0	0	0.0	8	40	20	5	0	40	20	5	0	40	20
5	No	0	0	0	0	0	0	0	0.0	8	40	20	5	0	40	20	5	0	40	20
6	No	0	0	0	0	0	0	0	0.0	8	40	20	5	0	40	20	5	0	40	20

Preempt 1

Phase	Exit Phase	Exit Calls
1	No	Yes
2	No	Yes
3	No	Yes
4	Yes	Yes
5	No	Yes
6	No	Yes
7	No	Yes
8	Yes	Yes

Preempt 2

Phase	Exit Phase	Exit Calls
1	No	Yes
2	No	Yes
3	No	Yes
4	Yes	Yes
5	No	Yes
6	No	Yes
7	No	Yes
8	Yes	Yes

Preempt 3

Phase	Exit Phase	Exit Calls
1	No	Yes
2	Yes	Yes
3	No	Yes
4	No	Yes
5	No	Yes
6	Yes	Yes
7	No	Yes
8	No	Yes

Preempt 4

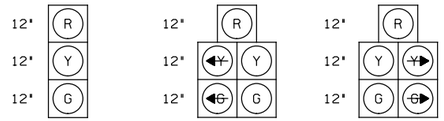
Phase	Exit Phase	Exit Calls
1	No	Yes
2	Yes	Yes
3	No	Yes
4	No	Yes
5	No	Yes
6	Yes	Yes
7	No	Yes
8	No	Yes

Preempt 5

Phase	Exit Phase	Exit Calls
1	No	Yes
2	Yes	Yes
3	No	Yes
4	No	Yes
5	No	Yes
6	Yes	Yes
7	No	Yes
8	No	Yes

Preempt 6

Phase	Exit Phase	Exit Calls
1	No	Yes
2	Yes	Yes
3	No	Yes
4	No	Yes
5	No	Yes
6	Yes	Yes
7	No	Yes
8	No	Yes



PROPOSED POLYCARBONATE SIGNAL HEAD

N1, S2, W1, E1

PROPOSED POLYCARBONATE SIGNAL HEAD

N2, S3, W2, E2

PROPOSED POLYCARBONATE SIGNAL HEAD

S1

PROPOSED PEDESTRIAN SIGNAL HEAD SEE NOTE #1

PS1, PS2, PS3, PS4, PS5, PS6, PS7, PS8

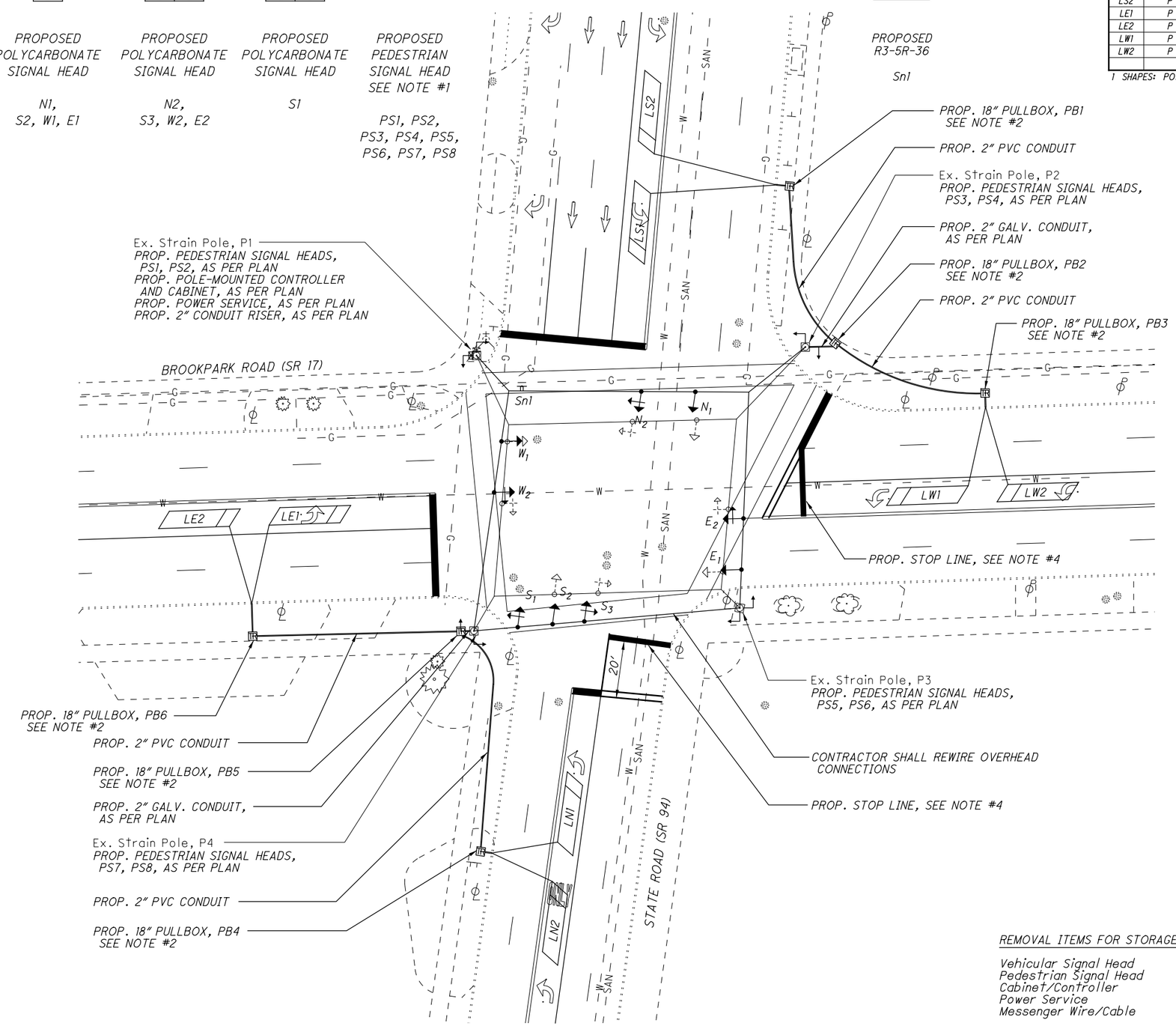
PROPOSED R3-5R-36

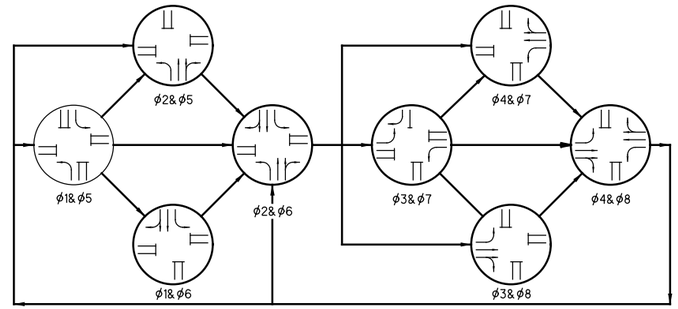
Sn1

LOOP DETECTOR UNIT SUMMARY

LOOP	SHAPE1	SIZE (FT)	TURNS	CONNECT TO PHASE	PRESENCE/ PULSE	LOCK/ NON-LOCK	LOOP UNIT	LOOP CHAN	EXTEND (SEC.)	DELAY (SEC.)
LN1	P	6X25	3	5	PRES	NON-LOCK	1	A	3.0	-
LN2	P	6X25	3	5	PRES	NON-LOCK	1	B	3.0	-
LS1	P	6X25	3	1	PRES	NON-LOCK	2	A	3.0	-
LS2	P	6X25	3	1	PRES	NON-LOCK	2	B	3.0	-
LE1	P	6X25	3	3	PRES	NON-LOCK	3	A	3.0	-
LE2	P	6X25	3	3	PRES	NON-LOCK	3	B	3.0	-
LW1	P	6X25	3	7	PRES	NON-LOCK	4	A	3.0	-
LW2	P	6X25	3	7	PRES	NON-LOCK	4	B	3.0	-

1 SHAPES: POWERHEAD (P), QUADRUPOLE (Q), ANGULAR DESIGN DETECTOR (ADD), RECTANGULAR (R), OR DIAMOND (D).





SIGNAL PHASING

*Ped Phases Not Shown

NOTE #1: Proposed pedestrian signal heads shall be oriented on the existing poles to match the existing pedestrian signal head orientation, with the exception of PS2.

NOTE #2: Contractor to contact OUPS for field location of existing utilities and resolution of potential conflicts. Utilities on plans based on historical information.

NOTE #3: The contractor shall restripe all pavement markings within 200' of the stop line on all approaches. See Sub-Summary for quantities.

NOTE #4: The contractor shall relocate the existing stop lines as shown, including removal of existing markings and restriping longitudinal markings

REMOVAL ITEMS FOR STORAGE

Vehicular Signal Head	8
Pedestrian Signal Head	8
Cabinet/Controller	1
Power Service	1
Messenger Wire/Cable	

UNDERGROUND UTILITIES
CONTACT BOTH SERVICES
CALL TWO WORKING DAYS
BEFORE YOU DIG
CALL
1-800-362-2764
(TOLL FREE)
OHIO UTILITIES PROTECTION SERVICE
NON-MEMBERS
MUST BE CALLED DIRECTLY
OIL & GAS PRODUCERS PROTECTIVE
SERVICE CALL: 1-800-925-0988

N

0 10 20 40
HORIZONTAL SCALE IN FEET

CALCULATED KRM
CHECKED SAK

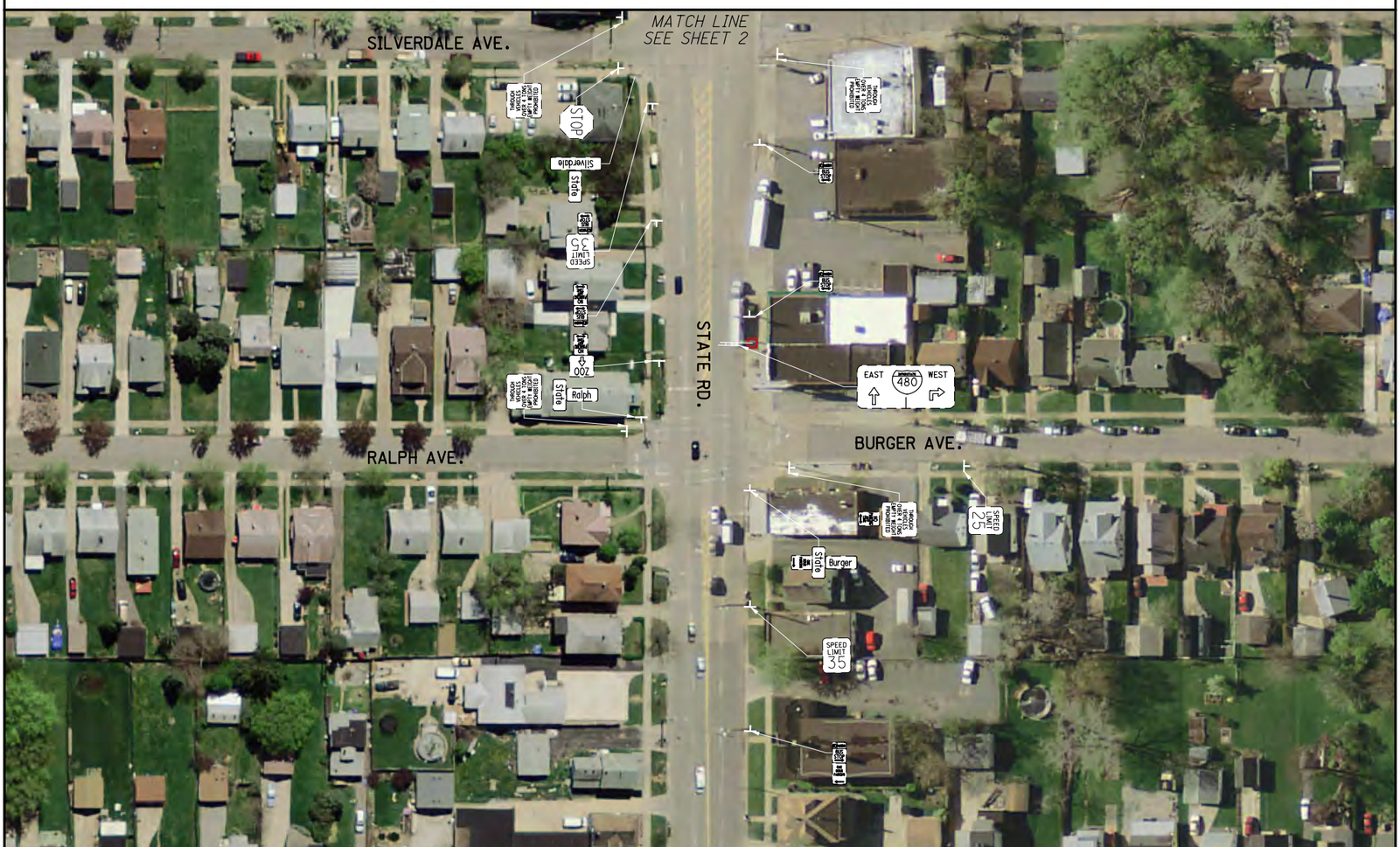
TRAFFIC SIGNAL PLAN
BROOKPARK RD (SR17) AND STATE RD (SR94)
CUY-17-10.78

APPENDIX B
EXISTING CONDITIONS DIAGRAM

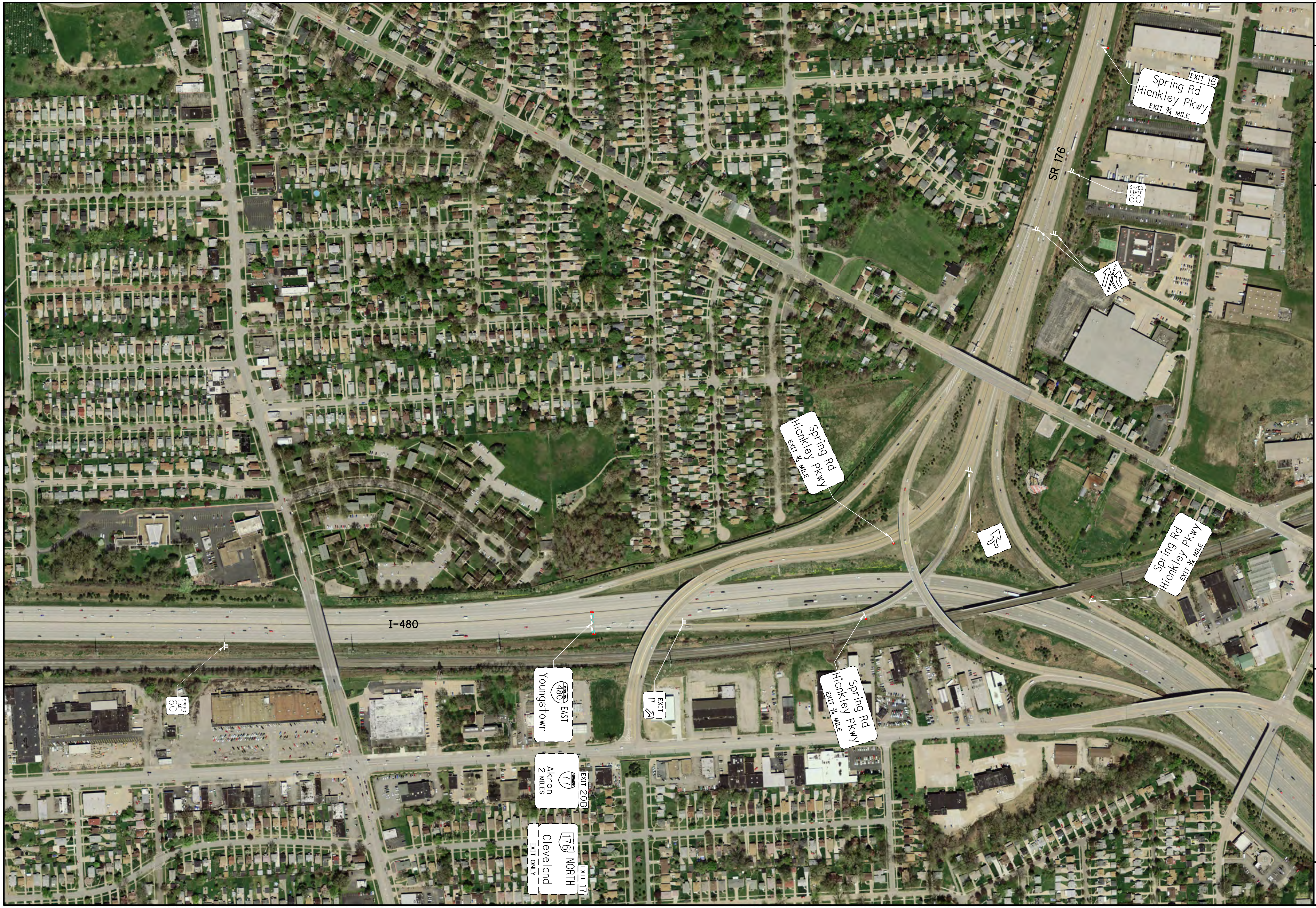
5	CUY-480-14.10-14.40 SAFETY STUDY	EXISTING CONDITIONS DIAGRAM	CALCULATED VM / CHECKED VM	0 50 25 100 HORIZONTAL SCALE IN FEET

5 / 2	CUY-480-14.10-14.40 SAFETY STUDY	EXISTING CONDITIONS DIAGRAM	CALCULATED VM / CHECKED VM	0 50 / 25 100 HORIZONTAL SCALE IN FEET

5 / 5	CUY-480-14.10-14.40 SAFETY STUDY	EXISTING CONDITIONS DIAGRAM	CALCULATED VM / CHECKED VM	0 50 25 100 HORIZONTAL SCALE IN FEET



5	CUY-480-14.10-14.40 SAFETY STUDY	EXISTING CONDITIONS DIAGRAM	CALCULATED VM	0 50	N
			CHECKED VM	25 100 HORIZONTAL SCALE IN FEET	



N

0 100 200 400
HORIZONTAL SCALE IN FEET

CALCULATED VM
CHECKED VM

EXISTING CONDITIONS DIAGRAM

CUY-480-14.10-14.40
SAFETY STUDY

5
5

APPENDIX C
STATE ROAD CORRIDOR OPERATIONS REVIEW

TMS Engineers, Inc.
Transportation Management Services
2112 Case Parkway South, #7 • Twinsburg, Ohio 44087
www.TMSEngineers.com

August 18, 2015

Mr. Scott Knebel, P.E.
LJB Inc.
6151 Wilson Mills Road
Suite 220
Cleveland, Ohio 44143

Re: State Road Operational Study

Dear Mr. Knebel:

TMS Engineers, Incorporated is pleased to prepare the following Operational Study for State Road in the City of Cleveland, Cuyahoga County, Ohio. State Road is primarily a four lane urban roadway which travels from the Pearl Road southward into Summit County. This operational study will focus on the section of State Road from the intersection at Brookpark Road to the intersection at Ralph Avenue / Burger Avenue. This portion of State Road includes the I-480 freeway interchange. **Attachment 1** shows the location of the corridor and the intersections under study. The operational study is described in the following portions of the report.

Traffic Data Review

TMS Engineers received eight-hour manual traffic counts at the two I-480 ramp intersection and the Ralph Avenue intersection which were collected by ODOT on October 30, 2014. A eight-hour manual traffic count was also received for the Brookpark Road intersection which was collected by DLZ Ohio, Inc on March 21st, 2012. TMS Engineers reviewed these counts and did not notice any errors or traffic irregularities. The counts were collected approximately one and a half years apart but the difference in the traffic counts was resolved by smoothing the traffic volumes across the intersections.

Field Inventory of Intersections

A field visit and inventory of the study intersections along State Road was performed by TMS Engineer's staff on June 9th, 2015. Intersection field inspection forms were filled out for each of the approaches of the four study intersections and these field inspection sheets are located in **Appendix A.** Photos of the signal controller cabinets and other locations with issues are shown in **Appendix B.** A summary of items which were noticed during the field visit is listed on the following page:

1. It was observed that the signal controller at the Brookpark Road intersection has been recently upgraded to a Siemans M50 controller while the remaining three intersection are currently controlled by the outdated and obsolete Eagle EPAC 300 controller.

2. It was observed that the signals along the State Road corridor are interconnected by twisted pair copper wire cables with the master controller located at the I-480 WB Ramp intersection. The master is an obsolete Eagle MARC 300 and the master is accessible via a phone drop. The State Road system is currently running as an interconnected system although the signals are not operating with the same cycle lengths.

3. It was observed that there is currently no signal loops at any of the signals along State Road (except on the left-turn lanes at the Brookpark Road intersection). The lack of signal loops requires the intersection to operate with fixed timings where the signal controllers are not responding to changes in traffic volumes on the different approaches but instead are following a fixed set of timing which may or may not be accurate for that particular day or time period.

4. It was observed that the traffic signals at the two I-480 ramps and Ralph Road intersection currently have a single span type of signal installation which does not allow the signal heads for the various approaches to be placed in the appropriate locations.

5. The signal and pedestrian equipment at the State Road intersections (except at the Brookpark Road intersection which appear to have been upgraded recently) appears to be very worn and at the end of their design life. The existing pushbuttons at the I-480 ramp intersections do not currently work and the pedestrian signal heads do not provide count down displays. The Ralph Road intersection currently has crosswalks and curb ramps but the intersection does not currently have pedestrian pushbuttons or pedestrian signal heads. Any modifications to the curb ramps at the signalized intersections can not be improved without also improving the pedestrian push buttons and pedestrian signal heads. Photos of these intersections are currently shown in **Appendix B**.

6. The lengths of the crosswalk at the State Road / Brookpark Road were observed to be at an angle which increases the length which pedestrians have to travel while crossing the roadways. This increased travel length also increases the amount of flashing don't walk time which is required for the pedestrian clearance times.

7. It was observed that several crosswalks at the I-480 ramp intersections do not currently have pedestrian signal heads or pushbuttons. The crosswalk across the initial portion of the I-480 Westbound On-Ramp does not have pedestrian signal heads which is especially dangerous due to higher speed vehicles turning right on red onto the ramp and the limited sight distance for pedestrians crossing the ramp.

8. It was observed that the Ralph Road intersection currently is utilizing incandescent light bulbs which use substantially more energy then LED signal heads.

9. It was observed that all of the signal heads along the State Road corridor currently do not have back plates which reduce the likelihood of crashes caused by sun glare.

10. It was observed that the traffic volumes on Ralph Road / Burger Road are very low and the intersection may not meet the necessary traffic signal warrants based on current traffic volumes.

Traffic Observation & Assessment

A field observation of traffic operations of the study intersections was performed by TMS Engineers staff. The field observation noticed that during the PM Peak Hour traffic queued at least a thousand feet on the westbound I-480 off ramp and at times queued onto westbound I-480 itself. A typical traffic count collects the number of vehicles turning at an intersection every 15 minutes so a typical count would not be able to count the actual turning demand since vehicles are queued waiting to make the turn.

TMS Engineer's staff performed an unmet demand traffic count at the State Road and I-480 WB Ramp intersection from 2:00 PM to 6:30 PM on June 10th, 2015. During this count the turning vehicles and the queued vehicles on the I-480 westbound off ramp were counted in order to determine how much unmet demand was queued on the ramp each 15 minutes. The queued vehicles for each 15 minute period were added to the actual turning (departure) count and the number of queued vehicles from the previous 15 minutes was subtracted. The results of the unmet demand traffic count is shown in **Attachment 2.** This unmet demand volume on the westbound left movement from the I-480 ramp was used in the Synchro analyses later described in this report.

All of the movements at the Eastbound I-480 Ramp, Brookpark Road and Ralph Road intersections were observed to not queue far enough to cause an unmet demand situation. Queuing was observed on northbound State Road traveling toward the I-480 westbound on-ramp intersection but all queued vehicles were able to make their turn during the peak hour.

Vehicle & Pedestrian Clearance Calculations

The yellow and all-red signal clearance timing were calculated for each of the approaches of the four study intersections. The clearance timing was calculated based on the current requirements from the **Ohio Manual of Uniform Traffic Control Devices** and the recommendations from the ODOT's **Traffic Engineering Manual**. In addition, all clearance timings were calculated based on the Standardization of Design of Clearance Intervals document published by ODOT's Traffic Planning.

A comparison of the existing signal clearance timings and the newly calculated clearance timing is shown on the Intersection Field Inspection Forms shown in **Appendix A**. All of the calculated clearance timings were rounded to the nearest second.

The pedestrian clearance timings for each intersection were also calculated based on ODOT requirements and these pedestrian clearance timings are shown in **Appendix C**.

Synchro Modeling and Proposed Signal Timing

A Synchro model of the existing conditions along the State Road corridor was provided to TMS Engineers and we had the following observations of the existing conditions at the intersections:

1. The Brookpark Road and Ralph Road intersections are currently operating with a 150 second cycle length during the entire day and the two I-480 ramp intersections are operating with a 100 second cycle length throughout the day. The different cycle lengths along the corridor do not allow the intersections to be coordinated or provide any progression of traffic thru the intersections. It is recommended that all of the four signals be set to one cycle length in order to provide a coordinated signal system.

2. Each of the signals currently have several timing plans available but all of the plans have identical splits and offsets so there is no difference between the plans. Due to the variation in traffic volumes along the corridor during the day, it is recommended that at least two different patterns (AM and PM Peaks) be installed at each intersection.

3. Based on the SimTraffic outputs, there is currently a maximum queue on the westbound I-480 Off-Ramp of approximately 1,100 feet. This modeled queue corresponds to the queue which was observed during the field visit at the intersection.

Various phasing plans and timing changes for the corridor was analyzed to determine what modifications or improvements would be necessary to provide a coordinated signal system, provide a LOS D or better on all approaches of the study intersection and lastly reduce the queue on the westbound I-480 Off-Ramp.

The following immediate changes to the coordination patterns are recommended to improve traffic flow:

1. A cycle length of 100 seconds was determined to be the optimum cycle length for all of the study intersections for Pattern 1 (AM Peak) and Pattern 2 (PM Peak). Both of these patterns were determined to require different phasing splits and offsets to provide optimal phasing. These patterns retain the existing phasing sequence. The proposed signal patterns are shown in **Appendix D.**

2. The Brookpark Road intersection is currently restricted to a cycle length of 130 seconds or higher due to the pedestrian clearance time necessary to allow pedestrians to cross State Road. It is recommended a minimum green time of less then the pedestrian clearance times be allowed for the east / west Brookpark Road movements at the Brookpark Road / State Road intersection. This will allow the cycle length at this intersection to be reduced to 100 seconds which will correspond to the optimal cycle length of the other three study intersections.

   There currently are no pedestrian pushbuttons on any of the four corners at the Brookpark Road intersection and the pedestrian phases are on pedestrian recall. It is recommended that pushbuttons should be installed on all four corners of the intersections so the pedestrian phase can be actuated only when a pedestrian is present. If a pedestrian does press the pushbutton to cross State Road the intersection, the intersection will temporarily drop out of coordination but there does not appear to be a significant number of pedestrians at this intersection to cause a continual disruption to the coordination of the signals.

The following minor (immediate) improvements are recommended at the State Road signals:

1. It is recommended that vehicle detection (loops or radar) be installed on all side streets and left turn movements on the mainline State Road to allow for the intersections to become semi-actuated and responsive to changes in traffic volumes. It is also recommended that system loops be installed on mainline State Road to allow the existing master to select various timing patterns based on the traffic volumes on State Road. The signal system currently is operating as an interconnected system but requires detection and a standard cycle length to operate in coordination.

2. It is recommended that all of the worn and / or broken pedestrian pushbuttons and pedestrian signal heads be replaced with signal equipment that meets the current ADA standards.

The following short-term improvements are recommended at the State Road signals:

1. It is recommended that pedestrian signal heads and pushbuttons be placed on the right-turn movement onto the I-480 westbound on-ramp. Pedestal mounted signal heads may need to be installed to alert motorists to pedestrian traffic.

2. All of the traffic signal heads along the State Road corridor should be replaced with signal heads with back plates to reduce the likelihood of crashes causes by sun glare. Signal heads with back plates are heavier so it is recommended that the span wire calculation be checked to insure the existing strain poles can handle the additional weight.

3. It is recommended that a warrant analyses be performed at State Road & Ralph Road / Burger Road intersection in order to confirm the signal meets at least one of the necessary signal warrants and is eligible for signal upgrades.

4. If the Ralph Road intersection meets at least one of the signal warrants, it is recommended that the incandescent signal heads be replaced by LED signal heads. In addition, pedestrian signal heads and pedestrian push buttons should be installed on all four corners of the intersection in accordance with current ADA requirements.

5. The crosswalks at the Brookpark Road intersection should be moved to allow pedestrians to cross perpendicular to the roadway. This will reduce the length pedestrians will have to travel while crossing the roadways which will reduce the amount of necessary pedestrian clearance time for the signal.

Construction Cost Estimate

The immediate cost of revising signal timings, installing vehicle detection, upgrading or installation of pedestrian pushbuttons / signal heads are estimated to cost $60,000.

The short-term cost of installing signal heads with back plates, updating all curb ramps to meet ADA requirements and the modifications to the crosswalks at the Brookpark Road intersection is estimated to cost $150,000.

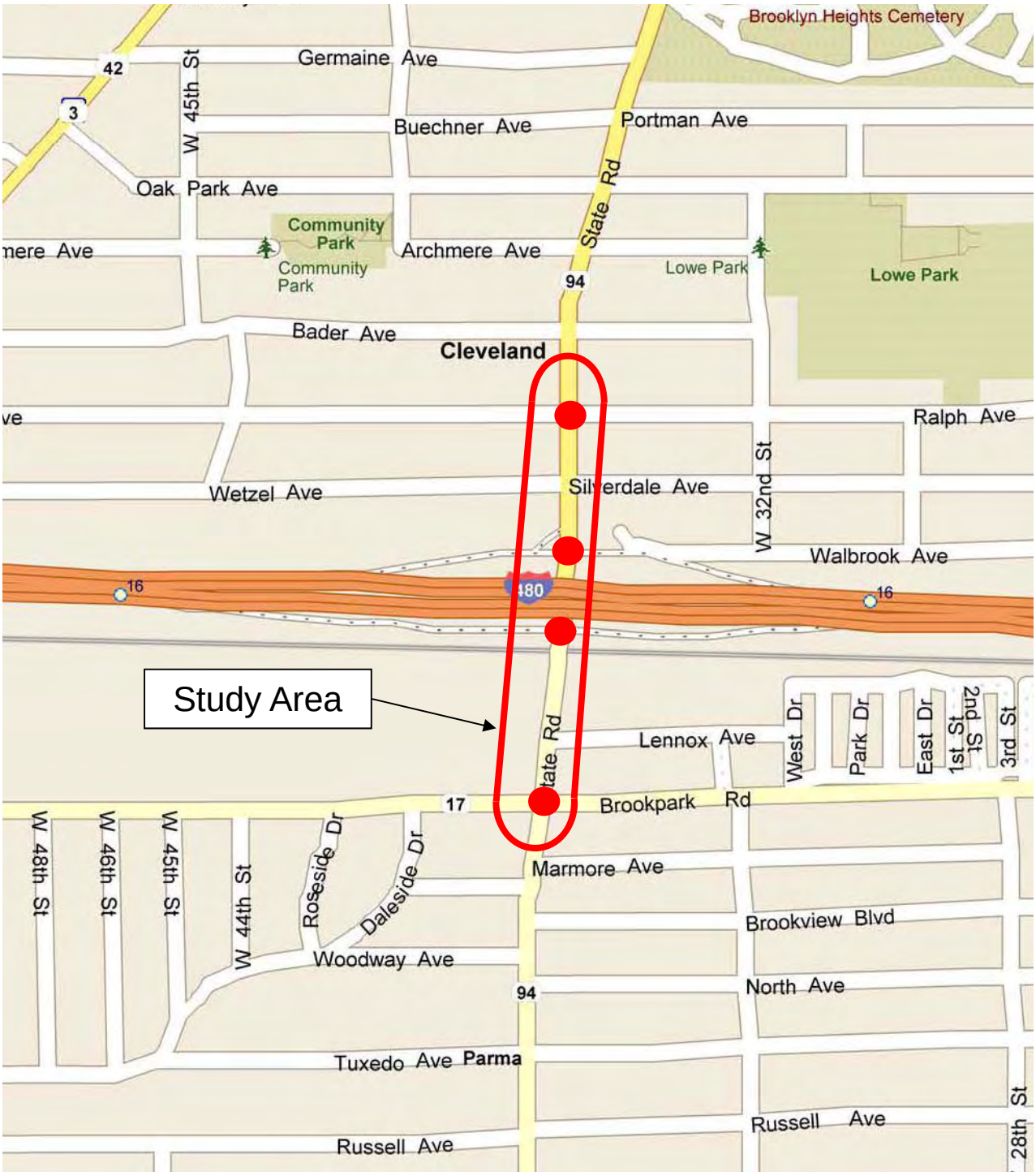
If you need additional information, please do not hesitate to call.

Very truly yours,

TMSEngineers, Inc.

Michael W. Schweickart, P.E., PTOE
President

NOT TO SCALE



● INTERSECTIONS WITHIN THE SYSTEM

TMS Engineers, Inc. Transportation Management Services 2112 Case Parkway S., Unit 7, Twinsburg, Ohio 44087 www.TMSEngineers.com	**State Road Operational Study City of Cleveland, Ohio**	**Location Map**	**Attachment 1**

VEHICULAR TRAFFIC COUNT SUMMARY

Municipality: City of Cleveland **At Intersection of:** State Road **and** I-480 WB Ramps

Date: 5/6/2015 **Day:** Wed. **Comments:** **Project:** 15-052

Weather: Clear **Recorder(s):** AJP / JS **Data entry by:** AJP **Date entered:** Jun. 10. 2015 State I480 WB Ramps

TIME BEGINS	State Road FROM NORTH						State Road FROM SOUTH						TOTAL NORTH SOUTH	I-480 WB Off Ramp FROM EAST						I-480 WB On Ramp FROM WEST						TOTAL EAST WEST	TOTAL ALL DIREC.	PEAK HOUR FACTOR			
	Left	Thru	Right	Total	Trk	Bus	Left	Thru	Right	Total	Trk	Bus		Left	Thru	Right	Total	Trk	Bus	Left	Thru	Right	Total	Trk	Bus			North	South	East	West
06:00																														
07:00																														
08:00																														
09:00																														
10:00																														
11:00																														
12:00																														
1:00																														
2:00														612	2	261	875	8	9							875	875			0.964	
3:00														760	4	286	1050	10	4							1050	1050			0.869	
4:00														792	1	300	1093	3	1							1093	1093			0.774	
5:00														946	1	288	1235	6	0							1235	1235			0.692	
6:00																														
7:00																														
8:00																														
9:00																														
TOTALS														3110	8	1135	4253	27	14							4253	4253				
ADT														3110	8	1135	4253	1.0%								4253	4253				

HOURLY FACTOR: 1.00 **MONTHLY FACTOR:** 1.00 **COMBINED FACTOR:** 1.00

TMS ENGINEERS, INC.
4547 Hudson Drive
Stow, Ohio 44224
(330) 686-6402 FAX: (330) 686-6417

Figure #: Attachment

APPENDIX D
TRAFFIC DATA

DLZ Ohio, Inc.

614 West Superior Avenue
Suite 1000
Cleveland, Ohio 44113
(216) 771-1090

File Name : CUY-17 @ SR 94
Site Code : 00000000
Start Date : 3/21/2012
Page No : 1

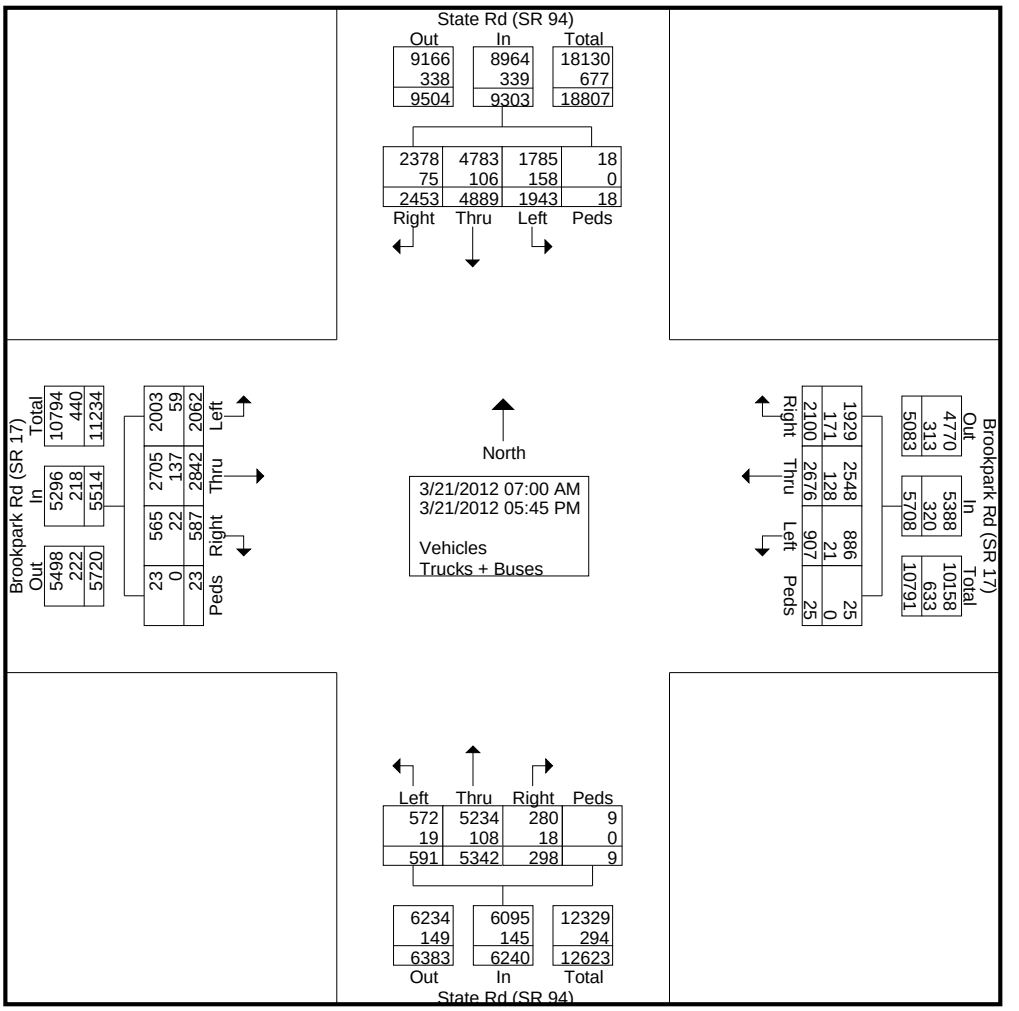
Groups Printed- Vehicles - Trucks + Buses

	State Rd (SR 94) Southbound					Brookpark Rd (SR 17) Westbound					State Rd (SR 94) Northbound					Brookpark Rd (SR 17) Eastbound					
Start Time	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Int. Total
07:00 AM	56	85	30	0	171	11	30	60	1	102	6	252	1	0	259	95	82	7	0	184	716
07:15 AM	60	107	69	0	236	3	44	68	0	115	9	286	5	0	300	116	137	2	0	255	906
07:30 AM	61	103	49	0	213	11	73	74	1	159	11	295	5	0	311	88	146	8	0	242	925
07:45 AM	64	97	45	0	206	11	64	53	0	128	21	210	4	0	235	91	116	11	0	218	787
Total	241	392	193	0	826	36	211	255	2	504	47	1043	15	0	1105	390	481	28	0	899	3334
08:00 AM	73	128	53	1	255	13	52	67	0	132	10	242	6	0	258	86	101	4	0	191	836
08:15 AM	64	106	41	0	211	12	58	65	0	135	14	216	6	1	237	80	71	10	0	161	744
08:30 AM	61	81	49	1	192	10	48	38	1	97	13	186	8	1	208	73	82	13	0	168	665
08:45 AM	74	104	36	0	214	9	47	57	2	115	18	160	12	1	191	76	67	12	0	155	675
Total	272	419	179	2	872	44	205	227	3	479	55	804	32	3	894	315	321	39	0	675	2920
09:00 AM	53	72	43	0	168	5	84	56	2	147	19	145	15	0	179	49	74	12	0	135	629
09:15 AM	60	91	51	0	202	9	56	49	0	114	25	178	8	0	211	54	68	14	0	136	663
09:30 AM	55	78	46	0	179	9	61	59	0	129	18	156	6	0	180	73	70	22	0	165	653
09:45 AM	59	108	45	0	212	8	67	43	0	118	15	124	9	1	149	49	57	15	0	121	600
Total	227	349	185	0	761	31	268	207	2	508	77	603	38	1	719	225	269	63	0	557	2545
10:00 AM	48	75	42	1	166	17	56	49	0	122	16	120	12	4	152	50	56	14	0	120	560
10:15 AM	50	82	37	0	169	15	56	42	0	113	29	126	8	0	163	48	84	13	0	145	590
10:30 AM	39	66	47	2	154	20	66	60	0	146	22	116	5	0	143	55	57	13	1	126	569
10:45 AM	0	0	0	0	0	0	0	0	0	0	24	126	8	0	158	51	72	16	1	140	298
Total	137	223	126	3	489	52	178	151	0	381	91	488	33	4	616	204	269	56	2	531	2017
*** BREAK ***																					
02:00 PM	63	125	76	1	265	20	90	67	1	178	19	122	4	1	146	59	87	28	1	175	764
02:15 PM	52	181	81	0	314	27	80	56	2	165	21	166	8	0	195	51	63	21	0	135	809
02:30 PM	59	168	75	3	305	37	117	71	0	225	16	115	15	0	146	54	110	12	0	176	852
02:45 PM	64	197	102	0	363	24	95	68	2	189	19	176	11	0	206	61	97	20	0	178	936
Total	238	671	334	4	1247	108	382	262	5	757	75	579	38	1	693	225	357	81	1	664	3361
03:00 PM	71	204	100	0	375	32	109	79	0	220	17	131	5	0	153	56	86	32	2	176	924
03:15 PM	64	218	113	0	395	42	109	70	1	222	26	177	8	0	211	44	110	21	0	175	1003
03:30 PM	60	186	118	0	364	41	108	77	0	226	26	179	13	0	218	49	87	24	0	160	968
03:45 PM	72	228	117	0	417	53	112	77	0	242	16	143	12	0	171	59	110	25	5	199	1029
Total	267	836	448	0	1551	168	438	303	1	910	85	630	38	0	753	208	393	102	7	710	3924
04:00 PM	66	229	106	0	401	43	109	92	10	254	22	162	13	0	197	63	88	20	2	173	1025
04:15 PM	81	260	127	0	468	62	119	82	0	263	18	139	10	0	167	54	101	27	1	183	1081
04:30 PM	71	252	109	4	436	49	125	88	0	262	18	149	18	0	185	69	93	41	1	204	1087
04:45 PM	69	255	125	2	451	66	135	83	0	284	20	156	13	0	189	61	89	30	2	182	1106
Total	287	996	467	6	1756	220	488	345	10	1063	78	606	54	0	738	247	371	118	6	742	4299
05:00 PM	73	275	118	0	466	59	136	105	1	301	26	151	15	0	192	73	117	31	1	222	1181
05:15 PM	61	251	153	0	465	63	133	92	0	288	17	160	11	0	188	61	102	32	2	197	1138
05:30 PM	71	249	131	3	454	64	134	80	1	279	16	129	12	0	157	49	87	22	3	161	1051
05:45 PM	69	228	119	0	416	62	103	73	0	238	24	149	12	0	185	65	75	15	1	156	995
Total	274	1003	521	3	1801	248	506	350	2	1106	83	589	50	0	722	248	381	100	7	736	4365
Grand Total	1943	4889	2453	18	9303	907	2676	2100	25	5708	591	5342	298	9	6240	2062	2842	587	23	5514	26765
Apprch %	20.9	52.6	26.4	0.2		15.9	46.9	36.8	0.4		9.5	85.6	4.8	0.1		37.4	51.5	10.6	0.4		
Total %	7.3	18.3	9.2	0.1	34.8	3.4	10	7.8	0.1	21.3	2.2	20	1.1	0	23.3	7.7	10.6	2.2	0.1	20.6	
Vehicles	1785	4783	2378	18	8964	886	2548	1929	25	5388	572	5234	280	9	6095	2003	2705	565	23	5296	25743
% Vehicles	91.9	97.8	96.9	100	96.4	97.7	95.2	91.9	100	94.4	96.8	98	94	100	97.7	97.1	95.2	96.3	100	96	96.2
Trucks + Buses	158	106	75	0	339	21	128	171	0	320	19	108	18	0	145	59	137	22	0	218	1022
% Trucks + Buses	8.1	2.2	3.1	0	3.6	2.3	4.8	8.1	0	5.6	3.2	2	6	0	2.3	2.9	4.8	3.7	0	4	3.8

DLZ Ohio, Inc.

614 West Superior Avenue
Suite 1000
Cleveland, Ohio 44113
(216) 771-1090

File Name : CUY-17 @ SR 94
Site Code : 00000000
Start Date : 3/21/2012
Page No : 2



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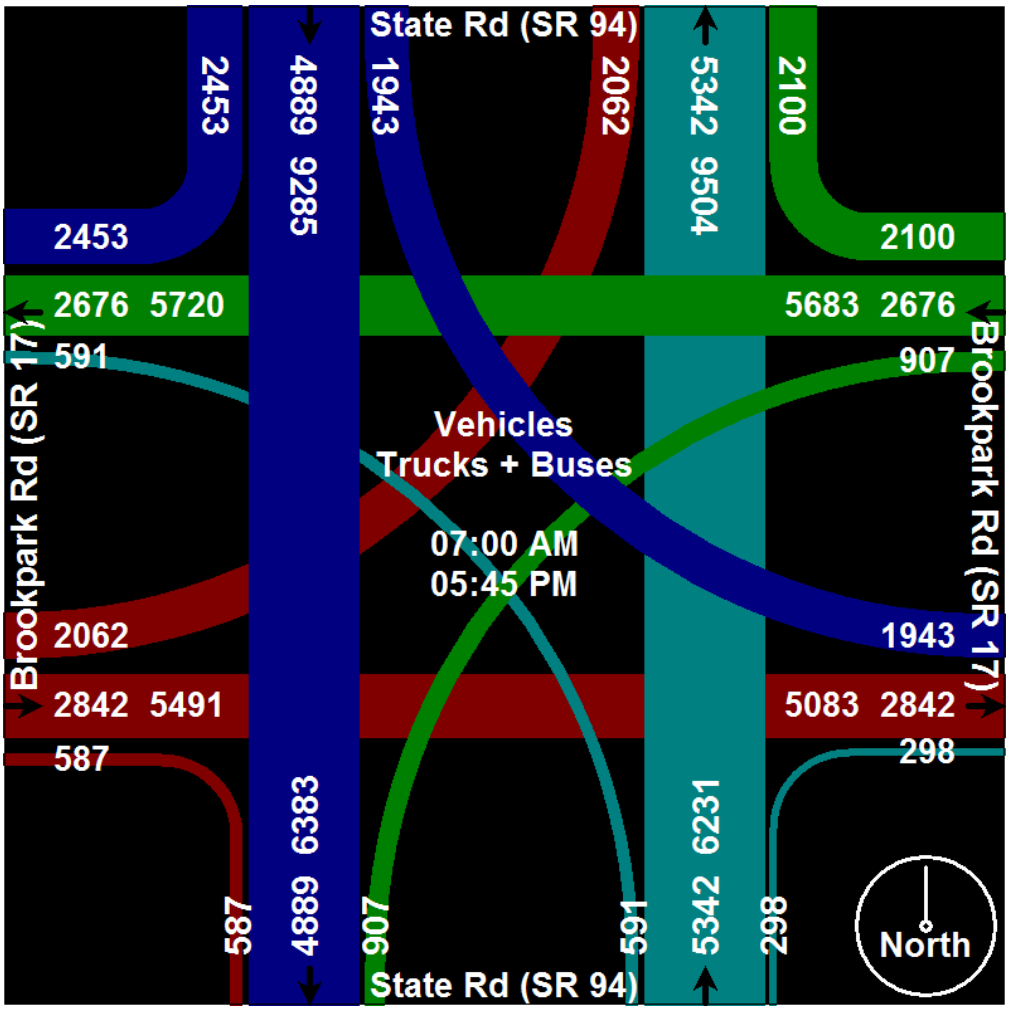

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File Name : CUY-17 @ SR 94
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Start Date : 3/21/2012
Page No : 4

	State Rd (SR 94) Southbound					Brookpark Rd (SR 17) Westbound					State Rd (SR 94) Northbound					Brookpark Rd (SR 17) Eastbound					
Start Time	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Int. Total
Peak Hour Analysis From 07:00 AM to 11:45 AM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 07:15 AM																					
07:15 AM	60	107	**69**	0	236	3	44	68	0	115	9	286	5	0	300	**116**	137	2	0	**255**	906
07:30 AM	61	103	49	0	213	11	**73**	**74**	**1**	**159**	11	**295**	5	0	**311**	88	**146**	8	0	242	**925**
07:45 AM	64	97	45	0	206	11	64	53	0	128	**21**	210	4	0	235	91	116	**11**	0	218	787
08:00 AM	**73**	**128**	53	**1**	**255**	**13**	52	67	0	132	10	242	**6**	0	258	86	101	4	0	191	836
Total Volume	258	435	216	1	910	38	233	262	1	534	51	1033	20	0	1104	381	500	25	0	906	3454
% App. Total	28.4	47.8	23.7	0.1		7.1	43.6	49.1	0.2		4.6	93.6	1.8	0		42.1	55.2	2.8	0		
PHF	.884	.850	.783	.250	.892	.731	.798	.885	.250	.840	.607	.875	.833	.000	.887	.821	.856	.568	.000	.888	.934
Peak Hour Analysis From 12:00 PM to 05:45 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 04:30 PM																					
04:30 PM	71	252	109	**4**									**18**					**41**			
04:45 PM	69	255	125	2	451	**66**	135	83	0	284	20	156	13	0	189	61	89	30	**2**	182	1106
05:00 PM	**73**	**275**	118	0	**466**	59	**136**	**105**	**1**	**301**	**26**	151	15	0	**192**	**73**	**117**	31	1	**222**	**1181**
05:15 PM	61	251	**153**	0	465	63	133	92	0	288	17	**160**	11	0	188	61	102	32	2	197	1138
Total Volume	274	1033	505	6	1818	237	529	368	1	1135	81	616	57	0	754	264	401	134	6	805	4512
% App. Total	15.1	56.8	27.8	0.3		20.9	46.6	32.4	0.1		10.7	81.7	7.6	0		32.8	49.8	16.6	0.7		
PHF	.938	.939	.825	.375	.975	.898	.972	.876	.250	.943	.779	.963	.792	.000	.982	.904	.857	.817	.750	.907	.955

Ohio Department of Transportation
1980 West Broad Street
Mail Stop 5160
Columbus, Ohio, United States 43223
+16147528099 Stephanie.Marik@dot.state.oh.us
Office of Traffic Engineering

Count Name: CUY-94 & I-480 EB TMC
Site Code:
Start Date: 10/30/2014

Turning Movement Data

Start Time	Southbound Approach				Northbound Approach				Eastbound Approach				
	Southbound				Northbound				Eastbound				
	Thru	Left	U-Turn	App. Total	Right	Thru	U-Turn	App. Total	Right	Thru	Left	App. Total	Int. Total
6:00 AM	39	36	0	75	163	65	0	228	43	0	10	53	356
6:15 AM	54	55	0	109	212	136	0	348	68	0	19	87	544
6:30 AM	63	74	0	137	251	153	0	404	108	0	21	129	670
6:45 AM	75	67	0	142	246	152	0	398	91	0	29	120	660
Hourly Total	231	232	0	463	872	506	0	1378	310	0	79	389	2230
7:00 AM	101	66	0	167	256	156	0	412	113	0	41	154	733
7:15 AM	125	58	0	183	231	205	0	436	141	0	66	207	826
7:30 AM	124	56	0	180	187	230	0	417	169	0	104	273	870
7:45 AM	122	38	0	160	180	210	0	390	173	0	80	253	803
Hourly Total	472	218	0	690	854	801	0	1655	596	0	291	887	3232
8:00 AM	115	52	1	168	171	167	0	338	153	0	84	237	743
8:15 AM	84	40	0	124	160	164	0	324	155	0	69	224	672
8:30 AM	104	55	0	159	151	164	0	315	148	0	58	206	680
8:45 AM	98	50	0	148	136	157	0	293	118	0	35	153	594
Hourly Total	401	197	1	599	618	652	0	1270	574	0	246	820	2689
9:00 AM	106	37	0	143	124	140	0	264	99	0	35	134	541
9:15 AM	111	40	0	151	121	165	0	286	103	0	22	125	562
9:30 AM	103	38	0	141	105	134	0	239	92	0	36	128	508
9:45 AM	93	38	0	131	92	138	0	230	99	0	38	137	498
Hourly Total	413	153	0	566	442	577	0	1019	393	0	131	524	2109
*** BREAK ***	-	-	-	-	-	-	-	-	-	-	-	-	-
2:00 PM	145	37	1	183	108	193	0	301	97	0	58	155	639
2:15 PM	200	43	1	244	102	182	0	284	119	0	64	183	711
2:30 PM	231	58	0	289	109	167	0	276	113	0	51	164	729
2:45 PM	199	73	0	272	121	223	0	344	144	0	75	219	835
Hourly Total	775	211	2	988	440	765	0	1205	473	0	248	721	2914
3:00 PM	257	65	0	322	85	196	0	281	139	0	68	207	810
3:15 PM	289	65	0	354	103	188	0	291	159	1	65	225	870
3:30 PM	271	78	0	349	115	223	0	338	165	0	90	255	942
3:45 PM	299	84	0	383	125	198	0	323	150	0	73	223	929
Hourly Total	1116	292	0	1408	428	805	0	1233	613	1	296	910	3551
4:00 PM	262	58	0	320	128	200	0	328	151	0	81	232	880
4:15 PM	279	46	0	325	107	243	0	350	163	0	72	235	910
4:30 PM	295	60	0	355	125	205	0	330	177	0	79	256	941
4:45 PM	301	52	0	353	112	209	0	321	193	0	93	286	960
Hourly Total	1137	216	0	1353	472	857	0	1329	684	0	325	1009	3691
5:00 PM	316	58	0	374	123	212	0	335	152	0	75	227	936

5:15 PM	336	48	0	384	97	175	0	272	192	0	83	275	931
5:30 PM	298	47	0	345	97	176	0	273	189	0	64	253	871
5:45 PM	313	48	0	361	94	182	0	276	158	0	64	222	859
Hourly Total	1263	201	0	1464	411	745	0	1156	691	0	286	977	3597
Grand Total	5808	1720	3	7531	4537	5708	0	10245	4334	1	1902	6237	24013
Approach %	77.1	22.8	0.0	-	44.3	55.7	0.0	-	69.5	0.0	30.5	-	-
Total %	24.2	7.2	0.0	31.4	18.9	23.8	0.0	42.7	18.0	0.0	7.9	26.0	-
Lights	5642	1692	3	7337	4414	5508	0	9922	4150	1	1880	6031	23290
% Lights	97.1	98.4	100.0	97.4	97.3	96.5	-	96.8	95.8	100.0	98.8	96.7	97.0
Mediums	140	23	0	163	98	172	0	270	145	0	22	167	600
% Mediums	2.4	1.3	0.0	2.2	2.2	3.0	-	2.6	3.3	0.0	1.2	2.7	2.5
Articulated Trucks	26	5	0	31	25	28	0	53	39	0	0	39	123
% Articulated Trucks	0.4	0.3	0.0	0.4	0.6	0.5	-	0.5	0.9	0.0	0.0	0.6	0.5

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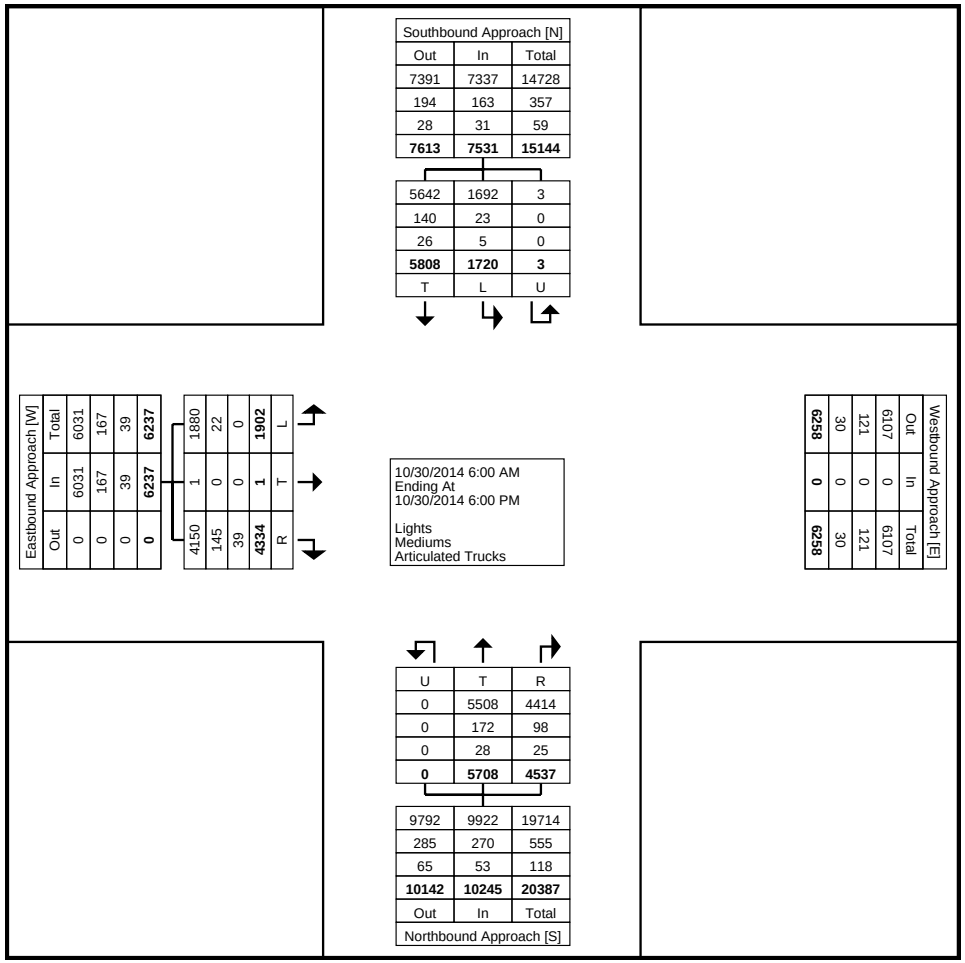

Turning Movement Data Plot

Ohio Department of Transportation
1980 West Broad Street
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Columbus, Ohio, United States 43223
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Office of Traffic Engineering

Count Name: CUY-94 & I-480 EB TMC
Site Code:
Start Date: 10/30/2014

Turning Movement Peak Hour Data (7:15 AM)

Start Time	Southbound Approach				Northbound Approach				Eastbound Approach				
	Southbound				Northbound				Eastbound				
	Thru	Left	U-Turn	App. Total	Right	Thru	U-Turn	App. Total	Right	Thru	Left	App. Total	Int. Total
7:15 AM	125	58	0	183	231	205	0	436	141	0	66	207	826
7:30 AM	124	56	0	180	187	230	0	417	169	0	104	273	870
7:45 AM	122	38	0	160	180	210	0	390	173	0	80	253	803
8:00 AM	115	52	1	168	171	167	0	338	153	0	84	237	743
Total	486	204	1	691	769	812	0	1581	636	0	334	970	3242
Approach %	70.3	29.5	0.1	-	48.6	51.4	0.0	-	65.6	0.0	34.4	-	-
Total %	15.0	6.3	0.0	21.3	23.7	25.0	0.0	48.8	19.6	0.0	10.3	29.9	-
PHF	0.972	0.879	0.250	0.944	0.832	0.883	0.000	0.907	0.919	0.000	0.803	0.888	0.932
Lights	456	201	1	658	759	792	0	1551	605	0	329	934	3143
% Lights	93.8	98.5	100.0	95.2	98.7	97.5	-	98.1	95.1	-	98.5	96.3	96.9
Mediums	23	3	0	26	8	17	0	25	24	0	5	29	80
% Mediums	4.7	1.5	0.0	3.8	1.0	2.1	-	1.6	3.8	-	1.5	3.0	2.5
Articulated Trucks	7	0	0	7	2	3	0	5	7	0	0	7	19
% Articulated Trucks	1.4	0.0	0.0	1.0	0.3	0.4	-	0.3	1.1	-	0.0	0.7	0.6

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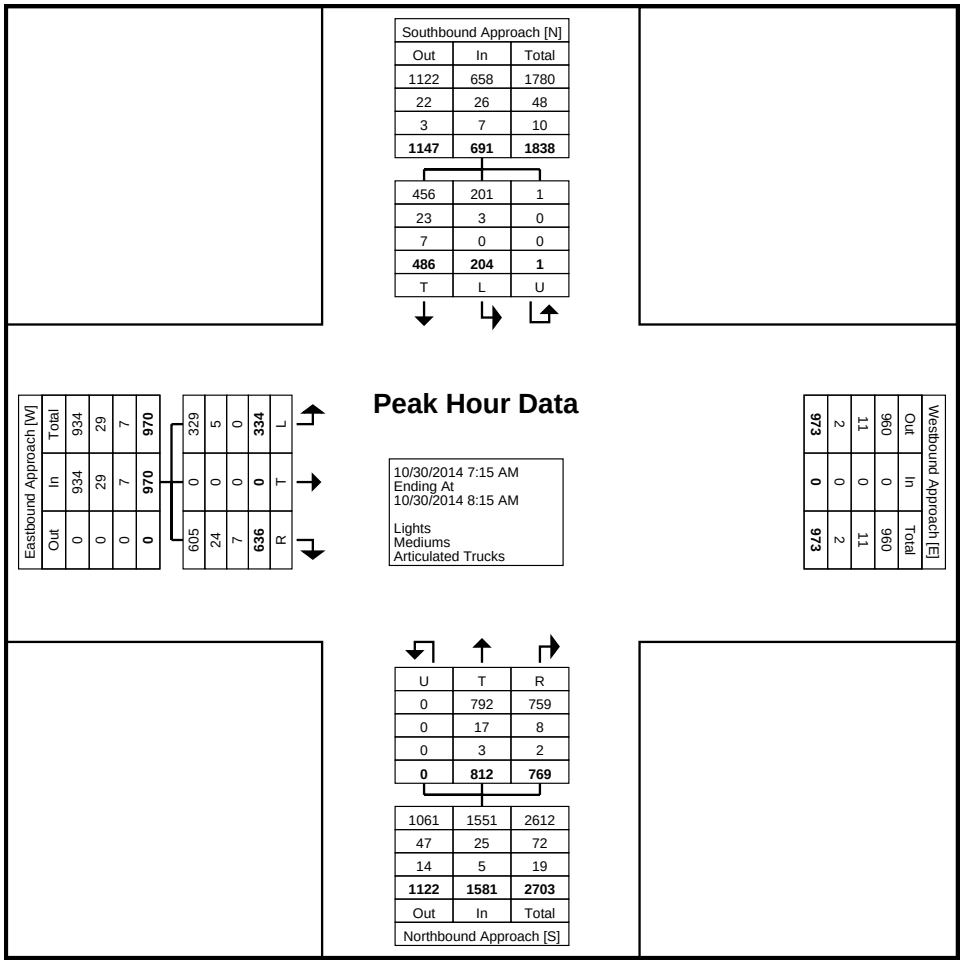
Site Code:
Start Date: 10/30/2014



Turning Movement Peak Hour Data Plot (7:15 AM)

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Office of Traffic Engineering

Count Name: CUY-94 & I-480 EB TMC
Site Code:
Start Date: 10/30/2014

Turning Movement Peak Hour Data (4:30 PM)

Start Time	Southbound Approach				Northbound Approach				Eastbound Approach				
	Southbound				Northbound				Eastbound				
	Thru	Left	U-Turn	App. Total	Right	Thru	U-Turn	App. Total	Right	Thru	Left	App. Total	Int. Total
4:30 PM	295	60	0	355	125	205	0	330	177	0	79	256	941
4:45 PM	301	52	0	353	112	209	0	321	193	0	93	286	960
5:00 PM	316	58	0	374	123	212	0	335	152	0	75	227	936
5:15 PM	336	48	0	384	97	175	0	272	192	0	83	275	931
Total	1248	218	0	1466	457	801	0	1258	714	0	330	1044	3768
Approach %	85.1	14.9	0.0	-	36.3	63.7	0.0	-	68.4	0.0	31.6	-	-
Total %	33.1	5.8	0.0	38.9	12.1	21.3	0.0	33.4	18.9	0.0	8.8	27.7	-
PHF	0.929	0.908	0.000	0.954	0.914	0.945	0.000	0.939	0.925	0.000	0.887	0.913	0.981
Lights	1226	217	0	1443	445	783	0	1228	695	0	326	1021	3692
% Lights	98.2	99.5	-	98.4	97.4	97.8	-	97.6	97.3	-	98.8	97.8	98.0
Mediums	18	1	0	19	12	14	0	26	15	0	4	19	64
% Mediums	1.4	0.5	-	1.3	2.6	1.7	-	2.1	2.1	-	1.2	1.8	1.7
Articulated Trucks	4	0	0	4	0	4	0	4	4	0	0	4	12
% Articulated Trucks	0.3	0.0	-	0.3	0.0	0.5	-	0.3	0.6	-	0.0	0.4	0.3

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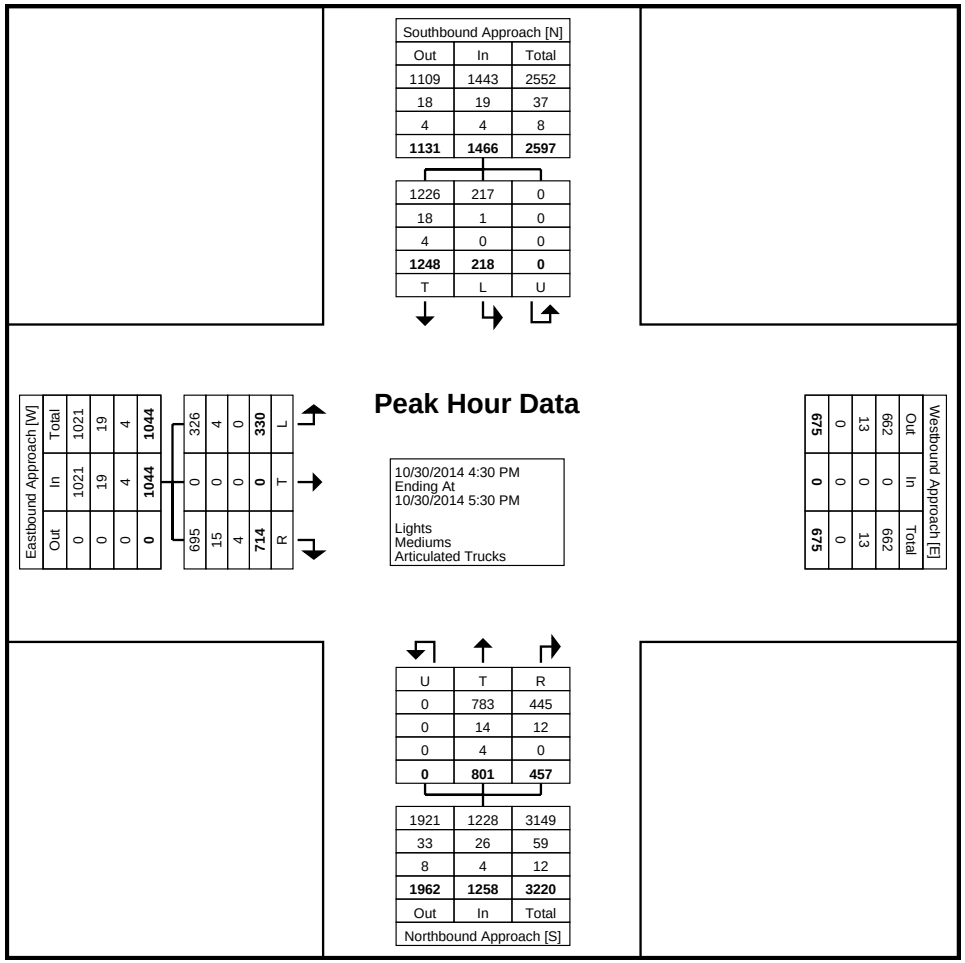

Turning Movement Peak Hour Data Plot (4:30 PM)

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Office of Traffic Engineering

Count Name: CUY-94 & I-480 WB TMC
Site Code:
Start Date: 10/30/2014

Turning Movement Data

Start Time	Southbound Approach Southbound				Westbound Approach Westbound				Northbound Approach Northbound				
	Right	Thru	U-Turn	App. Total	Right	Thru	Left	App. Total	Thru	Left	U-Turn	App. Total	Int. Total
6:00 AM	23	49	0	72	10	0	27	37	13	58	0	71	180
6:15 AM	48	80	0	128	23	0	33	56	44	108	0	152	336
6:30 AM	46	92	0	138	20	0	38	58	57	126	0	183	379
6:45 AM	62	93	0	155	35	0	52	87	65	118	0	183	425
Hourly Total	179	314	0	493	88	0	150	238	179	410	0	589	1320
7:00 AM	54	94	0	148	36	0	71	107	80	118	0	198	453
7:15 AM	83	106	0	189	56	0	78	134	113	163	0	276	599
7:30 AM	100	103	0	203	58	0	76	134	171	171	0	342	679
7:45 AM	104	81	0	185	72	0	80	152	130	158	0	288	625
Hourly Total	341	384	0	725	222	0	305	527	494	610	0	1104	2356
8:00 AM	80	100	0	180	45	0	70	115	140	129	0	269	564
8:15 AM	74	67	0	141	49	0	58	107	108	141	0	249	497
8:30 AM	45	102	0	147	42	0	57	99	99	129	0	228	474
8:45 AM	48	86	0	134	31	0	71	102	85	114	0	199	435
Hourly Total	247	355	0	602	167	0	256	423	432	513	0	945	1970
9:00 AM	41	93	0	134	37	0	59	96	79	107	0	186	416
9:15 AM	35	77	0	112	16	1	86	103	87	121	0	208	423
9:30 AM	52	78	0	130	22	0	66	88	68	104	0	172	390
9:45 AM	38	67	0	105	24	0	76	100	74	107	0	181	386
Hourly Total	166	315	0	481	99	1	287	387	308	439	0	747	1615
*** BREAK ***	-	-	-	-	-	-	-	-	-	-	-	-	-
2:00 PM	62	77	0	139	71	1	102	174	111	110	0	221	534
2:15 PM	61	91	0	152	63	1	148	212	111	117	0	228	592
2:30 PM	56	117	0	173	70	0	169	239	98	107	0	205	617
2:45 PM	59	93	0	152	83	0	149	232	118	120	0	238	622
Hourly Total	238	378	0	616	287	2	568	857	438	454	0	892	2365
3:00 PM	90	135	0	225	65	0	188	253	141	123	0	264	742
3:15 PM	97	155	0	252	84	0	204	288	124	125	0	249	789
3:30 PM	103	136	0	239	100	0	219	319	163	141	0	304	862
3:45 PM	97	153	0	250	95	0	240	335	145	129	0	274	859
Hourly Total	387	579	0	966	344	0	851	1195	573	518	0	1091	3252
4:00 PM	80	124	0	204	79	0	193	272	147	138	0	285	761
4:15 PM	69	115	0	184	88	0	213	301	145	163	0	308	793
4:30 PM	105	145	0	250	69	0	219	288	140	145	0	285	823
4:45 PM	89	132	0	221	75	0	226	301	153	155	0	308	830
Hourly Total	343	516	0	859	311	0	851	1162	585	601	0	1186	3207
5:00 PM	89	152	0	241	67	1	202	270	134	151	0	285	796

5:15 PM	66	156	0	222	92	0	225	317	155	104	0	259	798
5:30 PM	64	120	0	184	94	0	231	325	139	105	0	244	753
5:45 PM	64	126	0	190	72	0	230	302	124	113	0	237	729
Hourly Total	283	554	0	837	325	1	888	1214	552	473	0	1025	3076
Grand Total	2184	3395	0	5579	1843	4	4156	6003	3561	4018	0	7579	19161
Approach %	39.1	60.9	0.0	-	30.7	0.1	69.2	-	47.0	53.0	0.0	-	-
Total %	11.4	17.7	0.0	29.1	9.6	0.0	21.7	31.3	18.6	21.0	0.0	39.6	-
Lights	2155	3318	0	5473	1812	4	4025	5841	3482	3875	0	7357	18671
% Lights	98.7	97.7	-	98.1	98.3	100.0	96.8	97.3	97.8	96.4	-	97.1	97.4
Mediums	27	68	0	95	29	0	105	134	76	122	0	198	427
% Mediums	1.2	2.0	-	1.7	1.6	0.0	2.5	2.2	2.1	3.0	-	2.6	2.2
Articulated Trucks	2	9	0	11	2	0	26	28	3	21	0	24	63
% Articulated Trucks	0.1	0.3	-	0.2	0.1	0.0	0.6	0.5	0.1	0.5	-	0.3	0.3

Ohio Department of Transportation
1980 West Broad Street
Mail Stop 5160
Columbus, Ohio, United States 43223
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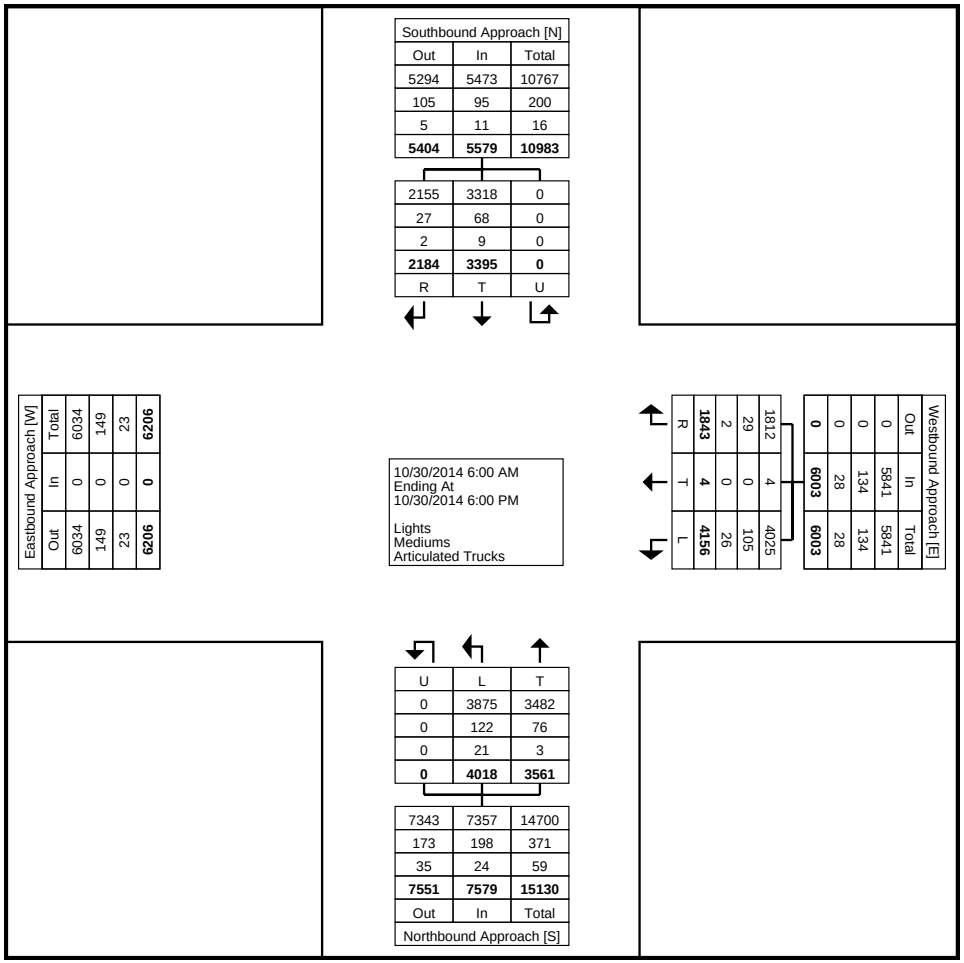
Office of Traffic Engineering

Count Name: CUY-94 & I-480 WB TMC
Site Code:
Start Date: 10/30/2014



Turning Movement Data Plot

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Office of Traffic Engineering

Count Name: CUY-94 & I-480 WB TMC
Site Code:
Start Date: 10/30/2014

Turning Movement Peak Hour Data (7:15 AM)

Start Time	Southbound Approach				Westbound Approach				Northbound Approach				
	Southbound				Westbound				Northbound				
	Right	Thru	U-Turn	App. Total	Right	Thru	Left	App. Total	Thru	Left	U-Turn	App. Total	Int. Total
7:15 AM	83	106	0	189	56	0	78	134	113	163	0	276	599
7:30 AM	100	103	0	203	58	0	76	134	171	171	0	342	679
7:45 AM	104	81	0	185	72	0	80	152	130	158	0	288	625
8:00 AM	80	100	0	180	45	0	70	115	140	129	0	269	564
Total	367	390	0	757	231	0	304	535	554	621	0	1175	2467
Approach %	48.5	51.5	0.0	-	43.2	0.0	56.8	-	47.1	52.9	0.0	-	-
Total %	14.9	15.8	0.0	30.7	9.4	0.0	12.3	21.7	22.5	25.2	0.0	47.6	-
PHF	0.882	0.920	0.000	0.932	0.802	0.000	0.950	0.880	0.810	0.908	0.000	0.859	0.908
Lights	359	381	0	740	226	0	283	509	541	606	0	1147	2396
% Lights	97.8	97.7	-	97.8	97.8	-	93.1	95.1	97.7	97.6	-	97.6	97.1
Mediums	8	8	0	16	5	0	16	21	13	13	0	26	63
% Mediums	2.2	2.1	-	2.1	2.2	-	5.3	3.9	2.3	2.1	-	2.2	2.6
Articulated Trucks	0	1	0	1	0	0	5	5	0	2	0	2	8
% Articulated Trucks	0.0	0.3	-	0.1	0.0	-	1.6	0.9	0.0	0.3	-	0.2	0.3

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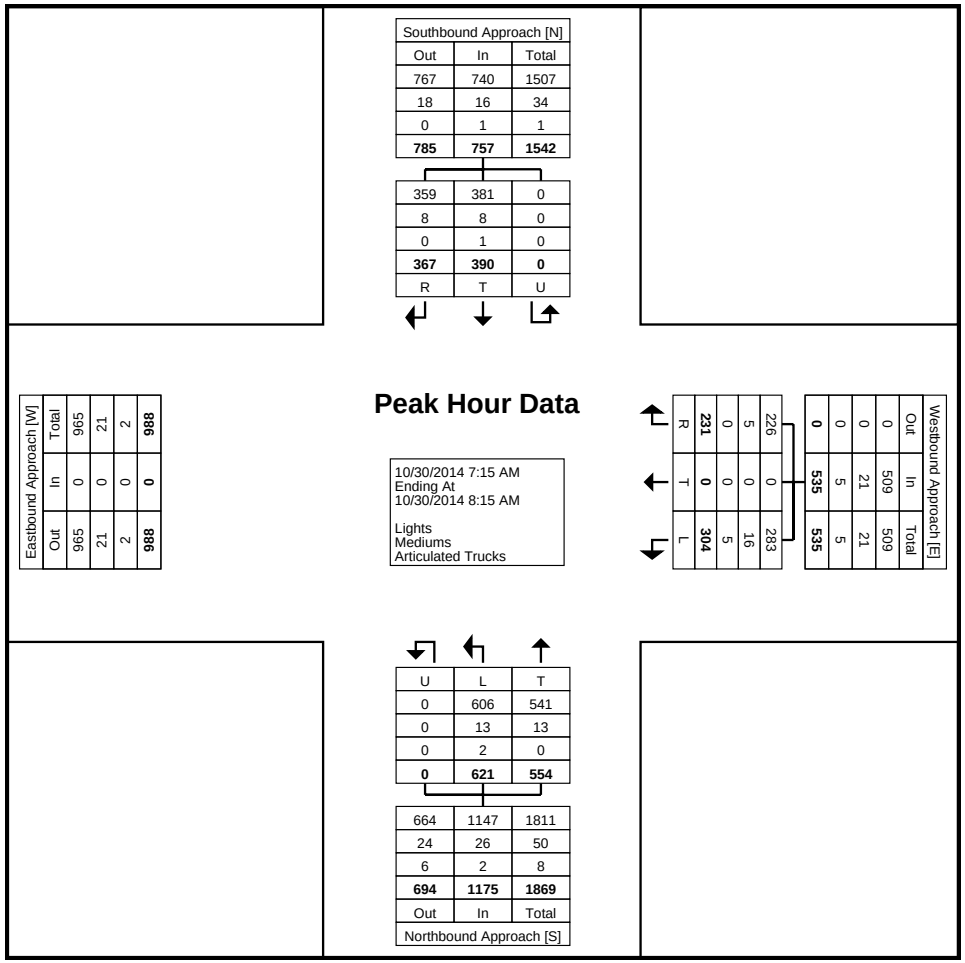

Turning Movement Peak Hour Data Plot (7:15 AM)

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Count Name: CUY-94 & I-480 WB TMC
Site Code:
Start Date: 10/30/2014

Turning Movement Peak Hour Data (3:30 PM)

Start Time	Southbound Approach				Westbound Approach				Northbound Approach				
	Southbound				Westbound				Northbound				
	Right	Thru	U-Turn	App. Total	Right	Thru	Left	App. Total	Thru	Left	U-Turn	App. Total	Int. Total
3:30 PM	103	136	0	239	100	0	219	319	163	141	0	304	862
3:45 PM	97	153	0	250	95	0	240	335	145	129	0	274	859
4:00 PM	80	124	0	204	79	0	193	272	147	138	0	285	761
4:15 PM	69	115	0	184	88	0	213	301	145	163	0	308	793
Total	349	528	0	877	362	0	865	1227	600	571	0	1171	3275
Approach %	39.8	60.2	0.0	-	29.5	0.0	70.5	-	51.2	48.8	0.0	-	-
Total %	10.7	16.1	0.0	26.8	11.1	0.0	26.4	37.5	18.3	17.4	0.0	35.8	-
PHF	0.847	0.863	0.000	0.877	0.905	0.000	0.901	0.916	0.920	0.876	0.000	0.950	0.950
Lights	347	518	0	865	359	0	849	1208	592	552	0	1144	3217
% Lights	99.4	98.1	-	98.6	99.2	-	98.2	98.5	98.7	96.7	-	97.7	98.2
Mediums	2	10	0	12	2	0	14	16	8	17	0	25	53
% Mediums	0.6	1.9	-	1.4	0.6	-	1.6	1.3	1.3	3.0	-	2.1	1.6
Articulated Trucks	0	0	0	0	1	0	2	3	0	2	0	2	5
% Articulated Trucks	0.0	0.0	-	0.0	0.3	-	0.2	0.2	0.0	0.4	-	0.2	0.2

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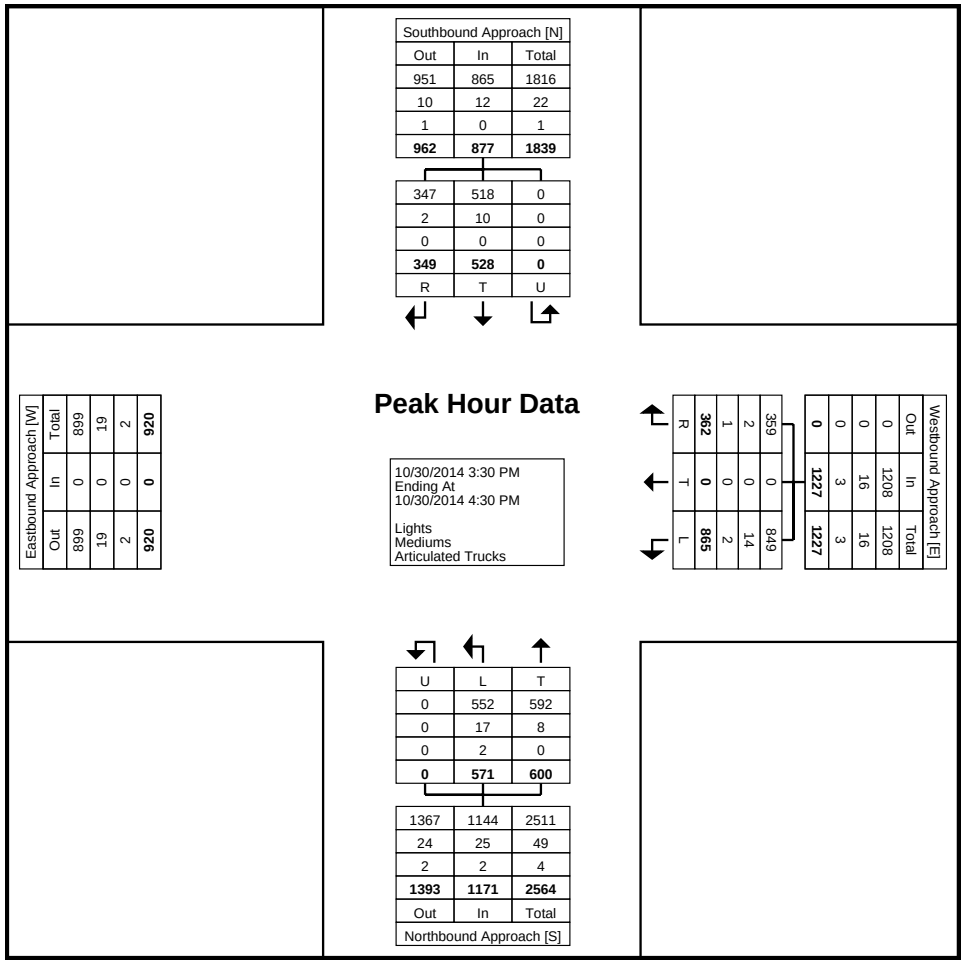

Turning Movement Peak Hour Data Plot (3:30 PM)

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Office of Traffic Engineering

Count Name: CUY-94 & RALPH TMC
Site Code:
Start Date: 10/30/2014

Turning Movement Data

Start Time	Southbound Approach					Westbound Approach					Northbound Approach					Eastbound Approach					
	Southbound					Westbound					Northbound					Eastbound					
	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Int. Total
6:00 AM	0	60	0	0	60	0	0	6	0	6	1	20	0	0	21	6	0	0	0	6	93
6:15 AM	0	106	2	0	108	1	0	3	0	4	1	55	2	0	58	11	1	0	0	12	182
6:30 AM	0	110	0	0	110	0	1	13	0	14	0	66	2	0	68	9	5	1	0	15	207
6:45 AM	1	110	0	0	111	2	1	14	0	17	3	86	4	0	93	13	0	0	0	13	234
Hourly Total	1	386	2	0	389	3	2	36	0	41	5	227	8	0	240	39	6	1	0	46	716
7:00 AM	0	106	0	0	106	0	1	13	0	14	1	105	3	0	109	14	2	1	0	17	246
7:15 AM	1	137	0	0	138	2	0	15	0	17	4	145	3	0	152	14	1	3	0	18	325
7:30 AM	1	154	2	0	157	1	0	14	0	15	6	175	3	0	184	12	5	4	0	21	377
7:45 AM	3	172	3	0	178	1	11	15	0	27	8	170	7	0	185	6	9	0	0	15	405
Hourly Total	5	569	5	0	579	4	12	57	0	73	19	595	16	0	630	46	17	8	0	71	1353
8:00 AM	0	132	1	0	133	0	3	12	0	15	6	161	1	0	168	11	0	3	0	14	330
8:15 AM	1	114	1	0	116	3	2	13	0	18	3	139	3	0	145	10	4	0	0	14	293
8:30 AM	2	131	1	0	134	0	1	4	0	5	3	125	4	0	132	8	0	1	0	9	280
8:45 AM	1	102	2	0	105	3	2	14	0	19	2	99	2	0	103	3	2	1	0	6	233
Hourly Total	4	479	5	0	488	6	8	43	0	57	14	524	10	0	548	32	6	5	0	43	1136
9:00 AM	1	89	2	0	92	1	0	12	0	13	4	103	4	2	113	5	5	1	0	11	229
9:15 AM	1	82	0	0	83	1	1	8	0	10	5	89	3	0	97	10	2	2	0	14	204
9:30 AM	0	97	0	0	97	2	2	5	0	9	1	81	3	0	85	9	0	3	0	12	203
9:45 AM	3	81	1	0	85	2	2	8	0	12	1	93	0	0	94	3	1	3	0	7	198
Hourly Total	5	349	3	0	357	6	5	33	0	44	11	366	10	2	389	27	8	9	0	44	834
*** BREAK ***	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2:00 PM	0	103	1	0	104	4	3	10	0	17	7	137	8	0	152	12	1	1	0	14	287
2:15 PM	3	134	1	0	138	3	2	4	0	9	1	132	12	0	145	11	0	1	0	12	304
2:30 PM	4	144	3	0	151	4	4	10	0	18	3	131	5	0	139	6	6	4	0	16	324
2:45 PM	1	114	0	0	115	2	4	13	0	19	8	156	9	0	173	13	4	1	0	18	325
Hourly Total	8	495	5	0	508	13	13	37	0	63	19	556	34	0	609	42	11	7	0	60	1240
3:00 PM	4	196	2	0	202	2	3	11	0	16	14	160	5	0	179	11	3	0	0	14	411
3:15 PM	6	222	7	0	235	3	3	15	0	21	4	164	7	0	175	10	2	4	0	16	447
3:30 PM	5	180	2	0	187	2	9	19	0	30	7	201	8	0	216	17	7	5	0	29	462
3:45 PM	5	186	4	0	195	5	3	21	0	29	10	186	8	0	204	12	6	2	0	20	448
Hourly Total	20	784	15	0	819	12	18	66	0	96	35	711	28	0	774	50	18	11	0	79	1768
4:00 PM	1	166	1	0	168	1	5	17	0	23	7	166	8	0	181	8	7	3	0	18	390
4:15 PM	0	161	2	0	163	2	4	18	0	24	9	175	6	0	190	7	3	3	0	13	390
4:30 PM	3	187	0	0	190	3	9	21	0	33	4	139	14	0	157	11	2	6	0	19	399
4:45 PM	2	188	4	0	194	0	5	13	0	18	7	167	8	0	182	7	3	5	0	15	409
Hourly Total	6	702	7	0	715	6	23	69	0	98	27	647	36	0	710	33	15	17	0	65	1588
5:00 PM	3	195	1	0	199	3	4	27	0	34	7	139	11	0	157	9	5	0	0	14	404

5:15 PM	2	159	3	0	164	2	4	8	0	14	12	197	7	0	216	9	2	4	0	15	409
5:30 PM	4	141	2	0	147	3	6	15	0	24	4	168	9	0	181	5	4	3	0	12	364
5:45 PM	1	158	2	0	161	1	5	16	0	22	3	166	5	0	174	6	3	1	0	10	367
Hourly Total	10	653	8	0	671	9	19	66	0	94	26	670	32	0	728	29	14	8	0	51	1544
Grand Total	59	4417	50	0	4526	59	100	407	0	566	156	4296	174	2	4628	298	95	66	0	459	10179
Approach %	1.3	97.6	1.1	0.0	-	10.4	17.7	71.9	0.0	-	3.4	92.8	3.8	0.0	-	64.9	20.7	14.4	0.0	-	-
Total %	0.6	43.4	0.5	0.0	44.5	0.6	1.0	4.0	0.0	5.6	1.5	42.2	1.7	0.0	45.5	2.9	0.9	0.6	0.0	4.5	-
Lights	57	4324	49	0	4430	58	100	406	0	564	156	4197	167	1	4521	289	95	64	0	448	9963
% Lights	96.6	97.9	98.0	-	97.9	98.3	100.0	99.8	-	99.6	100.0	97.7	96.0	50.0	97.7	97.0	100.0	97.0	-	97.6	97.9
Mediums	2	81	1	0	84	1	0	1	0	2	0	94	6	0	100	9	0	2	0	11	197
% Mediums	3.4	1.8	2.0	-	1.9	1.7	0.0	0.2	-	0.4	0.0	2.2	3.4	0.0	2.2	3.0	0.0	3.0	-	2.4	1.9
Articulated Trucks	0	12	0	0	12	0	0	0	0	0	0	5	1	1	7	0	0	0	0	0	19
% Articulated Trucks	0.0	0.3	0.0	-	0.3	0.0	0.0	0.0	-	0.0	0.0	0.1	0.6	50.0	0.2	0.0	0.0	0.0	-	0.0	0.2

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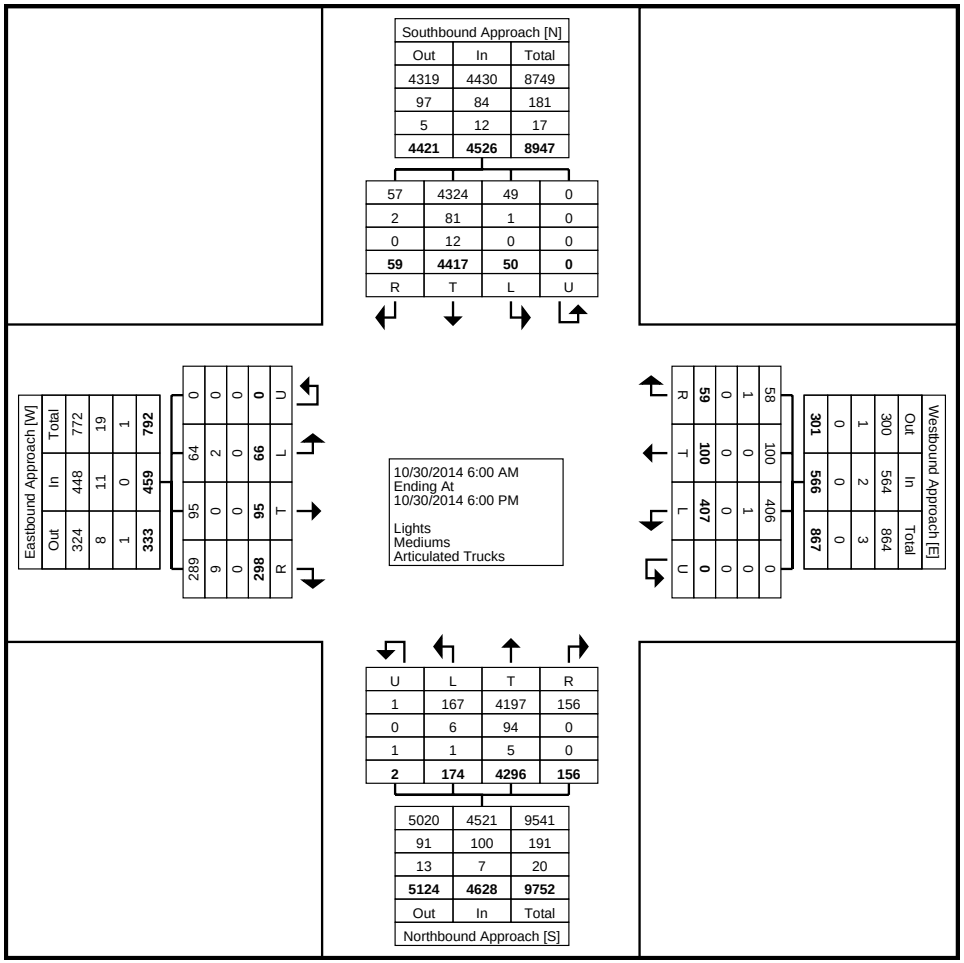

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Turning Movement Peak Hour Data (7:15 AM)

Start Time	Southbound Approach					Westbound Approach					Northbound Approach					Eastbound Approach					
	Southbound					Westbound					Northbound					Eastbound					
	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Int. Total
7:15 AM	1	137	0	0	138	2	0	15	0	17	4	145	3	0	152	14	1	3	0	18	325
7:30 AM	1	154	2	0	157	1	0	14	0	15	6	175	3	0	184	12	5	4	0	21	377
7:45 AM	3	172	3	0	178	1	11	15	0	27	8	170	7	0	185	6	9	0	0	15	405
8:00 AM	0	132	1	0	133	0	3	12	0	15	6	161	1	0	168	11	0	3	0	14	330
Total	5	595	6	0	606	4	14	56	0	74	24	651	14	0	689	43	15	10	0	68	1437
Approach %	0.8	98.2	1.0	0.0	-	5.4	18.9	75.7	0.0	-	3.5	94.5	2.0	0.0	-	63.2	22.1	14.7	0.0	-	-
Total %	0.3	41.4	0.4	0.0	42.2	0.3	1.0	3.9	0.0	5.1	1.7	45.3	1.0	0.0	47.9	3.0	1.0	0.7	0.0	4.7	-
PHF	0.417	0.865	0.500	0.000	0.851	0.500	0.318	0.933	0.000	0.685	0.750	0.930	0.500	0.000	0.931	0.768	0.417	0.625	0.000	0.810	0.887
Lights	5	580	6	0	591	4	14	55	0	73	24	637	13	0	674	41	15	10	0	66	1404
% Lights	100.0	97.5	100.0	-	97.5	100.0	100.0	98.2	-	98.6	100.0	97.8	92.9	-	97.8	95.3	100.0	100.0	-	97.1	97.7
Mediums	0	14	0	0	14	0	0	1	0	1	0	14	1	0	15	2	0	0	0	2	32
% Mediums	0.0	2.4	0.0	-	2.3	0.0	0.0	1.8	-	1.4	0.0	2.2	7.1	-	2.2	4.7	0.0	0.0	-	2.9	2.2
Articulated Trucks	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
% Articulated Trucks	0.0	0.2	0.0	-	0.2	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.1

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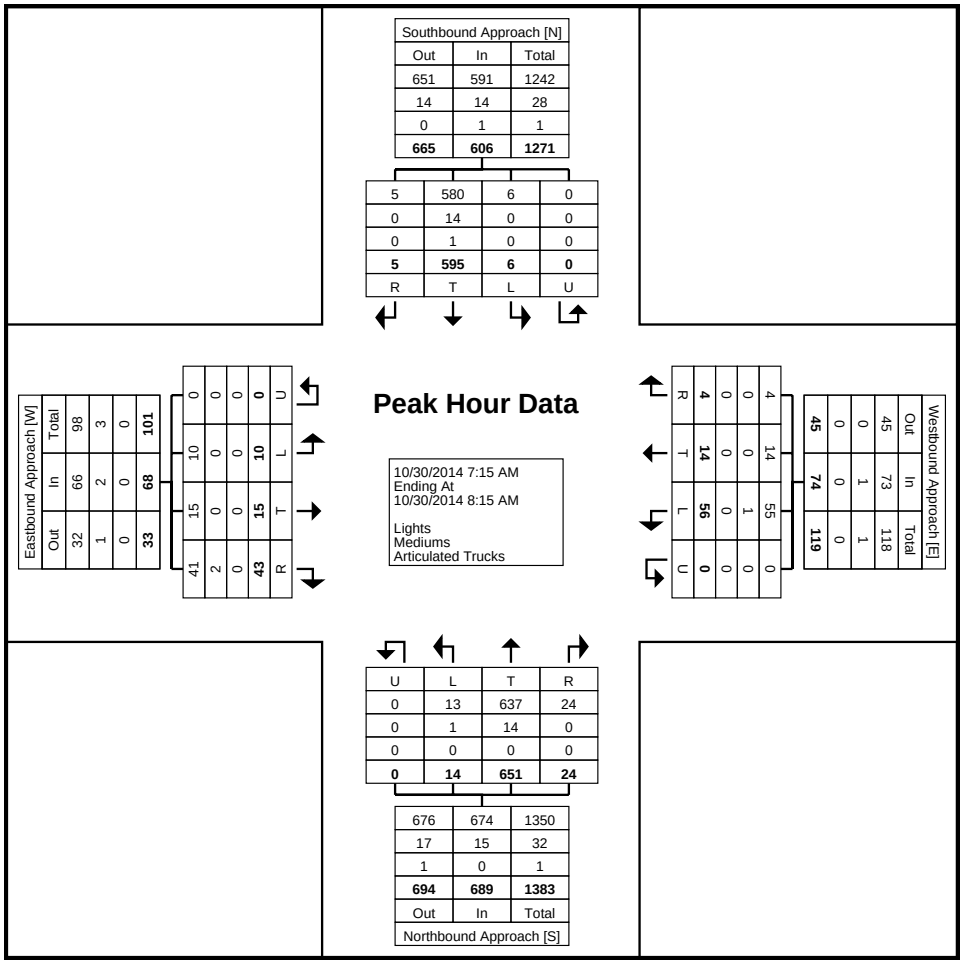

Turning Movement Peak Hour Data Plot (7:15 AM)

Ohio Department of Transportation
1980 West Broad Street
Mail Stop 5160
Columbus, Ohio, United States 43223
+16147528099 Stephanie.Marik@dot.state.oh.us
Office of Traffic Engineering

Count Name: CUY-94 & RALPH TMC
Site Code:
Start Date: 10/30/2014

Turning Movement Peak Hour Data (3:00 PM)

Start Time	Southbound Approach					Westbound Approach					Northbound Approach					Eastbound Approach					
	Southbound					Westbound					Northbound					Eastbound					
	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Int. Total
3:00 PM	4	196	2	0	202	2	3	11	0	16	14	160	5	0	179	11	3	0	0	14	411
3:15 PM	6	222	7	0	235	3	3	15	0	21	4	164	7	0	175	10	2	4	0	16	447
3:30 PM	5	180	2	0	187	2	9	19	0	30	7	201	8	0	216	17	7	5	0	29	462
3:45 PM	5	186	4	0	195	5	3	21	0	29	10	186	8	0	204	12	6	2	0	20	448
Total	20	784	15	0	819	12	18	66	0	96	35	711	28	0	774	50	18	11	0	79	1768
Approach %	2.4	95.7	1.8	0.0	-	12.5	18.8	68.8	0.0	-	4.5	91.9	3.6	0.0	-	63.3	22.8	13.9	0.0	-	-
Total %	1.1	44.3	0.8	0.0	46.3	0.7	1.0	3.7	0.0	5.4	2.0	40.2	1.6	0.0	43.8	2.8	1.0	0.6	0.0	4.5	-
PHF	0.833	0.883	0.536	0.000	0.871	0.600	0.500	0.786	0.000	0.800	0.625	0.884	0.875	0.000	0.896	0.735	0.643	0.550	0.000	0.681	0.957
Lights	20	769	15	0	804	12	18	66	0	96	35	692	27	0	754	48	18	11	0	77	1731
% Lights	100.0	98.1	100.0	-	98.2	100.0	100.0	100.0	-	100.0	100.0	97.3	96.4	-	97.4	96.0	100.0	100.0	-	97.5	97.9
Mediums	0	12	0	0	12	0	0	0	0	0	0	18	1	0	19	2	0	0	0	2	33
% Mediums	0.0	1.5	0.0	-	1.5	0.0	0.0	0.0	-	0.0	0.0	2.5	3.6	-	2.5	4.0	0.0	0.0	-	2.5	1.9
Articulated Trucks	0	3	0	0	3	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	4
% Articulated Trucks	0.0	0.4	0.0	-	0.4	0.0	0.0	0.0	-	0.0	0.0	0.1	0.0	-	0.1	0.0	0.0	0.0	-	0.0	0.2

Ohio Department of Transportation
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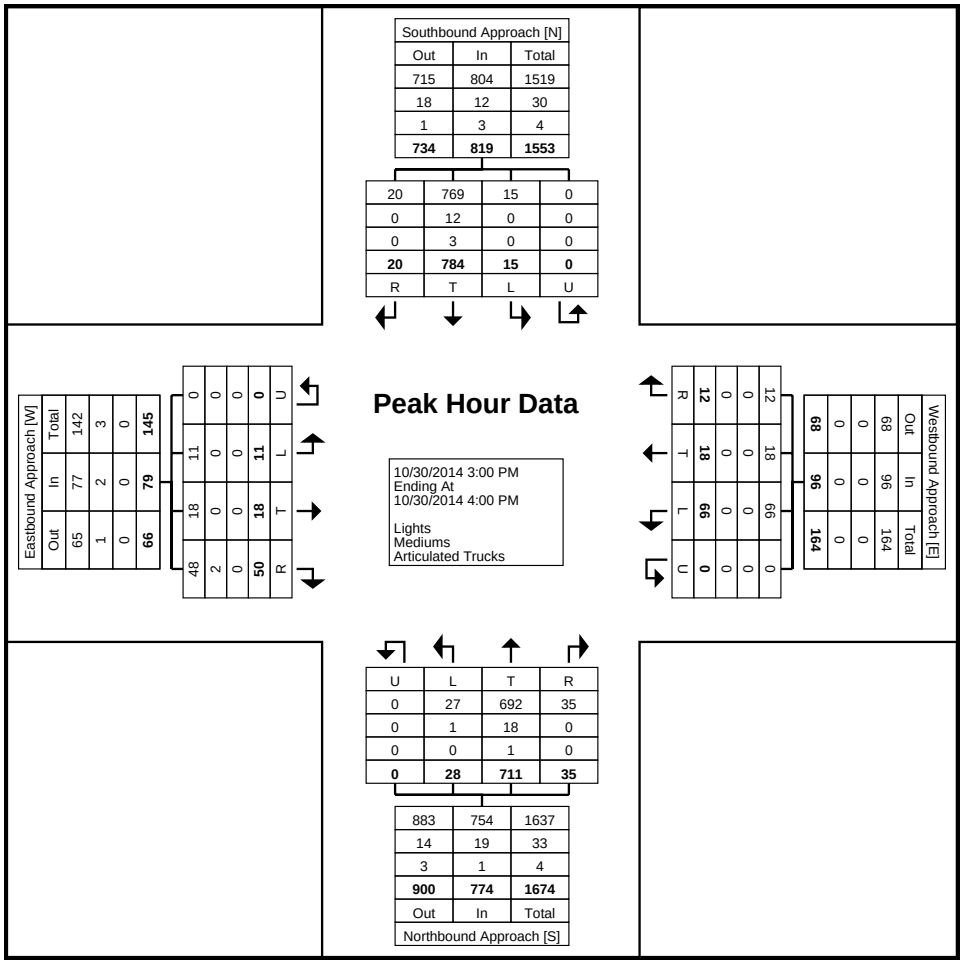


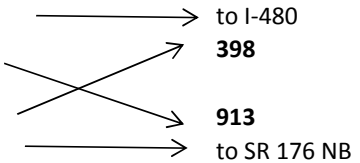
Turning Movement Peak Hour Data Plot (3:00 PM)

WEAVE VOLUME COUNT SUMMARY

By LJB Inc
Date Thursday, January 29, 2015
Time 7:00 AM to 8:00 AM

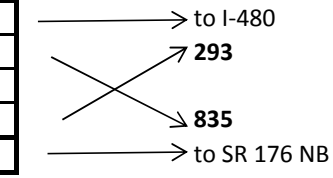
Location: IR-480 EB
Location 2: From I-480 EB to SR 176 NB
From State Rd. Entrance to I-480 EB

	I-480 EB to SR 176 NB			State Rd to I-480 EB		
Time	State Rd. Merge to Broadview overpass	Broadview overpass to SR 176 Ramp diverge	Total	State Rd. Merge to Broadview overpass	Broadview overpass to SR 176 Ramp diverge	Total
7:00 AM	138	47	185	87	6	93
7:15 AM	201	46	247	109	2	111
7:30 AM	205	53	258	106	1	107
7:45 AM	179	44	223	86	1	87
Hourly Total	**723**	**190**	**913**	**388**	**10**	**398**



Date Tuesday, February 03, 2015
Time 4:30 PM to 5:30 PM

	I-480 EB to SR 176 NB			State Rd to I-480 EB		
Time	State Rd. Merge to Broadview overpass	Broadview overpass to SR 176 Ramp diverge	Total	State Rd. Merge to Broadview overpass	Broadview overpass to SR 176 Ramp diverge	Total
4:30 PM	90	82	172	69	14	83
4:45 PM	104	126	230	57	13	70
5:00 PM	121	99	220	62	10	72
5:15 PM	90	123	213	60	8	68
Hourly Total	**405**	**430**	**835**	**248**	**45**	**293**



The following traffic count data was available for the I-480 mainline and ramps

- **I-480 mainline**: Permanent count station at SLM 12.210, 0.20 miles west of Ridge Road
- **Ramps**: 24 hour/48 hour count data for ramps at Ridge, State Road and SR 176/SR 17 interchanges in 2012 and 2013.

Following steps were followed to normalize traffic data from various time periods to a base 2014 year and to develop design year traffic.

1. Summarize available 24 hour traffic count data for I-480 permanent count station and for all ramps between the permanent count station and Jennings Freeway interchange
2. Apply seasonal adjustment factors and growth rates provided by NOACA to adjust all traffic to existing year (2014).
3. Estimate hourly mainline volume for the study sections using the permanent count station data by deducting exit ramp volume and adding entrance ramp volume.
4. Establish AM and PM peak hour volume for each location, and establish network wide peak hour volumes for the mainline and ramps. Balance volumes.
5. Apply growth rates provided by NOACA to generate design year (2034) volumes for the study location. Balance volumes for any discrepancies.

STATION ID		45018	45018	79218	79318	71918	71618	53918	54118	96218	96418	96318	53818	54018	71718	71818	81518	81618	53318	
LOCATION		ATR STATION 142, SLM 12.21 (EASTBOUND)	ATR STATION 142, SLM 12.21 (WESTBOUND)	EB IR-480 TO RIDGE RD	RIDGE RD TO EB IR-480	EB IR-480 TO STATE RD	STATE RD TO EB IR-480	EB IR-480 TO SR 176 NB	SR 176 SB TO IR-480 EB	SR 17 WB TO IR-480 EB	SR 17 EB TO IR-480 EB	WB IR-480 TO SR 17	WB IR-480 TO SR 176 NB	SR 176 SB TO IR-480 WB	WB IR-480 TO STATE RD	STATE RD TO WB IR-480	WB IR-480 TO RIDGE RD	RIDGE RD TO WB IR-480	SR 17/176 TO SR 176 NB	SR 176 SB TO SR 17-176
DATE COLLECTED		05/23/12	05/23/12	07/09/13	07/09/13	09/10/12	09/11/12	06/18/09	11/4-11/5/13	07/17/13	07/17/13	07/17/13	10/04/12	05/03/12	09/11/12	09/11/12	07/09/13	07/09/13	8/1-8/2/13	8/1-8/2/13
RAW VOLUMES BY HOUR OF DAY	0:00	620	560	148	80	96	51	163	113	9	33	46	188	266	121	56	162	86	41	84
	1:00	413	357	90	60	54	49	115	96	8	12	25	114	169	73	42	91	35	31	42
	2:00	381	290	54	65	64	44	127	82	3	10	15	89	131	44	28	79	40	22	47
	3:00	350	303	50	81	52	80	103	87	9	13	28	85	144	44	48	57	52	29	38
	4:00	665	604	80	185	73	155	196	205	11	41	21	132	112	41	106	77	79	59	40
	5:00	1857	1623	147	615	143	508	627	558	16	96	81	318	214	65	284	152	232	167	86
	6:00	4975	3658	367	1191	417	1061	1575	1255	61	247	190	957	507	234	578	420	494	451	174
	7:00	6845	5405	482	1141	767	1130	1876	1060	102	306	354	1471	893	515	902	690	705	614	332
	8:00	5121	4264	567	841	780	748	1517	1019	106	218	282	1305	769	400	734	705	593	429	324
	9:00	3788	3499	534	792	536	587	981	952	106	172	267	956	759	359	508	643	531	369	280
	10:00	3287	3141	529	743	502	463	855	794	95	155	219	740	773	367	506	662	528	307	251
	11:00	3311	3344	548	733	555	417	903	819	88	170	262	791	796	423	500	762	594	333	285
	12:00	3437	3559	626	822	494	482	939	784	84	189	253	859	931	479	544	872	682	328	345
	13:00	3495	3940	594	860	531	491	1053	847	102	162	260	923	1,023	486	558	872	689	332	341
	14:00	4119	4686	651	872	686	582	1135	1020	113	223	288	1128	1,357	735	687	1028	692	339	478
	15:00	4780	6085	697	935	818	599	1123	1335	155	181	340	1362	1,582	1,079	780	1254	725	418	640
	16:00	5447	6469	730	888	933	566	1076	1425	201	242	378	1547	1,771	1,139	815	1363	662	475	679
	17:00	5149	6248	722	807	925	519	1145	1396	196	218	328	1578	1,685	1,237	783	1372	606	433	749
	18:00	3695	4632	601	768	701	479	992	946	85	171	259	1410	1,307	872	668	1187	656	330	511
	19:00	2774	3137	570	578	603	369	763	552	50	100	195	852	876	597	507	770	498	208	326
	20:00	2704	2642	511	544	566	294	702	470	45	86	140	669	731	477	429	606	444	208	296
	21:00	2314	2240	391	475	413	253	659	447	25	81	111	535	619	386	338	519	328	184	259
	22:00	1762	1840	356	328	268	227	611	280	19	56	91	461	513	269	190	397	223	156	237
	23:00	1213	1091	221	180	192	108	377	227	9	54	79	302	439	236	136	319	164	93	160
	TOTAL	72502	73617	10266	14584	11169	10,262	19613	16769	1,698	3,236	4512	18772	18367	10678	10727	15059	10338	6356	7004

LOCATION		ATR STATION 142, SLM 12.21 (EASTBOUND)	ATR STATION 142, SLM 12.21 (WESTBOUND)	EB IR-480 TO RIDGE RD	RIDGE RD TO EB IR-480	EB IR-480 TO STATE RD	STATE RD TO EB IR-480	EB IR-480 TO SR 176 NB	SR 176 SB TO IR-480 EB	SR 17 WB TO IR-480 EB	SR 17 EB TO IR-480 EB	WB IR-480 TO SR 17	WB IR-480 TO SR 176 NB	SR 176 SB TO IR-480 WB	WB IR-480 TO STATE RD	STATE RD TO WB IR-480	WB IR-480 TO RIDGE RD	RIDGE RD TO WB IR-480	SR 17/176 TO SR 176 NB	SR 176 SB TO SR 17-176
EXISTING YEAR (2014) VOLUMES, BY HOUR OF DAY	0:00	570	510	130	70	100	50	140	110	10	30	40	170	230	110	50	150	80	40	70
	1:00	380	330	80	50	50	50	100	90	10	10	20	100	150	70	40	80	30	30	40
	2:00	350	260	50	60	60	40	110	80	0	10	10	80	120	40	30	70	40	20	40
	3:00	320	280	50	70	50	70	90	90	10	10	30	80	130	40	40	50	50	30	30
	4:00	610	550	70	170	70	140	170	200	10	40	20	120	100	40	100	70	70	50	40
	5:00	1700	1480	130	560	140	470	550	550	20	90	70	280	190	60	260	140	210	150	80
	6:00	4550	3340	330	1080	420	980	1370	1240	60	230	170	850	450	220	590	380	450	390	150
	7:00	6260	4940	440	1030	890	1050	1630	1040	90	280	320	1310	790	530	950	630	640	530	290
	8:00	4680	3900	510	760	820	820	1320	1000	100	200	260	1160	680	420	760	640	540	370	280
	9:00	3460	3200	480	720	540	540	850	940	100	160	240	850	670	390	610	580	480	320	240
	10:00	3000	2870	480	670	510	430	740	780	90	140	200	660	680	340	470	600	480	270	220
	11:00	3030	3060	500	660	560	390	790	810	80	160	240	700	700	390	460	690	540	290	250
	12:00	3140	3250	570	750	500	450	820	770	80	170	230	770	820	440	500	790	620	290	300
	13:00	3190	3600	540	780	530	460	920	830	90	150	240	820	900	450	520	790	620	290	300
	14:00	3760	4280	590	790	690	650	990	1000	100	200	260	1000	1190	860	690	930	630	300	420
	15:00	4370	5560	630	850	910	720	980	1310	140	170	310	1210	1390	1200	910	1140	660	360	560
	16:00	4980	5910	660	810	1010	690	940	1400	180	220	340	1380	1560	1160	940	1240	600	410	590
	17:00	4710	5710	650	730	980	610	1000	1370	180	200	300	1400	1480	1210	760	1240	550	380	650
	18:00	3380	4230	550	700	710	440	860	930	80	160	240	1260	1150	810	620	1080	590	290	440
	19:00	2540	2870	520	520	610	340	660	540	50	90	180	760	770	550	470	700	450	180	280
	20:00	2470	2410	460	490	570	270	610	460	40	80	130	600	640	440	400	550	400	180	260
	21:00	2110	2050	350	430	420	240	570	440	20	70	100	480	540	360	310	470	300	160	230
	22:00	1610	1680	320	300	270	210	530	280	20	50	80	410	450	250	180	360	200	140	210
	23:00	1110	1000	200	160	190	100	330	220	10	50	70	270	390	220	130	290	150	80	140
	TOTAL	66280	67270	9290	13210	11600	10210	17070	16480	1570	2970	4100	16720	16170	10600	10790	13660	9380	5550	6110

Note: Volumes are seasonally adjusted and projected to 2014

EXISTING YEAR (2014) RAMP VOLUMES

LOCATION		ATR STATION 142, SLM 12.21 (EASTBOUND)	ATR STATION 142, SLM 12.21 (WESTBOUND)	EB IR-480 TO RIDGE RD	RIDGE RD TO EB IR-480	EB IR-480 TO STATE RD	STATE RD TO EB IR-480	EB IR-480 TO SR 176 NB	SR 176 SB TO IR-480 EB	SR 17 WB TO IR-480 EB	SR 17 EB TO IR-480 EB	WB IR-480 TO SR 17	WB IR-480 TO SR 176 NB	SR 176 SB TO IR-480 WB	WB IR-480 TO STATE RD	STATE RD TO WB IR-480	WB IR-480 TO RIDGE RD	RIDGE RD TO WB IR-480	SR 17/176 TO SR 176 NB	SR 176 SB TO SR 17-176
FINAL (2014)	AM PEAK	6260	4940	510	1080	890	1050	1630	1240	90	280	320	1310	790	530	950	630	640	530	290
	PM PEAK	4980	5910	660	850	1010	720	1000	1400	180	220	340	1400	1560	1210	940	1240	660	410	650

EXISTING YEAR (2014) MAINLINE VOLUMES

LOCATION		I-480-WEST OF RIDGE RD		I-480-BETWEEN RIDGE RD RAMPS		I-480-RIDGE TO STATE		I-480-BETWEEN STATE RD RAMPS		I-480-STATE RD TO SR 176		I-480-BETWEEN SR 176 RAMPS		I-480-EAST OF SR 176/SR 17 RAMPS		SR 176 - N of I-480	
DIRECTION		EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	NB	SB
2014 FINAL	AM PEAK	6260	4940	5750	4300	6830	4930	5940	3980	6990	4510	5360	3720	6970	5350	3470	2320
	PM PEAK	4980	5910	4320	5250	5170	6490	4160	5550	4880	6760	3880	5200	5680	6940	2810	3610

*VOLUMES ARE ALL BALANCED

DESIGN YEAR (2034) MAINLINE AND RAMP VOLUMES

	LOCATION	EB IR-480 TO RIDGE RD	RIDGE RD TO EB IR-480	EB IR-480 TO STATE RD	STATE RD TO EB IR-480	EB IR-480 TO SR 176 NB	SR 176 SB TO IR-480 EB	SR 17 WB TO IR-480 EB	SR 17 EB TO IR-480 EB	WB IR-480 TO SR 17	WB IR-480 TO SR 176 NB	SR 176 SB TO IR-480 WB	WB IR-480 TO STATE RD	STATE RD TO WB IR-480	WB IR-480 TO RIDGE RD	RIDGE RD TO WB IR-480	SR 17/176 TO SR 176 NB	SR 176 SB TO SR 17-176
2034 FINAL	AM PEAK	510	1080	890	1060	1630	1240	90	280	320	1310	790	530	950	630	640	530	290
	PM PEAK	660	850	1010	720	1000	1400	180	220	340	1400	1560	1210	940	1240	660	410	650

	LOCATION	I-480-WEST OF RIDGE RD		I-480-BETWEEN RIDGE RD RAMPS		I-480-RIDGE TO STATE		I-480-BETWEEN STATE RD RAMPS		I-480-STATE RD TO SR 176		I-480-BETWEEN SR 176 RAMPS		I-480-EAST OF SR 176/SR 17 RAMPS		SR 176 - N of I-480	
	DIRECTION	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	NB	SB
2034 FINAL	AM PEAK	6530	5120	6090	4480	7120	5110	6230	4160	7290	4690	5660	3900	7270	5530	3470	2120
	PM PEAK	5140	6270	4480	5610	5330	6850	4320	5910	5040	7120	4040	5560	5840	7300	2810	3610

*VOLUMES ARE ALL BALANCED

BASED ON THE PEAK HOUR VOLUME (4PM-6PM)

From: Sahar Tawfiq <STawfiq@mpo.noaca.org>
To: "SKnebel@LJBinc.com" <SKnebel@LJBinc.com>,
Cc: Joshua Naramore <JNaramore@mpo.noaca.org>, "Brian.Blayney@dot.state.oh.us" <Brian.Blayney@dot.state.oh.us>
Date: 02/06/2015 11:36 AM
Subject: RE: D12 safety study growth rates/IR-480 Study

Scott,

Attached is CUY-480-14.10/14.40 study forecast. Please note the following:

- The growth rates per year for the IR-480 main line and ramps within the study area are based on NOACA's Regional Travel model base year 2010 network and future 2035 network. The growth rates can be used to establish the traffic for a different year.
- The turning movement forecast for the intersections of State Road with Brookpark Road and IR-480 WB and EB Ramps are based on NOACA's regional Travel Model and 2014 traffic count provided.
- Ralph Road is not on NOACA's Regional Model. Based on the model output for base year 2010 and future year 2035, the travel zones in that area north of IR-480 show a negative growth.

I will finish SR-17/Ridge Road intersection forecast next week.
Please let me know if you have any question.

Sahar Tawfiq
Northeast Ohio Areawide Coordinating Agency
1299 Superior Avenue
Cleveland, Ohio 44114-3204
PH: (216) 241-2414, Extension 280

stawfiq@mpo.noaca.org
www.noaca.org
Email

CUY-480-14.10/14.40 (State Road interchange to Jennings Frwy)

Mainline and Ramps Growth Rates

IR-480/SR-94	**Growth Rate per Year %**
IR-480 west of SR-94	0.1
Eastbound Exit Ramp	0
Westbound Entrance Ramp	0
Eastbound Entrance Ramp	0.02
Westbound Exit Ramp	0.02
SR-94 South of IR-480	0
SR-94 North of IR-481	0
IR-480/SR-176/Granger	
IR-480 West of SR-176	0.2
IR-480 Eastbound to SR-176 Northbound Ramp	0
SR-176 Southbound to Westbound IR-480 Ramp	0
IR-480 Westbound to SR-176 Northbound Ramp	0
SR-176 Southbound to Eastbound IR-480 Ramp	0
SR-176	0
Granger Road West of SR-176 Ramps	0
Granger Road East of SR-176 Ramps	0.23
Granger Road to SR-176 Northbound Ramp	0
SR-176 Southbound to Granger Road Ramp	0
IR-480 East of SR-176	0.15

State Road and Brookpark Road intersection

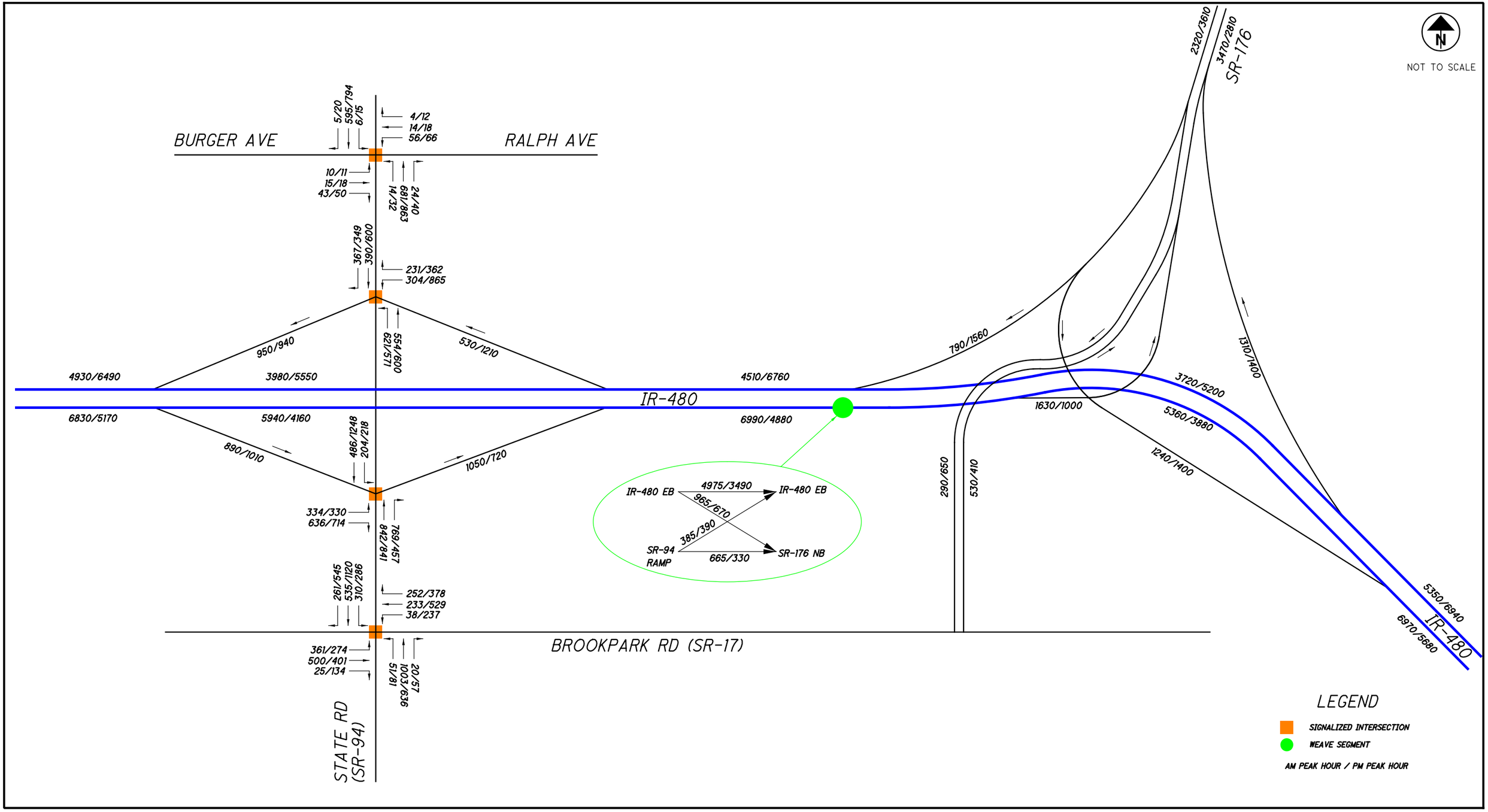
	Movement	2014 Count ADT	2035 Future Traffic		
			ADT	AM PEAK	PM PEAK
Brookpark Road	EB Left	3,891	3,700	360	250
	EB Thru	5,363	5,100	470	380
	EB Right	1,108	1,100	25	130
	WB Left	1,712	1,700	40	240
	WB Thru	5,050	5,000	230	520
	WB Right	3,963	3,900	260	360
State Road	NB Left	1,115	1,100	50	80
	NB Thru	10,080	10,000	1,020	610
	NB Right	562	600	20	60
	SB Left	3,666	3,650	260	270
	SB Thru	9,226	9,200	430	1,020
	SB Right	4,629	4,600	220	500

State Road and IR-489 EB Ramps intersection

	Movement	2014 Count ADT	2035 Future Traffic		
			ADT	AM PEAK	PM PEAK
IR-480 EB Ramps	EB Left	3,528	3,400	320	310
	EB Thru	0	0	0	0
	EB Right	8,040	7,600	600	670
	WB Left	0	0	0	0
	WB Thru	0	0	0	0
	WB Right	0	0	0	0
State Road	NB Left	0	0	0	0
	NB Thru	11,039	11,200	820	810
	NB Right	8,775	8,900	780	460
	SB Left	3,326	3,200	200	210
	SB Thru	11,233	10,800	470	1,200
	SB Right	0	0	0	0

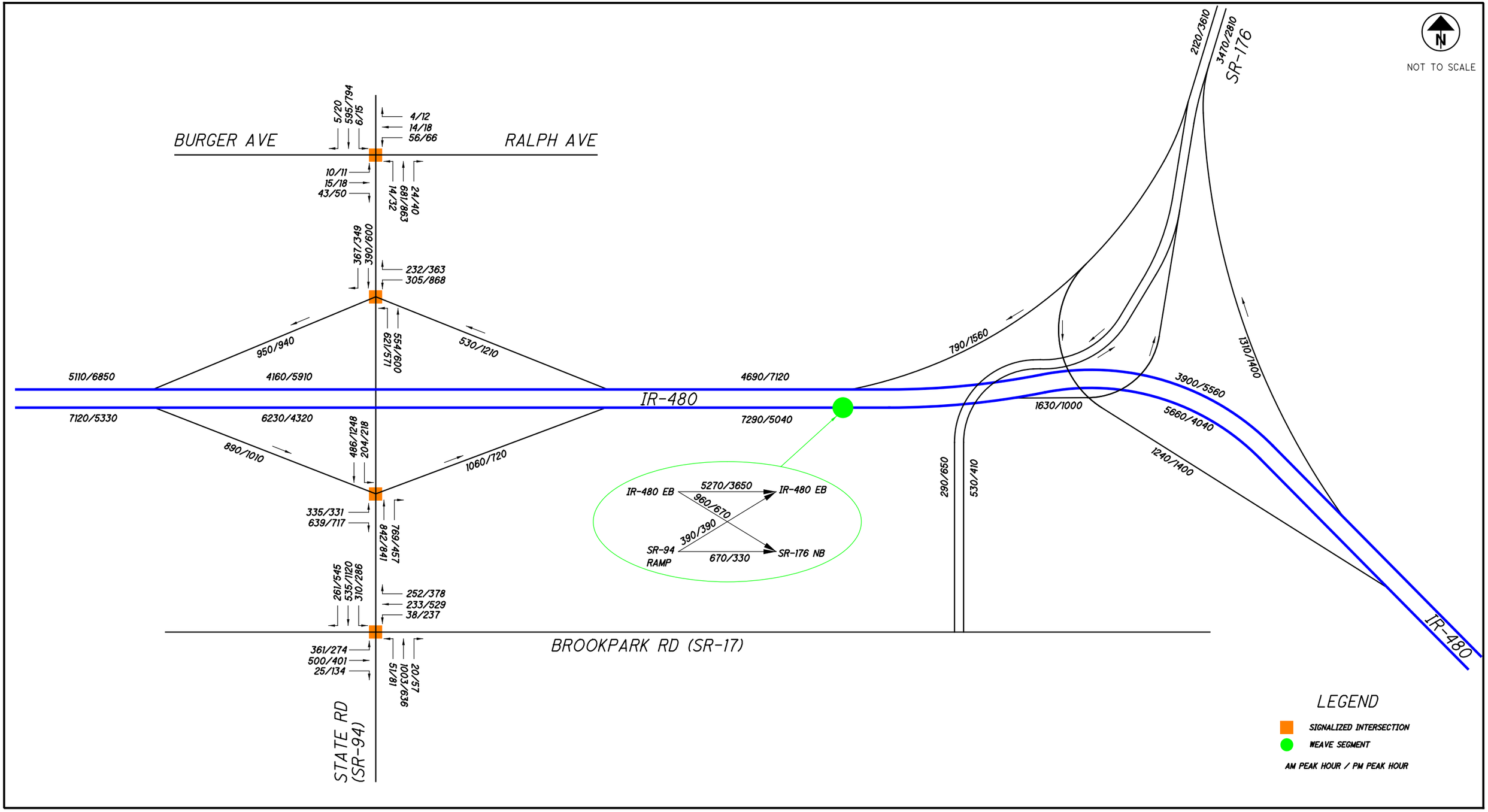
State Road and IR-489 WB Ramps intersection

	Movement	2014 Count ADT	2035 Future Traffic		
			ADT	AM PEAK	PM PEAK
IR-480 WB Ramps	EB Left	0	0	0	0
	EB Thru	0	0	0	0
	EB Right	0	0	0	0
	WB Left	7,709	7,600	300	850
	WB Thru	0	0	0	0
	WB Right	3,419	3,400	250	360
State Road	NB Left	7,771	7,300	600	550
	NB Thru	6,887	6,500	550	600
	NB Right	0	0	0	0
	SB Left	0	0	0	0
	SB Thru	6,566	5,700	350	460
	SB Right	4,224	3,700	350	300



> CUY-480-14.10/14.40 SAFETY STUDY

2014 EXISTING CONDITIONS PEAK HOUR VOLUMES

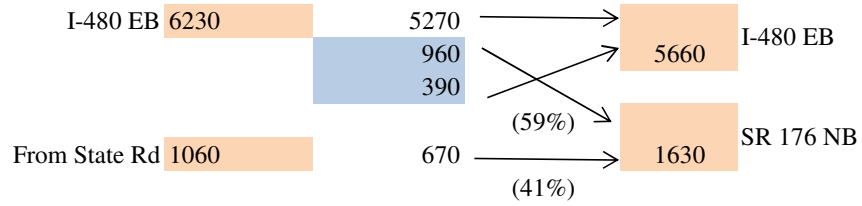


> CUY-480-14.10/14.40 SAFETY STUDY

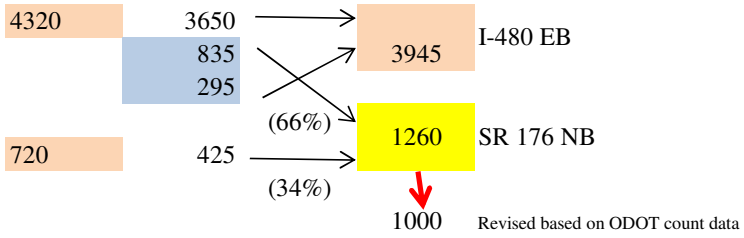
2034 EXISTING CONDITIONS PEAK HOUR VOLUMES

I-480 EB Weave Analysis Volume Calculations

2034 AM Peak



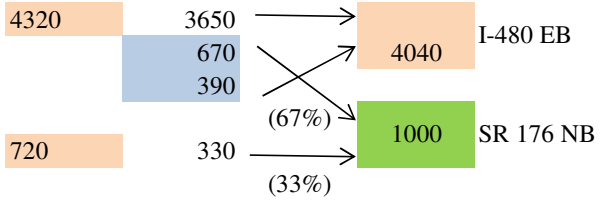
2034 PM Peak



Weave Percentages for EB traffic to SR 176

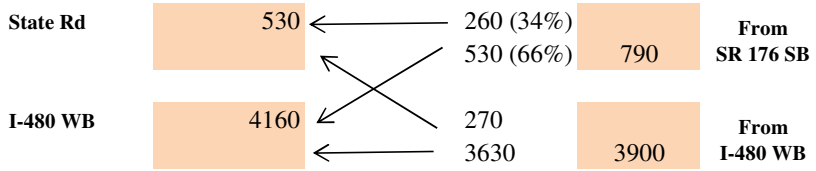
	From I-480	From State Rd
AM Peak	59%	41%
PM Peak	66%	34%

Adjusted Weave Volume

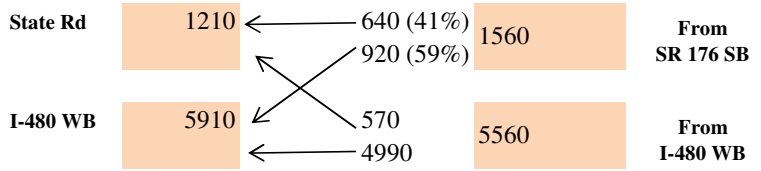


I-480 WB Weave Analysis Volume Calculations

2034 AM Peak



2034 PM Peak



Legend:

xx	Established AM/PM design hour volume
xx	LJB weave volume count (field observations)
xx	Adjusted volume to match design hour vol

Note: I-480 WB weave volumes are estimated based on I-480 EB weave patterns between State Rd and SR 176, and are applied for reciprocated peak (EB % in the AM applied to PM in the WB direction and PM % to AM)

APPENDIX E
CRASH DIAGRAMS

NUMBER OF CRASHES

9	PROPERTY DAMAGE ONLY
0	INJURY OR FATAL
9	TOTAL CRASHES

SYMBOLS

- MOVING VEHICLE
- BACKING VEHICLE
- NON-INVOLVED VEH.
- PEDESTRIAN
- PARKED VEHICLE
- FIXED OBJECT
- FATAL CRASH
- INJURY CRASH

TYPES OF CRASHES

- REAR END
- RIGHT ANGLE
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- HEAD ON

SHOW FOR EACH CRASH

1. TIME, DAY, DATE
2. WEATHER AND ROAD SURFACE IF UNUSUAL CONDITION EXISTED
3. NITE - IF BETWEEN DUSK AND DAWN

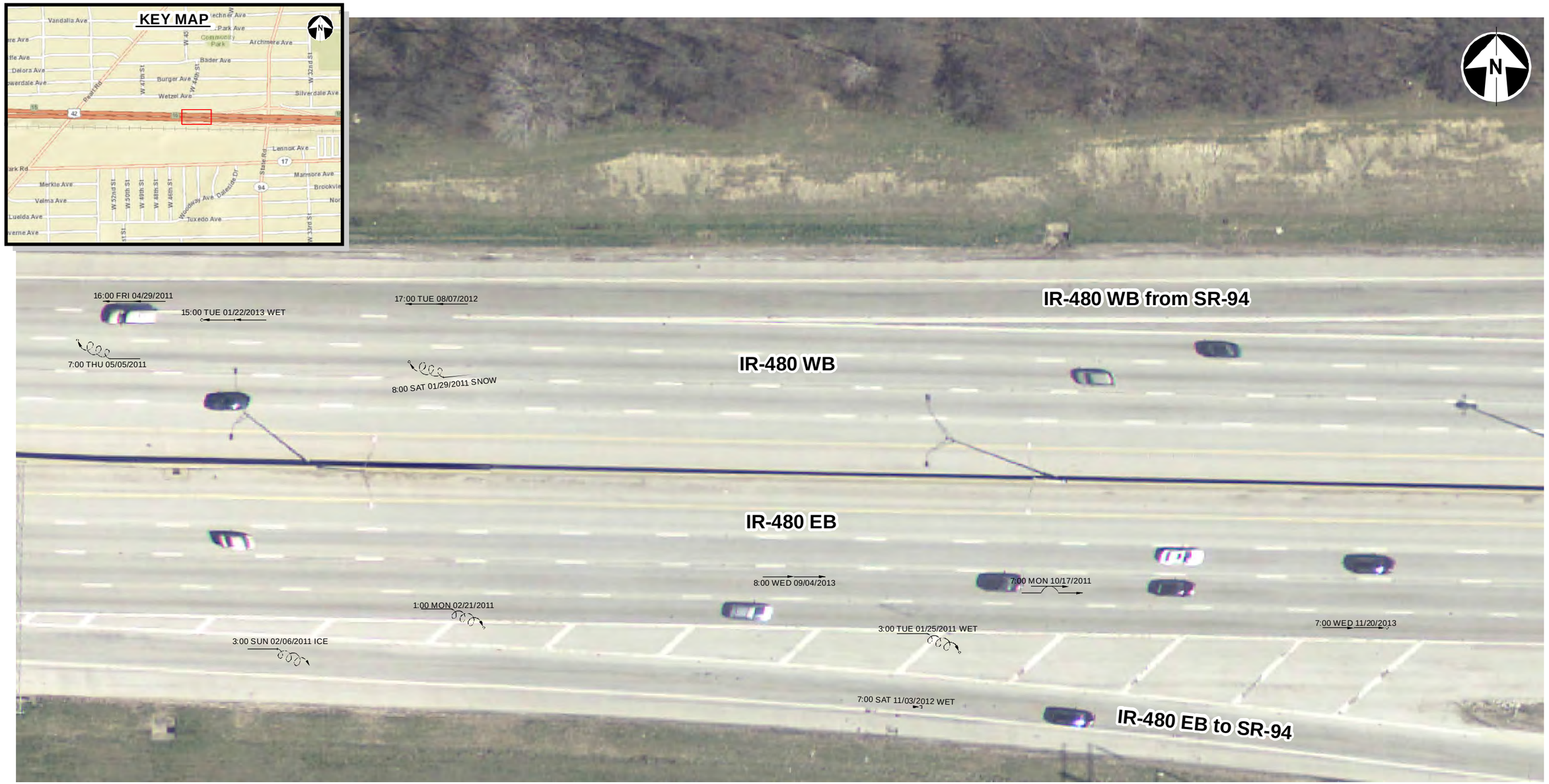
CRASH DIAGRAM

LOG POINT No. 13.88 TO 14.00

PERIOD 3 Years FROM 2011 TO 2013

CITY Cleveland ROUTE NUMBER IR-480

DATE: 1/29/2015



NUMBER OF CRASHES	
6	PROPERTY DAMAGE ONLY
6	INJURY OR FATAL
12	TOTAL CRASHES

SYMBOLS

- MOVING VEHICLE
- BACKING VEHICLE
- NON-INVOLVED VEH.
- PEDESTRIAN
- PARKED VEHICLE
- FIXED OBJECT
- FATAL CRASH
- INJURY CRASH

TYPES OF CRASHES

- REAR END
- RIGHT ANGLE
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- HEAD ON

SHOW FOR EACH CRASH

1. TIME, DAY, DATE
2. WEATHER AND ROAD SURFACE IF UNUSUAL CONDITION EXISTED
3. NITE - IF BETWEEN DUSK AND DAWN

CRASH DIAGRAM

LOG POINT No. 13.99 TO 14.11

PERIOD 3 Years FROM 2011 TO 2013

CITY Cleveland ROUTE NUMBER IR-480

DATE: 1/29/2015

NUMBER OF CRASHES

9	PROPERTY DAMAGE ONLY
1	INJURY OR FATAL
10	TOTAL CRASHES

SYMBOLS

- MOVING VEHICLE
- BACKING VEHICLE
- NON-INVOLVED VEH.
- PEDESTRIAN
- PARKED VEHICLE
- FIXED OBJECT
- FATAL CRASH
- INJURY CRASH

TYPES OF CRASHES

- REAR END
- RIGHT ANGLE
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- HEAD ON

SHOW FOR EACH CRASH

1. TIME, DAY, DATE
2. WEATHER AND ROAD SURFACE IF UNUSUAL CONDITION EXISTED
3. NITE - IF BETWEEN DUSK AND DAWN

CRASH DIAGRAM

LOG POINT No. 14.10 TO 14.22

PERIOD 3 Years FROM 2011 TO 2013

CITY Cleveland ROUTE NUMBER IR-480

DATE: 1/29/2015

NUMBER OF CRASHES

13	PROPERTY DAMAGE ONLY
6	INJURY OR FATAL
19	TOTAL CRASHES

SYMBOLS

- MOVING VEHICLE
- BACKING VEHICLE
- NON-INVOLVED VEH.
- PEDESTRIAN
- PARKED VEHICLE
- FIXED OBJECT
- FATAL CRASH
- INJURY CRASH

TYPES OF CRASHES

- REAR END
- RIGHT ANGLE
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- HEAD ON

SHOW FOR EACH CRASH

1. TIME, DAY, DATE
2. WEATHER AND ROAD SURFACE IF UNUSUAL CONDITION EXISTED
3. NITE - IF BETWEEN DUSK AND DAWN

CRASH DIAGRAM

LOG POINT No. 14.20 TO 14.32

PERIOD 3 Years FROM 2011 TO 2013

CITY Cleveland ROUTE NUMBER IR-480

DATE: 1/29/2015

NUMBER OF CRASHES

12	PROPERTY DAMAGE ONLY
9	INJURY OR FATAL
21	TOTAL CRASHES

SYMBOLS

- MOVING VEHICLE
- BACKING VEHICLE
- NON-INVOLVED VEH.
- PEDESTRIAN
- PARKED VEHICLE
- FIXED OBJECT
- FATAL CRASH
- INJURY CRASH

TYPES OF CRASHES

- REAR END
- RIGHT ANGLE
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- HEAD ON

SHOW FOR EACH CRASH

1. TIME, DAY, DATE
2. WEATHER AND ROAD SURFACE IF UNUSUAL CONDITION EXISTED
3. NITE - IF BETWEEN DUSK AND DAWN

CRASH DIAGRAM

LOG POINT No. 14.34 TO 14.46

PERIOD 3 Years FROM 2011 TO 2013

CITY Cleveland ROUTE NUMBER IR-480

DATE: 1/29/2015

NUMBER OF CRASHES

4	PROPERTY DAMAGE ONLY
3	INJURY OR FATAL
7	TOTAL CRASHES

SYMBOLS

- MOVING VEHICLE
- BACKING VEHICLE
- NON-INVOLVED VEH.
- PEDESTRIAN
- PARKED VEHICLE
- FIXED OBJECT
- FATAL CRASH
- INJURY CRASH

TYPES OF CRASHES

- REAR END
- RIGHT ANGLE
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- HEAD ON

SHOW FOR EACH CRASH

1. TIME, DAY, DATE
2. WEATHER AND ROAD SURFACE IF UNUSUAL CONDITION EXISTED
3. NITE - IF BETWEEN DUSK AND DAWN

CRASH DIAGRAM

LOG POINT No. 14.45 TO 14.57

PERIOD 3 Years FROM 2011 TO 2013

CITY Cleveland ROUTE NUMBER IR-480

DATE: 1/29/2015

NUMBER OF CRASHES

12	PROPERTY DAMAGE ONLY
4	INJURY OR FATAL
16	TOTAL CRASHES

SYMBOLS

- MOVING VEHICLE
- BACKING VEHICLE
- NON-INVOLVED VEH.
- PEDESTRIAN
- PARKED VEHICLE
- FIXED OBJECT
- FATAL CRASH
- INJURY CRASH

TYPES OF CRASHES

- REAR END
- RIGHT ANGLE
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- HEAD ON

SHOW FOR EACH CRASH

1. TIME, DAY, DATE
2. WEATHER AND ROAD SURFACE IF UNUSUAL CONDITION EXISTED
3. NITE - IF BETWEEN DUSK AND DAWN

CRASH DIAGRAM

LOG POINT No. 14.57 TO 14.68

PERIOD 3 Years FROM 2011 TO 2013

CITY Cleveland ROUTE NUMBER IR-480

DATE: 1/29/2015

NUMBER OF CRASHES		SYMBOLS	TYPES OF CRASHES	SHOW FOR EACH CRASH
9	PROPERTY DAMAGE ONLY	MOVING VEHICLE	REAR END	1. TIME, DAY, DATE
2	INJURY OR FATAL	BACKING VEHICLE	RIGHT ANGLE	2. WEATHER AND ROAD SURFACE IF UNUSUAL CONDITION EXISTED
11	TOTAL CRASHES	NON-INVOLVED VEH.	SIDE SWIPE	3. NITE - IF BETWEEN DUSK AND DAWN
		PEDESTRIAN	OUT OF CONTROL	
		PARKED VEHICLE	LEFT TURN	
		FIXED OBJECT	HEAD ON	
		FATAL CRASH		
		INJURY CRASH		

CRASH DIAGRAM

LOG POINT No. 14.68 TO 14.80

PERIOD 3 Years FROM 2011 TO 2013

CITY Cleveland ROUTE NUMBER IR-480

DATE: 1/29/2015

NUMBER OF CRASHES

6	PROPERTY DAMAGE ONLY
2	INJURY OR FATAL
8	TOTAL CRASHES

SYMBOLS

- MOVING VEHICLE
- BACKING VEHICLE
- NON-INVOLVED VEH.
- PEDESTRIAN
- PARKED VEHICLE
- FIXED OBJECT
- FATAL CRASH
- INJURY CRASH

TYPES OF CRASHES

- REAR END
- RIGHT ANGLE
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- HEAD ON

SHOW FOR EACH CRASH

1. TIME, DAY, DATE
2. WEATHER AND ROAD SURFACE IF UNUSUAL CONDITION EXISTED
3. NITE - IF BETWEEN DUSK AND DAWN

CRASH DIAGRAM

LOG POINT No. 14.82 TO 14.94

PERIOD 3 Years FROM 2011 TO 2013

CITY Cleveland ROUTE NUMBER IR-480

DATE: 1/29/2015

NUMBER OF CRASHES

4	PROPERTY DAMAGE ONLY
1	INJURY OR FATAL
5	TOTAL CRASHES

SYMBOLS

- MOVING VEHICLE
- BACKING VEHICLE
- NON-INVOLVED VEH.
- PEDESTRIAN
- PARKED VEHICLE
- FIXED OBJECT
- FATAL CRASH
- INJURY CRASH

TYPES OF CRASHES

- REAR END
- RIGHT ANGLE
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- HEAD ON

SHOW FOR EACH CRASH

1. TIME, DAY, DATE
2. WEATHER AND ROAD SURFACE IF UNUSUAL CONDITION EXISTED
3. NITE - IF BETWEEN DUSK AND DAWN

CRASH DIAGRAM

LOG POINT No. 14.98 TO 15.10

PERIOD 3 Years FROM 2011 TO 2013

CITY Cleveland ROUTE NUMBER IR-480

DATE: 1/29/2015

NUMBER OF CRASHES

7	PROPERTY DAMAGE ONLY
5	INJURY OR FATAL
12	TOTAL CRASHES

SYMBOLS

- MOVING VEHICLE
- BACKING VEHICLE
- NON-INVOLVED VEH.
- PEDESTRIAN
- PARKED VEHICLE
- FIXED OBJECT
- FATAL CRASH
- INJURY CRASH

TYPES OF CRASHES

- REAR END
- RIGHT ANGLE
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- HEAD ON

SHOW FOR EACH CRASH

1. TIME, DAY, DATE
2. WEATHER AND ROAD SURFACE IF UNUSUAL CONDITION EXISTED
3. NITE - IF BETWEEN DUSK AND DAWN

CRASH DIAGRAM

LOG POINT No. 15.09 TO 15.21

PERIOD 3 Years FROM 2011 TO 2013

CITY Cleveland ROUTE NUMBER IR-480

DATE: 1/29/2015

NUMBER OF CRASHES

9	PROPERTY DAMAGE ONLY
4	INJURY OR FATAL
13	TOTAL CRASHES

SYMBOLS

- MOVING VEHICLE
- BACKING VEHICLE
- NON-INVOLVED VEH.
- PEDESTRIAN
- PARKED VEHICLE
- FIXED OBJECT
- FATAL CRASH
- INJURY CRASH

TYPES OF CRASHES

- REAR END
- RIGHT ANGLE
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- HEAD ON

SHOW FOR EACH CRASH

1. TIME, DAY, DATE
2. WEATHER AND ROAD SURFACE IF UNUSUAL CONDITION EXISTED
3. NITE - IF BETWEEN DUSK AND DAWN

CRASH DIAGRAM

LOG POINT No. 15.21 TO 15.33

PERIOD 3 Years FROM 2011 TO 2013

CITY Cleveland ROUTE NUMBER IR-480

DATE: 1/29/2015

NUMBER OF CRASHES

14	PROPERTY DAMAGE ONLY
6	INJURY OR FATAL
20	TOTAL CRASHES

SYMBOLS

- MOVING VEHICLE
- BACKING VEHICLE
- NON-INVOLVED VEH.
- PEDESTRIAN
- PARKED VEHICLE
- FIXED OBJECT
- FATAL CRASH
- INJURY CRASH

TYPES OF CRASHES

- REAR END
- RIGHT ANGLE
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- HEAD ON

SHOW FOR EACH CRASH

1. TIME, DAY, DATE
2. WEATHER AND ROAD SURFACE IF UNUSUAL CONDITION EXISTED
3. NITE - IF BETWEEN DUSK AND DAWN

CRASH DIAGRAM

LOG POINT No. 15.33 TO 15.44

PERIOD 3 Years FROM 2011 TO 2013

CITY Cleveland ROUTE NUMBER IR-480

DATE: 1/30/2015

NUMBER OF CRASHES

8	PROPERTY DAMAGE ONLY
2	INJURY OR FATAL
10	TOTAL CRASHES

SYMBOLS

- MOVING VEHICLE
- BACKING VEHICLE
- NON-INVOLVED VEH.
- PEDESTRIAN
- PARKED VEHICLE
- FIXED OBJECT
- FATAL CRASH
- INJURY CRASH

TYPES OF CRASHES

- REAR END
- RIGHT ANGLE
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- HEAD ON

SHOW FOR EACH CRASH

1. TIME, DAY, DATE
2. WEATHER AND ROAD SURFACE IF UNUSUAL CONDITION EXISTED
3. NITE - IF BETWEEN DUSK AND DAWN

CRASH DIAGRAM

LOG POINT No. 15.50 TO 15.61

PERIOD 3 Years FROM 2011 TO 2013

CITY Cleveland ROUTE NUMBER IR-480

DATE: 1/30/2015

NUMBER OF CRASHES

4	PROPERTY DAMAGE ONLY
2	INJURY OR FATAL
6	TOTAL CRASHES

SYMBOLS

- MOVING VEHICLE
- BACKING VEHICLE
- NON-INVOLVED VEH.
- PEDESTRIAN
- PARKED VEHICLE
- FIXED OBJECT
- FATAL CRASH
- INJURY CRASH

TYPES OF CRASHES

- REAR END
- RIGHT ANGLE
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- HEAD ON

SHOW FOR EACH CRASH

1. TIME, DAY, DATE
2. WEATHER AND ROAD SURFACE IF UNUSUAL CONDITION EXISTED
3. NITE - IF BETWEEN DUSK AND DAWN

CRASH DIAGRAM

LOG POINT No. 10.37 TO 10.49

PERIOD 3 Years FROM 2011 TO 2013

CITY Cleveland ROUTE NUMBER SR-176

DATE: 1/30/2015

NUMBER OF CRASHES

3	PROPERTY DAMAGE ONLY
3	INJURY OR FATAL
6	TOTAL CRASHES

SYMBOLS

- MOVING VEHICLE
- BACKING VEHICLE
- NON-INVOLVED VEH.
- PEDESTRIAN
- PARKED VEHICLE
- FIXED OBJECT
- FATAL CRASH
- INJURY CRASH

TYPES OF CRASHES

- REAR END
- RIGHT ANGLE
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- HEAD ON

SHOW FOR EACH CRASH

1. TIME, DAY, DATE
2. WEATHER AND ROAD SURFACE IF UNUSUAL CONDITION EXISTED
3. NITE - IF BETWEEN DUSK AND DAWN

CRASH DIAGRAM

LOG POINT No. 10.51 TO 10.71

PERIOD 3 Years FROM 2011 TO 2013

CITY Cleveland ROUTE NUMBER SR-176

DATE: 1/30/2015

NUMBER OF CRASHES	
7	PROPERTY DAMAGE ONLY
2	INJURY OR FATAL
9	TOTAL CRASHES

SYMBOLS	TYPES OF CRASHES
MOVING VEHICLE	REAR END
BACKING VEHICLE	RIGHT ANGLE
NON-INVOLVED VEH.	SIDE SWIPE
PEDESTRIAN	OUT OF CONTROL
PARKED VEHICLE	LEFT TURN
FIXED OBJECT	HEAD ON
FATAL CRASH	
INJURY CRASH	

SHOW FOR EACH CRASH

1. TIME, DAY, DATE
2. WEATHER AND ROAD SURFACE IF UNUSUAL CONDITION EXISTED
3. NITE - IF BETWEEN DUSK AND DAWN

CRASH DIAGRAM

LOG POINT No. 10.80 TO 10.95

PERIOD 3 Years FROM 2011 TO 2013

CITY Cleveland ROUTE NUMBER SR-176

DATE: 1/30/2015

NUMBER OF CRASHES

13	PROPERTY DAMAGE ONLY
6	INJURY OR FATAL
19	TOTAL CRASHES

SYMBOLS

- MOVING VEHICLE
- BACKING VEHICLE
- NON-INVOLVED VEH.
- PEDESTRIAN
- PARKED VEHICLE
- FIXED OBJECT
- FATAL CRASH
- INJURY CRASH

TYPES OF CRASHES

- REAR END
- RIGHT ANGLE
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- HEAD ON

SHOW FOR EACH CRASH

1. TIME, DAY, DATE
2. WEATHER AND ROAD SURFACE IF UNUSUAL CONDITION EXISTED
3. NITE - IF BETWEEN DUSK AND DAWN

CRASH DIAGRAM

LOG POINT No. 10.15 TO 10.18

PERIOD 3 Years FROM 2011 TO 2013

CITY Cleveland ROUTE NUMBER SR-94

DATE: 1/29/2015

NUMBER OF CRASHES	
38	PROPERTY DAMAGE ONLY
13	INJURY OR FATAL
51	TOTAL CRASHES

SYMBOLS	
	MOVING VEHICLE
	BACKING VEHICLE
	NON-INVOLVED VEH.
	PEDESTRIAN
	PARKED VEHICLE
	FIXED OBJECT
	FATAL CRASH
	INJURY CRASH

TYPES OF CRASHES
REAR END
RIGHT ANGLE
SIDE SWIPE
OUT OF CONTROL
LEFT TURN
HEAD ON

SHOW FOR EACH CRASH

1. TIME, DAY, DATE
2. WEATHER AND ROAD SURFACE IF UNUSUAL CONDITION EXISTED
3. NITE - IF BETWEEN DUSK AND DAWN

CRASH DIAGRAM

LOG POINT No. 10.18 TO 10.35

PERIOD 3 Years FROM 2011 TO 2013

CITY Cleveland ROUTE NUMBER SR-94

DATE: 1/29/2015

NUMBER OF CRASHES

15	PROPERTY DAMAGE ONLY
13	INJURY OR FATAL
28	TOTAL CRASHES

SYMBOLS

- MOVING VEHICLE
- BACKING VEHICLE
- NON-INVOLVED VEH.
- PEDESTRIAN
- PARKED VEHICLE
- FIXED OBJECT
- FATAL CRASH
- INJURY CRASH

TYPES OF CRASHES

- REAR END
- RIGHT ANGLE
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- HEAD ON

SHOW FOR EACH CRASH

1. TIME, DAY, DATE
2. WEATHER AND ROAD SURFACE IF UNUSUAL CONDITION EXISTED
3. NITE - IF BETWEEN DUSK AND DAWN

CRASH DIAGRAM

LOG POINT No. 10.35 TO 10.48

PERIOD 3 Years FROM 2011 TO 2013

CITY Cleveland ROUTE NUMBER SR-94

DATE: 1/29/2015

NUMBER OF CRASHES

9	PROPERTY DAMAGE ONLY
1	INJURY OR FATAL
10	TOTAL CRASHES

SYMBOLS

- MOVING VEHICLE
- BACKING VEHICLE
- NON-INVOLVED VEH.
- PEDESTRIAN
- PARKED VEHICLE
- FIXED OBJECT
- FATAL CRASH
- INJURY CRASH

TYPES OF CRASHES

- REAR END
- RIGHT ANGLE
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- HEAD ON

SHOW FOR EACH CRASH

1. TIME, DAY, DATE
2. WEATHER AND ROAD SURFACE IF UNUSUAL CONDITION EXISTED
3. NITE - IF BETWEEN DUSK AND DAWN

CRASH DIAGRAM

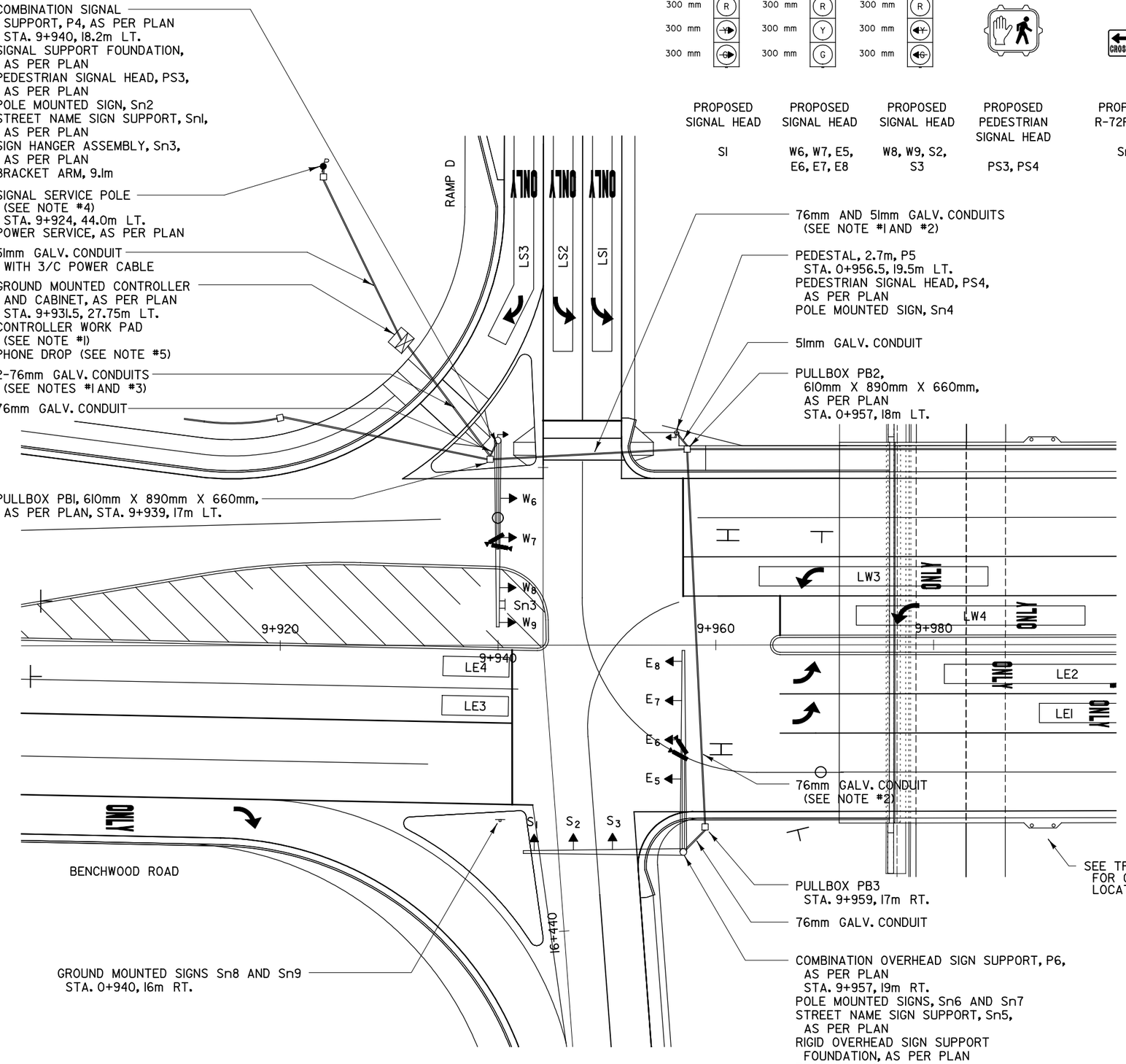
LOG POINT No. 14.34 TO 14.46

PERIOD 3 Years FROM 2011 TO 2013

CITY Cleveland ROUTE NUMBER IR-480

DATE: 1/29/2015

APPENDIX F
SAMPLE TIGHT DIAMOND INTERCHANGE SIGNAL PLAN



VEHICLE DETECTION ZONE SUMMARY

LOOP	DETECTION ZONE DIMENSIONS	CONNECT TO PHASE	PRESENCE/ PULSE	LOCK/ NON-LOCK	(E)XTEND/ (D)ELAY	CAMERA	LOCATION (STA.)	TYPE
LS1	1.8m X 33.5m	3	PRESENCE	LOCK	-	8	16+491	-
LS2	1.8m X 33.5m	3	PRESENCE	LOCK	-	8	16+491	-
LS3	1.8m X 33.5m	3	PRESENCE	LOCK	-	8	16+491	-
Q3	1.8m X 9.1m	-	PRESENCE	NON-LOCK	(D) 7 sec.	7	16+644	SPLIT
Q4	1.8m X 9.1m	-	PRESENCE	NON-LOCK	(D) 7 sec.	7	16+644	SPLIT
SL5	6.1m X 1.8m	-	PRESENCE	NON-LOCK	-	7	16+658	CYCLE
SL6	1.8m X 1.8m	-	PRESENCE	NON-LOCK	-	9	9+841.5	CYCLE
SL7	1.8m X 1.8m	-	PRESENCE	NON-LOCK	-	9	9+841.5	CYCLE
LE3	1.8m X 6.1m	6	PRESENCE	LOCK	(E) 3 sec.	10	9+940	-
LE4	1.8m X 6.1m	6	PRESENCE	LOCK	(E) 3 sec.	10	9+940	-
LW3	1.8m X 2m	1&4	PRESENCE	LOCK	-	5&6	9+964	-
LW4	1.8m X 2m	1&4	PRESENCE	LOCK	-	5&6	9+973	-

NOTE: See Interconnect Plan for camera locations. Location (STA.) reference is measured to detection zonenearest the stopline.

NOTES:
1. The minimum bend radius of the embedded conduit ell shall be equal to or greater than 305mm.
2. The contractor shall coordinate as necessary to permit galvanized conduit to be installed in advance of any pavement construction.
3. See Lighting Plans for conduit path and quantities of lighting circuit.
4. Payment for the wood pole and pullbox is included with power service (lump sum).
5. A second phone drop shall be installed at the ODOT District 7 offices as directed by the Engineer for connection of the Central Office Monitor.

N

HORIZONTAL SCALE IN METERS
0 2 4 8

CALCULATED CWG
CHECKED SAK

TRAFFIC SIGNAL PLAN
I-75 SB EXIT RAMP (RAMP D) AND BENCHWOOD ROAD

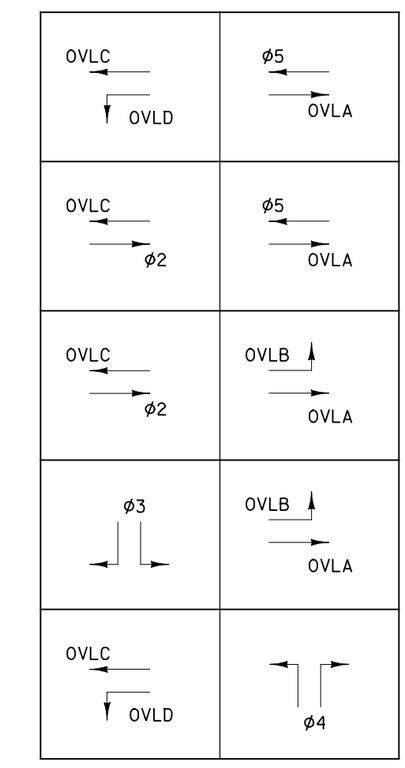
MOT-75-29.305

631
803

SUB-SUMMARY

ITEM	QUAN.	UNIT	DESCRIPTION
625	2	Each	Bracket Arm, 9.1 Meter
625	39	Meter	Conduit, 51mm, 713.04
625	83	Meter	Conduit, 76mm, 713.04
625	70.5	Meter	Trench
625	1	Each	Pullbox, 450mm, 713.08
625	2	Each	Pullbox, Misc.: Pullbox, 713.081, 610mm x 890mm x 660mm, As Per Plan
625	4	Each	Ground Rod
630	3.8	Meter	Ground Mounted Support, No. 3 Post
630	2	Each	Street Name Sign Support, As Per Plan
630	1	Each	Overhead Sign Support, Misc.: Combination Overhead Sign Support, Type TC-9.30M, 18.2m/14.4m, As Per Plan
630	1	Each	Sign Hanger Assembly, Mast Arm, As Per Plan
630	4	Each	Sign Support Assembly, Pole Mounted
630	2.23	SqMeter	Sign, Flat Sheet, Type G
630	2	Each	Sign, Double Faced, Street Name, Type G, As Per Plan
630	1	Each	Rigid Overhead Sign Support Foundation, As Per Plan
632	11	Each	Vehicular Signal Head, 3 Section, 300mm Lens, 1-Way, As Per Plan "A"
632	2	Each	Pedestrian Signal Head, Type D2, As Per Plan "A"
632	11	Each	Covering of Vehicular Signal Head
632	2	Each	Covering of Pedestrian Signal Head
632	392	Meter	Signal Cable, 5 Conductor, No. 14 AWG
632	50	Meter	Signal Cable, 3 Conductor, No. 12 AWG
632	178	Meter	Signal Cable, 5 Conductor, No. 12 AWG
632	50	Meter	Interconnect Cable, 6 Pair, No. 19 AWG, Solid, REA (PE-39), As Per Plan
632	2	Each	Phone Drop
632	1	Each	Signal Support Foundation, As Per Plan
632	1	Each	Pedestal Foundation
632	25	Meter	Power Cable, 2 Conductor, No. 6 AWG
632	1	Each	Power Service, As Per Plan
632	1	Each	Combination Signal Support, Misc.: Combination Signal Support, Type TC-81.20M, 16.8 m, As Per Plan
632	1	Each	Pedestal, 2.4m, Transformer Base
632	1	Lump	Signalization, Misc.: Optical Detection, As Per Plan
633	1	Each	Controller, Misc.: Controller, Actuated, 12 Phase, Solid State Digital Microprocessor, As Per Plan "A"
633	1	Each	Controller, Master, Traffic Responsive, As Per Plan
633	1.4	CuMeter	Concrete For Cabinet Foundation
633	1.04	SqMeter	Controller Work Pad

PHASING DIAGRAM



OVLA - 1,2,3,5,6

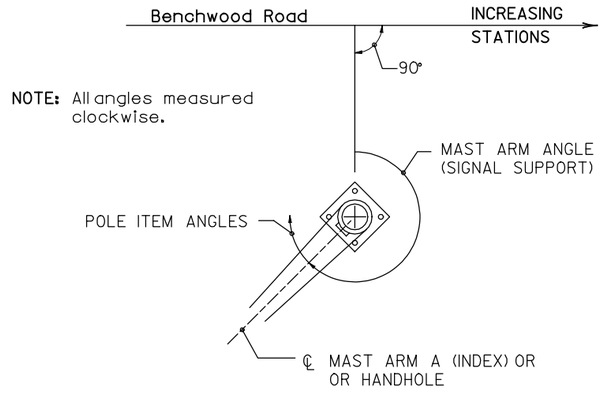
OVLB - 3,6

OVLC - 1,2,4,5,6

OVLD - 1,4

POLE ORIENTATION

POLE No/Ref	POLE HEIGHT (m)	INDEX LINE ANGLE (DEG)	ANGLE (DEG) FROM INDEX LINE: PEDESTRIAN SIGNAL	PEDESTRIAN PUSHBUTTON	WEATHERHEAD	CONDUIT ELL	POLE MTD SIGN	STREET NAME SIGN	SIGNAL HEAD	MASTARM B
P4	10.2	0 °	180 °	- °	0 °	45°	0 °	90°	- °	- °
P5	2.4	0 °	0 °	- °	- °	315 °	0 °	- °	- °	- °
P6	10.2	0 °	- °	- °	0 °	45°	0 °	- °	- °	270°
-	--	- °	- °	- °	- °	- °	- °	- °	- °	- °



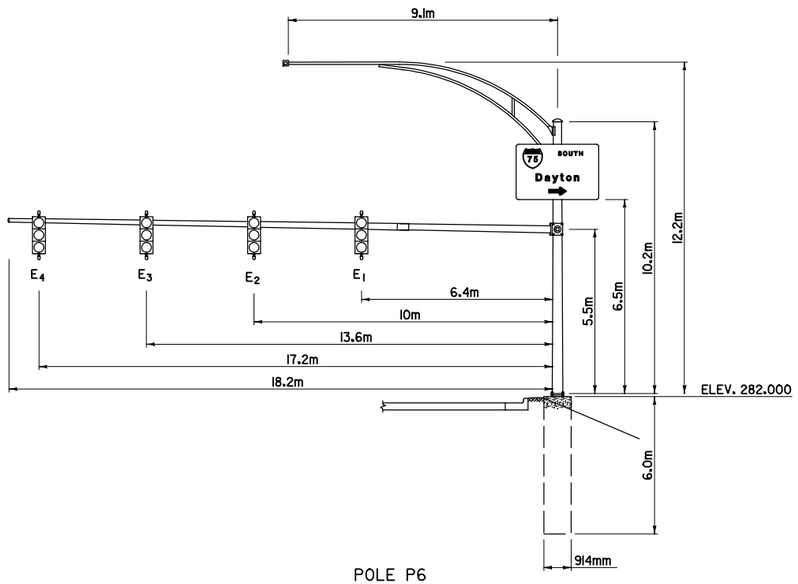
NOTE: All angles measured clockwise.

HORIZONTAL SCALE IN METERS

CALCULATED CWG CHECKED SAK

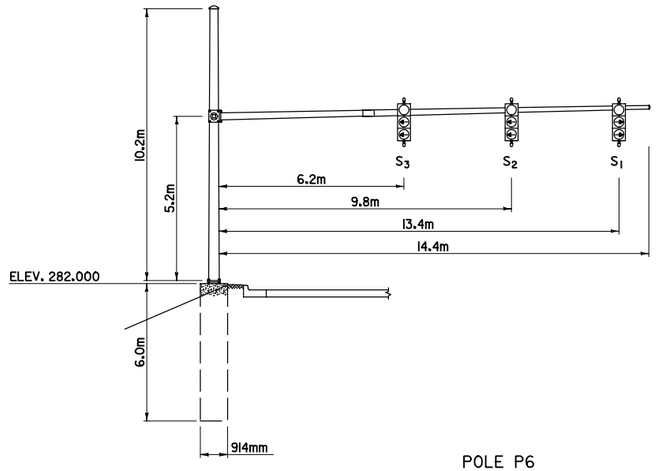
TRAFFIC SIGNAL DETAILS
I-75 SB EXIT RAMP (RAMP D) AND BENCHWOOD ROAD

MOT-75-29.305



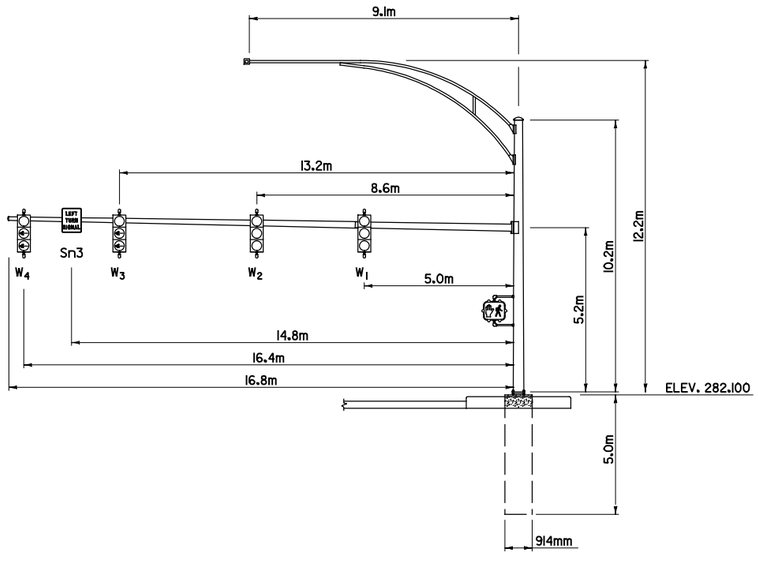
POLE P6

EASTBOUND ELEVATION



POLE P6

SOUTHBOUND ELEVATION



POLE P4

WESTBOUND ELEVATION

DESCRIPTION	DEAD LOAD (lbs)	RIGID ATTACH LOAD (lbs)	AREA (m^2/ft^2)
Vehicular Signal Head, 3 Section	88	25	0.38/4.08
Sign (Sn3)	19	30	0.70/7.5
Guide Sign (Each)	350	225	4.095/44.08
Bracket Arm	550	-	-

HORIZONTAL SCALE IN METERS

CALCULATED CWG

CHECKED SAK

TRAFFIC SIGNAL DETAILS

I-75 SB EXIT RAMP (RAMP D) AND BENCHWOOD ROAD

MOT-75-29.305

TRAFFIC SIGNAL CONTROLLER TIMING CHART

INTERSECTION Benchwood Road and Miller Lane

COORDINATION TIMING

CYCLE/OFFSET	PHASE (sec)								TIME
	1	2	3	4	5	6	7	8	
FREE									0:00 - 05:00
70 / 13	13	21	-	36	-	34	14	22	05:00 - 06:30
100 / 13	14	31	-	55	-	45	24	31	06:30 - 08:30
85 / 18	14	29	-	42	-	43	16	26	08:30 - 16:00
100 / 86	13	30	-	57	-	43	26	31	16:00 - 19:00
85 / 18	14	29	-	42	-	43	16	26	19:00 - 21:00
70 / 13	13	21	-	36	-	34	14	22	21:00 - 23:00
FREE									23:00 - 24:00

SPECIAL PATTERNS

CYCLE/OFFSET	PHASE (sec)								PATTERN
	1	2	3	4	5	6	7	8	
120 / 87	18	47		55		65	25	30	Sb EVENT
120 / 113	18	47		55		65	25	30	Nb EVENT
120 / 106	18	45		57		63	27	30	INTERSTATE PK
120 / 20	22	38		60		60	27	33	CHRISTMAS

NOTE: See Traffic Signal Plan For Additional Information.

TRAFFIC SIGNAL CONTROLLER TIMING CHART

INTERSECTION Wyse Road and Poe/Wyse Connector

COORDINATION TIMING

CYCLE/OFFSET	PHASE (sec)								TIME
	1	2	3	4	5	6	7	8	
FREE	-								0:00 - 05:00
70 / 7	-	30	-	15	-	30	-	25	05:00 - 06:30
100 / 23	-	41	-	16	-	41	-	43	06:30 - 08:30
85 / 13	-	38	-	15	-	38	-	32	08:30 - 16:00
100 / 38	-	40	-	18	-	40	-	42	16:00 - 19:00
85 / 13	-	38	-	15	-	38	-	32	19:00 - 21:00
70 / 7	-	30	-	15	-	30	-	25	21:00 - 23:00
FREE	-								23:00 - 24:00

SPECIAL PATTERNS

CYCLE/OFFSET	PHASE (sec)								PATTERN
	1	2	3	4	5	6	7	8	
120 /60		55		15		55		50	Sb EVENT
120 /72		55		15		55		50	Nb EVENT
120 /54		55		18		55		47	INTERSTATE PK
120 /29		100		15		60		45	CHRISTMAS

NOTE: See Traffic Signal Plan For Additional Information.

TRAFFIC SIGNAL CONTROLLER TIMING CHART

INTERSECTION I-75 and Benchwood/Wyse Road

START UP
START IN: Y/R FLASH ○; ALL RED ●
TIME FOR FLASH OR ALL RED 5 sec
FIRST PHASE(S) *2 & *5
COLOR DISPLAYED: GREEN ●; YELLOW ○

DUAL ENTRY ● RING 1
REST IN RED: RING 1 ○ ; RING 2 ○

OVERLAP	A	B	C	D
PHASES	1+2+3+5+6	3+6	1+2+4+5+6	1+4

INTERVAL OR FEATURE		CONTROLLER MOVEMENT No. 1	2	3	4	5	6	7	8
INTERSECTION MOVEMENT		WB Lt(L)	EB Th(L)	SB (L)	NB (R)	WB Th(R)	EB Lt(R)		
MINIMUM GREEN (INITIAL)	(SEC.)	6	7	7	7	7	6		
PASSAGE TIME (PRESET GAP)	(SEC.)								
MAXIMUM GREEN I	(SEC.)	20	15	30	30	15	20		
MAXIMUM GREEN II	(SEC.)	20	15	40	40	15	20		
YELLOW CHANGE	(SEC.)	3.6	3.4	3.3	3.4	3.4	3.6		
ALL RED CLEARANCE	(SEC.)	1.7	0.7	1.5	1.7	1.0	1.4		
WALK	(SEC.)		6			6			
PED. CLEAR THRU YELLOW	(SEC.)		6			6			
RECALL	MAXIMUM (NO/YES)								
	MINIMUM (NO/YES)	Y	N	N	N	N	Y		
	PEDESTRAIN (NO/YES)	N	Y	N	N	Y	N		
MEMORY	(ON/OFF)	ON	-	-	ON	-	ON		
CALL TO NON-ACTUATED	No. 1		X			X			
	No. 2								

COORDINATION TIMING

CYCLE/OFFSET	PHASE (sec)								TIME
	1	2	3	4	5	6	7	8	
FREE									0:00 - 05:00
70 / 0	13	18	19	20	18	13			05:00 - 06:30
100 / 0	21	17	30	32	21	17			06:30 - 08:30
85 / 0	23	21	20	21	23	21			08:30 - 16:00
100 / 0	23	22	25	30	23	22			16:00 - 19:00
85 / 0	23	21	20	21	23	21			19:00 - 21:00
70 / 0	13	18	19	20	18	13			21:00 - 23:00
FREE									23:00 - 24:00

SPECIAL PATTERNS

CYCLE/OFFSET	PHASE (sec)								PATTERN
	1	2	3	4	5	6	7	8	
120 / 0	18	28	45	29	26	20			Sb EVENT
120 / 0	22	28	28	42	22	28			Nb EVENT
120 / 0	22	22	33	43	22	22			INTERSTATE PK
120 / 0	28	28	28	36	28	28			CHRISTMAS

INTERVALS/PHASES

MOVEMENT		SIG.	FLASH	PHASE 1				2				3				4				5				6				7				8			
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1 Eb Th(L)	VEH	E5-8	R	R	R	R		G	G	G		G	Y	R		R	R	R		R	R	R													
	PED																																		
2 Wb Lt(L)	VEH	W8-9	R	~~G~~	~~Y~~	R		R	R	R		R	R	R		R	R	R		~~G~~	~~G~~	~~G~~													
3 Wb Th(L)	VEH	W6-7	R	G	G	G		G	G	G		G	Y	R		R	R	R		G	G	G													
	PED																																		
4 Sb	VEH	S1-3	R	R	R	R		R	R	R		R	R	R		G	Y	R		R	R	R													
5 Eb Th(R)	VEH	E1-2	R	G	G	G		G	G	G		G	G	G		G	Y	R		R	R	R													
	PED																																		
6 Eb Lt(R)	VEH	E3-4	R	R	R	R		R	R	R		~~G~~	~~G~~	~~G~~		~~G~~	~~Y~~	R		R	R	R													
	PED																																		
7 Wb Th(R)	VEH	W1-5	R	G	G	G		G	Y	R		R	R	R		R	R	R		R	R	R													
	PED																																		
8 Nb	VEH	N1-3	R	R	R	R		R	R	R		R	R	R		R	R	R		G	Y	R													

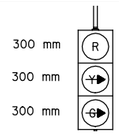
NOTE: (L) Denotes Left intersection (Ramp D) and (R) denote Right intersection (Ramp B).

HORIZONTAL SCALE IN METERS

CALCULATED SDG CHECKED SAK

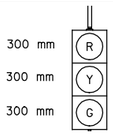
TRAFFIC SIGNAL TIMING

MOT-75-29.305



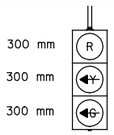
PROPOSED SIGNAL HEAD

N1



PROPOSED SIGNAL HEAD

E1, E2, W1, W2, W3, W4, W5



PROPOSED SIGNAL HEAD

E3, E4, N2, N3

PROPOSED PEDESTRIAN SIGNAL HEAD

PS1, PS2

PROPOSED R-72F(L)-18

Sn9

PROPOSED R-72F(R)-18

Sn7

PROPOSED R-72E-18

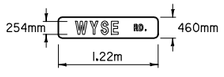
Sn2, Sn4, Sn6, Sn8

PROPOSED R-25E(L)-24

Sn3

PROPOSED R-23-24

Sn10

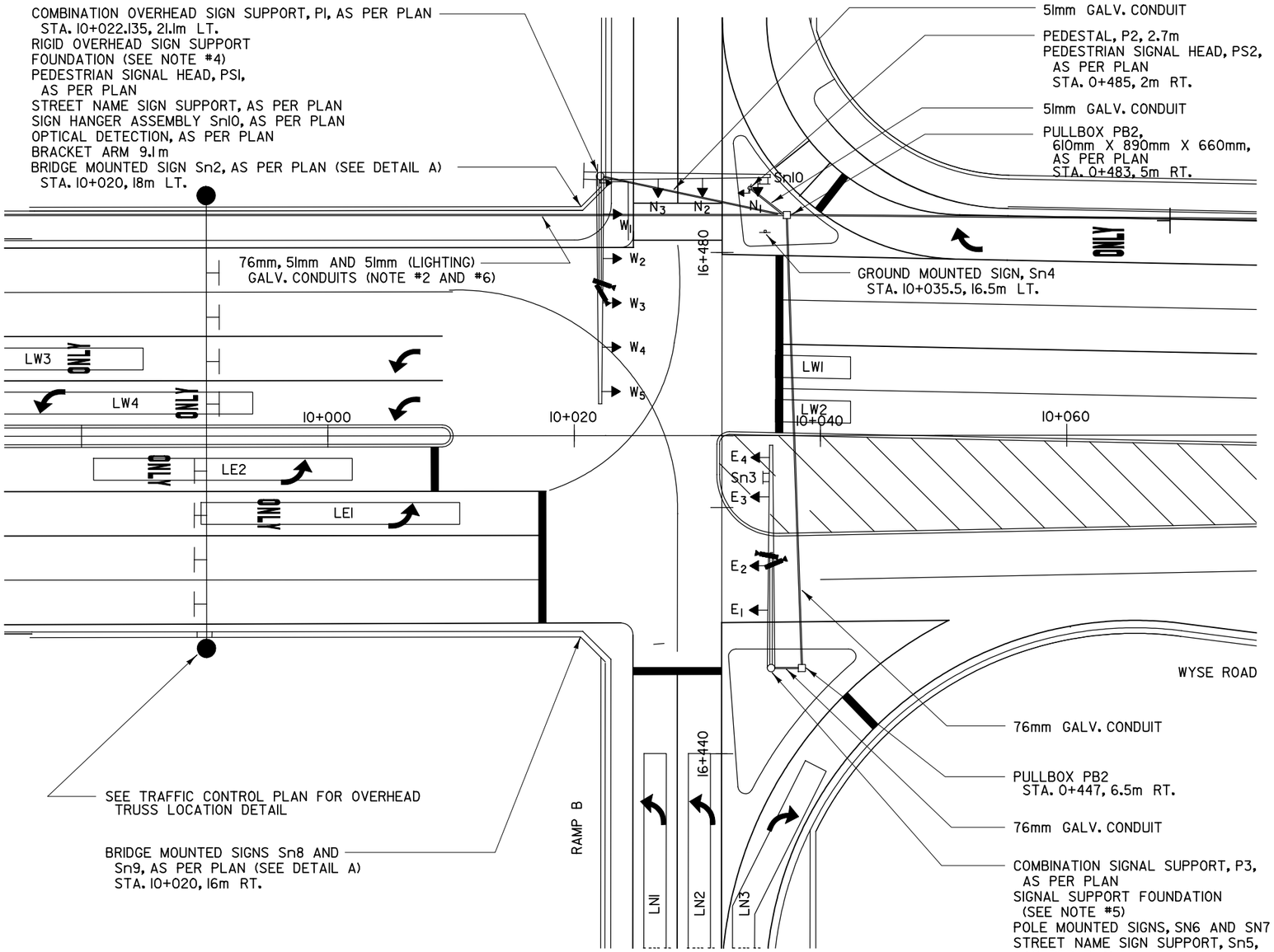


PROPOSED SPECIAL

Sn1, Sn5

POLE ORIENTATION

POLE No/Ref	POLE HEIGHT (m)	INDEX LINE ANGLE (DEG)	ANGLE (DEG) FROM INDEX LINE: PEDESTRIAN SIGNAL	PEDESTRIAN PUSHBUTTON	WEATHERHEAD	CONDUIT ELL	POLE MTD SIGN	STREET NAME SIGN	MASTARM B
P1	10.2	0 °	0 °	- °	0 °	280°	- °	270°	270°
P2	2.4	0 °	0 °	- °	- °	315 °	- °	- °	- °
P3	10.2	0 °	- °	- °	0 °	225°	0 °	270°	- °
P4	--	- °	- °	- °	- °	- °	- °	- °	- °



VEHICLE DETECTION ZONE SUMMARY

LOOP	DETECTION ZONE DIMENSIONS	CONNECT TO PHASE	PRESENCE/ PULSE	LOCK/ NON-LOCK	(E)XTEND/ (D)ELAY	CAMERA	LOCATION (STA.)	TYPE
LN1	1.8m X 33.5m	4	PRESENCE	LOCK	-	1	16+440	-
LN2	1.8m X 33.5m	4	PRESENCE	LOCK	-	1	16+440	-
LN3	1.8m X 33.5m	4	PRESENCE	LOCK	-	1	16+440	-
Q1	1.8m X 9.1m	-	PRESENCE	NON-LOCK	(D) 7 sec.	4	16+290	SPLIT
Q2	1.8m X 9.1m	-	PRESENCE	NON-LOCK	(D) 7 sec.	4	16+290	SPLIT
SL1	6.1m X 1.8m	-	PRESENCE	NON-LOCK	-	4	16+273	CYCLE
SL2	1.8m X 1.8m	-	PRESENCE	NON-LOCK	-	2	10+185	CYCLE
SL3	1.8m X 1.8m	-	PRESENCE	NON-LOCK	-	2	10+185	CYCLE
SL4	1.8m X 1.8m	-	PRESENCE	NON-LOCK	-	2	10+185	CYCLE
LW1	1.8m X 6.1m	1	PRESENCE	LOCK	(E) 3 sec.	3	10+037	-
LW2	1.8m X 6.1m	1	PRESENCE	LOCK	(E) 3 sec.	3	10+037	-
LE1	1.8m X 21m	3&6	PRESENCE	LOCK	-	5&6	10+002	-
LE2	1.8m X 21m	3&6	PRESENCE	LOCK	-	5&6	10+011	-

NOTE: See Interconnect Plan for camera locations. Location (STA.) reference is measured to detection zone nearest the stopline.

NOTES:

1. The minimum bend radius of the embedded conduit ell shall be equal to or greater than 305mm.
2. See Lighting Plans for conduit path and quantities of lighting circuit.
3. The contractor shall coordinate as necessary to permit galvanized conduit to be installed in advance of any roadway construction.
4. A detail of the rigid overhead support foundation for Pole P1 is shown as part of the bridge plans for MOT-75-30272 on Sheets 664-666 of 803. The signal contractor shall coordinate to ensure proper placement of the rigid overhead support foundation.
5. Signal support foundations requirements for Pole P3 are given on sheet 635. The signal contractor shall coordinate to ensure proper placement of the signal support foundation within the embankment of the MSE wall.
6. The conduit path shall be constructed in accordance with ODOT standard construction drawing HL-30.31M (5-1-95).

N

HORIZONTAL SCALE IN METERS
0 2 4 8

CALCULATED CWG
CHECKED SAK

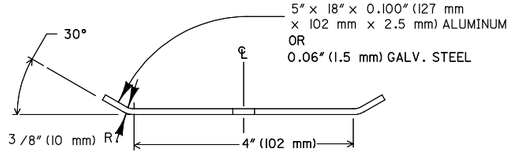
SIGNAL PLAN
TRAFFIC SIGNAL PLAN (RAMP B) AND WYSE ROAD
I-75 NB EXIT RAMP

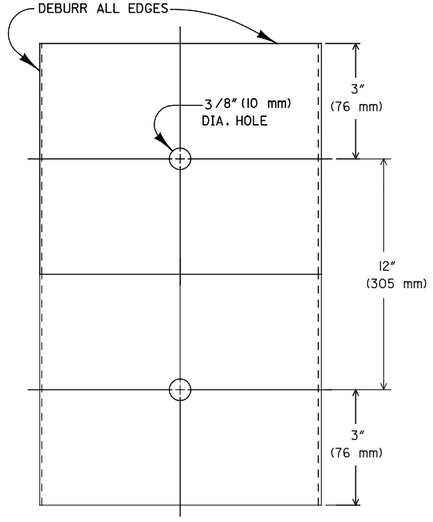
MOT-75-29.305

634
803

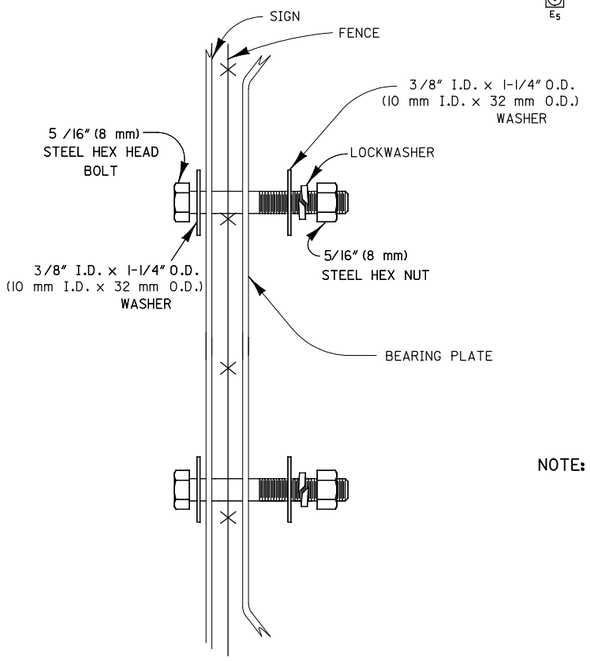
SUB-SUMMARY

ITEM	QUAN.	UNIT	DESCRIPTION
625	2	Each	Bracket Arm, 9.1 Meter
625	100.5	Meter	Conduit, 51mm, 713.04
625	118.5	Meter	Conduit, 76mm, 713.04
625	72	Meter	Trench
625	1	Each	Pullbox, 450mm, 713.08
625	1	Each	Pullbox, Misc.: Pullbox, 713.081, 610mm x 890mm x 660mm, As Per Plan
625	3	Each	Ground Rod
630	3.8	Meter	Ground Mounted Support, No. 3 Post
630	2	Each	Street Name Sign Support, As Per Plan
630	1	Each	Overhead Sign Support, Misc.: Combination Overhead Sign Support, Type TC-9.30M, 18.2m/13.5m, As Per Plan
630	2	Each	Sign Hanger Assembly, Mast Arm, As Per Plan
630	2	Each	Sign Support Assembly, Pole Mounted
630	3	Each	Sign Support Assembly, Bridge Mounted, As Per Plan
630	2.6	SqMeter	Sign, Flat Sheet, Type G
630	2	Each	Sign, Double Faced, Street Name, Type G, As Per Plan
632	10	Each	Vehicular Signal Head, 3 Section, 300mm Lens, 1-Way, As Per Plan "A"
632	2	Each	Pedestrian Signal Head, Type D2, As Per Plan "A"
632	10	Each	Covering of Vehicular Signal Head
632	2	Each	Covering of Pedestrian Signal Head
632	81	Meter	Signal Cable, 3 Conductor, No. 12 AWG
632	660	Meter	Signal Cable, 5 Conductor, No. 12 AWG
632	81	Meter	Interconnect Cable, 6 Pair, No. 19 AWG, Solid, REA (PE-39), As Per Plan
632	1	Each	Signal Support Foundation, As Per Plan
632	1	Each	Pedestal Foundation
632	1	Each	Combination Signal Support, Misc.: Combination Signal Support, TypeTC-81.20M, 17.8 m, As Per Plan
632	1	Each	Pedestal, 2.4m, Transformer Base



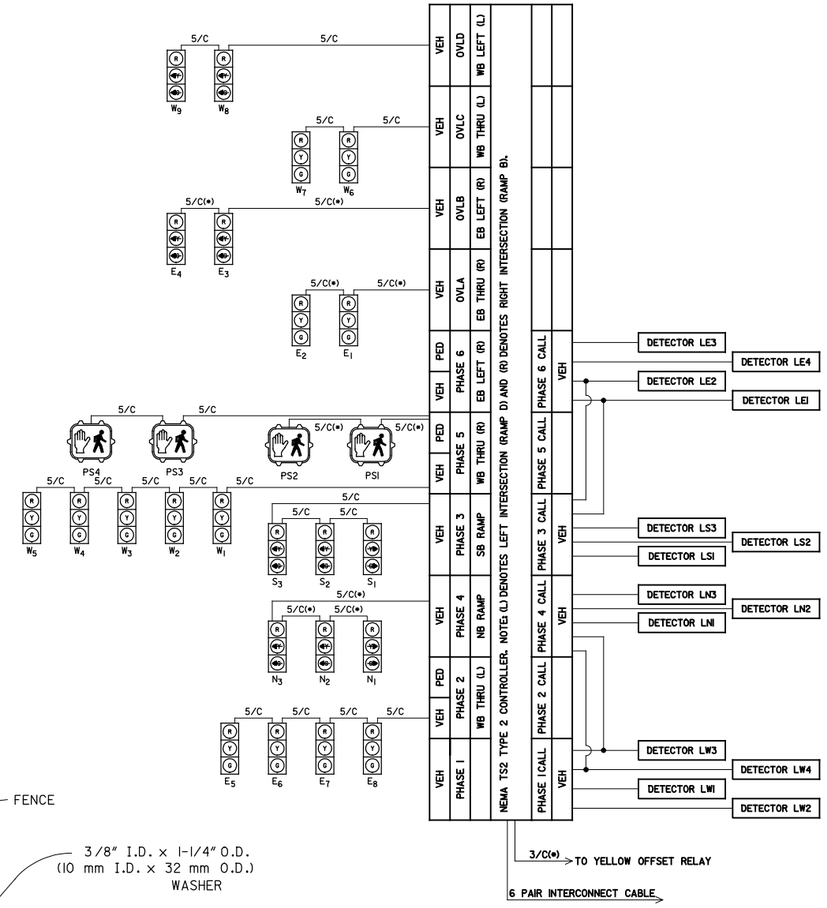


BEARING PLATE



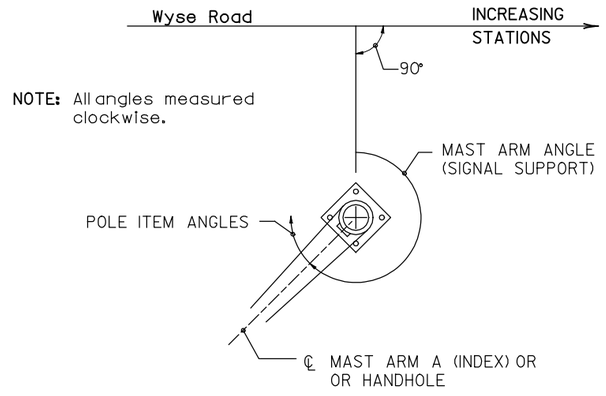
BRIDGE MOUNTED

SIGN ATTACHMENT DETAIL A



WIRING DIAGRAM

(•) = 12 AWG SIGNAL CABLE



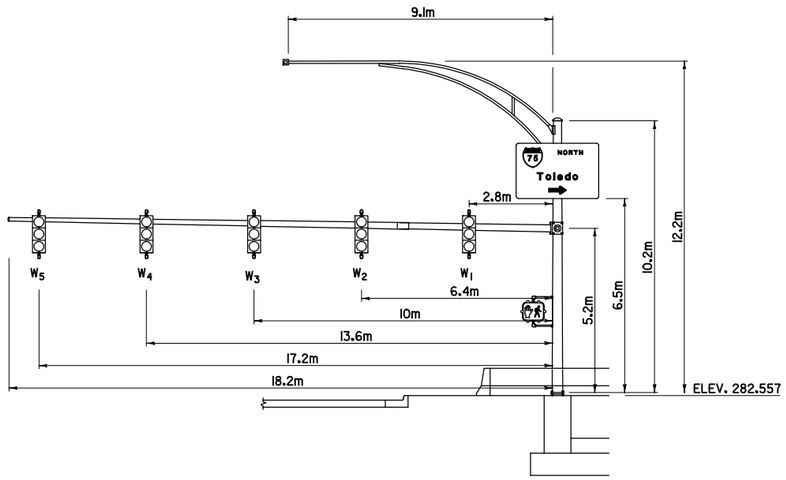
HORIZONTAL SCALE IN METERS

CALCULATED SCC CHECKED SAK

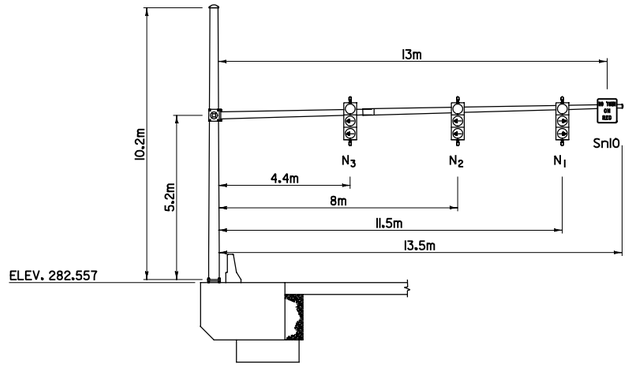
TRAFFIC SIGNAL DETAILS
I-75 NB EXIT RAMP (RAMP B) AND WYSE ROAD

MOT-75-29.305

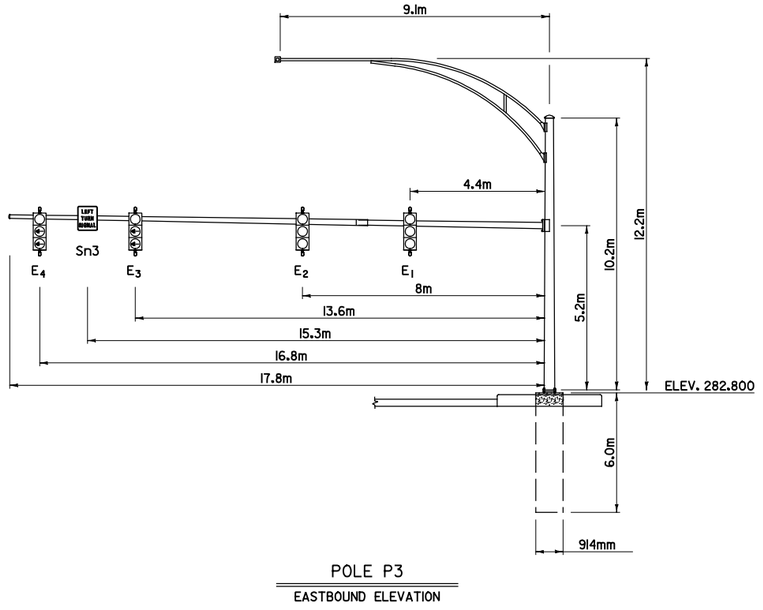
636
803



POLE P1
WESTBOUND ELEVATION



POLE P1
NORTHBOUND ELEVATION



POLE P3
EASTBOUND ELEVATION

DESCRIPTION	DEAD LOAD (lbs)	RIGID ATTACH LOAD (lbs)	AREA (m^2/ft^2)
Vehicular Signal Head, 3 Section	88	25	0.38/4.08
Sign (Sn3)	19	30	0.70/7.5
Sign (Sn10)	15	30	0.37/4.0
Guide Sign (Each)	350	225	4.095/44.08
Bracket Arm	550	-	-

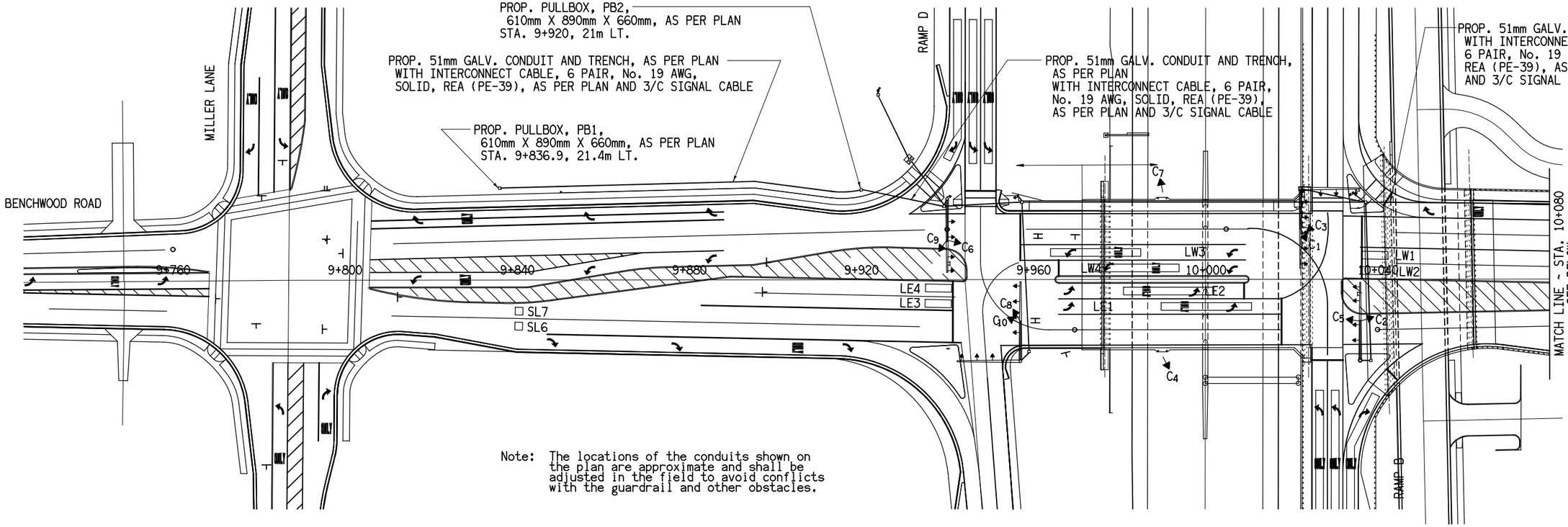
HORIZONTAL SCALE IN METERS

CALCULATED SDG
CHECKED SAK

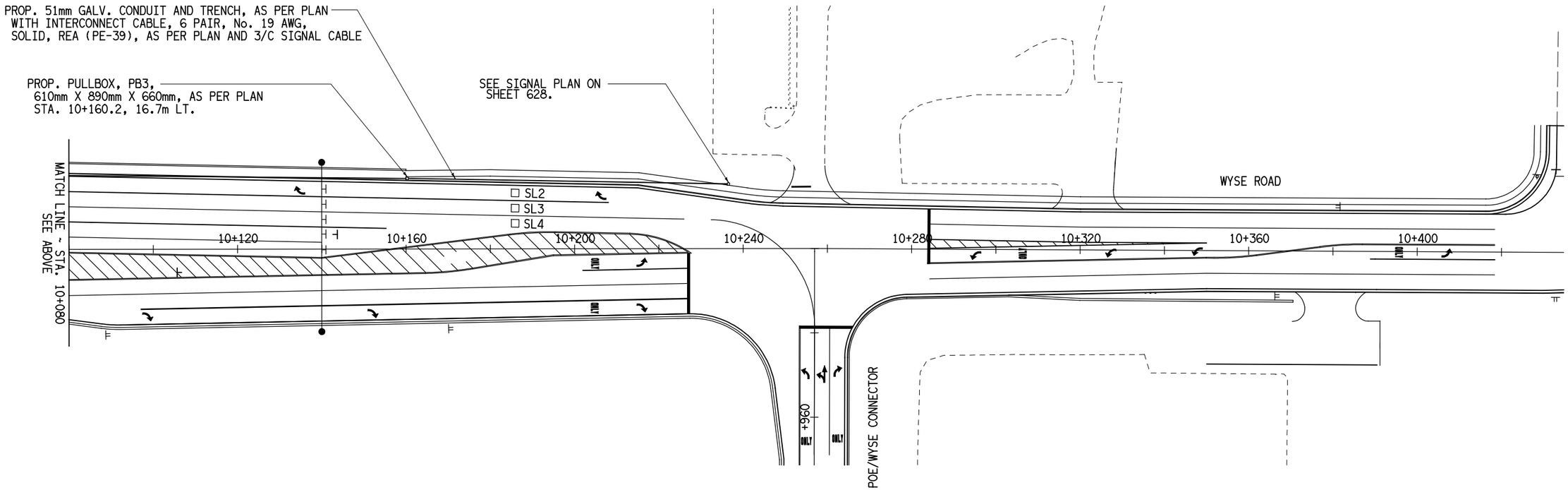
TRAFFIC SIGNAL DETAILS
I-75 NB EXIT RAMP (RAMP B) AND WYSE ROAD

MOT-75-29.305

635
803



C_8 ← = VIDEO DETECTION CAMERA

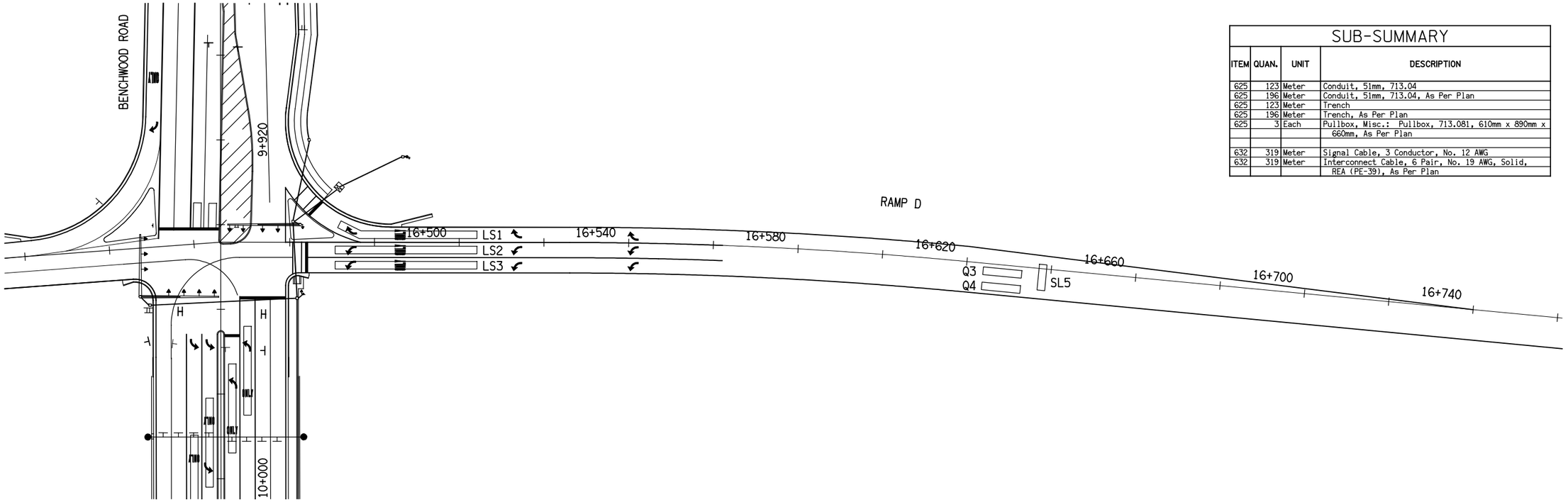


HORIZONTAL SCALE IN METERS
0 5 10 20

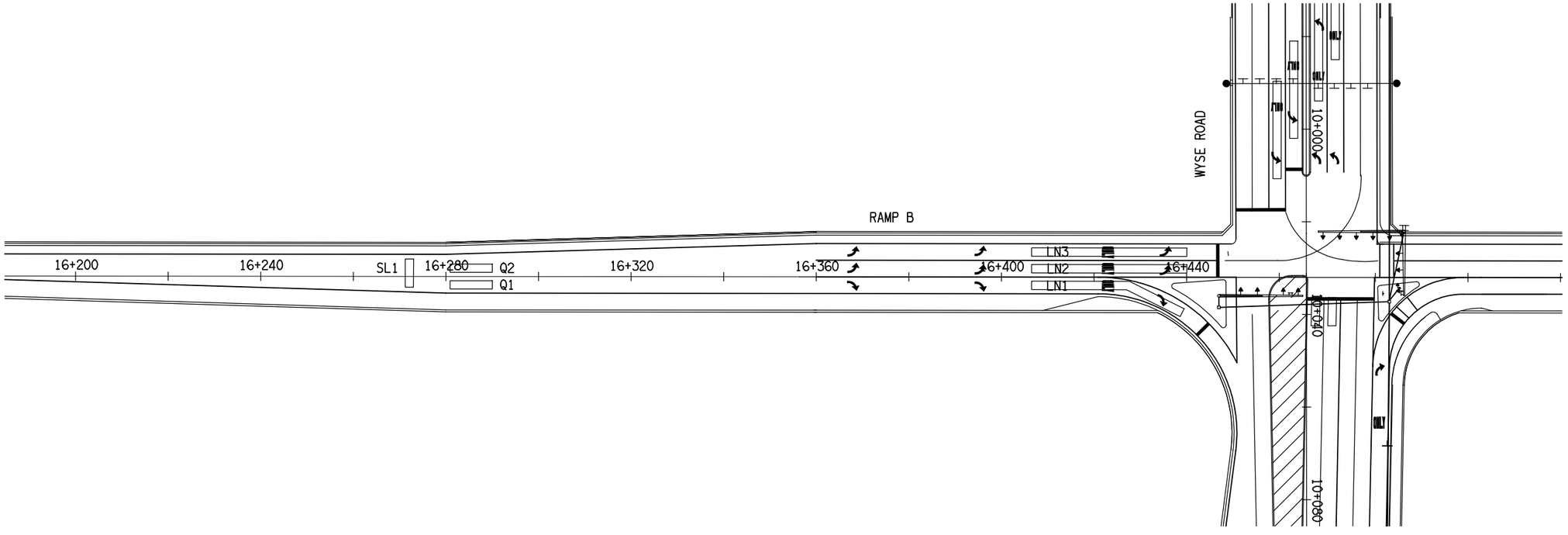
CALCULATED CWG
CHECKED SAK

INTERCONNECT PLAN
STA. 9+740 TO STA. 10+400

MOT-75-29.305



SUB-SUMMARY			
ITEM	QUAN.	UNIT	DESCRIPTION
625	123	Meter	Conduit, 51mm, 713.04
625	196	Meter	Conduit, 51mm, 713.04, As Per Plan
625	123	Meter	Trench
625	196	Meter	Trench, As Per Plan
625	3	Each	Pullbox, Misc.: Pullbox, 713.081, 610mm x 890mm x 660mm, As Per Plan
632	319	Meter	Signal Cable, 3 Conductor, No. 12 AWG
632	319	Meter	Interconnect Cable, 6 Pair, No. 19 AWG, Solid, REA (PE-39), As Per Plan



0 5 10 20
HORIZONTAL SCALE IN METERS

CALCULATED CWG
CHECKED SAK

INTERCONNECT PLAN RAMP B AND RAMP D

MOT-75-29.305

640
803

APPENDIX G
SIGNAL WARRANT ANALYSIS

SIGNAL WARRANT ANALYSIS

Traffic signals may be removed if the intersection does not meet at least one of the criteria specified in the Ohio Manual of Uniform Traffic Control Devices (OMUTCD), Section 4C.02.

- **Warrant 1, Eight-Hour Vehicular Volume:** This warrant requires traffic volumes on both the major and minor street approaches to satisfy minimum criteria for eight hours of an average day.
- **Warrant #2: Four Hour Volume.** This warrant requires that for a minimum of four hours of an average day traffic volumes on both the major and minor street fall above the applicable curve in the attached figures. The Four-Hour signal warrant conditions are intended to be applied where the volume of intersecting traffic is the principal reason to consider installing a traffic signal.
- **Warrant 3, Peak Hour**: This warrant requires that for a minimum of one hour of an average day traffic volumes on both the major and minor street fall above the applicable curve in the attached figures. The minimum side street volume is 150 vehicles in the peak hour. Warrant 3 is intended for use where traffic conditions are such that for a minimum of one hour of an average day, minor street traffic experiences undue delay when entering or crossing the major street.

Existing traffic volumes at State Road and Ralph Avenue/Burger Avenue intersection were evaluated against eight-hour, four-hour and peak-hour signal warrant criteria.

Warrants were evaluated based on low speed criteria applicable for roadways with posted speed limits of 40 miles per hour or less. The posted speed limit on State Road is 35 mph. State Road is considered the major street with two approach lanes, and Ralph Avenue/Burger Avenue as a minor street with a single lane. No reduction of right-turning vehicles was applied to side street traffic volumes.

Results indicate that the study intersection does not justify traffic signal control, as summarized in **Table I-1.** Detailed signal warrant worksheets are appended.

TABLE I-1: SIGNAL WARRANT SUMMARY

SIGNAL WARRANT	STATE/BURGER/RALPH
Warrant 1: 8 –Hour Vehicular Volume	**Warrant Not Met**
Warrant 2: 4-Hour Vehicular Volume	**Warrant Not Met**
Warrant 3: Peak Hour Volume	**Warrant Not Met**

Date: Thursday, October 30, 2014
Jurisdiction: Cleveland, Ohio
Intersection: State Road @ Ralph/Burger
Number of APPROACH Lanes:
Major Street = 2
Minor Street = 1
Speed Limit = 35 (mph)
Population above 10,000? Yes
70% Warrant Apply? No

Traffic Signal Warrant (OMUTCD - 2005)

	Warrant 1 - Condition A				Warrant 1 - Condition B			
	100%	80%	70%	56%	100%	80%	70%	56%
Major Approach:	600	480	420	336	900	720	630	504
Minor Approach:	150	120	105	84	75	60	53	42
Mid - 1AM								
1AM - 2AM								
2:00 AM								
3:00 AM								
4:00 AM								
5:00 AM								
6:00 AM								
7:00 AM						+	+	+
8:00 AM						+	+	+
9:00 AM								+
10:00 AM								
11:00 AM								
Noon - 1PM								
1PM - 2PM								
2:00 PM						+	+	+
3:00 PM				+	+	+	+	+
4:00 PM				+	+	+	+	+
5:00 PM				+	+	+	+	+
6:00 PM								
7:00 PM								
8:00 PM								
9:00 PM								
10:00 PM								
11:00 PM								
Hours Met =	0	0	0	3	3	6	6	7

Data:	Major St:		TOTAL	Minor St:		> OF TWO
Mid - 1AM	0	0	0	0	0	0
1AM - 2AM	0	0	0	0	0	0
2:00 AM	0	0	0	0	0	0
3:00 AM	0	0	0	0	0	0
4:00 AM	0	0	0	0	0	0
5:00 AM	0	0	0	0	0	0
6:00 AM	282	152	434	27	38	38
7:00 AM	516	541	1057	64	68	68
8:00 AM	561	627	1188	64	51	64
9:00 AM	377	396	773	51	44	51
10:00 AM	82	175	257	21	19	21
11:00 AM	0	0	0	0	0	0
Noon - 1PM	0	0	0	0	0	0
1PM - 2PM	79	0	79	0	0	0
2:00 PM	508	609	1117	63	60	63
3:00 PM	819	774	1593	96	79	96
4:00 PM	715	710	1425	98	65	98
5:00 PM	671	728	1399	94	51	94
6:00 PM	0	0	0	0	0	0
7:00 PM	0	0	0	0	0	0
8:00 PM	0	0	0	0	0	0
9:00 PM	0	0	0	0	0	0
10:00 PM	0	0	0	0	0	0
11:00 PM	0	0	0	0	0	0

Warrant 1 - Condition A:

100%	Warrant Met?	No
70%	Warrant Met?	No

Warrant 1 - Condition B:

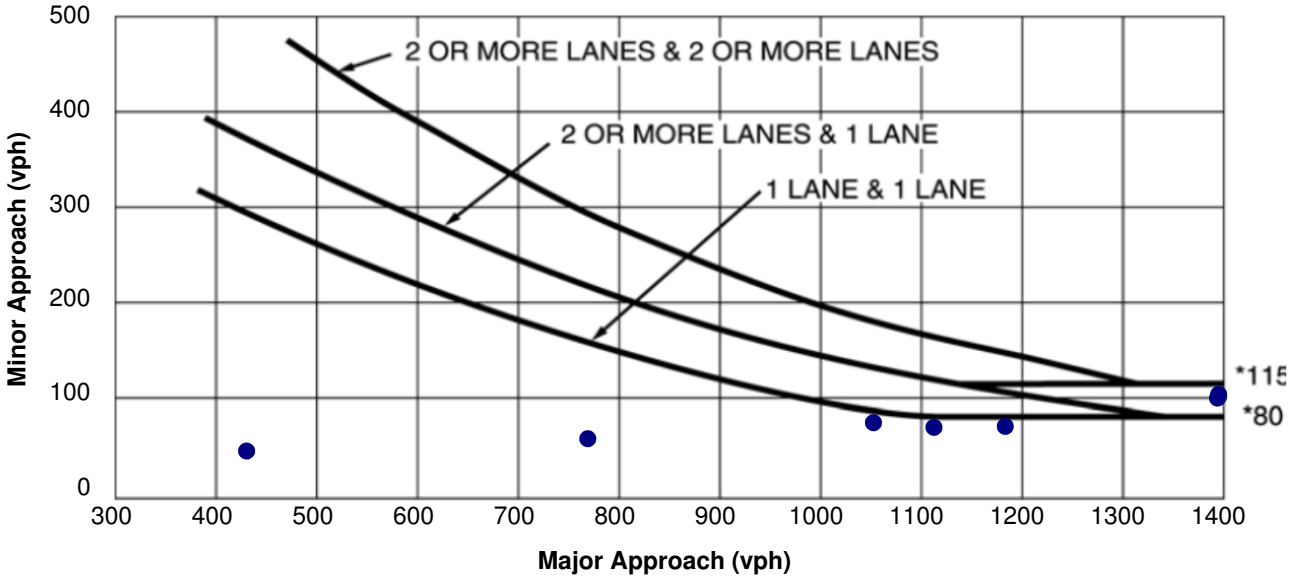
100%	Warrant Met?	No
70%	Warrant Met?	No

Combination of Warrant 1 - Conditions A & B:

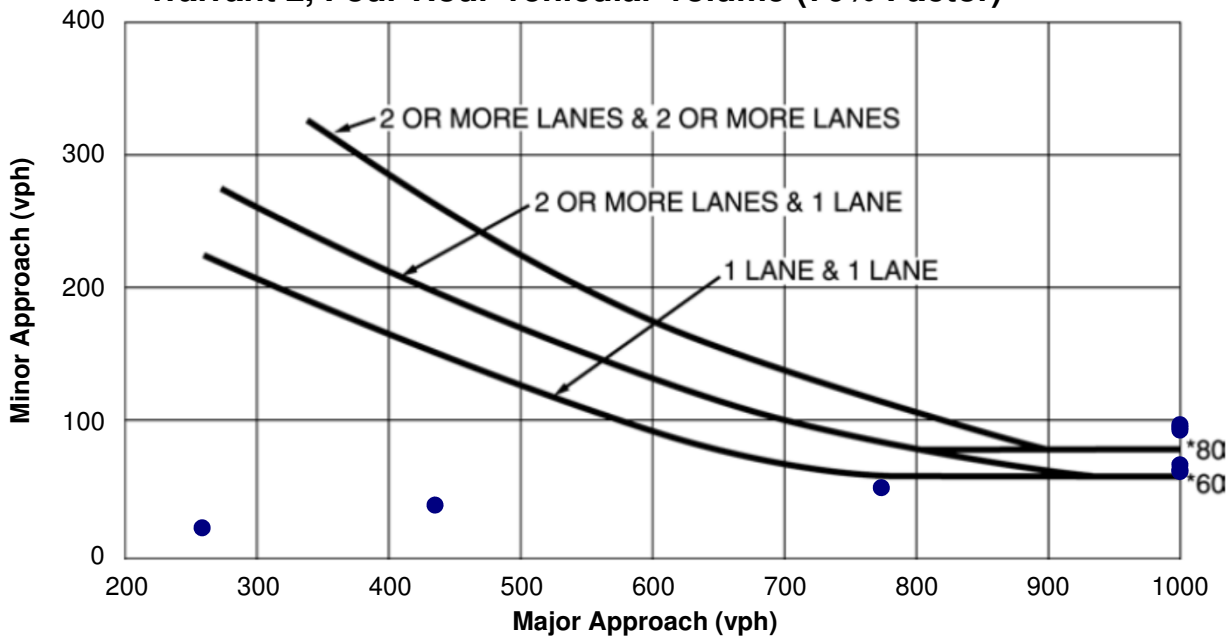
80%	Warrant Met?	No
56% (70%)	Warrant Met?	No

State Road @ Ralph/Burger

Warrant 2, Four-Hour Vehicular Volume



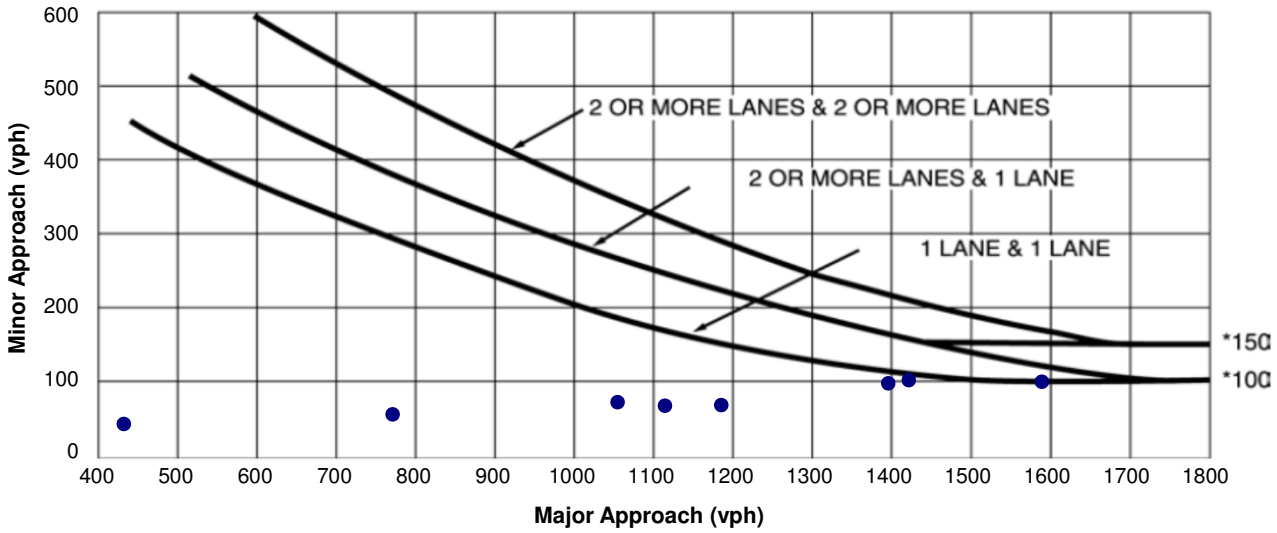
Warrant 2, Four-Hour Vehicular Volume (70% Factor)



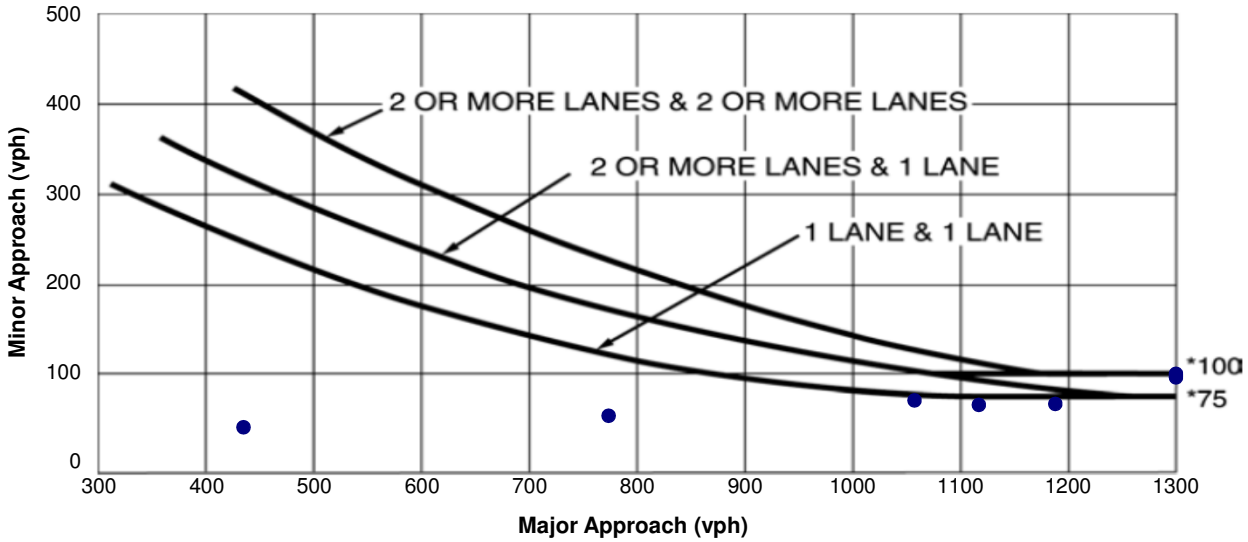
70% Warrant Apply? **No**

State Road @ Ralph/Burger

Warrant 3, Peak-Hour Vehicular Volume



Warrant 3, Peak-Hour Vehicular Volume (70% Factor)



70% Warrant Apply? **No**

ODOT District 12

Planning and Engineering Department

Office of Traffic Planning-BMB

Study Name : **PC Warrants State at Ralph**
Study Date : **11/06/14**
Page No. : **1**

Signal Warrants - Summary

Major Street Approaches

Northbound: **State Road**
Number of Lanes: **2**
85% Speed < 40 MPH.
Total Approach Volume: **4,626**

Southbound: **State Road**
Number of Lanes: **2**
85% Speed < 40 MPH.
Total Approach Volume: **4,526**

Minor Street Approaches

Eastbound: **Burger**
Number of Lanes: **1**
Total Approach Volume: **459**

Westbound: **Ralph**
Number of Lanes: **1**
Total Approach Volume: **566**

Warrant Summary **(Urban values apply.)**

Warrant 1 - Eight Hour Vehicular Volumes ..... **Not Satisfied**

Warrant 1A - Minimum Vehicular Volume .....**Not Satisfied**
Required volumes reached for 0 hours, 8 are needed

Warrant 1B - Interruption of Continuous Traffic .....**Not Satisfied**
Required volumes reached for 4 hours, 8 are needed

Warrant 1 A&B - Combination of Warrants .....**Not Satisfied**
Required volumes reached for 0 hours, 8 are needed

Warrant 2 - Four Hour Volumes ..... **Not Satisfied**
Number of hours (3) volumes exceed minimum < minimum required (4).

Warrant 3 - Peak Hour ..... **~~Satisfied~~**

Warrant 3A - Peak Hour Delay .....**Satisfied**
Number of hours (4) volumes exceed minimum >= required (1). Delay data not evaluated.

Warrant 3B - Peak Hour Volumes .....**Not Satisfied**
Volumes do not exceed minimums for any hour.

Warrant 4 - Pedestrian Volumes ..... **Not Evaluated**

Warrant 5 - School Crossing ..... **Not Evaluated**

Warrant 6 - Coordinated Signal System ..... **Not Satisfied**
Nearest coordinated signal (625) is less than 1,000 feet away.

Warrant 7 - Crash Experience ..... **Not Evaluated**

Warrant 8 - Roadway Network ..... **Not Evaluated**

Warrant 9 - Intersection Near a Grade Crossing ..... **Not Evaluated**

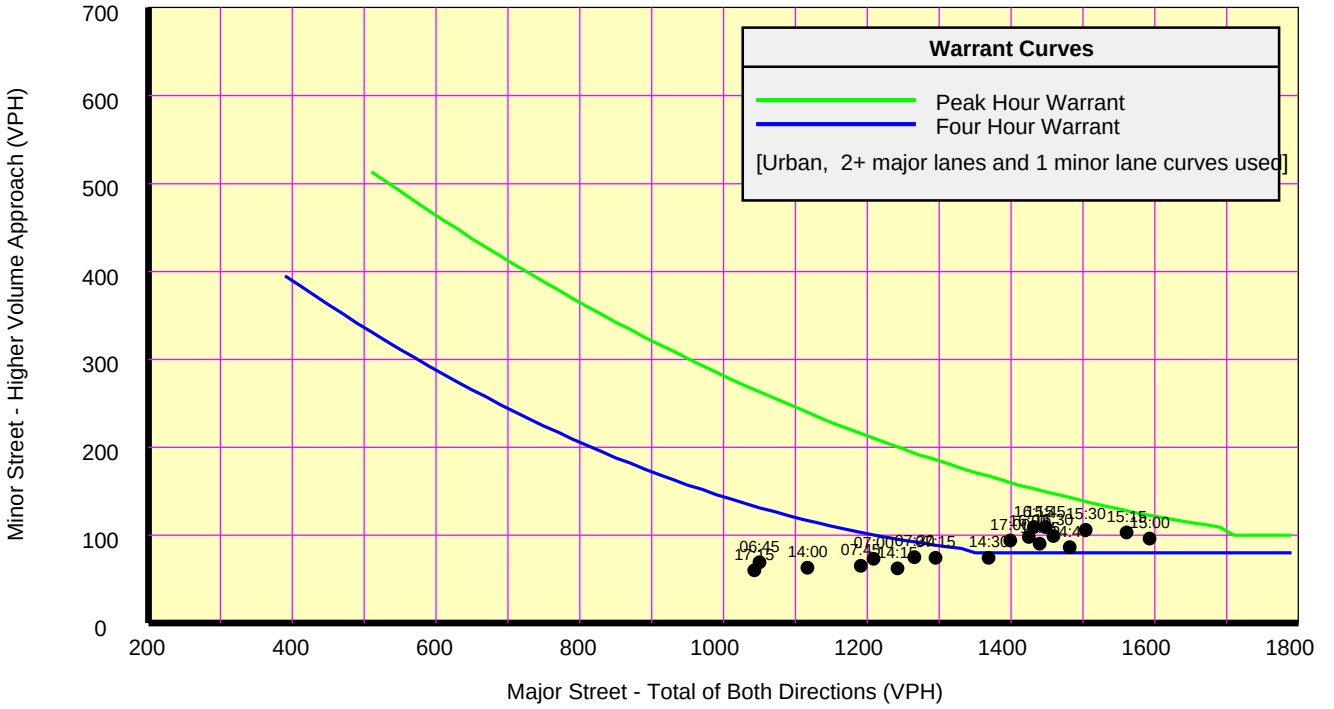
ODOT District 12

Planning and Engineering Department

Office of Traffic Planning-BMB

Study Name : **PC Warrants State at Ralph**
Study Date : **11/06/14**
Page No. : **2**

Signal Warrants - Summary



Analysis of 8-Hour Volume Warrants:

War 1A-Minimum Volume

Hour Begin	Major Total	Minor Vol	Minor Dir	Maj 600	Min 150
15:00	1,593	96	W	Yes	No
15:15	1,561	103	W	Yes	No
15:30	1,504	106	W	Yes	No
14:45	1,482	86	W	Yes	No
16:30	1,459	99	W	Yes	No
15:45	1,448	109	W	Yes	No
16:45	1,440	90	W	Yes	No
16:15	1,432	109	W	Yes	No
16:00	1,425	98	W	Yes	No
17:00	1,399	94	W	Yes	No
14:30	1,369	74	W	Yes	No
07:15	1,295	74	W	Yes	No
07:30	1,266	75	W	Yes	No
14:15	1,242	62	W	Yes	No
07:00	1,209	73	W	Yes	No
07:45	1,191	65	W	Yes	No
14:00	1,117	63	W	Yes	No
06:45	1,050	69	EB	Yes	No
17:15	1,043	60	W	Yes	No
08:00	1,036	57	W	Yes	No
08:15	938	55	W	Yes	No
06:30	887	63	EB	Yes	No
08:30	857	47	W	Yes	No
13:45	829	44	W	Yes	No

War 1B-Interruption of Traffic

Hour Begin	Major Total	Minor Vol	Minor Dir	Maj 900	Min 75
14:45	1,482	86	W	Yes	Yes
15:45	1,448	109	W	Yes	Yes
16:45	1,440	90	W	Yes	Yes
07:30	1,266	75	W	Yes	Yes
14:30	1,369	74	W	Yes	No
07:15	1,295	74	W	Yes	No
14:15	1,242	62	W	Yes	No
07:00	1,209	73	W	Yes	No
14:00	1,117	63	W	Yes	No
06:45	1,050	69	EB	Yes	No
06:30	887	63	EB	No	No
08:30	857	47	W	No	No
13:45	829	44	W	No	No
08:45	773	51	W	No	No
06:15	763	57	EB	No	No
09:00	744	44	W	No	No
06:00	629	46	EB	No	No
09:15	541	33	EB	No	No
13:30	539	26	W	No	No
05:45	425	33	EB	No	No
09:30	361	21	W	No	No
17:45	335	22	W	No	No
13:15	256	17	W	No	No
05:30	247	18	EB	No	No

War 1C-Combination of Warrants

Hour Begin	Major Total	Minor Vol	Minor Dir	Maj 720	Min 120
15:00	1,593	96	W	Yes	No
15:15	1,561	103	W	Yes	No
15:30	1,504	106	W	Yes	No
14:45	1,482	86	W	Yes	No
16:30	1,459	99	W	Yes	No
15:45	1,448	109	W	Yes	No
16:45	1,440	90	W	Yes	No
16:15	1,432	109	W	Yes	No
16:00	1,425	98	W	Yes	No
17:00	1,399	94	W	Yes	No
14:30	1,369	74	W	Yes	No
07:15	1,295	74	W	Yes	No
07:30	1,266	75	W	Yes	No
14:15	1,242	62	W	Yes	No
07:00	1,209	73	W	Yes	No
07:45	1,191	65	W	Yes	No
14:00	1,117	63	W	Yes	No
06:45	1,050	69	EB	Yes	No
17:15	1,043	60	W	Yes	No
08:00	1,036	57	W	Yes	No
08:15	938	55	W	Yes	No
06:30	887	63	EB	Yes	No
08:30	857	47	W	Yes	No
13:45	829	44	W	Yes	No

APPENDIX H
SYNCHRO INTERSECTION CAPACITY ANALYSIS REPORTS

INTERSECTION CAPACITY ANALYSIS

STATE ROAD CORRIDOR CAPACITY ANALYSIS

Intersection capacity was evaluated with the assistance of Synchro traffic simulation software (version 8) and with output provided using HCM algorithms. The results of the capacity analysis for the existing traffic conditions and existing volumes are provided in **Table H-1** and Synchro output summaries are appended to this section.

The following recommended improvements were evaluated at the critical intersections within the study area under Build conditions:

1. Revise signal phasing of the EB and WB ramp intersections to operate a 4/5 phase Buckeye diamond configuration. A single controller proposed to operate the revised sequence.
2. Add a westbound right turn lane at the Brookpark/State Road intersection.
3. Optimized signal timing and offsets on the State Road corridor.

Also, Burger/Ralph Ave and State Road intersection was analyzed as a two way stop controlled (TWSC) intersection with State Road having right of way. Signal removal was evaluated as the existing signal did not meet the signal warrant criteria.

The proposed condition levels of service and delay of the four study intersections within the study area are summarized in **Table H-2**. Traffic signal control removal at State Road and Burger/Ralph Avenue is not recommended due to the significant delays on the minor street approaches.

TABLE H-1: EXISTING INTERSECTION CAPACITY SUMMARY

Study Period	EB approach	WB approach	NB approach	SB approach	Intersection
State Road and Brookpark Road					
Existing - AM	**F/101.6**	D/50.0	**E/70.7**	**E/68.7**	E/74.8
Existing - PM	**E/76.4**	**F/112.7**	D/42.2	D/39.8	E/64.3
State Road and I-480 eastbound ramps					
Existing - AM	D/42.3		D/41.7	C/21.9	D/38.0
Existing - PM	D/41.6		C/31.6	C/20.7	C/30.2
State Road and I-480 westbound ramps					
Existing - AM		C/31.6	C/32.0	C/26.1	C/30.2
Existing - PM		**F/55.7**	C/31.0	C/29.2	D/39.4
State Road and Burger Ave/Ralph Ave					
Existing - AM	D/40.9	D/44.0	A/7.6	A/7.2	B/11.9
Existing - PM	D/40.9	D/48.4	A/9.2	A/8.4	B/12.8
Note: Letter/Number - Level of Service/Average Delay per Vehicle					
Legend: Red - LOS E or F or volume/capacity (v/c) ratio >1.0					

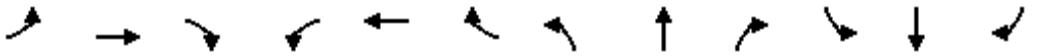
TABLE H-2: BUILD INTERSECTION CAPACITY SUMMARY

Study Period	EB approach	WB approach	NB approach	SB approach	Intersection
State Road and Brookpark Road					
Build - AM	**F/67.1**	D/45.7	**E/75.7**	**D/39.6**	**E/58.0**
Build - PM	D/49.7	D/48.7	**E/56.0**	D/40.6	D/46.7
State Road and I-480 eastbound ramps					
Build - AM	D/40.8		D/36.6	B/17.9	C/34.2
Build - PM	C/29.8		C/28.5	C/24.3	C/27.2
State Road and I-480 westbound ramps					
Build - AM		C/30.6	B/15.1	C/31.6	C/23.4
Build - PM		C/34.4	C/20.7	C/31.5	C/28.8
State Road and Burger Ave/Ralph Ave[1]					
Build - AM	C/19.1	**F/43.1**	A/8.7	A/9.0	NA
Build - PM	**F/40.1**	**F/220.4**	A/9.6	A/9.8	NA
Note: Letter/Number - Level of Service/Average Delay per Vehicle					
Legend: Red - LOS E or F or volume/capacity (v/c) ratio >1.0					
Note 1 - TWSC intersection with Burger/Ralph under stop control					

As shown in Table H-3, the proposed improvements reduce overall intersection delay by 10 percent to 27 percent.

TABLE H-3: SUMMARY OF INTERSECTION DELAY IMPROVEMENTS

Intersection	AM Peak			PM Peak		
	No-Build	Build	% Difference	No-Build	Build	% Difference
State Road and Brookpark Road	74.8	58.0	**22%**	64.3	46.7	**27%**
State Road and I-480 eastbound ramps	38.0	34.2	**10%**	30.2	27.2	**10%**
State Road and I-480 westbound ramps	30.2	23.4	**23%**	39.4	28.8	**27%**

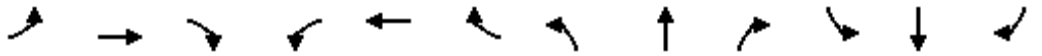


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	361	500	25	38	233	252	51	1003	20	310	535	261
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Grade (%)		0%			0%			0%			-3%	
Total Lost time (s)	5.0	6.0		5.0	6.0		5.0	6.0		5.0	6.0	5.0
Lane Util. Factor	1.00	0.95		1.00	0.95		1.00	0.95		1.00	0.95	1.00
Frt	1.00	0.99		1.00	0.93		1.00	1.00		1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1752	3404		1770	3140		1752	3525		1696	3592	1591
Flt Permitted	0.21	1.00		0.38	1.00		0.40	1.00		0.07	1.00	1.00
Satd. Flow (perm)	387	3404		703	3140		731	3525		130	3592	1591
Peak-hour factor, PHF	0.82	0.86	0.57	0.73	0.80	0.89	0.61	0.88	0.83	0.88	0.85	0.78
Adj. Flow (vph)	440	581	44	52	291	283	84	1140	24	352	629	335
RTOR Reduction (vph)	0	3	0	0	117	0	0	1	0	0	0	152
Lane Group Flow (vph)	440	622	0	52	457	0	84	1163	0	352	629	183
Heavy Vehicles (%)	3%	5%	4%	2%	5%	8%	3%	2%	6%	8%	2%	3%
Turn Type	pm+pt	NA		pm+pt	NA		pm+pt	NA		pm+pt	NA	pm+ov
Protected Phases	3	8		7	4		5	2		1	6	3
Permitted Phases	8			4			2			6		6
Actuated Green, G (s)	62.0	50.0		44.0	37.0		59.2	50.0		76.0	61.8	81.8
Effective Green, g (s)	62.0	50.0		44.0	37.0		59.2	50.0		76.0	61.8	81.8
Actuated g/C Ratio	0.41	0.33		0.29	0.25		0.39	0.33		0.51	0.41	0.55
Clearance Time (s)	5.0	6.0		5.0	6.0		5.0	6.0		5.0	6.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)	341	1134		256	774		351	1175		285	1479	867
v/s Ratio Prot	c0.17	0.18		0.01	0.15		0.01	0.33		c0.17	0.18	0.03
v/s Ratio Perm	c0.36			0.05			0.08			c0.45		0.09
v/c Ratio	1.29	0.55		0.20	0.59		0.24	0.99		1.24	0.43	0.21
Uniform Delay, d1	36.2	40.8		38.6	49.8		28.9	49.8		50.0	31.4	17.5
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	150.9	0.5		0.4	1.2		0.4	24.0		132.3	0.9	0.1
Delay (s)	187.1	41.3		39.0	51.0		29.2	73.7		182.3	32.3	17.6
Level of Service	F	D		D	D		C	E		F	C	B
Approach Delay (s)		101.6			50.0			70.7			68.7	
Approach LOS		F			D			E			E	

Intersection Summary			
HCM 2000 Control Delay	74.8	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.31		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	22.0
Intersection Capacity Utilization	98.4%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	334	0	636	0	0	0	0	842	769	204	486	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Grade (%)		0%			0%			3%			0%	
Total Lost time (s)	6.0		6.0					6.0	6.0	5.0	6.0	
Lane Util. Factor	0.97		*0.90					*0.60	1.00	1.00	0.91	
Frt	1.00		0.85					1.00	0.85	1.00	1.00	
Flt Protected	0.95		1.00					1.00	1.00	0.95	1.00	
Satd. Flow (prot)	3433		2769					3271	1575	1770	4893	
Flt Permitted	0.95		1.00					1.00	1.00	0.95	1.00	
Satd. Flow (perm)	3433		2769					3271	1575	1770	4893	
Peak-hour factor, PHF	0.80	0.92	0.92	0.92	0.92	0.92	0.92	0.88	0.83	0.88	0.97	0.92
Adj. Flow (vph)	418	0	691	0	0	0	0	957	927	232	501	0
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	484	0	0	0
Lane Group Flow (vph)	418	0	691	0	0	0	0	957	443	232	501	0
Heavy Vehicles (%)	2%	2%	5%	2%	2%	2%	2%	3%	1%	2%	6%	2%
Turn Type	Prot		Prot					NA	Perm	Prot	NA	
Protected Phases	4		4					2		3	2 3	
Permitted Phases									2			
Actuated Green, G (s)	28.0		28.0					34.0	34.0	21.0	61.0	
Effective Green, g (s)	28.0		28.0					34.0	34.0	21.0	61.0	
Actuated g/C Ratio	0.28		0.28					0.34	0.34	0.21	0.61	
Clearance Time (s)	6.0		6.0					6.0	6.0	5.0		
Vehicle Extension (s)	3.0		3.0					3.0	3.0	3.0		
Lane Grp Cap (vph)	961		775					1112	535	371	2984	
v/s Ratio Prot	0.12		c0.25					c0.29		c0.13	0.10	
v/s Ratio Perm									0.28			
v/c Ratio	0.43		0.89					0.86	0.83	0.63	0.17	
Uniform Delay, d1	29.5		34.5					30.8	30.3	35.9	8.5	
Progression Factor	1.00		1.00					1.00	1.00	0.89	1.63	
Incremental Delay, d2	1.4		14.7					8.8	13.7	7.0	0.1	
Delay (s)	30.9		49.2					39.6	44.0	39.0	13.9	
Level of Service	C		D					D	D	D	B	
Approach Delay (s)		42.3			0.0			41.7			21.9	
Approach LOS		D			A			D			C	

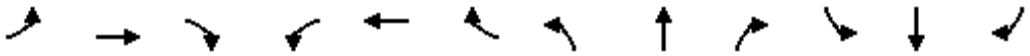
Intersection Summary			
HCM 2000 Control Delay	38.0	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.81		
Actuated Cycle Length (s)	100.0	Sum of lost time (s)	17.0
Intersection Capacity Utilization	82.6%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	304	0	231	621	554	0	0	390	367
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				6.0		6.0	5.0	6.0			6.0	
Lane Util. Factor				*0.64		1.00	*0.93	0.95			0.91	
Frt				1.00		0.85	1.00	1.00			0.93	
Flt Protected				0.95		1.00	0.95	1.00			1.00	
Satd. Flow (prot)				2159		1583	3291	3539			4707	
Flt Permitted				0.95		1.00	0.95	1.00			1.00	
Satd. Flow (perm)				2159		1583	3291	3539			4707	
Peak-hour factor, PHF	0.92	0.92	0.92	0.95	0.92	0.80	0.91	0.81	0.92	0.92	0.92	0.88
Adj. Flow (vph)	0	0	0	320	0	289	682	684	0	0	424	417
RTOR Reduction (vph)	0	0	0	0	0	178	0	0	0	0	179	0
Lane Group Flow (vph)	0	0	0	320	0	111	682	684	0	0	662	0
Heavy Vehicles (%)	2%	2%	2%	7%	2%	2%	2%	2%	2%	2%	2%	2%
Turn Type				Prot		Prot	Prot	NA			NA	
Protected Phases				4		4	3	2 3			2	
Permitted Phases												
Actuated Green, G (s)				28.0		28.0	21.0	61.0			34.0	
Effective Green, g (s)				28.0		28.0	21.0	61.0			34.0	
Actuated g/C Ratio				0.28		0.28	0.21	0.61			0.34	
Clearance Time (s)				6.0		6.0	5.0				6.0	
Vehicle Extension (s)				3.0		3.0	3.0				3.0	
Lane Grp Cap (vph)				604		443	691	2158			1600	
v/s Ratio Prot				c0.15		0.07	c0.21	0.19			c0.14	
v/s Ratio Perm												
v/c Ratio				0.53		0.25	0.99	0.32			0.41	
Uniform Delay, d1				30.4		27.9	39.4	9.4			25.3	
Progression Factor				1.00		1.00	0.72	1.54			1.00	
Incremental Delay, d2				3.3		1.4	21.0	0.3			0.8	
Delay (s)				33.7		29.2	49.2	14.8			26.1	
Level of Service				C		C	D	B			C	
Approach Delay (s)		0.0			31.6			32.0			26.1	
Approach LOS		A			C			C			C	

Intersection Summary			
HCM 2000 Control Delay	30.2	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	100.0	Sum of lost time (s)	17.0
Intersection Capacity Utilization	82.6%	ICU Level of Service	E
Analysis Period (min)	15		

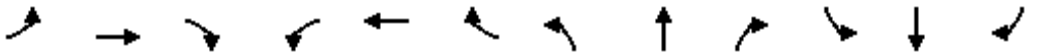
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	15	43	56	14	4	14	681	24	6	595	5
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0			5.0			6.0			6.0	
Lane Util. Factor		1.00			1.00			0.95			0.95	
Frt		0.93			0.99			0.99			1.00	
Flt Protected		0.99			0.97			1.00			1.00	
Satd. Flow (prot)		1710			1813			3508			3496	
Flt Permitted		0.95			0.78			0.91			0.94	
Satd. Flow (perm)		1639			1456			3188			3281	
Peak-hour factor, PHF	0.63	0.42	0.77	0.93	0.32	0.50	0.50	0.93	0.75	0.50	0.87	0.42
Adj. Flow (vph)	16	36	56	60	44	8	28	732	32	12	684	12
RTOR Reduction (vph)	0	32	0	0	2	0	0	2	0	0	1	0
Lane Group Flow (vph)	0	76	0	0	110	0	0	790	0	0	707	0
Heavy Vehicles (%)	0%	0%	5%	2%	0%	0%	7%	2%	0%	0%	3%	0%
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		4			4			2			2	
Permitted Phases	4			4			2			2		
Actuated Green, G (s)		25.0			25.0			84.0			84.0	
Effective Green, g (s)		25.0			25.0			84.0			84.0	
Actuated g/C Ratio		0.21			0.21			0.70			0.70	
Clearance Time (s)		5.0			5.0			6.0			6.0	
Vehicle Extension (s)		3.0			3.0			3.0			3.0	
Lane Grp Cap (vph)		341			303			2231			2296	
v/s Ratio Prot												
v/s Ratio Perm		0.05			c0.08			c0.25			0.22	
v/c Ratio		0.22			0.36			0.35			0.31	
Uniform Delay, d1		39.4			40.7			7.2			6.9	
Progression Factor		1.00			1.00			1.00			1.00	
Incremental Delay, d2		1.5			3.3			0.4			0.3	
Delay (s)		40.9			44.0			7.6			7.2	
Level of Service		D			D			A			A	
Approach Delay (s)		40.9			44.0			7.6			7.2	
Approach LOS		D			D			A			A	

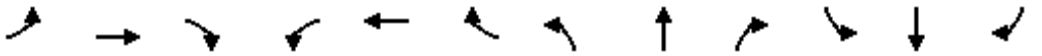
Intersection Summary			
HCM 2000 Control Delay	11.9	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.36		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	11.0
Intersection Capacity Utilization	49.5%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group



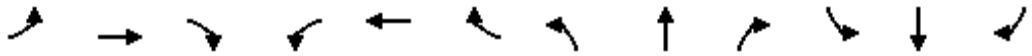
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	274	401	134	237	529	378	81	636	57	286	1120	545
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Grade (%)		0%			0%			0%			-3%	
Total Lost time (s)	5.0	6.0		5.0	6.0		5.0	6.0		5.0	6.0	5.0
Lane Util. Factor	1.00	0.95		1.00	0.95		1.00	0.95		1.00	0.95	1.00
Frt	1.00	0.96		1.00	0.93		1.00	0.99		1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1752	3313		1770	3171		1752	3474		1696	3592	1591
Flt Permitted	0.10	1.00		0.21	1.00		0.08	1.00		0.20	1.00	1.00
Satd. Flow (perm)	193	3313		395	3171		155	3474		363	3592	1591
Peak-hour factor, PHF	0.90	0.86	0.82	0.90	0.97	0.88	0.78	0.96	0.79	0.94	0.94	0.83
Adj. Flow (vph)	304	466	163	263	545	430	104	662	72	304	1191	657
RTOR Reduction (vph)	0	23	0	0	95	0	0	5	0	0	0	96
Lane Group Flow (vph)	304	606	0	263	880	0	104	729	0	304	1191	561
Heavy Vehicles (%)	3%	5%	4%	2%	5%	8%	3%	2%	6%	8%	2%	3%
Turn Type	pm+pt	NA		pm+pt	NA		pm+pt	NA		pm+pt	NA	pm+ov
Protected Phases	3	8		7	4		5	2		1	6	3
Permitted Phases	8			4			2			6		6
Actuated Green, G (s)	58.2	38.2		55.8	37.0		62.5	51.8		76.0	60.3	80.3
Effective Green, g (s)	58.2	38.2		55.8	37.0		62.5	51.8		76.0	60.3	80.3
Actuated g/C Ratio	0.39	0.25		0.37	0.25		0.42	0.35		0.51	0.40	0.54
Clearance Time (s)	5.0	6.0		5.0	6.0		5.0	6.0		5.0	6.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)	282	843		319	782		178	1199		354	1443	851
v/s Ratio Prot	c0.14	0.18		0.10	c0.28		0.04	0.21		c0.11	0.33	0.09
v/s Ratio Perm	0.27			0.20			0.20			c0.32		0.26
v/c Ratio	1.08	0.72		0.82	1.13		0.58	0.61		0.86	0.83	0.66
Uniform Delay, d1	46.9	51.0		36.4	56.5		32.0	40.7		26.3	40.1	25.0
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	75.9	3.0		15.7	72.5		4.8	2.3		18.3	5.5	1.9
Delay (s)	122.8	54.0		52.1	129.0		36.8	43.0		44.6	45.6	26.9
Level of Service	F	D		D	F		D	D		D	D	C
Approach Delay (s)		76.4			112.7			42.2			39.8	
Approach LOS		E			F			D			D	

Intersection Summary			
HCM 2000 Control Delay	64.3	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	0.99		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	22.0
Intersection Capacity Utilization	98.6%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	330	0	714	0	0	0	0	841	457	218	1248	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Grade (%)		0%			0%			3%			0%	
Total Lost time (s)	6.0		6.0					6.0	6.0	5.0	6.0	
Lane Util. Factor	0.97		*0.99					*0.61	1.00	1.00	*0.83	
Frt	1.00		0.85					1.00	0.85	1.00	1.00	
Flt Protected	0.95		1.00					1.00	1.00	0.95	1.00	
Satd. Flow (prot)	3467		3105					3358	1544	1787	4638	
Flt Permitted	0.95		1.00					1.00	1.00	0.95	1.00	
Satd. Flow (perm)	3467		3105					3358	1544	1787	4638	
Peak-hour factor, PHF	0.89	0.92	0.93	0.92	0.92	0.92	0.92	0.95	0.91	0.91	0.93	0.92
Adj. Flow (vph)	371	0	768	0	0	0	0	885	502	240	1342	0
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	331	0	0	0
Lane Group Flow (vph)	371	0	768	0	0	0	0	885	171	240	1342	0
Heavy Vehicles (%)	1%	2%	3%	2%	2%	2%	2%	2%	3%	1%	2%	2%
Turn Type	Prot		Prot					NA	Perm	Prot	NA	
Protected Phases	4		4					2		3	2 3	
Permitted Phases									2			
Actuated Green, G (s)	28.0		28.0					34.0	34.0	21.0	61.0	
Effective Green, g (s)	28.0		28.0					34.0	34.0	21.0	61.0	
Actuated g/C Ratio	0.28		0.28					0.34	0.34	0.21	0.61	
Clearance Time (s)	6.0		6.0					6.0	6.0	5.0		
Vehicle Extension (s)	3.0		3.0					3.0	3.0	3.0		
Lane Grp Cap (vph)	970		869					1141	524	375	2829	
v/s Ratio Prot	0.11		c0.25					c0.26		c0.13	0.29	
v/s Ratio Perm									0.11			
v/c Ratio	0.38		0.88					0.78	0.33	0.64	0.47	
Uniform Delay, d1	29.0		34.4					29.6	24.5	36.1	10.7	
Progression Factor	1.00		1.00					1.00	1.00	0.81	1.66	
Incremental Delay, d2	1.1		12.7					5.2	1.7	6.4	0.3	
Delay (s)	30.2		47.1					34.8	26.1	35.4	18.0	
Level of Service	C		D					C	C	D	B	
Approach Delay (s)		41.6			0.0			31.6			20.7	
Approach LOS		D			A			C			C	

Intersection Summary			
HCM 2000 Control Delay	30.2	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.78		
Actuated Cycle Length (s)	100.0	Sum of lost time (s)	17.0
Intersection Capacity Utilization	105.5%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	865	0	362	571	600	0	0	600	349
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				6.0		6.0	5.0	6.0			6.0	
Lane Util. Factor				0.97		1.00	*0.93	0.95			0.91	
Frt				1.00		0.85	1.00	1.00			0.94	
Flt Protected				0.95		1.00	0.95	1.00			1.00	
Satd. Flow (prot)				3433		1599	3260	3574			4820	
Flt Permitted				0.95		1.00	0.95	1.00			1.00	
Satd. Flow (perm)				3433		1599	3260	3574			4820	
Peak-hour factor, PHF	0.92	0.92	0.92	0.90	0.92	0.91	0.88	0.92	0.92	0.92	0.86	0.85
Adj. Flow (vph)	0	0	0	961	0	398	649	652	0	0	698	411
RTOR Reduction (vph)	0	0	0	0	0	191	0	0	0	0	106	0
Lane Group Flow (vph)	0	0	0	961	0	207	649	652	0	0	1003	0
Heavy Vehicles (%)	2%	2%	2%	2%	2%	1%	3%	1%	2%	2%	2%	1%
Turn Type				Prot		Prot	Prot	NA			NA	
Protected Phases				4		4	3	2 3			2	
Permitted Phases												
Actuated Green, G (s)				28.0		28.0	21.0	61.0			34.0	
Effective Green, g (s)				28.0		28.0	21.0	61.0			34.0	
Actuated g/C Ratio				0.28		0.28	0.21	0.61			0.34	
Clearance Time (s)				6.0		6.0	5.0				6.0	
Vehicle Extension (s)				3.0		3.0	3.0				3.0	
Lane Grp Cap (vph)				961		447	684	2180			1638	
v/s Ratio Prot				c0.28		0.13	c0.20	0.18			c0.21	
v/s Ratio Perm												
v/c Ratio				1.00		0.46	0.95	0.30			0.61	
Uniform Delay, d1				36.0		29.8	39.0	9.3			27.5	
Progression Factor				1.00		1.00	0.75	1.48			1.00	
Incremental Delay, d2				29.0		3.4	18.9	0.3			1.7	
Delay (s)				65.0		33.2	48.0	14.0			29.2	
Level of Service				E		C	D	B			C	
Approach Delay (s)		0.0			55.7			31.0			29.2	
Approach LOS		A			E			C			C	

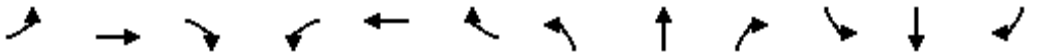
Intersection Summary			
HCM 2000 Control Delay	39.4	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.83		
Actuated Cycle Length (s)	100.0	Sum of lost time (s)	17.0
Intersection Capacity Utilization	105.5%	ICU Level of Service	G
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	11	18	50	66	18	12	32	863	40	15	794	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0			5.0			6.0			6.0	
Lane Util. Factor		1.00			1.00			0.95			0.95	
Frt		0.92			0.98			0.99			1.00	
Flt Protected		0.99			0.97			1.00			1.00	
Satd. Flow (prot)		1695			1809			3473			3524	
Flt Permitted		0.94			0.70			0.88			0.89	
Satd. Flow (perm)		1600			1304			3067			3134	
Peak-hour factor, PHF	0.55	0.64	0.74	0.79	0.50	0.60	0.88	0.88	0.63	0.54	0.88	0.83
Adj. Flow (vph)	20	28	68	84	36	20	36	981	63	28	902	24
RTOR Reduction (vph)	0	43	0	0	5	0	0	4	0	0	2	0
Lane Group Flow (vph)	0	73	0	0	135	0	0	1076	0	0	953	0
Heavy Vehicles (%)	0%	0%	4%	0%	0%	0%	4%	3%	0%	0%	2%	0%
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		4			4			2			2	
Permitted Phases	4			4			2			2		
Actuated Green, G (s)		25.0			25.0			84.0			84.0	
Effective Green, g (s)		25.0			25.0			84.0			84.0	
Actuated g/C Ratio		0.21			0.21			0.70			0.70	
Clearance Time (s)		5.0			5.0			6.0			6.0	
Vehicle Extension (s)		3.0			3.0			3.0			3.0	
Lane Grp Cap (vph)		333			271			2146			2193	
v/s Ratio Prot												
v/s Ratio Perm		0.05			c0.10			c0.35			0.30	
v/c Ratio		0.22			0.50			0.50			0.43	
Uniform Delay, d1		39.4			42.0			8.3			7.8	
Progression Factor		1.00			1.00			1.00			1.00	
Incremental Delay, d2		1.5			6.4			0.8			0.6	
Delay (s)		40.9			48.4			9.2			8.4	
Level of Service		D			D			A			A	
Approach Delay (s)		40.9			48.4			9.2			8.4	
Approach LOS		D			D			A			A	

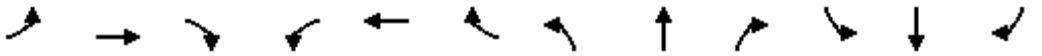
Intersection Summary			
HCM 2000 Control Delay	12.8	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.50		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	11.0
Intersection Capacity Utilization	69.7%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group



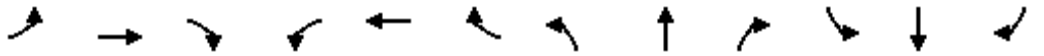
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	361	500	25	38	233	252	51	1003	20	310	535	261
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Grade (%)		0%			0%			0%			-3%	
Total Lost time (s)	5.0	6.0		5.0	6.0	5.0	5.0	6.0		5.0	6.0	5.0
Lane Util. Factor	1.00	0.95		1.00	0.95	1.00	1.00	0.95		1.00	0.95	1.00
Frt	1.00	0.99		1.00	1.00	0.85	1.00	1.00		1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1752	3404		1770	3438	1495	1752	3525		1696	3592	1591
Flt Permitted	0.39	1.00		0.40	1.00	1.00	0.41	1.00		0.09	1.00	1.00
Satd. Flow (perm)	727	3404		736	3438	1495	762	3525		169	3592	1591
Peak-hour factor, PHF	0.82	0.86	0.57	0.73	0.80	0.89	0.61	0.88	0.83	0.88	0.85	0.78
Adj. Flow (vph)	440	581	44	52	291	283	84	1140	24	352	629	335
RTOR Reduction (vph)	0	4	0	0	0	87	0	1	0	0	0	81
Lane Group Flow (vph)	440	621	0	52	291	196	84	1163	0	352	629	254
Heavy Vehicles (%)	3%	5%	4%	2%	5%	8%	3%	2%	6%	8%	2%	3%
Turn Type	pm+pt	NA		pm+pt	NA	pm+ov	pm+pt	NA		pm+pt	NA	pm+ov
Protected Phases	3	8		7	4	1	5	2		1	6	3
Permitted Phases	8			4		4	2			6		6
Actuated Green, G (s)	56.0	44.3		34.7	28.0	55.8	50.2	49.2		70.0	70.0	93.0
Effective Green, g (s)	56.0	44.3		34.7	28.0	55.8	50.2	49.2		70.0	70.0	93.0
Actuated g/C Ratio	0.37	0.30		0.23	0.19	0.37	0.33	0.33		0.47	0.47	0.62
Clearance Time (s)	5.0	6.0		5.0	6.0	5.0	5.0	6.0		5.0	6.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)	428	1005		216	641	556	301	1156		361	1676	986
v/s Ratio Prot	c0.16	0.18		0.01	0.08	0.07	0.01	c0.33		c0.18	0.18	0.04
v/s Ratio Perm	c0.23			0.04		0.07	0.08			0.27		0.12
v/c Ratio	1.03	0.62		0.24	0.45	0.35	0.28	1.01		0.98	0.38	0.26
Uniform Delay, d1	42.8	45.6		45.7	54.2	34.1	37.3	50.4		47.7	25.9	12.9
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	50.9	2.9		0.6	2.3	0.4	0.5	28.0		40.4	0.6	0.1
Delay (s)	93.7	48.4		46.2	56.5	34.4	37.8	78.4		88.1	26.5	13.0
Level of Service	F	D		D	E	C	D	E		F	C	B
Approach Delay (s)		67.1			45.7			75.7			39.6	
Approach LOS		E			D			E			D	

Intersection Summary			
HCM 2000 Control Delay	58.0	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.04		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	22.0
Intersection Capacity Utilization	90.3%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	334	0	636	0	0	0	0	842	769	204	486	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Grade (%)		0%			0%			3%			0%	
Total Lost time (s)	6.0		6.0					6.0	6.0	5.0	5.0	
Lane Util. Factor	0.97		0.88					0.91	1.00	1.00	0.91	
Frt	1.00		0.85					1.00	0.85	1.00	1.00	
Flt Protected	0.95		1.00					1.00	1.00	0.95	1.00	
Satd. Flow (prot)	3433		2707					4960	1575	1770	4893	
Flt Permitted	0.95		1.00					1.00	1.00	0.95	1.00	
Satd. Flow (perm)	3433		2707					4960	1575	1770	4893	
Peak-hour factor, PHF	0.80	0.92	0.92	0.92	0.92	0.92	0.92	0.88	0.83	0.88	0.97	0.92
Adj. Flow (vph)	418	0	691	0	0	0	0	957	927	232	501	0
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	503	0	0	0
Lane Group Flow (vph)	418	0	691	0	0	0	0	957	424	232	501	0
Heavy Vehicles (%)	2%	2%	5%	2%	2%	2%	2%	3%	1%	2%	6%	2%
Turn Type	Prot		Prot					NA	Perm	Prot	NA	
Protected Phases	8		8					6		5	5 6	
Permitted Phases									6			
Actuated Green, G (s)	29.0		29.0					33.0	33.0	21.0	60.0	
Effective Green, g (s)	29.0		29.0					33.0	33.0	21.0	54.0	
Actuated g/C Ratio	0.29		0.29					0.33	0.33	0.21	0.54	
Clearance Time (s)	6.0		6.0					6.0	6.0	5.0		
Vehicle Extension (s)	3.0		3.0					3.0	3.0	3.0		
Lane Grp Cap (vph)	995		785					1636	519	371	2642	
v/s Ratio Prot	0.12		c0.26					0.19		c0.13	0.10	
v/s Ratio Perm									c0.27			
v/c Ratio	0.42		0.88					0.58	0.82	0.63	0.19	
Uniform Delay, d1	28.7		33.8					27.8	30.7	35.9	11.8	
Progression Factor	1.00		1.00					1.00	1.00	0.18	1.66	
Incremental Delay, d2	1.3		13.5					1.5	13.3	7.4	0.1	
Delay (s)	30.0		47.3					29.4	44.0	14.1	19.7	
Level of Service	C		D					C	D	B	B	
Approach Delay (s)		40.8			0.0			36.6			17.9	
Approach LOS		D			A			D			B	

Intersection Summary			
HCM 2000 Control Delay	34.2	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.77		
Actuated Cycle Length (s)	100.0	Sum of lost time (s)	17.0
Intersection Capacity Utilization	82.6%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	304	0	231	621	554	0	0	390	367
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				6.0		6.0	5.0	5.0			6.0	6.0
Lane Util. Factor				*0.64		1.00	*0.93	0.95			0.91	1.00
Frt				1.00		0.85	1.00	1.00			1.00	0.85
Flt Protected				0.95		1.00	0.95	1.00			1.00	1.00
Satd. Flow (prot)				2159		1583	3291	3539			5085	1583
Flt Permitted				0.95		1.00	0.95	1.00			1.00	1.00
Satd. Flow (perm)				2159		1583	3291	3539			5085	1583
Peak-hour factor, PHF	0.92	0.92	0.92	0.95	0.92	0.80	0.91	0.81	0.92	0.92	0.92	0.88
Adj. Flow (vph)	0	0	0	320	0	289	682	684	0	0	424	417
RTOR Reduction (vph)	0	0	0	0	0	175	0	0	0	0	0	313
Lane Group Flow (vph)	0	0	0	320	0	114	682	684	0	0	424	104
Heavy Vehicles (%)	2%	2%	2%	7%	2%	2%	2%	2%	2%	2%	2%	2%
Turn Type				Prot		Prot	Prot	NA			NA	Perm
Protected Phases				4		4	1	1 2			2	
Permitted Phases												2
Actuated Green, G (s)				29.0		29.0	29.0	59.0			25.0	25.0
Effective Green, g (s)				29.0		29.0	29.0	59.0			25.0	25.0
Actuated g/C Ratio				0.29		0.29	0.29	0.59			0.25	0.25
Clearance Time (s)				6.0		6.0	5.0				6.0	6.0
Vehicle Extension (s)				3.0		3.0	3.0				3.0	3.0
Lane Grp Cap (vph)				626		459	954	2088			1271	395
v/s Ratio Prot				c0.15		0.07	c0.21	c0.19			c0.08	
v/s Ratio Perm												0.07
v/c Ratio				0.51		0.25	0.71	0.33			0.33	0.26
Uniform Delay, d1				29.6		27.2	31.8	10.4			30.7	30.1
Progression Factor				1.00		1.00	0.29	1.61			1.00	1.00
Incremental Delay, d2				3.0		1.3	3.8	0.4			0.7	1.6
Delay (s)				32.6		28.4	13.0	17.2			31.4	31.7
Level of Service				C		C	B	B			C	C
Approach Delay (s)		0.0			30.6			15.1			31.6	
Approach LOS		A			C			B			C	

Intersection Summary			
HCM 2000 Control Delay	23.4	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	100.0	Sum of lost time (s)	17.0
Intersection Capacity Utilization	82.6%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

TWO-WAY STOP CONTROL SUMMARY

General Information

Analyst	*VM*
Agency/Co.	
Date Performed	*5/29/2015*
Analysis Time Period	*AM Peak*

Site Information

Intersection	*State at Burger/Ralph*
Jurisdiction	*Cleveland*
Analysis Year	*2014-Build*

Project Description *CUY-480-Safety Study*

East/West Street: *Burger/Ralph* | North/South Street: *State Road*

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

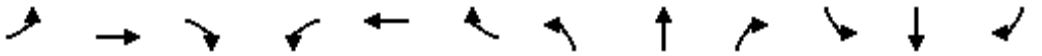
Vehicle Volumes and Adjustments

Major Street	Northbound			Southbound		
Movement	1	2	3	4	5	6
	L	T	R	L	T	R
Volume (veh/h)	*14*	*681*	*24*	*6*	*595*	*5*
Peak-Hour Factor, PHF	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*
Hourly Flow Rate, HFR (veh/h)	*14*	*681*	*24*	*6*	*595*	*5*
Percent Heavy Vehicles	*0*	--	--	*0*	--	--
Median Type	*Undivided*					
RT Channelized			*0*			*0*
Lanes	*0*	*2*	*0*	*0*	*2*	*0*
Configuration	*LT*		*TR*	*LT*		*TR*
Upstream Signal		*0*			*0*	

Minor Street	Eastbound			Westbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume (veh/h)	*10*	*15*	*43*	*56*	*14*	*4*
Peak-Hour Factor, PHF	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*
Hourly Flow Rate, HFR (veh/h)	*10*	*15*	*43*	*56*	*14*	*4*
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*	*1*	*0*	*0*	*1*	*0*
Configuration		*LTR*			*LTR*	

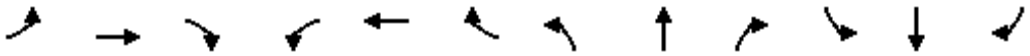
Delay, Queue Length, and Level of Service

Approach	Northbound	Southbound	Westbound			Eastbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration	*LT*	*LT*		*LTR*			*LTR*	
v (veh/h)	*14*	*6*		*74*			*68*	
C (m) (veh/h)	*987*	*902*		*166*			*322*	
v/c	*0.01*	*0.01*		*0.45*			*0.21*	
95% queue length	*0.04*	*0.02*		*2.05*			*0.78*	
Control Delay (s/veh)	*8.7*	*9.0*		*43.1*			*19.1*	
LOS	*A*	*A*		*E*			*C*	
Approach Delay (s/veh)	--	--	*43.1*			*19.1*		
Approach LOS	--	--	*E*			*C*		



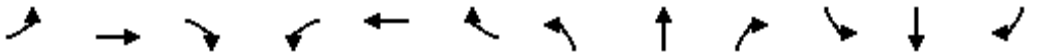
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	274	401	134	237	529	378	81	636	57	286	1120	545
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Grade (%)		0%			0%			0%			-3%	
Total Lost time (s)	5.0	6.0		5.0	6.0	5.0	5.0	6.0		5.0	6.0	5.0
Lane Util. Factor	1.00	0.95		1.00	0.95	1.00	1.00	0.95		1.00	0.95	1.00
Frt	1.00	0.96		1.00	1.00	0.85	1.00	0.99		1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1752	3313		1770	3438	1495	1752	3474		1696	3592	1591
Flt Permitted	0.21	1.00		0.25	1.00	1.00	0.09	1.00		0.20	1.00	1.00
Satd. Flow (perm)	390	3313		473	3438	1495	172	3474		350	3592	1591
Peak-hour factor, PHF	0.90	0.86	0.82	0.90	0.97	0.88	0.78	0.96	0.79	0.94	0.94	0.83
Adj. Flow (vph)	304	466	163	263	545	430	104	662	72	304	1191	657
RTOR Reduction (vph)	0	23	0	0	0	67	0	6	0	0	0	37
Lane Group Flow (vph)	304	606	0	263	545	363	104	728	0	304	1191	620
Heavy Vehicles (%)	3%	5%	4%	2%	5%	8%	3%	2%	6%	8%	2%	3%
Turn Type	pm+pt	NA		pm+pt	NA	pm+ov	pm+pt	NA		pm+pt	NA	pm+ov
Protected Phases	3	8		7	4	1	5	2		1	6	3
Permitted Phases	8			4		4	2			6		6
Actuated Green, G (s)	64.1	40.0		53.6	34.5	60.4	51.9	43.0		74.9	60.0	84.6
Effective Green, g (s)	64.1	40.0		53.6	34.5	60.4	51.9	43.0		74.9	60.0	84.6
Actuated g/C Ratio	0.43	0.27		0.36	0.23	0.40	0.35	0.29		0.50	0.40	0.56
Clearance Time (s)	5.0	6.0		5.0	6.0	5.0	5.0	6.0		5.0	6.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)	390	883		334	790	601	153	995		407	1436	897
v/s Ratio Prot	c0.13	0.18		0.10	0.16	0.10	0.04	0.21		c0.13	c0.33	0.11
v/s Ratio Perm	c0.21			0.18		0.14	0.19			0.24		0.28
v/c Ratio	0.78	0.69		0.79	0.69	0.60	0.68	0.73		0.75	0.83	0.69
Uniform Delay, d1	32.1	49.4		37.3	52.9	35.3	65.5	48.3		44.1	40.4	23.4
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	9.5	4.3		11.6	4.9	1.7	11.4	4.8		7.3	5.7	2.3
Delay (s)	41.6	53.7		48.9	57.8	37.1	76.9	53.1		51.4	46.1	25.7
Level of Service	D	D		D	E	D	E	D		D	D	C
Approach Delay (s)		49.7			48.7			56.0			40.6	
Approach LOS		D			D			E			D	

Intersection Summary			
HCM 2000 Control Delay	46.7	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.83		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	22.0
Intersection Capacity Utilization	86.5%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	330	0	714	0	0	0	0	841	457	218	1248	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Grade (%)		0%			0%			3%			0%	
Total Lost time (s)	6.0		6.0					6.0	6.0	5.0	5.0	
Lane Util. Factor	0.97		*0.99					0.91	1.00	1.00	0.91	
Frt	1.00		0.85					1.00	0.85	1.00	1.00	
Flt Protected	0.95		1.00					1.00	1.00	0.95	1.00	
Satd. Flow (prot)	3467		3105					5009	1544	1787	5085	
Flt Permitted	0.95		1.00					1.00	1.00	0.95	1.00	
Satd. Flow (perm)	3467		3105					5009	1544	1787	5085	
Peak-hour factor, PHF	0.89	0.92	0.93	0.92	0.92	0.92	0.92	0.95	0.91	0.91	0.93	0.92
Adj. Flow (vph)	371	0	768	0	0	0	0	885	502	240	1342	0
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	346	0	0	0
Lane Group Flow (vph)	371	0	768	0	0	0	0	885	156	240	1342	0
Heavy Vehicles (%)	1%	2%	3%	2%	2%	2%	2%	2%	3%	1%	2%	2%
Turn Type	Prot		Prot					NA	Perm	Prot	NA	
Protected Phases	8		8					6		5	5 6	
Permitted Phases									6			
Actuated Green, G (s)	34.7		34.7					31.0	31.0	17.3	54.3	
Effective Green, g (s)	34.7		34.7					31.0	31.0	17.3	48.3	
Actuated g/C Ratio	0.35		0.35					0.31	0.31	0.17	0.48	
Clearance Time (s)	6.0		6.0					6.0	6.0	5.0		
Vehicle Extension (s)	3.0		3.0					3.0	3.0	3.0		
Lane Grp Cap (vph)	1203		1077					1552	478	309	2456	
v/s Ratio Prot	0.11		c0.25					c0.18		c0.13	0.26	
v/s Ratio Perm									0.10			
v/c Ratio	0.31		0.71					0.57	0.33	0.78	0.55	
Uniform Delay, d1	23.9		28.3					28.9	26.5	39.5	18.2	
Progression Factor	1.00		1.00					1.00	1.00	0.19	1.39	
Incremental Delay, d2	0.7		4.0					0.5	0.4	10.1	0.2	
Delay (s)	24.5		32.4					29.4	26.9	17.5	25.5	
Level of Service	C		C					C	C	B	C	
Approach Delay (s)		29.8			0.0			28.5			24.3	
Approach LOS		C			A			C			C	

Intersection Summary			
HCM 2000 Control Delay	27.2	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	100.0	Sum of lost time (s)	17.0
Intersection Capacity Utilization	107.7%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	865	0	362	571	600	0	0	600	349
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)				6.0		6.0	5.0	5.0			6.0	6.0
Lane Util. Factor				0.97		1.00	*0.93	0.95			0.91	1.00
Frt				1.00		0.85	1.00	1.00			1.00	0.85
Flt Protected				0.95		1.00	0.95	1.00			1.00	1.00
Satd. Flow (prot)				3433		1599	3260	3574			5085	1599
Flt Permitted				0.95		1.00	0.95	1.00			1.00	1.00
Satd. Flow (perm)				3433		1599	3260	3574			5085	1599
Peak-hour factor, PHF	0.92	0.92	0.92	0.90	0.92	0.91	0.88	0.92	0.92	0.92	0.86	0.85
Adj. Flow (vph)	0	0	0	961	0	398	649	652	0	0	698	411
RTOR Reduction (vph)	0	0	0	0	0	158	0	0	0	0	0	305
Lane Group Flow (vph)	0	0	0	961	0	240	649	652	0	0	698	106
Heavy Vehicles (%)	2%	2%	2%	2%	2%	1%	3%	1%	2%	2%	2%	1%
Turn Type				Prot		Prot	Prot	NA			NA	Perm
Protected Phases				4		4	1	1 2			2	
Permitted Phases												2
Actuated Green, G (s)				34.0		34.0	23.3	54.0			25.7	25.7
Effective Green, g (s)				34.0		34.0	23.3	54.0			25.7	25.7
Actuated g/C Ratio				0.34		0.34	0.23	0.54			0.26	0.26
Clearance Time (s)				6.0		6.0	5.0				6.0	6.0
Vehicle Extension (s)				3.0		3.0	3.0				3.0	3.0
Lane Grp Cap (vph)				1167		543	759	1929			1306	410
v/s Ratio Prot				c0.28		0.15	c0.20	0.18			c0.14	
v/s Ratio Perm												0.07
v/c Ratio				0.82		0.44	0.86	0.34			0.53	0.26
Uniform Delay, d1				30.2		25.6	36.7	12.9			32.0	29.6
Progression Factor				1.00		1.00	0.40	1.43			1.00	1.00
Incremental Delay, d2				6.6		2.6	8.2	0.1			0.4	0.3
Delay (s)				36.9		28.2	22.8	18.6			32.4	29.9
Level of Service				D		C	C	B			C	C
Approach Delay (s)		0.0			34.4			20.7			31.5	
Approach LOS		A			C			C			C	

Intersection Summary			
HCM 2000 Control Delay	28.8	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.74		
Actuated Cycle Length (s)	100.0	Sum of lost time (s)	17.0
Intersection Capacity Utilization	107.7%	ICU Level of Service	G
Analysis Period (min)	15		

c Critical Lane Group

TWO-WAY STOP CONTROL SUMMARY

General Information

Analyst	*VM*
Agency/Co.	
Date Performed	*5/29/2015*
Analysis Time Period	*PM Peak*

Site Information

Intersection	*State at Burger/Ralph*
Jurisdiction	*Cleveland*
Analysis Year	*2014-Build*

Project Description *CUY-480-Safety Study*

East/West Street: *Burger/Ralph* | North/South Street: *State Road*

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)	*32*	*863*	*40*	*15*	*794*	*20*
Peak-Hour Factor, PHF	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*
Hourly Flow Rate, HFR (veh/h)	*32*	*863*	*40*	*15*	*794*	*20*
Percent Heavy Vehicles	*0*	--	--	*0*	--	--
Median Type	*Undivided*					
RT Channelized			*0*			*0*
Lanes	*0*	*2*	*0*	*0*	*2*	*0*
Configuration	*LT*		*TR*	*LT*		*TR*
Upstream Signal		*0*			*0*	

Minor Street	Eastbound			Westbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume (veh/h)	*11*	*18*	*50*	*66*	*18*	*12*
Peak-Hour Factor, PHF	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*
Hourly Flow Rate, HFR (veh/h)	*11*	*18*	*50*	*66*	*18*	*12*
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*	*1*	*0*	*0*	*1*	*0*
Configuration		*LTR*			*LTR*	

Delay, Queue Length, and Level of Service

Approach	Northbound	Southbound	Westbound			Eastbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration	*LT*	*LT*		*LTR*			*LTR*	
v (veh/h)	*32*	*15*		*96*			*79*	
C (m) (veh/h)	*822*	*761*		*86*			*179*	
v/c	*0.04*	*0.02*		*1.12*			*0.44*	
95% queue length	*0.12*	*0.06*		*6.66*			*2.04*	
Control Delay (s/veh)	*9.6*	*9.8*		*220.4*			*40.1*	
LOS	*A*	*A*		*F*			*E*	
Approach Delay (s/veh)	--	--	*220.4*			*40.1*		
Approach LOS	--	--	*F*			*E*		

APPENDIX I
HCS MAINLINE/RAMPS CAPACITY ANALYSIS REPORTS

TECHNICAL ANALYSIS

Capacity analyses were performed to evaluate the Existing and Build conditions based on existing (2014) and design year (2034) traffic. Analyses were conducted using the 2010 Highway Capacity Manual methodologies. The freeway, weave, ramp merge/diverge analysis results are summarized by direction in the following sections.

I-480 EB MAINLINE AND RAMPS CAPACITY ANALYSIS

Freeway sections, ramp merge/diverge, weave analysis and ramp roadway capacity analysis for the I-480 Eastbound sections are included in **Tables I-1 through I-3**. The LOS results are graphically shown in **Figure I-1 and I-2** for the design year No-Build and Build conditions, respectively. Output reports are appended to this section**.**

TABLE I-1: LOS SUMMARY - I-480 EASTBOUND FREEWAY ANALYSIS

Direction	Section of IR-480	Time Period	2014 Existing	2034 Existing	2034 Build
EB	Between SR-94 ramps	AM	C / 25.6	D / 27.1	Same as No-Build
		PM	B / 17.7	C / 18.4	
	Between SR-176 ramps	AM	C / 23.0	C / 24.4	
		PM	B / 16.6	B / 17.3	
	SR 94 to SR 176	AM	Weave		C / 25.1
		PM			B / 17.2

Alphanumeric values represent level of service, Numeric values represent density in pc/lane/mile

TABLE I-2: LOS SUMMARY - I-480 EB WEAVE ANALYSIS

IR-480 EB Weave	Time Period	2014 Existing	2034 Existing	2034 Build[1]
Between SR-176 and SR-94	AM	D / 31.9	D / 33.5	N/A
	PM	C / 20.5	C / 21.3	

Alphanumeric values represent level of service, Numeric values represent density in pc/lane/mile

Note 1: With 2-lane I-480 EB to SR 176 NB ramp geometry, weave analysis is not applicable as the available distance (3500') between the ramps exceeds the max. weave distance of 3040'.

TABLE I-3: LOS SUMMARY - I-480 EASTBOUND RAMP MERGE/DIVERGE ANALYSIS

Ramp	Merge/ Diverge	Time Period	2014 Existing	2034 Existing	2034 Build
IR-480 EB to SR-94	Diverge	AM	C / 23.9	C / 25.1	Same as No-Build
		PM	B / 17.6	B / 18.3	
SR-94 to IR-480 EB	Merge	AM	Weave		C / 25.9
		PM			B / 16.7
IR-480 EB to SR-176	Diverge	AM			A/3.0
		PM			A/5.2

Alphanumeric values represent level of service, Numeric values represent density in pc/lane/mile

RAMP ROADWAY LEVEL OF SERVICE – I-480/SR176 INTERCHANGE

The ramp roadway capacity analysis was performed for all the free-flow ramps at the I-480/SR 176 interchange. **Table I-4** summarizes the results for I-480 EB and SR 176 NB ramps.

The ramp configuration of SR 176 NB was revised to mitigate the over-capacity condition highlighted in the table. The SR 176 NB ramp from I-480 EB is revised to 2-lane ramp whereas the SR 176 NB ramp from I-480 WB is reduced to a single lane.

TABLE I-4: RAMP ROADWAY V/C RATIO SUMMARY – I-480 EB AND SR 176 NB RAMPS

Ramp ID	Ramp Location	Ramp Free Flow Speed	Ramp Volume - 2034 (pc/hr)	No-Build					Build				
				No. of Lanes	Ramp Capacity (pc/hr)	V/C ratio	Under or Over Capacity?	Notes	No. of Lanes	Ramp Capacity (pc/hr)	V/C ratio	Under or Over Capacity?	Notes
2014 & 2034 AM PEAK VOLUMES													
R1	IR-480 EB exit to SR-176 NB	45 mph	1630	**1**	2100	0.78	Under Capacity	Ramp Roadway	2	4200	0.39	Over Capacity	Ramp Roadway
R2	SR-176 NB entrance ramp from Brookpark	45 mph	530	1	2100	0.25	Under Capacity	Ramp Roadway	1	2100	**C/20.3 (HCS Freeway/Ramp Merge Conditions)[1]**		
R3	SR-176 NB - single lane merge of I-480 EB and Brookpark Entrance ramps	45 mph	**2160**	**1**	2100	**1.03**	**Over Capacity**	Ramp Roadway	2	4200			
R4	SR-176 NB entrance ramp from IR-480 WB	45 mph	1310	**2**	4200	0.31	Under Capacity	Ramp Roadway	1	2100	0.62	Over Capacity	Ramp Roadway
2014 & 2034 PM PEAK VOLUMES													
R1	IR-480 EB exit to SR-176 NB	45 mph	1000	**1**	2100	0.48	Under Capacity	Ramp Roadway	2	4200	0.24	Under Capacity	Ramp Roadway
R2	SR-176 NB entrance ramp from Brookpark	45 mph	410	1	2100	0.20	Under Capacity	Ramp Roadway	1	2100	**B/14.0 (HCS Freeway/Ramp Merge Conditions)[1]**		
R3	SR-176 NB - single lane merge of I-480 EB and Brookpark Entrance ramps	45 mph	1410	**1**	2100	0.67	Under Capacity	Ramp Roadway	2	4200			
R4	SR-176 NB entrance ramp from IR-480 WB	45 mph	1400	**2**	4200	0.33	Under Capacity	Ramp Roadway	1	2100	0.67	Under Capacity	Ramp Roadway

Note 1 - Legend: Letter/Numerical value - Level of service/density in pc/lane/mile

I-480 WB MAINLINE AND RAMPS CAPACITY ANALYSIS

Freeway sections, ramp merge/diverge, weave analysis and ramp roadway capacity analysis for the I-480 EB and SR 176 NB sections are included in **Tables I-5 through I-7**. The LOS results are graphically shown in Figure 1 and 2 for the design year No-Build and Build conditions, respectively. Output reports are provided in **Appendix E.**

TABLE I-5: LOS SUMMARY - I-480 WESTBOUND FREEWAY ANALYSIS

Direction	Section of IR-480	Time Period	2014 Existing	2034 Existing	2034 Build
WB	Between SR-176 ramps	AM	B / 15.9	B / 16.7	Same as No-Build
		PM	C / 22.2	C / 23.9	
	Between SR-94 and SR-176	AM	C / 19.2	C / 20.0	Weave
		PM	D / 29.6	D / 31.9	
	Between SR-94 ramps	AM	B / 16.9	B / 17.7	Same as No-Build
		PM	C / 23.7	C / 25.2	

Alphanumeric values represent level of service, Numeric values represent density in pc/lane/mile

TABLE I-6: LOS SUMMARY - I-480 WB WEAVE ANALYSIS

IR-480 WB Weave	Time Period	Existing	2034 Build
Between SR-176 and SR-94	AM	N/A (Freeway section)	B / 19.1
	PM		D / 33.2

Alphanumeric values represent LOS, Numeric values represent density in pc/lane/mile

TABLE I-7: LOS SUMMARY - I-480 WESTBOUND RAMP MERGE/DIVERGE ANALYSIS

Ramp	Merge/ Diverge	Time Period	2014 Existing	2034 Existing	2034 Build
SR-176 SB to IR-480 WB	Merge	AM	C / 20.2	C / 20.8	Weave
		PM	D / 31.4	D / 32.6	
IR-480 WB to SR-94	Diverge	AM	C / 20.6	C / 21.3	
		PM	D / 33.5	D / 35.0	
SR-94 to IR-480 WB	Merge	AM	B / 17.5	B / 18.1	Same as No-Build
		PM	C / 22.8	C / 24.1	

Alphanumeric values represent level of service, Numeric values represent density in pc/lane/mile

RAMP ROADWAY LEVEL OF SERVICE – I-480/SR176 INTERCHANGE

Table I-8 summarizes the results for I-480 WB and SR 176 SB ramps. Note that the No-Build and Build geometry remains the same for these ramp roadways, and hence the capacity analysis results are unchanged.

TABLE I-8: RAMP ROADWAY V/C RATIO SUMMARY – I-480 WB AND SR 176 SB RAMPS

Ramp ID	Ramp Location	Ramp Free Flow Speed	Ramp Volume - 2034 (pc/hr)	No-Build/Build				
				No. of Lanes	Ramp Capacity (pc/hr)	V/C ratio	Under or Over Capacity?	Notes
2014 & 2034 AM PEAK VOLUMES								
R5	SR-176 SB exit to Brookpark	45 mph	290	1	2100	0.14	Under Capacity	Ramp Roadway
R6	SR-176 SB exit to IR-480 (EB/WB)	45 mph	2030	2	4200	0.48	Under Capacity	Ramp Roadway
R7	SR-176 SB exit to IR-480 EB	45 mph	1240	1	2100	0.59	Under Capacity	Ramp Roadway
R8	SR-176 SB exit to IR-480 WB	45 mph	790	1	2100	0.38	Under Capacity	Ramp Roadway
2014 & 2034 PM PEAK VOLUMES								
R5	SR-176 SB exit to SR-17	45 mph	650	1	2100	0.31	Under Capacity	Ramp Roadway
R6	SR-176 SB exit to IR-480 EB/WB	45 mph	2960	2	4200	0.70	Under Capacity	Ramp Roadway
R7	SR-176 SB exit to IR-480 EB	45 mph	1400	1	2100	0.67	Under Capacity	Ramp Roadway
R8	SR-176 SB exit to IR-480 WB	45 mph	1560	1	2100	0.74	Under Capacity	Ramp Roadway
Note: No-Build and Buiild geometry remains unchanged, hence the LOS remains the same for both conditions								

FIGURE I-1 – DESIGN YEAR (2034) – NO BUILD LOS SUMMARY

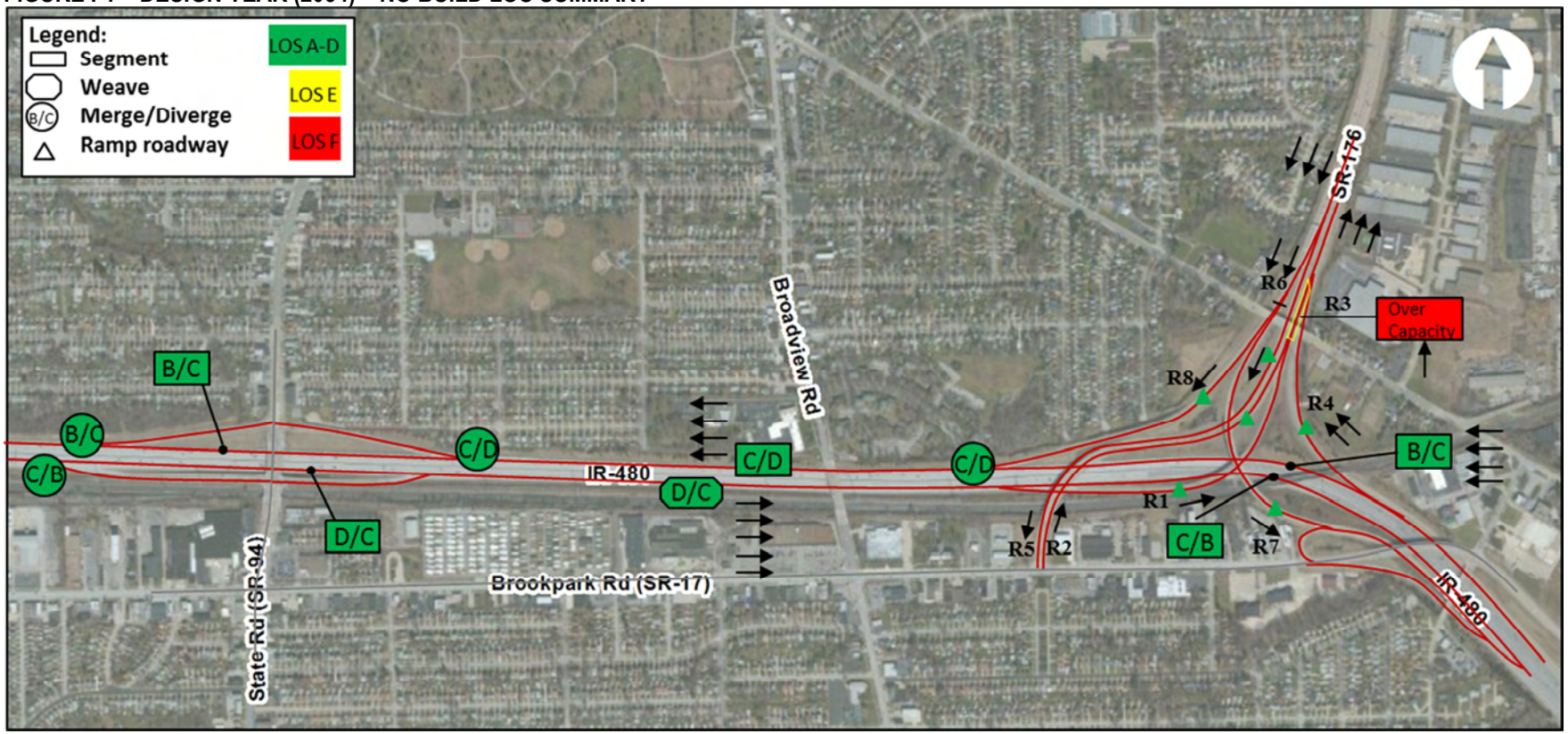
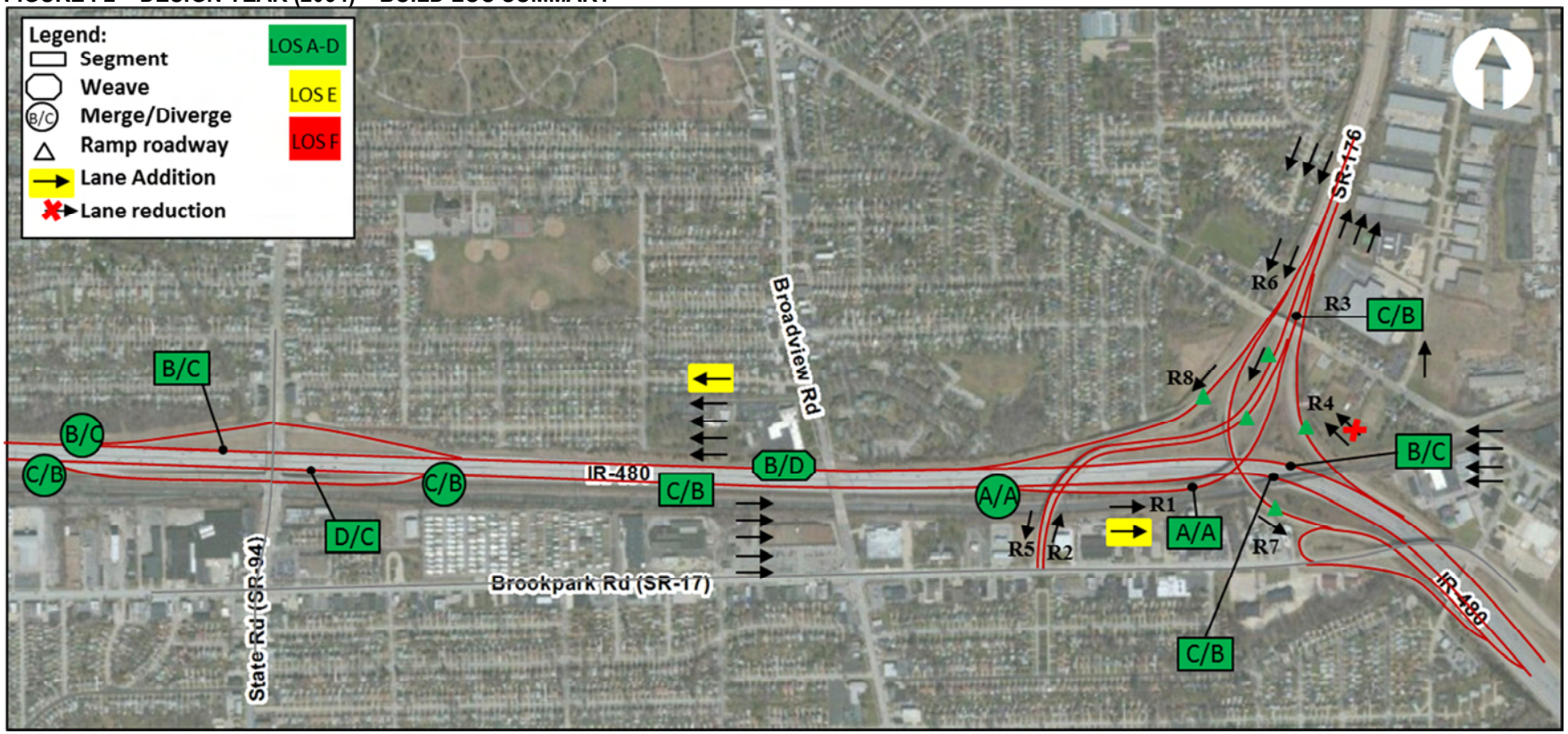


FIGURE I-2 – DESIGN YEAR (2034) – BUILD LOS SUMMARY



2014 AM PEAK

BASIC FREEWAY SEGMENTS WORKSHEET

General Information

Analyst	
Agency or Company	*LJB Inc*
Date Performed	*3/6/2015*
Analysis Time Period	*AM Peak*

Site Information

Highway/Direction of Travel	*IR-480 EB*
From/To	*Between SR-94 ramps*
Jurisdiction	*Cleveland*
Analysis Year	*2014*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*5940*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*8*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.962*

Speed Inputs

Lane Width		ft
Rt-Side Lat. Clearance		ft
Number of Lanes, N	*4*	
Total Ramp Density, TRD		ramps/mi
FFS (measured)	*65.0*	mph
Base free-flow Speed, BFFS		mph

Calc Speed Adj and FFS

f_{LW}		mph
f_{LC}		mph
TRD Adjustment		mph
FFS	*65.0*	mph

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*1643*	pc/h/ln
S	*64.2*	mph
D = v_p / S	*25.6*	pc/mi/ln
LOS	*C*	

Design (N)

Design (N)

Design LOS		
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)		pc/h/ln
S		mph
D = v_p / S		pc/mi/ln
Required Number of Lanes, N		

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
E_T - Exhibits 11-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
f_p - Page 11-18	TRD - Page 11-11
LOS, S, FFS, v_p - Exhibits 11-2, 11-3	

FREEWAY WEAVING WORKSHEET

General Information

Analyst	
Agency/Company	LJB Inc
Date Performed	3/6/2015
Analysis Time Period	AM Peak

Site Information

Freeway/Dir of Travel	IR-480 EB
Weaving Segment Location	Between SR-176 and SR-94
Analysis Year	2014

Project Description CUY-480 Safety Study

Inputs

Weaving configuration	One-Sided	Segment type	Freeway
Weaving number of lanes, N	5	Freeway minimum speed, S_{MIN}	15
Weaving segment length, L_S	3500ft	Freeway maximum capacity, C_{IFL}	2350
Freeway free-flow speed, FFS	65 mph	Terrain type	Level

Conversions to pc/h Under Base Conditions

	V (veh/h)	PHF	Truck (%)	RV (%)	E_T	E_R	f_{HV}	f_p	v (pc/h)
V_{FF}	4975	0.94	8	0	1.5	1.2	0.962	1.00	5504
V_{RF}	385	0.94	2	0	1.5	1.2	0.990	1.00	414
V_{FR}	965	0.94	4	0	1.5	1.2	0.980	1.00	1047
V_{RR}	665	0.94	2	0	1.5	1.2	0.990	1.00	715
V_{NW}	6219							V =	7680
V_W	1461								
VR	0.190								

Configuration Characteristics

Minimum maneuver lanes, N_{WL}	2 lc	Minimum weaving lane changes, LC_{MIN}	1461 lc/h
Interchange density, ID	1.0 int/mi	Weaving lane changes, LC_W	2421 lc/h
Minimum RF lane changes, LC_{RF}	1 lc/pc	Non-weaving lane changes, LC_{NW}	3076 lc/h
Minimum FR lane changes, LC_{FR}	1 lc/pc	Total lane changes, LC_{ALL}	5497 lc/h
Minimum RR lane changes, LC_{RR}	lc/pc	Non-weaving vehicle index, I_{NW}	2177

Weaving Segment Speed, Density, Level of Service, and Capacity

Weaving segment flow rate, v	7437 veh/h	Weaving intensity factor, W	0.323
Weaving segment capacity, c_w	10952 veh/h	Weaving segment speed, S	48.1 mph
Weaving segment v/c ratio	0.679	Average weaving speed, S_W	52.8 mph
Weaving segment density, D	31.9 pc/mi/ln	Average non-weaving speed, S_{NW}	47.1 mph
Level of Service, LOS	D	Maximum weaving length, L_{MAX}	4437 ft

Notes

a. Weaving segments longer than the calculated maximum length should be treated as isolated merge and diverge areas using the procedures of Chapter 13, "Freeway Merge and Diverge Segments".
b. For volumes that exceed the weaving segment capacity, the level of service is "F".

BASIC FREEWAY SEGMENTS WORKSHEET

General Information

Analyst	
Agency or Company	*LJB Inc*
Date Performed	*3/6/2015*
Analysis Time Period	*AM Peak*

Site Information

Highway/Direction of Travel	*IR-480 EB*
From/To	*Between SR-176 ramps*
Jurisdiction	*Cleveland*
Analysis Year	*2014*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*5360*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*9*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.957*

Speed Inputs

Lane Width		ft
Rt-Side Lat. Clearance		ft
Number of Lanes, N	*4*	
Total Ramp Density, TRD		ramps/mi
FFS (measured)	*65.0*	mph
Base free-flow Speed, BFFS		mph

Calc Speed Adj and FFS

f_{LW}		mph
f_{LC}		mph
TRD Adjustment		mph
FFS	*65.0*	mph

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*1490*	pc/h/ln
S	*64.9*	mph
D = v_p / S	*23.0*	pc/mi/ln
LOS	*C*	

Design (N)

Design (N)

Design LOS	
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	pc/h/ln
S	mph
D = v_p / S	pc/mi/ln
Required Number of Lanes, N	

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
E_T - Exhibits 11-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
f_p - Page 11-18	TRD - Page 11-11
LOS, S, FFS, v_p - Exhibits 11-2, 11-3	

BASIC FREEWAY SEGMENTS WORKSHEET

General Information

Analyst	
Agency or Company	*LJB Inc*
Date Performed	*3/6/2015*
Analysis Time Period	*AM Peak*

Site Information

Highway/Direction of Travel	*IR-480 WB*
From/To	*Between SR-176 ramps*
Jurisdiction	*Cleveland*
Analysis Year	*2014*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*3720*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*9*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.957*

Speed Inputs

Lane Width		ft
Rt-Side Lat. Clearance		ft
Number of Lanes, N	*4*	
Total Ramp Density, TRD		ramps/mi
FFS (measured)	*65.0*	mph
Base free-flow Speed, BFFS		mph

Calc Speed Adj and FFS

f_{LW}		mph
f_{LC}		mph
TRD Adjustment		mph
FFS	*65.0*	mph

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*1034*	pc/h/ln
S	*65.0*	mph
D = v_p / S	*15.9*	pc/mi/ln
LOS	*B*	

Design (N)

Design (N)

Design LOS	
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	pc/h/ln
S	mph
D = v_p / S	pc/mi/ln
Required Number of Lanes, N	

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
E_T - Exhibits 11-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
f_p - Page 11-18	TRD - Page 11-11
LOS, S, FFS, v_p - Exhibits 11-2, 11-3	

BASIC FREEWAY SEGMENTS WORKSHEET

General Information		Site Information	
Analyst		Highway/Direction of Travel	*IR-480 WB*
Agency or Company	*LJB Inc*	From/To	*Between SR-94 and SR-176*
Date Performed	*3/6/2015*	Jurisdiction	*Cleveland*
Analysis Time Period	*AM Peak*	Analysis Year	*2014*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*4510*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*8*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.962*

Speed Inputs			Calc Speed Adj and FFS		
Lane Width		ft			
Rt-Side Lat. Clearance		ft	f_{LW}		mph
Number of Lanes, N	*4*		f_{LC}		mph
Total Ramp Density, TRD		ramps/mi	TRD Adjustment		mph
FFS (measured)	*65.0*	mph	FFS	*65.0*	mph
Base free-flow Speed, BFFS		mph			

LOS and Performance Measures			Design (N)	
Operational (LOS)			Design (N)	
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*1247*	pc/h/ln	Design LOS	
S	*65.0*	mph	v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	pc/h/ln
D = v_p / S	*19.2*	pc/mi/ln	S	mph
LOS	*C*		D = v_p / S	pc/mi/ln
			Required Number of Lanes, N	

Glossary		Factor Location	
N - Number of lanes	S - Speed	E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
V - Hourly volume	D - Density	E_T - Exhibits 11-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
v_p - Flow rate	FFS - Free-flow speed	f_p - Page 11-18	TRD - Page 11-11
LOS - Level of service	BFFS - Base free-flow speed	LOS, S, FFS, v_p - Exhibits 11-2, 11-3	
DDHV - Directional design hour volume			

BASIC FREEWAY SEGMENTS WORKSHEET

General Information

Analyst	
Agency or Company	*LJB Inc*
Date Performed	*3/6/2015*
Analysis Time Period	*AM Peak*

Site Information

Highway/Direction of Travel	*IR-480 WB*
From/To	*Between SR-94 ramps*
Jurisdiction	*Cleveland*
Analysis Year	*2014*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*3980*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*8*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.962*

Speed Inputs

Lane Width		ft
Rt-Side Lat. Clearance		ft
Number of Lanes, N	*4*	
Total Ramp Density, TRD		ramps/mi
FFS (measured)	*65.0*	mph
Base free-flow Speed, BFFS		mph

Calc Speed Adj and FFS

f_{LW}		mph
f_{LC}		mph
TRD Adjustment		mph
FFS	*65.0*	mph

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*1101*	pc/h/ln
S	*65.0*	mph
D = v_p / S	*16.9*	pc/mi/ln
LOS	*B*	

Design (N)

Design (N)

Design LOS		
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)		pc/h/ln
S		mph
D = v_p / S		pc/mi/ln
Required Number of Lanes, N		

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
E_T - Exhibits 11-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
f_p - Page 11-18	TRD - Page 11-11
LOS, S, FFS, v_p - Exhibits 11-2, 11-3	

RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information

Analyst		Freeway/Dir of Travel	IR-480 EB
Agency or Company	LJB Inc	Junction	SR-94
Date Performed	3/3/2015	Jurisdiction	Cleveland
Analysis Time Period	AM Peak	Analysis Year	2014

Project Description CUY-480 Safety Study

Site Information

Inputs

Upstream Adj Ramp
☐ Yes ☐ On
☑ No ☐ Off
L_{up} = ft
V_u = veh/h

Freeway Number of Lanes, N	4
Ramp Number of Lanes, N	1
Acceleration Lane Length, L_A	
Deceleration Lane Length L_D	1500
Freeway Volume, V_F	6830
Ramp Volume, V_R	890
Freeway Free-Flow Speed, S_{FF}	65.0
Ramp Free-Flow Speed, S_{FR}	45.0

Downstream Adj Ramp
☐ Yes ☐ On
☑ No ☐ Off
L_{down} = ft
V_D = veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	6830	0.94	Level	9	0	0.957	1.00	7593
Ramp	890	0.94	Level	4	0	0.980	1.00	966
UpStream								
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)
P_{FM} = using Equation (Exhibit 13-6)
V_{12} = pc/h
V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)
Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No
Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No
If Yes,V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}		Exhibit 13-8		

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ V_{12} - 0.00627\ L_A$

D_R = (pc/mi/ln)
LOS = (Exhibit 13-2)

Speed Determination

M_S = (Exibit 13-11)
S_R= mph (Exhibit 13-11)
S_0= mph (Exhibit 13-11)
S = mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)
P_{FD} = 0.436 using Equation (Exhibit 13-7)
V_{12} = 3855 pc/h
V_3 or V_{av34} 1869 pc/h (Equation 13-14 or 13-17)
Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No
Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☑ No
If Yes,V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F	7593	Exhibit 13-8	9400	No
$V_{FO} = V_F - V_R$	6627	Exhibit 13-8	9400	No
V_R	966	Exhibit 13-10	2100	No

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}	3855	Exhibit 13-8	4400:All	No

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\ V_{12} - 0.009\ L_D$

D_R = 23.9 (pc/mi/ln)
LOS = C (Exhibit 13-2)

Speed Determination

D_s = 0.385 (Exhibit 13-12)
S_R= 56.1 mph (Exhibit 13-12)
S_0= 67.9 mph (Exhibit 13-12)
S = 61.4 mph (Exhibit 13-13)

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RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information / Site Information

Analyst		Freeway/Dir of Travel	IR-480 WB
Agency or Company	LJB Inc	Junction	SR-176 SB
Date Performed	3/6/2015	Jurisdiction	Cleveland
Analysis Time Period	AM Peak	Analysis Year	2014

Project Description CUY-480 Safety Study

Inputs

Upstream Adj Ramp		Freeway Number of Lanes, N	4	Downstream Adj Ramp	
☐ Yes	☐ On	Ramp Number of Lanes, N	1	☐ Yes	☐ On
☑ No	☐ Off	Acceleration Lane Length, L_A	700	☑ No	☐ Off
L_{up} =	ft	Deceleration Lane Length L_D		L_{down} =	ft
V_u =	veh/h	Freeway Volume, V_F	3720	V_D =	veh/h
		Ramp Volume, V_R	790		
		Freeway Free-Flow Speed, S_{FF}	65.0		
		Ramp Free-Flow Speed, S_{FR}	45.0		

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	3720	0.94	Level	8	0	0.962	1.00	4116
Ramp	790	0.94	Level	3	0	0.985	1.00	853
UpStream								
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 0.111 using Equation (Exhibit 13-6)

V_{12} = 458 pc/h

V_3 or V_{av34} = 1829 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☑ Yes ☐ No

If Yes, V_{12a} = 1646 pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}	4969	Exhibit 13-8		No

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}	2499	Exhibit 13-8	4600:All	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ V_{12} - 0.00627\ L_A$

D_R = 20.2 (pc/mi/ln)

LOS = C (Exhibit 13-2)

Speed Determination

M_S = 0.305 (Exibit 13-11)

S_R = 58.0 mph (Exhibit 13-11)

S_0 = 62.4 mph (Exhibit 13-11)

S = 60.1 mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = using Equation (Exhibit 13-7)

V_{12} = pc/h

V_3 or V_{av34} = pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F		Exhibit 13-8		
$V_{FO} = V_F - V_R$		Exhibit 13-8		
V_R		Exhibit 13-10		

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\ V_{12} - 0.009\ L_D$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

D_s = (Exhibit 13-12)

S_R = mph (Exhibit 13-12)

S_0 = mph (Exhibit 13-12)

S = mph (Exhibit 13-13)

RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information / Site Information

Analyst		Freeway/Dir of Travel	IR-480 WB
Agency or Company	LJB Inc	Junction	SR-94
Date Performed	3/3/2015	Jurisdiction	Cleveland
Analysis Time Period	AM Peak	Analysis Year	2014

Project Description CUY-480 Safety Study

Inputs

Upstream Adj Ramp		Downstream Adj Ramp
☐ Yes ☐ On	Freeway Number of Lanes, N: 4	☐ Yes ☐ On
☑ No ☐ Off	Ramp Number of Lanes, N: 1	☑ No ☐ Off
L_{up} = ft	Acceleration Lane Length, L_A:	L_{down} = ft
V_u = veh/h	Deceleration Lane Length L_D: 575	V_D = veh/h
	Freeway Volume, V_F: 4510	
	Ramp Volume, V_R: 530	
	Freeway Free-Flow Speed, S_{FF}: 65.0	
	Ramp Free-Flow Speed, S_{FR}: 45.0	

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	$v = V/PHF \times f_{HV} \times f_p$
Freeway	4510	0.94	Level	8	0	0.962	1.00	4990
Ramp	530	0.94	Level	3	0	0.985	1.00	572
UpStream								
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = using Equation (Exhibit 13-6)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}		Exhibit 13-8		

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ V_{12} - 0.00627\ L_A$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

M_S = (Exibit 13-11)

S_R = mph (Exhibit 13-11)

S_0 = mph (Exhibit 13-11)

S = mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 0.436 using Equation (Exhibit 13-7)

V_{12} = 2498 pc/h

V_3 or V_{av34} 1246 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☑ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F	4990	Exhibit 13-8	9400	No
$V_{FO} = V_F - V_R$	4418	Exhibit 13-8	9400	No
V_R	572	Exhibit 13-10	2100	No

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}	2498	Exhibit 13-8	4400:All	No

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\ V_{12} - 0.009\ L_D$

D_R = 20.6 (pc/mi/ln)

LOS = C (Exhibit 13-2)

Speed Determination

D_s = 0.349 (Exhibit 13-12)

S_R = 57.0 mph (Exhibit 13-12)

S_0 = 70.3 mph (Exhibit 13-12)

S = 62.9 mph (Exhibit 13-13)

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RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information

Analyst	
Agency or Company	LJB Inc
Date Performed	3/6/2015
Analysis Time Period	AM Peak

Site Information

Freeway/Dir of Travel	IR-480 WB
Junction	SR-94
Jurisdiction	Cleveland
Analysis Year	2014

Project Description CUY-480 Safety Study

Inputs

Upstream Adj Ramp		Freeway Number of Lanes, N	4	Downstream Adj Ramp	
☐ Yes	☐ On	Ramp Number of Lanes, N	1	☐ Yes	☐ On
☑ No	☐ Off	Acceleration Lane Length, L_A	1500	☑ No	☐ Off
L_{up} =	ft	Deceleration Lane Length L_D		L_{down} =	ft
V_u =	veh/h	Freeway Volume, V_F	3980	V_D =	veh/h
		Ramp Volume, V_R	950		
		Freeway Free-Flow Speed, S_{FF}	65.0		
		Ramp Free-Flow Speed, S_{FR}	45.0		

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	3980	0.94	Level	8	0	0.962	1.00	4403
Ramp	950	0.94	Level	7	0	0.966	1.00	1046
UpStream								
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 0.087 using Equation (Exhibit 13-6)

V_{12} = 383 pc/h

V_3 or V_{av34} 2010 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☑ Yes ☐ No

If Yes,V_{12a} = 1761 pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}	5449	Exhibit 13-8		No

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}	2807	Exhibit 13-8	4600:All	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ V_{12} - 0.00627\ L_A$

D_R = 17.5 (pc/mi/ln)

LOS = B (Exhibit 13-2)

Speed Determination

M_S = 0.251 (Exibit 13-11)

S_R= 59.2 mph (Exhibit 13-11)

S_0= 62.0 mph (Exhibit 13-11)

S = 60.6 mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = using Equation (Exhibit 13-7)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes,V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F		Exhibit 13-8		
$V_{FO} = V_F - V_R$		Exhibit 13-8		
V_R		Exhibit 13-10		

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\ V_{12} - 0.009\ L_D$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

D_s = (Exhibit 13-12)

S_R= mph (Exhibit 13-12)

S_0= mph (Exhibit 13-12)

S = mph (Exhibit 13-13)

2014 PM PEAK

BASIC FREEWAY SEGMENTS WORKSHEET

General Information

Analyst	
Agency or Company	*LJB Inc*
Date Performed	*3/6/2015*
Analysis Time Period	*PM Peak*

Site Information

Highway/Direction of Travel	*IR-480 EB*
From/To	*Between SR-94 ramps*
Jurisdiction	*Cleveland*
Analysis Year	*2014*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*4160*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*8*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.962*

Speed Inputs

Lane Width		ft
Rt-Side Lat. Clearance		ft
Number of Lanes, N	*4*	
Total Ramp Density, TRD		ramps/mi
FFS (measured)	*65.0*	mph
Base free-flow Speed, BFFS		mph

Calc Speed Adj and FFS

f_{LW}		mph
f_{LC}		mph
TRD Adjustment		mph
FFS	*65.0*	mph

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*1151*	pc/h/ln
S	*65.0*	mph
D = v_p / S	*17.7*	pc/mi/ln
LOS	*B*	

Design (N)

Design (N)

Design LOS	
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	pc/h/ln
S	mph
D = v_p / S	pc/mi/ln
Required Number of Lanes, N	

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
E_T - Exhibits 11-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
f_p - Page 11-18	TRD - Page 11-11
LOS, S, FFS, v_p - Exhibits 11-2, 11-3	

FREEWAY WEAVING WORKSHEET

General Information

Analyst	
Agency/Company	LJB Inc
Date Performed	3/6/2015
Analysis Time Period	PM Peak

Site Information

Freeway/Dir of Travel	IR-480 EB
Weaving Segment Location	Between SR-176 and SR-94
Analysis Year	2014

Project Description CUY-480 Safety Study

Inputs

Weaving configuration	One-Sided	Segment type	Freeway
Weaving number of lanes, N	5	Freeway minimum speed, S_{MIN}	15
Weaving segment length, L_S	3500ft	Freeway maximum capacity, C_{IFL}	2350
Freeway free-flow speed, FFS	65 mph	Terrain type	Level

Conversions to pc/h Under Base Conditions

	V (veh/h)	PHF	Truck (%)	RV (%)	E_T	E_R	f_{HV}	f_p	v (pc/h)
V_{FF}	3490	0.94	8	0	1.5	1.2	0.962	1.00	3861
V_{RF}	390	0.94	2	0	1.5	1.2	0.990	1.00	419
V_{FR}	670	0.94	4	0	1.5	1.2	0.980	1.00	727
V_{RR}	330	0.94	2	0	1.5	1.2	0.990	1.00	355
V_{NW}	4216							V =	5362
V_W	1146								
VR	0.214								

Configuration Characteristics

Minimum maneuver lanes, N_{WL}	2 lc	Minimum weaving lane changes, LC_{MIN}	1146 lc/h
Interchange density, ID	1.0 int/mi	Weaving lane changes, LC_W	2106 lc/h
Minimum RF lane changes, LC_{RF}	1 lc/pc	Non-weaving lane changes, LC_{NW}	2026 lc/h
Minimum FR lane changes, LC_{FR}	1 lc/pc	Total lane changes, LC_{ALL}	4132 lc/h
Minimum RR lane changes, LC_{RR}	lc/pc	Non-weaving vehicle index, I_{NW}	1476

Weaving Segment Speed, Density, Level of Service, and Capacity

Weaving segment flow rate, v	5192 veh/h	Weaving intensity factor, W	0.258
Weaving segment capacity, c_w	10797 veh/h	Weaving segment speed, S	52.2 mph
Weaving segment v/c ratio	0.481	Average weaving speed, S_W	54.8 mph
Weaving segment density, D	20.5 pc/mi/ln	Average non-weaving speed, S_{NW}	51.6 mph
Level of Service, LOS	C	Maximum weaving length, L_{MAX}	4677 ft

Notes

a. Weaving segments longer than the calculated maximum length should be treated as isolated merge and diverge areas using the procedures of Chapter 13, "Freeway Merge and Diverge Segments".
b. For volumes that exceed the weaving segment capacity, the level of service is "F".

BASIC FREEWAY SEGMENTS WORKSHEET

General Information

Analyst	
Agency or Company	*LJB Inc*
Date Performed	*3/6/2015*
Analysis Time Period	*PM Peak*

Site Information

Highway/Direction of Travel	*IR-480 EB*
From/To	*Between SR-176 ramps*
Jurisdiction	*Cleveland*
Analysis Year	*2014*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*3880*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*9*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.957*

Speed Inputs

Lane Width		ft
Rt-Side Lat. Clearance		ft
Number of Lanes, N	*4*	
Total Ramp Density, TRD		ramps/mi
FFS (measured)	*65.0*	mph
Base free-flow Speed, BFFS		mph

Calc Speed Adj and FFS

f_{LW}		mph
f_{LC}		mph
TRD Adjustment		mph
FFS	*65.0*	mph

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*1078*	pc/h/ln
S	*65.0*	mph
D = v_p / S	*16.6*	pc/mi/ln
LOS	*B*	

Design (N)

Design (N)

Design LOS		
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)		pc/h/ln
S		mph
D = v_p / S		pc/mi/ln
Required Number of Lanes, N		

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
E_T - Exhibits 11-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
f_p - Page 11-18	TRD - Page 11-11
LOS, S, FFS, v_p - Exhibits 11-2, 11-3	

BASIC FREEWAY SEGMENTS WORKSHEET

General Information

Analyst	
Agency or Company	*LJB Inc*
Date Performed	*3/6/2015*
Analysis Time Period	*PM Peak*

Site Information

Highway/Direction of Travel	*IR-480 WB*
From/To	*Between SR-176 ramps*
Jurisdiction	*Cleveland*
Analysis Year	*2014*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*5200*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*9*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.957*

Speed Inputs

Lane Width		ft
Rt-Side Lat. Clearance		ft
Number of Lanes, N	*4*	
Total Ramp Density, TRD		ramps/mi
FFS (measured)	*65.0*	mph
Base free-flow Speed, BFFS		mph

Calc Speed Adj and FFS

f_{LW}		mph
f_{LC}		mph
TRD Adjustment		mph
FFS	*65.0*	mph

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*1445*	pc/h/ln
S	*65.0*	mph
D = v_p / S	*22.2*	pc/mi/ln
LOS	*C*	

Design (N)

Design (N)

Design LOS	
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	pc/h/ln
S	mph
D = v_p / S	pc/mi/ln
Required Number of Lanes, N	

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
E_T - Exhibits 11-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
f_p - Page 11-18	TRD - Page 11-11
LOS, S, FFS, v_p - Exhibits 11-2, 11-3	

BASIC FREEWAY SEGMENTS WORKSHEET

General Information

Analyst	
Agency or Company	*LJB Inc*
Date Performed	*3/6/2015*
Analysis Time Period	*PM Peak*

Site Information

Highway/Direction of Travel	*IR-480 WB*
From/To	*Between SR-94 and SR-176*
Jurisdiction	*Cleveland*
Analysis Year	*2014*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*6760*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*5*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.976*

Speed Inputs

Lane Width		ft
Rt-Side Lat. Clearance		ft
Number of Lanes, N	*4*	
Total Ramp Density, TRD		ramps/mi
FFS (measured)	*65.0*	mph
Base free-flow Speed, BFFS		mph

Calc Speed Adj and FFS

f_{LW}		mph
f_{LC}		mph
TRD Adjustment		mph
FFS	*65.0*	mph

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*1843*	pc/h/ln
S	*62.2*	mph
D = v_p / S	*29.6*	pc/mi/ln
LOS	*D*	

Design (N)

Design (N)

Design LOS	
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	pc/h/ln
S	mph
D = v_p / S	pc/mi/ln
Required Number of Lanes, N	

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
E_T - Exhibits 11-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
f_p - Page 11-18	TRD - Page 11-11
LOS, S, FFS, v_p - Exhibits 11-2, 11-3	

BASIC FREEWAY SEGMENTS WORKSHEET

General Information

Analyst	
Agency or Company	*LJB Inc*
Date Performed	*3/6/2015*
Analysis Time Period	*PM Peak*

Site Information

Highway/Direction of Travel	*IR-480 WB*
From/To	*Between SR-94 ramps*
Jurisdiction	*Cleveland*
Analysis Year	*2014*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*5550*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*8*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.962*

Speed Inputs

Lane Width		ft
Rt-Side Lat. Clearance		ft
Number of Lanes, N	*4*	
Total Ramp Density, TRD		ramps/mi
FFS (measured)	*65.0*	mph
Base free-flow Speed, BFFS		mph

Calc Speed Adj and FFS

f_{LW}		mph
f_{LC}		mph
TRD Adjustment		mph
FFS	*65.0*	mph

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*1535*	pc/h/ln
S	*64.7*	mph
D = v_p / S	*23.7*	pc/mi/ln
LOS	*C*	

Design (N)

Design (N)

Design LOS	
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	pc/h/ln
S	mph
D = v_p / S	pc/mi/ln
Required Number of Lanes, N	

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
E_T - Exhibits 11-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
f_p - Page 11-18	TRD - Page 11-11
LOS, S, FFS, v_p - Exhibits 11-2, 11-3	

RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information / Site Information

Analyst		Freeway/Dir of Travel	IR-480 EB
Agency or Company	LJB Inc	Junction	SR-94
Date Performed	3/3/2015	Jurisdiction	Cleveland
Analysis Time Period	PM Peak	Analysis Year	2014

Project Description CUY-480 Safety Study

Inputs

Upstream Adj Ramp		Freeway Number of Lanes, N	4	Downstream Adj Ramp	
☐ Yes	☐ On	Ramp Number of Lanes, N	1	☐ Yes	☐ On
☑ No	☐ Off	Acceleration Lane Length, L_A		☑ No	☐ Off
L_{up} =	ft	Deceleration Lane Length L_D	1500	L_{down} =	ft
V_u =	veh/h	Freeway Volume, V_F	5170	V_D =	veh/h
		Ramp Volume, V_R	1010		
		Freeway Free-Flow Speed, S_{FF}	65.0		
		Ramp Free-Flow Speed, S_{FR}	45.0		

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	5170	0.94	Level	9	0	0.957	1.00	5748
Ramp	1010	0.94	Level	4	0	0.980	1.00	1096
UpStream								
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = using Equation (Exhibit 13-6)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}		Exhibit 13-8		

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ V_{12} - 0.00627\ L_A$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

M_S = (Exibit 13-11)

S_R = mph (Exhibit 13-11)

S_0 = mph (Exhibit 13-11)

S = mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 0.436 using Equation (Exhibit 13-7)

V_{12} = 3124 pc/h

V_3 or V_{av34} 1312 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☑ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F	5748	Exhibit 13-8	9400	No
$V_{FO} = V_F - V_R$	4652	Exhibit 13-8	9400	No
V_R	1096	Exhibit 13-10	2100	No

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}	3124	Exhibit 13-8	4400:All	No

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\ V_{12} - 0.009\ L_D$

D_R = 17.6 (pc/mi/ln)

LOS = B (Exhibit 13-2)

Speed Determination

D_s = 0.397 (Exhibit 13-12)

S_R = 55.9 mph (Exhibit 13-12)

S_0 = 70.1 mph (Exhibit 13-12)

S = 61.6 mph (Exhibit 13-13)

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RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information

Analyst	
Agency or Company	LJB Inc
Date Performed	3/6/2015
Analysis Time Period	PM Peak

Site Information

Freeway/Dir of Travel	IR-480 WB
Junction	SR-176 SB
Jurisdiction	Cleveland
Analysis Year	2014

Project Description CUY-480 Safety Study

Inputs

Upstream Adj Ramp
☐ Yes ☐ On
☑ No ☐ Off
L_{up} = ft
V_u = veh/h

Freeway Number of Lanes, N	4
Ramp Number of Lanes, N	1
Acceleration Lane Length, L_A	700
Deceleration Lane Length L_D	
Freeway Volume, V_F	5200
Ramp Volume, V_R	1560
Freeway Free-Flow Speed, S_{FF}	65.0
Ramp Free-Flow Speed, S_{FR}	45.0

Downstream Adj Ramp
☐ Yes ☐ On
☑ No ☐ Off
L_{down} = ft
V_D = veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	5200	0.94	Level	8	0	0.962	1.00	5753
Ramp	1560	0.94	Level	3	0	0.985	1.00	1684
UpStream								
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)
P_{FM} = 0.007 using Equation (Exhibit 13-6)
V_{12} = 42 pc/h
V_3 or V_{av34} = 2855 pc/h (Equation 13-14 or 13-17)
Is V_3 or V_{av34} > 2,700 pc/h? ☑ Yes ☐ No
Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☑ Yes ☐ No
If Yes,V_{12a} = 2301 pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}	7437	Exhibit 13-8		No

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}	3985	Exhibit 13-8	4600:All	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ V_{12} - 0.00627\ L_A$

D_R = 31.4 (pc/mi/ln)
LOS = D (Exhibit 13-2)

Speed Determination

M_S = 0.468 (Exibit 13-11)
S_R = 54.2 mph (Exhibit 13-11)
S_0 = 60.6 mph (Exhibit 13-11)
S = 57.0 mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)
P_{FD} = using Equation (Exhibit 13-7)
V_{12} = pc/h
V_3 or V_{av34} = pc/h (Equation 13-14 or 13-17)
Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No
Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No
If Yes,V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F		Exhibit 13-8		
$V_{FO} = V_F - V_R$		Exhibit 13-8		
V_R		Exhibit 13-10		

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\ V_{12} - 0.009\ L_D$

D_R = (pc/mi/ln)
LOS = (Exhibit 13-2)

Speed Determination

D_s = (Exhibit 13-12)
S_R = mph (Exhibit 13-12)
S_0 = mph (Exhibit 13-12)
S = mph (Exhibit 13-13)

RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information

Analyst		Freeway/Dir of Travel	IR-480 WB
Agency or Company	LJB Inc	Junction	SR-94
Date Performed	3/3/2015	Jurisdiction	Cleveland
Analysis Time Period	PM Peak	Analysis Year	2014

Project Description CUY-480 Safety Study

Site Information

Inputs

Upstream Adj Ramp		Freeway Number of Lanes, N	4	Downstream Adj Ramp	
☐ Yes	☐ On	Ramp Number of Lanes, N	1	☐ Yes	☐ On
☑ No	☐ Off	Acceleration Lane Length, L_A		☑ No	☐ Off
L_{up} =	ft	Deceleration Lane Length L_D	575	L_{down} =	ft
V_u =	veh/h	Freeway Volume, V_F	6760	V_D =	veh/h
		Ramp Volume, V_R	1210		
		Freeway Free-Flow Speed, S_{FF}	65.0		
		Ramp Free-Flow Speed, S_{FR}	45.0		

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	6760	0.94	Level	8	0	0.962	1.00	7479
Ramp	1210	0.94	Level	3	0	0.985	1.00	1307
UpStream								
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = using Equation (Exhibit 13-6)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}		Exhibit 13-8		

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ V_{12} - 0.00627\ L_A$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

M_S = (Exibit 13-11)

S_R = mph (Exhibit 13-11)

S_0 = mph (Exhibit 13-11)

S = mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 0.436 using Equation (Exhibit 13-7)

V_{12} = 3998 pc/h

V_3 or V_{av34} 1740 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☑ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F	7479	Exhibit 13-8	9400	No
$V_{FO} = V_F - V_R$	6172	Exhibit 13-8	9400	No
V_R	1307	Exhibit 13-10	2100	No

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}	3998	Exhibit 13-8	4400:All	No

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\ V_{12} - 0.009\ L_D$

D_R = 33.5 (pc/mi/ln)

LOS = D (Exhibit 13-2)

Speed Determination

D_s = 0.416 (Exhibit 13-12)

S_R = 55.4 mph (Exhibit 13-12)

S_0 = 68.4 mph (Exhibit 13-12)

S = 60.8 mph (Exhibit 13-13)

RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information

Analyst	
Agency or Company	LJB Inc
Date Performed	3/6/2015
Analysis Time Period	PM Peak

Site Information

Freeway/Dir of Travel	IR-480 WB
Junction	SR-94
Jurisdiction	Cleveland
Analysis Year	2014

Project Description CUY-480 Safety Study

Inputs

Upstream Adj Ramp
☐ Yes ☐ On
☑ No ☐ Off
L_{up} = ft
V_u = veh/h

Freeway Number of Lanes, N	4
Ramp Number of Lanes, N	1
Acceleration Lane Length, L_A	1500
Deceleration Lane Length L_D	
Freeway Volume, V_F	5550
Ramp Volume, V_R	940
Freeway Free-Flow Speed, S_{FF}	65.0
Ramp Free-Flow Speed, S_{FR}	45.0

Downstream Adj Ramp
☐ Yes ☐ On
☑ No ☐ Off
L_{down} = ft
V_D = veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	5550	0.94	Level	8	0	0.962	1.00	6140
Ramp	940	0.94	Level	7	0	0.966	1.00	1035
UpStream								
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)
P_{FM} = 0.088 using Equation (Exhibit 13-6)
V_{12} = 543 pc/h
V_3 or V_{av34} = 2798 pc/h (Equation 13-14 or 13-17)
Is V_3 or V_{av34} > 2,700 pc/h? ☑ Yes ☐ No
Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☑ Yes ☐ No
If Yes, V_{12a} = 2456 pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}	7175	Exhibit 13-8		No

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}	3491	Exhibit 13-8	4600:All	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ V_{12} - 0.00627\ L_A$

D_R = 22.8 (pc/mi/ln)
LOS = C (Exhibit 13-2)

Speed Determination

M_S = 0.314 (Exibit 13-11)
S_R = 57.8 mph (Exhibit 13-11)
S_0 = 60.2 mph (Exhibit 13-11)
S = 59.0 mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)
P_{FD} = using Equation (Exhibit 13-7)
V_{12} = pc/h
V_3 or V_{av34} = pc/h (Equation 13-14 or 13-17)
Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No
Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No
If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F		Exhibit 13-8		
$V_{FO} = V_F - V_R$		Exhibit 13-8		
V_R		Exhibit 13-10		

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\ V_{12} - 0.009\ L_D$

D_R = (pc/mi/ln)
LOS = (Exhibit 13-2)

Speed Determination

D_s = (Exhibit 13-12)
S_R = mph (Exhibit 13-12)
S_0 = mph (Exhibit 13-12)
S = mph (Exhibit 13-13)

2034 AM PEAK

BASIC FREEWAY SEGMENTS WORKSHEET

General Information

Analyst	
Agency or Company	*LJB Inc*
Date Performed	*3/6/2015*
Analysis Time Period	*AM Peak*

Site Information

Highway/Direction of Travel	*IR-480 EB*
From/To	*Between SR-94 ramps*
Jurisdiction	*Cleveland*
Analysis Year	*2034*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*6230*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*8*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.962*

Speed Inputs

Lane Width		ft
Rt-Side Lat. Clearance		ft
Number of Lanes, N	*4*	
Total Ramp Density, TRD		ramps/mi
FFS (measured)	*65.0*	mph
Base free-flow Speed, BFFS		mph

Calc Speed Adj and FFS

f_{LW}		mph
f_{LC}		mph
TRD Adjustment		mph
FFS	*65.0*	mph

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*1723*	pc/h/ln
S	*63.5*	mph
D = v_p / S	*27.1*	pc/mi/ln
LOS	*D*	

Design (N)

Design (N)

Design LOS	
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	pc/h/ln
S	mph
D = v_p / S	pc/mi/ln
Required Number of Lanes, N	

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
E_T - Exhibits 10-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
f_p - Page 11-18	TRD - Page 11-11
LOS, S, FFS, v_p - Exhibits 11-2, 11-3	

FREEWAY WEAVING WORKSHEET

General Information

Analyst	
Agency/Company	LJB Inc
Date Performed	3/6/2015
Analysis Time Period	AM Peak

Site Information

Freeway/Dir of Travel	IR-480 EB
Weaving Segment Location	Between SR-176 and SR-94
Analysis Year	2034 No-Build

Project Description CUY-480 Safety Study

Inputs

Weaving configuration	One-Sided	Segment type	Freeway
Weaving number of lanes, N	5	Freeway minimum speed, S_{MIN}	15
Weaving segment length, L_S	3500ft	Freeway maximum capacity, C_{IFL}	2350
Freeway free-flow speed, FFS	65 mph	Terrain type	Level

Conversions to pc/h Under Base Conditions

	V (veh/h)	PHF	Truck (%)	RV (%)	E_T	E_R	f_{HV}	f_p	v (pc/h)
V_{FF}	5270	0.94	8	0	1.5	1.2	0.962	1.00	5831
V_{RF}	390	0.94	2	0	1.5	1.2	0.990	1.00	419
V_{FR}	960	0.94	4	0	1.5	1.2	0.980	1.00	1042
V_{RR}	670	0.94	2	0	1.5	1.2	0.990	1.00	720
V_{NW}	6551							V =	8012
V_W	1461								
VR	0.182								

Configuration Characteristics

Minimum maneuver lanes, N_{WL}	2 lc	Minimum weaving lane changes, LC_{MIN}	1461 lc/h
Interchange density, ID	1.0 int/mi	Weaving lane changes, LC_W	2421 lc/h
Minimum RF lane changes, LC_{RF}	1 lc/pc	Non-weaving lane changes, LC_{NW}	3150 lc/h
Minimum FR lane changes, LC_{FR}	1 lc/pc	Total lane changes, LC_{ALL}	5571 lc/h
Minimum RR lane changes, LC_{RR}	lc/pc	Non-weaving vehicle index, I_{NW}	2293

Weaving Segment Speed, Density, Level of Service, and Capacity

Weaving segment flow rate, v	7756 veh/h	Weaving intensity factor, W	0.326
Weaving segment capacity, c_w	10981 veh/h	Weaving segment speed, S	47.8 mph
Weaving segment v/c ratio	0.706	Average weaving speed, S_W	52.7 mph
Weaving segment density, D	33.5 pc/mi/ln	Average non-weaving speed, S_{NW}	46.8 mph
Level of Service, LOS	D	Maximum weaving length, L_{MAX}	4357 ft

Notes

a. Weaving segments longer than the calculated maximum length should be treated as isolated merge and diverge areas using the procedures of Chapter 13, "Freeway Merge and Diverge Segments".
b. For volumes that exceed the weaving segment capacity, the level of service is "F".

FREEWAY WEAVING WORKSHEET

General Information

Analyst	
Agency/Company	LJB Inc
Date Performed	3/6/2015
Analysis Time Period	AM Peak

Site Information

Freeway/Dir of Travel	IR-480 EB
Weaving Segment Location	Between SR-176 and SR-94
Analysis Year	2034 Build

Project Description CUY-480 Safety Study

Inputs

Weaving configuration	One-Sided	Segment type	Freeway
Weaving number of lanes, N	5	Freeway minimum speed, S_{MIN}	15
Weaving segment length, L_S	3500ft	Freeway maximum capacity, C_{IFL}	2350
Freeway free-flow speed, FFS	65 mph	Terrain type	Level

Conversions to pc/h Under Base Conditions

	V (veh/h)	PHF	Truck (%)	RV (%)	E_T	E_R	f_{HV}	f_p	v (pc/h)
V_{FF}	5270	0.94	8	0	1.5	1.2	0.962	1.00	5831
V_{RF}	390	0.94	2	0	1.5	1.2	0.990	1.00	419
V_{FR}	960	0.94	4	0	1.5	1.2	0.980	1.00	1042
V_{RR}	670	0.94	2	0	1.5	1.2	0.990	1.00	720
V_{NW}	6551							V =	8012
V_W	1461								
VR	0.182								

Configuration Characteristics

Minimum maneuver lanes, N_{WL}	3 lc	Minimum weaving lane changes, LC_{MIN}	419 lc/h
Interchange density, ID	1.0 int/mi	Weaving lane changes, LC_W	lc/h
Minimum RF lane changes, LC_{RF}	1 lc/pc	Non-weaving lane changes, LC_{NW}	lc/h
Minimum FR lane changes, LC_{FR}	0 lc/pc	Total lane changes, LC_{ALL}	lc/h
Minimum RR lane changes, LC_{RR}	lc/pc	Non-weaving vehicle index, I_{NW}	

Weaving Segment Speed, Density, Level of Service, and Capacity

Weaving segment flow rate, v	veh/h	Weaving intensity factor, W	
Weaving segment capacity, c_w	veh/h	Weaving segment speed, S	mph
Weaving segment v/c ratio		Average weaving speed, S_W	mph
Weaving segment density, D	pc/mi/ln	Average non-weaving speed, S_{NW}	mph
Level of Service, LOS		Maximum weaving length, L_{MAX}	2791 ft

Notes

a. Weaving segments longer than the calculated maximum length should be treated as isolated merge and diverge areas using the procedures of Chapter 13, "Freeway Merge and Diverge Segments".
b. For volumes that exceed the weaving segment capacity, the level of service is "F".

BASIC FREEWAY SEGMENTS WORKSHEET

General Information

Analyst	
Agency or Company	*LJB Inc*
Date Performed	*3/6/2015*
Analysis Time Period	*AM Peak*

Site Information

Highway/Direction of Travel	*IR-480 EB*
From/To	*SR-94 to SR 176*
Jurisdiction	*Cleveland*
Analysis Year	*2034 Build*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*7290*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*8*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.962*

Speed Inputs

Lane Width		ft
Rt-Side Lat. Clearance		ft
Number of Lanes, N	*5*	
Total Ramp Density, TRD		ramps/mi
FFS (measured)	*65.0*	mph
Base free-flow Speed, BFFS		mph

Calc Speed Adj and FFS

f_{LW}		mph
f_{LC}		mph
TRD Adjustment		mph
FFS	*65.0*	mph

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*1613*	pc/h/ln
S	*64.4*	mph
D = v_p / S	*25.1*	pc/mi/ln
LOS	*C*	

Design (N)

Design (N)

Design LOS		
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)		pc/h/ln
S		mph
D = v_p / S		pc/mi/ln
Required Number of Lanes, N		

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
E_T - Exhibits 11-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
f_p - Page 11-18	TRD - Page 11-11
LOS, S, FFS, v_p - Exhibits 11-2, 11-3	

BASIC FREEWAY SEGMENTS WORKSHEET

General Information

Analyst	
Agency or Company	*LJB Inc*
Date Performed	*3/6/2015*
Analysis Time Period	*AM Peak*

Site Information

Highway/Direction of Travel	*IR-480 EB*
From/To	*Between SR-176 ramps*
Jurisdiction	*Cleveland*
Analysis Year	*2034*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*5660*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*9*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.957*

Speed Inputs

Lane Width		ft
Rt-Side Lat. Clearance		ft
Number of Lanes, N	*4*	
Total Ramp Density, TRD		ramps/mi
FFS (measured)	*65.0*	mph
Base free-flow Speed, BFFS		mph

Calc Speed Adj and FFS

f_{LW}		mph
f_{LC}		mph
TRD Adjustment		mph
FFS	*65.0*	mph

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*1573*	pc/h/ln
S	*64.6*	mph
D = v_p / S	*24.4*	pc/mi/ln
LOS	*C*	

Design (N)

Design (N)

Design LOS	
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	pc/h/ln
S	mph
D = v_p / S	pc/mi/ln
Required Number of Lanes, N	

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
E_T - Exhibits 11-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
f_p - Page 11-18	TRD - Page 11-11
LOS, S, FFS, v_p - Exhibits 11-2, 11-3	

BASIC FREEWAY SEGMENTS WORKSHEET

General Information

Analyst	
Agency or Company	*LJB Inc*
Date Performed	*3/6/2015*
Analysis Time Period	*AM Peak*

Site Information

Highway/Direction of Travel	*IR-480 WB*
From/To	*Between SR-176 ramps*
Jurisdiction	*Cleveland*
Analysis Year	*2034*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*3900*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*9*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.957*

Speed Inputs

Lane Width		ft
Rt-Side Lat. Clearance		ft
Number of Lanes, N	*4*	
Total Ramp Density, TRD		ramps/mi
FFS (measured)	*65.0*	mph
Base free-flow Speed, BFFS		mph

Calc Speed Adj and FFS

f_{LW}		mph
f_{LC}		mph
TRD Adjustment		mph
FFS	*65.0*	mph

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*1084*	pc/h/ln
S	*65.0*	mph
D = v_p / S	*16.7*	pc/mi/ln
LOS	*B*	

Design (N)

Design (N)

Design LOS		
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)		pc/h/ln
S		mph
D = v_p / S		pc/mi/ln
Required Number of Lanes, N		

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
E_T - Exhibits 11-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
f_p - Page 11-18	TRD - Page 11-11
LOS, S, FFS, v_p - Exhibits 11-2, 11-3	

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BASIC FREEWAY SEGMENTS WORKSHEET

General Information

Analyst	
Agency or Company	*LJB Inc*
Date Performed	*3/6/2015*
Analysis Time Period	*AM Peak*

Site Information

Highway/Direction of Travel	*IR-480 WB*
From/To	*Between SR-94 and SR-176*
Jurisdiction	*Cleveland*
Analysis Year	*2034 No Build*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*4690*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*8*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.962*

Speed Inputs

Lane Width		ft
Rt-Side Lat. Clearance		ft
Number of Lanes, N	*4*	
Total Ramp Density, TRD		ramps/mi
FFS (measured)	*65.0*	mph
Base free-flow Speed, BFFS		mph

Calc Speed Adj and FFS

f_{LW}		mph
f_{LC}		mph
TRD Adjustment		mph
FFS	*65.0*	mph

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*1297*	pc/h/ln
S	*65.0*	mph
D = v_p / S	*20.0*	pc/mi/ln
LOS	*C*	

Design (N)

Design (N)

Design LOS	
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	pc/h/ln
S	mph
D = v_p / S	pc/mi/ln
Required Number of Lanes, N	

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
E_T - Exhibits 11-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
f_p - Page 11-18	TRD - Page 11-11
LOS, S, FFS, v_p - Exhibits 11-2, 11-3	

FREEWAY WEAVING WORKSHEET

General Information

Analyst	
Agency/Company	LJB Inc
Date Performed	3/6/2015
Analysis Time Period	AM Peak

Site Information

Freeway/Dir of Travel	IR-480 WB
Weaving Segment Location	Between SR-176 and SR-94
Analysis Year	2034 Build

Project Description CUY-480 Safety Study

Inputs

Weaving configuration	One-Sided	Segment type	Freeway
Weaving number of lanes, N	5	Freeway minimum speed, S_{MIN}	15
Weaving segment length, L_S	3530ft	Freeway maximum capacity, C_{IFL}	2350
Freeway free-flow speed, FFS	65 mph	Terrain type	Level

Conversions to pc/h Under Base Conditions

	V (veh/h)	PHF	Truck (%)	RV (%)	E_T	E_R	f_{HV}	f_p	v (pc/h)
V_{FF}	3630	0.94	8	0	1.5	1.2	0.962	1.00	4016
V_{RF}	530	0.94	2	0	1.5	1.2	0.990	1.00	569
V_{FR}	270	0.94	4	0	1.5	1.2	0.980	1.00	293
V_{RR}	260	0.94	2	0	1.5	1.2	0.990	1.00	279
V_{NW}	4295							V =	5157
V_W	862								
VR	0.167								

Configuration Characteristics

Minimum maneuver lanes, N_{WL}	2 lc	Minimum weaving lane changes, LC_{MIN}	862 lc/h
Interchange density, ID	1.0 int/mi	Weaving lane changes, LC_W	1827 lc/h
Minimum RF lane changes, LC_{RF}	1 lc/pc	Non-weaving lane changes, LC_{NW}	2105 lc/h
Minimum FR lane changes, LC_{FR}	1 lc/pc	Total lane changes, LC_{ALL}	3932 lc/h
Minimum RR lane changes, LC_{RR}	lc/pc	Non-weaving vehicle index, I_{NW}	1516

Weaving Segment Speed, Density, Level of Service, and Capacity

Weaving segment flow rate, v	4990 veh/h	Weaving intensity factor, W	0.246
Weaving segment capacity, c_w	11048 veh/h	Weaving segment speed, S	54.1 mph
Weaving segment v/c ratio	0.452	Average weaving speed, S_W	55.1 mph
Weaving segment density, D	19.1 pc/mi/ln	Average non-weaving speed, S_{NW}	53.8 mph
Level of Service, LOS	B	Maximum weaving length, L_{MAX}	4203 ft

Notes

a. Weaving segments longer than the calculated maximum length should be treated as isolated merge and diverge areas using the procedures of Chapter 13, "Freeway Merge and Diverge Segments".
b. For volumes that exceed the weaving segment capacity, the level of service is "F".

BASIC FREEWAY SEGMENTS WORKSHEET

General Information

Analyst	
Agency or Company	*LJB Inc*
Date Performed	*3/6/2015*
Analysis Time Period	*AM Peak*

Site Information

Highway/Direction of Travel	*IR-480 WB*
From/To	*Between SR-94 ramps*
Jurisdiction	*Cleveland*
Analysis Year	*2034*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*4160*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*8*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.962*

Speed Inputs

Lane Width		ft
Rt-Side Lat. Clearance		ft
Number of Lanes, N	*4*	
Total Ramp Density, TRD		ramps/mi
FFS (measured)	*65.0*	mph
Base free-flow Speed, BFFS		mph

Calc Speed Adj and FFS

f_{LW}		mph
f_{LC}		mph
TRD Adjustment		mph
FFS	*65.0*	mph

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*1151*	pc/h/ln
S	*65.0*	mph
D = v_p / S	*17.7*	pc/mi/ln
LOS	*B*	

Design (N)

Design (N)

Design LOS	
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	pc/h/ln
S	mph
D = v_p / S	pc/mi/ln
Required Number of Lanes, N	

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
E_T - Exhibits 11-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
f_p - Page 11-18	TRD - Page 11-11
LOS, S, FFS, v_p - Exhibits 11-2, 11-3	

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BASIC FREEWAY SEGMENTS WORKSHEET

General Information		Site Information	
Analyst	*VM*	Highway/Direction of Travel	*SR 176 NB*
Agency or Company	*LJB Inc*	From/To	*I-480EB to SR 176 NB Entr Ramp*
Date Performed	*3/6/2015*	Jurisdiction	*Cleveland*
Analysis Time Period	*AM Peak*	Analysis Year	*2034 Build*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*1630*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*8*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.962*

Speed Inputs

Lane Width		ft
Rt-Side Lat. Clearance		ft
Number of Lanes, N	*4*	
Total Ramp Density, TRD		ramps/mi
FFS (measured)	*65.0*	mph
Base free-flow Speed, BFFS		mph

Calc Speed Adj and FFS

f_{LW}		mph
f_{LC}		mph
TRD Adjustment		mph
FFS	*65.0*	mph

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*451*	pc/h/ln
S	*65.0*	mph
D = v_p / S	*6.9*	pc/mi/ln
LOS	*A*	

Design (N)

Design (N)

Design LOS	
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	pc/h/ln
S	mph
D = v_p / S	pc/mi/ln
Required Number of Lanes, N	

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
E_T - Exhibits 11-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
f_p - Page 11-18	TRD - Page 11-11
LOS, S, FFS, v_p - Exhibits 11-2, 11-3	

RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information

Analyst		Freeway/Dir of Travel	IR-480 EB
Agency or Company	LJB Inc	Junction	SR-94
Date Performed	3/3/2015	Jurisdiction	Cleveland
Analysis Time Period	AM Peak	Analysis Year	2034

Project Description CUY-480 Safety Study

Site Information

Inputs

Upstream Adj Ramp
☐ Yes ☐ On
☑ No ☐ Off
L_{up} = ft
V_u = veh/h

Freeway Number of Lanes, N	4
Ramp Number of Lanes, N	1
Acceleration Lane Length, L_A	
Deceleration Lane Length L_D	1500
Freeway Volume, V_F	7120
Ramp Volume, V_R	890
Freeway Free-Flow Speed, S_{FF}	65.0
Ramp Free-Flow Speed, S_{FR}	45.0

Downstream Adj Ramp
☐ Yes ☐ On
☑ No ☐ Off
L_{down} = ft
V_D = veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	7120	0.94	Level	9	0	0.957	1.00	7915
Ramp	890	0.94	Level	4	0	0.980	1.00	966
UpStream								
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)
P_{FM} = using Equation (Exhibit 13-6)
V_{12} = pc/h
V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)
Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No
Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No
If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}		Exhibit 13-8		

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ V_{12} - 0.00627\ L_A$

D_R = (pc/mi/ln)
LOS = (Exhibit 13-2)

Speed Determination

M_S = (Exibit 13-11)
S_R = mph (Exhibit 13-11)
S_0 = mph (Exhibit 13-11)
S = mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)
P_{FD} = 0.436 using Equation (Exhibit 13-7)
V_{12} = 3996 pc/h
V_3 or V_{av34} 1959 pc/h (Equation 13-14 or 13-17)
Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No
Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☑ No
If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F	7915	Exhibit 13-8	9400	No
$V_{FO} = V_F - V_R$	6949	Exhibit 13-8	9400	No
V_R	966	Exhibit 13-10	2100	No

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}	3996	Exhibit 13-8	4400:All	No

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\ V_{12} - 0.009\ L_D$

D_R = 25.1 (pc/mi/ln)
LOS = C (Exhibit 13-2)

Speed Determination

D_s = 0.385 (Exhibit 13-12)
S_R = 56.1 mph (Exhibit 13-12)
S_0 = 67.6 mph (Exhibit 13-12)
S = 61.3 mph (Exhibit 13-13)

RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information

Analyst	
Agency or Company	LJB Inc
Date Performed	3/6/2015
Analysis Time Period	AM Peak

Site Information

Freeway/Dir of Travel	IR-480 EB
Junction	SR-94
Jurisdiction	Cleveland
Analysis Year	2034 Build

Project Description CUY-480 Safety Study

Inputs

Upstream Adj Ramp		Freeway Number of Lanes, N	4	Downstream Adj Ramp	
☐ Yes	☐ On	Ramp Number of Lanes, N	1	☐ Yes	☐ On
☑ No	☐ Off	Acceleration Lane Length, L_A	1500	☑ No	☐ Off
L_{up} =	ft	Deceleration Lane Length L_D		L_{down} =	ft
V_u =	veh/h	Freeway Volume, V_F	6230	V_D =	veh/h
		Ramp Volume, V_R	1060		
		Freeway Free-Flow Speed, S_{FF}	65.0		
		Ramp Free-Flow Speed, S_{FR}	45.0		

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	6230	0.94	Level	8	0	0.962	1.00	6893
Ramp	1060	0.94	Level	2	0	0.990	1.00	1139
UpStream								
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 0.075 using Equation (Exhibit 13-6)

V_{12} = 520 pc/h

V_3 or V_{av34} 3186 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☑ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☑ Yes ☐ No

If Yes,V_{12a} = 2757 pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}	8032	Exhibit 13-8		No

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}	3896	Exhibit 13-8	4600:All	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ V_{12} - 0.00627\ L_A$

D_R = 25.9 (pc/mi/ln)

LOS = C (Exhibit 13-2)

Speed Determination

M_S = 0.378 (Exibit 13-11)

S_R= 56.3 mph (Exhibit 13-11)

S_0= 59.4 mph (Exhibit 13-11)

S = 57.8 mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = using Equation (Exhibit 13-7)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes,V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F		Exhibit 13-8		
$V_{FO} = V_F - V_R$		Exhibit 13-8		
V_R		Exhibit 13-10		

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\ V_{12} - 0.009\ L_D$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

D_s = (Exhibit 13-12)

S_R= mph (Exhibit 13-12)

S_0= mph (Exhibit 13-12)

S = mph (Exhibit 13-13)

RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information / Site Information

Analyst		Freeway/Dir of Travel	IR-480 EB
Agency or Company	LJB Inc	Junction	SR 176 NB (2 LN RAMP)
Date Performed	3/3/2015	Jurisdiction	Cleveland
Analysis Time Period	AM Peak	Analysis Year	2034 BUILD

Project Description CUY-480 Safety Study

Inputs

Upstream Adj Ramp		Downstream Adj Ramp
☐ Yes ☐ On	Freeway Number of Lanes, N: 5	☐ Yes ☐ On
☑ No ☐ Off	Ramp Number of Lanes, N: 2	☑ No ☐ Off
L_{up} = ft	Acceleration Lane Length, L_A:	L_{down} = ft
V_u = veh/h	Deceleration Lane Length L_D: 1500	V_D = veh/h
	Freeway Volume, V_F: 7290	
	Ramp Volume, V_R: 1630	
	Freeway Free-Flow Speed, S_{FF}: 65.0	
	Ramp Free-Flow Speed, S_{FR}: 45.0	

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	7290	0.94	Level	9	0	0.957	1.00	8104
Ramp	1630	0.94	Level	4	0	0.980	1.00	1769
UpStream								
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = using Equation (Exhibit 13-6)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}		Exhibit 13-8		

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ V_{12} - 0.00627\ L_A$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

M_S = (Exibit 13-11)

S_R = mph (Exhibit 13-11)

S_0 = mph (Exhibit 13-11)

S = mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 0.260 using Equation (Exhibit 13-7)

V_{12} = 2995 pc/h

V_3 or V_{av34} 1744 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☑ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F	6484	Exhibit 13-8	9400	No
$V_{FO} = V_F - V_R$	4715	Exhibit 13-8	9400	No
V_R	1769	Exhibit 13-10	4200	No

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}	2995	Exhibit 13-8	4400:All	No

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\ V_{12} - 0.009\ L_D$

D_R = 3.0 (pc/mi/ln)

LOS = A (Exhibit 13-2)

Speed Determination

D_s = 0.457 (Exhibit 13-12)

S_R = 54.5 mph (Exhibit 13-12)

S_0 = 68.4 mph (Exhibit 13-12)

S = 61.2 mph (Exhibit 13-13)

RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information / Site Information

Analyst		Freeway/Dir of Travel	IR-480 WB
Agency or Company	LJB Inc	Junction	SR-176 SB
Date Performed	3/6/2015	Jurisdiction	Cleveland
Analysis Time Period	AM Peak	Analysis Year	2034

Project Description CUY-480 Safety Study

Inputs

Upstream Adj Ramp		Freeway Number of Lanes, N	4	Downstream Adj Ramp	
☐ Yes	☐ On	Ramp Number of Lanes, N	1	☐ Yes	☐ On
☑ No	☐ Off	Acceleration Lane Length, L_A	700	☑ No	☐ Off
L_{up} =	ft	Deceleration Lane Length L_D		L_{down} =	ft
V_u =	veh/h	Freeway Volume, V_F	3900	V_D =	veh/h
		Ramp Volume, V_R	790		
		Freeway Free-Flow Speed, S_{FF}	65.0		
		Ramp Free-Flow Speed, S_{FR}	45.0		

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	3900	0.94	Level	8	0	0.962	1.00	4315
Ramp	790	0.94	Level	3	0	0.985	1.00	853
UpStream								
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 0.111 using Equation (Exhibit 13-6)

V_{12} = 480 pc/h

V_3 or V_{av34} = 1917 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☑ Yes ☐ No

If Yes, V_{12a} = 1726 pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}	5168	Exhibit 13-8		No

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}	2579	Exhibit 13-8	4600:All	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ V_{12} - 0.00627\ L_A$

D_R = 20.8 (pc/mi/ln)

LOS = C (Exhibit 13-2)

Speed Determination

M_S = 0.309 (Exibit 13-11)

S_R = 57.9 mph (Exhibit 13-11)

S_0 = 62.1 mph (Exhibit 13-11)

S = 59.9 mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = using Equation (Exhibit 13-7)

V_{12} = pc/h

V_3 or V_{av34} = pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F		Exhibit 13-8		
$V_{FO} = V_F - V_R$		Exhibit 13-8		
V_R		Exhibit 13-10		

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\ V_{12} - 0.009\ L_D$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

D_s = (Exhibit 13-12)

S_R = mph (Exhibit 13-12)

S_0 = mph (Exhibit 13-12)

S = mph (Exhibit 13-13)

RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information / Site Information

Analyst		Freeway/Dir of Travel	IR-480 WB
Agency or Company	LJB Inc	Junction	SR-94
Date Performed	3/3/2015	Jurisdiction	Cleveland
Analysis Time Period	AM Peak	Analysis Year	2034-No Build

Project Description CUY-480 Safety Study

Inputs

Upstream Adj Ramp		Freeway Number of Lanes, N	4	Downstream Adj Ramp	
☐ Yes	☐ On	Ramp Number of Lanes, N	1	☐ Yes	☐ On
☑ No	☐ Off	Acceleration Lane Length, L_A		☑ No	☐ Off
L_{up} =	ft	Deceleration Lane Length L_D	575	L_{down} =	ft
V_u =	veh/h	Freeway Volume, V_F	4690	V_D =	veh/h
		Ramp Volume, V_R	530		
		Freeway Free-Flow Speed, S_{FF}	65.0		
		Ramp Free-Flow Speed, S_{FR}	45.0		

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	4690	0.94	Level	8	0	0.962	1.00	5189
Ramp	530	0.94	Level	3	0	0.985	1.00	572
UpStream								
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = using Equation (Exhibit 13-6)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}		Exhibit 13-8		

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ V_{12} - 0.00627\ L_A$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

M_S = (Exibit 13-11)

S_R = mph (Exhibit 13-11)

S_0 = mph (Exhibit 13-11)

S = mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 0.436 using Equation (Exhibit 13-7)

V_{12} = 2585 pc/h

V_3 or V_{av34} 1302 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☑ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F	5189	Exhibit 13-8	9400	No
$V_{FO} = V_F - V_R$	4617	Exhibit 13-8	9400	No
V_R	572	Exhibit 13-10	2100	No

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}	2585	Exhibit 13-8	4400:All	No

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\ V_{12} - 0.009\ L_D$

D_R = 21.3 (pc/mi/ln)

LOS = C (Exhibit 13-2)

Speed Determination

D_s = 0.349 (Exhibit 13-12)

S_R = 57.0 mph (Exhibit 13-12)

S_0 = 70.1 mph (Exhibit 13-12)

S = 62.9 mph (Exhibit 13-13)

RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information

Analyst	
Agency or Company	LJB Inc
Date Performed	3/6/2015
Analysis Time Period	AM Peak

Site Information

Freeway/Dir of Travel	IR-480 WB
Junction	SR-94
Jurisdiction	Cleveland
Analysis Year	2034

Project Description CUY-480 Safety Study

Inputs

Upstream Adj Ramp		Freeway Number of Lanes, N	4	Downstream Adj Ramp	
☐ Yes	☐ On	Ramp Number of Lanes, N	1	☐ Yes	☐ On
☑ No	☐ Off	Acceleration Lane Length, L_A	1500	☑ No	☐ Off
L_{up} =	ft	Deceleration Lane Length L_D		L_{down} =	ft
V_u =	veh/h	Freeway Volume, V_F	4160	V_D =	veh/h
		Ramp Volume, V_R	950		
		Freeway Free-Flow Speed, S_{FF}	65.0		
		Ramp Free-Flow Speed, S_{FR}	45.0		

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	4160	0.94	Level	8	0	0.962	1.00	4603
Ramp	950	0.94	Level	7	0	0.966	1.00	1046
UpStream								
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 0.087 using Equation (Exhibit 13-6)

V_{12} = 401 pc/h

V_3 or V_{av34} 2101 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☑ Yes ☐ No

If Yes,V_{12a} = 1841 pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}	5649	Exhibit 13-8		No

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}	2887	Exhibit 13-8	4600:All	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734 v_R + 0.0078 V_{12} - 0.00627 L_A$

D_R = 18.1 (pc/mi/ln)

LOS = B (Exhibit 13-2)

Speed Determination

M_S = 0.256 (Exibit 13-11)

S_R= 59.1 mph (Exhibit 13-11)

S_0= 61.8 mph (Exhibit 13-11)

S = 60.4 mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = using Equation (Exhibit 13-7)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes,V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F		Exhibit 13-8		
$V_{FO} = V_F - V_R$		Exhibit 13-8		
V_R		Exhibit 13-10		

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086 V_{12} - 0.009 L_D$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

D_s = (Exhibit 13-12)

S_R= mph (Exhibit 13-12)

S_0= mph (Exhibit 13-12)

S = mph (Exhibit 13-13)

RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information

Analyst	
Agency or Company	LJB Inc
Date Performed	3/6/2015
Analysis Time Period	AM Peak

Site Information

Freeway/Dir of Travel	SR 176 NB
Junction	On-ramp from Brookpark
Jurisdiction	Cleveland
Analysis Year	2034 Build

Project Description CUY-480 Safety Study

Inputs

Upstream Adj Ramp

☐ Yes ☐ On

☑ No ☐ Off

L_{up} = ft

V_u = veh/h

Freeway Number of Lanes, N	2
Ramp Number of Lanes, N	1
Acceleration Lane Length, L_A	500
Deceleration Lane Length L_D	
Freeway Volume, V_F	1630
Ramp Volume, V_R	530
Freeway Free-Flow Speed, S_{FF}	45.0
Ramp Free-Flow Speed, S_{FR}	45.0

Downstream Adj Ramp

☐ Yes ☐ On

☑ No ☐ Off

L_{down} = ft

V_D = veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	1630	0.94	Level	4	0	0.980	1.00	1769
Ramp	530	0.94	Level	2	0	0.990	1.00	569
UpStream								
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 1.000 using Equation (Exhibit 13-6)

V_{12} = 1769 pc/h

V_3 or V_{av34} 0 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☑ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}	2338	Exhibit 13-8		No

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}	2550	Exhibit 13-8	4600:All	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ V_{12} - 0.00627\ L_A$

D_R = 20.3 (pc/mi/ln)

LOS = C (Exhibit 13-2)

Speed Determination

M_S = 0.326 (Exibit 13-11)

S_R = 44.0 mph (Exhibit 13-11)

S_0 = N/A mph (Exhibit 13-11)

S = 44.0 mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = using Equation (Exhibit 13-7)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F		Exhibit 13-8		
$V_{FO} = V_F - V_R$		Exhibit 13-8		
V_R		Exhibit 13-10		

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\ V_{12} - 0.009\ L_D$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

D_s = (Exhibit 13-12)

S_R = mph (Exhibit 13-12)

S_0 = mph (Exhibit 13-12)

S = mph (Exhibit 13-13)

2034 PM PEAK

BASIC FREEWAY SEGMENTS WORKSHEET

General Information

Analyst	
Agency or Company	*LJB Inc*
Date Performed	*3/6/2015*
Analysis Time Period	*PM Peak*

Site Information

Highway/Direction of Travel	*IR-480 EB*
From/To	*Between SR-94 ramps*
Jurisdiction	*Cleveland*
Analysis Year	*2034*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*4320*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*8*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.962*

Speed Inputs

Lane Width		ft
Rt-Side Lat. Clearance		ft
Number of Lanes, N	*4*	
Total Ramp Density, TRD		ramps/mi
FFS (measured)	*65.0*	mph
Base free-flow Speed, BFFS		mph

Calc Speed Adj and FFS

f_{LW}		mph
f_{LC}		mph
TRD Adjustment		mph
FFS	*65.0*	mph

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*1195*	pc/h/ln
S	*65.0*	mph
D = v_p / S	*18.4*	pc/mi/ln
LOS	*C*	

Design (N)

Design (N)

Design LOS	
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	pc/h/ln
S	mph
D = v_p / S	pc/mi/ln
Required Number of Lanes, N	

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
E_T - Exhibits 11-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
f_p - Page 11-18	TRD - Page 11-11
LOS, S, FFS, v_p - Exhibits 11-2, 11-3	

FREEWAY WEAVING WORKSHEET

General Information

Analyst	
Agency/Company	LJB Inc
Date Performed	3/6/2015
Analysis Time Period	PM Peak

Site Information

Freeway/Dir of Travel	IR-480 EB
Weaving Segment Location	Between SR-176 and SR-94
Analysis Year	2034-No Build

Project Description CUY-480 Safety Study

Inputs

Weaving configuration	One-Sided	Segment type	Freeway
Weaving number of lanes, N	5	Freeway minimum speed, S_{MIN}	15
Weaving segment length, L_S	3500ft	Freeway maximum capacity, C_{IFL}	2350
Freeway free-flow speed, FFS	65 mph	Terrain type	Level

Conversions to pc/h Under Base Conditions

	V (veh/h)	PHF	Truck (%)	RV (%)	E_T	E_R	f_{HV}	f_p	v (pc/h)
V_{FF}	3650	0.94	8	0	1.5	1.2	0.962	1.00	4038
V_{RF}	390	0.94	2	0	1.5	1.2	0.990	1.00	419
V_{FR}	670	0.94	4	0	1.5	1.2	0.980	1.00	727
V_{RR}	330	0.94	2	0	1.5	1.2	0.990	1.00	355
V_{NW}	4393							V =	5539
V_W	1146								
VR	0.207								

Configuration Characteristics

Minimum maneuver lanes, N_{WL}	2 lc	Minimum weaving lane changes, LC_{MIN}	1146 lc/h
Interchange density, ID	1.0 int/mi	Weaving lane changes, LC_W	2106 lc/h
Minimum RF lane changes, LC_{RF}	1 lc/pc	Non-weaving lane changes, LC_{NW}	2142 lc/h
Minimum FR lane changes, LC_{FR}	1 lc/pc	Total lane changes, LC_{ALL}	4248 lc/h
Minimum RR lane changes, LC_{RR}	lc/pc	Non-weaving vehicle index, I_{NW}	1538

Weaving Segment Speed, Density, Level of Service, and Capacity

Weaving segment flow rate, v	5362 veh/h	Weaving intensity factor, W	0.263
Weaving segment capacity, c_w	10889 veh/h	Weaving segment speed, S	52.1 mph
Weaving segment v/c ratio	0.492	Average weaving speed, S_W	54.6 mph
Weaving segment density, D	21.3 pc/mi/ln	Average non-weaving speed, S_{NW}	51.4 mph
Level of Service, LOS	C	Maximum weaving length, L_{MAX}	4607 ft

Notes

a. Weaving segments longer than the calculated maximum length should be treated as isolated merge and diverge areas using the procedures of Chapter 13, "Freeway Merge and Diverge Segments".
b. For volumes that exceed the weaving segment capacity, the level of service is "F".

FREEWAY WEAVING WORKSHEET

General Information

Analyst	
Agency/Company	LJB Inc
Date Performed	3/6/2015
Analysis Time Period	PM Peak

Site Information

Freeway/Dir of Travel	IR-480 EB
Weaving Segment Location	Between SR-176 and SR-94
Analysis Year	2034 build

Project Description CUY-480 Safety Study

Inputs

Weaving configuration	One-Sided	Segment type	Freeway
Weaving number of lanes, N	5	Freeway minimum speed, S_{MIN}	15
Weaving segment length, L_S	3500ft	Freeway maximum capacity, C_{IFL}	2350
Freeway free-flow speed, FFS	65 mph	Terrain type	Level

Conversions to pc/h Under Base Conditions

	V (veh/h)	PHF	Truck (%)	RV (%)	E_T	E_R	f_{HV}	f_p	v (pc/h)
V_{FF}	3650	0.94	8	0	1.5	1.2	0.962	1.00	4038
V_{RF}	390	0.94	2	0	1.5	1.2	0.990	1.00	419
V_{FR}	670	0.94	4	0	1.5	1.2	0.980	1.00	727
V_{RR}	330	0.94	2	0	1.5	1.2	0.990	1.00	355
V_{NW}	4393							V =	5539
V_W	1146								
VR	0.207								

Configuration Characteristics

Minimum maneuver lanes, N_{WL}	3 lc	Minimum weaving lane changes, LC_{MIN}	419 lc/h
Interchange density, ID	1.0 int/mi	Weaving lane changes, LC_W	lc/h
Minimum RF lane changes, LC_{RF}	1 lc/pc	Non-weaving lane changes, LC_{NW}	lc/h
Minimum FR lane changes, LC_{FR}	0 lc/pc	Total lane changes, LC_{ALL}	lc/h
Minimum RR lane changes, LC_{RR}	lc/pc	Non-weaving vehicle index, I_{NW}	

Weaving Segment Speed, Density, Level of Service, and Capacity

Weaving segment flow rate, v	5362 veh/h	Weaving intensity factor, W	
Weaving segment capacity, c_w	veh/h	Weaving segment speed, S	mph
Weaving segment v/c ratio		Average weaving speed, S_W	mph
Weaving segment density, D	pc/mi/ln	Average non-weaving speed, S_{NW}	mph
Level of Service, LOS		Maximum weaving length, L_{MAX}	3041 ft

Notes

a. Weaving segments longer than the calculated maximum length should be treated as isolated merge and diverge areas using the procedures of Chapter 13, "Freeway Merge and Diverge Segments".
b. For volumes that exceed the weaving segment capacity, the level of service is "F".

BASIC FREEWAY SEGMENTS WORKSHEET

General Information

Analyst	
Agency or Company	*LJB Inc*
Date Performed	*3/6/2015*
Analysis Time Period	*PM Peak*

Site Information

Highway/Direction of Travel	*IR-480 EB*
From/To	*SR-94 to SR 176*
Jurisdiction	*Cleveland*
Analysis Year	*2034 Build*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*5040*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*8*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.962*

Speed Inputs

Lane Width		ft
Rt-Side Lat. Clearance		ft
Number of Lanes, N	*5*	
Total Ramp Density, TRD		ramps/mi
FFS (measured)	*65.0*	mph
Base free-flow Speed, BFFS		mph

Calc Speed Adj and FFS

f_{LW}		mph
f_{LC}		mph
TRD Adjustment		mph
FFS	*65.0*	mph

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*1115*	pc/h/ln
S	*65.0*	mph
D = v_p / S	*17.2*	pc/mi/ln
LOS	*B*	

Design (N)

Design (N)

Design LOS		
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)		pc/h/ln
S		mph
D = v_p / S		pc/mi/ln
Required Number of Lanes, N		

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
E_T - Exhibits 11-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
f_p - Page 11-18	TRD - Page 11-11
LOS, S, FFS, v_p - Exhibits 11-2, 11-3	

BASIC FREEWAY SEGMENTS WORKSHEET

General Information		Site Information	
Analyst	*VM*	Highway/Direction of Travel	*SR 176 NB (2 ln rmp)*
Agency or Company	*LJB Inc*	From/To	*I-480EB to SR 176 NB Entr Ramp*
Date Performed	*3/6/2015*	Jurisdiction	*Cleveland*
Analysis Time Period	*PM Peak*	Analysis Year	*2034 Build*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*1000*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*8*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.962*

Speed Inputs			Calc Speed Adj and FFS		
Lane Width		ft			
Rt-Side Lat. Clearance		ft	f_{LW}		mph
Number of Lanes, N	*4*		f_{LC}		mph
Total Ramp Density, TRD		ramps/mi	TRD Adjustment		mph
FFS (measured)	*65.0*	mph	FFS	*65.0*	mph
Base free-flow Speed, BFFS		mph			

LOS and Performance Measures			Design (N)	
Operational (LOS)			Design (N)	
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*277*	pc/h/ln	Design LOS	
S	*65.0*	mph	v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	pc/h/ln
D = v_p / S	*4.3*	pc/mi/ln	S	mph
LOS	*A*		D = v_p / S	pc/mi/ln
			Required Number of Lanes, N	

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
E_T - Exhibits 11-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
f_p - Page 11-18	TRD - Page 11-11
LOS, S, FFS, v_p - Exhibits 11-2, 11-3	

BASIC FREEWAY SEGMENTS WORKSHEET

General Information

Analyst	
Agency or Company	*LJB Inc*
Date Performed	*3/6/2015*
Analysis Time Period	*PM Peak*

Site Information

Highway/Direction of Travel	*IR-480 EB*
From/To	*Between SR-176 ramps*
Jurisdiction	*Cleveland*
Analysis Year	*2034*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*4040*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*9*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.957*

Speed Inputs

Lane Width		ft
Rt-Side Lat. Clearance		ft
Number of Lanes, N	*4*	
Total Ramp Density, TRD		ramps/mi
FFS (measured)	*65.0*	mph
Base free-flow Speed, BFFS		mph

Calc Speed Adj and FFS

f_{LW}		mph
f_{LC}		mph
TRD Adjustment		mph
FFS	*65.0*	mph

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*1123*	pc/h/ln
S	*65.0*	mph
D = v_p / S	*17.3*	pc/mi/ln
LOS	*B*	

Design (N)

Design (N)

Design LOS	
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	pc/h/ln
S	mph
D = v_p / S	pc/mi/ln
Required Number of Lanes, N	

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
E_T - Exhibits 10-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
f_p - Page 11-18	TRD - Page 11-11
LOS, S, FFS, v_p - Exhibits 11-2, 11-3	

BASIC FREEWAY SEGMENTS WORKSHEET

General Information

Analyst	
Agency or Company	*LJB Inc*
Date Performed	*3/6/2015*
Analysis Time Period	*PM Peak*

Site Information

Highway/Direction of Travel	*IR-480 WB*
From/To	*Between SR-176 ramps*
Jurisdiction	*Cleveland*
Analysis Year	*2034*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*5560*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*9*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.957*

Speed Inputs

Lane Width		ft
Rt-Side Lat. Clearance		ft
Number of Lanes, N	*4*	
Total Ramp Density, TRD		ramps/mi
FFS (measured)	*65.0*	mph
Base free-flow Speed, BFFS		mph

Calc Speed Adj and FFS

f_{LW}		mph
f_{LC}		mph
TRD Adjustment		mph
FFS	*65.0*	mph

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*1545*	pc/h/ln
S	*64.7*	mph
D = v_p / S	*23.9*	pc/mi/ln
LOS	*C*	

Design (N)

Design (N)

Design LOS	
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	pc/h/ln
S	mph
D = v_p / S	pc/mi/ln
Required Number of Lanes, N	

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
E_T - Exhibits 11-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
f_p - Page 11-18	TRD - Page 11-11
LOS, S, FFS, v_p - Exhibits 11-2, 11-3	

BASIC FREEWAY SEGMENTS WORKSHEET

General Information

Analyst	
Agency or Company	*LJB Inc*
Date Performed	*3/6/2015*
Analysis Time Period	*PM Peak*

Site Information

Highway/Direction of Travel	*IR-480 WB*
From/To	*Between SR-94 and SR-176*
Jurisdiction	*Cleveland*
Analysis Year	*2034-No build*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*7120*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*5*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.976*

Speed Inputs

Lane Width		ft
Rt-Side Lat. Clearance		ft
Number of Lanes, N	*4*	
Total Ramp Density, TRD		ramps/mi
FFS (measured)	*65.0*	mph
Base free-flow Speed, BFFS		mph

Calc Speed Adj and FFS

f_{LW}		mph
f_{LC}		mph
TRD Adjustment		mph
FFS	*65.0*	mph

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*1941*	pc/h/ln
S	*60.8*	mph
D = v_p / S	*31.9*	pc/mi/ln
LOS	*D*	

Design (N)

Design (N)

Design LOS	
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	pc/h/ln
S	mph
D = v_p / S	pc/mi/ln
Required Number of Lanes, N	

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
E_T - Exhibits 11-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
f_p - Page 11-18	TRD - Page 11-11
LOS, S, FFS, v_p - Exhibits 11-2, 11-3	

FREEWAY WEAVING WORKSHEET

General Information

Analyst	
Agency/Company	LJB Inc
Date Performed	3/6/2015
Analysis Time Period	PM Peak

Site Information

Freeway/Dir of Travel	IR-480 WB
Weaving Segment Location	Between SR-176 and SR-94
Analysis Year	2034 Build

Project Description CUY-480 Safety Study

Inputs

Weaving configuration	One-Sided	Segment type	Freeway
Weaving number of lanes, N	5	Freeway minimum speed, S_{MIN}	15
Weaving segment length, L_S	3530ft	Freeway maximum capacity, C_{IFL}	2350
Freeway free-flow speed, FFS	65 mph	Terrain type	Level

Conversions to pc/h Under Base Conditions

	V (veh/h)	PHF	Truck (%)	RV (%)	E_T	E_R	f_{HV}	f_p	v (pc/h)
V_{FF}	4990	0.94	8	0	1.5	1.2	0.962	1.00	5521
V_{RF}	920	0.94	2	0	1.5	1.2	0.990	1.00	989
V_{FR}	570	0.94	4	0	1.5	1.2	0.980	1.00	619
V_{RR}	640	0.94	2	0	1.5	1.2	0.990	1.00	688
V_{NW}	6209							V =	7817
V_W	1608								
VR	0.206								

Configuration Characteristics

Minimum maneuver lanes, N_{WL}	2 lc	Minimum weaving lane changes, LC_{MIN}	1608 lc/h
Interchange density, ID	1.0 int/mi	Weaving lane changes, LC_W	2573 lc/h
Minimum RF lane changes, LC_{RF}	1 lc/pc	Non-weaving lane changes, LC_{NW}	3074 lc/h
Minimum FR lane changes, LC_{FR}	1 lc/pc	Total lane changes, LC_{ALL}	5647 lc/h
Minimum RR lane changes, LC_{RR}	lc/pc	Non-weaving vehicle index, I_{NW}	2192

Weaving Segment Speed, Density, Level of Service, and Capacity

Weaving segment flow rate, v	7575 veh/h	Weaving intensity factor, W	0.327
Weaving segment capacity, c_w	10909 veh/h	Weaving segment speed, S	47.2 mph
Weaving segment v/c ratio	0.694	Average weaving speed, S_W	52.7 mph
Weaving segment density, D	33.2 pc/mi/ln	Average non-weaving speed, S_{NW}	45.9 mph
Level of Service, LOS	D	Maximum weaving length, L_{MAX}	4595 ft

Notes

a. Weaving segments longer than the calculated maximum length should be treated as isolated merge and diverge areas using the procedures of Chapter 13, "Freeway Merge and Diverge Segments".
b. For volumes that exceed the weaving segment capacity, the level of service is "F".

BASIC FREEWAY SEGMENTS WORKSHEET

General Information

Analyst	
Agency or Company	*LJB Inc*
Date Performed	*3/6/2015*
Analysis Time Period	*PM Peak*

Site Information

Highway/Direction of Travel	*IR-480 WB*
From/To	*Between SR-94 ramps*
Jurisdiction	*Cleveland*
Analysis Year	*2034*

Project Description *CUY-480 Safety Study*

☑ Oper.(LOS) ☐ Des.(N) ☐ Planning Data

Flow Inputs

Volume, V	*6720*	veh/h	Peak-Hour Factor, PHF	*0.94*
AADT		veh/day	%Trucks and Buses, P_T	*8*
Peak-Hr Prop. of AADT, K			%RVs, P_R	*0*
Peak-Hr Direction Prop, D			General Terrain:	*Level*
DDHV = AADT x K x D		veh/h	Grade % Length Up/Down %	*mi*

Calculate Flow Adjustments

f_p	*1.00*	E_R	*1.2*
E_T	*1.5*	$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	*0.962*

Speed Inputs

Lane Width		ft
Rt-Side Lat. Clearance		ft
Number of Lanes, N	*4*	
Total Ramp Density, TRD		ramps/mi
FFS (measured)	*65.0*	mph
Base free-flow Speed, BFFS		mph

Calc Speed Adj and FFS

f_{LW}		mph
f_{LC}		mph
TRD Adjustment		mph
FFS	*65.0*	mph

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	*1859*	pc/h/ln
S	*62.0*	mph
D = v_p / S	*30.0*	pc/mi/ln
LOS	*D*	

Design (N)

Design (N)

Design LOS	
v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	pc/h/ln
S	mph
D = v_p / S	pc/mi/ln
Required Number of Lanes, N	

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 11-10, 11-12	f_{LW} - Exhibit 11-8
E_T - Exhibits 11-10, 11-11, 11-13	f_{LC} - Exhibit 11-9
f_p - Page 11-18	TRD - Page 11-11
LOS, S, FFS, v_p - Exhibits 11-2, 11-3	

RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information / Site Information

Analyst		Freeway/Dir of Travel	IR-480 EB
Agency or Company	LJB Inc	Junction	SR-94
Date Performed	3/3/2015	Jurisdiction	Cleveland
Analysis Time Period	PM Peak	Analysis Year	2034

Project Description CUY-480 Safety Study

Inputs

Upstream Adj Ramp		Downstream Adj Ramp
☐ Yes ☐ On	Freeway Number of Lanes, N: 4	☐ Yes ☐ On
☑ No ☐ Off	Ramp Number of Lanes, N: 1	☑ No ☐ Off
L_{up} = ft	Acceleration Lane Length, L_A:	L_{down} = ft
V_u = veh/h	Deceleration Lane Length L_D: 1500	V_D = veh/h
	Freeway Volume, V_F: 5330	
	Ramp Volume, V_R: 1010	
	Freeway Free-Flow Speed, S_{FF}: 65.0	
	Ramp Free-Flow Speed, S_{FR}: 45.0	

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	$v = V/PHF \times f_{HV} \times f_p$
Freeway	5330	0.94	Level	9	0	0.957	1.00	5925
Ramp	1010	0.94	Level	4	0	0.980	1.00	1096
UpStream								
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = using Equation (Exhibit 13-6)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}		Exhibit 13-8		

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ V_{12} - 0.00627\ L_A$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

M_S = (Exibit 13-11)

S_R = mph (Exhibit 13-11)

S_0 = mph (Exhibit 13-11)

S = mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 0.436 using Equation (Exhibit 13-7)

V_{12} = 3201 pc/h

V_3 or V_{av34} 1362 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☑ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F	5925	Exhibit 13-8	9400	No
$V_{FO} = V_F - V_R$	4829	Exhibit 13-8	9400	No
V_R	1096	Exhibit 13-10	2100	No

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}	3201	Exhibit 13-8	4400:All	No

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\ V_{12} - 0.009\ L_D$

D_R = 18.3 (pc/mi/ln)

LOS = B (Exhibit 13-2)

Speed Determination

D_s = 0.397 (Exhibit 13-12)

S_R = 55.9 mph (Exhibit 13-12)

S_0 = 69.9 mph (Exhibit 13-12)

S = 61.6 mph (Exhibit 13-13)

RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information

Analyst	
Agency or Company	LJB Inc
Date Performed	3/6/2015
Analysis Time Period	PM Peak

Site Information

Freeway/Dir of Travel	IR-480 EB
Junction	SR-94
Jurisdiction	Cleveland
Analysis Year	2034 Build

Project Description CUY-480 Safety Study

Inputs

Upstream Adj Ramp

☐ Yes ☐ On

☑ No ☐ Off

L_{up} = ft

V_u = veh/h

Freeway Number of Lanes, N	4
Ramp Number of Lanes, N	1
Acceleration Lane Length, L_A	1500
Deceleration Lane Length L_D	
Freeway Volume, V_F	4320
Ramp Volume, V_R	720
Freeway Free-Flow Speed, S_{FF}	65.0
Ramp Free-Flow Speed, S_{FR}	45.0

Downstream Adj Ramp

☐ Yes ☐ On

☑ No ☐ Off

L_{down} = ft

V_D = veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	4320	0.94	Level	9	0	0.957	1.00	4803
Ramp	720	0.94	Level	2	0	0.990	1.00	774
UpStream								
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 0.121 using Equation (Exhibit 13-6)

V_{12} = 581 pc/h

V_3 or V_{av34} 2111 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☑ Yes ☐ No

If Yes,V_{12a} = 1921 pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}	5577	Exhibit 13-8		No

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}	2695	Exhibit 13-8	4600:All	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ V_{12} - 0.00627\ L_A$

D_R = 16.7 (pc/mi/ln)

LOS = B (Exhibit 13-2)

Speed Determination

M_S = 0.244 (Exibit 13-11)

S_R= 59.4 mph (Exhibit 13-11)

S_0= 61.6 mph (Exhibit 13-11)

S = 60.5 mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = using Equation (Exhibit 13-7)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes,V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F		Exhibit 13-8		
$V_{FO} = V_F - V_R$		Exhibit 13-8		
V_R		Exhibit 13-10		

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\ V_{12} - 0.009\ L_D$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

D_s = (Exhibit 13-12)

S_R= mph (Exhibit 13-12)

S_0= mph (Exhibit 13-12)

S = mph (Exhibit 13-13)

RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information / Site Information

Analyst		Freeway/Dir of Travel	IR-480 EB
Agency or Company	LJB Inc	Junction	SR 176 NB (2 Ln Ramp)
Date Performed	3/3/2015	Jurisdiction	Cleveland
Analysis Time Period	PM Peak	Analysis Year	2034 Build

Project Description CUY-480 Safety Study

Inputs

Upstream Adj Ramp		Freeway Number of Lanes, N	5	Downstream Adj Ramp	
☐ Yes	☐ On	Ramp Number of Lanes, N	2	☐ Yes	☐ On
☑ No	☐ Off	Acceleration Lane Length, L_A		☑ No	☐ Off
L_{up} =	ft	Deceleration Lane Length L_D	1500	L_{down} =	ft
V_u =	veh/h	Freeway Volume, V_F	5040	V_D =	veh/h
		Ramp Volume, V_R	1000		
		Freeway Free-Flow Speed, S_{FF}	65.0		
		Ramp Free-Flow Speed, S_{FR}	45.0		

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	5040	0.94	Level	9	0	0.957	1.00	5603
Ramp	1000	0.94	Level	4	0	0.980	1.00	1085
UpStream								
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = using Equation (Exhibit 13-6)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}		Exhibit 13-8		

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ V_{12} - 0.00627\ L_A$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

M_S = (Exibit 13-11)

S_R = mph (Exhibit 13-11)

S_0 = mph (Exhibit 13-11)

S = mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 0.260 using Equation (Exhibit 13-7)

V_{12} = 2041 pc/h

V_3 or V_{av34} 1361 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☑ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F	4763	Exhibit 13-8	9400	No
$V_{FO} = V_F - V_R$	3678	Exhibit 13-8	9400	No
V_R	1085	Exhibit 13-10	4200	No

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}	2041	Exhibit 13-8	4400:All	No

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\ V_{12} - 0.009\ L_D$

D_R = -5.2 (pc/mi/ln)

LOS = A (Exhibit 13-2)

Speed Determination

D_s = 0.396 (Exhibit 13-12)

S_R = 55.9 mph (Exhibit 13-12)

S_0 = 69.9 mph (Exhibit 13-12)

S = 63.1 mph (Exhibit 13-13)

RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information / Site Information

Analyst		Freeway/Dir of Travel	IR-480 WB
Agency or Company	LJB Inc	Junction	SR-176 SB
Date Performed	3/6/2015	Jurisdiction	Cleveland
Analysis Time Period	PM Peak	Analysis Year	2034-No Build

Project Description CUY-480 Safety Study

Inputs

Upstream Adj Ramp		Freeway Number of Lanes, N	4	Downstream Adj Ramp	
☐ Yes	☐ On	Ramp Number of Lanes, N	1	☐ Yes	☐ On
☑ No	☐ Off	Acceleration Lane Length, L_A	700	☑ No	☐ Off
L_{up} =	ft	Deceleration Lane Length L_D		L_{down} =	ft
V_u =	veh/h	Freeway Volume, V_F	5560	V_D =	veh/h
		Ramp Volume, V_R	1560		
		Freeway Free-Flow Speed, S_{FF}	65.0		
		Ramp Free-Flow Speed, S_{FR}	45.0		

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	5560	0.94	Level	8	0	0.962	1.00	6151
Ramp	1560	0.94	Level	3	0	0.985	1.00	1684
UpStream								
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 0.007 using Equation (Exhibit 13-6)

V_{12} = 45 pc/h

V_3 or V_{av34} 3053 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☑ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☑ Yes ☐ No

If Yes,V_{12a} = 2460 pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}	7835	Exhibit 13-8		No

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}	4144	Exhibit 13-8	4600:All	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ V_{12} - 0.00627\ L_A$

D_R = 32.6 (pc/mi/ln)

LOS = D (Exhibit 13-2)

Speed Determination

M_S = 0.504 (Exibit 13-11)

S_R = 53.4 mph (Exhibit 13-11)

S_0 = 60.2 mph (Exhibit 13-11)

S = 56.4 mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = using Equation (Exhibit 13-7)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes,V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F		Exhibit 13-8		
$V_{FO} = V_F - V_R$		Exhibit 13-8		
V_R		Exhibit 13-10		

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\ V_{12} - 0.009\ L_D$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

D_s = (Exhibit 13-12)

S_R = mph (Exhibit 13-12)

S_0 = mph (Exhibit 13-12)

S = mph (Exhibit 13-13)

RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information / Site Information

Analyst		Freeway/Dir of Travel	IR-480 WB
Agency or Company	LJB Inc	Junction	SR-94
Date Performed	3/3/2015	Jurisdiction	Cleveland
Analysis Time Period	PM Peak	Analysis Year	2034- No Build

Project Description CUY-480 Safety Study

Inputs

Upstream Adj Ramp		Freeway Number of Lanes, N	4	Downstream Adj Ramp	
☐ Yes	☐ On	Ramp Number of Lanes, N	1	☐ Yes	☐ On
☑ No	☐ Off	Acceleration Lane Length, L_A		☑ No	☐ Off
L_{up} =	ft	Deceleration Lane Length L_D	575	L_{down} =	ft
V_u =	veh/h	Freeway Volume, V_F	7120	V_D =	veh/h
		Ramp Volume, V_R	1210		
		Freeway Free-Flow Speed, S_{FF}	65.0		
		Ramp Free-Flow Speed, S_{FR}	45.0		

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	7120	0.94	Level	8	0	0.962	1.00	7877
Ramp	1210	0.94	Level	3	0	0.985	1.00	1307
UpStream								
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = using Equation (Exhibit 13-6)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}		Exhibit 13-8		

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ V_{12} - 0.00627\ L_A$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

M_S = (Exibit 13-11)

S_R = mph (Exhibit 13-11)

S_0 = mph (Exhibit 13-11)

S = mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 0.436 using Equation (Exhibit 13-7)

V_{12} = 4172 pc/h

V_3 or V_{av34} 1852 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☑ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F	7877	Exhibit 13-8	9400	No
$V_{FO} = V_F - V_R$	6570	Exhibit 13-8	9400	No
V_R	1307	Exhibit 13-10	2100	No

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}	4172	Exhibit 13-8	4400:All	No

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\ V_{12} - 0.009\ L_D$

D_R = 35.0 (pc/mi/ln)

LOS = D (Exhibit 13-2)

Speed Determination

D_s = 0.416 (Exhibit 13-12)

S_R = 55.4 mph (Exhibit 13-12)

S_0 = 68.0 mph (Exhibit 13-12)

S = 60.7 mph (Exhibit 13-13)

RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information

Analyst	
Agency or Company	LJB Inc
Date Performed	3/6/2015
Analysis Time Period	PM Peak

Site Information

Freeway/Dir of Travel	IR-480 WB
Junction	SR-94
Jurisdiction	Cleveland
Analysis Year	2034

Project Description CUY-480 Safety Study

Inputs

Upstream Adj Ramp		Downstream Adj Ramp
☐ Yes ☐ On	Freeway Number of Lanes, N: 4	☐ Yes ☐ On
☑ No ☐ Off	Ramp Number of Lanes, N: 1	☑ No ☐ Off
L_{up} = ft	Acceleration Lane Length, L_A: 1500	L_{down} = ft
V_u = veh/h	Deceleration Lane Length L_D:	V_D = veh/h
	Freeway Volume, V_F: 5910	
	Ramp Volume, V_R: 940	
	Freeway Free-Flow Speed, S_{FF}: 65.0	
	Ramp Free-Flow Speed, S_{FR}: 45.0	

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	5910	0.94	Level	8	0	0.962	1.00	6539
Ramp	940	0.94	Level	7	0	0.966	1.00	1035
UpStream								
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 0.088 using Equation (Exhibit 13-6)

V_{12} = 578 pc/h

V_3 or V_{av34} = 2980 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☑ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☑ Yes ☐ No

If Yes, V_{12a} = 2615 pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}	7574	Exhibit 13-8		No

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}	3650	Exhibit 13-8	4600:All	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ V_{12} - 0.00627\ L_A$

D_R = 24.1 (pc/mi/ln)

LOS = C (Exhibit 13-2)

Speed Determination

M_S = 0.336 (Exibit 13-11)

S_R = 57.3 mph (Exhibit 13-11)

S_0 = 59.7 mph (Exhibit 13-11)

S = 58.5 mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = using Equation (Exhibit 13-7)

V_{12} = pc/h

V_3 or V_{av34} = pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F		Exhibit 13-8		
$V_{FO} = V_F - V_R$		Exhibit 13-8		
V_R		Exhibit 13-10		

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\ V_{12} - 0.009\ L_D$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

D_s = (Exhibit 13-12)

S_R = mph (Exhibit 13-12)

S_0 = mph (Exhibit 13-12)

S = mph (Exhibit 13-13)

RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information / Site Information

Analyst		Freeway/Dir of Travel	SR 176NB-2 lane rmp from 480EB
Agency or Company	LJB Inc	Junction	On-ramp from Brookpark
Date Performed	8/27/2015	Jurisdiction	Cleveland
Analysis Time Period	PM Peak	Analysis Year	2034 Build

Project Description CUY-480 Safety Study

Inputs

Upstream Adj Ramp		Downstream Adj Ramp
☐ Yes ☐ On	Freeway Number of Lanes, N: 2	☐ Yes ☐ On
☑ No ☐ Off	Ramp Number of Lanes, N: 1	☑ No ☐ Off
L_{up} = ft	Acceleration Lane Length, L_A: 500	L_{down} = ft
V_u = veh/h	Deceleration Lane Length L_D:	V_D = veh/h
	Freeway Volume, V_F: 1000	
	Ramp Volume, V_R: 410	
	Freeway Free-Flow Speed, S_{FF}: 45.0	
	Ramp Free-Flow Speed, S_{FR}: 45.0	

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	1000	0.94	Level	4	0	0.980	1.00	1085
Ramp	410	0.94	Level	2	0	0.990	1.00	441
UpStream								
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 1.000 using Equation (Exhibit 13-6)

V_{12} = 1085 pc/h

V_3 or V_{av34} 0 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☑ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}	1526	Exhibit 13-8		No

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}	1656	Exhibit 13-8	4600:All	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ V_{12} - 0.00627\ L_A$

D_R = 14.0 (pc/mi/ln)

LOS = B (Exhibit 13-2)

Speed Determination

M_S = 0.296 (Exibit 13-11)

S_R = 44.1 mph (Exhibit 13-11)

S_0 = N/A mph (Exhibit 13-11)

S = 44.1 mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = using Equation (Exhibit 13-7)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F		Exhibit 13-8		
$V_{FO} = V_F - V_R$		Exhibit 13-8		
V_R		Exhibit 13-10		

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\ V_{12} - 0.009\ L_D$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

D_s = (Exhibit 13-12)

S_R = mph (Exhibit 13-12)

S_0 = mph (Exhibit 13-12)

S = mph (Exhibit 13-13)

APPENDIX J
STORAGE LENGTH CALCULATIONS

STORAGE LANE LENGTHS

Turn lane lengths were calculated for turn lanes at the study intersections. Lane lengths were first calculated using guidelines specified in the Location and Design Manual Section 401 (Ohio Department of Transportation). Lane lengths based on the ODOT's standard criteria assume design speed limits and include vehicle storage, deceleration length and a 50 foot diverging taper. The calculated lengths were compared to the existing turn lane sizing. A summary of the lane sizing comparison is shown in **Table J1** with lane sizing calculations included in this section**.**

Turn lane lengths were calculated using the following parameters:

- 2034 certified traffic volumes
- 35 miles per hour speed for Brookpark Road and State Road
- 45 miles per hour speed for I- 480 ramps
- 150 second cycle length for the State Road/Brookpark Road intersection for both peaks
- 100 second cycle length for the ramp intersections for the AM and PM peak
- Lengths rounded up in 5-foot increments

TABLE J1: LANE SIZING CALCULATIONS

Movement	Existing Storage Length (with taper) (feet)	Turn Lane Sizing (feet)		
		ODOT Calculated[1]	No Block Turn Lane Length[1]	Recommended[1]
Intersection: Brookpark Road at State Road				
NB Left Turn (State Road)	155[3]	210	740	No changes
SB Left Turn (State Road)	355	470	740	No changes
SB Right Turn (State Road)	660	775	740	No changes
WB Right Turn (Brookpark Road)	NA	600	400	400 feet
WB Left Turn (Brookpark Road)	265[3]	425	400	No changes
EB Left Turn (Brookpark Road)	295[3]	600	385	No changes
Intersection: State Road and I- 480 eastbound ramp				
NB Right Turn (State Road)	655/370[2]	785	300	No changes
SB Left Turn (State Road)	200	305	425	No changes
EB Left Turn (I-480 EB Exit ramp)	815/815[2]	320/320[2]	375/375[2]	No changes
EB Right Turn (I-480 EB Exit ramp)	815/815[2]	500/500[2]	190/190[2]	No changes
Intersection: State Road and I- 480 westbound ramp				
NB Left Turn (State Road)	205/205[2]	390/390[2]	370/370[2]	No changes
SB Right Turn (State Road)	220	430	195	No changes
WB Left Turn (I-480 WB Exit ramp)	330/330[2]	580/580[2]	375/375[2]	600/600[2]
WB Right Turn (I-480 WB Exit ramp)	330	505	450	600 feet

Note 1: Length includes vehicle storage, deceleration and diverging taper, rounded to nearest 5 ft.
Note 2: Length provided by lane: (inside lane / outside lane) for 2-lane conditions.
Note 3: Additional storage provided in two way left turn lane

CUY-480-14.10/14.40
Turn Lane Length Calculations
STATE ROAD AND BROOKPARK ROAD

STATE ROUTE 94 (STATE ROAD) NBLT 2034 PEAK HOUR VOLUMES			
Movement	AM	PM	
Design Speed	35	35	mph
Cycle Length	150	150	seconds
Control (Stop or Signal)	Signal	Signal	
Through Volume	1033	616	vph
Number of Through Lanes	2	2	
Turning Volume	51	81	vph
Number of Turning Lanes	1	1	
Design Condition	A	A	A, B, or C
Turning Percentage	5%	12%	
Vehicles Per Cycle	2.1	3.4	
Storage Length	105	160	feet
Deceleration/Taper	50	50	feet
Calculated Turn Lane Length	155	210	feet
No Block Distance	738	470	feet
No Block Turn Lane Length	738	470	feet

STATE ROUTE 94 (STATE ROAD) SBLT 2034 AM PEAK HOUR VOLUMES			
Movement	AM	PM	
Design Speed	35	35	mph
Cycle Length	150	150	seconds
Control (Stop or Signal)	Signal	Signal	
Through Volume	435	1033	vph
Number of Through Lanes	2	2	
Turning Volume	258	274	vph
Number of Turning Lanes	1	1	
Design Condition	A	A	A, B, or C
Turning Percentage	37%	21%	
Vehicles Per Cycle	10.8	11.4	
Storage Length	395	420	feet
Deceleration/Taper	50	50	feet
Calculated Turn Lane Length	445	470	feet
No Block Distance	350	738	feet
No Block Turn Lane Length	445	738	feet

STATE ROUTE 94 (STATE ROAD) EBLT 2034 AM PEAK HOUR VOLUMES			
Movement	AM	PM	
Design Speed	35	35	mph
Cycle Length	150	150	seconds
Control (Stop or Signal)	Signal	Signal	
Through Volume	500	401	vph
Number of Through Lanes	2	2	
Turning Volume	381	264	vph
Number of Turning Lanes	1	1	
Design Condition	A	A	A, B, or C
Turning Percentage	43%	40%	
Vehicles Per Cycle	15.9	11.0	
Storage Length	548	400	feet
Deceleration/Taper	50	50	feet
Calculated Turn Lane Length	598	450	feet
No Block Distance	385	333	feet
No Block Turn Lane Length	598	450	feet

STATE ROUTE 94 (STATE ROAD) SBRT 2034 PM PEAK HOUR VOLUMES			
Movement	AM	PM	
Design Speed	35	35	mph
Cycle Length	150	150	seconds
Control (Stop or Signal)	Signal	Signal	
Through Volume	435	1033	vph
Number of Through Lanes	2	2	
Turning Volume	216	505	vph
Number of Turning Lanes	1	1	
Design Condition	A	A	A, B, or C
Turning Percentage	33%	33%	
Vehicles Per Cycle	9.0	21.0	
Storage Length	350	725	feet
Deceleration/Taper	50	50	feet
Calculated Turn Lane Length	400	775	feet
No Block Distance	350	738	feet
No Block Turn Lane Length	400	775	feet

STATE ROUTE 94 (STATE ROAD) WBLT 2034 PM PEAK HOUR VOLUMES			
Movement	AM	PM	
Design Speed	35	35	mph
Cycle Length	150	150	seconds
Control (Stop or Signal)	Signal	Signal	
Through Volume	233	529	vph
Number of Through Lanes	2	2	
Turning Volume	38	237	vph
Number of Turning Lanes	1	1	
Design Condition	A	A	A, B, or C
Turning Percentage	14%	31%	
Vehicles Per Cycle	1.6	9.9	
Storage Length	80	373	feet
Deceleration/Taper	50	50	feet
Calculated Turn Lane Length	130	423	feet
No Block Distance	195	400	feet
No Block Turn Lane Length	195	423	feet

STATE ROUTE 94 (STATE ROAD) WBRT 2034 PM PEAK HOUR VOLUMES			
Movement	AM	PM	
Design Speed	35	35	mph
Cycle Length	150	150	seconds
Control (Stop or Signal)	Signal	Signal	
Through Volume	233	529	vph
Number of Through Lanes	2	2	
Turning Volume	252	378	vph
Number of Turning Lanes	1	1	
Design Condition	A	A	A, B, or C
Turning Percentage	52%	42%	
Vehicles Per Cycle	10.5	15.8	
Storage Length	388	545	feet
Deceleration/Taper	50	50	feet
Calculated Turn Lane Length	438	595	feet
No Block Distance	195	400	feet
No Block Turn Lane Length	438	595	feet

CUY-480-14.10/14.40
Turn Lane Length Calculations
STATE ROUTE 94 (STATE ROAD) AND I-480 EB RAMPS

STATE ROUTE 94 (STATE ROAD) NBRT 2034 PEAK HOUR VOLUMES			
Movement	NBRT		
Design Speed	35	35	mph
Cycle Length	100	100	seconds
Control (Stop or Signal)	Signal	Signal	
Through Volume	812	801	vph
Number of Through Lanes	3	3	
Turning Volume	769	457	vph
Number of Turning Lanes	1	1	
Design Condition	A	A	A, B, or C
Turning Percentage	49%	36%	
Vehicles Per Cycle	21.4	12.7	
Storage Length	735	468	feet
Deceleration/Taper	50	50	feet
Calculated Turn Lane Length	785	518	feet
No Block Distance	300	295	feet
No Block Turn Lane Length	785	518	feet

STATE ROUTE 94 (STATE ROAD) SBLT 2034 PEAK HOUR VOLUMES			
Movement	SBLT		
Design Speed	35	35	mph
Cycle Length	100	100	seconds
Control (Stop or Signal)	Signal	Signal	
Through Volume	486	1248	vph
Number of Through Lanes	3	3	
Turning Volume	204	218	vph
Number of Turning Lanes	1	1	
Design Condition	A	A	A, B, or C
Turning Percentage	30%	15%	
Vehicles Per Cycle	5.7	6.1	
Storage Length	235	253	feet
Deceleration/Taper	50	50	feet
Calculated Turn Lane Length	285	303	feet
No Block Distance	188	425	feet
No Block Turn Lane Length	285	425	feet

INTERSTATE ROUTE 480 EB OFF RAMP EBLT 2034 PEAK HOUR VOLUMES			
Movement	AM	PM	
Design Speed	45	45	mph
Cycle Length	100	100	seconds
Control (Stop or Signal)	Signal	Signal	
Through Volume	639	717	vph
Number of Through Lanes	2	2	
Turning Volume	335	331	vph
Number of Turning Lanes	2	2	
Design Condition	C	C	A, B, or C
Turning Percentage	34%	32%	
Vehicles Per Cycle	4.7	4.6	
Storage Length	193	190	feet
Deceleration/Taper	125	125	feet
Calculated Turn Lane Length	318	315	feet
No Block Distance	345	373	feet
No Block Turn Lane Length	345	373	feet

INTERSTATE ROUTE 480 EB OFF RAMP EBRT 2034 PEAK HOUR VOLUMES			
Movement	AM	PM	
Design Speed	45	45	mph
Cycle Length	100	100	seconds
Control (Stop or Signal)	Signal	Signal	
Through Volume	335	331	vph
Number of Through Lanes	2	2	
Turning Volume	639	717	vph
Number of Turning Lanes	2	2	
Design Condition	C	C	A, B, or C
Turning Percentage	66%	68%	
Vehicles Per Cycle	8.9	10.0	
Storage Length	348	375	feet
Deceleration/Taper	125	125	feet
Calculated Turn Lane Length	473	500	feet
No Block Distance	190	188	feet
No Block Turn Lane Length	473	500	feet

CUY-480-14.10/14.40
Turn Lane Length Calculations
STATE ROUTE 94 (STATE ROAD) AND I-480 WB RAMPS

STATE ROUTE 94 (STATE ROAD) NBLT 2034 PEAK HOUR VOLUMES			
Movement	AM	PM	
Design Speed	35	35	mph
Cycle Length	100	100	seconds
Control (Stop or Signal)	Signal	Signal	
Through Volume	554	600	vph
Number of Through Lanes	2	2	
Turning Volume	621	571	vph
Number of Turning Lanes	2	2	
Design Condition	A	A	A, B, or C
Turning Percentage	53%	49%	
Vehicles Per Cycle	8.6	7.9	
Storage Length	340	320	feet
Deceleration/Taper	50	50	feet
Calculated Turn Lane Length	390	370	feet
No Block Distance	305	333	feet
No Block Turn Lane Length	390	370	feet

STATE ROUTE 94 (STATE ROAD) SBRT 2034 PEAK HOUR VOLUMES			
Movement	AM	PM	
Design Speed	35	35	mph
Cycle Length	100	100	seconds
Control (Stop or Signal)	Signal	Signal	
Through Volume	390	528	vph
Number of Through Lanes	3	3	
Turning Volume	367	349	vph
Number of Turning Lanes	1	1	
Design Condition	A	A	A, B, or C
Turning Percentage	48%	40%	
Vehicles Per Cycle	10.2	9.7	
Storage Length	380	368	feet
Deceleration/Taper	50	50	feet
Calculated Turn Lane Length	430	418	feet
No Block Distance	165	195	feet
No Block Turn Lane Length	430	418	feet

INTERSTATE ROUTE 480 WB OFF RAMP WBLT 2034 PEAK HOUR VOLUMES			
Movement	AM	PM	
Design Speed	45	45	mph
Cycle Length	100	100	seconds
Control (Stop or Signal)	Signal	Signal	
Through Volume	232	363	vph
Number of Through Lanes	1	1	
Turning Volume	305	868	vph
Number of Turning Lanes	2	2	
Design Condition	C	C	A, B, or C
Turning Percentage	57%	71%	
Vehicles Per Cycle	4.2	12.1	
Storage Length	180	453	feet
Deceleration/Taper	125	125	feet
Calculated Turn Lane Length	305	578	feet
No Block Distance	260	375	feet
No Block Turn Lane Length	305	578	feet

INTERSTATE ROUTE 480 WB OFF RAMP WBRT 2034 PEAK HOUR VOLUMES			
Movement	AM	PM	
Design Speed	45	45	mph
Cycle Length	100	100	seconds
Control (Stop or Signal)	Signal	Signal	
Through Volume	305	868	vph
Number of Through Lanes	2	2	
Turning Volume	232	363	vph
Number of Turning Lanes	1	1	
Design Condition	C	C	A, B, or C
Turning Percentage	43%	29%	
Vehicles Per Cycle	6.4	10.1	
Storage Length	260	378	feet
Deceleration/Taper	125	125	feet
Calculated Turn Lane Length	385	503	feet
No Block Distance	180	450	feet
No Block Turn Lane Length	385	503	feet

APPENDIX K
DESIGN EXCEPTIONS

MEMO

To: Project File

From: Matt Gardner, P.E., ENV SP

Date: May 21, 2015

Subject: CUY-480 EB to SR 176 NB Ramp
Design Exception for 2-lane ramp

Project #: 0110095A.00 – Task 09

The proposed improvement at the I-480 EB exit ramp to SR 176 NB ramps converts the existing single lane ramp to a 2-lane configuration. Dimensions of the existing ramp are shown in **Table H1.**

TABLE H1 - Existing Condition

Existing Section	Width
Ramp pavement width	28 feet
Ramp toe of parapet to toe of parapet	30 feet
Ramp graded shoulder width left	9 feet
Ramp guardrail offset to the left	6 feet
Ramp graded shoulder width right	13 feet

The ODOT L&D criteria (Figure 303-1E) for a 2-lane ramp configuration are summarized below.

- Pavement width = 38 feet (2-12 ft lanes + 4 ft paved shoulder LT+ 10 ft paved shoulder RT)
- Toe to toe of parapet = 38 ft (2-12 ft lanes +4 ft offset to conc barrier +10 ft offset to conc barrier)

  Figure 302-2E states the minimum lateral clearance on the existing bridge to remain = 6.5 feet right and 3.5 feet left which results in a toe-to-toe width of 34 feet. However, there is a statement that in no case shall the lateral clearance be less than the approach shoulder width.

- Graded shoulder width left = 9feet
- Guardrail offset to the left = 6feet
- Graded shoulder width right= 15feet

A summary of design exceptions to retrofit a 2-lane ramp having an advisory speed of 45 miles per hour and a pavement width of 30 feet is shown in **Table H2**.

TABLE H2: Design Exceptions

Design Element	Proposed	Required
Paved Shoulder Width (RT)	4 ft (left) and 2 ft (right)	4 ft (left) and 10 ft (right)
Bridge width	30 feet	38 feet
Lateral Clearance	4 ft (left) and 2 ft (right)	4 ft (left) and 10 ft (right)
Graded Shoulder Width	7 ft (left) and 7ft (right)	9 feet (left) and 15 feet (right)

The paved shoulder width on the bridge is proposed to be reduced from 8 ft (existing) to a minimum 2 ft width.

APPENDIX L
COST ESTIMATE
BENEFIT COST ANALYSIS

CUY-480-14.10_14.40 SAFETY STUDY
I-480 EB TO SR 176 NB RAMP -2 LANE RAMP (RECONSTRUCTION) - OPTION B, CLEVELAND OHIO, ODOT DISTRICT 12
PRELIMINARY CONSTRUCTION ESTIMATE - MAY 1, 2015

MDE JUNE 2, 2015

ITEM	IDESCRL	QUANTITY	CODEDESC	UNIT COST	TOTAL COST
201E11000	CLEARING AND GRUBBING	1	LS	$ 20,566.14	$ 20,567.00
202E11000	STRUCTURE REMOVED	1	LS	$ 13,251.51	$ 13,252.00
202E22900	APPROACH SLAB REMOVED	200	SY	$ 36.18	$ 7,236.00
202E23000	PAVEMENT REMOVED	47900	SY	$ 9.47	$ 453,461.00
202E38000	GUARDRAIL REMOVED	1195	FT	$ 1.73	$ 2,063.00
202E47800	IMPACT ATTENUATOR REMOVED	1	EACH	$ 304.10	$ 305.00
203E10000	EXCAVATION	1500	CY	$ 14.38	$ 21,566.00
203E20000	EMBANKMENT	4000	CY	$ 11.59	$ 46,368.00
209E60500	LINEAR GRADING	0.3	MILE	$ 1,780.28	$ 535.00
304E20000	AGGREGATE BASE	1262	CY	$ 47.66	$ 60,148.00
407E10000	TACK COAT	240	GAL	$ 2.37	$ 568.00
408E10000	PRIME COAT	240	GAL	$ 4.12	$ 989.00
441E10100	ASPHALT CONCRETE SURFACE COURSE, TYPE 1, (446), PG70-22M	400	CY	$ 207.69	$ 83,076.00
441E10200	ASPHALT CONCRETE INTERMEDIATE COURSE, TYPE 2, (446)	160	CY	$ 158.02	$ 25,283.00
451E14010	9" REINFORCED CONCRETE PAVEMENT, CLASS QC1	1260	SY	$ 73.38	$ 92,459.00
451E16010	12" REINFORCED CONCRETE PAVEMENT, CLASS QC1	14000	SY	$ 80.00	$ 1,120,000.00
451E30000	SPECIAL - PRESSURE RELIEF JOINT, TYPE A	140	FT	$ 190.63	$ 26,689.00
605E11100	6" SHALLOW PIPE UNDERDRAINS	3500	FT	$ 9.38	$ 32,819.00
605E14000	6" BASE PIPE UNDERDRAINS	3500	FT	$ 8.29	$ 29,027.00
606E15050	GUARDRAIL, TYPE MGS	1250	FT	$ 16.19	$ 20,242.00
606E26150	ANCHOR ASSEMBLY, MGS TYPE E	1	EACH	$ 2,094.76	$ 2,095.00
606E32160	BRIDGE TERMINAL ASSEMBLY, TYPE TST	4	EACH	$ 1,357.68	$ 5,431.00
614E11000	MAINTAINING TRAFFIC	1	LS	$ 68,572.55	$ 68,573.00
618E40600	RUMBLE STRIPS, (ASPHALT CONCRETE)	0.15	MILE	$ 796.72	$ 119.00
618E40700	RUMBLE STRIPS, (CONCRETE)	0.51	MILE	$ 2,625.31	$ 1,330.00
619E16000	FIELD OFFICE, TYPE A	18	MNTH	$ 1,737.08	$ 31,268.00
622	CONCRETE BARRIER	800	FT	$ 90.00	$ 72,000.00
623E10000	CONSTRUCTION LAYOUT STAKES AND SURVEYING	1	LS	$ 40,000.00	$ 40,000.00
624E10000	MOBILIZATION	1	LS	$ 200,000.00	$ 200,000.00
644E00100	EDGE LINE, 4"	1.43	MILE	$ 2,701.03	$ 3,871.00
644E00200	LANE LINE, 4"	0.91	MILE	$ 1,639.29	$ 1,486.00
644E00400	CHANNELIZING LINE, 8"	535	FT	$ 1.48	$ 791.00
644E01514	DOTTED LINE, 8"	1500	FT	$ 2.07	$ 3,112.00
659E00300	TOPSOIL	1000	CY	$ 17.68	$ 17,676.00
659E10000	SEEDING AND MULCHING	9000	SY	$ 2.00	$ 18,000.00
659E14000	REPAIR SEEDING AND MULCHING	450	SY	$ 4.00	$ 1,800.00
659E15000	INTER-SEEDING	450	SY	$ 2.00	$ 900.00
659E20000	COMMERCIAL FERTILIZER	1.26	TON	$ 1,000.00	$ 1,260.00
659E31000	LIME	1.86	ACRE	$ 200.00	$ 372.00
659E35000	WATER	52	MGAL	$ 10.00	$ 520.00
832E15000	STORM WATER POLLUTION PREVENTION PLAN	1	LS	$ 15,000.00	$ 15,000.00
832E30000	EROSION CONTROL	15000	EACH	$ 1.00	$ 15,021.00
	STRUCTURE	21052	SF	$ 225.00	$ 4,736,700.00
				Subtotal	**$ 7,326,969.00**
				Subtotal	$ 7,326,969.00
				Design Risk (35%)	$ 2,565,000.00
				Subtotal	$ 9,891,969.00
				Inflation Cost (12.9%)	1,277,000.00
				Total	**$ 11,168,969.00**

Notes:

1 Right of way is not anticipated
2 Existing pavement is assumed to be asphalt
3 Private utility relocation not included
4 Inflation base upon construction in 2018

CUY-480-14.10_14.40 SAFETY STUDY
ADD LANE ON I-480 WESTBOUND - SR 176 SB ENT RAMP TO STATE RD OVERPASS, CLEVELAND OHIO, ODOT DISTRICT 12
PRELIMINARY CONSTRUCTION ESTIMATE - MAY 1, 2015

ITEM	IDESCRL	QUANTITY	CODEDESC	UNIT COST	TOTAL COST
201E11000	CLEARING AND GRUBBING	1	LS	$ 17,883.60	$ 17,884.00
202E23000	PAVEMENT REMOVED	5700.00	SY	$ 8.23	$ 46,923.00
202E23500	WEARING COURSE REMOVED	9000.00	SY	$ 4.96	$ 44,624.00
202E35100	PIPE REMOVED, 24" AND UNDER	500	FT	$ 14.40	$ 7,200.00
202E38000	GUARDRAIL REMOVED	325	FT	$ 1.50	$ 488.00
202E42010	ANCHOR ASSEMBLY REMOVED, TYPE E	2	EACH	$ 153.49	$ 307.00
202E58100	CATCH BASIN REMOVED	5	EACH	$ 388.28	$ 1,942.00
203E10000	EXCAVATION	1500	CY	$ 12.50	$ 18,753.00
203E20000	EMBANKMENT	4000	CY	$ 10.08	$ 40,320.00
209E60500	LINEAR GRADING	1	MILE	$ 1,548.07	$ 1,549.00
304E20000	AGGREGATE BASE	6,300.00	CY	$ 41.44	$ 261,095.00
407E10000	TACK COAT	900.00	GAL	$ 2.06	$ 1,852.00
408E10000	PRIME COAT	4800.00	GAL	$ 3.58	$ 17,187.00
441E10100	ASPHALT CONCRETE SURFACE COURSE, TYPE 1, (446), PG70-22M	420.00	CY	$ 180.60	$ 75,852.00
441E10200	ASPHALT CONCRETE INTERMEDIATE COURSE, TYPE 2, (446)	580.00	CY	$ 137.41	$ 79,697.00
451E14010	9" REINFORCED CONCRETE PAVEMENT, CLASS QC1	12020.00	SY	$ 63.81	$ 766,979.00
605E11100	6" SHALLOW PIPE UNDERDRAINS	5200	FT	$ 8.15	$ 42,399.00
605E14000	6" BASE PIPE UNDERDRAINS	5200	FT	$ 7.21	$ 37,500.00
606E15050	GUARDRAIL, TYPE MGS	325	FT	$ 14.08	$ 4,577.00
606E26150	ANCHOR ASSEMBLY, MGS TYPE E	1	EACH	$ 1,821.53	$ 1,822.00
609E26000	CURB, TYPE 6	4200	FT	$ 17.33	$ 72,793.00
611E05900	15" CONDUIT, TYPE B	3100	FT	$ 73.53	$ 227,948.00
611E07400	18" CONDUIT, TYPE B	1000	FT	$ 85.56	$ 85,560.00
611E98150	CATCH BASIN, NO. 3	1	EACH	$ 2,978.92	$ 2,979.00
611E98180	CATCH BASIN, NO. 3A	21	EACH	$ 2,319.84	$ 48,717.00
611E99574	MANHOLE, NO. 3	7	EACH	$ 3,833.95	$ 26,838.00
614E11000	MAINTAINING TRAFFIC	1	LS	$ 59,628.30	$ 59,629.00
618E40600	RUMBLE STRIPS, (ASPHALT CONCRETE)	0.96	MILE	$ 692.80	$ 663.00
619E16000	FIELD OFFICE, TYPE A	12	MNTH	$ 1,510.50	$ 18,127.00
623E10000	CONSTRUCTION LAYOUT STAKES AND SURVEYING	1	LS	$ 14,852.98	$ 14,853.00
624E10000	MOBILIZATION	1	LS	$ 59,409.15	$ 59,410.00
630E21000	OVERHEAD SIGN SUPPORT, TYPE TC-12.30, DESIGN 10	1	EACH	$ 16,464.64	$ 16,465.00
630E45500	OVERHEAD SIGN SUPPORT, TYPE TC-7.65, DESIGN 8	1	EACH	$ 34,085.58	$ 34,086.00
644E00100	EDGE LINE, 4"	1.09	MILE	$ 2,348.73	$ 2,567.00
644E00200	LANE LINE, 4"	0.51	MILE	$ 1,425.47	$ 726.00
644E00400	CHANNELIZING LINE, 8"	595	FT	$ 1.28	$ 765.00
659E00300	TOPSOIL	1000	CY	$ 15.37	$ 15,370.00
659E10000	SEEDING AND MULCHING	9000	SY	$ 0.65	$ 5,872.00
659E14000	REPAIR SEEDING AND MULCHING	450	SY	$ 0.43	$ 194.00
659E15000	INTER-SEEDING	450	SY	$ 0.22	$ 98.00
659E20000	COMMERCIAL FERTILIZER	1.26	TON	$ 479.16	$ 604.00
659E31000	LIME	1.86	ACRE	$ 96.55	$ 180.00
659E35000	WATER	52	MGAL	$ 3.52	$ 184.00
832E15000	STORM WATER POLLUTION PREVENTION PLAN	1	LS	$ 8,971.46	$ 8,972.00
832E30000	EROSION CONTROL	10000	EACH	$ 1.00	$ 10,014.00
				Subtotal	**$2,183,000.00**
				Subtotal	$ 2,183,000
				Design Risk (35%)	$ 765,000
				Subtotal	$ 2,948,000
				Inflation Cost (12.9%)	$ 381,000
				Total	**$ 3,329,000**

Notes:

1 Right of way is not anticipated
2 Existing pavement is assumed to be asphalt
3 Private utility relocation not included
4 Inflation base upon construction in 2018

CUY-480-14.10/14.40, STATE ROAD IMPROVEMENTS
CUYAHOGA COUNTY, OHIO
PRELIMINARY CONSTRUCTION ESTIMATE - MAY 29, 2015

ITEM	DESCRIPTION	QUANTITY	UNIT COST	TOTAL COST
201	CLEARING AND GRUBBING	1 LS	$ 5,000.00	$ 5,000.00
202	PAVEMENT REMOVED, CONCRETE	50 SY	$ 15.00	$ 750.00
202	CONCRETE MEDIAN REMOVED	420 SY	$ 25.00	$ 10,500.00
202	CATCH BASIN OR INLET REMOVED	1 EA	$ 1,500.00	$ 1,500.00
203	EXCAVATION	1200 CY	$ 10.00	$ 12,000.00
203	EMBANKMENT	250 CY	$ 15.00	$ 3,750.00
204	SUBGRADE COMPACTION	2000 SY	$ 2.00	$ 4,000.00
206	CEMENT STABILIZED SUBGRADE, 16" DEEP	2000 SY	$ 7.50	$ 15,000.00
252	FULL DEPTH PAVEMENT SAWING	2500 FT	$ 2.00	$ 5,000.00
254	PAVEMENT PLANING, ASPHALT CONCRETE	5000 SY	$ 2.50	$ 12,500.00
448	ASPHALT CONCRETE SURFACE COURSE 3"	1500 CY	$ 150.00	$ 225,000.00
304	AGGREGATE BASE, 10"	550 CY	$ 50.00	$ 27,500.00
407	TACK COAT	2500 GAL	$ 2.00	$ 5,000.00
452	8" CONCRETE PAVEMENT	2000 SY	$ 75.00	$ 150,000.00
500	STRUCTURE WORK	1 LS	$ 50,000.00	$ 50,000.00
603	15" CONDUIT, TYPE B	25 FT	$ 100.00	$ 2,500.00
604	CATCH BASIN	1 EA	$ 3,000.00	$ 3,000.00
605	6" BASE PIPE UNDERDRAIN	2500 FT	$ 6.00	$ 15,000.00
606	GUARD RAIL	100 FT	$ 15.00	$ 1,500.00
609	CONCRETE CURB	450 FT	$ 15.00	$ 6,750.00
606	CONCRETE MEDIAN	500 FT	$ 15.00	$ 7,500.00
630	SIGNAGE	1 LS	$ 5,000.00	$ 5,000.00
632	OVERHEAD SIGN RELOCATED/REPLACED	3 EA	$ 25,000.00	$ 75,000.00
632	TRAFFIC DETECTOR RELOCATED	5 EA	$ 5,000.00	$ 25,000.00
632	TRAFFIC SIGNAL UPGRADE	3 EA	$ 50,000.00	$ 150,000.00
644	PAVEMENT MARKINGS	1 LS	$ 15,000.00	$ 15,000.00
659	SEEDING AND MULCHING	550 SY	$ 2.00	$ 1,100.00
832	SWPPP	1 LS	$ 5,000.00	$ 5,000.00
832	EROSION CONTROL	2500 EA	$ 1.00	$ 2,500.00

			Subtotal	$ 843,000.00
614	MAINTAINING TRAFFIC	1 LS	$ 75,000.00	$ 75,000.00
619	FIELD OFFICE, TYPE B	9 MN	$ 2,000.00	$ 18,000.00
623	CONSTRUCTION LAYOUT STAKES	1 LS	$ 15,000.00	$ 15,000.00
624	MOBILIZATION	1 LS	$ 40,000.00	$ 40,000.00
			Subtotal	$ 991,000.00
			Design Risk (35%)	$ 347,000.00
			Subtotal	$ 1,338,000.00
			Inflation Cost (12.9%)	$ 173,000.00
			Total	**$ 1,511,000.00**

Notes:

1 R/W and utlilities are not included in this estimate. (New R/W not anticipated)
2 Existing pavement is assumed to be concrete.
3 Pavement widening is assumed to be concrete. Entire work area overlaid with asphalt after construction.
4 Construction assumed in 2018

CUY-480 (14.10-14.40) SAFETY STUDY - WB RIGHT TURN LANE IMPROVEMENT AT BROOKPARK/STATE INTERSECTION
CUYAHOGA COUNTY, OHIO
PRELIMINARY RIGHT OF WAY ESTIMATE - SEPTEMBER 2015

Parcel ID	Land Use	Land Value	Structure Value	Total [A]	TOTAL ACREAGE (ACRES) [B]	Structure Impact	Area: Fee Simple [C]	Area: Temporary	Cost: Fee Simple [D=A/B*C]	Cost: Temporary [E]	Labor costs [F]	Relocation [G]	Sub-Total Cost [D+E+F+G]	Cost to Cure	Comments
011-25-004	COMMERCIAL	$2,362,200		$2,362,200	2.018	NO	0.033		$38,971	$0	$12,150		$51,121	$25,000	TEMPORARY R/W NOT CONSIDERED
								Sub-Totals	**$38,971**	**$0**	**$0**	**$51,121**	**$25,000**	
	Administrative Costs		[(sub-total)x0.15]x1.20										$9,202		
	Jury trial Costs		[(sub-total)x0.10]x1.50										$7,668		
	Incidental transfer Costs		[(sub-total)x0.90]x0.025										$1,150		
								Estimated Cost					**$94,141**		
								Contingency (35%)					**$32,949**		
								TOTAL COST					**$127,090**		

* Labor Cost Includes the following:
(per ODOT Cost Estimating Procedures For Acquiring Rights of Way)

Titles		Detailed Appraisal	Detailed Appraisal Review	Negotiation	Closings	Project Management
$400		$4,500	$2,000	$1,100	$400	$550

Notes:

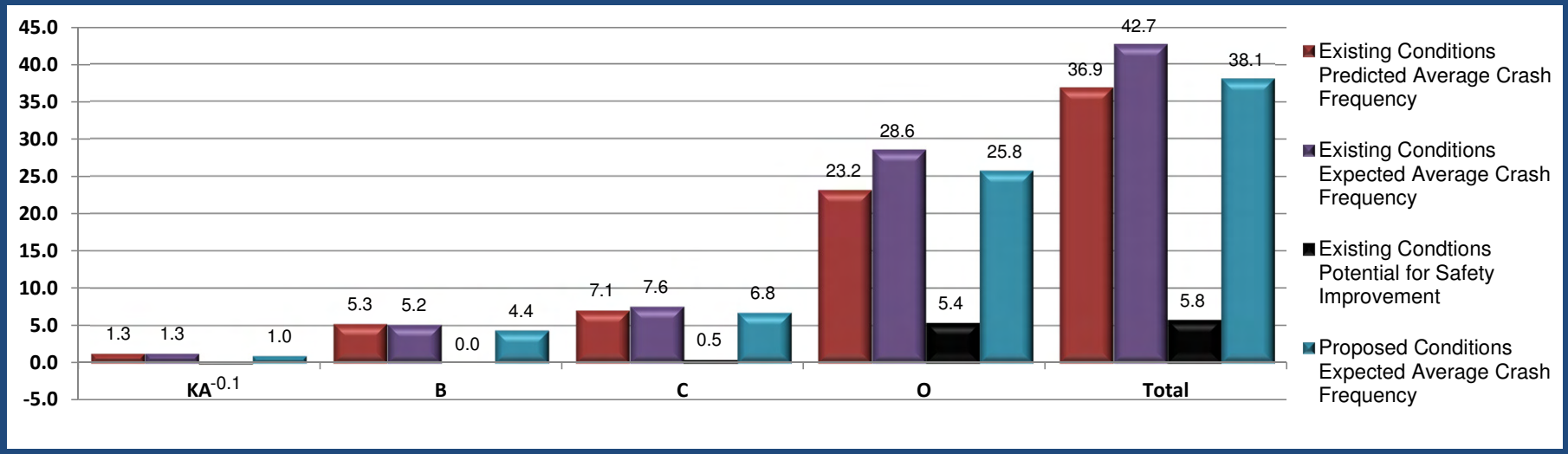
1 **Existing ROW** - From face of curb to back of sidewalk - 18.5' (0.5' Curb, 13' Tree lawn, 5' SW), **Required ROW** is 22' (12' RT lane, 7.5' SW, 2.5 ft for Type C&G) - **New ROW** needed - 3.5'
2 Required Area is estimated for a 3.5' width take for the length of the WB RT lane (400') at Brookpark/State,
3 Existing R/W estimated using GIS parcel lines, where available
4 Where R/W cannot be easily estimated from GIS parcels, existing R/W is assumed to be 1' behind walk
5 Proposed permanent R/W is assumed to be 1' behind proposed walk
6 Cost to cure assumes some damages to existing car dealership parking lot

Project Safety Performance Report

General Information

Project Name	CUY-480-14.1-14.4 Safety Study	Contact Email	
Project Description	I-480/SR 94 interchange safety improvements	Contact Phone	
Reference Number		Date Performed	5/29/2015
Analyst	VM	Analysis Year	2013
Agency/Company	LJB Inc		State Road Improvements

Summary of Anticipated Safety Performance of the Project (average crashes/year)



Project Summary Results (Without Animal Crashes)

	KA	B	C	O	Total
$N_{predicted}$ - Existing Conditions	1.3399	5.2874	7.1047	23.1709	36.9029
$N_{expected}$ - Existing Conditions	1.2549	5.2403	7.6431	28.5772	42.7155
$N_{potential\ for\ improvement}$ - Existing Conditions	-0.0850	-0.0471	**0.5384**	**5.4063**	**5.8126**
$N_{expected}$ - Proposed Conditions	0.9819	4.4383	6.8409	25.8489	38.1100

Project Safety Performance Report

General Information

Project Name	CUY-480-14.1-14.4 Safety Study	Contact Email	
Project Description	I-480/SR 94 interchange safety improvements	Contact Phone	
Reference Number		Date Performed	5/29/2015
Analyst	VM	Analysis Year	2013
Agency/Company	LJB Inc		State Road Improvements

Summary by Crash Type

Crash Type	Existing			Proposed
	Predicted Crash Frequency	Expected Crash Frequency	PSI	Expected Crash Frequency
Unknown	0.0250	0.0252	**0.0002**	0.0196
Head On	0.2341	0.2391	**0.0050**	0.1947
Rear End	16.5354	21.9802	**5.4448**	21.2808
Backing	0.7821	0.7523	-0.0298	0.6211
Sideswipe - Meeting	0.5015	0.5078	**0.0063**	0.4078
Sideswipe - Passing	3.8281	3.9849	**0.1568**	3.2684
Angle	6.2277	6.9899	**0.7622**	6.0794
Parked Vehicle	0.8335	0.7655	-0.0680	0.6371
Pedestrian	1.5327	1.1370	-0.3957	0.6646
Animal	0.0231	0.0227	-0.0004	0.0102
Train	0.0016	0.0016	0.0000	0.0013
Pedalcycles	0.9381	0.8154	-0.1227	0.4780
Other Non-Vehicle	0.0000	0.0000	0.0000	0.0000
Fixed Object	1.3812	1.3947	**0.0135**	1.0999
Other Object	0.0486	0.0484	-0.0002	0.0380
Overturning	0.0823	0.0823	0.0000	0.0674
Other Non-Collision	0.1818	0.1788	-0.0030	0.1482
Left Turn	3.7690	3.8124	**0.0434**	3.1039
Right Turn	0.0000	0.0000	0.0000	0.0000

Project Cost Estimate

Project Name	CUY-480-14.1-14.4 Safety Study	Contact Email	
Project Description	I-480/SR 94 interchange safety improvements	Contact Phone	
Reference Number		Date Performed	5/29/2015
Analyst	VM	Analysis Year	2013
Agency/Company	LJB Inc		State Road Improvements

Engineering Design %	10%
Contingency %	35%

Countermeasures	Construction Costs	Right of Way Costs	Engineering Design Costs	Contingency Amount	Total Cost of Countermeasure	Annual Maintenance & Energy Costs	Salvage Value
Site Characteristic Improvements (i.e. Lane widening)			$0.00	$0.00	**$0.00**		
Site Characteristic Improvements (i.e. Lighting)			$0.00	$0.00	**$0.00**		
Site Characteristic Improvements (i.e. Signal Phasing)			$0.00	$0.00	**$0.00**		
Site Characteristic Improvements (i.e. Added Right Turn Lane)	$886,000.00		$88,600.00	$310,100.00	**$1,284,700.00**		
CMF 1 - Four to five lane conversion	$100,000.00		$10,000.00	$35,000.00	**$145,000.00**		
CMF 2 - Provide a right turn lane on one major road approach		$94,200.00	$9,420.00	$32,970.00	**$136,590.00**		
CMF 3 - Modify change plus clearance interval to ITE 1985 Proposed Recommended Practice (4-leg signalized)	$5,000.00		$500.00	$1,750.00	**$7,250.00**		
CMF 4 - Provide (Extend) a left turn lane on one major road approach			$0.00	$0.00	**$0.00**		
CMF 5 - Add through lane (Improve lane channelization)			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
Totals	**$991,000.00**	**$94,200.00**	**$108,520.00**	**$379,820.00**	**$1,573,540.00**	**$0.00**	**$0.00**

Inflation %	13%

Final Costruction Cost:	**$1,776,526.66**

*Final construction cost should match the Project Cost Estimate

Safety Benefit - Cost Analysis

General Information

Project Name	CUY-480-14.1-14.4 Safety Study	Contact Email	
Project Description	I-480/SR 94 interchange safety improvements	Contact Phone	
Reference Number		Date Performed	5/29/2015
Analyst	VM	Analysis Year	2013
Agency/Company	LJB Inc		State Road Improvements

Select Site Types to be used in Benefit-Cost Analysis:

All Sites

Comments:

Countermeasure Service Lives, Costs, and Safety Benefits

Countermeasures	Service Life (Years)	Initial Cost of Countermeasure	Annual Maintenance & Energy Costs	Salvage Value	Net Present Cost of Countermeasure	Total Cost of Countermeasures	Summary of Annual Crash Modifications	Net Present Value of Safety Benefits
Site Characteristic Improvements (i.e. Lane widening)		$0.00			$0.00	$0.00	-0.356	$125,955
Site Characteristic Improvements (i.e. Lighting)		$0.00			$0.00	$0.00		
Site Characteristic Improvements (i.e. Signal Phasing)		$0.00			$0.00	$0.00		
Site Characteristic Improvements (i.e. Added Right Turn Lane)	20	$1,284,700.00			$1,284,700.00	$1,284,700.00		
CMF 1 - Four to five lane conversion	20	$145,000.00			$145,000.00	$145,000.00	-0.167	$70,070
CMF 2 - Provide a right turn lane on one major road approach	20	$136,590.00			$136,590.00	$136,590.00	-2.759	$909,607
CMF 3 - Modify change plus clearance interval to ITE 1985 Proposed Recommended Practice (4-leg signalized)	5	$7,250.00			$29,000.00	$39,859.35	0.744	$699,767
CMF 4 - Provide (Extend) a left turn lane on one major road approach	20	$0.00			$0.00	$0.00	-0.504	$175,622
CMF 5 - Add through lane (Improve lane channelization)	20	$0.00			$0.00	$0.00	-1.563	$494,386
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
Totals		**$1,573,540.00**	**$0.00**	**$0.00**	**$1,595,290.00**	**$1,606,149.35**	**-4.606**	**$2,475,408**

Safety Benefit - Cost Analysis

General Information

Project Name	CUY-480-14.1-14.4 Safety Study	Contact Email	
Project Description	I-480/SR 94 interchange safety improvements	Contact Phone	
Reference Number		Date Performed	5/29/2015
Analyst	VM	Analysis Year	2013
Agency/Company	LJB Inc		State Road Improvements

Benefit - Cost Calculator

Net Present Value of Project	$1,595,290.00
Net Present Value of Safety Benefits	$2,475,408.08
Net Benefit	$880,118.08
Benefit / Cost Ratio	1.55

Expected Annual Crash Adjustment

Number of Fatal & Incapacitating Injury Crashes	-0.273
Number of Injury Crashes	-1.877
Number of Total Crashes	-4.606

Comments: