

# Interchange Modification Study

I-24 at U.S. Route 72  
Marion County, Tennessee



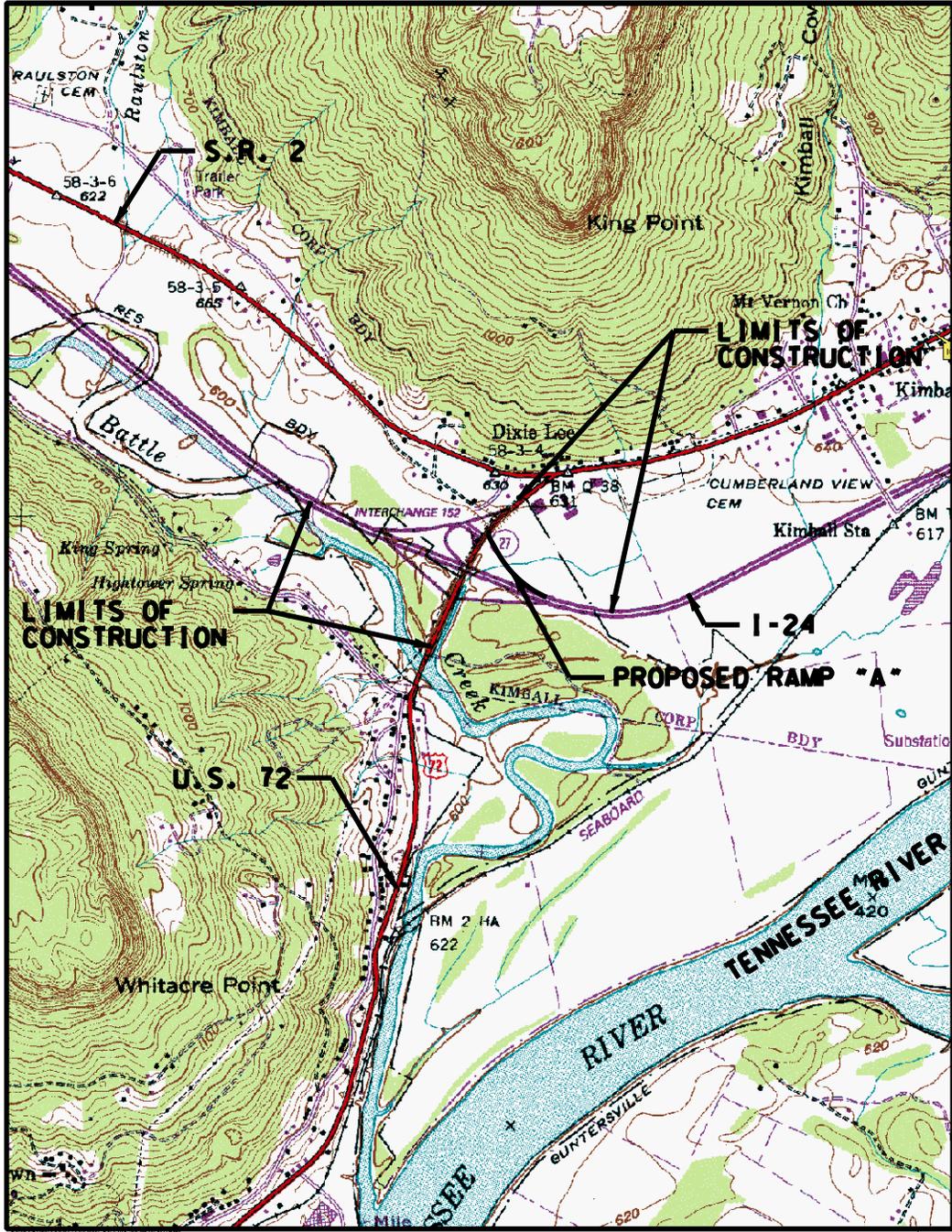
Prepared By:  
Florence & Hutcheson, Inc.

For:  
The Tennessee Department of Transportation  
Bureau of Planning and Development

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I-24 at U.S. 72 Interchange Modification Study  
Marion County, Tennessee

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SCALE  
 1000' 2000'  
 1" = 2000'

**PROJECT LOCATION MAP  
 INTERCHANGE MODIFICATION STUDY  
 I-24 AT U.S. 72  
 USGS QUADSHEET "SOUTH PITTSBURG"  
 KIMBALL, MARION COUNTY, TN**



# Summary Data Table

Interchange Modification Study I-24 at U.S. 72

| <u>Item</u>                                | <u>Proposed Improvements</u>   |
|--|--|
| Functional Class I-24                      | Freeway  |
| Functional Class U.S. 72                   | Rural Principal Arterial/Rural Major Collector   |
| System Class I-24                          |  |
| System Class U.S. 72                       |  |
| Length of Construction (I-24)              | 0.71 Miles   |
| Length of Construction (U.S. 72)           | 0.37 Miles   |
| Cross Section I-24                         | 2 @12' lanes (each direction), 12' usable outside shoulder, 60' median                             |
| Cross Section U.S. 72                      | 2 @ 12' lanes (each direction), typical 4' usable shoulder with curb & gutter, median width varies |
| Present ADT I-24 (2007)                    | 44,940   |
| Present ADT U.S. 72 (2007)                 | 24,780   |
| Future ADT I-24 (2027)                     | 73,280   |
| Future ADT U.S. 72 (2027)                  | 37,170   |
| Future DHV I-24 (2027)                     | 7,328  |
| Future DHV U.S. 72 (2027)                  | 3,717  |
| % Trucks I-24                              | 23% (DHV)  |
| % Trucks U.S. 72                           | 7% (DHV)   |
| Estimated Right-of-Way Acquisition (Acres) | 15.69  |
| Estimated Right-of-Way Tracts Affected     | 1  |
| Estimated Family Displacements             | 0  |
| Estimated Business Displacements           | 0  |
| Estimated Non-Profit Displacements         | 0  |
| Estimated Right-of-Way Cost                | \$50,000   |
| Estimated Utility Cost Reimbursable        | \$0  |
| Estimated Utility Cost Non-Reimbursable    | \$15,000   |
| Estimated Total Construction Cost          | \$3,733,000  |
| Estimated Preliminary Engineering Cost     | \$340,000  |
| Total Estimated Project Cost               | \$4,140,000  |

## **Purpose of Study**

This study was undertaken at the request of the Tennessee Department of Transportation to examine ways to improve the functionality of the I-24 with U.S. 72 interchange in Marion County, Tennessee. TDOT recognizes a need to increase the vertical clearances between U.S. 72 and the I-24 bridges. With construction imminent at this location to improve these vertical clearances, it was decided to commission this report to investigate additional improvements that will increase the operational characteristics of this interchange.

## **Deficiencies and Existing Conditions**

This interchange is located just south of Kimball, Tennessee and approximately 30 miles west of Chattanooga. This interchange provides access between I-24 and U.S. Route 72. U.S. 72 is a Rural Principal Arterial/Rural Major Collector, with partial control-of-access south of the interchange. There is no control-of-access on U.S. 72 north of the interchange. I-24 has two lanes in each direction. U.S. 72's basic cross-section consists of two lanes in each direction. However, in the southbound direction one lane is currently dropped, becoming the left turn lane to access the ramp to I-24 eastbound. This causes U.S. 72 Southbound to contain only one continuous lane through the interchange. Several businesses are located in close proximity north of the interchange, including gas stations and fast food restaurants. Adjacent interchanges along I-24 are located approximately nine miles to the west and three miles to the east of this interchange.

There are currently four ramps which provide access between I-24 and U.S. 72. Three of these are directional ramps (U.S. 72 to I-24 Westbound, I-24 Eastbound to U.S. 72, and U.S. 72 to I-24 Eastbound), and one is a loop ramp (I-24 Westbound to U.S. 72.) All of the ramp terminals with I-24 are geometrically insufficient, except for the ramp from I-24 Eastbound to U.S. 72. The three deficient ramps' acceleration/deceleration lengths at I-24 are shorter than current AASHTO guidelines specify. The intersection between the I-24 Eastbound ramps and U.S. 72 is currently a stop-controlled intersection. The intersection between the I-24 Westbound ramps and U.S. 72 is a signalized intersection.

The vertical clearance above U.S. 72 (under the I-24 bridges) varies from 14.90 feet to 15.73 feet. AASHTO recommends maintaining a minimum of 16 feet for freeways and arterial systems (16.50 feet for new construction to accommodate future resurfacing.) These bridges have been struck several times by tall trucks. These collisions demonstrate that the vertical clearance needs to be increased to at least 16.50 feet.

The Levels of Service (LOS) on I-24 Westbound are calculated to be poor in 2007 and failing by 2027. The LOS in the eastbound direction are calculated to be slightly better on I-24, but still not optimal. These LOS will not improve unless I-24 is widened from its existing two lanes in each direction to three. Due to the isolated location of this interchange, widening is not perceived in the near future. When I-24 is widened, construction would presumably start in Chattanooga and work west to this interchange. Recommending this length of widening is assumed beyond the scope of this report. Therefore, the poor LOS on the mainline of I-24 are not addressed.

The intersection formed by the I-24 westbound ramps with U.S. 72 currently functions with an acceptable level of service (LOS.) However, by 2027 the LOS is predicted to fall to a "D". The ramp from I-24 Westbound to U.S. 72 is a loop ramp. The Design Hourly Volume (DHV) on this ramp is predicted to increase to 1314 vehicles per hour by 2027. This is a large vehicular volume for a loop ramp. This large loop ramp volume, in conjunction with the predicted decrease in the LOS for this intersection, are

deficiencies that are addressed with the proposed improvements recommended in this report.

The intersection formed by the I-24 Eastbound ramps with U.S. 72 operates with poor levels of service in the base year of 2007. This is currently a stop-controlled intersection. The functionality of this intersection needs to be improved.

## **Proposed Improvements**

Proposed improvements to I-24 include raising the grade to increase the vertical clearance above U.S. 72 by 1.60 feet to 16.50 feet. Using previous plans for this interchange, it appears possible to make this grade change by decreasing the length of a vertical curve on I-24. According to these same plans, lowering the grade on U.S. 72 to increase the vertical clearance is not possible because U.S. 72's grade is only 2' above a flood plain. The existing plans referenced are I-24-2(14)151 and I-24-2(33)148.

The two existing I-24 bridges over U.S. 72 should be replaced with a single bridge. This bridge will have a 60' median with barrier. This single bridge will allow for future lane additions in the I-24 median. Any decrease in bridge beam depth in relation to the existing bridge will decrease the grade revision necessary on I-24. Therefore, the costs of a shallower, presumably more expensive, beam design should be considered versus the cost savings associated with a reduced grade revision.

On I-24, three of the four existing ramp terminals' acceleration/deceleration lengths also need to be increased. The lone exception is the exit ramp from I-24 Eastbound to U.S. 72. It meets current AASHTO standards. All of these improved ramp terminals with I-24 should be constructed with a parallel type design for uniformity. Although these increased lengths will in some instances slightly improve the levels of service predicted for the ramp terminals, the primary goal of increasing their length is to meet current AASHTO standards, which will make them safer and more comfortable for drivers.

A major improvement proposed in this report is the addition of a new directional ramp from I-24 Westbound to U.S. 72 Northbound in the northeast quadrant of this interchange. The existing loop ramp that currently carries traffic from I-24 Westbound to U.S. 72 Northbound and Southbound will then only carry vehicles to U.S. 72 Southbound. This will reduce the volumes carried on this existing loop ramp, which will improve its performance. The new ramp will convert the heavy left turn from I-24 to U.S. 72 northbound into a right turn. Signing for this proposed ramp on I-24 will not be difficult due to the adjacent interchange being three miles to the east. This proposed ramp can have an optimal horizontal and vertical geometric design because of flat topography in the northeast quadrant of this interchange. The geometric design can also be optimized because more than adequate Right-of-Way is available. Adding this proposed ramp will also eliminate the occurrence of an "on-ramp" terminal being located adjacent to an "off-ramp" terminal at U.S. 72. This will reduce the risk of a head-on collision by a driver inadvertently entering the "off-ramp" from I-24 westbound. The proposed ramp should be a minimum of 16 feet wide and meet all AASHTO and TDOT design standards. The terminal of this proposed ramp at U.S. 72 should be at least 300 feet from the proposed Right-of-Way fence to the north.

Several improvements are proposed on U.S. 72. In the southbound direction, U.S. 72 currently maintains only one continuous lane through this interchange. It is proposed to maintain two continuous lanes through this interchange. This will create route continuity and should increase functionality. It is proposed to lengthen the left turn lane from U.S. 72 Southbound to I-24 Eastbound to meet TDOT's design guideline deceleration length standards. The same is proposed for the U.S. 72 Northbound to I-24 Westbound turn lane. This will cause these lanes to be extended under the proposed I-

24 bridge. It is also recommended to add a right turn lane for U.S. 72 Northbound to the ramp for I-24 Eastbound. This right turn lane will enable vehicles to decelerate from U.S. 72 to this ramp, which will decrease the risk of rear-end collisions and increase the functionality of the interchange of U.S. 72 with the I-24 Eastbound Ramps. Creating a suitable deceleration lane is especially beneficial at this location because drivers will be arriving from a high speed, access controlled section of U.S. 72 to this intersection.

Some improvements are also recommended for a few of the existing ramp terminals at U.S. 72. It is recommended to add a left turn lane to the I-24 Eastbound to U.S. 72 ramp. The proposed left turn lane should have at least 150 feet of storage. The existing loop ramp from I-24 Westbound to U.S. 72 Southbound is shown modified at the U.S. 72 terminal. At the office review held for this study, it was requested to add an auxiliary lane on U.S. 72 under the I-24 Bridge for this loop ramp. This acceleration lane length and design does not meet AASHTO design standards, however, and needs to be signed as a "Yield" condition. It may be desired to design the I-24 Bridge to accommodate this auxiliary lane, but not build the lane. This loop ramp could then be modified at its terminal with U.S. 72 to have a standard yield condition large radius right turn with no auxiliary lane. This is because vehicles may accelerate into the downstream intersection with an auxiliary lane, creating a safety hazard. These concerns should be addressed by the engineer in charge of designing this interchange.

The intersection between U.S. 72 and the I-24 Westbound lanes is currently signalized. This intersection should remain signalized with the proposed geometric improvements described previously. Signalization, in conjunction with these proposed improvements at this intersection, will increase the levels of service predicted.

It is proposed to signalize the intersection between U.S. 72 and the I-24 Eastbound Ramps. This intersection is currently stop-controlled and performing poorly. The vehicular volumes are predicted to increase at this location, which will cause a decrease in the levels of service (LOS) in the future without signalization. As discussed previously, it is proposed to add a right turn lane on U.S. 72 Northbound for the ramp to I-24 Eastbound, and a left turn lane on the ramp from I-24 Eastbound. These geometric improvements, along with signalization, will create excellent LOS through the year 2027. Adequate sight distance for the signal heads must be ensured for drivers heading southbound on U.S. 72 under the I-24 Bridge. This should not be an issue, assuming 16.5 feet of clearance is created under the proposed I-24 bridge, and the signal heads are hung at a standard height. This sight distance should still be ensured in design, however. Signal Warrants were not calculated at this location. Considering the intersection at U.S. 72 and the I-24 Westbound Ramps is currently signalized, and the comparable volumes between that intersection and this one, proving the warrants are met should not be an issue.

The recommended proposed improvements at this interchange will greatly increase the levels of service (LOS) along U.S. 72 in this location. Through the year 2027 no less than a "B" is anticipated. The LOS along the I-24 mainline sections are not addressed in this report. According to the traffic data, a third lane needs to be added to I-24 in each direction to improve these LOS. This widening would logically traverse from Chattanooga to this interchange. Such a recommendation is out of the scope of this report. However, this report does recommend replacing the two existing I-24 Bridges with a single bridge which will accommodate such lane additions in the future. Moderate increases are anticipated in the LOS at some of the existing ramp terminals with I-24 due to their acceleration/deceleration lengths being extended. The loop ramp from I-24 Westbound to U.S. 72 Southbound will perform better functionally with the reduced vehicular volumes anticipated. The volume on this ramp will be reduced because of the addition of the proposed directional ramp from I-24 Westbound to U.S. 72 Northbound.

The terminal of this proposed ramp at I-24 will perform as well as the mainline sections directly before and after it. Therefore, this ramp terminal will not adversely affect the LOS along I-24. With future widening of I-24 this ramp terminal's LOS will improve in conjunction with the mainline.

The total cost for these proposed improvements is estimated to be \$4,139,376. Please refer to the "Cost Data Sheet" for an itemized breakdown of this cost estimate.

## **Intelligent Transportation System**

Implementation of an intelligent transportation system is not anticipated at this rural location in the near future.

## **Disposition of Existing Route**

The location of routes is not altered, and there are no sections of existing roadway that are being taken off the Federal system and transferred to local governments.

## **FHWA Policy Requirements**

*FHWA policy states: "The existing interchanges and/or local roads and streets in the corridor can neither provide the necessary access nor be improved to satisfactorily accommodate the design-year traffic demands while at the same time providing the access intended by the proposal."*

The proposed ramp will reduce the volume on an existing heavily traveled loop ramp. This will improve the circulation between the interstate highway and U.S. Route 72, which is a regional highway. Therefore, the proposed ramp is not primarily for local circulation. No adjacent interchanges or local roads can be improved to provide the access intended by this proposal. Furthermore, the addition of this ramp should improve the levels of service anticipated in this interchange.

*FHWA policy states: "All reasonable alternatives for design options, location, and transportation system management type improvements (such as ramp metering, mass transit, and HOV facilities) have been assessed and provided for if currently justified, or provisions are included for accommodating such facilities if a future need is identified."*

Due to its rural location, no reasonable non-design alternative option exists to improve the operations of this interchange. The proposed I-24 Bridge will have a wide median, which will accommodate a future HOV lane, if desired.

*FHWA policy states: "The proposed access point does not have a significant adverse impact on the safety and operation of the Interstate facility based on analysis of current and future traffic. The operational analysis for existing conditions shall, particularly in urbanized areas, include an analysis of sections of Interstate to and including at least the first adjacent existing or proposed interchange on each side. Crossroads and other roads and streets shall be included in the analysis to the extent necessary to assure their ability to collect and distribute traffic to and from the interchange with the new or revised access points."*

The improvements proposed in this report are shown to not adversely affect the operation of the Interstate facility. The proposed improvements, which include extending the acceleration and deceleration lanes, improve the operation in many instances. An analysis of this interchange was performed using the procedures in the Highway Capacity Manual, and is included in this report. The adjacent interchanges are located three miles to the east and nine miles to the west. Because of these distances, and the rural location of this interchange, the adjacent interchanges were not analyzed.

FHWA policy states: *“The proposed access connects to a public road only and will provide for all traffic movements. Less than “full interchanges” for special purpose access for transit vehicles, for HOV’s, or into park and ride lots may be considered on a case-by-case basis. The proposed access will be designed to meet or exceed current standards for Federal-aid projects on the Interstate System.”*

This interchange provides for full access between I-24 and U.S. 72. U.S. 72 is a public road.

FHWA policy states: *“The proposal considers and is consistent with local and regional land use and transportation plans. Prior to final approval, all requests for new or revised access must be consistent with the metropolitan and or statewide transportation plan, as appropriate, the applicable provisions of 23 CFR part 450 and transportation conformity requirements of 40 CFR parts 51 and 93.”*

This location is in a rural location. The proposed improvements include an allowance for future widening in the median of I-24 when it becomes necessary.

FHWA policy states: *“In areas where the potential exists for future multiple interchange additions, all requests for new or revised access are supported by a comprehensive Interstate network study with recommendations that address all proposed and desired access within the context of a long-term plan.”*

No new or revised access points are currently being planned or programmed in the vicinity of this interchange.

FHWA policy states: *“The request for a new or revised access generated by new or expanded development demonstrates appropriate coordination between the development and related or otherwise required transportation system improvements.”*

The revised access proposed in this report was not generated by new or expanded development. These proposed improvements were generated by a need to increase the vertical clearance under the I-24 Bridges and because of rising vehicular volumes in this location.

FHWA policy states: *“The request for new or revised access contains information relative to the planning requirements and the status of the environmental processing of the proposal.”*

A wetland is located in the northeast quadrant of this interchange. This is the same quadrant that the proposed directional ramp from I-24 Westbound to U.S. 72 Northbound will be located. Therefore, environmental permits will most likely be required for construction. With the large amount of right-of-way available in this quadrant, plenty of space is available for wetland mitigation. This will decrease the impact to the environment caused by these proposed improvements. No environmental issues are anticipated with respect to historical artifacts, etc.

## Field Investigation

On May 14<sup>th</sup>, 2002, Stan King and Jon Storey from Florence and Hutcheson performed a preliminary field inspection of this interchange. After this inspection they met with the City of Kimball's Chief of Police (Chief Ray Durham, phone number 423-837-7040) to discuss the operational deficiencies addressed in this report. An office review was then held on June 13<sup>th</sup>, 2002 to discuss this interchange. In attendance were:

| <u>Name</u>       | <u>Agency/Company</u>                     | <u>Phone Number</u> |
|-------------------|---|---------------------|
| Bill Hart         | TDOT Planning                             | 741-3688            |
| Matt Ashby        | TDOT Planning                             | 741-6743            |
| Steve Allen       | TDOT Planning                             | 741-2208            |
| Debbi Howard      | TDOT Planning – Mapping<br>and Statistics | 741-0957            |
| Charles Graves    | TDOT Planning                             | 741-6410            |
| Henry Pate        | TDOT Structures                           | 741-3351            |
| Terry Leatherwood | TDOT Structures                           | 741-0806            |
| David Davis       | TDOT Design Region 2                      | 741-0450            |
| Mark Doctor       | FHWA                                      | 781-5788            |
| John Steele       | FHWA                                      | 781-5777            |
| Chad Thompson     | FHWA                                      | 781-5770            |
| Stan King         | Florence & Hutcheson                      | 399-9090            |
| Jon Storey        | Florence & Hutcheson                      | 399-9090            |

It was decided at this office review that a field review was not necessary for this project. Everyone in attendance is familiar with this interchange. It was also decided at this review that the proposed improvements in this report are the only logical options for improving the operational characteristics of this interchange. Therefore, additional alternates were not devised for this report.

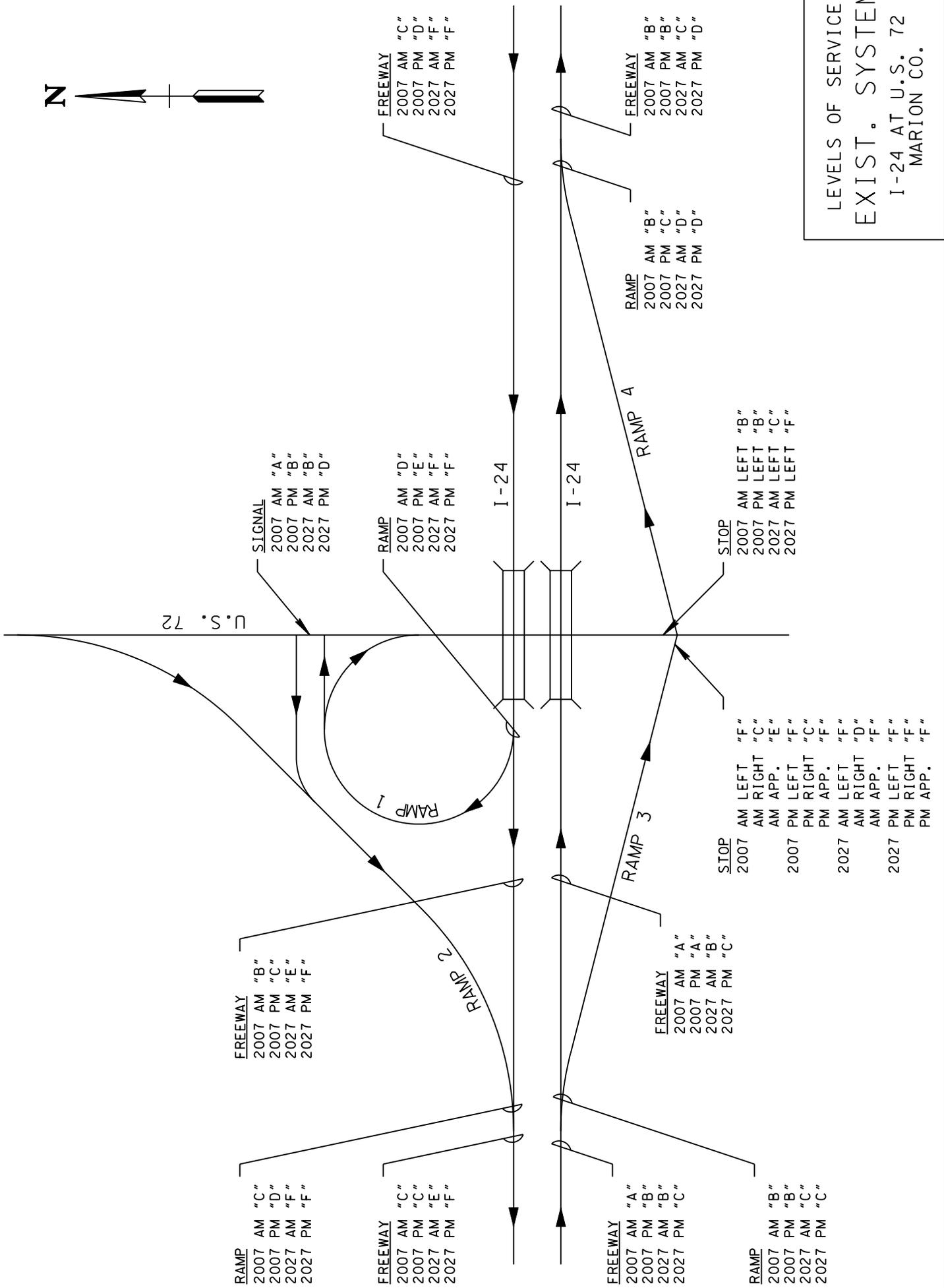
## Photographs



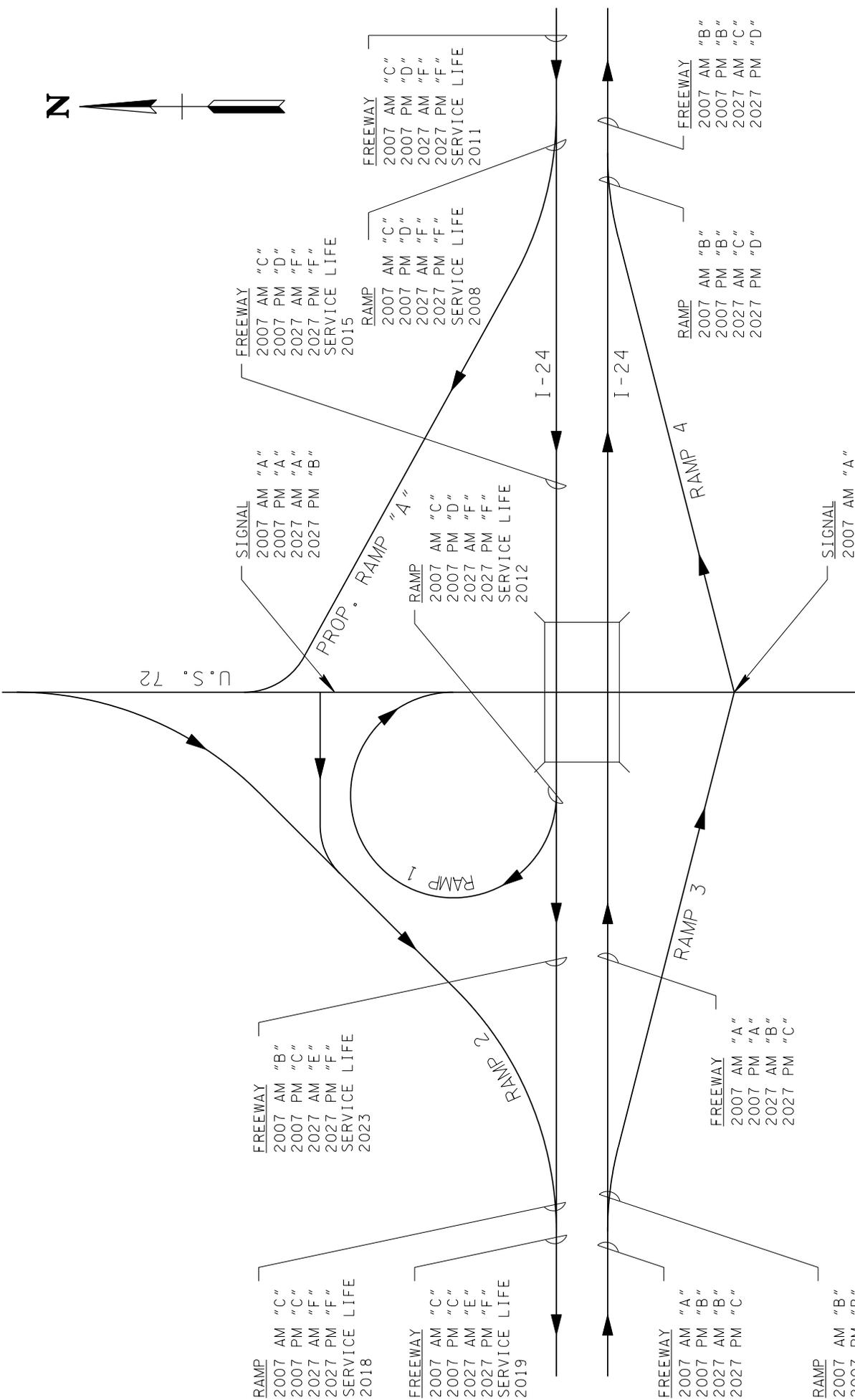
Wetland in northeast quadrant of interchange



Crack in bridge beam due to impacts



LEVELS OF SERVICE  
EXIST. SYSTEM  
I-24 AT U.S. 72  
MARION CO.



FREEMWAY  
2007 AM "C"  
2007 PM "D"  
2027 AM "F"  
2027 PM "F"  
SERVICE LIFE  
2015

SIGNAL  
2007 AM "A"  
2007 PM "A"  
2027 AM "A"  
2027 PM "B"

RAMP  
2007 AM "C"  
2007 PM "D"  
2027 AM "F"  
2027 PM "F"  
SERVICE LIFE  
2012

FREEMWAY  
2007 AM "C"  
2007 PM "D"  
2027 AM "F"  
2027 PM "F"  
SERVICE LIFE  
2011

FREEMWAY  
2007 AM "B"  
2007 PM "C"  
2027 AM "E"  
2027 PM "F"  
SERVICE LIFE  
2023

RAMP  
2007 AM "C"  
2007 PM "C"  
2027 AM "F"  
2027 PM "F"  
SERVICE LIFE  
2018

FREEMWAY  
2007 AM "C"  
2007 PM "C"  
2027 AM "E"  
2027 PM "F"  
SERVICE LIFE  
2019

FREEMWAY  
2007 AM "A"  
2007 PM "B"  
2027 AM "B"  
2027 PM "C"

FREEMWAY  
2007 AM "A"  
2007 PM "A"  
2027 AM "B"  
2027 PM "C"

RAMP  
2007 AM "B"  
2007 PM "B"  
2027 AM "C"  
2027 PM "D"

FREEMWAY  
2007 AM "B"  
2007 PM "B"  
2027 AM "C"  
2027 PM "D"

SIGNAL  
2007 AM "A"  
2007 PM "A"  
2027 AM "A"  
2027 PM "B"

RAMP  
2007 AM "B"  
2007 PM "B"  
2027 AM "C"  
2027 PM "C"

LEVELS OF SERVICE  
PROPOSED IMPROVEMENTS  
I-24 AT U.S. 72  
MARION CO.

## Checklist of Determinants for Location Study

Location: I-24 at U.S. 72 Interchange Modification Study

If preliminary field reviews indicate the presence of any of the following facilities or ESE categories, place a "X" in the blank opposite the item. Where more than one alternate is to be considered, place its letter designation in the blank.

1. Agricultural land usage.....
2. Airport (existing or proposed).....
3. Commercial area, shopping center..... X
4. Floodplains..... X
5. Forested land..... X
6. Historical, archaeological, cultural, or natural landmark, or cemeteries.....
7. Industrial park, factory.....
8. Institutional usage's
  - a. School or other educational institution.....
  - b. Church or other religious institution.....
  - c. Hospital or other medical facility.....
  - d. Public building, e.g., fire station.....
  - e. Defense installation.....
9. Recreational usage's
  - a. Park or recreational area, State Natural Area.....
  - b. Wildlife refuge or wildlife management area.....
10. Residential establishment.....
11. Urban area, town, city, or community..... X
12. Waterway, lake, pond, river, stream, spring, wetland..... X
 

Permit required: Coast Guard \_\_\_\_\_ Section 404   X  

Section 10 \_\_\_\_\_ TVA Section 26a review \_\_\_\_\_

NPDES   X   Aquatic Resources Alteration Permit   X  

Class V Injection Wells \_\_\_\_\_
13. Location coordinated with local officials..... X
14. Railroad Crossings.....
15. Hazardous Material Site.....
16. Other \_\_\_\_\_.....

02038

→ Stan King

TENNESSEE DEPARTMENT OF TRANSPORTATION  
MAPPING AND STATISTICS OFFICE  
TRAFFIC AND SAFETY PLANNING SECTION

(REV. 2/7/02)

PROJECT NO.: \_\_\_\_\_ ROUTE: I-24 @ US-72 (SR-27/150)  
COUNTY: MARION CITY: KIMBALL  
PROJECT DESCRIPTION: INTERCHANGE MODIFICATION STUDY  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**DIVISION REQUESTING:**

MAINTENANCE  SPECIAL DESIGN   
PLANNING  STRUCTURES   
PROG. DEVELOPMENT & ADM.  SURVEY & DESIGN   
PUBLIC TRANS. & AERO.  OTHER \_\_\_\_\_   
YEAR PROJECT PROGRAMMED FOR CONSTRUCTION: \_\_\_\_\_  
PROJECTED LETTING DATE: \_\_\_\_\_

**TRAFFIC ASSIGNMENT:**

|     | BASE YEAR |      | DESIGN YEAR |       |    |      | DESIGN ROADWAY % TRUCKS |     | DESIGN AVERAGE DAILY LOADS |      |       |
|-----|-----------|------|-------------|-------|----|------|-------------------------|-----|----------------------------|------|-------|
|     | ADT       | YEAR | ADT         | DHV   | %  | YEAR | DIR.DIST.               | DHV | ADT                        | FLEX | RIGID |
| (1) | 44,940    | 2007 | 73,280      | 7,328 | 10 | 2027 | 55-45                   | 23  | 34                         |      |       |
| (2) | 24,780    | 2007 | 37,170      | 3,717 | 10 | 2027 | 60-40                   | 7   | 10                         |      |       |
|     |           |      |             |       |    |      |                         |     |                            |      |       |
|     |           |      |             |       |    |      |                         |     |                            |      |       |

REQUESTED BY: NAME MATT ASHBY DATE 4/10/02  
DIVISION FACILITIES PLANNING  
ADDRESS SUITE 900, J.K. POLK BLDG.  
NASHVILLE, TN.

REVIEWED BY: TONY ARMSTRONG *Tony Armstrong* DATE 4-18-02  
TRANSPORTATION MANAGER 1  
SUITE 1000, JAMES K. POLK BUILDING

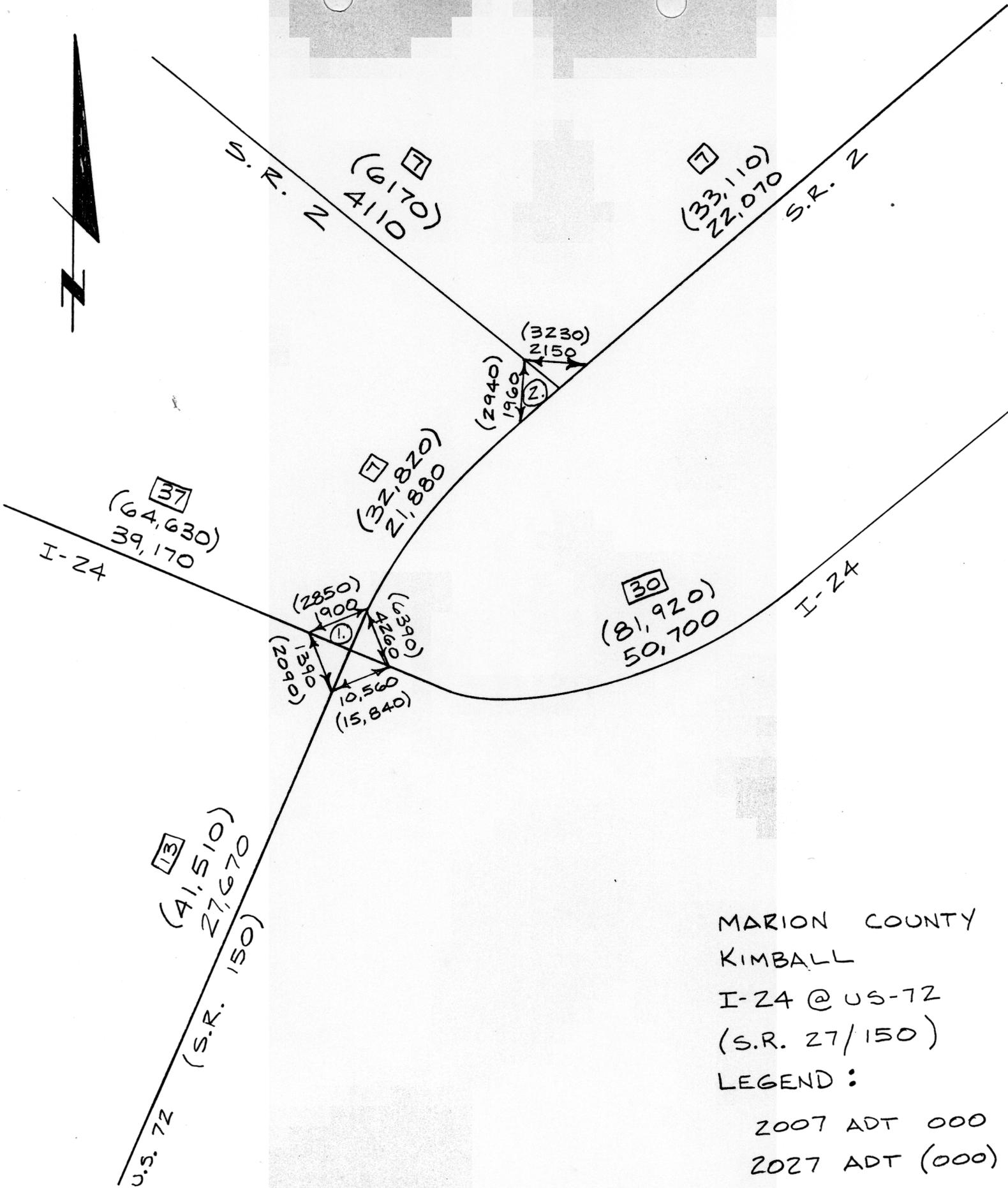
APPROVED BY: STEVE ALLEN *Steve Allen* DATE 4-18-02  
TRANSPORTATION MANAGER 2  
SUITE 1000, JAMES K. POLK BUILDING

**COMMENTS:**

THIS PROJECT BASED ON PREVIOUSLY PREPARED PROJECT DATED 11-13-00.

- (1) I-24 TRAFFIC DATA
- (2) US-72 (SR-27/150) TRAFFIC DATA

**DHV'S ARE NOT REQUIRED FOR SIDE ROADS LESS THAN 1000 ADT.**  
**NOTE:** FOR BRIDGE REPLACEMENT PROJECTS, ADLs ARE NOT REQUIRED FOR ADTs OF 1000 OR LESS AND PERCENTAGE OF TRUCKS OF 7% OR LESS.  
SEE ATTACHMENTS FOR TURNING MOVEMENTS AND/OR OTHER DETAILS.



MARION COUNTY  
KIMBALL

I-24 @ US-72  
(S.R. 27/150)

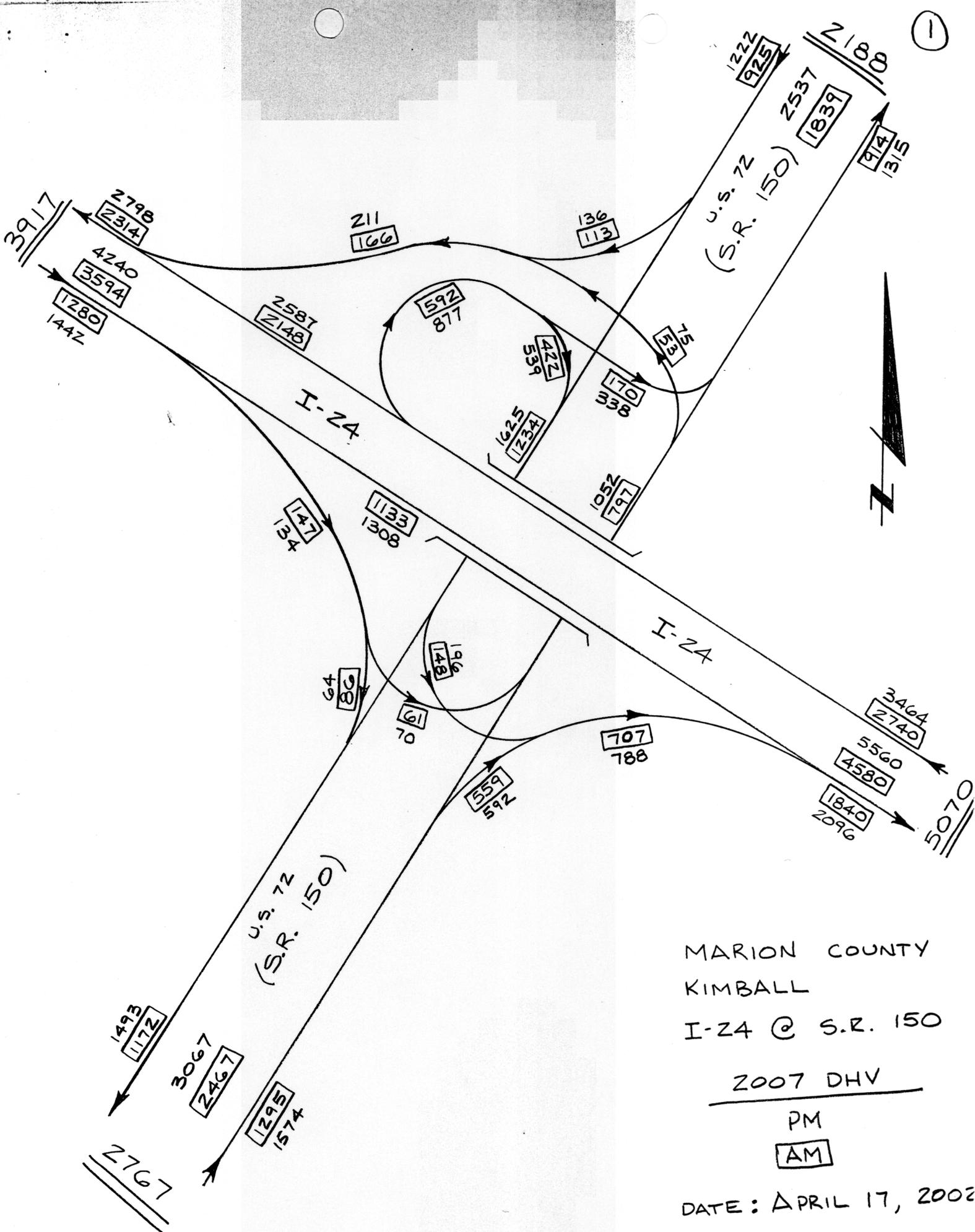
LEGEND :

2007 ADT 000  
2027 ADT (000)

ADT TRUCK %

DATE: APRIL 17, 2002

D.I.B.



MARION COUNTY  
 KIMBALL  
 I-24 @ S.R. 150

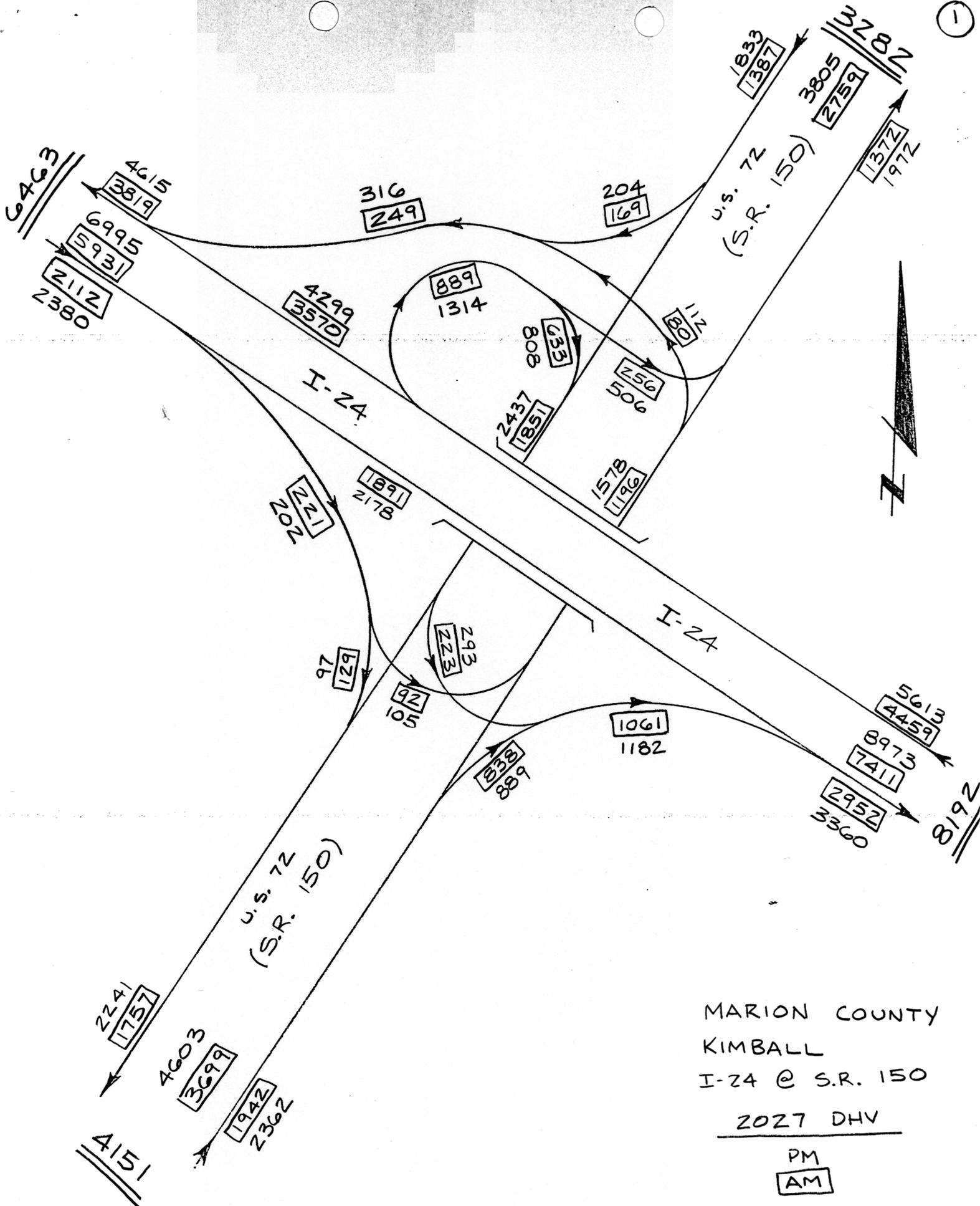
2007 DHV

PM

AM

DATE: APRIL 17, 2002

R.L.B.



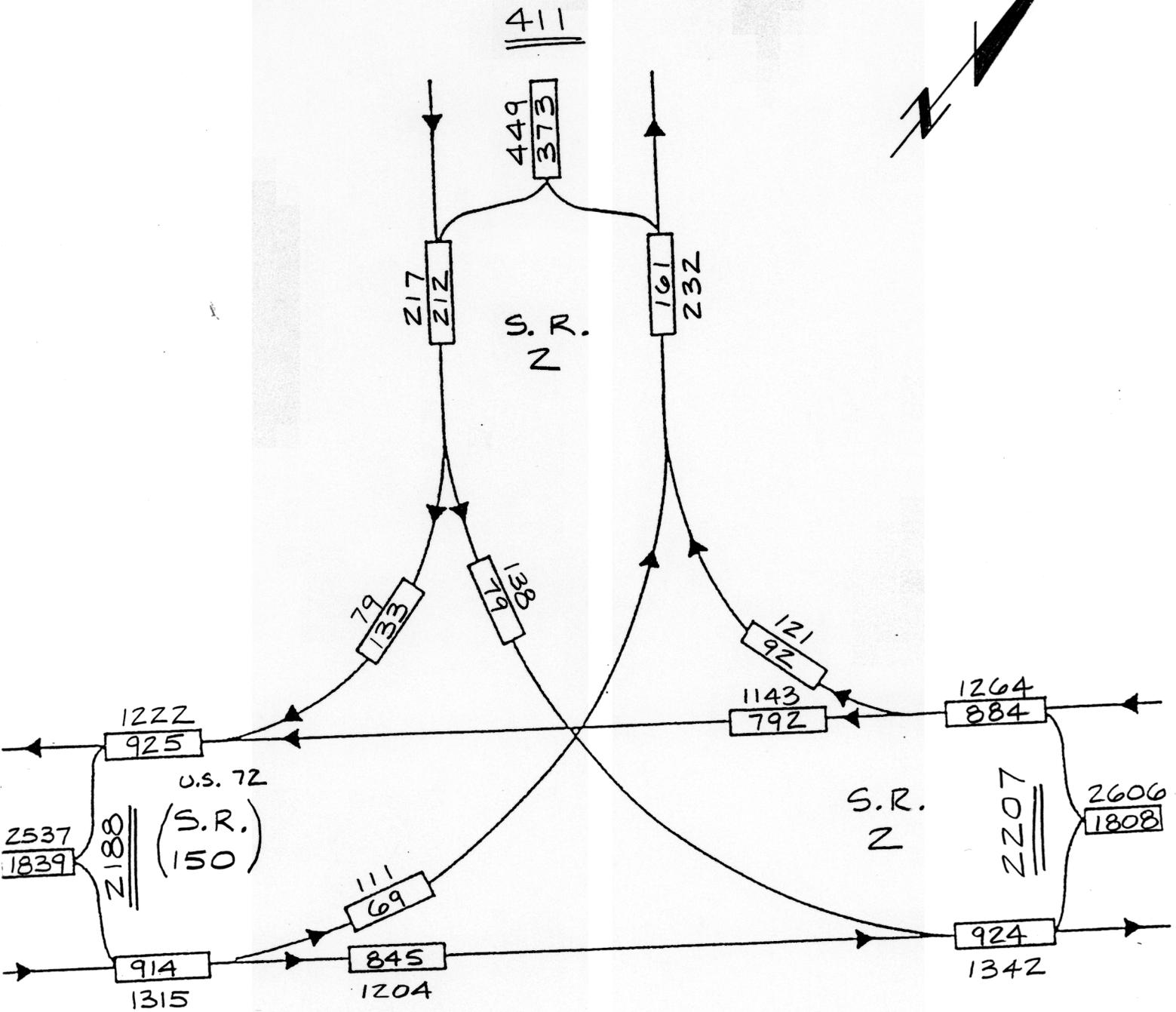
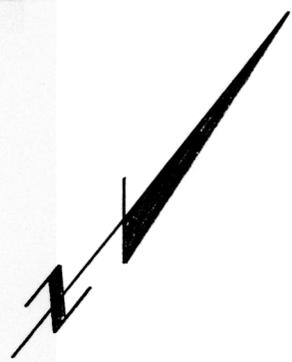
MARION COUNTY  
 KIMBALL  
 I-24 @ S.R. 150

2027 DHV

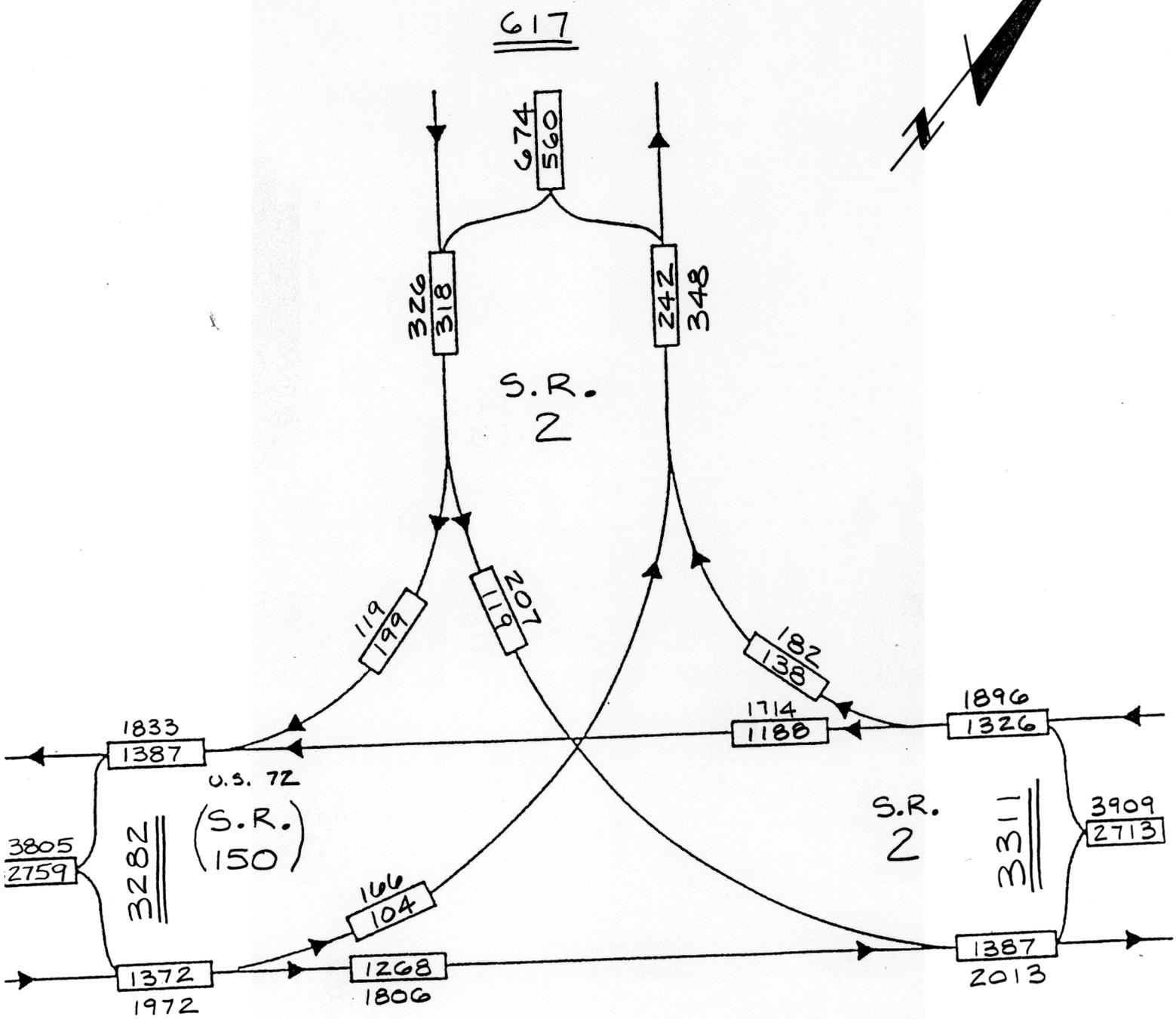
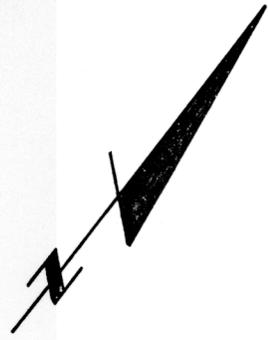
PM  
 AM

DATE: APRIL 18, 2002

R.L.B.



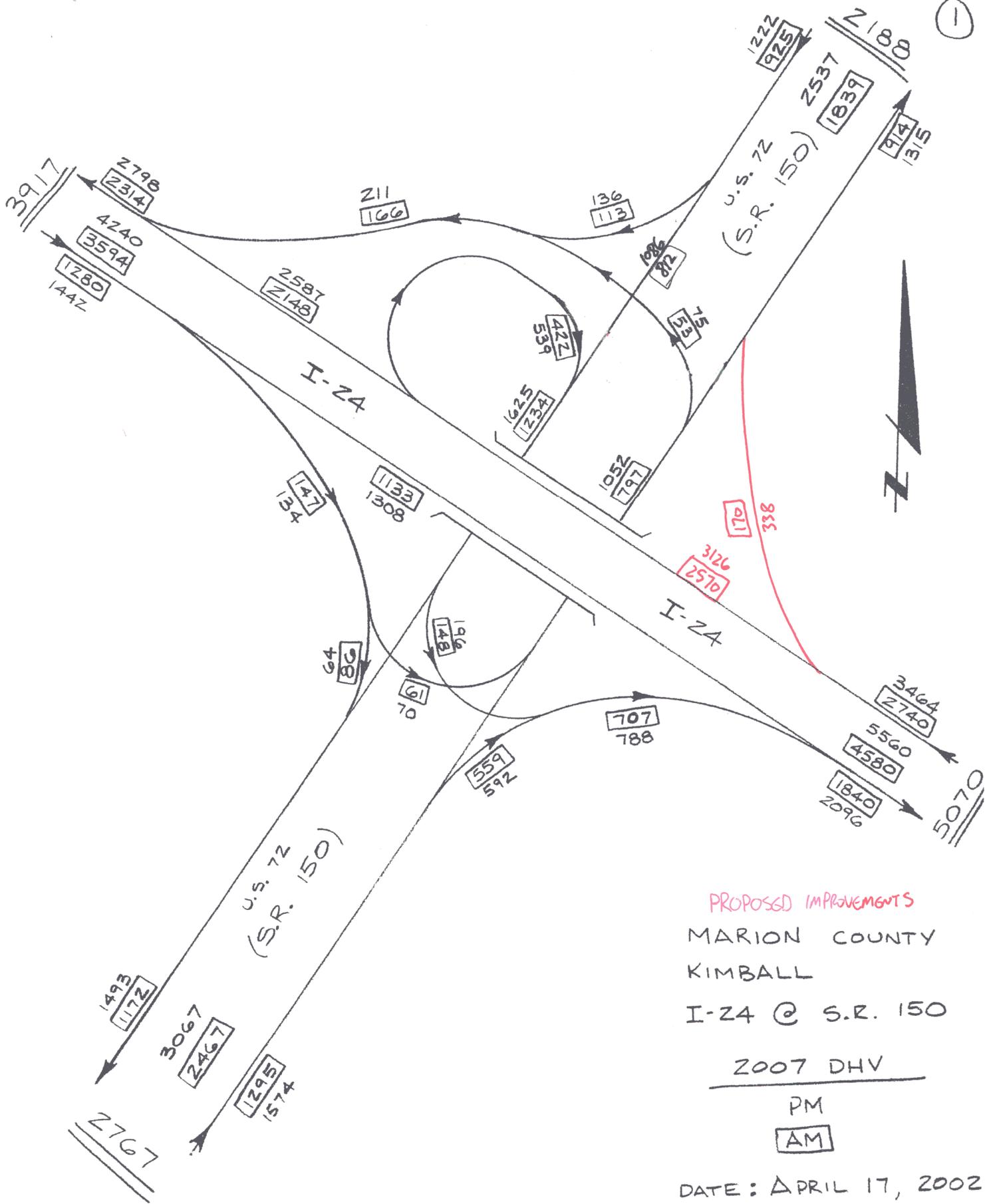
MARION COUNTY  
 KIMBALL  
 S.R. 2 @ S.R. 150  
2007 DHV  
 PM  
 AM  
 DATE: APRIL 17, 2002  
 P. 2



MARION COUNTY  
KIMBALL  
S.R. 2 @ S.R. 150

2027 DHV  
PM  
AM

DATE: APRIL 18, 2002  
R.L.B.

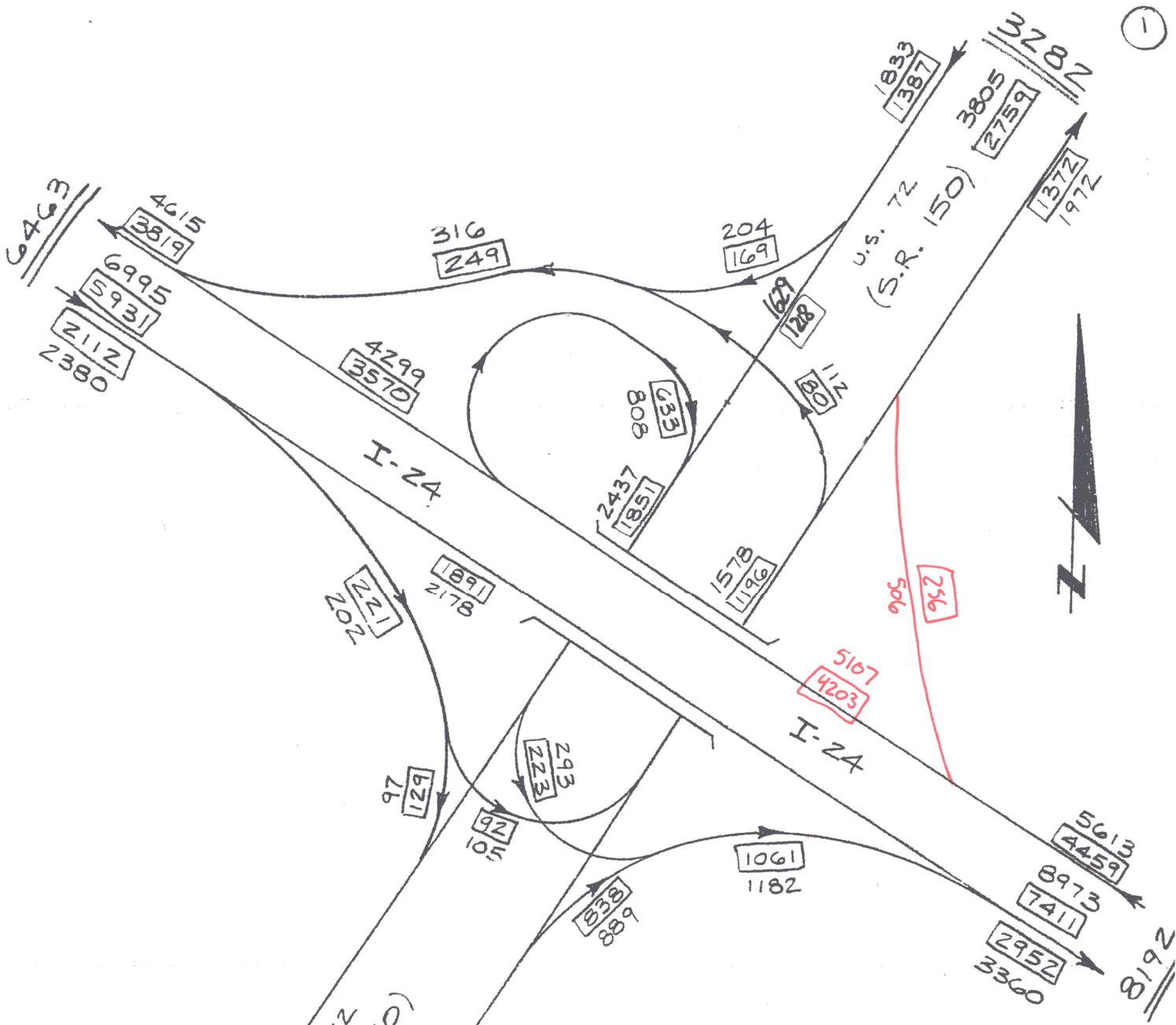


PROPOSED IMPROVEMENTS  
 MARION COUNTY  
 KIMBALL  
 I-24 @ S.R. 150

2007 DHV  
 PM  
 AM

DATE: APRIL 17, 2002

R.L.B.



PROPOSED IMPROVEMENTS  
 MARION COUNTY  
 KIMBALL  
 I-24 @ S.R. 150  
 2027 DHV  
 PM  
 AM  
 DATE: APRIL 18, 2002  
 R.L.B.

**Tennessee Department of Transportation  
Design Criteria for Location and Design Phase**

Route: I-24  
Option: N/A  
Section: N/A  
Region: TDOT Region 2  
County: Marion  
Project No.:  
Location: I-24 at U.S. 72 Interchange Modification Study

Present ADT (2007).....44940  
Future ADT (2027)..... 73280  
Percent Trucks..... 23  
Future DHV (2027)..... 7328  
Functional Classification..... Rural Freeway  
Minimum Design Speed..... 70 mph  
Access Control..... Yes  
Minimum Curve..... 3°15'  
Maximum Superelevation..... Existing  
Maximum Grade..... Existing  
Minimum Stopping Sight Distance..... Existing  
Surface Width..... Existing  
Number of Lanes..... Existing  
Useable Shoulder Width..... Existing  
Median Width..... Existing  
Minimum Right-of-Way..... Existing  
Signalization..... N/A

Remarks:

**Tennessee Department of Transportation  
Design Criteria for Location and Design Phase**

Route: U.S. 72  
Option: N/A  
Section: N/A  
Region: TDOT Region 2  
County: Marion  
Project No.:  
Location: I-24 at U.S. 72 Interchange Modification Study

Present ADT (2007).....24780  
Future ADT (2027)..... 37170  
Percent Trucks..... 7 (DHV), 10 (ADT)  
Future DHV (2027)..... 3717  
Functional Classification..... Urban Principal Arterial  
Minimum Design Speed..... 45 mph  
Access Control..... No  
Minimum Curve..... R= 730', Dc = 7°51'  
Maximum Superelevation..... 4%  
Maximum Grade..... 7%  
Minimum Stopping Sight Distance..... 360 ft.  
Surface Width..... 2 @ 12' each direction (basic section)  
Number of Lanes..... 4 (basic section)  
Useable Shoulder Width..... 4 ft. (with curb and gutter)  
Median Width..... Varies  
Minimum Right-of-Way..... 66 ft. (from existing plans)  
Signalization..... Yes

Remarks:

## Cost Data Sheet

**Project:** I-24 at U.S. 72 Interchange Modification Study  
**Location:** Marion County, TN  
**Alternate:** Proposed Improvements  
**Length:** I-24: 0.71 Miles, U.S. 72: 0.37 Miles

### Right of Way

|                              |                   |          |
|------------------------------|-------------------|----------|
| Land, Improvements & Damages | (Acres = 2.5)     | \$50,000 |
| Incidentals                  | (Tracts = 1)      | \$2,500  |
| Relocation Payments          | (Residences = 0)  | \$0      |
|                              | (Businesses = 0)  | \$0      |
|                              | (Non-Profits = 0) | \$0      |

### Total Right-of-Way Cost

**\$52,500**

### Utility Relocation

|                  |          |
|------------------|----------|
| Reimbursable     | \$0      |
| Non-Reimbursable | \$15,600 |

### Total Utility Relocation Cost

**\$15,600**

### Construction

|                                   |             |
|-----------------------------------|-------------|
| Clearing and Grubbing             | \$2,500     |
| Earthwork                         | \$70,700    |
| Pavement Removal                  | \$20,600    |
| Drainage                          |             |
| (Erosion Control = \$58,950)      | \$132,180   |
| Structures (Proposed Bridge)      | \$1,597,600 |
| Paving                            | \$663,250   |
| Retaining Walls                   | \$0         |
| Maintenance of Traffic            | \$200,000   |
| Topsoil                           | \$12,000    |
| Seeding                           | \$4,100     |
| Sodding                           | \$10,000    |
| Signing                           | \$20,000    |
| Signalization                     | \$80,000    |
| Fence                             | \$9,100     |
| Guardrail                         | \$87,200    |
| Rip-Rap or Slope Protection       | \$10,000    |
| Other Construction Items (10%)    | \$292,000   |
| Mobilization                      | \$181,500   |
| 10% Engineering and Contingencies | \$339,273   |

### Total Construction Cost

**\$3,732,003**

### Preliminary Engineering (10% of Construction Cost)

**\$339,273**

### Total Cost for Proposed Improvements

**\$4,139,376**

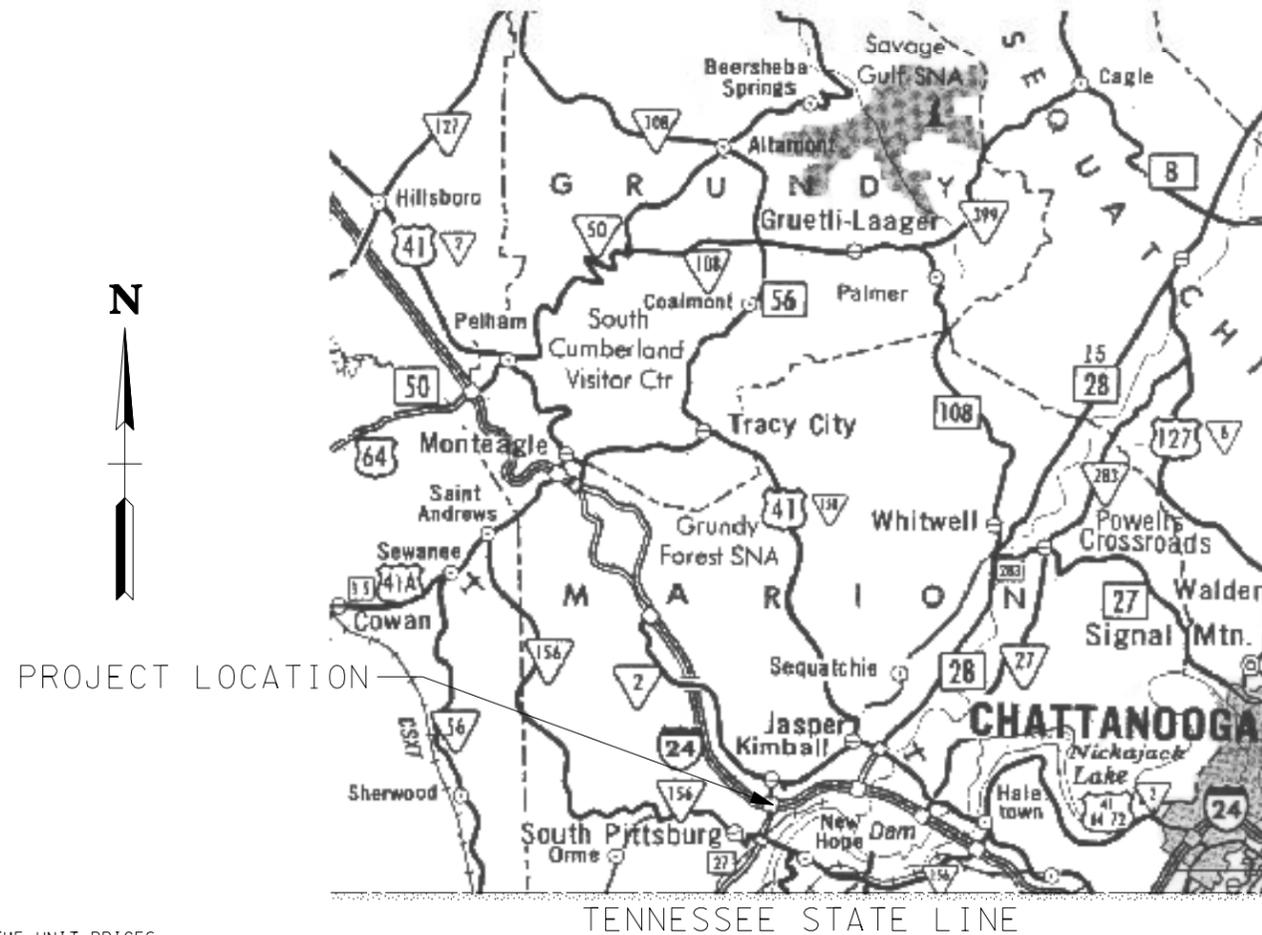
Index Of Sheets

- 1 ..... TITLE SHEET
- 2 ..... TYPICAL SECTIONS
- 3-6 .. FUNCTIONAL PLANS
- 7 ..... PROFILE I-24

STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION  
BUREAU OF PLANNING AND DEVELOPMENT

|                    |      |           |
|--------------------|------|-----------|
| TENN.              | YEAR | SHEET NO. |
|                    | 2002 | 1         |
| FED. AID PROJ. NO. |      |           |
| STATE PROJ. NO.    |      |           |

INTERCHANGE MODIFICATION STUDY  
I-24 AT U.S. 72  
MARION COUNTY



SPECIAL NOTES

PROPOSALS MAY BE REJECTED BY THE COMMISSIONER IF ANY OF THE UNIT PRICES CONTAINED THEREIN ARE OBVIOUSLY UNBALANCED, EITHER EXCESSIVE OR BELOW THE REASONABLE COST ANALYSIS VALUE.

THIS PROJECT TO BE CONSTRUCTED UNDER THE STANDARD SPECIFICATIONS OF THE TENNESSEE DEPARTMENT OF TRANSPORTATION DATED MARCH 1, 1995 AND ADDITIONAL SPECIFICATIONS AND SPECIAL PROVISIONS CONTAINED IN THE PLANS AND IN THE PROPOSAL CONTRACT

TDOT ROAD SP. SV. 2 \_\_\_\_\_  
 DESIGNER \_\_\_\_\_ CHECKED BY \_\_\_\_\_  
 P.E. NO. \_\_\_\_\_

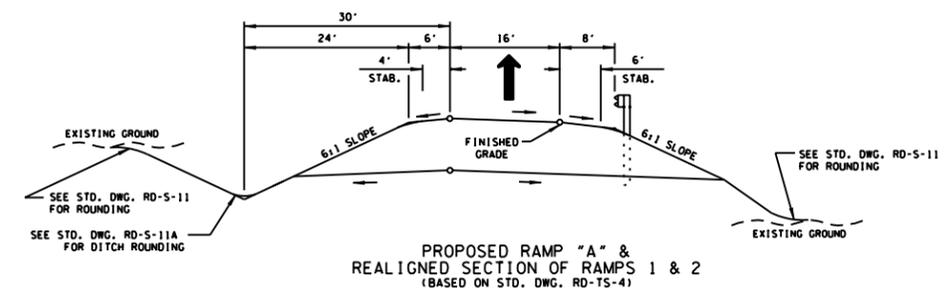
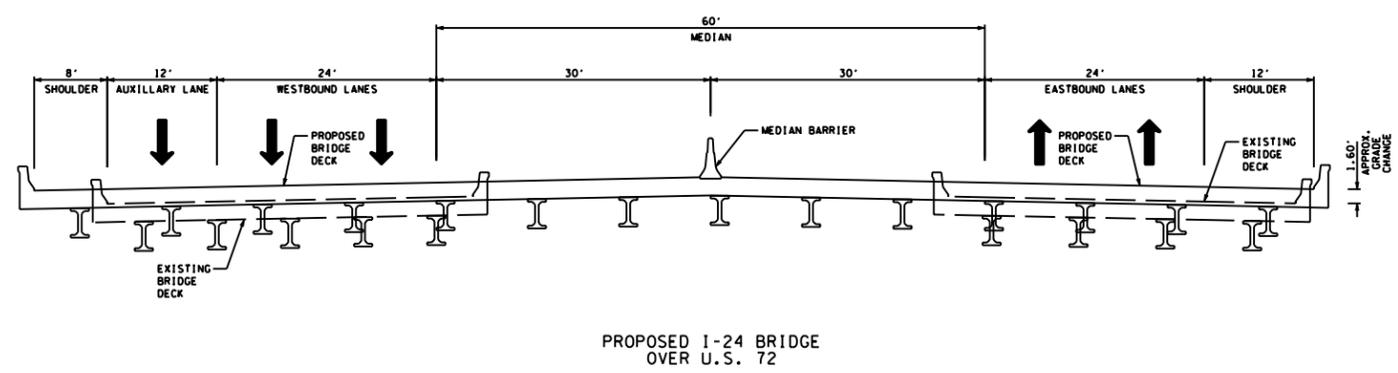
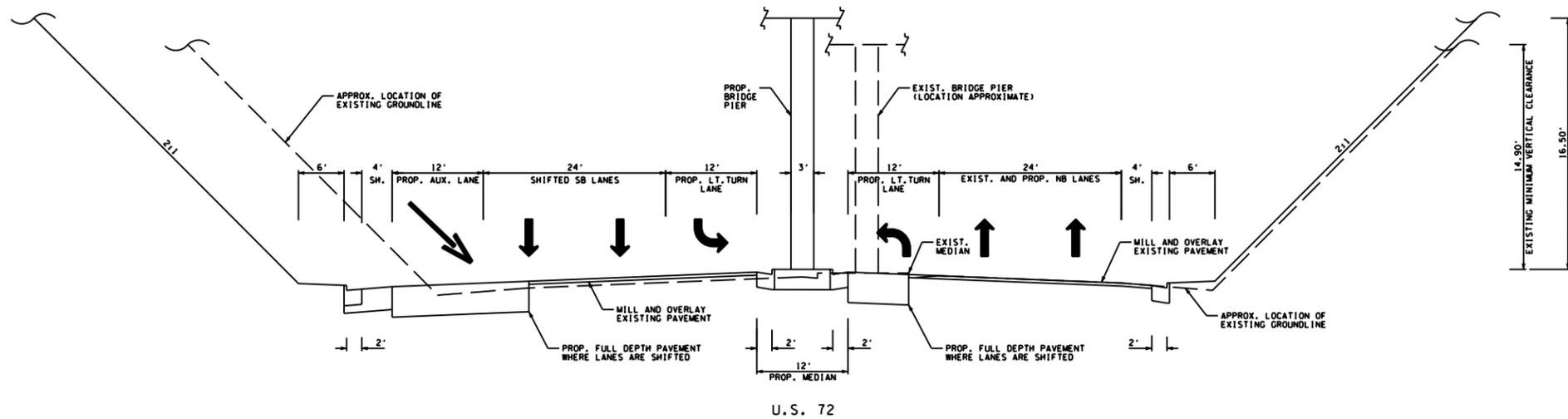
APPROVED: \_\_\_\_\_  
 DIRECTOR, DESIGN DIVISION  
 DATE: \_\_\_\_\_  
 APPROVED: \_\_\_\_\_  
 COMMISSIONER

U.S. DEPARTMENT OF TRANSPORTATION  
FEDERAL HIGHWAY ADMINISTRATION

APPROVED: \_\_\_\_\_  
 DIVISION ADMINISTRATOR      DATE

SCALE: 1" = 8 MILES

| TYPE   | YEAR | PROJECT NO. | SHEET NO. |
|--------|------|-------------|-----------|
| FUNCT. | 02   |             | 2         |
|        |      |             |           |
|        |      |             |           |



STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION  
BUREAU OF PLANNING & DEVELOPMENT

FUNCTIONAL  
LAYOUT  
TYPICAL SECTIONS

N. T. S.

| TYPE   | YEAR | PROJECT NO. | SHEET NO. |
|--------|------|-------------|-----------|
| FUNCT. | 02   |             | 3         |
|        |      |             |           |
|        |      |             |           |



MATCH LINE SEE SHEET NO. 5

MATCH LINE SEE SHEET NO. 4

BATTLE CREEK

STATE OF TENNESSEE  
 DEPARTMENT OF TRANSPORTATION  
 BUREAU OF PLANNING & DEVELOPMENT

**FUNCTIONAL LAYOUT**

SCALE: 1"=100'

| TYPE   | YEAR | PROJECT NO. | SHEET NO. |
|--------|------|-------------|-----------|
| FUNCT. | 02   |             | 4         |
|        |      |             |           |
|        |      |             |           |



MATCH LINE SEE SHEET NO. 3

MATCH LINE SEE SHEET NO. 5

SEE SHEET NO. 5

MATCH LINE



STATE OF TENNESSEE  
 DEPARTMENT OF TRANSPORTATION  
 BUREAU OF PLANNING & DEVELOPMENT

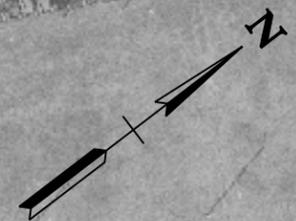
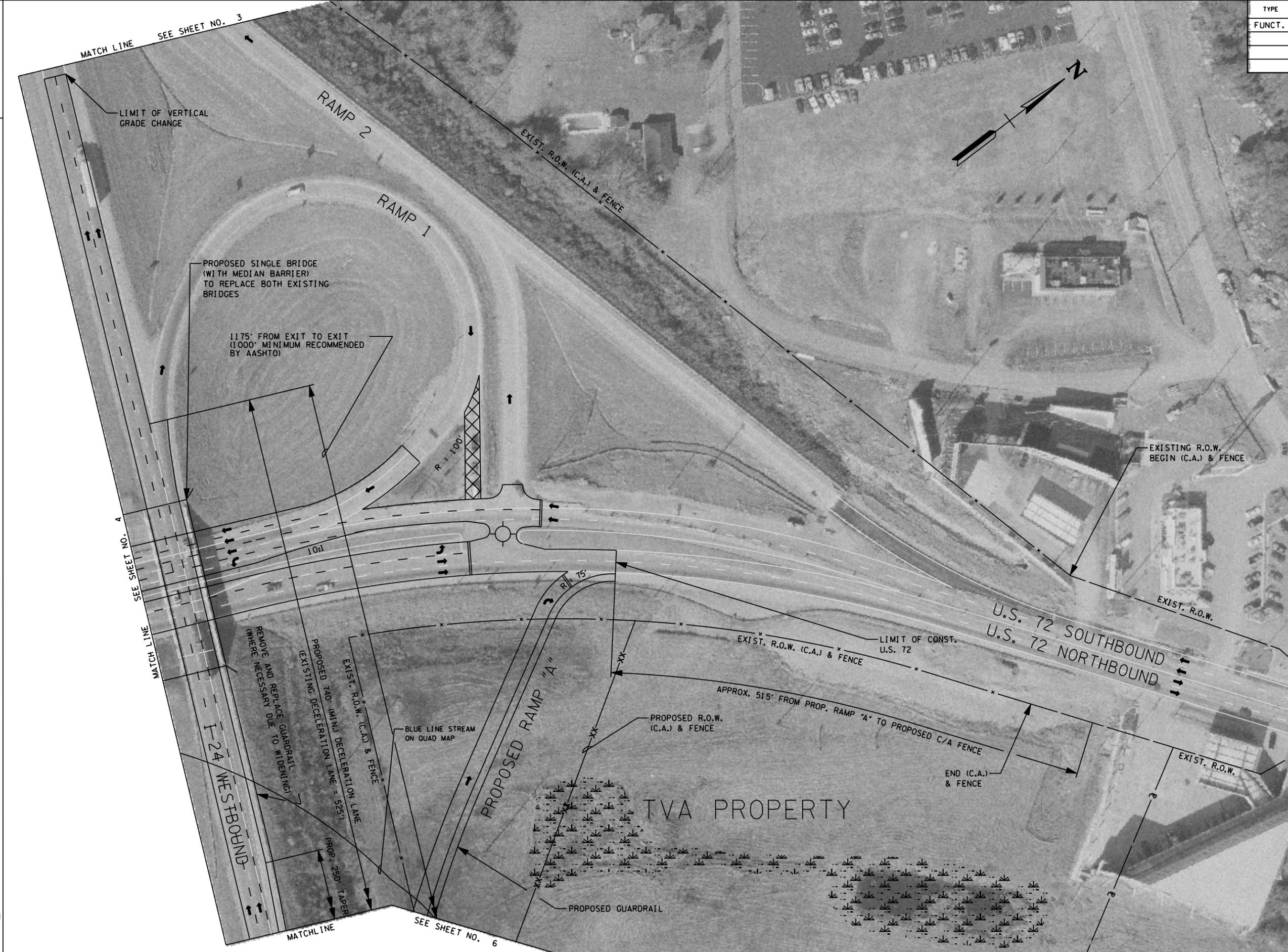
**FUNCTIONAL LAYOUT**

SCALE: 1"=100'



TENNESSEE D.O.T.  
 DESIGN DIVISION  
 FILE NO.

| TYPE   | YEAR | PROJECT NO. | SHEET NO. |
|--------|------|-------------|-----------|
| FUNCT. | 02   |             | 5         |
|        |      |             |           |
|        |      |             |           |



STATE OF TENNESSEE  
 DEPARTMENT OF TRANSPORTATION  
 BUREAU OF PLANNING & DEVELOPMENT

FUNCTIONAL LAYOUT

SCALE: 1"=100'



| TYPE   | YEAR | PROJECT NO. | SHEET NO. |
|--------|------|-------------|-----------|
| FUNCT. | 02   |             | 6         |
|        |      |             |           |
|        |      |             |           |

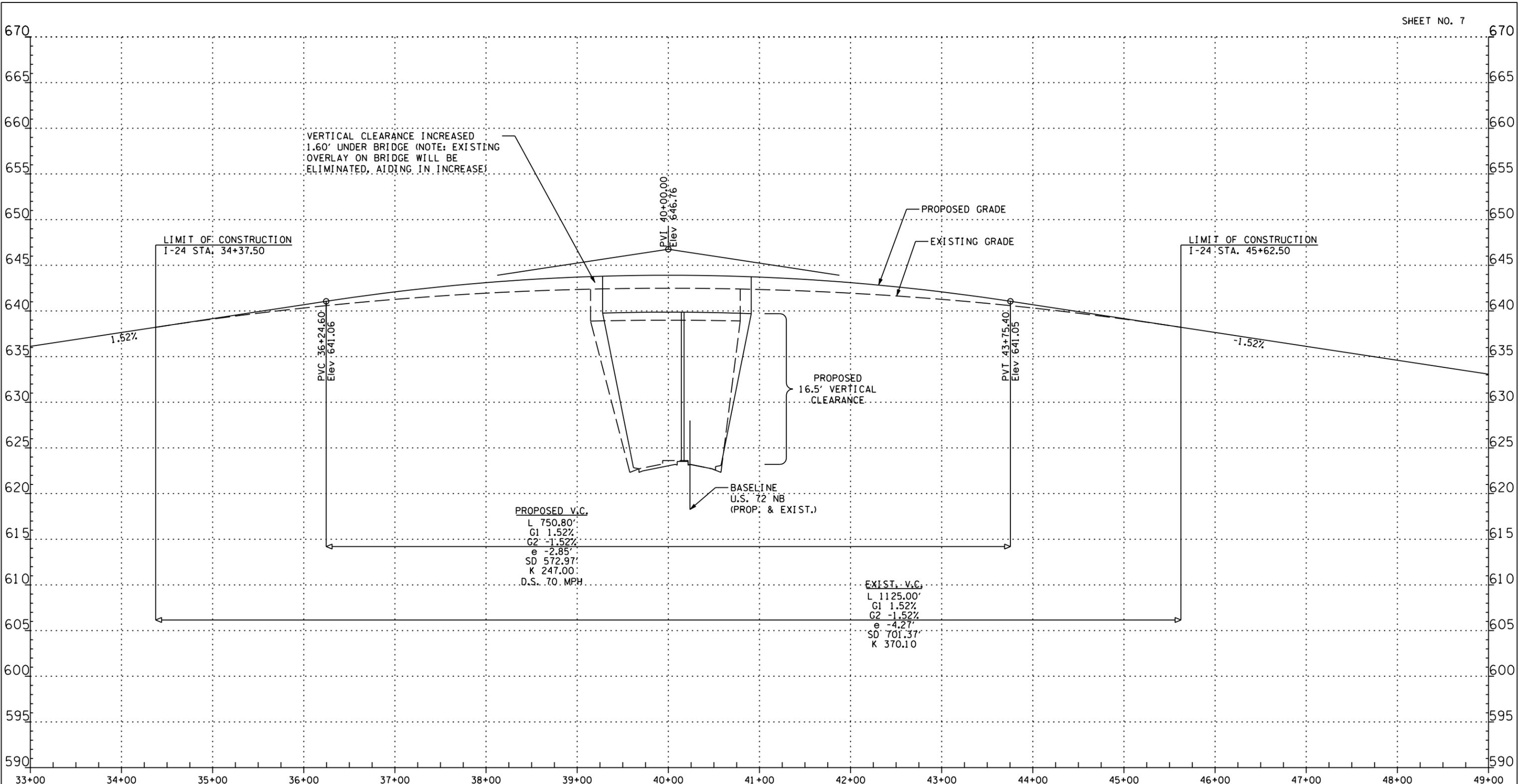


APPROXIMATE LIMITS OF WETLANDS AS TAKEN FROM AERIAL PHOTOGRAPHY

STATE OF TENNESSEE  
 DEPARTMENT OF TRANSPORTATION  
 BUREAU OF PLANNING & DEVELOPMENT

# FUNCTIONAL LAYOUT

SCALE: 1"=100'



I-24 PROFILE  
1" = 100'  
DEMONSTRATING IMPROVED  
VERTICAL CLEARANCE ACHIEVED  
BY SHORTENING THE EXISTING  
VERTICAL CURVE

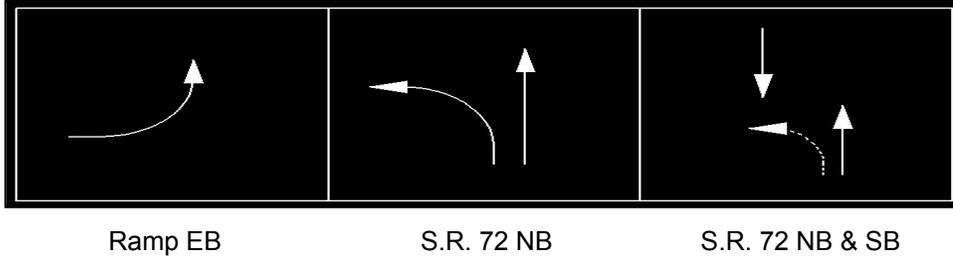
# **Highway Capacity Analysis**

Synopsis of Signal and Stop-Controlled Data

I-24 at U.S. 72 Interchange Modification Study  
Marion County, Tennessee

**Existing System  
Signal Data  
I-24 (Ramps 1 & 2) at U.S. 72  
Marion Co.**

**Approach Delay, Levels of Service, and Queue Length**



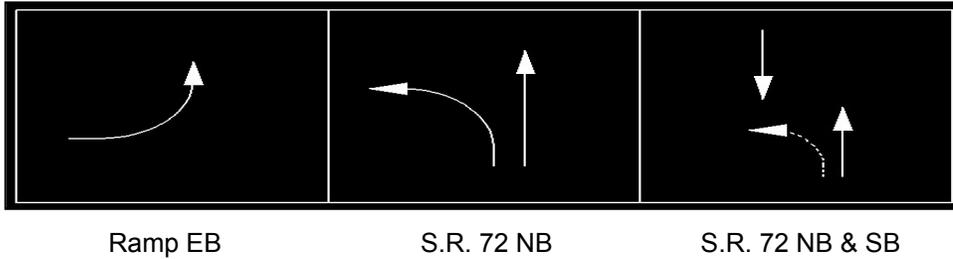
|                                       |                      |             |                      |                               |                      |      |
|---------------------------------------|----------------------|-------------|----------------------|-------------------------------|----------------------|------|
| <b>2007 AM</b>                        | G                    | 10          | G                    | 8                             | G                    | 25   |
|                                       | Y                    | 3           | Y                    | 3                             | Y                    | 3    |
|                                       | LT. Q <sub>AVG</sub> | 3.0         | LT. Q <sub>AVG</sub> | 0.4                           |                      |      |
|                                       |                      |             | NB Q <sub>AVG</sub>  | 2.9                           | SB Q <sub>AVG</sub>  | 5.4  |
|                                       | Q <sub>SPACING</sub> | 24.9        | Q <sub>SPACING</sub> | 24.9                          | Q <sub>SPACING</sub> | 24.9 |
|                                       | L <sub>LT REQ</sub>  | 75          | L <sub>LT REQ</sub>  | 10                            |                      |      |
|                                       |                      |             | L <sub>NB REQ</sub>  | 72                            | L <sub>SB REQ</sub>  | 134  |
|                                       | APP. DELAY           | 26.6        | APP. DELAY           | 3.7                           | APP. DELAY           | 10.9 |
| APP. L.O.S.                           | C                    | APP. L.O.S. | A                    | APP. L.O.S.                   | B                    |      |
| <b>INTERSECTION DELAY = 9.2 s/veh</b> |                      |             |                      | <b>INTERSECTION L.O.S.= A</b> |                      |      |

|  |                      |             |                      |                               |                      |      |
|--|----------------------|-------------|----------------------|-------------------------------|----------------------|------|
| <b>2007 PM</b>                         | G                    | 24          | G                    | 8                             | G                    | 40   |
|  | Y                    | 3           | Y                    | 3                             | Y                    | 3    |
|  | LT. Q <sub>AVG</sub> | 9.4         | LT. Q <sub>AVG</sub> | 1.2                           |                      |      |
|  |                      |             | NB Q <sub>AVG</sub>  | 7.8                           | SB Q <sub>AVG</sub>  | 13.0 |
|  | Q <sub>SPACING</sub> | 24.9        | Q <sub>SPACING</sub> | 24.9                          | Q <sub>SPACING</sub> | 24.9 |
|  | L <sub>LT REQ</sub>  | 234         | L <sub>LT REQ</sub>  | 30                            |                      |      |
|  |                      |             | L <sub>NB REQ</sub>  | 194                           | L <sub>SB REQ</sub>  | 324  |
|  | APP. DELAY           | 35.8        | APP. DELAY           | 9.3                           | APP. DELAY           | 18.9 |
| APP. L.O.S.                            | D                    | APP. L.O.S. | A                    | APP. L.O.S.                   | B                    |      |
| <b>INTERSECTION DELAY = 17.2 s/veh</b> |                      |             |                      | <b>INTERSECTION L.O.S.= B</b> |                      |      |

Note: Signal timing optimized using SOAP 2K with minimum green time of 8 s and yellow time of 3 s.

**Existing System  
Signal Data  
I-24 (Ramps 1 & 2) at U.S. 72  
Marion Co.**

**Approach Delay, Levels of Service, and Queue Length**



|                |                      |             |                      |             |                      |      |
|----------------|----------------------|-------------|----------------------|-------------|----------------------|------|
| <b>2027 AM</b> | G                    | 17          | G                    | 8           | G                    | 53   |
|                | Y                    | 3           | Y                    | 3           | Y                    | 3    |
|                | LT. Q <sub>AVG</sub> | 8.9         | LT. Q <sub>AVG</sub> | 1.1         |                      |      |
|                |                      |             | NB Q <sub>AVG</sub>  | 7.5         | SB Q <sub>AVG</sub>  | 12.7 |
|                | Q <sub>SPACING</sub> | 24.9        | Q <sub>SPACING</sub> | 24.9        | Q <sub>SPACING</sub> | 24.9 |
|                | L <sub>LT REQ</sub>  | 222         | L <sub>LT REQ</sub>  | 27          |                      |      |
|                |                      |             | L <sub>NB REQ</sub>  | 187         | L <sub>SB REQ</sub>  | 316  |
|                | APP. DELAY           | 58.1        | APP. DELAY           | 5.8         | APP. DELAY           | 12.8 |
| APP. L.O.S.    | E                    | APP. L.O.S. | A                    | APP. L.O.S. | B                    |      |

**INTERSECTION DELAY = 14.0 s/veh      INTERSECTION L.O.S.= B**

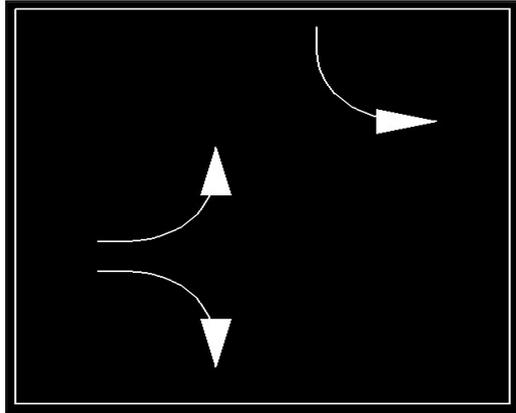
|                |                      |             |                      |             |                      |      |
|----------------|----------------------|-------------|----------------------|-------------|----------------------|------|
| <b>2027 PM</b> | G                    | 41          | G                    | 10          | G                    | 80   |
|                | Y                    | 3           | Y                    | 3           | Y                    | 3    |
|                | LT. Q <sub>AVG</sub> | 35.3        | LT. Q <sub>AVG</sub> | 4.6         |                      |      |
|                |                      |             | NB Q <sub>AVG</sub>  | 24.6        | SB Q <sub>AVG</sub>  | 42.5 |
|                | Q <sub>SPACING</sub> | 24.9        | Q <sub>SPACING</sub> | 24.9        | Q <sub>SPACING</sub> | 24.9 |
|                | L <sub>LT REQ</sub>  | 879         | L <sub>LT REQ</sub>  | 115         |                      |      |
|                |                      |             | L <sub>NB REQ</sub>  | 613         | L <sub>SB REQ</sub>  | 1058 |
|                | APP. DELAY           | 133.6       | APP. DELAY           | 20.5        | APP. DELAY           | 38.1 |
| APP. L.O.S.    | F                    | APP. L.O.S. | C                    | APP. L.O.S. | D                    |      |

**INTERSECTION DELAY = 43.7 s/veh      INTERSECTION L.O.S.= D**

Note: Signal timing optimized using SOAP 2K with minimum green time of 8 s and yellow time of 3 s.

**Existing System  
 Stop Control Data  
 I-24 (Ramps 3 & 4) at U.S. 72  
 Marion Co.**

**Approach Delay and Levels of Service**



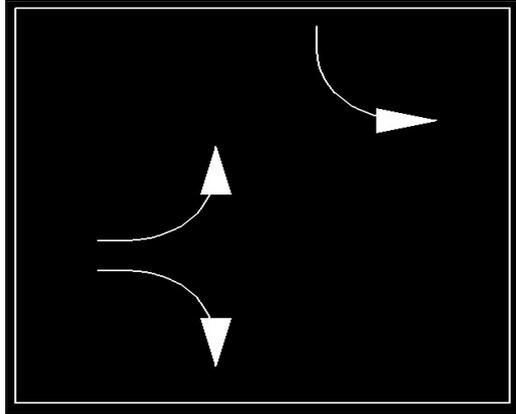
| 2007 AM | EASTBOUND              |          | SOUTHBOUND                  |
|---------|------------------------|----------|-----------------------------|
|         | LT. Q <sub>AVG</sub>   | 2.67     | LT. Q <sub>AVG</sub> 0.8    |
|         | RT. Q <sub>AVG</sub>   | 0.83     |                             |
|         | Q <sub>SPACING</sub>   | 24.9     | Q <sub>SPACING</sub> 24.9   |
|         | L <sub>LT REQ</sub>    | 66       | L <sub>LT REQ</sub> 20      |
|         | L <sub>RT REQ</sub>    | 21       |                             |
|         | LT. APP. DELAY (s/veh) | 66.6     | LT. APP. DELAY (s/veh) 10.9 |
|         | RT. APP. DELAY (s/veh) | 15.7     |                             |
|         | APP. DELAY (s/veh)     | 36.8     | APP. DELAY (s/veh) 10.9     |
|         | LT. L.O.S.             | F        | LT. L.O.S. B                |
|         | RT. L.O.S.             | C        |                             |
|         | <b>APP. L.O.S.</b>     | <b>E</b> | <b>APP. L.O.S. B</b>        |

| 2007 PM | EASTBOUND              |          | SOUTHBOUND                  |
|---------|------------------------|----------|-----------------------------|
|         | LT. Q <sub>AVG</sub>   | 7.62     | LT. Q <sub>AVG</sub> 1.62   |
|         | RT. Q <sub>AVG</sub>   | 0.83     |                             |
|         | Q <sub>SPACING</sub>   | 24.9     | Q <sub>SPACING</sub> 24.9   |
|         | L <sub>LT REQ</sub>    | 190      | L <sub>LT REQ</sub> 40      |
|         | L <sub>RT REQ</sub>    | 21       |                             |
|         | LT. APP. DELAY (s/veh) | 422.9    | LT. APP. DELAY (s/veh) 14.2 |
|         | RT. APP. DELAY (s/veh) | 19.4     |                             |
|         | APP. DELAY (s/veh)     | 229.3    | APP. DELAY (s/veh) 14.2     |
|         | LT. L.O.S.             | F        | LT. L.O.S. B                |
|         | RT. L.O.S.             | C        |                             |
|         | <b>APP. L.O.S.</b>     | <b>F</b> | <b>APP. L.O.S. B</b>        |

**Existing System**

**Stop Control Data**  
**I-24 (Ramps 3 & 4) at U.S. 72**  
**Marion Co.**

**Approach Delay and Levels of Service**

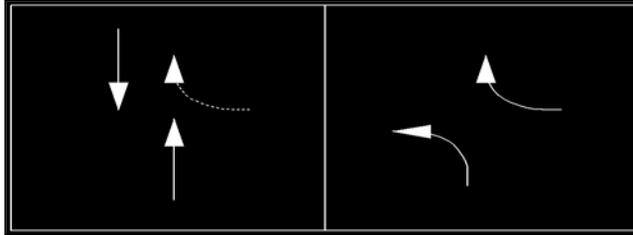


| <b>2027 AM</b>         | <b>EASTBOUND</b> | <b>SOUTHBOUND</b>           |
|------------------------|------------------|-----------------------------|
| LT. Q <sub>AVG</sub>   | 12.05            | LT. Q <sub>AVG</sub> 2.40   |
| RT. Q <sub>AVG</sub>   | 2.86             |                             |
| Q <sub>SPACING</sub>   | 24.9             | Q <sub>SPACING</sub> 24.9   |
| L <sub>LT REQ</sub>    | 300              | L <sub>LT REQ</sub> 60      |
| L <sub>RT REQ</sub>    | 71               |                             |
| LT. APP. DELAY (s/veh) | x                | LT. APP. DELAY (s/veh) 17.3 |
| RT. APP. DELAY (s/veh) | 32.4             |                             |
| APP. DELAY (s/veh)     | 559.3            | APP. DELAY (s/veh) 17.3     |
| LT. L.O.S.             | F                | LT. L.O.S. C                |
| RT. L.O.S.             | D                |                             |
| <b>APP. L.O.S.</b>     | <b>F</b>         | <b>APP. L.O.S. C</b>        |

| <b>2027 PM</b>         | <b>EASTBOUND</b> | <b>SOUTHBOUND</b>           |
|------------------------|------------------|-----------------------------|
| LT. Q <sub>AVG</sub>   | 16.73            | LT. Q <sub>AVG</sub> 8.58   |
| RT. Q <sub>AVG</sub>   | 3.43             |                             |
| Q <sub>SPACING</sub>   | 24.9             | Q <sub>SPACING</sub> 24.9   |
| L <sub>LT REQ</sub>    | 417              | L <sub>LT REQ</sub> 214     |
| L <sub>RT REQ</sub>    | 85               |                             |
| LT. APP. DELAY (s/veh) | x                | LT. APP. DELAY (s/veh) 55.1 |
| RT. APP. DELAY (s/veh) | 54.7             |                             |
| APP. DELAY (s/veh)     | x                | APP. DELAY (s/veh) 55.1     |
| LT. L.O.S.             | F                | LT. L.O.S. F                |
| RT. L.O.S.             | F                |                             |
| <b>APP. L.O.S.</b>     | <b>F</b>         | <b>APP. L.O.S. F</b>        |

**Proposed Improvements**  
**Signal Data**  
**I-24 (Ramps 1 & 2) at U.S. 72**  
**Marion Co.**

**Approach Delay, Levels of Service, and Queue Length**



S.R. 72 NB & SB

Left & Right Turns

|                |                      |                |                      |         |   |  |
|----------------|----------------------|----------------|----------------------|---------|---|--|
| <b>2007 AM</b> | G                    | 27             | G                    | 8       |   |  |
|                | Y                    | 3              | Y                    | 3       |   |  |
|                | NB Q <sub>AVG</sub>  | 2.5            | LT. Q <sub>AVG</sub> | 0.6     |   |  |
|                | SB Q <sub>AVG</sub>  | 2.8            | RT. Q <sub>AVG</sub> | 1.6     |   |  |
|                | Q <sub>SPACING</sub> | 24.9           | Q <sub>SPACING</sub> | 24.9    |   |  |
|                | L <sub>NB REQ</sub>  | 62             | L <sub>LT REQ</sub>  | 15      |   |  |
|                | L <sub>SB REQ</sub>  | 70             | L <sub>RT REQ</sub>  | 40      |   |  |
|                |                      | NB APP. DELAY= | 4.3                  | NB LOS= | A |  |
|                | SB APP. DELAY=       | 3.6            | SB LOS=              | A       |   |  |
|                | WB APP. DELAY=       | 18.8           | WB LOS=              | B       |   |  |

**INTERSECTION DELAY = 5.0 s/veh**

**INTERSECTION L.O.S.= A**

|                |                      |                |                      |         |   |  |
|----------------|----------------------|----------------|----------------------|---------|---|--|
| <b>2007 PM</b> | G                    | 19             | G                    | 8       |   |  |
|                | Y                    | 3              | Y                    | 3       |   |  |
|                | NB Q <sub>AVG</sub>  | 3.7            | LT. Q <sub>AVG</sub> | 0.7     |   |  |
|                | SB Q <sub>AVG</sub>  | 4.3            | RT. Q <sub>AVG</sub> | 3.0     |   |  |
|                | Q <sub>SPACING</sub> | 24.9           | Q <sub>SPACING</sub> | 24.9    |   |  |
|                | L <sub>NB REQ</sub>  | 92             | L <sub>LT REQ</sub>  | 17      |   |  |
|                | L <sub>SB REQ</sub>  | 107            | L <sub>RT REQ</sub>  | 75      |   |  |
|                |                      | NB APP. DELAY= | 5.6                  | NB LOS= | A |  |
|                | SB APP. DELAY=       | 5.7            | SB LOS=              | A       |   |  |
|                | WB APP. DELAY=       | 21.3           | WB LOS=              | C       |   |  |

**INTERSECTION DELAY = 7.3 s/veh**

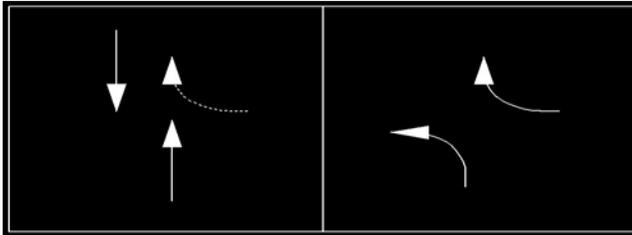
**INTERSECTION L.O.S.= A**

Note: Signal timing optimized using SOAP 2K with minimum green time of 8 s and yellow time of 3 s. It was assumed that 25% of the right turning vehicles from Prop. Ramp "A" can turn on red.

**Proposed Improvements**

**Signal Data**  
**I-24 (Ramps 1 & 2) at U.S. 72**  
**Marion Co.**

**Approach Delay, Levels of Service, and Queue Length**



S.R. 72 NB & SB

Left & Right Turns

|                |                      |      |                      |      |  |  |
|----------------|----------------------|------|----------------------|------|--|--|
| <b>2027 AM</b> | G                    | 36   | G                    | 8    |  |  |
|                | Y                    | 3    | Y                    | 3    |  |  |
|                | NB Q <sub>AVG</sub>  | 4.5  | LT. Q <sub>AVG</sub> | 1.2  |  |  |
|                | SB Q <sub>AVG</sub>  | 5.2  | RT. Q <sub>AVG</sub> | 2.2  |  |  |
|                | Q <sub>SPACING</sub> | 24.9 | Q <sub>SPACING</sub> | 24.9 |  |  |
|                | L <sub>NB REQ</sub>  | 112  | L <sub>LT REQ</sub>  | 30   |  |  |
|                | L <sub>SB REQ</sub>  | 129  | L <sub>RT REQ</sub>  | 55   |  |  |
|                | NB APP. DELAY=       | 4.8  | NB LOS=              | A    |  |  |
|                | SB APP. DELAY=       | 3.9  | SB LOS=              | A    |  |  |
|                | WB APP. DELAY=       | 27.2 | WB LOS=              | C    |  |  |

**INTERSECTION DELAY = 5.5 s/veh**

**INTERSECTION L.O.S.= A**

|                |                      |      |                      |      |  |  |
|----------------|----------------------|------|----------------------|------|--|--|
| <b>2027 PM</b> | G                    | 29   | G                    | 14   |  |  |
|                | Y                    | 3    | Y                    | 3    |  |  |
|                | NB Q <sub>AVG</sub>  | 10.6 | LT. Q <sub>AVG</sub> | 1.4  |  |  |
|                | SB Q <sub>AVG</sub>  | 13.8 | RT. Q <sub>AVG</sub> | 8    |  |  |
|                | Q <sub>SPACING</sub> | 24.9 | Q <sub>SPACING</sub> | 24.9 |  |  |
|                | L <sub>NB REQ</sub>  | 264  | L <sub>LT REQ</sub>  | 35   |  |  |
|                | L <sub>SB REQ</sub>  | 344  | L <sub>RT REQ</sub>  | 199  |  |  |
|                | NB APP. DELAY=       | 10.4 | NB LOS=              | B    |  |  |
|                | SB APP. DELAY=       | 12.6 | SB LOS=              | B    |  |  |
|                | WB APP. DELAY=       | 38.5 | WB LOS=              | D    |  |  |

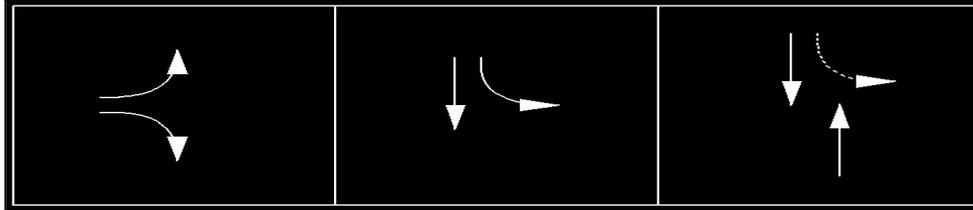
**INTERSECTION DELAY = 14.3 s/veh**

**INTERSECTION L.O.S.= B**

Note: Signal timing optimized using SOAP 2K with minimum green time of 8 s and yellow time of 3 s. It was assumed that 25% of the right turning vehicles from Prop. Ramp "A" can turn on red.

**Proposed Improvements**  
**Signal Data**  
**I-24 (Ramps 3 & 4) at U.S. 72**  
**Marion Co.**

**Approach Delay, Levels of Service, and Queue Length**



Ramp EB

S.R. 72 SB

S.R. 72 SB & NB

| 2007 AM | G                    | 12   | G                    | 8    | G                    | 82   |
|---------|----------------------|------|----------------------|------|----------------------|------|
|         | Y                    | 3    | Y                    | 3    | Y                    | 3    |
|         | LT. Q <sub>AVG</sub> | 2.2  | LT. Q <sub>AVG</sub> | 1.5  |                      |      |
|         | RT. Q <sub>AVG</sub> | 2.2  | SB Q <sub>AVG</sub>  | 5.7  | NB Q <sub>AVG</sub>  | 5    |
|         | Q <sub>SPACING</sub> | 24.9 | Q <sub>SPACING</sub> | 24.9 | Q <sub>SPACING</sub> | 24.9 |
|         | L <sub>LT REQ</sub>  | 55   | L <sub>LT REQ</sub>  | 37   |                      |      |
|         | L <sub>RT REQ</sub>  | 55   | L <sub>SB REQ</sub>  | 142  | L <sub>NB REQ</sub>  | 125  |
|         | APP. DELAY           | 51.7 | APP. DELAY           | 2.7  | APP. DELAY           | 5.2  |
|         | APP. L.O.S.          | D    | APP. L.O.S.          | A    | APP. L.O.S.          | A    |

**INTERSECTION DELAY = 6.5 s/veh**

**INTERSECTION L.O.S.= A**

| 2007 PM | G                    | 8    | G                    | 8    | G                    | 76   |
|---------|----------------------|------|----------------------|------|----------------------|------|
|         | Y                    | 3    | Y                    | 3    | Y                    | 3    |
|         | LT. Q <sub>AVG</sub> | 2.5  | LT. Q <sub>AVG</sub> | 2.3  |                      |      |
|         | RT. Q <sub>AVG</sub> | 1.3  | SB Q <sub>AVG</sub>  | 7.2  | NB Q <sub>AVG</sub>  | 6.4  |
|         | Q <sub>SPACING</sub> | 24.9 | Q <sub>SPACING</sub> | 24.9 | Q <sub>SPACING</sub> | 24.9 |
|         | L <sub>LT REQ</sub>  | 62   | L <sub>LT REQ</sub>  | 57   |                      |      |
|         | L <sub>RT REQ</sub>  | 32   | L <sub>SB REQ</sub>  | 179  | L <sub>NB REQ</sub>  | 159  |
|         | APP. DELAY           | 56.1 | APP. DELAY           | 2.7  | APP. DELAY           | 4.9  |
|         | APP. L.O.S.          | E    | APP. L.O.S.          | A    | APP. L.O.S.          | A    |

**INTERSECTION DELAY = 5.7 s/veh**

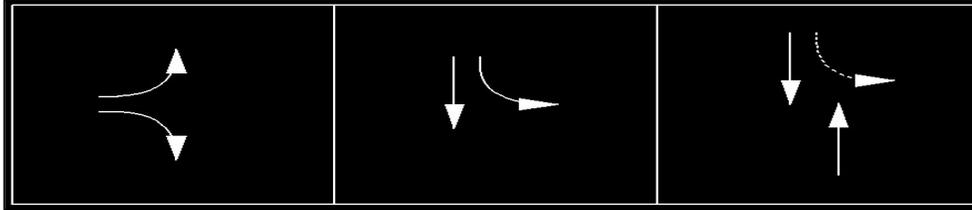
**INTERSECTION L.O.S.= A**

Note: Signal timing optimized using SOAP 2K with minimum green time of 8 s and yellow time of 3 s. Right turn from U.S. 72 NB to Ramp 4 taken out of signal calculations due to the large turning radius that will effectively remove the movement from the functionality of the signal.

**Proposed Improvements**

**Signal Data**  
**I-24 (Ramps 3 & 4) at U.S. 72**  
**Marion Co.**

**Approach Delay, Levels of Service, and Queue Length**



Ramp EB

S.R. 72 SB

S.R. 72 SB & NB

|                |                      |      |                      |      |                      |      |
|----------------|----------------------|------|----------------------|------|----------------------|------|
| <b>2027 AM</b> | G                    | 12   | G                    | 8    | G                    | 79   |
|                | Y                    | 3    | Y                    | 3    | Y                    | 3    |
|                | LT. Q <sub>AVG</sub> | 3.3  | LT. Q <sub>AVG</sub> | 3.8  |                      |      |
|                | RT. Q <sub>AVG</sub> | 4.0  | SB Q <sub>AVG</sub>  | 11.6 | NB Q <sub>AVG</sub>  | 8.8  |
|                | Q <sub>SPACING</sub> | 24.9 | Q <sub>SPACING</sub> | 24.9 | Q <sub>SPACING</sub> | 24.9 |
|                | L <sub>LT REQ</sub>  | 82   | L <sub>LT REQ</sub>  | 95   |                      |      |
|                | L <sub>RT REQ</sub>  | 100  | L <sub>SB REQ</sub>  | 289  | L <sub>NB REQ</sub>  | 219  |
|                | APP. DELAY           | 58.9 | APP. DELAY           | 4.9  | APP. DELAY           | 6.5  |
|                | APP. L.O.S.          | E    | APP. L.O.S.          | A    | APP. L.O.S.          | A    |

**INTERSECTION DELAY = 8.8 s/veh**

**INTERSECTION L.O.S.= A**

|                |                      |      |                      |      |                      |      |
|----------------|----------------------|------|----------------------|------|----------------------|------|
| <b>2027 PM</b> | G                    | 12   | G                    | 16   | G                    | 88   |
|                | Y                    | 3    | Y                    | 3    | Y                    | 3    |
|                | LT. Q <sub>AVG</sub> | 4.7  | LT. Q <sub>AVG</sub> | 8.8  |                      |      |
|                | RT. Q <sub>AVG</sub> | 3.1  | SB Q <sub>AVG</sub>  | 23.3 | NB Q <sub>AVG</sub>  | 18.3 |
|                | Q <sub>SPACING</sub> | 24.9 | Q <sub>SPACING</sub> | 24.9 | Q <sub>SPACING</sub> | 24.9 |
|                | L <sub>LT REQ</sub>  | 117  | L <sub>LT REQ</sub>  | 219  |                      |      |
|                | L <sub>RT REQ</sub>  | 77   | L <sub>SB REQ</sub>  | 580  | L <sub>NB REQ</sub>  | 456  |
|                | APP. DELAY           | 70.5 | APP. DELAY           | 11.3 | APP. DELAY           | 12.2 |
|                | APP. L.O.S.          | E    | APP. L.O.S.          | B    | APP. L.O.S.          | B    |

**INTERSECTION DELAY = 14.4 s/veh**

**INTERSECTION L.O.S.= B**

Note: Signal timing optimized using SOAP 2K with minimum green time of 8 s and yellow time of 3 s. Right turn from U.S. 72 NB to Ramp 4 taken out of signal calculations due to the large turning radius that will effectively remove the movement from the functionality of the signal.

# Highway Capacity Software Data

I-24 at U.S. 72  
Interchange Modification Study  
Marion County, Tennessee

# Existing System

## HCS Level of Service Calculations

### **I-24 Mainline (pp. HCS 6 – HCS 54)**

2007 AM

- Westbound Before Ramp 1
- Westbound Between Ramp 1 and Ramp 2
- Westbound After Ramp 2
- Eastbound Before Ramp 3
- Eastbound Between Ramp 3 and Ramp 4
- Eastbound After Ramp 4

2007 PM

- Westbound Before Ramp 1
- Westbound Between Ramp 1 and Ramp 2
- Westbound After Ramp 2
- Eastbound Before Ramp 3
- Eastbound Between Ramp 3 and Ramp 4
- Eastbound After Ramp 4

2027 AM

- Westbound Before Ramp 1
- Westbound Between Ramp 1 and Ramp 2
- Westbound After Ramp 2
- Eastbound Before Ramp 3
- Eastbound Between Ramp 3 and Ramp 4
- Eastbound After Ramp 4

2027 PM

- Westbound Before Ramp 1
- Westbound Between Ramp 1 and Ramp 2
- Westbound After Ramp 2
- Eastbound Before Ramp 3
- Eastbound Between Ramp 3 and Ramp 4
- Eastbound After Ramp 4

# Existing System

HCS Level of Service Calculations (continued)

## **I-24 Ramp Terminals (pp. HCS 55 – HCS 85)**

2007 AM

Ramp 1

Ramp 2

Ramp 3

Ramp 4

2007 PM

Ramp 1

Ramp 2

Ramp 3

Ramp 4

2027 AM

Ramp 1

Ramp 2

Ramp 3

Ramp 4

2027 PM

Ramp 1

Ramp 2

Ramp 3

Ramp 4

## **U.S. 72 at Ramps 1 and 2 (Signalized Intersection) (pp. HCS 86 – HCS 122)**

2007 AM

2007 PM

2027 AM

2027 PM

## **U.S. 72 at Ramps 3 and 4 (Stop Controlled Intersection) (pp. HCS 123 – HCS 155)**

2007 AM

2007 PM

2027 AM

2027 PM

# Proposed System

## HCS Level of Service Calculations

### **I-24 Mainline (pp. HCS 156 – HCS 164)**

(Note: These calculations include only those different from the Existing System.)

Between Proposed Ramp “A” and Ramp 1

2007 AM

2007 PM

2027 AM

2027 PM

### **I-24 Ramp Terminals (pp. HCS 165 – HCS 197)**

(Note: These calculations include only those different from the Existing System.)

2007 AM

Ramp 1

Ramp 2

Ramp 4

Proposed Ramp A

2007 PM

Ramp 1

Ramp 2

Ramp 4

Proposed Ramp A

2027 AM

Ramp 1

Ramp 2

Ramp 4

Proposed Ramp A

2027 PM

Ramp 1

Ramp 2

Ramp 4

Proposed Ramp A

### **U.S. 72 at Ramps “A” and 2 (Signalized Intersection) (pp. HCS 198 – HCS 234)**

2007 AM

2007 PM

2027 AM

2027 PM

# Proposed System

HCS Level of Service Calculations (Continued)

**U.S. 72 at Ramps 3 and 4 (Signalized Intersection) (pp. HCS 235 – HCS 271)**

2007 AM

2007 PM

2027 AM

2027 PM

# **I-24 Mainline**

Existing System

HCS2000: Basic Freeway Segments Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: AM Peak  
 Freeway/Direction: I-24 WB  
 From/To: Before Ramp 1  
 Jurisdiction: Marion Co.  
 Analysis Year: 2007  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 2740  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 761   | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 1697  | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 1697 | pc/h/ln |
|---------------|------|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 75.0 | mi/h     |
| Average passenger-car speed, S | 72.5 | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     | 23.4 | pc/mi/ln |
| Level of service, LOS          | C    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: AM Peak  
 Freeway/Direction: I-24 WB  
 From/To: Between Ramp 1 and Ramp 2  
 Jurisdiction: Marion Co.  
 Analysis Year: 2007  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 2148  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 597   | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 1331  | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 1331 | pc/h/ln |
|---------------|------|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 75.0 | mi/h     |
| Average passenger-car speed, S | 74.9 | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     | 17.8 | pc/mi/ln |
| Level of service, LOS          | B    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: AM Peak  
 Freeway/Direction: I-24 WB  
 From/To: After Ramp 2  
 Jurisdiction: Marion Co.  
 Analysis Year: 2007  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 2314  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 643   | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 1433  | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 1433 | pc/h/ln |
|---------------|------|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 75.0 | mi/h     |
| Average passenger-car speed, S | 74.5 | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     | 19.2 | pc/mi/ln |
| Level of service, LOS          | C    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: AM Peak  
 Freeway/Direction: I-24 EB  
 From/To: Before Ramp 3  
 Jurisdiction: Marion Co.  
 Analysis Year: 2007  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 1280  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 356   | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 793   | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |     |         |
|---------------|-----|---------|
| Flow rate, vp | 793 | pc/h/ln |
|---------------|-----|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 75.0 | mi/h     |
| Average passenger-car speed, S | 75.0 | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     | 10.6 | pc/mi/ln |
| Level of service, LOS          | A    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: AM Peak  
 Freeway/Direction: I-24 EB  
 From/To: Between Ramp 3 and Ramp 4  
 Jurisdiction: Marion Co.  
 Analysis Year: 2007  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 1133  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 315   | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 702   | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |     |         |
|---------------|-----|---------|
| Flow rate, vp | 702 | pc/h/ln |
|---------------|-----|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 75.0 | mi/h     |
| Average passenger-car speed, S | 75.0 | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     | 9.4  | pc/mi/ln |
| Level of service, LOS          | A    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: AM Peak  
 Freeway/Direction: I-24 EB  
 From/To: After Ramp 4  
 Jurisdiction: Marion Co.  
 Analysis Year: 2007  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 1840  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 511   | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 1140  | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 1140 | pc/h/ln |
|---------------|------|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 75.0 | mi/h     |
| Average passenger-car speed, S | 75.0 | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     | 15.2 | pc/mi/ln |
| Level of service, LOS          | B    |          |

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: PM Peak  
 Freeway/Direction: I-24 WB  
 From/To: Before Ramp 1  
 Jurisdiction: Marion Co.  
 Analysis Year: 2007  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 3464  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 962   | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 2146  | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 2146 | pc/h/ln |
|---------------|------|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 75.0 | mi/h     |
| Average passenger-car speed, S | 63.0 | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     | 34.1 | pc/mi/ln |
| Level of service, LOS          | D    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

---

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: PM Peak  
 Freeway/Direction: I-24 WB  
 From/To: Between Ramp 1 and Ramp 2  
 Jurisdiction: Marion Co.  
 Analysis Year: 2007  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

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|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 2587  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 719   | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 1603  | pc/h/ln |

Speed Inputs and Adjustments

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|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

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|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 1603 | pc/h/ln |
|---------------|------|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 75.0 | mi/h     |
| Average passenger-car speed, S | 73.5 | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     | 21.8 | pc/mi/ln |
| Level of service, LOS          | C    |          |

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: PM Peak  
 Freeway/Direction: I-24 WB  
 From/To: After Ramp 2  
 Jurisdiction: Marion Co.  
 Analysis Year: 2007  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 2798  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 777   | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 1733  | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 1733 | pc/h/ln |
|---------------|------|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 75.0 | mi/h     |
| Average passenger-car speed, S | 72.0 | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     | 24.1 | pc/mi/ln |
| Level of service, LOS          | C    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: PM Peak  
 Freeway/Direction: I-24 EB  
 From/To: Before Ramp 3  
 Jurisdiction: Marion Co.  
 Analysis Year: 2007  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 1442  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 401   | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 893   | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |     |         |
|---------------|-----|---------|
| Flow rate, vp | 893 | pc/h/ln |
|---------------|-----|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 75.0 | mi/h     |
| Average passenger-car speed, S | 75.0 | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     | 11.9 | pc/mi/ln |
| Level of service, LOS          | B    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: PM Peak  
 Freeway/Direction: I-24 EB  
 From/To: Between Ramp 3 and Ramp 4  
 Jurisdiction: Marion Co.  
 Analysis Year: 2007  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 1308  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 363   | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 810   | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |     |         |
|---------------|-----|---------|
| Flow rate, vp | 810 | pc/h/ln |
|---------------|-----|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 75.0 | mi/h     |
| Average passenger-car speed, S | 75.0 | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     | 10.8 | pc/mi/ln |
| Level of service, LOS          | A    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: PM Peak  
 Freeway/Direction: I-24 EB  
 From/To: After Ramp 4  
 Jurisdiction: Marion Co.  
 Analysis Year: 2007  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 2096  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 582   | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 1298  | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 1298 | pc/h/ln |
|---------------|------|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 75.0 | mi/h     |
| Average passenger-car speed, S | 74.9 | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     | 17.3 | pc/mi/ln |
| Level of service, LOS          | B    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: AM Peak  
 Freeway/Direction: I-24 WB  
 From/To: Before Ramp 1  
 Jurisdiction: Marion Co.  
 Analysis Year: 2027  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 4459  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 1239  | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 2762  | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 2762 | pc/h/ln |
|---------------|------|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 75.0 | mi/h     |
| Average passenger-car speed, S |      | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     |      | pc/mi/ln |
| Level of service, LOS          | F    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: AM Peak  
 Freeway/Direction: I-24 WB  
 From/To: Between Ramp 1 and Ramp 2  
 Jurisdiction: Marion Co.  
 Analysis Year: 2027  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 3570  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 992   | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 2211  | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 2211 | pc/h/ln |
|---------------|------|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 75.0 | mi/h     |
| Average passenger-car speed, S | 60.9 | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     | 36.3 | pc/mi/ln |
| Level of service, LOS          | E    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: AM Peak  
 Freeway/Direction: I-24 WB  
 From/To: After Ramp 2  
 Jurisdiction: Marion Co.  
 Analysis Year: 2027  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 3819  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 1061  | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 2366  | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 2366 | pc/h/ln |
|---------------|------|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 75.0 | mi/h     |
| Average passenger-car speed, S | 54.8 | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     | 43.1 | pc/mi/ln |
| Level of service, LOS          | E    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: AM Peak  
 Freeway/Direction: I-24 EB  
 From/To: Before Ramp 3  
 Jurisdiction: Marion Co.  
 Analysis Year: 2027  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 2112  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 587   | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 1308  | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 1308 | pc/h/ln |
|---------------|------|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 75.0 | mi/h     |
| Average passenger-car speed, S | 74.9 | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     | 17.5 | pc/mi/ln |
| Level of service, LOS          | B    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: AM Peak  
 Freeway/Direction: I-24 EB  
 From/To: Between Ramp 3 and Ramp 4  
 Jurisdiction: Marion Co.  
 Analysis Year: 2027  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 1891  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 525   | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 1171  | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 1171 | pc/h/ln |
|---------------|------|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 75.0 | mi/h     |
| Average passenger-car speed, S | 75.0 | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     | 15.6 | pc/mi/ln |
| Level of service, LOS          | B    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-mail: jstorey@flohut.com

Fax: (615) 399-9049

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: AM Peak  
 Freeway/Direction: I-24 EB  
 From/To: After Ramp 4  
 Jurisdiction: Marion Co.  
 Analysis Year: 2027  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 2952  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 820   | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 1829  | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 1829 | pc/h/ln |
|---------------|------|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 75.0 | mi/h     |
| Average passenger-car speed, S | 70.6 | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     | 25.9 | pc/mi/ln |
| Level of service, LOS          | C    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

---

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: PM Peak  
 Freeway/Direction: I-24 WB  
 From/To: Before Ramp 1  
 Jurisdiction: Marion Co.  
 Analysis Year: 2027  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

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|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 5613  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 1559  | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 3477  | pc/h/ln |

Speed Inputs and Adjustments

---

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

---

|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 3477 | pc/h/ln |
|---------------|------|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 75.0 | mi/h     |
| Average passenger-car speed, S |      | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     |      | pc/mi/ln |
| Level of service, LOS          | F    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: PM Peak  
 Freeway/Direction: I-24 WB  
 From/To: Between Ramp 1 and Ramp 2  
 Jurisdiction: Marion Co.  
 Analysis Year: 2027  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 4299  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 1194  | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 2663  | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 2663 | pc/h/ln |
|---------------|------|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 75.0 | mi/h     |
| Average passenger-car speed, S |      | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     |      | pc/mi/ln |
| Level of service, LOS          | F    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: PM Peak  
 Freeway/Direction: I-24 WB  
 From/To: After Ramp 2  
 Jurisdiction: Marion Co.  
 Analysis Year: 2027  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 4615  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 1282  | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 2859  | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 2859 | pc/h/ln |
|---------------|------|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 75.0 | mi/h     |
| Average passenger-car speed, S |      | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     |      | pc/mi/ln |
| Level of service, LOS          | F    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

---

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: PM Peak  
 Freeway/Direction: I-24 EB  
 From/To: Before Ramp 3  
 Jurisdiction: Marion Co.  
 Analysis Year: 2027  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

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|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 2380  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 661   | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 1474  | pc/h/ln |

Speed Inputs and Adjustments

---

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

---

|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 1474 | pc/h/ln |
|---------------|------|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 75.0 | mi/h     |
| Average passenger-car speed, S | 74.4 | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     | 19.8 | pc/mi/ln |
| Level of service, LOS          | C    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: PM Peak  
 Freeway/Direction: I-24 EB  
 From/To: Between Ramp 3 and Ramp 4  
 Jurisdiction: Marion Co.  
 Analysis Year: 2027  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 2178  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 605   | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 1349  | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 1349 | pc/h/ln |
|---------------|------|---------|

|                                |       |          |
|--------------------------------|-------|----------|
| Free-flow speed, FFS           | 75.0  | mi/h     |
| Average passenger-car speed, S | 74.8  | mi/h     |
| Number of lanes, N             | 2     |          |
| Density, D                     | 18.0+ | pc/mi/ln |
| Level of service, LOS          | C     |          |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 5/29/2002  
 Analysis Time Period: PM Peak  
 Freeway/Direction: I-24 EB  
 From/To: After Ramp 4  
 Jurisdiction: Marion Co.  
 Analysis Year: 2027  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 3360  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 933   | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 2081  | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 75.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 75.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 2081 | pc/h/ln |
|---------------|------|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 75.0 | mi/h     |
| Average passenger-car speed, S | 64.9 | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     | 32.1 | pc/mi/ln |
| Level of service, LOS          | D    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

# I-24 Ramp Terminals

Existing System

HCS2000: Ramps and Ramp Junctions Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Diverge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/3/2002  
 Analysis time period: 2007 AM  
 Freeway/dir or travel: I-24 Westbound  
 Junction: I-24 WB to US 72  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |         |     |
|----------------------------|---------|-----|
| Type of analysis           | Diverge |     |
| Number of lanes in freeway | 2       |     |
| Free-flow speed on freeway | 70.0    | mph |
| Volume on freeway          | 2740    | vph |

Off Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-Flow speed on ramp           | 35.0  | mph |
| Volume on ramp                    | 592   | vph |
| Length of first accel/decel lane  | 525   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |            |     |
|---------------------------|------------|-----|
| Does adjacent ramp exist? | Yes        |     |
| Volume on adjacent ramp   | 166        | vph |
| Position of adjacent ramp | Downstream |     |
| Type of adjacent ramp     | On         |     |
| Distance to adjacent ramp | 900        | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 2740    | 592   | 166           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 761     | 164   | 46            | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

|                               |       |    |       |    |       |      |
|-------------------------------|-------|----|-------|----|-------|------|
| Grade                         | 0.00  | %  | 0.00  | %  | 0.00  | %    |
| Length                        | 0.00  | mi | 0.00  | mi | 0.00  | mi   |
| Trucks and buses PCE, ET      | 1.5   |    | 1.5   |    | 1.5   |      |
| Recreational vehicle PCE, ER  | 1.2   |    | 1.2   |    | 1.2   |      |
| Heavy vehicle adjustment, fHV | 0.897 |    | 0.966 |    | 0.966 |      |
| Driver population factor, fP  | 1.00  |    | 1.00  |    | 1.00  |      |
| Flow rate, vp                 | 3395  |    | 681   |    | 191   | pcph |

---

Estimation of V12 Diverge Areas

---

L = 0.00 (Equation 25-8 or 25-9)  
EQ  
P = 1.000 Using Equation 0  
FD  
 $v_{12} = v_R + (v_F - v_R) P = 3395$  pc/h

---

Capacity Checks

---

|                      | Actual | Maximum | LOS F? |
|----------------------|--------|---------|--------|
| $v_{Fi} = v_F$       | 3395   | 4800    | No     |
| $v_{12}$             | 3395   | 4400    | No     |
| $v_{FO} = v_F - v_R$ | 2714   | 4800    | No     |
| $v_R$                | 681    | 2000    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v_{12} - 0.009 D = 28.7$  pc/mi/ln  
Level of service for ramp-freeway junction areas of influence D

---

Speed Estimation

---

|  |           |     |
|--|-----------|-----|
| Intermediate speed variable,             | D = 0.489 |     |
| Space mean speed in ramp influence area, | S = 56    | mph |
| Space mean speed in outer lanes,         | S = N/A   | mph |
| Space mean speed for all vehicles,       | S = 56.3  | mph |

---

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-mail: jstorey@flohut.com

Fax: (615) 399-9049

Merge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/3/2002  
 Analysis time period: 2007 AM  
 Freeway/dir or travel: I-24 Westbound  
 Junction: US 72 to I-24 Westbound  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |       |     |
|----------------------------|-------|-----|
| Type of analysis           | Merge |     |
| Number of lanes in freeway | 2     |     |
| Free-flow speed on freeway | 70.0  | mph |
| Volume on freeway          | 2148  | vph |

On Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-flow speed on ramp           | 45.0  | mph |
| Volume on ramp                    | 166   | vph |
| Length of first accel/decel lane  | 500   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |            |     |
|---------------------------|------------|-----|
| Does adjacent ramp exist? | Yes        |     |
| Volume on adjacent Ramp   | 592        | vph |
| Position of adjacent Ramp | Downstream |     |
| Type of adjacent Ramp     | Off        |     |
| Distance to adjacent Ramp | 900        | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 2148    | 166   | 592           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 597     | 46    | 164           | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

| Grade Length                  |       | %<br>mi | %<br>mi | %<br>mi |
|-------------------------------|-------|---------|---------|---------|
| Trucks and buses PCE, ET      | 1.5   | 1.5     | 1.5     |         |
| Recreational vehicle PCE, ER  | 1.2   | 1.2     | 1.2     |         |
| Heavy vehicle adjustment, fHV | 0.897 | 0.966   | 0.966   |         |
| Driver population factor, fP  | 1.00  | 1.00    | 1.00    |         |
| Flow rate, vp                 | 2661  | 191     | 681     | pcph    |

---

Estimation of V12 Merge Areas

---

$L = 0.00$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 1.000$  Using Equation 0  
 FM  
 $v_{12} = v_F (P_{FM}) = 2661$  pc/h

---

Capacity Checks

---

|                  | Actual | Maximum | LOS F? |
|------------------|--------|---------|--------|
| v <sub>FO</sub>  | 2852   | 4800    | No     |
| v <sub>R12</sub> | 2852   | 4600    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A = 24.5$  pc/mi/ln  
 Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

|  |               |     |
|--|---------------|-----|
| Intermediate speed variable,             | $M_S = 0.344$ |     |
| Space mean speed in ramp influence area, | $S_R = 60.4$  | mph |
| Space mean speed in outer lanes,         | $S_0 = N/A$   | mph |
| Space mean speed for all vehicles,       | $S = 60.4$    | mph |

---

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-mail: jstorey@flohut.com

Fax: (615) 399-9049

Diverge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/3/2002  
 Analysis time period: 2007 AM  
 Freeway/dir or travel: I-24 Eastbound  
 Junction: I-24 EB to US 72  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |         |     |
|----------------------------|---------|-----|
| Type of analysis           | Diverge |     |
| Number of lanes in freeway | 2       |     |
| Free-flow speed on freeway | 70.0    | mph |
| Volume on freeway          | 1280    | vph |

Off Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-Flow speed on ramp           | 45.0  | mph |
| Volume on ramp                    | 147   | vph |
| Length of first accel/decel lane  | 200   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |            |     |
|---------------------------|------------|-----|
| Does adjacent ramp exist? | Yes        |     |
| Volume on adjacent ramp   | 707        | vph |
| Position of adjacent ramp | Downstream |     |
| Type of adjacent ramp     | On         |     |
| Distance to adjacent ramp | 1600       | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 1280    | 147   | 707           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 356     | 41    | 196           | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

|                               |       |    |       |    |       |      |
|-------------------------------|-------|----|-------|----|-------|------|
| Grade                         | 0.00  | %  | 0.00  | %  | 0.00  | %    |
| Length                        | 0.00  | mi | 0.00  | mi | 0.00  | mi   |
| Trucks and buses PCE, ET      | 1.5   |    | 1.5   |    | 1.5   |      |
| Recreational vehicle PCE, ER  | 1.2   |    | 1.2   |    | 1.2   |      |
| Heavy vehicle adjustment, fHV | 0.897 |    | 0.966 |    | 0.966 |      |
| Driver population factor, fP  | 1.00  |    | 1.00  |    | 1.00  |      |
| Flow rate, vp                 | 1586  |    | 169   |    | 813   | pcph |

---

Estimation of V12 Diverge Areas

---

L = 0.00 (Equation 25-8 or 25-9)  
EQ  
P = 1.000 Using Equation 0  
FD  
 $v_{12} = v_R + (v_F - v_R) P = 1586$  pc/h

---

Capacity Checks

---

|                      | Actual | Maximum | LOS F? |
|----------------------|--------|---------|--------|
| $v_{Fi} = v_F$       | 1586   | 4800    | No     |
| $v_{12}$             | 1586   | 4400    | No     |
| $v_{FO} = v_F - v_R$ | 1417   | 4800    | No     |
| $v_R$                | 169    | 2100    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v_{12} - 0.009 D = 16.1$  pc/mi/ln  
Level of service for ramp-freeway junction areas of influence B

---

Speed Estimation

---

|  |           |     |
|--|-----------|-----|
| Intermediate speed variable,             | D = 0.313 |     |
| Space mean speed in ramp influence area, | S = 61    | mph |
| Space mean speed in outer lanes,         | S = N/A   | mph |
| Space mean speed for all vehicles,       | S = 61.2  | mph |

---

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Merge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/3/2002  
 Analysis time period: 2007 AM  
 Freeway/dir or travel: I-24 Eastbound  
 Junction: US 72 to I-24 Eastbound  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |       |     |
|----------------------------|-------|-----|
| Type of analysis           | Merge |     |
| Number of lanes in freeway | 2     |     |
| Free-flow speed on freeway | 70.0  | mph |
| Volume on freeway          | 1133  | vph |

On Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-flow speed on ramp           | 50.0  | mph |
| Volume on ramp                    | 707   | vph |
| Length of first accel/decel lane  | 610   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |          |     |
|---------------------------|----------|-----|
| Does adjacent ramp exist? | Yes      |     |
| Volume on adjacent Ramp   | 147      | vph |
| Position of adjacent Ramp | Upstream |     |
| Type of adjacent Ramp     | Off      |     |
| Distance to adjacent Ramp | 1600     | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 1133    | 707   | 147           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 315     | 196   | 41            | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

| Grade Length                  |  | %<br>mi | %<br>mi | %<br>mi |
|-------------------------------|--|---------|---------|---------|
| Trucks and buses PCE, ET      |  | 1.5     | 1.5     | 1.5     |
| Recreational vehicle PCE, ER  |  | 1.2     | 1.2     | 1.2     |
| Heavy vehicle adjustment, fHV |  | 0.897   | 0.966   | 0.966   |
| Driver population factor, fP  |  | 1.00    | 1.00    | 1.00    |
| Flow rate, vp                 |  | 1404    | 813     | 169     |

---

Estimation of V12 Merge Areas

---

$L = 0.00$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 1.000$  Using Equation 0  
 FM  
 $v_{12} = v_F (P_{FM}) = 1404$  pc/h

---

Capacity Checks

---

|                  | Actual | Maximum | LOS F? |
|------------------|--------|---------|--------|
| v <sub>FO</sub>  | 2217   | 4800    | No     |
| v <sub>R12</sub> | 2217   | 4600    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A = 18.6$  pc/mi/ln  
 Level of service for ramp-freeway junction areas of influence B

---

Speed Estimation

---

|  |                  |
|--|------------------|
| Intermediate speed variable,             | $M_S = 0.296$    |
| Space mean speed in ramp influence area, | $S_R = 61.7$ mph |
| Space mean speed in outer lanes,         | $S_0 = N/A$ mph  |
| Space mean speed for all vehicles,       | $S = 61.7$ mph   |

---

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-mail: jstorey@flohut.com

Fax: (615) 399-9049

Diverge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/3/2002  
 Analysis time period: 2007 PM  
 Freeway/dir or travel: I-24 Westbound  
 Junction: I-24 WB to US 72  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |         |     |
|----------------------------|---------|-----|
| Type of analysis           | Diverge |     |
| Number of lanes in freeway | 2       |     |
| Free-flow speed on freeway | 70.0    | mph |
| Volume on freeway          | 3464    | vph |

Off Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-Flow speed on ramp           | 35.0  | mph |
| Volume on ramp                    | 877   | vph |
| Length of first accel/decel lane  | 525   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |            |     |
|---------------------------|------------|-----|
| Does adjacent ramp exist? | Yes        |     |
| Volume on adjacent ramp   | 211        | vph |
| Position of adjacent ramp | Downstream |     |
| Type of adjacent ramp     | On         |     |
| Distance to adjacent ramp | 900        | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 3464    | 877   | 211           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 962     | 244   | 59            | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

|                               |       |    |       |    |       |      |
|-------------------------------|-------|----|-------|----|-------|------|
| Grade                         | 0.00  | %  | 0.00  | %  | 0.00  | %    |
| Length                        | 0.00  | mi | 0.00  | mi | 0.00  | mi   |
| Trucks and buses PCE, ET      | 1.5   |    | 1.5   |    | 1.5   |      |
| Recreational vehicle PCE, ER  | 1.2   |    | 1.2   |    | 1.2   |      |
| Heavy vehicle adjustment, fHV | 0.897 |    | 0.966 |    | 0.966 |      |
| Driver population factor, fP  | 1.00  |    | 1.00  |    | 1.00  |      |
| Flow rate, vp                 | 4292  |    | 1009  |    | 243   | pcph |

---

Estimation of V12 Diverge Areas

---

$L = 0.00$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 1.000$  Using Equation 0  
 FD  
 $v_{12} = v_R + (v_F - v_R) P = 4292$  pc/h  
 FD

---

Capacity Checks

---

|                      | Actual | Maximum | LOS F? |
|----------------------|--------|---------|--------|
| $v_{12} = v_{12}$    | 4292   | 4800    | No     |
| $v_{12}$             | 4292   | 4400    | No     |
| $v_{FO} = v_F - v_R$ | 3283   | 4800    | No     |
| $v_R$                | 1009   | 2000    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v_{12} - 0.009 D = 36.4$  pc/mi/ln  
 Level of service for ramp-freeway junction areas of influence E

---

Speed Estimation

---

|  |             |     |
|--|-------------|-----|
| Intermediate speed variable,             | $D = 0.519$ |     |
| Space mean speed in ramp influence area, | $S = 55$    | mph |
| Space mean speed in outer lanes,         | $S = N/A$   | mph |
| Space mean speed for all vehicles,       | $S = 55.5$  | mph |

---

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-mail: jstorey@flohut.com

Fax: (615) 399-9049

Merge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/3/2002  
 Analysis time period: 2007 PM  
 Freeway/dir or travel: I-24 Westbound  
 Junction: US 72 to I-24 Westbound  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |       |     |
|----------------------------|-------|-----|
| Type of analysis           | Merge |     |
| Number of lanes in freeway | 2     |     |
| Free-flow speed on freeway | 70.0  | mph |
| Volume on freeway          | 2587  | vph |

On Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-flow speed on ramp           | 45.0  | mph |
| Volume on ramp                    | 211   | vph |
| Length of first accel/decel lane  | 500   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |            |     |
|---------------------------|------------|-----|
| Does adjacent ramp exist? | Yes        |     |
| Volume on adjacent Ramp   | 877        | vph |
| Position of adjacent Ramp | Downstream |     |
| Type of adjacent Ramp     | Off        |     |
| Distance to adjacent Ramp | 900        | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 2587    | 211   | 877           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 719     | 59    | 244           | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

| Grade Length                  |  | %<br>mi | %<br>mi | %<br>mi   |
|-------------------------------|--|---------|---------|-----------|
| Trucks and buses PCE, ET      |  | 1.5     | 1.5     | 1.5       |
| Recreational vehicle PCE, ER  |  | 1.2     | 1.2     | 1.2       |
| Heavy vehicle adjustment, fHV |  | 0.897   | 0.966   | 0.966     |
| Driver population factor, fP  |  | 1.00    | 1.00    | 1.00      |
| Flow rate, vp                 |  | 3205    | 243     | 1009 pcph |

---

Estimation of V12 Merge Areas

---

L = 0.00 (Equation 25-2 or 25-3)  
EQ  
P = 1.000 Using Equation 0  
FM  
 $v_{12} = v_F (P_{FM}) = 3205 \text{ pc/h}$

---

Capacity Checks

---

|                  | Actual | Maximum | LOS F? |
|------------------|--------|---------|--------|
| v <sub>FO</sub>  | 3448   | 4800    | No     |
| v <sub>R12</sub> | 3448   | 4600    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A = 29.1 \text{ pc/mi/ln}$   
Level of service for ramp-freeway junction areas of influence D

---

Speed Estimation

---

|  |                       |     |
|--|-----------------------|-----|
| Intermediate speed variable,             | M = 0.399             |     |
| Space mean speed in ramp influence area, | S <sub>R</sub> = 58.8 | mph |
| Space mean speed in outer lanes,         | S <sub>O</sub> = N/A  | mph |
| Space mean speed for all vehicles,       | S = 58.8              | mph |

---

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-mail: jstorey@flohut.com

Fax: (615) 399-9049

Diverge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/3/2002  
 Analysis time period: 2007 PM  
 Freeway/dir or travel: I-24 Eastbound  
 Junction: I-24 EB to US 72  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |         |     |
|----------------------------|---------|-----|
| Type of analysis           | Diverge |     |
| Number of lanes in freeway | 2       |     |
| Free-flow speed on freeway | 70.0    | mph |
| Volume on freeway          | 1442    | vph |

Off Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-Flow speed on ramp           | 45.0  | mph |
| Volume on ramp                    | 134   | vph |
| Length of first accel/decel lane  | 200   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |            |     |
|---------------------------|------------|-----|
| Does adjacent ramp exist? | Yes        |     |
| Volume on adjacent ramp   | 788        | vph |
| Position of adjacent ramp | Downstream |     |
| Type of adjacent ramp     | On         |     |
| Distance to adjacent ramp | 1600       | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 1442    | 134   | 788           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 401     | 37    | 219           | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

|                               |       |    |       |    |       |      |
|-------------------------------|-------|----|-------|----|-------|------|
| Grade                         | 0.00  | %  | 0.00  | %  | 0.00  | %    |
| Length                        | 0.00  | mi | 0.00  | mi | 0.00  | mi   |
| Trucks and buses PCE, ET      | 1.5   |    | 1.5   |    | 1.5   |      |
| Recreational vehicle PCE, ER  | 1.2   |    | 1.2   |    | 1.2   |      |
| Heavy vehicle adjustment, fHV | 0.897 |    | 0.966 |    | 0.966 |      |
| Driver population factor, fP  | 1.00  |    | 1.00  |    | 1.00  |      |
| Flow rate, vp                 | 1786  |    | 154   |    | 906   | pcph |

---

Estimation of V12 Diverge Areas

---

L = 0.00 (Equation 25-8 or 25-9)  
EQ  
P = 1.000 Using Equation 0  
FD  
 $v_{12} = v_R + (v_F - v_R) P = 1786$  pc/h

---

Capacity Checks

---

|                      | Actual | Maximum | LOS F? |
|----------------------|--------|---------|--------|
| $v_{Fi} = v_F$       | 1786   | 4800    | No     |
| $v_{12}$             | 1786   | 4400    | No     |
| $v_{FO} = v_F - v_R$ | 1632   | 4800    | No     |
| $v_R$                | 154    | 2100    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v_{12} - 0.009 D = 17.8$  pc/mi/ln  
Level of service for ramp-freeway junction areas of influence B

---

Speed Estimation

---

|  |           |     |
|--|-----------|-----|
| Intermediate speed variable,             | D = 0.312 |     |
| Space mean speed in ramp influence area, | S = 61    | mph |
| Space mean speed in outer lanes,         | S = N/A   | mph |
| Space mean speed for all vehicles,       | S = 61.3  | mph |

---

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-mail: jstorey@flohut.com

Fax: (615) 399-9049

Merge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/3/2002  
 Analysis time period: 2007 PM  
 Freeway/dir or travel: I-24 Eastbound  
 Junction: US 72 to I-24 Eastbound  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |       |     |
|----------------------------|-------|-----|
| Type of analysis           | Merge |     |
| Number of lanes in freeway | 2     |     |
| Free-flow speed on freeway | 70.0  | mph |
| Volume on freeway          | 1308  | vph |

On Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-flow speed on ramp           | 50.0  | mph |
| Volume on ramp                    | 788   | vph |
| Length of first accel/decel lane  | 610   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |          |     |
|---------------------------|----------|-----|
| Does adjacent ramp exist? | Yes      |     |
| Volume on adjacent Ramp   | 134      | vph |
| Position of adjacent Ramp | Upstream |     |
| Type of adjacent Ramp     | Off      |     |
| Distance to adjacent Ramp | 1600     | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 1308    | 788   | 134           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 363     | 219   | 37            | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

| Grade Length                  |  | %<br>mi | %<br>mi | %<br>mi |
|-------------------------------|--|---------|---------|---------|
| Trucks and buses PCE, ET      |  | 1.5     | 1.5     | 1.5     |
| Recreational vehicle PCE, ER  |  | 1.2     | 1.2     | 1.2     |
| Heavy vehicle adjustment, fHV |  | 0.897   | 0.966   | 0.966   |
| Driver population factor, fP  |  | 1.00    | 1.00    | 1.00    |
| Flow rate, vp                 |  | 1620    | 906     | 154     |

---

Estimation of V12 Merge Areas

---

$L = 0.00$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 1.000$  Using Equation 0  
 FM  
 $v_{12} = v_F (P_{FM}) = 1620$  pc/h

---

Capacity Checks

---

|                  | Actual | Maximum | LOS F? |
|------------------|--------|---------|--------|
| v <sub>FO</sub>  | 2526   | 4800    | No     |
| v <sub>R12</sub> | 2526   | 4600    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A = 20.9$  pc/mi/ln  
 Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

|  |                  |
|--|------------------|
| Intermediate speed variable,             | $M_S = 0.309$    |
| Space mean speed in ramp influence area, | $S_R = 61.4$ mph |
| Space mean speed in outer lanes,         | $S_O = N/A$ mph  |
| Space mean speed for all vehicles,       | $S = 61.4$ mph   |

---

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Diverge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/3/2002  
 Analysis time period: 2027 AM  
 Freeway/dir or travel: I-24 Westbound  
 Junction: I-24 WB to US 72  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |         |     |
|----------------------------|---------|-----|
| Type of analysis           | Diverge |     |
| Number of lanes in freeway | 2       |     |
| Free-flow speed on freeway | 70.0    | mph |
| Volume on freeway          | 4459    | vph |

Off Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-Flow speed on ramp           | 35.0  | mph |
| Volume on ramp                    | 889   | vph |
| Length of first accel/decel lane  | 525   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |            |     |
|---------------------------|------------|-----|
| Does adjacent ramp exist? | Yes        |     |
| Volume on adjacent ramp   | 249        | vph |
| Position of adjacent ramp | Downstream |     |
| Type of adjacent ramp     | On         |     |
| Distance to adjacent ramp | 900        | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 4459    | 889   | 249           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 1239    | 247   | 69            | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

|                               |       |    |       |    |       |      |
|-------------------------------|-------|----|-------|----|-------|------|
| Grade                         | 0.00  | %  | 0.00  | %  | 0.00  | %    |
| Length                        | 0.00  | mi | 0.00  | mi | 0.00  | mi   |
| Trucks and buses PCE, ET      | 1.5   |    | 1.5   |    | 1.5   |      |
| Recreational vehicle PCE, ER  | 1.2   |    | 1.2   |    | 1.2   |      |
| Heavy vehicle adjustment, fHV | 0.897 |    | 0.966 |    | 0.966 |      |
| Driver population factor, fP  | 1.00  |    | 1.00  |    | 1.00  |      |
| Flow rate, vp                 | 5524  |    | 1022  |    | 286   | pcph |

---

Estimation of V12 Diverge Areas

---

$L = 0.00$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 1.000$  Using Equation 0  
 FD  
 $v_{12} = v_R + (v_F - v_R) P = 5524$  pc/h  
 FD

---

Capacity Checks

---

|                      | Actual | Maximum | LOS F? |
|----------------------|--------|---------|--------|
| $v_{12} = v_{Fi}$    | 5524   | 4800    | Yes    |
| $v_{12}$             | 5524   | 4400    | Yes    |
| $v_{FO} = v_F - v_R$ | 4502   | 4800    | No     |
| $v_R$                | 1022   | 2000    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v_{12} - 0.009 L_D = 47.0$  pc/mi/ln  
 Level of service for ramp-freeway junction areas of influence F

---

Speed Estimation

---

|  |             |     |
|--|-------------|-----|
| Intermediate speed variable,             | $D = 0.520$ |     |
| Space mean speed in ramp influence area, | $S = 55$    | mph |
| Space mean speed in outer lanes,         | $S = N/A$   | mph |
| Space mean speed for all vehicles,       | $S = 55.4$  | mph |

---

HCS2000: Ramps and Ramp Junctions Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Merge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/3/2002  
 Analysis time period: 2027 AM  
 Freeway/dir or travel: I-24 Westbound  
 Junction: US 72 to I-24 Westbound  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |       |     |
|----------------------------|-------|-----|
| Type of analysis           | Merge |     |
| Number of lanes in freeway | 2     |     |
| Free-flow speed on freeway | 70.0  | mph |
| Volume on freeway          | 3570  | vph |

On Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-flow speed on ramp           | 45.0  | mph |
| Volume on ramp                    | 249   | vph |
| Length of first accel/decel lane  | 500   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |            |     |
|---------------------------|------------|-----|
| Does adjacent ramp exist? | Yes        |     |
| Volume on adjacent Ramp   | 889        | vph |
| Position of adjacent Ramp | Downstream |     |
| Type of adjacent Ramp     | Off        |     |
| Distance to adjacent Ramp | 900        | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 3570    | 249   | 889           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 992     | 69    | 247           | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

| Grade Length                  |  | %<br>mi | %<br>mi | %<br>mi   |
|-------------------------------|--|---------|---------|-----------|
| Trucks and buses PCE, ET      |  | 1.5     | 1.5     | 1.5       |
| Recreational vehicle PCE, ER  |  | 1.2     | 1.2     | 1.2       |
| Heavy vehicle adjustment, fHV |  | 0.897   | 0.966   | 0.966     |
| Driver population factor, fP  |  | 1.00    | 1.00    | 1.00      |
| Flow rate, vp                 |  | 4423    | 286     | 1022 pcph |

---

Estimation of V12 Merge Areas

---

L = 0.00 (Equation 25-2 or 25-3)  
EQ  
P = 1.000 Using Equation 0  
FM  
 $v_{12} = v_F (P_{FM}) = 4423 \text{ pc/h}$

---

Capacity Checks

---

|                  | Actual | Maximum | LOS F? |
|------------------|--------|---------|--------|
| v <sub>FO</sub>  | 4709   | 4800    | No     |
| v <sub>R12</sub> | 4709   | 4600    | Yes    |

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A = 38.9 \text{ pc/mi/ln}$   
Level of service for ramp-freeway junction areas of influence F

---

Speed Estimation

---

|  |                       |     |
|--|-----------------------|-----|
| Intermediate speed variable,             | M = 0.709             |     |
| Space mean speed in ramp influence area, | S <sub>R</sub> = 50.2 | mph |
| Space mean speed in outer lanes,         | S <sub>O</sub> = N/A  | mph |
| Space mean speed for all vehicles,       | S = 50.2              | mph |

---

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-mail: jstorey@flohut.com

Fax: (615) 399-9049

Diverge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/3/2002  
 Analysis time period: 2027 AM  
 Freeway/dir or travel: I-24 Eastbound  
 Junction: I-24 EB to US 72  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |         |     |
|----------------------------|---------|-----|
| Type of analysis           | Diverge |     |
| Number of lanes in freeway | 2       |     |
| Free-flow speed on freeway | 70.0    | mph |
| Volume on freeway          | 2112    | vph |

Off Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-Flow speed on ramp           | 45.0  | mph |
| Volume on ramp                    | 221   | vph |
| Length of first accel/decel lane  | 200   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |            |     |
|---------------------------|------------|-----|
| Does adjacent ramp exist? | Yes        |     |
| Volume on adjacent ramp   | 1061       | vph |
| Position of adjacent ramp | Downstream |     |
| Type of adjacent ramp     | On         |     |
| Distance to adjacent ramp | 1600       | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 2112    | 221   | 1061          | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 587     | 61    | 295           | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

|                               |       |    |       |    |       |      |
|-------------------------------|-------|----|-------|----|-------|------|
| Grade                         | 0.00  | %  | 0.00  | %  | 0.00  | %    |
| Length                        | 0.00  | mi | 0.00  | mi | 0.00  | mi   |
| Trucks and buses PCE, ET      | 1.5   |    | 1.5   |    | 1.5   |      |
| Recreational vehicle PCE, ER  | 1.2   |    | 1.2   |    | 1.2   |      |
| Heavy vehicle adjustment, fHV | 0.897 |    | 0.966 |    | 0.966 |      |
| Driver population factor, fP  | 1.00  |    | 1.00  |    | 1.00  |      |
| Flow rate, vp                 | 2617  |    | 254   |    | 1220  | pcph |

---

Estimation of V12 Diverge Areas

---

$L = 0.00$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 1.000$  Using Equation 0  
 FD  
 $v_{12} = v_R + (v_F - v_R) P = 2617$  pc/h  
 FD

---

Capacity Checks

---

|                      | Actual | Maximum | LOS F? |
|----------------------|--------|---------|--------|
| $v_{Fi} = v_F$       | 2617   | 4800    | No     |
| $v_{12}$             | 2617   | 4400    | No     |
| $v_{FO} = v_F - v_R$ | 2363   | 4800    | No     |
| $v_R$                | 254    | 2100    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v_{12} - 0.009 D = 25.0$  pc/mi/ln  
 Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

|  |             |     |
|--|-------------|-----|
| Intermediate speed variable,             | $D = 0.321$ |     |
| Space mean speed in ramp influence area, | $S = 61$    | mph |
| Space mean speed in outer lanes,         | $S = N/A$   | mph |
| Space mean speed for all vehicles,       | $S = 61.0$  | mph |

---

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-mail: jstorey@flohut.com

Fax: (615) 399-9049

Merge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/3/2002  
 Analysis time period: 2027 AM  
 Freeway/dir or travel: I-24 Eastbound  
 Junction: US 72 to I-24 Eastbound  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |       |     |
|----------------------------|-------|-----|
| Type of analysis           | Merge |     |
| Number of lanes in freeway | 2     |     |
| Free-flow speed on freeway | 70.0  | mph |
| Volume on freeway          | 1891  | vph |

On Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-flow speed on ramp           | 50.0  | mph |
| Volume on ramp                    | 1061  | vph |
| Length of first accel/decel lane  | 610   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |          |     |
|---------------------------|----------|-----|
| Does adjacent ramp exist? | Yes      |     |
| Volume on adjacent Ramp   | 221      | vph |
| Position of adjacent Ramp | Upstream |     |
| Type of adjacent Ramp     | Off      |     |
| Distance to adjacent Ramp | 1600     | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 1891    | 1061  | 221           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 525     | 295   | 61            | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

| Grade Length                  |  | %<br>mi | %<br>mi | %<br>mi |
|-------------------------------|--|---------|---------|---------|
| Trucks and buses PCE, ET      |  | 1.5     | 1.5     | 1.5     |
| Recreational vehicle PCE, ER  |  | 1.2     | 1.2     | 1.2     |
| Heavy vehicle adjustment, fHV |  | 0.897   | 0.966   | 0.966   |
| Driver population factor, fP  |  | 1.00    | 1.00    | 1.00    |
| Flow rate, vp                 |  | 2343    | 1220    | 254     |

---

Estimation of V12 Merge Areas

---

$L = 0.00$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 1.000$  Using Equation 0  
 FM  
 $v_{12} = v_F (P_{FM}) = 2343$  pc/h

---

Capacity Checks

---

|                  | Actual | Maximum | LOS F? |
|------------------|--------|---------|--------|
| v <sub>FO</sub>  | 3563   | 4800    | No     |
| v <sub>R12</sub> | 3563   | 4600    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A = 28.9$  pc/mi/ln  
 Level of service for ramp-freeway junction areas of influence D

---

Speed Estimation

---

|  |                  |
|--|------------------|
| Intermediate speed variable,             | $M_S = 0.398$    |
| Space mean speed in ramp influence area, | $S_R = 58.9$ mph |
| Space mean speed in outer lanes,         | $S_O = N/A$ mph  |
| Space mean speed for all vehicles,       | $S = 58.9$ mph   |

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HCS2000: Ramps and Ramp Junctions Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-mail: jstorey@flohut.com

Fax: (615) 399-9049

Diverge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/3/2002  
 Analysis time period: 2027 PM  
 Freeway/dir or travel: I-24 Westbound  
 Junction: I-24 WB to US 72  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |         |     |
|----------------------------|---------|-----|
| Type of analysis           | Diverge |     |
| Number of lanes in freeway | 2       |     |
| Free-flow speed on freeway | 70.0    | mph |
| Volume on freeway          | 5613    | vph |

Off Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-Flow speed on ramp           | 35.0  | mph |
| Volume on ramp                    | 1314  | vph |
| Length of first accel/decel lane  | 525   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |            |     |
|---------------------------|------------|-----|
| Does adjacent ramp exist? | Yes        |     |
| Volume on adjacent ramp   | 316        | vph |
| Position of adjacent ramp | Downstream |     |
| Type of adjacent ramp     | On         |     |
| Distance to adjacent ramp | 900        | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 5613    | 1314  | 316           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 1559    | 365   | 88            | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

|                               |       |    |       |    |       |      |
|-------------------------------|-------|----|-------|----|-------|------|
| Grade                         | 0.00  | %  | 0.00  | %  | 0.00  | %    |
| Length                        | 0.00  | mi | 0.00  | mi | 0.00  | mi   |
| Trucks and buses PCE, ET      | 1.5   |    | 1.5   |    | 1.5   |      |
| Recreational vehicle PCE, ER  | 1.2   |    | 1.2   |    | 1.2   |      |
| Heavy vehicle adjustment, fHV | 0.897 |    | 0.966 |    | 0.966 |      |
| Driver population factor, fP  | 1.00  |    | 1.00  |    | 1.00  |      |
| Flow rate, vp                 | 6954  |    | 1511  |    | 363   | pcph |

---

Estimation of V12 Diverge Areas

---

$L = 0.00$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 1.000$  Using Equation 0  
 FD  
 $v_{12} = v_R + (v_F - v_R) P = 6954$  pc/h  
 FD

---

Capacity Checks

---

|                      | Actual | Maximum | LOS F? |
|----------------------|--------|---------|--------|
| $v_{Fi} = v_F$       | 6954   | 4800    | Yes    |
| $v_{12}$             | 6954   | 4400    | Yes    |
| $v_{FO} = v_F - v_R$ | 5443   | 4800    | No     |
| $v_R$                | 1511   | 2000    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v_{12} - 0.009 D = 59.3$  pc/mi/ln  
 Level of service for ramp-freeway junction areas of influence F

---

Speed Estimation

---

|  |             |     |
|--|-------------|-----|
| Intermediate speed variable,             | $D = 0.564$ |     |
| Space mean speed in ramp influence area, | $S = 54$    | mph |
| Space mean speed in outer lanes,         | $S = N/A$   | mph |
| Space mean speed for all vehicles,       | $S = 54.2$  | mph |

---

HCS2000: Ramps and Ramp Junctions Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Merge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/3/2002  
 Analysis time period: 2027 PM  
 Freeway/dir or travel: I-24 Westbound  
 Junction: US 72 to I-24 Westbound  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |       |     |
|----------------------------|-------|-----|
| Type of analysis           | Merge |     |
| Number of lanes in freeway | 2     |     |
| Free-flow speed on freeway | 70.0  | mph |
| Volume on freeway          | 4299  | vph |

On Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-flow speed on ramp           | 45.0  | mph |
| Volume on ramp                    | 316   | vph |
| Length of first accel/decel lane  | 500   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |            |     |
|---------------------------|------------|-----|
| Does adjacent ramp exist? | Yes        |     |
| Volume on adjacent Ramp   | 1314       | vph |
| Position of adjacent Ramp | Downstream |     |
| Type of adjacent Ramp     | Off        |     |
| Distance to adjacent Ramp | 900        | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 4299    | 316   | 1314          | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 1194    | 88    | 365           | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

| Grade Length                  |  | %<br>mi | %<br>mi | %<br>mi |
|-------------------------------|--|---------|---------|---------|
| Trucks and buses PCE, ET      |  | 1.5     | 1.5     | 1.5     |
| Recreational vehicle PCE, ER  |  | 1.2     | 1.2     | 1.2     |
| Heavy vehicle adjustment, fHV |  | 0.897   | 0.966   | 0.966   |
| Driver population factor, fP  |  | 1.00    | 1.00    | 1.00    |
| Flow rate, vp                 |  | 5326    | 363     | 1511    |

---

Estimation of V12 Merge Areas

---

L = 0.00 (Equation 25-2 or 25-3)  
EQ  
P = 1.000 Using Equation 0  
FM  
 $v_{12} = v_F (P_{FM}) = 5326 \text{ pc/h}$

---

Capacity Checks

---

|                  | Actual | Maximum | LOS F? |
|------------------|--------|---------|--------|
| v <sub>FO</sub>  | 5689   | 4800    | Yes    |
| v <sub>R12</sub> | 5689   | 4600    | Yes    |

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A = 46.5 \text{ pc/mi/ln}$   
Level of service for ramp-freeway junction areas of influence F

---

Speed Estimation

---

|  |           |     |
|--|-----------|-----|
| Intermediate speed variable,             | M = 1.429 |     |
| Space mean speed in ramp influence area, | S = 30.0  | mph |
| Space mean speed in outer lanes,         | S = N/A   | mph |
| Space mean speed for all vehicles,       | S = 30.0  | mph |

---

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-mail: jstorey@flohut.com

Fax: (615) 399-9049

Merge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/3/2002  
 Analysis time period: 2027 PM  
 Freeway/dir or travel: I-24 Eastbound  
 Junction: US 72 to I-24 Eastbound  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |       |     |
|----------------------------|-------|-----|
| Type of analysis           | Merge |     |
| Number of lanes in freeway | 2     |     |
| Free-flow speed on freeway | 70.0  | mph |
| Volume on freeway          | 2178  | vph |

On Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-flow speed on ramp           | 50.0  | mph |
| Volume on ramp                    | 1182  | vph |
| Length of first accel/decel lane  | 610   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |          |     |
|---------------------------|----------|-----|
| Does adjacent ramp exist? | Yes      |     |
| Volume on adjacent Ramp   | 202      | vph |
| Position of adjacent Ramp | Upstream |     |
| Type of adjacent Ramp     | Off      |     |
| Distance to adjacent Ramp | 1600     | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 2178    | 1182  | 202           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 605     | 328   | 56            | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

| Grade Length                  |  | %<br>mi | %<br>mi | %<br>mi |
|-------------------------------|--|---------|---------|---------|
| Trucks and buses PCE, ET      |  | 1.5     | 1.5     | 1.5     |
| Recreational vehicle PCE, ER  |  | 1.2     | 1.2     | 1.2     |
| Heavy vehicle adjustment, fHV |  | 0.897   | 0.966   | 0.966   |
| Driver population factor, fP  |  | 1.00    | 1.00    | 1.00    |
| Flow rate, vp                 |  | 2698    | 1359    | 232     |

---

Estimation of V12 Merge Areas

---

$L = 0.00$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 1.000$  Using Equation 0  
 FM  
 $v_{12} = v_F (P_{FM}) = 2698$  pc/h

---

Capacity Checks

---

|                  | Actual | Maximum | LOS F? |
|------------------|--------|---------|--------|
| v <sub>FO</sub>  | 4057   | 4800    | No     |
| v <sub>R12</sub> | 4057   | 4600    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A = 32.7$  pc/mi/ln  
 Level of service for ramp-freeway junction areas of influence D

---

Speed Estimation

---

|  |                  |
|--|------------------|
| Intermediate speed variable,             | $M_S = 0.485$    |
| Space mean speed in ramp influence area, | $S_R = 56.4$ mph |
| Space mean speed in outer lanes,         | $S_O = N/A$ mph  |
| Space mean speed for all vehicles,       | $S = 56.4$ mph   |

---

# Signalized Intersection

U.S. 72 at Ramps 1 & 2  
Existing System

HCS2000: Signalized Intersections Release 4.1b

Analyst: Jon Storey Inter.: I-24 at US 72  
 Agency: Florence & Hutcheson Area Type: All other areas  
 Date: 6/3/2002 Jurisd: Marion Co.  
 Period: 2007 AM Year : 2002  
 Project ID: Interchange Modification Study  
 E/W St: I-24 Westbound (Ramps) N/S St: US 72

SIGNALIZED INTERSECTION SUMMARY

|            | Eastbound |   |   | Westbound |   |   | Northbound |      |   | Southbound |      |   |
|------------|-----------|---|---|-----------|---|---|------------|------|---|------------|------|---|
|            | L         | T | R | L         | T | R | L          | T    | R | L          | T    | R |
| No. Lanes  | 1         | 0 | 0 | 0         | 0 | 0 | 1          | 2    | 0 | 0          | 1    | 0 |
| LGConfig   | L         |   |   |           |   |   | L          | T    |   |            | T    |   |
| Volume     | 170       |   |   |           |   |   | 53         | 744  |   |            | 812  |   |
| Lane Width | 12.0      |   |   |           |   |   | 12.0       | 12.0 |   |            | 12.0 |   |
| RTOR Vol   |           |   |   |           |   |   |            |      |   |            |      |   |

Duration 0.25 Area Type: All other areas

Signal Operations

| Phase Combination | 1    | 2   | 3   | 4   | 5        | 6    | 7   | 8   |
|-------------------|------|-----|-----|-----|----------|------|-----|-----|
| EB Left           | P    |     |     |     | NB Left  | P    | P   |     |
| Thru              |      |     |     |     | Thru     | P    | P   |     |
| Right             |      |     |     |     | Right    |      |     |     |
| Peds              |      |     |     |     | Peds     |      |     |     |
| WB Left           |      |     |     |     | SB Left  |      |     |     |
| Thru              |      |     |     |     | Thru     | P    |     |     |
| Right             |      |     |     |     | Right    |      |     |     |
| Peds              |      |     |     |     | Peds     |      |     |     |
| NB Right          |      |     |     |     | EB Right |      |     |     |
| SB Right          |      |     |     |     | WB Right |      |     |     |
| Green             | 15.0 | 0.0 | 0.0 | 0.0 | 8.0      | 70.0 | 0.0 | 0.0 |
| Yellow            | 3.0  | 0.0 | 0.0 |     | 3.0      | 3.0  | 0.0 |     |
| All Red           | 0.0  | 0.0 | 0.0 |     | 0.0      | 0.0  | 0.0 |     |

Cycle Length: 102.0 secs

Intersection Performance Summary

| Appr/<br>Lane<br>Grp | Lane<br>Group<br>Capacity | Adj Sat<br>Flow Rate<br>(s) | Ratios |      | Lane Group |     | Approach |     |
|----------------------|---------------------------|-----------------------------|--------|------|------------|-----|----------|-----|
|                      |                           |                             | v/c    | g/C  | Delay      | LOS | Delay    | LOS |
| Eastbound            |                           |                             |        |      |            |     |          |     |
| L                    | 248                       | 1687                        | 0.76   | 0.15 | 61.4       | E   | 61.4     | E   |
| Westbound            |                           |                             |        |      |            |     |          |     |
| Northbound           |                           |                             |        |      |            |     |          |     |
| L                    | 453                       | 1687                        | 0.13   | 0.79 | 4.4        | A   |          |     |
| T                    | 2679                      | 3374                        | 0.31   | 0.79 | 3.2        | A   | 3.2      | A   |
| Southbound           |                           |                             |        |      |            |     |          |     |
| T                    | 1219                      | 1776                        | 0.74   | 0.69 | 14.3       | B   | 14.3     | B   |

Intersection Delay = 13.8 (sec/veh) Intersection LOS = B

HCS2000: Signalized Intersections Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-Mail: jstorey@flohut.com

Fax: (615) 399-9049

OPERATIONAL ANALYSIS

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date Performed: 6/3/2002  
 Analysis Time Period: 2007 AM  
 Intersection: I-24 at US 72  
 Area Type: All other areas  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Project ID: Interchange Modification Study

East/West Street North/South Street  
 I-24 Westbound (Ramps) US 72

VOLUME DATA

|              | Eastbound |   |   | Westbound                  |   |   | Northbound |       |   | Southbound |       |   |
|--------------|-----------|---|---|----------------------------|---|---|------------|-------|---|------------|-------|---|
|              | L         | T | R | L                          | T | R | L          | T     | R | L          | T     | R |
| Volume       | 170       |   |   |                            |   |   | 53         | 744   |   |            | 812   |   |
| % Heavy Veh  | 7         |   |   |                            |   |   | 7          | 7     |   |            | 7     |   |
| PHF          | 0.90      |   |   |                            |   |   | 0.90       | 0.90  |   |            | 0.90  |   |
| PK 15 Vol    | 47        |   |   |                            |   |   | 15         | 207   |   |            | 226   |   |
| Hi Ln Vol    |           |   |   |                            |   |   |            |       |   |            |       |   |
| % Grade      |           | 0 |   |                            |   |   |            | 0     |   |            | 0     |   |
| Ideal Sat    | 1900      |   |   |                            |   |   | 1900       | 1900  |   |            | 1900  |   |
| ParkExist    |           |   |   |                            |   |   |            |       |   |            |       |   |
| NumPark      |           |   |   |                            |   |   |            |       |   |            |       |   |
| No. Lanes    | 1         | 0 | 0 | 0                          | 0 | 0 | 1          | 2     | 0 | 0          | 1     | 0 |
| LGConfig     | L         |   |   |                            |   |   | L          | T     |   |            | T     |   |
| Lane Width   | 12.0      |   |   |                            |   |   | 12.0       | 12.0  |   |            | 12.0  |   |
| RTOR Vol     |           |   |   |                            |   |   |            |       |   |            |       |   |
| Adj Flow     | 189       |   |   |                            |   |   | 59         | 827   |   |            | 902   |   |
| %InSharedLn  |           |   |   |                            |   |   |            |       |   |            |       |   |
| Prop LTs     |           |   |   |                            |   |   | 1.000      | 0.000 |   |            | 0.000 |   |
| Prop RTs     |           |   |   |                            |   |   |            | 0.000 |   |            | 0.000 |   |
| Peds Bikes   |           |   |   | 0                          |   |   |            |       |   |            | 0     |   |
| Buses        | 0         |   |   |                            |   |   | 0          | 0     |   |            | 0     |   |
| %InProtPhase |           |   |   |                            |   |   | 0.0        |       |   |            |       |   |
| Duration     | 0.25      |   |   | Area Type: All other areas |   |   |            |       |   |            |       |   |

OPERATING PARAMETERS

|  | Eastbound |   |   | Westbound |   |   | Northbound |   |   | Southbound |   |   |
|--|-----------|---|---|-----------|---|---|------------|---|---|------------|---|---|
|  | L         | T | R | L         | T | R | L          | T | R | L          | T | R |

|             |     |       |     |     |       |  |       |
|-------------|-----|-------|-----|-----|-------|--|-------|
| Init Unmet  | 0.0 |       |     | 0.0 | 0.0   |  | 0.0   |
| Arriv. Type | 3   |       |     | 3   | 3     |  | 3     |
| Unit Ext.   | 3.0 |       |     | 3.0 | 3.0   |  | 3.0   |
| I Factor    |     | 1.000 |     |     | 1.000 |  | 1.000 |
| Lost Time   | 2.0 |       |     | 2.0 | 2.0   |  | 2.0   |
| Ext of g    | 2.0 |       |     | 2.0 | 2.0   |  | 2.0   |
| Ped Min g   |     |       | 3.2 |     |       |  | 3.2   |

PHASE DATA

| Phase Combination | 1    | 2   | 3   | 4   | 5        | 6    | 7   | 8   |
|-------------------|------|-----|-----|-----|----------|------|-----|-----|
| EB Left           | P    |     |     |     | NB Left  | P    | P   |     |
| Thru              |      |     |     |     | Thru     | P    | P   |     |
| Right             |      |     |     |     | Right    |      |     |     |
| Peds              |      |     |     |     | Peds     |      |     |     |
| WB Left           |      |     |     |     | SB Left  |      |     |     |
| Thru              |      |     |     |     | Thru     | P    |     |     |
| Right             |      |     |     |     | Right    |      |     |     |
| Peds              |      |     |     |     | Peds     |      |     |     |
| NB Right          |      |     |     |     | EB Right |      |     |     |
| SB Right          |      |     |     |     | WB Right |      |     |     |
| Green             | 15.0 | 0.0 | 0.0 | 0.0 | 8.0      | 70.0 | 0.0 | 0.0 |
| Yellow            | 3.0  | 0.0 | 0.0 |     | 3.0      | 3.0  | 0.0 |     |
| All Red           | 0.0  | 0.0 | 0.0 |     | 0.0      | 0.0  | 0.0 |     |

Cycle Length: 102.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

| Volume Adjustment | Eastbound |   |   | Westbound |   |   | Northbound |       |   | Southbound |       |   |
|-------------------|-----------|---|---|-----------|---|---|------------|-------|---|------------|-------|---|
|                   | L         | T | R | L         | T | R | L          | T     | R | L          | T     | R |
| Volume, V         | 170       |   |   |           |   |   | 53         | 744   |   |            | 812   |   |
| PHF               | 0.90      |   |   |           |   |   | 0.90       | 0.90  |   |            | 0.90  |   |
| Adj flow          | 189       |   |   |           |   |   | 59         | 827   |   |            | 902   |   |
| No. Lanes         | 1         | 0 | 0 | 0         | 0 | 0 | 1          | 2     | 0 | 0          | 1     | 0 |
| Lane group        | L         |   |   |           |   |   | L          | T     |   |            | T     |   |
| Adj flow          | 189       |   |   |           |   |   | 59         | 827   |   |            | 902   |   |
| Prop LTs          |           |   |   |           |   |   | 1.000      | 0.000 |   |            | 0.000 |   |
| Prop RTs          |           |   |   |           |   |   |            | 0.000 |   |            | 0.000 |   |

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

| LG    | Eastbound |   |   | Westbound |   |   | Northbound |       |   | Southbound |       |   |
|-------|-----------|---|---|-----------|---|---|------------|-------|---|------------|-------|---|
|       | L         | T | R | L         | T | R | L          | T     | R | L          | T     | R |
| So    | 1900      |   |   |           |   |   | 1900       | 1900  |   |            | 1900  |   |
| Lanes | 1         | 0 | 0 | 0         | 0 | 0 | 1          | 2     | 0 | 0          | 1     | 0 |
| fW    | 1.000     |   |   |           |   |   | 1.000      | 1.000 |   |            | 1.000 |   |
| fHV   | 0.935     |   |   |           |   |   | 0.935      | 0.935 |   |            | 0.935 |   |
| fG    | 1.000     |   |   |           |   |   | 1.000      | 1.000 |   |            | 1.000 |   |
| fP    | 1.000     |   |   |           |   |   | 1.000      | 1.000 |   |            | 1.000 |   |

|      |       |  |       |       |  |       |
|------|-------|--|-------|-------|--|-------|
| fBB  | 1.000 |  | 1.000 | 1.000 |  | 1.000 |
| fA   | 1.00  |  | 1.00  | 1.00  |  | 1.00  |
| fLU  | 1.00  |  | 1.00  | 0.95  |  | 1.00  |
| fRT  |       |  |       | 1.000 |  | 1.000 |
| fLT  | 0.950 |  | 0.950 | 1.000 |  | 1.000 |
| Sec. |       |  | 0.253 |       |  |       |
| fLpb | 1.000 |  | 1.000 | 1.000 |  | 1.000 |
| fRpb |       |  |       | 1.000 |  | 1.000 |
| S    | 1687  |  | 1687  | 3374  |  | 1776  |
| Sec. |       |  | 449   |       |  |       |

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

| Appr/<br>Mvmt | Lane<br>Group | Adj<br>Flow Rate<br>(v) | Adj Sat<br>Flow Rate<br>(s) | Flow<br>Ratio<br>(v/s) | Green<br>Ratio<br>(g/C) | --Lane Group--<br>Capacity<br>(c) | v/c<br>Ratio |
|---------------|---------------|-------------------------|-----------------------------|------------------------|-------------------------|-----------------------------------|--------------|
| Eastbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left L        | 189                     | 1687                        | # 0.11                 | 0.15                    | 248                               | 0.76         |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Westbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Northbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          | 59                      | 1687                        | # 0.03                 | 0.078                   | 132                               | 0.45         |
|               | Perm          | 0                       | 449                         | 0.00                   | 0.716                   | 321                               | 0.00         |
|               | Left L        | 59                      |                             |                        | 0.79                    | 453                               | 0.13         |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru T        | 827                     | 3374                        | 0.25                   | 0.79                    | 2679                              | 0.31         |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Southbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru T        | 902                     | 1776                        | # 0.51                 | 0.69                    | 1219                              | 0.74         |
|               | Right         |                         |                             |                        |                         |                                   |              |

Sum of flow ratios for critical lane groups,  $Y_c = \text{Sum (v/s)} = 0.65$   
Total lost time per cycle,  $L = 9.00 \text{ sec}$   
Critical flow rate to capacity ratio,  $X_c = (Y_c) (C) / (C-L) = 0.72$

Control Delay and LOS Determination

| Appr/<br>Lane | Ratios | Unf<br>Del | Prog<br>Adj | Lane<br>Grp | Incremental<br>Factor | Res<br>Del | Lane Group | Approach |
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|

| Grp   | v/c  | g/C  | d1   | Fact  | Cap  | k    | d2   | d3  | Delay | LOS | Delay | LOS |
|---|------|------|------|-------|------|------|------|-----|-------|-----|-------|-----|
| Eastbound   |      |      |      |       |      |      |      |     |       |     |       |     |
| L   | 0.76 | 0.15 | 41.8 | 1.000 | 248  | 0.50 | 19.6 | 0.0 | 61.4  | E   | 61.4  | E   |
| Westbound   |      |      |      |       |      |      |      |     |       |     |       |     |
| Northbound  |      |      |      |       |      |      |      |     |       |     |       |     |
| L   | 0.13 | 0.79 | 3.8  | 1.000 | 453  | 0.50 | 0.6  | 0.0 | 4.4   | A   |       |     |
| T   | 0.31 | 0.79 | 2.9  | 1.000 | 2679 | 0.50 | 0.3  | 0.0 | 3.2   | A   | 3.2   | A   |
| Southbound  |      |      |      |       |      |      |      |     |       |     |       |     |
| T   | 0.74 | 0.69 | 10.2 | 1.000 | 1219 | 0.50 | 4.1  | 0.0 | 14.3  | B   | 14.3  | B   |
| <hr/> Intersection delay = 13.8 (sec/veh)      Intersection LOS = B |      |      |      |       |      |      |      |     |       |     |       |     |

SUPPLEMENTAL PERMITTED LT WORKSHEET

for exclusive lefts

Input

|  | EB | WB | NB    | SB   |
|--|----|----|-------|------|
| Cycle length, C  |    |    |       |      |
| Total actual green time for LT lane group, G (s)                             |    |    | 81.0  |      |
| Effective permitted green time for LT lane group, g(s)                       |    |    | 73.0  |      |
| Opposing effective green time, go (s)  |    |    | 70.0  |      |
| Number of lanes in LT lane group, N  |    |    | 1     |      |
| Number of lanes in opposing approach, No                                     |    |    | 1     |      |
| Adjusted LT flow rate, VLT (veh/h)   |    |    | 59    |      |
| Proportion of LT in LT lane group, PLT                                       |    |    | 1.000 |      |
| Proportion of LT in opposing flow, PLTo                                      |    |    | 0.00  |      |
| Adjusted opposing flow rate, Vo (veh/h)                                      |    |    | 902   |      |
| Lost time for LT lane group, tL  |    |    | 3.00  |      |
| Computation  |    |    |       |      |
| LT volume per cycle, LTC=VLTC/3600   |    |    | 1.67  |      |
| Opposing lane util. factor, fLUo   |    |    | 1.00  | 0.95 |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)                          |    |    | 25.56 |      |
| gf=G[exp(- a * (LTC ** b))]-tL, gf<=g  |    |    | 0.0   |      |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)                            |    |    | 1.00  |      |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]                                 |    |    | 0.31  |      |
| gq, (see Exhibit C16-4,5,6,7,8)  |    |    | 17.07 |      |
| gu=g-gq if gq>=gf, or = g-gf if gq<gf  |    |    | 55.93 |      |
| n=Max(gq-gf)/2,0)  |    |    | 8.54  |      |
| PTHo=1-PLTo  |    |    | 1.00  |      |
| PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]   |    |    | 1.00  |      |
| EL1 (refer to Exhibit C16-3)   |    |    | 3.03  |      |
| EL2=Max((1-Ptho**n)/Plto, 1.0)   |    |    |       |      |
| fmin=2(1+PL)/g or fmin=2(1+Pl)/g   |    |    | 0.05  |      |
| gdiff=max(gq-gf,0)   |    |    | 0.00  |      |
| fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)                          |    |    | 0.25  |      |
| flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)], (fmin<=fm<=1.00) |    |    |       |      |
| or flt=[fm+0.91(N-1)]/N**  |    |    |       |      |

Left-turn adjustment, fLT

0.253

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET

for shared lefts

Input

|   | EB | WB | NB    | SB    |
|---|----|----|-------|-------|
| Cycle length, C   |    |    |       |       |
| Total actual green time for LT lane group, G (s)  |    |    |       |       |
| Effective permitted green time for LT lane group, g(s)  |    |    |       |       |
| Opposing effective green time, go (s)   |    |    |       |       |
| Number of lanes in LT lane group, N   |    |    |       |       |
| Number of lanes in opposing approach, No  |    |    |       |       |
| Adjusted LT flow rate, VLT (veh/h)  |    |    |       |       |
| Proportion of LT in LT lane group, PLT  |    |    | 0.000 | 0.000 |
| Proportion of LT in opposing flow, PLTo   |    |    |       |       |
| Adjusted opposing flow rate, Vo (veh/h)   |    |    |       |       |
| Lost time for LT lane group, tL   |    |    |       |       |
| Computation   |    |    |       |       |
| LT volume per cycle, LTC=VLTC/3600  |    |    |       |       |
| Opposing lane util. factor, fLUo  |    |    | 1.00  | 0.95  |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)   |    |    |       |       |
| $gf = G[\exp(-a * (LTC ** b))] - tL$ , $gf \leq g$  |    |    |       |       |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)   |    |    |       |       |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]  |    |    |       |       |
| gq, (see Exhibit C16-4,5,6,7,8)   |    |    |       |       |
| $gu = g - gq$ if $gq \geq gf$ , or $= g - gf$ if $gq < gf$  |    |    |       |       |
| $n = \text{Max}(gq - gf) / 2, 0$  |    |    |       |       |
| $PTHo = 1 - PLTo$   |    |    |       |       |
| $PL* = PLT[1 + (N-1)g / (gf + gu / EL1 + 4.24)]$  |    |    |       |       |
| EL1 (refer to Exhibit C16-3)  |    |    |       |       |
| $EL2 = \text{Max}((1 - Ptho ** n) / Plto, 1.0)$   |    |    |       |       |
| $fmin = 2(1 + PL) / g$ or $fmin = 2(1 + Pl) / g$  |    |    |       |       |
| $gdiff = \text{max}(gq - gf, 0)$  |    |    |       |       |
| $fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)]$ , (min=fmin;max=1.00)                                    |    |    |       |       |
| $flt = fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)] + [gdiff/g] / [1 + PL(EL2 - 1)]$ , (fmin<=fm<=1.00) |    |    |       |       |
| or $flt = [fm + 0.91(N-1)] / N **$  |    |    |       |       |
| Left-turn adjustment, fLT   |    |    |       |       |

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns

| EB | WB | NB | SB |
|----|----|----|----|
|----|----|----|----|

Effective pedestrian green time,  $g_p$  (s)  
 Conflicting pedestrian volume,  $V_{ped}$  (p/h)  
 Pedestrian flow rate,  $V_{pedg}$  (p/h)  
 $OCC_{pedg}$   
 Opposing queue clearing green,  $g_q$  (s)  
 Eff. ped. green consumed by opp. veh. queue,  $g_q/g_p$   
 $OCC_{pedu}$   
 Opposing flow rate,  $V_o$  (veh/h)  
 $OCC_r$   
 Number of cross-street receiving lanes,  $N_{rec}$   
 Number of turning lanes,  $N_{turn}$   
 $ApbT$   
 Proportion of left turns,  $PLT$   
 Proportion of left turns using protected phase,  $PLTA$   
 Left-turn adjustment,  $f_{Lpb}$   
 Permitted Right Turns  
 Effective pedestrian green time,  $g_p$  (s)  
 Conflicting pedestrian volume,  $V_{ped}$  (p/h)  
 Conflicting bicycle volume,  $V_{bic}$  (bicycles/h)  
 $V_{pedg}$   
 $OCC_{pedg}$   
 Effective green,  $g$  (s)  
 $V_{bicg}$   
 $OCC_{bicg}$   
 $OCC_r$   
 Number of cross-street receiving lanes,  $N_{rec}$   
 Number of turning lanes,  $N_{turn}$   
 $ApbT$   
 Proportion right-turns,  $PRT$   
 Proportion right-turns using protected phase,  $PRTA$   
 Right turn adjustment,  $f_{Rpb}$

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SUPPLEMENTAL UNIFORM DELAY WORKSHEET

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|   |       | EBLT | WBLT | NBLT  | SBLT |
|---|-------|------|------|-------|------|
| Cycle length, $C$   | 102.0 |      |      |       |      |
| Adj. LT vol from Vol Adjustment Worksheet, $v$            |       |      |      | 59    |      |
| $v/c$ ratio from Capacity Worksheet, $X$                  |       |      |      | 0.13  |      |
| Protected phase effective green interval, $g$ (s)         |       |      |      | 8.0   |      |
| Opposing queue effective green interval, $g_q$            |       |      |      | 17.07 |      |
| Unopposed green interval, $g_u$                           |       |      |      | 55.93 |      |
| Red time $r=(C-g-g_q-g_u)$                                |       |      |      | 21.0  |      |
| Arrival rate, $q_a=v/(3600(\max[X,1.0]))$                 |       |      |      | 0.02  |      |
| Protected ph. departure rate, $S_p=s/3600$                |       |      |      | 0.469 |      |
| Permitted ph. departure rate, $S_s=s(g_q+g_u)/(g_u*3600)$ |       |      |      | 0.16  |      |
| XPerm   |       |      |      | 0.13  |      |
| XProt   |       |      |      | 0.13  |      |
| Case  |       |      |      | 1     |      |
| Queue at beginning of green arrow, $Q_a$                  |       |      |      | 0.34  |      |
| Queue at beginning of unsaturated green, $Q_u$            |       |      |      | 0.28  |      |
| Residual queue, $Q_r$                                     |       |      |      | 0.00  |      |
| Uniform Delay, $d_l$                                      |       |      |      | 3.8   |      |

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DELAY/LOS WORKSHEET WITH INITIAL QUEUE

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|       | Initial Dur. | Uniform Delay | Initial Queue | Final Queue | Initial Lane | Lane Group |
|-------|--------------|---------------|---------------|-------------|--------------|------------|
| Appr/ | Unmet        | Unmet         | Unmet         | Unmet       | Unmet        | Unmet      |

| Lane Group | Demand Q veh | Demand t hrs. | Unadj. ds | Adj. dl sec | Param. u | Demand Q veh | Delay d3 sec | Delay d sec |
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|

Eastbound

Westbound

Northbound

Southbound

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Intersection Delay 13.8 sec/veh      Intersection LOS B

BACK OF QUEUE WORKSHEET

|                         | Eastbound |       |   | Westbound |   |   | Northbound |       |   | Southbound |   |   |
|-------------------------|-----------|-------|---|-----------|---|---|------------|-------|---|------------|---|---|
| LaneGroup               | L         |       |   |           |   |   | L          | T     |   | T          |   |   |
| Init Queue              | 0.0       |       |   |           |   |   | 0.0        | 0.0   |   | 0.0        |   |   |
| Flow Rate               | 189       |       |   |           |   |   | 59         | 413   |   | 902        |   |   |
| So                      | 1900      |       |   |           |   |   | 1900       | 1900  |   | 1900       |   |   |
| No.Lanes                | 1         | 0     | 0 | 0         | 0 | 0 | 1          | 2     | 0 | 0          | 1 | 0 |
| SL                      | 1687      |       |   |           |   |   | 1687       | 1687  |   | 1776       |   |   |
| LnCapacity              | 248       |       |   |           |   |   | 453        | 1339  |   | 1219       |   |   |
| Flow Ratio              | 0.11      |       |   |           |   |   | 0.03       | 0.24  |   | 0.51       |   |   |
| v/c Ratio               | 0.76      |       |   |           |   |   | 0.13       | 0.31  |   | 0.74       |   |   |
| Grn Ratio               | 0.15      |       |   |           |   |   | 0.79       | 0.79  |   | 0.69       |   |   |
| I Factor                |           | 1.000 |   |           |   |   |            | 1.000 |   | 1.000      |   |   |
| AT or PVG               | 3         |       |   |           |   |   | 3          | 3     |   | 3          |   |   |
| Pltn Ratio              | 1.00      |       |   |           |   |   | 1.00       | 1.00  |   | 1.00       |   |   |
| PF2                     | 1.00      |       |   |           |   |   | 1.00       | 1.00  |   | 1.00       |   |   |
| Q1                      | 5.1       |       |   |           |   |   | 0.3        | 3.2   |   | 16.3       |   |   |
| kB                      | 0.5       |       |   |           |   |   | 1.5        | 1.5   |   | 1.4        |   |   |
| Q2                      | 1.3       |       |   |           |   |   | 0.2        | 0.7   |   | 3.7        |   |   |
| Q Average               | 6.4       |       |   |           |   |   | 0.6        | 3.9   |   | 20.0       |   |   |
| Q Spacing               | 24.9      |       |   |           |   |   | 24.9       | 24.9  |   | 24.9       |   |   |
| Q Storage               | 150       |       |   |           |   |   | 250        | 1000  |   | 1000       |   |   |
| Q S Ratio               | 1.1       |       |   |           |   |   | 0.1        | 0.1   |   | 0.5        |   |   |
| 70th Percentile Output: |           |       |   |           |   |   |            |       |   |            |   |   |
| fB%                     | 1.2       |       |   |           |   |   | 1.3        | 1.2   |   | 1.2        |   |   |
| BOQ                     | 7.9       |       |   |           |   |   | 0.7        | 4.8   |   | 24.1       |   |   |
| QSRatio                 | 1.3       |       |   |           |   |   | 0.1        | 0.1   |   | 0.6        |   |   |
| 85th Percentile Output: |           |       |   |           |   |   |            |       |   |            |   |   |
| fB%                     | 1.5       |       |   |           |   |   | 1.7        | 1.5   |   | 1.4        |   |   |
| BOQ                     | 9.5       |       |   |           |   |   | 1.0        | 6.0   |   | 28.1       |   |   |

|                         |      |  |     |     |  |      |  |
|-------------------------|------|--|-----|-----|--|------|--|
| QSRatio                 | 1.6  |  | 0.1 | 0.1 |  | 0.7  |  |
| 90th Percentile Output: |      |  |     |     |  |      |  |
| fB%                     | 1.6  |  | 1.9 | 1.7 |  | 1.5  |  |
| BOQ                     | 10.5 |  | 1.1 | 6.7 |  | 30.2 |  |
| QSRatio                 | 1.7  |  | 0.1 | 0.2 |  | 0.8  |  |
| 95th Percentile Output: |      |  |     |     |  |      |  |
| fB%                     | 1.9  |  | 2.5 | 2.1 |  | 1.6  |  |
| BOQ                     | 12.1 |  | 1.4 | 8.0 |  | 32.4 |  |
| QSRatio                 | 2.0  |  | 0.1 | 0.2 |  | 0.8  |  |
| 98th Percentile Output: |      |  |     |     |  |      |  |
| fB%                     | 2.1  |  | 3.0 | 2.4 |  | 1.7  |  |
| BOQ                     | 13.6 |  | 1.7 | 9.3 |  | 34.6 |  |
| QSRatio                 | 2.3  |  | 0.2 | 0.2 |  | 0.9  |  |

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ERROR MESSAGES

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No errors to report.

HCS2000: Signalized Intersections Release 4.1b

Analyst: Jon Storey Inter.: I-24 at US 72  
 Agency: Florence & Hutcheson Area Type: All other areas  
 Date: 6/3/2002 Jurisd: Marion Co.  
 Period: 2007 PM Year : 2002  
 Project ID: Interchange Modification Study  
 E/W St: I-24 Westbound (Ramps) N/S St: US 72

SIGNALIZED INTERSECTION SUMMARY

|            | Eastbound |   |   | Westbound |   |   | Northbound |      |   | Southbound |      |   |
|------------|-----------|---|---|-----------|---|---|------------|------|---|------------|------|---|
|            | L         | T | R | L         | T | R | L          | T    | R | L          | T    | R |
| No. Lanes  | 1         | 0 | 0 | 0         | 0 | 0 | 1          | 2    | 0 | 0          | 1    | 0 |
| LGConfig   | L         |   |   |           |   |   | L          | T    |   |            | T    |   |
| Volume     | 338       |   |   |           |   |   | 75         | 977  |   |            | 1086 |   |
| Lane Width | 12.0      |   |   |           |   |   | 12.0       | 12.0 |   |            | 12.0 |   |
| RTOR Vol   |           |   |   |           |   |   |            |      |   |            |      |   |

Duration 0.25 Area Type: All other areas

Signal Operations

| Phase Combination | 1    | 2   | 3   | 4   | 5        | 6    | 7   | 8   |
|-------------------|------|-----|-----|-----|----------|------|-----|-----|
| EB Left           | P    |     |     |     | NB Left  | P    | P   |     |
| Thru              |      |     |     |     | Thru     | P    | P   |     |
| Right             |      |     |     |     | Right    |      |     |     |
| Peds              |      |     |     |     | Peds     |      |     |     |
| WB Left           |      |     |     |     | SB Left  |      |     |     |
| Thru              |      |     |     |     | Thru     | P    |     |     |
| Right             |      |     |     |     | Right    |      |     |     |
| Peds              |      |     |     |     | Peds     |      |     |     |
| NB Right          |      |     |     |     | EB Right |      |     |     |
| SB Right          |      |     |     |     | WB Right |      |     |     |
| Green             | 24.0 | 0.0 | 0.0 | 0.0 | 8.0      | 80.0 | 0.0 | 0.0 |
| Yellow            | 3.0  | 0.0 | 0.0 |     | 3.0      | 3.0  | 0.0 |     |
| All Red           | 0.0  | 0.0 | 0.0 |     | 0.0      | 0.0  | 0.0 |     |

Cycle Length: 121.0 secs

Intersection Performance Summary

| Appr/<br>Lane<br>Grp | Lane<br>Group<br>Capacity | Adj Sat<br>Flow Rate<br>(s) | Ratios |      | Lane Group |     | Approach |     |
|----------------------|---------------------------|-----------------------------|--------|------|------------|-----|----------|-----|
|                      |                           |                             | v/c    | g/C  | Delay      | LOS | Delay    | LOS |
| Eastbound            |                           |                             |        |      |            |     |          |     |
| L                    | 335                       | 1687                        | 1.12   | 0.20 | 135.0      | F   | 135.0    | F   |
| Westbound            |                           |                             |        |      |            |     |          |     |
| Northbound           |                           |                             |        |      |            |     |          |     |
| L                    | 318                       | 1687                        | 0.26   | 0.75 | 9.4        | A   |          |     |
| T                    | 2537                      | 3374                        | 0.43   | 0.75 | 6.0        | A   | 6.3      | A   |
| Southbound           |                           |                             |        |      |            |     |          |     |
| T                    | 1174                      | 1776                        | 1.03   | 0.66 | 54.2       | D   | 54.2     | D   |

Intersection Delay = 44.9 (sec/veh) Intersection LOS = D

HCS2000: Signalized Intersections Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-Mail: jstorey@flohut.com

Fax: (615) 399-9049

OPERATIONAL ANALYSIS

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date Performed: 6/3/2002  
 Analysis Time Period: 2007 PM  
 Intersection: I-24 at US 72  
 Area Type: All other areas  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Project ID: Interchange Modification Study

East/West Street North/South Street  
 I-24 Westbound (Ramps) US 72

VOLUME DATA

|              | Eastbound |   |   | Westbound                  |   |   | Northbound |       |   | Southbound |      |       |
|--------------|-----------|---|---|----------------------------|---|---|------------|-------|---|------------|------|-------|
|              | L         | T | R | L                          | T | R | L          | T     | R | L          | T    | R     |
| Volume       | 338       |   |   |                            |   |   | 75         | 977   |   |            |      | 1086  |
| % Heavy Veh  | 7         |   |   |                            |   |   | 7          | 7     |   |            |      | 7     |
| PHF          | 0.90      |   |   |                            |   |   | 0.90       | 0.90  |   |            |      | 0.90  |
| PK 15 Vol    | 94        |   |   |                            |   |   | 21         | 271   |   |            |      | 302   |
| Hi Ln Vol    |           |   |   |                            |   |   |            |       |   |            |      |       |
| % Grade      |           | 0 |   |                            |   |   |            | 0     |   |            |      | 0     |
| Ideal Sat    | 1900      |   |   |                            |   |   | 1900       | 1900  |   |            |      | 1900  |
| ParkExist    |           |   |   |                            |   |   |            |       |   |            |      |       |
| NumPark      |           |   |   |                            |   |   |            |       |   |            |      |       |
| No. Lanes    | 1         | 0 | 0 | 0                          | 0 | 0 | 1          | 2     | 0 | 0          | 1    | 0     |
| LGConfig     | L         |   |   |                            |   |   | L          | T     |   |            | T    |       |
| Lane Width   | 12.0      |   |   |                            |   |   | 12.0       | 12.0  |   |            | 12.0 |       |
| RTOR Vol     |           |   |   |                            |   |   |            |       |   |            |      |       |
| Adj Flow     | 376       |   |   |                            |   |   | 83         | 1086  |   |            |      | 1207  |
| %InSharedLn  |           |   |   |                            |   |   |            |       |   |            |      |       |
| Prop LTs     |           |   |   |                            |   |   | 1.000      | 0.000 |   |            |      | 0.000 |
| Prop RTs     |           |   |   |                            |   |   |            | 0.000 |   |            |      | 0.000 |
| Peds Bikes   |           |   |   | 0                          |   |   |            |       |   |            |      | 0     |
| Buses        | 0         |   |   |                            |   |   | 0          | 0     |   |            |      | 0     |
| %InProtPhase |           |   |   |                            |   |   | 0.0        |       |   |            |      |       |
| Duration     | 0.25      |   |   | Area Type: All other areas |   |   |            |       |   |            |      |       |

OPERATING PARAMETERS

|  | Eastbound |   |   | Westbound |   |   | Northbound |   |   | Southbound |   |   |
|--|-----------|---|---|-----------|---|---|------------|---|---|------------|---|---|
|  | L         | T | R | L         | T | R | L          | T | R | L          | T | R |

|             |     |       |     |     |       |  |       |
|-------------|-----|-------|-----|-----|-------|--|-------|
| Init Unmet  | 0.0 |       |     | 0.0 | 0.0   |  | 0.0   |
| Arriv. Type | 3   |       |     | 3   | 3     |  | 3     |
| Unit Ext.   | 3.0 |       |     | 3.0 | 3.0   |  | 3.0   |
| I Factor    |     | 1.000 |     |     | 1.000 |  | 1.000 |
| Lost Time   | 2.0 |       |     | 2.0 | 2.0   |  | 2.0   |
| Ext of g    | 2.0 |       |     | 2.0 | 2.0   |  | 2.0   |
| Ped Min g   |     |       | 3.2 |     |       |  | 3.2   |

PHASE DATA

| Phase Combination | 1    | 2   | 3   | 4   | 5        | 6    | 7   | 8   |
|-------------------|------|-----|-----|-----|----------|------|-----|-----|
| EB Left           | P    |     |     |     | NB Left  | P    | P   |     |
| Thru              |      |     |     |     | Thru     | P    | P   |     |
| Right             |      |     |     |     | Right    |      |     |     |
| Peds              |      |     |     |     | Peds     |      |     |     |
| WB Left           |      |     |     |     | SB Left  |      |     |     |
| Thru              |      |     |     |     | Thru     | P    |     |     |
| Right             |      |     |     |     | Right    |      |     |     |
| Peds              |      |     |     |     | Peds     |      |     |     |
| NB Right          |      |     |     |     | EB Right |      |     |     |
| SB Right          |      |     |     |     | WB Right |      |     |     |
| Green             | 24.0 | 0.0 | 0.0 | 0.0 | 8.0      | 80.0 | 0.0 | 0.0 |
| Yellow            | 3.0  | 0.0 | 0.0 |     | 3.0      | 3.0  | 0.0 |     |
| All Red           | 0.0  | 0.0 | 0.0 |     | 0.0      | 0.0  | 0.0 |     |

Cycle Length: 121.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

| Volume Adjustment | Eastbound |   |   | Westbound |   |   | Northbound |       |   | Southbound |       |   |
|-------------------|-----------|---|---|-----------|---|---|------------|-------|---|------------|-------|---|
|                   | L         | T | R | L         | T | R | L          | T     | R | L          | T     | R |
| Volume, V         | 338       |   |   |           |   |   | 75         | 977   |   |            | 1086  |   |
| PHF               | 0.90      |   |   |           |   |   | 0.90       | 0.90  |   |            | 0.90  |   |
| Adj flow          | 376       |   |   |           |   |   | 83         | 1086  |   |            | 1207  |   |
| No. Lanes         | 1         | 0 | 0 | 0         | 0 | 0 | 1          | 2     | 0 | 0          | 1     | 0 |
| Lane group        | L         |   |   |           |   |   | L          | T     |   |            | T     |   |
| Adj flow          | 376       |   |   |           |   |   | 83         | 1086  |   |            | 1207  |   |
| Prop LTs          |           |   |   |           |   |   | 1.000      | 0.000 |   |            | 0.000 |   |
| Prop RTs          |           |   |   |           |   |   |            | 0.000 |   |            | 0.000 |   |

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

| LG    | Eastbound |   |   | Westbound |   |   | Northbound |       |   | Southbound |       |   |
|-------|-----------|---|---|-----------|---|---|------------|-------|---|------------|-------|---|
|       | L         | T | R | L         | T | R | L          | T     | R | L          | T     | R |
| So    | 1900      |   |   |           |   |   | 1900       | 1900  |   |            | 1900  |   |
| Lanes | 1         | 0 | 0 | 0         | 0 | 0 | 1          | 2     | 0 | 0          | 1     | 0 |
| fW    | 1.000     |   |   |           |   |   | 1.000      | 1.000 |   |            | 1.000 |   |
| fHV   | 0.935     |   |   |           |   |   | 0.935      | 0.935 |   |            | 0.935 |   |
| fG    | 1.000     |   |   |           |   |   | 1.000      | 1.000 |   |            | 1.000 |   |
| fP    | 1.000     |   |   |           |   |   | 1.000      | 1.000 |   |            | 1.000 |   |

|      |       |  |       |       |       |
|------|-------|--|-------|-------|-------|
| fBB  | 1.000 |  | 1.000 | 1.000 | 1.000 |
| fA   | 1.00  |  | 1.00  | 1.00  | 1.00  |
| fLU  | 1.00  |  | 1.00  | 0.95  | 1.00  |
| fRT  |       |  |       | 1.000 | 1.000 |
| fLT  | 0.950 |  | 0.950 | 1.000 | 1.000 |
| Sec. |       |  | 0.169 |       |       |
| fLpb | 1.000 |  | 1.000 | 1.000 | 1.000 |
| fRpb |       |  |       | 1.000 | 1.000 |
| S    | 1687  |  | 1687  | 3374  | 1776  |
| Sec. |       |  | 300   |       |       |

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

| Appr/<br>Mvmt | Lane<br>Group | Adj<br>Flow Rate<br>(v) | Adj Sat<br>Flow Rate<br>(s) | Flow<br>Ratio<br>(v/s) | Green<br>Ratio<br>(g/C) | --Lane Group--<br>Capacity<br>(c) | v/c<br>Ratio |
|---------------|---------------|-------------------------|-----------------------------|------------------------|-------------------------|-----------------------------------|--------------|
| Eastbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left L        | 376                     | 1687                        | # 0.22                 | 0.20                    | 335                               | 1.12         |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Westbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Northbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          | 83                      | 1687                        | # 0.05                 | 0.066                   | 112                               | 0.74         |
|               | Perm          | 0                       | 300                         | 0.00                   | 0.686                   | 206                               | 0.00         |
|               | Left L        | 83                      |                             |                        | 0.75                    | 318                               | 0.26         |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru T        | 1086                    | 3374                        | 0.32                   | 0.75                    | 2537                              | 0.43         |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Southbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru T        | 1207                    | 1776                        | # 0.68                 | 0.66                    | 1174                              | 1.03         |
|               | Right         |                         |                             |                        |                         |                                   |              |

Sum of flow ratios for critical lane groups,  $Y_c = \text{Sum (v/s)} = 0.95$   
 Total lost time per cycle,  $L = 9.00 \text{ sec}$   
 Critical flow rate to capacity ratio,  $X_c = (Y_c) (C) / (C-L) = 1.03$

Control Delay and LOS Determination

| Appr/<br>Lane | Ratios | Unf<br>Del | Prog<br>Adj | Lane<br>Grp | Incremental<br>Factor | Res<br>Del | Lane Group | Approach |
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|

| Grp   | v/c  | g/C  | d1   | Fact  | Cap  | k    | d2   | d3  | Delay | LOS | Delay | LOS |
|---|------|------|------|-------|------|------|------|-----|-------|-----|-------|-----|
| Eastbound   |      |      |      |       |      |      |      |     |       |     |       |     |
| L   | 1.12 | 0.20 | 48.5 | 1.000 | 335  | 0.50 | 86.5 | 0.0 | 135.0 | F   | 135.0 | F   |
| Westbound   |      |      |      |       |      |      |      |     |       |     |       |     |
| Northbound  |      |      |      |       |      |      |      |     |       |     |       |     |
| L   | 0.26 | 0.75 | 7.4  | 1.000 | 318  | 0.50 | 2.0  | 0.0 | 9.4   | A   |       |     |
| T   | 0.43 | 0.75 | 5.5  | 1.000 | 2537 | 0.50 | 0.5  | 0.0 | 6.0   | A   | 6.3   | A   |
| Southbound  |      |      |      |       |      |      |      |     |       |     |       |     |
| T   | 1.03 | 0.66 | 20.5 | 1.000 | 1174 | 0.50 | 33.7 | 0.0 | 54.2  | D   | 54.2  | D   |
| <hr/> Intersection delay = 44.9 (sec/veh)      Intersection LOS = D |      |      |      |       |      |      |      |     |       |     |       |     |

SUPPLEMENTAL PERMITTED LT WORKSHEET  
for exclusive lefts

| Input   | EB    | WB | NB    | SB   |
|---|-------|----|-------|------|
| Cycle length, C   |       |    |       |      |
| Total actual green time for LT lane group, G (s)                              | 121.0 |    |       |      |
| Effective permitted green time for LT lane group, g(s)                        |       |    | 91.0  |      |
| Opposing effective green time, go (s)   |       |    | 80.0  |      |
| Number of lanes in LT lane group, N   |       |    | 1     |      |
| Number of lanes in opposing approach, No                                      |       |    | 1     |      |
| Adjusted LT flow rate, VLT (veh/h)  |       |    | 83    |      |
| Proportion of LT in LT lane group, PLT  |       |    | 1.000 |      |
| Proportion of LT in opposing flow, PLTo                                       |       |    | 0.00  |      |
| Adjusted opposing flow rate, Vo (veh/h)                                       |       |    | 1207  |      |
| Lost time for LT lane group, tL   |       |    | 3.00  |      |
| Computation   |       |    |       |      |
| LT volume per cycle, LTC=VLTC/3600  |       |    | 2.79  |      |
| Opposing lane util. factor, fLUo  |       |    | 1.00  | 0.95 |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)                           |       |    | 40.57 |      |
| gf=G[exp(- a * (LTC ** b))]-tL, gf<=g   |       |    | 0.0   |      |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)                             |       |    | 1.00  |      |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]                                  |       |    | 0.34  |      |
| gq, (see Exhibit C16-4,5,6,7,8)   |       |    | 26.35 |      |
| gu=g-gq if gq>=gf, or = g-gf if gq<gf   |       |    | 56.65 |      |
| n=Max(gq-gf)/2,0)   |       |    | 13.17 |      |
| PTHo=1-PLTo   |       |    | 1.00  |      |
| PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]  |       |    | 1.00  |      |
| EL1 (refer to Exhibit C16-3)  |       |    | 4.04  |      |
| EL2=Max((1-Ptho**n)/Plto, 1.0)  |       |    |       |      |
| fmin=2(1+PL)/g or fmin=2(1+Pl)/g  |       |    | 0.05  |      |
| gdifff=max(gq-gf,0)   |       |    | 0.00  |      |
| fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)                           |       |    | 0.17  |      |
| flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdifff/g]/[1+PL(EL2-1)], (fmin<=fm<=1.00) |       |    |       |      |
| or flt=[fm+0.91(N-1)]/N**   |       |    |       |      |

Left-turn adjustment, fLT

0.169

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET

for shared lefts

Input

|   | EB | WB | NB    | SB    |
|---|----|----|-------|-------|
| Cycle length, C   |    |    |       |       |
| 121.0 sec   |    |    |       |       |
| Total actual green time for LT lane group, G (s)  |    |    |       |       |
| Effective permitted green time for LT lane group, g(s)  |    |    |       |       |
| Opposing effective green time, go (s)   |    |    |       |       |
| Number of lanes in LT lane group, N   |    |    |       |       |
| Number of lanes in opposing approach, No  |    |    |       |       |
| Adjusted LT flow rate, VLT (veh/h)  |    |    |       |       |
| Proportion of LT in LT lane group, PLT  |    |    | 0.000 | 0.000 |
| Proportion of LT in opposing flow, PLTo   |    |    |       |       |
| Adjusted opposing flow rate, Vo (veh/h)   |    |    |       |       |
| Lost time for LT lane group, tL   |    |    |       |       |
| Computation   |    |    |       |       |
| LT volume per cycle, LTC=VLTC/3600  |    |    |       |       |
| Opposing lane util. factor, fLUo  |    |    | 1.00  | 0.95  |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)   |    |    |       |       |
| $gf = G[\exp(-a * (LTC ** b))] - tL$ , $gf \leq g$  |    |    |       |       |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)   |    |    |       |       |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]  |    |    |       |       |
| gq, (see Exhibit C16-4,5,6,7,8)   |    |    |       |       |
| $gu = g - gq$ if $gq \geq gf$ , or $= g - gf$ if $gq < gf$  |    |    |       |       |
| $n = \text{Max}(gq - gf) / 2, 0$  |    |    |       |       |
| $PTHo = 1 - PLTo$   |    |    |       |       |
| $PL* = PLT[1 + (N-1)g / (gf + gu / EL1 + 4.24)]$  |    |    |       |       |
| EL1 (refer to Exhibit C16-3)  |    |    |       |       |
| $EL2 = \text{Max}((1 - Ptho ** n) / Plto, 1.0)$   |    |    |       |       |
| $fmin = 2(1 + PL) / g$ or $fmin = 2(1 + Pl) / g$  |    |    |       |       |
| $gdiff = \text{max}(gq - gf, 0)$  |    |    |       |       |
| $fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)]$ , (min=fmin;max=1.00)                                    |    |    |       |       |
| $flt = fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)] + [gdiff/g] / [1 + PL(EL2 - 1)]$ , (fmin<=fm<=1.00) |    |    |       |       |
| or $flt = [fm + 0.91(N-1)] / N **$  |    |    |       |       |
| Left-turn adjustment, fLT   |    |    |       |       |

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns

EB WB NB SB

Effective pedestrian green time, gp (s)  
 Conflicting pedestrian volume, Vped (p/h)  
 Pedestrian flow rate, Vpedg (p/h)  
 OCCpedg  
 Opposing queue clearing green, gq (s)  
 Eff. ped. green consumed by opp. veh. queue, gq/gp  
 OCCpedu  
 Opposing flow rate, Vo (veh/h)  
 OCCr  
 Number of cross-street receiving lanes, Nrec  
 Number of turning lanes, Nturn  
 ApbT  
 Proportion of left turns, PLT  
 Proportion of left turns using protected phase, PLTA  
 Left-turn adjustment, fLpb  
 Permitted Right Turns  
 Effective pedestrian green time, gp (s)  
 Conflicting pedestrian volume, Vped (p/h)  
 Conflicting bicycle volume, Vbic (bicycles/h)  
 Vpedg  
 OCCpedg  
 Effective green, g (s)  
 Vbicg  
 OCCbicg  
 OCCr  
 Number of cross-street receiving lanes, Nrec  
 Number of turning lanes, Nturn  
 ApbT  
 Proportion right-turns, PRT  
 Proportion right-turns using protected phase, PRTA  
 Right turn adjustment, fRpb

SUPPLEMENTAL UNIFORM DELAY WORKSHEET

---

|   |       | EBLT | WBLT | NBLT  | SBLT |
|---|-------|------|------|-------|------|
| Cycle length, C                                     | 121.0 |      |      |       |      |
| Adj. LT vol from Vol Adjustment Worksheet, v        |       |      |      | 83    |      |
| v/c ratio from Capacity Worksheet, X                |       |      |      | 0.26  |      |
| Protected phase effective green interval, g (s)     |       |      |      | 8.0   |      |
| Opposing queue effective green interval, gq         |       |      |      | 26.35 |      |
| Unopposed green interval, gu                        |       |      |      | 56.65 |      |
| Red time r=(C-g-gq-gu)                              |       |      |      | 30.0  |      |
| Arrival rate, qa=v/(3600(max[X,1.0]))               |       |      |      | 0.02  |      |
| Protected ph. departure rate, Sp=s/3600             |       |      |      | 0.469 |      |
| Permitted ph. departure rate, Ss=s(gq+gu)/(gu*3600) |       |      |      | 0.12  |      |
| XPerm   |       |      |      | 0.28  |      |
| XProt   |       |      |      | 0.23  |      |
| Case  |       |      |      | 1     |      |
| Queue at beginning of green arrow, Qa               |       |      |      | 0.69  |      |
| Queue at beginning of unsaturated green, Qu         |       |      |      | 0.61  |      |
| Residual queue, Qr                                  |       |      |      | 0.00  |      |
| Uniform Delay, dl                                   |       |      |      | 7.4   |      |

DELAY/LOS WORKSHEET WITH INITIAL QUEUE

---

|       | Initial Dur. | Uniform Delay | Initial Queue | Final Queue | Initial Lane | Lane Group |
|-------|--------------|---------------|---------------|-------------|--------------|------------|
| Appr/ | Unmet        | Unmet         | Unmet         | Unmet       | Unmet        |            |

| Lane Group | Demand Q veh | Demand t hrs. | Unadj. ds | Adj. dl sec | Param. u | Demand Q veh | Delay d3 sec | Delay d sec |
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|

Eastbound

Westbound

Northbound

Southbound

---

|                    |      |         |                  |   |
|--------------------|------|---------|------------------|---|
| Intersection Delay | 44.9 | sec/veh | Intersection LOS | D |
|--------------------|------|---------|------------------|---|

BACK OF QUEUE WORKSHEET

|                         | Eastbound |       |   | Westbound |   |   | Northbound |       |   | Southbound |       |   |
|-------------------------|-----------|-------|---|-----------|---|---|------------|-------|---|------------|-------|---|
| LaneGroup               | L         |       |   |           |   |   | L          | T     |   |            | T     |   |
| Init Queue              | 0.0       |       |   |           |   |   | 0.0        | 0.0   |   |            | 0.0   |   |
| Flow Rate               | 376       |       |   |           |   |   | 83         | 543   |   |            | 1207  |   |
| So                      | 1900      |       |   |           |   |   | 1900       | 1900  |   |            | 1900  |   |
| No.Lanes                | 1         | 0     | 0 | 0         | 0 | 0 | 1          | 2     | 0 | 0          | 1     | 0 |
| SL                      | 1687      |       |   |           |   |   | 1687       | 1687  |   |            | 1776  |   |
| LnCapacity              | 335       |       |   |           |   |   | 318        | 1268  |   |            | 1174  |   |
| Flow Ratio              | 0.22      |       |   |           |   |   | 0.05       | 0.32  |   |            | 0.68  |   |
| v/c Ratio               | 1.12      |       |   |           |   |   | 0.26       | 0.43  |   |            | 1.03  |   |
| Grn Ratio               | 0.20      |       |   |           |   |   | 0.75       | 0.75  |   |            | 0.66  |   |
| I Factor                |           | 1.000 |   |           |   |   |            | 1.000 |   |            | 1.000 |   |
| AT or PVG               | 3         |       |   |           |   |   | 3          | 3     |   |            | 3     |   |
| Pltn Ratio              | 1.00      |       |   |           |   |   | 1.00       | 1.00  |   |            | 1.00  |   |
| PF2                     | 1.00      |       |   |           |   |   | 1.00       | 1.00  |   |            | 1.00  |   |
| Q1                      | 12.6      |       |   |           |   |   | 0.7        | 6.7   |   |            | 40.6  |   |
| kB                      | 0.7       |       |   |           |   |   | 1.7        | 1.7   |   |            | 1.6   |   |
| Q2                      | 8.7       |       |   |           |   |   | 0.6        | 1.2   |   |            | 17.6  |   |
| Q Average               | 21.3      |       |   |           |   |   | 1.3        | 7.9   |   |            | 58.2  |   |
| Q Spacing               | 24.9      |       |   |           |   |   | 24.9       | 24.9  |   |            | 24.9  |   |
| Q Storage               | 150       |       |   |           |   |   | 250        | 1000  |   |            | 1000  |   |
| Q S Ratio               | 3.5       |       |   |           |   |   | 0.1        | 0.2   |   |            | 1.4   |   |
| 70th Percentile Output: |           |       |   |           |   |   |            |       |   |            |       |   |
| fB%                     | 1.2       |       |   |           |   |   | 1.3        | 1.2   |   |            | 1.2   |   |
| BOQ                     | 25.6      |       |   |           |   |   | 1.6        | 9.6   |   |            | 69.8  |   |
| QSRatio                 | 4.2       |       |   |           |   |   | 0.2        | 0.2   |   |            | 1.7   |   |
| 85th Percentile Output: |           |       |   |           |   |   |            |       |   |            |       |   |
| fB%                     | 1.4       |       |   |           |   |   | 1.6        | 1.5   |   |            | 1.4   |   |
| BOQ                     | 29.9      |       |   |           |   |   | 2.1        | 11.5  |   |            | 81.4  |   |

|                         |      |  |     |      |  |      |  |
|-------------------------|------|--|-----|------|--|------|--|
| QSRatio                 | 5.0  |  | 0.2 | 0.3  |  | 2.0  |  |
| 90th Percentile Output: |      |  |     |      |  |      |  |
| fB%                     | 1.5  |  | 1.9 | 1.6  |  | 1.5  |  |
| BOQ                     | 32.1 |  | 2.4 | 12.7 |  | 87.3 |  |
| QSRatio                 | 5.3  |  | 0.2 | 0.3  |  | 2.2  |  |
| 95th Percentile Output: |      |  |     |      |  |      |  |
| fB%                     | 1.6  |  | 2.4 | 1.8  |  | 1.6  |  |
| BOQ                     | 34.4 |  | 3.0 | 14.3 |  | 93.1 |  |
| QSRatio                 | 5.7  |  | 0.3 | 0.4  |  | 2.3  |  |
| 98th Percentile Output: |      |  |     |      |  |      |  |
| fB%                     | 1.7  |  | 2.9 | 2.0  |  | 1.7  |  |
| BOQ                     | 36.7 |  | 3.7 | 15.9 |  | 98.9 |  |
| QSRatio                 | 6.1  |  | 0.4 | 0.4  |  | 2.5  |  |

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ERROR MESSAGES

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No errors to report.

HCS2000: Signalized Intersections Release 4.1b

Analyst: Jon Storey Inter.: I-24 at US 72  
 Agency: Florence & Hutcheson Area Type: All other areas  
 Date: 6/3/2002 Jurisd: Marion Co.  
 Period: 2027 AM Year : 2002  
 Project ID: Interchange Modification Study  
 E/W St: I-24 Westbound (Ramps) N/S St: US 72

SIGNALIZED INTERSECTION SUMMARY

|            | Eastbound |   |   | Westbound |   |   | Northbound |      |   | Southbound |      |   |
|------------|-----------|---|---|-----------|---|---|------------|------|---|------------|------|---|
|            | L         | T | R | L         | T | R | L          | T    | R | L          | T    | R |
| No. Lanes  | 1         | 0 | 0 | 0         | 0 | 0 | 1          | 2    | 0 | 0          | 1    | 0 |
| LGConfig   | L         |   |   |           |   |   | L          | T    |   |            | T    |   |
| Volume     | 256       |   |   |           |   |   | 80         | 1116 |   |            | 1218 |   |
| Lane Width | 12.0      |   |   |           |   |   | 12.0       | 12.0 |   |            | 12.0 |   |
| RTOR Vol   |           |   |   |           |   |   |            |      |   |            |      |   |

Duration 0.25 Area Type: All other areas

Signal Operations

| Phase Combination | 1    | 2   | 3   | 4   | 5        | 6    | 7   | 8   |
|-------------------|------|-----|-----|-----|----------|------|-----|-----|
| EB Left           | P    |     |     |     | NB Left  | P    | P   |     |
| Thru              |      |     |     |     | Thru     | P    | P   |     |
| Right             |      |     |     |     | Right    |      |     |     |
| Peds              |      |     |     |     | Peds     |      |     |     |
| WB Left           |      |     |     |     | SB Left  |      |     |     |
| Thru              |      |     |     |     | Thru     | P    |     |     |
| Right             |      |     |     |     | Right    |      |     |     |
| Peds              |      |     |     |     | Peds     |      |     |     |
| NB Right          |      |     |     |     | EB Right |      |     |     |
| SB Right          |      |     |     |     | WB Right |      |     |     |
| Green             | 15.0 | 0.0 | 0.0 | 0.0 | 8.0      | 80.0 | 0.0 | 0.0 |
| Yellow            | 3.0  | 0.0 | 0.0 |     | 3.0      | 3.0  | 0.0 |     |
| All Red           | 0.0  | 0.0 | 0.0 |     | 0.0      | 0.0  | 0.0 |     |

Cycle Length: 112.0 secs

Intersection Performance Summary

| Appr/<br>Lane<br>Grp | Lane<br>Group<br>Capacity | Adj Sat<br>Flow Rate<br>(s) | Ratios |      | Lane Group |     | Approach |     |
|----------------------|---------------------------|-----------------------------|--------|------|------------|-----|----------|-----|
|                      |                           |                             | v/c    | g/C  | Delay      | LOS | Delay    | LOS |
| Eastbound            |                           |                             |        |      |            |     |          |     |
| L                    | 226                       | 1687                        | 1.26   | 0.13 | 194.8      | F   | 194.8    | F   |
| Westbound            |                           |                             |        |      |            |     |          |     |
| Northbound           |                           |                             |        |      |            |     |          |     |
| L                    | 327                       | 1687                        | 0.27   | 0.81 | 7.1        | A   |          |     |
| T                    | 2741                      | 3374                        | 0.45   | 0.81 | 3.7        | A   | 3.9      | A   |
| Southbound           |                           |                             |        |      |            |     |          |     |
| T                    | 1269                      | 1776                        | 1.07   | 0.71 | 60.9       | E   | 60.9     | E   |

Intersection Delay = 48.2 (sec/veh) Intersection LOS = D

HCS2000: Signalized Intersections Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-Mail: jstorey@flohut.com

Fax: (615) 399-9049

OPERATIONAL ANALYSIS

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date Performed: 6/3/2002  
 Analysis Time Period: 2027 AM  
 Intersection: I-24 at US 72  
 Area Type: All other areas  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Project ID: Interchange Modification Study

East/West Street North/South Street  
 I-24 Westbound (Ramps) US 72

VOLUME DATA

|              | Eastbound |   |   | Westbound                  |   |   | Northbound |       |   | Southbound |       |   |
|--------------|-----------|---|---|----------------------------|---|---|------------|-------|---|------------|-------|---|
|              | L         | T | R | L                          | T | R | L          | T     | R | L          | T     | R |
| Volume       | 256       |   |   |                            |   |   | 80         | 1116  |   |            | 1218  |   |
| % Heavy Veh  | 7         |   |   |                            |   |   | 7          | 7     |   |            | 7     |   |
| PHF          | 0.90      |   |   |                            |   |   | 0.90       | 0.90  |   |            | 0.90  |   |
| PK 15 Vol    | 71        |   |   |                            |   |   | 22         | 310   |   |            | 338   |   |
| Hi Ln Vol    |           |   |   |                            |   |   |            |       |   |            |       |   |
| % Grade      |           | 0 |   |                            |   |   |            | 0     |   |            | 0     |   |
| Ideal Sat    | 1900      |   |   |                            |   |   | 1900       | 1900  |   |            | 1900  |   |
| ParkExist    |           |   |   |                            |   |   |            |       |   |            |       |   |
| NumPark      |           |   |   |                            |   |   |            |       |   |            |       |   |
| No. Lanes    | 1         | 0 | 0 | 0                          | 0 | 0 | 1          | 2     | 0 | 0          | 1     | 0 |
| LGConfig     | L         |   |   |                            |   |   | L          | T     |   |            | T     |   |
| Lane Width   | 12.0      |   |   |                            |   |   | 12.0       | 12.0  |   |            | 12.0  |   |
| RTOR Vol     |           |   |   |                            |   |   |            |       |   |            |       |   |
| Adj Flow     | 284       |   |   |                            |   |   | 89         | 1240  |   |            | 1353  |   |
| %InSharedLn  |           |   |   |                            |   |   |            |       |   |            |       |   |
| Prop LTs     |           |   |   |                            |   |   | 1.000      | 0.000 |   |            | 0.000 |   |
| Prop RTs     |           |   |   |                            |   |   |            | 0.000 |   |            | 0.000 |   |
| Peds Bikes   |           |   |   | 0                          |   |   |            |       |   |            | 0     |   |
| Buses        | 0         |   |   |                            |   |   | 0          | 0     |   |            | 0     |   |
| %InProtPhase |           |   |   |                            |   |   | 0.0        |       |   |            |       |   |
| Duration     | 0.25      |   |   | Area Type: All other areas |   |   |            |       |   |            |       |   |

OPERATING PARAMETERS

|  | Eastbound |   |   | Westbound |   |   | Northbound |   |   | Southbound |   |   |
|--|-----------|---|---|-----------|---|---|------------|---|---|------------|---|---|
|  | L         | T | R | L         | T | R | L          | T | R | L          | T | R |

|             |       |     |       |       |       |
|-------------|-------|-----|-------|-------|-------|
| Init Unmet  | 0.0   |     | 0.0   | 0.0   | 0.0   |
| Arriv. Type | 3     |     | 3     | 3     | 3     |
| Unit Ext.   | 3.0   |     | 3.0   | 3.0   | 3.0   |
| I Factor    | 1.000 |     | 1.000 | 1.000 | 1.000 |
| Lost Time   | 2.0   |     | 2.0   | 2.0   | 2.0   |
| Ext of g    | 2.0   |     | 2.0   | 2.0   | 2.0   |
| Ped Min g   |       | 3.2 |       |       | 3.2   |

PHASE DATA

| Phase Combination | 1    | 2   | 3   | 4   | 5        | 6    | 7   | 8   |
|-------------------|------|-----|-----|-----|----------|------|-----|-----|
| EB Left           | P    |     |     |     | NB Left  | P    | P   |     |
| Thru              |      |     |     |     | Thru     | P    | P   |     |
| Right             |      |     |     |     | Right    |      |     |     |
| Peds              |      |     |     |     | Peds     |      |     |     |
| WB Left           |      |     |     |     | SB Left  |      |     |     |
| Thru              |      |     |     |     | Thru     | P    |     |     |
| Right             |      |     |     |     | Right    |      |     |     |
| Peds              |      |     |     |     | Peds     |      |     |     |
| NB Right          |      |     |     |     | EB Right |      |     |     |
| SB Right          |      |     |     |     | WB Right |      |     |     |
| Green             | 15.0 | 0.0 | 0.0 | 0.0 | 8.0      | 80.0 | 0.0 | 0.0 |
| Yellow            | 3.0  | 0.0 | 0.0 |     | 3.0      | 3.0  | 0.0 |     |
| All Red           | 0.0  | 0.0 | 0.0 |     | 0.0      | 0.0  | 0.0 |     |

Cycle Length: 112.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

Volume Adjustment

|            | Eastbound |   |   | Westbound |   |   | Northbound |       |   | Southbound |       |   |
|------------|-----------|---|---|-----------|---|---|------------|-------|---|------------|-------|---|
|            | L         | T | R | L         | T | R | L          | T     | R | L          | T     | R |
| Volume, V  | 256       |   |   |           |   |   | 80         | 116   |   |            | 1218  |   |
| PHF        | 0.90      |   |   |           |   |   | 0.90       | 0.90  |   |            | 0.90  |   |
| Adj flow   | 284       |   |   |           |   |   | 89         | 1240  |   |            | 1353  |   |
| No. Lanes  | 1         | 0 | 0 | 0         | 0 | 0 | 1          | 2     | 0 | 0          | 1     | 0 |
| Lane group | L         |   |   |           |   |   | L          | T     |   |            | T     |   |
| Adj flow   | 284       |   |   |           |   |   | 89         | 1240  |   |            | 1353  |   |
| Prop LTs   |           |   |   |           |   |   | 1.000      | 0.000 |   |            | 0.000 |   |
| Prop RTs   |           |   |   |           |   |   |            | 0.000 |   |            | 0.000 |   |

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

|       | Eastbound |   |   | Westbound |   |   | Northbound |       |   | Southbound |       |   |
|-------|-----------|---|---|-----------|---|---|------------|-------|---|------------|-------|---|
|       | L         | T | R | L         | T | R | L          | T     | R | L          | T     | R |
| LG    | L         |   |   |           |   |   | L          | T     |   |            | T     |   |
| So    | 1900      |   |   |           |   |   | 1900       | 1900  |   |            | 1900  |   |
| Lanes | 1         | 0 | 0 | 0         | 0 | 0 | 1          | 2     | 0 | 0          | 1     | 0 |
| fW    | 1.000     |   |   |           |   |   | 1.000      | 1.000 |   |            | 1.000 |   |
| fHV   | 0.935     |   |   |           |   |   | 0.935      | 0.935 |   |            | 0.935 |   |
| fG    | 1.000     |   |   |           |   |   | 1.000      | 1.000 |   |            | 1.000 |   |
| fP    | 1.000     |   |   |           |   |   | 1.000      | 1.000 |   |            | 1.000 |   |

|      |       |  |       |       |       |
|------|-------|--|-------|-------|-------|
| fBB  | 1.000 |  | 1.000 | 1.000 | 1.000 |
| fA   | 1.00  |  | 1.00  | 1.00  | 1.00  |
| fLU  | 1.00  |  | 1.00  | 0.95  | 1.00  |
| fRT  |       |  |       | 1.000 | 1.000 |
| fLT  | 0.950 |  | 0.950 | 1.000 | 1.000 |
| Sec. |       |  | 0.157 |       |       |
| fLpb | 1.000 |  | 1.000 | 1.000 | 1.000 |
| fRpb |       |  |       | 1.000 | 1.000 |
| S    | 1687  |  | 1687  | 3374  | 1776  |
| Sec. |       |  | 278   |       |       |

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

| Appr/<br>Mvmt | Lane<br>Group | Adj<br>Flow Rate<br>(v) | Adj Sat<br>Flow Rate<br>(s) | Flow<br>Ratio<br>(v/s) | Green<br>Ratio<br>(g/C) | --Lane Group--<br>Capacity<br>(c) | v/c<br>Ratio |
|---------------|---------------|-------------------------|-----------------------------|------------------------|-------------------------|-----------------------------------|--------------|
| Eastbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left L        | 284                     | 1687                        | # 0.17                 | 0.13                    | 226                               | 1.26         |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Westbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Northbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          | 89                      | 1687                        | # 0.05                 | 0.071                   | 121                               | 0.74         |
|               | Perm          | 0                       | 278                         | 0.00                   | 0.741                   | 206                               | 0.00         |
|               | Left L        | 89                      |                             |                        | 0.81                    | 327                               | 0.27         |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru T        | 1240                    | 3374                        | 0.37                   | 0.81                    | 2741                              | 0.45         |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Southbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru T        | 1353                    | 1776                        | # 0.76                 | 0.71                    | 1269                              | 1.07         |
|               | Right         |                         |                             |                        |                         |                                   |              |

Sum of flow ratios for critical lane groups,  $Y_c = \text{Sum (v/s)} = 0.98$   
Total lost time per cycle,  $L = 9.00$  sec  
Critical flow rate to capacity ratio,  $X_c = (Y_c) (C) / (C-L) = 1.07$

Control Delay and LOS Determination

| Appr/<br>Lane | Ratios | Unf<br>Del | Prog<br>Adj | Lane<br>Grp | Incremental<br>Factor | Res<br>Del | Lane Group | Approach |
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|

| Grp   | v/c  | g/C  | d1   | Fact  | Cap  | k    | d2    | d3  | Delay | LOS | Delay | LOS |
|---|------|------|------|-------|------|------|-------|-----|-------|-----|-------|-----|
| Eastbound   |      |      |      |       |      |      |       |     |       |     |       |     |
| L   | 1.26 | 0.13 | 48.5 | 1.000 | 226  | 0.50 | 146.3 | 0.0 | 194.8 | F   | 194.8 | F   |
| Westbound   |      |      |      |       |      |      |       |     |       |     |       |     |
| Northbound  |      |      |      |       |      |      |       |     |       |     |       |     |
| L   | 0.27 | 0.81 | 5.1  | 1.000 | 327  | 0.50 | 2.0   | 0.0 | 7.1   | A   |       |     |
| T   | 0.45 | 0.81 | 3.1  | 1.000 | 2741 | 0.50 | 0.5   | 0.0 | 3.7   | A   | 3.9   | A   |
| Southbound  |      |      |      |       |      |      |       |     |       |     |       |     |
| T   | 1.07 | 0.71 | 16.0 | 1.000 | 1269 | 0.50 | 44.9  | 0.0 | 60.9  | E   | 60.9  | E   |
| Intersection delay = 48.2 (sec/veh)      Intersection LOS = D |      |      |      |       |      |      |       |     |       |     |       |     |

SUPPLEMENTAL PERMITTED LT WORKSHEET  
for exclusive lefts

| Input  | EB    | WB | NB    | SB   |
|--|-------|----|-------|------|
| Cycle length, C  |       |    |       |      |
| Total actual green time for LT lane group, G (s)                             | 112.0 |    |       |      |
| Effective permitted green time for LT lane group, g(s)                       |       |    | 91.0  |      |
| Opposing effective green time, go (s)  |       |    | 80.0  |      |
| Number of lanes in LT lane group, N  |       |    | 1     |      |
| Number of lanes in opposing approach, No                                     |       |    | 1     |      |
| Adjusted LT flow rate, VLT (veh/h)   |       |    | 89    |      |
| Proportion of LT in LT lane group, PLT                                       |       |    | 1.000 |      |
| Proportion of LT in opposing flow, PLTo                                      |       |    | 0.00  |      |
| Adjusted opposing flow rate, Vo (veh/h)                                      |       |    | 1353  |      |
| Lost time for LT lane group, tL  |       |    | 3.00  |      |
| Computation  |       |    |       |      |
| LT volume per cycle, LTC=VLTC/3600   |       |    | 2.77  |      |
| Opposing lane util. factor, fLUo   |       |    | 1.00  | 0.95 |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)                          |       |    | 42.09 |      |
| gf=G[exp(- a * (LTC ** b))]-tL, gf<=g  |       |    | 0.0   |      |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)                            |       |    | 1.00  |      |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]                                 |       |    | 0.29  |      |
| gq, (see Exhibit C16-4,5,6,7,8)  |       |    | 22.61 |      |
| gu=g-gq if gq>=gf, or = g-gf if gq<gf  |       |    | 60.39 |      |
| n=Max(gq-gf)/2,0)  |       |    | 11.31 |      |
| PTHo=1-PLTo  |       |    | 1.00  |      |
| PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]   |       |    | 1.00  |      |
| EL1 (refer to Exhibit C16-3)   |       |    | 4.64  |      |
| EL2=Max((1-Ptho**n)/Plto, 1.0)   |       |    |       |      |
| fmin=2(1+PL)/g or fmin=2(1+Pl)/g   |       |    | 0.05  |      |
| gdiff=max(gq-gf,0)   |       |    | 0.00  |      |
| fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)                          |       |    | 0.16  |      |
| flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)], (fmin<=fm<=1.00) |       |    |       |      |
| or flt=[fm+0.91(N-1)]/N**  |       |    |       |      |

Left-turn adjustment, fLT

0.157

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET

for shared lefts

Input

|   | EB | WB | NB    | SB    |
|---|----|----|-------|-------|
| Cycle length, C   |    |    |       |       |
| Total actual green time for LT lane group, G (s)  |    |    |       |       |
| Effective permitted green time for LT lane group, g(s)  |    |    |       |       |
| Opposing effective green time, go (s)   |    |    |       |       |
| Number of lanes in LT lane group, N   |    |    |       |       |
| Number of lanes in opposing approach, No  |    |    |       |       |
| Adjusted LT flow rate, VLT (veh/h)  |    |    |       |       |
| Proportion of LT in LT lane group, PLT  |    |    | 0.000 | 0.000 |
| Proportion of LT in opposing flow, PLTo   |    |    |       |       |
| Adjusted opposing flow rate, Vo (veh/h)   |    |    |       |       |
| Lost time for LT lane group, tL   |    |    |       |       |
| Computation   |    |    |       |       |
| LT volume per cycle, LTC=VLTC/3600  |    |    |       |       |
| Opposing lane util. factor, fLUo  |    |    | 1.00  | 0.95  |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)   |    |    |       |       |
| $gf = G[\exp(-a * (LTC ** b))] - tL$ , $gf \leq g$  |    |    |       |       |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)   |    |    |       |       |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]  |    |    |       |       |
| gq, (see Exhibit C16-4,5,6,7,8)   |    |    |       |       |
| $gu = g - gq$ if $gq \geq gf$ , or $= g - gf$ if $gq < gf$  |    |    |       |       |
| $n = \text{Max}(gq - gf) / 2, 0$  |    |    |       |       |
| $PTHo = 1 - PLTo$   |    |    |       |       |
| $PL* = PLT[1 + (N-1)g / (gf + gu / EL1 + 4.24)]$  |    |    |       |       |
| EL1 (refer to Exhibit C16-3)  |    |    |       |       |
| $EL2 = \text{Max}((1 - Ptho ** n) / Plto, 1.0)$   |    |    |       |       |
| $fmin = 2(1 + PL) / g$ or $fmin = 2(1 + Pl) / g$  |    |    |       |       |
| $gdiff = \text{max}(gq - gf, 0)$  |    |    |       |       |
| $fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)]$ , (min=fmin;max=1.00)                                    |    |    |       |       |
| $flt = fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)] + [gdiff/g] / [1 + PL(EL2 - 1)]$ , (fmin<=fm<=1.00) |    |    |       |       |
| or $flt = [fm + 0.91(N-1)] / N **$  |    |    |       |       |
| Left-turn adjustment, fLT   |    |    |       |       |

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns

| EB | WB | NB | SB |
|----|----|----|----|
|----|----|----|----|

Effective pedestrian green time, gp (s)  
 Conflicting pedestrian volume, Vped (p/h)  
 Pedestrian flow rate, Vpedg (p/h)  
 OCCpedg  
 Opposing queue clearing green, gq (s)  
 Eff. ped. green consumed by opp. veh. queue, gq/gp  
 OCCpedu  
 Opposing flow rate, Vo (veh/h)  
 OCCr  
 Number of cross-street receiving lanes, Nrec  
 Number of turning lanes, Nturn  
 ApbT  
 Proportion of left turns, PLT  
 Proportion of left turns using protected phase, PLTA  
 Left-turn adjustment, fLpb  
 Permitted Right Turns  
 Effective pedestrian green time, gp (s)  
 Conflicting pedestrian volume, Vped (p/h)  
 Conflicting bicycle volume, Vbic (bicycles/h)  
 Vpedg  
 OCCpedg  
 Effective green, g (s)  
 Vbicg  
 OCCbicg  
 OCCr  
 Number of cross-street receiving lanes, Nrec  
 Number of turning lanes, Nturn  
 ApbT  
 Proportion right-turns, PRT  
 Proportion right-turns using protected phase, PRTA  
 Right turn adjustment, fRpb

SUPPLEMENTAL UNIFORM DELAY WORKSHEET

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|   |       | EBLT | WBLT | NBLT  | SBLT |
|---|-------|------|------|-------|------|
| Cycle length, C                                     | 112.0 |      |      |       |      |
| Adj. LT vol from Vol Adjustment Worksheet, v        |       |      |      | 89    |      |
| v/c ratio from Capacity Worksheet, X                |       |      |      | 0.27  |      |
| Protected phase effective green interval, g (s)     |       |      |      | 8.0   |      |
| Opposing queue effective green interval, gq         |       |      |      | 22.61 |      |
| Unopposed green interval, gu                        |       |      |      | 60.39 |      |
| Red time r=(C-g-gq-gu)                              |       |      |      | 21.0  |      |
| Arrival rate, qa=v/(3600(max[X,1.0]))               |       |      |      | 0.02  |      |
| Protected ph. departure rate, Sp=s/3600             |       |      |      | 0.469 |      |
| Permitted ph. departure rate, Ss=s(gq+gu)/(gu*3600) |       |      |      | 0.11  |      |
| XPerm   |       |      |      | 0.32  |      |
| XProt   |       |      |      | 0.19  |      |
| Case  |       |      |      | 1     |      |
| Queue at beginning of green arrow, Qa               |       |      |      | 0.52  |      |
| Queue at beginning of unsaturated green, Qu         |       |      |      | 0.56  |      |
| Residual queue, Qr                                  |       |      |      | 0.00  |      |
| Uniform Delay, dl                                   |       |      |      | 5.1   |      |

DELAY/LOS WORKSHEET WITH INITIAL QUEUE

---

|       | Initial Dur. | Uniform Delay | Initial Queue | Final Queue | Initial Lane | Lane Group |
|-------|--------------|---------------|---------------|-------------|--------------|------------|
| Appr/ | Unmet        | Unmet         | Unmet         | Unmet       | Unmet        | Unmet      |

| Lane Group | Demand Q veh | Demand t hrs. | Unadj. ds | Adj. dl sec | Param. u | Demand Q veh | Delay d3 sec | Delay d sec |
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|

Eastbound

Westbound

Northbound

Southbound

---

Intersection Delay 48.2 sec/veh      Intersection LOS D

BACK OF QUEUE WORKSHEET

|                         | Eastbound |       |   | Westbound |   |   | Northbound |       |   | Southbound |   |   |
|-------------------------|-----------|-------|---|-----------|---|---|------------|-------|---|------------|---|---|
| LaneGroup               | L         |       |   |           |   |   | L          | T     |   | T          |   |   |
| Init Queue              | 0.0       |       |   |           |   |   | 0.0        | 0.0   |   | 0.0        |   |   |
| Flow Rate               | 284       |       |   |           |   |   | 89         | 620   |   | 1353       |   |   |
| So                      | 1900      |       |   |           |   |   | 1900       | 1900  |   | 1900       |   |   |
| No.Lanes                | 1         | 0     | 0 | 0         | 0 | 0 | 1          | 2     | 0 | 0          | 1 | 0 |
| SL                      | 1687      |       |   |           |   |   | 1687       | 1687  |   | 1776       |   |   |
| LnCapacity              | 226       |       |   |           |   |   | 327        | 1370  |   | 1269       |   |   |
| Flow Ratio              | 0.17      |       |   |           |   |   | 0.05       | 0.37  |   | 0.76       |   |   |
| v/c Ratio               | 1.26      |       |   |           |   |   | 0.27       | 0.45  |   | 1.07       |   |   |
| Grn Ratio               | 0.13      |       |   |           |   |   | 0.81       | 0.81  |   | 0.71       |   |   |
| I Factor                |           | 1.000 |   |           |   |   |            | 1.000 |   | 1.000      |   |   |
| AT or PVG               | 3         |       |   |           |   |   | 3          | 3     |   | 3          |   |   |
| Pltn Ratio              | 1.00      |       |   |           |   |   | 1.00       | 1.00  |   | 1.00       |   |   |
| PF2                     | 1.00      |       |   |           |   |   | 1.00       | 1.00  |   | 1.00       |   |   |
| Q1                      | 8.8       |       |   |           |   |   | 0.5        | 5.7   |   | 42.1       |   |   |
| kB                      | 0.5       |       |   |           |   |   | 1.7        | 1.7   |   | 1.6        |   |   |
| Q2                      | 9.1       |       |   |           |   |   | 0.6        | 1.4   |   | 22.4       |   |   |
| Q Average               | 17.9      |       |   |           |   |   | 1.1        | 7.1   |   | 64.5       |   |   |
| Q Spacing               | 24.9      |       |   |           |   |   | 24.9       | 24.9  |   | 24.9       |   |   |
| Q Storage               | 150       |       |   |           |   |   | 250        | 1000  |   | 1000       |   |   |
| Q S Ratio               | 3.0       |       |   |           |   |   | 0.1        | 0.2   |   | 1.6        |   |   |
| 70th Percentile Output: |           |       |   |           |   |   |            |       |   |            |   |   |
| fB%                     | 1.2       |       |   |           |   |   | 1.3        | 1.2   |   | 1.2        |   |   |
| BOQ                     | 21.6      |       |   |           |   |   | 1.5        | 8.7   |   | 77.4       |   |   |
| QSRatio                 | 3.6       |       |   |           |   |   | 0.1        | 0.2   |   | 1.9        |   |   |
| 85th Percentile Output: |           |       |   |           |   |   |            |       |   |            |   |   |
| fB%                     | 1.4       |       |   |           |   |   | 1.6        | 1.5   |   | 1.4        |   |   |
| BOQ                     | 25.2      |       |   |           |   |   | 1.9        | 10.4  |   | 90.3       |   |   |

|                         |      |  |     |      |  |       |  |
|-------------------------|------|--|-----|------|--|-------|--|
| QSRatio                 | 4.2  |  | 0.2 | 0.3  |  | 2.2   |  |
| 90th Percentile Output: |      |  |     |      |  |       |  |
| fB%                     | 1.5  |  | 1.9 | 1.6  |  | 1.5   |  |
| BOQ                     | 27.1 |  | 2.2 | 11.5 |  | 96.7  |  |
| QSRatio                 | 4.5  |  | 0.2 | 0.3  |  | 2.4   |  |
| 95th Percentile Output: |      |  |     |      |  |       |  |
| fB%                     | 1.6  |  | 2.4 | 1.8  |  | 1.6   |  |
| BOQ                     | 29.2 |  | 2.7 | 13.0 |  | 103.2 |  |
| QSRatio                 | 4.8  |  | 0.3 | 0.3  |  | 2.6   |  |
| 98th Percentile Output: |      |  |     |      |  |       |  |
| fB%                     | 1.7  |  | 2.9 | 2.1  |  | 1.7   |  |
| BOQ                     | 31.2 |  | 3.3 | 14.6 |  | 109.6 |  |
| QSRatio                 | 5.2  |  | 0.3 | 0.4  |  | 2.7   |  |

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ERROR MESSAGES

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No errors to report.

HCS2000: Signalized Intersections Release 4.1b

Analyst: Jon Storey Inter.: I-24 at US 72  
 Agency: Florence & Hutcheson Area Type: All other areas  
 Date: 6/3/2002 Jurisd: Marion Co.  
 Period: 2027 PM Year : 2002  
 Project ID: Interchange Modification Study  
 E/W St: I-24 Westbound (Ramps) N/S St: US 72

SIGNALIZED INTERSECTION SUMMARY

|            | Eastbound |   |   | Westbound |   |   | Northbound |      |   | Southbound |      |   |
|------------|-----------|---|---|-----------|---|---|------------|------|---|------------|------|---|
|            | L         | T | R | L         | T | R | L          | T    | R | L          | T    | R |
| No. Lanes  | 1         | 0 | 0 | 0         | 0 | 0 | 1          | 2    | 0 | 0          | 1    | 0 |
| LGConfig   | L         |   |   |           |   |   | L          | T    |   |            | T    |   |
| Volume     | 506       |   |   |           |   |   | 112        | 1466 |   |            | 1629 |   |
| Lane Width | 12.0      |   |   |           |   |   | 12.0       | 12.0 |   |            | 12.0 |   |
| RTOR Vol   |           |   |   |           |   |   |            |      |   |            |      |   |

Duration 0.25 Area Type: All other areas

Signal Operations

| Phase Combination | 1    | 2   | 3   | 4   | 5        | 6     | 7   | 8   |
|-------------------|------|-----|-----|-----|----------|-------|-----|-----|
| EB Left           | P    |     |     |     | NB Left  | P     | P   |     |
| Thru              |      |     |     |     | Thru     | P     | P   |     |
| Right             |      |     |     |     | Right    |       |     |     |
| Peds              |      |     |     |     | Peds     |       |     |     |
| WB Left           |      |     |     |     | SB Left  |       |     |     |
| Thru              |      |     |     |     | Thru     | P     |     |     |
| Right             |      |     |     |     | Right    |       |     |     |
| Peds              |      |     |     |     | Peds     |       |     |     |
| NB Right          |      |     |     |     | EB Right |       |     |     |
| SB Right          |      |     |     |     | WB Right |       |     |     |
| Green             | 25.0 | 0.0 | 0.0 | 0.0 | 8.0      | 100.0 | 0.0 | 0.0 |
| Yellow            | 3.0  | 0.0 | 0.0 |     | 3.0      | 3.0   | 0.0 |     |
| All Red           | 0.0  | 0.0 | 0.0 |     | 0.0      | 0.0   | 0.0 |     |

Cycle Length: 142.0 secs

Intersection Performance Summary

| Appr/<br>Lane<br>Grp | Lane<br>Group<br>Capacity | Adj Sat<br>Flow Rate<br>(s) | Ratios<br>v/c g/C |      | Lane Group<br>Delay LOS |   | Approach<br>Delay LOS |   |
|----------------------|---------------------------|-----------------------------|-------------------|------|-------------------------|---|-----------------------|---|
| Eastbound            |                           |                             |                   |      |                         |   |                       |   |
| L                    | 297                       | 1687                        | 1.89              | 0.18 | 472.5                   | F | 472.5                 | F |
| Westbound            |                           |                             |                   |      |                         |   |                       |   |
| Northbound           |                           |                             |                   |      |                         |   |                       |   |
| L                    | 213                       | 1687                        | 0.58              | 0.78 | 23.5                    | C |                       |   |
| T                    | 2637                      | 3374                        | 0.62              | 0.78 | 7.6                     | A | 8.8                   | A |
| Southbound           |                           |                             |                   |      |                         |   |                       |   |
| T                    | 1251                      | 1776                        | 1.45              | 0.70 | 226.6                   | F | 226.6                 | F |

Intersection Delay = 167.5 (sec/veh)      Intersection LOS = F

HCS2000: Signalized Intersections Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-Mail: jstorey@flohut.com

Fax: (615) 399-9049

OPERATIONAL ANALYSIS

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date Performed: 6/3/2002  
 Analysis Time Period: 2027 PM  
 Intersection: I-24 at US 72  
 Area Type: All other areas  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Project ID: Interchange Modification Study

East/West Street      North/South Street  
 I-24 Westbound (Ramps)      US 72

VOLUME DATA

|              | Eastbound |   |   | Westbound                  |   |   | Northbound |       |   | Southbound |       |   |
|--------------|-----------|---|---|----------------------------|---|---|------------|-------|---|------------|-------|---|
|              | L         | T | R | L                          | T | R | L          | T     | R | L          | T     | R |
| Volume       | 506       |   |   |                            |   |   | 112        | 1466  |   |            | 1629  |   |
| % Heavy Veh  | 7         |   |   |                            |   |   | 7          | 7     |   |            | 7     |   |
| PHF          | 0.90      |   |   |                            |   |   | 0.90       | 0.90  |   |            | 0.90  |   |
| PK 15 Vol    | 141       |   |   |                            |   |   | 31         | 407   |   |            | 453   |   |
| Hi Ln Vol    |           |   |   |                            |   |   |            |       |   |            |       |   |
| % Grade      |           | 0 |   |                            |   |   |            | 0     |   |            | 0     |   |
| Ideal Sat    | 1900      |   |   |                            |   |   | 1900       | 1900  |   |            | 1900  |   |
| ParkExist    |           |   |   |                            |   |   |            |       |   |            |       |   |
| NumPark      |           |   |   |                            |   |   |            |       |   |            |       |   |
| No. Lanes    | 1         | 0 | 0 | 0                          | 0 | 0 | 1          | 2     | 0 | 0          | 1     | 0 |
| LGConfig     | L         |   |   |                            |   |   | L          | T     |   |            | T     |   |
| Lane Width   | 12.0      |   |   |                            |   |   | 12.0       | 12.0  |   |            | 12.0  |   |
| RTOR Vol     |           |   |   |                            |   |   |            |       |   |            |       |   |
| Adj Flow     | 562       |   |   |                            |   |   | 124        | 1629  |   |            | 1810  |   |
| %InSharedLn  |           |   |   |                            |   |   |            |       |   |            |       |   |
| Prop LTs     |           |   |   |                            |   |   | 1.000      | 0.000 |   |            | 0.000 |   |
| Prop RTs     |           |   |   |                            |   |   |            | 0.000 |   |            | 0.000 |   |
| Peds Bikes   |           |   |   | 0                          |   |   |            |       |   |            | 0     |   |
| Buses        | 0         |   |   |                            |   |   | 0          | 0     |   |            | 0     |   |
| %InProtPhase |           |   |   |                            |   |   | 0.0        |       |   |            |       |   |
| Duration     | 0.25      |   |   | Area Type: All other areas |   |   |            |       |   |            |       |   |

OPERATING PARAMETERS

|  | Eastbound |   |   | Westbound |   |   | Northbound |   |   | Southbound |   |   |
|--|-----------|---|---|-----------|---|---|------------|---|---|------------|---|---|
|  | L         | T | R | L         | T | R | L          | T | R | L          | T | R |

|             |       |     |       |       |       |
|-------------|-------|-----|-------|-------|-------|
| Init Unmet  | 0.0   |     | 0.0   | 0.0   | 0.0   |
| Arriv. Type | 3     |     | 3     | 3     | 3     |
| Unit Ext.   | 3.0   |     | 3.0   | 3.0   | 3.0   |
| I Factor    | 1.000 |     | 1.000 | 1.000 | 1.000 |
| Lost Time   | 2.0   |     | 2.0   | 2.0   | 2.0   |
| Ext of g    | 2.0   |     | 2.0   | 2.0   | 2.0   |
| Ped Min g   |       | 3.2 |       |       | 3.2   |

PHASE DATA

| Phase Combination | 1    | 2   | 3   | 4   | 5        | 6     | 7   | 8   |
|-------------------|------|-----|-----|-----|----------|-------|-----|-----|
| EB Left           | P    |     |     |     | NB Left  | P     | P   |     |
| Thru              |      |     |     |     | Thru     | P     | P   |     |
| Right             |      |     |     |     | Right    |       |     |     |
| Peds              |      |     |     |     | Peds     |       |     |     |
| WB Left           |      |     |     |     | SB Left  |       |     |     |
| Thru              |      |     |     |     | Thru     | P     |     |     |
| Right             |      |     |     |     | Right    |       |     |     |
| Peds              |      |     |     |     | Peds     |       |     |     |
| NB Right          |      |     |     |     | EB Right |       |     |     |
| SB Right          |      |     |     |     | WB Right |       |     |     |
| Green             | 25.0 | 0.0 | 0.0 | 0.0 | 8.0      | 100.0 | 0.0 | 0.0 |
| Yellow            | 3.0  | 0.0 | 0.0 |     | 3.0      | 3.0   | 0.0 |     |
| All Red           | 0.0  | 0.0 | 0.0 |     | 0.0      | 0.0   | 0.0 |     |

Cycle Length: 142.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

| Volume Adjustment | Eastbound |   |   | Westbound |   |   | Northbound |       |   | Southbound |       |   |
|-------------------|-----------|---|---|-----------|---|---|------------|-------|---|------------|-------|---|
|                   | L         | T | R | L         | T | R | L          | T     | R | L          | T     | R |
| Volume, V         | 506       |   |   |           |   |   | 112        | 1466  |   |            | 1629  |   |
| PHF               | 0.90      |   |   |           |   |   | 0.90       | 0.90  |   |            | 0.90  |   |
| Adj flow          | 562       |   |   |           |   |   | 124        | 1629  |   |            | 1810  |   |
| No. Lanes         | 1         | 0 | 0 | 0         | 0 | 0 | 1          | 2     | 0 | 0          | 1     | 0 |
| Lane group        | L         |   |   |           |   |   | L          | T     |   |            | T     |   |
| Adj flow          | 562       |   |   |           |   |   | 124        | 1629  |   |            | 1810  |   |
| Prop LTs          |           |   |   |           |   |   | 1.000      | 0.000 |   |            | 0.000 |   |
| Prop RTs          |           |   |   |           |   |   |            | 0.000 |   |            | 0.000 |   |

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

| LG    | Eastbound |   |   | Westbound |   |   | Northbound |       |   | Southbound |       |   |
|-------|-----------|---|---|-----------|---|---|------------|-------|---|------------|-------|---|
|       | L         | T | R | L         | T | R | L          | T     | R | L          | T     | R |
| So    | 1900      |   |   |           |   |   | 1900       | 1900  |   |            | 1900  |   |
| Lanes | 1         | 0 | 0 | 0         | 0 | 0 | 1          | 2     | 0 | 0          | 1     | 0 |
| fW    | 1.000     |   |   |           |   |   | 1.000      | 1.000 |   |            | 1.000 |   |
| fHV   | 0.935     |   |   |           |   |   | 0.935      | 0.935 |   |            | 0.935 |   |
| fG    | 1.000     |   |   |           |   |   | 1.000      | 1.000 |   |            | 1.000 |   |
| fP    | 1.000     |   |   |           |   |   | 1.000      | 1.000 |   |            | 1.000 |   |

|      |       |  |       |       |  |       |
|------|-------|--|-------|-------|--|-------|
| fBB  | 1.000 |  | 1.000 | 1.000 |  | 1.000 |
| fA   | 1.00  |  | 1.00  | 1.00  |  | 1.00  |
| fLU  | 1.00  |  | 1.00  | 0.95  |  | 1.00  |
| fRT  |       |  |       | 1.000 |  | 1.000 |
| fLT  | 0.950 |  | 0.950 | 1.000 |  | 1.000 |
| Sec. |       |  | 0.091 |       |  |       |
| fLpb | 1.000 |  | 1.000 | 1.000 |  | 1.000 |
| fRpb |       |  |       | 1.000 |  | 1.000 |
| S    | 1687  |  | 1687  | 3374  |  | 1776  |
| Sec. |       |  | 162   |       |  |       |

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

| Appr/<br>Mvmt | Lane<br>Group | Adj<br>Flow Rate<br>(v) | Adj Sat<br>Flow Rate<br>(s) | Flow<br>Ratio<br>(v/s) | Green<br>Ratio<br>(g/C) | --Lane Group--<br>Capacity<br>(c) | v/c<br>Ratio |
|---------------|---------------|-------------------------|-----------------------------|------------------------|-------------------------|-----------------------------------|--------------|
| Eastbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left L        | 562                     | 1687                        | # 0.33                 | 0.18                    | 297                               | 1.89         |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Westbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Northbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          | 95                      | 1687                        | # 0.06                 | 0.056                   | 95                                | 1.00         |
|               | Perm          | 29                      | 162                         | 0.18                   | 0.725                   | 118                               | 0.25         |
|               | Left L        | 124                     |                             |                        | 0.78                    | 213                               | 0.58         |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru T        | 1629                    | 3374                        | 0.48                   | 0.78                    | 2637                              | 0.62         |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Southbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru T        | 1810                    | 1776                        | # 1.02                 | 0.70                    | 1251                              | 1.45         |
|               | Right         |                         |                             |                        |                         |                                   |              |

Sum of flow ratios for critical lane groups,  $Y_c = \text{Sum (v/s)} = 1.41$   
Total lost time per cycle,  $L = 9.00 \text{ sec}$   
Critical flow rate to capacity ratio,  $X_c = (Y_c) (C) / (C-L) = 1.50$

Control Delay and LOS Determination

| Appr/<br>Lane | Ratios | Unf<br>Del | Prog<br>Adj | Lane<br>Grp | Incremental<br>Factor | Res<br>Del | Lane Group | Approach |
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|

| Grp                                  | v/c  | g/C  | d1   | Fact  | Cap  | k                    | d2    | d3  | Delay | LOS | Delay | LOS |
|--------------------------------------|------|------|------|-------|------|----------------------|-------|-----|-------|-----|-------|-----|
| Eastbound                            |      |      |      |       |      |                      |       |     |       |     |       |     |
| L                                    | 1.89 | 0.18 | 58.5 | 1.000 | 297  | 0.50                 | 414.0 | 0.0 | 472.5 | F   | 472.5 | F   |
| Westbound                            |      |      |      |       |      |                      |       |     |       |     |       |     |
| Northbound                           |      |      |      |       |      |                      |       |     |       |     |       |     |
| L                                    | 0.58 | 0.78 | 12.4 | 1.000 | 213  | 0.50                 | 11.1  | 0.0 | 23.5  | C   |       |     |
| T                                    | 0.62 | 0.78 | 6.5  | 1.000 | 2637 | 0.50                 | 1.1   | 0.0 | 7.6   | A   | 8.8   | A   |
| Southbound                           |      |      |      |       |      |                      |       |     |       |     |       |     |
| T                                    | 1.45 | 0.70 | 21.0 | 1.000 | 1251 | 0.50                 | 205.6 | 0.0 | 226.6 | F   | 226.6 | F   |
| Intersection delay = 167.5 (sec/veh) |      |      |      |       |      | Intersection LOS = F |       |     |       |     |       |     |

SUPPLEMENTAL PERMITTED LT WORKSHEET

for exclusive lefts

| Input  | EB    | WB | NB    | SB   |
|--|-------|----|-------|------|
| Cycle length, C  |       |    |       |      |
| Total actual green time for LT lane group, G (s)                             | 142.0 |    |       |      |
| Effective permitted green time for LT lane group, g(s)                       |       |    | 111.0 |      |
| Opposing effective green time, go (s)  |       |    | 103.0 |      |
| Number of lanes in LT lane group, N  |       |    | 1     |      |
| Number of lanes in opposing approach, No                                     |       |    | 1     |      |
| Adjusted LT flow rate, VLT (veh/h)   |       |    | 124   |      |
| Proportion of LT in LT lane group, PLT                                       |       |    | 1.000 |      |
| Proportion of LT in opposing flow, PLTo                                      |       |    | 0.00  |      |
| Adjusted opposing flow rate, Vo (veh/h)                                      |       |    | 1810  |      |
| Lost time for LT lane group, tL  |       |    | 3.00  |      |
| Computation  |       |    |       |      |
| LT volume per cycle, LTC=VLTC/3600   |       |    | 4.89  |      |
| Opposing lane util. factor, fLUo   |       |    | 1.00  | 0.95 |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)                          |       |    | 71.39 |      |
| gf=G[exp(- a * (LTC ** b))]-tL, gf<=g  |       |    | 0.0   |      |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)                            |       |    | 1.00  |      |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]                                 |       |    | 0.30  |      |
| gq, (see Exhibit C16-4,5,6,7,8)  |       |    | 35.09 |      |
| gu=g-gq if gq>=gf, or = g-gf if gq<gf  |       |    | 67.91 |      |
| n=Max(gq-gf)/2,0)  |       |    | 17.54 |      |
| PTHo=1-PLTo  |       |    | 1.00  |      |
| PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]   |       |    | 1.00  |      |
| EL1 (refer to Exhibit C16-3)   |       |    | 7.22  |      |
| EL2=Max((1-Ptho**n)/Plto, 1.0)   |       |    |       |      |
| fmin=2(1+PL)/g or fmin=2(1+Pl)/g   |       |    | 0.04  |      |
| gdiff=max(gq-gf,0)   |       |    | 0.00  |      |
| fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)                          |       |    | 0.09  |      |
| flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)], (fmin<=fm<=1.00) |       |    |       |      |
| or flt=[fm+0.91(N-1)]/N**  |       |    |       |      |

Left-turn adjustment, fLT

0.091

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET

for shared lefts

Input

|   | EB | WB | NB    | SB    |
|---|----|----|-------|-------|
| Cycle length, C   |    |    |       |       |
| Total actual green time for LT lane group, G (s)  |    |    |       |       |
| Effective permitted green time for LT lane group, g(s)  |    |    |       |       |
| Opposing effective green time, go (s)   |    |    |       |       |
| Number of lanes in LT lane group, N   |    |    |       |       |
| Number of lanes in opposing approach, No  |    |    |       |       |
| Adjusted LT flow rate, VLT (veh/h)  |    |    |       |       |
| Proportion of LT in LT lane group, PLT  |    |    | 0.000 | 0.000 |
| Proportion of LT in opposing flow, PLTo   |    |    |       |       |
| Adjusted opposing flow rate, Vo (veh/h)   |    |    |       |       |
| Lost time for LT lane group, tL   |    |    |       |       |
| Computation   |    |    |       |       |
| LT volume per cycle, LTC=VLTC/3600  |    |    |       |       |
| Opposing lane util. factor, fLUo  |    |    | 1.00  | 0.95  |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)   |    |    |       |       |
| $gf = G[\exp(-a * (LTC ** b))] - tL$ , $gf \leq g$  |    |    |       |       |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)   |    |    |       |       |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]  |    |    |       |       |
| gq, (see Exhibit C16-4,5,6,7,8)   |    |    |       |       |
| $gu = g - gq$ if $gq \geq gf$ , or $= g - gf$ if $gq < gf$  |    |    |       |       |
| $n = \text{Max}(gq - gf) / 2, 0$  |    |    |       |       |
| $PTHo = 1 - PLTo$   |    |    |       |       |
| $PL* = PLT[1 + (N-1)g / (gf + gu / EL1 + 4.24)]$  |    |    |       |       |
| EL1 (refer to Exhibit C16-3)  |    |    |       |       |
| $EL2 = \text{Max}((1 - Ptho ** n) / Plto, 1.0)$   |    |    |       |       |
| $fmin = 2(1 + PL) / g$ or $fmin = 2(1 + Pl) / g$  |    |    |       |       |
| $gdiff = \text{max}(gq - gf, 0)$  |    |    |       |       |
| $fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)]$ , (min=fmin;max=1.00)                                    |    |    |       |       |
| $flt = fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)] + [gdiff/g] / [1 + PL(EL2 - 1)]$ , (fmin<=fm<=1.00) |    |    |       |       |
| or $flt = [fm + 0.91(N-1)] / N **$  |    |    |       |       |
| Left-turn adjustment, fLT   |    |    |       |       |

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns

| EB | WB | NB | SB |
|----|----|----|----|
|----|----|----|----|

Effective pedestrian green time,  $g_p$  (s)  
 Conflicting pedestrian volume,  $V_{ped}$  (p/h)  
 Pedestrian flow rate,  $V_{pedg}$  (p/h)  
 $OCC_{pedg}$   
 Opposing queue clearing green,  $g_q$  (s)  
 Eff. ped. green consumed by opp. veh. queue,  $g_q/g_p$   
 $OCC_{pedu}$   
 Opposing flow rate,  $V_o$  (veh/h)  
 $OCC_r$   
 Number of cross-street receiving lanes,  $N_{rec}$   
 Number of turning lanes,  $N_{turn}$   
 $ApbT$   
 Proportion of left turns,  $PLT$   
 Proportion of left turns using protected phase,  $PLTA$   
 Left-turn adjustment,  $f_{Lpb}$   
 Permitted Right Turns  
 Effective pedestrian green time,  $g_p$  (s)  
 Conflicting pedestrian volume,  $V_{ped}$  (p/h)  
 Conflicting bicycle volume,  $V_{bic}$  (bicycles/h)  
 $V_{pedg}$   
 $OCC_{pedg}$   
 Effective green,  $g$  (s)  
 $V_{bicg}$   
 $OCC_{bicg}$   
 $OCC_r$   
 Number of cross-street receiving lanes,  $N_{rec}$   
 Number of turning lanes,  $N_{turn}$   
 $ApbT$   
 Proportion right-turns,  $PRT$   
 Proportion right-turns using protected phase,  $PRTA$   
 Right turn adjustment,  $f_{Rpb}$

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SUPPLEMENTAL UNIFORM DELAY WORKSHEET

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|   |       | EBLT | WBLT | NBLT  | SBLT |
|---|-------|------|------|-------|------|
| Cycle length, $C$   | 142.0 |      |      |       |      |
| Adj. LT vol from Vol Adjustment Worksheet, $v$            |       |      |      | 124   |      |
| $v/c$ ratio from Capacity Worksheet, $X$                  |       |      |      | 0.58  |      |
| Protected phase effective green interval, $g$ (s)         |       |      |      | 8.0   |      |
| Opposing queue effective green interval, $g_q$            |       |      |      | 35.09 |      |
| Unopposed green interval, $g_u$                           |       |      |      | 67.91 |      |
| Red time $r=(C-g-g_q-g_u)$                                |       |      |      | 31.0  |      |
| Arrival rate, $q_a=v/(3600(\max[X,1.0]))$                 |       |      |      | 0.03  |      |
| Protected ph. departure rate, $S_p=s/3600$                |       |      |      | 0.469 |      |
| Permitted ph. departure rate, $S_s=s(g_q+g_u)/(g_u*3600)$ |       |      |      | 0.07  |      |
| XPerm   |       |      |      | 0.77  |      |
| XProt   |       |      |      | 0.36  |      |
| Case  |       |      |      | 1     |      |
| Queue at beginning of green arrow, $Q_a$                  |       |      |      | 1.07  |      |
| Queue at beginning of unsaturated green, $Q_u$            |       |      |      | 1.21  |      |
| Residual queue, $Q_r$                                     |       |      |      | 0.00  |      |
| Uniform Delay, $d_l$                                      |       |      |      | 12.4  |      |

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DELAY/LOS WORKSHEET WITH INITIAL QUEUE

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|       | Initial Dur. | Uniform Delay | Initial Queue | Final Queue | Initial Lane | Lane Group |
|-------|--------------|---------------|---------------|-------------|--------------|------------|
| Appr/ | Unmet        | Unmet         | Unmet         | Unmet       | Unmet        |            |

| Lane Group | Demand Q veh | Demand t hrs. | Unadj. ds | Adj. dl sec | Param. u | Demand Q veh | Delay d3 sec | Delay d sec |
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|

Eastbound

Westbound

Northbound

Southbound

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Intersection Delay 167.5 sec/veh      Intersection LOS F

BACK OF QUEUE WORKSHEET

|                         | Eastbound |       |   | Westbound |   |   | Northbound |       |   | Southbound |   |   |
|-------------------------|-----------|-------|---|-----------|---|---|------------|-------|---|------------|---|---|
| LaneGroup               | L         |       |   |           |   |   | L          | T     |   | T          |   |   |
| Init Queue              | 0.0       |       |   |           |   |   | 0.0        | 0.0   |   | 0.0        |   |   |
| Flow Rate               | 562       |       |   |           |   |   | 124        | 814   |   | 1810       |   |   |
| So                      | 1900      |       |   |           |   |   | 1900       | 1900  |   | 1900       |   |   |
| No.Lanes                | 1         | 0     | 0 | 0         | 0 | 0 | 1          | 2     | 0 | 0          | 1 | 0 |
| SL                      | 1687      |       |   |           |   |   | 1687       | 1687  |   | 1776       |   |   |
| LnCapacity              | 297       |       |   |           |   |   | 213        | 1318  |   | 1251       |   |   |
| Flow Ratio              | 0.33      |       |   |           |   |   | 0.07       | 0.48  |   | 1.02       |   |   |
| v/c Ratio               | 1.89      |       |   |           |   |   | 0.58       | 0.62  |   | 1.45       |   |   |
| Grn Ratio               | 0.18      |       |   |           |   |   | 0.78       | 0.78  |   | 0.70       |   |   |
| I Factor                |           | 1.000 |   |           |   |   |            | 1.000 |   | 1.000      |   |   |
| AT or PVG               | 3         |       |   |           |   |   | 3          | 3     |   | 3          |   |   |
| Pltn Ratio              | 1.00      |       |   |           |   |   | 1.00       | 1.00  |   | 1.00       |   |   |
| PF2                     | 1.00      |       |   |           |   |   | 1.00       | 1.00  |   |            |   |   |
| Q1                      | 22.2      |       |   |           |   |   | 1.1        | 13.6  |   |            |   |   |
| kB                      | 0.7       |       |   |           |   |   | 1.9        | 1.9   |   | 1.8        |   |   |
| Q2                      | 34.5      |       |   |           |   |   | 2.2        | 2.9   |   | 75.4       |   |   |
| Q Average               | 56.7      |       |   |           |   |   | 3.3        | 16.5  |   |            |   |   |
| Q Spacing               | 24.9      |       |   |           |   |   | 24.9       | 24.9  |   | 24.9       |   |   |
| Q Storage               | 150       |       |   |           |   |   | 250        | 1000  |   | 1000       |   |   |
| Q S Ratio               | 9.4       |       |   |           |   |   | 0.3        | 0.4   |   |            |   |   |
| 70th Percentile Output: |           |       |   |           |   |   |            |       |   |            |   |   |
| fB%                     | 1.2       |       |   |           |   |   | 1.3        | 1.2   |   |            |   |   |
| BOQ                     | 68.0      |       |   |           |   |   | 4.2        | 19.9  |   |            |   |   |
| QSRatio                 | 11.3      |       |   |           |   |   | 0.4        | 0.5   |   |            |   |   |
| 85th Percentile Output: |           |       |   |           |   |   |            |       |   |            |   |   |
| fB%                     | 1.4       |       |   |           |   |   | 1.6        | 1.4   |   |            |   |   |
| BOQ                     | 79.3      |       |   |           |   |   | 5.2        | 23.3  |   |            |   |   |

|                         |      |  |     |      |  |  |
|-------------------------|------|--|-----|------|--|--|
| QSRatio                 | 13.2 |  | 0.5 | 0.6  |  |  |
| 90th Percentile Output: |      |  |     |      |  |  |
| fB%                     | 1.5  |  | 1.8 | 1.5  |  |  |
| BOQ                     | 85.0 |  | 5.8 | 25.0 |  |  |
| QSRatio                 | 14.1 |  | 0.6 | 0.6  |  |  |
| 95th Percentile Output: |      |  |     |      |  |  |
| fB%                     | 1.6  |  | 2.1 | 1.6  |  |  |
| BOQ                     | 90.7 |  | 7.0 | 27.0 |  |  |
| QSRatio                 | 15.0 |  | 0.7 | 0.7  |  |  |
| 98th Percentile Output: |      |  |     |      |  |  |
| fB%                     | 1.7  |  | 2.5 | 1.8  |  |  |
| BOQ                     | 96.3 |  | 8.2 | 29.0 |  |  |
| QSRatio                 | 16.0 |  | 0.8 | 0.7  |  |  |

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ERROR MESSAGES

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No errors to report.

# **Stop-Controlled Intersection**

U.S. 72 at Ramps 3 & 4  
Existing System

HCS2000: Unsignalized Intersections Release 4.1b

TWO-WAY STOP CONTROL SUMMARY

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date Performed: 6/3/2002  
 Analysis Time Period: 2007 AM  
 Intersection: I-24 EB Ramps at US 72  
 Jurisdiction: Marion Co.  
 Units: U. S. Customary  
 Analysis Year: 2002  
 Project ID: Interchange Modification Study  
 East/West Street: I-24 Ramps  
 North/South Street: US 72  
 Intersection Orientation: NS Study period (hrs): 0.25

Vehicle Volumes and Adjustments

| Major Street: | Approach<br>Movement | Northbound |        |        |  | Southbound |        |        |  |
|---------------|----------------------|------------|--------|--------|--|------------|--------|--------|--|
|               |                      | 1<br>L     | 2<br>T | 3<br>R |  | 4<br>L     | 5<br>T | 6<br>R |  |

|                        |        |      |    |  |  |      |      |    |
|------------------------|--------|------|----|--|--|------|------|----|
| Volume                 |        | 736  |    |  |  | 148  | 1086 |    |
| Peak-Hour Factor, PHF  |        | 0.90 |    |  |  | 0.90 | 0.90 |    |
| Hourly Flow Rate, HFR  |        | 817  |    |  |  | 164  | 1206 |    |
| Percent Heavy Vehicles |        | --   | -- |  |  | 7    | --   | -- |
| Median Type            | TWLTTL |      |    |  |  |      |      |    |
| RT Channelized?        |        |      |    |  |  |      |      |    |
| Lanes                  |        | 2    |    |  |  | 1    | 2    |    |
| Configuration          |        | T    |    |  |  | L    | T    |    |
| Upstream Signal?       |        | No   |    |  |  |      | No   |    |

| Minor Street: | Approach<br>Movement | Westbound |        |        |  | Eastbound |         |         |  |
|---------------|----------------------|-----------|--------|--------|--|-----------|---------|---------|--|
|               |                      | 7<br>L    | 8<br>T | 9<br>R |  | 10<br>L   | 11<br>T | 12<br>R |  |

|                        |         |  |   |  |  |      |      |     |
|------------------------|---------|--|---|--|--|------|------|-----|
| Volume                 |         |  |   |  |  | 61   | 86   |     |
| Peak Hour Factor, PHF  |         |  |   |  |  | 0.90 | 0.90 |     |
| Hourly Flow Rate, HFR  |         |  |   |  |  | 67   | 95   |     |
| Percent Heavy Vehicles |         |  |   |  |  | 7    | 7    |     |
| Percent Grade (%)      |         |  | 0 |  |  |      | 0    |     |
| Median Storage         | 6       |  |   |  |  |      |      |     |
| Flared Approach:       | Exists? |  |   |  |  |      |      |     |
|                        | Storage |  |   |  |  |      |      |     |
| RT Channelized?        |         |  |   |  |  |      |      | Yes |
| Lanes                  |         |  |   |  |  | 1    | 1    |     |
| Configuration          |         |  |   |  |  | L    | R    |     |

Delay, Queue Length, and Level of Service

| Approach<br>Movement | NB<br>1 | SB<br>4 | Westbound |   |   | Eastbound |    |    |
|----------------------|---------|---------|-----------|---|---|-----------|----|----|
|                      |         |         | 7         | 8 | 9 | 10        | 11 | 12 |

|             |  |     |  |  |  |  |  |     |  |     |
|-------------|--|-----|--|--|--|--|--|-----|--|-----|
| Lane Config |  | L   |  |  |  |  |  | L   |  | R   |
| v (vph)     |  | 164 |  |  |  |  |  | 67  |  | 95  |
| C (m) (vph) |  | 775 |  |  |  |  |  | 121 |  | 430 |

|                  |      |      |      |
|------------------|------|------|------|
| v/c              | 0.21 | 0.55 | 0.22 |
| 95% queue length | 0.80 | 2.67 | 0.83 |
| Control Delay    | 10.9 | 66.6 | 15.7 |
| LOS              | B    | F    | C    |
| Approach Delay   |      | 36.8 |      |
| Approach LOS     |      | E    |      |

HCS2000: Unsignalized Intersections Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-Mail: jstorey@flohut.com

Fax: (615) 399-9049

TWO-WAY STOP CONTROL (TWSC) ANALYSIS

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date Performed: 6/3/2002  
 Analysis Time Period: 2007 AM  
 Intersection: I-24 EB Ramps at US 72  
 Jurisdiction: Marion Co.  
 Units: U. S. Customary  
 Analysis Year: 2002  
 Project ID: Interchange Modification Study  
 East/West Street: I-24 Ramps  
 North/South Street: US 72  
 Intersection Orientation: NS Study period (hrs): 0.25

Vehicle Volumes and Adjustments

| Major Street Movements | 1     | 2    | 3  | 4    | 5    | 6  |
|------------------------|-------|------|----|------|------|----|
|                        | L     | T    | R  | L    | T    | R  |
| Volume                 |       | 736  |    | 148  | 1086 |    |
| Peak-Hour Factor, PHF  |       | 0.90 |    | 0.90 | 0.90 |    |
| Peak-15 Minute Volume  |       | 204  |    | 41   | 302  |    |
| Hourly Flow Rate, HFR  |       | 817  |    | 164  | 1206 |    |
| Percent Heavy Vehicles |       | --   | -- | 7    | --   | -- |
| Median Type            | TWLTL |      |    |      |      |    |
| RT Channelized?        |       |      |    |      |      |    |
| Lanes                  |       | 2    |    | 1    | 2    |    |
| Configuration          |       | T    |    | L    | T    |    |
| Upstream Signal?       |       | No   |    |      | No   |    |

---

| Minor Street Movements | 7 | 8 | 9 | 10   | 11 | 12   |
|------------------------|---|---|---|------|----|------|
|                        | L | T | R | L    | T  | R    |
| Volume                 |   |   |   | 61   |    | 86   |
| Peak Hour Factor, PHF  |   |   |   | 0.90 |    | 0.90 |
| Peak-15 Minute Volume  |   |   |   | 17   |    | 24   |
| Hourly Flow Rate, HFR  |   |   |   | 67   |    | 95   |

Percent Heavy Vehicles 7 7  
 Percent Grade (%) 0 0  
 Median Storage 6  
 Flared Approach: Exists?  
 Storage  
 RT Channelized? Yes  
 Lanes 1 1  
 Configuration L R

Pedestrian Volumes and Adjustments

| Movements              | 13   | 14   | 15   | 16   |
|------------------------|------|------|------|------|
| Flow (ped/hr)          | 0    | 0    | 0    | 0    |
| Lane Width (ft)        | 12.0 | 12.0 | 12.0 | 12.0 |
| Walking Speed (ft/sec) | 4.0  | 4.0  | 4.0  | 4.0  |
| Percent Blockage       | 0    | 0    | 0    | 0    |

Upstream Signal Data

|                         | Prog.<br>Flow<br>vph | Sat<br>Flow<br>vph | Arrival<br>Type | Green<br>Time<br>sec | Cycle<br>Length<br>sec | Prog.<br>Speed<br>mph | Distance<br>to Signal<br>feet |
|-------------------------|----------------------|--------------------|-----------------|----------------------|------------------------|-----------------------|-------------------------------|
| S2 Left-Turn<br>Through |                      |                    |                 |                      |                        |                       |                               |
| S5 Left-Turn<br>Through |                      |                    |                 |                      |                        |                       |                               |

Worksheet 3-Data for Computing Effect of Delay to Major Street Vehicles

|                                       | Movement 2 | Movement 5 |
|---------------------------------------|------------|------------|
| Shared ln volume, major th vehicles:  |            |            |
| Shared ln volume, major rt vehicles:  |            |            |
| Sat flow rate, major th vehicles:     |            |            |
| Sat flow rate, major rt vehicles:     |            |            |
| Number of major street through lanes: |            |            |

Worksheet 4-Critical Gap and Follow-up Time Calculation

| Critical Gap Calculation |      |      |      |      |      |      |      |      |
|--------------------------|------|------|------|------|------|------|------|------|
| Movement                 | 1    | 4    | 7    | 8    | 9    | 10   | 11   | 12   |
|                          | L    | L    | L    | T    | R    | L    | T    | R    |
| t(c,base)                |      | 4.1  |      |      |      | 7.5  |      | 6.9  |
| t(c,hv)                  | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| P(hv)                    |      | 7    |      |      |      | 7    |      | 7    |
| t(c,g)                   |      |      | 0.20 | 0.20 | 0.10 | 0.20 | 0.20 | 0.10 |
| Grade/100                |      |      | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| t(3,lt)                  |      | 0.00 |      |      |      | 0.70 |      | 0.00 |
| t(c,T): 1-stage          | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2-stage                  | 0.00 | 0.00 | 1.00 | 1.00 | 0.00 | 1.00 | 1.00 | 0.00 |
| t(c) 1-stage             |      | 4.2  |      |      |      | 6.9  |      | 7.0  |
| 2-stage                  |      | 4.2  |      |      |      | 5.9  |      | 7.0  |

| Follow-Up Time Calculations |      |      |      |      |      |      |      |      |
|-----------------------------|------|------|------|------|------|------|------|------|
| Movement                    | 1    | 4    | 7    | 8    | 9    | 10   | 11   | 12   |
|                             | L    | L    | L    | T    | R    | L    | T    | R    |
| t(f,base)                   |      | 2.20 |      |      |      | 3.50 |      | 3.30 |
| t(f,HV)                     | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| P(HV)                       |      | 7    |      |      |      | 7    |      | 7    |
| t(f)                        |      | 2.3  |      |      |      | 3.6  |      | 3.4  |

Worksheet 5-Effect of Upstream Signals

| Computation 1-Queue Clearance Time at Upstream Signal |            |           |            |           |
|---|------------|-----------|------------|-----------|
|   | Movement 2 |           | Movement 5 |           |
|   | V(t)       | V(l,prot) | V(t)       | V(l,prot) |
| V prog  |            |           |            |           |
| Total Saturation Flow Rate, s (vph)                   |            |           |            |           |
| Arrival Type  |            |           |            |           |
| Effective Green, g (sec)                              |            |           |            |           |
| Cycle Length, C (sec)                                 |            |           |            |           |
| Rp (from table 9-2)                                   |            |           |            |           |
| Proportion vehicles arriving on green P               |            |           |            |           |
| g(q1)   |            |           |            |           |
| g(q2)   |            |           |            |           |
| g(q)  |            |           |            |           |

| Computation 2-Proportion of TWSC Intersection Time blocked |            |           |            |           |
|--|------------|-----------|------------|-----------|
|  | Movement 2 |           | Movement 5 |           |
|  | V(t)       | V(l,prot) | V(t)       | V(l,prot) |
| alpha  |            |           |            |           |
| beta   |            |           |            |           |
| Travel time, t(a) (sec)                                    |            |           |            |           |
| Smoothing Factor, F  |            |           |            |           |
| Proportion of conflicting flow, f                          |            |           |            |           |
| Max platooned flow, V(c,max)                               |            |           |            |           |
| Min platooned flow, V(c,min)                               |            |           |            |           |
| Duration of blocked period, t(p)                           |            |           |            |           |
| Proportion time blocked, p                                 |            |           | 0.000      | 0.000     |

| Computation 3-Platoon Event Periods | Result |
|-------------------------------------|--------|
| p(2)                                | 0.000  |
| p(5)                                | 0.000  |
| p(dom)                              |        |
| p(subo)                             |        |
| Constrained or unconstrained?       |        |

| Proportion unblocked for minor movements, p(x) | (1)<br>Single-stage Process | (2)<br>Two-Stage Process<br>Stage I | (3)<br>Stage II |
|--|-----------------------------|-------------------------------------|-----------------|
| p(1)   |                             |                                     |                 |

p(4)  
 p(7)  
 p(8)  
 p(9)  
 p(10)  
 p(11)  
 p(12)

---

Computation 4 and 5  
 Single-Stage Process

|          |   |   |   |   |   |    |    |    |
|----------|---|---|---|---|---|----|----|----|
| Movement | 1 | 4 | 7 | 8 | 9 | 10 | 11 | 12 |
|          | L | L | L | T | R | L  | T  | R  |

---

|         |  |     |  |  |  |      |  |     |
|---------|--|-----|--|--|--|------|--|-----|
| V c,x   |  | 817 |  |  |  | 1942 |  | 603 |
| s       |  |     |  |  |  |      |  |     |
| Px      |  |     |  |  |  |      |  |     |
| V c,u,x |  |     |  |  |  |      |  |     |

---

|          |  |  |  |  |  |  |  |  |
|----------|--|--|--|--|--|--|--|--|
| C r,x    |  |  |  |  |  |  |  |  |
| C plat,x |  |  |  |  |  |  |  |  |

---

Two-Stage Process

|  |        |        |        |        |        |        |        |        |
|--|--------|--------|--------|--------|--------|--------|--------|--------|
|  | 7      |        | 8      |        | 10     |        | 11     |        |
|  | Stage1 | Stage2 | Stage1 | Stage2 | Stage1 | Stage2 | Stage1 | Stage2 |

---

|          |  |  |  |  |      |      |  |  |
|----------|--|--|--|--|------|------|--|--|
| V(c,x)   |  |  |  |  | 1534 | 408  |  |  |
| s        |  |  |  |  |      | 3400 |  |  |
| P(x)     |  |  |  |  |      |      |  |  |
| V(c,u,x) |  |  |  |  |      |      |  |  |

---

|           |  |  |  |  |  |  |  |  |
|-----------|--|--|--|--|--|--|--|--|
| C(r,x)    |  |  |  |  |  |  |  |  |
| C(plat,x) |  |  |  |  |  |  |  |  |

Worksheet 6-Impedance and Capacity Equations

---

|                           |  |   |  |  |  |  |    |
|---------------------------|--|---|--|--|--|--|----|
| Step 1: RT from Minor St. |  | 9 |  |  |  |  | 12 |
|---------------------------|--|---|--|--|--|--|----|

---

|                               |  |  |  |  |      |  |      |
|-------------------------------|--|--|--|--|------|--|------|
| Conflicting Flows             |  |  |  |  |      |  | 603  |
| Potential Capacity            |  |  |  |  |      |  | 430  |
| Pedestrian Impedance Factor   |  |  |  |  | 1.00 |  | 1.00 |
| Movement Capacity             |  |  |  |  |      |  | 430  |
| Probability of Queue free St. |  |  |  |  | 1.00 |  | 0.78 |

---

|                           |  |   |  |  |  |  |   |
|---------------------------|--|---|--|--|--|--|---|
| Step 2: LT from Major St. |  | 4 |  |  |  |  | 1 |
|---------------------------|--|---|--|--|--|--|---|

---

|                               |  |  |  |  |      |  |      |
|-------------------------------|--|--|--|--|------|--|------|
| Conflicting Flows             |  |  |  |  | 817  |  |      |
| Potential Capacity            |  |  |  |  | 775  |  |      |
| Pedestrian Impedance Factor   |  |  |  |  | 1.00 |  | 1.00 |
| Movement Capacity             |  |  |  |  | 775  |  |      |
| Probability of Queue free St. |  |  |  |  | 0.79 |  | 1.00 |
| Maj L-Shared Prob Q free St.  |  |  |  |  |      |  |      |

---

|                           |  |  |  |  |   |  |    |
|---------------------------|--|--|--|--|---|--|----|
| Step 3: TH from Minor St. |  |  |  |  | 8 |  | 11 |
|---------------------------|--|--|--|--|---|--|----|

---

|                    |  |  |  |  |  |  |  |
|--------------------|--|--|--|--|--|--|--|
| Conflicting Flows  |  |  |  |  |  |  |  |
| Potential Capacity |  |  |  |  |  |  |  |

|  |      |      |
|--|------|------|
| Pedestrian Impedance Factor            | 1.00 | 1.00 |
| Cap. Adj. factor due to Impeding mvmnt | 0.79 | 0.79 |
| Movement Capacity                      |      |      |
| Probability of Queue free St.          | 1.00 | 1.00 |

---

Step 4: LT from Minor St. 7 10

|  |      |      |
|--|------|------|
| Conflicting Flows                      |      | 1942 |
| Potential Capacity                     |      | 54   |
| Pedestrian Impedance Factor            | 1.00 | 1.00 |
| Maj. L, Min T Impedance factor         | 0.79 |      |
| Maj. L, Min T Adj. Imp Factor.         | 0.84 |      |
| Cap. Adj. factor due to Impeding mvmnt | 0.65 | 0.79 |
| Movement Capacity                      |      | 43   |

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Worksheet 7-Computation of the Effect of Two-stage Gap Acceptance

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Step 3: TH from Minor St. 8 11

---

Part 1 - First Stage

|  |      |      |
|--|------|------|
| Conflicting Flows                      |      |      |
| Potential Capacity                     | 393  | 180  |
| Pedestrian Impedance Factor            | 1.00 | 1.00 |
| Cap. Adj. factor due to Impeding mvmnt | 1.00 | 0.79 |
| Movement Capacity                      | 393  | 142  |
| Probability of Queue free St.          | 1.00 | 1.00 |

---

Part 2 - Second Stage

|  |      |      |
|--|------|------|
| Conflicting Flows                      |      |      |
| Potential Capacity                     | 180  | 393  |
| Pedestrian Impedance Factor            | 1.00 | 1.00 |
| Cap. Adj. factor due to Impeding mvmnt | 0.79 | 1.00 |
| Movement Capacity                      | 142  | 393  |

---

Part 3 - Single Stage

|  |      |      |
|--|------|------|
| Conflicting Flows                      |      |      |
| Potential Capacity                     |      |      |
| Pedestrian Impedance Factor            | 1.00 | 1.00 |
| Cap. Adj. factor due to Impeding mvmnt | 0.79 | 0.79 |
| Movement Capacity                      |      |      |

---

Result for 2 stage process:

|                               |      |      |
|-------------------------------|------|------|
| a                             | 0.99 | 0.99 |
| y                             |      |      |
| C t                           |      |      |
| Probability of Queue free St. | 1.00 | 1.00 |

---

Step 4: LT from Minor St. 7 10

---

Part 1 - First Stage

|  |      |      |
|--|------|------|
| Conflicting Flows                      |      | 1534 |
| Potential Capacity                     | 400  | 156  |
| Pedestrian Impedance Factor            | 1.00 | 1.00 |
| Cap. Adj. factor due to Impeding mvmnt | 1.00 | 0.79 |
| Movement Capacity                      | 400  | 123  |

---

Part 2 - Second Stage

|  |      |      |
|--|------|------|
| Conflicting Flows                      |      | 408  |
| Potential Capacity                     | 349  | 625  |
| Pedestrian Impedance Factor            | 1.00 | 1.00 |
| Cap. Adj. factor due to Impeding mvmnt | 0.61 | 1.00 |
| Movement Capacity                      | 214  | 625  |

Part 3 - Single Stage

|  |      |      |
|--|------|------|
| Conflicting Flows                      |      | 1942 |
| Potential Capacity                     |      | 54   |
| Pedestrian Impedance Factor            | 1.00 | 1.00 |
| Maj. L, Min T Impedance factor         | 0.79 |      |
| Maj. L, Min T Adj. Imp Factor.         | 0.84 |      |
| Cap. Adj. factor due to Impeding mvmnt | 0.65 | 0.79 |
| Movement Capacity                      |      | 43   |

Results for Two-stage process:

|     |      |      |
|-----|------|------|
| a   | 0.99 | 0.99 |
| y   |      | 0.19 |
| C t |      | 121  |

Worksheet 8-Shared Lane Calculations

| Movement                   | 7 | 8 | 9 | 10  | 11 | 12  |
|----------------------------|---|---|---|-----|----|-----|
|                            | L | T | R | L   | T  | R   |
| Volume (vph)               |   |   |   | 67  |    | 95  |
| Movement Capacity (vph)    |   |   |   | 121 |    | 430 |
| Shared Lane Capacity (vph) |   |   |   |     |    |     |

Worksheet 9-Computation of Effect of Flared Minor Street Approaches

| Movement        | 7 | 8 | 9 | 10  | 11 | 12  |
|-----------------|---|---|---|-----|----|-----|
|                 | L | T | R | L   | T  | R   |
| C sep           |   |   |   | 121 |    | 430 |
| Volume          |   |   |   | 67  |    | 95  |
| Delay           |   |   |   |     |    |     |
| Q sep           |   |   |   |     |    |     |
| Q sep +1        |   |   |   |     |    |     |
| round (Qsep +1) |   |   |   |     |    |     |

n max  
 C sh  
 SUM C sep  
 n  
 C act

Worksheet 10-Delay, Queue Length, and Level of Service

| Movement    | 1 | 4   | 7 | 8 | 9 | 10 | 11 | 12 |
|-------------|---|-----|---|---|---|----|----|----|
| Lane Config |   | L   |   |   |   | L  |    | R  |
| v (vph)     |   | 164 |   |   |   | 67 |    | 95 |

|                  |      |      |      |
|------------------|------|------|------|
| C(m) (vph)       | 775  | 121  | 430  |
| v/c              | 0.21 | 0.55 | 0.22 |
| 95% queue length | 0.80 | 2.67 | 0.83 |
| Control Delay    | 10.9 | 66.6 | 15.7 |
| LOS              | B    | F    | C    |
| Approach Delay   |      |      | 36.8 |
| Approach LOS     |      |      | E    |

Worksheet 11-Shared Major LT Impedance and Delay

|   | Movement 2 | Movement 5 |
|---|------------|------------|
| p(oj)   | 1.00       | 0.79       |
| v(i1), Volume for stream 2 or 5               |            |            |
| v(i2), Volume for stream 3 or 6               |            |            |
| s(i1), Saturation flow rate for stream 2 or 5 |            |            |
| s(i2), Saturation flow rate for stream 3 or 6 |            |            |
| P*(oj)  |            |            |
| d(M,LT), Delay for stream 1 or 4              |            | 10.9       |
| N, Number of major street through lanes       |            |            |
| d(rank,1) Delay for stream 2 or 5             |            |            |

HCS2000: Unsignalized Intersections Release 4.1b

TWO-WAY STOP CONTROL SUMMARY

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date Performed: 6/3/2002  
 Analysis Time Period: 2007 PM  
 Intersection: I-24 EB Ramps at US 72  
 Jurisdiction: Marion Co.  
 Units: U. S. Customary  
 Analysis Year: 2002  
 Project ID: Interchange Modification Study  
 East/West Street: I-24 Ramps  
 North/South Street: US 72  
 Intersection Orientation: NS Study period (hrs): 0.25

Vehicle Volumes and Adjustments

| Major Street: | Approach | Northbound |   |   |  | Southbound |   |   |  |
|---------------|----------|------------|---|---|--|------------|---|---|--|
|               | Movement | 1          | 2 | 3 |  | 4          | 5 | 6 |  |
|               |          | L          | T | R |  | L          | T | R |  |

|                        |        |      |    |  |  |      |      |    |
|------------------------|--------|------|----|--|--|------|------|----|
| Volume                 |        | 982  |    |  |  | 196  | 1429 |    |
| Peak-Hour Factor, PHF  |        | 0.90 |    |  |  | 0.90 | 0.90 |    |
| Hourly Flow Rate, HFR  |        | 1091 |    |  |  | 217  | 1587 |    |
| Percent Heavy Vehicles |        | --   | -- |  |  | 7    | --   | -- |
| Median Type            | TWLTTL |      |    |  |  |      |      |    |
| RT Channelized?        |        |      |    |  |  |      |      |    |
| Lanes                  |        | 2    |    |  |  | 1    | 2    |    |
| Configuration          |        | T    |    |  |  | L    | T    |    |
| Upstream Signal?       |        | No   |    |  |  |      | No   |    |

| Minor Street: | Approach | Westbound |   |   |  | Eastbound |    |    |  |
|---------------|----------|-----------|---|---|--|-----------|----|----|--|
|               | Movement | 7         | 8 | 9 |  | 10        | 11 | 12 |  |
|               |          | L         | T | R |  | L         | T  | R  |  |

|                        |         |  |   |  |  |      |      |     |
|------------------------|---------|--|---|--|--|------|------|-----|
| Volume                 |         |  |   |  |  | 70   | 64   |     |
| Peak Hour Factor, PHF  |         |  |   |  |  | 0.90 | 0.90 |     |
| Hourly Flow Rate, HFR  |         |  |   |  |  | 77   | 71   |     |
| Percent Heavy Vehicles |         |  |   |  |  | 7    | 7    |     |
| Percent Grade (%)      |         |  | 0 |  |  |      | 0    |     |
| Median Storage         | 6       |  |   |  |  |      |      |     |
| Flared Approach:       | Exists? |  |   |  |  |      |      |     |
|                        | Storage |  |   |  |  |      |      |     |
| RT Channelized?        |         |  |   |  |  |      |      | Yes |
| Lanes                  |         |  |   |  |  | 1    | 1    |     |
| Configuration          |         |  |   |  |  | L    | R    |     |

Delay, Queue Length, and Level of Service

| Approach    | NB | SB | Westbound |   |   | Eastbound |  |    |    |    |
|-------------|----|----|-----------|---|---|-----------|--|----|----|----|
| Movement    | 1  | 4  |           | 7 | 8 | 9         |  | 10 | 11 | 12 |
| Lane Config |    | L  |           |   |   |           |  | L  |    | R  |

|            |  |     |  |  |  |  |  |    |  |     |
|------------|--|-----|--|--|--|--|--|----|--|-----|
| v (vph)    |  | 217 |  |  |  |  |  | 77 |  | 71  |
| C(m) (vph) |  | 607 |  |  |  |  |  | 52 |  | 320 |

|                  |      |       |      |
|------------------|------|-------|------|
| v/c              | 0.36 | 1.48  | 0.22 |
| 95% queue length | 1.62 | 7.16  | 0.83 |
| Control Delay    | 14.2 | 422.9 | 19.4 |
| LOS              | B    | F     | C    |
| Approach Delay   |      | 229.3 |      |
| Approach LOS     |      | F     |      |

HCS2000: Unsignalized Intersections Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-Mail: jstorey@flohut.com

Fax: (615) 399-9049

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 East/West Street: I-24 Ramps  
 North/South Street: US 72  
 Intersection Orientation: NS Study period (hrs): 0.25

Vehicle Volumes and Adjustments

| Major Street Movements | 1     | 2    | 3  | 4    | 5    | 6  |
|------------------------|-------|------|----|------|------|----|
|                        | L     | T    | R  | L    | T    | R  |
| Volume                 |       | 982  |    | 196  | 1429 |    |
| Peak-Hour Factor, PHF  |       | 0.90 |    | 0.90 | 0.90 |    |
| Peak-15 Minute Volume  |       | 273  |    | 54   | 397  |    |
| Hourly Flow Rate, HFR  |       | 1091 |    | 217  | 1587 |    |
| Percent Heavy Vehicles |       | --   | -- | 7    | --   | -- |
| Median Type            | TWLTL |      |    |      |      |    |
| RT Channelized?        |       |      |    |      |      |    |
| Lanes                  |       | 2    |    | 1    | 2    |    |
| Configuration          |       | T    |    | L    | T    |    |
| Upstream Signal?       |       | No   |    |      | No   |    |

---

| Minor Street Movements | 7 | 8 | 9 | 10   | 11 | 12   |
|------------------------|---|---|---|------|----|------|
|                        | L | T | R | L    | T  | R    |
| Volume                 |   |   |   | 70   |    | 64   |
| Peak Hour Factor, PHF  |   |   |   | 0.90 |    | 0.90 |
| Peak-15 Minute Volume  |   |   |   | 19   |    | 18   |
| Hourly Flow Rate, HFR  |   |   |   | 77   |    | 71   |

Percent Heavy Vehicles 7 7  
 Percent Grade (%) 0 0  
 Median Storage 6  
 Flared Approach: Exists?  
 Storage  
 RT Channelized? Yes  
 Lanes 1 1  
 Configuration L R

Pedestrian Volumes and Adjustments

| Movements              | 13   | 14   | 15   | 16   |
|------------------------|------|------|------|------|
| Flow (ped/hr)          | 0    | 0    | 0    | 0    |
| Lane Width (ft)        | 12.0 | 12.0 | 12.0 | 12.0 |
| Walking Speed (ft/sec) | 4.0  | 4.0  | 4.0  | 4.0  |
| Percent Blockage       | 0    | 0    | 0    | 0    |

Upstream Signal Data

|                         | Prog.<br>Flow<br>vph | Sat<br>Flow<br>vph | Arrival<br>Type | Green<br>Time<br>sec | Cycle<br>Length<br>sec | Prog.<br>Speed<br>mph | Distance<br>to Signal<br>feet |
|-------------------------|----------------------|--------------------|-----------------|----------------------|------------------------|-----------------------|-------------------------------|
| S2 Left-Turn<br>Through |                      |                    |                 |                      |                        |                       |                               |
| S5 Left-Turn<br>Through |                      |                    |                 |                      |                        |                       |                               |

Worksheet 3-Data for Computing Effect of Delay to Major Street Vehicles

|                                       | Movement 2 | Movement 5 |
|---------------------------------------|------------|------------|
| Shared ln volume, major th vehicles:  |            |            |
| Shared ln volume, major rt vehicles:  |            |            |
| Sat flow rate, major th vehicles:     |            |            |
| Sat flow rate, major rt vehicles:     |            |            |
| Number of major street through lanes: |            |            |

Worksheet 4-Critical Gap and Follow-up Time Calculation

| Critical Gap Calculation |      |      |      |      |      |      |      |      |
|--------------------------|------|------|------|------|------|------|------|------|
| Movement                 | 1    | 4    | 7    | 8    | 9    | 10   | 11   | 12   |
|                          | L    | L    | L    | T    | R    | L    | T    | R    |
| t(c,base)                |      | 4.1  |      |      |      | 7.5  |      | 6.9  |
| t(c,hv)                  | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| P(hv)                    |      | 7    |      |      |      | 7    |      | 7    |
| t(c,g)                   |      |      | 0.20 | 0.20 | 0.10 | 0.20 | 0.20 | 0.10 |
| Grade/100                |      |      | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| t(3,lt)                  |      | 0.00 |      |      |      | 0.70 |      | 0.00 |
| t(c,T): 1-stage          | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2-stage                  | 0.00 | 0.00 | 1.00 | 1.00 | 0.00 | 1.00 | 1.00 | 0.00 |
| t(c) 1-stage             |      | 4.2  |      |      |      | 6.9  |      | 7.0  |
| 2-stage                  |      | 4.2  |      |      |      | 5.9  |      | 7.0  |

| Follow-Up Time Calculations |      |      |      |      |      |      |      |      |
|-----------------------------|------|------|------|------|------|------|------|------|
| Movement                    | 1    | 4    | 7    | 8    | 9    | 10   | 11   | 12   |
|                             | L    | L    | L    | T    | R    | L    | T    | R    |
| t(f,base)                   |      | 2.20 |      |      |      | 3.50 |      | 3.30 |
| t(f,HV)                     | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| P(HV)                       |      | 7    |      |      |      | 7    |      | 7    |
| t(f)                        |      | 2.3  |      |      |      | 3.6  |      | 3.4  |

Worksheet 5-Effect of Upstream Signals

| Computation 1-Queue Clearance Time at Upstream Signal |            |           |            |           |
|---|------------|-----------|------------|-----------|
|   | Movement 2 |           | Movement 5 |           |
|   | V(t)       | V(l,prot) | V(t)       | V(l,prot) |
| V prog  |            |           |            |           |
| Total Saturation Flow Rate, s (vph)                   |            |           |            |           |
| Arrival Type  |            |           |            |           |
| Effective Green, g (sec)                              |            |           |            |           |
| Cycle Length, C (sec)                                 |            |           |            |           |
| Rp (from table 9-2)                                   |            |           |            |           |
| Proportion vehicles arriving on green P               |            |           |            |           |
| g(q1)   |            |           |            |           |
| g(q2)   |            |           |            |           |
| g(q)  |            |           |            |           |

| Computation 2-Proportion of TWSC Intersection Time blocked |            |           |            |           |
|--|------------|-----------|------------|-----------|
|  | Movement 2 |           | Movement 5 |           |
|  | V(t)       | V(l,prot) | V(t)       | V(l,prot) |
| alpha  |            |           |            |           |
| beta   |            |           |            |           |
| Travel time, t(a) (sec)                                    |            |           |            |           |
| Smoothing Factor, F  |            |           |            |           |
| Proportion of conflicting flow, f                          |            |           |            |           |
| Max platooned flow, V(c,max)                               |            |           |            |           |
| Min platooned flow, V(c,min)                               |            |           |            |           |
| Duration of blocked period, t(p)                           |            |           |            |           |
| Proportion time blocked, p                                 |            | 0.000     |            | 0.000     |

| Computation 3-Platoon Event Periods | Result |
|-------------------------------------|--------|
| p(2)                                | 0.000  |
| p(5)                                | 0.000  |
| p(dom)                              |        |
| p(subo)                             |        |
| Constrained or unconstrained?       |        |

| Proportion unblocked for minor movements, p(x) | (1)<br>Single-stage Process | (2)<br>Two-Stage Process<br>Stage I | (3)<br>Stage II |
|--|-----------------------------|-------------------------------------|-----------------|
| p(1)   |                             |                                     |                 |

p(4)  
 p(7)  
 p(8)  
 p(9)  
 p(10)  
 p(11)  
 p(12)

---

Computation 4 and 5  
 Single-Stage Process

|          |   |   |   |   |   |    |    |    |
|----------|---|---|---|---|---|----|----|----|
| Movement | 1 | 4 | 7 | 8 | 9 | 10 | 11 | 12 |
|          | L | L | L | T | R | L  | T  | R  |

---

|         |  |      |  |  |  |      |  |     |
|---------|--|------|--|--|--|------|--|-----|
| V c,x   |  | 1091 |  |  |  | 2566 |  | 794 |
| s       |  |      |  |  |  |      |  |     |
| Px      |  |      |  |  |  |      |  |     |
| V c,u,x |  |      |  |  |  |      |  |     |

---

|          |  |  |  |  |  |  |  |  |
|----------|--|--|--|--|--|--|--|--|
| C r,x    |  |  |  |  |  |  |  |  |
| C plat,x |  |  |  |  |  |  |  |  |

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Two-Stage Process

|  |        |        |        |        |        |        |        |        |
|--|--------|--------|--------|--------|--------|--------|--------|--------|
|  | 7      |        | 8      |        | 10     |        | 11     |        |
|  | Stage1 | Stage2 | Stage1 | Stage2 | Stage1 | Stage2 | Stage1 | Stage2 |

---

|          |  |  |  |  |      |      |  |  |
|----------|--|--|--|--|------|------|--|--|
| V(c,x)   |  |  |  |  | 2021 | 545  |  |  |
| s        |  |  |  |  |      | 3400 |  |  |
| P(x)     |  |  |  |  |      |      |  |  |
| V(c,u,x) |  |  |  |  |      |      |  |  |

---

|           |  |  |  |  |  |  |  |  |
|-----------|--|--|--|--|--|--|--|--|
| C(r,x)    |  |  |  |  |  |  |  |  |
| C(plat,x) |  |  |  |  |  |  |  |  |

Worksheet 6-Impedance and Capacity Equations

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|                           |  |   |  |    |
|---------------------------|--|---|--|----|
| Step 1: RT from Minor St. |  | 9 |  | 12 |
|---------------------------|--|---|--|----|

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|                               |  |      |  |      |
|-------------------------------|--|------|--|------|
| Conflicting Flows             |  |      |  | 794  |
| Potential Capacity            |  |      |  | 320  |
| Pedestrian Impedance Factor   |  | 1.00 |  | 1.00 |
| Movement Capacity             |  |      |  | 320  |
| Probability of Queue free St. |  | 1.00 |  | 0.78 |

---

|                           |  |   |  |   |
|---------------------------|--|---|--|---|
| Step 2: LT from Major St. |  | 4 |  | 1 |
|---------------------------|--|---|--|---|

---

|                               |  |      |  |      |
|-------------------------------|--|------|--|------|
| Conflicting Flows             |  | 1091 |  |      |
| Potential Capacity            |  | 607  |  |      |
| Pedestrian Impedance Factor   |  | 1.00 |  | 1.00 |
| Movement Capacity             |  | 607  |  |      |
| Probability of Queue free St. |  | 0.64 |  | 1.00 |
| Maj L-Shared Prob Q free St.  |  |      |  |      |

---

|                           |  |   |  |    |
|---------------------------|--|---|--|----|
| Step 3: TH from Minor St. |  | 8 |  | 11 |
|---------------------------|--|---|--|----|

---

|                    |  |  |  |  |
|--------------------|--|--|--|--|
| Conflicting Flows  |  |  |  |  |
| Potential Capacity |  |  |  |  |



|  |      |      |
|--|------|------|
| Part 2 - Second Stage                  |      |      |
| Conflicting Flows                      |      | 545  |
| Potential Capacity                     | 244  | 531  |
| Pedestrian Impedance Factor            | 1.00 | 1.00 |
| Cap. Adj. factor due to Impeding mvmnt | 0.50 | 1.00 |
| Movement Capacity                      | 122  | 531  |
| <hr/>                                  |      |      |
| Part 3 - Single Stage                  |      |      |
| Conflicting Flows                      |      | 2566 |
| Potential Capacity                     |      | 20   |
| Pedestrian Impedance Factor            | 1.00 | 1.00 |
| Maj. L, Min T Impedance factor         | 0.64 |      |
| Maj. L, Min T Adj. Imp Factor.         | 0.72 |      |
| Cap. Adj. factor due to Impeding mvmnt | 0.56 | 0.64 |
| Movement Capacity                      |      | 13   |
| <hr/>                                  |      |      |
| Results for Two-stage process:         |      |      |
| a                                      | 0.99 | 0.99 |
| y                                      |      | 0.13 |
| C t                                    |      | 52   |
| <hr/>                                  |      |      |

Worksheet 8-Shared Lane Calculations

|                            |   |   |   |    |    |     |
|----------------------------|---|---|---|----|----|-----|
| Movement                   | 7 | 8 | 9 | 10 | 11 | 12  |
|                            | L | T | R | L  | T  | R   |
| <hr/>                      |   |   |   |    |    |     |
| Volume (vph)               |   |   |   | 77 |    | 71  |
| Movement Capacity (vph)    |   |   |   | 52 |    | 320 |
| Shared Lane Capacity (vph) |   |   |   |    |    |     |
| <hr/>                      |   |   |   |    |    |     |

Worksheet 9-Computation of Effect of Flared Minor Street Approaches

|                 |   |   |   |    |    |     |
|-----------------|---|---|---|----|----|-----|
| Movement        | 7 | 8 | 9 | 10 | 11 | 12  |
|                 | L | T | R | L  | T  | R   |
| <hr/>           |   |   |   |    |    |     |
| C sep           |   |   |   | 52 |    | 320 |
| Volume          |   |   |   | 77 |    | 71  |
| Delay           |   |   |   |    |    |     |
| Q sep           |   |   |   |    |    |     |
| Q sep +1        |   |   |   |    |    |     |
| round (Qsep +1) |   |   |   |    |    |     |
| <hr/>           |   |   |   |    |    |     |
| n max           |   |   |   |    |    |     |
| C sh            |   |   |   |    |    |     |
| SUM C sep       |   |   |   |    |    |     |
| n               |   |   |   |    |    |     |
| C act           |   |   |   |    |    |     |
| <hr/>           |   |   |   |    |    |     |

Worksheet 10-Delay, Queue Length, and Level of Service

|             |   |     |   |   |   |    |    |    |
|-------------|---|-----|---|---|---|----|----|----|
| Movement    | 1 | 4   | 7 | 8 | 9 | 10 | 11 | 12 |
| Lane Config |   | L   |   |   |   | L  |    | R  |
| <hr/>       |   |     |   |   |   |    |    |    |
| v (vph)     |   | 217 |   |   |   | 77 |    | 71 |

|                  |      |       |       |
|------------------|------|-------|-------|
| C(m) (vph)       | 607  | 52    | 320   |
| v/c              | 0.36 | 1.48  | 0.22  |
| 95% queue length | 1.62 | 7.16  | 0.83  |
| Control Delay    | 14.2 | 422.9 | 19.4  |
| LOS              | B    | F     | C     |
| Approach Delay   |      |       | 229.3 |
| Approach LOS     |      |       | F     |

Worksheet 11-Shared Major LT Impedance and Delay

|   | Movement 2 | Movement 5 |
|---|------------|------------|
| p(oj)   | 1.00       | 0.64       |
| v(i1), Volume for stream 2 or 5               |            |            |
| v(i2), Volume for stream 3 or 6               |            |            |
| s(i1), Saturation flow rate for stream 2 or 5 |            |            |
| s(i2), Saturation flow rate for stream 3 or 6 |            |            |
| P*(oj)  |            |            |
| d(M,LT), Delay for stream 1 or 4              |            | 14.2       |
| N, Number of major street through lanes       |            |            |
| d(rank,1) Delay for stream 2 or 5             |            |            |

HCS2000: Unsignalized Intersections Release 4.1b

TWO-WAY STOP CONTROL SUMMARY

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date Performed: 6/3/2002  
 Analysis Time Period: 2027 AM  
 Intersection: I-24 EB Ramps at US 72  
 Jurisdiction: Marion Co.  
 Units: U. S. Customary  
 Analysis Year: 2002  
 Project ID: Interchange Modification Study  
 East/West Street: I-24 Ramps  
 North/South Street: US 72  
 Intersection Orientation: NS Study period (hrs): 0.25

Vehicle Volumes and Adjustments

| Major Street:          | Approach<br>Movement | Northbound |        |        |             | Southbound |        |    |  |
|------------------------|----------------------|------------|--------|--------|-------------|------------|--------|----|--|
|                        |                      | 1<br>L     | 2<br>T | 3<br>R | 4<br> <br>L | 5<br>T     | 6<br>R |    |  |
| Volume                 |                      |            | 1104   |        |             | 223        | 1628   |    |  |
| Peak-Hour Factor, PHF  |                      |            | 0.90   |        |             | 0.90       | 0.90   |    |  |
| Hourly Flow Rate, HFR  |                      |            | 1226   |        |             | 247        | 1808   |    |  |
| Percent Heavy Vehicles |                      |            | --     | --     |             | 7          | --     | -- |  |
| Median Type            | TWLTTL               |            |        |        |             |            |        |    |  |
| RT Channelized?        |                      |            |        |        |             |            |        |    |  |
| Lanes                  |                      |            | 2      |        |             | 1          | 2      |    |  |
| Configuration          |                      |            | T      |        |             | L          | T      |    |  |
| Upstream Signal?       |                      |            | No     |        |             |            | No     |    |  |

| Minor Street:          | Approach<br>Movement | Westbound |        |        |              | Eastbound |         |     |  |
|------------------------|----------------------|-----------|--------|--------|--------------|-----------|---------|-----|--|
|                        |                      | 7<br>L    | 8<br>T | 9<br>R | 10<br> <br>L | 11<br>T   | 12<br>R |     |  |
| Volume                 |                      |           |        |        |              | 92        | 129     |     |  |
| Peak Hour Factor, PHF  |                      |           |        |        |              | 0.90      | 0.90    |     |  |
| Hourly Flow Rate, HFR  |                      |           |        |        |              | 102       | 143     |     |  |
| Percent Heavy Vehicles |                      |           |        |        |              | 7         | 7       |     |  |
| Percent Grade (%)      |                      |           | 0      |        |              |           | 0       |     |  |
| Median Storage         | 6                    |           |        |        |              |           |         |     |  |
| Flared Approach:       | Exists?              |           |        |        |              |           |         |     |  |
|                        | Storage              |           |        |        |              |           |         |     |  |
| RT Channelized?        |                      |           |        |        |              |           |         | Yes |  |
| Lanes                  |                      |           |        |        |              | 1         | 1       |     |  |
| Configuration          |                      |           |        |        |              | L         | R       |     |  |

Delay, Queue Length, and Level of Service

| Approach<br>Movement | NB<br>1 | SB<br>4<br>L | Westbound |   |   | Eastbound    |     |         |
|----------------------|---------|--------------|-----------|---|---|--------------|-----|---------|
|                      |         |              | 7<br>     | 8 | 9 | 10<br> <br>L | 11  | 12<br>R |
| v (vph)              |         | 247          |           |   |   |              | 102 | 143     |
| C (m) (vph)          |         | 537          |           |   |   |              | 31  | 270     |

|                  |      |       |      |
|------------------|------|-------|------|
| v/c              | 0.46 | 3.29  | 0.53 |
| 95% queue length | 2.40 | 12.05 | 2.86 |
| Control Delay    | 17.3 |       | 32.4 |
| LOS              | C    | F     | D    |
| Approach Delay   |      | 559.3 |      |
| Approach LOS     |      | F     |      |

HCS2000: Unsignalized Intersections Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-Mail: jstorey@flohut.com

Fax: (615) 399-9049

TWO-WAY STOP CONTROL (TWSC) ANALYSIS

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date Performed: 6/3/2002  
 Analysis Time Period: 2027 AM  
 Intersection: I-24 EB Ramps at US 72  
 Jurisdiction: Marion Co.  
 Units: U. S. Customary  
 Analysis Year: 2002  
 Project ID: Interchange Modification Study  
 East/West Street: I-24 Ramps  
 North/South Street: US 72  
 Intersection Orientation: NS Study period (hrs): 0.25

Vehicle Volumes and Adjustments

| Major Street Movements | 1     | 2    | 3  | 4    | 5    | 6  |
|------------------------|-------|------|----|------|------|----|
|                        | L     | T    | R  | L    | T    | R  |
| Volume                 |       | 1104 |    | 223  | 1628 |    |
| Peak-Hour Factor, PHF  |       | 0.90 |    | 0.90 | 0.90 |    |
| Peak-15 Minute Volume  |       | 307  |    | 62   | 452  |    |
| Hourly Flow Rate, HFR  |       | 1226 |    | 247  | 1808 |    |
| Percent Heavy Vehicles |       | --   | -- | 7    | --   | -- |
| Median Type            | TWLTL |      |    |      |      |    |
| RT Channelized?        |       |      |    |      |      |    |
| Lanes                  |       | 2    |    | 1    | 2    |    |
| Configuration          |       | T    |    | L    | T    |    |
| Upstream Signal?       |       | No   |    |      | No   |    |

---

| Minor Street Movements | 7 | 8 | 9 | 10   | 11 | 12   |
|------------------------|---|---|---|------|----|------|
|                        | L | T | R | L    | T  | R    |
| Volume                 |   |   |   | 92   |    | 129  |
| Peak Hour Factor, PHF  |   |   |   | 0.90 |    | 0.90 |
| Peak-15 Minute Volume  |   |   |   | 26   |    | 36   |
| Hourly Flow Rate, HFR  |   |   |   | 102  |    | 143  |

Percent Heavy Vehicles 7 7  
 Percent Grade (%) 0 0  
 Median Storage 6  
 Flared Approach: Exists?  
 Storage  
 RT Channelized? Yes  
 Lanes 1 1  
 Configuration L R

Pedestrian Volumes and Adjustments

| Movements              | 13   | 14   | 15   | 16   |
|------------------------|------|------|------|------|
| Flow (ped/hr)          | 0    | 0    | 0    | 0    |
| Lane Width (ft)        | 12.0 | 12.0 | 12.0 | 12.0 |
| Walking Speed (ft/sec) | 4.0  | 4.0  | 4.0  | 4.0  |
| Percent Blockage       | 0    | 0    | 0    | 0    |

Upstream Signal Data

|                         | Prog.<br>Flow<br>vph | Sat<br>Flow<br>vph | Arrival<br>Type | Green<br>Time<br>sec | Cycle<br>Length<br>sec | Prog.<br>Speed<br>mph | Distance<br>to Signal<br>feet |
|-------------------------|----------------------|--------------------|-----------------|----------------------|------------------------|-----------------------|-------------------------------|
| S2 Left-Turn<br>Through |                      |                    |                 |                      |                        |                       |                               |
| S5 Left-Turn<br>Through |                      |                    |                 |                      |                        |                       |                               |

Worksheet 3-Data for Computing Effect of Delay to Major Street Vehicles

|                                       | Movement 2 | Movement 5 |
|---------------------------------------|------------|------------|
| Shared ln volume, major th vehicles:  |            |            |
| Shared ln volume, major rt vehicles:  |            |            |
| Sat flow rate, major th vehicles:     |            |            |
| Sat flow rate, major rt vehicles:     |            |            |
| Number of major street through lanes: |            |            |

Worksheet 4-Critical Gap and Follow-up Time Calculation

| Critical Gap Calculation |      |      |      |      |      |      |      |      |
|--------------------------|------|------|------|------|------|------|------|------|
| Movement                 | 1    | 4    | 7    | 8    | 9    | 10   | 11   | 12   |
|                          | L    | L    | L    | T    | R    | L    | T    | R    |
| t(c,base)                |      | 4.1  |      |      |      | 7.5  |      | 6.9  |
| t(c,hv)                  | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| P(hv)                    |      | 7    |      |      |      | 7    |      | 7    |
| t(c,g)                   |      |      | 0.20 | 0.20 | 0.10 | 0.20 | 0.20 | 0.10 |
| Grade/100                |      |      | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| t(3,lt)                  |      | 0.00 |      |      |      | 0.70 |      | 0.00 |
| t(c,T): 1-stage          | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2-stage                  | 0.00 | 0.00 | 1.00 | 1.00 | 0.00 | 1.00 | 1.00 | 0.00 |
| t(c) 1-stage             |      | 4.2  |      |      |      | 6.9  |      | 7.0  |
| 2-stage                  |      | 4.2  |      |      |      | 5.9  |      | 7.0  |

| Follow-Up Time Calculations |      |      |      |      |      |      |      |      |
|-----------------------------|------|------|------|------|------|------|------|------|
| Movement                    | 1    | 4    | 7    | 8    | 9    | 10   | 11   | 12   |
|                             | L    | L    | L    | T    | R    | L    | T    | R    |
| t(f,base)                   |      | 2.20 |      |      |      | 3.50 |      | 3.30 |
| t(f,HV)                     | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| P(HV)                       |      | 7    |      |      |      | 7    |      | 7    |
| t(f)                        |      | 2.3  |      |      |      | 3.6  |      | 3.4  |

Worksheet 5-Effect of Upstream Signals

| Computation 1-Queue Clearance Time at Upstream Signal |            |           |            |           |
|---|------------|-----------|------------|-----------|
|   | Movement 2 |           | Movement 5 |           |
|   | V(t)       | V(l,prot) | V(t)       | V(l,prot) |
| V prog  |            |           |            |           |
| Total Saturation Flow Rate, s (vph)                   |            |           |            |           |
| Arrival Type  |            |           |            |           |
| Effective Green, g (sec)                              |            |           |            |           |
| Cycle Length, C (sec)                                 |            |           |            |           |
| Rp (from table 9-2)                                   |            |           |            |           |
| Proportion vehicles arriving on green P               |            |           |            |           |
| g(q1)   |            |           |            |           |
| g(q2)   |            |           |            |           |
| g(q)  |            |           |            |           |

| Computation 2-Proportion of TWSC Intersection Time blocked |            |           |            |           |
|--|------------|-----------|------------|-----------|
|  | Movement 2 |           | Movement 5 |           |
|  | V(t)       | V(l,prot) | V(t)       | V(l,prot) |
| alpha  |            |           |            |           |
| beta   |            |           |            |           |
| Travel time, t(a) (sec)                                    |            |           |            |           |
| Smoothing Factor, F  |            |           |            |           |
| Proportion of conflicting flow, f                          |            |           |            |           |
| Max platooned flow, V(c,max)                               |            |           |            |           |
| Min platooned flow, V(c,min)                               |            |           |            |           |
| Duration of blocked period, t(p)                           |            |           |            |           |
| Proportion time blocked, p                                 |            | 0.000     |            | 0.000     |

| Computation 3-Platoon Event Periods | Result |
|-------------------------------------|--------|
| p(2)                                | 0.000  |
| p(5)                                | 0.000  |
| p(dom)                              |        |
| p(subo)                             |        |
| Constrained or unconstrained?       |        |

| Proportion unblocked for minor movements, p(x) | (1)<br>Single-stage Process | (2)<br>Two-Stage Process<br>Stage I | (3)<br>Stage II |
|--|-----------------------------|-------------------------------------|-----------------|
| p(1)   |                             |                                     |                 |

p(4)  
 p(7)  
 p(8)  
 p(9)  
 p(10)  
 p(11)  
 p(12)

---

Computation 4 and 5  
 Single-Stage Process

|          |   |   |   |   |   |    |    |    |
|----------|---|---|---|---|---|----|----|----|
| Movement | 1 | 4 | 7 | 8 | 9 | 10 | 11 | 12 |
|          | L | L | L | T | R | L  | T  | R  |

---

|         |  |      |  |  |  |      |  |     |
|---------|--|------|--|--|--|------|--|-----|
| V c,x   |  | 1226 |  |  |  | 2915 |  | 904 |
| s       |  |      |  |  |  |      |  |     |
| Px      |  |      |  |  |  |      |  |     |
| V c,u,x |  |      |  |  |  |      |  |     |

---

C r,x  
 C plat,x

---

Two-Stage Process

|  |        |        |        |        |        |        |        |        |
|--|--------|--------|--------|--------|--------|--------|--------|--------|
|  | 7      |        | 8      |        | 10     |        | 11     |        |
|  | Stage1 | Stage2 | Stage1 | Stage2 | Stage1 | Stage2 | Stage1 | Stage2 |

---

|          |  |  |  |  |      |      |  |  |
|----------|--|--|--|--|------|------|--|--|
| V(c,x)   |  |  |  |  | 2302 | 613  |  |  |
| s        |  |  |  |  |      | 3400 |  |  |
| P(x)     |  |  |  |  |      |      |  |  |
| V(c,u,x) |  |  |  |  |      |      |  |  |

---

C(r,x)  
 C(plat,x)

---

Worksheet 6-Impedance and Capacity Equations

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|                           |  |   |  |    |
|---------------------------|--|---|--|----|
| Step 1: RT from Minor St. |  | 9 |  | 12 |
|---------------------------|--|---|--|----|

---

|                               |  |      |  |      |
|-------------------------------|--|------|--|------|
| Conflicting Flows             |  |      |  | 904  |
| Potential Capacity            |  |      |  | 270  |
| Pedestrian Impedance Factor   |  | 1.00 |  | 1.00 |
| Movement Capacity             |  |      |  | 270  |
| Probability of Queue free St. |  | 1.00 |  | 0.47 |

---

|                           |  |   |  |   |
|---------------------------|--|---|--|---|
| Step 2: LT from Major St. |  | 4 |  | 1 |
|---------------------------|--|---|--|---|

---

|                               |  |      |  |      |
|-------------------------------|--|------|--|------|
| Conflicting Flows             |  | 1226 |  |      |
| Potential Capacity            |  | 537  |  |      |
| Pedestrian Impedance Factor   |  | 1.00 |  | 1.00 |
| Movement Capacity             |  | 537  |  |      |
| Probability of Queue free St. |  | 0.54 |  | 1.00 |
| Maj L-Shared Prob Q free St.  |  |      |  |      |

---

|                           |  |   |  |    |
|---------------------------|--|---|--|----|
| Step 3: TH from Minor St. |  | 8 |  | 11 |
|---------------------------|--|---|--|----|

---

Conflicting Flows  
 Potential Capacity

|  |      |      |
|--|------|------|
| Pedestrian Impedance Factor            | 1.00 | 1.00 |
| Cap. Adj. factor due to Impeding mvmnt | 0.54 | 0.54 |
| Movement Capacity                      |      |      |
| Probability of Queue free St.          | 1.00 | 1.00 |

---

Step 4: LT from Minor St. 7 10

---

|  |      |      |
|--|------|------|
| Conflicting Flows                      |      | 2915 |
| Potential Capacity                     |      | 11   |
| Pedestrian Impedance Factor            | 1.00 | 1.00 |
| Maj. L, Min T Impedance factor         | 0.54 |      |
| Maj. L, Min T Adj. Imp Factor.         | 0.64 |      |
| Cap. Adj. factor due to Impeding mvmnt | 0.30 | 0.54 |
| Movement Capacity                      |      | 6    |

---

Worksheet 7-Computation of the Effect of Two-stage Gap Acceptance

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Step 3: TH from Minor St. 8 11

---

Part 1 - First Stage

|  |      |      |
|--|------|------|
| Conflicting Flows                      |      |      |
| Potential Capacity                     | 253  | 74   |
| Pedestrian Impedance Factor            | 1.00 | 1.00 |
| Cap. Adj. factor due to Impeding mvmnt | 1.00 | 0.54 |
| Movement Capacity                      | 253  | 40   |
| Probability of Queue free St.          | 1.00 | 1.00 |

---

Part 2 - Second Stage

|  |      |      |
|--|------|------|
| Conflicting Flows                      |      |      |
| Potential Capacity                     | 74   | 253  |
| Pedestrian Impedance Factor            | 1.00 | 1.00 |
| Cap. Adj. factor due to Impeding mvmnt | 0.54 | 1.00 |
| Movement Capacity                      | 40   | 253  |

---

Part 3 - Single Stage

|  |      |      |
|--|------|------|
| Conflicting Flows                      |      |      |
| Potential Capacity                     |      |      |
| Pedestrian Impedance Factor            | 1.00 | 1.00 |
| Cap. Adj. factor due to Impeding mvmnt | 0.54 | 0.54 |
| Movement Capacity                      |      |      |

---

Result for 2 stage process:

|                               |      |      |
|-------------------------------|------|------|
| a                             | 0.99 | 0.99 |
| y                             |      |      |
| C t                           |      |      |
| Probability of Queue free St. | 1.00 | 1.00 |

---

Step 4: LT from Minor St. 7 10

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Part 1 - First Stage

|  |      |      |
|--|------|------|
| Conflicting Flows                      |      | 2302 |
| Potential Capacity                     | 244  | 57   |
| Pedestrian Impedance Factor            | 1.00 | 1.00 |
| Cap. Adj. factor due to Impeding mvmnt | 1.00 | 0.54 |
| Movement Capacity                      | 244  | 31   |

---

|  |      |      |
|--|------|------|
| Part 2 - Second Stage                  |      |      |
| Conflicting Flows                      |      | 613  |
| Potential Capacity                     | 198  | 489  |
| Pedestrian Impedance Factor            | 1.00 | 1.00 |
| Cap. Adj. factor due to Impeding mvmnt | 0.25 | 1.00 |
| Movement Capacity                      | 50   | 489  |
| <hr/>                                  |      |      |
| Part 3 - Single Stage                  |      |      |
| Conflicting Flows                      |      | 2915 |
| Potential Capacity                     |      | 11   |
| Pedestrian Impedance Factor            | 1.00 | 1.00 |
| Maj. L, Min T Impedance factor         | 0.54 |      |
| Maj. L, Min T Adj. Imp Factor.         | 0.64 |      |
| Cap. Adj. factor due to Impeding mvmnt | 0.30 | 0.54 |
| Movement Capacity                      |      | 6    |
| <hr/>                                  |      |      |
| Results for Two-stage process:         |      |      |
| a                                      | 0.99 | 0.99 |
| y                                      |      | 0.11 |
| C t                                    |      | 31   |
| <hr/>                                  |      |      |

Worksheet 8-Shared Lane Calculations

| Movement                   | 7 | 8 | 9 | 10  | 11 | 12  |
|----------------------------|---|---|---|-----|----|-----|
|                            | L | T | R | L   | T  | R   |
| Volume (vph)               |   |   |   | 102 |    | 143 |
| Movement Capacity (vph)    |   |   |   | 31  |    | 270 |
| Shared Lane Capacity (vph) |   |   |   |     |    |     |

Worksheet 9-Computation of Effect of Flared Minor Street Approaches

| Movement        | 7 | 8 | 9 | 10  | 11 | 12  |
|-----------------|---|---|---|-----|----|-----|
|                 | L | T | R | L   | T  | R   |
| C sep           |   |   |   | 31  |    | 270 |
| Volume          |   |   |   | 102 |    | 143 |
| Delay           |   |   |   |     |    |     |
| Q sep           |   |   |   |     |    |     |
| Q sep +1        |   |   |   |     |    |     |
| round (Qsep +1) |   |   |   |     |    |     |
| <hr/>           |   |   |   |     |    |     |
| n max           |   |   |   |     |    |     |
| C sh            |   |   |   |     |    |     |
| SUM C sep       |   |   |   |     |    |     |
| n               |   |   |   |     |    |     |
| C act           |   |   |   |     |    |     |

Worksheet 10-Delay, Queue Length, and Level of Service

| Movement    | 1 | 4   | 7 | 8 | 9 | 10  | 11 | 12  |
|-------------|---|-----|---|---|---|-----|----|-----|
| Lane Config |   | L   |   |   |   | L   |    | R   |
| v (vph)     |   | 247 |   |   |   | 102 |    | 143 |

|                  |      |       |       |
|------------------|------|-------|-------|
| C(m) (vph)       | 537  | 31    | 270   |
| v/c              | 0.46 | 3.29  | 0.53  |
| 95% queue length | 2.40 | 12.05 | 2.86  |
| Control Delay    | 17.3 |       | 32.4  |
| LOS              | C    | F     | D     |
| Approach Delay   |      |       | 559.3 |
| Approach LOS     |      |       | F     |

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Worksheet 11-Shared Major LT Impedance and Delay

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|   | Movement 2 | Movement 5 |
|---|------------|------------|
| p(oj)   | 1.00       | 0.54       |
| v(i1), Volume for stream 2 or 5               |            |            |
| v(i2), Volume for stream 3 or 6               |            |            |
| s(i1), Saturation flow rate for stream 2 or 5 |            |            |
| s(i2), Saturation flow rate for stream 3 or 6 |            |            |
| P*(oj)  |            |            |
| d(M,LT), Delay for stream 1 or 4              |            | 17.3       |
| N, Number of major street through lanes       |            |            |
| d(rank,1) Delay for stream 2 or 5             |            |            |

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HCS2000: Unsignalized Intersections Release 4.1b

TWO-WAY STOP CONTROL SUMMARY

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date Performed: 6/3/2002  
 Analysis Time Period: 2027 PM  
 Intersection: I-24 EB Ramps at US 72  
 Jurisdiction: Marion Co.  
 Units: U. S. Customary  
 Analysis Year: 2002  
 Project ID: Interchange Modification Study  
 East/West Street: I-24 Ramps  
 North/South Street: US 72  
 Intersection Orientation: NS Study period (hrs): 0.25

Vehicle Volumes and Adjustments

| Major Street:          | Approach<br>Movement | Northbound |        |        |          | Southbound |        |  |  |
|------------------------|----------------------|------------|--------|--------|----------|------------|--------|--|--|
|                        |                      | 1<br>L     | 2<br>T | 3<br>R | 4<br>  L | 5<br>T     | 6<br>R |  |  |
| Volume                 |                      | 1473       |        |        | 293      | 2144       |        |  |  |
| Peak-Hour Factor, PHF  |                      | 0.90       |        |        | 0.90     | 0.90       |        |  |  |
| Hourly Flow Rate, HFR  |                      | 1636       |        |        | 325      | 2382       |        |  |  |
| Percent Heavy Vehicles |                      | --         | --     |        | 7        | --         | --     |  |  |
| Median Type            | TWLTTL               |            |        |        |          |            |        |  |  |
| RT Channelized?        |                      |            |        |        |          |            |        |  |  |
| Lanes                  |                      | 2          |        |        | 1        | 2          |        |  |  |
| Configuration          |                      | T          |        |        | L        | T          |        |  |  |
| Upstream Signal?       |                      | No         |        |        |          | No         |        |  |  |

| Minor Street:          | Approach<br>Movement | Westbound |        |        |           | Eastbound |         |  |  |
|------------------------|----------------------|-----------|--------|--------|-----------|-----------|---------|--|--|
|                        |                      | 7<br>L    | 8<br>T | 9<br>R | 10<br>  L | 11<br>T   | 12<br>R |  |  |
| Volume                 |                      |           |        |        | 105       | 97        |         |  |  |
| Peak Hour Factor, PHF  |                      |           |        |        | 0.90      | 0.90      |         |  |  |
| Hourly Flow Rate, HFR  |                      |           |        |        | 116       | 107       |         |  |  |
| Percent Heavy Vehicles |                      |           |        |        | 7         | 7         |         |  |  |
| Percent Grade (%)      |                      | 0         |        |        |           | 0         |         |  |  |
| Median Storage         | 6                    |           |        |        |           |           |         |  |  |
| Flared Approach:       | Exists?<br>Storage   |           |        |        |           |           |         |  |  |
| RT Channelized?        |                      |           |        |        |           |           | Yes     |  |  |
| Lanes                  |                      |           |        |        | 1         | 1         |         |  |  |
| Configuration          |                      |           |        |        | L         | R         |         |  |  |

Delay, Queue Length, and Level of Service

| Approach<br>Movement | NB<br>1 | SB<br>4 | Westbound |   |   | Eastbound |     |     |
|----------------------|---------|---------|-----------|---|---|-----------|-----|-----|
|                      |         |         | 7         | 8 | 9 | 10        | 11  | 12  |
| Lane Config          |         | L       |           |   |   |           | L   | R   |
| v (vph)              |         | 325     |           |   |   |           | 116 | 107 |
| C(m) (vph)           |         | 370     |           |   |   |           | 3   | 173 |

|                  |      |       |      |
|------------------|------|-------|------|
| v/c              | 0.88 | 38.67 | 0.62 |
| 95% queue length | 8.58 | 16.73 | 3.43 |
| Control Delay    | 55.1 |       | 54.7 |
| LOS              | F    | F     | F    |
| Approach Delay   |      |       |      |
| Approach LOS     |      |       | F    |

HCS2000: Unsignalized Intersections Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-Mail: jstorey@flohut.com

Fax: (615) 399-9049

TWO-WAY STOP CONTROL (TWSC) ANALYSIS

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date Performed: 6/3/2002  
 Analysis Time Period: 2027 PM  
 Intersection: I-24 EB Ramps at US 72  
 Jurisdiction: Marion Co.  
 Units: U. S. Customary  
 Analysis Year: 2002  
 Project ID: Interchange Modification Study  
 East/West Street: I-24 Ramps  
 North/South Street: US 72  
 Intersection Orientation: NS Study period (hrs): 0.25

Vehicle Volumes and Adjustments

| Major Street Movements | 1     | 2    | 3  | 4    | 5    | 6  |
|------------------------|-------|------|----|------|------|----|
|                        | L     | T    | R  | L    | T    | R  |
| Volume                 |       | 1473 |    | 293  | 2144 |    |
| Peak-Hour Factor, PHF  |       | 0.90 |    | 0.90 | 0.90 |    |
| Peak-15 Minute Volume  |       | 409  |    | 81   | 596  |    |
| Hourly Flow Rate, HFR  |       | 1636 |    | 325  | 2382 |    |
| Percent Heavy Vehicles |       | --   | -- | 7    | --   | -- |
| Median Type            | TWLTL |      |    |      |      |    |
| RT Channelized?        |       |      |    |      |      |    |
| Lanes                  |       | 2    |    | 1    | 2    |    |
| Configuration          |       | T    |    | L    | T    |    |
| Upstream Signal?       |       | No   |    |      | No   |    |

---

| Minor Street Movements | 7 | 8 | 9 | 10   | 11 | 12   |
|------------------------|---|---|---|------|----|------|
|                        | L | T | R | L    | T  | R    |
| Volume                 |   |   |   | 105  |    | 97   |
| Peak Hour Factor, PHF  |   |   |   | 0.90 |    | 0.90 |
| Peak-15 Minute Volume  |   |   |   | 29   |    | 27   |
| Hourly Flow Rate, HFR  |   |   |   | 116  |    | 107  |

Percent Heavy Vehicles 7 0 7  
 Percent Grade (%) 0 0  
 Median Storage 6  
 Flared Approach: Exists?  
 Storage  
 RT Channelized? Yes  
 Lanes 1 1  
 Configuration L R

Pedestrian Volumes and Adjustments

| Movements              | 13   | 14   | 15   | 16   |
|------------------------|------|------|------|------|
| Flow (ped/hr)          | 0    | 0    | 0    | 0    |
| Lane Width (ft)        | 12.0 | 12.0 | 12.0 | 12.0 |
| Walking Speed (ft/sec) | 4.0  | 4.0  | 4.0  | 4.0  |
| Percent Blockage       | 0    | 0    | 0    | 0    |

Upstream Signal Data

|                         | Prog.<br>Flow<br>vph | Sat<br>Flow<br>vph | Arrival<br>Type | Green<br>Time<br>sec | Cycle<br>Length<br>sec | Prog.<br>Speed<br>mph | Distance<br>to Signal<br>feet |
|-------------------------|----------------------|--------------------|-----------------|----------------------|------------------------|-----------------------|-------------------------------|
| S2 Left-Turn<br>Through |                      |                    |                 |                      |                        |                       |                               |
| S5 Left-Turn<br>Through |                      |                    |                 |                      |                        |                       |                               |

Worksheet 3-Data for Computing Effect of Delay to Major Street Vehicles

|                                       | Movement 2 | Movement 5 |
|---------------------------------------|------------|------------|
| Shared ln volume, major th vehicles:  |            |            |
| Shared ln volume, major rt vehicles:  |            |            |
| Sat flow rate, major th vehicles:     |            |            |
| Sat flow rate, major rt vehicles:     |            |            |
| Number of major street through lanes: |            |            |

Worksheet 4-Critical Gap and Follow-up Time Calculation

| Critical Gap Calculation |      |      |      |      |      |      |      |      |
|--------------------------|------|------|------|------|------|------|------|------|
| Movement                 | 1    | 4    | 7    | 8    | 9    | 10   | 11   | 12   |
|                          | L    | L    | L    | T    | R    | L    | T    | R    |
| t(c,base)                |      | 4.1  |      |      |      | 7.5  |      | 6.9  |
| t(c,hv)                  | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| P(hv)                    |      | 7    |      |      |      | 7    |      | 7    |
| t(c,g)                   |      |      | 0.20 | 0.20 | 0.10 | 0.20 | 0.20 | 0.10 |
| Grade/100                |      |      | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| t(3,lt)                  |      | 0.00 |      |      |      | 0.70 |      | 0.00 |
| t(c,T): 1-stage          | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2-stage                  | 0.00 | 0.00 | 1.00 | 1.00 | 0.00 | 1.00 | 1.00 | 0.00 |
| t(c) 1-stage             |      | 4.2  |      |      |      | 6.9  |      | 7.0  |
| 2-stage                  |      | 4.2  |      |      |      | 5.9  |      | 7.0  |

| Follow-Up Time Calculations |      |      |      |      |      |      |      |      |
|-----------------------------|------|------|------|------|------|------|------|------|
| Movement                    | 1    | 4    | 7    | 8    | 9    | 10   | 11   | 12   |
|                             | L    | L    | L    | T    | R    | L    | T    | R    |
| t(f,base)                   |      | 2.20 |      |      |      | 3.50 |      | 3.30 |
| t(f,HV)                     | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| P(HV)                       |      | 7    |      |      |      | 7    |      | 7    |
| t(f)                        |      | 2.3  |      |      |      | 3.6  |      | 3.4  |

Worksheet 5-Effect of Upstream Signals

| Computation 1-Queue Clearance Time at Upstream Signal |            |           |            |           |
|---|------------|-----------|------------|-----------|
|   | Movement 2 |           | Movement 5 |           |
|   | V(t)       | V(l,prot) | V(t)       | V(l,prot) |
| V prog  |            |           |            |           |
| Total Saturation Flow Rate, s (vph)                   |            |           |            |           |
| Arrival Type  |            |           |            |           |
| Effective Green, g (sec)                              |            |           |            |           |
| Cycle Length, C (sec)                                 |            |           |            |           |
| Rp (from table 9-2)                                   |            |           |            |           |
| Proportion vehicles arriving on green P               |            |           |            |           |
| g(q1)   |            |           |            |           |
| g(q2)   |            |           |            |           |
| g(q)  |            |           |            |           |

| Computation 2-Proportion of TWSC Intersection Time blocked |            |           |            |           |
|--|------------|-----------|------------|-----------|
|  | Movement 2 |           | Movement 5 |           |
|  | V(t)       | V(l,prot) | V(t)       | V(l,prot) |
| alpha  |            |           |            |           |
| beta   |            |           |            |           |
| Travel time, t(a) (sec)                                    |            |           |            |           |
| Smoothing Factor, F  |            |           |            |           |
| Proportion of conflicting flow, f                          |            |           |            |           |
| Max platooned flow, V(c,max)                               |            |           |            |           |
| Min platooned flow, V(c,min)                               |            |           |            |           |
| Duration of blocked period, t(p)                           |            |           |            |           |
| Proportion time blocked, p                                 |            |           | 0.000      | 0.000     |

| Computation 3-Platoon Event Periods | Result |
|-------------------------------------|--------|
| p(2)                                | 0.000  |
| p(5)                                | 0.000  |
| p(dom)                              |        |
| p(subo)                             |        |
| Constrained or unconstrained?       |        |

| Proportion unblocked for minor movements, p(x) | (1)<br>Single-stage Process | (2)<br>Two-Stage Process<br>Stage I | (3)<br>Stage II |
|--|-----------------------------|-------------------------------------|-----------------|
| p(1)   |                             |                                     |                 |

p(4)  
 p(7)  
 p(8)  
 p(9)  
 p(10)  
 p(11)  
 p(12)

---

Computation 4 and 5  
 Single-Stage Process

|          |   |   |   |   |   |    |    |    |
|----------|---|---|---|---|---|----|----|----|
| Movement | 1 | 4 | 7 | 8 | 9 | 10 | 11 | 12 |
|          | L | L | L | T | R | L  | T  | R  |

---

|         |  |      |  |  |  |      |  |      |
|---------|--|------|--|--|--|------|--|------|
| V c,x   |  | 1636 |  |  |  | 3850 |  | 1191 |
| s       |  |      |  |  |  |      |  |      |
| Px      |  |      |  |  |  |      |  |      |
| V c,u,x |  |      |  |  |  |      |  |      |

---

C r,x  
 C plat,x

---

Two-Stage Process

|  |        |        |        |        |        |        |        |        |
|--|--------|--------|--------|--------|--------|--------|--------|--------|
|  | 7      |        | 8      |        | 10     |        | 11     |        |
|  | Stage1 | Stage2 | Stage1 | Stage2 | Stage1 | Stage2 | Stage1 | Stage2 |

---

|          |  |  |  |  |      |      |  |  |
|----------|--|--|--|--|------|------|--|--|
| V(c,x)   |  |  |  |  | 3032 | 818  |  |  |
| s        |  |  |  |  |      | 3400 |  |  |
| P(x)     |  |  |  |  |      |      |  |  |
| V(c,u,x) |  |  |  |  |      |      |  |  |

---

C(r,x)  
 C(plat,x)

---

Worksheet 6-Impedance and Capacity Equations

---

|                           |  |   |  |    |
|---------------------------|--|---|--|----|
| Step 1: RT from Minor St. |  | 9 |  | 12 |
|---------------------------|--|---|--|----|

---

|                               |  |      |  |      |
|-------------------------------|--|------|--|------|
| Conflicting Flows             |  |      |  | 1191 |
| Potential Capacity            |  |      |  | 173  |
| Pedestrian Impedance Factor   |  | 1.00 |  | 1.00 |
| Movement Capacity             |  |      |  | 173  |
| Probability of Queue free St. |  | 1.00 |  | 0.38 |

---

|                           |  |   |  |   |
|---------------------------|--|---|--|---|
| Step 2: LT from Major St. |  | 4 |  | 1 |
|---------------------------|--|---|--|---|

---

|                               |  |      |  |      |
|-------------------------------|--|------|--|------|
| Conflicting Flows             |  | 1636 |  |      |
| Potential Capacity            |  | 370  |  |      |
| Pedestrian Impedance Factor   |  | 1.00 |  | 1.00 |
| Movement Capacity             |  | 370  |  |      |
| Probability of Queue free St. |  | 0.12 |  | 1.00 |
| Maj L-Shared Prob Q free St.  |  |      |  |      |

---

|                           |  |   |  |    |
|---------------------------|--|---|--|----|
| Step 3: TH from Minor St. |  | 8 |  | 11 |
|---------------------------|--|---|--|----|

---

Conflicting Flows  
 Potential Capacity



|  |      |      |
|--|------|------|
| Part 2 - Second Stage                  |      |      |
| Conflicting Flows                      |      | 818  |
| Potential Capacity                     | 114  | 382  |
| Pedestrian Impedance Factor            | 1.00 | 1.00 |
| Cap. Adj. factor due to Impeding mvmnt | 0.05 | 1.00 |
| Movement Capacity                      | 5    | 382  |
| <hr/>                                  |      |      |
| Part 3 - Single Stage                  |      |      |
| Conflicting Flows                      |      | 3850 |
| Potential Capacity                     |      | 2    |
| Pedestrian Impedance Factor            | 1.00 | 1.00 |
| Maj. L, Min T Impedance factor         | 0.12 |      |
| Maj. L, Min T Adj. Imp Factor.         | 0.25 |      |
| Cap. Adj. factor due to Impeding mvmnt | 0.10 | 0.12 |
| Movement Capacity                      |      | 0    |
| <hr/>                                  |      |      |
| Results for Two-stage process:         |      |      |
| a                                      | 0.99 | 0.99 |
| y                                      |      | 0.05 |
| C t                                    |      | 3    |

Worksheet 8-Shared Lane Calculations

| Movement                   | 7 | 8 | 9 | 10  | 11 | 12  |
|----------------------------|---|---|---|-----|----|-----|
|                            | L | T | R | L   | T  | R   |
| Volume (vph)               |   |   |   | 116 |    | 107 |
| Movement Capacity (vph)    |   |   |   | 3   |    | 173 |
| Shared Lane Capacity (vph) |   |   |   |     |    |     |

Worksheet 9-Computation of Effect of Flared Minor Street Approaches

| Movement        | 7 | 8 | 9 | 10  | 11 | 12  |
|-----------------|---|---|---|-----|----|-----|
|                 | L | T | R | L   | T  | R   |
| C sep           |   |   |   | 3   |    | 173 |
| Volume          |   |   |   | 116 |    | 107 |
| Delay           |   |   |   |     |    |     |
| Q sep           |   |   |   |     |    |     |
| Q sep +1        |   |   |   |     |    |     |
| round (Qsep +1) |   |   |   |     |    |     |
| <hr/>           |   |   |   |     |    |     |
| n max           |   |   |   |     |    |     |
| C sh            |   |   |   |     |    |     |
| SUM C sep       |   |   |   |     |    |     |
| n               |   |   |   |     |    |     |
| C act           |   |   |   |     |    |     |

Worksheet 10-Delay, Queue Length, and Level of Service

| Movement    | 1 | 4   | 7 | 8 | 9 | 10  | 11 | 12  |
|-------------|---|-----|---|---|---|-----|----|-----|
| Lane Config |   | L   |   |   |   | L   |    | R   |
| v (vph)     |   | 325 |   |   |   | 116 |    | 107 |

|                  |      |       |      |
|------------------|------|-------|------|
| C(m) (vph)       | 370  | 3     | 173  |
| v/c              | 0.88 | 38.67 | 0.62 |
| 95% queue length | 8.58 | 16.73 | 3.43 |
| Control Delay    | 55.1 |       | 54.7 |
| LOS              | F    | F     | F    |
| Approach Delay   |      |       |      |
| Approach LOS     |      |       | F    |

Worksheet 11-Shared Major LT Impedance and Delay

|   | Movement 2 | Movement 5 |
|---|------------|------------|
| p(oj)   | 1.00       | 0.12       |
| v(i1), Volume for stream 2 or 5               |            |            |
| v(i2), Volume for stream 3 or 6               |            |            |
| s(i1), Saturation flow rate for stream 2 or 5 |            |            |
| s(i2), Saturation flow rate for stream 3 or 6 |            |            |
| P*(oj)  |            |            |
| d(M,LT), Delay for stream 1 or 4              |            | 55.1       |
| N, Number of major street through lanes       |            |            |
| d(rank,1) Delay for stream 2 or 5             |            |            |

# **I-24 Mainline**

Proposed System

HCS2000: Basic Freeway Segments Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 6/7/2002  
 Analysis Time Period: 2007 AM  
 Freeway/Direction: I-24 Westbound  
 From/To: Between Ramp 1 and Ramp "A"  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 2570  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 714   | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 1592  | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 70.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 70.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 1592 | pc/h/ln |
|---------------|------|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 70.0 | mi/h     |
| Average passenger-car speed, S | 69.5 | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     | 22.9 | pc/mi/ln |
| Level of service, LOS          | C    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

---

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 6/7/2002  
 Analysis Time Period: 2007 PM  
 Freeway/Direction: I-24 Westbound  
 From/To: Between Ramp 1 and Ramp "A"  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

---

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 3126  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 868   | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 1936  | pc/h/ln |

Speed Inputs and Adjustments

---

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 70.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 70.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

---

|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 1936 | pc/h/ln |
|---------------|------|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 70.0 | mi/h     |
| Average passenger-car speed, S | 66.0 | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     | 29.3 | pc/mi/ln |
| Level of service, LOS          | D    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 6/7/2002  
 Analysis Time Period: 2027 AM  
 Freeway/Direction: I-24 Westbound  
 From/To: Between Ramp 1 and Ramp "A"  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 4203  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 1168  | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 2604  | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 70.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 70.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 2604 | pc/h/ln |
|---------------|------|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 70.0 | mi/h     |
| Average passenger-car speed, S |      | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     |      | pc/mi/ln |
| Level of service, LOS          | F    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Operational Analysis

Analyst: Jon Storey  
 Agency or Company: Florence & Hutcheson  
 Date Performed: 6/7/2002  
 Analysis Time Period: 2027 PM  
 Freeway/Direction: I-24 Westbound  
 From/To: Between Ramp 1 and Ramp "A"  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Flow Inputs and Adjustments

|                               |       |         |
|-------------------------------|-------|---------|
| Volume, V                     | 5107  | veh/h   |
| Peak-hour factor, PHF         | 0.90  |         |
| Peak 15-min volume, v15       | 1419  | v       |
| Trucks and buses              | 23    | %       |
| Recreational vehicles         | 0     | %       |
| Terrain type:                 | Level |         |
| Grade                         | 0.00  | %       |
| Segment length                | 0.00  | mi      |
| Trucks and buses PCE, ET      | 1.5   |         |
| Recreational vehicle PCE, ER  | 1.2   |         |
| Heavy vehicle adjustment, fHV | 0.897 |         |
| Driver population factor, vp  | 1.00  |         |
| Flow rate, vp                 | 3164  | pc/h/ln |

Speed Inputs and Adjustments

|                                     |       |                |
|-------------------------------------|-------|----------------|
| Lane width                          | 12.0  | ft             |
| Right-shoulder lateral clearance    | 6.0   | ft             |
| Interchange density                 | 0.28  | interchange/mi |
| Number of lanes, N                  | 2     |                |
| Free-flow speed:                    | Ideal |                |
| FFS or BFFS                         | 70.0  | mi/h           |
| Lane width adjustment, fLW          | 0.0   | mi/h           |
| Lateral clearance adjustment, fLC   | 0.0   | mi/h           |
| Interchange density adjustment, fID | 0.0   | mi/h           |
| Number of lanes adjustment, fN      | 0.0   | mi/h           |
| Free-flow speed, FFS                | 70.0  | mi/h           |

Rural Freeway

LOS and Performance Measures

|               |      |         |
|---------------|------|---------|
| Flow rate, vp | 3164 | pc/h/ln |
|---------------|------|---------|

|                                |      |          |
|--------------------------------|------|----------|
| Free-flow speed, FFS           | 70.0 | mi/h     |
| Average passenger-car speed, S |      | mi/h     |
| Number of lanes, N             | 2    |          |
| Density, D                     |      | pc/mi/ln |
| Level of service, LOS          | F    |          |

Overall results are not computed when free-flow speed is less than 55 mph.

# **I-24 Ramp Terminals**

Proposed System

HCS2000: Ramps and Ramp Junctions Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Diverge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/7/2002  
 Analysis time period: 2007 AM  
 Freeway/dir or travel: I-24 Westbound  
 Junction: Ramp 1  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |         |     |
|----------------------------|---------|-----|
| Type of analysis           | Diverge |     |
| Number of lanes in freeway | 2       |     |
| Free-flow speed on freeway | 70.0    | mph |
| Volume on freeway          | 2570    | vph |

Off Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-Flow speed on ramp           | 35.0  | mph |
| Volume on ramp                    | 422   | vph |
| Length of first accel/decel lane  | 740   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |          |     |
|---------------------------|----------|-----|
| Does adjacent ramp exist? | Yes      |     |
| Volume on adjacent ramp   | 170      | vph |
| Position of adjacent ramp | Upstream |     |
| Type of adjacent ramp     | Off      |     |
| Distance to adjacent ramp | 1200     | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 2570    | 422   | 170           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 714     | 117   | 47            | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

|                               |       |    |       |    |       |      |
|-------------------------------|-------|----|-------|----|-------|------|
| Grade                         | 0.00  | %  | 0.00  | %  | 0.00  | %    |
| Length                        | 0.00  | mi | 0.00  | mi | 0.00  | mi   |
| Trucks and buses PCE, ET      | 1.5   |    | 1.5   |    | 1.5   |      |
| Recreational vehicle PCE, ER  | 1.2   |    | 1.2   |    | 1.2   |      |
| Heavy vehicle adjustment, fHV | 0.897 |    | 0.966 |    | 0.966 |      |
| Driver population factor, fP  | 1.00  |    | 1.00  |    | 1.00  |      |
| Flow rate, vp                 | 3184  |    | 485   |    | 195   | pcph |

---

Estimation of V12 Diverge Areas

---

$L = 0.00$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 1.000$  Using Equation 0  
 FD  
 $v_{12} = v_R + (v_F - v_R) P = 3184$  pc/h  
 FD

---

Capacity Checks

---

|                      | Actual | Maximum | LOS F? |
|----------------------|--------|---------|--------|
| $v_{12} = v_{12}$    | 3184   | 4800    | No     |
| $v_{12}$             | 3184   | 4400    | No     |
| $v_{FO} = v_F - v_R$ | 2699   | 4800    | No     |
| $v_R$                | 485    | 2000    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v_{12} - 0.009 D = 25.0$  pc/mi/ln  
 Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

|  |             |     |
|--|-------------|-----|
| Intermediate speed variable,             | $D = 0.472$ |     |
| Space mean speed in ramp influence area, | $S = 57$    | mph |
| Space mean speed in outer lanes,         | $S = N/A$   | mph |
| Space mean speed for all vehicles,       | $S = 56.8$  | mph |

---

HCS2000: Ramps and Ramp Junctions Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Merge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/3/2002  
 Analysis time period: 2007 AM  
 Freeway/dir or travel: I-24 Westbound  
 Junction: US 72 to I-24 Westbound  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |       |     |
|----------------------------|-------|-----|
| Type of analysis           | Merge |     |
| Number of lanes in freeway | 2     |     |
| Free-flow speed on freeway | 70.0  | mph |
| Volume on freeway          | 2148  | vph |

On Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-flow speed on ramp           | 45.0  | mph |
| Volume on ramp                    | 166   | vph |
| Length of first accel/decel lane  | 880   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |            |     |
|---------------------------|------------|-----|
| Does adjacent ramp exist? | Yes        |     |
| Volume on adjacent Ramp   | 592        | vph |
| Position of adjacent Ramp | Downstream |     |
| Type of adjacent Ramp     | Off        |     |
| Distance to adjacent Ramp | 900        | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 2148    | 166   | 592           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 597     | 46    | 164           | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

| Grade Length                  |       | %<br>mi | %<br>mi | %<br>mi |
|-------------------------------|-------|---------|---------|---------|
| Trucks and buses PCE, ET      | 1.5   | 1.5     | 1.5     |         |
| Recreational vehicle PCE, ER  | 1.2   | 1.2     | 1.2     |         |
| Heavy vehicle adjustment, fHV | 0.897 | 0.966   | 0.966   |         |
| Driver population factor, fP  | 1.00  | 1.00    | 1.00    |         |
| Flow rate, vp                 | 2661  | 191     | 681     | pcph    |

---

Estimation of V12 Merge Areas

---

$L = 0.00$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 1.000$  Using Equation 0  
 FM  
 $v_{12} = v_F (P_{FM}) = 2661$  pc/h

---

Capacity Checks

---

|                  | Actual | Maximum | LOS F? |
|------------------|--------|---------|--------|
| v <sub>FO</sub>  | 2852   | 4800    | No     |
| v <sub>R12</sub> | 2852   | 4600    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A = 22.1$  pc/mi/ln  
 Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

|  |              |     |
|--|--------------|-----|
| Intermediate speed variable,             | $M = 0.309$  |     |
| Space mean speed in ramp influence area, | $S_R = 61.3$ | mph |
| Space mean speed in outer lanes,         | $S_0 = N/A$  | mph |
| Space mean speed for all vehicles,       | $S = 61.3$   | mph |

---

HCS2000: Ramps and Ramp Junctions Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Merge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/3/2002  
 Analysis time period: 2007 AM  
 Freeway/dir or travel: I-24 Eastbound  
 Junction: US 72 to I-24 Eastbound  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |       |     |
|----------------------------|-------|-----|
| Type of analysis           | Merge |     |
| Number of lanes in freeway | 2     |     |
| Free-flow speed on freeway | 70.0  | mph |
| Volume on freeway          | 1133  | vph |

On Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-flow speed on ramp           | 50.0  | mph |
| Volume on ramp                    | 707   | vph |
| Length of first accel/decel lane  | 880   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |          |     |
|---------------------------|----------|-----|
| Does adjacent ramp exist? | Yes      |     |
| Volume on adjacent Ramp   | 147      | vph |
| Position of adjacent Ramp | Upstream |     |
| Type of adjacent Ramp     | Off      |     |
| Distance to adjacent Ramp | 1600     | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 1133    | 707   | 147           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 315     | 196   | 41            | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

| Grade Length                  |       | %<br>mi | %<br>mi | %<br>mi |
|-------------------------------|-------|---------|---------|---------|
| Trucks and buses PCE, ET      | 1.5   | 1.5     | 1.5     |         |
| Recreational vehicle PCE, ER  | 1.2   | 1.2     | 1.2     |         |
| Heavy vehicle adjustment, fHV | 0.897 | 0.966   | 0.966   |         |
| Driver population factor, fP  | 1.00  | 1.00    | 1.00    |         |
| Flow rate, vp                 | 1404  | 813     | 169     | pcph    |

---

Estimation of V12 Merge Areas

---

L = 0.00 (Equation 25-2 or 25-3)  
EQ  
P = 1.000 Using Equation 0  
FM  
 $v_{12} = v_F (P_{FM}) = 1404 \text{ pc/h}$

---

Capacity Checks

---

|                  | Actual | Maximum | LOS F? |
|------------------|--------|---------|--------|
| v <sub>FO</sub>  | 2217   | 4800    | No     |
| v <sub>R12</sub> | 2217   | 4600    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A = 16.9 \text{ pc/mi/ln}$   
Level of service for ramp-freeway junction areas of influence B

---

Speed Estimation

---

|  |                       |     |
|--|-----------------------|-----|
| Intermediate speed variable,             | M = 0.269             |     |
| Space mean speed in ramp influence area, | S <sub>R</sub> = 62.5 | mph |
| Space mean speed in outer lanes,         | S <sub>O</sub> = N/A  | mph |
| Space mean speed for all vehicles,       | S = 62.5              | mph |

---

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-mail: jstorey@flohut.com

Fax: (615) 399-9049

Diverge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/7/2002  
 Analysis time period: 2007 AM  
 Freeway/dir or travel: I-24 Westbound  
 Junction: Prop. Ramp "A"  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |         |     |
|----------------------------|---------|-----|
| Type of analysis           | Diverge |     |
| Number of lanes in freeway | 2       |     |
| Free-flow speed on freeway | 70.0    | mph |
| Volume on freeway          | 2740    | vph |

Off Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-Flow speed on ramp           | 55.0  | mph |
| Volume on ramp                    | 170   | vph |
| Length of first accel/decel lane  | 800   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |            |     |
|---------------------------|------------|-----|
| Does adjacent ramp exist? | Yes        |     |
| Volume on adjacent ramp   | 592        | vph |
| Position of adjacent ramp | Downstream |     |
| Type of adjacent ramp     | Off        |     |
| Distance to adjacent ramp | 1500       | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 2740    | 170   | 592           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 761     | 47    | 164           | v   |
| Trucks and buses        | 23      | 7     | 0             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

|                               |       |    |       |    |       |      |
|-------------------------------|-------|----|-------|----|-------|------|
| Grade                         | 0.00  | %  | 0.00  | %  | 0.00  | %    |
| Length                        | 0.00  | mi | 0.00  | mi | 0.00  | mi   |
| Trucks and buses PCE, ET      | 1.5   |    | 1.5   |    | 1.5   |      |
| Recreational vehicle PCE, ER  | 1.2   |    | 1.2   |    | 1.2   |      |
| Heavy vehicle adjustment, fHV | 0.897 |    | 0.966 |    | 1.000 |      |
| Driver population factor, fP  | 1.00  |    | 1.00  |    | 1.00  |      |
| Flow rate, vp                 | 3395  |    | 195   |    | 658   | pcph |

---

Estimation of V12 Diverge Areas

---

$$L = 0.00 \quad (\text{Equation 25-8 or 25-9})$$

$$EQ$$

$$P = 1.000 \quad \text{Using Equation 0}$$

$$FD$$

$$v_{12} = v_R + (v_F - v_R) P = 3395 \quad \text{pc/h}$$

---

Capacity Checks

---

|                      | Actual | Maximum | LOS F? |
|----------------------|--------|---------|--------|
| $v_{12} = v_F$       | 3395   | 4800    | No     |
| $v_{12}$             | 3395   | 4400    | No     |
| $v_{FO} = v_F - v_R$ | 3200   | 4800    | No     |
| $v_R$                | 195    | 2200    | No     |

---

Level of Service Determination (if not F)

---

$$\text{Density, } D = 4.252 + 0.0086 v_{12} - 0.009 D = 26.2 \quad \text{pc/mi/ln}$$

Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

|  |                  |     |
|--|------------------|-----|
| Intermediate speed variable,             | $D = 0.186$      |     |
| Space mean speed in ramp influence area, | $S = 65$         | mph |
| Space mean speed in outer lanes,         | $S = \text{N/A}$ | mph |
| Space mean speed for all vehicles,       | $S = 64.8$       | mph |

---

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-mail: jstorey@flohut.com

Fax: (615) 399-9049

Diverge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/7/2002  
 Analysis time period: 2007 PM  
 Freeway/dir or travel: I-24 Westbound  
 Junction: Ramp 1  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |         |     |
|----------------------------|---------|-----|
| Type of analysis           | Diverge |     |
| Number of lanes in freeway | 2       |     |
| Free-flow speed on freeway | 70.0    | mph |
| Volume on freeway          | 3126    | vph |

Off Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-Flow speed on ramp           | 35.0  | mph |
| Volume on ramp                    | 539   | vph |
| Length of first accel/decel lane  | 740   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |          |     |
|---------------------------|----------|-----|
| Does adjacent ramp exist? | Yes      |     |
| Volume on adjacent ramp   | 338      | vph |
| Position of adjacent ramp | Upstream |     |
| Type of adjacent ramp     | Off      |     |
| Distance to adjacent ramp | 1200     | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 3126    | 539   | 338           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 868     | 150   | 94            | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

|                               |       |    |       |    |       |      |
|-------------------------------|-------|----|-------|----|-------|------|
| Grade                         | 0.00  | %  | 0.00  | %  | 0.00  | %    |
| Length                        | 0.00  | mi | 0.00  | mi | 0.00  | mi   |
| Trucks and buses PCE, ET      | 1.5   |    | 1.5   |    | 1.5   |      |
| Recreational vehicle PCE, ER  | 1.2   |    | 1.2   |    | 1.2   |      |
| Heavy vehicle adjustment, fHV | 0.897 |    | 0.966 |    | 0.966 |      |
| Driver population factor, fP  | 1.00  |    | 1.00  |    | 1.00  |      |
| Flow rate, vp                 | 3873  |    | 620   |    | 389   | pcph |

---

Estimation of V12 Diverge Areas

---

L = 0.00 (Equation 25-8 or 25-9)  
EQ  
P = 1.000 Using Equation 0  
FD  
 $v_{12} = v_R + (v_F - v_R) P = 3873$  pc/h

---

Capacity Checks

---

|                      | Actual | Maximum | LOS F? |
|----------------------|--------|---------|--------|
| $v_{Fi} = v_F$       | 3873   | 4800    | No     |
| $v_{12}$             | 3873   | 4400    | No     |
| $v_{FO} = v_F - v_R$ | 3253   | 4800    | No     |
| $v_R$                | 620    | 2000    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v_{12} - 0.009 D = 30.9$  pc/mi/ln  
Level of service for ramp-freeway junction areas of influence D

---

Speed Estimation

---

|  |           |     |
|--|-----------|-----|
| Intermediate speed variable,             | D = 0.484 |     |
| Space mean speed in ramp influence area, | S = 56    | mph |
| Space mean speed in outer lanes,         | S = N/A   | mph |
| Space mean speed for all vehicles,       | S = 56.5  | mph |

---

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-mail: jstorey@flohut.com

Fax: (615) 399-9049

Merge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/3/2002  
 Analysis time period: 2007 PM  
 Freeway/dir or travel: I-24 Westbound  
 Junction: US 72 to I-24 Westbound  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |       |     |
|----------------------------|-------|-----|
| Type of analysis           | Merge |     |
| Number of lanes in freeway | 2     |     |
| Free-flow speed on freeway | 70.0  | mph |
| Volume on freeway          | 2587  | vph |

On Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-flow speed on ramp           | 45.0  | mph |
| Volume on ramp                    | 211   | vph |
| Length of first accel/decel lane  | 880   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |            |     |
|---------------------------|------------|-----|
| Does adjacent ramp exist? | Yes        |     |
| Volume on adjacent Ramp   | 877        | vph |
| Position of adjacent Ramp | Downstream |     |
| Type of adjacent Ramp     | Off        |     |
| Distance to adjacent Ramp | 900        | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 2587    | 211   | 877           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 719     | 59    | 244           | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

| Grade Length                  |  | %<br>mi | %<br>mi | %<br>mi   |
|-------------------------------|--|---------|---------|-----------|
| Trucks and buses PCE, ET      |  | 1.5     | 1.5     | 1.5       |
| Recreational vehicle PCE, ER  |  | 1.2     | 1.2     | 1.2       |
| Heavy vehicle adjustment, fHV |  | 0.897   | 0.966   | 0.966     |
| Driver population factor, fP  |  | 1.00    | 1.00    | 1.00      |
| Flow rate, vp                 |  | 3205    | 243     | 1009 pcph |

---

Estimation of V12 Merge Areas

---

$L = 0.00$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 1.000$  Using Equation 0  
 FM  
 $v_{12} = v_F (P_{FM}) = 3205$  pc/h

---

Capacity Checks

---

|                  | Actual | Maximum | LOS F? |
|------------------|--------|---------|--------|
| v <sub>FO</sub>  | 3448   | 4800    | No     |
| v <sub>R12</sub> | 3448   | 4600    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A = 26.7$  pc/mi/ln  
 Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

|  |               |     |
|--|---------------|-----|
| Intermediate speed variable,             | $M_S = 0.364$ |     |
| Space mean speed in ramp influence area, | $S_R = 59.8$  | mph |
| Space mean speed in outer lanes,         | $S_O = N/A$   | mph |
| Space mean speed for all vehicles,       | $S = 59.8$    | mph |

---

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Merge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/3/2002  
 Analysis time period: 2007 PM  
 Freeway/dir or travel: I-24 Eastbound  
 Junction: US 72 to I-24 Eastbound  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |       |     |
|----------------------------|-------|-----|
| Type of analysis           | Merge |     |
| Number of lanes in freeway | 2     |     |
| Free-flow speed on freeway | 70.0  | mph |
| Volume on freeway          | 1308  | vph |

On Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-flow speed on ramp           | 50.0  | mph |
| Volume on ramp                    | 788   | vph |
| Length of first accel/decel lane  | 880   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |          |     |
|---------------------------|----------|-----|
| Does adjacent ramp exist? | Yes      |     |
| Volume on adjacent Ramp   | 134      | vph |
| Position of adjacent Ramp | Upstream |     |
| Type of adjacent Ramp     | Off      |     |
| Distance to adjacent Ramp | 1600     | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 1308    | 788   | 134           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 363     | 219   | 37            | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

| Grade Length                  |       | %<br>mi | %<br>mi | %<br>mi |
|-------------------------------|-------|---------|---------|---------|
| Trucks and buses PCE, ET      | 1.5   | 1.5     | 1.5     |         |
| Recreational vehicle PCE, ER  | 1.2   | 1.2     | 1.2     |         |
| Heavy vehicle adjustment, fHV | 0.897 | 0.966   | 0.966   |         |
| Driver population factor, fP  | 1.00  | 1.00    | 1.00    |         |
| Flow rate, vp                 | 1620  | 906     | 154     | pcph    |

---

Estimation of V12 Merge Areas

---

$L = 0.00$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 1.000$  Using Equation 0  
 FM  
 $v_{12} = v_F (P_{FM}) = 1620$  pc/h

---

Capacity Checks

---

|                  | Actual | Maximum | LOS F? |
|------------------|--------|---------|--------|
| v <sub>FO</sub>  | 2526   | 4800    | No     |
| v <sub>R12</sub> | 2526   | 4600    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A = 19.2$  pc/mi/ln  
 Level of service for ramp-freeway junction areas of influence B

---

Speed Estimation

---

|  |               |     |
|--|---------------|-----|
| Intermediate speed variable,             | $M_S = 0.282$ |     |
| Space mean speed in ramp influence area, | $S_R = 62.1$  | mph |
| Space mean speed in outer lanes,         | $S_O = N/A$   | mph |
| Space mean speed for all vehicles,       | $S = 62.1$    | mph |

---

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Diverge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/7/2002  
 Analysis time period: 2007 PM  
 Freeway/dir or travel: I-24 Westbound  
 Junction: Prop. Ramp "A"  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |         |     |
|----------------------------|---------|-----|
| Type of analysis           | Diverge |     |
| Number of lanes in freeway | 2       |     |
| Free-flow speed on freeway | 70.0    | mph |
| Volume on freeway          | 3464    | vph |

Off Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-Flow speed on ramp           | 55.0  | mph |
| Volume on ramp                    | 338   | vph |
| Length of first accel/decel lane  | 800   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |            |     |
|---------------------------|------------|-----|
| Does adjacent ramp exist? | Yes        |     |
| Volume on adjacent ramp   | 539        | vph |
| Position of adjacent ramp | Downstream |     |
| Type of adjacent ramp     | Off        |     |
| Distance to adjacent ramp | 1500       | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 3464    | 338   | 539           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 962     | 94    | 150           | v   |
| Trucks and buses        | 23      | 7     | 0             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

|                               |       |    |       |    |       |      |
|-------------------------------|-------|----|-------|----|-------|------|
| Grade                         | 0.00  | %  | 0.00  | %  | 0.00  | %    |
| Length                        | 0.00  | mi | 0.00  | mi | 0.00  | mi   |
| Trucks and buses PCE, ET      | 1.5   |    | 1.5   |    | 1.5   |      |
| Recreational vehicle PCE, ER  | 1.2   |    | 1.2   |    | 1.2   |      |
| Heavy vehicle adjustment, fHV | 0.897 |    | 0.966 |    | 1.000 |      |
| Driver population factor, fP  | 1.00  |    | 1.00  |    | 1.00  |      |
| Flow rate, vp                 | 4292  |    | 389   |    | 599   | pcph |

---

Estimation of V12 Diverge Areas

---

$L = 0.00$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 1.000$  Using Equation 0  
 FD  
 $v_{12} = v_R + (v_F - v_R) P = 4292$  pc/h  
 FD

---

Capacity Checks

---

|                      | Actual | Maximum | LOS F? |
|----------------------|--------|---------|--------|
| $v_{Fi} = v_F$       | 4292   | 4800    | No     |
| $v_{12}$             | 4292   | 4400    | No     |
| $v_{FO} = v_F - v_R$ | 3903   | 4800    | No     |
| $v_R$                | 389    | 2200    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v_{12} - 0.009 D = 34.0$  pc/mi/ln  
 Level of service for ramp-freeway junction areas of influence D

---

Speed Estimation

---

|  |             |     |
|--|-------------|-----|
| Intermediate speed variable,             | $D = 0.203$ |     |
| Space mean speed in ramp influence area, | $S = 64$    | mph |
| Space mean speed in outer lanes,         | $S = N/A$   | mph |
| Space mean speed for all vehicles,       | $S = 64.3$  | mph |

---

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-mail: jstorey@flohut.com

Fax: (615) 399-9049

Diverge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/7/2002  
 Analysis time period: 2027 AM  
 Freeway/dir or travel: I-24 Westbound  
 Junction: Ramp 1  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |         |     |
|----------------------------|---------|-----|
| Type of analysis           | Diverge |     |
| Number of lanes in freeway | 2       |     |
| Free-flow speed on freeway | 70.0    | mph |
| Volume on freeway          | 4203    | vph |

Off Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-Flow speed on ramp           | 35.0  | mph |
| Volume on ramp                    | 633   | vph |
| Length of first accel/decel lane  | 740   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |          |     |
|---------------------------|----------|-----|
| Does adjacent ramp exist? | Yes      |     |
| Volume on adjacent ramp   | 256      | vph |
| Position of adjacent ramp | Upstream |     |
| Type of adjacent ramp     | Off      |     |
| Distance to adjacent ramp | 1200     | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 4203    | 633   | 256           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 1168    | 176   | 71            | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

|                               |       |    |       |    |       |      |
|-------------------------------|-------|----|-------|----|-------|------|
| Grade                         | 0.00  | %  | 0.00  | %  | 0.00  | %    |
| Length                        | 0.00  | mi | 0.00  | mi | 0.00  | mi   |
| Trucks and buses PCE, ET      | 1.5   |    | 1.5   |    | 1.5   |      |
| Recreational vehicle PCE, ER  | 1.2   |    | 1.2   |    | 1.2   |      |
| Heavy vehicle adjustment, fHV | 0.897 |    | 0.966 |    | 0.966 |      |
| Driver population factor, fP  | 1.00  |    | 1.00  |    | 1.00  |      |
| Flow rate, vp                 | 5207  |    | 728   |    | 294   | pcph |

---

Estimation of V12 Diverge Areas

---

$L = 0.00$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 1.000$  Using Equation 0  
 FD  
 $v_{12} = v_R + (v_F - v_R) P = 5207$  pc/h  
 FD

---

Capacity Checks

---

|                      | Actual | Maximum | LOS F? |
|----------------------|--------|---------|--------|
| $v_{12} = v_F$       | 5207   | 4800    | Yes    |
| $v_{12}$             | 5207   | 4400    | Yes    |
| $v_{FO} = v_F - v_R$ | 4479   | 4800    | No     |
| $v_R$                | 728    | 2000    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v_{12} - 0.009 D = 42.4$  pc/mi/ln  
 Level of service for ramp-freeway junction areas of influence F

---

Speed Estimation

---

|  |             |     |
|--|-------------|-----|
| Intermediate speed variable,             | $D = 0.494$ |     |
| Space mean speed in ramp influence area, | $S = 56$    | mph |
| Space mean speed in outer lanes,         | $S = N/A$   | mph |
| Space mean speed for all vehicles,       | $S = 56.2$  | mph |

---

HCS2000: Ramps and Ramp Junctions Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Merge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/3/2002  
 Analysis time period: 2027 AM  
 Freeway/dir or travel: I-24 Westbound  
 Junction: US 72 to I-24 Westbound  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |       |     |
|----------------------------|-------|-----|
| Type of analysis           | Merge |     |
| Number of lanes in freeway | 2     |     |
| Free-flow speed on freeway | 70.0  | mph |
| Volume on freeway          | 3570  | vph |

On Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-flow speed on ramp           | 45.0  | mph |
| Volume on ramp                    | 249   | vph |
| Length of first accel/decel lane  | 880   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |            |     |
|---------------------------|------------|-----|
| Does adjacent ramp exist? | Yes        |     |
| Volume on adjacent Ramp   | 889        | vph |
| Position of adjacent Ramp | Downstream |     |
| Type of adjacent Ramp     | Off        |     |
| Distance to adjacent Ramp | 900        | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 3570    | 249   | 889           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 992     | 69    | 247           | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

| Grade Length                  |       | %<br>mi | %<br>mi | %<br>mi |
|-------------------------------|-------|---------|---------|---------|
| Trucks and buses PCE, ET      | 1.5   | 1.5     | 1.5     |         |
| Recreational vehicle PCE, ER  | 1.2   | 1.2     | 1.2     |         |
| Heavy vehicle adjustment, fHV | 0.897 | 0.966   | 0.966   |         |
| Driver population factor, fP  | 1.00  | 1.00    | 1.00    |         |
| Flow rate, vp                 | 4423  | 286     | 1022    | pcph    |

---

Estimation of V12 Merge Areas

---

L = 0.00 (Equation 25-2 or 25-3)  
EQ  
P = 1.000 Using Equation 0  
FM  
 $v_{12} = v_F (P_{FM}) = 4423 \text{ pc/h}$

---

Capacity Checks

---

|                  | Actual | Maximum | LOS F? |
|------------------|--------|---------|--------|
| v <sub>FO</sub>  | 4709   | 4800    | No     |
| v <sub>R12</sub> | 4709   | 4600    | Yes    |

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A = 36.6 \text{ pc/mi/ln}$   
Level of service for ramp-freeway junction areas of influence F

---

Speed Estimation

---

|  |                       |     |
|--|-----------------------|-----|
| Intermediate speed variable,             | M = 0.674             |     |
| Space mean speed in ramp influence area, | S <sub>R</sub> = 51.1 | mph |
| Space mean speed in outer lanes,         | S <sub>O</sub> = N/A  | mph |
| Space mean speed for all vehicles,       | S = 51.1              | mph |

---

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-mail: jstorey@flohut.com

Fax: (615) 399-9049

Merge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/3/2002  
 Analysis time period: 2027 AM  
 Freeway/dir or travel: I-24 Eastbound  
 Junction: US 72 to I-24 Eastbound  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |       |     |
|----------------------------|-------|-----|
| Type of analysis           | Merge |     |
| Number of lanes in freeway | 2     |     |
| Free-flow speed on freeway | 70.0  | mph |
| Volume on freeway          | 1891  | vph |

On Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-flow speed on ramp           | 50.0  | mph |
| Volume on ramp                    | 1061  | vph |
| Length of first accel/decel lane  | 880   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |          |     |
|---------------------------|----------|-----|
| Does adjacent ramp exist? | Yes      |     |
| Volume on adjacent Ramp   | 221      | vph |
| Position of adjacent Ramp | Upstream |     |
| Type of adjacent Ramp     | Off      |     |
| Distance to adjacent Ramp | 1600     | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 1891    | 1061  | 221           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 525     | 295   | 61            | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

| Grade Length                  |       | %<br>mi | %<br>mi | %<br>mi |
|-------------------------------|-------|---------|---------|---------|
| Trucks and buses PCE, ET      | 1.5   | 1.5     | 1.5     |         |
| Recreational vehicle PCE, ER  | 1.2   | 1.2     | 1.2     |         |
| Heavy vehicle adjustment, fHV | 0.897 | 0.966   | 0.966   |         |
| Driver population factor, fP  | 1.00  | 1.00    | 1.00    |         |
| Flow rate, vp                 | 2343  | 1220    | 254     | pcph    |

---

Estimation of V12 Merge Areas

---

$L = 0.00$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 1.000$  Using Equation 0  
 FM  
 $v_{12} = v_F (P_{FM}) = 2343$  pc/h

---

Capacity Checks

---

|                  | Actual | Maximum | LOS F? |
|------------------|--------|---------|--------|
| v <sub>FO</sub>  | 3563   | 4800    | No     |
| v <sub>R12</sub> | 3563   | 4600    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A = 27.2$  pc/mi/ln  
 Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

|  |               |     |
|--|---------------|-----|
| Intermediate speed variable,             | $M_S = 0.371$ |     |
| Space mean speed in ramp influence area, | $S_R = 59.6$  | mph |
| Space mean speed in outer lanes,         | $S_0 = N/A$   | mph |
| Space mean speed for all vehicles,       | $S = 59.6$    | mph |

---

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Diverge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/7/2002  
 Analysis time period: 2027 AM  
 Freeway/dir or travel: I-24 Westbound  
 Junction: Prop. Ramp "A"  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |         |     |
|----------------------------|---------|-----|
| Type of analysis           | Diverge |     |
| Number of lanes in freeway | 2       |     |
| Free-flow speed on freeway | 70.0    | mph |
| Volume on freeway          | 4459    | vph |

Off Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-Flow speed on ramp           | 55.0  | mph |
| Volume on ramp                    | 256   | vph |
| Length of first accel/decel lane  | 800   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |            |     |
|---------------------------|------------|-----|
| Does adjacent ramp exist? | Yes        |     |
| Volume on adjacent ramp   | 633        | vph |
| Position of adjacent ramp | Downstream |     |
| Type of adjacent ramp     | Off        |     |
| Distance to adjacent ramp | 1500       | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 4459    | 256   | 633           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 1239    | 71    | 176           | v   |
| Trucks and buses        | 23      | 7     | 0             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

|                               |       |    |       |    |       |      |
|-------------------------------|-------|----|-------|----|-------|------|
| Grade                         | 0.00  | %  | 0.00  | %  | 0.00  | %    |
| Length                        | 0.00  | mi | 0.00  | mi | 0.00  | mi   |
| Trucks and buses PCE, ET      | 1.5   |    | 1.5   |    | 1.5   |      |
| Recreational vehicle PCE, ER  | 1.2   |    | 1.2   |    | 1.2   |      |
| Heavy vehicle adjustment, fHV | 0.897 |    | 0.966 |    | 1.000 |      |
| Driver population factor, fP  | 1.00  |    | 1.00  |    | 1.00  |      |
| Flow rate, vp                 | 5524  |    | 294   |    | 703   | pcph |

---

Estimation of V12 Diverge Areas

---

$L = 0.00$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 1.000$  Using Equation 0  
 FD  
 $v_{12} = v_R + (v_F - v_R) P = 5524$  pc/h  
 FD

---

Capacity Checks

---

|                      | Actual | Maximum | LOS F? |
|----------------------|--------|---------|--------|
| $v_{12} = v_F$       | 5524   | 4800    | Yes    |
| $v_{12}$             | 5524   | 4400    | Yes    |
| $v_{FO} = v_F - v_R$ | 5230   | 4800    | No     |
| $v_R$                | 294    | 2200    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v_{12} - 0.009 D = 44.6$  pc/mi/ln  
 Level of service for ramp-freeway junction areas of influence F

---

Speed Estimation

---

|  |             |     |
|--|-------------|-----|
| Intermediate speed variable,             | $D = 0.194$ |     |
| Space mean speed in ramp influence area, | $S = 65$    | mph |
| Space mean speed in outer lanes,         | $S = N/A$   | mph |
| Space mean speed for all vehicles,       | $S = 64.6$  | mph |

---

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-mail: jstorey@flohut.com

Fax: (615) 399-9049

Diverge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/7/2002  
 Analysis time period: 2027 PM  
 Freeway/dir or travel: I-24 Westbound  
 Junction: Ramp 1  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |         |     |
|----------------------------|---------|-----|
| Type of analysis           | Diverge |     |
| Number of lanes in freeway | 2       |     |
| Free-flow speed on freeway | 70.0    | mph |
| Volume on freeway          | 5107    | vph |

Off Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-Flow speed on ramp           | 35.0  | mph |
| Volume on ramp                    | 808   | vph |
| Length of first accel/decel lane  | 740   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |          |     |
|---------------------------|----------|-----|
| Does adjacent ramp exist? | Yes      |     |
| Volume on adjacent ramp   | 506      | vph |
| Position of adjacent ramp | Upstream |     |
| Type of adjacent ramp     | Off      |     |
| Distance to adjacent ramp | 1200     | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 5107    | 808   | 506           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 1419    | 224   | 141           | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

|                               |       |    |       |    |       |      |
|-------------------------------|-------|----|-------|----|-------|------|
| Grade                         | 0.00  | %  | 0.00  | %  | 0.00  | %    |
| Length                        | 0.00  | mi | 0.00  | mi | 0.00  | mi   |
| Trucks and buses PCE, ET      | 1.5   |    | 1.5   |    | 1.5   |      |
| Recreational vehicle PCE, ER  | 1.2   |    | 1.2   |    | 1.2   |      |
| Heavy vehicle adjustment, fHV | 0.897 |    | 0.966 |    | 0.966 |      |
| Driver population factor, fP  | 1.00  |    | 1.00  |    | 1.00  |      |
| Flow rate, vp                 | 6327  |    | 929   |    | 582   | pcph |

---

Estimation of V12 Diverge Areas

---

L = 0.00 (Equation 25-8 or 25-9)  
EQ  
P = 1.000 Using Equation 0  
FD  
 $v_{12} = v_R + (v_F - v_R) P = 6327$  pc/h

---

Capacity Checks

---

|                      | Actual | Maximum | LOS F? |
|----------------------|--------|---------|--------|
| $v_{12} = v_{F1}$    | 6327   | 4800    | Yes    |
| $v_{12}$             | 6327   | 4400    | Yes    |
| $v_{FO} = v_F - v_R$ | 5398   | 4800    | No     |
| $v_R$                | 929    | 2000    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v_{12} - 0.009 D = 52.0$  pc/mi/ln  
Level of service for ramp-freeway junction areas of influence F

---

Speed Estimation

---

|  |           |     |
|--|-----------|-----|
| Intermediate speed variable,             | D = 0.512 |     |
| Space mean speed in ramp influence area, | S = 56    | mph |
| Space mean speed in outer lanes,         | S = N/A   | mph |
| Space mean speed for all vehicles,       | S = 55.7  | mph |

---

HCS2000: Ramps and Ramp Junctions Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Merge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/3/2002  
 Analysis time period: 2027 PM  
 Freeway/dir or travel: I-24 Westbound  
 Junction: US 72 to I-24 Westbound  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |       |     |
|----------------------------|-------|-----|
| Type of analysis           | Merge |     |
| Number of lanes in freeway | 2     |     |
| Free-flow speed on freeway | 70.0  | mph |
| Volume on freeway          | 4299  | vph |

On Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-flow speed on ramp           | 45.0  | mph |
| Volume on ramp                    | 316   | vph |
| Length of first accel/decel lane  | 880   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |            |     |
|---------------------------|------------|-----|
| Does adjacent ramp exist? | Yes        |     |
| Volume on adjacent Ramp   | 1314       | vph |
| Position of adjacent Ramp | Downstream |     |
| Type of adjacent Ramp     | Off        |     |
| Distance to adjacent Ramp | 900        | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 4299    | 316   | 1314          | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 1194    | 88    | 365           | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

| Grade Length                  |  | %<br>mi | %<br>mi | %<br>mi |
|-------------------------------|--|---------|---------|---------|
| Trucks and buses PCE, ET      |  | 1.5     | 1.5     | 1.5     |
| Recreational vehicle PCE, ER  |  | 1.2     | 1.2     | 1.2     |
| Heavy vehicle adjustment, fHV |  | 0.897   | 0.966   | 0.966   |
| Driver population factor, fP  |  | 1.00    | 1.00    | 1.00    |
| Flow rate, vp                 |  | 5326    | 363     | 1511    |

---

Estimation of V12 Merge Areas

---

L = 0.00 (Equation 25-2 or 25-3)  
EQ  
P = 1.000 Using Equation 0  
FM  
 $v_{12} = v_F (P_{FM}) = 5326 \text{ pc/h}$

---

Capacity Checks

---

|                  | Actual | Maximum | LOS F? |
|------------------|--------|---------|--------|
| v <sub>FO</sub>  | 5689   | 4800    | Yes    |
| v <sub>R12</sub> | 5689   | 4600    | Yes    |

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A = 44.2 \text{ pc/mi/ln}$   
Level of service for ramp-freeway junction areas of influence F

---

Speed Estimation

---

|  |                       |     |
|--|-----------------------|-----|
| Intermediate speed variable,             | M = 1.395             |     |
| Space mean speed in ramp influence area, | S <sub>R</sub> = 31.0 | mph |
| Space mean speed in outer lanes,         | S <sub>O</sub> = N/A  | mph |
| Space mean speed for all vehicles,       | S = 31.0              | mph |

---

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Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090 Fax: (615) 399-9049  
 E-mail: jstorey@flohut.com

Merge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/3/2002  
 Analysis time period: 2027 PM  
 Freeway/dir or travel: I-24 Eastbound  
 Junction: US 72 to I-24 Eastbound  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |       |     |
|----------------------------|-------|-----|
| Type of analysis           | Merge |     |
| Number of lanes in freeway | 2     |     |
| Free-flow speed on freeway | 70.0  | mph |
| Volume on freeway          | 2178  | vph |

On Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-flow speed on ramp           | 50.0  | mph |
| Volume on ramp                    | 1182  | vph |
| Length of first accel/decel lane  | 880   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |          |     |
|---------------------------|----------|-----|
| Does adjacent ramp exist? | Yes      |     |
| Volume on adjacent Ramp   | 202      | vph |
| Position of adjacent Ramp | Upstream |     |
| Type of adjacent Ramp     | Off      |     |
| Distance to adjacent Ramp | 1600     | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 2178    | 1182  | 202           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 605     | 328   | 56            | v   |
| Trucks and buses        | 23      | 7     | 7             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

| Grade Length                  |  | %<br>mi | %<br>mi | %<br>mi |
|-------------------------------|--|---------|---------|---------|
| Trucks and buses PCE, ET      |  | 1.5     | 1.5     | 1.5     |
| Recreational vehicle PCE, ER  |  | 1.2     | 1.2     | 1.2     |
| Heavy vehicle adjustment, fHV |  | 0.897   | 0.966   | 0.966   |
| Driver population factor, fP  |  | 1.00    | 1.00    | 1.00    |
| Flow rate, vp                 |  | 2698    | 1359    | 232     |

---

Estimation of V12 Merge Areas

---

$L = 0.00$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 1.000$  Using Equation 0  
 FM  
 $v_{12} = v_F (P_{FM}) = 2698$  pc/h

---

Capacity Checks

---

|                  | Actual | Maximum | LOS F? |
|------------------|--------|---------|--------|
| v <sub>FO</sub>  | 4057   | 4800    | No     |
| v <sub>R12</sub> | 4057   | 4600    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A = 31.0$  pc/mi/ln  
 Level of service for ramp-freeway junction areas of influence D

---

Speed Estimation

---

|  |                  |
|--|------------------|
| Intermediate speed variable,             | $M_S = 0.458$    |
| Space mean speed in ramp influence area, | $S_R = 57.2$ mph |
| Space mean speed in outer lanes,         | $S_0 = N/A$ mph  |
| Space mean speed for all vehicles,       | $S = 57.2$ mph   |

---

HCS2000: Ramps and Ramp Junctions Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-mail: jstorey@flohut.com

Fax: (615) 399-9049

Diverge Analysis

Analyst: Jon Storey  
 Agency/Co.: Florence & Hutcheson  
 Date performed: 6/7/2002  
 Analysis time period: 2027 PM  
 Freeway/dir or travel: I-24 Westbound  
 Junction: Prop. Ramp "A"  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Description: Interchange Modification Study

Freeway Data

|                            |         |     |
|----------------------------|---------|-----|
| Type of analysis           | Diverge |     |
| Number of lanes in freeway | 2       |     |
| Free-flow speed on freeway | 70.0    | mph |
| Volume on freeway          | 5613    | vph |

Off Ramp Data

|                                   |       |     |
|-----------------------------------|-------|-----|
| Side of freeway                   | Right |     |
| Number of lanes in ramp           | 1     |     |
| Free-Flow speed on ramp           | 55.0  | mph |
| Volume on ramp                    | 506   | vph |
| Length of first accel/decel lane  | 800   | ft  |
| Length of second accel/decel lane |       | ft  |

Adjacent Ramp Data (if one exists)

|                           |            |     |
|---------------------------|------------|-----|
| Does adjacent ramp exist? | Yes        |     |
| Volume on adjacent ramp   | 808        | vph |
| Position of adjacent ramp | Downstream |     |
| Type of adjacent ramp     | Off        |     |
| Distance to adjacent ramp | 1500       | ft  |

Conversion to pc/h Under Base Conditions

| Junction Components     | Freeway | Ramp  | Adjacent Ramp |     |
|-------------------------|---------|-------|---------------|-----|
| Volume, V (vph)         | 5613    | 506   | 808           | vph |
| Peak-hour factor, PHF   | 0.90    | 0.90  | 0.90          |     |
| Peak 15-min volume, v15 | 1559    | 141   | 224           | v   |
| Trucks and buses        | 23      | 7     | 0             | %   |
| Recreational vehicles   | 0       | 0     | 0             | %   |
| Terrain type:           | Level   | Level | Level         |     |

|                               |       |    |       |    |       |      |
|-------------------------------|-------|----|-------|----|-------|------|
| Grade                         | 0.00  | %  | 0.00  | %  | 0.00  | %    |
| Length                        | 0.00  | mi | 0.00  | mi | 0.00  | mi   |
| Trucks and buses PCE, ET      | 1.5   |    | 1.5   |    | 1.5   |      |
| Recreational vehicle PCE, ER  | 1.2   |    | 1.2   |    | 1.2   |      |
| Heavy vehicle adjustment, fHV | 0.897 |    | 0.966 |    | 1.000 |      |
| Driver population factor, fP  | 1.00  |    | 1.00  |    | 1.00  |      |
| Flow rate, vp                 | 6954  |    | 582   |    | 898   | pcph |

---

Estimation of V12 Diverge Areas

---

$L = 0.00$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 1.000$  Using Equation 0  
 FD  
 $v_{12} = v_R + (v_F - v_R) P = 6954$  pc/h  
 FD

---

Capacity Checks

---

|                      | Actual | Maximum | LOS F? |
|----------------------|--------|---------|--------|
| $v_{12} = v_F$       | 6954   | 4800    | Yes    |
| $v_{12}$             | 6954   | 4400    | Yes    |
| $v_{FO} = v_F - v_R$ | 6372   | 4800    | No     |
| $v_R$                | 582    | 2200    | No     |

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v_{12} - 0.009 D = 56.9$  pc/mi/ln  
 Level of service for ramp-freeway junction areas of influence F

---

Speed Estimation

---

|  |             |     |
|--|-------------|-----|
| Intermediate speed variable,             | $D = 0.220$ |     |
| Space mean speed in ramp influence area, | $S = 64$    | mph |
| Space mean speed in outer lanes,         | $S = N/A$   | mph |
| Space mean speed for all vehicles,       | $S = 63.8$  | mph |

---

# Signalized Intersection

U.S. 72 at Ramps "A" & 2  
Proposed System

HCS2000: Signalized Intersections Release 4.1b

Analyst: Jonathan Storey Inter.: I-24 at U.S. 72  
 Agency: Florence & Hutcheson Area Type: All other areas  
 Date: 6/5/2002 Jurisd: Marion Co.  
 Period: 2007 AM Year : 2002  
 Project ID: Interchange Modification Study  
 E/W St: I-24 Ramps 2 and Prop. "A" N/S St: U.S. 72

SIGNALIZED INTERSECTION SUMMARY

|            | Eastbound |   |   | Westbound |   |      | Northbound |      |   | Southbound |      |   |
|------------|-----------|---|---|-----------|---|------|------------|------|---|------------|------|---|
|            | L         | T | R | L         | T | R    | L          | T    | R | L          | T    | R |
| No. Lanes  | 0         | 0 | 0 | 0         | 0 | 1    | 1          | 2    | 0 | 0          | 2    | 0 |
| LGConfig   |           |   |   |           |   | R    | L          | T    |   |            | T    |   |
| Volume     |           |   |   |           |   | 170  | 53         | 744  |   |            | 812  |   |
| Lane Width |           |   |   |           |   | 12.0 | 12.0       | 12.0 |   |            | 12.0 |   |
| RTOR Vol   |           |   |   |           |   | 43   |            |      |   |            |      |   |

Duration 0.25 Area Type: All other areas

Signal Operations

| Phase Combination | 1   | 2   | 3   | 4   | 5        | 6   | 7   | 8   |
|-------------------|-----|-----|-----|-----|----------|-----|-----|-----|
| EB Left           |     |     |     |     | NB Left  | P   |     |     |
| Thru              |     |     |     |     | Thru     | P   |     |     |
| Right             |     |     |     |     | Right    |     |     |     |
| Peds              |     |     |     |     | Peds     |     |     |     |
| WB Left           |     |     |     |     | SB Left  |     |     |     |
| Thru              |     |     |     |     | Thru     | P   |     |     |
| Right             |     |     |     |     | Right    |     |     |     |
| Peds              |     |     |     |     | Peds     |     |     |     |
| NB Right          |     |     |     |     | EB Right |     |     |     |
| SB Right          |     |     |     |     | WB Right | P   |     |     |
| Green             | 0.0 | 0.0 | 0.0 | 0.0 | 27.0     | 8.0 | 0.0 | 0.0 |
| Yellow            | 0.0 | 0.0 | 0.0 |     | 3.0      | 3.0 | 0.0 |     |
| All Red           | 0.0 | 0.0 | 0.0 |     | 0.0      | 0.0 | 0.0 |     |

Cycle Length: 41.0 secs

Intersection Performance Summary

| Appr/<br>Lane<br>Grp | Lane<br>Group<br>Capacity | Adj Sat<br>Flow Rate<br>(s) | Ratios<br>v/c g/C |  | Lane Group<br>Delay LOS |  | Approach<br>Delay LOS |  |
|----------------------|---------------------------|-----------------------------|-------------------|--|-------------------------|--|-----------------------|--|
|----------------------|---------------------------|-----------------------------|-------------------|--|-------------------------|--|-----------------------|--|

Eastbound

Westbound

|            |      |      |      |      |      |   |      |   |
|------------|------|------|------|------|------|---|------|---|
| R          | 321  | 1644 | 0.44 | 0.20 | 18.8 | B | 18.8 | B |
| Northbound |      |      |      |      |      |   |      |   |
| L          | 352  | 1805 | 0.17 | 0.20 | 14.8 | B |      |   |
| T          | 2377 | 3610 | 0.35 | 0.66 | 3.5  | A | 4.3  | A |

Southbound

|   |      |      |      |      |     |   |     |   |
|---|------|------|------|------|-----|---|-----|---|
| T | 2377 | 3610 | 0.38 | 0.66 | 3.6 | A | 3.6 | A |
|---|------|------|------|------|-----|---|-----|---|

Intersection Delay = 5.0 (sec/veh) Intersection LOS = A

HCS2000: Signalized Intersections Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-Mail: jstorey@flohut.com

Fax: (615) 399-9049

OPERATIONAL ANALYSIS

Analyst: Jonathan Storey  
 Agency/Co.: Florence & Hutcheson  
 Date Performed: 6/5/2002  
 Analysis Time Period: 2007 AM  
 Intersection: I-24 at U.S. 72  
 Area Type: All other areas  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Project ID: Interchange Modification Study  
                     East/West Street                      North/South Street  
                     I-24 Ramps 2 and Prop. "A"                      U.S. 72

VOLUME DATA

|              | Eastbound |   |   | Westbound                  |   |       | Northbound |       |   | Southbound |       |   |
|--------------|-----------|---|---|----------------------------|---|-------|------------|-------|---|------------|-------|---|
|              | L         | T | R | L                          | T | R     | L          | T     | R | L          | T     | R |
| Volume       |           |   |   |                            |   | 170   | 53         | 744   |   |            | 812   |   |
| % Heavy Veh  |           |   |   |                            |   | 0     | 0          | 0     |   |            | 0     |   |
| PHF          |           |   |   |                            |   | 0.90  | 0.90       | 0.90  |   |            | 0.90  |   |
| PK 15 Vol    |           |   |   |                            |   | 47    | 15         | 207   |   |            | 226   |   |
| Hi Ln Vol    |           |   |   |                            |   |       |            |       |   |            |       |   |
| % Grade      |           |   |   |                            | 0 |       |            | 0     |   |            | 0     |   |
| Ideal Sat    |           |   |   |                            |   | 1900  | 1900       | 1900  |   |            | 1900  |   |
| ParkExist    |           |   |   |                            |   |       |            |       |   |            |       |   |
| NumPark      |           |   |   |                            |   |       |            |       |   |            |       |   |
| No. Lanes    | 0         | 0 | 0 | 0                          | 0 | 1     | 1          | 2     | 0 | 0          | 2     | 0 |
| LGConfig     |           |   |   |                            |   | R     | L          | T     |   |            | T     |   |
| Lane Width   |           |   |   |                            |   | 12.0  | 12.0       | 12.0  |   |            | 12.0  |   |
| RTOR Vol     |           |   |   |                            |   | 43    |            |       |   |            |       |   |
| Adj Flow     |           |   |   |                            |   | 140   | 59         | 827   |   |            | 902   |   |
| %InSharedLn  |           |   |   |                            |   |       |            |       |   |            |       |   |
| Prop LTs     |           |   |   |                            |   |       |            | 0.000 |   |            | 0.000 |   |
| Prop RTs     |           |   |   |                            |   | 1.000 | 0.000      |       |   | 0.000      |       |   |
| Peds Bikes   |           |   |   | 0                          |   |       |            |       |   | 0          |       |   |
| Buses        |           |   |   |                            |   | 0     | 0          | 0     |   | 0          |       |   |
| %InProtPhase |           |   |   |                            |   |       |            |       |   |            |       |   |
| Duration     | 0.25      |   |   | Area Type: All other areas |   |       |            |       |   |            |       |   |

OPERATING PARAMETERS

|  | Eastbound |   |   | Westbound |   |   | Northbound |   |   | Southbound |   |   |
|--|-----------|---|---|-----------|---|---|------------|---|---|------------|---|---|
|  | L         | T | R | L         | T | R | L          | T | R | L          | T | R |

|             |  |       |       |       |       |
|-------------|--|-------|-------|-------|-------|
| Init Unmet  |  | 0.0   | 0.0   | 0.0   | 0.0   |
| Arriv. Type |  | 3     | 3     | 3     | 3     |
| Unit Ext.   |  | 3.0   | 3.0   | 3.0   | 3.0   |
| I Factor    |  | 1.000 | 1.000 | 1.000 | 1.000 |
| Lost Time   |  | 2.0   | 2.0   | 2.0   | 2.0   |
| Ext of g    |  | 2.0   | 2.0   | 2.0   | 2.0   |
| Ped Min g   |  | 3.2   |       |       | 3.2   |

PHASE DATA

| Phase Combination | 1   | 2   | 3   | 4   | 5        | 6   | 7   | 8   |
|-------------------|-----|-----|-----|-----|----------|-----|-----|-----|
| EB Left           |     |     |     |     | NB Left  | P   |     |     |
| Thru              |     |     |     |     | Thru     | P   |     |     |
| Right             |     |     |     |     | Right    |     |     |     |
| Peds              |     |     |     |     | Peds     |     |     |     |
| WB Left           |     |     |     |     | SB Left  |     |     |     |
| Thru              |     |     |     |     | Thru     | P   |     |     |
| Right             |     |     |     |     | Right    |     |     |     |
| Peds              |     |     |     |     | Peds     |     |     |     |
| NB Right          |     |     |     |     | EB Right |     |     |     |
| SB Right          |     |     |     |     | WB Right | P   |     |     |
| Green             | 0.0 | 0.0 | 0.0 | 0.0 | 27.0     | 8.0 | 0.0 | 0.0 |
| Yellow            | 0.0 | 0.0 | 0.0 |     | 3.0      | 3.0 | 0.0 |     |
| All Red           | 0.0 | 0.0 | 0.0 |     | 0.0      | 0.0 | 0.0 |     |

Cycle Length: 41.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

| Volume Adjustment | Eastbound |   |   | Westbound |   |       | Northbound |       |   | Southbound |       |   |
|-------------------|-----------|---|---|-----------|---|-------|------------|-------|---|------------|-------|---|
|                   | L         | T | R | L         | T | R     | L          | T     | R | L          | T     | R |
| Volume, V         |           |   |   |           |   | 170   | 53         | 744   |   |            | 812   |   |
| PHF               |           |   |   |           |   | 0.90  | 0.90       | 0.90  |   |            | 0.90  |   |
| Adj flow          |           |   |   |           |   | 140   | 59         | 827   |   |            | 902   |   |
| No. Lanes         | 0         | 0 | 0 | 0         | 0 | 1     | 1          | 2     | 0 | 0          | 2     | 0 |
| Lane group        |           |   |   |           |   | R     | L          | T     |   |            | T     |   |
| Adj flow          |           |   |   |           |   | 140   | 59         | 827   |   |            | 902   |   |
| Prop LTs          |           |   |   |           |   |       |            | 0.000 |   |            | 0.000 |   |
| Prop RTs          |           |   |   |           |   | 1.000 |            | 0.000 |   |            | 0.000 |   |

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

|       | Eastbound |   |   | Westbound |   |       | Northbound |       |   | Southbound |       |   |
|-------|-----------|---|---|-----------|---|-------|------------|-------|---|------------|-------|---|
| LG    |           |   |   |           |   | R     | L          | T     |   |            | T     |   |
| So    |           |   |   |           |   | 1900  | 1900       | 1900  |   |            | 1900  |   |
| Lanes | 0         | 0 | 0 | 0         | 0 | 1     | 1          | 2     | 0 | 0          | 2     | 0 |
| fW    |           |   |   |           |   | 1.000 | 1.000      | 1.000 |   |            | 1.000 |   |
| fHV   |           |   |   |           |   | 1.000 | 1.000      | 1.000 |   |            | 1.000 |   |
| fG    |           |   |   |           |   | 1.000 | 1.000      | 1.000 |   |            | 1.000 |   |
| fP    |           |   |   |           |   | 1.000 | 1.000      | 1.000 |   |            | 1.000 |   |

|      |       |       |       |       |
|------|-------|-------|-------|-------|
| fBB  | 1.000 | 1.000 | 1.000 | 1.000 |
| fA   | 1.00  | 1.00  | 1.00  | 1.00  |
| fLU  | 1.00  | 1.00  | 0.95  | 0.95  |
| fRT  | 0.865 |       | 1.000 | 1.000 |
| fLT  |       | 0.950 | 1.000 | 1.000 |
| Sec. |       |       |       |       |
| fLpb |       | 1.000 | 1.000 | 1.000 |
| fRpb | 1.000 |       | 1.000 | 1.000 |
| S    | 1644  | 1805  | 3610  | 3610  |
| Sec. |       |       |       |       |

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

| Appr/<br>Mvmt | Lane<br>Group | Adj<br>Flow Rate<br>(v) | Adj Sat<br>Flow Rate<br>(s) | Flow<br>Ratio<br>(v/s) | Green<br>Ratio<br>(g/C) | --Lane Group--<br>Capacity<br>(c) | v/c<br>Ratio |
|---------------|---------------|-------------------------|-----------------------------|------------------------|-------------------------|-----------------------------------|--------------|
| Eastbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Westbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right         | R                       | 140                         | 1644                   | # 0.09                  | 0.20                              | 321 0.44     |
| Northbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          | L                       | 59                          | 1805                   | 0.03                    | 0.20                              | 352 0.17     |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          | T                       | 827                         | 3610                   | 0.23                    | 0.66                              | 2377 0.35    |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Southbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          | T                       | 902                         | 3610                   | # 0.25                  | 0.66                              | 2377 0.38    |
|               | Right         |                         |                             |                        |                         |                                   |              |

Sum of flow ratios for critical lane groups,  $Y_c = \text{Sum (v/s)} = 0.34$   
 Total lost time per cycle,  $L = 6.00$  sec  
 Critical flow rate to capacity ratio,  $X_c = (Y_c) (C) / (C-L) = 0.39$

Control Delay and LOS Determination

| Appr/<br>Lane | Ratios | Unf<br>Del | Prog<br>Adj | Lane<br>Grp | Incremental<br>Factor | Res<br>Del | Lane Group | Approach |
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|

| Grp  | v/c  | g/C  | d1   | Fact  | Cap  | k    | d2  | d3  | Delay | LOS | Delay | LOS |
|--|------|------|------|-------|------|------|-----|-----|-------|-----|-------|-----|
| Eastbound  |      |      |      |       |      |      |     |     |       |     |       |     |
| Westbound  |      |      |      |       |      |      |     |     |       |     |       |     |
| R  | 0.44 | 0.20 | 14.5 | 1.000 | 321  | 0.50 | 4.3 | 0.0 | 18.8  | B   | 18.8  | B   |
| Northbound   |      |      |      |       |      |      |     |     |       |     |       |     |
| L  | 0.17 | 0.20 | 13.7 | 1.000 | 352  | 0.50 | 1.0 | 0.0 | 14.8  | B   |       |     |
| T  | 0.35 | 0.66 | 3.1  | 1.000 | 2377 | 0.50 | 0.4 | 0.0 | 3.5   | A   | 4.3   | A   |
| Southbound   |      |      |      |       |      |      |     |     |       |     |       |     |
| T  | 0.38 | 0.66 | 3.2  | 1.000 | 2377 | 0.50 | 0.5 | 0.0 | 3.6   | A   | 3.6   | A   |
| <hr/> Intersection delay = 5.0 (sec/veh)      Intersection LOS = A |      |      |      |       |      |      |     |     |       |     |       |     |

SUPPLEMENTAL PERMITTED LT WORKSHEET  
for exclusive lefts

Input

|   | EB   | WB | NB   | SB   |
|---|------|----|------|------|
| Cycle length, C   |      |    |      |      |
| Total actual green time for LT lane group, G (s)                              | 41.0 |    |      |      |
| Effective permitted green time for LT lane group, g(s)                        |      |    |      |      |
| Opposing effective green time, go (s)   |      |    |      |      |
| Number of lanes in LT lane group, N   |      |    |      |      |
| Number of lanes in opposing approach, No                                      |      |    |      |      |
| Adjusted LT flow rate, VLT (veh/h)  |      |    |      |      |
| Proportion of LT in LT lane group, PLT  |      |    |      |      |
| Proportion of LT in opposing flow, PLTo                                       |      |    |      |      |
| Adjusted opposing flow rate, Vo (veh/h)                                       |      |    |      |      |
| Lost time for LT lane group, tL   |      |    |      |      |
| Computation   |      |    |      |      |
| LT volume per cycle, LTC=VLTC/3600  |      |    |      |      |
| Opposing lane util. factor, fLUo  |      |    | 0.95 | 0.95 |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)                           |      |    |      |      |
| gf=G[exp(- a * (LTC ** b))]-tL, gf<=g   |      |    |      |      |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)                             |      |    |      |      |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]                                  |      |    |      |      |
| gq, (see Exhibit C16-4,5,6,7,8)   |      |    |      |      |
| gu=g-gq if gq>=gf, or = g-gf if gq<gf   |      |    |      |      |
| n=Max(gq-gf)/2,0)   |      |    |      |      |
| PTHo=1-PLTo   |      |    |      |      |
| PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]  |      |    |      |      |
| EL1 (refer to Exhibit C16-3)  |      |    |      |      |
| EL2=Max((1-Ptho**n)/Plto, 1.0)  |      |    |      |      |
| fmin=2(1+PL)/g or fmin=2(1+Pl)/g  |      |    |      |      |
| gdifff=max(gq-gf,0)   |      |    |      |      |
| fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)                           |      |    |      |      |
| flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdifff/g]/[1+PL(EL2-1)], (fmin<=fm<=1.00) |      |    |      |      |
| or flt=[fm+0.91(N-1)]/N**   |      |    |      |      |

Left-turn adjustment, fLT

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET

for shared lefts

Input

|   | EB | WB | NB    | SB    |
|---|----|----|-------|-------|
| Cycle length, C   |    |    |       |       |
| 41.0 sec  |    |    |       |       |
| Total actual green time for LT lane group, G (s)  |    |    |       |       |
| Effective permitted green time for LT lane group, g(s)  |    |    |       |       |
| Opposing effective green time, go (s)   |    |    |       |       |
| Number of lanes in LT lane group, N   |    |    |       |       |
| Number of lanes in opposing approach, No  |    |    |       |       |
| Adjusted LT flow rate, VLT (veh/h)  |    |    |       |       |
| Proportion of LT in LT lane group, PLT  |    |    | 0.000 | 0.000 |
| Proportion of LT in opposing flow, PLTo   |    |    |       |       |
| Adjusted opposing flow rate, Vo (veh/h)   |    |    |       |       |
| Lost time for LT lane group, tL   |    |    |       |       |
| Computation   |    |    |       |       |
| LT volume per cycle, LTC=VLTC/3600  |    |    |       |       |
| Opposing lane util. factor, fLUo  |    |    | 0.95  | 0.95  |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)   |    |    |       |       |
| $gf = G[\exp(-a * (LTC ** b))] - tL$ , $gf \leq g$  |    |    |       |       |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)   |    |    |       |       |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]  |    |    |       |       |
| gq, (see Exhibit C16-4,5,6,7,8)   |    |    |       |       |
| $gu = g - gq$ if $gq \geq gf$ , or $= g - gf$ if $gq < gf$  |    |    |       |       |
| $n = \text{Max}(gq - gf) / 2, 0$  |    |    |       |       |
| $PTHo = 1 - PLTo$   |    |    |       |       |
| $PL* = PLT[1 + (N-1)g / (gf + gu / EL1 + 4.24)]$  |    |    |       |       |
| EL1 (refer to Exhibit C16-3)  |    |    |       |       |
| $EL2 = \text{Max}((1 - Ptho ** n) / Plto, 1.0)$   |    |    |       |       |
| $fmin = 2(1 + PL) / g$ or $fmin = 2(1 + Pl) / g$  |    |    |       |       |
| $gdiff = \text{max}(gq - gf, 0)$  |    |    |       |       |
| $fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)]$ , (min=fmin;max=1.00)                                    |    |    |       |       |
| $flt = fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)] + [gdiff/g] / [1 + PL(EL2 - 1)]$ , (fmin<=fm<=1.00) |    |    |       |       |
| or $flt = [fm + 0.91(N-1)] / N **$  |    |    |       |       |
| Left-turn adjustment, fLT   |    |    |       |       |

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns

EB WB NB SB

Effective pedestrian green time,  $g_p$  (s)  
 Conflicting pedestrian volume,  $V_{ped}$  (p/h)  
 Pedestrian flow rate,  $V_{pedg}$  (p/h)  
 $OCC_{pedg}$   
 Opposing queue clearing green,  $g_q$  (s)  
 Eff. ped. green consumed by opp. veh. queue,  $g_q/g_p$   
 $OCC_{pedu}$   
 Opposing flow rate,  $V_o$  (veh/h)  
 $OCC_r$   
 Number of cross-street receiving lanes,  $N_{rec}$   
 Number of turning lanes,  $N_{turn}$   
 $ApbT$   
 Proportion of left turns,  $PLT$   
 Proportion of left turns using protected phase,  $PLTA$   
 Left-turn adjustment,  $f_{Lpb}$   
 Permitted Right Turns  
 Effective pedestrian green time,  $g_p$  (s)  
 Conflicting pedestrian volume,  $V_{ped}$  (p/h)  
 Conflicting bicycle volume,  $V_{bic}$  (bicycles/h)  
 $V_{pedg}$   
 $OCC_{pedg}$   
 Effective green,  $g$  (s)  
 $V_{bicg}$   
 $OCC_{bicg}$   
 $OCC_r$   
 Number of cross-street receiving lanes,  $N_{rec}$   
 Number of turning lanes,  $N_{turn}$   
 $ApbT$   
 Proportion right-turns,  $PRT$   
 Proportion right-turns using protected phase,  $PRTA$   
 Right turn adjustment,  $f_{Rpb}$

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SUPPLEMENTAL UNIFORM DELAY WORKSHEET

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|   |      | EBLT | WBLT | NBLT | SBLT |
|---|------|------|------|------|------|
| Cycle length, $C$   | 41.0 |      |      |      |      |
| Adj. LT vol from Vol Adjustment Worksheet, $v$            |      |      |      |      |      |
| $v/c$ ratio from Capacity Worksheet, $X$                  |      |      |      |      |      |
| Protected phase effective green interval, $g$ (s)         |      |      |      |      |      |
| Opposing queue effective green interval, $g_q$            |      |      |      |      |      |
| Unopposed green interval, $g_u$                           |      |      |      |      |      |
| Red time $r=(C-g-g_q-g_u)$                                |      |      |      |      |      |
| Arrival rate, $q_a=v/(3600(\max[X,1.0]))$                 |      |      |      |      |      |
| Protected ph. departure rate, $S_p=s/3600$                |      |      |      |      |      |
| Permitted ph. departure rate, $S_s=s(g_q+g_u)/(g_u*3600)$ |      |      |      |      |      |
| $X_{Perm}$  |      |      |      |      |      |
| $X_{Prot}$  |      |      |      |      |      |
| Case  |      |      |      |      |      |
| Queue at beginning of green arrow, $Q_a$                  |      |      |      |      |      |
| Queue at beginning of unsaturated green, $Q_u$            |      |      |      |      |      |
| Residual queue, $Q_r$                                     |      |      |      |      |      |
| Uniform Delay, $d_l$                                      |      |      |      |      |      |

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DELAY/LOS WORKSHEET WITH INITIAL QUEUE

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|       | Initial Dur. | Uniform Delay | Initial Queue | Final Queue | Initial Lane | Lane Group |
|-------|--------------|---------------|---------------|-------------|--------------|------------|
| Appr/ | Unmet        | Unmet         | _____         | Unmet       | Queue        | Group      |

| Lane Group | Demand Q veh | Demand t hrs. | Unadj. ds | Adj. dl sec | Param. u | Demand Q veh | Delay d3 sec | Delay d sec |
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|

Eastbound

Westbound

Northbound

Southbound

|                    |     |         |                  |   |
|--------------------|-----|---------|------------------|---|
| Intersection Delay | 5.0 | sec/veh | Intersection LOS | A |
|--------------------|-----|---------|------------------|---|

BACK OF QUEUE WORKSHEET

|                         | Eastbound |   |   | Westbound |      |       | Northbound |   |   | Southbound |   |   |
|-------------------------|-----------|---|---|-----------|------|-------|------------|---|---|------------|---|---|
| LaneGroup               |           |   |   | R         | L    | T     |            |   |   | T          |   |   |
| Init Queue              |           |   |   | 0.0       | 0.0  | 0.0   |            |   |   | 0.0        |   |   |
| Flow Rate               |           |   |   | 140       | 59   | 413   |            |   |   | 451        |   |   |
| So                      |           |   |   | 1900      | 1900 | 1900  |            |   |   | 1900       |   |   |
| No.Lanes                | 0         | 0 | 0 | 0         | 0    | 1     | 1          | 2 | 0 | 0          | 2 | 0 |
| SL                      |           |   |   | 1644      | 1805 | 1805  |            |   |   | 1805       |   |   |
| LnCapacity              |           |   |   | 321       | 352  | 1188  |            |   |   | 1188       |   |   |
| Flow Ratio              |           |   |   | 0.09      | 0.03 | 0.23  |            |   |   | 0.25       |   |   |
| v/c Ratio               |           |   |   | 0.44      | 0.17 | 0.35  |            |   |   | 0.38       |   |   |
| Grn Ratio               |           |   |   | 0.20      | 0.20 | 0.66  |            |   |   | 0.66       |   |   |
| I Factor                |           |   |   | 1.000     |      | 1.000 |            |   |   | 1.000      |   |   |
| AT or PVG               |           |   |   | 3         | 3    | 3     |            |   |   | 3          |   |   |
| Pltn Ratio              |           |   |   | 1.00      | 1.00 | 1.00  |            |   |   | 1.00       |   |   |
| PF2                     |           |   |   | 1.00      | 1.00 | 1.00  |            |   |   | 1.00       |   |   |
| Q1                      |           |   |   | 1.4       | 0.6  | 2.1   |            |   |   | 2.3        |   |   |
| kB                      |           |   |   | 0.3       | 0.3  | 0.7   |            |   |   | 0.7        |   |   |
| Q2                      |           |   |   | 0.2       | 0.1  | 0.4   |            |   |   | 0.5        |   |   |
| Q Average               |           |   |   | 1.6       | 0.6  | 2.5   |            |   |   | 2.8        |   |   |
| Q Spacing               |           |   |   | 24.9      | 24.9 | 24.9  |            |   |   | 24.9       |   |   |
| Q Storage               |           |   |   | 0         | 0    | 0     |            |   |   | 0          |   |   |
| Q S Ratio               |           |   |   |           |      |       |            |   |   |            |   |   |
| 70th Percentile Output: |           |   |   |           |      |       |            |   |   |            |   |   |
| fB%                     |           |   |   | 1.3       | 1.3  | 1.3   |            |   |   | 1.3        |   |   |
| BOQ                     |           |   |   | 2.1       | 0.8  | 3.1   |            |   |   | 3.5        |   |   |
| QSRatio                 |           |   |   |           |      |       |            |   |   |            |   |   |
| 85th Percentile Output: |           |   |   |           |      |       |            |   |   |            |   |   |
| fB%                     |           |   |   | 1.6       | 1.7  | 1.6   |            |   |   | 1.6        |   |   |
| BOQ                     |           |   |   | 2.6       | 1.0  | 3.9   |            |   |   | 4.4        |   |   |

|                         |  |  |     |     |     |  |     |
|-------------------------|--|--|-----|-----|-----|--|-----|
| QSRatio                 |  |  |     |     |     |  |     |
| 90th Percentile Output: |  |  |     |     |     |  |     |
| fB%                     |  |  | 1.9 | 1.9 | 1.8 |  | 1.8 |
| BOQ                     |  |  | 3.0 | 1.2 | 4.5 |  | 5.0 |
| QSRatio                 |  |  |     |     |     |  |     |
| 95th Percentile Output: |  |  |     |     |     |  |     |
| fB%                     |  |  | 2.3 | 2.5 | 2.2 |  | 2.2 |
| BOQ                     |  |  | 3.8 | 1.5 | 5.5 |  | 6.1 |
| QSRatio                 |  |  |     |     |     |  |     |
| 98th Percentile Output: |  |  |     |     |     |  |     |
| fB%                     |  |  | 2.8 | 3.0 | 2.6 |  | 2.6 |
| BOQ                     |  |  | 4.5 | 1.9 | 6.5 |  | 7.1 |
| QSRatio                 |  |  |     |     |     |  |     |

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ERROR MESSAGES

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No errors to report.

HCS2000: Signalized Intersections Release 4.1b

Analyst: Jonathan Storey Inter.: I-24 at U.S. 72  
 Agency: Florence & Hutcheson Area Type: All other areas  
 Date: 6/5/2002 Jurisd: Marion Co.  
 Period: 2007 PM Year : 2002  
 Project ID: Interchange Modification Study  
 E/W St: I-24 Ramps 2 and Prop. "A" N/S St: U.S. 72

SIGNALIZED INTERSECTION SUMMARY

|            | Eastbound |   |   | Westbound |   |      | Northbound |      |   | Southbound |      |   |
|------------|-----------|---|---|-----------|---|------|------------|------|---|------------|------|---|
|            | L         | T | R | L         | T | R    | L          | T    | R | L          | T    | R |
| No. Lanes  | 0         | 0 | 0 | 0         | 0 | 1    | 1          | 2    | 0 | 0          | 2    | 0 |
| LGConfig   |           |   |   |           |   | R    | L          | T    |   |            | T    |   |
| Volume     |           |   |   |           |   | 338  | 75         | 977  |   |            | 1086 |   |
| Lane Width |           |   |   |           |   | 12.0 | 12.0       | 12.0 |   |            | 12.0 |   |
| RTOR Vol   |           |   |   |           |   | 85   |            |      |   |            |      |   |

Duration 0.25 Area Type: All other areas

Signal Operations

| Phase Combination | 1   | 2   | 3   | 4   | 5        | 6   | 7   | 8   |
|-------------------|-----|-----|-----|-----|----------|-----|-----|-----|
| EB Left           |     |     |     |     | NB Left  | P   |     |     |
| Thru              |     |     |     |     | Thru     | P   |     |     |
| Right             |     |     |     |     | Right    |     |     |     |
| Peds              |     |     |     |     | Peds     |     |     |     |
| WB Left           |     |     |     |     | SB Left  |     |     |     |
| Thru              |     |     |     |     | Thru     | P   |     |     |
| Right             |     |     |     |     | Right    |     |     |     |
| Peds              |     |     |     |     | Peds     |     |     |     |
| NB Right          |     |     |     |     | EB Right |     |     |     |
| SB Right          |     |     |     |     | WB Right | P   |     |     |
| Green             | 0.0 | 0.0 | 0.0 | 0.0 | 19.0     | 8.0 | 0.0 | 0.0 |
| Yellow            | 0.0 | 0.0 | 0.0 |     | 3.0      | 3.0 | 0.0 |     |
| All Red           | 0.0 | 0.0 | 0.0 |     | 0.0      | 0.0 | 0.0 |     |

Cycle Length: 33.0 secs

Intersection Performance Summary

| Appr/<br>Lane<br>Grp | Lane<br>Group<br>Capacity | Adj Sat<br>Flow Rate<br>(s) | Ratios<br>v/c g/C |  | Lane Group<br>Delay LOS | Approach<br>Delay LOS |
|----------------------|---------------------------|-----------------------------|-------------------|--|-------------------------|-----------------------|
|----------------------|---------------------------|-----------------------------|-------------------|--|-------------------------|-----------------------|

Eastbound

Westbound

|            |      |      |      |      |      |   |      |   |
|------------|------|------|------|------|------|---|------|---|
| R          | 399  | 1644 | 0.70 | 0.24 | 21.3 | C | 21.3 | C |
| Northbound |      |      |      |      |      |   |      |   |
| L          | 438  | 1805 | 0.19 | 0.24 | 10.9 | B |      |   |
| T          | 2078 | 3610 | 0.52 | 0.58 | 5.2  | A | 5.6  | A |

Southbound

|   |      |      |      |      |     |   |     |   |
|---|------|------|------|------|-----|---|-----|---|
| T | 2078 | 3610 | 0.58 | 0.58 | 5.7 | A | 5.7 | A |
|---|------|------|------|------|-----|---|-----|---|

Intersection Delay = 7.3 (sec/veh) Intersection LOS = A

HCS2000: Signalized Intersections Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-Mail: jstorey@flohut.com

Fax: (615) 399-9049

OPERATIONAL ANALYSIS

Analyst: Jonathan Storey  
 Agency/Co.: Florence & Hutcheson  
 Date Performed: 6/5/2002  
 Analysis Time Period: 2007 PM  
 Intersection: I-24 at U.S. 72  
 Area Type: All other areas  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Project ID: Interchange Modification Study  
                     East/West Street                      North/South Street  
                     I-24 Ramps 2 and Prop. "A"                      U.S. 72

VOLUME DATA

|              | Eastbound |   |   | Westbound                  |   |       | Northbound |   |       | Southbound |   |       |
|--------------|-----------|---|---|----------------------------|---|-------|------------|---|-------|------------|---|-------|
|              | L         | T | R | L                          | T | R     | L          | T | R     | L          | T | R     |
| Volume       |           |   |   |                            |   | 338   | 75         |   | 977   |            |   | 1086  |
| % Heavy Veh  |           |   |   |                            |   | 0     | 0          |   | 0     |            |   | 0     |
| PHF          |           |   |   |                            |   | 0.90  | 0.90       |   | 0.90  |            |   | 0.90  |
| PK 15 Vol    |           |   |   |                            |   | 93    | 21         |   | 271   |            |   | 302   |
| Hi Ln Vol    |           |   |   |                            |   |       |            |   |       |            |   |       |
| % Grade      |           |   |   |                            | 0 |       |            |   | 0     |            |   | 0     |
| Ideal Sat    |           |   |   |                            |   | 1900  | 1900       |   | 1900  |            |   | 1900  |
| ParkExist    |           |   |   |                            |   |       |            |   |       |            |   |       |
| NumPark      |           |   |   |                            |   |       |            |   |       |            |   |       |
| No. Lanes    | 0         | 0 | 0 | 0                          | 0 | 1     | 1          | 2 | 0     | 0          | 2 | 0     |
| LGConfig     |           |   |   |                            |   | R     | L          |   | T     |            |   | T     |
| Lane Width   |           |   |   |                            |   | 12.0  | 12.0       |   | 12.0  |            |   | 12.0  |
| RTOR Vol     |           |   |   |                            |   | 85    |            |   |       |            |   |       |
| Adj Flow     |           |   |   |                            |   | 280   | 83         |   | 1086  |            |   | 1207  |
| %InSharedLn  |           |   |   |                            |   |       |            |   |       |            |   |       |
| Prop LTs     |           |   |   |                            |   |       |            |   | 0.000 |            |   | 0.000 |
| Prop RTs     |           |   |   |                            |   | 1.000 | 0.000      |   |       |            |   | 0.000 |
| Peds Bikes   |           |   |   | 0                          |   |       |            |   |       | 0          |   |       |
| Buses        |           |   |   |                            |   | 0     | 0          |   | 0     |            |   | 0     |
| %InProtPhase |           |   |   |                            |   |       |            |   |       |            |   |       |
| Duration     | 0.25      |   |   | Area Type: All other areas |   |       |            |   |       |            |   |       |

OPERATING PARAMETERS

|  | Eastbound |   |   | Westbound |   |   | Northbound |   |   | Southbound |   |   |
|--|-----------|---|---|-----------|---|---|------------|---|---|------------|---|---|
|  | L         | T | R | L         | T | R | L          | T | R | L          | T | R |

|             |  |       |       |       |       |
|-------------|--|-------|-------|-------|-------|
| Init Unmet  |  | 0.0   | 0.0   | 0.0   | 0.0   |
| Arriv. Type |  | 3     | 3     | 3     | 3     |
| Unit Ext.   |  | 3.0   | 3.0   | 3.0   | 3.0   |
| I Factor    |  | 1.000 | 1.000 | 1.000 | 1.000 |
| Lost Time   |  | 2.0   | 2.0   | 2.0   | 2.0   |
| Ext of g    |  | 2.0   | 2.0   | 2.0   | 2.0   |
| Ped Min g   |  | 3.2   |       |       | 3.2   |

PHASE DATA

| Phase Combination | 1   | 2   | 3   | 4   | 5        | 6   | 7   | 8   |
|-------------------|-----|-----|-----|-----|----------|-----|-----|-----|
| EB Left           |     |     |     |     | NB Left  | P   |     |     |
| Thru              |     |     |     |     | Thru     | P   |     |     |
| Right             |     |     |     |     | Right    |     |     |     |
| Peds              |     |     |     |     | Peds     |     |     |     |
| WB Left           |     |     |     |     | SB Left  |     |     |     |
| Thru              |     |     |     |     | Thru     | P   |     |     |
| Right             |     |     |     |     | Right    |     |     |     |
| Peds              |     |     |     |     | Peds     |     |     |     |
| NB Right          |     |     |     |     | EB Right |     |     |     |
| SB Right          |     |     |     |     | WB Right | P   |     |     |
| Green             | 0.0 | 0.0 | 0.0 | 0.0 | 19.0     | 8.0 | 0.0 | 0.0 |
| Yellow            | 0.0 | 0.0 | 0.0 |     | 3.0      | 3.0 | 0.0 |     |
| All Red           | 0.0 | 0.0 | 0.0 |     | 0.0      | 0.0 | 0.0 |     |

Cycle Length: 33.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

Volume Adjustment

|            | Eastbound |   |   | Westbound |   |       | Northbound |       |   | Southbound |       |   |
|------------|-----------|---|---|-----------|---|-------|------------|-------|---|------------|-------|---|
|            | L         | T | R | L         | T | R     | L          | T     | R | L          | T     | R |
| Volume, V  |           |   |   |           |   | 338   | 75         | 977   |   |            | 1086  |   |
| PHF        |           |   |   |           |   | 0.90  | 0.90       | 0.90  |   |            | 0.90  |   |
| Adj flow   |           |   |   |           |   | 280   | 83         | 1086  |   |            | 1207  |   |
| No. Lanes  | 0         | 0 | 0 | 0         | 0 | 1     | 1          | 2     | 0 | 0          | 2     | 0 |
| Lane group |           |   |   |           |   | R     | L          | T     |   |            | T     |   |
| Adj flow   |           |   |   |           |   | 280   | 83         | 1086  |   |            | 1207  |   |
| Prop LTs   |           |   |   |           |   |       |            | 0.000 |   |            | 0.000 |   |
| Prop RTs   |           |   |   |           |   | 1.000 |            | 0.000 |   |            | 0.000 |   |

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

|       | Eastbound |   |   | Westbound |   |       | Northbound |       |   | Southbound |       |   |
|-------|-----------|---|---|-----------|---|-------|------------|-------|---|------------|-------|---|
| LG    |           |   |   |           |   | R     | L          | T     |   |            | T     |   |
| So    |           |   |   |           |   | 1900  | 1900       | 1900  |   |            | 1900  |   |
| Lanes | 0         | 0 | 0 | 0         | 0 | 1     | 1          | 2     | 0 | 0          | 2     | 0 |
| fW    |           |   |   |           |   | 1.000 | 1.000      | 1.000 |   |            | 1.000 |   |
| fHV   |           |   |   |           |   | 1.000 | 1.000      | 1.000 |   |            | 1.000 |   |
| fG    |           |   |   |           |   | 1.000 | 1.000      | 1.000 |   |            | 1.000 |   |
| fP    |           |   |   |           |   | 1.000 | 1.000      | 1.000 |   |            | 1.000 |   |

|      |       |       |       |       |
|------|-------|-------|-------|-------|
| fBB  | 1.000 | 1.000 | 1.000 | 1.000 |
| fA   | 1.00  | 1.00  | 1.00  | 1.00  |
| fLU  | 1.00  | 1.00  | 0.95  | 0.95  |
| fRT  | 0.865 |       | 1.000 | 1.000 |
| fLT  |       | 0.950 | 1.000 | 1.000 |
| Sec. |       |       |       |       |
| fLpb |       | 1.000 | 1.000 | 1.000 |
| fRpb | 1.000 |       | 1.000 | 1.000 |
| S    | 1644  | 1805  | 3610  | 3610  |
| Sec. |       |       |       |       |

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

| Appr/<br>Mvmt | Lane<br>Group | Adj<br>Flow Rate<br>(v) | Adj Sat<br>Flow Rate<br>(s) | Flow<br>Ratio<br>(v/s) | Green<br>Ratio<br>(g/C) | --Lane Group--<br>Capacity<br>(c) | v/c<br>Ratio |
|---------------|---------------|-------------------------|-----------------------------|------------------------|-------------------------|-----------------------------------|--------------|
| Eastbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Westbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right R       | 280                     | 1644                        | # 0.17                 | 0.24                    | 399                               | 0.70         |
| Northbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left L        | 83                      | 1805                        | 0.05                   | 0.24                    | 438                               | 0.19         |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru T        | 1086                    | 3610                        | 0.30                   | 0.58                    | 2078                              | 0.52         |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Southbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru T        | 1207                    | 3610                        | # 0.33                 | 0.58                    | 2078                              | 0.58         |
|               | Right         |                         |                             |                        |                         |                                   |              |

Sum of flow ratios for critical lane groups,  $Y_c = \text{Sum (v/s)} = 0.50$   
Total lost time per cycle,  $L = 6.00 \text{ sec}$   
Critical flow rate to capacity ratio,  $X_c = (Y_c) (C) / (C-L) = 0.62$

Control Delay and LOS Determination

| Appr/<br>Lane | Ratios | Unf<br>Del | Prog<br>Adj | Lane<br>Grp | Incremental<br>Factor | Res<br>Del | Lane Group | Approach |
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|

| Grp  | v/c  | g/C  | d1   | Fact  | Cap  | k    | d2  | d3  | Delay | LOS | Delay | LOS |
|--|------|------|------|-------|------|------|-----|-----|-------|-----|-------|-----|
| Eastbound  |      |      |      |       |      |      |     |     |       |     |       |     |
| Westbound  |      |      |      |       |      |      |     |     |       |     |       |     |
| R  | 0.70 | 0.24 | 11.4 | 1.000 | 399  | 0.50 | 9.9 | 0.0 | 21.3  | C   | 21.3  | C   |
| Northbound   |      |      |      |       |      |      |     |     |       |     |       |     |
| L  | 0.19 | 0.24 | 9.9  | 1.000 | 438  | 0.50 | 1.0 | 0.0 | 10.9  | B   |       |     |
| T  | 0.52 | 0.58 | 4.2  | 1.000 | 2078 | 0.50 | 0.9 | 0.0 | 5.2   | A   | 5.6   | A   |
| Southbound   |      |      |      |       |      |      |     |     |       |     |       |     |
| T  | 0.58 | 0.58 | 4.5  | 1.000 | 2078 | 0.50 | 1.2 | 0.0 | 5.7   | A   | 5.7   | A   |
| <hr/> Intersection delay = 7.3 (sec/veh)      Intersection LOS = A |      |      |      |       |      |      |     |     |       |     |       |     |

SUPPLEMENTAL PERMITTED LT WORKSHEET

for exclusive lefts

Input

|  | EB   | WB | NB   | SB   |
|--|------|----|------|------|
| Cycle length, C  |      |    |      |      |
| Total actual green time for LT lane group, G (s)                             | 33.0 |    |      |      |
| Effective permitted green time for LT lane group, g(s)                       |      |    |      |      |
| Opposing effective green time, go (s)  |      |    |      |      |
| Number of lanes in LT lane group, N  |      |    |      |      |
| Number of lanes in opposing approach, No                                     |      |    |      |      |
| Adjusted LT flow rate, VLT (veh/h)   |      |    |      |      |
| Proportion of LT in LT lane group, PLT                                       |      |    |      |      |
| Proportion of LT in opposing flow, PLTo                                      |      |    |      |      |
| Adjusted opposing flow rate, Vo (veh/h)                                      |      |    |      |      |
| Lost time for LT lane group, tL  |      |    |      |      |
| Computation  |      |    |      |      |
| LT volume per cycle, LTC=VLTC/3600   |      |    |      |      |
| Opposing lane util. factor, fLUo   |      |    | 0.95 | 0.95 |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)                          |      |    |      |      |
| gf=G[exp(- a * (LTC ** b))]-tL, gf<=g  |      |    |      |      |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)                            |      |    |      |      |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]                                 |      |    |      |      |
| gq, (see Exhibit C16-4,5,6,7,8)  |      |    |      |      |
| gu=g-gq if gq>=gf, or = g-gf if gq<gf  |      |    |      |      |
| n=Max(gq-gf)/2,0)  |      |    |      |      |
| PTHo=1-PLTo  |      |    |      |      |
| PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]   |      |    |      |      |
| EL1 (refer to Exhibit C16-3)   |      |    |      |      |
| EL2=Max((1-Ptho**n)/Plto, 1.0)   |      |    |      |      |
| fmin=2(1+PL)/g or fmin=2(1+Pl)/g   |      |    |      |      |
| gdiff=max(gq-gf,0)   |      |    |      |      |
| fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)                          |      |    |      |      |
| flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)], (fmin<=fm<=1.00) |      |    |      |      |
| or flt=[fm+0.91(N-1)]/N**  |      |    |      |      |

Left-turn adjustment, fLT

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET

for shared lefts

Input

|   | EB | WB | NB    | SB    |
|---|----|----|-------|-------|
| Cycle length, C   |    |    |       |       |
| 33.0 sec  |    |    |       |       |
| Total actual green time for LT lane group, G (s)  |    |    |       |       |
| Effective permitted green time for LT lane group, g(s)  |    |    |       |       |
| Opposing effective green time, go (s)   |    |    |       |       |
| Number of lanes in LT lane group, N   |    |    |       |       |
| Number of lanes in opposing approach, No  |    |    |       |       |
| Adjusted LT flow rate, VLT (veh/h)  |    |    |       |       |
| Proportion of LT in LT lane group, PLT  |    |    | 0.000 | 0.000 |
| Proportion of LT in opposing flow, PLTo   |    |    |       |       |
| Adjusted opposing flow rate, Vo (veh/h)   |    |    |       |       |
| Lost time for LT lane group, tL   |    |    |       |       |
| Computation   |    |    |       |       |
| LT volume per cycle, LTC=VLTC/3600  |    |    |       |       |
| Opposing lane util. factor, fLUo  |    |    | 0.95  | 0.95  |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)   |    |    |       |       |
| $gf = G[\exp(-a * (LTC ** b))] - tL$ , $gf \leq g$  |    |    |       |       |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)   |    |    |       |       |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]  |    |    |       |       |
| gq, (see Exhibit C16-4,5,6,7,8)   |    |    |       |       |
| $gu = g - gq$ if $gq \geq gf$ , or $= g - gf$ if $gq < gf$  |    |    |       |       |
| $n = \text{Max}(gq - gf) / 2, 0$  |    |    |       |       |
| $PTHo = 1 - PLTo$   |    |    |       |       |
| $PL* = PLT[1 + (N-1)g / (gf + gu / EL1 + 4.24)]$  |    |    |       |       |
| EL1 (refer to Exhibit C16-3)  |    |    |       |       |
| $EL2 = \text{Max}((1 - Ptho ** n) / Plto, 1.0)$   |    |    |       |       |
| $fmin = 2(1 + PL) / g$ or $fmin = 2(1 + Pl) / g$  |    |    |       |       |
| $gdiff = \text{max}(gq - gf, 0)$  |    |    |       |       |
| $fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)]$ , (min=fmin;max=1.00)                                    |    |    |       |       |
| $flt = fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)] + [gdiff/g] / [1 + PL(EL2 - 1)]$ , (fmin<=fm<=1.00) |    |    |       |       |
| or $flt = [fm + 0.91(N-1)] / N **$  |    |    |       |       |
| Left-turn adjustment, fLT   |    |    |       |       |

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns

EB WB NB SB

Effective pedestrian green time,  $g_p$  (s)  
 Conflicting pedestrian volume,  $V_{ped}$  (p/h)  
 Pedestrian flow rate,  $V_{pedg}$  (p/h)  
 $OCC_{pedg}$   
 Opposing queue clearing green,  $g_q$  (s)  
 Eff. ped. green consumed by opp. veh. queue,  $g_q/g_p$   
 $OCC_{pedu}$   
 Opposing flow rate,  $V_o$  (veh/h)  
 $OCC_r$   
 Number of cross-street receiving lanes,  $N_{rec}$   
 Number of turning lanes,  $N_{turn}$   
 $ApbT$   
 Proportion of left turns,  $PLT$   
 Proportion of left turns using protected phase,  $PLTA$   
 Left-turn adjustment,  $f_{Lpb}$   
 Permitted Right Turns  
 Effective pedestrian green time,  $g_p$  (s)  
 Conflicting pedestrian volume,  $V_{ped}$  (p/h)  
 Conflicting bicycle volume,  $V_{bic}$  (bicycles/h)  
 $V_{pedg}$   
 $OCC_{pedg}$   
 Effective green,  $g$  (s)  
 $V_{bicg}$   
 $OCC_{bicg}$   
 $OCC_r$   
 Number of cross-street receiving lanes,  $N_{rec}$   
 Number of turning lanes,  $N_{turn}$   
 $ApbT$   
 Proportion right-turns,  $PRT$   
 Proportion right-turns using protected phase,  $PRTA$   
 Right turn adjustment,  $f_{Rpb}$

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SUPPLEMENTAL UNIFORM DELAY WORKSHEET

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|   |      | EBLT | WBLT | NBLT | SBLT |
|---|------|------|------|------|------|
| Cycle length, $C$   | 33.0 |      |      |      |      |
| Adj. LT vol from Vol Adjustment Worksheet, $v$            |      |      |      |      |      |
| $v/c$ ratio from Capacity Worksheet, $X$                  |      |      |      |      |      |
| Protected phase effective green interval, $g$ (s)         |      |      |      |      |      |
| Opposing queue effective green interval, $g_q$            |      |      |      |      |      |
| Unopposed green interval, $g_u$                           |      |      |      |      |      |
| Red time $r=(C-g-g_q-g_u)$                                |      |      |      |      |      |
| Arrival rate, $q_a=v/(3600(\max[X,1.0]))$                 |      |      |      |      |      |
| Protected ph. departure rate, $S_p=s/3600$                |      |      |      |      |      |
| Permitted ph. departure rate, $S_s=s(g_q+g_u)/(g_u*3600)$ |      |      |      |      |      |
| $X_{Perm}$  |      |      |      |      |      |
| $X_{Prot}$  |      |      |      |      |      |
| Case  |      |      |      |      |      |
| Queue at beginning of green arrow, $Q_a$                  |      |      |      |      |      |
| Queue at beginning of unsaturated green, $Q_u$            |      |      |      |      |      |
| Residual queue, $Q_r$                                     |      |      |      |      |      |
| Uniform Delay, $d_l$                                      |      |      |      |      |      |

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DELAY/LOS WORKSHEET WITH INITIAL QUEUE

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|       | Initial Dur. | Uniform Delay | Initial Queue | Final Queue | Initial Lane | Lane Group |
|-------|--------------|---------------|---------------|-------------|--------------|------------|
| Appr/ | Unmet        | Unmet         | _____         | Unmet       | Queue        | Group      |

| Lane Group | Demand Q veh | Demand t hrs. | Unadj. ds | Adj. dl sec | Param. u | Demand Q veh | Delay d3 sec | Delay d sec |
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|

Eastbound

Westbound

Northbound

Southbound

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Intersection Delay 7.3 sec/veh      Intersection LOS A

BACK OF QUEUE WORKSHEET

|                         | Eastbound |   |   | Westbound |   |       | Northbound |      |       | Southbound |   |   |       |
|-------------------------|-----------|---|---|-----------|---|-------|------------|------|-------|------------|---|---|-------|
| LaneGroup               |           |   |   |           |   |       | R          | L    | T     |            |   |   | T     |
| Init Queue              |           |   |   |           |   |       | 0.0        | 0.0  | 0.0   |            |   |   | 0.0   |
| Flow Rate               |           |   |   |           |   |       | 280        | 83   | 543   |            |   |   | 603   |
| So                      |           |   |   |           |   |       | 1900       | 1900 | 1900  |            |   |   | 1900  |
| No.Lanes                | 0         | 0 | 0 | 0         | 0 | 1     | 1          | 2    | 0     | 0          | 2 | 0 |       |
| SL                      |           |   |   |           |   |       | 1644       | 1805 | 1805  |            |   |   | 1805  |
| LnCapacity              |           |   |   |           |   |       | 399        | 438  | 1039  |            |   |   | 1039  |
| Flow Ratio              |           |   |   |           |   |       | 0.17       | 0.05 | 0.30  |            |   |   | 0.33  |
| v/c Ratio               |           |   |   |           |   |       | 0.70       | 0.19 | 0.52  |            |   |   | 0.58  |
| Grn Ratio               |           |   |   |           |   |       | 0.24       | 0.24 | 0.58  |            |   |   | 0.58  |
| I Factor                |           |   |   |           |   | 1.000 |            |      | 1.000 |            |   |   | 1.000 |
| AT or PVG               |           |   |   |           |   |       | 3          | 3    | 3     |            |   |   | 3     |
| Pltn Ratio              |           |   |   |           |   |       | 1.00       | 1.00 | 1.00  |            |   |   | 1.00  |
| PF2                     |           |   |   |           |   |       | 1.00       | 1.00 | 1.00  |            |   |   | 1.00  |
| Q1                      |           |   |   |           |   |       | 2.3        | 0.6  | 3.0   |            |   |   | 3.5   |
| kB                      |           |   |   |           |   |       | 0.3        | 0.3  | 0.6   |            |   |   | 0.6   |
| Q2                      |           |   |   |           |   |       | 0.7        | 0.1  | 0.6   |            |   |   | 0.8   |
| Q Average               |           |   |   |           |   |       | 3.0        | 0.7  | 3.7   |            |   |   | 4.3   |
| Q Spacing               |           |   |   |           |   |       | 24.9       | 24.9 | 24.9  |            |   |   | 24.9  |
| Q Storage               |           |   |   |           |   |       | 0          | 0    | 0     |            |   |   | 0     |
| Q S Ratio               |           |   |   |           |   |       |            |      |       |            |   |   |       |
| 70th Percentile Output: |           |   |   |           |   |       |            |      |       |            |   |   |       |
| fB%                     |           |   |   |           |   |       | 1.3        | 1.3  | 1.2   |            |   |   | 1.2   |
| BOQ                     |           |   |   |           |   |       | 3.8        | 0.9  | 4.6   |            |   |   | 5.4   |
| QSRatio                 |           |   |   |           |   |       |            |      |       |            |   |   |       |
| 85th Percentile Output: |           |   |   |           |   |       |            |      |       |            |   |   |       |
| fB%                     |           |   |   |           |   |       | 1.6        | 1.7  | 1.5   |            |   |   | 1.5   |
| BOQ                     |           |   |   |           |   |       | 4.7        | 1.1  | 5.6   |            |   |   | 6.6   |

|                         |  |  |     |     |     |  |      |
|-------------------------|--|--|-----|-----|-----|--|------|
| QSRatio                 |  |  |     |     |     |  |      |
| 90th Percentile Output: |  |  |     |     |     |  |      |
| fB%                     |  |  | 1.8 | 1.9 | 1.7 |  | 1.7  |
| BOQ                     |  |  | 5.3 | 1.3 | 6.4 |  | 7.4  |
| QSRatio                 |  |  |     |     |     |  |      |
| 95th Percentile Output: |  |  |     |     |     |  |      |
| fB%                     |  |  | 2.1 | 2.5 | 2.1 |  | 2.0  |
| BOQ                     |  |  | 6.5 | 1.7 | 7.6 |  | 8.7  |
| QSRatio                 |  |  |     |     |     |  |      |
| 98th Percentile Output: |  |  |     |     |     |  |      |
| fB%                     |  |  | 2.5 | 3.0 | 2.4 |  | 2.3  |
| BOQ                     |  |  | 7.6 | 2.0 | 8.8 |  | 10.1 |
| QSRatio                 |  |  |     |     |     |  |      |

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ERROR MESSAGES

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No errors to report.

HCS2000: Signalized Intersections Release 4.1b

Analyst: Jonathan Storey Inter.: I-24 at U.S. 72  
 Agency: Florence & Hutcheson Area Type: All other areas  
 Date: 6/5/2002 Jurisd: Marion Co.  
 Period: 2027 AM Year : 2002  
 Project ID: Interchange Modification Study  
 E/W St: I-24 Ramps 2 and Prop. "A" N/S St: U.S. 72

SIGNALIZED INTERSECTION SUMMARY

|            | Eastbound |   |   | Westbound |   |      | Northbound |      |   | Southbound |      |   |
|------------|-----------|---|---|-----------|---|------|------------|------|---|------------|------|---|
|            | L         | T | R | L         | T | R    | L          | T    | R | L          | T    | R |
| No. Lanes  | 0         | 0 | 0 | 0         | 0 | 1    | 1          | 2    | 0 | 0          | 2    | 0 |
| LGConfig   |           |   |   |           |   | R    | L          | T    |   |            | T    |   |
| Volume     |           |   |   |           |   | 256  | 80         | 1116 |   |            | 1218 |   |
| Lane Width |           |   |   |           |   | 12.0 | 12.0       | 12.0 |   |            | 12.0 |   |
| RTOR Vol   |           |   |   |           |   | 127  |            |      |   |            |      |   |

Duration 0.25 Area Type: All other areas

Signal Operations

| Phase Combination | 1   | 2   | 3   | 4   | 5        | 6   | 7   | 8   |
|-------------------|-----|-----|-----|-----|----------|-----|-----|-----|
| EB Left           |     |     |     |     | NB Left  | P   |     |     |
| Thru              |     |     |     |     | Thru     | P   |     |     |
| Right             |     |     |     |     | Right    |     |     |     |
| Peds              |     |     |     |     | Peds     |     |     |     |
| WB Left           |     |     |     |     | SB Left  |     |     |     |
| Thru              |     |     |     |     | Thru     | P   |     |     |
| Right             |     |     |     |     | Right    |     |     |     |
| Peds              |     |     |     |     | Peds     |     |     |     |
| NB Right          |     |     |     |     | EB Right |     |     |     |
| SB Right          |     |     |     |     | WB Right | P   |     |     |
| Green             | 0.0 | 0.0 | 0.0 | 0.0 | 36.0     | 8.0 | 0.0 | 0.0 |
| Yellow            | 0.0 | 0.0 | 0.0 |     | 3.0      | 3.0 | 0.0 |     |
| All Red           | 0.0 | 0.0 | 0.0 |     | 0.0      | 0.0 | 0.0 |     |

Cycle Length: 50.0 secs

Intersection Performance Summary

| Appr/<br>Lane<br>Grp | Lane<br>Group<br>Capacity | Adj Sat<br>Flow Rate<br>(s) | Ratios<br>v/c g/C |  | Lane Group<br>Delay LOS |  | Approach<br>Delay LOS |  |
|----------------------|---------------------------|-----------------------------|-------------------|--|-------------------------|--|-----------------------|--|
|----------------------|---------------------------|-----------------------------|-------------------|--|-------------------------|--|-----------------------|--|

Eastbound

Westbound

|            |      |      |      |      |      |   |      |   |
|------------|------|------|------|------|------|---|------|---|
| R          | 263  | 1644 | 0.54 | 0.16 | 27.2 | C | 27.2 | C |
| Northbound |      |      |      |      |      |   |      |   |
| L          | 289  | 1805 | 0.31 | 0.16 | 21.3 | C |      |   |
| T          | 2599 | 3610 | 0.48 | 0.72 | 3.6  | A | 4.8  | A |

Southbound

|   |      |      |      |      |     |   |     |   |
|---|------|------|------|------|-----|---|-----|---|
| T | 2599 | 3610 | 0.52 | 0.72 | 3.9 | A | 3.9 | A |
|---|------|------|------|------|-----|---|-----|---|

Intersection Delay = 5.5 (sec/veh) Intersection LOS = A

HCS2000: Signalized Intersections Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-Mail: jstorey@flohut.com

Fax: (615) 399-9049

OPERATIONAL ANALYSIS

Analyst: Jonathan Storey  
 Agency/Co.: Florence & Hutcheson  
 Date Performed: 6/5/2002  
 Analysis Time Period: 2027 AM  
 Intersection: I-24 at U.S. 72  
 Area Type: All other areas  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Project ID: Interchange Modification Study  
                     East/West Street                      North/South Street  
                     I-24 Ramps 2 and Prop. "A"                      U.S. 72

VOLUME DATA

|              | Eastbound |   |   | Westbound                  |   |       | Northbound |       |   | Southbound |       |   |
|--------------|-----------|---|---|----------------------------|---|-------|------------|-------|---|------------|-------|---|
|              | L         | T | R | L                          | T | R     | L          | T     | R | L          | T     | R |
| Volume       |           |   |   |                            |   | 256   | 80         | 1116  |   |            | 1218  |   |
| % Heavy Veh  |           |   |   |                            |   | 0     | 0          | 0     |   |            | 0     |   |
| PHF          |           |   |   |                            |   | 0.90  | 0.90       | 0.90  |   |            | 0.90  |   |
| PK 15 Vol    |           |   |   |                            |   | 71    | 22         | 310   |   |            | 338   |   |
| Hi Ln Vol    |           |   |   |                            |   |       |            |       |   |            |       |   |
| % Grade      |           |   |   |                            | 0 |       |            | 0     |   |            | 0     |   |
| Ideal Sat    |           |   |   |                            |   | 1900  | 1900       | 1900  |   |            | 1900  |   |
| ParkExist    |           |   |   |                            |   |       |            |       |   |            |       |   |
| NumPark      |           |   |   |                            |   |       |            |       |   |            |       |   |
| No. Lanes    | 0         | 0 | 0 | 0                          | 0 | 1     | 1          | 2     | 0 | 0          | 2     | 0 |
| LGConfig     |           |   |   |                            |   | R     | L          | T     |   |            | T     |   |
| Lane Width   |           |   |   |                            |   | 12.0  | 12.0       | 12.0  |   |            | 12.0  |   |
| RTOR Vol     |           |   |   |                            |   | 127   |            |       |   |            |       |   |
| Adj Flow     |           |   |   |                            |   | 143   | 89         | 1240  |   |            | 1353  |   |
| %InSharedLn  |           |   |   |                            |   |       |            |       |   |            |       |   |
| Prop LTs     |           |   |   |                            |   |       |            | 0.000 |   |            | 0.000 |   |
| Prop RTs     |           |   |   |                            |   | 1.000 | 0.000      |       |   | 0.000      |       |   |
| Peds Bikes   |           |   |   | 0                          |   |       |            |       |   | 0          |       |   |
| Buses        |           |   |   |                            |   | 0     | 0          | 0     |   | 0          |       |   |
| %InProtPhase |           |   |   |                            |   |       |            |       |   |            |       |   |
| Duration     | 0.25      |   |   | Area Type: All other areas |   |       |            |       |   |            |       |   |

OPERATING PARAMETERS

|  | Eastbound |   |   | Westbound |   |   | Northbound |   |   | Southbound |   |   |
|--|-----------|---|---|-----------|---|---|------------|---|---|------------|---|---|
|  | L         | T | R | L         | T | R | L          | T | R | L          | T | R |

|             |  |       |       |       |       |
|-------------|--|-------|-------|-------|-------|
| Init Unmet  |  | 0.0   | 0.0   | 0.0   | 0.0   |
| Arriv. Type |  | 3     | 3     | 3     | 3     |
| Unit Ext.   |  | 3.0   | 3.0   | 3.0   | 3.0   |
| I Factor    |  | 1.000 | 1.000 | 1.000 | 1.000 |
| Lost Time   |  | 2.0   | 2.0   | 2.0   | 2.0   |
| Ext of g    |  | 2.0   | 2.0   | 2.0   | 2.0   |
| Ped Min g   |  | 3.2   |       |       | 3.2   |

PHASE DATA

| Phase Combination | 1   | 2   | 3   | 4   | 5        | 6   | 7   | 8   |
|-------------------|-----|-----|-----|-----|----------|-----|-----|-----|
| EB Left           |     |     |     |     | NB Left  | P   |     |     |
| Thru              |     |     |     |     | Thru     | P   |     |     |
| Right             |     |     |     |     | Right    |     |     |     |
| Peds              |     |     |     |     | Peds     |     |     |     |
| WB Left           |     |     |     |     | SB Left  |     |     |     |
| Thru              |     |     |     |     | Thru     | P   |     |     |
| Right             |     |     |     |     | Right    |     |     |     |
| Peds              |     |     |     |     | Peds     |     |     |     |
| NB Right          |     |     |     |     | EB Right |     |     |     |
| SB Right          |     |     |     |     | WB Right | P   |     |     |
| Green             | 0.0 | 0.0 | 0.0 | 0.0 | 36.0     | 8.0 | 0.0 | 0.0 |
| Yellow            | 0.0 | 0.0 | 0.0 |     | 3.0      | 3.0 | 0.0 |     |
| All Red           | 0.0 | 0.0 | 0.0 |     | 0.0      | 0.0 | 0.0 |     |

Cycle Length: 50.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

Volume Adjustment

|            | Eastbound |   |   | Westbound |   |       | Northbound |       |   | Southbound |       |   |
|------------|-----------|---|---|-----------|---|-------|------------|-------|---|------------|-------|---|
|            | L         | T | R | L         | T | R     | L          | T     | R | L          | T     | R |
| Volume, V  |           |   |   |           |   | 256   | 80         | 1116  |   |            | 1218  |   |
| PHF        |           |   |   |           |   | 0.90  | 0.90       | 0.90  |   |            | 0.90  |   |
| Adj flow   |           |   |   |           |   | 143   | 89         | 1240  |   |            | 1353  |   |
| No. Lanes  | 0         | 0 | 0 | 0         | 0 | 1     | 1          | 2     | 0 | 0          | 2     | 0 |
| Lane group |           |   |   |           |   | R     | L          | T     |   |            | T     |   |
| Adj flow   |           |   |   |           |   | 143   | 89         | 1240  |   |            | 1353  |   |
| Prop LTs   |           |   |   |           |   |       |            | 0.000 |   |            | 0.000 |   |
| Prop RTs   |           |   |   |           |   | 1.000 |            | 0.000 |   |            | 0.000 |   |

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

|       | Eastbound |   |   | Westbound |   |       | Northbound |       |   | Southbound |       |   |
|-------|-----------|---|---|-----------|---|-------|------------|-------|---|------------|-------|---|
|       | L         | T | R | L         | T | R     | L          | T     | R | L          | T     | R |
| LG    |           |   |   |           |   | R     | L          | T     |   |            | T     |   |
| So    |           |   |   |           |   | 1900  | 1900       | 1900  |   |            | 1900  |   |
| Lanes | 0         | 0 | 0 | 0         | 0 | 1     | 1          | 2     | 0 | 0          | 2     | 0 |
| fW    |           |   |   |           |   | 1.000 | 1.000      | 1.000 |   |            | 1.000 |   |
| fHV   |           |   |   |           |   | 1.000 | 1.000      | 1.000 |   |            | 1.000 |   |
| fG    |           |   |   |           |   | 1.000 | 1.000      | 1.000 |   |            | 1.000 |   |
| fP    |           |   |   |           |   | 1.000 | 1.000      | 1.000 |   |            | 1.000 |   |

|      |       |       |       |       |
|------|-------|-------|-------|-------|
| fBB  | 1.000 | 1.000 | 1.000 | 1.000 |
| fA   | 1.00  | 1.00  | 1.00  | 1.00  |
| fLU  | 1.00  | 1.00  | 0.95  | 0.95  |
| fRT  | 0.865 |       | 1.000 | 1.000 |
| fLT  |       | 0.950 | 1.000 | 1.000 |
| Sec. |       |       |       |       |
| fLpb |       | 1.000 | 1.000 | 1.000 |
| fRpb | 1.000 |       | 1.000 | 1.000 |
| S    | 1644  | 1805  | 3610  | 3610  |
| Sec. |       |       |       |       |

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

| Appr/<br>Mvmt | Lane<br>Group | Adj<br>Flow Rate<br>(v) | Adj Sat<br>Flow Rate<br>(s) | Flow<br>Ratio<br>(v/s) | Green<br>Ratio<br>(g/C) | --Lane Group--<br>Capacity<br>(c) | v/c<br>Ratio |
|---------------|---------------|-------------------------|-----------------------------|------------------------|-------------------------|-----------------------------------|--------------|
| Eastbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Westbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right R       | 143                     | 1644                        | # 0.09                 | 0.16                    | 263                               | 0.54         |
| Northbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left L        | 89                      | 1805                        | 0.05                   | 0.16                    | 289                               | 0.31         |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru T        | 1240                    | 3610                        | 0.34                   | 0.72                    | 2599                              | 0.48         |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Southbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru T        | 1353                    | 3610                        | # 0.37                 | 0.72                    | 2599                              | 0.52         |
|               | Right         |                         |                             |                        |                         |                                   |              |

Sum of flow ratios for critical lane groups,  $Y_c = \text{Sum (v/s)} = 0.46$   
Total lost time per cycle,  $L = 6.00$  sec  
Critical flow rate to capacity ratio,  $X_c = (Y_c) (C) / (C-L) = 0.52$

Control Delay and LOS Determination

| Appr/<br>Lane | Ratios | Unf<br>Del | Prog<br>Adj | Lane<br>Grp | Incremental<br>Factor | Res<br>Del | Lane Group | Approach |
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|

| Grp                      | v/c  | g/C  | d1   | Fact  | Cap  | k    | d2        | d3  | Delay                | LOS | Delay | LOS |
|--------------------------|------|------|------|-------|------|------|-----------|-----|----------------------|-----|-------|-----|
| Eastbound                |      |      |      |       |      |      |           |     |                      |     |       |     |
| Westbound                |      |      |      |       |      |      |           |     |                      |     |       |     |
| R                        | 0.54 | 0.16 | 19.3 | 1.000 | 263  | 0.50 | 7.9       | 0.0 | 27.2                 | C   | 27.2  | C   |
| Northbound               |      |      |      |       |      |      |           |     |                      |     |       |     |
| L                        | 0.31 | 0.16 | 18.6 | 1.000 | 289  | 0.50 | 2.7       | 0.0 | 21.3                 | C   |       |     |
| T                        | 0.48 | 0.72 | 3.0  | 1.000 | 2599 | 0.50 | 0.6       | 0.0 | 3.6                  | A   | 4.8   | A   |
| Southbound               |      |      |      |       |      |      |           |     |                      |     |       |     |
| T                        | 0.52 | 0.72 | 3.1  | 1.000 | 2599 | 0.50 | 0.7       | 0.0 | 3.9                  | A   | 3.9   | A   |
| Intersection delay = 5.5 |      |      |      |       |      |      | (sec/veh) |     | Intersection LOS = A |     |       |     |

SUPPLEMENTAL PERMITTED LT WORKSHEET

for exclusive lefts

Input

|   | EB | WB | NB   | SB   |
|---|----|----|------|------|
| Cycle length, C   |    |    |      |      |
| Total actual green time for LT lane group, G (s)                              |    |    |      |      |
| Effective permitted green time for LT lane group, g(s)                        |    |    |      |      |
| Opposing effective green time, go (s)   |    |    |      |      |
| Number of lanes in LT lane group, N   |    |    |      |      |
| Number of lanes in opposing approach, No                                      |    |    |      |      |
| Adjusted LT flow rate, VLT (veh/h)  |    |    |      |      |
| Proportion of LT in LT lane group, PLT  |    |    |      |      |
| Proportion of LT in opposing flow, PLTo                                       |    |    |      |      |
| Adjusted opposing flow rate, Vo (veh/h)                                       |    |    |      |      |
| Lost time for LT lane group, tL   |    |    |      |      |
| Computation   |    |    |      |      |
| LT volume per cycle, LTC=VLTC/3600  |    |    |      |      |
| Opposing lane util. factor, fLUo  |    |    | 0.95 | 0.95 |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)                           |    |    |      |      |
| gf=G[exp(- a * (LTC ** b))]-tL, gf<=g   |    |    |      |      |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)                             |    |    |      |      |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]                                  |    |    |      |      |
| gq, (see Exhibit C16-4,5,6,7,8)   |    |    |      |      |
| gu=g-gq if gq>=gf, or = g-gf if gq<gf   |    |    |      |      |
| n=Max(gq-gf)/2,0)   |    |    |      |      |
| PTHo=1-PLTo   |    |    |      |      |
| PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]  |    |    |      |      |
| EL1 (refer to Exhibit C16-3)  |    |    |      |      |
| EL2=Max((1-Ptho**n)/Plto, 1.0)  |    |    |      |      |
| fmin=2(1+PL)/g or fmin=2(1+Pl)/g  |    |    |      |      |
| gdifff=max(gq-gf,0)   |    |    |      |      |
| fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)                           |    |    |      |      |
| flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdifff/g]/[1+PL(EL2-1)], (fmin<=fm<=1.00) |    |    |      |      |
| or flt=[fm+0.91(N-1)]/N**   |    |    |      |      |

Left-turn adjustment, fLT

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET

for shared lefts

Input

|   | EB | WB | NB    | SB    |
|---|----|----|-------|-------|
| Cycle length, C   |    |    |       |       |
| 50.0 sec  |    |    |       |       |
| Total actual green time for LT lane group, G (s)  |    |    |       |       |
| Effective permitted green time for LT lane group, g(s)  |    |    |       |       |
| Opposing effective green time, go (s)   |    |    |       |       |
| Number of lanes in LT lane group, N   |    |    |       |       |
| Number of lanes in opposing approach, No  |    |    |       |       |
| Adjusted LT flow rate, VLT (veh/h)  |    |    |       |       |
| Proportion of LT in LT lane group, PLT  |    |    | 0.000 | 0.000 |
| Proportion of LT in opposing flow, PLTo   |    |    |       |       |
| Adjusted opposing flow rate, Vo (veh/h)   |    |    |       |       |
| Lost time for LT lane group, tL   |    |    |       |       |
| Computation   |    |    |       |       |
| LT volume per cycle, LTC=VLTC/3600  |    |    |       |       |
| Opposing lane util. factor, fLUo  |    |    | 0.95  | 0.95  |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)   |    |    |       |       |
| $gf = G[\exp(-a * (LTC ** b))] - tL$ , $gf \leq g$  |    |    |       |       |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)   |    |    |       |       |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]  |    |    |       |       |
| gq, (see Exhibit C16-4,5,6,7,8)   |    |    |       |       |
| $gu = g - gq$ if $gq \geq gf$ , or $= g - gf$ if $gq < gf$  |    |    |       |       |
| $n = \text{Max}(gq - gf) / 2, 0$  |    |    |       |       |
| $PTHo = 1 - PLTo$   |    |    |       |       |
| $PL* = PLT[1 + (N-1)g / (gf + gu / EL1 + 4.24)]$  |    |    |       |       |
| EL1 (refer to Exhibit C16-3)  |    |    |       |       |
| $EL2 = \text{Max}((1 - Ptho ** n) / Plto, 1.0)$   |    |    |       |       |
| $fmin = 2(1 + PL) / g$ or $fmin = 2(1 + Pl) / g$  |    |    |       |       |
| $gdiff = \text{max}(gq - gf, 0)$  |    |    |       |       |
| $fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)]$ , (min=fmin;max=1.00)                                    |    |    |       |       |
| $flt = fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)] + [gdiff/g] / [1 + PL(EL2 - 1)]$ , (fmin<=fm<=1.00) |    |    |       |       |
| or $flt = [fm + 0.91(N-1)] / N **$  |    |    |       |       |
| Left-turn adjustment, fLT   |    |    |       |       |

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns

EB WB NB SB

Effective pedestrian green time,  $g_p$  (s)  
 Conflicting pedestrian volume,  $V_{ped}$  (p/h)  
 Pedestrian flow rate,  $V_{pedg}$  (p/h)  
 $OCC_{pedg}$   
 Opposing queue clearing green,  $g_q$  (s)  
 Eff. ped. green consumed by opp. veh. queue,  $g_q/g_p$   
 $OCC_{pedu}$   
 Opposing flow rate,  $V_o$  (veh/h)  
 $OCC_r$   
 Number of cross-street receiving lanes,  $N_{rec}$   
 Number of turning lanes,  $N_{turn}$   
 $ApbT$   
 Proportion of left turns,  $PLT$   
 Proportion of left turns using protected phase,  $PLTA$   
 Left-turn adjustment,  $f_{Lpb}$   
 Permitted Right Turns  
 Effective pedestrian green time,  $g_p$  (s)  
 Conflicting pedestrian volume,  $V_{ped}$  (p/h)  
 Conflicting bicycle volume,  $V_{bic}$  (bicycles/h)  
 $V_{pedg}$   
 $OCC_{pedg}$   
 Effective green,  $g$  (s)  
 $V_{bicg}$   
 $OCC_{bicg}$   
 $OCC_r$   
 Number of cross-street receiving lanes,  $N_{rec}$   
 Number of turning lanes,  $N_{turn}$   
 $ApbT$   
 Proportion right-turns,  $PRT$   
 Proportion right-turns using protected phase,  $PRTA$   
 Right turn adjustment,  $f_{Rpb}$

---

SUPPLEMENTAL UNIFORM DELAY WORKSHEET

---

|   | EBLT | WBLT | NBLT | SBLT |
|---|------|------|------|------|
| Cycle length, $C$   |      |      |      |      |
| 50.0  |      |      |      |      |
| sec   |      |      |      |      |
| Adj. LT vol from Vol Adjustment Worksheet, $v$            |      |      |      |      |
| $v/c$ ratio from Capacity Worksheet, $X$                  |      |      |      |      |
| Protected phase effective green interval, $g$ (s)         |      |      |      |      |
| Opposing queue effective green interval, $g_q$            |      |      |      |      |
| Unopposed green interval, $g_u$                           |      |      |      |      |
| Red time $r=(C-g-g_q-g_u)$                                |      |      |      |      |
| Arrival rate, $q_a=v/(3600(\max[X,1.0]))$                 |      |      |      |      |
| Protected ph. departure rate, $S_p=s/3600$                |      |      |      |      |
| Permitted ph. departure rate, $S_s=s(g_q+g_u)/(g_u*3600)$ |      |      |      |      |
| $X_{Perm}$  |      |      |      |      |
| $X_{Prot}$  |      |      |      |      |
| Case  |      |      |      |      |
| Queue at beginning of green arrow, $Q_a$                  |      |      |      |      |
| Queue at beginning of unsaturated green, $Q_u$            |      |      |      |      |
| Residual queue, $Q_r$                                     |      |      |      |      |
| Uniform Delay, $d_l$                                      |      |      |      |      |

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DELAY/LOS WORKSHEET WITH INITIAL QUEUE

---

|       | Initial Dur. | Uniform Delay | Initial Queue | Final Queue | Initial Lane | Lane Group |
|-------|--------------|---------------|---------------|-------------|--------------|------------|
| Appr/ | Unmet        | Unmet         |               | Unmet       | Queue        |            |
|       |              |               |               |             |              |            |

| Lane Group | Demand Q veh | Demand t hrs. | Unadj. ds | Adj. dl sec | Param. u | Demand Q veh | Delay d3 sec | Delay d sec |
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|

Eastbound

Westbound

Northbound

Southbound

|                    |     |         |                  |   |
|--------------------|-----|---------|------------------|---|
| Intersection Delay | 5.5 | sec/veh | Intersection LOS | A |
|--------------------|-----|---------|------------------|---|

BACK OF QUEUE WORKSHEET

|                         | Eastbound |   |   | Westbound |      |       | Northbound |   |   | Southbound |   |   |
|-------------------------|-----------|---|---|-----------|------|-------|------------|---|---|------------|---|---|
| LaneGroup               |           |   |   | R         | L    | T     |            |   |   | T          |   |   |
| Init Queue              |           |   |   | 0.0       | 0.0  | 0.0   |            |   |   | 0.0        |   |   |
| Flow Rate               |           |   |   | 143       | 89   | 620   |            |   |   | 676        |   |   |
| So                      |           |   |   | 1900      | 1900 | 1900  |            |   |   | 1900       |   |   |
| No.Lanes                | 0         | 0 | 0 | 0         | 0    | 1     | 1          | 2 | 0 | 0          | 2 | 0 |
| SL                      |           |   |   | 1644      | 1805 | 1805  |            |   |   | 1805       |   |   |
| LnCapacity              |           |   |   | 263       | 289  | 1299  |            |   |   | 1299       |   |   |
| Flow Ratio              |           |   |   | 0.09      | 0.05 | 0.34  |            |   |   | 0.37       |   |   |
| v/c Ratio               |           |   |   | 0.54      | 0.31 | 0.48  |            |   |   | 0.52       |   |   |
| Grn Ratio               |           |   |   | 0.16      | 0.16 | 0.72  |            |   |   | 0.72       |   |   |
| I Factor                |           |   |   | 1.000     |      | 1.000 |            |   |   | 1.000      |   |   |
| AT or PVG               |           |   |   | 3         | 3    | 3     |            |   |   | 3          |   |   |
| Pltn Ratio              |           |   |   | 1.00      | 1.00 | 1.00  |            |   |   | 1.00       |   |   |
| PF2                     |           |   |   | 1.00      | 1.00 | 1.00  |            |   |   | 1.00       |   |   |
| Q1                      |           |   |   | 1.8       | 1.1  | 3.7   |            |   |   | 4.2        |   |   |
| kB                      |           |   |   | 0.3       | 0.3  | 0.9   |            |   |   | 0.9        |   |   |
| Q2                      |           |   |   | 0.3       | 0.1  | 0.8   |            |   |   | 1.0        |   |   |
| Q Average               |           |   |   | 2.2       | 1.2  | 4.5   |            |   |   | 5.2        |   |   |
| Q Spacing               |           |   |   | 24.9      | 24.9 | 24.9  |            |   |   | 24.9       |   |   |
| Q Storage               |           |   |   | 0         | 0    | 0     |            |   |   | 0          |   |   |
| Q S Ratio               |           |   |   |           |      |       |            |   |   |            |   |   |
| 70th Percentile Output: |           |   |   |           |      |       |            |   |   |            |   |   |
| fB%                     |           |   |   | 1.3       | 1.3  | 1.2   |            |   |   | 1.2        |   |   |
| BOQ                     |           |   |   | 2.7       | 1.6  | 5.6   |            |   |   | 6.4        |   |   |
| QSRatio                 |           |   |   |           |      |       |            |   |   |            |   |   |
| 85th Percentile Output: |           |   |   |           |      |       |            |   |   |            |   |   |
| fB%                     |           |   |   | 1.6       | 1.6  | 1.5   |            |   |   | 1.5        |   |   |
| BOQ                     |           |   |   | 3.5       | 2.0  | 6.8   |            |   |   | 7.8        |   |   |

|                         |  |  |     |     |      |  |      |
|-------------------------|--|--|-----|-----|------|--|------|
| QSRatio                 |  |  |     |     |      |  |      |
| 90th Percentile Output: |  |  |     |     |      |  |      |
| fB%                     |  |  | 1.8 | 1.9 | 1.7  |  | 1.7  |
| BOQ                     |  |  | 4.0 | 2.3 | 7.7  |  | 8.7  |
| QSRatio                 |  |  |     |     |      |  |      |
| 95th Percentile Output: |  |  |     |     |      |  |      |
| fB%                     |  |  | 2.2 | 2.4 | 2.0  |  | 2.0  |
| BOQ                     |  |  | 4.9 | 2.9 | 9.0  |  | 10.1 |
| QSRatio                 |  |  |     |     |      |  |      |
| 98th Percentile Output: |  |  |     |     |      |  |      |
| fB%                     |  |  | 2.7 | 2.9 | 2.3  |  | 2.2  |
| BOQ                     |  |  | 5.8 | 3.5 | 10.4 |  | 11.6 |
| QSRatio                 |  |  |     |     |      |  |      |

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ERROR MESSAGES

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No errors to report.

HCS2000: Signalized Intersections Release 4.1b

Analyst: Jonathan Storey Inter.: I-24 at U.S. 72  
 Agency: Florence & Hutcheson Area Type: All other areas  
 Date: 6/5/2002 Jurisd: Marion Co.  
 Period: 2027 PM Year : 2002  
 Project ID: Interchange Modification Study  
 E/W St: I-24 Ramps 2 and Prop. "A" N/S St: U.S. 72

SIGNALIZED INTERSECTION SUMMARY

|            | Eastbound |   |   | Westbound |   |      | Northbound |      |   | Southbound |      |   |
|------------|-----------|---|---|-----------|---|------|------------|------|---|------------|------|---|
|            | L         | T | R | L         | T | R    | L          | T    | R | L          | T    | R |
| No. Lanes  | 0         | 0 | 0 | 0         | 0 | 1    | 1          | 2    | 0 | 0          | 2    | 0 |
| LGConfig   |           |   |   |           |   | R    | L          | T    |   |            | T    |   |
| Volume     |           |   |   |           |   | 506  | 112        | 1466 |   |            | 1629 |   |
| Lane Width |           |   |   |           |   | 12.0 | 12.0       | 12.0 |   |            | 12.0 |   |
| RTOR Vol   |           |   |   |           |   | 127  |            |      |   |            |      |   |

Duration 0.25 Area Type: All other areas

Signal Operations

| Phase Combination | 1   | 2   | 3   | 4   | 5        | 6    | 7   | 8   |
|-------------------|-----|-----|-----|-----|----------|------|-----|-----|
| EB Left           |     |     |     |     | NB Left  | P    |     |     |
| Thru              |     |     |     |     | Thru     | P    |     |     |
| Right             |     |     |     |     | Right    |      |     |     |
| Peds              |     |     |     |     | Peds     |      |     |     |
| WB Left           |     |     |     |     | SB Left  |      |     |     |
| Thru              |     |     |     |     | Thru     | P    |     |     |
| Right             |     |     |     |     | Right    |      |     |     |
| Peds              |     |     |     |     | Peds     |      |     |     |
| NB Right          |     |     |     |     | EB Right |      |     |     |
| SB Right          |     |     |     |     | WB Right | P    |     |     |
| Green             | 0.0 | 0.0 | 0.0 | 0.0 | 29.0     | 14.0 | 0.0 | 0.0 |
| Yellow            | 0.0 | 0.0 | 0.0 |     | 3.0      | 3.0  | 0.0 |     |
| All Red           | 0.0 | 0.0 | 0.0 |     | 0.0      | 0.0  | 0.0 |     |

Cycle Length: 49.0 secs

Intersection Performance Summary

| Appr/<br>Lane<br>Grp | Lane<br>Group<br>Capacity | Adj Sat<br>Flow Rate<br>(s) | Ratios<br>v/c g/C |  | Lane Group<br>Delay LOS | Approach<br>Delay LOS |
|----------------------|---------------------------|-----------------------------|-------------------|--|-------------------------|-----------------------|
|----------------------|---------------------------|-----------------------------|-------------------|--|-------------------------|-----------------------|

Eastbound

Westbound

|            |      |      |      |      |      |   |      |   |
|------------|------|------|------|------|------|---|------|---|
| R          | 470  | 1644 | 0.89 | 0.29 | 38.5 | D | 38.5 | D |
| Northbound |      |      |      |      |      |   |      |   |
| L          | 516  | 1805 | 0.24 | 0.29 | 14.5 | B |      |   |
| T          | 2137 | 3610 | 0.76 | 0.59 | 10.1 | B | 10.4 | B |

Southbound

|   |      |      |      |      |      |   |      |   |
|---|------|------|------|------|------|---|------|---|
| T | 2137 | 3610 | 0.85 | 0.59 | 12.6 | B | 12.6 | B |
|---|------|------|------|------|------|---|------|---|



|             |  |       |       |       |       |
|-------------|--|-------|-------|-------|-------|
| Init Unmet  |  | 0.0   | 0.0   | 0.0   | 0.0   |
| Arriv. Type |  | 3     | 3     | 3     | 3     |
| Unit Ext.   |  | 3.0   | 3.0   | 3.0   | 3.0   |
| I Factor    |  | 1.000 | 1.000 | 1.000 | 1.000 |
| Lost Time   |  | 2.0   | 2.0   | 2.0   | 2.0   |
| Ext of g    |  | 2.0   | 2.0   | 2.0   | 2.0   |
| Ped Min g   |  | 3.2   |       |       | 3.2   |

PHASE DATA

| Phase Combination | 1   | 2   | 3   | 4   | 5        | 6    | 7   | 8   |
|-------------------|-----|-----|-----|-----|----------|------|-----|-----|
| EB Left           |     |     |     |     | NB Left  | P    |     |     |
| Thru              |     |     |     |     | Thru     | P    |     |     |
| Right             |     |     |     |     | Right    |      |     |     |
| Peds              |     |     |     |     | Peds     |      |     |     |
| WB Left           |     |     |     |     | SB Left  |      |     |     |
| Thru              |     |     |     |     | Thru     | P    |     |     |
| Right             |     |     |     |     | Right    |      |     |     |
| Peds              |     |     |     |     | Peds     |      |     |     |
| NB Right          |     |     |     |     | EB Right |      |     |     |
| SB Right          |     |     |     |     | WB Right | P    |     |     |
| Green             | 0.0 | 0.0 | 0.0 | 0.0 | 29.0     | 14.0 | 0.0 | 0.0 |
| Yellow            | 0.0 | 0.0 | 0.0 |     | 3.0      | 3.0  | 0.0 |     |
| All Red           | 0.0 | 0.0 | 0.0 |     | 0.0      | 0.0  | 0.0 |     |

Cycle Length: 49.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

| Volume Adjustment | Eastbound |   |   | Westbound |   |       | Northbound |       |   | Southbound |       |   |
|-------------------|-----------|---|---|-----------|---|-------|------------|-------|---|------------|-------|---|
|                   | L         | T | R | L         | T | R     | L          | T     | R | L          | T     | R |
| Volume, V         |           |   |   |           |   | 506   | 112        | 1466  |   |            | 1629  |   |
| PHF               |           |   |   |           |   | 0.90  | 0.90       | 0.90  |   |            | 0.90  |   |
| Adj flow          |           |   |   |           |   | 419   | 124        | 1629  |   |            | 1810  |   |
| No. Lanes         | 0         | 0 | 0 | 0         | 0 | 1     | 1          | 2     | 0 | 0          | 2     | 0 |
| Lane group        |           |   |   |           |   | R     | L          | T     |   |            | T     |   |
| Adj flow          |           |   |   |           |   | 419   | 124        | 1629  |   |            | 1810  |   |
| Prop LTs          |           |   |   |           |   |       |            | 0.000 |   |            | 0.000 |   |
| Prop RTs          |           |   |   |           |   | 1.000 |            | 0.000 |   |            | 0.000 |   |

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

|       | Eastbound |   |   | Westbound |   |       | Northbound |       |   | Southbound |       |   |
|-------|-----------|---|---|-----------|---|-------|------------|-------|---|------------|-------|---|
| LG    |           |   |   |           |   | R     | L          | T     |   |            | T     |   |
| So    |           |   |   |           |   | 1900  | 1900       | 1900  |   |            | 1900  |   |
| Lanes | 0         | 0 | 0 | 0         | 0 | 1     | 1          | 2     | 0 | 0          | 2     | 0 |
| fW    |           |   |   |           |   | 1.000 | 1.000      | 1.000 |   |            | 1.000 |   |
| fHV   |           |   |   |           |   | 1.000 | 1.000      | 1.000 |   |            | 1.000 |   |
| fG    |           |   |   |           |   | 1.000 | 1.000      | 1.000 |   |            | 1.000 |   |
| fP    |           |   |   |           |   | 1.000 | 1.000      | 1.000 |   |            | 1.000 |   |

|      |       |       |       |       |
|------|-------|-------|-------|-------|
| fBB  | 1.000 | 1.000 | 1.000 | 1.000 |
| fA   | 1.00  | 1.00  | 1.00  | 1.00  |
| fLU  | 1.00  | 1.00  | 0.95  | 0.95  |
| fRT  | 0.865 |       | 1.000 | 1.000 |
| fLT  |       | 0.950 | 1.000 | 1.000 |
| Sec. |       |       |       |       |
| fLpb |       | 1.000 | 1.000 | 1.000 |
| fRpb | 1.000 |       | 1.000 | 1.000 |
| S    | 1644  | 1805  | 3610  | 3610  |
| Sec. |       |       |       |       |

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

| Appr/<br>Mvmt | Lane<br>Group | Adj<br>Flow Rate<br>(v) | Adj Sat<br>Flow Rate<br>(s) | Flow<br>Ratio<br>(v/s) | Green<br>Ratio<br>(g/C) | --Lane Group--<br>Capacity<br>(c) | v/c<br>Ratio |
|---------------|---------------|-------------------------|-----------------------------|------------------------|-------------------------|-----------------------------------|--------------|
| Eastbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Westbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right R       | 419                     | 1644                        | # 0.25                 | 0.29                    | 470                               | 0.89         |
| Northbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left L        | 124                     | 1805                        | 0.07                   | 0.29                    | 516                               | 0.24         |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru T        | 1629                    | 3610                        | 0.45                   | 0.59                    | 2137                              | 0.76         |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Southbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru T        | 1810                    | 3610                        | # 0.50                 | 0.59                    | 2137                              | 0.85         |
|               | Right         |                         |                             |                        |                         |                                   |              |

Sum of flow ratios for critical lane groups,  $Y_c = \text{Sum (v/s)} = 0.76$   
Total lost time per cycle,  $L = 6.00$  sec  
Critical flow rate to capacity ratio,  $X_c = (Y_c) (C) / (C-L) = 0.86$

Control Delay and LOS Determination

| Appr/<br>Lane | Ratios | Unf<br>Del | Prog<br>Adj | Lane<br>Grp | Incremental<br>Factor | Res<br>Del | Lane Group | Approach |
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|

| Grp   | v/c  | g/C  | d1   | Fact  | Cap  | k    | d2   | d3  | Delay | LOS | Delay | LOS |
|---|------|------|------|-------|------|------|------|-----|-------|-----|-------|-----|
| Eastbound   |      |      |      |       |      |      |      |     |       |     |       |     |
| Westbound   |      |      |      |       |      |      |      |     |       |     |       |     |
| R   | 0.89 | 0.29 | 16.8 | 1.000 | 470  | 0.50 | 21.8 | 0.0 | 38.5  | D   | 38.5  | D   |
| Northbound  |      |      |      |       |      |      |      |     |       |     |       |     |
| L   | 0.24 | 0.29 | 13.4 | 1.000 | 516  | 0.50 | 1.1  | 0.0 | 14.5  | B   |       |     |
| T   | 0.76 | 0.59 | 7.4  | 1.000 | 2137 | 0.50 | 2.6  | 0.0 | 10.1  | B   | 10.4  | B   |
| Southbound  |      |      |      |       |      |      |      |     |       |     |       |     |
| T   | 0.85 | 0.59 | 8.2  | 1.000 | 2137 | 0.50 | 4.4  | 0.0 | 12.6  | B   | 12.6  | B   |
| Intersection delay = 14.3 (sec/veh)      Intersection LOS = B |      |      |      |       |      |      |      |     |       |     |       |     |

SUPPLEMENTAL PERMITTED LT WORKSHEET  
for exclusive lefts

Input

|   | EB   | WB | NB   | SB   |
|---|------|----|------|------|
| Cycle length, C   |      |    |      |      |
| Total actual green time for LT lane group, G (s)                              | 49.0 |    |      |      |
| Effective permitted green time for LT lane group, g(s)                        |      |    |      |      |
| Opposing effective green time, go (s)   |      |    |      |      |
| Number of lanes in LT lane group, N   |      |    |      |      |
| Number of lanes in opposing approach, No                                      |      |    |      |      |
| Adjusted LT flow rate, VLT (veh/h)  |      |    |      |      |
| Proportion of LT in LT lane group, PLT  |      |    |      |      |
| Proportion of LT in opposing flow, PLTo                                       |      |    |      |      |
| Adjusted opposing flow rate, Vo (veh/h)                                       |      |    |      |      |
| Lost time for LT lane group, tL   |      |    |      |      |
| Computation   |      |    |      |      |
| LT volume per cycle, LTC=VLTC/3600  |      |    |      |      |
| Opposing lane util. factor, fLUo  |      |    | 0.95 | 0.95 |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)                           |      |    |      |      |
| gf=G[exp(- a * (LTC ** b))]-tL, gf<=g   |      |    |      |      |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)                             |      |    |      |      |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]                                  |      |    |      |      |
| gq, (see Exhibit C16-4,5,6,7,8)   |      |    |      |      |
| gu=g-gq if gq>=gf, or = g-gf if gq<gf   |      |    |      |      |
| n=Max(gq-gf)/2,0)   |      |    |      |      |
| PTHo=1-PLTo   |      |    |      |      |
| PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]  |      |    |      |      |
| EL1 (refer to Exhibit C16-3)  |      |    |      |      |
| EL2=Max((1-Ptho**n)/Plto, 1.0)  |      |    |      |      |
| fmin=2(1+PL)/g or fmin=2(1+Pl)/g  |      |    |      |      |
| gdifff=max(gq-gf,0)   |      |    |      |      |
| fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)                           |      |    |      |      |
| flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdifff/g]/[1+PL(EL2-1)], (fmin<=fm<=1.00) |      |    |      |      |
| or flt=[fm+0.91(N-1)]/N**   |      |    |      |      |

Left-turn adjustment, fLT

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET

for shared lefts

Input

|   | EB | WB | NB    | SB    |
|---|----|----|-------|-------|
| Cycle length, C   |    |    |       |       |
| 49.0 sec  |    |    |       |       |
| Total actual green time for LT lane group, G (s)  |    |    |       |       |
| Effective permitted green time for LT lane group, g(s)  |    |    |       |       |
| Opposing effective green time, go (s)   |    |    |       |       |
| Number of lanes in LT lane group, N   |    |    |       |       |
| Number of lanes in opposing approach, No  |    |    |       |       |
| Adjusted LT flow rate, VLT (veh/h)  |    |    |       |       |
| Proportion of LT in LT lane group, PLT  |    |    | 0.000 | 0.000 |
| Proportion of LT in opposing flow, PLTo   |    |    |       |       |
| Adjusted opposing flow rate, Vo (veh/h)   |    |    |       |       |
| Lost time for LT lane group, tL   |    |    |       |       |
| Computation   |    |    |       |       |
| LT volume per cycle, LTC=VLTC/3600  |    |    |       |       |
| Opposing lane util. factor, fLUo  |    |    | 0.95  | 0.95  |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)   |    |    |       |       |
| $gf = G[\exp(-a * (LTC ** b))] - tL$ , $gf \leq g$  |    |    |       |       |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)   |    |    |       |       |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]  |    |    |       |       |
| gq, (see Exhibit C16-4,5,6,7,8)   |    |    |       |       |
| $gu = g - gq$ if $gq \geq gf$ , or $= g - gf$ if $gq < gf$  |    |    |       |       |
| $n = \text{Max}(gq - gf) / 2, 0$  |    |    |       |       |
| PTHo=1-PLTo   |    |    |       |       |
| $PL* = PLT[1 + (N-1)g / (gf + gu / EL1 + 4.24)]$  |    |    |       |       |
| EL1 (refer to Exhibit C16-3)  |    |    |       |       |
| $EL2 = \text{Max}((1 - Ptho ** n) / Plto, 1.0)$   |    |    |       |       |
| $fmin = 2(1 + PL) / g$ or $fmin = 2(1 + Pl) / g$  |    |    |       |       |
| $gdiff = \text{max}(gq - gf, 0)$  |    |    |       |       |
| $fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)]$ , (min=fmin;max=1.00)                                    |    |    |       |       |
| $flt = fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)] + [gdiff/g] / [1 + PL(EL2 - 1)]$ , (fmin<=fm<=1.00) |    |    |       |       |
| or $flt = [fm + 0.91(N-1)] / N **$  |    |    |       |       |
| Left-turn adjustment, fLT   |    |    |       |       |

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns

EB WB NB SB

Effective pedestrian green time,  $g_p$  (s)  
 Conflicting pedestrian volume,  $V_{ped}$  (p/h)  
 Pedestrian flow rate,  $V_{pedg}$  (p/h)  
 $OCC_{pedg}$   
 Opposing queue clearing green,  $g_q$  (s)  
 Eff. ped. green consumed by opp. veh. queue,  $g_q/g_p$   
 $OCC_{pedu}$   
 Opposing flow rate,  $V_o$  (veh/h)  
 $OCC_r$   
 Number of cross-street receiving lanes,  $N_{rec}$   
 Number of turning lanes,  $N_{turn}$   
 $ApbT$   
 Proportion of left turns,  $PLT$   
 Proportion of left turns using protected phase,  $PLTA$   
 Left-turn adjustment,  $f_{Lpb}$   
 Permitted Right Turns  
 Effective pedestrian green time,  $g_p$  (s)  
 Conflicting pedestrian volume,  $V_{ped}$  (p/h)  
 Conflicting bicycle volume,  $V_{bic}$  (bicycles/h)  
 $V_{pedg}$   
 $OCC_{pedg}$   
 Effective green,  $g$  (s)  
 $V_{bicg}$   
 $OCC_{bicg}$   
 $OCC_r$   
 Number of cross-street receiving lanes,  $N_{rec}$   
 Number of turning lanes,  $N_{turn}$   
 $ApbT$   
 Proportion right-turns,  $PRT$   
 Proportion right-turns using protected phase,  $PRTA$   
 Right turn adjustment,  $f_{Rpb}$

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SUPPLEMENTAL UNIFORM DELAY WORKSHEET

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|   |      | EBLT | WBLT | NBLT | SBLT |
|---|------|------|------|------|------|
| Cycle length, $C$   | 49.0 |      |      |      |      |
| Adj. LT vol from Vol Adjustment Worksheet, $v$            |      |      |      |      |      |
| $v/c$ ratio from Capacity Worksheet, $X$                  |      |      |      |      |      |
| Protected phase effective green interval, $g$ (s)         |      |      |      |      |      |
| Opposing queue effective green interval, $g_q$            |      |      |      |      |      |
| Unopposed green interval, $g_u$                           |      |      |      |      |      |
| Red time $r=(C-g-g_q-g_u)$                                |      |      |      |      |      |
| Arrival rate, $q_a=v/(3600(\max[X,1.0]))$                 |      |      |      |      |      |
| Protected ph. departure rate, $S_p=s/3600$                |      |      |      |      |      |
| Permitted ph. departure rate, $S_s=s(g_q+g_u)/(g_u*3600)$ |      |      |      |      |      |
| $X_{Perm}$  |      |      |      |      |      |
| $X_{Prot}$  |      |      |      |      |      |
| Case  |      |      |      |      |      |
| Queue at beginning of green arrow, $Q_a$                  |      |      |      |      |      |
| Queue at beginning of unsaturated green, $Q_u$            |      |      |      |      |      |
| Residual queue, $Q_r$                                     |      |      |      |      |      |
| Uniform Delay, $d_l$                                      |      |      |      |      |      |

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DELAY/LOS WORKSHEET WITH INITIAL QUEUE

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|       | Initial Dur. | Uniform Delay | Initial Queue | Final Queue | Initial Lane | Lane Group |
|-------|--------------|---------------|---------------|-------------|--------------|------------|
| Appr/ | Unmet        | Unmet         | _____         | Unmet       | Queue        | Group      |

| Lane Group | Demand Q veh | Demand t hrs. | Unadj. ds | Adj. dl sec | Param. u | Demand Q veh | Delay d3 sec | Delay d sec |
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|

Eastbound

Westbound

Northbound

Southbound

---

Intersection Delay 14.3 sec/veh      Intersection LOS B

BACK OF QUEUE WORKSHEET

|                         | Eastbound |   |   | Westbound |   |   | Northbound |      |       | Southbound |   |   |       |   |
|-------------------------|-----------|---|---|-----------|---|---|------------|------|-------|------------|---|---|-------|---|
| LaneGroup               |           |   |   |           |   |   | R          | L    | T     |            |   |   | T     |   |
| Init Queue              |           |   |   |           |   |   | 0.0        | 0.0  | 0.0   |            |   |   | 0.0   |   |
| Flow Rate               |           |   |   |           |   |   | 419        | 124  | 814   |            |   |   | 905   |   |
| So                      |           |   |   |           |   |   | 1900       | 1900 | 1900  |            |   |   | 1900  |   |
| No.Lanes                | 0         | 0 | 0 | 0         | 0 | 0 | 1          | 1    | 2     | 0          | 0 | 0 | 2     | 0 |
| SL                      |           |   |   |           |   |   | 1644       | 1805 | 1805  |            |   |   | 1805  |   |
| LnCapacity              |           |   |   |           |   |   | 470        | 516  | 1068  |            |   |   | 1068  |   |
| Flow Ratio              |           |   |   |           |   |   | 0.25       | 0.07 | 0.45  |            |   |   | 0.50  |   |
| v/c Ratio               |           |   |   |           |   |   | 0.89       | 0.24 | 0.76  |            |   |   | 0.85  |   |
| Grn Ratio               |           |   |   |           |   |   | 0.29       | 0.29 | 0.59  |            |   |   | 0.59  |   |
| I Factor                |           |   |   |           |   |   | 1.000      |      | 1.000 |            |   |   | 1.000 |   |
| AT or PVG               |           |   |   |           |   |   | 3          | 3    | 3     |            |   |   | 3     |   |
| Pltn Ratio              |           |   |   |           |   |   | 1.00       | 1.00 | 1.00  |            |   |   | 1.00  |   |
| PF2                     |           |   |   |           |   |   | 1.00       | 1.00 | 1.00  |            |   |   | 1.00  |   |
| Q1                      |           |   |   |           |   |   | 5.5        | 1.3  | 8.2   |            |   |   | 10.1  |   |
| kB                      |           |   |   |           |   |   | 0.4        | 0.5  | 0.8   |            |   |   | 0.8   |   |
| Q2                      |           |   |   |           |   |   | 2.6        | 0.1  | 2.3   |            |   |   | 3.7   |   |
| Q Average               |           |   |   |           |   |   | 8.0        | 1.4  | 10.6  |            |   |   | 13.8  |   |
| Q Spacing               |           |   |   |           |   |   | 24.9       | 24.9 | 24.9  |            |   |   | 24.9  |   |
| Q Storage               |           |   |   |           |   |   | 0          | 0    | 0     |            |   |   | 0     |   |
| Q S Ratio               |           |   |   |           |   |   |            |      |       |            |   |   |       |   |
| 70th Percentile Output: |           |   |   |           |   |   |            |      |       |            |   |   |       |   |
| fB%                     |           |   |   |           |   |   | 1.2        | 1.3  | 1.2   |            |   |   | 1.2   |   |
| BOQ                     |           |   |   |           |   |   | 9.8        | 1.8  | 12.8  |            |   |   | 16.6  |   |
| QSRatio                 |           |   |   |           |   |   |            |      |       |            |   |   |       |   |
| 85th Percentile Output: |           |   |   |           |   |   |            |      |       |            |   |   |       |   |
| fB%                     |           |   |   |           |   |   | 1.5        | 1.6  | 1.4   |            |   |   | 1.4   |   |
| BOQ                     |           |   |   |           |   |   | 11.7       | 2.3  | 15.2  |            |   |   | 19.5  |   |

|                         |  |  |      |     |      |  |      |
|-------------------------|--|--|------|-----|------|--|------|
| QSRatio                 |  |  |      |     |      |  |      |
| 90th Percentile Output: |  |  |      |     |      |  |      |
| fB%                     |  |  | 1.6  | 1.9 | 1.6  |  | 1.5  |
| BOQ                     |  |  | 12.9 | 2.7 | 16.5 |  | 21.1 |
| QSRatio                 |  |  |      |     |      |  |      |
| 95th Percentile Output: |  |  |      |     |      |  |      |
| fB%                     |  |  | 1.8  | 2.3 | 1.7  |  | 1.7  |
| BOQ                     |  |  | 14.5 | 3.4 | 18.2 |  | 22.9 |
| QSRatio                 |  |  |      |     |      |  |      |
| 98th Percentile Output: |  |  |      |     |      |  |      |
| fB%                     |  |  | 2.0  | 2.8 | 1.9  |  | 1.8  |
| BOQ                     |  |  | 16.1 | 4.1 | 19.9 |  | 24.7 |
| QSRatio                 |  |  |      |     |      |  |      |

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ERROR MESSAGES

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No errors to report.

# Signalized Intersection

U.S. 72 at Ramps 3 & 4  
Proposed System

HCS2000: Signalized Intersections Release 4.1b

Analyst: Jonathan Storey Inter.: I-24 at U.S. 72  
 Agency: Florence & Hutcheson Area Type: All other areas  
 Date: 6/6/2002 Jurisd: Marion Co.  
 Period: 2007 AM Year : 2002  
 Project ID: Interchange Modification Study  
 E/W St: I-24 Ramps 3 & 4 N/S St: U.S. 72

SIGNALIZED INTERSECTION SUMMARY

|            | Eastbound |   |      | Westbound |   |   | Northbound |      |   | Southbound |      |   |
|------------|-----------|---|------|-----------|---|---|------------|------|---|------------|------|---|
|            | L         | T | R    | L         | T | R | L          | T    | R | L          | T    | R |
| No. Lanes  | 1         | 0 | 1    | 0         | 0 | 0 | 0          | 2    | 0 | 1          | 2    | 0 |
| LGConfig   | L         |   | R    |           |   |   |            | T    |   | L          | T    |   |
| Volume     | 61        |   | 86   |           |   |   |            | 736  |   | 148        | 1086 |   |
| Lane Width | 12.0      |   | 12.0 |           |   |   |            | 12.0 |   | 12.0       | 12.0 |   |
| RTOR Vol   |           |   | 24   |           |   |   |            |      |   |            |      |   |

Duration 0.25 Area Type: All other areas

Signal Operations

| Phase Combination | 1    | 2   | 3   | 4   | 5        | 6    | 7   | 8   |
|-------------------|------|-----|-----|-----|----------|------|-----|-----|
| EB Left           | P    |     |     |     | NB Left  |      |     |     |
| Thru              |      |     |     |     | Thru     | P    |     |     |
| Right             | P    |     |     |     | Right    |      |     |     |
| Peds              |      |     |     |     | Peds     |      |     |     |
| WB Left           |      |     |     |     | SB Left  | P    | P   |     |
| Thru              |      |     |     |     | Thru     | P    | P   |     |
| Right             |      |     |     |     | Right    |      |     |     |
| Peds              |      |     |     |     | Peds     |      |     |     |
| NB Right          |      |     |     |     | EB Right |      |     |     |
| SB Right          |      |     |     |     | WB Right |      |     |     |
| Green             | 12.0 | 0.0 | 0.0 | 0.0 | 8.0      | 82.0 | 0.0 | 0.0 |
| Yellow            | 3.0  | 0.0 | 0.0 |     | 3.0      | 3.0  | 0.0 |     |
| All Red           | 0.0  | 0.0 | 0.0 |     | 0.0      | 0.0  | 0.0 |     |

Cycle Length: 111.0 secs

Intersection Performance Summary

| Appr/<br>Lane<br>Grp | Lane<br>Group<br>Capacity | Adj Sat<br>Flow Rate<br>(s) | Ratios |      | Lane Group |     | Approach |     |
|----------------------|---------------------------|-----------------------------|--------|------|------------|-----|----------|-----|
|                      |                           |                             | v/c    | g/C  | Delay      | LOS | Delay    | LOS |
| Eastbound            |                           |                             |        |      |            |     |          |     |
| L                    | 195                       | 1805                        | 0.35   | 0.11 | 50.7       | D   | 51.7     | D   |
| R                    | 175                       | 1615                        | 0.39   | 0.11 | 52.7       | D   |          |     |
| Westbound            |                           |                             |        |      |            |     |          |     |
| Northbound           |                           |                             |        |      |            |     |          |     |
| T                    | 2667                      | 3610                        | 0.31   | 0.74 | 5.2        | A   | 5.2      | A   |
| Southbound           |                           |                             |        |      |            |     |          |     |
| L                    | 576                       | 1805                        | 0.28   | 0.84 | 3.3        | A   |          |     |
| T                    | 3025                      | 3610                        | 0.40   | 0.84 | 2.6        | A   | 2.7      | A   |



|             |     |       |  |     |       |     |       |
|-------------|-----|-------|--|-----|-------|-----|-------|
| Init Unmet  | 0.0 | 0.0   |  |     | 0.0   | 0.0 | 0.0   |
| Arriv. Type | 3   | 3     |  |     | 3     | 3   | 3     |
| Unit Ext.   | 3.0 | 3.0   |  |     | 3.0   | 3.0 | 3.0   |
| I Factor    |     | 1.000 |  |     | 1.000 |     | 1.000 |
| Lost Time   | 2.0 | 2.0   |  |     | 2.0   | 2.0 | 2.0   |
| Ext of g    | 2.0 | 2.0   |  |     | 2.0   | 2.0 | 2.0   |
| Ped Min g   |     | 3.2   |  | 3.2 |       | 3.2 |       |

PHASE DATA

| Phase Combination | 1    | 2   | 3   | 4   | 5        | 6    | 7   | 8   |
|-------------------|------|-----|-----|-----|----------|------|-----|-----|
| EB Left           |      | P   |     |     | NB Left  |      |     |     |
| Thru              |      |     |     |     | Thru     |      | P   |     |
| Right             |      | P   |     |     | Right    |      |     |     |
| Peds              |      |     |     |     | Peds     |      |     |     |
| WB Left           |      |     |     |     | SB Left  | P    | P   |     |
| Thru              |      |     |     |     | Thru     | P    | P   |     |
| Right             |      |     |     |     | Right    |      |     |     |
| Peds              |      |     |     |     | Peds     |      |     |     |
| NB Right          |      |     |     |     | EB Right |      |     |     |
| SB Right          |      |     |     |     | WB Right |      |     |     |
| Green             | 12.0 | 0.0 | 0.0 | 0.0 | 8.0      | 82.0 | 0.0 | 0.0 |
| Yellow            | 3.0  | 0.0 | 0.0 |     | 3.0      | 3.0  | 0.0 |     |
| All Red           | 0.0  | 0.0 | 0.0 |     | 0.0      | 0.0  | 0.0 |     |

Cycle Length: 111.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

Volume Adjustment

|            | Eastbound |   |      | Westbound |   |   | Northbound |   |   | Southbound |       |   |
|------------|-----------|---|------|-----------|---|---|------------|---|---|------------|-------|---|
|            | L         | T | R    | L         | T | R | L          | T | R | L          | T     | R |
| Volume, V  | 61        |   | 86   |           |   |   | 736        |   |   | 148        | 1086  |   |
| PHF        | 0.90      |   | 0.90 |           |   |   | 0.90       |   |   | 0.90       | 0.90  |   |
| Adj flow   | 68        |   | 69   |           |   |   | 818        |   |   | 164        | 1207  |   |
| No. Lanes  | 1         | 0 | 1    | 0         | 0 | 0 | 0          | 2 | 0 | 1          | 2     | 0 |
| Lane group | L         |   | R    |           |   |   | T          |   |   | L          | T     |   |
| Adj flow   | 68        |   | 69   |           |   |   | 818        |   |   | 164        | 1207  |   |
| Prop LTs   |           |   |      |           |   |   | 0.000      |   |   | 1.000      | 0.000 |   |
| Prop RTs   |           |   |      |           |   |   | 0.000      |   |   | 0.000      |       |   |

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

| LG    | Eastbound |       | Westbound |   |   | Northbound |       | Southbound |  |
|-------|-----------|-------|-----------|---|---|------------|-------|------------|--|
|       | L         | R     | L         | T | R | T          | L     | T          |  |
| So    | 1900      | 1900  |           |   |   | 1900       | 1900  | 1900       |  |
| Lanes | 1         | 0     | 1         | 0 | 0 | 0          | 2     | 0          |  |
| fW    | 1.000     | 1.000 |           |   |   | 1.000      | 1.000 | 1.000      |  |
| fHV   | 1.000     | 1.000 |           |   |   | 1.000      | 1.000 | 1.000      |  |
| fG    | 1.000     | 1.000 |           |   |   | 1.000      | 1.000 | 1.000      |  |
| fP    | 1.000     | 1.000 |           |   |   | 1.000      | 1.000 | 1.000      |  |

|      |       |       |       |       |       |       |
|------|-------|-------|-------|-------|-------|-------|
| fBB  | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| fA   | 1.00  | 1.00  | 1.00  | 1.00  | 1.00  | 1.00  |
| fLU  | 1.00  | 1.00  | 0.95  | 1.00  | 0.95  |       |
| fRT  |       | 0.850 | 1.000 |       | 1.000 |       |
| fLT  | 0.950 |       | 1.000 | 0.950 | 1.000 |       |
| Sec. |       |       |       |       | 0.306 |       |
| fLpb | 1.000 |       | 1.000 | 1.000 | 1.000 | 1.000 |
| fRpb |       | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| S    | 1805  | 1615  | 3610  | 1805  | 3610  |       |
| Sec. |       |       |       |       | 582   |       |

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

| Appr/<br>Mvmt | Lane<br>Group | Adj<br>Flow Rate<br>(v) | Adj Sat<br>Flow Rate<br>(s) | Flow<br>Ratio<br>(v/s) | Green<br>Ratio<br>(g/C) | --Lane Group--<br>Capacity<br>(c) | v/c<br>Ratio |
|---------------|---------------|-------------------------|-----------------------------|------------------------|-------------------------|-----------------------------------|--------------|
| Eastbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left L        | 68                      | 1805                        | 0.04                   | 0.11                    | 195                               | 0.35         |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right R       | 69                      | 1615                        | # 0.04                 | 0.11                    | 175                               | 0.39         |
| Westbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Northbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru T        | 818                     | 3610                        | 0.23                   | 0.74                    | 2667                              | 0.31         |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Southbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          | 130                     | 1805                        | 0.07                   | 0.072                   | 130                               | 1.00         |
|               | Perm          | 34                      | 582                         | 0.06                   | 0.766                   | 446                               | 0.08         |
|               | Left L        | 164                     |                             |                        | 0.84                    | 576                               | 0.28         |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru T        | 1207                    | 3610                        | # 0.33                 | 0.84                    | 3025                              | 0.40         |
|               | Right         |                         |                             |                        |                         |                                   |              |

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Sum of flow ratios for critical lane groups,  $Y_c = \text{Sum (v/s)} = 0.38$   
Total lost time per cycle,  $L = 6.00 \text{ sec}$   
Critical flow rate to capacity ratio,  $X_c = (Y_c) (C) / (C-L) = 0.40$

Control Delay and LOS Determination

| Appr/<br>Lane | Ratios | Unf<br>Del | Prog<br>Adj | Lane<br>Grp | Incremental<br>Factor | Res<br>Del | Lane Group | Approach |
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|

| Grp  | v/c  | g/C  | d1   | Fact  | Cap  | k    | d2  | d3  | Delay | LOS | Delay | LOS |
|--|------|------|------|-------|------|------|-----|-----|-------|-----|-------|-----|
| Eastbound  |      |      |      |       |      |      |     |     |       |     |       |     |
| L  | 0.35 | 0.11 | 45.9 | 1.000 | 195  | 0.50 | 4.9 | 0.0 | 50.7  | D   |       |     |
| R  | 0.39 | 0.11 | 46.1 | 1.000 | 175  | 0.50 | 6.5 | 0.0 | 52.7  | D   | 51.7  | D   |
| Westbound  |      |      |      |       |      |      |     |     |       |     |       |     |
| Northbound   |      |      |      |       |      |      |     |     |       |     |       |     |
| T  | 0.31 | 0.74 | 4.9  | 1.000 | 2667 | 0.50 | 0.3 | 0.0 | 5.2   | A   | 5.2   | A   |
| Southbound   |      |      |      |       |      |      |     |     |       |     |       |     |
| L  | 0.28 | 0.84 | 2.1  | 1.000 | 576  | 0.50 | 1.2 | 0.0 | 3.3   | A   |       |     |
| T  | 0.40 | 0.84 | 2.2  | 1.000 | 3025 | 0.50 | 0.4 | 0.0 | 2.6   | A   | 2.7   | A   |
| <hr/> Intersection delay = 6.5 (sec/veh)      Intersection LOS = A |      |      |      |       |      |      |     |     |       |     |       |     |

SUPPLEMENTAL PERMITTED LT WORKSHEET

for exclusive lefts

Input

|  | EB | WB | NB   | SB    |
|--|----|----|------|-------|
| Cycle length, C  |    |    |      |       |
| Total actual green time for LT lane group, G (s)                             |    |    |      | 93.0  |
| Effective permitted green time for LT lane group, g(s)                       |    |    |      | 85.0  |
| Opposing effective green time, go (s)  |    |    |      | 82.0  |
| Number of lanes in LT lane group, N  |    |    |      | 1     |
| Number of lanes in opposing approach, No                                     |    |    |      | 2     |
| Adjusted LT flow rate, VLT (veh/h)   |    |    |      | 164   |
| Proportion of LT in LT lane group, PLT                                       |    |    |      | 1.000 |
| Proportion of LT in opposing flow, PLTo                                      |    |    |      | 0.00  |
| Adjusted opposing flow rate, Vo (veh/h)                                      |    |    |      | 818   |
| Lost time for LT lane group, tL  |    |    |      | 3.00  |
| Computation  |    |    |      |       |
| LT volume per cycle, LTC=VLTC/3600   |    |    |      | 5.06  |
| Opposing lane util. factor, fLUo   |    |    | 0.95 | 0.95  |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)                          |    |    |      | 13.27 |
| gf=G[exp(- a * (LTC ** b))]-tL, gf<=g  |    |    |      | 0.0   |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)                            |    |    |      | 1.00  |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]                                 |    |    |      | 0.26  |
| gq, (see Exhibit C16-4,5,6,7,8)  |    |    |      | 9.12  |
| gu=g-gq if gq>=gf, or = g-gf if gq<gf  |    |    |      | 75.88 |
| n=Max(gq-gf)/2,0)  |    |    |      | 4.56  |
| PTHo=1-PLTo  |    |    |      | 1.00  |
| PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]   |    |    |      | 1.00  |
| EL1 (refer to Exhibit C16-3)   |    |    |      | 2.91  |
| EL2=Max((1-Ptho**n)/Plto, 1.0)   |    |    |      |       |
| fmin=2(1+PL)/g or fmin=2(1+Pl)/g   |    |    |      | 0.05  |
| gdiff=max(gq-gf,0)   |    |    |      | 0.00  |
| fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)                          |    |    |      | 0.31  |
| flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)], (fmin<=fm<=1.00) |    |    |      |       |
| or flt=[fm+0.91(N-1)]/N**  |    |    |      |       |

Left-turn adjustment, fLT

0.306

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET

for shared lefts

Input

|   | EB | WB | NB    | SB    |
|---|----|----|-------|-------|
| Cycle length, C   |    |    |       |       |
| Total actual green time for LT lane group, G (s)  |    |    |       |       |
| Effective permitted green time for LT lane group, g(s)  |    |    |       |       |
| Opposing effective green time, go (s)   |    |    |       |       |
| Number of lanes in LT lane group, N   |    |    |       |       |
| Number of lanes in opposing approach, No  |    |    |       |       |
| Adjusted LT flow rate, VLT (veh/h)  |    |    |       |       |
| Proportion of LT in LT lane group, PLT  |    |    | 0.000 | 0.000 |
| Proportion of LT in opposing flow, PLTo   |    |    |       |       |
| Adjusted opposing flow rate, Vo (veh/h)   |    |    |       |       |
| Lost time for LT lane group, tL   |    |    |       |       |
| Computation   |    |    |       |       |
| LT volume per cycle, LTC=VLTC/3600  |    |    |       |       |
| Opposing lane util. factor, fLUo  |    |    | 0.95  | 0.95  |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)   |    |    |       |       |
| $gf = G[\exp(-a * (LTC ** b))] - tL$ , $gf \leq g$  |    |    |       |       |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)   |    |    |       |       |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]  |    |    |       |       |
| gq, (see Exhibit C16-4,5,6,7,8)   |    |    |       |       |
| $gu = g - gq$ if $gq \geq gf$ , or $= g - gf$ if $gq < gf$  |    |    |       |       |
| $n = \text{Max}(gq - gf) / 2, 0$  |    |    |       |       |
| $PTHo = 1 - PLTo$   |    |    |       |       |
| $PL* = PLT[1 + (N-1)g / (gf + gu / EL1 + 4.24)]$  |    |    |       |       |
| EL1 (refer to Exhibit C16-3)  |    |    |       |       |
| $EL2 = \text{Max}((1 - Ptho ** n) / Plto, 1.0)$   |    |    |       |       |
| $fmin = 2(1 + PL) / g$ or $fmin = 2(1 + Pl) / g$  |    |    |       |       |
| $gdiff = \text{max}(gq - gf, 0)$  |    |    |       |       |
| $fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)]$ , (min=fmin;max=1.00)                                    |    |    |       |       |
| $flt = fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)] + [gdiff/g] / [1 + PL(EL2 - 1)]$ , (fmin<=fm<=1.00) |    |    |       |       |
| or $flt = [fm + 0.91(N-1)] / N **$  |    |    |       |       |
| Left-turn adjustment, fLT   |    |    |       |       |

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns

| EB | WB | NB | SB |
|----|----|----|----|
|----|----|----|----|

Effective pedestrian green time, gp (s)  
 Conflicting pedestrian volume, Vped (p/h)  
 Pedestrian flow rate, Vpedg (p/h)  
 OCCpedg  
 Opposing queue clearing green, gq (s)  
 Eff. ped. green consumed by opp. veh. queue, gq/gp  
 OCCpedu  
 Opposing flow rate, Vo (veh/h)  
 OCCr  
 Number of cross-street receiving lanes, Nrec  
 Number of turning lanes, Nturn  
 ApbT  
 Proportion of left turns, PLT  
 Proportion of left turns using protected phase, PLTA  
 Left-turn adjustment, fLpb  
 Permitted Right Turns  
 Effective pedestrian green time, gp (s)  
 Conflicting pedestrian volume, Vped (p/h)  
 Conflicting bicycle volume, Vbic (bicycles/h)  
 Vpedg  
 OCCpedg  
 Effective green, g (s)  
 Vbicg  
 OCCbicg  
 OCCr  
 Number of cross-street receiving lanes, Nrec  
 Number of turning lanes, Nturn  
 ApbT  
 Proportion right-turns, PRT  
 Proportion right-turns using protected phase, PRTA  
 Right turn adjustment, fRpb

SUPPLEMENTAL UNIFORM DELAY WORKSHEET

---

|   |       | EBLT | WBLT | NBLT | SBLT  |
|---|-------|------|------|------|-------|
| Cycle length, C                                     | 111.0 |      |      |      |       |
| Adj. LT vol from Vol Adjustment Worksheet, v        |       |      |      |      | 164   |
| v/c ratio from Capacity Worksheet, X                |       |      |      |      | 0.28  |
| Protected phase effective green interval, g (s)     |       |      |      |      | 8.0   |
| Opposing queue effective green interval, gq         |       |      |      |      | 9.12  |
| Unopposed green interval, gu                        |       |      |      |      | 75.88 |
| Red time r=(C-g-gq-gu)                              |       |      |      |      | 18.0  |
| Arrival rate, qa=v/(3600(max[X,1.0]))               |       |      |      |      | 0.05  |
| Protected ph. departure rate, Sp=s/3600             |       |      |      |      | 0.501 |
| Permitted ph. departure rate, Ss=s(gq+gu)/(gu*3600) |       |      |      |      | 0.18  |
| XPerm   |       |      |      |      | 0.28  |
| XProt   |       |      |      |      | 0.30  |
| Case  |       |      |      |      | 1     |
| Queue at beginning of green arrow, Qa               |       |      |      |      | 0.82  |
| Queue at beginning of unsaturated green, Qu         |       |      |      |      | 0.42  |
| Residual queue, Qr                                  |       |      |      |      | 0.00  |
| Uniform Delay, dl                                   |       |      |      |      | 2.1   |

DELAY/LOS WORKSHEET WITH INITIAL QUEUE

---

|       | Initial Dur. | Uniform Delay | Initial Queue | Final Queue | Initial Lane | Lane Group |
|-------|--------------|---------------|---------------|-------------|--------------|------------|
| Appr/ | Unmet        | Unmet         | Unmet         | Unmet       | Unmet        |            |

| Lane Group | Demand Q veh | Demand t hrs. | Unadj. ds | Adj. dl sec | Param. u | Demand Q veh | Delay d3 sec | Delay d sec |
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|

Eastbound

Westbound

Northbound

Southbound

---

|                    |     |         |                  |   |
|--------------------|-----|---------|------------------|---|
| Intersection Delay | 6.5 | sec/veh | Intersection LOS | A |
|--------------------|-----|---------|------------------|---|

BACK OF QUEUE WORKSHEET

|                         | Eastbound |       |   | Westbound |   |   | Northbound |   |      | Southbound |   |   |
|-------------------------|-----------|-------|---|-----------|---|---|------------|---|------|------------|---|---|
| LaneGroup               | L         | R     |   |           |   |   | T          |   | L    | T          |   |   |
| Init Queue              | 0.0       | 0.0   |   |           |   |   | 0.0        |   | 0.0  | 0.0        |   |   |
| Flow Rate               | 68        | 69    |   |           |   |   | 409        |   | 164  | 603        |   |   |
| So                      | 1900      | 1900  |   |           |   |   | 1900       |   | 1900 | 1900       |   |   |
| No.Lanes                | 1         | 0     | 1 | 0         | 0 | 0 | 0          | 2 | 0    | 1          | 2 | 0 |
| SL                      | 1805      | 1615  |   |           |   |   | 1805       |   | 1805 | 1805       |   |   |
| LnCapacity              | 195       | 175   |   |           |   |   | 1333       |   | 576  | 1512       |   |   |
| Flow Ratio              | 0.04      | 0.04  |   |           |   |   | 0.23       |   | 0.09 | 0.33       |   |   |
| v/c Ratio               | 0.35      | 0.39  |   |           |   |   | 0.31       |   | 0.28 | 0.40       |   |   |
| Grn Ratio               | 0.11      | 0.11  |   |           |   |   | 0.74       |   | 0.84 | 0.84       |   |   |
| I Factor                |           | 1.000 |   |           |   |   | 1.000      |   |      | 1.000      |   |   |
| AT or PVG               | 3         | 3     |   |           |   |   | 3          |   | 3    | 3          |   |   |
| Pltn Ratio              | 1.00      | 1.00  |   |           |   |   | 1.00       |   | 1.00 | 1.00       |   |   |
| PF2                     | 1.00      | 1.00  |   |           |   |   | 1.00       |   | 1.00 | 1.00       |   |   |
| Q1                      | 1.9       | 2.0   |   |           |   |   | 4.3        |   | 0.8  | 4.5        |   |   |
| kB                      | 0.4       | 0.4   |   |           |   |   | 1.6        |   | 1.8  | 1.8        |   |   |
| Q2                      | 0.2       | 0.2   |   |           |   |   | 0.7        |   | 0.7  | 1.2        |   |   |
| Q Average               | 2.2       | 2.2   |   |           |   |   | 5.0        |   | 1.5  | 5.7        |   |   |
| Q Spacing               | 24.9      | 24.9  |   |           |   |   | 24.9       |   | 24.9 | 24.9       |   |   |
| Q Storage               | 0         | 0     |   |           |   |   | 0          |   | 0    | 0          |   |   |
| Q S Ratio               |           |       |   |           |   |   |            |   |      |            |   |   |
| 70th Percentile Output: |           |       |   |           |   |   |            |   |      |            |   |   |
| fB%                     | 1.3       | 1.3   |   |           |   |   | 1.2        |   | 1.3  | 1.2        |   |   |
| BOQ                     | 2.7       | 2.8   |   |           |   |   | 6.2        |   | 2.0  | 7.0        |   |   |
| QSRatio                 |           |       |   |           |   |   |            |   |      |            |   |   |
| 85th Percentile Output: |           |       |   |           |   |   |            |   |      |            |   |   |
| fB%                     | 1.6       | 1.6   |   |           |   |   | 1.5        |   | 1.6  | 1.5        |   |   |
| BOQ                     | 3.5       | 3.6   |   |           |   |   | 7.5        |   | 2.5  | 8.5        |   |   |

|                         |  |     |  |     |  |      |  |
|-------------------------|--|-----|--|-----|--|------|--|
| QSRatio                 |  |     |  |     |  |      |  |
| 90th Percentile Output: |  |     |  |     |  |      |  |
| fB%                     |  | 1.8 |  | 1.8 |  | 1.7  |  |
| BOQ                     |  | 4.0 |  | 4.1 |  | 8.4  |  |
| QSRatio                 |  |     |  |     |  |      |  |
| 95th Percentile Output: |  |     |  |     |  |      |  |
| fB%                     |  | 2.2 |  | 2.2 |  | 2.0  |  |
| BOQ                     |  | 4.9 |  | 5.0 |  | 9.8  |  |
| QSRatio                 |  |     |  |     |  |      |  |
| 98th Percentile Output: |  |     |  |     |  |      |  |
| fB%                     |  | 2.7 |  | 2.7 |  | 2.3  |  |
| BOQ                     |  | 5.8 |  | 5.9 |  | 11.2 |  |
| QSRatio                 |  |     |  |     |  |      |  |

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ERROR MESSAGES

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No errors to report.

HCS2000: Signalized Intersections Release 4.1b

Analyst: Jonathan Storey Inter.: I-24 at U.S. 72  
 Agency: Florence & Hutcheson Area Type: All other areas  
 Date: 6/6/2002 Jurisd: Marion Co.  
 Period: 2007 PM Year : 2002  
 Project ID: Interchange Modification Study  
 E/W St: I-24 Ramps 3 & 4 N/S St: U.S. 72

SIGNALIZED INTERSECTION SUMMARY

|            | Eastbound |   |      | Westbound |   |   | Northbound |      |   | Southbound |      |   |
|------------|-----------|---|------|-----------|---|---|------------|------|---|------------|------|---|
|            | L         | T | R    | L         | T | R | L          | T    | R | L          | T    | R |
| No. Lanes  | 1         | 0 | 1    | 0         | 0 | 0 | 0          | 2    | 0 | 1          | 2    | 0 |
| LGConfig   | L         |   | R    |           |   |   |            | T    |   | L          | T    |   |
| Volume     | 70        |   | 64   |           |   |   |            | 982  |   | 196        | 1429 |   |
| Lane Width | 12.0      |   | 12.0 |           |   |   |            | 12.0 |   | 12.0       | 12.0 |   |
| RTOR Vol   |           |   | 24   |           |   |   |            |      |   |            |      |   |

Duration 0.25 Area Type: All other areas

Signal Operations

| Phase Combination | 1   | 2   | 3   | 4   | 5        | 6    | 7   | 8   |
|-------------------|-----|-----|-----|-----|----------|------|-----|-----|
| EB Left           | P   |     |     |     | NB Left  |      |     |     |
| Thru              |     |     |     |     | Thru     | P    |     |     |
| Right             | P   |     |     |     | Right    |      |     |     |
| Peds              |     |     |     |     | Peds     |      |     |     |
| WB Left           |     |     |     |     | SB Left  | P    | P   |     |
| Thru              |     |     |     |     | Thru     | P    | P   |     |
| Right             |     |     |     |     | Right    |      |     |     |
| Peds              |     |     |     |     | Peds     |      |     |     |
| NB Right          |     |     |     |     | EB Right |      |     |     |
| SB Right          |     |     |     |     | WB Right |      |     |     |
| Green             | 8.0 | 0.0 | 0.0 | 0.0 | 8.0      | 76.0 | 0.0 | 0.0 |
| Yellow            | 3.0 | 0.0 | 0.0 |     | 3.0      | 3.0  | 0.0 |     |
| All Red           | 0.0 | 0.0 | 0.0 |     | 0.0      | 0.0  | 0.0 |     |

Cycle Length: 101.0 secs

Intersection Performance Summary

| Appr/<br>Lane<br>Grp | Lane<br>Group<br>Capacity | Adj Sat<br>Flow Rate<br>(s) | Ratios |      | Lane Group |     | Approach |     |
|----------------------|---------------------------|-----------------------------|--------|------|------------|-----|----------|-----|
|                      |                           |                             | v/c    | g/C  | Delay      | LOS | Delay    | LOS |
| Eastbound            |                           |                             |        |      |            |     |          |     |
| L                    | 143                       | 1805                        | 0.55   | 0.08 | 58.9       | E   | 56.1     | E   |
| R                    | 128                       | 1615                        | 0.34   | 0.08 | 51.2       | D   |          |     |
| Westbound            |                           |                             |        |      |            |     |          |     |
| Northbound           |                           |                             |        |      |            |     |          |     |
| T                    | 2716                      | 3610                        | 0.40   | 0.75 | 4.9        | A   | 4.9      | A   |
| Southbound           |                           |                             |        |      |            |     |          |     |
| L                    | 475                       | 1805                        | 0.46   | 0.86 | 5.5        | A   |          |     |
| T                    | 3110                      | 3610                        | 0.51   | 0.86 | 2.3        | A   | 2.7      | A   |



|             |     |       |  |     |       |     |       |
|-------------|-----|-------|--|-----|-------|-----|-------|
| Init Unmet  | 0.0 | 0.0   |  |     | 0.0   | 0.0 | 0.0   |
| Arriv. Type | 3   | 3     |  |     | 3     | 3   | 3     |
| Unit Ext.   | 3.0 | 3.0   |  |     | 3.0   | 3.0 | 3.0   |
| I Factor    |     | 1.000 |  |     | 1.000 |     | 1.000 |
| Lost Time   | 2.0 | 2.0   |  |     | 2.0   | 2.0 | 2.0   |
| Ext of g    | 2.0 | 2.0   |  |     | 2.0   | 2.0 | 2.0   |
| Ped Min g   |     | 3.2   |  | 3.2 |       | 3.2 |       |

PHASE DATA

| Phase Combination | 1   | 2   | 3   | 4   | 5        | 6    | 7   | 8   |
|-------------------|-----|-----|-----|-----|----------|------|-----|-----|
| EB Left           |     | P   |     |     | NB Left  |      |     |     |
| Thru              |     |     |     |     | Thru     |      | P   |     |
| Right             |     | P   |     |     | Right    |      |     |     |
| Peds              |     |     |     |     | Peds     |      |     |     |
| WB Left           |     |     |     |     | SB Left  | P    | P   |     |
| Thru              |     |     |     |     | Thru     | P    | P   |     |
| Right             |     |     |     |     | Right    |      |     |     |
| Peds              |     |     |     |     | Peds     |      |     |     |
| NB Right          |     |     |     |     | EB Right |      |     |     |
| SB Right          |     |     |     |     | WB Right |      |     |     |
| Green             | 8.0 | 0.0 | 0.0 | 0.0 | 8.0      | 76.0 | 0.0 | 0.0 |
| Yellow            | 3.0 | 0.0 | 0.0 |     | 3.0      | 3.0  | 0.0 |     |
| All Red           | 0.0 | 0.0 | 0.0 |     | 0.0      | 0.0  | 0.0 |     |

Cycle Length: 101.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

Volume Adjustment

|            | Eastbound |   |      | Westbound |   |   | Northbound |   |   | Southbound |       |   |
|------------|-----------|---|------|-----------|---|---|------------|---|---|------------|-------|---|
|            | L         | T | R    | L         | T | R | L          | T | R | L          | T     | R |
| Volume, V  | 70        |   | 64   |           |   |   | 982        |   |   | 196        | 1429  |   |
| PHF        | 0.90      |   | 0.90 |           |   |   | 0.90       |   |   | 0.90       | 0.90  |   |
| Adj flow   | 78        |   | 44   |           |   |   | 1091       |   |   | 218        | 1588  |   |
| No. Lanes  | 1         | 0 | 1    | 0         | 0 | 0 | 0          | 2 | 0 | 1          | 2     | 0 |
| Lane group | L         |   | R    |           |   |   | T          |   |   | L          | T     |   |
| Adj flow   | 78        |   | 44   |           |   |   | 1091       |   |   | 218        | 1588  |   |
| Prop LTs   |           |   |      |           |   |   | 0.000      |   |   | 1.000      | 0.000 |   |
| Prop RTs   |           |   |      |           |   |   | 0.000      |   |   | 0.000      |       |   |

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

| LG    | Eastbound |   |       | Westbound |   |   | Northbound |   |  | Southbound |       |   |
|-------|-----------|---|-------|-----------|---|---|------------|---|--|------------|-------|---|
|       | L         |   | R     | L         | T | R | T          |   |  | L          | T     |   |
| So    | 1900      |   | 1900  |           |   |   | 1900       |   |  | 1900       | 1900  |   |
| Lanes | 1         | 0 | 1     | 0         | 0 | 0 | 2          | 0 |  | 1          | 2     | 0 |
| fW    | 1.000     |   | 1.000 |           |   |   | 1.000      |   |  | 1.000      | 1.000 |   |
| fHV   | 1.000     |   | 1.000 |           |   |   | 1.000      |   |  | 1.000      | 1.000 |   |
| fG    | 1.000     |   | 1.000 |           |   |   | 1.000      |   |  | 1.000      | 1.000 |   |
| fP    | 1.000     |   | 1.000 |           |   |   | 1.000      |   |  | 1.000      | 1.000 |   |

|      |       |       |       |       |       |       |
|------|-------|-------|-------|-------|-------|-------|
| fBB  | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| fA   | 1.00  | 1.00  | 1.00  | 1.00  | 1.00  | 1.00  |
| fLU  | 1.00  | 1.00  | 0.95  | 1.00  | 0.95  |       |
| fRT  |       | 0.850 | 1.000 |       | 1.000 |       |
| fLT  | 0.950 |       | 1.000 | 0.950 | 1.000 |       |
| Sec. |       |       |       |       | 0.223 |       |
| fLpb | 1.000 |       | 1.000 | 1.000 | 1.000 | 1.000 |
| fRpb |       | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| S    | 1805  | 1615  | 3610  | 1805  | 3610  |       |
| Sec. |       |       |       |       | 424   |       |

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

| Appr/<br>Mvmt | Lane<br>Group | Adj<br>Flow Rate<br>(v) | Adj Sat<br>Flow Rate<br>(s) | Flow<br>Ratio<br>(v/s) | Green<br>Ratio<br>(g/C) | --Lane Group--<br>Capacity<br>(c) | v/c<br>Ratio |
|---------------|---------------|-------------------------|-----------------------------|------------------------|-------------------------|-----------------------------------|--------------|
| Eastbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left L        | 78                      | 1805                        | # 0.04                 | 0.08                    | 143                               | 0.55         |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right R       | 44                      | 1615                        | 0.03                   | 0.08                    | 128                               | 0.34         |
| Westbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Northbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru T        | 1091                    | 3610                        | 0.30                   | 0.75                    | 2716                              | 0.40         |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Southbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          | 143                     | 1805                        | 0.08                   | 0.079                   | 143                               | 1.00         |
|               | Perm          | 75                      | 424                         | 0.18                   | 0.782                   | 332                               | 0.23         |
|               | Left L        | 218                     |                             |                        | 0.86                    | 475                               | 0.46         |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru T        | 1588                    | 3610                        | # 0.44                 | 0.86                    | 3110                              | 0.51         |
|               | Right         |                         |                             |                        |                         |                                   |              |

Sum of flow ratios for critical lane groups,  $Y_c = \text{Sum (v/s)} = 0.48$   
Total lost time per cycle,  $L = 6.00 \text{ sec}$   
Critical flow rate to capacity ratio,  $X_c = (Y_c) (C) / (C-L) = 0.51$

Control Delay and LOS Determination

| Appr/<br>Lane | Ratios | Unf<br>Del | Prog<br>Adj | Lane<br>Grp | Incremental<br>Factor | Res<br>Del | Lane Group | Approach |
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|

| Grp  | v/c  | g/C  | d1   | Fact  | Cap  | k    | d2   | d3  | Delay | LOS | Delay | LOS |
|--|------|------|------|-------|------|------|------|-----|-------|-----|-------|-----|
| Eastbound  |      |      |      |       |      |      |      |     |       |     |       |     |
| L  | 0.55 | 0.08 | 44.8 | 1.000 | 143  | 0.50 | 14.1 | 0.0 | 58.9  | E   |       |     |
| R  | 0.34 | 0.08 | 44.0 | 1.000 | 128  | 0.50 | 7.2  | 0.0 | 51.2  | D   | 56.1  | E   |
| Westbound  |      |      |      |       |      |      |      |     |       |     |       |     |
| Northbound   |      |      |      |       |      |      |      |     |       |     |       |     |
| T  | 0.40 | 0.75 | 4.4  | 1.000 | 2716 | 0.50 | 0.4  | 0.0 | 4.9   | A   | 4.9   | A   |
| Southbound   |      |      |      |       |      |      |      |     |       |     |       |     |
| L  | 0.46 | 0.86 | 2.3  | 1.000 | 475  | 0.50 | 3.2  | 0.0 | 5.5   | A   |       |     |
| T  | 0.51 | 0.86 | 1.7  | 1.000 | 3110 | 0.50 | 0.6  | 0.0 | 2.3   | A   | 2.7   | A   |
| <hr/> Intersection delay = 5.7 (sec/veh)      Intersection LOS = A |      |      |      |       |      |      |      |     |       |     |       |     |

SUPPLEMENTAL PERMITTED LT WORKSHEET

for exclusive lefts

Input

|  | EB    | WB | NB   | SB    |
|--|-------|----|------|-------|
| Cycle length, C  |       |    |      |       |
| Total actual green time for LT lane group, G (s)                             | 101.0 |    |      | sec   |
| Effective permitted green time for LT lane group, g(s)                       |       |    |      | 87.0  |
| Opposing effective green time, go (s)  |       |    |      | 79.0  |
| Number of lanes in LT lane group, N  |       |    |      | 1     |
| Number of lanes in opposing approach, No                                     |       |    |      | 2     |
| Adjusted LT flow rate, VLT (veh/h)   |       |    |      | 218   |
| Proportion of LT in LT lane group, PLT                                       |       |    |      | 1.000 |
| Proportion of LT in opposing flow, PLTo                                      |       |    |      | 0.00  |
| Adjusted opposing flow rate, Vo (veh/h)                                      |       |    |      | 1091  |
| Lost time for LT lane group, tL  |       |    |      | 3.00  |
| Computation  |       |    |      |       |
| LT volume per cycle, LTC=VLTC/3600   |       |    |      | 6.12  |
| Opposing lane util. factor, fLUo   |       |    | 0.95 | 0.95  |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)                          |       |    |      | 16.11 |
| gf=G[exp(- a * (LTC ** b))]-tL, gf<=g  |       |    |      | 0.0   |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)                            |       |    |      | 1.00  |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]                                 |       |    |      | 0.25  |
| gq, (see Exhibit C16-4,5,6,7,8)  |       |    |      | 11.71 |
| gu=g-gq if gq>=gf, or = g-gf if gq<gf  |       |    |      | 67.29 |
| n=Max(gq-gf)/2,0)  |       |    |      | 5.86  |
| PTHo=1-PLTo  |       |    |      | 1.00  |
| PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]   |       |    |      | 1.00  |
| EL1 (refer to Exhibit C16-3)   |       |    |      | 3.82  |
| EL2=Max((1-Ptho**n)/Plto, 1.0)   |       |    |      |       |
| fmin=2(1+PL)/g or fmin=2(1+Pl)/g   |       |    |      | 0.05  |
| gdiff=max(gq-gf,0)   |       |    |      | 0.00  |
| fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)                          |       |    |      | 0.22  |
| flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)], (fmin<=fm<=1.00) |       |    |      |       |
| or flt=[fm+0.91(N-1)]/N**  |       |    |      |       |

Left-turn adjustment, fLT

0.223

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET

for shared lefts

Input

|   | EB | WB | NB    | SB    |
|---|----|----|-------|-------|
| Cycle length, C   |    |    |       |       |
| Total actual green time for LT lane group, G (s)  |    |    |       |       |
| Effective permitted green time for LT lane group, g(s)  |    |    |       |       |
| Opposing effective green time, go (s)   |    |    |       |       |
| Number of lanes in LT lane group, N   |    |    |       |       |
| Number of lanes in opposing approach, No  |    |    |       |       |
| Adjusted LT flow rate, VLT (veh/h)  |    |    |       |       |
| Proportion of LT in LT lane group, PLT  |    |    | 0.000 | 0.000 |
| Proportion of LT in opposing flow, PLTo   |    |    |       |       |
| Adjusted opposing flow rate, Vo (veh/h)   |    |    |       |       |
| Lost time for LT lane group, tL   |    |    |       |       |
| Computation   |    |    |       |       |
| LT volume per cycle, LTC=VLTC/3600  |    |    |       |       |
| Opposing lane util. factor, fLUo  |    |    | 0.95  | 0.95  |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)   |    |    |       |       |
| $gf = G[\exp(-a * (LTC ** b))] - tL$ , $gf \leq g$  |    |    |       |       |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)   |    |    |       |       |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]  |    |    |       |       |
| gq, (see Exhibit C16-4,5,6,7,8)   |    |    |       |       |
| $gu = g - gq$ if $gq \geq gf$ , or $= g - gf$ if $gq < gf$  |    |    |       |       |
| $n = \text{Max}(gq - gf) / 2, 0$  |    |    |       |       |
| $PTHo = 1 - PLTo$   |    |    |       |       |
| $PL* = PLT[1 + (N-1)g / (gf + gu / EL1 + 4.24)]$  |    |    |       |       |
| EL1 (refer to Exhibit C16-3)  |    |    |       |       |
| $EL2 = \text{Max}((1 - Ptho ** n) / Plto, 1.0)$   |    |    |       |       |
| $fmin = 2(1 + PL) / g$ or $fmin = 2(1 + Pl) / g$  |    |    |       |       |
| $gdiff = \text{max}(gq - gf, 0)$  |    |    |       |       |
| $fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)]$ , (min=fmin;max=1.00)                                    |    |    |       |       |
| $flt = fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)] + [gdiff/g] / [1 + PL(EL2 - 1)]$ , (fmin<=fm<=1.00) |    |    |       |       |
| or $flt = [fm + 0.91(N-1)] / N **$  |    |    |       |       |
| Left-turn adjustment, fLT   |    |    |       |       |

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns

| EB | WB | NB | SB |
|----|----|----|----|
|----|----|----|----|

Effective pedestrian green time, gp (s)  
 Conflicting pedestrian volume, Vped (p/h)  
 Pedestrian flow rate, Vpedg (p/h)  
 OCCpedg  
 Opposing queue clearing green, gq (s)  
 Eff. ped. green consumed by opp. veh. queue, gq/gp  
 OCCpedu  
 Opposing flow rate, Vo (veh/h)  
 OCCr  
 Number of cross-street receiving lanes, Nrec  
 Number of turning lanes, Nturn  
 ApbT  
 Proportion of left turns, PLT  
 Proportion of left turns using protected phase, PLTA  
 Left-turn adjustment, fLpb  
 Permitted Right Turns  
 Effective pedestrian green time, gp (s)  
 Conflicting pedestrian volume, Vped (p/h)  
 Conflicting bicycle volume, Vbic (bicycles/h)  
 Vpedg  
 OCCpedg  
 Effective green, g (s)  
 Vbicg  
 OCCbicg  
 OCCr  
 Number of cross-street receiving lanes, Nrec  
 Number of turning lanes, Nturn  
 ApbT  
 Proportion right-turns, PRT  
 Proportion right-turns using protected phase, PRTA  
 Right turn adjustment, fRpb

SUPPLEMENTAL UNIFORM DELAY WORKSHEET

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|   |       | EBLT | WBLT | NBLT | SBLT  |
|---|-------|------|------|------|-------|
| Cycle length, C                                     | 101.0 |      |      |      |       |
| Adj. LT vol from Vol Adjustment Worksheet, v        |       |      |      |      | 218   |
| v/c ratio from Capacity Worksheet, X                |       |      |      |      | 0.46  |
| Protected phase effective green interval, g (s)     |       |      |      |      | 8.0   |
| Opposing queue effective green interval, gq         |       |      |      |      | 11.71 |
| Unopposed green interval, gu                        |       |      |      |      | 67.29 |
| Red time r=(C-g-gq-gu)                              |       |      |      |      | 14.0  |
| Arrival rate, qa=v/(3600(max[X,1.0]))               |       |      |      |      | 0.06  |
| Protected ph. departure rate, Sp=s/3600             |       |      |      |      | 0.501 |
| Permitted ph. departure rate, Ss=s(gq+gu)/(gu*3600) |       |      |      |      | 0.14  |
| XPerm   |       |      |      |      | 0.51  |
| XProt   |       |      |      |      | 0.33  |
| Case  |       |      |      |      | 1     |
| Queue at beginning of green arrow, Qa               |       |      |      |      | 0.85  |
| Queue at beginning of unsaturated green, Qu         |       |      |      |      | 0.71  |
| Residual queue, Qr                                  |       |      |      |      | 0.00  |
| Uniform Delay, dl                                   |       |      |      |      | 2.3   |

DELAY/LOS WORKSHEET WITH INITIAL QUEUE

---

|       | Initial Dur. | Uniform Delay | Initial Queue | Final Queue | Initial Lane | Lane Group |
|-------|--------------|---------------|---------------|-------------|--------------|------------|
| Appr/ | Unmet        | Unmet         | Unmet         | Unmet       | Unmet        |            |

| Lane Group | Demand Q veh | Demand t hrs. | Unadj. ds | Adj. dl sec | Param. u | Demand Q veh | Delay d3 sec | Delay d sec |
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|

Eastbound

Westbound

Northbound

Southbound

---

Intersection Delay 5.7 sec/veh      Intersection LOS A

BACK OF QUEUE WORKSHEET

|                         | Eastbound |       |   | Westbound |   |   | Northbound |   |      | Southbound |   |  |
|-------------------------|-----------|-------|---|-----------|---|---|------------|---|------|------------|---|--|
| LaneGroup               | L         | R     |   |           |   |   | T          |   | L    | T          |   |  |
| Init Queue              | 0.0       | 0.0   |   |           |   |   | 0.0        |   | 0.0  | 0.0        |   |  |
| Flow Rate               | 78        | 44    |   |           |   |   | 545        |   | 218  | 794        |   |  |
| So                      | 1900      | 1900  |   |           |   |   | 1900       |   | 1900 | 1900       |   |  |
| No.Lanes                | 1         | 0     | 1 | 0         | 0 | 0 | 2          | 0 | 1    | 2          | 0 |  |
| SL                      | 1805      | 1615  |   |           |   |   | 1805       |   | 1805 | 1805       |   |  |
| LnCapacity              | 143       | 128   |   |           |   |   | 1358       |   | 475  | 1555       |   |  |
| Flow Ratio              | 0.04      | 0.03  |   |           |   |   | 0.30       |   | 0.12 | 0.44       |   |  |
| v/c Ratio               | 0.55      | 0.34  |   |           |   |   | 0.40       |   | 0.46 | 0.51       |   |  |
| Grn Ratio               | 0.08      | 0.08  |   |           |   |   | 0.75       |   | 0.86 | 0.86       |   |  |
| I Factor                |           | 1.000 |   |           |   |   | 1.000      |   |      | 1.000      |   |  |
| AT or PVG               | 3         | 3     |   |           |   |   | 3          |   | 3    | 3          |   |  |
| Pltn Ratio              | 1.00      | 1.00  |   |           |   |   | 1.00       |   | 1.00 | 1.00       |   |  |
| PF2                     | 1.00      | 1.00  |   |           |   |   | 1.00       |   | 1.00 | 1.00       |   |  |
| Q1                      | 2.1       | 1.2   |   |           |   |   | 5.4        |   | 0.9  | 5.5        |   |  |
| kB                      | 0.3       | 0.3   |   |           |   |   | 1.5        |   | 1.7  | 1.7        |   |  |
| Q2                      | 0.4       | 0.2   |   |           |   |   | 1.0        |   | 1.4  | 1.7        |   |  |
| Q Average               | 2.5       | 1.3   |   |           |   |   | 6.4        |   | 2.3  | 7.2        |   |  |
| Q Spacing               | 24.9      | 24.9  |   |           |   |   | 24.9       |   | 24.9 | 24.9       |   |  |
| Q Storage               | 0         | 0     |   |           |   |   | 0          |   | 0    | 0          |   |  |
| Q S Ratio               |           |       |   |           |   |   |            |   |      |            |   |  |
| 70th Percentile Output: |           |       |   |           |   |   |            |   |      |            |   |  |
| fB%                     | 1.3       | 1.3   |   |           |   |   | 1.2        |   | 1.3  | 1.2        |   |  |
| BOQ                     | 3.1       | 1.7   |   |           |   |   | 7.9        |   | 2.8  | 8.9        |   |  |
| QSRatio                 |           |       |   |           |   |   |            |   |      |            |   |  |
| 85th Percentile Output: |           |       |   |           |   |   |            |   |      |            |   |  |
| fB%                     | 1.6       | 1.6   |   |           |   |   | 1.5        |   | 1.6  | 1.5        |   |  |
| BOQ                     | 3.9       | 2.2   |   |           |   |   | 9.5        |   | 3.6  | 10.6       |   |  |

|                         |     |     |  |  |      |          |
|-------------------------|-----|-----|--|--|------|----------|
| QSRatio                 |     |     |  |  |      |          |
| 90th Percentile Output: |     |     |  |  |      |          |
| fB%                     | 1.8 | 1.9 |  |  | 1.6  | 1.8 1.6  |
| BOQ                     | 4.5 | 2.5 |  |  | 10.5 | 4.1 11.7 |
| QSRatio                 |     |     |  |  |      |          |
| 95th Percentile Output: |     |     |  |  |      |          |
| fB%                     | 2.2 | 2.4 |  |  | 1.9  | 2.2 1.8  |
| BOQ                     | 5.5 | 3.1 |  |  | 12.1 | 5.0 13.3 |
| QSRatio                 |     |     |  |  |      |          |
| 98th Percentile Output: |     |     |  |  |      |          |
| fB%                     | 2.6 | 2.9 |  |  | 2.1  | 2.7 2.1  |
| BOQ                     | 6.5 | 3.8 |  |  | 13.6 | 6.0 14.9 |
| QSRatio                 |     |     |  |  |      |          |

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ERROR MESSAGES

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No errors to report.

HCS2000: Signalized Intersections Release 4.1b

Analyst: Jonathan Storey Inter.: I-24 at U.S. 72  
 Agency: Florence & Hutcheson Area Type: All other areas  
 Date: 6/6/2002 Jurisd: Marion Co.  
 Period: 2027 AM Year : 2002  
 Project ID: Interchange Modification Study  
 E/W St: I-24 Ramps 3 & 4 N/S St: U.S. 72

SIGNALIZED INTERSECTION SUMMARY

|            | Eastbound |   |      | Westbound |   |   | Northbound |      |   | Southbound |      |   |
|------------|-----------|---|------|-----------|---|---|------------|------|---|------------|------|---|
|            | L         | T | R    | L         | T | R | L          | T    | R | L          | T    | R |
| No. Lanes  | 1         | 0 | 1    | 0         | 0 | 0 | 0          | 2    | 0 | 1          | 2    | 0 |
| LGConfig   | L         |   | R    |           |   |   |            | T    |   | L          | T    |   |
| Volume     | 92        |   | 129  |           |   |   |            | 1104 |   | 223        | 1628 |   |
| Lane Width | 12.0      |   | 12.0 |           |   |   |            | 12.0 |   | 12.0       | 12.0 |   |
| RTOR Vol   |           |   | 24   |           |   |   |            |      |   |            |      |   |

Duration 0.25 Area Type: All other areas

Signal Operations

| Phase Combination | 1    | 2   | 3   | 4   | 5        | 6    | 7   | 8   |
|-------------------|------|-----|-----|-----|----------|------|-----|-----|
| EB Left           | P    |     |     |     | NB Left  |      |     |     |
| Thru              |      |     |     |     | Thru     | P    |     |     |
| Right             | P    |     |     |     | Right    |      |     |     |
| Peds              |      |     |     |     | Peds     |      |     |     |
| WB Left           |      |     |     |     | SB Left  | P    | P   |     |
| Thru              |      |     |     |     | Thru     | P    | P   |     |
| Right             |      |     |     |     | Right    |      |     |     |
| Peds              |      |     |     |     | Peds     |      |     |     |
| NB Right          |      |     |     |     | EB Right |      |     |     |
| SB Right          |      |     |     |     | WB Right |      |     |     |
| Green             | 12.0 | 0.0 | 0.0 | 0.0 | 8.0      | 79.0 | 0.0 | 0.0 |
| Yellow            | 3.0  | 0.0 | 0.0 |     | 3.0      | 3.0  | 0.0 |     |
| All Red           | 0.0  | 0.0 | 0.0 |     | 0.0      | 0.0  | 0.0 |     |

Cycle Length: 108.0 secs

Intersection Performance Summary

| Appr/<br>Lane<br>Grp | Lane<br>Group<br>Capacity | Adj Sat<br>Flow Rate<br>(s) | Ratios |      | Lane Group |     | Approach |     |
|----------------------|---------------------------|-----------------------------|--------|------|------------|-----|----------|-----|
|                      |                           |                             | v/c    | g/C  | Delay      | LOS | Delay    | LOS |
| Eastbound            |                           |                             |        |      |            |     |          |     |
| L                    | 201                       | 1805                        | 0.51   | 0.11 | 54.1       | D   | 58.9     | E   |
| R                    | 179                       | 1615                        | 0.65   | 0.11 | 63.1       | E   |          |     |
| Westbound            |                           |                             |        |      |            |     |          |     |
| Northbound           |                           |                             |        |      |            |     |          |     |
| T                    | 2641                      | 3610                        | 0.46   | 0.73 | 6.5        | A   | 6.5      | A   |
| Southbound           |                           |                             |        |      |            |     |          |     |
| L                    | 398                       | 1805                        | 0.62   | 0.83 | 11.8       | B   |          |     |
| T                    | 3008                      | 3610                        | 0.60   | 0.83 | 3.9        | A   | 4.9      | A   |

Intersection Delay = 8.8 (sec/veh) Intersection LOS = A

HCS2000: Signalized Intersections Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-Mail: jstorey@flohut.com

Fax: (615) 399-9049

OPERATIONAL ANALYSIS

Analyst: Jonathan Storey  
 Agency/Co.: Florence & Hutcheson  
 Date Performed: 6/6/2002  
 Analysis Time Period: 2027 AM  
 Intersection: I-24 at U.S. 72  
 Area Type: All other areas  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Project ID: Interchange Modification Study

East/West Street North/South Street  
 I-24 Ramps 3 & 4 U.S. 72

VOLUME DATA

|              | Eastbound |   |      | Westbound                  |   |   | Northbound |   |   | Southbound |       |   |
|--------------|-----------|---|------|----------------------------|---|---|------------|---|---|------------|-------|---|
|              | L         | T | R    | L                          | T | R | L          | T | R | L          | T     | R |
| Volume       | 92        |   | 129  |                            |   |   | 1104       |   |   | 223        | 1628  |   |
| % Heavy Veh  | 0         |   | 0    |                            |   |   | 0          |   |   | 0          | 0     |   |
| PHF          | 0.90      |   | 0.90 |                            |   |   | 0.90       |   |   | 0.90       | 0.90  |   |
| PK 15 Vol    | 26        |   | 36   |                            |   |   | 307        |   |   | 62         | 452   |   |
| Hi Ln Vol    |           |   |      |                            |   |   |            |   |   |            |       |   |
| % Grade      |           | 0 |      |                            |   |   | 0          |   |   |            | 0     |   |
| Ideal Sat    | 1900      |   | 1900 |                            |   |   | 1900       |   |   | 1900       | 1900  |   |
| ParkExist    |           |   |      |                            |   |   |            |   |   |            |       |   |
| NumPark      |           |   |      |                            |   |   |            |   |   |            |       |   |
| No. Lanes    | 1         | 0 | 1    | 0                          | 0 | 0 | 0          | 2 | 0 | 1          | 2     | 0 |
| LGConfig     | L         |   | R    |                            |   |   |            | T |   | L          | T     |   |
| Lane Width   | 12.0      |   | 12.0 |                            |   |   | 12.0       |   |   | 12.0       | 12.0  |   |
| RTOR Vol     |           |   | 24   |                            |   |   |            |   |   |            |       |   |
| Adj Flow     | 102       |   | 117  |                            |   |   | 1227       |   |   | 248        | 1809  |   |
| %InSharedLn  |           |   |      |                            |   |   |            |   |   |            |       |   |
| Prop LTs     |           |   |      |                            |   |   | 0.000      |   |   | 1.000      | 0.000 |   |
| Prop RTs     |           |   |      |                            |   |   | 0.000      |   |   | 0.000      |       |   |
| Peds Bikes   | 0         |   |      | 0                          |   |   | 0          |   |   |            |       |   |
| Buses        | 0         |   | 0    |                            |   |   | 0          |   |   | 0          | 0     |   |
| %InProtPhase |           |   |      |                            |   |   |            |   |   | 0.0        |       |   |
| Duration     | 0.25      |   |      | Area Type: All other areas |   |   |            |   |   |            |       |   |

OPERATING PARAMETERS

|  | Eastbound |   |   | Westbound |   |   | Northbound |   |   | Southbound |   |   |
|--|-----------|---|---|-----------|---|---|------------|---|---|------------|---|---|
|  | L         | T | R | L         | T | R | L          | T | R | L          | T | R |

|             |     |       |  |     |       |     |       |
|-------------|-----|-------|--|-----|-------|-----|-------|
| Init Unmet  | 0.0 | 0.0   |  |     | 0.0   | 0.0 | 0.0   |
| Arriv. Type | 3   | 3     |  |     | 3     | 3   | 3     |
| Unit Ext.   | 3.0 | 3.0   |  |     | 3.0   | 3.0 | 3.0   |
| I Factor    |     | 1.000 |  |     | 1.000 |     | 1.000 |
| Lost Time   | 2.0 | 2.0   |  |     | 2.0   | 2.0 | 2.0   |
| Ext of g    | 2.0 | 2.0   |  |     | 2.0   | 2.0 | 2.0   |
| Ped Min g   |     | 3.2   |  | 3.2 |       | 3.2 |       |

PHASE DATA

| Phase Combination | 1    | 2   | 3   | 4   | 5        | 6    | 7   | 8   |
|-------------------|------|-----|-----|-----|----------|------|-----|-----|
| EB Left           | P    |     |     |     | NB Left  |      |     |     |
| Thru              |      |     |     |     | Thru     | P    |     |     |
| Right             | P    |     |     |     | Right    |      |     |     |
| Peds              |      |     |     |     | Peds     |      |     |     |
| WB Left           |      |     |     |     | SB Left  | P    | P   |     |
| Thru              |      |     |     |     | Thru     | P    | P   |     |
| Right             |      |     |     |     | Right    |      |     |     |
| Peds              |      |     |     |     | Peds     |      |     |     |
| NB Right          |      |     |     |     | EB Right |      |     |     |
| SB Right          |      |     |     |     | WB Right |      |     |     |
| Green             | 12.0 | 0.0 | 0.0 | 0.0 | 8.0      | 79.0 | 0.0 | 0.0 |
| Yellow            | 3.0  | 0.0 | 0.0 |     | 3.0      | 3.0  | 0.0 |     |
| All Red           | 0.0  | 0.0 | 0.0 |     | 0.0      | 0.0  | 0.0 |     |

Cycle Length: 108.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

| Volume Adjustment | Eastbound |   |      | Westbound |   |   | Northbound |   |   | Southbound |       |   |
|-------------------|-----------|---|------|-----------|---|---|------------|---|---|------------|-------|---|
|                   | L         | T | R    | L         | T | R | L          | T | R | L          | T     | R |
| Volume, V         | 92        |   | 129  |           |   |   | 1104       |   |   | 223        | 1628  |   |
| PHF               | 0.90      |   | 0.90 |           |   |   | 0.90       |   |   | 0.90       | 0.90  |   |
| Adj flow          | 102       |   | 117  |           |   |   | 1227       |   |   | 248        | 1809  |   |
| No. Lanes         | 1         | 0 | 1    | 0         | 0 | 0 | 0          | 2 | 0 | 1          | 2     | 0 |
| Lane group        | L         |   | R    |           |   |   | T          |   |   | L          | T     |   |
| Adj flow          | 102       |   | 117  |           |   |   | 1227       |   |   | 248        | 1809  |   |
| Prop LTs          |           |   |      |           |   |   | 0.000      |   |   | 1.000      | 0.000 |   |
| Prop RTs          |           |   |      |           |   |   | 0.000      |   |   | 0.000      |       |   |

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

| LG    | Eastbound |       | Westbound |   |   | Northbound |       | Southbound |   |   |   |
|-------|-----------|-------|-----------|---|---|------------|-------|------------|---|---|---|
|       | L         | R     | L         | T | R | T          | L     | T          | R |   |   |
| So    | 1900      | 1900  |           |   |   | 1900       | 1900  | 1900       |   |   |   |
| Lanes | 1         | 0     | 1         | 0 | 0 | 0          | 2     | 0          | 1 | 2 | 0 |
| fW    | 1.000     | 1.000 |           |   |   | 1.000      | 1.000 | 1.000      |   |   |   |
| fHV   | 1.000     | 1.000 |           |   |   | 1.000      | 1.000 | 1.000      |   |   |   |
| fG    | 1.000     | 1.000 |           |   |   | 1.000      | 1.000 | 1.000      |   |   |   |
| fP    | 1.000     | 1.000 |           |   |   | 1.000      | 1.000 | 1.000      |   |   |   |

|      |       |       |       |       |       |       |
|------|-------|-------|-------|-------|-------|-------|
| fBB  | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| fA   | 1.00  | 1.00  | 1.00  | 1.00  | 1.00  | 1.00  |
| fLU  | 1.00  | 1.00  | 0.95  | 1.00  | 0.95  |       |
| fRT  |       | 0.850 | 1.000 |       | 1.000 |       |
| fLT  | 0.950 |       | 1.000 | 0.950 | 1.000 |       |
| Sec. |       |       |       |       | 0.183 |       |
| fLpb | 1.000 |       | 1.000 | 1.000 | 1.000 | 1.000 |
| fRpb |       | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| S    | 1805  | 1615  | 3610  | 1805  | 3610  |       |
| Sec. |       |       |       |       | 348   |       |

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

| Appr/<br>Mvmt | Lane<br>Group | Adj<br>Flow Rate<br>(v) | Adj Sat<br>Flow Rate<br>(s) | Flow<br>Ratio<br>(v/s) | Green<br>Ratio<br>(g/C) | --Lane Group--<br>Capacity<br>(c) | v/c<br>Ratio |
|---------------|---------------|-------------------------|-----------------------------|------------------------|-------------------------|-----------------------------------|--------------|
| Eastbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left L        | 102                     | 1805                        | 0.06                   | 0.11                    | 201                               | 0.51         |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right R       | 117                     | 1615                        | # 0.07                 | 0.11                    | 179                               | 0.65         |
| Westbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Northbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru T        | 1227                    | 3610                        | 0.34                   | 0.73                    | 2641                              | 0.46         |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Southbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          | 134                     | 1805                        | 0.07                   | 0.074                   | 134                               | 1.00         |
|               | Perm          | 114                     | 348                         | 0.33                   | 0.759                   | 264                               | 0.43         |
|               | Left L        | 248                     |                             |                        | 0.83                    | 398                               | 0.62         |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru T        | 1809                    | 3610                        | # 0.50                 | 0.83                    | 3008                              | 0.60         |
|               | Right         |                         |                             |                        |                         |                                   |              |

---

Sum of flow ratios for critical lane groups,  $Y_c = \text{Sum (v/s)} = 0.57$   
Total lost time per cycle,  $L = 6.00$  sec  
Critical flow rate to capacity ratio,  $X_c = (Y_c) (C) / (C-L) = 0.61$

Control Delay and LOS Determination

| Appr/<br>Lane | Ratios | Unf<br>Del | Prog<br>Adj | Lane<br>Grp | Incremental<br>Factor | Res<br>Del | Lane Group | Approach |
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|

| Grp  | v/c  | g/C  | d1   | Fact  | Cap  | k    | d2   | d3  | Delay | LOS | Delay | LOS |
|--|------|------|------|-------|------|------|------|-----|-------|-----|-------|-----|
| Eastbound  |      |      |      |       |      |      |      |     |       |     |       |     |
| L  | 0.51 | 0.11 | 45.2 | 1.000 | 201  | 0.50 | 8.9  | 0.0 | 54.1  | D   |       |     |
| R  | 0.65 | 0.11 | 46.0 | 1.000 | 179  | 0.50 | 17.1 | 0.0 | 63.1  | E   | 58.9  | E   |
| Westbound  |      |      |      |       |      |      |      |     |       |     |       |     |
| Northbound   |      |      |      |       |      |      |      |     |       |     |       |     |
| T  | 0.46 | 0.73 | 5.9  | 1.000 | 2641 | 0.50 | 0.6  | 0.0 | 6.5   | A   | 6.5   | A   |
| Southbound   |      |      |      |       |      |      |      |     |       |     |       |     |
| L  | 0.62 | 0.83 | 4.6  | 1.000 | 398  | 0.50 | 7.2  | 0.0 | 11.8  | B   |       |     |
| T  | 0.60 | 0.83 | 3.0  | 1.000 | 3008 | 0.50 | 0.9  | 0.0 | 3.9   | A   | 4.9   | A   |
| Intersection delay = 8.8 (sec/veh)      Intersection LOS = A |      |      |      |       |      |      |      |     |       |     |       |     |

SUPPLEMENTAL PERMITTED LT WORKSHEET

for exclusive lefts

Input

|  | EB | WB | NB   | SB        |
|--|----|----|------|-----------|
| Cycle length, C  |    |    |      | 108.0 sec |
| Total actual green time for LT lane group, G (s)                             |    |    |      | 90.0      |
| Effective permitted green time for LT lane group, g(s)                       |    |    |      | 82.0      |
| Opposing effective green time, go (s)  |    |    |      | 79.0      |
| Number of lanes in LT lane group, N  |    |    |      | 1         |
| Number of lanes in opposing approach, No                                     |    |    |      | 2         |
| Adjusted LT flow rate, VLT (veh/h)   |    |    |      | 248       |
| Proportion of LT in LT lane group, PLT                                       |    |    |      | 1.000     |
| Proportion of LT in opposing flow, PLTo                                      |    |    |      | 0.00      |
| Adjusted opposing flow rate, Vo (veh/h)                                      |    |    |      | 1227      |
| Lost time for LT lane group, tL  |    |    |      | 3.00      |
| Computation  |    |    |      |           |
| LT volume per cycle, LTC=VLTC/3600   |    |    |      | 7.44      |
| Opposing lane util. factor, fLUo   |    |    | 0.95 | 0.95      |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)                          |    |    |      | 19.37     |
| gf=G[exp(- a * (LTC ** b))]-tL, gf<=g  |    |    |      | 0.0       |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)                            |    |    |      | 1.00      |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]                                 |    |    |      | 0.27      |
| gq, (see Exhibit C16-4,5,6,7,8)  |    |    |      | 16.23     |
| gu=g-gq if gq>=gf, or = g-gf if gq<gf  |    |    |      | 65.77     |
| n=Max(gq-gf)/2,0)  |    |    |      | 8.11      |
| PTHo=1-PLTo  |    |    |      | 1.00      |
| PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]   |    |    |      | 1.00      |
| EL1 (refer to Exhibit C16-3)   |    |    |      | 4.38      |
| EL2=Max((1-Ptho**n)/Plto, 1.0)   |    |    |      |           |
| fmin=2(1+PL)/g or fmin=2(1+Pl)/g   |    |    |      | 0.05      |
| gdiff=max(gq-gf,0)   |    |    |      | 0.00      |
| fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)                          |    |    |      | 0.18      |
| flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)], (fmin<=fm<=1.00) |    |    |      |           |
| or flt=[fm+0.91(N-1)]/N**  |    |    |      |           |

Left-turn adjustment, fLT

0.183

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET

for shared lefts

Input

|   | EB | WB | NB    | SB    |
|---|----|----|-------|-------|
| Cycle length, C   |    |    |       |       |
| Total actual green time for LT lane group, G (s)  |    |    |       |       |
| Effective permitted green time for LT lane group, g(s)  |    |    |       |       |
| Opposing effective green time, go (s)   |    |    |       |       |
| Number of lanes in LT lane group, N   |    |    |       |       |
| Number of lanes in opposing approach, No  |    |    |       |       |
| Adjusted LT flow rate, VLT (veh/h)  |    |    |       |       |
| Proportion of LT in LT lane group, PLT  |    |    | 0.000 | 0.000 |
| Proportion of LT in opposing flow, PLTo   |    |    |       |       |
| Adjusted opposing flow rate, Vo (veh/h)   |    |    |       |       |
| Lost time for LT lane group, tL   |    |    |       |       |
| Computation   |    |    |       |       |
| LT volume per cycle, LTC=VLTC/3600  |    |    |       |       |
| Opposing lane util. factor, fLUo  |    |    | 0.95  | 0.95  |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)   |    |    |       |       |
| $gf = G[\exp(-a * (LTC ** b))] - tL$ , $gf \leq g$  |    |    |       |       |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)   |    |    |       |       |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]  |    |    |       |       |
| gq, (see Exhibit C16-4,5,6,7,8)   |    |    |       |       |
| $gu = g - gq$ if $gq \geq gf$ , or $= g - gf$ if $gq < gf$  |    |    |       |       |
| $n = \text{Max}(gq - gf) / 2, 0$  |    |    |       |       |
| $PTHo = 1 - PLTo$   |    |    |       |       |
| $PL* = PLT[1 + (N-1)g / (gf + gu / EL1 + 4.24)]$  |    |    |       |       |
| EL1 (refer to Exhibit C16-3)  |    |    |       |       |
| $EL2 = \text{Max}((1 - Ptho ** n) / Plto, 1.0)$   |    |    |       |       |
| $fmin = 2(1 + PL) / g$ or $fmin = 2(1 + Pl) / g$  |    |    |       |       |
| $gdiff = \text{max}(gq - gf, 0)$  |    |    |       |       |
| $fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)]$ , (min=fmin;max=1.00)                                    |    |    |       |       |
| $flt = fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)] + [gdiff/g] / [1 + PL(EL2 - 1)]$ , (fmin<=fm<=1.00) |    |    |       |       |
| or $flt = [fm + 0.91(N-1)] / N **$  |    |    |       |       |
| Left-turn adjustment, fLT   |    |    |       |       |

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns

| EB | WB | NB | SB |
|----|----|----|----|
|----|----|----|----|

Effective pedestrian green time, gp (s)  
 Conflicting pedestrian volume, Vped (p/h)  
 Pedestrian flow rate, Vpedg (p/h)  
 OCCpedg  
 Opposing queue clearing green, gq (s)  
 Eff. ped. green consumed by opp. veh. queue, gq/gp  
 OCCpedu  
 Opposing flow rate, Vo (veh/h)  
 OCCr  
 Number of cross-street receiving lanes, Nrec  
 Number of turning lanes, Nturn  
 ApbT  
 Proportion of left turns, PLT  
 Proportion of left turns using protected phase, PLTA  
 Left-turn adjustment, fLpb  
 Permitted Right Turns  
 Effective pedestrian green time, gp (s)  
 Conflicting pedestrian volume, Vped (p/h)  
 Conflicting bicycle volume, Vbic (bicycles/h)  
 Vpedg  
 OCCpedg  
 Effective green, g (s)  
 Vbicg  
 OCCbicg  
 OCCr  
 Number of cross-street receiving lanes, Nrec  
 Number of turning lanes, Nturn  
 ApbT  
 Proportion right-turns, PRT  
 Proportion right-turns using protected phase, PRTA  
 Right turn adjustment, fRpb

SUPPLEMENTAL UNIFORM DELAY WORKSHEET

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|   |       | EBLT | WBLT | NBLT | SBLT  |
|---|-------|------|------|------|-------|
| Cycle length, C                                     | 108.0 |      |      |      |       |
| Adj. LT vol from Vol Adjustment Worksheet, v        |       |      |      |      | 248   |
| v/c ratio from Capacity Worksheet, X                |       |      |      |      | 0.62  |
| Protected phase effective green interval, g (s)     |       |      |      |      | 8.0   |
| Opposing queue effective green interval, gq         |       |      |      |      | 16.23 |
| Unopposed green interval, gu                        |       |      |      |      | 65.77 |
| Red time r=(C-g-gq-gu)                              |       |      |      |      | 18.0  |
| Arrival rate, qa=v/(3600(max[X,1.0]))               |       |      |      |      | 0.07  |
| Protected ph. departure rate, Sp=s/3600             |       |      |      |      | 0.501 |
| Permitted ph. departure rate, Ss=s(gq+gu)/(gu*3600) |       |      |      |      | 0.12  |
| XPerm   |       |      |      |      | 0.71  |
| XProt   |       |      |      |      | 0.45  |
| Case  |       |      |      |      | 1     |
| Queue at beginning of green arrow, Qa               |       |      |      |      | 1.24  |
| Queue at beginning of unsaturated green, Qu         |       |      |      |      | 1.12  |
| Residual queue, Qr                                  |       |      |      |      | 0.00  |
| Uniform Delay, dl                                   |       |      |      |      | 4.6   |

DELAY/LOS WORKSHEET WITH INITIAL QUEUE

---

|       | Initial Dur. | Uniform Delay | Initial Queue | Final Queue | Initial Lane | Lane Group |
|-------|--------------|---------------|---------------|-------------|--------------|------------|
| Appr/ | Unmet        | Unmet         | Unmet         | Unmet       | Unmet        |            |

| Lane Group | Demand Q veh | Demand t hrs. | Unadj. ds | Adj. dl sec | Param. u | Demand Q veh | Delay d3 sec | Delay d sec |
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|

Eastbound

Westbound

Northbound

Southbound

---

Intersection Delay 8.8 sec/veh      Intersection LOS A

BACK OF QUEUE WORKSHEET

|                         | Eastbound |       |   | Westbound |   |   | Northbound |   |      | Southbound |   |  |
|-------------------------|-----------|-------|---|-----------|---|---|------------|---|------|------------|---|--|
| LaneGroup               | L         | R     |   |           |   |   | T          |   | L    | T          |   |  |
| Init Queue              | 0.0       | 0.0   |   |           |   |   | 0.0        |   | 0.0  | 0.0        |   |  |
| Flow Rate               | 102       | 117   |   |           |   |   | 613        |   | 248  | 904        |   |  |
| So                      | 1900      | 1900  |   |           |   |   | 1900       |   | 1900 | 1900       |   |  |
| No.Lanes                | 1         | 0     | 1 | 0         | 0 | 0 | 2          | 0 | 1    | 2          | 0 |  |
| SL                      | 1805      | 1615  |   |           |   |   | 1805       |   | 1805 | 1805       |   |  |
| LnCapacity              | 201       | 179   |   |           |   |   | 1320       |   | 398  | 1504       |   |  |
| Flow Ratio              | 0.06      | 0.07  |   |           |   |   | 0.34       |   | 0.14 | 0.50       |   |  |
| v/c Ratio               | 0.51      | 0.65  |   |           |   |   | 0.46       |   | 0.62 | 0.60       |   |  |
| Grn Ratio               | 0.11      | 0.11  |   |           |   |   | 0.73       |   | 0.83 | 0.83       |   |  |
| I Factor                |           | 1.000 |   |           |   |   | 1.000      |   |      | 1.000      |   |  |
| AT or PVG               | 3         | 3     |   |           |   |   | 3          |   | 3    | 3          |   |  |
| Pltn Ratio              | 1.00      | 1.00  |   |           |   |   | 1.00       |   | 1.00 | 1.00       |   |  |
| PF2                     | 1.00      | 1.00  |   |           |   |   | 1.00       |   | 1.00 | 1.00       |   |  |
| Q1                      | 2.9       | 3.4   |   |           |   |   | 7.5        |   | 1.3  | 9.1        |   |  |
| kB                      | 0.4       | 0.4   |   |           |   |   | 1.6        |   | 1.7  | 1.7        |   |  |
| Q2                      | 0.4       | 0.7   |   |           |   |   | 1.3        |   | 2.5  | 2.5        |   |  |
| Q Average               | 3.3       | 4.0   |   |           |   |   | 8.8        |   | 3.8  | 11.6       |   |  |
| Q Spacing               | 24.9      | 24.9  |   |           |   |   | 24.9       |   | 24.9 | 24.9       |   |  |
| Q Storage               | 0         | 0     |   |           |   |   | 0          |   | 0    | 0          |   |  |
| Q S Ratio               |           |       |   |           |   |   |            |   |      |            |   |  |
| 70th Percentile Output: |           |       |   |           |   |   |            |   |      |            |   |  |
| fB%                     | 1.3       | 1.2   |   |           |   |   | 1.2        |   | 1.2  | 1.2        |   |  |
| BOQ                     | 4.1       | 5.0   |   |           |   |   | 10.7       |   | 4.8  | 14.0       |   |  |
| QSRatio                 |           |       |   |           |   |   |            |   |      |            |   |  |
| 85th Percentile Output: |           |       |   |           |   |   |            |   |      |            |   |  |
| fB%                     | 1.6       | 1.5   |   |           |   |   | 1.5        |   | 1.5  | 1.4        |   |  |
| BOQ                     | 5.1       | 6.2   |   |           |   |   | 12.8       |   | 5.9  | 16.5       |   |  |

|                         |     |     |  |  |      |          |
|-------------------------|-----|-----|--|--|------|----------|
| QSRatio                 |     |     |  |  |      |          |
| 90th Percentile Output: |     |     |  |  |      |          |
| fB%                     | 1.8 | 1.7 |  |  | 1.6  | 1.7 1.5  |
| BOQ                     | 5.8 | 7.0 |  |  | 14.0 | 6.6 17.9 |
| QSRatio                 |     |     |  |  |      |          |
| 95th Percentile Output: |     |     |  |  |      |          |
| fB%                     | 2.1 | 2.0 |  |  | 1.8  | 2.1 1.7  |
| BOQ                     | 7.0 | 8.3 |  |  | 15.6 | 7.9 19.7 |
| QSRatio                 |     |     |  |  |      |          |
| 98th Percentile Output: |     |     |  |  |      |          |
| fB%                     | 2.5 | 2.4 |  |  | 2.0  | 2.4 1.8  |
| BOQ                     | 8.2 | 9.6 |  |  | 17.3 | 9.2 21.4 |
| QSRatio                 |     |     |  |  |      |          |

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ERROR MESSAGES

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No errors to report.

HCS2000: Signalized Intersections Release 4.1b

Analyst: Jonathan Storey Inter.: I-24 at U.S. 72  
 Agency: Florence & Hutcheson Area Type: All other areas  
 Date: 6/6/2002 Jurisd: Marion Co.  
 Period: 2027 PM Year : 2002  
 Project ID: Interchange Modification Study  
 E/W St: I-24 Ramps 3 & 4 N/S St: U.S. 72

SIGNALIZED INTERSECTION SUMMARY

|            | Eastbound |   |      | Westbound |   |   | Northbound |      |   | Southbound |      |   |
|------------|-----------|---|------|-----------|---|---|------------|------|---|------------|------|---|
|            | L         | T | R    | L         | T | R | L          | T    | R | L          | T    | R |
| No. Lanes  | 1         | 0 | 1    | 0         | 0 | 0 | 0          | 2    | 0 | 1          | 2    | 0 |
| LGConfig   | L         |   | R    |           |   |   |            | T    |   | L          | T    |   |
| Volume     | 105       |   | 97   |           |   |   |            | 1473 |   | 293        | 2144 |   |
| Lane Width | 12.0      |   | 12.0 |           |   |   |            | 12.0 |   | 12.0       | 12.0 |   |
| RTOR Vol   |           |   | 24   |           |   |   |            |      |   |            |      |   |

| Duration                 | 0.25 | Area Type: All other areas |     |     |          |      |     |     |  |  |  |
|--------------------------|------|----------------------------|-----|-----|----------|------|-----|-----|--|--|--|
| Signal Operations        |      |                            |     |     |          |      |     |     |  |  |  |
| Phase Combination        | 1    | 2                          | 3   | 4   | 5        | 6    | 7   | 8   |  |  |  |
| EB Left                  |      | P                          |     |     | NB Left  |      |     |     |  |  |  |
| Thru                     |      |                            |     |     | Thru     |      | P   |     |  |  |  |
| Right                    |      | P                          |     |     | Right    |      |     |     |  |  |  |
| Peds                     |      |                            |     |     | Peds     |      |     |     |  |  |  |
| WB Left                  |      |                            |     |     | SB Left  | P    | P   |     |  |  |  |
| Thru                     |      |                            |     |     | Thru     | P    | P   |     |  |  |  |
| Right                    |      |                            |     |     | Right    |      |     |     |  |  |  |
| Peds                     |      |                            |     |     | Peds     |      |     |     |  |  |  |
| NB Right                 |      |                            |     |     | EB Right |      |     |     |  |  |  |
| SB Right                 |      |                            |     |     | WB Right |      |     |     |  |  |  |
| Green                    | 12.0 | 0.0                        | 0.0 | 0.0 | 16.0     | 88.0 | 0.0 | 0.0 |  |  |  |
| Yellow                   | 3.0  | 0.0                        | 0.0 |     | 3.0      | 3.0  | 0.0 |     |  |  |  |
| All Red                  | 0.0  | 0.0                        | 0.0 |     | 0.0      | 0.0  | 0.0 |     |  |  |  |
| Cycle Length: 125.0 secs |      |                            |     |     |          |      |     |     |  |  |  |

Intersection Performance Summary

| Appr/<br>Lane<br>Grp | Lane<br>Group<br>Capacity | Adj Sat<br>Flow Rate<br>(s) | Ratios |      | Lane Group |     | Approach |     |
|----------------------|---------------------------|-----------------------------|--------|------|------------|-----|----------|-----|
|                      |                           |                             | v/c    | g/C  | Delay      | LOS | Delay    | LOS |
| Eastbound            |                           |                             |        |      |            |     |          |     |
| L                    | 173                       | 1805                        | 0.68   | 0.10 | 73.8       | E   | 70.5     | E   |
| R                    | 155                       | 1615                        | 0.52   | 0.10 | 65.8       | E   |          |     |
| Westbound            |                           |                             |        |      |            |     |          |     |
| Northbound           |                           |                             |        |      |            |     |          |     |
| T                    | 2541                      | 3610                        | 0.64   | 0.70 | 11.3       | B   | 11.3     | B   |
| Southbound           |                           |                             |        |      |            |     |          |     |
| L                    | 362                       | 1805                        | 0.90   | 0.86 | 59.7       | E   |          |     |
| T                    | 3090                      | 3610                        | 0.77   | 0.86 | 5.7        | A   | 12.2     | B   |

Intersection Delay = 14.4 (sec/veh) Intersection LOS = B

HCS2000: Signalized Intersections Release 4.1b

Jonathan H. Storey  
 Florence & Hutcheson  
 Florence & Hutcheson  
 1217 Murfreesboro Rd. #320  
 Nashville, TN 37217  
 Phone: (615) 399-9090  
 E-Mail: jstorey@flohut.com

Fax: (615) 399-9049

OPERATIONAL ANALYSIS

Analyst: Jonathan Storey  
 Agency/Co.: Florence & Hutcheson  
 Date Performed: 6/6/2002  
 Analysis Time Period: 2027 PM  
 Intersection: I-24 at U.S. 72  
 Area Type: All other areas  
 Jurisdiction: Marion Co.  
 Analysis Year: 2002  
 Project ID: Interchange Modification Study

East/West Street North/South Street  
 I-24 Ramps 3 & 4 U.S. 72

VOLUME DATA

|              | Eastbound |   |      | Westbound                  |   |   | Northbound |   |   | Southbound |       |   |
|--------------|-----------|---|------|----------------------------|---|---|------------|---|---|------------|-------|---|
|              | L         | T | R    | L                          | T | R | L          | T | R | L          | T     | R |
| Volume       | 105       |   | 97   |                            |   |   | 1473       |   |   | 293        | 2144  |   |
| % Heavy Veh  | 0         |   | 0    |                            |   |   | 0          |   |   | 0          | 0     |   |
| PHF          | 0.90      |   | 0.90 |                            |   |   | 0.90       |   |   | 0.90       | 0.90  |   |
| PK 15 Vol    | 29        |   | 27   |                            |   |   | 409        |   |   | 81         | 596   |   |
| Hi Ln Vol    |           |   |      |                            |   |   |            |   |   |            |       |   |
| % Grade      |           | 0 |      |                            |   |   | 0          |   |   |            | 0     |   |
| Ideal Sat    | 1900      |   | 1900 |                            |   |   | 1900       |   |   | 1900       | 1900  |   |
| ParkExist    |           |   |      |                            |   |   |            |   |   |            |       |   |
| NumPark      |           |   |      |                            |   |   |            |   |   |            |       |   |
| No. Lanes    | 1         | 0 | 1    | 0                          | 0 | 0 | 0          | 2 | 0 | 1          | 2     | 0 |
| LGConfig     | L         |   | R    |                            |   |   |            | T |   | L          | T     |   |
| Lane Width   | 12.0      |   | 12.0 |                            |   |   | 12.0       |   |   | 12.0       | 12.0  |   |
| RTOR Vol     |           |   | 24   |                            |   |   |            |   |   |            |       |   |
| Adj Flow     | 117       |   | 81   |                            |   |   | 1637       |   |   | 326        | 2382  |   |
| %InSharedLn  |           |   |      |                            |   |   |            |   |   |            |       |   |
| Prop LTs     |           |   |      |                            |   |   | 0.000      |   |   | 1.000      | 0.000 |   |
| Prop RTs     |           |   |      |                            |   |   | 0.000      |   |   | 0.000      |       |   |
| Peds Bikes   | 0         |   |      | 0                          |   |   | 0          |   |   |            |       |   |
| Buses        | 0         |   | 0    |                            |   |   | 0          |   |   | 0          | 0     |   |
| %InProtPhase |           |   |      |                            |   |   |            |   |   | 0.0        |       |   |
| Duration     | 0.25      |   |      | Area Type: All other areas |   |   |            |   |   |            |       |   |

OPERATING PARAMETERS

|  | Eastbound |   |   | Westbound |   |   | Northbound |   |   | Southbound |   |   |
|--|-----------|---|---|-----------|---|---|------------|---|---|------------|---|---|
|  | L         | T | R | L         | T | R | L          | T | R | L          | T | R |

|             |     |       |  |     |       |     |       |
|-------------|-----|-------|--|-----|-------|-----|-------|
| Init Unmet  | 0.0 | 0.0   |  |     | 0.0   | 0.0 | 0.0   |
| Arriv. Type | 3   | 3     |  |     | 3     | 3   | 3     |
| Unit Ext.   | 3.0 | 3.0   |  |     | 3.0   | 3.0 | 3.0   |
| I Factor    |     | 1.000 |  |     | 1.000 |     | 1.000 |
| Lost Time   | 2.0 | 2.0   |  |     | 2.0   | 2.0 | 2.0   |
| Ext of g    | 2.0 | 2.0   |  |     | 2.0   | 2.0 | 2.0   |
| Ped Min g   |     | 3.2   |  | 3.2 |       | 3.2 |       |

PHASE DATA

| Phase Combination | 1    | 2   | 3   | 4   | 5        | 6    | 7   | 8   |
|-------------------|------|-----|-----|-----|----------|------|-----|-----|
| EB Left           | P    |     |     |     | NB Left  |      |     |     |
| Thru              |      |     |     |     | Thru     | P    |     |     |
| Right             | P    |     |     |     | Right    |      |     |     |
| Peds              |      |     |     |     | Peds     |      |     |     |
| WB Left           |      |     |     |     | SB Left  | P    | P   |     |
| Thru              |      |     |     |     | Thru     | P    | P   |     |
| Right             |      |     |     |     | Right    |      |     |     |
| Peds              |      |     |     |     | Peds     |      |     |     |
| NB Right          |      |     |     |     | EB Right |      |     |     |
| SB Right          |      |     |     |     | WB Right |      |     |     |
| Green             | 12.0 | 0.0 | 0.0 | 0.0 | 16.0     | 88.0 | 0.0 | 0.0 |
| Yellow            | 3.0  | 0.0 | 0.0 |     | 3.0      | 3.0  | 0.0 |     |
| All Red           | 0.0  | 0.0 | 0.0 |     | 0.0      | 0.0  | 0.0 |     |

Cycle Length: 125.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

| Volume Adjustment | Eastbound |   |      | Westbound |   |   | Northbound |   |   | Southbound |       |   |
|-------------------|-----------|---|------|-----------|---|---|------------|---|---|------------|-------|---|
|                   | L         | T | R    | L         | T | R | L          | T | R | L          | T     | R |
| Volume, V         | 105       |   | 97   |           |   |   | 1473       |   |   | 293        | 2144  |   |
| PHF               | 0.90      |   | 0.90 |           |   |   | 0.90       |   |   | 0.90       | 0.90  |   |
| Adj flow          | 117       |   | 81   |           |   |   | 1637       |   |   | 326        | 2382  |   |
| No. Lanes         | 1         | 0 | 1    | 0         | 0 | 0 | 0          | 2 | 0 | 1          | 2     | 0 |
| Lane group        | L         |   | R    |           |   |   | T          |   |   | L          | T     |   |
| Adj flow          | 117       |   | 81   |           |   |   | 1637       |   |   | 326        | 2382  |   |
| Prop LTs          |           |   |      |           |   |   | 0.000      |   |   | 1.000      | 0.000 |   |
| Prop RTs          |           |   |      |           |   |   | 0.000      |   |   | 0.000      |       |   |

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

| LG    | Eastbound |   |       | Westbound |   |   | Northbound |   |  | Southbound |       |   |
|-------|-----------|---|-------|-----------|---|---|------------|---|--|------------|-------|---|
|       | L         |   | R     | L         | T | R | T          |   |  | L          | T     |   |
| So    | 1900      |   | 1900  |           |   |   | 1900       |   |  | 1900       | 1900  |   |
| Lanes | 1         | 0 | 1     | 0         | 0 | 0 | 2          | 0 |  | 1          | 2     | 0 |
| fW    | 1.000     |   | 1.000 |           |   |   | 1.000      |   |  | 1.000      | 1.000 |   |
| fHV   | 1.000     |   | 1.000 |           |   |   | 1.000      |   |  | 1.000      | 1.000 |   |
| fG    | 1.000     |   | 1.000 |           |   |   | 1.000      |   |  | 1.000      | 1.000 |   |
| fP    | 1.000     |   | 1.000 |           |   |   | 1.000      |   |  | 1.000      | 1.000 |   |

|      |       |       |       |       |       |       |
|------|-------|-------|-------|-------|-------|-------|
| fBB  | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| fA   | 1.00  | 1.00  | 1.00  | 1.00  | 1.00  | 1.00  |
| fLU  | 1.00  | 1.00  | 0.95  | 1.00  | 0.95  |       |
| fRT  |       | 0.850 | 1.000 |       | 1.000 |       |
| fLT  | 0.950 |       | 1.000 | 0.950 | 1.000 |       |
| Sec. |       |       |       |       | 0.095 |       |
| fLpb | 1.000 |       | 1.000 | 1.000 | 1.000 | 1.000 |
| fRpb |       | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| S    | 1805  | 1615  | 3610  | 1805  | 3610  |       |
| Sec. |       |       |       | 180   |       |       |

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

| Appr/<br>Mvmt | Lane<br>Group | Adj<br>Flow Rate<br>(v) | Adj Sat<br>Flow Rate<br>(s) | Flow<br>Ratio<br>(v/s) | Green<br>Ratio<br>(g/C) | --Lane Group--<br>Capacity<br>(c) | v/c<br>Ratio |
|---------------|---------------|-------------------------|-----------------------------|------------------------|-------------------------|-----------------------------------|--------------|
| Eastbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left L        | 117                     | 1805                        | # 0.06                 | 0.10                    | 173                               | 0.68         |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right R       | 81                      | 1615                        | 0.05                   | 0.10                    | 155                               | 0.52         |
| Westbound     |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru          |                         |                             |                        |                         |                                   |              |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Northbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Left          |                         |                             |                        |                         |                                   |              |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru T        | 1637                    | 3610                        | 0.45                   | 0.70                    | 2541                              | 0.64         |
|               | Right         |                         |                             |                        |                         |                                   |              |
| Southbound    |               |                         |                             |                        |                         |                                   |              |
|               | Prot          | 231                     | 1805                        | 0.13                   | 0.128                   | 231                               | 1.00         |
|               | Perm          | 95                      | 180                         | 0.53                   | 0.728                   | 131                               | 0.73         |
|               | Left L        | 326                     |                             |                        | 0.86                    | 362                               | 0.90         |
|               | Prot          |                         |                             |                        |                         |                                   |              |
|               | Perm          |                         |                             |                        |                         |                                   |              |
|               | Thru T        | 2382                    | 3610                        | # 0.66                 | 0.86                    | 3090                              | 0.77         |
|               | Right         |                         |                             |                        |                         |                                   |              |

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Sum of flow ratios for critical lane groups,  $Y_c = \text{Sum (v/s)} = 0.72$   
Total lost time per cycle,  $L = 6.00 \text{ sec}$   
Critical flow rate to capacity ratio,  $X_c = (Y_c) (C) / (C-L) = 0.76$

Control Delay and LOS Determination

| Appr/<br>Lane | Ratios | Unf<br>Del | Prog<br>Adj | Lane<br>Grp | Incremental<br>Factor | Res<br>Del | Lane Group | Approach |
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|
|---------------|--------|------------|-------------|-------------|-----------------------|------------|------------|----------|

| Grp   | v/c  | g/C  | d1   | Fact  | Cap  | k    | d2   | d3  | Delay | LOS | Delay | LOS |
|---|------|------|------|-------|------|------|------|-----|-------|-----|-------|-----|
| Eastbound   |      |      |      |       |      |      |      |     |       |     |       |     |
| L   | 0.68 | 0.10 | 54.6 | 1.000 | 173  | 0.50 | 19.2 | 0.0 | 73.8  | E   |       |     |
| R   | 0.52 | 0.10 | 53.8 | 1.000 | 155  | 0.50 | 12.0 | 0.0 | 65.8  | E   | 70.5  | E   |
| Westbound   |      |      |      |       |      |      |      |     |       |     |       |     |
| Northbound  |      |      |      |       |      |      |      |     |       |     |       |     |
| T   | 0.64 | 0.70 | 10.0 | 1.000 | 2541 | 0.50 | 1.3  | 0.0 | 11.3  | B   | 11.3  | B   |
| Southbound  |      |      |      |       |      |      |      |     |       |     |       |     |
| L   | 0.90 | 0.86 | 31.9 | 1.000 | 362  | 0.50 | 27.8 | 0.0 | 59.7  | E   |       |     |
| T   | 0.77 | 0.86 | 3.8  | 1.000 | 3090 | 0.50 | 1.9  | 0.0 | 5.7   | A   | 12.2  | B   |
| <hr/> Intersection delay = 14.4 (sec/veh)      Intersection LOS = B |      |      |      |       |      |      |      |     |       |     |       |     |

SUPPLEMENTAL PERMITTED LT WORKSHEET

for exclusive lefts

| Input  | EB | WB | NB   | SB    |
|--|----|----|------|-------|
| Cycle length, C  |    |    |      |       |
| Total actual green time for LT lane group, G (s)                             |    |    |      | 107.0 |
| Effective permitted green time for LT lane group, g(s)                       |    |    |      | 91.0  |
| Opposing effective green time, go (s)  |    |    |      | 88.0  |
| Number of lanes in LT lane group, N  |    |    |      | 1     |
| Number of lanes in opposing approach, No                                     |    |    |      | 2     |
| Adjusted LT flow rate, VLT (veh/h)   |    |    |      | 326   |
| Proportion of LT in LT lane group, PLT                                       |    |    |      | 1.000 |
| Proportion of LT in opposing flow, PLTo                                      |    |    |      | 0.00  |
| Adjusted opposing flow rate, Vo (veh/h)                                      |    |    |      | 1637  |
| Lost time for LT lane group, tL  |    |    |      | 3.00  |
| Computation  |    |    |      |       |
| LT volume per cycle, LTC=VLTC/3600   |    |    |      | 11.32 |
| Opposing lane util. factor, fLUo   |    |    | 0.95 | 0.95  |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)                          |    |    |      | 29.92 |
| gf=G[exp(- a * (LTC ** b))]-tL, gf<=g  |    |    |      | 0.0   |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)                            |    |    |      | 1.00  |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]                                 |    |    |      | 0.30  |
| gq, (see Exhibit C16-4,5,6,7,8)  |    |    |      | 33.97 |
| gu=g-gq if gq>=gf, or = g-gf if gq<gf  |    |    |      | 57.03 |
| n=Max(gq-gf)/2,0)  |    |    |      | 16.99 |
| PTHo=1-PLTo  |    |    |      | 1.00  |
| PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]   |    |    |      | 1.00  |
| EL1 (refer to Exhibit C16-3)   |    |    |      | 6.63  |
| EL2=Max((1-Ptho**n)/Plto, 1.0)   |    |    |      |       |
| fmin=2(1+PL)/g or fmin=2(1+Pl)/g   |    |    |      | 0.04  |
| gdiff=max(gq-gf,0)   |    |    |      | 0.00  |
| fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)                          |    |    |      | 0.09  |
| flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)], (fmin<=fm<=1.00) |    |    |      |       |
| or flt=[fm+0.91(N-1)]/N**  |    |    |      |       |

Left-turn adjustment, fLT

0.095

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET

for shared lefts

Input

|   | EB | WB | NB    | SB    |
|---|----|----|-------|-------|
| Cycle length, C   |    |    |       |       |
| Total actual green time for LT lane group, G (s)  |    |    |       |       |
| Effective permitted green time for LT lane group, g(s)  |    |    |       |       |
| Opposing effective green time, go (s)   |    |    |       |       |
| Number of lanes in LT lane group, N   |    |    |       |       |
| Number of lanes in opposing approach, No  |    |    |       |       |
| Adjusted LT flow rate, VLT (veh/h)  |    |    |       |       |
| Proportion of LT in LT lane group, PLT  |    |    | 0.000 | 0.000 |
| Proportion of LT in opposing flow, PLTo   |    |    |       |       |
| Adjusted opposing flow rate, Vo (veh/h)   |    |    |       |       |
| Lost time for LT lane group, tL   |    |    |       |       |
| Computation   |    |    |       |       |
| LT volume per cycle, LTC=VLTC/3600  |    |    |       |       |
| Opposing lane util. factor, fLUo  |    |    | 0.95  | 0.95  |
| Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)   |    |    |       |       |
| $gf = G[\exp(-a * (LTC ** b))] - tL$ , $gf \leq g$  |    |    |       |       |
| Opposing platoon ratio, Rpo (refer Exhibit 16-11)   |    |    |       |       |
| Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]  |    |    |       |       |
| gq, (see Exhibit C16-4,5,6,7,8)   |    |    |       |       |
| $gu = g - gq$ if $gq \geq gf$ , or $= g - gf$ if $gq < gf$  |    |    |       |       |
| $n = \text{Max}(gq - gf) / 2, 0$  |    |    |       |       |
| $PTHo = 1 - PLTo$   |    |    |       |       |
| $PL* = PLT[1 + (N-1)g / (gf + gu / EL1 + 4.24)]$  |    |    |       |       |
| EL1 (refer to Exhibit C16-3)  |    |    |       |       |
| $EL2 = \text{Max}((1 - Ptho ** n) / Plto, 1.0)$   |    |    |       |       |
| $fmin = 2(1 + PL) / g$ or $fmin = 2(1 + Pl) / g$  |    |    |       |       |
| $gdiff = \text{max}(gq - gf, 0)$  |    |    |       |       |
| $fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)]$ , (min=fmin;max=1.00)                                    |    |    |       |       |
| $flt = fm = [gf/g] + [gu/g] / [1 + PL(EL1 - 1)] + [gdiff/g] / [1 + PL(EL2 - 1)]$ , (fmin<=fm<=1.00) |    |    |       |       |
| or $flt = [fm + 0.91(N-1)] / N **$  |    |    |       |       |
| Left-turn adjustment, fLT   |    |    |       |       |

For special case of single-lane approach opposed by multilane approach, see text.

\* If  $PL \geq 1$  for shared left-turn lanes with  $N > 1$ , then assume de-facto left-turn lane and redo calculations.

\*\* For permitted left-turns with multiple exclusive left-turn lanes,  $flt = fm$ . For special case of multilane approach opposed by single-lane approach or when  $gf > gq$ , see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns

| EB | WB | NB | SB |
|----|----|----|----|
|----|----|----|----|

Effective pedestrian green time,  $g_p$  (s)  
 Conflicting pedestrian volume,  $V_{ped}$  (p/h)  
 Pedestrian flow rate,  $V_{pedg}$  (p/h)  
 $OCC_{pedg}$   
 Opposing queue clearing green,  $g_q$  (s)  
 Eff. ped. green consumed by opp. veh. queue,  $g_q/g_p$   
 $OCC_{pedu}$   
 Opposing flow rate,  $V_o$  (veh/h)  
 $OCC_r$   
 Number of cross-street receiving lanes,  $N_{rec}$   
 Number of turning lanes,  $N_{turn}$   
 $ApbT$   
 Proportion of left turns,  $PLT$   
 Proportion of left turns using protected phase,  $PLTA$   
 Left-turn adjustment,  $f_{Lpb}$   
 Permitted Right Turns  
 Effective pedestrian green time,  $g_p$  (s)  
 Conflicting pedestrian volume,  $V_{ped}$  (p/h)  
 Conflicting bicycle volume,  $V_{bic}$  (bicycles/h)  
 $V_{pedg}$   
 $OCC_{pedg}$   
 Effective green,  $g$  (s)  
 $V_{bicg}$   
 $OCC_{bicg}$   
 $OCC_r$   
 Number of cross-street receiving lanes,  $N_{rec}$   
 Number of turning lanes,  $N_{turn}$   
 $ApbT$   
 Proportion right-turns,  $PRT$   
 Proportion right-turns using protected phase,  $PRTA$   
 Right turn adjustment,  $f_{Rpb}$

SUPPLEMENTAL UNIFORM DELAY WORKSHEET

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|   |       | EBLT | WBLT | NBLT | SBLT  |
|---|-------|------|------|------|-------|
| Cycle length, $C$   | 125.0 |      |      |      |       |
| Adj. LT vol from Vol Adjustment Worksheet, $v$            |       |      |      |      | 326   |
| $v/c$ ratio from Capacity Worksheet, $X$                  |       |      |      |      | 0.90  |
| Protected phase effective green interval, $g$ (s)         |       |      |      |      | 16.0  |
| Opposing queue effective green interval, $g_q$            |       |      |      |      | 33.97 |
| Unopposed green interval, $g_u$                           |       |      |      |      | 57.03 |
| Red time $r=(C-g-g_q-g_u)$                                |       |      |      |      | 18.0  |
| Arrival rate, $q_a=v/(3600(\max[X,1.0]))$                 |       |      |      |      | 0.09  |
| Protected ph. departure rate, $S_p=s/3600$                |       |      |      |      | 0.501 |
| Permitted ph. departure rate, $S_s=s(g_q+g_u)/(g_u*3600)$ |       |      |      |      | 0.08  |
| $X_{Perm}$  |       |      |      |      | 1.81  |
| $X_{Prot}$  |       |      |      |      | 0.38  |
| Case  |       |      |      |      | 3     |
| Queue at beginning of green arrow, $Q_a$                  |       |      |      |      | 5.32  |
| Queue at beginning of unsaturated green, $Q_u$            |       |      |      |      | 3.08  |
| Residual queue, $Q_r$                                     |       |      |      |      | 3.69  |
| Uniform Delay, $d_l$                                      |       |      |      |      | 31.9  |

DELAY/LOS WORKSHEET WITH INITIAL QUEUE

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|       | Initial Dur. | Uniform Delay | Initial Queue | Final Queue | Initial Lane | Lane Group |
|-------|--------------|---------------|---------------|-------------|--------------|------------|
| Appr/ | Unmet        | Unmet         | Unmet         | Unmet       | Unmet        | Unmet      |

| Lane Group | Demand Q veh | Demand t hrs. | Unadj. ds | Adj. dl sec | Param. u | Demand Q veh | Delay d3 sec | Delay d sec |
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|
|------------|--------------|---------------|-----------|-------------|----------|--------------|--------------|-------------|

Eastbound

Westbound

Northbound

Southbound

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Intersection Delay 14.4 sec/veh      Intersection LOS B

BACK OF QUEUE WORKSHEET

|                         | Eastbound |       |   | Westbound |   |   | Northbound |   |      | Southbound |   |  |
|-------------------------|-----------|-------|---|-----------|---|---|------------|---|------|------------|---|--|
| LaneGroup               | L         | R     |   |           |   |   | T          |   | L    | T          |   |  |
| Init Queue              | 0.0       | 0.0   |   |           |   |   | 0.0        |   | 0.0  | 0.0        |   |  |
| Flow Rate               | 117       | 81    |   |           |   |   | 818        |   | 326  | 1191       |   |  |
| So                      | 1900      | 1900  |   |           |   |   | 1900       |   | 1900 | 1900       |   |  |
| No.Lanes                | 1         | 0     | 1 | 0         | 0 | 0 | 2          | 0 | 1    | 2          | 0 |  |
| SL                      | 1805      | 1615  |   |           |   |   | 1805       |   | 1805 | 1805       |   |  |
| LnCapacity              | 173       | 155   |   |           |   |   | 1270       |   | 362  | 1545       |   |  |
| Flow Ratio              | 0.06      | 0.05  |   |           |   |   | 0.45       |   | 0.18 | 0.66       |   |  |
| v/c Ratio               | 0.68      | 0.52  |   |           |   |   | 0.64       |   | 0.90 | 0.77       |   |  |
| Grn Ratio               | 0.10      | 0.10  |   |           |   |   | 0.70       |   | 0.86 | 0.86       |   |  |
| I Factor                |           | 1.000 |   |           |   |   | 1.000      |   |      | 1.000      |   |  |
| AT or PVG               | 3         | 3     |   |           |   |   | 3          |   | 3    | 3          |   |  |
| Pltn Ratio              | 1.00      | 1.00  |   |           |   |   | 1.00       |   | 1.00 | 1.00       |   |  |
| PF2                     | 1.00      | 1.00  |   |           |   |   | 1.00       |   | 1.00 | 1.00       |   |  |
| Q1                      | 3.9       | 2.7   |   |           |   |   | 15.4       |   | 1.8  | 17.5       |   |  |
| kB                      | 0.4       | 0.4   |   |           |   |   | 1.7        |   | 1.9  | 1.9        |   |  |
| Q2                      | 0.8       | 0.4   |   |           |   |   | 2.9        |   | 6.9  | 5.8        |   |  |
| Q Average               | 4.7       | 3.1   |   |           |   |   | 18.3       |   | 8.8  | 23.3       |   |  |
| Q Spacing               | 24.9      | 24.9  |   |           |   |   | 24.9       |   | 24.9 | 24.9       |   |  |
| Q Storage               | 0         | 0     |   |           |   |   | 0          |   | 0    | 0          |   |  |
| Q S Ratio               |           |       |   |           |   |   |            |   |      |            |   |  |
| 70th Percentile Output: |           |       |   |           |   |   |            |   |      |            |   |  |
| fB%                     | 1.2       | 1.3   |   |           |   |   | 1.2        |   | 1.2  | 1.2        |   |  |
| BOQ                     | 5.8       | 3.9   |   |           |   |   | 22.0       |   | 10.7 | 28.0       |   |  |
| QSRatio                 |           |       |   |           |   |   |            |   |      |            |   |  |
| 85th Percentile Output: |           |       |   |           |   |   |            |   |      |            |   |  |
| fB%                     | 1.5       | 1.6   |   |           |   |   | 1.4        |   | 1.5  | 1.4        |   |  |
| BOQ                     | 7.2       | 4.8   |   |           |   |   | 25.8       |   | 12.8 | 32.7       |   |  |

|                         |      |     |  |  |      |           |
|-------------------------|------|-----|--|--|------|-----------|
| QSRatio                 |      |     |  |  |      |           |
| 90th Percentile Output: |      |     |  |  |      |           |
| fB%                     | 1.7  | 1.8 |  |  | 1.5  | 1.6 1.5   |
| BOQ                     | 8.0  | 5.5 |  |  | 27.7 | 13.9 35.1 |
| QSRatio                 |      |     |  |  |      |           |
| 95th Percentile Output: |      |     |  |  |      |           |
| fB%                     | 2.0  | 2.1 |  |  | 1.6  | 1.8 1.6   |
| BOQ                     | 9.4  | 6.6 |  |  | 29.8 | 15.6 37.5 |
| QSRatio                 |      |     |  |  |      |           |
| 98th Percentile Output: |      |     |  |  |      |           |
| fB%                     | 2.3  | 2.5 |  |  | 1.7  | 2.0 1.7   |
| BOQ                     | 10.8 | 7.7 |  |  | 31.8 | 17.2 40.0 |
| QSRatio                 |      |     |  |  |      |           |

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ERROR MESSAGES

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No errors to report.