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Sheyenne Street & Interstate 94 Interchange Simulation Analysis

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Prepared for:
Fargo-Moorhead Council of Governments
Fargo, ND

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BACKGROUND

This simulation analysis is one component of the 9th/57th Street Traffic Projections and Simulation Analysis project for the Fargo-Moorhead Council of Governments (F-M COG). The southwest portion of the metropolitan area has experienced significant population growth over the past several years. As a result, traffic congestion has also developed within the area, as well as along corridors accessing other portions of the metropolitan area. Sheyenne St. (County Highway 17) serves as the major north/south arterial for West Fargo having an average daily traffic (ADT) as high as 14,450 (NDDOT, 2007). Sheyenne St. is the only arterial providing direct access from the southwest portion of West Fargo to Interstate 94 (I-94) and the northern part of the city. The next closest alternative route is 45th St. in Fargo, which is two miles to the east. The Sheyenne St. and I-94 Interchange has been experiencing increased traffic congestion during the peak-hour periods, especially during the morning (AM) peak period.

Two problem areas exist at the Sheyenne St. Interchange. Currently, the southbound left-turn maneuver at the south ramp encounters significant delay during the AM peak period. The southbound left-turn movement and the northbound approach have high traffic volumes, which limits the available gaps for left-turn movement. To a lesser extent, the westbound loop ramp traffic experiences delay when trying to turn southbound onto Sheyenne St. during the afternoon (PM) peak period.

Another interchange along I-94 has been approved at 9th St./57th St., which is one mile east of Sheyenne St., and will be operational by 2009. Originally, this new interchange would only consist of an overpass; however, it will now include the overpass and interchange ramps. With the ramp inclusions, the traffic volume and resulting congestion at the Sheyenne St. interchanges could be significantly reduced at least in the short to medium term.

OBJECTIVES

The main objective of this study is to analyze the existing traffic conditions (2007) of the Sheyenne St. & I-94 Interchange, as well as the projected conditions of 2010. Both the AM and PM peak periods will be evaluated using the CORSIM traffic simulation model. The analysis area includes Sheyenne St. intersecting with 19th Ave., I-94 North Ramp, and I-94 South Ramp.

ANALYSIS SCENARIOS

This study will have three main groups of analysis scenarios. The scenarios contain two time periods of traffic data (2007 and 2010 projections) and two network configurations (existing and proposed), which form the following three scenarios:

- 2007 Traffic – Existing Geometry: 2007 AM and PM traffic with current interchange geometry without the 9th St./57th St. & I-94 Interchange.
- 2010 Traffic – Existing Geometry: Projected 2010 AM and PM traffic with current interchange geometry with the 9th St./57th St. & I-94 Interchange.
- 2010 Traffic – Proposed Geometry: Projected 2010 AM and PM traffic with proposed interchange geometry with the 9th St./57th St. & I-94 Interchange.

Network Geometry

The existing geometry of Sheyenne St. at the interchanges includes one northbound and southbound through travel lane entering the interchange (Figure 1). Left-turn lanes are provided for both the north and south ramps (~370 feet of storage each). In addition, a short auxiliary lane (~150 feet) is available for the westbound to northbound traffic using the westbound off ramp.

The proposed geometry of the Sheyenne St. Interchange, which was proposed by the City of West Fargo, would add capacity to several intersection approaches. First, the auxiliary lane for the westbound to northbound traffic would be extended north to the intersection of 19th Ave. Second, an additional southbound lane would be created for the westbound loop ramp traffic, which would extend south of the south ramp. Finally, a channelized, northbound right-turn lane would be constructed at the South Ramp.

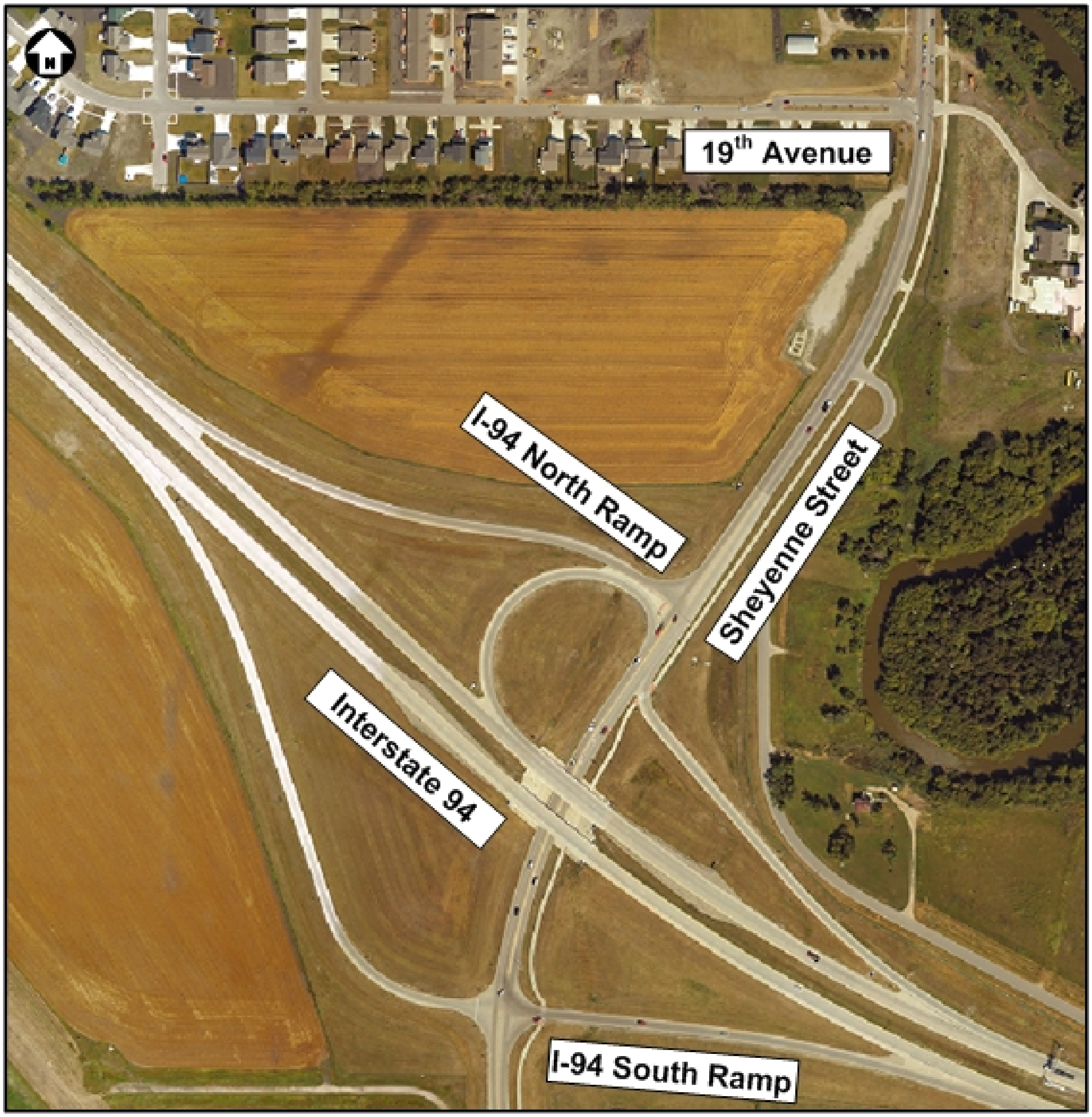


Figure 1. Sheyenne St. & I-94 Interchange Study Area

Traffic Volume

This study will analyze the 2007 and 2010 peak-hour traffic, which are provided in Appendix A. The 2007 traffic volumes were collected by the NDDOT on December 12, 2006, and consisted of the turning movement data for the North and South Ramps. The most recent turning movement count at 19th Ave. was from 2004; therefore, the traffic at this intersection was factored using the entering/existing traffic from the North Ramp.

The 2010 peak-hour traffic was obtained using F-M COG's regional travel demand model, which incorporated the 2010 projected socio-economic data, as well as an overpass with ramps at the 9th St./57th St. & I-94 Interchange. As expected, the projected traffic volume of the Sheyenne St. Interchange decreased as a result of the 9th St./57th St. Interchange. Projected 2010 approach volumes displayed decreasing traffic volumes ranging from 7% to 25% (Figure 2). Only the eastbound off ramp of the interchange received an increase in traffic.

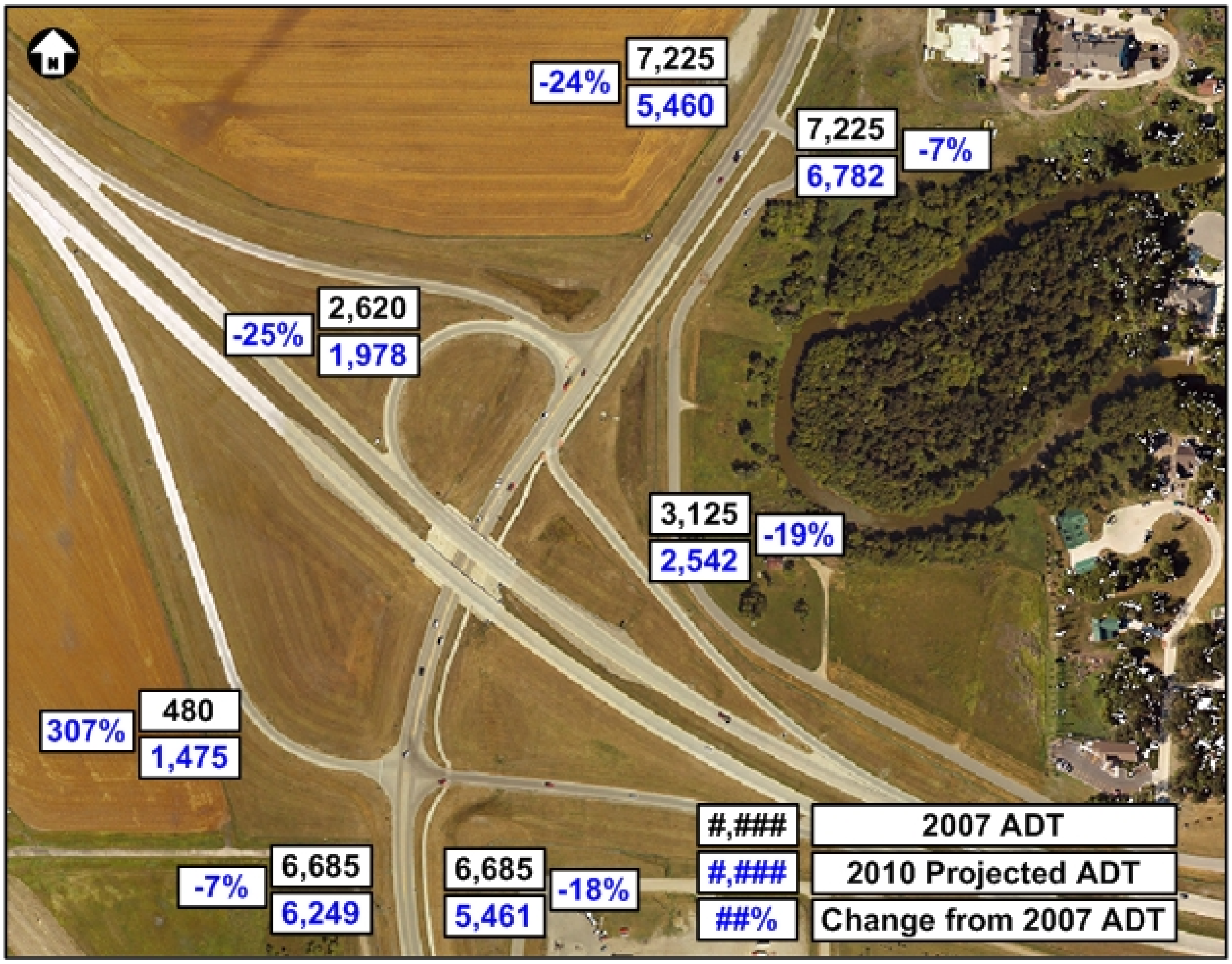


Figure 2. Sheyenne St. & I-94 Interchange ADT Comparison

For simulation modeling purposes, the projected 2010 ADT for the analysis area needed to be converted into peak-hour volume. This was performed by determining the existing (2007) peak-hour turning movement volume as a percentage of the 2007 ADT (provided by NDDOT). This percentage was then multiplied to the projected 2010 ADT. For example, the southbound approach of Sheyenne St. at the I-94 South Ramp in 2007 had a volume of 603 during the AM peak hour, which was 6.4% of the ADT (9,435). Of the 603 vehicles, 60% or 361 made a southbound left turn. This compares to 285 vehicles (7,160*6.4%*60%) making the same movement using the projected 2010 traffic, since the ADT for the approach is 7,160.

Traffic Control

Currently, both ramp intersections are unsignalized. The intersecting approaches with Sheyenne St. at the North Ramp are controlled by YIELD signs, while the south ramp is controlled by a STOP sign. The intersection of Sheyenne St. and 19th Ave. is controlled by an actuated traffic signal. Due to traffic congestion with some movements during the peak-hour periods, implementing traffic signals at the ramp intersections have been discussed in the past. However, since these intersections have not met signal warrants in the past, the initial decrease in traffic due to the 9th St./57th St. Interchange will probably ensure that the warrants will not be met for several more years. Therefore, the simulation scenarios used in this study will incorporate the existing traffic control devices within the study area.

TRAFFIC SIMULATION

Traffic simulation models allow practitioners to evaluate different scenarios prior to field implementation by replicating current and proposed traffic volume, network geometry, and traffic control devices. This study used CORSIM (TSIS 6.0), which is a microscopic, stochastic, traffic simulation model, developed for the Federal Highway Administration. CORSIM provides numerical and visual output to assess the operational conditions of a transportation network, such as queue lengths and delay time.

The input parameters for CORSIM included the roadway geometry, turning movement counts, and traffic control. The existing and proposed network geometries for the simulation scenarios are illustrated in Appendix B. The peak-hour traffic was entered using 4, 15-minute time periods. To provide a degree of peak flow within the peak hour, a peak-hour factor (PHF) was incorporated. A uniform PHF of .85 was used for the second 15-minute period. The other three time periods used an anti-PHF to simulate the remaining peak traffic within the hour.

Each scenario had a seed time of 10 minutes followed by a 60 minute simulation. The seed time loads vehicles into the network while not producing simulation output. In addition, each scenario was simulated 30 times to normalize the results.

Simulation Results

The simulation analysis compared the total network delay, the South Ramp's southbound left-turn (SBL) delay, and the South Ramp's northbound right-turn (NBR) delay among the simulation scenarios. The existing AM peak traffic and network geometry produced network delay time that was more than twice the 2010 traffic with existing and proposed geometry (Table 1). The 2010 AM peak traffic with existing and proposed network geometry reduced the network delay by 57 and 59 percent, respectively. The major reason for this delay time reduction is due to the projected decrease in the South Ramp' s SBL volume. The increased capacity proposed for the interchange had a marginal improvement to the network delay by reducing the delay by an additional two percent over the existing geometry.

The PM peak period also experienced reductions in network delay time. The 2010 PM traffic reduced the network delay time by 23 percent while incorporating the existing geometry. The additional capacity provided an additional delay time reduction of 12 percent. This reduction is primarily due to the decrease in delay time for the North Ramp's westbound loop ramp.

Table 1. Network Delay Time Comparison

Traffic - Geometric Scenario	Network Delay Time (hr)		Change from 2007	
	AM Peak	PM Peak	AM Peak	PM Peak
2007 Traffic - Existing Geometry	24.8	11.3	-	-
2010 Traffic - Existing Geometry	10.8	8.7	-57%	-23%
2010 Traffic - Proposed Geometry	10.2	7.3	-59%	-35%

The South Ramp's SBL movement is the critical movement for the AM peak period. Due to the high traffic volume making both the SBL movement and the northbound through (NBT) movement, the SBL traffic experiences significant delay time. The queue length during the AM peak for the SBL movement often extends past the North Ramp (Figure 3).

Figure 3. Southbound Left-turn Queue Length during AM Peak Period

The South Ramp's SBL delay time is limited to the link that has the left-turn lane, which has a length of approximately 400 feet. Therefore, the delay time value is very conservative since the queue length extends several hundred feet upstream from this link. Although not all of the delay time associated with the SBL movement can be assessed, it was accounted for in the network delay time. Compared to the existing conditions, the 2010 AM peak traffic with existing and proposed network geometry reduced the SBL delay by 73 and 92 percent, respectively (Table 2). Since the PM peak period experiences lower SBL and NBT traffic, the SBL movement encounters low delay time. The 2010 PM traffic reduced the SBL delay time by 14 percent and the geometric changes provided another 20 percent reduction.

Table 2. South Ramp SBL Delay Time Comparison

Traffic - Geometric Scenario	South Ramp SBL Delay (sec/veh)		Change from 2007	
	AM Peak	PM Peak	AM Peak	PM Peak
2007 Traffic - Existing Geometry	83.5	6.8	-	-
2010 Traffic - Existing Geometry	22.9	5.8	-73%	-14%
2010 Traffic - Proposed Geometry	7.0	4.5	-92%	-34%

To assist the South Ramp's SBL movement, the NBR movement was separated from the NBT traffic using a channelized lane that acts as a ramp merging with the SBL traffic. This geometric configuration benefits the SBL traffic but impedes the NBR traffic since it must yield to the SBL traffic. However, based on the simulation output, the restriction to the NBR traffic did not significantly impact the movement's operation. The 2010 AM and PM peak traffic with the proposed network geometry increased the NBR delay by 57 and 28 percent, respectively (Table 3). Although the percent change seems significant, the existing delay time values were very low for this movement so an increase of a few seconds can create a high percent of change.

Table 3. South Ramp NBR Delay Time Comparison

Traffic - Geometric Scenario	South Ramp NBR Delay (sec/veh)		Change from 2007	
	AM Peak	PM Peak	AM Peak	PM Peak
2007 Traffic - Existing Geometry	5.2	4.7	-	-
2010 Traffic - Existing Geometry	5.0	4.7	-5%	1%
2010 Traffic - Proposed Geometry	8.2	6.0	57%	28%

SUMMARY

This study analyzed the existing traffic conditions (2007) of the Sheyenne St. & I-94 Interchange, as well as the projected conditions (2010). Both the AM and PM peak periods were evaluated using the CORSIM traffic simulation model.

The 2010 peak-hour traffic was obtained using F-M COG's regional travel demand model, which incorporated the 2010 projected socio-economic data as well as an overpass with ramps at the 9th St./57th St. & I-94 Interchange. As expected, the projected traffic volume of the Sheyenne St. Interchange decreased as a result of the 9th St./57th St. Interchange. The projected 2010 approach volumes decreased traffic from 7 percent to 25 percent.

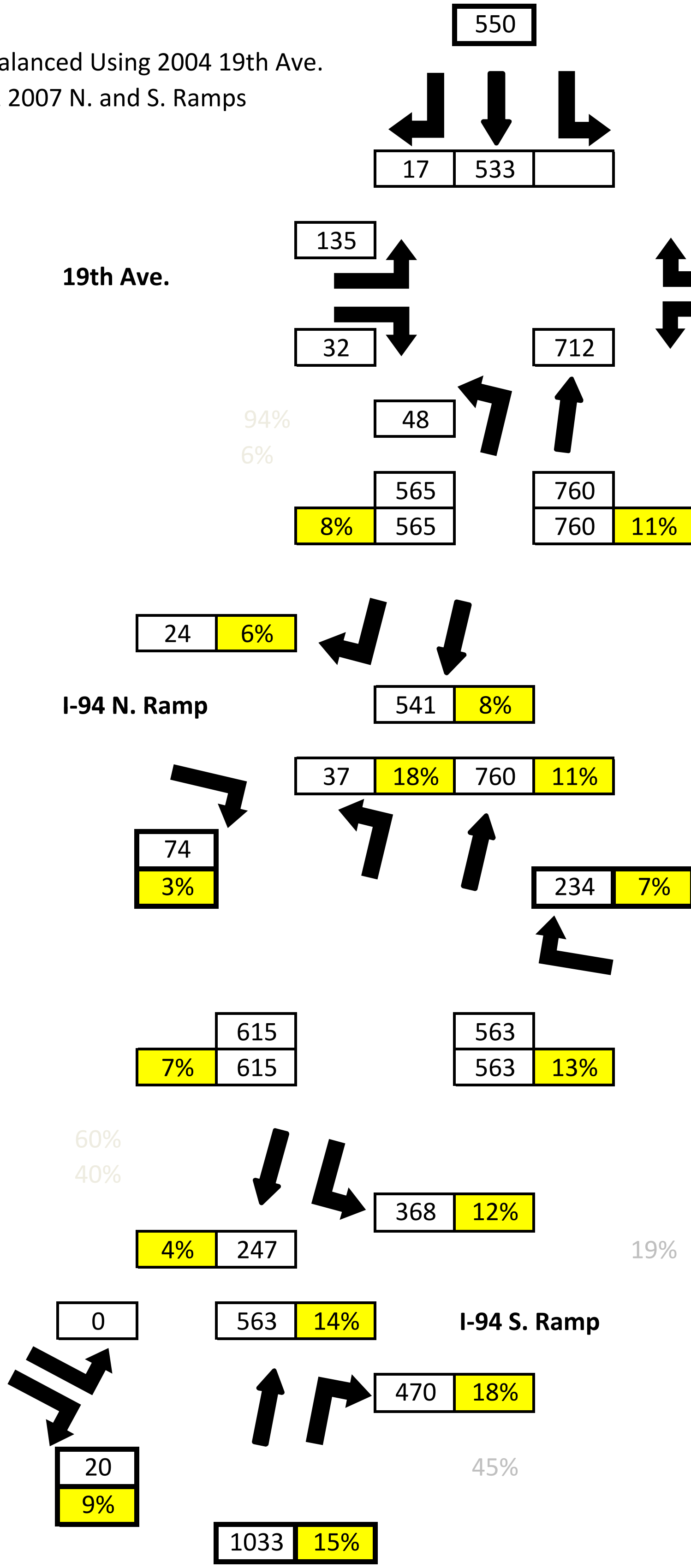
The projected reductions in peak-hour traffic (2010 conditions) greatly improved the traffic operations of the study area. When incorporating the existing geometry, the 2010 traffic provided network delay reductions for AM and PM peak periods of 57 and 23 percent, respectively. In addition, the 2010 traffic reduced the South Ramp's SBL delay time for the AM and PM peak periods by 73 and 14 percent, respectively.

Although most of this study's delay time reductions were attributed to the projected decrease in 2010 traffic volume, additional delay time savings were realized due to the proposed geometric improvements. Additional network delay time reductions due to the proposed geometry for the AM and PM peak periods were 2 and 12 percent, respectively. In addition, the South Ramp's SBL movement achieved additional delay time reductions with the proposed geometry of 19 percent (AM peak) and 20 percent (PM peak).

APPENDIX A:
2007 and 2010 AM and PM Turning Movement Data

SHEYENNE ST. & I-94 INTERCHANGE
Existing AM Peak-Hour Traffic

Balanced Using 2004 19th Ave.
& 2007 N. and S. Ramps



I-94 WB Input

4275	10%	428
ADT	Pk %	Pk Hr

WB Source Input = 736 | 9%

19% Includes off-ramp and loop ramp

I-94 EB Input

5595	10%	560
ADT	Pk %	Pk Hr

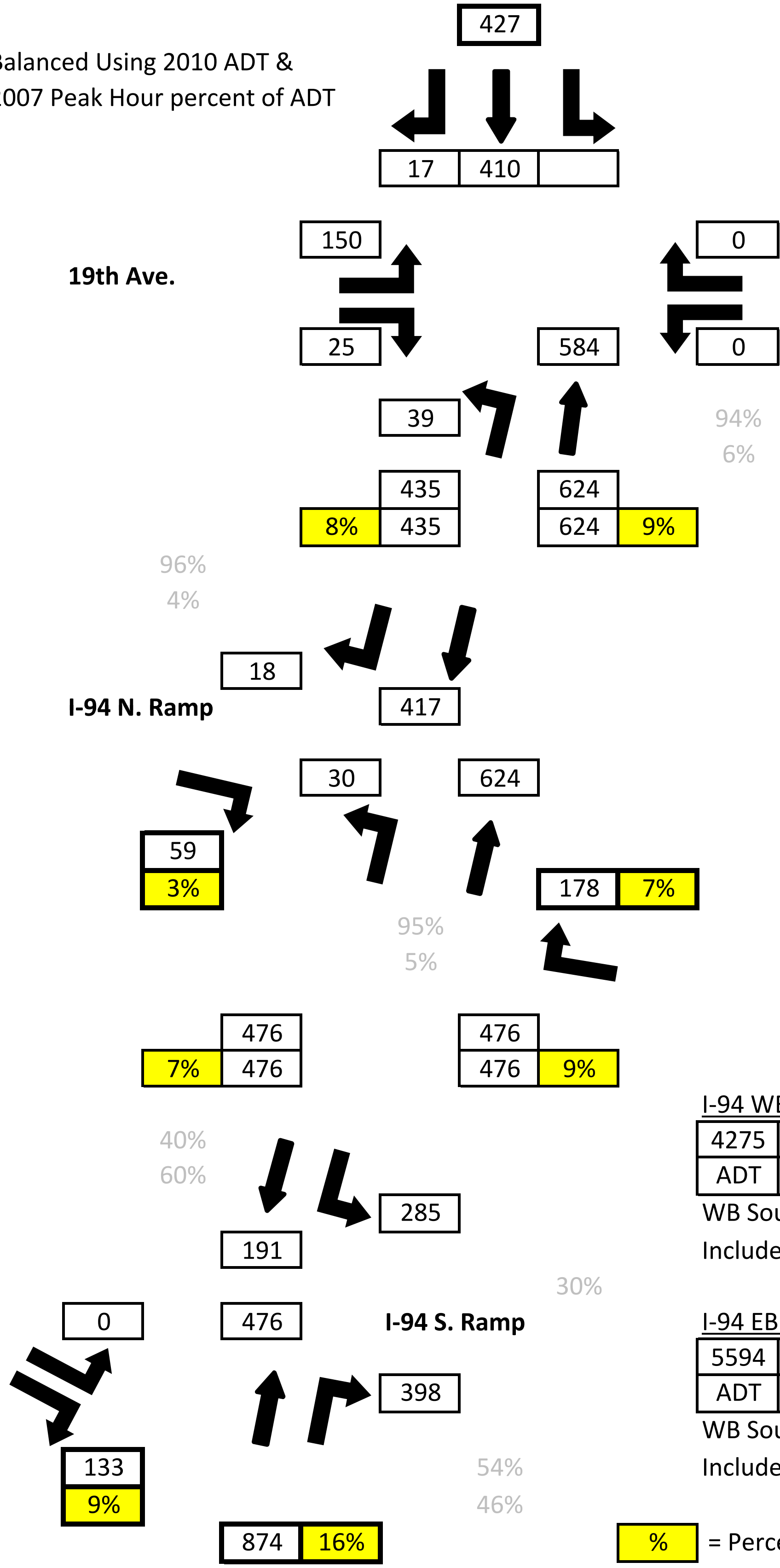
WB Source Input = 580 | 8%

Includes off-ramp

% = Percent of 2007 ADT

SHEYENNE ST. & I-94 INTERCHANGE
Projected 2010 AM Peak-Hour Traffic

Balanced Using 2010 ADT &
2007 Peak Hour percent of ADT



I-94 WB Input

4275	10%	428
ADT	Pk %	Pk Hr

WB Source Input = 665 8%

Includes off-ramp and loop ramp

I-94 EB Input

5594	10%	559
ADT	Pk %	Pk Hr

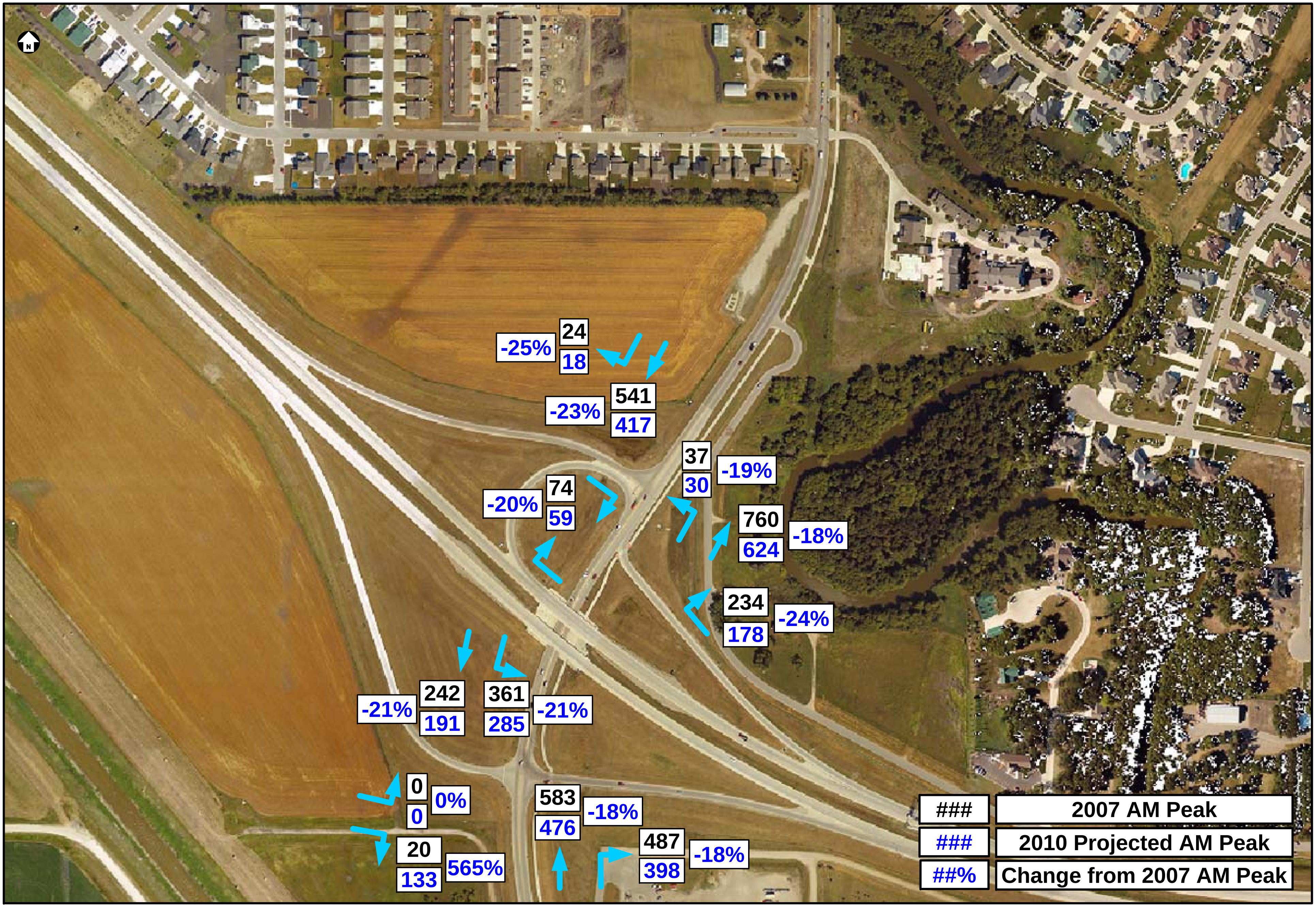
WB Source Input = 692 10%

Includes off-ramp

% = Percent of Projected 2010 ADT

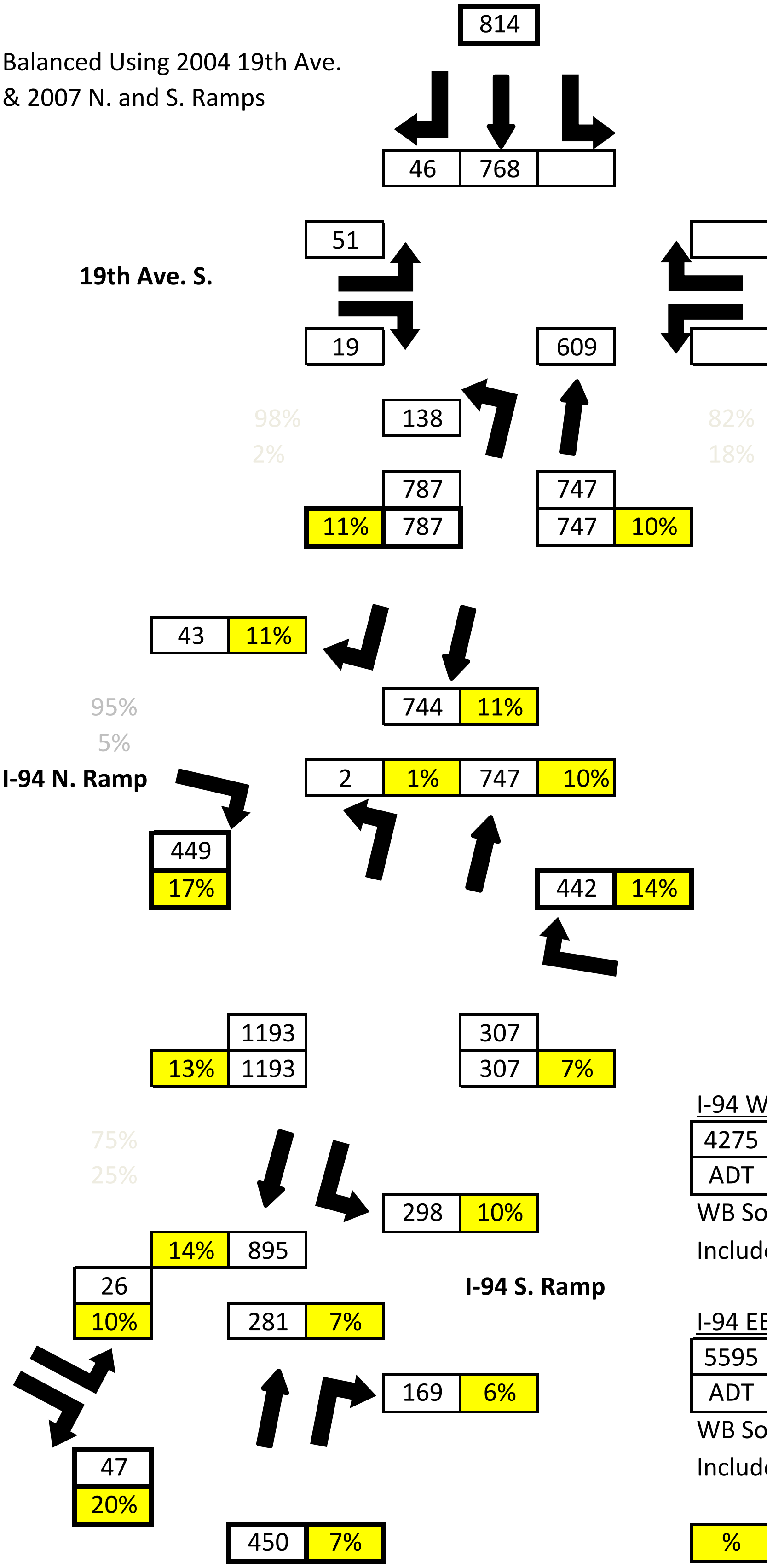
Sheyenne St. & I-94 Interchange: Projected 2010 AM Peak Hour Traffic

Sheyenne St. & I-94 Interchange: 2007/2010 AM Peak Turning Movement Comparison
(9th St./57th St. Interchange with Overpass and Ramps)



SHEYENNE ST. & I-94 INTERCHANGE
Existing PM Peak-Hour Traffic

Balanced Using 2004 19th Ave.
& 2007 N. and S. Ramps



I-94 WB Input

4275	10%	428
ADT	Pk %	Pk Hr

WB Source Input = 1319 15%

Includes off-ramp and loop ramp

I-94 EB Input

5595	10%	560
ADT	Pk %	Pk Hr

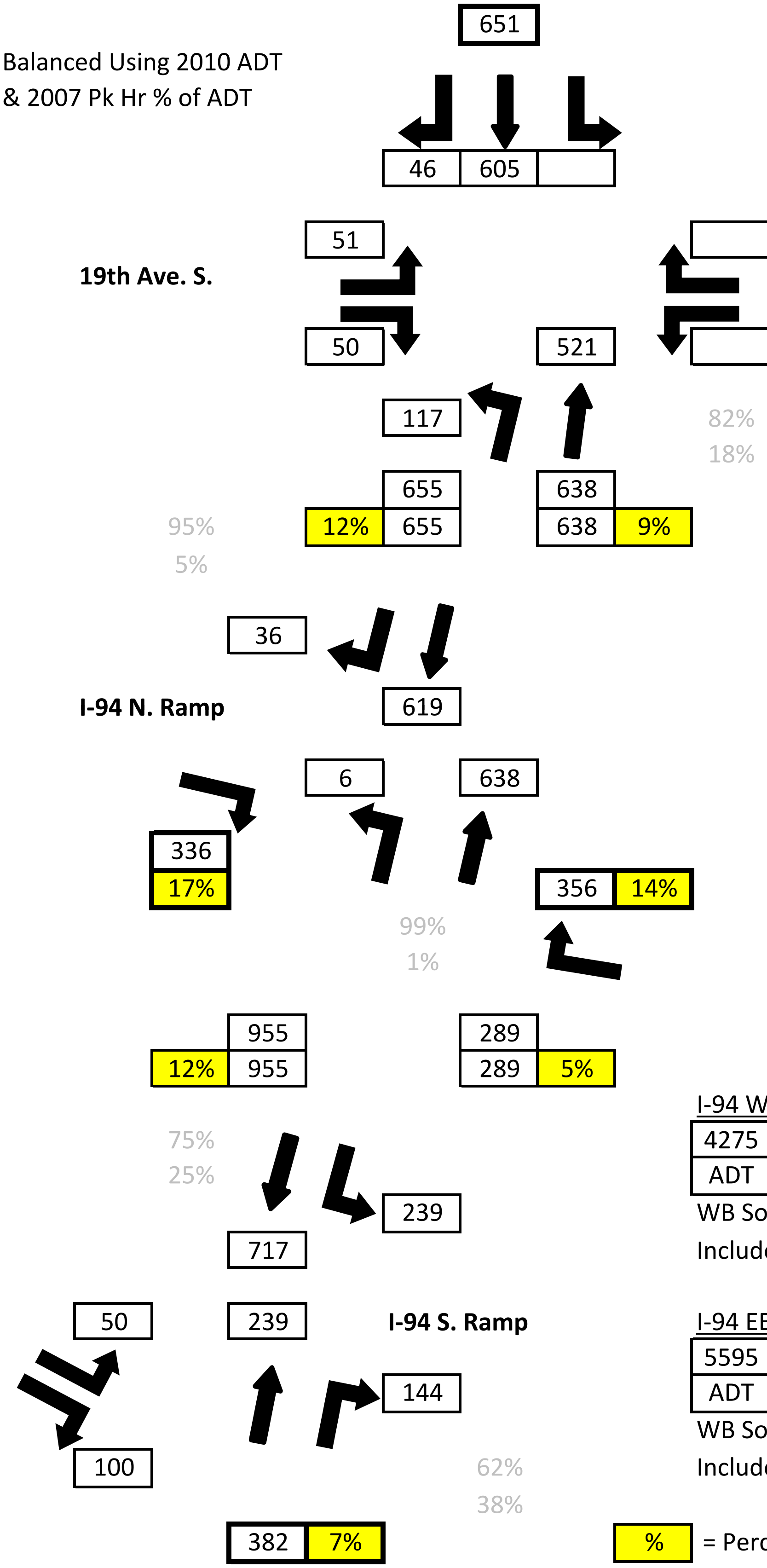
WB Source Input = 633 9%

Includes off-ramp

% = Percent of 2007 ADT

SHEYENNE ST. & I-94 INTERCHANGE
Projected 2010 PM Peak-Hour Traffic

Balanced Using 2010 ADT
& 2007 Pk Hr % of ADT



I-94 WB Input

4275	10%	428
ADT	Pk %	Pk Hr

WB Source Input = 1120 13%
Includes off-ramp and loop ramp

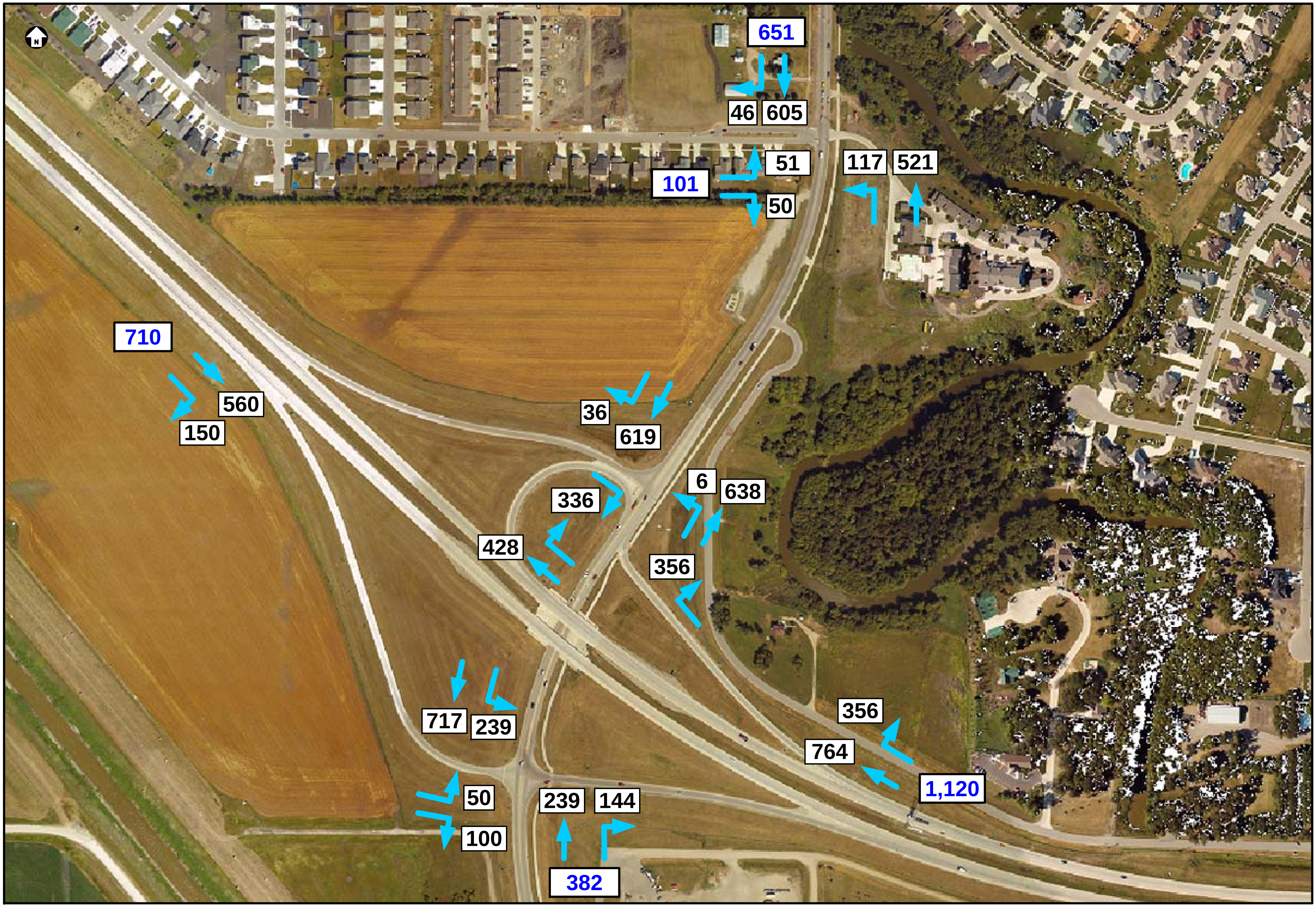
I-94 EB Input

5595	10%	560
ADT	Pk %	Pk Hr

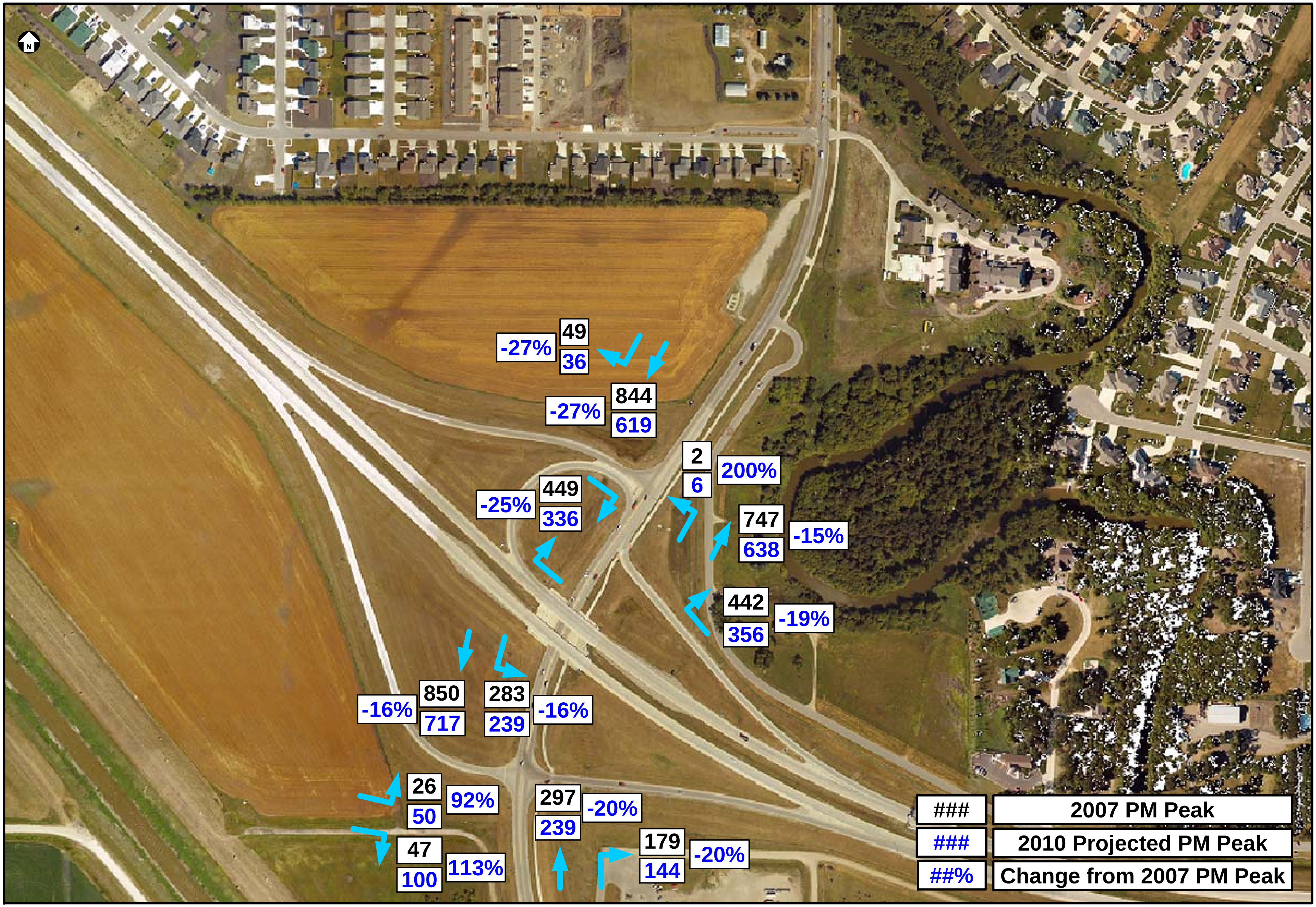
WB Source Input = 710 10%
Includes off-ramp

% = Percent of Projected 2010 ADT

Sheyenne St. & I-94 Interchange: Projected 2010 PM Peak Hour Traffic

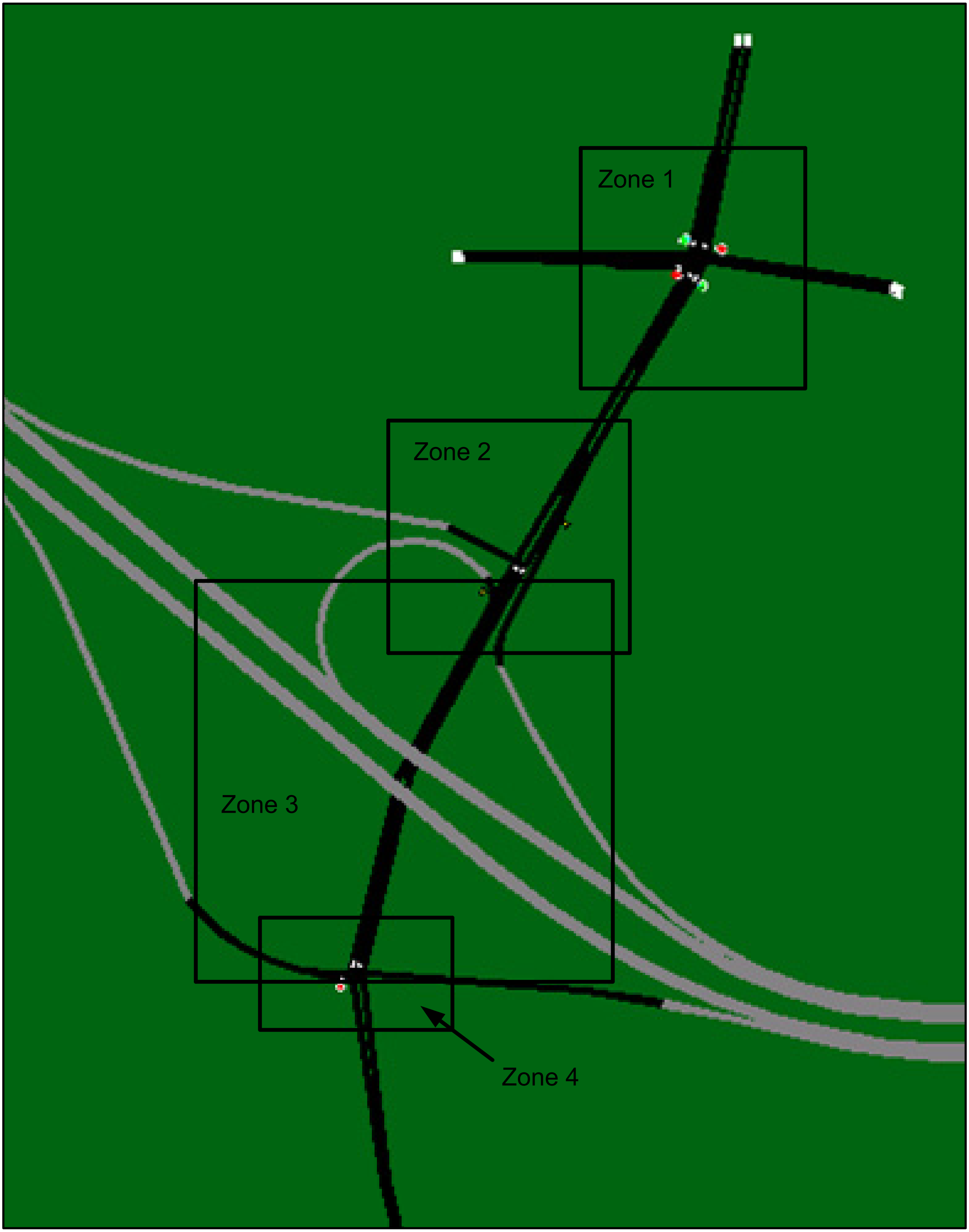


Sheyenne St. & I-94 Interchange: 2007/2010 PM Peak Turning Movement Comparison
(9th St./57th St. Interchange with Overpass and Ramps)

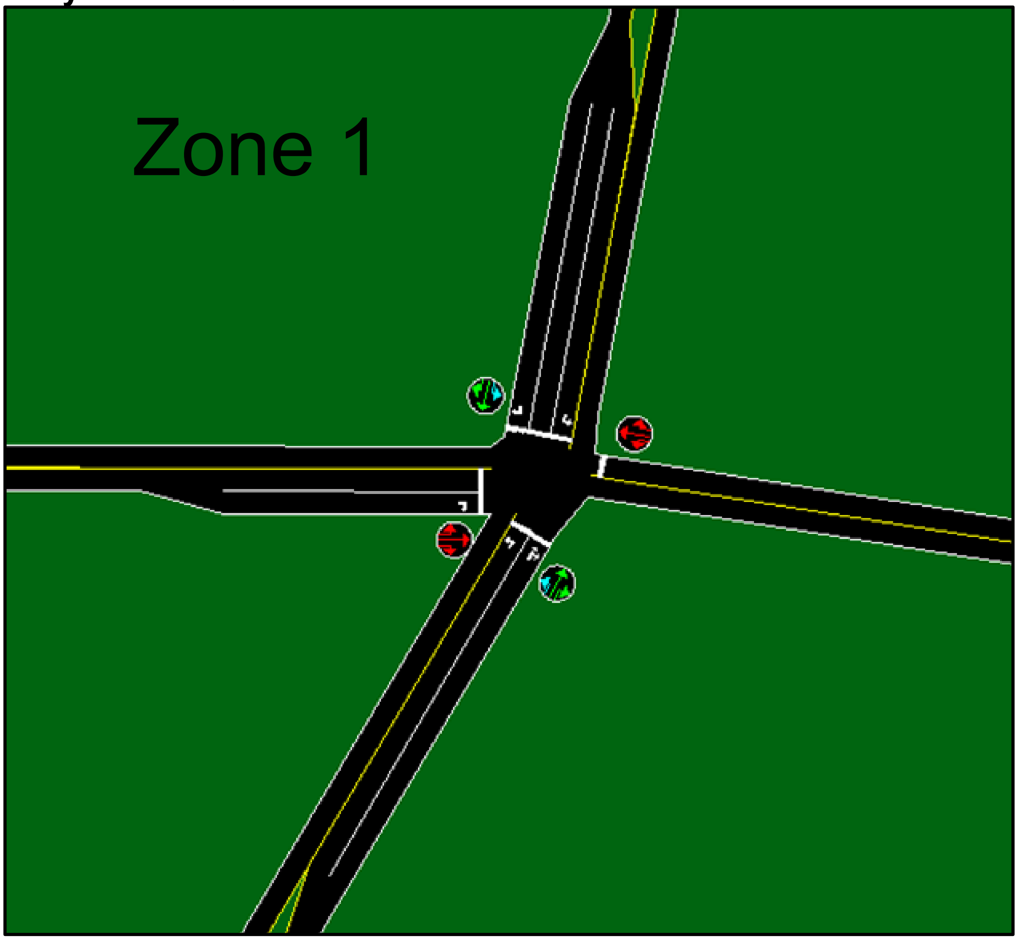


APPENDIX B:
Existing and Proposed CORSIM Networks

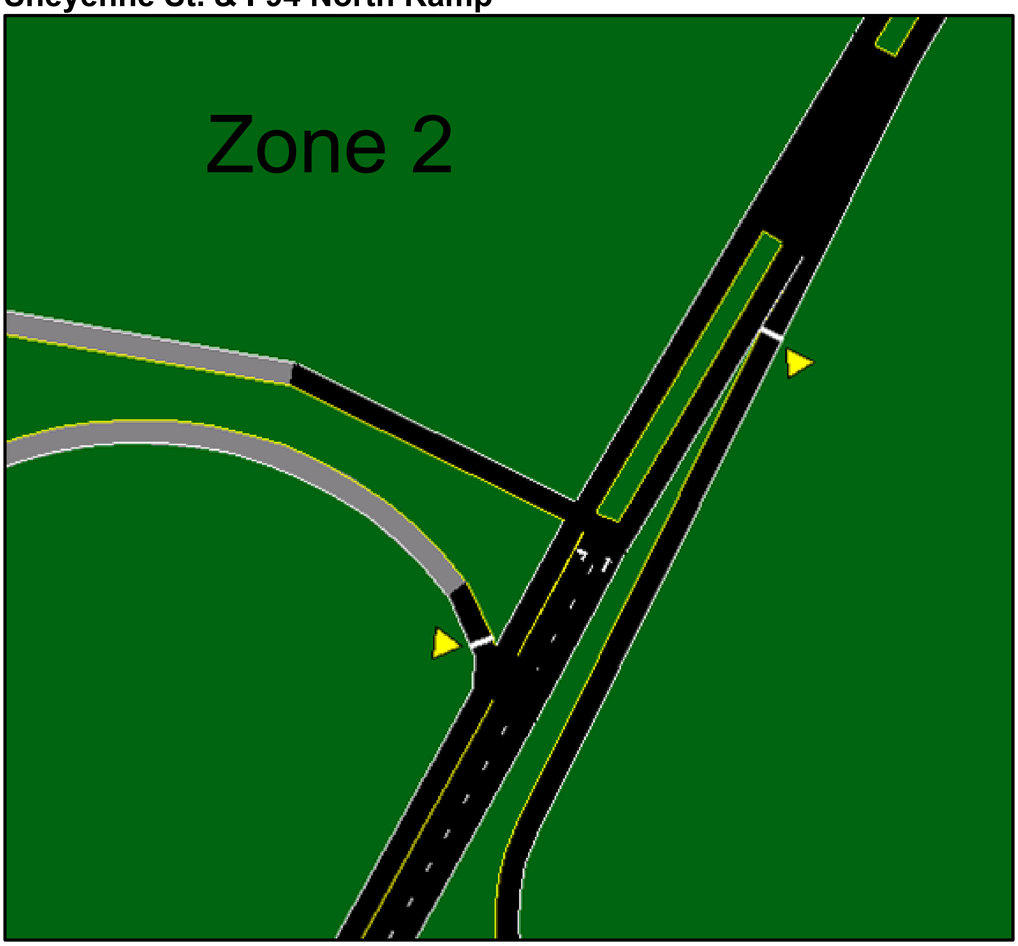
Sheyenne St. & I-94 Interchange: CORSIM Network (Existing)



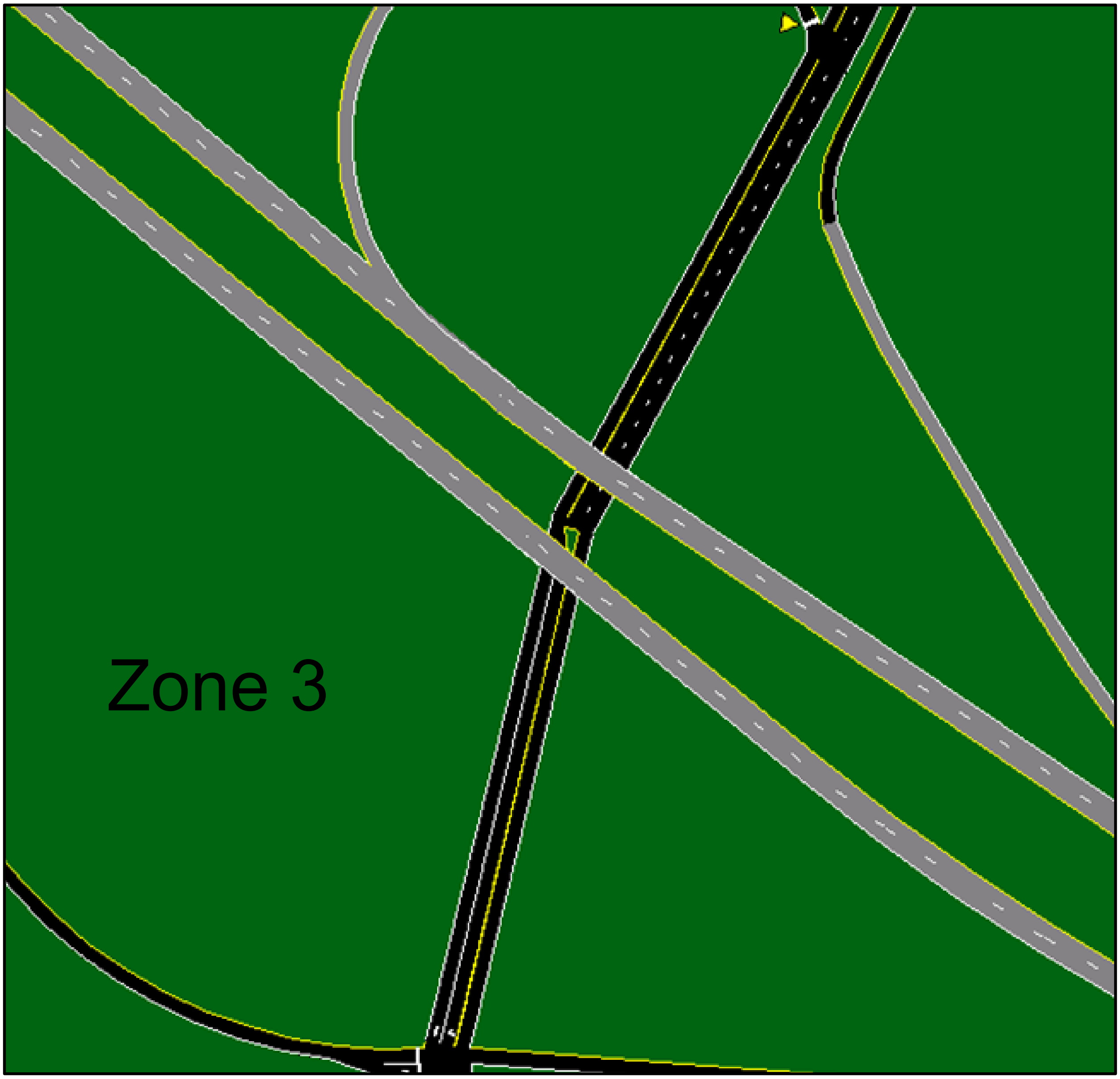
Sheyenne St. & 19th Ave. S.



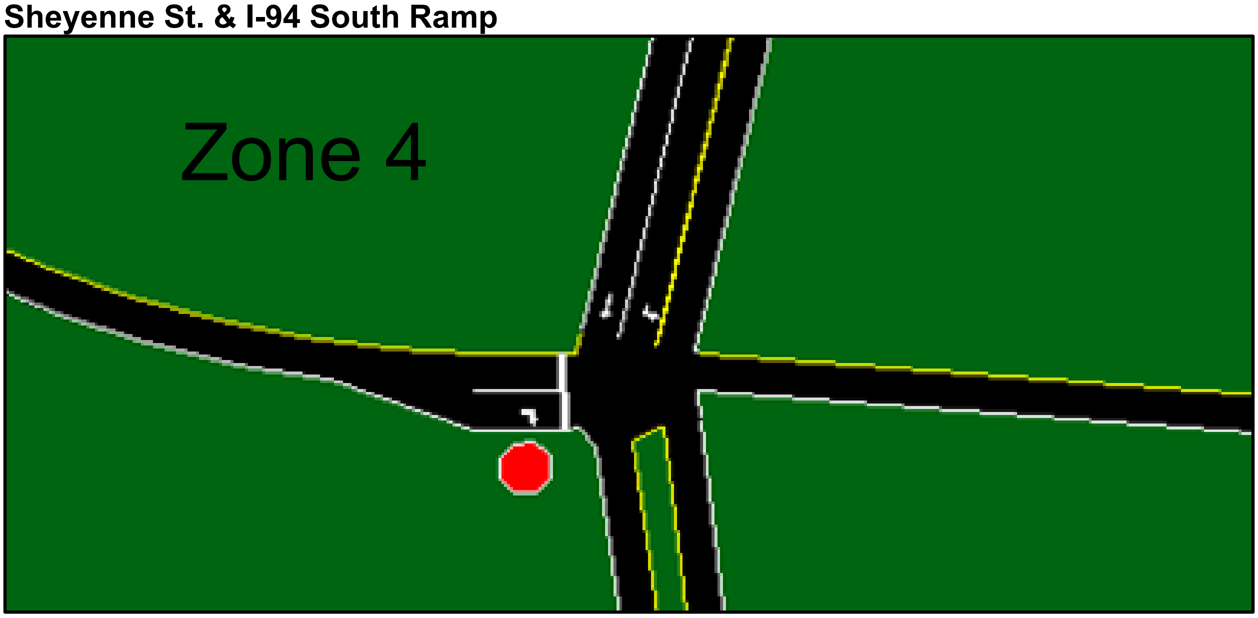
Sheyenne St. & I-94 North Ramp



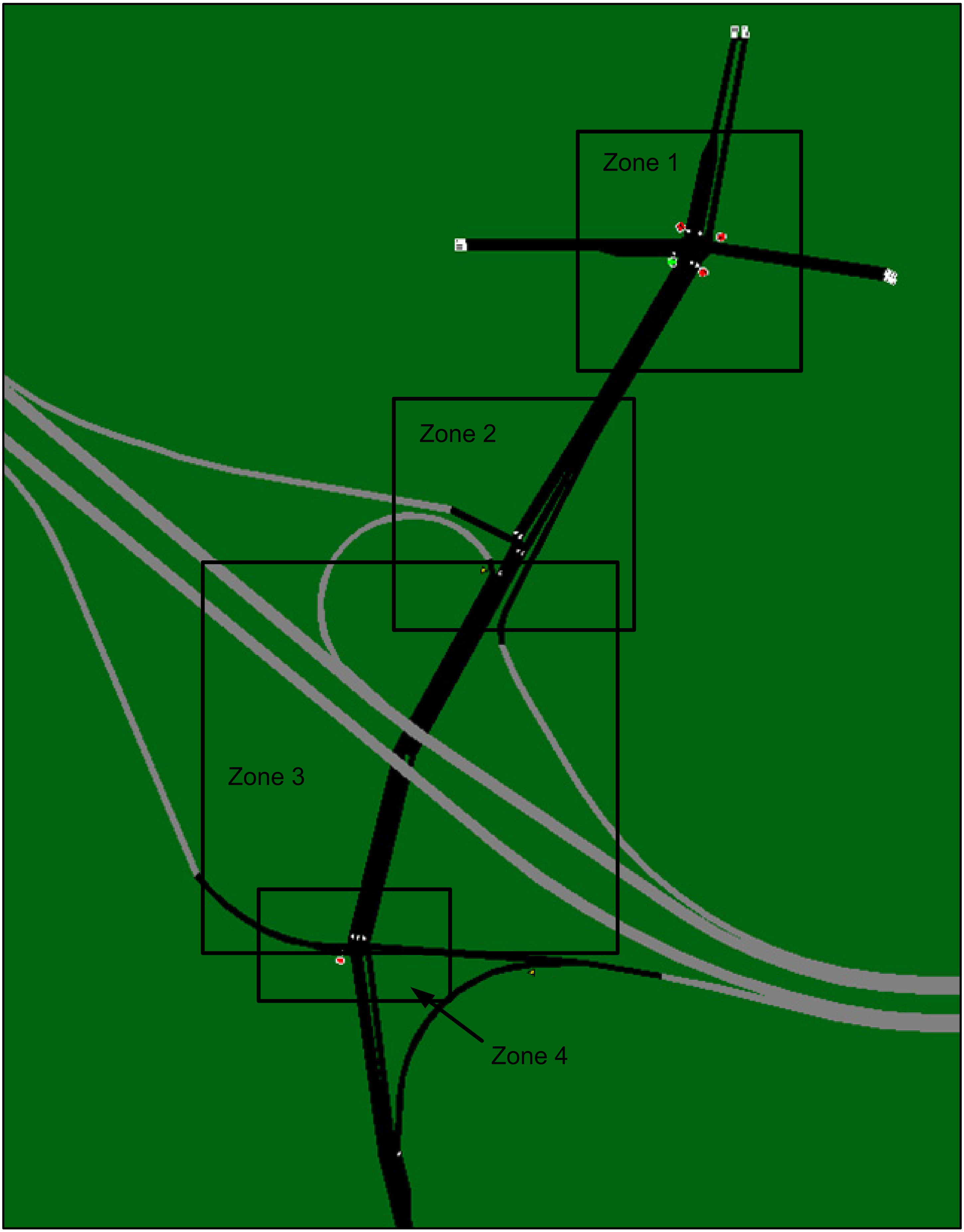
Sheyenne St. between I-94 North and South Ramps



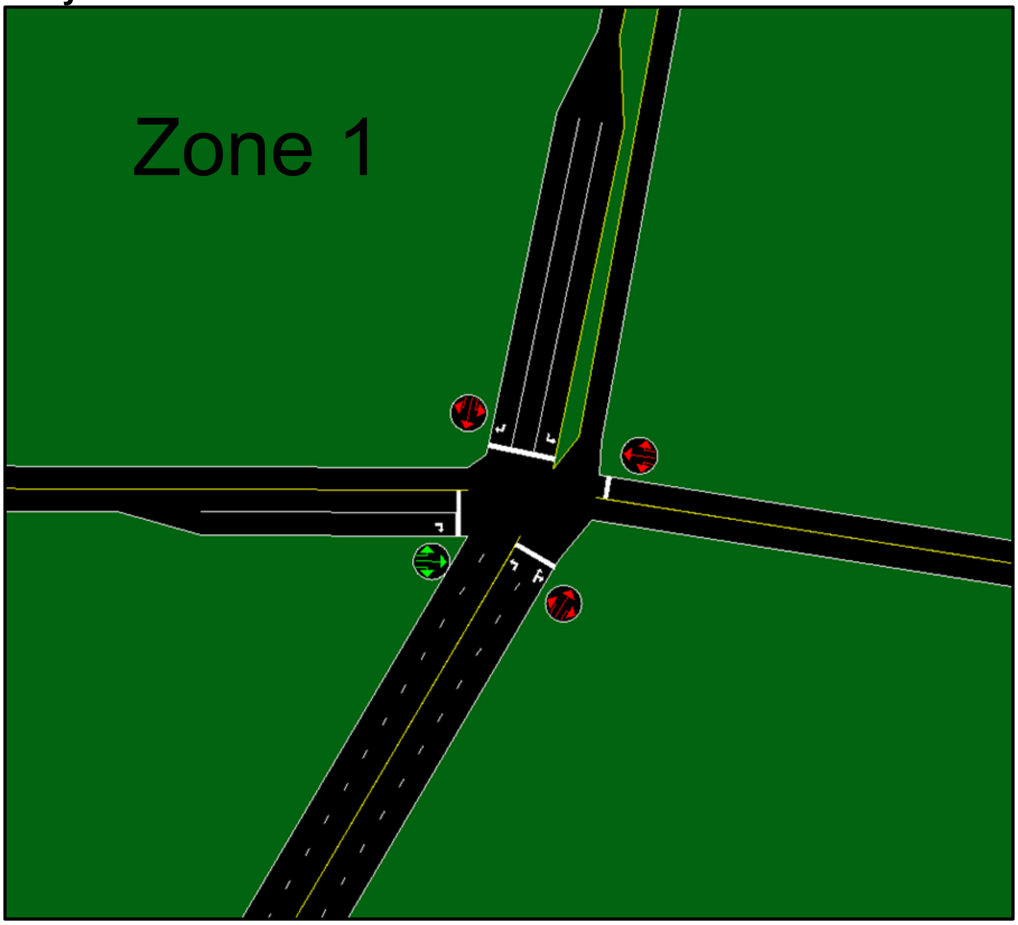
Sheyenne St. & I-94 South Ramp



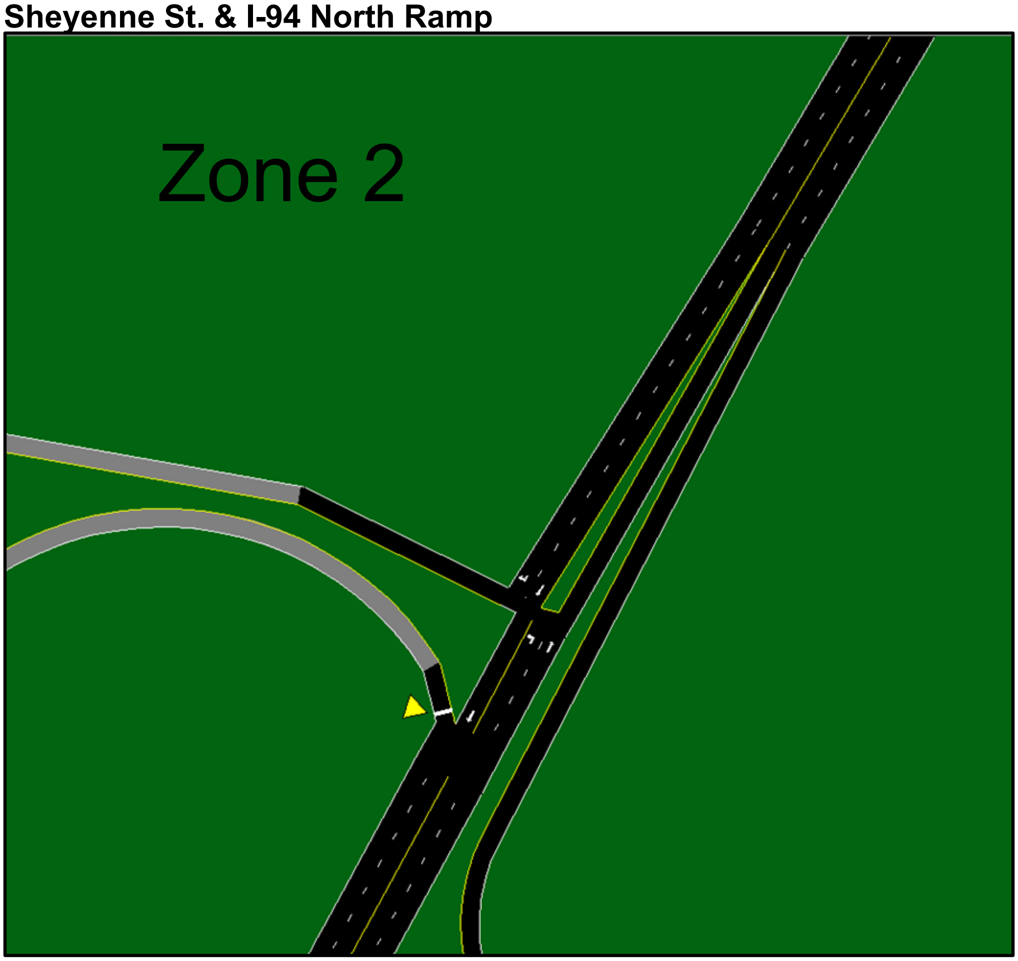
Sheyenne St. & I-94 Interchange: CORSIM Network (Proposed)



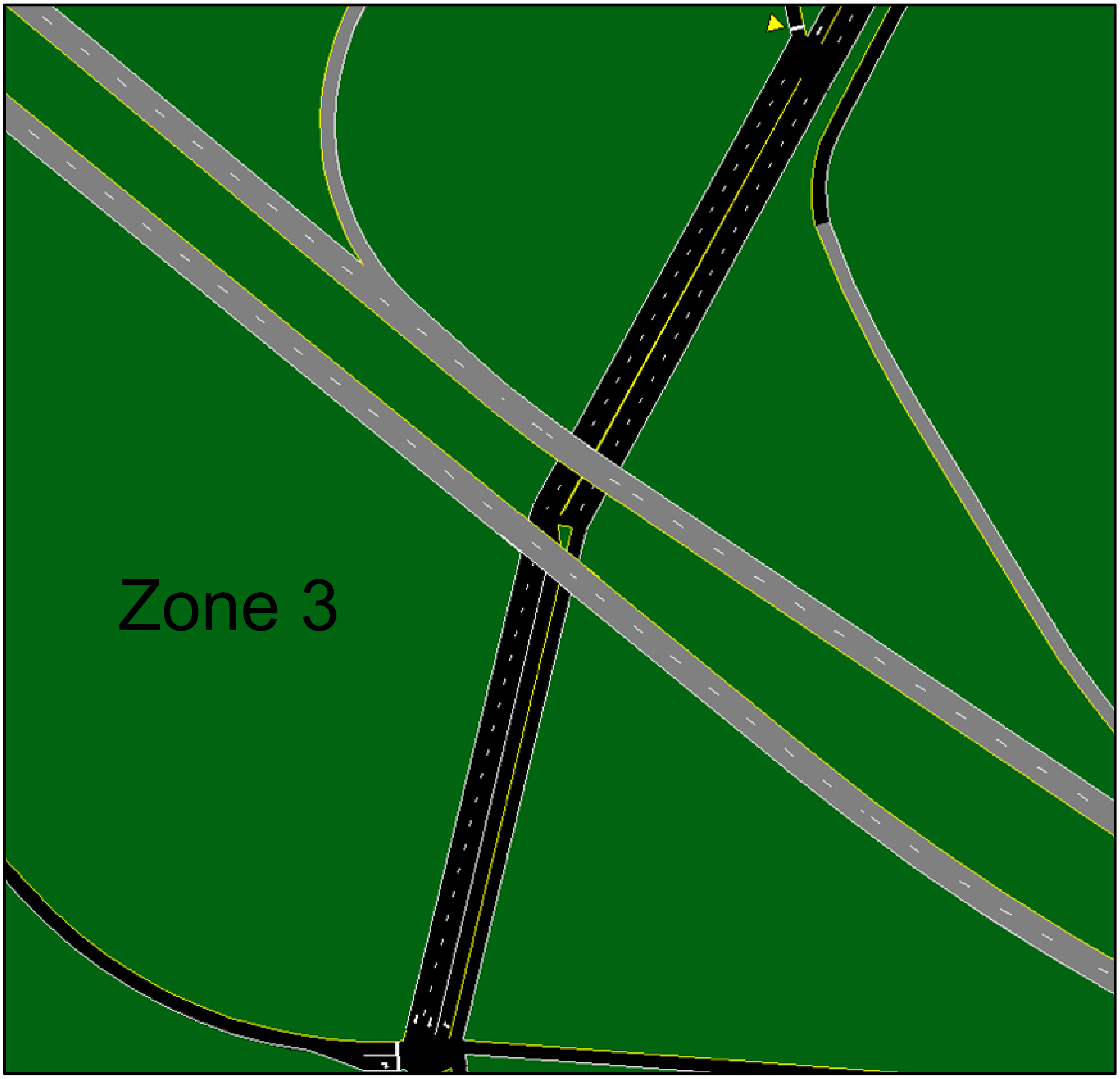
Sheyenne St. & 19th Ave. S.



Sheyenne St. & I-94 North Ramp



Sheyenne St. between I-94 North and South Ramps



Sheyenne St. & I-94 South Ramp