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Attachment C

Traffic and Safety Technical Report

Michigan Department of Transportation

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Notice

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This document has 64 pages including the cover.

Document history

Revision	Purpose description	Originated	Checked	Reviewed	Authorized	Date
Rev 1.0	Traffic & Safety tech report, ready for QC step 1	Pat Cawley		<initials>	<initials>	12-20-22
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	Traffic & Safety tech report, QC comments addressed step 2	Pat Cawley		TK	JB	1-11-23

Table of contents

Figures

Tables

List of Appendices

1. Introduction

The Michigan Department of Transportation (MDOT) is conducting a Planning and Environmental Linkages (PEL) study for Eastbound (EB) M-14 and the Barton Drive Interchange. The intent of the study is to analyze the environmental and social impacts of alternatives to improve the geometry of the EB M-14 and Barton Drive on and off ramps and to assess the future condition needs of the M-14 bridge over the Huron River.

This report summarizes traffic analysis of the four (4) study alternatives and will study the traffic patterns produced for the alternatives, the traffic operations of the freeway and arterial network and the safety implications of proposed changes. This analysis includes examination of traffic conditions in the assumed opening year of 2025 and the long term horizon year of 2045.

1.1 Traffic Study Area

The primary study area for the M-14 / Barton Drive PEL includes M-14 and the ramp system to Barton Drive and Whitmore Lake Road. For this project, the traffic analysis area for the operational analysis includes the transportation network beyond the immediate interchange area, including Barton Drive east of the interchange to Pontiac Trail, Whitmore Lake Road to Barton Shores / M-14 westbound (WB) ramps and on N. Main Street (US-23BR) southerly to Summit Street. Figure 1 depicts the traffic analysis area.

The traffic operations analysis area is larger than the study area because traffic within the study area is influenced by, and influences, the surrounding transportation network, which extends beyond the study area. The traffic analysis area was created to capture the impact of project on the arterial roadway system out to the first signalized intersection.

Additionally, for the predictive crash analysis the study area included an expanded roadway network outside the limits to measure the impacts. This encompassed the impacts on the local network due to changes in the freeway access (ramp closure). The arterial roads with access to M-14 / US-23 were examined and included Jackson Avenue, Miller Road and Plymouth Road along others impacted.

Figure 1 Traffic Analysis Area

1.2 Traffic Analysis Methodology

The traffic analysis is comprised of three (3) components, travel demand modeling, traffic operational analysis and traffic safety analysis. The travel demand modeling' s primary tool was *Transcad* software utilizing the Southeast Michigan Council of Governments' (SEMCOG) regional demand model. The operational analysis included the use of *VISSIM*, *Highway Capacity Software* and *Synchro*. A complete view of the methodology and assumptions of the travel demand forecasting, as well as the *VISSIM* assumptions is contained in the *Traffic Forecasting and Methodology Approach – M-14 Barton Drive PEL* memo contained in Appendix C.

1.3 Safety Analysis Methodology

The first level of safety analysis for the project consisted of a traditional approach of examining the crash history of area and determining possible causes for crashes in the area. The analysis is contained in the existing conditions report (see Attachment A).

In addition to that approach, the predictive analysis for each of the alternatives was performed in order to compare the relative expected safety performance. This analysis was conducted using the Federal Highway Administration (FHWA) *Highway Safety Manual* methodology. Details of the predictive analysis are contained within this section while the inputs and calculations are provided in Appendix D.

1.4 Organization of Technical Report

The remainder of this technical report is organized into the following chapters:

- Overview of the alternatives analyzed
- Comparison of Travel Demand for alternatives
- Summary of traffic operations for alternatives
    - 2025 VISSIM, Synchro and HCS analysis
    - 2045 VISSIM, Synchro and HCS analysis
- Safety analysis results

2. Overview of Alternatives Analyzed

A total of four (4) concepts were identified for refinement and analysis based on the initial screening. Using Cad tools and available aerial photography the concepts were drawn to scale and overlaid on the existing site.

The alternatives are:

1. No Action Alternative
2. Close Eastbound Ramps
3. Modified Loop
4. Dual Roundabout

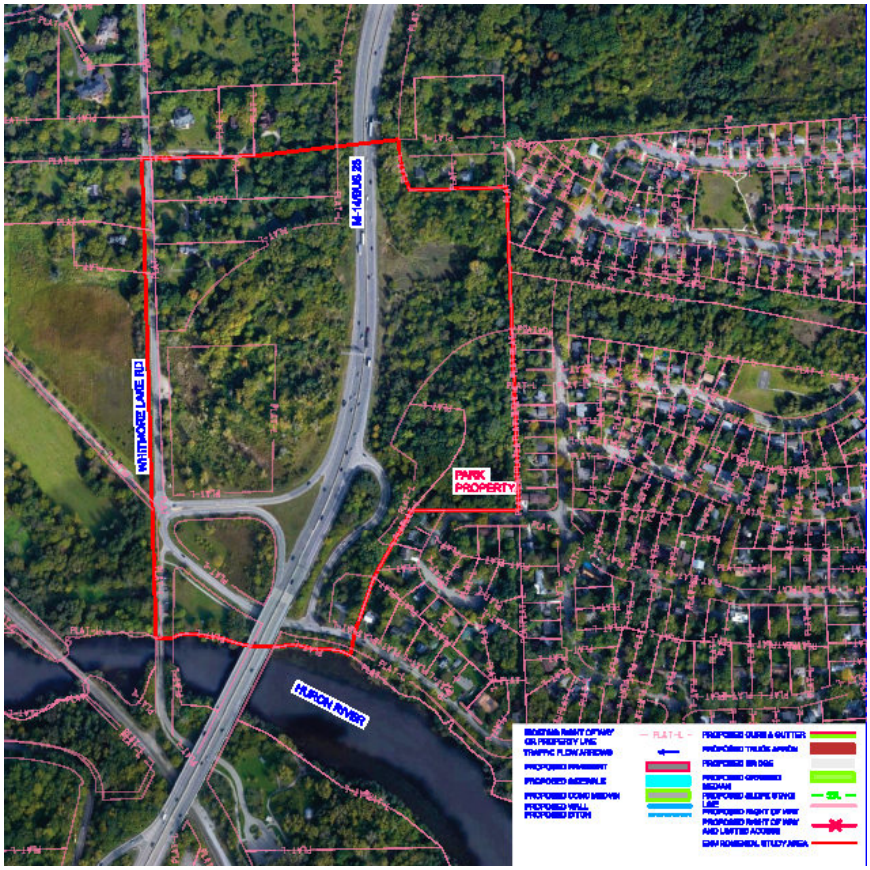
2.1 Core Concept of Each Alternative

Below is a brief discussion about each of the four alternatives.

No Action Alternative

The no action alternative concept presents the expected future condition if no action is taken. This alternative, however, includes planned mobility improvements in the region within the SEMCOG Long Range plan. This alternative is not the same as the existing conditions.

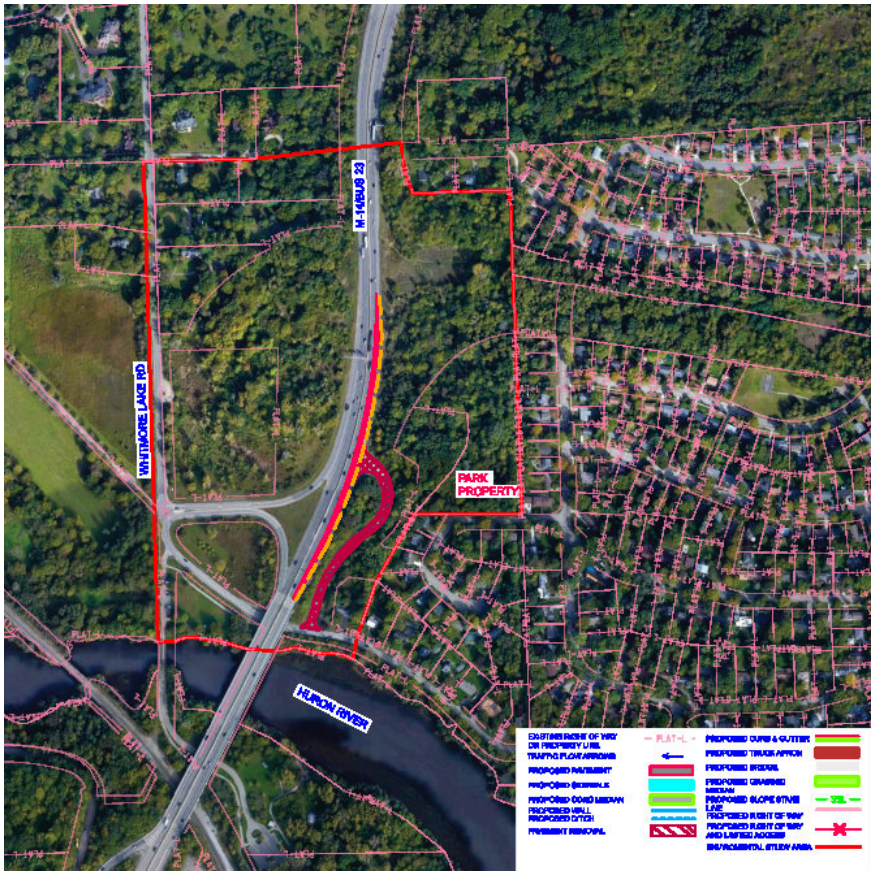
Figure 2 No Action Alternative



Close Eastbound Ramps

The Close Eastbound ramps alternative is a concept that would close the eastbound on and off ramps between Barton Drive and M-14. Access to/ from eastbound M-14 would be severed and traffic would reroute throughout the network

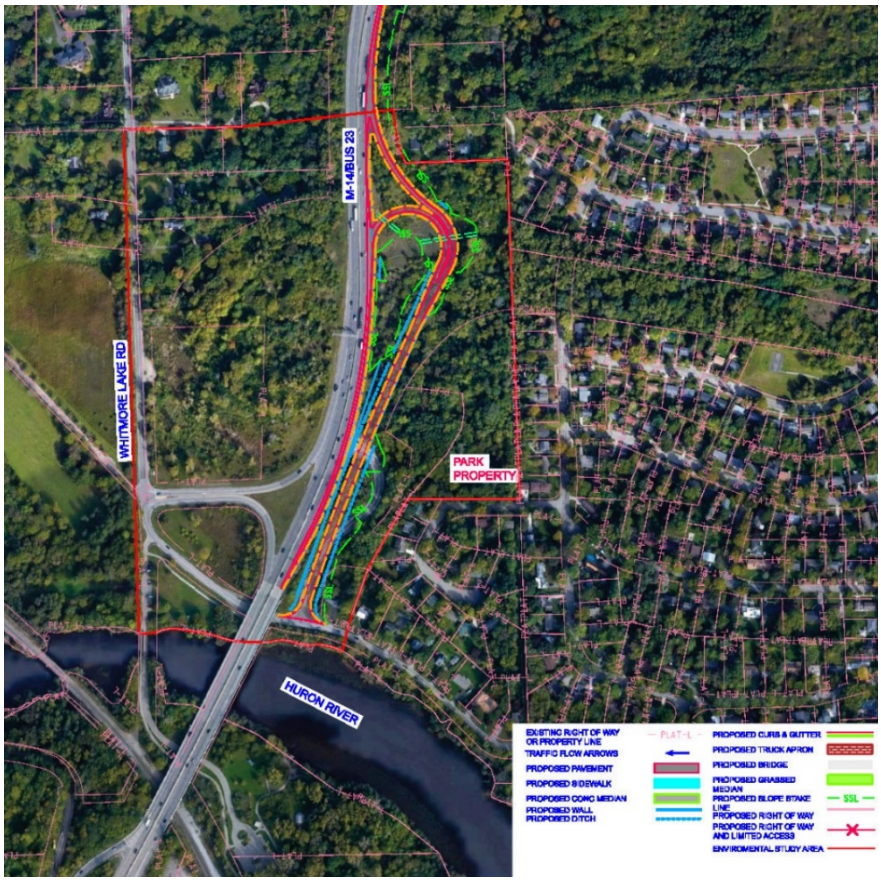
Figure 3 Close EB Ramps Alternative



Modified Loop

The Modified Loop concept would alter the existing interchange geometry but keep the same basic configuration. It would increase the radius of the EB off loop ramp. The design speed would be increased to 25 mph. Additionally, the on ramp would be modified to be a free flow on ramp with an auxiliary lane of proper merging length. To fit this in the available right of way, the location of the loop and directional ramp would be relocated north.

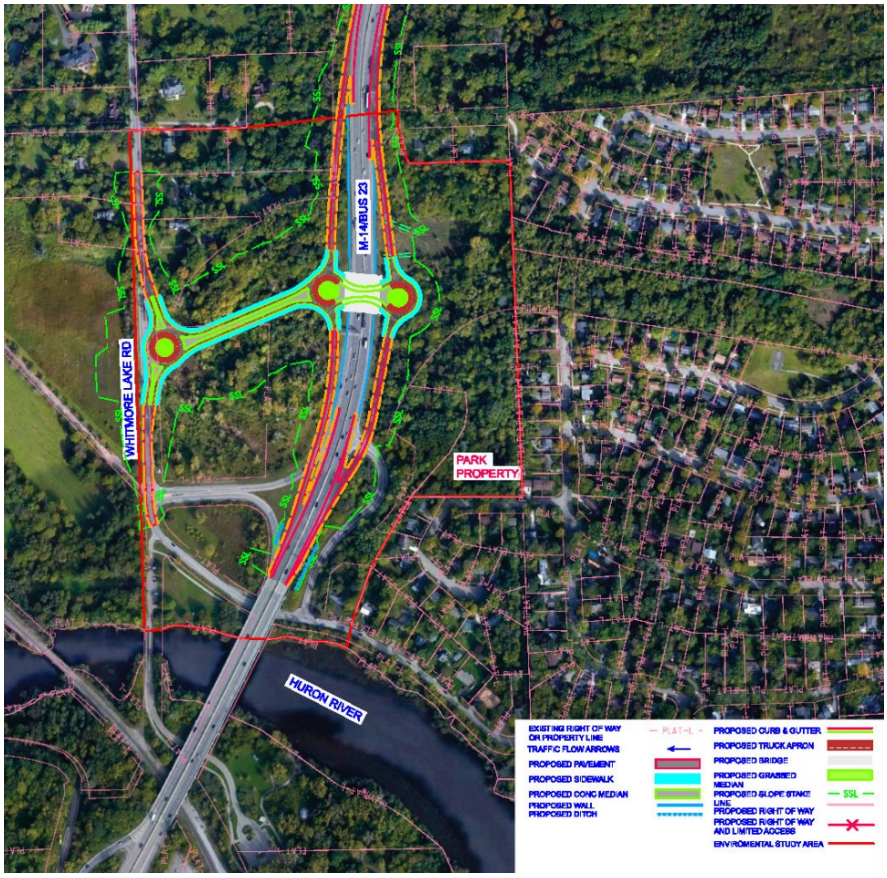
Figure 4 Modified Loop Alternative



Dual Roundabout

The Dual Roundabout concept would reconfigure the interchange to be a diamond layout with roundabout intersections at the terminals. This would provide on/off ramps in each quadrant and provide a connector road under M-14 to Whitmore Lake Road. This provides full access to/ from M-14 utilizing limited space between the ramps to reduce the footprint of the interchange.

Figure 5 Dual Roundabout Alternative



3. Alternatives Traffic Related Evaluation Methodology

Several tools were used to evaluate the traffic operations in the area. The primary tool utilized for the freeway mainline, auxiliary lanes and ramp systems was VISSIM. This microsimulation and visualization model is a powerful software package that can provide detailed measures of effectiveness for geometric concepts.

Additional analysis using Synchro software was performed to assess operation at intersections along the arterial network. This extended from the M-14 freeway to the nearest signalized intersection along Barton Drive and Main Street (US-23BR).

The third analysis tool used was Highway Capacity Software which allowed us to confirm operations and level of service results obtained from VISSIM.

4. Travel Demand Modeling and Comparison of Alternative 2

4.1 Future Travel Demand Growth

Atkins received SEMCOG latest version of SEMCOG E7 Travel Demand Model from MDOT. The E7 model was comprised of the 2020 base and 2045 forecast years.

The SEMCOG E7 travel model is a regional model based on the forecast of SEMCOG socioeconomic growth projections. It has a comprehensive modelling process, particularly the activity-based trip purposes and the university model and is calibrated with an extensive set of data. Atkins reviewed input data, zonal granularity, and highway network and confirmed that the SEMCOG E7 travel model to be used for travel demand forecasting. The travel model includes the future planned developments in the study area and captures the future growth.

In review of the model and the check for the inclusion of the US-23 flex lane, discrepancies in the laneage in the dual section of the M-14 / US-23 along with the section of M-14 at Barton Drive were discovered. These segments were modified to reflect the actual roadway network in those locations. Aside from those modifications the model was utilized as is and adequately represents the roadway network.

4.2 Impacts on Travel Demand

The Transcad model was used to measure the future growth of traffic across the network. Overall growth in the area is expected to be 0.41% per year for the period 2020-2045. As there was some variability within the network, the growth rate was calculated on a link-by-link basis for use in the analysis.

Due to the nature of the alternative to close the eastbound ramps (Alternative 2), it was also necessary to compare the travel patterns of that alternative to the no action and others. The Transcad model was modified to account for the ramp removal and the resulting traffic volume changes reported.

4.3 Impacts

The closure of the eastbound ramps will result in the diversion of the future expected volume of 12,000 vehicles per day (vpd) using the ramps to different routes. In general, Transcad model showed that this closure will result in additional traffic diverting to Jackson Avenue / Huron Street, Miller Road, Plymouth Road and Whitmore Lake Road. Localized decreases are expected such as in the immediate vicinity along Barton Drive.

Increased traffic in the 2045 horizon year is on the order of 2,000 vehicles per day (vpd) on the westbound off ramp to Whitmore Lake Road. Additionally, approximately 2,900 vpd are expected to utilize Whitmore Lake Road south of N. Territorial Road, further the loading on the roadway as well as the US-23 interchange. Other notable increases include an 850 vpd increase on Plymouth Road (west of US-23), an 675 vpd increase on Miller Road east of M-

14, 1,050 vpd increase on Broadway Street (at Maiden Lane) and an increase of 475 vpd on Jackson Avenue.

5. Alternatives Analysis Traffic Results

5.1 Alternatives Modeling Methodology

Using the travel demand model, the base year (2020) traffic volumes were appropriately adjusted to reflect the future traffic levels. The diversion of traffic due to the network changes was also factored in.

5.2 Alternatives Traffic Volumes

5.2.1 Average Daily Traffic Volumes

The existing volumes were obtained through count data provided by the MDOT and the City of Ann Arbor. This included data residing in the MDOT TDMS, 24-hour volumes and turning movement counts at select locations.

Using the Transcad model, link growth rates from 2020 to 2045 were computed. These rates were applied to the existing traffic volumes to determine the opening year (2025) and the horizon year (2045) traffic volumes. Complete details on the traffic volumes are contained in Appendix A of this attachment.

5.2.2 Peak Hour Traffic Volumes

Peak hour traffic volumes were compiled from the same sources, MDOT and the City of Ann Arbor. This count data included both turning movement volumes or link counts. The existing base volumes had appropriate growth rates and diversion factors applied.

Generally speaking, westbound M-14 traffic into the City of Ann Arbor was higher in the AM period, while eastbound (outbound) was higher in the afternoon and PM peak period.

Complete details on the traffic volumes utilized are contained in Appendix A of this attachment.

5.3 Alternatives Operational Analysis

Operational analysis for the effort included the analysis of the freeway and ramp network using the VISSIM modelling tool. This comprised of obtaining results under the software and comparing to the thresholds in the Highway Capacity Manual to assess as a level of service. Complete details on the methodology are contained in Appendix C.

Additional analysis was performed using the Highway Capacity Manual methods with HCS software to substantiate the results. The HCS results showed some variation of performance output compared to the VISSIM. This is generally attributed to the fact that HCS is a site-specific evaluation tool compared to the systemwide analysis capability of VISSIM.

A limited analysis was also performed on the arterial network for Barton Drive and Main Street. This analysis measured performance at select intersections for the different scenarios.

5.3.1 2025 Alternatives VISSIM Modeling

All four alternatives were modelled in VISSIM for the 2025 opening year and the 2045 horizon year. A total of 10 simulation runs were conducted and the results averaged. The performance was examined by comparing the performance measures including density, speed, volume and the implied level of service from the MOEs.

For the no action alternative, the eastbound M-14 freeway / ramp system performs at level of service (LOS) B in the AM peak and LOS C in the PM peak. The westbound direction performs at LOS C in the AM period and LOS B in the PM period. The simulated speeds through the corridor indicate acceptable levels, with only localized slowing at the stop controlled on ramp from Barton Drive. See figures 6 and 7 for schematic results.

Under the Close the Eastbound ramps (Alternative 2) scenario, the eastbound M-14 freeway system performs at level of service B and C in AM/PM peaks respectively. The westbound direction performs at LOS C/B during the AM and PM reported similar to the Alternative 1. Due to the ramp closure the westbound traffic volumes increase resulting in degradation of the weaving area between Whitmore Lake and Main Street. Details are contained in figures 8 and 9.

The increase in the traffic volumes on Whitmore Lake Road leads to poor operations at the ramp terminal which shows a LOS F and D during the AM/PM peaks respectively.

For the Modified Loop alternative, the eastbound M-14 freeway / ramp system performs at LOS B in the AM peak and LOS C in the PM peak. This is identical to the no action alternative despite the slight improvements in spacing. The westbound direction performs at LOS C in the AM period and LOS B in the PM period. Detailed lane schematics are shown in figures 10 and 11.

For the Dual Roundabout alternative, the eastbound M-14 freeway / ramp system performs at LOS C in both the AM peak and the PM peak. The westbound direction performs at LOS C in the AM period and LOS B in the PM period. Overall, it shows very similar performance compared to the No Action alternative and slight improvement over other alternatives. Speed

differentials appear to be smoother than others (higher ramp design speeds). Detailed lane schematics are shown in figures 12 and 13.

Figure 6 Alternative 1 - Lane Schematic - AM Peak – 2025

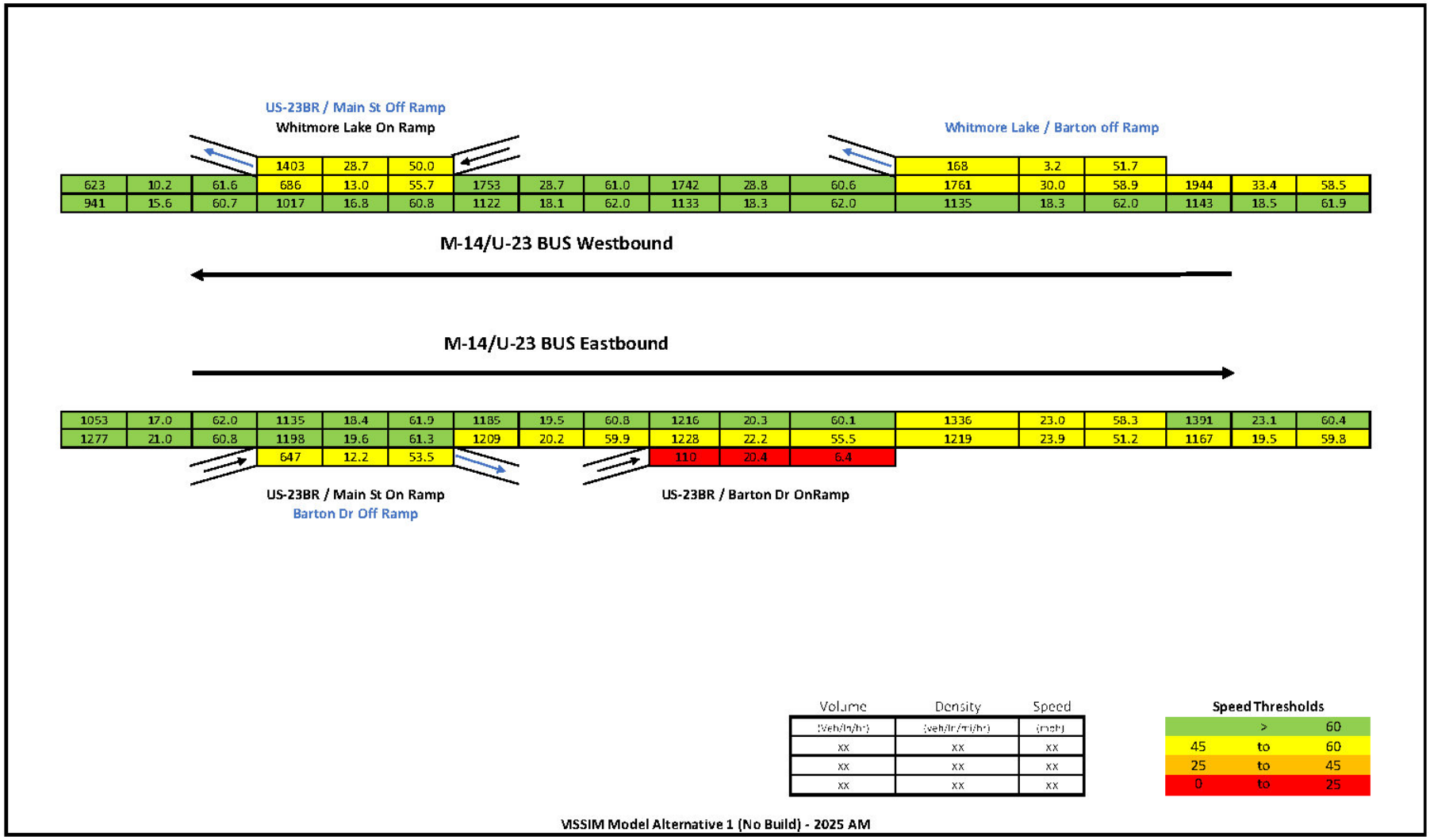


Figure 7 Alternative 1 - Lane Schematic - PM Peak – 2025

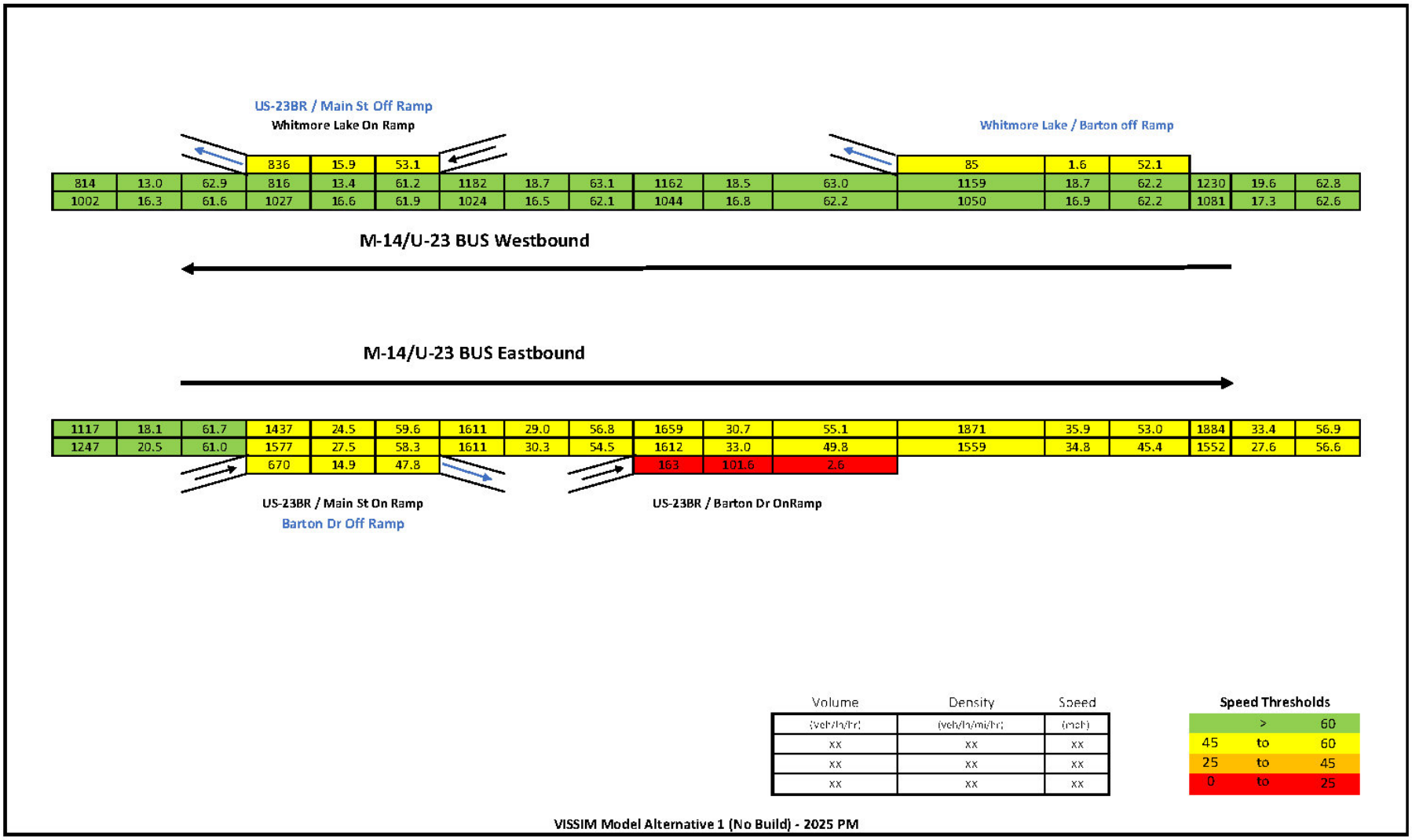


Figure 8 Alternative 2 - Lane Schematic - AM Peak – 2025

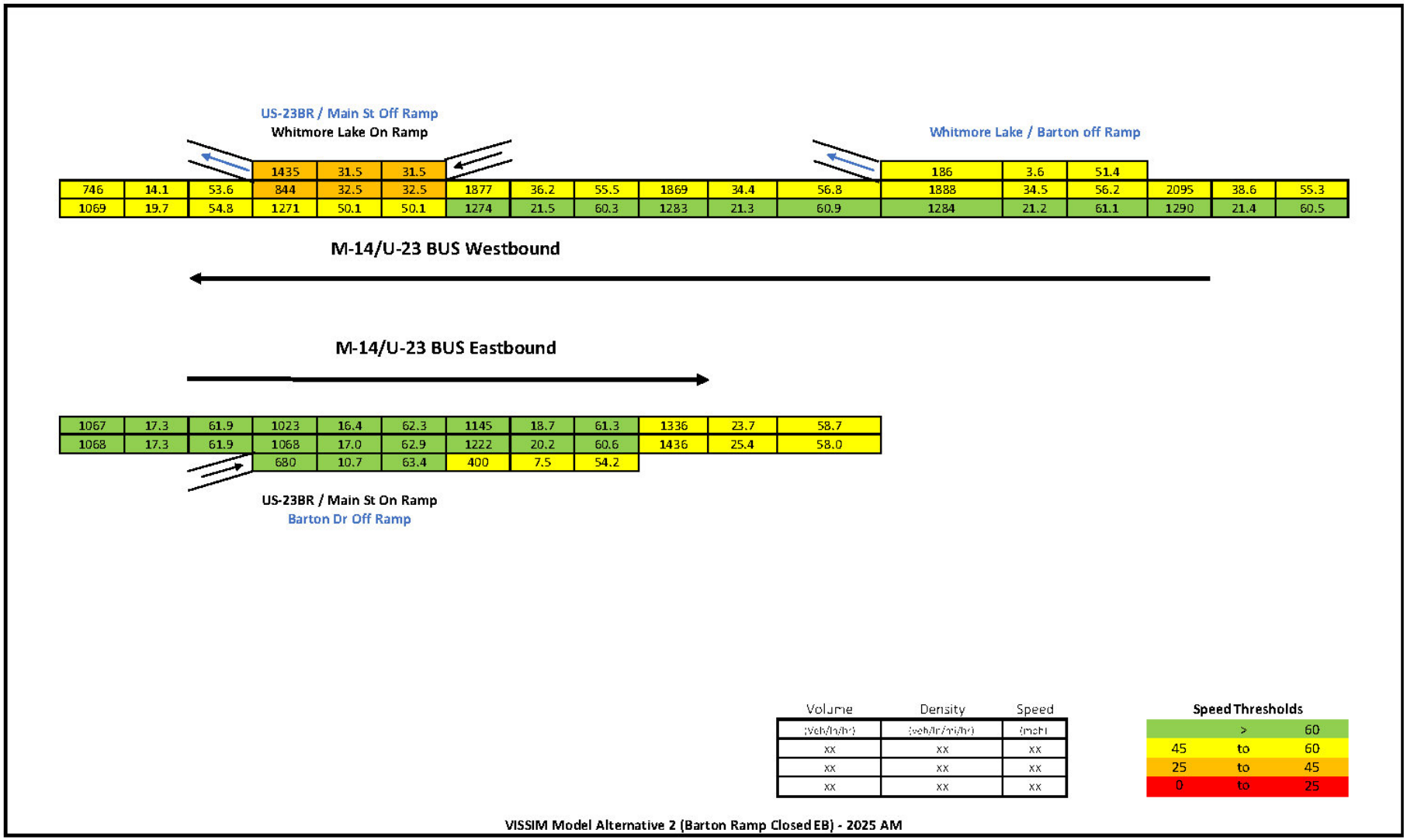


Figure 9 Alternative 2 - Lane Schematic - PM Peak – 2025

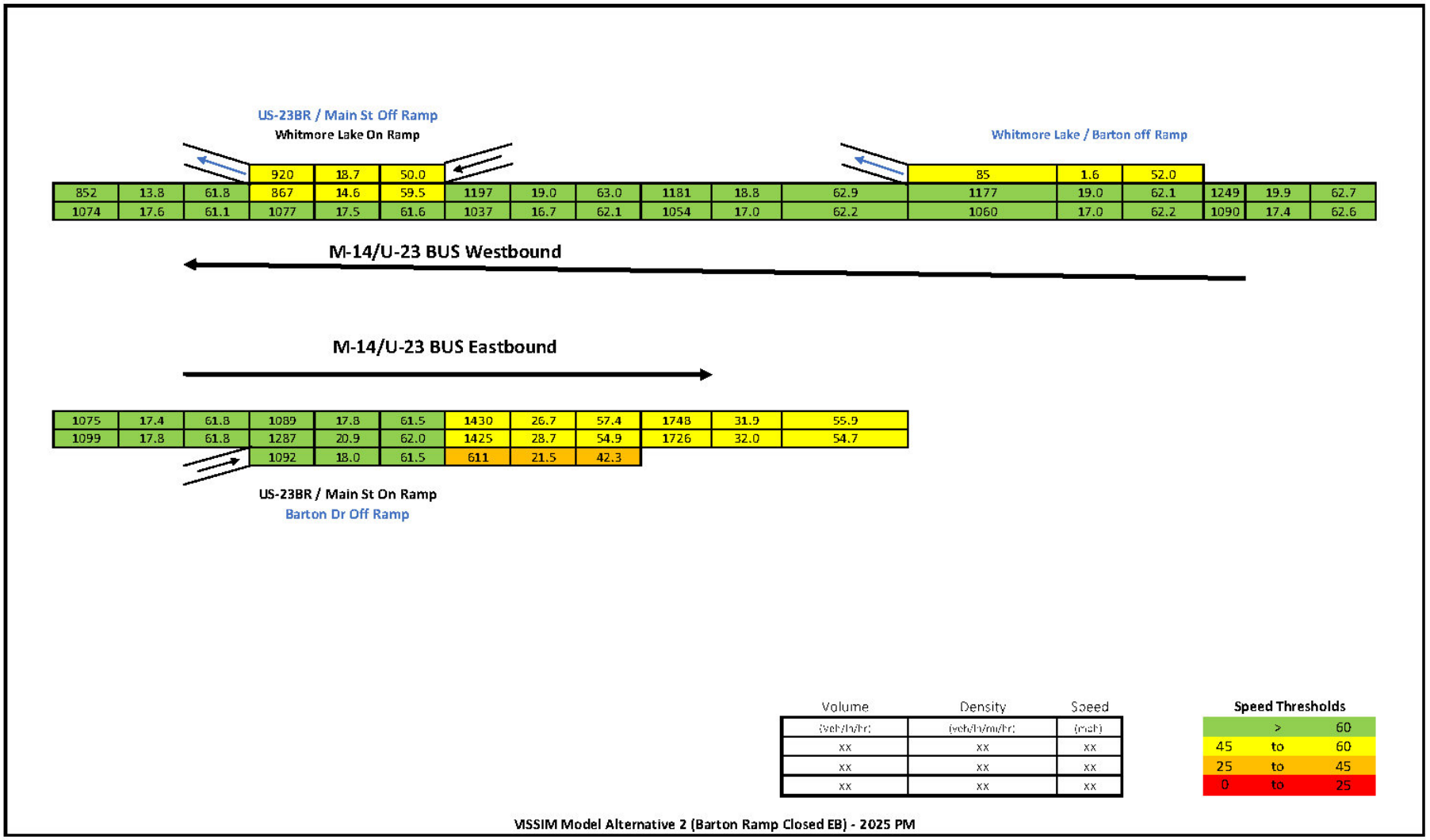


Figure 10 Alternative 3 - Lane Schematic - AM Peak – 2025

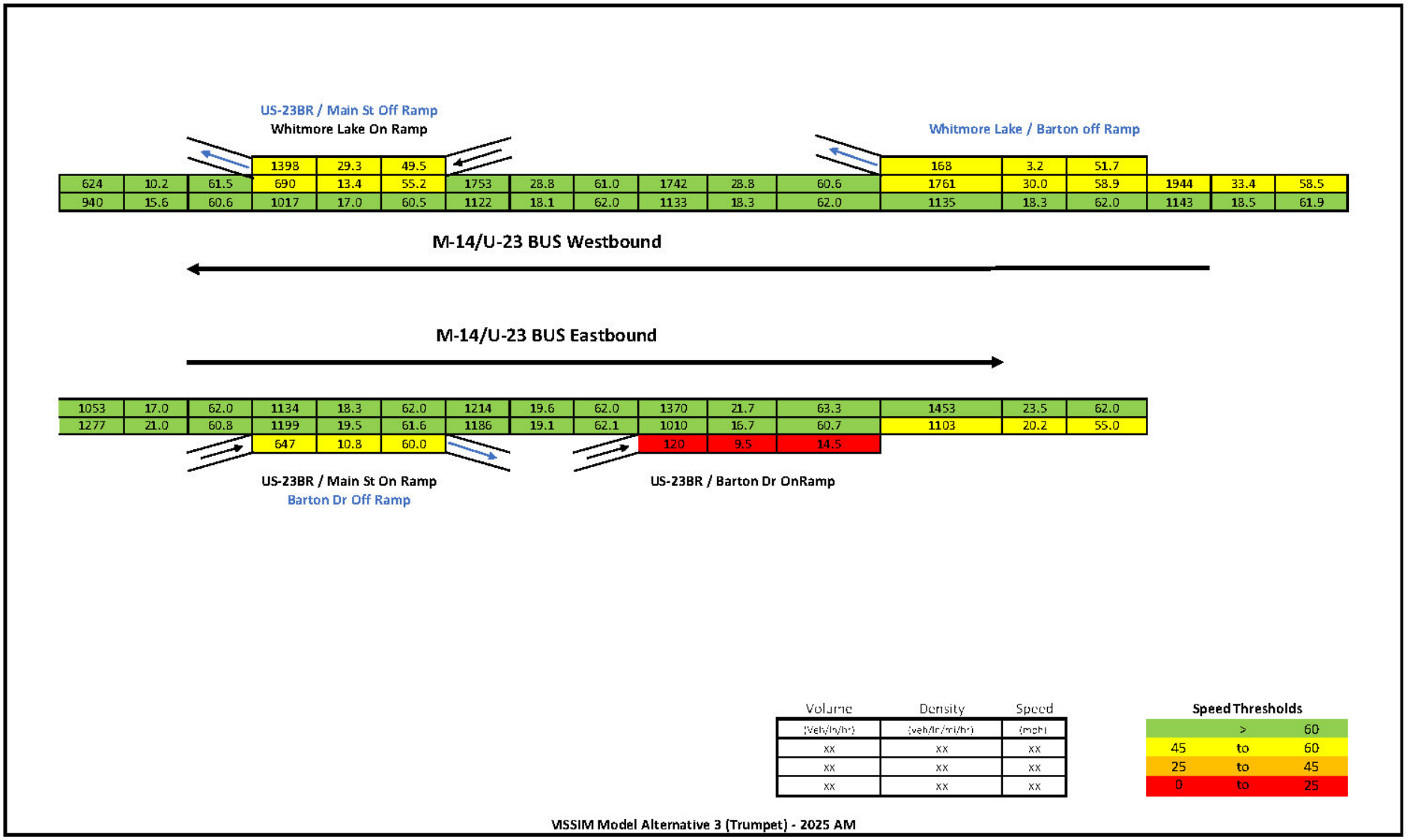


Figure 11 Alternative 3 - Lane Schematic - PM Peak – 2025

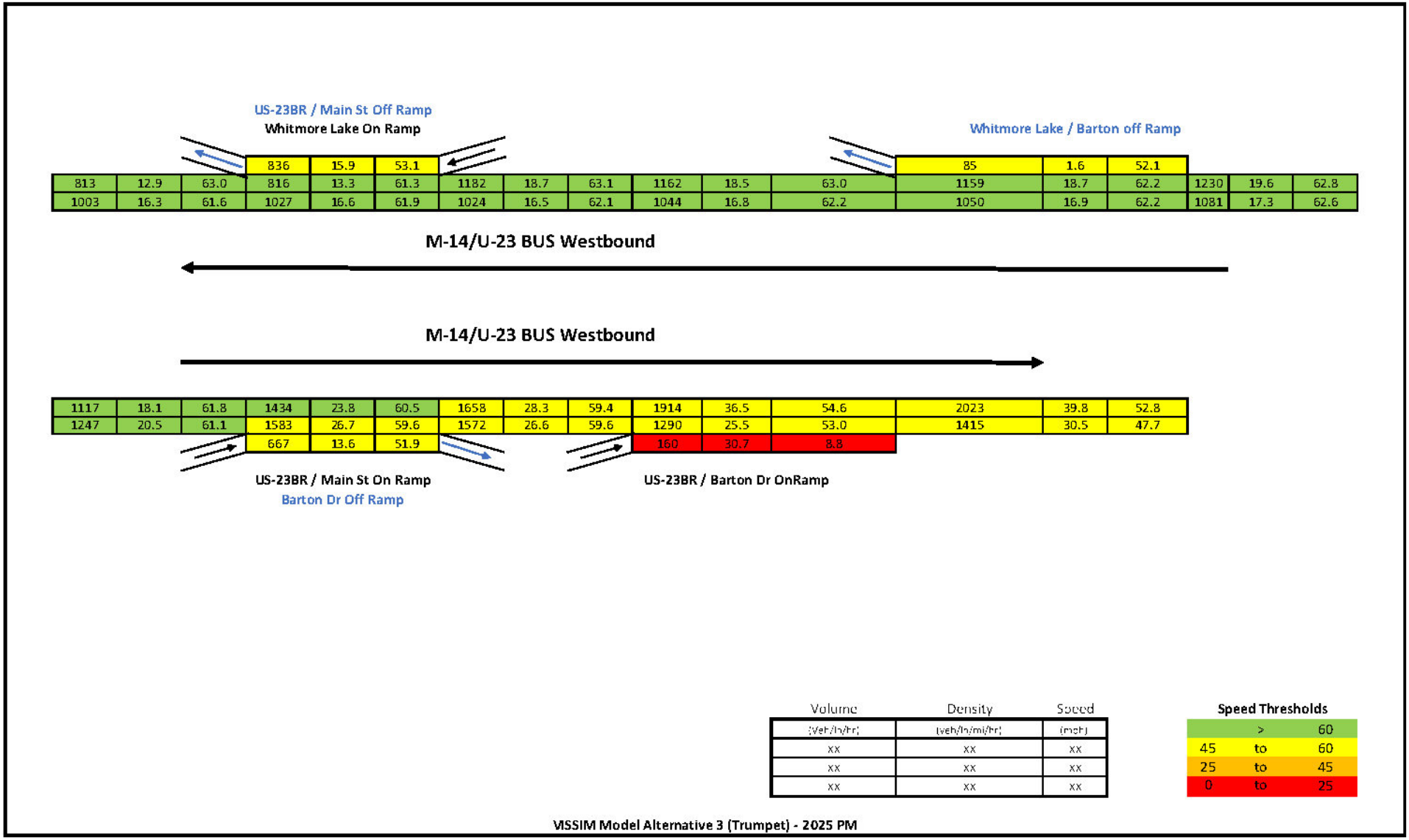


Figure 12 Alternative 4 - Lane Schematic - AM Peak – 2025

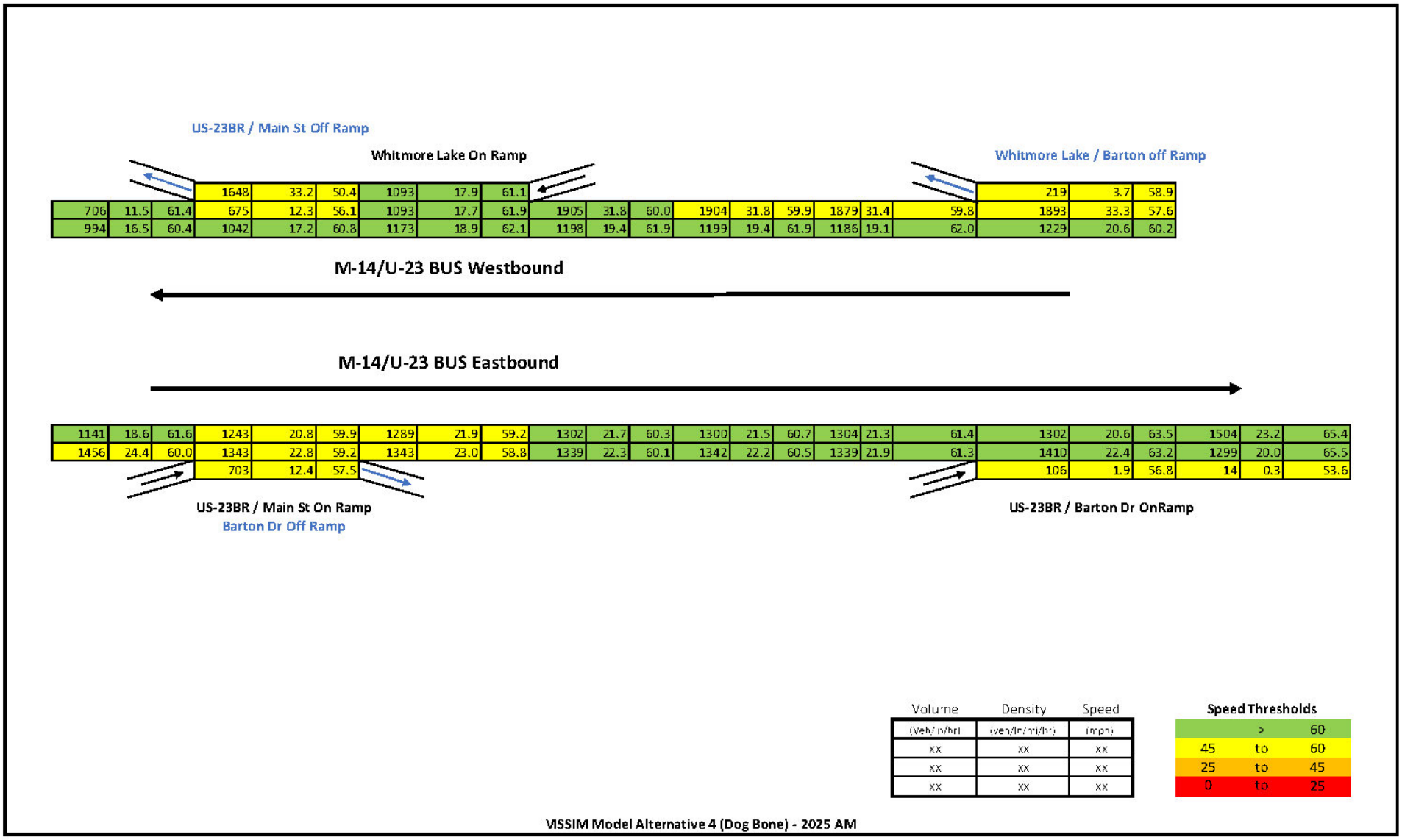
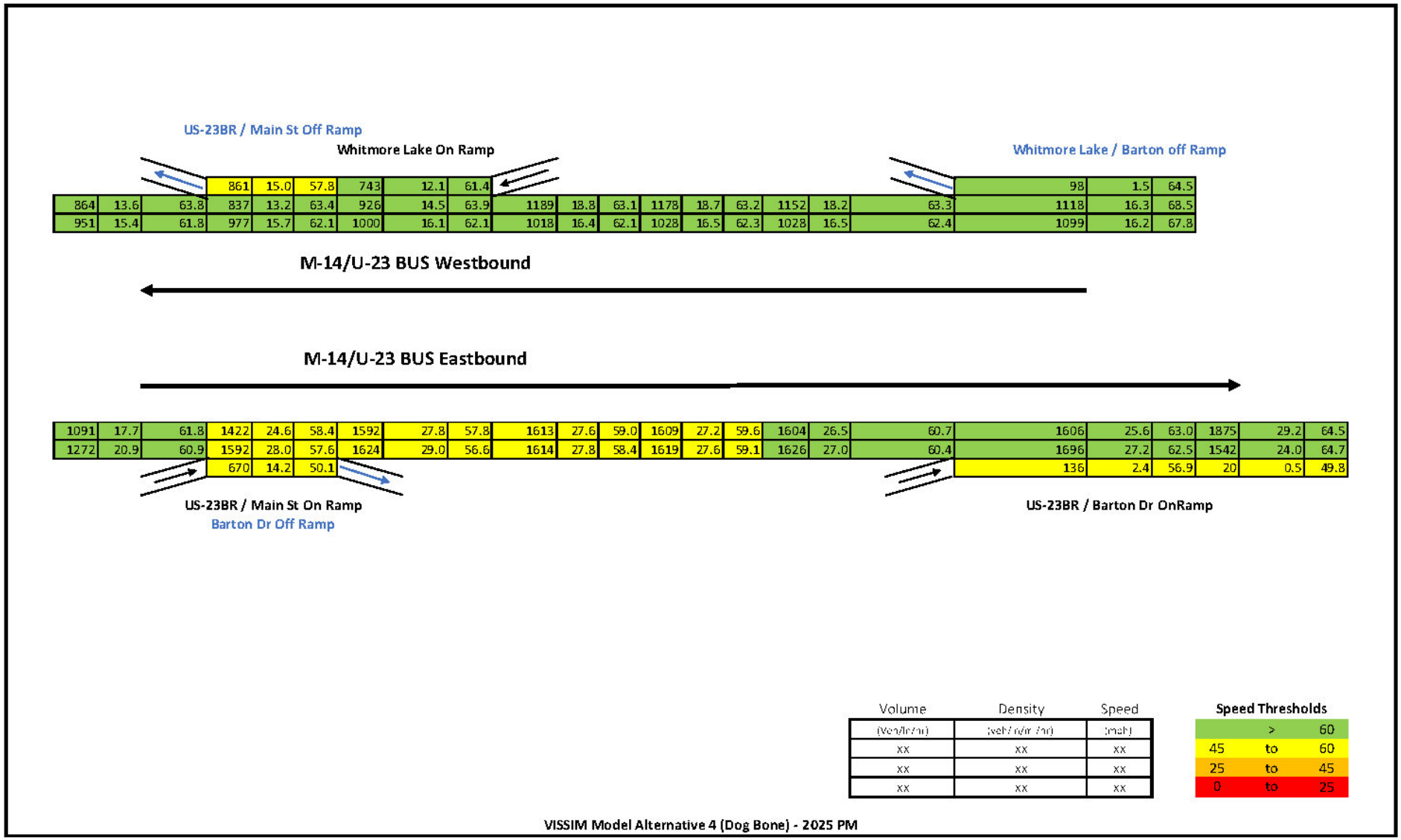


Figure 13 Alternative 4 - Lane Schematic - PM Peak - 2025



5.3.2 - 2025 Alternatives Synchro Analysis

Trafficware's Synchro software tool was used to examine the operations of the local roadway network. The segments included the Barton Road corridor between M-14 and Pontiac Trail intersection and the Main Street corridor from M-14 to Depot Street. These two segments represent the network from the interchange access to the nearest signalized intersection.

Using the traffic volumes developed for the 2025 opening year period and the volumes were overlaid on the existing geometry of the intersections (except at the interchange) for input into the software. The analysis was performed and reported in HCM methodology. The thresholds are shown below in Table 1.

Table 1: Intersection Level of Service (LOS) Thresholds

Level of Service	Traffic Signal Control Delay (sec/veh)	Stop Controlled Delay (sec/veh)
A	≤10	≤10
B	<20	<15
C	<35	<25
D	<55	<35
E	<80	<50

For the no action alternative, the All Way Stop Sign controlled ramp terminal intersection with Barton Drive is projected to operate at a LOS F during the AM and PM peak periods. The Whitmore Lake Road intersection with the westbound ramps is projected to operate at LOS C and A in the AM and PM peak respectively. The Barton Drive and Main Street corridors are detailed in Tables 2 and 3. The Barton Drive and Pontiac Trail intersection performs at LOS D / D.

For the Close the Eastbound ramps alternatives, Whitmore Lake Road ramp volume are projected to increase and this leads to poor operations at the ramp terminal. The Whitmore Lake ramp terminal intersection performs at LOS F/D. The Barton Drive and Main Street corridors are detailed in Tables 4 and 5. The Barton Drive and Pontiac Trail intersection performs at LOS C/D. The Main Street and Depot Street intersection performs at LOS D / F.

The Modified Loop alternative is equivalent in operations for the local network to the no action alternative – details are in Tables 2 and 3.

The Dual Roundabout alternative is very similar in operations with chief difference being the roundabout control at the terminals. The LOS is improved such that the LOS is reported at the realigned Barton Drive exit ramp would be LOS D for both periods. The Whitmore Lake Road terminal is improved over Alternative 2.

Table 2 Barton Drive Synchro Analysis - Alternative 1 & 3 - 2025

Peak	Intersection	Control	Northbound		Southbound		Eastbound		Westbound	
			Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
AM	Barton Dr/Whitmore Lake Rd & M-14 Ramps	Unsignalized	NA	NA	NA	NA	17.6	C	79.8	F
	Barton Dr and M-14 NB Ramp	Unsignalized	NA	NA	101.6	F	25.3	D	23.3	C
	Barton Dr and Brede Pl	Unsignalized	NA	NA	14.4	B	NA	NA	NA	NA
	Barton Dr and Longshore Dr	Unsignalized	19.9	C	NA	NA	NA	NA	NA	NA
	Barton Dr and Chandler Rd	Unsignalized	17.2	C	NA	NA	NA	NA	NA	NA
	Barton Dr and Pontiac Trail	Signalized	21.6	C	33	C	53.4	D	18.4	B
PM	Barton Dr/Whitmore Lake Rd & M-14 Ramps	Unsignalized	NA	NA	NA	NA	19.8	C	36.3	E
	Barton Dr and M-14 NB Ramp	Unsignalized	NA	NA	12.5	B	132.9	F	22.9	C
	Barton Dr and Brede Pl	Unsignalized	NA	NA	21.2	C	NA	NA	NA	NA
	Barton Dr and Longshore Dr	Unsignalized	16.7	C	NA	NA	NA	NA	NA	NA
	Barton Dr and Chandler Rd	Unsignalized	23	C	NA	NA	NA	NA	NA	NA
	Barton Dr and Pontiac Trail	Signalized	29.9	C	20.4	C	70.3	E	34	C

Table 3 MainStreet Synchro Analysis - Alternative 1,3 & 4 - 2025

Peak	Intersection	Control	Northbound		Southbound		Eastbound		Westbound	
			Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
AM	Huron River and M-14 EB On Ramp	Unsignalized	NA	NA	NA	NA	12.1	B	NA	NA
	Main St. and Huron River and M-14 WB Off Ramp	Unsignalized	NA	NA	NA	NA	48.9	E	53.2	F
	Main St. and Huronview Blvd	Unsignalized	NA	NA	NA	NA	18.8	C	NA	NA
	Main St. and Lakeshore Dr	Unsignalized	NA	NA	NA	NA	NA	NA	33.5	D
	Main St. and Depot St	Signalized	22.8	C	46.2	D	44.5	D	23.7	C
PM	Huron River and M-14 EB On Ramp	Unsignalized	NA	NA	NA	NA	21.9	C	NA	NA
	Main St. and Huron River and M-14 WB Off Ramp	Unsignalized	NA	NA	NA	NA	14.4	B	18.4	C
	Main St. and Huronview Blvd	Unsignalized	NA	NA	NA	NA	21	C	NA	NA

	Main St. and Lakeshore Dr	Unsignalized	NA	NA	NA	NA	NA	NA	52.7	F
	Main St. and Depot St	Signalized	33.4	C	24.1	C	44.7	D	177.6	F

Table 4 Barton Drive Synchro Analysis - Alternative 2 - 2025

Peak	Intersection	Control	Northbound		Southbound		Eastbound		Westbound	
			Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
AM	Barton Dr/Whitmore Lake Rd & M-14 Ramps	Unsignalized	NA	NA	NA	NA	25.2	D	853.7	F
	Barton Dr and Brede Pl	Unsignalized	NA	NA	12.5	B	NA	NA	NA	NA
	Barton Dr and Longshore Dr	Unsignalized	16.9	C	NA	NA	NA	NA	NA	NA
	Barton Dr and Chandler Rd	Unsignalized	15	C	NA	NA	NA	NA	NA	NA
	Barton Dr and Pontiac Trail	Signalized	15.4	B	22.6	C	34.9	C	20.2	C
PM	Barton Dr/Whitmore Lake Rd & M-14 Ramps	Unsignalized	NA	NA	NA	NA	20.6	C	210.3	F
	Barton Dr and Brede Pl	Unsignalized	NA	NA	19.8	C	NA	NA	NA	NA
	Barton Dr and Longshore Dr	Unsignalized	14.7	B	NA	NA	NA	NA	NA	NA
	Barton Dr and Chandler Rd	Unsignalized	17.9	C	NA	NA	NA	NA	NA	NA
	Barton Dr and Pontiac Trail	Signalized	24.6	C	16.3	B	29	C	36.1	D

Table 5 Main Street Synchro Analysis - Alternative 2 - 2025

Peak	Intersection	Control	Northbound		Southbound		Eastbound		Westbound	
			Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
AM	Huron River and M-14 EB On Ramp	Unsignalized	NA	NA	NA	NA	12.4	B	NA	NA
	Main St. and Huron River and M-14 WB Off Ramp	Unsignalized	NA	NA	NA	NA	51.5	F	54.5	F
	Main St. and Huronview Blvd	Unsignalized	NA	NA	NA	NA	83.3	F	NA	NA
	Main St. and Lakeshore Dr	Unsignalized	NA	NA	NA	NA	NA	NA	33.3	D
	Main St. and Depot St	Signalized	23	C	46.7	D	44.5	D	25.2	C
PM	Huron River and M-14 EB On Ramp	Unsignalized	NA	NA	NA	NA	21.8	C	NA	NA

	Main St. and Huron River and M-14 WB Off Ramp	Unsignalized	NA	NA	NA	NA	19.7	C	26.6	D
	Main St. and Huronview Blvd	Unsignalized	NA	NA	NA	NA	877.9	F	NA	NA
	Main St. and Lakeshore Dr	Unsignalized	NA	NA	NA	NA	NA	NA	48.6	E
	Main St. and Depot St	Signalized	30.3	C	19.5	B	44.7	D	176.3	F

Table 6 Barton Drive Synchro Analysis - Alternative 4 - 2025

Peak	Intersection	Control	Northbound		Southbound		Eastbound		Westbound	
			Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
AM	Barton Dr and Brede Pl	Unsignalized	NA	NA	10.3	B	NA	NA	NA	NA
	Barton Dr and Longshore Dr	Unsignalized	20.2	C	NA	NA	NA	NA	NA	NA
	Barton Dr and Chandler Rd	Unsignalized	17.5	C	NA	NA	NA	NA	NA	NA
	Barton Dr and Pontiac Trail	Signalized	22.1	C	35.1	D	54	D	18.8	B
	Roundabout - Barton/Whitmore & M-14 SB Ramps	Unsignalized	E							
	Roundabout - M-14 SB Ramps & M-14 SB	Unsignalized	C							
	Roundabout - M-14 NB & Barton Dr Ramp	Unsignalized	D							
PM	Barton Dr and Brede Pl	Unsignalized	NA	NA	18.4	C	NA	NA	NA	NA
	Barton Dr and Longshore Dr	Unsignalized	15.8	C	NA	NA	NA	NA	NA	NA
	Barton Dr and Chandler Rd	Unsignalized	23.5	C	NA	NA	NA	NA	NA	NA
	Barton Dr and Pontiac Trail	Unsignalized	27.8	C	19.8	B	37.1	D	43.8	D
	Roundabout - Barton/Whitmore & M-14 SB Ramps	Unsignalized	D							
	Roundabout - M-14 SB Ramps & M-14 SB	Unsignalized	B							
	Roundabout - M-14 NB & Barton Dr Ramp	Signalized	D							

5.3.3 - 2025 Alternatives Highway Capacity Analysis

Using the Highway Capacity Software (HCS), freeway mainline and ramp elements were evaluated to compare performances for each alternative. The LOS thresholds based on the Highway Capacity Manual (HCM) are shown in Tables 7 and 8.

Table 7: Urban Freeway Level of Service Thresholds – Basic

Level of Service	Freeway Facility Density (pc/mi/ln)
A	≤11
B	>11-18
C	>18-26
D	>26-35
E	>35-45
F	>45 or any component segment with a volume-to-capacity ratio greater than 1.00

Source: Highway Capacity Manual, 6th Edition.

Table 8: Urban Freeway Level of Service (LOS) Thresholds – Weaving

Level of Service	Freeway Facility Density (pc/mi/ln)
A	≤10
B	>10-20
C	>20-28
D	>28-35
E	>35
F	>43 or any component segment with a volume-to-capacity ratio greater than 1.00

Source: Highway Capacity Manual, 6th Edition.

For the no action alternative, the eastbound M-14 freeway / ramp system performs at level of service (LOS) C in the AM peak and LOS F in the PM peak. The westbound direction performs at LOS E / F in the AM period and LOS C/D in the PM period.

Table 9 HCS Analysis - Alternative 1- 2025

Route	Segment	Type	AM Peak			PM Peak		
			Volume	Density	LOS	Volume	Density	LOS
M-14 EB	M-14 EB	Basic	2781	24.4	C	4043	-	F
	Main St. On Ramp	Merge	836	33.7	C	1797	-	F
	M-14 EB	Weave	1623	26.9	C	2168	-	F
	Barton Dr Off Ramp	Diverge	937	29.6	C	695	42.2	E
M-14 WB	M-14 WB	Basic	3429	33	D	2948	26.3	D
	Whitmore Lake Off Ramp	Diverge	314	39.4	E	301	37.4	D
	Whitmore Lake On Ramp	Merge	571	-	F	474	32.8	D
	M-14 WB	Weave	2364	-	F	1379	24.9	C
	Main St. Off Ramp	Diverge	1943	-	F	991	25.6	C

Under the Close the Eastbound ramps (Alternative 2) scenario, the eastbound M-14 freeway / ramp system performs at level of service (LOS) E/ F in the AM and LOS F in the PM peak. The westbound direction performs at LOS D /F in the AM period and LOS B /C in the PM period. Some degradation is noted on the westbound direction as additional traffic loading is projected on the WB ramp to Whitmore Lake Road. This is due to eastbound traffic rerouting via a downstream interchange to back track to the Whitmore Lake Rd interchange.

Table 10 HCS Analysis - Alternative 2- 2025

Route	Segment	Type	AM Peak			PM Peak		
			Volume	Density	LOS	Volume	Density	LOS
M-14 EB	M-14 EB	Basic	3517	34.5	D	4505	-	F
	Main St. On Ramp	Merge	881	37.8	D	1793	-	F
M-14 WB	M-14 WB	Basic	3339	31.6	D	2855	25.2	C
	Whitmore Lake Off Ramp	Diverge	584	33.3	D	756	25.5	C
	Whitmore Lake On Ramp	Merge	651	37.1	D	541	27.1	C
	M-14 WB	Weave	2501	-	F	1427	20.7	C
	Main St. Off Ramp	Diverge	1968	-	F	984	19.9	B

For the Modified Loop alternative, the eastbound M-14 freeway / ramp system performs at level of service (LOS) C/D in the AM peak and LOS F in the PM peak. Some degradation is shown on the segment north of Barton due to the free-flow ramp impacts (entering traffic not metered by stop control). The westbound direction performs at LOS E/F in the AM period and LOS C/D in the PM period.

Table 11 HCS Analysis - Alternative 3- 2025

Route	Segment	Type	AM Peak			PM Peak		
			Volume	Density	LOS	Volume	Density	LOS
M-14 EB	M-14 EB	Basic	2781	24.4	C	4043	-	F
	Main St. On Ramp	Merge	836	31.5	D	1797	45	F
	Barton On Ramp	Merge	316	28.3	C	410	-	F
	M-14 EB	Weave	1623	26.7	C	2168	-	F
	Barton Dr Off Ramp	Diverge	937	29.6	C	695	42.2	E
M-14 WB	M-14 WB	Basic	3429	33	D	2948	26.3	D
	Whitmore Lake Off Ramp	Diverge	314	39.4	E	301	37.4	D
	Whitmore Lake On Ramp	Merge	571	-	F	474	32.8	D
	M-14 WB	Weave	2364	-	F	1379	24.9	C
	Main St. Off Ramp	Diverge	1943	-	F	991	25.6	C

The Dual Roundabout alternative performs at LOS C in the AM peak and LOS F in the PM peak. The westbound direction performs at LOS E/F in the AM period and LOS C/D in the PM period. Thus overall it shows slightly improved performance compared to No Action and improvement over other alternatives.

Table 12 HCS Analysis - Alternative 4- 2025

Route	Segment	Type	AM Peak			PM Peak		
			Volume	Density	LOS	Volume	Density	LOS
M-14 EB	M-14 EB	Basic	2781	24.4	C	4043	-	F
	Main St. On Ramp	Merge	836	33.9	C	1797	-	F
	Barton On Ramp	Merge	316	28.2	C	410	-	F
	M-14 EB	Weave	1623	26.7	C	2168	-	F
	Barton Dr Off Ramp	Diverge	937	29.6	C	695	42.2	E
M-14 WB	M-14 WB	Basic	3429	33	D	2948	26.3	D
	Whitmore Lake Off Ramp	Diverge	314	39.4	E	301	37.4	D
	Whitmore Lake On Ramp	Merge	571	-	F	474	32.8	D
	M-14 WB	Weave	2364	-	F	1379	24.9	C
	Main St. Off Ramp	Diverge	1943	-	F	991	25.6	C

5.3.4 2045 Alternatives VISSIM Modeling

The four alternatives were modelled in VISSIM loaded with 2045 volumes. A total of 10 simulation runs were conducted for each alternative and the results were averaged. The alternatives were evaluated for performance measures that included density, speed, volumes and the implied level of service based on these MOEs.

For the No Action alternative, the eastbound M-14 freeway / ramp system performs at LOS C in the AM peak and LOS E/F in the PM peak respectively. The westbound direction performs at LOS B - D in the AM period and LOS B/C in the PM period.

Under the Close the Eastbound ramps (Alternative 2) scenario the eastbound M-14 freeway / ramp system performs at LOS F in both the AM and PM peaks. The westbound direction performs at LOS B - E in the AM period and LOS B /C in the PM period. Due to the additional traffic loading on the westbound direction, due to eastbound traffic turning around and re-routing to the interchange, decreased performance is shown.

For the Modified Loop alternative, the eastbound M-14 freeway / ramp system performs at LOS B/C in the AM peak and LOS D/E/F in the PM peak. Some degradation is shown on the segment north of Barton due to the free-flow ramp impacts (entering traffic not metered by stop control). The westbound direction performs at LOS B thru D in the AM period and LOS B/C in the PM period.

For the Dual Roundabout alternative, the eastbound M-14 freeway / ramp system performs at LOS B/C in the AM peak and LOS C/D in the PM peak. The westbound direction performs at LOS B/C in the AM period and LOS B in the PM period. Thus overall, it shows slightly improved performance compared to the No Action and an improvement over other build alternatives.

Figure 14 Alternative 1 - Lane Schematic - AM Peak – 2045

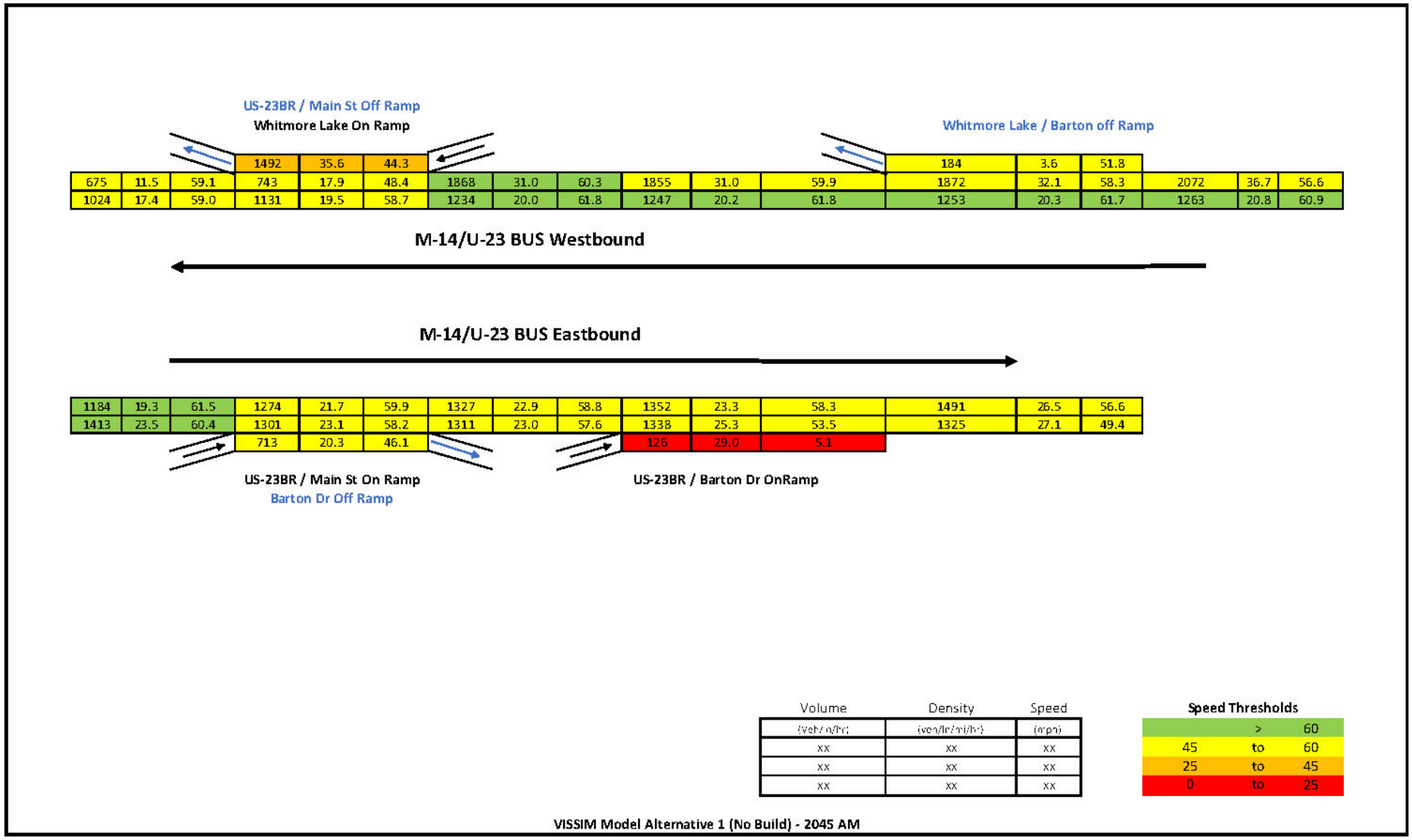


Figure 15 Alternative 1 - Lane Schematic - PM Peak – 2045

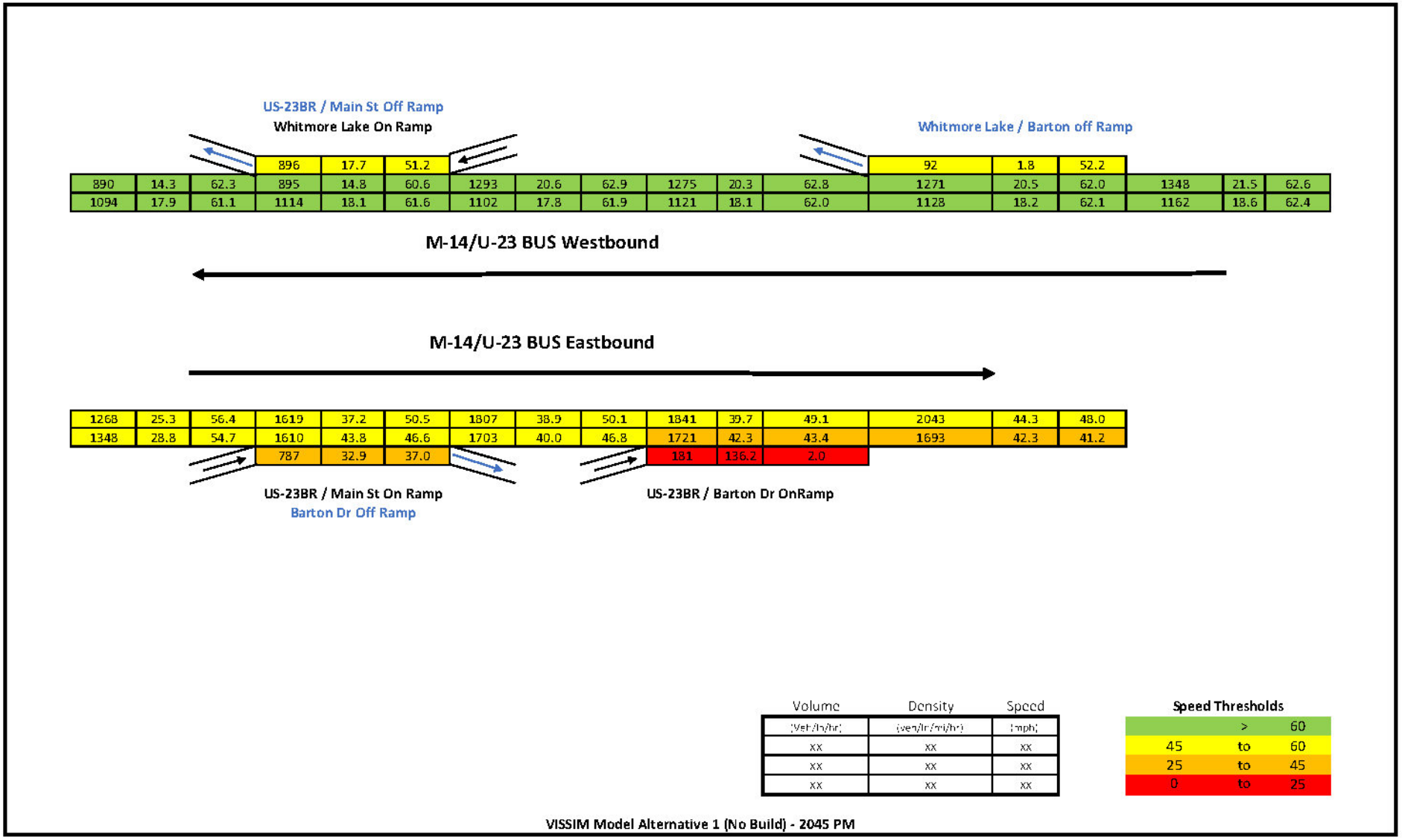


Figure 16 Alternative 2 - Lane Schematic - AM Peak – 2045

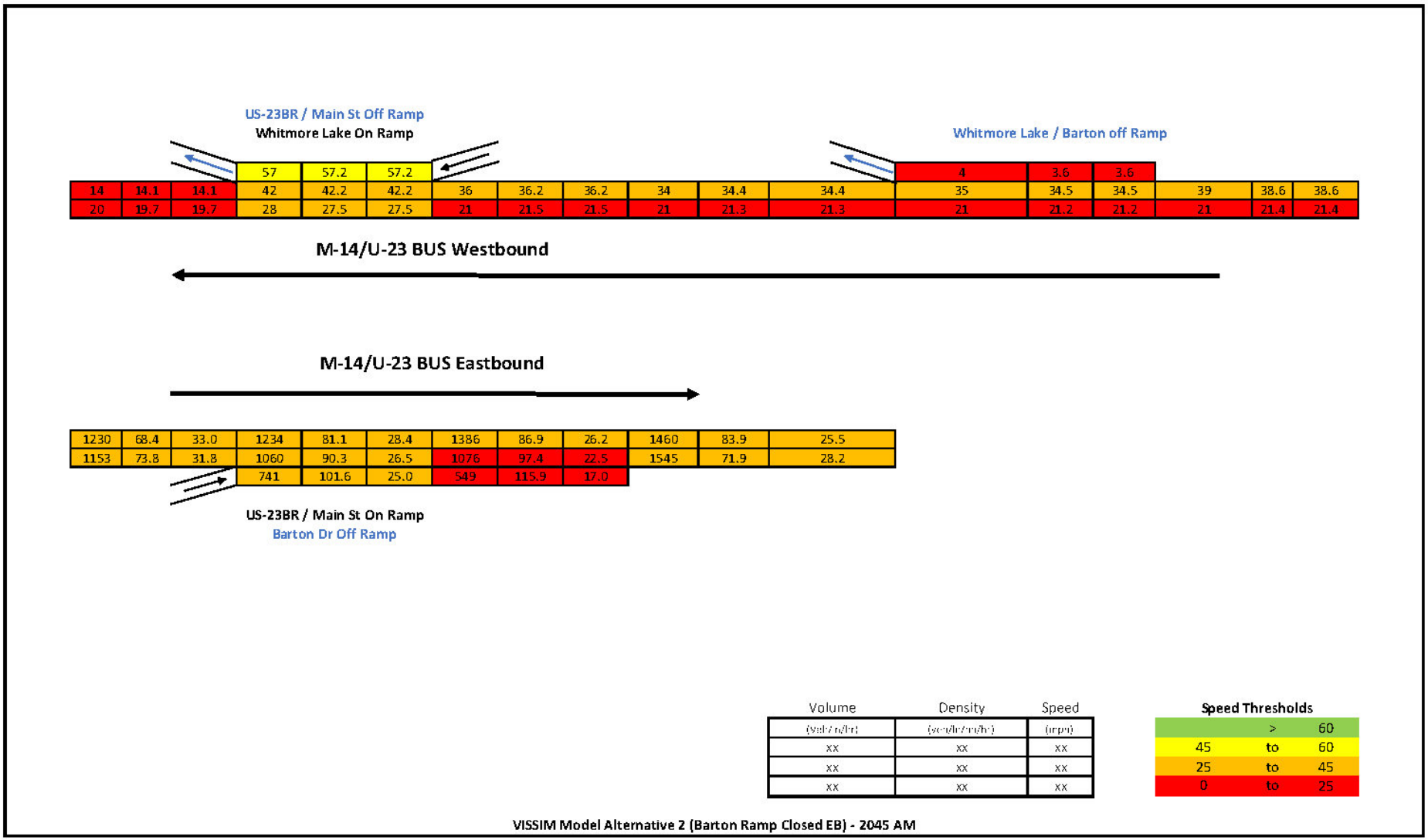


Figure 17 Alternative 2 - Lane Schematic - PM Peak – 2045

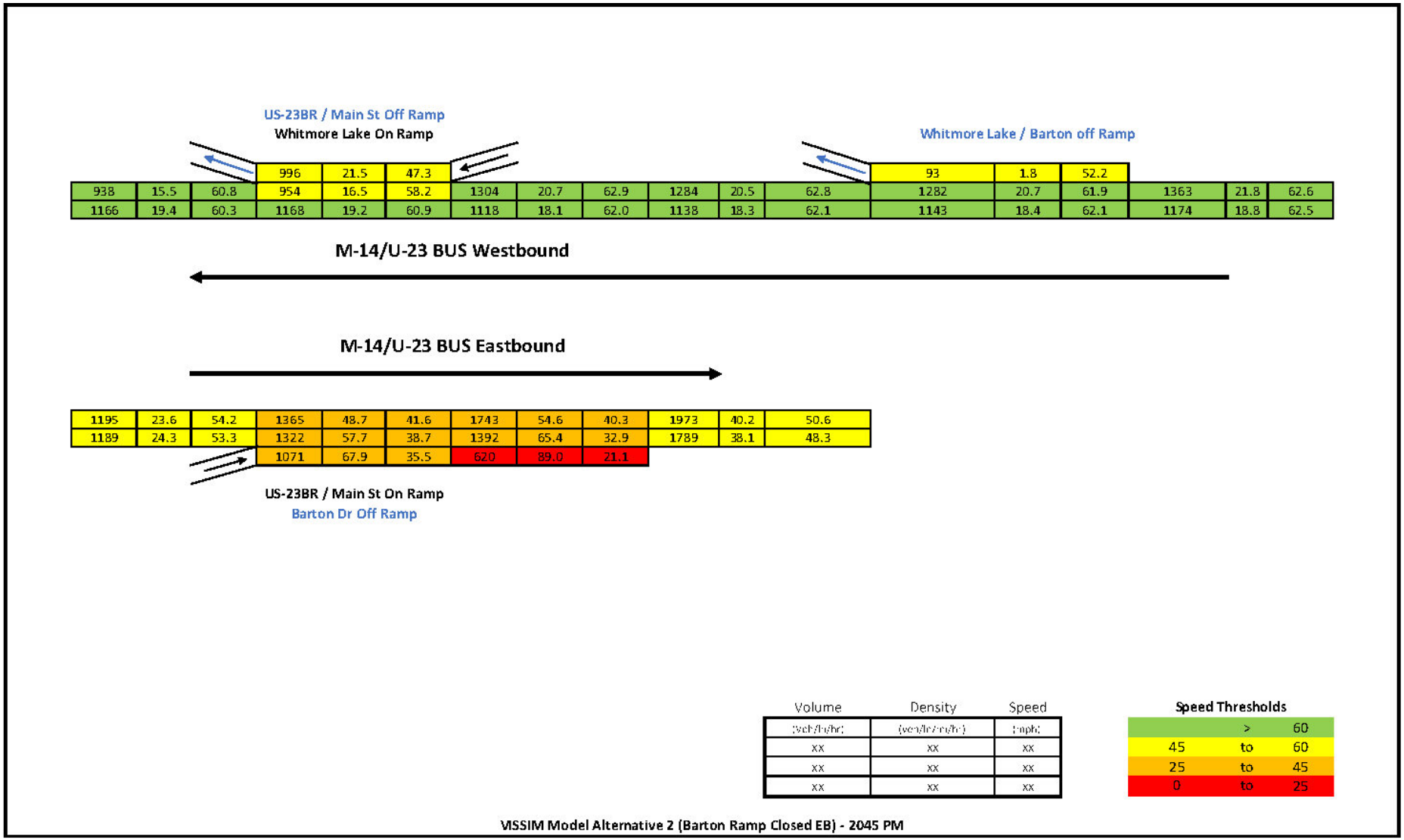


Figure 18 Alternative 3 - Lane Schematic - AM Peak – 2045

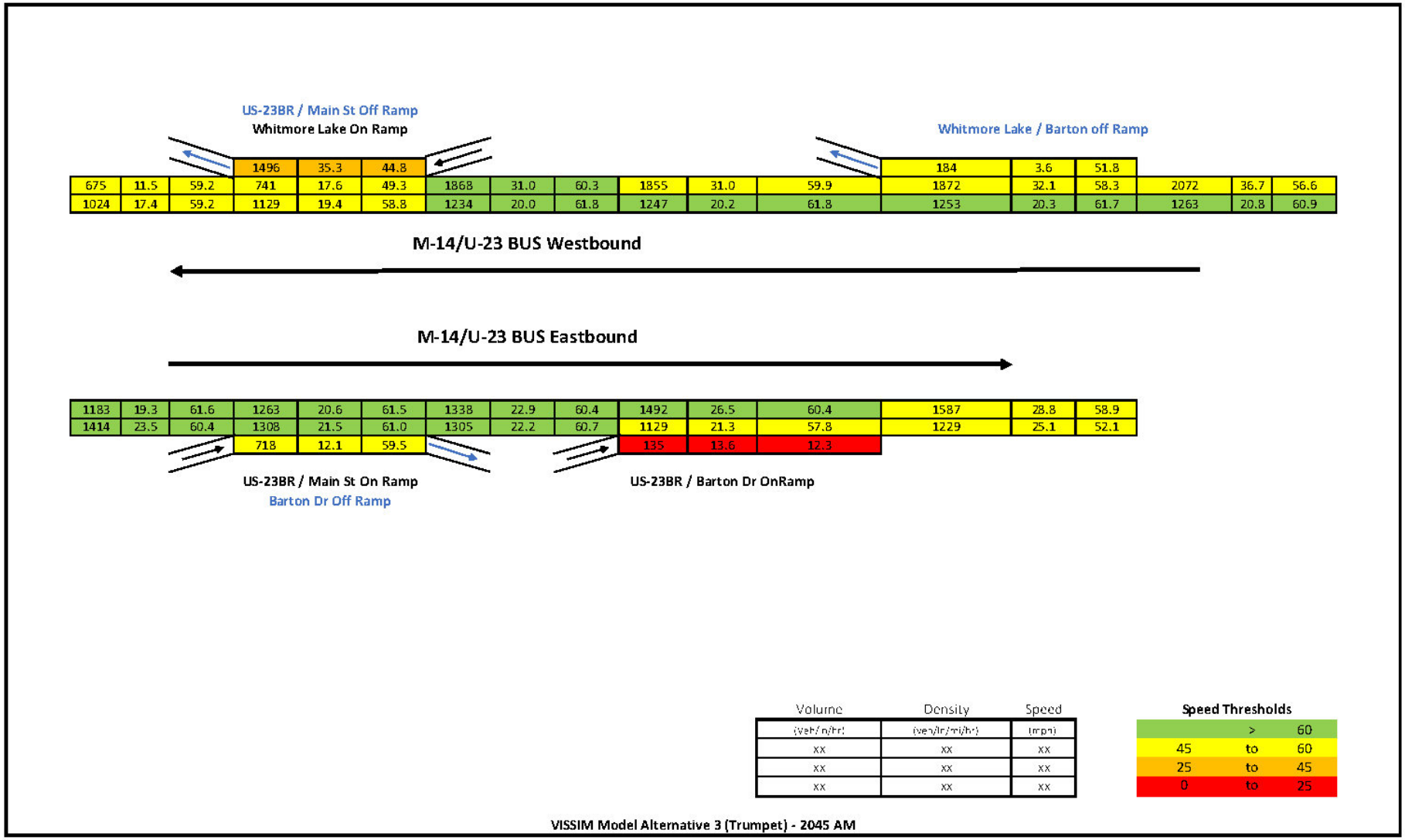


Figure 19 Alternative 3 - Lane Schematic - PM Peak – 2045

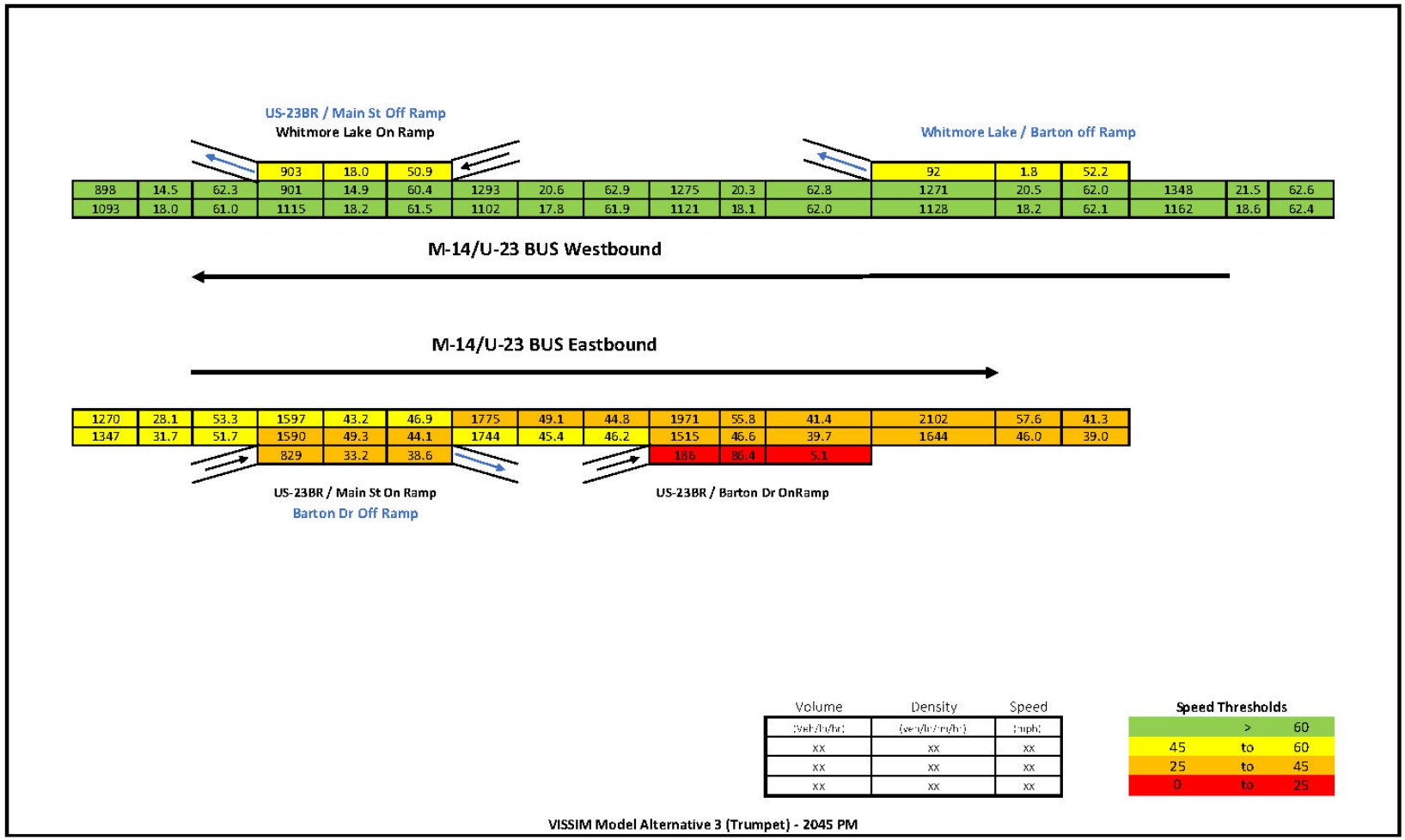


Figure 20 Alternative 4 - Lane Schematic - AM Peak – 2045

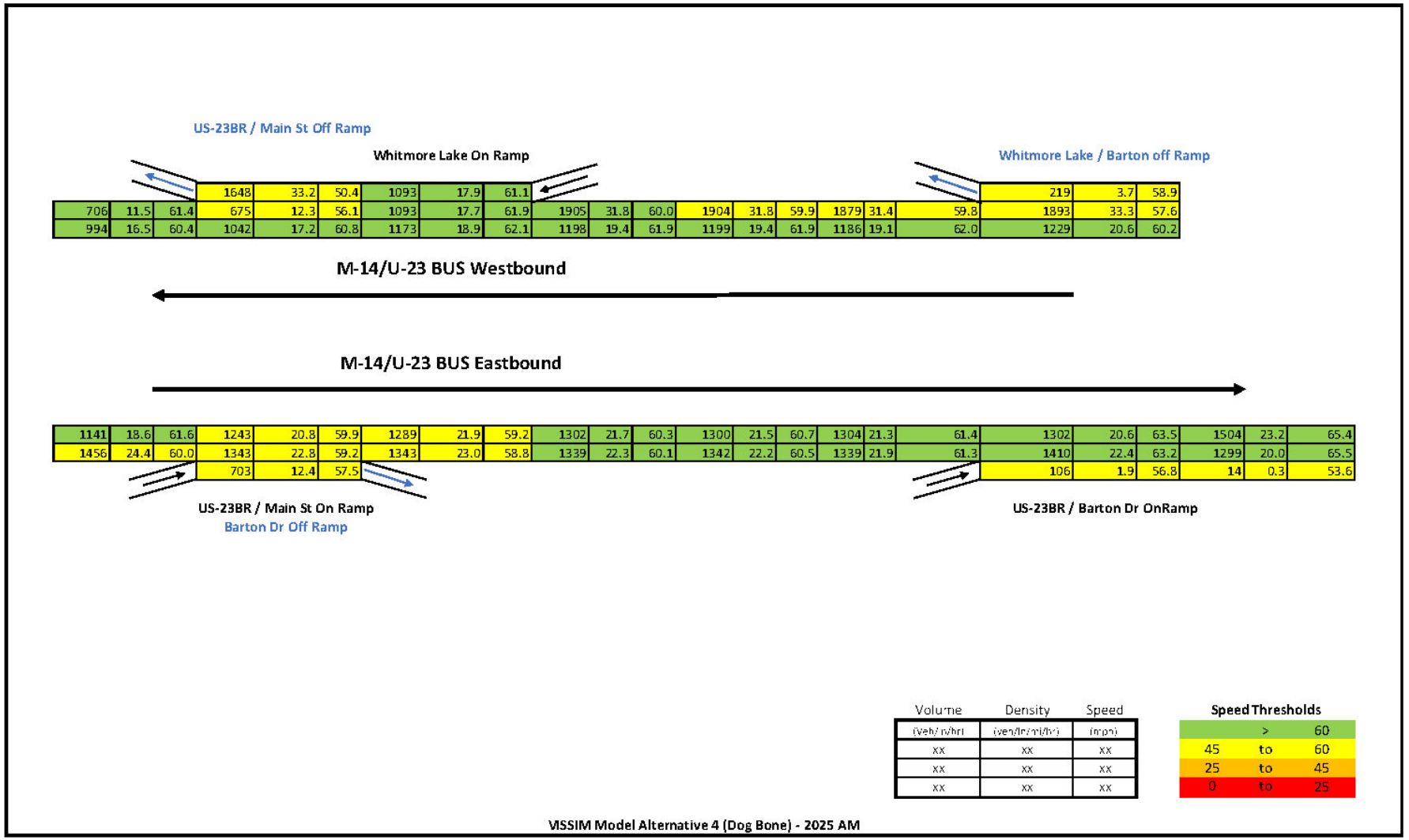
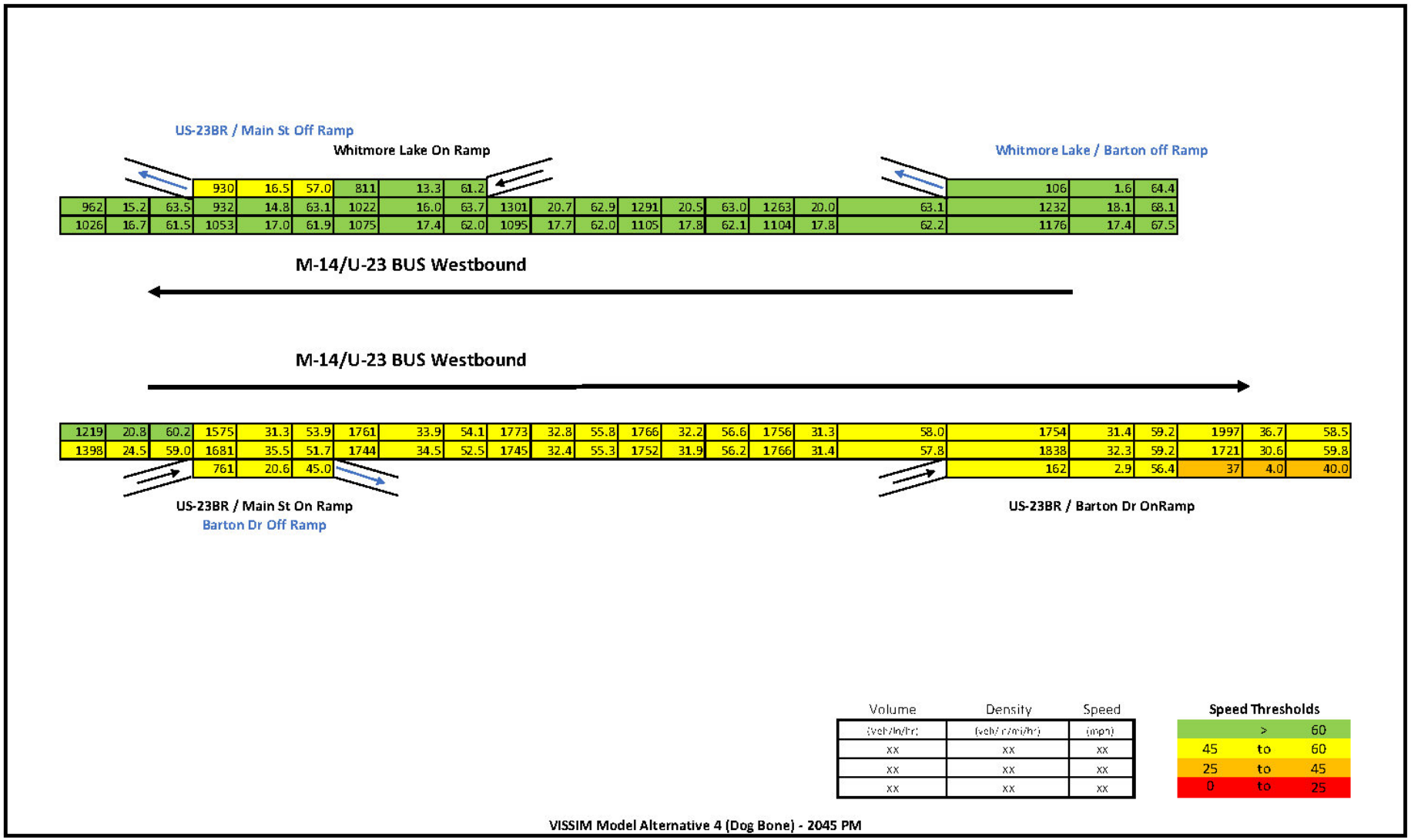


Figure 21 Alternative 4 - Lane Schematic - PM Peak – 2045



5.3.5 2045 Alternatives Synchro Analysis

The four alternatives were examined for the horizon year 2045 traffic volumes using the Synchro software. The limits of the Synchro analysis was the Barton Road corridor between M-14 and the Pontiac Trail intersection and the Main Street corridor from M-14 to Depot Street. These both represent the local roadway network from the interchange access to the signalized intersection nearest the freeway.

Using the traffic volumes developed for the 2045 horizon year period and the overlaying on the existing geometry of the intersections (except at the interchange). The analysis was performed and reported in HCM methodology. The thresholds were shown previously in Table 1.

For the no action alternative, the all way stop controlled ramp terminal intersection with Barton Drive is projected to operate at a LOS F during the AM and PM peak periods. Alternatively, the Whitmore Lake Road intersection with the westbound ramps operates at LOS C and A in the AM and PM peak respectively. The Barton Drive and Main Street corridors are detailed in tables 14. The Barton Drive and Pontiac Trail intersection performs at LOS D / D.

For the Close the Eastbound ramps alternatives, Whitmore Lake Road ramp volume are increased and this leads to poor operations at the ramp terminal. The Whitmore Lake ramp terminal intersection performs at LOS F/D. The Barton Drive and Main Street corridors are detailed in tables 15 and 16. The Barton Drive and Pontiac Trail intersection performs at LOS C/D. The Main Street and Depot Street intersection performs at LOS D / F.

The Modified Loop alternative is equivalent in operations for the local network to the no action alternative – details are in Tables 14.

The Dual Roundabout alternative is very similar in operations with chief difference being the roundabout control at the terminals. The LOS is improved such that the LOS is reported at the realigned Barton Drive exit ramp would be LOS D for both periods. The Whitmore Lake Road terminal is improved over Alternative 2.

Table 13 Barton Drive Synchro Analysis - Alternative 1 & 3 - 2045

Peak	Intersection	Control	Northbound		Southbound		Eastbound		Westbound	
			Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
AM	Barton Dr/Whitmore Lake Rd & M-14 Ramps	Unsignalized	NA	NA	NA	NA	22	C	254	F
	Barton Dr and M-14 NB Ramp	Unsignalized	NA	NA	174	F	42.9	E	28.6	D
	Barton Dr and Brede Pl	Unsignalized	NA	NA	16	C	NA	NA	NA	NA
	Barton Dr and Longshore Dr	Unsignalized	21.8	C	NA	NA	NA	NA	NA	NA
	Barton Dr and Chandler Rd	Unsignalized	18.4	C	NA	NA	NA	NA	NA	NA
	Barton Dr and Pontiac Trail	Signalized	24.8	C	38.3	D	76.7	E	18.9	B
PM	Barton Dr/Whitmore Lake Rd & M-14 Ramps	Unsignalized	NA	NA	NA	NA	25.1	D	74.6	F
	Barton Dr and M-14 NB Ramp	Unsignalized	NA	NA	32.5	D	13.9	B	212	F
	Barton Dr and Brede Pl	Unsignalized	NA	NA	24.2	C	NA	NA	NA	NA
	Barton Dr and Longshore Dr	Unsignalized	19.1	C	NA	NA	NA	NA	NA	NA
	Barton Dr and Chandler Rd	Unsignalized	24.5	C	NA	NA	NA	NA	NA	NA
	Barton Dr and Pontiac Trail	Signalized	35.8	D	21.3	C	128	F	44.3	D

Table 14 Barton Drive Synchro Analysis - Alternative 2 - 2045

Peak	Intersection	Control	Northbound		Southbound		Eastbound		Westbound	
			Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
AM	Barton Dr/Whitmore Lake Rd & M-14 Ramps	Unsignalized	NA	NA	NA	NA	59.1	F	-	F
	Barton Dr and Brede Pl	Unsignalized	NA	NA	13.8	B	NA	NA	NA	NA
	Barton Dr and Longshore Dr	Unsignalized	18.9	C	NA	NA	NA	NA	NA	NA
	Barton Dr and Chandler Rd	Unsignalized	16.1	C	NA	NA	NA	NA	NA	NA
	Barton Dr and Pontiac Trail	Signalized	16.6	B	23	C	35.9	D	20.1	C
PM	Barton Dr/Whitmore Lake Rd & M-14 Ramps	Unsignalized	NA	NA	NA	NA	31.2	D	788	F
	Barton Dr and Brede Pl	Unsignalized	NA	NA	15.5	C	NA	NA	NA	NA
	Barton Dr and Longshore Dr	Unsignalized	13.2	B	NA	NA	NA	NA	NA	NA
	Barton Dr and Chandler Rd	Unsignalized	18.8	C	NA	NA	NA	NA	NA	NA
	Barton Dr and Pontiac Trail	Signalized	32	C	20.3	C	30.1	C	43.1	D

Table 15 Main Street Synchro Analysis - Alternative 2 2045

Peak	Intersection	Control	Northbound		Southbound		Eastbound		Westbound	
			Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
AM	Huron River and M-14 EB On Ramp	Unsignalized	NA	NA	NA	NA	13	C	NA	NA
	Main St. and Huron River and M-14 WB Off Ramp	Unsignalized	NA	NA	NA	NA	89.6	F	69.6	F
	Main St. and Huronview Blvd	Unsignalized	NA	NA	NA	NA	20.6	C	NA	NA
	Main St. and Lakeshore Dr	Unsignalized	NA	NA	NA	NA	NA	NA	37.4	E
	Main St. and Depot St	Signalized	23.3	C	58.2	E	44.5	D	24.3	C
PM	Huron River and M-14 EB On Ramp	Unsignalized	NA	NA	NA	NA	22.4	C	NA	NA
	Main St. and Huron River and M-14 WB Off Ramp	Unsignalized	NA	NA	NA	NA	15.1	C	19.4	C
	Main St. and Huronview Blvd	Unsignalized	NA	NA	NA	NA	-	F	NA	NA
	Main St. and Lakeshore Dr	Unsignalized	NA	NA	NA	NA	NA	NA	61.8	F
	Main St. and Depot St	Signalized	37.3	D	29.5	C	44.7	D	235	F

Table 16 Barton Drive Synchro Analysis - Alternative 4 - 2045

Peak	Intersection	Control	Northbound		Southbound		Eastbound		Westbound	
			Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
AM	Barton Dr and Brede Pl	Unsignalized	NA	NA	10.6	B	NA	NA	NA	NA
	Barton Dr and Longshore Dr	Unsignalized	23.2	C	NA	NA	NA	NA	NA	NA
	Barton Dr and Chandler Rd	Unsignalized	19.8	C	NA	NA	NA	NA	NA	NA
	Barton Dr and Pontiac Trail	Signalized	39.3	D	48.3	D	87.4	F	19.3	B
	Roundabout - Barton/Whitmore & M-14 SB Ramps	Unsignalized	F							
	Roundabout - M-14 SB Ramps & M-14 SB	Unsignalized	D							
	Roundabout - M-14 NB & Barton Dr Ramp	Unsignalized	E							
PM	Barton Dr and Brede Pl	Unsignalized	NA	NA	20.7	C	NA	NA	NA	NA
	Barton Dr and Longshore Dr	Unsignalized	16.7	C	NA	NA	NA	NA	NA	NA
	Barton Dr and Chandler Rd	Unsignalized	30.6	D	NA	NA	NA	NA	NA	NA
	Barton Dr and Pontiac Trail	Signalized	31.3	C	20.7	C	75.7	E	65.6	E
	Roundabout - Barton/Whitmore & M-14 SB Ramps	Unsignalized	E							
	Roundabout - M-14 SB Ramps & M-14 SB	Unsignalized	C							
	Roundabout - M-14 NB & Barton Dr Ramp	Unsignalized	D							

5.3.6 2045 Alternatives Highway Capacity Analysis

Using the Highway Capacity Software (HCS), freeway mainline and ramp elements were evaluated to compare performances for each alternative. The LOS thresholds based on the Highway Capacity Manual (HCM) are shown in Tables 18 and 19.

Table 17: Urban Freeway Level of Service Thresholds – Basic

Level of Service	Freeway Facility Density (pc/mi/ln)
A	≤11
B	>11-18
C	>18-26
D	>26-35
E	>35-45
F	>45 or any component segment with a volume-to-capacity ratio greater than 1.00

Source: Highway Capacity Manual, 6th Edition.

Table 18: Urban Freeway Level of Service (LOS) Thresholds – Weaving

Level of Service	Freeway Facility Density (pc/mi/ln)
A	≤10
B	>10-20
C	>20-28
D	>28-35
E	>35
F	>43 or any component segment with a volume-to-capacity ratio greater than 1.00

Source: Highway Capacity Manual, 6th Edition.

Table 19 HCS Alternative 1 (No Action) 2045

Route	Segment	Type	AM Peak			PM Peak		
			Volume	Density	LOS	Volume	Density	LOS
M-14 EB	M-14 EB	Basic	3613	36.2	E	5312	-	F
	Main St. On Ramp	Merge	837	37.9	D	1938	-	F
	M-14 EB	Weave	1734	36.4	E	2350	-	F
	Barton Dr Off Ramp	Diverge	1047	32.3	C	760	-	F
M-14 WB	M-14 WB	Basic	3684	37.6	E	3184	29.3	D
	Whitmore Lake Off Ramp	Diverge	344	40	E	312	34.3	D
	Whitmore Lake On Ramp	Merge	571	-	F	537	37.4	D
	M-14 WB	Weave	2585	-	F	1490	28	C
	Main St. Off Ramp	Diverge	2116	-	F	1049	28.5	C

For the No Action alternative, the eastbound M-14 freeway / ramp system performs at level of service (LOS) E in the AM peak and LOS F in the PM peak. The westbound direction performs at LOS E / F in the AM period and LOS C/D in the PM period.

Table 20 HCS Alternative 2 - 2045

Route	Segment	Type	AM Peak			PM Peak		
			Volume	Density	LOS	Volume	Density	LOS
M-14 EB	M-14 EB	Basic	3877	41.8	E	5321	-	F
	Main St. On Ramp	Merge	892	-	F	1897	-	F
M-14 WB	M-14 WB	Basic	3594	35.8	E	3079	27.9	D
	Whitmore Lake Off Ramp	Diverge	584	33.3	D	756	25.5	C
	Whitmore Lake On Ramp	Merge	714	39.8	D	539	28.2	C
	M-14 WB	Weave	2745	-	F	1432	21.4	C
	Main St. Off Ramp	Diverge	2159	-	F	991	20.9	B

Under the Close Eastbound Ramps (Alternative 2) scenario the eastbound M-14 freeway / ramp system performs at level of service (LOS) E/ F in the AM and LOS F in the PM peak. The westbound direction performs at LOS D /F in the AM period and LOS B /C in the PM period. Some degradation is noted on the westbound direction as additional traffic loading is shown on the WB ramp to Whitmore Lake Road as eastbound traffic is shown to back track to the interchange.

Table 21 HCS Analysis- Alternative 3 - 2045

Route	Segment	Type	AM Peak			PM Peak		
			Volume	Density	LOS	Volume	Density	LOS
M-14 EB	M-14 EB	Basic	3613	36.2	E	5312	-	F
	Main St. On Ramp	Merge	837	36.5	E	1938	45	F
	Barton On Ramp	Merge	328	-	F	430	-	F
	M-14 EB	Weave	1734	36.2	E	2350	-	F
	Barton Dr Off Ramp	Diverge	1047	32.3	C	760	-	F
M-14 WB	M-14 WB	Basic	3684	37.6	E	3184	29.3	D
	Whitmore Lake Off Ramp	Diverge	344	40	E	312	31.2	D
	Whitmore Lake On Ramp	Merge	571	-	F	537	37.4	D
	M-14 WB	Weave	2585	-	F	1490	28	C
	Main St. Off Ramp	Diverge	2116	-	F	1049	28.5	C

For the Modified Loop alternative, the eastbound M-14 freeway / ramp system performs at level of service (LOS) E/F in the AM peak and LOS F in the PM peak. Some degradation is shown on the segment north of Barton due to the free-flow ramp impacts (entering traffic not metered by stop control). The westbound direction performs at LOS E/F in the AM period and LOS C/D in the PM period.

Table 22 HCS Analysis -Alternative 4 - 2045

Route	Segment	Type	AM Peak			PM Peak		
			Volume	Density	LOS	Volume	Density	LOS
M-14 EB	M-14 EB	Basic	3613	36.2	E	5312	-	F
	Main St. On Ramp	Merge	837	38.1	D	1938	-	F
	Barton On Ramp	Merge	328	-	F	430	-	F
	M-14 EB	Weave	1734	36.2	E	2350	-	F
	Barton Dr Off Ramp	Diverge	1047	32.3	C	760	-	F
M-14 WB	M-14 WB	Basic	3684	37.6	E	3184	29.3	D
	Whitmore Lake Off Ramp	Diverge	344	40	E	312	34.3	D
	Whitmore Lake On Ramp	Merge	571	-	F	537	37.4	D
	M-14 WB	Weave	2585	-	F	1490	28	C
	Main St. Off Ramp	Diverge	2116	-	F	1049	28.5	C

For the Dual Roundabout alternative, the eastbound M-14 freeway / ramp system performs at level of service (LOS) D through F in the AM peak and LOS F in the PM peak. The westbound direction performs at LOS E/F in the AM period and LOS C/D in the PM period. Overall it shows slightly improved performance compared to No action and improvement over other alternatives.

6. Safety Analysis Results

To comprehensively understand the safety performance of the proposed interchange alternatives on a local and network level, a detailed safety analysis was performed for both freeway and arterial components. This section describes the proposed methodology for the safety analysis, analysis results, observations, and conclusions.

6.1 Safety Analysis Methodology

To perform comprehensive safety analysis, Atkins divided the roadway network into two components – freeways and arterials. All the freeway components (segments, ramps, connectors, and interchanges) were analyzed using ISAT-E. For the arterial components, intersections, safety analysis was performed using MDOT's HSM Analysis Spreadsheet. 2019 was used as a baseline year for the analysis; 2025 and 2045 were used as the future analysis years. Except in the vicinity of the M-14 and the Barton Dr interchange, Alternatives 1, 3 and 4 have similar traffic volumes on the freeways and arterial roads for all the three analysis years. Closure of Barton Dr ramps in Alternative 2 directly influenced the traffic volumes on the freeways and arterial roads. Using the travel demand modeling analysis conducted as part of this project, it was determined that due to the Barton Drive ramp closures, traffic was primarily diverted onto arterials such as Jackson Avenue, Miller Road, North Territorial Road, Whitmore Lake Road, Plymouth Road and Broadway Street.
Safety analysis for the PEL included the following arterial roads:

- Jackson Avenue (Maple Rd to Dexter/Revena), West Huron Street (Tulip Tree Ct to N Main St)
- East Huron Street (4th Ave to Division St)
- Miller Road (Kuehnle Ave to N Main St)
- Catherine Street (4th Ave to N Division St)
- Beakes Street (N 4th Ave to Detroit/Summit/Division)
- Division and Carey Street, Broadway Street (Swift St to Maiden Ln)
- Plymouth Road (Broadway St to Green Rd),
- Whitmore Lake Road (North Territorial Rd to Barton Shore Dr S).

The following freeway interchanges included in the analysis:

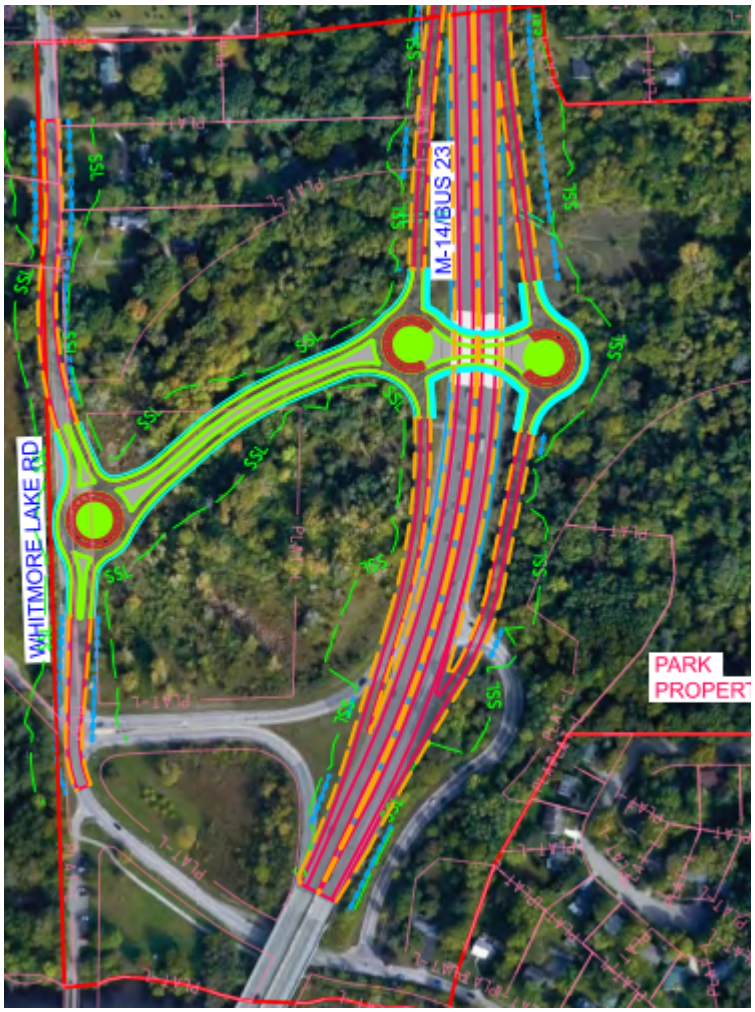
- I-94/M-14,
- M-14/Miller Rd/N Maple Rd,
- M-14/Main St
- M-14/Barton Dr/Whitmore Lake Dr,
- West interchange of M-14 and US-23,
- East interchange of M-14 and US-23 an
- US-23/Plymouth Rd.

6.2 Geometry and Traffic Volumes

Google Earth/Maps in addition to field visits were used to gather and use roadway data elements for the HSM arterial analysis. This included intersection type, major/ minor road, flow type, median presence, through and turn lanes, right turn on red status, lighting presence, major street left turn lane on all approaches and similar roadway and geometric inputs required for the ISAT-E freeway analysis.

MDOT Transportation Data Management System (TDMS) was used for historic AADT data and Michigan Traffic Crash Facts (MTCF) was used to collect the relevant crash data. Based on MDOT's recommended practice, we used 5- years crash data from 2015 through 2019. Atkins did not include crash data from years 2020 and 2021 to avoid COVID-19 impact on the traffic volumes. For future years 2025 and 2045, traffic growth factors based on TransCAD model runs for 2025 and 2045 were applied on the 2019 AADT volumes. Based on traffic diversions in Alternative 2 with the ramp closures, there were perceivable changes (increase/decrease) to freeway and arterial traffic volumes for Alternative 2 in comparison to Alternative 1.

Figure 22 Sketch of Alternative 4



The primary difference between Alternative 1 and Alternative 4 (see Figure 1) is the introduction of a single-lane dog-bone roundabout pair at the interchange ramp terminals in addition to a new single-lane roundabout on S Whitmore Lake Rd. The new interchange configuration reduces the weaving distance between the Main St ramps and the Barton Dr ramps by approximately 450 feet; however, the Barton Dr exit ramp is now a much higher speed exit ramp compared to Alternative 1. Given that ISAT-E does not include roundabouts as part of the interchange ramp terminals, we used the Safety Performance Functions Total Crashes = 0.0023(AADT)^0.7490 and Injury Crashes = 0.0013(AADT)^0.5923 for 4 legged roundabouts with 1 circulating lane and AADT values in the range of 4,000 to 37,000 AADT (NCHRP Report 888 Table A2-3).

Figure 23 Sketch of Alternative 3

The primary difference between Alternative 1 and Alternative 3 (see Figure 2) is the additional weaving distance on M-14 between the north and south ramps on the bridge, the increased radii of curvature for the Barton Dr ramps and better sight distance for vehicles from Barton Dr entering M-14 North. The increased Barton Dr ramp distance, reconfigured ramp from M-14 N to Barton Dr and reconfigured ramp from Barton Dr to M-14 N is expected to create safety improvements based on ISAT-E results.

6.3 Results

The MDOT HSM arterial analysis and the ISAT-E freeway analysis were performed in parallel for all four alternatives and the overall results were then compiled together in Table 1. Appendix D has relevant output tables from the HSM and ISAT-E analysis. The differences in expected safety performance of Alternative 1, Alternative 3 and Alternative 4 are primarily based on roadway geometric design differences in the M-14/Barton Dr interchange area. For Alternative 2, along with the roadway geometric design differences in M-14/Barton Dr interchange area due to the Barton Dr ramp closures, there are impacts across the entire freeway and arterial network due to the traffic diversion and rerouting with the Barton Dr ramp closures. The changes to the M-14/Barton Dr interchange area, also referred to as “Study Area”, are compared in detail for Alternative 1, Alternative2, Alternative 3 and Alternative 4 in Table 23.

Table 23 Freeway and Arterial Safety Performance- Alt 1 - Alt 4 for 2025 and 2045

	Alt 1	Alt 2	Alt 3	Alt 4	Alt 2 - Alt 1	Alt 3 - Alt 1	Alt 4 - Alt 1	Alt 1	Alt 2	Alt 3	Alt 4	Alt 2 - Alt 1	Alt 3 - Alt 1	Alt 4 - Alt 1
Arterial Safety Performance Metrics	**2025**	**2025**	**2025**	**2025**	**2025**	**2025**	**2025**	**2045**	**2045**	**2045**	**2045**	**2045**	**2045**	**2045**
Expected Crashes all (crashes/yr)	177.8	183.6	177.8	177.8	5.8	0.0	0.0	190.6	199	190.6	190.6	8.4	0.0	0.0
Expected Crashes F/I (crashes/yr)	32.4	34.2	32.4	32.4	1.8	0.0	0.0	35.4	37.6	35.4	35.4	2.2	0.0	0.0
Expected Crashes PDO (crashes/yr)	145.4	149.4	145.4	145.4	4.0	0.0	0.0	155.2	161.4	155.2	155.2	6.2	0.0	0.0
	Alt 1	Alt 2	Alt 3	Alt 4	Alt 2 - Alt 1	Alt 3 - Alt 1	Alt 4 - Alt 1	Alt 1	Alt 2	Alt 3	Alt 4	Alt 2 - Alt 1	Alt 3 - Alt 1	Alt 4 - Alt 1
Freeway Study Area Safety Performance Metrics	**2025**	**2025**	**2025**	**2025**	**2025**	**2025**	**2025**	**2045**	**2045**	**2045**	**2045**	**2045**	**2045**	**2045**
Expected Crashes all (crashes/yr)	68.4	56.9	66.0	56.2	-11.5	-2.4	-12.2	78.2	64.1	75.0	62.0	-14.1	-3.1	-16.2
Expected Crashes F/I (crashes/yr)	12.9	9.9	12.5	10.3	-3.0	-0.4	-2.6	14.8	11.0	14.2	11.1	-3.7	-0.5	-3.7
Expected Crashes PDO (crashes/yr)	55.5	47.0	53.5	45.9	-8.5	-2.0	-9.6	63.4	53.0	60.8	50.9	-10.4	-2.6	-12.5
	Alt 1	Alt 2	Alt 3	Alt 4	Alt 2 - Alt 1	Alt 3 - Alt 1	Alt 4 - Alt 1	Alt 1	Alt 2	Alt 3	Alt 4	Alt 2 - Alt 1	Alt 3 - Alt 1	Alt 4 - Alt 1
Freeway Other than Study Area Safety Performance Metrics	**2025**	**2025**	**2025**	**2025**	**2025**	**2025**	**2025**	**2045**	**2045**	**2045**	**2045**	**2045**	**2045**	**2045**
Expected Crashes all (crashes/yr)	237.0	246.9	237.0	237.0	9.9	0.0	0.0	270.9	277.9	270.9	270.9	7.0	0.0	0.0
Expected Crashes F/I (crashes/yr)	49.1	51.6	49.1	49.1	2.5	0.0	0.0	56.1	57.5	56.1	56.1	1.4	0.0	0.0
Expected Crashes PDO (crashes/yr)	187.9	195.3	187.9	187.9	7.4	0.0	0.0	214.8	220.5	214.8	214.8	5.7	0.0	0.0
	Alt 1	Alt 2	Alt 3	Alt 4	Alt 2 - Alt 1	Alt 3 - Alt 1	Alt 4 - Alt 1	Alt 1	Alt 2	Alt 3	Alt 4	Alt 2 - Alt 1	Alt 3 - Alt 1	Alt 4 - Alt 1
All Freeway Safety Performance Metrics	**2025**	**2025**	**2025**	**2025**	**2025**	**2025**	**2025**	**2045**	**2045**	**2045**	**2045**	**2045**	**2045**	**2045**
Expected Crashes all (crashes/yr)	305.4	303.8	303.0	293.2	-1.6	-2.4	-12.2	349.1	342.0	346.0	332.8	-7.1	-3.1	-16.2
Expected Crashes F/I (crashes/yr)	62.0	61.5	61.6	59.3	-0.5	-0.4	-2.6	70.9	68.5	70.4	67.2	-2.4	-0.5	-3.7
Expected Crashes PDO (crashes/yr)	243.4	242.3	241.4	233.9	-1.1	-2.0	-9.6	278.2	273.5	275.6	265.7	-4.7	-2.6	-12.5
	Alt 1	Alt 2	Alt 3	Alt 4	Alt 2 - Alt 1	Alt 3 - Alt 1	Alt 4 - Alt 1	Alt 1	Alt 2	Alt 3	Alt 4	Alt 2 - Alt 1	Alt 3 - Alt 1	Alt 4 - Alt 1
Freeway + Arterial Safety Performance Metrics	**2025**	**2025**	**2025**	**2025**	**2025**	**2025**	**2025**	**2045**	**2045**	**2045**	**2045**	**2045**	**2045**	**2045**
Expected Crashes all (crashes/yr)	483.2	487.4	480.8	471.0	4.2	-2.4	-12.2	539.7	541.0	536.6	523.4	1.3	-3.1	-16.2
Expected Crashes F/I (crashes/yr)	94.4	95.7	94.0	91.7	1.3	-0.4	-2.6	106.3	106.1	105.8	102.6	-0.2	-0.5	-3.7
Expected Crashes PDO (crashes/yr)	388.8	391.7	386.8	379.3	2.9	-2.0	-9.6	433.4	434.9	430.8	420.9	1.5	-2.6	-12.5
Adjustments to Expected Crashes based on Geometric Improvements in the Freeway Study Area														

	Alt 1	Alt 2	Alt 3	Alt 4	Alt 2 - Alt 1	Alt 3 - Alt 1	Alt 4 - Alt 1	Alt 1	Alt 2	Alt 3	Alt 4	Alt 2 - Alt 1	Alt 3 - Alt 1	Alt 4 - Alt 1
Freeway + Arterial Safety Performance Metrics	**2025**	**2025**	**2025**	**2025**	**2025**	**2025**	**2025**	**2045**	**2045**	**2045**	**2045**	**2045**	**2045**	**2045**
Expected Crashes all (crashes/yr)	483.2	471.4	466.8	455.0	-11.8	-16.4	-28.2	539.7	522.7	518.3	505.2	-17.0	-21.4	-34.5
Expected Crashes F/I (crashes/yr)	94.4	90.8	89.1	86.8	-3.6	-5.3	-7.5	106.3	100.5	100.2	97.0	-5.8	-6.1	-9.3
Expected Crashes PDO (crashes/yr)	388.8	380.6	377.7	368.2	-8.2	-11.1	-20.7	433.4	422.2	418.2	408.2	-11.2	-15.3	-25.2

Table 24: Freeway and Arterial Safety Performance for Alt 1, Alt 2, Alt 3, Alt 4 in the M-14/Barton Dr interchange area for 2025

Sr No	Roadway Segment	PDO Crashes/ year	Injury Crashes/ year	Total Crashes/ year
Observed Safety Performance (2015-2019)				
Freeway Mainline Segments				
1	M-14 North between Barton Dr and Main St ramps	24.2	5.2	29.4
2	M-14 South between Barton Dr and Main St ramps	34.0	6.0	40.0
	Total	**58.2**	**11.2**	**69.4**
Freeway Ramps and Interchange Connectors				
1	M-14 N Ramp to Barton Dr	2.2	1.2	3.4
2	Barton Dr to M-14 N Ramp	25.8	3.2	29.0
3	M-14 S Ramp to Whitmore Lake Rd	6.0	0.8	6.8
4	Whitmore Lake Rd Ramp to M-14 S	2.8	0.2	3.0
	Total	**36.8**	**5.4**	**42.2**
Freeway Interchange Ramp Terminals				
1	Whitmore Lake Rd	2.2	0.4	2.6
2	Barton Dr	2.8	1.0	3.8
	Total	**5.0**	**1.4**	**6.4**
	GRAND TOTAL	**100.0**	**18.0**	**118.0**
Expected Safety Performance for Alt 1 (2025)				
Freeway Mainline Segment				
1	M-14 North and M-14 South between Barton Dr and Whitmore Lake Rd ramps	43.8	9.0	52.7
Freeway Ramps and Interchange Connectors				
1	M-14 N Ramp to Barton Dr; Barton Dr to M-14 N Ramp; M-14 S Ramp to Whitmore Lake Rd; Whitmore Lake Rd Ramp to M-14 S	6.9	1.9	8.7
Freeway Interchange Ramp Terminals				
1	Whitmore Lake Rd and Barton Dr	4.9	2.1	6.9
	TOTAL	**55.5**	**12.9**	**68.4**
Expected Safety Performance for Alt 4 (2025)				
Freeway Mainline Segment				
1	M-14 North and M-14 South between Barton Dr and Whitmore Lake Rd ramps	43.5	8.9	52.4
Freeway Ramps and Interchange Connectors				
1	M-14 N Ramp to Barton Dr; Barton Dr to M-14 N Ramp; M-14 S Ramp to Whitmore Lake Rd; Whitmore Lake Rd Ramp to M-14 S	1.3	0.6	1.8

Freeway Interchange Ramp Terminals				
1	Whitmore Lake Rd and Barton Dr	1.2	0.8	2.0
	TOTAL	**45.9**	**10.3**	**56.2**
Comparison of Safety Performance Alt 4 - Alt 1 (2025)				
	TOTAL	**-9.6**	**-2.6**	**-12.2**
Expected Safety Performance for Alt 3 (2025)				
Freeway Mainline Segment				
1	M-14 North and M-14 South between Barton Dr and Whitmore Lake Rd ramps	43.6	8.9	52.5
Freeway Ramps and Interchange Connectors				
1	M-14 N Ramp to Barton Dr; Barton Dr to M-14 N Ramp; M-14 S Ramp to Whitmore Lake Rd; Whitmore Lake Rd Ramp to M-14 S	5.1	1.5	6.6
Freeway Interchange Ramp Terminals				
1	Whitmore Lake Rd and Barton Dr	4.9	2.1	6.9
	TOTAL	**53.5**	**12.5**	**66.0**
Comparison of Safety Performance Alt 3 - Alt 1 (2025)				
	TOTAL	**-2.0**	**-0.4**	**-2.4**
Expected Safety Performance for Alt 2 (2025)				
Freeway Mainline Segment				
1	M-14 North and M-14 South between Barton Dr and Main St ramps	43.5	8.9	52.4
Freeway Ramps and Interchange Connectors				
1	M-14 S Ramp to Whitmore Lake Rd; Whitmore Lake Rd Ramp to M-14 S	1.6	0.3	2.0
Freeway Interchange Ramp Terminals				
1	Whitmore Lake Rd	1.9	0.7	2.6
	TOTAL	**47.0**	**9.9**	**57.0**
Comparison of Safety Performance Alt 2 - Alt 1 (2025)				
	TOTAL	**-8.4**	**-3.0**	**-11.4**

The comparison of observed crashes in years 2015-2019 and expected Alternative 1 crashes for year 2025 is shown in Table 26. From Table 26, it is observed that the ratio of Expected to Observed total freeway crashes in the study area is 58% when compared to 71% for the entire freeway network. This shows a significantly higher Observed crash rate in the study area compared to rest of the network. Therefore, with the introduction of Alternative 2, Alternative 3, and Alternative 4, the practically achievable reduction in crashes may be much higher than the reduction in Expected crashes calculated from the ISAT-E analysis and closer to the difference between the Observed and Expected crashes. The adjustment in Expected crashes at the bottom of Table 1 reflect the practically achievable reduction in crashes for Alternative 2, Alternative 3, and Alternative 4.

Table 26: Comparison of Observed (2015-2019) and Expected 2025 Alt 1 Crashes

Crashes on Roadway Segments	Observed Crashes/yr 2015-2019	Alt 1 Expected Crashes/yr 2025	Difference % (Expected/ Observed)
Freeway Study Area Fatal/Injury	18.0	12.9	72%
Freeway Study Area PDO	100.0	55.5	56%
Freeway Study Area Total	**118.0**	**68.4**	**58%**
Freeway Non-Study Area Fatal/Injury	49.4	49.1	99%
Freeway Non-Study Area PDO	264.8	187.9	71%
Freeway Non-Study Area Total	314.2	237.0	75%
Freeway Total	**432.2**	**305.4**	**71%**
Arterial Fatal/Injury	37.0	32.4	88%
Arterial PDO	172.2	145.4	84%
Arterial Total	**209.2**	**177.8**	**85%**
Freeway + Arterial Total	**641.4**	**483.2**	**75%**

Statistical Significance

To determine whether the differences between the No Action alternative (Alternative 1) and the three improvement alternative (Alternatives 2, 3, and 4) were statistically significant, a Chi Square Test was applied. Statistical significance was based determined whether difference had a level of confidence greater than 95%. Based on the analysis outlined below, none of the reductions were found to be statistically significant to a level of confidence of greater than 95%.

	Observed Crashes (2015-2019)	Alt 1	Alt 2	Alt 3	Alt 4	Obs - Alt 2	X^2 Alt 2	Statistical Significance Alt 2	Obs - Alt 3	X^2 Alt 3	Statistical Significance Alt 3	Ob s- Alt 4	X^2 Alt 4	Statistical Significance Alt 4
Freeway + Arterial Safety Performance Metrics		2025	2025	2025	2025	2025	2025	2025	2025	2025	2025	2025	2025	2025
Expected Crashes all (crashes/yr) - Study Area	118	68.4	56.9	66	56.2	61.1	65.61	Yes (>95%)	52	40.97	Yes (>95%)	61.8	67.96	Yes (>95%)
Expected Crashes F/I (crashes/yr) - Study Area	18	12.9	9.9	12.5	10.3	8.1	6.63	Yes (>95%)	5.5	2.42	No	7.7	5.76	No
Expected Crashes PDO (crashes/yr) - Study Area	100	55.5	47	53.5	45.9	53	59.77	Yes (>95%)	46.5	40.42	Yes (>95%)	54.1	63.76	Yes (>95%)
Expected Crashes all (crashes/yr) - Outside Study Area	523.4	414.8	414.5	400.8	455	108.9	28.61	Yes (>95%)	122.6	37.50	Yes (>95%)	68.4	10.28	Yes (>95%)
Expected Crashes F/I (crashes/yr) - Outside Study Area	86.4	81.5	80.9	76.6	86.8	5.5	0.37	No	9.8	1.25	No	-0.4	0.00	No
Expected Crashes PDO (crashes/yr) - Outside Study Area	437	333.3	333.6	324.2	368.2	103.4	32.05	Yes (>95%)	112.8	39.25	Yes (>95%)	68.8	12.86	Yes (>95%)

	Observed Crashes (2015-2019)	Alt 1	Alt 2	Alt 3	Alt 4	Obs -Alt 2	X^2 Alt 2	Statistical Significance Alt 2	Obs -Alt 3	X^2 Alt 3	Statistical Significance Alt 3	Obs – Alt 4	X^2 Alt 4	Statistical Significance Alt 4
Freeway + Arterial Safety Performance Metrics		2045	2045	2045	2045	2045	2045	2025	2045	2045	2025	2045	2045	2025
Expected Crashes all (crashes/yr) - Study Area	118	78.2	64.1	75	62	53.9	45.32	Yes (>95%)	43	24.65	Yes (>95%)	56	50.58	Yes (>95%)
Expected Crashes F/I (crashes/yr) - Study Area	18	14.8	11	14.2	11.1	7	4.45	Yes (>80%)	3.8	1.02	No	6.9	4.29	Yes (>80%)
Expected Crashes PDO (crashes/yr) - Study Area	100	63.4	53	60.8	50.9	47	41.68	Yes (>95%)	39.2	25.27	Yes (>95%)	49.1	47.36	Yes (>95%)
Expected Crashes all (crashes/yr) - Outside Study Area	523.4	461.5	476.9	461.6	461.4	46.5	4.53	No	61.8	8.27	Yes (>95%)	62	8.33	Yes (>95%)
Expected Crashes F/I (crashes/yr) - Outside Study Area	86.4	91.5	95.1	91.6	91.5	-8.7	0.80	No	-5.2	0.30	No	-5.1	0.28	No
Expected Crashes PDO (crashes/yr) - Outside Study Area	437	370	381.8	370	369.9	55.2	7.98	Yes (>95%)	67	12.13	Yes (>95%)	67.1	12.17	Yes (>95%)

Observations and Conclusions

The traffic diversion due to ramp closure in Alternative 2 creates additional vehicle-miles of travel throughout the arterial network creating delays, congestion, travel time reliability challenges and possibly a worse safety performance on arterials. Table 1 shows the safety performance on the freeway is expected to be slightly better for Alternative 2 with the ramp closures compared to Alternative 1 whereas the arterial safety performance for Alternative 2 vs Alternative 1 is expected to be slightly worse. Overall, the safety performance for Alternative 2 is expected to be worse by 4.2 crashes/year in 2025 and worse by 1.3 crashes/year in 2045. The Alternative 4 geometric improvements are expected to reduce 12.2 crashes/year and 16.2 crashes/years in 2025 and 2045, respectively, compared to the expected safety performance for Alternative 1. The Alternative 3 geometric improvements are expected to reduce 2.4 crashes/year and 3.1 crashes/years in 2025 and 2045, respectively, compared to the expected safety performance for Alternative 1.

After the adjustments are made to account for regression-to-mean statistical effects in the freeway study area with geometric improvements under Alternative 2, Alternative 3, and Alternative 4, the safety performance is compared to Alternative 1 in the last section of Table 1. The safety performance for Alternative 2 is expected to be reduce 11.8 crashes/year in 2025 and 17.0 crashes/year in 2045. The Alternative 4 geometric improvements are expected to reduce 28.2 crashes/year and 34.5 crashes/years in 2025 and 2045, respectively, compared to the expected safety performance for Alternative 1. The Alternative 3 geometric improvements are expected to reduce 16.4 crashes/year and 21.4 crashes/years in 2025 and 2045, respectively, compared to the expected safety performance for Alternative 1.

Benefit Cost Analysis

Using the above results of the safety and operations analysis, a benefit cost analysis was conducted to quantify the safety impacts of the four alternatives was conducted. The benefit cost analysis assumed a 20 year service life and a 7% discount rate. It also assumed an annual maintenance savings of $150,000 per year for all alternatives. To calculate the benefits, crash data was compared to societal costs of traffic crashes from the National Safety Council. Since the HSM analyses utilize the sum of all FI crashes as a key performance measure, it was necessary to determine a crash cost for FI crashes. This was done by utilizing the MDOT safety benefit cost for the FY 2025 safety grant application figures. This is an average of fatal, A-level, B-level, and C-level injuries costs based on the 2021 NSC crash costs. The weighted average FI societal cost of $448,800 and PDO cost of $12,200.

	NSC Societal Crash Cost
K	$ 1,750,000.00
A	$ 101,000.00
B	$ 29,200.00
C	$ 23,900.00
TOTAL	
	Societal Costs Applied
Fatal & Injury (weighted average of NSC costs)	$ 448,800
PDO (NSC cost)	$ 12,200.00

For the operations component of the analysis, the following user costs from MDOTs CO3 manual were applied:

- Cars - $22.23 per hour
- Trucks - $39.22 per hour

The user costs were weighted based on volumes of cars and trucks.

Cost estimates developed as part of the project were also utilized. The equivalent uniform annual cost and benefits methodology was applied. The benefit cost ratio (BCR) for each alternative is outlined below.

	Alternative 2- Close the Eastbound Ramps	Alternative 3 - Modify the Existing Ramp Geometry	Alternative 4 - Dual Roundabout Interchange
BENEFIT			
Reduction in PDO Crashes	53	46.5	54.1
Reduction in FI Crashes	8.1	5.5	7.7
Reduction Crash Costs	$4,281,880.00	$3,035,700.00	$4,115,780.00
Reduction in User Delay Cost	$(61,430.46)	$6,800.85	$22,326.82
TOTAL BENEFIT	$4,220,449.54	$3,042,500.85	$4,138,106.82
COST			
Implementation Cost	$4,000,000.00	$15,000,000.00	$41,000,000.00
Capital Recovery Factor	0.09455	0.09455	0.09455
Annual Local Maintenance Savings	$(150,000.00)	$(150,000.00)	(150,000.00)
TOTAL COST	$228,200.00	$1,268,250.00	$ 3,726,550.00
Benefit Cost Ratio	18.49	2.40	1.11

Below is a summary of the results.

- Alternative 1 – Due to no changes and no costs the BCR for this alternative is 0
- Alternative 2 – While this alternative had the lowest crash reduction, it also had the lowest construction cost. This resulted in a highest BCR. While this alternative had the highest BCR, the crash reductions utilized were not statistically significant.
- Alternative 3 – The BCR is greater than1 but low due to the combination of the $15M construction cost and the reductions in crashes which were not statistically significant.
- Alternative 4 – The BCR is greater than 1 but low due to the combination of the $41M construction cost and the reductions in crashes which were not statistically significant.