MEMO

TO: Michelle O'Neill, PE

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SUBJECT: Alternatives Analysis Memo

DATE: December 17, 2019

PURPOSE

The intent of this memorandum is to summarize the anticipated performance of the various improvement alternatives at the I-94/US-131 system interchange developed collaboratively with the Michigan Department of Transportation (MDOT), the Kalamazoo Area Transportation Study (KATS), and the City of Portage. The alternatives were all analyzed in VISSIM for a 20-year future forecast (2039) per TSMO funding template requirements. A description of the alternatives follows as well as a summary of the analysis methodology and resulting measures of effectiveness (MOEs) for each alternative model.

ALTERNATIVES

Several improvement alternatives were developed to address the current congestion for the I-94 WB to US-131 NB movement. This operational issues were verified through MDOT feedback, field review, video observation. Based on discussions with local MDOT staff, the congestion is frequent but volatile, as the typical queue length in this area can range from localized slowing to extreme backups which persist along the mainline.

To address this congestion, alternatives ranged from geometric capacity improvements to transportation system management (TSM) strategies such as ramp metering and traffic signal retiming. The alternatives considered in this analysis are outlined in Table 1 and a more detailed description follows.

Table 1. Alternatives Overview

Alternative	Description
0	**No-build**: No changes to the existing roadway network
1	**Two Lane Ramp**: Two lane ramp for I-94 WB to US-131 NB
2	**Auxiliary Lane**: Auxiliary lane on US-131 NB from I-94 WB on ramp to Stadium Dr off ramp
3	**Acceleration Lane Extension**: Acceleration lane extension on US-131 NB from I-94 WB on ramp
4	**Traffic Signal Retiming**: Signal retiming at I-94 EB and Oakland Dr and I-94 WB and Oakland Dr
5	**Ramp Meter Local**: Ramp meter infrastructure at I-94 WB Oakland Dr on ramp
6	**Ramp Meter System**: Ramp meter infrastructure at I-94 WB Oakland Dr on ramp and I-94 WB Westnedge Ave on ramp

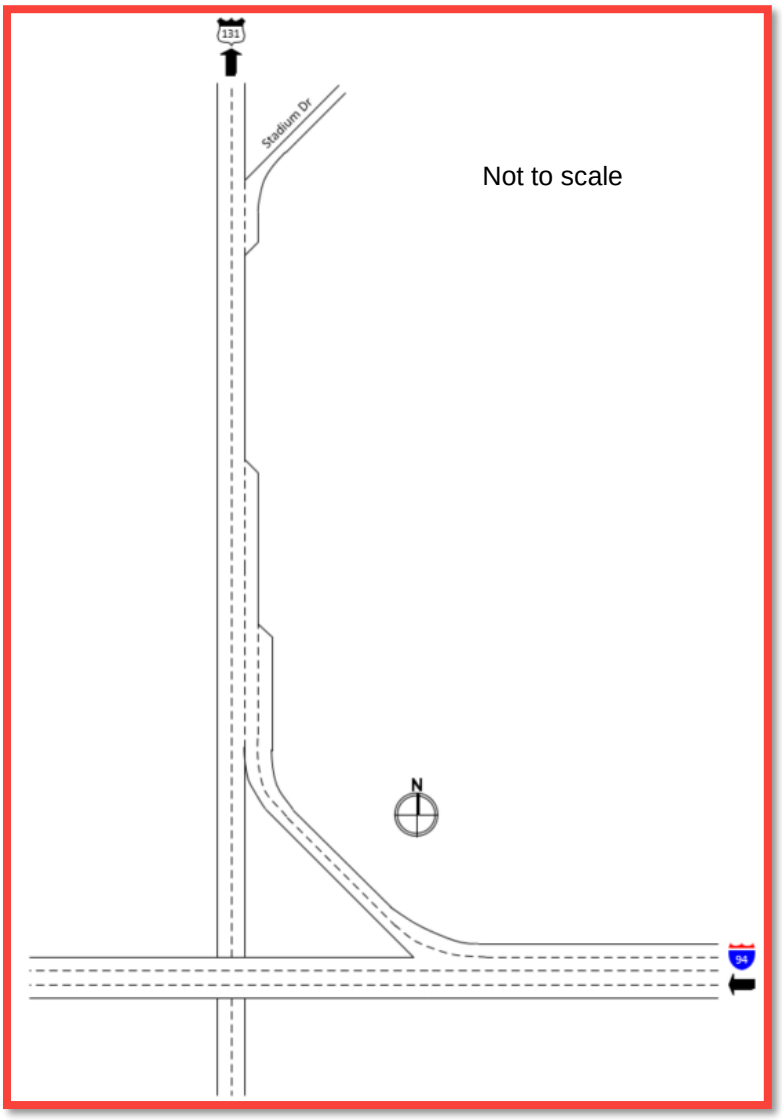
ALTERNATIVE 0: NO-BUILD

Alternative 0 is the No-Build alternative. Under the No-Build alternative, the existing geometry and laneage is assumed for the future year condition. This alternative provides a baseline set of MOEs to compare against the other improvement alternatives.

ALTERNATIVE 1: TWO LANE RAMP

Alternative 1 expands the capacity of the I-94 WB to US-131 NB interchange ramp. Under this alternative, an additional ramp lane would be constructed to increase the ramp laneage from one lane to two lanes. This additional lane would be a shared through/exit lane on the I-94 WB corridor and terminate with two sequential merges on the US-131 NB corridor. To accommodate these merges, the existing US-131 NB mainline lanes will be shifted towards the median and then transitioned back to the original alignment after the sequential merges. The intent of this alternative is to provide additional capacity at the I-94 WB diverge to US-131 NB as well as a lengthened merge area along US-131 NB for this ramp. This alternative is conceptually illustrated in Figure 1.

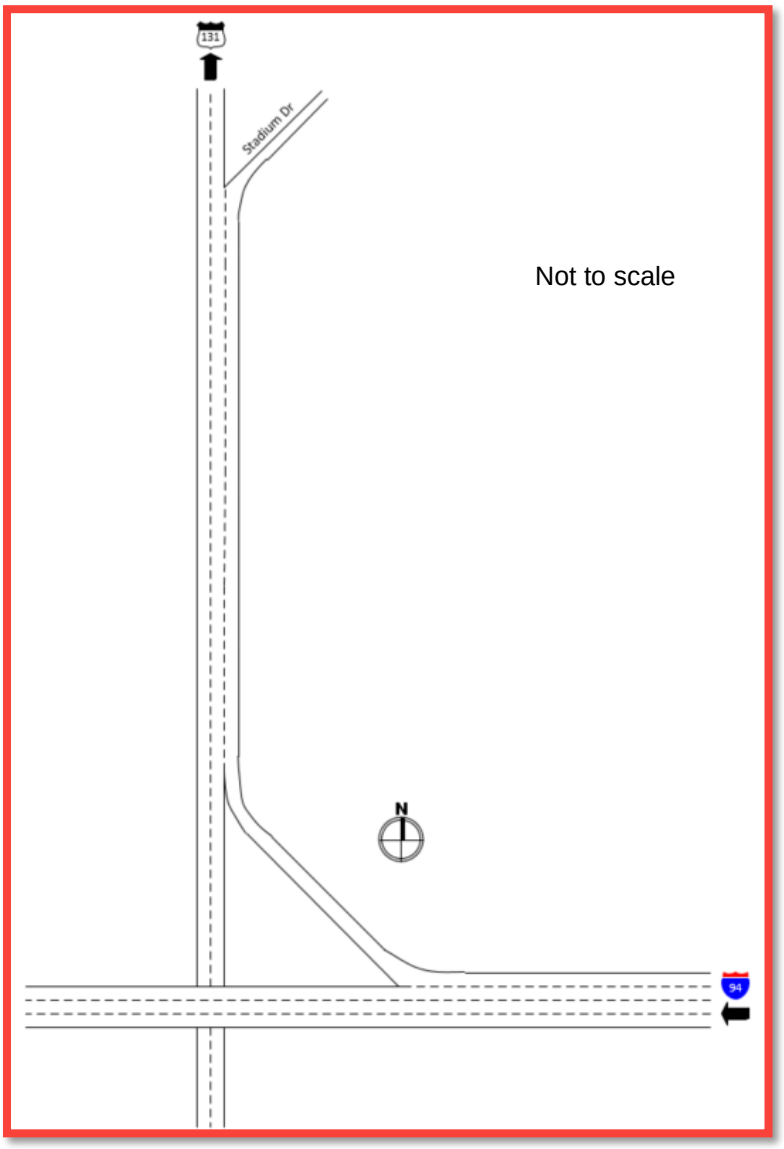
Figure 1. Alternative 1



ALTERNATIVE 2: AUXILIARY LANE

Alternative 2 expands the capacity of the US-131 NB corridor after the I-94 WB on ramp. Under this alternative, an auxiliary lane would be constructed on the US-131 NB corridor between the I-94 WB on ramp and the Stadium Dr off ramp. The intent of this alternative is to reduce the immediate merging behavior of vehicles entering US-131 NB from the I-94 WB on ramp and allowing additional time and space for the merge from I-94 WB to US-131 NB to be completed. Note that this alternative maintains the existing single lane ramp from I-94 WB to US-131 NB. This alternative is conceptually shown in Figure 2.

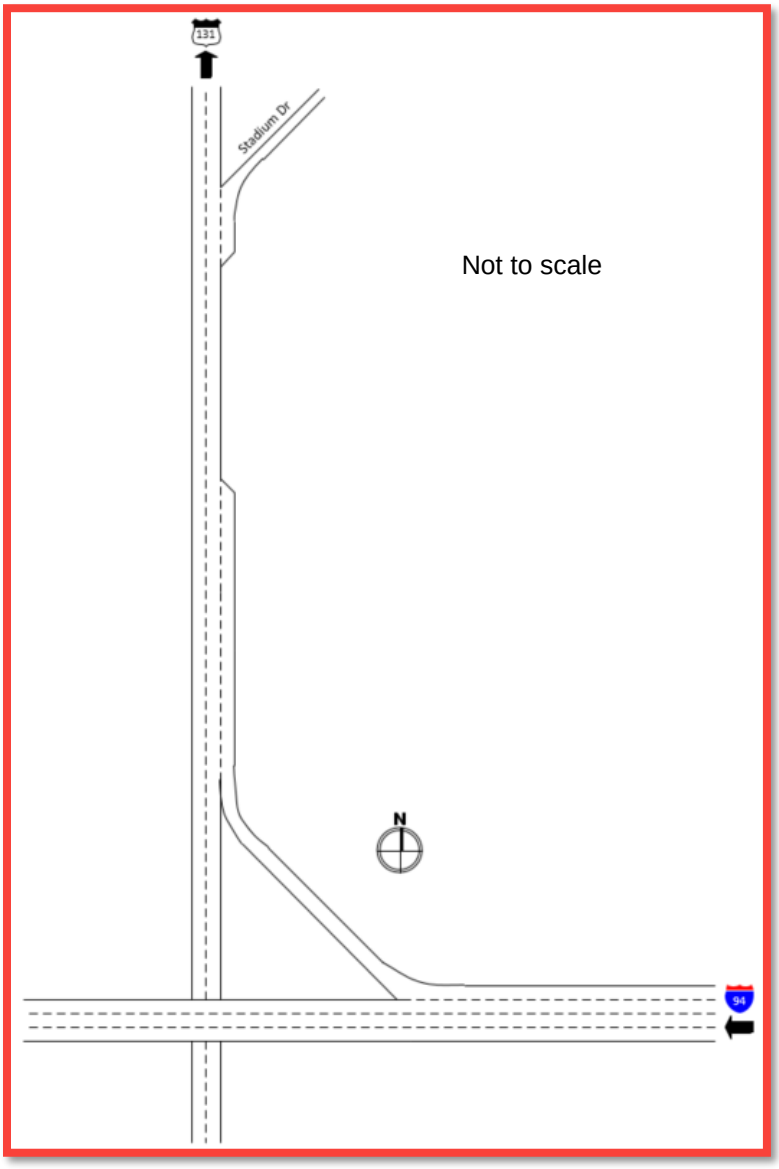
Figure 2. Alternative 2



ALTERNATIVE 3: ACCELERATION LANE EXTENSION

Alternative 3 lengthens the merge area along US-131 NB where the I-94 WB on ramp joins. Under this alternative, the acceleration lane on US-131 NB from the I-94 WB on ramp would be extended about 2,300 ft further than base conditions. The remainder of US-131 NB would remain two lanes after this extension. The intent of this alternative is to reduce the immediate merging behavior of vehicles entering US-131 NB from the I-94 WB on ramp and allowing additional time and space for the merge to be completed. Note that this alternative maintains the existing single lane ramp from I-94 WB to US-131 NB. This alternative is depicted in Figure 3.

Figure 3. Alternative 3



ALTERNATIVE 4: TRAFFIC SIGNAL RETIMING

Alternative 4 optimizes the signal timings at the intersections of the I-94 EB off ramp and Oakland Dr and the I-94 WB off ramp and Oakland Dr. The intent of this alternative is to determine if signal optimization at the Oakland Dr intersections can improve operations along I-94 WB between Oakland Drive and the I-94 WB to US-131 NB ramp.

ALTERNATIVE 5: RAMP METER LOCAL

Alternative 5 is an optimization and infrastructure alternative which optimizes the signal timings at the intersections of the I-94 EB off ramp and Oakland Dr and the I-94 WB off ramp and Oakland Dr. Additionally, ramp meter infrastructure will be included at the I-94 WB Oakland Dr on ramp. The intent of this alternative is to see if TSM strategies such as signal retiming and ramp metering can provide enough gaps in the traffic stream along I-94 WB to better facilitate the weaving operations and reduce congestion along I-94 WB between Oakland Drive and the I-94 WB to US-131 NB ramp.

ALTERNATIVE 6: RAMP METER SYSTEM

Alternative 6 includes ramp meter infrastructure at the I-94 WB Oakland Dr on ramp and the I-94 WB Westnedge Ave on ramp. The intent of this alternative is to see if TSM strategies such as ramp metering can provide enough gaps in the traffic stream along I-94 WB to better facilitate the weaving operations and reduce congestion along I-94 WB between Westnedge Ave and the I-94 WB to US-131 NB ramp.

METHODOLOGY

As mentioned previously, a 2039 future year was established as the desired future year for the alternatives analysis by MDOT. The traffic growth factors to establish future 2039 conditions were provided by MDOT's Planning Department and were applied to the calibrated and validated base condition model to grow the traffic volumes to anticipated 2039 conditions and create the No-Build model (Alternative 0). Table 2 contains the growth factors that were utilized for this analysis:

Table 2. Future Condition Growth Factors

Facility	Growth (%)
I-94 WB	12.3
US-131 NB	8.7
All Others	2

Note: Growth reported is total growth from 2019 to 2039

Figure 4 through Figure 8 illustrate the anticipated traffic volumes for the year 2039 within the study area for the PM peak hour (4:45pm – 5:45pm). Note that all traffic volumes within these figures are directional in nature.

Figure 4. Westnedge Ave Volume Exhibit

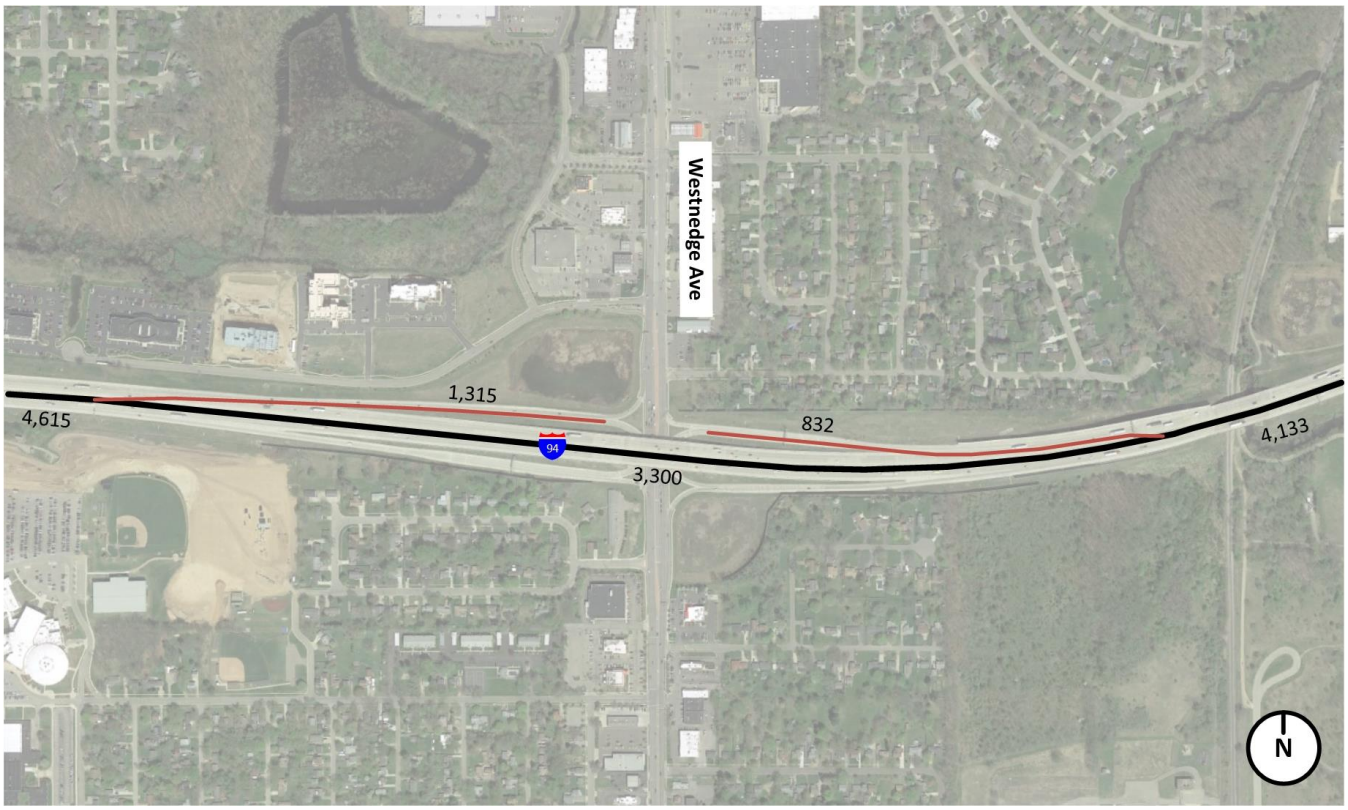


Figure 5. Oakland Dr Volume Exhibit

Figure 6. I-94 and US-131 Interchange Volume Exhibit

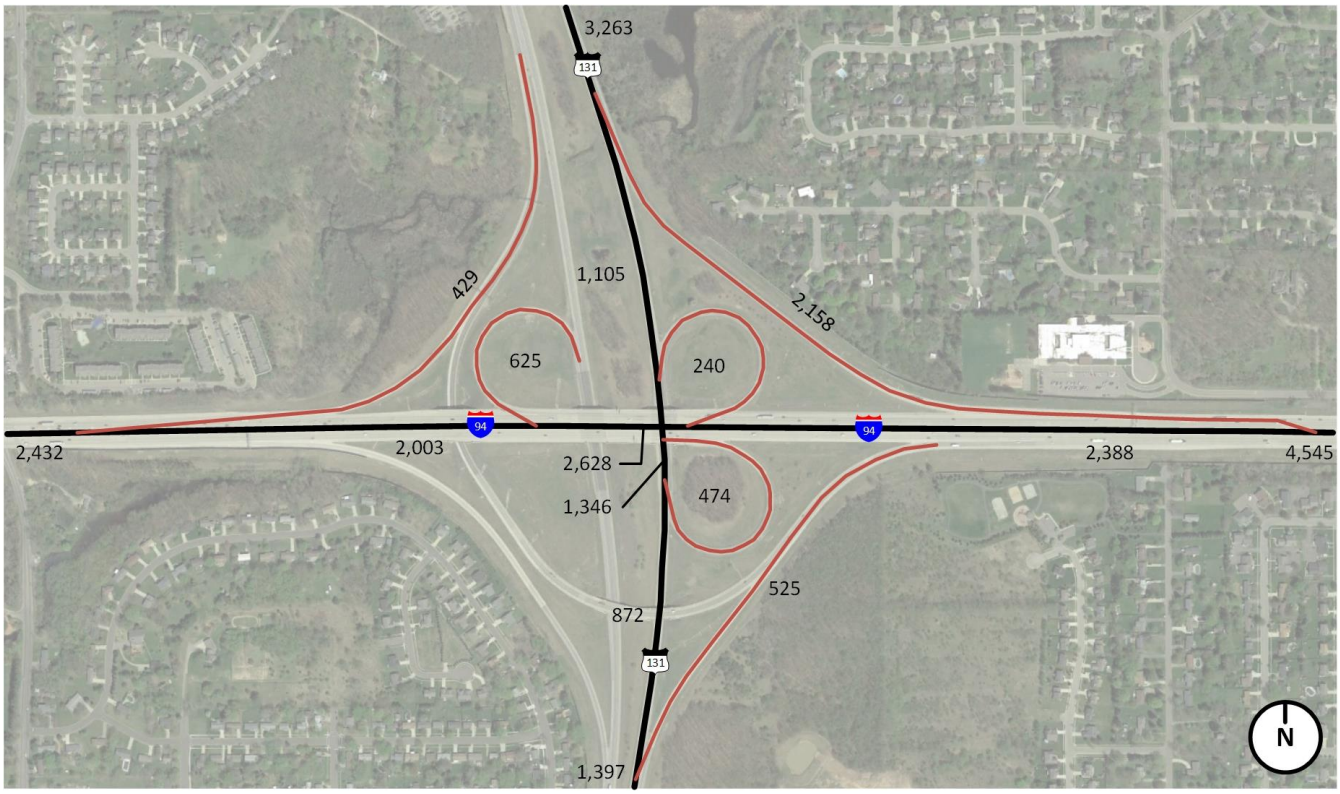


Figure 7. 9th Street Volume Exhibit

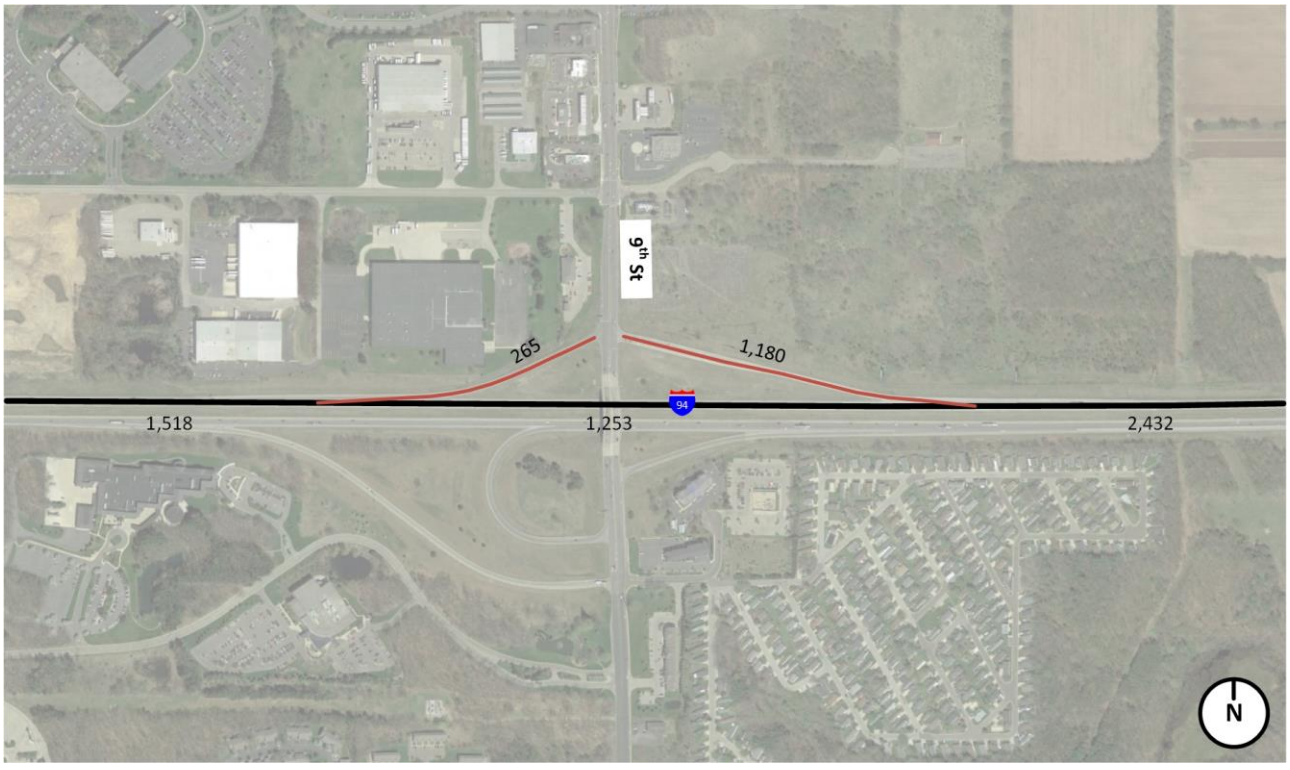


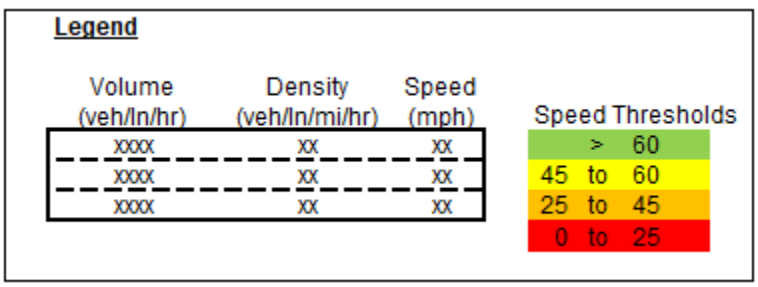
Figure 8. Stadium Dr Volume Exhibit

The No-Build model was then modified either geometrically, operationally, or both to create the models for the subsequent improvement alternatives (Alternatives 1 through 6). MOEs reported for each alternative are based on the average of 10 iterations using different random number seeds, consistent with the base conditions MOE summaries.

MEASURES OF EFFECTIVENESS

Following the completion of the ten simulation runs for each alternative model, lane schematics were created for both the I-94 WB corridor and the US-131 NB corridor for each alternative. The lane schematics depict various MOEs, including volume (vehicle throughput), density, and speed per lane. Figure 9 contains a legend that depicts the layout of the MOEs for each lane segment, the units for each MOE, and how the segments are color coded:

Figure 9. Lane Schematic Legend



Note that the results displayed for the following schematics are averaged over ten simulation runs and include MOEs during the PM peak period (4:45 PM to 5:45 PM). Figure 10 and Figure 11 contain the lane schematics for both corridors for all the alternatives and a brief summary of these results follows.

Figure 10. All Alternative I-94 WB Lane Schematics

Figure 11. All Alternative US-131 NB Lane Schematics

ALTERNATIVE 0: NO-BUILD (NOT RECOMMENDED)

- The congestion along the I-94 WB corridor is expected to worsen significantly during the PM peak period under future conditions with regular queuing in all lanes along I-94 WB from the diverge to US-131 NB to Westnedge Ave.
- The two locations with localized speed reductions along US-131 NB are the weave area between the I-94 EB on ramp and the I-94 WB off ramp, as well as the merge area for the I-94 WB on ramp. These results are consistent with existing conditions.

ALTERNATIVE 1: TWO LANE RAMP (RECOMMENDED)

- This alternative reduces the weaving required between I-94 WB mainline motorists and Oakland Dr on ramp motorists and allows for smoother merging behavior in this area. The two lanes for the system interchange also do not experience the capacity restrictions that are present in the other alternatives.
- As shown in the lane schematics, the major bottleneck congestion along I-94 WB to US-131 NB is alleviated with this alternative.
- The two locations with localized speed reductions along US-131 NB are the weave area between the I-94 EB on ramp and the I-94 WB off ramp, as well as the merge area for the I-94 WB on ramp. Both of these localized speed reductions are expected due to the geometrics.

ALTERNATIVE 2: AUXILIARY LANE (NOT RECOMMENDED AT THIS TIME)

- Alternative 2 congestion along the I-94 WB corridor is expected to be similar to the No-Build, indicating that a capacity improvement or TSM strategy is necessary along I-94 WB for any improvement in congestion to be realized.
- Alternative 2 provided some improvement to the localized speed reduction along US-131 NB where I-94 WB entered, but this improvement of providing an auxiliary lane along US-131 NB is not anticipated to alleviate the current congestion along I-94 WB from the diverge to US-131 NB.

ALTERNATIVE 3: ACCELERATION LANE EXTENSION (NOT RECOMMENDED AT THIS TIME)

- Alternative 3 congestion along the I-94 WB corridor is expected to be similar to the No-Build, indicating that a capacity improvement or TSM strategy is necessary along I-94 WB for any improvement in congestion to be realized.
- Alternative 3 provided some improvement to the localized speed reduction along US-131 NB where I-94 WB entered, but this improvement of providing a longer acceleration lane along US-131 NB is not anticipated to alleviate the current congestion along I-94 WB from the diverge to US-131 NB.

ALTERNATIVE 4: TRAFFIC SIGNAL RETIMING (NOT RECOMMENDED AT THIS TIME)

- Alternative 4 congestion along the I-94 WB corridor is expected to be similar to the No-Build, indicating that signal timing adjustments alone at the Oakland Dr. interchange are not expected to significantly reduce congestion along I-94 WB.
- Alternative 4 congestion along the US-131 NB corridor is expected to be similar to the No-Build.

ALTERNATIVE 5: RAMP METER LOCAL (NOT RECOMMENDED AT THIS TIME)

- Alternative 5 congestion along the I-94 WB corridor is expected to be similar to the No-Build, indicating that ramp metering alone at the Oakland Dr. WB on ramp is not expected to significantly reduce congestion along I-94 WB.
- Alternative 5 congestion along the US-131 NB corridor is expected to be similar to the No-Build.

ALTERNATIVE 6: RAMP METER SYSTEM (NOT RECOMMENDED AT THIS TIME)

- Alternative 6 congestion along the I-94 WB corridor is expected to be similar to the No-Build, indicating that ramp metering alone at the Oakland Dr. WB on ramp and the Westnedge Ave. WB on ramp are not expected to significantly reduce congestion along I-94 WB.
- Alternative 4 congestion along the US-131 NB corridor is expected to be similar to the No-Build.

Based on these results, it is recommended that **Alternative 1** be considered for future implementation. This alternative is the only alternative analyzed which improves the future condition MOEs for both the I-94 WB corridor and the US-131 NB corridor. All other considered alternatives have similar congestion along I-94 WB to the No-Build. The surface street intersection LOS and queue summaries for Alternative 1 are included in Table 3 and Table 4, respectively. Signal timing adjustments are anticipated to alleviate the failing LOS F (anticipated in 2039) for the westbound left-turn at the Westnedge Avenue interchange but were not incorporated into the modeling since the queuing on this approach was not spilling back and impacting mainline I-94.

Table 3. Alternative 1 LOS Results

Intersection	Northbound				Southbound				Eastbound				Westbound				Total
	LT	TH	RT	Approach	LT	TH	RT	Approach	LT	TH	RT	Approach	LT	TH	RT	Approach	
I-94 and Westnedge Ave	E	C	A	C	E	C	A	C	E	NA	C	D	F	NA	B	F	D
I-94 EB and Oakland Dr	NA	C	B	C	C	A	NA	A	D	NA	C	D	NA	NA	NA	NA	C
I-94 WB and Oakland Dr	E	A	NA	B	NA	D	D	D	NA	NA	NA	NA	D	NA	C	D	C

Table 4. Alternative 1 Queue Results

Intersection	Northbound		Southbound		Eastbound		Westbound	
	Average (ft)	Maximum (ft)	Average (ft)	Maximum (ft)	Average (ft)	Maximum (ft)	Average (ft)	Maximum (ft)
I-94 and Westnedge Ave	72	333	53	245	108	424	229	823
I-94 EB and Oakland Dr	227	1,091	39	439	93	291	NA	NA
I-94 WB and Oakland Dr	33	363	443	1,047	NA	NA	88	313

ADDITIONAL ANALYSES

Following a meeting with MDOT, additional analyses were recommended. The recommended analyses were as follows:

1. **Base Condition Ramp Metering**: Establish the performance of the base condition model with ramp meter infrastructure at the I-94 WB Oakland Dr on ramp.
2. **Sensitivity Analysis**: Perform a sensitivity analysis on the preferred (recommended) alternative.
3. **I-94 WB Inside Lane Drop**: Determine if the inside lane drop on the I-94 WB mainline has a negative impact on traffic operations.

The additional analyses were performed, and the results are discussed in detail in the following sections.

BASE CONDITION RAMP METERING

This analysis was to incorporate ramp metering into the base conditions model at the I-94 WB Oakland Dr on ramp. The intent of this analysis is to determine if adding ramp meter infrastructure to the existing conditions would create better performance at the area of interest as a low-cost interim improvement until a second lane can be constructed for the I-94 WB to US-131 NB ramp. The previous base condition model was altered to include ramp meter infrastructure at the I-94 WB Oakland Dr on ramp. Like the previous alternative models, ten simulation runs were completed to ensure that all reasonable variability was captured in the resultant MOEs. Following these runs, lane schematics were generated to compare the MOEs with the original base conditions. Figure 12 contains the lane schematics for the I-94 WB corridor, while Figure 13 depicts the lane schematics for the US-131 NB corridor.

Figure 12. Base Condition Ramp Metering I-94 WB Lane Schematics

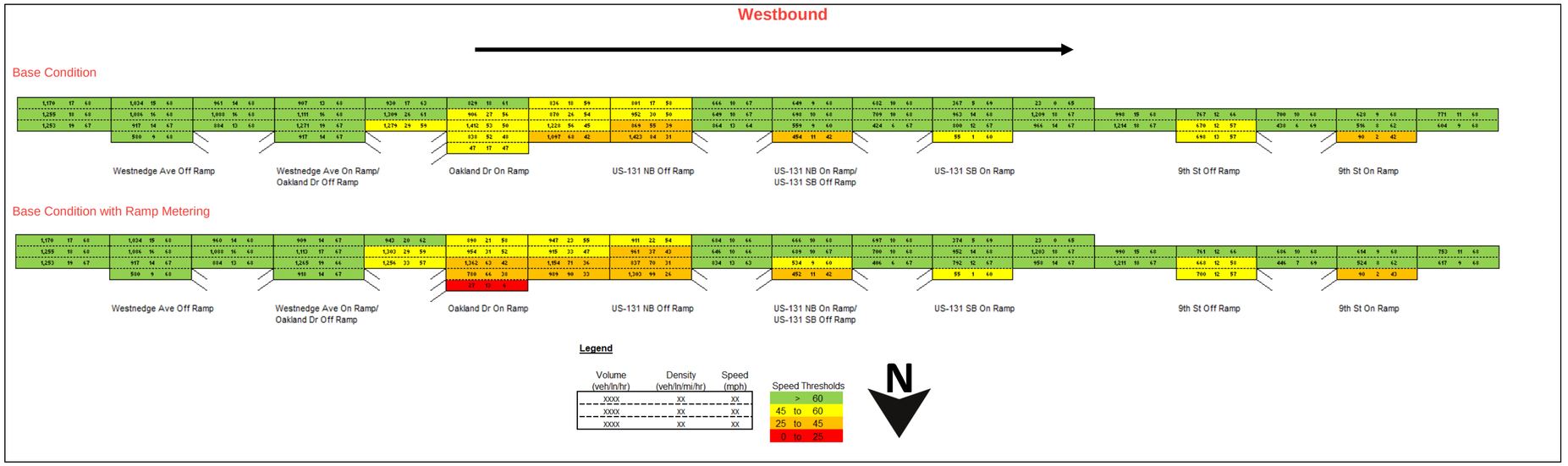
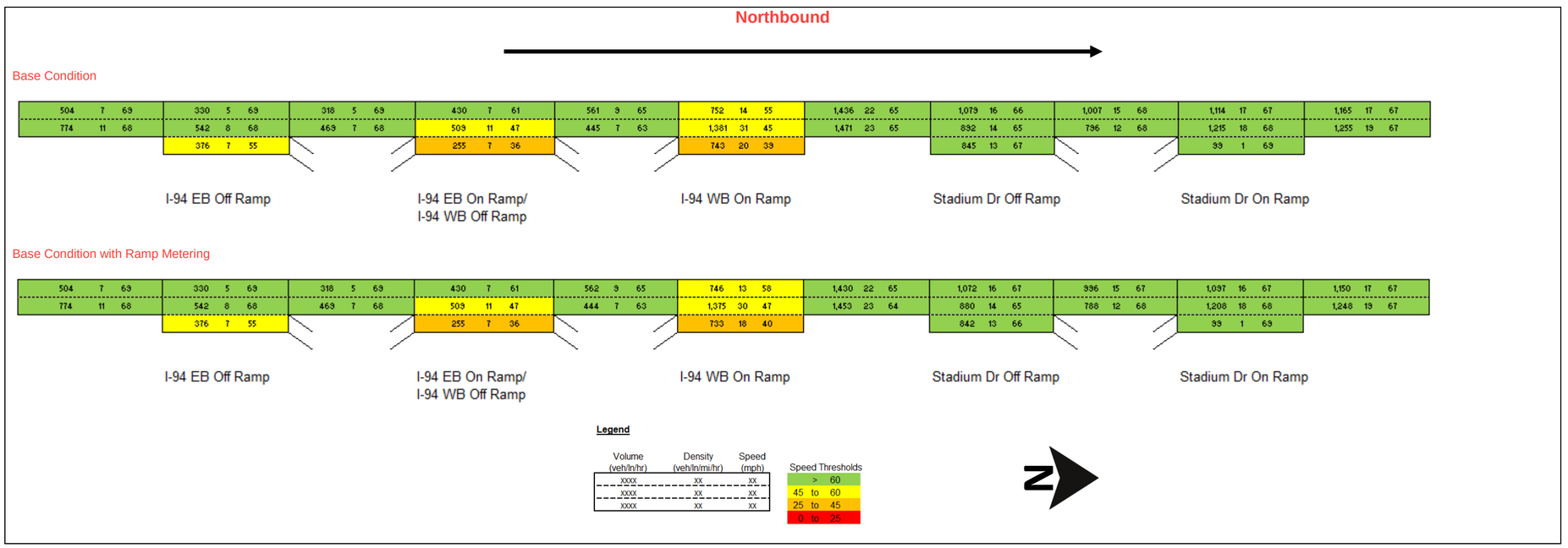


Figure 13. Base Condition Ramp Metering US-131 NB Lane Schematics



Based on the resultant lane schematics, adding ramp meter infrastructure to the I-94 WB Oakland Dr on ramp does not result in a benefit to the base condition operations. Comparing the I-94 WB base condition lane schematic with the base conditions with ramp metering lane schematic (Figure 12), the Oakland Dr on ramp experiences lower speeds when the ramp meter infrastructure is implemented. This may be due to the location of the ramp meter infrastructure. The ramp meter is placed approximately 650 ft. upstream of the subsequent merge point. This placement ensures that any ramp meter queueing does not exceed the ramps capacity and impact the signal operations at the upstream intersection. However, the trade-off with this placement is that the acceleration distance is reduced for vehicles entering the interstate system. This distance reduction is likely the cause of the reduced speeds documented in the lane schematics. Also, it seems that the ramp metering infrastructure is not impactful on the downstream congestion at the I-94 WB diverge to US-131 NB, as both lane schematics depict similar results. As expected, the ramp meter infrastructure at the I-94 WB Oakland Dr on ramp did not have any significant impact on the US-131 NB corridor, as the performance between the base conditions and the base conditions with ramp metering (Figure 13) is similar. Because of this, it is not recommended to install ramp meter infrastructure at the I-94 WB Oakland Dr on ramp as an interim improvement.

SENSITIVITY ANALYSIS

The intent of this analysis is to determine the robustness of the preferred alternative by adding additional artificial traffic volume to the study area until the modeled performance of the alternative becomes unacceptable. In other words, the sensitivity analysis will estimate the amount of traffic growth the preferred alternative can handle before operations begin to deteriorate significantly.

The sensitivity analysis was performed on Alternative 1, as this is the preferred alternative. To test the robustness of the microsimulation model, the traffic volumes on the mainline corridors (i.e. I-94 WB and US-131 NB) were increased in 5% increments for each consecutive simulation run. Each of these simulation runs was viewed for qualitative performance, with specific attention directed toward queue length and congestion. Ultimately, the sensitivity analysis determined that the preferred alternative (Alternative 1) can handle approximately a **30% increase** in traffic volume (from existing 2019 traffic volumes) before some localized congestion starts to form again at the I-94 WB to US-131 NB diverge along I-94 and subsequent merge along US-131. Current forecasts provided by MDOT indicate an anticipated total growth of approximately 12.3% along I-94 WB and 8.7% along US-131 NB in the next 20 years (2039). Lane schematics results are displayed in Figure 14 and Figure 15.

Figure 14. Sensitivity Analysis I-94 WB Lane Schematics

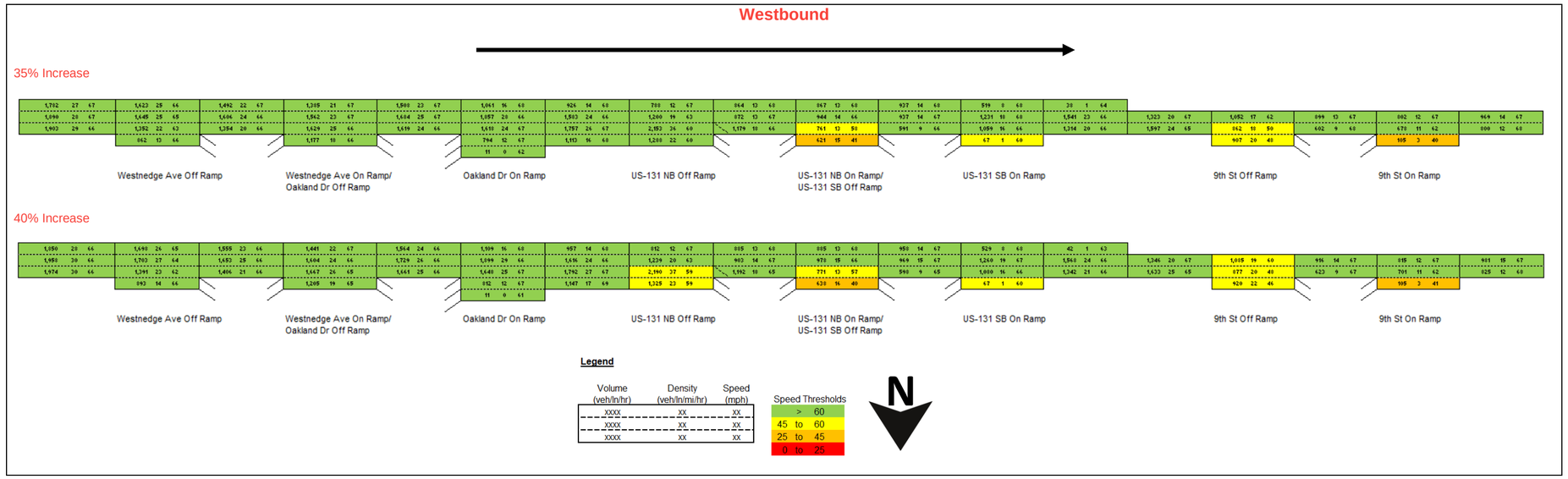
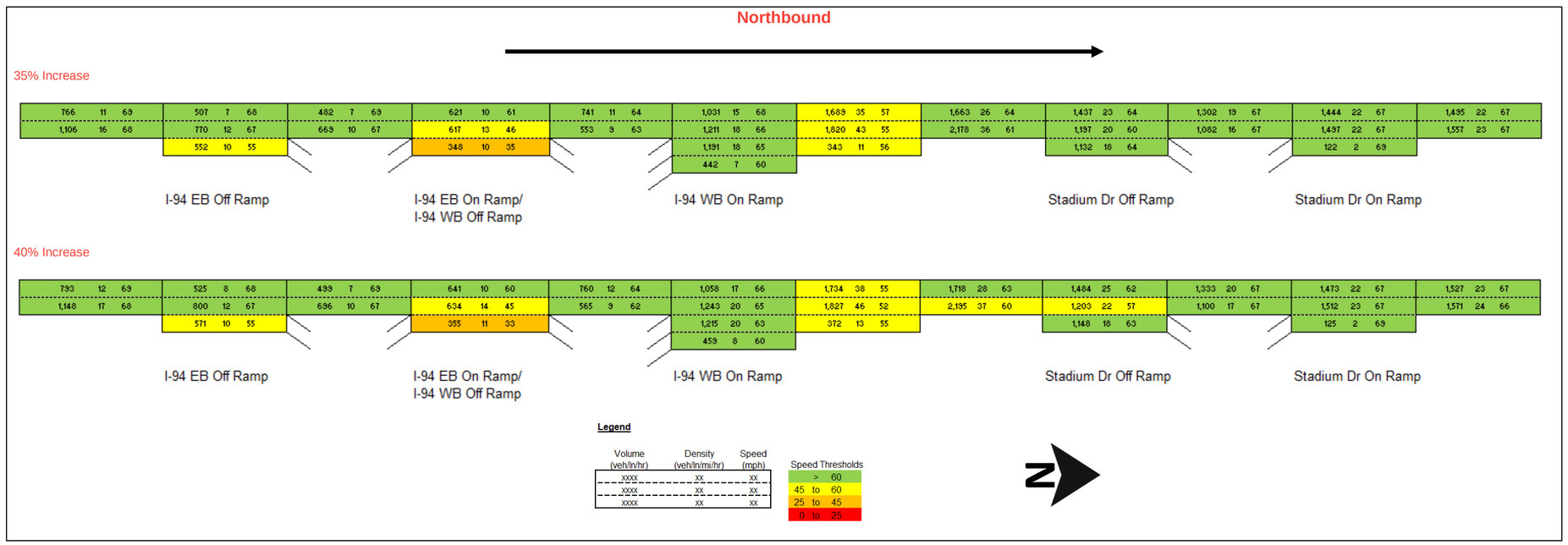


Figure 15. Sensitivity Analysis US-131 NB Lane Schematic



I-94 WB INSIDE LANE DROP

This analysis was to determine if the inside lane drop on I-94 WB mainline results in a negative impact on traffic operations. The lane drop of concern is on I-94 WB immediately after the US-131 SB on ramp. While the traffic from the on ramp is merging from the right onto a three-lane roadway, the inside lane begins to drop before this merge is completed, ultimately ending in a two-lane roadway after both merges. The concern in this area is that the merge maneuvers create negative impacts on traffic operations as traffic merges from both sides of the roadway simultaneously.

The lane schematics of the preferred alternative (Alternative 1) were reviewed to see if the resultant MOEs indicated any negative impacts from the inside lane drop at this location. Based on the results in Figure 10, the inside lane drop did not show any significant negative impact on any of the MOEs based on the simulation model. Field review indicated that typically free-flow speeds can be maintained through this area during the PM peak period, but there are frequent instances of slow downs and point congestion from merging behavior that is able to recover quickly. The inside lane drop within the same influence area of the outside lane drop may be more of a safety concern than an operational concern, and subsequent analysis may be better through a safety lens to determine if alternatives should be considered in this area. Suggested analyses could include a review of existing crash data, a “Near Miss” analysis using video analytics to determine if there is an above normal risk for crashes because of the current geometrics, or a Surrogate Safety Assessment Model (SSAM) that would utilize the microsimulation modeling results to review individual vehicle trajectories and statistically quantify safety risk in this area.