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7/21/2022

Milwaukee County North-South Transit Enhancement Study

TIER 2 EVALUATION

Appendix C

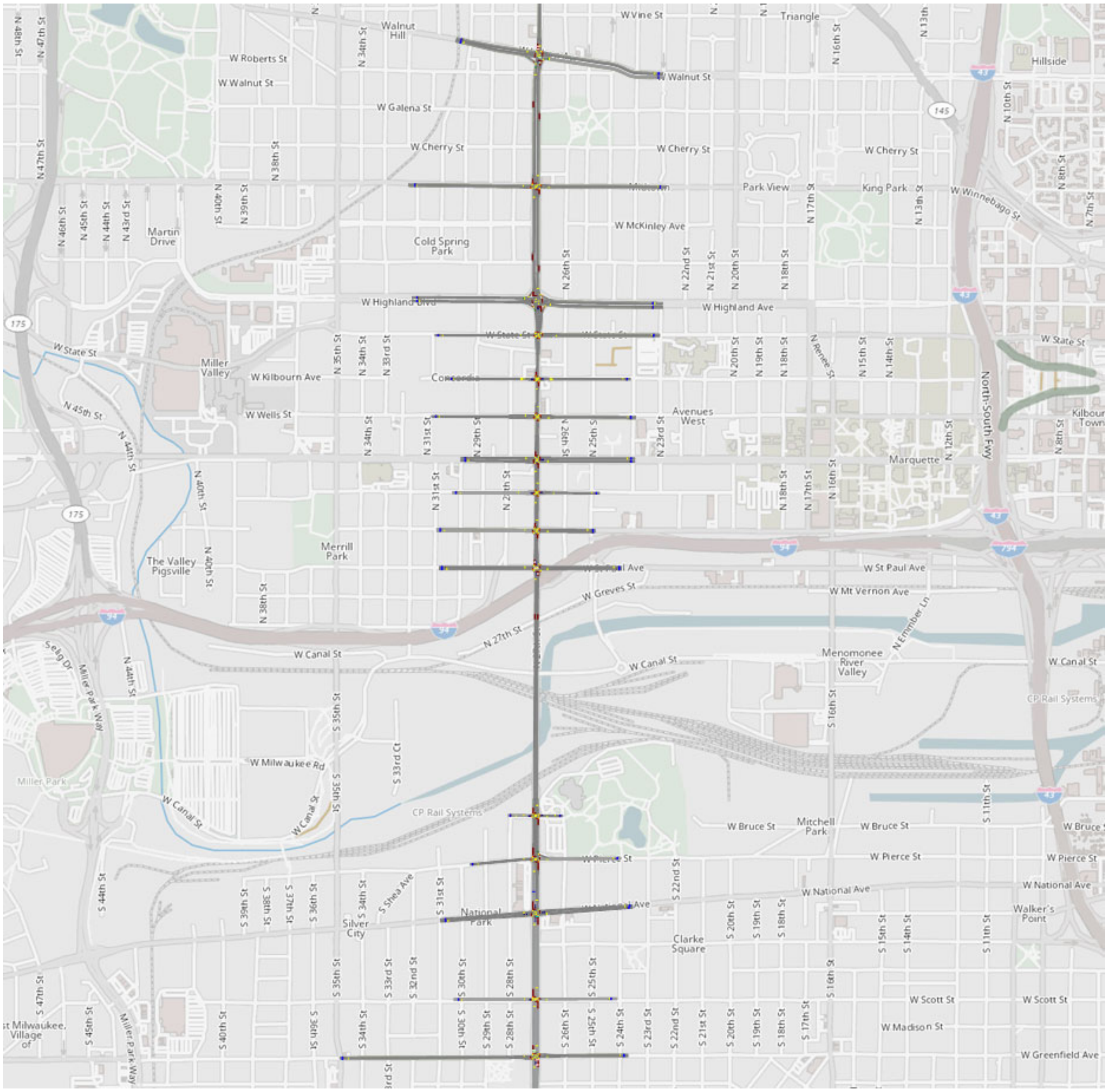
MICROSIMULATION ANALYSIS

OVERVIEW

This appendix summarizes the Southeastern Wisconsin Regional Planning Commission's (SEWRPC) efforts in forecasting potential transit travel time and intersection level of service (LOS) impacts associated with the implementation of transit signal priority (TSP) and the conversion of traffic lanes to exclusive transit bus lanes along the study alignment. This forecasting analysis was conducted using a microsimulation model implemented with PTV Vissim. As the 27th Street corridor under consideration includes more than 50 signalized intersections, a representative subsegment of the corridor was selected to identify the potential impacts on traffic and transit operational speeds. As such SEWRPC focused on the segment of 27th Street/Layton Boulevard between Lisbon Avenue/Walnut Street and Greenfield Avenue that includes 15 signalized intersections. Figure C.1 shows the location of the segment and the intersections analyzed.

This appendix first presents the efforts undertaken to calibrate and validate the microsimulation model to the base year 2019 data. Next, the results of the scenario analysis of travel lane conversion and TSP are presented for each of the analysis years (2025 and 2045). The last section of the appendix presents the conclusions based on the microsimulation analysis.

Figure C.1
Project Corridor Location



Source: SEWRPC

BASE YEAR 2019 VISSIM MODEL CALIBRATION AND VALIDATION

Initial model development processes must be completed before model calibration and validation processes can begin. The initial model development processes include network coding, including coding of signal timing plan data, determining input traffic volumes, and establishing analysis period, number of simulation runs, etc.

Calibration and validation of the microsimulation model were conducted as outlined in Chapter 16, Section 20 of the Wisconsin Department of Transportation's (WisDOT) Traffic Engineering, Operations & Safety Manual. Calibration of a microsimulation traffic model requires adjustments to the selected input parameters within the model, usually related to driver behavior and vehicle characteristics, such that the model represents field conditions. Model validation, on the other hand, is an independent process after calibration in which the model outputs are compared against benchmark field data, such as traffic volumes, travel speeds and times, queue lengths, time gap distribution, etc. Calibration and validation form an iterative process. After calibration, the model is run, and model results are compared against field data to check whether the model performance meets the validation targets. If validation thresholds are not satisfied, additional model calibration is carried out. This iterative process continues until validation thresholds are met.

Network Coding

Microsimulation traffic models require transportation (vehicular/transit/pedestrian/bicycle) facilities, including traffic control devices, to be coded in detail and their physical geometries coded to scale. This study focused on vehicular traffic at signalized intersections. Traffic lane configuration, traffic control device, and transit bus stop facilities were coded using aerial imagery and Google Street View.

Traffic Signal Timing Plan Data

Actual traffic signal timing plan data were encoded into the model for all signalized intersections on the study corridor based on information obtained from the City of Milwaukee, Milwaukee County, and WisDOT.

Analysis Period

It was found, based on 2019 hourly traffic count data, that the study corridor carried higher traffic volumes during the PM peak hour compared to the AM peak hour. Since the study was focused on identifying the upper end of expected time savings associated with implementing TSP, the PM peak hour (4:30 p.m. – 5:30 p.m.) was therefore selected as the model analysis period. An additional warm-up period of 15 minutes was used in this analysis based on the average PM peak-hour travel time of about 10 minutes measured in the field on the study corridor. A warm-up period allows traffic to load onto the network and helps the model reach a traffic condition expected in the field at the start of an analysis period. In addition, a cool-down period of 30 minutes was used in this analysis. A cool-down period allows vehicles loaded during the analysis period to complete their trips.

Traffic Volume Data

Microsimulation models typically utilize vehicular travel information in the form of Origin-Destination (OD) trip tables. OD tables for the corridor were estimated using an iterative processing technique known as Origin-Destination Matrix Estimation (ODME). In ODME, a seed table is adjusted iteratively until the volumes assigned match a set of target mainline and turning movement volumes. The seed table in this analysis was derived from SEWRPC's 5th Generation travel demand model. The traffic volume targets were established based on WisDOT triennial traffic count data. The following are the major inputs provided to the ODME process:

- *Seed OD tables*: SEWRPC's fifth generation travel demand models were used to extract the base year 2019 PM peak-hour seed OD tables.

- *Target link volumes*: Year 2019 PM peak-hour directional count volumes at locations on the analyzed segment, including cross streets, obtained from WisDOT triennial coverage count datasets. Latest prior year count volume data were used if 2019 count volume data were not available.

- *Target turn volumes*: Year 2019 turn movement count volumes obtained from WisDOT turn movement count datasets (found available only at the intersection of 27th Street & St. Paul Avenue).

The output from the ODME process is the adjusted seed OD tables (that result in highway assignments close to the target volumes) and are referred to in this appendix as ODME estimated trip tables, which after minor adjustments based on engineering judgment were the traffic volume data input to the Vissim microsimulation model. Two percent of traffic volumes were considered heavy vehicles (WisDOT defaults). However, heavy vehicles were prohibited from entering link segments that had truck restriction in place based on the information obtained from the City of Milwaukee.

Model Runs

Real-world traffic varies considerably over a day and from day to day. To mimic this variability, microsimulation models utilize stochastic variables that determine the release pattern of vehicles (how many and when) and the distribution of driver characteristics (behavior, speed, etc.) for each model run. The stochasticity (randomness) is obtained by using pseudo-random number generator, which is an algorithm within the modeling package. It requires a seed to initiate the underlying algorithm; two microsimulation model runs with the same seed yield identical results.

Typically, a scenario is run multiple times and the model results associated with that scenario is the average results of multiple runs. In this analysis, 10 simulation runs were used for base year 2019 scenario as well as for all future-year scenario runs. Each of 10 simulation runs (per scenario) utilized 10 distinct seed values as recommended in the WisDOT modeling guide.

Model Calibration

A range of input parameters are available to calibrate a Vissim model. A list of these parameters, along with recommended ranges, is provided in Chapter 16, Section 20 of the WisDOT Traffic Engineering, Operations & Safety Manual.

The input calibration parameters are broadly classified into two groups – global parameters and local parameters. The global parameters include simulation settings (simulation resolution, simulation speed, etc.), traffic settings (vehicle/pedestrian compositions), and base settings (vehicle fleet, vehicle/pedestrian types/classes, vehicle characteristics/functions/distributions, such as maximum/desired acceleration/deceleration, etc.). The local parameters include driving behavior (car following, lane change, lateral) and driver behavior at signal control. The WisDOT has prepared a set of defaults for these input parameters that simulate the traffic and vehicle characteristics specific to Wisconsin and have made them available on the WisDOT website (Vehicle Defaults for Vissim 2020 Version 1.2 (INPX file)). Given the range of input parameters, multiple parameter combinations may exist to calibrate a specific modeling condition in Vissim. The WisDOT advises that the model be calibrated by adjusting the global parameters first and then, only if necessary, adjusting the local parameters.

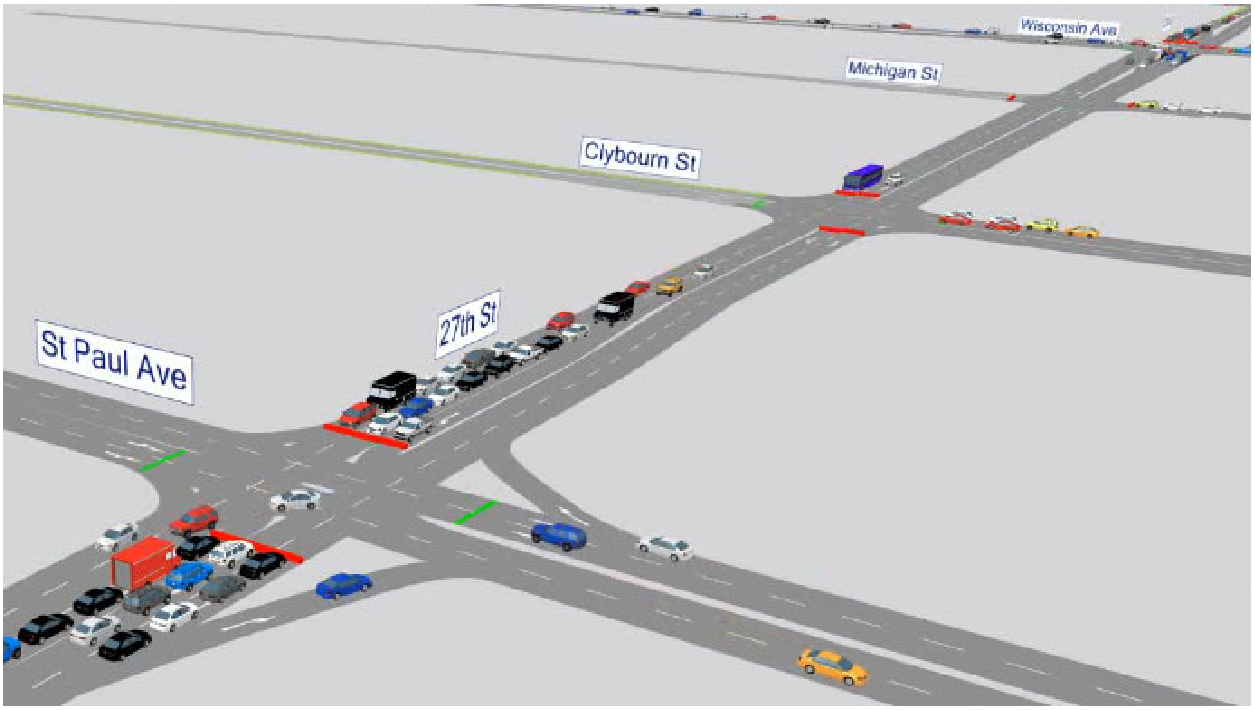
The Vissim model developed for this analysis incorporated WisDOT default calibration parameters applicable for arterial highways (as opposed to the freeways). The speed distribution inputs selected from WisDOT defaults were those corresponding to the posted speed limits on the study segments. Car-following model parameter was the only local calibration parameter that was changed in this analysis as Wiedemann

74 car-following model for car-following behavior on arterial highways was used with the following parameter values:

- Average standstill distance: 3.28 feet
- Additive part of safety distance: 1.00
- Multiplicative part of safety distance: 2.00

Average standstill distance defines the average desired distance between two stopped cars. Additive part of safety distance is used for the computation of the desired safety distance. Higher values of these parameters result in larger distances between cars and lower capacity. Multiplicative part of safety distance is also used for the computation of the desired safety distance; higher values result in greater standard deviation (greater spread) of the distribution of safety distance. The values of these parameters used in this analysis are on the lower end of the range of recommended values and were found appropriate in this study located in a large urban area to simulate closely spaced vehicles on a signalized corridor in low-speed condition. Figure C.2 provides a snapshot of the street level visualization of a microsimulation run used in this analysis.

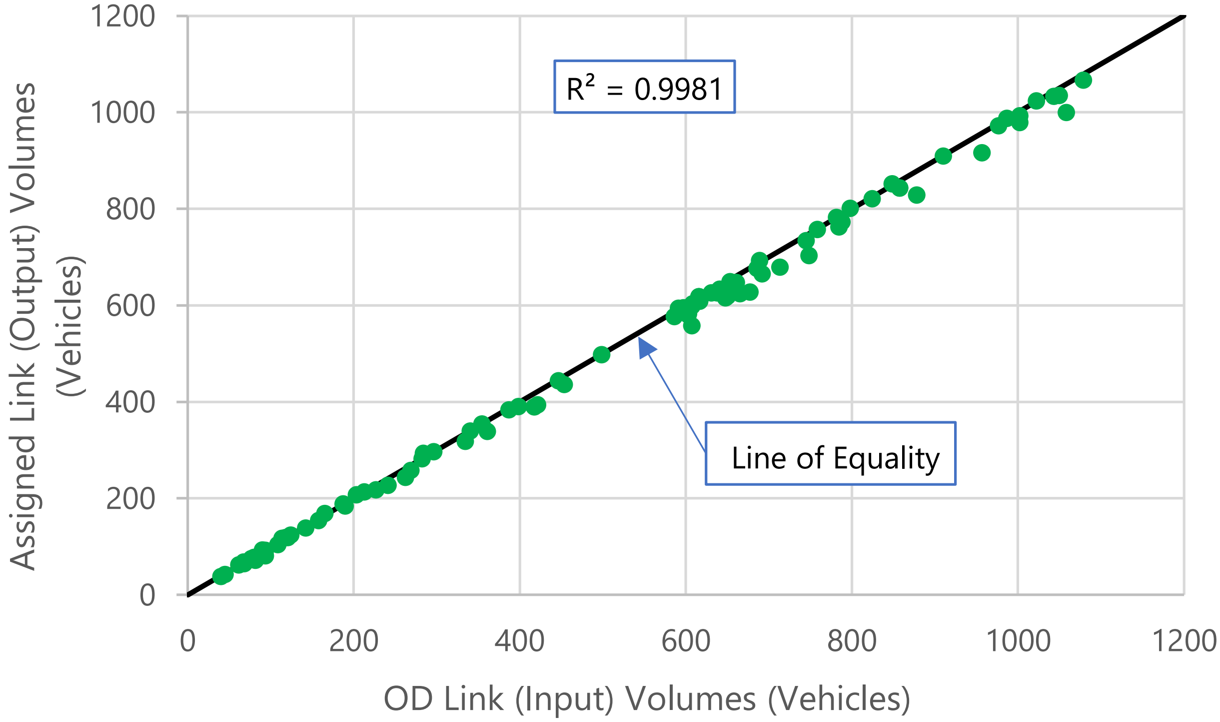
Figure C.2
A Snapshot of Vissim Microsimulation Model



Source: SEWRPC

In microsimulation models, as in the real world, roadway physical space places a hard cap on its capacity. If traffic demand input (OD tables in this study) exceeds network capacity, not all of the vehicles will get assigned to the network, as some vehicles (blocked vehicles) will be unable to enter the network at their desired time due to downstream vehicle queues. Figure C.3 compares the PM peak-hour input OD volumes through link assignment not constrained by network capacity to the capacity-constrained Vissim link volumes assigned during the PM peak-hour analysis period. A figure like this is essentially a way to check whether all input vehicles were able to travel to their intended destinations (indicated by a high R-square value) and helps detect the presence of blocked vehicles, unreleased vehicles (vehicles that were able to enter the network but not exit) and stalled/stuck vehicles. In this study, the stalled/stuck vehicles were not allowed to diffuse (disappear) from the network. The figure also helps identify other issues related to model calibration, warm up and cool down periods, and model evaluation setups. In such situations, the capacity-constrained assigned volumes, when plotted as in Figure C.3, will fall below the 45-degree line of equality (with a lower R-square value).

Figure C.3
Comparison Between the PM Peak-Hour OD Link (Input) Volumes and Assigned Link (Output) Volumes

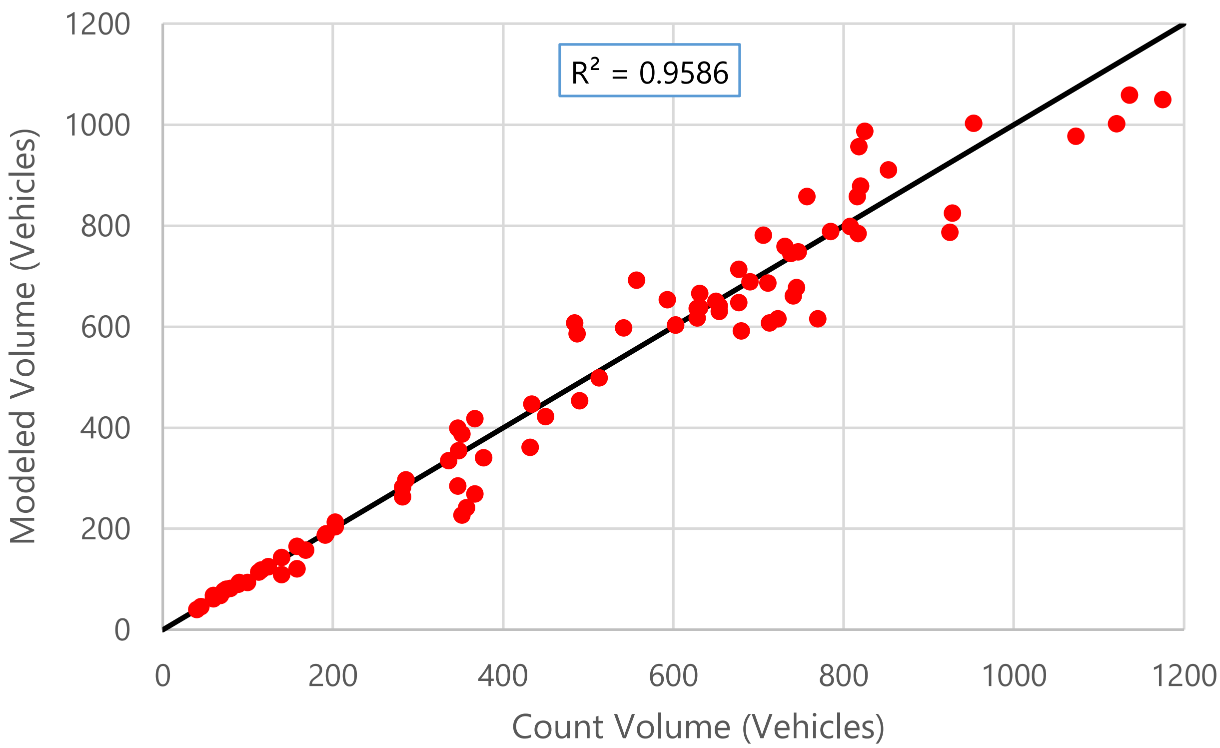


Source: SEWRPC

Model Validation

The base year 2019 Vissim model was validated for OD trip tables used in the analysis, turn movement volumes at count locations, travel time, travel speed, and traffic volume. Figure C.4 shows the comparison between target PM peak-hour directional link volumes (count volumes) and modeled PM peak-hour directional link volumes resulting from the assignment of ODME estimated trip tables. Figure C.5 shows the modeled PM peak-hour turn movement volumes compared to turn movement count volumes at the intersection of St. Paul Avenue and 27th Street. These figures show the validity of ODME estimated trip tables to model base year 2019 traffic volumes.

Figure C.4
Comparison between 2019 PM Peak-Hour Count Volumes (Target Volumes) and Modeled Volumes Obtained through ODME Process

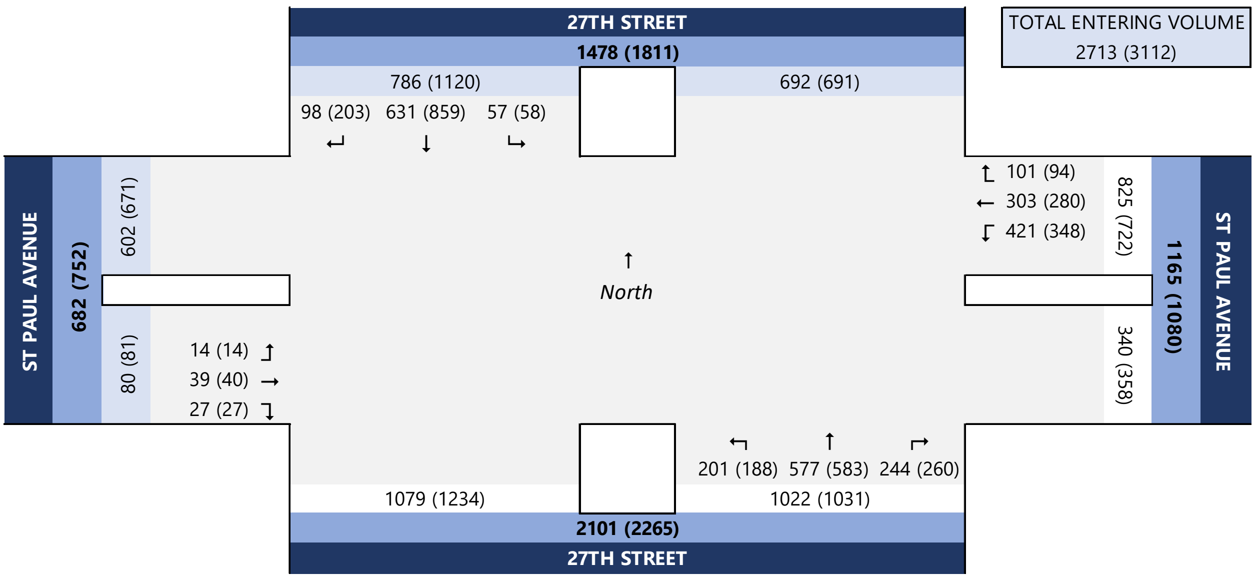


Source: SEWRPC

Table C.1 shows the base year 2019 PM peak-hour modeled travel times and travel speeds compared to the peak-hour travel times and travel speeds obtained from the 2019 National Performance Management Research Data Set (NPMRDS). The table shows the northbound modeled peak-hour travel times are within a minute and travel speeds within one mph compared to NPMRDS data; however, the modeled southbound travel time on the whole corridor is about 1.5 minutes longer and the travel speed about 3.5 mph slower than shown in the NPMRDS data. Field measurements of travel times carried out by the Commission staff found that the PM peak-hour southbound travel times on the study corridor to be significantly longer (by

3 minutes on an average on the whole corridor) compared to the travel times obtained from NPMRDS data. Table C.2 shows the NPMRDS, and modeled PM peak-hour travel times compared to the travel times measured in the field. Table C.3 shows the 2019 PM peak-hour modeled transit bus (PurpleLine) travel times compared to the travel times obtained from the Milwaukee County Transit System (MCTS) bus schedule. The modeled transit bus travel times are found to be within 2 minutes of the travel times estimated from bus schedule.

Figure C.5
2019 PM Peak-Hour Modeled Turn Movement Volumes Compared to Turn Movement Counts



Note: xxx = 2019 PM peak-hour modeled turn movement volume; (xxx) = 2019 PM peak-hour (4:00-5:00 pm) turn movement count.

Source: Wisconsin Department of Transportation and SEWRPC

Table C.1
2019 PM Peak-Hour Modeled Travel Time and Speed Compared to Travel Time and Speed Obtained from 2019 NPMRDS

Direction	Distance (Miles)	Travel Time (Minutes) NPMRDS	Travel Time (Minutes) Modeled	Travel Time (Minutes) Difference	Travel Speed (mph) NPMRDS	Travel Speed (mph) Modeled	Travel Speed (mph) Difference
NB - Whole Corridor	2.5	7.7	8.3	0.6	19.5	18.3	-1.2
NB - Greenfield to St Paul	1.2	3.2	3.4	0.2	23.0	22.0	-1.0
NB - St Paul to Lisbon	1.3	4.5	4.8	0.3	17.1	16.1	-1.0
SB - Whole Corridor	2.5	7.2	8.6	1.4	21.0	17.6	-3.4
SB - Lisbon to St Paul	1.3	4.4	5.1	0.7	17.6	15.3	-2.3
SB - St Paul to Greenfield	1.2	2.8	3.4	0.6	26.2	21.2	-5.0

Source: NPMRDS and SEWRPC

Table C.2
The NPMRDS and Modeled Peak-Hour Travel Times Compared to the Field Measured Travel Times

Direction	Distance (Miles)	Travel Time (Minutes): Measured at Field, Measurement 1[a] Run1	Run2	Run3	Average	Measurement 2[b]	NPMRDS	Modeled	Difference[c] NPMRDS	Difference[c] Modeled
NB - Whole Corridor	2.5	7.9	8.5	8.8	8.4	8.6	7.7	8.3	-0.7	-0.1
NB - Greenfield to St Paul	1.2	3.2	3.5	3.2	3.3	2.8	3.2	3.4	-0.1	0.1
NB - St Paul to Lisbon	1.3	4.7	5.0	5.6	5.1	5.8	4.5	4.8	-0.6	-0.3
SB - Whole Corridor	2.5	9.5	9.9	11.8	10.4	-[d]	7.2	8.6	-3.2	-1.8
SB - Lisbon to St Paul	1.3	5.0	5.6	8.8	6.5	-	4.4	5.1	-2.1	-1.4
SB - St Paul to Greenfield	1.2	4.5	4.4	3.0	4.0	6.3	2.8	3.4	-1.2	-0.6

[a] *Travel times measured at field on Wednesday February 09, 2022, between 4:30-5:30 pm.*

[b] *Travel times measured at field in 2016 between 4:30-5:30 pm.*

[c] *Difference compared to Average of Field Measurement 1.*

[d] *Not measured due to construction delay.*

Source: SEWRPC

Table C.3
2019 PM Peak-Hour Modeled Transit Bus Travel Time Compared to Travel Time Obtained from MCTS Bus Schedule

Direction	Distance (Miles)	Travel Time (Minutes): Purple Line[a] Transit Bus	Modeled	Difference
NB - Whole Corridor	2.5	14.0	15.0	1.0
NB - Greenfield to St Paul	1.2	5.0	6.5	1.5
NB - St Paul to Lisbon	1.3	9.0	8.4	-0.6
SB - Whole Corridor	2.5	14.0	15.8	1.8
SB - Lisbon to St Paul	1.3	9.0	9.3	0.3
SB - St Paul to Greenfield	1.2	5.0	6.4	1.4

[a] *Travel time estimated from MCTS bus schedule.*

Source: MCTS and SEWRPC

SCENARIO ANALYSIS

The major goal of scenario analysis was to quantify the impacts of converting travel lanes to exclusive transit bus lanes and TSP implementation on corridor travel times and intersection LOS. TSP is a common method of providing preferential signal timing for transit at an intersection. TSP aims to improve the reliability of transit by reducing delay at intersections, thereby reducing average running time. TSP can improve LOS for vehicles operating in the direction of transit but could also impair LOS on the cross streets. TSP operates by shifting green time from cross streets to the street where transit is operating, however priority is not preemption. If the signal controller determines that the cross street is already at its minimum time, no action will be taken. This occurs more frequently in controllers with shorter cycle lengths or longer pedestrian clearance times, either of which determines the minimum red time. Similarly, TSP could be used in a fashion where it is activated conditionally to only prioritize transit that is sufficiently late.

TSP implementation generally involves exclusive bus lanes and lights, protected turns, and/or green extension and red truncation. Green extension refers to the amount of time a green signal will be extended to allow transit to cross an intersection. Red truncation (also known as early green) refers to the amount of time a red signal will be truncated after receiving a call from transit. Green extension provides greater time savings (by allowing a red phase to be skipped altogether), but only if transit approaches the intersection at the end of a green signal. Alternatively, red truncation allows for small time savings (equaling truncation time), but in a more consistent manner as the probability of approaching a signal at red phase (thus activating red truncation) is considerably higher than the probability of approaching a signal near the end of green phase (activating green extension). Green extension and red truncation are usually used in conjunction to provide greater and consistent time savings at signalized intersections.

The impacts of TSP in this study were modeled by coding additional TSP setups in the network and by appending TSP variables, values, and thresholds to the base year 2019 signal timing parameters. Green extension and red truncation both were modeled but only one would be activated in a signal cycle depending on the phase when a TSP call was received. Additionally, the TSP was conservatively assumed to activate conditionally (being triggered only if the transit vehicle was behind schedule by at least 30 seconds as determined based on the difference between desired transit operating speed and actual simulated speed).

Scenarios

The base year 2019 calibrated and validated Vissim model was utilized to analyze three different scenarios in each of the analysis years 2025 and 2045. The following are the scenarios analyzed:

- **No Build:** No exclusive travel lanes and no TSP provided for transit bus

- **Build without TSP:** Exclusive travel lanes on the segments where conversion of travel lanes is recommended without TSP provided for transit bus

- **Build with TSP:** Exclusive travel lanes on the segments where conversion of travel lanes is recommended with TSP at all signalized intersections provided for transit bus.

The traffic volume data for the analysis years 2025/2045 were determined by estimating change in 2025/2045 trips compared to the base year 2019 trips obtained from the Commission travel demand models. The forecast change in trips was then added to the base year 2019 ODME estimated trip tables to obtain the traffic volume input for 2025/2045 Vissim microsimulation models. As in the case of base year 2019, two percent of traffic volumes were considered heavy vehicles. Truck restrictions that exist in the base year were assumed to continue into 2025/2045.

The signal timing plan data input for the scenario analysis remained the same as for the base year 2019. The difference between the base year 2019 and 2025/2045 No-Build scenarios was the growth in traffic volumes in 2025/2045. The difference between 2025/2045 No-Build and Build without TSP scenarios was the conversion of travel lanes to transit bus-only lanes where recommended. Non-transit vehicles were prohibited from traveling on transit bus-only lanes. The difference between 2025/2045 Build without TSP and Build with TSP scenarios was the implementation of TSP at signalized intersections.

Model Results

The paragraphs that follow present the model results in terms of simulated travel times and LOS under various scenarios. The travel times and the LOS simulated under the base year 2019 are also presented.

Travel Time

The northbound and southbound travel times on the whole corridor, as well as the segment between Greenfield Avenue and St. Paul Avenue and the segment between St. Paul Avenue and Lisbon Avenue/Walnut Street, are shown for overall traffic in Table C.4 and for transit buses in Table C.5 under different scenarios. In general, travel times increased as congestion built up resulting from some growth in traffic expected in the areas surrounding the analyzed corridor. Conversion of travel lanes to exclusive bus lanes affected travel times as expected; negatively (up to one minute longer) for overall roadway traffic and positively (up to 3 minutes shorter) for transit. However, the conditional implementation of TSP included in this analysis was found to have minimal impact on typical travel times, resulting in a time saving of less than one minute for transit. There are likely travel time reliability benefits (which would appear when the vehicle is more dramatically behind schedule) that are not captured within this analysis.

Level of Service

The forecast level of service is presented in Figure C.6. In general, the modeled overall intersection LOS is C or better under different scenarios, except for the intersections at Greenfield Avenue (LOS E for Build scenarios) and Wisconsin Avenue (LOS D for all 2025 and 2045 scenarios). The specific turn movement LOS at intersections is generally D or better. However, some turn movements have been forecast to be failing (LOS F), the most prominent of which are the turn movements from Greenfield Avenue and the eastbound movements at State Street. The eastbound left at National Avenue and the westbound left at Wisconsin Avenue have also been modeled to be operating under LOS F.

C.4 CONCLUSION

This appendix summarized SEWRPC's efforts in conducting an intersection-level analysis using the PTV Vissim microsimulation tool on a segment in the core of the study corridor on 27th Street/Layton Boulevard between Lisbon Avenue/Walnut Street and Greenfield Avenue. The major objectives of the analysis were to quantify the impacts of TSP and travel lane conversion to exclusive transit bus lanes on the corridor travel times and the intersection LOS. As expected, the conversion of travel lanes to exclusive transit bus lanes was found to affect travel times negatively for overall roadway traffic and positively for transit buses. However, the implementation of TSP was found to have little effect on travel times, given the conditional application of TSP assumed under this analysis, and the need to make generalized assumptions about station locations that were not optimized to take advantage of TSP.

The majority of the intersections were found to operate under overall intersection LOS C or better, and intersection turn movements under LOS D or better. However, a couple of intersections and some turn movements were forecast to be operating under LOS E or worse. Further study involving optimization of signal timing on the study corridor as well as on adjacent corridors with turn movement count data at all signalized intersections is necessary to better model intersection turn movements and estimate a more precise intersection operating environment.

Table C.4
Modeled PM Peak-Hour Travel Speed on the Study Corridor

Direction	Travel Time (Minutes)																												
	Base Year 2019	No Build		Build (Without TSP)		Build (With TSP)																							
						Average Travel Time												Change in Average Travel Time											
						10 sec extension/truncation[A]						15 sec extension/truncation						10 sec extension/truncation						15 sec extension/truncation					
						18 mph[B]		20 mph		22 mph		18 mph		20 mph		22 mph		18 mph		20 mph		22 mph		18 mph		20 mph		22 mph	
		2025	2045	2025	2045	2025	2045	2025	2045	2025	2045	2025	2045	2025	2045	2025	2045	2025	2045	2025	2045	2025	2045	2025	2045	2025	2045	2025	2045
NB - Whole Corridor	8.4	8.6	8.7	9.6	9.5	9.5	9.4	9.5	9.4	9.5	9.5	9.5	9.4	9.5	9.4	9.5	9.4	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
NB - Greenfield to St Paul	3.4	3.4	3.5	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.5	4.6	4.6	4.6	4.5	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0
NB - St Paul to Lisbon	4.9	5.0	5.1	5.1	5.1	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3
SB - Whole Corridor	8.8	8.8	9.1	8.9	9.1	8.8	9.1	8.8	9.1	8.8	9.0	8.8	9.0	8.8	9.1	8.8	9.1	-0.1	0.0	-0.1	0.0	-0.1	0.0	-0.1	-0.1	-0.1	0.0	-0.1	0.0
SB - Lisbon to St Paul	5.2	5.2	5.5	5.3	5.6	5.3	5.5	5.2	5.5	5.3	5.5	5.3	5.5	5.2	5.5	5.2	5.5	0.0	0.0	-0.1	0.0	-0.1	0.0	0.0	0.0	-0.1	0.0	-0.1	0.0
SB - St Paul to Greenfield	3.5	3.5	3.5	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[a] *Extension if TSP requires current green at an intersection to extend, truncation if TSP requires current red at an intersection to truncate early.*

[b] *Desired transit operating speed.*

Source: SEWRPC

Table C.5
Modeled PM Peak-Hour Travel Speed of Transit Bus on the Study Corridor

Direction	Travel Time (Minutes)																												
	Base Year 2019	No Build		Build (Without TSP)		Build (With TSP)																							
						Average Travel Time												Change in Average Travel Time											
						10 sec extension/truncation[A]						15 sec extension/truncation						10 sec extension/truncation						15 sec extension/truncation					
						18 mph[B]		20 mph		22 mph		18 mph		20 mph		22 mph		18 mph		20 mph		22 mph		18 mph		20 mph		22 mph	
		2025	2045	2025	2045	2025	2045	2025	2045	2025	2045	2025	2045	2025	2045	2025	2045	2025	2045	2025	2045	2025	2045	2025	2045	2025	2045	2025	2045
NB - Whole Corridor	15.3	15.0	15.3	13.4	13.5	12.8	13.0	12.7	12.9	12.7	12.9	12.8	13.0	12.7	12.9	12.7	12.9	-0.6	-0.5	-0.7	-0.6	-0.7	-0.6	-0.6	-0.5	-0.7	-0.6	-0.7	-0.6
NB - Greenfield to St Paul	6.6	6.7	6.7	4.9	4.9	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.9	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NB - St Paul to Lisbon	8.6	8.4	8.6	8.5	8.6	7.9	8.1	7.9	8.0	7.8	8.0	7.9	8.1	7.9	8.0	7.8	8.0	-0.5	-0.5	-0.6	-0.5	-0.6	-0.5	-0.5	-0.5	-0.6	-0.5	-0.6	-0.5
SB - Whole Corridor	16.1	16.2	16.4	13.8	13.8	13.3	13.3	13.3	13.2	13.3	13.2	13.3	13.3	13.3	13.2	13.3	13.2	-0.5	-0.5	-0.6	-0.6	-0.6	-0.6	-0.5	-0.5	-0.6	-0.6	-0.6	-0.5
SB - Lisbon to St Paul	9.5	9.6	9.8	8.2	8.1	7.6	7.7	7.6	7.7	7.6	7.7	7.6	7.7	7.6	7.7	7.6	7.7	-0.5	-0.4	-0.6	-0.4	-0.5	-0.4	-0.5	-0.5	-0.6	-0.4	-0.5	-0.4
SB - St Paul to Greenfield	6.5	6.5	6.6	5.7	5.7	5.8	5.7	5.7	5.6	5.7	5.6	5.8	5.7	5.7	5.6	5.7	5.6	0.1	0.0	0.0	-0.1	0.0	0.0	0.1	0.0	0.0	-0.1	0.0	-0.1

[a] *Extension if TSP requires current green at an intersection to extend, truncation if TSP requires current red at an intersection to truncate early.*

[b] *Desired transit operating speed.*

Source: SEWRPC

Figure C.6
Modeled Intersection and Turn Movement Level of Service

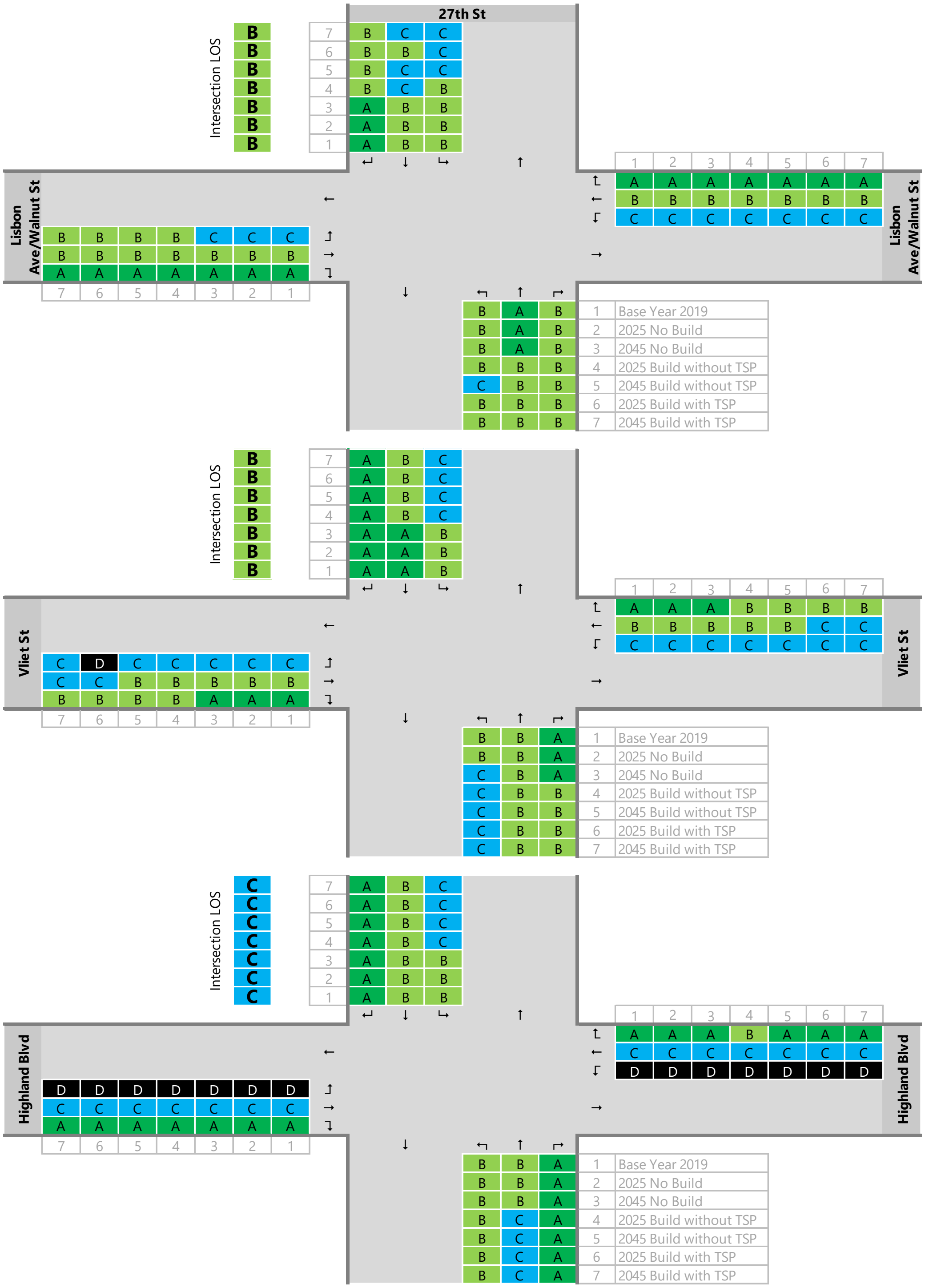


Figure C.6 (Continued)

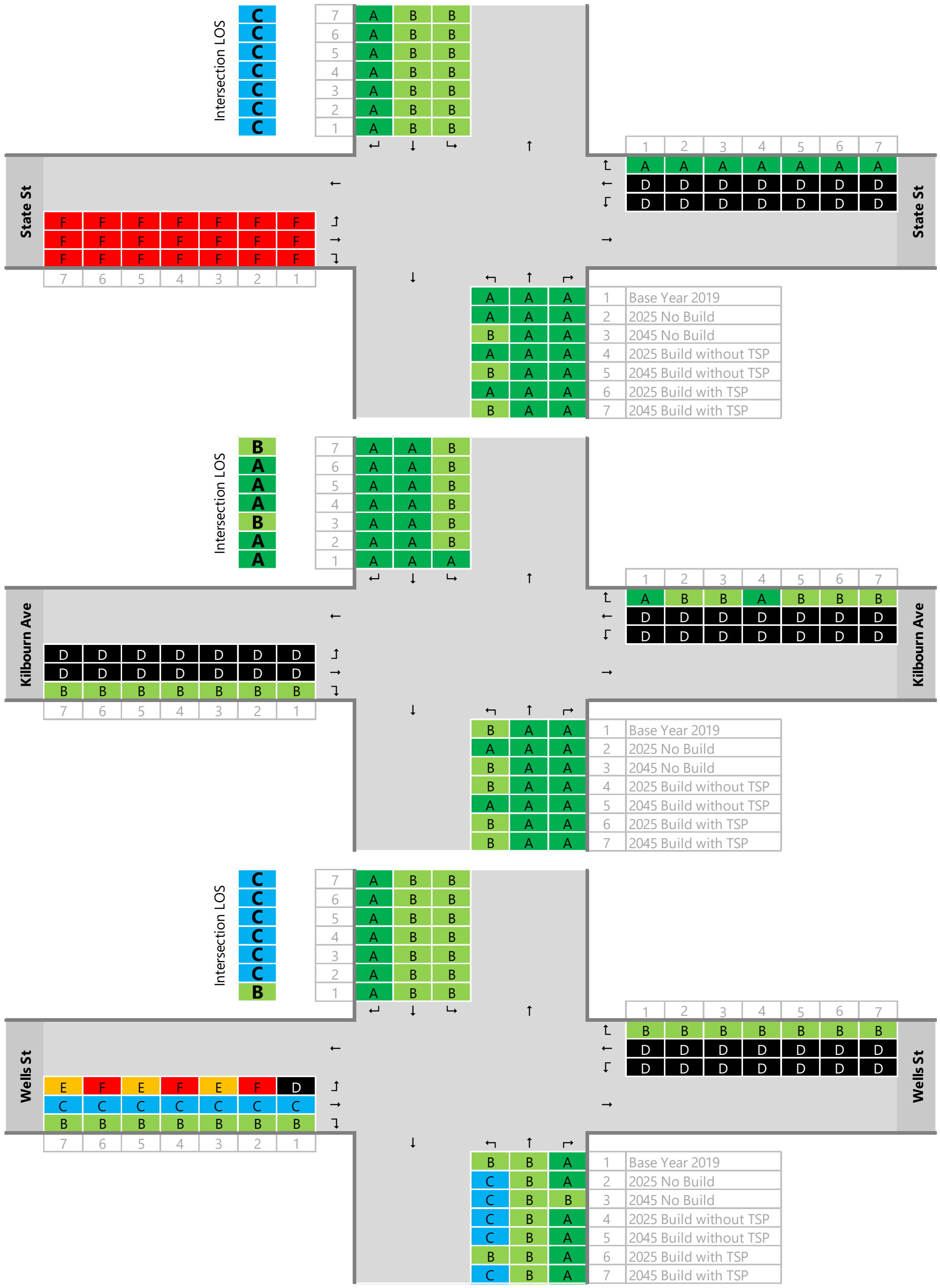


Figure C.6 (Continued)

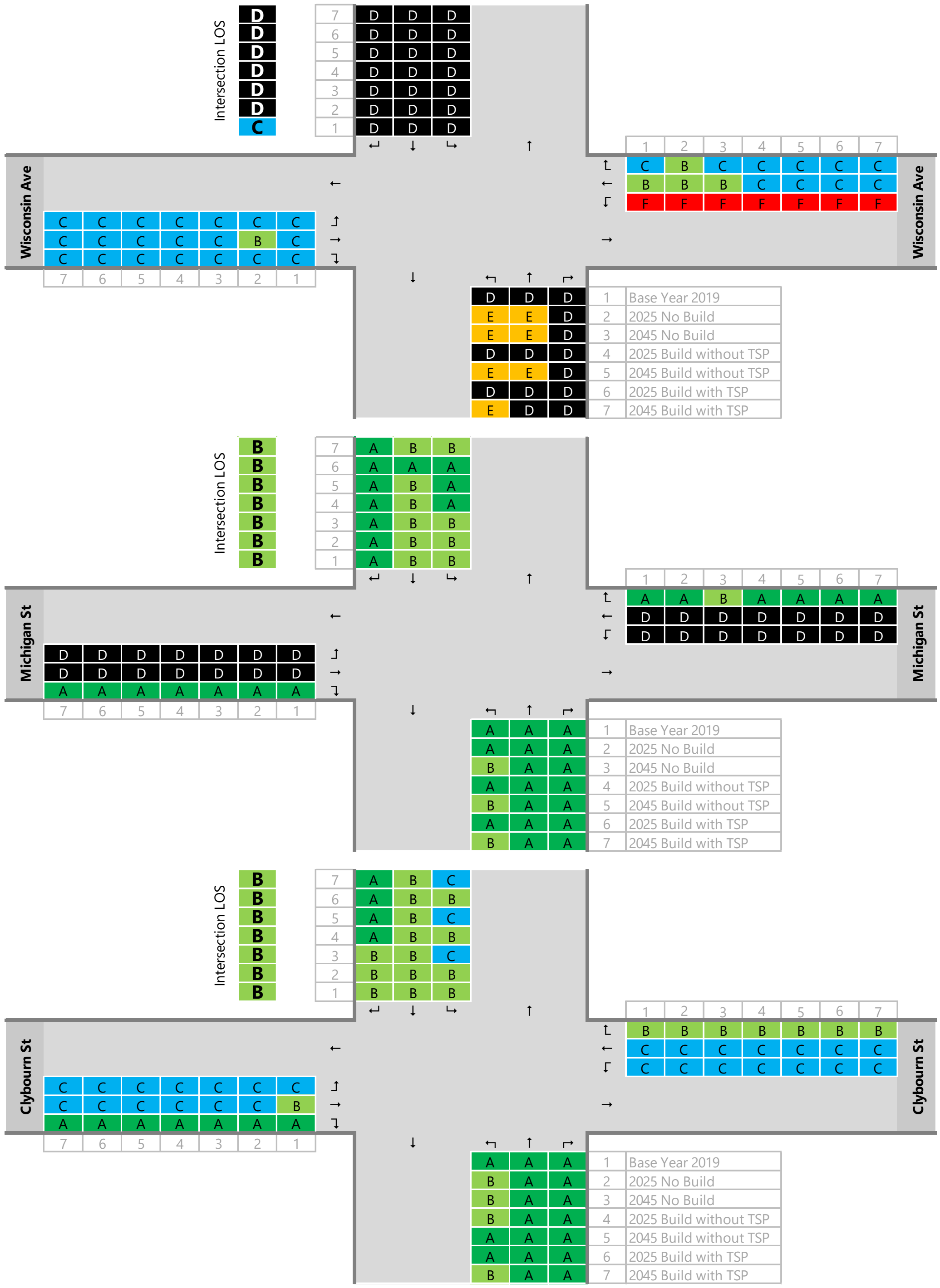


Figure C.6 (Continued)

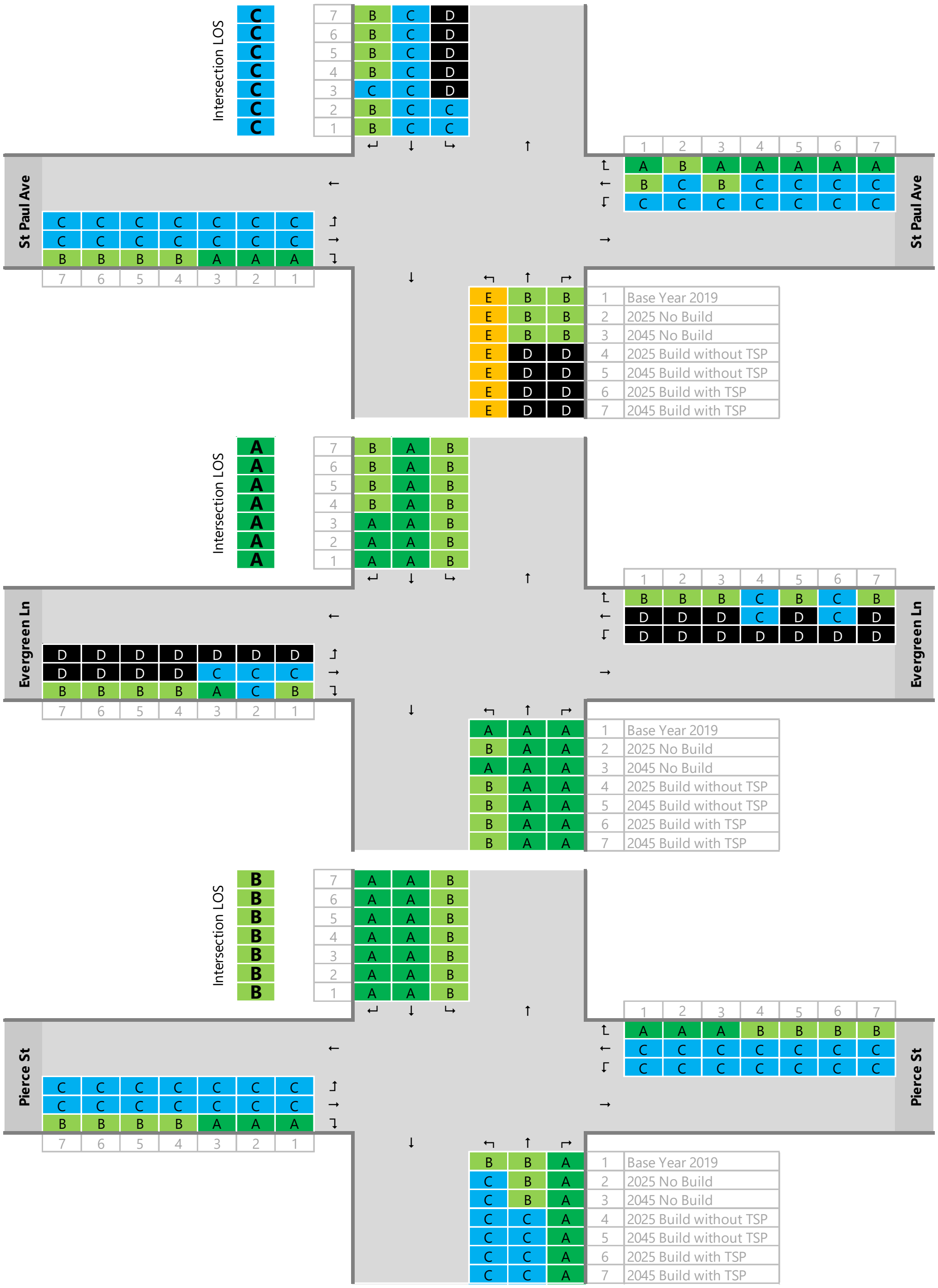
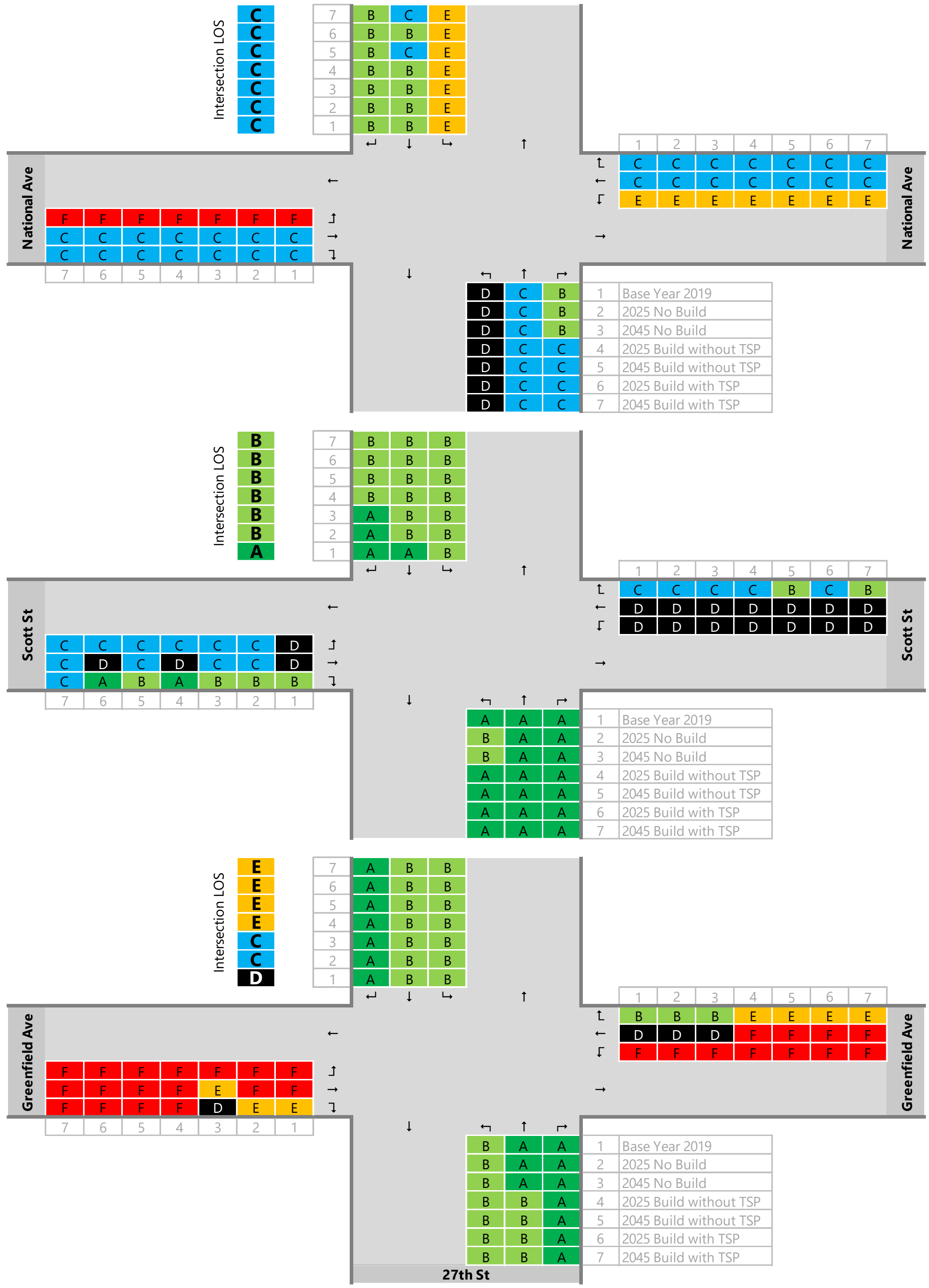


Figure C.6 (Continued)



Note: a) Assumes 10 sec extension if TSP requires current green at an intersection to extend, or 10 sec truncation if TSP requires current red at an intersection to truncate early, b) Assumes 18 mph desired transit operating speed.

Source: SEWRPC