PREPARED FOR

Wisconsin Department of Transportation
944 Vanderperren Way
Green Bay, WI 54304

PREPARED BY

HNTB Corporation (with Strand Assoc.)
10 W. Mifflin Street
Suite 300
Madison, WI 53703

Contact:
Jerry Shadewald
(608) 294-5009
jshadewald@hntb.com

I-41 TRAFFIC AND ENGINEERING STUDY

I-41 from CTH BB (Prospect Avenue) to CTH S

FINAL REPORT SEPTEMBER 2019

Contents

List of Figures

List of Tables

PROJECT OVERVIEW

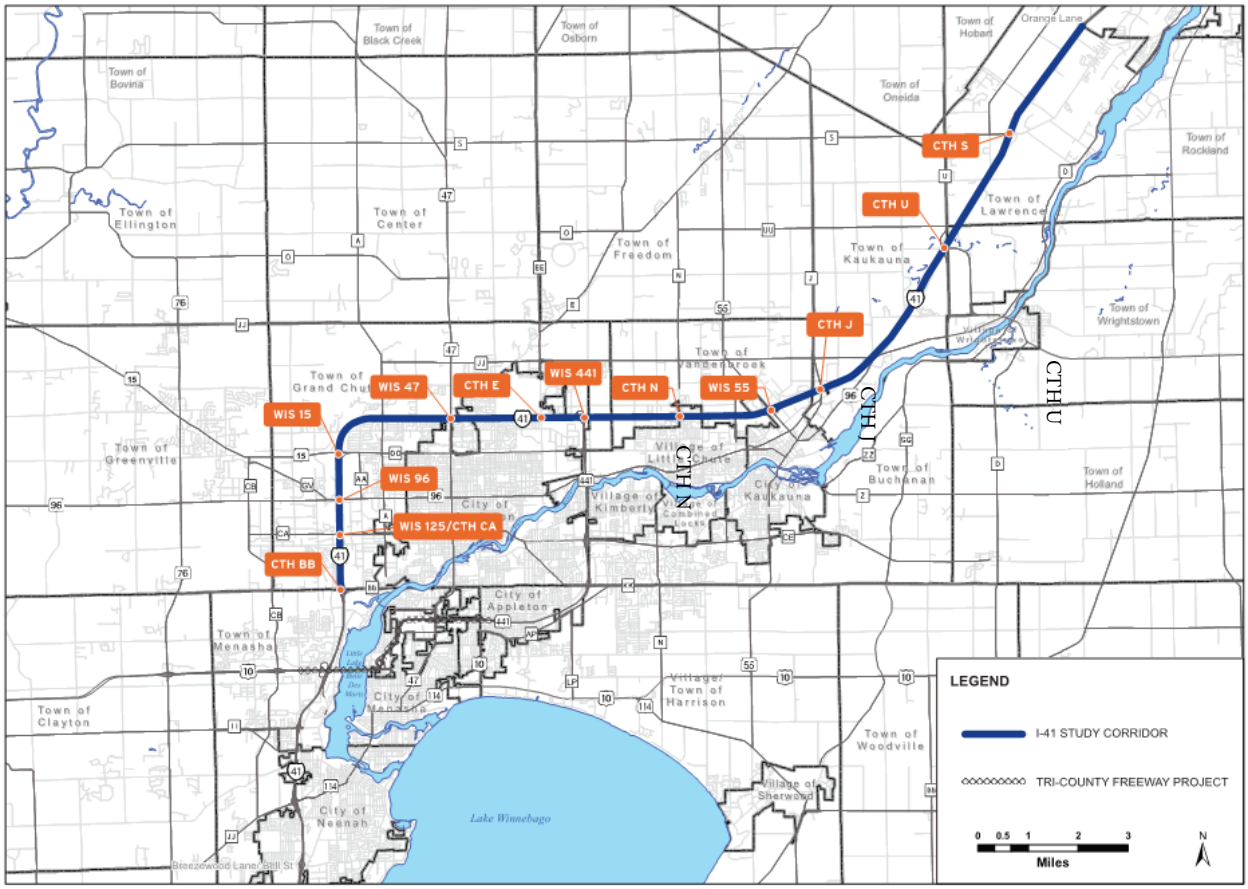
The purpose of the I-41 Traffic and Engineering Study is to analyze mainline and ramp terminal intersection peak hour traffic operations, identify future infrastructure needs, and gauge safety impacts along the I-41 corridor in the greater Appleton area. This report documents the findings of the study, including the existing and future I-41 traffic operations, recommended future improvements, and the safety evaluation.

The limits of this project are in the Appleton, WI area along I-41 from south of the CTH BB/Prospect Avenue interchange in the south to north of the CTH S interchange in the north, approximately 23 miles. The project limits include twelve interchanges, including the WIS 441 north system interchange, and the I-41 ramp terminal intersections at each interchange. The study area includes the following I-41 interchanges:

- CTH BB/Prospect Avenue – signalized intersections
- WIS 125/College Avenue – signalized intersections
- WIS 96/Wisconsin Avenue – signalized intersections
- WIS 15/Northland Avenue – signalized intersections
- WIS 47/Richmond Street – signalized intersections
- CTH E/Ballard Road – signalized intersections
- WIS 441 – north system interchange
- CTH N/Freedom Road – signalized intersections
- WIS 55/Delanglade Street – roundabout intersections
- CTH J/Hyland Avenue – roundabout intersections
- CTH U/County Line Road – two-way stop sign intersections
- CTH S/Freedom Road – two-way stop sign intersections

Figure 1 below shows the general project limits of the I-41 Traffic and Engineering Study.

Figure 1: I-41 Traffic and Engineering Study Project Limits



DATA COLLECTION

Field data was collected from various sources to analyze existing traffic operations and to analyze existing safety. The following describes the data utilized in each analysis.

The data resources described below were used for the traffic operations analysis.

- Link and Turning Volumes – Raw field traffic counts were obtained from WisDOT & East Central Wisconsin Region Planning Commission (ECWRPC) and modified with seasonal factors and balanced as described in the year 2018 existing volume development section below. Appendix A includes the traffic counts.
    - Existing volumes are based on the vehicle traffic counts conducted over various years by ECWRPC, WisDOT automatic traffic recording (ATR) stations and the WisDOT turning movement count program.
    - The WisTransportal website was used for the majority of the I-41 mainline counts. ECWRPC supplemented these locations with counts on the direct connect ramps at the I-41/WIS 441 north system interchange.
    - WisDOT's turning movement count program provided intersection counts at a majority of the ramp terminals. ECWRPC supplemented these locations with intersection counts at WIS 55, CTH J, and CTH U. Intersection counts were conducted on various days between 2011 and 2019.
- Speeds –National Performance Management Research Data Set (NPMRDS) data was collected for the year 2018 at 50 Traffic Message Channels (TMC) which were summarized to five northbound and southbound segments along the I-41 mainline:
    - I-41, from CTH BB/Prospect Avenue exit ramp to WIS 96/Wisconsin Avenue exit ramp.
    - I-41, from WIS 96/Wisconsin Avenue exit ramp to WIS 47/Richmond Street exit ramp.
    - I-41, from WIS 47/Richmond Street exit ramp to WIS 441 entrance ramp.
    - I-41, from WIS 441 entrance ramp to CTH J/Hyland Avenue entrance ramp.
    - I-41, from CTH J/Hyland Avenue to CTH S exit ramp.
- Travel Times – Travel time data is calculated based on the NPMRDS speed data.
- Lane Utilization – Lane utilization field data was provided by WisDOT for ATRs at the following five locations along the I-41 mainline:
    - I-41, south of CTH BB/Prospect Avenue.
    - I-41, between WIS 125/College Avenue and WIS 96/Wisconsin Avenue.
    - I-41, between CTH E/Ballard Road and WIS 441.
    - I-41, between WIS 441 and CTH N/Freedom Road.
    - I-41, between CTH U/County Line Road and CTH S.
- Traffic Signal Timings – The most current signal timings for all signalized intersections in the project study area were provided by WisDOT. They are included in Appendix B.

The data resources described below were used for the safety analysis. Explanation on how the data was used for the Interactive Highway Safety Design Model (IHSDM) safety analysis is included later in the document in the Safety sections.

- Geometric Data:
  - As-built plans and design files, as available, from south of CTH BB to south of CTH F.
  - Aerials for Winnebago, Outagamie, and Brown County.
  - Online mapping services to supplement the as-built plans and aerials.
- Traffic Volume Data:
  - Balanced daily traffic volumes for the I-41 mainline, ramps, and intersection turning movements.
  - Mainline hourly traffic data at ATR sites provided by WisDOT.
  - WisTransPortal website for hourly counts.
  - Weigh station traffic data provided by WisDOT Division of State Patrol.
- Crash Data:
  - Spreadsheet listings provided by WisDOT via WisTransPortal.
  - Police reports provided by WisDOT via WisTransPortal.
  - Intersection crash diagrams provided by WisDOT.

EXISTING TRAFFIC VOLUME DEVELOPMENT

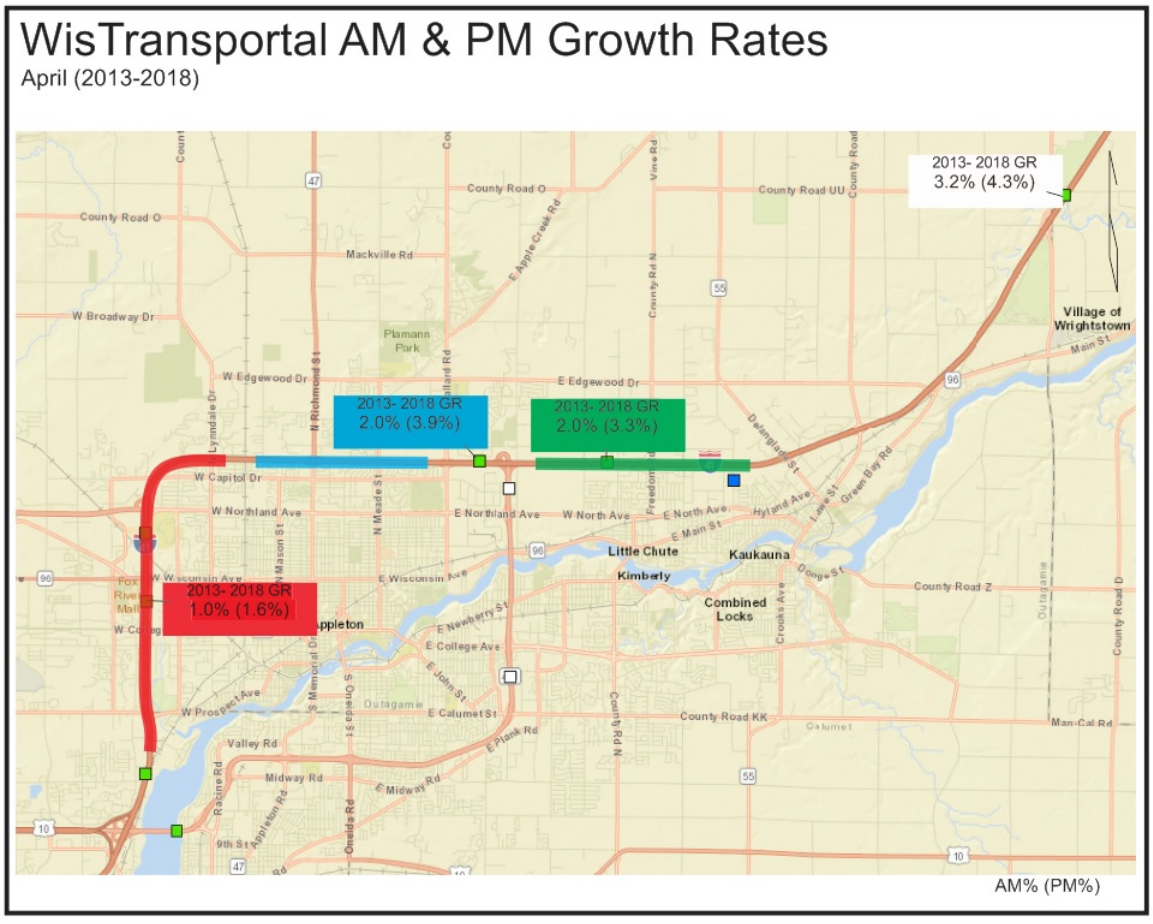
This section describes the development of the year 2018 existing traffic volumes.

Year 2018 Existing Volume Development

WisTransportal data was averaged Monday thru Thursday data during the month of May 2018. ECWRPC data was collected in March 2019. Each of the data sources were seasonally adjusted for the month of data collection. WisTransportal and ECWRPC data utilized a seasonal factor of 0.958 and 1.062, respectively.

Each intersection turning movement count was adjusted by seasonal factors and daily factors to represent an average count. A background growth rate was applied to each count to represent the year 2018. Background growth rates were calculated from WisTransportal data and applied to ramp terminals by section. Figure 2 presents the background growth rates and the applied area. Note that the north section between WIS 55 and CTH S does not have a background growth rate since these counts were collected in year 2019 and do not need adjustment.

Figure 2: Background growth rate



Project counts were reviewed as a collective data set and the peak hours were determined to be 7:00-8:00 AM and 4:15-5:15 PM. For the VISSIM microsimulation models, shoulder hour pre- and post- peak were also determined to create a 3-hour period model. Peak hour volumes were balanced and adjusted to reflect the 250th highest hour of the year (K-250). Guidance from WisDOT FDM 11-5-3.5.1.1 indicates that K-250 is appropriate for an urban area which represents a majority of the project study area. The balanced volumes were compared to K-tables provided by WisDOT at two locations on I-41: Site 440105 (Between WIS 96 & WIS 125) and Site 441218 (East of CTH E). Figure 3 presents the estimated K-values at both locations.

Figure 3: Estimated K Values

Site 440105
I-41 BTWN STH 125 & STH 96 APPLETON

Cross Section		
I-41	Balanced Volume	Estimated K
AM	6240	317
PM	6270	304

Site 441218
I-41 EAST OF CTH E APPLETON

Cross Section		
I-41	Balanced Volume	Estimated K
AM	6570	211
PM	6710	172

In addition to peak hour volumes, daily traffic volumes were estimated and balanced. Since mainline data was obtained from WisDOT's ATR stations and ECWRPC, daily mainline data was used directly and factored for seasonal adjustment. Turning movement data ranged from 6 hours to 12 hours of data collection. Therefore, daily volumes for turning movements were estimated by utilizing an AM/PM to daily conversion factor of 3.035. This conversion factor is derived from the mainline counts and is the sum of the 2-hour AM period and 2-hour PM period with respect to the total daily volume. Since multiple mainline counts were available from ECWRPC and WisTransportal, the conversion factors were averaged and ranged from 2.6 to 3.3.

Balanced peak hour and daily volumes are provided in Appendix C. These volumes were approved by the WisDOT project team on March 29, 2019.

EXISTING TRAFFIC CONDITIONS

This section describes the analysis of existing year 2018 traffic operations at the I-41 ramp terminal intersections during the AM and PM peak hours in the project study area.

Existing Traffic Operations Summary

Peak hour traffic operations analysis throughout this I-41 Traffic and Engineering Study utilizes Synchro 10 traffic engineering software at signalized intersections and stop-sign intersections and HCS7 software for roundabout intersections. Traffic operations of LOS D or better are generally considered acceptable traffic operations.

Existing peak hour traffic counts and signal timings were collected and used in the existing traffic operations analysis. Exhibits provided in Appendix C present the existing AM and PM peak hour traffic volumes within the study area .

The existing traffic operations analysis shows that most intersections operate with all turn movements at LOS D or better during both AM and PM peak hours. Intersection locations with turn movements at LOS E or worse are shown in Table 1 below.

Table 1: Existing Intersection Peak Hour Traffic Operations Summary

Location	Intersection Control	2018 Existing	
		AM Peak	PM Peak
IH 41 NB ramps & CTH S (Freedom Rd)	Two-Way Stop Sign		
IH-41 SB ramps & CTH S (Freedom Rd)	Two-Way Stop Sign		
IH 41 NB ramps & CTH U (County Line Rd)	Two-Way Stop Sign		
IH 41 SB ramps & CTH U (County Line Rd)	Two-Way Stop Sign		
IH 41 NB ramps & CTH J (Hyland Ave)	Roundabout		
IH 41 SB ramps & CTH J (Hyland Ave)	Roundabout		
IH 41 NB ramps & WIS 55 (Delanglade St)	Roundabout		
IH 41 SB ramps & WIS 55 (Delanglade St)	Roundabout		
IH 41 NB ramps & CTH N (Freedom Rd)	Traffic Signal		
IH 41 SB ramps & CTH N (Freedom Rd)	Traffic Signal		
IH 41 NB ramps & CTH E (Ballard Rd)	Traffic Signal		X
IH 41 SB ramps & CTH E (Ballard Rd)	Traffic Signal		
IH 41 NB ramps & WIS 47 (Richmond St)	Traffic Signal		
IH 41 SB ramps & WIS 47 (Richmond St)	Traffic Signal		
IH 41 NB ramps & WIS 15 (Northland Ave)	Traffic Signal		X
IH 41 SB ramps & WIS 15 (Northland Ave)	Traffic Signal		
IH 41 NB ramps & WIS 96 (Wisconsin Ave)	Traffic Signal		
IH 41 SB ramps & WIS 96 (Wisconsin Ave)	Traffic Signal	X	X
IH 41 NB ramps & WIS 125 (College Ave)	Traffic Signal		
IH 41 SB ramps & WIS 125 (College Ave)	Traffic Signal		
IH 41 NB off ramp & CTH BB (Prospect Ave)	Traffic Signal		
IH 41 NB on ramp & CTH BB (Prospect Ave)	Traffic Signal		
IH 41 SB off ramps & CTH BB (Prospect Ave)	Traffic Signal		X
Locations with LOS E or F	Stop Sign or RAB	0	0
	Traffic Signal	1	4

Table 1 shows that 1 intersection in the AM peak hour and 4 intersections in the PM peak hour have at least one turn movement that operates at LOS E or F under existing traffic conditions. Additional intersection analysis details including traffic volumes, delay, and LOS by movement are available in Appendix D. The year 2018 existing Synchro output files for signalized and stop sign intersections and the year 2018 existing HCS7 output files for roundabout intersections are provided in Appendix F1, F2, and F3.

EXISTING VISSIM MODEL DEVELOPMENT

AM and PM peak hour VISSIM microsimulation models were developed to replicate the current 2018 traffic conditions. Within each model, traffic volume is assigned to the shortest path between origins and destinations. In addition to origin-destination routing, model attributes are refined and conform to WisDOT modeling standards. Each of the existing VISSIM models were peer reviewed by WisDOT. With the conclusion of the peer review process, the models are considered validated. Formal WisDOT documentation (DT2291) are provided in Appendix E.

VISSIM O-D Development

Volumes in each of the existing VISSIM models are controlled by vehicle specific (auto or truck) origin-destination (O-D) matrices. VISSIM volumes were determined for a total of 3 hours that include the peak hour as well as the pre- and post- shoulder hours. Each O-D matrix includes 25 zones that represent the extents of the VISSIM model. Appendix G includes a map of zone locations.

Each O-D matrix is fratar-factored to represent the balanced counts of each of the 3 hours. The initial pattern for the fratar-factoring process was extracted from the ECWRPC travel demand model. Although this travel demand model is not calibrated at the AM and PM peak period level, the extracted pattern naturally provides weight to more significant O-D pairs. The fratar-factoring process modifies the initial pattern to reflect the WisDOT approved balanced roadway segment and turning movement volumes.

The matrices representing each of the three hours are refined to twelve 15-minute matrices by applying mainline and turning movement volume profiles (observed in the field traffic counts) to the balanced volumes. With 15-minute matrices, specific auto and truck matrices were derived utilizing truck percentages (observed in the field traffic counts).

VISSIM Model Attributes

The I-41 Traffic and Engineering Study micro-simulation model utilizes VISSIM software, version 10. The roadway network is coded based on the Bing Map aerials within VISSIM. Because the WIS 55/Delanglade Street roundabouts were constructed after the aerial mapping was collected, WisDOT provided as-builts of the WIS 55/I-41 ramp terminal roundabout designs for use in coding the roundabout intersections into the VISSIM network.

Desired speeds decisions are determined by the posted speed limit. The I-41 mainline posted speed limit is 70 mph, and WIS 441 mainline posted speed limit is 65 mph. Cross street posted limits vary from 35 mph to 55 mph. Two desired speed decisions are placed along the ramps. The first ramp desired speed decision provides a transitional speed between the cross street and I-41 mainline, the second desired speed decision along the ramp increases ramp traffic to mainline desired speed near the end of the entrance ramps or decreases ramp traffic to the desired cross traffic speeds near the end of the exit ramps.

Reduced speed areas are included along intersection turns. Generally, left turns include a 25 km/hr (15.5 mph) reduced speed area, and right turns include a 20 km/hr (12.4 mph) reduced speed area.

Roundabouts and roundabout approaches are also coded at 20 or 25 km/hr reduced speed areas to better model vehicle speeds as they travel through roundabout intersections. Additionally, the curves of the WIS 441 interchange ramps include reduced speeds areas based on assumed speeds. The WIS 441 ramps to and from I-41 northbound include 85 km/hr (approximately 55 mph) reduced speed areas. The WIS 441 ramp to I-41 southbound includes a 70 km/hr (approximately 45 mph) reduced speed area and the loop ramp from I-41 southbound to WIS 441 includes a 60 km/hr (approximately 40 mph) reduced speed area.

The most current signal timing plans were provided by WisDOT. These signal timing plans are used to code the project area's ramp terminal signalized intersection timings and phasings. Data collection points were included in the model to collect lane utilization data for model validation purposes. Vehicle travel time segments were also included in the model to collect travel times for model validation.

New driver behavior types were added to the AM and PM models to better calibrate vehicle flow in the I-41 southbound direction near WIS 441 and CTH E/Ballard Road. The new driver types are called the following:

- Merge (E)
- Freeway (E)
- Weave (441/E)
- Freeway (441)

Some of the driver behavior parameters were changed to better calibrate traffic flow through the entire model. These parameter changes are summarized below in Table 2. A more expansive summary of the driver behavior parameter changes is included in Appendix H.

Table 2: VISSIM Model Driver Behavior Model Adjustment Summary

Driver Behavior Category		Default Value	AM Model Adjustment	PM Model Adjustment
Car Following	Look Ahead Distance Observed Vehicle	2	4 (all)	4 (all)
	CC1 - Headway Time (sec)	0.9	1.0 (freeway); 1.3 (merge/diverge/weave); 1.1 (41 SB - 441/CTH E area)	1.0 (freeway); 1.3 (merge/diverge/weave); 1.1 (41 SB - 441/CTH E area)
Lane Change	Warning Time Before Diffusion	60	360 (all)	360 (all)
	Safety Distance Reduction Factor	0.60	0.40 (Merge); 0.40 (Merge - 41 SB/CTH E)	0.40 (Merge); 0.40 (Merge - 41 SB/CTH E)
	Cooperative Lane Change	No	Yes (all)	Yes (all)
	Maximum Speed Difference (mph)	6.71	8.71 (Merge); 8.71 (Merge - 41 SB/CTH E)	8.71 (Merge); 8.71 (Merge - 41 SB/CTH E)

The vehicle types are a typical North American fleet. The various vehicle types are shown in Table 3 below.

Table 3: VISSIM Model Vehicle Types

Vehicle	Percent Distribution	Length	Width	Joint Front	Axle Front	Axle Rear	Joint Rear
Light Truck - Ford F150 (2009)	19.2%	17.753	7.632	--	2.829	14.063	17.410
Light Truck - Chevrolet Silverado (2008)	15.1%	21.887	8.524	--	3.561	17.286	21.401
Car - Toyota Camry (2006)	13.5%	15.568	6.441	--	3.156	12.078	15.568
SUV - Ford Explorer (2008)	10.6%	16.047	7.012	--	2.891	12.362	15.737
Car - Honda Accord (2003)	12.9%	15.620	6.767	--	3.190	12.181	15.620
Van – Plymouth Voyager (1999)	5.5%	16.014	7.942	--	2.861	12.801	16.014
SUV - Jeep Grand Cherokee (2002)	5.8%	15.226	7.486	--	2.721	11.546	14.873
Car - Plymouth Voyager (1999)	6.4%	16.014	7.942	--	2.861	12.801	16.014
SUV - GMC Yukon XL (2008)	5.0%	17.831	7.685	--	2.953	13.804	17.487
Car - Nissan Altima (2005)	6.0%	16.024	6.806	--	3.234	12.521	16.024
HGV - US AASHTO WB-50 Tractor	43.0%	21.635	9.603	--	5.112	16.869	17.101
HGV - US AASHTO WB-50 Trailer		41.594	8.660	3.695	3.699	33.863	40.952
HGV - EU 04 Tractor	24.9%	33.514	8.189	--	5.115	24.058	32.612
HGV - US AASHTO WB-40 Tractor	9.5%	17.852	8.291	--	2.697	15.776	15.523
HGV - US AASHTO WB-40 Trailer		33.193	8.634	2.992	2.992	27.731	32.614
HGV - US Flatbed	4.4%	32.577	8.189	--	2.510	20.373	32.577
HGV - US AASHTO WB-67D Tractor	4.2%	16.140	8.279	--	3.963	13.690	13.152
HGV - US AASHTO WB-67D Trailer		28.811	8.703	2.389	2.389	23.898	28.261
HGV - US AASHTO WB-67D Trailer Connector		10.000	8.581	0.174	0.175	7.950	7.972
HGV - US AASHTO WB-67D Trailer		28.811	8.703	2.389	2.389	23.898	28.261
HGV - US AASHTO WB-65 Tractor	4.0%	26.819	8.343	--	2.655	21.157	22.390
HGV - US AASHTO WB-65 Trailer		54.144	8.166	2.959	2.953	43.732	53.882
Bus - C2 Standard 2-doors	10.0%	40.682	9.974	--	9.186	28.806	39.600

VISSIM MODEL CALIBRATION

This section describes how the model calibration parameters were determined, such as the minimum number of Measures of Effectiveness (MOE) and the number of model simulation seeds required. The existing year AM and PM peak hour model validation results are also summarized.

Complexity Score

The VISSIM traffic model complexity score (described in the *WisDOT Traffic Engineering, Operations & Safety Manual*, Chapter 16, Section 20) is used to determine the minimum number of MOEs required for model validation. Table 4 below outlines the complexity score for the I-41 Traffic and Engineering Study micro-simulation model.

Table 4: VISSIM Model Complexity Score

Criteria	Model Type	Score
Project Type	Corridor Study, Standard Improvement Project (Large Network)	3
Intersections and Streets/Corridors	Signal Corridor (coordinated) and Roundabout Corridor	2
Freeways	Freeway with Interchanges and Arterials	1
Routing	Single Routes (Intersection or Corridor)	0
OD Estimation	Large Network, Few Routes	2
Existing/Anticipated Level of Congestion	LOS C-D Operations Moderate Queuing Minor Delays in Travel Speeds/Times	1
Model Complexity Score		9

The total VISSIM model complexity score is 9, therefore 2 to 3 Primary MOEs and 1 Secondary MOEs are required for model validation. Based on coordination with WisDOT staff, the following MOEs were selected for model validation:

- Link and Turning Movement Volumes – required for all projects
- Speeds – Primary MOE
- Travel Times – Primary MOE
- Lane Utilization – Secondary MOE

VISSIM Model Simulation Seed Determination

The number of seeds required for the VISSIM model validation process was determined using two ATR sites – Site 440105 (I-41, between WIS 125/College Avenue and WIS 96/Wisconsin Avenue) and Site 440103 (I-41, between WIS 441 and CTH N/Freedom Rd). October 2018 field data from these sites was compared to the VISSIM volume from seven initial runs with different seeds at these two sites to assess model variability. Based on the variability of the VISSIM output data from the field data, the estimated

number of runs was calculated to be a range of one to five across at all tested locations. Therefore, the minimum number of seven seeds is used in the base model validation process. The model uses these seven seeds – 199, 409, 619, 829, 1039, 1249, and 1459. Appendix I shows the model simulation seed determination worksheets.

VISSIM Model Validation Summary

Table 5 summarizes the existing AM and PM peak hour VISSIM model results compared to WisDOT microsimulation validation parameters. Mainline and Intersection Volume (15-minute periods) results are provided at both 15-minute and 60-minute periods. Speed, Travel Time and Lane utilization is evaluated at 15-minute periods.

Table 5: VISSIM Existing Model Validation Summary

MOE	Validation Tiers	Target	VISSIM Model		Validated?	
			AM	PM	AM	PM
Mainline Volume	Tier 1 – 60 minute period	RMSPE <5%	2%	3%	Yes	Yes
	Tier 2 – 60 minute period	RNSE < 3 for 85% of links	100%	99%	Yes	Yes
	Tier 1 – 15 minute period*	RMSPE <5%	6%	5%	No*	No*
	Tier 2 – 15 minute period*	RNSE < 3 for 85% of links	97%	99%	Yes*	Yes*
Intersection Volume	Tier 1 – 60 minute period	RMSPE <5%	Not applicable	Not applicable	--	--
	Tier 2 – 60 minute period	RNSE < 3 for 75% of links	100%	97%	Yes	Yes
	Tier 1 – 15 minute period*	RMSPE <5%	Not applicable	Not applicable	--	--
	Tier 2 – 15 minute period*	RNSE < 3 for 75% of links	99%	99%	Yes*	Yes*
Speed	Tier 1	RMSPE <10%	6%	5%	Yes	Yes
	Tier 2	+/- 20% for 85% of data points	100%	100%	Yes	Yes
Travel Time	Tier 1	RMSPE <10%	6%	5%	Yes	Yes
	Tier 2	+/- 15% for 85% of routes	100%	100%	Yes	Yes
Lane Utilization	Tier 1	Not applicable	--	--	--	--
	Tier 2	RNSE < 3 for 85% of data points	46%	44%	No	No

*Note: The 15-minute period targets are additional targets that are not required, but are included as an attempt to further refine the model validation beyond the required 60-minute targets.

Table 5 shows that the AM and PM peak hour I-41 VISSIM models meet all four of the required Primary Tier MOEs – the Mainline and Intersection Volume (60-minute period) Tiers 1 and 2, Speed Tiers 1 and 2, and Travel Time Tiers 1 and 2. The I-41 microsimulation models do not meet the Secondary Tier MOE – Lane Utilization Tier 2's observed data as currently provided. In addition, the AM and PM peak hour models met the additional targets of 15-minute period Tier 2 Mainline and Intersection Volumes, but barely missed the 15-minute period Tier 1 Mainline Volumes target by 1%.

Regarding the Lane Utilization model results, the comparison between model data and field data is relatively low in both AM and PM peak hours with approximately 45% of the data points being less than RNSE of 3.0. Closer inspection of the lane utilization comparison tables in Appendix J shows that along I-41 between WIS 125 and WIS 96, the left lane's distribution in the VISSIM model is very similar to the right lane distribution of the ATR data. This "reversed" lane utilization calibration occurs at all locations during both the AM and PM peak hours. This universal discrepancy was discussed with WisDOT and it was determined that the model was yielding reasonable lane utilization results. Typically, the auxiliary lane is expected to have the lowest lane utilization. The VISSIM model reflects the expected lane utilization with approximately 10% (+/-5%) lane utilization in the auxiliary lane in the AM and PM peak hour models in both the northbound and southbound directions. WisDOT Bureau of Traffic Operations concurs that the model lane use seems acceptable, and that it is possible that there is an issue with the lane utilization field data causing the substandard comparison to the model data.

Table 6 shows a comparison of the I-41 travel time between the VISSIM model and the NPMRDS field data. It shows that travel times recorded in the VISSIM model are very similar to the field data, within one minute along both the I-41 northbound and southbound sections through the project study area corridor.

Table 6: Existing VISSIM Model Travel Time Comparison

MOE	Direction	VISSIM Model Travel Time (in minutes)					
		Year 2018 Existing (VISSIM)		Year 2018 Existing (NPMRDS)		Difference (in minutes)	
		AM	PM	AM	PM	AM	PM
Travel Time	I-41 Northbound	23.1	23.1	23.7	23.8	-0.6	-0.7
	I-41 Southbound	23.8	23.1	24.0	24.0	-0.2	-0.9

Appendix J1 and J2 shows the full details of the existing year AM and PM peak hour microsimulation model validation MOE data. Appendix J also includes the existing VISSIM files. The existing VISSIM microsimulation models were peer reviewed by WisDOT with formal WisDOT documentation (DT 1887) provided in Appendix E.

EXISTING SAFETY ANALYSIS

Existing IHSDM models were developed by Strand Associates Inc. for comparison to the No Build and Build alternatives utilizing the geometric, volume, and crash data collected. The existing IHSDM analysis for the I-41 mainline corridor was performed using five years of crash data from 2013 to 2017 and two different observed crash data sets. The existing models were calibrated and submitted to WisDOT by Strand Associates for review. The comparative results of the Existing analysis with the No Build and Build safety analyses are provided in the No Build Safety Analysis, 2028 Short Term, and 2048 Long Term analysis sections of this report.

TRAVEL DEMAND MODELING

This section describes how the ECWRPC Cube travel demand modeling software was used to analyze the future demographics and demand, as well as generate growth rates.

Model Version

Travel demand models from ECWRPC were run for both the current year (2010) and the future year (2045). The year 2010 and year 2045 model output was generated from version 8 of the Northeast Region Travel Demand Model, running on Cube version 6.4.4.

Background

Models for year 2010 and year 2045 were used to analyze the effect of adding one lane in each direction along I-41 between CTH BB in Outagamie County and CTH S in Brown County. With the additional lanes, the I-41 mainline section would have eight lanes between CTH BB and WIS 15 and six lanes between WIS 15 and CTH S. Three scenarios were run, including year 2010 existing, year 2045 no build, and year 2045 build.

Model Runs

The current year model used a year 2010 network that included committed projects that have recently been built, including the expansion of I-41 in Brown and Winnebago counties and the Tri-County freeway expansion project. The inclusion of these recently built projects makes the network comparable to a 2018 model in terms of transportation movements and, therefore, comparable to year 2018 traffic counts. One committed project was excluded from the model runs. This was an expansion of WIS 96 from two to four lanes between CTH CB and WIS 76, which was cancelled prior to our analysis.

The future year model used a year 2045 network that included committed projects used in the year 2010 model and planned projects. The new Southern Arterial bridge was included in both the no build and build scenarios. The build scenario included the additional mainline lanes on I-41 between CTH BB in Outagamie county and CTH S in Brown county.

No models were run for interim years because there was no accurate socio-economic data.

Growth Rates

Growth rates were generated from the year 2010 and year 2045 model runs, which were applied to the counts to develop forecasts. Table 7 below shows the travel demand model growth rates along I-41 mainline.

Table 7: I-41 Mainline Growth Rate Summary – Travel Demand Model

Beginning Interchange	Ending Interchange	2010 Assignment	2045 Assignment	Growth Rate
WIS 96	WIS 15	51,396	64,426	0.72%
WIS 15	WIS 47	52,448	73,716	1.16%
WIS 47	CTH E	57,665	77,743	0.99%
CTH E	WIS 441	58,656	81,645	1.12%
WIS 441	CTH N	58,987	85,409	1.28%
CTH N	WIS 55	55,327	83,575	1.46%
WIS 55	CTH J	49,636	76,786	1.56%
CTH J	CTH U	51,697	77,364	1.42%
CTH U	CTH S	55,253	85,261	1.55%

Table 7 shows that the travel demand model annual growth rates along I-41 mainline in the project study area between the year 2010 model and the year 2045 model vary from 0.72% to 1.56%.

Validation

Demographic maps were created for the Appleton and Green Bay areas to validate the household and employment data for 2010 and 2045. Included projects were validated using maps that showed committed and planned projects within the geodatabase. WisDOT and ECWRPC staff approved 2045 model inputs on March 15, 2019. Appendix K includes the demographic maps and the committed and planned project maps.

TRAFFIC FORECASTING

Traffic forecasts were developed for four scenarios; 2028 No Build, 2048 No Build, 2048 No Build with Peak Spreading, and 2048 Build. Each scenario included AM, PM and Daily forecasts for each roadway segment on I-41 mainline and each turning movement at the service interchanges within the study limits. Each forecast scenario was provided to WisDOT traffic forecasting section for peer review and approved. For the purposes of the study, a 2028 Build forecast was not specifically developed since an interim year travel demand model is not available. Therefore, 2028 No Build and 2028 Build are assumed to be the same. This decision was confirmed by WisDOT.

Year 2028 No Build/Build

Daily 2028 projections are developed in three steps; 1) Interpolating the 2010 Existing and 2045 No Build travel demand models to represent 2018 and 2028, 2) projecting mainline, ramps, and arterials 3) projecting turning movements. Travel demand model interpolation is linear to 2018 and 2028. Mainline, ramps and arterials are forecasted by averaging the absolute change (equation 1) and relative change (equation 2) between the 2018 and 2028 interpolated travel demand models in accordance with the transportation planning manual.

Equation 1 (Absolute Change):

$$Forecast = (Count - 2018\ Base\ Assignment) + 2028\ Future\ Assignment$$

Equation 2 (Relative Change):

$$Forecast = \left(\frac{Count}{2018\ Base\ Assignment}\right) * 2028\ Future\ Assignment$$

The result of the equations is balanced to produce a balanced mainline and ramp forecast.

Daily turning movement forecasts are estimated by applying a turning movement distribution that represents the existing turning movement distribution to the ramp and arterial forecasts. The turning movement forecasts are balanced to complete the forecast.

AM and PM peak hour forecasts are derived from the daily forecasts by applying a K-factor. The K-factor is calculated using the percent difference between the AM and PM existing volumes and the Daily existing volumes.

$$AM/PM\ K - Factor = \left(\frac{2018\ AM/PM\ Balanced\ Count}{2018\ Daily\ Balanced\ Count}\right)$$

$$2028\ AM/PM\ Forecast = 2028\ Daily\ Forecast * AM/PM\ K - Factor$$

The forecasts for the study limits are balanced to complete the forecast and provided in Appendix L.

Year 2048 No Build

Daily 2048 projections are developed in three steps; 1) Interpolating the 2010 Existing and 2045 No Build travel demand models to represent 2018 and 2048, 2) projecting mainline, ramps, and arterials 3) projecting turning movements. Travel demand model interpolation is linear to 2018 and 2048. Mainline, ramps and arterials are forecasted by averaging the absolute change (equation 1) and relative change (equation 2) between the 2018 and 2048 interpolated travel demand models in accordance with the transportation planning manual.

Equation 1 (Absolute Change):

$$Forecast = (Count - 2018\ Base\ Assignment) + 2048\ Future\ Assignment$$

Equation 2 (Relative Change):

$$Forecast = \left(\frac{Count}{2018\ Base\ Assignment}\right) * 2048\ Future\ Assignment$$

The result of the equations is balanced to produce a balanced mainline and ramp forecast.

Daily turning movement forecasts are estimated by applying a turning movement distribution that represents the existing turning movement distribution to the ramp and arterial forecasts. The turning movement forecasts are balanced to complete the forecast.

AM and PM peak hour forecasts are derived from the daily forecasts by applying a K-factor. The K-factor is calculated using the percent difference between the AM and PM existing volumes and the Daily existing volumes.

$$AM/PM\ K - Factor = \left(\frac{2018\ AM/PM\ Balanced\ Count}{2018\ Daily\ Balanced\ Count}\right)$$

$$2048\ AM/PM\ Forecast = 2048\ Daily\ Forecast * AM/PM\ K - Factor$$

The forecasts for the study limits are balanced to complete the forecast and provided in Appendix L.

Year 2048 No Build with Peak Spreading

The purpose of this section is to outline the process used to estimate peak period traffic demand spreading during future year peak periods.

Peak Spreading

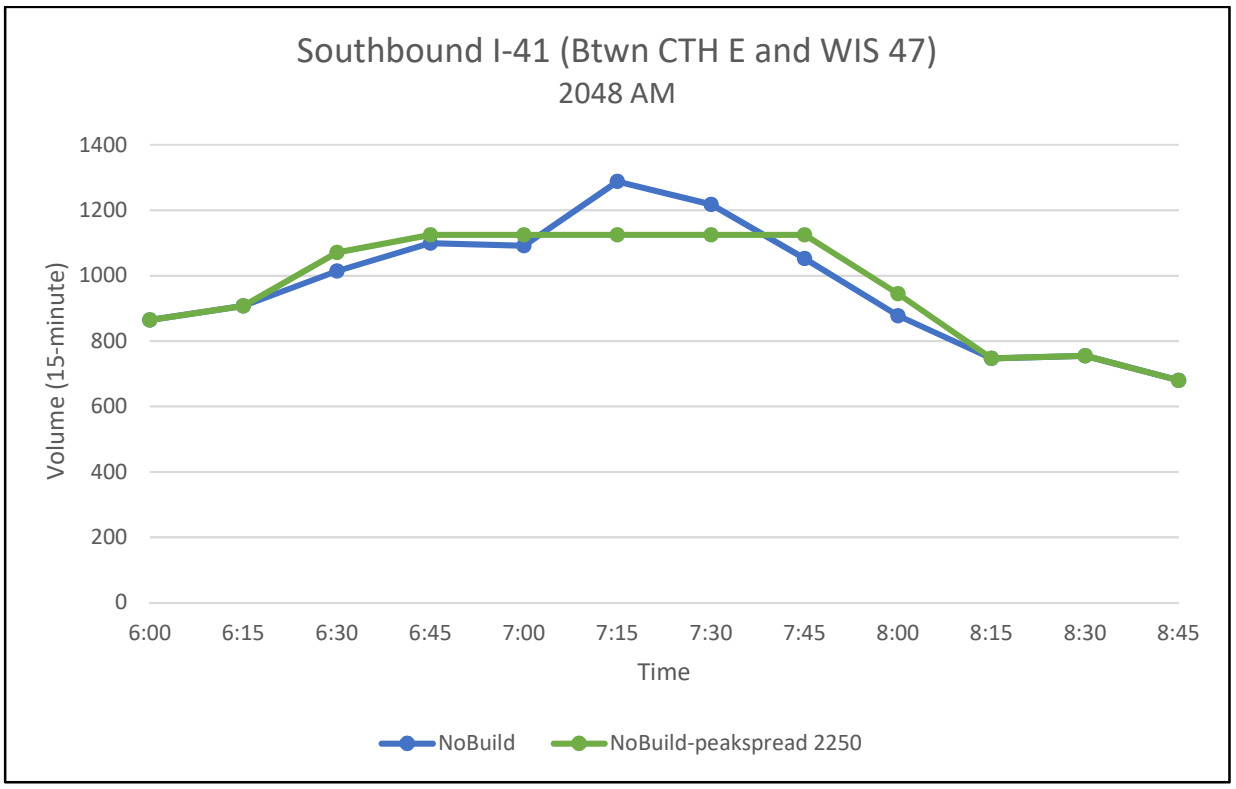
Periodic traffic congestion is recognized by WisDOT between WIS 15 and WIS 441 during peak hours. This congestion is anticipated to progressively become more significant without any roadway infrastructure improvements. The Northeast Regional Travel Demand Model (NERTDM) forecasts that I-41 traffic demand will increase approximately 1 percent annually through year 2048, which would result in projected traffic demands greater than the theoretical capacity of the I-41 facility. Therefore, “peak

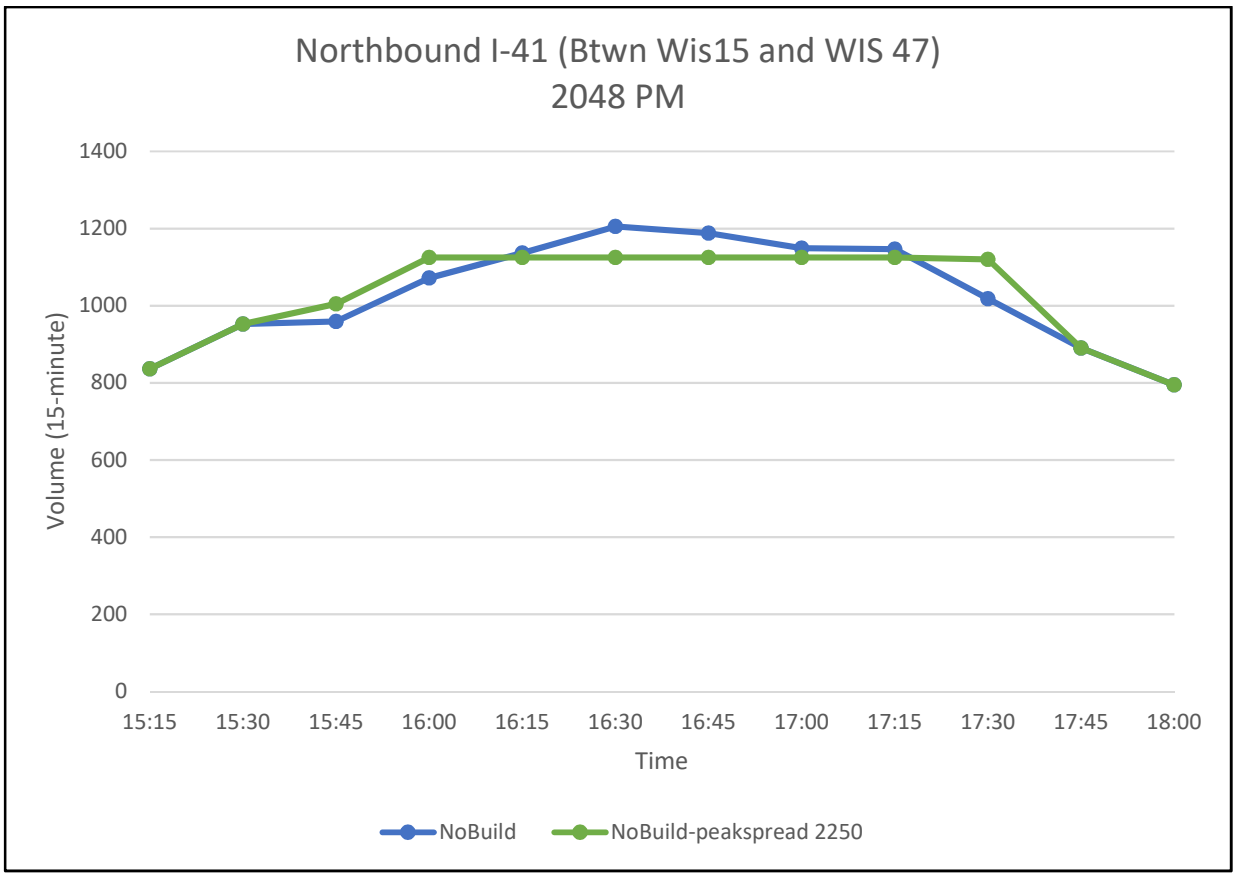
spreading" is examined to determine how future traffic volumes may spread outside the peak hour due to congested conditions.

Traffic forecasts for the 2048 no-build condition have been developed by the project team which use the existing temporal distribution across the peak hour, but uniformly grow the traffic demands for each 15-minute period in the hour. These values are represented in Figure 4 as the No Build. This standard process assumes drivers are not influenced by the projected increase in roadway congestion over time and therefore do not change their existing departure times. The traffic forecasts developed for 2048 no-build using the existing temporal distribution were tested within VISSIM to estimate future operational performance of the I-41 corridor in 2048 assuming no transportation improvements and no change in temporal distribution.

The recurring congestion projected for the 2048 no-build condition may likely influence some I-41 users to modify their time of departure to avoid congestion. This departure time modification is commonly known as "peak spreading". The concept of peak spreading assumes vehicles anticipate roadway delays and adjust their trip accordingly by departing earlier or later then they would otherwise. For the purposes of the I-41 Traffic and Engineering Study, peak spreading is limited to 30 minutes. This 30-minute assumption recognizes that drivers may not have substantial flexibility due to set work hours and school schedules. Furthermore, drivers are not anticipated to modify their trip on average by more than 30 minutes to reduce their travel delay by a few minutes.

Figure 4: AM and PM Peak Spreading – No Build





The National Cooperative Highway Research Program (NCHRP) 765 recommends determining the roadway capacity and identifying the demand that can be reallocated to other subsequent time periods. This procedure determines the number of time periods which are required to serve the demand near the volume to capacity (V/C) ratio of 1. NCHRP 765 methodology does not limit the temporal distribution and could impact multiple hours. Furthermore, the process does not define what 'capacity' is appropriate for the analysis.

Initial efforts by the project team attempted to determine the segment with the minimum capacity in the 2048 no-build condition. Limiting demands to this value resulted in spreading traffic demands across nearly all of the 15-minute time periods representing a 3-hour peak period, indicating a driver may flex their travel time by upwards of an hour. While avoiding traffic congestion is desirable, the project team determined that extensive peak spreading was unreasonable for the I-41 corridor.

Through discussions with WisDOT's traffic forecasting section, it was determined that restricting the temporal distribution is an appropriate application to NCHRP 765 guidance. Therefore, a similar NCHRP 765 peak-spreading technique is applied to identify the demand threshold that modifies trips by up to 30 minutes. By iteratively reducing the demand threshold from a theoretical 2,400 vehicles per hour per lane (vphpl) to 2,250 (vphpl), the amount of temporal re-distribution increases. At a demand threshold of 2,250 vphpl, traffic demand is observed to redistribute by up to 30 minutes. See Figure 4 for AM and PM peak spreading with demand limited to 2,250 vphpl (1,125 vehicles per 15 minutes on 2 lanes). Note the increase in demands for 1 or 2 of the adjacent 15-minute bins.

The actual capacity of I-41 is expected to be less than 2,250 vphpl and therefore roadway congestion is still anticipated. The 2048 No Build VISSIM models confirm that the actual roadway capacity is less than 2,250 vphpl as significant roadway congestion is observed within the model.

The project team analyzed traffic operations with VISSIM using the traffic demands for a 2048 no-build condition which spreads traffic demands across the peak period consistent with a demand threshold of 2,250 vphpl. This second 2048 no-build VISSIM scenario was used as a sensitivity test to determine if peak spreading alone would have a significant impact on the operations of the I-41 corridor and influence the needs for transportation improvements.

Peak Spreading Summary

The guidance from NCHRP 765 does not clearly identify what the maximum traffic demand should be in order to estimate the peak spreading that is expected on I-41. I-41 users are assumed to not have substantial flexibility due to set work hours and school schedules. Therefore, WisDOT and HNTB have agreed to determine the demand threshold that modifies trips by up to 30 minutes. HNTB's iterative analysis indicates reducing the demand threshold to 2,250 vphpl modifies demands to be within 30 minutes of the original departure time. Subsequent testing of these spread demand tables within VISSIM resulted in unacceptable traffic operations, indicating peak spreading would not sufficiently address the future operational issues projected for the corridor.

Year 2048 Build Forecasts

Daily 2048 projections are developed in three steps; 1) Interpolating the 2010 Existing and 2045 Build travel demand models to represent 2018 and 2048, 2) projecting mainline, ramps, and arterials 3) projecting turning movements. Travel demand model interpolation is linear to 2018 and 2048. Mainline, ramps and arterials are forecasted by averaging the absolute change (equation 1) and relative change (equation 2) between the 2018 and 2048 interpolated travel demand models in accordance with the transportation planning manual.

Equation 1 (Absolute Change):

$$Forecast = (Count - 2018\ Base\ Assignment) + 2048\ Future\ Assignment$$

Equation 2 (Relative Change):

$$Forecast = \left(\frac{Count}{2018\ Base\ Assignment}\right) * 2048\ Future\ Assignment$$

The result of the equations is balanced to produce a balanced mainline and ramp forecast.

Daily turning movement forecasts are estimated by applying a turning movement distribution that represents the existing turning movement distribution to the ramp and arterial forecasts. The turning movement forecasts are balanced to complete the forecast.

AM and PM peak hour forecasts are derived from the daily forecasts by applying a K-factor. The K-factor is calculated using the percent difference between the AM and PM existing volumes and the Daily existing volumes.

$$AM/PM\ K - Factor = \left(\frac{2018\ AM/PM\ Balanced\ Count}{2018\ Daily\ Balanced\ Count}\right)$$

$$2048\ AM/PM\ Forecast = 2048\ Daily\ Forecast * AM/PM\ K - Factor$$

The forecasts for the study limits are balanced to complete the forecast and provided in Appendix L

YEAR 2028 NO BUILD TRAFFIC CONDITIONS

This section describes the Year 2028 future no build traffic conditions. It also includes a discussion of signal control retimings and their impacts on traffic operations.

Year 2028 No Build Traffic Operations Summary

Year 2028 No Build peak hour traffic volumes were forecasted based on the methods described previously. Existing signal timings and lane geometry were used. Exhibits provided in Appendix L present the 2028 No Build AM and PM peak hour traffic volumes within the study area.

The Year 2028 No Build traffic operations analysis shows that several intersections operate with turn movements at LOS E or worse during AM and PM peak hours. Table 8 presents intersections with turn movements that are expected to be LOS E or worse in the 2028 No Build condition and also identifies ramp terminals that are expected to degrade when compared to the Existing traffic operations analysis summary.

Table 8: Year 2028 No Build Peak Hour Intersection Traffic Operations Summary

Location	Intersection Control	2018 Existing		2028 NoBuild	
		AM Peak	PM Peak	AM Peak	PM Peak
IH 41 NB ramps & CTH S (Freedom Rd)	Two-Way Stop Sign			X	
IH-41 SB ramps & CTH S (Freedom Rd)	Two-Way Stop Sign				
IH 41 NB ramps & CTH U (County Line Rd)	Two-Way Stop Sign				
IH 41 SB ramps & CTH U (County Line Rd)	Two-Way Stop Sign				
IH 41 NB ramps & CTH J (Hyland Ave)	Roundabout				
IH 41 SB ramps & CTH J (Hyland Ave)	Roundabout				
IH 41 NB ramps & WIS 55 (Delanglade St)	Roundabout				
IH 41 SB ramps & WIS 55 (Delanglade St)	Roundabout				
IH 41 NB ramps & CTH N (Freedom Rd)	Traffic Signal				X
IH 41 SB ramps & CTH N (Freedom Rd)	Traffic Signal				
IH 41 NB ramps & CTH E (Ballard Rd)	Traffic Signal		X	X	X
IH 41 SB ramps & CTH E (Ballard Rd)	Traffic Signal				
IH 41 NB ramps & WIS 47 (Richmond St)	Traffic Signal				
IH 41 SB ramps & WIS 47 (Richmond St)	Traffic Signal				
IH 41 NB ramps & WIS 15 (Northland Ave)	Traffic Signal		X	X	X
IH 41 SB ramps & WIS 15 (Northland Ave)	Traffic Signal				
IH 41 NB ramps & WIS 96 (Wisconsin Ave)	Traffic Signal				X
IH 41 SB ramps & WIS 96 (Wisconsin Ave)	Traffic Signal	X	X	X	X
IH 41 NB ramps & WIS 125 (College Ave)	Traffic Signal				X
IH 41 SB ramps & WIS 125 (College Ave)	Traffic Signal				
IH 41 NB off ramp & CTH BB (Prospect Ave)	Traffic Signal				
IH 41 NB on ramp & CTH BB (Prospect Ave)	Traffic Signal				
IH 41 SB off ramps & CTH BB (Prospect Ave)	Traffic Signal		X	X	X
Locations with LOS E or F	Stop Sign or RAB	0	0	1	0
	Traffic Signal	1	4	4	7

Table 8 shows that there are 5 intersections in the AM peak hour and 7 intersections in the PM peak hour that include at least one turn movement operating at LOS E or LOS F during the year 2028 No Build conditions. Comparatively, the existing traffic operations analysis summary shows only 1 intersection in

the AM peak hour and 4 intersections in the PM peak hour operating with at least one turn movement at LOS E or worse.

Additional intersection analysis details including traffic volumes, delay, and LOS by movement are available in Appendix M. Each of the 2028 No Build intersection analysis models were peer reviewed by WisDOT with formal WisDOT documentation (DT 1887) provided in Appendix N. The year 2028 No Build Synchro output files for signalized and stop sign intersections and the year 2028 No Build HCS7 output files for roundabout intersections are provided in Appendix O1, O2, and O3.

Year 2028 No Build Intersection Signal Control Retiming

The project team examined the impact of retiming the signalized intersections upon improving peak hour traffic operations to LOS D or better under year 2028 No Build conditions. Therefore, a separate Year 2028 No Build scenario with new signal timings was analyzed. Upon analysis in the Synchro 10 traffic engineering software, the following re-timings were applied to optimize future year 2028 No Build traffic conditions at intersections:

- I-41 NB ramps & CTH N (Freedom Rd)
    - AM peak hour – no change
    - PM peak hour - EB approach +8 seconds, SBL approach -8s
- I-41 SB ramps & CTH N (Freedom Rd) – no change
- I-41 NB ramps & CTH E (Ballard Rd)
    - AM peak hour
        - SBL approach +6s, SBT approach +1s, NB approach -5s, EB approach -1s
    - PM peak hour
        - NB approach +3s, SBL approach -2s, SBT approach +1s, EB approach -1s
- I-41 SB ramps & CTH E (Ballard Rd) – no change
- I-41 NB ramps & WIS 47 (Richmond St) – no change
- I-41 SB ramps & WIS 47 (Richmond St) – no change
- I-41 NB ramps & WIS 15 (Northland Ave) – no change
- I-41 SB ramps & WIS 15 (Northland Ave) – no change
- I-41 NB ramps & WIS 96 (Wisconsin Ave) – no change
- I-41 SB ramps & WIS 96 (Wisconsin Ave) – no change
- I-41 NB ramps & WIS 125 (College Ave)
    - AM peak hour – no change
    - PM peak hour
        - EBL approach -3s, WBT approach +3s
- I-41 SB ramps & WIS 125 (College Ave) – no change
- I-41 NB off ramp & CTH BB (Prospect Ave) – no change
- I-41 NB on ramp & CTH BB (Prospect Ave) – no change
- I-41 SB ramps & CTH BB (Prospect Ave)

- AM peak hour
  - EBT approach +2s, SB approach -2s, WBT approach +2s
- PM peak hour
  - SB approach -12s, WBL approach +9s, WBT approach +12s, EBT approach +3s

Year 2028 No Build with Retimings Traffic Operations Summary

Year 2028 No Build with Retimings traffic operations were analyzed under the same conditions as the year 2028 No Build scenario, except for the addition of the minor signal retimings described above.

Table 9 below shows a summary of the intersections under the Year 2028 No Build with Retimings scenario that have at least one turn movement operation at LOS E or worse conditions during AM and PM peak hours. This traffic operations summary is compared to previously presented traffic operations under Existing conditions and year 2028 No Build conditions.

Table 9: Year 2028 No Build with Retimings Traffic Operations Conditions Summary

Location	Intersection Control	2018 Existing		2028 NoBuild		2028 NoBuild (Retimed)	
		AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
IH 41 NB ramps & CTH S (Freedom Rd)	Two-Way Stop Sign			X		X	
IH-41 SB ramps & CTH S (Freedom Rd)	Two-Way Stop Sign						
IH 41 NB ramps & CTH U (County Line Rd)	Two-Way Stop Sign						
IH 41 SB ramps & CTH U (County Line Rd)	Two-Way Stop Sign						
IH 41 NB ramps & CTH J (Hyland Ave)	Roundabout						
IH 41 SB ramps & CTH J (Hyland Ave)	Roundabout						
IH 41 NB ramps & WIS 55 (Delanglade St)	Roundabout						
IH 41 SB ramps & WIS 55 (Delanglade St)	Roundabout						
IH 41 NB ramps & CTH N (Freedom Rd)	Traffic Signal				X		
IH 41 SB ramps & CTH N (Freedom Rd)	Traffic Signal						
IH 41 NB ramps & CTH E (Ballard Rd)	Traffic Signal		X	X	X	X	
IH 41 SB ramps & CTH E (Ballard Rd)	Traffic Signal						
IH 41 NB ramps & WIS 47 (Richmond St)	Traffic Signal						
IH 41 SB ramps & WIS 47 (Richmond St)	Traffic Signal						
IH 41 NB ramps & WIS 15 (Northland Ave)	Traffic Signal		X	X	X	X	X
IH 41 SB ramps & WIS 15 (Northland Ave)	Traffic Signal						
IH 41 NB ramps & WIS 96 (Wisconsin Ave)	Traffic Signal				X		X
IH 41 SB ramps & WIS 96 (Wisconsin Ave)	Traffic Signal	X	X	X	X	X	X
IH 41 NB ramps & WIS 125 (College Ave)	Traffic Signal				X		
IH 41 SB ramps & WIS 125 (College Ave)	Traffic Signal						
IH 41 NB off ramp & CTH BB (Prospect Ave)	Traffic Signal						
IH 41 NB on ramp & CTH BB (Prospect Ave)	Traffic Signal						
IH 41 SB off ramps & CTH BB (Prospect Ave)	Traffic Signal		X	X	X	X	X
Locations with LOS E or F	Stop Sign or RAB	0	0	1	0	1	0
	Traffic Signal	1	4	4	7	4	4

Table 9 shows that traffic operations improve under the year 2028 No Build with Retimings scenario compared to the year 2028 No Build scenario. The year 2028 No Build with Retimings scenario shows 5 intersections in the AM peak hour and 4 intersections in the PM peak hour operating with at least one turn movement at LOS E or LOS F. Under the year 2028 No Build conditions traffic operations analysis, there are 5 intersections in the AM peak hour and 7 intersections in the PM peak hour operating with at least one turn movement at LOS E or F operations. Therefore, the PM peak hour includes three fewer signalized intersections operating at LOS E or LOS F operations with the signal retimings. Although this is

an improvement in operations, several intersections still include unacceptable traffic operations even with the optimized signal timings.

Additional intersection analysis details including traffic volumes, delay, and LOS by movement are available in Appendix M. Each of the 2028 No Build with retiming intersection analysis models were peer reviewed by WisDOT with formal WisDOT documentation (DT 1887) provided in Appendix N. The year 2028 No Build with Retimings Synchro output files for signalized and stop sign intersections and the year 2028 No Build HCS7 output files for roundabout intersections are provided in Appendix O3, O4, and O5.

Year 2028 No Build VISSIM Model Operations

Traffic operations along I-41 were examined by analyzing the VISSIM microsimulation model under Year 2028 No Build conditions. The 2028 No Build microsimulation models utilize the validated existing models to assess the impact of increased volume demand on the current roadway infrastructure.

Table 10 shows how the mainline and intersection volume from the VISSIM No Build simulation models output calibrates to the year 2028 projected target volumes using the standard validation tiers compared to the year 2028 No Build with Signal Retimings scenario. Table 11 compares the VISSIM simulation model travel time along I-41 between CTH S and CTH BB under year 2028 No Build conditions and year 2028 No Build with Signal Retimings conditions.

Table 10: VISSIM 2028 No Build Model With and Without Retimings Traffic Volume Comparison

MOE	Validation Tiers	Target	Year 2028 No Build				Year 2028 No Build Retimed			
			VISSIM Model		Validated?		VISSIM Model		Validated?	
			AM	PM	AM	PM	AM	PM	AM	PM
Mainline Volume	Tier 1 – 60 minute period	RMSPE <5%	4%	5%	Yes	No	4%	7%	Yes	No
	Tier 2 – 60 minute period	RNSE < 3 for 85% of links	87%	70%	Yes	No	86%	64%	Yes	No
	Tier 1 – 15 minute period*	RMSPE <5%	7%	7%	No*	No*	7%	8%	No*	No*
	Tier 2 – 15 minute period*	RNSE < 3 for 85% of links	90%	92%	Yes*	Yes*	90%	80%	Yes*	No*
Intersection Volume	Tier 1 – 60 minute period	RMSPE <5%	N/A	N/A	--	--	N/A	N/A	--	--
	Tier 2 – 60 minute period	RNSE < 3 for 75% of links	99%	92%	Yes	Yes	97%	93%	Yes	Yes
	Tier 1 – 15 minute period*	RMSPE <5%	N/A	N/A	--	--	N/A	N/A	--	--
	Tier 2 – 15 minute period*	RNSE < 3 for 75% of links	99%	97%	Yes*	Yes*	98%	97%	Yes*	Yes*

*Note: The 15-minute period targets are additional targets that are not required, but are included as an attempt to further refine the model validation beyond the required 60-minute targets.

Table 11: VISSIM 2028 No Build Model With and Without Retimings Travel Time Comparison

MOE	Direction	VISSIM Model Travel Time (in minutes)			
		Year 2028 No Build		Year 2028 No Build Retimed	
		AM	PM	AM	PM
Travel Time	I-41 Northbound	23.6	23.4	23.6	23.1
	I-41 Southbound	26.2	23.7	26.5	30.3

Table 10 shows that both year 2028 No Build scenarios have similarly validated mainline and intersection volumes. Some of the volume validation statistics are validated under both year 2028 No Build scenarios in both AM and PM peak hours. This indicates that the Signal Retimings do not create sufficiently better traffic volume flow and less congestion with the projected year 2028 peak hour traffic volume.

Table 11 also shows that both year 2028 No Build scenarios have similar travel times along I-41 between CTH S and CTH BB. This further indicates that the Signal Retimings are not sufficient to meet the demands of projected year 2028 peak hour traffic volume in the I-41 project study area.

It should be noted that some statistics are worse under the Retimed scenario because although the optimized signal timings may result in better LOS operations in the isolated intersection analyses in Synchro, the high volume-to-capacity ratios and congestion at the intersections and along the mainline are producing volatile traffic operations where slight changes in signal timings can cause larger impacts to the mainline.

Appendix P1, P2, P3, and P4 show the year 2028 No Build and year 2028 No Build with Signal Retimings VISSIM model simulation statistics including mainline and intersection volume, mainline speed, lane utilization and travel time. Appendix P also includes the year 2028 No Build VISSIM files. Each of the 2028 No Build VISSIM simulation models were peer reviewed by WisDOT with formal WisDOT documentation (DT 1887) provided in Appendix N.

NO BUILD SAFETY ANALYSIS

The future No Build safety analysis was analyzed over a ten-year timeframe from 2028 to 2037 using IHSDM models by Strand Associates Inc. The No Build crash predictive results focused on relative differences between Existing conditions and No Build conditions. Table 12 shows a comparison of the annual average Existing conditions expected crash results (over a 5-year timeframe) versus the annual average future No Build conditions expected crash results (over a 10-year timeframe). As anticipated, if no improvements are made to the I-41 mainline, the average annual crashes will increase as traffic volumes grow and congestion worsens. In areas that are heavily congested today, such as north of WIS 15 to east of WIS 441 (analysis segments 3 and 4), the number of expected crashes is shown to grow at a higher rate than less-congested parts of the corridor. Overall, total crashes are expected to increase by 15.7% under the No Build conditions throughout the entire project study area along the I-41 mainline corridor, according to IHSDM analysis results, while fatal and injury crashes are expected to increase by 16.9%. See Appendix Q for a technical memorandum prepared by Strand Associates documenting the IHSDM analysis methodology and results for the study and for more detail on the No Build Alternative.

Table 12 Expected Crash Results: Future No-Build vs. Existing Conditions

	Analysis Segments			Percent Differences Annual Average Expected Crashes No-Build vs. Existing		
	Segment No.	Dist (mi)	General Limits	Total	FI	PDO
Analysis Segments	1	2.7	South of CTH BB to STH 96	12.6%	15.0%	11.7%
	2	2.5	STH 96 to North of STH 15	18.6%	20.3%	18.1%
	3	2.5	North of STH 15 to West of CTH E	21.9%	22.9%	21.5%
	4	3.1	West of CTH E to East of STH 441	16.6%	18.1%	16.0%
	5	2.2	East of STH 441 to West of STH 55	14.1%	15.6%	13.5%
	6	3.2	West of STH 55 to East of CTH J	14.0%	15.0%	13.6%
	7	3.0	East of CTH J to CTH U (County Line)	13.3%	13.9%	13.0%
	8	2.1	CTH U (County Line) to South of CTH S	14.6%	15.2%	14.4%
	9	1.7	South of CTH S to North of CTH S	14.1%	14.3%	14.0%
	10	2.3	North of CTH S to South of CTH F	14.5%	14.6%	14.5%
Subtotals	1-2	5.2	South of CTH BB to North of STH 15	15.3%	17.2%	14.6%
	3-4	5.6	North of STH 15 to East of STH 441	18.9%	20.2%	18.4%
	5-7	8.5	East of STH 441 to CTH U (Brown County)	13.8%	14.9%	13.4%
	8-10	6.2	CTH U to South of CTH F	14.4%	14.7%	14.3%
	Overall	*25.5*	*South of CTH BB to South of CTH F*	15.7%	16.9%	15.2%

Notes:
Existing represents annual average expected crashes over five years (2013 to 2017).
No-Build represents annual average expected crashes over ten years (2028 to 2037).

YEAR 2048 NO BUILD TRAFFIC CONDITIONS

This section describes the Year 2048 future no build traffic conditions. It also includes a discussion of signal control retimings and their impacts on traffic operations.

Year 2048 No Build Traffic Operations Summary

Year 2048 No Build peak hour traffic volumes were forecasted based on the methods described previously and includes peak spreading. Existing signal timings and lane geometry were used. Appendix L shows exhibits of the year 2048 No Build AM and PM peak hour traffic volumes at the study area intersections.

The Year 2048 No Build traffic operations analysis shows that several intersections operate with turn movements at LOS E or worse during AM and PM peak hours. Table 13 shows intersections with turn movements that are expected to be LOS E or worse and they are compared to the Existing and year 2028 No Build traffic operations analysis summary.

Table 13: Year 2048 No Build Peak Hour Intersection Traffic Operations Summary

Location	Intersection Control	2018 Existing		2028 NoBuild		2048 NoBuild	
		AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
IH 41 NB ramps & CTH S (Freedom Rd)	Two-Way Stop Sign			X		X	X
IH-41 SB ramps & CTH S (Freedom Rd)	Two-Way Stop Sign					X	X
IH 41 NB ramps & CTH U (County Line Rd)	Two-Way Stop Sign					X	X
IH 41 SB ramps & CTH U (County Line Rd)	Two-Way Stop Sign					X	X
IH 41 NB ramps & CTH J (Hyland Ave)	Roundabout					X	X
IH 41 SB ramps & CTH J (Hyland Ave)	Roundabout						X
IH 41 NB ramps & WIS 55 (Delanglade St)	Roundabout						
IH 41 SB ramps & WIS 55 (Delanglade St)	Roundabout						
IH 41 NB ramps & CTH N (Freedom Rd)	Traffic Signal				X		X
IH 41 SB ramps & CTH N (Freedom Rd)	Traffic Signal						
IH 41 NB ramps & CTH E (Ballard Rd)	Traffic Signal		X	X	X	X	X
IH 41 SB ramps & CTH E (Ballard Rd)	Traffic Signal					X	X
IH 41 NB ramps & WIS 47 (Richmond St)	Traffic Signal						X
IH 41 SB ramps & WIS 47 (Richmond St)	Traffic Signal						
IH 41 NB ramps & WIS 15 (Northland Ave)	Traffic Signal		X	X	X	X	X
IH 41 SB ramps & WIS 15 (Northland Ave)	Traffic Signal						X
IH 41 NB ramps & WIS 96 (Wisconsin Ave)	Traffic Signal				X		X
IH 41 SB ramps & WIS 96 (Wisconsin Ave)	Traffic Signal	X	X	X	X	X	X
IH 41 NB ramps & WIS 125 (College Ave)	Traffic Signal				X		X
IH 41 SB ramps & WIS 125 (College Ave)	Traffic Signal						
IH 41 NB off ramp & CTH BB (Prospect Ave)	Traffic Signal						
IH 41 NB on ramp & CTH BB (Prospect Ave)	Traffic Signal						X
IH 41 SB off ramps & CTH BB (Prospect Ave)	Traffic Signal		X	X	X	X	X
Locations with LOS E or F	Stop Sign or RAB	0	0	1	0	5	6
	Traffic Signal	1	4	4	7	5	11

Table 13 shows that there are 10 intersections in the AM peak hour and 17 intersections in the PM peak hour that include at least one turn movement operating at LOS E or LOS F during the year 2048 No Build conditions. Comparatively, the year 2028 No Build traffic operations analysis summary shows 5 intersection in the AM peak hour and 7 intersections in the PM peak hour operating with at least one turn movement at LOS E or worse.

Additional intersection analysis details including traffic volumes, delay, and LOS by movement are available in Appendix M. The 2048 No Build intersection analysis models were peer reviewed by WisDOT with formal WisDOT documentation (DT 1887) provided in Appendix N. The year 2048 No Build Synchro output files for signalized and stop sign intersections and the year 2048 No Build HCS7 output files for roundabout intersections are provided in Appendix O6, O7, and O8.

Year 2048 No Build Intersection Signal Control Retiming

The project team examined the impact of retiming the signalized intersections upon improving peak hour traffic operations to LOS D or better under year 2048 No Build conditions. Therefore, a separate Year 2048 No Build scenario with new signal timings was analyzed. Upon analysis in the Synchro 10 traffic engineering software, the following re-timings were applied to optimize future year 2048 No Build traffic conditions at intersections:

- I-41 NB ramps & CTH N (Freedom Rd)
  - AM peak hour – no change
  - PM peak hour - EB approach +8 seconds(s), SBL approach -8s
- I-41 SB ramps & CTH N (Freedom Rd) – no change
- I-41 NB ramps & CTH E (Ballard Rd)
  - AM peak hour
    - EB approach +3s, NB approach -3s, SBT approach -3s
  - PM peak hour
    - NB approach +3s, SBL approach -2s, SBT approach +1s, EB approach -1s
- I-41 SB ramps & CTH E (Ballard Rd)
  - AM peak hour - SB approach +5s, NBL approach -2s, WB approach -3s, NBT approach +3s
  - PM peak hour – SBT approach +10s, WB approach -10s, NBT approach +10s
- I-41 NB ramps & WIS 47 (Richmond St)
  - AM peak hour – no change
  - PM peak hour – NB approach +9s, SBL approach -7s, SBT approach +2s, EB approach -2s
- I-41 SB ramps & WIS 47 (Richmond St) – no change
- I-41 NB ramps & WIS 15 (Northland Ave)
  - AM peak hour – NB approach +1s, WBT approach -1s, EB approach -1s
  - PM peak hour – no change
- I-41 SB ramps & WIS 15 (Northland Ave)
  - AM peak hour – no change
  - PM peak hour – EBL approach +7s, WBT approach -7s
- I-41 NB ramps & WIS 96 (Wisconsin Ave) – no change
- I-41 SB ramps & WIS 96 (Wisconsin Ave)
  - AM peak hour – SB approach +5s, EBT approach -3s, WBL approach -2s, WBT approach -5s

    - PM peak hour – no change
- I-41 NB ramps & WIS 125 (College Ave)
    - AM peak hour – no change
    - PM peak hour
        - NB approach -11s, EBL approach +6s, EBT approach +11s, WBT approach +5s
- I-41 SB ramps & WIS 125 (College Ave) – no change
- I-41 NB off ramp & CTH BB (Prospect Ave) – no change
- I-41 NB on ramp & CTH BB (Prospect Ave)
    - AM peak hour – no change
    - PM peak hour – EBL approach -3s, WBT approach +3s
- I-41 SB ramps & CTH BB (Prospect Ave)
    - AM peak hour
        - EBT approach -1s, WBL +1s
    - PM peak hour
        - SB approach -11s, WBL approach +8s, WBT approach +11s, EBT approach +3s

Year 2048 No Build with Retimings Traffic Operations Summary

Year 2048 No Build with Retimings traffic operations were analyzed under the same conditions as the year 2048 No Build scenario, except for the addition of the minor signal retimings described above.

Table 14 below shows a summary of the intersections under the Year 2048 No Build with Retimings scenario that have at least one turn movement operation at LOS E or worse conditions during AM and PM peak hours. This traffic operations summary is compared to previously presented traffic operations under Existing, year 2028 No Build conditions, year 2028 No Build with Retimings, and year 2048 No Build conditions.

Table 14: Year 2048 No Build with Retimings Peak Hour Intersection Traffic Operations Summary

Location	Intersection Control	2018 Existing		2028 NoBuild		2028 NoBuild (Retimed)		2048 NoBuild		2048 NoBuild (Retimed)	
		AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
IH 41 NB ramps & CTH S (Freedom Rd)	Two-Way Stop Sign			X		X		X	X	X	X
IH-41 SB ramps & CTH S (Freedom Rd)	Two-Way Stop Sign							X	X	X	X
IH 41 NB ramps & CTH U (County Line Rd)	Two-Way Stop Sign							X	X	X	X
IH 41 SB ramps & CTH U (County Line Rd)	Two-Way Stop Sign							X	X	X	X
IH 41 NB ramps & CTH J (Hyland Ave)	Roundabout							X	X	X	X
IH 41 SB ramps & CTH J (Hyland Ave)	Roundabout								X		X
IH 41 NB ramps & WIS 55 (Delanglade St)	Roundabout										
IH 41 SB ramps & WIS 55 (Delanglade St)	Roundabout										
IH 41 NB ramps & CTH N (Freedom Rd)	Traffic Signal				X				X		
IH 41 SB ramps & CTH N (Freedom Rd)	Traffic Signal										
IH 41 NB ramps & CTH E (Ballard Rd)	Traffic Signal		X	X	X	X		X	X	X	X
IH 41 SB ramps & CTH E (Ballard Rd)	Traffic Signal							X	X	X	
IH 41 NB ramps & WIS 47 (Richmond St)	Traffic Signal								X		
IH 41 SB ramps & WIS 47 (Richmond St)	Traffic Signal										
IH 41 NB ramps & WIS 15 (Northland Ave)	Traffic Signal		X	X	X	X	X	X	X	X	X
IH 41 SB ramps & WIS 15 (Northland Ave)	Traffic Signal								X		
IH 41 NB ramps & WIS 96 (Wisconsin Ave)	Traffic Signal				X		X		X		X
IH 41 SB ramps & WIS 96 (Wisconsin Ave)	Traffic Signal	X	X	X	X	X	X	X	X	X	X
IH 41 NB ramps & WIS 125 (College Ave)	Traffic Signal				X				X		
IH 41 SB ramps & WIS 125 (College Ave)	Traffic Signal										
IH 41 NB off ramp & CTH BB (Prospect Ave)	Traffic Signal										
IH 41 NB on ramp & CTH BB (Prospect Ave)	Traffic Signal								X		
IH 41 SB off ramps & CTH BB (Prospect Ave)	Traffic Signal		X	X	X	X	X	X	X	X	X
Locations with LOS E or F	Stop Sign or RAB	0	0	1	0	1	0	5	6	5	6
	Traffic Signal	1	4	4	7	4	4	5	11	5	5

Table 14 shows that traffic operations improve under the year 2048 No Build with Retimings scenario compared to the year 2048 No Build scenario. The year 2048 No Build with Retimings scenario shows 10 intersections in the AM peak hour and 11 intersections in the PM peak hour operating with at least one turn movement at LOS E or LOS F. Under the year 2048 No Build conditions traffic operations analysis, there are 10 intersections in the AM peak hour and 17 intersections in the PM peak hour operating with at least one turn movement at LOS E or F operations. Therefore, the PM peak hour includes six fewer signalized intersections operating at LOS E or LOS F operations with the signal retimings. Although this is an improvement in operations, several intersections still include unacceptable traffic operations even with the optimized signal timings.

Additional intersection analysis details including traffic volumes, delay, and LOS by movement are available in Appendix M. Each of the 2048 No Build with retiming intersection analysis models were peer reviewed by WisDOT with formal WisDOT documentation (DT 1887) provided in Appendix N. The year 2048 No Build with Retimings Synchro output files for signalized and stop sign intersections and the year 2048 No Build HCS7 output files for roundabout intersections are provided in Appendix O8, O9, and O10.

Year 2048 No Build VISSIM Model Operations

Traffic operations along I-41 were examined by analyzing the VISSIM microsimulation model under Year 2048 No Build conditions. The 2048 No Build microsimulation models utilize the validated existing models to assess the impact of increased volume demand on the current roadway infrastructure.

Table 15 shows how the mainline and intersection volume from the VISSIM No Build simulation models output calibrates to the year 2048 projected target volumes using the standard validation tiers compared to the year 2048 No Build with Signal Retimings scenario. Table 16 compares the VISSIM simulation

model travel time along I-41 between CTH S and CTH BB under year 2048 No Build conditions and year 2048 No Build with Signal Retimings conditions.

Table 15: VISSIM 2048 No Build Model With and Without Retimings Traffic Volume Comparison

MOE	Validation Tiers	Target	Year 2048 No Build				Year 2048 No Build Retimed			
			VISSIM Model		Validated?		VISSIM Model		Validated?	
			AM	PM	AM	PM	AM	PM	AM	PM
Mainline Volume	Tier 1 – 60 minute period	RMSPE <5%	13%	13%	No	No	15%	19%	No	No
	Tier 2 – 60 minute period	RNSE < 3 for 85% of links	43%	39%	No	No	41%	30%	No	No
	Tier 1 – 15 minute period*	RMSPE <5%	14%	14%	No*	No*	15%	20%	No*	No*
	Tier 2 – 15 minute period*	RNSE < 3 for 85% of links	63%	55%	No*	No*	54%	46%	No*	No*
Intersection Volume	Tier 1 – 60 minute period	RMSPE <5%	N/A	N/A	--	--	N/A	N/A	--	--
	Tier 2 – 60 minute period	RNSE < 3 for 75% of links	82%	64%	Yes	No	81%	62%	Yes	No
	Tier 1 – 15 minute period*	RMSPE <5%	N/A	N/A	--	--	N/A	N/A	--	--
	Tier 2 – 15 minute period*	RNSE < 3 for 75% of links	89%	82%	Yes*	Yes*	89%	81%	Yes*	Yes*

*Note: The 15-minute period targets are additional targets that are not required, but are included as an attempt to further refine the model validation beyond the required 60-minute targets.

Table 16: VISSIM 2048 No Build Model With and Without Retimings Travel Time Comparison

MOE	Direction	VISSIM Model Travel Time (in minutes)			
		Year 2048 No Build		Year 2048 No Build Retimed	
		AM	PM	AM	PM
Travel Time	I-41 Northbound	26.7	27.0	25.9	25.7
	I-41 Southbound	38.4	27.4	44.1	51.5

Table 15 shows that both year 2048 No Build scenarios have similarly validated mainline and intersection volumes with few of the volume validation statistics being validated under both year 2048 No Build scenarios in both AM and PM peak hours. This indicates that the Signal Retimings do not create sufficiently better traffic volume flow and less congestion with the projected year 2048 peak hour traffic volume.

Table 16 shows that the I-41 Northbound corridor in both year 2048 No Build scenarios have similar travel times along I-41 between CTH S and CTH BB. However, in the I-41 Southbound direction, the Retimed scenarios show a higher travel time. This further indicates that the Signal Retimings are not sufficient to meet the demands of projected year 2048 peak hour traffic volume in the I-41 project study area.

It should be noted that some statistics are worse under the Retimed scenario because although the optimized signal timings may result in better LOS operations in the isolated intersection analyses in Synchro, the high volume-to-capacity ratios and congestion at the intersections and along the mainline are producing volatile traffic operations where slight changes in signal timings can cause larger impacts to the mainline.

Appendix P5, P6, P7, and P8 show the year 2048 No Build and year No Build with Signal Retimings VISSIM model simulation statistics including mainline and intersection volume, mainline speed, lane utilization and travel time. Appendix P also includes the year 2048 No Build VISSIM files. The 2048 No Build intersection analysis models were peer reviewed by WisDOT with formal WisDOT documentation (DT 1887) provided in Appendix N.

YEAR 2028 SHORT TERM BUILD TRAFFIC CONDITIONS

This section describes the peak hour intersection traffic operations analysis of short term improvements applied during year 2028 traffic conditions.

Year 2028 Short Term Improvements

The short term improvements include improvements to the project study area intersections and acceleration lanes along the I-41 mainline in order to achieve LOS D or better during peak hours at intersections and provide improved traffic flow along the mainline. Recommended 2028 Short Term Build improvements are listed below. They include recommended improvements at the ramp terminals of three interchanges (WIS 96, WIS 15, and CTH E) and to the acceleration lanes at five of the entrance ramps. Appendix R includes exhibits showing graphical representations of these improvements.

- I-41 & WIS 96 (Wisconsin Avenue)
    - SB Ramp intersection
        - SB ramp approach – dual right turn lane
        - WB approach – third through lane
        - West of Intersection – third WB through lane
    - NB Ramp intersection
        - NB ramp approach – dual right turn lane
        - WB approach – fourth through lane
- I-41 & WIS 15 (Northland Ave)
    - SB Ramp intersection
        - SB ramp approach – dual right turn lane
    - NB Ramp intersection
        - NB ramp approach – dual left turn lane
        - EB approach – dual left turn lane
        - WB approach – third through lane
        - West of Intersection – third through lane
- I-41 & CTH E (Ballard Rd)
    - SB Ramp intersection
        - WB ramp approach – dual right turn lane
        - SB approach – third through lane (look-ahead left)
    - NB Ramp intersection
        - EB ramp approach – dual right turn lane
        - EB ramp approach – extend left turn lane
        - NB approach – third through lane (look-ahead left)
- I-41 NB entrance ramp from WIS 15 (Northland Ave)
    - Acceleration lane lengthened from 750 feet to 1,000 feet
- I-41 SB entrance ramp from WIS 47 (Richmond Street)

    - Acceleration lane lengthened from 1,000 feet to 2,275 feet
- I-41 SB entrance ramp from CTH E (Ballard Rd)
    - Acceleration lane lengthened from 400 feet to 1,200 feet
- I-41 NB exit ramp to CTH E (Ballard Rd)
    - Deceleration lane lengthened from 100 feet to 1,200 feet
- I-41 NB entrance ramp from CTH N (Freedom Rd)
    - Acceleration lane lengthened from 400 feet to 900 feet
- I-41 SB entrance ramp from CTH N (Freedom Rd)
    - Acceleration lane lengthened from 400 feet to 970 feet
- I-41 NB entrance ramp from CTH S
    - Acceleration lane lengthened from 360 feet to 1,200 feet

Year 2028 Build with Short Term Improvements Traffic Operations Summary

Year 2028 Build with Short Term Improvements traffic operations were analyzed using year 2028 traffic volumes with the short term improvements presented in the previous section.

Table 17 below shows a summary of the peak hour intersection traffic operations under the Year 2028 Build with Short Term Improvements scenario that have at least one turn movement operation at LOS E or worse conditions during AM and PM peak hours. The summary only includes the three interchanges that have intersections with short term improvements (WIS 96, WIS 15 and CTH E). The Year 2028 No Build and Year 2028 No Build with Retimings are included for comparative purposes.

Table 17: Year 2028 Build with Short Term Improvements Traffic Operations Summary

Location	Intersection Control	2028 NoBuild		2028 NoBuild (Retimed)		2028 Short Term Improvements	
		AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
IH 41 NB ramps & CTH E (Ballard Rd)	Traffic Signal	X	X	X			
IH 41 SB ramps & CTH E (Ballard Rd)	Traffic Signal					X	X
IH 41 NB ramps & WIS 15 (Northland Ave)	Traffic Signal	X	X	X	X		
IH 41 SB ramps & WIS 15 (Northland Ave)	Traffic Signal					X	X
IH 41 NB ramps & WIS 96 (Wisconsin Ave)	Traffic Signal		X		X		
IH 41 SB ramps & WIS 96 (Wisconsin Ave)	Traffic Signal	X	X	X	X		X
Locations with LOS E or F	Stop Sign or RAB	-	-	-	-	-	-
	Traffic Signal	3	4	3	3	2	3

*Note: I-41 SB ramp intersections with CTH E and with WIS 15 show worse operations under Short Term Improvements because the dual-right turn lane improvements from the I-41 SB ramp approaches at both CTH E and WIS 15 assume zero right turns on red. If at least 25% of the right turn volume is assumed to turn on red, these Short Term LOS E/F's will become LOS D or better.

Table 17 shows that peak hour traffic operations under the year 2028 Build with Short Term Improvements scenario at the WIS 96, WIS 15 and CTH E ramp terminal intersections have only a fewer instances of turn movements that are expected to be LOS E or LOS F. However, it is important to note that the only turn movements that are expected to be at LOS E or LOS F with the Short Term Improvements are right turn movements. These include:

- I-41 SB ramps & CTH E – Westbound right turn (AM and PM)

- I-41 SB ramps & WIS 15 – Southbound right turn (AM and PM)
- I-41 SB ramps & WIS 96 – Southbound right turn (PM only)

The peak hour traffic operations at these right turns can be improved by assuming right turns on red. The current analysis assumes the most conservative approach, which assumes zero right turns on red. Therefore, if these right turn movement traffic operations are addressed, then all of the turn movements at these six intersections will be expected to operate at LOS D or better under year 2028 Build with Short Term Improvements conditions.

Additional intersection analysis details including traffic volumes, delay, and LOS by movement are available in Appendix M. Each of the 2028 Short Term Improvement intersection analysis models were peer reviewed by WisDOT with formal WisDOT documentation (DT 1887) provided in Appendix N. The year 2028 Build with Short Term Improvements Synchro output files for signalized intersections are provided in Appendix O11 and O12.

Year 2028 Build with Short Term Improvements VISSIM Model Operations

Traffic operations along I-41 were examined by analyzing the VISSIM simulation model under Year 2028 Build with Short Term Improvements conditions. Table 18 shows how the mainline and intersection volume from the VISSIM simulation model output calibrates to the year 2028 projected target volumes using the standard validation tiers compared to the year 2028 No Build with Signal Retimings scenario. Table 19 compares the VISSIM simulation model travel time along I-41 between CTH S and CTH BB under year 2028 Build with Short Term Improvements conditions and year 2028 No Build with Signal Retimings conditions.

Table 18: VISSIM Model Traffic Volume Comparison: 2028 No Build with Retimings vs 2028 Build with Short Term Improvements

MOE	Validation Tiers	Target	Year 2028 No Build Retimed				Year 2028 Build Short Term Imp			
			VISSIM Model		Validated?		VISSIM Model		Validated?	
			AM	PM	AM	PM	AM	PM	AM	PM
Mainline Volume	Tier 1 – 60 minute period	RMSPE <5%	4%	7%	Yes	No	3%	2%	Yes	Yes
	Tier 2 – 60 minute period	RNSE < 3 for 85% of links	86%	64%	Yes	No	91%	99%	Yes	Yes
	Tier 1 – 15 minute period*	RMSPE <5%	7%	8%	No*	No*	6%	5%	No*	No*
	Tier 2 – 15 minute period*	RNSE < 3 for 85% of links	90%	80%	Yes*	No*	92%	97%	Yes*	Yes*
Intersection Volume	Tier 1 – 60 minute period	RMSPE <5%	N/A	N/A	--	--	N/A	N/A	--	--
	Tier 2 – 60 minute period	RNSE < 3 for 75% of links	97%	93%	Yes	Yes	99%	100%	Yes	Yes
	Tier 1 – 15 minute period*	RMSPE <5%	N/A	N/A	--	--	N/A	N/A	--	--
	Tier 2 – 15 minute period*	RNSE < 3 for 75% of links	98%	97%	Yes*	Yes*	99%	100%	Yes*	Yes*

*Note: The 15-minute period targets are additional targets that are not required, but are included as an attempt to further refine the model validation beyond the required 60-minute targets.

Table 19: VISSIM Model Travel Time Comparison: 2028 No Build with Retimings vs 2028 Build with Short Term Improvements

MOE	Direction	VISSIM Model Travel Time (in minutes)			
		Year 2028 No Build Retimed		Year 2028 Build Short Term Imp	
		AM	PM	AM	PM
Travel Time	I-41 Northbound	23.6	23.1	23.4	23.5
	I-41 Southbound	26.5	30.3	25.6	23.2

Table 18 shows that the year 2028 Build with Short Term Improvements scenario has better validated mainline and intersection volumes than the year 2028 No Build with Signal Retimings. All of the volume validation statistics are improved under the Short Term Improvements scenario compared to the No Build with Signal Retimings scenario in both AM and PM peak hours. Additionally, all of the volume tiers are validated under the Short Term Improvements scenarios, except for the non-required 15-minute period mainline volume tier, which barely miss the 5% threshold. This indicates that the Short Term Improvements creates better traffic volume flow and less congestion with the projected year 2028 peak hour traffic volume.

Table 19 shows that the year 2028 Build with Short Term Improvements scenario generally has shorter travel times than the year 2028 No Build with Signal Retimings scenario in both the northbound and southbound directions along I-41 between CTH S and CTH BB in both the AM and PM peak hours. This further indicates that the Short Term Improvements provide better traffic flow with projected year 2028 peak hour traffic volume.

Furthermore, the I-41 mainline traffic operations in the VISSIM model are showing good traffic flow with the Short Term Improvements in place. Appendix P includes a color-coded table showing VISSIM model average speed, density, and LOS of I-41 mainline operations. The only areas with slowdowns with the Short Term Improvements in place are the I-41 southbound sections between the CTH N exit ramp and the CTH N entrance ramp, which operates at LOS E in the AM peak hour, and between the CTH E entrance ramp and the WIS 47 entrance ramp, which operates at LOS F in the AM peak hour. All other mainline sections in both the AM and PM peak hours are showing near free flow speed at LOS D or better, according to the VISSIM models.

Appendix P9 and P10 show the year 2028 Build with Short Term Improvements VISSIM model simulation statistics including mainline and intersection volume, mainline operations, mainline speed, lane utilization and travel time. Appendix P also includes the year 2028 Build with Short Term Improvements VISSIM files. The 2028 Short Term Improvement VISSIM microsimulation models were peer reviewed by WisDOT with formal WisDOT documentation (DT 2291) provided in Appendix N.

YEAR 2028 SHORT TERM BUILD SAFETY ANALYSIS

The crash prediction results for the proposed I-41 mainline improvements in the year 2028 Build with Short Term Improvements alternative were compared to the future No Build scenarios using the Empirical-Bayes (E-B) Method. For intersections, the E-B Method was used for comparisons where applicable.

Figure 5 and Table 20 show a summary of the overall safety analysis for the Short Term Build alternative.

Figure 5 Short-Term Build Alternative Safety Analysis Summary

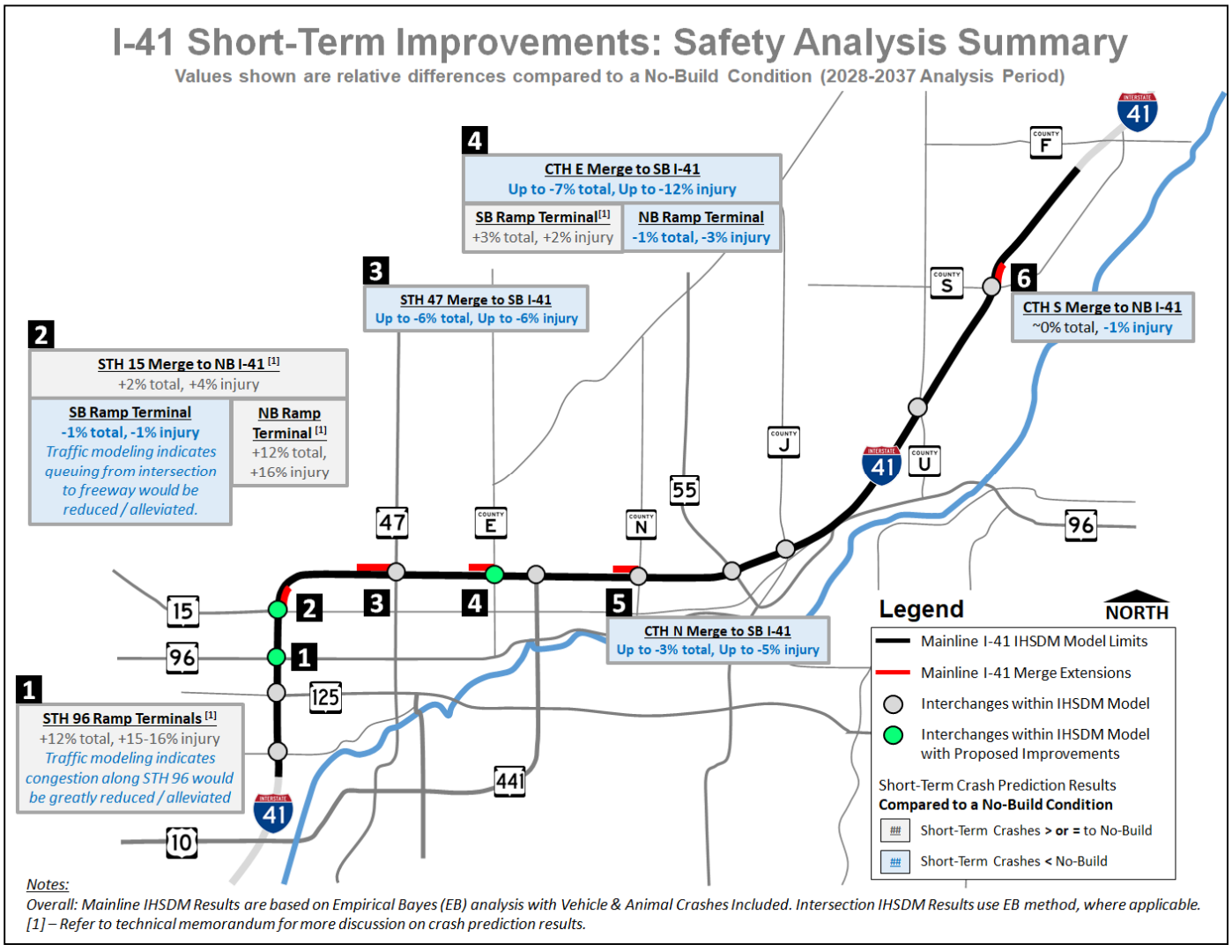


Table 20: Short-Term Build Alternative Mainline Crash Prediction Results

I-41 Acceleration Lane Addition or Extension	Proposed Merge Length (feet)	Coded as Through Lane?	Percent Difference in Expected Crashes vs. No-Build	
			Total Crashes	FI Crashes
STH 15 Northbound	1,050	No	+2.3%	+4.4%
STH 47 Southbound	2,500	Yes[1]	-6.3%	-6.3%
CTH E Southbound	1,560	Yes[1, 2]	-7.0%	-11.6%
CTH N Southbound	1,560	Yes[1, 2]	-2.8%	-4.7%
CTH S Northbound	960	No	+0.1%	-0.9%

[1] A reduction is congestion is accounted for by reducing high-volume hour percentage.
[2] Merge location is within 25 feet of the threshold to be considered as a through lane per the HSM (0.30 miles, or approximately 1,584 feet)

The Short Term Build alternative analysis indicates safety improvements could be anticipated at several locations. However, the limitations of the IHSDM related to traffic operations and congestion relief provides counter-intuitive results at some intersections and mainline merges. The proposed improvements should be considered in both a quantitative and qualitative manner when making design decisions.

See Appendix Q for a technical memorandum prepared by Strand Associates documenting the IHSDM analysis methodology and results for the study and for more detail on the Short Term Build alternative.

YEAR 2048 SHORT TERM BUILD TRAFFIC CONDITIONS

This section describes the peak hour intersection traffic operations analysis of short term improvements applied during year 2048 traffic conditions.

Year 2048 Short Term Build Traffic Operations Summary

Year 2048 Build with Short Term Improvements traffic operations were analyzed using year 2048 traffic volumes with the short term improvements presented in the previous section.

Table 21 below shows a summary of the peak hour intersection traffic operations under the Year 2048 Build with Short Term Improvements scenario that have at least one turn movement operation at LOS E or worse conditions during AM and PM peak hours. The summary only includes the three interchanges that have intersections with short term improvements (WIS 96, WIS 15 and CTH E). The Year 2048 No Build and Year 2048 No Build with Retimings are included for comparative purposes.

Table 21: Year 2048 Build with Short Term Improvements Traffic Operations Summary

Location	Intersection Control	2048 NoBuild		2048 NoBuild (Retimed)		2048 Short Term Improvements	
		AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
IH 41 NB ramps & CTH E (Ballard Rd)	Traffic Signal	X	X	X	X	X	X
IH 41 SB ramps & CTH E (Ballard Rd)	Traffic Signal	X	X	X		X	X
IH 41 NB ramps & WIS 15 (Northland Ave)	Traffic Signal	X	X	X	X		X
IH 41 SB ramps & WIS 15 (Northland Ave)	Traffic Signal		X			X	X
IH 41 NB ramps & WIS 96 (Wisconsin Ave)	Traffic Signal		X		X		X
IH 41 SB ramps & WIS 96 (Wisconsin Ave)	Traffic Signal	X	X	X	X		X
Locations with LOS E or F	Stop Sign or RAB	-	-	-	-	-	-
	Traffic Signal	4	6	4	4	3	6

*Note: I-41 SB ramp intersections with CTH E and with WIS 15 show worse operations under Short Term Improvements because the dual-right turn lane improvements from the I-41 SB ramp approaches at both CTH E and WIS 15 assume zero right turns on red. If at least 33% of the right turn volume is assumed to turn on red, these Short Term LOS E/F's will become LOS D or better.

Table 21 shows that peak hour traffic operations under the year 2048 Build with Short Term Improvements scenario at the WIS 96, WIS 15 and CTH E ramp terminal intersections are only slightly better than the other year 2048 No Build scenarios. Even with the Short Term Build improvements, these six intersections are expected to include turn movements of LOS E or LOS F. Unlike the year 2028 Build with Short Term Improvements conditions, the LOS E and LOS F movements are not confined to right turn movements only.

Additional intersection analysis details including traffic volumes, delay, and LOS by movement are available in Appendix M. The 2048 Short Term Improvement intersection analysis models were peer reviewed by WisDOT with formal WisDOT documentation (DT 1887) provided in Appendix N. The year 2048 Build with Short Term Improvements Synchro output files for signalized intersections are provided in Appendix O13 and O14.

Year 2048 Build with Short Term Improvements VISSIM Model Operations

Traffic operations along I-41 were examined by analyzing the VISSIM simulation model under Year 2048 Build with Short Term Improvements conditions. Table 22 shows how the mainline and intersection volume from the VISSIM simulation model output calibrates to the year 2048 projected target volumes using the standard validation tiers compared to the year 2048 No Build with Signal Retimings scenario. Table 23 compares the VISSIM simulation model travel time along I-41 between CTH S and CTH BB under year 2048 Build with Short Term Improvements conditions and year 2048 No Build with Signal Retimings conditions.

Table 22: VISSIM Model Traffic Volume Comparison: 2048 No Build with Retimings vs 2048 Build with Short Term Improvements

MOE	Validation Tiers	Target	Year 2048 No Build Retimed				Year 2048 Build Short Term Imp			
			VISSIM Model		Validated?		VISSIM Model		Validated?	
			AM	PM	AM	PM	AM	PM	AM	PM
Mainline Volume	Tier 1 – 60 minute period	RMSPE <5%	15%	19%	No	No	10%	10%	No	No
	Tier 2 – 60 minute period	RNSE < 3 for 85% of links	41%	30%	No	No	50%	56%	No	No
	Tier 1 – 15 minute period*	RMSPE <5%	15%	20%	No*	No*	12%	11%	No*	No*
	Tier 2 – 15 minute period*	RNSE < 3 for 85% of links	54%	46%	No*	No*	70%	69%	No*	No*
Intersection Volume	Tier 1 – 60 minute period	RMSPE <5%	N/A	N/A	--	--	N/A	N/A	--	--
	Tier 2 – 60 minute period	RNSE < 3 for 75% of links	81%	62%	Yes	No	88%	79%	Yes	Yes
	Tier 1 – 15 minute period*	RMSPE <5%	N/A	N/A	--	--	N/A	N/A	--	--
	Tier 2 – 15 minute period*	RNSE < 3 for 75% of links	89%	81%	Yes*	Yes*	94%	90%	Yes*	Yes*

*Note: The 15-minute period targets are additional targets that are not required, but are included as an attempt to further refine the model validation beyond the required 60-minute targets.

Table 23: VISSIM Model Travel Time Comparison: 2048 No Build with Retimings vs 2048 Build with Short Term Improvements

MOE	Direction	VISSIM Model Travel Time (in minutes)			
		Year 2048 No Build Retimed		Year 2048 Build Short Term Imp	
		AM	PM	AM	PM
Travel Time	I-41 Northbound	25.9	25.7	25.7	31.9
	I-41 Southbound	44.1	51.5	38.4	23.7

Table 22 shows that the year 2048 Build with Short Term Improvements scenario has slightly better validated mainline and intersection volumes than the year 2048 No Build with Signal Retimings. However, most of the volume tiers are still not validated with the Short Term Improvements in place in year 2048. None of the mainline volume tiers are validated under the year 2048 Build with Short Term Improvements scenario. This indicates that the I-41 mainline still observes significant congestion with the Short Term Improvements in place with the projected year 2048 peak hour traffic volume.

Table 23 shows that the year 2048 Build with Short Term Improvements scenario generally has shorter travel times than the year 2048 No Build with Signal Retimings scenario along I-41 between CTH S and CTH BB in both the AM and PM peak hours, especially in the Southbound direction. However, travel times are still relatively high. This further indicates that the Short Term Improvements do not sufficiently provide better traffic flow with projected year 2048 peak hour traffic volume.

Furthermore, the I-41 mainline traffic operations in the VISSIM model are showing poor traffic flow with the Short Term Improvements in place. Appendix P includes a color-coded table showing VISSIM model average speed, density, and LOS of I-41 mainline operations. Several mainline segments are showing significant slowdowns with LOS E/F operations with the Short Term Improvements in place, including the I-41 northbound section between the CTH U exit ramp and the CTH S entrance ramp and the I-41 southbound section between the CTH J exit ramp and the WIS 47 entrance ramp in the AM peak hour, and the I-41 northbound sections between the WIS 125 exit ramp and the WIS 15 entrance ramp and between the CTH N entrance ramp and the CTH J exit ramp in the PM peak hour, according to the VISSIM models.

Appendix P11 and P12 show the year 2048 Build with Short Term Improvements VISSIM model simulation statistics including mainline and intersection volume, mainline operations, mainline speed, lane utilization and travel time. Appendix P also includes the year 2048 Build with Short Term Improvements VISSIM files. The 2048 Short Term Improvement VISSIM microsimulation models were peer reviewed by WisDOT with formal WisDOT documentation (DT 2291) provided in Appendix N.

YEAR 2048 LONG TERM BUILD TRAFFIC CONDITIONS

This section describes the peak hour intersection traffic operations analysis of long term improvements applied during year 2048 Build traffic conditions.

Year 2048 Long Term Improvements

The long term improvements include improvements to the project study area intersections and the mainline lanes along the I-41 mainline in order to achieve LOS D or better during peak hours at intersections and provide improved traffic flow along the mainline. Recommended 2048 Long Term Build improvements are listed below. They include recommended improvements at the ramp terminals of six interchanges (WIS 96, WIS 47, CTH E, CTH J, CTH U, and CTH S) and to the I-41 mainline lanes from CTH S through WIS 15. Appendix R includes exhibits showing graphical representations of these improvements.

- I-41 Mainline 6-lane cross section from north of CTH S through WIS 15, including a westbound CD-System (two-lane ingress/egress) between WIS 441 and CTH E.
- I-41 & WIS 96 (Wisconsin Avenue)
    - Ramp terminal improvements (dual lefts and rights, look ahead lefts, etc.)
- I-41 & WIS 47 (Richmond Street)
    - Ramp terminal improvements (northbound and southbound look ahead lefts)
- I-41 & CTH E (Ballard Avenue)
    - Ramp terminal improvements (triple lefts, nine-lane bridge)

  Note: CTH E was analyzed with K250 volumes, which only required dual lefts. However, K30 volumes may require the triple lefts identified in the previous I-41 Operational Needs Study.
- I-41 & CTH J
    - Add roundabout bypass lanes (to/from all on/off ramps)
- I-41 & CTH U
    - Add left turn bay extensions (four lanes under bridge)
    - Add right turn bays on exit ramps
- I-41 & CTH S
    - Signalize, if warranted.

Year 2048 Build with Long Term Improvements Traffic Operations Summary

Year 2048 Build with Long Term Improvements traffic operations were analyzed under the same conditions as the year 2048 Build scenario with the addition of the long term improvements described above.

Table 24 below shows a summary of the intersections under the Year 2048 Build with Long Term Improvements scenario that have at least one turn movement operation at LOS E or worse conditions during AM and PM peak hours. This traffic operations summary is compared to previously presented

traffic operations of year 2048 No Build conditions and year 2048 No Build with Retimings for comparative purposes.

Table 24: Year 2048 Build with Long Term Improvements Traffic Operations Summary

Location	Intersection Control	2048 NoBuild		2048 NoBuild (Retimed)		2048 Long Term Improvements	
		AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
IH 41 NB ramps & CTH S (Freedom Rd)	Two-Way Stop Sign*	X	X	X	X		
IH-41 SB ramps & CTH S (Freedom Rd)	Two-Way Stop Sign*	X	X	X	X		
IH 41 NB ramps & CTH U (County Line Rd)	Two-Way Stop Sign	X	X	X	X		X
IH 41 SB ramps & CTH U (County Line Rd)	Two-Way Stop Sign	X	X	X	X		X
IH 41 NB ramps & CTH J (Hyland Ave)	Roundabout	X	X	X	X		
IH 41 SB ramps & CTH J (Hyland Ave)	Roundabout		X		X		
IH 41 NB ramps & WIS 55 (Delanglade St)	Roundabout						
IH 41 SB ramps & WIS 55 (Delanglade St)	Roundabout						
IH 41 NB ramps & CTH N (Freedom Rd)	Traffic Signal		X				
IH 41 SB ramps & CTH N (Freedom Rd)	Traffic Signal						
IH 41 NB ramps & CTH E (Ballard Rd)	Traffic Signal	X	X	X	X	X	
IH 41 SB ramps & CTH E (Ballard Rd)	Traffic Signal	X	X	X		X	
IH 41 NB ramps & WIS 47 (Richmond St)	Traffic Signal		X				
IH 41 SB ramps & WIS 47 (Richmond St)	Traffic Signal						
IH 41 NB ramps & WIS 15 (Northland Ave)	Traffic Signal	X	X	X	X		
IH 41 SB ramps & WIS 15 (Northland Ave)	Traffic Signal		X				
IH 41 NB ramps & WIS 96 (Wisconsin Ave)	Traffic Signal		X		X		
IH 41 SB ramps & WIS 96 (Wisconsin Ave)	Traffic Signal	X	X	X	X		X
IH 41 NB ramps & WIS 125 (College Ave)	Traffic Signal		X				X
IH 41 SB ramps & WIS 125 (College Ave)	Traffic Signal						
IH 41 NB off ramp & CTH BB (Prospect Ave)	Traffic Signal						
IH 41 NB on ramp & CTH BB (Prospect Ave)	Traffic Signal		X				
IH 41 SB off ramps & CTH BB (Prospect Ave)	Traffic Signal	X	X	X	X		
Locations with LOS E or F	Stop Sign or RAB	5	6	5	6	0	2
	Traffic Signal	5	11	5	5	2	2

*Both CTH S intersections are signalized under the year 2048 Long Term Improvements scenario.

Table 24 shows that traffic operations improve significantly under the year 2048 Build with Long Term Improvements scenario compared to the year 2048 No Build scenarios. The year 2048 Build with Long Term Improvements scenario shows only 2 intersections in the AM peak hour and 4 intersections in the PM peak hour operating with at least one turn movement at LOS E or LOS F. Under the year 2048 No Build conditions traffic operations analysis, there are 10 intersections in the AM peak hour and 17 intersections in the PM peak hour operating with at least one turn movement at LOS E or F operations. And, under the year 2048 No Build with Retimings conditions traffic operations analysis, there are 10 intersections in the AM peak hour and 11 intersections in the PM peak hour operating with at least one turn movement at LOS E or F operations. Therefore, the number of intersections with at least one turn movement at LOS E or LOS F is expected to be significantly reduced with the Long Term Improvements in place.

Additional Long Term Improvements could potentially be included to address the remaining locations with LOS E or F peak hour operations. For example, the CTH U intersections could be signalized if warranted, and the CTH E, WIS 96, and WIS 125 intersections could include right turns on red and additional signal retimings could be explored. The CTH U signalization is not included in the recommendations nor in the costs presented in the "Cost Estimates" section later in the report.

Additional intersection analysis details including traffic volumes, delay, and LOS by movement are available in Appendix M. Each of the 2048 Long Term Improvement intersection analysis models were peer reviewed by WisDOT with formal WisDOT documentation (DT 1887) provided in Appendix N. The year 2048 Build with Long Term Improvements Synchro output files for signalized and stop sign intersections and the year 2048 Build HCS7 output files for roundabout intersections are provided in Appendix O15, O16, and O17.

Year 2048 Build with Long Term Improvements VISSIM Model Operations

Traffic operations along I-41 were examined by analyzing the VISSIM simulation model under Year 2048 Build with Long Term Improvements conditions. Table 25 shows how the mainline and intersection volume from the VISSIM simulation model output calibrates to the year 2048 projected target volumes using the standard validation tiers compared to the year 2048 Build with Short Term Improvements scenario. Table 26 compares the VISSIM simulation model travel time along I-41 between CTH S and CTH BB under year 2048 Build with Long Term Improvements conditions and year 2048 Build with Short Term Improvements conditions.

Table 25: VISSIM Model Traffic Volume Comparison: 2048 Build with Short Term Improvements vs 2048 Build with Long Term Improvements

MOE	Validation Tiers	Target	Year 2048 Build Short Term Imp				Year 2028 Build Long Term Imp			
			VISSIM Model		Validated?		VISSIM Model		Validated?	
			AM	PM	AM	PM	AM	PM	AM	PM
Mainline Volume	Tier 1 – 60 minute period	RMSPE <5%	10%	10%	No	No	3%	2%	Yes	Yes
	Tier 2 – 60 minute period	RNSE < 3 for 85% of links	50%	56%	No	No	96%	97%	Yes	Yes
	Tier 1 – 15 minute period*	RMSPE <5%	12%	11%	No*	No*	7%	5%	No*	No*
	Tier 2 – 15 minute period*	RNSE < 3 for 85% of links	70%	69%	No*	No*	88%	97%	Yes*	Yes*
Intersection Volume	Tier 1 – 60 minute period	RMSPE <5%	N/A	N/A	--	--	N/A	N/A	--	--
	Tier 2 – 60 minute period	RNSE < 3 for 75% of links	88%	79%	Yes	Yes	98%	100%	Yes	Yes
	Tier 1 – 15 minute period*	RMSPE <5%	N/A	N/A	--	--	N/A	N/A	--	--
	Tier 2 – 15 minute period*	RNSE < 3 for 75% of links	94%	90%	Yes	Yes	98%	97%	Yes	Yes

*Note: The 15-minute period targets are additional targets that are not required, but are included as an attempt to further refine the model validation beyond the required 60-minute targets.

Table 26: VISSIM Model Travel Time Comparison: 2048 Build with Short Term Improvements vs 2048 Build with Long Term Improvements

MOE	Direction	VISSIM Model Travel Time (in minutes)			
		Year 2048 Build Short Term Imp		Year 2048 Build Long Term Imp	
		AM	PM	AM	PM
Travel Time	I-41 Northbound	25.7	31.9	22.9	23.1
	I-41 Southbound	38.4	23.7	23.5	22.9

Table 25 shows that the year 2048 Build with Long Term Improvements scenario has better validated mainline and intersection volumes than the year 2028 Build with Short Term Improvements. All of the volume validation statistics are improved under the Long Term Improvements scenario compared to the Build with Short Term Improvements scenario in both AM and PM peak hours. Additionally, all of the volume tiers are validated under the year 2048 Build with Long Term Improvements scenario, except for the non-required 15-minute period mainline volume tier, which barely miss the 5% threshold. This indicates that the Long Term Improvements creates better traffic volume flow and less congestion with the projected year 2048 peak hour traffic volume.

Table 26 shows that the year 2048 Build with Long Term Improvements scenario has shorter travel times than the year 2048 Build with Short Term Improvements scenario in both the northbound and southbound directions along I-41 between CTH S and CTH BB in both the AM and PM peak hours. This further indicates that the Long Term Improvements provide better traffic flow with projected year 2048 peak hour traffic volume and that the Long Term Improvements are expected to accommodate the demands of year 2048 traffic volumes.

Furthermore, the I-41 mainline traffic operations in the VISSIM model are showing stable traffic flow with the Long Term Improvements in place. Appendix P includes a color-coded table showing VISSIM model average speed, density, and LOS of I-41 mainline operations. The only area with some slowdowns with the Long Term Improvements in place is the I-41 northbound section between the CTH E entrance ramp and the WIS 441 exit ramp in the PM peak hour. All other mainline sections in both AM and PM peak hours are showing near free flow speed at LOS D or better, according to the VISSIM models.

Appendix P13 and P14 show the year 2048 Build with Long Term Improvements VISSIM model simulation statistics including mainline and intersection volume, mainline operations, mainline speed, lane utilization and travel time. Appendix P also includes the year 2048 Build with Long Term Improvements VISSIM files. The 2048 Long Term Improvement VISSIM microsimulation models were peer reviewed by WisDOT with formal WisDOT documentation (DT 1887) provided in Appendix N.

YEAR 2048 LONG TERM BUILD SAFETY ANALYSIS

The year 2048 Long Term Build safety analysis was conducted by Strand Associates Inc. The 2048 Build with Long Term Improvements predictive crash results were compared to the No Build scenario. The Empirical-Bayes (E-B) Method is not applicable for analysis of the I-41 mainline in the Long Term Build alternative because the number of basic lanes along the corridor changes for the majority of the corridor compared to existing conditions. Therefore, the Predictive Method was used to compare the relative differences in predicted crashes between the Long Term Build Alternative and the future No Build Alternative. This analysis methodology indicates that, in general, a reduction in Fatal and Injury (FI) crashes could be anticipated with the proposed improvements compared to a No-Build condition. The analysis also indicates that total crashes could increase due to a rise in predicted property-damage only (PDO) crashes. The Long Term Build alternative analysis segments are shown in Figure 6 and relative predictive crash analysis results for the I-41 mainline are shown in Table 27.

Figure 6 Analysis Segments for Long-Term Build Alternative

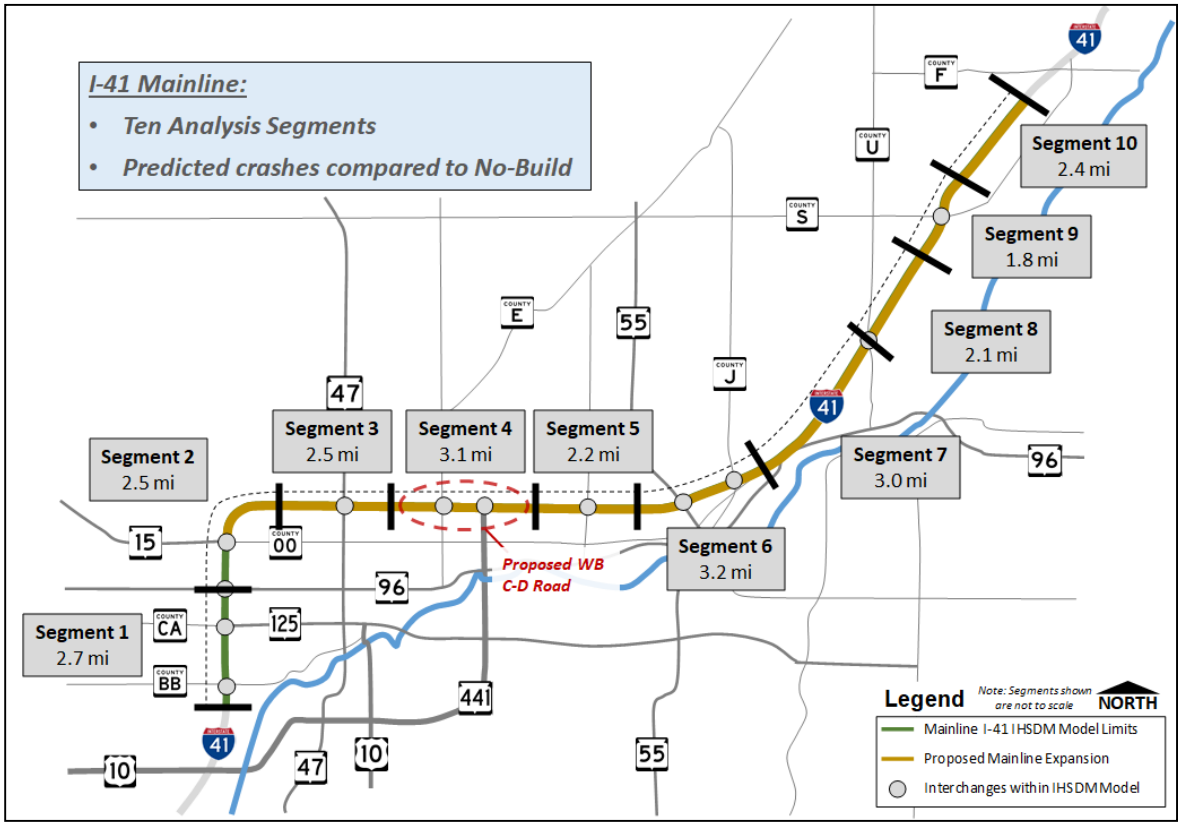


Table 27 Long-Term Build Alternative Mainline Crash Prediction Results

	Analysis Segments			Percent Differences Long-Term Build vs. No-Build		
	Segment No.	Dist (mi)	General Limits	Total	FI	PDO
Analysis Segments	1	2.7	South of CTH BB to STH 96	1.3%	1.5%	1.2%
	2	2.5	STH 96 to North of STH 15	-1.3%	-3.6%	-0.3%
	3	2.5	North of STH 15 to West of CTH E	2.4%	-5.8%	6.2%
	4	3.1	West of CTH E to East of STH 441	5.4%	0.4%	7.7%
	5	2.2	East of STH 441 to West of STH 55	4.7%	-4.7%	8.9%
	6	3.2	West of STH 55 to East of CTH J	-0.6%	-6.9%	2.3%
	7	3.0	East of CTH J to CTH U (County Line)	10.0%	0.2%	14.1%
	8	2.1	CTH U (County Line) to South of CTH S	9.5%	-1.6%	14.1%
	9	1.7	South of CTH S to North of CTH S	6.9%	-2.6%	10.9%
	10	2.3	North of CTH S to South of CTH F	9.1%	-2.6%	13.8%
Subtotals	1-2	5.2	South of CTH BB to North of STH 15	0.1%	-0.9%	0.5%
	3-4	5.6	North of STH 15 to East of STH 441	4.0%	-2.5%	7.0%
	5-7	8.5	East of STH 441 to CTH U (Brown County)	4.2%	-4.2%	7.9%
	8-10	6.2	CTH U to South of CTH F	8.6%	-2.2%	13.1%
	Overall	*25.5*	*South of CTH BB to South of CTH F*	3.9%	-2.5%	6.7%

Note: Crash prediction results shown above reflect 2028 to 2037 time period using the Predictive Method

Table 27 shows that an overall increase in crashes along the I-41 corridor is expected, however a decrease in fatal and injury crashes is anticipated. The rise in PDO crashes could be attributed to increased traffic volumes and the introduction of median barrier throughout the corridor. The existing conditions E-B analysis indicates that the software may be under predicting the number of crashes in the higher volume and congested portions of the corridor from the southern limit to east of WIS 441. While unknown, this indicates that the positive benefit of the Long Term Build alternative may not be fully captured in the more congested portions of the corridor.

See Appendix Q for a technical memorandum prepared by Strand Associates documenting the IHSDM analysis methodology and results for the study and for more detail on the Long Term Build alternative.

COST ESTIMATES

The I-41 Traffic and Engineering Study included updating previously developed[†] cost estimates for the short term and long term improvements. The updates completed by the team include revising unit cost values based on recent bid trends and adjusting quantities associated with geometric design changes defined by the traffic analysis and updated design standards. These updates are reflected in both the 2028 short term and the 2048 long term improvement recommendations.

Unit Cost Development

The study team developed updated unit costs for the major construction items referencing recent bid prices from the greater Fox Valley area. Table 28 displays the WisDOT proposal numbers for the five projects used to help adjust unit prices. Outlier winning bid prices were not used in the evaluation (i.e., $20.00 per square yard of pavement removal for proposal 2019051402) and the average unit prices were rounded to the nearest dollar. Engineering judgement was applied using countywide bid price averages for the last calendar year in the project geographic region to arrive at a final unit price.

Table 28: Proposals Evaluated for Unit Cost Adjustment

Proposal No.	County	Highway	Type of Work
20190212006	Winnebago	Midway Road	Ramp realignments for USH 10/STH 441 interchange
20190514022	Calumet	USH 10	Roadway expansion and horizontal curve realignment
20180612013	Calumet	STH 55	Shoulder length change, resurfacing, parking lane expansion
20161213016	Outagamie, Brown	I-41	Regraded roadway & expanded shoulder length
20171212014	Brown, Oconto	I-41, USH 141	Replacement of culverts, repaving, expansion of shoulders and ramps, structure repair

Comparing the 2012 unit prices to the updated values presented in this report results in an approximate 25-percent increase in total project cost. The bid items with the greatest unit cost increase are concrete barrier wall, concrete pavement, bridge replacement, noise/retaining walls and roadway aggregates (base course and breaker run/select crush). The recent increases in unit cost are likely attributed to larger construction companies working along the I-39/90 corridor and the FoxConn development near Racine and smaller contractors winning more projects in the Fox Valley. Additionally, a large portion of the available resources, like aggregate, are being funneled to the large projects in the southern part of the state.

[†] Previous study "US 41-WIS 441 Operational Needs Study." 2012. Project ID 1130-31-00

2028 Cost Estimates

Short term improvement costs are summarized in Table 29. Unit costs for the 2028 short term improvements match the values selected for the 2048 long term improvements. The project team did not adjust unit costs to account for quantity differences between the short term and long term alternatives. In addition to unit cost adjustments the geometric improvement quantities were reviewed for accuracy. Additional improvements were identified and added based on safety concerns such as protecting steep slopes. These improvements are shown in more detail in Appendix R.

Table 29: 2028 Short Term Improvement Cost Summary

Interchange	Total Cost (2019 Dollars)
WIS 96 (West Wisconsin Avenue) Interchange	$ 1,197,000
WIS 15/County OO (West Northland Avenue) Interchange	$ 1,093,000
WIS 47 (Richmond Street) Interchange	$463,000
County E (Ballard Road) Interchange	$ 1,441,000
County N (Freedom Road) Interchange	$ 924,000
County S (Freedom Road) Interchange	$1,189,000

A more detailed breakdown of the year 2028 short term improvements' cost estimates is provided in Appendix S.

2048 Cost Estimates

Long term improvement costs are summarized in Table 30. In addition to unit cost adjustments from the 2012 Operational Needs Study the cost estimates include quantity adjustments reflecting additional geometric changes identified in this study. These improvements are shown in more detail in Appendix R and include:

- *WIS 96 / I-41 Interchange* – Addition of a second look ahead left turn lane for the WB and EB WIS 96 approaches to the ramp terminal intersections.
- *WIS 47 / I-41 Interchange* – Addition of look ahead left turn lanes for the NB and SB WIS 47 approaches to the ramp terminal intersections and replaced WIS 47 bridge with an added NB left turn lane to the SB I-41 on ramp.
- *Mainline I-41 from WIS 47 to CTH E* – Added a lane to the WB collector-distributor (CD) lanes.
- *CTH E / I-41 Interchange* – NB I-41 off ramp modified from three left turn lanes to two, lane configuration update for NB CTH E approach to the SB ramp terminal intersection, and additional receiving lane added to the SB I-41 on ramp.

- *Mainline I-41 at WIS 441* – Second CD lane added for SB I-41 west of Holland Road through the WIS 441 overpass.
- *CTH J / I-41 Interchange* – Partial bypass lanes added to the ramp terminal intersection roundabouts.

Table 30: 2048 Long Term Improvement Cost Summary

Segment	Interchange / Mainline Segment	Total Cost (2019 Dollars)
Segment 2	MAINLINE I-41 South of County BB to North of WIS 96 Structures	$ 110,648,000
	County BB (West Prospect Avenue) Interchange	$ 18,867,000
	WIS 125 (West College Avenue) Interchange	$ 46,724,000
	WIS 96 (West Wisconsin Avenue) Interchange	$ 26,408,000
Segment 3	MAINLINE I-41 North of WIS 96 Structures to South of WIS 15 Structures	$ 43,943,000
Segment 4	MAINLINE I-41 South of WIS 15 Structures to West of County E	$ 172,945,000
	WIS 15/County OO (West Northland Avenue) Interchange	$ 61,447,000
	WIS 47 (Richmond Street) Interchange	$6,812,000
Segment 5	MAINLINE I-41 West of County E to West of County N (Includes US41/WIS 441 North System Interchange) & WIS 441: Fox River Bridge to I-41	$ 181,920,000
	County E (Ballard Road) Interchange	$ 35,116,000
Segment 6	MAINLINE I-41 West of County N to West of County J	$ 74,665,000
	County N (Freedom Road) Interchange	$ 18,098,000
	WIS 55 (Delanglade Street) Interchange	$ 12,500,000
Segment 7	MAINLINE I-41 West of County J to Orange Lane	$ 244,033,000
	MAINLINE I-41 (Optional barrier costs)* West of County J to Orange Lane	$12,182,000*
	County J (Hyland Avenue) Interchange	$ 6,169,000
	County U (South County Line Road) Interchange	$ 3,615,000
	County S (Freedom Road) Interchange	$ 11,996,000

*Note: The $12,182,000 cost is optional and not included in the total Long Term improvements' cost.

A more detailed breakdown of the year 2048 long term improvements' cost estimates is provided in Appendix S.

Median Storm Drainage Improvements

The capacity expansion of I-41 will result in lanes being added over the existing rural median between the NB and SB lanes. The resulting roadway typical section will result in the need for storm drainage infrastructure to collect the water at the median concrete barrier, divert it to a storm drain trunk line pipe and discharge it to the outside shoulders. A sample section of roadway at 1% and 2% longitudinal slope was analyzed with a 25-year design storm and a time-of-concentration of 5 minutes. It was determined that to maintain a maximum trunk line pipe diameter of 24-inches the storm water, at 75% of full flow, would need to be discharged every 500-feet. Table 31 provides the drainage related costs per 500-feet of interstate roadway which averages the design using 1% and 2% longitudinal roadway slope. The maximum spread from the median barrier was set at 10-feet.

Table 31: Drainage Pay Items and Unit Costs per 500 Feet

Pay Item	Unit Cost	Quantity	Total Cost
Storm RCP Class IV 12-inch	$70	90 LFT	$ 6,300
Storm RCP Class IV 18-inch	$75	140 LFT	$ 10,500
Storm RCP Class IV 24-inch	$90	235 LFT	$ 21,150
Manholes 4-ft Diameter	$2,100	5 EACH	$ 10,500
Inlets 2x3-ft	$1,600	5 EACH	$ 8,000
Inlet Covers Type V	$700	10 EACH	$ 7,000
Total Cost Per 500' of Interstate			**$ 63,450**

In addition to the storm drainage items summarized in Table 31, the added impervious surface will require additional water management as described within Chapter 13 of the WisDOT Facilities Development Manual (FDM). Providing for the proper storm water management within the corridor, it is expected that additional right-of-way will be acquired to account for the added runoff rates.

The drainage cost estimate as described in this section was completed to determine the impacts of converting a rural corridor to an urban cross section by eliminating the pervious median. It does not include potential necessary drainage improvements beyond the outside shoulder of the interstate. The drainage cost estimate details are not shown within the segment and interchange cost estimate summaries as the drainage component cost of the project is set as a percentage of the major roadway items. Comparing the rural to urban median conversion drainage costs to the drainage percentage costs documented in the segment and interchange cost estimate summaries confirmed that the percentage values were accurate. The percentage values also include additional drainage associated with added collector/distributor lanes, concrete barrier along the outside shoulder, and additional detention facilities.

PROJECT MANAGEMENT

The I-41 Traffic and Engineering Study included project management and coordination techniques to ensure proper and ongoing project direction and communication between WisDOT Northeast Region, WisDOT Bureau of Traffic Operations and the project consultant team, which included HNTB Corporation and Strand Associates Inc.

On-going weekly coordination meetings were held throughout the project's length with members of WisDOT, ECWRPC, HNTB, and Strand present. During these meetings WisDOT would provide direction and clarification for ongoing project issues and decision points. The consultant team would provide status reports, project results, and communicate progress toward deadlines. The coordination meetings were held from February to August 2019.

A decision log was kept at each weekly meeting noting decisions that were made for throughout the project, including notes and reasoning on the decision, who made the decision, what medium the decision was made (i.e. email, phone, meeting, etc.), and the date that the decision was made. Appendix T includes the decision log for the project.

A schedule of task deadlines was provided at the beginning of the project. The schedule was updated as the project progressed when necessary. As the consultant team completed project tasks, such as traffic volume projections, intersection and mainline traffic operations analysis, and simulation model development, the work was forward to WisDOT for review. WisDOT would send review comments and the consultant team addressed the comments. Documentation of these project reviews and comment responses between WisDOT and the consultant team are included in Appendix E and N.

SUMMARY

Year 2018 Existing peak hour operations in the project study area include four intersections with at least one turning movement operating at LOS E or F operations during the peak hours and I-41 mainline traffic flow is at or near free flow speeds along most of the corridor. Under year 2028 No Build conditions, peak hour traffic operations are expected to worsen with seven intersections having at least one turning movement operating at LOS E or F conditions and I-41 mainline traffic flow slowing by about 2.5 minutes in the I-41 southbound direction in the AM peak hour. By year 2048 No Build conditions, seventeen intersections are expected to include at least one turning movement operating at LOS E or F conditions during the peak hours, and I-41 mainline traffic flow is expected to include slower travel times, including about 15 minutes slower in the I-41 southbound direction in the AM peak hour.

In order to improve traffic operations by year 2028, some Short Term Improvements were presented that include intersection improvements at the ramp terminals of three interchanges (WIS 96, WIS 15, and CTH E) and the lengthening of six I-41 entrance ramps and one I-41 exit ramp. These improvements are expected to improve intersection peak hour operations at the intersections of these three interchanges and improve travel times along the I-41 mainline corridor, including a decrease of about seven minutes along the I-41 Southbound direction during the PM peak hour.

In order to improve traffic operations by 2048, additional Long Term Improvements were recommended that include expanding the I-41 mainline from four lanes to six lanes between CTH S and WIS 15, and including a westbound C-D system between WIS 441 and CTH E. In addition, improvements to intersections at six of the interchanges were presented (WIS 96, WIS 47, CTH E, CTH J, CTH U, and CTH S).

The safety analysis for the Short Term alternative used the E-B method, where applicable. The safety analysis for the Long Term alternative used the Predictive Method. The safety benefits of the year 2028 Short Term Improvements could be expected at several locations, but were not significant. The safety impacts of the year 2048 Long Term Improvements include an anticipated slight increase of overall crashes by 3.9% throughout the I-41 project area mainline corridor, however the total number of fatal and injury accidents is expected to decrease by 2.5%.

The total cost estimate of the year 2028 Short Term Improvements is $6,307,000 in year 2019 dollars. The total cost estimate of the year 2048 Long Term Improvements is $1,075,906,000 in year 2019 dollars, which doesn't include the optional barrier costs.