



TRAFFIC ANALYSIS & DESIGN, INC.

www.tadi-us.com

John Campbell, P.E., RSP₂

414-350-3256

jcampbell@tadi-us.com

Christian R. Sternke, P.E., RSP₂

csternke@tadi-us.com

WZTAT Update Project Summary

**WisDOT Supervisors – 9:00 AM
March 13th, 2024**



Today's Agenda



- What is the WZTAT
- Why it is was needed
- How it was made
- Overview of tool
- How it is used
- Q&A



What is the WZTAT

- **Work Zone Traffic Analysis Tool (WZTAT)**
- **Microsoft Excel based tool**
- **Designed for freeway & expressway work zone lane closures**
- **WZTAT Estimates:**
 - **Work zone capacity**
 - **Queue length**
 - **Work zone delay**
 - **Road user costs**
 - **Diversion volumes**



What is the WZTAT

- **Original Version (2020)**
 - Weekly & annual tools
 - Diversion, if used, was manually estimated & input
- **Updated Version (March 15, 2024)**
 - Annual tool (weekly tool discontinued)
 - Two-way analysis instead of only one-way
 - **Diversion**
 - Automatically estimated
 - Optional ability to distribute to local network
 - **New summary tabs**



Why the WZTAT was needed

- **Mix of tools**



- **Inconsistent results**
- **Accuracy questionable**
 - **Delay/queues/road user costs**
 - **Lane closure windows**



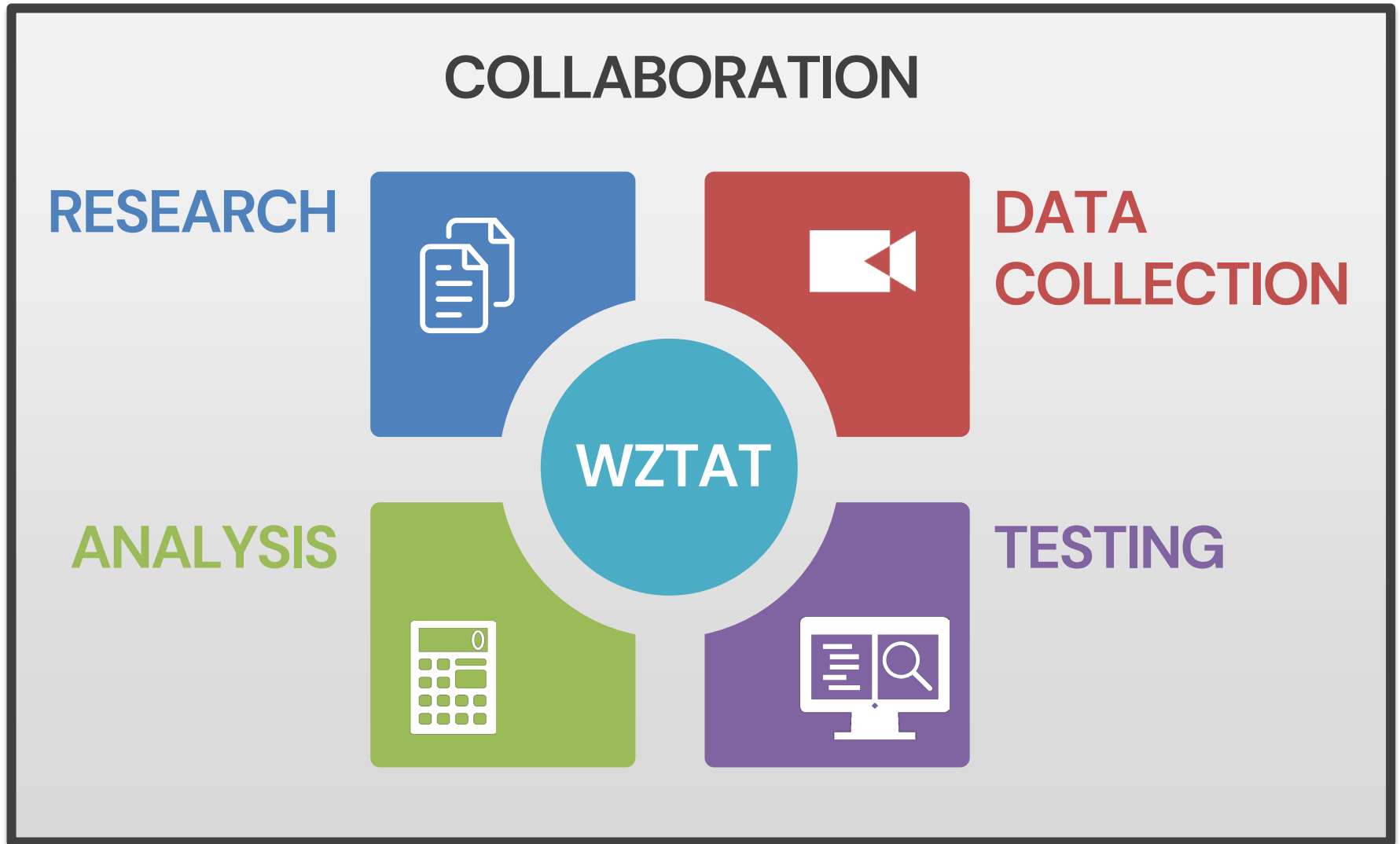
Why the WZTAT was needed

There was a need for:

- A consistent methodology
- A tool that's
 - Powerful
 - Versatile
 - Accurate
 - Easy to use
- The WZTAT is that tool

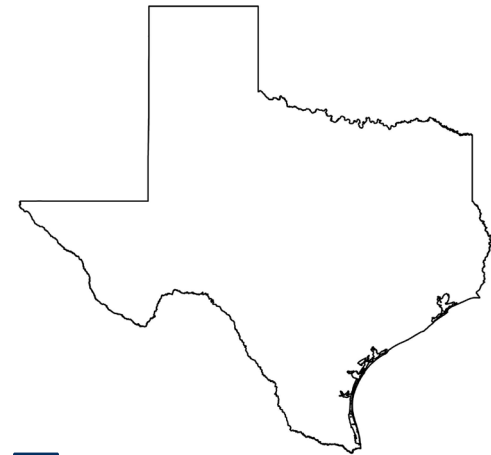


How the WZTAT Was Made



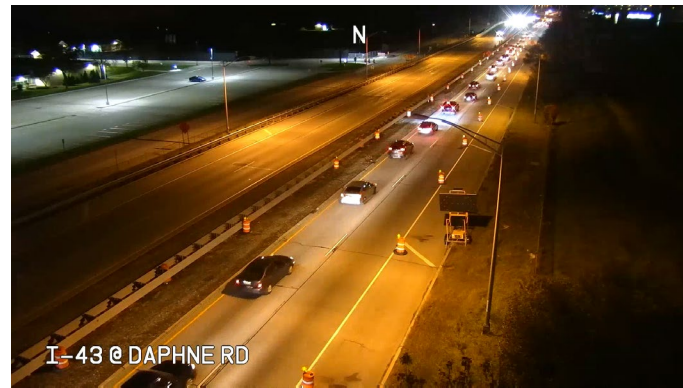
Research

- **Attended course in 2019:**
Work Zone Traffic Management Analysis Using Analytical Methods, offered by WisDOT
- **Reviewed methods of other states (MO, OH, IL, MI, TX)**
- **Researched HCM and WisDOT FDM methodologies**

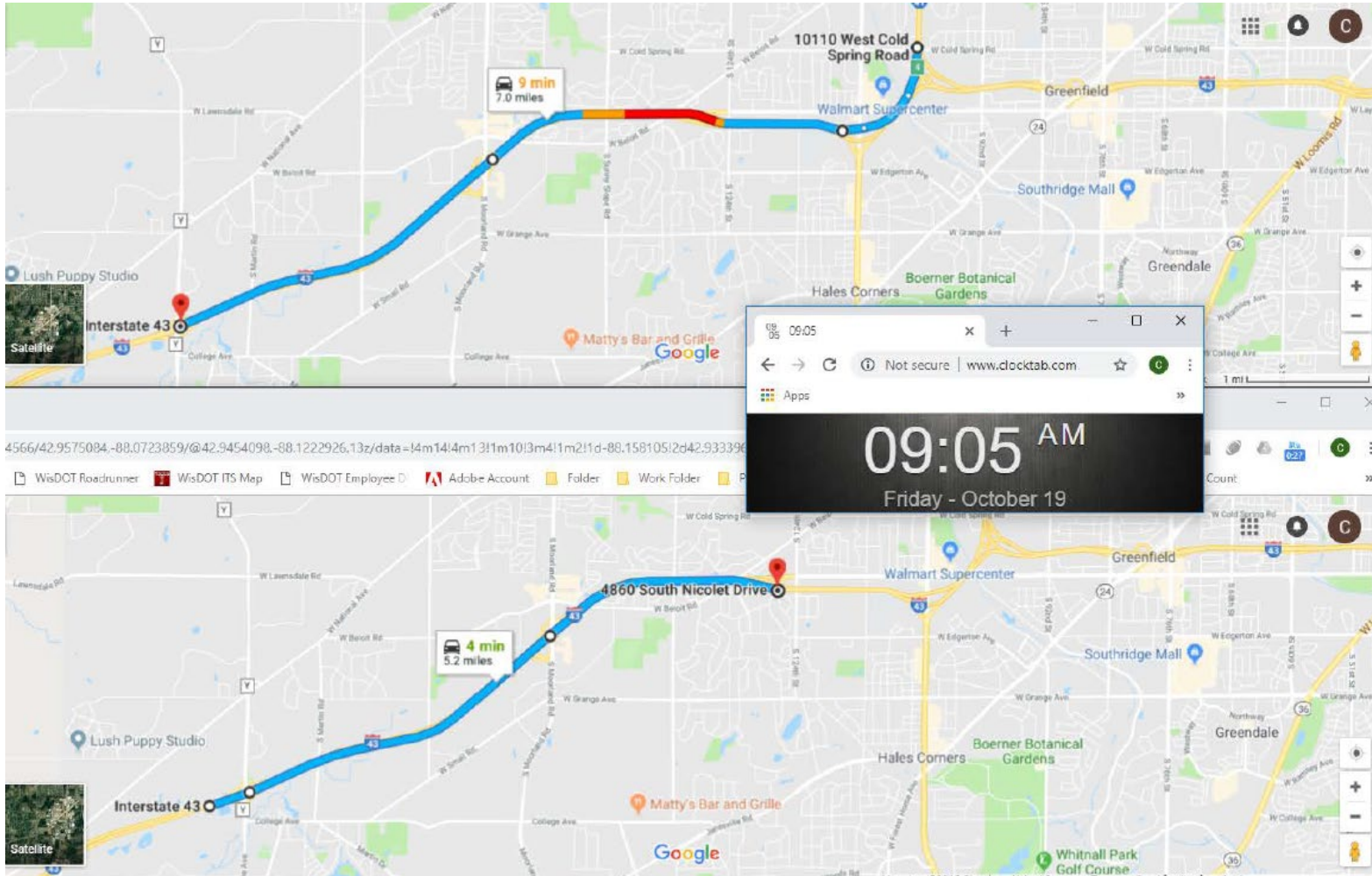


Data Collection

- Selected sites that were expected to have queues and delays due to work zone activity
- Data collection equipment included:
 - Cameras
 - CCTV
 - Google Travel Times



Data Collection



Data Collection

- **Initial Study (2018 – 2020)**
 - 14 sites (52 samples)
 - Mostly in SW & SE Region
 - Used to develop capacity model
- **2020 Model Validation**
 - 3 sites (18 samples)
 - Used to validate capacity model
- **Tool Updates (2022 – 2024)**
 - 9 sites (25 samples)
 - Mostly northern regions
 - Used to validate capacity model & develop diversion model



Analysis

- **Capacity**

- **24 different linear regression analyses with various combinations of variables led to:**

Average QDR_{PCE}

$$= 1,866 - 40f_{LCSI} - 132f_{barrier} - 101f_{TOD} - 205f_{area} - 207f_{CI} - 47f_{regional}$$

- **Queues**

- **Model based on HCM/FHWA speed/density relationship**
- **Determine speed of queue by FHWA cited Speed/Capacity relationship**
- **Combining relationships led to:**

Average PCE Headway

$$= (3.1495) \left(\frac{FFS}{2} \right) \left(1 - \left(\frac{WZ \text{ QDR} * \# \text{ of open lanes}}{FFC * \# \text{ of normal lanes}} \right)^{\frac{1}{2}} \right) + 27.789$$

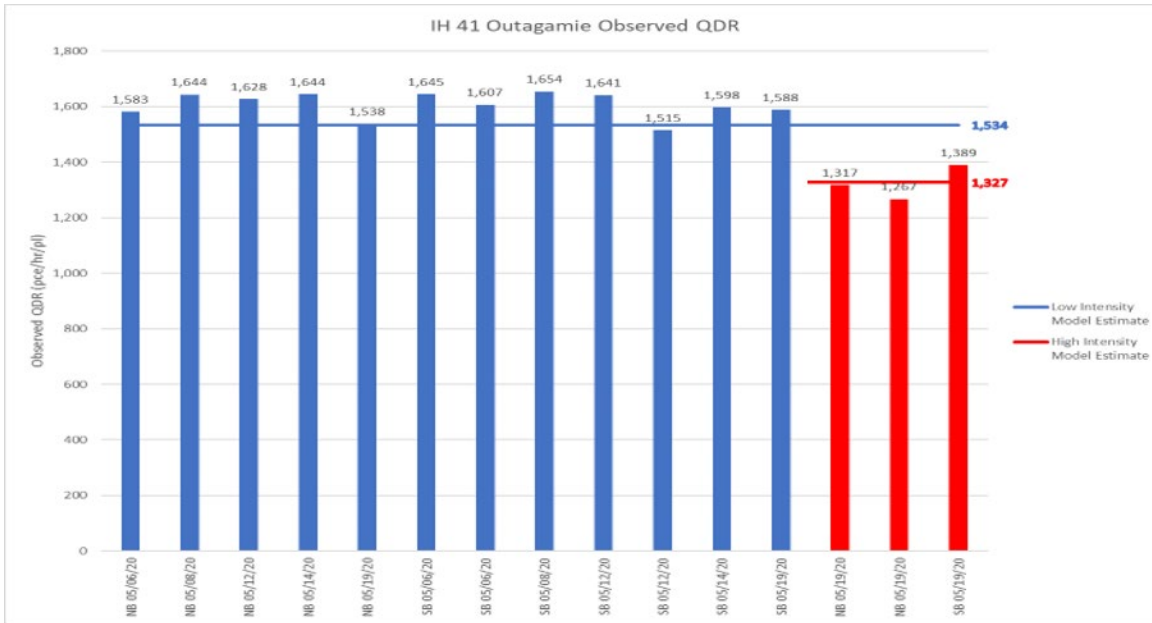


Testing/Validation

- **Two Capacity Validation Efforts**
 - **2020 (18 observations)**
 - **2022 (25 observations)**
- **Compared field observations vs. model estimates**



2020 Observed QDR vs Model

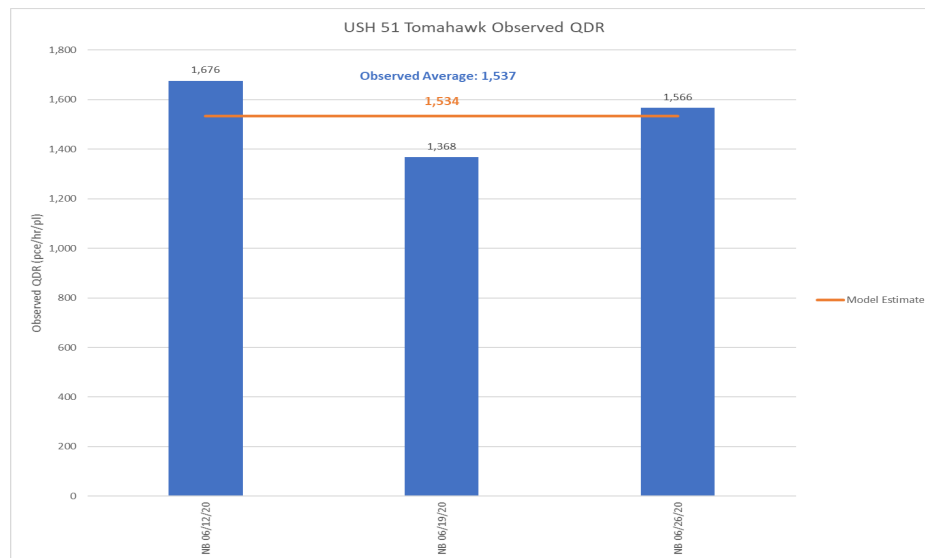


IH-41 Outagamie County

- ✓ Low intensity scenarios
- ✓ High intensity scenarios

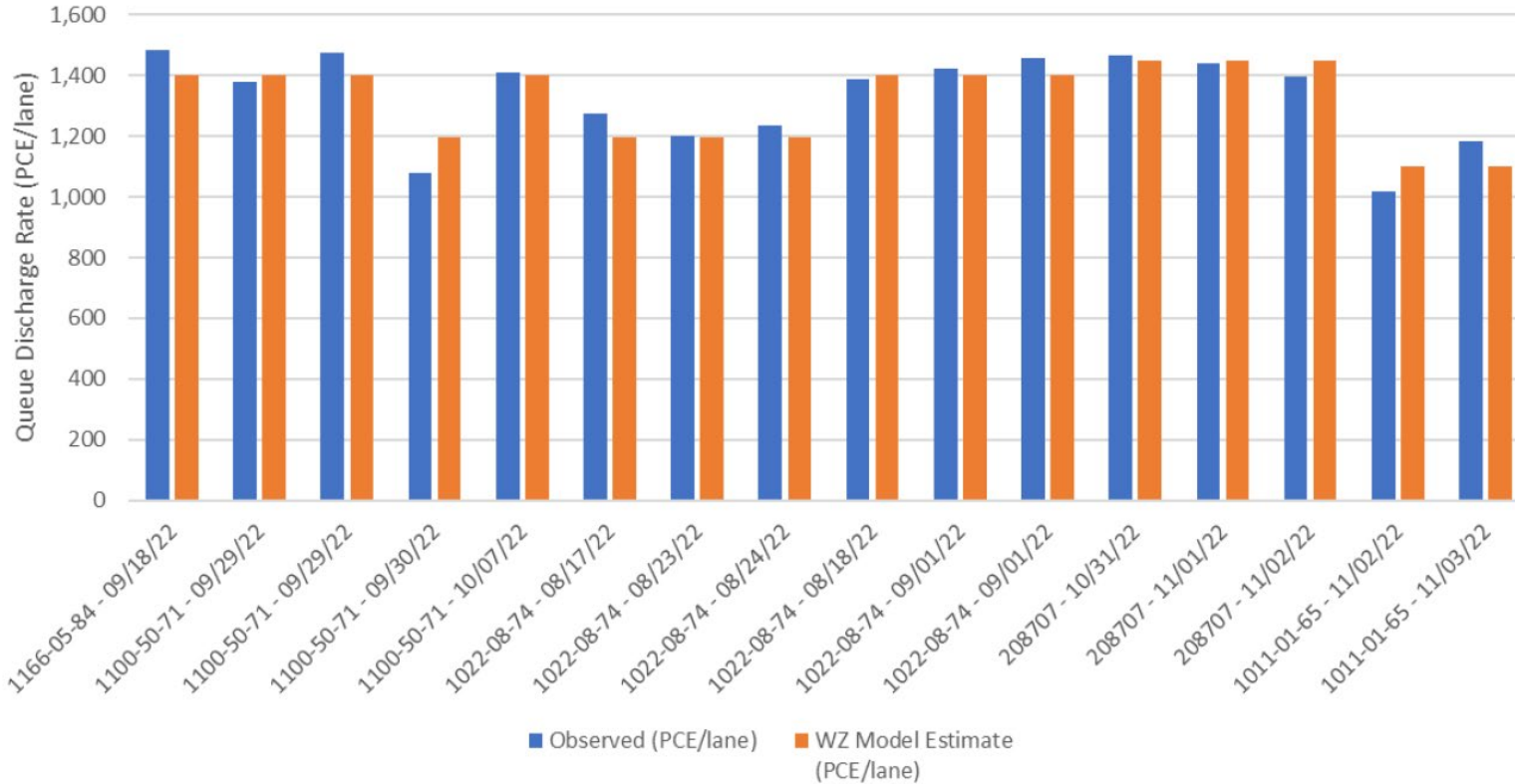
USH 51 Lincoln County

- ✓ Model estimate: 1,537 PCEs
- ✓ Observed avg: 1,534 PCEs



2022 Observed QDR vs Model

WZ Model QDR Estimate vs. Observed QDR



Collaboration

- **Typically checked-in at quarterly work zone engineer meetings**
- **Discussed**
 - **Active or upcoming lane closures**
 - **Tool needs and desired features**
- **Collaboration team included:**
 - **Cara Abts – North Central Region**
 - **Tom Boyke & Rebecca Klein – Southeast Region**
 - **Joshua Falk – Northeast Region**
 - **Chad Hines – Northwest Region**
 - **Joe Schneider & Jason Koster – Southwest Region**
 - **Erin Schwark & Andrew Heidtke – Central Office**
 - **Russell Lewis – DTIM**



Overview of WZTAT - Tabs

Pos
Inputs/Neg
Inputs

Volume
Import

Diversion
Inputs
(Optional)

Volume Stats

Calculations

Avg. Monthly
Volumes

Adj. Volumes

Queue Miles

Queue
Minutes

Total Costs

Info for
TMPs

TW Summary

Queue
Summary

Overall
Summary



Overview of WZTAT – Volume Import

Volume Import

- Import annual volume file from Jackalope SQL
- Worked with DTIM to make volume download process as easy as possible
- ***New Feature***
 - *For miss any missing data, tool will automatically use the monthly/weekday/hourly average for each hour missing*
 - *All 8,760 hours of year will be used in analysis*



Overview of WZTAT – Volume Stats

Volume Stats

- Shows statistics on quality of imported data
- Shows which dates had missing data

WB	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Total Month %
Jan	100%	80%	100%	75%	100%	100%	80%	90%
Feb	100%	100%	75%	75%	100%	100%	100%	93%
Mar	75%	75%	100%	100%	100%	100%	75%	90%
Apr	75%	100%	100%	100%	100%	100%	80%	93%
May	100%	100%	100%	100%	100%	100%	100%	100%
Jun	100%	100%	100%	100%	100%	100%	100%	100%
Jul	100%	100%	100%	100%	100%	100%	100%	100%
Aug	100%	100%	100%	100%	100%	100%	100%	100%
Sep	100%	75%	100%	100%	100%	100%	100%	97%
Oct	100%	100%	100%	100%	100%	100%	100%	100%
Nov	75%	100%	80%	100%	100%	100%	100%	93%
Dec	100%	75%	75%	75%	60%	60%	100%	77%
Total Week %	94%	92%	94%	94%	96%	96%	94%	

Missing data filled in with monthly, weekday, hourly average for the following dates:

EB	WB						
01/05/22	01/05/22						
01/08/22	01/08/22						
01/24/22	01/24/22						
02/02/22	02/02/22						
02/22/22	02/22/22						
03/07/22	03/07/22						



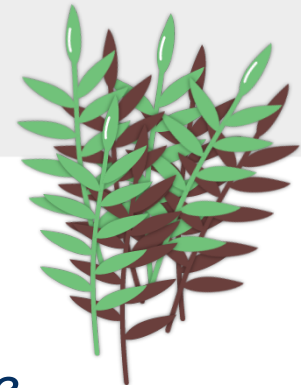
Trip Shift/Diversion Model



- **Diversion** is defined as when a driver is traveling on the highway with the work zone and diverts to an alternate route to bypass the work zone.
- **Trip shift** is defined as drivers that modify their travel plans due to the presence of a work zone.
 - changing the time or day of their trip
 - taking a substantially different route
 - stopping for an extended period to eat or shop until the delay has decreased
 - cancelling their trip altogether



Trip Shift/Diversion Model



- ***The model is a power function***
 - *as the demand increases compared to the QDR, the rate of the trip shift/diversion percentage also increases*
 - *as a work zone becomes busier due to large demand, more drivers will want to avoid the work zone*

$$TSD\% = \min \left[\left(\frac{Demand}{QDR} \right)^A * B ; 60\% \right]$$

$$A = 1.352; B = 16.61\%$$

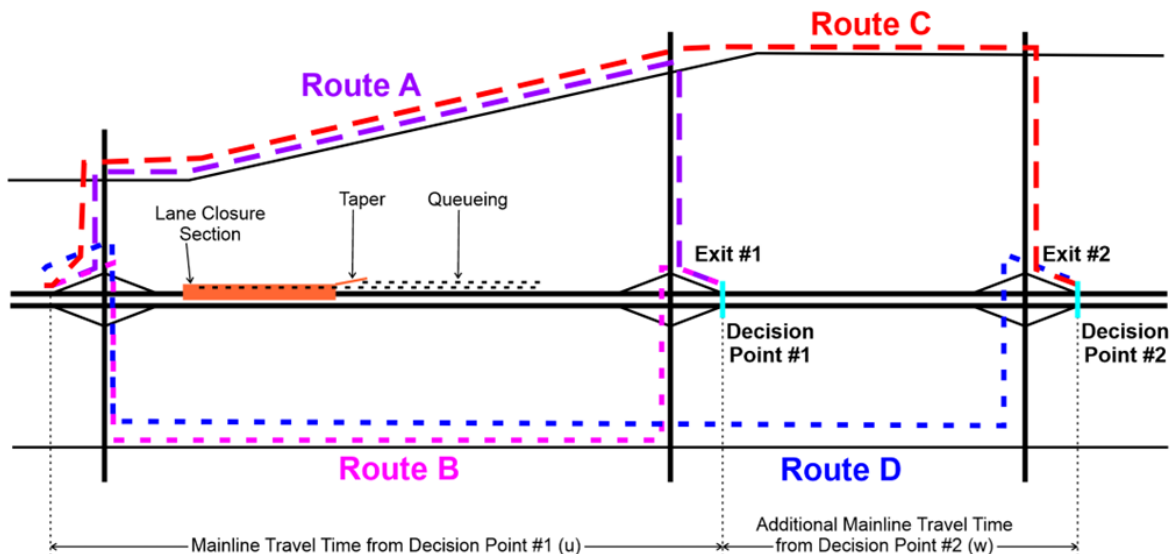
- ***Trip shift and diversion are combined into a single volume estimate***



Distribution Model



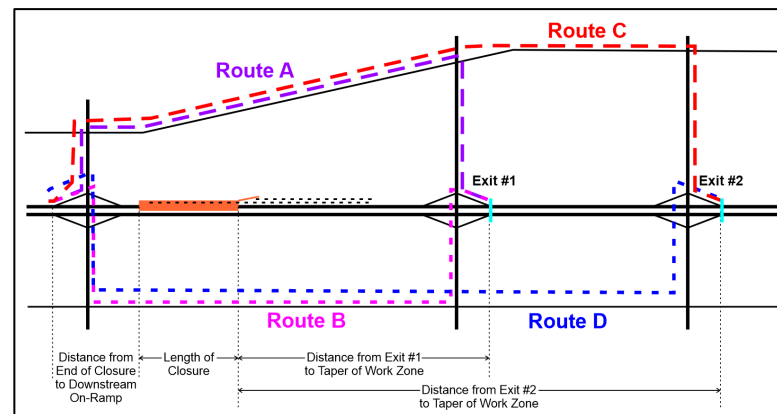
- Travel time equilibrium-based model
- Incremental delay added to diversion route base travel time to achieve equilibrium
 - Developed model using Synchro 11 and randomly selected interchanges
- Static system of equations developed to estimate diverted volumes to all routes



Overview of WZTAT – Diversion Inputs

Diversion Inputs (Optional)

- This will distribute the trip shift/diversion volumes calculated to one of four diversion routes and a trip shift estimate
- Tab is used to provide the user with a local road diversion volume estimate
- Inputs include interchange distance and diversion route travel times



Overview of WZTAT – Calculations

Calculations

- Tables where the queue miles, queue minutes, queue costs, and trip shift/diversion volumes are calculated for every hour of every day in both freeway directions
- Queue miles are estimated using the queue model derived as part of the first study (2020)
 - A faster moving queue will have larger spacing between vehicles than a slower moving queue
- Trip shift/diversion volumes are estimated using the model derived as part of the updated study (2024)



Overview of WZTAT – Overall Summary



WZTAT OVERALL SUMMARY - EB

New Tab!

Overall Summary

Base Information			
Region	Southeast	Area Type	Urban
County	Waukesha	Normal Posted Speed Limit	70 mph
Construction ID	0000-00-00	Work Zone Speed Limit	55 mph
Highway	I-94 EB	Closure Length	1.7 mi

Rows colored by minutes of delay

Months included in analysis: January, February, March, April, May, June, July, August, September, October, November, December	<u>Annual HV%</u> 8%	Version 5.2 User: DRAFT Released: 03/05/2024 Date: 12/15/2022
---	-------------------------	--

Delay Legend	<15 min	15-30 min	30-60 min	60-120 min	>120 min
--------------	---------	-----------	-----------	------------	----------

TMP Inputs

	Daytime WZ Capacity	Nighttime WZ Capacity	Expected Max. Delay	Expected Max. Queue	Road User Costs	Max Hourly Diversion to Local Roads (vph)
Mon-Thu Avg.			19 min	3.3 mi	\$47,623 per day	287
Friday Avg.			24 min	4.1 mi	\$59,653 per day	361
Saturday Avg.			---	---	---	---
Sunday Avg.			---	---	---	---
Daily Avg.	1,372 vphpl	1,353 vphpl	20 min	3.5 mi	\$50,029 per day	302
Daily Max.	<-----Fri 08/05/22----->		56 min	9.1 mi	\$317,598 max day	486
Total					\$13,007,575 total	

Daily Averages

Maximums

Overall

Description: The lane closure takes place on an urban 1.7 mile segment of I-94 EB in Waukesha County in the Southeast Region.

Automated description, but can be edited as needed



Overview of WZTAT – Overall Summary

New Tab!

Overall Summary

WZTAT OVERALL SUMMARY - EB												
Base Information												
Region	Southeast		Area Type	Urban								
County	Waukesha		Normal Posted Speed Limit	70 mph								
Construction ID	0000-00-00		Work Zone Speed Limit	55 mph								
Highway	I-94 EB		Closure Length	1.7 mi								
Months included in analysis: January, February, March, April, May, June, July, August, September, October, November, December			Annual HV% 8%	Version 5.2 Released: 03/05/2024	User: Date: 12/08/23	DRAFT						
<table border="1"> <tr> <th>Delay Legend</th> <td><15 min</td> <td>15-30 min</td> <td>30-60 min</td> <td>60-120 min</td> <td>>120 min</td> </tr> </table>							Delay Legend	<15 min	15-30 min	30-60 min	60-120 min	>120 min
Delay Legend	<15 min	15-30 min	30-60 min	60-120 min	>120 min							
	Daytime WZ Capacity	Nighttime WZ Capacity	Expected Max. Delay	Expected Max. Queue	Road User Costs	Max Hourly Diversion to Local Roads (vph)						
Overall	Mon-Thu Avg.		19 min	3.3 mi	\$47,623 per day	287						
	Friday Avg.		24 min	4.1 mi	\$59,653 per day	361						
	Saturday Avg.		---	---	---	---						
	Sunday Avg.		---	---	---	---						
	Daily Avg.	1,372 vphpl	1,353 vphpl	20 min	3.5 mi	\$50,029 per day	302					
	Daily Max.	<-----Fri 08/05/22----->		56 min	9.1 mi	\$317,598 max day	486					
Total					\$13,007,575 total							
Description: The lane closure takes place on an urban 1.7 mile segment of I-94 EB in Waukesha County in the Southeast Region.												
Closure #1	Mon-Thu Avg.		19 min	3.3 mi	\$46,986 per day	287						
	Friday Avg.		24 min	4.1 mi	\$59,089 per day	361						
	Saturday Avg.		---	---	---	---						
	Sunday Avg.		---	---	---	---						
	Daily Avg.	1,372 vphpl	1,305 vphpl	20 min	3.5 mi	\$49,406 per day	302					
	Daily Max.	<-----Fri 08/05/22----->		56 min	9.1 mi	\$316,736 max day	486					
Total					\$12,845,689 total							
Description: Closure #1 is a 3 lane to 2 lane closure with a soft barrier and high construction activity. Mon: 6 AM to 10 PM ---- Tue: 6 AM to 10 PM ---- Wed: 6 AM to 10 PM ---- Thu: 6 AM to 10 PM Fri: 6 AM to 10 PM ---- Sat: no closure ---- Sun: no closure												
Closure #2	Mon-Thu Avg.		0 min	0.0 mi	\$637 per day	0						
	Friday Avg.		0 min	0.0 mi	\$564 per day	0						
	Saturday Avg.		---	---	---	---						
	Sunday Avg.		---	---	---	---						
	Daily Avg.	---	1,383 vphpl	0 min	0.0 mi	\$623 per day	0					
	Daily Max.	---	---	---	---	\$947 max day	---					
Total					\$161,886 total							
Description: Closure #2 is a 3 lane to 2 lane closure with a soft barrier and low construction activity. Mon: 10 PM to 6 AM ---- Tue: 10 PM to 6 AM ---- Wed: 10 PM to 6 AM ---- Thu: 10 PM to 6 AM Fri: no closure ---- Sat: no closure ---- Sun: no closure												

Overall

Closure #1

Closure #2

Up to 4 scenarios!



Overview of WZTAT – Queue Summary

New Tab!

Queue Summary

Monthly Averages

Queue Graph

Avg. Max Queue (Miles)

Time of Max Queue

of que

Road User Costs

Max Delay (Minutes)

	February	Queue	Max Queue	Approx. Time of Max Queue	# of Queueing Hours	Max Delay	Total Road User Cost*
Averages	Mon - Thurs		2.0 mi	7:45 AM	7 hours	11.6 min	\$ 15,321
	Friday		1.7 mi	4:30 PM	6 hours	9.8 min	\$ 14,375
	Saturday						\$ -
	Sunday						\$ -
	Max. Queue	<-----Fri 02/25/22----->		2.8 mi	5:00 PM	4 hours	16.2 min
Total Monthly Road User Costs						\$	302,636

*If a queue was not observed, decreased speeds through the work zone can still result in delay costs.

Stats for Day of Monthly Maximum

Total Monthly Road User Costs



Overview of WZTAT – Queue Summary



WZTAT QUEUE SUMMARY - EB

New Tab!

Queue Summary

Base Information			
Region	Southeast	Area Type	Urban
County	Waukesha	Normal Posted Speed Limit	70 mph
Construction ID	0000-00-00	Work Zone Speed Limit	55 mph
Highway	I-94 EB	Closure Length	1.7 mi

blank = no queue
 --- = no data

Queue Legend
 5.0 mi
 2.5 mi
 0.0 mi

Version 5.2
 Released: 03/05/2024

User: DRAFT
 Date: 12/8/2023

Delay Legend	<15 min	15-30 min	30-60 min	60-120 min	>120 min
--------------	---------	-----------	-----------	------------	----------

February	Queue	Max Queue	Approx. Time of Max Queue	# of Queueing Hours	Max Delay	Total Road User Cost*
01 Tue		2.5 mi	8:00 AM	7 hours	14.3 min	\$ 20,611
02 Wed		1.8 mi	7:45 AM	7 hours	10.5 min	\$ 13,924
03 Thu		1.9 mi	7:45 AM	6 hours	10.7 min	\$ 13,803
04 Fri		0.9 mi	3:45 PM	4 hours	5.4 min	\$ 8,469
05 Sat						\$ -
06 Sun						\$ -
07 Mon		2.0 mi	7:45 AM	7 hours	11.3 min	\$ 10,422
08 Tue		2.5 mi	7:45 AM	7 hours	14.4 min	\$ 17,653
09 Wed		2.1 mi	7:45 AM	7 hours	12.0 min	\$ 14,633
10 Thu		2.0 mi	8:00 AM	8 hours	11.7 min	\$ 16,084
11 Fri		1.6 mi	4:30 PM	8 hours	9.2 min	\$ 11,509
12 Sat						\$ -
13 Sun						\$ -
14 Mon		1.6 mi	4:30 PM	6 hours	9.0 min	\$ 11,546
15 Tue		2.7 mi	8:00 AM	9 hours	15.2 min	\$ 20,254
16 Wed		2.3 mi	8:00 AM	7 hours	13.3 min	\$ 15,509
17 Thu		2.1 mi	4:45 PM	7 hours	12.1 min	\$ 16,257
18 Fri		2.4 mi	4:30 PM	7 hours	13.6 min	\$ 17,523
19 Sat						\$ -
20 Sun						\$ -
21 Mon		1.4 mi	7:45 AM	6 hours	7.8 min	\$ 9,653
22 Tue		2.6 mi	8:00 AM	7 hours	14.7 min	\$ 19,470
23 Wed		1.9 mi	4:30 PM	7 hours	10.6 min	\$ 13,097
24 Thu		2.0 mi	7:45 AM	7 hours	11.5 min	\$ 16,543
25 Fri		2.8 mi	5:00 PM	4 hours	16.2 min	\$ 19,997
26 Sat						\$ -
27 Sun						\$ -
28 Mon		2.3 mi	7:45 AM	7 hours	13.3 min	\$ 15,509
February	Queue	Max Queue	Approx. Time of Max Queue	# of Queueing Hours	Max Delay	Total Road User Cost*
Mon - Thurs		2.0 mi	7:45 AM	7 hours	11.6 min	\$ 15,321
Friday		1.7 mi	4:30 PM	6 hours	9.8 min	\$ 14,375
Saturday						\$ -
Sunday						\$ -
Max. Queue	<-----Fri 02/25/22----->	2.8 mi	5:00 PM	4 hours	16.2 min	\$ 19,997
Total Monthly Road User Costs						\$ 302,636

Same delay-based color scheme

Shows each day of the month

Averages for each day of the month

Day of observed monthly maximum



*If a queue is not observed, decreased speeds through the work zone can still result in delay costs.

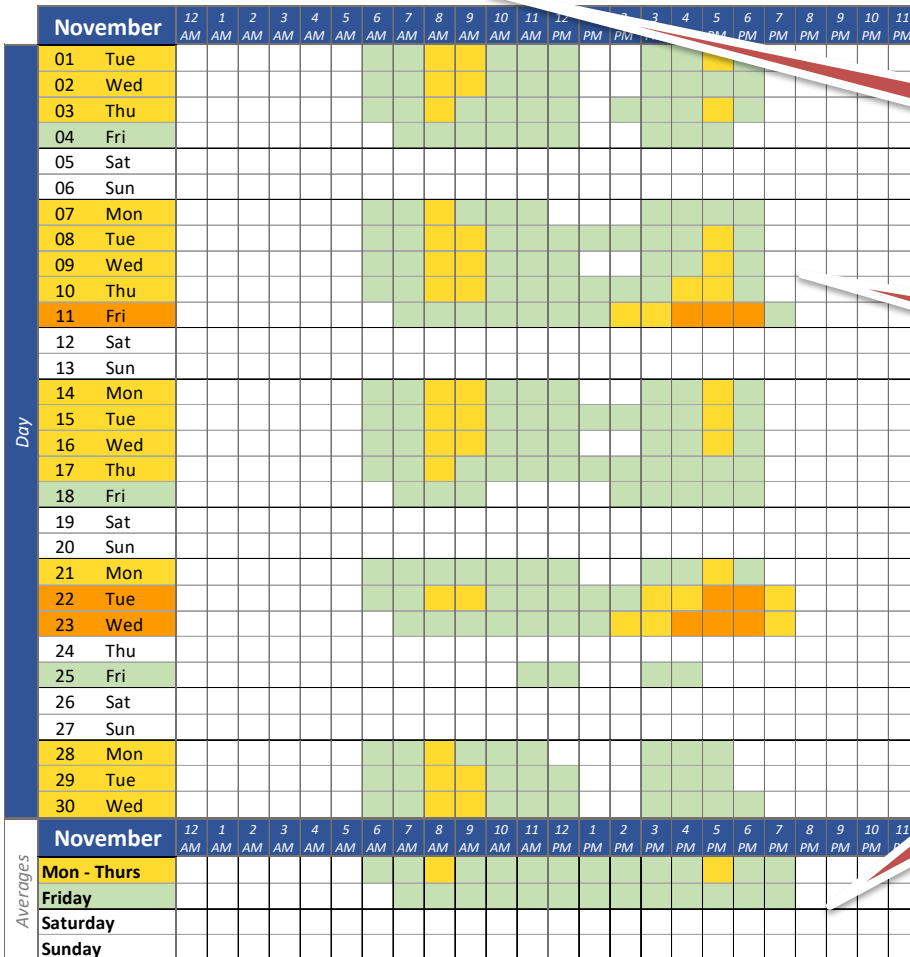
Overview of WZTAT – Time Window Summary



WZTAT TIME WINDOW SUMMARY - EB

Base Information			
Region	Southeast	Area Type	Urban
County	Waukesha	Normal Posted Speed Limit	70 mph
Construction ID	0000-00-00	Work Zone Speed Limit	55 mph
Highway	I-94 EB	Closure Length	1.7 mi

N/A	0	15	30	60	120	Version 5.2	User: DRAFT
	<15 min	15-30 min	30-60 min	60-120 min	>120 min	Released: 03/05/2024	Date: 12/8/2023



New Tab!



Same delay-based color scheme

Delay for each hour of each day

Displays the average days



How the WZTAT is Used

- **Approved for use on freeways and expressways**
 - **Determining lane closure windows**
 - **Reporting road user costs**
- **Used for improvement project program**
- **Used for highway maintenance**



Final Thoughts

- **Would not have been possible without the collaborative effort**
- **Impacts of freeway lane closures will be more consistently and accurately estimated**
- **Freeway TMPs easier to complete**
- **Lane closure windows easier to identify**
- **Diversion estimates now possible**
- **Official planned release date:
March 15th, 2024**



Discussion / Questions





TRAFFIC ANALYSIS & DESIGN, INC.

www.tadi-us.com

John Campbell, P.E., RSP₂

414-350-3256

jcampbell@tadi-us.com

Christian R. Sternke, P.E., RSP₂

csternke@tadi-us.com

Thank You

