2022 Tennessee Statewide Freight Bottleneck Study

Transportation Performance Measures Reporting for MAP-21 Compliance

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Overview

The purpose of this 2022 Tennessee Statewide Freight Bottleneck Study (SFBS) is to identify freight bottlenecks along the Interstate Highway System in Tennessee and develop a ranked list of the most severe locations. This process is required every four years per the Moving Ahead for Progress in the 21st Century Act (MAP-21), a federal law that identifies specific requirements for monitoring and reporting transportation performance measures.

The Tennessee Department of Transportation (TDOT) last prepared a SFBS covering 2018 conditions, the *Tennessee Interstate Freight Bottleneck Analysis* dated January 11, 2019. This current assessment is based on system performance in 2021, the most recent full year for which data is available.

For the purposes of this study, a "freight bottleneck" is considered a location where there are issues with one or both of the following measures:

- **Recurring Congestion**, as measured by vehicle-hours of delay per mile, which quantifies the magnitude of truck delay along that segment
- **Segment Reliability**, measured by a ratio known as the "truck travel time reliability" (TTTR) index, which expresses how much longer travel times are during worst-case, usually non-recurring, congestion events

Segments were ranked based on their performance in terms of both of these factors, combined through a hybrid standardized score.

The analysis process, documented in the Analysis Methodology section, identified 26 distinct bottleneck locations across the state. These locations, listed in Table 1 below and mapped in Figure 2 in the Results section, were chosen by first identifying the worst-performing individual segments in the state and then identifying clusters of segments that together function as a single bottleneck.

A full discussion of these segments and contributing factors is included the Results section.

Table 1. Top Truck Bottleneck Locations and Correlated Factors

Location Details					Performance Metrics		Indicator Factors						Other Related Factors	
Rank	Route	County	Bottleneck Extent	Length	Reliability (Highest TTTR)	Truck Delay (VHD/mi per day)	Capacity	Crashes	Grade 2.5%+	Grade 4.0%+	Curvature	Severe Weather	Construction or Other Incident	Weight/Height Restrictions
1.	**I-75 NB**	Hamilton	Georgia State Line to I-75/I-24 Interchange	1.51 mi	6.97	248.38		X					X	
2.	**I-55 NB**	Shelby	S 3rd Street (Exit 7) to Arkansas State Line	5.19 mi	9.08	64.81						X	X	X
3.	**I-24 WB**	Davidson	I-24/I-40 Interchange (western) to I-24/I-65 Interchange (southern)	3.24 mi	4.28	203.01	X	X	X	X		X		
4.	**I-24 EB**	Davidson	Spring St (Exit 47) to I-24/I-40 Interchange (southern)	2.44 mi	6.49	131.64	X	X						
5.	**I-24/I-65 EB/SB**	Davidson	I-24/I-65 Interchange (northern) to I-24/I-65 Interchange (southern)	3.40 mi	5.97	139.15		X	X	X		X		
6.	**I-24 WB**	Hamilton	I-75/I-24 Interchange to I-24/US 27 (SR 29) Interchange	7.39 mi	7.60	53.58		X	X		X	X		X
7.	**I-40/I-65 EB/SB**	Davidson	Charlotte Ave (Exit 209) to I-40/I-65 Interchange (southern)	1.77 mi	7.06	61.84	X		X					
8.	**I-24/I-40 WB**	Davidson	I-24/I-40 Interchange (eastern) to I-24/I-40 Interchange (western)	2.10 mi	4.21	143.56	X	X	X	X		X		
9.	**I-24 EB**	Davidson	I-24/I-440 Interchange to SR 155 (Briley Pkwy)	1.66 mi	4.42	122.23			X					
10.	**I-24 EB**	Davidson	I-24/I-40 Interchange (eastern) to I-24/I-440 Interchange	1.24 mi	5.74	75.39	X	X	X	X				
11.	**I-65 NB**	Davidson	I-40/I-65 Interchange (northern) to I-24/I-65 Interchange (southern)	1.78 mi	4.73	92.75	X		X					
12.	**I-24 EB**	Hamilton	E 23rd Street (Exit 181) to I-75/I-24 Interchange	3.55 mi	4.71	83.22		X	X		X	X		X
13.	**I-24 WB**	Davidson	I-24/I-440 Interchange to I-24/I-40 Interchange (eastern)	1.02 mi	4.98	71.39	X	X	X	X				
14.	**I-65 SB**	Williamson	I-65/I-840 Interchange to SR 106/Lewisburg Pike	1.90 mi	6.47	12.57			X					
15.	**I-65 NB**	Davidson	I-65/I-440 Interchange to Wedgewood Ave (Exit 81)	1.07 mi	6.22	16.13	X							
16.	**I-440 EB**	Davidson	I-65/I-440 Interchange to SR 11/Nolensville Rd (Exit 6)	1.17 mi	6.19	15.64								
17.	**I-55 SB**	Shelby	Arkansas State Line to Crump Blvd/Riverside Dr (Exit 12)	0.75 mi	2.05	147.32							X	
18.	**I-65 NB**	Davidson	Rivergate Pkwy (Exit 96) to SR 174/Long Hollow Pk (Exit 97)	0.98 mi	4.24	76.13	X		X					
19.	**I-24/I-40 EB**	Davidson	I-24/I-40 Interchange (western) to I-24/I-40 Interchange (eastern)	2.11 mi	4.02	69.23	X	X	X	X		X		
20.	**I-40/I-75 WB/SB**	Knox	I-40/I-140 Interchange to SR 131/Lovell Rd (Exit 374)	2.35 mi	5.62	11.70			X					
21.	**I-24 EB**	Hamilton	Georgia State Line to US 41/Cummings Hwy (Exit 174)	3.11 mi	5.18	18.26			X	X				
22.	**I-40 WB**	Davidson	Spence Ln (Exit 213) to I-24/I-40 Interchange (eastern)	0.78 mi	3.46	70.04	X	X	X					
23.	**I-40/I-65 WB/NB**	Davidson	Church Street to Clinton Street	0.44 mi	3.76	58.57	X		X					
24.	**I-40 WB**	Knox	SR 115/Alcoa Hwy (Exit 386B) to SR 169/Middlebrook Pike	1.13 mi	4.91	20.30	X	X	X					
25.	**I-40 WB**	Madison	Christmasville Rd (Exit 85) to Old Medina Rd/Campbell St (Exit 83)	0.91 mi	3.81	49.92			X				X	
26.	**I-40/I-65 WB/NB**	Davidson	I-40/I-65 Interchange (southern) to Division Street	0.68 mi	2.24	86.11	X							

Analysis Methodology

The analysis approach used in this assessment is based on methodology outlined in the *Truck Freight Bottleneck Reporting Guidebook* (FHWA, 2018), with specific performance metrics and screening thresholds selected by the TDOT project team. The general methodology and assumptions are as follows.

Source Data

The primary data source for this assessment was the National Performance Management Research Data Set (NPMRDS), a resource containing speed and travel time data for freeway and arterial roadways across the National Highway System, which includes interstates. The Federal Highway Administration (FHWA) provides free NPMRDS access to state DOTs and other agencies in part to assist those agencies with fulfilling MAP-21 requirements, such as preparing a quadrennial SFBS like this document.

Specific to this effort, the NPMRDS provides 50th and 95th percentile travel times as well as calculated TTTR values for AM, mid-day, PM, overnight, and weekend time periods. The NPMRDS also provides a “reference speed” for each segment, representing the free-flow travel speed during uncongested conditions.

NPMRDS data was obtained for all 1,826 segments that comprise the Interstate Highway System in Tennessee covering calendar year 2021 conditions, the most recent full year for which data is available. From those, several gaps were identified, including 22 segments without travel time data and 8 segments representing ramps or state routes that were miscoded as interstates. Ultimately, 1,796 segments were carried forward into the analysis.

It should also be noted that the segments included in the NPMRDS are coded for continuity through system interchanges, where two or more interstates meet. This means that segments for a given interstate are carried through the interchange but that additional segments are generally not provided for any supplementary interstate-to-interstate movements within the interchange, as seen in the southwest quadrant of the I-24/I-75 interchange in Chattanooga in Figure 1.

Figure 1. Example of Segments Missing at a System Interchange (NPMRDS data in blue)

Because of this shortcoming in the NPMRDS, this assessment will treat system interchanges as breakpoints when grouping segments together into bottleneck locations, meaning that many identified bottleneck locations will start and/or end at system interchanges and may continue on the other side of the interchange as a separate bottleneck. Moving forward, this means that any subsequent feasibility studies conducted at bottleneck locations identified in this report should be expanded to include any directly adjacent system interchanges to ensure that relevant upstream and/or downstream interchange interactions are accounted for in the analysis.

Performance Metrics

Several performance metrics were considered for this assessment, with the project team eventually selecting two distinct metrics that could indicate the existence of a bottleneck.

Recurring Congestion: Vehicle-Hours of Delay per Mile

The first metric included was a measure of truck delay, which quantifies the amount of added travel time experienced by the trucking population, on average, compared to free-flowing conditions. This value represents the magnitude of delay for a given segment and inherently favors more heavily traveled segments in and around the state's urban areas, which is justified in order to capture impacts that affect the largest amount of users.

The specific delay measure used here, expressed in terms of vehicle-hours of delay (VHD) for a segment, is simply the average delay per truck multiplied by the volume of truck traffic using that segment over a given time period, summed across the AM, mid-day, PM, overnight, and weekend periods that comprise the NPMRDS dataset for a typical day:

$$\text{VHD, typical day} = \sum_{\substack{\text{all periods,} \\ \text{weighted by} \\ \text{duration}}} \left[\begin{pmatrix} \text{average delay} \\ \text{per truck} \end{pmatrix} \times \begin{pmatrix} \text{truck volume} \\ \text{of segment} \end{pmatrix} \right]$$

where: $\text{average delay per truck} = (\text{truck travel time}_{50^{\text{th}}\text{ percentile}}) - (\text{truck travel time}_{\text{free-flow}})$

and: $\text{truck travel time}_{\text{free-flow}} = \frac{\text{segment length}}{\text{NPMRDS reference speed}}$, with appropriate unit conversions

For this assessment, the VHD value is then normalized by the segment length in order to put segments of all lengths on equal footing, otherwise longer segments would be favored in the analysis:

$$\text{VHD/mi, typical day} = \frac{\text{VHD}}{\text{segment length}}$$

Vehicle-hours of delay per mile (VHD/mi) per day results for truck traffic were calculated for all 1,796 NPMRDS segments comprising Tennessee's interstate system. Figure 3 in the Technical Attachments shows a map of the calculated VHD/mi per day for all segments statewide.

Segment Reliability: Truck Travel Time Reliability Index

While the overall magnitude of delay experienced by an average truck is important in identifying freight bottlenecks, it is also critical to consider the impact of more extreme congestion events. This assessment used a ratio called the Truck Travel Time Reliability (TTTR) Index to quantify the reliability – or more accurately, the unreliability – of each segment.

The TTTR for a given period is the ratio of the 95th percentile travel time for truck traffic to the median travel time:

$$\text{TTTR}_{\text{period}} = \frac{\text{truck travel time}_{95^{\text{th}}\text{ percentile}}}{\text{truck travel time}_{50^{\text{th}}\text{ percentile}}}$$

The NPMRDS provides TTTR values for AM, mid-day, PM, overnight, and weekend time periods. The maximum TTTR of these five periods is reported as the TTTR for a given segment, representing the least reliable condition for that segment over the course of the year.

For this assessment, the maximum TTTR value for a given segment occurred almost exclusively during one of the weekday periods. In practical terms, the 95th percentile travel time for a weekday peak period would occur on the twelfth worst weekday of the year, meaning the TTTR is the ratio showing how much longer truck travel would take during an extreme congestion event compared to an average day. In this way, TTTR is able to capture impacts from less frequent and potentially non-recurring events that could occur in either urban or rural contexts, such as construction activities, severe weather, crash/incident response, and more.

TTTR results were also calculated for all NPMRDS segments along Tennessee's interstate system. Figure 4 in the Technical Attachments shows a map of the calculated TTTR, reflecting the worst-case time period in the NPMRDS data, for all segments statewide.

Screening & Grouping

The next step was to identify the worst-performing segments and identify clusters of segments that together function as individual bottlenecks. To accomplish this, the VHD/mi and TTTR metrics were combined into a single hybrid score by calculating the standardized (z-score) value of each factor and summing those values with equal weight.

All segments were ranked using their hybrid standardized score and the top 150 ranked segments were plotted on a map. This number was selected both to result in approximately 25 grouped segments, a common threshold when identifying top freight bottlenecks for peer states, and also based on an inspection of the ranked data which found that score values flattened out significantly beyond the top 150.

Clusters were then identified from the plotted map by joining adjacent segments from the top 150 list. Where appropriate, additional segments from outside of but near the top 150 list were incorporated in order to merge closely spaced clusters. As discussed in the Source Data section, system interchanges were used as breakpoints in urban areas, particularly in downtown Nashville. For this reason, each identified bottleneck essentially includes directly adjacent system interchanges where present. Subsequent feasibility studies for improvement efforts should include adjacent system interchanges in the study area to account for these effects.

The screening process resulted in a total of 26 bottleneck locations, which included 163 segments in total and 149 of the top 150 worst-performing segments.

Prioritization of Bottleneck Locations

Next, all 26 bottleneck locations were analyzed to determine an overall ranking. This process began with the same calculations of VHD/mi, expanded to include all segments making up each location, and TTTR, which was simply the highest TTTR of the component segments. These values were again standardized and combined into a hybrid standardized score, resulting in the rankings enumerated in Table 1, contained in the Overview section above. Table 1 also lists the component VHD/mi and TTTR values of each bottleneck location.

Validation of Bottleneck Locations

The resulting prioritized list of bottleneck locations, having been developed entirely through data-driven methods, was next subjected to validation by relevant stakeholders to ensure that it appropriately captured freight issues in Tennessee circa 2021. This validation process was conducted during a meeting of the statewide Freight Advisory Committee (FAC) on Wednesday, September 7, 2022 in Nashville and broadcast by video conference to remote participants across the state.

During the meeting, FAC members were presented with draft versions of the maps and tables in this report and were given the opportunity to provide feedback during an open discussion. Specifically, FAC members were asked to identify areas that stood out on the map either as “false positives” or “false negatives”.

The group did not identify any specific false positives, generally confirming that the identified bottlenecks are in known areas of congestion throughout the state. A few of the listed bottleneck locations were discussed as having been the location of temporary incidents or construction activities; these findings were incorporated into the “Construction or Other Transient Incidents” section below as potential contributing factors which may have exacerbated preexisting bottleneck conditions.

The group also considered several additional areas of concern that were not flagged as bottlenecks. These potential false negatives included various mountain passes in the eastern portion of the state and several additional corridors in urban and suburban areas. However, after further discussion and review of each corridor’s delay and reliability metrics (discussed above and included as Figure 3 and Figure 4 in the Technical Attachments) the FAC and TDOT decided not to advance any additional corridors as top freight bottlenecks based on 2021 conditions.

Potential Causal Factors

The final step in the bottleneck assessment was to perform an analysis of potentially correlated factors to identify roadway elements or field conditions that may contribute to the presence of a given bottleneck.

Indicator Analysis

The first set of factors to be considered are referred to as “indicators” in the FHWA literature. This section presents several potential indicators and the screening thresholds for each.

Bottleneck locations where these factors may apply are listed in the Indicator Factors section of Table 1.

- *Volume-to-Capacity Ratio*

  Traffic congestion is a substantial source of vehicle delay and poor reliability. With all 26 identified bottlenecks located in generally urbanized areas, it is likely that congestion is a contributing factor to most, if not all segments, to some degree.

  For this indicator assessment, the volume-to-capacity ratio was calculated for critical segments within the 26 bottleneck locations to provide a rough metric of congestion. Segment traffic volumes were compared to a calculated carrying capacity for the roadway, based on the number of lanes and percentage of trucks present along the segment using the NCHRP 825 method for capacity. Bottleneck locations with a volume-to-capacity ratio of greater than 0.95 are noted under the Capacity indicator in Table 1.

- *Crashes and Incident Response*

  In addition to the harm they cause to involved individuals and society as a whole, traffic crashes and the incident response activities that come with them have a transient but tangible impact on the performance of the roadway system.

  Statewide crash data along all of Tennessee's interstates for the entirety of 2021 was collected from TDOT's Electronic Traffic Information Management System (E-TRIMS) and plotted to create a heat map of overall crash prevalence. Bottleneck locations were overlaid on the heat map and locations that overlapped with areas of higher crash incidence were identified empirically and noted under the Crashes indicator in Table 1.

- *Steep Grades*

  Trucks are generally heavier and less maneuverable than passenger cars, which limits their performance on steep grades. E-TRIMS data was used to identify segments with an average grade that exceeded ±2.5%. Most bottlenecks were found to have at least one segment that exceeded this threshold, so a second, more rigorous indicator was established at ±4.0%. Bottleneck locations with even one segment satisfying these two levels are noted under the Grades indicators in Table 1.

- *Roadway Curvature*

  Sharp curves can also contribute to the formation of a bottleneck if they lead to braking events or general driver unease. E-TRIMS data was again used to identify segments with a degree of curvature greater than 3.0, excluding those segments within system interchanges where curvature is expected. Bottleneck locations exceeding this level are noted under the Curvature indicator in Table 1.

- *Severe Weather*

  The final category included in this indicator analysis is the prevalence of severe weather events.

Roadway closure data was not appropriate for this indicator analysis since the urban freeway segments which dominate the bottlenecks list are generally cleared quickly and see few weather-related closures. This determination also could not be made solely based on historical weather records, which would have led to entire regions being categorized similarly since weather conditions are generally consistent across a given metropolitan area.

Rather, this assessment sought out proxy data to pinpoint detrimental impacts from weather along specific corridors, namely weather-related crashes. E-TRIMS crash data was again used to create a heat map of crashes where snow, ice, fog, strong winds, and the like were cited as a contributing factor. Rain events were excluded from this analysis since the commonplace nature of rainstorms meant that the distribution pattern of rain events correlated strongly with the Crashes indicator already discussed above. As with the Crashes indicator, the resulting heat map of non-rain weather events was overlaid with the 26 bottleneck locations and resulting points of overlap were noted under the Severe Weather indicator in Table 1.

Other Related Factors

This assessment also identified two additional factors that are not directly considered to be indicators. Bottleneck locations where these factors apply are listed in the Other Related Factors section of Table 1.

- *Construction or Other Transient Incidents*

  During the screening, grouping, and indicator analysis steps and based on input received during the validation process, it became apparent that several of the identified bottlenecks were likely influenced by temporary issues such as construction or maintenance activities which may have worsened preexisting bottleneck conditions. These segments are noted under the "Construction or Other Incident" section of Table 1 and are listed here:

  - I-75 NB in Hamilton County (Bottleneck 1): This location is adjacent to the I-24/I-75 interchange which is undergoing a long-term improvement program of which Phase 1 was completed in 2021. It is likely that delay and reliability in this area were exacerbated by construction activities beyond the level present in no-build conditions. This segment should be reassessed in future years to determine if the interchange reconstruction has improved conditions within the bottleneck.

  - I-55 NB/SB in Shelby County (Bottlenecks 2 and 17): This location was significantly impacted by the approximately 12-week long closure of the nearby Hernando de Soto Bridge on I-40 to conduct emergency repairs. The I-40 bridge closure forced all traffic to use the remining Memphis & Arkansas Bridge, which carries I-55, reducing the number of travel lanes crossing the Mississippi River in each direction from five to two. This led to significant backups in both directions along I-55 in Tennessee and Arkansas. Without the added traffic volume that I-55 was forced to carry during this closure, it is extremely likely that both bottlenecks would not have ranked as highly.

Looking to the future, a major improvement project commenced in June 2022 to reconstruct the interchange of I-55, Crump Boulevard, and Riverside Drive to establish flyover ramps for the I-55 movements in place of the tight cloverleaf ramps that exist at present where I-55 makes a 90-degree bend. This project will likely improve conditions further within each bottleneck, and as such both should be reassessed in future years once the project is completed, scheduled for early 2025.

- I-40 WB in Madison County (Bottleneck 25): Interstate 40 is currently undergoing a long-term widening project in Madison County and the City of Jackson. Construction activities may have contributed to the delay and TTTR values observed on this segment, which should be reassessed in future years to determine if the widening has alleviated congestion issues in Jackson.

- *Weight/Height Restrictions*
  Truck travel can also be impacted by geometric and weight restrictions, which require oversize and overweight vehicles to bypass certain constraining segments. The *Truck Freight Bottleneck Reporting Guidebook* (FHWA, 2018) includes steps to identify and quantify the impact of truck restrictions, due to the fact that vehicles that bypass bottleneck segments due to height or weight restrictions are inherently impacted by the bottleneck as well, even though they are not counted along with the delayed vehicles using a given segment.

  Additional detail on the screening process is discussed in the “Supplementary Analysis: Impact of Truck Restrictions” section of this report, along with the tabulated additional mileage and travel time experienced by diverted trucks. The bottleneck locations that include truck restrictions are noted in the Weight/Height Restrictions column of Table 1.

Results

This section contains results from the bottleneck analysis and ranking as well as data about truck travel reliability for the state as a whole, through the calculation of a Statewide TTTR.

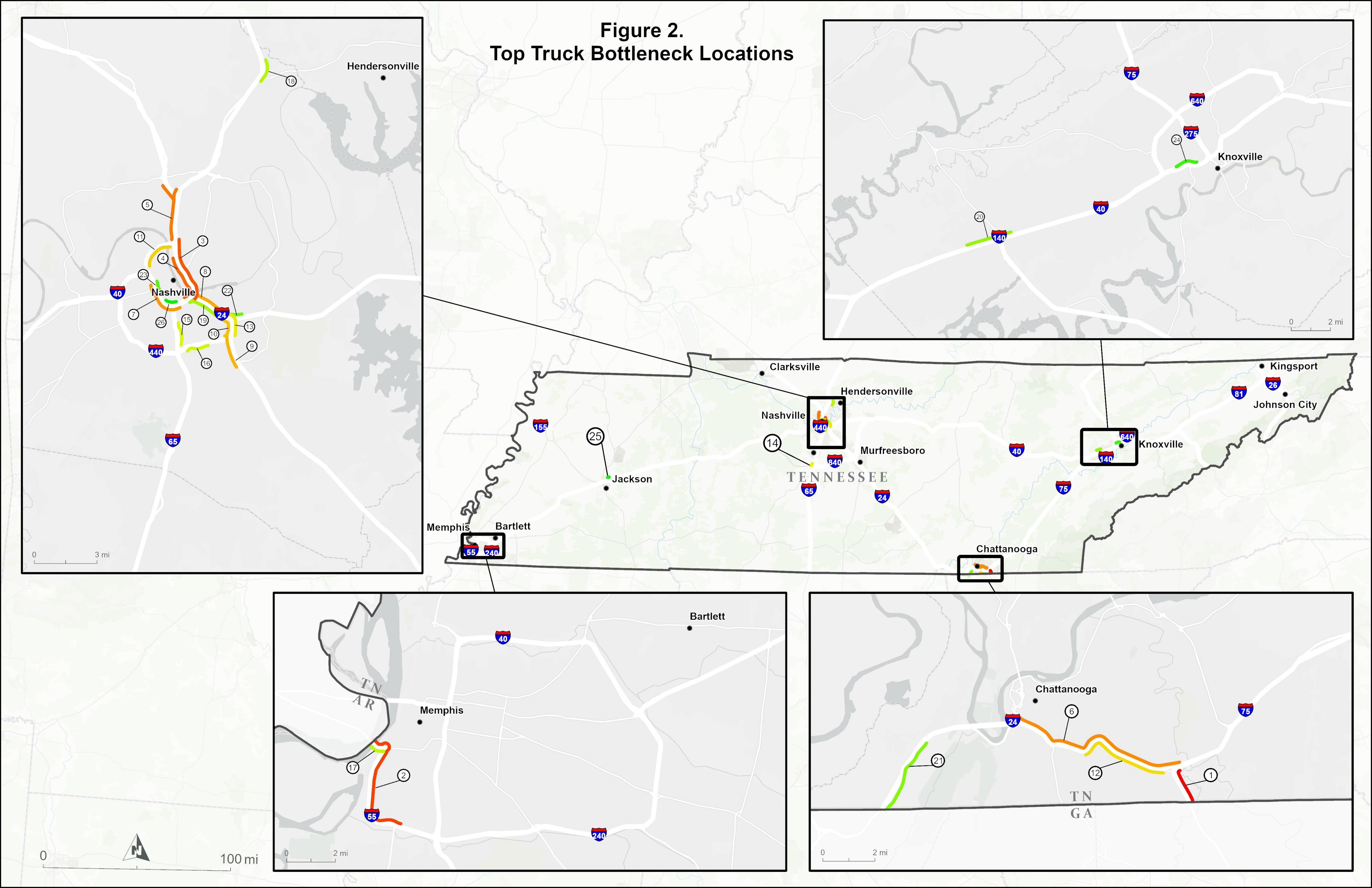
Worst-Performing Bottleneck Locations

The top 26 bottleneck segments on Tennessee's interstates for 2021, identified as part of this assessment, are mapped on Figure 2, below, and listed in Table 1 in the Overview section, above. As detailed in the Analysis Methodology section, these identified bottlenecks contain the worst-performing interstate segments in the state in 2021 based on a combination of recurring congestion and segment reliability in terms of VHD/mi and TTTR, respectively. Table 1 also includes a summary of potential causal factors identified through the indicator analysis and assessment of other related factors that could explain the presence of these bottlenecks.

It should be noted that the issues in some of these locations may have been fully or partially resolved since the end of 2021. As discussed in the "Construction or Other Transient Incidents" section, some locations hosted active construction zones in 2021, exacerbating existing issues while roadway improvements were underway. Still other segments were impacted by maintenance incidents that have since been cleared. This prioritized list is but a snapshot of the 26 worst-performing bottleneck locations over the course of 2021, and subsequent data should be considered in selecting locations to bring forward for investment and improvement. It is also likely that traffic conditions in 2021 were disrupted due to the coronavirus (COVID-19) pandemic's impact on travel patterns, particularly along commuter corridors, and conditions should continue to be monitored as commute patterns continue to evolve in the coming years.

Additionally, as discussed in the Source Data section, system interchanges were treated as breakpoints when encountered in the grouping of segments into bottleneck locations. Any subsequent feasibility studies conducted at bottleneck locations identified in this report should be expanded to include any directly adjacent system interchanges to ensure that relevant upstream and/or downstream interchange interactions are accounted for, since the capacity of a given segment can be significantly influenced by the laneage and merge configuration of adjacent interchanges.

Figure 2. Top Truck Bottleneck Locations



Comparison of 2022 Rankings to 2019 SFBS Findings

This section presents a comparison between the new rankings discussed above, which are based on 2021 data, and the findings from Tennessee's most recent SFBS, the *Tennessee Interstate Freight Bottleneck Analysis*, which is based on 2018 data and dated January 11, 2019 (the "2019 SFBS"). The 2019 SFBS identified twelve bottleneck locations, listed in Table 2.

It should be noted that the 2019 SFBS was conducted using a methodology that centered candidate bottlenecks at major interchanges rather than identifying the directionality and specific extents of a given bottleneck as was done in this 2022 SFBS, which used system interchanges as breakpoints in the bottleneck segmentation. For this reason and as noted previously, each bottleneck location identified in the 2022 SFBS should be assumed to include directly adjacent system interchanges where present.

As such, an interchange identified as a bottleneck by the 2019 SFBS may touch multiple 2022 SFBS bottleneck segments and vice versa. The rightmost column of Table 2 includes a listing of which 2022 SFBS bottlenecks are adjacent to each bottleneck interchange that was ranked in the 2019 SFBS.

Table 2. Bottleneck Rankings from 2019 SFBS (2018 data)

Rank	Location	County	Adjacent to these 2022 SFBS Bottlenecks:
1.	**I-24 at US-27 Interchange**	Hamilton	6
2.	**I-24 at I-440 Interchange**	Davidson	9, 10, 13
3.	**I-40 at I-240 Interchange (eastern)**	Shelby	*Not on 2022 List*
4.	**I-65 at I-440 Interchange**	Davidson	15, 16
5.	**I-40 at I-65 Interchange (western)**	Davidson	11
6.	**I-65 at SR 386 Interchange**	Davidson	18
7.	**I-24 at I-65 Interchange (northern)**	Davidson	5
8.	**I-40/I-75 at I-140 Interchange**	Knox	20
9.	**I-40 at I-640 Interchange (western)**	Knox	*Not on 2022 List*
10.	**I-24 at I-65 Interchange (southern)**	Davidson	3, 5, 11
11.	**I-40 at I-24 Interchange**	Davidson	3, 4, 8, 19
12.	**I-75 at I-24 Interchange**	Hamilton	1, 6, 12

Table 3 expands upon this comparison, presenting a "crosswalk" between the 2022 and 2019 SFBS bottleneck rankings. As discussed above, bottleneck locations identified in the 2022 SFBS are assumed to include directly adjacent system interchanges and as such may correspond to up to two bottleneck interchanges from the 2019 SFBS, noted in the rightmost columns. Table 3 also presents the change in ranking from 2019 to 2022, based on the worst ranking from 2019 in locations adjacent to two ranked interchanges.

Table 3. Comparison of 2022 and 2019 SFBS Bottleneck Rankings

2022 SFBS Ranking (2021 data)						2019 SFBS Ranking (2018 data)	
Rank	**Route**	**County**	**Bottleneck Extent**			**Rank**	**Change**
1.	**I-75 NB**	Hamilton	Georgia State Line	to	I-75/I-24 Interchange	12	**▲ 11 spots**
2.	**I-55 NB**	Shelby	S 3rd Street (Exit 7)	to	Arkansas State Line	*Unranked*	*New in 2022*
3.	**I-24 WB**	Davidson	I-24/I-40 Interchange (western)	to	I-24/I-65 Interchange (southern)	10, 11	**▲ 7 spots**
4.	**I-24 EB**	Davidson	Spring St (Exit 47)	to	I-24/I-40 Interchange (southern)	11	**▲ 7 spots**
5.	**I-24/I-65 EB/SB**	Davidson	I-24/I-65 Interchange (northern)	to	I-24/I-65 Interchange (southern)	7, 10	**▲ 2 spots**
6.	**I-24 WB**	Hamilton	I-75/I-24 Interchange	to	I-24/US 27 (SR 29) Interchange	1, 12	**▼ 5 spots**
7.	**I-40/I-65 EB/SB**	Davidson	Charlotte Ave (Exit 209)	to	I-40/I-65 Interchange (southern)	*Unranked*	*New in 2022*
8.	**I-24/I-40 WB**	Davidson	I-24/I-40 Interchange (eastern)	to	I-24/I-40 Interchange (western)	11	**▲ 3 spots**
9.	**I-24 EB**	Davidson	I-24/I-440 Interchange	to	SR 155 (Briley Pkwy)	2	**▼ 7 spots**
10.	**I-24 EB**	Davidson	I-24/I-40 Interchange (eastern)	to	I-24/I-440 Interchange	2	**▼ 8 spots**
11.	**I-65 NB**	Davidson	I-40/I-65 Interchange (northern)	to	I-24/I-65 Interchange (southern)	5, 10	**▼ 6 spots**
12.	**I-24 EB**	Hamilton	E 23rd Street (Exit 181)	to	I-75/I-24 Interchange	12	**Unchanged**
13.	**I-24 WB**	Davidson	I-24/I-440 Interchange	to	I-24/I-40 Interchange (eastern)	2	**▼ 11 spots**
14.	**I-65 SB**	Williamson	I-65/I-840 Interchange	to	SR 106/Lewisburg Pike	*Unranked*	*New in 2022*
15.	**I-65 NB**	Davidson	I-65/I-440 Interchange	to	Wedgewood Ave (Exit 81)	4	**▼ 11 spots**
16.	**I-440 EB**	Davidson	I-65/I-440 Interchange	to	SR 11/Nolensville Rd (Exit 6)	4	**▼ 12 spots**
17.	**I-55 SB**	Shelby	Arkansas State Line	to	Crump Blvd/Riverside Dr (Exit 12)	*Unranked*	*New in 2022*
18.	**I-65 NB**	Davidson	Rivergate Pkwy (Exit 96)	to	SR 174/Long Hollow Pk (Exit 97)	6	**▼ 12 spots**
19.	**I-24/I-40 EB**	Davidson	I-24/I-40 Interchange (western)	to	I-24/I-40 Interchange (eastern)	11	**▼ 8 spots**
20.	**I-40/I-75 WB/SB**	Knox	I-40/I-140 Interchange	to	SR 131/Lovell Rd (Exit 374)	8	**▼ 12 spots**
21.	**I-24 EB**	Hamilton	Georgia State Line	to	US 41/Cummings Hwy (Exit 174)	*Unranked*	*New in 2022*
22.	**I-40 WB**	Davidson	Spence Ln (Exit 213)	to	I-24/I-40 Interchange (eastern)	*Unranked*	*New in 2022*
23.	**I-40/I-65 WB/NB**	Davidson	Church Street	to	Clinton Street	*Unranked*	*New in 2022*
24.	**I-40 WB**	Knox	SR 115/Alcoa Hwy (Exit 386B)	to	SR 169/Middlebrook Pike	*Unranked*	*New in 2022*
25.	**I-40 WB**	Madison	Christmasville Rd (Exit 85)	to	Old Medina Rd/Campbell St (Exit 83)	*Unranked*	*New in 2022*
26.	**I-40/I-65 WB/NB**	Davidson	I-40/I-65 Interchange (southern)	to	Division Street	*Unranked*	*New in 2022*
Bottlenecks from 2019 SFBS Unranked in 2022							
Unranked		Shelby	I-40/I-240 Interchange (eastern)			3	*Unranked in 2022*
Unranked		Knox	I-40/I-640 Interchange (western)			9	*Unranked in 2022*

As can be seen in Table 3, this 2022 SFBS shows a significant reshuffling in rankings compared to the 2019 SFBS. While some portion of this reshuffling is likely attributable to the updated analysis methodology used in the 2022 SFBS, changing travel patterns due both to overall population growth and the disruption in commuter behavior resulting from the COVID-19 pandemic have undoubtedly had a significant effect as well in changing the location, duration, and severity of bottleneck impacts.

It should also be noted that the locations that moved the furthest up the list from 2019 to 2022, I-75 northbound in Hamilton County (up 11 spots to #1) and I-55 northbound in Shelby County (from unranked to #2) are both likely to drop significantly or disappear altogether in subsequent SFBS analyses. As discussed previously, I-75 was undergoing a long-term interchange improvement program of which Phase 1 was completed in 2021, which is expected to improve delay and reliability in this area, and I-55 experienced significant but temporary impacts from detoured traffic during the extended closure of the parallel I-40 Hernando de Soto Bridge for emergency repairs in the summer of 2021.

Statewide Performance

The *Truck Freight Bottleneck Reporting Guidebook* (FHWA, 2018) also includes methodology to determine the overall reliability of a system of roadways through the calculation of a Statewide TTTR. This calculation, included in Table 4, shows that across the 1,796 interstate segments in the NPMRDS database, the Statewide TTTR for 2021 was 1.32. This is an improvement over the stated Statewide TTTR goal for 2021 of 1.37 per FHWA's "Transportation Performance Reporting: State Performance Dashboard" website.

Statewide TTTR data from past years and peer states is also summarized in Table 4, which shows that Tennessee's 2021 Statewide TTTR of 1.32 is an improvement over pre-pandemic conditions from 2017-2019. As of 2020, the most recent year for which peer state data is available, Tennessee's Statewide TTTR of 1.25 is near the middle of the range for the eight bordering states, and on par with comparably urbanized states like North Carolina.

Table 4. Statewide Truck Travel Time Reliability Index

Aggregated Metric		Value
Sum of Length-Weighted TTTR, 2021 (1,796 segments)		3,134.89
Tennessee Interstate Miles in NPMRDS Dataset		2,376.60
Tennessee Statewide TTTR, 2021		**1.32**
Historical Tennessee Statewide TTTR Data[1]	*2020*	*1.25*
	2019	*1.35*
	2018	*1.37*
	2017	*1.35*
2020 Statewide TTTR Results for Peer States[1,2]	Mississippi	1.12
	Arkansas	1.13
	Alabama	1.14
	Missouri	1.15
	Kentucky	1.16
	North Carolina	1.23
	Tennessee	**1.25**
	Virginia	1.32
	Georgia	1.37

[Note 1] Source: FHWA "Transportation Performance Reporting: State Performance Dashboard", https://www.fhwa.dot.gov/tpm/reporting/state/

[Note 2] Peer state data from 2020 should be compared to Tennessee's results from the same year to account for the coronavirus (COVID-19) pandemic's impact on travel patterns

Supplementary Analysis: Impact of Truck Restrictions

The *Truck Freight Bottleneck Reporting Guidebook* (FHWA, 2018) includes additional steps for identifying and quantifying the related impacts that come from truck restrictions on interstate routes, namely height, weight, and width restrictions at bridges and other constrained locations.

This supplementary data quantifies the added distance and travel time incurred by truck traffic that must bypass a given obstruction entirely due to physical restrictions. In this way, truck restrictions layer on additional bottleneck delay that was not accounted for directly in the previous sections.

- _Location Screening_
  TDOT's Oversize & Overweight (OS/OW) Permit Office maintains information on truck restrictions in Tennessee. Data provided by that office in August 2022 identified a total of 66 restrictions on interstate routes, of which 29 were height-related and 37 were weight restrictions.

  A single additional width-based restriction was identified, but subsequent discussions with OS/OW Permit Office staff indicated that this width restriction was due to temporary construction and was not active in 2021.

- _Quantify Truck Diversion_
  Once the restrictions were identified, the number of trucks impacted by each restriction was calculated. This information could be derived directly through an analysis of all OS/OW permits granted in 2021, but such an intensive level of effort was determined to be inappropriate for this high-level analysis.

  In the absence of direct diversion quantities, the amount of truck diversion for each restriction was estimated using distributions of the weight, height, and width of the overall truck population to determine what percentage of trucks would be impacted by a given height or weight restriction. Distribution curves could not be located in federal or Tennessee-specific research materials, so the distributions for this assessment were taken from a North Carolina study: *Determination of Bridge Deterioration Models and Bridge User Costs for the NCDOT Bridge Management System* (Cavalline, Whelan, et al; UNC Charlotte, 2015).

- _Bypass Analysis_
  Lastly, the added distance and travel time required to bypass the identified restrictions was determined. The 66 restrictions were clustered into 22 assumed detour routes. Lengths were determined for each pair of original and bypass routes, and the corresponding travel times were calculated by assuming a representative speed for each level of functionally classified road.

  As in the previous section, it should be noted that these calculations are approximate and do not incorporate the full listing of predefined bypass routes maintained by the OS/OW Permit Office.

Table 5 shows that the resulting total added distance and added travel time on an average day for trucks across the state are approximately 21,000 vehicle-miles and 660 vehicle-hours.

Table 5. Distance and Travel Time Impacts from Interstate Truck Restrictions

Bottle-neck Rank	Location	County	Constraint(s) [Segment Length]	Added Distance (vehicle-miles per day)	Added Travel Time (vehicle-hours per day)	Added T. Time (VHD/mi)
2.	**I-55 NB**	Shelby	7x height- or weight-restricted bridges; as low as 13'6" [11.1mi]	1,482.20	24.70	2.22
6.	**I-24 WB**	Hamilton	Spring Creek Road Bridge (15'6" height limit) [3.5mi]	1.36	0.17	0.05
12.	**I-24 EB**	Hamilton	Spring Creek Road Bridge (15'6" height limit) [3.5mi]	1.36	0.17	0.05
			Subtotal: Impacts within Bottleneck Locations	**1,484.92**	**25.03**	**---**
n/a	**I-40**	Decatur	Prospect Road bridge (weight restricted), US-641 bridge (height limit) [17.1mi]	7,086.19	192.09	11.23
n/a	**I-24**	Marion	Sequatchie River bridge (weight restricted) [3.6mi]	1,088.67	33.66	9.35
n/a	**I-81**	Greene/ Hamblin	12x height- or-weight-restricted bridges from US 11E to Sinking Creek [16.3mi]	3,209.31	97.22	5.95
n/a	**I-40**	Roane	US 27 bridge (weight restricted) [9.7mi]	1,208.34	38.69	3.99
n/a	**I-75**	Anderson	Clinch River bridge, Wolf Valley Road bridge (weight restricted) [12.0mi]	1,460.56	46.35	3.87
n/a	**I-65**	Robertson	4x height- or weight-restricted bridges near SR-25 [10.5mi]	626.12	38.84	3.68
n/a	**I-24**	Coffee	Duck River bridge (weight restricted) [5.8mi]	373.62	18.85	3.24
n/a	**I-55**	Shelby	Brooks Road bridge (weight restricted) [0.8mi]	33.26	2.53	3.17
n/a	**I-75**	Bradley/ McMinn	5x height- or weight-restricted bridges, including Hiwassee River [35.0mi]	1,293.03	87.20	2.49
n/a	**I-55**	Shelby	11x height- or weight-restricted bridges, excluding northbound traffic already included in Bottleneck 2 [11.1mi]	1,482.20	24.70	2.22
n/a	**I-65**	Giles	Diana Road bridge (weight restricted), Baugh Road bridge (height limit) [21.8mi]	1,199.68	45.32	2.08
n/a	**I-40**	Haywood	Hatchie River bridge (weight restricted) [5.3mi]	8.39	6.18	1.17
n/a	**I-640**	Knox	N Broadway bridge, Rutledge Pike bridge (weight restricted) [7.0mi]	222.48	3.71	0.53
n/a	**I-40**	Shelby	Whitten Road bridge (height limit) [0.6mi]	1.90	0.09	0.15
n/a	**I-240**	Shelby	Poplar Avenue bridge (height limit) [2.9mi]	9.43	0.36	0.12
n/a	**I-65**	Maury	New Lewisburg Hwy bridge (height limit) [14.2mi]	24.85	0.72	0.05
n/a	**I-40**	Davidson	Elm Hill Pike bridge (height limit) [5.0mi]	4.26	0.16	0.03
n/a	**I-24**	Grundy	SR-50 bridge (height limit) [1.0mi]	0.00	0.02	0.02
n/a	**I-24**	Marion	Trussell Road bridge (height limit) [21.4mi]	9.45	0.48	0.02
n/a	**I-40**	Davidson	SR-109 bridge (height limit) [0.8mi]	0.21	0.02	0.02
n/a	**I-40**	Henderson	SR-22 bridge (height limit) [0.5mi]	0.03	0.00	0.00
			Subtotal: Impacts in Other Areas	**19,341.98**	**637.21**	**---**
			Grand Total: Statewide Impacts from Interstate Truck Restrictions	**20,826.90**	**662.24**	**---**

The 72 restrictions were then cross-referenced with the 26 bottleneck locations, finding a total of nine restrictions occurring within three bottlenecks, which are noted in the top section of Table 3. Notably, seven restrictions were found in Bottleneck 2 alone, all due to low-clearance bridges along I-55 in Memphis. Although the detour route for these seven restrictions is entirely along interstate routes, following I-40 and I-240, this detour contributes an additional 24.70 vehicle-hours of delay per day to northbound I-55 traffic above and beyond the daily delay for Bottleneck 2 already accounted for in Table 1.

It should also be noted that the OS/OW Permit Office data indicates that the Spring Creek Road Bridge impacts conditions within Bottlenecks 6 and 12; however, this bridge was replaced as part of Phase 1 of the I-75/I-24 interchange improvements project and as such this restriction may no longer be extant as of 2022.

More generally, Table 5 shows that very few of the active OS/OW truck restrictions on Tennessee's interstate system overlap with identified bottleneck locations. The non-bottleneck truck restriction impacts with the highest delay generally occur within rural areas without nearby parallel bypass routes, thereby requiring lengthy detours to reach alternate, truck-compatible routes.

The final column of Table 5 shows the added travel time from the identified truck restrictions normalized over the length of the affected interstate segment, in terms of vehicle-hours of delay per mile (VHD/mi) per day. When comparing these values to the normalized VHD/mi results for the 26 bottleneck segments in Table 1, it can be seen that the impact from even the most significant truck restriction, at 11.23 VHD/mi per day, is significantly lower than the delay impacts from the identified bottlenecks, which range from 11.70 to 248.38 VHD/mi per day.

Technical Attachments

The following supplementary maps are provided as Technical Attachments to this report to show the statewide results for the two component performance metrics comprising the hybrid standardized score that was used in the overall screening and prioritization of bottleneck segments:

- Figure 3. Truck Vehicle-Hours of Delay per Mile per Day, Statewide
- Figure 4. Truck Travel Time Reliability Index, Statewide

These maps both show similar trends in the data, with the worst-performing segments in both categories generally clustered in urban areas across the state and generally favorable conditions elsewhere, even in mountainous areas.

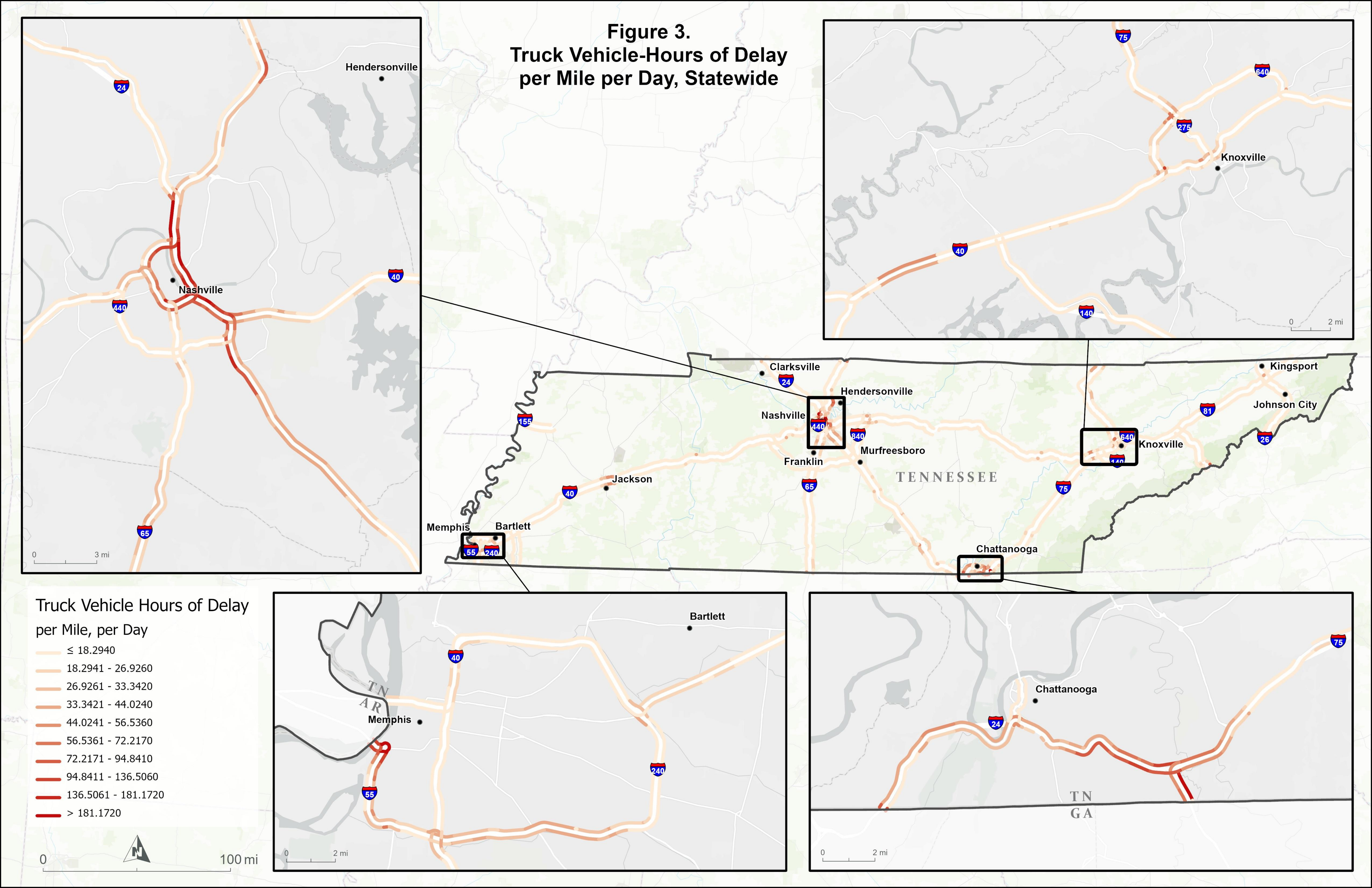


Figure 3.
Truck Vehicle-Hours of Delay per Mile per Day, Statewide

Figure 4.
Truck Travel Time Reliability Index, Statewide