2012-2013

MICHIGAN DEPARTMENT OF TRANSPORTATION

# Congestion & Mobility Report

## Freeway Performance Measures

*Chapter 1*

## Acknowledgements

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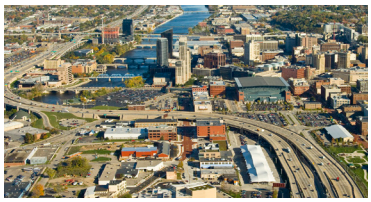
Chapter 2 - Bay Region Summary


Chapter 3 - Grand Region Summary

Chapter 4 - Metro Region Summary

Chapter 5 - North Region Summary

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# HISTORY

In recent years, the Michigan Department of Transportation (MDOT) has been able to monitor its freeways with in-field detectors, such as pavement loops, microwave or wireless sensors, among other technologies. Due to the high costs associated with this infrastructure, these technologies are mainly located in urban areas and are very limited in rural parts of the state with the main intent to capture volumes. To monitor a specific segment for construction or other needs on the freeway where no detection exists, MDOT staff would perform travel time runs. With MDOT's mission of providing the highest quality integrated transportation services for economic benefit and improved quality of life, MDOT concluded that there was a need to improve the department's understanding of how the freeway system operated.

In an effort to get more robust information, MDOT started purchasing probe data from HERE (formally Navteq) in 2009. Probe data is speed information collected from a variety of electronic devices including but not limited to commercial fleet tracking systems, smartphones, GPS and in-car navigation systems. Probe data also can be enhanced with data from the in-field devices that MDOT already owns to improve the accuracy of this data. With the introduction of probe data feeds, MDOT now is able to monitor freeway speeds 24 hours a day.

# Introduction

Performance measures are growing in the transportation arena to better monitor traffic conditions, improve traveler information, and identify congested areas with the aim of improving operations on roadways. MDOT initially used probe data to show travel time information to the public. Due to the enormous amount of data collected, it made it difficult to use for any other type of analysis. The University of Maryland Center for Advanced Transportation Technology Lab developed a visual analytics and information visualization tool called the Regional Integrated Transportation Information System (RITIS). With this tool, MDOT is able to monitor speed, incidents, weather, events and many other types of data.

In 2010, the MDOT Southwest Region started using probe data to develop performance measures with the aim of improving traffic flow on I-94. Using this information, the Southwest Region was able to monitor delay caused by incidents, work zones and winter weather. After seeing the success of this project, it was expanded to cover I-94 statewide and eventually to multiple other freeways in the state.

This report expands the performance measures to all freeway routes in Michigan and offers additional measures (except some small segments due to data quality issues). This document is for internal use to help MDOT regions, Transportation Service Centers (TSCs), and planners expand their knowledge on how Michigan freeways are operating over time and how they compare to each other. This information helps identify congested areas, when congestion occurs and how often, corridor rankings, cause of delay, and more. This report is only a starting point, with the potential for a more in depth analysis. If your area has plans to share this information externally, please contact the Congestion and Mobility Unit to ensure the correct measures are being used.

Each performance measure provides a view of how freeways may be operating. Looking at it from many perspectives can give a more complete picture and better understanding of what is going on.

## Probe Data

Although, probe data provides a more thorough view of how MDOT freeways operate, the data has some limitations. Some segments on the freeway have a minimal number of probe data collections during parts of the day. This is typically associated with low volumes in rural areas and during some nighttime hours. This results in some individual probes over-representing average speeds on certain segments of roadway. These data limitations should be reduced over time as the number of probes on the roadway has been increasing at a substantial rate, which improves the accuracy of the speed data. Michigan is one of only a few states that have different speed limits for commercial and passenger vehicles on the freeways. The posted speed limit for commercial vehicles is 60 mph; for passenger vehicles it's 70 mph. This results in lower average speeds during free-flow conditions.

## Total Delay

Delay is calculated by taking the difference between actual speeds when they fall below 60 mph and the speed limit for freeways posted at 70 mph. This is to take out the delay caused by the lower average speeds from commercial vehicles. Figure 1 is an illustration of when delay is calculated.

The following tables display the top 10 locations statewide 60 mph; for passenger vehicles it's 70 mph separately. This data is presented separately in order to rank congested corridors, and due to the fact that Metro Region traffic patterns differ from the rest of the state. Tables 1 and 3 highlight the total hours of delay per year, while tables 2 and 4 show the delay hours per mile. Each freeway segment consists of the TSC limits of each route.

***Figure 1 (Delay)***

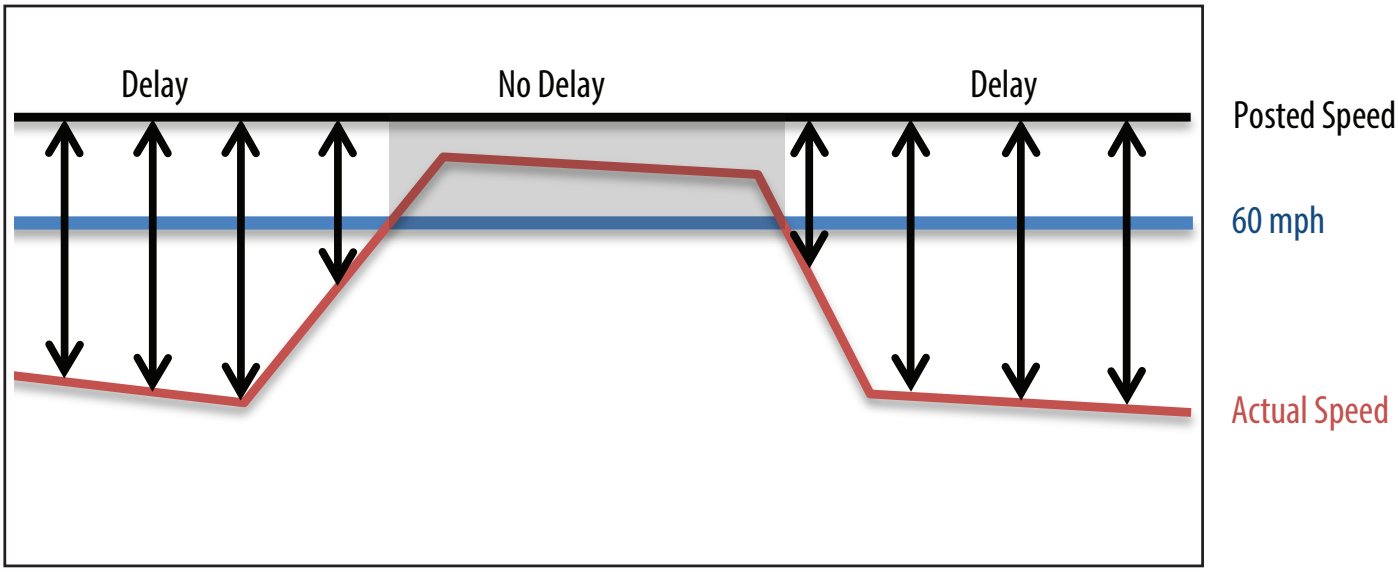


*Table 1 (Total Delay Statewide, excluding Metro Region)*

| 2012 | | |
|---|---|---|
| Rank | Total Delay (Hrs.) | Location (TSC, Route) |
| 1 | 1,417,888 | Brighton US-23 |
| 2 | 1,320,530 | Grand Rapids US-131 |
| 3 | 631,277 | Brighton I-94 |
| 4 | 488,688 | Grand Rapids I-196 |
| 5 | 449,452 | Coloma I-94 |
| 6 | 367,489 | Davison I-69 |
| 7 | 366,327 | Brighton I-75 |
| 8 | 362,781 | Grand Rapids I-96 |
| 9 | 345,768 | Brighton M-14 |
| 10 | 339,943 | Muskegon US-31 |

| 2013 | | |
|---|---|---|
| Rank | Total Delay (Hrs.) | Location (TSC, Route) |
| 1 | 1,284,664 | Brighton US-23 |
| 2 | 1,268,895 | Grand Rapids US-131 |
| 3 | 711,781 | Coloma I-94 |
| 4 | 697,060 | Grand Rapids I-196 |
| 5 | 626,316 | Brighton I-94 |
| 6 | 450,068 | Grand Rapids I-96 |
| 7 | 393,852 | Muskegon US-31 |
| 8 | 371,556 | Davison I-69 |
| 9 | 308,984 | Kalamazoo US-131 |
| 10 | 308,817 | Kalamazoo I-94 |

*Table 2 (Delay per Mile Statewide, excluding Metro Region)*

| 2012 | | |
|---|---|---|
| Rank | Delay Per Mile (Hrs./Mile) | Location (TSC, Route) |
| 1 | 18,100 | Grand Rapids I-196 |
| 2 | 10,170 | Brighton M-14 |
| 3 | 9,089 | Brighton US-23 |
| 4 | 8,891 | Brighton I-94 |
| 5 | 8,851 | Lansing I-496 |
| 6 | 8,575 | Grand Rapids US-131 |
| 7 | 6,660 | Brighton I-75 |
| 8 | 6,202 | Davison I-475 |
| 9 | 5,859 | Bay City I-675 |
| 10 | 5,025 | Brighton I-96 |

| 2013 | | |
|---|---|---|
| Rank | Delay Per Mile (Hrs./Mile) | Location (TSC, Route) |
| 1 | 25,817 | Grand Rapids I-196 |
| 2 | 9,371 | Lansing I-496 |
| 3 | 8,821 | Brighton I-94 |
| 4 | 8,240 | Grand Rapids US-131 |
| 5 | 8,235 | Brighton US-23 |
| 6 | 6,176 | Kalamazoo I-94 |
| 7 | 5,836 | Brighton M-14 |
| 8 | 5,651 | Bay City I-675 |
| 9 | 5,312 | Coloma I-94 |
| 10 | 4,763 | Davison I-475 |

*Table 3 (Total Delay Metro Region Only)*

| 2012 | | |
|---|---|---|
| Rank | Total Delay (Hrs.) | Location (TSC, Route) |
| 1 | 2,565,843 | Oakland I-75 |
| 2 | 1,751,370 | Oakland I-696 |
| 3 | 1,681,813 | Detroit I-75 |
| 4 | 1,471,667 | Detroit I-94 |
| 5 | 1,195,372 | Taylor I-275 |
| 6 | 1,085,900 | Macomb – St. Clair I-94 |
| 7 | 953,914 | Taylor I-96 |
| 8 | 944,176 | Detroit M-39 |
| 9 | 861,513 | Taylor I-94 |
| 10 | 748,767 | Oakland I-96 |

| 2013 | | |
|---|---|---|
| Rank | Total Delay (Hrs.) | Location (TSC, Route) |
| 1 | 3,034,341 | Oakland I-75 |
| 2 | 2,505,679 | Oakland I-696 |
| 3 | 2,168,284 | Detroit I-75 |
| 4 | 1,560,907 | Detroit I-94 |
| 5 | 1,341,643 | Macomb – St. Clair I-94 |
| 6 | 1,208,622 | Taylor I-96 |
| 7 | 1,098,296 | Detroit M-39 |
| 8 | 1,025,600 | Oakland I-96 |
| 9 | 871,859 | Taylor I-94 |
| 10 | 802,383 | Macomb – St. Clair I-696 |

*Table 4 (Delay per Mile Metro Region Only)*

| 2012 | | |
|---|---|---|
| Rank | Delay Per Mile (Hrs./Mile) | Location (TSC, Route) |
| 1 | 47,473 | Detroit I-94 |
| 2 | 45,454 | Detroit I-75 |
| 3 | 41,668 | Detroit I-375 |
| 4 | 37,263 | Oakland I-696 |
| 5 | 35,917 | Oakland M-10 |
| 6 | 33,721 | Detroit M-39 |
| 7 | 33,222 | Macomb – St. Clair I-696 |
| 8 | 31,797 | Taylor I-96 |
| 9 | 26,742 | Oakland I-96 |
| 10 | 26,452 | Oakland I-75 |

| 2013 | | |
|---|---|---|
| Rank | Delay Per Mile (Hrs./Mile) | Location (TSC, Route) |
| 1 | 58,602 | Detroit I-75 |
| 2 | 53,312 | Oakland I-696 |
| 3 | 52,541 | Detroit I-375 |
| 4 | 50,352 | Detroit I-94 |
| 5 | 45,360 | Oakland M-10 |
| 6 | 40,287 | Taylor I-96 |
| 7 | 40,119 | Macomb – St. Clair I-696 |
| 8 | 39,225 | Detroit M-39 |
| 9 | 36,629 | Oakland I-96 |
| 10 | 31,282 | Oakland I-75 |

The rankings vary between total delay and delay hours per mile as each freeway segment is a different length. In the statewide table, US-23 in the Brighton TSC area has the most total delay but I-196 in the Grand Rapids TSC area is shown to be more concentrated and therefore has a ranking higher in delay hours per mile. These tables are able to show the magnitude of delay and are an easy way to compare freeways segments to each other.

The tables below are showing the top and bottom 20 segments statewide, including Metro Region, with a percent increase or decrease in delay from 2012 to 2013.

***Table 5 (Increase/Decrease in Delay Statewide)***

| 2012 to 2013 | | |
|---|---|---|
| **Rank** | **% Increase Delay** | **Location (TSC, Route)** |
| 1 | 67% | Muskegon I-96 |
| 2 | 58% | Coloma I-94 |
| 3 | 50% | Muskegon I-196 |
| 4 | 43% | Oakland I-696 |
| 5 | 43% | Grand Rapids I-196 |
| 6 | 41% | Kalamazoo I-94 |
| 7 | 37% | Oakland I-96 |
| 8 | 37% | Coloma US-31 |
| 9 | 32% | Detroit I-96 |
| 10 | 29% | Detroit I-75 |
| 11 | 27% | Taylor I-96 |
| 12 | 26% | Oakland M-10 |
| 13 | 26% | Detroit I-375 |
| 14 | 24% | Grand Rapids I-96 |
| 15 | 24% | Macomb – St. Clair I-94 |
| 16 | 21% | Macomb – St. Clair I-696 |
| 17 | 20% | Brighton I-275 |
| 18 | 18% | Oakland I-75 |
| 19 | 16% | Detroit M-10 |
| 20 | 16% | Detroit M-39 |

| 2012 to 2013 | | |
|---|---|---|
| **Rank** | **% Decrease Delay** | **Location (TSC, Route)** |
| 1 | -62% | Taylor I-275 |
| 2 | -59% | Kalamazoo I-196 |
| 3 | -43% | Brighton M-14 |
| 4 | -42% | Taylor I-75 |
| 5 | -31% | Brighton I-75 |
| 6 | -30% | Gaylord US-127 |
| 7 | -29% | Gaylord I-75 |
| 8 | -28% | Mt. Pleasant US-127 |
| 9 | -26% | Lansing I-96 |
| 10 | -23% | Davison I-475 |
| 11 | -23% | Bay City I-75 |
| 12 | -19% | Cadillac US-131 |
| 13 | -14% | Marshall I-69 |
| 14 | -14% | Brighton I-96 |
| 15 | -9% | Jackson I-94 |
| 16 | -9% | Brighton US-23 |
| 17 | -8% | Davison I-75 |
| 18 | -6% | Davison US-23 |
| 19 | -4% | Mt. Pleasant US-10 |
| 20 | -4% | Grand Rapids US-131 |

Eighteen out of the top 20 segments with the largest decrease in delay were outside the Metro Region area. Large increases or decreases in delay are typically the result of a construction project from one year to another year. The smaller changes are typically the result of different weather events, increases or decreases in traffic volumes.

## User Delay Costs

User Delay Costs (UDC) is calculated by multiplying delay x hourly volume x hourly user cost. Delay is calculated by taking the difference between actual speeds when they fall below 60 mph and the posted speed limit. Hourly volumes are derived from Average Daily Traffic (ADT) and Commercial Average Daily Traffic (CADT). Hourly user costs are based on Federal Highway Administration (FHWA) publication number FHWA-SA-98-079, "Life-Cycle Cost Analysis in Pavement Design." Currently, MDOT updates these costs yearly using the Consumer Price Index (CPI), which follows the same methodology as detailed in the FHWA publication. This can be located at: *http://www.michigan.gov/mdot/0,1607,7-151-9625_54944-227053--,00.html*

The following rates were used for 2012 and 2013.

| Hourly User Costs | | |
|---|---|---|
| | 2012 | 2013 |
| Passenger | $17.09 | $17.44 |
| Commercial | $30.14 | $30.77 |

Probe data does not include volumes as it is cost-prohibitive to have traffic counters on every mile of freeway. This necessitates the use of ADT and CADT and an hourly profile created for each day of week. Although the calculations are not actual volumes, most trends and comparisons are useful and valid. UDC calculations do not start until speeds are below 60 mph. This is to eliminate counting the delay caused by slower commercial vehicles having a speed limit of 60 mph.

The following maps show 2013 UDC for each route by TSC broken down per mile to compare the various lengths of each route.

*Figure 2*

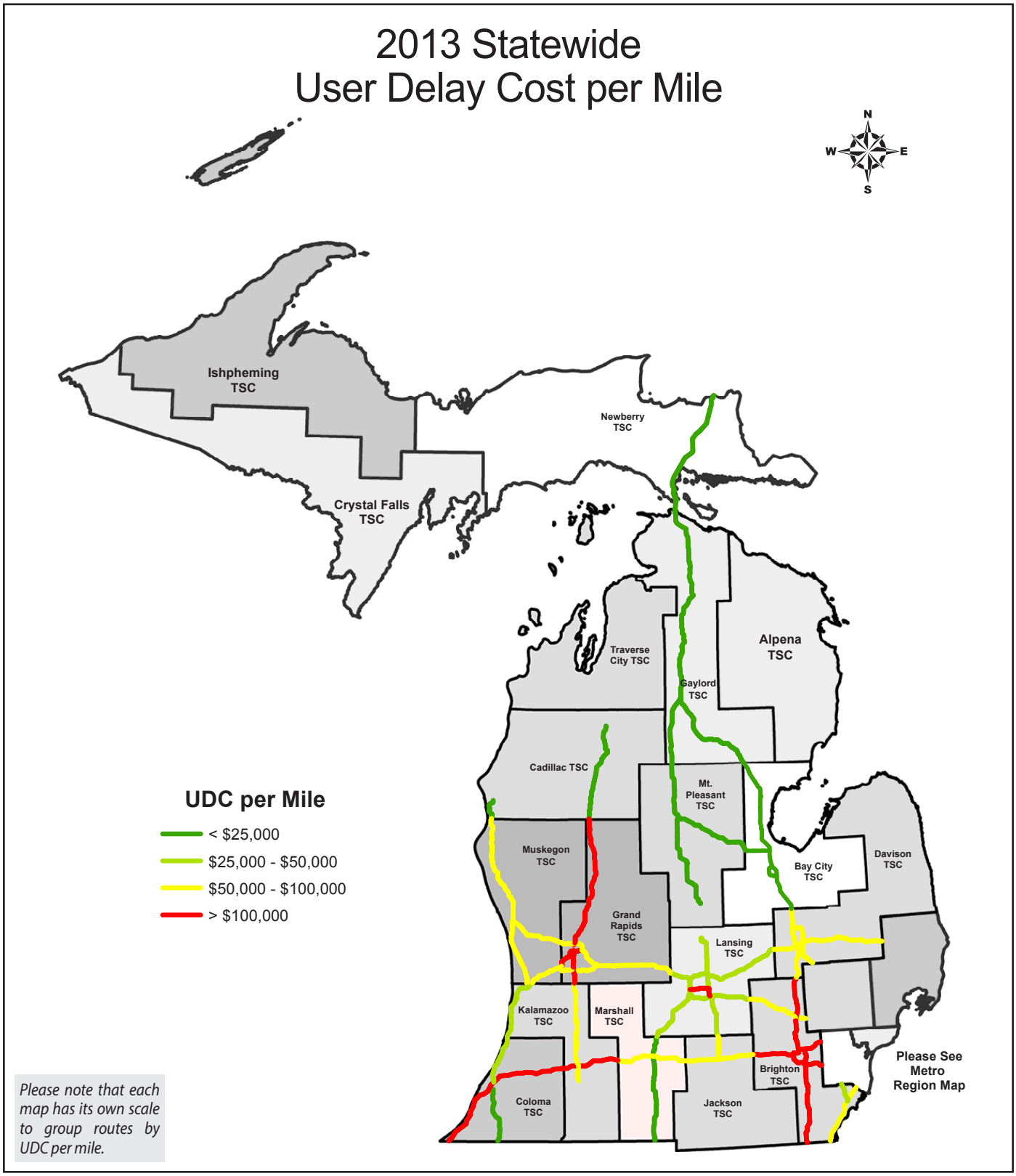
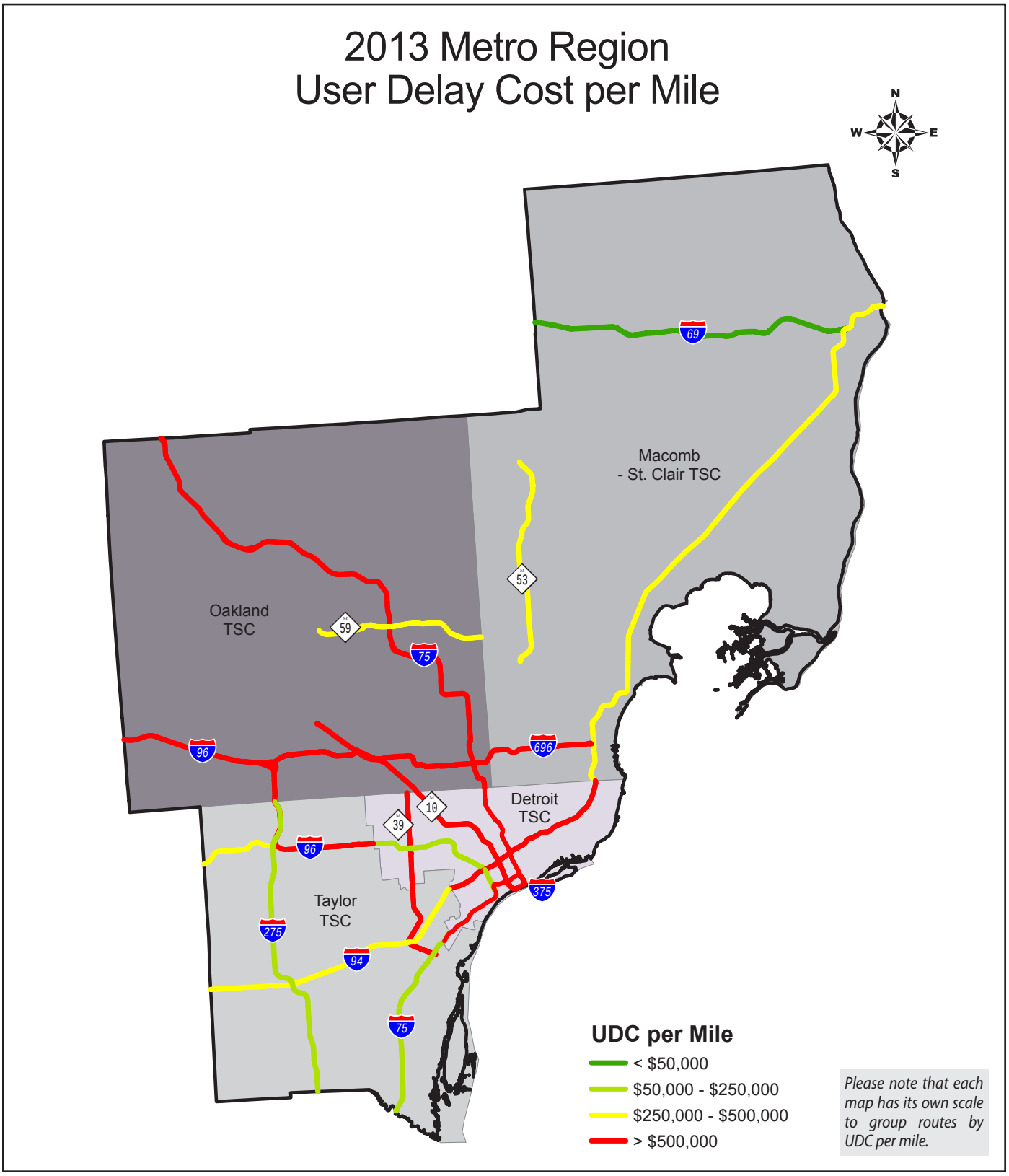
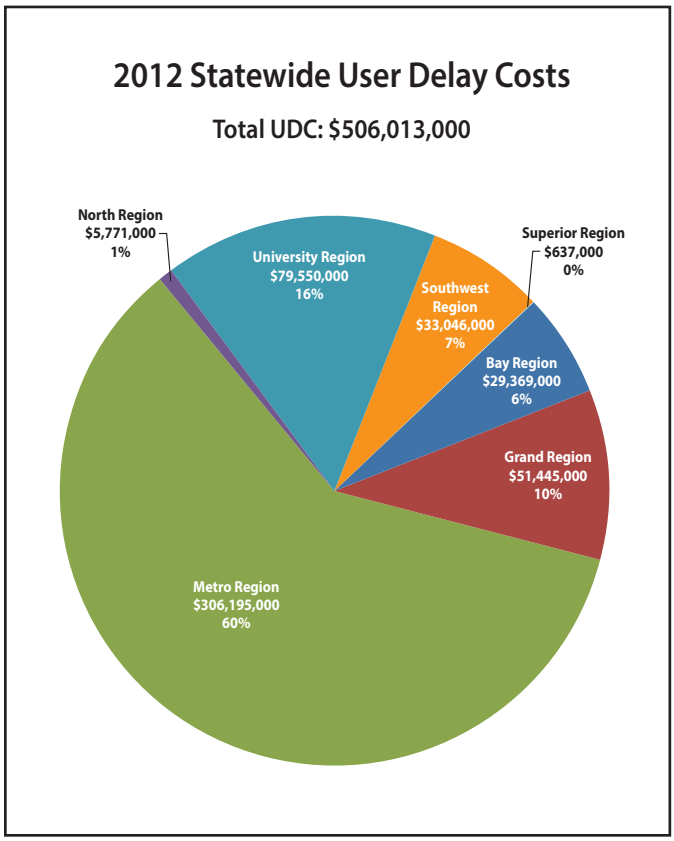

2013 Statewide
User Delay Cost per Mile
N
W
E
S
Ishpheming TSC
Newberry TSC
Crystal Falls TSC
Traverse City TSC
Alpena TSC
Gaylord TSC
Cadillac TSC
Mt. Pleasant TSC
Muskegon TSC
Bay City TSC
Davison TSC
Grand Rapids TSC
Lansing TSC
Kalamazoo TSC
Marshall TSC
Brighton TSC
Coloma TSC
Jackson TSC
Please See Metro Region Map
UDC per Mile
< $25,000
$25,000 - $50,000
$50,000 - $100,000
> $100,000
Please note that each map has its own scale to group routes by UDC per mile.

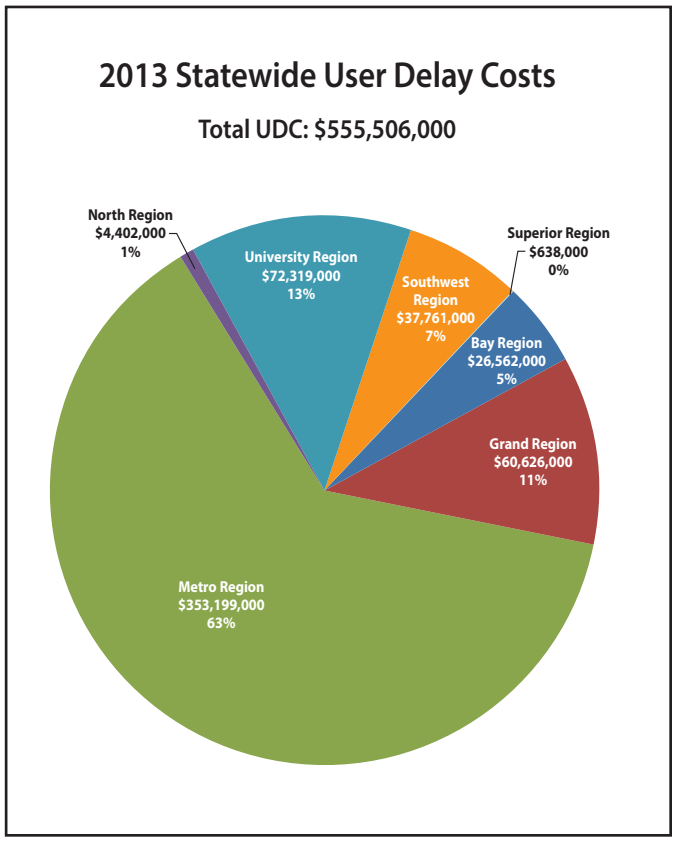
*Figure 3*


2013 Metro Region
User Delay Cost per Mile
N
W
E
S
Macomb
- St. Clair TSC
Oakland
TSC
Detroit
TSC
Taylor
TSC
69
53
59
75
96
696
10
39
96
375
275
94
75
UDC per Mile
< $50,000
$50,000 - $250,000
$250,000 - $500,000
> $500,000
Please note that each map has its own scale to group routes by UDC per mile.

A breakdown per region is shown below. 2012 and 2013 UDCs are shown side-by-side to give an idea of trends from year-to-year.

### *Figure 4 (UDC Breakdown)*

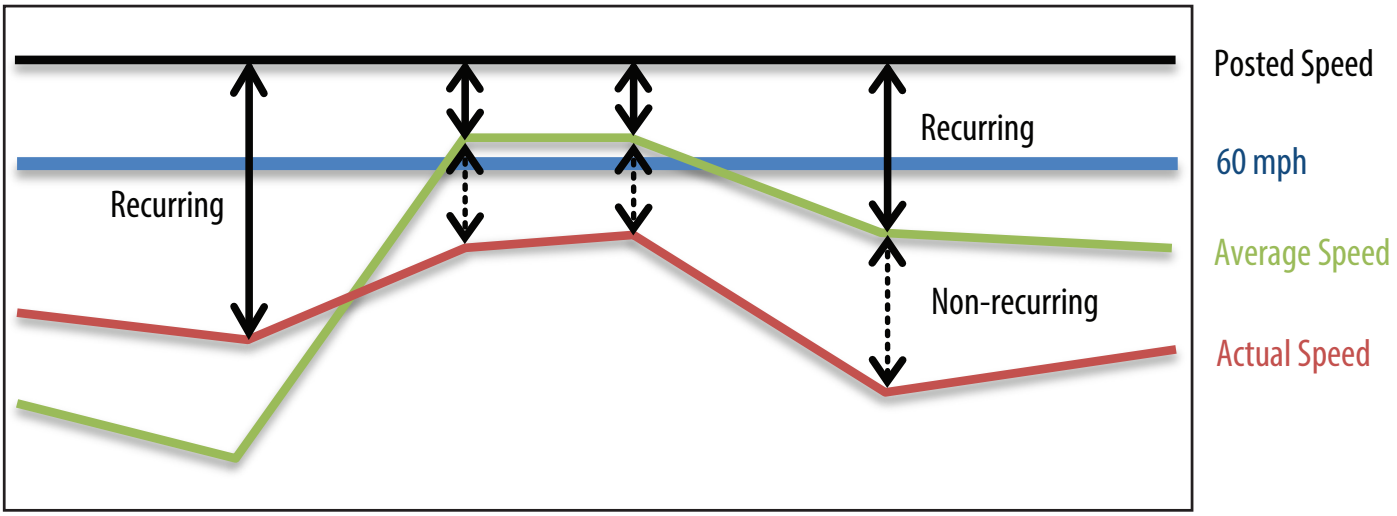



The two pie charts above show there was more than a 10 percent increase in UDC in 2013. This was attributed to a large increase in winter snowfall, especially on the west side of the state. Metro Region saw a large increase in UDC due to winter events in 2013; however, this does not explain all of the increases. Some could be attributed to construction and/or an increase in traffic volume. As the area recovers from the "Great Recession," certain segments that are near or at capacity are much more sensitive to small volume increases and the UDC can increase greatly compared with routes that have much more available capacity. A more in-depth analysis would be required to verify the cause of the increase.

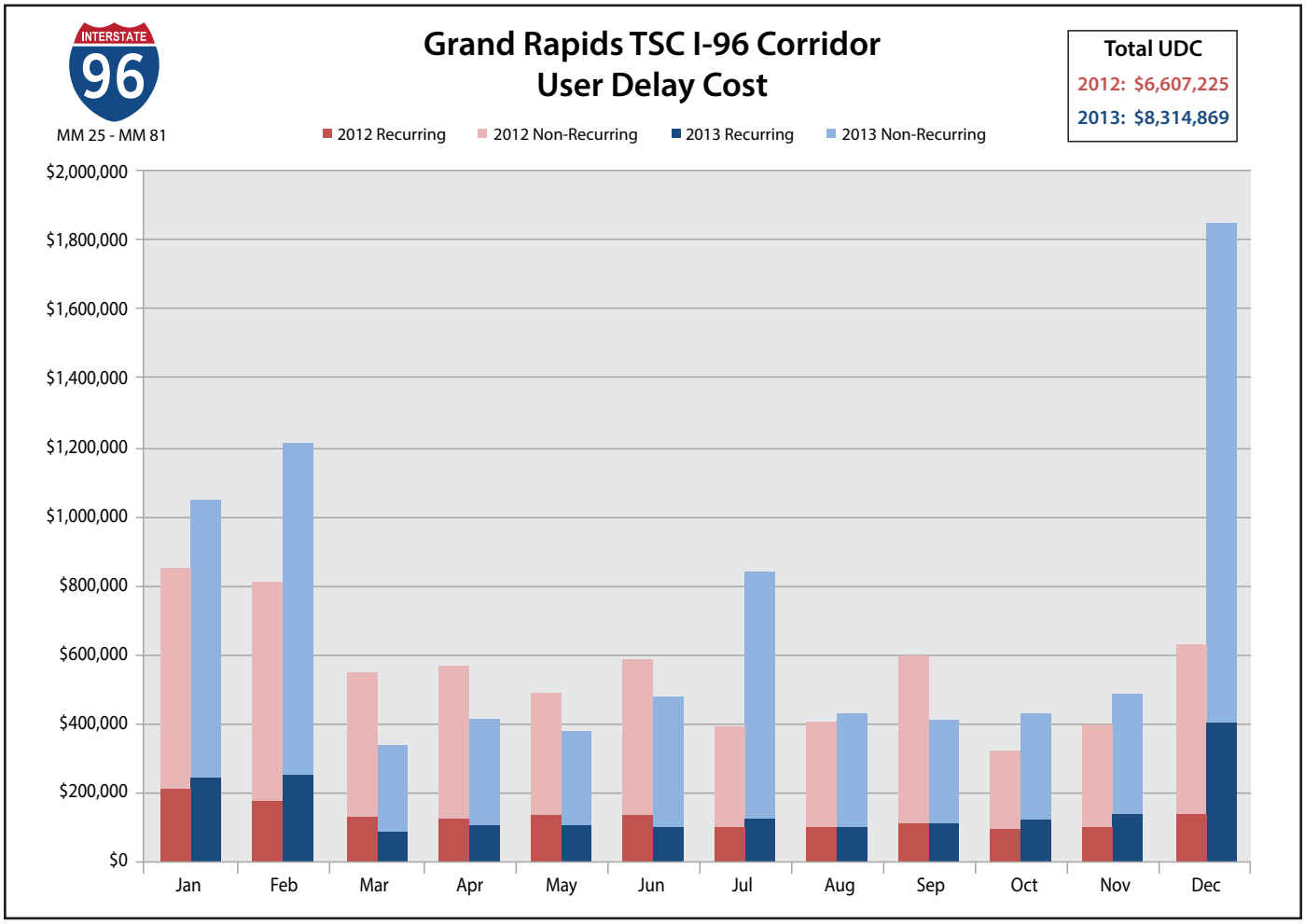
Non-recurring UDC is calculated in a similar manner; however, non-recurring delay is calculated by taking the difference between the actual speed (any time the speed falls below 60 mph) and the average speed. The average speed used was an average of speed readings from August 2009 to July 2012. The average speed calculation is an average of the speeds for that day of week and time of day for each individual location. In future years, this value may change to a rolling consecutive two or three-year average. Recurring UDC is the difference of total UDC and non-recurring UDC.

*Figure 5*




The following figure shows what months are incurring the most UDC, and compares how the UDC patterns changed from 2012 to 2013. This also shows the amount of recurring/non-recurring per month. This highlights the impacts that winter weather and construction can have on the amount on non-recurring delay.

*Figure 6*




Major winter storms had a significant impact on UDC in the last two weeks of December 2013 for the Grand Rapids TSC area (as shown in Figure 6) and other TSC areas statewide. Winter events in December accounted for more than 10 percent of the UDC for the entire year for I-96 in the Grand Rapids TSC area.

UDC also can be broken into two categories (passenger vehicles and trucks), as shown in Figure 7. This helps highlight areas with a larger percentage of trucks. Most recurring congestion happens only a few hours out of the day during the peak periods.

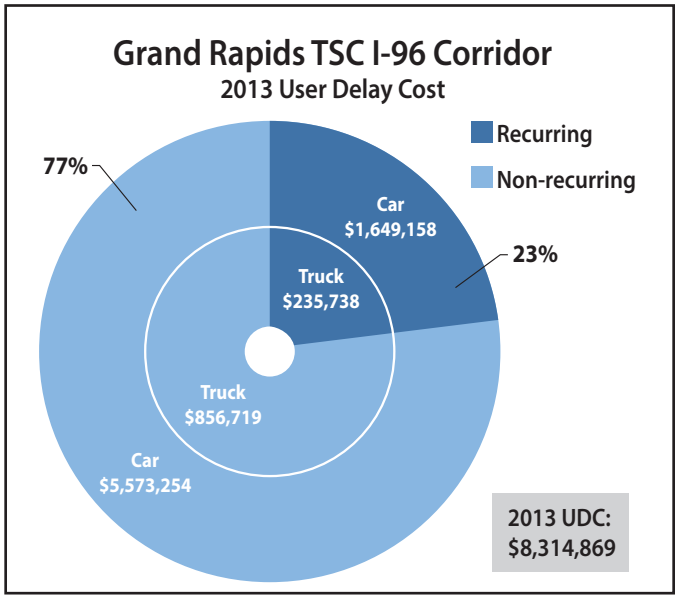



*Figure 7*

# Average Speeds

Average speed charts were created to compare how peak period speed trends change from year to year, and identify low speed areas.

The following criteria were used for these charts:

- Weekday is Monday through Friday
- Morning peak hour is the worst ranked hour between 6 – 9 a.m.
- Evening peak hour is the worst ranked hour between 3 – 7 p.m.
- Worst ranked hour is based on the lowest average speed and minimum speed experienced during the peak hours

The following figures show how the morning and evening peak speeds can vary by time and magnitude on the same route.

Figure 9 shows a much larger drop in speed over a short distance compared to Figure 8. This could be the result of more people leaving work at the same time during the PM peak compared to arriving over a longer period of time to work during the AM peak. Another explanation could be more traffic is entering the freeway during the PM peak creating more turbulence to the traffic flow, whereas during the AM peak, traffic is driving through or exiting the freeway. More in depth analysis would be required to understand the dynamics of traffic flow shown in these figures.

*Figure 8*

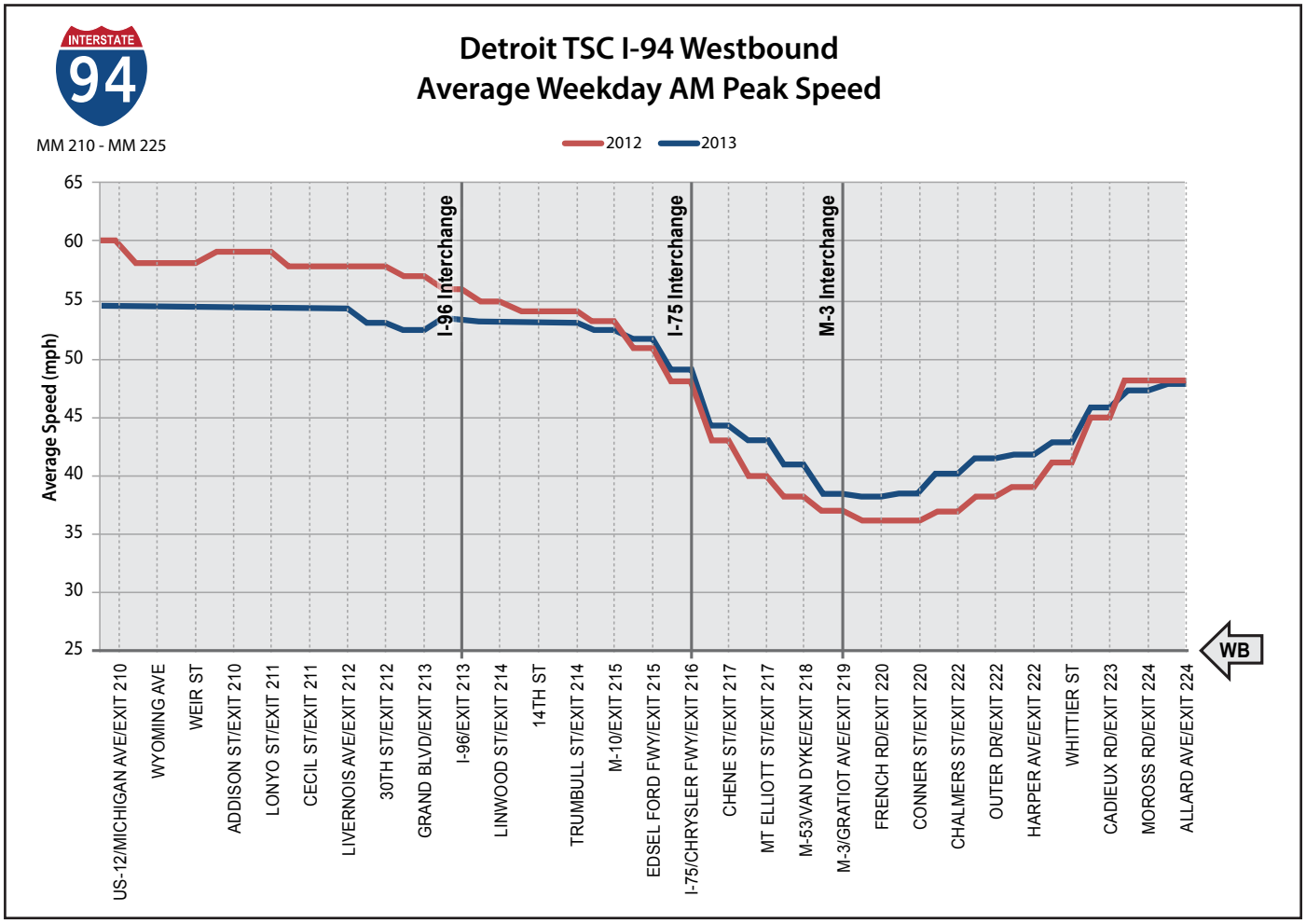
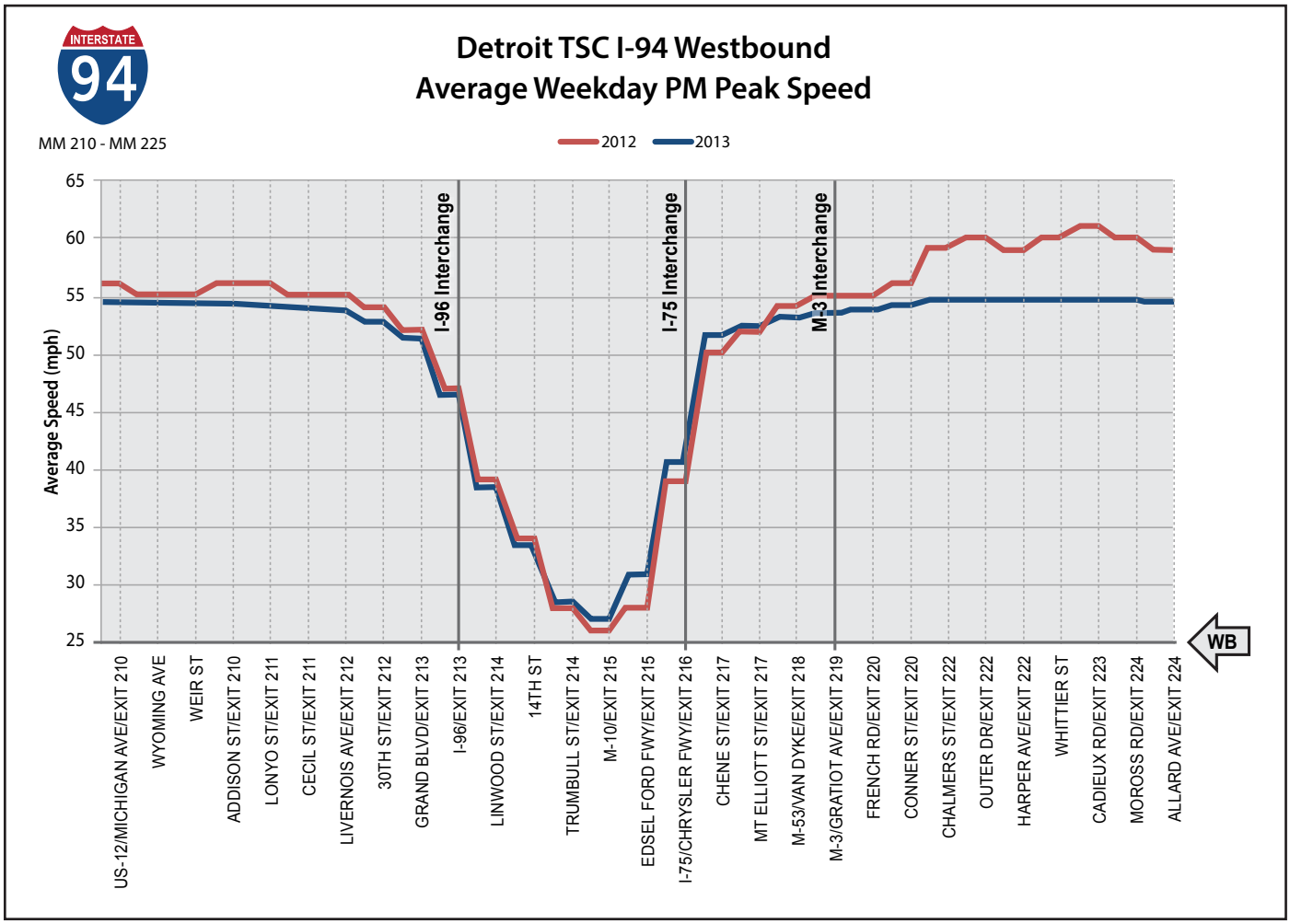


*Figure 9*




Charts also were created for a few northbound/southbound routes that see additional traffic in the summer months. These charts were created for US-131, US-127, and I-75, and can be used to compare summer traffic trends and how summer traffic compares to average conditions. The following criteria were used for these corridors.

1. **Northbound Summer Friday Peak Speed**
2. **Southbound Summer Sunday Peak Speed**
   - Summer Friday peak was from May to August (18 Fridays)
   - Summer Sundays were from June to September (18 Sundays)
   - The purpose of these time frames was to include major travel days from Labor Day to Memorial Day
   - Worst Friday hour looked at hours from noon to midnight
   - Worst Sunday hour looked at 9 a.m. to midnight

Also included on these maps was an average speed that included all Fridays or Sundays for a two-year time frame (*) in order to give a normal speed comparison to the summer speeds.

*Figure 10*

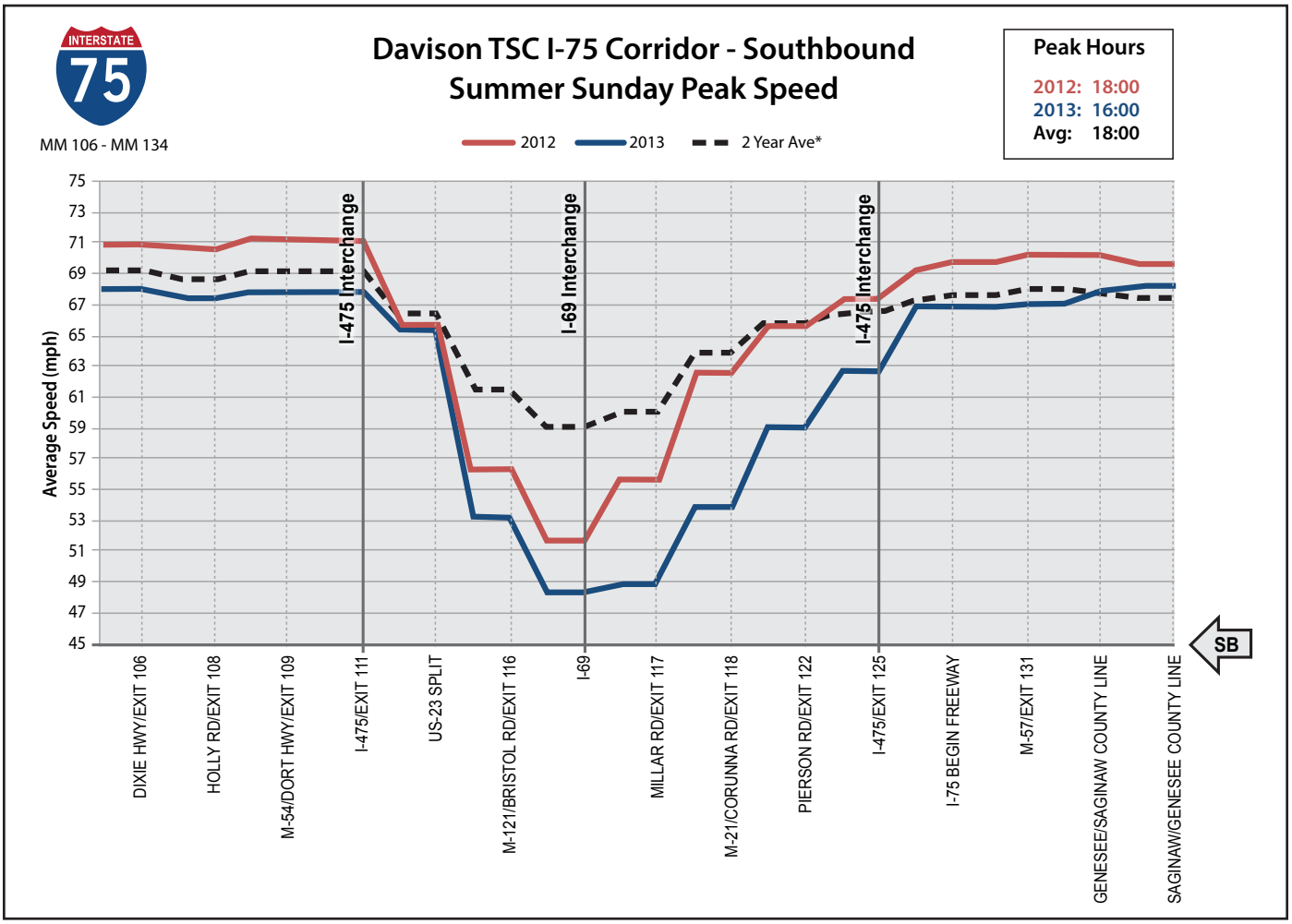



Figure 10 shows that average speeds on I-75 in the Davison TSC area in the summer season dropped 7-11 mph compared to the two-year average Sunday Peak. This also shows that the peak in 2013 occurred two hours earlier than in 2012.

# Congestion

Congestion is being calculated as the number of hours below 45 mph per Traffic Message Channel (TMC). A TMC is a standard for delivering real-time traffic information. They vary from tenths of a mile long to several miles long.

Using speed and segment information provided by the probe data, the following performance measures were developed to analyze congestion on Michigan freeways.

- Congestion Hours: Number of hours a freeway segment has an average speed of less than 45 mph. This number is useful for plotting on a map to show congested areas.
- Weighted Congestion Hours: Number of congestion hours multiplied by the segment length. Congestion along longer segments will get more consideration than congestion along shorter segments.

The following maps display the 2013 congestion hours for Michigan freeways. In order to show more detail, the Metro Region is displayed separately and uses a different scale than the statewide map.

*Figure 11*

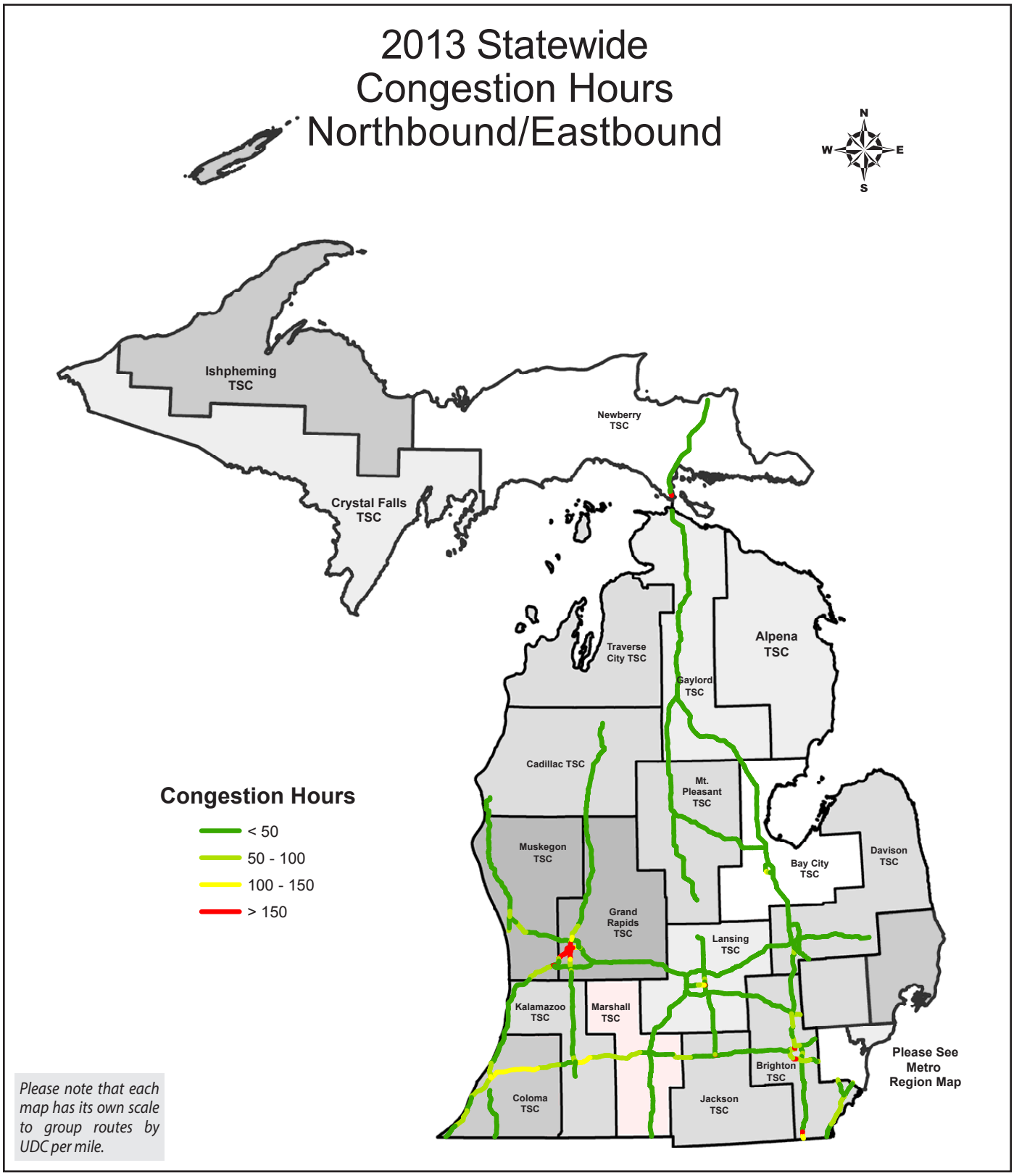

2013 Statewide
Congestion Hours
Northbound/Eastbound
N
W
E
S
Ishpheming TSC
Crystal Falls TSC
Newberry TSC
Traverse City TSC
Alpena TSC
Gaylord TSC
Cadillac TSC
Mt. Pleasant TSC
Muskegon TSC
Bay City TSC
Davison TSC
Grand Rapids TSC
Lansing TSC
Kalamazoo TSC
Marshall TSC
Brighton TSC
Coloma TSC
Jackson TSC
Please See Metro Region Map
Congestion Hours
< 50
50 - 100
100 - 150
> 150
Please note that each map has its own scale to group routes by UDC per mile.

*Figure 12*

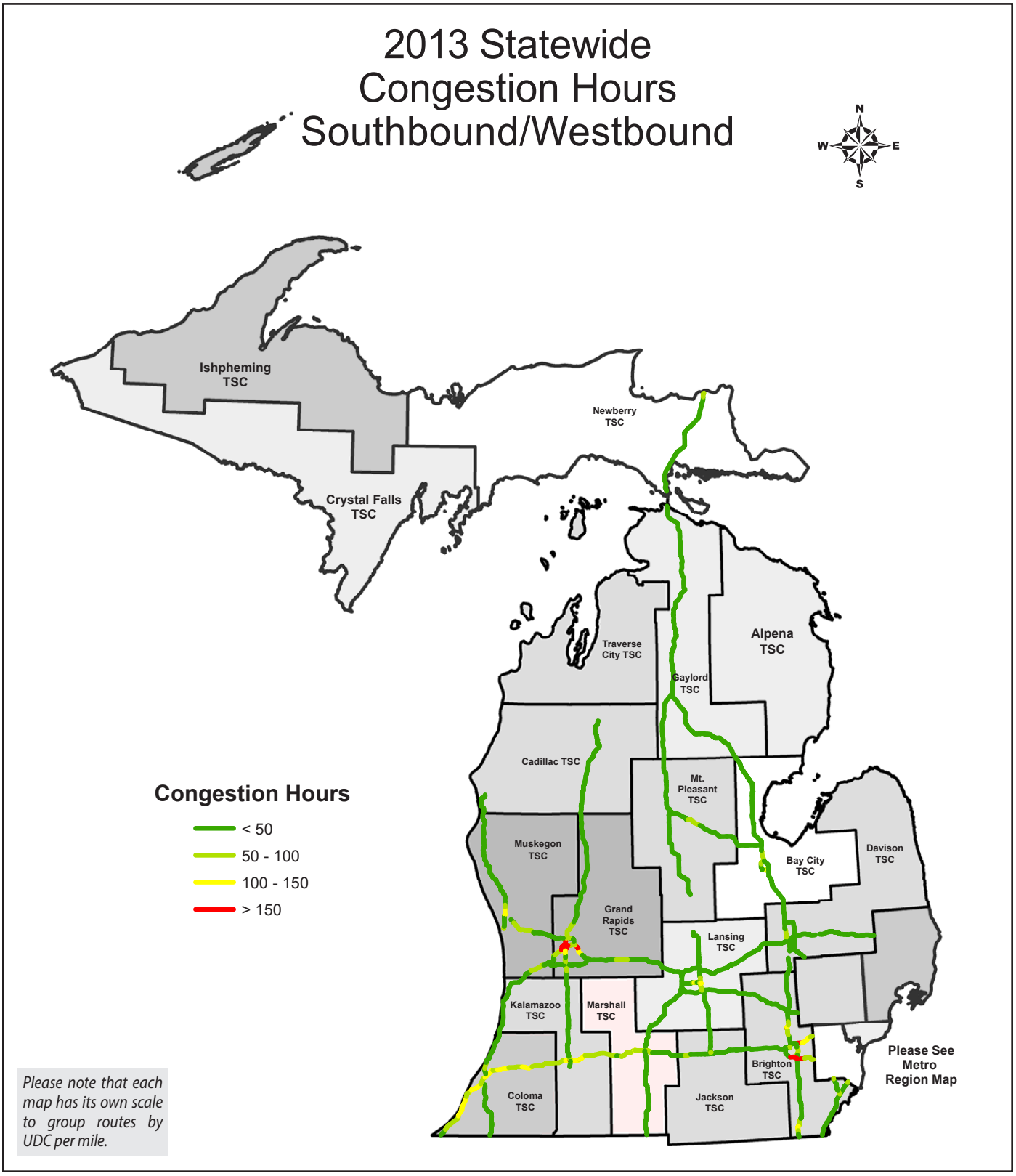

2013 Statewide
Congestion Hours
Southbound/Westbound
N
W
E
S
Ishpheming TSC
Newberry TSC
Crystal Falls TSC
Traverse City TSC
Alpena TSC
Gaylord TSC
Cadillac TSC
Mt. Pleasant TSC
Muskegon TSC
Bay City TSC
Davison TSC
Grand Rapids TSC
Lansing TSC
Kalamazoo TSC
Marshall TSC
Brighton TSC
Coloma TSC
Jackson TSC
Please See Metro Region Map
Congestion Hours
< 50
50 - 100
100 - 150
> 150
Please note that each map has its own scale to group routes by UDC per mile.

*Figure 13*

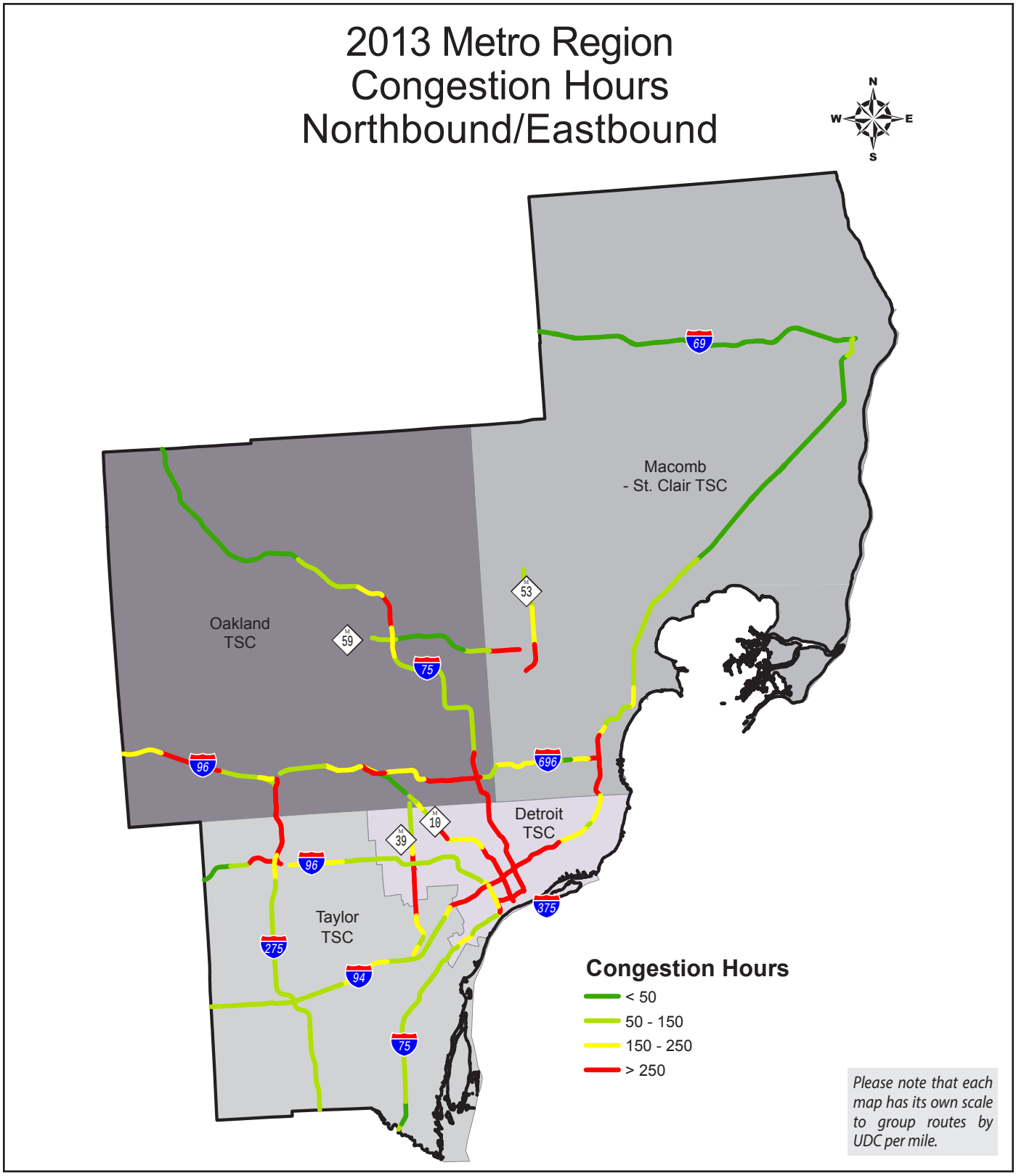
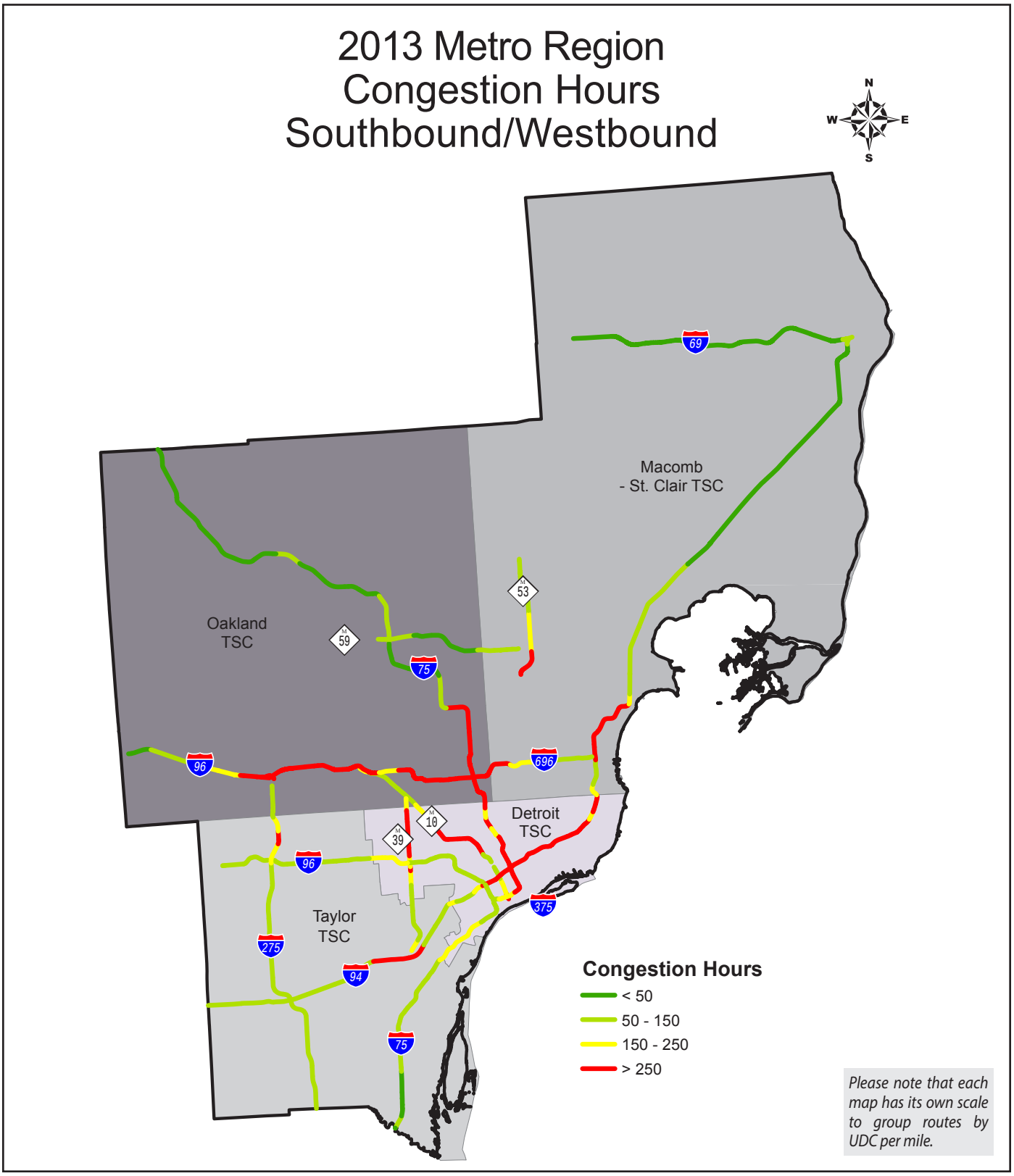

2013 Metro Region
Congestion Hours
Northbound/Eastbound
N
W
E
S
Macomb
- St. Clair TSC
Oakland
TSC
Detroit
TSC
Taylor
TSC
69
53
59
75
96
696
10
39
96
375
275
94
75
Congestion Hours
< 50
50 - 150
150 - 250
> 250
Please note that each map has its own scale to group routes by UDC per mile.

*Figure 14*


2013 Metro Region
Congestion Hours
Southbound/Westbound
N
W
E
S
Macomb
- St. Clair TSC
Oakland
TSC
Detroit
TSC
Taylor
TSC
69
59
53
75
96
696
10
39
375
275
94
Congestion Hours
< 50
50 - 150
150 - 250
> 250
Please note that each map has its own scale to group routes by UDC per mile.

The following charts display weighted congestion hours. They are broken up into four different time periods to help determine when the highest amount of congestion occurs. Some areas have distinct AM and PM congestion, while other areas have congestion occurring during non-peak periods. Non-peak period congestion can be attributed to incidents, weather or other non-recurring events.

The four time periods are defined as:

- Off-Peak: Midnight - 6 a.m. and 7 p.m. - Midnight (11 hours)
- AM Peak: 6 - 9 a.m. (three hours)
- Afternoon Peak: 9 a.m. - 3 p.m. (six hours)
- PM Peak: 3 - 7 p.m. (four hours)

*Figure 15*

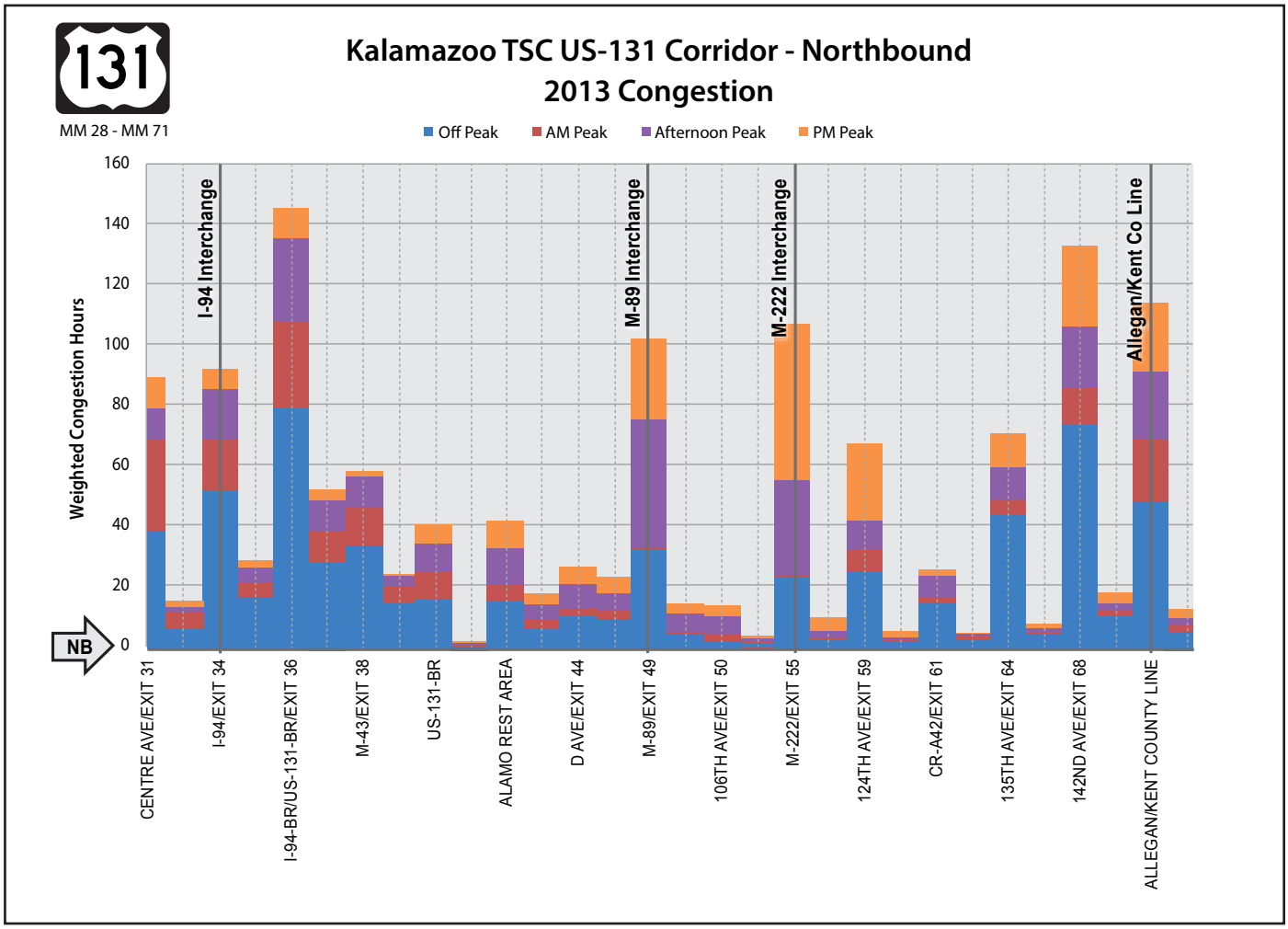
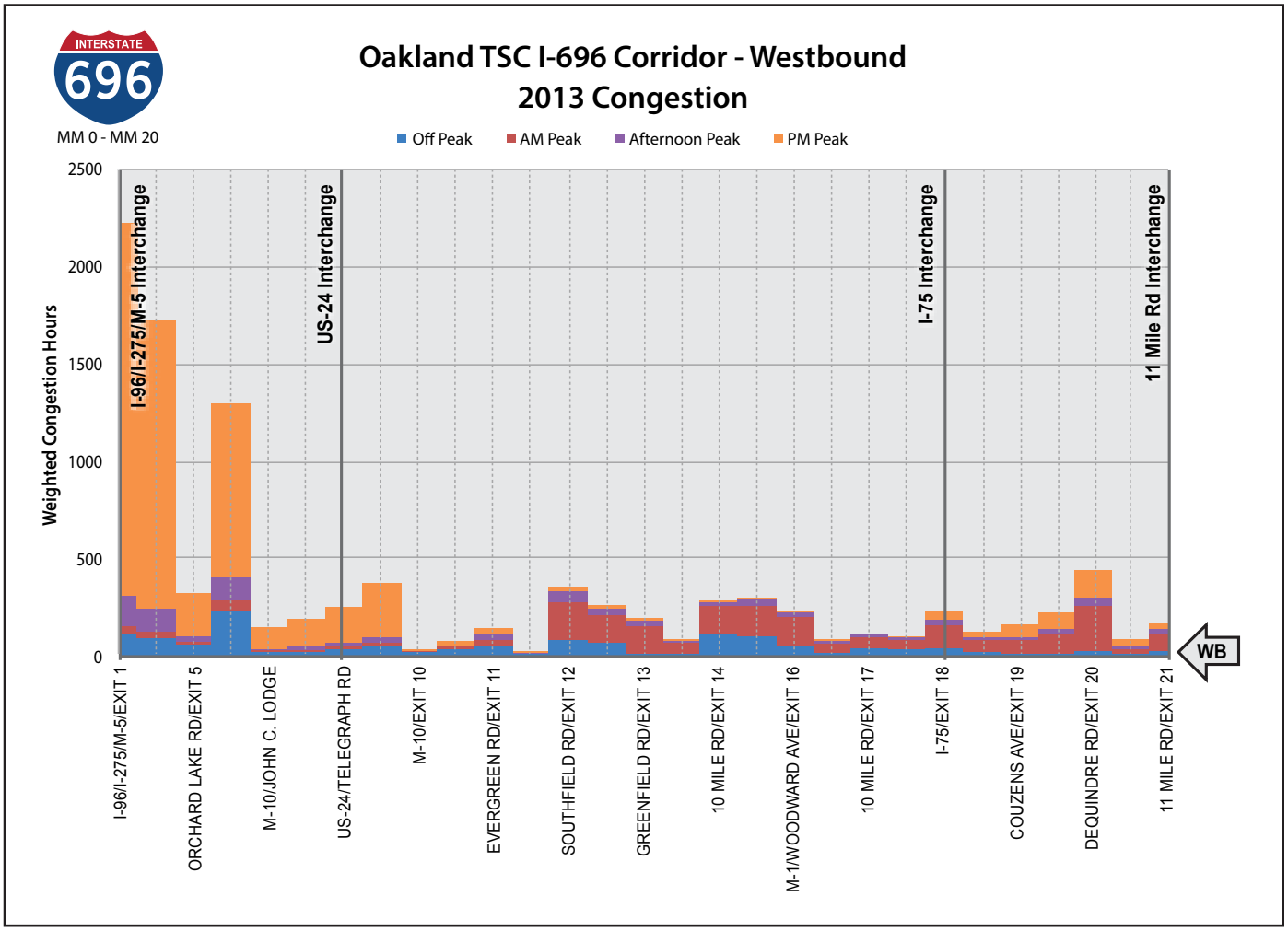
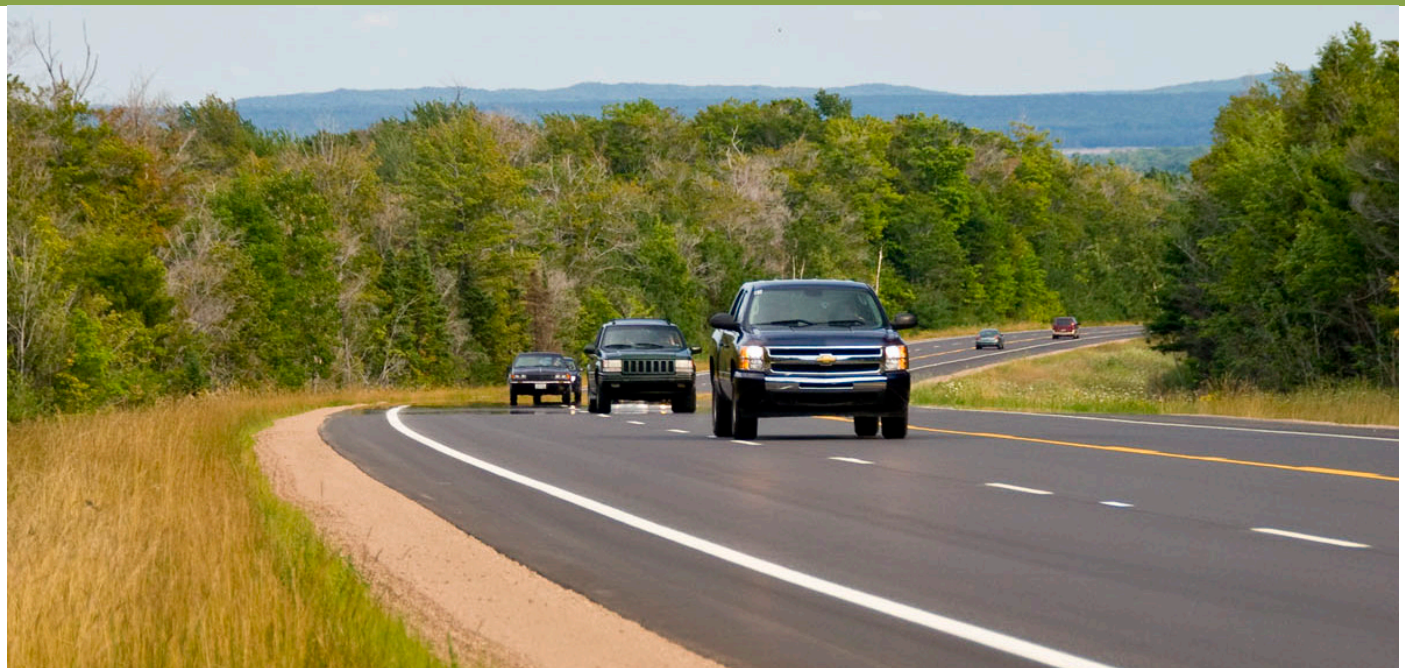


Figure 15 shows the weighted congestion hours along US-131 within the Kalamazoo TSC area. The highest congestion levels are typically shown at the interchanges where the most vehicle interactions occur. The weighted congestion is spread out across all time periods. In contrast, Figure 16 shows the weighted congestion is heavy during the AM and especially during the PM peak time periods along I-696 near I-275 in Oakland TSC.

*Figure 16*





## Conclusion

The main body of this report is meant to show examples of each type of performance measure that was created using probe data and to explain what they mean. The Region Summary Chapters include all of the performance measures for each MDOT region. These are organized by region, TSC and route to make it easy to get to the information that is most useful.

It is the Congestion and Mobility Unit's goal that these performance measures are not just numbers and figures, but information to help MDOT personnel understand how traffic is operating on its freeways and make actionable decisions on improving traffic. They could be used to help prioritize projects, determine where and when problems are occurring, and how significant they are.

We intend to provide these performance measures on an annual basis to help identify trends on the system and to keep MDOT up to date on freeway operations. Various performance measures may change due to changing federal requirements or MDOT needs. As probe data improves, this may expand to non-freeway routes as well. The Congestion and Mobility Unit welcomes any feedback on this report to help us improve it in the future and maximize its usefulness.

## Contact Info

Please contact the Congestion and Mobility unit if you have any questions/comments or would like to have the actual data for further analysis.

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# Notes

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