CHAPTER 7—GRAPHICAL ILLUSTRATION OF MOBILITY MEASUREMENT

Chapter Summary

Communicating mobility analysis results is a vital step in illustrating system performance and demonstrating the need for transportation improvements. Effective graphical presentation of mobility results typically includes spatial and/or temporal aspects. This chapter provides state-of-the-art examples of effective ways of communicating mobility results.

A key step in any mobility analysis is communicating the results. This chapter illustrates some premier examples of communicating temporal and spatial congestion characteristics. Tables can certainly be effective in communicating results; however, providing congestion severity spatially through maps or temporally through trend analyses illustrates a visually effective way of communicating results. Additional methods of illustrating temporal and spatial congestion characteristics are included in this chapter.

The examples in this chapter are primarily from real-time data sources; however, similar graphics can certainly be created for measures computed from other data sources. While some of the graphical displays may initially appear time consuming to create, automated methods can be developed to facilitate report generation.

Exhibit S-1 and the measures presented in Chapter 5 are not the only measures illustrated in the examples shown in this chapter. The mobility measures in Chapter 5 represent the primary measures that often form the foundation of a mobility analysis. The measures shown in Chapter 5 are the focus of the applications shown in Chapter 8 as well.

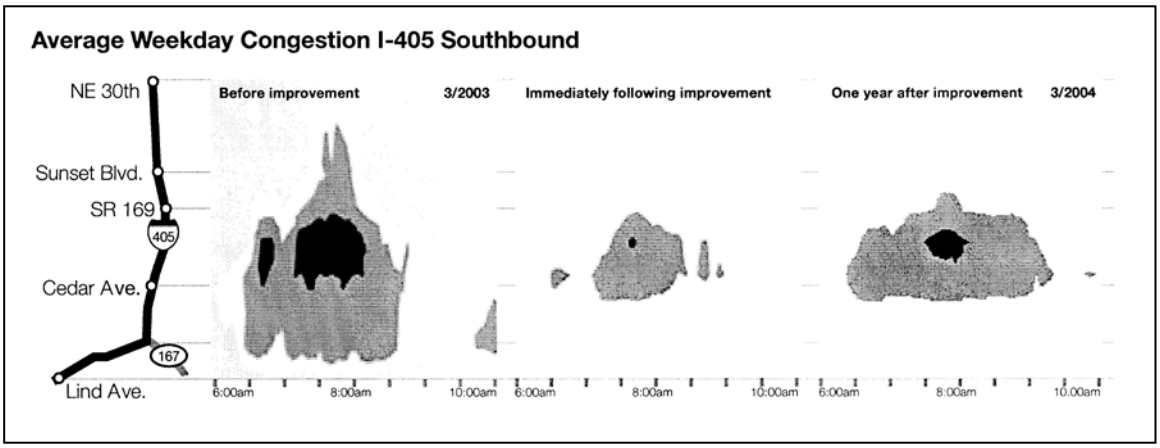
It should also be noted that all aspects of congestion (duration, extent, intensity, and variation) can be illustrated with graphical methods. It is important to consider what questions are to be answered when selecting the appropriate graphic to quantify congestion levels.

7.1 Graphical Examples Illustrating Temporal Congestion Aspects

Numerous graphics that present the temporal aspects of congestion are presented in this section. These graphics typically present information at one particular location over time. Similar graphics could be generated for different locations of interest and compared to provide a spatial perspective on congestion.

Exhibit 7-1 illustrates severity and duration of congestion. These “thermal graphs” combine multiple datasets to display a corridor over time. It illustrates when and where the freeway is congested along with the severity, duration, and location. It provides a quick assessment to the viewer, and “before-and-after” graphics could be created to identify transportation improvements. Exhibit 7-1 shows “before-and-after” decreased congestion due to the construction of a flyover ramp at I-405 and SR 167 in the Puget Sound area.

Exhibit 7-1. Average Weekday and Weekend Congestion at I-405 Southbound.
Source: Washington State Department of Transportation (*1*)



The Mobility Monitoring Program (*2*) includes numerous examples of presenting congestion statistics computed from real-time (ITS) data sources. Several graphics from MMP are included here to illustrate various presentation methods with data from the freeway systems of different cities across the nation in 2003. Exhibit 7-2 illustrates computed measures and trends related to performance measures, explanatory measures, and data quality measures. The exhibit provides a system-level summary to the reader at a glance while also providing color-coded arrows for the changes from past years to the current year.

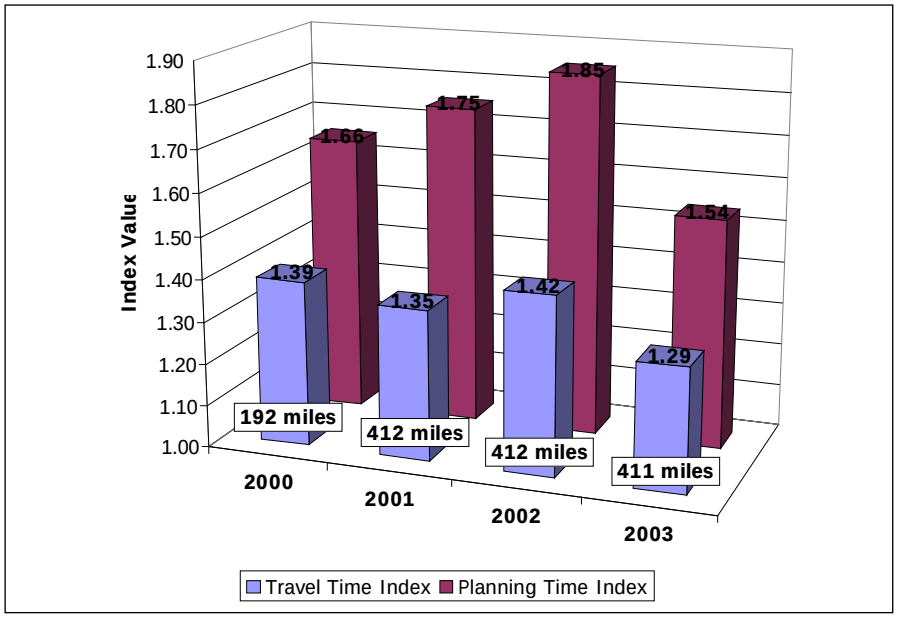
Exhibit 7-2. Illustration of Measures and Trends.

Measures	Current Year	Last Year		Two Years Ago	
	2003	2002	Change	2001	Change
Performance Measures					
Travel Time Index	1.23	1.20	+2% ↑	1.27	-3% ↓
Planning Time Index	1.52	1.49	+2% ↑	1.61	-5% ↓
Buffer Index	20%	21%	-1% ↓	23%	-3% ↓
% Congested Travel	37%	39%	-2% ↓	50%	-13% ↓
Total Delay (vehicle-hours) per 1000 VMT	3.92	3.78	+4% ↑	4.86	-19% ↓
Explanatory Measures					
Peak Period VMT (000)	5,750	4,720	+22% ↑	4,560	+26% ↑
Avg. Annual DVMT (000)	19,610	16,160	+21% ↑	15,520	+26% ↑
Data Quality Measures					
% Complete	79%	85%	-6% ↓	98%	-19% ↓
% Valid	78%	89%	-11% ↓	92%	-14% ↓
% of VMT Covered	72%	59%	+13% ↑	55%	+17% ↑
% of Freeway Miles	69%	60%	+9% ↑	60%	+9% ↑

DVMT = Daily Vehicle Miles Traveled
Source: FHWA (*2*)

Exhibit 7-3 illustrates trends in the system-level travel time index and the planning time index values from 2000 to 2003. The planning time index is statistically defined as the 95th percentile travel time index and also represents the extra time most travelers add to a free-flow travel time when planning trips. Exhibit 7-3 also shows the miles of freeway coverage.

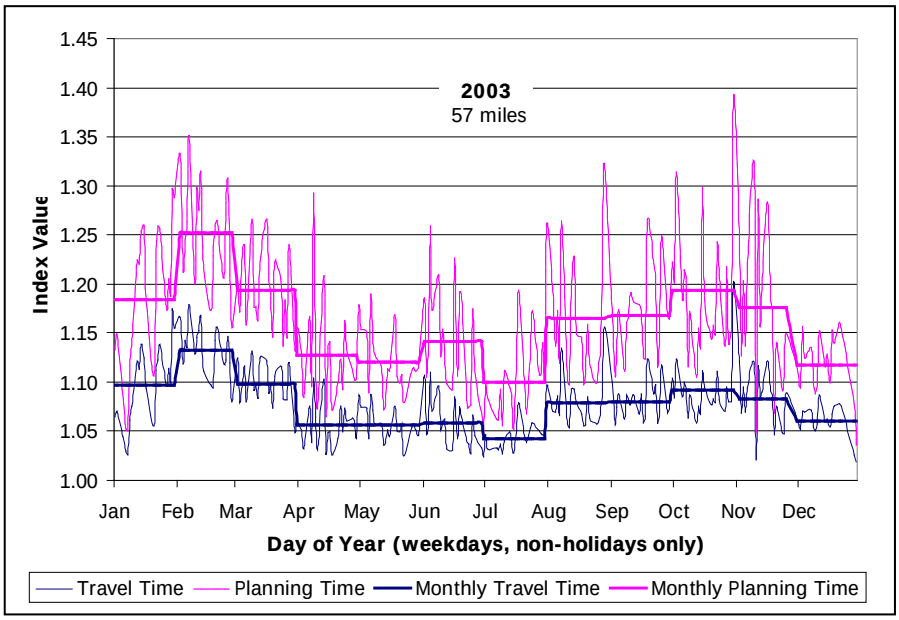
Exhibit 7-3. Illustration of Annual Trends in Travel Time Index and Planning Index.



Source: FHWA (*3*)

Exhibit 7-4 illustrates daily, monthly, seasonal, and yearly trends in the travel time index and the planning time index. Therefore, several temporal levels of detail are provided in one graphic for the system (in this case), or this exhibit could be produced for specific areas of interest.

Exhibit 7-4. Illustration of Daily and Monthly Trends in Travel Time Index and Planning Index.

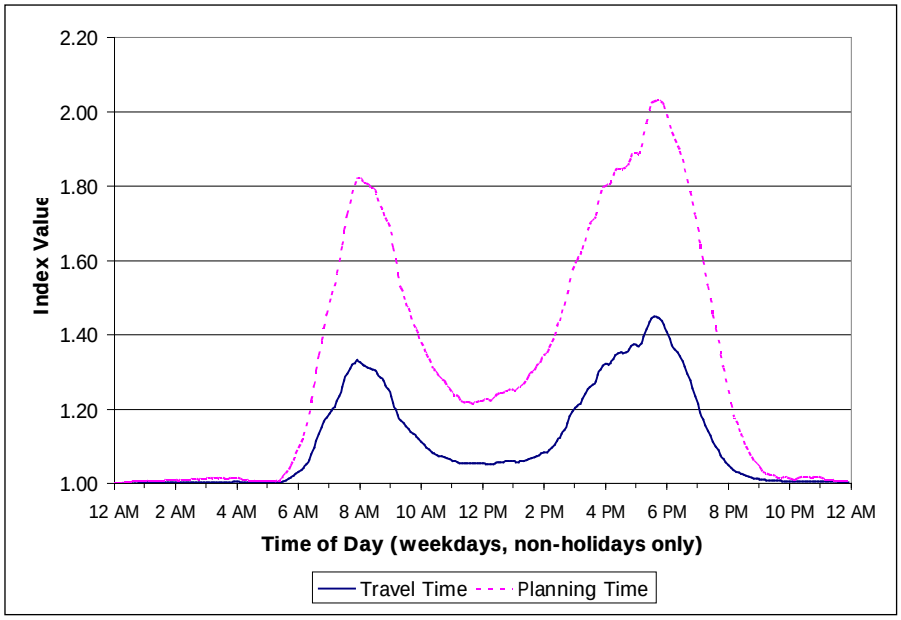


Source: FHWA (*3*)

Exhibit 7-5 and Exhibit 7-6 illustrate travel time index and planning time index values by time of day. Exhibit 7-5 shows areawide congestion and reliability patterns. The difference between the solid line (travel time index) and the dashed line (planning time index) is the additional "buffer" or "time cushion" that travelers must add to average trip times to ensure 95 percent on-time arrival. Exhibit 7-5 also indicates that the evening congestion level is higher and longer than in the morning and that travelers must add 25 to 35 percent additional buffer time during peak periods to account for traffic unreliability. While this graphic is for areawide conditions, a similar graphic could be created for specific locations as well.

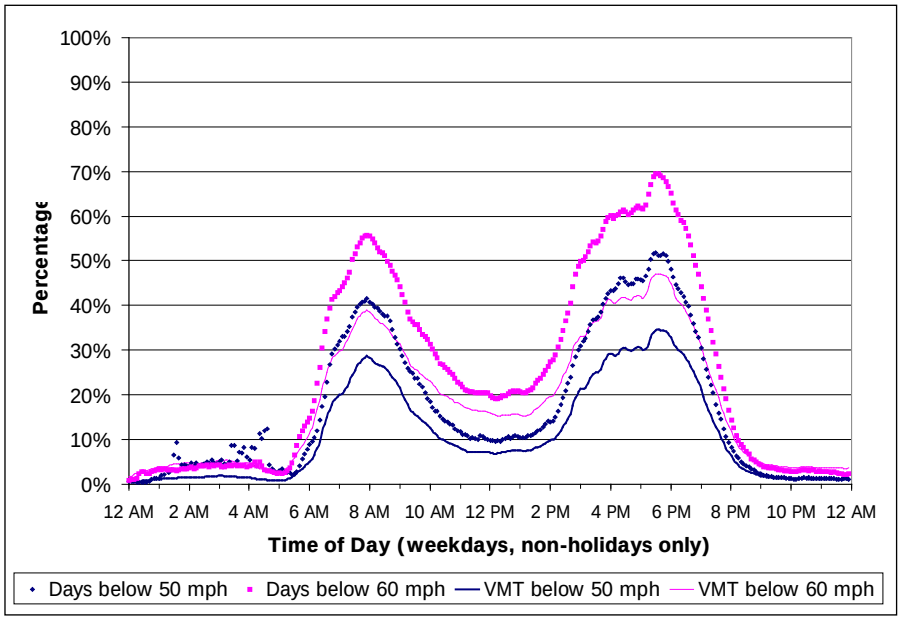
Exhibit 7-6 illustrates the difference in using two different speed thresholds (50 and 60 mph) to compute the percent of congested days as well as the percent of congested travel (as vehicle-miles of travel). There is about a 10 to 15 percent difference in using a 50 mph or 60 mph congestion threshold in this example.

Exhibit 7-5. Illustration of Mobility and Reliability by Time of Average Weekday.



Source: FHWA (*3*)

Exhibit 7-6. Illustration of Frequency and Percentage of Congested Travel by Time of Average Weekday.

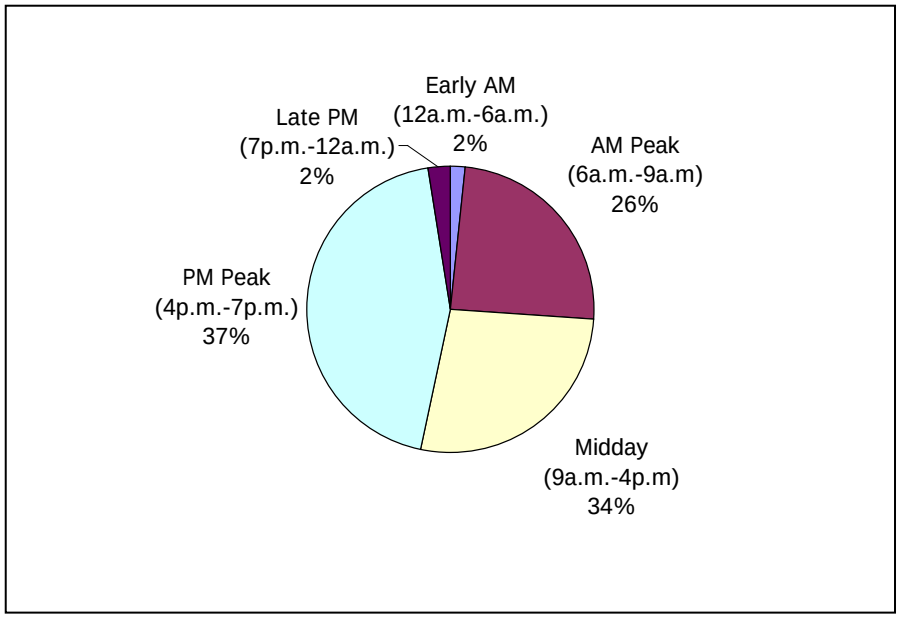


Source: FHWA (*3*)

Exhibit 7-7 illustrates a method to present congestion levels by time period of the day with a pie chart. It shows the percent of delay that occurs during different time periods of an average weekday. Note that the morning and afternoon peak periods are the same duration (3 hours each), but other time periods have different lengths. As illustrated in Exhibit 7-5, the delay in the afternoon is greater than the morning peak period. Exhibit 7-8 illustrates congestion and reliability (shown as bars) as well as delay (shown as a line) during different time periods of

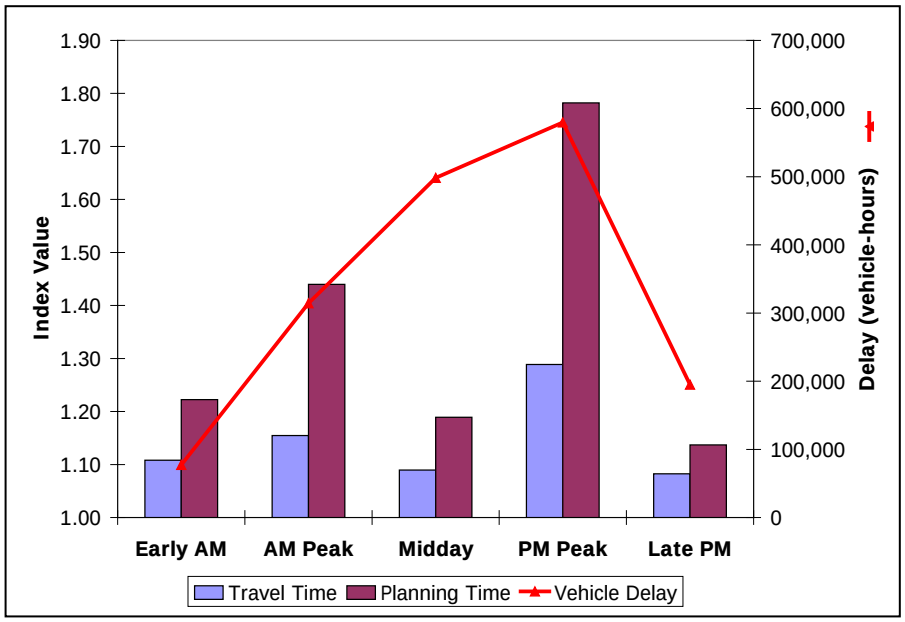
an average weekday. The trends in this graphic follow closely to those illustrated in Exhibit 7-7. Note that the travel time index for the midday period is low, but the delay is relatively high because of the length of this time period (7 hours).

Exhibit 7-7. Illustration of Percent of Delay by Time Period.



Source: FHWA (*3*)

Exhibit 7-8. Illustration of Mobility, Reliability, and Delay by Time Period.

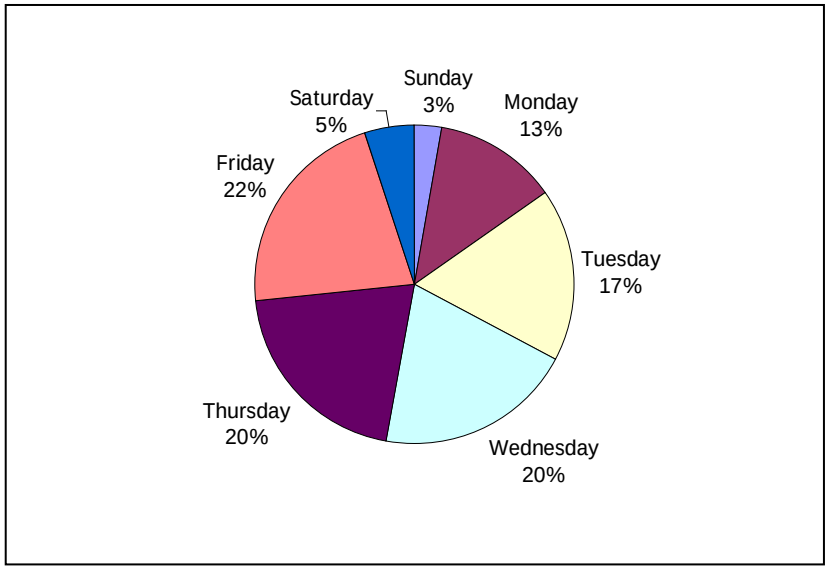


Source: FHWA (*3*)

Exhibits 7-9 and 7-10 illustrate day of week variations in congestion. Exhibit 7-9 shows the percent of total daily delay that occurred during each day of the week. The pie chart indicates that delay on Mondays is significantly less than all other weekdays, and delay on all

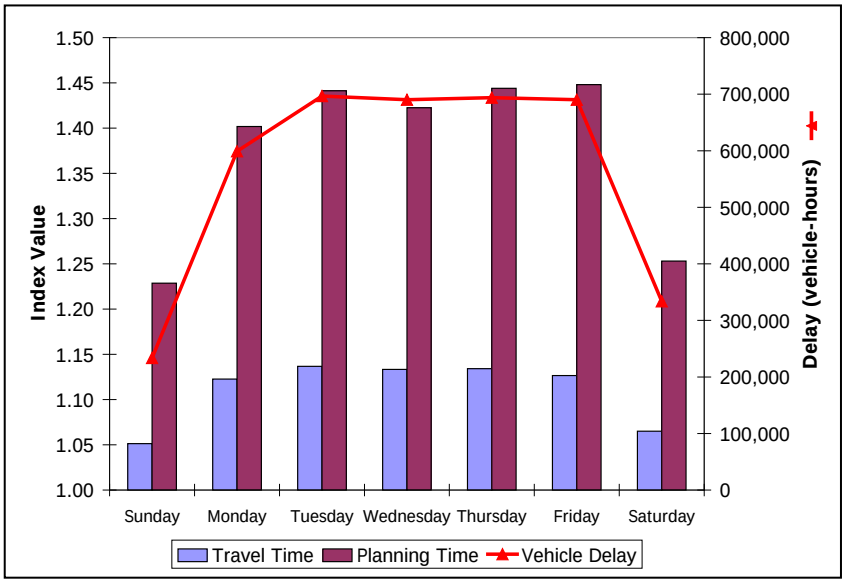
other weekdays is comparable. Both weekend days combined have about half of the normal weekday delay. Exhibit 7-10 is similar to Exhibit 7-8 except it investigates congestion by day of the week. The chart shows the average daily congestion and reliability (shown as bars) as well as total daily delay (show as a line) during each day of the week. The trends shown in Exhibit 7-10 closely follow those shown in Exhibit 7-9. Friday has the most delay, and it is the least reliable day (highest planning time index).

Exhibit 7-9. Illustration of Percent of Delay by Day of Week.



Source: FHWA (*3*)

Exhibit 7-10. Illustration of Mobility, Reliability, and Delay by Day of Week.



Source: FHWA (*3*)

7.2 Graphical Examples Illustrating Spatial Congestion Aspects

Most of the temporal graphics presented thus far can also provide some level of spatial congestion analysis as well. In the simplest form, this includes creating the temporal graphic of interest at two or more locations and then comparing the graphics. Alternatively, spatial illustrations of congestion levels can be well represented through maps. One example was shown previously in Exhibit 7-1. The examples in this section include illustrations of spatial maps that illustrate congestion levels. Finally, additional examples of displaying congestion levels are provided that can be created for numerous locations and compared.

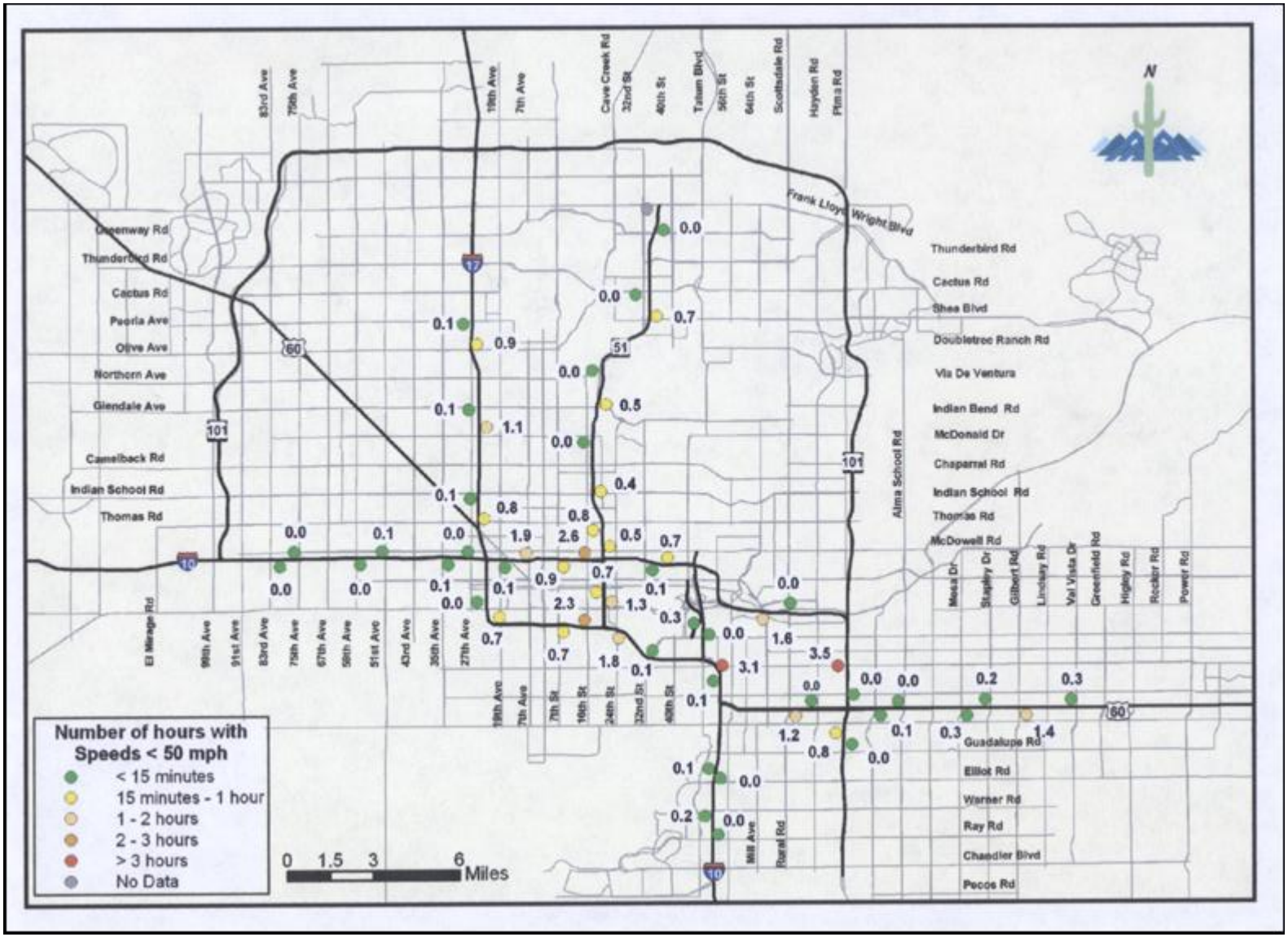
Exhibit 7-11 illustrates a spatial example of the hours of congestion in the afternoon and early evening hours in Phoenix. Color-coded points are indicated on the roadway that correspond to different ranges in the number of congested hours. The color-coded points on the map are located where the directional real-time (ITS) detectors are located in the freeway. Exhibit 7-12 presents the average speeds for the weekday evening peak period in the Phoenix area. Speed data are again provided at color-coded point locations. This provides the reader spatial congestion impacts throughout the region. Exhibit 7-13 provides another representation of the severity of congestion. In this example, delay is illustrated spatially throughout the Puget Sound region. The vertical length of the bars indicates the extent of the delay at the location indicated.

Exhibit 7-14 displays the concept of "lost capacity." The November 13 data represent relatively free-flow travel at this location throughout the day. November 12 represents a day with a reduction in speed beginning at approximately 3:30 p.m. Note that prior to 3:30 p.m., the volume traces for both days were relatively similar. Using November 13 as a "baseline," the "lost capacity" is shown on the graphic as the difference between the traffic volumes for these two days. The "lost capacity" can be illustrated graphically in this manner and/or displayed for different locations to provide a spatial comparison. It should be noted that each day of data could be investigated to determine capacity. November 13 is just used for illustrative purposes in Exhibit 7-14. Alternatively, the efficiency at a point can be presented in the form of a map such as Exhibit 7-15 that displays the efficiency as a color-coded point on the map.

Exhibit 7-16 provides another way to perform side-by-side comparisons of different locations while also providing a comparison over consecutive years. The exhibit illustrates "stamp graphs" (named for their size) that visually describe the percent of days when speeds are less than 35 mph. The graphics compare data for two years over the daily time periods of interest.

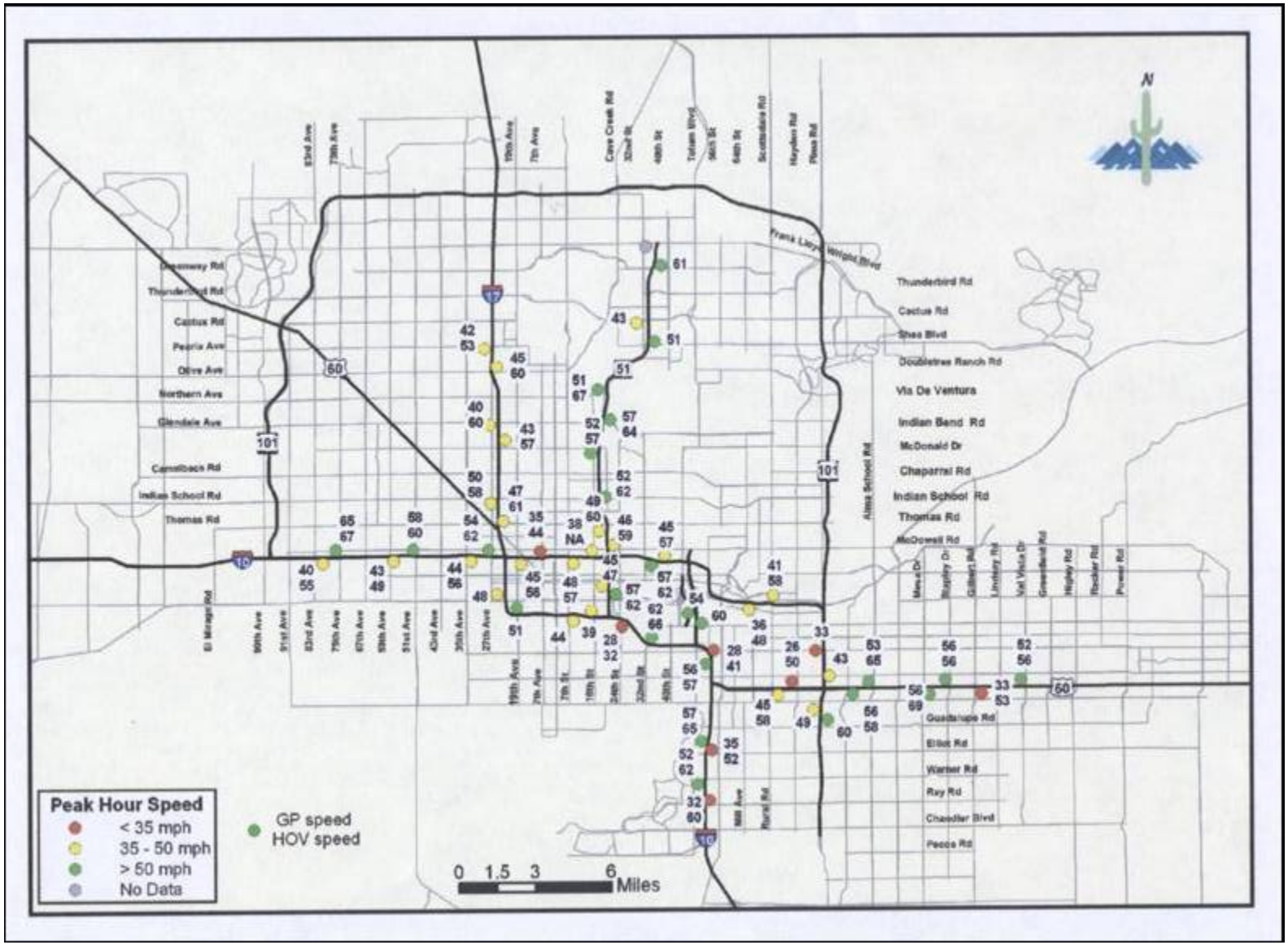
Exhibit 7-17 illustrates the percent of vehicle-miles of travel, time, and delay in different speed ranges. This chart is useful to determine how much VMT and delay are occurring at different congestion levels. About 75 percent of the VMT occurred at speeds greater than 60 mph. More than 85 percent of the delay is at speeds less than 40 mph. Though this graphic is for a regional system for the entire year, the graphic could also be created for specific locations and then compared—thus providing a spatial illustration of the congestion levels.

Exhibit 7-11. Hours of Congestion in the Afternoon and Early Evening (2 p.m. to 7 p.m.), 2004.



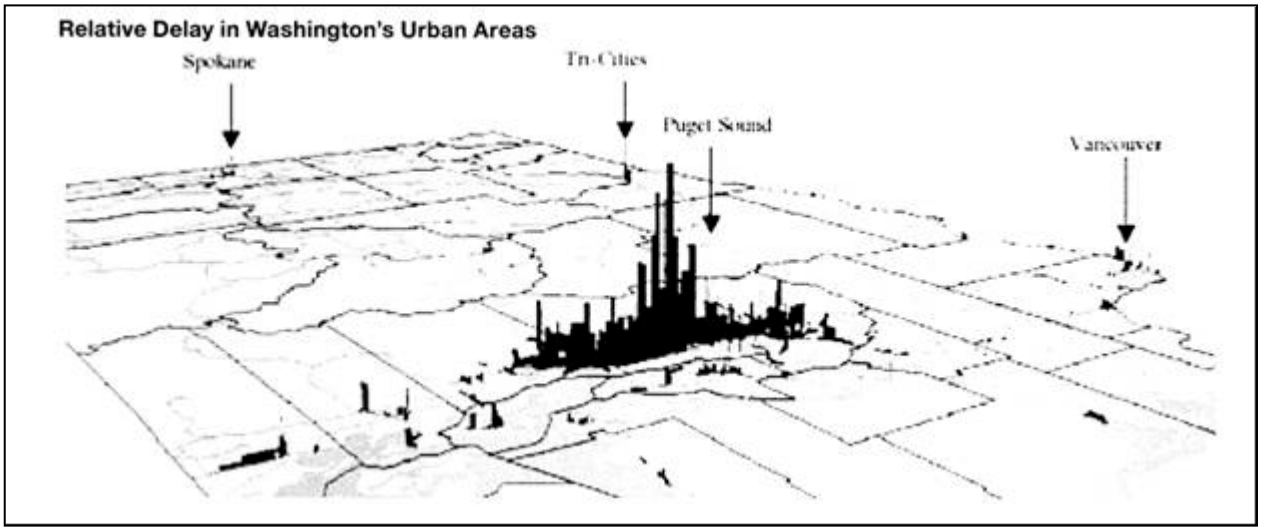
Source: FHWA (*4*)

Exhibit 7-12. Average Weekday Evening Peak Period Speeds, 2004.



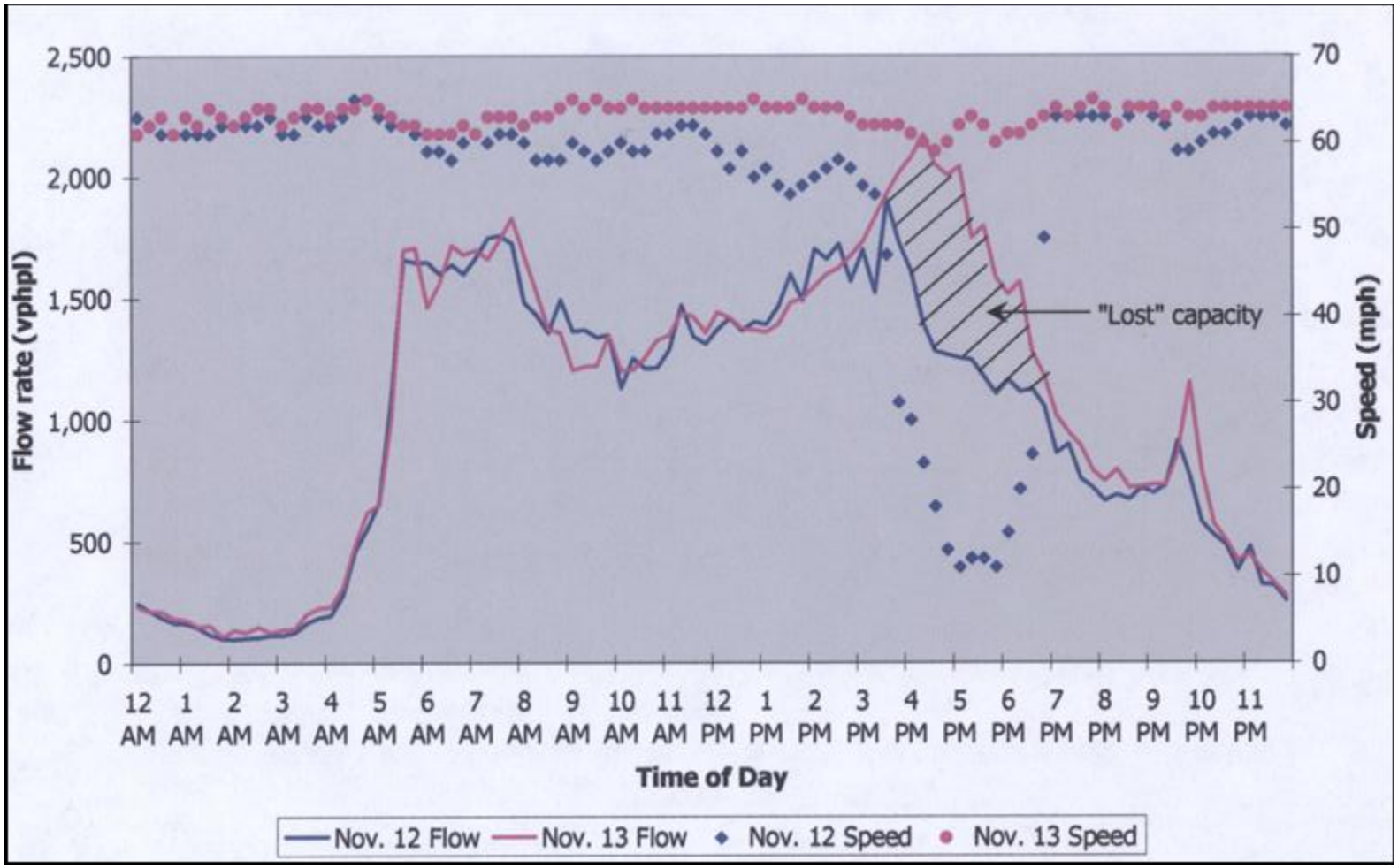
Source: FHWA (*4*)

Exhibit 7-13. Puget Sound Freeway Delay.



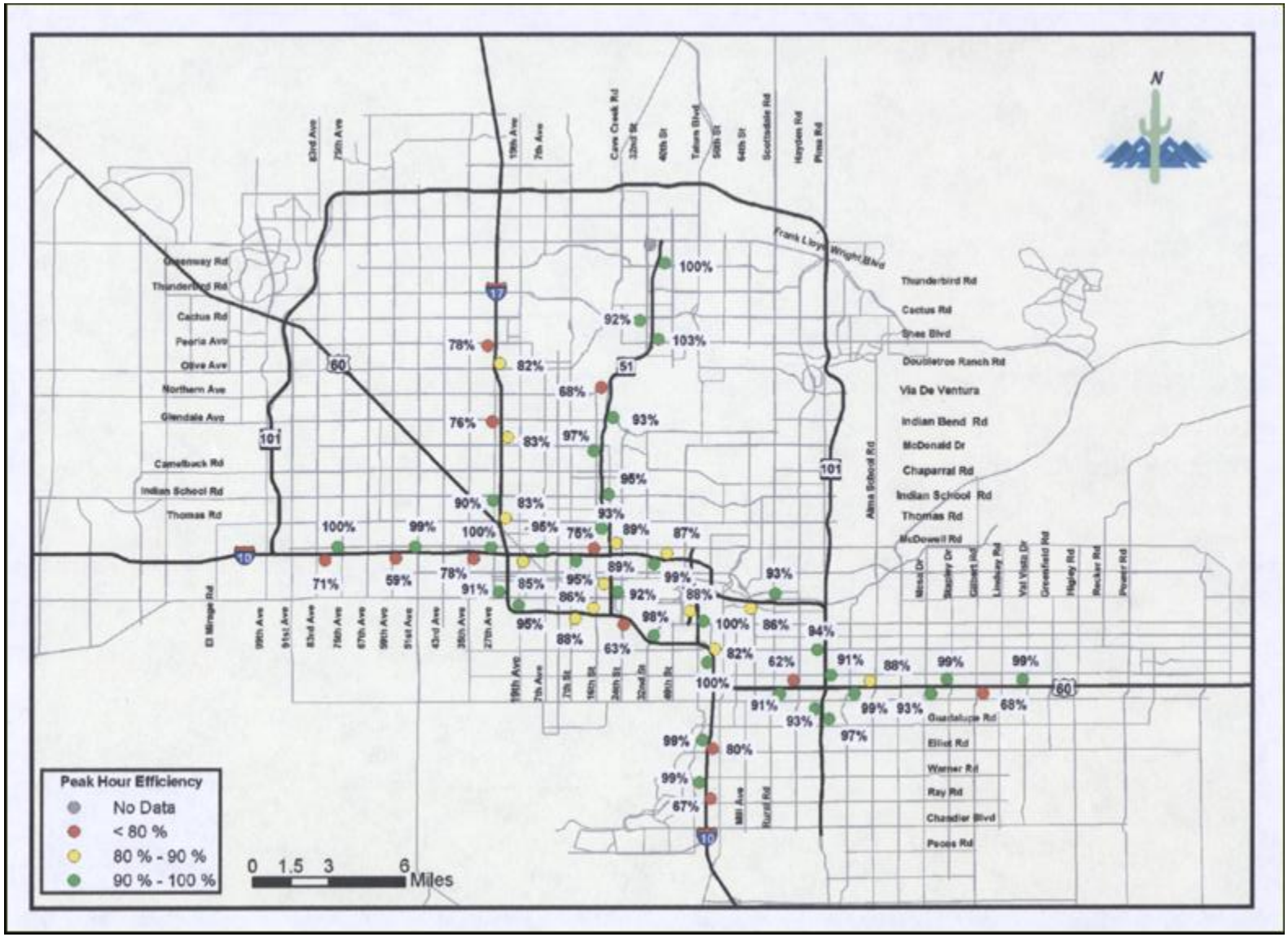
Source: Washington State Department of Transportation (*1*)

Exhibit 7-14. Illustration of "Lost Capacity."



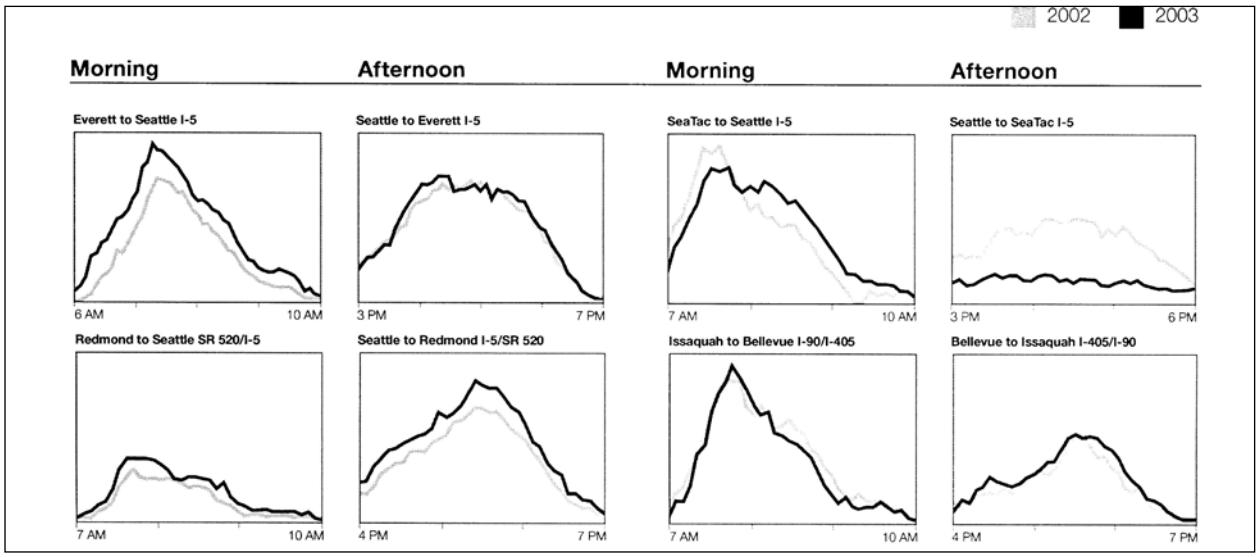
Source: FHWA (*4*).

Exhibit 7-15. Peak Hour Efficiency Values Based on "Lost Capacity" Concepts.



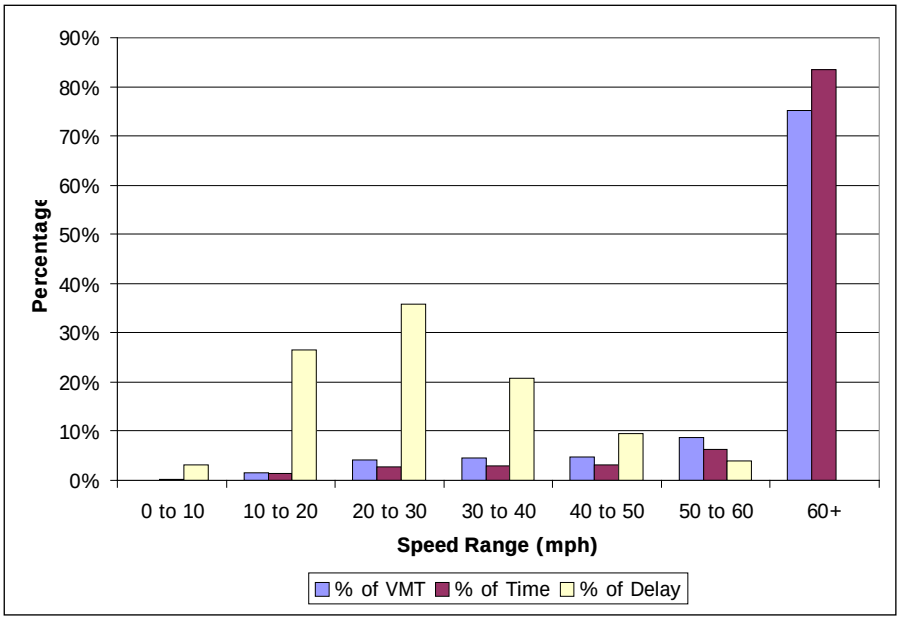
Source: FHWA (*4*).

Exhibit 7-16. Percent of Days with Speeds Less Than 35 mph.



Source: Washington State Department of Transportation (*1*)

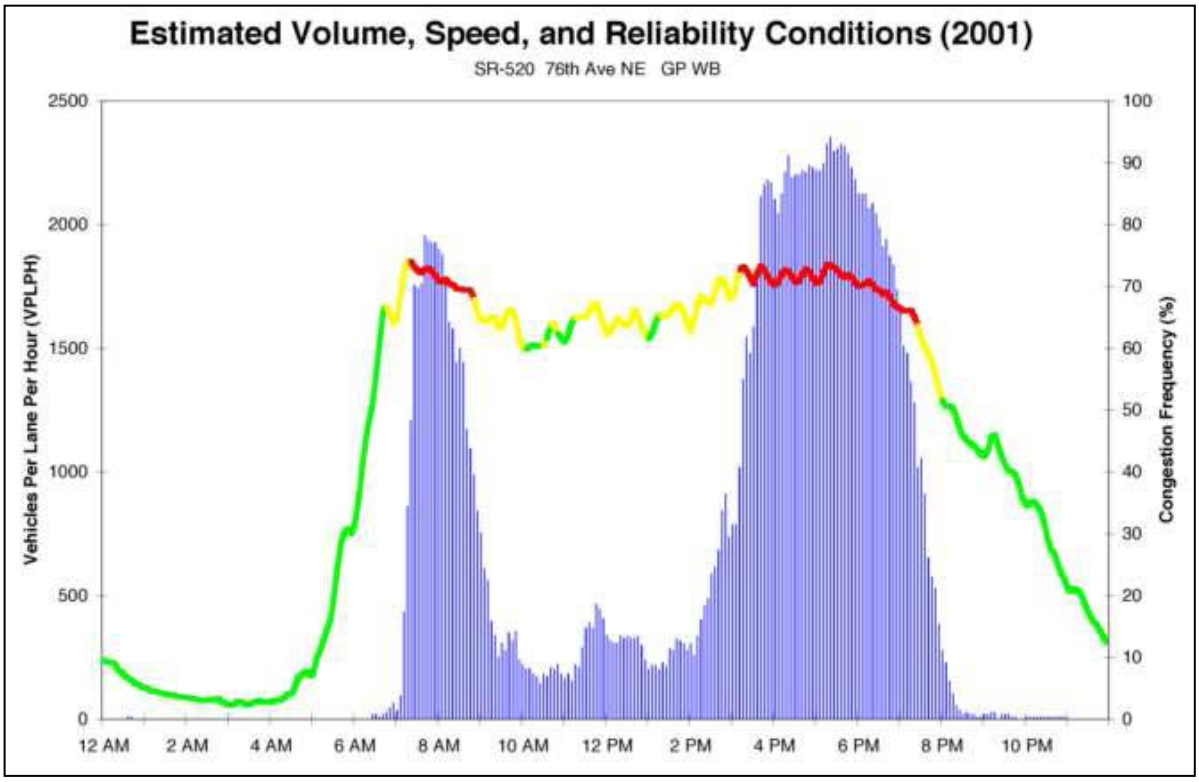
Exhibit 7-17. Percent of VMT, Delay, and Time Periods in Different Speed Ranges.



Source: FHWA (*3*)

Exhibit 7-18 illustrates a method for displaying volume, speed, and reliability conditions for SR 520 in the Puget Sound region. The information is provided by time of day. Vertical bars provide the congestion frequency (percent chance trips are below 45 mph). The volume line is color-coded to represent speeds of >55 mph (green), 45-55 mph (yellow), and <45 mph (red) for each 5-minute period.

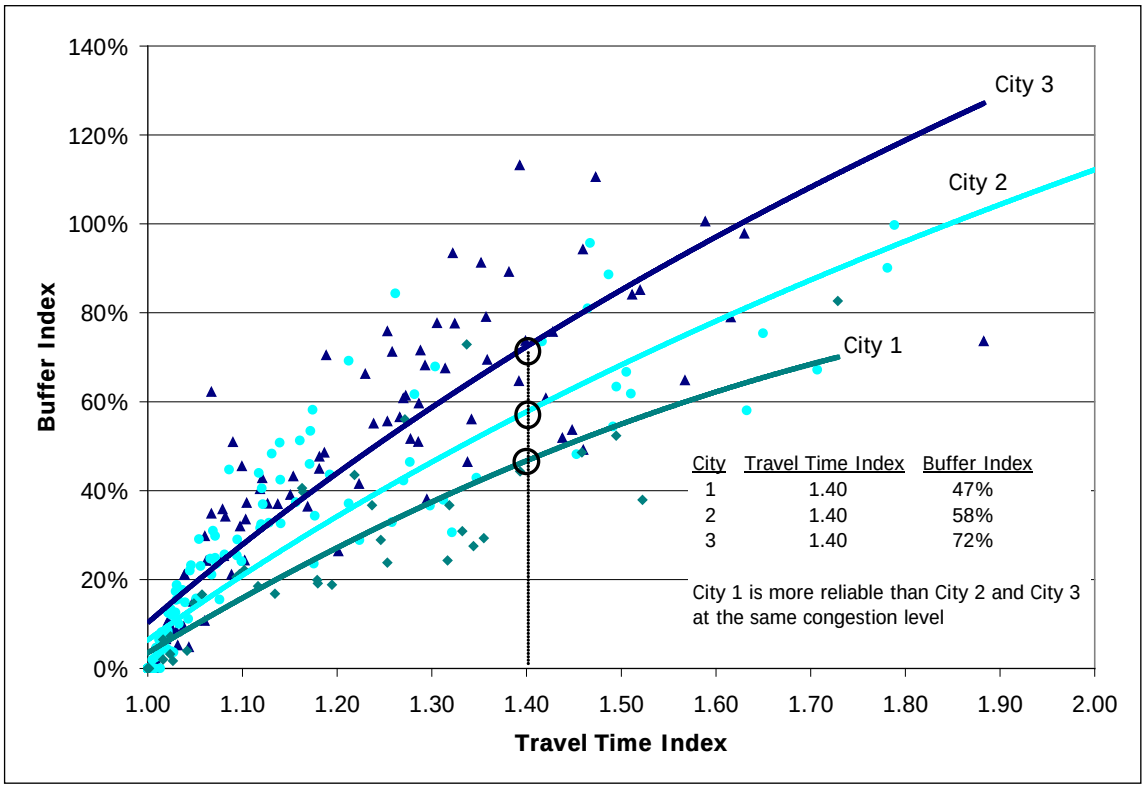
Exhibit 7-18. Change in HOV Speed and Reliability: I-5 Southbound, South of the Seattle CBD, S Spokane Street to S 184th Street.



Source: TTI (*4*)

Exhibit 7-19 illustrates an alterative way of estimating reliability. Travel time reliability is estimated as a function of the buffer index. Research continues at the Texas Transportation Institute to further identify the relationships between the travel time index and the buffer index using archived ITS data.

Exhibit 7-19. Exploring the Relationship between Congestion Level and Travel Reliability.



Source: FHWA (*2*)

7.3 References

1. "Measures, Markers and Mileposts: The Gray Notebook for the Quarter Ending September 30, 2004." Washington State Department of Transportation, November 2004. Available at: http://www.wsdot.wa.gov/accountability.

2. *Monitoring Urban Freeways in 2003: Current Conditions and Trends from Archived Operations Data*. U.S. Department of Transportation, Federal Highway Administration, Report No. FHWA-HOP-05-018, December 2004. Available at: http://mobility.tamu.edu/mmp/.

3. "FHWA Mobility Monitoring Program: 2003 City Reports." U.S. Department of Transportation, Federal Highway Administration, February 2005. Available at: http://mobility.tamu.edu/mmp.

4. "Freeway Traffic Conditions and Trends in the Phoenix Region, 2004." Sponsored by Maricopa Association of Governments (MAG), performed by the Texas Transportation Institute, College Station, Texas, first draft, March 2005.