Weekend Freeway Performance and the Use of HOV Lanes on Weekends

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Prepared for

Washington State Transportation Commission

April 2000

WEEKEND FREEWAY PERFORMANCE AND THE USE OF HOV LANES ON WEEKENDS

This paper discusses the use of HOV lanes on weekends in the Puget Sound metropolitan region. It is based on data from the WSDOT freeway management system (FLOW) and assumes that readers are familiar with the performance reporting graphics WSDOT uses for monitoring congestion in the metropolitan region.[1]

HOV lane volumes are closely tied to two basic conditions, general demand for freeway capacity and the percentage of vehicles eligible to use those lanes. In general, but particularly with HOV lanes located on the left side of roadways, most vehicles do not use HOV lanes even when they are eligible to use those lanes unless drivers see a need for a speed advantage over the other cars on the freeway. This occurs most frequently when congestion starts to build on the freeway. However, if congestion does begin to build, HOV volumes only grow if a sufficient number of vehicles are eligible to use those lanes.

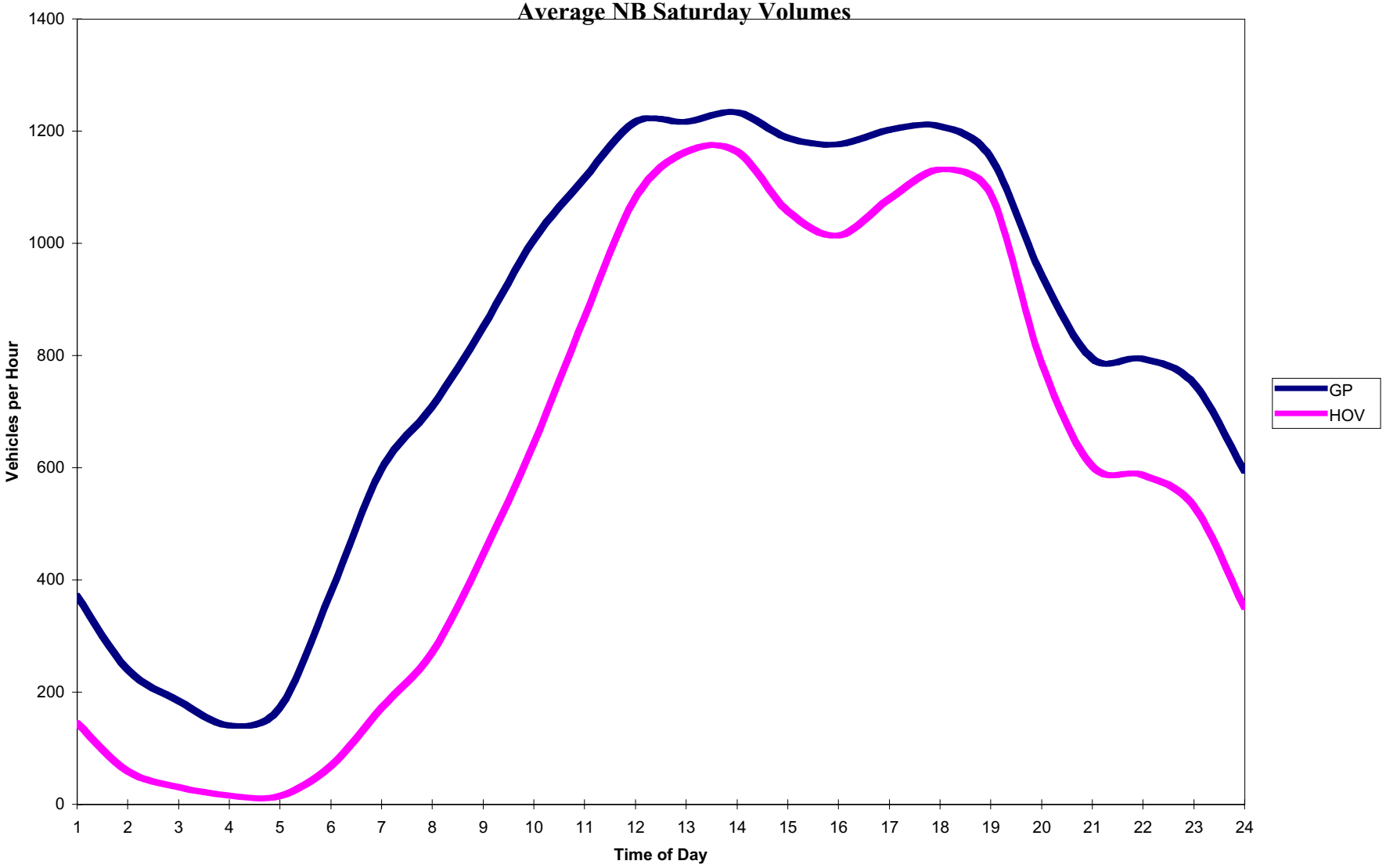
While WSDOT has formally collected few vehicle occupancy data on weekends, the little data collection it has performed (both formally and informally by TRAC researchers) indicates that weekend car occupancy rates tend to be much higher than weekday car occupancy rates. In fact, the fraction of vehicles eligible to use HOV lanes on weekends appears to vary from between 30 and 60 percent, depending on the facility and time of day.

Given these occupancy rates, HOV lane usage on weekends is basically a function of sufficient "congestion" (where "congestion" means enough traffic to give drivers an incentive to choose the left-most lane of travel over the other lanes). The data collected from the FLOW system strongly support this hypothesis.

In almost all cases, HOV volumes are considerably lower than general purpose (GP) lane volumes until the GP lanes reach approximately Level of Service (LOS) C (the point at which the freedom to change lanes and pass vehicles begins to be slightly limited). At this point, HOV volumes begin to rise quickly until HOV lane volumes are only slightly lower than GP lane volumes. (See Figure 1.)

[1] For instructions on how to read these graphics, please see the WSDOT report "Central Puget Sound Regional Freeway Network Usage and Performance," March 1999, WA-RD 466.1. To learn about the techniques used to create the graphics, please see the report "FLOW Evaluation Design Technical Report," WA-RD 466.2, March 1999.

Figure 1: I-5 at N. Boeing Field
Average NB Saturday Volumes



This same effect can be seen in the way motorists use the "fast" lane of the freeway. Motorists tend to avoid driving continuously in the left-most lane of a freeway (because it is easier to be spotted "speeding" and thus be given a ticket) until congestion in the other freeway lanes is sufficiently high to make continuously changing lanes bothersome. (See Figure 2.)

Given these general observations of motorist behavior, it is fairly easy to understand the potential effects of removing HOV lane restrictions on the weekends. The remainder of this paper describes current weekend usage and congestion trends on Puget Sound freeways. It then describes the author's view of the effects removing the HOV lane restrictions on weekends will have on vehicle volumes and speeds.

CONGESTION IN GENERAL PURPOSE LANES

For most of the Puget Sound freeway system, there is little "true congestion" on weekends, where "true congestion" is defined as Level of Service F (unstable speeds). However, several locations can be expected to experience LOS F congestion on several weekend days each month. A number of additional locations experience frequent LOS D conditions (that is, speeds are restricted to about 55 mph, and changing lanes requires effort and care). Many motorists expecting to find free flow conditions are likely to consider these conditions "congested" on weekends, whereas they would conclude that the freeway was working quite well if they encountered those same conditions on weekdays during the peak period. (This is because "bad congestion" is really a relative term. It most often means that traffic is worse than it "ought to be" in the eyes of the individual.)

Figures 3 through 7 show contour graphics[2] of the "average weekend" congestion condition on general purpose lanes in the Puget Sound freeway system for 1999. These graphics show that significant weekend congestion occurs only in two places in the metropolitan area. These are on I-5 approaching the downtown area (from both directions) and on I-405 approaching the SR 167 interchange (again from both directions). In both cases, a combination of high volumes and significant merge/diverge congestion causes routine slow downs and delay.

On I-5 (see Figure 3), the southbound congestion starts at the Mercer weave and extends northward, sometimes as far as Northgate. Significant congestion occurs at the Ship Canal Bridge as often as six to eight times a month (i.e., over half the time), can start as early as 11:00

[2] On these figures, the color green can be interpreted to indicate routine free flow conditions. Yellow means that the freeway is routinely "full" but operating at 60 mph. Red means that the freeway occasionally operates below

Figure 2: I-90 @ 161st Ave SE, Westbound (1999 weekdays average)

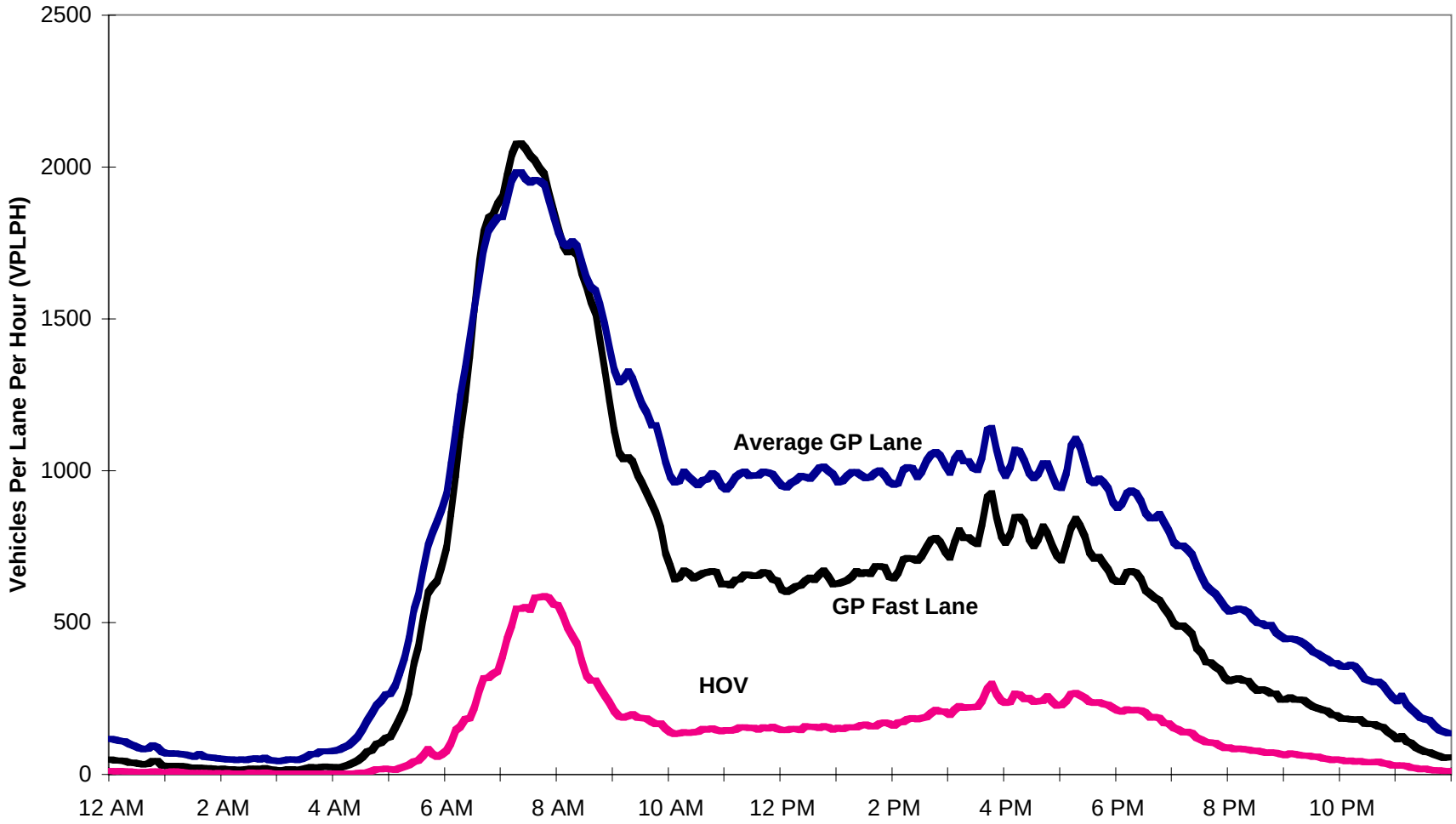


Figure 3

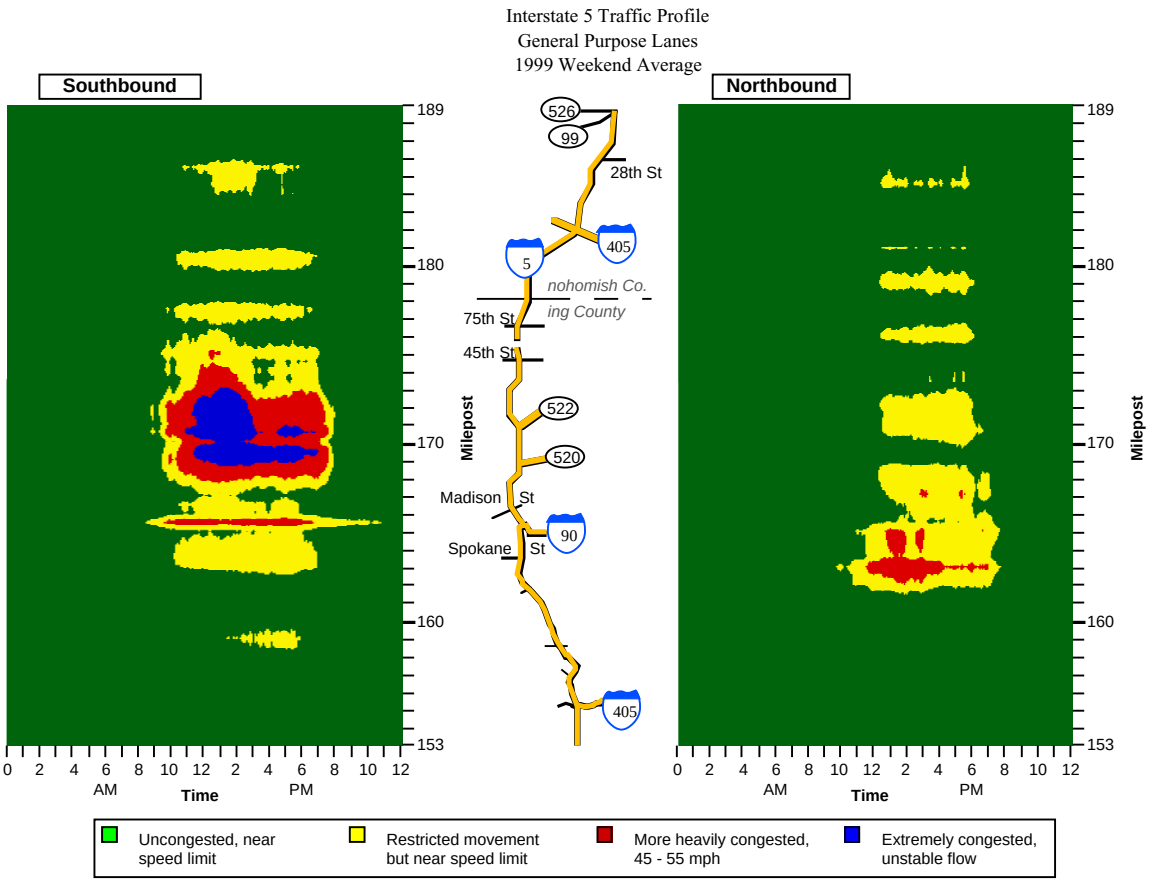

Interstate 5 Traffic Profile
General Purpose Lanes
1999 Weekend Average
Southbound
Northbound
526
99
28th St
405
5
nohomish Co.
ing County
75th St
45th St
522
520
Madison St
90
Spokane St
405
Milepost
189
180
170
160
153
0 2 4 6 8 10 12 2 4 6 8 10 12
AM
Time
PM
Uncongested, near speed limit
Restricted movement but near speed limit
More heavily congested, 45 - 55 mph
Extremely congested, unstable flow

Figure 4. Interstate 405 North Traffic Profile
General Purpose Lanes
1999 Weekday Average

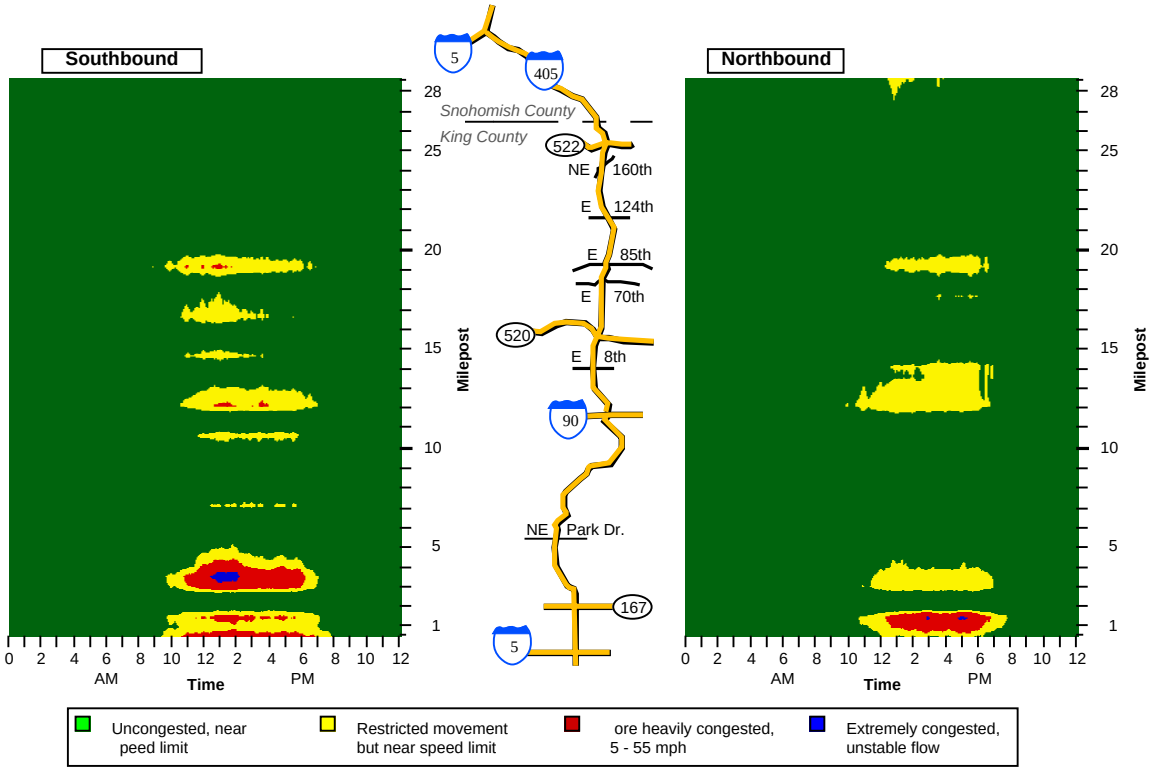


Figure 5. SR 167 Traffic Profile
General Purpose Lanes
1999 Weekday Average

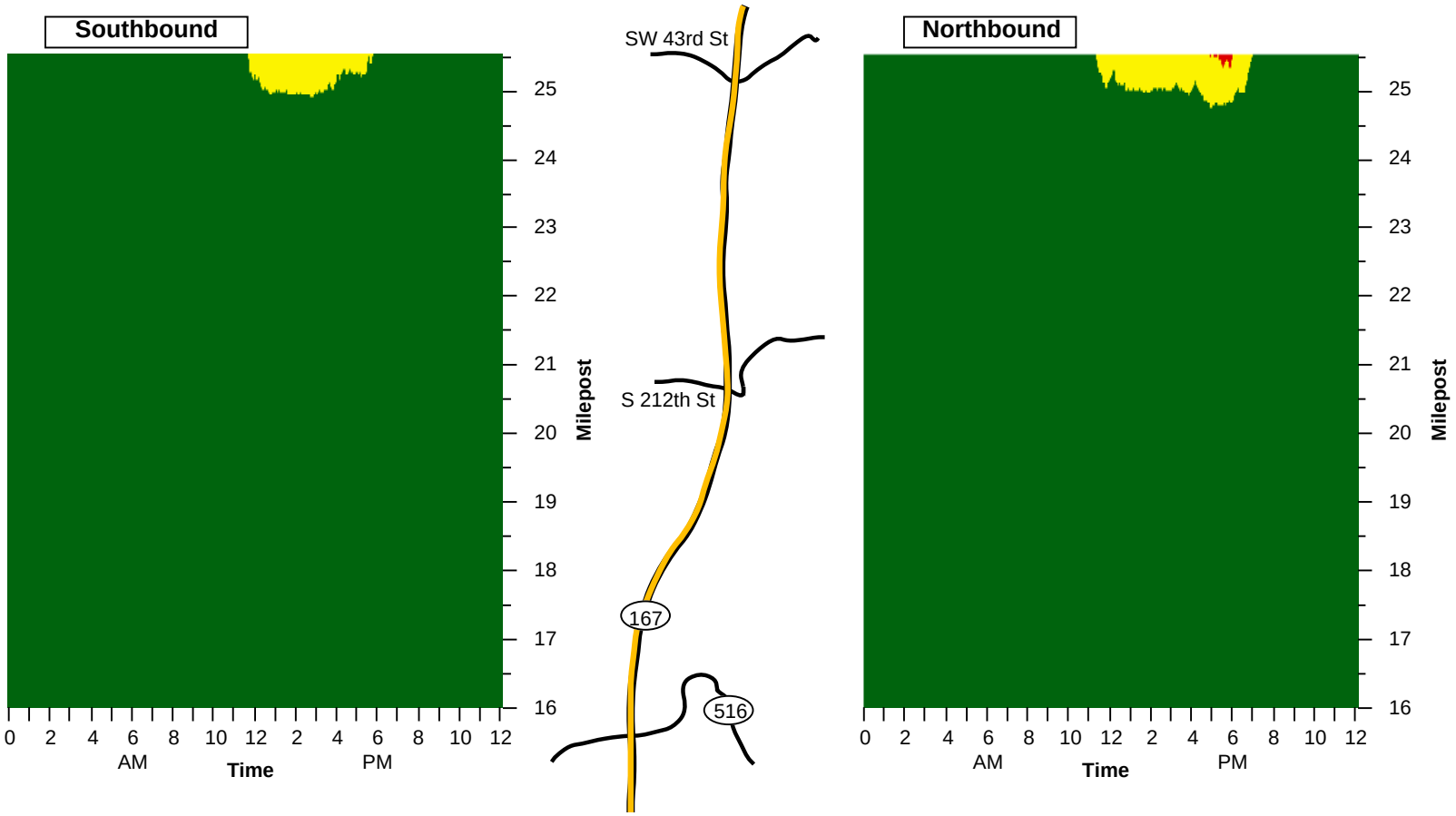


Figure 6

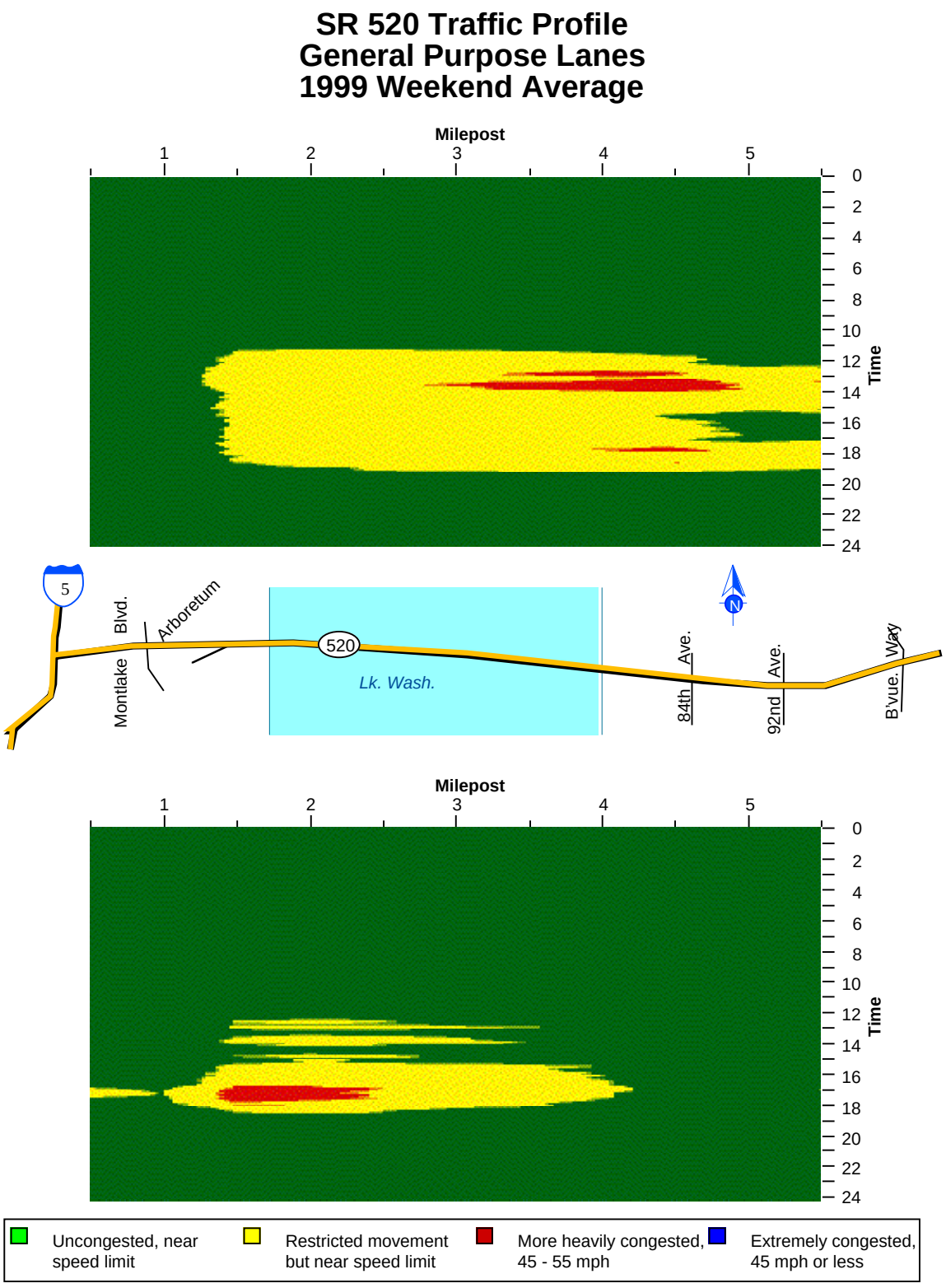
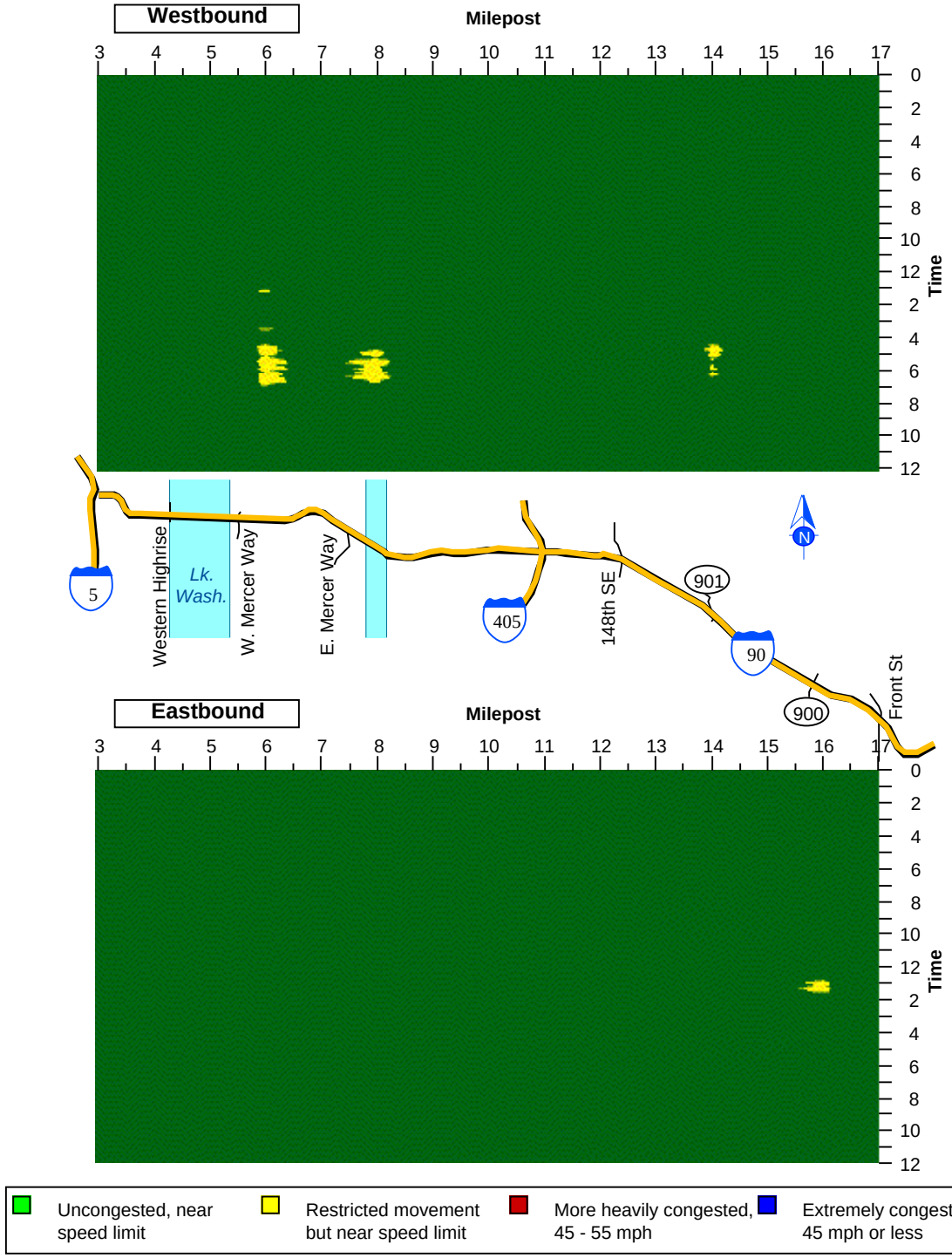

SR 520 Traffic Profile
General Purpose Lanes
1999 Weekend Average
Milepost
1
2
3
4
5
0
2
4
6
8
10
12
14
16
18
20
22
24
Time
5
Blvd.
Arboretum
Montlake
520
Lk. Wash.
84th
Ave.
92nd
Ave.
B'vue.
Way
Milepost
Time
Uncongested, near speed limit
Restricted movement but near speed limit
More heavily congested, 45 - 55 mph
Extremely congested, 45 mph or less

Figure 7. Interstate 90 Traffic Profile
General Purpose Lanes
1999 Weekend Average



AM, and can last as late as 8:00 PM. A combination of factors causes this congestion. These factors include high traffic volumes, the lack of an HOV lane, operation of the Express lanes northbound as opposed to southbound, the Mercer weave, and the merge/weave effects of the NE 45th Street ramp.

On I-5 northbound, the approach to the southern edge of downtown Seattle is also bad, although congestion is not as bad as at the Ship Canal Bridge. Northbound traffic routinely slows at the merge with the West Seattle Freeway and continues to experience congestion problems through the Mercer Weave. However, LOS F congestion occurs only two or three times a month.

(Note: On I-5 southbound, north of Everett, another bottleneck exists, but this congestion is north of the location where WSDOT has surveillance equipment. This bottleneck breaks loose south of Everett where the HOV system begins.)

I-405 congestion (see Figure 4) is similar in size and scope to that found on northbound I-5. Congestion extends both north and south of the SR 167 interchange. Traffic in both directions approaching the SR 167 interchange reaches LOS F three to five times per month.

The rest of I-405 experiences much lower levels of congestion. North of Renton, the freeway often operates in a nearly full condition, but it rarely breaks down in either direction. Crowded but free flowing conditions are common through Bellevue, Kirkland, and Totem Lake.

Likewise, SR 167 (see Figure 5) experiences very little actual congestion, although the merge at the I-405 interchange can slow traffic during the late afternoon and early evening.

SR 520 experiences more congestion than SR 167 but slightly less than I-405 in the south end. Westbound, SR 520 falls to LOS F roughly twice a month during both the early and late afternoon approaching the floating bridge (see Figure 6). Eastbound, the approaches to the bridge also become congested roughly twice a month.

Finally, I-90 is almost completely free of congestion outside of its interchange with I-5 and the exits to downtown Seattle. (See Figure 7, which does not include the ramp congestion.) The downtown interchange is dramatically affected by special event traffic. Outside of downtown Seattle, only occasional congestion at the exits to Issaquah causes congestion on the weekends.

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55 mph, and breaks down occasionally. Blue means that LOS F conditions occur frequently (that is, more than 20 percent of the time).

VOLUMES IN HOV AND GENERAL PURPOSE LANES

With a few exceptions, HOV volumes follow the trends described earlier. On average, volumes in HOV lanes are slightly lower than those in adjacent general purpose lanes. However, whenever congestion is present on weekend days, HOV lane volumes tend to be roughly equal to GP lane volumes. As a result, at times on weekends when congestion is routine, average GP volumes are only marginally higher than average HOV volumes. In addition, because GP volumes are high enough to warrant use of the HOV lane by eligible vehicles, HOV lane volumes are increasing faster than GP volumes.

Figures 8 and 9 illustrate these basic trends. They illustrate weekend volumes in 1995 and 1999, northbound on I-5 near Spokane Street. The volume differential has dropped from over 600 vehicles per hour in 1995 to about 400 vehicles per hour in 1999. Minor congestion has also begun to appear during the mid- to late-afternoon in both GP and HOV lanes. (The congestion frequency histogram is plotted only for GP lanes, although HOV lane speeds are also routinely below the speed limit at this location.)

Figures 10 and 11 illustrate weekend HOV and GP volumes on I-405 in Renton. At this location near the SR 169 interchange (north of SR 167), the 1999 southbound HOV lane volumes in the middle of the day are only 200 to 300 vehicles per hour lower than the general purpose lane volumes. In 1997, the midday volume difference between these lanes was closer to 500 vehicles per hour. At the same time, it also apparent that the GP lanes are heavily congested 15 to 20 percent of the time in the afternoons, and these congested periods are likely to be both holding down average volumes and encouraging HOV eligible vehicles to use the HOV lane.

Two areas where exceptions to the "conventional" HOV volume patterns occur are on SR 520 approaching the bridge and on SR 167 approaching I-405. On SR 520, HOV volumes remain very low. The 3+ occupancy requirement and the tight shoulder configuration of the HOV lane on this facility discourage use of the lane. HOV volumes have actually decreased slightly from 1997 to 1999. (See Figures 12 and 13.) The decrease is almost entirely due to a reduction in the frequency of congestion on this facility in the afternoons. TRAC speculates that this reduction is a result of the opening of the I-90 ramps into downtown Seattle, with their improved service of Safeco Field and the old Kingdome. This new facility makes travel to the stadium area south of downtown much easier via I-90 and consequently draws traffic away from SR 520 during some of the peak weekend periods. These peak period demand reductions lower the frequency of congestion on SR 520 and consequently reduce the need for HOV eligible vehicles to use the shoulder lane.

Figure 8: Estimated Weekend Volume, Speed, and Reliability Conditions (1995)

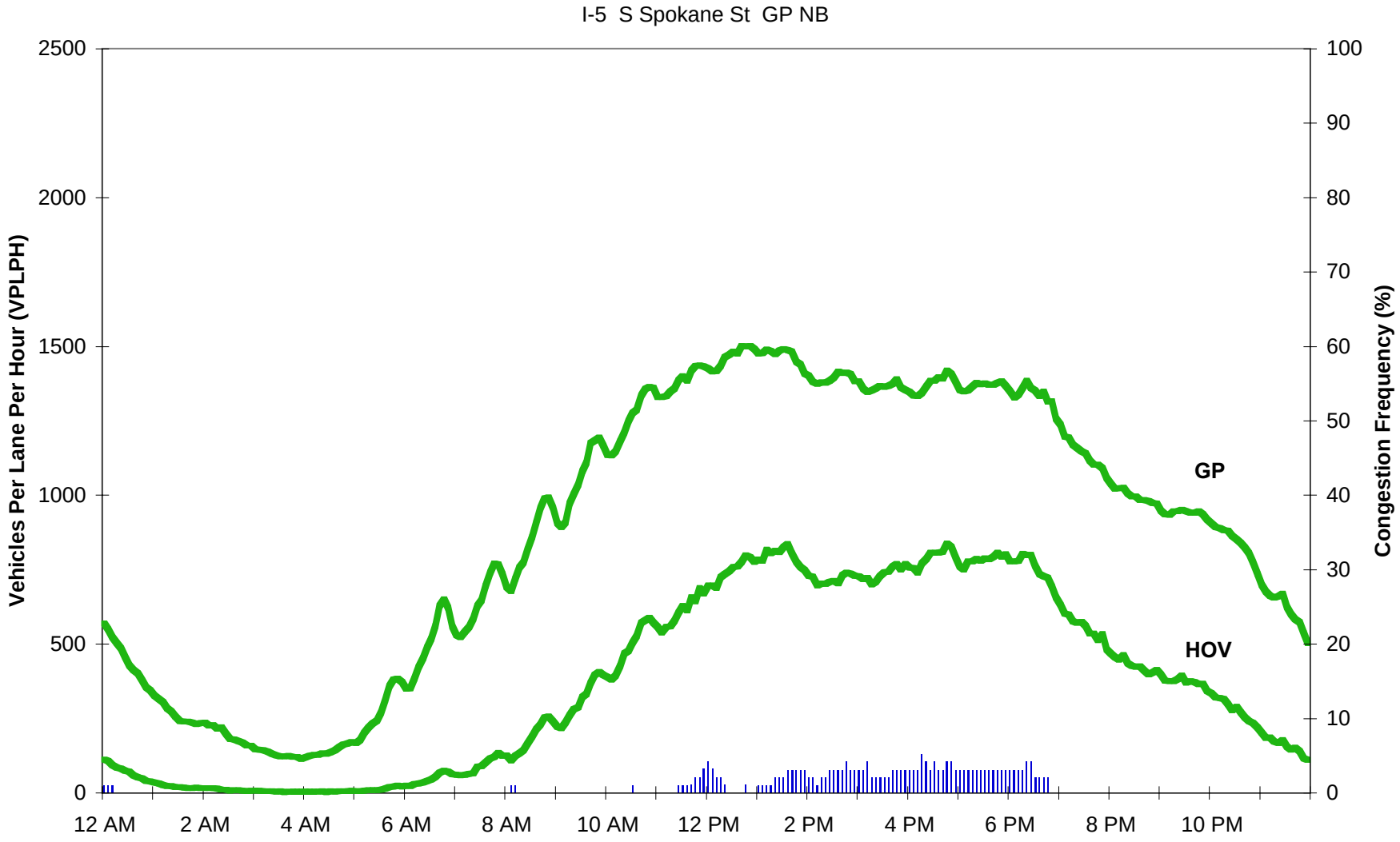


Figure 9: Estimated Weekend Volume, Speed, and Reliability Conditions (1999)

I-5 S Spokane St GP NB

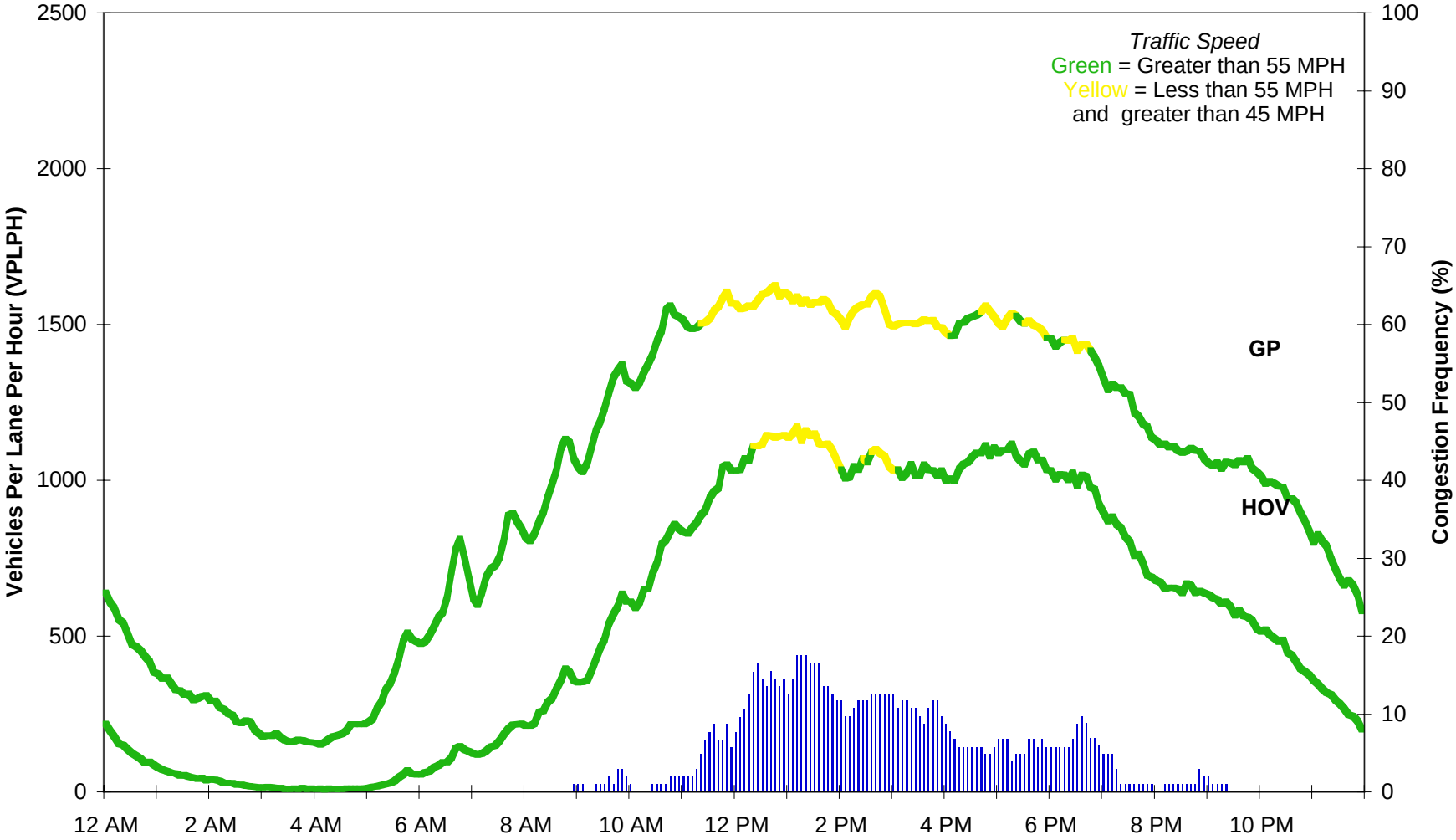


Figure 10: Estimated Weekend Volume, Speed, and Reliability Conditions (1997)

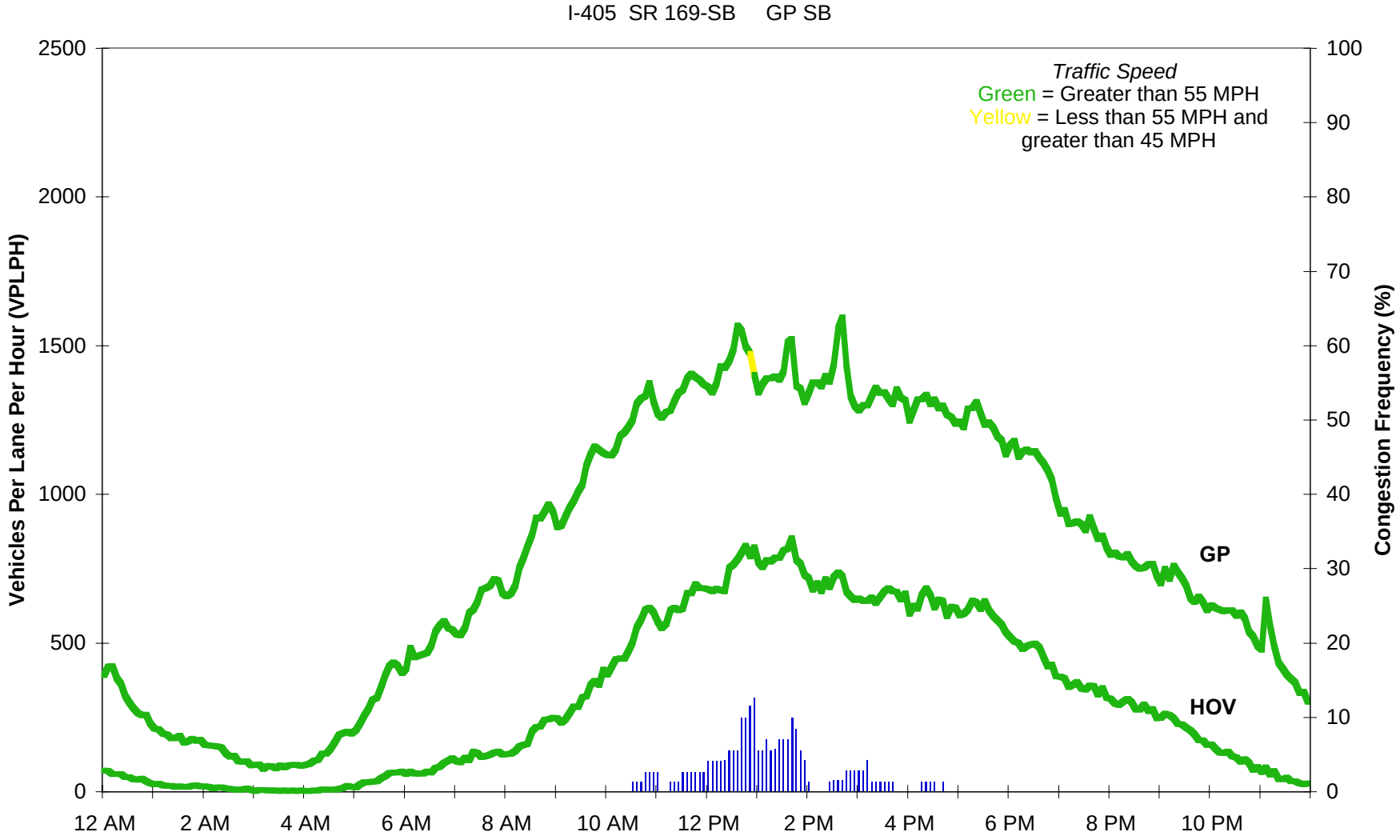


Figure 11: Estimated Weekend Volume, Speed, and Reliability Conditions (1999)

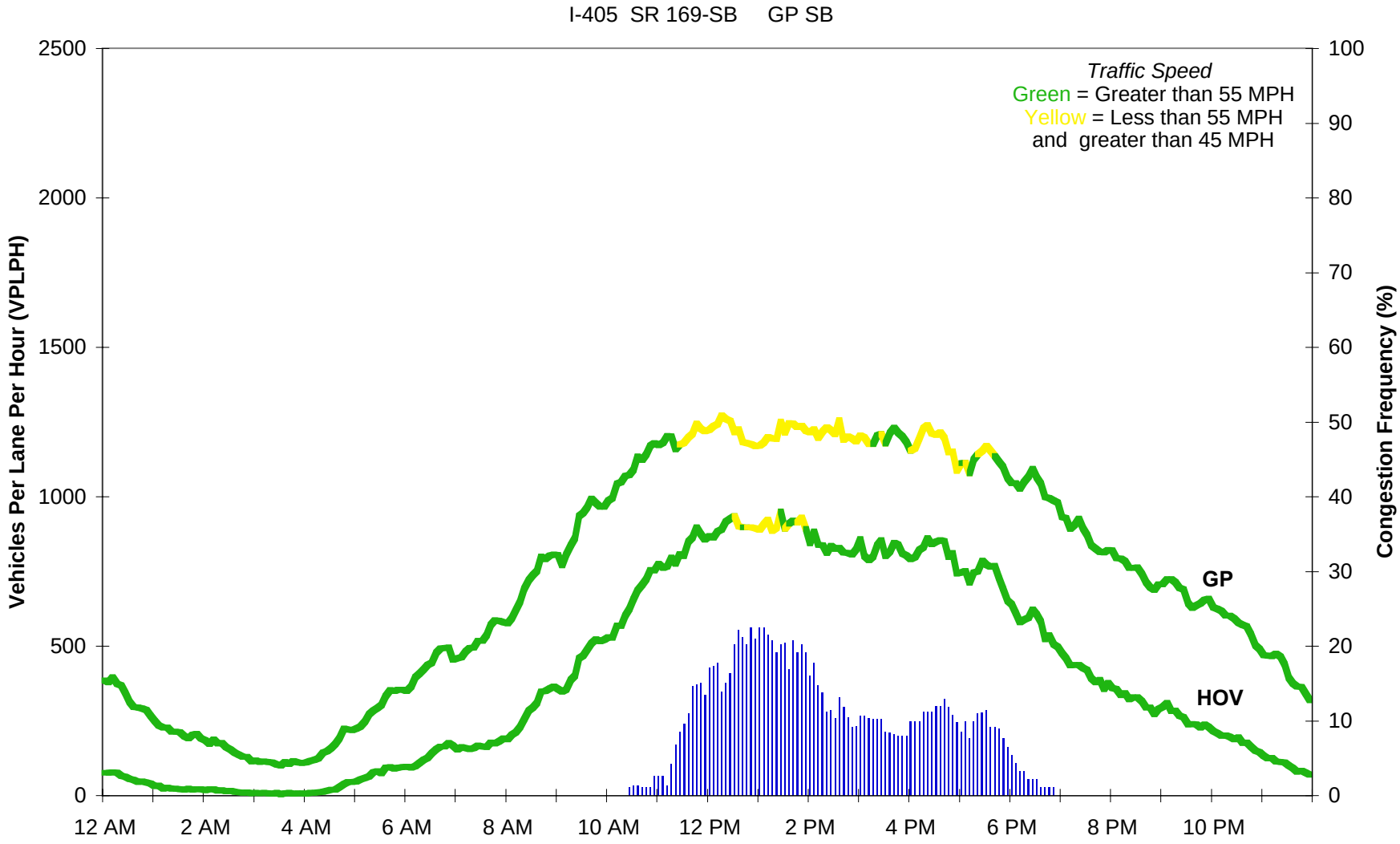


Figure 12: Estimated Weekend Volume, Speed, and Reliability Conditions (1997)

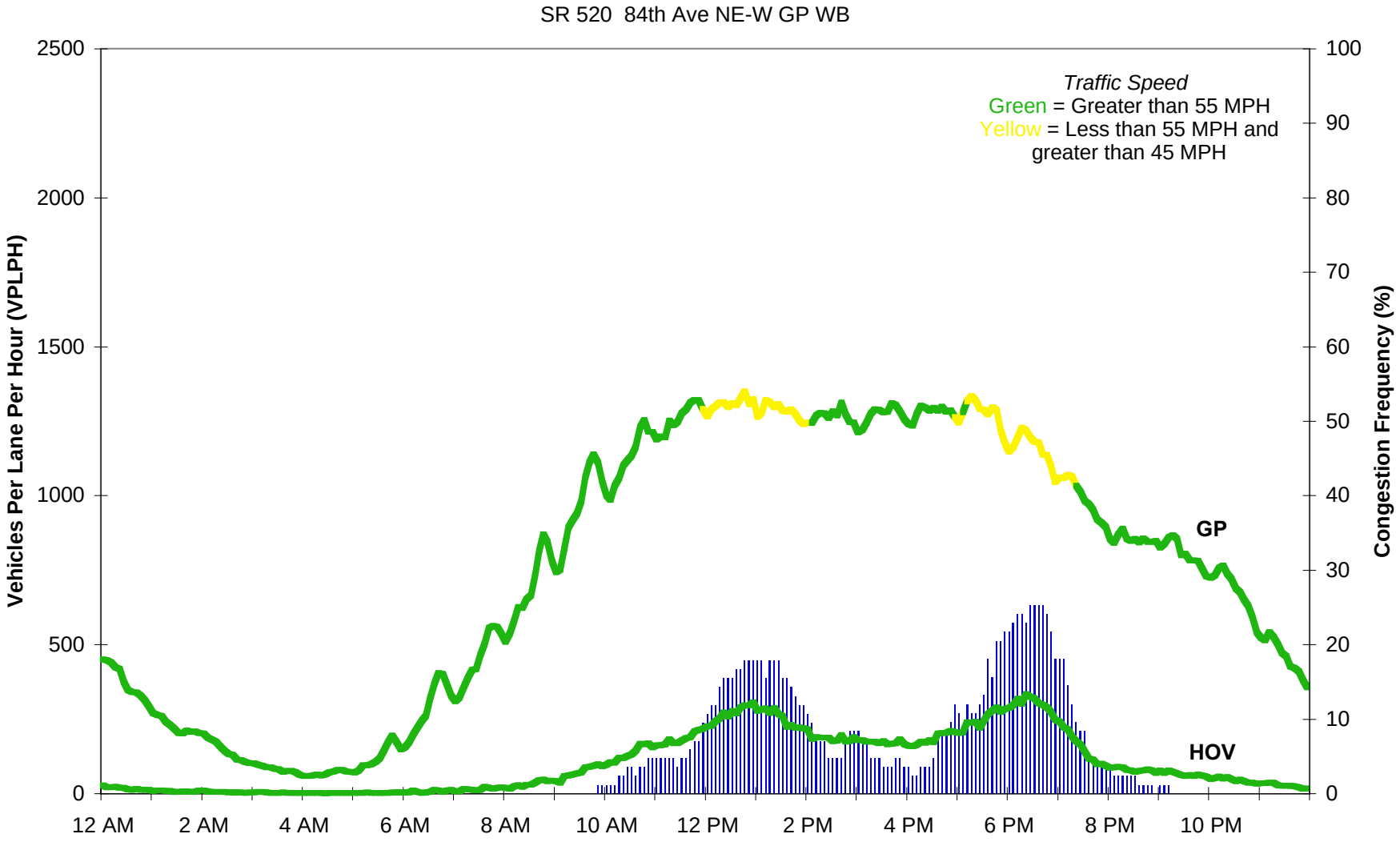
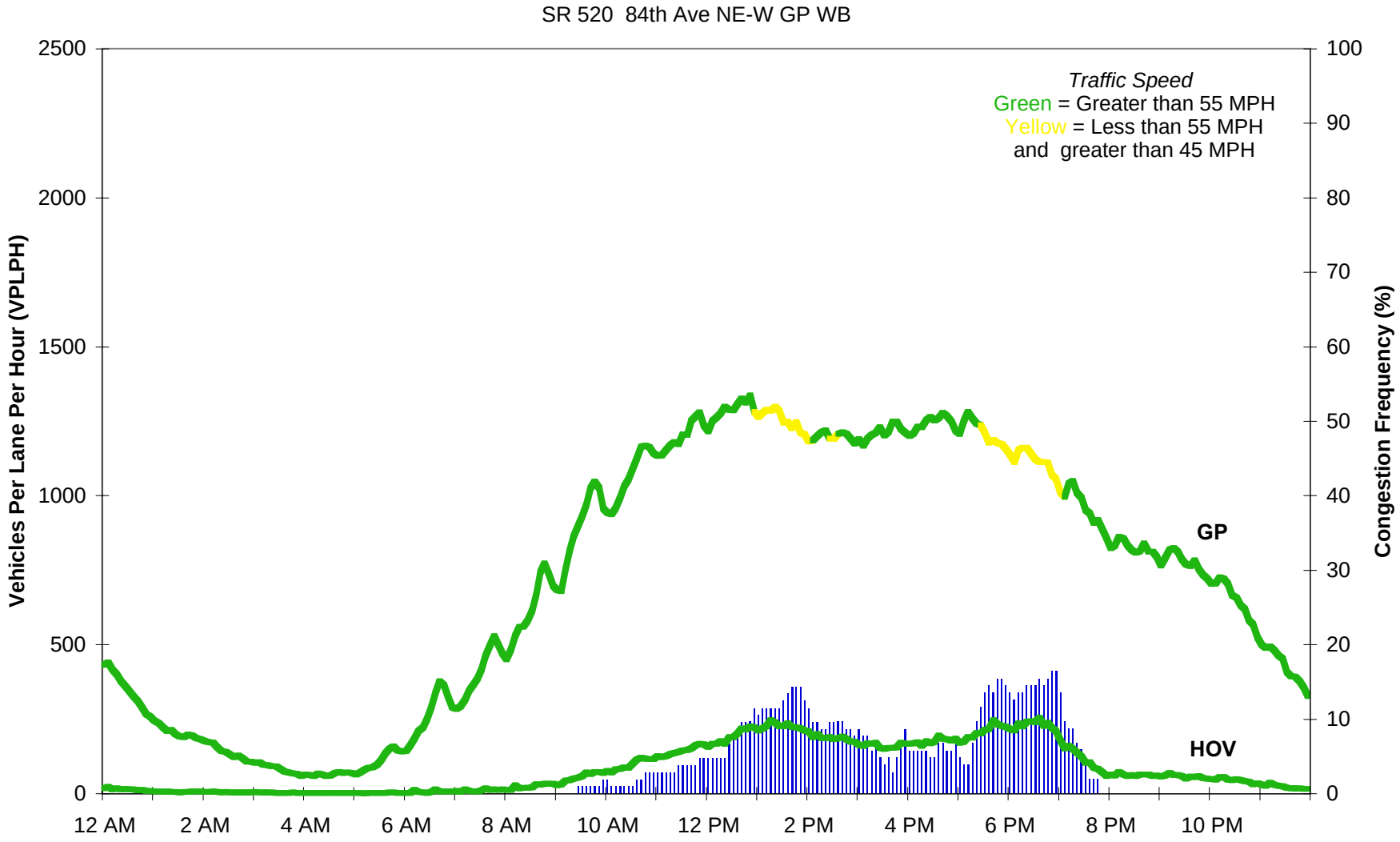


Figure 13: Estimated Weekend Volume, Speed, and Reliability Conditions (1999)



SR 167 has lower HOV volumes approaching the I-405 interchange (see Figure 14) for different reasons. In this case, the data collection location is within 1/2 mile of the exit ramp to northbound I-405. Thus many HOV vehicles have already exited the left-hand HOV lane in order to weave across the GP lanes to use the right-hand exit to northbound I-405. Some HOVs are also likely to have exited the lane at this point to travel southward on I-405. An analysis of HOV volumes farther south on SR 167 (see Figure 15) shows a GP to HOV volume relationship equivalent to what is seen elsewhere in the region.

SPEED AND PERFORMANCE OF HOV AND GP LANES

HOV lane speeds tend to be slightly higher than speeds in the general purpose lanes. Even when the general purpose lanes are free flowing, vehicles in the HOV lanes tend to travel slightly faster. (See Figures 16 and 17.) HOV lane speeds on the weekend tend to average 70 mph in free flow conditions, whereas GP lanes average closer to 60 or 65 mph. This speed differential is consistent with the basic idea that HOV lanes are used on the weekends primarily by HOV eligible vehicles that wish to go slightly faster than traffic in the GP lanes. Thus, under free flow conditions, most HOV lane users are drivers who wish to go 70 mph. As GP speeds slow down, more and more HOV eligible vehicles use the HOV lanes, and speeds drop slightly as these motorists are more likely to be happy driving 60 to 65 mph.

EFFECT OF "PERCEPTION" ON CONGESTION FREQUENCY

The issue of using the HOV lanes to "go fast" on the weekends is consistent with much of the desire to open up the HOV lanes to GP traffic. While theories are difficult to quantify scientifically, many in the traffic engineering profession believe that a significant fraction of the driving public wishes to drive faster than the speed limit partly out of the desire to "make up for time spent stuck in traffic elsewhere," partly because modern cars are easily driven at faster speeds, and partly because time constraints in personal lives put pressure on drivers to get where they are going as quickly as possible. Access to the HOV lanes would allow this segment of the population greater freedom to relieve their frustration at being constrained by other vehicles' speeds by giving them additional space in which to pass slower moving vehicles, even though those vehicles are traveling at or near the speed limit.

To these individuals, "congestion" is defined as traffic volumes that constrain their ability to travel at the speed they select (rather than the legal speed posted). To illustrate the effect of perception on a driver's view of facility performance, we have revised the contour graphic

Figure 14: Estimated Weekend Volume, Speed, and Reliability Conditions

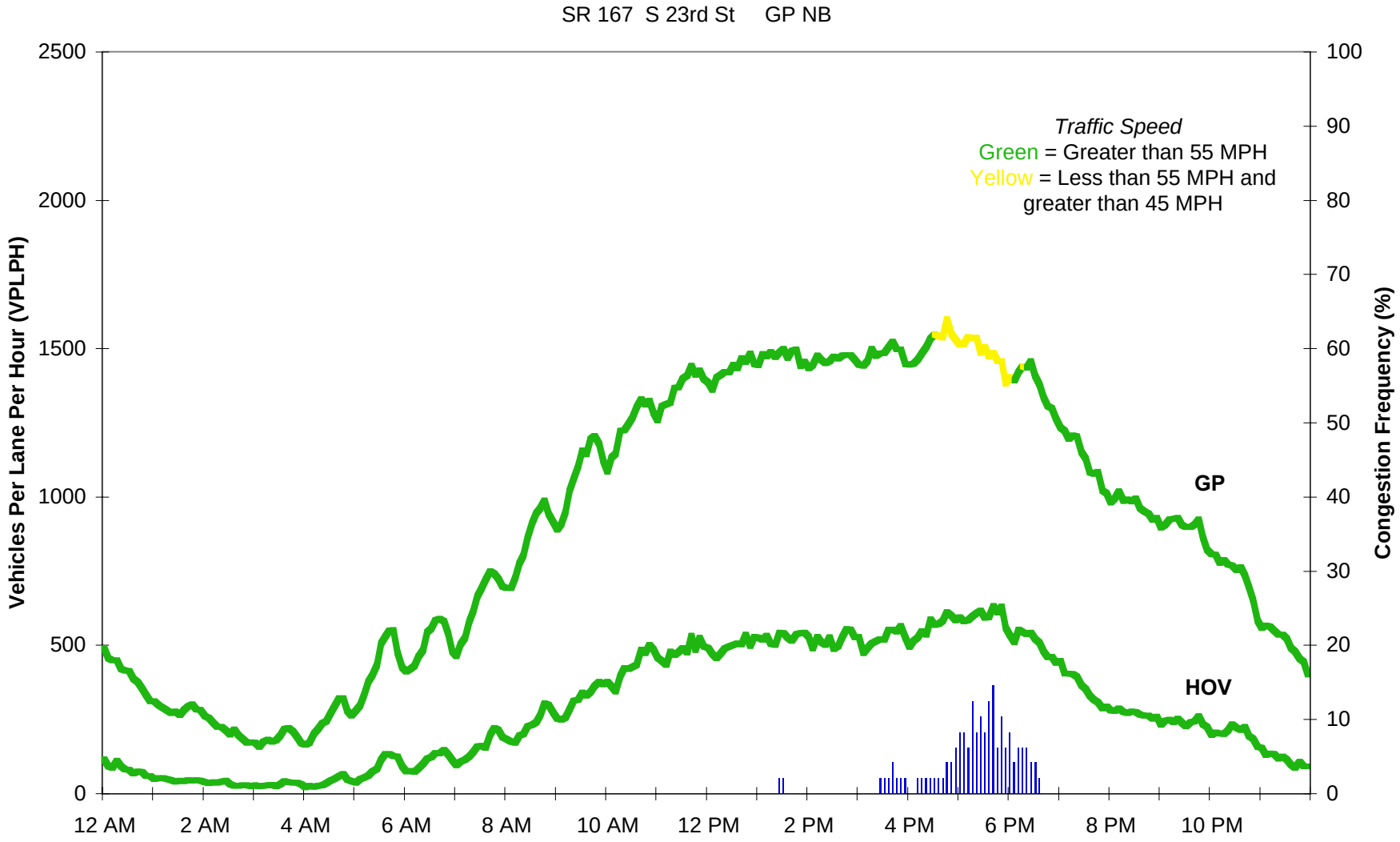


Figure 15: Estimated Weekend Volume, Speed, and Reliability Conditions (1999)

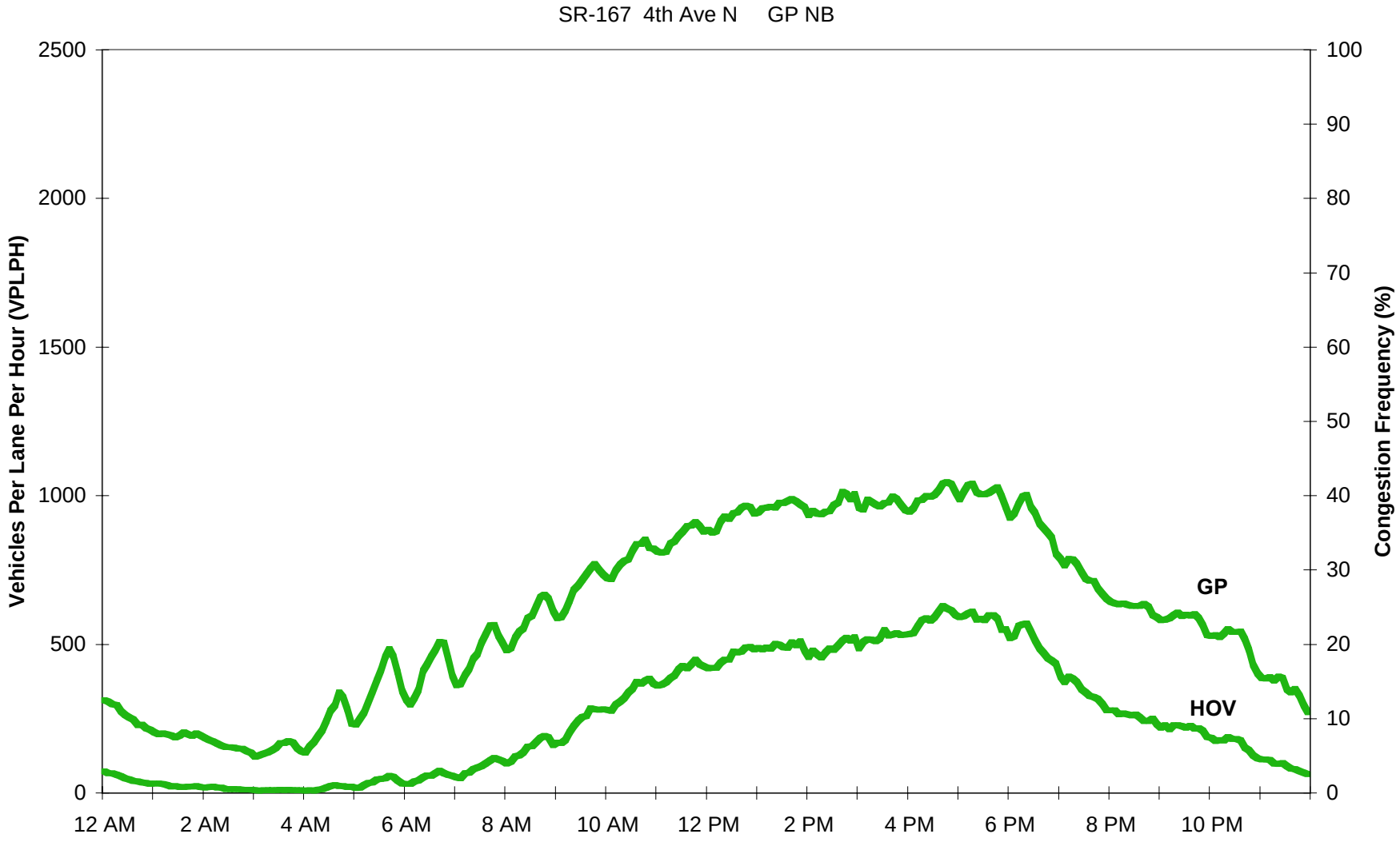


Figure 16: I-405 at NE 24th St.
Saturday NB Speeds

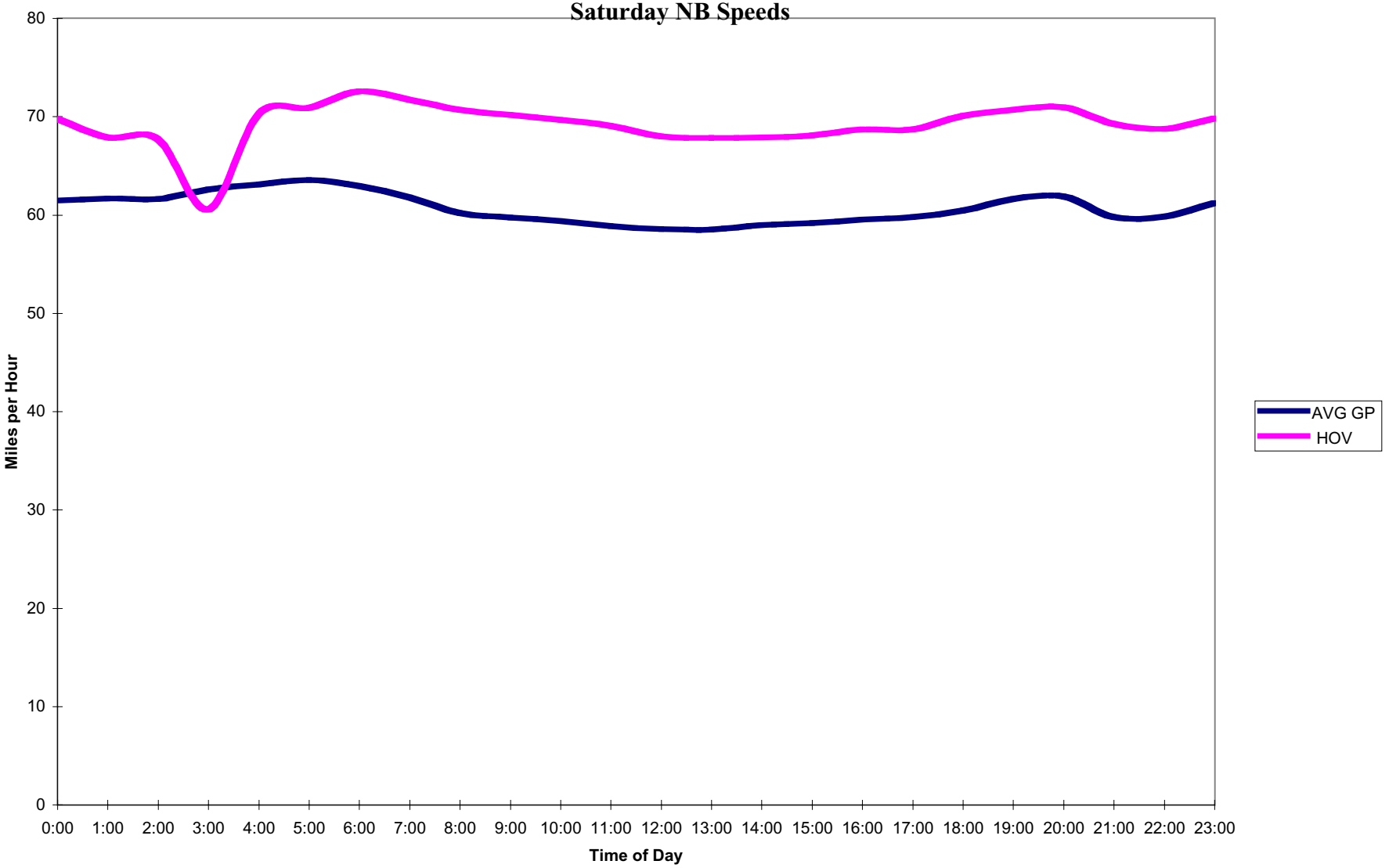
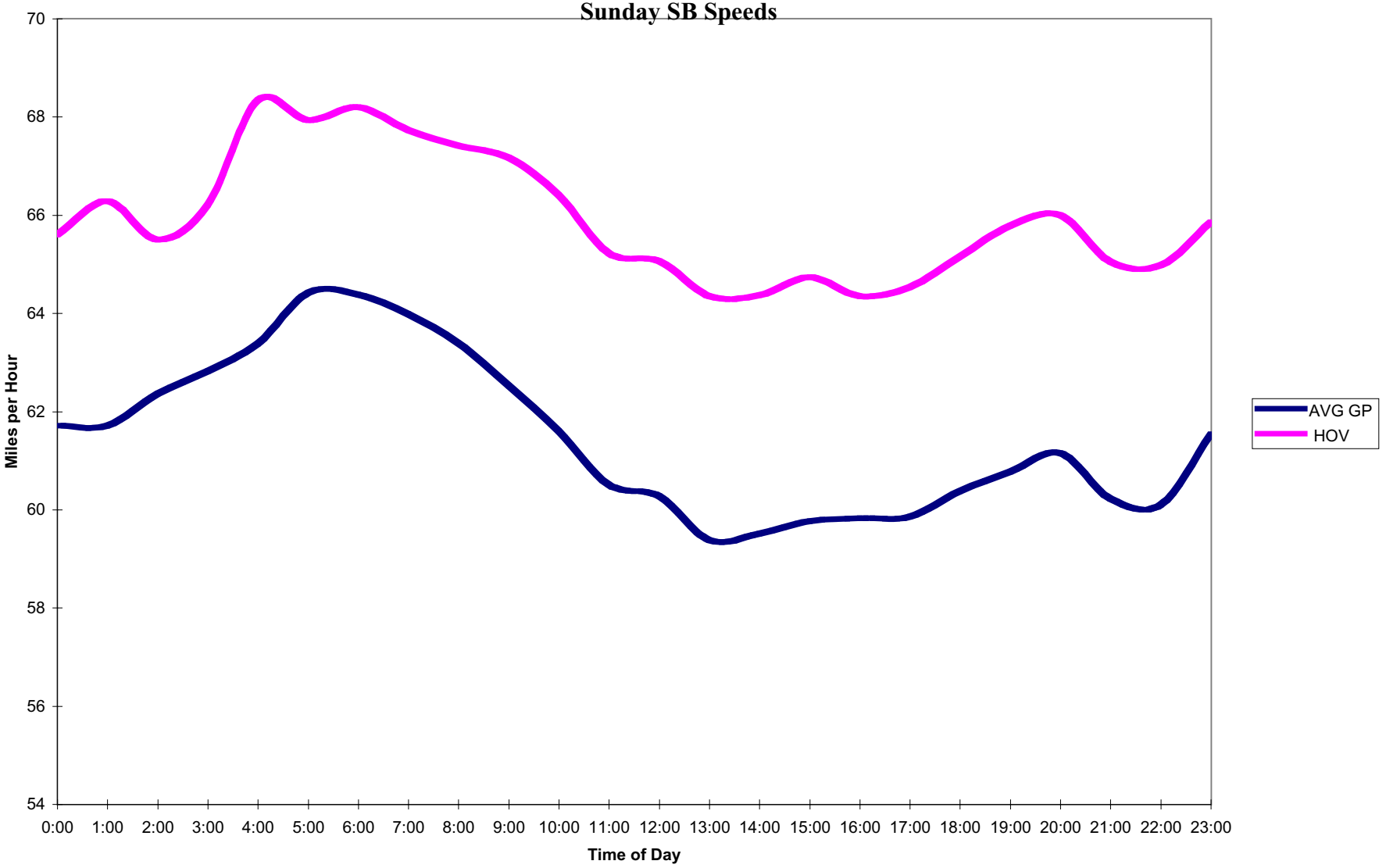


Figure 17: I-405 at NE 24th St.
Sunday SB Speeds



shown in Figure 3. This time, instead of illustrating the "average weekend condition" the same contour technique illustrates the frequency with which "congestion" occurs. Figure 18 shows how frequently I-5 becomes congested on weekends when the definition of "congestion" is the beginning of LOS F (that is, where vehicle speeds become unstable). In this graph, light gray represents up to one weekend day per month of congestion. Gray represents more than one day but no more than two days per month of congestion. Light blue represents more than two, but less than three days of congestion. Dark blue is more than three but no more than six days of congestion. Black represents more than six days of congestion per month.

Keeping the same color scale but changing the definition of "congestion" to the beginning of LOS E (speeds of 45 to 55 mph, little room to change lanes) produces an image of worse congestion on southbound I-5. (See Figure 19.) Changing the definition of congestion to the beginning of LOS D (speeds below 60 mph, care required to change lanes because of high volumes) produces extremely frequent congestion on I-5. (See Figure 20.)

For drivers intent on driving faster than 65, Figure 20 is probably a closer representation of what they consider "congestion" than the image that shows congestion from a pure traffic engineering standpoint (Figure 18). These drivers also correctly observe that vehicles in the HOV lanes are traveling faster than those in the GP lane (although not much faster) and want to reduce their frustration by using that lane. The frustration they feel by not being able to always use that lane creates the political push to open the HOV lanes for general purposes on weekends.

VOLUME AND PERFORMANCE EFFECTS OF USING THE HOV LANES FOR GENERAL PURPOSES ON WEEKENDS

In the author's opinion, for most Puget Sound freeways, converting HOV lanes to GP lanes on weekends will have very little effect on either traffic volumes or vehicle speeds. In almost all cases, the number of vehicles eligible to use the carpool lane is already sufficient to make the HOV lanes as full as the GP lanes. Those vehicles simply do not choose to use the HOV lanes unless congestion warrants it. In the vast majority of cases, when congestion appears, the HOV lanes are heavily used.

In a few cases, particularly bottleneck situations, encouraging GP vehicles to use the HOV lane system will cause a bad situation to get worse, such as on SR 520 approaching the bridge. In the case of I-405 at SR 167, it is unclear what the benefits will be. Some improvement in vehicle speed might be obtained for vehicles that remain on I-405. (A more detailed analysis of the relative size of the competing movements at this interchange is needed to deter-

Figure 18. Interstate 5 LOS F Frequency
General Purpose Lanes
1999 Weekend Average

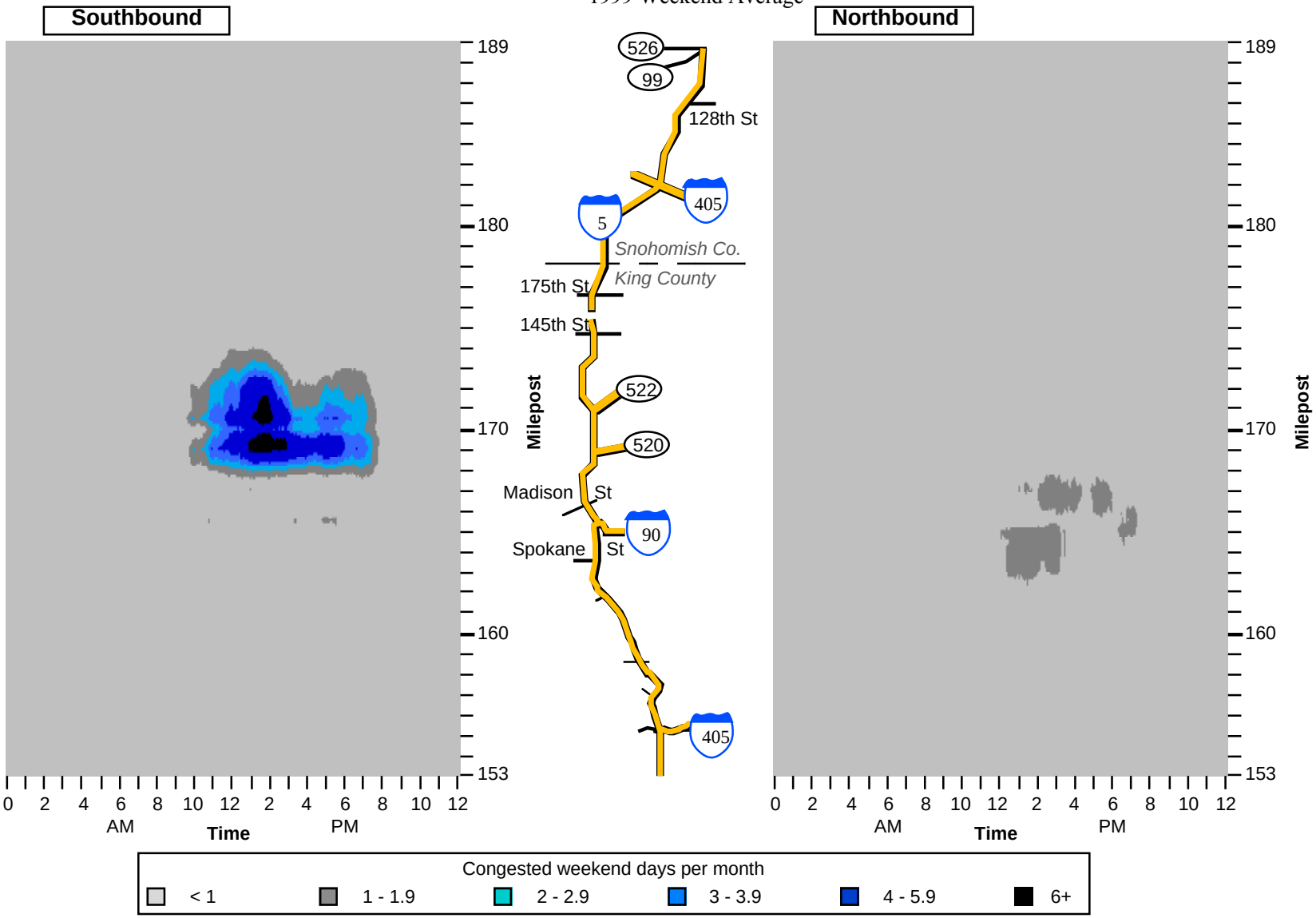


Figure 19. Interstate 5 LOS E Frequency
General Purpose Lanes
1999 Weekend Average

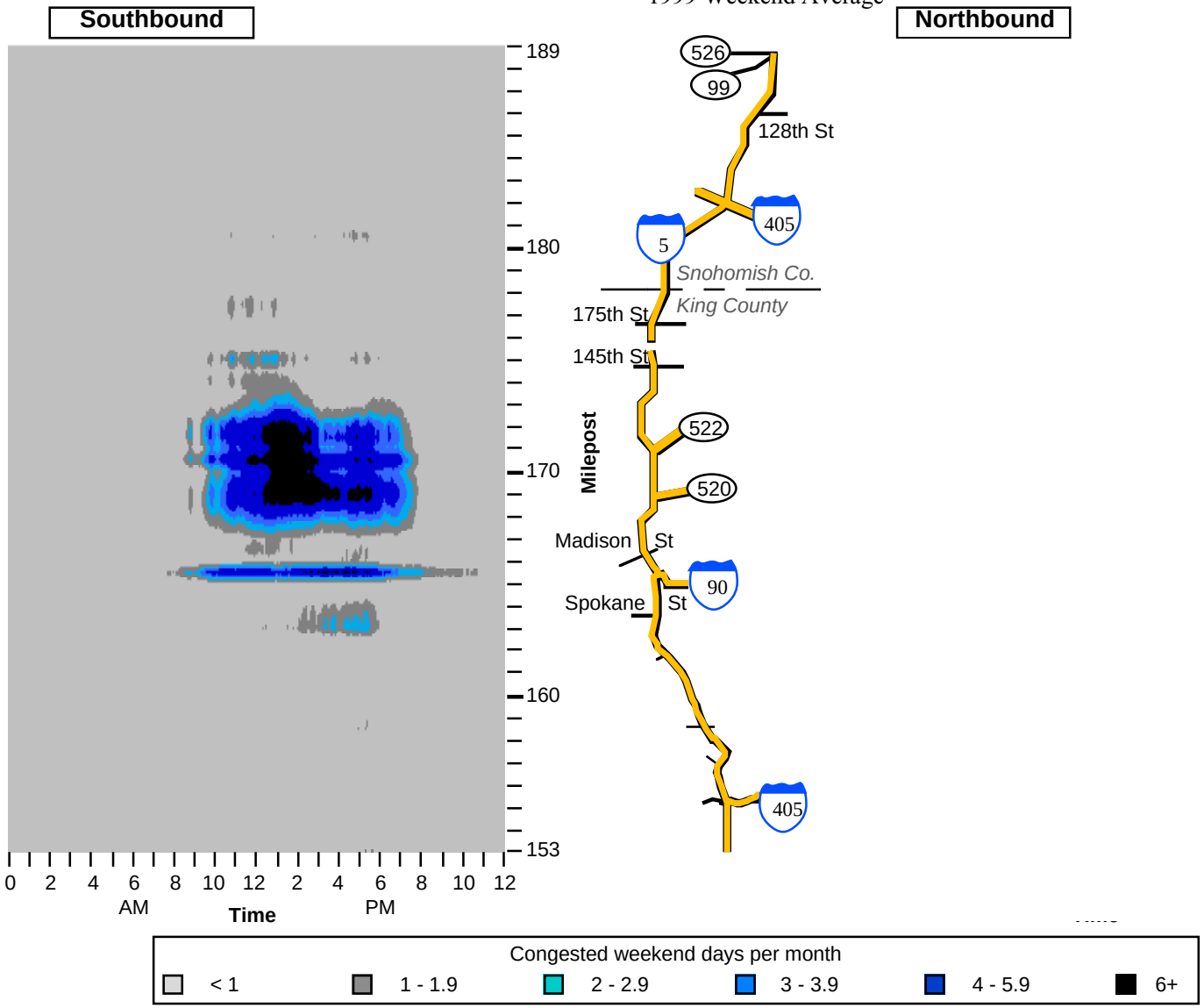
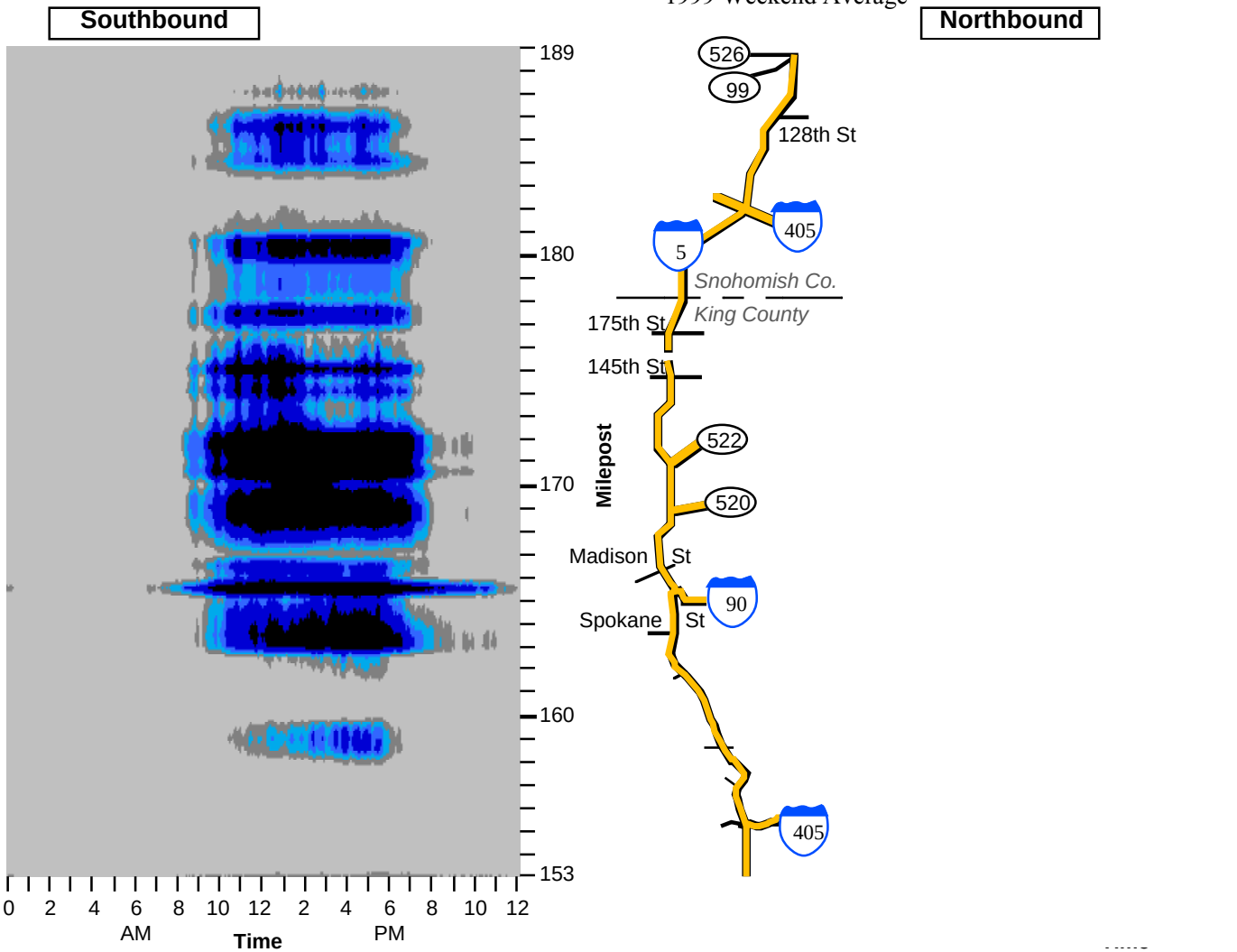


Figure 20. Interstate 5 LOS D Frequency
General Purpose Lanes
1999 Weekend Average



mine actual benefits that would be obtained.) However, vehicles trying to exit to SR 167 will receive no benefit, and the added lane of through-traffic may in fact create a safety hazard at the collector-distributor gore point as vehicles try to drive past the exit ramp queue and push in to the line at the gore point itself. (This already occurs at the SR 520 / I-405 interchange, where the completion of the new HOV lane has created this exact situation.) If WSDOT receives funding to improve this interchange (according to the Northwest Region this project is one of the highest rated projects in the area), the congestion that currently exists at this interchange will essentially disappear. In that case, no benefit will be gained from opening up the HOV lane to GP traffic.

On I-5, no HOV facility crosses the Ship Canal bridge southbound on weekends. Thus, relaxation of the HOV rules will have no impact whatsoever on the weekend's worst congestion location. Northbound, the HOV lane is congested almost as often as the GP lanes. (See Figure 21.) To further illustrate this point, the WSDOT database was searched for weekend days when congestion occurred on both I-5 and I-405. The volumes in the GP and HOV lanes were then compared. Figure 22 shows the effect of congestion on northbound I-5 at Spokane Street. Figure 23 shows the effect of congestion on southbound I-405 at SR 169 (just north of SR 167). In both cases, HOV lane volumes are lower than GP lane volumes until congestion starts to occur. At that time, HOV lane volumes either equal GP lane volumes (on I-5) or exceed GP lane volumes (on I-405, where the HOV lane is affected less by the backup from the SR 167 exit). Neither of these results is surprising, given the high level of vehicles eligible to use the carpool lane on weekends. Thus, relaxation of the HOV rules may provide a slight increase in HOV lane use, but little or no actual congestion relief will occur because the HOV lanes are congested whenever significant congestion occurs in the GP lanes.

Figure 21: Estimated Weekend Volume, Speed, and Reliability Conditions (1999)

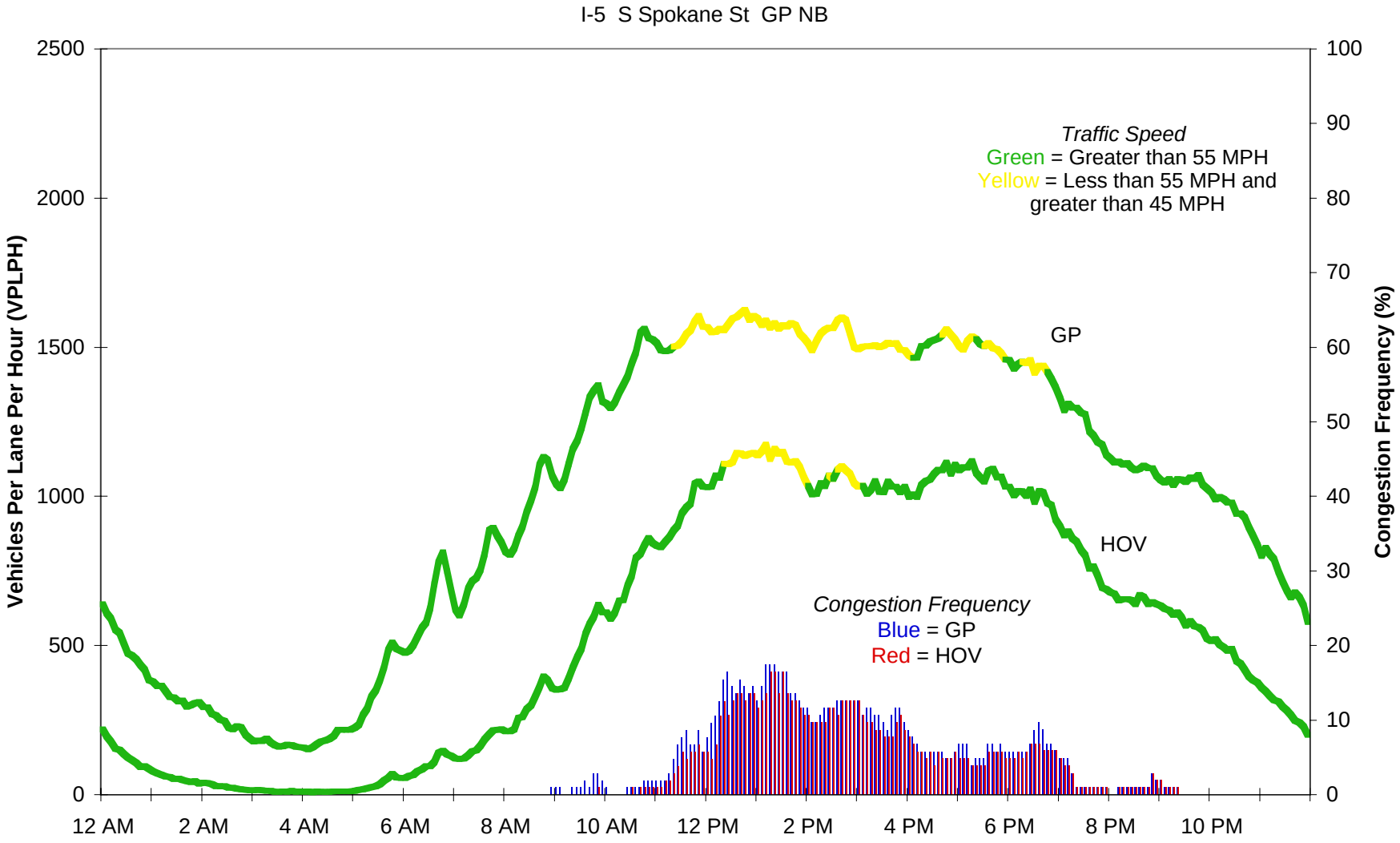


Figure 22: Estimated GP and HOV Volume and Speed

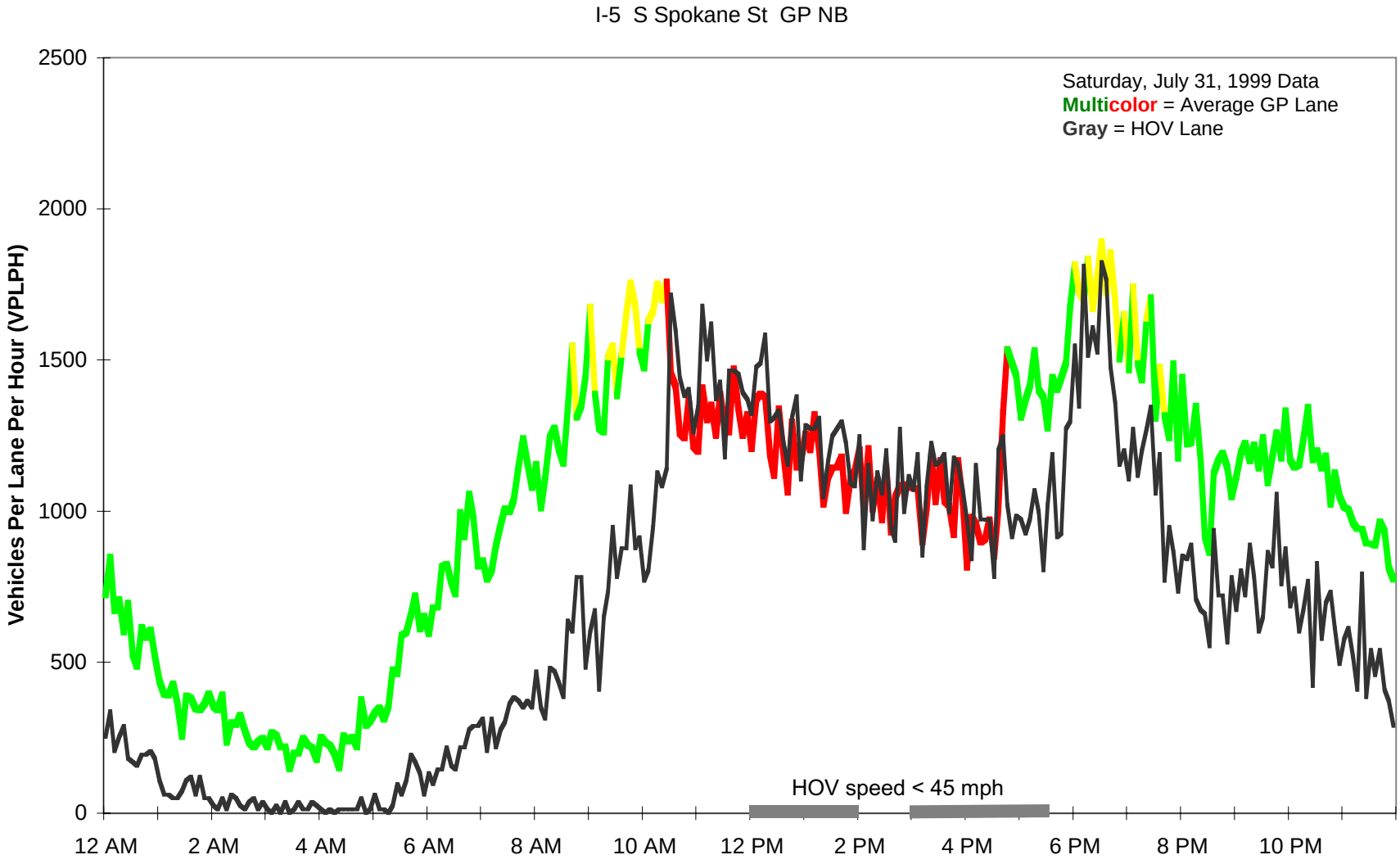


Figure 23: Estimated GP and HOV Volume and Speed Conditions