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HOV LANE PERFORMANCE MONITORING: 1998 ANNUAL REPORT

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16. ABSTRACT

High occupancy vehicle (HOV) lanes, also known as carpool lanes and diamond lanes, are designated for use by carpoolers, transit riders, ridesharers, and motorcycles that meet the occupancy requirement. By restricting access, the HOV lanes benefit users by allowing them to travel the freeway system at a faster speed, thus saving time and experiencing greater travel time reliability in comparison to motorists on general purpose (GP) lanes. To accurately evaluate the system's effectiveness, a state policy requires an annual HOV system report to document system performance, examining the HOV lanes' person-carrying capability, travel time savings, and trip reliability benefits in comparison to adjacent GP lanes, as well as the lanes' violation rates.

This report describes the results of an extensive monitoring effort of HOV lane use and performance in the Puget Sound area in 1998. It presents an analysis of data collected to describe the number of people and vehicles that use those lanes, the reliability of the HOV lanes, travel time savings in comparison to general purpose lanes, violation rates, and public perceptions. This information is intended to serve as reliable input for transportation decision makers and planners in evaluating the impact and adequacy of the existing HOV lane system in the Puget Sound area and in planning for other HOV facilities.

Descriptions of the tool set and methodology for analyzing HOV facility usage and performance in terms of vehicle and person throughput, travel time, and speed and reliability measures are provided in a separate report titled *Evaluation Tools for HOV Lanes Performance Monitoring*. Other relevant supplemental information, such as historical quarterly occupancy and probe vehicle speed data, is available from the HOV report Web site at <http://www.wsdot.wa.gov/eesc/atb/atb/hov/Titlepg.html>.

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High occupancy vehicle (HOV) lanes, also known as carpool lanes and diamond lanes, are designated for use by carpoolers, transit riders, ridesharers, and motorcycles that meets the occupancy requirement. By restricting access, the HOV lane benefits users by allowing them to travel the freeway system at a faster speed, thus saving time and experiencing greater travel time reliability in comparison to motorists on general purpose (GP) lanes.

HOV lanes exist in major corridors around the Puget Sound area, such as I-5, I-405, I-90, SR 520, and SR 167. Virtually all HOV lanes are available 24 hours a day, 7 days a week for vehicles that meet the occupancy requirement. The occupancy requirement for HOV lanes on limited access freeways is two or more persons, with the exception of the SR 520 westbound lanes, which havs a 3+ passenger requirement. Other exceptions to the occupancy requirement include motorcyclists, who can travel on any HOV lane, and SOVs traveling on the I-90 reversible lanes between Mercer Island and Seattle.

This report describes the results of an extensive monitoring effort of HOV lane use and performance in 1998. It presents an analysis of data collected to describe the number of people and vehicles that use those lanes, the reliability of the HOV lanes, travel time savings in comparison to general purpose lanes, violation rates, and public perceptions. This information is intended to serve as reliable input for policy making within the metropolitan area.

USAGE

The analysis revealed that HOV lanes are heavily used within the Puget Sound area, but usage varies with both time and location. In general, HOV lanes are used most heavily during peak commute periods and in peak directions. Usage is highest near high-density employment sites and diminishes near the suburban ends of individual HOV facilities. HOV volumes can be as high as 1,500 vehicles per lane per hour during the peak hours of operation, but midday HOV use is generally moderate with volumes near 500 vehicles per hour. However, HOV lane usage strengthens throughout the day, with particular growth in the shoulders of the HOV peak period. While not empty, the lanes do give an impression to many people of being under-utilized during these off-peak periods.

Three factors significantly affect HOV use:

- the level of transit service (quality, frequency, and number of buses) on the HOV lane
- the rules that govern HOV use
- the level of congestion found on the adjacent general purpose (GP) lanes.

High levels of quality transit service with consistent, on-time performance (which can only be assured with reliably functioning HOV lanes) significantly increase the number of people using HOV lanes, while adding only marginally to the number of vehicles that use the HOV lanes. This can result in lanes that "look empty" but that are actually moving considerably more people than the general purpose lane next to the HOV lane.

Where transit service is not superb, HOV lane people moving is performed primarily by carpools. Carpool use of HOV lanes is most significantly affected by the occupancy restriction placed on individual HOV facilities. Significant increases in an HOV lane's traffic volume occur under a 2+ in comparison to a 3+ carpool definition. Conversely, use of a 3+ carpool definition is a simple and effective means of limiting HOV lane volumes when geometric and operational safety concerns (e.g., on SR 520 westbound) outweigh the public's desire for HOV system access..

While excellent transit service and low carpool occupancy rules both provide strong incentives for using HOV lanes, heavy HOV lane usage only occurs when routine daily congestion on the adjoining GP lanes produces a significant disincentive for single occupancy vehicle use. When the incentives and disincentives outlined above are combined, HOV usage is high. When only one of these factors is present, HOV use is moderate.

OPERATIONAL PERFORMANCE

In general, HOV lanes perform as intended, maintaining an average speed of 45 mph or faster 90 percent of the time. However, some corridors do not meet that standard. A review of why they do not meet the standard shows that many of HOV lane delays are caused by GP lane congestion. That is, when stop-and-go congestion occurs in the GP lane, HOV traffic slows down because drivers are uncomfortable with traveling at 55 mph so close to stopped traffic. This is called "lane friction" and is not something that can be easily solved without the addition of a barrier between the GP lanes and HOV lane. Other causes for reduced HOV speed include the following: (1) congestion at the end point of HOV facilities, when HOV vehicles are forced to merge with GP lanes, (2) nearby incidents and incidents that block the HOV lane, (3) adverse weather such as a snow storm, and (4) geometric constraints of roadways such as hills and curves.

VIOLATION RATES

Violation rates are low in general. Low violation rates show that most people obey the HOV restrictions. Violations tend to increase in areas where getting caught is unlikely, such as near off-ramps where HOV and SOVs share the lane, and near the end of HOV facilities where HOV traffic merges into the GP lane. While we did study the effects of HOV enforcement, limitations in the types of data collected and stored did not allow us to determine a valid statistic that describes the effect that enforcement actions have on HOV lane violation rates.

PUBLIC PERCEPTION

Overall, the support for HOV lanes continues to remain high among all commuters. Although the opinions of HOV drivers and SOV drivers diverge on issues related to HOV lane usage, performance, and funding, the majority of both HOV and SOV drivers favor the idea of HOV lanes and additional HOV lane construction. A majority of commuters believe that HOV lanes are a fair use of taxpayers' money.

HOV Lane Utilization

Most surveyed drivers agreed that HOV lanes are easy to use. When asked about whether HOV lanes help save all commuters a lot of time, not surprisingly, SOV users tended to be more negative because they are forced to wait in congestion bottlenecks during the peak commute period. The predominant reason that drivers did not use HOV lanes is that traffic was already moving fast enough. Other reasons that HOV lanes were not used include the perception that they are slower than adjoining GP lanes during free flowing conditions and that changing lanes from them is difficult.

HOV Lane Operation

Public opinion showed a preference for keeping restrictions on HOV lanes at all times, with most respondents agreeing that HOV lanes should never be opened to all traffic. 86 percent of HOV drivers and 56 percent of SOV drivers supported this issue.

HOV Lane Violations

More than half of the respondents believed that HOV violations are common during the commute hours. The majority of the survey respondents were neutral in their opinion of the HERO program. This suggests that further public education may be needed to provide commuters with a greater understanding of the important role that 764-HERO plays in controlling HOV lane violations.

HOV Lane Improvements

Regarding options that may help improve the current HOV system, the public supports issues related to expansion and enforcement over issues linked to transportation management such as employer subsidies, increased bus service, and more park & ride lots. Constructing access ramps for inside HOV lanes received a fair amount of support as well. This may be due to the public's strong desire to continue expansion of the freeways to improve efficiency and lane capacity. Respondents also clearly favored inside HOV lanes, as well as wider and safer lanes.

CHAPTER ONE
INTRODUCTION

High occupancy vehicle (HOV) lanes, also known as carpool lanes and diamond lanes, are designated for use by carpoolers, transit riders, ridesharers, and motorcycles that meet the occupancy requirement. By restricting access in this way, the HOV lane benefits users by allowing them to travel the freeway system at a faster speed, thus saving time and experiencing greater travel time reliability in comparison to motorists on general purpose (GP) lanes. As indicated in the *1992 Washington State Freeway HOV System Policy* report, the objectives of the HOV facilities are threefold:

- *Improve the capability of congested freeway corridors to move more people by increasing the number of people per vehicle,*
- *Provide travel time savings and a more reliable trip time to high occupancy vehicles that use the facilities, and*
- *Provide safe travel options for high occupancy vehicles without unduly affecting the safety of freeway general-purpose mainlines.*

To ensure that these incentives for HOV users provide benefit, a state policy related to speed and reliability standards has been established. It states that any HOV facility "should maintain or exceed an average speed of 45 mph or greater at least 90 percent of the time" during the peak hour. To accurately evaluate the system's effectiveness, the policy also requires an annual report to document HOV system performance, examining the HOV lanes' person-carrying capability, travel time savings, and trip reliability benefits in comparison to adjacent GP lanes, as well as the lanes' violation rates.

REPORT OBJECTIVE

The objective of this report is to illustrate the performance of the HOV facilities in the Puget Sound area by using an advanced set of performance measures and tools. These results can help guide transportation decision makers and planners in evaluating the impact and adequacy of the existing HOV lane system in the Puget Sound area and in planning for other HOV facilities.

Descriptions of the tool set and methodology for analyzing HOV facility usage and performance in terms of vehicle and person throughput, travel time, and speed and reliability measures are provided in a separate report titled *Evaluation Tools for HOV Lanes Performance Monitoring.* Other relevant supplemental information, such as historical quarterly occupancy and probe vehicle speed data, is available from the HOV report Web site at <http://www.wsdot.wa.gov/eesc/atb/atb/hov/Titlepg.html>.

STUDIED CORRIDORS

HOV lanes exist in major corridors around the Puget Sound area. Virtually all HOV lanes are available 24 hours a day, 7 days a week for vehicles that meet the occupancy requirement. The occupancy requirement for HOV lanes on limited access freeways is two or more persons, with the exception of the SR 520 westbound lanes, which have a 3+ passenger requirement. Other exceptions to the occupancy requirement include motorcyclists, who can travel on any HOV lane, and SOVs traveling on the I-90 reversible lanes between Mercer Island and Seattle. Operational specifications for each of the studied HOV facilities are provided in Table 1-1.

This report presents corridor-wide and location specific HOV performance results for the following corridors: I-5, I-405, I-90, SR 520, and SR 167. Analysis on other corridors and locations (i.e., SR 16, SR 410, and SR 512) were not feasible because of limited data availability. Transit services offered on the measured corridors include Community Transit, Metro Transit, and Pierce Transit, which provide express service to several downtown locations and cross Lake Washington. As of late 1998, all HOV lanes have operated along the freeway median, with the exception of the HOV lane on SR 520, which operates along the shoulder. The outside to inside HOV lane conversion for I-405 north of the I-90 interchange was completed in autumn 1998.

Table 1-1. HOV System in Washington State

HOV Corridors	*Geometric*	*Direction*	*Number of Lanes*	*Operating Hours*	*Occupancy Requirement*
I-5	Concurrent Flow	NB, SB	1 each direction	24-hr	2+ HOVs
	Barrier Separated Express Lane Reversible Flow	SB (AM only)			
I-405	Concurrent Flow	NB, SB	1 each direction	24-hr	2+ HOVs
I-90	Concurrent Flow	WB, E	1 each direction	24-hr	2+ HOVs
	Barrier Separated Reversible Flow	WB (AM only) EB (PM only)	2 reversible		
SR 520	Concurrent Flow	WB	1 (WB only)	24-hr	3+ HOVs
SR 167	Concurrent Flow	NB, SB	1 each direction	24-hr	2+ HOVs

MEASURES OF EFFECTIVENESS

The measures of effectiveness (MOEs) for this project provide a valid basis for evaluating the performance of the current HOV lane system. In addition to their usefulness in making decisions concerning lane configuration, occupancy requirement policies, and general purpose lane conversion, the MOEs also help address WSDOT's needs for information to help determine where and when to construct new HOV facilities.

As stated by the WSDOT's *HOV Lane Minimum Threshold Policy*, four preconditions for HOV lane construction must exist:

1. Facility demand exceeds capacity for more than one hour each day.
2. Evidence exists that an HOV lane will move more people per hour during peak periods than the per-lane average of the adjacent general purpose lanes.
3. There is local support for HOV lane construction.
4. The HOV lane segment will improve continuity by linking other HOV lane corridors identified in the *Year 2000 HOV Core Lane System* report.

The impact of the HOV system is reflected through primary measures of effectiveness such as person throughput, vehicle occupancy, travel time, speed, and reliability. The ability of the HOV facility to carry more people is reflected through measures of vehicle and person throughput, as well as of vehicle occupancy. Travel time speed, and trip reliability illustrate the performance of the HOV facility. Secondary performance measures include enforcement and violations rates along the HOV lane system. In addition to the analysis supported by the quantitative data, it is also important to assess how the public perceives the performance of the HOV facility. A brief description of the primary and secondary measures on which the data collection efforts were focused is provided below.

Primary Measures

- **Vehicle Volume**—Number of vehicles recorded passing a given freeway location during weekday morning and evening peak commute periods, as well as over an average 24-hour weekday.

- **Person Volume**—Number of passengers measured at a given freeway location during weekday morning and evening peak commute periods.
- **Average Vehicle Occupancy**—Average number of occupants in a vehicle—which includes persons in cars, vanpools, and transit buses—at a given freeway location during weekday morning and evening peak commute periods.
- **Speed and Trip Reliability**—Average vehicle speeds based on the average travel time for a given trip. Trip reliability refers to the percentage of time that the vehicle travels less than 45 mph.
- **Travel Time**—Average time in hours and minutes required to complete a trip from point A to point B based on trip start time throughout an average weekday.

Secondary Measures

- **HOV Violations**—Because restrictions along the Puget Sound freeway HOV system apply 24 hours a day, the only violation to enforce is when motorists do not meet the minimum occupancy requirement. Indicators for HOV violations include violations observed on area highways by traffic observers, tickets and warnings issued by law enforcement officers, activity levels on the region's violation reporting hotline (764-HERO), and the support of the judicial system when tickets are contested in the courts.
- **Safety**—Public opinion survey results provide a variety of information about commuters' perceptions of HOV lane safety. These data measure the level of concern about safety and its impact on mode choice.
- **Public Opinion**—Public opinion data indicate the HOV program's perceived importance and effectiveness, as well as ways it may be modified to appeal to more of

the region's drivers. This report presents public opinion data that rank various options to improve the HOV system and that indicate differences in opinion between ridesharers and SOV commuters regarding HOV related issues.

REPORT ORGANIZATION

The intent of this report is to provide the results of an analysis of HOV system performance. Chapter 2 illustrates HOV lanes' ability to carry persons and vehicles. Speed and reliability for HOV lanes and travel time comparisons between GP and HOV lanes are presented in Chapter 3. HOV violation information is discussed in Chapter 4. Chapter 5 includes the results of a public opinion survey.

CHAPTER TWO
THROUGHPUT

To investigate the effectiveness of the HOV system, person and vehicle volumes were analyzed at specific sites along major HOV corridors, and the results were compared with those of GP lanes for morning and afternoon peak periods in the direction of heaviest traffic flow (directional flow). The purpose of these measures is to determine (1) whether the HOV lane is enhancing the person-carrying capacity of the system, and (2) to what extent an HOV lane is being used. Various types of HOV performance are reflected in the following sections:

- **General Results**

  General comparison of HOV vs. GP person throughput on a per-lane basis is provided for the representative sites over the defined peak periods. HOV person-carrying ability is described by the rate of average vehicle occupancy (AVO). Mode split and bus ridership in HOV lanes are also presented.

- **HOV Volume Flow**

  To examine more closely the extent and variation of changes in vehicle volumes observed along HOV corridors, HOV volumes along HOV corridors are depicted geographically during the peak periods for average weekdays. These graphics help identify directional patterns as well as locations with high and low HOV usage.

- **GP vs. HOV 24-hour Volume Profile**

  A 24-hour average daily traffic volume profile for each combination of lane type and traffic direction are presented for each of the representative sites.

For each location, the 24-hour GP and HOV volumes are expressed as volume per lane per hour (vplph) for both directions.

- **GP vs. HOV Throughput Comparison**

  Person and vehicle volumes for HOV and GP lanes are compared by lane type (i.e., GP, HOV) and by per-lane unit for both morning and afternoon peak periods for each representative site. The average vehicle occupancy rate is also presented. The per-lane comparison allows a true comparison between HOV and GP lane vehicle- and person-carrying abilities.

Ten representative sites were selected in the major corridors (i.e., I-5, I-405, I-90, SR 167 and SR 520) for detailed usage analysis. Selection was based on points of interest as well as the availability and usability of input data in 1998 (see Figure 2-1):

I-5 @ 112th SE – Everett (Near Everett)

I-5 @ NE 137th St. (Near Northgate)

I-5 @ Albro Place (South of Seattle Downtown)

I-405 @NE 85th St. (Near Kirkland)

I-405 @ SE 59nd St. (Near Factoria)

I-405 @ Tukwila Parkway (Near Southcenter)

I-90 @ Midspand (Floating Bridge)

I-90 @ Newport Way (Near Issaquah)

SR 520 @ 84th Ave. NE (Near Medina)

SR 167 @ S. 208th (Near Kent)

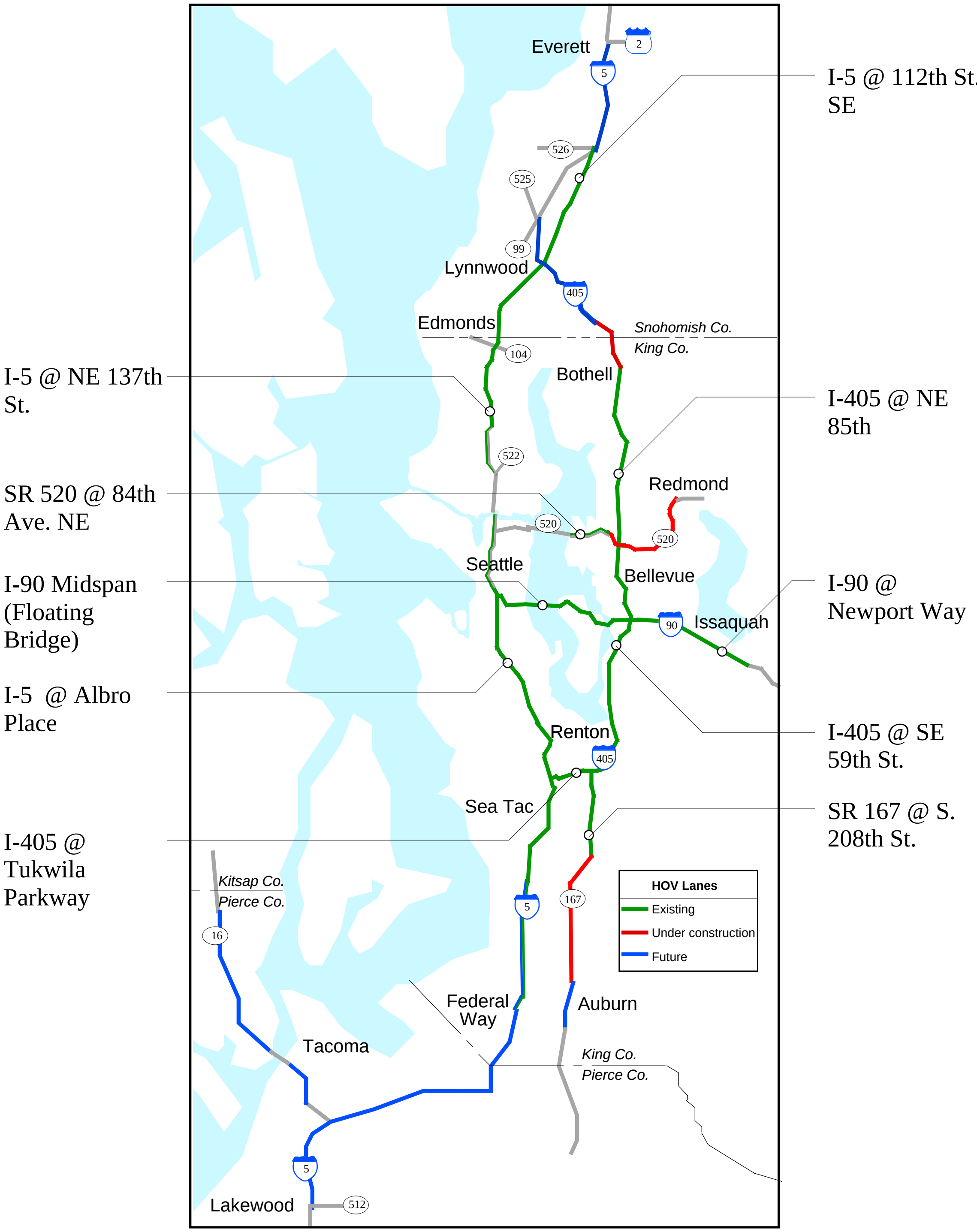


Figure 2-1. Selected HOV Analysis Sites

Note that loop volume data for the I-5 HOV lanes south of the I-405 interchange were not available for this report because of recent construction in the area. Therefore, no analysis of HOV performance for this section of freeway is provided in this report.

GENERAL RESULTS

Typically, the major freeway corridors have one HOV lane and two to four GP lanes in each direction (except I-90, which has two non-exclusive HOV lanes from Mercer Island through the Mt. Baker tunnel to Seattle). Figure 2-2 shows person volume, vehicle volume, and AVO for each of the ten representative sites during the morning peak period, and Figure 2-3 shows the same data for the evening peak period. In addition, these figures also indicate whether the HOV lane carried more or fewer people during these periods in comparison to the adjacent GP lane.

Both vehicle and person volumes in the HOV lanes were high on I-5 near Northgate and south of downtown Seattle, and on I-405 near Kirkland and Factoria during the peak periods. For example, the HOV lane on I-5 near Northgate carried over twice as many people in about 30 percent fewer vehicles in comparison to an average adjoining GP lane (refer to Figure 2-30).

Figure 2-4 shows the percentages of people carried by buses, cars, and vans in HOV lanes during the peak periods. The high person volumes observed on I-5 were due, in large part, to high bus ridership: about 30 to 40 percent of the people carried in the HOV lanes at the selected sites on I-5 were carried by buses. Significant use of transit buses allowed the HOV lane to move considerably more people than the adjacent GP lanes. More specific throughput comparisons between HOV and GP lanes are provided later in this chapter.

In contrast, the I-90 and SR 520 HOV facilities carried fewer people in comparison to the adjacent GP lane during the peak periods. However, these levels of performance are lower for different reasons. I-90 has relatively low congestion levels in comparison to other major freeway corridors in the Puget Sound area. In addition, HOV volumes are split between two lanes on I-90 midspan. On the other hand, SR 520 is among the most congested facilities in the state. Nonetheless, it is harder for motorists to form and maintain carpools to satisfy the 3+ occupancy requirement that currently applies (for safety and operational reasons) to this HOV facility.

Interestingly, although the vehicle volume on the westbound SR 520 HOV lane near Medina was relatively low, the AM peak period AVO was 14.2, whereas the typical AVO value ranged between 2.1 and 4.1 at other studied sites. This is because transit buses frequently use this HOV facility. Figure 2-5 shows the vehicle classification percentages in HOV lanes based on field measurements for the selected sites during morning and afternoon peak periods. On westbound SR 520 during the morning commute period, 32 percent of the inbound traffic comprised buses, which carried 67 percent of all HOV lane travelers (see Figure 2-4). High percentages of HOV users, from 32 to 43 percent, were also observed commuting by transit bus in the HOV lanes on I-5 near Northgate, Boeing Field, and in the reversible HOV lanes on I-90.

Note that HOV volumes are not necessarily evenly distributed during the hours within the peak periods, and that HOV volumes become higher during the peak commute hour. Thus the HOV lane performs even better during the peak hour than suggested by its peak period performance described in this chapter. The timing of the true peak hour HOV lane volume varies from location to location (e.g., 7:35 AM to 8:35 AM or 7:50

AM to 8:50 AM) depending on the nature of travel demand at that location. Figure 2-6 shows that peak hour volumes can increase from 15 percent to as high as 48 percent over the average hourly volume during the peak period.

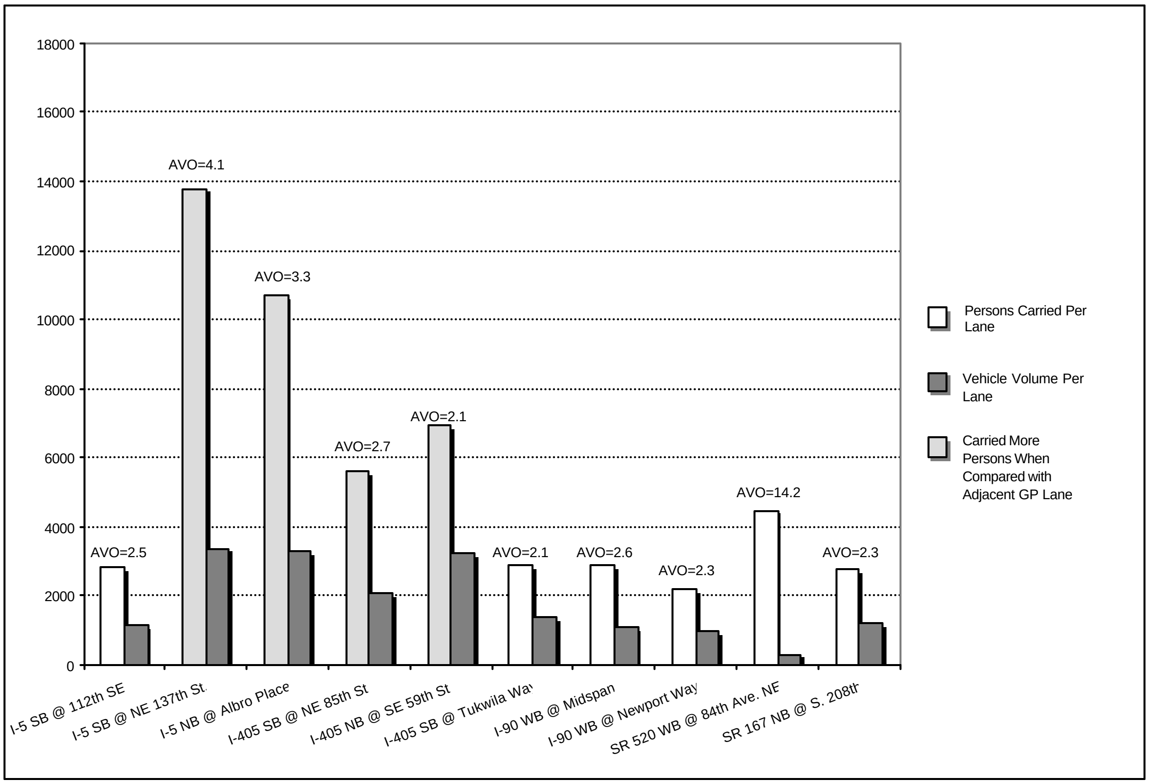


Figure 2-2. HOV Lane Usage During AM Peak Period (1998)

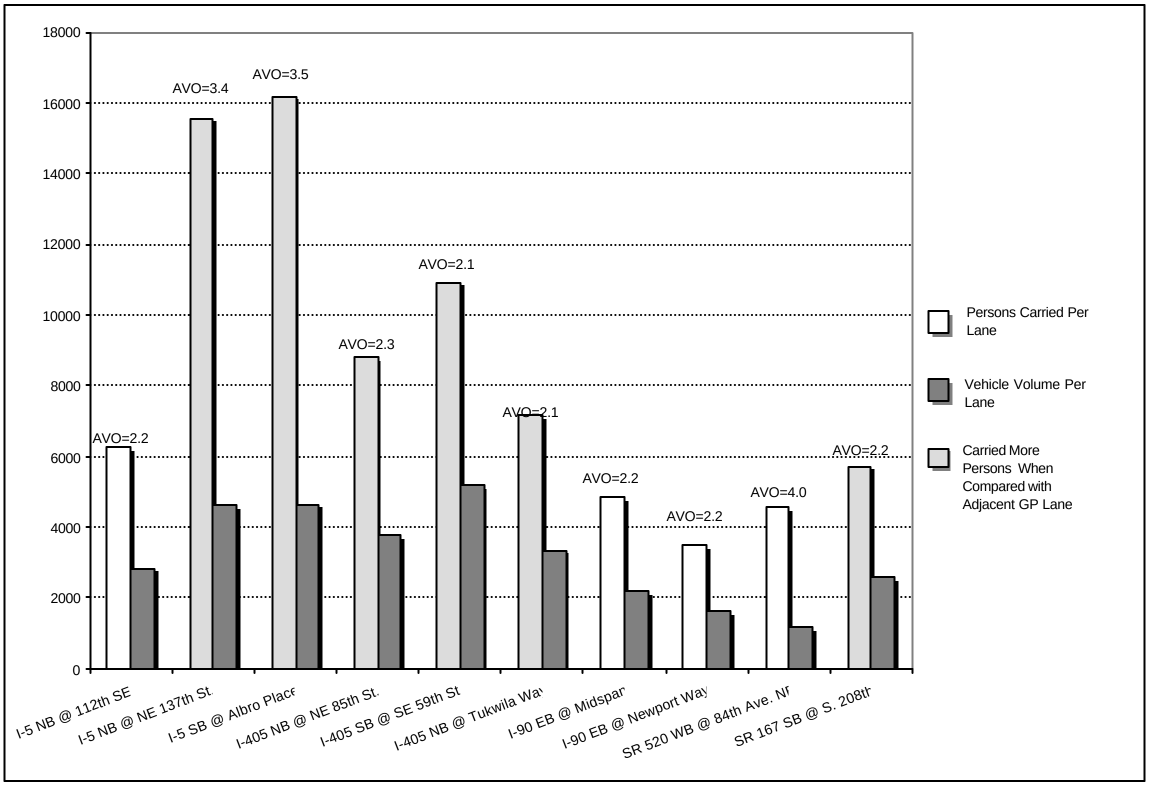


Figure 2-3. HOV Lane Usage During PM Peak Period (1998)

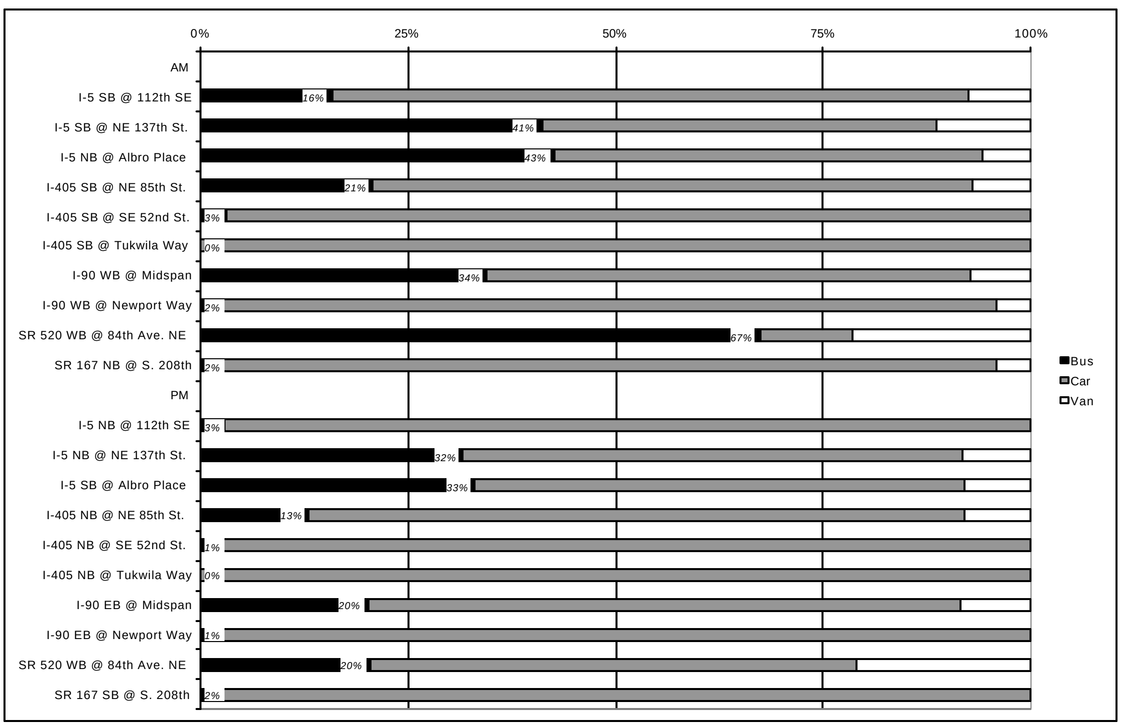


Figure 2-4. Percent of People Carried in HOV Lanes by Mode of Travel During Peak Periods (1998)

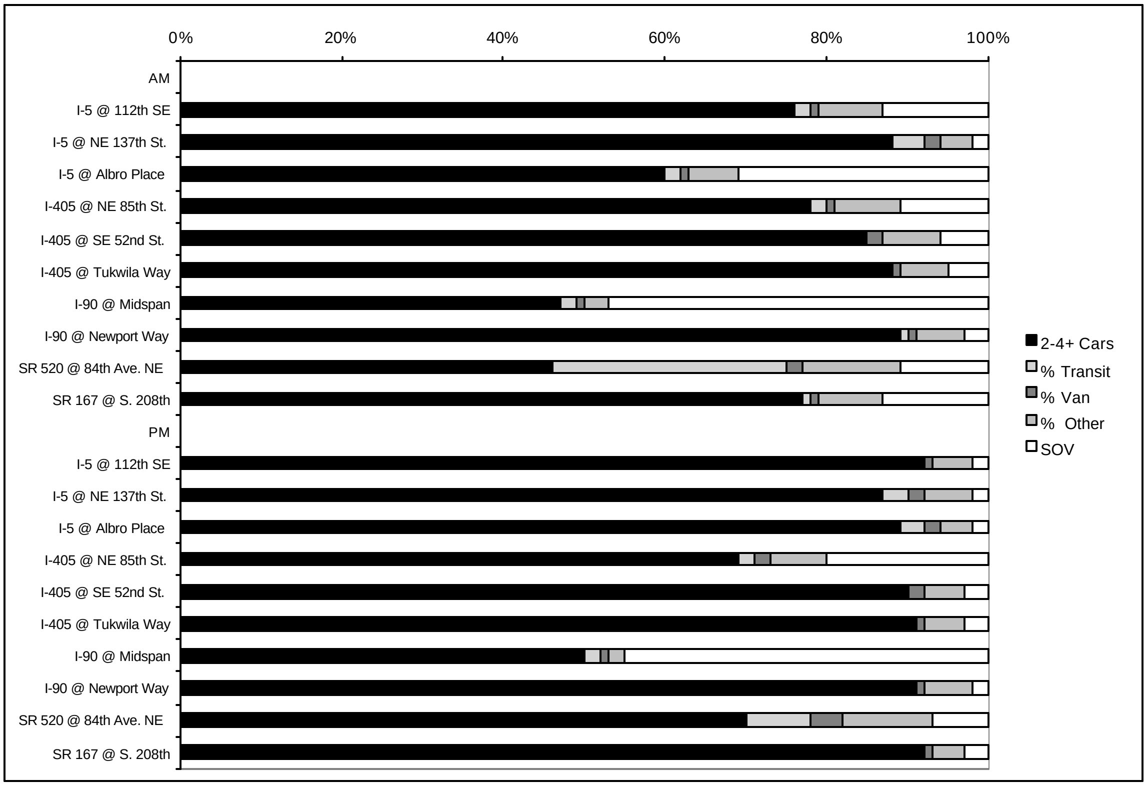


Figure 2-5. Mode Split in HOV Lanes (1998)

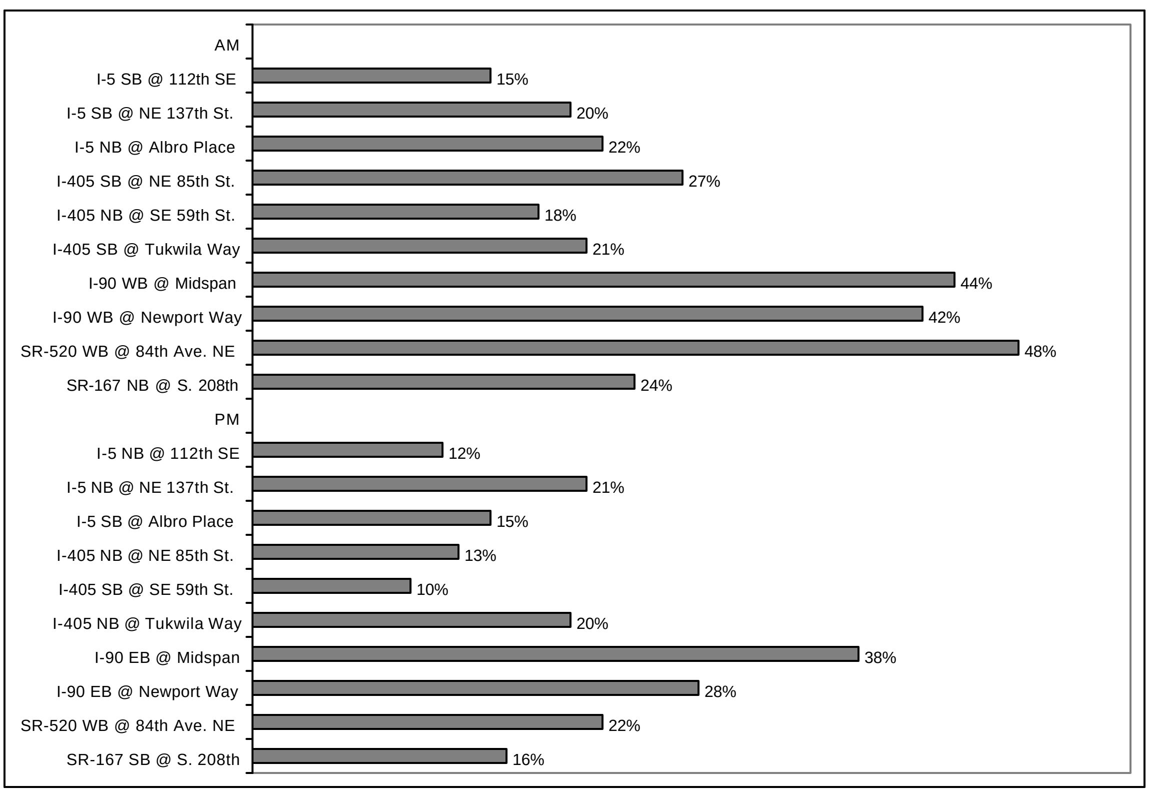


Figure 2-6. Percentage of Increase in HOV Volumes: Peak Hour Volume vs. Peak Period Average Hourly Volume (1998)

HOV VOLUME FLOW

Figures 2-7 through 2-18 examine more closely the extent and variation of change in vehicle volumes observed along HOV corridors during the average weekdays. In general, HOV volumes increased when the lanes were closer to dense employment centers and decreased on the suburban ends of HOV facilities. Low usage rates were also expected at the endpoints of HOV facilities where HOV traffic merges with GP traffic. As explained in the previous section, the low HOV volumes on I-90 and SR 520 were largely due to low congestion levels on I-90 and the more restrictive 3+ occupancy requirement on SR 520.

I-5 North of the Seattle Central Business District (CBD) (see figures 2-7, 2-8)

On I-5 between Alderwood and Northgate, HOV volumes were significant southbound during the AM peak period (>3,000 vehicles) and northbound during the PM peak period (>4,000 vehicles). This HOV corridor presents a strong directional pattern, with high southbound volumes traveling toward the University District and downtown Seattle in the morning, and high northbound volumes traveling away from downtown Seattle in the evening.

I-5 South of the Seattle CBD (see figures 2-9, 2-10)

On I-5 between the I-90 interchange and the I-405 interchange, HOV traffic during the AM peak period exhibited a typical in-bound commute flow, with northbound peak period volumes sometimes exceeding 3,000 vehicles. HOV volumes were significant in both directions during the PM peak period, with the southbound HOV lane carrying over 4,000 vehicles and the northbound HOV lane topping out at over 3,000 vehicles.

I-405 North of I-90 (see figures 2-11, 2-12)

This corridor exhibited classic directional commute characteristics in the morning, with HOV users traveling toward downtown Bellevue and the over cross-lake bridges from surrounding rural areas and reversing flow during the evening commute. The northbound HOV volumes were concentrated between downtown Bellevue and the Totem Lake area, carrying as many as 4,000 vehicles. The highest southbound HOV volumes centered around downtown Belluevue, carring more than 4,500 vehicles each peak period.

I-405 South of I-90 (see figures 2-13, 2-14)

Along the I-405 corridor south of the I-90 interchange, HOV volumes tended to be higher for both directions during the PM peak period than during the AM peak period. Also, volumes were generally higher between the Newcastle area and Factoria during both the morning and evening commutes as this facility services the bedroom communities of Newcastle and Newport Hills

I-90 (see Figure 2-15)

The main area of interest along this corridor was the section containing the I-90 reversible express lanes. Note that the reversible lanes between Mercer Island and the Mt. Baker Tunnel include mixed-flow traffic comprising both HOV traffic and Mercer Island GP traffic. Thus HOV volumes are higher in the reversible lanes than at locations between the I-405 interchange and Issaquah.

SR 520 (see Figure 2-16)

Comparatively, SR 520 carried the least amount of HOV vehicular traffic because of its 3+ occupancy requirement. HOV volumes were highest during the PM peak period partly because westbound PM transit service is not as good as the AM westbound service. One note of interest is that the design of this HOV lane was intended to improve transit service by allowing buses to pass the queue of cars.

SR 167 (see figures 2-17, 2-18)

Like I-405 north, this corridor exhibited classic directional commute characteristics. HOV volumes were highest in the northbound direction during the AM peak period between 15th St. NW and 84th Ave S. and during the reverse flow of the PM peak period. This section of the HOV system opened in September 1998.

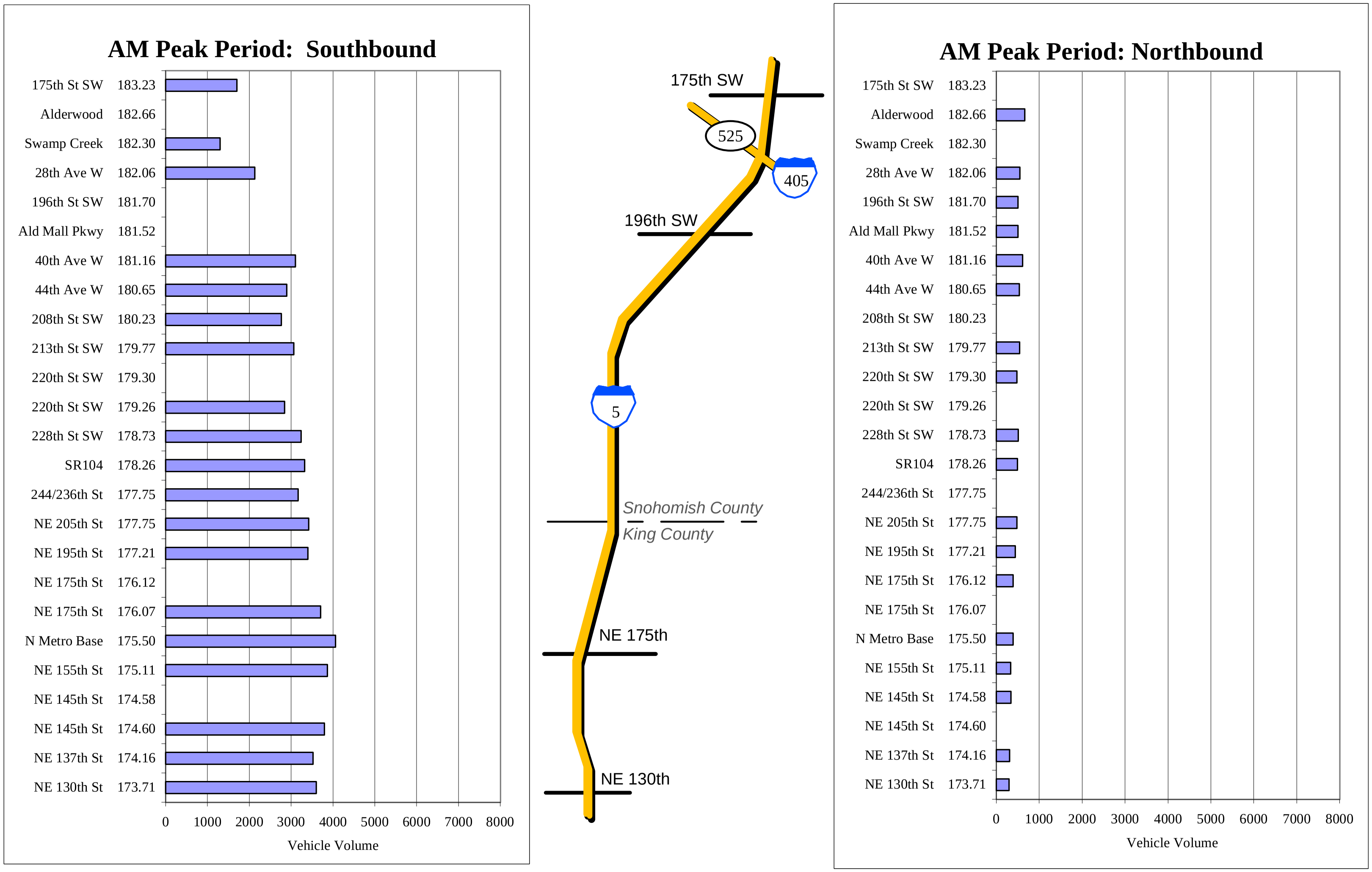


Figure 2-7. HOV Traffic Flow Profile (1998): I-5 North of the Seattle CBD During the AM Peak Period

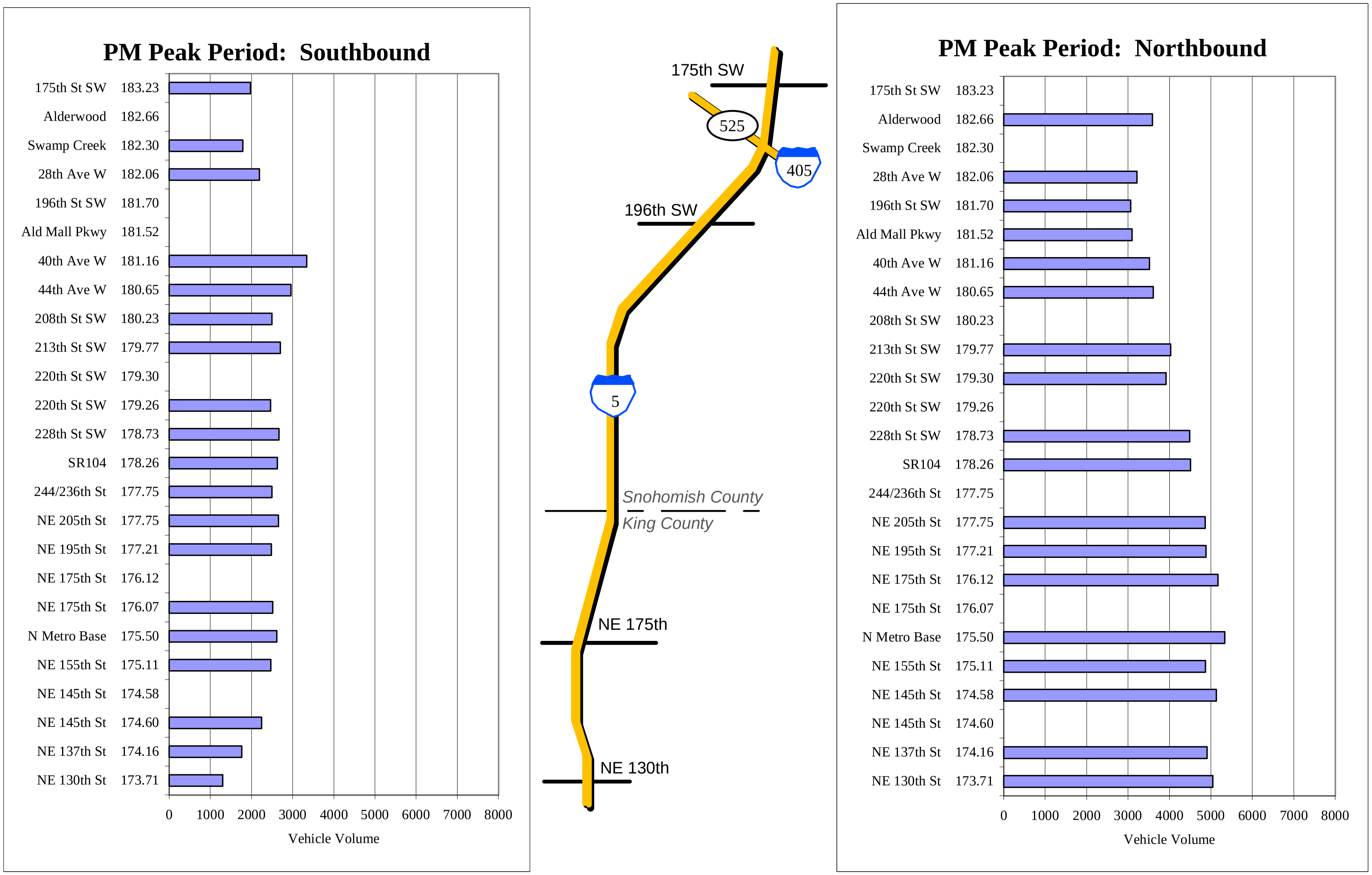


Figure 2-8. HOV Traffic Flow Profile (1998): I-5 North of the Seattle CBD During the PM Peak Period

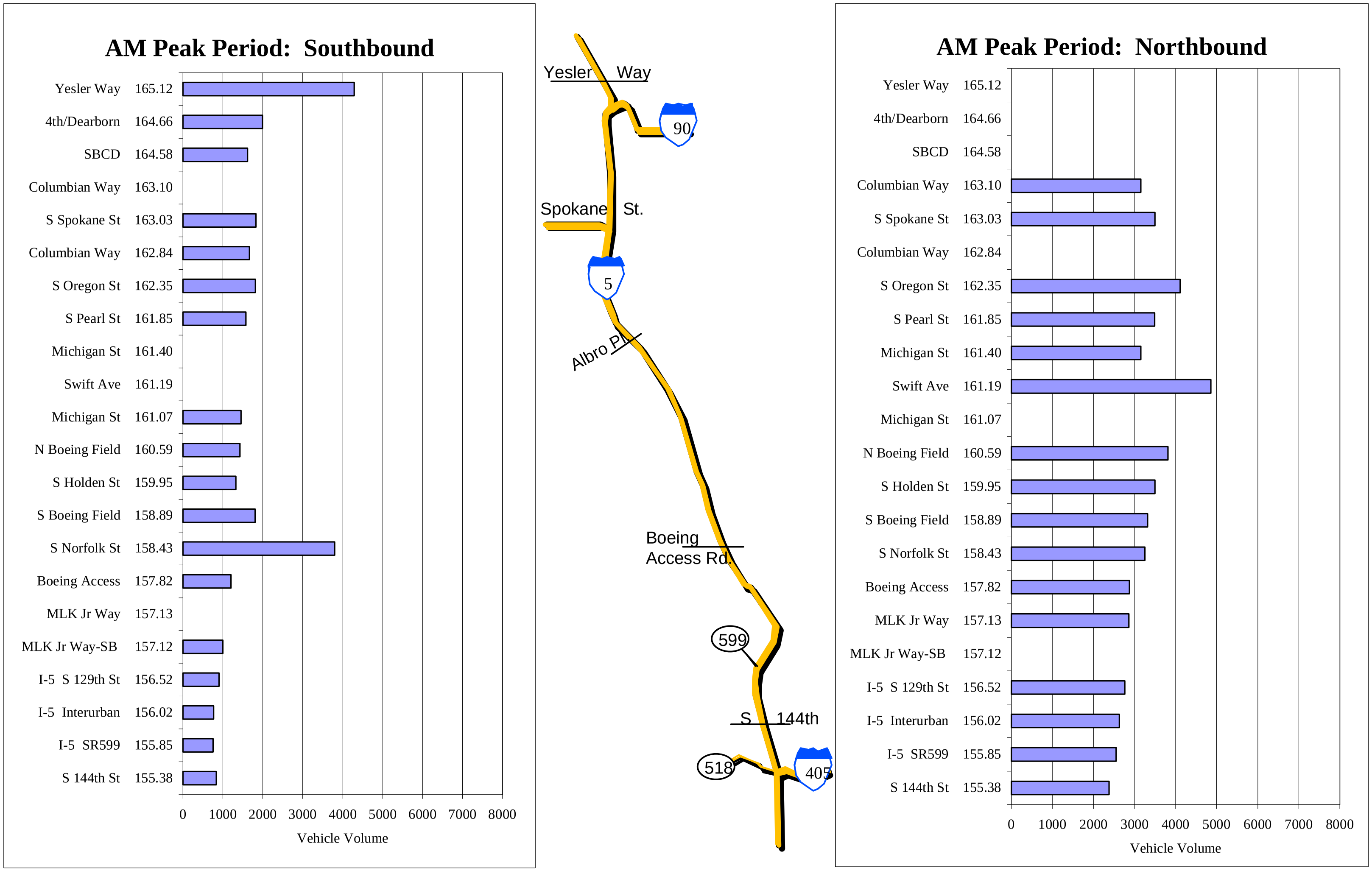


Figure 2-9. HOV Traffic Flow Profile (1998): I-5 South of the Seattle CBD During the AM Peak Period

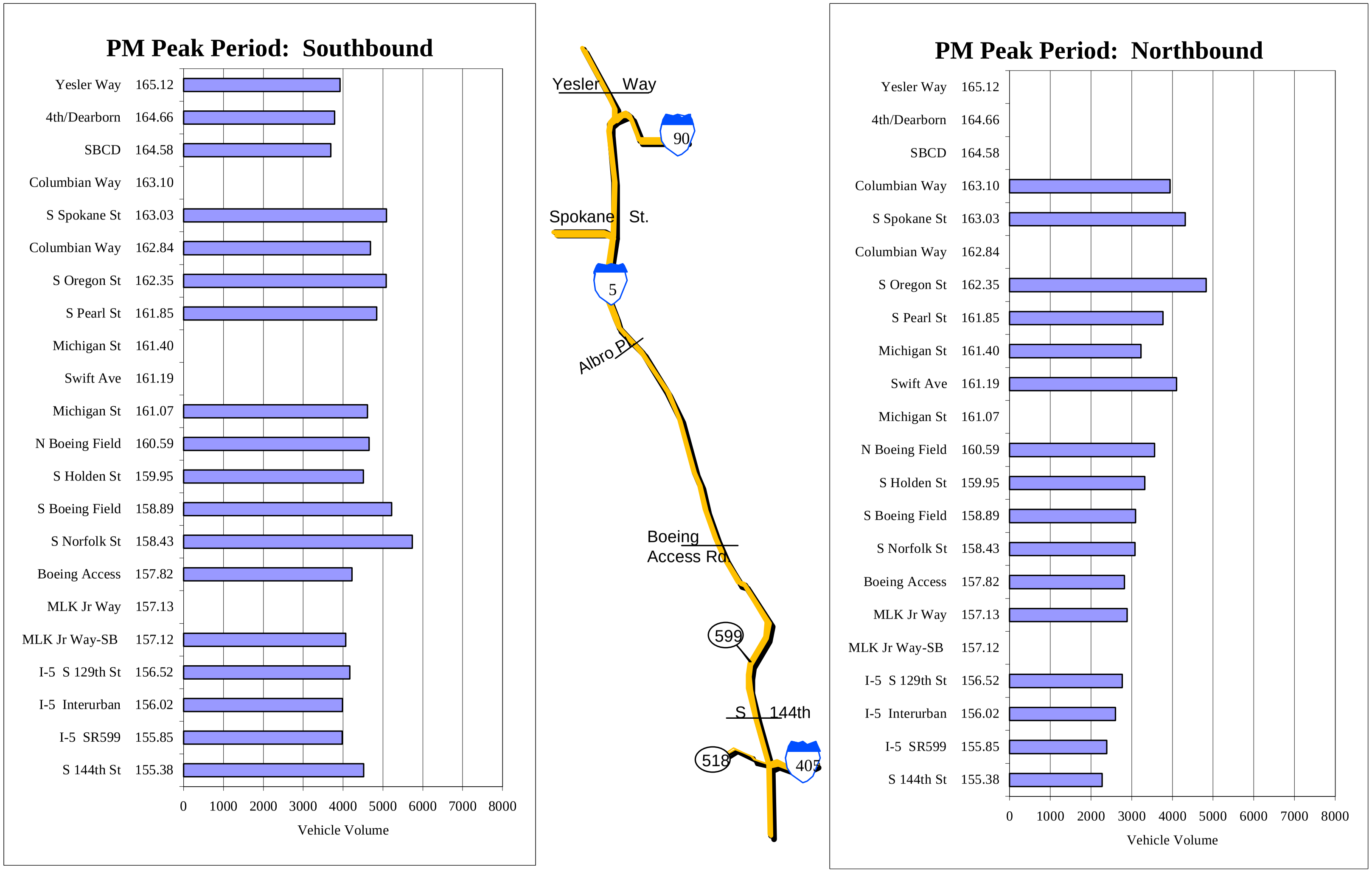


Figure 2-10. HOV Traffic Flow Profile (1998): I-5 South of the Seattle CBD During the PM Peak Period

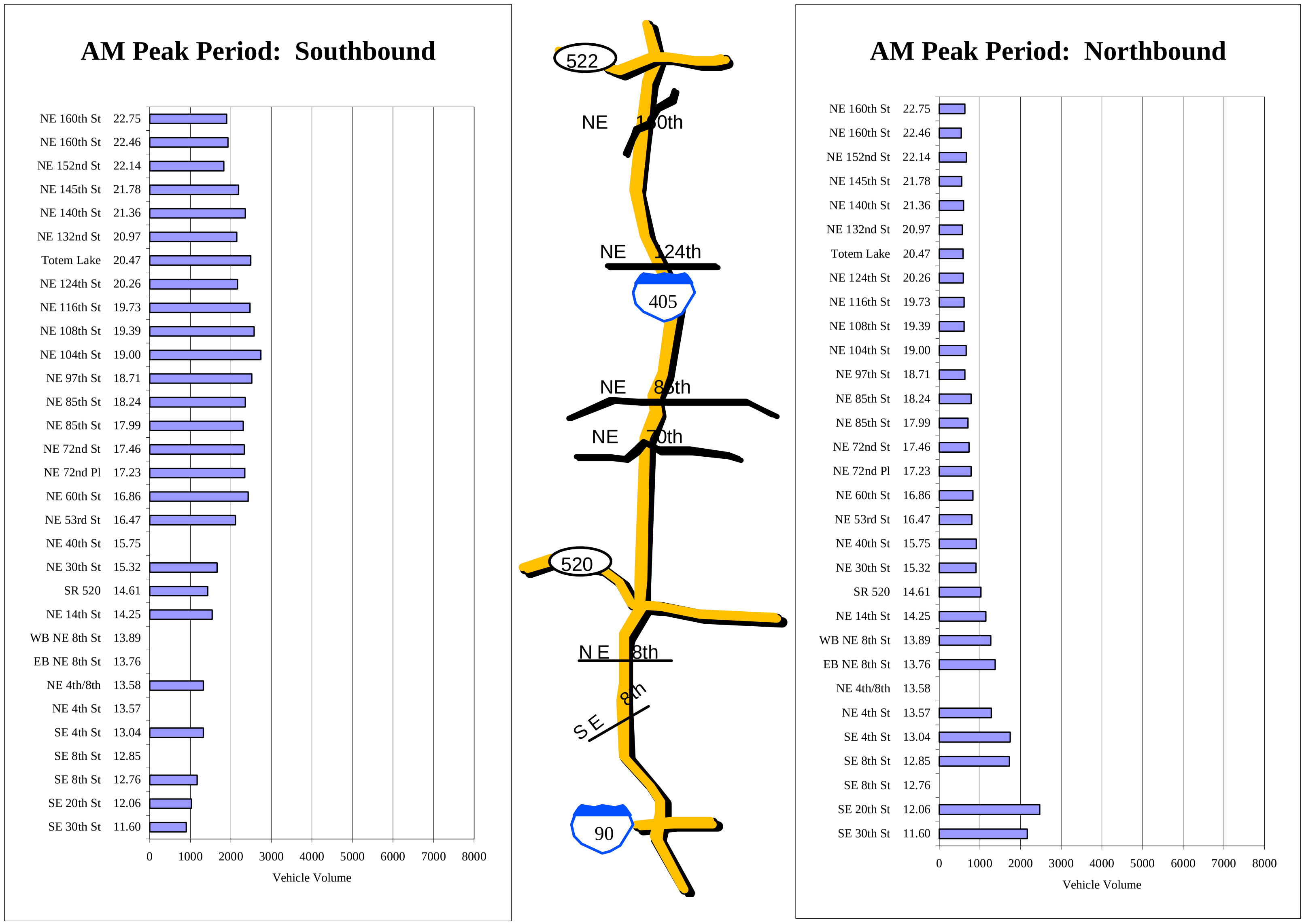


Figure 2-11. HOV Traffic Flow Profile (Nov-Dec, 1998): I-405 North of I-90 Interchange During the AM Peak Period

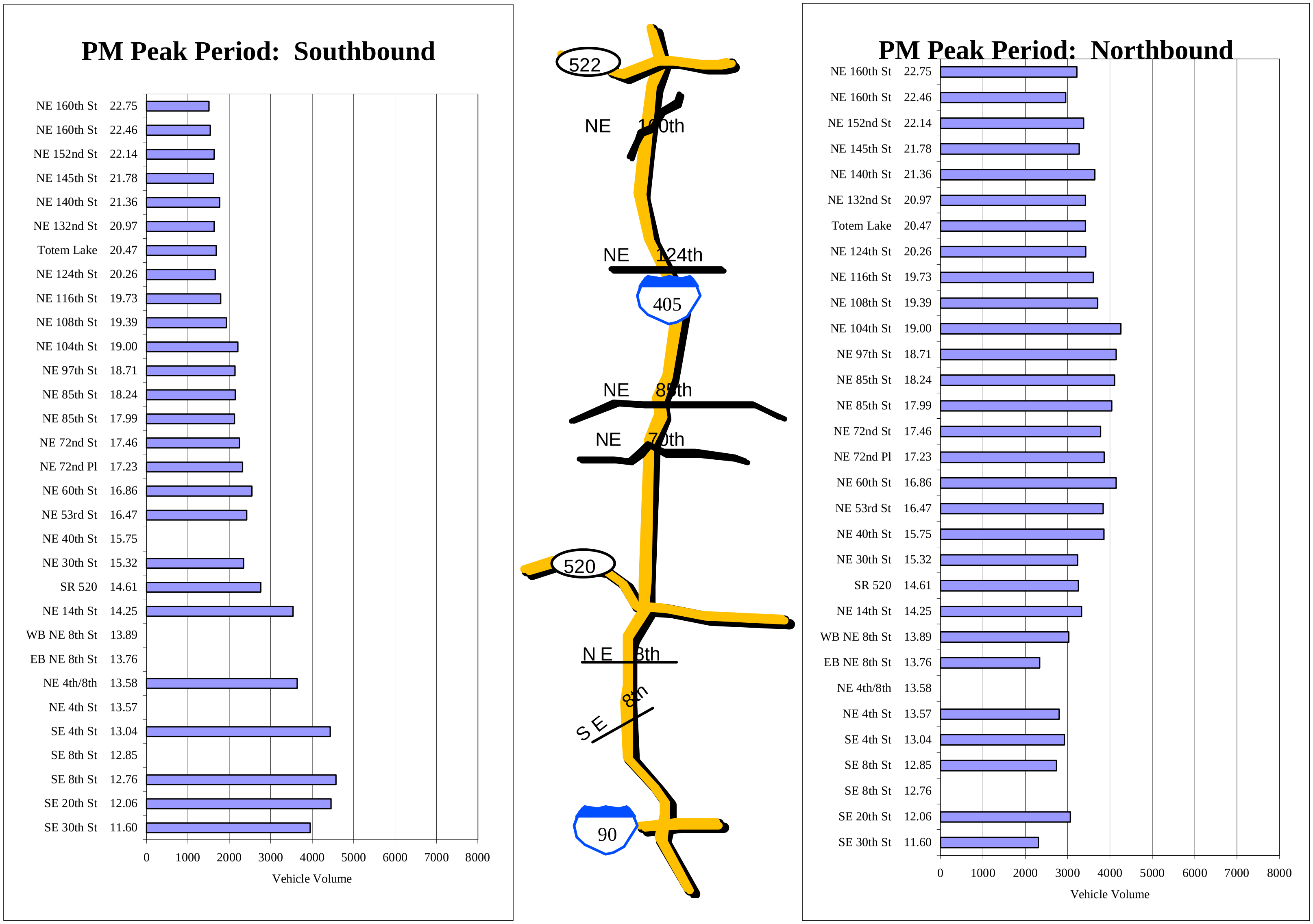


Figure 2-12. HOV Traffic Flow Profile (Nov-Dec, 1998): I-405 North of I-90 Interchange During the PM Peak Period

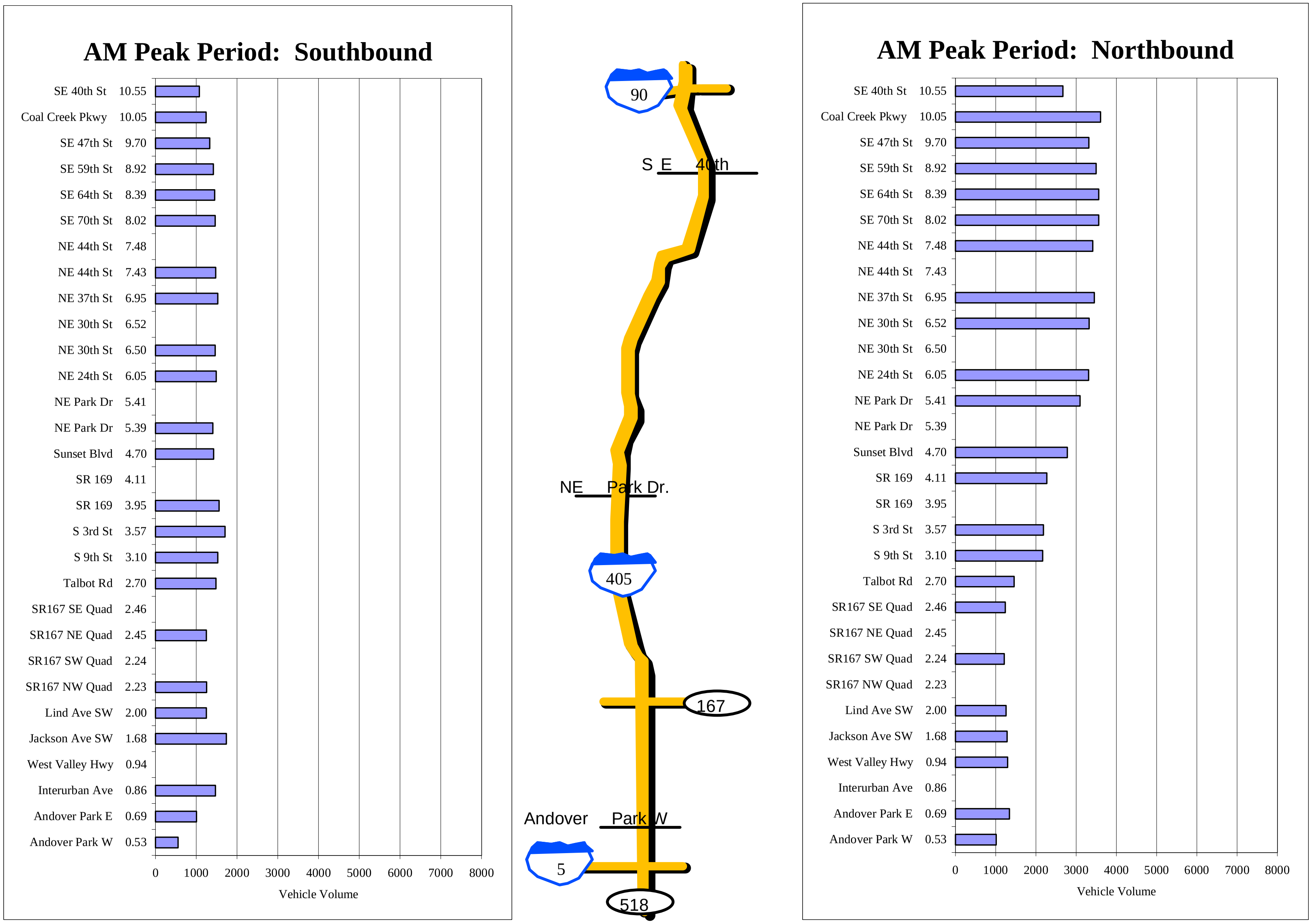


Figure 2-13. HOV Traffic Flow Profile (1998): I-405 South of I-90 Interchange During the AM Peak Period

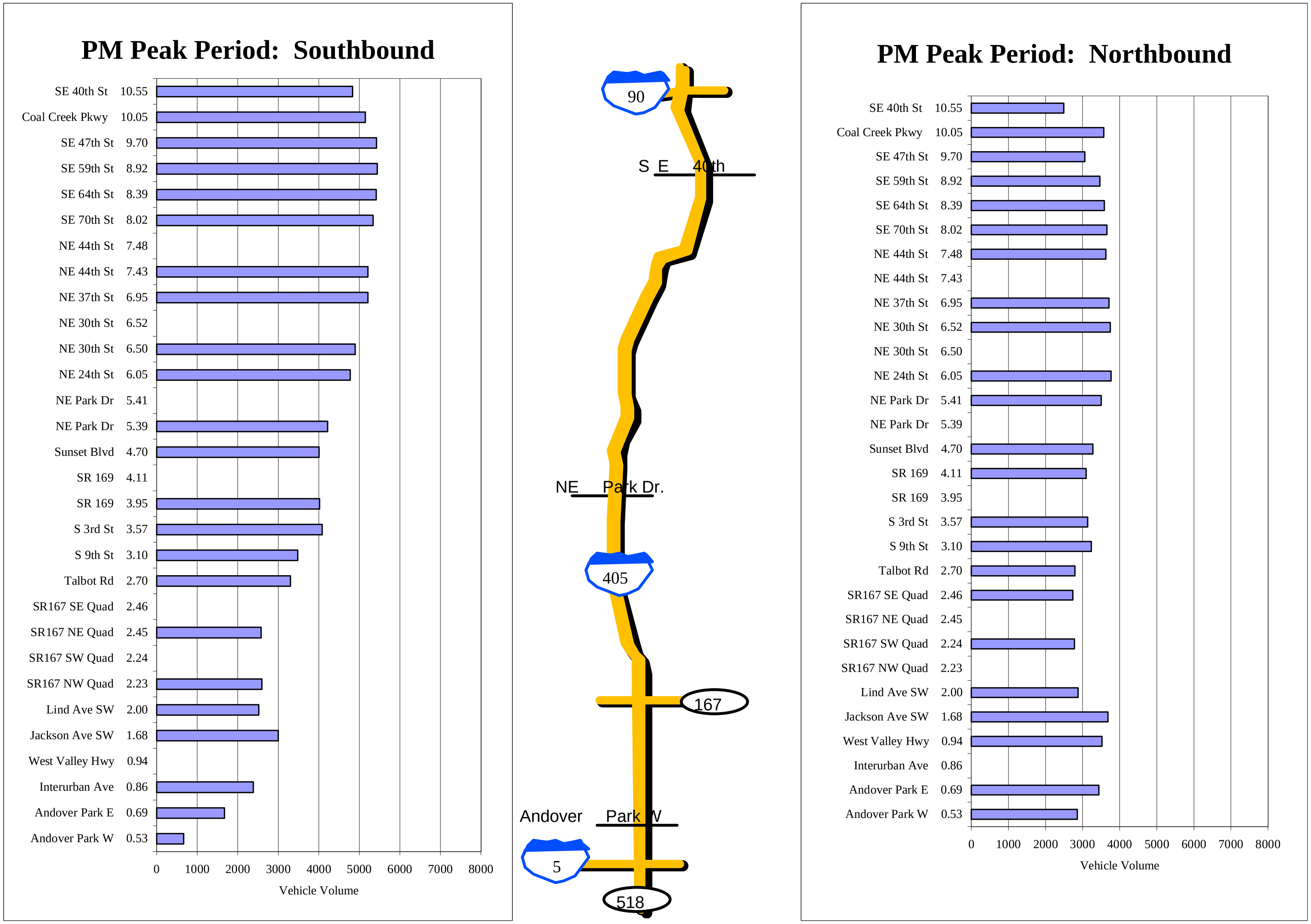


Figure 2-14. HOV Traffic Flow Profile (1998): I-405 South of I-90 Interchange During the PM Peak Period

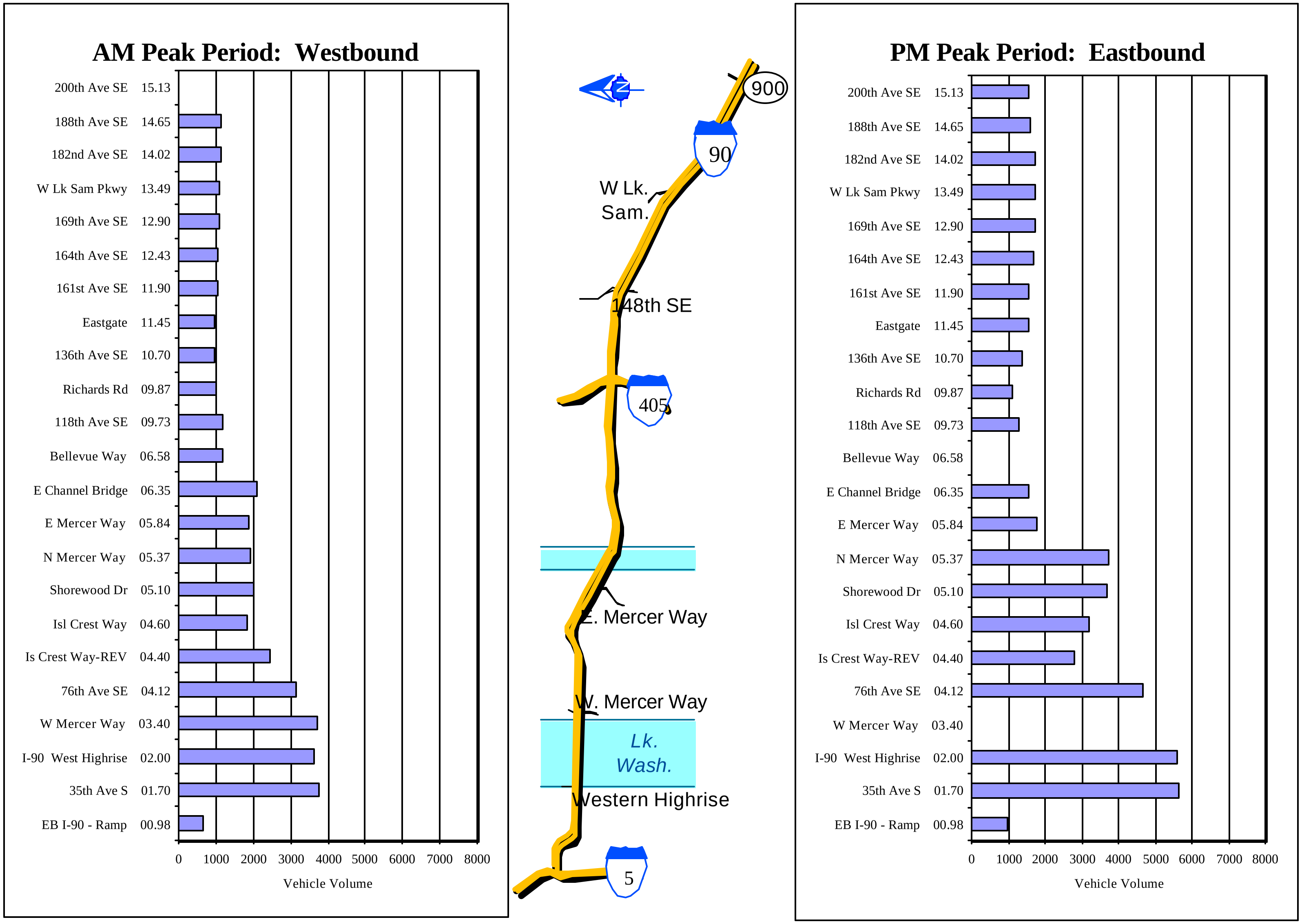


Figure 2-15. HOV Traffic Flow Profile (1998): I-90 During Peak Periods

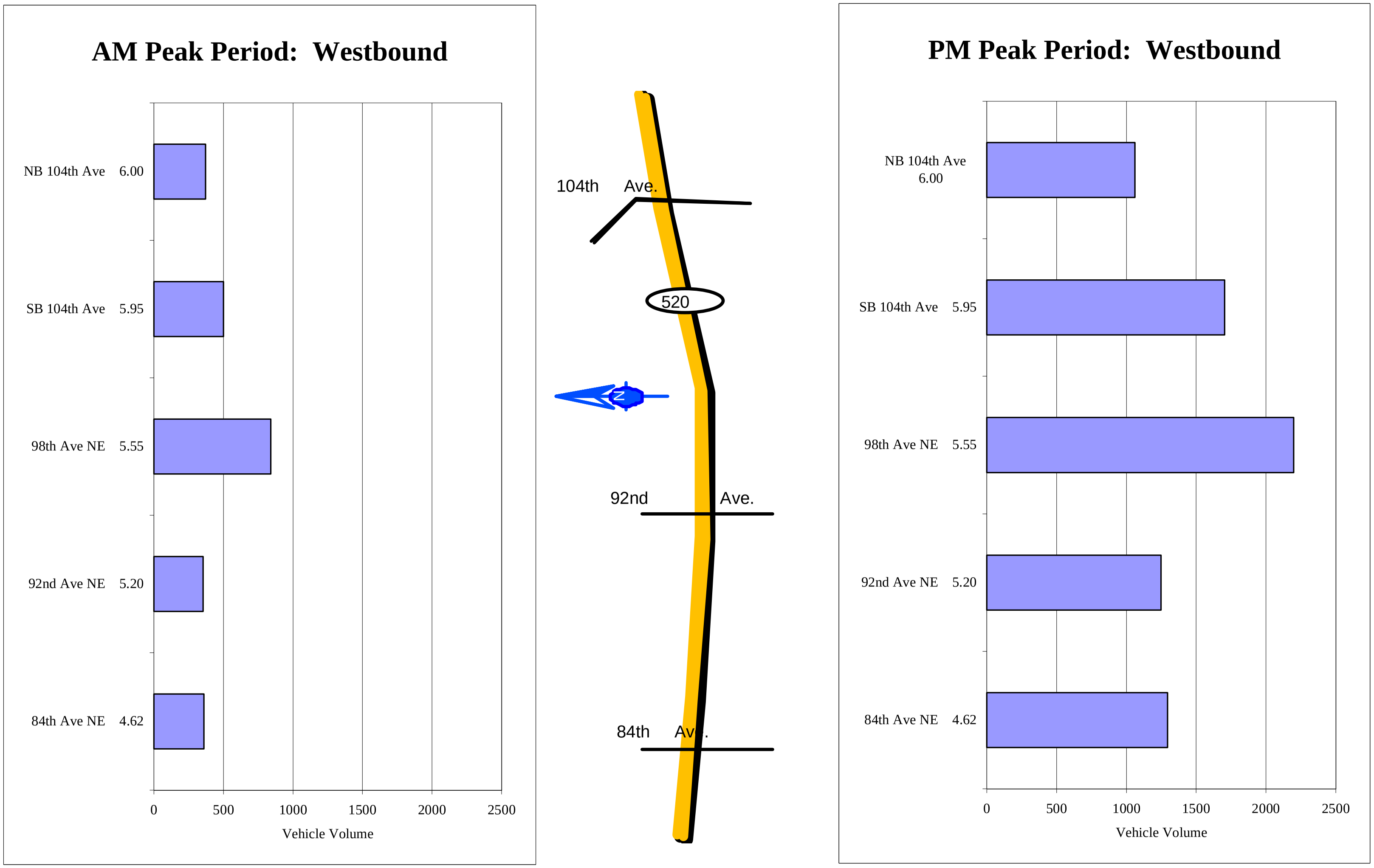


Figure 2-16. HOV Traffic Flow Profile (1998): SR 520 During Peak Periods

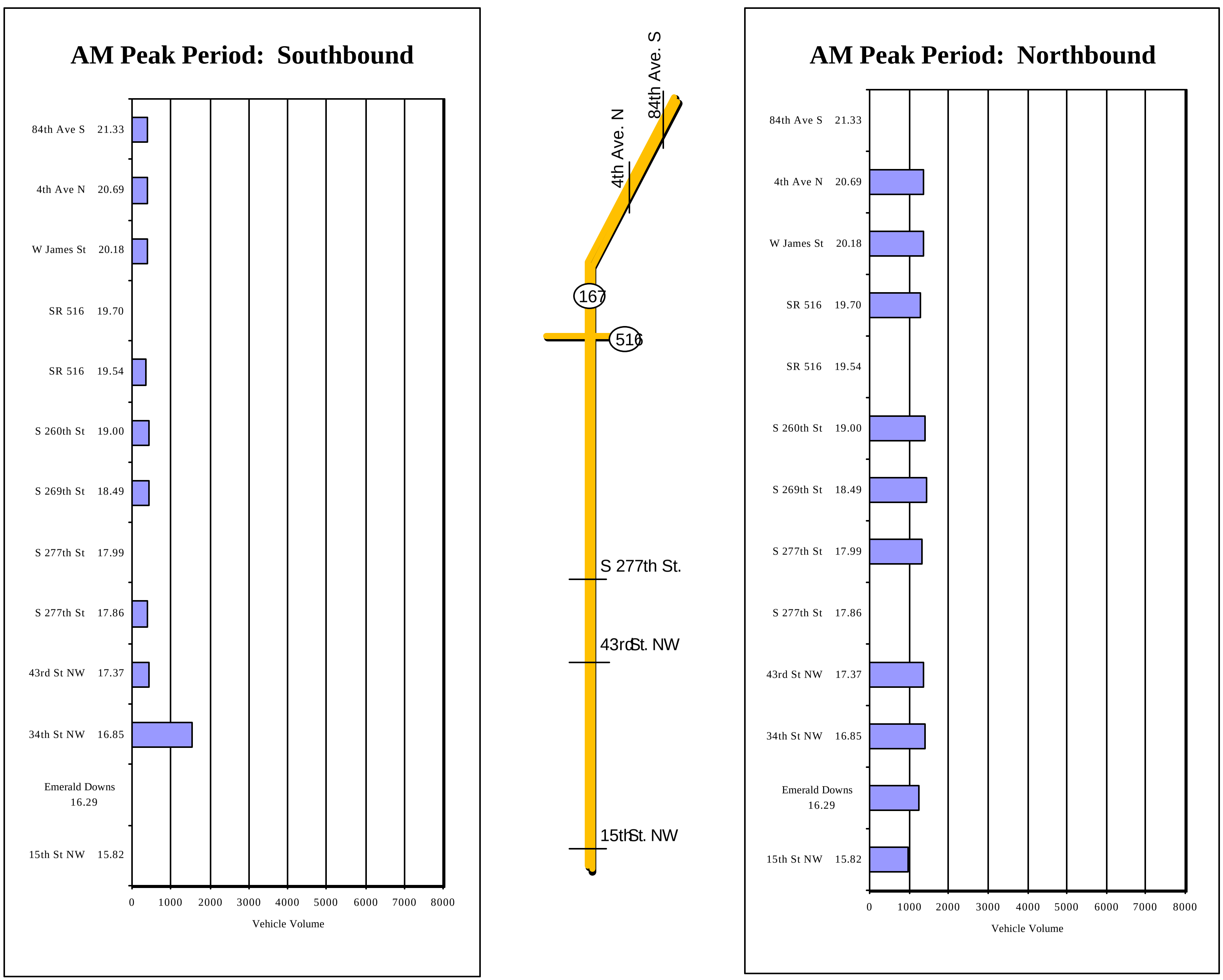


Figure 2-17. HOV Traffic Flow Profile (1998): SR 167 During the AM Peak Period

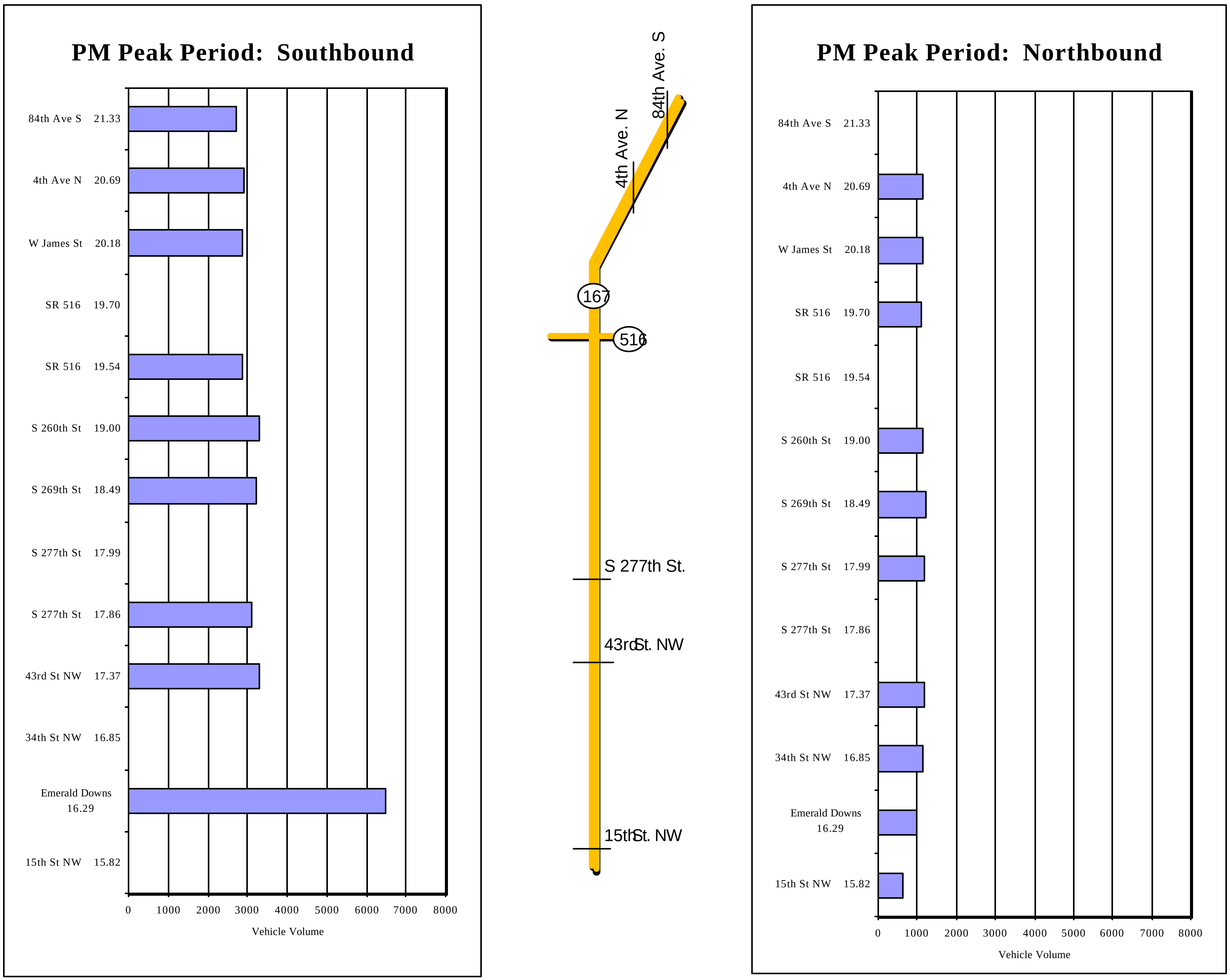


Figure 2-18. HOV Traffic Flow Profile (1998): SR 167 During the PM Peak Period

GP VS. HOV 24-HOUR VOLUME PROFILE

Figures 2-19 to 2-28 illustrate variations of HOV volume throughout the day and the relationship between HOV traffic and GP traffic at selected locations. Like GP lanes, traffic volumes on HOV lanes vary by time of day and location. High HOV use typically coincides with high levels of travel demand and with locations that routinely experience elevated congestion levels in adjoining GP lanes. This largely occurs sometime during the traditional peak commute periods.

On a per-lane basis, HOV lanes can carry a significant number of vehicles in comparison to their GP counterparts. For example, traffic volumes in the HOV lanes approach 1500 vehicles per hour at various locations during these times (i.e., near Northgate, south of Seattle downtown, and at Factoria); this is a very high rate even for GP lanes. In fact, at some locations and times of day HOV volumes actually match or even exceed GP volumes on a per-lane basis (see SE 59th St. on I-405) as a result of severe congestion within the GP lanes. Additional performance information on HOV volumes in relation to speed and congestion frequency are presented in Chapter Three.

I-5 North of the Seattle CBD – 112th St. SW (see Figure 2-19)

On a per-lane basis, the northbound HOV volumes were approximately 50 percent of northbound GP volumes during the afternoon peak period. The southbound HOV lane could approach 40 to 50 percent of corresponding GP volumes during the afternoon peak period.

I-5 North of the Seattle CBD – NE 137th St. (see Figure 2-20)

HOV volumes had prominent peak values during the given commute periods. The northbound HOV volumes during the afternoon peak period and the southbound

HOV volumes during the morning peak period could reach 1,500 vplph, that is, nearly 70 to 80 percent of GP per lane volumes.

I-5 South of the Seattle CBD – Albro Place (see Figure 2-21)

HOV volumes were significant in comparison to GP volumes, particularly on northbound interstate I-5 during the morning peak period and southbound during the afternoon peak period. Peak period HOV volumes could approach 1,500 vplph.

I-405 North of I-90 – NE 85th St. (see Figure 2-22)

Peak period HOV volumes approached 1,000 to 1,200 vplph. The northbound HOV lane carried approximately 80 percent of the volume of an adjacent GP lane during the afternoon peak period. Southbound HOV volumes could approach 70 percent of southbound GP per-lane volumes during the morning peak period.

I-405 South of I-90 – SE 59th St. (see Figure 2-23)

HOV vehicular volumes (~1,500 vplph) at this location actually exceeded GP volumes (~1,400 vplph) in the northbound direction between 7:30 AM and 8:00 AM. This was partly the result of a reduction in GP lane capacity caused by high congestion levels at this location. Southbound HOV volumes were approximately 90 percent of corresponding GP volumes during the afternoon peak period.

I-405 South of I-90 – Tukwila Parkway (see Figure 2-24)

HOV volumes were significant during the afternoon peak period for both directions. Northbound HOV volumes approached 80 percent of adjacent per-lane GP volumes. Southbound HOV volumes only approached 50 percent of the corresponding GP volumes during the afternoon peak period. Data at this recording location were biased by the design characteristics of the SR 167 interchange.

I-90 – Midspan (see Figure 2-25)

The reversible facility volumes had prominent peak values during each corresponding peak period. Peak period volumes approached 25 to 35 percent of adjoining general traffic volumes on a per-lane basis. Note, however, that the reversible lanes at this point contained mixed-flow traffic comprising both HOV traffic and Mercer Island GP traffic.

I-90 – Lake Sammamish Parkway (see Figure 2-26)

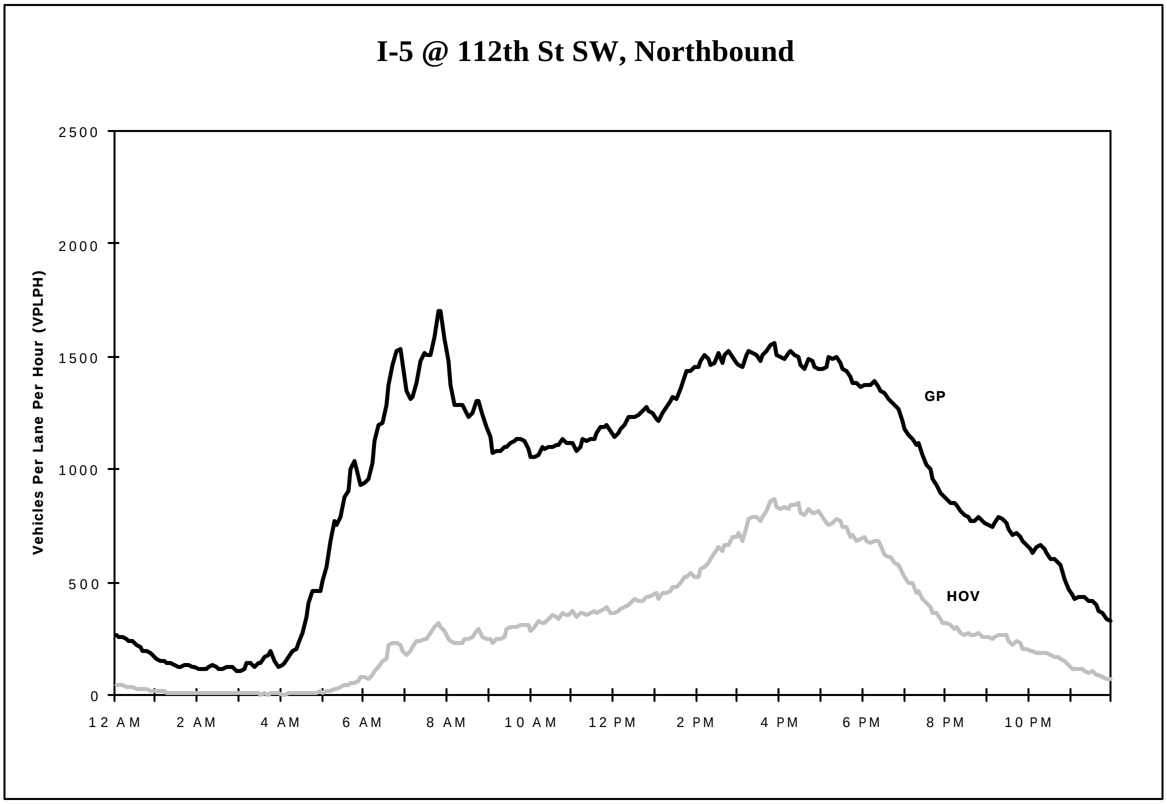
HOV volumes approached 500 vplph heading eastbound during the afternoon peak period and westbound during the morning peak period. HOV volumes peaked around 30 percent of corresponding GP volumes during the peak periods. Congestion was virtually non-existent along this HOV segment.

SR 520 – 84th Ave NE (see Figure 2-27)

HOV volumes were relatively low at this location. A strict occupancy requirement (3+ occupants per vehicle) applies to this converted shoulder HOV facility. The main purpose of this segment is to allow transit vehicles to pass the queue of cars.

SR 167– S 208th St (see Figure 2-28)

Classic directional commute characteristics exist along this corridor. The southbound HOV volumes approached to 800 vplph during the afternoon peak period. This was nearly 70 percent of the adjacent GP lane's volume.



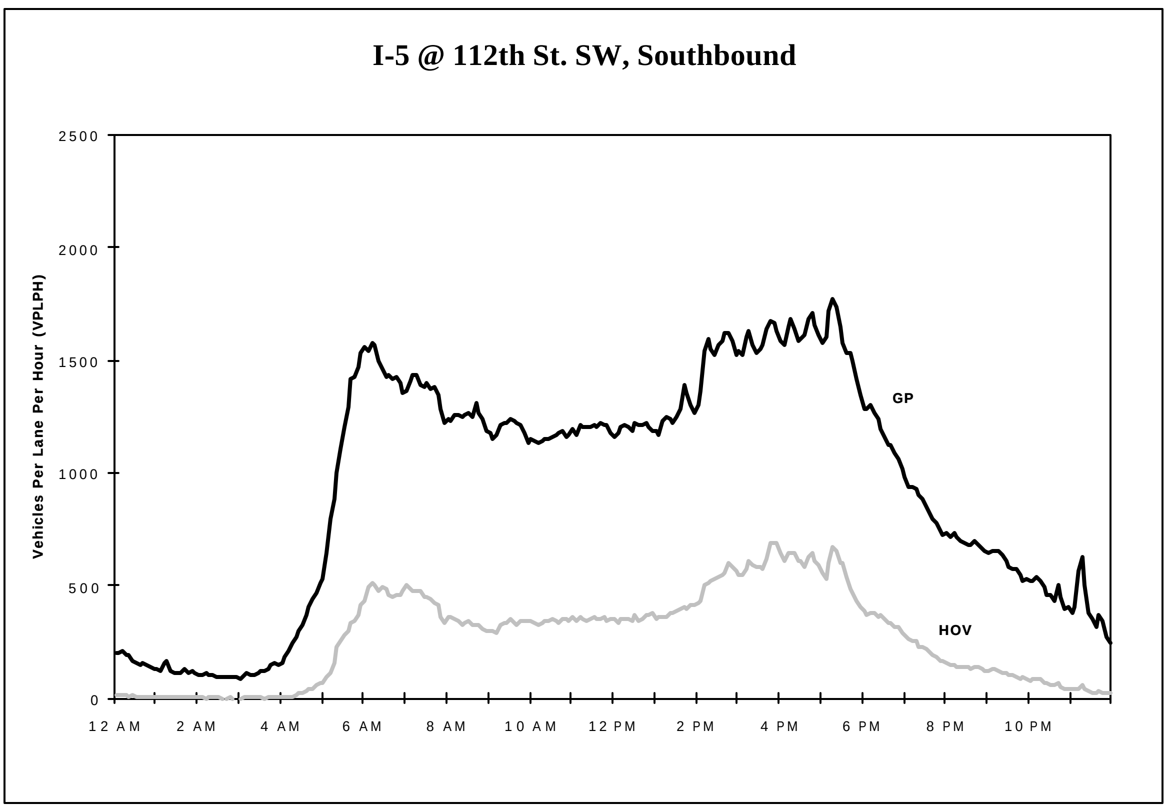
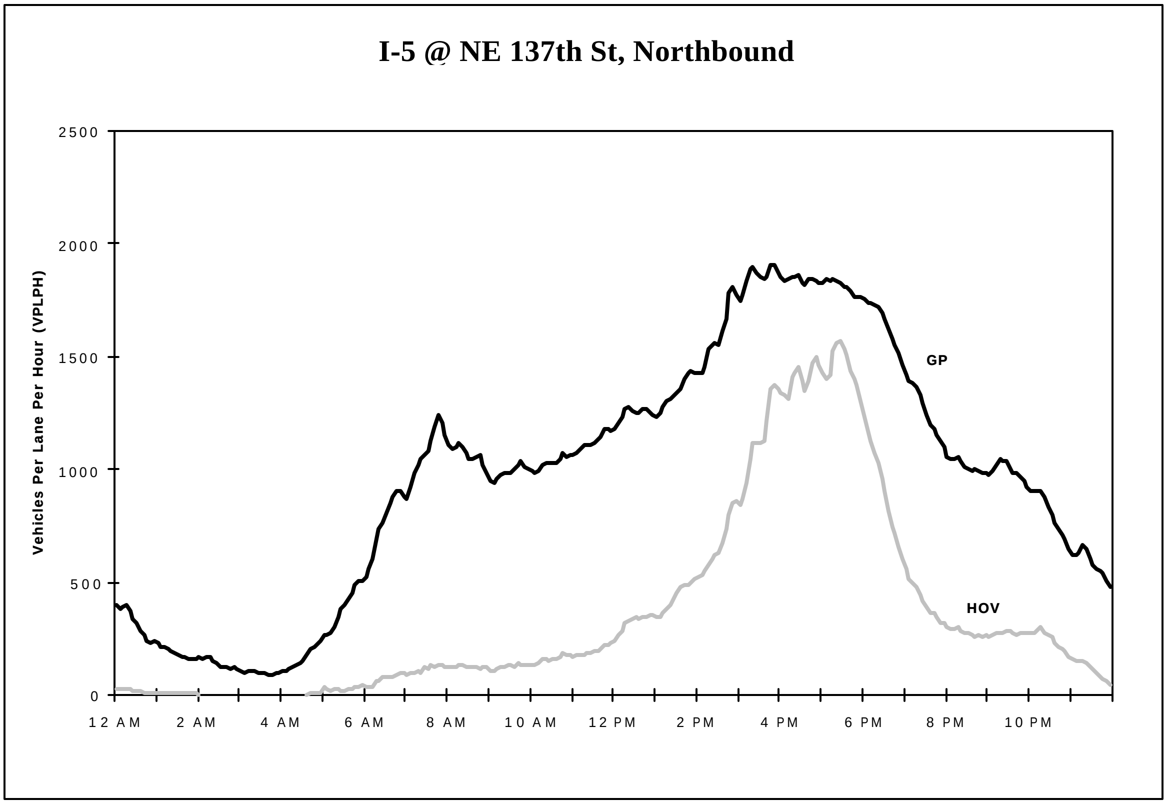


Figure 2-19. Average Weekday GP and HOV Volume Profile (1998): I-5 @ 112th St SW



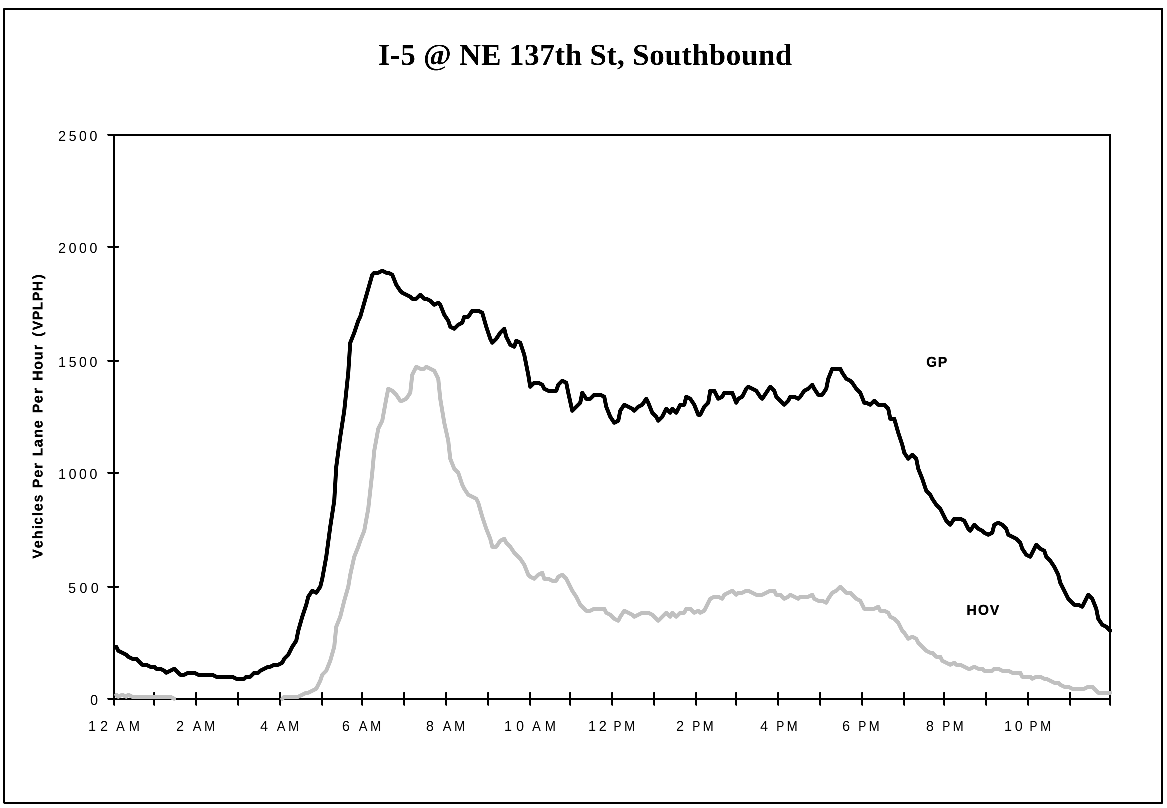
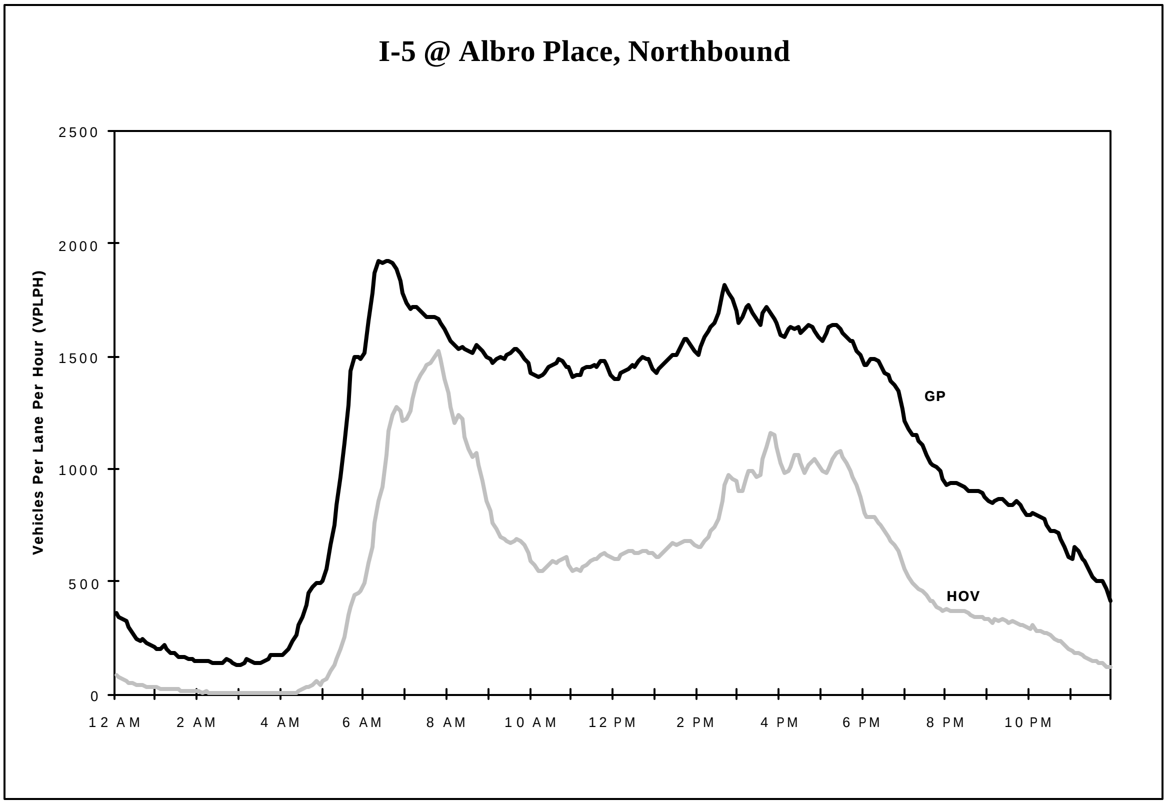


Figure 2-20. Average Weekday GP and HOV Volume Profile (1998): I-5 @ NE 137th St



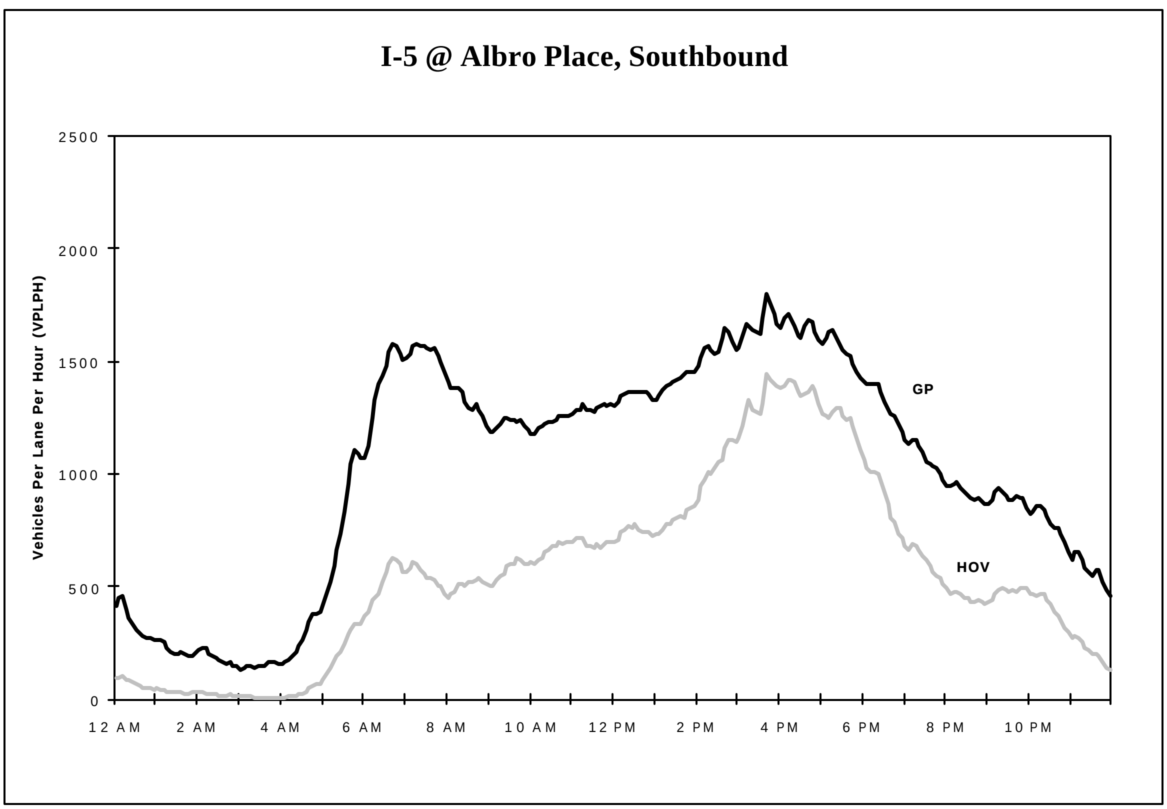
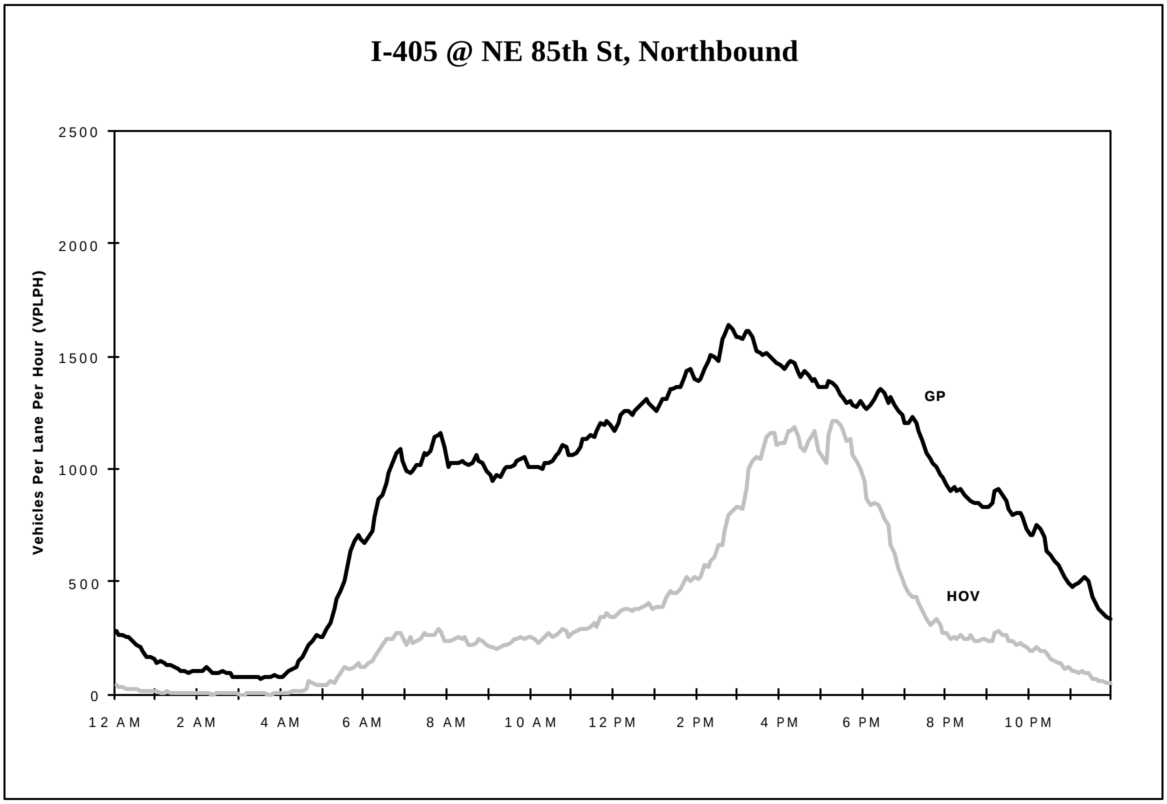


Figure 2-21. Average Weekday GP and HOV Volume Profile (1998): I-5 @ Albro Place



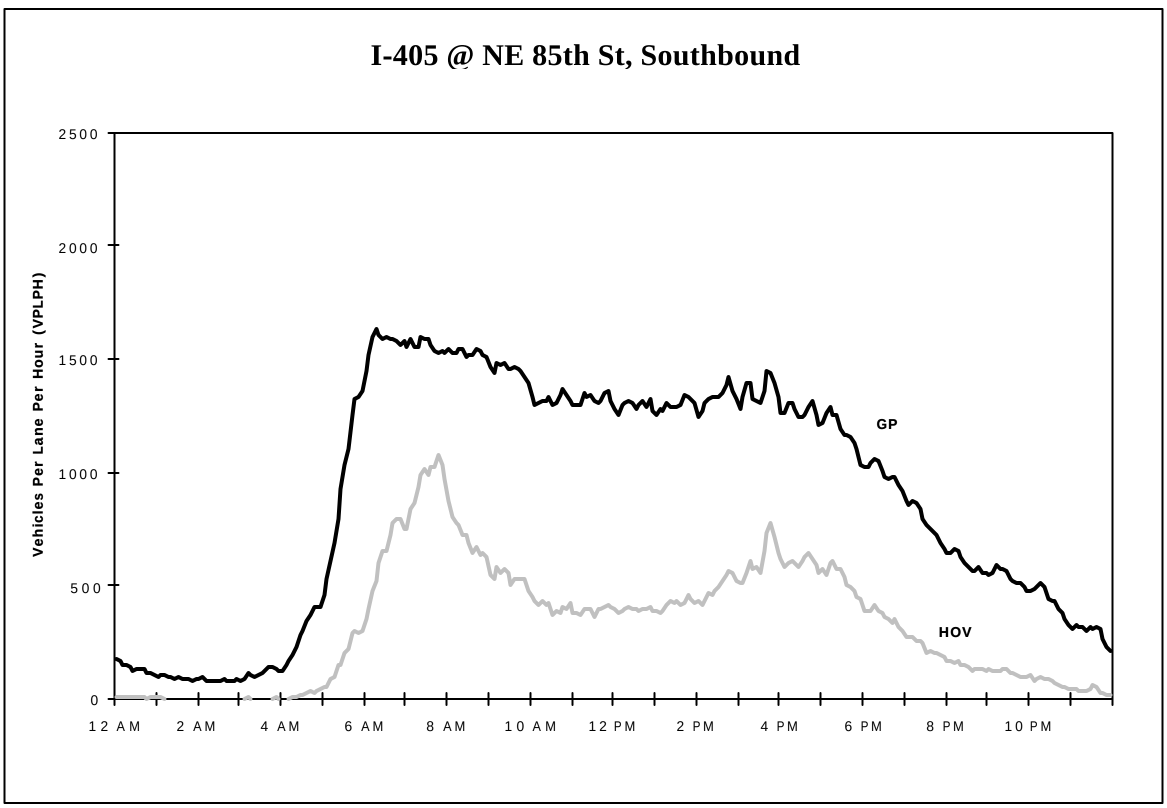
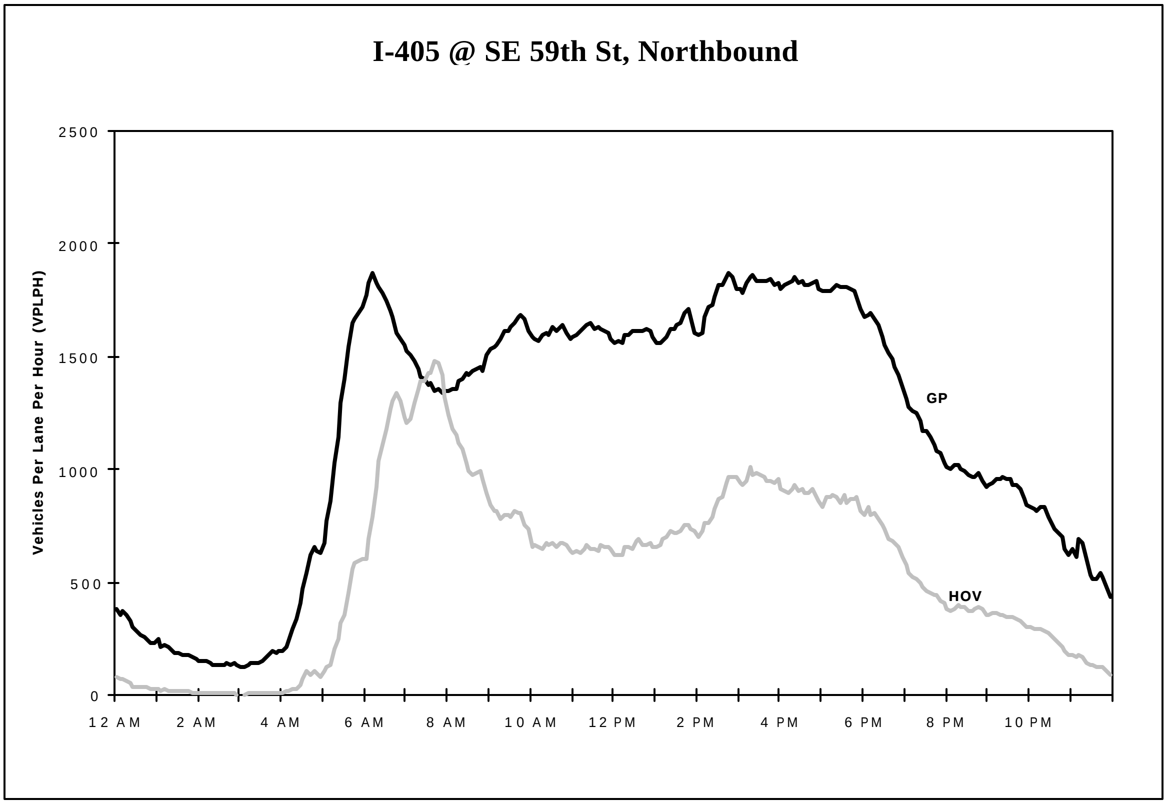


Figure 2-22. Average Weekday GP and HOV Volume Profile (1998): I-405 @ NE 85th St



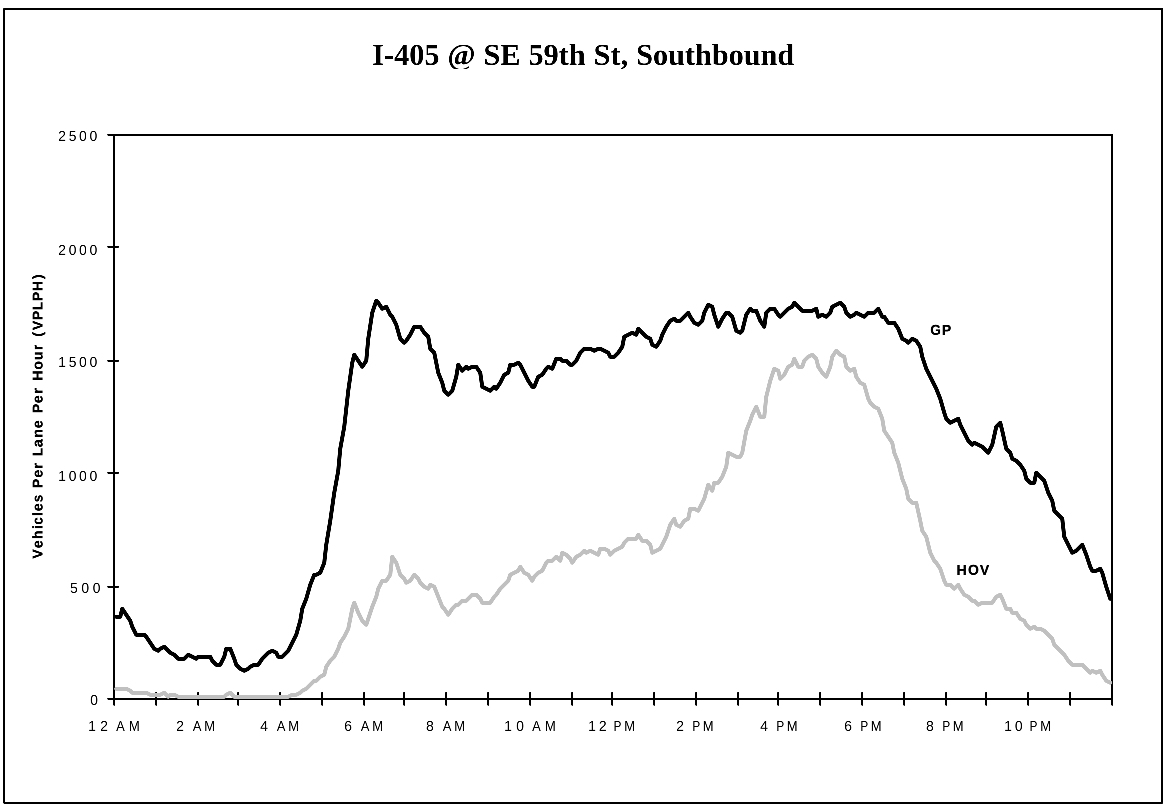
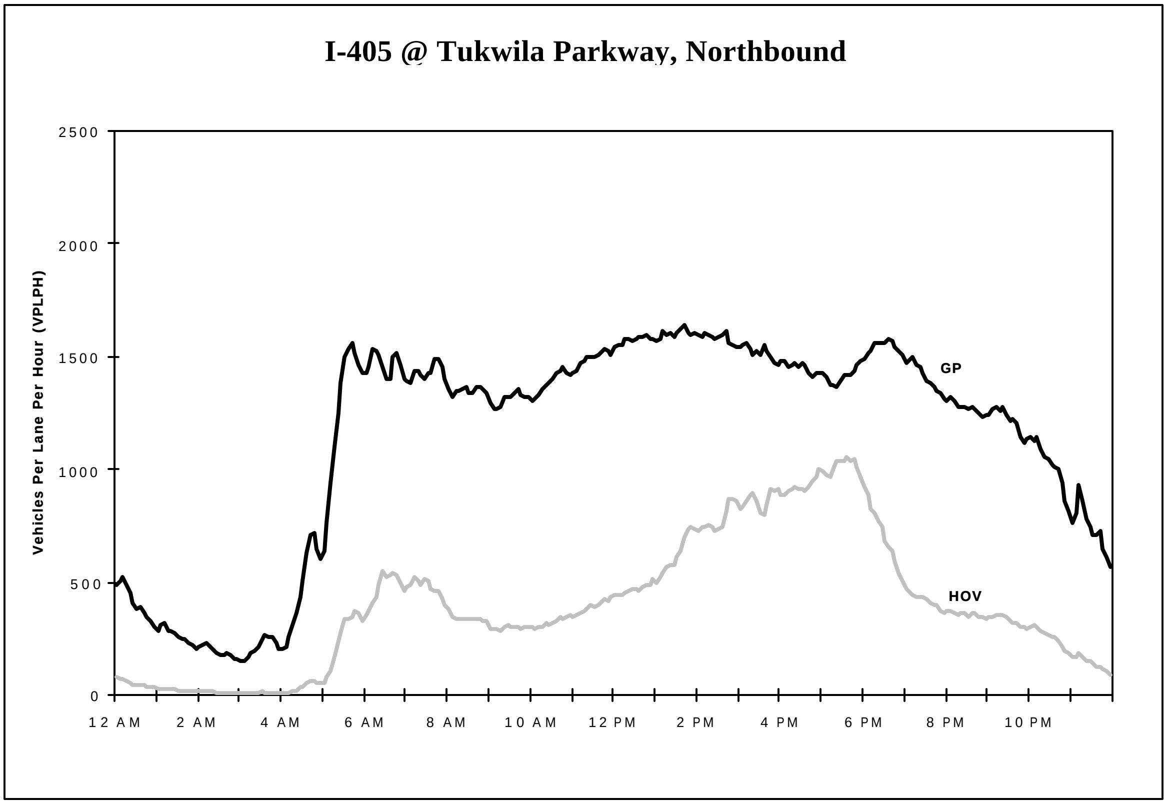


Figure 2-23. Average Weekday GP and HOV Volume Profile (1998): I-405 @ SE 59th St



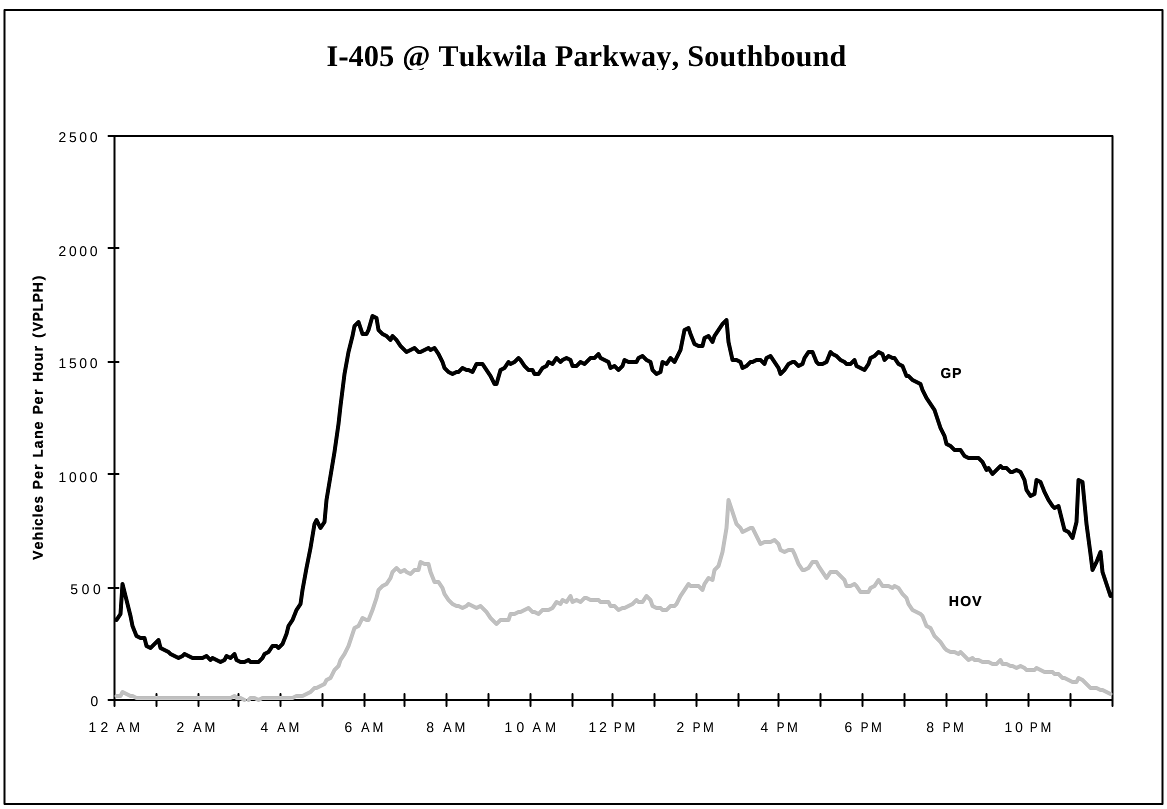
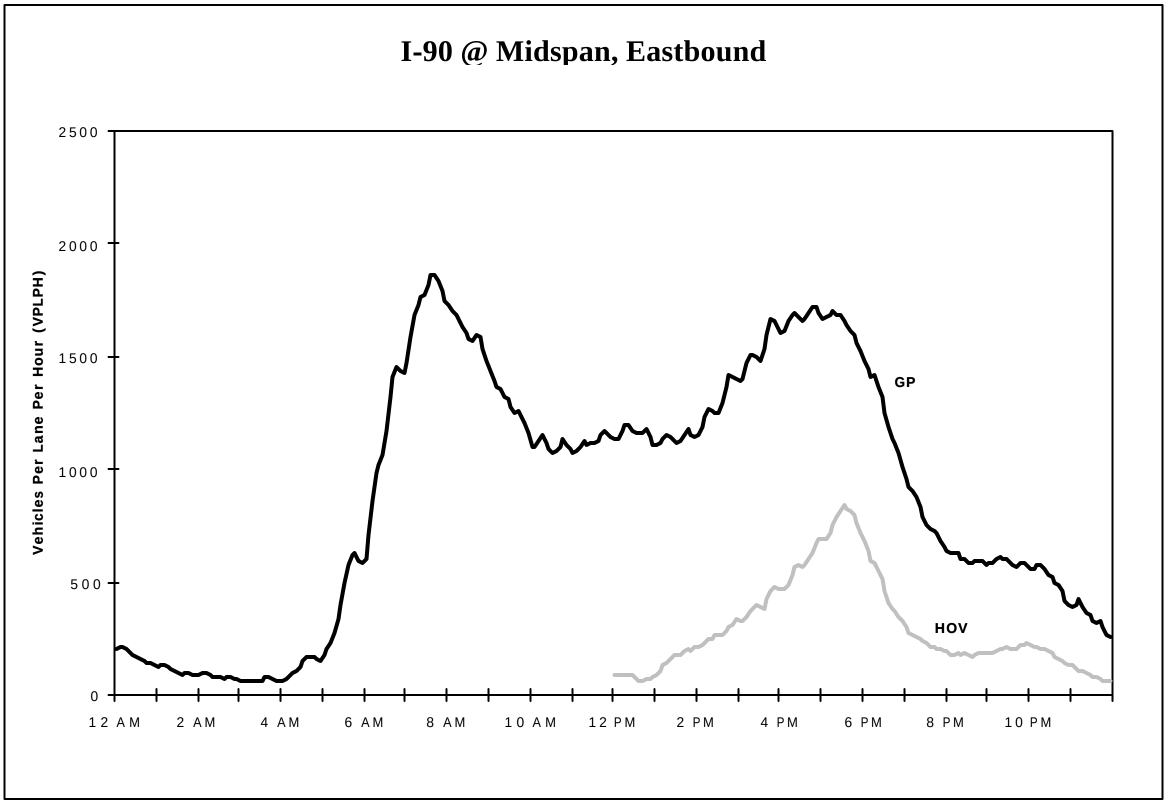


Figure 2-24. Average Weekday GP and HOV Volume Profile (1998): I-405 @ Tukwila Parkway



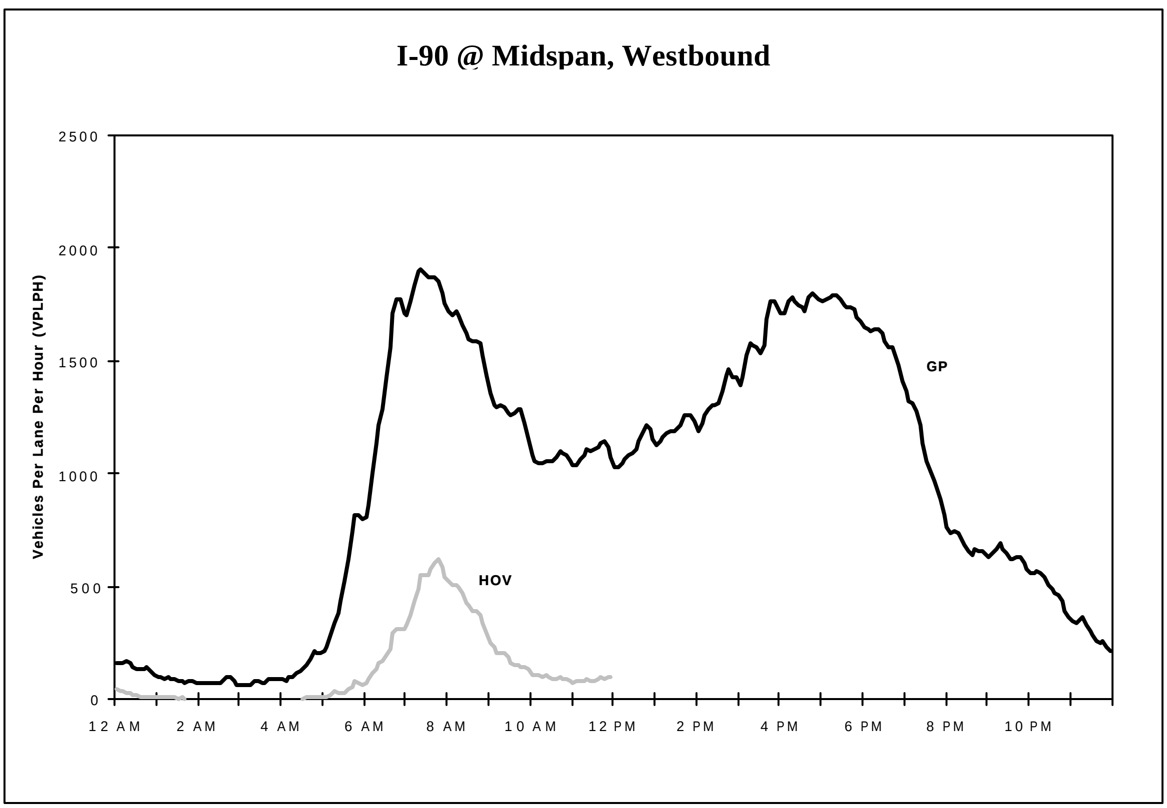
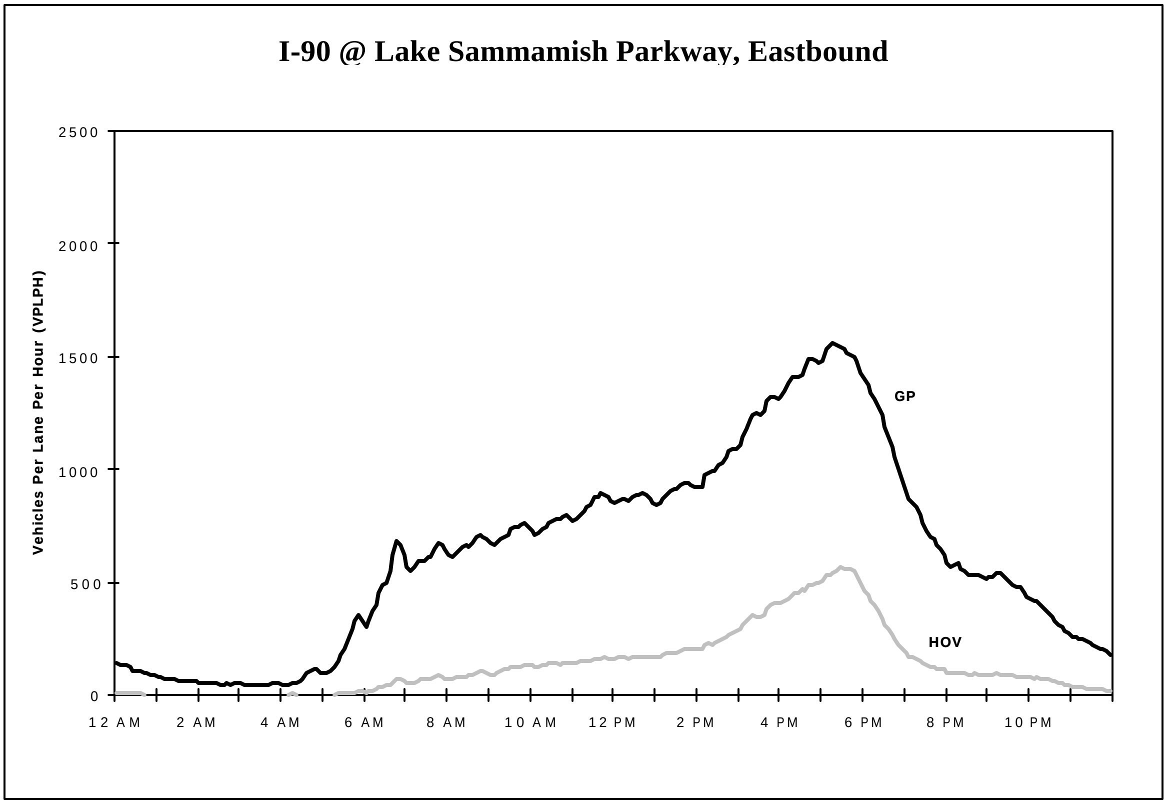


Figure 2-25. Average Weekday GP and HOV Volume Profile (1998): I-90 @ Midspan



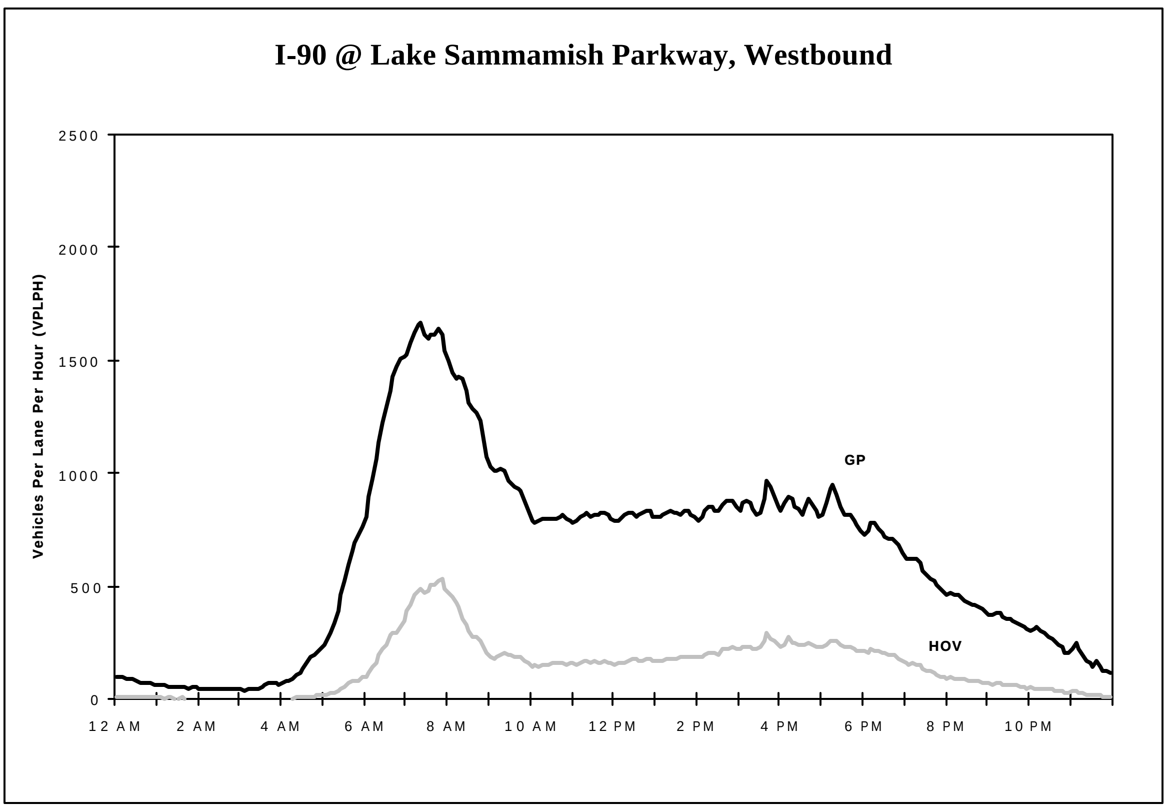


Figure 2-26. Average Weekday GP and HOV Volume Profile (1998): I-90 @ Lake Sammamish Parkway

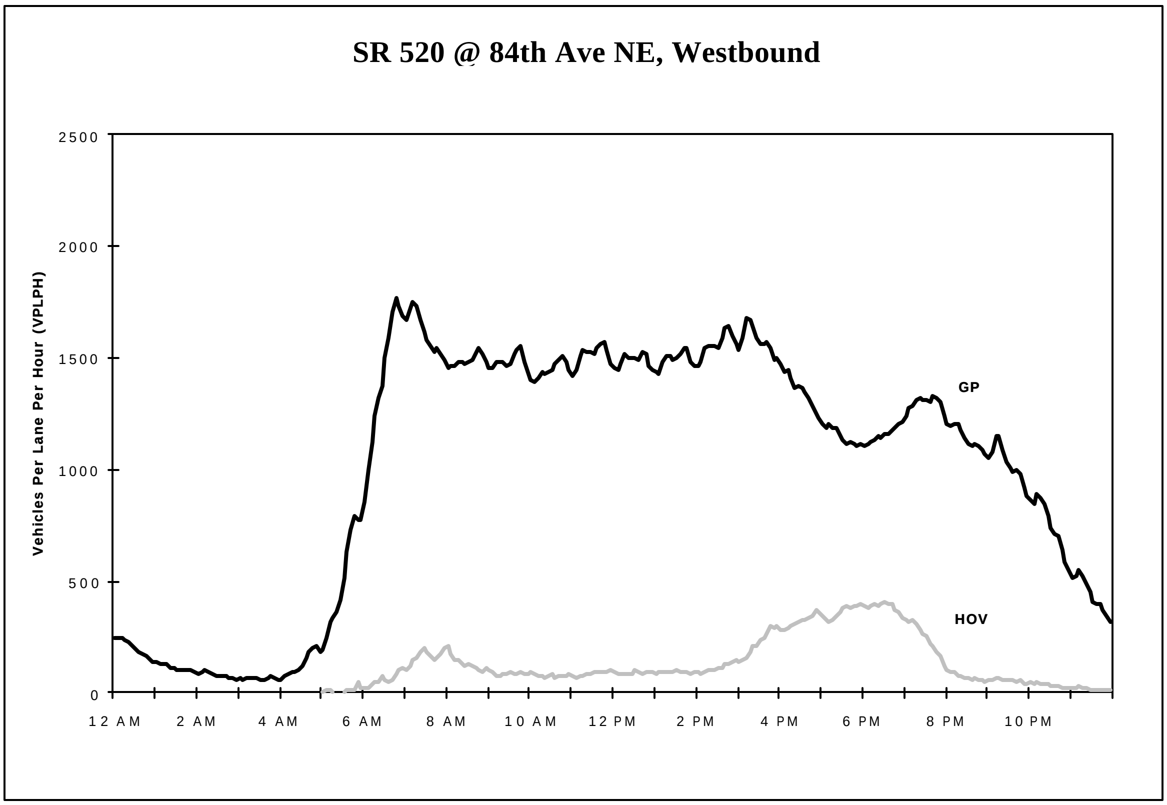
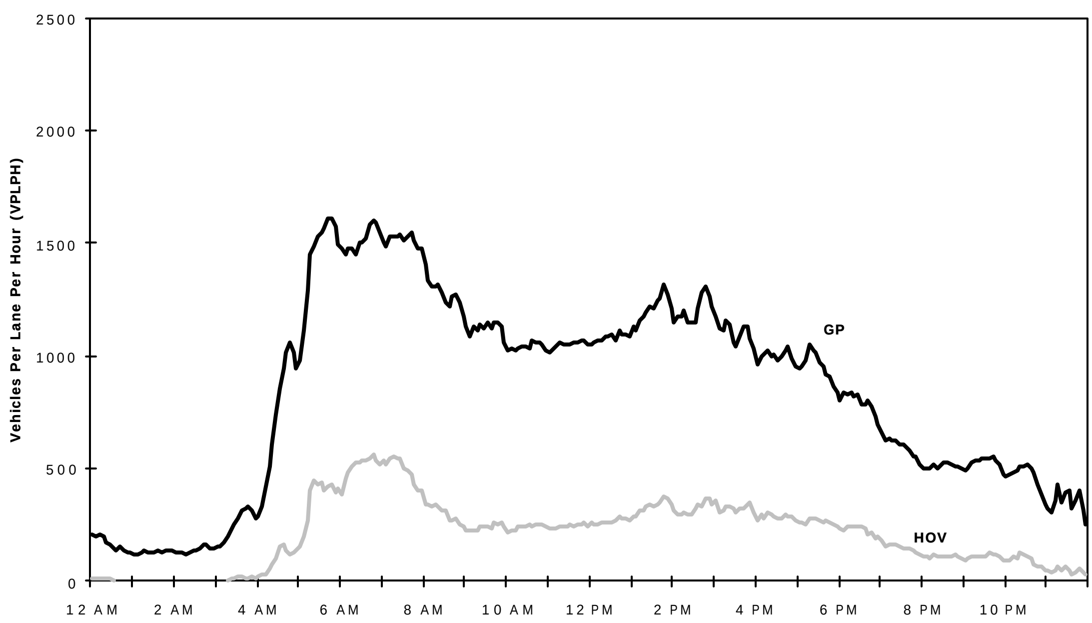


Figure 2-27. Average Weekday GP and HOV Volume Profile (1998): SR 520 @ 84th Ave NE

SR 167 @ S 208th St, Northbound



SR 167 @ S 208th St, Southbound

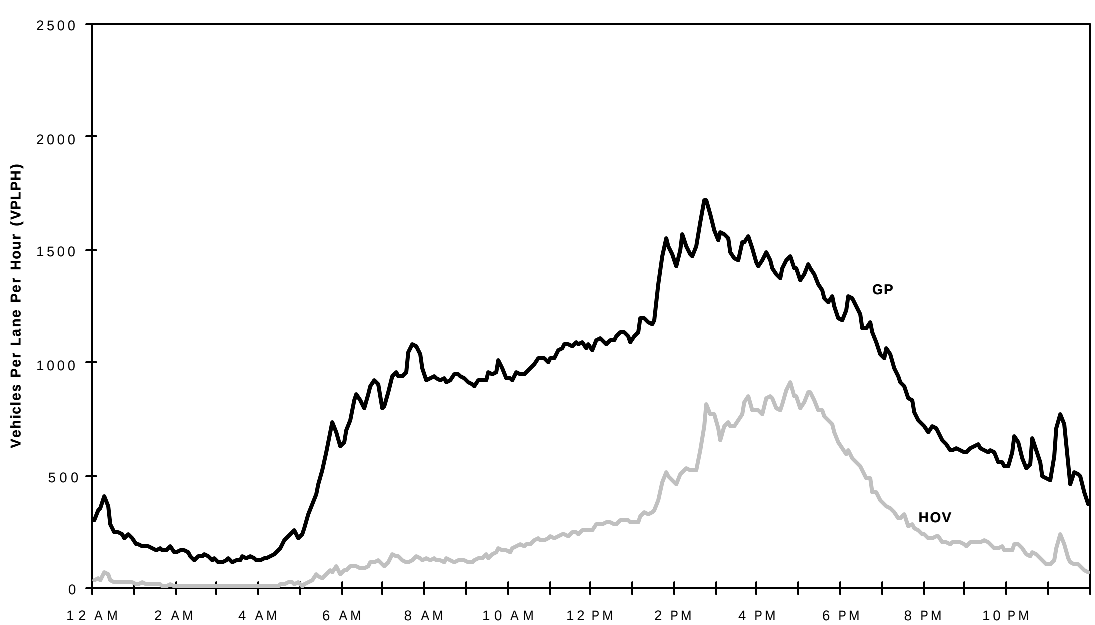


Figure 2-28. Average Weekday GP and HOV Volume Profile (1998): SR 167 @ S 208th St

GP VS. HOV THROUGHPUT COMPARISON

To what extent is an HOV lane being used? Figures 2-29 though 2-38 break down person and vehicle volumes within GP and HOV lanes along the peak volume direction. Several pieces of throughput information are depicted for each representative site. The vehicle and person throughput data for GP and HOV lanes are presented as both *overall* and *per-lane* statistics. This allows the determination of what proportion of total throughput the HOV facility provides, while also allowing a fairer comparison of how much throughput the HOV lane is providing in comparison to a single GP lane.

I-5 North of the Seattle CBD – 112th St. SW (see Figure 2-29)

AM Peak Period. 1,152 vehicles in the southbound HOV lane moved 2,842 people, resulting in an average vehicle occupancy that was nearly two and a half times that of the adjacent GP lane (2.5 people per vehicle versus 1.1 people per vehicle).

PM Peak Period. The northbound HOV lane carried 24 percent of all people in 15 percent of all cars, with an AVO of 2.2. On a per-lane basis, the HOV lane carried nearly the same number of people as the GP lane carried but in half the number of vehicles.

I-5 North of the Seattle CBD – NE 137th St. (see Figure 2-30)

AM Peak Period. 61 percent of the people travelling southbound toward the University of Washington and downtown Seattle were carried by four GP lanes; the single southbound HOV lane carried the remaining 39 percent of all travelers in 15 percent of the vehicles in the forms of carpools, vanpools, and buses. About 41 percent of all people carried in the HOV lane were bus riders (refer to Figure 2-4), resulting in an average vehicle occupancy of 4.1. On a per-lane basis, the HOV lane carried 152 percent more people in 32 percent fewer vehicles than the adjacent GP lane.

PM Peak Period. In the evening peak period, the HOV lane carried 33 percent of all people and 14 percent of all vehicles. On average, 3.4 people were in each vehicle in the HOV lane. About 36 percent of all people travelling in the HOV lane were carried by Community Transit and Metro buses. On a per-lane basis, the HOV lane carried 96 percent more people in 33 percent fewer vehicles than the adjacent GP lane.

<u>I-5 South of the Seattle CBD – Albro Place (see Figure 2-31)</u>

AM Peak Period. 32 percent of all people travelling northbound used the HOV lane and were carried in 15 percent of the vehicles. Unlike other inside HOV lanes, the northbound HOV lane at this location is also an exit lane, so it includes a mixture of SOV and HOV traffic. This slightly lowered the average vehicle occupancy rate. About 44 percent of people carried in the HOV lane were bus riders. On a per-lane basis, the HOV lane carried 10,695 people in 3,275 vehicles, or 90 percent more people in 28 percent fewer vehicles than the adjacent GP lane.

PM Peak Period. The northbound HOV lane carried 37 percent of all people in 17 percent of all vehicles, equivalent to an AVO of 3.5 people in each vehicle. About a quarter of all people travelling in the HOV lane were carried by Pierce Transit and Metro buses. On a per-lane basis, the HOV lane carried 137 percent more people in 18 percent fewer vehicles than the adjacent GP lane.

<u>I-405 North of I-90 – NE 85th St. (see Figure 2-32)</u>

AM Peak Period. The southbound HOV lane carried 30 percent of all people in 14 percent of all vehicles, or 5,586 people in 4,377 vehicles, resulting in an AVO of 2.7 people per vehicle. Per lane, the HOV lane carried 28 percent more people in half as many vehicles as the adjacent GP lane.

PM Peak Period. The northbound HOV lane carried 33 percent of all people in 19 percent of all vehicles with an average of 2.3 people in each vehicle. On a per-lane basis, the HOV lane carried 49 percent more people in about two thirds as many vehicles as the adjacent GP lane.

I-405 South of I-90 – SE 59th St. (see Figure 2-33)

AM Peak Period. The northbound HOV usage during the morning peak period was relatively high. The HOV lane carried 44 percent of the people in 28 percent of the vehicles, an average of 2.1 people in each vehicle. When compared to the adjacent GP lane on a per-lane basis, the HOV lane carried 59 percent more people in about 21 percent fewer vehicles.

PM Peak Period. The southbound HOV usage during the evening peak period was almost as high as in the adjacent northbound traffic during both the morning and evening peak period. About 44 percent of the people were carried in the HOV lane in 29 percent of the vehicles, with an average of 2.1 people in each vehicle. In comparison to the adjacent GP lane, the HOV lane carried 58 percent more people in about 19 percent fewer vehicles.

I-405 South of I-90 – Tukwila Parkway (see Figure 2-34)

AM Peak Period. The level of person and vehicle throughput at this location in the southbound HOV lane was moderate in comparison to the adjacent GP lane during the morning commute.

PM Peak Period. The northbound HOV lane carried 15 percent more people in 40 percent fewer vehicles than the adjacent GP lane during the afternoon peak period.

I-90 - Midspan (see Figure 2-35)

AM Peak Period. 29 percent of the westbound commuters utilized the westbound center lanes traveling in a mixture of transit, carpools, vanpools, and GP vehicles. Traffic volumes along the center roadway at this time of day represented 14 percent of all vehicles on I-90. On a per-lane basis, the HOV lane carried 40 percent fewer people and 76 percent fewer vehicles than the GP lane.

PM Peak Period. In the evening peak period, 33 percent of the people travelling eastbound used the center lanes in 20 percent of all vehicles commuting on the I-90 bridge. On a per-lane basis, the HOV lane carried 27 percent fewer people and 63 percent fewer vehicles than a GP lane.

I-90 – Lake Sammamish Parkway (see Figure 2-36)

HOV usage during both commute periods was moderate. Overall, the HOV lane carried about 15 percent of all people in less than 10 percent of all vehicles. On a per-lane basis, the HOV lane carried fewer people and vehicles than the adjacent GP lanes. This moderate usage of the HOV facility was primarily due to the low congestion level on I-90.

SR 520 – 84th Ave NE (see Figure 2-37)

AM Peak Period. The westbound HOV lane on SR 520 (the only freeway HOV lane in Puget Sound that requires three or more occupants) carried 31 percent of all people in only 3 percent of all vehicles. Of the people carried in the HOV lane, Figure 2-4 shows that bus riders represented 67 percent. On a per-lane basis, the HOV lane carried 9 percent fewer people and 93 percent fewer vehicles than the GP lane.

PM Peak Period. The westbound HOV lane carried 28 percent of all people heading across Lake Washington in 10 percent of all vehicles. There were fewer bus riders in the HOV lane during the evening peak period because of decreased transit service in the "reverse" direction. On a per-lane basis, the HOV lane carried 22 percent fewer people and 78 percent fewer vehicles than the GP lane.

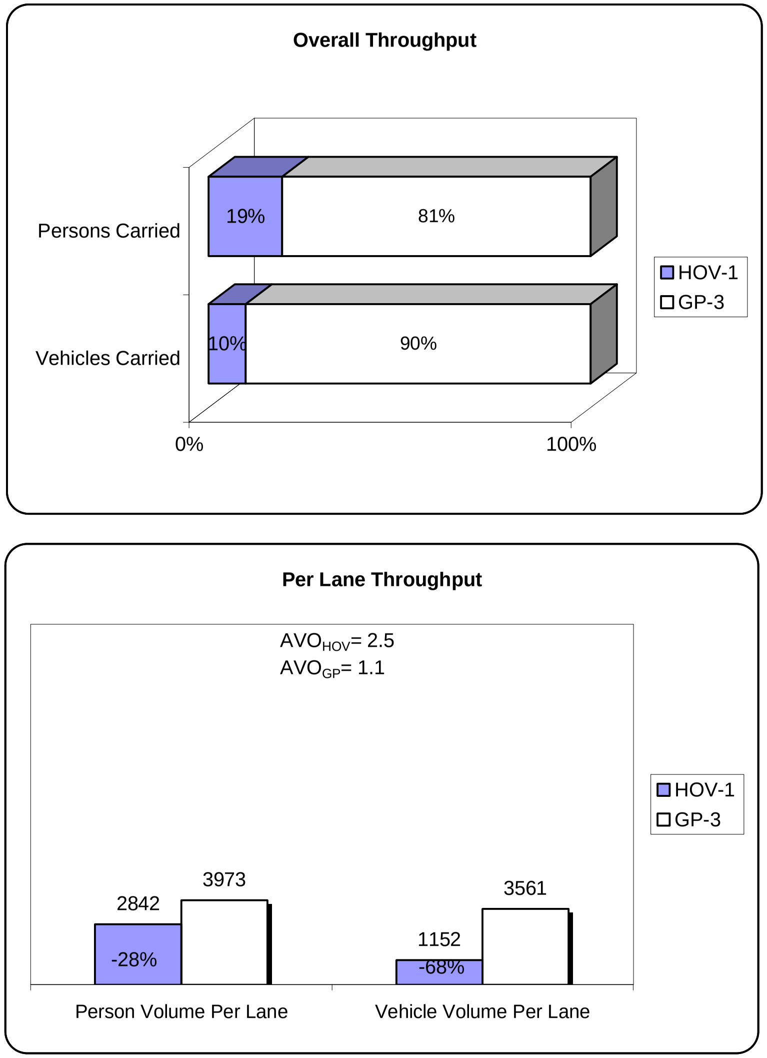
SR 167– S. 208th (see Figure 2-38)

AM Peak Period. HOV usage during the morning peak period was relatively low. In comparison to the adjacent GP lane on a per-lane basis, the northbound HOV lane carried fewer vehicles and people.

PM Peak Period. The southbound HOV usage during the afternoon peak period was moderate. About 36 percent of all people were carried in the HOV lane in 24 percent of all vehicles, with an average of 2.2 people in each vehicle. In comparison to the adjacent GP lane on a per-lane basis, the HOV lane carried 14 percent more people in about 37 percent fewer vehicles.

Note that at the time of this analysis, several loop stations along the northern section of this HOV corridor were not active, which adversely affected study results, particularly those in the northbound direction.

AM Peak Period: Southbound



PM Peak Period: Northbound

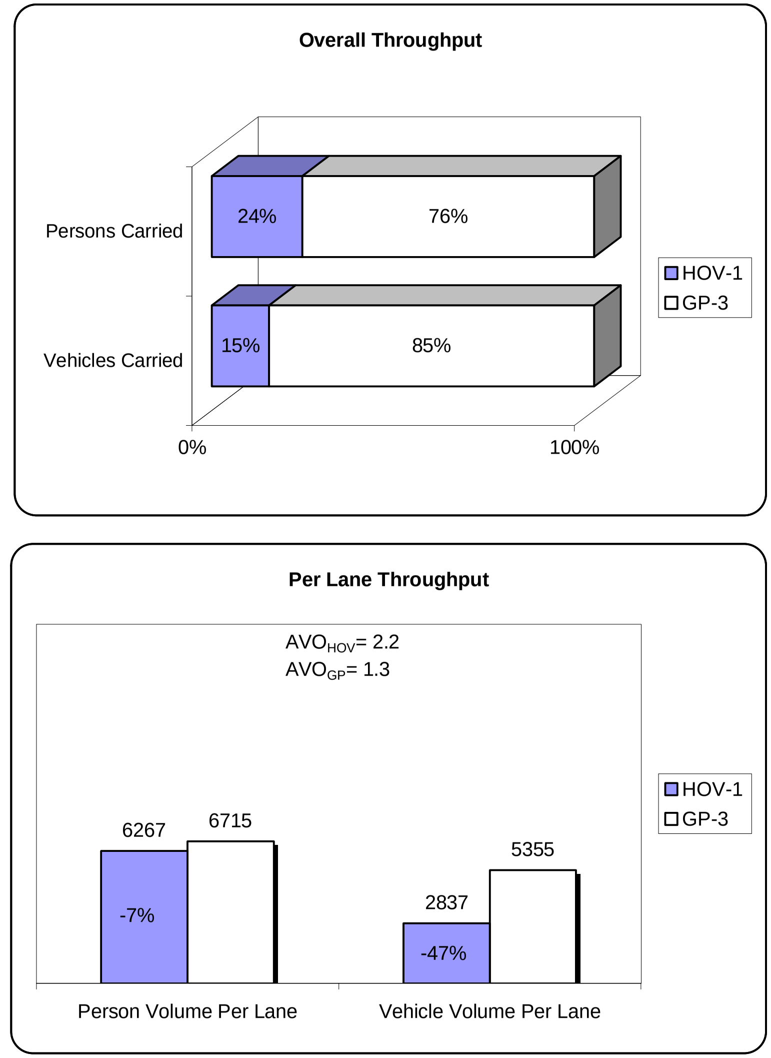
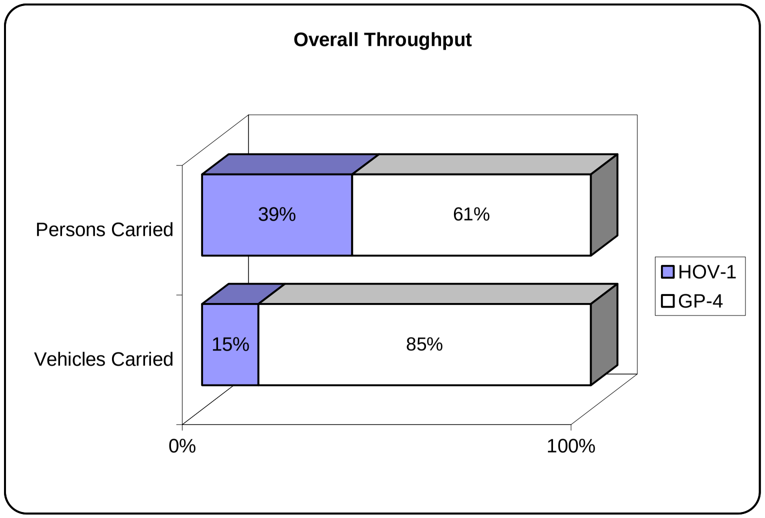
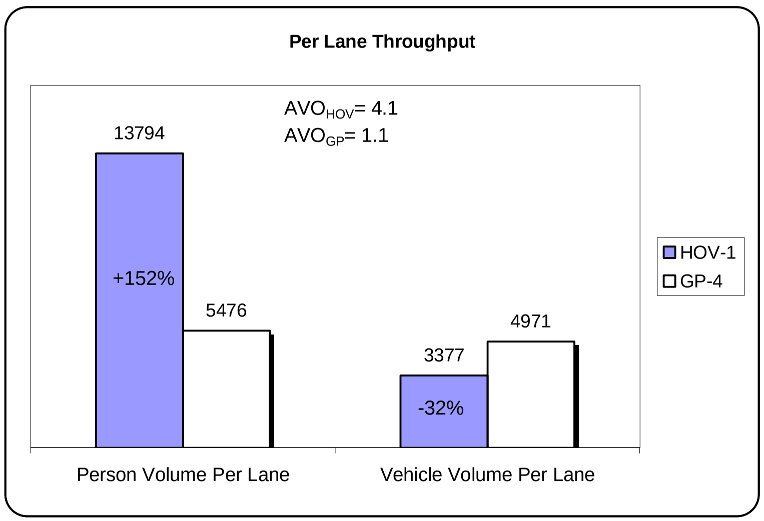


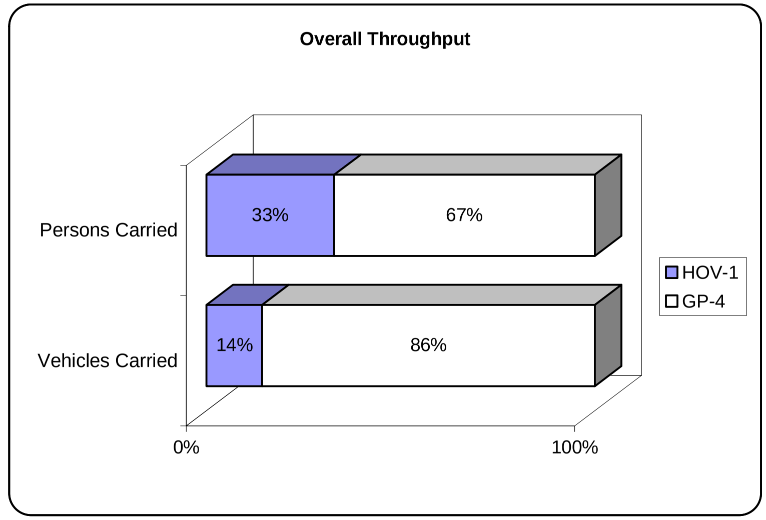
Figure 2-29. GP vs. HOV Throughput Comparison (1998): I-5 @ 112th SE

AM Peak Period: Southbound





PM Peak Period: Northbound



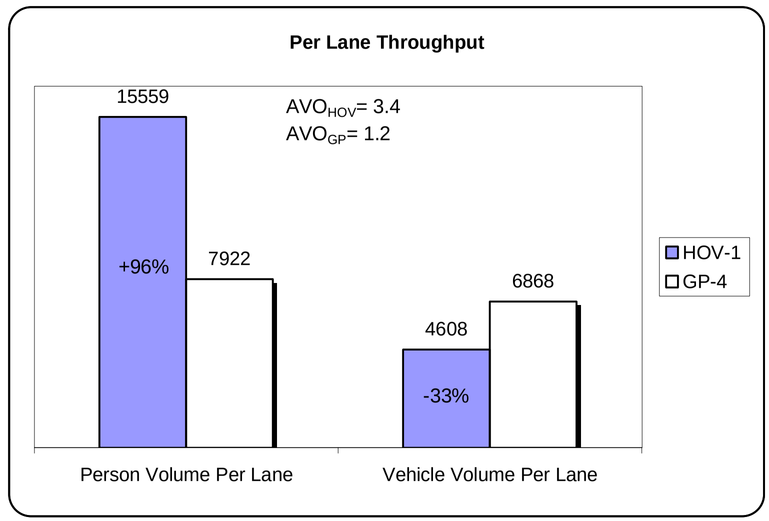
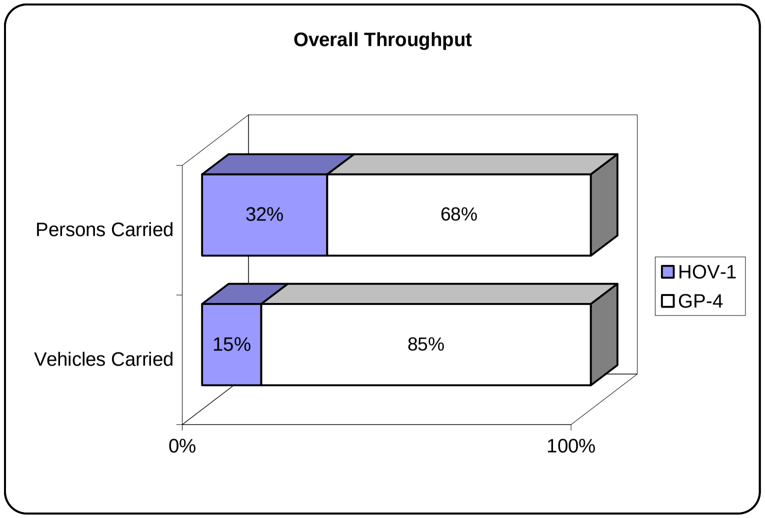
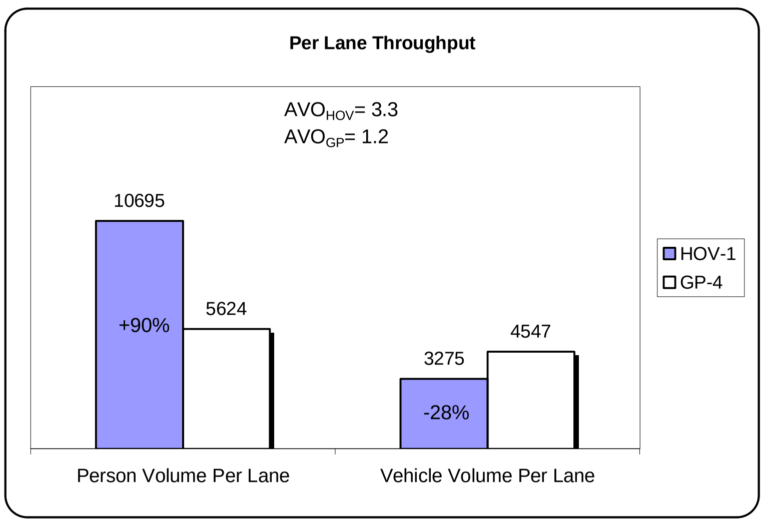


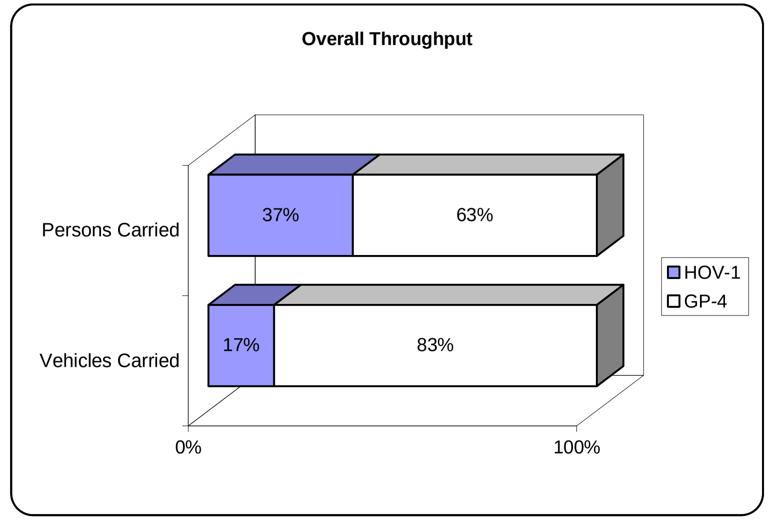
Figure 2-30. GP vs. HOV Throughput Comparison (1998): I-5 @ NE 137th St.

AM Peak Period: Northbound





PM Peak Period: Southbound



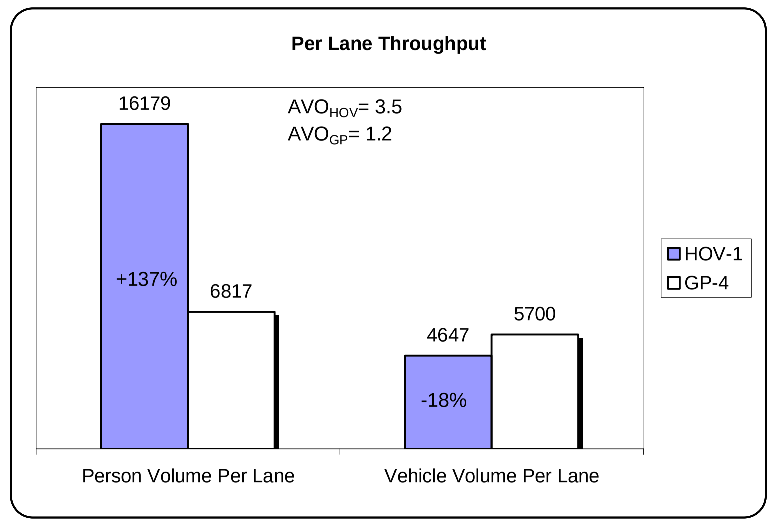
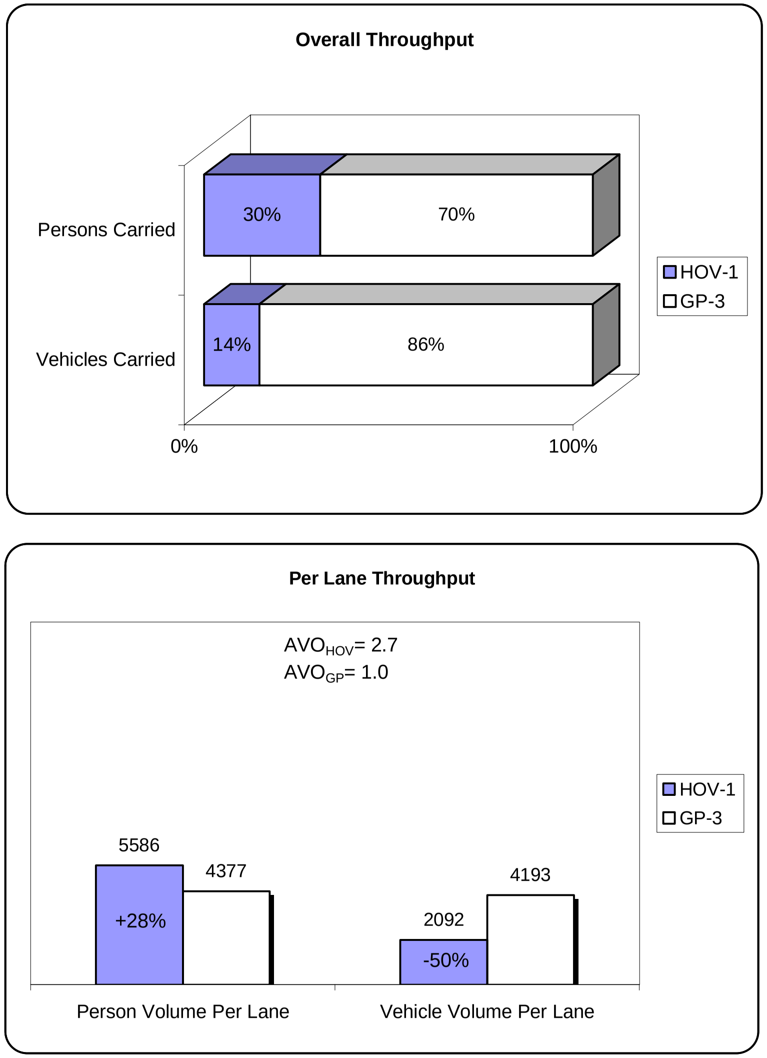


Figure 2-31. GP vs. HOV Throughput Comparison (1998): I-5 @ Albro Place

AM Peak Period: Southbound



PM Peak Period: Northbound

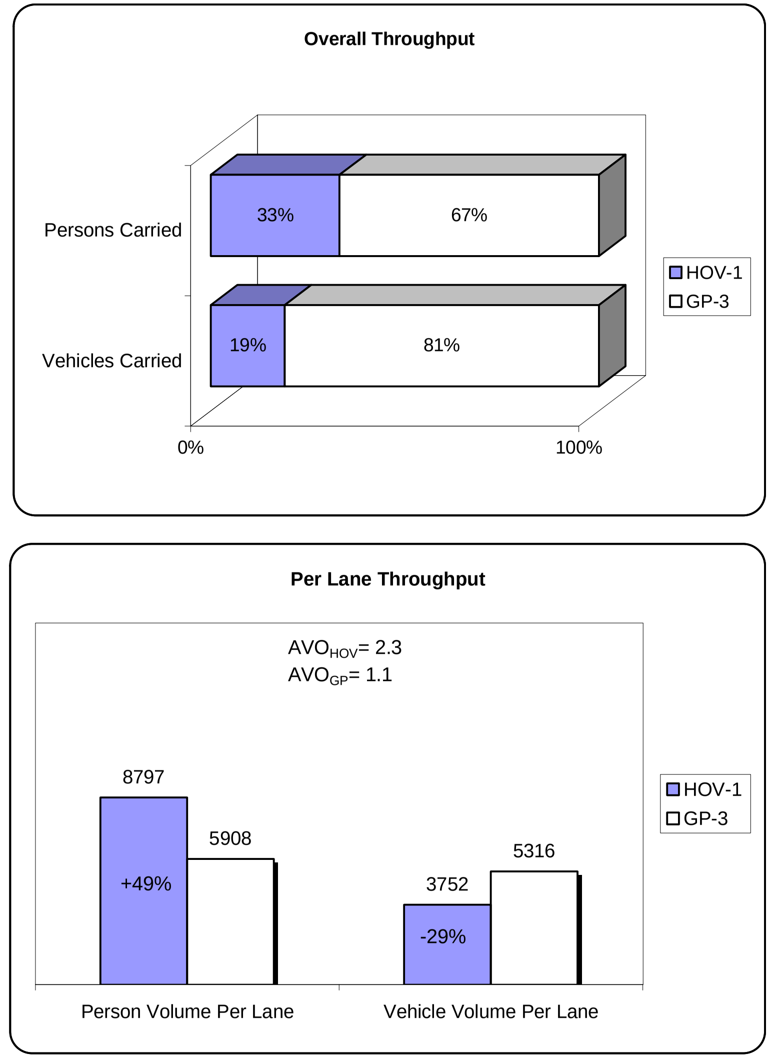


Figure 2-32. GP vs. HOV Throughput Comparison (1998): I-405 @ NE 85th St.

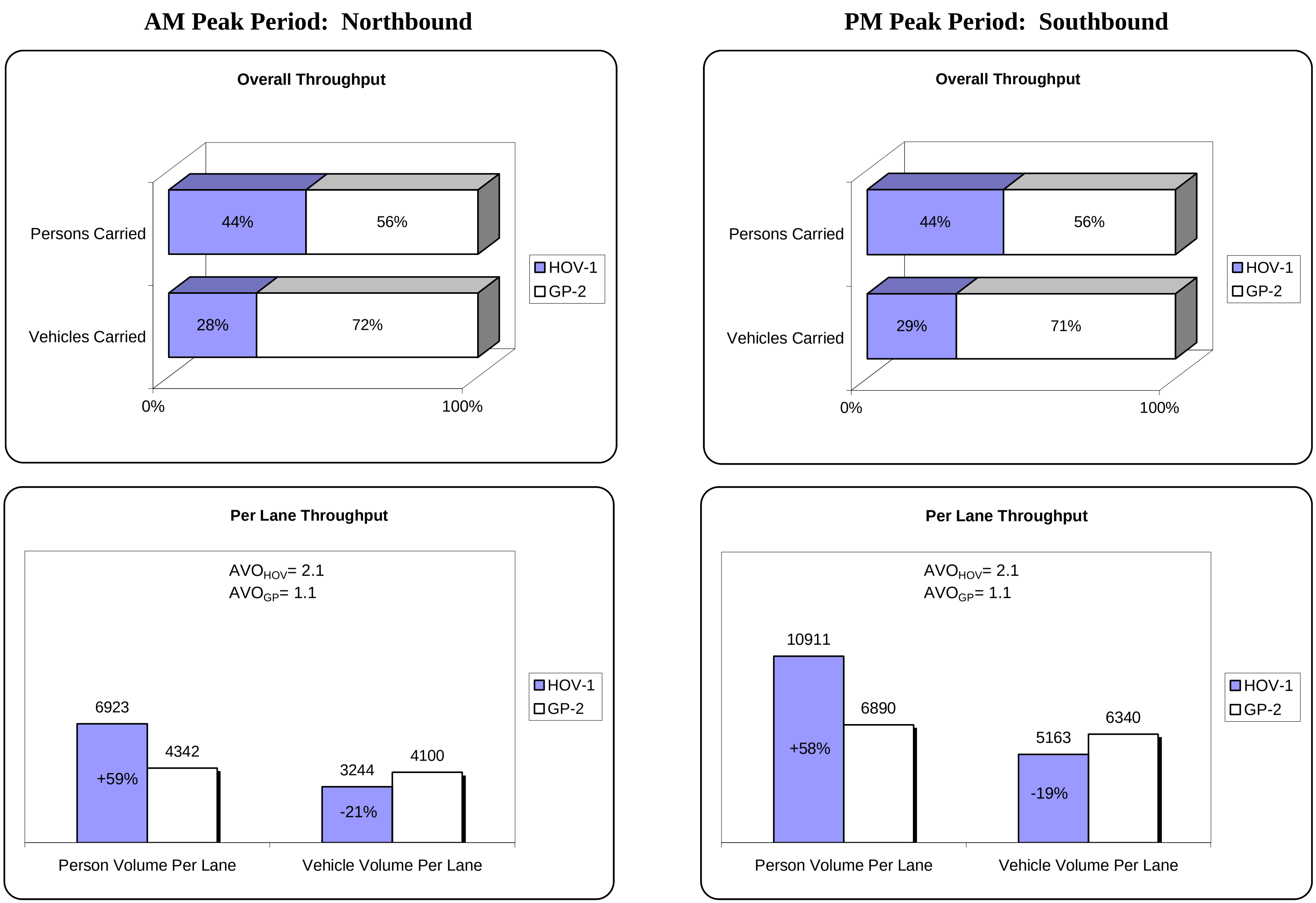
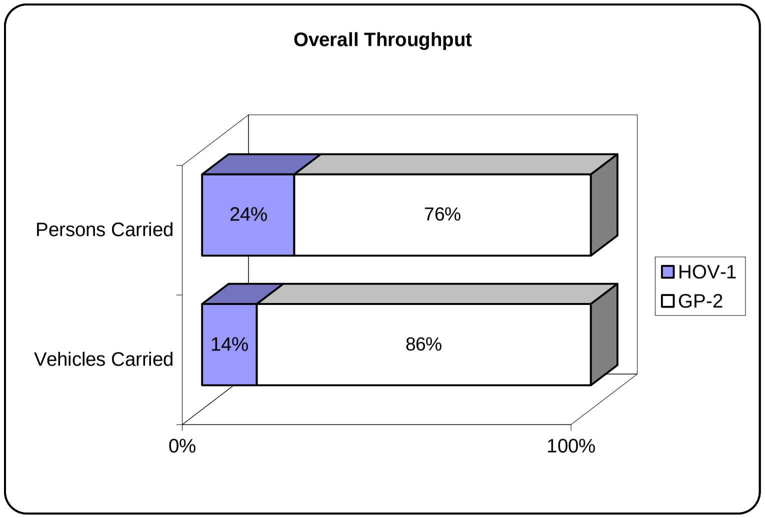
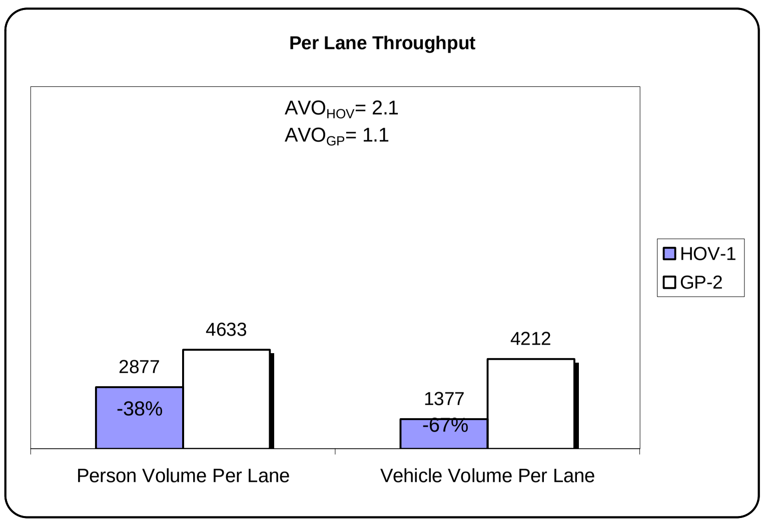


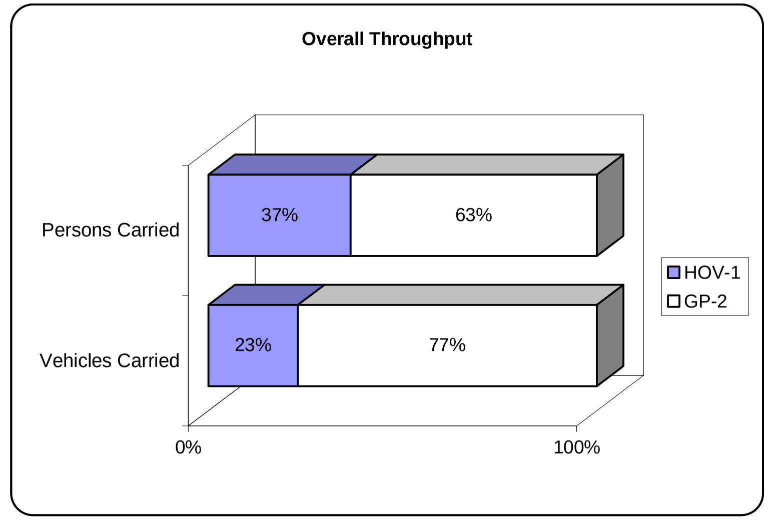
Figure 2-33. GP vs. HOV Throughput Comparison (1998): I-405 @ SE 59th St.

AM Peak Period: Southbound





PM Peak Period: Northbound



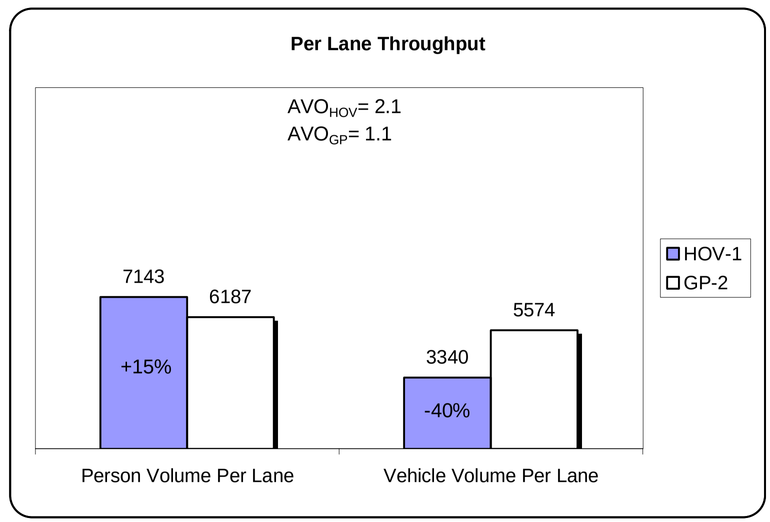


Figure 2-34. GP vs. HOV Throughput Comparison (1998): I-405 @ Tukwila Parkway

AM Peak Period: Westbound

PM Peak Period: Eastbound

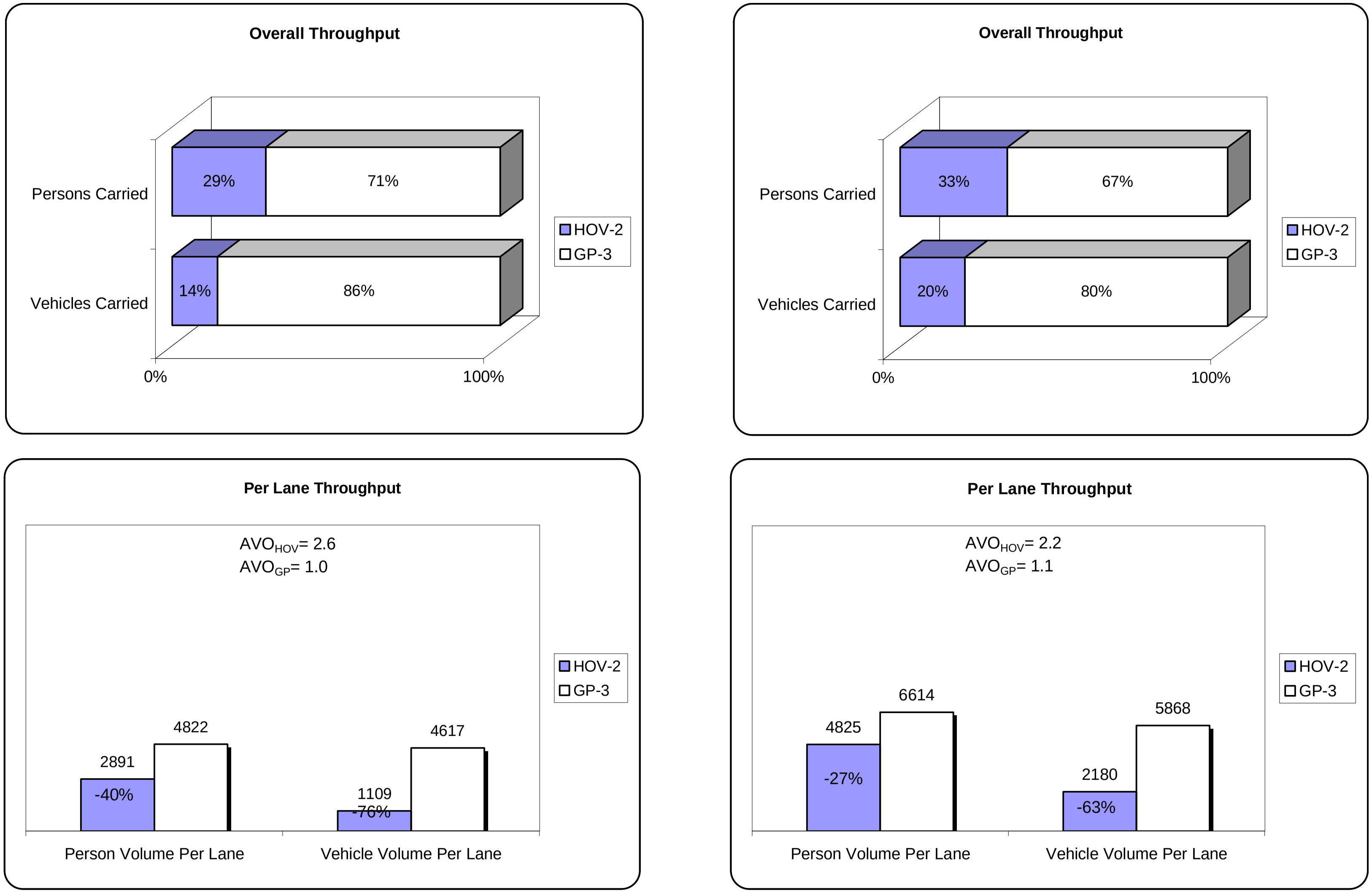


Figure 2-35. GP vs. HOV Throughput Comparison (1998): I-90 @ Midspan

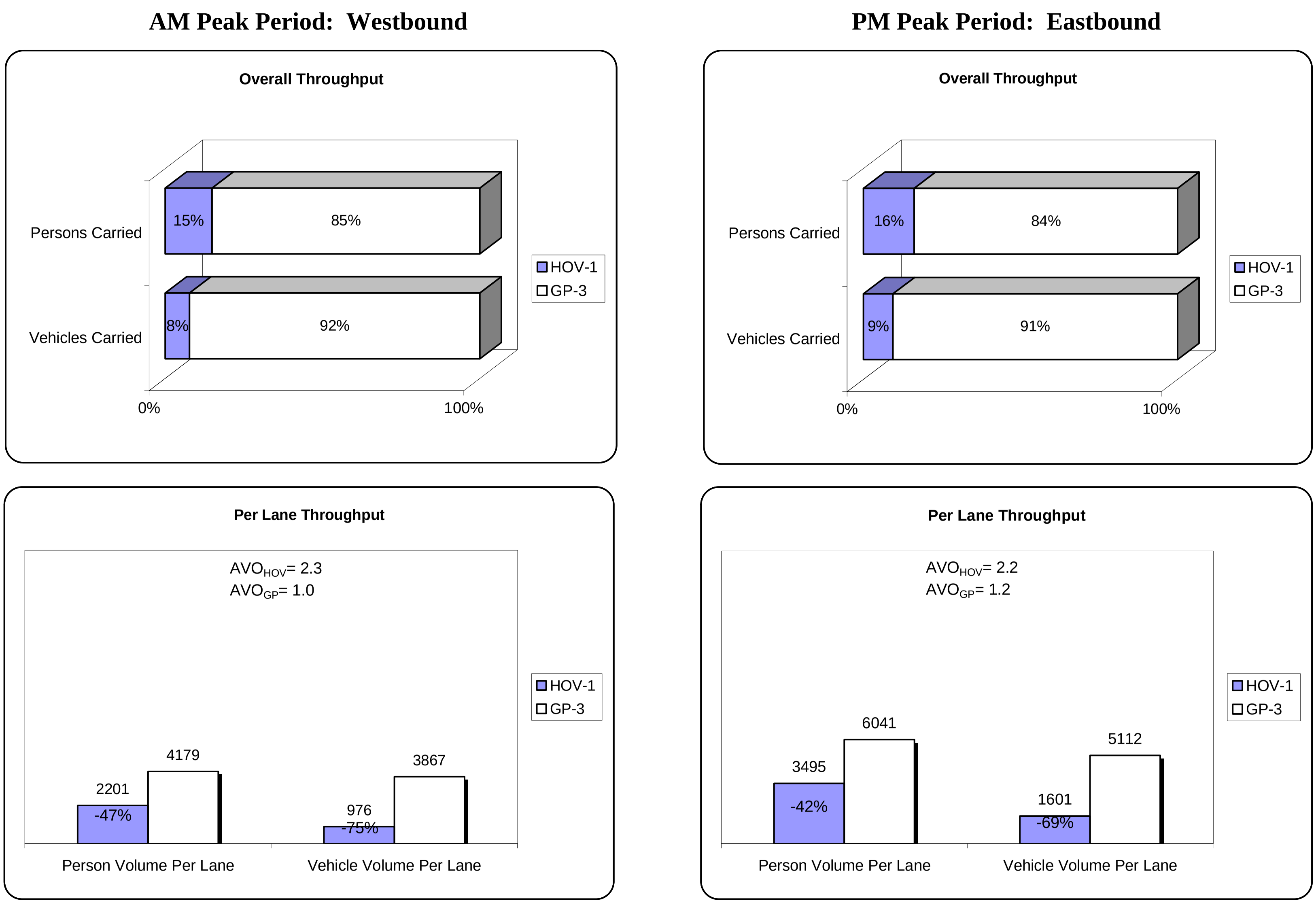


Figure 2-36. GP vs. HOV Throughput Comparison (1998): I-90 @ Newport Way

AM Peak Period: Westbound

PM Peak Period: Westbound

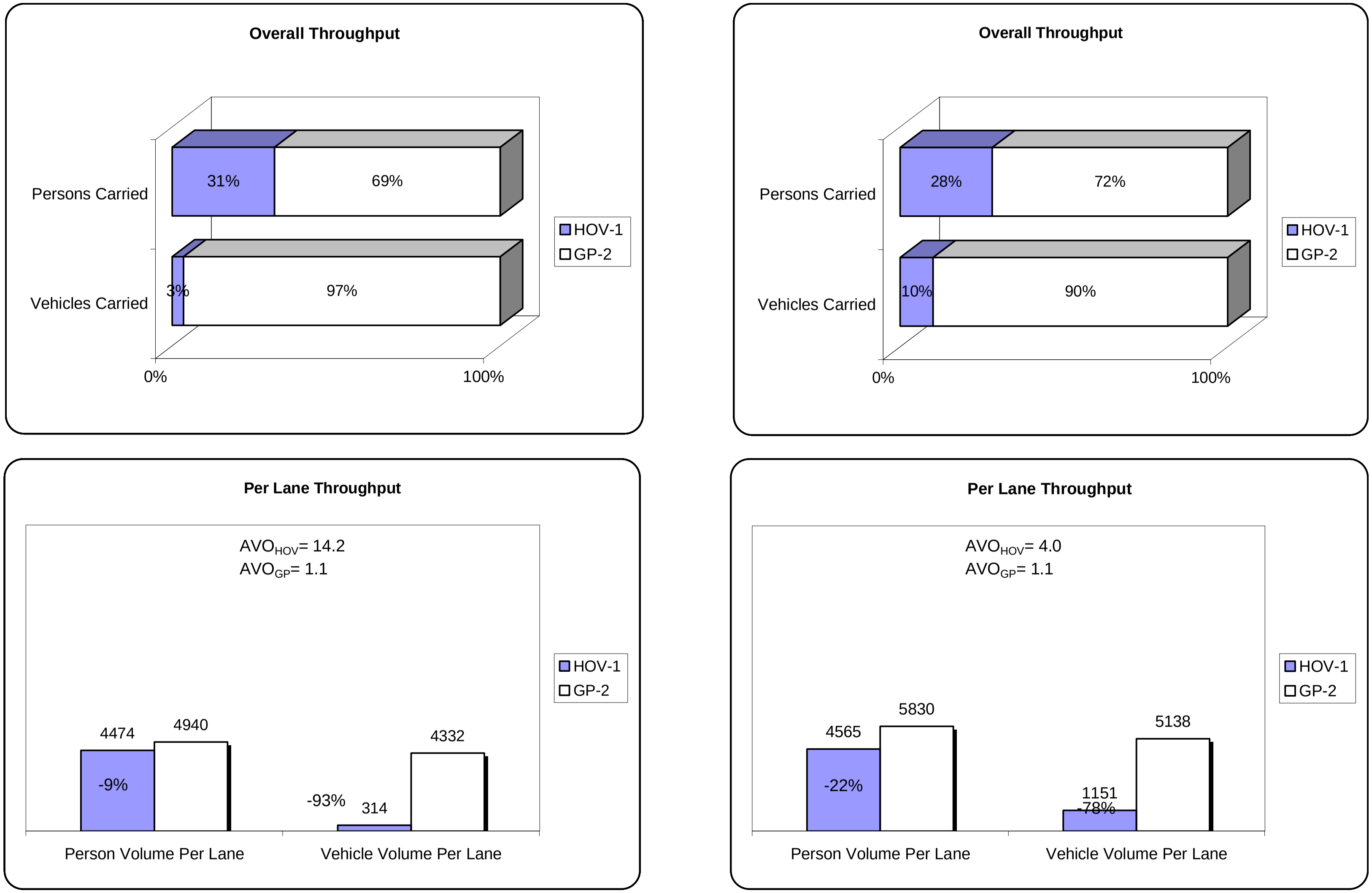
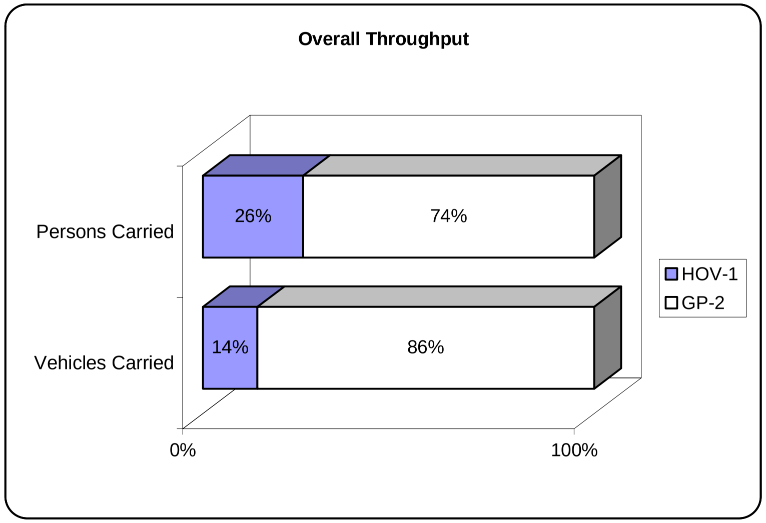
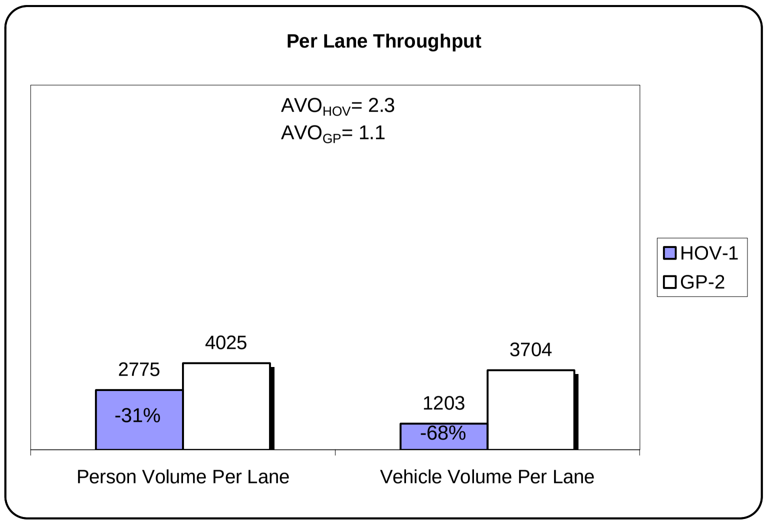


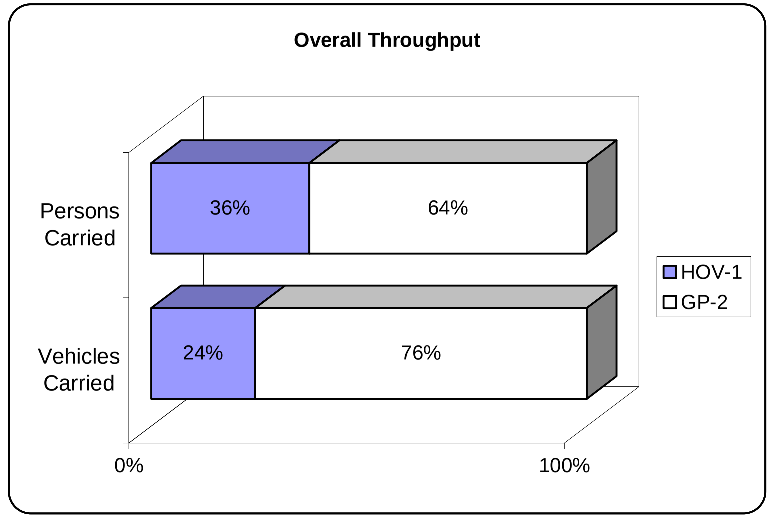
Figure 2-37. GP vs. HOV Throughput Comparison (1998): SR 520 @ 84th Ave NE

AM Peak Period: Northbound





PM Peak Period: Southbound



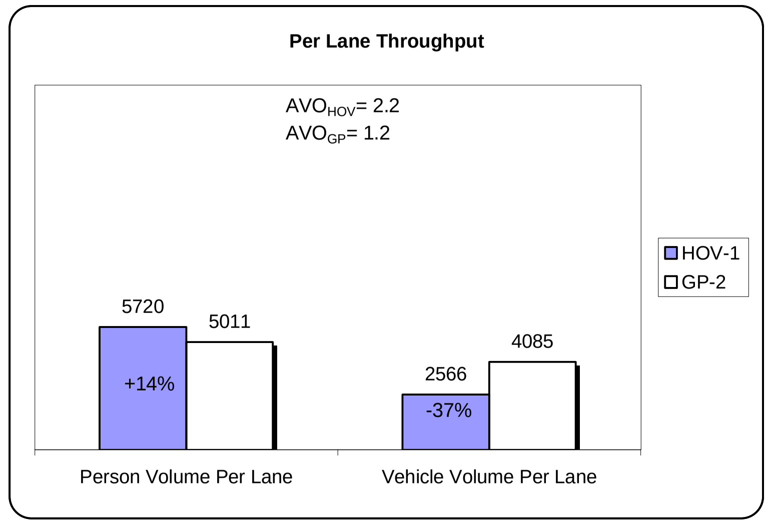


Figure 2-38. GP vs. HOV Throughput Comparison (1998): SR 167 @ S. 208th

CHAPTER THREE
SPEED RELIABILITY AND TRAVEL TIME

The WSDOT HOV system policy states that "HOV lane vehicles should maintain or exceed an average speed of 45 mph or greater at least 90 percent of the time they use that lane during the peak hour (measured for a consecutive six-month period)." To best gage whether HOV facilities are offering users faster travel speed and a more reliable trip than the GP lanes, HOV operational performance was measured in terms of

- speed
- reliability
- congestion pattern
- travel time.

The purpose of these measures is to describe the following:

- the average travel speed variation for a range of trip start times throughout the day
- the likelihood of the average trip in the HOV lane becoming congested (with a speed of less than 45mph)
- how traffic conditions change from location to location along an HOV corridor throughout the day
- how HOV and GP travel times compare
- the travel time savings realized when the HOV lane is used.

This chapter presents the corridor-wide and site-specific operational performance of HOV facilities .

The results of the operational performance analysis allow us to identify "problems" that can then be examined in more detail. It is important to obtain an understanding of why a particular corridor is not meeting the criteria set by the HOV policy before making operational changes. In many cases, the cause of the deficiency may not be easily fixed. For instance, when stop-and-go congestion occurs in the GP lane, HOV traffic slows down because drivers are uncomfortable with traveling at 55 mph so close to stopped traffic. This is called "lane friction" because friction between vehicles with only a lane line separating them is too great. The fact that HOV vehicles slow down under these conditions improves safety as well as driver comfort, and it should not necessarily be viewed as a "bad" outcome.

Another concern is how incidents affect HOV lane operations. This requires determining whether they physically block the HOV lane or are simply nearby, and how these incidents cause delays. Other factors, such as adverse weather and the geometric constraints of roadways, can also affect HOV lane operation. Geometric constraints, such as hills and curves, have a pronounced effect, particularly when steep grades prevent buses from maintaining desired speeds. Last, congestion often occurs where HOV facilities merge with GP lanes, as HOV vehicles are forced to contend with weaving GP traffic. This merge phenomenon happens in places such as on I-405 near SR 522, and can even happen in the middle of a corridor, such as on I-405 at SR 167.

CORRIDOR-WIDE OPERATIONAL PERFORMANCE

This section describes the performance measures used to evaluate the operational characteristics of the region's HOV facilities. Each HOV corridor is discussed independently. Operational performance was assessed with the following measures:

speed, speed reliability, level of traffic congestion, and travel time savings. Each of these measures is defined below:

- **<u>90th Percentile Average Speed, by Trip Start Time.</u>** Because the state policy standard for HOV lane performance requires an average speed of 45 mph or better 90 percent of the time during the peak hour, 90th percentile weekday HOV lane speeds were estimated for a range of trip start times throughout an average 24-hour weekday. This measurement indicates that nine times out of ten (i.e., 90 percent of the time) a vehicle will travel at a particular speed or faster.
- **<u>Trip Reliability, by Trip Start Time.</u>** In contrast to the 90th percentile average travel speed, this measurement indicates the likelihood (percentage of weekdays) that the average trip speed will be below 45 mph for a given trip start time.
- **<u>Average Traffic Congestion Levels.</u>** To better understand how traffic conditions change as vehicles travel from one location to another on the HOV system, the researchers measured HOV lane congestion patterns at different points (mileposts) along the corridor. The data presented are the average of conditions (average annual weekday lane occupancy data from WSDOT's loop detectors) measured for the weekdays during the year. The result is an image of the "routine" conditions in each HOV lane corridor for all 24 hours of the average weekday.
- **<u>Average Travel Time.</u>** Travel times are another measure of corridor-wide freeway performance. This measure is particularly useful for conveying

corridor congestion because it is in a form that is readily understood and that individual travelers can compare to their own experiences. It is also useful for tracking changes in facility performance over time and for comparing GP and HOV lane performance. For this report, travel times were estimated for trips that traverse the length of GP and HOV lane in the analysis, for a range of start times. For a range of start times for each trip, the project estimated the average of GP and HOV lane travel times measured for the weekdays during the year.

Table 3-1 lists the corridors for which operational performance was measured.

Table 3-1. HOV Corridors for Operational Performance Monitoring

CORRIDORS	DIR	FROM	TO	LENGTH (MILES)
I-5 North of the Seattle CBD	NB	NE 130th St.	Alderwood	9.0
	SB	175th St. SW	NE 130th St.	9.5
I-5 South of the Seattle CBD	NB	S. 144th St.	Columbian Way	7.7
	SB	S. Spokane St.	S. 144th St.	7.7
I-405 North of I-90	NB	SE 20th St.	NE 160th St.	10.7
	SB	NE 160th St.	I-90 Interchange	11.7
I-405 South of I-90	NB	Andover Park E	Coal Creek Parkway	9.4
	SB	Coal Creek Parkway	Andover Park E	9.4
I-90	EB	Mt. Baker Tunnel	200th Ave. SE	14.2
	WB	188th Ave. SE	Mt. Baker Tunnel	13.7
SR 520	WB	104th Ave. NE	84th Ave. NE	1.4
SR 167	NB	43rd St. NW	4th Ave. N	3.3
	SB	4th Ave. N	43rd St. NW	3.3

Reading the Speed and Reliability Graphs

The speed and reliability measures described above are illustrated together in the same set of figures. For the corridor trips listed in Table 3-1, graphs were created to plot the 90th percentile average speed and the 45 mph speed reliability (that is, the frequency at which the average vehicle speed falls below 45 mph during trips for a given trip start time). The following instructions are intended to help the reader understand how to interpret these graphics.

Figure 3-1 is an 8-hour slice of speed and reliability graph for the northbound HOV lane on I-5 near Northgate from Northgate to Alderwood. Both of these measures depend on the time of day the traveler leaves. The starting time of a trip is shown along the horizontal axis from midnight to midnight. The line graph (near the top of the figure) represents the 90th percentile average speed for HOVs on I-5 at this location. It is measured with the left vertical axis. It indicates that HOV lane vehicles travel at a speed below 45mph between 4:00 PM and 5:00 PM.

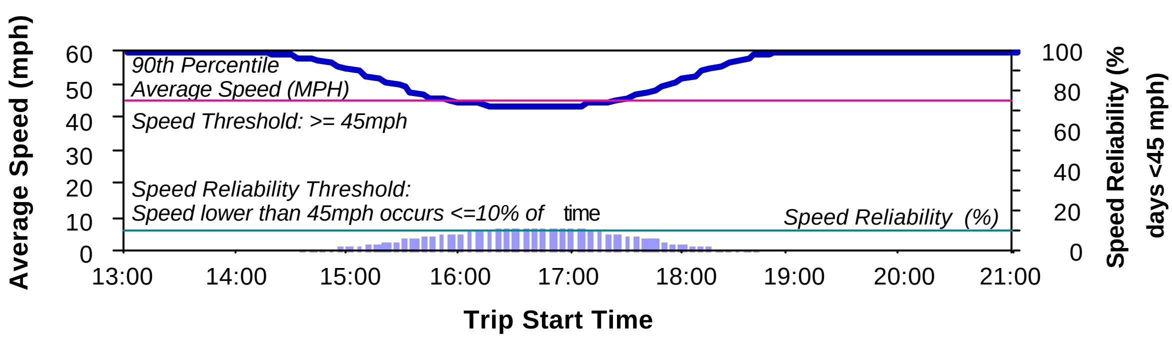


Figure 3-1. Average Weekday HOV Speed and Reliability Graph: I-5 North of the Seattle CBD, Northbound from NE 130th St. to Alderwood

The column graph at the bottom of the figure is measured with the right vertical axis. It illustrates the frequency with which congestion is experienced in the HOV lane on a given trip, where congestion is defined as an average travel speed of less than 45 mph. In this example, the frequency of travelling slower than 45 mph between 4:00 and 5:00 PM is about 10 percent, or once every two weeks (10 weekdays).

Reading the Contour Graphs (Average Congestion Conditions)

The second set of graphics shown in this chapter illustrates the geographic and temporal extent of congestion in the HOV lanes. These graphics were developed to help the reader better understand how traffic conditions change as vehicles travel from one location to another on the HOV network.

Each map shows one HOV corridor and is presented in a contour format similar to that of a topographic or elevation map. Various colors indicate the relative levels of congestion a commuter may experience as a function of time of day and location (milepost) along the corridor. Figure 3-2 shows a slice of one of these contour graphs for the northbound HOV lane on I-5 near Northgate. The conditions illustrated represent the average condition for all 261 weekdays of 1998. Vertically, the graph represents the geographic extent of the corridor. Horizontally, the graph shows a 24-hour day, from midnight to midnight. The colors on the profile represent congestion, measured in units of level of service, as follows:

- green means that traffic generally moves at or near the speed limit under free-flow conditions
- yellow means that travelers encounter borderline traffic conditions with more restricted movements, but still travel near the speed limit
- red is heavily congested traffic traveling perhaps between 45 and 55 mph

- blue denotes an extremely congested situation, with unstable traffic ranging from stop and go to 45 mph. For the HOV facilities, this usually means "free flow" conditions, but with speeds of 35 mph or lower.

Beside each graph is a map of the freeway corridor and major cross-streets to provide a means of reference to the freeway milepost locations.

Studying the portrait of the HOV segment in Figure 3-2 shows that, on average, vehicles in the HOV lane experience heavy congestion between approximately 5:00 PM to 6:00 PM. This congestion is mostly caused by friction with slow moving GP volumes as large numbers of vehicles move away from downtown Seattle in the afternoon commute period. Traffic is free flowing for the rest of the day.

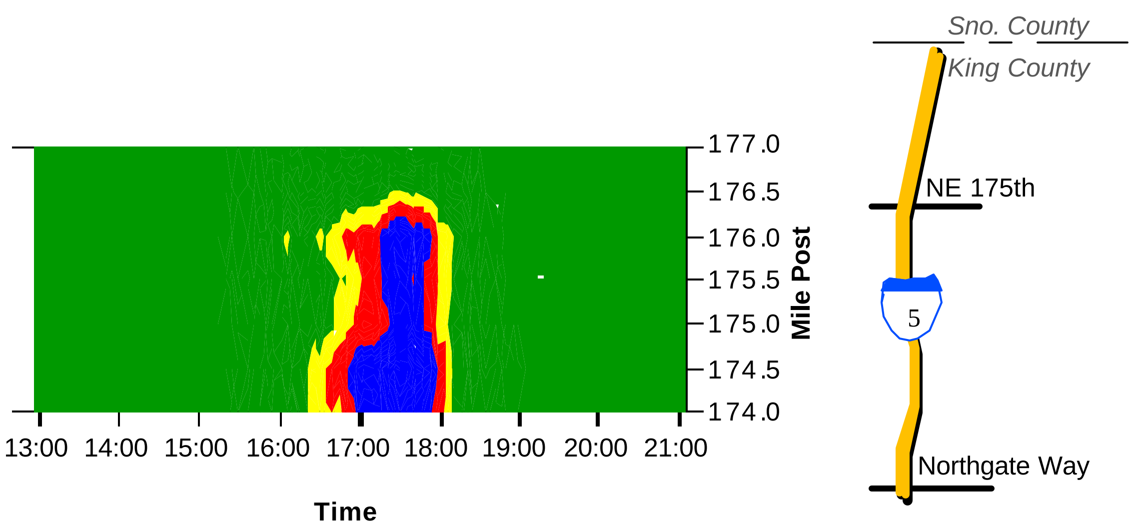


Figure 3-2. Corridor Contour Graph: I-5 North of Seattle CBD, Northbound from NE 137th St. to Alderwood

SPEED AND RELIABILITY RESULTS BY CORRIDOR

Statistics and graphics produced in this section are based on data collected by WSDOT throughout 1998. In most cases, the data presented are based on all weekdays within a given year. Note that current conditions may be different than those described below, particularly when new sections of HOV facility open or where major changes in operational procedures take place. In addition, note that many of the statistics presented are for "average" conditions. Thus, on any given day, conditions can be much better or much worse than those depicted and discussed below.

I-5 North of the Seattle CBD

Northbound

As the volume flow map indicated previously in Chapter 2, this HOV corridor has a strong directional pattern, with high southbound volumes traveling toward downtown Seattle in the morning, and high northbound volumes traveling in the reverse direction during the afternoon commute. Near Northgate, HOV volumes can exceed 1,500 vplph during the PM commute.

Figure 3-3a shows that for the trip from Northgate to Alderwood, HOV lane vehicles travel at 45 mph or faster nearly all the time, with the exception of the peak evening commute (between 4:00 PM and 5:00 PM). During the peak of the evening commute, speeds can drop below 45 mph about once every two weeks. The contour map (see Figure 3-3b) indicates that northbound congestion is mostly limited to between Northgate and the Snohomish/King County line during the PM peak period. An examination of the operation of this stretch of roadway shows that the slowdown in the HOV lane is mostly caused by friction with slower moving GP volumes, as large numbers of vehicles move away from downtown Seattle in the afternoon commute period. In the northern end of this corridor, HOV traffic also slows near the I-5/I-405 interchange between 4:00 PM to 5:30 PM. These delays are caused primarily by a reduction from four to three general purpose lanes near Lynnwood.

Southbound

This is one of the most routinely congested freeway segments in the metropolitan area, and the HOV lanes are severely affected by this congestion. Southbound HOV lane vehicles experience slower travel speeds primarily during the AM peak period between 6:00 AM and 8:00 AM (see Figure 3-3a). HOV vehicle speeds fall below 45 mph in the corridor as often as 30 percent of the time. The contour map shows routine congestion near SR 104, and the HOV lane remains relatively congested through the Northgate area as it approaches the entrance of the I-5 express lanes (see Figure 3-3b). HOV volumes are considerable during the morning commute (1,500 vplph) as traffic moves toward downtown Seattle. While HOV volumes are high, they are not sufficient in size or duration to cause the HOV lane to congest. Instead, much of the slowdown may be attributed to an uphill grade at the southern terminus of this section and the resulting lane friction with the adjacent, slow moving GP traffic.

I-5 South of the Seattle CBD

Northbound

The 90th percentile speed for HOV vehicles drops to 30-45 mph during the AM peak period between 6:30 AM and 8:00 AM; this heavy congestion occurs as often as every other day (see Figure 3-4a). The contour map shows that morning congestion northbound extends from Boeing Field to the end of the study section at the West Seattle Freeway interchange (see Figure 3-4b). The slowdowns in HOV traffic are caused in part by friction between HOV and GP traffic. This is exacerbated by the loss of freeway capacity as the outside GP lane becomes an exit-only lane through the West Seattle Freeway interchange.

HOV traffic normally flows freely during the rest of the day, except from 3:30 PM to 4:30 PM, when HOV speeds occasionally slow to 45 mph. Northbound afternoon congestion pales in comparison to the morning traffic situation. One source of afternoon congestion is the spill-back from the express lanes entrance. The HOV lane terminates near Yesler Way, so all traffic may enter the express lanes in the afternoon. The congestion level shown in the contour map makes evident the severe impact of this situation.

Southbound

Figure 3-4a shows that when HOVs travel southbound in the PM peak period, the average vehicle speed can slow to between 40 and 45 mph 15 percent of the time. Much of the significant slowdown is due to routine congestion near Boeing Field and along the Southcenter Hill area near the I-405 interchange (see Figure 3-4b). In addition, moderate congestion occurs just south of the Seattle CBD near Columbian Way as result of traffic merging from the I-5 mainline and the collector distributor from I-90. [BB1]

I-405 – North of I-90

Northbound

Like most sections of the HOV lane system, this freeway corridor's HOV lane operates relatively well for most times during the day. However, during the peak of the evening commute, there is 20 percent chance that an HOV will travel at an average speed of less than 45 mph (see Figure 3-5a). The 90th percentile speed for the HOV lane averages less than 45 mph for roughly an hour and a half. Figure 3-5b shows that significant congestion is present only at the northern end of the facility where the HOV lane ends near the SR 522 Bothell/Woodinville interchange. Congestion from this merge point (and the major construction project that extends north from this interchange) often spills back, affecting the HOV lanes. Although congestion in the HOV lanes along this corridor is fairly minor, the high volume of merge/diverge movements within the corridor can affect average travel speeds. These include significant merge/diverge movements near the Redmond/Kirkland interchanges at NE 85th and Totem Lake.

Note that the results described above and shown in figures 3-5a and 3-5b are only for the period in 1998 after the HOV lanes had been moved from the outside (near the exit ramps) to the inside of the facility. Figure 3-5d illustrates the routine congestion before the lane switch. At that time, consistent, routine congestion occurred at a number of locations within the corridor, including downtown Bellevue, Redmond/Kirkland, and Totem Lake. Congestion at these locations lasted the entire evening commute period and even included the morning commute period in downtown Bellevue. The entry and exit of mixed GP and HOV vehicles caused much of this congestion as they entered and exited the facility. As a result, the average HOV vehicle speed would slow to below 45 mph nearly 30 percent of the time during the PM peak period (see Figure 3-5c). Movement of the HOV lanes to the inside of I-405 has relieved most of this congestion. The average speed and reliability have also improved.

<u>Southbound</u>

Figure 3-5a reveals that the I-405 HOV lanes operate better in the southbound direction than they do northbound. This may be in part because there is no end point congestion. (That is, the HOV facility continues south to Renton, whereas congestion occurs in the northbound direction when the HOV lane ends just before SR 522.) The only significant HOV lane congestion in the southbound direction is through the downtown Bellevue CBD during the afternoon commute (see Figure 3-5b). This section of HOV facility is unique in that congestion occurs in both directions during the afternoon peak but in neither direction during the AM peak. (Note, however, that most of the southbound congestion occurs from downtown Bellevue to I-90, whereas northbound congestion occurs near Woodinville/Bothell.)

The switch from outside to inside HOV lanes also had a major impact on southbound HOV lane performance. Figure 3-5c shows that considerable congestion existed in both the AM and PM peak periods in downtown Bellevue when the HOV lane was near the shoulder. A large portion of this congestion has been eliminated by the lane conversion. In addition, the AM peak HOV congestion between Totem Lake and the Redmond/Kirkland interchanges has mostly disappeared.

I-405 South of I-90

Northbound

The 90th percentile HOV speed drops below 45 mph for 30 minutes during the AM peak period (see Figure 3-6a). Figure 3-6b reveals that heavy congestion occurs over the Kennydale hill until just south of SE 52nd St. during the AM peak period. This minor but consistent slowing in the HOV lane is caused primarily by friction between HOVs and the slower moving GP traffic next to them. During the rest of the day, the HOV lanes perform as intended.

Southbound

The southbound HOV lanes on this section of freeway are less congested than the northbound HOV lanes. The low level of congestion is apparent in the 90th percentile speeds and the reliability of the facility (see Figure 3-6a). At no time during the day does the 90th percentile travel time fall below 45 mph, meaning that an HOV can consistently expect to travel faster than 45 mph at all times during the day. Only a minor section of the southbound roadway, roughly corresponding to the Kennydale hill, exhibits routine congestion (see Figure 3-6b).

I-90

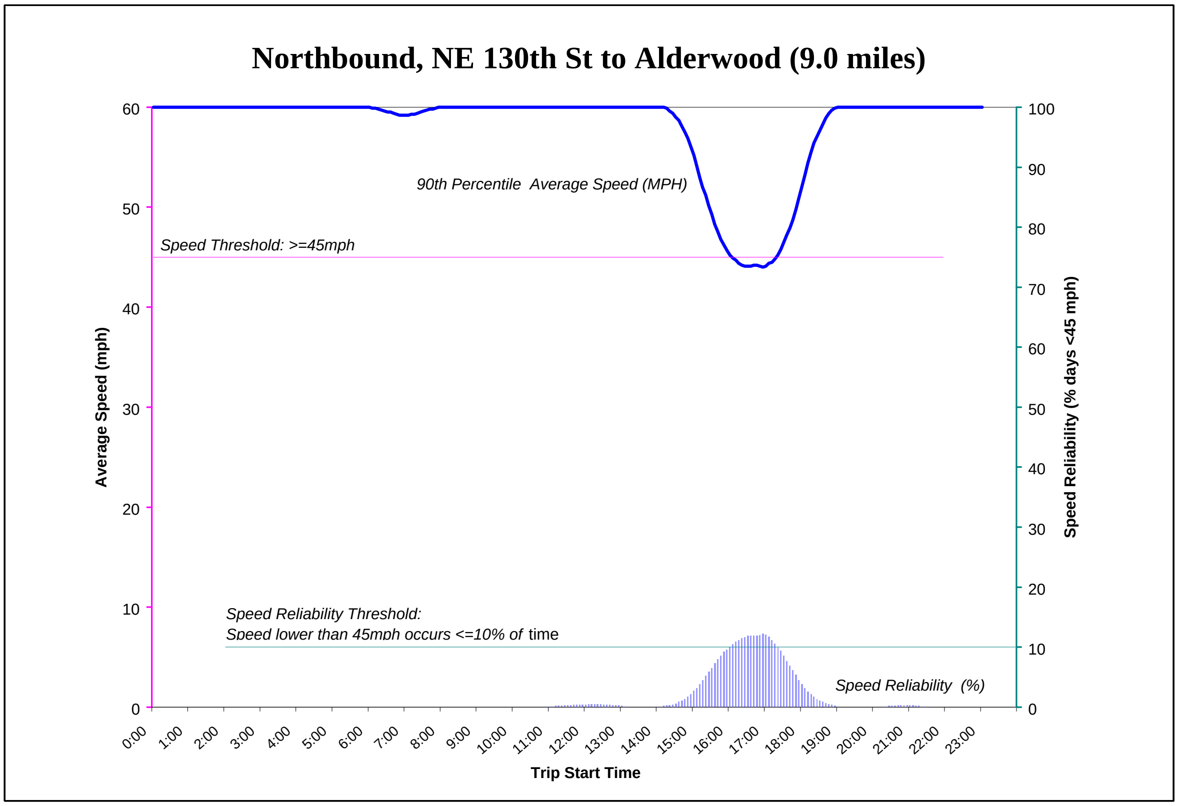
No congestion was observed in HOV lanes (using the reversible lanes) on I-90. HOVs can expect to travel at or near the speed limit nearly all the time (see Figure 3-7).

SR 520

Westbound HOV lane vehicles travel at or close to free flow speeds, with slight slowdowns between 4:30 PM and 6:30 PM (see Figure 3-8). As mentioned earlier, vehicle volumes on this HOV facility are lower than on other HOV facilities in the region because of the strict 3+ vehicle occupancy requirement.

SR 167

Northbound HOV lane vehicles travel at free flow speeds at all times. Because of limits in available data, the northern terminus of this HOV lane segment was not included in this analysis. Future reports will expand the study zone to capture the remaining northern section and provide performance information near the I-405/SR 167 Interchange. At no time during the day does the 90th percentile travel time fall below 45 mph for southbound HOV traffic (see Figure 3-9). Slight slowdowns occur only during the PM peak period.



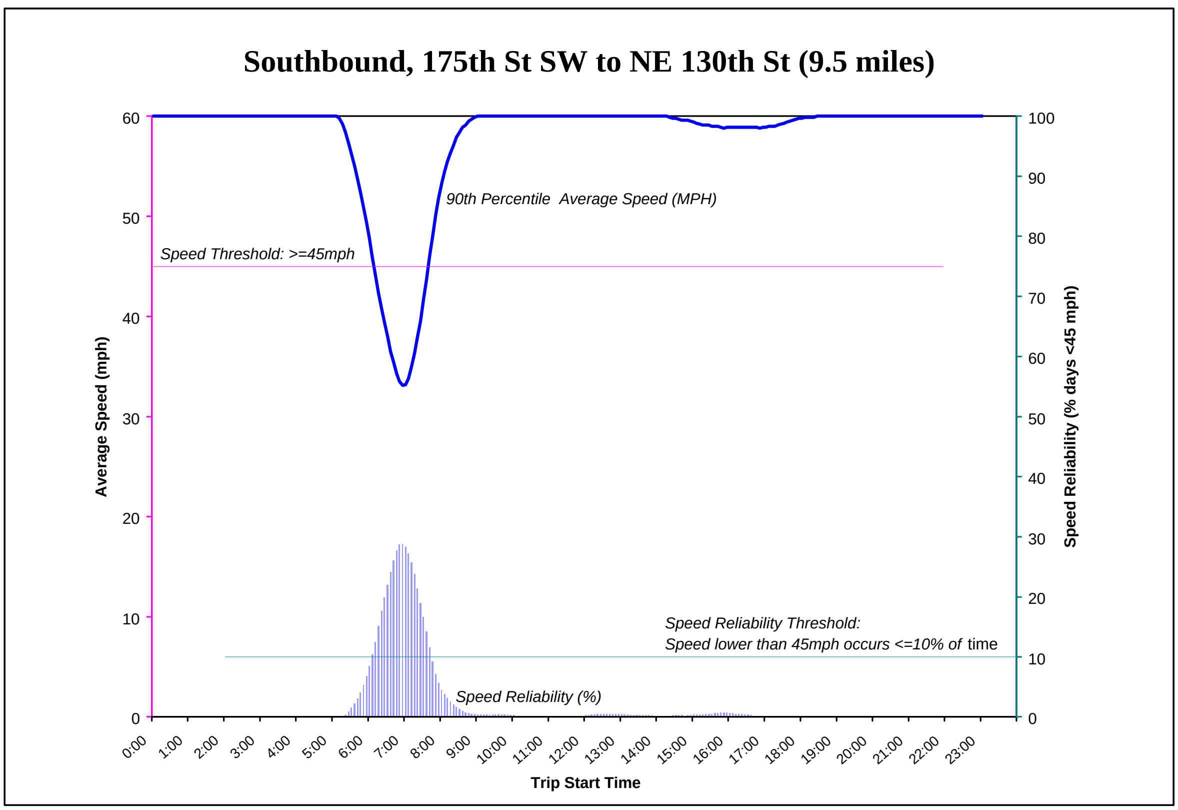


Figure 3-3a. Average Weekday HOV Speed and Reliability (1998): I-5 North of the Seattle CBD

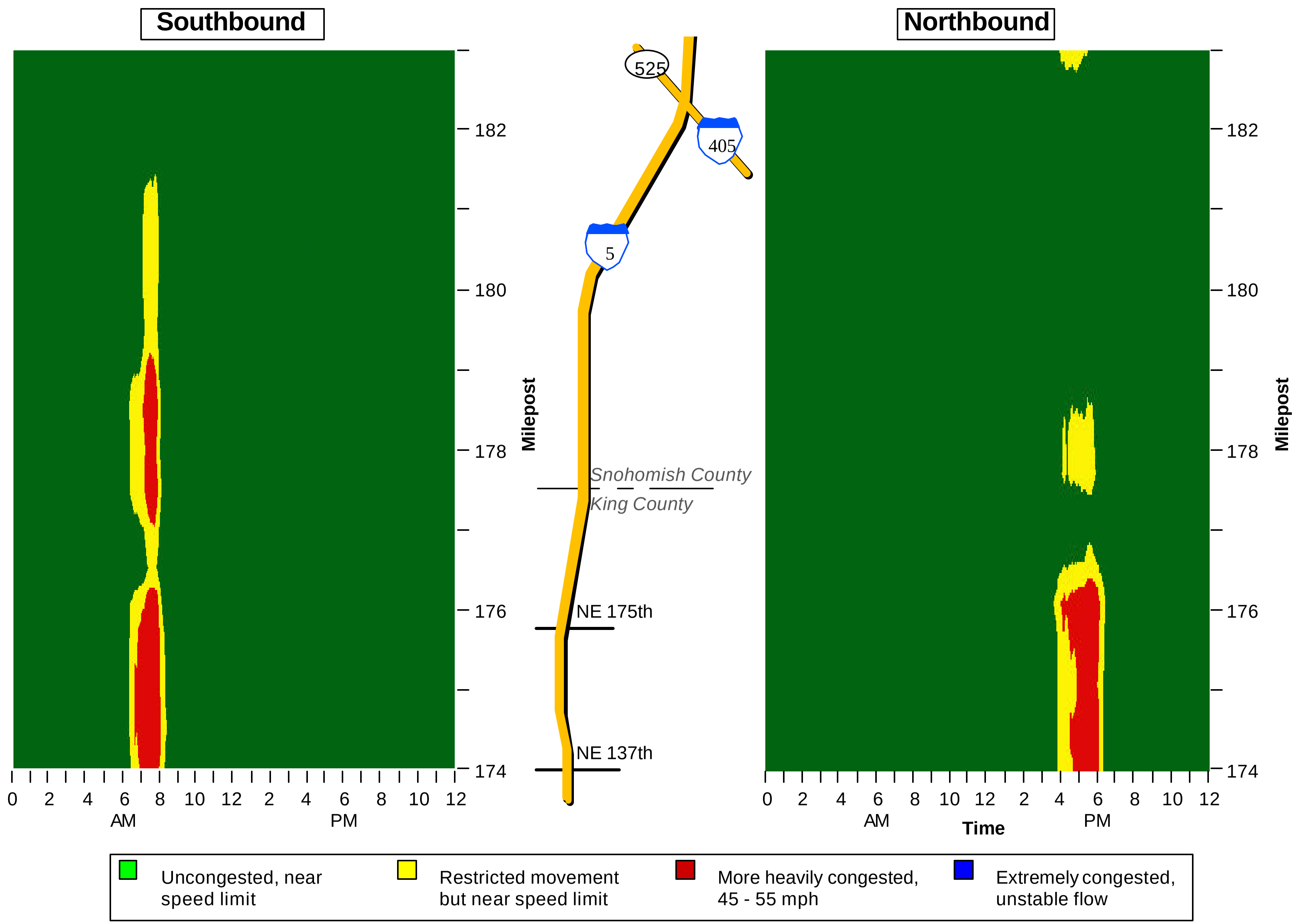
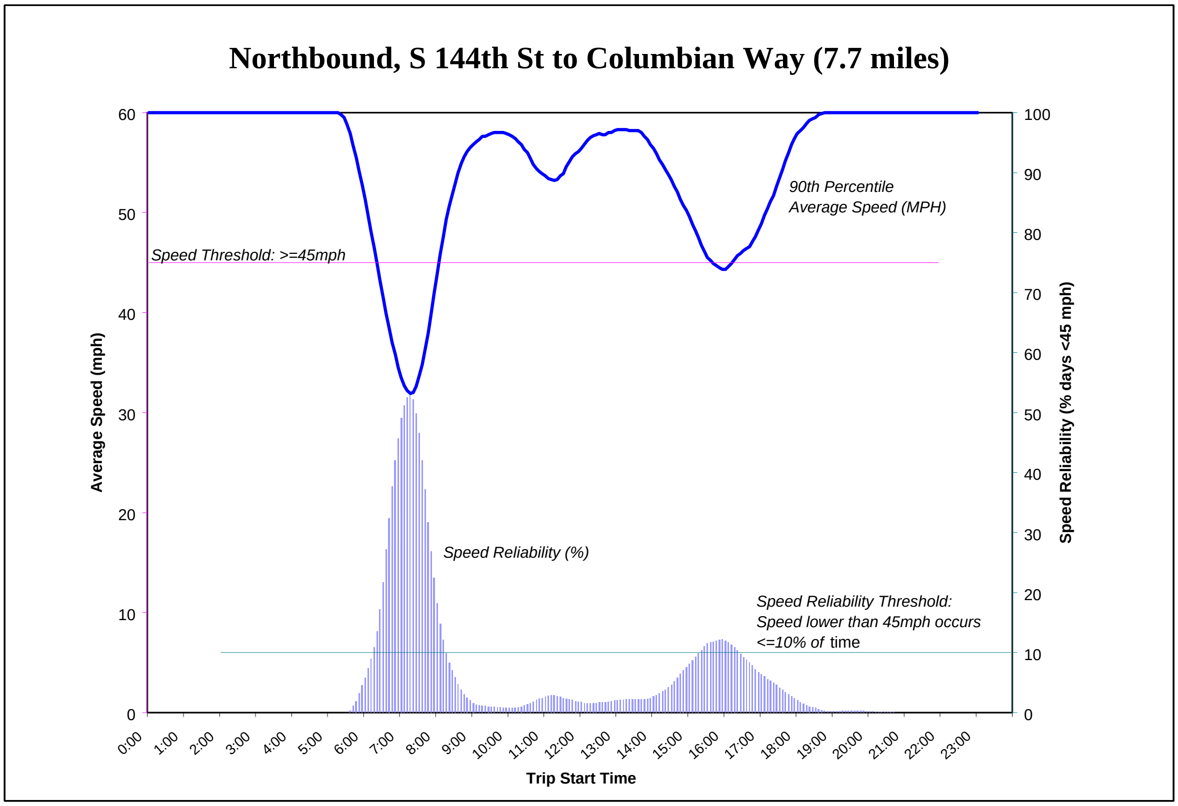


Figure 3-3b. 1998 Weekday Average HOV Traffic Profile: I-5 North of the Seattle CBD



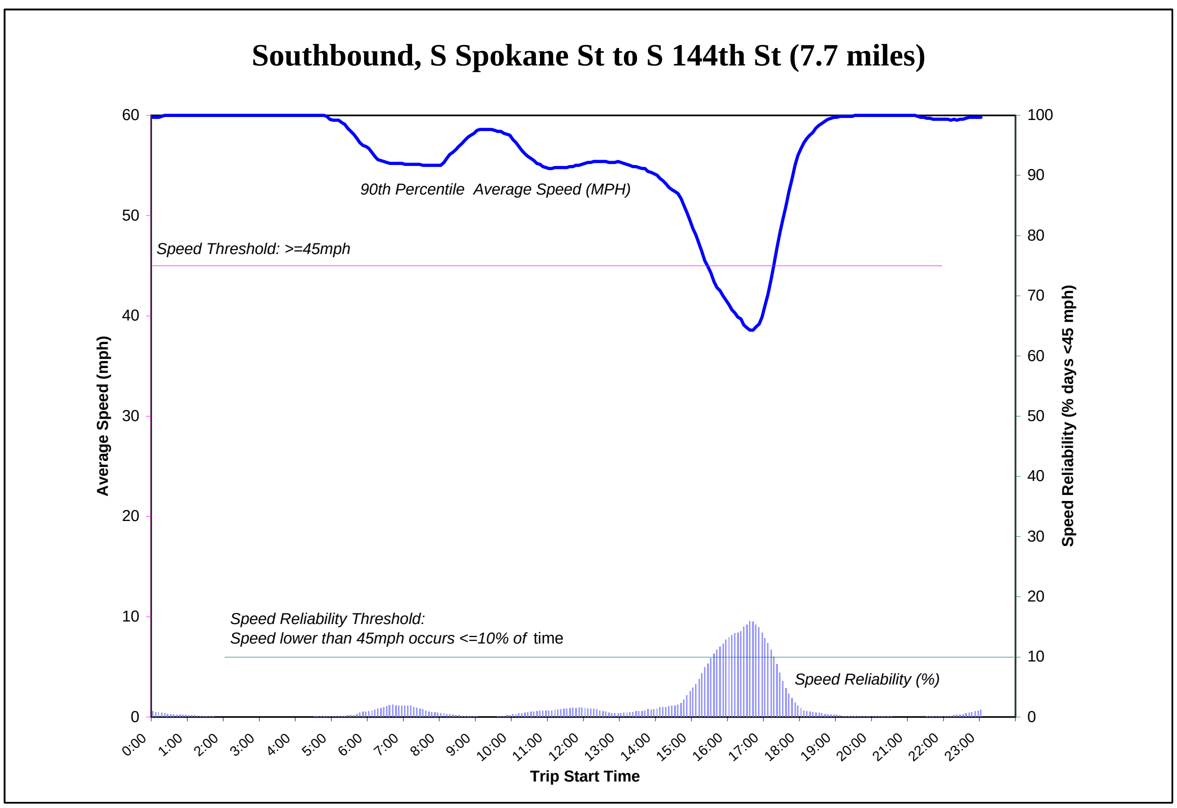


Figure 3-4a. Average Weekday HOV Speed and Reliability (1998): I-5 South of the Seattle CBD

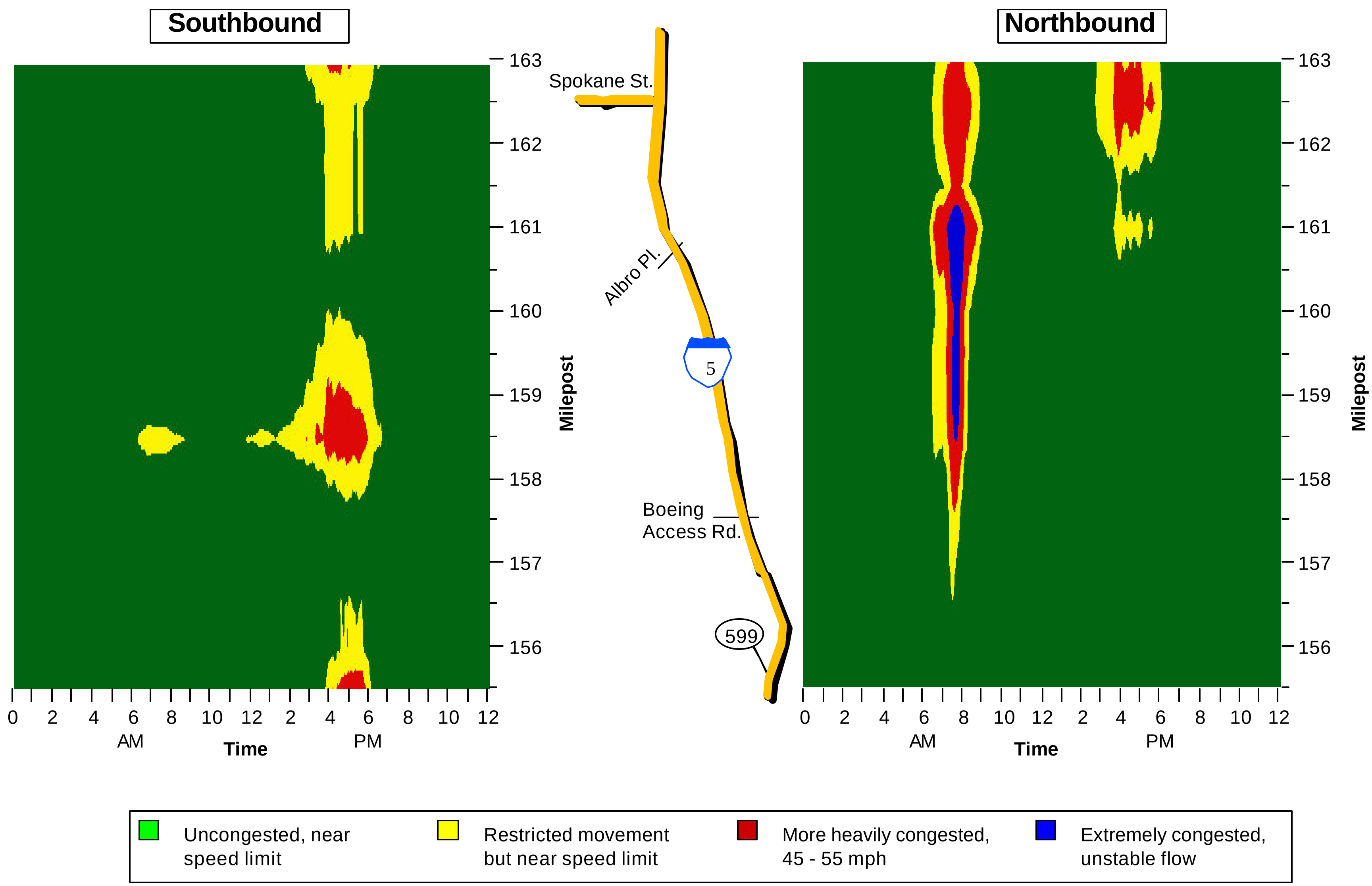
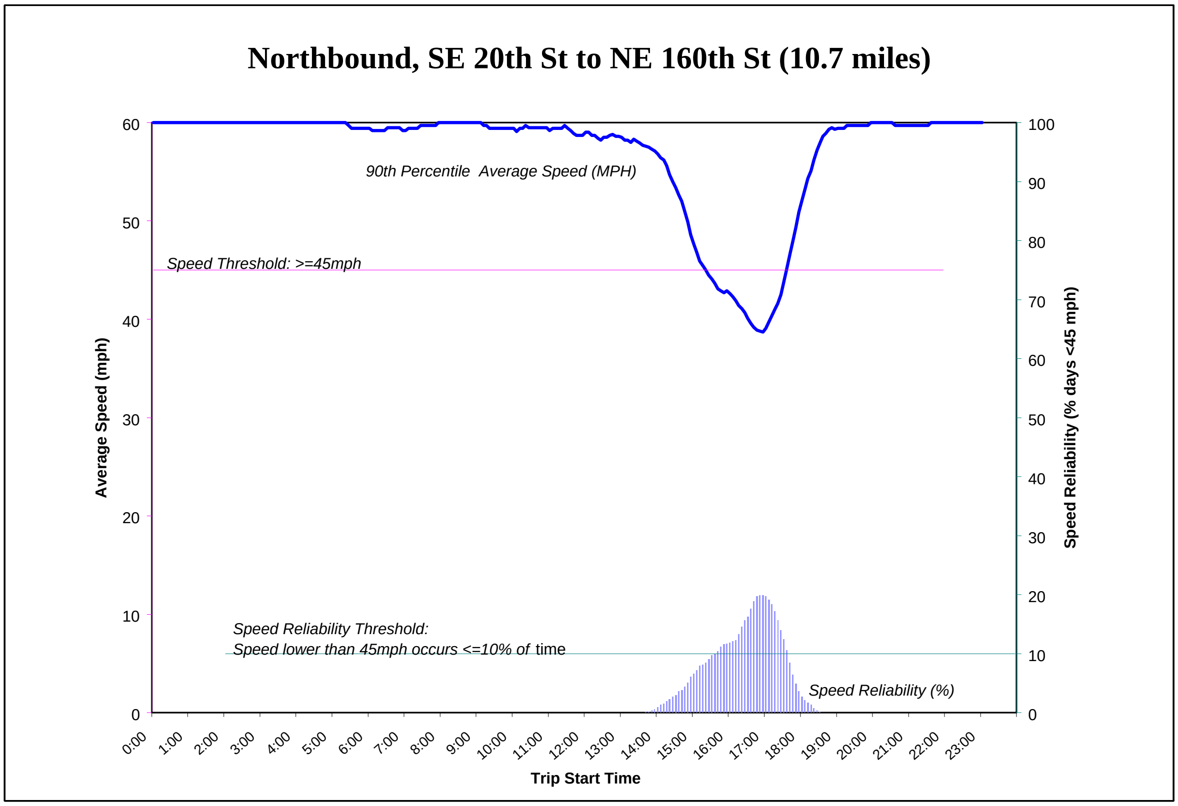


Figure 3-4b. 1998 Weekday Average HOV Traffic Profile: I-5 South of the Seattle CBD



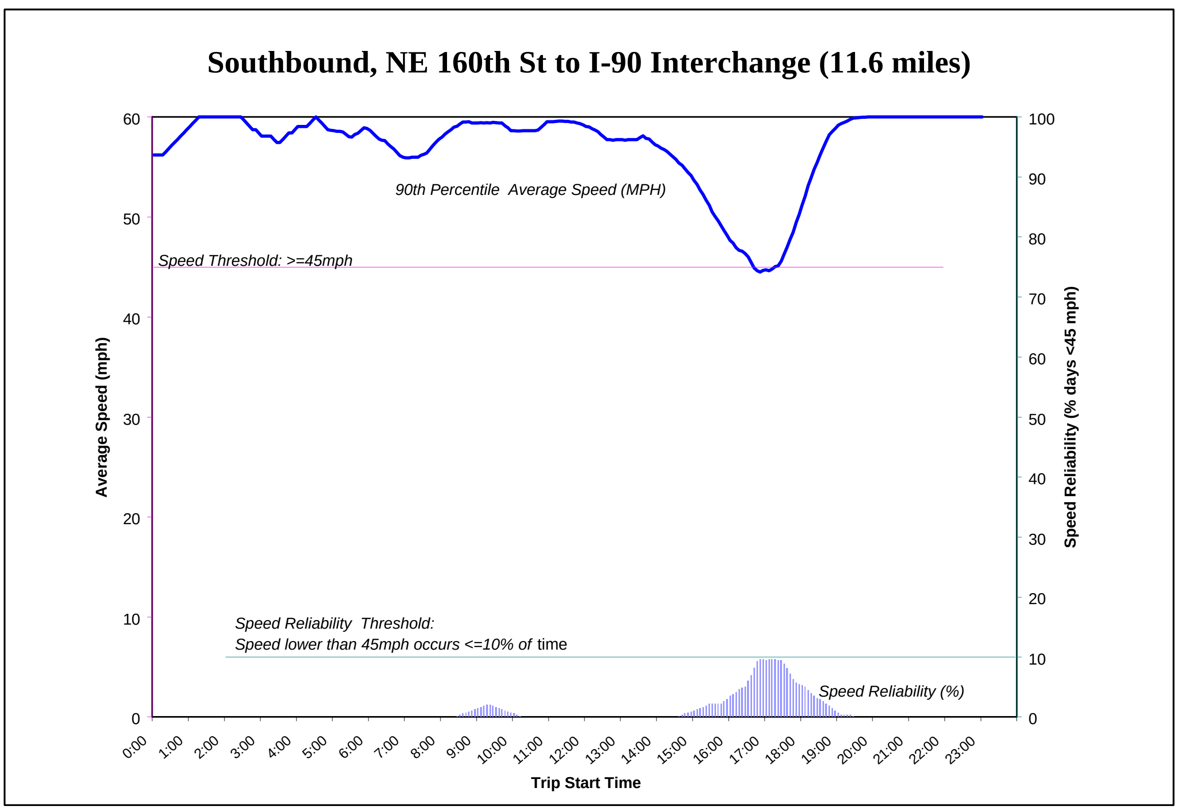


Figure 3-5a. Average Weekday HOV Speed and Reliability (Nov-Dec, 1998): I-405 North of I-90

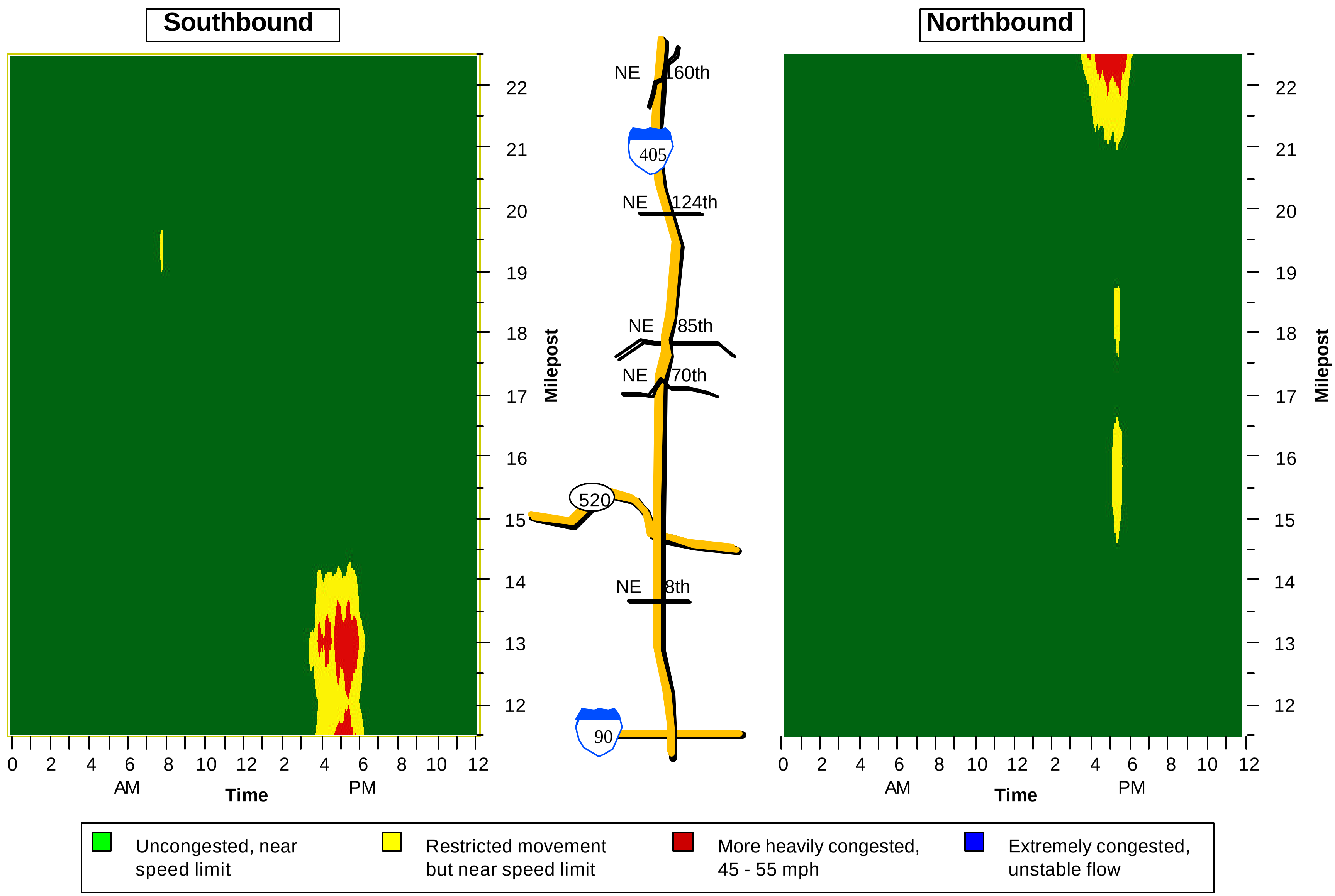
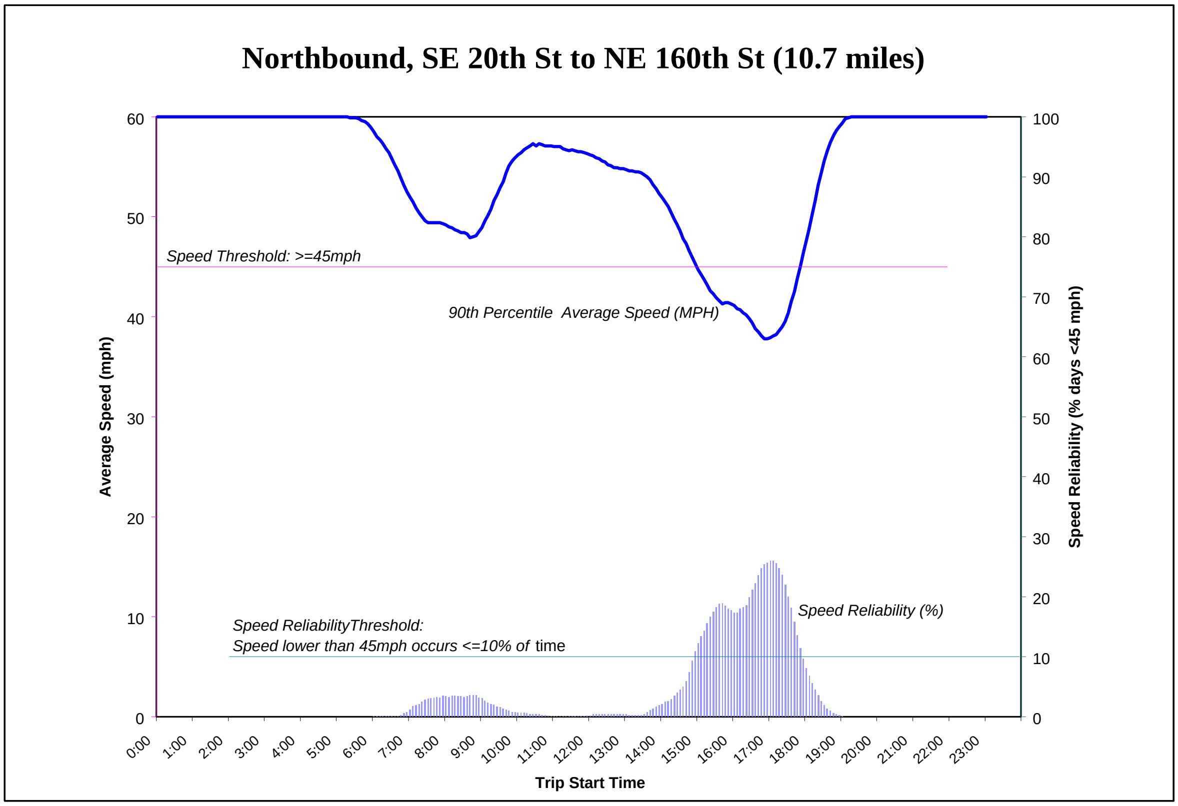


Figure 3-5b. 1998 Weekday Average HOV Traffic Profile: I-405 North of I-90 *(HOV Lane Placed Inside)*



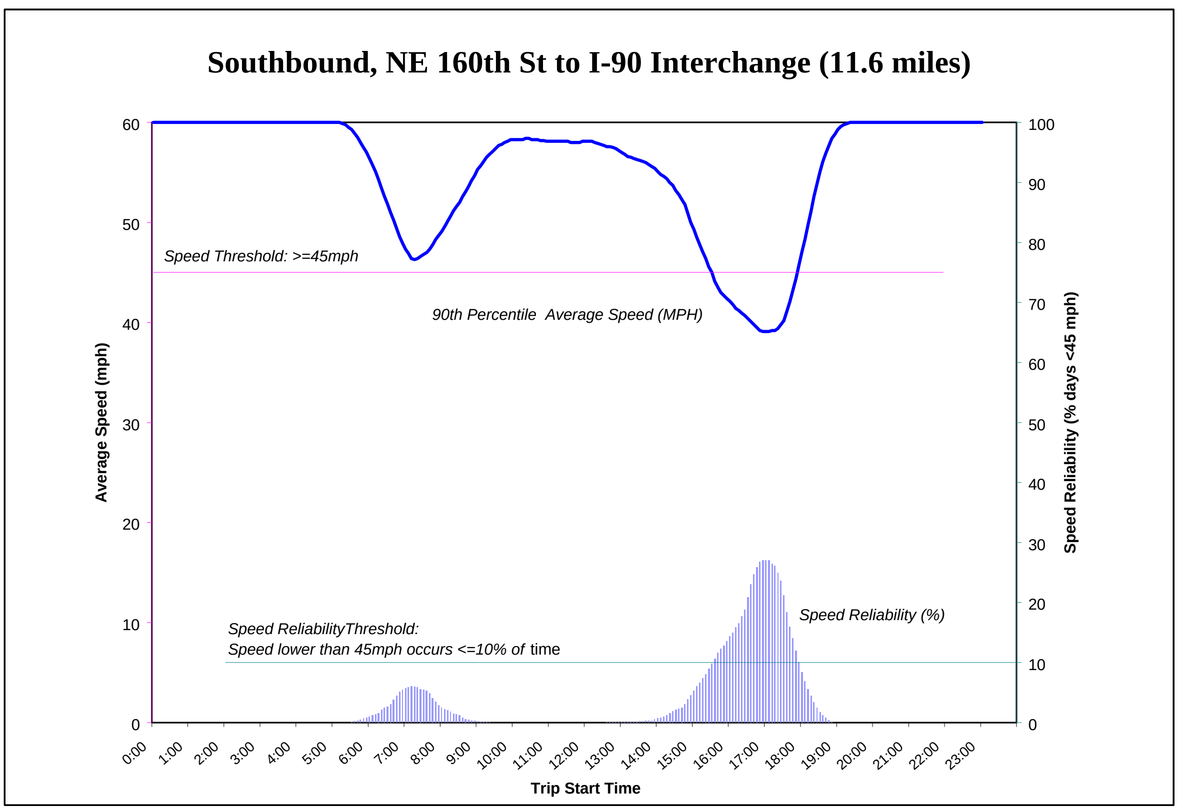


Figure 3-5c. Average Weekday HOV Speed and Reliability (Jan-Jun, 1998): I-405 North of I-90

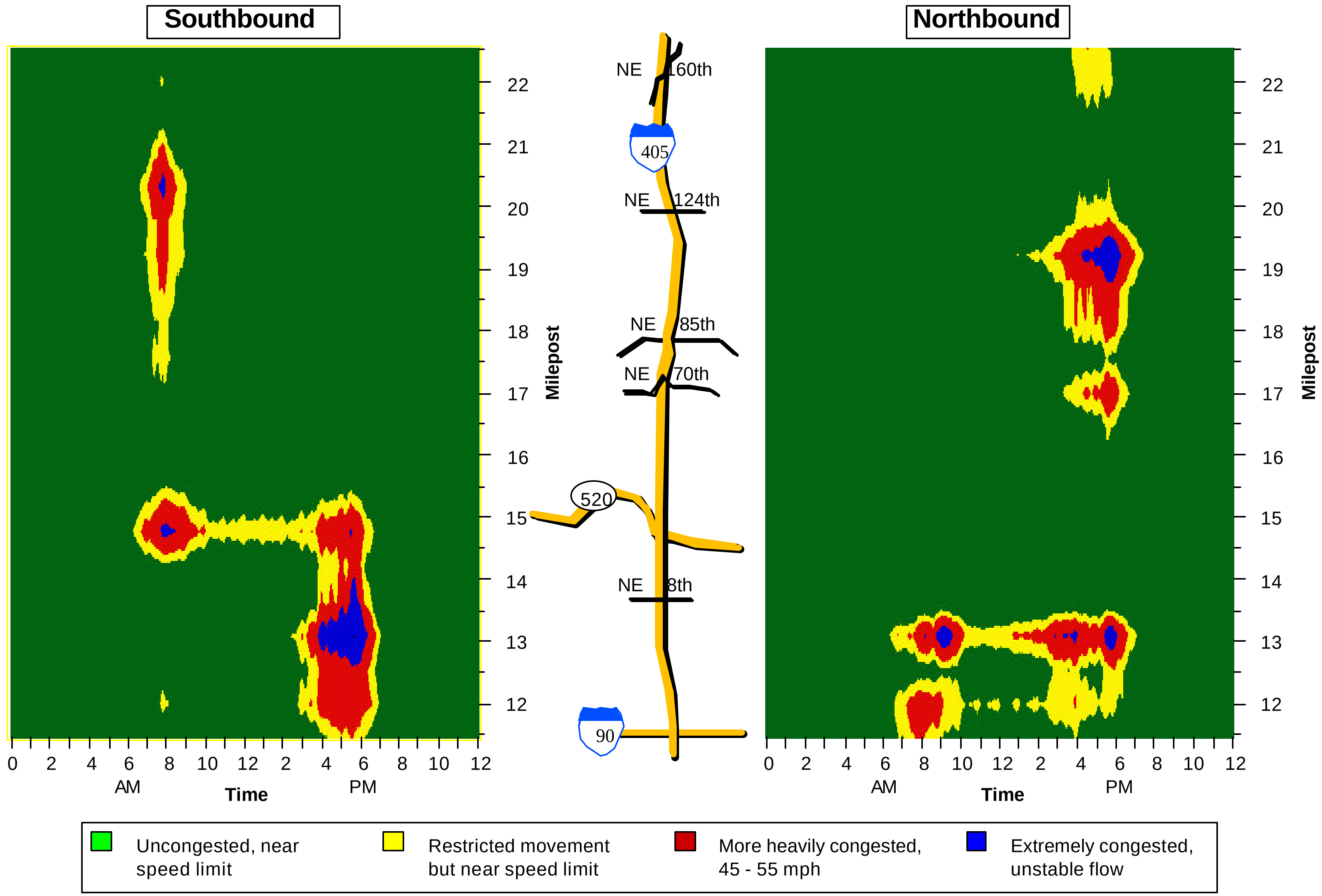
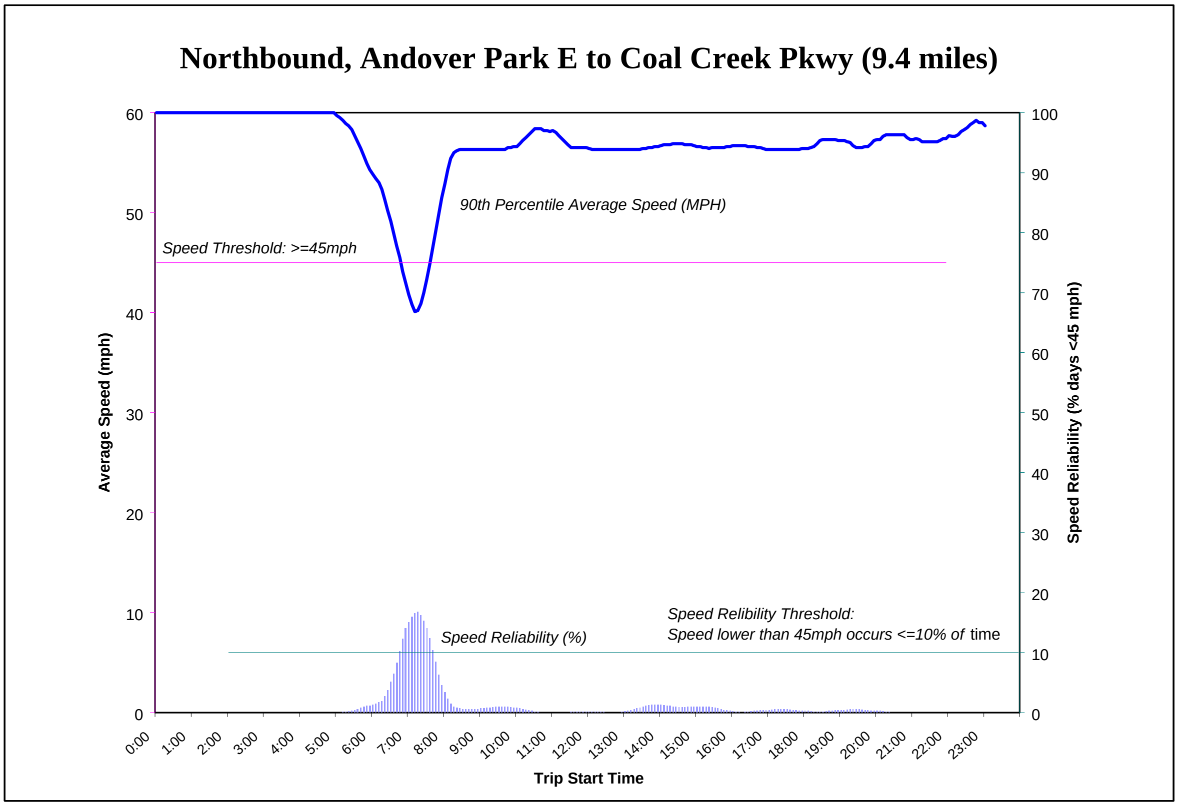


Figure 3-5d. 1998 Weekday Average HOV Traffic Profile: I-405 North of I-90 ***(HOV Lane Placed Outside)***



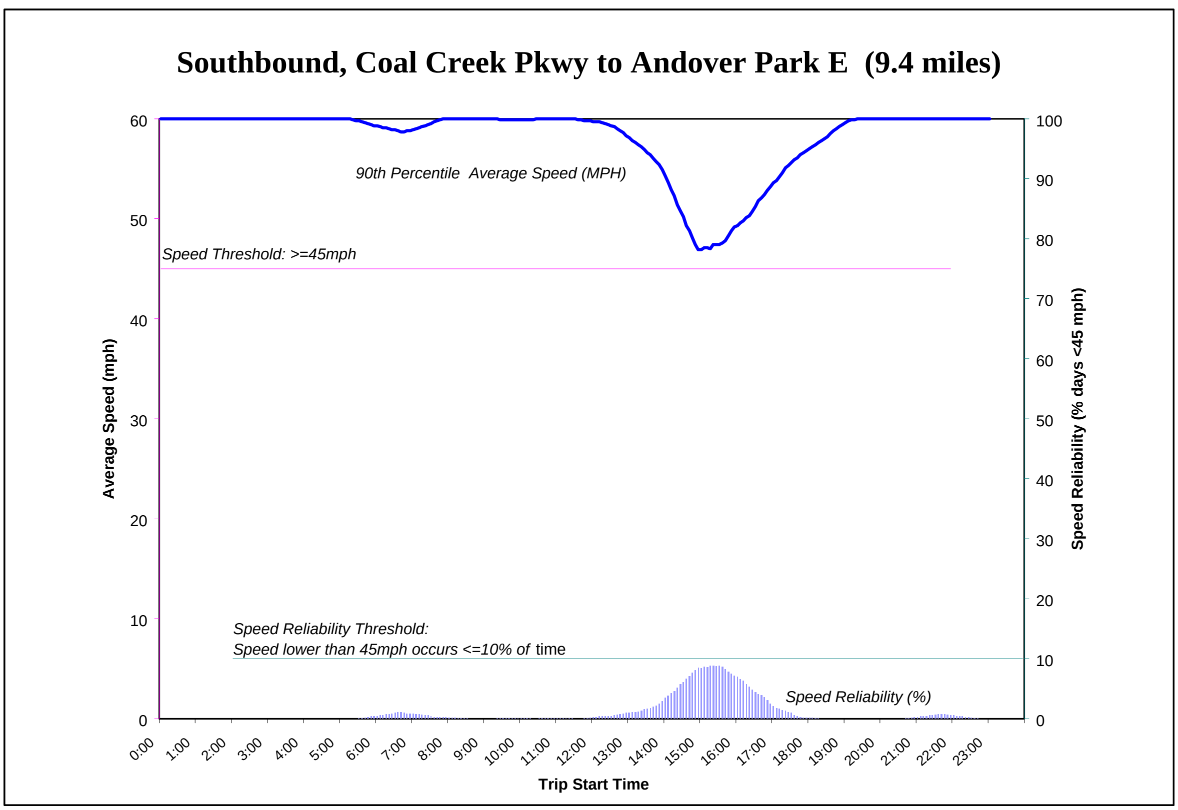


Figure 3-6a. Average Weekday HOV Speed and Reliability (1998): I-405 South of I-90

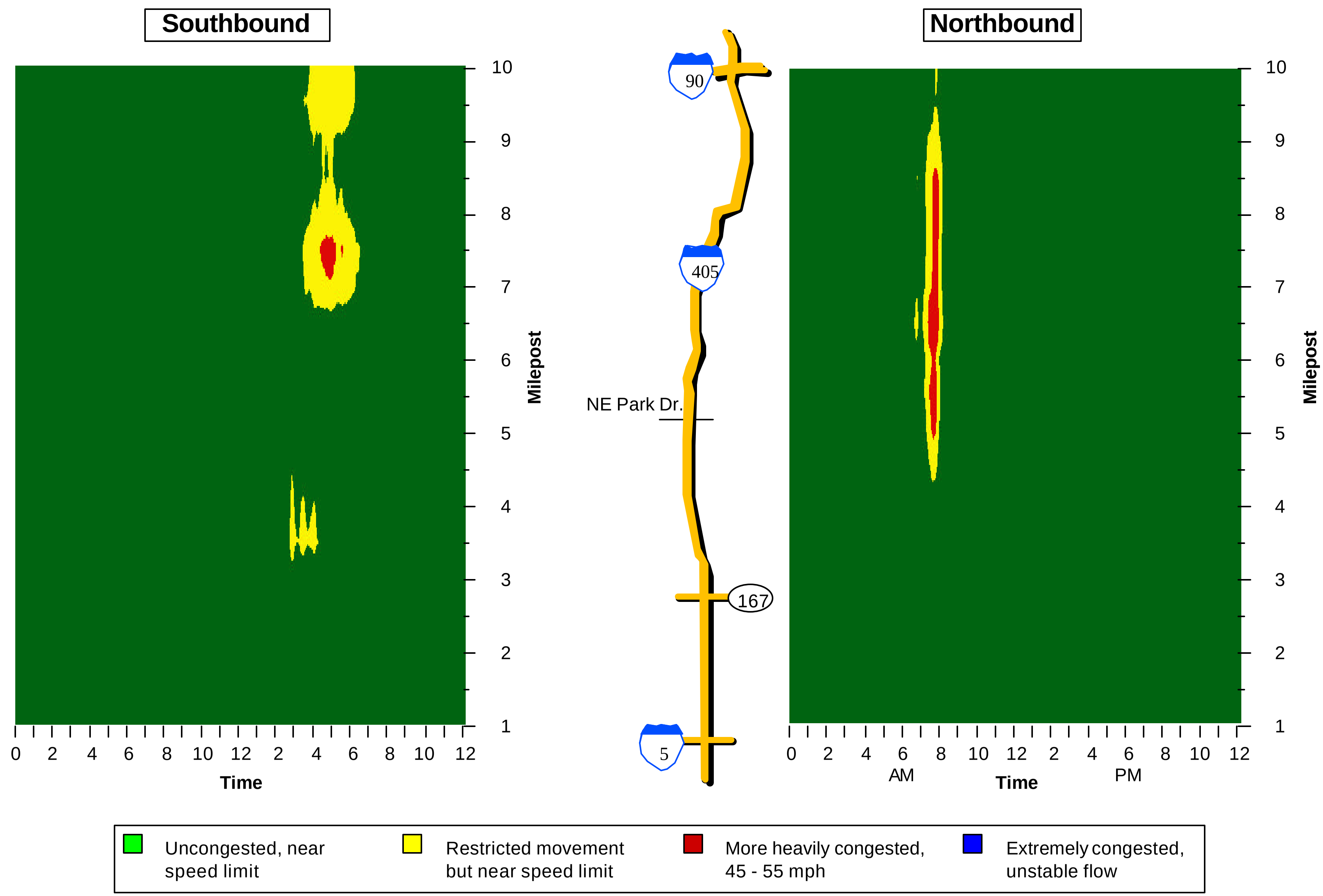
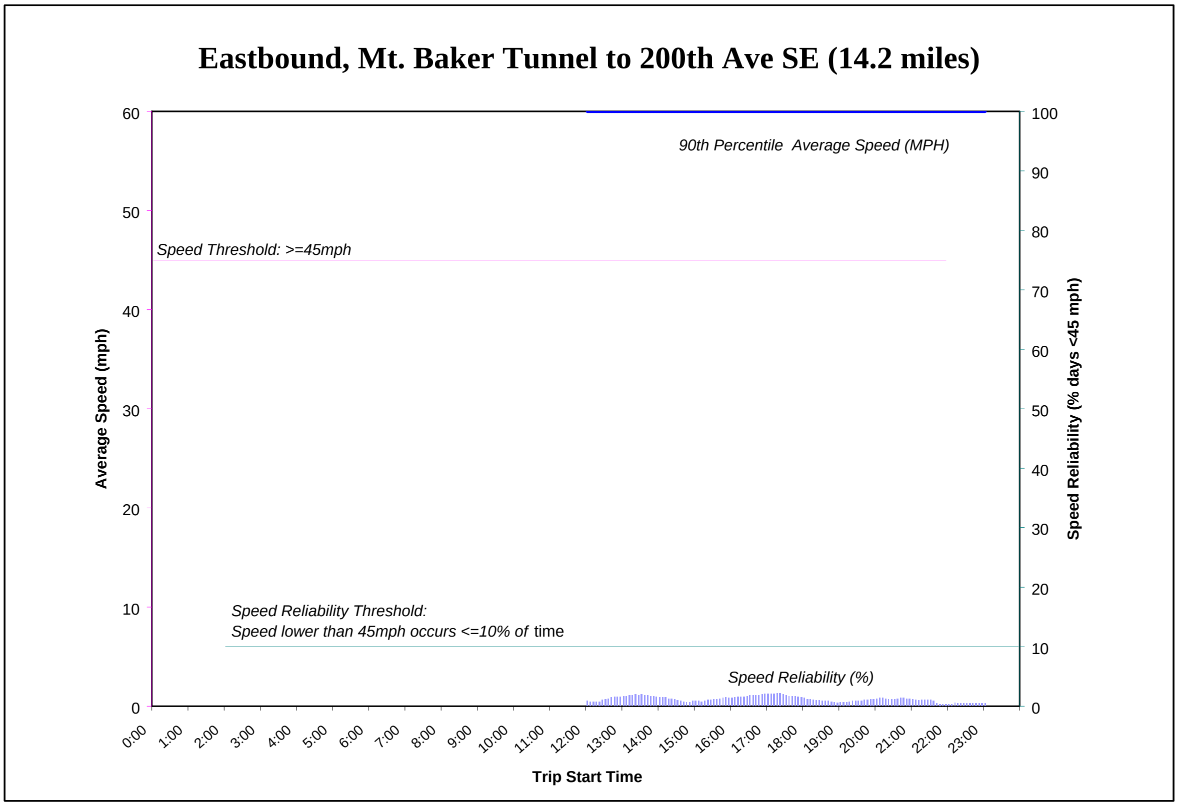


Figure 3-6b. 1998 Weekday Average HOV Traffic Profile: I-405 South of I-90



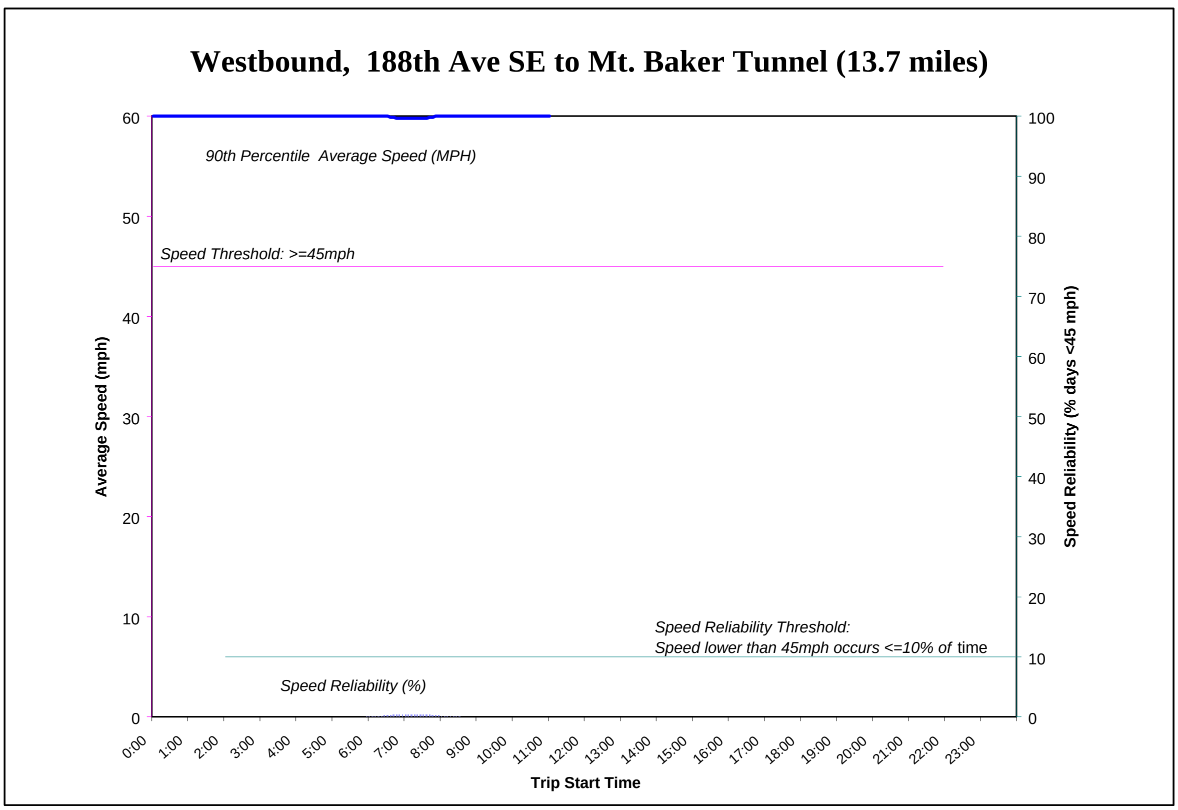


Figure 3-7. Average Weekday HOV Speed and Reliability (1998): I-90

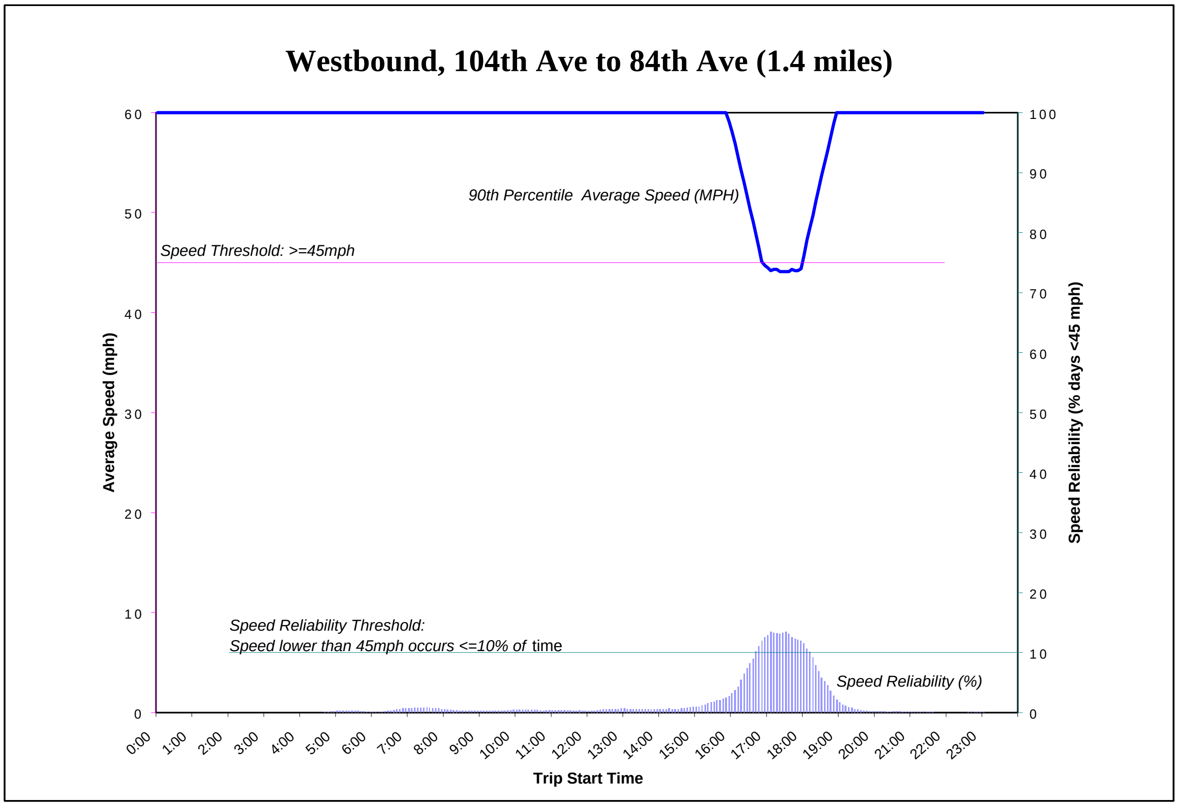
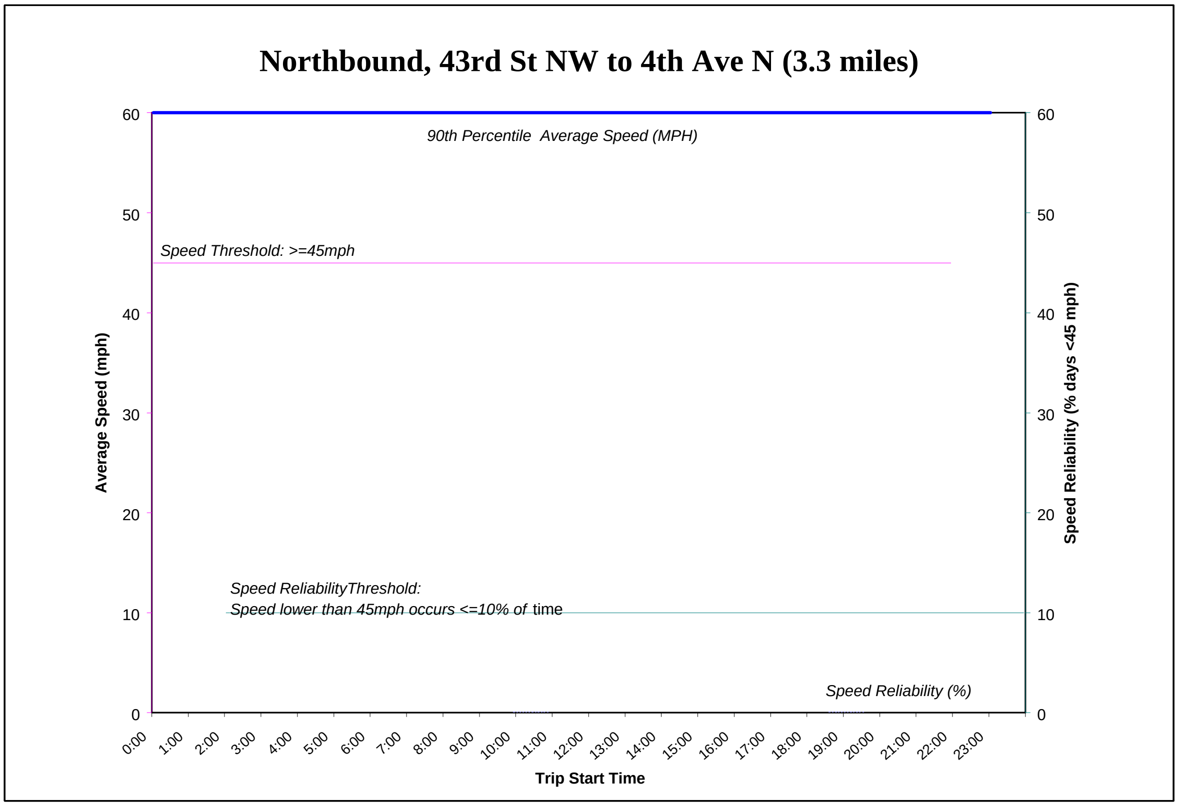


Figure 3-8. Average Weekday HOV Speed and Reliability (1998): SR-520



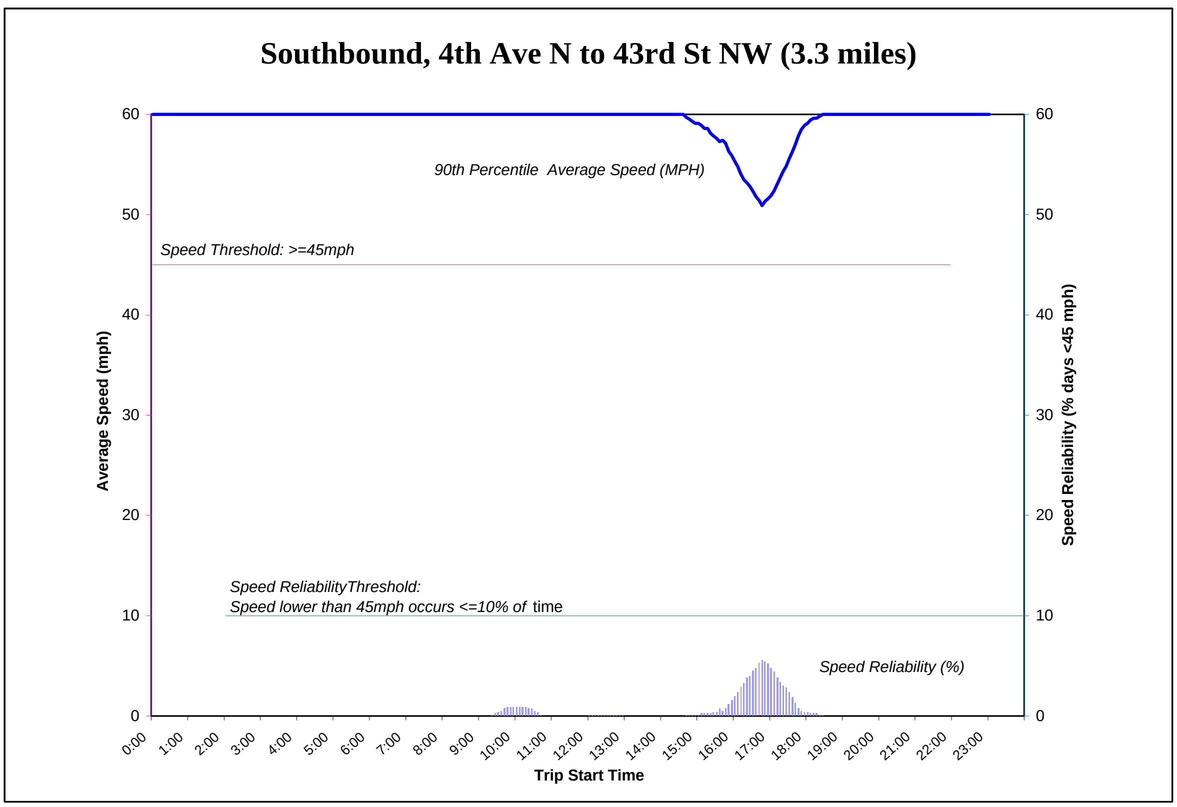


Figure 3-9. Average Weekday HOV Speed and Reliability (1998): SR-167

TRAVEL TIME SAVINGS

Reading the Travel Time Graphs

To describe the time savings travelers can expect to obtain when using the HOV lanes, a set of graphics that compare expected HOV and GP travel times were created. These graphs show estimated HOV travel time relative to GP travel time. Each graph describes the time it takes to complete a particular route by traveling in the HOV lane or the GP lanes. The average travel time for the trip can be read along the vertical axis. The horizontal axis shows the time of day when the traveler enters the freeway. The average HOV travel time savings for the directional commute during the peak period is written in the figure.

Figure 3-10 shows an example of this type of graph, an 8-hour slice of the travel time comparison graph for northbound I-5 from NE 137th St. to Alderwood. The results show that it takes longer to travel in the GP lane (roughly 13 minutes) than in the HOV lane (roughly 10 minutes) during the afternoon peak period. On average HOV lane users experience a travel time advantage of nearly 3 minutes during the afternoon peak period over the travelers in the adjacent GP lanes.

Figures 3-11 through 3-17 present GP and HOV travel time comparisons for the studied corridors. Travel times are computed for trips on each HOV corridor. Travel time on I-90 was computed only for trips using the reversible HOV lanes. Table 3-2 summarizes the travel time savings along the various corridors during 1998 in units of minutes and seconds per mile. These results show sizable benefits in travel time savings in most of the corridors. Some of the most significant savings are on I-5 during the morning commute traveling southbound toward downtown Seattle, on I-405 in the

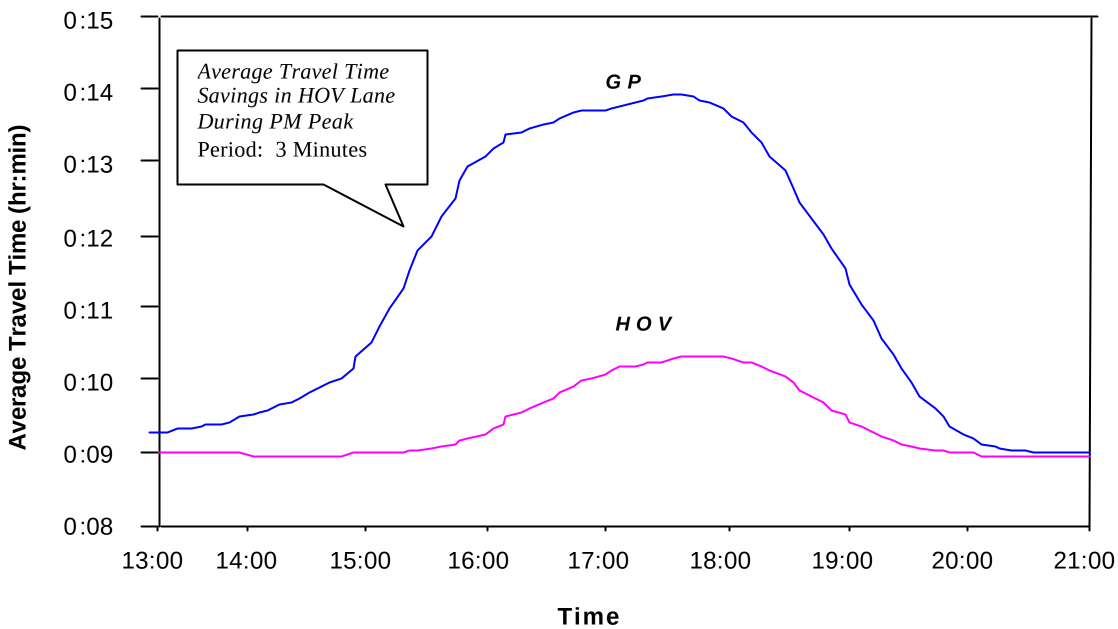


Figure 3-10. Average Weekday Travel Time Graph: I-5 North of Seattle CBD, Northbound from NE 137th St. to Alderwood

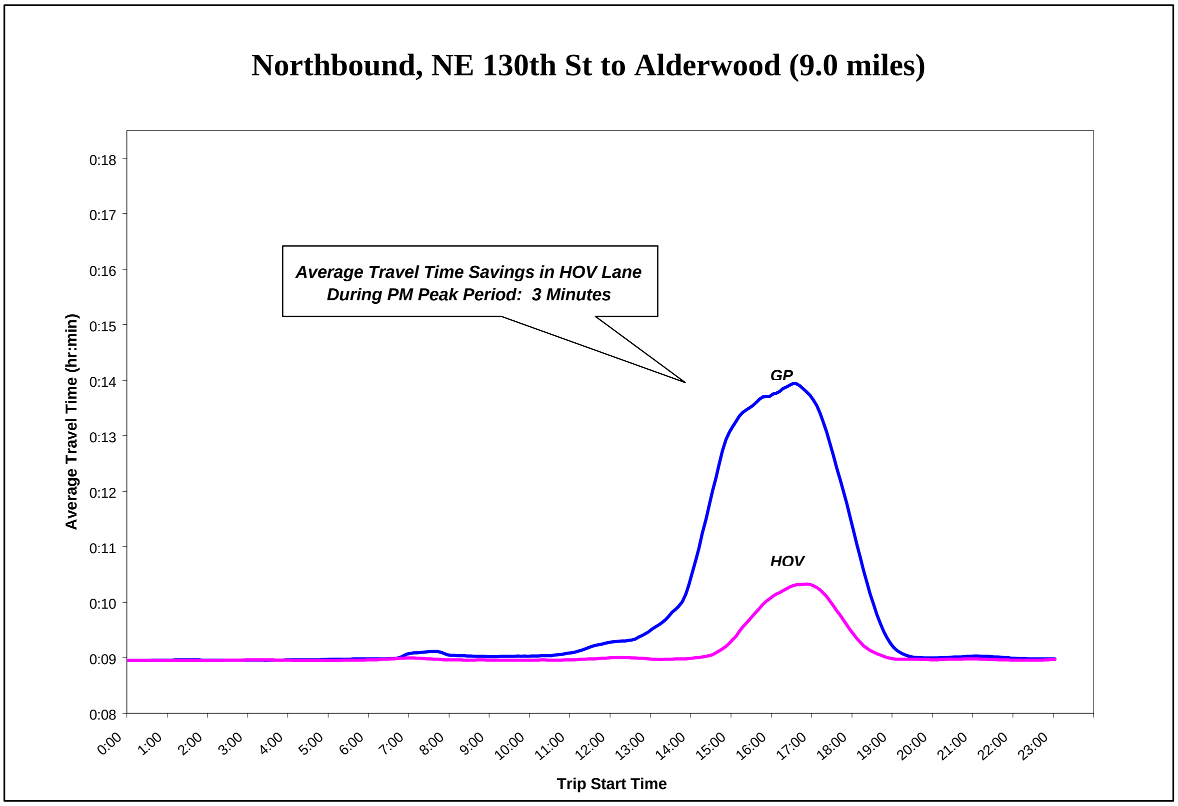
traditional commute directions, and westbound on SR 520 and southbound on SR 167 during the afternoon peak period.

In many cases, the more moderate level of travel time savings observed in the remaining HOV corridors is due to a variety of causes. These include low levels of traffic congestion (e.g., on I-90) and lane friction with congested adjacent GP lanes (e.g., southbound on I-5 south of the Seattle CBD during the afternoon commute where GP speed is below 45 mph).

It is interesting to note that although HOV facilities in two corridors may provide similar travel time savings (in seconds per mile), users may perceive the two facilities differently. For example, on northbound I-5 south of the Seattle CBD and southbound I-405 north of I-90, GP traffic experiences considerable, routine congestion during the morning peak period. However, whereas the HOV traffic on southbound I-405 traveling toward downtown Bellevue moves near the speed limit, the northbound I-5 HOV traffic is forced to slow down because of lane friction with slower moving vehicles in the adjacent GP lane (see contour map). As a result, although HOV users in both corridors receive the same travel time saving benefit (31 seconds per mile) during the morning peak period, the perceived benefits to the HOV users traveling at 60 mph may seem greater than those travelling at slower speeds.

Table 3-2. Travel Time Savings (Estimated from Average Speed)

			Travel Time Savings (Minutes)		Travel Time Savings (Seconds per Mile)	
CORRIDORS	DIR.	LENGTH (MILES)	AM (6-9AM)	PM (3-7PM)	AM (6-9AM)	PM (3-7PM)
I-5 North of the Seattle CBD (Alderwood – NE 130th St)	NB	9.0		3		20
	SB	9.5	5		32	
I-5 South of the Seattle CBD (Columbian Way – S. 144th St.)	NB	7.7	4		31	
	SB	7.7		1		8
I-405 North of I-90 (NE 160th St. – I-90 Interchange)	NB	10.7		8		45
	SB	11.7	6		31	
I-405 South of I-90 (Coal Creek Pkwy – Andover Park E)	NB	9.4	13		83	
	SB	9.4		4		26
I-90 (Mt. Baker Tunnel – 200th Ave. SE)	EB	14.2		3		13
	WB	13.7	4		18	
SR 520 (84th Ave. NE – 104th Ave. NE)	WB	1.4		4		171
SR 167 (4th Ave. N – 43rd St. NW)	NB	3.3	1		18	
	SB	3.3		3		55



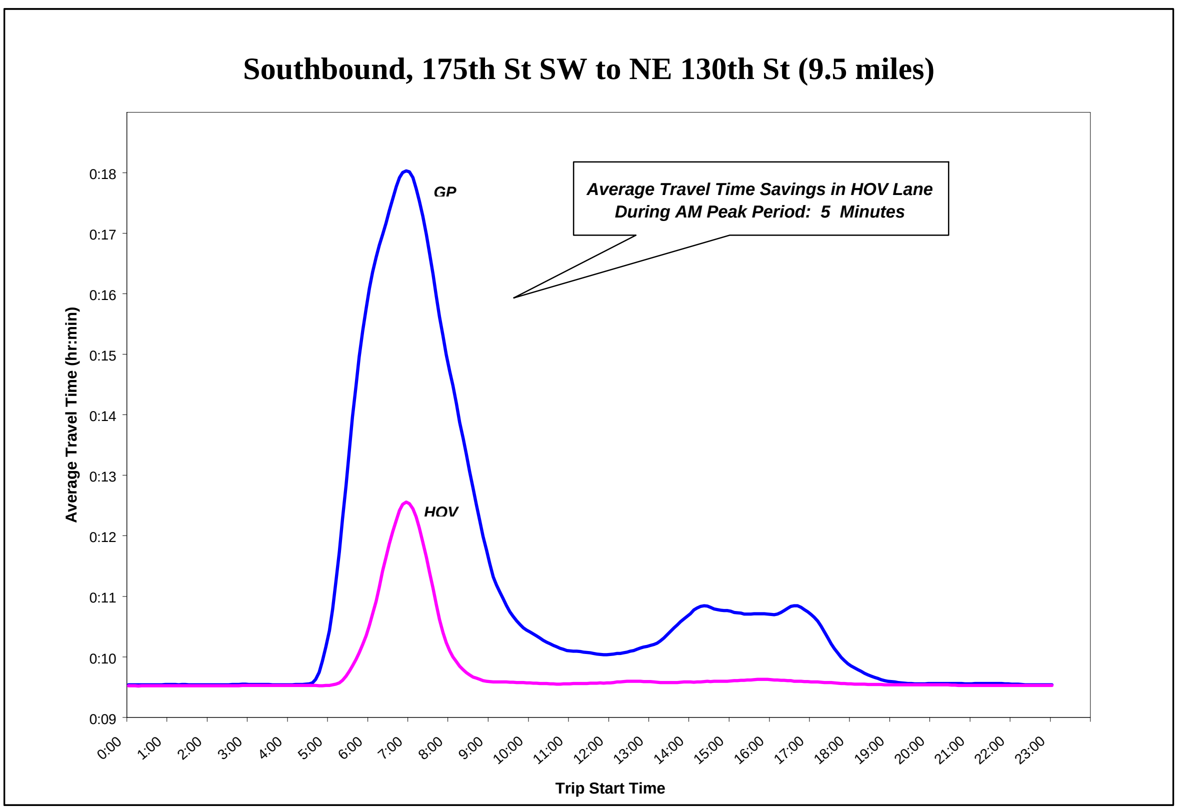
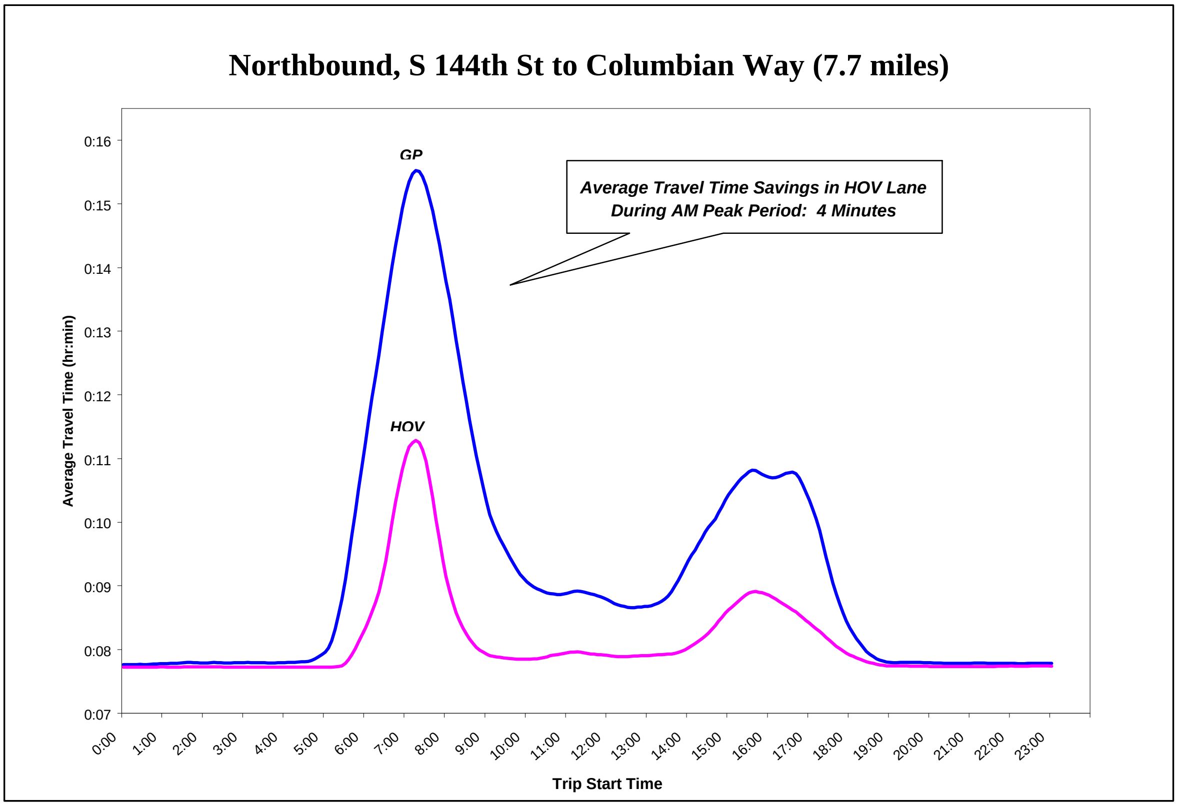


Figure 3-11. Average Weekday GP and HOV Travel Time (1998): I-5 North of the Seattle CBD



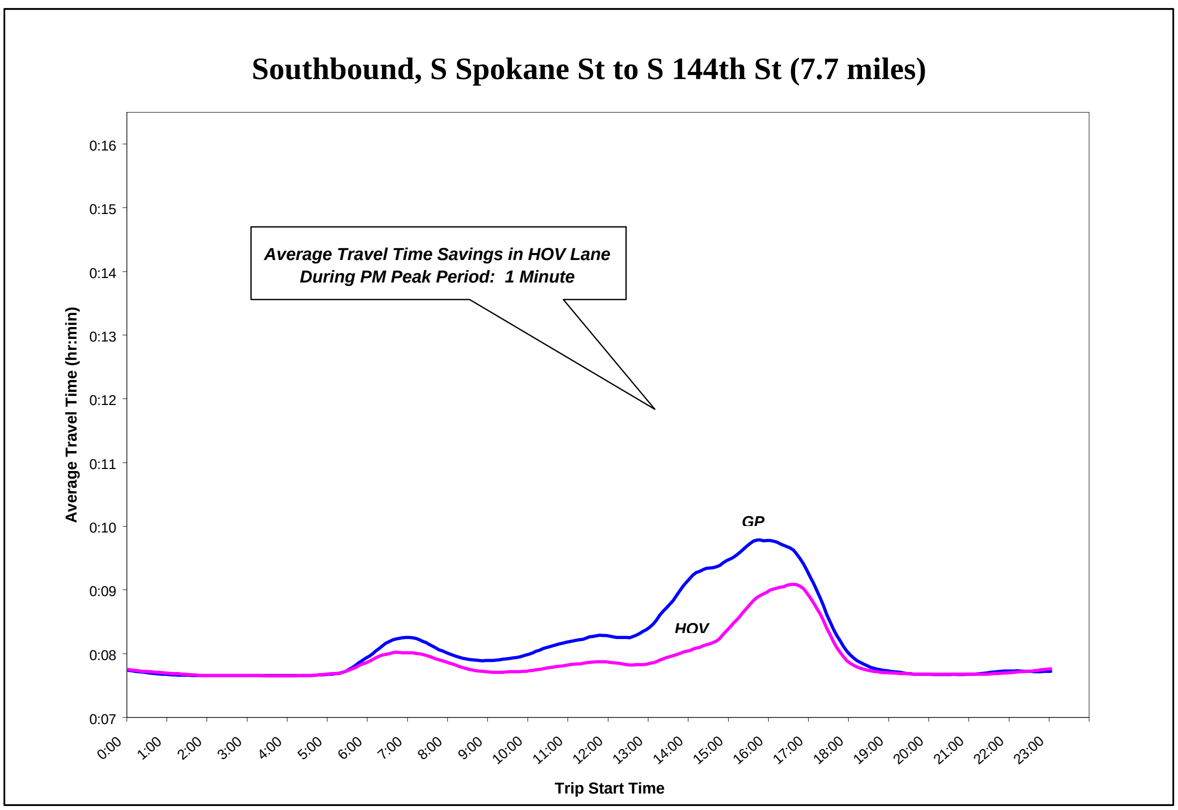
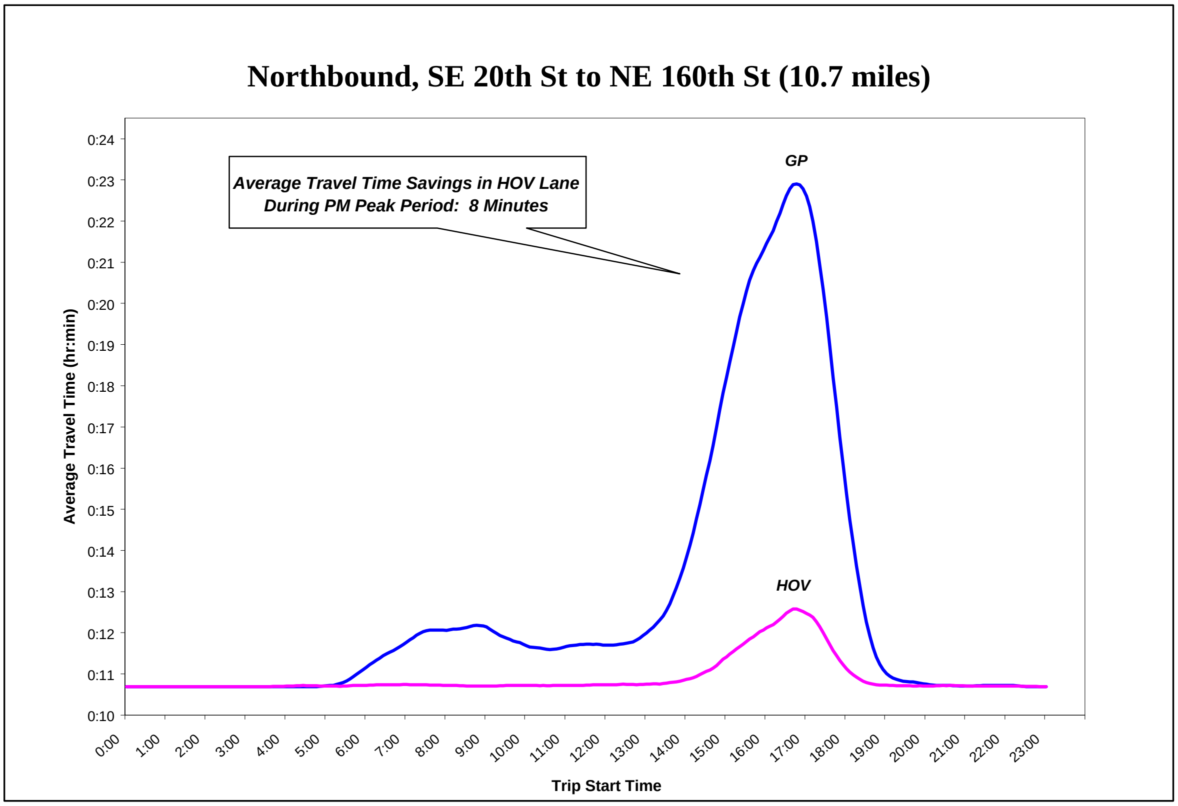


Figure 3-12. Average Weekday GP and HOV Travel Time (1998): I-5 South of the Seattle CBD



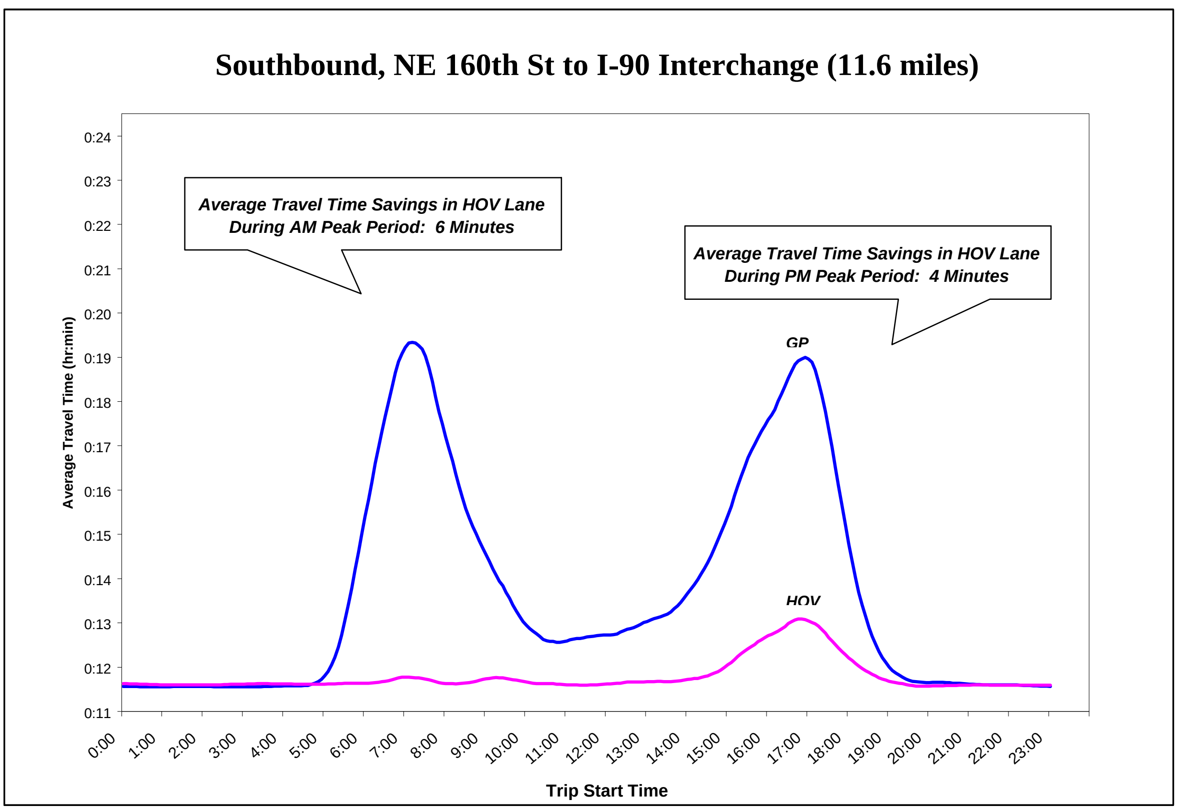
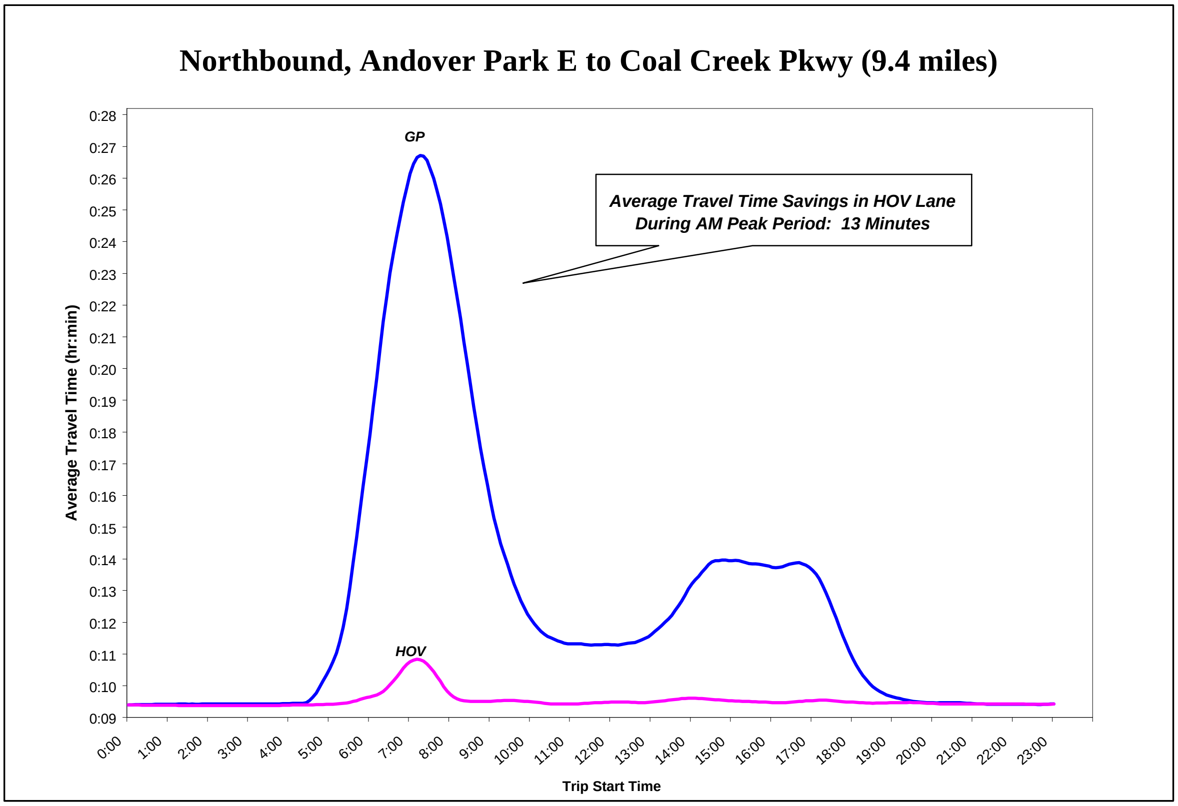


Figure 3-13. Average Weekday GP and HOV Travel Time (1998): I-5 North I-90



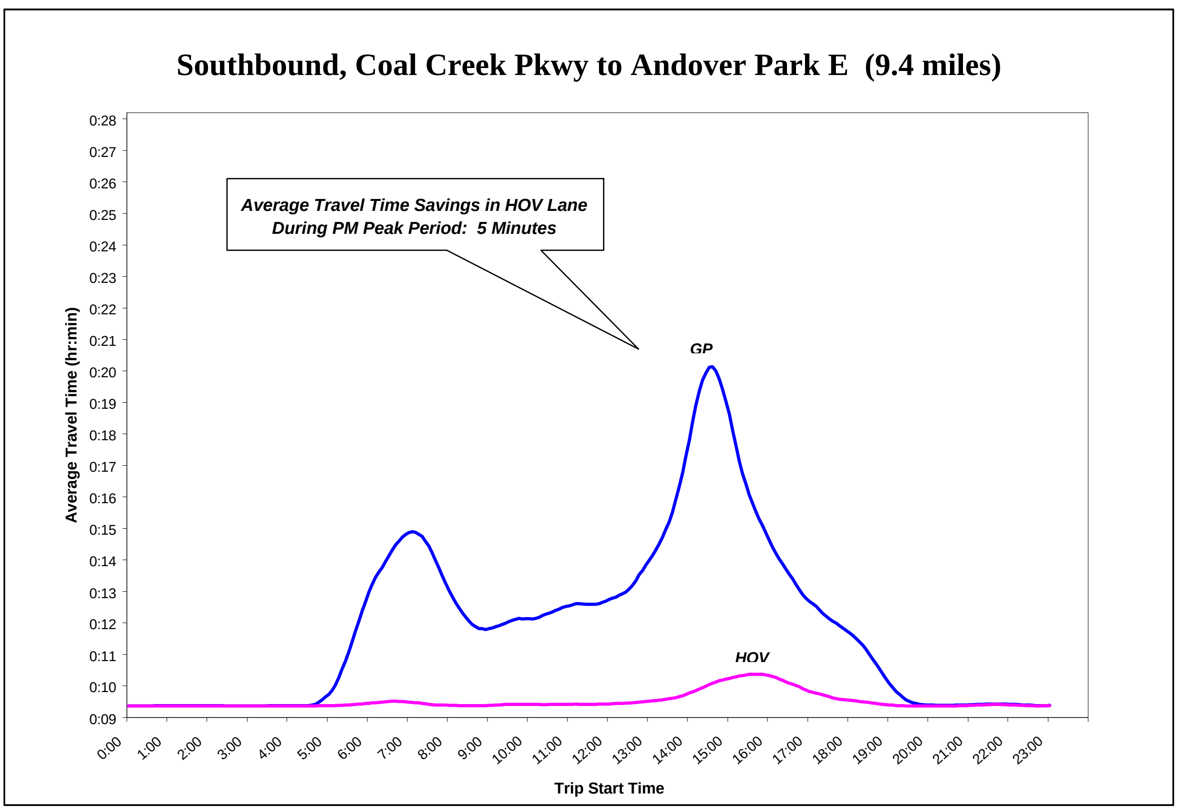
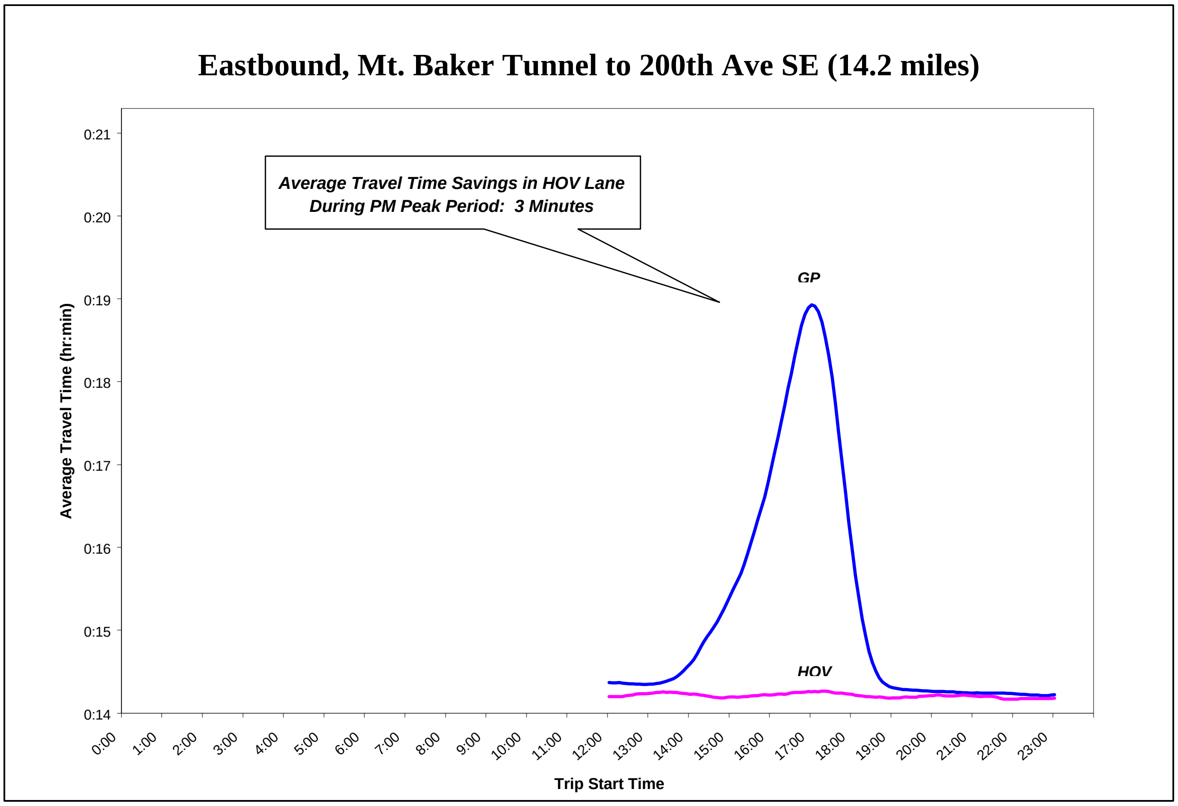


Figure 3-14. Average Weekday GP and HOV Travel Time (1998): I-405 South of I-90



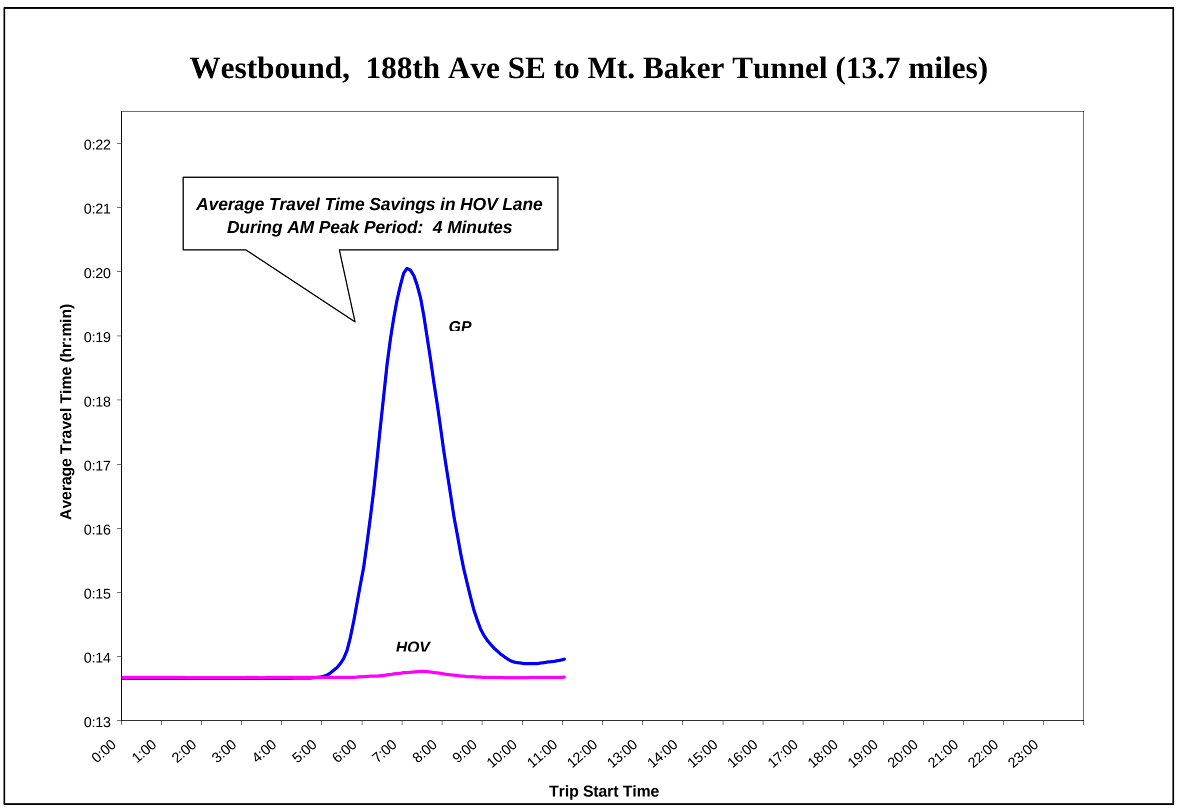


Figure 3-15. Average Weekday GP and HOV Travel Time (1998): I-90

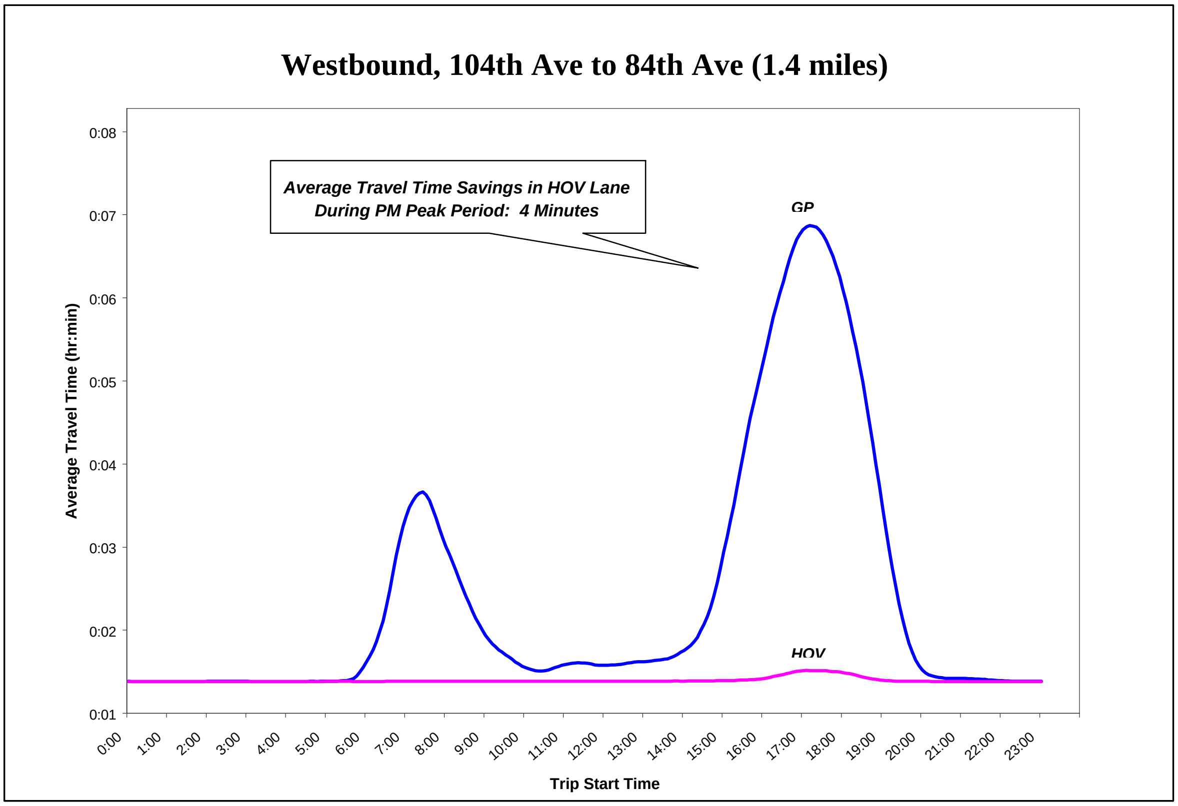
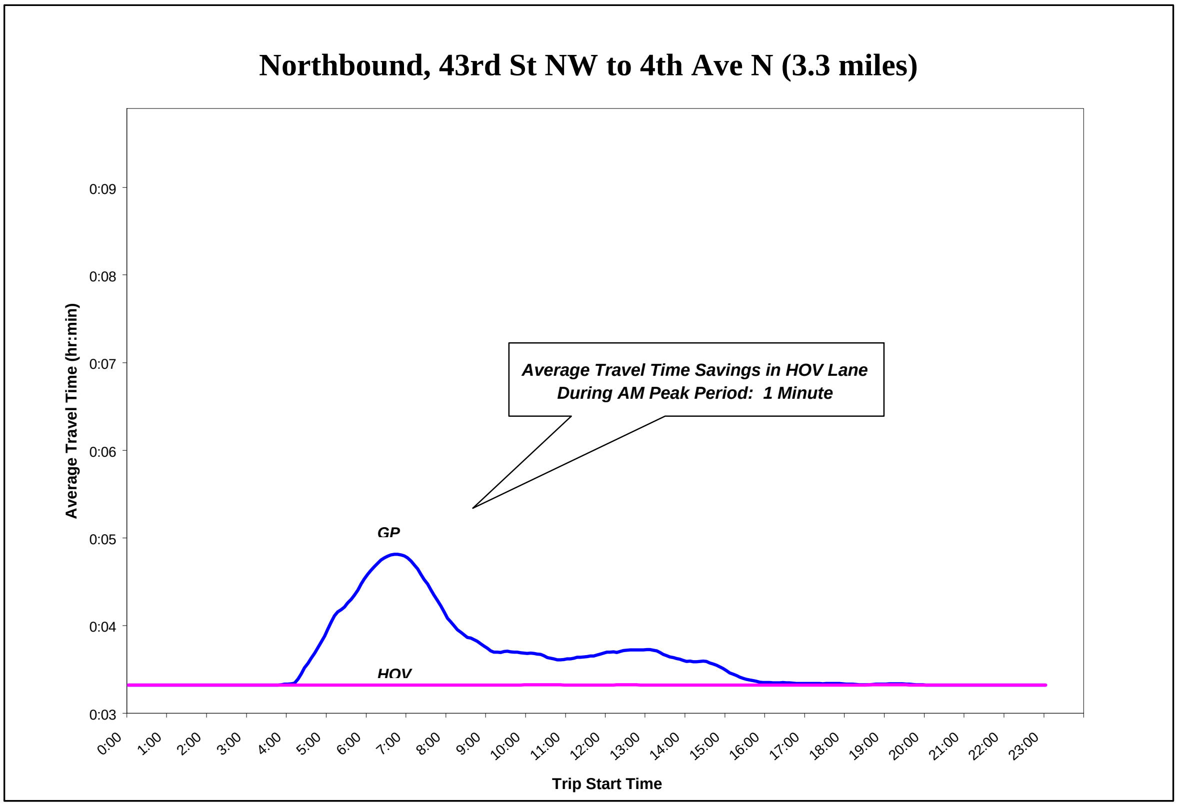


Figure 3-16. Average Weekday GP and HOV Travel Time (1998): SR-520



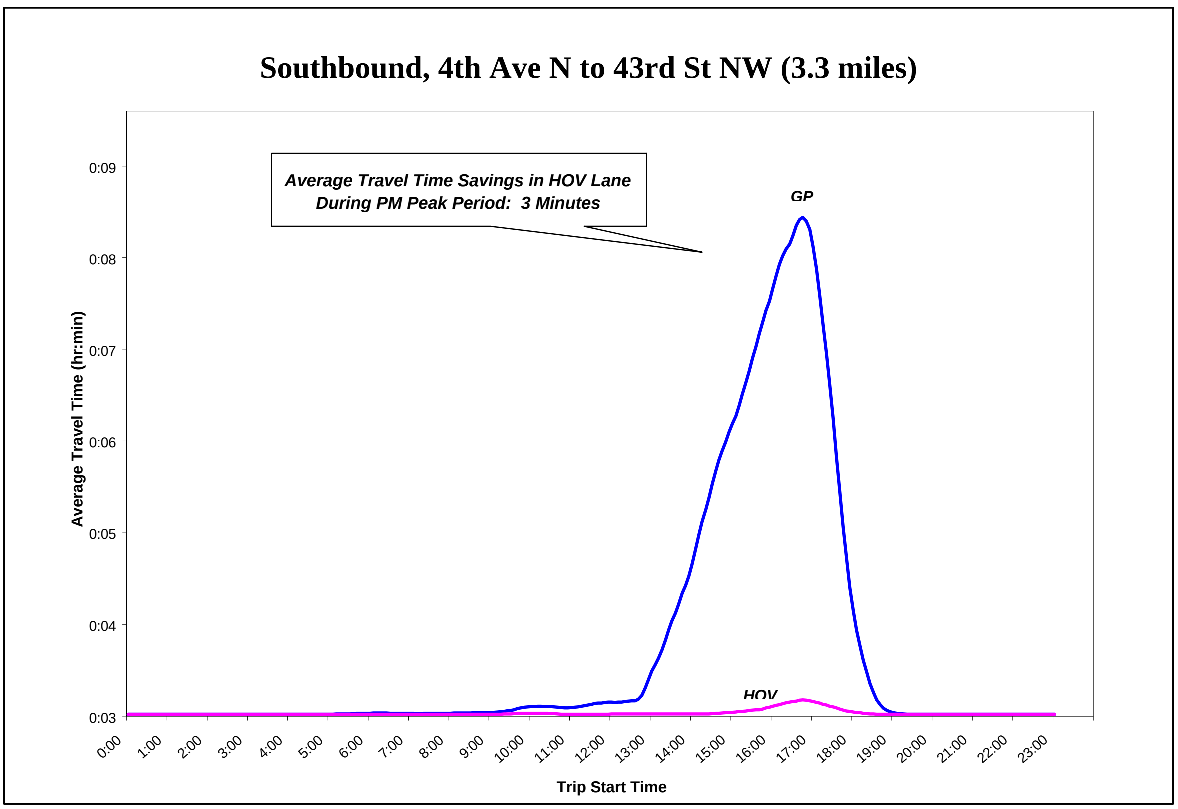


Figure 3-17. Average Weekday GP and HOV Travel Time (1998): SR-167

SITE-SPECIFIC OPERATIONAL PERFORMANCE

Although the measures presented above provide a top-level overview of system performance along a corridor as a whole, more detail about HOV traffic performance can be provided by examining the operation of HOV lanes at specific locations. The principal measures used to evaluate HOV performance at a particular site include the following:

- **Average Vehicle Volume at a Location, by Time of Day.** Vehicle volumes were calculated at 5-minute intervals over a 24-hour weekday and averaged over a full year at a given site. These volumes were then adjusted to a "per lane" hourly rate (vehicles per lane per hour, or VPLPH) to allow direct comparison between sites with varying numbers of lanes.
- **Average Speed at a Location, by Time of Day.** Weekday speed for a location was calculated at 5-minute intervals over a 24-hour weekday and averaged over a full year.
- **Percentage of Days During Which the Average Speed Is < 45 MPH at a Location.** The percentage of weekdays during which vehicles in the HOV lane at this location travel less than 45 mph was computed. This measure helps show how "reliable" a given facility is.

Locations for which data are presented in this report include the following sites:

I-5 North of the Seattle CBD
- I-5 @ 112th SE – Everett (Near Everett)
- I-5 @ NE 137th St. (Near Northgate)

I-5 South of the Seattle CBD
- I-5 @ Albro Place (South of Seattle Downtown)

I-405 North of I-90	• I-405 @NE 85th St. (Near Kirkland)
I-405 South of I-90	• I-405 @ SE 59th St. (Near Factoria) • I-405 @ Tukwila Parkway (Near Southcenter)
I-90	• I-90 @ Midspand (Floating Bridge) • I-90 @ Newport Way (Near Issaquah)
SR 520	• SR 520 @ 84th Ave. NE (Near Medina)
SR 167	• SR 167 @ 84th Ave. S (Near Kent)

Reading the Average Weekday Volume, Speed, and Reliability Conditions Graphs

To present these statistics, a new graph is presented. The following section describes how to read the HOV site performance graphs. The example provided (Figure 3-18) is for the southbound I-5 HOV lane at NE 137th St. near Northgate. It shows average volumes and travel speed conditions from 4:00 AM to 12:00 PM. The horizontal axis represents time of day, from midnight to midnight (for this example only 8 hours are actually shown). The line shows the expected traffic volume and is measured with the left vertical axis in units of vehicles per lane per hour. The volume line is further enhanced with color-coding. The color of the line reflects the expected speed of vehicles in the HOV lane on the average day:

- gray indicates that traffic moves at or faster than 45 mph
- black represents traffic traveling slower than 45 mph.

The column graph is measured with the right vertical axis. It illustrates the frequency with which congestion occurs at this location. At this site HOV volumes can get as high as 1,400+ vplph during the AM peak period. Travelers can count on moving faster than 45 mph in the morning, except between 7:00 AM and 8:00 AM, when they have a 30 percent chance of encountering speeds of less than 45 mph.

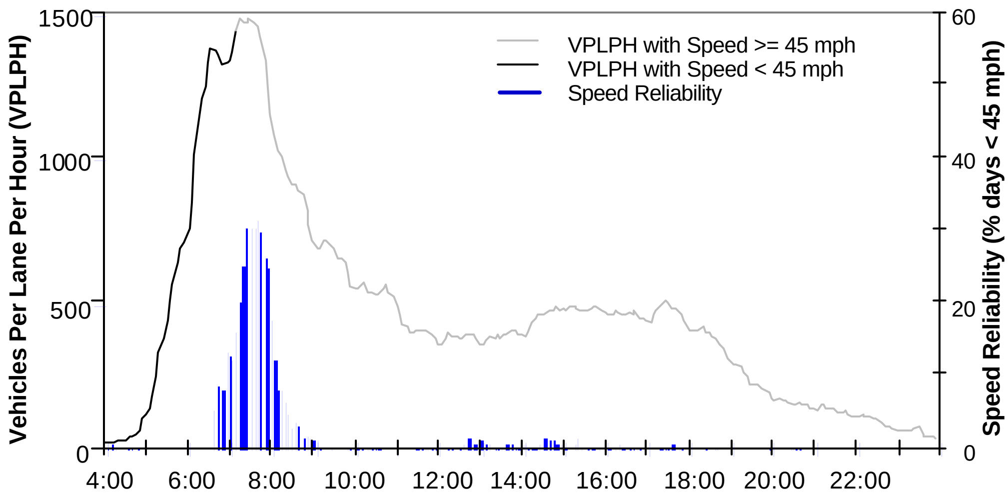


Figure 3-18. Average Volumes, Speed, and Speed Reliability Conditions Graph: Southbound on I-5 NE 137th St.

RESULTS FOR SELECTED LOCATIONS

I-5 North of the Seattle CBD – 112th St. SW. (see Figure 3-19)

Northbound

HOV volumes can approach 900 vplph during the PM peak period. Although moderate congestion occurs about once every two weeks during the PM peak period, the average speed is still above 45 mph.

Southbound

HOV volumes are moderate throughout the day. Volumes approach 700 vplph during the PM peak period. No significant congestion was observed.

I-5 North of the Seattle CBD – NE 137th St. (see Figure 3-20)

Northbound

HOV volumes are very high during the PM peak period and can exceed 1,500 vplph during the evening commute. Moderate congestion occurs about once a week during the evening peak period. However, the average speed is still above 45 mph.

Southbound

HOV volumes reach as high as 1,400+ vplph during the AM peak period, but volumes remain below 700 vplph for the rest of the day. Between 7:30 AM and 8:00 AM, a moderate frequency of heavy congestion occurs and is accompanied by an average speed of less than 45 mph.

I-5 South of the Seattle CBD – Albro Place (see Figure 3-21)

Northbound

The highest volumes during the day are in the AM peak, when close to 1,500 vplph use this HOV lane. This high volume results in an average speed of lower than 45 mph. Significant volumes (1,000+ vplph) also occur in the PM peak, although with less congestion. Volumes remain around 600+ vplph throughout the business hours of the day.

Southbound

HOV volumes are significantly higher in the PM peak than during the rest of the day. Peak volumes of around 1,400+ vplph occur, although little congestion results. Volumes during the day are in the range of 500+ to 700+ vplph, with average speed always greater than 45 mph.

I-405 North of SR 520 – NE 85th St. (see Figure 3-22)

Northbound

During the PM peak, HOV volumes exceed 1,000 vplph with little or no congestion. During the remainder of the workday, HOV volumes remain constant, near 300+ vplph.

Southbound

HOV volumes peak at 1000+ vplph during the AM peak and at 600+ during the PM peak. No congestion was observed at this location. (Note that the graphs for this site present data for only time periods after the conversion from outside to inside HOV lanes.)

I-405 South of I-90 – SE 59th St. (see Figure 3-23)

Northbound

HOV volumes reach 1400+ during the AM peak. Volumes during the day are slightly below 700 vplph, but they increase to 900+ in the PM peak. Congestion frequency is well below 10 percent during both peak periods.

Southbound

HOV volumes are very high during the PM peak period, exceeding 1,500 vplph between 4:00 PM and 5:30 PM and starting to drop around 5:30 PM. During the rest of the day, volumes are around 500+ to 600+ vplph. Congestion frequency is low.

I-405 South of I-90 – Interurban (see Figure 3-24)

Northbound

HOV volumes during the PM peak period are greater than those in the AM peak period. HOV volumes are roughly 700 vehicles throughout the morning and midday. The highest volumes are 900+ in the evening peak. There is no congestion.

Southbound

HOV volumes are low to moderate (~ 600+ vplph) with no congestion. Volumes increase slightly during the AM and PM peak periods.

I-90 – Midspan (see Figure 3-25)

Reversible Lanes

There are two prominent volume peaks, with 600 vplph (inbound to Seattle) in the AM peak and 800+ vplph (outbound to Mercer Island) in the PM peak. Volumes during the rest of the day are relatively low. There is no congestion.

I-90 – Lake Sammamish Parkway (see Figure 3-26)

Eastbound

HOV volumes can approach 500 vplph during the PM peak period. Volumes are relatively low throughout the rest of the day. HOV speeds are greater than 45 mph throughout the day.

Westbound

HOV volumes can approach 500 vplph during the AM peak period. Volumes are relatively low throughout the rest of the day. No congestion was observed.

SR 520 – 84th Ave NE (see Figure 3-27)

Westbound

HOV volumes are highest during the PM peak period (~ 350+ vplph). Volumes are low to moderate throughout the rest of the day. Congestion in the HOV lane occurs during the PM peak period less than 5 percent of the time.

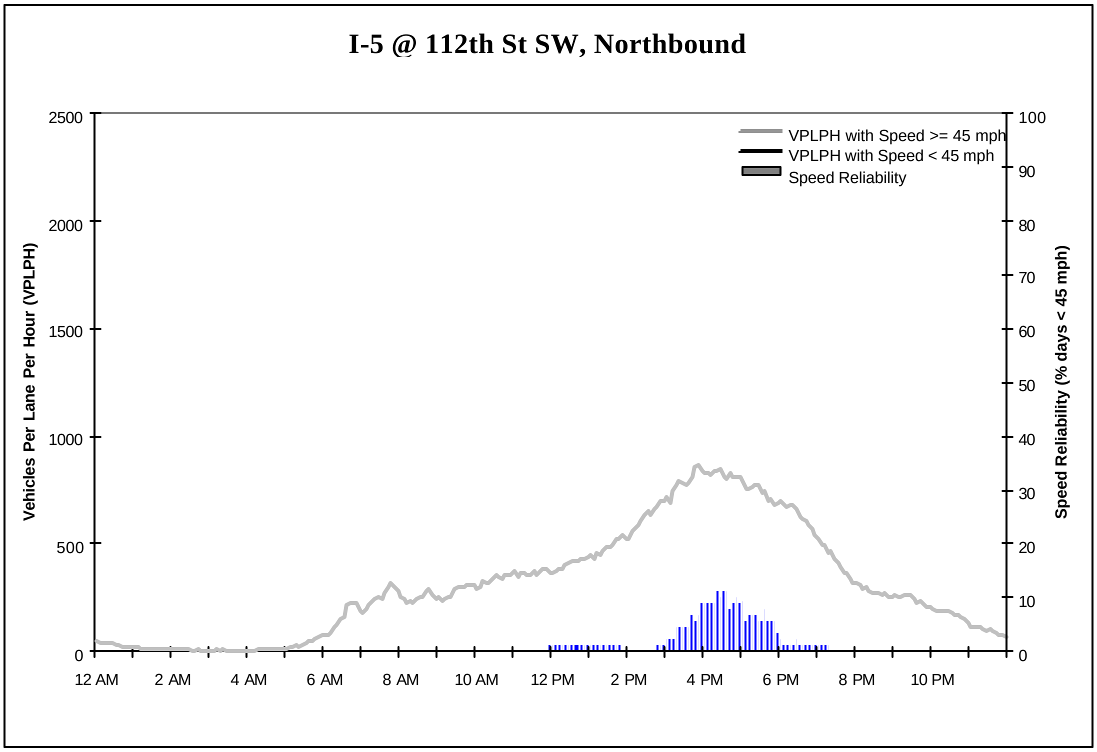
SR 167– S. 208th St (see Figure 3-28)

Northbound

HOV volumes are moderate during the AM peak period. Volumes remain around 300+ vplph throughout midday. There is no congestion at this location.

Southbound

Although HOV volumes are more significant (> 700 vplph) during the afternoon peak period, there is still no congestion at this location.



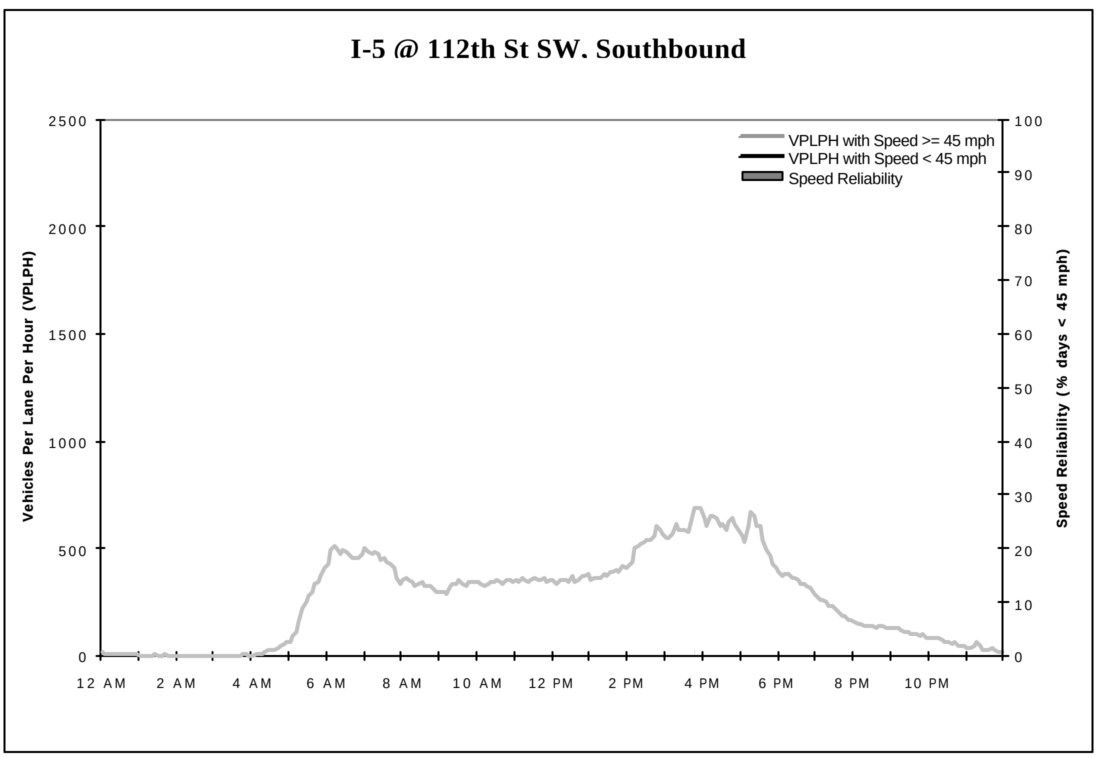
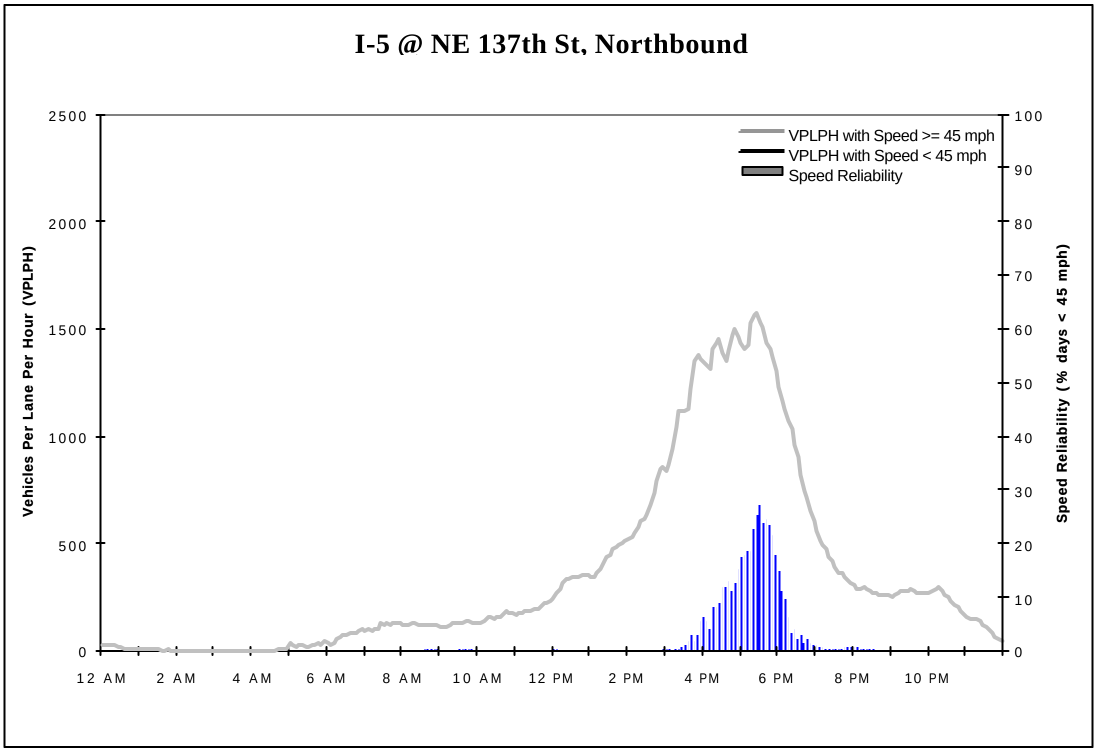


Figure 3-19. Average Weekday Volume, Speed, and Reliability Conditions: I-5 @ 112th St SW



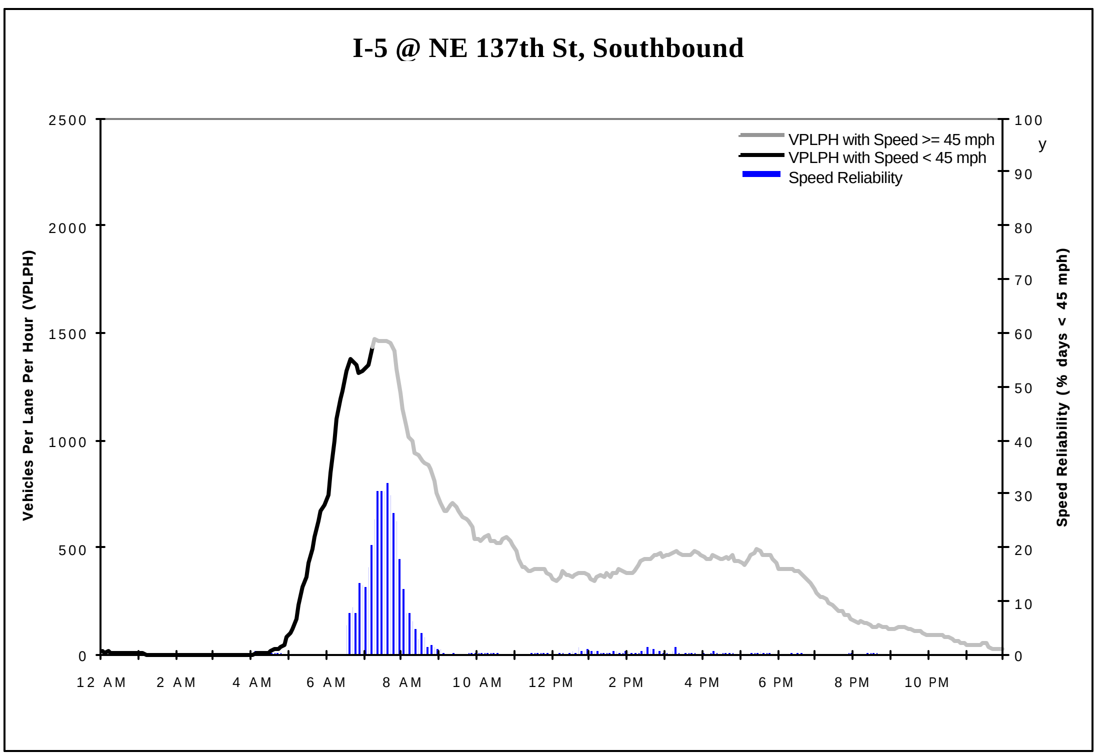
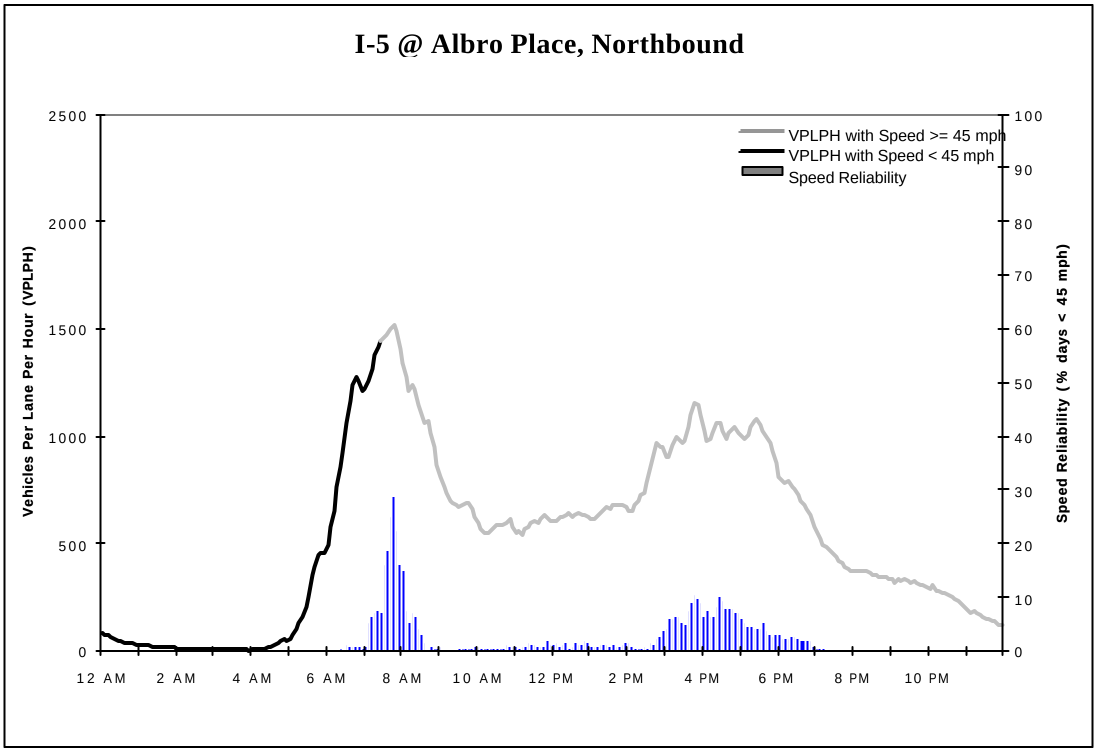


Figure 3-20. Average Weekday Volume, Speed, and Reliability Conditions: I-5 @ NE 137th St



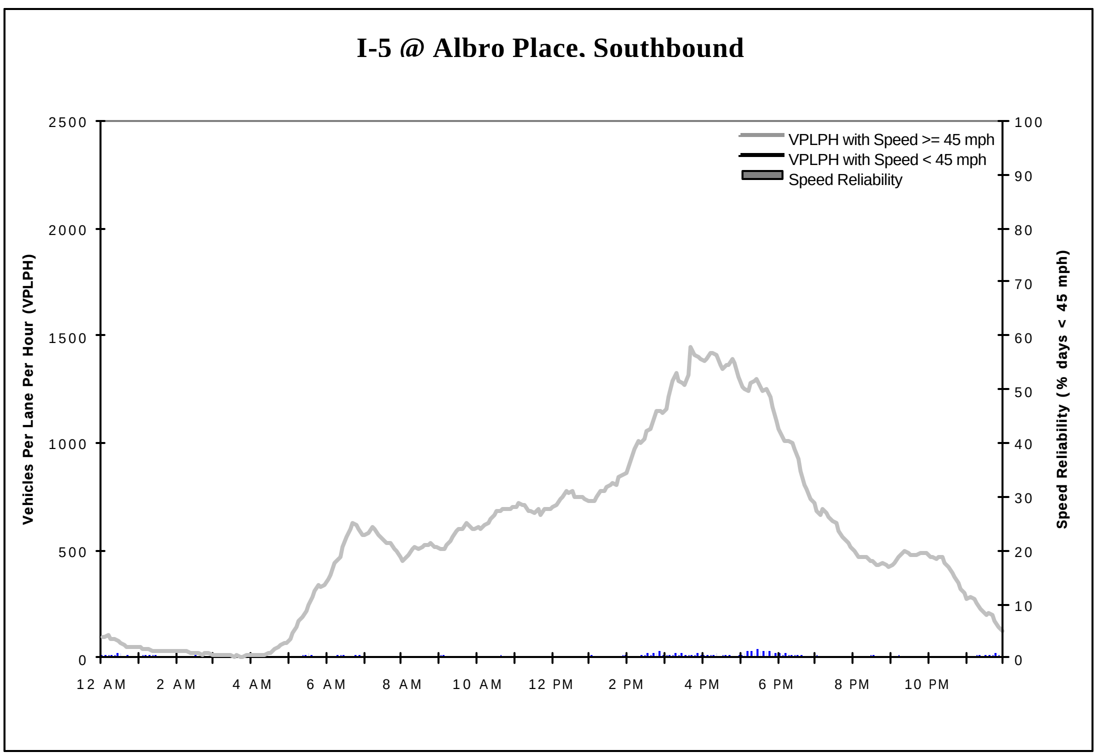
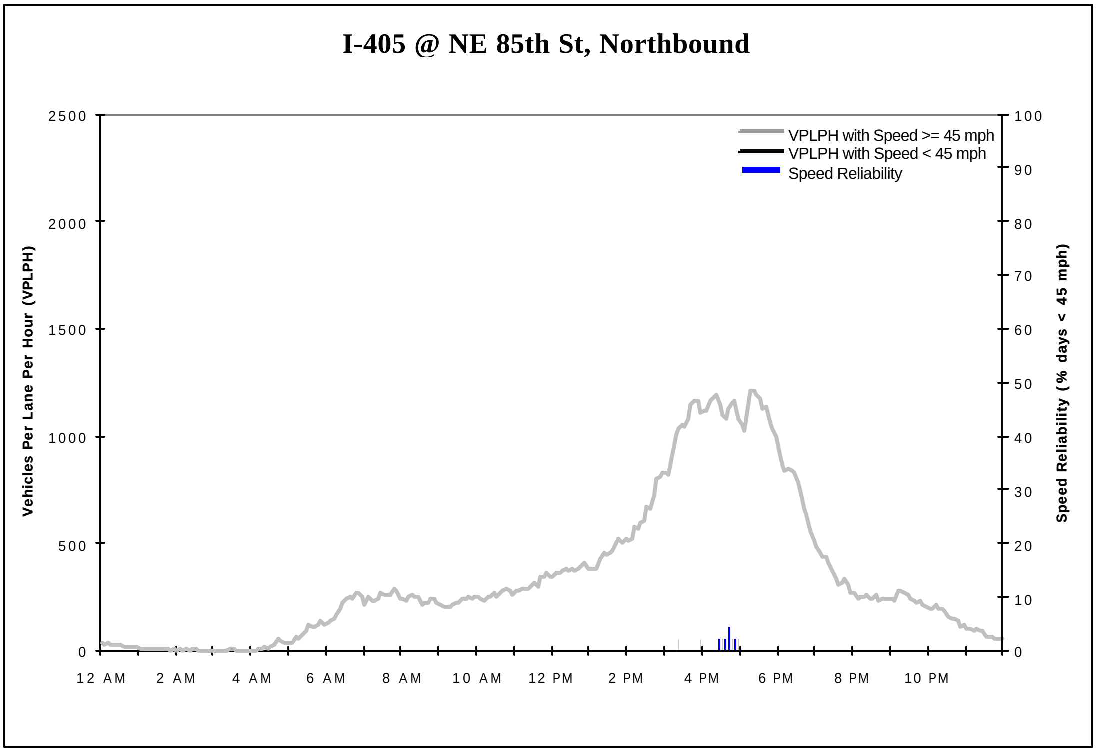


Figure 3-21. Average Weekday Volume, Speed, and Reliability Conditions: I-5 @ Albro Place



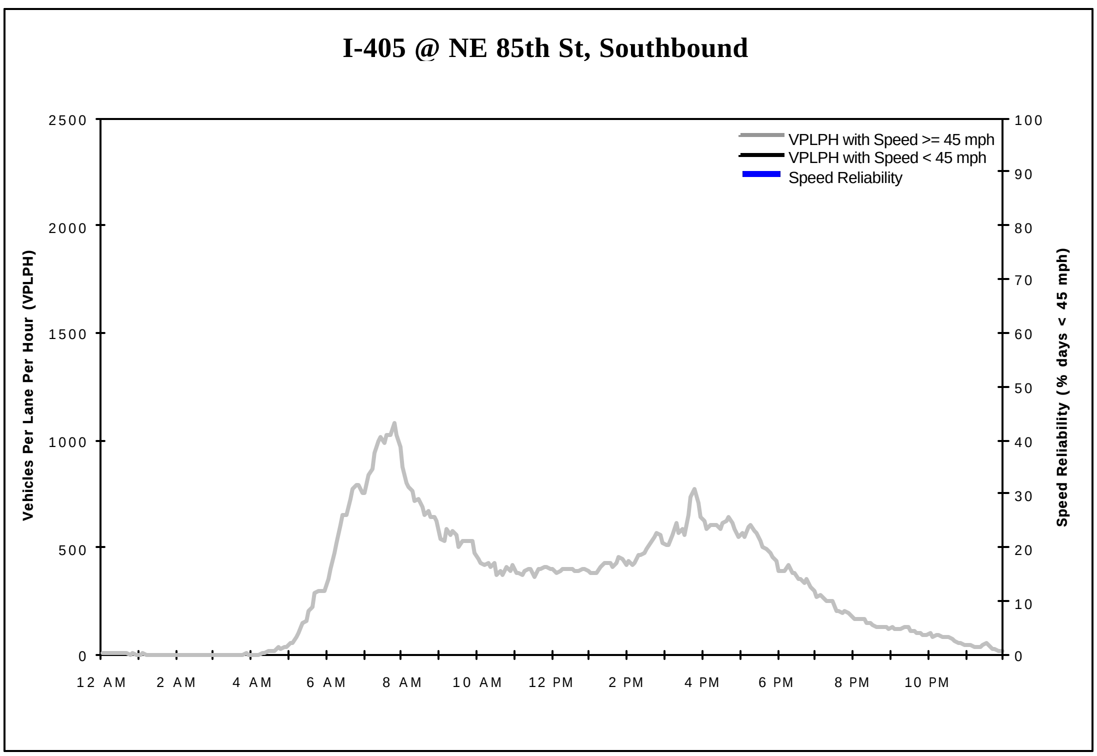
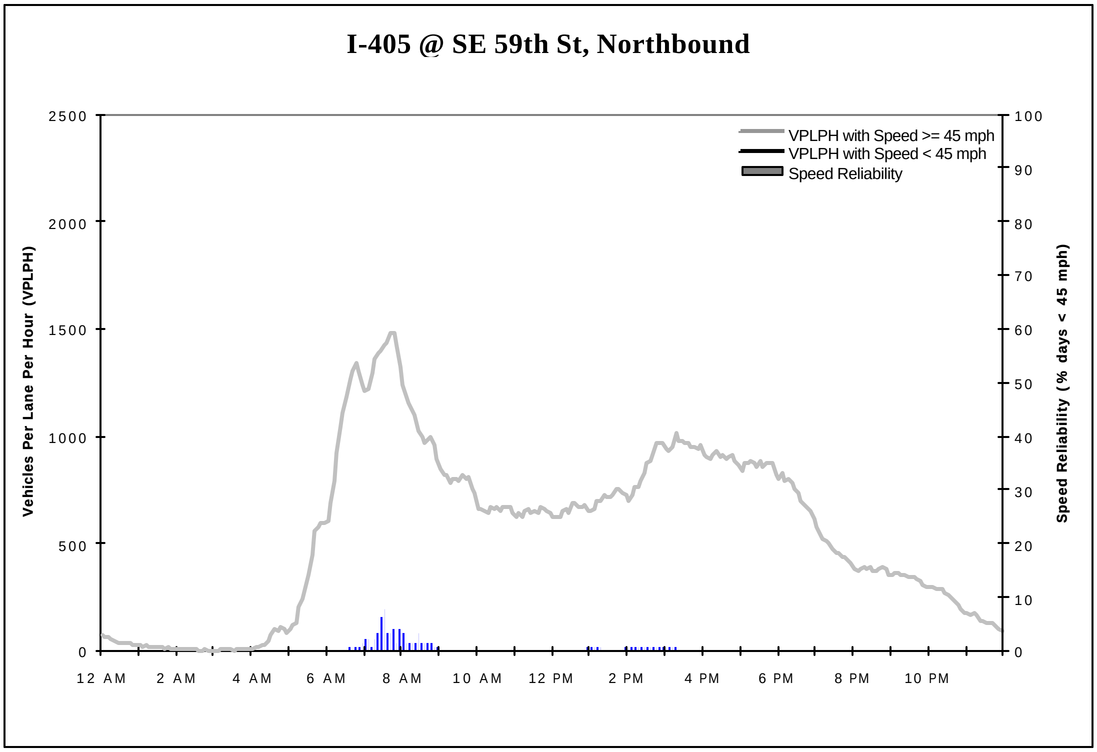


Figure 3-22. Average Weekday Volume, Speed, and Reliability Conditions: I-405 @ NE 85th St



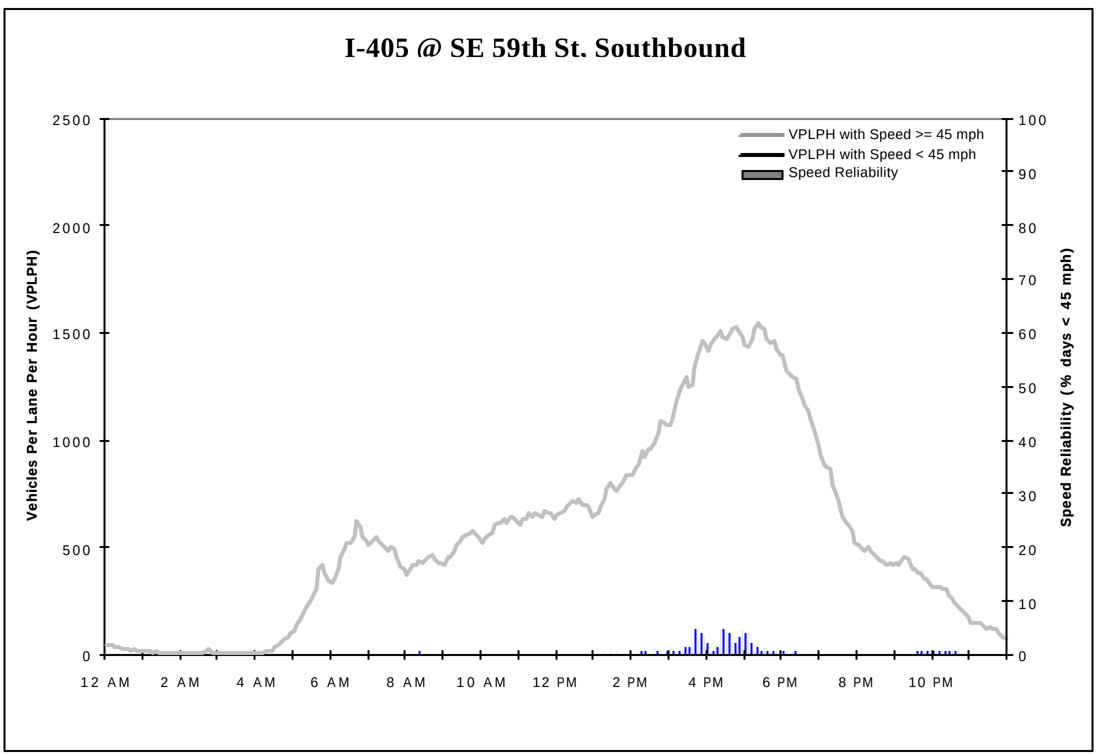
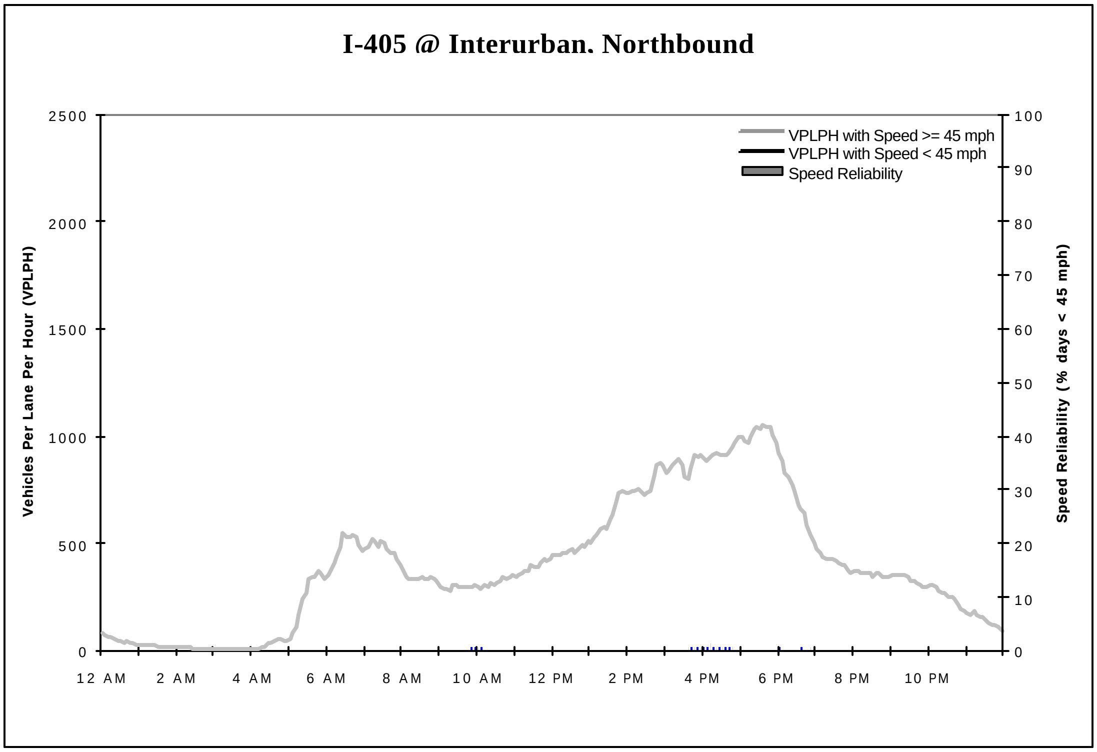


Figure 3-23. Average Weekday Volume, Speed, and Reliability Conditions: I-405 @ SE 59th St



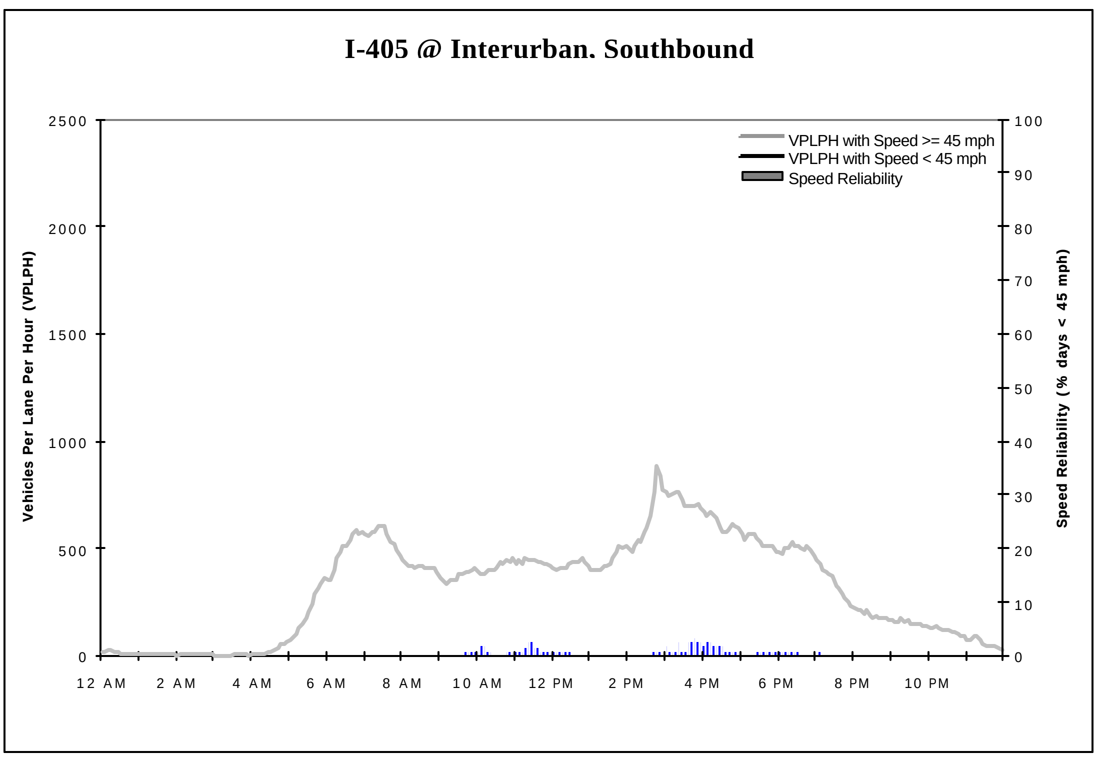


Figure 3-24. Average Weekday Volume, Speed, and Reliability Conditions: I-405 @ Interurban

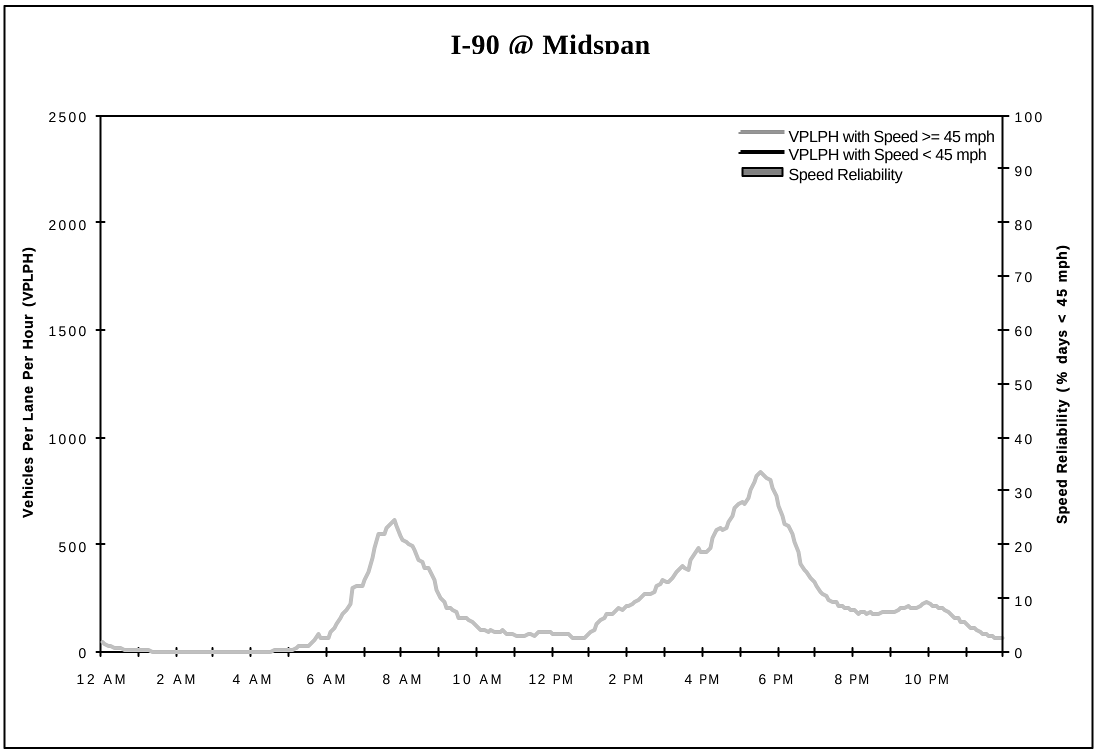
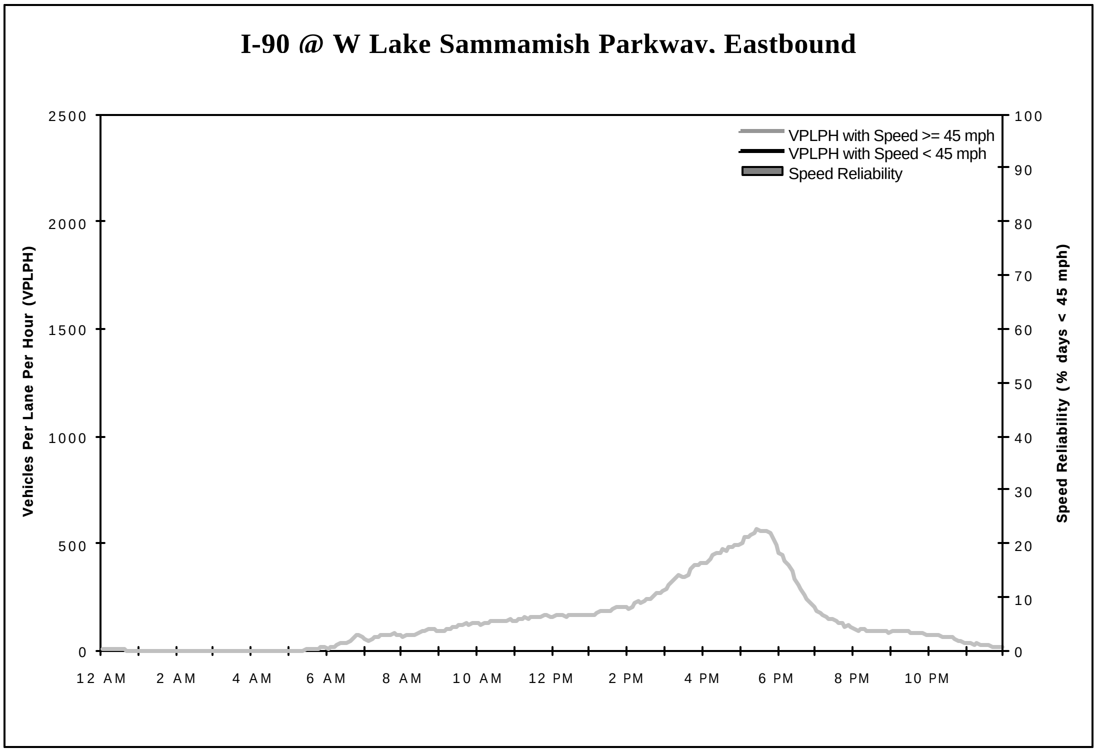


Figure 3-25. Average Weekday Volume, Speed, and Reliability Conditions: I-90 @ Midspan



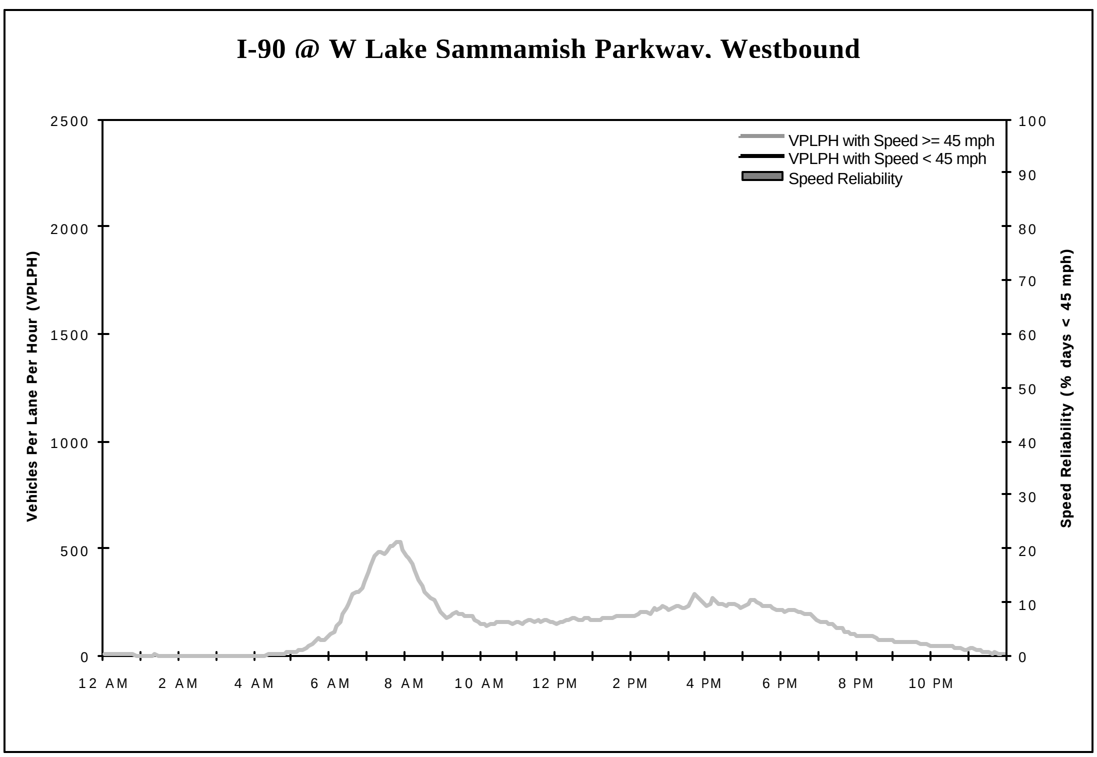


Figure 3-26. Average Weekday Volume, Speed, and Reliability Conditions: I-90 @ W Lk Sammamish Pkwy

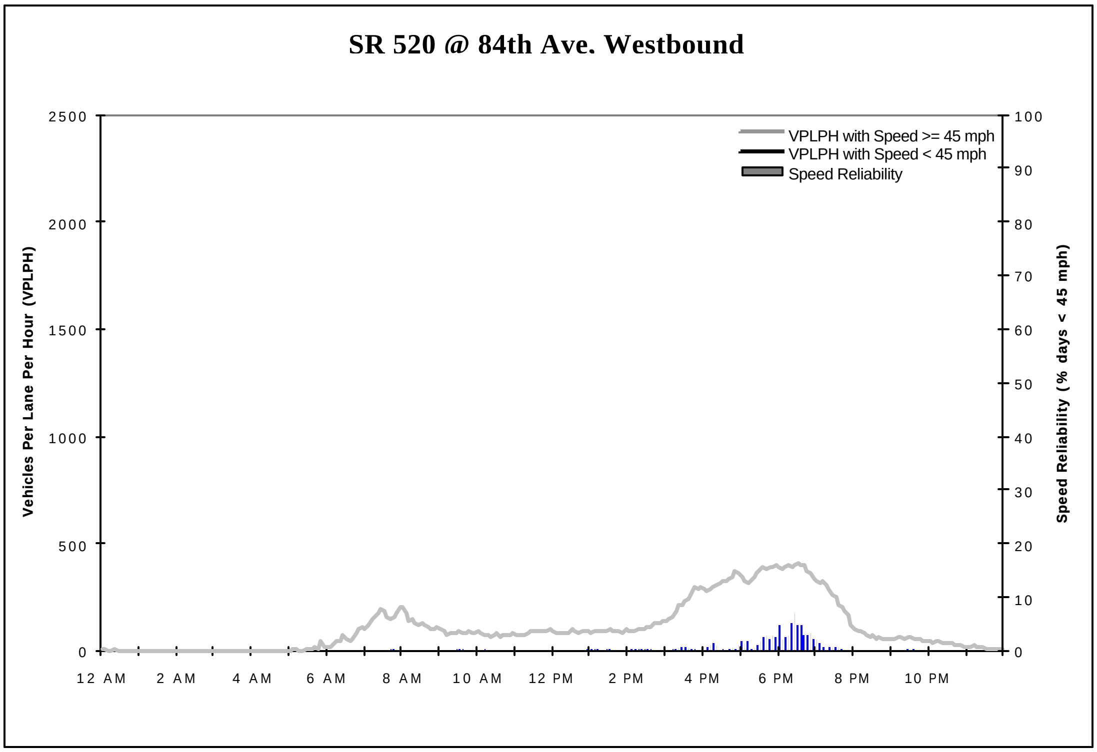
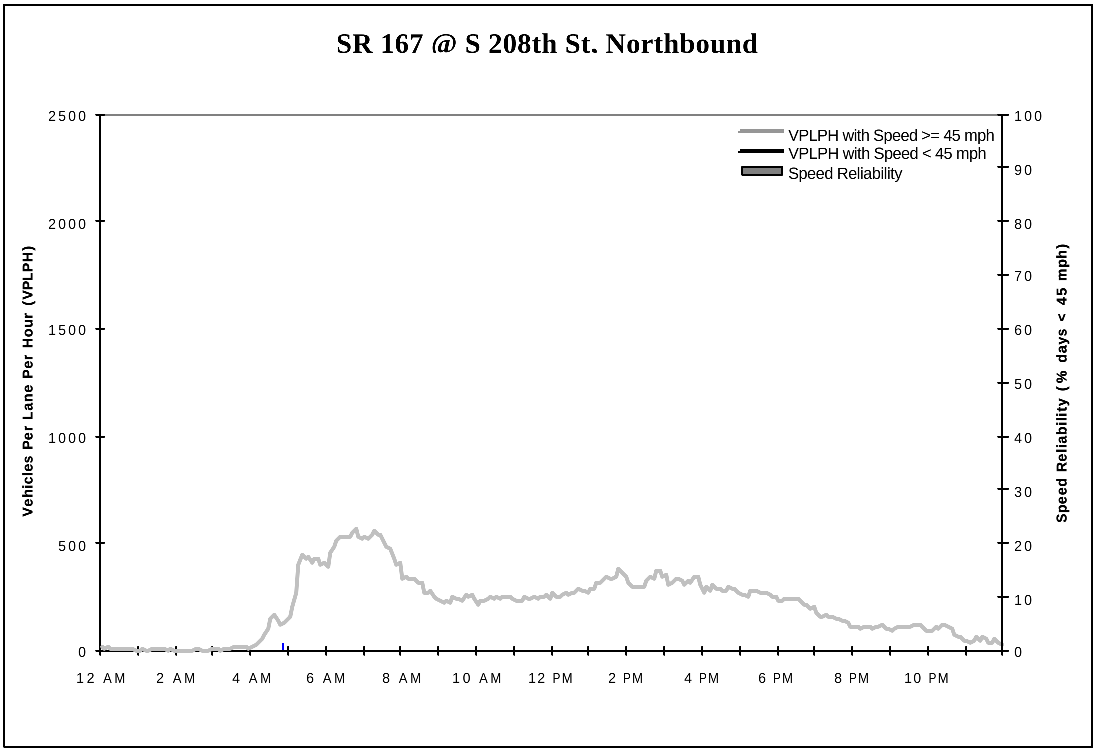


Figure 3-27. Average Weekday Volume, Speed, and Reliability Conditions: SR 520 @ 84th Ave NE



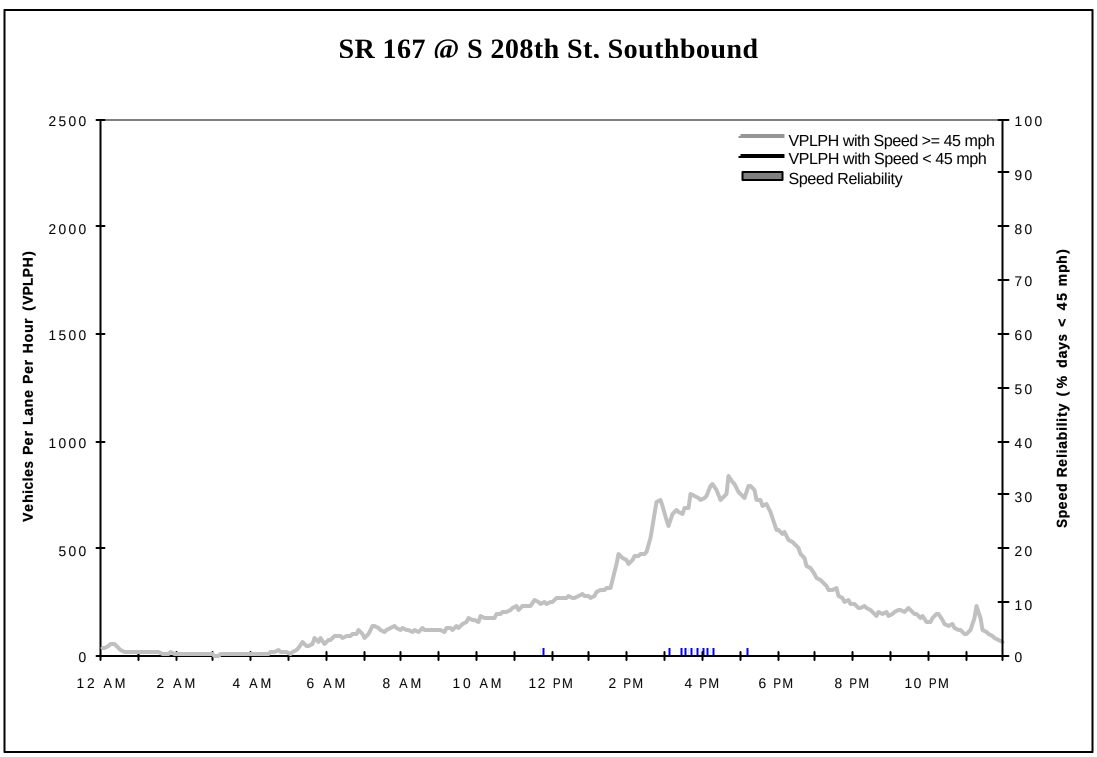


Figure 3-28. Average Weekday Volume, Speed, and Reliability Conditions: SR 167 @ S 208th St

CHAPTER FOUR
HOV VIOLATIONS

A crude violation rate was calculated on the basis of the average vehicle occupancy (AVO) data collected by traffic observers. Other sources that provided some insight into HOV violation rates and the outcomes of enforcement actions include the following:

- violation reports made to King County Metro's HERO program
- warnings and citations issued by the Washington State Patrol
- HOV cases processed in the district courts in counties that have HOV lanes.

In addition to these measures of HOV violations, motorists' perceptions of compliance and enforcement of HOV restrictions were also solicited through a yearly public opinion survey. Most motorists indicated that improving enforcement would be the highest priority for making HOV lanes more attractive. HOV violation, considered a serious traffic violation, is perceived as common during peak commute hours. For more detailed information on the public's opinion regarding violations, please refer to Chapter Five, Public Opinion.

VIOLATION RATES

Figure 4-1 presents HOV violation rates based on the percentage of SOVs found in the average vehicle occupancy (AVO) counts of HOV lanes. The violation rates in general are quite low, typically ranging from 2 percent to 13 percent, excluding some special cases. These low violation rates suggest that most people obey the HOV restrictions. At a few locations, higher SOV volumes were observed in the HOV lanes, namely I-90 midspan across Lake Washington (45 percent, 47 percent), I-5 northbound at Albro Place (31 percent), and I-405 northbound at NE 85th St. (20 percent). On I-90 midspan between Mercer Island and the Mt. Baker tunnel (45 percent, 47 percent), a special provision allows the residents of Mercer Island to use the 2-lane reversible HOV facility without having to meet the 2+ occupancy requirement. The high percentage of observed SOVs in the HOV lane northbound on I-5 at Albro Place (31 percent) is largely due to the fact that the HOV lane is also an inside exit lane where traffic mixes. When field measurements were collected for 1998, the HOV lane at NE 85th St. on I-405 was still located on the outside next to the off-ramp. Therefore, the HOV lane could include both HOV users and exiting vehicles. The last two examples suggest that violations increase toward the ends of facilities and where HOV lanes are shared with exits.

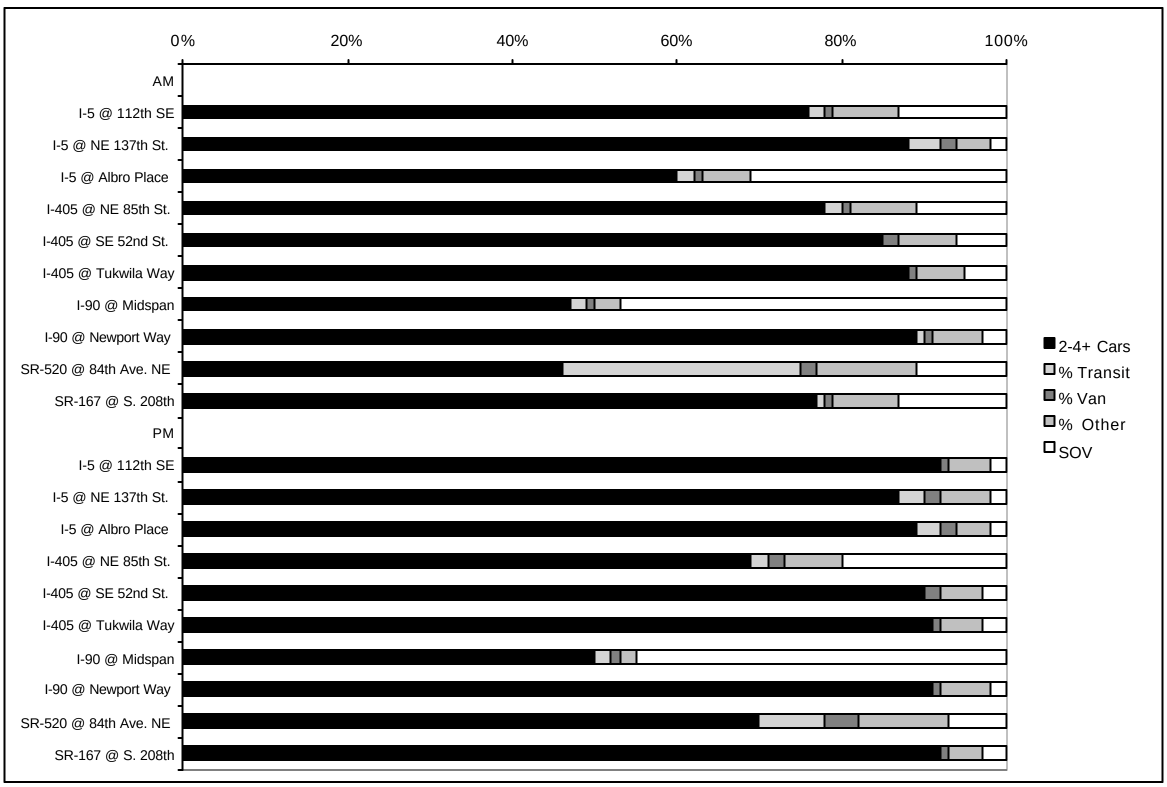


Figure 4-1. Mode Split in HOV Lanes, from Observed Occupancy Rate (1998)

Violations also tend to go up when the opportunity to get caught decreases, such as in areas that lack barrier separation or enforcement zones.

THE HERO PROGRAM

The HERO program is a service provided by King County Metro that encourages motorists to report HOV violators by calling 764-HERO. The HERO program does not issue tickets because the State Patrol must actually observe the violation to enforce the infraction. However, HERO reports repeat violators to the WSP for possible enforcement action. A brochure is sent to the alleged violator by HERO staff to provide information on HOV lane policy and restrictions. Following a second report, the violator receives a letter from WSDOT, issued by the HERO office, which explains that the person's auto was observed violating HOV lane restrictions. If a third violation is observed, the vehicle owner receives a letter from the Washington State Patrol (WSP), also issued by the HERO office. The number of reported violations has increased steadily since 1993, with the total annual number of reported violators reaching 41,731 in 1998. Figure 4-2 shows a comparison of annual violation report rates for the HERO program by month from 1996 to 1998. Reported violation rates decrease in the winter months because of diminished light levels, which make it difficult to see the number of occupants or the vehicle license plate of nearby cars.

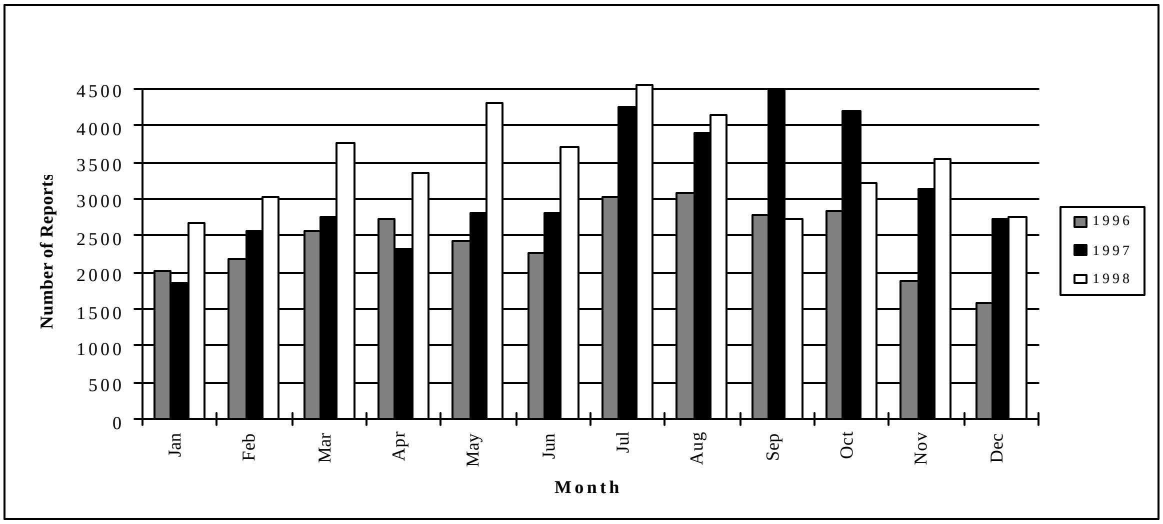


Figure 4-2 HERO Program Actions 1996 - 1998

<u>WASHINGTON STATE PATROL</u>

The Washington State Patrol has primary responsibility for enforcing HOV lane restrictions on state highways. Although the WSP catches only a fraction of HOV violators on any single day, repeat violators have a significant chance of eventually getting caught. Troopers have the discretion to ticket offenders or to give verbal or written warnings as they see fit. (WSP officers have adopted a "zero tolerance" policy regarding HOV violations in an effort to curb persistent violation rates.) For 1998 the WSP reported 21,098 contacts with HOV violators and issued 12,582 tickets, for a ticketing rate of 60 percent (see Table 4-1). The number of tickets issued by officers in 1998 increased 79 percent over the previous year (1997). The 1998 ticketing rate was also the highest in the past seven years.

Table 4-1. Washington State Patrol HOV Enforcement Actions, 1992-1998

Type of Action	***Arrest Citations***	***Verbal Warnings***	***Written Warnings***	***Accident Citations***	***Other***	***Total***
1992	3,790	3,717	248	7	21	**7,783**
1993	3,655	3,389	259	5	33	**7,341**
1994	2,809	3,159	225	N/A	11	**6,204**
1995	3,893	2,734	415	N/A	11	**7,053**
1996	4,784	5,574	327	N/A	23	**10,708**
1997	7,014	4,786	503	N/A	24	**12,327**
1998	12,582	8,078	440	N/A	44	**21,098**

ADJUDICATION DATA

While reports of violations and the number of warnings and tickets issued provide useful insight into HOV violation rates, it is also useful to know what happens once HOV violators have been ticketed. As shown in Figure 4-3, violations committed in 1997 were up significantly in comparison to the 1995 and 1996 results. Three categories (Dismissed with Prejudice, Dismissed without Prejudice, and Amended) have been omitted from the figure because there were fewer than five cases in each.

The outcome data are also broken down by court district and by type of outcomes (see Table 4-2). The results shown represent the number of cases considered for each classification in each of the eight most active districts. Drivers ticketed in most districts tend to pay the fines at roughly the same frequency (37 percent to 46 percent of tickets are paid without being contested). The convenience of appearing in court or underlying opinions about the legitimacy of HOV lane restrictions may guide those decisions. Results from the Renton district are higher than the other districts because they represent the combined caseloads of the Renton District Court and the Renton Municipal Court.

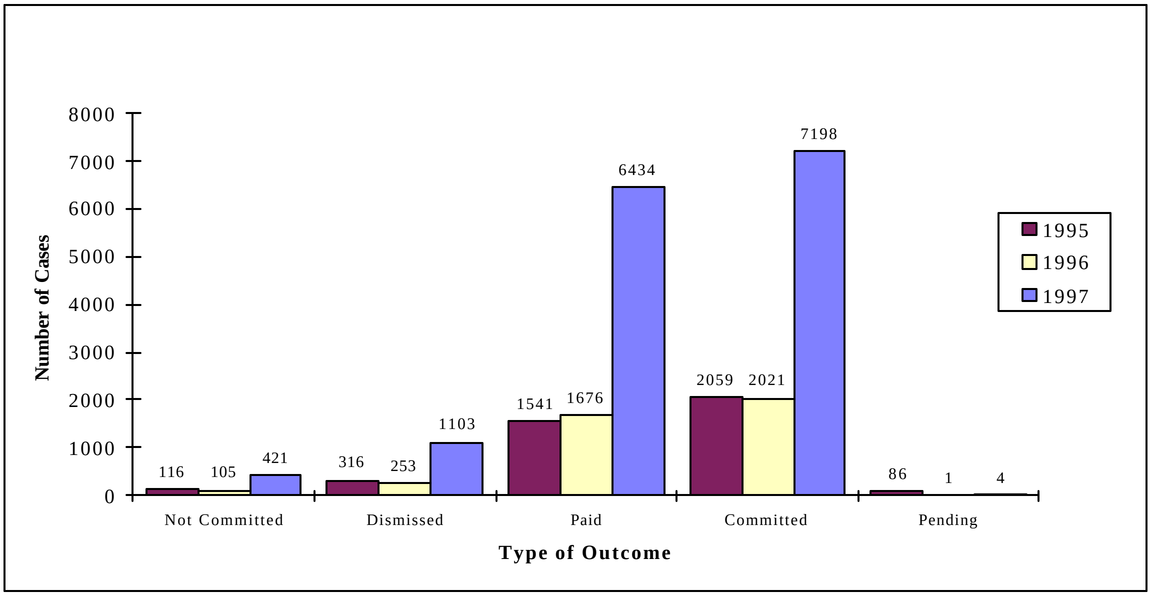


Figure 4-3 HOV Adjudication Outcomes 1995 - 1997

Table 4-2. HOV Violation Outcomes by District (1997):

District Court	***Direct Fine Payment***	***Committed***	***Dismissed by Court***	***Total***
King County (Aukeen)	559	563	99	1221
King County (Northeast)	1150	1278	354	2782
King County (Shoreline)	351	506	83	940
King County (Southwest)	404	586	104	1094
Bellevue	576	655	95	1326
Federal Way	781	868	164	1813
Issaquah	489	531	148	1168
Renton (district court plus municipal court)	1639	1709	274	3622
Total Cases	**5949**	**6696**	**1321**	**13966**
	(43%)	**(48%)**	**(9%)**	**(100%)**

CHAPTER FIVE
PUBLIC OPINION SURVEY FINDINGS

Since July of 1993, 42,159 surveys have been mailed to owners of vehicles identified as HOVs and SOVs by traffic observers in the field. The overall response rate for the entire survey population has been 23 percent, with a response rate of 24 percent from HOVs and 22 percent from SOVs. Many of the figures presented in this report are based on data collected from January 1998 until June 1999 to better illustrate the changes in demographics and opinion since the previous survey period. These opinions are compiled from the responses of returned surveys. Because of the random nature of the mailing and those returning the surveys, conclusions drawn from these data should not be considered completely representative of the driving population; rather they should be considered and further investigated in a more analytical fashion.

DEMOGRAPHIC CHARACTERISTICS

The majority of survey respondents were male (57 percent), as depicted in Figure 5-1. The ages of the respondents ranged primarily from 31 to 64 (see Figure 5-2). As shown in Figure 5-3, 70 percent of survey respondents possessed a college degree or post-graduate education, 21 percent had attended only a community college, and 8 percent had finished only high school.

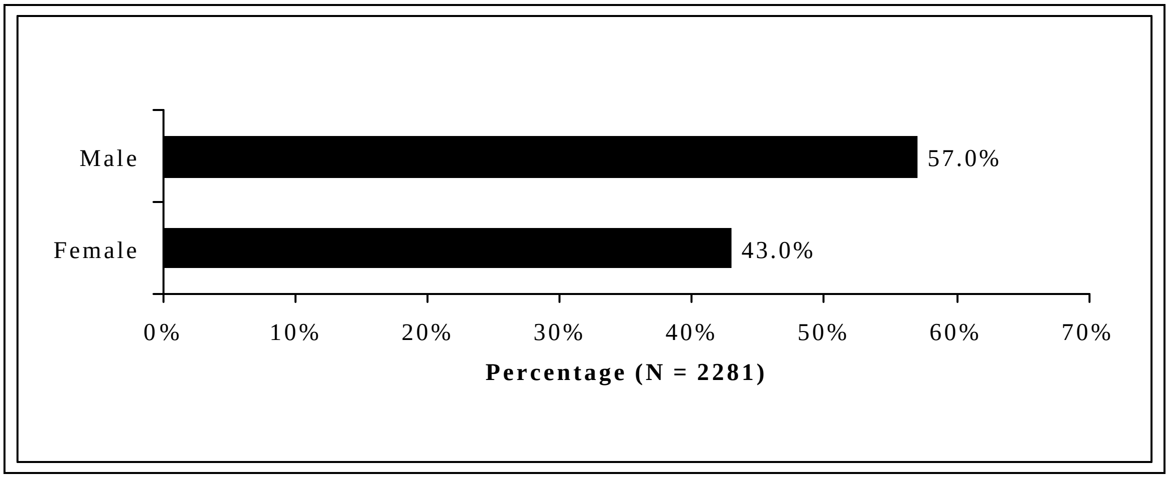


Figure 5-1. Gender of Respondents

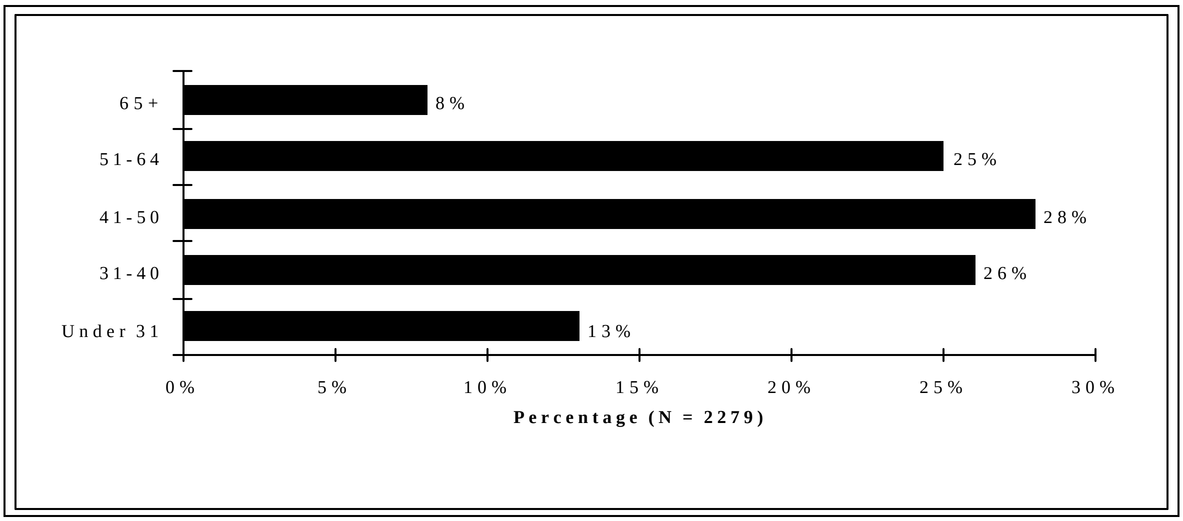


Figure 5-2. Age of Respondents

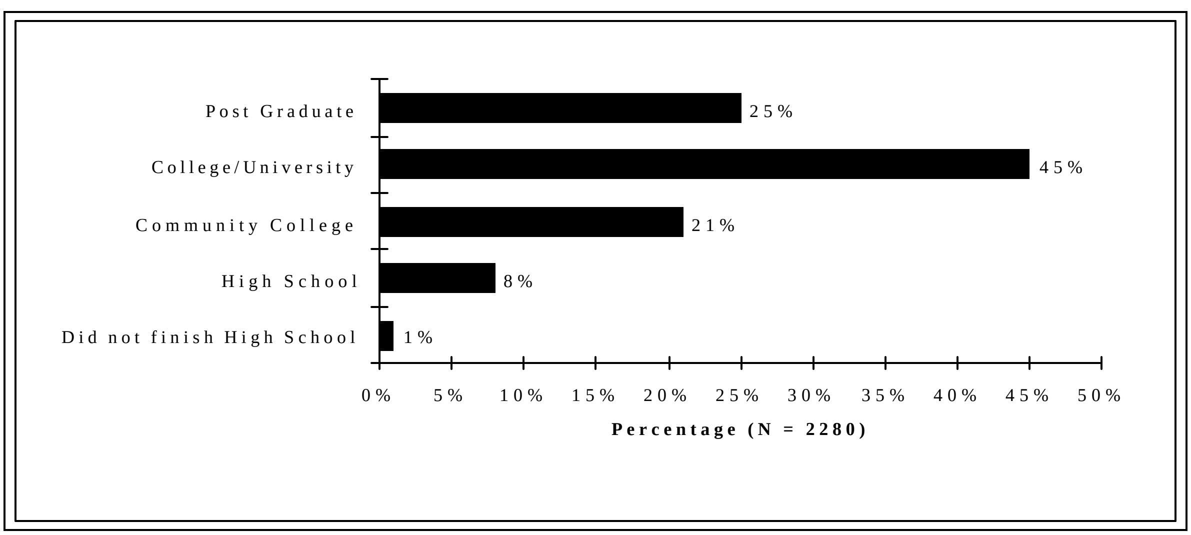


Figure 5-3. Education Level of Respondents

The public opinion survey also asked respondents to provide information on their domestic conditions. Of the returned responses, the most common cluster of domestic conditions comprised two people living in the household with no people under age 15 in the home, both working outside the home, and two vehicles (see Table 5-1).

Table 5-1. Domestic Conditions of Respondents

Domestic Conditions	Number	Percentage
2 people living in house No people under 15 years of age 2 people working outside house 2 vehicles	**446**	**20%**
1 person living in house No people under 15 years of age 1 person working outside house 1 vehicle	**139**	**6%**
3 people living in house 1 person under 15 years of age 2 people working outside house 2 vehicles	**118**	**5%**
3-4 people living in house 2 or less people under 15 years of age 2 person working outside house 3 vehicle	**106**	**5%**
2 people living in house No people under 15 years of age 2 people working outside house 3 vehicles	**100**	**4%**
2 people living in house No people under 15 years of age 1 person working outside house 2 vehicles	**114**	**5%**
4 people living in house 2 people under 15 years of age 2 people working outside house 2 vehicles	**100**	**4%**
3-4 people living in house 2 or less people under 15 years of age 1 person working outside house 2 vehicles	**119**	**5%**
Other/No Response	**1038**	**46%**
Total	**2280**	**100%**

COMMUTE CHARACTERISTICS

The survey respondents were asked to describe their commute characteristics:

- their normal commute and trip routes
- their typical commute mode
- whether they had ever used HOV lanes to commute and in which corridor
- whether they had ever opted not to use the HOV lanes when they were qualified to use the lanes, and the reasons for not using HOV lanes.

Commute and Trip Routes

Figures 5-4 and 5-5 show the normal commute and trip routes for survey respondents. The percentage given represents the use of a given corridor by the survey population and not the percentage of total use for freeway corridors within the Puget Sound region. Originally, the commute route was determined by the highway corridor in which motorists were observed. This designation could then be used to measure sub-regional differences in opinion about HOV lanes. However, many respondents were observed in locations outside their normal commute routes or had commute routes that included more than one traffic observation corridor. To best analyze sub-regional differences in opinion, the commute route information was broken down into categories containing complete information on the commute route and other travel during peak hours. The major freeways located within the Puget Sound region were divided into ten corridors.

1)	I-5 North	6)	I-405
2)	I-5 Central	7)	SR 16
3)	I-5 South	8)	SR 167
4)	I-90	9)	SR 410
5)	SR 520	10)	SR 512

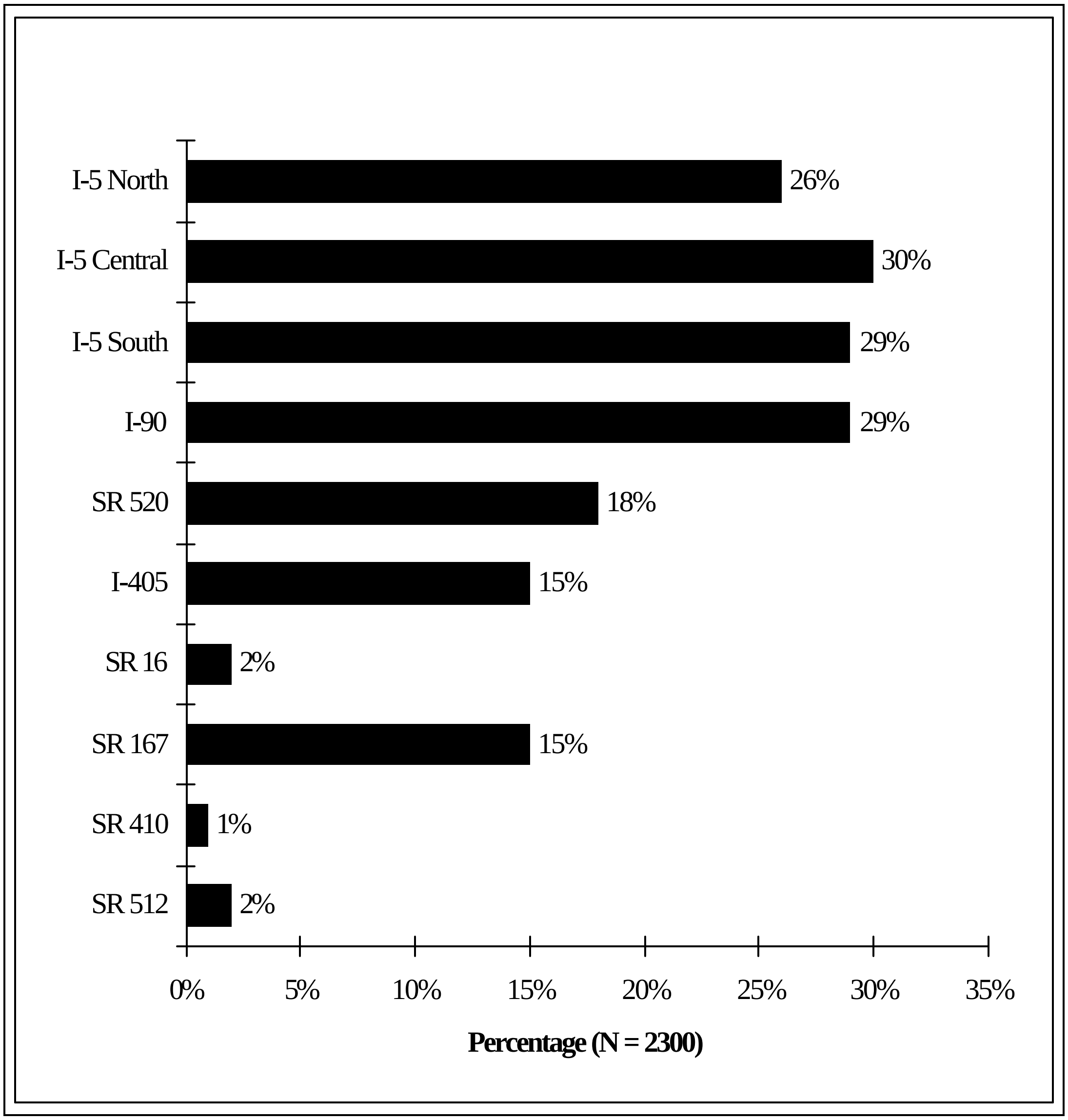


Figure 5-4. Normal Commute Route

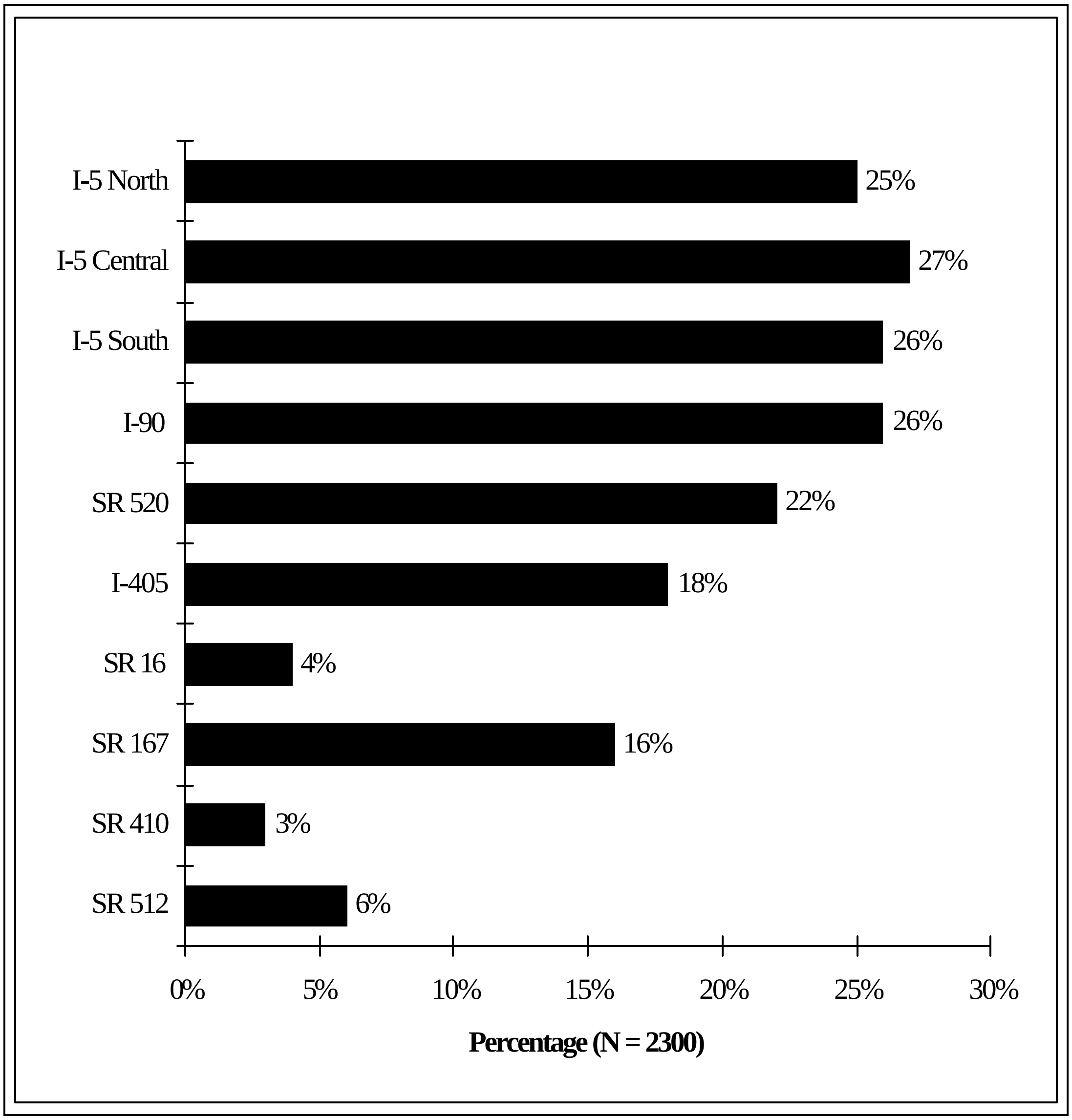


Figure 5-5. Normal Trip Route

Commute Mode

One of the controls for classifying survey responses is commute mode. Figure 5-6 shows the actual commute modes of survey respondents. SOVs far outweigh those who rideshare, despite attempts to generate comparable samples of HOV and SOV drivers.

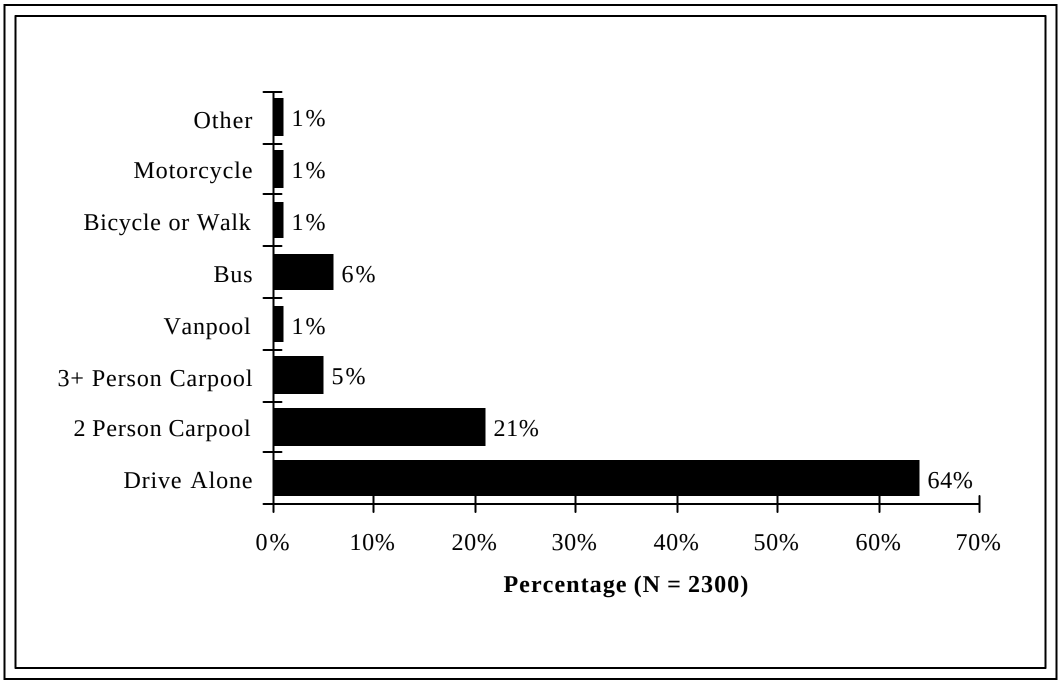


Figure 5-6. Commute Mode

Past Use of HOV Lane

Several major HOV system projects within the Seattle area had been completed since the last survey period. As a result, respondents expressed a greater frequency of HOV use throughout the Puget Sound region. Percentages in most corridors remained the same or rose slightly over previous results. These results are definitely linked to these recent expansions to the HOV system (see Figure 5-7).

When asked about their usual driving mode while utilizing the HOV lanes, about 64 percent of the respondents reported to be in a 2-person carpool (see Figure 5-8). Trends in HOV commute mode have continued to be dominated by 2- and 3-or-more-person carpools. These mode choices are influenced by a variety of factors, one being the pressure of congestion levels. It is possible that commuters are responding to congestion pressures and subsequently have altered their commute mode for a more favorable option, namely HOV lanes. The high response percentage in 2-person and 3+person carpools suggests that HOV lanes are popular during the work week when employees commute together.

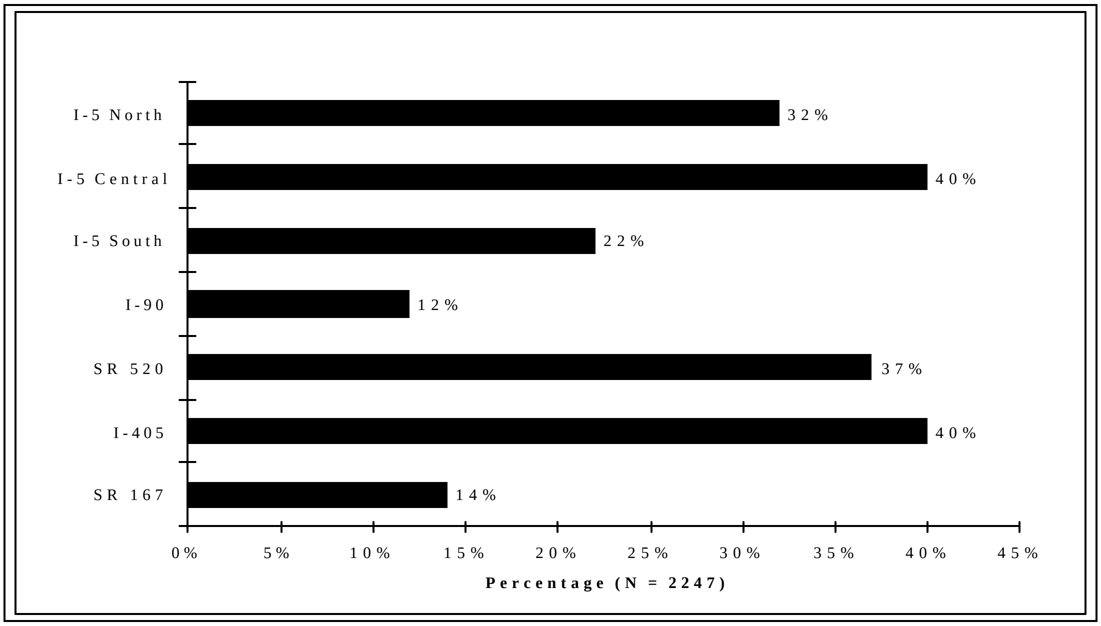


Figure 5-7. Past Use of HOV Lane Corridors

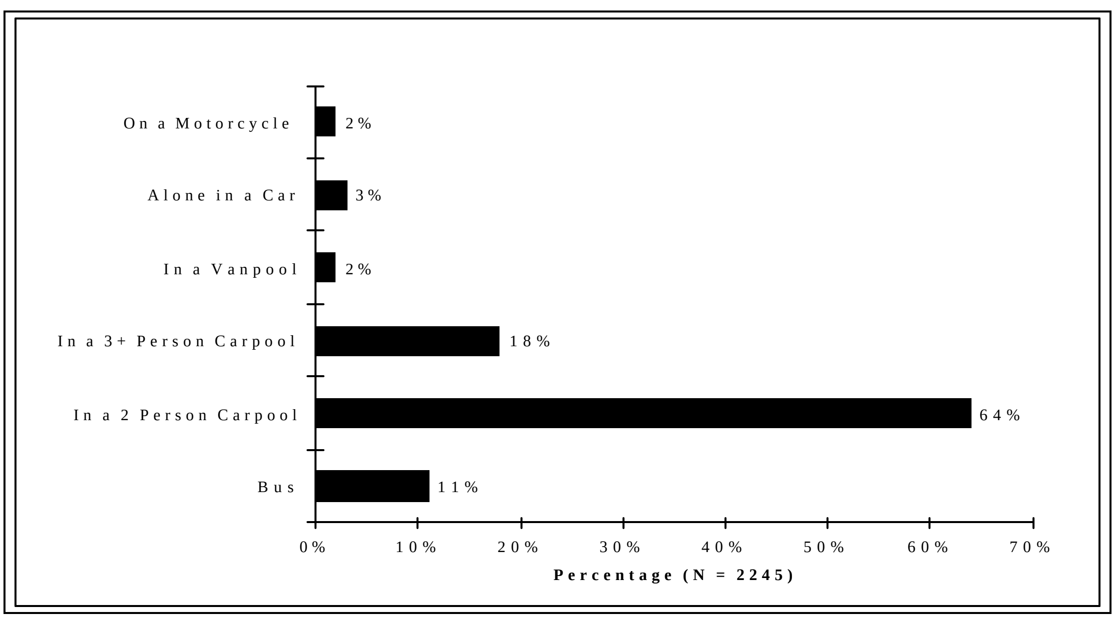


Figure 5-8. Past Use of HOV Lanes

Not Using HOV Lane

The survey results show a significant number of respondents who, in the past, had chosen to not use HOV lanes when they were qualified to use the HOV lanes (see Figure 5-9). As shown in Figure 5-10, the most popular reason that kept them from using HOV lanes when they were eligible to use them was that the GP lane traffic was fast enough. Other reasons were that the traffic in the HOV lanes was slower than that in the GP lanes and trouble with changing lanes.

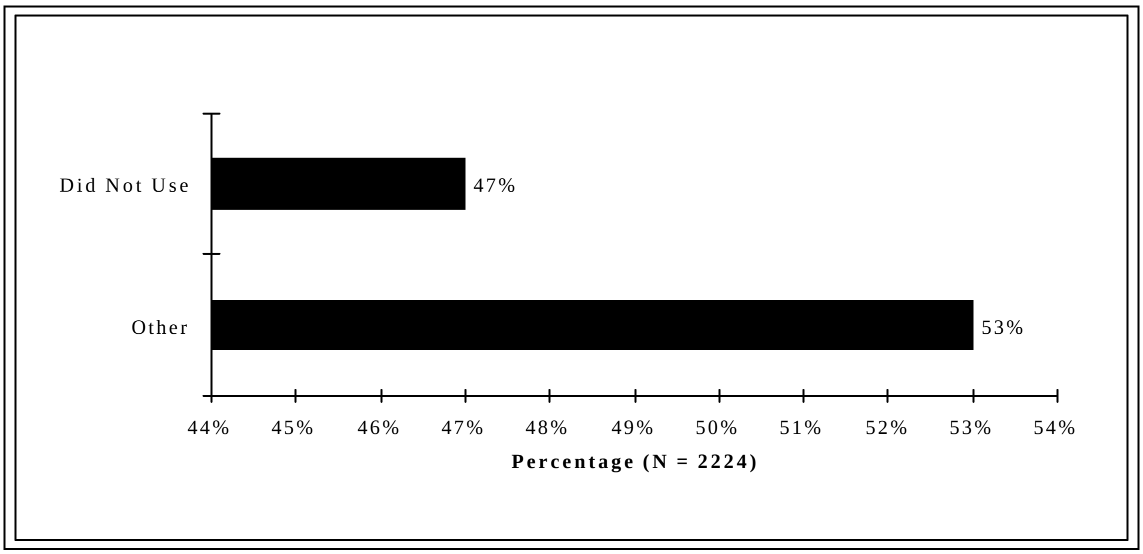


Figure 5-9. Qualified for HOV Lane Use

PUBLIC OPINONS ON VARIOUS HOV ISSUES

The survey responses are broken down by normal commute mode and by the degree to which respondents agreed with individual assertions. Sample sizes for both HOV and SOV groups are provided for each question. A p-value, representing statistical significance, is also provided for each question. A p-value of .05 or less represents statistically significant differences of opinion between HOV and SOV groups.

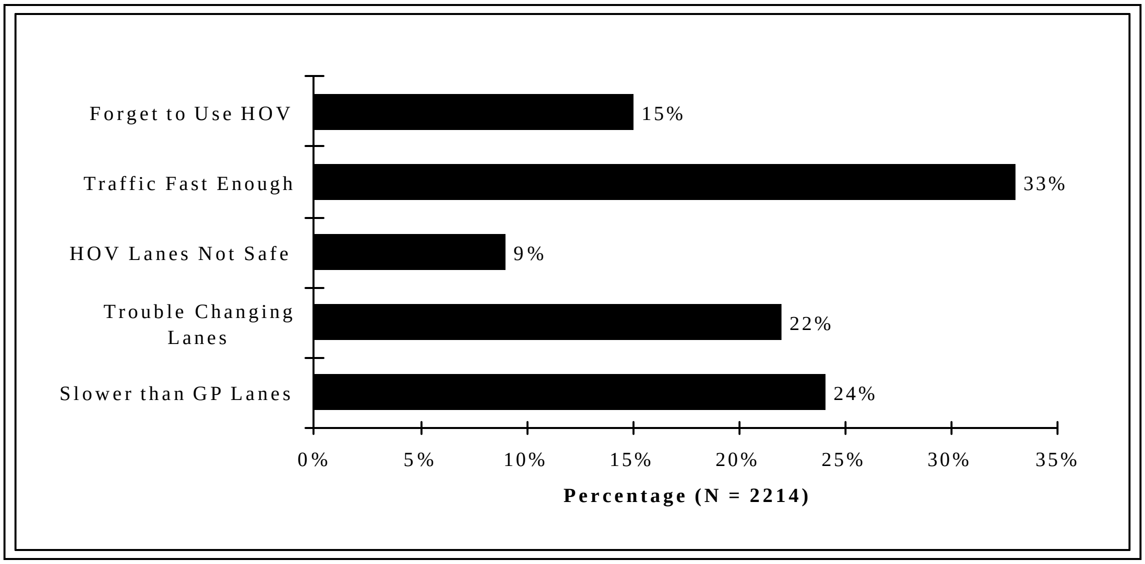


Figure 5-10. Reasons HOV Lanes Were Not Used

It is important to note that in most cases, HOV and SOV drivers tend to share the same basic opinions on issues related to HOV lane effectiveness. The differences in opinion among HOV and SOV drivers are frequently based on the degree of support for or opposition to a particular issue. The survey results are grouped as follows: General Perception, HOV Lane Operation, HOV Lane Violations, and HOV Lane Improvements.

General Perception

Overall, the support for HOV lanes continues to remain high among all commuters. Figure 5-11 shows that support for HOV lanes continues to be high among both SOV and HOV drivers, but support among SOV commuters has been showing signs of meager decline. Both groups agree that HOV lanes are convenient to use (see Figure 5-12). As expected, HOV drivers are stronger supporters because they are more familiar with the benefits and hazards of the HOV system. However, many respondents felt that the HOV lanes are not fully utilized (see Figure 5-13). Forty-six percent of respondents disagreed that the HOV lanes are adequately used, 37 percent thought otherwise, and 17 percent remained neutral on this point.

Figure 5-14 shows that a majority of commuters believe that HOV lanes are a fair use of taxpayers' money. HOV users have a united stance on this question. Although the opinions of HOV drivers and SOV drivers diverge on issues related to HOV lane usage, performance, and funding, the majority of both HOV and SOV drivers favor the idea of HOV lanes and additional HOV lane construction (see Figure 5-15). About 40 percent of HOV drivers, as opposed to 23 percent of SOV drivers, felt that more HOV lanes will encourage carpooling (see Figure 5-16). However, when asked about whether HOV lanes help save all commuters a lot of time, a significant difference of opinion on the travel time issue was revealed (see Figure 5-17). As expected, SOV users tend to be more negative, as they are forced to wait in congestion bottlenecks during the peak commute period. Last, most respondents were basically neutral about whether vehicles darting in and out of the HOV lanes create a safety issue (see Figure 5-18).

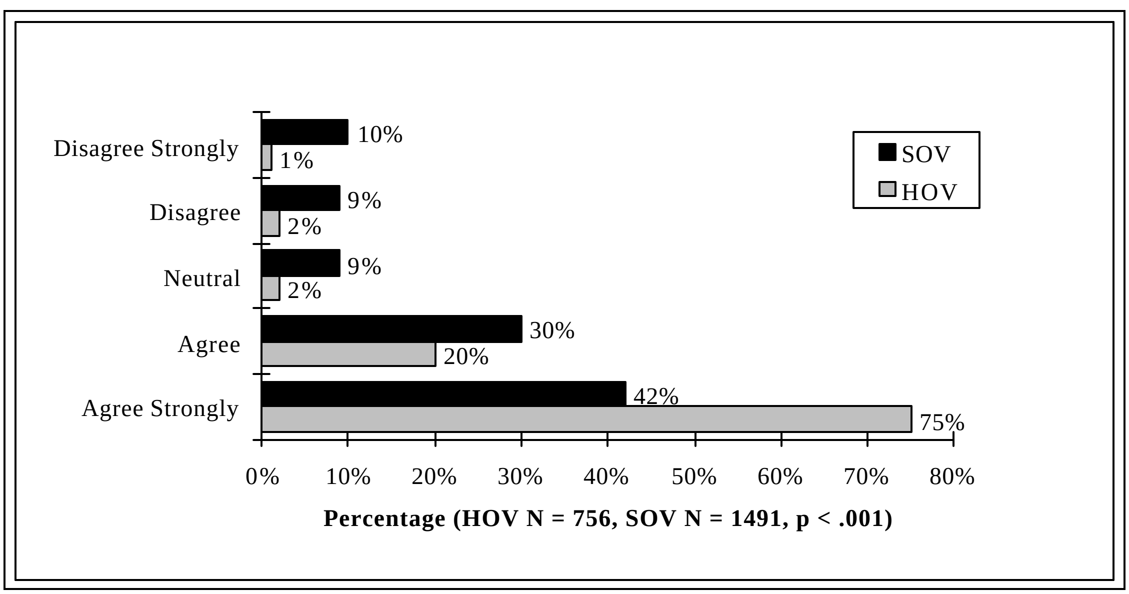


Figure 5-11. HOV Lanes Are a Good Idea

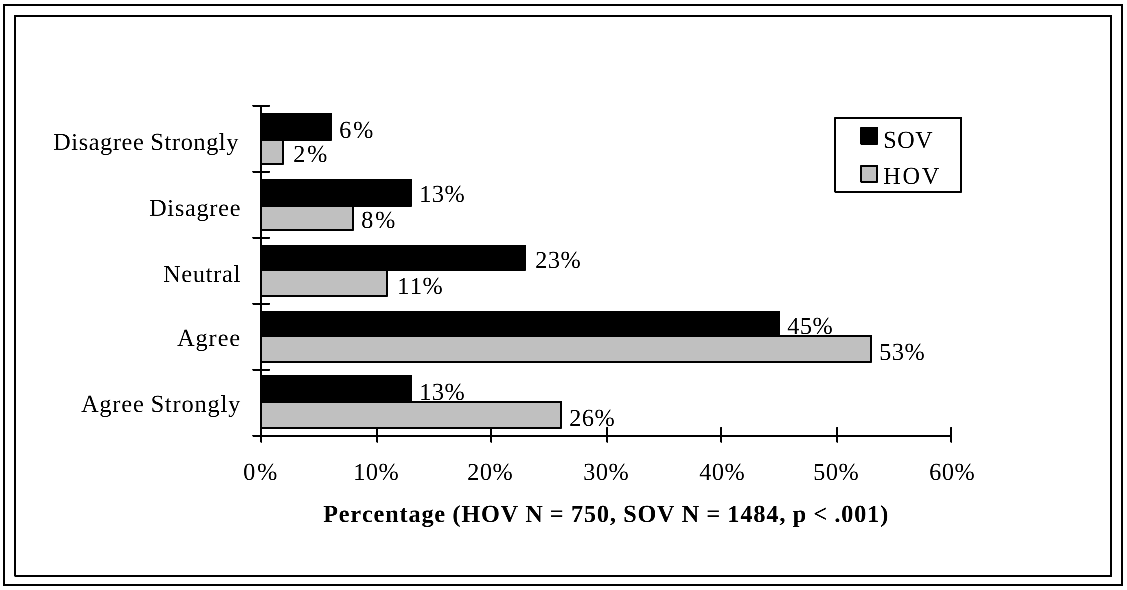


Figure 5-12. HOV Lanes Are Convenient to Use

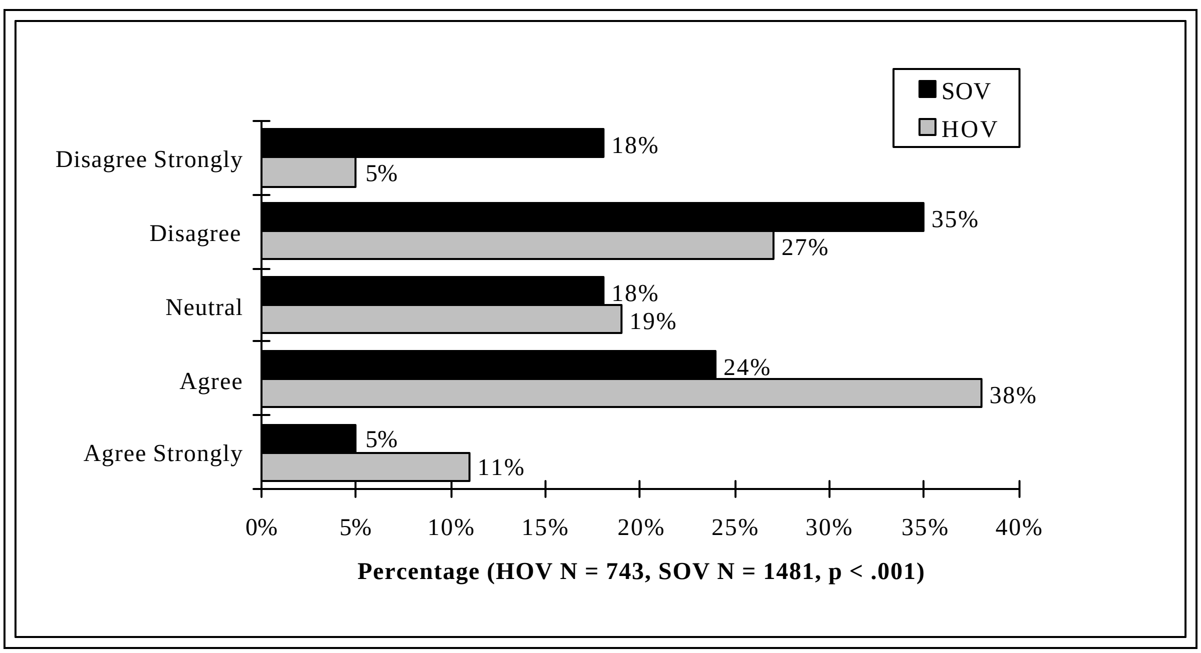


Figure 5-13. Existing HOV Lanes Are Being Adequately Used

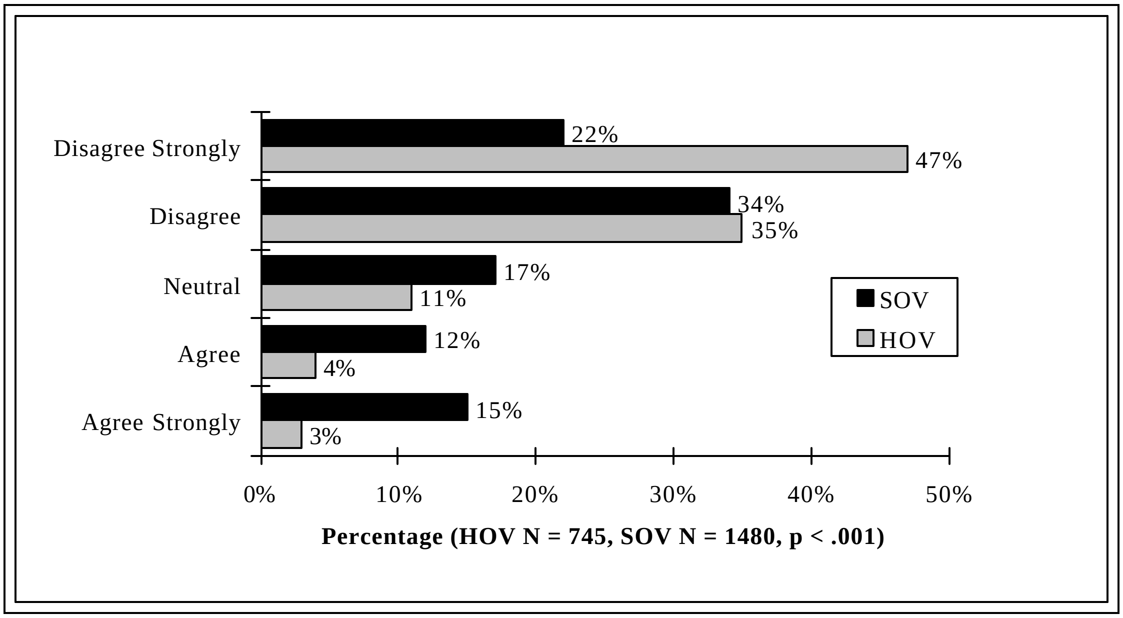


Figure 5-14. Constructing HOV Lanes Is Unfair to Taxpayers Who Choose to Drive Alone

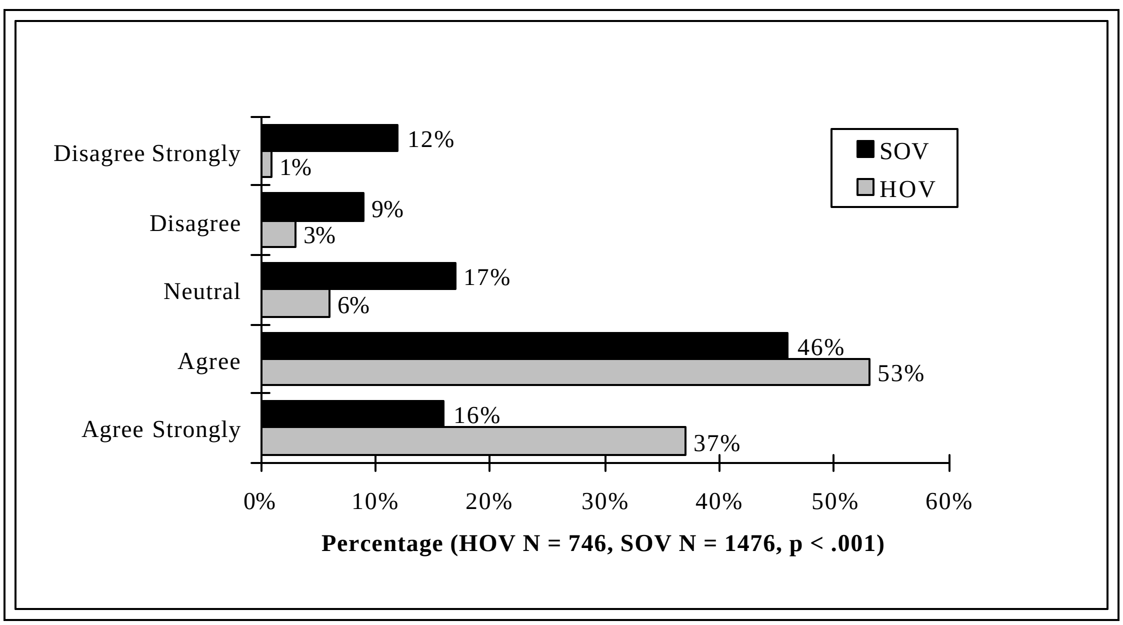


Figure 5-15. HOV Lane Construction Should Continue, in General

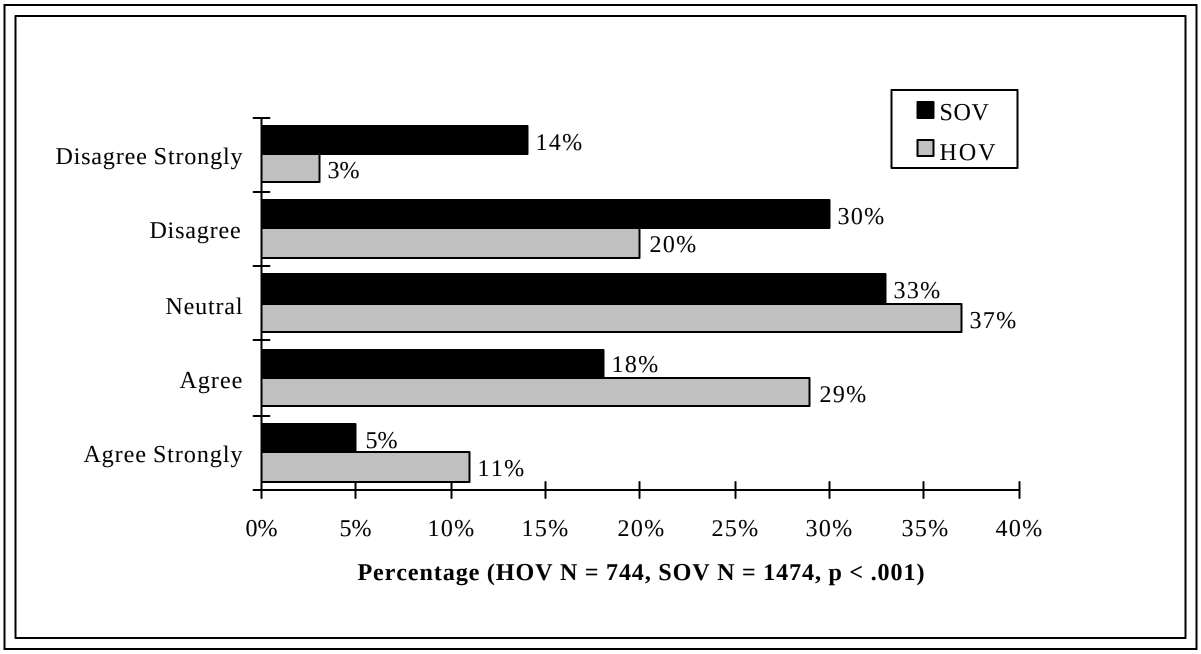


Figure 5-16. More People Would Carpool if HOV Lanes Were More Widespread

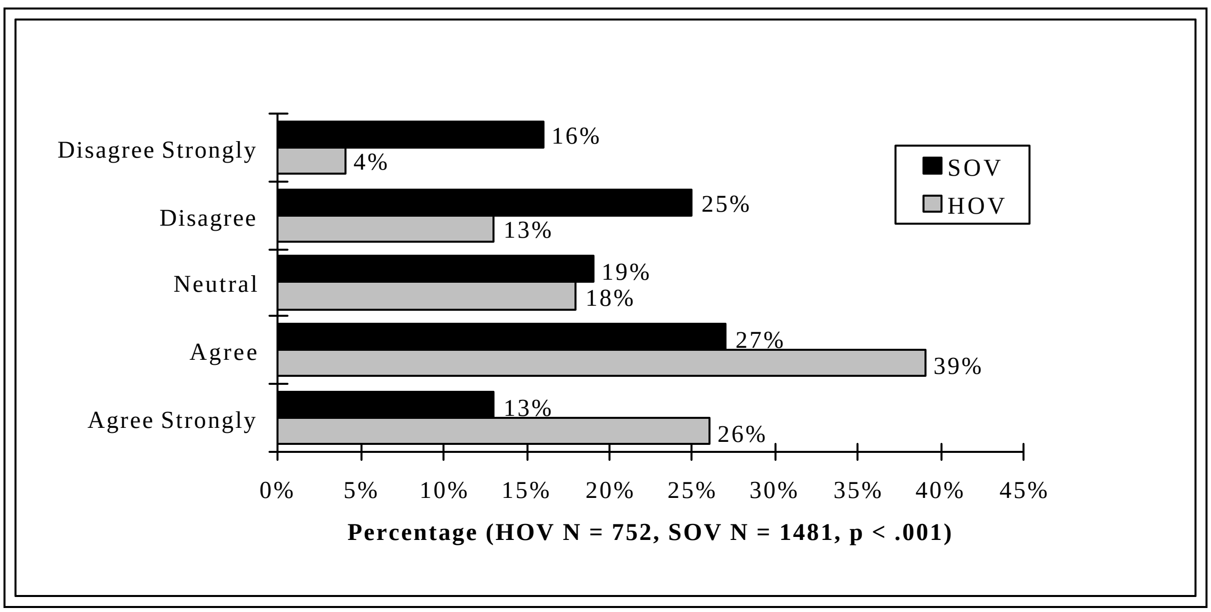


Figure 5-17. HOV Lanes Help Save All Commuters a Lot of Time

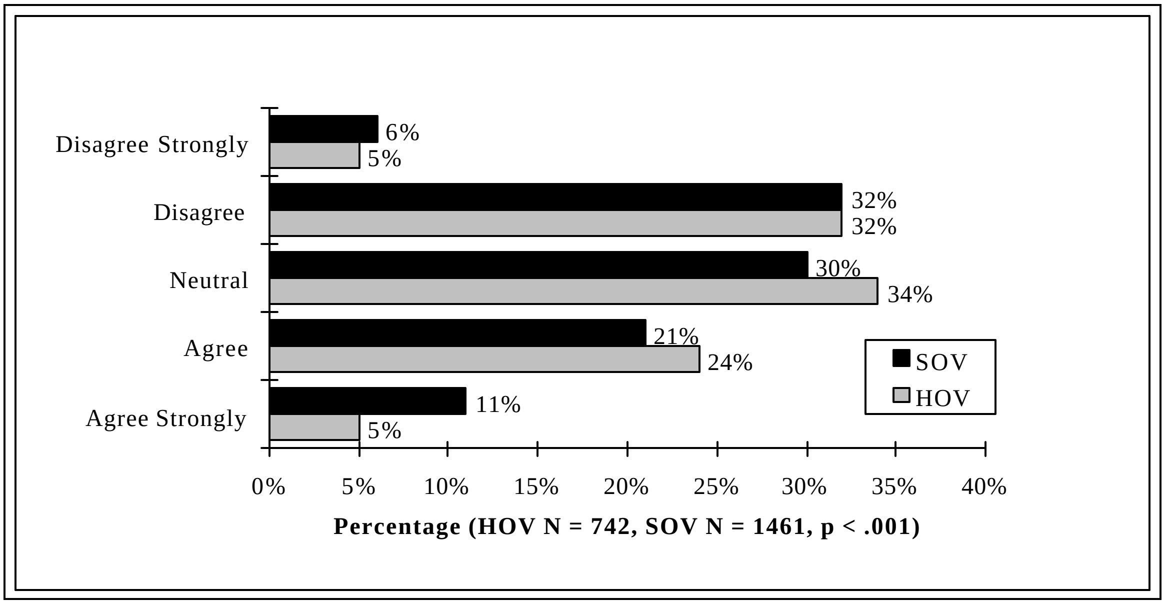


Figure 5-18. Vehicles Dart In and Out of HOV Lanes Too Often for the Lanes to be Safe

HOV Lane Operation

Most respondents felt that HOV lanes should not be opened to all traffic; this was the opinion of 86 percent of the HOV drivers and 56 percent of the SOV drivers (see Figure 5-19). The difference in opinion between groups on this issue remained the same as it was in previous surveys.

Figure 5-20 shows that SOV users favor opening HOV lanes during non-commute hours, with 65 percent agreeing; HOV drivers remain undecided, with 40 percent agreeing and 44 percent against. Overall, HOV opinion leans toward keeping restrictions on HOV lanes even during non-commute times. Opinions on this option continue to vary widely.

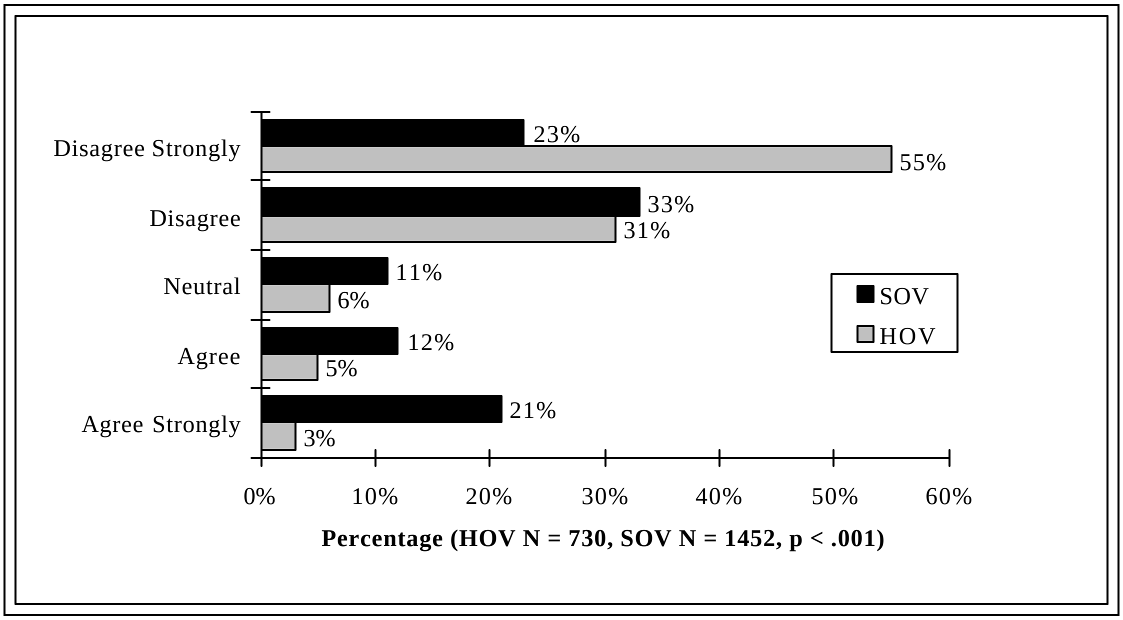


Figure 5-19. HOV Lanes Should Be Opened to All Traffic

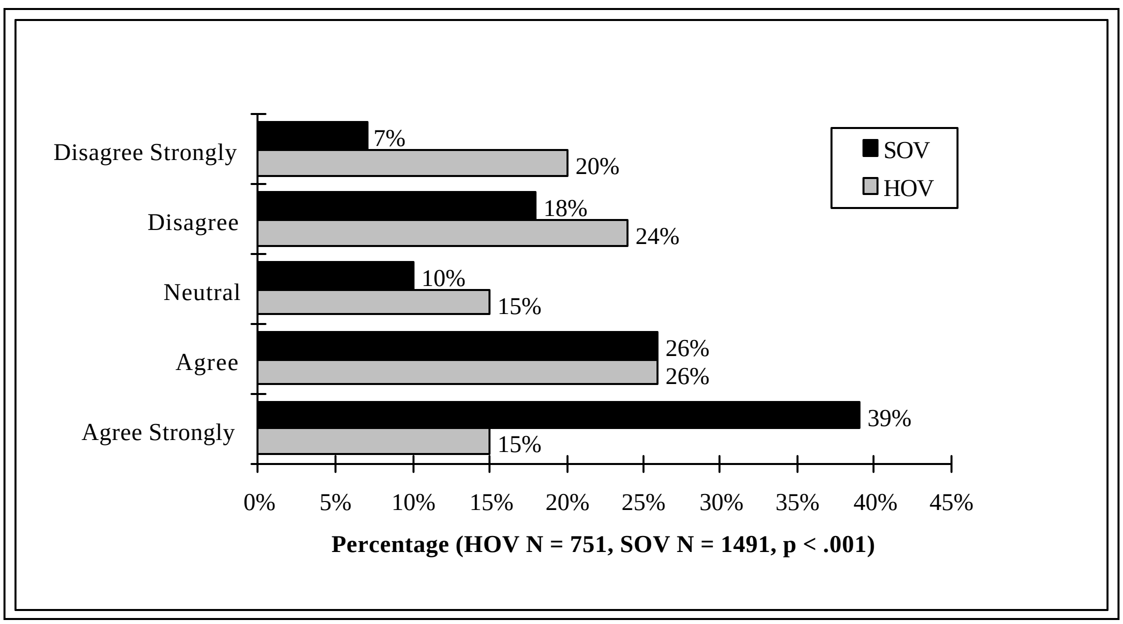


Figure 5-20. HOV Lanes Should Open to All Traffic During Non-Commute Hours

HOV Lane Violations

Overall, over half of the respondents agreed that violations are common during the commute hours (see Figure 5-21). Both groups appear to resent the fact that HOV lane violators are unwilling to sit in traffic like everyone else (see Figure 5-22). The majority of the survey respondents were neutral in their opinion of the HERO program (see Figure 5-23). This suggests that public education may be needed to help commuters better understand the important role 764-HERO plays in controlling HOV lane violations.

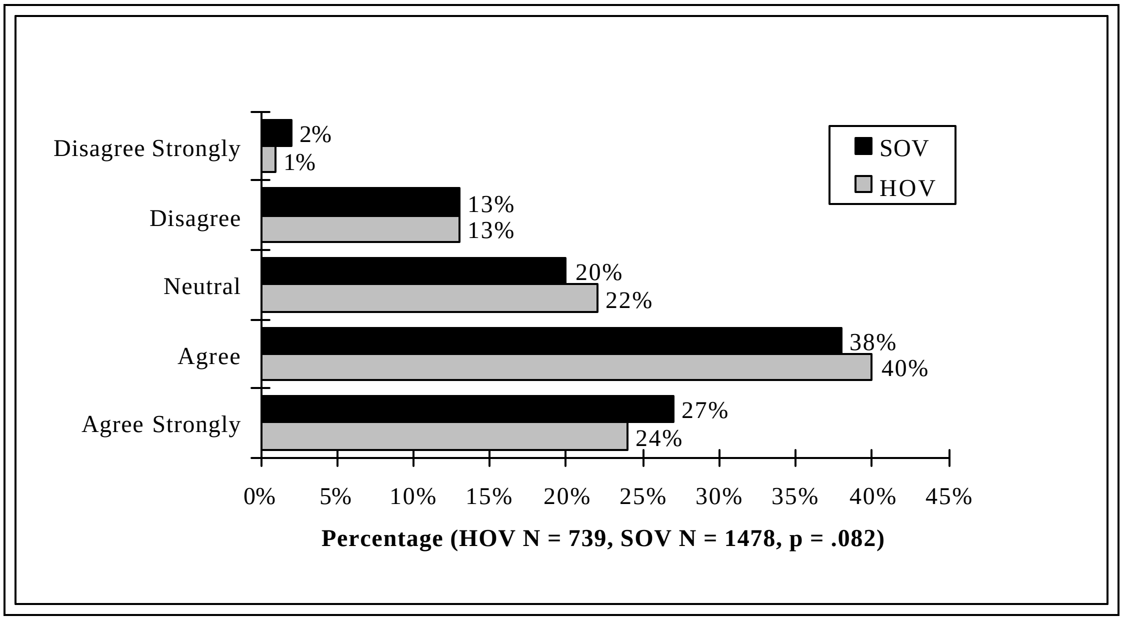


Figure 5-21. HOV Violations Are Common During the Commute Hours

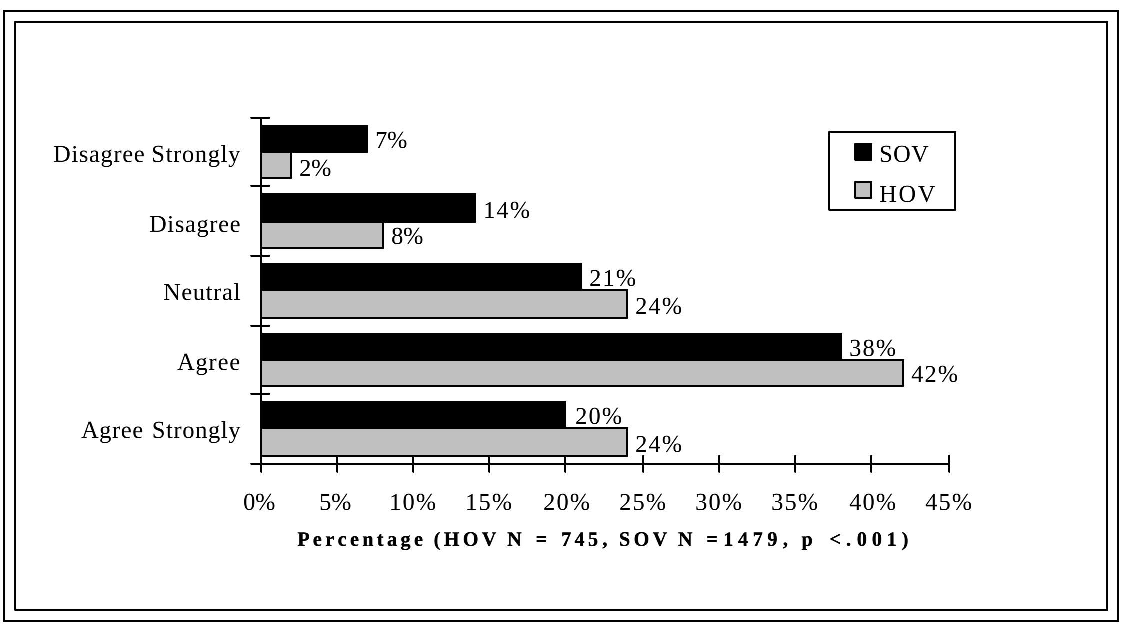


Figure 5-22. HOV Violators Commit a Serious Traffic Violation

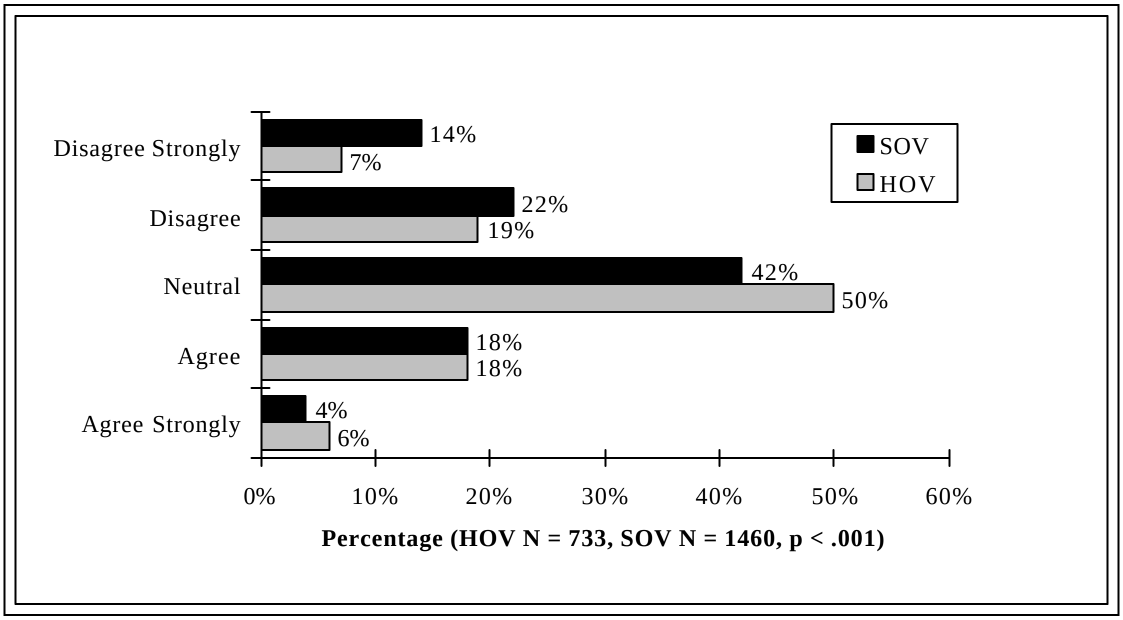


Figure 5-23. HERO Program Helps Reduce HOV Lane Violations

HOV Lane Improvements

Regarding options to improve HOV lane usage, enforcement concerns and access issues appear to outweigh transportation demand management measures such as employer subsidies for ridesharing and additional park-and-ride lots (see Figure 5-24). Figures 5-25 through 5-32 present how HOV and SOV users view these options for improving HOV lane usage.

Better enforcement was selected the best option for increasing the attractiveness of HOV lanes (see Figure 5-24). As indicated earlier in Figure 5-21, HOV violations are perceived as common during the commute hours. Both HOV and SOV travelers appear sensitive to others abusing this special privilege (see Figure 5-25). Respondents also clearly favor constructing access ramps for inside HOV lanes (see Figure 5-26). Figures 5-27 and 5-28 reveal that respondents favor inside HOV lanes (38 percent) over outside HOV lanes (17 percent). This favorable response may be due to the public's strong desire to continue expansion of the freeways to improve efficiency and lane capacity.

Making HOV lanes wider and safer continues to receive support from both groups of drivers (see Figure 5-29). The marginal difference between groups may be due to carpoolers having more experience with using HOV lanes.

Employer subsidies and increased frequency of bus service ranked equally as the most favored of the TDM measures (see figures 5-30, 5-31). However, their overall priority did not compare with issues related to HOV lane access, enforcement, and safety. Support for the option of building park-and-ride lots near freeway entrances and exits has remained relatively unchanged, with SOV drivers showing slightly more support than their ridesharing counterparts (see Figure 5-32). This may reflect the idea that park-and-ride lots are not as much assembly places for carpools as they are links to bus service.

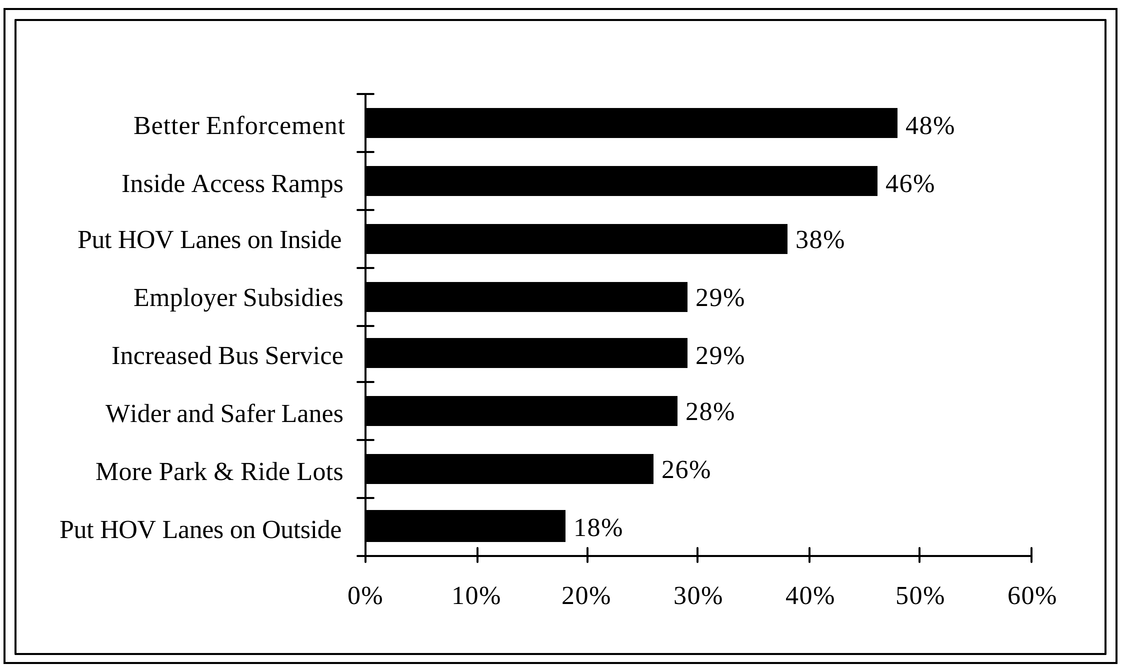


Figure 5-24. Options to Improve HOV Lane Usage

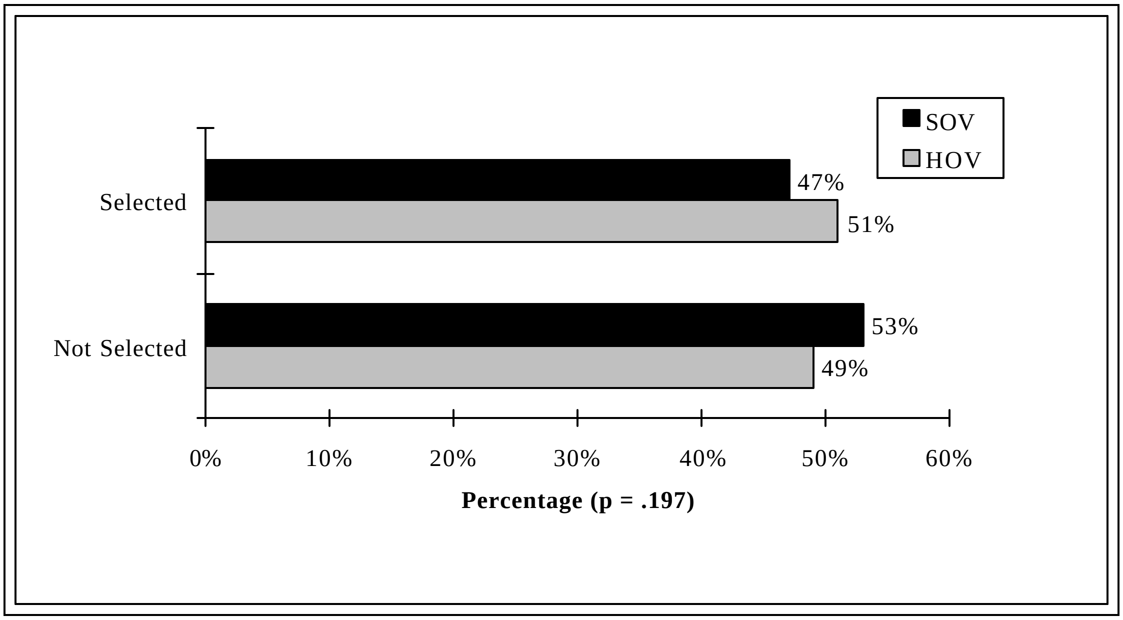


Figure 5-25. Better Police Enforcement Against Violators

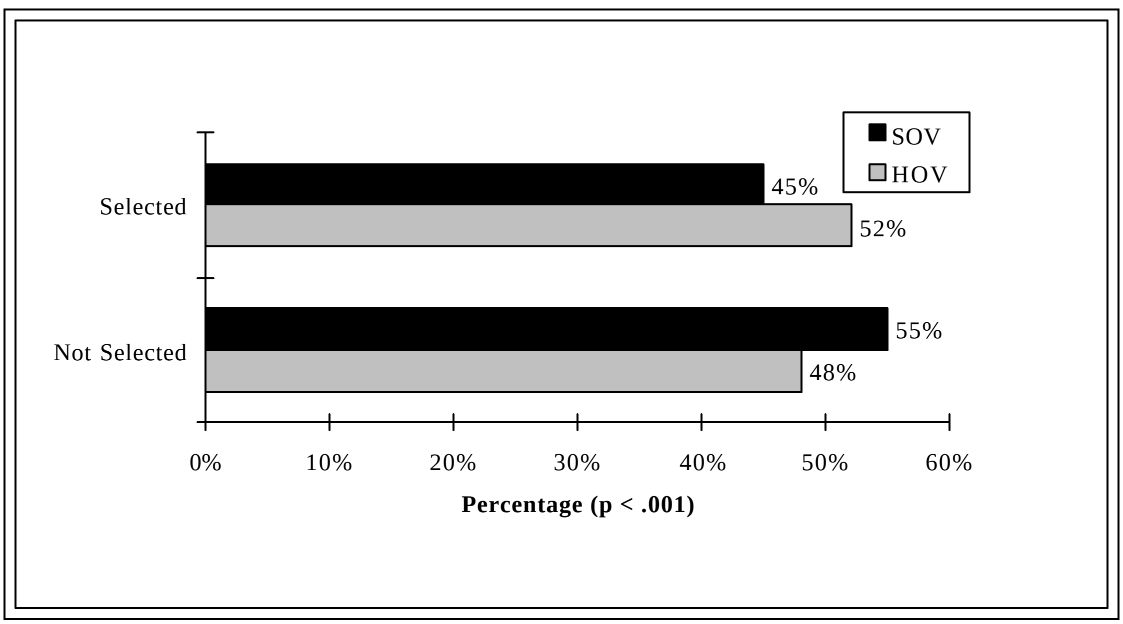


Figure 5-26. Construct Access Ramps for Inside HOV Lanes.

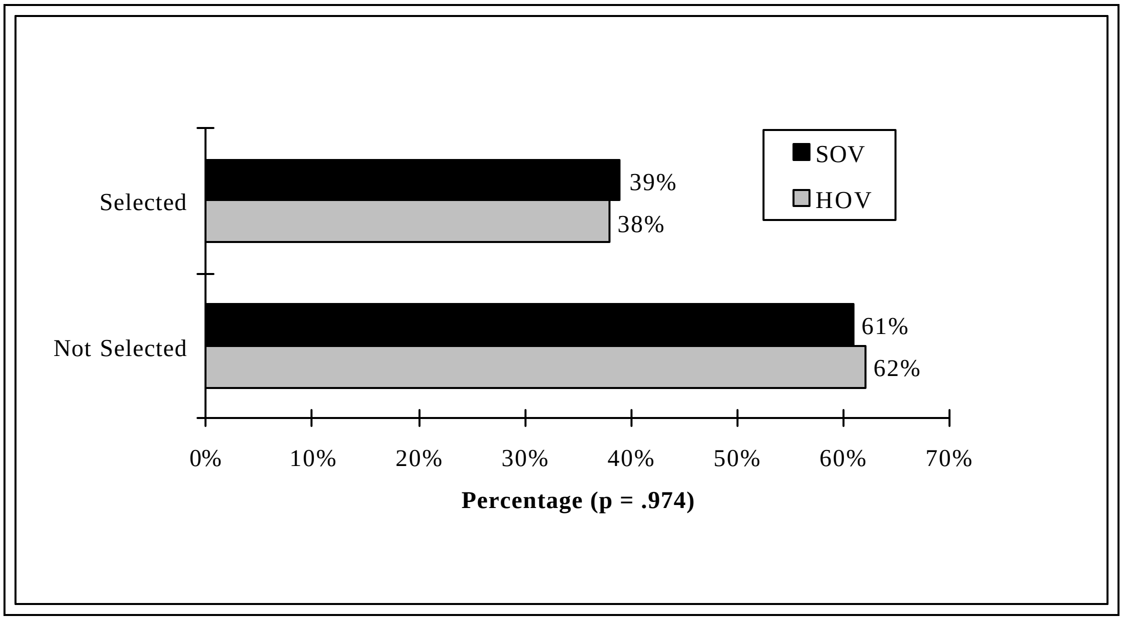


Figure 5-27. HOV Lanes on Inside of Freeway.

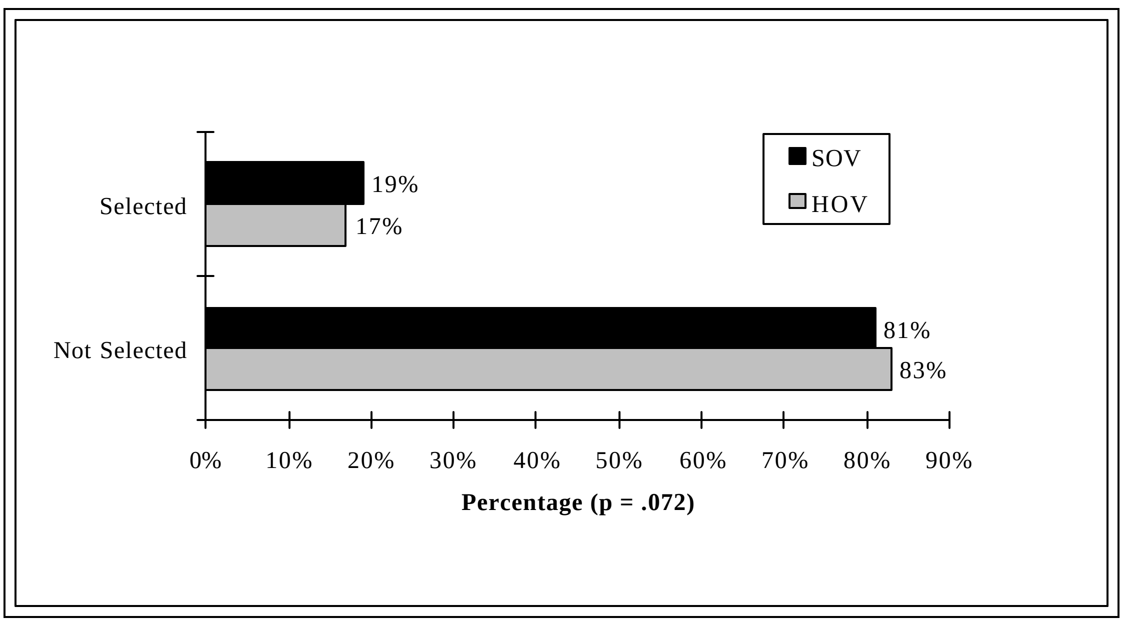


Figure 5-28. HOV Lanes on Outside of Freeway

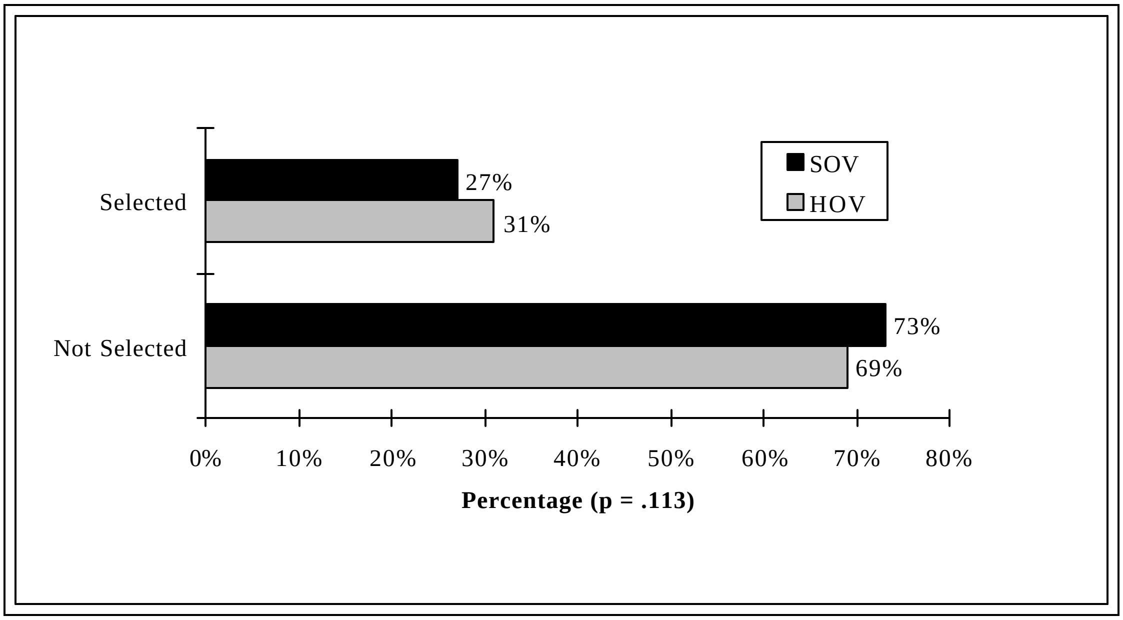


Figure 5-29. Wider and Safer Lanes.

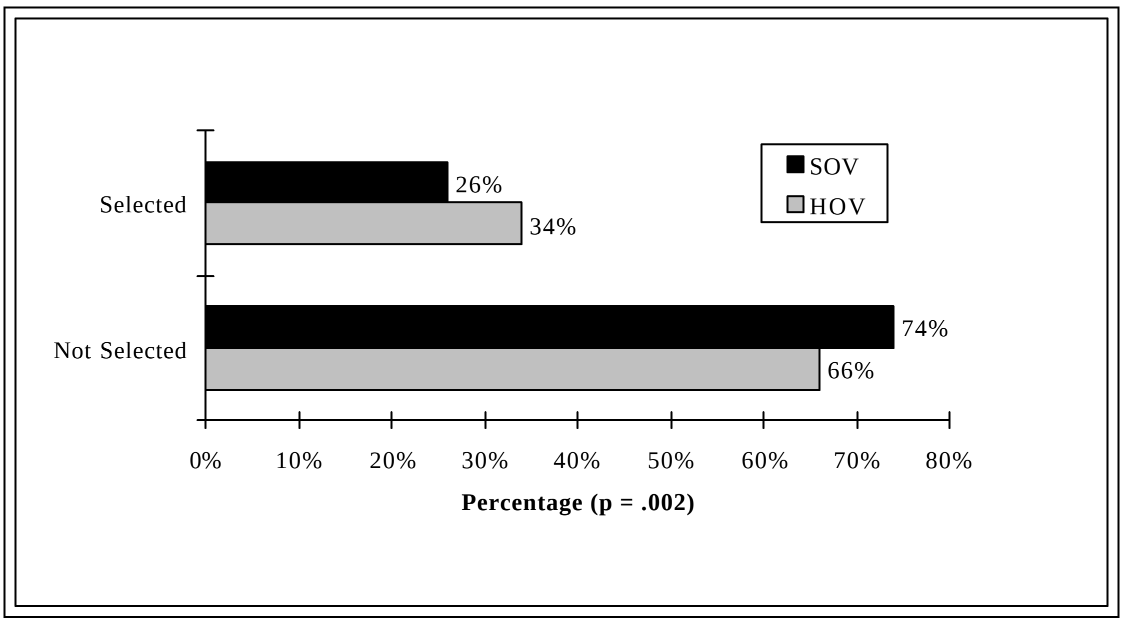


Figure 5-30. Employer Subsidies for Ridesharing

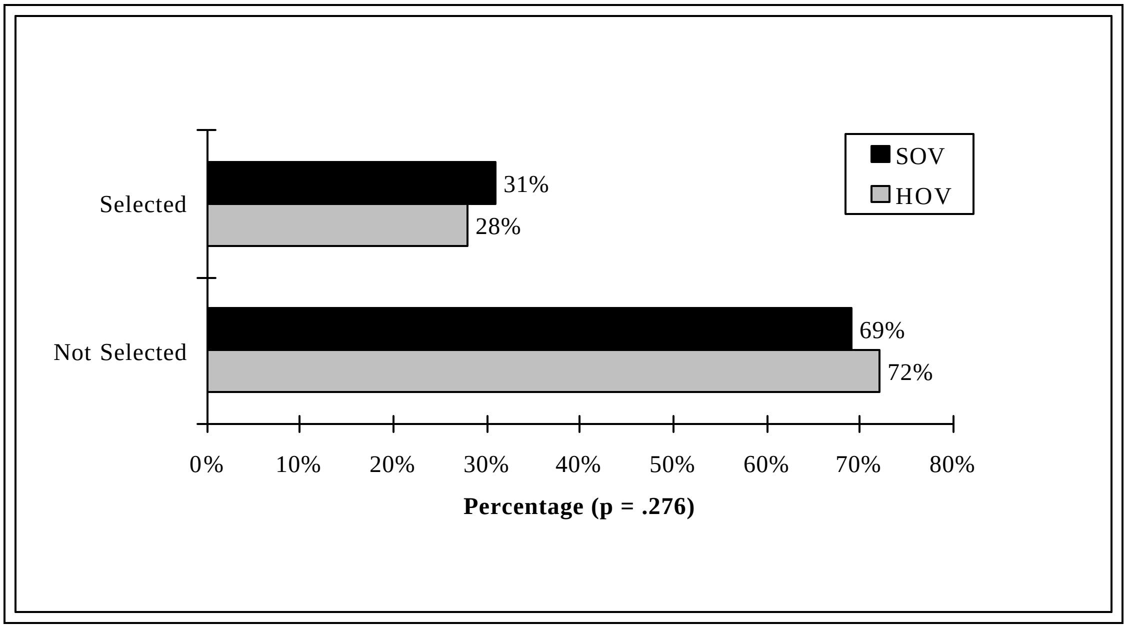


Figure 5-31. Increased Frequency of Bus Service

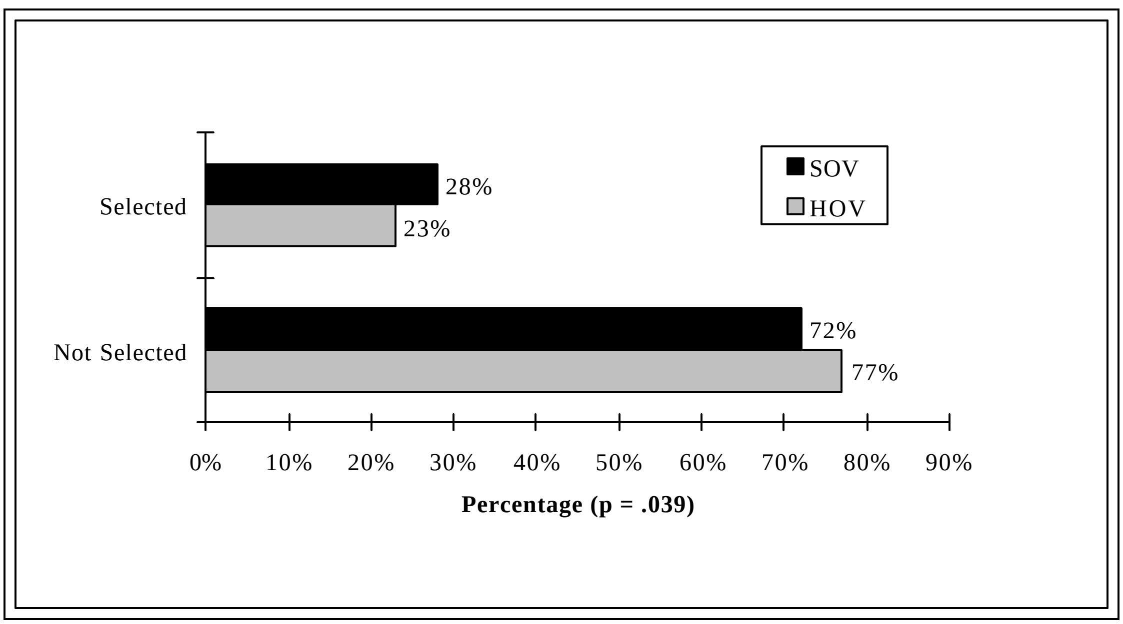


Figure 5-32. Park-and-Ride Lots Near Freeway Entrances and Exits