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HOV Monitoring VII

HOV LANE PERFORMANCE MONITORING:

2002 REPORT- VOLUME 1

by

Jennifer Nee
Research Engineer

John Ishimaru
Senior Research Engineer

Mark E. Hallenbeck
Director

Washington State Transportation Center (TRAC)
University of Washington, Box 354802
University District Building
1107 NE 45th Street, Suite 535
Seattle, Washington 98105-4631

Washington State Department of Transportation
Technical Monitor
Pete Briglia
ITS Program Manager
Advanced Technology Branch
Doug Brodin
Project Manager

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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, ride sharers and motorcyclists 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 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, and to examine the HOV lanes' person-carrying capability, travel time savings, and trip reliability benefits in comparison to adjacent GP lanes. HOV lane violation rates are also evaluated.

This report describes the results of an extensive monitoring effort of HOV lane use and performance in the Puget Sound area in 2002. It presents an analysis of data collected to describe the number of people and vehicles that use HOV lanes, the reliability of the HOV lanes, the travel time savings in comparison to GP 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.

This is volume 1 of a two-volume set. Volume 2 provides an overview of major trends in HOV lane performance by comparing data presented in the 2000 HOV Performance Report

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CHAPTER 1. INTRODUCTION

This report describes the performance of the Puget Sound region's freeway HOV lane system during 2002. This report covers a time period when High Occupancy Vehicle (HOV) lanes had restricted access 24 hours a day, seven days a week. Since then, the operational policies of WSDOT have changed: Today, some of the HOV lanes have no restrictions between the hours of 7:00 PM and 5 AM.

HOV lanes, also known as carpool lanes and diamond lanes, are designated for use by carpoolers, transit riders, ride-sharers, and motorcyclists who 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.
- 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 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.

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, 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*.[1] The raw vehicle occupancy data collected as part of this report can be obtained from an Internet Web site at the following URL:

http://trac29.trac.washington.edu:8080/hov/

STUDIED CORRIDORS

HOV lanes exist in major corridors around the Puget Sound area. During 2002, virtually all HOV lanes were restricted to vehicles that met the HOV occupancy requirements 24 hours a day, 7 days a week. 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 minimum three-passenger requirement. Other exceptions to the occupancy requirement include motorcyclists, who may travel on any HOV lane,

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[1] Nee, Jennifer, et. al., *Evaluation Tools for HOV Lanes Performance Monitoring*, for the Washington State Department of Transportation, WA-RD 473.2, August 1999

and single occupancy vehicles (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 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, Pierce Transit, and Sound Transit. All four provide express service to several downtown locations and across Lake Washington. As of fourth quarter 1998, all HOV lanes have operated along the freeway median, with the exception of the HOV lane on SR 520, which is located 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 as of 2002

HOV Corridors	***Geometric***	***Direction***	***Number of Lanes***	***Operating Hours***	***Occupancy Requirement***
I-5	Concurrent Flow Barrier Separated Express Lane Reversible Flow	NB, SB SB (AM only)	1 each direction	24-hr	2+ HOVs
I-405	Concurrent Flow	NB, SB	1 each direction	24-hr	2+ HOVs
I-90	Concurrent Flow Barrier Separated Reversible Flow	WB, EB WB (AM only) EB (PM only)	1 each direction 2 reversible	24-hr	2+ HOVs
SR 520	Concurrent Flow	EB WB	1 each direction	24-hr	2+ HOVs (EB) 3+ HOVs (WB)
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 decision-making concerning lane configuration, occupancy requirement policies, and general purpose lane conversion, MOEs also provide WSDOT with 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 must exceed 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 (GP) 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 demonstrated by 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 demonstrated by measures of vehicle and person throughput, as well as by vehicle occupancy. Travel time speed and trip reliability demonstrate the performance of the HOV facility. Secondary performance measures include enforcement and violation 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 focused is as follows:

Primary Measures

- **Vehicle Volume:** Number of vehicles recorded passing a given freeway location during weekday morning and evening peak commute periods, as well as during 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, including 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 are 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.

  Note: This report deals primarily with *peak period*, not peak hour, statistics for HOV use. The peak periods are defined as 6:00 AM to 9:00 AM and 3:00 PM to 7:00 PM on weekdays. Peak period is used in place of peak hour because it does a more complete job of explaining facility performance during the busiest parts of the day, and it includes the majority of commute trips. Because of the expansion of the peak travel periods beyond a single hour, peak hour statistics do a poor job of explaining both growth in facility use and the length and duration of congestion associated with facility use.

Secondary Measures

- **HOV Violations:** Because restrictions along the Puget Sound freeway HOV system apply 24 hours a day, seven days a week, not meeting the minimum occupancy requirement is the only violation that needs enforcing . Indicators for HOV violations include violations observed on area highways by traffic observers, tickets and warnings issued by law enforcement officers, and by activity levels on the region’s violation reporting hotline (764-HERO).

- **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 drivers. This report presents public opinion data that rank various options to improve the HOV system; the data also show differences in opinion between ride-sharers and SOV commuters about HOV related issues.

REPORT ORGANIZATION

This report provides the results of an analysis of HOV system performance. **Chapter 2, Throughput,** illustrates HOV lanes' success at moving people and vehicles. **Chapter 3, Speed Reliability and Travel,** provides speed and reliability for HOV lanes and travel time comparisons between GP and HOV lanes. **Chapter 4, HOV Violations,** discusses HOV violation information. **Chapter 5, Public Opinion Survey Findings,** includes the results of the last major public opinion survey that WSDOT performed concerning HOV lanes.

CHAPTER 2. THROUGHPUT

To investigate the effectiveness of the HOV system, person and vehicle volumes were analyzed at specific sites along major HOV corridors during morning and afternoon peak periods (e.g., 6:00 AM-9:00 AM, 3:00 PM-7:00 PM) in the direction of the heaviest traffic flow.

The results were then compared with the identical location, direction, and time periods for the GP lanes. Since a typical freeway corridor generally has only one HOV lane and several GP lanes, GP lane throughput is determined by dividing the total volume of all GP lanes by the number of GP lanes. This provides a per-lane average for comparative purposes.

The purposes 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 measures of HOV performance are reflected in the following sections:

- **General Results:** A general comparison of HOV vs. GP person throughput on a per-lane basis. HOV person-carrying ability is described by average vehicle occupancy (AVO) including bus ridership.
- **HOV Volume Flow:** The overall HOV volume flow showing directional patterns and locations with high and low HOV usage.
- **GP vs. HOV 24-hour Volume Profile:** A comparison between 24-hour average daily traffic volume profile for HOV lanes and the adjacent GP lanes made by measuring volume per lane per hour (VPLPH).
- **GP vs. HOV Throughput Comparison:** Person and vehicle volumes for HOV and GP lanes are compared for both morning and afternoon peak periods along with average vehicle occupancy (AVO) rates. This comparison provides an accurate measurement of HOV and GP lane vehicle- and person-carrying abilities.

SITE SELECTION

Eleven sites were selected for study. All were along I-90, I-5, I-405, SR 167 and SR 520. Selection was based on points of interest and the availability and usability of input data gathered in 2002.

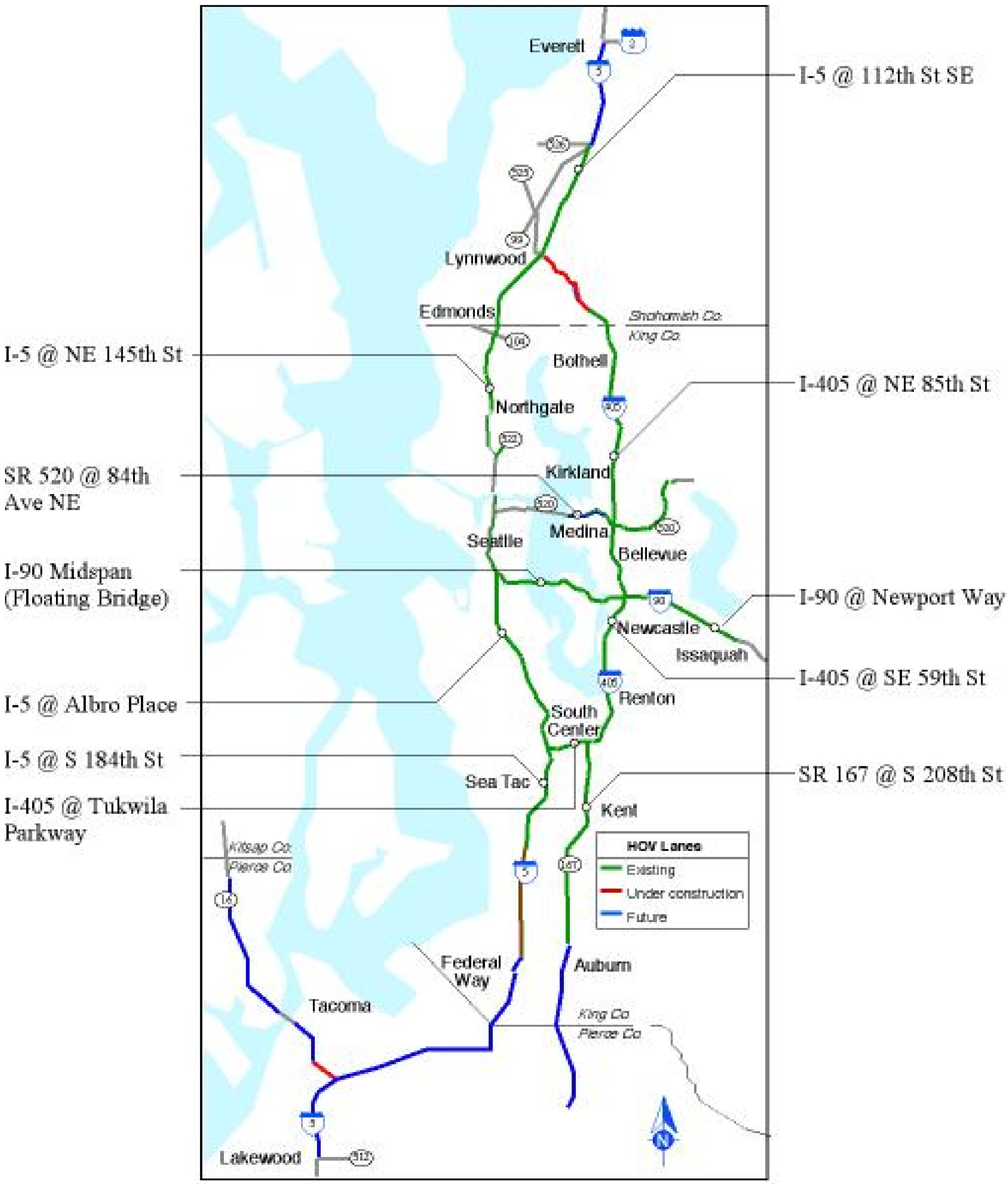


Figure 2-1- Map of Selected Site Locations

Table 2-1. Eleven HOV Sites Selected for Analysis

Corridor	Locations
I-5 North of the Seattle CBD	I-5 @ 112th SE – Everett (near Everett) I-5 @ NE 145th St. (near Northgate)
I-5 South of the Seattle CBD	I-5 @ Albro Place (south of Seattle Downtown) I-5 @ S 184th St. (south of Southcenter)
I-405 North of I-90	I-405 @ NE 85th St. (near Kirkland) I-405 @ SE 52nd St. (near Newcastle)
I-405 South of I-90	I-405 @ Tukwila Parkway (near Southcenter)
I-90	I-90 @ Midspan (Floating Bridge) I-90 @ W Lk Sammamish Pkway (near Issaquah)
SR 520	SR 520 @ 84th Ave. NE (near Medina)
SR 167	SR 167 @ S 204th Ave. S (near Kent)

GENERAL RESULTS

Typically, the major freeway corridors have one HOV lane and two, three or four GP lanes in each direction. The exception is I-90, which has two non-exclusive HOV lanes from Mercer Island through the Mt. Baker tunnel to Seattle. Figures 2-2 and 2-3 show person volume, vehicle volume, and AVO for each of the eleven representative sites during the morning and evening peak periods. In addition, these figures also indicate which HOV lanes carried more people during these periods than the adjacent GP lanes, and which HOV lanes carried fewer.

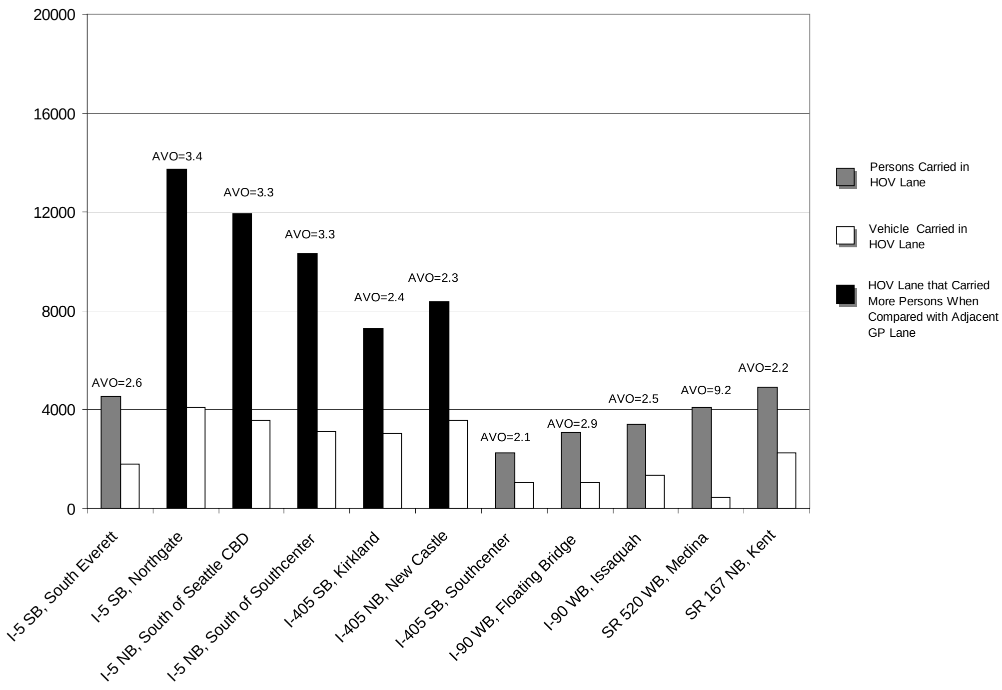


Figure 2-2. HOV Lane Usage During AM 3-Hour Peak Period (2002)

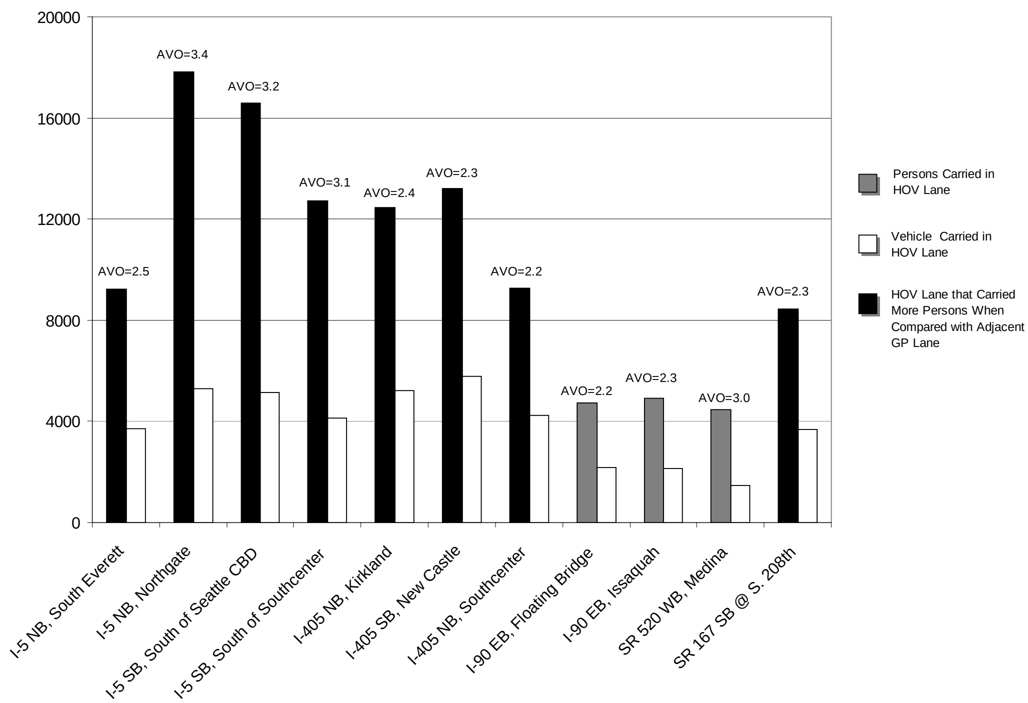


Figure 2-3. HOV Lane Usage During PM 4-Hour Peak Period (2002)

Both vehicle and person volumes in the HOV lanes are high on I-5 near Northgate, south of downtown Seattle, and on I-405 near Kirkland and Newcastle during the peak periods. For example, the HOV lane on southbound I-5 near Northgate carries more than twice as many people in approximately 30 percent fewer vehicles than an average adjoining GP lane (see Figure 2-31). HOV lane use tends to decline somewhat as distance increases from major employment centers.

Figure 2-4 shows the percentages of people carried by buses, cars, and vans in HOV lanes during the peak periods. This information sheds light on how modes of transport strongly affect person throughput.

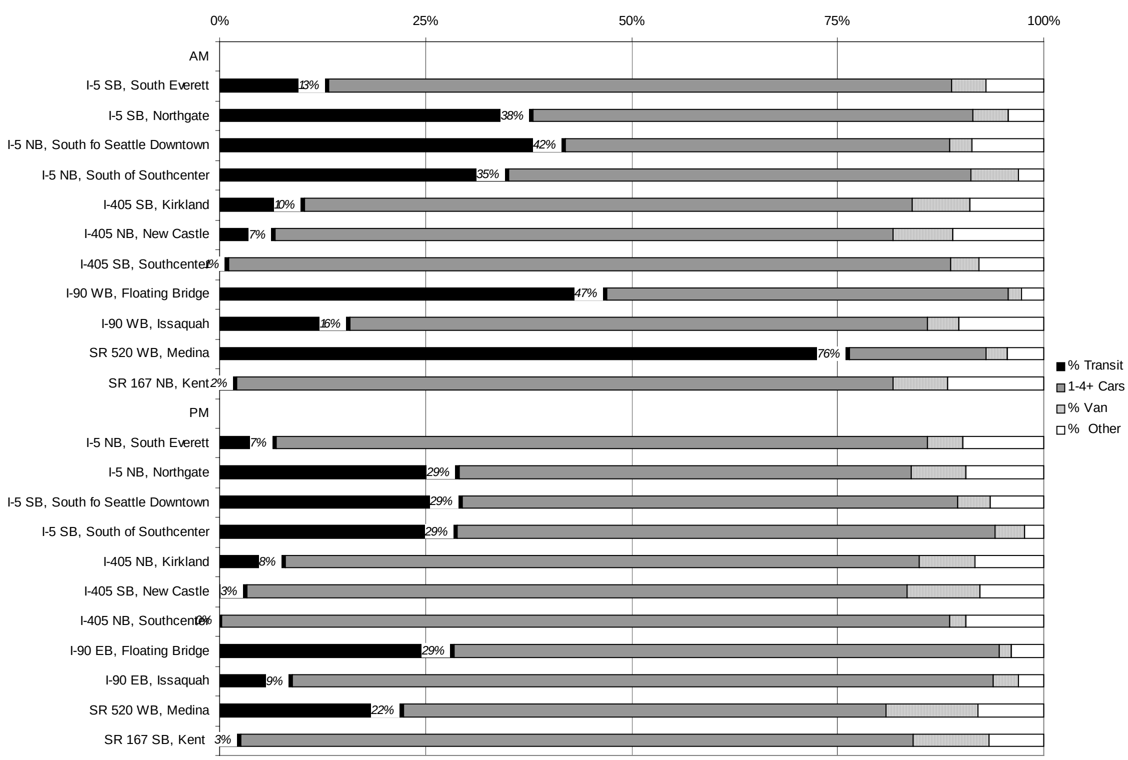


Figure 2-4. Percentage of People Carried in HOV Lanes by Different Modes of Travel During Peak Periods (2002)

Figure 2-5. Vehicle Classification in HOV Lanes (2002)

The high person-volumes observed on I-5 were due, in large part, to high bus ridership where between 29 and 42 percent of the people in the HOV lanes at the selected sites on I-5 are carried by buses. This significant use of transit buses allows 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 lanes 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 throughput is split between two lanes on the reversible lane section of I-90 (i.e., mid-span), and person throughput in the reversible lanes is only partly enhanced by the use of those lanes by legal SOVs bound to/from Mercer Island.

SR 520, however, is one of the most congested facilities in the state. Nevertheless, use of the HOV lanes by motorists is probably limited by the three-person minimum occupancy requirement that's in effect for safety and operational reasons. Carpools of three or more are more difficult it is to organize and maintain than carpools of two, and consequently carpool volumes are moderately low.

Interestingly, although the overall average vehicle volume on the westbound SR 520 HOV lane near Medina was relatively low, the AM peak period average vehicle occupancy was 9.2, whereas the typical AVO value ranged between 2.1 and 3.4 at other studied sites. This is because many heavily used transit buses 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, buses comprised 27 percent of the inbound vehicle traffic, while carrying 76 percent of all HOV lane travelers (see Figure 2-4).

PEAK HOUR VS. PEAK PERIOD

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 of HOV lane volume varies from location to location depending on the nature of travel demand. Figure 2-6 shows that peak hour volumes can increase from 12 percent to as high as 55 percent over the average hourly volume during the peak period.

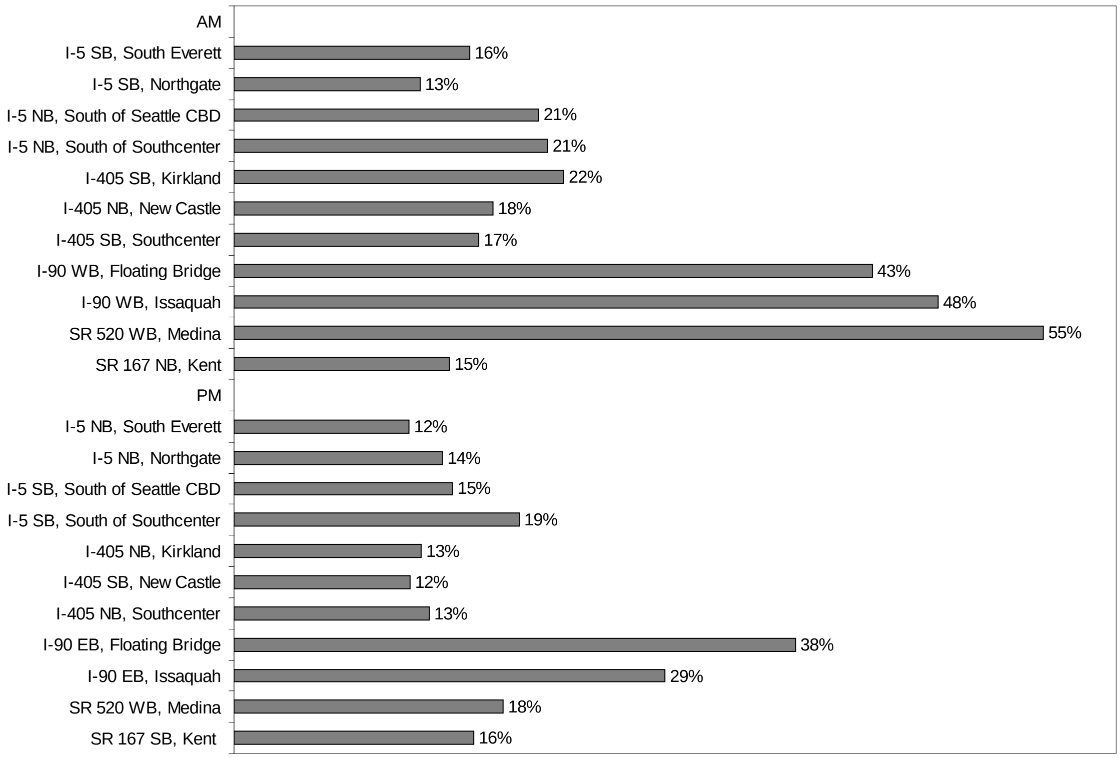


Figure 2-6. Percentage of Increase in HOV Volumes: Peak Hour Volume vs. Peak Period Average Hourly Volume (2002)

HOV VOLUME FLOW

Figures 2-7 through 2-18 examine more closely the geographic changes in vehicle volumes observed along HOV corridors during the average weekday. In general, HOV volumes increase when the lanes are closer to dense employment centers and decrease on the suburban ends of HOV facilities. Lower usage rates are 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 are largely due to the combination of having two lanes of travel and lower 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 SR 526, HOV volumes are significant southbound during the AM peak period, carrying more than 3,000 vehicles, and northbound during the PM peak period, carrying more than 4,000 vehicles. This HOV corridor exhibits 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 lane traffic during the AM peak period exhibits a typical in-bound commute flow, with northbound peak period volumes sometimes exceeding 3,000 vehicles. HOV lane volumes are significant in both directions during the PM peak period, with the southbound HOV lane carrying over 4,000 vehicles, and the northbound HOV lane experiencing over 3,000 vehicles.

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

This corridor exhibits classic directional commute characteristics in the morning, with HOV users traveling toward downtown Bellevue and the cross-lake bridges from surrounding suburban areas, and reversing flow during the evening commute. The northbound HOV lane volumes are concentrated between downtown Bellevue and the Bothell area, carrying as many as 5,000 vehicles. The highest southbound HOV lane volumes are between Totem Lake and Kirkland, where the HOV lane carries more than 3,000 vehicles during the afternoon peak period.

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

The I-405 HOV lane corridor south of the I-90 interchange, but north of the SR 167 interchange—northbound in the morning and southbound in the evening—experiences one of the highest vehicle volumes in the region. However, person volumes on this facility are not equal to those found on I-5 because of a much lower level of transit service and use. Northbound AM peak period volumes go as high as 4,000 vehicles. The southbound volumes are highest during the PM peak period, tallying as many as 6,000 vehicles. Southbound volumes dropped significantly at the SR 167 interchange. Relatively few high occupancy vehicles use this facility southbound through Tukwila.

I-90 (see Figure 2-15)

The main area of interest along this corridor is 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 vehicle volumes are higher in the reversible lanes than in the "pure" HOV lane present between the I-405 interchange and Issaquah.

SR 520 (see Figure 2-16)

The westbound SR 520 HOV lane that begins west of I-405 carries the lowest of vehicle volume of all Puget Sound freeway HOV lanes because of its 3+ occupancy requirement. HOV lane volumes on this facility are highest during the PM peak period partly because westbound PM transit service is not as good as the AM westbound service.

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

This corridor exhibited classic directional commute characteristics. HOV lane volumes are highest in the northbound direction during the AM peak period between 15th St. NW and S. 23rd St., and then southbound during the reverse flow of the PM peak period. HOV lane volumes southbound during the PM peak period reach 4,000 vehicles. This section of the HOV system opened in September 1998

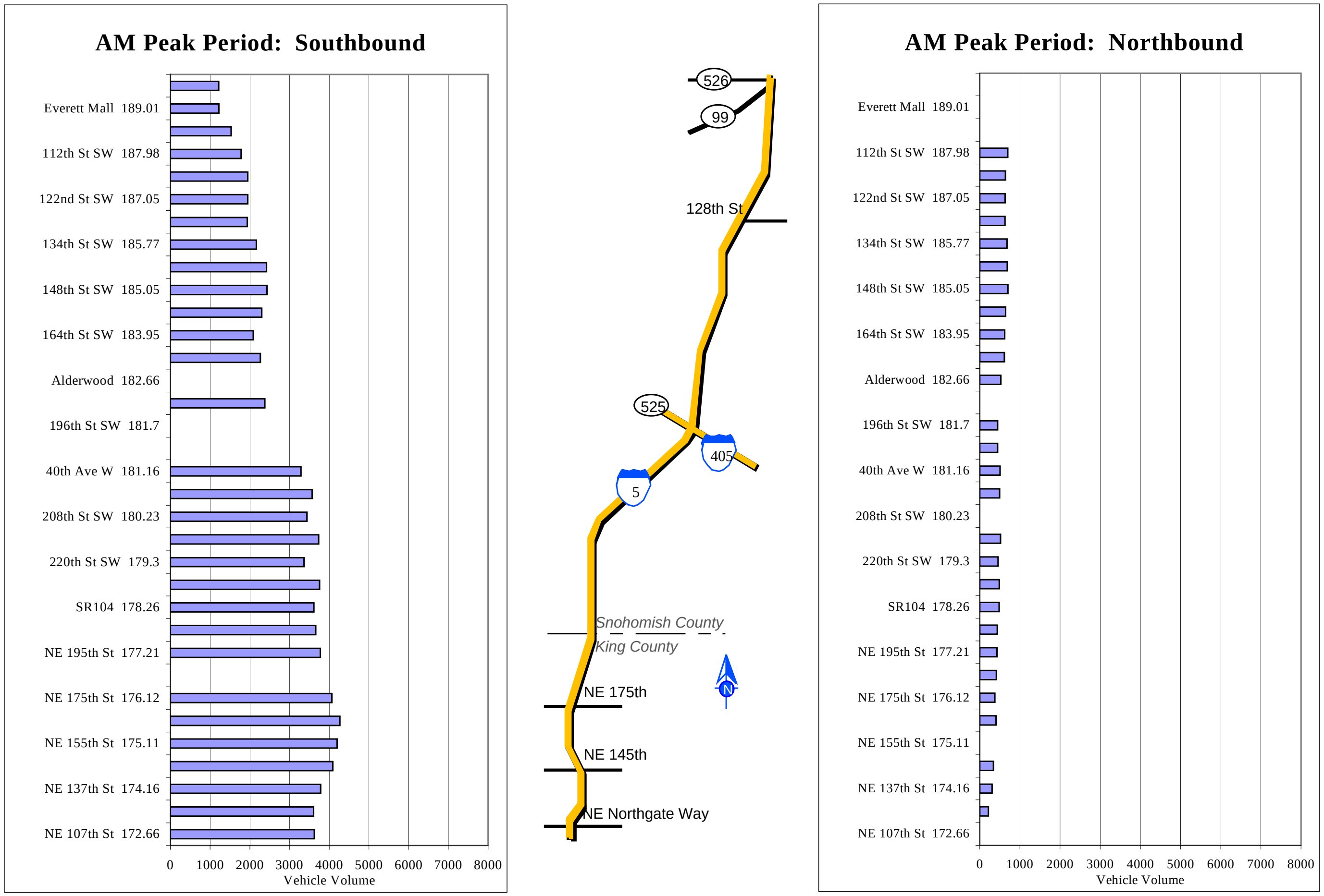


Figure 2-7. HOV Traffic Flow Profile (2002): 1-5 North of Seattle CBD During the 3-Hour AM Peak Period

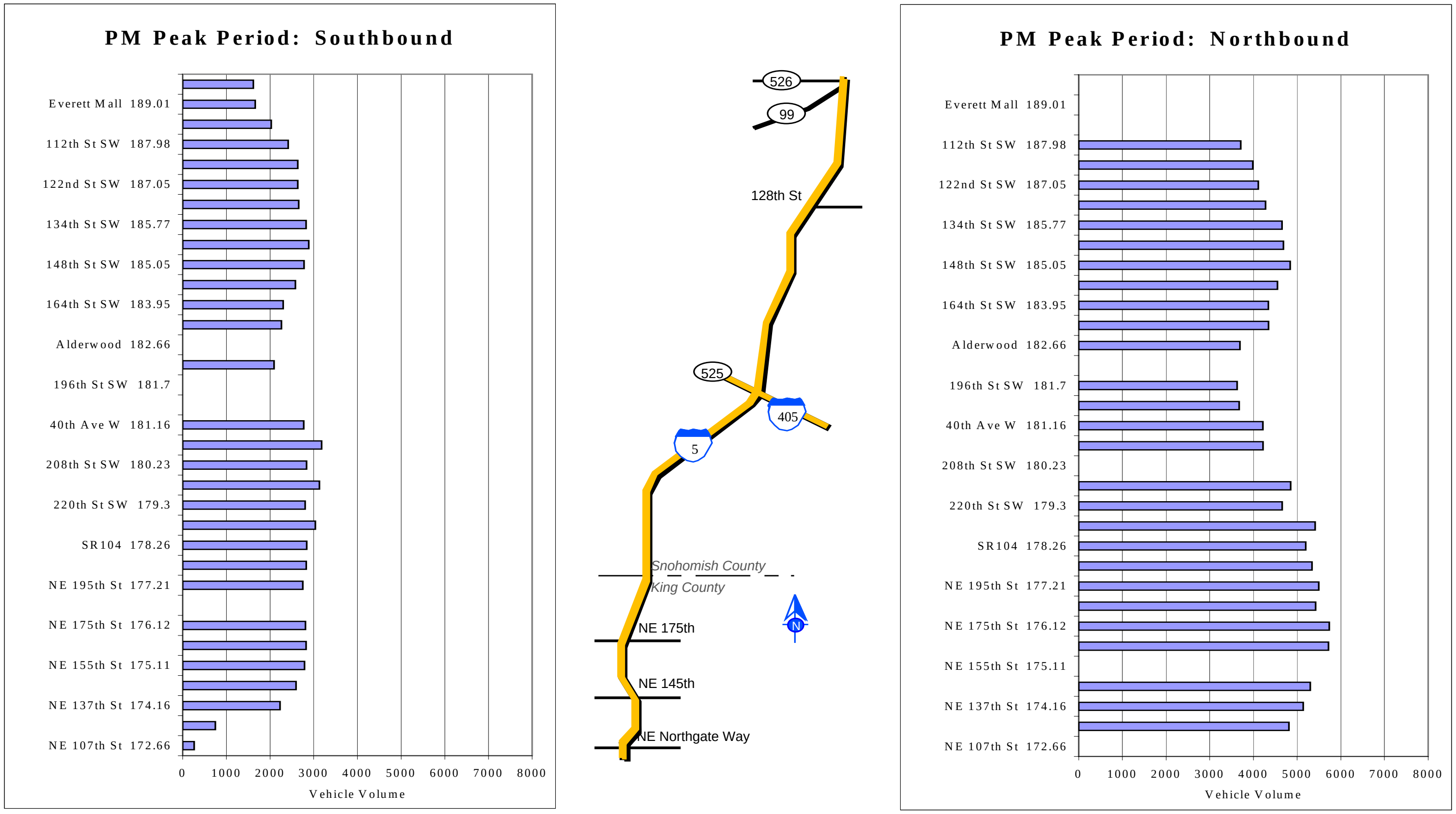


Figure 2-8. HOV Traffic Flow Profile (2002): 1-5 North of Seattle CBD During the 4-Hour PM Peak Period

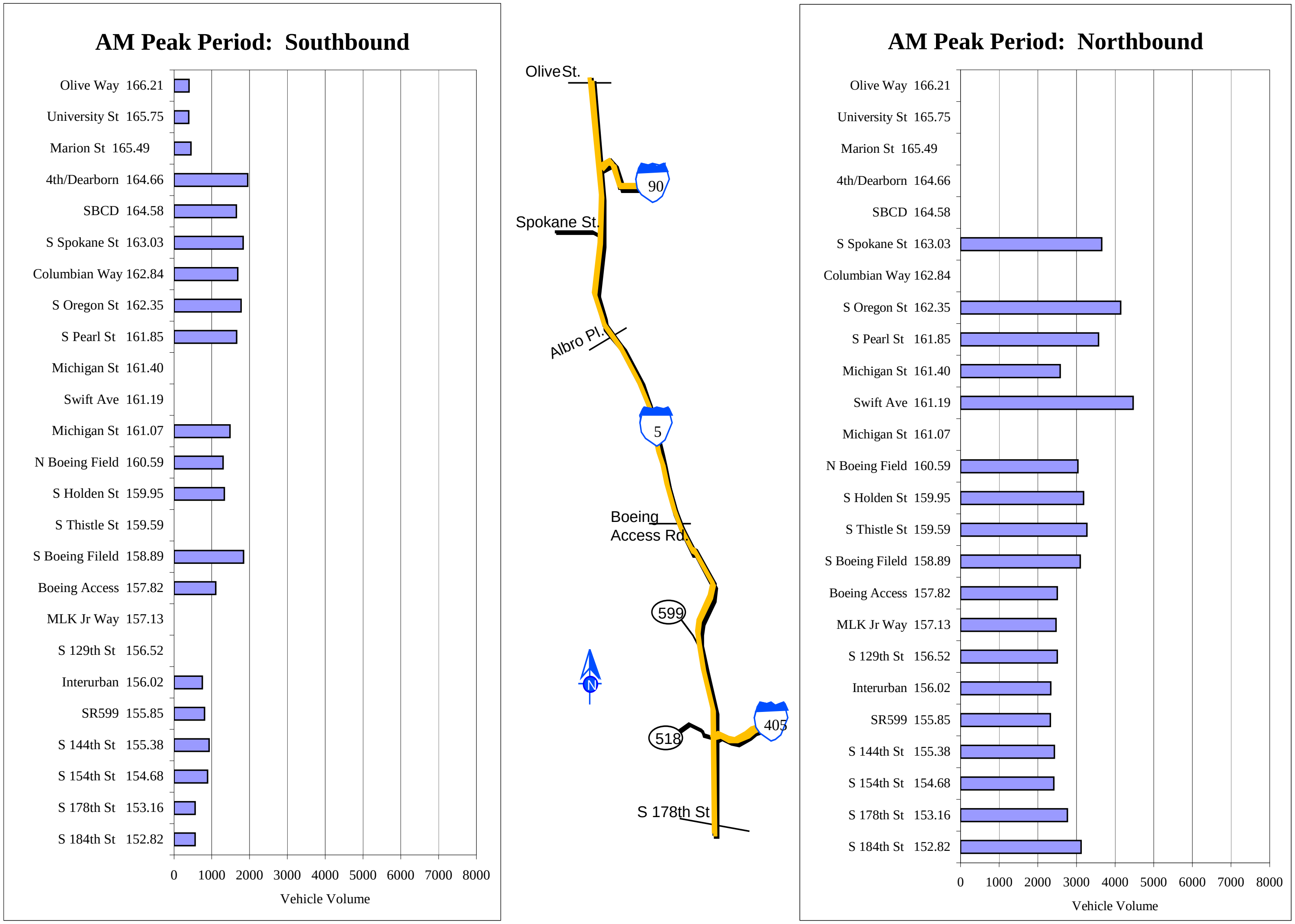


Figure 2-9. HOV Traffic Flow Profile (2002): 1-5 South of Seattle CBD During the 3-Hour AM Peak Period

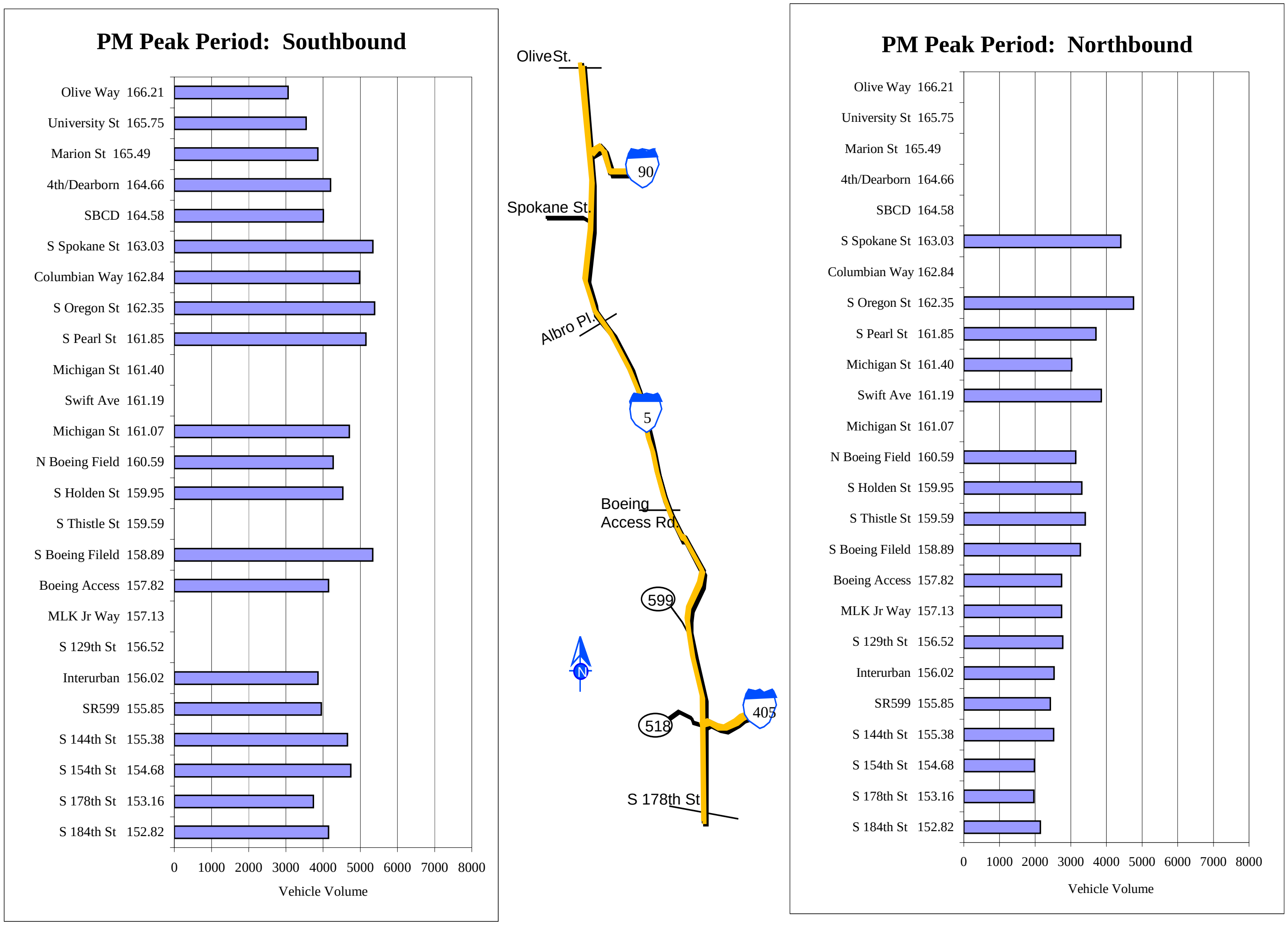


Figure 2-10. HOV Traffic Flow Profile (2002): I-5 South of Seattle CBD During the 4-Hour PM Peak Period

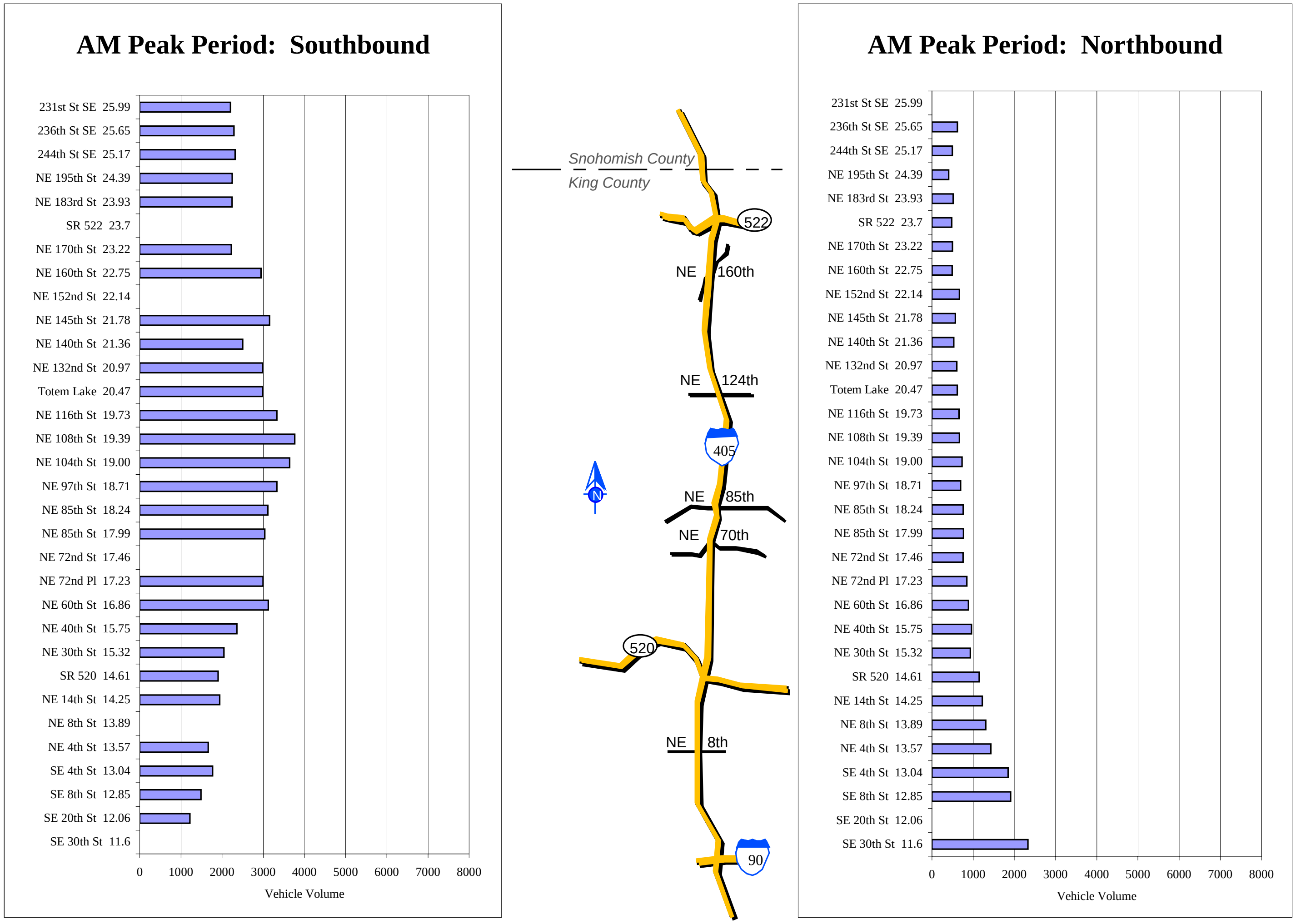


Figure 2-11. HOV Traffic Flow Profile (2002): I-405 North of I-90 Interchange During the 3-Hour AM Peak Period

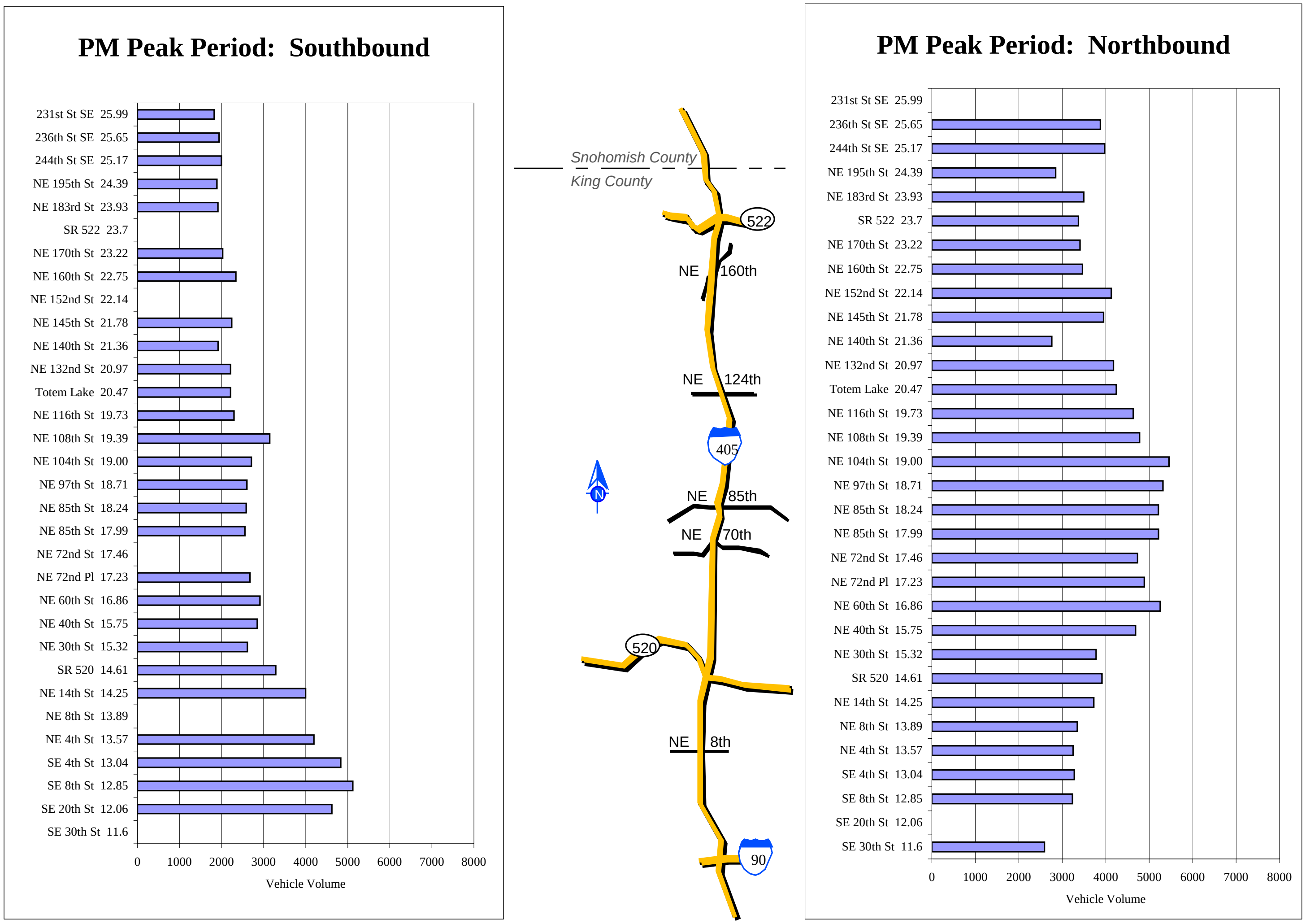


Figure 2-12. HOV Traffic Flow Profile (2002): I-405 North of I-90 Interchange During the 4-Hour PM Peak Period

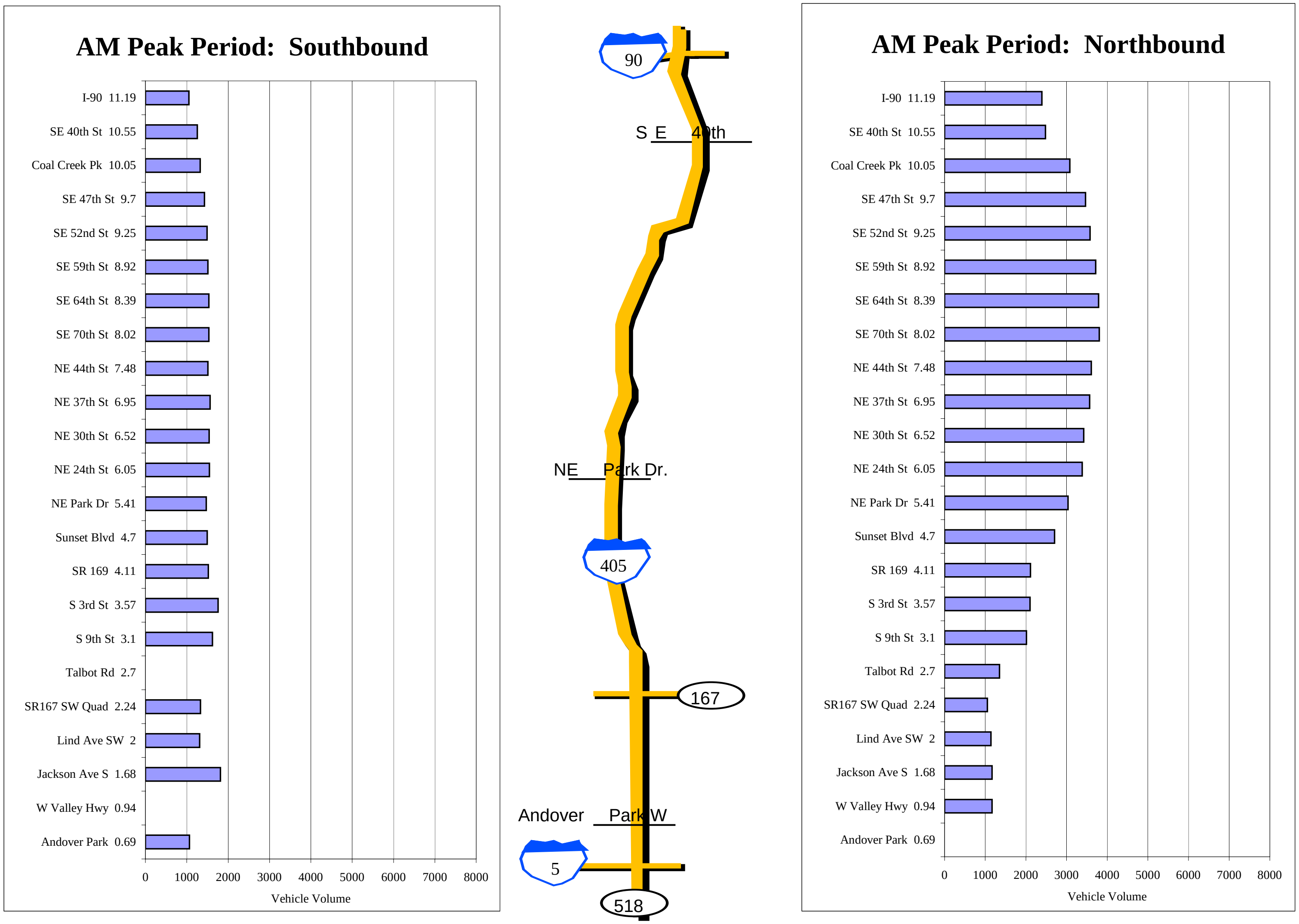


Figure 2-13: HOV Traffic Flow Profile (2002): I-405 South of I-90 Interchange During the 3-Hour AM Peak Period

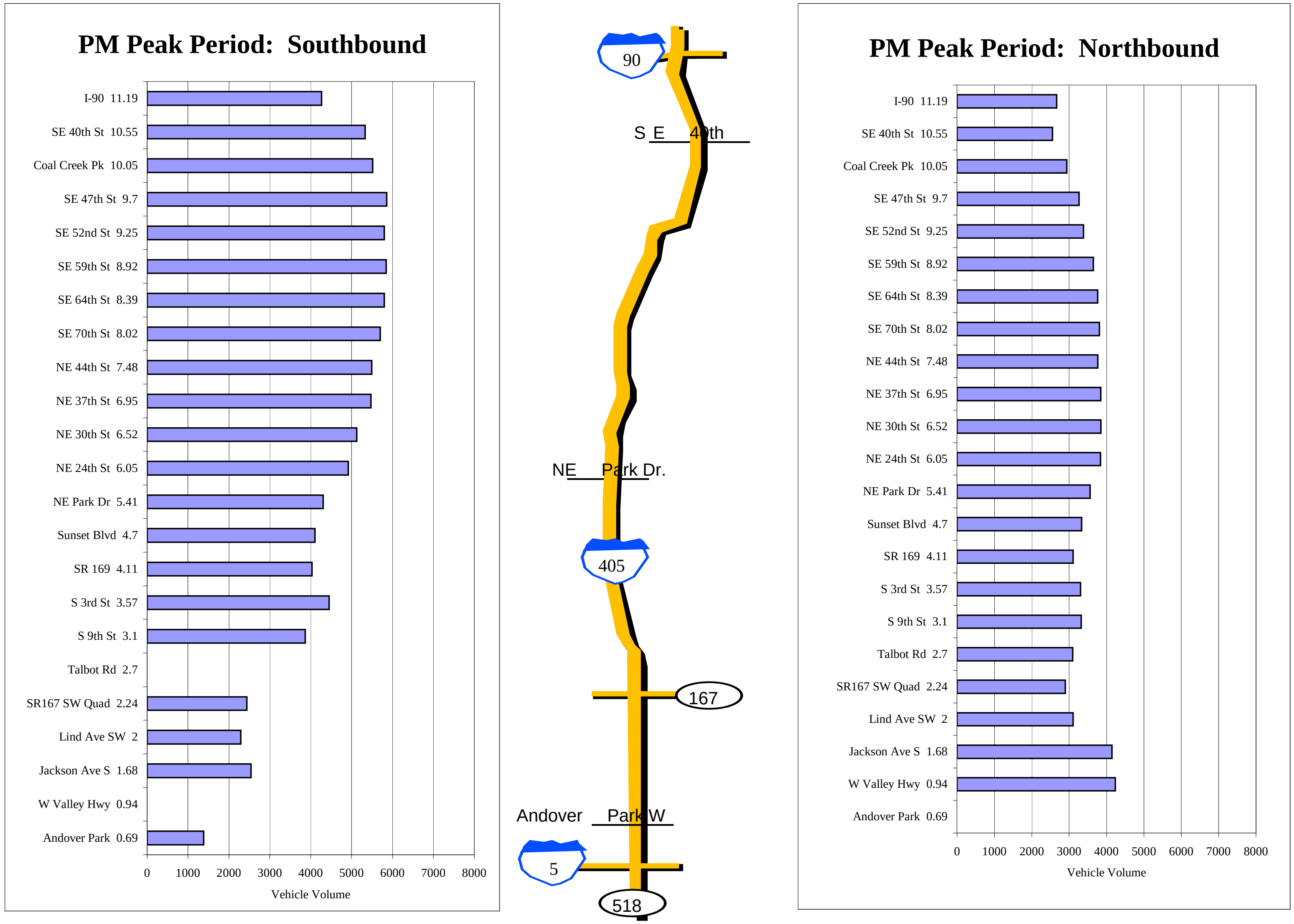


Figure 2-14. HOV Traffic Flow Profile (2002): I-405 South of I-90 Interchange During the PM Peak Period

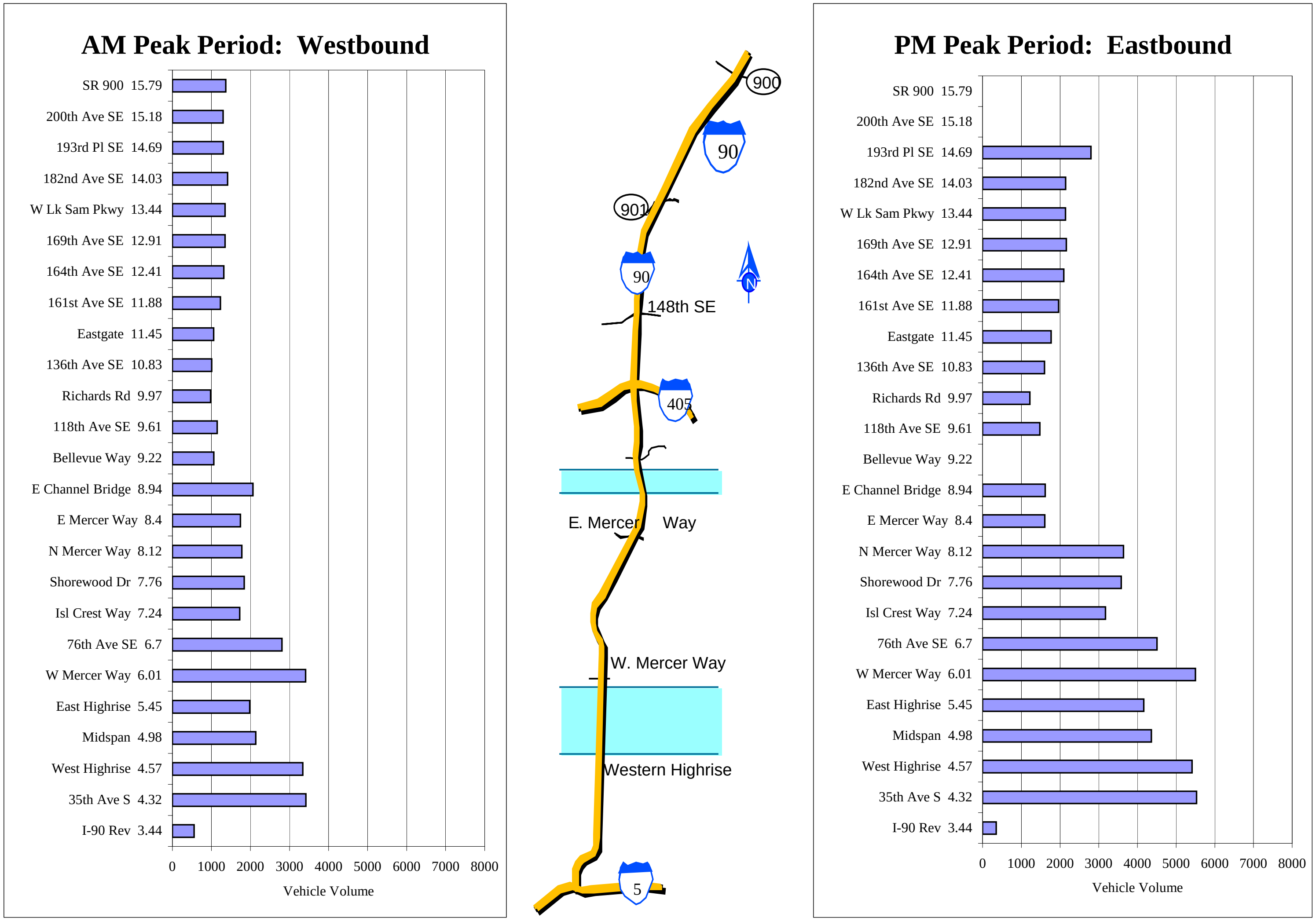


Figure 2-15: HOV Traffic Flow Profile (2002): I-90 During 3-Hour AM and 4-Hour PM Peak Periods

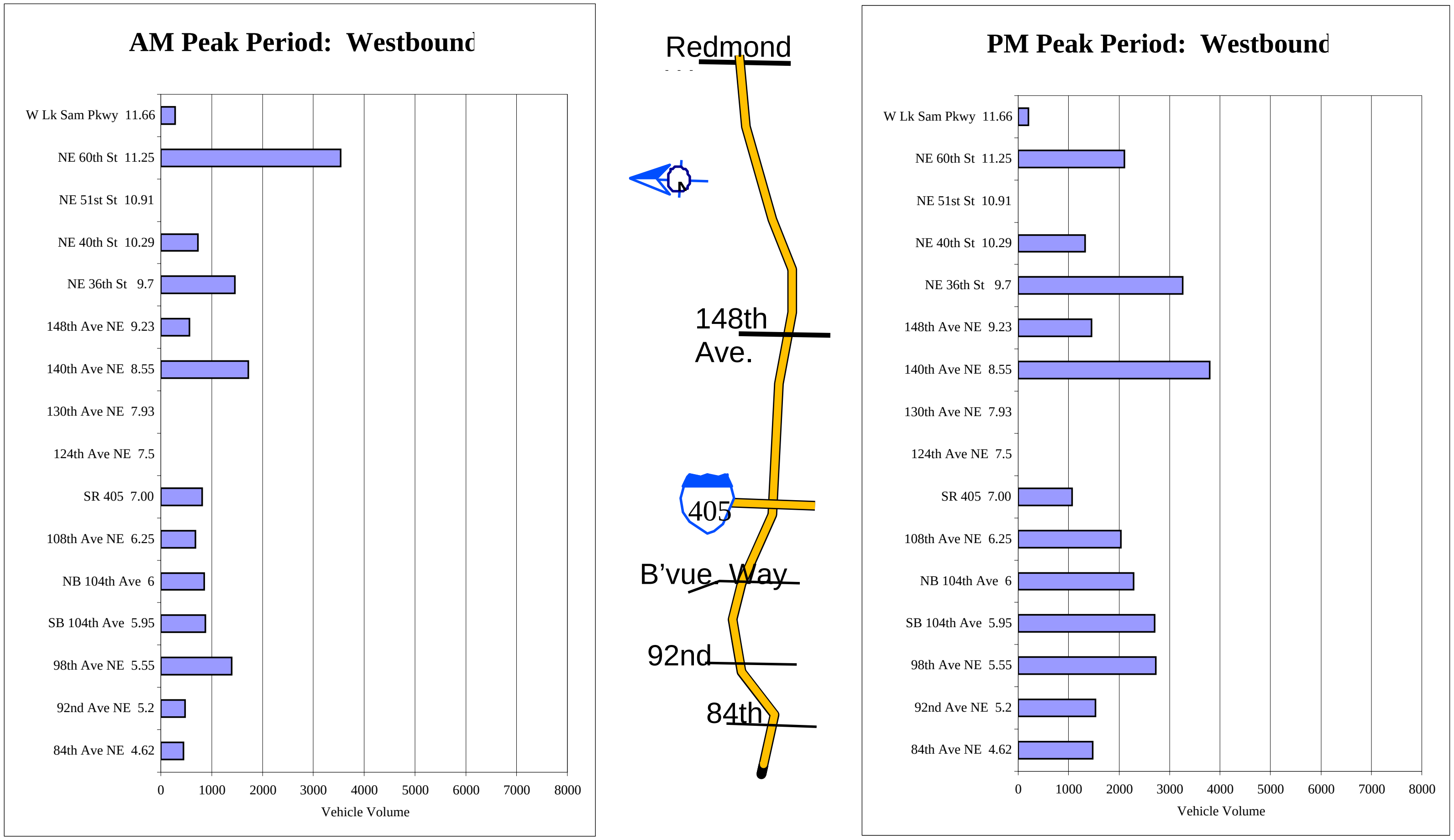


Figure 2-16. HOV Traffic Flow Profile (2002): SR 520 During the 3-Hour AM Peak Period

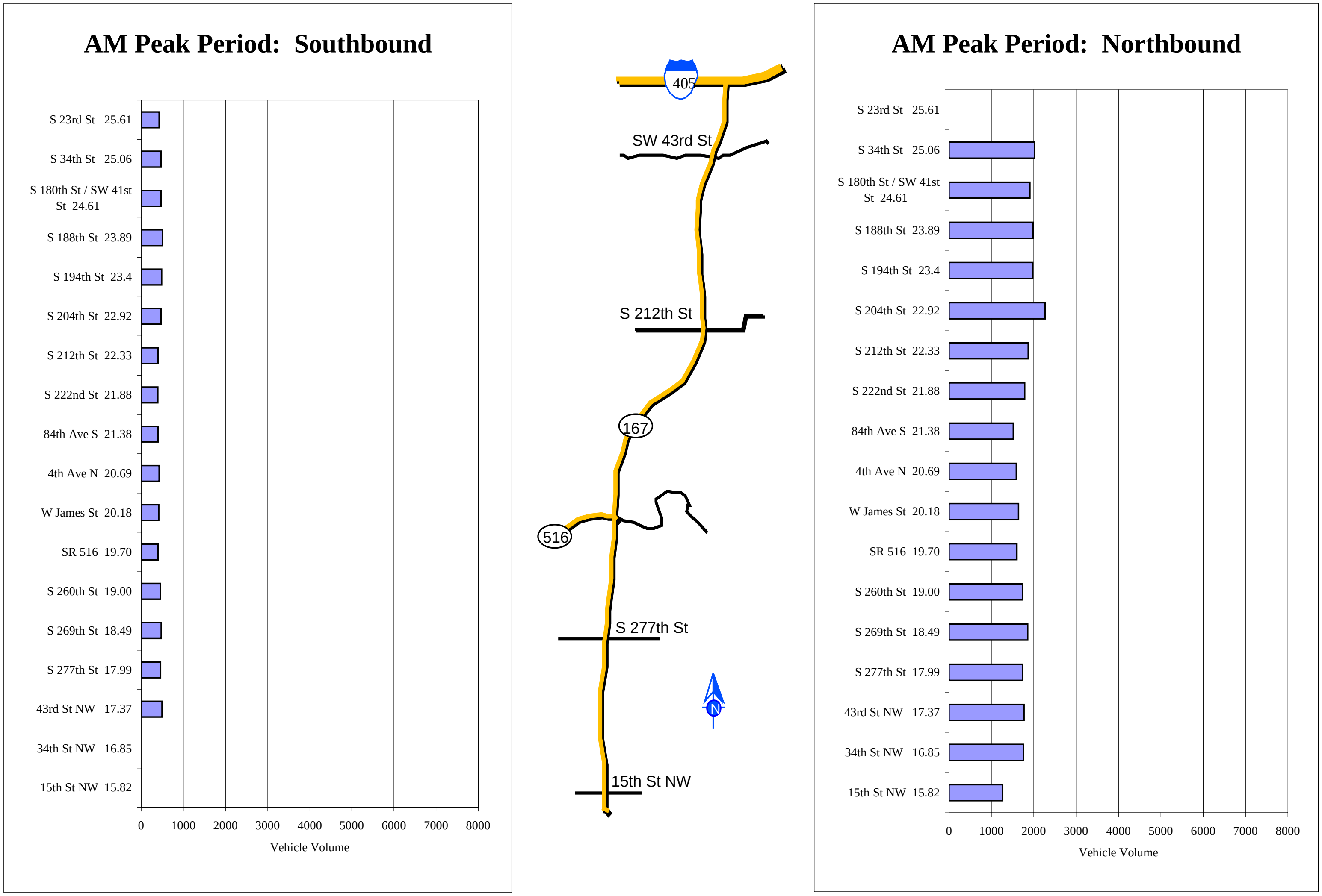


Figure 2-17. HOV Traffic Flow Profile (2002): SR 167 During the 3-Hour AM Peak Period

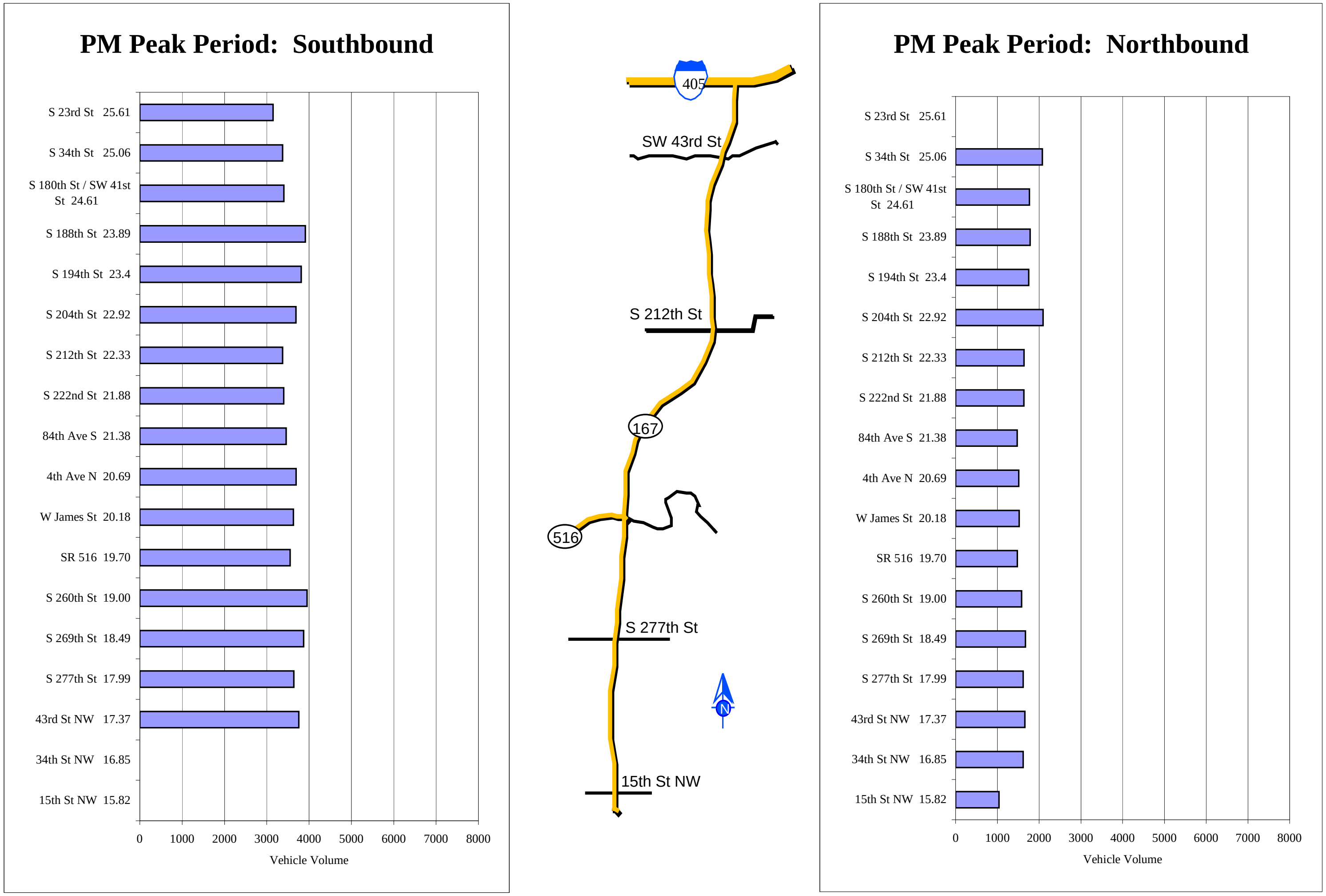


Figure 2-18. HOV Traffic Flow Profile (2002): SR 167 During the 4-Hour PM Peak Period

GP VS. HOV 24-HOUR VEHICLE VOLUME PROFILES

Like GP lanes, traffic volumes on HOV lanes vary by time of day and location. High HOV lane use typically coincides with high levels of travel demand, and with locations that routinely experience heavy congestion in the adjacent GP lanes. This generally occurs during the traditional peak commute periods.

HOV lanes frequently carry vehicle volumes that are comparable to their adjacent GP lane. For example, traffic volumes in the HOV lanes near Northgate, south of Seattle downtown, and at Newcastle, approach 1,500 vehicles per hour. In fact, at some locations and times of day, HOV lane vehicle volumes actually match or even exceed GP lane vehicle volumes on a per-lane basis. (See Figure 2-24, SE 52th St. on I-405) This usually occurs when high HOV lane volumes and severe GP lane congestion occur simultaneously.

Table 2.2 shows the average per lane vehicle volume during peak periods for each of the key HOV corridors. Additional performance information on HOV lane volumes in relation to speed and congestion frequency is presented in Chapter 3.

Table 2-2. Relationship of HOV Lane Vehicle Volumes to GP Lane Volumes During Peak Periods

2002 Location	Milepost	HOV (vplph) NB/EB 6-9AM	HOV (vplph) NB/EB 3-7PM	HOV (vplph) SB/WB 6-9 AM	HOV (vplph) SB/WB 3-7 PM	HOV vs. GP (per lane basis) NB/EB 6-9 AM	HOV vs. GP (per lane basis) NB/EB 3-7 PM	HOV vs. GP (per lane basis) SB/WB 6-9 AM	HOV vs. GP (per lane basis) SB/WB 3-7 PM
1-5 S 184th St	152.82	1040	537	186	1036	53%	37%	21%	82%
1-5 S Pearl St	161.85	1191	926	552	1287	71%	58%	40%	81%
I-5 NE 145th St.	174.6	112	1325	1362	649	14%	90%	74%	47%
I-5 112th St. SW	187.98	231	928	595	603	17%	61%	38%	39%
SR-167 S 212th St.- NB	22.33	623	410	134	844	45%	37%	15%	62%
SR 520 84th Ave NE -W	4.62			148	370			11%	27%
I-405 Andover Park	.69	401	1063	355	346	32%	84%	26%	24%
1-405 SE 52nd St.- SB	9.25	1193	846	497	1449	74%	49%	32%	83%
I-405 NE 85th St. SB	17.99	256	1304	1013	640	23%	85%	60%	49%
I-90 Midspan WB	4.98		545	356			37%	23%	
I-90 W Lk Sam Pkwy	13.44	90	535	450	320	13%	37%	32%	34%

I-5 near South Everett (see Figure 2-19)

The northbound HOV lanes carry approximately 60 percent of the vehicle volume of a typical northbound GP lane during the afternoon peak period. The southbound HOV lane vehicle volume approaches 40 percent of a typical southbound GP lane volume during both peak periods.

I-5 near Northgate (see Figure 2-20)

HOV lane volumes are extremely high during the commute periods. The northbound HOV volumes, during the afternoon peak period and the southbound HOV volumes during the morning peak period, reaches 1,500 vehicles per lane per hour (VPLPH), which exceeds 80 percent of the average GP lane's volume for this location.

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

HOV lane vehicle volumes almost equal the volume of a typical GP lane at this location, particularly northbound during the morning peak period, and southbound during the afternoon peak period. Peak period HOV lane volumes in both directions approach 1,500 VPLPH, 80 to 90 percent of typical GP lane volumes during the same time periods.

I-5 South of Southcenter (see Figure 2-22)

HOV lane volumes are significant during the commute periods. Peak period HOV volumes approach 1,500 VPLPH. The HOV lane carries about 50 percent of the vehicle volume of the neighboring GP lane during the morning peak period in the northbound direction, and 70 percent during the afternoon peak period in the southbound direction.

I-405 near Kirkland (see Figure 2-23)

Peak period HOV lane volumes range between 1,000 and 1,500 VPLPH. The northbound HOV lane carries approximately 85 percent of the volume of an adjacent GP lane during the afternoon peak period. Southbound HOV volumes serve roughly 60 percent of southbound GP per-lane volumes during the morning peak period.

I-405 near Newcastle (see Figure 2-24)

Afternoon peak period HOV lane southbound vehicle volumes are as high as 90 percent of adjoining GP per-lane volumes. The HOV lane carries approximately 70-80 percent of the vehicle volume of an adjacent GP lane during the commute periods.

Note that little opportunity exists for GP volume growth on this segment of freeway. Thus, a large proportion of all growth on this facility is multi-passenger vehicle traffic. Anecdotal evidence suggests that people traveling in this corridor go out of their way to create carpools so they can take advantage of the trip reliability offered by the HOV lane.

I-405 near Southcenter (see Figure 2-25)

Northbound HOV lane volumes exceed adjacent per-lane GP volumes during the height of the evening peak period and are greater than 80 percent of the average GP lane volume for the entire PM peak period. However, morning southbound HOV volumes only approach 30 percent of the corresponding GP volumes during the afternoon peak period. Traffic flows at this location are biased by the design characteristics of the I-405 interchanges with SR 167 and I-5. In the northbound direction, considerable incentive exists to use the HOV lane, as it allows travelers to avoid significant GP lane congestion approaching the SR 167 interchange. Southbound on this stretch of I-405, travelers have already passed the SR 167 interchange congestion, and many HOVs have already exited the HOV lane (which exits to northbound I-5) in order to use the ramp to southbound I-5 or to use SR 518 towards SeaTac airport.

I-90 Floating Bridge (see Figure 2-26)

The reversible facility volumes are high during the peak periods, but peak period volumes per lane still only approach 50 to 70 percent of the per-lane vehicle volumes found in the adjacent general travel lanes. Note that the reversible lanes at this point contain mixed-flow traffic comprising both multi-occupancy vehicle traffic and Mercer Island-bound SOV traffic.

I-90 near Issaquah (see Figure 2-27)

HOV lane volumes exceed 500 VPLPH heading eastbound during the afternoon peak period, and westbound during the morning peak period. HOV lane volumes peaked around 40 percent of corresponding GP lane volumes during the peak periods. Congestion was virtually non-existent along this HOV lane segment.

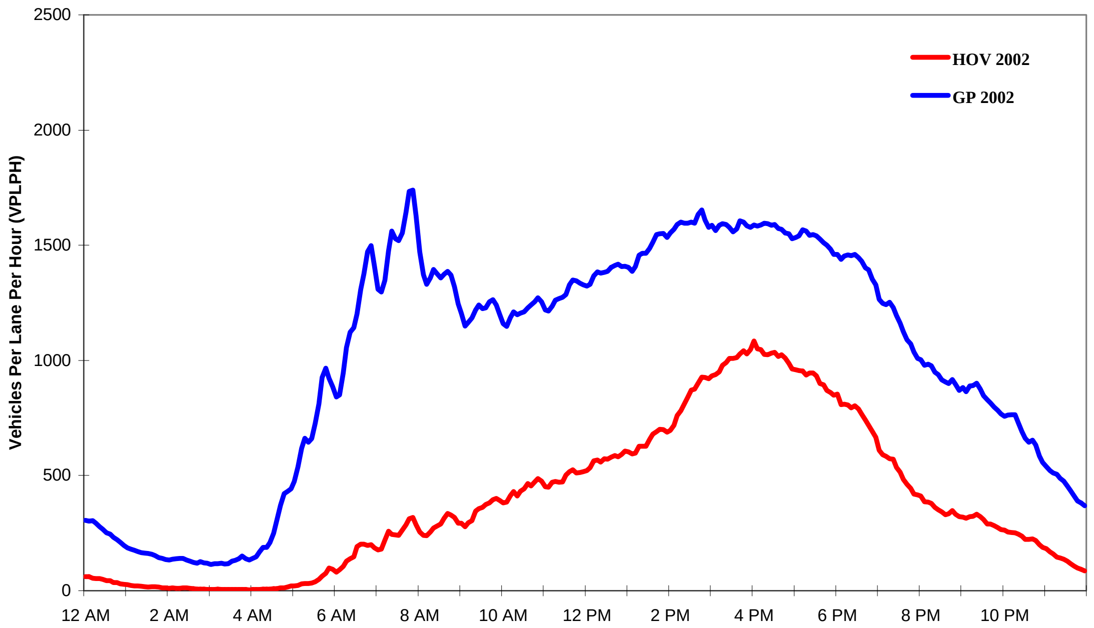
SR 520 near Medina (see Figure 2-28)

HOV lane volumes are relatively low at this location—less than 400 VPLPH. PM peak HOV lane volumes exceed AM peak volumes, in part, because AM transit service is much better than PM service. This results in a much higher level of carpool formation in the evening, thus higher volumes in the HOV lanes. A strict occupancy requirement of 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 near Kent (see Figure 2-29)

Classic directional commute characteristics exist along this corridor. The southbound HOV lane volumes exceed 1,000 VPLPH during the afternoon peak period, which is nearly 60 percent of the adjacent GP lane's volume.

I-5 Northbound, South Everett (112th St SW)



I-5 Southbound, South Everett (112th St SW)

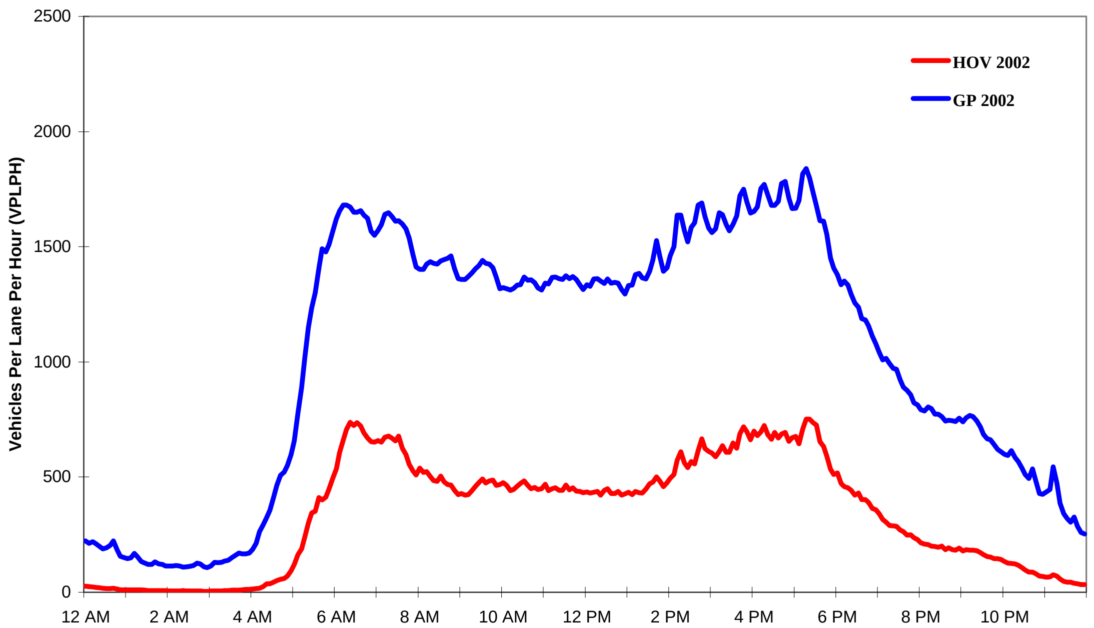
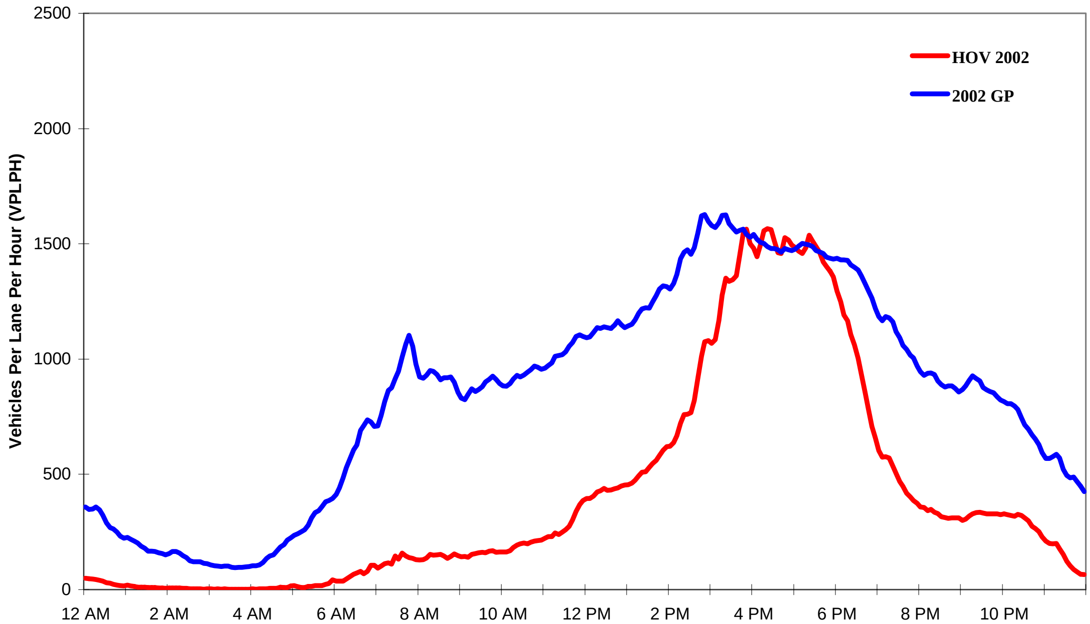


Figure 2-19. Average Weekday GP and HOV Volume Profile (2002): I-5 @ 112th St SW

I-5 Northbound, Northgate (NE 145th St)



I-5 Southbound, Northgate (NE 145th St)

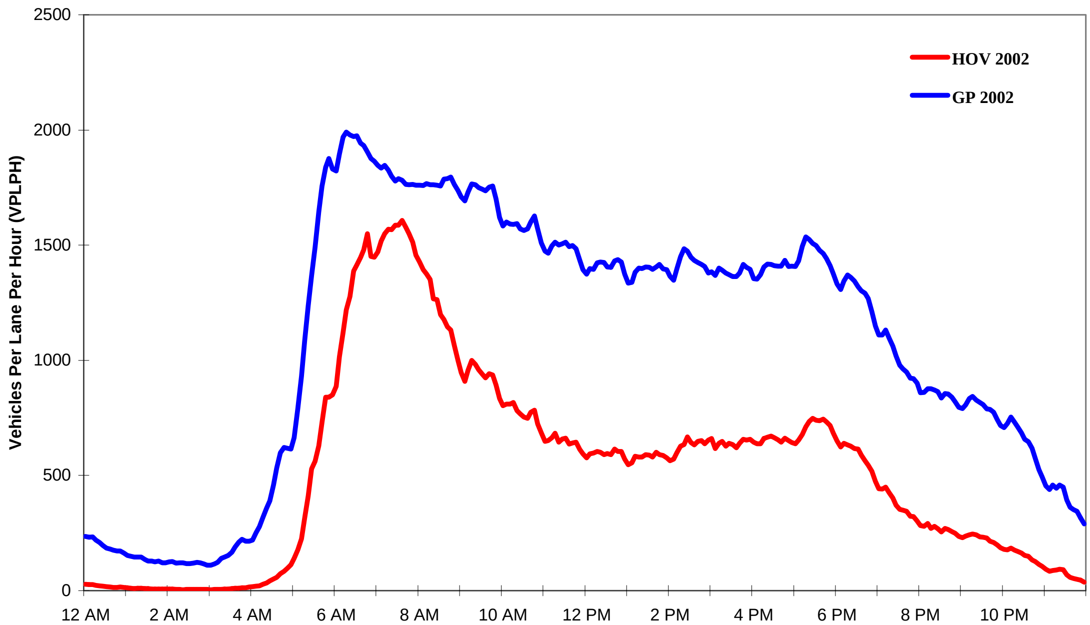
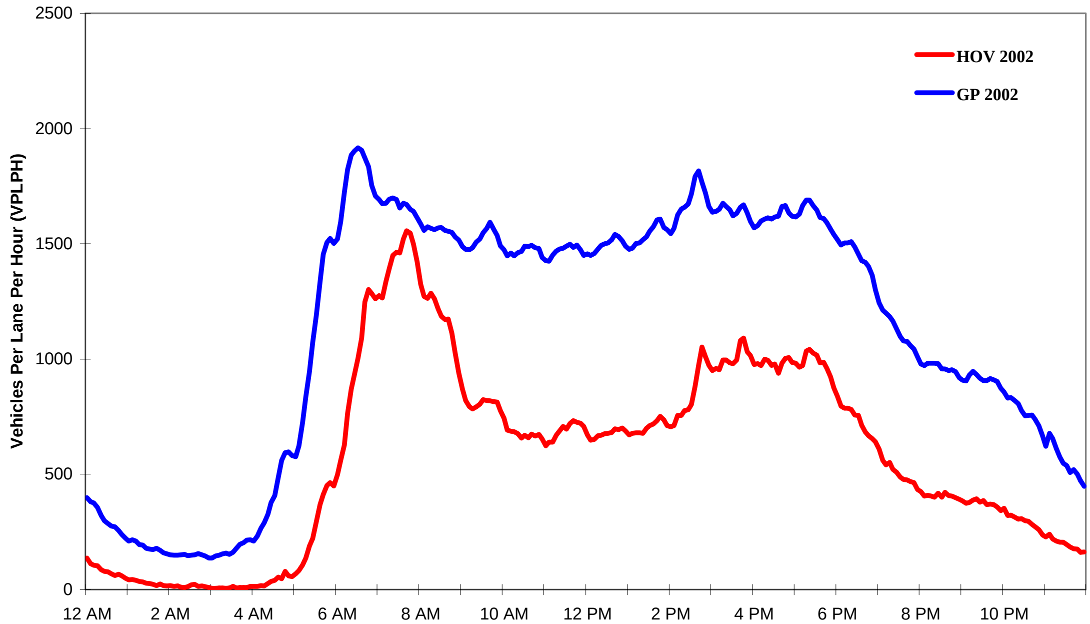


Figure 2-20. Average Weekday GP and HOV Volume Profile (2002): I-5 @ NE 145th St

I-5 Northbound, South of Seattle CBD (S Pearl St)



I-5 Southbound, South of Seattle CBD (S Pearl St)

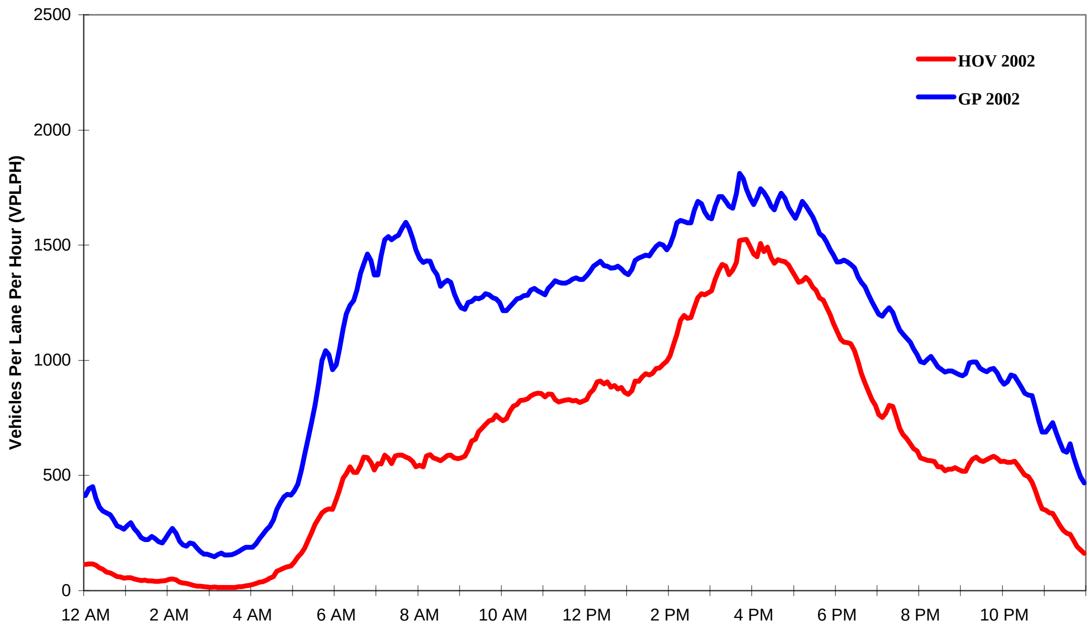
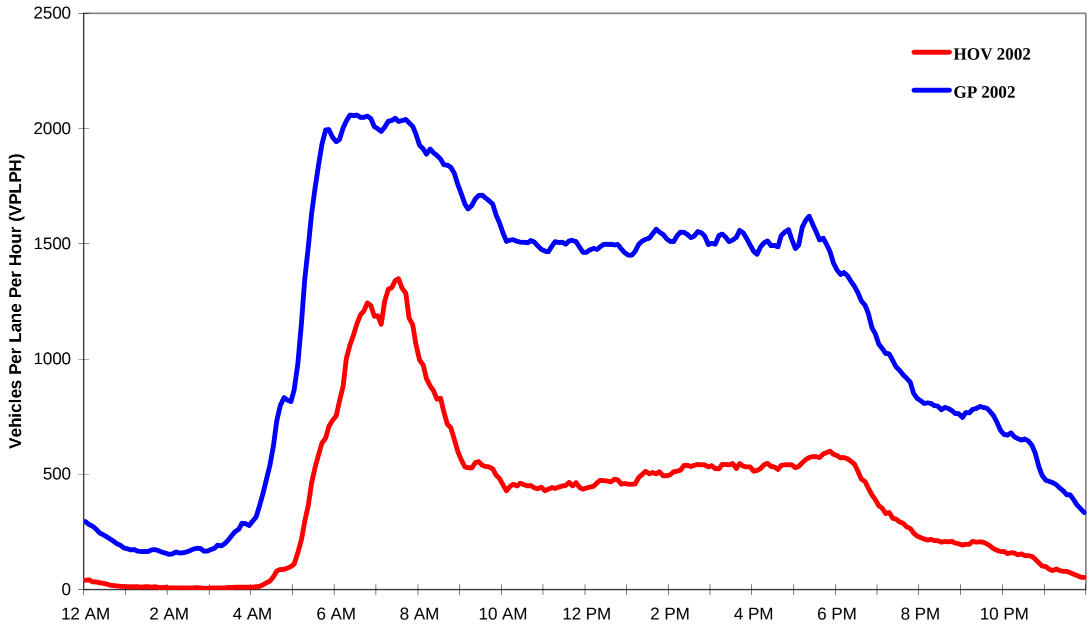


Figure 2-21. Average Weekday GP and HOV Volume Profile (2002): I-5 @ Albro Place

I-5 Northbound, South of Southcenter (S 184th St)



I-5 Southbound, South of Southcenter (S 184th St)

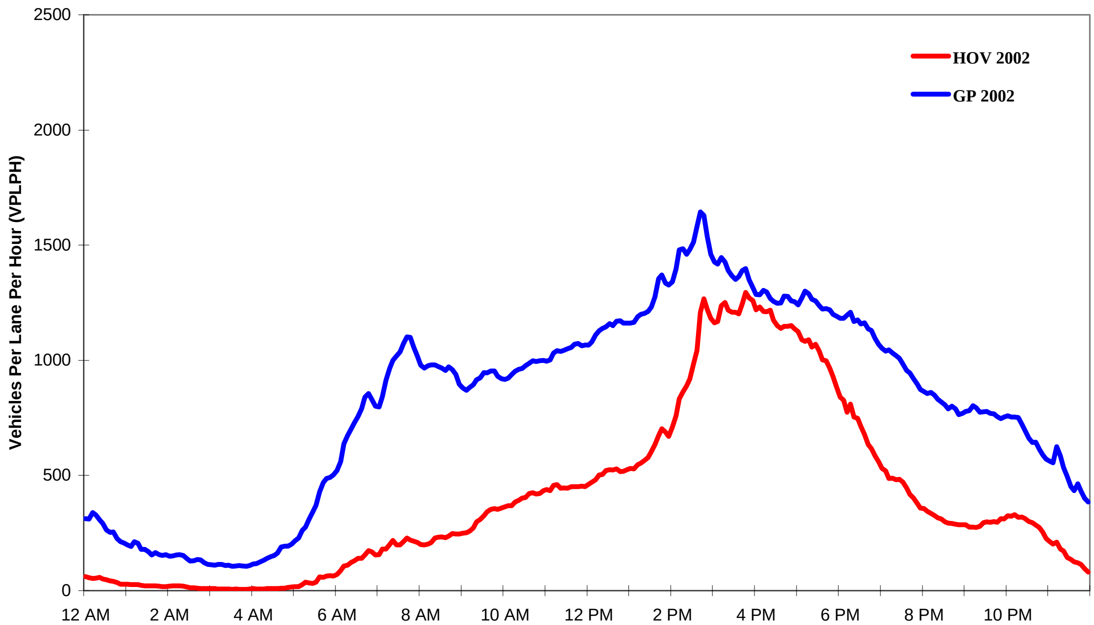
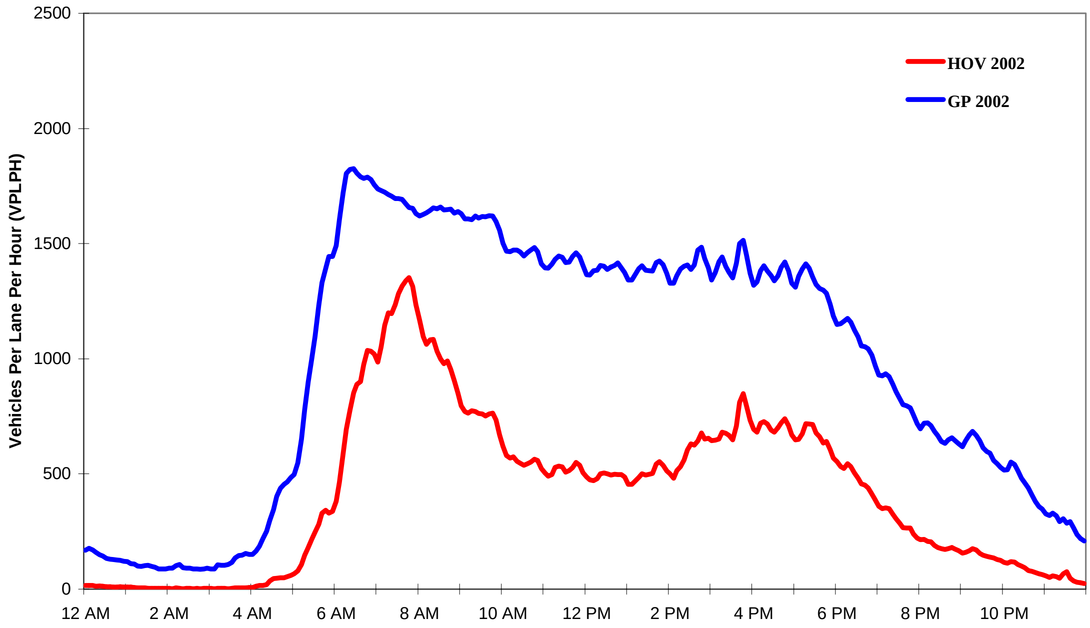


Figure 2-22. Average Weekday GP and HOV Volume Profile (2002): I-5 @ S 184th St.

I-405 Southbound, Kirkland (NE 85th St)



I-405 Northbound, Kirkland (NE 85th St)

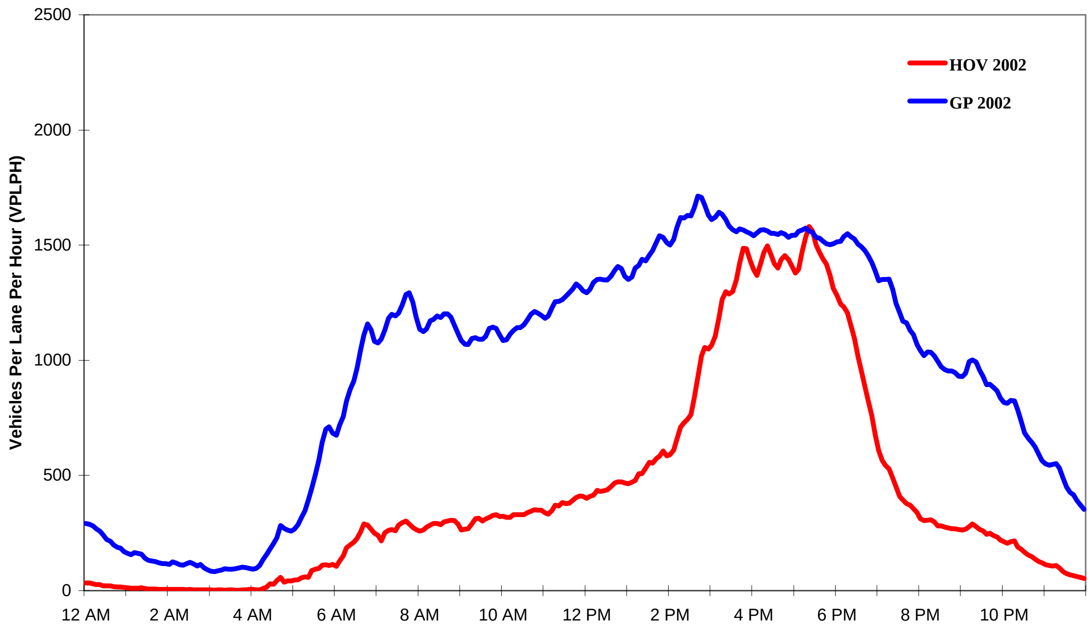
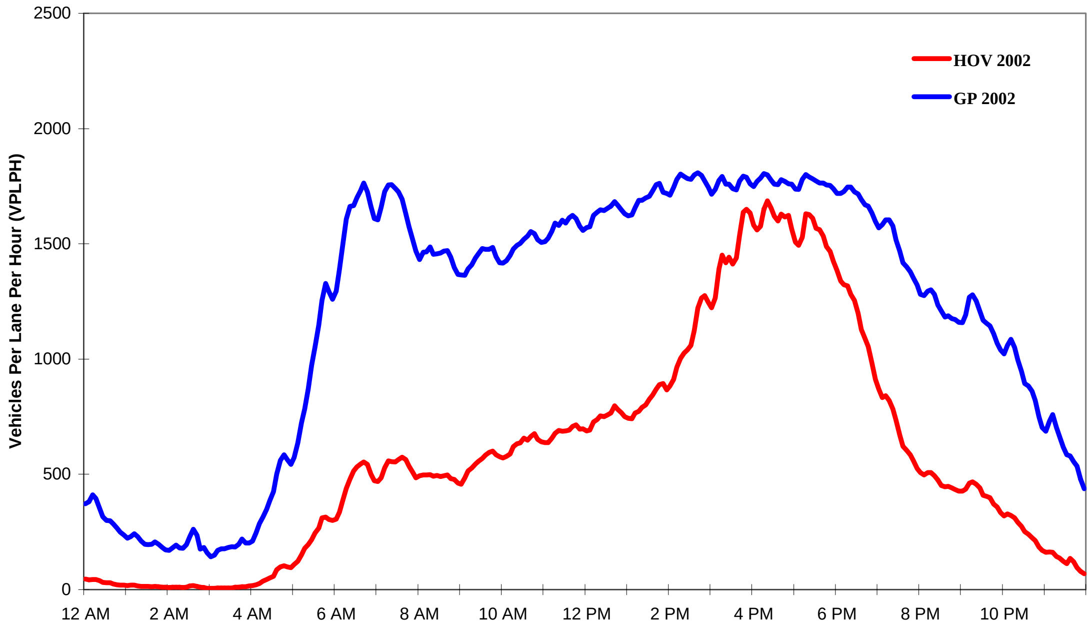


Figure 2-23. Average Weekday GP and HOV Volume Profile (2002): I-405 @ NE 85th St.

I-405 Southbound, Newcastle (SE 52nd St)



I-405 Northbound, Newcastle (SE 52nd St)

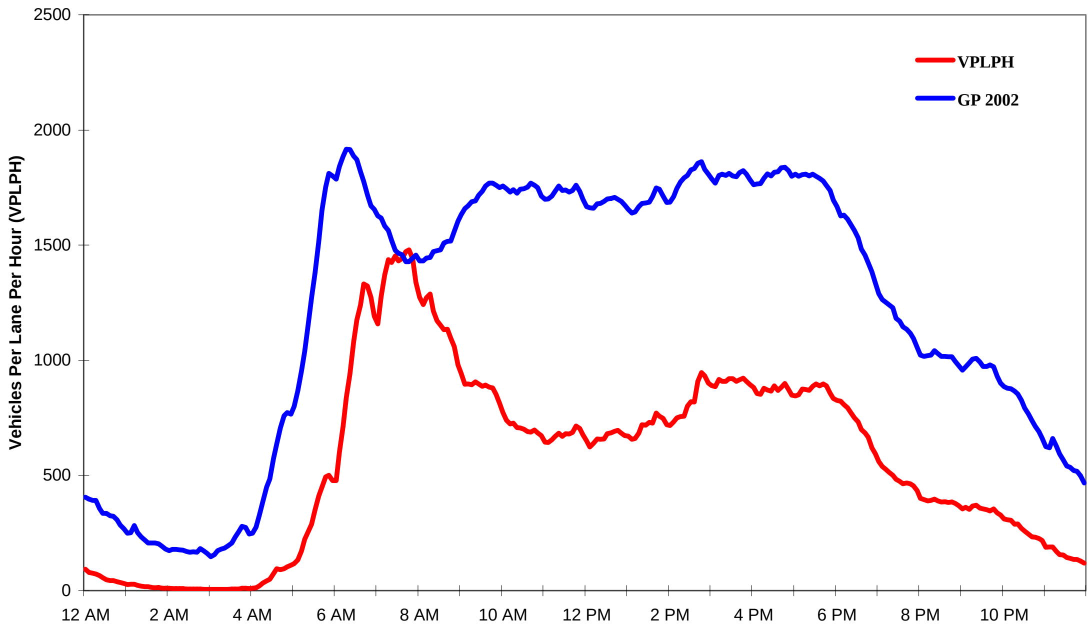
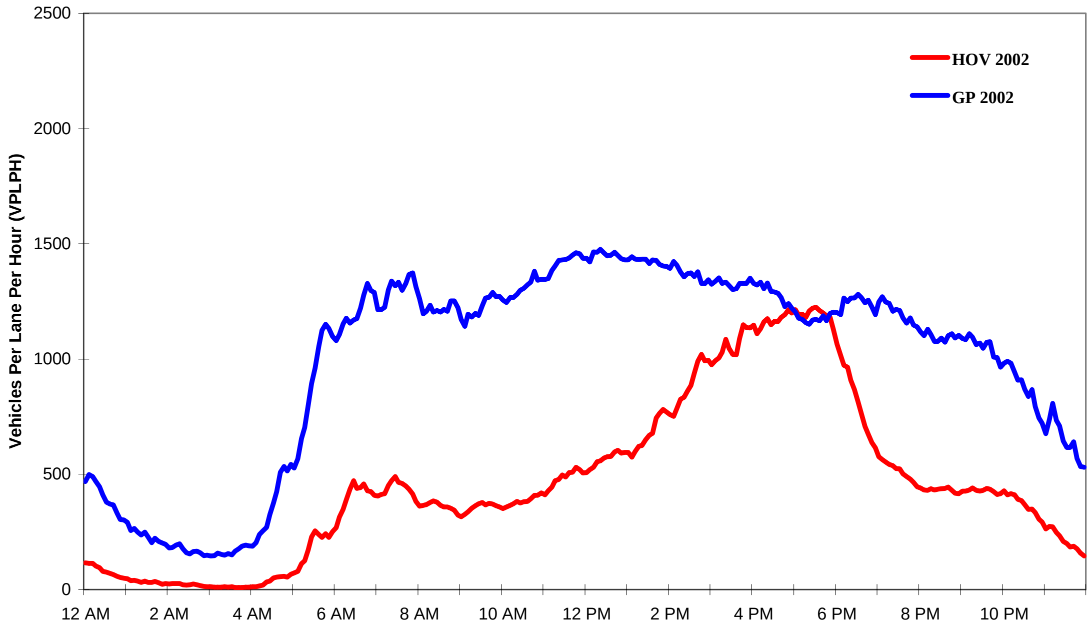


Figure 2-24. Average Weekday GP and HOV Volume Profile (2002): I-405 @ SE 52nd St

I-405 Northbound, Southcenter (Andover Park)



I-405 Southbound, Southcenter (Andover Park)

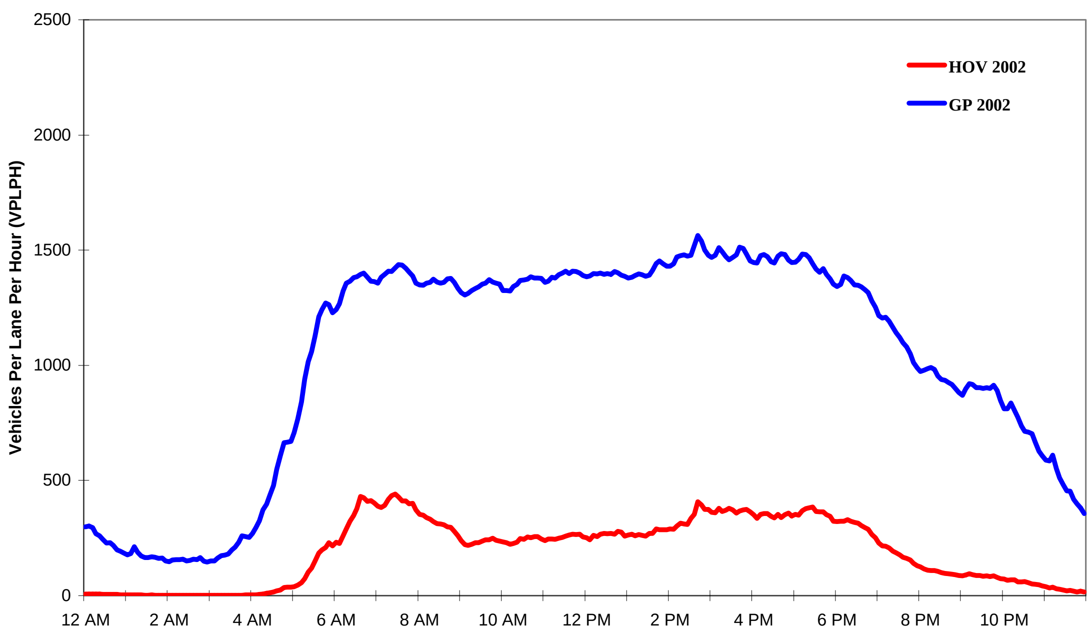
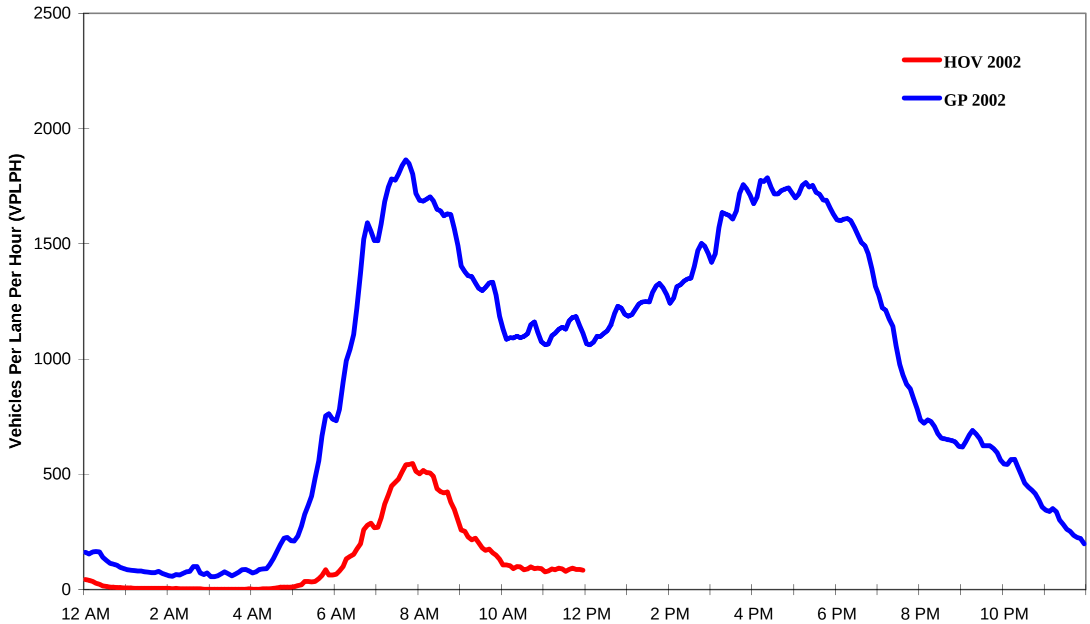


Figure 2-25. Average Weekday GP and HOV Volume Profile (2002): I-405 @ Andover Park

I-90 Westbound, Floating Bridge (Midspan)



I-90 Eastbound, Floating Bridge (Midspan)

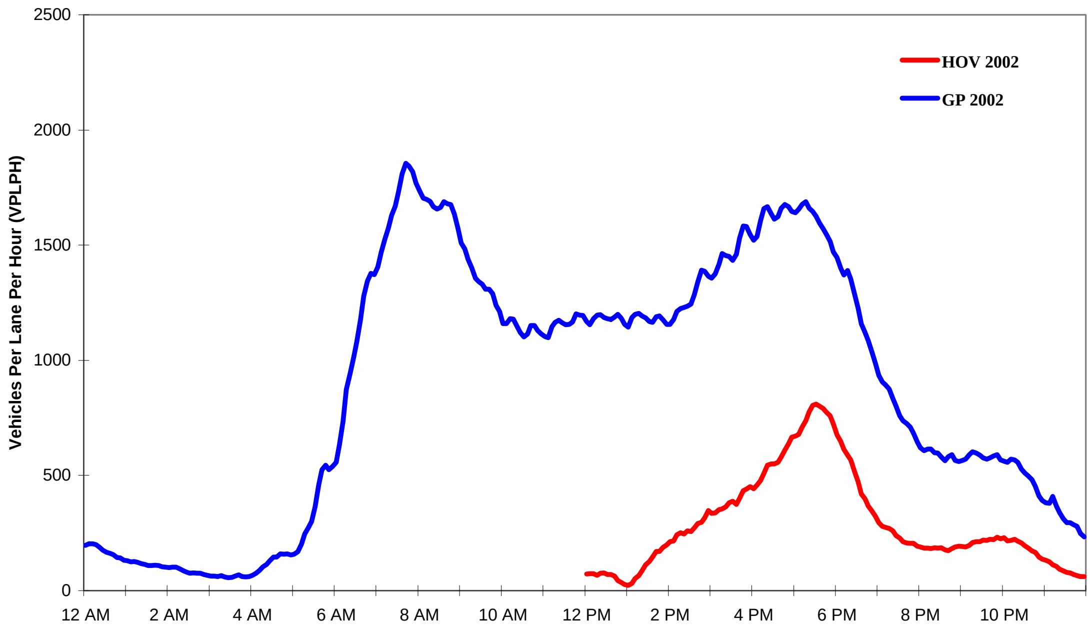
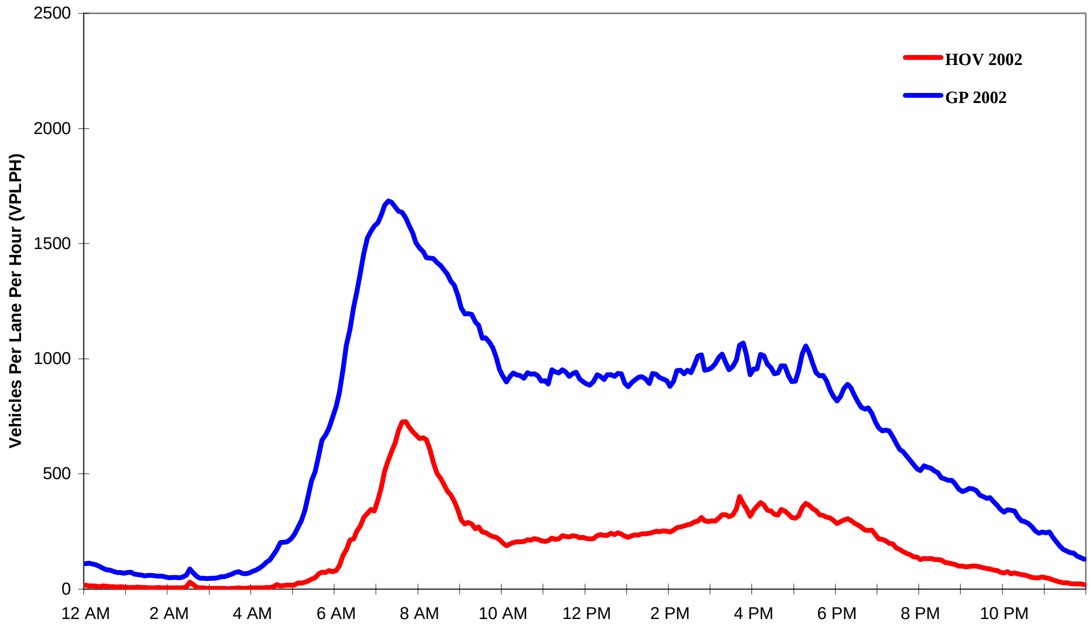


Figure 2-26. Average Weekday GP and HOV Volume Profile (2002): I-90 @ Midspan

I-90 Westbound, Issaquah (W Lake Sammamish Pkwy)



I-90 Eastbound, Issaquah (W Lake Sammamish Pkwy)

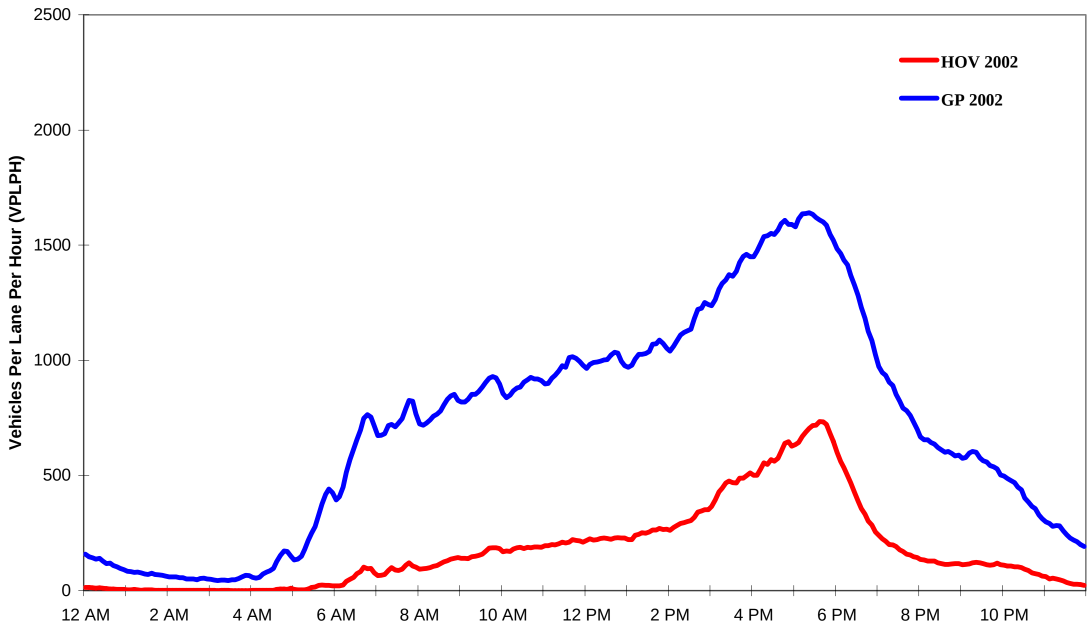


Figure 2-27. Average Weekday GP and HOV Volume Profile (2002): I-90 @ W Lake Sammamish Pkwy

SR 520 Westbound, Medina (84th Ave NE)

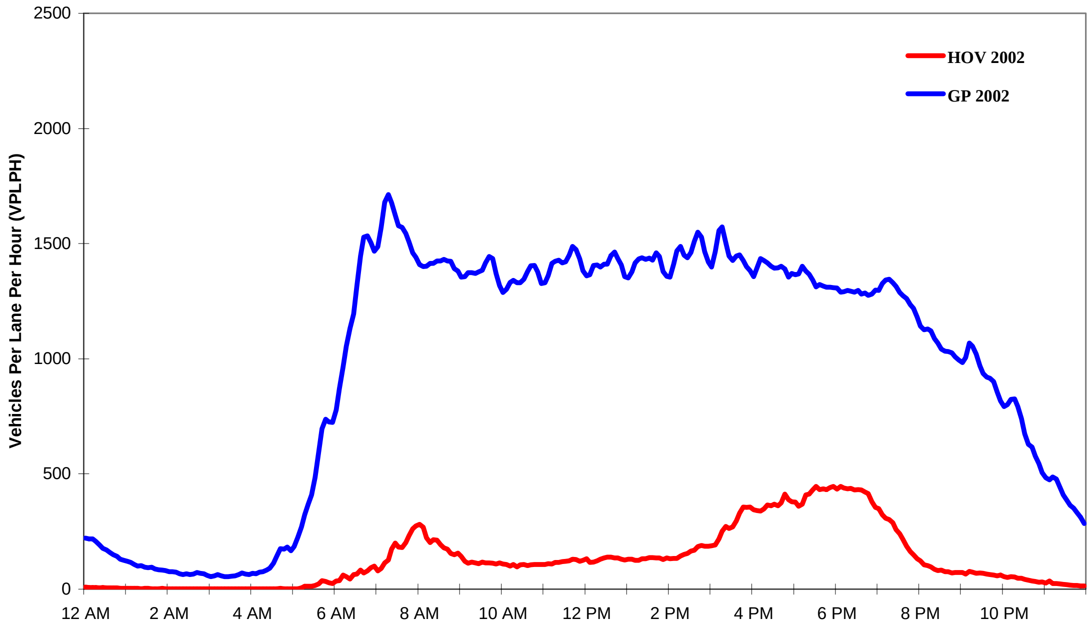
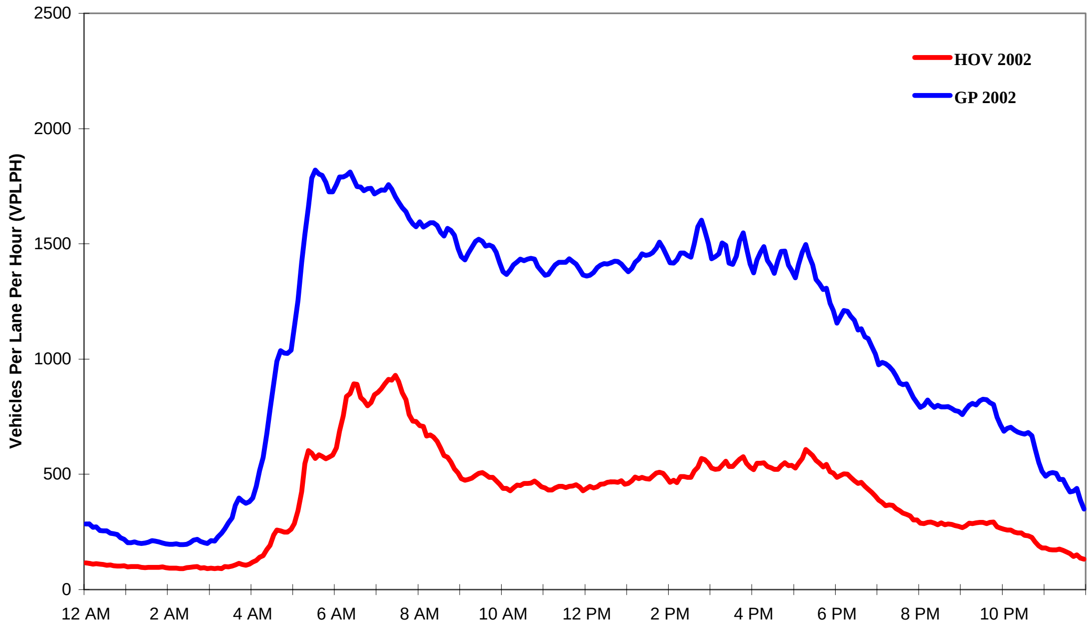


Figure 2-28. Average Weekday GP and HOV Volume Profile (2002): SR 520 @ 84th Ave NE

(There is no HOV lane Eastbound)

SR 167 Northbound, Kent (S 204th St)



SR 167 Southbound, Kent (S 204th St)

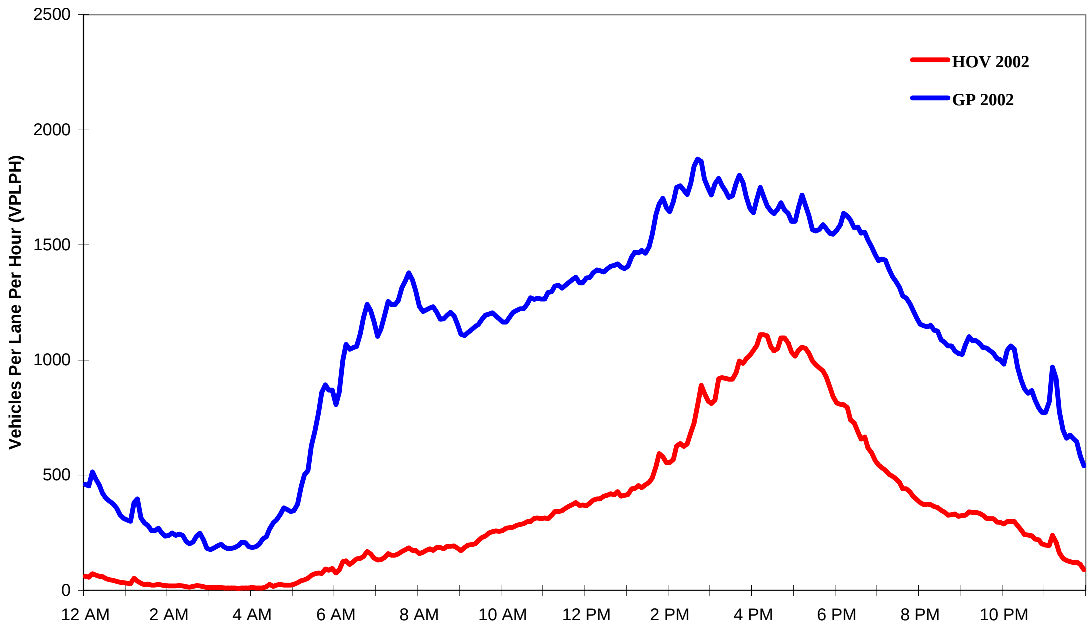


Figure 2-29. Average Weekday GP and HOV Volume Profile (2002): SR 167 @ S 204th St

GP LANE VS. HOV LANE PERSON THROUGHPUT COMPARISON

To what extent is an HOV lane being used? A complete answer to this question requires an analysis of both person and vehicle throughput. Figures 2-30 through 2-40 break down person and vehicle volumes within GP and HOV lanes during the peak times and directions. Several pieces of throughput information are itemized 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 determines what proportion of total throughput the HOV facility provides; it also presents an accurate comparison of how much person throughput the HOV lane provides in comparison to a single GP lane.

I-5 near South Everett (see Figure 2-30)

AM Peak Period. The southbound HOV lane carries more than 20 percent of all people in 11 percent of all cars, resulting in an average vehicle occupancy that is greater than two times that of the adjacent GP lane (2.6 people per vehicle versus 1.2 people per vehicle). Transit riders make up more than ten percent of HOV lane users. On a per-lane basis, the southbound HOV lane carries 16 percent fewer people and 62 percent fewer vehicles than the adjacent GP lane.

PM Peak Period. The northbound HOV lane carries 28 percent of all people in 17 percent of all cars, with an AVO of 2.5. On a per-lane basis, the HOV lane carries 19 percent more people in 39 percent fewer vehicles than the adjacent GP lane.

I-5 near Northgate (see Figure 2-31)

AM Peak Period. Fifty-seven percent of the people traveling southbound toward the University of Washington and downtown Seattle are carried by four GP lanes; and the single southbound HOV lane carries the remaining 43 percent of all travelers in 20 percent of the vehicles that are comprised of carpools, vanpools, and buses. Approximately 40 percent of total people in the HOV lane are bus riders (refer to Figure 2-4), resulting in an average vehicle occupancy of 3.4. On a per-lane basis, the HOV lane carries 122 percent more people in 26 percent fewer vehicles than the adjacent GP lane.

PM Peak Period. In the evening peak period, the HOV lane carries approximately 40 percent of all people and 18 percent of all vehicles. On average, 3.4 people are in each vehicle in the HOV lane. Approximately 30 percent of all people traveling in the HOV lane use transit services. The HOV lane carries 160 percent more people in 10 percent fewer vehicles than the adjacent GP lane.

I-5 South of the Seattle CBD (see Figure 2-32)

AM Peak Period. About one third of all people traveling northbound in the peak period use the HOV lane and are 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 single occupant vehicles and multi-occupant vehicles. This slightly lowers the average vehicle occupancy rate. Forty four percent of people in the HOV lane are bus riders. The HOV lane carries 11,943 people in 3,572 vehicles, or twice as many people in 29 percent fewer vehicles than the adjacent GP lane.

PM Peak Period. The southbound HOV lane carries 34 percent of all people in the evening peak period in 17 percent of the vehicles, with an average of 3.2 people in each vehicle. About one-third of all people traveling in the HOV lane use transit services. The HOV lane carries 107 percent more people in 19 percent fewer vehicles than the adjacent GP lane.

I-5 South of Southcenter (see Figure 2-33)

AM Peak Period. About 26 percent of all people traveling northbound use the HOV lane and are carried in 12 percent of the vehicles. About 35 percent of the HOV lane users are bus riders. The HOV lane carries 10,301 people in 3,120 vehicles, or 44 percent more people in 47 percent fewer vehicles than the adjacent GP lane.

PM Peak Period. In the evening peak period, the southbound HOV lane carries 26 percent of all people and 12 percent of all vehicles. On average, 3.1 people are in each vehicle in the HOV lane. About 30 percent of all people traveling in the HOV lane use transit services. The HOV lane carries 75 percent more people in 32 percent fewer vehicles than the adjacent GP lane.

I-405 near Kirkland (see Figure 2-34)

AM Peak Period. The southbound HOV lane carries approximately 30 percent of all people in 17 percent of all vehicles, or 7,295 people in 3,039 vehicles, resulting in an average of 2.4 people per vehicle. The HOV lane carries 24 percent more people in 40 percent fewer vehicles than the adjacent GP lane. Approximately 12 percent of travelers in the HOV lane are in transit vehicles.

PM Peak Period. The northbound HOV lane carries almost 40 percent of all people in 22 percent of all vehicles with an average of 2.4 people in each vehicle. The HOV lane carries 79 percent more people in about 15 percent fewer vehicles than the adjacent GP lane.

I-405 near Newcastle (see Figure 2-35)

AM Peak Period. The northbound HOV usage during the morning peak period is relatively high, although transit patronage at this location is modest. The HOV lane carries almost half of the people in 27 percent of the vehicles, an average of 2.3 people in each vehicle. The vast majority of HOV lane users are in carpools, with only 11 percent using transit on this portion of I-405. In comparison to the adjacent GP lane, the HOV lane carries 51 percent more people in approximately 26 percent fewer vehicles.

PM Peak Period. The HOV usage during the evening peak period is also high. About 46 percent of the people using I-405 southbound are carried in the HOV lanes in 29 percent of the vehicles, with an average of 2.3 people in each vehicle. This is roughly 68 percent more people in about 17 percent fewer vehicles than in the adjacent GP lane.

I-405 near Southcenter (see Figure 2-36)

AM Peak Period. HOV lane use at this location is moderate in comparison to the adjacent GP lane during the morning commute. GP person and vehicle throughput per lane both exceed HOV lane throughput on this section of roadway.

PM Peak Period. Unlike the morning peak in the southbound direction for this location, the northbound HOV lane outperforms the adjacent GP lanes during the evening peak period. It carries 59 percent more people in 16 percent fewer vehicles than the adjacent GP lane during the afternoon peak period.

I-90 Floating Bridge (see Figure 2-37)

AM Peak Period. Almost 30 percent of the westbound commuters utilize the center roadway, traveling in a mixture of transit, carpools, vanpools, and GP vehicles. Traffic volumes along the center roadway at this time of day represent 13 percent of all vehicles on I-90. On a per-lane basis, each HOV lane carries 40 percent fewer people and 77 percent fewer vehicles than an adjacent GP lane.

PM Peak Period. In the evening peak period, 32 percent of the people traveling eastbound use the center lanes in 20 percent of all vehicles traveling on the I-90 Bridge. Each HOV lane carries 29 percent fewer people in 63 percent fewer vehicles than an adjacent GP lane.

I-90 near Issaquah (see Figure 2-38)

HOV usage during both the commute periods is moderate. Overall, the HOV lane carries approximately 20 percent of all people in ten percent of all vehicles. On a per-lane basis, the HOV lane carries fewer people and vehicles than the adjacent GP lanes. This moderate usage of the HOV facility is primarily due to the low congestion level on I-90; however, note that HOV volumes in the AM are growing much more quickly than GP volumes as congestion in the GP lanes increases (see Figure 2-27, presented earlier).

SR 520 near Medina (see Figure 2-39)

AM Peak Period. The westbound HOV lane on SR 520—the only freeway HOV lane in Puget Sound that requires three or more occupants—carries 31 percent of all people in only 5 percent of all vehicles. Seventy-six percent of the people in the HOV lane are in buses.

PM Peak Period. Despite lower levels of transit service in the PM, the westbound HOV lane carries almost 30 percent of all people heading across Lake Washington in only 12 percent of the vehicles. Per lane, the HOV lane carries 26 percent fewer people in 73 percent fewer vehicles than either of the GP lanes adjacent to it.

SR 167 near Kent (see Figure 2-40)

AM Peak Period. HOV lane usage during the morning peak period is relatively low. (Peak HOV lane use occurs farther north near the interchange with I-405.) On a per-lane basis, the HOV lane carries 16 percent fewer people and 55 percent fewer vehicles than the adjacent GP lanes.

PM Peak Period. The southbound HOV usage during the afternoon peak period is slightly better than in the morning. About 35 percent of all people are carried in 22 percent of all vehicles, with an average of 2.3 people in each vehicle. Person throughput per lane is roughly equal for both the GP and HOV lanes at this location, but the HOV lane serves only about half the vehicle volume.

AM Peak Period: Southbound **PM Peak Period: Northbound**

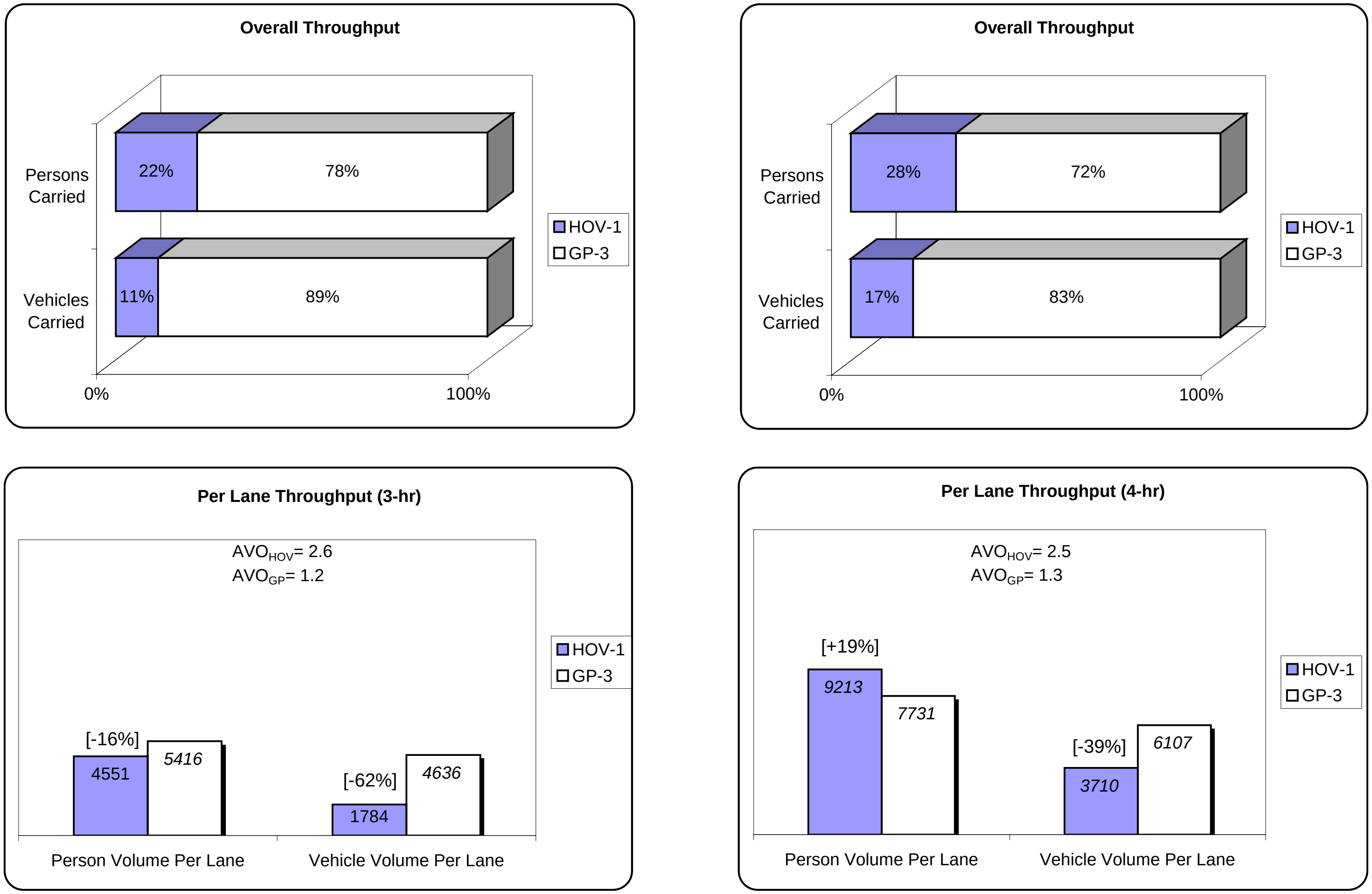


Figure 2-30. GP vs. HOV Throughput Comparison (2002): 1-5 near South Everett

AM Peak Period: Southbound **PM Peak Period: Northbound**

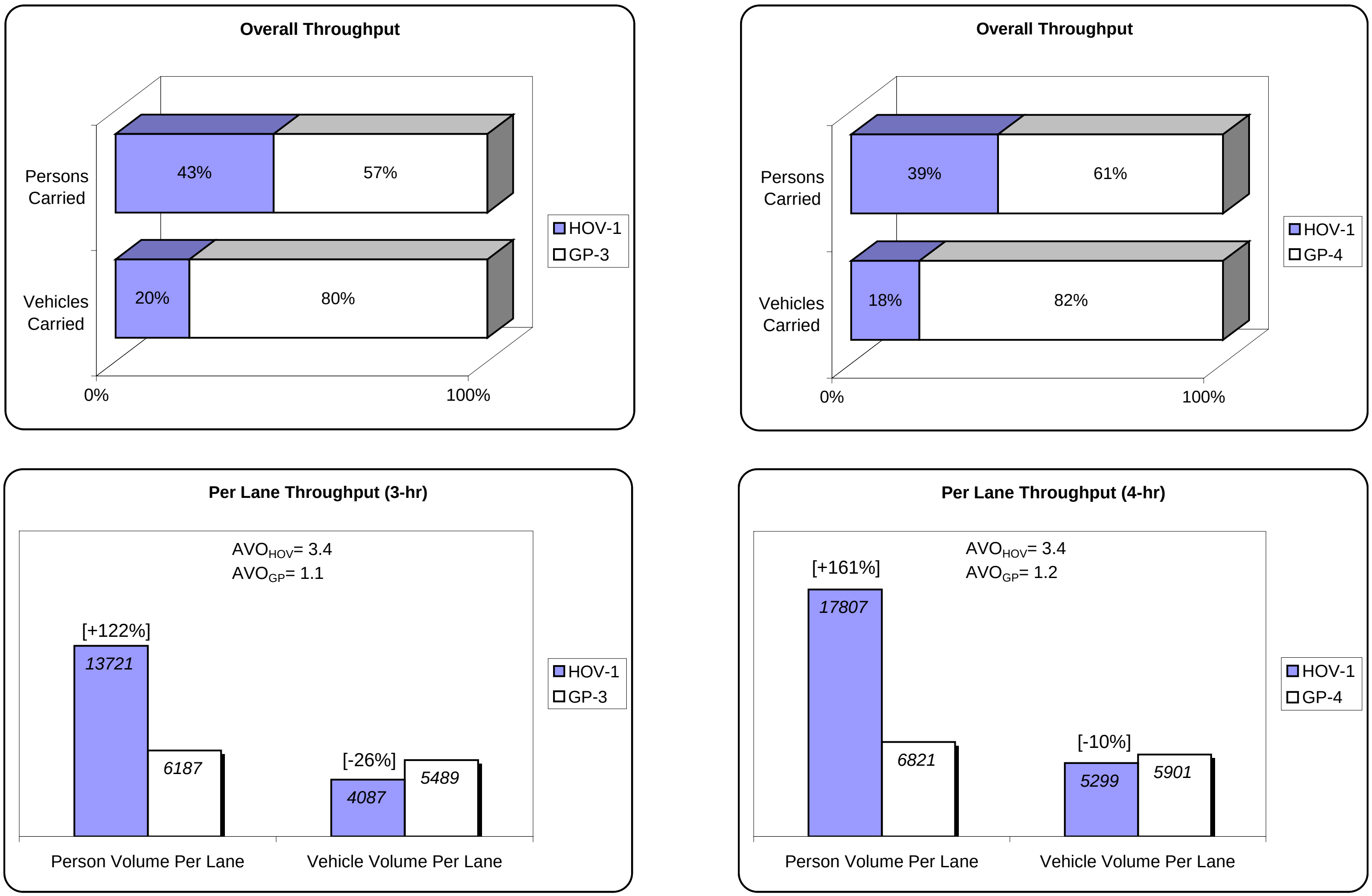


Figure 2-31. GP vs. HOV Throughput Comparison (2002): 1-5 near Northgate

AM Peak Period: Northbound

PM Peak Period: Southbound

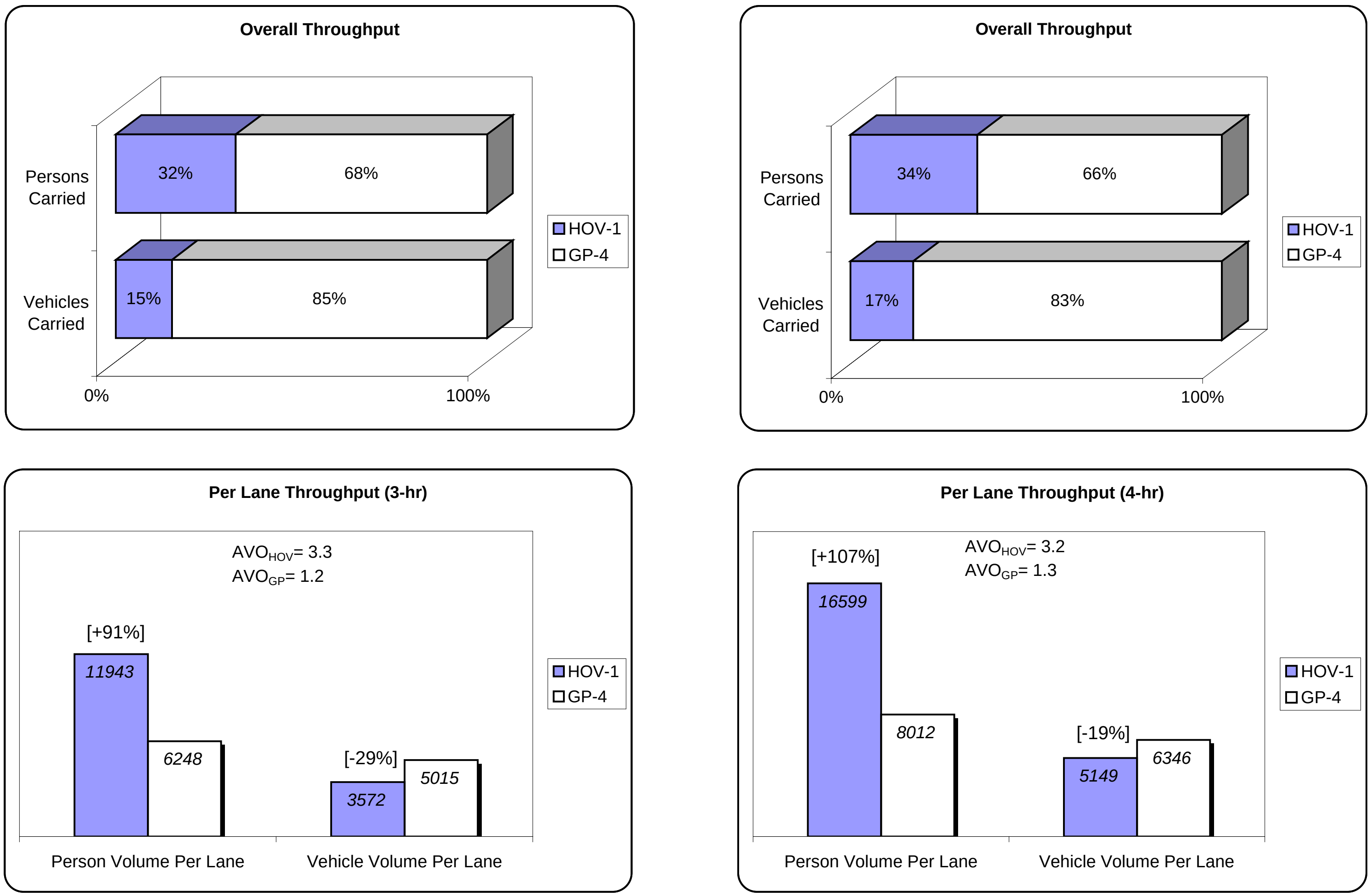
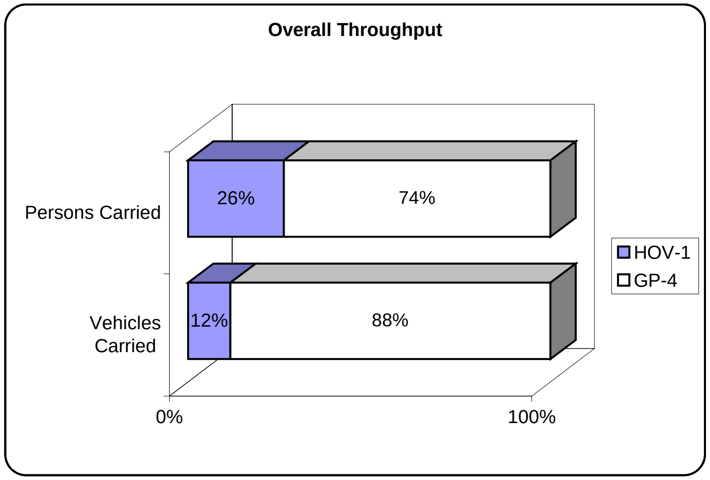
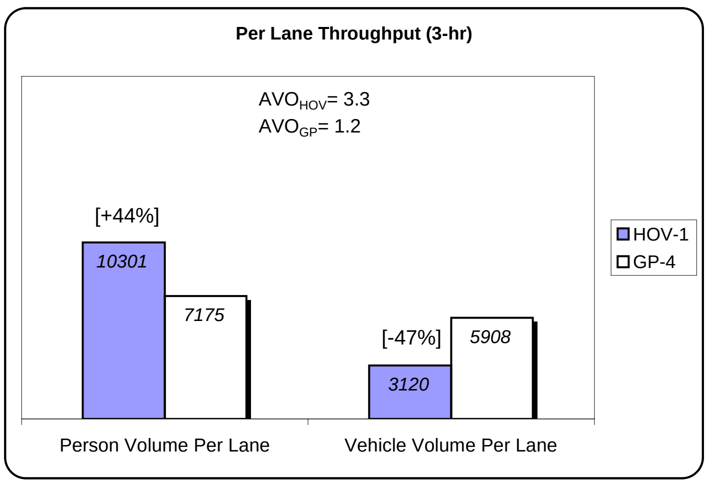


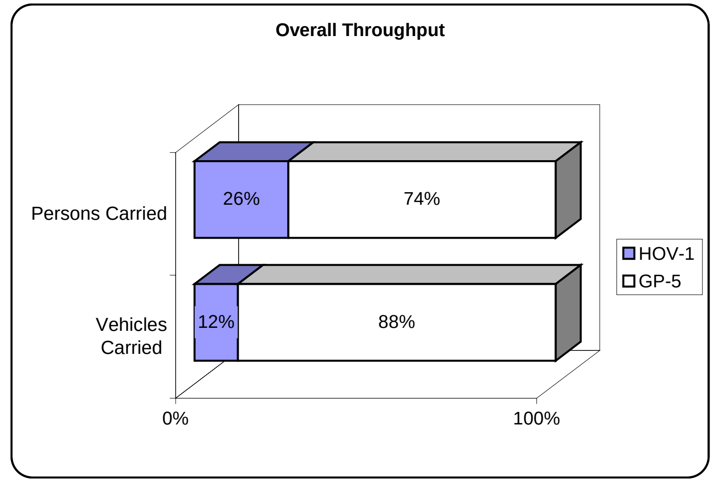
Figure 2-32. GP vs. HOV Throughput Comparison (2002): 1-5 South of Seattle CBD

AM Peak Period: Northbound





PM Peak Period: Southbound



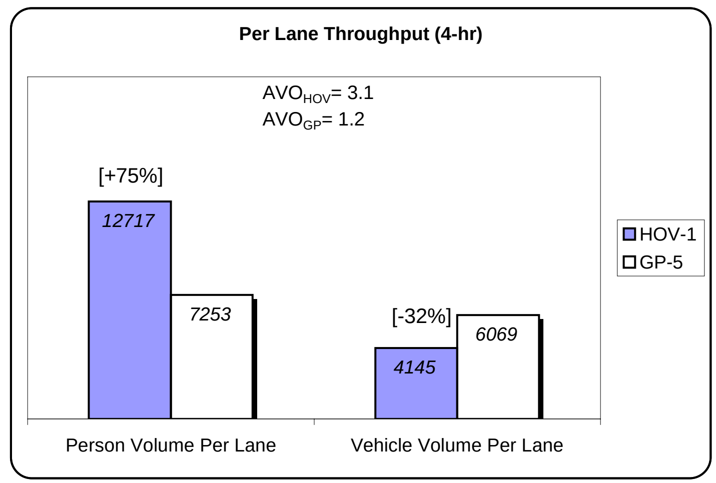


Figure 2-33. GP vs. HOV Throughput Comparison (2002): 1-5 Southcenter

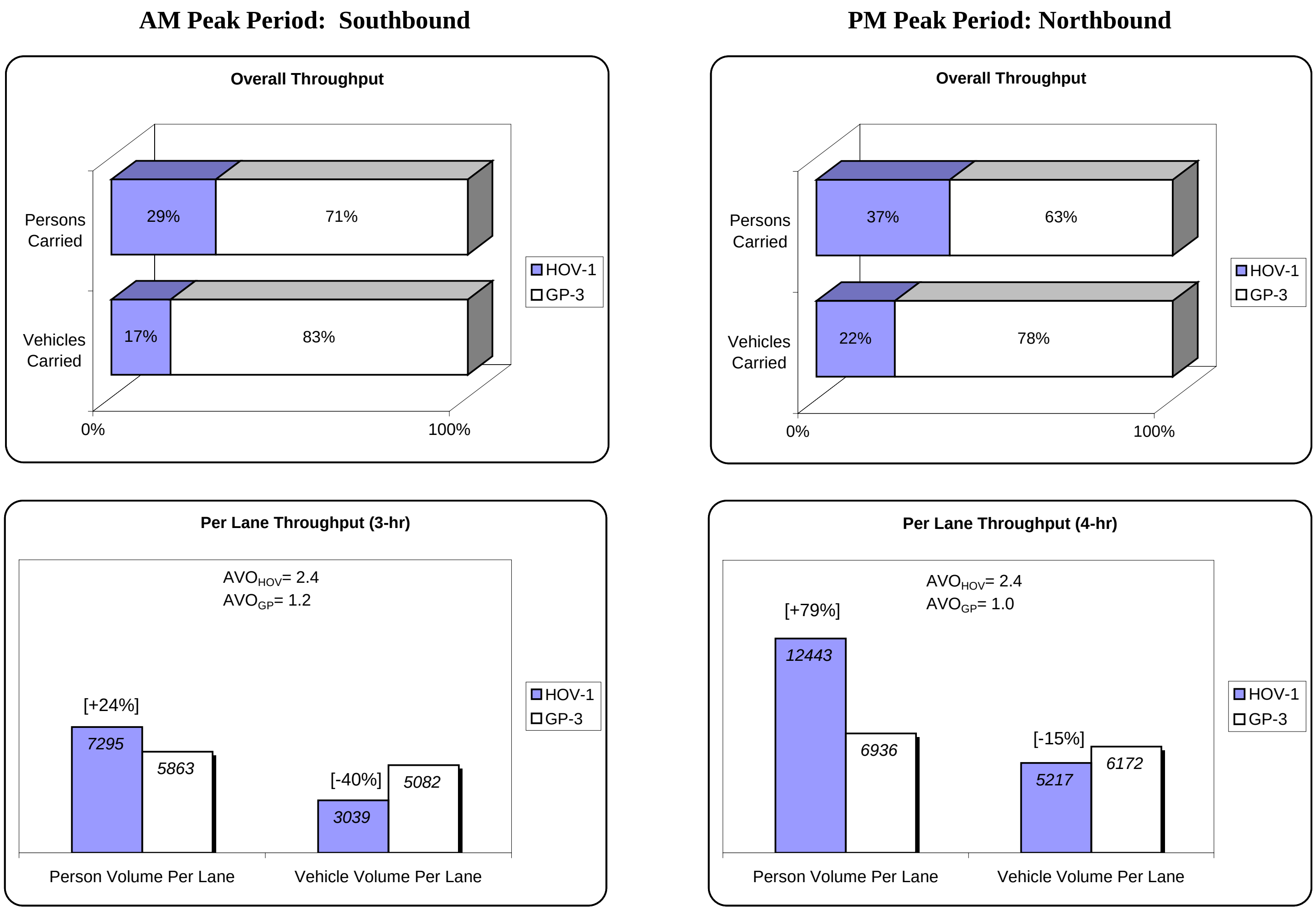


Figure 2-34. GP vs. HOV Throughput Comparison (2002) I-405 near Kirkland

AM Peak Period: Northbound | **PM Peak Period: Southbound**

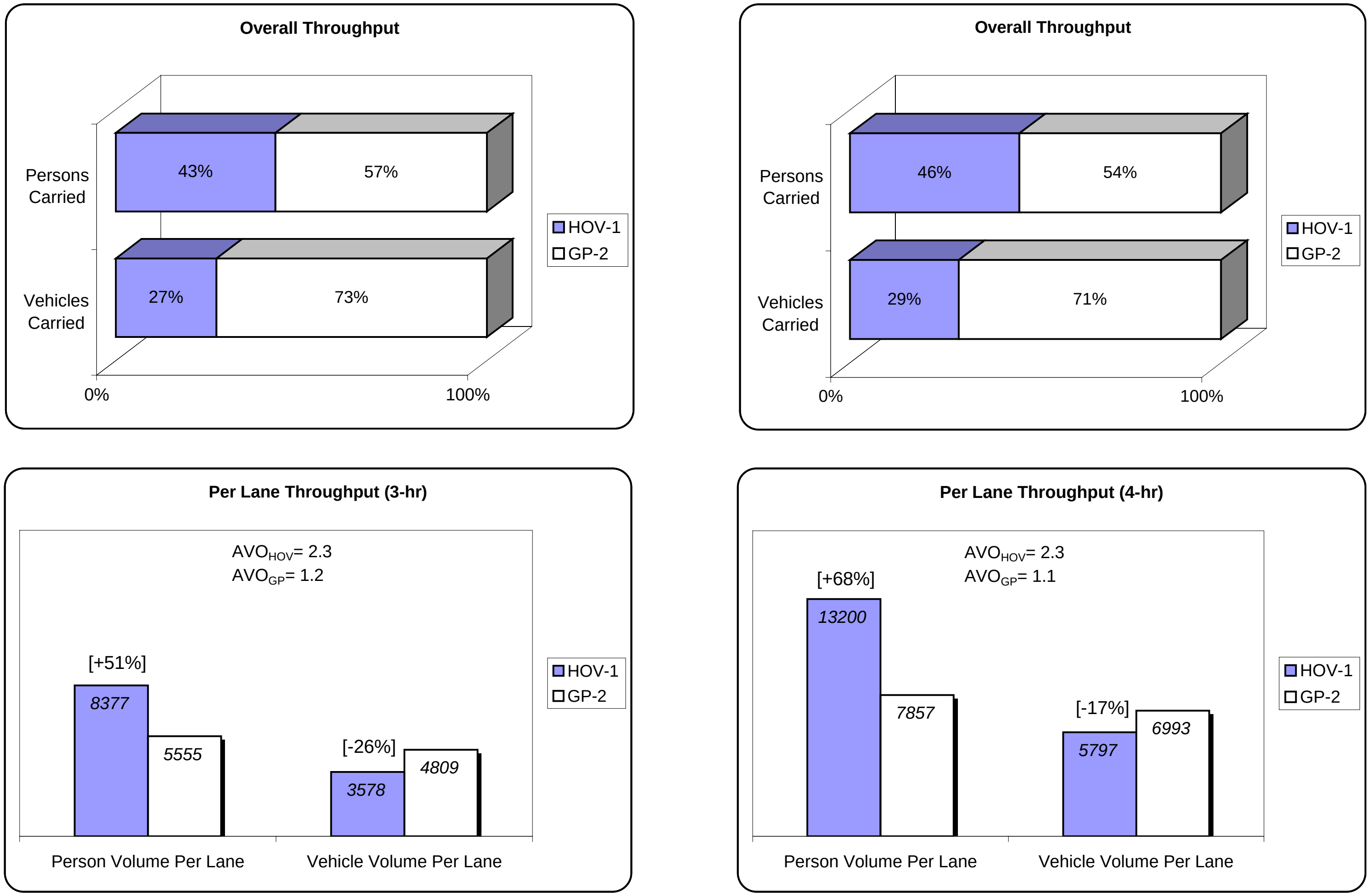


Figure 2-35. GP vs HOV Throughput Comparison (2002): I-405 near Newcastle

AM Peak Period: Southbound | **PM Peak Period: Northbound**

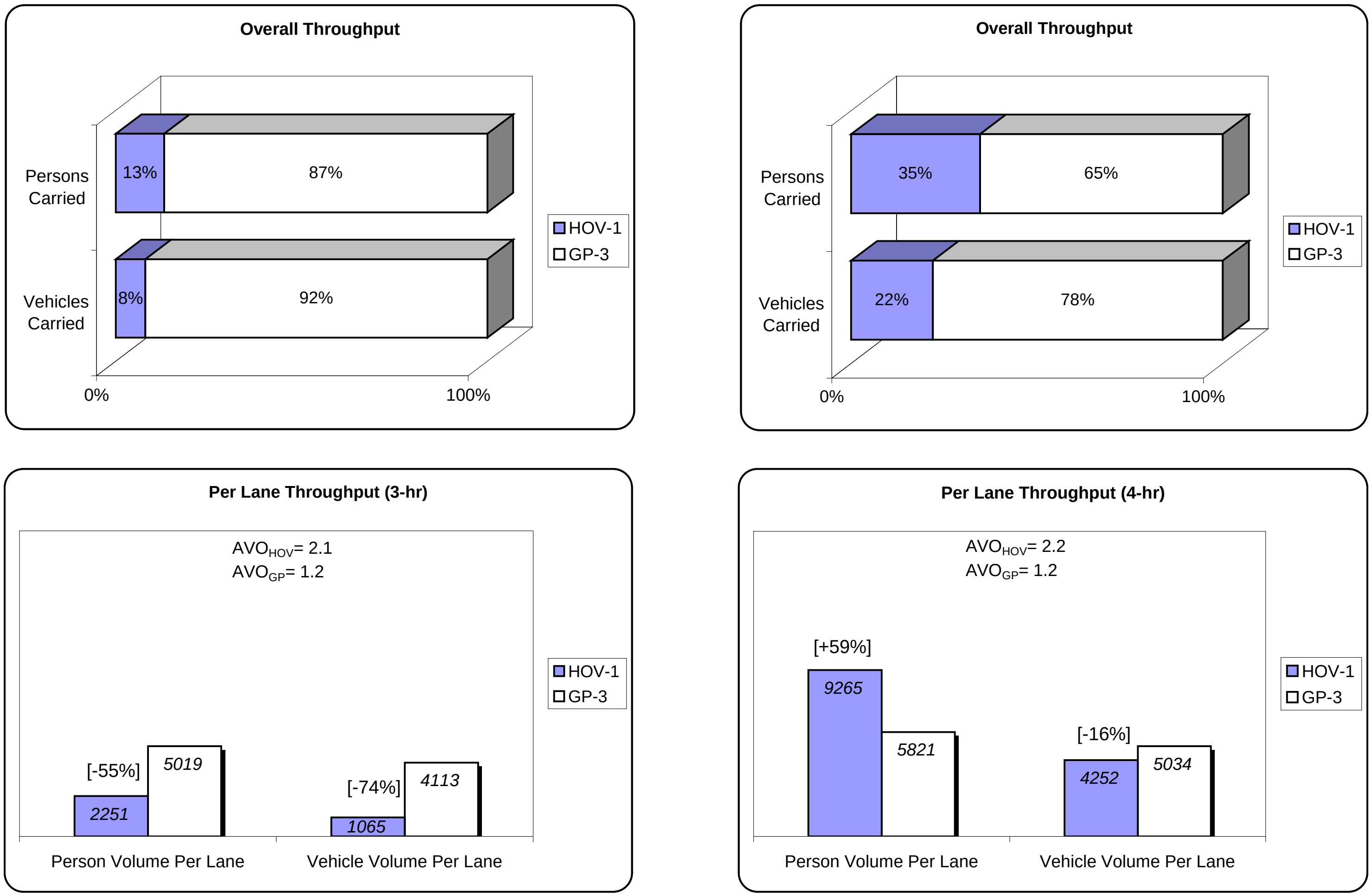


Figure 2-36. GP vs. HOV Throughput Comparison (2002): 1-405 near Southcenter

AM Peak Period: Westbound | **PM Peak Period: Eastbound**

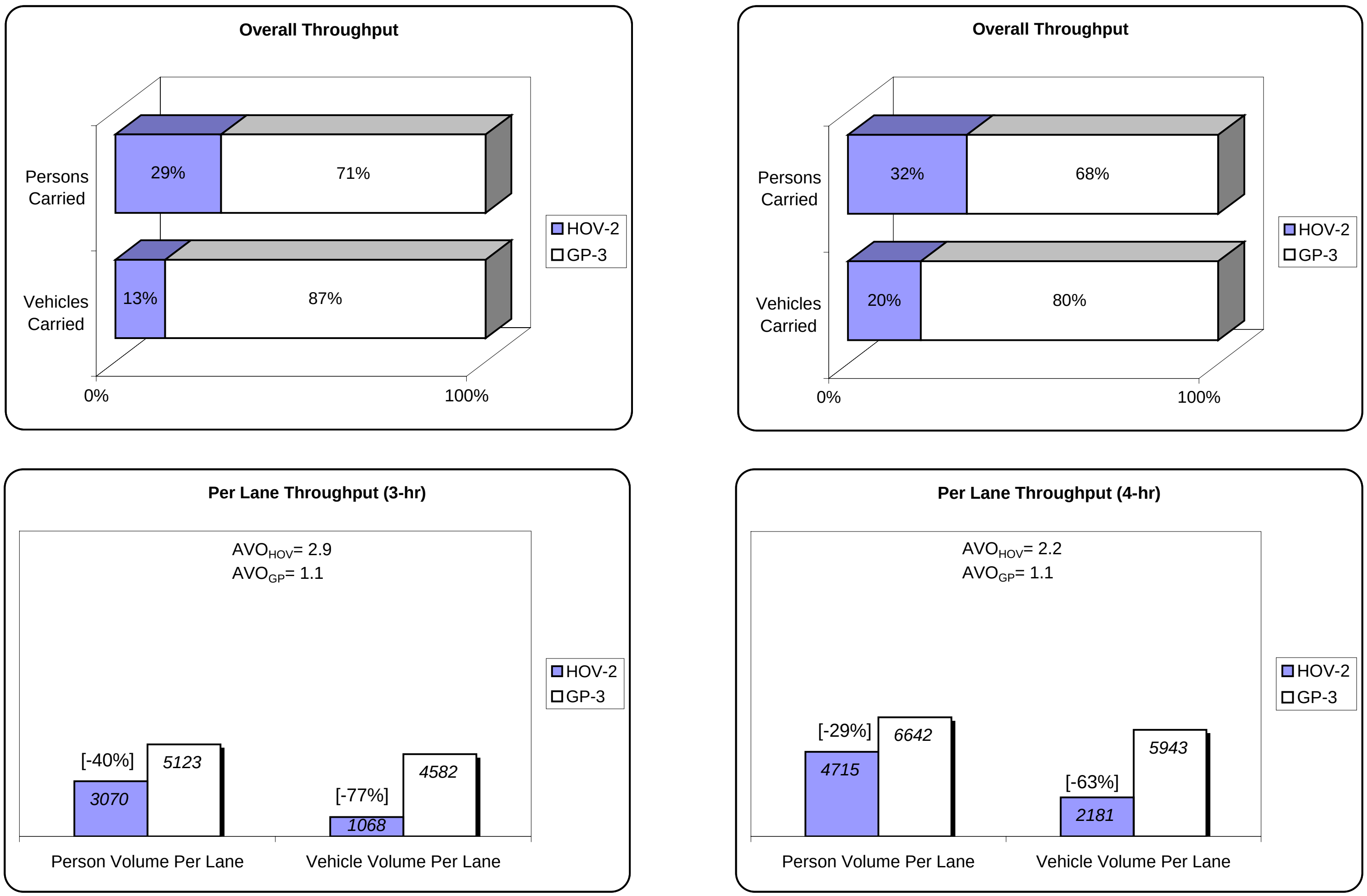


Figure 2-37. GP vs. HOV Throughput Comparison (2002): I-90 Floating Bridge

AM Peak Period: Westbound | **PM Peak Period: Eastbound**

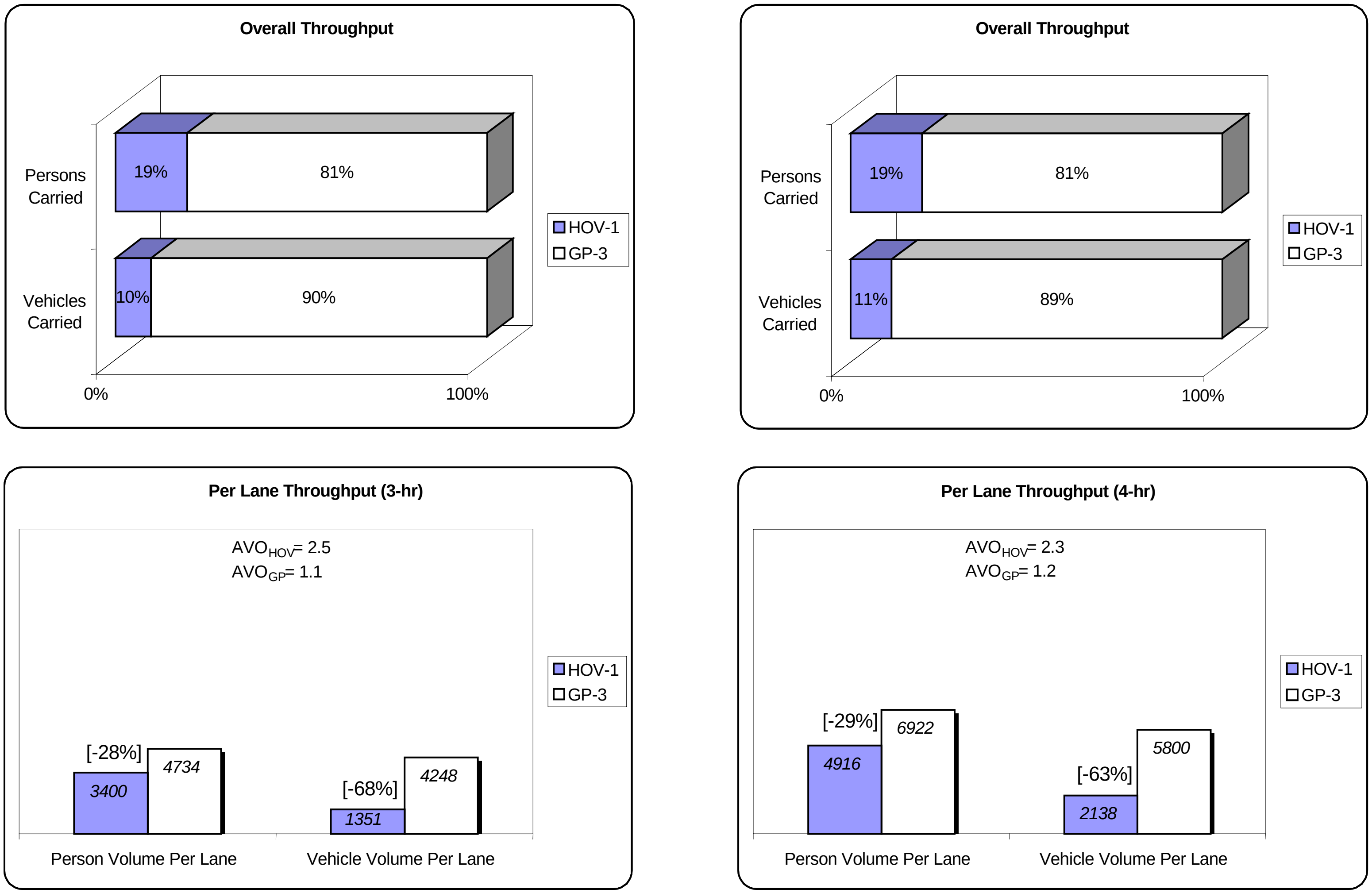
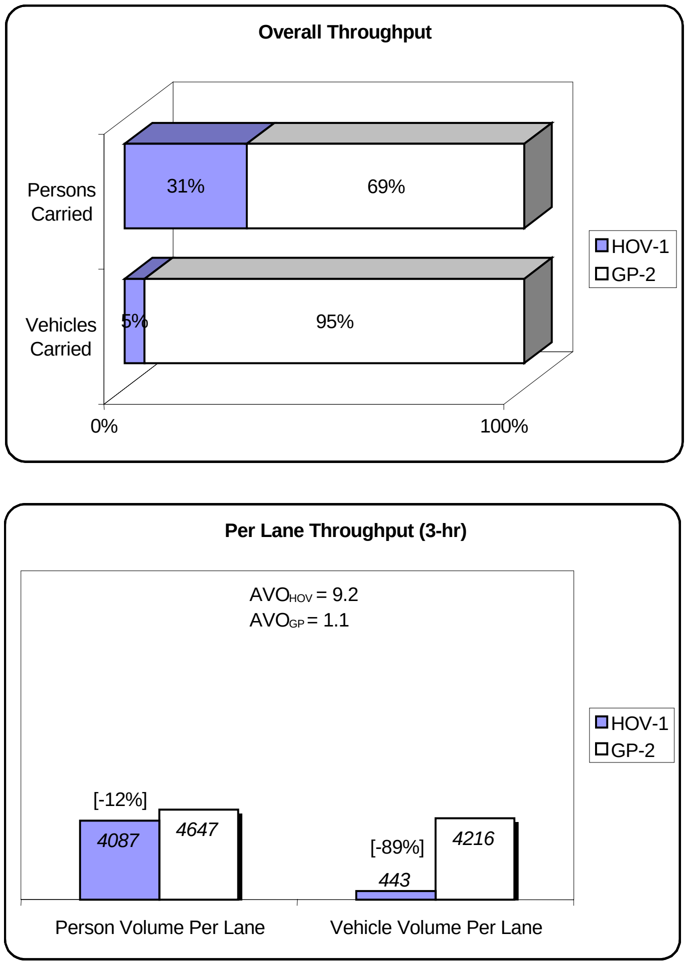


Figure 2-38. GP vs. HOV Throughput Comparison (2002): 1-90 near Issaquah

AM Peak Period:



PM Peak Period: Westbound

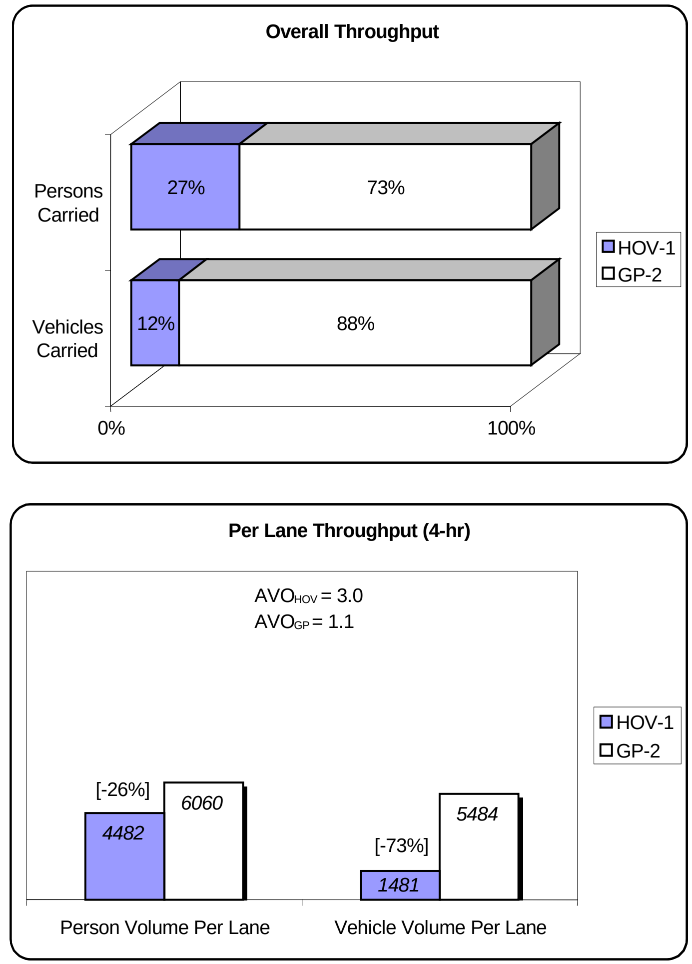


Figure 2-39. GP vs. HOV Throughput Comparison (2002): SR 520 near Median

AM Peak Period: Northbound **PM Peak Period: Southbound**

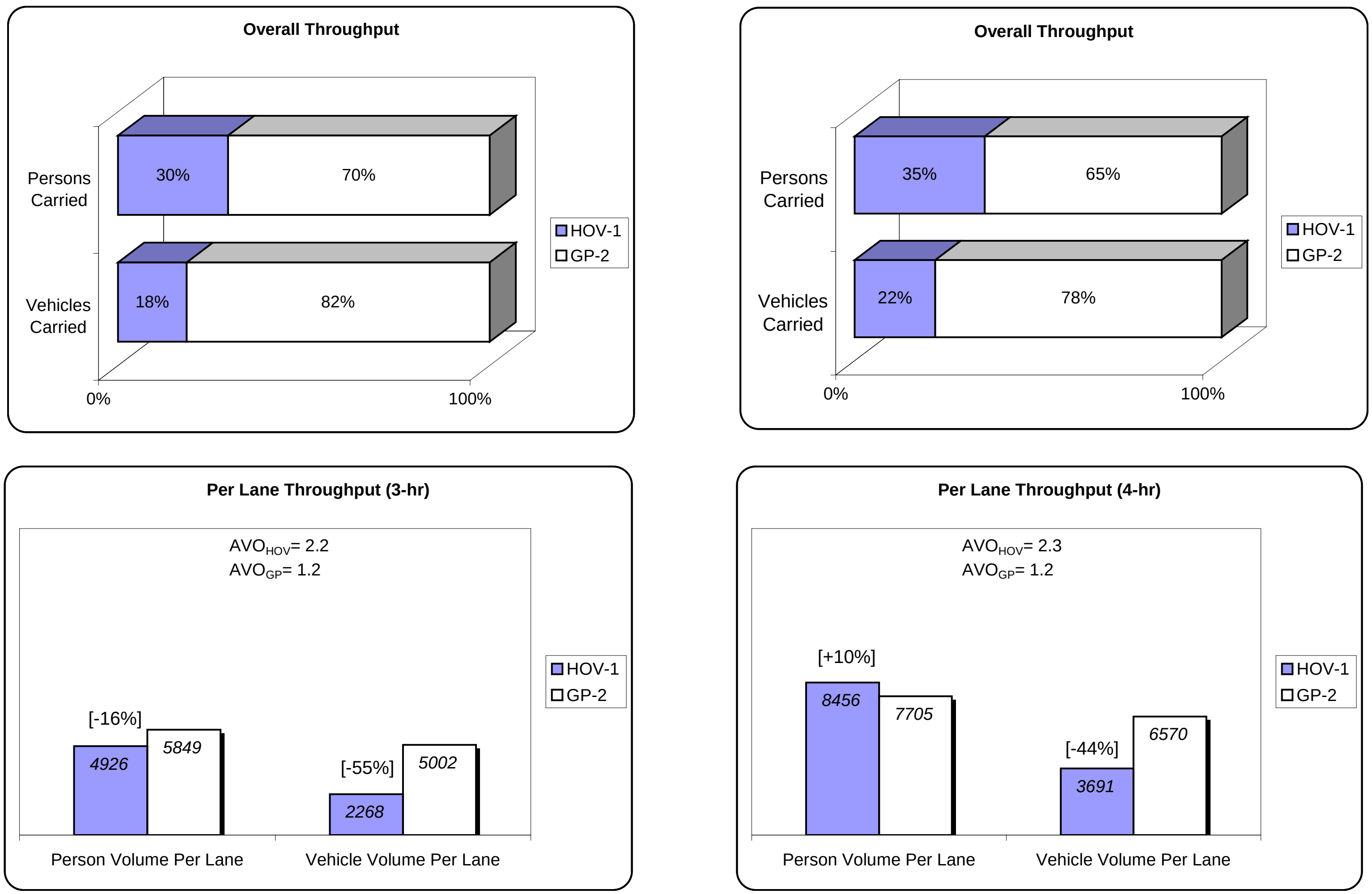


Figure 2-40. GP vs. HOV Throughput Comparison (2002): SR 167 near Kent

CHAPTER 3. SPEED RELIABILITY AND TRAVEL

This chapter presents the corridor-wide and site-specific operational performance of HOV facilities. 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 gauge whether HOV facilities are offering users faster travel speed and a more reliable trip than the GP lanes, HOV operational performance is measured in terms of speed, reliability, congestion patterns and travel time.

The purpose of these measures is to describe the following:

- The HOV lane travel speeds that can be expected 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 45 mph).
- 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.

The results of the operational performance analysis allow us to identify "problems" that can then be examined in more detail. When problems occur it is important to understand 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 lanes, HOV traffic often slows down because drivers are uncomfortable with traveling at 55 mph so close to stopped traffic. This is called "lane friction." The fact that HOV vehicles slow down under these conditions improves safety as well as driver comfort, and should not necessarily be viewed as a “bad” outcome, even if that means the HOV lanes operate below the 45 mph standard. Meanwhile, the geometric improvements required to limit friction slow downs are very expensive and create their own operational difficulties.

Another concern is how incidents affect HOV lane operations. This requires determining whether incidents physically block the HOV lane or whether they 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 on vehicle speeds, particularly when steep grades prevent buses from maintaining desired speeds.

Last, congestion often occurs where HOV facilities merge with GP lanes as GP traffic merges into the HOV lane, or where vehicles exit the HOV lane by weaving through congested GP lanes. Examples of merge-related congestion in 2002 are on I-405 near SR 522 and on I-405 at SR 167, although this phenomenon happens to a greater or lesser extent on all major HOV lanes in the region.

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 is assessed with four measures: 1) speed, 2) speed reliability, 3) level of traffic congestion, and 4) travel time savings. These measures are defined as follows:

Speed: 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, the 90th percentile weekday HOV lane speeds are estimated for a range of trip start times throughout an average 24-hour weekday. This measurement indicates that nine times out of ten, a vehicle will travel at a particular speed or faster.

Speed Reliability: In contrast to the 90th percentile average travel speed, this measurement indicates the percentage of weekdays that the average trip speed will be below 45 mph for a given trip start time. This measure indicates how frequently an HOV lane fails the 45 mph standard adopted for Puget Sound freeways.

Level of Traffic Congestion: To better understand how traffic conditions change as vehicles travel from one location to another on the HOV system, the researchers measure HOV lane congestion patterns at different mileposts along the corridor. The data presented are the average of conditions—specifically the average annual weekday lane occupancy data from WSDOT's loop detectors—measured for all 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.

Travel Time Savings: 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 by the public. It allows individual travelers to compare their own experiences against the reported statistics. 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 are estimated for a range of start times for trips that traverse the length of particular GP and HOV lanes in the analysis. 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. HOV Corridors Measured for Operational Performance

Corridors	Dir	From	To	Length (miles)
I-5 North of the Seattle CBD	NB	Northgate	112th St SW	15.1
	SB	SR 526 Interchange	Northgate	16.6
I-5 South of the Seattle CBD	NB	S 184th St	Columbian Way	10.3
	SB	S Spokane St	S 184th St	10.2
I-405 North of I-90	NB	I-90 Interchange	SR 524 Interchange	18.4
	SB	SR 524 Interchange	I-90 Interchange	18.4
I-405 South of I-90	NB	W Valley Hwy	I-90 Interchange	10.3
	SB	I-90 Interchange	Andover Park E	10.5
I-90	EB	Mt. Baker Tunnel	193rd PL SE	11.3
	WB	SR 900	23rd Ave S	12.4
SR 520	EB	I-405 Interchange	NE 51st St	3.9
	WB	W Lk Sammamish Pkwy	84th Ave NE	7.0
SR 167	NB	15th St NW	S 34th St	9.2
	SB	S 23rd St	43rd St NW	8.2

Reading the Speed and Reliability Graphs

Speed and reliability measures are illustrated in figures 3-3a through 3-9a in this report. For the corridor trips listed in Table 3-1, specific graphs were created to plot the 90th percentile average speed and the 45 mph speed reliability—that is, the percentage of time during which the average vehicle speed for that trip, at that start time, falls below an average speed of 45 mph.

Here are instructions for interpreting the graphics:

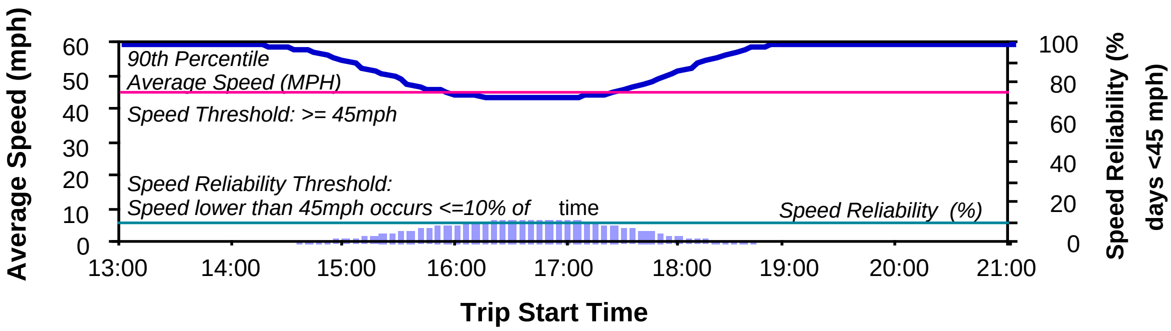


Figure 3-1. (Example) Average Weekday HOV Speed and Reliability Graph: I-5 North of the Seattle CBD, Northbound from NE 130th St. to Alderwood

Figure 3-1 is an 8-hour slice of a speed and reliability graph for the northbound HOV lane on I-5 near Northgate. 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 which runs from midnight to midnight. (In this example, however, only the hours from 1:00 PM to 9:00 PM are shown.) The line graph, near the top of the figure, represents the 90th percentile average speed for HOVs using I-5 from Northgate to Alderwood. It is measured with the left vertical axis. It indicates that HOV lane vehicles travel at a speed below 45 mph (about 44 mph) between 4:00 PM and 5:20 PM.

The column graph at the bottom of the figure is measured with the right vertical axis. It illustrates the reliability of this HOV trip. It shows the percentage of time travel speed for this trip (leaving at the time indicated) averages less than 45 mph. In this example, between 4:00 and 5:00 PM, the reliability of this trip is about 10 percent. This can be interpreted as a "a carpool on this route will average less than 45 mph once every two weeks when making this trip in the evening rush hour."

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 provide a visual representation of 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, from milepost to milepost. Horizontally, the graph shows the hours of measurement.

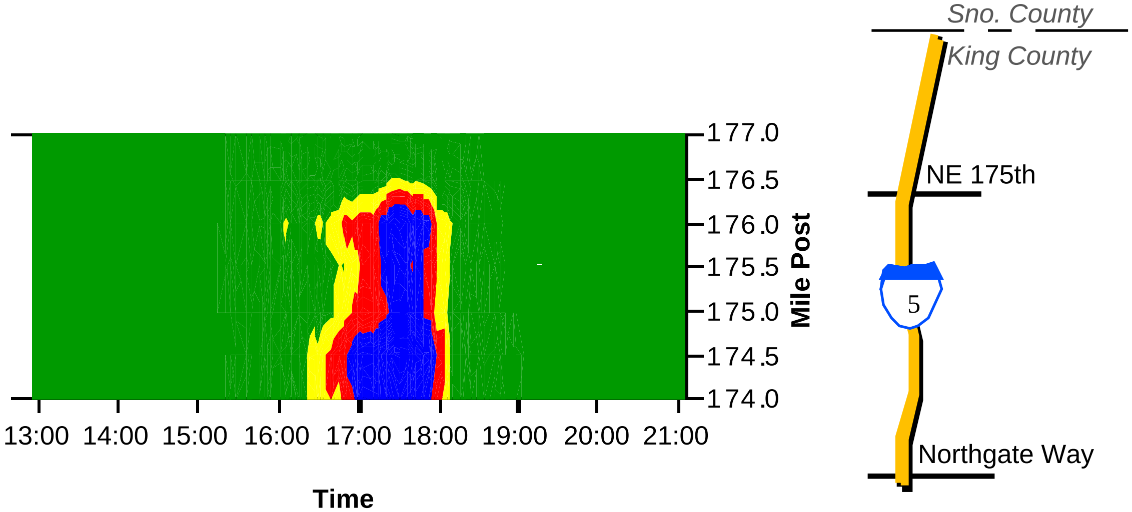


Figure 3-2. (Example) Corridor Contour Graph: I-5 North of Seattle CBD, Northbound from NE 137th St. to Alderwood

The colors on the profile represent congestion, measured in units of level of service:

- **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 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.

A map segment of the pertinent freeway corridor, including major cross-streets, is also provided to provide a means of reference for the exact location of the measured area.

In our example, Figure 3-2, the HOV segment shows that, on average, vehicles in the HOV lane experience heavy congestion from milepost 174 almost to milepost 176.5 from approximately 5:00 PM to 6:00 PM. Traffic is free flowing for the rest of the day.

SPEED AND RELIABILITY RESULTS BY CORRIDOR

Statistics and graphics produced in this section are based on data collected by WSDOT throughout 2002. In most cases, the presented data are based on all weekdays within a given year. 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, 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 (See Figures 3-3a and 3-3b)

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 northbound trip from Northgate to 112th St SW, HOV lane vehicle travel can average less than 45 mph as often as 20 percent of the time during the evening commutes. The contour map (see Figure3-3b) indicates that the northbound congestion is mostly limited to the corridor 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. HOV traffic also slows near the I-5/I-405 interchange between 3:00 PM to 6:00 PM.

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 40 percent of the time. The contour map shows routine congestion near SR 104, and the HOV lane remains relatively congested from the I-5/I-405 interchange through the Northgate area as vehicles approach the entrance of the I-5 express lanes (see Figure 3-3b). HOV volumes are considerable during the morning commute (1,500 VPLPH near the Express Lanes entrance) as traffic moves toward downtown Seattle. While HOV volumes are high, they are not sufficient enough 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 lane friction resulting from the adjacent slow moving GP traffic.

I-5 South of the Seattle CBD (see Figures 3-4a and 3-4b)

Northbound (see Figures 3-4a and 3-4b)

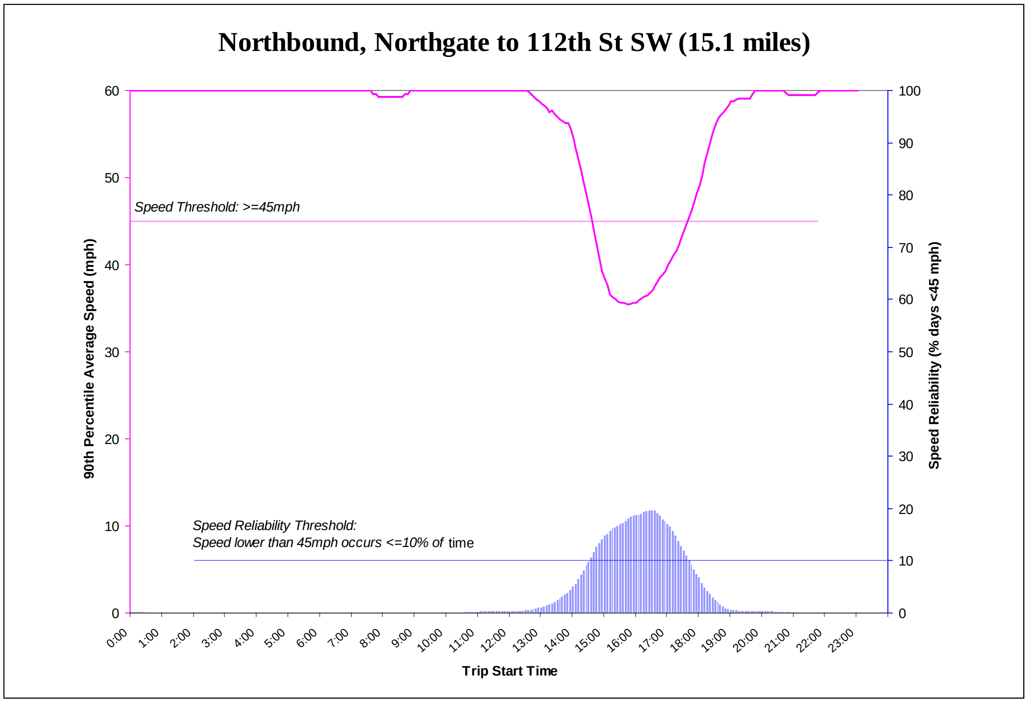
The 90th percentile speed for HOV vehicles drops below 45 mph during the AM peak period between 6:30 AM and 8:00 AM; this heavy congestion occurs approximately once a week (see Figure 3-4a). The contour map shows that routine morning congestion northbound extends from Boeing Field to the end of the study section at the I-90 interchange (see Figure 3-4b). HOV lane congestion on this ending segment is frequent, but because of the normally "good" performance of the lane farther south, it meets the 45 mph standard most of the time.

Unlike the merge congestion at the northern end of this segment associated with the end of the HOV facility, HOV lane slowdowns on the southern end are caused in part by friction between HOV and GP lane traffic. This is exacerbated by the loss of freeway capacity as the outside, (right) GP lane becomes an exit-only lane through the West Seattle Freeway interchange.

HOV lane traffic normally flows freely much of the rest of the day, although some slow downs occur from 3:00 PM to 6:00 PM. Northbound afternoon congestion is not as significant as morning congestion. However, given that this is an "off peak" movement, it is still substantial. One source of afternoon congestion is the spillback from the express lanes entrance. The HOV lane terminates near Yesler Way so that all traffic may enter the express lanes in the afternoon. The congestion level shown in the contour map evidences the severe impact of this situation.

Southbound

The HOV lane southbound out of the Seattle CBD has traditionally been the poorest performing of the area's HOV facilities. Figure 3-4a shows that HOV lane travel southbound in the PM peak period can slow to an average vehicle speed between 35 and 45 mph more than 30 percent of the time. Much of the significant slowdown is due to the effects of the Southcenter Hill (see Figure 3-4b.) For most of 2002, this location has three attributes which slowed HOV travel. First, the effects of merging/diverging traffic with the I-405 interchange frequently cause HOV's to slow. Second, the Southcenter Hill itself is a long, steep grade—steep enough that many fully loaded transit vehicles that have been slowed by merge/diverge congestion at the base of the hill are not able to accelerate back to the speed limit as they climb the hill. Lastly, until the last quarter of 2002 when a construction project extending the HOV lane was completed, the HOV lane ended at the top of the Southcenter Hill, at the same time that a GP lane was dropped. This reduction in total roadway capacity along with the GP/HOV merge diverge creates additional congestion at the top of the hill. Finally, not all HOV lane congestion on this route can be blamed on the Southcenter Hill, as can be seen in Figure 3-4b. 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. This congestion further reduces HOV lane performance.



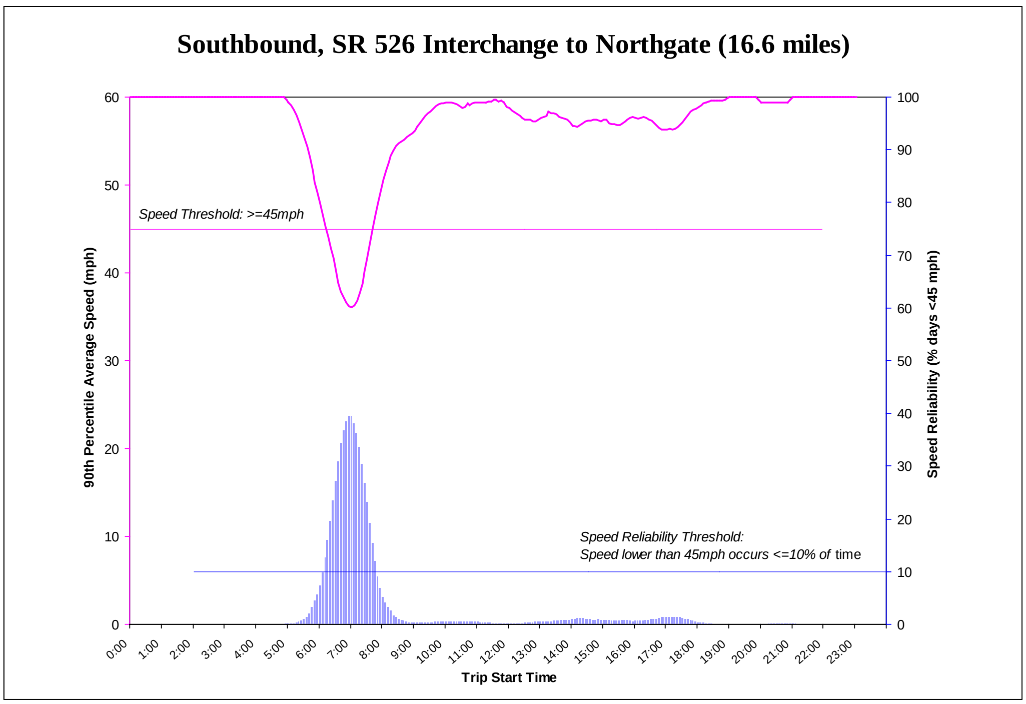


Figure 3-3a. Average Weekday HOV Speed and Reliability (2002):I-5 North of the Seattle CBD

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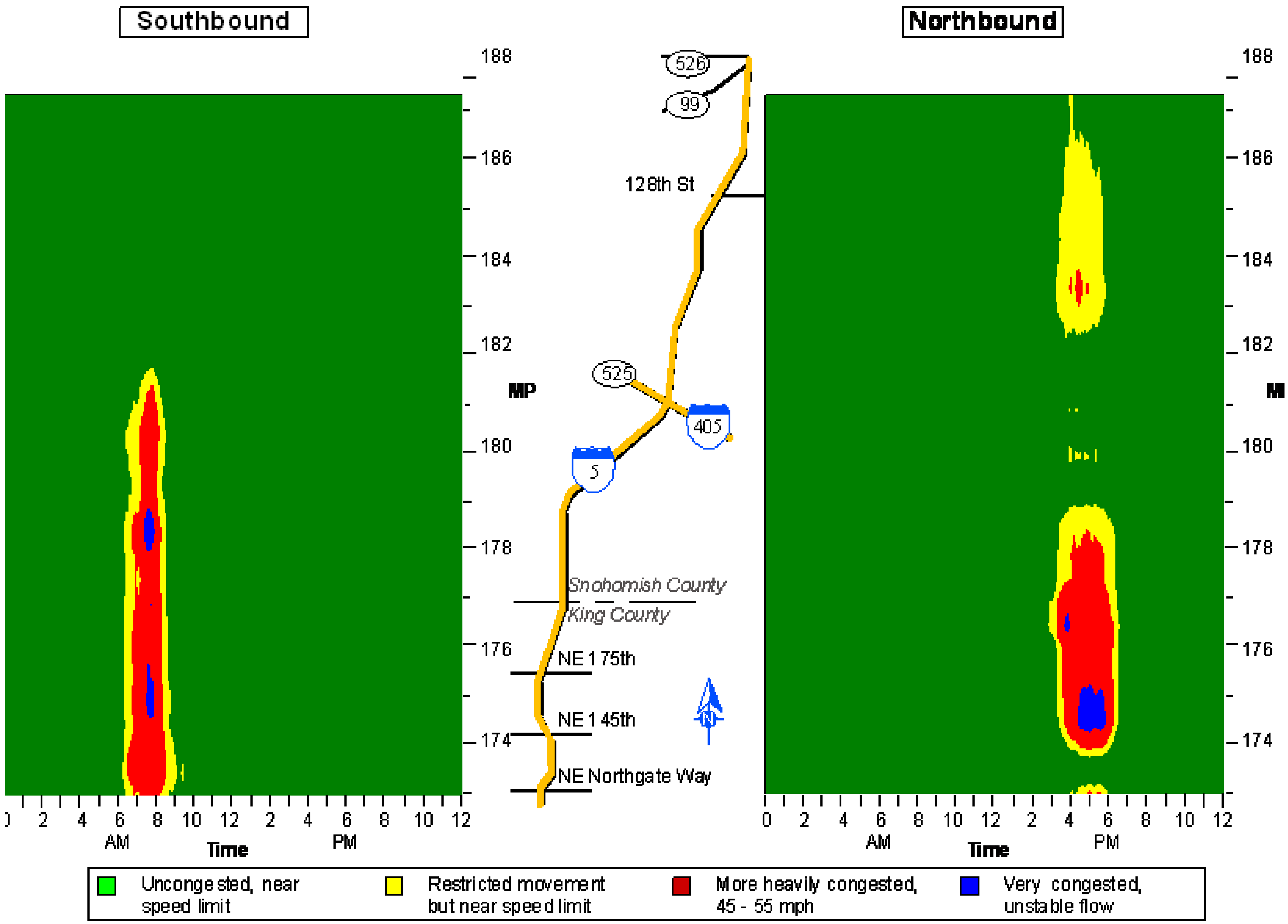
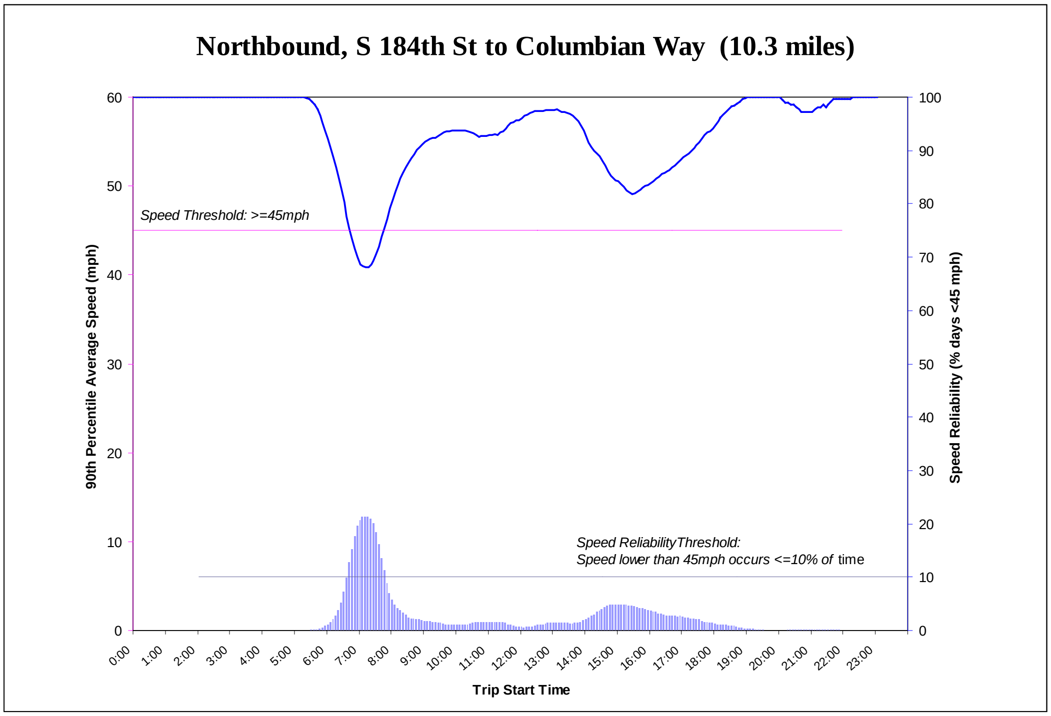


Figure 3-3b. 2002 Weekday Average HOV Traffic Profile: I-5 North of the Seattle CBD I-5 South of the Seattle CBD



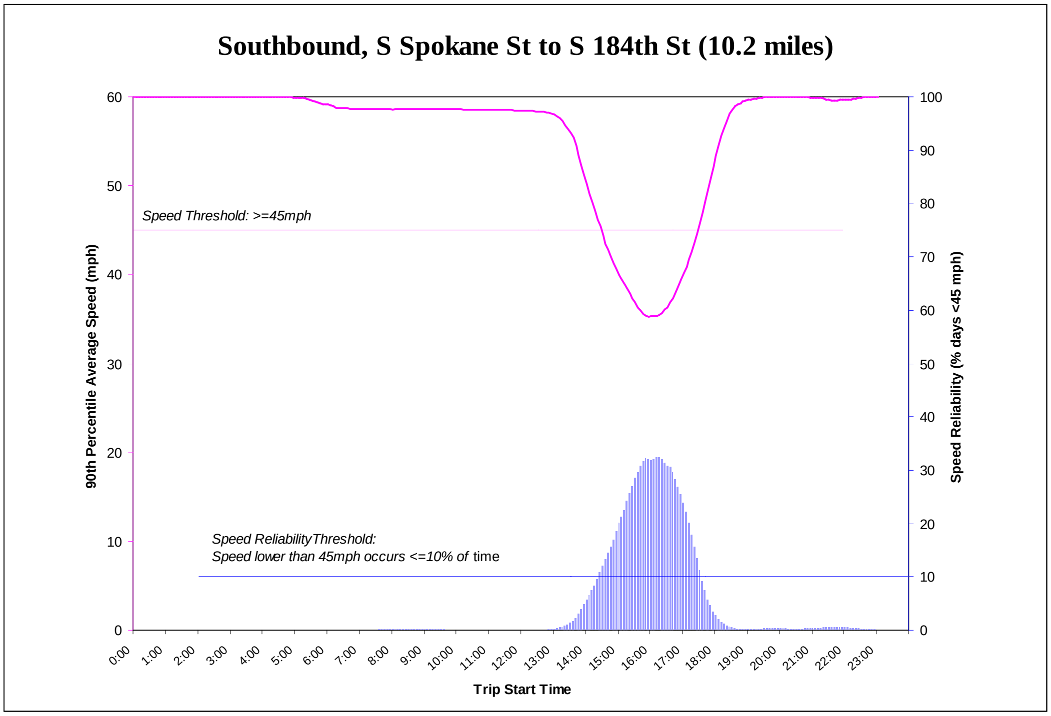


Figure 3-4a. Average Weekday HOV Speed and Reliability (2002):I-5 South of the Seattle CBD

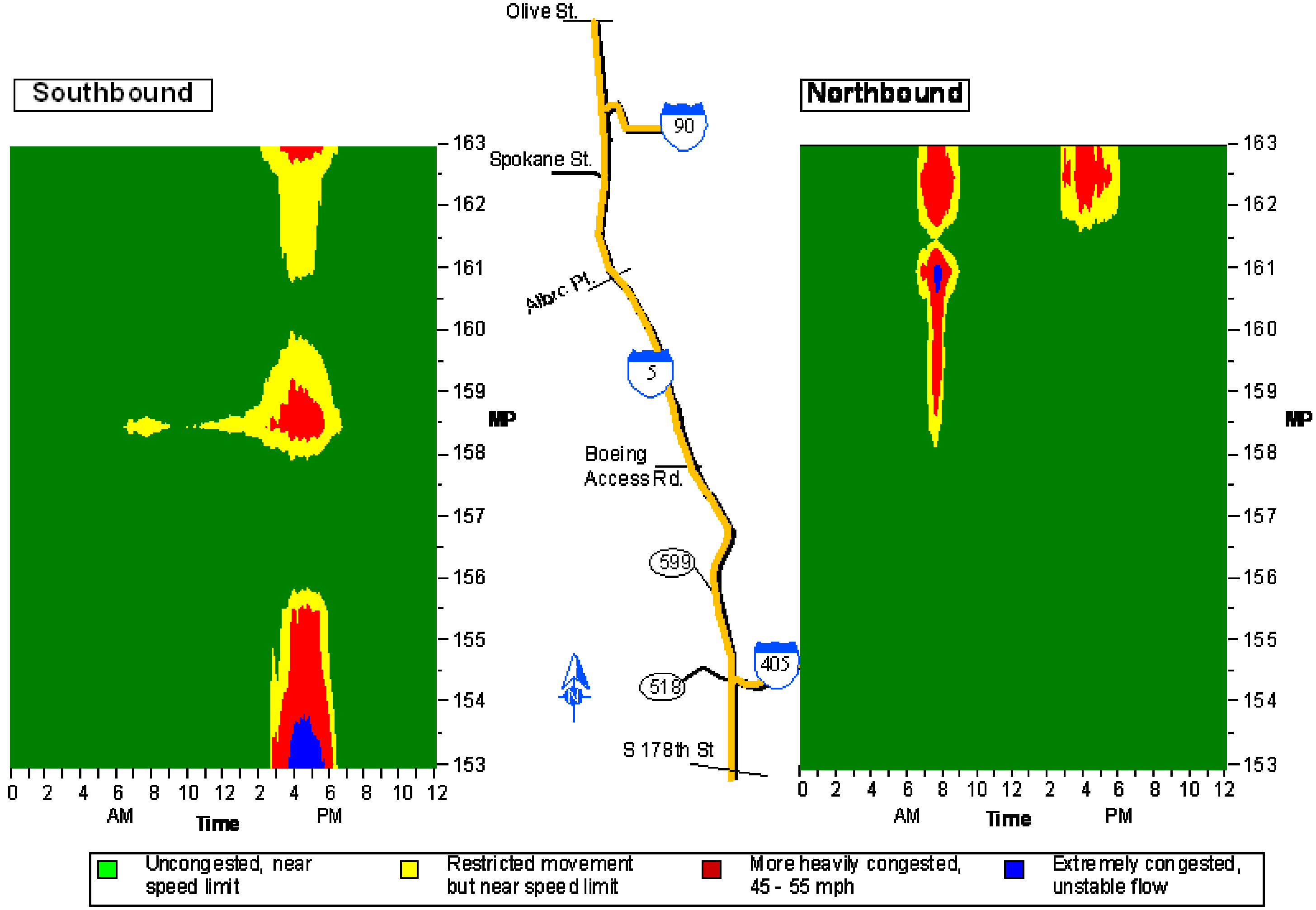


Figure 3-4b. 2002 Weekday Average HOV Traffic Profile: I-5 South of Seattle CBD

I-405 – North of I-90 (See Figures 3-5a-1, 3-5a-2 and 3-5b)

Two sets of measures were taken on this corridor in 2002. For the first three quarters, data collection occurred northbound on the 14.5 miles between 236th St SE and the I-90 Interchange, and southbound between 231st St SE to the I-90 Interchange. In the Fall of 2002, data collection was extended between the SR 527 interchange and the SR 524 interchange. Results are reported for both the entire year for the shorter distance, and for the longer corridor for just the fourth quarter, although the differences in corridor performance were relatively minor.

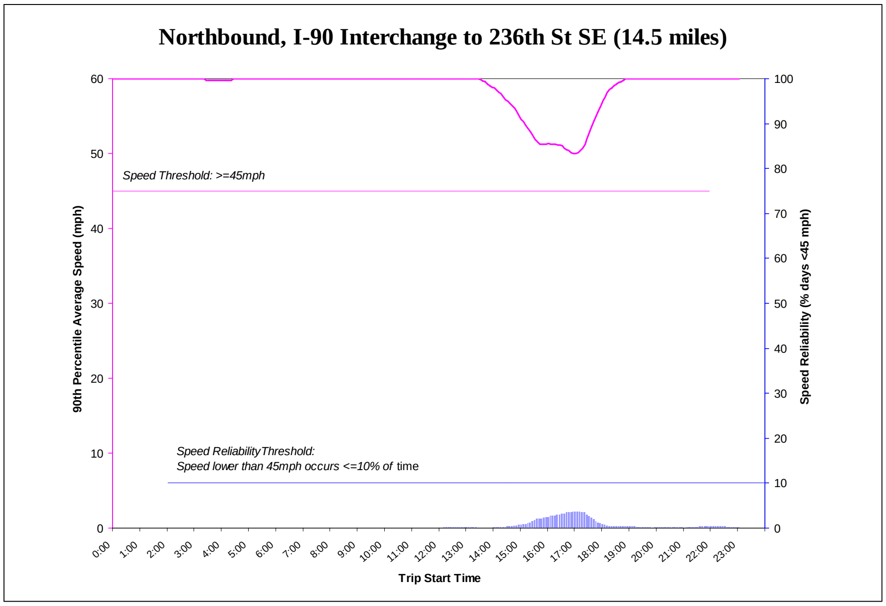
Northbound

Like most sections of the HOV lane system, this corridor's HOV lane operates relatively well during the day (see Figures 3-5a-1 and 3-5a-2). Although congestion is present between north of the SR 520 interchange and NE 85th (see Figure 3-5b), the northbound HOV lane vehicles travel at—or near—the speed limit throughout the day.

Southbound

Figures 3-5a-1, and 3-5a-2 reveal that the southbound HOV lane in this corridor also operates relatively well for most times during the day. The only significant routine southbound HOV lane congestion is near the Redmond/Kirkland interchanges at NE 85th and Totem Lake during the morning commute, and from the downtown Bellevue CBD tI-90 during the afternoon commute (see Figure 3-5b). At Totem Lake, much of the congestion is related to friction from the vehicles merging to or diverging from the HOV lanes to/from ramps at Totem Lake and at NE 85th.

In the evening, congestion backups develop at the I-90 interchange south of the Bellevue CBD as HOVs try to merge from the left-hand HOV lane to the right hand exits to I-90, and extend back to downtown Bellevue where on-ramp traffic trying to enter the HOV lanes exacerbates the congestion. Southbound HOV lane congestion near downtown Bellevue during the AM peak is rare.



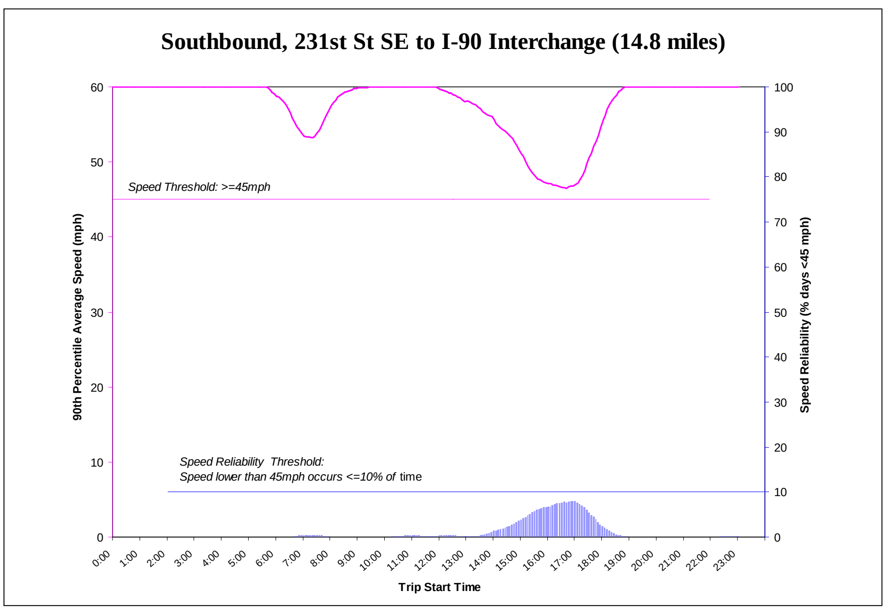
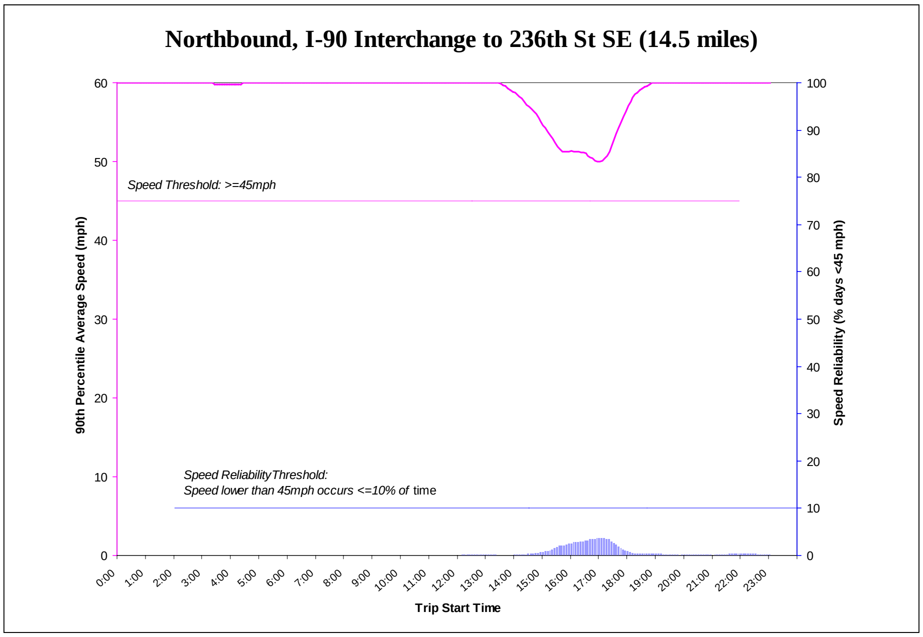


Figure 3-5a-1. Average Weekday HOV Speed and Reliability (2002): I-405 North of I-90 (12 month measure)



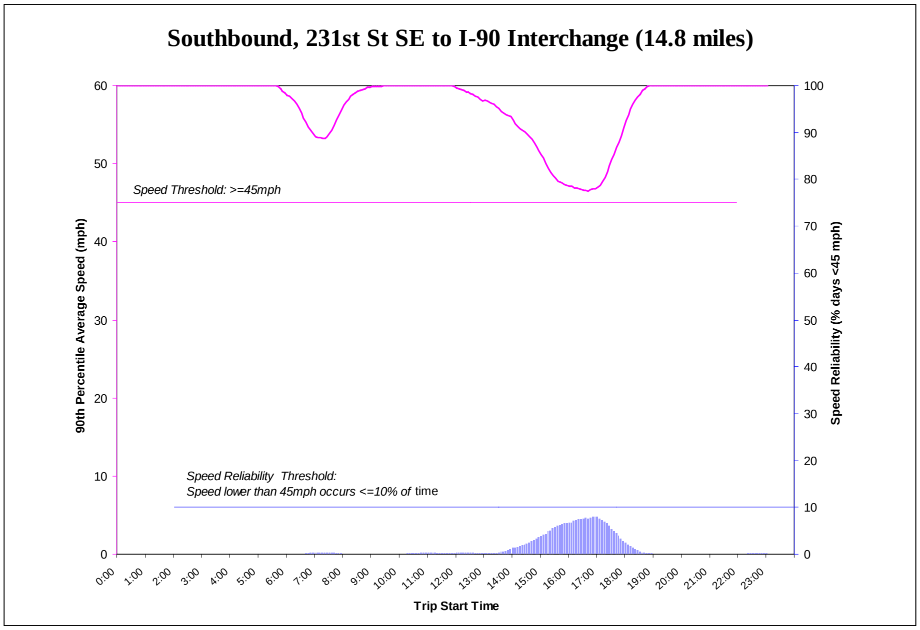


Figure 3-5a-2. Average Weekday HOV Speed and Reliability (2002): I-405 North of I-90 (4th quarter measure only)

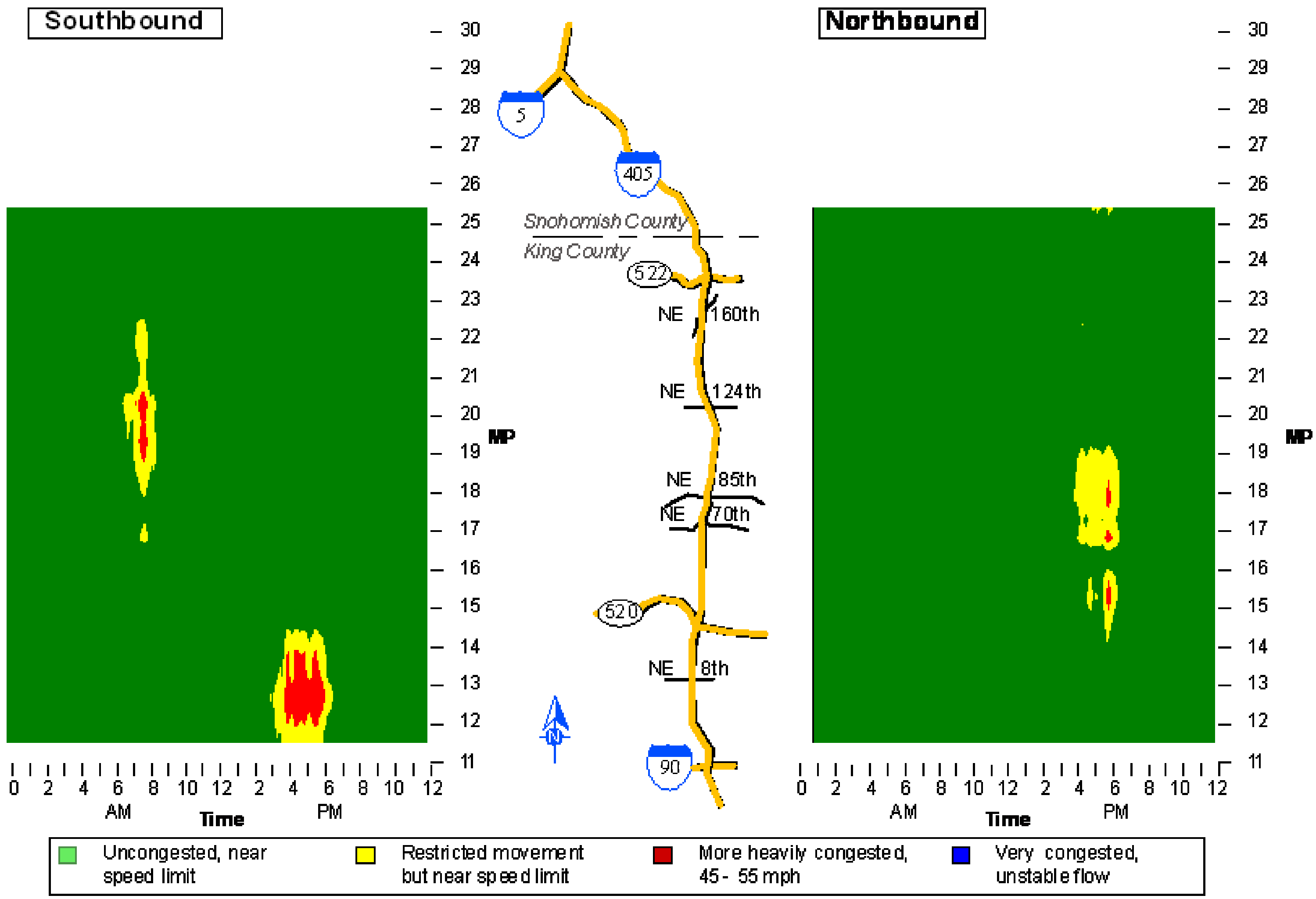


Figure 3-5b. 2002 Weekday Average HOV Traffic Profile: I-405 North of I-90

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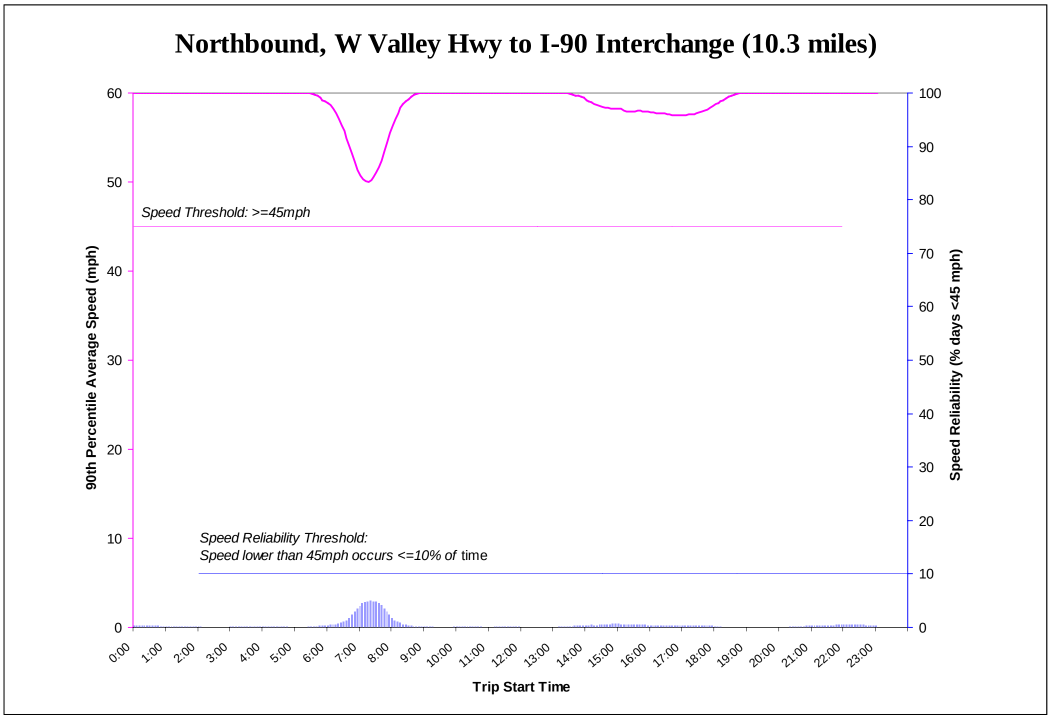
I-405 South of I-90 (See figures 3-6a and 3-6b)

Northbound

The northbound stretch of I-405 from Renton to Factoria is one of the most congested GP facilities in the Puget Sound. However, the GP congestion does not appear to significantly impede the HOV lane's performance. Figure 3-6a shows that while heavy morning congestion occurs daily in the GP lane, the HOV lanes perform as intended. Figure 3-6b shows that this congestion does cause minor slowing in the HOV lanes from the Kennydale hill to immediately south of Coal Creek Parkway during the AM peak period. This minor but consistent slowing in the HOV lane is caused primarily by friction between HOV lane traffic and the slower moving adjacent GP lane. Figure 3-6b also shows the congestion in the HOV lane associated with the northbound approach to the SR 167 interchange in the afternoon.

Southbound

The southbound HOV lanes on this section of freeway are more congested than the northbound HOV lanes. However, the HOV vehicle speed is still above 45 mph throughout the day (see Figure 3-6a). Routine congestion mainly occurs at sections of the southbound roadway from downtown Bellevue to the Kennydale hill, and from Sunset Blvd to just north of the SR 167/I-405 Interchange (see Figure 3-6b).



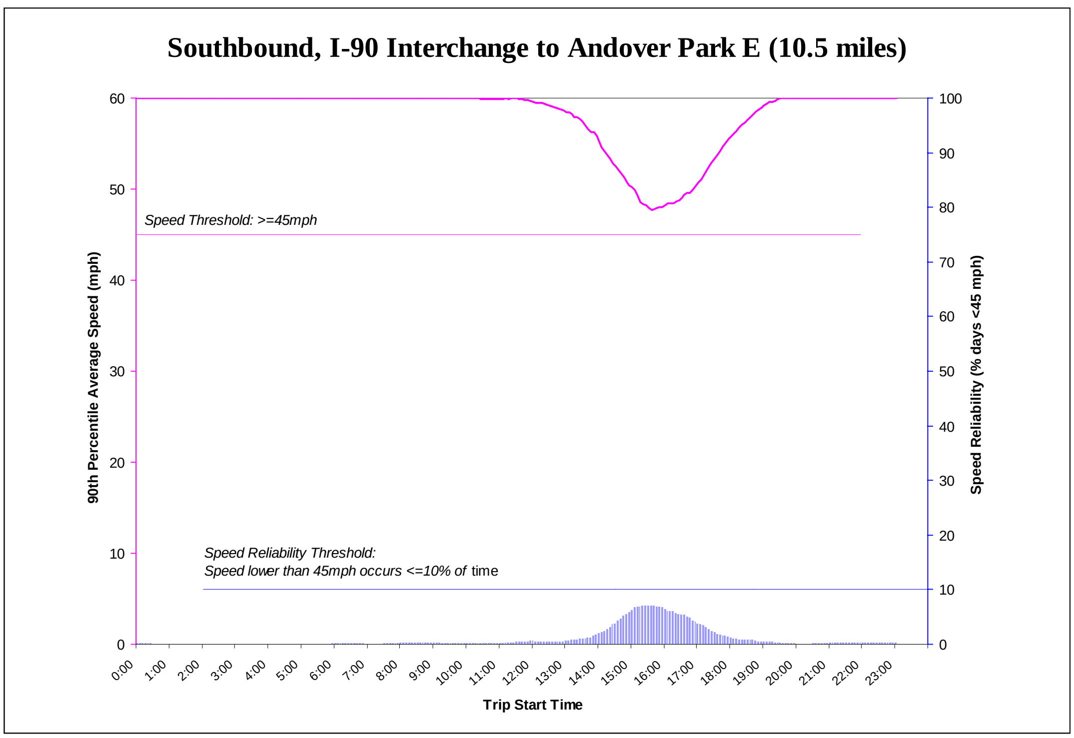


Figure 3-6a. Average Weekday HOV Speed and Reliability (2002):I-405 South of I-90

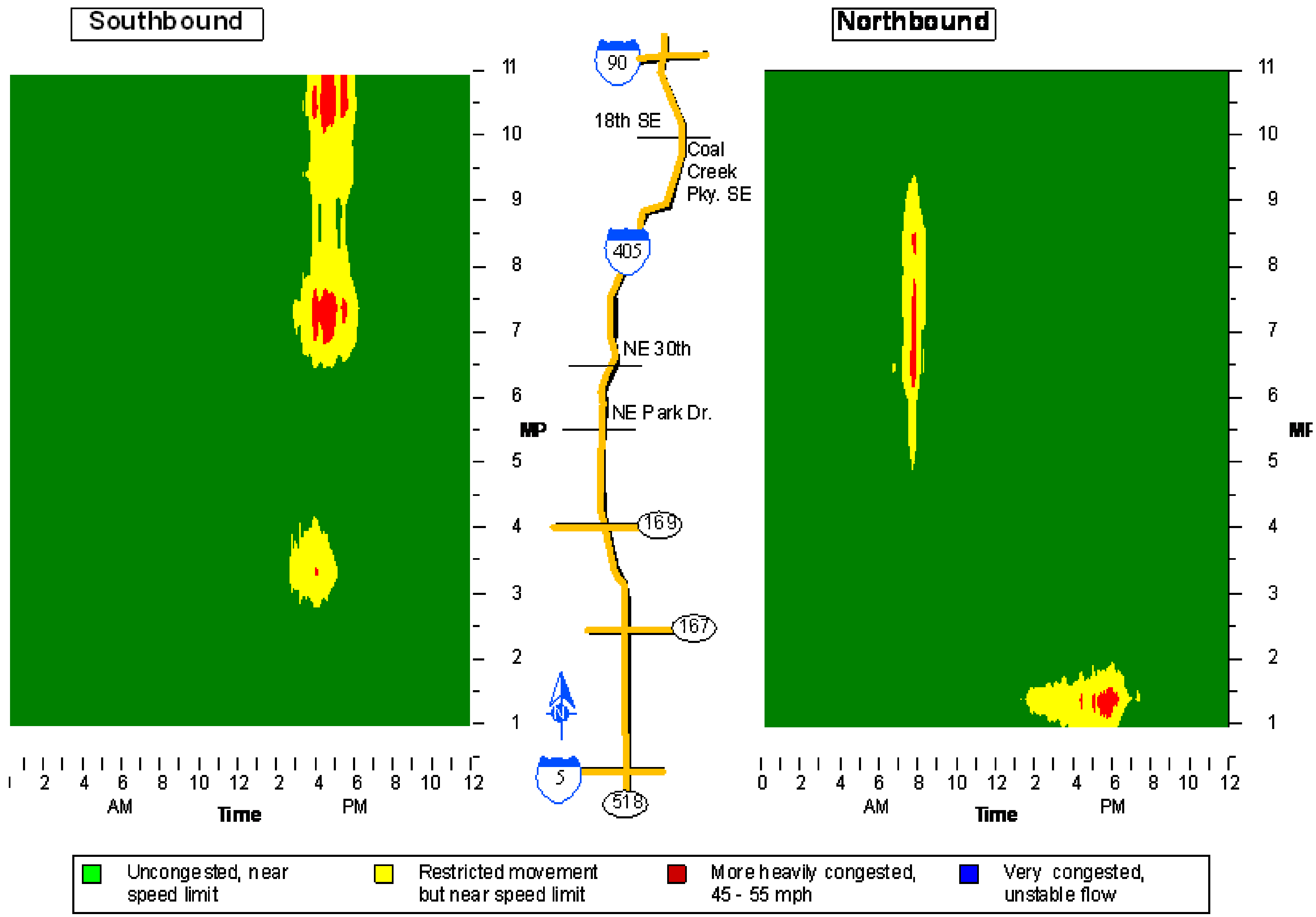
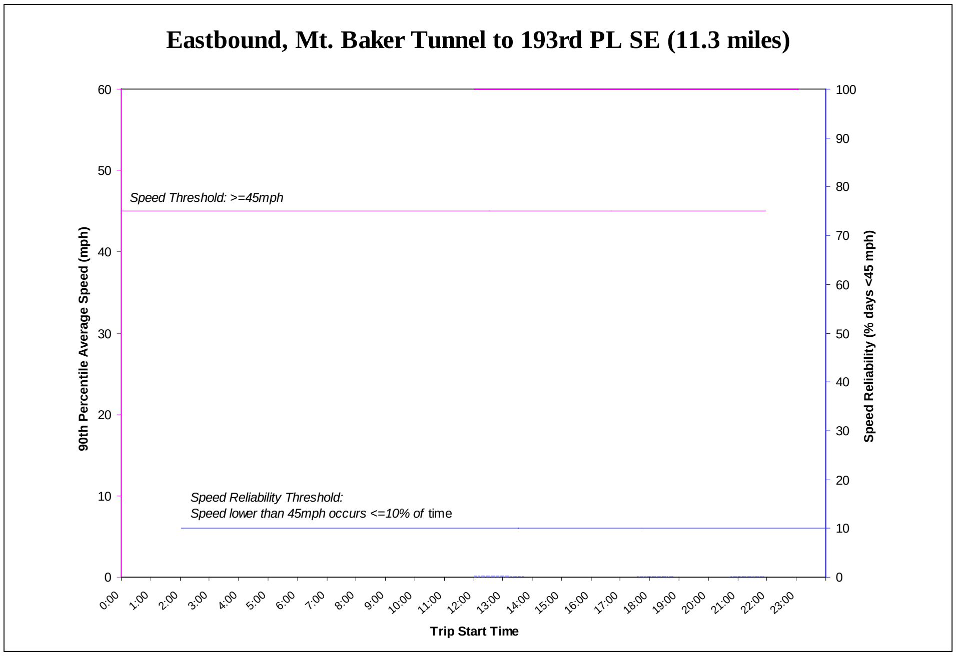


Figure 3-6b. 2002 Weekday Average HOV Traffic Profile: I-405 South of I-90

I-90 (See Figure 3-7)

No significant routine congestion was observed in the HOV lanes using the reversible lanes on I-90, or on the traditional HOV lanes between I-405 and Issaquah. HOV lane travel can expect to be at or near the speed limit nearly all the time.



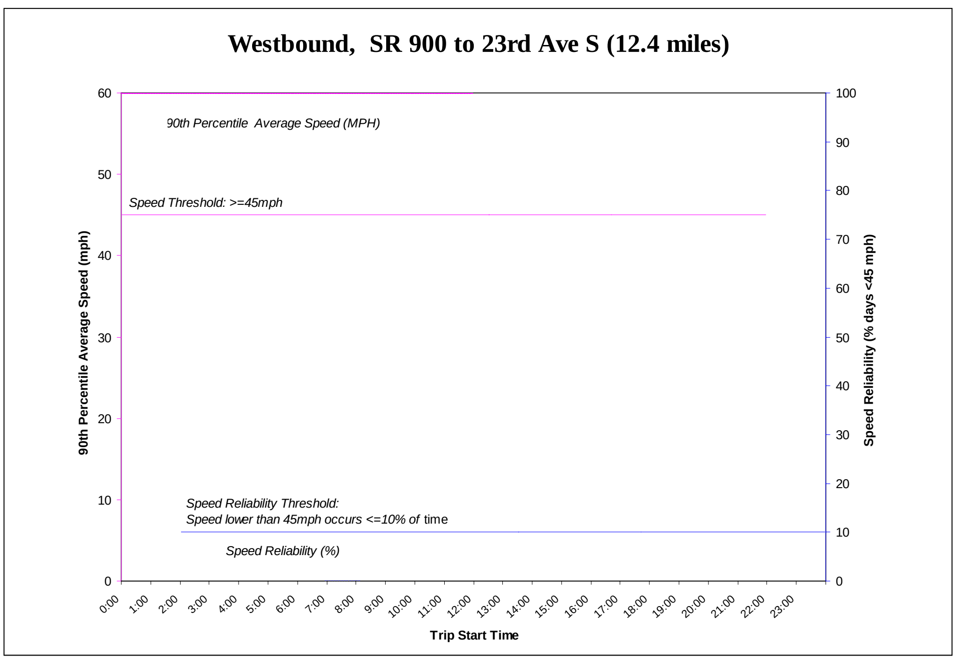


Figure 3-7: I-90 Eastbound, Mount Baker Tunnel /Westbound to 33rd Ave S

SR 520 (See Figures 3-8a and 3-8b)

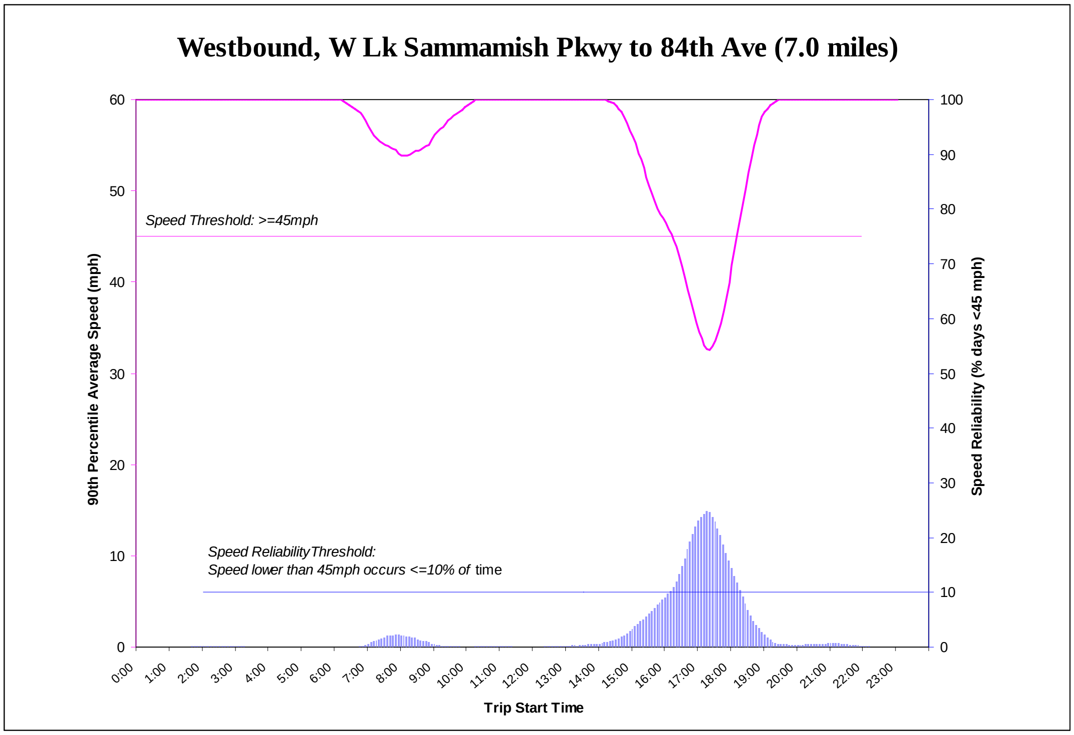
The HOV lanes on SR 520 were extended east of the SR 520/I-405 interchange in 2000. Carpools with 2 or more people may use these HOV lanes. Minor revisions to the starting point of the westbound, 3+ HOV lane, west of the I-405 interchange also took place as part of the HOV lane construction project. This lane still ends prior to the Evergreen Point floating bridge. No eastbound HOV lane exists west of I-405. Consequently, the eastbound and westbound HOV corridors are not "symmetrical" and those differences are illustrated in the graphics below. The eastbound corridor performance report includes only the new 2+ facility east of I-405. The westbound corridor performance includes both the new section and the old, 3+ HOV shoulder lane, west of I-405.

Eastbound

No significant recurring congestion is observed in the HOV lanes east of the I-405 interchange on SR 520. HOV lane performance meets the policy standard (see Figure 3-8a), although minor slowdowns occasionally occur in the morning commute period.

Westbound

Westbound HOV lane vehicles average below the 45 mph standard between 4:00 PM and 6:00 PM (see Figure 3-8a) as frequently as one fourth of the time during the evening commute. This is due to a series of factors, including extreme GP lane congestion, merge congestion caused by two factors: 1) Vehicles entering the freeway from the SR 520/I-405 interchange, as well as the Bellevue ramps, where drivers must weave through the HOV lane into the stop-and-go GP lanes, and 2) the effect merge congestion has on the final merge immediately east of the Evergreen Point floating bridge (see Figure 3-8b). Significantly, these conditions have less of an impact in the morning peak period. This is partly because GP congestion is lower, and partly because HOV lane volumes are much lower in the morning than in the evening. Transit volumes are much higher in the morning.



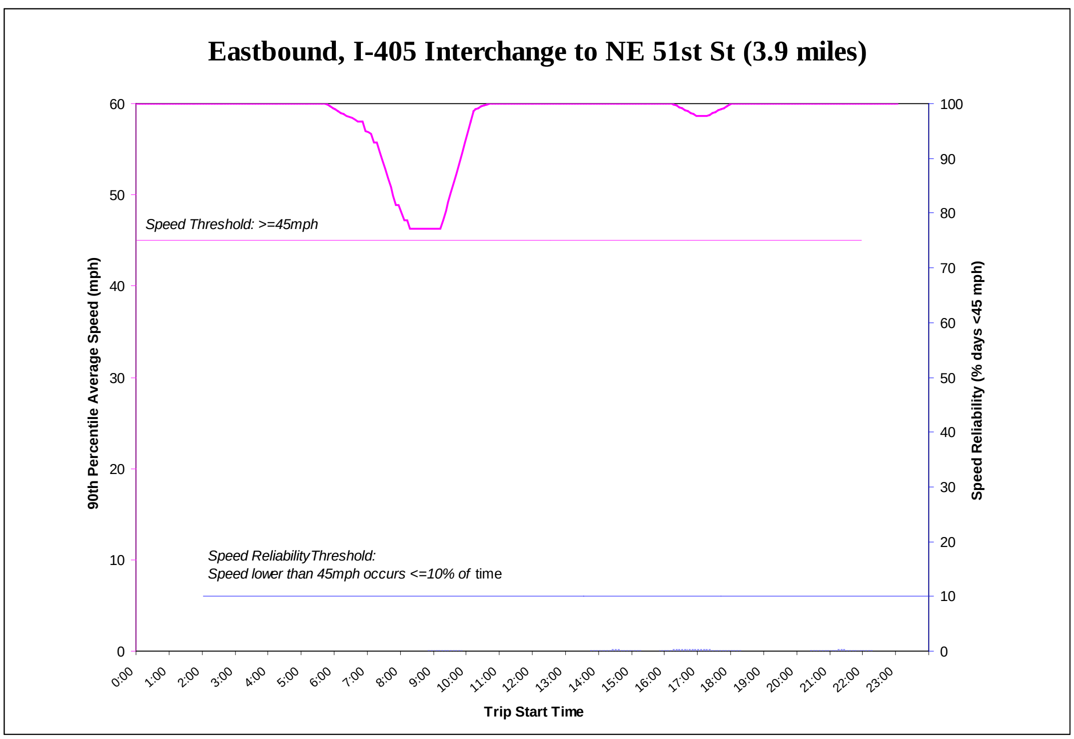


Figure 3-8a. Average Weekday HOV Speed and Reliability (2002): SR 520

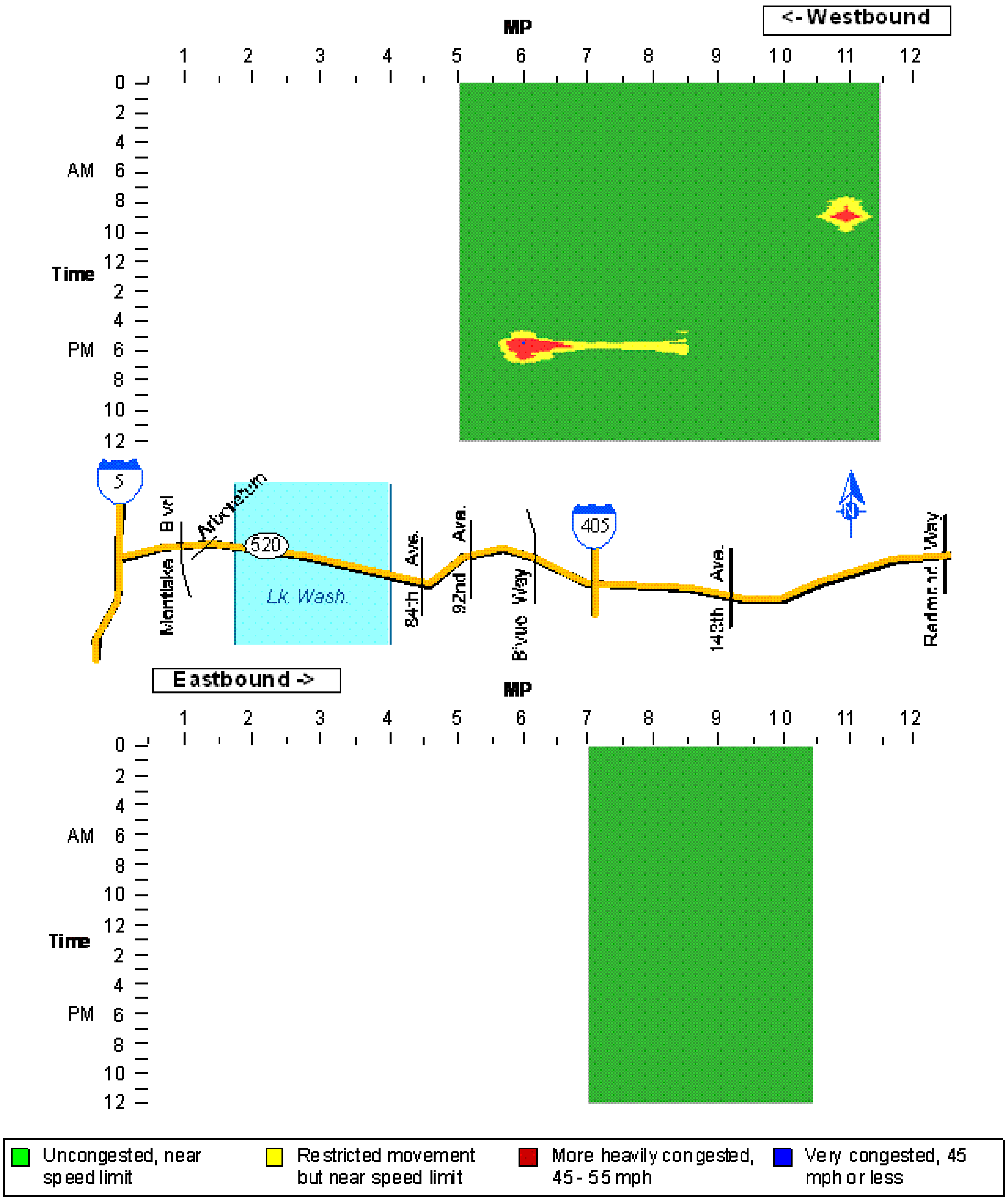
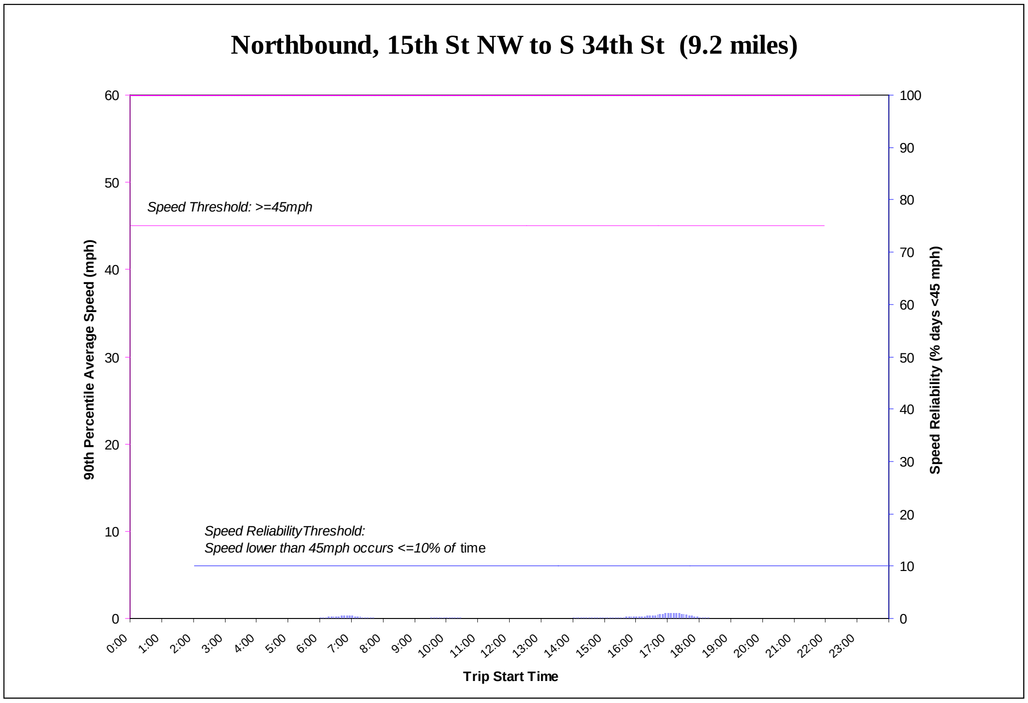


Figure 3-8b. 2002 Weekday Average HOV Traffic Profile: SR 520

SR 167 (see Figure 3-9)

HOV lanes on SR 167 routinely travel at free flow speeds throughout the day in both directions. At no time during the day does the 90th percentile travel time fall below 45 mph for either northbound or southbound HOV traffic (see Figure 3-9). However, slowdowns occur near the southern terminus in the evening, mostly due to congestion caused as the HOV lane ends and becomes a GP lane at the same time one of the GP lanes becomes an 'exit only' lane.



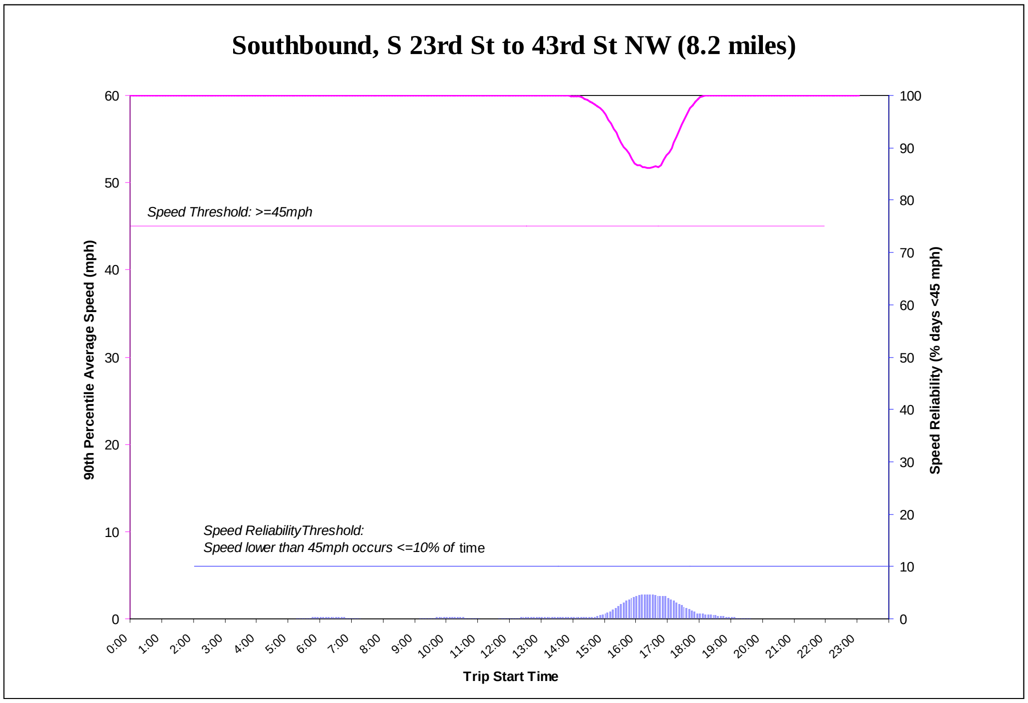


Figure 3-9. Average Weekday HOV Speed and Reliability (2002) SR 167

TRAVEL TIME SAVINGS

Reading the Travel Time Graphs

The time savings that travelers can expect to accrue when using the HOV lanes are expressed in a set of graphs that compare expected HOV lane and GP lane travel times. Each graph describes the time it takes to complete a particular route by traveling in the HOV lane and by traveling in the GP lanes. The average travel time for the trip can be read along the vertical axis. (Note that the vertical axis on these graphics does not start at zero.) 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 recorded.

Figure 3-10— showing an 8-hour slice of the travel time comparison for northbound I-5 from NE 137th St. to Alderwood—provides an example: it takes roughly 13 to 14 minutes to travel in the GP lane between 4 and 6:30 PM, and roughly 10 minutes in the HOV lane, a differential of three to four minutes.

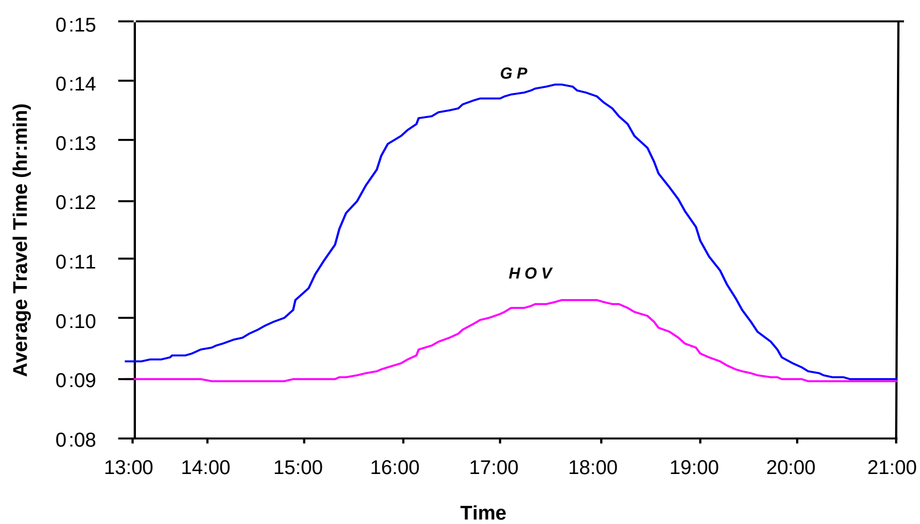


Figure 3-10. (Example) Average Weekday Travel Time Graph: I-5 North of Seattle CBD, Northbound from NE 137th St. to Alderwood

Figures 3-11 through 3-17 present GP and HOV lane travel time comparisons for the studied corridors. Travel times are computed for trips on each HOV corridor. Travel time on I-90 is computed only for trips using the reversible HOV lanes (AM westbound, PM eastbound).

Table 3-2 summarizes the travel time savings along the various corridors during 2002 in units of minutes and seconds per mile. These results show sizable benefits in travel time savings in most of the HOV lanes. Four of the most significant savings are:

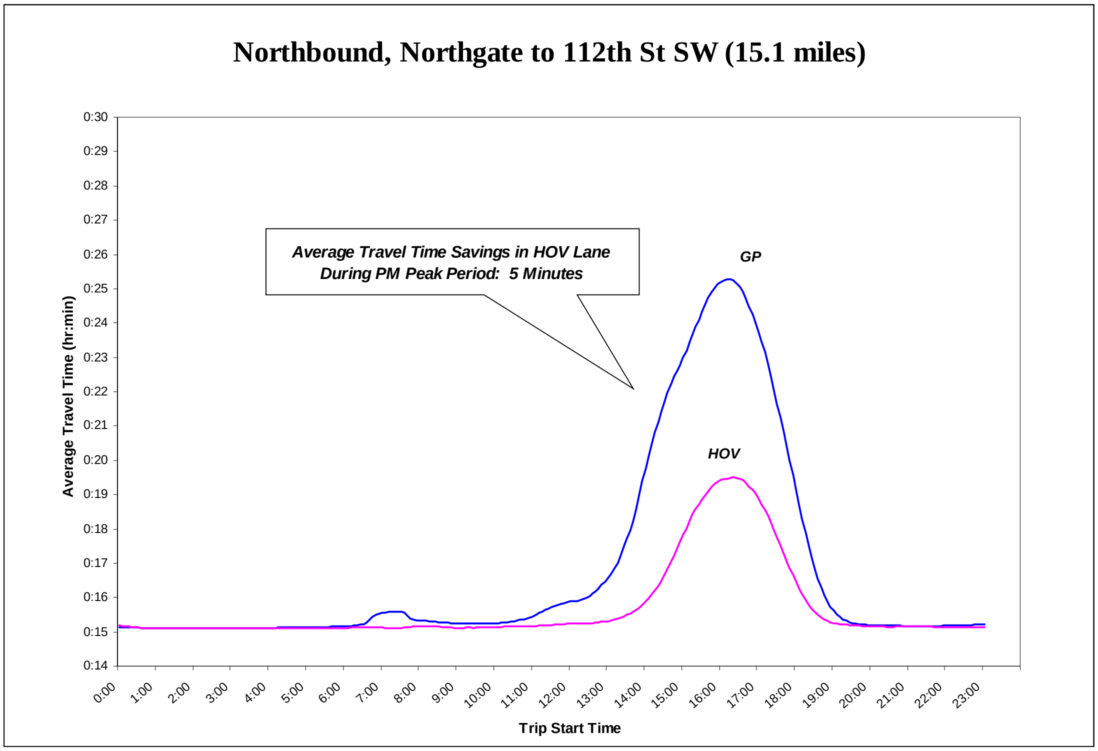
- I-5 during the morning commute traveling southbound toward downtown Seattle
- I-405 in the traditional commute directions
- Westbound on SR 520
- Southbound on SR 167 during the afternoon peak period.

Table 3-2. HOV Lane Travel Time *(Estimated from Average Speed)*

Corridors	Dir.	Length (miles)	Travel Time Savings (Minutes) AM (6-9AM)	Travel Time Savings (Minutes) PM (3-7PM)	Travel Time Savings (Seconds per Mile) AM (6-9AM)	Travel Time Savings (Seconds per Mile) PM (3-7PM)
I-5 North of the Seattle CBD (Northgate – 112th St SW)	NB	15.1		5		20
	SB	16.6	6		22	
I-5 South of the Seattle CBD (S Spokane St – S 184th St)	NB	10.3	4		23	
	SB	10.2		1		6
I-405 North of I-90 (SR 524 Interchange – I-90 Interchange)-4th quarter	NB	18.4		8		26
	SB	18.4	12.5		41	
I-405 North of I-90 (SR 524 Interchange – I-90 Interchange)-12 mo	NB	14.5		7		29
	SB	14.8	9		36	
I-405 South of I-90 (I-90 Interchange – Andover Park E)	NB	10.3	10		58	
	SB	10.5		3		17
I-90 (23rd Ave S – SR 900)	EB	11.3		2		11
	WB	12.4	3		15	
SR 520 (84th Ave NE – W Lk Sammamish Pkwy)	WB	7.0		4		34
SR 167 (S 23rd St – 43rd St NW)	NB	9.2	4		26	
	SB	8.2		5		37

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, such as on I-90, and lane friction with congested adjacent GP lanes, such as southbound on I-5 south of the Seattle CBD during the afternoon commute.

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, the HOV traffic on northbound I-405 traveling away from downtown Bellevue moves near the speed limit, whereas the southbound I-5 HOV traffic is forced to slow down because of lane friction with slower moving vehicles in the adjacent GP lane. As a result, although HOV lane users in both corridors receive roughly the same travel time savings benefit —27 to 33 seconds per mile—during the peak periods, the perceived benefits to the HOV users traveling at 60 mph may seem greater than those traveling at slower speeds.



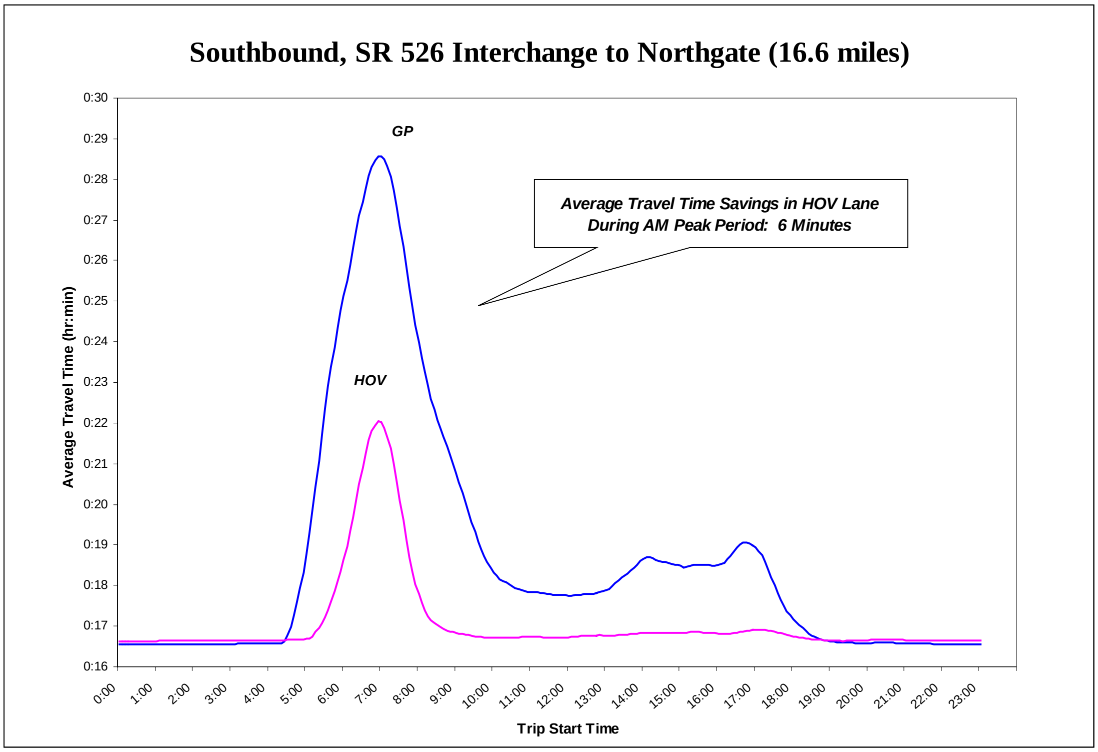


Figure 3-11. Average Weekday GP and HOV Travel Time (2002): I-5 North of the Seattle CBD

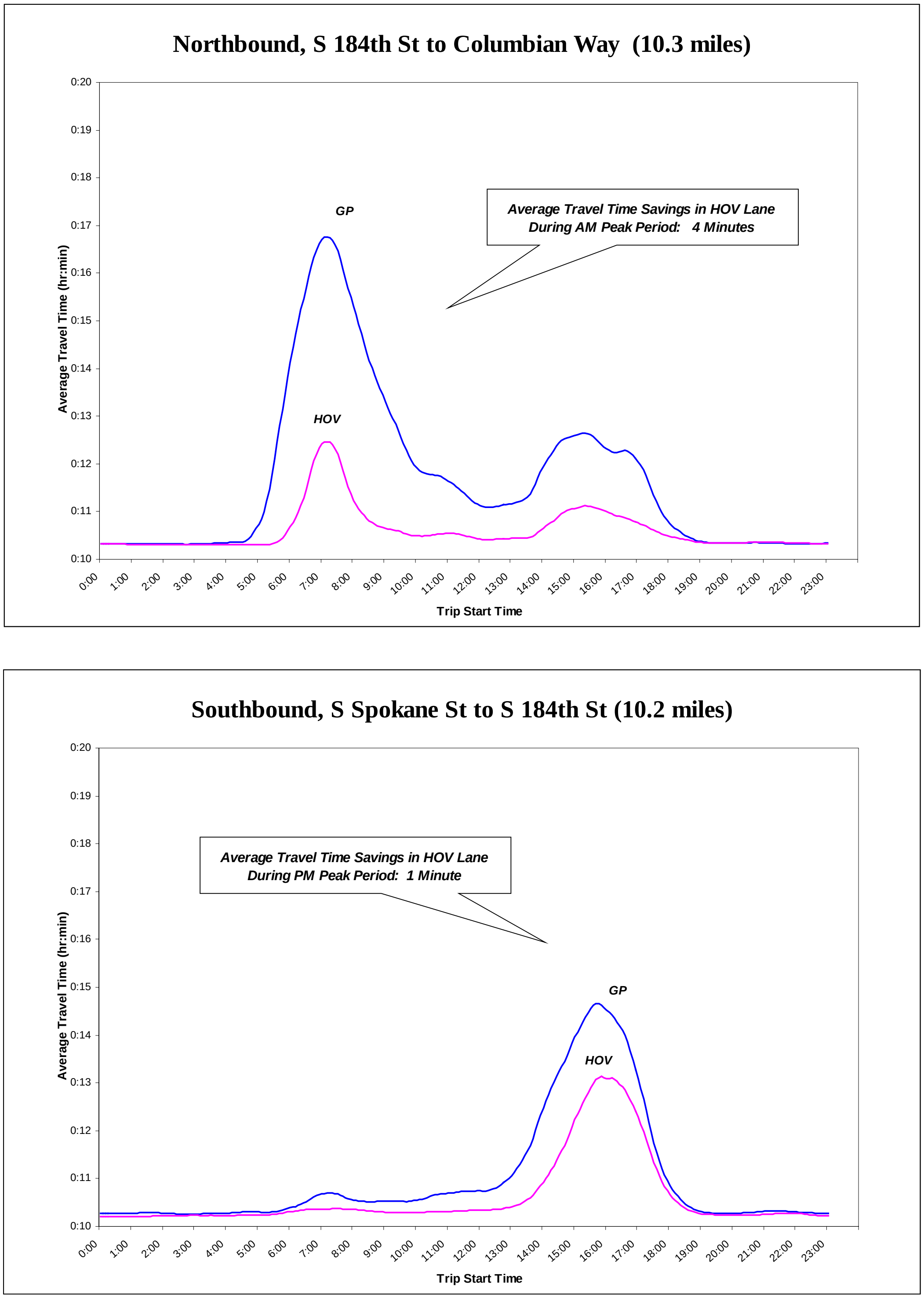
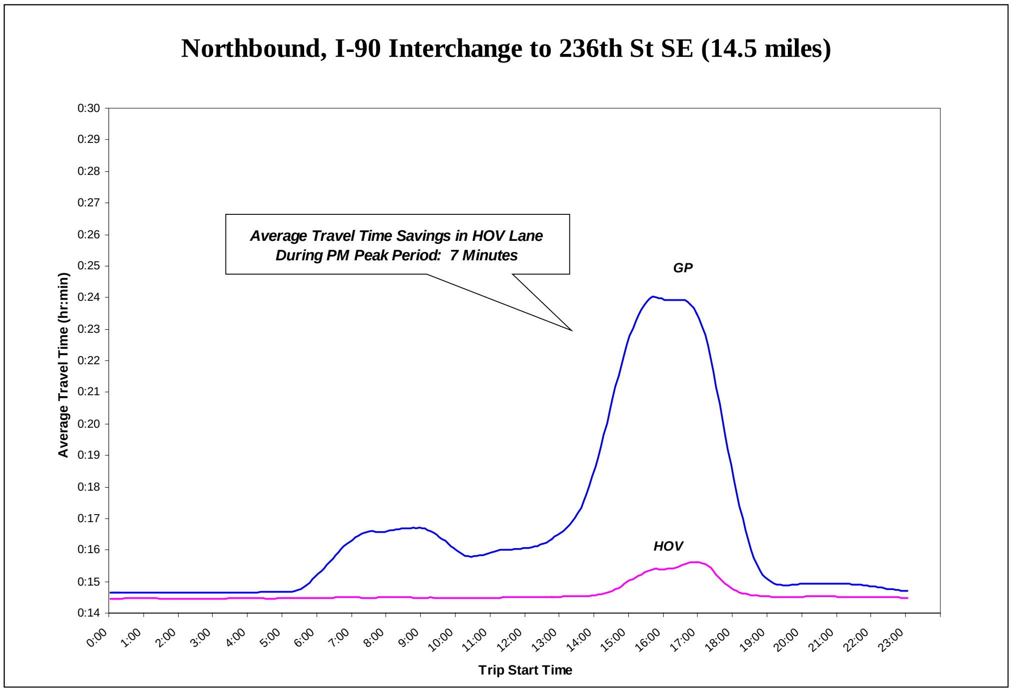


Figure 3-12. Average Weekday GP and HOV Travel Time (2002): I-5 South of the Seattle CBD



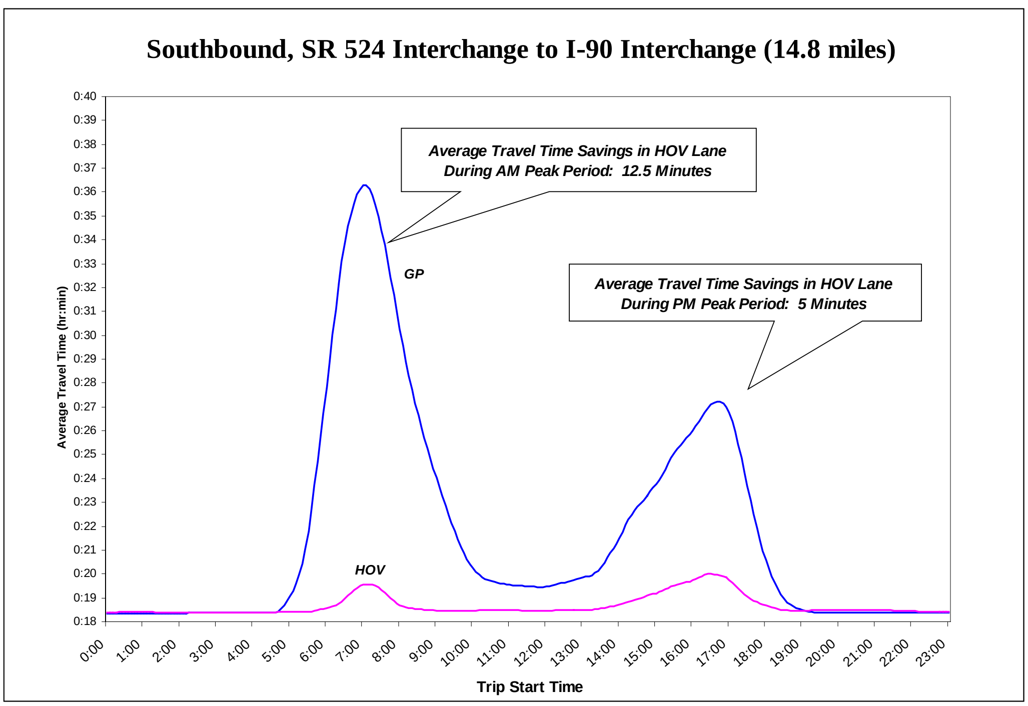
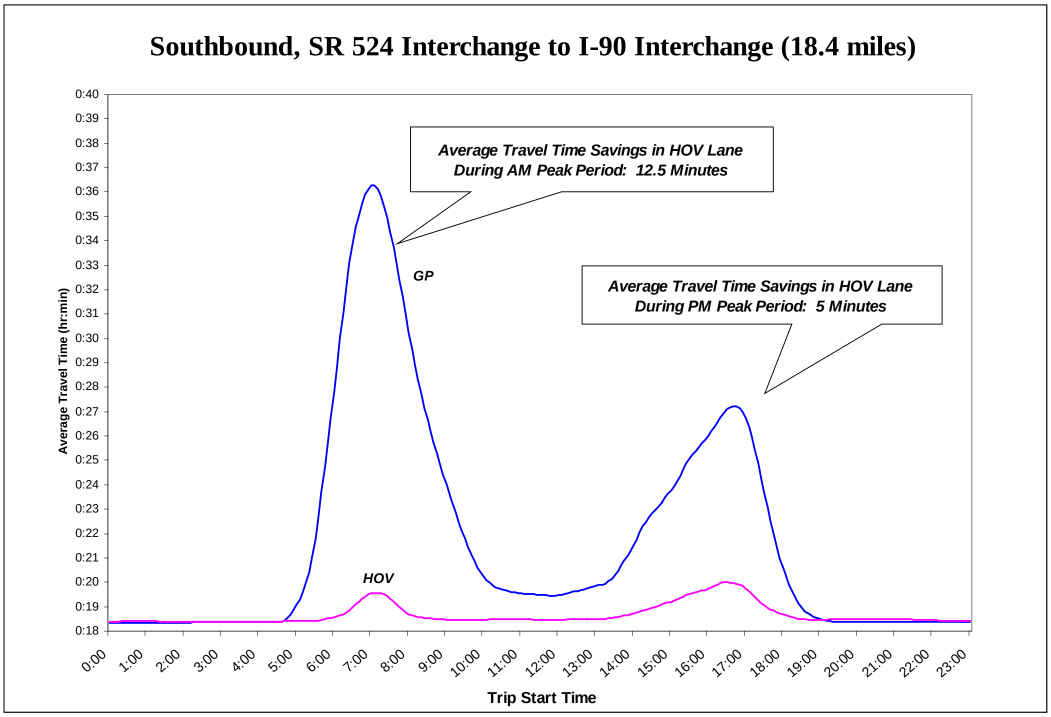


Figure 3-13. Average Weekday GP and HOV Travel time (2002): I-405 North of I-90 (12 month measure)



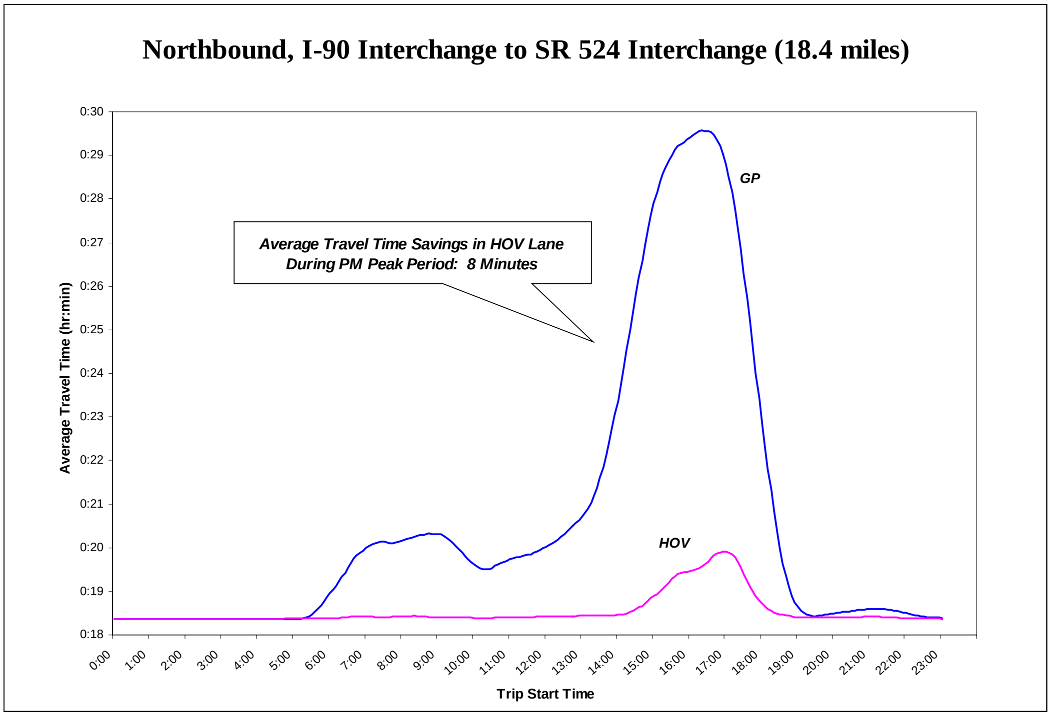
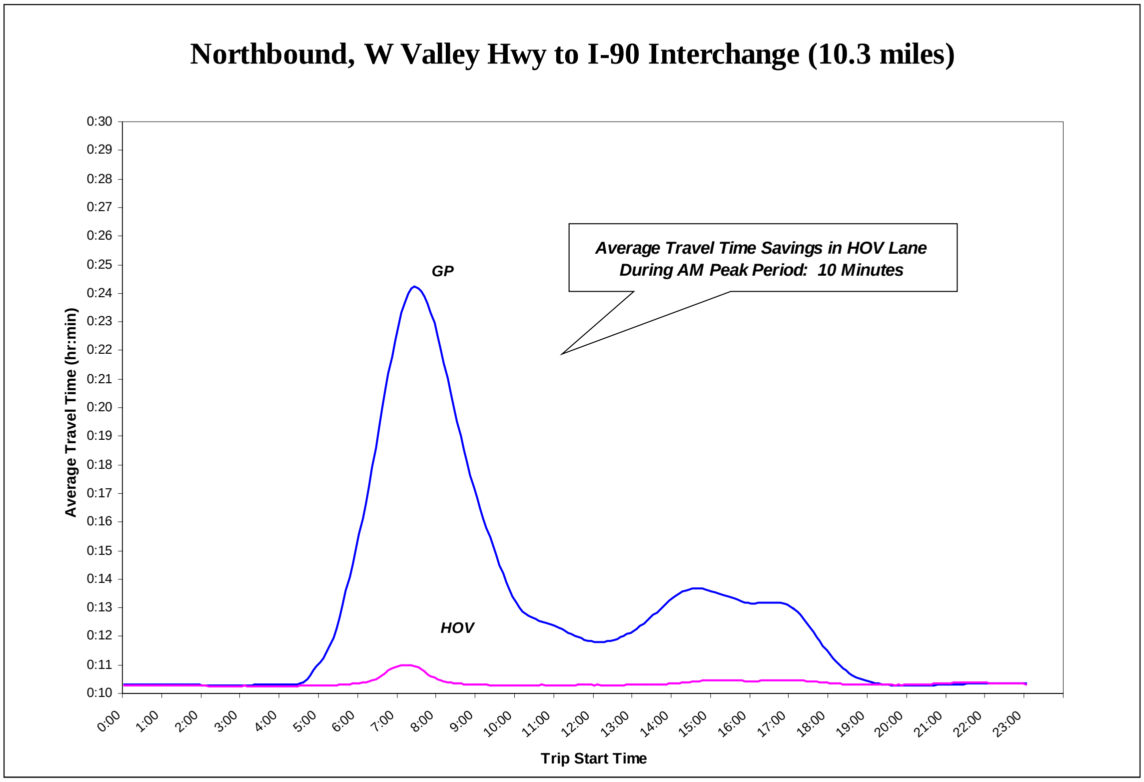


Figure 3-13. Average Weekday GP and HOV Travel Time (2002): I-405 North of I-90 (Fourth Quarter Measure)



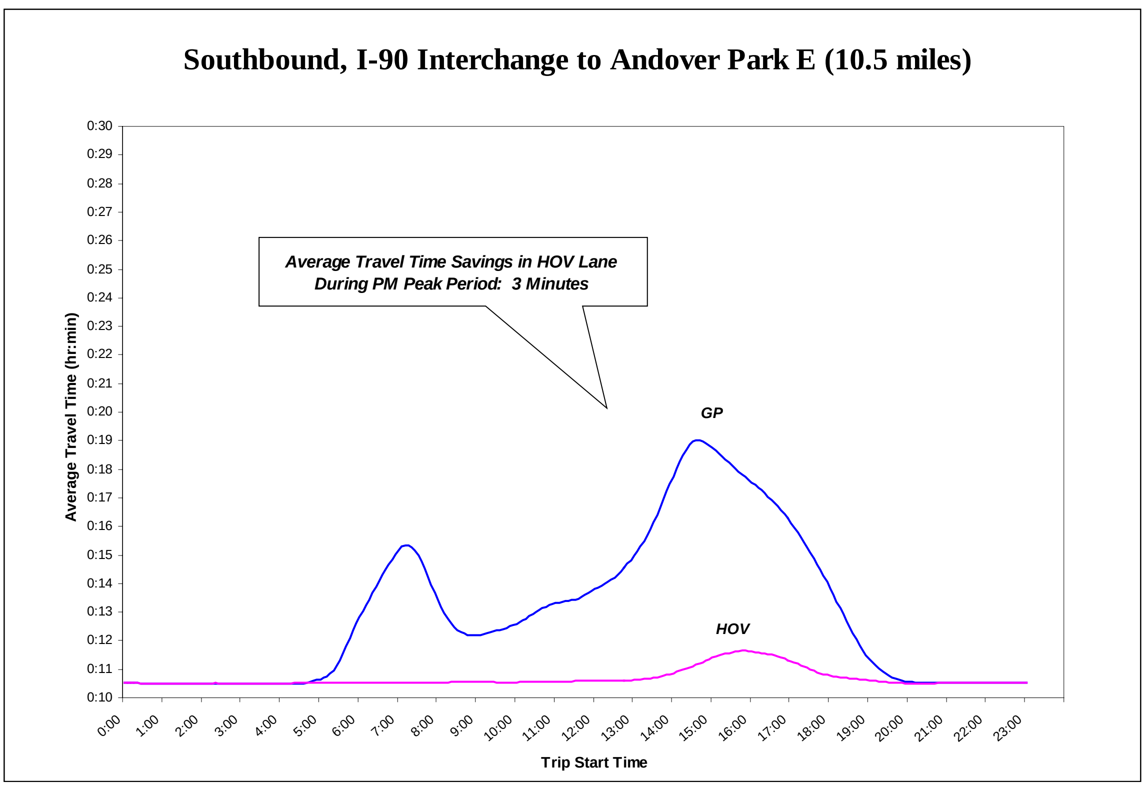
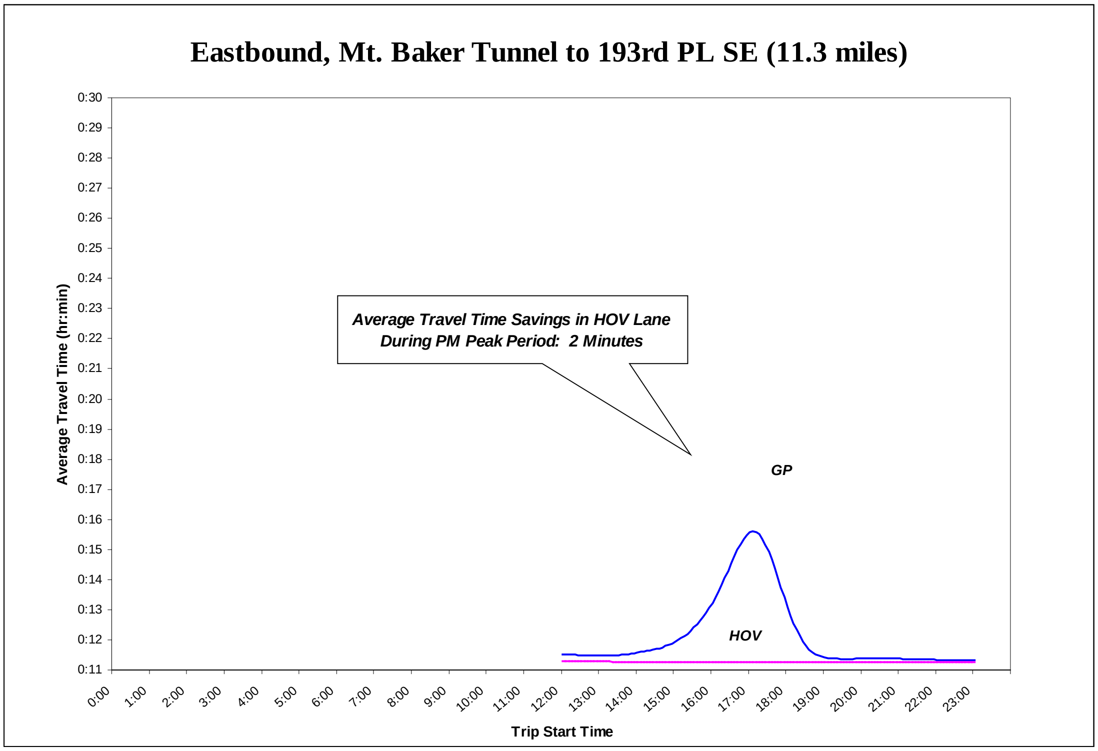


Figure 3-14. Average Weekday GP and HOV Travel Time (2002): I-405 South of I-90



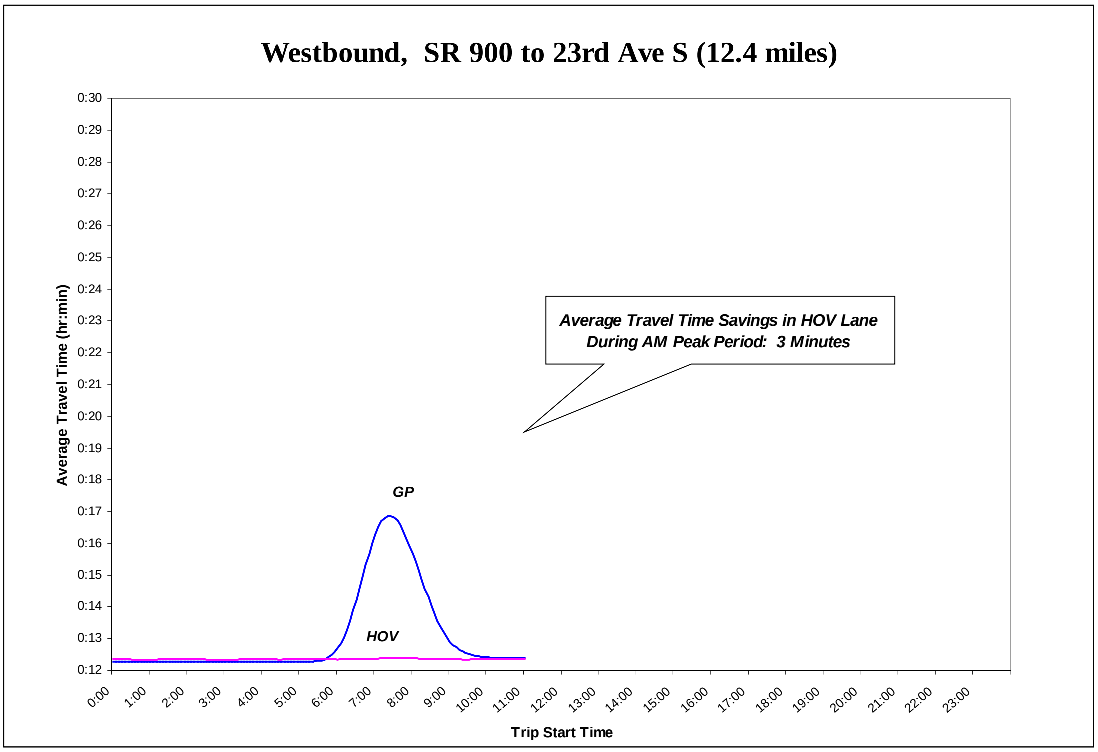
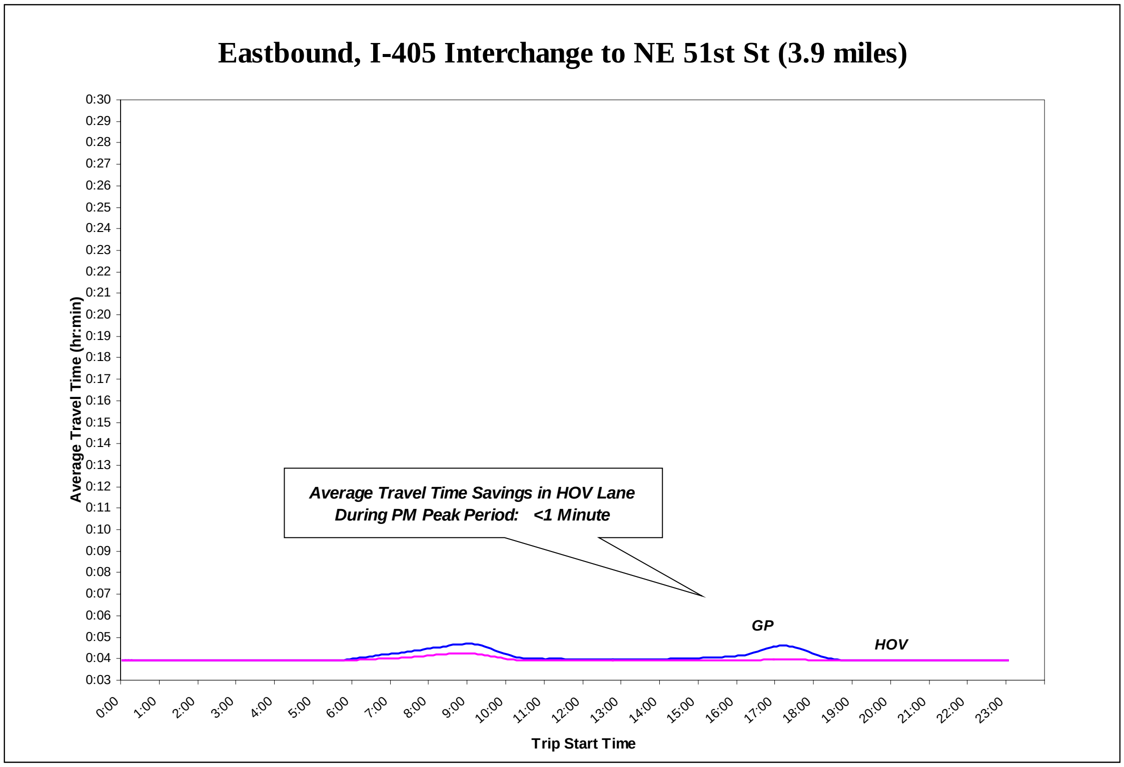


Figure 3-15. Average Weekday GP and HOV Travel Time (2002): I-90



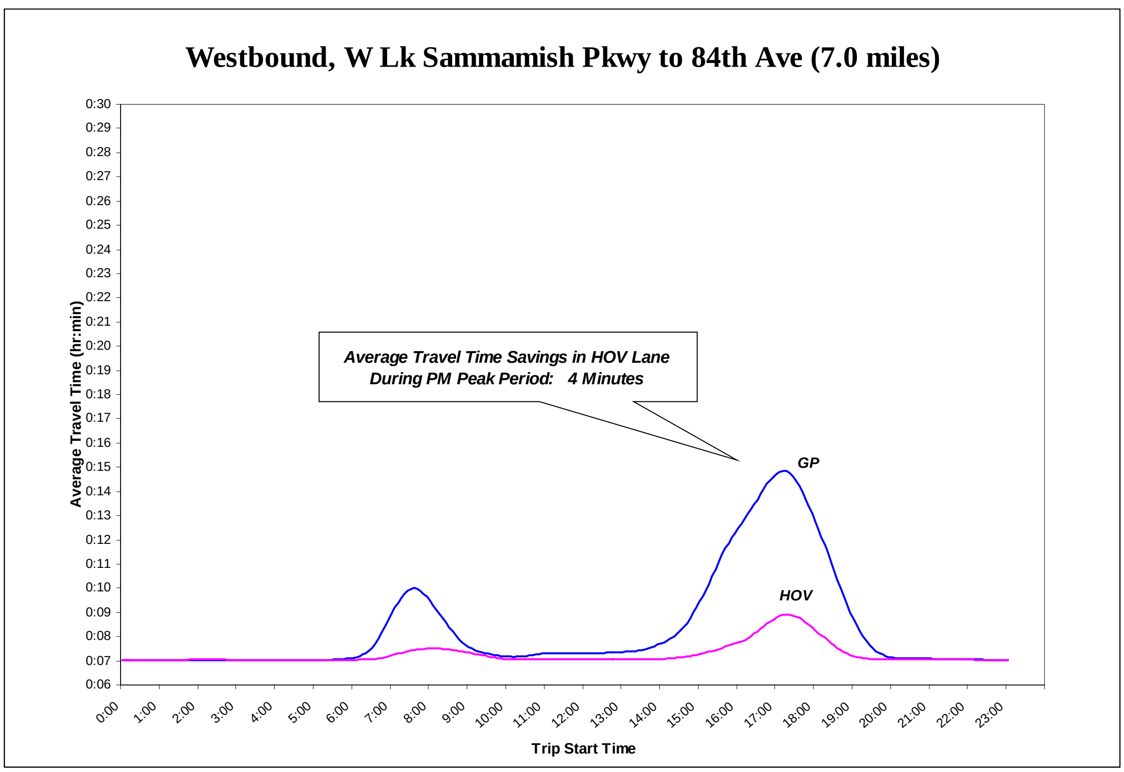
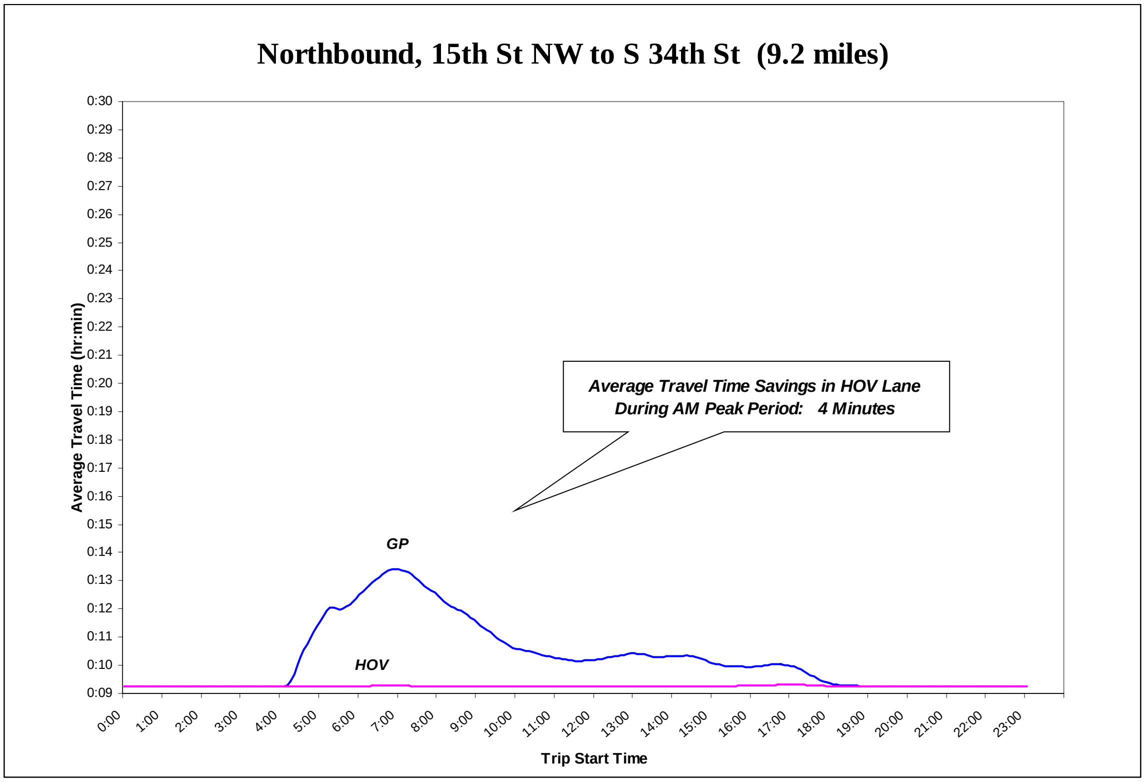


Figure 3-16. Average Weekday GP and HOV Travel Time (2002): SR 520



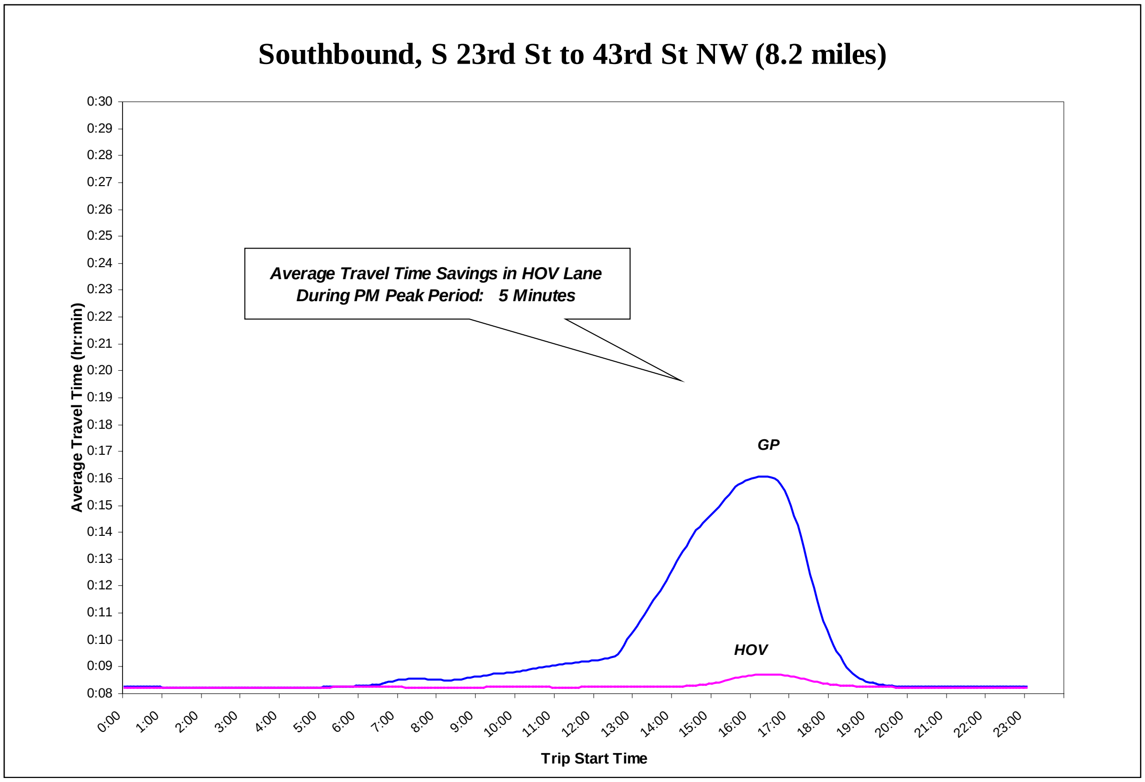


Figure 3-17. Average Weekday GP and HOV Travel Time (2002): SR 167

SITE-SPECIFIC OPERATIONAL PERFORMANCE

Examining the operation of HOV lanes at specific locations provides more detail about HOV traffic performance. 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 calculated at 5-minute intervals over a 24-hour weekday, and averaged over a full year at a given site. These volumes are then adjusted to a "per lane" hourly rate, or vehicles per lane per hour (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 less than 45 mph at a location.** The percentage of weekdays during which vehicles in the HOV lane at a specific time period and a specific location travel at less than 45 mph. This measure helps show how "reliable" a given facility is.

Locations for which data are presented in this report include the eleven sites studied in detail as listed in Table 2-1.

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

Site-specific HOV lane performance is illustrated with a graph that combines HOV lane volume by time of day, and the frequency with which the HOV lane at that location fails to average 45 mph. Figure 3-18 provides an example:

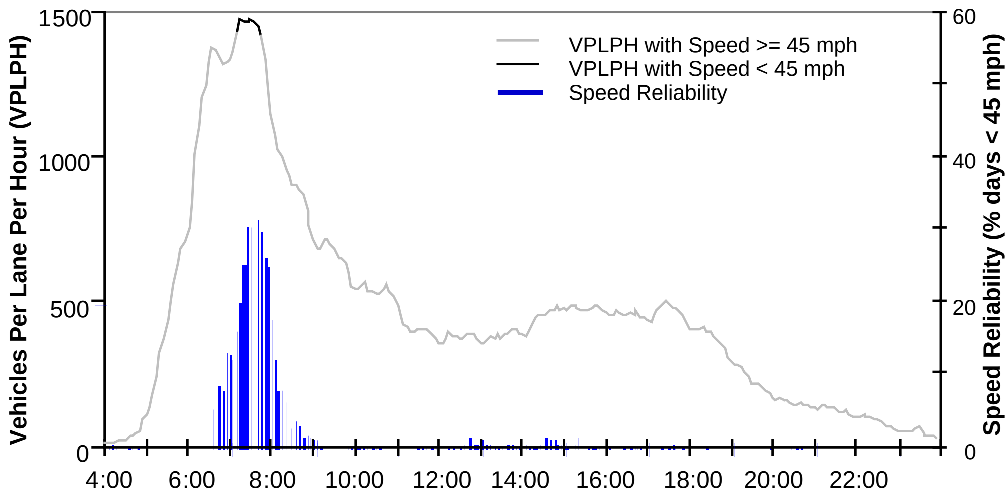


Figure 3-18. (Example) Average Volumes, Speed, and Speed Reliability Conditions Graph: Southbound on I-5 NE 137th St.

This figure illustrates performance 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 midnight. The horizontal axis represents time of day. (Usually from midnight to midnight, but for this example only twenty 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 color of the line indicates the expected speed of vehicles in the HOV lane on the average day: 1) Gray indicates that traffic moves at or faster than 45 mph. 2) Black represents traffic traveling slower than 45 mph.

The column graph is read from the right vertical axis, which shows the frequency of congestion occurrences. In this example, HOV volumes exceeds 1,400+ VPLPH during the AM peak period. Travelers can expect to travel faster than 45 mph throughout the day, except between 7:00 AM and 8:00 AM, when they they have approximately a 30 percent chance of encountering speeds of less than 45 mph.

I-5 near South Everett (see Figure 3-19)

Northbound

Average HOV lane volumes can exceed 1,000 VPLPH during the PM peak period. Although moderate congestion occurs about once every week during the PM peak period, the average speed is still above 45 mph. In part, high Friday afternoon volumes, presumably recreational travelers heading north for the weekend, are the cause of the high volume at this location and direction.

Southbound

HOV volumes are moderate throughout the day. Volumes approach 700 VPLPH during the AM peak period. No significant congestion is observed. Note that the southbound direction is not subject to the same combination of peak period commute travel with peak recreational travel.

I-5 near Northgate (see Figure 3-20)

Northbound

This location is just north of the end of the Express Lanes. HOV volumes are very high during the PM peak period reaching as high as 1,500 VPLPH during the evening commute, causing congestion approximately half of the time during the evening peak period. This congestion frequently reduces the HOV lane speed to less than 45 mph during the evening peak period.

Southbound

HOV volumes reach as high as 1,500 VPLPH during the AM peak period, but volumes remain below 700 VPLPH for the rest of the day. There is a significant chance of encountering speeds below 45 mph at this location between 7:00 AM and 8:00 AM.

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

Northbound

The highest volumes during the day at this location are during the AM peak period, when the HOV lane reaches nearly 1,500 VPLPH. This high volume, combined with recurring congestion in the adjacent GP lanes, results in an average HOV speed of lower than 45 mph as frequently as twice a week in the heart of the AM peak period. Significant volumes of 1,000+ VPLPH also occur in the PM peak, although with less congestion. Meanwhile, off-peak movement experiences congestion as frequently as once every two weeks. Much of the midday and afternoon congestion in the HOV lanes at this location is caused by spillback from congestion in downtown Seattle where the HOV lanes end before the Express Lanes entrance. This HOV lane becomes a GP lane just after the start of the I-90 interchange, and significant queuing in the lane occurs as vehicles wait to enter the Express Lanes. Volumes in the HOV lane remain significant throughout the business hours of the day.

Southbound

Southbound HOV lane volumes are significantly higher in the PM peak than during the rest of the day, although these peak volumes of approximately 1,500 VPLPH generate little direct congestion. This is, in part, because merge and friction related congestion occurs upstream of this point, allowing traffic at this location to flow smoothly. Volumes during the middle of the day range between 500 to 1,000 VPLPH, with speeds always greater than 45 mph.

I-5 near South of Southcenter (see Figure 3-22)

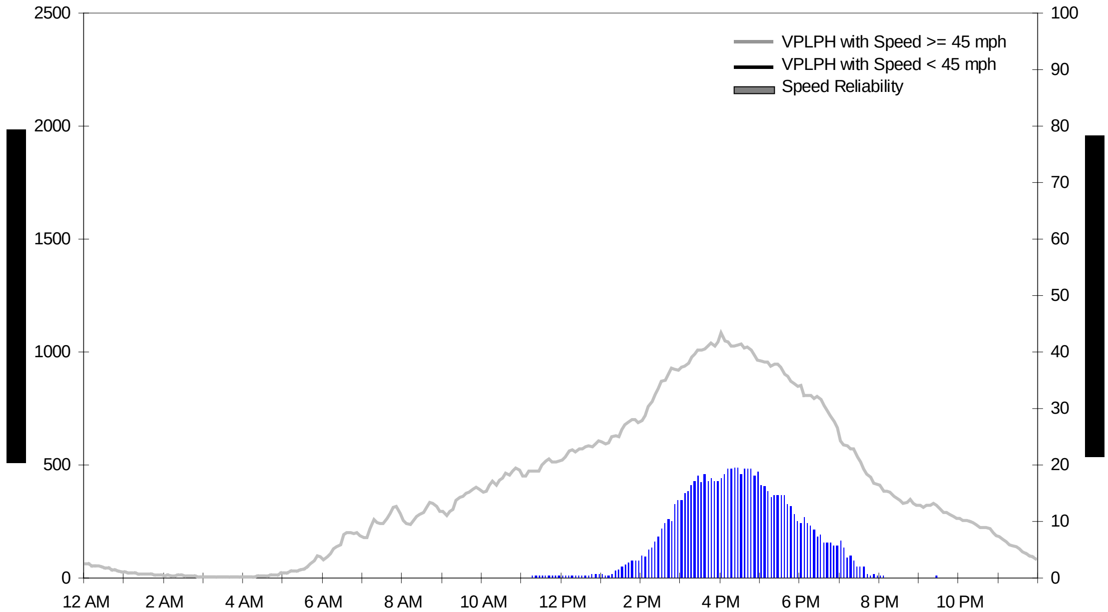
Northbound

HOV volumes at this location are heavy at peak periods, and midday volumes are still substantial at approximately 500 VPLPH. Peak volumes approach 1,400 VPLPH during the AM peak period. This location is relatively free of congestion at all times during the day.

<u>Southbound</u>

The southbound HOV patterns are different than the northbound travel patterns. Most important is the considerable congestion that occurs in the evening peak period. At the top of the Southcenter Hill, the congestion is caused by a combination of the heavy HOV volumes, the grade of the roadway, and the fact that the HOV lane ended and became a GP lane just south of this location for most of 2002. (Note that a considerable reduction in congestion occurred in the last two months of 2002 as a result of the completion of the HOV lane construction project which extended the HOV lane 3 miles farther south.) Volumes in the evening peak period can reach more than 1,400 vehicles. Speeds lower than 45 mph can occur as frequently as fifty percent of the time between 3:00 PM and 6:00 PM. Southbound off-peak HOV volumes at this location are much lower than northbound off-peak HOV lane volumes. The northbound HOV lane has considerable off-peak use, while the southbound lane has relatively little use before noon.

I-5 @ 112th St SW, Northbound



I-5 @ 112th St SW, Southbound

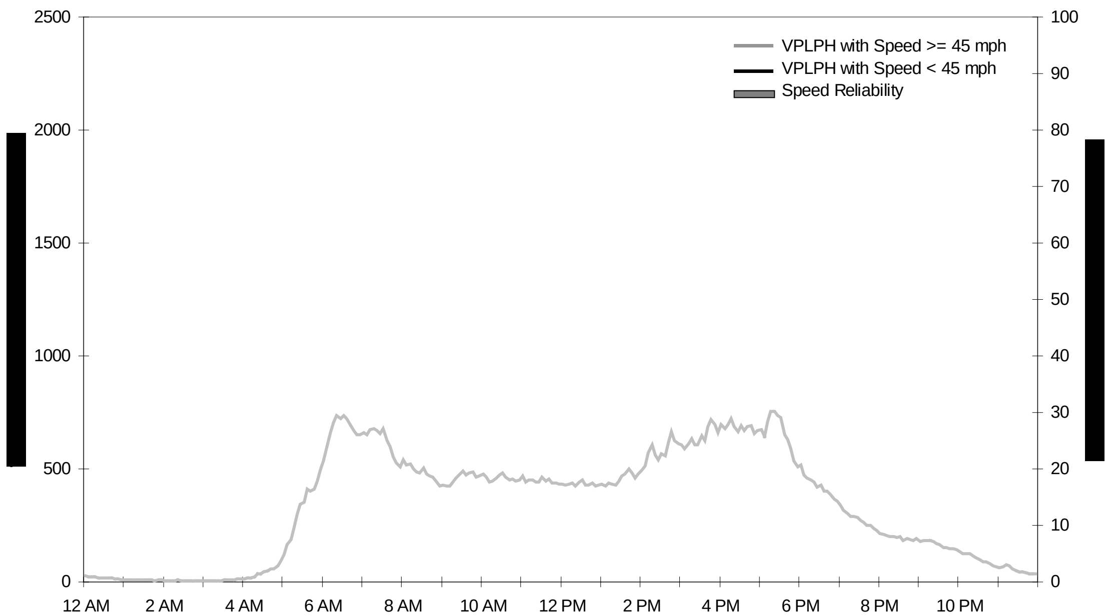
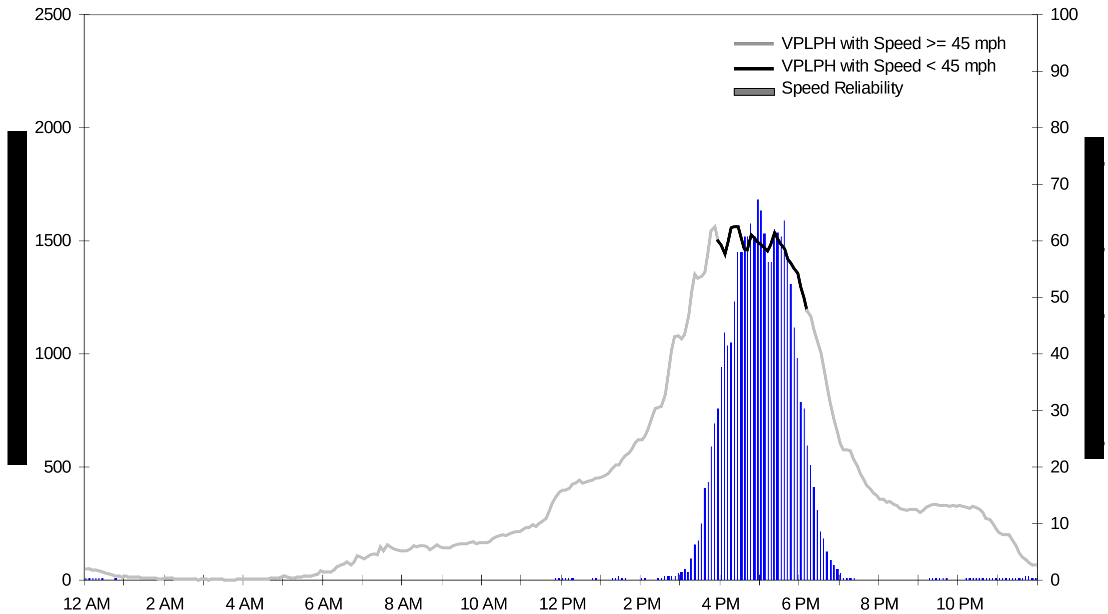


Figure 3-19. Average Weekday Volume, Speed, and Reliability Condition: I-5 @112th St SW

I-5 @ NE 145th St, Northbound



I-5 @ NE 145th St, Southbound

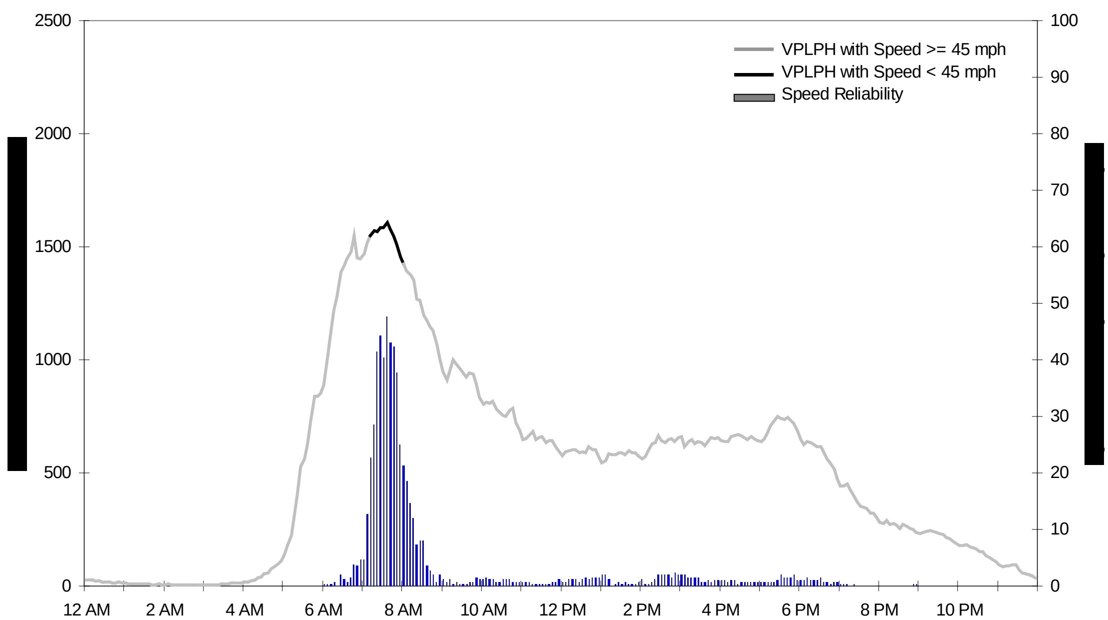
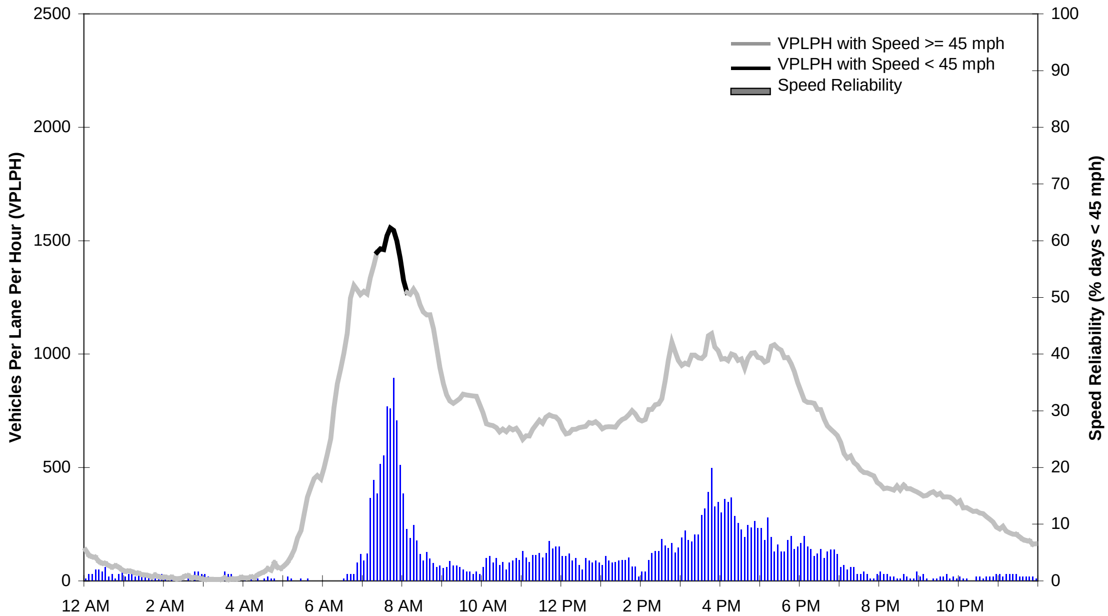


Figure 3-20. Average Weekday Volume, Speed, and Reliability Condition: I-5 @ NE 145th St

I-5 @ Albro Place, Northbound



I-5 @ Albro Place, Southbound

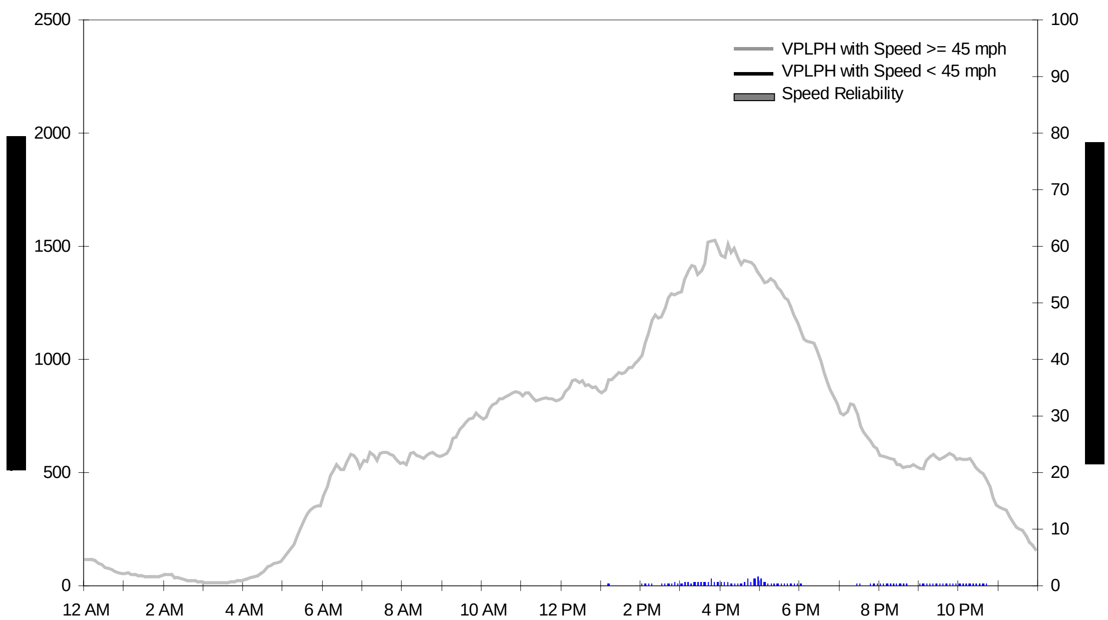
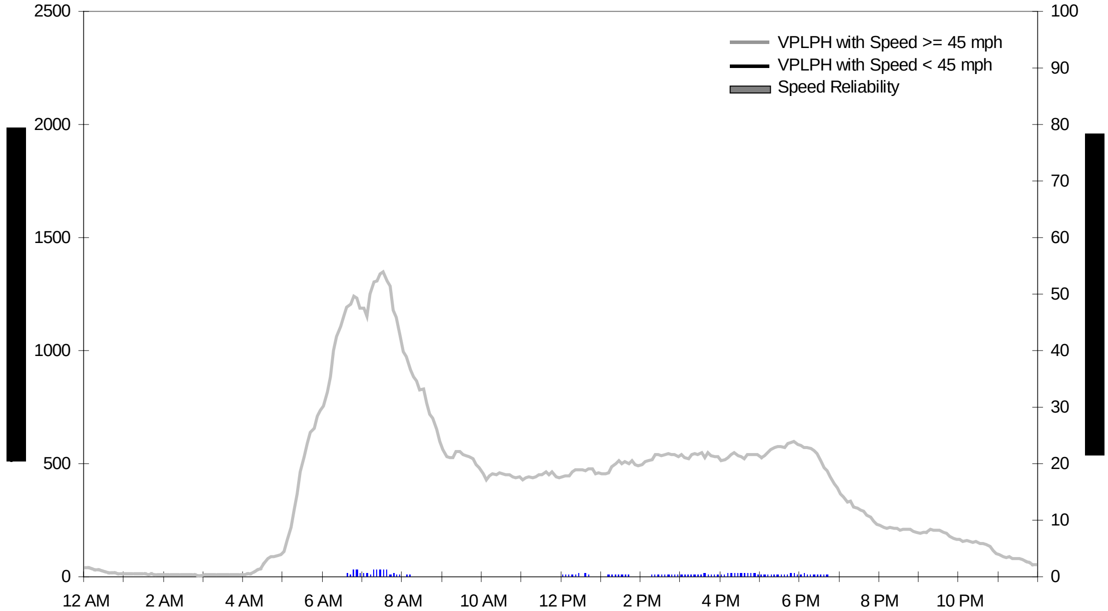


Figure 3-21. Average Weekday Volume, Speed and Reliability Conditions: I-5 @ Albro Place

I-5 @ S 184th St, Northbound



I-5 @ S 184th St, Southbound

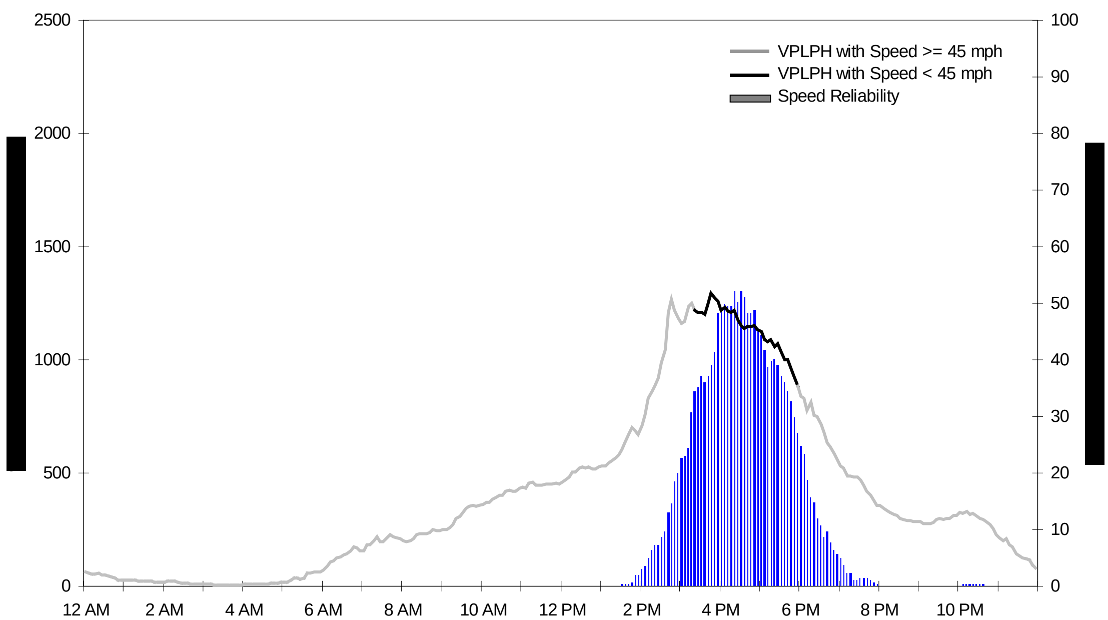


Figure 3-22. Average Weekday Volume, Speed, and Reliability Condition: I-5 @ S 184th St

I-405 near Kirkland (see Figure 3-23)

Northbound

Relatively little congestion occurs in the HOV lane at this location. Instead, congestion occurs farther north. During the PM peak, HOV volumes approach 1,500 VPLPH, and these volumes stay high for more than three hours. During the remainder of the workday, HOV volumes remain fairly constant at a modest 300 VPLPH.

Southbound

The southbound HOV performance at this location is very similar to the northbound performance, although with a slightly lower peak period volume and a slightly higher off-peak volume. HOV volumes peak at 1,300+ VPLPH during the morning commute; remain near 500 vehicles in the middle of the day; and climb back to over 600 VPLPH during the PM peak. Little significant congestion was observed at this location.

I-405 near Newcastle (see Figure 3-24)

Northbound

The HOV lanes on I-405 between Renton and Bellevue carry some of the highest volumes in the region. Northbound vehicle volumes approach 1,500 VPLPH during the AM peak. Midday volumes are near 700 VPLPH, but an increase to more than 900 VPLPH occurs in the PM peak.

Southbound

Southbound HOV volumes exceed 1,600 VPLPH between 4:00 PM and 5:30 PM and remain substantial until after 7:00 PM. Congestion frequency is very low. During the rest of the day, volumes average between 500 and 800 VPLPH with little congestion.

I-405 near Southcenter (see Figure 3-25)

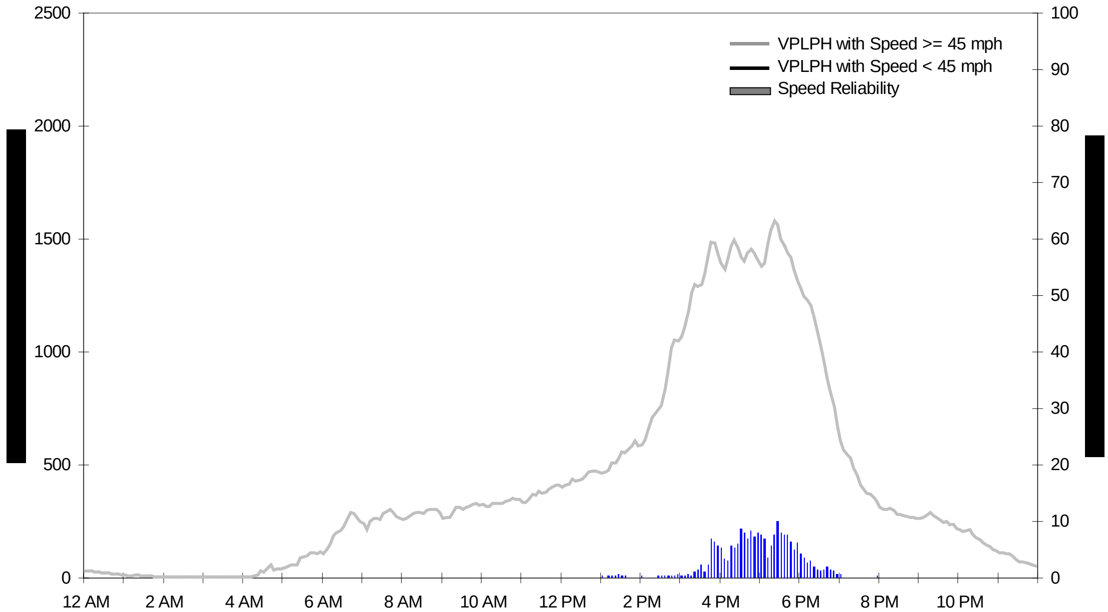
Northbound

The far south end of I-405 has moderately low HOV use, especially in comparison to the section north of the SR 167 interchange. Also unlike the section north of SR 167, HOV volumes during the PM peak period are greater than those in the AM peak period. HOV volumes are approximately 500 VPLPH throughout the morning and midday. The highest volumes of the day exceed 1,100 VPLPH during the evening peak. Congestion is significantly less than ten percent; and almost all of it is caused by slow moving HOV lane traffic trying to merge through the slower moving GP lanes so that the multi-passenger vehicles can exit to southbound SR 167.

Southbound

Southbound HOV volumes are lower than northbound volumes, and they are quite constant throughout most of the day. Both AM and PM peak periods experience roughly 400 VPLPH with no congestion. Midday volumes are slightly lower.

I-405 @ NE 85th St, Northbound



I-405 @ NE 85th St, Southbound

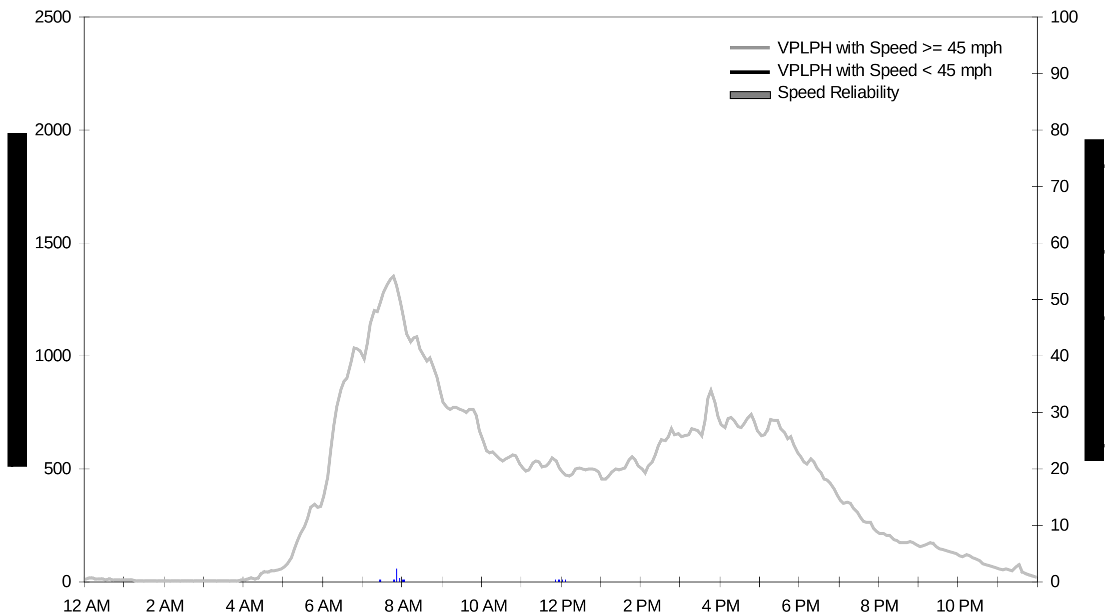
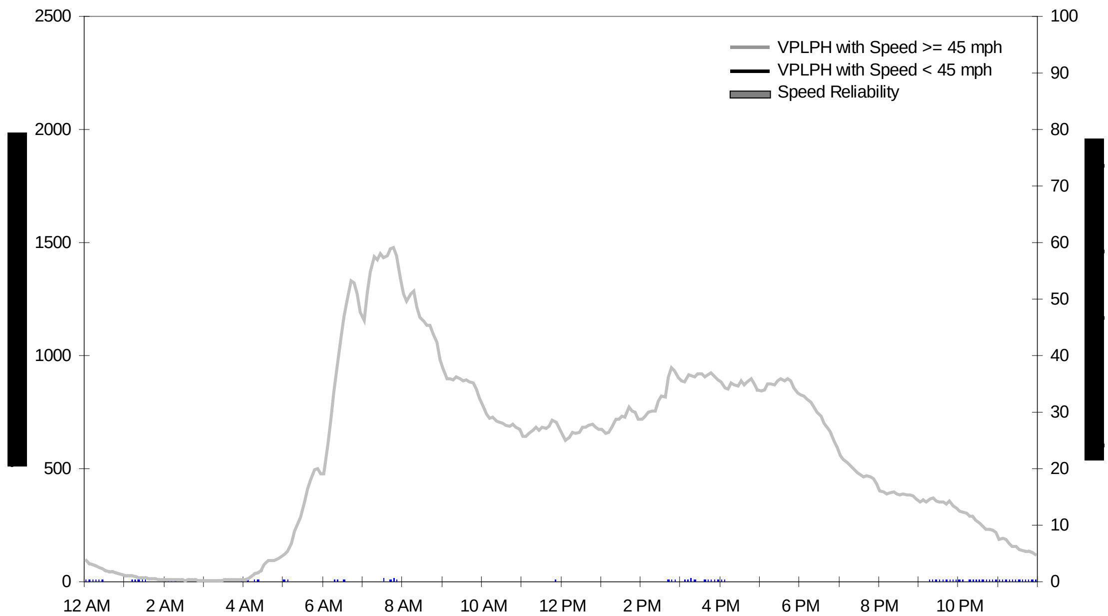


Figure 3-23. Average Weekday Volume, Speed, and Reliability Condition: I-405 @ NE 85th St

I-405 @ SE 52nd St, Northbound



I-405 @ SE 52nd St, Southbound

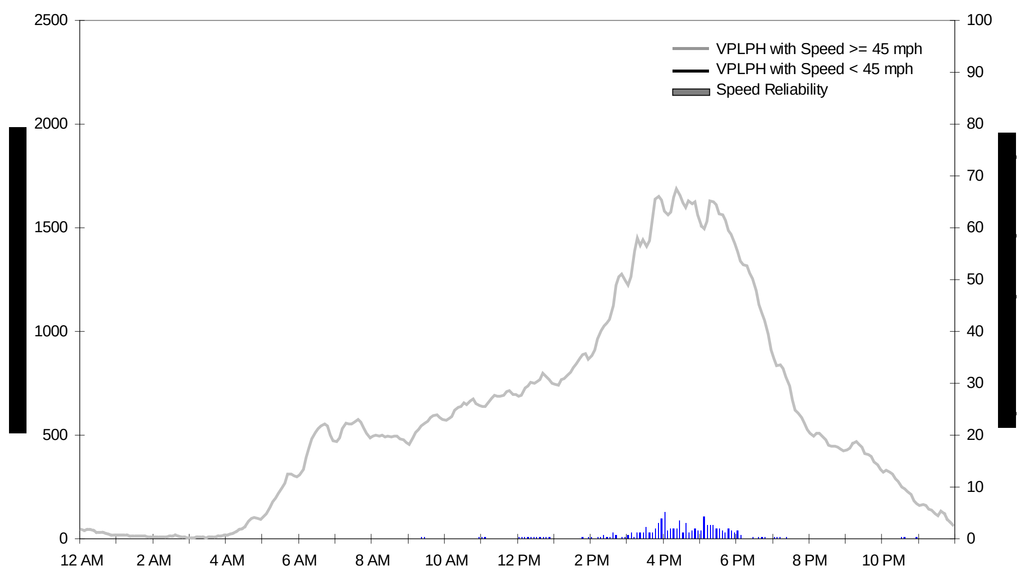
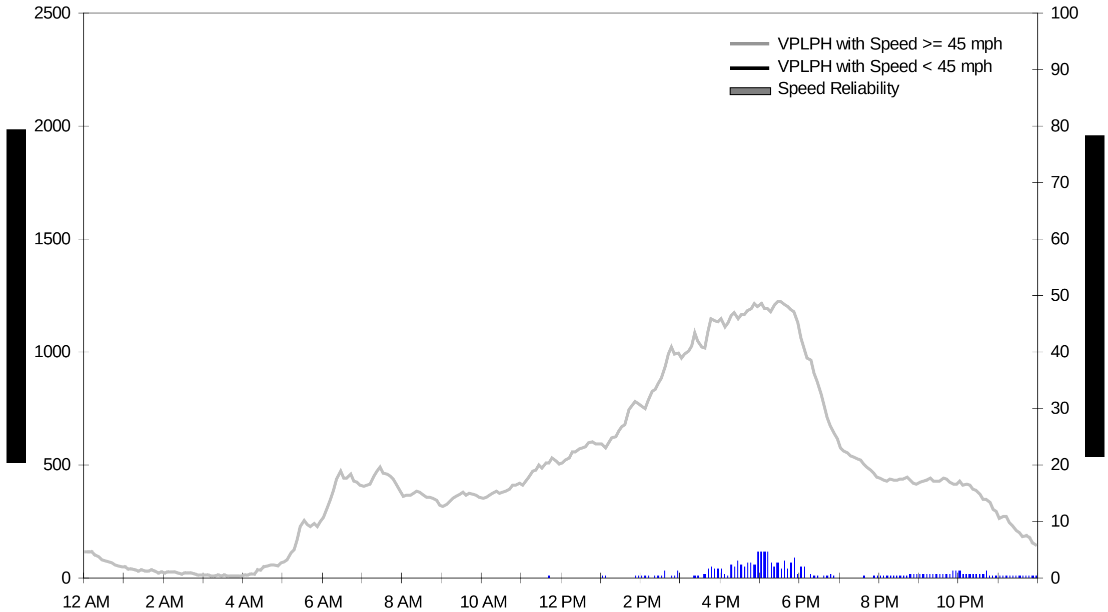


Figure 3-24. Average Weekday Volume, Speed, and Reliability Conditions: I-405 @ SE 52nd Street

I-405 @ Andover Park, Northbound



I-405 @ Andover Park, Sounthbound

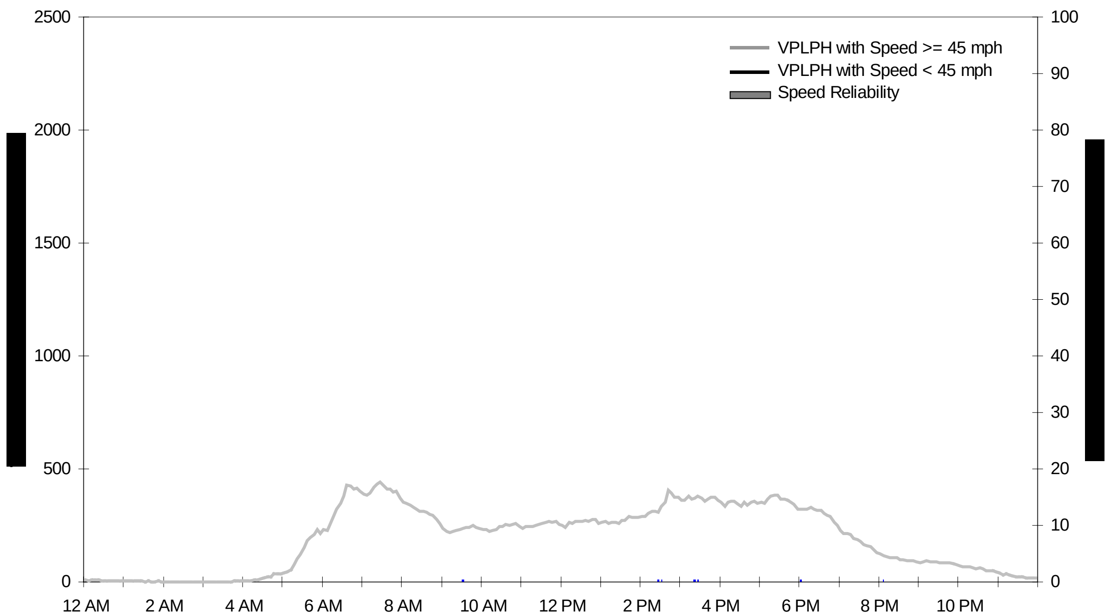


Figure 3-25. Average Weekday Volume, Speed, and Reliability Condition: I-405 @ Andover Park

I-90 Floating Bridge (see Figure 3-26)

Reversible Lanes

The reversible roadway contains both multi-passenger vehicles and Mercer Island-bound traffic in two lanes. There are two prominent volume peaks with 500 VPLPH, inbound to Seattle, in the AM peak hour, and 800 VPLPH, outbound to Mercer Island, in the PM peak hour. Volumes during the rest of the day are relatively low. There is no congestion.

I-90 near Issaquah (see Figure 3-27)

Eastbound

The eastern end of I-90 has modest, to low, HOV volumes. While these HOV lanes are experiencing considerable volume growth as development continues in the eastern suburbs, these lanes do not experience either the volumes or congestion frequency observed on most Puget Sound area freeways.

Eastbound HOV lane volumes approach 600 VPLPH during the PM peak period. Volumes are relatively low throughout the rest of the day, as are GP lane volumes. HOV lane speeds are greater than 45 mph throughout the day.

Westbound

HOV lane volumes can approach 700 VPLPH during the AM peak period. Volumes are relatively low throughout the rest of the day. No congestion is observed.

I-90 @ Midspan

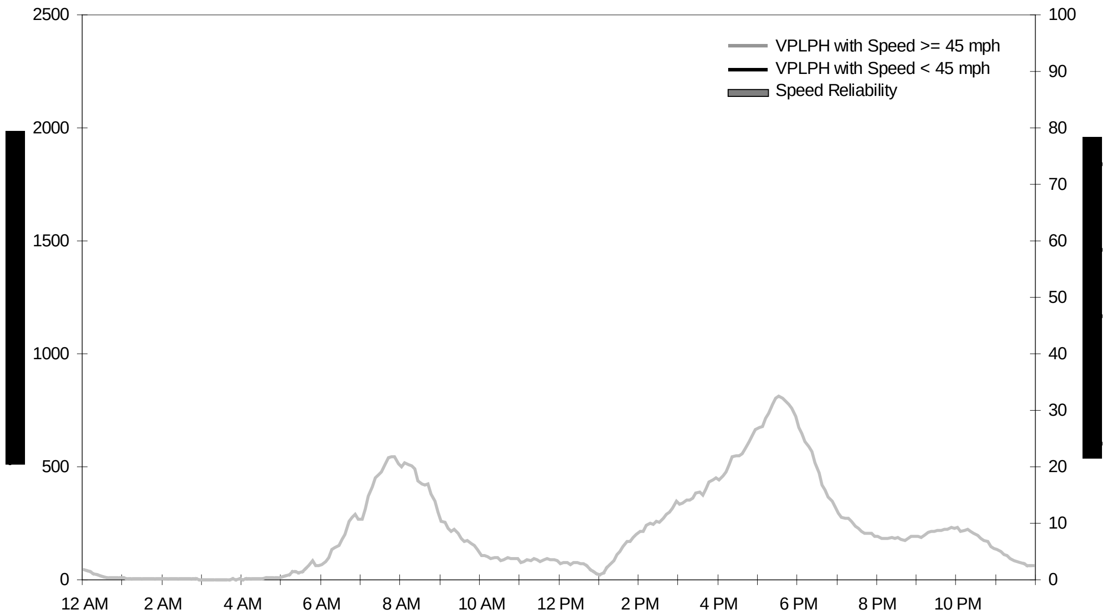
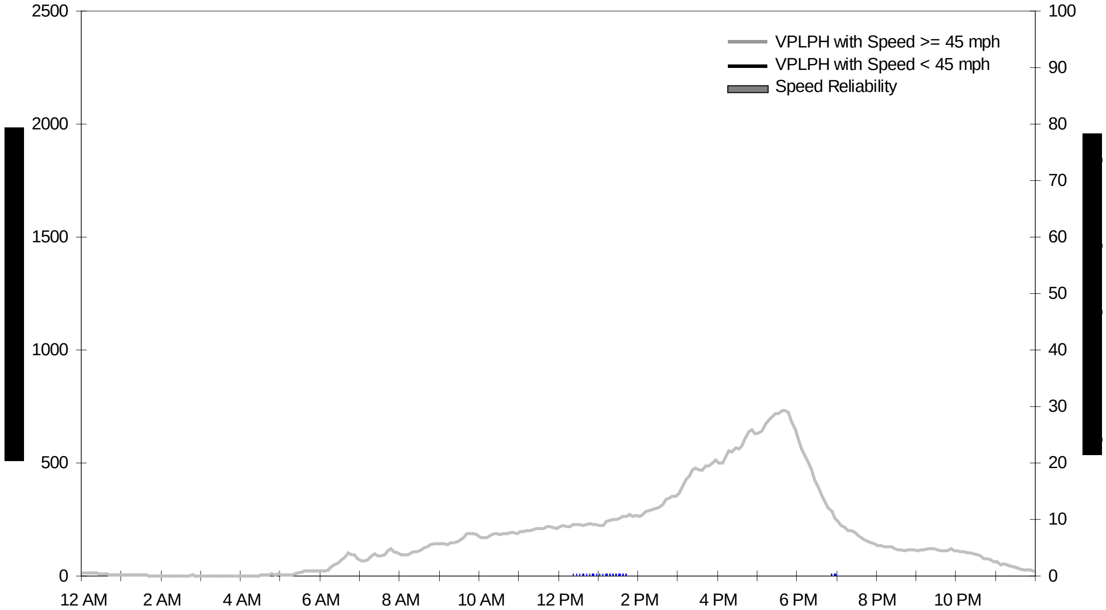


Figure 3-26. Average Weekday Volume, Speed, and Reliability Condition: I-90 @ Midspan

I-90 @ W Lk Sam Pkwy, Eastbound



I-90 @ W Lk Sam Pkwy, Westbound

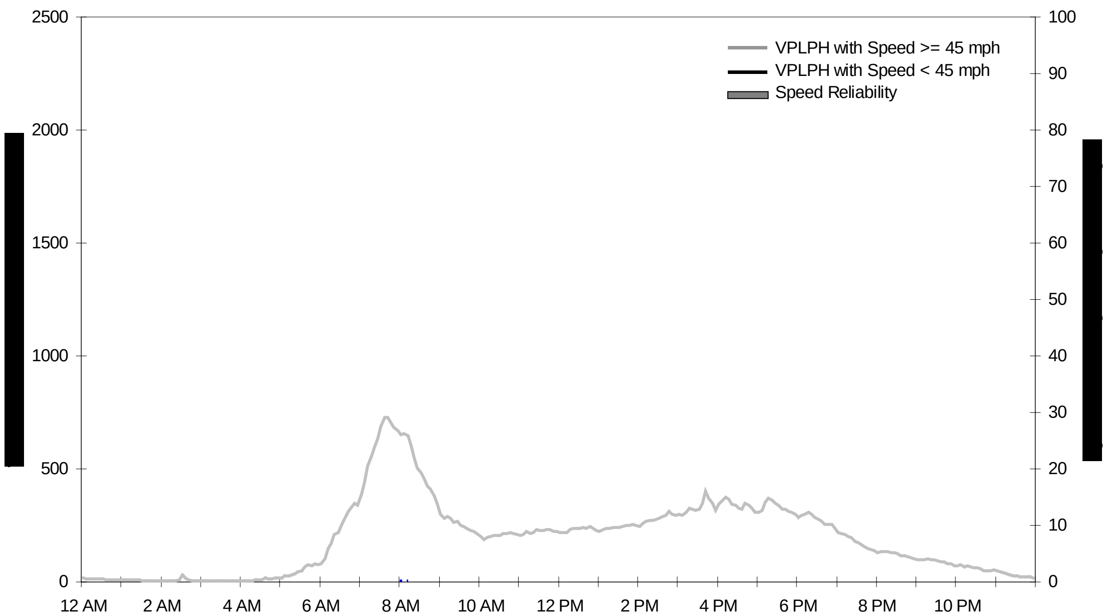


Figure 3-27. Average Weekday Volume, Speed, and Reliability Condition: I-90 @ W Lake Sammamish Parkway

SR 520 near Medina (see Figure 3-28)

Westbound

HOV lane volumes on SR 520 are constrained by the three-passenger minimum requirement on this portion of the facility. Vehicle volumes are highest during the PM peak period, averaging slightly more than 400 VPLPH. Volumes are low to moderate throughout the rest of the day. Congestion in the HOV lane at this location occurs during the PM peak period less than five percent of the time. Most congestion here is caused by spillback from accidents/disabled vehicles on the bridge that stops all traffic, although some slowing occurs because of friction with the slow moving GP lanes and merge congestion associated with the 84th Ave N.E. ramp and the approaching end of the HOV lane. There is no HOV lane eastbound.

SR 520 @ 84th Ave NE, Westbound

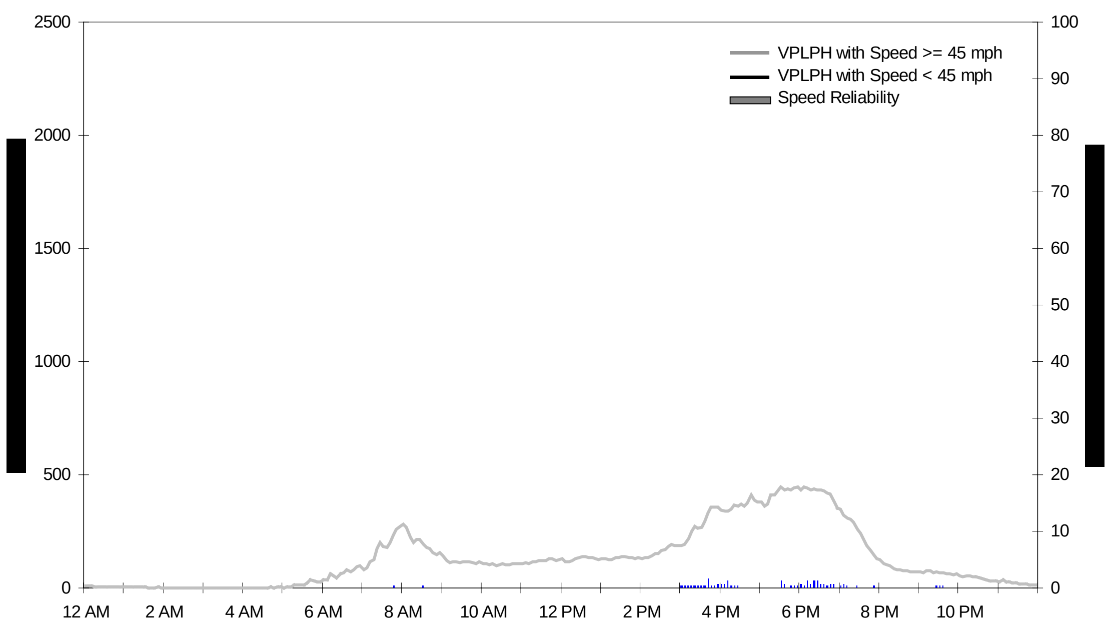


Figure 3-28. Average Weekday Volume, Speed, and Reliability Condition: SR 520 @ 84th Ave NE

SR 167 near Kent (see Figure 3-29)

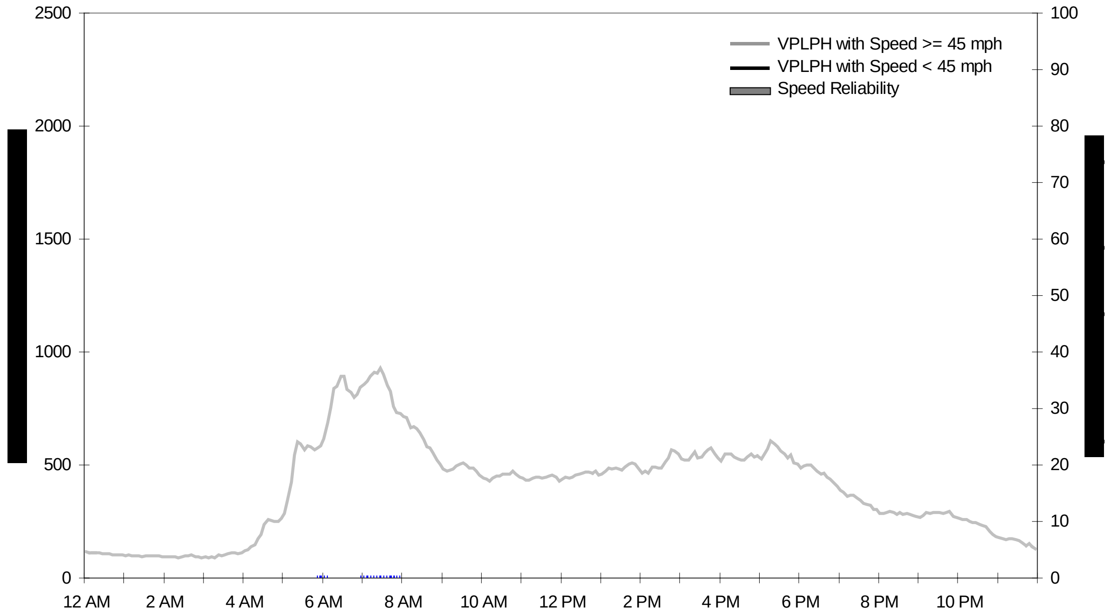
Northbound

Northbound HOV volumes are high during the AM peak period—up to 900+ VPLPH—but modest, at 500+ VPLPH, throughout the midday and evening. There is no HOV lane congestion at this location.

Southbound

Southbound PM peak period HOV volumes are more significant than northbound AM peak period volumes. Peak period volumes of 1,000+ VPLPH are higher, and the duration of the peak period is longer than the morning, northbound movement. However, the southbound movement has lower off-peak use than the northbound HOV lane, which has near constant volumes from 9:00 AM until 6:00 PM, while this southbound movement is almost nonexistent until 10:00 AM. There is still no congestion at this location.

SR 167 @ S 204th St, Northbound



SR 167 @ S 204th St, Southbound

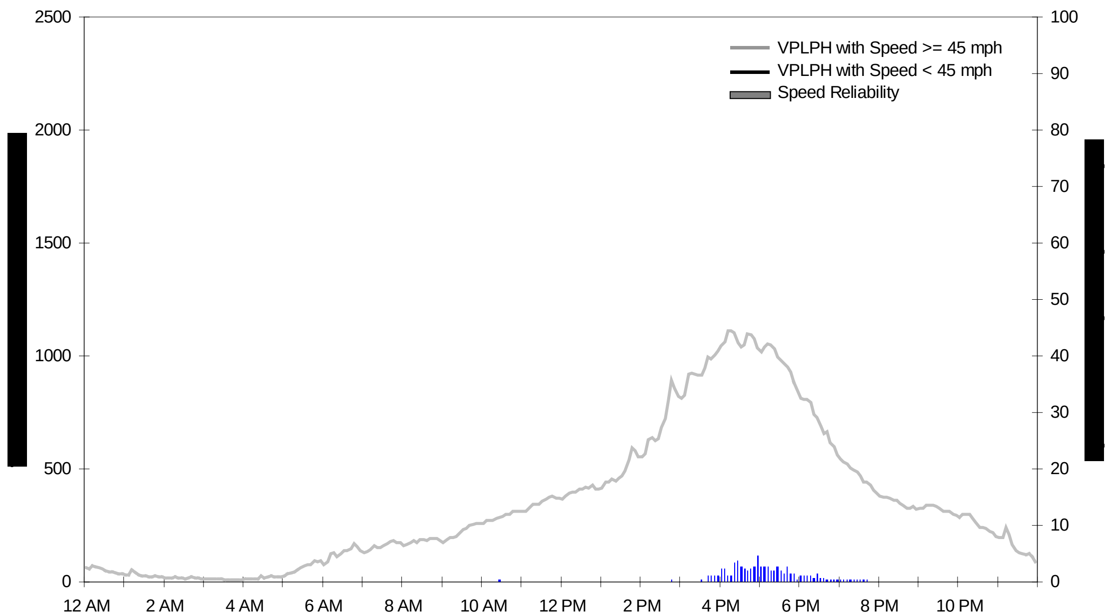


Figure 3-29. Average Weekday Volume, Speed, and Reliability Condition: SR 167 @ S 204th St

CHAPTER 4. HOV VIOLATIONS

HOV lane violation rates are not constant. They vary considerably from facility to facility, and from location to location along a facility. In general, the higher the HOV lane use, the lower the violation rate. Meanwhile, the better the opportunity to cheat and not get caught, the higher the violation rate. For example, violation rates tend to increase near points where HOV lanes merge with general purpose lanes, since some motorists seem to believe that getting into the HOV lane "just a little early" is not really a violation, and the short time spent in the HOV lane limits the chance that they will be observed by a State Patrol officer. Consequently, violations increase at the very end of HOV facilities and in the right hand HOV lanes approaching exits. SR 520 westbound approaching 92nd Ave NE is an example of where this later type of violation occurs frequently.

For this report, violation rates are calculated by using vehicle occupancy data collected by traffic observers at a limited number of locations throughout the region. The rates reported are reasonable measures of system-wide violation rates; they should not be taken as representative of the violation rates at specific locations.

Other sources used in this report that provide insight into HOV violation rates and the outcomes of enforcement actions include violation reports made to King County Metro's HERO program, and warnings and citations issued by the Washington State Patrol.

Additionally, motorists' perceptions of compliance and enforcement of HOV restrictions were also solicited through a public opinion survey. Almost half of the respondents indicated that improving enforcement is among their highest priority for improving HOV lanes. HOV lane violations, considered a serious traffic violation, are perceived as common during peak commute hours. More detailed information on the public's opinion regarding violations is contained in Chapter 5 of this report, Public Opinion.

VIOLATION RATES

Table 4-1 presents HOV violation rates measured as part of the routine system performance measurements. Figure 4-1 illustrates these violations in the context of the vehicle mode split measured at each data collection location. The violation rates in general are quite low, typically ranging from one percent to eleven percent, excluding some special cases. These low violation rates suggest that most people obey the HOV restrictions.

At a few locations, higher SOV volumes are observed in the HOV lanes. For example, at the HOV lane northbound on I-5 at Albro Place, the high percentage (twenty six percent) of observed SOVs is largely due to the fact that the HOV lane also serves as an inside exit lane at this location, and thus general purposes traffic mixes with the HOV traffic. This illustrates the point that violations increase toward the end of facilities and where HOV lanes are shared with exits.

The I-90 Midspan HOV lane measurement also shows a high SOV volume (fifty percent). This is caused by the legal access of SOVs traveling between Mercer Island and the Mt. Baker tunnel. Thus, while these vehicles decrease the average vehicle occupancy for this facility, they do not violate HOV regulations.

Table 4-1. HOV Violation Rates

Location	AM Violation Rate and Roadway Direction	PM Violation Rate and Roadway Direction
I-5 @ 112th SE	2% (SB)	1% (SB)
I-5 @ NE 137th St.	3% (SB)	1% (SB)
I-5 @ Albro	26% (NB)[2]	1% (SB)
I-5 @ S 216th St	2% (NB)	2% (SB)
I-405 @ NE 85th St.	3% (SB)	3% (NB)
I-405 @ SE 59th St.	5% (NB)	5% (SB)
I-405 @ Tukwila Parkway	8% (SB)	4% (NB)
I-90 @ Midspan	52% (WB)3	51% (EB)[2]
I-90 @ Newport Way	5.5% (WB)	7% (EB)
SR 520 @ 84th Ave NE	6% (WB)	11% (WB)
SR 167 @ S. 208th St.	4% (NB)	4% (SB)

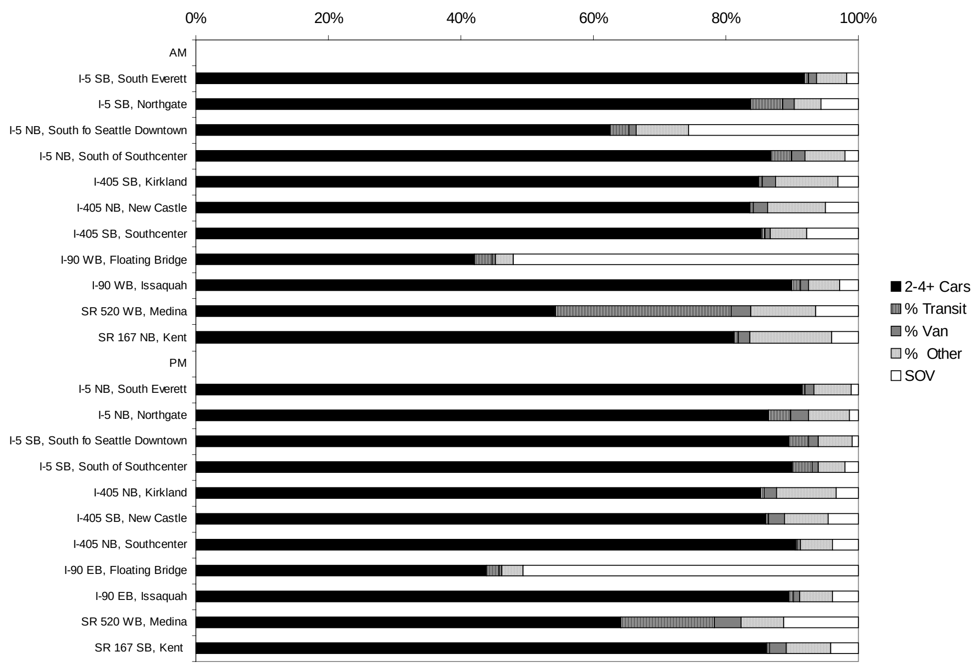


Figure 4-1. Mode Split in HOV Lanes, from Observed Occupancy Rate (2002)

[2] The HOV lane at this location includes SOVs legally using the lane to exit the freeway.
[3] SOVs may use the I-90 reversible roadway legally traveling between Mercer Island and downtown Seattle.

THE HERO PROGRAM

The HERO program is a service provided in 2002 by King County Metro that encourages motorists to report HOV violators by calling (206) 764-HERO or by sending in reports of violations electronically. The HERO program does not issue tickets because the Washington State Patrol (WSP) must actually observe the violation to enforce the infraction. However, HERO reports repeat violators to the WSP for possible enforcement action. Upon a first report, 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, that 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 WSP, also issued by the HERO office.

Figure 4-2 shows the annual violation report rates for the HERO program from 1994 to 2002. The number of reported violations has increased steadily until 2000, with the total annual number of reported violators reaching almost 44,000 in 2000. This increase is fueled, in part, by the increase of the HOV lane system, and in part by the availability of cellular phones, which make access to the HERO hotline easier. Figure 4-3 compares the violation report rates for the HERO program by month for the last three years. Reported violation rates usually 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.

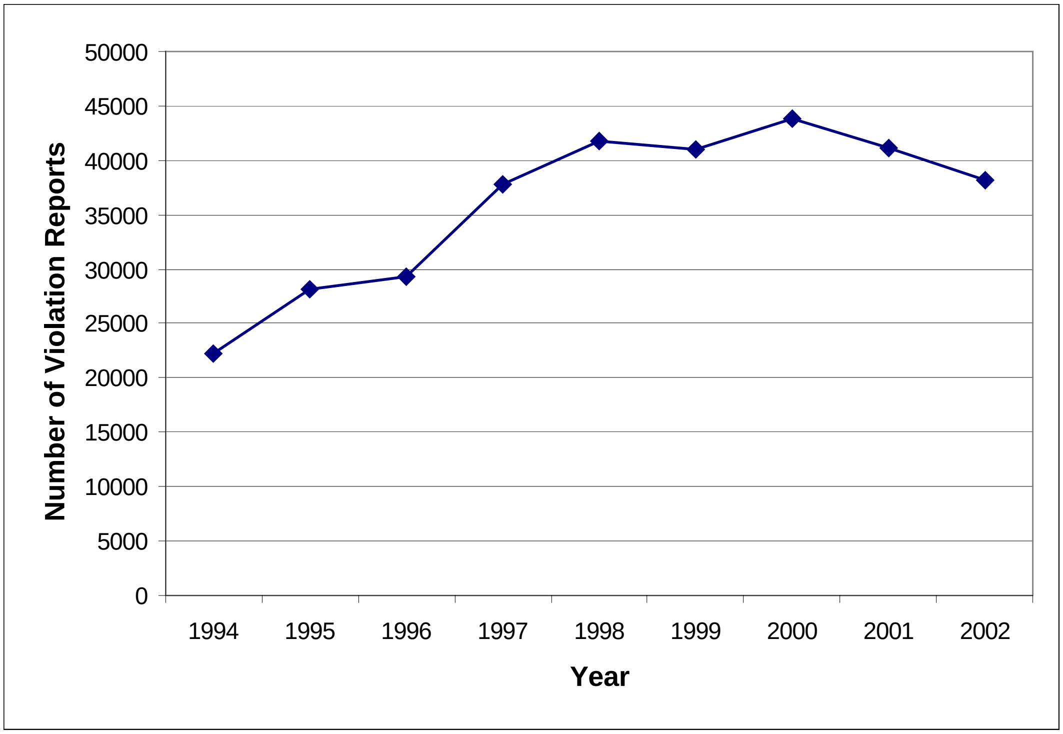


Figure 4-2. HERO Program Actions by Year

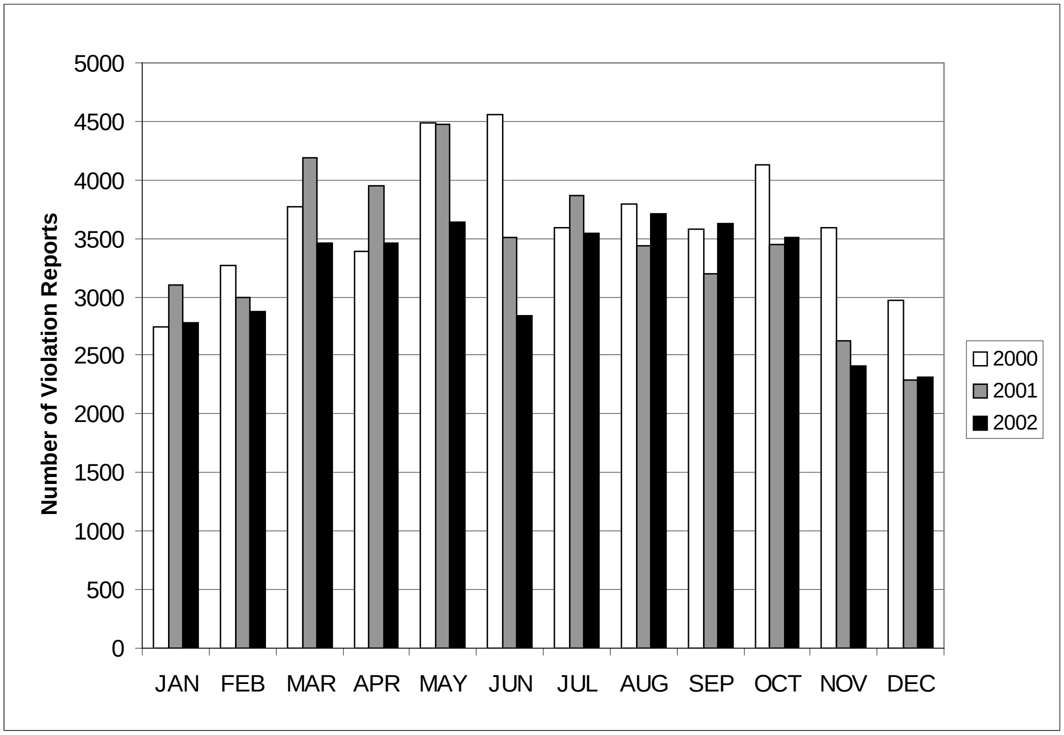


Figure 4-3. HERO Program Actions by Month

WASHINGTON STATE PATROL

The Washington State Patrol has primary responsibility for enforcing HOV lane restrictions on state highways. However, HOV enforcement is only one of many critical jobs performed by the WSP officers. Therefore, the number of HOV violation contacts and the number of citations issued is usually not controlled by the number of HOV violators, but by the officer time available for this function. The number of officer hours available for HOV enforcement is a function of the number of officer positions funded by the legislature and the priority of HOV enforcement in comparison to other critical duties.

Although 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. In 2002, the WSP reported 11,581 contacts with HOV violators and issued 8,814 tickets, a ticketing rate of seventy six percent (see Table 4-2). This was the highest ticketing rate in the past ten years.

Table 4-2. Washington State Patrol HOV Enforcement Actions, 1993-2002

Type of Action	*Arrest Citations*	*Verbal Warnings*	*Written Warnings*	*Accident Citations*	*Other*	*Total*
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	6,291	4,039	220	N/A	22	**10,572**
1999	7,915	3,534	190	N/A	20	**11,659**
2000	9,045	3,421	120	N/A	5	**12,591**
2001*	11,088	3,885	190	N/A	N/A	**15,163**
2002	8,814	2,703	64	N/A	N/A	**11,581**

CHAPTER 5. PUBLIC OPINION SURVEY FINDINGS

The results presented in this report are based on data collected during October and November in 2002. The surveys were mailed to the registered owners of vehicles identified as HOVs and SOVs by traffic observers in the field. In 2002, the surveys were also handed out directly to bus riders at major Park and Ride lots. Four hundred sixty five (465) individuals responded. Because of the semi-random nature of the mailing and returning of the surveys, conclusions drawn from these data should not be considered completely representative of either the traveling public, or the driving population.

DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

The following are descriptive statistics about the survey respondents:

- 52 percent of survey respondents were male (See Figure 5-1).
- The majority of respondents were between the ages of 31years and 64 years (see Figure 5-2).
- 70 percent of respondents had a college degree or post-graduate education
- 6 percent had finished high school but not studied further (See Figure 5-3).
- Approximately 30 percent had more than three people living in their household (See Table 5-1).
- Over 85 percent of the respondents had two people living in the house that were sixteen years or older, while 75 percent had two or more cars.
- A common domestic condition included having one to two people working outside of home.

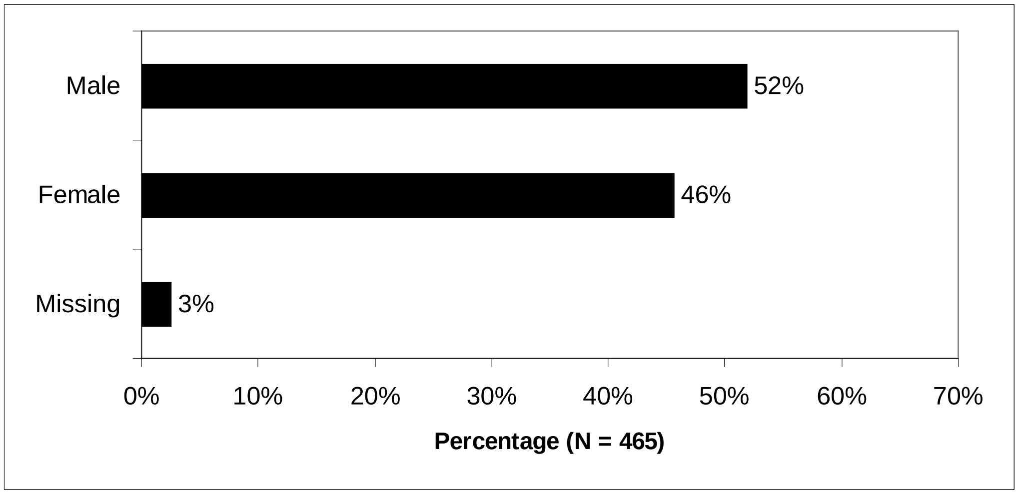


Figure 5-1. Gender of Respondents

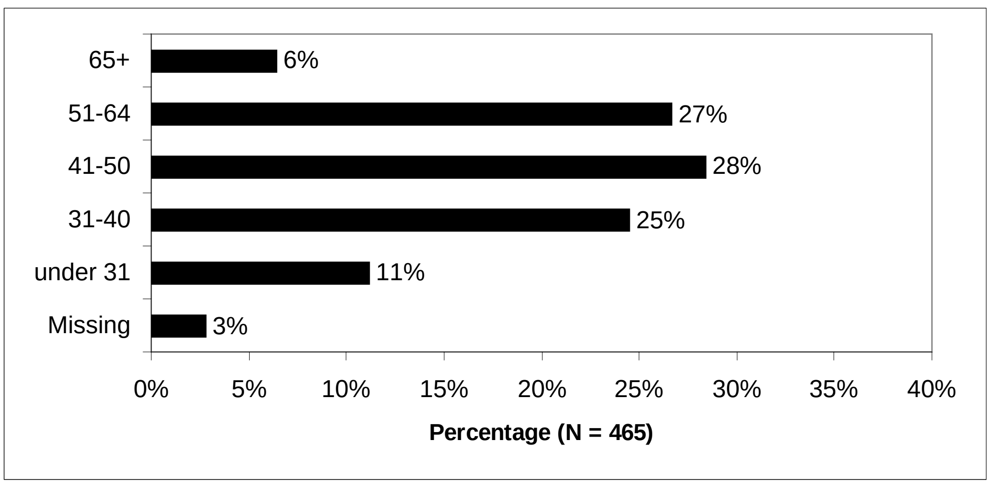


Figure 5-2. Age of Respondents

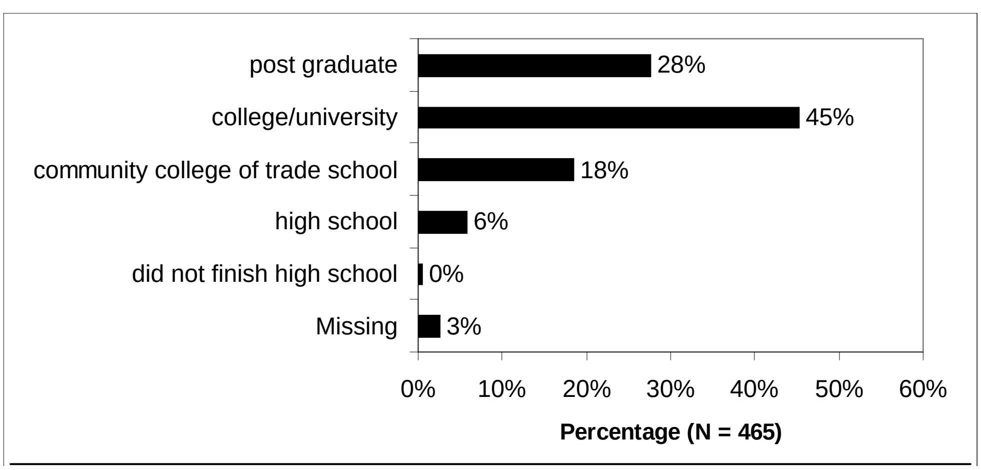


Figure 5-3. Education Level of Respondents

Table 5-1. Demographics of Respondents

Domestic Conditions		Percentage (N =465)	Accumulative Percentage
No. of people living in the household			
	1	15%	15%
	2	36%	51%
	3	17%	68%
	4	21%	89%
No. of people over age 15			
	1	15%	15%
	2	56%	71%
	3	13%	85%
	4	8%	92%
No. of people working outside of home			
	1	31%	31%
	2	50%	81%
	3	7%	89%
	4	3%	91%
No. of vehicles			
	1 vehicle	19%	19%
	2 vehicles	48%	67%
	3 vehicles	20%	87%
	4 vehicles	7%	94%

* 2001 total does not include November and December.

SURVEY RESULTS

Route Familiarity (See Figure 5-4)

Figure 5-4 shows the normal peak period routes used by the respondents. In addition to commutes, over half of the respondents frequently use one or more HOV lane equipped freeways for non-commute purposes during the peak period. Almost 40 percent of respondents use more than one freeway corridor during the peak period. In the sample response, use of both SR 167 and I-405 for non-commute trips exceeds use of those facilities for commuter trips. When both trip purposes are combined, the use of the different corridors as reported by the sample population closely resembles the actual person volume patterns measured on the freeway system. Thus, geographically, the sample respondents have little bias relative to Puget Sound freeway use.

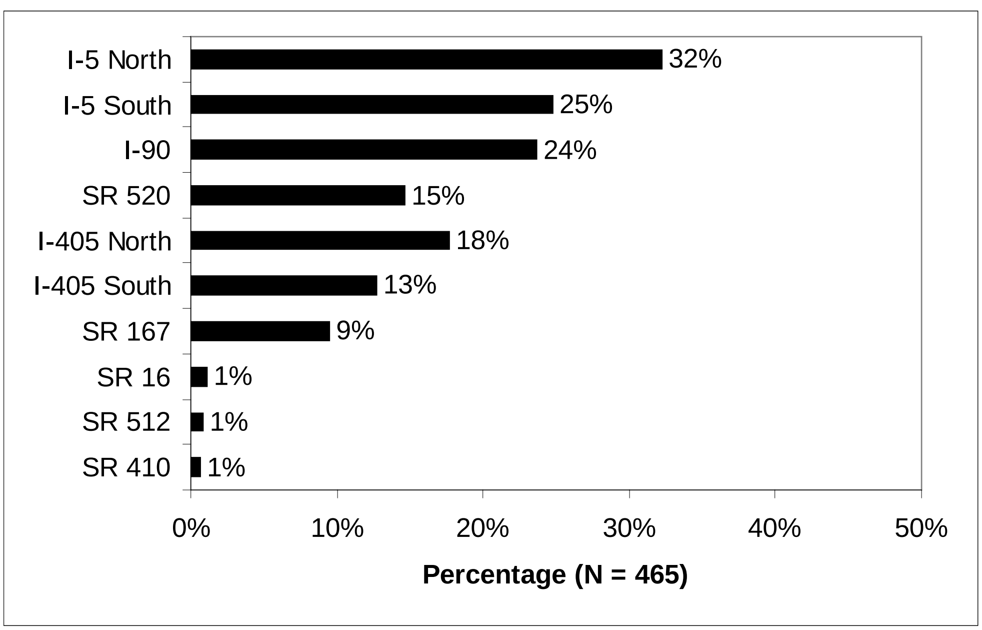


Figure 5-4. Normal Commute Routes Used

Peak Period Mode Choice (See Figure 5-5)

Figure 5-5 shows the “usual” mode of travel during the peak period, as reported by the survey respondents. The largest group of survey respondents (45 percent) usually drives alone. However, more than half of the survey respondents use a form of HOV mode to get to work. Using the figures from earlier chapters of this report, it can be estimated that freeway use for all major roads near the urban core consists of roughly 65 percent SOV users during the peak periods. Consequently, it is possible to state that these survey responses are slightly biased towards HOV users when compared to the general population of freeway users.

Figure 5-5 also shows that the majority (71 percent) of survey respondents who use HOV modes routinely are bus riders. Since transit riders make up usually between 12 and 50 percent of peak period HOV lane users, it can also be stated that carpoolers are under-represented in the survey and transit riders are over-represented.

However, focusing just on the ‘usual mode’ of travel, tends to under-estimate HOV lane use. While 45 percent of the survey respondents “usually” drive alone, ninety-one percent of survey respondents have used the HOV lanes. When asked to list all of the modes they have taken when using the HOV lanes, carpool usage was by far the largest response. (See Fig 5-6.) This would indicate that a large ‘periodic’ carpool market exists in the region.

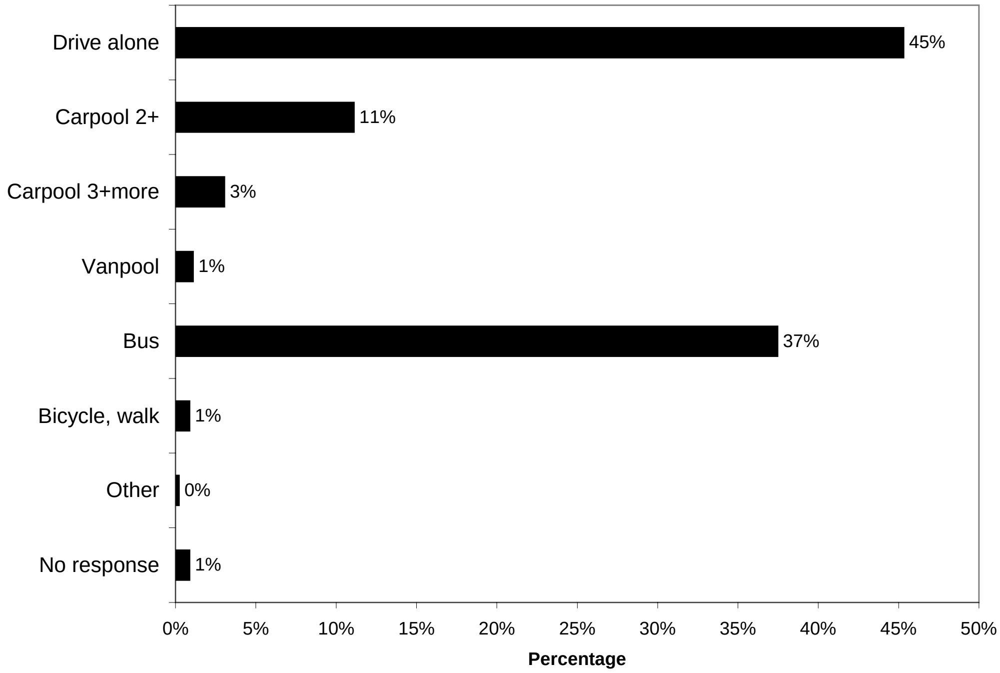


Figure 5-5. 'Usual' Peak Period Mode Choice

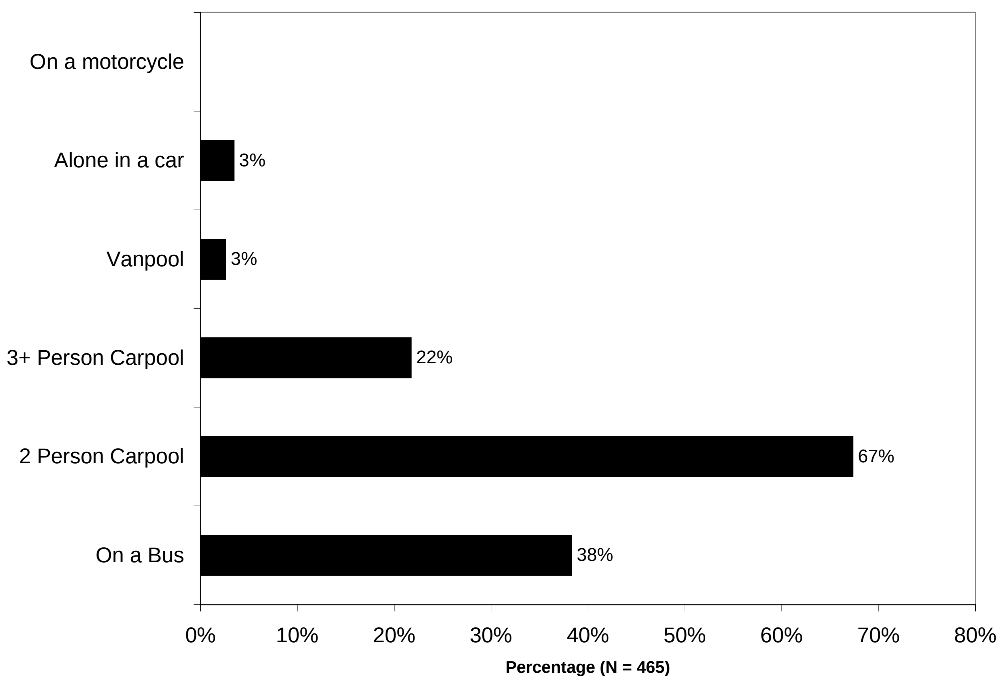


Figure 5-6. Modes Used When Taking Advantage of HOV Lane Eligibility

Why drivers don't use the HOV lanes (See Figure 5-7)

It is well known in traffic engineering circles that HOV eligible vehicles frequently choose not use the HOV lanes. 40 percent of survey respondents indicated that they did not always use the HOV lane even when they knew they were in an eligible vehicle and provided a variety of reasons why they chose not to use the HOV lanes. The most prevalent reason stated was that traffic was already fast enough in the GP lane. Other reasons included trouble in changing lanes, and the traffic in the HOV lanes being slower than that in the GP lanes (See Figure 5-7). Note that respondents could give more than one reason for not using the HOV lane.

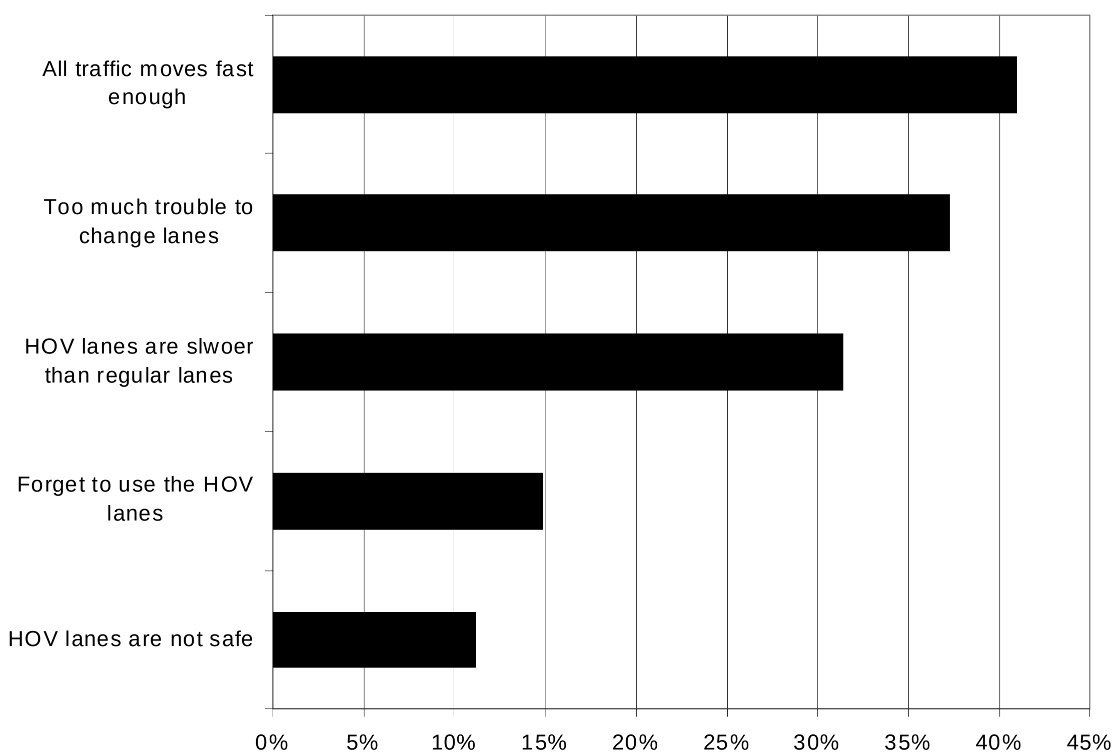


Figure 5-7. Reasons HOV Lanes Were Not Used

Support for HOV Lanes and Attitudes Towards Their Current Use

The primary reason to undertake this survey was to determine the attitudes of freeway users towards the HOV system. The survey results are grouped as follows: General Perception, HOV Lane Operation, HOV Lane Violations, and HOV Lane Improvements. Survey responses are broken down by the respondent stated ‘normal commute mode’ so that differences in the attitudes of HOV and SOV users can be understood. Sample sizes for both HOV and SOV groups are provided for each question.

Overall, the support for HOV lanes continues to remain high among all commuters, whether they are SOV or HOV drivers (See Figure 5-8). Both groups agree that HOV lanes are convenient to use (see Figure 5-9). However, about one third of respondents felt that the HOV lanes are not fully utilized (see Figure 5-10).

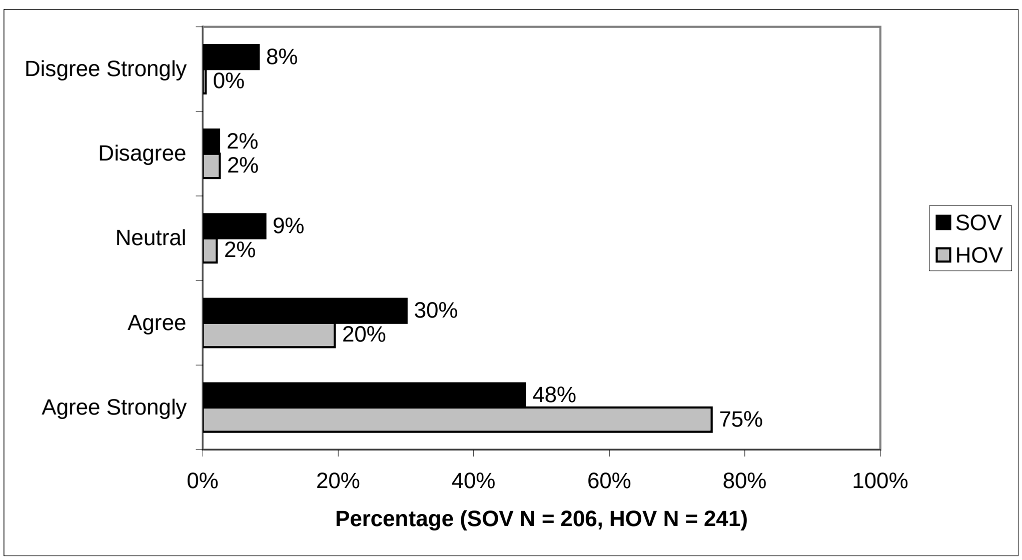


Figure 5-8. HOV Lanes are a Good Idea

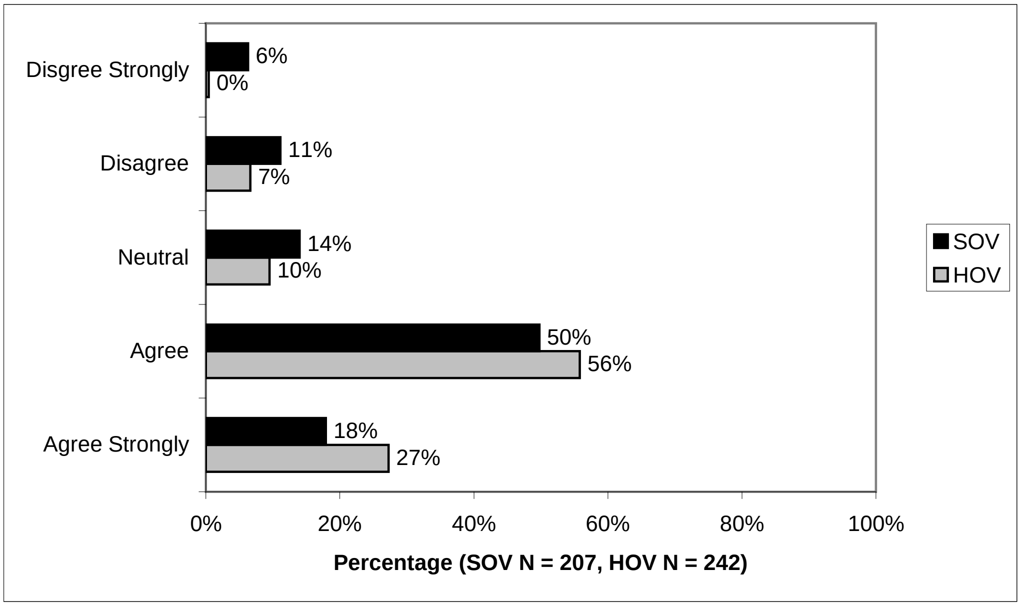


Figure 5-9. HOV Lanes are Convenient to Use

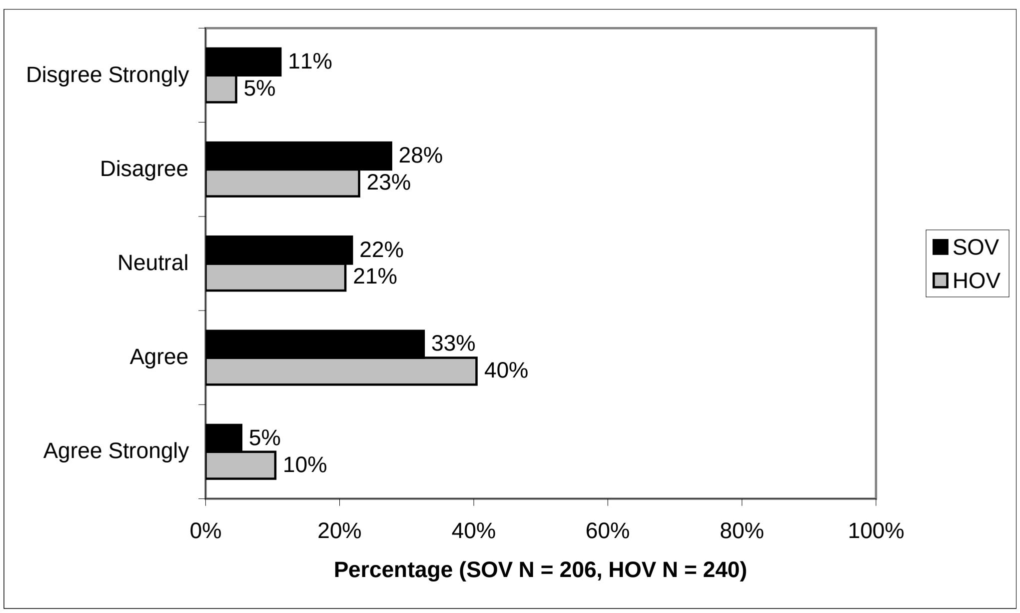


Figure 5-10. Existing HOV Lanes are Being Adequately Used

Answers to these three questions help explain the public's general attitude towards continued HOV lane operations. A significant majority of respondents feel that HOV lanes should remain in place (see Figure 5-11), although not surprisingly, a larger percentage SOV users favor opening HOV lanes to all traffic than HOV users. The fact that 78 percent of SOV users think HOV lanes are a good idea, but that only 59 percent think they should remain as HOV lanes, indicates that their support for HOV lanes is likely based on a view that HOV lanes provide an increase in total roadway capacity which they view as their key attribute.

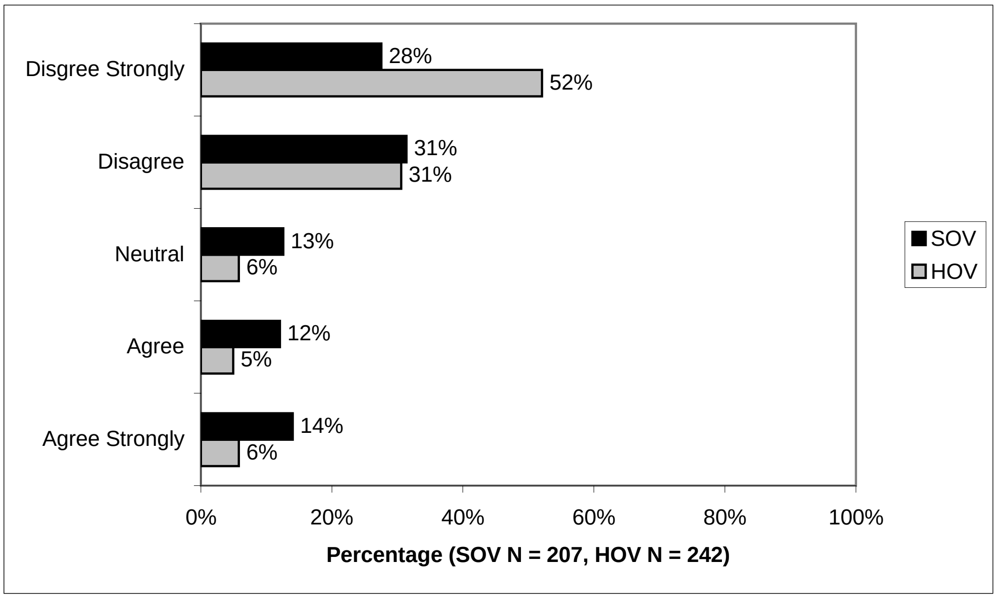


Figure 5-11. HOV Lanes Should Be Opened to All Traffic

The fact that respondents are somewhat ambivalent about the how heavily HOV lanes are being used (Figure 5-10 above), combined with the 26 percent of SOV users who don't like HOV lanes (Figure 5-11 above) leads to a fairly strong public opinion that HOV lanes should be opened to all traffic during non-commute hours. (See Figure 5-12) Importantly, even routine HOV users are rather ambivalent about this proposal, with 42 percent agreeing, 40 percent against, and 18 percent neutral.

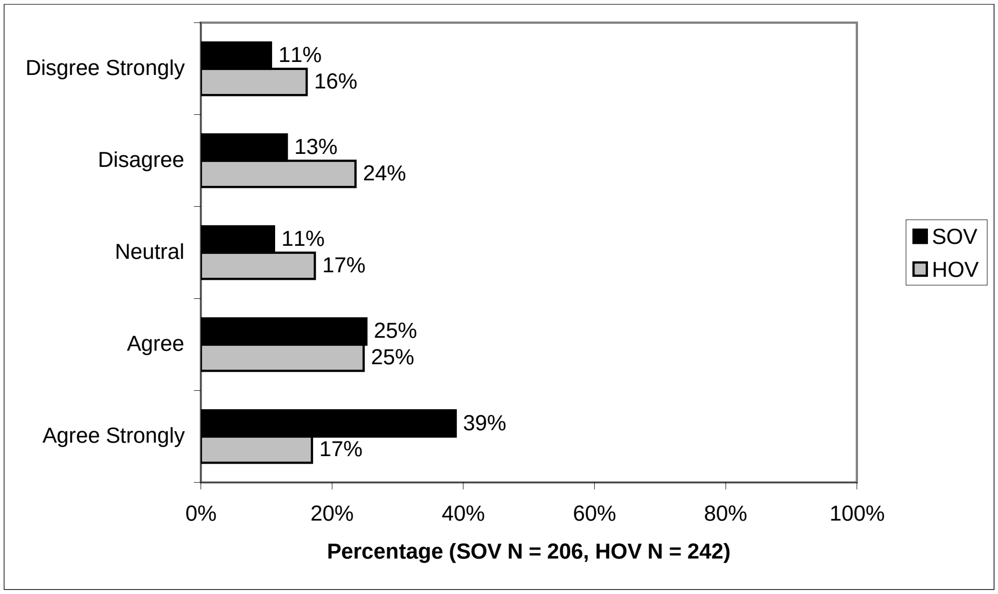


Figure 5-12. HOV Lanes Should Be Opened to All Traffic During Non-Commute Hours

The desire to use HOV lanes off-peak does not prevent a significant majority of respondents from being interested in seeing continued HOV construction (see Figure 5-13) with HOV users tending to be very strongly in favor of this effort. Further support for HOV lanes is apparent in the fact that the vast majority of respondents believe that HOV lanes are a fair use of taxpayers' money, although not surprisingly, SOV users are less likely to think this way than HOV users. (See Figure 5-14)

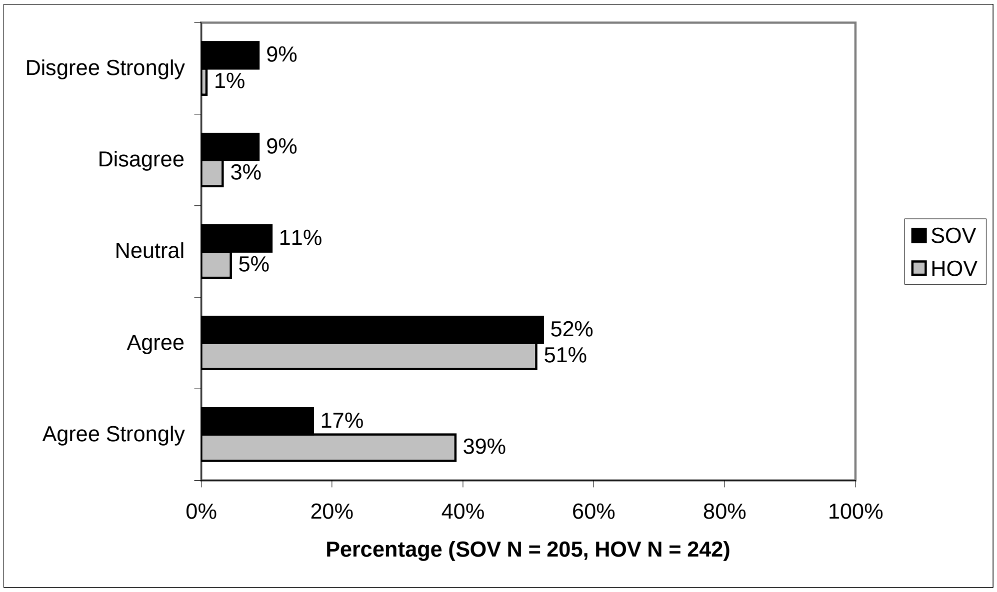


Figure 5-13. HOV Lane Construction Should Continue

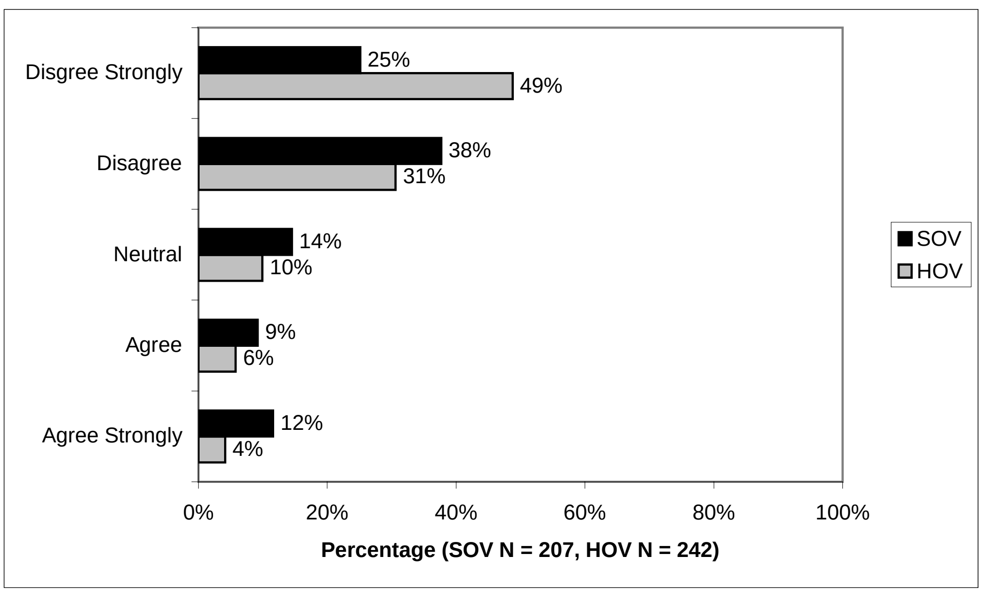


Figure 5-14. Constructing HOV Lanes is Unfair to Taxpayers Who Choose to Drive Alone

There is less certainty and less agreement that extending the HOV lanes will actually result in changing people's travel habits. (see Figure 5-15). It is significant that very few respondents answered this question "very strongly" either in agreement or disagreement. In addition, the differences between SOV and HOV responses to this question are fairly modest. HOV users are only slightly more positive about the effect carpool lanes have on mode choice than SOV users. This would indicate that the general population is not at all certain about how much of an effect HOV lanes have on traveler's mode choice.

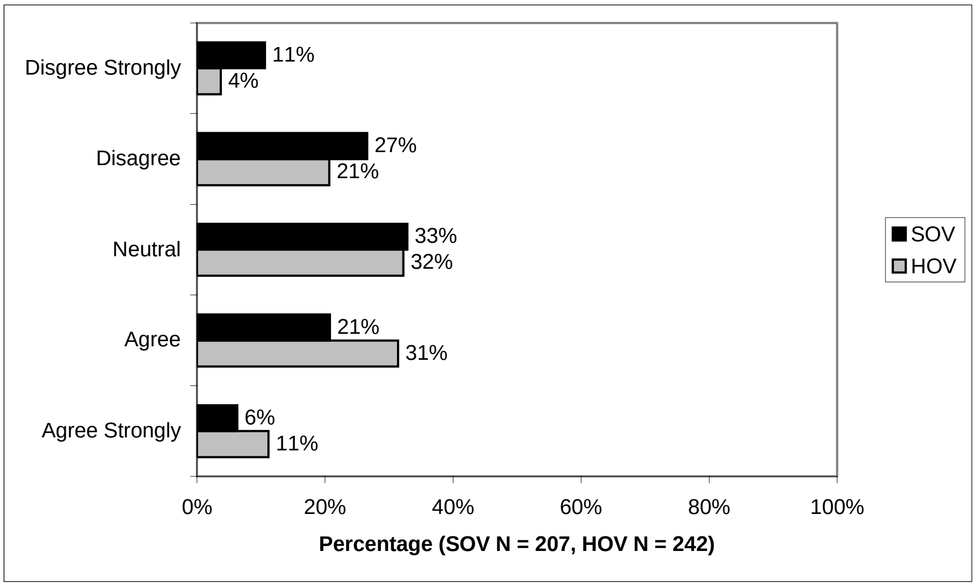


Figure 5-15. More People Would Carpool if HOV Lanes Were More Widespread

A similar ambivalence is apparent in respondent's attitudes towards whether HOV lanes save travel for SOV users as well as HOV users (See Figure 5-16), although in this case, there is a more significant difference between people who routinely drive alone, versus those who use HOV modes. The argument that HOV lanes save everyone time is based on the concept that HOV lanes encourage mode shift, which then results in a reduction in total vehicle demand on that road. If respondents are not sure HOV lanes have a mode shift causing effect, they are unlikely to believe that HOV lanes improve travel times for all commuters.

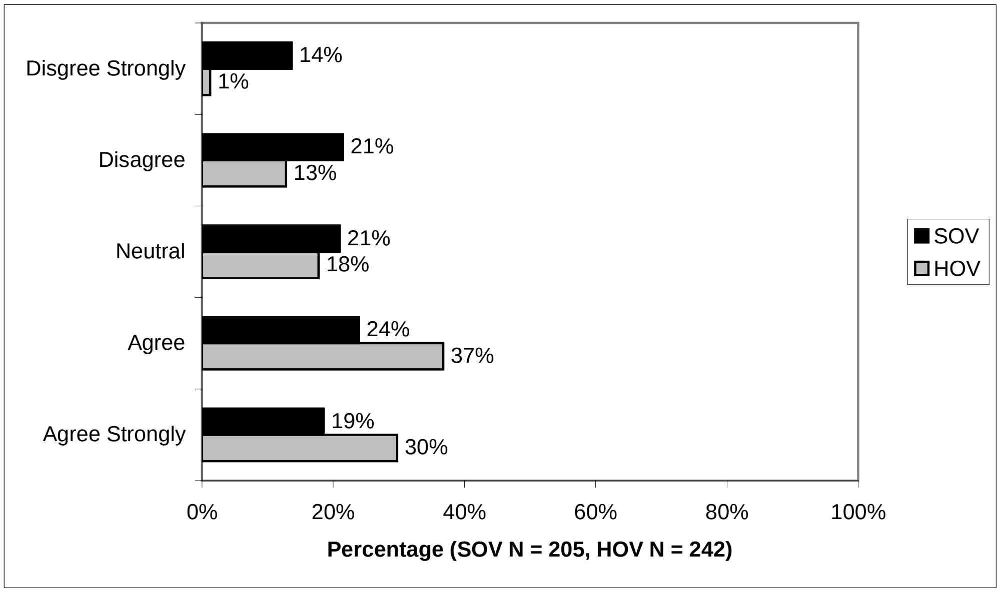


Figure 5-16. HOV Lanes Help Save All Commuters a Lot of Time

HOV Lane Violations and Enforcement

Over half of the survey respondents agree that violations are common during the commute hours (see Figure 5-17). Only about 15 percent of respondents think that violations are not common. SOV and HOV users generally share the opinion that these violations are serious traffic offenses (see Figure 5-18). They are not sure, however, that the HERO program helps reduce the occurrence of these violations (see Figure 5-19).

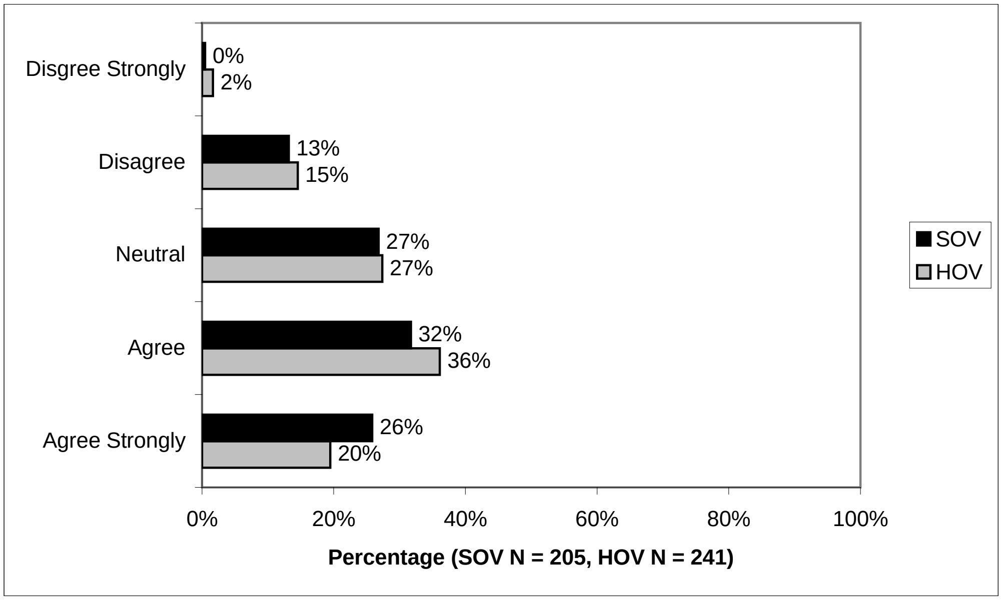


Figure 5-17. HOV Violations are Common During the Commute Hours

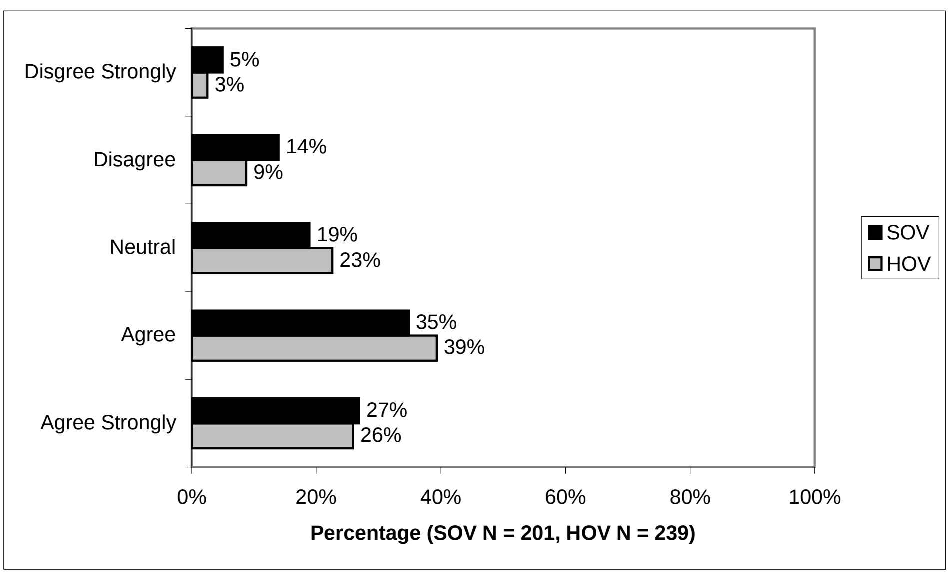


Figure 5-18. HOV Violators Commit a Serious Traffic Violation

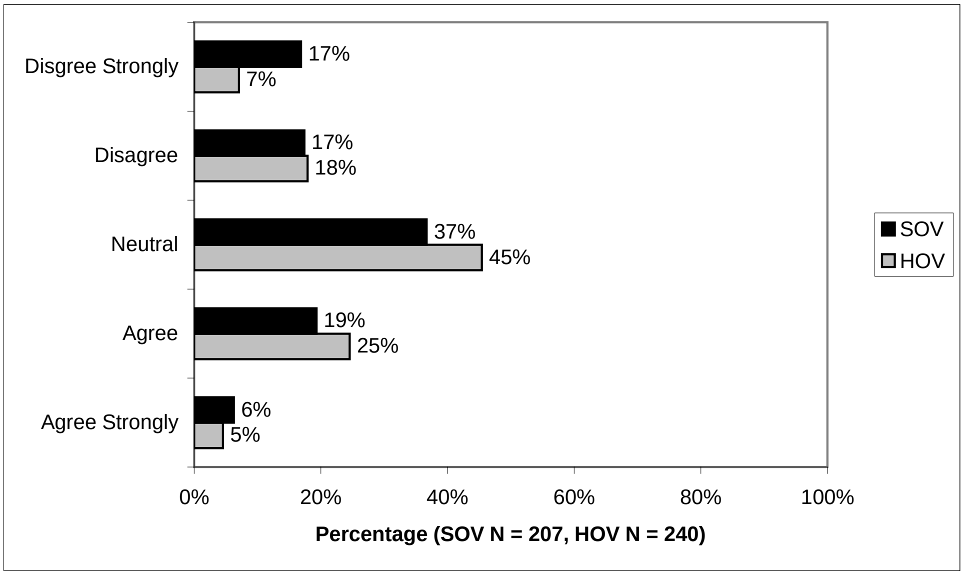


Figure 5-19. HERO Program Helps Reduce HOV Lane Violations

HOV Lane Improvements

Respondents do not generally see the current HOV lane operations as being unsafe. Figure 5-20 shows that only slightly more than one quarter of the respondents see vehicle entrance and exiting from the HOV lanes as being unsafe. SOV users are slightly more likely to believe that there is a safety issue with vehicle entrance and exit from the HOV lane.

When given the opportunity to select up to three options to make HOV lanes more attractive, SOV and HOV user responses were reasonably similar, although SOV users were more likely to select physical improvements to the HOV lanes and better enforcement, while HOV users had a much higher propensity for more frequent, lower cost transit services that used the HOV lanes. (See Figure 5-21.)

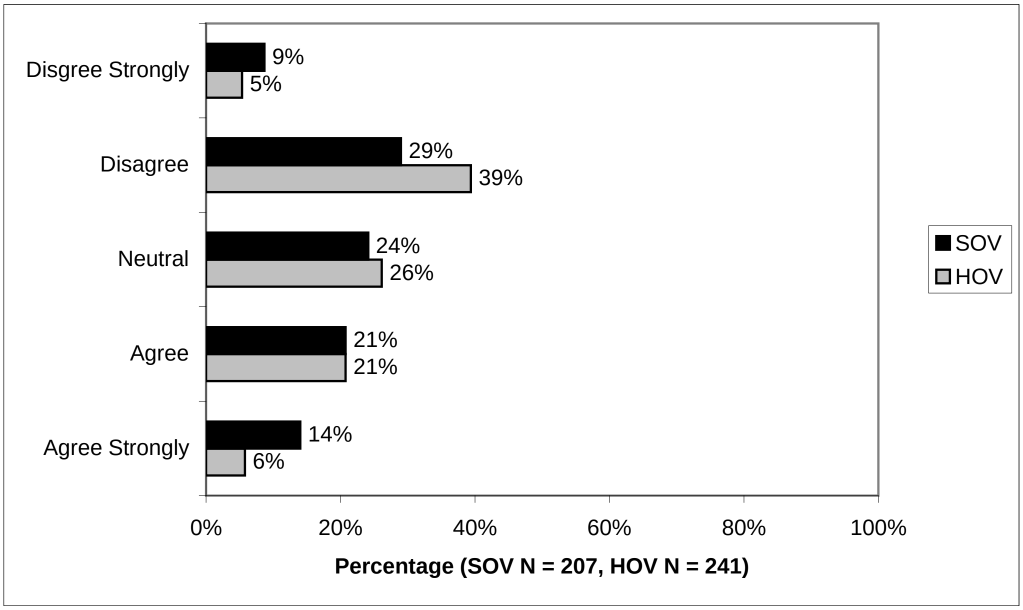


Figure 5-20. Vehicles Dart In and Out of HOV Lanes Too Often for the Lanes to be Safe

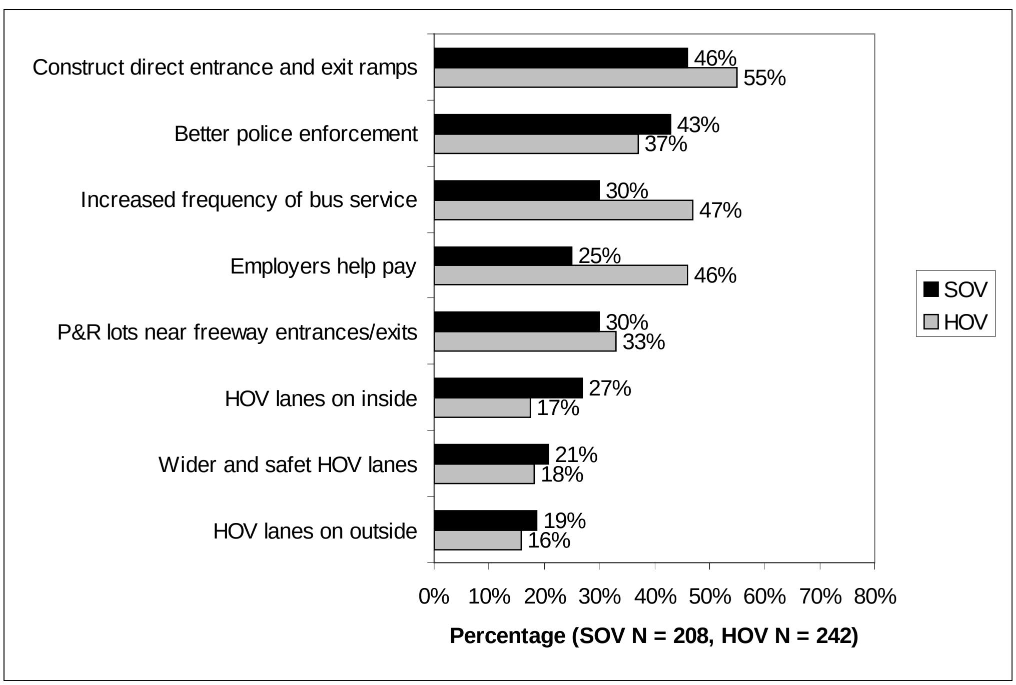


Figure 5-21. Options to Improve HOV Lane Usage