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POTENTIAL USE OF PUGET SOUND HOV LANES BY GENERAL PURPOSE VEHICLES IN OFF-PEAK HOURS: A SUMMARY PAPER

by

John M. Ishimaru	Mark E. Hallenbeck	Jennifer Nee
Senior Research Engineer	Director	Research Engineer

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

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16. ABSTRACT

Off-peak traffic volumes in the Puget Sound region of Washington State are increasing, and public concern about congestion during non-commute periods has caused WSDOT to re-examine the current policy of restricting HOV lanes to transit vehicles and carpools 24 hours per day, 7 days per week. In many parts of the country, HOV lanes are open to general traffic during non-peak hours. Should WSDOT adopt this less restrictive lane use policy?

This report examines the trade-offs that a change in weekend HOV lane usage would involve. The basic issues that are examined include the following:

- What congestion relief benefits would result?
- Would these changes have adverse impacts on HOV formation and/or HOV lane compliance rates?
- Would the weekend use of HOV lanes by general purpose vehicles create safety concerns?
- Would highway and transit operational problems be created?
- What would be the monetary impacts of changing weekend HOV lane usage?

Supported by a variety of performance graphics and statistics, the report concludes that no improvement in mobility would be obtained by relaxing the current Puget Sound HOV lane operating restrictions to allow off-peak use of the HOV lanes by general purpose traffic.

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The Puget Sound region has some of the most severe traffic congestion in the country. To help combat this congestion, the region has built one of the nation's most extensive and successful HOV systems. During peak commute periods, the majority of the region's freeway HOV lanes carry more people, in fewer vehicles, at faster speeds, than the general purpose (GP) lane adjacent to them.

However, population and employment growth in the region continues to outstrip the region's ability to build roadway capacity. Midday and weekend traffic volumes are increasing, and public concern about the congestion occurring during non-commute periods has caused WSDOT to reexamine the current policy of restricting HOV lanes to transit vehicles and carpools 24 hours per day, 7 days per week. In many parts of the country, HOV lanes are open to general traffic during non-peak hours. Should WSDOT adopt this less restrictive lane use policy?

This paper examines the trade-offs a change in HOV lane usage would involve. The basic issues that need to be examined include the following:

- What congestion relief benefits would result?
- Would these changes have adverse impacts on HOV formation and/or HOV lane compliance rates?
- Would the use of HOV lanes by general purpose vehicles create safety concerns?
- Would highway and transit operational problems be created?
- What would be the monetary impacts of changing HOV lane usage?

This paper primarily discusses the WSDOT freeway HOV system in the Puget Sound region. However, the reader must note that the region contains a significant number of short HOV segments on arterials. These facilities are normally designed as "queue jumps" that allow transit vehicles to by-pass known congestion locations. Opening these HOV facilities would have a significant impact on local congestion at those locations. These facilities are discussed only briefly in this paper, and if they are considered for opening, they need to be analyzed individually.

CONGESTION RELIEF

The amount of congestion relief that would result from opening the HOV lanes to general purpose traffic during non-commute times is a function of the congestion currently present in the general purpose lanes and the number of HOV eligible[1] vehicles currently using the roadways. In general, where no GP lane congestion exists, opening the HOV lanes to general traffic would have no effect on congestion. Similarly, if a large percentage of vehicles are HOV eligible but are not using the HOV lane because the GP lanes are moving well enough, opening the HOV lane to GP traffic would also have no effect on overall congestion levels.

In general, but particularly with HOV lanes located on the left side of roadways, WSDOT surveillance data have shown that most HOV eligible vehicles do not use HOV lanes unless drivers see a need for a speed advantage over the other cars on the freeway. This occurs most frequently when congestion starts to build on the freeway. When congestion does begin to build, HOV volumes grow substantially whenever there is a sufficient number of eligible vehicles.

These basic factors that govern HOV lane use differ depending on time and location. Because congestion levels and the number of HOV eligible vehicles change by time of day and day of week, it is necessary to look at different time periods and locations to summarize the congestion relief possible from the relaxation of current HOV lane regulations in the Puget Sound region. Consequently, this report splits time of day and day of week into four basic periods:

- commute times
- late night traffic (on all days)
- weekend traffic
- midday on weekdays (simply called "midday" hereafter).

Each of these periods is discussed below. However, the majority of this section discusses the two periods on which most interest in removing HOV lane restrictions has been focused: weekends and midday weekdays.

The conclusions presented in this section are based on data from the WSDOT freeway management system (FLOW). The graphics presented are taken from existing WSDOT freeway performance reports. This paper assumes that readers are familiar with the performance reporting graphics WSDOT uses for monitoring congestion in the metropolitan region.[2]

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[1] HOV lane eligible vehicles are carpools legal for that facility, regardless of whether they are physically using the carpool lane.

[2] For instructions on how to read these graphics, please see the WSDOT report "Central Puget Sound Regional Freeway Network Usage and Performance," March 1999, WA.RD #466.1. To learn about the

Commute Periods[3]

In summary, most HOV lanes are heavily used during commute periods. Some routes (such as I-5) have very high levels of person throughput on HOV lanes in the peak period. Other routes, primarily newer HOV lanes with lower levels of transit service (such as SR 167), have HOV lane person throughput that roughly equals that of the GP lane next to them, but in far fewer cars.

HOV vehicle volumes are high during commute periods, although usually lower than the volume in the adjacent GP lane. Because most HOV lanes are fairly heavily used, removal of HOV lane restrictions would generally result in an increase in congestion and delay, as well as a decrease in person throughput. Removal of HOV lane restrictions would also cause a mode shift away from shared ride transportation and to single occupant vehicle (SOV) travel. On most facilities, even a small shift away from HOV modes to single occupant cars (for example, if only 7 percent of HOV users chose to drive alone) would produce a net increase in vehicles per lane. Any increase in the number of vehicles using the road adds to the congestion that occurs at area bottlenecks. These bottleneck points would then become more congested, increasing both the duration of congestion and the length of the back-up approaching those choke points.

Late Night Traffic

Traffic late at night travels basically free from congestion. Therefore, removing the HOV lane restrictions late at night should have no impact on congestion. Congestion does occur at night during WSDOT construction activities, but during these periods, traffic control often allows all vehicles into the HOV lanes to reduce construction related delays. Thus, a change in the current HOV regulatory practice to allow nighttime GP use of HOV lanes would result in no practical change in freeway performance.

Weekend Congestion Relief

Data collected by WSDOT indicate that the fraction of vehicles eligible to use HOV lanes on weekends generally varies from 30 to 60 percent, depending on the facility and time of day. Given these occupancy rates, HOV lane usage on weekends is basically a function of whether sufficient "congestion" exists to encourage eligible vehicles to use the HOV lanes (where "congestion" means enough traffic to give drivers an incentive to choose the left-most lane of travel over the other lanes).

In almost all cases, hourly HOV volumes are considerably lower than GP lane volumes until the GP lanes reach approximately Level of Service (LOS) C (the point at

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techniques used to create the graphics, please see the report "FLOW Evaluation Design Technical Report," WA.RD #466.2, March 1999.

[3] HOV lane performance during commute periods is discussed in the WSDOT report "HOV Lane Performance Monitoring, 1998 Annual Report," It can be obtained through WSDOT's Research Office as Report Number WA-RD 473.1, or via the web at <http://depts.washington.edu/trac/pdf/hovlane_perform.print.pdf>.

which the freedom to change lanes and pass vehicles begins to be slightly limited). At this point, HOV volumes begin to rise quickly until HOV lane volumes are only slightly lower than GP lane volumes. (See Figure 1.)

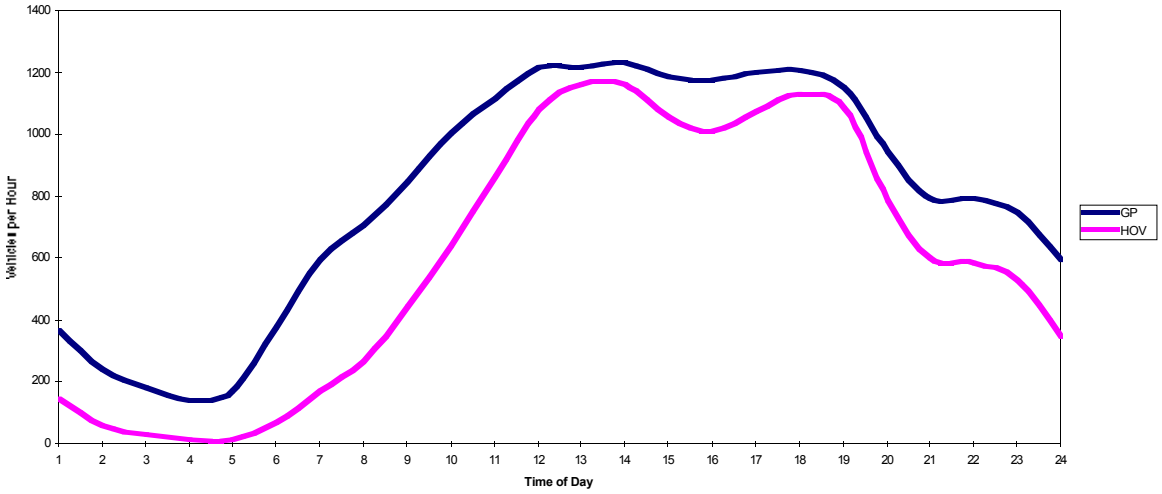

Figure 1: I-5 at North Boeing Field, average northbound Saturday volumes

When congestion occurs in the GP lanes on weekends, HOV volumes quickly grow to equal GP volumes. Where congestion occurs in the right-most lane (for example, on I-405 approaching the SR 167 interchange), HOV lane volumes actually exceed GP lane volumes. (See Figure 2.)

Weekend Congestion in the General Purpose Lanes

For most of the Puget Sound freeway system, there is little "true congestion" on weekends, where "true congestion" is defined as Level of Service F (unstable speeds/stop and go traffic). This, and the discussion above, explains why average HOV lane volumes on weekends are slightly below average GP lane volumes.

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

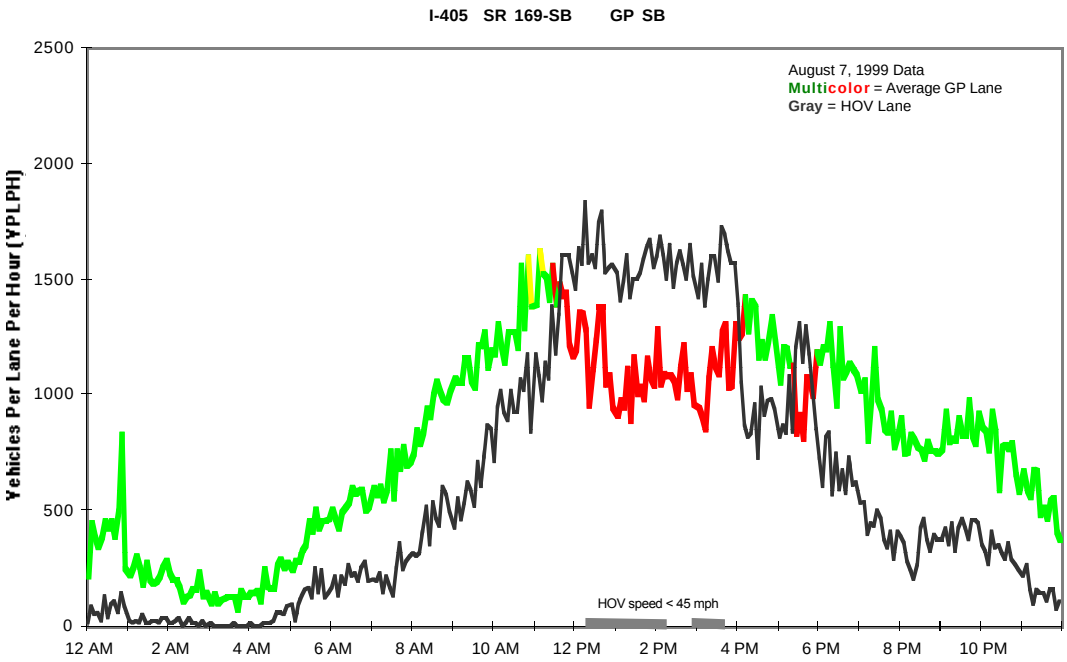

Figure 2: Estimated GP and HOV volume and speed conditions, I-405 and SR 169 southbound

Figures 3 and 4 show contour graphics[4] of the "average weekend" congestion condition on GP lanes on I-5 and I-405 for 1999. These graphics show the only two places where significant weekend congestion occurs in the metropolitan area. These are on I-5 approaching the downtown area (from both directions) and on I-405 approaching the SR 167 interchange (again from both directions). In both cases, a combination of high volumes and significant merge/diverge congestion causes routine slow downs and delay.

On I-5, the southbound congestion starts at the Mercer weave and extends northward, sometimes as far as Northgate. Significant congestion occurs at the Ship Canal Bridge as often as six to eight times a month (i.e., over half the time), can start as early as 11:00 AM, and can last as late as 8:00 PM. A combination of factors causes this congestion. These factors include high traffic volumes, the lack of an HOV lane, operation of the Express lanes northbound as opposed to southbound, the Mercer weave, and the merge/weave effects of the NE 45th Street ramp. It is important to note that this location has no HOV lane on weekends. Thus, changes to HOV lane operating rules would have no impact on this congestion.

[4] On these figures, the color green can be interpreted to indicate routine free flow conditions. Yellow means that the freeway is routinely "full" but operating at 60 mph. Red means that the freeway occasionally operates below 55 mph, and breaks down occasionally. Blue means that LOS F conditions occur frequently (that is, more than 20 percent of the time).

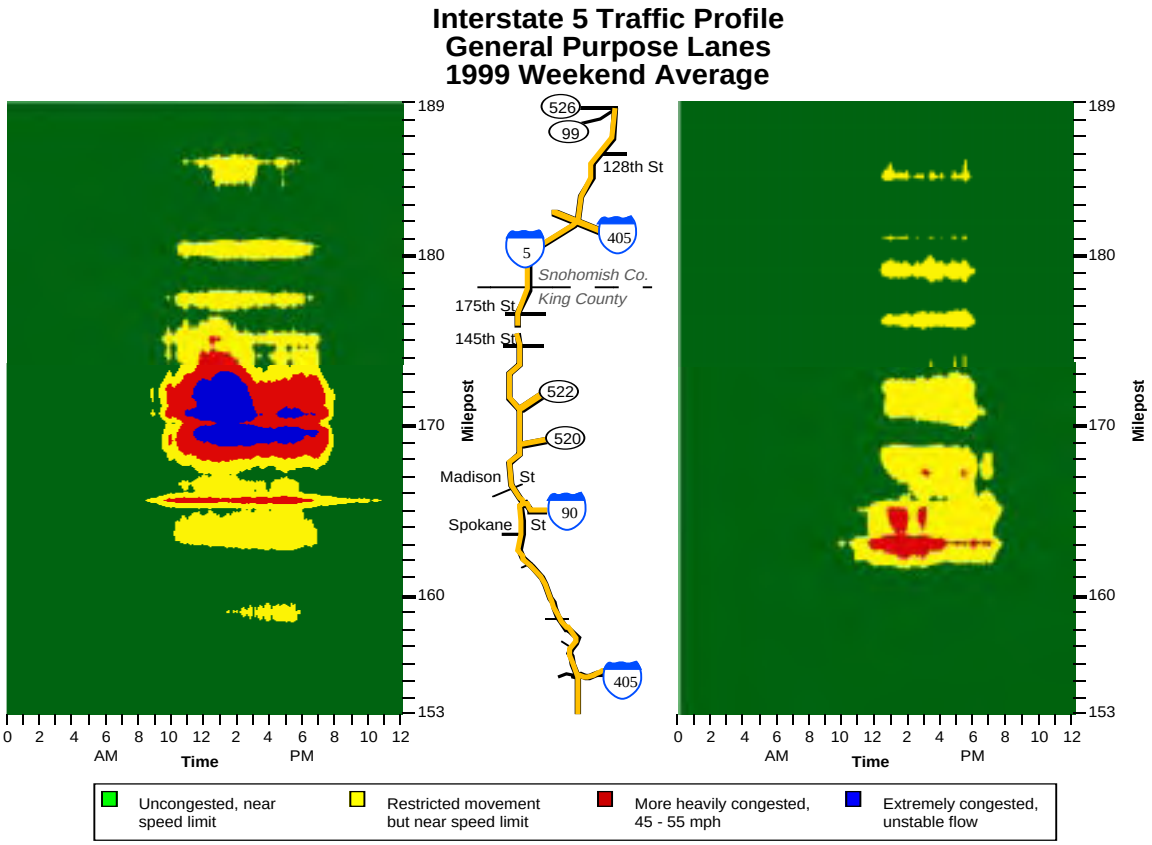

Figure 3: Weekend congestion on I-5

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

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

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

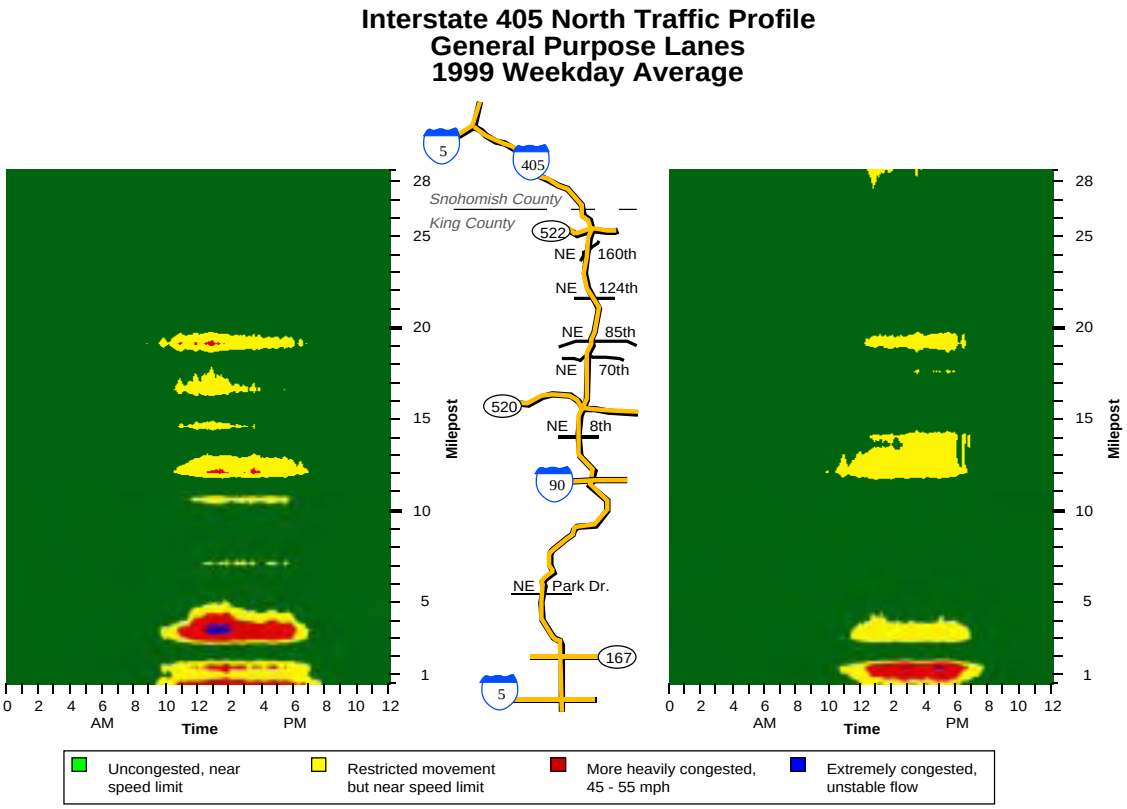

Figure 4: Weekend congestion on I-405

Other freeways in the region experience similar levels of traffic. For example, SR 167 experiences very little LOS F congestion, but the merge at the I-405 interchange often slows traffic during the late afternoon and early evening. SR 520 experiences more congestion than SR 167 but slightly less than I-405 in the south end. Westbound, SR 520 falls to LOS F roughly twice a month during both the early and late afternoon approaching the floating bridge. Eastbound, the approaches to the bridge also become congested roughly twice a month. Finally, I-90 is almost completely free of congestion outside of its interchange with I-5 and the exits to downtown Seattle. The downtown interchange is dramatically affected by special event traffic. Outside of downtown Seattle, only occasional congestion at the exits to Issaquah cause congestion on I-90 during the weekends.

Weekend Volumes in HOV and General Purpose Lanes[5]

Figures 5 and 6 illustrate the basic trends in weekend GP and HOV lane volumes. They illustrate weekend volumes in 1995 and 1999, northbound on I-5 near Spokane

[5] A more complete description of the weekend HOV and GP volumes and congestion can be found in the report, "Weekend Freeway Performance and the Use of HOV Lanes on Weekends" presented to the Washington State Transportation Commission on April 19th. The report is available on the Web at http://depts.washington.edu/trac/pdf/weekendhov.pdf

Street. The volume differential has dropped from over 600 vehicles per hour in 1995 to about 400 vehicles per hour in 1999. Minor congestion has also begun to appear during the mid to late afternoon in both GP and HOV lanes. (The congestion frequency histogram is plotted only for GP lanes, although HOV lane speeds are also routinely below the speed limit at this location.) Figure 7 shows what happens to HOV and GP volumes on days when congestion actually occurs.

Figures 8 and 9 illustrate weekend HOV and GP volumes on I-405 in Renton. At this location near the SR 169 interchange (north of SR 167), the 1999 southbound HOV lane volumes in the middle of the day are only 200 to 300 vehicles per hour lower than the GP lane volumes. In 1997, the midday volume difference between these lanes was closer to 500 vehicles per hour. At the same time, it also apparent that the GP lanes are heavily congested 15 to 20 percent of the time in the afternoons, and these congested periods are likely to be both holding down average volumes and encouraging HOV eligible vehicles to use the HOV lane. (Figure 2, shown earlier, confirms this, showing how congestion in the right hand lane at this site, caused by the SR-167 interchange, results in significant numbers of HOV vehicles moving out of the GP lanes and into the HOV lane.)

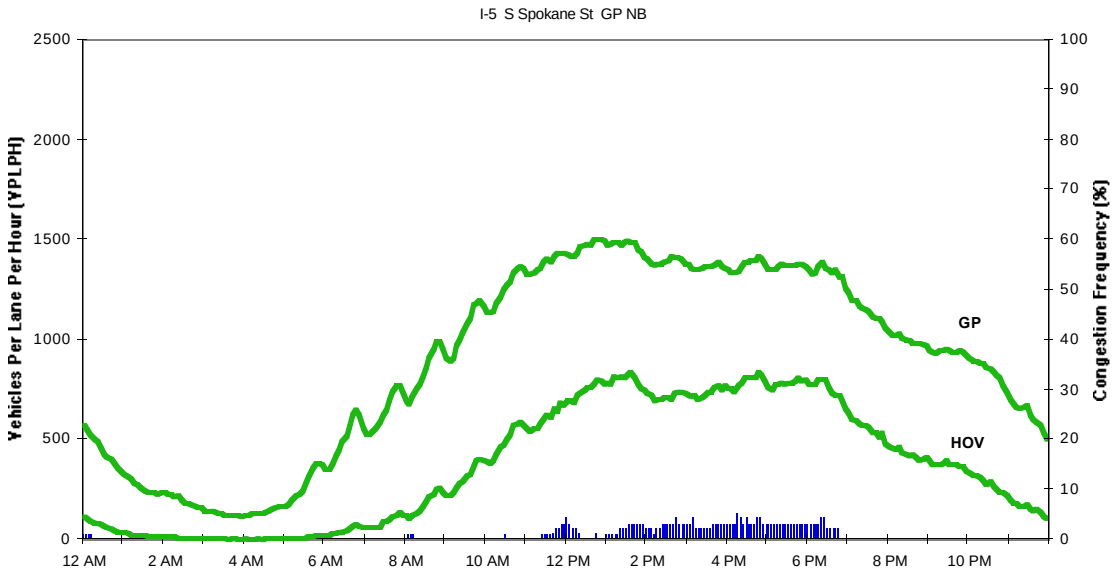

Figure 5: Estimated weekend volume, speed, and reliability conditions (1995), I-5 S. Spokane St., general purpose lanes, northbound

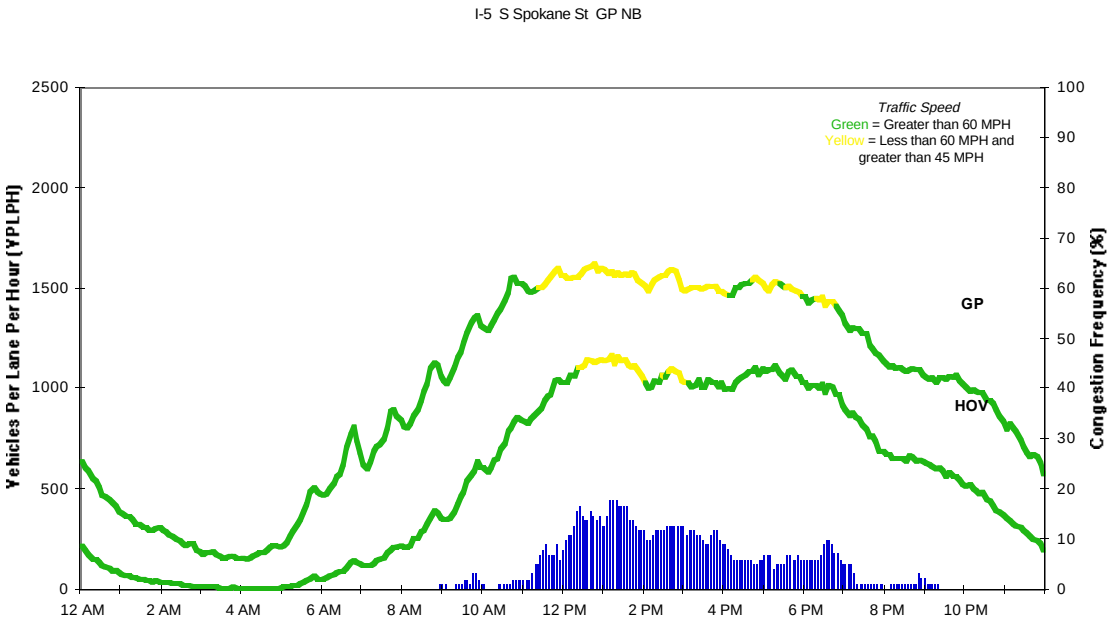

Figure 6: Estimated weekend volume, speed, and reliability conditions (1999), I-5 S. Spokane St., general purpose lanes northbound

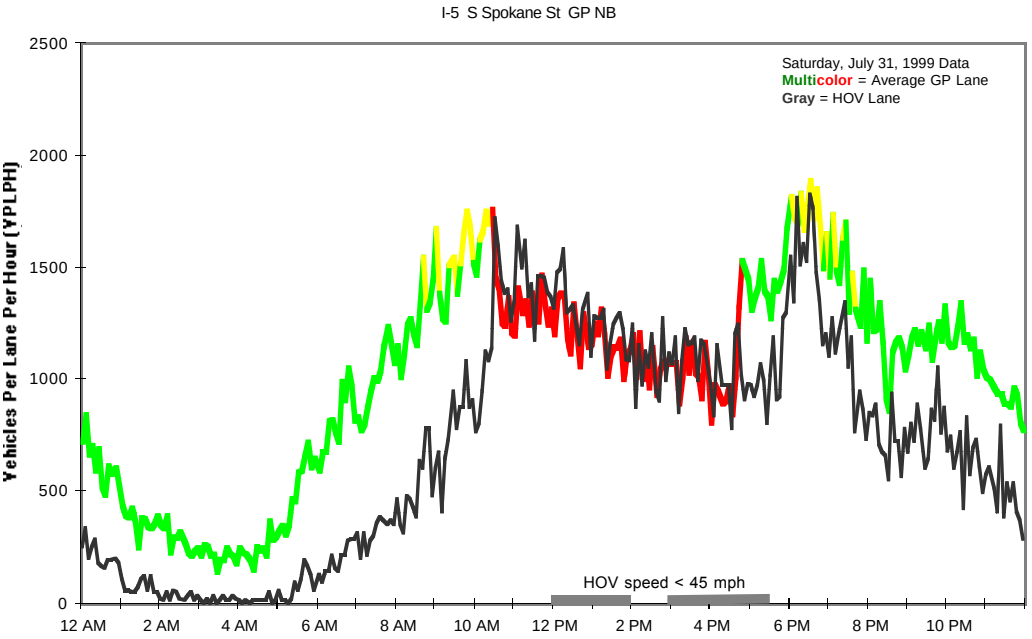

Figure 7: Estimated GP and HOV volume and speed, I-5 S. Spokane St., general purpose lanes northbound

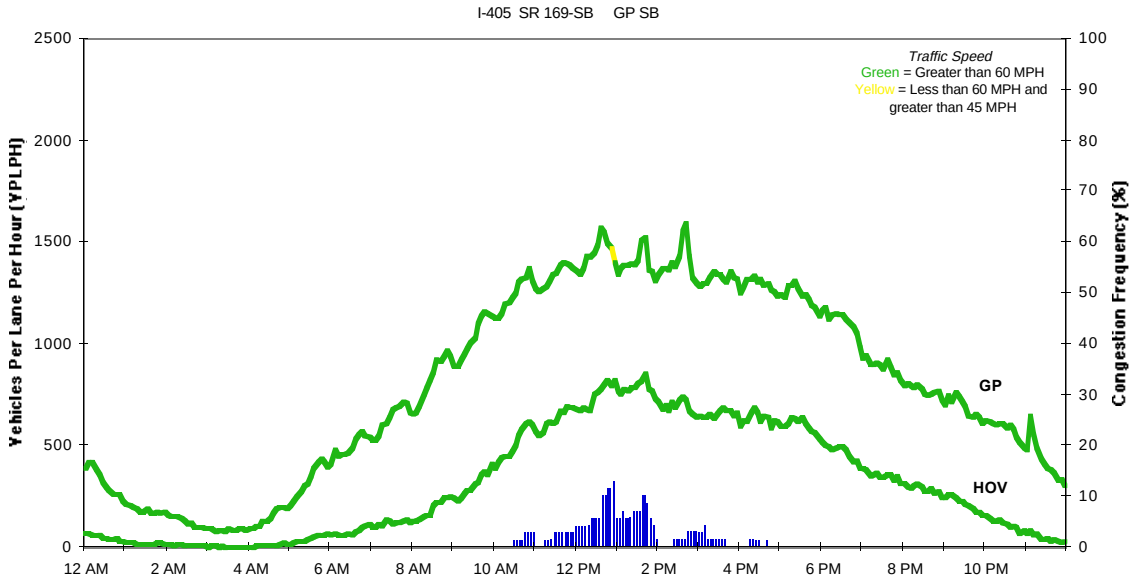

Figure 8: Estimated weekend volume, speed, and reliability conditions (1997), I-405 and SR 169, general purpose lanes southbound

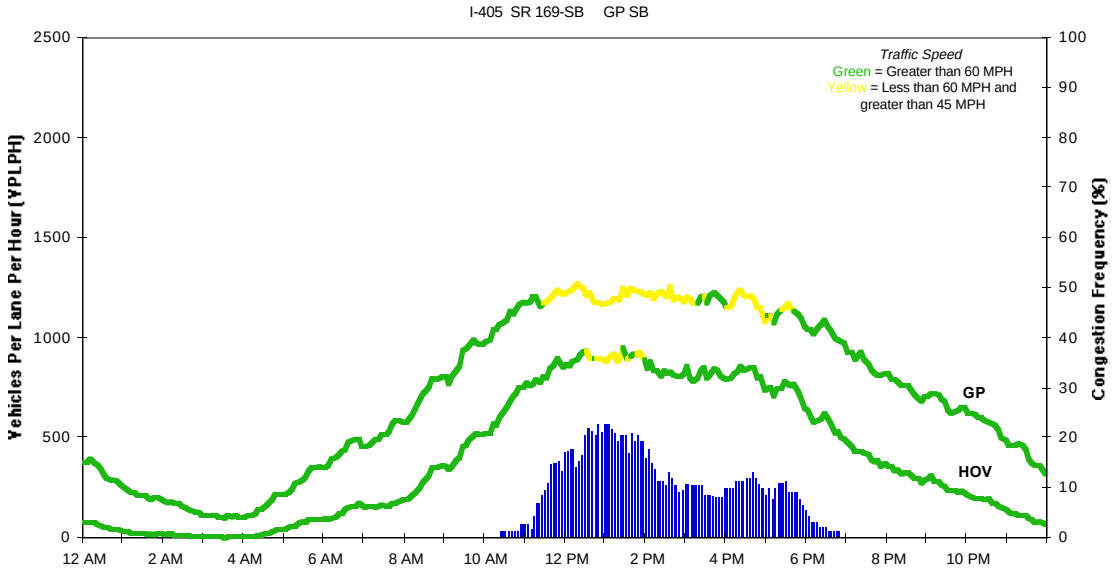

Figure 9: Estimated weekend volume, speed, and reliability conditions (1999), I-405 and SR 169, southbound

Summary Effects of Allowing GP Vehicles into HOV Lanes on Weekends

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

In a few cases, particularly bottleneck situations, encouraging general traffic to use the HOV lane system would cause a bad situation to get worse. The best example of this is on SR 520 approaching the floating bridge. Even in the case of I-405 at SR 167, it appears that there would be few benefits. Southbound approaching this interchange, the HOV lane becomes congested whenever the GP lanes become congested. Thus relaxing the HOV lane restriction would produce little or no congestion relief. The HOV lanes already fulfill that role. Northbound, approaching this interchange, the HOV lanes are slightly less congested than the GP lanes, suggesting that some minor improvements to flow might be obtained by relaxing the HOV lane restriction. However, the days on which savings would be apparent appear to be less than one day per month. (A more detailed analysis of the relative size of the competing movements at this interchange is needed to determine actual benefits that would be obtained.) If WSDOT receives funding to improve the SR 167/I-405 interchange (according to the Northwest Region this is one of the highest rated projects in the area), the congestion that currently exists at this interchange will essentially disappear. In that case, no benefit would be gained from opening up the HOV lane to GP traffic.

On I-5, no HOV facility crosses the Ship Canal bridge southbound on weekends. Thus, relaxation of the HOV rules would have no impact whatsoever on the weekend's worst congestion location. Northbound, the HOV lane south of downtown Seattle is congested almost as often as the GP lanes. Relaxation of the HOV rules might provide a slight increase in HOV lane use, but little or no actual congestion relief would occur because the HOV lanes are congested whenever significant congestion occurs in the GP lanes.

Midday Weekday Congestion Relief

Midday weekday HOV and GP lane use differs from weekend HOV and GP lane use in a number of important ways. In general, fewer HOV lane eligible vehicles are on the roadway during the middle of the weekday than during the weekend. This reduces the number of potential legal HOV lane users when conditions warrant their use of the HOV facility.

In addition, midday traffic is affected by, and subsequently affects, commute period traffic volumes and congestion. (That is, congestion during the morning peak period can result in midday congestion, while congestion during the middle of the day can cause significant PM peak period congestion.)

Even though moderately high GP lane volumes may be similar between weekdays and weekends, the differences between weekday and weekend traffic volumes and vehicle occupancies result in several significant differences in HOV lane use.

Midday Volumes in GP and HOV Lanes

Figures 10 and 11 show typical weekday time-of-day volume curves for freeways in the Puget Sound region. Also included in these figures is an indication of how often the GP lanes at these locations become congested. The graphics illustrate HOV lanes that experience their heaviest traffic in the morning peak period. In general, HOV lane use crests later in the peak period than GP lane traffic. HOV volumes then fall off more quickly, and then rise again during the evening peak period. HOV volumes tend to peak around 1,500 vehicles per lane per hour, (slightly less, in most cases, than what occurs in the adjacent GP lanes). During midday, they tend to operate between 500 and 1,000 vehicles per lane per hour (depending on the roadway and location), whereas GP lane volumes tend to be between 1,000 and 1,500 vehicles per lane per hour.

Some GP lanes show generally higher midday per lane volumes (I-5 in downtown Seattle, I-405 south of Renton, SR 520 approaching the floating bridge), whereas others show lower volumes per lane (I-90 by Issaquah, I-405 north of Totem Lake). Similarly, HOV volumes can be higher or lower depending on geographic differences in HOV use and the level of congestion in the GP lanes. In general, near the outlying parts of the metropolitan area (Issaquah, Lynnwood, Federal Way) HOV volumes tend to be lower than at more central locations (Northgate, Factoria, Downtown Seattle).

As on weekends, when there is no congestion, HOV eligible vehicles do not always use HOV lanes. (For example, on I-90 by Issaquah, few vehicles are in either the HOV lane or the left most GP lane during off-peak travel times on weekdays.) However, on the weekdays, unlike the weekends, the number of HOV lane eligible vehicles is generally not a large percentage of the total traffic stream. As a result, when congestion occurs in the GP lanes, the HOV lanes do not congest as often on weekdays as they do on weekends. This is beneficial in providing HOV travel time advantages and particularly useful in keeping transit vehicles on schedule, but it does mean that HOV lanes are less utilized during midday on weekdays than they are on weekends.

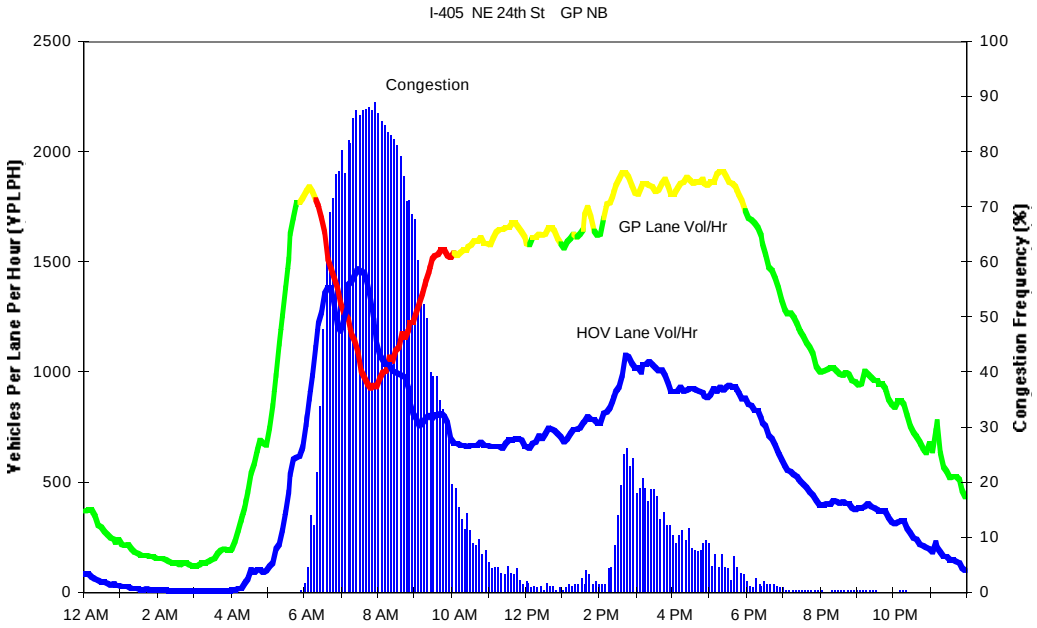

Figure 10: Weekday volume, speed, and reliability conditions, I-405 at NE 24th St., northbound

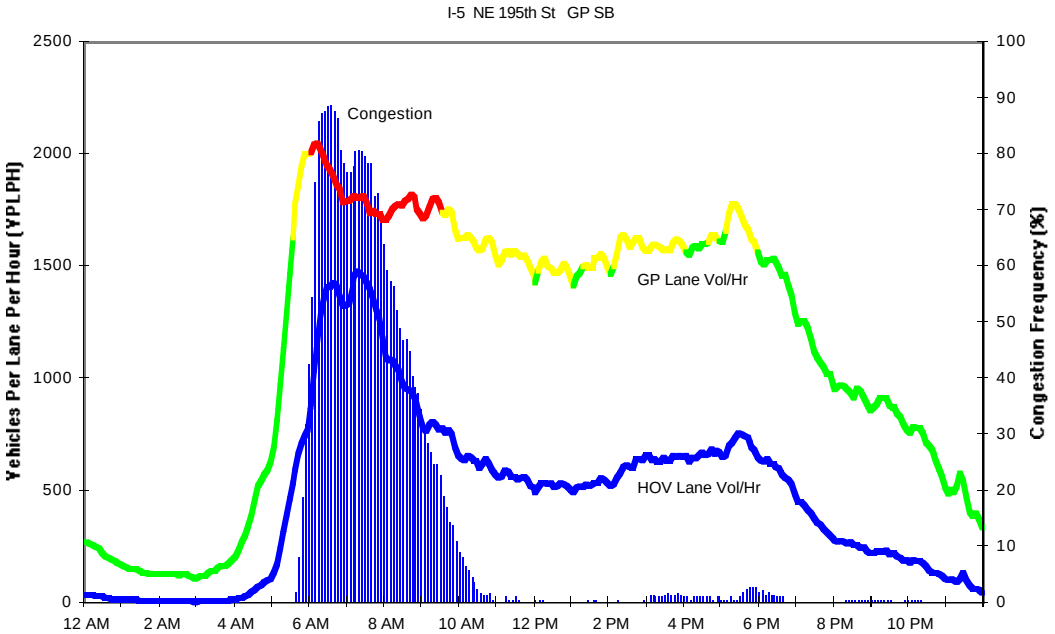

Figure 11: Weekday volume, speed, and reliability conditions (1999), I-5 at NE 195th St., southbound

Midday Congestion in the GP Lanes

Midday weekday congestion on Puget Sound freeways occurs between 5 and 20 percent of the time. This translates into midday congestion an average of once a month on the least congested facilities to an average of once every week in the worst locations. Congestion occurs more frequently on the shoulders of the peak period, either because of congestion is still dissipating from the morning commute, or because incidents and accidents that occur in the middle of the day have greater impact as afternoon volumes build.

While most midday congestion is caused by incidents and other non-volume related disturbances, at some bottleneck locations traffic volumes can cause congestion without a specific incident. The primary midday bottleneck locations were mentioned as part of the weekend discussion above. They include I-5 approaching downtown Seattle (from both directions), I-405 approaching the SR 167 interchange (from both directions), and SR 520 approaching the Evergreen Point Floating Bridge. At each bottleneck, only a minor catalyst can create congestion.

Effects of Allowing GP Vehicles into HOV Lanes during Weekdays Midday

One of the biggest problems with opening the HOV lanes to GP traffic during "midday" is to define "midday." For example, on SR 520 at the Evergreen Point Floating Bridge, traffic volumes are nearly constant for 13 to 14 hours a day. In general, the "commute period" is assumed to last from 6:00 AM to 9:00 AM and from 3:30 PM to 7:30 or 8:00 PM. Because there is no spare capacity in the peak hour, almost all traffic volume growth occurs in the "off-peak" hours, with most "commute growth" occurring in the shoulders of the peak period (i.e., 6:00 to 6:30 AM, 8:30 – 9:00 AM, 3:30 to 4:00 PM, and 6:30 to 7:30 PM). HOV lane volume growth is also occurring most rapidly in the shoulders of the peak HOV periods.

It is during the edges of these shoulder periods that the most "routine congestion relief" could be obtained by relaxing the current HOV regulations. This is because during the edges of the shoulder periods, GP and HOV lane volumes show the greatest difference. These periods are most likely to experience congested GP lanes and lightly used HOV lanes.

However, the penalties for removing the HOV restrictions would also be greatest during these same periods. HOV lane performance and reliability during these periods is particularly critical to the transit operators, as buses operating early in the shoulder period can make additional trips later in the peak if they can travel quickly and reliably. This significantly reduces the number of buses and drivers needed to serve the commute market. The shoulders of the peak are also the periods in which HOV traffic is growing the fastest.

Outside of the peak period shoulders, "congestion relief" from removal of the HOV lane restriction would be fairly minimal. In a few cases (I-405 in the south end), the extra lane capacity might help some vehicles travel more reliably. (Vehicles traveling

through Renton to or from I-5 would benefit by being removed from the I-405/SR 167 interchange congestion. However, vehicles on I-405 trying to exit to SR 167 would likely experience a slight increase in congestion because most congestion at that location is caused by the interchange geometry. The "extra lane" of capacity would likely cause an increase in the aggressive driving tactic of "late merging" at the SR 167 exit.)

While I-405 through Renton is one of the few locations where some congestion relief might occur, other locations would actually see more congestion. Northbound I-5 just south of the Convention Center, one of the region's most congested locations, is a good example. This is because congestion here is caused by a combination of merging I-90 traffic and the fact that only two GP lanes continue through downtown Seattle. Adding more vehicles to this overworked interchange by opening the HOV lanes (which do not continue through the city) would actually increase the number of merging vehicles, adding to the congestion. SR 520 westbound, approaching the bridge, would also become more congested if HOV lanes were opened to general traffic.

The majority of freeway segments fall into neither of these categories (although the above sections are likely to dominate motorists' perceptions of congestion). Most freeway segments operate at LOS C most of the midday period. This means that vehicles travel at 60 mph, but there is sufficient traffic volume to limit drivers' opportunities to travel at 65 or 70 mph. Opening up the HOV lanes to GP traffic might allow a modest increase in speed for drivers trying to travel 65 or 70 mph. It would not have a significant impact on the average traveler's travel time or trip reliability.

Under incident conditions, congestion would still occur even if the HOV lanes were opened to general traffic. The congestion back-up would be slightly shorter (geographically), but HOV vehicles (often buses) would suffer a significant decrease in trip reliability. In addition, the loss of HOV lanes would mean that all lanes would be congested, not just the GP lanes. This would reduce the ability of emergency response vehicles to use the HOV lanes to access the incident scene and would increase response times to major accidents. This in turn might actually increase the duration of accidents and result in a net increase in congestion durations for larger accidents.

The relationship of HOV lanes to incident response is only one of several issues that must be carefully reviewed to understand the benefits and costs of allowing general traffic into the current HOV lanes. Some of these other issues are discussed below.

IMPACTS ON HOV FORMATION AND COMPLIANCE RATES

A major concern with the use of HOV lanes by general traffic in off-peak periods is that HOV lane violations would increase during periods when the HOV lanes were restricted.

Experience elsewhere in the country has indicated that violation rates increase near the beginning and end of the HOV-only time period. In Virginia, the DOT had to install electronic clocks on its variable message signs (VMS) to eliminate arguments

about the time from the enforcement process. (Motorists would argue that according to their watch, GP vehicles were legal in the HOV lane.) While the installation of VMS clocks could reduce those problems, it would significantly increase the cost of signage and maintenance.

Experience has also shown that violations tend to generate other violations. That is, the more violations that motorists observe, the more likely they are to violate those restrictions themselves.

How much of an impact opening the HOV lanes would have on violation rates would be a function of how well the public understood the new rules and how heavily those rules were enforced. WSDOT staff currently believe that opening the HOV lanes on weekends would probably have a less dramatic impact on violation rates than relaxation of midday weekday restrictions. WSDOT staff are especially concerned about the effects that a "partial removal" of lane restrictions would have. (That is, if some HOV lanes were opened to general traffic but not others.) The concern is that motorists would a) not understand which lanes could be used when, and b) use the opening of some lanes as an excuse for using other HOV facilities that had not been opened to general traffic, producing a significant increase in violations.

SAFETY ISSUES

The WSDOT is concerned about a number of major safety issues that should be addressed before HOV lanes are opened to general traffic. Much of the HOV lane system was built to a lower design standard than the general purpose lanes. These "design deviations" have been approved by FHWA because during most of the day relatively modest traffic volumes are expected in the HOV lanes, and during peak travel times, the majority of drivers using the facility are commuters familiar with the decision points and traffic conditions on a particular roadway. Under these conditions, FHWA permits (on a case by case basis) modest relaxation of normal Interstate design standards. Figure 12 summarizes the design deviations granted for the HOV system.

If the HOV lane regulations were changed, the basic assumptions about their operating conditions would no longer be valid. FHWA requires a complete review of these design deviations before allowing the adoption of new operating rules. Geometric changes may be necessary to address safety and liability concerns caused by design based on geometry that is sub-standard for routinely high volumes of general traffic.

Examples of problematic design deviations that must be considered before HOV lanes are opened to general traffic are as follows.

Right Side HOV Lanes

Traffic from on- and off-ramps weaves through right side HOV lanes. Where ramp tapers and merging and diverging areas have been designed to accommodate high

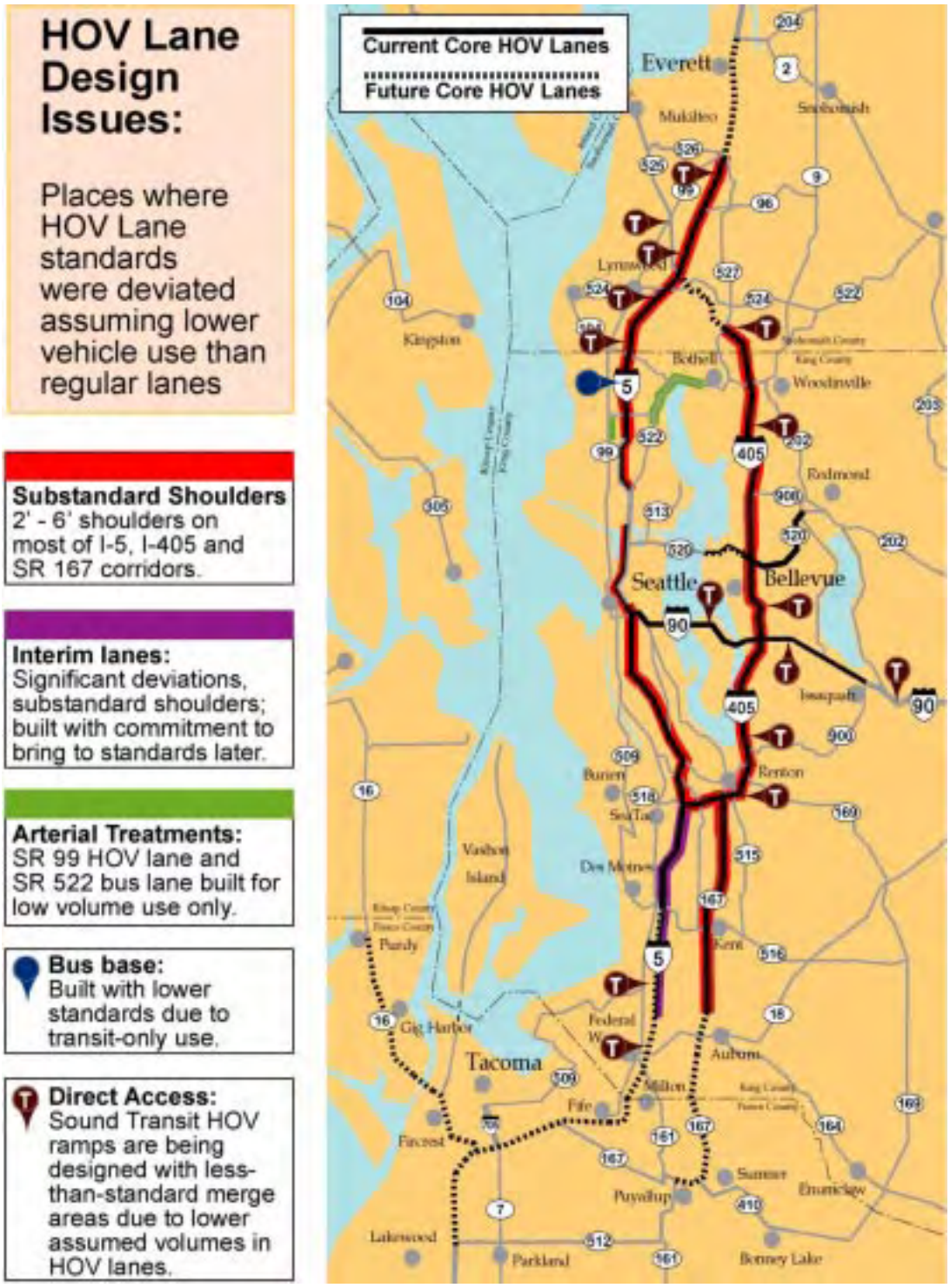

Figure 12. Locations where HOV lane standards deviate from general purpose lane standards

volumes of traffic, safety is not an issue. On SR 520, however, the HOV facility was added after construction of the original lanes and uses the original shoulder of the freeway. The original ramp tapers and merging areas are largely unchanged from the pre-existing configuration. The resulting merging areas are only appropriate for low volumes of mainline traffic. The HOV designation west of 405 is three or more because of the concern about traffic merging through the on- and off-ramps. It would not be feasible to change the occupancy designation on SR 520 (or tolerate substantial increases in shoulder lane traffic) without extensive reconstruction.

Transit-Only Facilities

Several facilities in the region have been designed for the exclusive use of transit. Clearly it is not feasible to open the facilities to general use traffic because of the purposes they serve and the safety issues that would arise if non-transit vehicles were to use the lanes. Examples of transit-only facilities are the entrances to the Seattle Transit Tunnel, the Metro North Bus Base, freeway flyer stops, and entrances to some park-and-ride facilities near the freeway.

Arterial HOV Lanes

Arterial HOV lanes are not the primary focus of this analysis. However, the pose serious safety issues. Opening arterial HOV lanes to general traffic would likely require the adoption of access restrictions for turning traffic (e.g., limiting left turns to signalized intersections with left turn bays and left turn arrows), if those restrictions do not already exist. WSDOT has shown that there is a link between increased crashes and high volume arterials with two-way left turn lanes and seven-lane cross sections. Access restrictions would be needed to prevent any increase in accidents.

Major Decision Points

At the entrance to the express lanes drivers make a basic decision about what route provides them the best advantage. Some drivers make the choice early on, deliberately merging over to the lanes well before the decision point. However, experience has shown that other drivers make the choices at the last minute, merging over several lanes in just a few hundred feet. At the I-5 express lanes southbound WSDOT has had direct experience with the consequences of this behavior. For many years the entrance to the express lanes was the only location on the I-5 mainline in the Northwest Region that was classified as a High Accident Location. This was primarily due to motorists racing to the end of the GP lane when the express lanes were closed and then forcing their way back into traffic. A WSDOT project recently corrected that situation by continuing the GP lane southbound. If general traffic were allowed in the HOV lanes, the hazardous situation that was eliminated with the construction project a few years back would be recreated. This situation would be repeated in other locations where the HOV lane ends with a merge to the GP lanes (e.g., in the express lanes on I-5 under the Convention Center).

Independent Alignments

I-5 has three locations near Southcenter where the HOV lanes separate from the general purpose lanes and traverse independent alignments. There is also one location on SR 509 approaching the First Avenue South Bridge. In these cases the alignments were specifically designed for HOV traffic. As in the case of the express lane entrances, some motorists wait until the last possible minute to decide which lane offers the best advantage. This decision is more complex on I-5 at Southcenter because drivers have to weave through traffic exiting to I-405. (See Figure 13.) The added complications of having general traffic make that choice in an already complex area is a safety concern. (When this design was approved, it was assumed that HOV lane users would quickly become familiar with the alignment and, as a result, would not be placed in a situation of having to make these complex decisions unexpectedly. This assumption is acceptable for commute traffic but not for midday general traffic.)

Figure 13: I-5 southbound at Southcenter near an independent alignment

Sound Transit Direct Access Projects

Sound Transit will be building a series of ramps from local streets and park-and-rides that tie directly to the freeway HOV lanes. Because the access points serve the HOV system, they enter and exit the roadway on the left hand side. Opening those interchanges to general traffic would create a series of left hand off-ramps throughout the Puget Sound. Several issues would have to be addressed in the design of those ramps because currently they are being designed with HOV traffic specifically in mind. FHWA has required that Sound Transit address the changes in traffic patterns that would result from such a revision in its design documentation. At a minimum, this would require delay to the Sound Transit program as the analysis was completed. In the worst case, the new Sound Transit ramps would create hazardous merging conditions if volumes in the HOV lanes were substantially higher than designed for. WSDOT would need to see the results of the analysis to determine how the change might affect project costs or the approval of the permit to add the ramps.

HIGHWAY AND TRANSIT OPERATIONAL ISSUES

WSDOT and the transit authorities that use the HOV lanes have a number of concerns about the removal of HOV designations. The largest of these is the loss of transit schedule reliability, which would entail a substantial increase in the cost of transit service, as discussed above. However, a number of other operational issues would have to be addressed before HOV facilities could be opened to general traffic.

Queue Jumps and Freeway to Freeway Connections

A queue jump is an HOV facility that moves transit and carpools around a freeway or arterial bottleneck. For the most part they have been designed specifically for HOV and carpool traffic. If queue jumps were opened to general traffic, they would become ineffective and confusing to motorists. (Basically, with high volumes, queue jumps exacerbate existing congestion conditions, degrading service to all vehicles, rather than providing benefits to high priority vehicles at little cost to single occupant vehicles.) Examples of transit queue jumps are northbound at the SR 167/I-405 interchange (see Figure 14), northbound on SR 509 near the First Avenue South Bridge, and southbound on I-405 to northbound on I-5. Removal of the queue jumps would require changes to the geometry of the ramps.

Ramp Meter Bypasses

Ramp meter bypasses are lanes in which traffic is not required to stop when a ramp meter is active. Currently most of the ramps in the Puget Sound region allow HOV traffic to by-pass the ramp meter when it is active. Opening the bypasses to all vehicles would obviously make metering ineffective and would increase merging and passing on ramps, creating a safety problem. It is recommended that HOV ramp meter bypasses not be opened to general traffic.

Figure 14: Queue jump on SR 167 northbound to I-405 northbound

Effects on Traffic Patterns on Local Streets

It is not possible within the scope of this report to determine the effects on local streets of removing freeway HOV lane restrictions. In the past, Seattle has asked WSDOT to consult with the city before any switching the HOV designation of ramps that directly serve the downtown core. The effects of the change in traffic patterns on streets in downtown Seattle and for any of the Sound Transit direct access ramps would have to be quantified.

Consistency and Driver Expectations

One last concern that WSDOT traffic engineers have is the ability to maintain consistent operational policy throughout the region. Good traffic engineering practice attempts to operate all facilities in a consistent manner. This allows motorists to concentrate on the movement of vehicles around them, and not on the signs that indicate what rules apply at a particular location at a particular time. Increasing the variety of rules under which HOV lanes operate ("this facility can be used for GP traffic starting at 9:30 AM, that facility can be used at 9:00 AM") produces motorist confusion and

decreases the average driver's ability to concentrate on the driving task. This both decreases operational efficiency and increases accident risk.

MONETARY COSTS

WSDOT engineers point out that the cost of changing HOV lane restrictions is far greater than simply painting new signs. As noted earlier, relaxation of current rules to allow midday general traffic would likely require the addition of a large number of VMS capable of displaying the current time. Without those signs, enforcement of the HOV restrictions near the boundary time periods would become problematic.

Even the replacement of standard signs is more expensive than might be thought. In most cases, sign removal requires night time work and traffic control because shoulders on the freeways are too narrow to allow safe sign replacement without these precautions.

In addition to the issue of signs, a significant amount of money would be required to "fix" any design deficiencies that are not acceptable for general traffic conditions. This work might include widening existing shoulders, removing or relocating signs and signal heads, and a variety of other geometric improvements.

Finally, changes in HOV lane designations have the potential to violate environmental commitments WSDOT has made both to the federal government (Federal Highway Administration and Environmental Protection Agency) and various local communities. The cost of required mitigation is not easily determined without further study.

FHWA has stated that opening HOV lanes to general traffic on weekends or for midday operations is a significant action, and WSDOT would be required to complete project documentation required by the National Environmental Policy Act (NEPA.) Part of that process is documentation of previous environmental commitments. A partial review of WSDOT documentation found that corridor-wide commitments were made in the I-90 corridor and in the SR 522 corridor, as well as at the locations of transit-only interchanges and other facilities throughout the region. Additional study would be necessary to further document environmental commitments and impacts to FHWA.

A preliminary cost estimate for converting HOV lanes to allow general traffic on weekends for the southern section of I-405 and all of SR 167 was more than $1,000,000.[6] These costs included all construction, signing, environmental reviews, and other costs.

[6] Dave McCormick, presentation at the April 20th, 2000 Washington State Transportation Commission meeting.

SUMMARY

A brief summary of the potential for using HOV lanes off-peak in the Puget Sound region is as follows.

Use of HOV lanes for general traffic on weekends would have little or no beneficial effect, in that HOV lanes on weekends already operate at capacity when conditions warrant their use.

Use of HOV lanes during the off-peak times during weekdays would offer some modest facility performance improvements on a limited subset of freeway corridors. At the same time, it would result in a significant decrease in performance at several existing freeway bottlenecks. The majority of freeway segments would not see a measurable change in travel reliability as a result of general access to HOV lanes during the middle of the day.

The costs for achieving these limited benefits would be significant. HOV lanes were not designed for high volume, general traffic, and their design would be deficient for such volumes. Safe freeway operations would require these deficiencies to be studied, and in some cases, eliminated or otherwise corrected.

WSDOT engineers firmly believe that there are far better ways to spend the resources needed to convert HOV lanes to general traffic. The two most promising congestion relief mechanisms currently waiting for funding are

- the provision of Service Patrols on the Puget Sound freeway system
- an increase in staffing that would allow WSDOT to decrease the time needed to switch the direction of express lane operation and increase its flexibility to use the reversible roadways to meet changing travel demands.

Both of these proposals are likely to result in far greater congestion relief than removal of the HOV lane restrictions, and neither has significant downsides in terms of safety, environmental impacts, or HOV violation rates.