HOV Compliance Monitoring and the Evaluation of the Hero Hotline Program

WA-RD 205.2

Final Technical Report
February 1990

Washington State Department of Transportation
Planning, Research and Public Transportation Division

in cooperation with the
United States Department of Transportation
Federal Highway Administration

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
WA-RD 205.2		

4. TITLE AND SUBTITLE	5. REPORT DATE
HOV COMPLIANCE MONITORING AND THE EVALUATION OF THE HERO HOTLINE PROGRAM	February 1990
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
Ruth Kinchen, Mark Hallenbeck, G. Scott Rutherford, Leslie N. Jacobson, and Amy O'Brien	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. WORK UNIT NO.
Washington State Transportation Center (TRAC) University of Washington, JE-10 The Corbet Building, Suite 204; 4507 University Way N.E. Seattle, Washington 98105	11. CONTRACT OR GRANT NO. GC8286, Task 28
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
Washington State Department of Transportation Transportation Building, KF-10 Olympia, Washington 98504	Final Technical Report
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16. ABSTRACT

This report discusses the development of recommended and alternative systems for monitoring the use of HOV lanes and compliance with HOV occupancy regulations in the Seattle metropolitan area. The report includes a state-of-the-art review of techniques for monitoring HOV lane use and the results of tests of the most promising of these techniques. In addition, the report presents a review of the existing HERO (HOV violation reporting hotline) program, including the results of a 500-person telephone survey on the public's awareness of and attitude toward the HERO program and HOV facilities in general. Finally, the report describes software written to ease the storage of HERO data and improve the reporting of HERO statistics.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
HOV, HOV lanes, HOV compliance, HOV violations, traffic data collection	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22616

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
None	None	186	

DOT FORM 310-022 (11/86) -1216-

Final Technical Report

Research Project GC 8286, Task 28
HOV Compliance Monitoring

HOV COMPLIANCE MONITORING AND THE EVALUATION OF THE HERO HOTLINE PROGRAM

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U.S. Department of Transportation
Federal Highway Administration

February 1990

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SUMMARY OF PRINCIPAL FINDINGS

The primary purposes of this project were to develop a method of monitoring the violation rates on Seattle area HOV lanes on a continuing basis, to determine the public's attitude toward both the HOV system and the HERO hotline program, and to evaluate the effectiveness of the HERO program. This summary covers the following topics:

- the results of a survey that details the public's awareness of and attitude toward the HOV system and HERO hotline program,
- the results of a three-week HOV violation rate data collection effort,
- a statistically valid method of monitoring HOV lane violations and a system to house an HOV violation rate database, and
- an analysis of the continuing effectiveness of the HERO program and recommendations regarding the continued operation of the HERO program.

PUBLIC AWARENESS SURVEY RESULTS

The results of the public awareness survey were very positive. Most people sampled were both aware of and in favor of the HOV system and the HERO hotline program. The principal findings are outlined below.

- About 85 percent of those surveyed (i.e., persons living near a corridor that contains an HOV facility) had traveled on an HOV lane at least once, and 67 percent of those who had used the lanes said they did so most frequently as part of a carpool.
- Most people knew the minimum occupancy requirements for the HOV facilities nearest them. People who lived near both SR-520 (3+ HOV lane) and I-405 (2+ HOV lanes) were most likely to know that the occupancy requirements vary by facility.

- Almost 85 percent of those surveyed thought having HOV lanes in the Seattle area is a good idea. Another 4 percent thought HOV lanes are basically a good idea but qualified their answers.
- Approximately 80 percent of those sampled knew about the HERO hotline.
- Half of those who knew about HERO felt the hotline helps reduce HOV violations, but only 6 percent felt HERO reduces violations a great deal.
- Approximately 6 percent of the people who knew about HERO said they had used the hotline.

DATA COLLECTION RESULTS

HOV violation data were collected each morning during the peak hour (i.e., 6:45-7:45 a.m.) for three weeks at three sites: on westbound SR-520 at 92nd Avenue, on southbound I-5 at N.E. 175th Street, and at N.E. 145th Street. The number of peak hour violations counted each day at each site was compared to the number of HOV violations reported through the HERO hotline to determine whether the two parameters were related. If the number of violations reported through the HERO hotline had been found to be related to the number of HOV violations that had been measured during the monitoring effort, data from the HERO program might have been a means of monitoring HOV violation rates. However, other means of monitoring the violation rate will have to be used because no relationship was found between the two parameters.

Although the number of violations reported through HERO was not related to the actual violation rate, it was found to be related to three other parameters: the speed, lane occupancy, and traffic volume in the general purpose lanes.

THE HOV VIOLATIONS MONITORING SYSTEM

A statistically valid method of determining quarterly a.m. peak period violation rates was developed that will use data from an auto occupancy project that will begin in July 1989. The auto occupancy data will be collected during at least 30 half-hour monitoring

sessions from five HOV lane sites. Although the exact locations of these sites have not been determined, the HOV lanes on both directions of I-405 and I-5 will be monitored, as will the HOV lane on westbound SR-520. HOV lane violation rates for these facilities can easily be determined from the auto occupancy data and the use of these data will greatly reduce data collection costs.

A prototype of an HOV violation rate database was developed with the help of a Lotus 1-2-3 spreadsheet. The spreadsheet program calculates the HOV violation rate obtained from each individual monitoring session, as well as quarterly and annual violation rates. The only information required from the user is the number of SOVs and two-person carpools in the HOV lane, the total volume in the HOV lane, and the number of persons traveling in the HOV lane. This information can be extracted from data collected during each auto occupancy monitoring session. The spreadsheet program developed to house the HOV violations database is both extremely easy to use and is able to graph the HOV violation rate results.

THE HERO HOTLINE PROGRAM

The project team evaluated the HERO program by using both the results of the HOV violations data collection effort and the results of the public awareness survey. This project could not demonstrate that the HERO program has kept the violation rate lower than it might otherwise be, but it could also not rule out that possibility. Nonetheless, the program is viewed quite favorably by the public. The public's favorable opinion of the program apparently does not stem exclusively from a perception that the HERO hotline significantly reduces HOV violations. Although 50 percent of those who knew about the hotline felt it reduced HOV lane violations, only 6 percent felt it reduced violations a great deal.

People may also be in favor of the HERO hotline because it allows them the opportunity to vent their frustration at having to wait in traffic while HOV lane violators

drive by at 55 mph, usually without being caught by the State Patrol. This hypothesis seems borne out by the fact that, at least during the three-week monitoring effort, the number of violations reported through the hotline was found to be related to the speed, lane occupancy, and traffic volume in the general lanes. People were more likely to report HOV lane violators when traffic became congested, and not necessarily when the number of HOV violations increased. However, additional studies on the reasons people use the HERO hotline need to be conducted before it can be definitively shown that people use the hotline as a means of reducing frustration.

CHAPTER ONE

THE PROBLEM AND THE RESEARCH APPROACH

THE PROBLEM

Continuing geographic, economic, and population growth in Washington state's urban areas has resulted in increased traffic congestion on roads, especially in the Seattle metropolitan area. At the same time, the public has become increasingly resistant to the construction of new roads. The development and use of high occupancy vehicle (HOV) facilities has provided a cost effective way to increase the efficiency of the existing transportation network with relatively few environmental and/or social impacts. (1) However, the long-term effectiveness of these facilities cannot be determined unless the facilities are monitored on a continuing basis. It is especially important to monitor violation or compliance rates, since high violation rates are frustrating to motorists and compromise their incentives for taking the bus or car/vanpool.

In 1984, the Washington State Department of Transportation (WSDOT) developed a public telephone hotline (HERO) for reporting HOV facility violators in the Seattle area. A study done at that time showed that the HERO hotline reduced violation rates on the region's HOV facilities by 33 percent. (2) However, WSDOT does not know whether the hotline continues to deter violators because no one has evaluated the HERO program since then. In addition, no study has ever sought to determine whether a correlation exists between compliance or violation rates and the number of calls received on the hotline. Finally, the state has not yet developed techniques to monitor HOV lane violation rates on a continuing basis, even though continuous monitoring would provide useful information to WSDOT and other agencies. HOV lane violation data could be used, along with other data, to evaluate the continuing effectiveness of the HOV lanes and to determine whether particular HOV facilities need more enforcement. In addition, HOV violation rates might be used in programs aimed at educating the public about the HOV system.

Project Objectives

The primary objectives of this project were as follows:

- to conduct a state-of-the-art literature review to investigate techniques used in other states to monitor HOV compliance,
- to develop and test methods of monitoring HOV compliance and/or violation rates,
- to develop a system to house an HOV compliance database,
- to determine the public's attitudes toward both the HERO program and the HOV system through a survey,
- to analyze the effectiveness of the HERO program, and
- to establish methods of improving the effectiveness of the HERO program.

RESEARCH APPROACH

The section outlines the research approach that was used to develop the public awareness survey and to monitor HOV lane compliance. The state-of-the-art literature review on HOV compliance monitoring methods is discussed in Appendix A, and a description of the development of the new HERO hotline database is found in Appendix C.

Survey Development

The chief objectives of the public awareness survey were to determine

- the public's awareness of the HERO program and the HOV system,
- whether the public believes the two systems are successful, and
- whether the public agrees with the concept of the HERO program and the HOV system.

The questions used in the survey were constructed through a joint effort by personnel from WSDOT, Metro, and the Washington State Transportation Center (TRAC). A private market research firm hired to conduct the survey, Gilmore Research Group, also suggested the wording of specific survey questions. A private firm was contracted to help

write and conduct the survey because of such firms' abilities to quickly survey a random sample of the target population and their experience in writing and performing surveys.

The project team was most interested in the opinions and attitudes of people who had at least seen, if not used, the area's HOV facilities (Figure 1.1). To maximize the number of these respondents, the communities surveyed were located either close to routes with HOV facilities or where their residents could reasonably be expected to use these routes fairly frequently (Figure 1.2).

Following the selection of the areas to be surveyed, the market research firm constructed a list of telephone prefixes from those areas. It then used a computer-generated list of random numbers to obtain the last four digits of the telephone numbers. This procedure assured that all households within the study area, including those households that had recently moved or that had unlisted telephone numbers, had a nearly equal opportunity of being included in the sample.

The surveyors made calls weekday afternoons and evenings and all day Saturdays. They called households up to five times at different times of the day to ensure that busy people were not underrepresented. The total sample size was 551 households.

The survey company did not analyze the survey results. Instead, they were analyzed at the Washington State Transportation Center (TRAC). A copy of the survey and the complete results of the frequency analysis are given in Appendix C. A discussion of the major findings of the survey can be found in Chapter Two.

HOV Monitoring Effort

HOV violation data were collected at three locations on two of the area's major HOV facilities. Some facilities were not monitored because of personnel limitations. The two routes monitored, SR-520 and I-5, were selected because of the availability of possible monitoring locations and because an examination of the calls received on the HERO hotline revealed that more calls were received regarding violations on SR-520 and I-5 than on the other facilities. I-5 was monitored at two sites because the HOV lane on that facility is

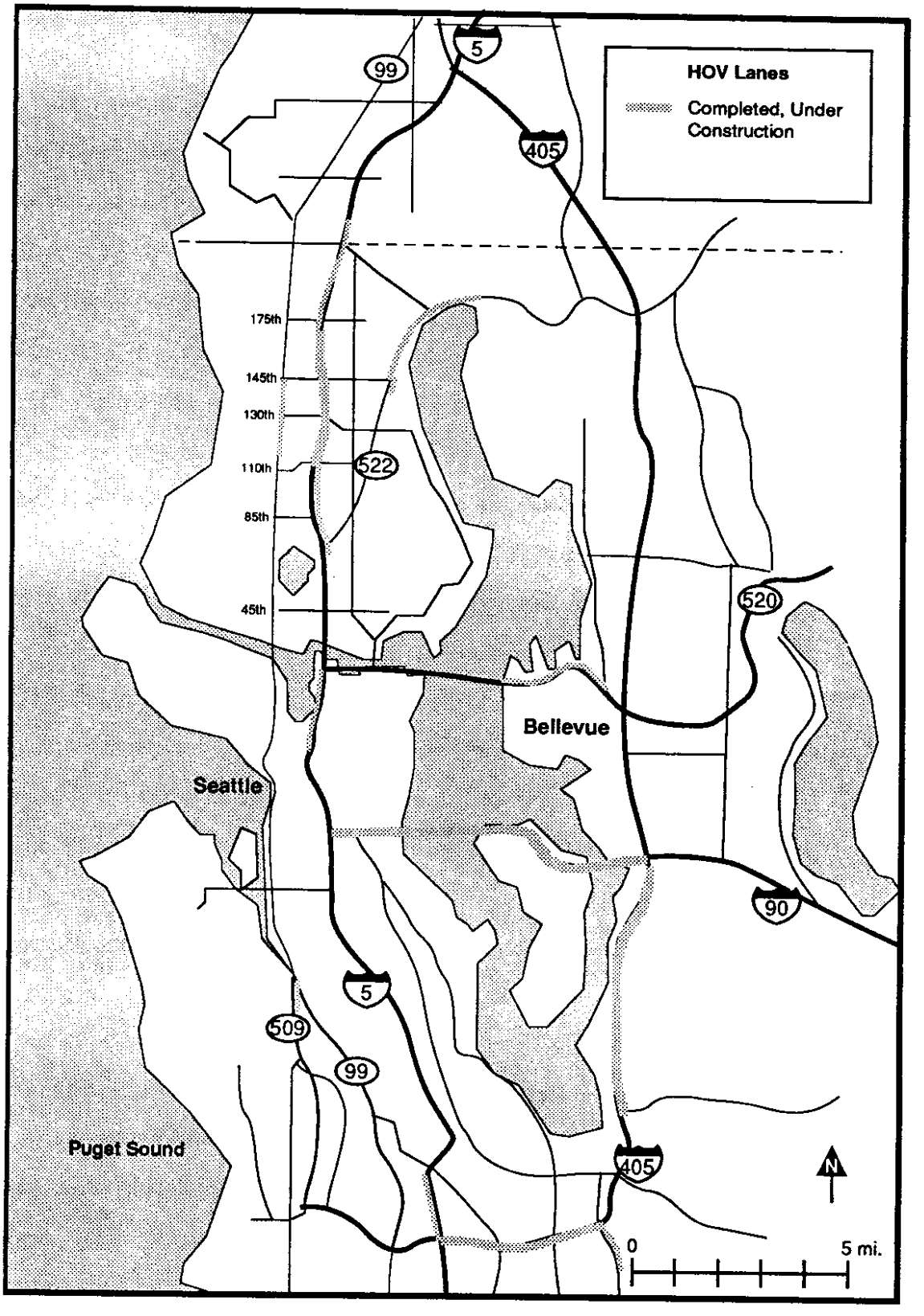


Figure 1.1. HOV Lanes

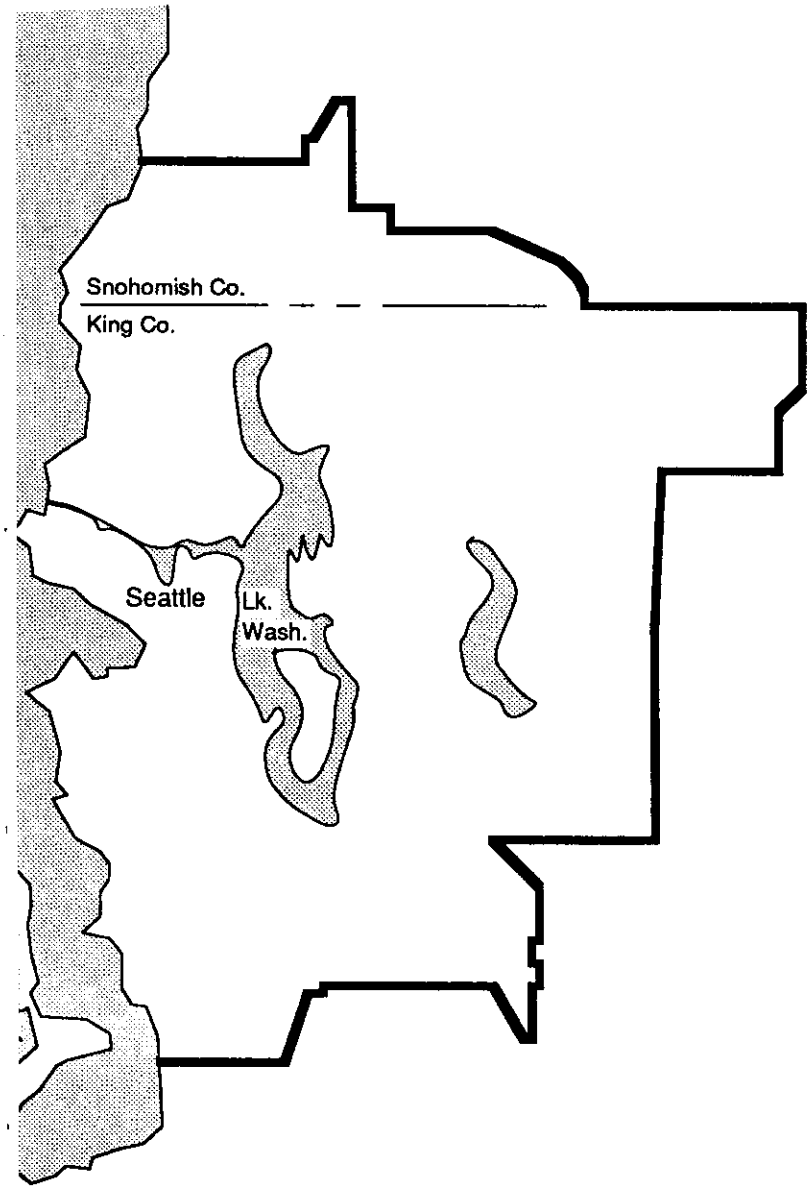


Figure 1.2. Study Area

fairly long (i.e., 5 miles in the southbound direction). In addition, the project team wanted to compare the violation rate at the two sites.

The three selected sites were monitored on weekday mornings during the peak period (6:45-7:45) every day for three consecutive weeks in late March and early April 1989. Mondays and Fridays, days on which traffic conditions are often atypical, were included in the monitoring because the project team wanted to compare the violation rate with the number of HERO calls received over a range of traffic conditions.

The violation data were collected by one person at each location. The collectors used small, portable computers (i.e., weighing between 2 and 3 pounds) that were programmable with the BASIC language. A program written for the study (Appendix B) allowed the data collector to classify each vehicle simply by pressing a single key. Vehicles were classified as SOVs, 2-person carpools, 3-or-more-person carpools, vanpools, buses, motorcycles, or "misses." Vehicles were classified as "misses" if the observer could not ascertain the number of occupants. When the observer pressed the appropriate key (e.g., "1" for SOV, "2" for 2-person carpool, etc.), the computer recorded the time of the observation. Keys not needed for data collection (i.e., all the letters and some of the numbers) were disabled and beeped if pressed accidentally.

The portable computers were selected to help collect data because they offered several advantages over more conventional recording devices, such as traffic counter boards.

1. The computers were able to record the time of each observation. This ability largely eliminated the need to supervise the data collectors once these personnel had learned how to use the computers because the data collected could be checked by examining the recording times.
2. The data collected could be easily transferred to a microcomputer for further analysis.

3. The third advantage of using the computers is that the computer program allowed the observers to make corrections on past observations.

The complete results of monitoring efforts are given in Appendix D, and a discussion of the major findings of the monitoring effort can be found in Appendix E.

Structure of the Paper

During the initial phase of the project, literature on HOV compliance and violation rate monitoring was reviewed to determine whether any state or other jurisdiction had monitored HOV lane violation rates on a long-term basis and, if so, what kinds of monitoring methods were used. Because of the dearth of published material on the subject, knowledgeable personnel from various states' transportation departments were contacted to obtain additional information. The results of both the literature review and conversations with transportation personnel are discussed in Appendix A.

After the literature review, a survey of King and Snohomish County residents was conducted to determine the public's awareness of and attitude toward both the HOV system and the HERO hotline program. The results of this survey are discussed in Chapter Two.

Chapter Three outlines the results of three-week monitoring effort. HOV lane violation data were collected daily for three weeks during the a.m. peak hour (i.e., 6:45 a.m. to 7:45 a.m.) at two sites. The results of the monitoring effort were used to help evaluate the HERO hotline program and to aid in the design of the HOV violation rate database.

This database is the subject of discussion in the Chapter Four. The need for such a database is discussed, as are the data requirements. A prototype of a database to store HOV violation data is also proposed.

Chapter Five discusses an evaluation of the HERO hotline program that used both the results of the public awareness survey and the HOV violation monitoring effort. Both the weaknesses and the strengths of the program are discussed.

Finally, a series of recommendations are presented in Chapter Six. These recommendations concern both the development of an HOV violation rate monitoring system and improvements that may increase the effectiveness of the HERO program.

CHAPTER TWO

PUBLIC AWARENESS SURVEY RESULTS

This chapter addresses the public's attitude toward and awareness of both the HOV facilities and the HERO program, as revealed in a telephone survey conducted by a market research firm in January and February 1989. Residents of areas served by HOV lanes were surveyed to determine the following:

- how aware the public is of each program,
- whether the public feels the programs are successful, and
- whether the public agrees with the concept of each program.

Before the development of this survey, the public's general attitude toward HOV lanes and HERO had been determined through periodic surveys conducted by the Municipality of Metropolitan Seattle (Metro) and Community Transit, who operate two of the area's transit systems (Metro operates buses within King County, while Community Transit provides service to residents of Snohomish County, north of King County). However, because each agency had only examined the opinions of residents of its own service area, no single survey had examined the opinions of *all* area residents who live adjacent to HOV facilities. Furthermore, the focus of these other surveys had been on other matters, so few questions had been devoted to the HOV system and the HERO program. No agency, including WSDOT, had conducted an in-depth survey specifically aimed at determining people's feelings toward and beliefs about the area's HOV lanes and the HERO program. The results of this survey will therefore provide WSDOT with valuable information that can be used for marketing and educational purposes.

SUMMARY OF KEY FINDINGS

The telephone survey of 551 King and Snohomish county residents led to the following conclusions regarding the public's awareness of and attitude toward the HOV system and the HERO hotline program.

The HOV System

Almost 85 percent of those surveyed had traveled on an HOV lane at least once. Much of this travel took place in carpools: 67 percent of the respondents used HOV lanes most frequently as part of a carpool. While most people reported traveling on HOV lanes, they do so infrequently. Approximately 38 percent of the people who had used HOV lanes said they used HOV lanes less than once a month, and another 31 percent of these people said they used the lanes at least once a month but less than once a week. Only about 14 percent of the HOV lane users said they used the lanes three to five days a week, the same percentage who said they used the lanes once or twice a week.

Slightly more than half of those who had used HOV lanes at least once knew that either two or three persons were necessary to travel in the lanes. More importantly, stratification of the results by residential areas showed that most people knew the minimum occupancy requirements for the HOV facilities nearest them. The majority (80 percent) of those who lived near both SR-520 (3 person carpools) and I-405 (2-person carpools) knew that the minimum occupancy requirements vary by facility.

Almost 85 percent of those surveyed thought having HOV lanes in the Seattle area is a good idea. Another four percent of the sample thought HOV lanes are basically a good idea, but qualified their responses with statements such as "only if the lanes are operational just during rush hour." Overall, only about nine percent of the sample didn't like the idea of HOV lanes.

Over 50 percent of the respondents felt HOV lane violations are only a minor problem, while about 17 percent of those sampled felt these violations are not a problem at all. However, the interpretation of this result is difficult; either people do not think enough violations are occurring to warrant labeling the problem as "serious," or many people do not view HOV lane violations as being serious infractions of the law. Only one-quarter of the sample felt HOV violations are a serious problem.

The HERO Program

Most people sampled (81 percent) knew about the HERO program. This result is encouraging, since no marketing of the program has taken place since 1984, when the program was first begun. Although only 6.3 percent of the respondents who knew about the hotline said they had actually used it to report an HOV violation, the majority (71 percent) nonetheless thought the program was a good idea.

About half of those who knew about the HERO program felt that HERO helps reduce HOV violations, but only six percent of these people thought HERO reduces HOV violations a great deal. Most of those sampled generally approve of the HERO program in spite of the fact that they do not think the program reduces the violation rate a great deal. Therefore, the general acceptance of HERO may stem from another source. Perhaps many people are in favor of HERO because it gives them the chance to vent their frustration at being delayed by traffic congestion while violators apparently get rewarded for breaking the law by being able to drive by at 55 mph in the HOV lane.

SURVEY FINDINGS ABOUT THE HOV SYSTEM

Awareness and Usage of the HOV System

As stated previously, a major objective of the survey was to determine the public's awareness of the HOV system. Therefore, questions were designed to establish the frequency of HOV lane usage, the usage of the lanes by mode, and the public's knowledge of HOV regulations (i.e., hours of operation and occupancy requirements.

Usage by Mode. The respondents were asked the following question to determine the types of vehicles people ride in while using HOV lanes:

"Have you ever used the carpool lanes while traveling in a..."

Bus,
Carpool,
Vanpool,
Motorcycle,
By yourself, even for a short period of time,

By yourself for exiting or turning right, or
Never used lanes.

The respondents were asked to select *all* the modes that they had ever used while traveling on an HOV lane. Almost 85 percent (84.5 percent) of the sample had traveled on an HOV lane at least once. The most frequently chosen answer was carpool (77 percent). The second most commonly selected choice was the bus, which only 22 percent of those surveyed had ever used (Figure 2.1). When the survey was analyzed to determine which one mode was used most often by each respondent when he or she traveled on an HOV lane, the outcome was similar: 67 percent used the lanes most frequently as part of a carpool, whereas only 10 percent of those sampled most often used an HOV lane while on a bus (Figure 2.2).

The percentage of people who used HOV lanes as part of carpools or while in buses varied significantly among the different HOV facilities (Figure 2.3). For example, 88 percent of those who reported using the HOV lanes on I-405 did so as part of carpools, whereas approximately 74 percent of the people who traveled on I-5 traveled in carpools. The fact that the definition of "carpool" is three people per vehicle on I-5 but only two people on I-405, combined with the fact that far more buses travel along I-5 than along I-405, is probably responsible for this difference.

An interesting fact revealed by the survey is that 10 percent of the sample reported using an HOV lane at least once while traveling alone in a car. However, when respondents were asked to choose the one mode they used most frequently while traveling on an HOV lane, only 4.4 percent admitted they usually used HOV lanes while alone in a vehicle. In fact, cross-tabulation of the results of these two questions with the results from the question on frequency of HOV lane use (question 6) revealed that most of the people who admitted using HOV lanes illegally did so less than once a month (63 percent).

Frequency of Use. When people who said they had used the HOV lanes at least once in the past were asked how often they used the lane, the most commonly selected answer was "less than once a month" (38.4 percent). The second most popular answer

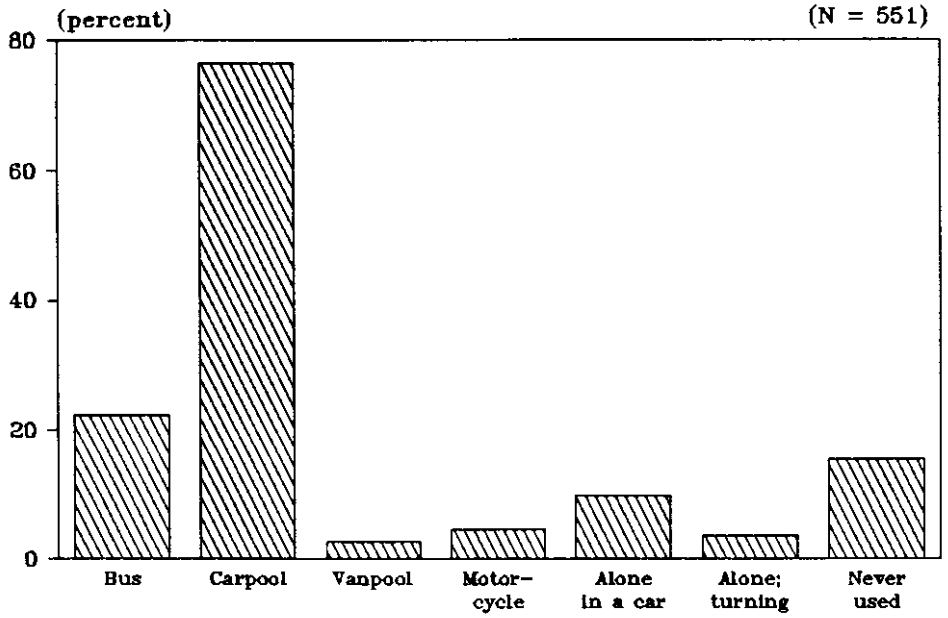


Figure 2.1. Have you ever used the carpool lanes while traveling in a . . .

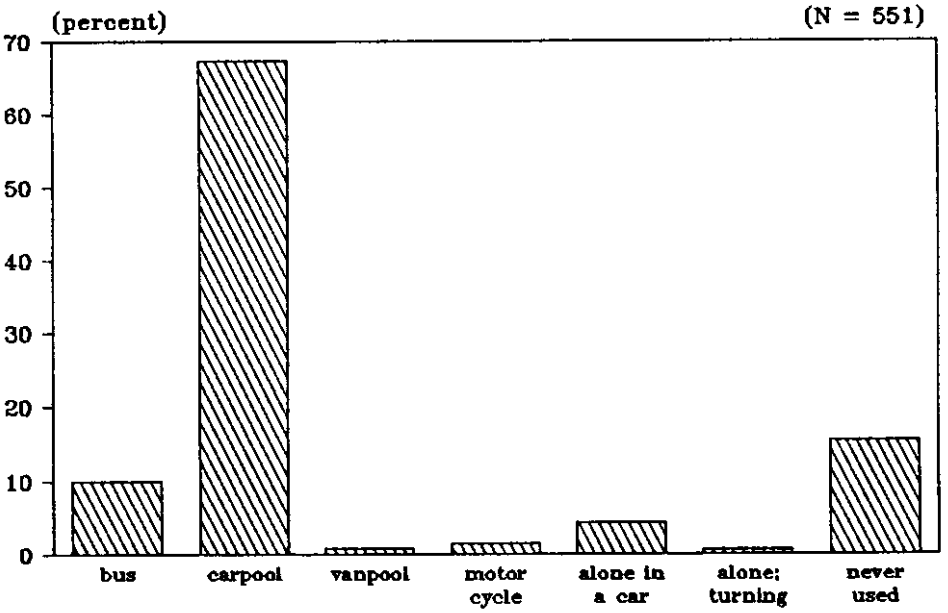


Figure 2.2. Type of Vehicle Used Most Often While in the HOV Lane

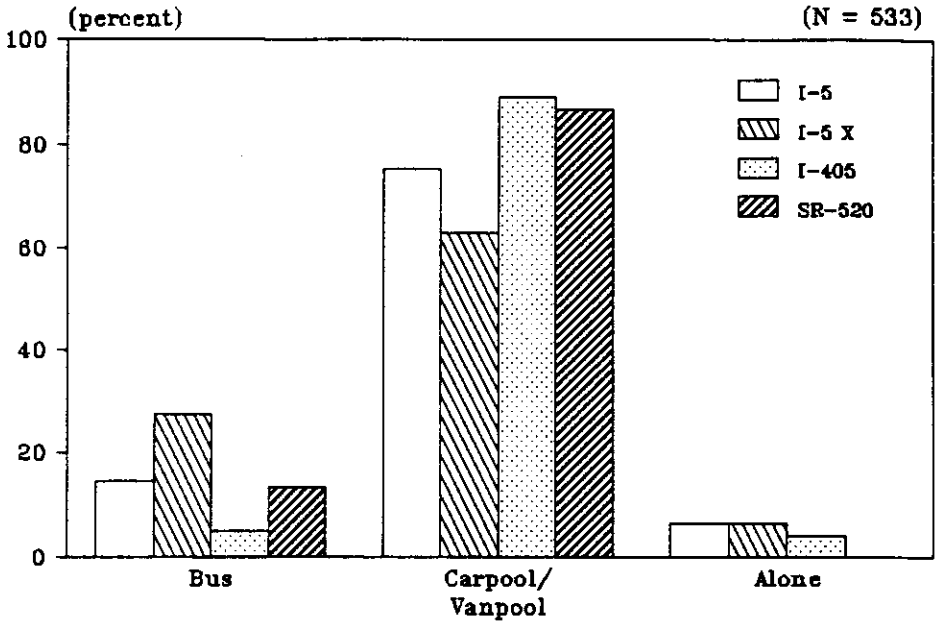


Figure 2.3. Type of Vehicle Used in HOV Lane
(by facility)

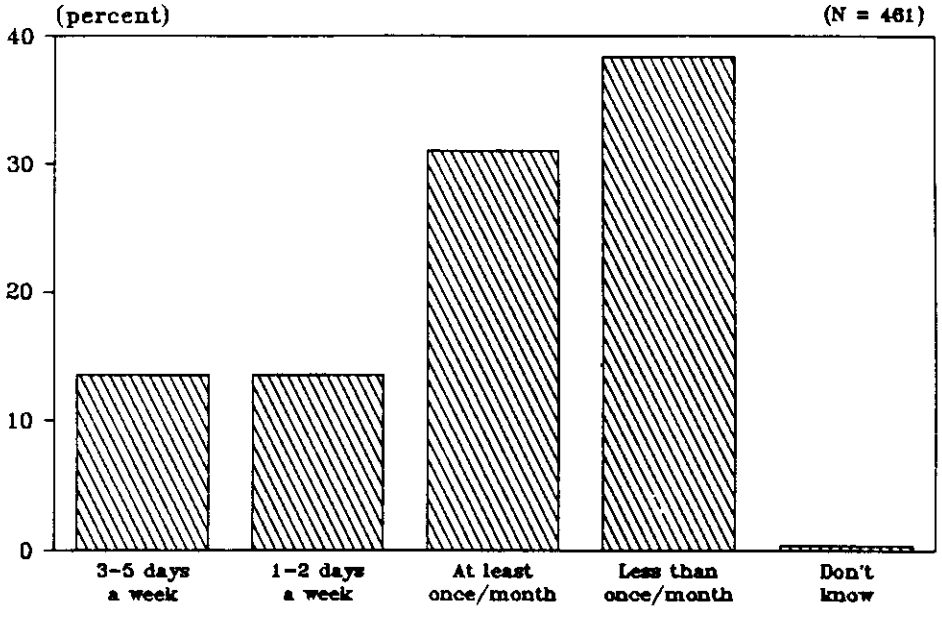


Figure 2.4. How often do you use the carpool lanes?

was "at least once a month" (31.1 percent). Only 13.6 percent of these respondents said they used the lanes between three and five days a week. The same percentage (13.6) traveled on HOV lanes only once or twice a week (Figure 2.4).

These results differed slightly by mode choice (Figure 2.5). Thirty-one percent of the bus riders stated they used HOV lanes between three and five days a week, whereas only 11 percent of the carpoolers used HOV lanes that frequently. On the other hand, 47 percent of the bus riders said they used HOV lanes less than once a month, while only 35 percent of the carpoolers used the lanes that infrequently.

Frequency of HOV lane use was also cross-tabulated with area of residence and with HOV facility used. While no statistically significant difference in frequency of HOV lane use was found among different areas, the facility used did appear to influence HOV lane usage (Figure 2.6). People who reported using the HOV lanes on the I-5 express lanes were more likely to travel on the HOV lanes between three and five days a week than were people who traveled on the other major HOV lanes (SR-520, I-5 mainline, and I-405), probably because of the large number of bus routes that utilize the I-5 express lanes. Nonetheless, only 23 percent of the people who used the I-5 express lanes HOV facility used the lanes this frequently. More importantly, the most common answer for users of every major HOV facility when asked how often they used HOV lanes was "less than once a month." This pattern of answers indicates that while most people have used HOV lanes at least once, the majority of people only travel on the lanes infrequently, and relatively few people use the lanes daily.

Non-Usage of HOV Lanes When Qualified. When respondents were asked whether they ever chose not to use the HOV lanes at times when they had enough people in the car to use them, 46.6 percent of them said "yes." However, when these people were asked why they sometimes failed to use HOV lanes when they were qualified to use them, almost two-thirds (65.4 percent) replied that traffic was not heavy enough at those times. These people might might have been qualified to use the HOV lanes during the evening or

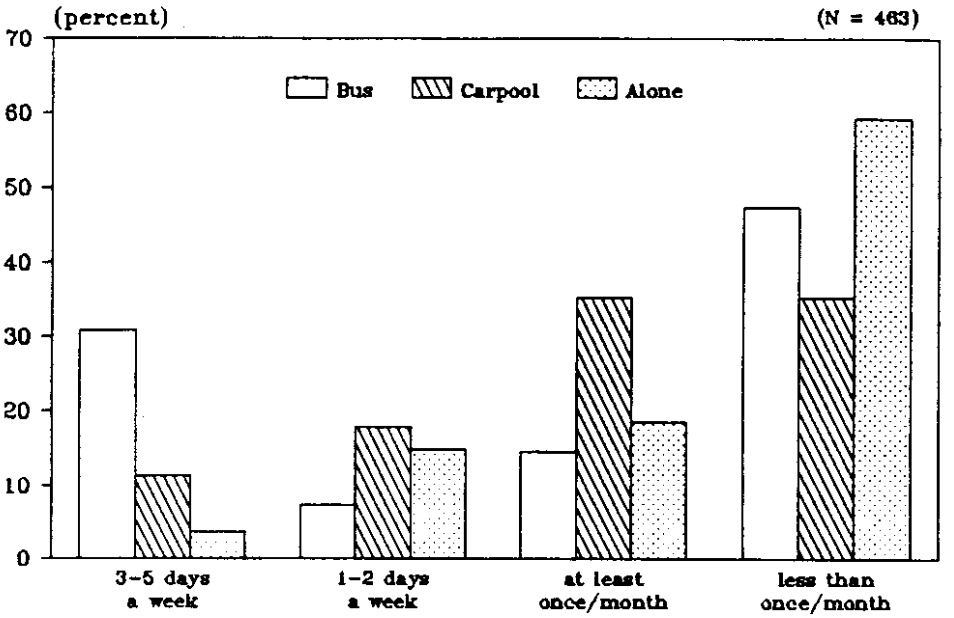
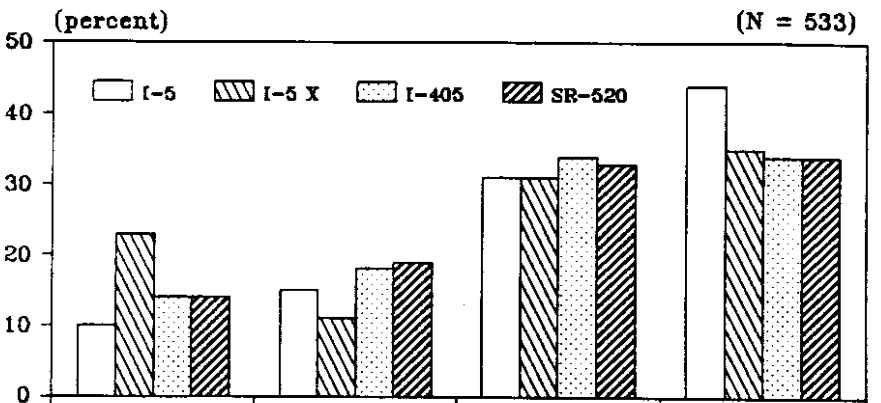


Figure 2.5. How often do you use the carpool lanes? (by mode)



	3-5 days a week	1-2 days a week	at least once/month	less than once/month
I-5	10	15	31	44
I-5 X	23	11	31	35
I-405	14	18	34	34
SR-520	14	19	33	34

Figure 2.6. How often do you use the carpool lanes? (by facility)

on a weekend, when congestion is usually not present. The second most frequently stated response was, "it takes too much trouble to change lanes" (11.7 percent).

Knowledge of Regulations. One way of determining the public's awareness of the HOV system is to assess the public's knowledge of the regulations regarding the use of the area's HOV facilities. Two regulations of particular interest pertaining to the HOV system are those governing the hours of operation and the minimum occupancy requirements. Because the hours of HOV operation have changed over time, and because regulations regarding the minimum occupancy of the area's HOV facilities vary among the facilities, the public's understanding of these two regulations was not known. The HOV lanes currently operate 24 hours a day on almost all facilities, but at one time the lanes on one facility, SR-520, operated only during the a.m. and p.m. peak periods. The fact that the minimum occupancy necessary to use the area's HOV facilities is either two or three persons (two persons on I-405 and three persons on most other facilities) may also cause confusion among motorists.

The survey results showed that the majority of those sampled (79 percent) knew that HOV lanes are in effect at all times (Figure 2.7). Residents of the northeastern part of the study area were slightly more likely to know this fact (84.7 percent) than were residents in other areas, but the differences between the groups were not statistically significant.

However, the public was not nearly as knowledgeable about the minimum occupancy necessary to use the area's HOV lanes. Slightly more than half of those who had used the lanes at least once knew that either two or three persons were necessary to travel in the lanes (53 percent). This result is not surprising, given that many people have not been exposed to all the area's HOV lanes and thus only know the occupancy requirements for those lanes that they have seen or used.

A more precise way to measure people's knowledge of the minimum occupancy requirements is to break the sample into groups by residential area to determine whether

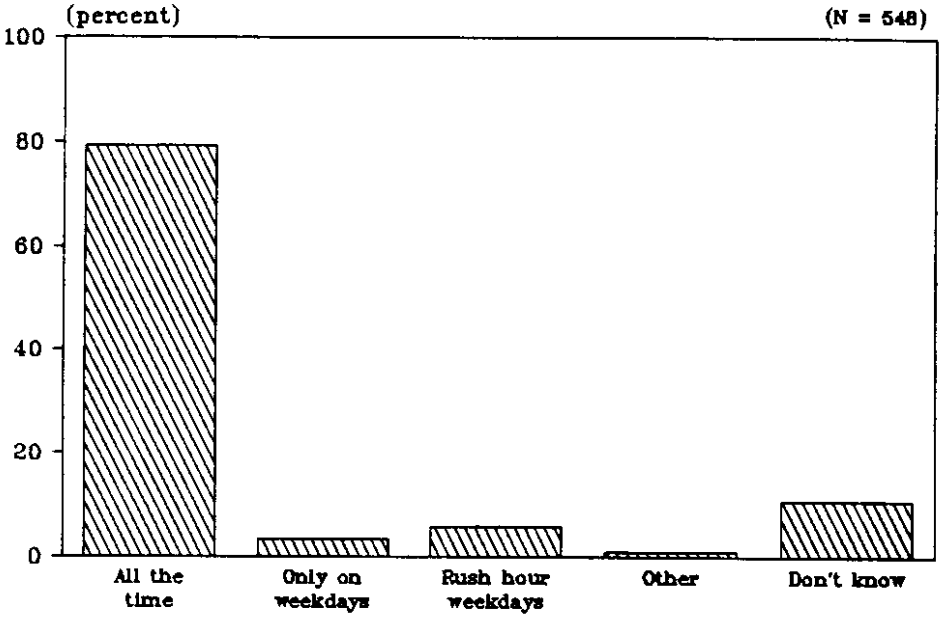


Figure 2.7. When are the carpool lanes restricted to buses and carpools?

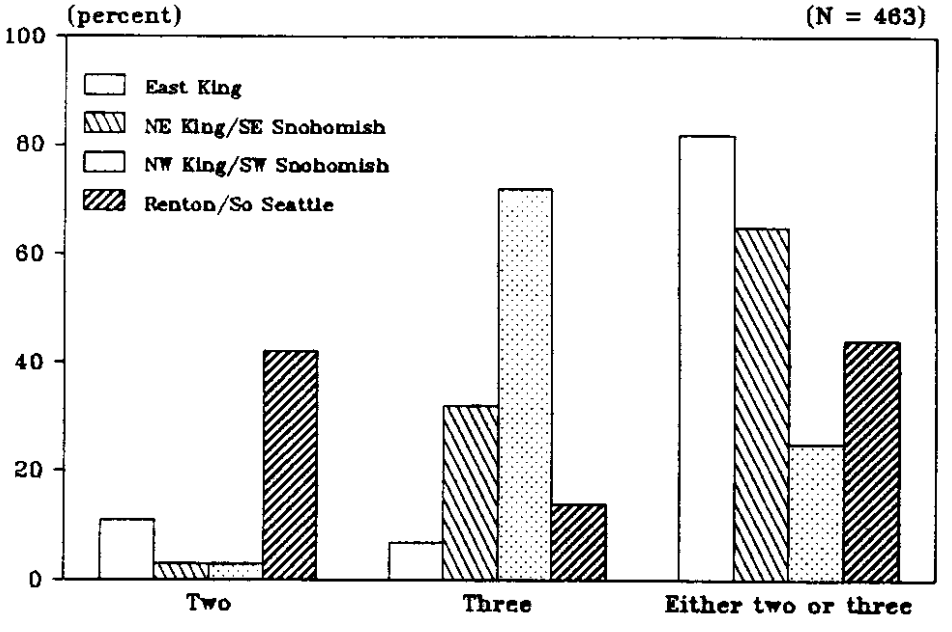


Figure 2.9. How many people per vehicle are needed to use the carpool lanes? (by area)

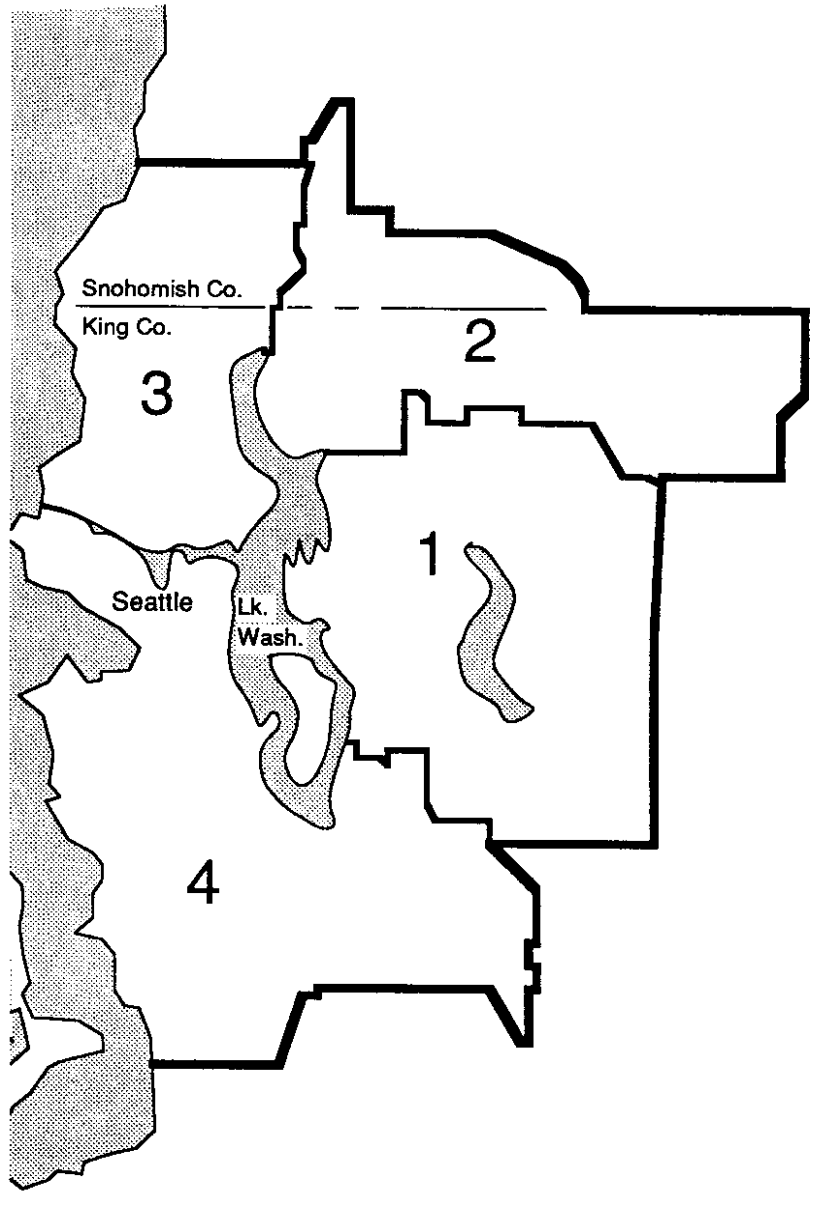


Figure 2.8. Study Area and Zones

each group knows the occupancy requirements of the HOV facility(ies) in that area. The four subareas used in this survey are shown in Figure 2.8.

The results of this analysis were as expected (Figure 2.9). A majority of those living on the east side of Lake Washington (81.6 percent), where HOV lanes with each of the two occupancy requirements are represented, knew that minimum occupancy is either two or three persons. In contrast, only 24.7 percent of those living on the west side of the lake, where the occupancy requirement for all major HOV facilities is three persons, knew that the occupancy requirement varies between facilities. More importantly, however, 71.7 percent of this group said three people were necessary to qualify as a carpool, indicating that residents of this area did know the occupancy requirements for the HOV lane nearest them.

Attitudes Toward HOV Lanes

A number of questions were designed to assess the respondents' attitude toward the HOV system. The results were very encouraging. When asked whether they thought having carpool lanes in the Seattle area is a good idea, 84.6 of the respondents said "yes" (Figure 2.10). Another 4.5 percent felt that the lanes were a good idea, but qualified their answers with statements such as "only if the lane restrictions are enforced," or "if the lanes are for buses only." Only 9.1 percent of those surveyed responded to the question with a "no." This pattern did not differ significantly by area of residence or by travel mode. Over 75 percent of every mode group, including people who admitted using HOV lanes while alone in a vehicle, felt that HOV lanes are a good idea. However, the percentage of women who felt HOV lanes are a good idea was higher than the percentage of men who felt that way (90 percent versus 80 percent). Younger people were also more likely to be in favor of HOV lanes (Figure 2.11 and 2.12).

Another question designed to determine the public's attitude toward HOV lane violations was, "Do you feel that the use of carpool lanes by cars without the proper number of people is a serious problem, minor problem, or not a problem?" The results of

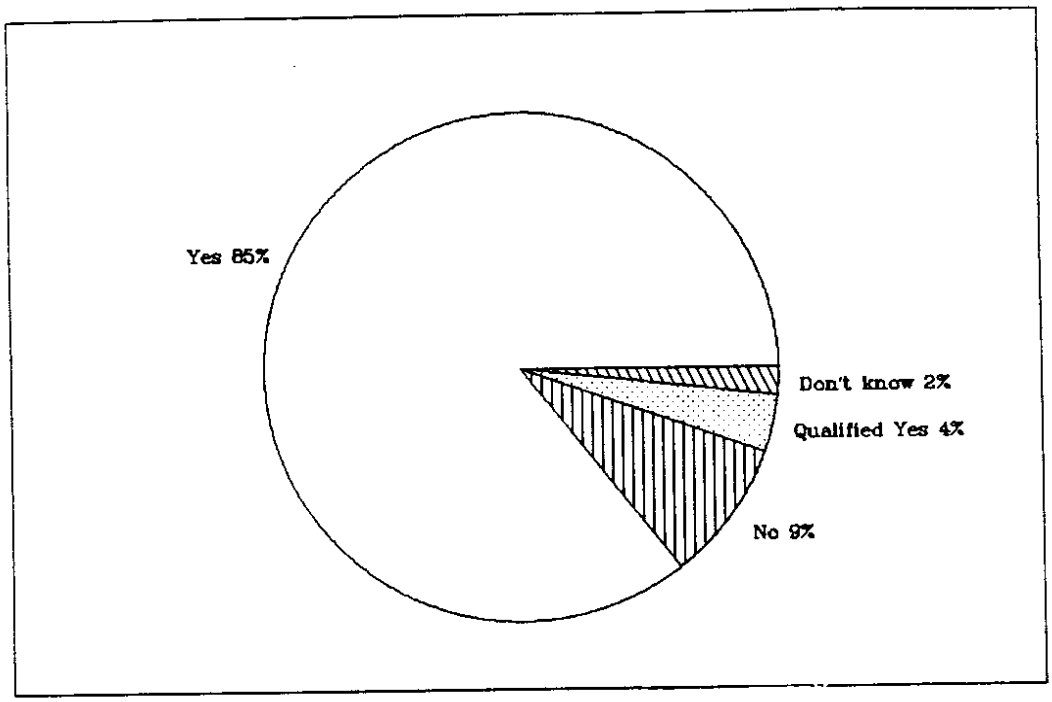
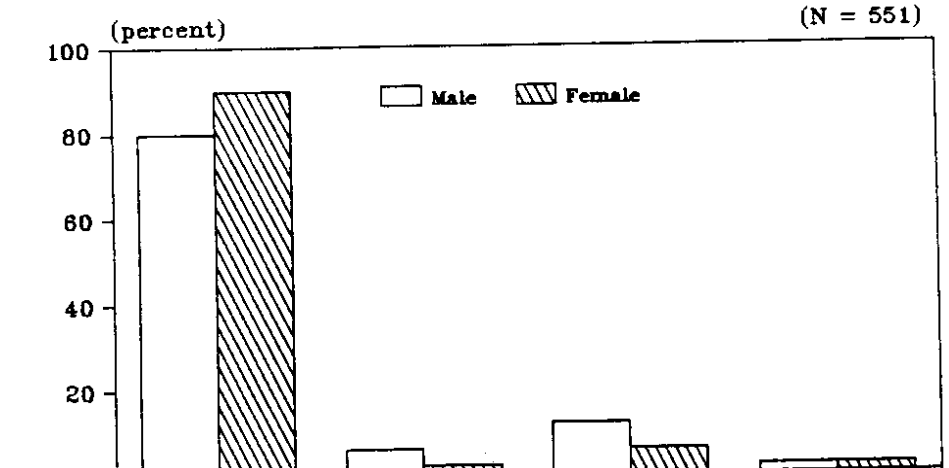
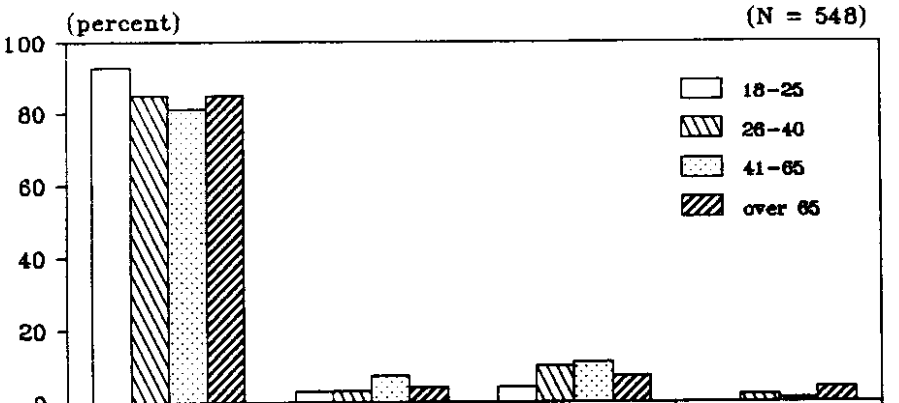


Figure 2.10. Do you think having carpool lanes in Seattle is a good idea? (N=551)



	Yes	Qualified yes	No	Don't know
Male	80	6	12	2
Female	90	2	6	2

Figure 2.11. Are HOV lanes in Seattle a good idea? (by gender)



	Yes	Qualified yes	No	Don't know
18-25	93	3	4	0
26-40	85	3	10	2
41-65	81	7	11	1
over 65	85	4	7	4

Figure 2.12. Are HOV lanes in Seattle a good idea? (by age group)

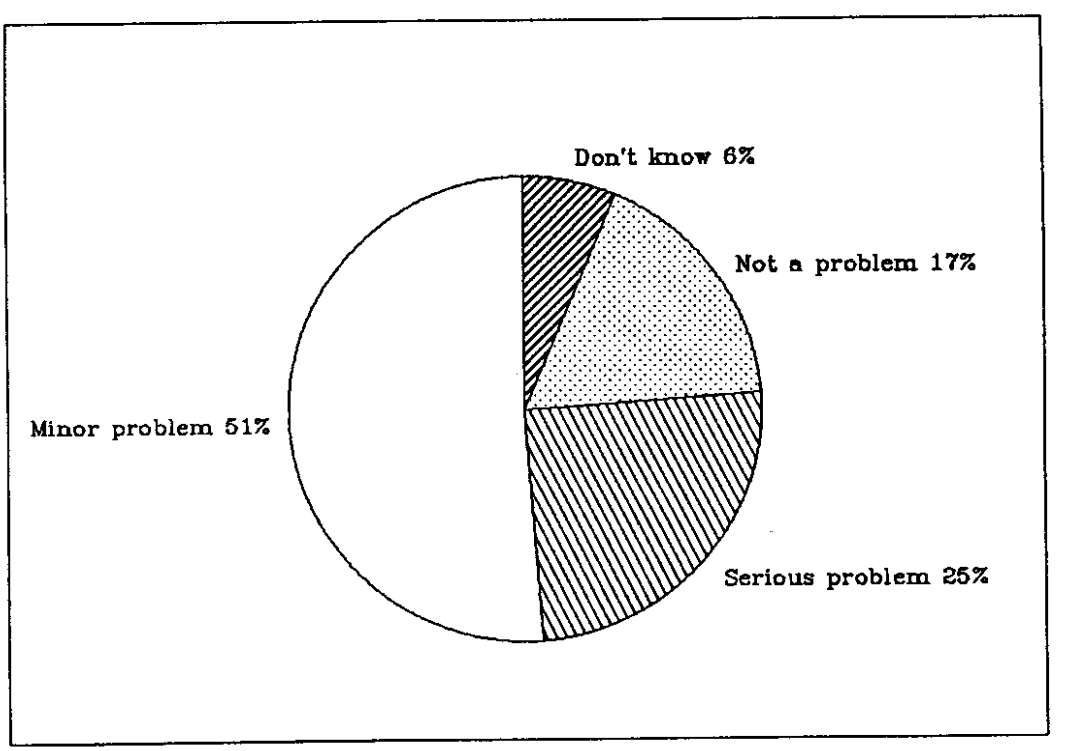


Figure 2.13. Do you feel the use of carpool lanes by violators is a . . . (N=551)

this question were fairly positive. Only 25 percent of the sample felt HOV lane violations were a serious problem. Over 50 percent of the respondents (51.2 percent) felt HOV violations were a minor problem, while 17.4 percent felt these violations were not a problem at all (Figure 2.13). Apparently, most people surveyed either felt that HOV violations are not serious infractions of the law or that not enough violations are occurring to label the situation a "serious problem."

Neither mode choice nor area of residence had a significant effect on people's attitudes toward HOV violations. However, when the results of this question were cross-tabulated with the results from the previously discussed question (i.e., "Are HOV lanes a good idea?"), a statistically significant difference was found between people who felt HOV lanes are a good idea and those who felt they are not a good idea (Table 2.1). People who did not think HOV lanes are a good idea were more likely to feel HOV lane violations are

TABLE 2.1 - People's Attitudes Towards HOV Lanes Crosstabulated with their perceptions of HOV Lane Violations (N = 551)

HOW SERIOUS ARE HOV VIOLATIONS? (ARE HOV LANES IN SEATTLE A GOOD IDEA? (READ ACROSS))	YES; A GOOD IDEA	QUALIFIED YES	NOT A GOOD IDEA	DON'T KNOW
A serious problem	120[a] (25.8)[b]	8 (32.0)	10 (20.0)	0 (0.0)
A minor problem	247 (53.0)	12 (48.0)	19 (38.0)	4 (40.0)
Not a problem	70 (15.0)	3 (12.0)	20 (40.0)	3 (30.0)
Don't know	29 (6.2)	2 (8.0)	0 (0.0)	3 (30.0)
Refused to answer	0 (0.0)	0 (0.0)	1 (2.0)	0 (0.0)
Total	466 (100.0)	25 (100.0)	50 (100.0)	10 (100.0)

[a] number of respondents
[b] percent of respondents

either a minor problem or not a problem than were those who thought HOV lanes are a good idea.

Finally, the people surveyed were presented with a series of statements about HOV lanes and their effects. Respondents were asked whether they agreed or disagreed with each statement. The results of these questions are shown in Table 2.2. Most of those sampled agreed with the statement that HOV lanes save time for people who use the lane (96 percent agreed strongly or somewhat with this statement). The majority of those sampled also felt that HOV lanes do not worsen traffic in other lanes, are not unfair to drivers who cannot use them, and do not increase the number of accidents. However, the results of two other questions were less positive. Only 39 percent of the sample felt HOV lanes reduce traffic congestion in all lanes, approximately the same percentage that disagreed with the statement that HOV lanes reduce air pollution.

All six of the statements were cross-tabulated with travel mode to determine whether there were statistically significant differences among the opinions of users of different travel modes. The differences among the groups were not significant. It had been expected that those who had admitted to traveling on HOV lanes while alone in a vehicle would react to the statements differently than would other people, but this was not the case.

FINDINGS ABOUT THE HERO PROGRAM

Previous studies Metro has conducted have shown that most people are generally in favor of the HERO hotline program. For example, a survey Metro conducted in 1986 (Municipality of Metropolitan Seattle, Rider/Non-Rider Telephone Survey, 1986) found that over 60 percent of those surveyed were glad they could use HERO to report HOV violations (Figure 2.14). However, since the hotline's inception in 1984, no survey has examined people's attitudes toward the HERO program's effectiveness in reducing HOV lane violations, nor has any survey determined the percentage of people who know of

TABLE 2.2 - RESPONSES TO QUESTIONS 12A THROUGH 12F[b]

QUESTIONS	DISAGREE STRONGLY	DISAGREE SOMEWHAT	DON'T KNOW	AGREE SOMEWHAT	AGREE STRONGLY	REFUSED
HOV lanes save time for people who use them	0.90[a]	2.50	0.50	15.40	80.60	0.00
HOV lanes worsen traffic in other lanes	44.60	28.30	3.10	10.90	13.10	0.00
HOV lanes are unfair to those who don't use them	53.70	26.70	3.10	7.80	8.70	0.00
HOV lanes reduce congestion in all lanes	20.50	18.10	5.40	31.80	24.00	0.20
HOV lanes increase the number of accidents	51.40	26.50	10.70	6.50	4.00	0.90
HOV lanes reduce air pollution	23.00	16.50	14.50	26.10	19.10	0.40

[a]Numbers shown are percentages

[b]Rows total to 100%

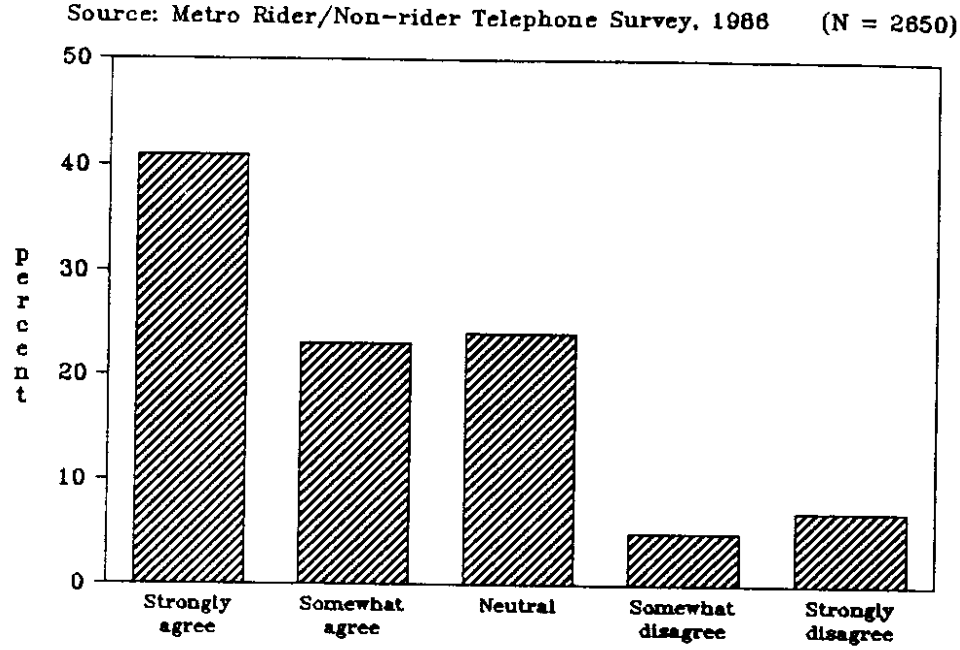


Figure 2.14. I'm glad there is a phone number to report carpool lane violators

HERO's existence. Eight of this survey's questions were therefore devoted to determining the public's awareness of and attitude toward the HERO program.

Awareness of the HERO Program

Knowledge of the hotline's existence was fairly high; 81 percent of the sample knew about the HERO program. Carpoolers were more likely to know about the program than were people who used other modes while in the HOV lanes. Of the carpoolers, 87 percent knew about HERO, whereas about 82 percent of the bus-riders in the sample had heard of HERO. Approximately 65 percent of those who had never used the lanes knew about the program.

Knowledge of the HERO program also differed among residential areas. People who lived on the east side of Lake Washington were most likely to know about the HERO program (89.9 percent), followed by residents of the northeastern part of the study area

(81.8 percent), and residents of North Seattle (77.9 percent). Residents of Renton and south Seattle were least likely to know about HERO (72.1 percent). The high percentage of people who lived on the east side of the lake who knew about the HERO program is not surprising, since two of the major freeways on that side of Lake Washington have HOV lanes (SR-520 and I-405).

Most of the people who knew about the HERO program had seen signs about the hotline next to the freeway (96.7 percent). Signs that ask motorists to report HOV lane violators and provide the hotline telephone number are extensively posted next to HOV facilities, but the number of people who actually noticed these signs was unknown before this survey.

Usage of the Hotline

Not many of the people in the sample had actually used the hotline to report an HOV violation (i.e., 6.3 percent of those who knew about HERO, or 5.1 percent of the total sample). This result was expected, since only 67 percent of those surveyed said they traveled on roads with HOV lanes during the peak periods. Another reason for the low report rate may be the difficulty motorists have in seeing and writing down the license plate numbers of the violating vehicles, which are typically moving much faster than vehicles in the general lanes. Given the fact that Metro and WSDOT have not marketed the program since 1984, the percentage sampled who said they have used the hotline is not unreasonably low.

Attitudes Toward the HERO Program

When people who knew about HERO were asked whether they thought the program was a good idea, the majority (71 percent) thought the program *was* a good idea (Figure 2.15). The percentage of people who liked the idea of the HERO program differed only slightly among users of different modes (Figure 2.16). Slightly more bus riders than carpoolers were in favor of the HERO program, but the difference was not significant (73

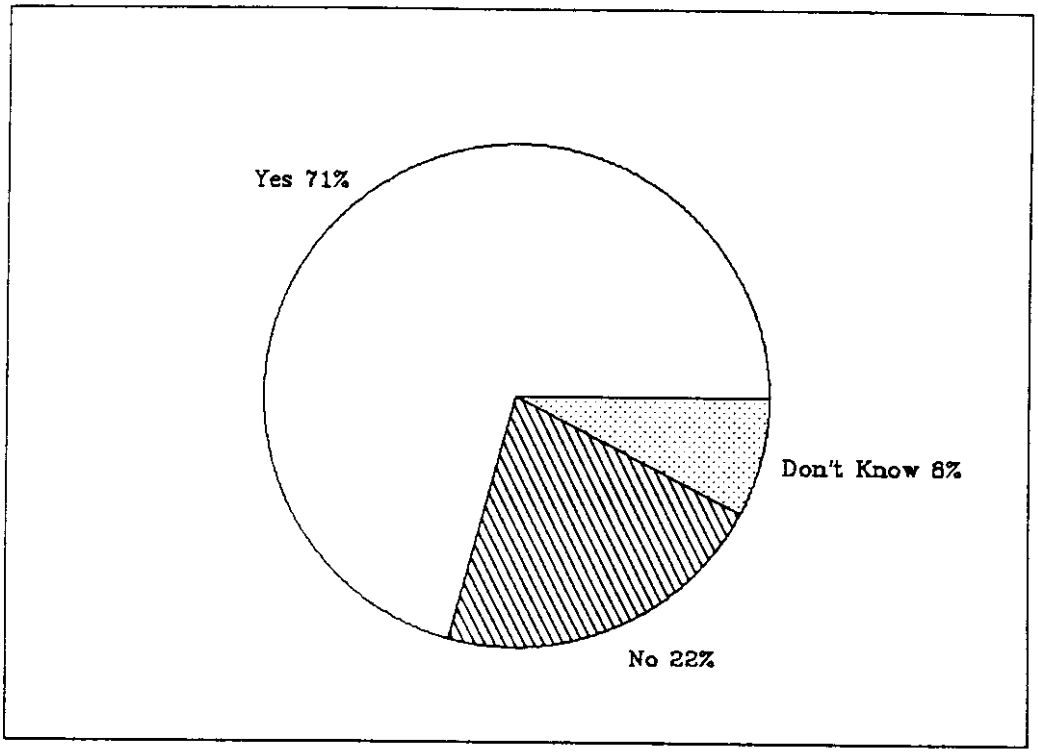
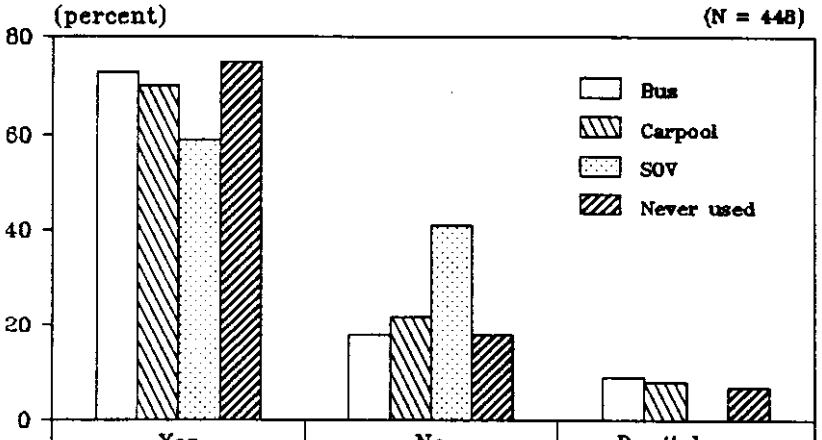


Figure 2.15. Do you think HERO is a good idea?



	Yes	No	Don't know
Bus	73	18	9
Carpool	70	22	8
SOV	59	41	0
Never used	75	18	7

Figure 2.16. Is HERO a good idea?
(by vehicle used in the HOV lane)

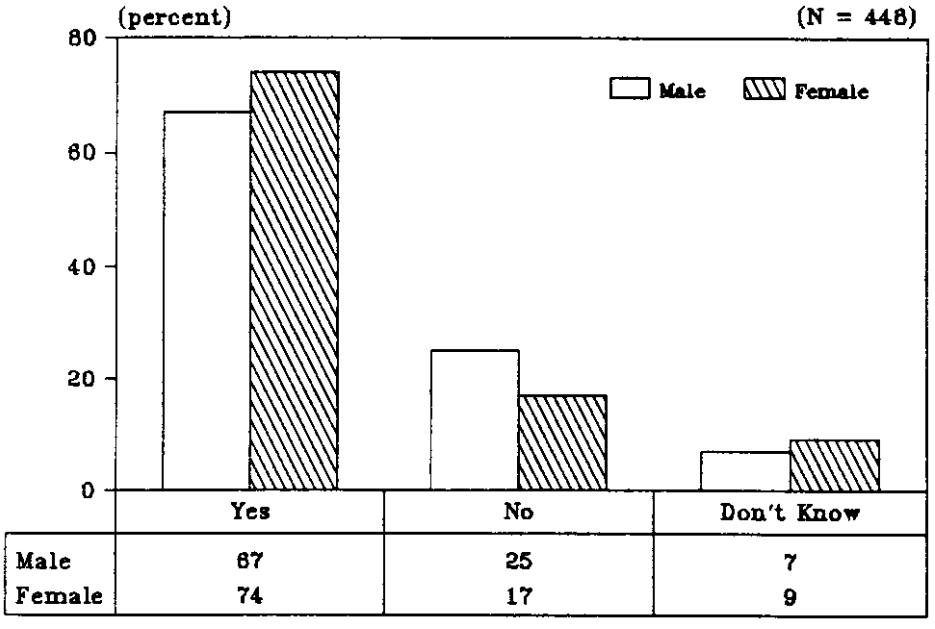
versus 70 percent). Interestingly, 75 percent of those who said they had never used the HOV lanes thought HERO was a good idea (only 22 percent thought HERO was actually a bad idea). In contrast, approximately 59 percent of those who admitted using an HOV lane while alone in a vehicle were in favor of the HERO program.

The percentages of people who thought HERO is a good idea also differed among residential areas, although not significantly. People from east King county and from north Seattle and southwest Snohomish county were more likely to think HERO is a good idea than were people from other areas, perhaps because they were more familiar with the program.

Gender also appeared to have a significant effect on people's attitudes toward the HERO program. Women were more likely to be in favor of the hotline than were men. About three-fourths of the women (74 percent) who knew about the HERO program thought that HERO is a good idea, while only 68 percent of the men felt that way (Figure 2.17).

Attitudes Toward HERO's Effectiveness in Reducing the Violation Rate

Two of the survey's questions were designed to determine whether people feel that HERO reduces the illegal use of HOV facilities. Half of the people who knew about the HERO program felt that the hotline does help reduce violations (Figure 2.18). However, when asked *how much* they thought HERO reduces HOV violations, only 6 percent of those sampled felt the hotline reduces HOV violations a great deal. Almost 25 percent (23.7) of those asked thought HERO does not reduce HOV violations at all (Figure 2.19). These results are interesting, given that 70 percent of those asked felt that HERO is a good idea. Apparently, even though many people feel the HERO hotline does not significantly reduce the illegal use of HOV lanes by unqualified vehicles, the majority of people are nonetheless in favor of the HERO program. Perhaps many people are in favor of the program because it gives them the ability to "do something" about HOV lane violators.



	Yes	No	Don't Know
Male	67	25	7
Female	74	17	9

Figure 2.17. Is HERO a good idea? (by gender)

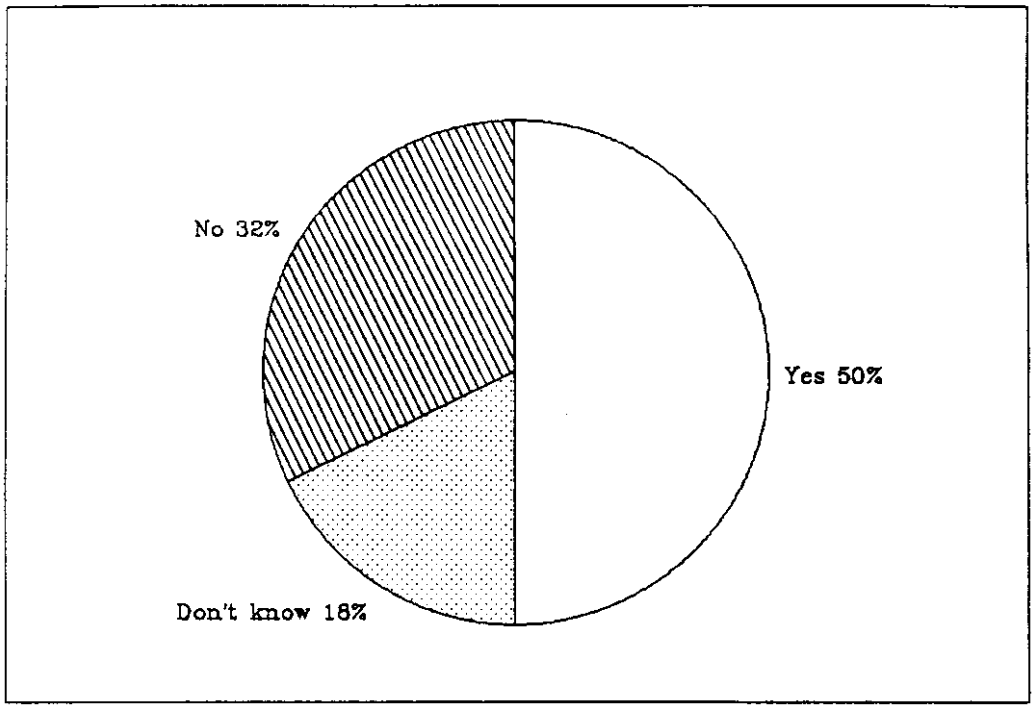


Figure 2.18. Do you think the HERO hotline reduces violations? (N=448)

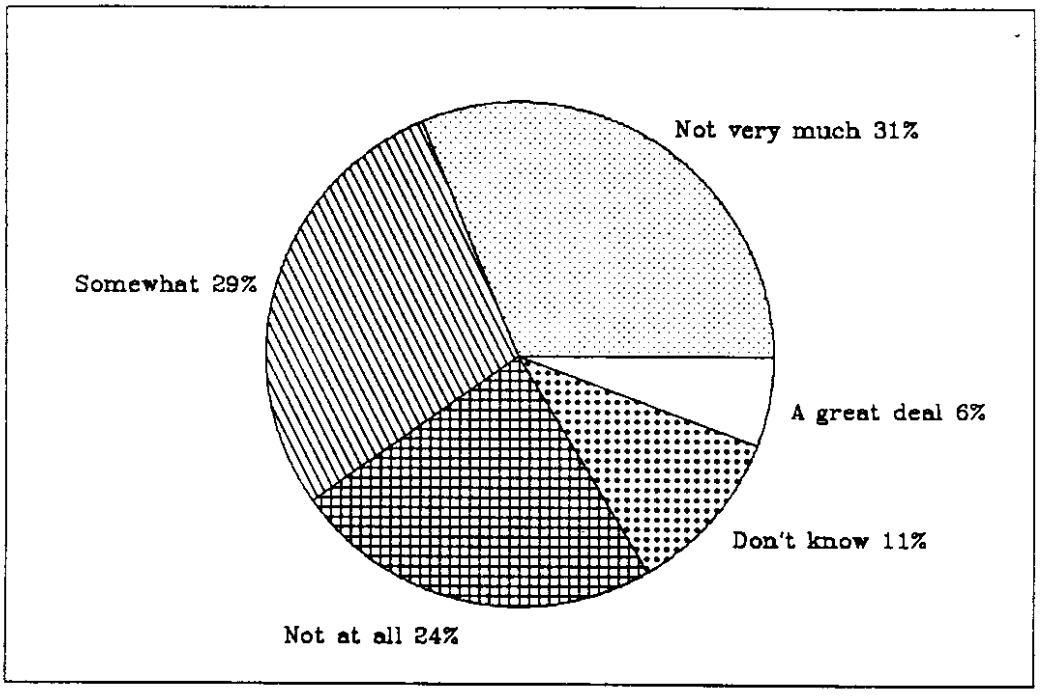


Figure 2.19. How much does HERO reduce the illegal use of HOV lanes?

CONCLUSION

Support for both the HOV system and the HERO hotline program was quite high. Almost everyone sampled knew about the HOV system and the majority had used an HOV lane at least once. The high level of support for HOV lanes (85 percent thought they are a good idea) was particularly gratifying, since many people used the HOV lanes only infrequently.

Similarly, the majority of those sampled knew about the program and most of those who knew about it were in favor of it. Since people generally didn't feel the program significantly reduces HOV lane violations, the public's favorable attitude must stem from a different source. Probably people like the program because it allows them to vent their frustration at being caught in traffic and seeing HOV lane violators drive by at 55 mph without being penalized.

CHAPTER THREE

HOV VIOLATION MONITORING RESULTS

The results of a three-week HOV lane violation/compliance monitoring effort on I-5 and SR-520 are presented in this section. However, the objective of the monitoring effort was not merely to determine the violation rates on these two facilities. The primary purpose of the monitoring was to test possible monitoring locations and to find out whether HOV lane violations are related to the calls received on the HERO hotline. The monitoring results were also used to evaluate HERO's effectiveness. The research team compared the violation rates with previously measured violation rates on the two facilities to determine whether the violation rate remained at the same level after the HERO program had been implemented.

SUMMARY OF KEY RESULTS

HOV violation rates were monitored daily over three weeks. This effort led to a number of conclusions:

1. The best vantage point from which to determine occupancy in the HOV lane on SR-520, which is located on the outside lane, is from a position slightly above and in front of the vehicles, at an angle of about 45° measured from the long axis of the vehicle. On I-5, a better view of the interiors of vehicles in the HOV lanes, which are located on the inside of the freeway, can be obtained from the inside shoulder. The I-5 HOV lanes can also be viewed from a position on a raised outside shoulder, but the view into passing HOV vehicles can be blocked by passing trucks, buses and other large vehicles.
2. Violation rates were lowest on the SR-520 HOV lane. The highest violation rates were found at the 175th Street site on I-5.
3. The number of violations observed at the SR-520 monitoring site was negatively related to the speed in the adjacent general purpose lanes. In other words,

violations increased when speeds decreased. When speeds higher than 45 mph were excluded, a similar relationship was found to exist between speed and violations on I-5. In addition, HOV violations on I-5 were positively related to the lane occupancy in the general purpose lanes: as lane occupancy increased, the number of violations also increased.

4. On I-5, the number of violations reported through the HERO hotline was related to traffic volume, lane occupancy, and speed in the general purpose lanes. The number of calls received through HERO increased as traffic volume and lane occupancy increased and speeds decreased. This finding could not be duplicated for SR-520 because of the low number of violations reported through HERO for that facility.

5. The number of violations reported through HERO was not significantly associated with the violation rate on I-5. Perhaps the lack of severe congestion on most days that violations were monitored along southbound I-5 (as evidenced by the generally high speeds measured by the data station at NE 175th Street) may have been responsible for the lack of relationship. In contrast, SR-520 was congested to some degree on most days, but no relationship was found between actual violations and those reported through HERO because of a lack of a sufficient number of HERO calls during the study period. A relationship may in fact exist between actual and reported (i.e., through HERO) violations, but there were not enough violations reported through HERO during the monitoring period to statistically prove the relationship.

SELECTION OF MONITORING LOCATIONS

A primary consideration in the selection of monitoring locations was that the data collection be located near data stations. These stations collect information such as traffic volume, speed, and lane occupancy for all lanes of traffic. WSDOT has installed a number

of these along all the major freeways in the region. The ideal monitoring site would be positioned so that there were no entrances or exits between the monitoring site and the data station. The use of data stations to collect traffic volume data reduces the amount of data that would otherwise have to be collected by either human observers or photographic equipment.

Other factors besides proximity to a data station were also considered when monitoring sites were selected. These criteria included the following:

- the interior of the vehicle must be visible to monitoring personnel and/or photographic equipment;
- the monitoring locations need to be located in areas where the safety of monitoring personnel will not compromised (e.g., narrow shoulders); and
- the locations need to be fairly well lit.

All of the above monitoring site selection criteria can also be used to select possible photographic monitoring sites. Photographic equipment was not used in this study, due in part to its cost, which can be as much as $70,000, depending on the equipment used. However, people around the United States reported having used or that they were using photographic equipment to monitor traffic (but not necessarily the violation rate). The results of these contacts are given in the Literature Review, in Appendix A.

The initial list of all possible monitoring locations consisted of sites along three major HOV facilities (I-5, I-405, and SR-520) that were located adjacent to data stations. Each of these sites was then screened to find sites near each data station. Videotapes of all state and interstate roads, which WSDOT makes every two years, were used for this initial screening. These films were helpful in locating the exact location of each data station and also allowed for the quick selection of data stations that were located near possible monitoring locations (e.g., locations that had wide shoulders or over-crossings).

Each of the remaining possible monitoring sites was then visited to discover whether the occupancy of vehicles traveling in the HOV lane could be determined from the

site. It was initially hoped that over-crossings would make acceptable monitoring locations because they are usually fairly accessible and safe. However, most over-crossings were too high to allow observers to clearly see into the back seats of passing vehicles. Instead, a good vantage point from which to determine occupancy was found to be slightly above and in front of the vehicles, at an angle of about 45° measured from the long axis of the vehicle. Raised embankments to the right of passing traffic were found to provide the best vantage points.

Figure 3.1 shows the locations of the three monitoring locations used for this project. Two of the sites, the SR-520 site and one of the I-5 sites, were located on the right-hand, outside shoulder. The SR-520 monitoring location was especially good, since the HOV lane on that road was located on the furthest outside lane. The data collector at that site sat fairly far up on the embankment, so few motorists were aware of him.

The other site monitored from the outside shoulder was located on I-5 at 145th Street. While this monitoring location did provide a fairly good view into passing HOV vehicles, this site was not as ideal as the one on SR-520, since the HOV lanes on I-5 were located in the inside lanes. Observers were therefore separated from the HOV lane by three general purpose lanes. Nonetheless, the data collector was usually able to determine the occupancy of vehicles in the HOV lane unless a truck or other large vehicle in the general purpose lanes obscured his/her view.

The third site, on I-5 at 175th Street, was located on the inside shoulder. The observer was therefore very close to the HOV lane but also had very little time to determine each vehicle's occupancy. This site was chosen because no suitable outside shoulder locations were found along that stretch of I-5.

VIOLATION AND COMPLIANCE RATE RESULTS

As stated previously, the collectors gathered data at the three monitoring locations with portable computers. After being down-loaded into IBM compatible microcomputers,

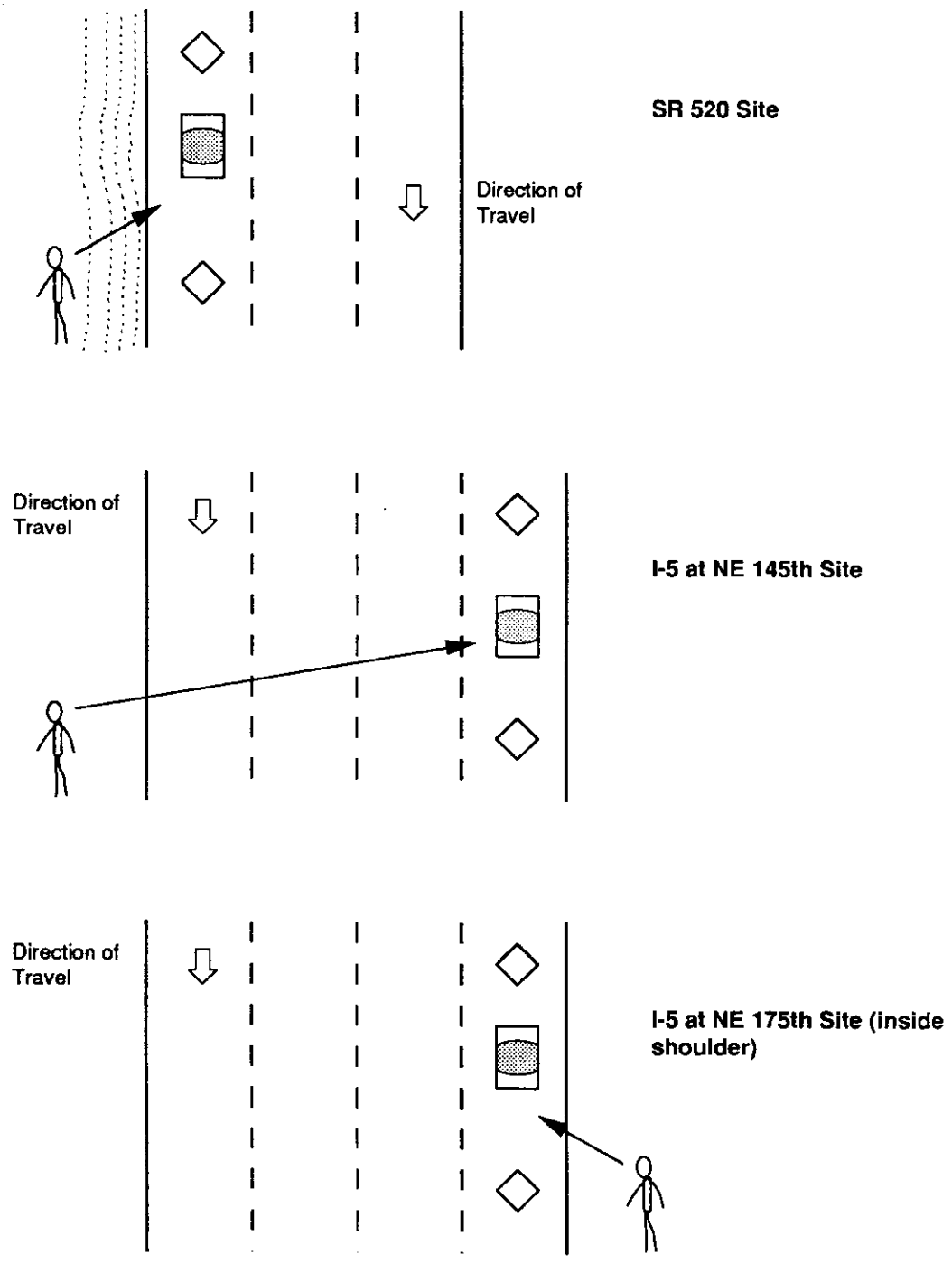


Figure 3.1. Observer Locations for HOV Lane Monitoring

the data were aggregated into 15-minute time periods. The violation rate was determined for each 15-minute interval and for each hour-long monitoring period. The minimum and maximum violation rates for each interval and monitoring period were also calculated. The formulae used to obtain the minimum and maximum violation rates for HOV lanes with 3+ minimum occupancy requirements are given below:

$$\text{Min. Viol. Rate} = \frac{\text{\# of SOVs + \# of 2-pers. carpools}}{\text{total volume in the HOV lane}} \quad \text{(Equation 3.1)}$$

$$\text{Max. Viol. Rate} = \frac{\text{\# of SOVs + \# of 2-pers. carpools + \# of "misses"}}{\text{total volume in the HOV lane}} \quad \text{(Equation 3.2)}$$

The "misses" included in the formula for the maximum violation rate are those vehicles whose occupancies the data collectors could not determine because of tinted or small side windows. The presence of large trucks or buses in the general purpose lanes also sometimes blocked the observers' view of the HOV lane. The "true" violation rate lay somewhere between the minimum and the maximum violation rate.

Violation Rates at Each Site by Interval

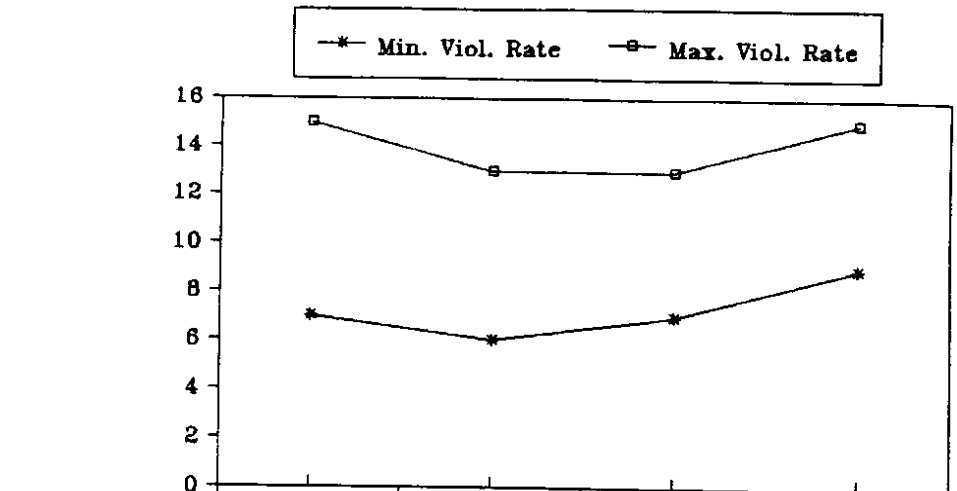
Table 3.1 shows the minimum and maximum violation rates for each of the monitoring sites. The complete results of the monitoring effort are given in Appendix E. The violation rates varied somewhat among the four 15-minute intervals and among the three sites. Figures 3.2 through 3.4 graphically present the mean, minimum, and maximum violation rates at each monitoring location for each 15-minute interval during the peak hour. The highest violation rate at each site occurred between 7:30 and 7:45 a.m. This result seems intuitively correct because one would expect people to be more likely to violate the HOV lanes as congestion, measured by decreased speed and increased lane occupancy, increased.

The fact that the second highest violation rate at all three sites occurred between 6:45 and 7:00 a.m. is more surprising. However, an examination of the number of violations that occurred during each interval revealed that the mean number of violations

Table 3.1 - MINIMUM & MAXIMUM VIOLATION RATES AT EACH MONITORING LOCATION

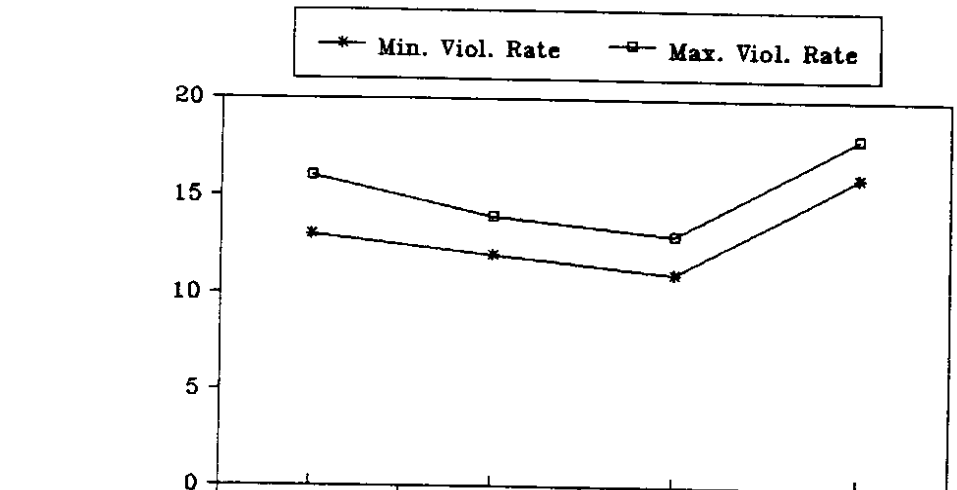
MONITORING LOCATION	6:45-7:00	7:00-7:15	7:15-7:30	7:30-7:45	ENTIRE PERIOD
WB SR-520	7.06[a] 10.51[b]	3.80 9.56	4.40 9.63	5.32 12.44	5.01 10.69
I-5 / 145TH	6.71 14.89	6.37 12.74	6.93 13.38	9.19 15.28	7.26 14.33
I-5 / 175TH	13.00 16.44	12.23 14.29	11.19 13.46	16.23 18.14	13.01 15.29

[a] minimum
[b] maximum



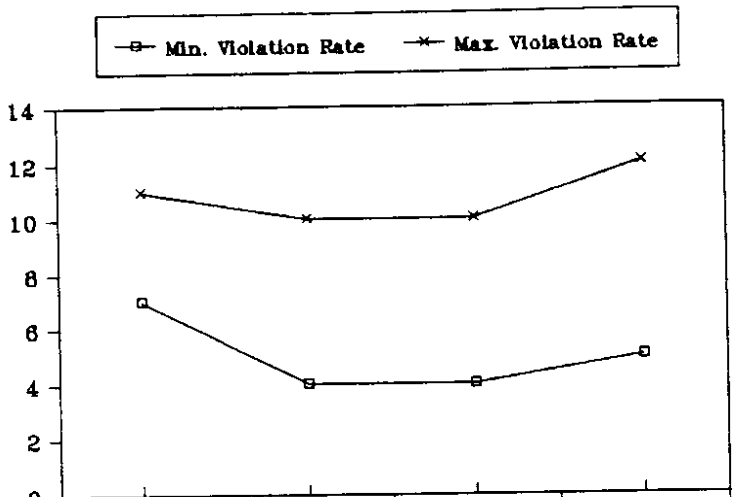
	6:45–7:00	7:00–7:15	7:15–7:30	7:30–7:45
Min. Viol. Rate	7	6	7	9
Max. Viol. Rate	15	13	13	15

Figure 3.2. Min and Max Violation Rates During the AM Peak Hour on SB I-5 at NE 145th Street



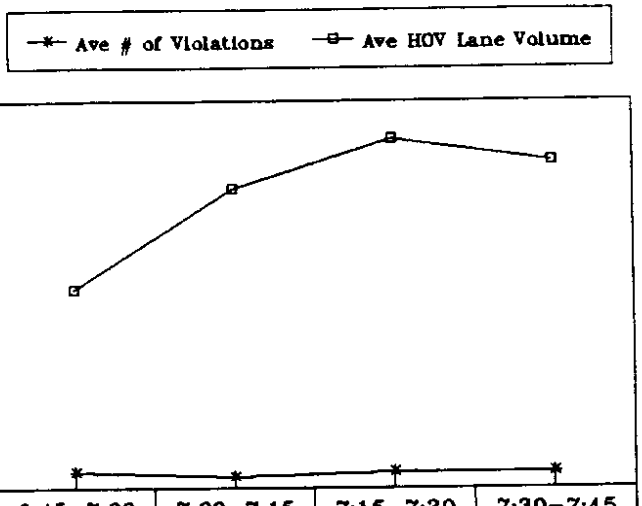
	6:45–7:00	7:00–7:15	7:15–7:30	7:30–7:45
Min. Viol. Rate	13	12	11	16
Max. Viol. Rate	16	14	13	18

Figure 3.3. Min and Max Violation Rates During the AM Peak Hour on SB I-5 at NE 175th Street



	6:45–7:00	7:00–7:15	7:15–7:30	7:30–7:45
Min. Violation Rate	7	4	4	5
Max. Violation Rate	11	10	10	12

Figure 3.4. Min and Max Violation Rates During the AM Peak Hour on WB SR-520



	6:45–7:00	7:00–7:15	7:15–7:30	7:30–7:45
Ave # of Violations	3	2	3	3
Ave HOV Lane Volume	36	54	63	59

Figure 3.5. HOV Lane Volume and Number of Violations During the AM Peak Hour on SR-520

remained almost constant during the peak hour. Variations in HOV lane volumes during the four intervals were almost solely responsible for the fluctuations in the violation rate. This fact is depicted graphically in Figures 3.5, 3.6, and 3.7.

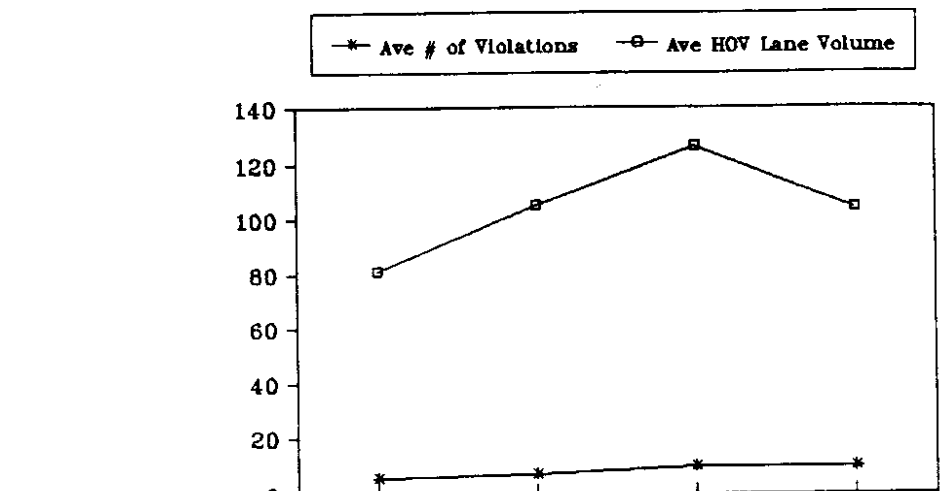
Comparison of Violation Rates at the Three Sites

It is interesting to compare the violation rates at the three monitoring locations (Table 3.1). Violation rates were lowest at the SR-520 site during all four intervals. The difference in the configurations of the HOV lanes may be responsible for the difference in the violation rates. Another factor that may account for the lower violation rates along SR-520 is that motorists using SR-520 can more easily associate the Washington State Patrol's (WSP's) enforcement with HOV lane violations. Troopers enforcing SR-520 are able to cite violators in refuge areas adjacent to the HOV lane, whereas troopers on I-5, where the HOV lane is located on the inside lane, often must escort violators across several lanes of traffic in order to write up tickets. Once the violator is parked on the outside shoulder, other motorists may not be able to determine why the violator was pulled over.

A statistically significant difference in the minimum violation rates was also found between the two monitoring sites on I-5 ($\alpha = .05$). The minimum violation rates were lower on average at the 145th Street site than at the 175th Street location (Figure 3.8). This difference was probably caused by the higher levels of congestion typically found at the northern I-5 site (i.e., at 175th). Much of this congestion was due to the construction of a new Metro bus storage facility south of the 175th Street site and north of the 145th Street site. Traffic speeds in the general lanes were generally higher at the 145th Street location, so motorists had less incentive for motorists to violate the HOV lane at this site.

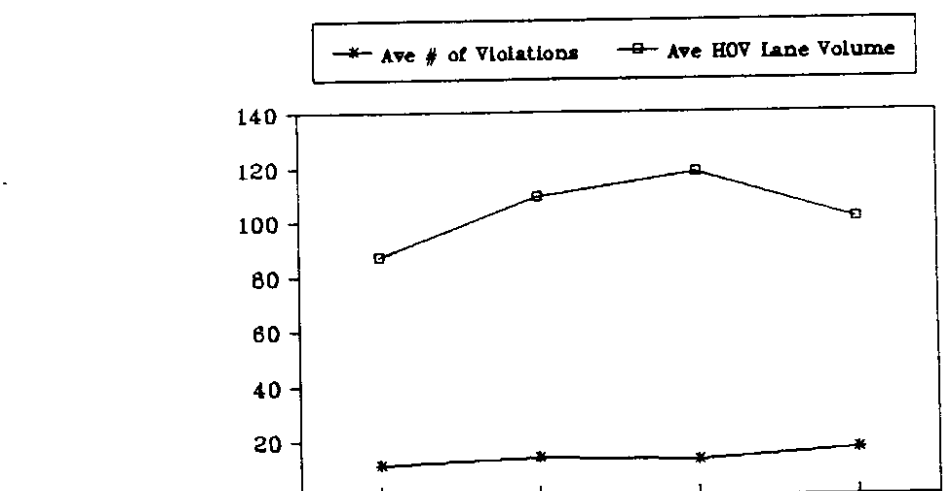
Interestingly, the *maximum* violation rates observed at the 175th Street site were not statistically different from those observed at the other I-5 location, although the rates were slightly higher at the former site (Figure 3.9).

This discovery pinpoints the fact that the measurement of the violation rate at the 145th Street site was less precise than that at the 175th Street location. The actual violation



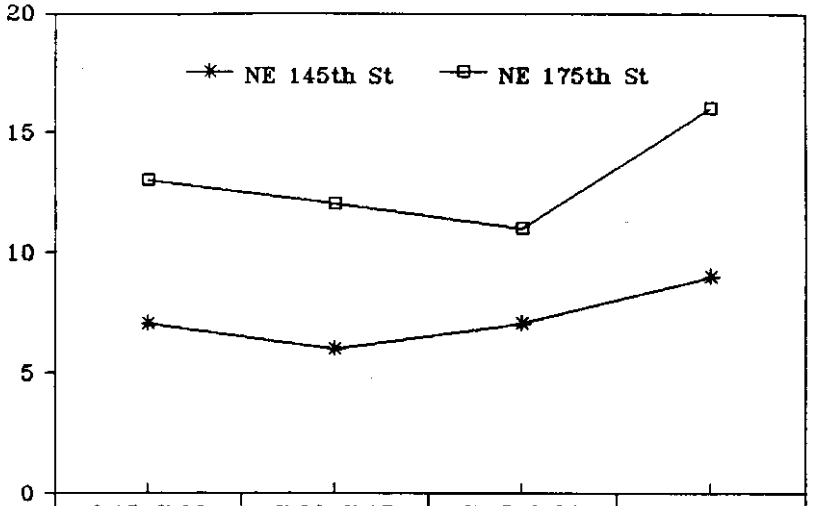
	6:45–7:00	7:00–7:15	7:15–7:30	7:30–7:45
Ave # of Violations	8	7	10	10
Ave HOV Lane Volume	81	105	126	104

Figure 3.6. HOV Lane Volume and Number of Violations During the AM Peak Hour on I-5 at NE 145th Street



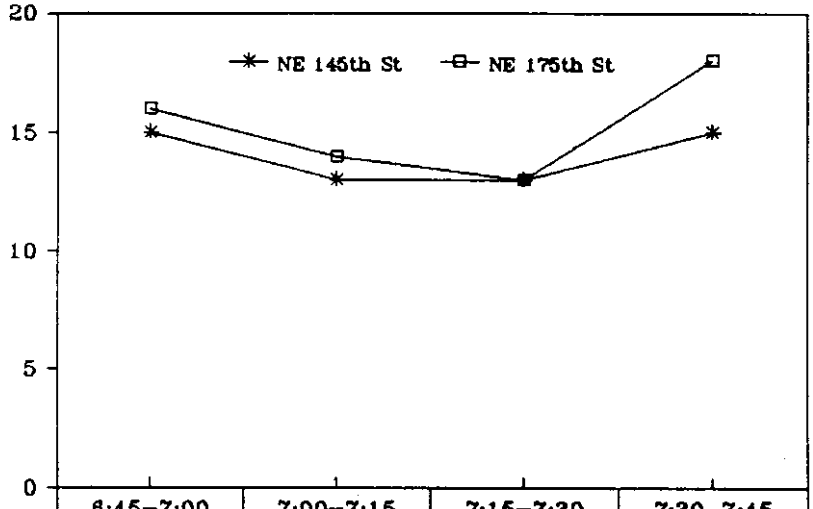
	6:45–7:00	7:00–7:15	7:15–7:30	7:30–7:45
Ave # of Violations	11	14	13	17
Ave HOV Lane Volume	87	109	118	101

Figure 3.7. HOV Lane Volume and Number of Violations During the AM Peak Hour n I-5 at NE 175th Street



	6:45–7:00	7:00–7:15	7:15–7:30	7:30–7:45
NE 145th St	7	6	7	9
NE 175th St	13	12	11	16

Figure 3.8. Minimum Violation Rates During the AM Peak Hour on I-5 at Both Sites



	6:45–7:00	7:00–7:15	7:15–7:30	7:30–7:45
NE 145th St	15	13	13	15
NE 175th St	16	14	13	18

Figure 3.9. Maximum Violation Rates During the AM Peak Hour on I-5 at Both Sites

rate lay somewhere between the minimum and the maximum violation rates (subject to the variability in the sample). This range was larger for the 145th Street monitoring site, possibly because of the observer's vantage point at that location (i.e., across three lanes of general purpose traffic). Thus there may have been no significant difference between the violation rates at the two sites.

THE RELATIONSHIP BETWEEN VIOLATIONS AND OTHER PARAMETERS

Initially it was hypothesized that a relationship might exist between the number of violations that occurred at a particular site and several other parameters. The parameters for which data were available from the data stations included the following:

- the occupancy in the adjacent general purpose lanes (lane occupancy is the percentage of the time in which a traffic loop detector is covered by vehicles in a given time period),
- the speed of traffic in the general purpose lanes, and
- the traffic volume in the general purpose lanes.

The HOV violation rate may also be related to the level of enforcement by the state patrol, but data on enforcement was unavailable.

Data from the data stations were available for only two of the three sites. Data on lane occupancy, speed, and traffic volumes were not available for the 145th Street site on I-5 because of a malfunctioning data station. At the other two sites, linear regression was used to test for a relationship between the minimum number of violations that occurred during each day of the three-week long monitoring period and each of the above parameters. Linear regression was used to test for the presence of a relationship between the number of HOV violations and the other variables because of the test's simplicity and because a preliminary examination of the raw data gave the researchers no reason to believe that the relationships between the variables were non-linear. The results of these analyses

are shown in Table 3.2. The numbers that are given in parentheses (α) are the probabilities that relationships that were said to exist did not in fact exist.

Only one statistically significant relationship (at the 94 percent confidence level) was uncovered: the number of violations that occurred on SR-520 was found to be weakly negatively related to the speed of traffic in the general purpose lanes. In other words, HOV lane violations tended to increase on SR-520 as the speed in the adjacent general purpose lanes decreased. This relationship is presented graphically in Figure 3.10.

Interestingly, no such relationship was found between violations and speed on I-5, perhaps because traffic speeds were generally high on I-5 during the three weeks that the sites were monitored. An examination of data obtained from the data station next to the 175th Street site revealed that during four of the monitoring periods, the speed recorded by the data station never fell below 50 mph. During four additional monitoring periods, speeds of 50 mph were recorded for at least half of the hour-long monitoring period. In contrast, 50 mph speeds were recorded on SR-520 on only one day during the monitoring effort. The fact that traffic speeds on I-5 were generally high, indicating a lack of significant congestion, may have been responsible for the inability to find a relationship between speed and HOV violations on that facility. Incentives to violate the HOV lane do not exist when traffic speeds in the general purpose lanes are high.

TABLE 3.2 - THE EXISTENCE OF RELATIONSHIPS BETWEEN VIOLATIONS AND OTHER PARAMETERS DURING HOUR-LONG MONITORING PERIODS (N= 14)

VARIABLES	SR-520	I-5 AT NE 175TH
No. of Violations versus Occupancy	no relationship (α = .24)	no relationship (α =.77)
No. of Violations versus Speed	negaitvely related (α = .06)[a]	no relationship (α =.98)
No. of Violations versus Volume	no relationship (α = .82)	no relationship (α =.83)

[a] R^2 = .21

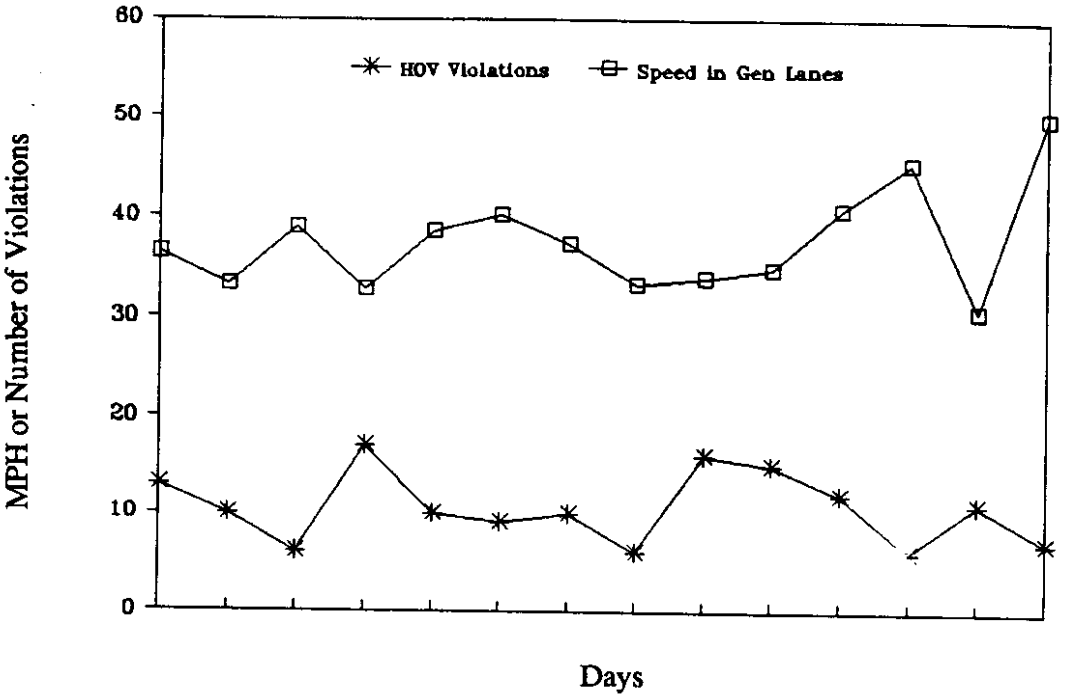


Figure 3.10. HOV Lane Violations and the Average Speed in the General Lanes on SR-520 Plotted for Each Day

TABLE 3.3 - THE RELATIONSHIP BETWEEN HOV LANE VIOLATIONS AND OTHER PARAMETERS DURING 15-MINUTE MONITORING PERIODS

VARIABLES	SR-520	I-5 AT NE 175TH
Nbr. violations versus occupancy	not significantly related	positvely related[a] $R^2 = .08$ $\alpha = .03$
Nbr. violations versus speed	negatively related[b] $R^2 = .05$, $\alpha = .07$	negatively related[c] $R^2 = .12$, $\alpha = .07$

[a] occupancies lower than 40 percent included, n = 51
[b] all speeds included, n = 51
[c] speeds lower than 45 mph included, n = 20

Therefore, to determine whether a relationship between HOV lane violations and the other parameters existed on I-5 when the general purpose lanes were congested (i.e., they had low speeds and high lane occupancies), data on general purpose lane occupancy and speed and HOV lane violations were disaggregated into 15-minute periods, rather than hour-long intervals, and periods in which congestion was not present were excluded from

the sample. Linear regression was then used to test for the existence of any relationships between violations and the other parameters. The results are shown in Table 3.3.

All but one of the four relationships tested was found to be statistically significant (at the 93 percent confidence level). However, the relationships found were fairly weak, as evidenced by the low R^2 values. The R^2 value gives the percentage of the variation in the dependent variable (HOV lane violations) explained by the independent variable (either speed or occupancy).

On I-5, HOV violations were related to traffic speed in the general purpose lanes when the speed was lower than 45 mph. When data points with speeds above this level were included in the sample, no significant relationship was found, probably because there was little incentive for motorists to violate the HOV lanes when traffic in the general purpose lanes was not moving much slower than that in the HOV lane.

HOV violations on I-5 were also found to be related to the occupancy in the general purpose lanes; as lane occupancy increased, the number of violations also tended to increase. However, this relationship only existed when the four observations with occupancies above 40 percent were excluded from the sample. These four observations were excluded (all of them occurred on the same day) because traffic conditions were atypical that day; a three-car accident occurred just upstream of the monitoring site during the hour that the lanes were being monitored.

THE RELATIONSHIP BETWEEN HERO AND OTHER PARAMETERS

One of the primary purposes of the monitoring effort was to determine the parameters that influence the number of violations reported through the HERO hotline program. In particular, it was hoped that a correlation could be established between the number of violations recorded at a specific site and the number of violations reported through the hotline for that site during a specified time period. However, it was felt that

other factors, such as the speed, volume, and occupancy in the general purpose lanes, might also influence the violations reported through the HERO program.

Simple linear regression methods were used to test for the existence of any relationships between the number of HERO calls received and the other four parameters. Data on HERO violations reported during the monitoring period were obtained from Metro staff, who operate the hotline program.

The HERO database, developed as part of this project, was fully operational by the time the violation monitoring effort occurred. Therefore, Metro staff were easily able to obtain data on the number of violations reported on each of the two HOV facilities (i.e., southbound I-5 and westbound SR-520) during the days and times the lanes were monitored. No differentiation was made between the two I-5 sites because many of the callers who reported violations did not specify the location on I-5 at which the violation occurred.

An analysis of the phone calls regarding violations that occurred at the same time that I-5 and SR-520 were being monitored revealed that very few violations were reported for the exact times and dates of the monitoring period (i.e., March 22 through April 11, 1989, between 6:45 and 7:45 a.m.). In fact, only six violations were reported on southbound I-5 and only three were reported for westbound SR-520.

Because so few violations were reported between 6:45 and 7:45 a.m. during the monitoring period, all reported HOV violations that occurred on southbound I-5 and westbound SR-520 between 5:30 and 9:30 a.m. were examined. Table 3.4 gives the number of violations reported through HERO for each of the two HOV facilities.

Significantly more I-5 HOV violations were reported for the longer time period than for the times the lane was actually monitored. However, only four HOV violations were reported for SR-520 during the longer time period. Therefore, the relationship between HERO calls and other parameters could only be examined for I-5. Table 3.5 gives the results of the linear regression analysis of these variables.

TABLE 3.4 - HERO CALLS RECEIVED BETWEEN 5:30 AND 9:30 A.M.

	NUMBER OF CALLS FOR EACH ROUTE	
DATE	I-5 AT 175TH	SR-520
3/22	2	0
3/23	0	0
3/27	9	0
3/28	2	0
3/29	2	0
3/30	3	1
3/31	10	0
4/03	0	0
4/04	2	1
4/05	3	1
4/06	6	1
4/07	2	0
4/10	3	0
4/11	2	0

TABLE 3.5 - THE EXISTENCE OF RELATIONSHIPS BETWEEN HERO CALLS AND OTHER PARAMETERS (N=14)

VARIABLES	REALTIONSHIP EXISTS?	ADJ. R^2	α
HERO CALLS[1] VS OCCUPANCY [2]	yes (positive)	0.264	0.035
HERO CALLS VS SPEED[2] @ 175TH	yes (negative)	0.551	0.001
HERO CALLS VS VOLUME[2] @ 175TH	yes (negative)	0.480	0.004
HERO CALLS VS # VIOLATIONS[3] @ 175TH	no	NA	0.750
HERO CALLS VS # VIOLATIONS[3] @ 145TH	no	NA	0.338

[1] between 5:30 and 9:30 a.m.
[2] between 6:00 and 9:30 a.m.
[3] between 6:45 and 7:45 a.m.

As Table 3.5 shows, the number of HOV violations reported on southbound I-5 was fairly strongly related to both the speed (Figure 3.11) and the occupancy (Figure 3.12) in the general purpose lanes. In fact, congestion in the general purpose lanes, indicated by speed, explained approximately 55 percent (i.e., the adjusted R^2's for speed and occupancy) of the variation in the number of a.m. HERO calls received. This finding indicates that motorists became more inclined to report HOV violations as traffic congestion in the mixed-flow lanes increased.

The relationship between HOV violations reported and the volume in the general purpose lanes was less strong. This result seems intuitively correct, since traffic volume is not linearly related to congestion (as measured by speed or lane occupancy). Low volumes can be accompanied by *either* low or high traffic speeds. When volumes are low and traffic speeds are ***high***, one would expect few HOV violation reports on HERO for several reasons. First, fewer HOV violations probably occur when speeds in the mixed-flow lanes are high. Second, violations that do occur when mixed-flow speeds are high are probably less frustrating to non-violating motorists. However, low volumes accompanied by *low* speeds would be expected to have the opposite effect; motorists who saw someone violating the HOV lane might well become frustrated at the situation and report the violation on the HERO hotline.

The most disappointing result shown in Table 3.5 is the lack of a relationship between the violations reported through HERO and the number of HOV violations at either I-5 site. In Figure 3.13 both the observed (minimum) number of violations at I-5 at 175th Street and the number of violations reported through the HERO hotline are plotted. Figure 3.14 shows this information for the 145th Street site.

Although linear regression analysis did not reveal a correlation between HERO calls received and observed violations at either I-5 site, an examination of Figure 3.14 indicates that the number of violations reported through HERO seemed to follow the same general

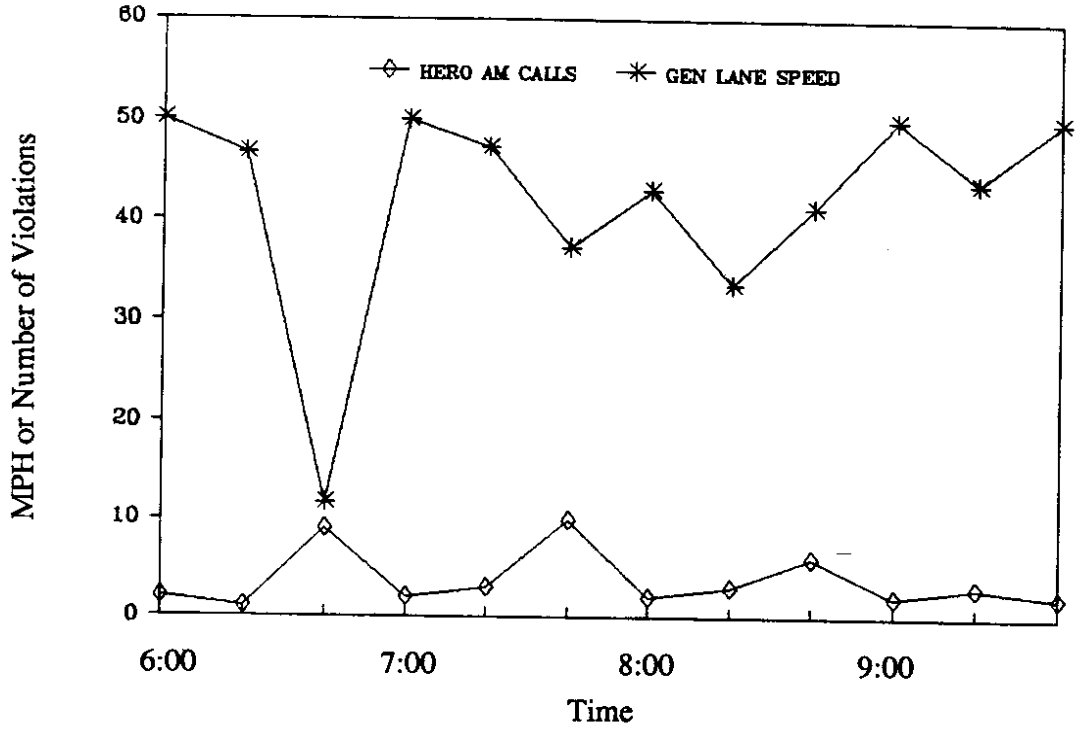


Figure 3.11. HERO Calls Received and Speed in the General Purpose Lanes During the AM Peak Period on I-5 at NE 175th Street

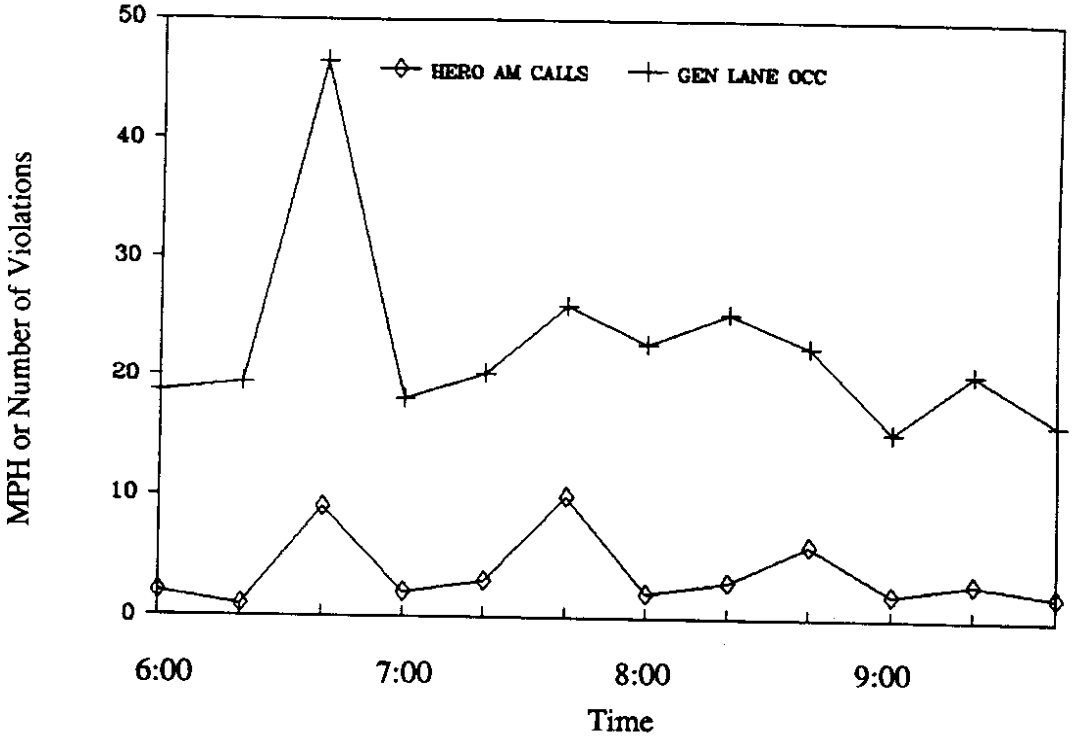


Figure 3.12. Hero Calls Received and Occupancy in the General Purpose Lanes During the AM Peak Period on I-5 at NE 175th Street

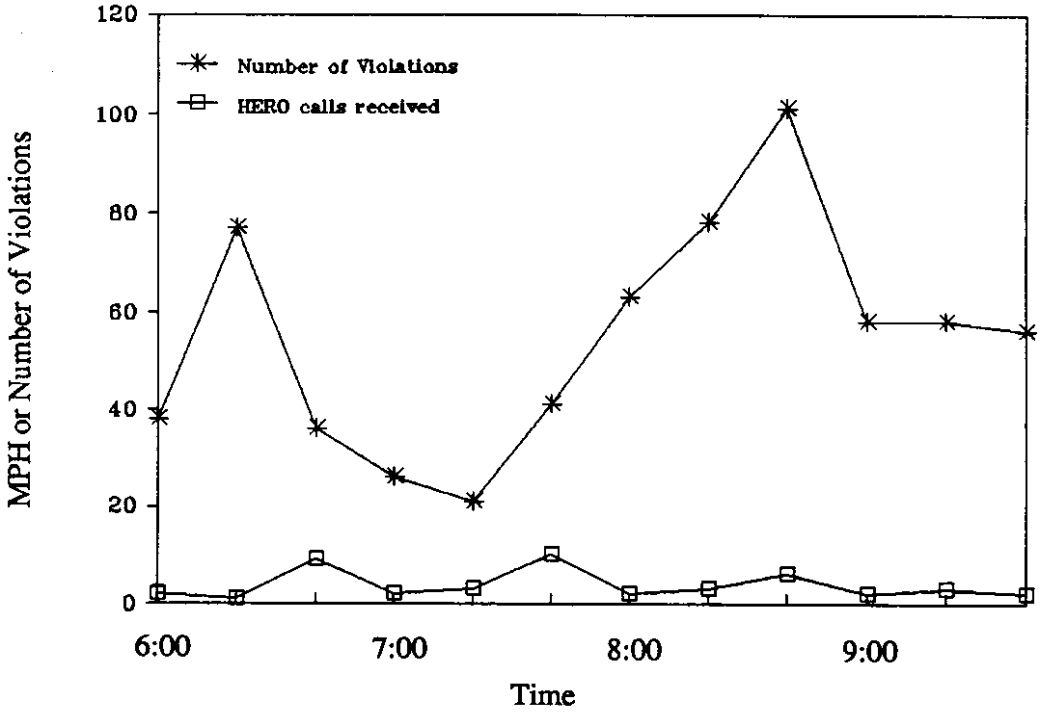


Figure 3.13. Hero Calls Received and Minimum HOV Violations During the AM Peak Period on I-5 at NE 175th

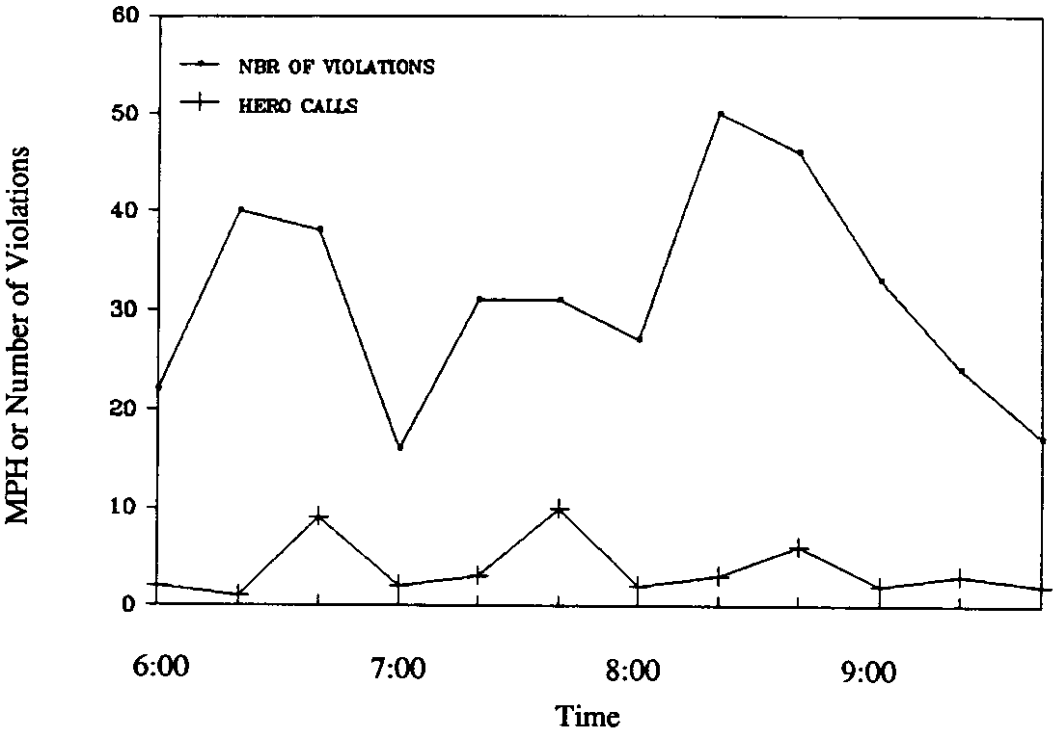


Figure 3.14. Hero Calls Received and Minimum HOV Violations During the AM Peak Period on I-5 at NE 145th Street

trend as the observed number of violations at 145th Street. This pattern does not seem to be present on Figure 3.13.

Several factors may have prevented the observation of any relationship between observed and reported violations. First, the HERO reports included all violations that occurred anywhere on southbound I-5 between the lane's origin at 236th Street Southwest and the entrance to the express lanes, at Northgate. However, these reports were compared to the violation rate at a single site. To control for this, the violation rates from both I-5 sites were averaged to form a mean violation rate for I-5. However, this averaged violation rate was not found to be significantly related to HERO calls received.

Another factor that may have affected the results of the analysis is the different time periods used for the two variables. The observed violation rates used in the analysis may have been inaccurate because only the peak hour rate was measured. If a peak period violation rate could have been obtained and compared with the HERO calls received, a relationship between the two might have been observed.

CONCLUSIONS

Although it was initially hoped that a relationship would exist between actual violations, as measured by observers, and reported violations, as obtained through HERO, this relationship could not demonstrated by this project, primarily because of lack of data. However, the number of violations observed on SR-520 during the monitoring effort was negatively related to speed in the general purpose lanes. At the same time, speed on I-5 was negatively related to the number of violations reported through HERO. These two findings imply that a relationship may exist between actual and reported violations. Such a relationship, if it exists, might be demonstrated if enough HOV violation data were collected.

CHAPTER FOUR

DEVELOPMENT OF AN HOV VIOLATION RATE DATABASE

This chapter will discuss the need for an HOV compliance database, the number of data necessary to determine statistically valid HOV violation rates, and a proposed HOV violation rate database that could help with continual monitoring of the violation rate on the area's HOV facilities.

SUMMARY OF KEY POINTS

The current methods of collecting and storing HOV violation rate data have a number of shortcomings:

- the lack of both a regularly scheduled HOV violation rate monitoring program and a procedure to compile the collected violation data,
- the storage of collected data in several locations, and
- the collection of an insufficient number of data to determine statistically valid HOV violation rates.

To overcome these shortcomings, a system should be established to regularly collect and report HOV violation data and to store the data in a format that will allow long-term trends in HOV violation rates to be traced over time. Sufficient data should be collected to establish statistically valid HOV violation rates on a quarterly basis. The determination of annual violation rates requires fewer data than the determination of monthly or quarterly rates, but changes in the violation rate within a given year could not be observed. Conversely, changes in the violation rate could be more closely monitored if sufficient data to determine monthly violation rates were collected, but the large number of data required to determine monthly violation rates would be difficult to collect.

The most cost-efficient means of obtaining the data needed to determine quarterly HOV violation rates would be to use data collected for another project designed to determine average vehicle occupancy. The auto occupancy project will begin collecting

data in July 1989. The number of data that the auto occupancy project will collect (at least 30 one-half hour monitoring sessions per quarter at each HOV monitoring location) will be sufficient to guarantee statistically valid quarterly violation rates.

A Lotus 1-2-3 spreadsheet program was developed to calculate the violation rate for each individual monitoring session, as well as the quarterly and annual violation rates. The spreadsheet program is both easy to use and also allows users to graph individual and quarterly violation rates.

The HOV violation rate data and database should be stored where the information is accessible to all who may need it. The Transportation Planning Office, located at WSDOT's headquarters in Olympia, may be the best place to house the database, both because that office will also be responsible for compiling data for the auto occupancy project and because that office would be able to collect information on future HOV facilities that might be constructed outside the Seattle area.

NEED FOR AN HOV VIOLATION RATE DATABASE

The ability to monitor the violation rates on the area's HOV facilities would be useful to WSDOT and other agencies for the following reasons:

- HOV violation data could be used to evaluate the continuing effectiveness of the HOV lanes;
- HOV violation rates could be used in marketing and public education programs; and
- with the ability to monitor the HOV lanes on an ongoing basis, WSDOT and WSP would be able to pinpoint HOV facilities that needed additional enforcement.

A number of difficulties are associated with using the data currently available to examine trends in HOV violation rates over time. First, WSDOT does not regularly monitor the violation rate on any of the area's HOV facilities, although WSDOT traffic

monitoring crews do occasionally collect auto occupancy and HOV violation data, especially on the I-5 HOV lanes. In general, HOV violation rates are monitored only as part of larger studies attempting to evaluate the effectiveness of a given HOV facility. The HOV lanes on I-5 are perhaps monitored more frequently than are other HOV lanes. However, even on this facility the violation rates are examined only every two or three years, and little attempt has been made to track the violation rate on this facility over the course of several years.

In addition, unless the data are being collected as part of a specific study, enough data to determine a statistically valid violation rate are not always available. In other words, HOV violation data must be collected on at least several different days in a month at a given location to ensure that the data collected are truly representative of that facility's monthly violation rate. In the past, personnel limitations have often prevented the collection of a sufficient number of data to determine a statistically valid violation rate.

Furthermore, no system currently exists to gather data that are collected in a single location so that changes in the violation rate can be observed over time. Several factors contribute to this problem. First, several groups within WSDOT may collect data for different purposes. Therefore, the data may be stored in several locations. Second, the primary responsibility of the group that collects most of the HOV violation data is the collection of data, not the interpretation of the collected data. In fact, since the group is also responsible for many of the region's other data collection needs, the group simply does not have the time or personnel necessary to interpret all the data it collects.

To overcome the problems just discussed, a system should be established to regularly collect HOV violation data and store these data in a format that will allow any long-term trends in HOV violation rates to be traced over time. The remainder of this chapter comprises a description of such a system.

DATA COLLECTION PLAN

The two most important elements of any HOV violation data collection effort are as follows:

- the HOV lanes should be monitored on a regular basis and not just as part of a larger project whose focus may be on other factors; and
- the HOV lanes should be monitored often enough so that a statistically valid determination of the violation rate can be made for a given time period (e.g., a month, quarter, or year).

Selection of a Time Period

An appropriate time period must be selected to determine the number of data that should be collected. In other words, more data are required to determine the monthly HOV violation rate at a given location than are needed to establish the quarterly violation rate. Even fewer data are necessary to determine the annual violation rate.

However, balanced against these data requirements is the usefulness of the data obtained in each case. For example, while relatively few observations are needed to determine the annual HOV violation rate at a given location, variations in the violation rate that might occur within the year would be masked. Determining the monthly HOV violation rate might be a better way to uncover these variations, but the number of data required would be unreasonable (as high as 25 observations per month might be necessary, depending on the facility). Therefore, collecting enough data to determine a statistically valid quarterly violation rate for the major HOV facilities might be a good compromise between the two levels of effort. The number of data required to determine the quarterly HOV violation rate would not be unreasonable, and variations in the violation rate within each year could still be traced.

Data Collection Methods

HOV violation data can be collected by a number of methods. Usually, human observers collect data with either manual traffic counters, portable computers, paper and pencils, or tape recorders. However, several problems are associated with the use of human observers. Data collection is a tedious task, so sometimes agencies have trouble finding enough people willing to do the job. This method is also relatively expensive. In addition, the use of human observers to collect data usually takes large amounts of time (i.e., to drive to and from the monitoring location, to collect the data, and to process the data).

Because of the difficulties associated with the use of humans to collect data, one of the aims of this project was to examine the feasibility of obtaining HOV violation data by means other than human observers. Two alternative ways of collecting HOV violation data were explored: photographic equipment and the HERO program. After examining these alternative methods, the researchers decided that human observers still represent the best method of collecting HOV violation data. The reasons the other methods were not chosen are outlined below.

Photographic Equipment. Several types of photographic equipment showed promise for determining vehicle occupancy (and thus determining the violation rate): closed circuit television (CCTV), video cameras, and still photography.

Initially, the use of CCTV to monitor the HOV lanes seemed the most promising of the three types of photographic monitoring methods examined. WSDOT has approximately 40 CCTV cameras permanently mounted above freeways in the Puget Sound area. The cameras monitor traffic flow on area roads. Almost half of the cameras are located adjacent to HOV lanes. Unfortunately, no CCTV cameras are located adjacent to the SR-405 or SR-520 HOV lanes; only the I-5 HOV lanes can be viewed through CCTV, although WSDOT has plans to install cameras on the other two routes.

A more serious drawback is that the insides of passing vehicles cannot be seen from the monitors. Even if more powerful lenses were installed on the cameras, the cameras would probably not be able to obtain a clear view of the back seats of vehicles because of the heights at which the cameras are mounted. In addition, the installation of more powerful lenses on the CCTV cameras would prevent them from being used for the purpose for which they were originally installed: to survey the freeway for congestion. This finding ruled out the use of CCTV, since the back seats of passing vehicles must be seen to ascertain the violation rate on HOV lanes with 3+ occupancy requirements. For 2+ HOV facilities CCTV could be adapted for remote HOV monitoring, although additional cameras would be needed to monitor both HOV use and general freeway operation simultaneously.

The use of video cameras to monitor HOV violation rates was also considered. The team discovered through conversations with personnel from different agencies across the United States that video cameras are currently being used in several areas to monitor HOV lanes. As was the case with CCTV technology, video cameras are sometimes not able to clearly film the back seats of vehicles. When passing vehicles are filmed from the passenger side (i.e., the right-hand side of the vehicles), most vehicles' occupancies cannot be determined because of their speed. On the other hand, when the camera is placed in front of passing vehicles, the back seat occupancy cannot usually be determined. Recent work with a set of three cameras and sophisticated VCR playback equipment was demonstrated at TRB. This new design reduces much of the error but at increased equipment and staff costs.

Still photography was the third photographic method considered. As discussed in Appendix A, this technology is currently being used in several areas of the country for a variety of traffic monitoring purposes. However the use of still photography to monitor HOV lanes presents several problems. One problem is associated with the flash unit, the use of which would be necessary during several months of the year. While infrared flash

units could illuminate passing vehicles without alarming their occupants, the units might become too hot to work toward the end of an hour-long monitoring session. Furthermore, the units might not be able to recharge quickly enough after each picture.

However, the most serious drawback to the use of still photography proved to be the expense of purchasing the equipment required. The price of the equipment was estimated to be between $40,000 and $72,000.

The HERO Program. The use of data collected through the HERO hotline to determine HOV lane violation rates was dependent on the discovery of a relationship between the number of violations reported through the hotline at a particular location and the observed violation rate at that location. As was described in Appendix E, no relationship between the two parameters was uncovered, although the number of calls received through HERO was found to be related to other parameters, such as the speed, lane occupancy, and volume in the general purpose lanes. Because a relationship between reported violations and actual violations could not be established, the HERO database is not recommended as an HOV monitoring tool.

The Use of Data Collected for Other Purposes

The three-person team that is currently responsible for collecting a wide range of traffic data for much of the region would probably be unable to meet the data collection needs of a long-term HOV violation data collection effort because requests for data collection already exceed their capabilities. However, the Puget Sound Council of Governments (PSCOG) and WSDOT will begin a joint, year-long auto occupancy data collection effort in July 1989. This project will monitor the average vehicle occupancy at many sites throughout the region; five of the sites will be on HOV facilities. Both directions of the I-405 and the I-5 HOV lanes will be monitored by the auto occupancy group, as will the HOV lane on westbound SR-520. The exact locations from which data will be collected have not yet been determined, although two of the sites are near N.E.

145th Street on I-5 and near 92nd Avenue N.E. on SR-520. (The interim I-90 HOV facility is not being monitored as part of this project.)

The goal of the auto occupancy monitoring project is to determine the auto occupancy on a number of the region's major roads. Each site will be monitored a number of times during each quarter, and each monitoring session will last half an hour. The monitoring sessions will not always occur at the same time during every session, but all sessions will take place within the peak period (i.e., 6-9 a.m. and 3-6 p.m.). The accuracy of the measured peak period auto occupancy will be somewhere between 1.1 and 1.7 percent at the 95 percent confidence level, based on quarterly data.

The number of observations necessary to yield the above accuracy depends upon the traffic volume at each site. On the basis of the average volume in the HOV lane during the peak hour, the auto occupancy project team estimates that it will have to monitor the HOV sites between 30 and 40 times each quarter.

The data obtained from the auto occupancy monitoring project can easily be used to determine the HOV violation rate for those HOV sites that are included in the auto occupancy project. However, to ensure that the data obtained from the auto occupancy project will yield HOV violation rates that are statistically valid on a quarterly basis, the sample size necessary to yield the desired level of accuracy (at the 95 percent confidence level) must be determined. Conversations with WSDOT personnel have led to the conclusion that an accuracy of about 2 percent is acceptable (e.g., if the violation rate were measured as 10 percent, the true violation rate would be between 8 and 12 percent).

The number of monitoring sessions necessary to achieve this 2 percent accuracy was found to be about 10 sessions for SR-520 and 25 sessions for I-5. Since the auto occupancy team estimates it will monitor these facilities at least 30 times a quarter, the data yielded by the auto occupancy monitoring effort should provide statistically valid quarterly HOV violation rates.

Several statistical tests were performed (the results are shown in Appendix D) to ascertain that the auto occupancy data can also be used to determine the quarterly HOV violation rate. Because auto occupancy data collection will only take place during 30 minutes of the peak period, it was necessary to determine whether 30 minutes of data collection could be used to represent the normal peak period conditions. To test this theory for both SR-520 and I-5 (at the N.E. 175th Street site), the project team decided to determine whether a difference existed between the average violation rate during the first half-hour (i.e., 6:45 to 7:15 a.m.) of this project's monitoring effort and the second half-hour.

For each of the two locations, the mean violation rate of the first period was compared to the mean violation rate of the second period. The means of the two periods were compared with a t-test to determine whether the difference was statistically significant. There was no statistical difference between the two means for either location (Appendix E).

The above finding implies that there are no significant differences between half-hour intervals within the peak period (i.e., 6 to 9 a.m.). However, additional HOV violation data should be collected to ascertain that the mean violation rate of other half-hour intervals within the peak period are not significantly different from the mean violation rate of the entire peak period.

Since no significant difference existed between the means of the two half-hour data collection periods for this project, the mean HOV violation rate (and its standard deviation) for the entire hour-long monitoring period can be used to estimate the true mean violation rate for the peak period. These data can then be used to determine the number of monitoring sessions necessary to achieve the desired level of accuracy.

Using the formulae outlined in Appendix E, the researchers determined that 25 half-hour monitoring sessions would be required on I-5 to determine the violation rate with an accuracy of $\pm$ 2 percent and that only 10 sessions would be necessary on SR-520 to achieve an accuracy of $\pm$ 1 percent. Greater accuracy with fewer observation can be

obtained on SR-520 than on I-5 because the number of HOV violations that occur on SR-520 varies much less from day to day than the number of violations that take place on I-5 (i.e., the standard deviation measured on SR-520 was much less than that measured on I-5).

STORAGE OF THE HOV VIOLATION DATA

The use of data obtained from the auto occupancy monitoring program to determine HOV violation rates eliminates much of the difficulty associated with obtaining sufficient personnel to regularly monitor the HOV facilities. However, procedures must be set up to ensure that HOV violation rates are extracted from the auto occupancy data and that the violation rates are stored in a manner that will allow changes in a given facility's violation rate over time to be easily traced.

The HOV Violation Rate Spreadsheet

HOV violation data could be stored in a number of ways. Perhaps the simplest way would be to store the data on paper, as is currently done. However, storing data on paper would not be practical if the data were collected with portable computers. Also, graphically tracing changes in the violation rate over time would be a time-consuming task if the data were stored on paper; either graphs would have to be drawn by hand or the information would have to be entered onto a microcomputer. A more efficient method of storing the data would therefore be to store the information directly on a microcomputer. Probably the most efficient method of storing and comparing the data over time is the use of a computer spreadsheet program, such as Lotus 1-2-3. This software package offers the twin advantages of being simple to use and having some graphics capability.

Therefore, the researchers designed a simple Lotus spreadsheet that can compute the violation rate for each given monitoring session from data the user inputs. For each given half-hour monitoring session, the user must input the number of single occupancy vehicles, the number of two-person carpools (if the minimum occupancy requirement is

two persons, this does not have to be input), and the total volume in the HOV lane. At the end of the quarter, the spreadsheet program also computes both the mean quarterly HOV violation rate and the standard deviation of this rate. The program is also able to graph both the violation rates within each quarter and the quarterly violation rates so that variations in the rate over time can be examined. A copy of the spreadsheet HOV violation rate program is shown in Appendix G.

Physical Location of the HOV Violation Data

Almost as important as the design of the database was the decision about where the data and the database should be physically located. As stated previously, HOV violation rate data are not currently stored in a single location, although the data collected by the three-person traffic data collection team, which collects much of the region's traffic data, are all stored together. However, the chief responsibility of this group is the collection of data, not the interpretation of the collected data. In the past, individuals and groups working on specific projects have interpreted the data. As this HOV violation rate monitoring effort is not aligned with any single project, it is important that the data be stored where they are accessible to all who may need them.

The data could be stored in any one of the three following locations:

- within the Transportation Planning Office at WSDOT's headquarters in Olympia,
- at the District 1 office, either within the Data Collection office or the Traffic Operations group, or
- at the Washington State Transportation Center (TRAC).

The most feasible location for the database is probably at the Transportation Planning Office in Olympia. This office will be responsible for analyzing the auto occupancy data. Storing the database at WSDOT's headquarters is also advantageous because data on HOV violations on HOV facilities across the state could be stored in one location, which would probably not be the case if the data were stored at the District 1

Office. Although almost all of the state's HOV facilities are located within District 1, additional HOV facilities may someday be constructed in other areas of the state.

CHAPTER FIVE

EVALUATION OF THE HERO HOTLINE PROGRAM

The HERO hotline program, conceived as a method of reducing the HOV violation rate without resorting to expensive special enforcement efforts, was first implemented in February 1984 by WSDOT, WSP, and Metro. Studies of the HOV violation rate conducted before and after HERO's implementation showed that the violation rate on the I-5 HOV lanes decreased by 33 percent (from 28.3 to 19.1 percent averaged over four mainline I-5 locations) after the hotline program had begun. This decrease was attributed to the existence of the HERO program. Because the program's implementation had been coordinated with an extensive public information campaign, the public was well aware of the new program, and this awareness presumably discouraged people from violating the HOV lanes. Because of the reduction in violation rates, the HERO hotline program was judged to be successful.

The HERO program has not been evaluated since the publication of the first study. Such an evaluation is necessary both to examine the long-term effects of the HERO program and to justify continued expenditure on the program. Therefore, the HERO hotline program will be evaluated in this chapter from the results of the public opinion survey, the three-week-long monitoring effort, and an examination of historical violation data.

LONG-TERM TRENDS IN VIOLATION RATES

Since 1984, violation rates on the HOV lanes, which are posted with HERO hotline signs, have not been regularly monitored to determine whether HOV violation rates have remained low. If violation rates have remained low, the argument might be made that the HERO hotline is still effective in preventing an increase in the violation rate, despite no marketing of the hotline since 1984 and a general increase in traffic congestion.

Although HOV violation data have not been regularly collected with the specific intent of monitoring HOV violation rates, some data were collected for southbound I-5 as part of other studies.* These data can be used to determine general trends in the HOV violation rate and represent one way in which the HERO hotline program can be evaluated. Table 5.1 shows the available data on HOV violation rates for southbound I-5 at N.E. 175th Street.

The data available are extremely sketchy, but the violation rate on I-5 at N.E. 175th seems to have remained fairly constant over time. The violation rate was significantly lower after HERO's implementation (8.5 percent) than it was just before HERO was implemented (17.3 percent), but it was back up to 15 percent by May 1987. The maximum violation rate (15.3 percent) obtained through the data collection effort associated with this project was not significantly lower than the May 1987 violation rate. However, the minimum violation rate (13.0 percent) obtained through this project's data collection effort does appear to be significantly lower than the May 1987 violation rate. Because the actual violation rate is probably lower than 15.3 percent but higher than 13.0 percent, the HOV violation rate during March and April 1989 is probably slightly lower than it was during May 1987.

TABLE 5.1 - HOV VIOLATION RATES FOR SOUTHBOUND I-5 AT N.E. 175TH STREET (6:45 to 7:45 a.m.)

DATE	VIOLATION RATE (%)
9/83 - 1/84[a]	17.3
2/84 - 6/84[b]	8.5
5/87	15.0
3/89 - 4/89[c]	13.0 (min) 15.3 (max)

[a] data collected before HERO's implementation
[b] data collected after HERO's implementation
[c] data collected as part of this project

*No data on historic violation rates on SR-520 were available.

From these results, it cannot be determined whether the effect of the HERO hotline on the violation rate was permanent. The dramatic improvement in the violation rate that occurred just after the hotline program was implemented was probably a result of the relative "newness" of the program and of the intense marketing effort that occurred during the implementation process. After people became accustomed to the idea of the hotline and the marketing campaign ceased, the violation rate climbed almost to the level it had been before the hotline had been introduced.

The difference between the violation rates measured in March and April 1987 (15.3 percent) and those measured before the hotline's implementation (17.3 percent) may or may not be significant. The significance of the difference could not be tested because the original data used to determine the before HERO violation rate were not available.

In any event, the fact that the recently measured HOV violation rate is lower than the rate measured before HERO's introduction does not necessarily mean that the presence of the hotline has kept the violation rate lower than it would otherwise have been. If the HOV violation rate measured as part of this project is in fact significantly lower than the "pre-HERO" violation rate, factors other than HERO may have been responsible for the decrease. Factors such as a decrease in traffic congestion or increased enforcement by WSP may also account for the decrease.

Sufficient data were not available to determine whether traffic congestion has decreased or enforcement has increased. However, WSDOT personnel felt that traffic congestion during the a.m. peak hour has not decreased since 1983, and there were no special enforcement efforts during the data collection effort. Therefore, it is possible that the presence of HERO has kept the violation rate lower than it would otherwise have been, but this project could neither prove nor disprove this hypothesis.

The introduction of another marketing campaign may succeed in decreasing the violation rate once more. However, the fact that the violation rate did not remain low several years after the 1984 HERO marketing campaign indicates that a single, one-time

marketing and education campaign about HERO will not permanently reduce the violation rate. Therefore, a more effective way of maintaining the public's awareness of the hotline program and possibly keeping the violation rate low may be to market the lanes regularly (e.g., once every few years).

DATA COLLECTED THROUGH THE HERO HOTLINE

Several kinds of information obtained from the HERO database itself can be used to help evaluate the HERO hotline program. These are the number of violations reported through the hotline and the completeness of the information obtained from the hotline. This information is evaluated below.

Number of HERO Calls Received

A comparison was made between the number of weekly violations reported through HERO in 1984 and those reported in late 1988 and early 1989. This comparison was made to determine whether usage of the hotline has declined since its introduction in 1984. The number of weekly violations reported through HERO in 1984 and 1988/1989 are plotted on Figures 5.1 and 5.2, respectively.

Figure 5.1 shows that, while a large number of violations were reported by the public during the first few weeks after the hotline was introduced, the number of violations reported after about June 1984 was generally between 100 and 200 calls per week. As Figure 5.2 shows, the number of HERO calls received per week between November 1988 and April 1989 was also usually between 100 and 200 calls per week. Most of the weeks when fewer than 100 calls were received took place during the Thanksgiving or Christmas holidays. Therefore, the number of violations reported through the hotline appears to have decreased initially (i.e., until approximately June 1984) but to have remained fairly constant after those two time periods.

However, several facts should be kept in mind during an examination of Figures 5.1 and 5.2. First, data on the violations reported through HERO for the years between

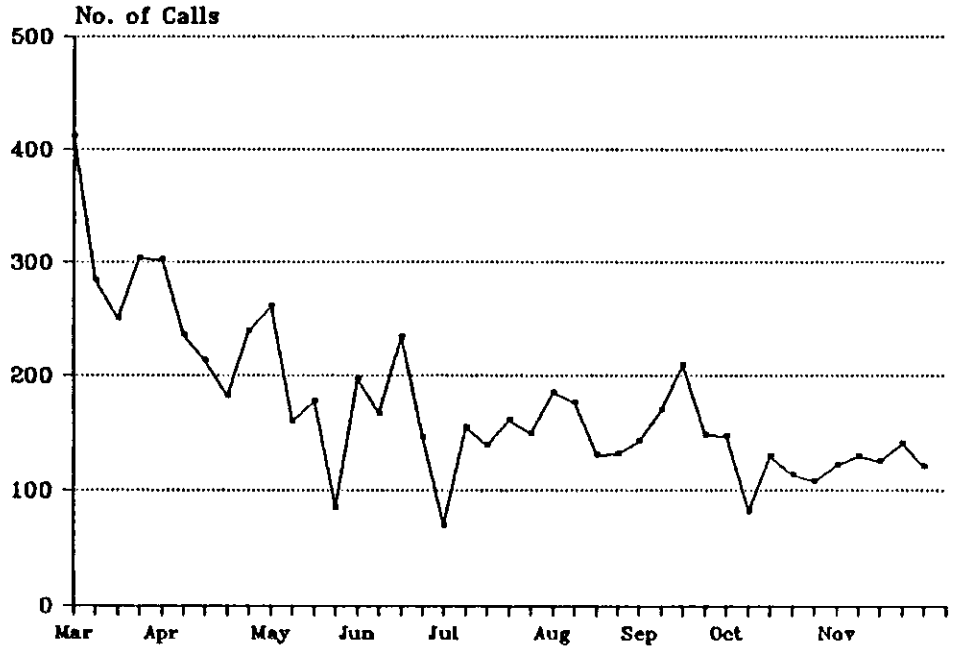


Figure 5.1. Weekly Number of HERO Calls Received During 1984

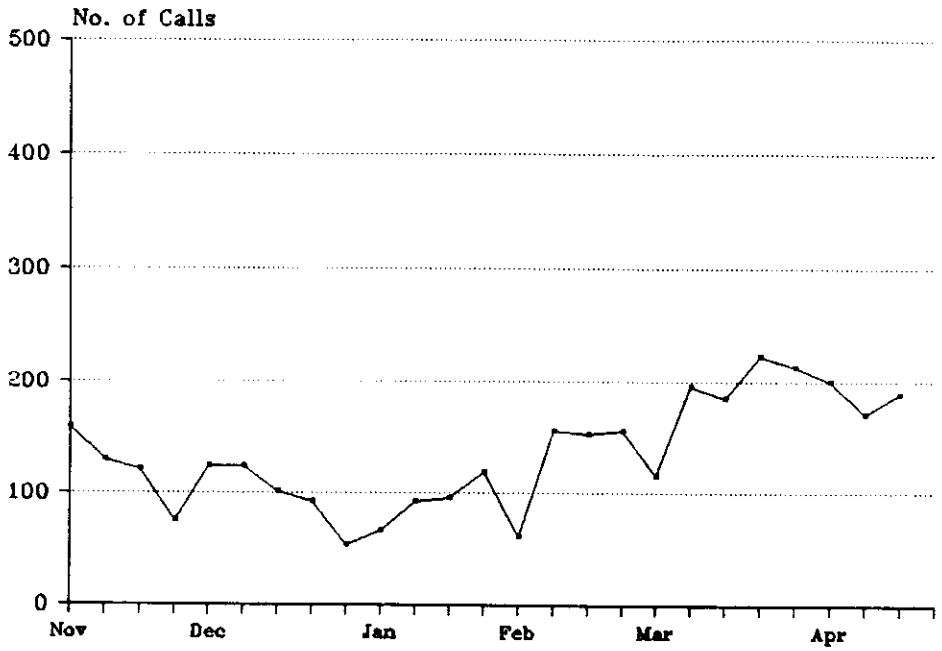


Figure 5.2. Weekly Number of HERO Calls Received between November 1988 and April 1989

1984 and 1988 could not be obtained. The computer system on which the HERO database was formerly stored (i.e., until the beginning of this project) made extraction of the this type of data difficult. The fact that the number of violations reported during late 1988 and early 1989 is approximately the same as the number of violations reported during the latter half of 1984 may be merely a coincidence.

Another fact which should be kept in mind is that traffic volumes have increased significantly on major roads (e.g., by 60 percent during the a.m. peak period on southbound I-5 since 1981, (3*)), and additional HERO signs have been installed since 1984. Therefore, far more people are exposed to the HERO hotline signs. If the number of calls has remained constant while traffic volumes have increased, a smaller *percentage* of the people traveling along the area's roads are using the hotline to report violators than did so in 1984. This finding implies that either a smaller percentage of people are aware of the HERO program or that a smaller percentage are reporting the violations they see. In either case, further marketing of the hotline program is likely to heighten the public's awareness of the program and to encourage more people to use the hotline.

Completeness of Data Obtained from HERO

It is informative to examine the completeness of the data obtained from the HERO hotline because this determines to some extent the ability of the information to be used for other purposes (e.g., to predict the number of violations that took place at a given location during a given time period).

Therefore, violations reported through the hotline between March 1, 1989, and April 15, 1989, were analyzed to determine whether callers were giving incomplete information. In particular, the violations that were reported on the answering machine, which answers calls before 8 a.m. and after 5 p.m., were compared with the violations reported directly to Metro staff. The results of this analysis are shown in Table 5.2.

More than half (55 percent) of the 1,304 violations that occurred within the time period analyzed were reported to the answering machine. Callers who left messages on the

TABLE 5.2 - COMPLETENESS OF VIOLATION DATA RECEIVED ON THE ANSWERING MACHINE DURING NON-WORK HOURS

TYPE OF INFO NOT GIVEN	(N = 718) REPORTED TO ANS. MACH.		(N = 586) REPORTED TO METRO STAFF	
	#	%	#	%
no cross street	289	40	205	35
no route	23	3	0	0
no direction	37	5	0	0
no violation time	16	2	7	1
mainline or ramp not specified	59	8	20	3
vehicle occupancy not specified	41	6	5	1
at leat one of the above left blank	320	45	207	35

answering machine were more likely to leave incomplete information than were callers who reported violations directly to Metro staff. However, both categories of people were fairly likely to leave incomplete information. Over one-third (35 percent) of those who spoke to Metro staff left at least one incomplete item, and almost half (45 percent) of those who left messages on the machine did so.

These findings indicate that the usefulness of the data received through the hotline is substantially reduced by the incompleteness of the information received. Efforts should be made to improve the quality of the information that is received, particularly from the answering machine. Metro and WSDOT should also examine methods of improving the quality of information that is given directly to Metro staff, although obviously people who report violations often do not have time to obtain complete information.

THE PUBLIC'S OPINION OF THE HERO HOTLINE

A detailed analysis of the public's opinion of the HERO program has never been conducted (before this project) to determine the public's perception of HERO, a factor that is almost as important as various agencies' opinion of the program. The survey analysis

itself is discussed in a previous section, but the key findings regarding the public's attitudes toward the HERO program will be reiterated here.

- Eighty-one percent of the people sampled knew about the HERO program.
- Only 6.3 percent of the respondents said they had used the hotline to report an HOV violator.
- Over two thirds (71 percent) of those who knew about the hotline said they thought it was a good idea.
- Fifty percent of those who knew of the HERO program felt that the program reduced HOV violations.
- Only 6 percent of the people who knew about HERO thought the hotline reduced HOV violations a great deal.

The public's awareness of and acceptance toward the HERO program were both quite high, considering that Metro and WSDOT have not marketed the program at all since the initial marketing and public education campaign in 1984.

Of special interest was the finding that most people did not feel that the hotline reduces violations a great deal, despite the fact that most of the people who knew about the hotline were in favor of it. This finding indicates that some people like the program not because they think it reduces HOV violations but because of other reasons. One possible reason the public is generally in favor of the hotline is that HERO offers them the opportunity to vent their frustration at being delayed by traffic congestion while HOV violators are able to drive 55 mph, often without being cited by the State Patrol.

Indeed, this hypothesis seems to be confirmed by the finding (see Chapter Three) that the number of HERO calls received during the a.m. peak period (i.e., for southbound I-5) increased as the speed in the general purpose lanes decreased. At the same time, the number of HERO calls received was not found to be related to the violation rate on I-5. People apparently are more likely to report HOV violations when they are stuck in traffic congestion (i.e., when speeds are low), and not necessarily when they see more violators.

CONCLUSIONS

The above discussion has outlined some of the factors that may be used to evaluate the HERO hotline program, including both the hotline's effect on the HOV lane violation rate and the public's attitude toward the hotline.

The relative importance of these two factors largely depends on the public's and various state agencies' (i.e., WSDOT, Metro, and WSP) perceptions of what the HERO program's primary objectives are. For example, if people generally feel that HERO is primarily a tool for reducing the violation rate on the HOV facilities, then clearly the most important criteria on which to judge HERO's success is the violation rate. On the other hand, if HERO is perceived to be a tool for relieving the public's frustration at seeing people violate the HOV lanes without getting cited, then the public's opinion of the program is the more important criteria with which to judge.

This project has not been able to either prove or disprove that the existence of the HERO program has, in the long run, discouraged people from violating the HOV lanes and thus kept the violation rate lower than it would have been if HERO had not existed. The violation rate measured as part of this project was slightly lower than the violation rate measured before HERO's implementation, but the significance of this difference could not be determined.

Even if the difference between the two rates *were* significant, it would be difficult to prove that the existence of the HERO program, rather than other factors, such as decreased traffic congestion or increased enforcement by WSP, was responsible for any decrease in the violation rate.

Although the researchers could not either prove or disprove that HERO's existence has kept the violation rate low, the public's attitude toward the program was quite favorable. The public's attitude is especially satisfactory because no educational programs regarding the program have been undertaken for over five years. In addition, most of the

people who knew about HERO liked it in spite of the fact that they thought it didn't appreciably reduce HOV violations.

People are apparently in favor of the program because it allows them the opportunity to have some control over a situation in which they would otherwise be powerless. Individual people can not prevent traffic congestion (although they can sometimes avoid it), nor can they force the State Patrol to enforce all HOV lanes at all times. However, HERO gives people the opportunity to at least report on someone who is breaking the law and who would otherwise not be penalized. Furthermore, the fact that most people are in favor of HERO despite the fact that such a small percentage of the public has used the hotline may indicate that people like the knowledge that they *can* "do something" about HOV violations, even if they do not choose to do so.

CHAPTER SIX

RECOMMENDATIONS

In this chapter, recommendations are made regarding a proposed HOV lane violation rate monitoring system, a database to house the monitoring results, and methods of improving the effectiveness of the HERO hotline program.

AN HOV VIOLATION RATE MONITORING SYSTEM

A detailed description of a proposed HOV violation rate monitoring program and a database to store the collected data are given in Chapter Four. The monitoring system and database described in that chapter form the basis for the recommendations that follow.

First, HOV violation data should be obtained from the auto occupancy project that will begin in July 1989. Because the same information that is collected to determine auto occupancy can also be used to determine HOV violation rates, the cost of collecting data for violation rates would be substantially less if data from the auto occupancy project were used than the cost would be if the data were collected independently.

Data for the auto occupancy project will be collected between 30 and 40 times a month on the HOV lane sites. Although the specific HOV monitoring sites have not been established, data will be collected from both directions of the I-405 and mainline I-5 HOV lanes and from the westbound SR-520 HOV lane. The data obtained from the auto occupancy project will yield the quarterly a.m. peak period HOV violation rate for each of these five HOV facilities. The violation rates derived will be statistically valid (i.e., at the 95 percent confidence level) with an accuracy of between 1 and 2 percentage points.

The second recommendation regarding the proposed HOV violation monitoring program concerns the database that will contain the violation data. A simple HOV violation database was developed with a Lotus 1-2-3 spreadsheet. A system similar to this spreadsheet program should be used to store HOV violation data because such a program is extremely easy to use and allows users to graph individual and quarterly violation rates.

In response to prompts from the spreadsheet, users could enter the monitoring time and date, the number of SOVs, the number of two-person carpools (not necessary if the monitored lane has 2+ occupancy), the total volume in the HOV lane, and the total number of persons traveling in the HOV lane. The spreadsheet program could automatically calculate the violation rate of each individual monitoring session, as well as the quarterly and annual violation rates.

The third recommendation regarding the proposed HOV violation rate monitoring system concerns the physical location of the database, and therefore the data. The database should be stored at WSDOT's headquarters in Olympia within either the Transportation Data Office or the Transportation Planning Office. Both of these offices will be involved with the auto occupancy project and thus will have ready access to the data. In addition, locating the database within WSDOT's headquarters would allow the database to be expanded to include information about violation rates on HOV facilities outside the Seattle area, as such facilities were constructed.

THE HERO HOTLINE PROGRAM

Because the HERO hotline seems to be an effective tool for relieving the public's frustration over often unpenalized HOV lane violators, the project team recommends that the hotline be continued. The team also recommends that WSDOT and/or Metro take the following actions to increase the effectiveness of the HERO hotline program:

- implement a marketing and education campaign about the HERO hotline;
- encourage people with cellular phones to use the hotline by allowing them to call in at no cost to themselves;
- explore ways to obtain more complete information from callers, particularly from people who report HOV violations during non-work hours (i.e., before 8 a.m. and after 5 p.m.); and

- give additional effort to better coordinate the information gathered by Metro, WSDOT, and WSP.

A marketing and public education campaign should be implemented to increase the public's awareness of the hotline and to encourage more people to use the hotline, since the study conducted after HERO was first implemented showed the hotline had a significant effect on the violation rate. Alternatively, more modest marketing of the program could be implemented at more frequent intervals (e.g., every two years) to ensure that the public does not "forget" about the program and that people who move into the Seattle area are informed about the program.

It is unclear who should fund and direct such a marketing campaign. Encouragement of HOV use is a function of both WSDOT and the various transit authorities. Thus the logical candidates for this function are either WSDOT or Seattle Metro, although a joint project might be the most equitable solution.

More attention should be focused on encouraging people with car phones to report HOV violations because as car phones have become more popular, more people have been using them to report HOV violations. People with car phones may be more likely to report HOV violations than people without them because people with phones in their vehicles do not have to write down the license numbers of violators and remember to call the hotline after they've reached their destinations. To encourage more car phone users to use HERO, Metro and/or WSDOT should consider paying for calls made from cellular phones on a trial basis to determine if this action significantly increases the number of violations reported.

Metro and/or WSDOT should also explore ways to obtain more complete information from people who call during non-work hours and who therefore must leave pertinent information about HOV violations on an answering machine. Currently, a large percentage of the calls that are recorded on the answering machine contain incomplete information, even though the recorded message gives a list of the information that should

be reported (i.e., the time, date, and location of the violation, the auto's occupancy, a description of the vehicle, and the license plate number).

One way in which additional information could be obtained would be to install an answering machine that can prompt callers through a series of questions. Callers could respond to each question by pressing the appropriate keys on a touch-tone phone. Another way to obtain the necessary information would be to hire part-time personnel to answer the hotline when Metro staff was not available (e.g., from 6 to 8 a.m. and from 5 to 7 p.m.). This option offers the advantage of not alienating people who do not like speaking to answering machines and who hang up if the phone is answered by a machine.

Finally, Metro, WSP, and WSDOT should give additional effort to coordinating information obtained from the HERO program (e.g., number of peak period calls) with other sources of information, such as traffic speed, lane occupancy, the violation rate, and HOV enforcement activity. The three-week monitoring effort undertaken as part of this project did not provide enough data to establish a relationship between the violation rate and the number of violations reported through the HERO hotline. If such a relationship were found to exist, the HERO hotline could be used to monitor the violation rate on the area's HOV facilities.

The HERO database developed as part of this project makes extraction of HERO data much easier than it was when HERO data were stored on the Perkin-Elmer computer housed at WSDOT. In addition, HOV violation data will be much easier to obtain from data collected by the AVO monitoring project (described in chapter on database development). Far more information will be more readily available than has been the case in the past, and efforts should be made to use this information as much as possible.

ACKNOWLEDGMENTS

The authors would like to thank the many people involved in performing this project. Often research is performed in a vacuum, but this project benefited significantly from the active participation of a number of interested advisors from a variety of agencies, each with a perspective that benefited the project.

Of most importance to this project were Mika Bucholtz and Laurel Cruce who helped design, debug, and implement the HERO database program. In addition, they provided the project team with large quantities of data, and a great deal of insight into the entire HERO program.

Of almost equal importance was the TRC and various METRO and WSDOT staff: Bill Roach, Andrea Maillet, Jeff Hamm, Bonnie McBryan, John Conrad, Kim Henry, Mark Morse, Steve Olds, and Sgt. Dan Bender. Their assistance in developing and reviewing the HERO/HOV telephone survey resulted in an excellent survey, which provides data far beyond what can be adequately presented within this report. Their assistance in shaping the direction of the project resulted in products of use to many people and agencies.

Finally, we would like to thank the TRAC staff for their assistance in putting this report together. While all of the TRAC staff contributed, special thanks go to Amy O'Brien, who did her usual splendid job of editing, Ron Porter, who did the word processing and managed the final report assembly, and Bev Odegaard, who kept the budgets straight.

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APPENDIX A

LITERATURE REVIEW

APPENDIX A

LITERATURE REVIEW

INTRODUCTION

The main purpose of this appendix is to review the methods agencies use to monitor compliance on HOV facilities. Although the primary objective of this review was to locate and examine those projects that surveyed compliance rates over long periods of time, short-term studies of HOV compliance rates were also reviewed. Both published and unpublished literature, as well as telephone conversations with knowledgeable professionals, provided the information presented in this section. The information presented here is not meant to be a complete list of freeway HOV facilities in the United States, or the monitoring methods used in all areas, but rather a representative sample of the monitoring methods used on some HOV facilities.

COMPLIANCE RATES VERSUS VIOLATION RATES

It is important to distinguish between the compliance rate and the violation rate. Most sources (e.g., 1) define the compliance rate as the percentage of the total non-HOV traffic that remains in the non-HOV lanes, while the violation rate is usually defined as the percentage of the traffic using the HOV lanes without meeting the eligibility criteria. In general, the compliance rate decreases as the violation rate increases.

Two commonly used formulae for compliance and violation rates are shown below:

$$\text{Compliance Rate} = \frac{\text{\# non HOV vehicles in HOV lane}}{\text{total \# non HOV vehicles in all lanes}} \qquad \text{(Equation 1)}$$

$$\text{Violation Rate} = \frac{\text{\# violating vehicles in HOV lane}}{\text{total \# vehicles in HOV lane}} \qquad \text{(Equation 2)}$$

There are advantages in using either rate as a means of monitoring HOV facilities. One advantage of using compliance rates is that these rates often pinpoint situations not fully revealed by an examination of violation rates. For example, a road can experience both high compliance rates and high violation rates if high general traffic volumes in non-HOV lanes are accompanied by low volumes in the HOV lanes, and relatively few people violate the HOV lane criteria.

However, a review of the literature on the subject reveals that compliance rates are rarely examined; most attempts to monitor HOV lanes have used violation rates as their means of measurement. Violation rates are used because the purpose of most studies has been to determine the effects of some change on the behavior of motorists in the HOV lanes, such as new signing or an increased level of enforcement. The violation rate is a more accurate way to monitor the influence of such a change. Due to the dearth of literature on HOV compliance monitoring, this section will concentrate on methods of monitoring violation rates rather than compliance rates.

SHORT-TERM VERSUS LONG-TERM MONITORING

Since one of the main objectives of this project was to identify methods of monitoring HOV violation rates over long periods of time, a primary goal of the project was to locate any monitoring programs in the U.S. that regularly monitor violation rates. Since important information regarding methodology can also be learned from studies that have monitored HOV violation rates over short periods of time, literature on short-term HOV violation monitoring was also reviewed.

Short-Term Monitoring

Short-term monitoring of violation rates on HOV facilities is fairly common and is often used to determine the effectiveness of recently constructed HOV lanes. Since the justification often given to the legislature for the construction of the HOV lanes is that they will significantly increase the people-carrying capacity of the

transportation network, state highway or transportation departments usually monitor the new facilities just after their construction to determine their impact on traffic flow.

Violation rates are commonly examined, since high violation rates may indicate a need for better enforcement or marketing of the HOV lanes, or a need to make engineering design changes. (2) Although HOV facilities with high violation rates may improve overall traffic conditions, they may still be unacceptable since the presence of many violators in the HOV lanes produces a public perception that the lanes are not successful.

Another reason for monitoring violation rates on new HOV facilities is that high violation rates may indicate a potential safety problem. (3) Since the construction of HOV lanes can be a politically sensitive issue (4), it is important that their construction not have a negative impact on the accident rate. HOV lanes are most likely to affect the accident rate in those areas where the HOV facilities are not physically separated from the mixed-flow lanes. This lack of separation allows vehicles to weave in and out of the HOV lane, causing a potentially dangerous situation, particularly when traffic in the HOV lane is flowing much faster than that in the mixed-flow lanes. High violation rates in such an area indicate a need to study the lanes more closely to determine whether a substantial amount of weaving is occurring.

Another type of short-term monitoring program examines the effects that selected changes in the HOV facility have on the violation rate. Examples of such changes include the following:

- changes in occupancy requirement (5; 6),
- new signs or markings (7),
- changes in hours of operation (8), or
- an increased level of enforcement (2).

Of the above, an increased level of enforcement is the change that is usually reviewed in conjunction with violation rates, since enforcement probably has more impact on violation rates than the other modifications. Note that many studies examine the effects of changes on HOV lanes as part of the study that is conducted immediately after the facility is opened. New HOV lanes often have unacceptably high violation rates and changes must be made to reduce those rates.

Long-Term Monitoring

The literature contains few references to ongoing HOV violation monitoring programs. This absence probably reflects the fact that such programs are relatively expensive and may have no immediate impacts on traffic congestion. Therefore, the program expense is not easily justified when compared to construction activities or other, more "visible" projects. This survey identified only three states that have continuing HOV violation rate monitoring programs; these are Virginia, California, and Texas. In addition, the Oregon Department of Transportation had an ongoing program that monitored the HOV lanes on the Banfield Freeway, near Portland, from the lanes' inception in the mid-1970s until 1982, when the lanes were removed. Table A-1 briefly describes these states' monitoring programs, as well as that of New Jersey, which monitored the HOV lanes on the approach to the George Washington Bridge for several years both before and after their implementation. Specific details about the monitoring programs used in these states, as well as methods used in other, short-term programs, are given below.

HOV VIOLATION MONITORING METHODS

As stated previously, most states that currently have or have had HOV lanes monitor those lanes for at least a short period of time just after the lanes have been constructed. However, not all states examine violation rates as part of this initial study, and of those that do, not all of them include methodology information in their reports. For this reason, letters were sent to those states operating HOV lanes,

soliciting them for information regarding HOV compliance monitoring methodology. Therefore, the methodology information that follows came from sources other than published literature on the subject, including unpublished literature, written responses to a letter, and telephone conversations with knowledgeable professionals in the states' transportation departments.

Washington

The Washington State Department of Transportation (WSDOT) currently does not monitor violation rates on the state's HOV facilities on a continuing basis. WSDOT periodically collects data on HOV violation rates and vehicle occupancy in the HOV lanes, but these studies are not conducted regularly. Little effort has gone into both collecting information on HOV violation rates at a given location over a long period of time and compiling the information that has been collected so that long- or short-term trends in the violation rate can be observed.

The Seattle area has a number of HOV facilities consisting of both concurrent flow HOV lanes in the inside or outside lane and HOV on-ramps, some of which bypass metered general purpose on-ramps. The HOV lane on the outside shoulder of westbound SR-520 was the first HOV lane to be opened in the Seattle area (1973), followed by the opening of HOV lanes on the inside lanes of I-5 in 1983 and the outside lanes of I-405 in 1984. The newly constructed (June 1989) I-90 bridge across Lake Washington will also have two reversible HOV lanes when the entire bridge system is completed in 1992. (In the interim, there is a single, westbound HOV lane). HOV lanes also exist on SR-522, north of Seattle, and on Aurora Avenue and SR-509 in Seattle.

Several studies have been done since the inception of these lanes to evaluate their overall performance. However, these studies have generally focused their attention on the HOV facilities on I-5 (e.g., 9 and 10), and their intent was not to establish violation rates but to examine a range of parameters, such as HOV volumes, vehicle occupancy in the HOV lanes, and the accident rate on roads that

contain HOV lanes. One recent study examined the violation rate on the I-405 HOV lanes associated with an enforcement emphasis program, (11) and a previous study investigated violation rates on the I-5 HOV lanes after the HERO program was implemented. (10) However, both studies were short-term monitoring projects, and little effort has gone into monitoring HOV violation rates over the long term.

Generally, human observers with traffic counter boards collected HOV violation data for those studies that examined violation rates. However, small, portable computers have also been used to collect vehicle occupancy data. (13) These computers, which were programmable with the BASIC language, allowed the data collector to classify each vehicle by simply pressing a single key (e.g., "1" means SOV, "2" means 2-person carpool, etc.).

The use of these computers offered several advantages. First, the computers were able to record the time of each observation, an ability which largely eliminated the need to supervise data collectors. Second, the data collected could easily be transferred to a microcomputer for further analysis. Third, the program used to collect occupancy data allowed the data collector to correct past observations.

Virginia (14)

The Virginia Department of Transportation uses human observers to collect data on HOV violation rates and usage on Interstates 66, 95, and 395 annually. Table A-2 gives the violation rates for these three facilities. The HOV lanes on I-95 are concurrent flow, non-separated diamond lanes, while the Shirley Highway (I-395), which is a continuation of I-95, contains two fully separated and reversible HOV lanes. On I-66, the two lanes in the peak direction are reserved for carpools and buses during peak periods. The minimum occupancy required for use of the HOV lanes is three persons on all HOV facilities in the state.

On the Shirley Highway, one person observes each lane, recording up to six occupants per vehicle on traffic counter boards. In addition, vehicles are classified as cars, public buses, and private buses. Occupancy data on the buses are furnished

by the bus companies. Since no trucks are allowed in the HOV lanes, trucks are not counted.

The other HOV lanes in Virginia are monitored in a similar manner, although I-95 is more difficult to monitor, since the shoulders on that road are quite narrow, making observation of the lanes dangerous. The high violation rates on this facility may be due to the lack of separation between the general lanes and the HOV lane and the difficulty in enforcing the lane.

California (15)

The California Department of Transportation (Caltrans) operates a number of HOV facilities throughout the state. However, it only monitors the HOV lanes in the southern half of the state on a regular basis. Caltrans monitors occupancy on both the mixed flow and the HOV lanes bimonthly on a number of freeways in Los Angeles and Orange Counties. The three freeways monitored that include HOV lanes are Interstate 10 (the el Monte Busway) and State Routes 91 and 55. A portion of the el Monte Busway is physically separated from mixed flow traffic, but much of the rest of the HOV lane miles are separated from general traffic by only a buffer zone, if at all. Occupancy requirements also vary among the lanes; minimum occupancy is three on the Busway and two on the other lanes.

To obtain HOV occupancy rates, data are collected in 1/2-hour segments by a team of two counters for each location. One person is responsible for counting the number of persons in each vehicle, classifying each as having one through five occupants or six or more occupants. The second person records data on vehicle type, classifying vehicles as vanpools, motorcycles, buses, or trucks. Automobiles are not classified. The information collected from both people is then combined to determine the number and type of vehicles and the number of persons using the HOV facility. Violation rates can also be extracted from these data.

Data are collected only on clear weather weekdays when there are no unusual traffic conditions. Counts are not made on Mondays, Fridays, or any other

days that may exhibit unusual traffic conditions (e.g., the day before a holiday). In general, counts are conducted from elevated positions, to the right of the vehicle passenger side. Examples of such positions are overpasses, pedestrian overcrossings, and the tops of cut areas.

Caltrans also uses a video camera to monitor roads in southern California, but it does not use the camera to determine vehicle occupancy, since the camera is unable to "see" into the back seats of vehicles. The camera primarily provides Caltrans personnel with an overview of the roads. It is mounted on an overpass and is connected by wires to a truck kept hidden from passing vehicles. Observers within the truck can move the camera about to observe traffic.

The Orange County Transit District (OCTD) has also used video equipment. A private video firm designed a low-light, stop-motion video system to provide pictures of license plates for vehicle origin-destination studies. (16) The system was successfully able to take clear pictures of the license plates of vehicles traveling 60 to 70 miles per hour during low light conditions. The video equipment was placed on an overpass above the traffic to be filmed, where it would not disrupt traffic. Although the intent of the project was to film license numbers, OCTD personnel noticed that the occupants of the front seats were sometimes filmed as well.

Another agency within the state of California that has been experimenting with the use of photographic equipment for traffic purposes is the Pasadena Police Department. The department has been using a photo-radar system for almost a year to take photographs of speeding motorists. The camera, which is mounted on the back of a truck, is triggered by a radar gun, which can be set at any speed above 15 mph. The film cannister holds approximately 800 frames, but the camera itself is only able to take about 260 pictures per hour. However, police personnel who have been using the equipment feel that the flash unit would likely become too hot and would fail to work if it were used in conjunction with the camera for every picture. (17)

Texas

The Texas Transportation Institute (TTI) collects a wide range of data on the utilization of the HOV facilities in Texas. Many of this state's HOV facilities, especially those in the Houston metropolitan area, are in the form of transitways: reversible, barrier-separated HOV lanes located in the freeway median. Data collected monthly on the transitways include person and vehicle volumes and vehicle occupancy. Additional transitway data on travel times and speeds are collected quarterly. (6)

TTI does not monitor violation rates. However, the Metropolitan Transit Authority of Harris County (METRO) police (in the Houston area) enforces all transitways during most hours of operation. Most violators are cited, with the possible exception of violators who sneak by when an officer is issuing a citation to another person. Therefore, the number of violators using the HOV lane is very close to the number of citations issued. The violation rate is currently estimated to be one percent. (18)

Since techniques used to monitor occupancy can be modified to monitor violation rates, the methods used in Texas to monitor occupancy were also reviewed by this study. Human observers are used to collect occupancy data over the 3-1/2-hour peak periods. One person observes each lane and records the occupancy of each vehicle by speaking into a tape recorder. Only vanpools and buses are classified, since their occupancy can be determined later from data provided by other sources (e.g., from Metro, who operates the buses).

Currently, occupancy rates are determined from the data collected in the field, and this information is then loaded into a computer. The state has recently ordered new computerized equipment that is capable of recognizing hundreds of words. Information recorded by this machine can be loaded directly into a computer, greatly shortening the time necessary to process those data. (18)

Oregon (19; 20)

Oregon does not currently operate any mainline HOV lanes, although the state does have 14 HOV bypass lanes on metered on-ramps. The Banfield Freeway, near Portland, did contain an HOV lane in each direction, but these lanes were discontinued in 1982 when construction began for Portland's light rail system, which operates in the same corridor. However, when these HOV lanes were in operation, the Oregon Department of Transportation conducted an extensive monitoring program on the lanes to determine their effectiveness. Violation rates were also determined as part of this study.

Occupancy counts were usually conducted by two people, each of whom used a four-column traffic counter board on three consecutive days (Tuesday through Thursday) on the second full week of the month. One person collected data on the two general purpose lanes while the second determined occupancy in the HOV lane only. The counters recorded each vehicle as having one, two, or three or more occupants, but vehicles were not classified by type. However, when sufficient personnel were not available, one person collected all the data using two four-column counter boards.

When two people were available, data were collected for 10 minutes in the peak direction and then, following a 2-minute break, were collected in the non-peak direction for 5 minutes. This cycle was repeated throughout the 3-hour peak period. If only one person was collecting data, only one direction of traffic would be counted per day.

The average number of one, two and three or more occupant vehicles was found by taking the average of each over the three days. These figures were then used to determine both occupancy and violation rates. Violation rates varied over the course of the lane's operation, largely because the minimum occupancy necessary to use the lane was changed. Before February 1979, when the minimum occupancy was lowered from three to two persons, the violation rate was

approximately 20 percent. However, after the carpool definition changed, the violation rate dropped to about 10 percent.

New Jersey (5; 21)

The Port Authority of New York and New Jersey operates an HOV lane at each Hudson River Crossing between New Jersey and New York. In addition, the New Jersey Department of Transportation operates several HOV lanes. However, the only HOV lane in the state that has been recently monitored is located on the approach to the George Washington Bridge into New York City. In 1983 the New Jersey Department of Transportation conducted an extensive monitoring program of the bridge when it decided to expand the bus-only lane into a longer bus/carpool lane. Violation rates were examined as part of this study.

Data were manually recorded using a five button traffic counter. The first three buttons were used to record the number of cars containing one, two, and three or more persons; the fourth button recorded the number of trucks; and "misses" were recorded using the fifth button. If the observer saw a vehicle but could not determine the number of occupants, the sighting was counted as a "miss."

If the number of "misses" was low in comparison to the total traffic volume, this number was included in the total traffic volume figure but was not used for computing auto occupancy. However, if this number was large, project personnel then extrapolated how many one, two, and three-or-more person occupied vehicles this figure contained by examining the non-miss data. They assumed that the "miss" data would exhibit the same one/two/three-or-more split that the "nonmiss" data displayed. Excessive misses were considered reason to discount the affected interval's data.

The monitoring locations were three toll plazas, two of which had three outbound lanes. The third plaza had only two outbound lanes. At the larger toll plazas, two people monitored the three lanes One person observed the outside lane and the other observed the two inside lanes. Data were collected over 5-minute

intervals, with one person observing the outside lane and the other observing the two closer lanes. Every 5 minutes the two observers switched positions, but the counters were set back to zero only after 20 minutes had passed. At that point, the two observers took a 10-minute break, after which counting resumed for another 20 minutes. The same procedure was used to monitor lanes at the smaller toll plaza, except that a single person monitored the two lanes.

Although the HOV lane was operational only from 7 to 9 a.m., data were collected from 6:30 to 9:30 a.m. Counts were done once a month during the midweek (Tuesday through Thursday), usually during the third week of the month. Although data were generally not collected during inclement weather, darkness was not a deterrent because the count locations were relatively well-lit toll plazas.

Results from the monitoring program showed that violation rates varied during the hours the lane was in operation. Violation rates averaged about 40 percent during the first and last 15 minutes of the lane's operation, while these rates averaged only 30 percent during the core 1 1/2 hours of operation.

Other Monitoring Programs

Other states that have monitored HOV violation rates include Colorado, Florida, Hawaii, Massachusetts, and Minnesota. However, none of these states have monitored their HOV lanes on a regular basis, usually because of staff shortages or safety concerns. It was not easy to determine any specifics of the methods these states used to collect data on occupancy and violation rates. However, it was found that in all cases human observers were used.

Colorado (22; 23). This state has operated an HOV lane on the South Santa Fe Highway in Denver since October 1986. The Colorado Department of Highways recorded the lane's occupancy and violation rate for one year after the lane's inception but no longer monitors the facility regularly. Violation rates during the year the lane was monitored varied from 9 to 31 percent. There was no clear link between congestion in the mixed flow lanes and the HOV violation rate. In fact, the

variation may have been caused by the low usage of the lane. Small changes in the actual number of violators could have caused relatively large changes in the violation rate. The low usage of the lane was probably a result of the lack of congestion in the adjacent mixed-flow lanes. This supposition is borne out by the fact that as many as 50 percent of the vehicles eligible to use the lane drove in the mixed-flow lanes instead.

Florida. Although Florida has no ongoing compliance monitoring program (24), several years ago the University of Florida conducted a study of HOV lane usage on Interstate 95 in Miami. (25) Violation rates were determined by field observations made from a vehicle driving in the direction opposite to the movement in the HOV lane, which is on the far left-hand lane. (25) This study could not obtain more specific details on data collection because of changes in staff.

Hawaii. This state has incorporated HOV lanes on several roads in the Honolulu metropolitan area: the Kalanianaole Highway and the Moanalua Freeway. Although the HOV lanes on both roads were evaluated several years after they were constructed (26; 27), the lanes have not been regularly monitored since that time because of safety concerns. The shoulders on the sections of roadway that possessed HOV lanes are extremely narrow (sometimes less than 2 feet wide), thereby making it hazardous to observe vehicles from the side of the road. Attempts to monitor the lanes from overpasses have not been successful, either. (28)

Massachusetts. The only HOV lane in the state of Massachusetts is on southbound Interstate 93 in Boston. The lane, which is only about 4,000 feet long, is separated from the regular traffic lanes by a bituminous concrete curb located in the adjacent lane. The facility is enforced daily by the state police, who position themselves about 1,000 feet beyond the entrance to the lane. About 10 percent of the violators are actually cited; the rest are directed by the police to re-enter the general lanes through an "enforcement chute" designed for that purpose. (29) As a result of the constant police surveillance, violation rates are very low, around 1

percent. (30) Thus, a formal violation monitoring program is probably not necessary.

Minnesota (31). Currently, the state of Minnesota is operating a single, reversible HOV lane in the median of Highway 12 in Minneapolis. This facility is only temporary, since Highway 12 is being rebuilt into Interstate 394. When complete, the new freeway will include two HOV lanes.

The state Department of Transportation does not regularly monitor compliance on the temporary facility. When citizens complain about HOV violations, however, the State Patrol enforces the lane. When State Patrol officers do enforce the lane, they find few people actually violating the lane. Many of the apparent violators have children or dozers aboard who are not easily visible. Actual violation rates are not computed.

Photographic Monitoring Methods

Although much interest has been expressed in the use of photographic or video equipment to monitor HOV violations, the review of the literature revealed that no state has used photography for this purpose. Therefore research was conducted to determine whether photographic equipment that has been used for other traffic monitoring purposes might be applicable to monitoring HOV violations. In addition, research was conducted to identify those factors that influence the selection of photographic equipment.

The three primary considerations that affect photographic equipment selection include cost, the ability of the equipment to take usable pictures in low light conditions, and the size of the equipment. The cost of obtaining a camera capable of accurately determining vehicle occupancy is high. However, the camera can probably be used for other tasks besides monitoring vehicle occupancy. Thus its cost could be spread among several different tasks. Furthermore, while the camera should be able to take usable photographs in low light conditions, such as the early morning or evening hours (e.g., 7:30 am or 5:00 pm), the equipment does not need

to determine occupancy at night or under weather conditions in which human observers would be unable to determine occupancy. However, it is extremely important that the equipment be unobtrusive to passing motorists. Highly visible equipment may cause traffic disruptions or, at the very least, may cause HOV lane violators to alter their behavior as a result of the camera's presence.

Given these considerations, several types of photographic equipment show promise for determining the occupancy of moving vehicles: still photography, closed circuit television, and video cameras.

Still Photography. The prototype photographic system developed by the Naval Surface Weapons Center in 1977 is one example of a monitoring system that uses still photography. (29) The system consisted of a 16 mm camera and a flash unit (200 wattseconds), both mounted on a single tripod, and an optical vehicle sensor to ensure that the camera and flash unit operated in unison. The Shirley Highway (I-95) HOV facility in Virginia was selected as a test site for the prototype to ensure that the system could accurately determine the occupancy of vehicles with people in the back seat.

Initial tests of the system demonstrated that, of all the film/filter/ developer combinations tested, black and white infrared film with an infrared filter on the flash achieved the best results. These first tests also revealed that the best vantage point from which to see inside passing vehicles was in front of passing vehicles at an angle of about 45° measured from the axis of the vehicle.

Following the initial development tests, operational tests were conducted to determine how well the system performed under actual, continuous field conditions. The equipment was set up under a ramp buttress to minimize the visibility of the four-feet tall system.

Several important results were revealed by these tests:

- the presence of the camera had no adverse effects on passing traffic,

- the equipment was capable of recording the entire peak period without failure, and
- the number of occupants could usually be determined.

However, a major problem was also revealed by the operational tests. The infrared light from the flash unit was absorbed by some car windows without penetrating and illuminating the insides of these vehicles. As a result, human forms in the pictures of these vehicles could be discerned only slightly, if at all.

Several other camera systems using still photography have been developed since the Naval Surface Weapons Center conducted its research. However, these new systems have generally been developed for purposes other than for monitoring HOV violation rates. Zellweger Uster Ltd., a Swiss firm, has designed several high-speed camera systems. (32) One was designed to photograph the license numbers of vehicles that illegally cross an intersection during a red light. Another system photographs the license plate or the interior of those vehicles violating the posted speed limit. Each system is attached to a flash unit and can therefore take pictures at night. Although neither system was designed to monitor vehicle occupancy or HOV violation rates, it might be possible to develop a camera system specifically for monitoring vehicle occupancy from equipment similar to Zellweger's. However, the cost of using such a system to monitor HOV violation rates might well be prohibitive. Zellweger Uster estimated the price of a photo-radar unit on a tripod with a protective steel box to be $72,000. This price does not include installation.

Closed Circuit Television. The simplest photography monitoring method might be closed circuit television (CCTV) cameras because WSDOT has approximately 40 of these permanently mounted on roads in the Puget Sound area. Slightly less than half of these are located adjacent to HOV lanes. However, several difficulties are associated with the use of these cameras for monitoring HOV violation rates. First, no CCTV cameras are located adjacent to the SR-405 or SR-520 HOV lanes; only the I-5 HOV lanes can be viewed through CCTV. Second, the

lenses currently installed on the cameras are unable to determine the occupancy of even the front seats of passing vehicles, largely because the cameras were installed to allow WSDOT personnel to scan roads for accidents and other incidents and not to see inside individual vehicles.

These problems do not necessarily preclude CCTV cameras from further consideration as a potential means of monitoring HOV compliance. WSDOT plans to install additional cameras along both SR-405 and SR-520 adjacent to the current HOV lanes. Therefore, WSDOT should determine whether the existing cameras could be fitted with new lenses that could both overview the road and focus into the interiors of individual vehicles.

A Texas firm named Traffic Monitoring Technologies is currently experimenting with the use of CCTV in combination with still photography. (33) A TV camera and computer are set up in a vehicle near the HOV facility. A person inside the vehicle monitors the HOV lane and takes pictures of suspicious vehicles. Owners of vehicles who are found violating the HOV facility are then issued citations through the mail. However, because the primary purpose of the system is to enforce, rather than to monitor, HOV facilities, the equipment is not currently set up to take a photograph of every vehicle in the HOV lane.

Video Cameras. The use of video cameras to monitor HOV violation rates should also be considered. The advantages of the use of video cameras over more sophisticated photographic equipment are that the equipment is far less expensive, easier to acquire, and more lightweight and mobile.

The video camera Caltrans currently uses to observe traffic is capable of determining the front seat occupancy of vehicles being observed. If a similar system were set up in the Puget Sound area, violation rates could be extrapolated by the method described in the previous section.

A video system might also be specially designed to photograph the entire interior of moving vehicles. Infrared light might be used to illuminate vehicles'

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APPENDIX B

DOCUMENTATION FOR HERO DATABASE PROGRAM

DOCUMENTATION FOR HERO DATABASE PROGRAM

This document is intended to help programers understand and alter the HERO database source code.

The HERO database program is written in Rbase for DOS. The source code file is called HERO3CP.APP and has been compiled into the binary file HERO3.APX. You can edit the HERO3CP.APP file with any standard line editor. To convert the source code into a binary file for execution, use the Codelock function supplied with Rbase.

Before altering the HERO3CP.APP file, you should be familiar with the Rbase language and programing techniques. This document uses Rbase terminology but does not include definitions of common Rbase terms.

STRUCTURE OF THE APP SOURCE CODE FILE

The HERO3CP.APP file is structured in the normal manner for Rbase code. The processing code is listed first. This is followed by the various menu choices, and finally the help screens. In addition, the HERO3CP.APP file calls three subroutines, LABEL1.APP, LABEL2.APP, and LABEL3.APP. These files have also been converted into their equivalent APX files for execution. All produce labels for the database and are essentially the same, except for specific record selection choice (LABEL1 prints labels for brochures; LABEL2 prints labels for DOT letters; and LABEL3 prints labels for WSP letters.)

A complete list of the HERO3CP.APP file is included in the appendix to this report. Within this file, major sections of code are separated from each other by three to five comment lines. (A comment line starts with an "*" and any comments are included within parentheses.) Within each comment line block is a one-line description of the function the following code will perform.

This report uses the code's comment headers as the structure by which to describe the program.

PROGRAM FLOW

When the user initially starts the HERO program, the program provides a menu. From that menu, the user has five basic selections:

- Enter and/or edit HERO data,
- Print standard reports,
- Delete old HERO data,
- Use RBASE commands directly, or
- Quit the HERO program.

On the basis of the user's selection, the HERO program then branches to the appropriate program code and performs the given function. The RBASE code in the HERO3CP.APP file is structured in the same order as the list above. The paragraphs below describe the logic the program follows.

Initial Command Block

The initial block of code sets the defaults for the computer system. It chooses foreground and background colors, calls up the initial menu screen, and defines the primary variables used in program control.

Add/Edit HERO Data

After the user selects this main menu option (PICK1 EQ 1), the program asks him/her to select a method for searching the database for previous violations by that vehicle and/or person. The user can search for either

- vehicle license plate numbers,
- an owner's last name, or
- any part of the registered owner's name.

The first two of these searches are the fastest but require an exact match (the system is not case sensitive). The last of these searches makes use of the CONTAINS command

and will make matches with any record that contains the specified string. Thus, with this command the user can search and find a violation record on the basis of first names, last names, or even partial names. This flexibility can be helpful but not surprisingly, this method is the slowest of the three search procedures. The source code text is visually separated into three sections, one for each of the above selections.

License Plate Search

The license search is selected when the PICK2 variable equals 1. The license plate to be found is entered into the WHVAL1 variable, and pointer #2 is set so that the pointer path is equal to that license number.

If the license is not found, pointer #2 returns a non-zero value and the program asks the user whether a new license will be entered into the database. If not (CHECK NE Y), the program brings the user back to the main data entry/editing menu. If a new license will be added (CHECK EQ Y), the form OWNER4 is called up to assist with the data entry. By exiting the OWNER4 form the user automatically enters the license into the database owner table.

After the user enters the owner information into the database, he/she uses the ACT4FRM form to enter the violation information. Upon its completion, this form automatically enters the violation information into the database action table.

For both Owner and Action table entries, the modifier FOR 1 ROW allows the entry of only one owner or violation record. After the user has completed each violation entry, the program presents a screen that asks whether more violations will be entered for the vehicle owner. The user must request additional violation entries at this screen in order to enter more than one violation for an owner (ANSWER2 EQ Y). This decision loop repeats itself until the user no longer requests the entry of additional violation data for the owner.

When the user has completed the data entry for each license plate, a series of SET VAR and CHANGE commands are executed to change (or add) the latest violation information stored in the owner table. The program was created this way to prevent the

user from having to enter these data twice (once for the owner table and once for the action table), and to allow the user user to download (with the UNLOAD command) the data required to print the WSP and DOT letters mailed to frequent violators.

To perform the transfer of these duplicate data from one table to the other, the database selects the latest violation date (calendar date) and inserts it into the owner record, along with the other data needed to print the letters. These include violation time, location of the violation, the route on which the violation occurred, and a designator of whether to send a letter (and which kind of letter). To perform this switch, two row pointers must be set. These pointers sort the action file so that the latest violation information can be selected from the action file and inserted into the appropriate owner record.

This same switch takes place after each revision of a database record for a specific license plate. This updating occurs regardless of whether the user started the process by requesting the entry of a license plate (as described above) or a last name or mailing label (described below). Therefore, the switch code is repeated several times in the HERO3CP.APP file. The only differences in this code as it appears throughout the file is the formulation of the Set Pointer command, which is dependent on the variable the user entered (license, last name, or mailing label) to select the appropriate owner record.

If the license is found, the pointer #2 variable STATUS equals 0, and actions driven by the second portion of the license plate search code section take place. With an existing license plate, the program that gives the user the opportunity to edit the owner information present in the database. The form OWNER2 serves this purpose.

After the user has completed any desired edits, the program shows a summary of all violations made by the license plate that the database contains. (SELECT WHERE). For the program to make this search, the license plate of interest is stored in the WHVAL1 variable.

The program then gives the user the chance to edit any or all of the old violation data (using the ACT3FRM form). After the user has completed all the desired changes,

he/she may enter new violation data. After the user has entered one new violation record, any additional violation records are entered with the ACT7FRM form.

After the user has completed a database entry for each existing owner record, the program performs the switch described above to enter the latest violation data into the owner record from the newly entered or revised violations record.

Last Name Search

The last name search works in much the same way as the license plate search. As with the license plate search, this section of code is broken into two sections, the first for cases in which the last name is not found in the database, and the second for cases in which one or more last names are found to match the desired name. The biggest differences between this code and the code for the license plate search are (1) the use of specific RBASE default variables (primarily WHVAL1) and (2) the program's need to confirm the record (row) selection before editing commences (i.e., there are many "Smiths" in the database, but all license plates are unique.)

In this section of the HERO code, the variable WHVAL1 contains the requested last name rather than a license plate, as in the previous section. If no record with this last name is found, WHVAL1 is used to insert the last name into the form used for data entry. The variables ANSWER3 and TLICENSE contain the license information from the selected (or newly created) owner record that is needed to match the owner table to the appropriate violation information in the action table.

Last Name Not Found. As with the license plate search, if the last name is not found, the program asks whether the user wishes to enter a new record. If the user chooses not to enter a new record, control returns to the entry/edit menu screen. If the user chooses to enter a new record, the program calls up the appropriate owner and action forms. These forms are slightly different from the forms used in the license plate search. (OWNER5 and ACT8FRM are used for new owner entries, and OWNER3, ACT6FRM, and ACT8FRM are used for editing and entering data for existing records.) In programing

the code, different forms were required to allow the data to be entered appropriately and automatically into the forms to limit the amount of typing the user would have to do.

Last Name Exists. Because there can be multiple owner rows with the same last name, an additional step is needed to confirm that the selected record (based on the last name) is the record the user intends. Thus, when the database finds one or more records that match the input name, it presents the user with the Last Name, the Mailing Label and the License Plate for each possible record in the database (SELECT WHERE LANAME EQ .WHVAL1).

Once the user indicates that the displayed record is the one desired, the license plate variables are set and the editing/data entry sequence is started. (Note that the search for the appropriate matching last name is controlled by a WHILE . . . ENDWHILE clause and must be broken with a BREAK command.) As with the entry of new records based on last names, a different set of data entry and editing forms must be used from the license plate search, and information from the action tables is switched to the owner tables with the Set Pointer, Set Var, and Change commands after the data entry and editing have been completed for each owner record.

Registered Owner Search (Partial names on mailing labels)

This third section of Add/Edit HERO Data searches for the address label for the indicated individual. This search is carried out using the CONTAINS clause. The search command interrogates the ADDLABEL column in the owner record to find all occurrences of the input string. In this manner, all occurrences of that name are displayed (one at a time) for the user.

Registered owner table does not match input. If no matches can be made, the program prints the appropriate message and returns the user to the initial data entry/edit menu.

Matches to registered owner request found. If one or more matches are made, the program displays the address label, last name, and vehicle license number for each

matching record to the user (one owner record at a time). This function is similar to the one used in the last name section described above. When the user indicates that the appropriate record has been displayed, the database program extracts the license information for that record (into variables ANSWER3 and TLICENSE again) and uses that information for selecting the appropriate rows in the owner and action tables for editing.

Forms used in this section of the code are OWNER2, ACT3FRM, and ACT7FRM. As with the last name section above, a WHILE . . . ENDWHILE loop searches all possible correct answers for the CONTAINS clause, and this loop must be broken with a BREAK command.

Reporting Functions

Currently, three options for reports are functioning from this menu. These options are as follows:

- print labels and letters,
- print HERO statistics, and
- print location information.

Additional output functions may be made to the program if Metro staff determine that additions are desirable.

Print Labels and Letters

The first option within this menu prints the address labels for the brochures, DOT letters and WSP letters that are pending in the database. This option also creates a mail-merge file that helps create the actual WSP and DOT letters that will be mailed to violators.

Records to be printed are selected on the basis of the variables SENDLTR2 and ACTION in the Owner table. SENDLTR2 has been set to 1 for those records for which a label should printed. A label is printed for each of these rows when label reports are printed. Labels are printed for brochures first, DOT letters second, and WSP letters third.

After the labels have been printed, the program outputs a file containing the address and violation information included in the letters to be mailed by the HERO staff. To print the letters, the user must exit the HERO program, load Microsoft WORD, edit the letters as desired, and choose the Print Printer function. (Specific directions for performing this function are included as Appendix B of this report.) Rbase could print these letters directly, but the programers decided that the HERO staff would want to review the letters before they were printed, which was not possible using Rbase directly. This review allows the HERO staff to make a better choice of wording and also lets them check for missing data in the "default form letter."

HERO Statistics

The second report option prints the HERO statistics report. This report includes the distribution of violations between time periods (AM peak, PM peak, and off-peak) and describes the actions taken (number of letters and brochures sent) during the indicated time period. To print the report, the HERO code must make a large number of calculations. These calculations total the number of violations within the specified dates and categories. The dates used in the report are set by the user and stored in the variables BGDT (beginning date) and ENDDT (ending date). Thus, this same report can be used to print both monthly summaries and yearly summaries (or any other time period of interest.) After the report has been printed, the dummy variables used to hold the summary statistics are cleared to provide the computer memory necessary to continue Rbase operation.

The printer report uses the form HEROSTAT. You can find the definition of the variables used in the code by examining this report with the Rbase Report Express utility.

This report is followed by a crosstabulation of directional information with route information. The crosstabulation serves as both a good check for data validity and as a useful summary of violation data. Any abnormal values entered as routes or directions will be apparent in this report, and the user can pinpoint and correct them.

The last portion of this section of code prints a summary of violations by location. This printout should provide useful information on the severity of the violation problem at different locations and also serve as a check on the codes used for indicating locations. As with routes and directional codes, the user can easily spot any abnormal codes and can correct them. The new location coding technique used in this database includes individual route, direction, location and mainline/ramp variables. These variables allow the user to input an almost infinite number of locations into the database. The flexibility of the coding scheme is designed to accommodate expected increases in the number and length of HOV facilities in the Puget Sound region. The only drawback to this added flexibility is that it makes mis-coding relatively easy, but the violation crosstabulation is an effective way of identifying these mistakes so that they can be corrected.

Location Information

This report option prints two formalized summaries of violations by location. The first report (using the LOCNSTAT report form) prints summaries of the number of violations by facility. This report only classifies facilities by I-5, I-405, SR-520 and "other." If additional facilities are added to the HOV system, the form will either need to be changed, or the DOT will have to accept the reporting of violations on those facilities in the "other" category. In addition to the total number of violations for each facility, summaries are provided for both ramp versus mainline violations (by facility) and the percentage of all violations within each of those categories.

The program then prints a second formal report (LOCN2) with this same basic information but in a different format. LOCN2 prints the percentage of ramp versus mainline violations as a percentage of violations for each facility (as opposed to the percentage of all reported violations produced in LOCNSTAT). These reports are produced as separate Rbase forms because of an Rbase limitation of 40 variables per report form.

Finally, under this menu selection, the summary of violations by location code is reprinted. While this is a duplication of the earlier report, the program creators felt that it was applicable to the location reporting function as well as to the basic statistics report.

Delete Old Data

This main menu selection (PICK1 EQ 3) deletes data from the database on the basis of the date the user inputs. All data before the designated input date that do not have a special code (e.g., carries children in the car) are removed from the database.

All data to be deleted from the database are first written to a backup file (user specified) before being removed from the HERO database. The user can output these data with the UNLOAD command and may re-enter them into the HERO database at a later date with the LOAD command.

The deletion occurs in two parts. The first part backs up and deletes the owner table. The second part backs up and deletes the action table. The program requests the user to specify MS-DOS file names to contain the backed-up data and stores them in the FILE (ACTION table) and FILE2 (OWNER table) variables.

While deleting old violations data, the program also eliminates rows that do not contain valid license plate data from both tables. It also deletes Owner table rows lacking owner mailing labels and Action table rows lacking valid violation dates to eliminate the occasional bad records entered into the database.

Use of Rbase

This menu selection (PICK1 EQ 4) starts the Rbase Prompt-by-Example system. This system is designed to allow database users to design their own database queries and perform unanticipated database manipulation and modification.

Quit Database Program

This menu selection (PICK1 EQ 5) ends the HERO session, closes the database, and returns the user to the DOS prompt in the RBFILES directory.

STRUCTURE OF THE DATABASE TABLES

Three files contain all data, forms, and reports for the HERO database: HERO1.RBF, HERO2.RBF, and HERO3.RBF. The files are located on the RBFILES directory on the C drive of the HERO microcomputer. All other HERO related files (APP, APX, and assorted other files) are also located in the RBFILES directory.

The database record files are structured into two tables, Owner and Action. The contents of these tables are described below.

Owner Table

The Owner table contains all of the address information related to a particular vehicle license. In addition, it contains sufficient violation information (date, time, and location of the latest violation for that license) to allow the program to print the required WSP and DOT letters. This date information is also used in the selection of records to be deleted. The columns (variables) included in the table and their meanings are shown below:

Variable Name	Variable Type	Definition
Laname	TEXT	Last Name of the owner
License	TEXT	Vehicle license number
Addlabel	TEXT	All registered owners of the vehicle.
City	TEXT	City for the mailing address
State	TEXT	State for the mailing address
Aptno	TEXT	Apartment number for the mailing address

Variable Name	Variable Type	Definition
Make	TEXT	Make of the vehicle
Model	TEXT	Model of the vehicle
Year	TEXT	Year of the vehicle
Color	TEXT	Color of the vehicle
Violdate	DATE	Latest violation date
Violtime	TIME	Time of latest violation
Sendltr2	TEXT	1 if send letter, 2 if letter sent, 3 is letter was sent more than one cycle previously
Action	TEXT	B= brochure, W = WSP letter, D= DOT letter

Action Table

The Action table contains the information for each of the violations reported on the HERO hotline. Data in the Action table are cross referenced to the Owner table with the License variable. Columns (variables) included in the table are shown below:

Variable Name	Variable Type	Definition
License	TEXT	License plate number
Violdate	DATE	Latest violation date
Violtime	TIME	Time of latest violation
Sendletr	TEXT	Y if send letter, N if don't send letter
Action	TEXT	B= brochure, W = WSP letter, D= DOT letter
Calldate	DATE	Date violation reported to HERO
Calltime	TIME	Time violation reported to HERO

Variable Name	Variable Type	Definition
Answermach	TEXT	Y = answering machine was used
Vehocc	INTEGER	The number of occupants in the car
Route	TEXT	Route used by the violator
Locatn	TEXT	Location of the violator when seen
Directn	TEXT	Direction of travel
MorR	TEXT	M = mainline, R = ramp

SCREEN FORMS

As noted above, data entry and editing are both done from the same basic screen forms. These screens are located within the three HERO.RBF files and are accessible through the Forms Express utility of the Rbase Prompt-by-Example routines. One basic form exists for the Owner table and one form exists for the Action table. Different versions of these forms exist (e.g., the OWNER2 form and the OWNER4 form), depending on whether the form is being used for data entry or editing, and depending on what data are available for selecting the record to be edited. For example, if the user wishes to enter a new record starting with an owner's last name, a different form is needed than if the user starts with a new license plate number.

The data entry forms also differ slightly from the editing forms in that the entry forms provide default data entries (they assume the license plate is a Washington plate from King county) that the user can override, but that in most cases save the HERO staff time and keystrokes when entering information. In all other aspects the forms are essentially identical.

```
$COMMAND
HERO3
SET MESSAGE OFF
*(SET ECHO ON)
OPEN HERO
SET COLOR BACKGRND BLUE
SET COLOR FOREGRND WHITE
SET BELL OFF
SET VAR PICK1 INT
LABEL STARTAPP
NEWPAGE
CHOOSE PICK1 FROM Main IN HERO3.APX
IF PICK1 EQ -1 THEN
  NEWPAGE
  DISPLAY Help1 IN HERO3.APX
  WRITE "Press any key to continue "
  PAUSE
  GOTO STARTAPP
ENDIF
IF PICK1 EQ 0 THEN
 GOTO ENDAPP
ENDIF
*( )
*( )
*(Add / Edit HERO data)
*( )
*( )
IF PICK1 EQ 1 THEN
 SET VAR PICK2 INT
 SET VAR LEVEL2 INT
 SET VAR LEVEL2 TO 0
  WHILE LEVEL2 EQ 0  THEN
  NEWPAGE
  CHOOSE PICK2 FROM Choice1 IN HERO3.APX
  IF PICK2 EQ 0 THEN
   BREAK
  ENDIF
*( )
*(License Plate search)
*( )
  IF PICK2 EQ 1 THEN
    SET VAR answer TEXT
    SET VAR answer2 TEXT
    SET VAR ndate DATE
    SET VAR ntime TIME
    SET VAR ltr TEXT
    SET VAR locate TEXT
    SET VAR rte TEXT
    SET VAR act TEXT
    SET VARIABLE WHVAL1 TEXT
    FILLIN WHVAL1 USING "Please Enter The License Plate Number: "
    SET VARIABLE status INTEGER
    SET POINTER #2 status FOR owner WHERE license EQ .WHVAL1
*( )
*(If License Plate is not found)
```

```
*( )
   IF status < > 0 THEN
    SET VAR check TEXT
    NEWPAGE
    WRITE "License not found" AT 14 10
    FILLIN check USING +
    "Enter new License into database? (Y/N)" AT 16 10
    IF check EQ "Y" THEN
     ENTER Owner4 FOR 1 ROW
     ENTER Act4Frm FOR 1 ROW
     SET VAR answer TEXT
     SET VAR answer2 TEXT
LABEL READD1
     FILLIN answer2 USING +
 "Any more violations for this license? (Y/N)" AT 14 10
     IF answer2 EQ "Y" THEN
      ENTER Act5Frm FOR 1 ROW
      GOTO READD1
     ENDIF
     SET POINTER #1 status1 FOR action SORTED BY violdate =D +
     WHERE license EQ .WHVAL1
          SET POINTER #2 status FOR owner WHERE license EQ
.WHVAL1
     SET VAR ltr TO sendletr IN #1
     SET VAR ndate TO violdate IN #1
     IF ltr EQ "Y" THEN
      SET VAR ntime TO violtime IN #1
      SET VAR locate TO locatn2 IN #1
      SET VAR rte TO route IN #1
      SET VAR act TO action in #1
      CHANGE violdate TO .ndate IN #2
      CHANGE violtime TO .ntime IN #2
      CHANGE sendltr2 TO "1" IN #2
      CHANGE locatn2 TO .locate IN #2
      CHANGE route TO .rte IN #2
      CHANGE action TO .act IN #2
     ENDIF
     CLEAR WHVAL1
     CLEAR status
     CLEAR status1
    ENDIF
   ELSE
*( )
*(If License Plate is found)
*( )
    EDIT USING  Owner2 WHERE license  EQ .WHVAL1
    SELECT license violdate violtime route action +
     FROM Action WHERE license EQ .WHVAL1
    FILLIN answer USING +
  "Do you want to edit old violations data? (Y/N)" AT 24 10
    IF answer EQ "Y" THEN
     EDIT USING Act3Frm SORTED BY violdate=D +
     WHERE license EQ .WHVAL1
    ENDIF
    NEWPAGE
```

```
        FILLIN answer USING +
      "Add new violations data? (Y/N)" AT 14 10
        IF answer EQ "Y" THEN
         ENTER Act7Frm FOR 1 ROW
     LABEL READD3
         SET VAR answer2 TEXT
         FILLIN answer2 USING +
      "Add more violations for this license? (Y/N)" AT 14 10
         IF answer2 EQ "Y" THEN
          ENTER Act7Frm FOR 1 ROW
          GOTO READD3
         ENDIF
        ENDIF
       ENDIF
       SET POINTER #1 status1 FOR action SORTED BY violdate =D +
        WHERE license EQ .WHVAL1
       IF status EQ 0 AND status1 EQ 0 THEN
        SET VAR ltr TO sendletr IN #1
        SET VAR ndate TO violdate IN #1
        IF ltr EQ "Y" THEN
         SET VAR ntime TO violtime IN #1
         SET VAR locate TO locatn2 IN #1
         SET VAR rte TO route IN #1
         SET VAR act TO action IN #1
         CHANGE violdate TO .ndate IN #2
         CHANGE violtime TO .ntime IN #2
         CHANGE sendltr2 TO "1" IN #2
         CHANGE locatn2 TO .locate IN #2
         CHANGE route TO .rte IN #2
         CHANGE action TO .act IN #2
        ENDIF
       ENDIF
       CLEAR WHVAL1
       CLEAR status
       CLEAR status1
      ENDIF
     *( )
     *(Last Name Search)
     *( )
      IF PICK2 EQ 2 THEN
       SET VARIABLE WHVAL1     TEXT
       FILLIN WHVAL1 USING "Please Enter Last Name of Owner Record: "
       SET VARIABLE status INTEGER
       SET POINTER #2 status FOR owner WHERE laname EQ .WHVAL1
     *( )
     *(Last Name Not Found)
     *( )
       IF status < > 0 THEN
        SET VAR answer3 TEXT
        SET VAR answer3 TO "0"
        SET VAR check TEXT
        NEWPAGE
            FILLIN check USING "Last Name Not Found, Add Name To
Database? (Y/N)" AT 14 10
        IF check EQ "Y" THEN
```

```
            ENTER Owner5
                SET var answer3 TO license IN owner WHERE laname EQ
.WHVAL1
            ENTER Act8Frm
            SET POINTER #1 status1 FOR action SORTED BY violdate =D +
             WHERE license EQ .answer3
            SET VAR ndate TO violdate IN #1
            SET VAR ntime TO violtime IN #1
            SET VAR ltr TO sendletr IN #1
            SET VAR locate TO locatn2 IN #1
            SET VAR rte TO route IN #1
            SET VAR act TO action IN #1
            SET pointer #2 status FOR owner WHERE license EQ .answer3
            IF ltr EQ "Y" THEN
             CHANGE violdate TO .ndate IN #2
             CHANGE violtime TO .ntime IN #2
             CHANGE sendltr2 TO "1" IN #2
             CHANGE locatn2 TO .locate IN #2
             CHANGE route TO .rte IN #2
             CHANGE action TO .act IN #2
            ENDIF
           ENDIF
        *( )
        *(Last Name Exists)
        *( )
           ELSE
           WHILE status = 0 THEN
            SET VAR Tadlbl TEXT
            SET VAR tname TEXT
            SET VAR Tlicense TEXT
            SET VAR Tadlbl TO addlabel in #2
            SET VAR TName TO Laname in #2
            SET VAR Tlicense TO license IN #2
            NEWPAGE
            SHOW VAR Tadlbl AT 10 10
            SHOW VAR Tname AT 12 10
            SET VAR answer4 TEXT
            SHOW VAR Tlicense AT 14 10
            FILLIN answer4 USING "Is this the right person? (Y/N/Q)" +
             AT 16 10
            SET VAR answer3 TEXT
            SET VAR answer3 TO "0"
            IF answer4 EQ "Q" THEN
             BREAK
            ENDIF
            IF answer4 EQ "Y" THEN
             SET VAR answer3 TO .tlicense
             EDIT USING  Owner3  +
              WHERE license EQ .tlicense
             SELECT license violdate violtime route action +
              FROM Action WHERE license  EQ  .answer3
             FILLIN answer USING +
        "Do you want to edit old violations data? (Y/N)" AT 24 10
             IF answer EQ "Y" THEN
              EDIT USING Act6Frm SORTED BY violdate=D +
```

```
        WHERE license EQ .answer3
       ENDIF
       NEWPAGE
       FILLIN answer USING +
  "Do you want to add new violations data? (Y/N)" AT 14 10
       IF answer EQ "Y" THEN
        ENTER Act8Frm FOR 1 ROW
LABEL READD2
        SET VAR answer2 TEXT
        FILLIN answer2 USING +
  "Add more violations for this license? (Y/N)" AT 14 10
        IF answer2 EQ "Y" THEN
         ENTER Act8Frm FOR 1 ROW
         GOTO READD2
        ENDIF
       ENDIF
       IF answer3 NE "0" THEN
        SET POINTER #1 status1 FOR action SORTED BY violdate =D +
         WHERE license EQ .answer3
        SET VAR ndate TO violdate IN #1
        SET VAR ntime TO violtime IN #1
        SET VAR ltr TO sendletr IN #1
        SET VAR locate TO locatn2 IN #1
        SET VAR rte TO route IN #1
        SET VAR act TO action IN #1
        IF ltr EQ "Y" THEN
         CHANGE violdate TO .ndate IN #2
         CHANGE violtime TO .ntime IN #2
         CHANGE sendltr2 TO "1" IN #2
         CHANGE locatn2 TO .locate IN #2
         CHANGE route TO .rte IN #2
         CHANGE action TO .act IN #2
        ENDIF
       ENDIF
       BREAK
      ENDIF
      NEXT #2 status
     ENDWHILE
    ENDIF
    CLEAR WHVAL1
    CLEAR status
    CLEAR status1
  ENDIF
*( )
*(Search on the mailing label contents / all registered owners)
*( )
  IF PICK2 EQ 3 THEN
   SET VAR WHVAL1 TEXT
   NEWPAGE
   SET VAR answer TEXT
   FILLIN WHVAL1 USING +
   "Enter name to search for: " AT 14 10
   SET VAR status INTEGER
   SET POINTER #2 status FOR owner +
    WHERE addlabel CONTAINS .WHVAL1
```

```
*( )
*(Registered owner table does not match input)
*( )
  IF status < > 0 THEN
   WRITE "Name not found in database" AT 16 10
   WRITE "Please press a key to continue" AT 18 10
   PAUSE
  ENDIF
*( )
*(Matches to registered owner request found)
*( )
  WHILE status = 0 THEN
   SET VAR Tadlbl TEXT
   SET VAR tname TEXT
   SET VAR Tlicense TEXT
   SET VAR Tadlbl TO addlabel in #2
   SET VAR TName TO Laname in #2
   SET VAR Tlicense TO license IN #2
   NEWPAGE
   SHOW VAR Tadlbl AT 10 10
   SHOW VAR Tname AT 12 10
   SET VAR answer4 TEXT
   SHOW VAR Tlicense AT 14 10
   FILLIN answer4 USING "Is this the right person? (Y/N/Q)" +
     AT 16 10
   IF answer4 EQ "Q" THEN
    BREAK
   ENDIF
   IF answer4 EQ "Y" THEN
    SET VAR WHVAL1 TO .tlicense
    EDIT USING  Owner2  +
     WHERE license  EQ  .Tlicense
    SELECT license violdate violtime route action +
     FROM Action WHERE license EQ .Tlicense
    FILLIN answer USING +
 "Do you want to edit old violations data? (Y/N)" AT 24 10
    IF answer EQ "Y" THEN
     EDIT USING Act3Frm  SORTED BY violdate=D +
      WHERE license EQ .Tlicense
    ENDIF
    NEWPAGE
    FILLIN answer USING +
 "Add new violations data? (Y/N)" AT 14 10
    IF answer EQ "Y" THEN
     ENTER Act7Frm FOR 1 ROW
LABEL READD5
     SET VAR answer2 TEXT
     FILLIN answer2 USING +
     "Add more violations for this license? (Y/N)" +
      AT 14 10
     IF answer2 EQ "Y" THEN
      ENTER Act7Frm FOR 1 ROW
      GOTO READD5
     ENDIF
    ENDIF
```

```
      SET POINTER #1 status1 FOR action SORTED BY violdate =D +
       WHERE license EQ .Tlicense
      SET VAR ndate TO violdate IN #1
      SET VAR ntime TO violtime IN #1
      SET VAR ltr TO sendletr IN #1
      SET VAR locate TO locatn2 IN #1
      SET VAR rte TO route IN #1
      SET VAR act TO action IN #1
      IF ltr EQ "Y" THEN
        CHANGE violdate TO .ndate IN #2
        CHANGE violtime TO .ntime IN #2
        CHANGE sendltr2 TO "1" IN #2
        CHANGE locatn2 TO .locate IN #2
        CHANGE route TO .rte IN #2
        CHANGE action TO .act IN #2
      ENDIF
      CLEAR tlicense
      CLEAR WHVAL1
      CLEAR status
      CLEAR status1
      BREAK
     ENDIF
     NEXT #2 status
    ENDWHILE
   ENDIF
   IF PICK2 EQ 4 THEN
    BREAK
   ENDIF
  ENDWHILE
  CLEAR LEVEL2
  CLEAR PICK2
  CLEAR act
  CLEAR rte
  CLEAR locate
  CLEAR ltr
  CLEAR ntime
  CLEAR ndate
  CLEAR answer
  CLEAR answer2
  CLEAR check
  CLEAR answer3
  GOTO STARTAPP
 ENDIF
 *( )
 *(Reporting functions)
 *( )
 IF PICK1 EQ 2 THEN
  CLEAR ALL VARIABLES
  SET VAR PICK1 INT
  SET VAR PICK1 TO 2
  SET VAR PICK2 INT
  SET VAR LEVEL2 INT
  SET VAR LEVEL2 TO 0
  WHILE LEVEL2 EQ 0  THEN
   NEWPAGE
```

```
    CHOOSE PICK2 FROM Choice2 IN HERO3.APX
    IF PICK2 EQ 0 THEN
     BREAK
    ENDIF
*( )
*{Print Labels Brochures first, then DOT letters, then WSP letters)
*( )
    IF PICK2 EQ 1 THEN
     NEWPAGE
      WRITE "Please prepare printer for labels and type the RETURN Key"
AT 10 5
     PAUSE
     RUN prntlab in labels1.apx
     RUN prntlab in labels2.apx
     RUN prntlab in labels3.apx
*( )
*{Creates the WSDOT letter output file)
*( )
     OUTPUT dotltr.mrg
     WRITE "addlabel,address,aptno,city,state,zip,viodat,+
viotim,license,locatn2,route"
     UNLOAD DATA FOR owner USING +
     addlabel, address, aptno, city, state, zipcode, +
     violdate, violtime, license, locatn2, route AS ASCII +
      WHERE sendltr2 EQ "1" AND action EQ "D"
*( )
*{Creates the WSP output letter file)
*( )
     OUTPUT wspltr.mrg
     WRITE "addlabel,address,aptno,city,state,zip,viodat,+
viotim,license,locatn2,route"
     UNLOAD DATA FOR owner USING +
     addlabel, address, aptno, city, state, zipcode, +
     violdate, violtime, license, locatn2, route AS ASCII +
      WHERE sendltr2 EQ "1" AND action EQ "W"
     OUTPUT SCREEN
*( )
*{Update which records have had letters printed)
*( )
     UPDATE owner SET sendltr2 = "3" +
      WHERE sendltr2 EQ "2"
     UPDATE owner SET sendltr2 = "2" +
      WHERE sendltr2 EQ "1"
     UPDATE action SET sendletr = "N" WHERE sendletr EQ "Y"
    ENDIF
*( )
*{Print first set of output summary reports)
*( )
    IF PICK2 EQ 2 THEN
     SET VAR bgdt DATE
     SET VAR enddt DATE
     NEWPAGE
     WRITE "Enter Begining and ending dates for reports." AT 14 10
     FILLIN bgdt USING "From:" AT 16 10
     FILLIN enddt USING "To:" AT 18 12
```

```
SET VAR totviol INTEGER
COMPUTE totviol AS COUNT violdate FROM action +
 WHERE violdate GE .bgdt  AND violdate LE .enddt
SET VAR bact INTEGER
SET VAR pbact REAL
SET VAR spact INTEGER
SET VAR pspact REAL
SET VAR dotact INTEGER
SET VAR pdotact REAL
SET VAR spcnti INTEGER
SET VAR pspcnti REAL
SET VAR spcnts INTEGER
SET VAR pspcnts REAL
SET VAR unact INTEGER
SET VAR punact REAL
COMPUTE bact AS COUNT action FROM action +
 WHERE violdate GE .bgdt AND violdate LE .enddt +
 AND action EQ "B"
SET VAR pbact TO ( .bact / .totviol )
COMPUTE spact AS COUNT action FROM action +
 WHERE violdate GE .bgdt AND violdate LE .enddt +
 AND action EQ "W"
SET VAR pspact TO ( .spact / .totviol )
COMPUTE dotact AS COUNT action FROM action +
 WHERE violdate GE .bgdt AND violdate LE .enddt +
 AND action EQ "D"
SET VAR pdotact TO ( .dotact / .totviol )
COMPUTE spcnti AS COUNT action FROM action +
 WHERE violdate GE .bgdt AND violdate LE .enddt +
 AND action EQ "P"
SET VAR pspcnti TO ( .spcnti / .totviol )
COMPUTE spcnts AS COUNT action FROM action +
 WHERE violdate GE .bgdt AND violdate LE .enddt +
 AND action EQ "C"
SET VAR pspcnts TO ( .spcnts / .totviol )
SET VAR unact TO ( .totviol - .bact - .spact -.dotact +
   - .spcnti - .spcnts )
SET VAR punact TO ( .unact / .totviol )
SET VAR oneocc INTEGER
SET VAR twoocc INTEGER
SET VAR other INTEGER
SET VAR pone REAL
SET VAR ptwo REAL
SET VAR pother REAL
COMPUTE oneocc AS COUNT vehocc FROM action +
 WHERE vehocc EQ 1 AND violdate GT .bgdt +
 AND violdate LE .enddt
SET VAR pone TO ( .oneocc / .totviol )
COMPUTE twoocc AS COUNT vehocc FROM action +
 WHERE vehocc EQ 2 AND violdate GT .bgdt +
 AND violdate LE .enddt
SET VAR ptwo TO ( .twoocc / .totviol )
SET VAR other TO ( .totviol - .oneocc - .twoocc)
SET VAR pother TO ( .other / .totviol )
SET VAR ampk INTEGER
```

```
SET VAR pmpk INTEGER
SET VAR nonpk INTEGER
SET VAR pampk REAL
SET VAR ppmpk REAL
SET VAR totpk INTEGER
SET VAR pnonpk REAL
COMPUTE ampk AS COUNT violtime FROM action +
 WHERE violtime LE 9:00 AND violtime GE 6:30 +
 AND violdate GE .bgdt AND violdate LE .enddt
SET VAR pampk TO ( .ampk / .totviol )
COMPUTE pmpk AS COUNT violtime FROM action +
 WHERE violtime LE 18:30 AND violtime GE 16:00 +
 AND violdate GE .bgdt AND violdate LE .enddt
SET VAR ppmpk TO ( .pmpk / .totviol )
SET VAR nonpk TO ( .totviol - .ampk - .pmpk )
SET VAR totpk TO ( .ampk + .pmpk )
OUTPUT printer
PRINT herostat where license EQ "f"
NEWPAGE
WRITE "Crosstabulation of route versus direction of travel."
CROSSTAB COUNT violdate FOR route BY dirctn +
 FROM action WHERE violdate GE .bgdt AND violdate LE .enddt
NEWPAGE
WRITE "Number of violations by location code."
SELECT locatn2 COUNT violdate FROM action GROUP BY +
 locatn2  WHERE violdate GE .bgdt AND violdate LE .enddt
NEWPAGE
OUTPUT SCREEN
NEWPAGE
CLEAR bgdt
CLEAR enddt
CLEAR totviol
CLEAR bact
CLEAR pbact
CLEAR spact
CLEAR pspact
CLEAR dotact
CLEAR pdotact
CLEAR spcnti
CLEAR pspcnti
CLEAR spcnts
CLEAR pspcnts
CLEAR unact
CLEAR punact
CLEAR oneocc
CLEAR twoocc
CLEAR other
CLEAR pone
CLEAR ptwo
CLEAR pother
CLEAR ampk
CLEAR pmpk
CLEAR nonpk
CLEAR pampk
CLEAR ppmpk
```

```
    CLEAR pnonpk
    CLEAR totpk
   ENDIF
*( )
*(Prints the second set of output reports)
*( )
   IF PICK2 EQ 3 THEN
    SET VAR bgdt DATE
    SET VAR enddt DATE
    NEWPAGE
    WRITE "Enter Begining and ending dates for reports." AT 14 10
    FILLIN bgdt USING "From:" AT 16 10
    FILLIN enddt USING "To:" AT 18 10
    SET VAR totviol INTEGER
    COMPUTE totviol AS COUNT violdate FROM action +
     WHERE violdate GE .bgdt  AND violdate LE .enddt
    SET VAR ramptot INTEGER
    SET VAR maintot INTEGER
    SET VAR nctot INTEGER
    SET VAR other INTEGER
    SET VAR nc5 INTEGER
    SET VAR nc520 INTEGER
    SET VAR nc405 INTEGER
    SET VAR oramp INTEGER
    SET VAR omain INTEGER
    SET VAR onc INTEGER
    SET VAR main5 INTEGER
    SET VAR main405 INTEGER
    SET VAR main520 INTEGER
    SET VAR ramp5 INTEGER
    SET VAR ramp520 INTEGER
    SET VAR ramp405 INTEGER
    SET VAR tot5 INTEGER
    SET VAR tot520 INTEGER
    SET VAR tot405 INTEGER
    SET VAR tother INTEGER
    SET VAR pnc520 REAL
    SET VAR pnc5 REAL
    SET VAR pnc405 REAL
    SET VAR poramp REAL
    SET VAR pomain REAL
    SET VAR ponc REAL
    SET VAR pmntot REAL
    SET VAR pother REAL
    SET VAR prmptot REAL
    SET VAR pmain5 REAL
    SET VAR pmain405 REAL
    SET VAR pmain520 REAL
    SET VAR pramp5 REAL
    SET VAR pramp405 REAL
    SET VAR prmp520 REAL
    SET VAR ptot5 REAL
    SET VAR ptot520 REAL
    SET VAR ptot405 REAL
    SET VAR ptother REAL
```

```
SET VAR pm5 REAL
SET VAR pr5 REAL
SET VAR pm520 REAL
SET VAR pr520 REAL
SET VAR pm405 REAL
SET VAR pr405 REAL
COMPUTE main5 AS COUNT route FROM action WHERE +
 route EQ "5" AND morr EQ "M" +
 AND violdate GE .bgdt AND violdate LE .enddt
SET VAR pmain5 TO ( .main5 / .totviol )
COMPUTE main405 AS COUNT route FROM action WHERE +
 route EQ "405" AND morr EQ "M" +
 AND violdate GE .bgdt AND violdate LE .enddt
SET VAR pmain405 TO ( .main405 / .totviol )
COMPUTE main520 AS COUNT route FROM action WHERE +
 route EQ "520" AND morr EQ "M" +
 AND violdate GE .bgdt AND violdate LE .enddt
SET VAR pmain520 TO ( .main520 / .totviol )
COMPUTE ramp520 AS COUNT route FROM action WHERE +
 route EQ "520" AND morr EQ "R" AND +
 violdate GE .bgdt AND violdate LE .enddt
SET VAR prmp520 TO ( .ramp520 / .totviol )
COMPUTE ramp5 AS COUNT route FROM action WHERE +
 route EQ "5" AND morr EQ "R" AND +
 violdate GE .bgdt AND violdate LE .enddt
SET VAR pramp5 TO ( .ramp5 / .totviol )
COMPUTE ramp405 AS COUNT route FROM action WHERE +
 route EQ "405" AND morr EQ "R" AND +
 violdate GE .bgdt AND violdate LE .enddt
COMPUTE tot520 AS COUNT route FROM action WHERE+
 route EQ "520" AND violdate GE .bgdt AND violdate LE .enddt
COMPUTE tot5 AS COUNT route FROM action WHERE+
 route EQ "5" AND violdate GE .bgdt AND violdate LE .enddt
COMPUTE tot405 AS COUNT route FROM action WHERE+
 route EQ "405" AND violdate GE .bgdt AND violdate LE .enddt
SET VAR pramp405 TO ( .ramp405 / .totviol )
SET VAR nc5 TO ( .tot5 - .main5 - .ramp5 )
SET VAR nc520 TO ( .tot520 - .main520 - .ramp520 )
SET VAR nc405 TO ( .tot405 - .main405 - .ramp405 )
SET VAR pnc520 TO ( .nc520 / .totviol )
SET VAR pnc5 TO ( .nc5 / .totviol )
SET VAR pnc405 TO ( .nc405 / .totviol )
SET VAR tother TO ( .totviol - .tot5 - .tot520 - .tot405 )
SET VAR ptot5 TO ( .tot5 / .totviol )
SET VAR ptot520 TO ( .tot520 / .totviol )
SET VAR ptot405 TO ( .tot405 / .totviol )
COMPUTE ramptot AS COUNT morr FROM action WHERE+
 morr EQ "R" AND violdate GE .bgdt AND violdate LE .enddt
COMPUTE maintot AS COUNT morr FROM action WHERE+
 morr EQ "M" AND violdate GE .bgdt AND violdate LE .enddt
SET VAR other TO ( .totviol - .maintot - .ramptot )
SET VAR prmptot TO ( .ramptot / .totviol )
SET VAR pmntot TO ( .maintot / .totviol )
SET VAR pother TO ( .other / .totviol )
SET VAR ptother TO ( .tother / .totviol )
```

```
SET VAR oramp TO ( .ramptot - .ramp5 - .ramp520 - .ramp405 )
SET VAR omain TO ( .maintot - .main5 - .main520 - .main405 )
SET VAR onc TO ( .other - .nc5 - .nc520 - .nc405 )
SET VAR poramp TO ( .oramp / .totviol )
SET VAR pomain TO ( .omain / .totviol )
SET VAR ponc TO ( .onc / .totviol )
SET VAR pm5 TO ( .main5 / .tot5 )
SET VAR pr5 TO ( .ramp5 / .tot5 )
SET VAR pm520 TO ( .main520 / .tot520 )
SET VAR pr520 TO ( .ramp520 / .tot520 )
SET VAR pm405 TO ( .main405 / .tot405 )
SET VAR pr405 TO ( .ramp405 / .tot405 )
OUTPUT printer
PRINT locnstat where license EQ "f"
PRINT locn2 where license EQ "f"
NEWPAGE
WRITE "Number of violations grouped by location."
 SELECT locatn2 COUNT violdate FROM action GROUP BY locatn2
+
 WHERE violdate GE .bgdt AND violdate LE .enddt
NEWPAGE
OUTPUT SCREEN
NEWPAGE
CLEAR ramptot
CLEAR maintot
CLEAR nctot
CLEAR other
CLEAR nc5
CLEAR nc520
CLEAR nc405
CLEAR oramp
CLEAR omain
CLEAR onc
CLEAR onc
CLEAR main5
CLEAR main405
CLEAR main520
CLEAR ramp5
CLEAR ramp520
CLEAR ramp405
CLEAR tot5
CLEAR tot520
CLEAR tot405
CLEAR tother
CLEAR pnc520
CLEAR pnc5
CLEAR pnc405
CLEAR poramp
CLEAR pomain
CLEAR ponc
CLEAR pmntot
CLEAR pmain5
CLEAR pmain520
CLEAR pmain405
CLEAR pramp5
```

```
          CLEAR pramp405
          CLEAR pramp520
          CLEAR ptot5
          CLEAR ptot520
          CLEAR ptot405
          CLEAR ptother
          CLEAR pm5
          CLEAR pr5
          CLEAR pm520
          CLEAR pr520
          CLEAR pr405
          CLEAR pm405
         ENDIF
         IF PICK2 EQ 4 THEN
          BREAK
         ENDIF
        ENDWHILE
        CLEAR LEVEL2
        CLEAR PICK2
        GOTO STARTAPP
       ENDIF
       *( )
       *(Deletion of old data)
       *( )
       IF PICK1 EQ 3 THEN
        SET VARIABLE bgdt date
        FILLIN bgdt  USING "Delete Data Prior to What Date? "
        NEWPAGE
        SET VAR file TEXT
        FILLIN file USING "File name for the action file back-up?" AT 12 5
        OUTPUT .file
        UNLOAD ALL FOR action USING ALL WHERE violdate LT .bgdt
        OUTPUT SCREEN
        DELETE ROWS FROM action WHERE violdate LT .bgdt AND Comm1
NE "O3"
        DELETE ROWS FROM action WHERE license FAILS
        DELETE ROWS FROM action WHERE violdate FAILS
        SET VAR file2 TEXT
        FILLIN file2 USING "File name for the owner file back-up?" AT 14 5
        OUTPUT .file2
        UNLOAD ALL FOR owner USING ALL WHERE violdate LT .bgdt
        OUTPUT SCREEN
        DELETE ROWS FROM owner WHERE violdate LT .bgdt AND COMM1
NE "O3" AND COMM1 NE "OC"
        DELETE ROWS FROM owner WHERE license FAILS
        DELETE ROWS FROM owner WHERE addlabel FAILS
        CLEAR .bgdt
        NEWPAGE
        GOTO STARTAPP
       ENDIF
       *( )
       *(Start Rbase prompt)
       *( )
       IF PICK1 EQ 4 THEN
        prompt
```

```
  GOTO STARTAPP
 ENDIF
 *( )
 *(Print list of duplicate license plates)
 *( )
 IF PICK1 EQ 5 THEN
  set pointer #1 status for owner sorted by license +
   where license exists
  set var first text
  set var second text
  set var first to license in #1
  output printer
   while status eq 0 then
   next #1 status
   set var second to license in #1
   If first eq .second then
    write "duplicate license"
    sho var first
   endif
   set var first to license in #1
  endwhile
  output screen
  GOTO STARTAPP
 ENDIF
 IF PICK1 EQ 6 THEN
  GOTO ENDAPP
 ENDIF
 GOTO STARTAPP
 LABEL ENDAPP
 CLEAR ALL VARIABLES
 RETURN
 *( )
 *(End of Main Program)
 *(Begining of menu listings)
 *( )
 $MENU
 Main
 COLUMN HERO Database Main Menu
 Input/Edit Owner or Violation Data
 Print Standard Reports
 Delete Old Data
 Use R:base
 Print Duplicate License Plates
 Quit Database Program
 $MENU
 Choice1
 COLUMN Select Violations Record By:
 License Plate Number
 Last Name
 Names on Mailing Label (very slow)
 Return To Previous Menu
 $MENU
 Choice2
 COLUMN Select Standard Report To Be Produced
 Prepare Letters and Labels For Violators
```

HERO Statistics
Violations By Location Code
Exit To Previous Menu
$SCREEN
Help1
Use Option 1 (Input/Edit) to look up, input or change information stored in the HERO database.

Use Option 2 to produce standardized reports. A list of standardized reports is included with the HELP screen attached to the menu used to select those reports.

Use Option 3 to back-up and delete old HERO database records.

Use Option 4 to produce reports different from those available through Option 2. This option starts the basic R:base program, and assumes that you are capable of using R:base to create your own inquiries and reports.

Use Option 5 to return to the DOS processor and run other programs.

```
$COMMAND
PRNTLAB
CLS
WRITE "LABEL GENERATION IN PROGRESS - PLEASE WAIT" AT 3
15
OUTPUT printer
SET VAR numup TO 1
SET VAR lwidth TO 36
SET VAR maxcol TO (.numup*.lwidth)
*(numup and lwidth set label size; these can be changed)
SET VAR space TO " "
SET VAR col TO 1
SET VAR l1 TO " "
SET VAR l2 TO " "
SET VAR l3 TO " "
SET POINTER #1 s1 FOR owner WHERE sendltr2 EQ "1" AND +
    action EQ "B"
WHILE s1 EQ 0 THEN
 SET VAR line1 TO " "
 SET VAR line2p1 TO " "
 SET VAR line2p2 TO " "
 SET VAR line3p1 TO " "
 SET VAR line3p2 TO " "
 SET VAR line3p3 TO " "
*(first line)*
 SET VAR line1 TO addlabel IN #1
 *(second line)
 SET VAR line2p1 TO address IN #1
 SET VAR temp_apt TO aptno IN #1
 IF temp_apt EXISTS THEN
  SET VAR line2p2 TO ("# " & .temp_apt)
 ENDIF
 *(third line)
 SET VAR line3p1 TO city IN #1
 SET VAR line3p2 TO state IN #1
 SET VAR line3p3 TO zipcode IN #1
 *(Line 1 )
 SET VAR lineno TO 1
 SET VAR leng1 TO (SLEN(.line1))
 IF leng1 GT 36 THEN
  SET VAR line1 TO (SGET(.line1,.lwidth,1))
 ENDIF
 SET VAR l1 TO (SPUT(.l1,.line1,.col))
 SET VAR lineno TO (.lineno + 1)
 SET VAR line1 TO " "
 *( line 2 )
 SET VAR line2 TO (.line2p1 & .line2p2)
 SET VAR leng2 TO (SLEN(.line2))
 IF leng2 GT 36 THEN
  SET VAR line2 TO (SGET(.line2,.lwidth,1))
 ENDIF
 SET VAR l2 TO (SPUT(.l2,.line2,.col))
 SET VAR lineno TO (.lineno + 1)
 SET VAR line2 TO " "
 *( Line 3 )
```

```
SET VAR line3 TO (.line3p1 & .line3p2 & .line3p3)
SET VAR leng3 TO (SLEN(.line3))
IF leng3 GT 36 THEN
  SET VAR line3 TO (SGET(.line3,.lwidth,1))
ENDIF
SET VAR l3 TO (SPUT(.l3,.line3,.col))
SET VAR line3 to " "
SET VAR col TO (.col + .lwidth)
NEXT #1 s1
IF col GTA maxcol OR s1 NE 0 THEN
 WRITE .space
 WRITE .space
 WRITE .l1
 WRITE .l2
 WRITE .l3
 WRITE .space
 WRITE .space
 WRITE .space
 WRITE .space
 SET VAR col TO 1
 SET VAR l1 TO " "
 SET VAR l2 TO " "
 SET VAR l3 TO " "
ENDIF
ENDWHILE
CLEAR v11 v12 v21 v22
CLEAR v31 v32 v33
```

PRINTING DOT AND WSP HERO VIOLATION LETTERS

Printing of letters to be sent to second and third time HOV lane violators should be performed after all other database activities have been completed (including label generation).

To print the WSP and DOT letters, first select the "Print labels and letters option (option 1) from the Reports menu of the database program. Place the labels in the printer for label generation. Then follow the steps listed below to print actual letters:

- exit the HERO database program (choose menu option 5 from the Main Menu),
- start Microsoft WORD (type **WORD [CR]** from the c:\RBFILES> prompt),
- load the WSP form letter file (**type ESC T L HEROWSP.LTR [CR]**),
- merge the form letter to the database output file and print to a secondary file for editing (type **ESC P M D WSPFILE [CR] P**)
- If the computer asks if it may overwrite a file, answer yes (type **Y**),
- load the DOT form letter file (type **ESC T L HERODOT.LTR [CR]**),
- merge the form letter to the database output file and print to a secondary file for editing (type **ESC P M D DOTFILE [CR] P**)
- If the computer asks if it may overwrite a file, answer yes (type **Y**),
- Load the WSP letters for final editing and printing (**ESC T L WSPFILE [CR]**),
- Perform any text editing that is necessary to make the form letter wording correct (look at the wording for the routes and locations for each letter),

- Print the letter (**ESC P P**) (feed the WSP letterhead into the printer from the front of the printer face-up)
- Load the DOT letters for final editing and printing (**ESC T L DOTFILE [CR]**),
- Answer yes (Y) to the request to save the changes to the WSP file,
- Perform any text editing that is necessary to make the form letter wording correct (look at the wording for the routes and locations for each letter),
- Print the letter (**ESC P P**) (feed the DOT letterhead into the printer from the front of the printer face-up)
- Quit WORD (**ESC Q**)
- Answer yes (Y) to the request to save the changes to the DOT file.

The WSP and DOT letters mailed to the violators can be found on the files WSPFILE.DOC and DOTFILE.DOC. These files will remain intact until the next time WSP and DOT letters are printed. At that time, they will be over-written.

While using Microsoft WORD, the following keys will be useful.

- "ARROW" keys move the cursor in the direction of the arrow.
- the "Del" key deletes whatever is highlighted by the cursor.
- the "Ins" key inserts, at the current cursor location, whatever was last deleted.
- the F7 key highlights the word prior to the current cursor position.
- the F8 key highlights the word immediately after the current cursor position.
- the "Backspace" removes the letter prior to the current cursor position.
- The "Esc" key brings up or hides the program menu.
- Once in the menu, use the arrow keys to move between selections.
- Use the "Enter" key to select items from the menu.

The functions of other keys can be found in the Microsoft WORD manual.

APPENDIX C

PUBLIC AWARENESS SURVEY RESULTS

APPENDIX C

PUBLIC AWARENESS SURVEY RESULTS

Below are the frequency results for each of the questions asked in the public awareness survey. The frequency, percent, and valid percent (if different) are given for each response. Multiple responses were allowed for certain questions. The percentages for these questions therefore do not add to 100 percent. Those questions which allowed multiple responses are indicated by an asterisk next to the question number.

1. Do you normally drive I-5, I-90, I-405, SR-520, Aurora Avenue, or Lake City Way during rush hour?

	FREQ	%	VALID %
YES	370	67.2	67.2
NO	181	32.8	32.8
	551	100.0	100.0

2.* On which routes have you seen carpool lanes in King and Snohomish counties (choices were not read to the respondents)?

		FREQ.	VALID %
HAVEN'T SEEN	SKIP TO Q. 9	3	0.5
I-5		327	59.3
I-5 EXPRESS		151	27.4
I-90		54	9.8
I-405		334	60.6
AURORA AVE.		48	8.7
SR-522		44	8.0
SR-520		203	36.8
OTHER		6	1.0
DON'T KNOW		6	1.0

3. When are carpool lanes restricted to buses and carpools?

	FREQ	%	VALID %
ALL THE TIME	435	78.9	79.4
ONLY ON WEEKENDS	18	3.3	3.3
RUSH HOUR ON WEEKENDS	31	5.6	5.7
OTHER	5	0.9	0.9
DON'T KNOW	59	10.7	10.8
(MISSING)	3	0.5	
	551	100.0	100.0

4.* Have you ever used the carpool lanes while traveling in a...

		FREQ	VALID %
BUS		122	22.3
CARPOOL		419	76.5
VANPOOL		14	2.6
MOTORCYCLE		25	4.6
ALONE IN A CAR		53	9.7
ALONE IN A CAR FOR TURNING RIGHT		19	3.5
NEVER USED	SKIP TO Q. 9	85	15.5

5. Which type of vehicle do you use most often when you are in the carpool lanes?

	FREQ	%	VALID %
BUS	31	5.6	20.0
CARPOOL	101	18.3	65.2
VANPOOL	3	0.5	1.9
MOTORCYCLE	5	0.9	3.2
ALONE IN A CAR	15	2.7	9.7
(MISSING)	396	71.9	
	551	100.0	100.0

6. How often do you ride in the carpool lanes, either as a driver or a passenger??

	FREQ	%	VALID %
3-5 DAYS/WEEK	63	11.4	13.6
1-2 DAYS/WEEK	76	13.8	13.6
AT LEAST ONCE A MONTH	144	26.1	31.1
LESS THAN ONCE A MONTH	178	32.3	38.4
DON'T KNOW	2	0.4	0.4
(MISSING)	88	16.0	
	551	100.0	100.0

7. As far as you know, how many people do you need in a car to qualify for the carpool lanes (choices were not read to the respondents)?

	FREQ	%	VALID %
TWO	48	8.7	10.4
THREE	169	30.7	36.5
EITHER 2 OR 3	243	44.1	52.5
OTHER	2	0.4	0.4
DON'T KNOW	1	0.2	0.2
(MISSING)	88	16.0	
	551	100.0	100.0

8.* When you use the carpool lanes, which ones do you use most often, either as a driver or a passenger (choices were not read to the respondents)?

	FREQ	VALID %
I-5	157	33.9
I-5 EXPRESS	62	13.4
I-90	10	2.2
I-405	219	47.3
AURORA AVE.	6	1.3
SR-522	3	0.6
SR-520	67	14.5
DON'T KNOW	9	1.9

9. Do you feel that the use of carpool lanes by cars without the proper number of people is a...

	FREQ	VALID %
SERIOUS PROB.	138	25.0
MINOR PROB.	282	51.2
NOT A PROB.	96	17.4
DON'T KNOW	34	6.2
REFUSED	1	0.2
	551	100.0

10. Do you think that having carpool lanes in the Seattle area is a good idea?

	FREQ	VALID %
YES	466	84.6
QUALIFIED YES	5	0.9
NO	50	9.1
DON'T KNOW	10	1.8
ONLY IF FOR 2+ PEOPLE	6	1.1
IF LANES ARE FOR BUSES ONLY	4	0.7
IF RESTRICTION IS ENFORCED ONLY DURING RUSH HOUR	7	1.3
	3	0.5
	551	100.0

11a. Do you ever drive with enough people in the car to use a carpool lane but choose not to use it?

		FREQ	VALID %
YES		257	46.6
NO	SKIP TO Q. 12	289	52.5
DON'T KNOW		5	0.9
		551	100.0

11b.* Why don't you use the carpool lanes when you can?

	FREQ	VALID %
TOO MUCH TROUBLE TO CHANGE LANES	30	11.7
TRAFFIC ISN'T BAD ENOUGH TRAFFIC	168	65.4
MOVES TOO FAST	12	4.7
OTHER	9	3.5
DON'T KNOW	6	2.3
FORGET TO USE THEM	25	9.7
CARPPOOL LANE IS SLOWER	13	5.1

12. Please tell me if you agree or disagree (strongly or somewhat) with the following statements:

a. Carpool lanes save time for people who can use them.

	FREQ	VALID %
DISAGREE STRONGLY	5	0.9
DISAGREE SOMEWHAT	14	2.5
DON'T KNOW	3	0.5
AGREE SOMEWHAT	85	15.4
AGREE STRONGLY	444	80.6
	551	100.0

b. Carpool lanes make the traffic worse in the other lanes.

	FREQ	VALID %
DISAGREE STRONGLY	246	44.6
DISAGREE SOMEWHAT	156	28.3
DON'T KNOW	17	3.1
AGREE SOMEWHAT	60	10.9
AGREE STRONGLY	72	13.1
	551	100.0

c. Carpool lanes are unfair to drivers who cannot use them.

	FREQ	VALID %
DISAGREE STRONGLY	296	53.7
DISAGREE SOMEWHAT	147	26.7
DON'T KNOW	17	3.1
AGREE SOMEWHAT	43	7.8
AGREE STRONGLY	48	8.7
	551	100.0

d. Carpool lanes reduce traffic congestion in all lanes.

	FREQ	VALID %
DISAGREE STRONGLY	113	20.5
DISAGREE SOMEWHAT	100	18.1
DON'T KNOW	30	5.4
AGREE SOMEWHAT	175	31.8
AGREE STRONGLY	132	24.0
REFUSED	1	0.2
	551	100.0

e. Carpool lanes increase the number of accidents.

	FREQ	VALID %
DISAGREE STRONGLY	283	51.4
DISAGREE SOMEWHAT	146	26.5
DON'T KNOW	59	10.7
AGREE SOMEWHAT	36	6.5
AGREE STRONGLY	22	4.0
REFUSED	5	0.9
	551	100.0

f. Carpool lanes reduce air pollution.

	FREQ	VALID %
DISAGREE STRONGLY	127	23.0
DISAGREE SOMEWHAT	91	16.5
DON'T KNOW	80	14.5
AGREE SOMEWHAT	144	26.1
AGREE STRONGLY	107	19.1
REFUSED	2	0.4
	551	100.0

13. Did you know that there is a hotline you can call, 764-HERO, to report drivers who are using the carpool lanes illegally?

		FREQ	VALID %
YES		448	81.3
NO	SKIP TO Q. 17	103	18.7
		551	100.0

14a.* How did you first learn about this hotline (choices were not read to the respondents)?

	FREQ	VALID %
SIGNS NEXT TO THE FREEWAY	399	89.1
TV/NEWSPAPER	25	5.6
FRIENDS OR RELATIVES	9	2.0
BROCHURE RECEIVED IN THE MAIL	1	0.2
OTHER	2	0.4
DON'T KNOW	6	1.3
RADIO	14	3.1

14b. Have you ever seen signs for the hotline next to the freeway?

	FREQ	%	VALID %
YES	433	78.6	96.7
NO	12	2.2	2.7
DON'T KNOW	3	0.5	0.7
(MISSING)	103	18.7	
	551	100.0	100.0

14c. Do you feel that having this phone number reduces the illegal use of carpool lanes...

	FREQ	%	VALID %
A GREAT DEAL	26	4.7	5.8
SOMEWHAT	128	23.2	28.6
NOT VERY MUCH	140	25.4	31.3
NOT AT ALL	106	19.2	23.7
DON'T KNOW	48	8.7	10.7
(MISSING)	103	18.7	
	551	100.0	100.0

15a. Have you ever called 764-HERO to report a violation?

		FREQ	%	VALID %
YES		28	5.1	6.3
NO	SKIP TO Q. 16	420	76.2	93.8
(MISSING)		103	18.7	
		551	100.0	100.0

15b. How many times have you called:

	FREQ	%	VALID %
ONCE	11	2.0	39.3
TWICE	5	0.9	17.9
THREE OR MORE TIMES	11	2.0	39.3
DON'T KNOW	1	0.2	3.6
(MISSING)	523	94.9	
	551	100.0	100.0

16a. Do you think it is a good idea to have such a hotline?

	FREQ	%	VALID %
YES	317	57.5	70.8
NO	97	17.6	21.7
DON'T KNOW	34	6.2	7.6
(MISSING)	103	18.7	
	551	100.0	100.0

16b. Do you think the HERO hotline helps to reduce violations?

	FREQ	%	VALID %
YES	224	40.7	50.0
NO	144	26.1	32.1
DON'T KNOW	80	14.5	17.9
(MISSING)	103	18.7	
	551	100.0	100.0

17. What is your age?

	FREQ	VALID %
18-25 YEARS	69	12.5
26-40 YEARS	241	43.7
41-65 YEARS	191	34.7
OVER 65 YEARS	47	8.5
REFUSED	3	0.5
	551	100.0

18. What is your zipcode?

NOT SHOWN HERE

19. What is your household income?

	FREQ	VALID %
UNDER $10,000	32	5.8
$10,000-$25,000	93	16.9
$25,000-$40,000	170	30.9
OVER $40,000	189	34.3
DON'T KNOW	67	12.2
	551	100.0

APPENDIX D

PROGRAM FOR RECORDING HOV VIOLATIONS

APPENDIX D

PROGRAM FOR RECORDING HOV VIOLATIONS

```
10    OPEN "NUM" FOR INPUT AS 1
20    INPUT #1,N
30    FI$="D"+RIGHT$(STR$(N),LEN(STR$(N))-1)
40    INPUT#1,TL
50    CLOSE 1
60    CLS
70    OPEN FI$ FOR OUTPUT AS 1
80    T$=TIME$
90    T1=3600*VAL(LEFT$(T$,2))+60*VAL(MID$(T$,4,2))+VAL(RIGHT$(T
      $,2))
100   T$=TIME$
110   HR=VAL(LEFT$(T$,2))
120   MI=VAL(MID$(T$,4,2))
130   SE=VAL(RIGHT$(T$,2))
140   TT=3600*HR+60*MI+SE-T1
150   IF TT=TL THEN GOTO 380
160   A$=INKEY$
170   IF A$=" " THEN GOTO 100
180   NP=VAL(A$)
190   IF A$="0" THEN NP=10
200   IF A$="7" THEN NP=0
210   IF A$="8" THEN NP=0
220   IF NP=0 THEN SOUND 16300,10: CLS: PRINT @ 130,"ILLEGAL KEY":
      GOTO 100
230   FR=3000
240   IF A$="9" THEN FR=5000
250   SOUND FR,10
260   IF A$="0" THEN B$="UNSURE OF OCCUPANCY"
270   IF A$="1" THEN B$="SOV"
280   IF A$="2" THEN B$=A$+" PERS. CARPOOL"
290   IF A$="3" THEN B$=A$+" PERS. CARPOOL"
300   IF A$="4" THEN B$="VANPOOL"
310   IF A$="5" THEN B$="MOTORCYCLE"
320   IF A$="6" THEN B$="BUS"
330   IF A$="9" THEN B$="CORRECTION NOTED"
340   CLS
350   PRINT@120,TT;"..... ";B$
360   PRINT#1,USING "!!";A$,CHR$(TT MOD100+27)
370   GOTO 100
380   PRINT #1,"XXXX"
390   CLOSE 1
400   OPEN "NUM" FOR OUTPUT AS 1
410   N=N+1
420   PRINT #1,N
430   PRINT #1,TL
440   CLOSE 1
450   SOUND 400,20
460   MENU
```

APPENDIX E

HOV VIOLATION MONITORING RESULTS

APPENDIX E

HOV VIOLATION MONITORING RESULTS

This appendix gives the results of the three-week HOV violation monitoring effort which was done as part of this project. Minimum and maximum violations and violation rates, HOV lane and general purpose lanes volumes, and the speed and lane occupancy in the general purpose lanes are given for both the SR-520 and the I-5 at N.E. 175th Street sites. For the other I-5 site, only minimum and maximum HOV lane violations and violation rates, and HOV lane are given. Other data was not available due to a malfunctioning data station. An asterisk indicates data were lost or bad.

RESULTS FROM I-5 AT N.E. 175TH STREET

MINIMUM VIOLATIONS

TIME	3/22	3/23	3/24	3/27	3/28	3/30	3/31	4/03	4/04	4/05	4/06	4/07	4/10	4/11	AVG	STDEV
6:45	*	11	16	13	2	3	12	7	17	23	17	9	8	10	11.38	5.68
7:00	13	14	23	9	9	5	4	5	13	19	29	14	16	16	13.50	6.81
7:15	13	16	17	9	9	6	9	11	13	9	25	15	18	15	13.21	4.77
7:30	12	15	21	5	6	7	16	20	20	27	30	20	16	15	16.43	7.11
TTLS	38	56	77	36	26	21	41	43	43	78	101	58	58	56	53.71	21.00

MAXIMUM VIOLATIONS

TIME	3/22	3/23	3/24	3/27	3/28	3/30	3/31	4/03	4/04	4/05	4/06	4/07	4/10	4/11	AVG	STDEV
6:45	*	15	19	16	3	6	12	14	20	28	20	13	8	13	14.38	6.34
7:00	16	16	23	12	11	6	6	8	16	24	34	16	17	16	15.79	7.28
7:15	13	19	19	16	10	8	10	14	16	13	30	16	19	17	15.71	5.22
7:30	13	15	23	7	6	10	20	24	22	29	32	20	17	18	18.29	7.39
TTLS	42	65	84	51	30	30	48	60	74	94	116	65	61	64	63.14	22.90

HOV LANE VOLUME

TIME	3/22	3/23	3/24	3/27	3/28	3/30	3/31	4/03	4/04	4/05	4/06	4/07	4/10	4/11	AVG	STDEV
6:45	*	92	62	92	69	85	97	82	86	109	103	90	72	89	86.77	12.73
7:00	106	113	114	93	114	109	110	88	103	115	122	126	102	105	108.57	9.88
7:15	115	131	117	129	118	98	102	100	115	123	129	132	125	104	117.00	11.53
7:30	101	93	98	99	74	84	92	120	100	122	108	110	109	99	100.64	12.46
TTLS	322	429	391	413	375	376	401	390	404	469	462	458	408	397	406.79	37.69

GENERAL PURPOSE LANES VOLUMES

TIME	3/22	3/23	3/24	3/27	3/28	3/30	3/31	4/03	4/04	4/05	4/06	4/07	4/10	4/11	AVG	STDEV
6:45	*	1896	1591	867	1778	1619	1738	1350	1505	1399	1522	1565	1585	1463	1529.1	240.02
7:00	1760	1698	1654	887	1767	1827	1755	1150	1695	1390	1638	1649	1595	1582	1574.8	253.67
7:15	1922	1653	1633	963	1747	1821	1395	1342	1661	1442	1488	1523	1534	1629	1553.8	225.97
7:30	1622	1892	1657	883	1693	1758	1226	1495	1648	1362	1470	1517	1457	1585	1519.0	238.90
TTLS	5304	7139	6535	3600	6985	1025	6114	5337	6509	5593	6118	6254	6171	6259	6067.4	879.83

MINIMUM VIOLATION RATE

TIME	3/22	3/23	3/24	3/27	3/28	3/30	3/31	4/03	4/04	4/05	4/06	4/07	4/10	4/11	AVG	STDEV
6:45	*	12.0	25.8	14.1	2.9	3.5	12.4	8.5	19.8	21.1	16.5	10.0	11.1	11.2	13.0	6.3
7:00	11.3	12.4	20.2	9.7	7.9	4.6	3.6	5.7	12.6	16.5	23.8	11.1	15.7	15.2	12.2	5.8
7:15	11.3	12.2	14.5	7.0	7.6	6.1	8.8	11.0	11.3	7.3	19.4	11.4	14.4	14.4	11.2	3.7
7:30	11.9	16.1	21.4	5.1	8.1	8.3	17.4	16.7	20.0	22.1	27.8	18.2	14.7	15.2	16.2	6.0
TTLS	11.8	13.1	19.7	8.7	6.9	5.6	10.2	11.0	15.6	16.6	21.9	12.7	14.2	14.1	13.0	4.4

MAXIMUM VIOLATION RATE

TIME	3/22	3/23	3/24	3/27	3/28	3/30	3/31	4/03	4/04	4/05	4/06	4/07	4/10	4/11	AVG	STDEV
6:45	*	16.3	30.7	17.4	4.4	7.1	12.4	17.1	23.3	25.7	19.4	14.4	11.1	14.6	16.4	7.0
7:00	15.1	14.2	20.2	12.9	9.7	5.5	5.5	9.1	15.5	20.9	27.9	12.7	16.7	15.2	14.3	6.1
7:15	11.3	14.5	16.2	12.4	8.5	8.2	9.8	14.0	13.9	10.6	23.3	12.1	15.2	16.4	13.5	3.9
7:30	12.9	16.1	23.5	7.1	8.1	11.9	21.7	20.0	22.0	23.8	19.7	18.2	15.6	18.2	18.1	6.2
TTLS	13.0	15.2	21.5	12.4	8.0	8.0	12.0	15.4	18.3	20.0	25.1	14.2	15.0	16.1	15.3	4.6

AVERAGE SPEED IN THE GENERAL PURPOSE LANES

TIME	3/22	3/23	3/24	3/27	3/28	3/30	3/31	4/03	4/04	4/05	4/06	4/07	4/10	4/11	AVG	STDEV
6:45	50.0	50.0	50.0	11.5	50.0	38.9	50.0	38.1	36.0	32.7	49.7	50.0	50.0	50.0	43.4	10.8
7:00	50.0	50.0	45.7	11.7	50.0	50.0	47.2	50.0	50.0	32.2	42.3	50.0	50.0	50.0	44.9	10.4
7:15	50.0	50.0	43.9	11.8	50.0	50.0	27.7	50.0	43.0	37.1	37.6	50.0	39.1	50.0	42.2	10.8
7:30	50.0	48.3	47.2	11.8	50.0	50.0	24.0	49.5	43.1	32.3	35.4	50.0	35.8	50.0	41.2	11.5
TTLS	50.0	49.6	46.7	11.7	50.0	47.2	37.2	46.9	43.0	33.6	41.3	50.0	43.7	50.0	42.9	10.0

AVERAGE OCCUPANCY IN THE GENERAL PURPOSE LANES

TIME	3/22	3/23	3/24	3/27	3/28	3/30	3/31	4/03	4/04	4/05	4/06	4/07	4/10	4/11	AVG	STDEV
6:45	19.3	19.2	15.3	45.8	18.6	27.0	18.8	21.8	25.5	25.9	17.4	15.0	15.2	14.6	21.4	7.9
7:00	17.9	17.0	20.7	45.9	18.1	17.9	22.1	10.8	18.3	26.2	23.8	16.2	16.5	16.1	20.5	7.9
7:15	20.8	17.1	20.8	49.1	18.1	17.8	31.9	13.6	23.7	23.6	24.0	14.8	24.9	16.9	22.7	8.7
7:45	16.5	22.2	20.4	45.2	17.0	17.9	31.4	16.7	23.5	25.7	25.2	15.4	24.9	17.2	22.8	7.7
TTLS	18.6	18.9	19.3	46.5	18.0	20.2	26.0	15.7	22.8	25.4	22.6	15.4	20.4	16.2	21.8	7.5

RESULTS FROM SR-520

MINIMUM HOV VIOLATIONS

TIME	3/22	3/23	3/24	3/27	3/28	3/30	3/31	4/03	4/04	4/05	4/06	4/07	4/10	4/11	AVG	STDEV
6:45	*	*	1	3	3	3	2	1	6	2	4	2	2	1	2.50	1.38
7:00	*	4	1	5	2	1	0	2	3	4	0	1	3	2	2.15	1.51
7:15	*	3	0	3	5	4	5	1	3	4	3	1	1	3	2.77	1.53
7:30	*	3	4	6	0	1	3	2	4	5	5	2	5	1	3.15	1.79
TTLS	13	10	6	17	10	9	10	6	16	15	12	6	11	7	10.57	3.56

MAXIMUM HOV VIOLATIONS

TIME	3/22	3/23	3/24	3/27	3/28	3/30	3/31	4/03	4/04	4/05	4/06	4/07	4/10	4/11	AVG	STDEV
6:45	*	*	1	6	4	4	2	3	6	5	5	2	4	5	3.92	1.55
7:00	*	6	1	8	6	5	2	5	11	6	3	7	7	3	5.38	2.59
7:15	*	6	0	6	8	6	8	2	11	10	7	5	5	5	6.08	2.84
7:30	*	4	7	7	3	4	8	4	18	12	11	6	9	3	7.38	4.16
TTLS	26	16	9	27	21	19	20	14	46	33	26	20	25	16	22.71	8.78

HOV LANE VOLUME

TIME	3/22	3/23	3/24	3/27	3/28	3/30	3/31	4/03	4/04	4/05	4/06	4/07	4/10	4/11	AVG	STDEV
6:45	*	*	25	48	38	32	34	39	35	42	36	27	32	49	7.06	49.91
7:00	*	56	45	54	55	52	45	59	65	61	48	56	58	54	5.68	32.25
7:15	*	79	43	67	69	55	53	63	61	71	56	51	78	71	10.46	109.36
7:30	*	46	41	71	46	43	53	52	75	61	67	48	80	81	13.91	193.56
TTLS	210	181	154	240	208	182	185	213	236	235	207	182	248	255	29.11	847.20

GENERAL PURPOSE LANES VOLUMES

TIME	3/22	3/23	3/24	3/27	3/28	3/30	3/31	4/03	4/04	4/05	4/06	4/07	4/10	4/11	AVG	STDEV
6:45	*	*	672	661	834	881	853	839	828	766	822	793	795	347	757.6	139.6
7:00	*	*	851	604	820	852	823	827	741	712	782	860	759	295	743.8	152.6
7:15	*	733	657	676	742	782	791	701	745	681	786	865	711	267	702.9	137.2
7:30	*	871	801	584	776	809	781	769	773	695	785	841	700	300	729.6	142.2
TTLS	3319	*	2981	2525	3172	3324	3248	3136	3087	2854	3175	3359	2965	1209	2854.1	631.9

MINIMUM VIOLATION RATE

TIME	3/22	3/23	3/24	3/27	3/28	3/30	3/31	4/03	4/04	4/05	4/06	4/07	4/10	4/11	AVG	STDEV
6:45	*	*	4.0	6.3	7.9	9.4	5.9	2.6	17.1	4.8	11.1	7.4	6.3	2.0	7.1	4.0
7:00	*	7.1	2.2	9.3	3.6	1.9	0.0	3.4	4.6	6.6	0.0	1.8	5.2	3.7	3.8	2.6
7:15	*	3.8	0.0	4.5	7.3	7.3	9.4	1.6	4.9	5.6	5.4	2.0	1.3	4.2	4.4	2.6
7:30	*	6.5	9.8	8.5	0.0	2.3	5.7	3.9	5.3	8.2	7.5	4.2	6.3	1.2	5.3	2.8
TTLS	6.2	5.5	3.9	7.1	4.8	5.0	5.4	2.8	6.8	6.4	5.8	3.3	4.4	2.8	5.0	1.4

MAXIMUM VIOLATION RATE

TIME	3/22	3/23	3/24	3/27	3/28	3/30	3/31	4/03	4/04	4/05	4/06	4/07	4/10	4/11	AVG	STDEV
6:45	*	*	4.0	12.5	10.5	12.5	5.9	7.7	17.1	11.9	13.9	7.4	12.5	10.2	10.5	3.5
7:00	*	10.7	2.2	14.8	10.9	9.6	4.4	8.5	16.9	9.8	6.3	12.5	12.1	5.6	9.6	4.0
7:15	*	7.6	0.0	9.0	11.6	10.9	15.1	3.2	18.0	14.1	12.5	9.8	6.4	7.0	9.6	4.3
7:30	*	8.7	17.1	9.9	6.5	9.3	15.1	7.7	24.0	19.7	16.4	12.5	11.3	3.7	12.4	5.5
TTLS	12.4	8.8	5.8	11.3	10.1	10.4	10.8	6.6	19.5	14.0	12.6	11.0	10.1	6.3	10.7	3.4

AVERAGE SPEED IN THE GENERAL PURPOSE LANES

TIME	3/22	3/23	3/24	3/27	3/28	3/30	3/31	4/03	4/04	4/05	4/06	4/07	4/10	4/11	AVG	STDEV
6:45	44.3	21.7	47.3	34.6	39.0	48.9	35.6	30.1	31.4	36.1	47.4	50.0	38.1	50.0	38.9	8.9
7:00	37.6	36.6	40.1	35.3	38.4	41.5	38.5	40.7	34.5	39.3	43.6	48.6	32.9	50.0	39.8	4.7
7:15	27.3	36.2	28.0	29.8	36.6	32.3	36.9	26.3	32.6	31.6	32.2	38.3	31.4	50.0	33.5	5.8
7:30	36.4	38.2	40.2	31.5	40.1	37.9	38.0	35.8	37.3	31.8	39.6	44.4	29.6	50.0	37.9	5.0
TTLS	36.4	33.2	38.9	32.8	38.5	40.1	37.2	33.2	34.0	34.7	40.7	45.3	30.5	50.0	37.5	5.1

AVERAGE OCCUPANCY IN THE GENERAL PURPOSE LANES

TIME	3/22	3/23	3/24	3/27	3/28	3/30	3/31	4/03	4/04	4/05	4/06	4/07	4/10	4/11	AVG	STDEV
6:45	22.5	39.7	13.7	22.1	23.7	18.8	25.3	29.1	28.1	23.0	18.2	15.2	30.6	5.5	22.5	8.0
7:00	25.3	24.2	23.9	21.6	24.4	22.7	23.8	23.5	24.7	21.0	19.9	18.4	26.8	5.7	21.9	5.0
7:15	34.5	23.9	27.3	27.5	25.0	28.3	24.7	31.5	27.4	26.2	27.7	24.7	28.3	6.4	26.0	6.1
7:45	23.4	25.9	22.1	24.6	23.1	24.0	24.3	26.2	24.1	25.6	22.0	21.0	29.6	6.2	23.0	5.1
TTLS	26.4	28.4	21.8	24.0	24.1	23.5	24.5	27.6	26.1	24.0	22.0	19.8	28.8	6.0	23.3	5.4

RESULTS FROM I-5 AT N.E. 145TH STREET

MINIMUM HOV VIOLATIONS

TIME	3/22	3/23	3/24	3/27	3/28	3/30	3/31	4/03	4/04	4/05	4/06	4/07	4/10	4/11	AVG	STDEV
6:45	*	2	8	10	2	5	4	7	3	19	5	3	4	3	5.77	4.46
7:00	*	6	14	8	3	9	7	7	5	7	6	5	8	2	6.69	2.84
7:15	*	10	9	9	6	7	9	5	6	11	22	12	6	4	8.92	4.43
7:30	*	4	9	11	5	10	11	9	13	13	13	13	6	8	9.62	3.03
TTLS	22	22	40	38	16	31	31	28	27	50	46	33	24	17	30.36	9.90

MAXIMUM HOV VIOLATIONS

TIME	3/22	3/23	3/24	3/27	3/28	3/30	3/31	4/03	4/04	4/05	4/06	4/07	4/10	4/11	AVG	STDEV
6:45	*	9	17	22	5	6	8	13	11	31	13	9	8	9	12.38	6.97
7:00	*	14	17	18	12	14	13	12	8	18	11	11	18	8	13.38	3.41
7:15	*	27	20	19	15	13	14	10	10	26	32	19	8	10	17.15	7.23
7:30	*	8	13	23	11	17	18	17	15	20	21	24	9	11	15.92	5.06
TTLS	68	58	67	82	43	50	53	52	44	95	77	63	43	38	59.50	16.15

HOV VOLUMES

TIME	3/22	3/23	3/24	3/27	3/28	3/30	3/31	4/03	4/04	4/05	4/06	4/07	4/10	4/11	AVG	STDEV
6:45	*	51	82	93	67	83	81	89	90	109	90	62	58	101	81.23	16.51
7:00	*	95	108	95	110	107	103	99	104	108	106	113	118	103	105.31	6.35
7:15	*	125	126	125	128	104	131	103	117	150	146	131	130	121	125.92	12.91
7:30	*	83	104	110	81	94	95	111	104	130	103	114	127	97	104.08	14.12
TTLS	376	354	420	423	386	388	410	402	415	497	445	420	433	422	413.64	32.83

MINIMUM VIOLATION RATE

TIME	3/22	3/23	3/24	3/27	3/28	3/30	3/31	4/03	4/04	4/05	4/06	4/07	4/10	4/11	AVG	STDEV
6:45	*	3.9	9.8	10.8	3.0	6.0	4.9	7.9	3.3	17.4	5.6	4.8	6.9	3.0	6.7	3.9
7:00	*	6.3	13.0	8.4	2.7	8.4	6.8	7.1	4.8	6.5	5.7	4.4	6.8	1.9	6.4	2.7
7:15	*	8.0	7.1	7.2	4.7	6.7	6.9	4.9	5.1	7.3	15.1	9.2	4.6	3.3	6.9	2.8
7:30	*	4.8	8.7	10.0	6.2	10.6	11.6	8.1	12.5	10.0	12.6	11.4	4.7	8.3	9.2	2.6
TTLS	5.9	6.2	9.5	9.0	4.2	8.0	7.6	7.0	6.5	10.1	10.3	7.9	5.5	4.0	7.3	2.0

MAXIMUM VIOLATION RATE

TIME	3/22	3/23	3/24	3/27	3/28	3/30	3/31	4/03	4/04	4/05	4/06	4/07	4/10	4/11	AVG	STDEV
6:45	*	17.7	20.7	23.7	7.5	7.2	9.9	14.6	12.2	28.4	14.4	14.5	13.8	8.9	14.9	6.1
7:00	*	14.7	15.7	19.0	10.9	13.1	12.6	12.1	7.7	16.7	10.4	9.7	15.3	7.8	12.7	3.3
7:15	*	21.6	15.9	15.2	11.7	12.5	10.7	9.7	8.6	17.3	21.9	14.5	6.2	8.3	13.4	4.8
7:30	*	9.6	12.5	20.9	13.6	18.1	19.0	15.3	14.4	15.4	20.4	21.1	7.1	11.3	15.3	4.3
TTLS	18.1	16.4	16.0	19.4	11.1	12.9	12.9	12.9	10.6	19.1	17.3	15.0	9.9	9.0	14.3	3.3

APPENDIX F

DETERMINATION OF THE SAMPLE SIZE NECESSARY TO DETERMINE THE AM PEAK PERIOD VIOLATION RATE

APPENDIX F

DETERMINATION OF THE SAMPLE SIZE NECESSARY TO DETERMINE THE AM PEAK PERIOD VIOLATION RATE

The following formulae can be used to test whether two means are statistically different:

$$t = \frac{(\bar{x}_1 - \bar{x}_2)}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

subscript$_1$ refers to data from the first half-hour (6:45-7:15 a.m.)

subscript$_2$ refers to data from the second half-hour (7:15-7:45 a.m.)

where
- t = test statistic
- $\bar{x}$ = sample mean violation rate
- S = sample standard deviation
- n = sample size

Null hypothesis (H_0): $(\bar{x}_1 - \bar{x}_2) = \emptyset$

Alt. hypothesis (H_1): $(\bar{x}_1 - \bar{x}_2) \neq \emptyset$

If $t > t^*/_{\alpha} = .05$, $df = n_1 + n_2 - 2$, 2-tailed > reject H_0
otherwise no difference exists between the two intervals

SR-520	I-5
$\bar{x}_1 = 4.897$, $S_1 = 2.063$, $n_1 = 12$	$\bar{x}_1 = 12.62$, $S_1 = 5.61$, $n_1 = 13$
$\bar{x}_2 = 4.891$, $S_2 = 1.694$, $n_2 = 12$	$\bar{x}_2 = 13.58$, $S_2 = 4.55$, $n_2 = 13$
$t = .8$, $t^* = 2.074$	$t = .47$, $t^* = 2.064$
$t < t^*$	$t < t^*$

There is no significant difference between the two half-hour intervals on either SR-520 or I-5.

The following formula can be used to estimate the sample size necessary to generation a given level of accuracy:

$$n = \left[\frac{t^* \cdot S}{P}\right]^2$$

where
- n = sample size
- t* = critical value of t, let dF = 9, α = .05, 2-tailed
- S = sample standard deviation
- P = precision level

$$\underset{\text{rate}}{\text{estimated violation}} - P \leq \underset{\text{rate}}{\text{true violation}} \leq \underset{\text{rate}}{\text{estimated violation}} + P$$

SR-520	I-5
S = 1.37	S = 4.38
P = 1	P = 2
t* = 2.262	t* = 2.262
n = 9.6	n = 24.5
The violation rate on SR-520 can be estimated to within ± 1 using 10 observations	The violation rate on I-5 can be estimated to within ± 2 using 25 observations

APPENDIX G

PROTOTYPE OF AN HOV VIOLATION SPREADSHEET

APPENDIX G

PROTOTYPE OF AN HOV VIOLATION SPREADSHEET

The HOV violation spreadsheet program developed for this project consists of a template spreadsheet (HEROTMP.WK1) and the yearly spreadsheets that it produces. The researchers used Lotus 1-2-3 to develop the spreadsheets. In order for the user to enter data into a new spreadsheet, the user first enters the Lotus program. Next, the user retrieves the HEROTMP.WK1 spreadsheet. The start up macro will then take over.

This appendix describes the user instructions needed to work through the spreadsheet, describes the macros used by the spreadsheet, presents a layout of the spreadsheet itself, and provides a listing of all the macros used by the spreadsheet.

HOV VIOLATION SPREADSHEET USER INSTRUCTIONS

HEROTMP (HERO Template)

The HOV violation spreadsheet consists of four quarters plus yearly totals. The following sequence of events takes place:

- The user enters the year. The program enters the year into cell E7 and copies it to every quarter. The macro subtracts 1900 and places this value into cell A60 for OBDATE; and the user chooses location (I-5, I-405, SR520). The user enters the observation location and has two choices: northbound or southbound for I-5 and I-405, eastbound or westbound for SR520. (Additional locations can be added.) The macro will adjust the I-405 worksheet to delete "# of 2 PERS" because two-person carpools are allowed to use the I-405 HOV lanes.
- The macro puts TESTDATES into the appropriate cells for use in the DATA-ENTRY macro. (DATA-ENTRY will use these dates to put data into the right quarter.)

- The macro asks the user to save the worksheet. Possible names are
  - I5NB89
  - I405SB89
  - SR520W89

  (The user may select other file names.)
- Finally, the macro erases the startup macro, loads titles, and is ready to run DATA-ENTRY or PRINT macro.

DATA-ENTRY Macro [Alt]-A

The user

- enters month (e.g., 3 = March) -- DATA-ENTRY places this in cell A61, and
- enters day (e.g., 13) -- DATA-ENTRY places this in cell A62.
- DATA-ENTRY tests OBDATE and places it into the appropriate quarter. (If the date is not valid, DATA-ENTRY prompts the user to enter a new date that corresponds with the open worksheet.)

DATA-ENTRY then

- asks for the start time (e.g., 700 = 7:00 a.m.),
- asks for finish time (e.g., 700 = 7:00 a.m.),
- asks for number of SOV,
- asks for number of two-person carpools (except for I-405),
- asks for number of total persons,
- asks for number of vehicles in HOV, and
- calculates the violation rate.

The program then places the current observation into the bottom row of the quarter's observation field and places the number of observations into the appropriate cell: OBNUM1, OBNUM2, OBNUM3, or OBNUM4. Another menu then asks the user to QUIT or ENTER more observations.

- If ENTER is chosen, the macro runs again from the start.
- If QUIT is chosen, the program asks the user to save the worksheet.
- The final chore of the DATA-ENTRY macro is to compute year-to-date statistics, based only on the quarters that contain observations.

Print Macro [Alt]-P

The PRINT macro prints out a hard copy of the worksheet. There are three choices associated with the print macro: Quarter, Year, and All.

- Quarter allows the user to print out one of the four quarters of their choice.
- Year will print the year-to-date statistics.
- All will print all four quarters and the year-to-date statistics.

About the Worksheet

The worksheet is set up horizontally:

Quarter 1	Quarter 2	Quarter 3	Quarter 4	Year-to-Date

One quarter is on the screen at a time. To get to the next quarter use the TAB key. To scroll down the present quarter, use the DOWN-ARROW key.

Below the worksheet are the macros. These cannot be edited or deleted.

DESCRIPTION OF SPREADSHEET MACROS

Start-up Macro (\O)

This macro is executed only from the HEROTMP worksheet.

- First, the macro asks the user to enter the year. The macro tests the year to see if 1900 <= YEAR < 3000. If this is not true, the user is asked to enter the year again. If the year is valid, the macro stores the date minus 1900 in cell A60 for future use in the DATA-ENTRY macro. The macro stores the

year in cell E7 and copies it to the other three quarters and to the year-to-date statistics.

- Next, START-UP calls the LOCATION macro (described below) and then copies the location to all quarters and to the year-to-date statistics.
- Then START-UP erases the range name \O so the START-UP macro will not be executed upon opening this newly produced spreadsheet.
- START-UP calls the TESTDATE macro (described below) and then the SAVE macro (described below).
- Finally, START-UP sets the horizontal title and is then ready for the user to enter data or otherwise exercise the spreadsheet.

Location Macro (LOCATION)

The LOCATION macro determines to which observation location the worksheet will correspond.

- The macro prompts the user for the route: I-5, I-405, or SR 520.
- Next, the user must choose from the given locations. As of this writing, each roadway has two possible choices corresponding to one physical location and the direction of the observation. The choices are
  - I-5 at N.E. 145th Street (northbound or southbound),
  - I-405 at N. 30th Street (northbound or southbound), and
  - SR 520 at 92nd Avenue (eastbound or westbound).
- The macro places the location in cell C10.
- NOTE: If the user selects I-405, LOCATION calls the ADJUST macro (described below).
- NOTE: More selections can be added to any of these menus. The format of these new selections should resemble those already present. Refer to the Lotus 1-2-3 documentation.
- The LOCATION macro then returns to the calling macro.

Save Macro (SAVE)

The SAVE macro asks you to save the worksheet or to quit the START-UP macro.

- The macro provides two options, SAVE and QUIT.
- If SAVE is chosen, the macro prompts the user to enter the name of the file to be saved.
- NOTE: If a file already exists with the same file name, the system will replace it.
- The SAVE macro then returns to the calling macro.

Adjust Macro (ADJUST)

The LOCATION macro only calls the ADJUST macro if the user chooses I-405 in LOCATION.

- First, ADJUST erases the title for "# of 2 Person" and reduces this column to a width of 1. It then compensates for this by increasing the column width of "Total # Persons" to 14. The macro does this for four quarters.
- Next, ADJUST modifies each of the QUART macros so the user will not have to enter the "# of 2 Pers".
- Finally, ADJUST returns to the calling macro.

Test Date Macro (TESTDATE)

The TESTDATE macro places the observation dates in the appropriate cells. (The dates are entered in the DATA-ENTRY macro).

- TESTDATE places five dates into cells named T0DATE, T1DATE, T2DATE, T3DATE, and T4DATE. TESTDATE uses the year stored in cell A60 and the appropriate dates for the quarter breakdown:

- January 1 - March 31	Quarter 1
- April 1 - June 30	Quarter 2
- July 1 - September 30	Quarter 3
- October 1 - December 31	Quarter 4

- TESTDATE uses Lotus's @DATE function and then stores the serial number as a value.
- TESTDATE then puts messages at the top of the worksheet for every quarter explaining how to use the other macros (PRINT and DATA-ENTRY).
- Finally, TESTDATE returns to the calling macro.

Data Entry Macro (\A)

The DATA-ENTRY macro allows the user to enter data when prompted by the computer. It places this data into the appropriate quarter as well as assuring valid dates.

- DATA-ENTRY prompts the user to enter the month and stores it in cell A61.
- Then DATA-ENTRY prompts the user to enter the day and stores it in cell A62.
- DATA-ENTRY next places the serial number of the entered date into the cell named OBDATE. This value is compared to the five T_DATEs. If the value is valid, DATA-ENTRY calls the appropriate QUARTER macro. If OBDATE is not valid, DATA-ENTRY prompts the user for a new month and day.

QUARTER Macros (QUART1, QUART2, QUART3, QUART4)

All QUARTER macros are exactly the same except for the location of the cells in which the data are being stored.

- First, QUARTER copies OBDATE into the appropriate quarter and brings that quarter to the screen. Then a series of prompts ask the user to enter start time, finish time, number of SOV, number of 2 persons (if applicable), total number of persons, and number of vehicles in HOV. QUARTER places these values in the appropriate cells of the current line.

- Next, the current line is copied to the next open line of the quarter and the corresponding observation number is copied to the cell named OBNUM1, OBNUM2, OBNUM3, or OBNUM4, respectively.
- Finally, QUARTER calls the CHOICE macro.

CHOICE Macro (CHOICE)

The CHOICE macro allows the user to enter more observations or quit the DATA-ENTRY macro.

- CHOICE calls a macro containing ENTER and QUIT.
- Choosing ENTER returns the user to the top DATA-ENTRY macro.
- Choosing QUIT ends the DATA-ENTRY macro.

Hero-HOV Violation Data Base

[ALT]-A to run Data-Entry MACRO...
[ALT]-P to run Print MACRO...

FIRST QUARTER
January through March

LOCATION:

NUMBER OF OBSERVATIONS: 0

Observation Number	Date	Start Time	Finish Time	# of SOV	# of 2 Pers	Total # Persons	# Vehs in HOV	Violation Rate
CURRENT =>								0.00%
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								
32								
33								
34								
35								
36								
37								
38								
39								
40								
QUARTER AVERAGES				ERR		ERR		ERR

Figure G-1. Example of HOV Violation Data Entry Spreadsheets

```
\0          /xnEnter the Year (eg. 1989): ~DATE1~
            /xiDATE1<1900~/xg\0~
            /xiDATE1>2099~/xg\0~
            {goto}DATE1~/c~DATE2~/c~DATE3~/c~DATE4~/c~DATE5~{home}
            /xcLOCATION~
            {goto}LOC1~/c~LOC2~/c~LOC3~/c~LOC4~/c~LOC5~
            /rnd\0~/xcTESTDATE~
            {goto}a16~/wth/xcSAVE~/xq

LOCATION    /xmLOCMEN~

            I-5       I-405 SR 520
            InterstateIntersState Route 520 Locations
            /xmI-5MEN~/xmI-4/xmSR520MEN~

            I-5 @ 145tI-5 @ 145th SB
            Choose a LChoose a Location
            /cI-5NB~LO/cI-5SB~LOC1~{home}/xr

            I-405 @ 30I-405 @ 30th SB
            Choose a LChoose a Location
            /cI-405NB~/cI-405SB~LOC1~/xcADJUST~/xr

            SR 520 @ 9SR 520 @ 92nd WB
            Choose a LChoose a Location
            /cSR520EB~/cSR520WB~LOC1~{home}/xr

SAVE        /xmSAVEMEN~

            SAVE      QUIT
            Press <ENTQuit Strart-Up MACRO...
            /xlEnter n/xq

            ~/xr

ADJUST      {goto}g12~/re{down}~/wcs1~{right}/wcs14~
            {goto}q12~/wcs1~{right}/wcs14~/cg12..g13~q12~
            {goto}aa12~/wcs1~{right}/wcs14~/cg12..g13~aa12~
            {goto}ak12~/wcs1~{right}/wcs14~/cg12..g13~ak12~
            {goto}QUART12PERS~/wdr~
            {goto}QUART22PERS~/wdr~
            {goto}QUART32PERS~/wdr~
            {goto}QUART42PERS~/wdr~
            {home}/xr

TESTDATE    {goto}T0DATE~@date(a60,1,1)~/rv~~
            {goto}T1DATE~@date(a60,4,1)~/rv~~
            {goto}T2DATE~@date(a60,7,1)~/rv~~
            {goto}T3DATE~@date(a60,10,1)~/rv~~
            {goto}T4DATE~@date(a60,12,31)~/rv~~
            {goto}f2~ [ALT]-A to run Data-Entry MACRO...~
            {goto}f3~ [ALT]-P to run Print MACRO...~
            /cf2~p2~/cf2~z2~/cf2~aj2~/cf2~at2~{home}
            /cf3~p3~/cf3~z3~/cf3~aj3~/cf3~at3~{home}
            /xr

\A          /xnEnter the Month (eg. 3 = March):~a61~
```

```
            /xnEnter the Day (eg. 13):~a62~
            {goto}OBDATE~@date(a60,a61,a62)~/rv~~
            /xiOBDATE<T0DATE~/xg\A~




            /xiOBDATE<T1DATE~/xgQUART1~
            /xiOBDATE<T2DATE~/xgQUART2~
            /xiOBDATE<T3DATE~/xgQUART3~
            /xiOBDATE<=T4DATE~/xgQUART4~
            /xiOBDATE>T4DATE~/xg\A~
            /xq

QUART1      /cOBDATE~c15~{home}
            /xnEnter Start Time (eg. 700 = 7:00am):~d15~
            /xnEnter Finish Time (eg. 700 = 7:00am):~e15~
            /xnEnter # of SOV: ~f15~
            /xnEnter # of 2-Pers: ~g15~
            /xnEnter Total Persons: ~h15~
            /xnEnter # Veh in HOV: ~i15~
            /rpc15..j15~{goto}c14~
            /cc15..j15~{end}{down}{down}~
            /ruc15..j15~
            {goto}b14~/c{esc}{right}{end}{down}{left}~OBNUM1~
            {end}{down}{home}~
            /xcCHOICE~

QUART2      /cOBDATE~m15~{home}{bigright}
            /xnEnter Start Time (eg. 700 = 7:00am):~n15~
            /xnEnter Finish Time (eg. 700 = 7:00am):~o15~
            /xnEnter # of SOV: ~p15~
            /xnEnter # of 2-Pers: ~q15~
            /xnEnter Total Persons: ~r15~
            /xnEnter # Veh in HOV: ~s15~
            /rpm15..t15~{goto}m14~
            /cm15..t15~{end}{down}{down}~
            /rum15..t15~
            {goto}l14~/c{esc}{right}{end}{down}{left}~OBNUM2~
            {end}{down}{home}~
            /xcCHOICE~

QUART3      /cOBDATE~w15~{home}{bigright 2}
            /xnEnter Start Time (eg. 700 = 7:00am):~x15~
            /xnEnter Finish Time (eg. 700 = 7:00am):~y15~
            /xnEnter # of SOV: ~z15~
            /xnEnter # of 2-Pers: ~aa15~
            /xnEnter Total Persons: ~ab15~
            /xnEnter # Veh in HOV: ~ac15~
            /rpw15..ad15~{goto}w14~
            /cw15..ad15~{end}{down}{down}~
            /ruw15..ad15~
            {goto}v14~/c{esc}{right}{end}{down}{left}~OBNUM3~
            {end}{down}{home}~
            /xcCHOICE~

QUART4      /cOBDATE~ag15~{home}{bigright 3}
            /xnEnter Start Time (eg. 700 = 7:00am):~ah15~
```

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/xnEnter Finish Time (eg. 700 = 7:00am):~ai15~
/xnEnter # of SOV: ~aj15~
/xnEnter # of 2-Pers: ~ak15~
/xnEnter Total Persons: ~al15~
/xnEnter # Veh in HOV: ~am15~
/rpag15..an15~{goto}ag14~
/cag15..an15~{end}{down}{down}~
/ruag15..an15~
{goto}af14~/c{esc}{right}{end}{down}{left}~OBNUM4~



{end}{down}{home}~
/xcCHOICE~

CHOICE      /xmCHOICEMEN~

            ENTER     QUIT
            Enter AnotQuit DATA-ENTRY MACRO
            /xg\a~    /xcSAVE~/xq

\p          /xmPRINTMENU~

            QUARTER   YEAR  ALL
            Print QuarPrint Print Entire Worksheet
            /xmPQUART~/ppcra/xgPALL~

            QUARTER 1 QUARTEQUARTERQUARTER 4
            Print QuarPrint Print QPrint Quarter 4 Information
            /ppcrarPRI/ppcra/ppcrar/ppcrarPRINT4~gq

            /ppcrarPRINT1~gq
            /ppcrarPRINT2~gq
            /ppcrarPRINT3~gq
            /ppcrarPRINT4~gq
            /ppcrarPRINT5~gq
            /xq
```