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16. ABSTRACT

This report describes the evaluation approach and the process for acquiring data, performing analysis, and presenting output with a new analytical tool set for measuring HOV facility usage and performance in the central Puget Sound region. Specifically, the tool set includes the programs CDR (Compact disc Data Retrieval), CDR Auto, CDR Analyst, and associated utilities designed to produce graphical output. A description of the available analysis tools is provided.

Because data collection and analysis procedures for many of the existing measures, such as average car occupancy (ACO), speed, and travel time (using Baseline and HOVTT methods), as well as HOV violations and a public opinion survey, were documented extensively in the previous HOV evaluation and monitoring reports, they are not covered in this report. For related information, please refer to the previous documents, as well as to the project's Web site at <http://www.wsdot.wa.gov/eesc/atb/atb/hov/Titlepg.html>. For performance results of the HOV facility, please refer to the annual HOV lane performance monitoring report.

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HOV Monitoring IV

EVALUATION TOOLS FOR HOV LANE PERFORMANCE MONITORING

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DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Washington State Transportation Commission, Department of Transportation, or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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EXECUTIVE SUMMARY

This report describes the evaluation approach and the process for acquiring data, performing analysis, and presenting output with a new analytical tool set for measuring HOV facility usage and performance in the central Puget Sound region. Specifically, the tool set includes the following programs:

1 **CDR (Compact disc Data Retrieval)**—retrieves and reformats raw traffic data for each lane type and direction from one *specific* cabinet and one loop at a time for use by CDR Analyst

2 **CDR Auto**—automatically retrieves and reformats raw traffic data from *multiple* cabinets by lane type and direction for use by CDR Analyst

3 **CDR Analyst (and associated utilities)**—computes performance measures and presents the analyzed data in text and graphical formats.

This evaluation tool set was developed to evaluate the performance and effects of the FLOW traffic management system, which includes Puget Sound's core HOV system. The FLOW system is a coordinated network of traffic monitoring (e.g., closed-circuit television), measuring (e.g., inductance loop), information dissemination (e.g., Web, VMS, HAR), and control devices (e.g., HOV lanes, ramp meters) that operates on urban state and Interstate highways in the central Puget Sound region.

Because data collection and analysis procedures for many of the existing measures, such as average car occupancy (ACO), speed, and travel time (using Baseline and HOVTT methods), as well as HOV violations and a public opinion survey, were documented extensively in the previous HOV evaluation and monitoring reports, they are not covered in this report. For related information, please refer to the previous documents as indicated below, as well as to the project's Web site at <http://www.wsdot.wa.gov/eesc/atb/atb/ hov/Titlepg.html>.

For performance results of the HOV facility, please refer to the annual HOV lane performance monitoring report.

The analysis procedure is described in this report in sequence, from obtaining the data set, evaluating data quality, and running CDR Analyst, to producing graphical output with appropriate utilities for the following performance measures:

Average Daily Site Profiles

- **HOV Traffic Flow Profile (Utility A)**
  The resulting output describes HOV usage from location to location along a particular corridor for a specific direction during peak periods.

- **Average Weekday GP and HOV Volume Profile (Utility B)**
  The resulting output shows GP and HOV usage as a function of time of day for a specific location.

- **Average Weekday Volume, Speed, and Reliability Conditions (Utility C)**
  The resulting output is a 24-hour traffic performance profile of each site.

Average Daily Corridor Profile (Utility D)

- The resulting output includes a matrix of estimated congestion levels as a function of time of day and location along the corridor; this is converted into a topographic-style contour map

Average Speed and Travel Time Profiles

- **Average Weekday HOV Speed and Reliability (Utility E)**
  The resulting output describes HOV average 90th percentile speed, as well as speed reliability along a particular corridor as a function of trip start time

- **Average Weekday GP and HOV Travel Time (Utility F)**
  The resulting output shows GP and HOV travel time along a particular corridor as a function of trip start time.

The last section provides steps for computing person-carrying ability on HOV and GP facilities. The number of vehicles traveling on GP and HOV lanes at selected locations, computed by running CDR Analyst, is combined with available data about the average number of persons per vehicle (vehicle occupancy) to compare the number of people using GP and HOV lanes at selected sites on major corridors during the peak period. The vehicle and person throughput data for GP and HOV lanes are computed as both *overall* and *per-lane* statistics. This allows the determination of what proportion of total throughput is provided by the HOV facility, while also providing a fairer comparison of how much throughput the HOV lane is providing in comparison to a single GP lane.

CHAPTER ONE
INTRODUCTION

REPORT PURPOSE

This report supplements a previous tools manual titled ***HOV Monitoring and Evaluation Tool, WA-RD 318.1, 1993***. It describes a set of new tools and procedures for analyzing HOV facility usage and performance. Because data collection and analysis procedures for many of the existing measures, such as average car occupancy (ACO), speed, and travel time (using Baseline and HOVTT methods), as well as HOV violations and a public opinion survey, were documented extensively in the previous HOV evaluation and monitoring reports, they are not covered in this report. For related information, please refer to the previous documents as indicated below, as well as to the project's Web site at <**http://www.wsdot.wa.gov/eesc/atb/atb/hov/Titlepg.html**>.

- ***HOV Evaluation and Monitoring, Phase IV, WA-RD 456.1, 1998***
- ***HOV Evaluation and Monitoring, Phase III, WA-RD 414.2, 1997***
- ***HOV Evaluation and Monitoring, Phase III, WA-RD 414.1, 1996***
- ***HOV Evaluation and Monitoring, 1995***
- ***HOV Evaluation and Monitoring, WA-RD 343.1, 1994***
- ***HOV Monitoring and Evaluation Tool, WA-RD 318.1, 1993***
- ***HOV Travel Times (by Floating Car and Community Transit AVI Methods), 1996***

This report focuses on the latest innovations in methodology for analyzing HOV facility usage and performance in terms of vehicle and person throughput, speed and reliability, and travel time measures. This evaluation tool set was developed to evaluate the performance and effects of the FLOW traffic management system, which includes

Puget Sound's core HOV system. The FLOW system is a coordinated network of traffic monitoring (e.g., closed-circuit television), measuring (e.g., inductance loop), information dissemination (e.g., Web, VMS, HAR), and control devices (e.g., HOV lanes, ramp meters) that operates on urban state and Interstate highways in the central Puget Sound Region. Specifically, the tool set includes the programs CDR (Compact disc Data Retrieval), CDR Auto, CDR Analyst, and associated utilities designed for producing graphical output. This report describes how to effectively evaluate the 1998 HOV facility performance in Washington State. For performance results of the HOV facility, please refer to the 1998 annual HOV lane performance monitoring report.

MEASURES OF EFFECTIVENESS

HOV lanes are intended to reduce average travel time and to increase travel time reliability for transit users, carpoolers, and ridesharers. As indicated in the ***1992 Washington State Freeway HOV System Policy*** report, the objectives of the HOV facilities are threefold:

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

To determine whether the existing HOV facilities meet the intended objectives, person throughput, vehicle occupancy, travel time and reliability, and public opinion were chosen as the primary performance measures. The ability of the HOV facility to carry more people is reflected through measures of vehicle and person throughput, as well as of vehicle occupancy. Travel time and trip reliability illustrates the performance of the HOV facility. Secondary performance measures include accident rates, enforcement, and violations along HOV lanes. It is also important to ascertain the public's perception of the HOV system's level of performance. Below is a brief description of the primary and secondary measures on which the data collection efforts were focused.

Primary Measures

- **Vehicle Volume**—Number of vehicles recorded passing a given freeway location during weekday morning and evening peak commute periods, as well as over an average 24-hour weekday.
- **Person Volume**—Number of passengers measured at a given freeway location during weekday morning and evening peak commute periods.
- **Average Vehicle Occupancy**—Average number of occupants in a vehicle, which includes persons in cars, vanpools, and transit buses, at a given freeway location during weekday morning and evening peak commute periods.
- **Speed and Trip Reliability**—Average vehicle speeds based on the average travel time for a given trip. Trip reliability refers to the percentage of time that the vehicle travels slower than 45 mph.
- **Travel Time**—Average time in hours and minutes required to complete a trip from point A to point B based on a given trip start time throughout an average weekday.

Secondary Measures

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

REPORT ORGANIZATION

This report describes the evaluation approach and the process for acquiring data, performing analyses, and presenting information with the new analytical tool set for measuring HOV facility usage and performance in the central Puget Sound region. A description of the available analysis tools is provided. The arrangement of this report is as follows:

- Chapter 2 Analysis tools and procedures are described.

- Chapter 3 Instructions are provided for analyzing vehicle throughput, speed and reliability, and travel time measures.
- Chapter 4 The methodology for analyzing person throughput analysis is presented.

CHAPTER TWO
ANALYSIS TOOLS AND PROCEDURES

This section describes the specific functions of the analysis tool set, which includes the following components:

(1) **CDR (Compact disc Data Retrieval)**—retrieves and reformats raw traffic data for each lane type and direction from one *specific* cabinet and one loop at a time for use by CDR Analyst

(2) **CDR Auto**—automatically retrieves and reformats raw traffic data from *multiple* cabinets by lane type and direction for use by CDR Analyst

(3) **CDR Analyst (and associated utilities)**—computes performance measures and presents the analyzed data in text and graphical formats.

Most of the discussion centers on CDR Analyst. B ackground information on CDR can be found in the CDR User's Guide, which is available in PDF format on each WSDOT traffic data CD since early 1998. CDR Auto is a data re-formatting program that requires minimal discussion. The most recent version of the CDR Auto and CDR Analyst is Version 1.3 (as of August 1999).

The second part of the chapter describes the analysis procedure in sequence, from obtaining the data set, evaluating data quality, and running CDR Analyst, to producing graphical output. Chapter Three presents instructions for using CDR Analyst and its utilities to produce output for the following performance measures: average daily site profile, average daily corridor profile, and average speed and travel time profile.

DATA SET

The data set used by the analysis tools described in this report is available on compact discs that WSDOT produces. CD archives are available for data starting from mid-1993; two to four CDs are required to hold a year of data from all sensor locations in the central Puget Sound freeway network. These CDs include traffic data collected from electronic inductance loop sensors installed at approximately 1/2-mile intervals on mainline lanes and ramps of I-5, I-90, I-405, SR 18, SR 99, SR 167, SR 520, and SR 522.

Vehicle presence is detected by inductance loops. The resulting detection data are collected at 20-second intervals and transmitted to the WSDOT Transportation Systems Management Center for processing and archiving. Then 15 consecutive 20-second values are combined to produce a single 5-minute value for vehicle volumes and average lane occupancy percentage, which is stored on the data CD.

Vehicle volumes at a roadway location are estimated by recording the number of times that an inductance loop embedded in an individual road or ramp lane is "triggered" by a passing vehicle. Five-minute vehicle volumes can also be aggregated to produce data for other time intervals (e.g., hourly, daily, yearly averages).

Lane occupancy refers to the percentage of time that a given loop is in a triggered ("on") position, which indicates a vehicle's presence within the loop's detection range. For example, if a loop recorded a lane occupancy of 10 percent for a 5-minute period, this would mean that vehicles were sensed within the loop's detection range for a total of 30 seconds during the 5-minute interval (10 percent of 5 minutes = 30 seconds). Lane occupancy can be considered a surrogate measure for the density of vehicles on a roadway, and it can be used as a measure of congestion. Lane occupancy can also be combined with vehicle volume estimates to derive estimated vehicle speeds. Both vehicle volume and lane occupancy counts are recorded 24 hours a day, except when equipment is turned off, being serviced, or inoperative.

CDR

CDR is a program developed by WSDOT Northwest Region to access 5-minute traffic data stored on CD and produce a summarized report in a text file format. Users can specify dates of data collected, locations (lanes), and various levels of summarization. The output is in the form of a text file that can also be read directly into a spreadsheet program such as Microsoft Excel. Standard output from the program comprises 5-minute raw traffic data, including traffic volumes and average lane occupancy percentage, and a data quality/validity indicator. Data can also be aggregated to a 15-minute, hourly, peak hour, peak period, daily, weekly, monthly, or yearly level. At some locations, average estimated speed and vehicle length information can be provided. Minimum data quality thresholds for computing summary statistics are user-specified. As mentioned previously, additional operating and background information on CDR can be found in the CDR User's Guide, which is available in PDF format on each WSDOT traffic data CD since early 1998.

CDR AUTO

CDR Auto is a pre-processor for CDR Analyst that converts compact disc traffic data to a file format usable by CDR Analyst. CDR Auto allows user to automatically (not manually) extract information about mainline GP and HOV lanes for every day on each data CD for a specific or a range of locations automatically.

CDR ANALYST (AND ASSOCIATED UTILITIES)

CDR Analyst is a program developed by the Washington State Transportation Center (TRAC) to access 5-minute traffic data processed by CDR (or CDR Auto) and produce performance measures that are not normally available from CDR. Because CDR produces statistics for one lane (sensor) at a time, it does not directly produce statistics that reflect all the lanes in a given location traveling in a particular direction (e.g., the total average daily northbound volume on all GP mainline lanes on I-5 at University Street). CDR Analyst addresses this limitation by allowing the user to process all relevant lanes at a specific location when producing statistics. CDR Analyst also computes peak hour, peak period, and daily (e.g., Average Weekday Daily Traffic) values similar to those produced by CDR, but it does so for all relevant lanes (e.g., all northbound GP lanes at a specific location) rather than only one lane at a time. In addition, CDR Analyst produces supplementary performance measures beyond those computed by CDR, including 24-hour volume and speed profiles, congestion frequency statistics, corridor congestion summaries, travel time estimates, and travel time reliability measures.

CDR Analyst output can be post-processed with Analyst utilities and templates to produce color graphics that can be used for analysis and report preparation. These ancillary programs are written in Microsoft Excel and use the graphics capabilities of that program. They are described later in this report.

CDR Analyst's principal process is the conversion of multiple days of multi-lane traffic data into a single, average, 24-hour traffic profile at one site. The process can then be used at a series of sites along a corridor, in batch mode, to produce corridor profiles and travel time profiles. The process uses all available "good" data to produce the 24-hour average profile.

To process multiple days into a single average day, the following steps are taken:

1. For each 5-minute interval, do the following:

   A. For each day, do the following two steps:

      a. For each lane of traffic to be processed, do the following:

      Look at the data flag of a given 5-minute data value in a given lane in a given day. If the data point is labeled "good," or if it is labeled "suspect" but the user specified that suspect data are assumed to be good, then the value is used as is. If the data are labeled "suspect" and the user requested a data replacement, or if they are labeled "bad" or "disabled," the program searches for a good value in the (temporal) vicinity (and within the same lane) by moving back 5 minutes, then forward 5 minutes, then back 10 minutes, then forward 10 minutes, to a maximum of ±15 minutes. If a good data point is located within that window, it is used as a replacement value. If no such value is found, the data point is not included in subsequent calculations.

      b. Average the resulting values of each lane to get a per-lane average for that 5-minute interval for that day.

   B. Average the resulting per-lane averages across all days to get an overall average for that 5-minute interval.

2. Repeat the process for each 5-minute interval throughout a 24-hour day. Use this process for both volume information and lane occupancy data.

The descriptions of the algorithms used to implement various CDR Analyst options, such as the speed estimation method, the congestion frequency histogram method, the peak hour/peak period/daily volume estimation method, the contour computation method, and the average travel time profile method, are included in the *FLOW Evaluation Design Technical Report.* The user instructions for the tools described here in this report and in the FLOW evaluation technical report are based on the same assumptions. Note that the algorithms and user instructions described may be modified as the tools are enhanced.

ANALYSIS PROCEDURES

The recommended analysis steps are briefly introduced as follows:

Step 1. Data Retrieval

CDR Auto is a pre-processor for CDR Analyst and needs to be run only once for each year of data. CDR Auto extracts information about mainline GP and HOV lanes for every day on each data CD and places it into a data file. Each data file contains one combination of location, travel direction, and lane type (e.g., cabinet 100, northbound, GP). You have the option to extract two types of subsets from this collection of data files. First, you can determine which location(s), direction of travel, and lane type (GP or HOV) the program will analyze by indicating the specific data files of interest, either individually or in a batch file. Second, you can request that only weekday data be processed (Monday through Friday); otherwise, all seven days of the week are processed. In either case, data for an entire calendar year are processed. The resulting output files (which can take up to 2 Gb/year on a hard drive) are then used in all subsequent runs of CDR Analyst. Below are the steps for processing one year of data (two to four CDs).

If you wish to pick some other subset of the year (e.g., one particular month, weekends only, Tuesdays through Thursdays only), you can create these data files manually by using the CDR program (not CDR Analyst). You must run CDR once for each combination of location, travel direction, and lane type.

Running CDR-Auto

1. Double-click the program icon to start.
2. Enter the CD drive (e.g., E): Enter the letter of the CD-ROM drive where the data CD is located.
3. Enter data year (e.g., 1999): Enter the year of the data on the CD.

You are then prompted to specify a range of cabinet numbers to be processed by entering the first and last cabinet numbers of the range. All mainline GP, HOV, and reversible loops on the data CD that are associated with all cabinet numbers within the range specified are then processed into a form that can be used by CDR Analyst:

4. Enter first cabinet number: Enter a cabinet number.

   If you want all cabinets on the CD, enter 1. (Cabinet numbers may be obtained from the RMDC.LST file on the data CD. If the CD is 1998 data, for example, the RMDC.LST file (including path) is Data1998/RMDC.LST.)

   Note: If you wish to process only one cabinet location, enter the same cabinet number for the first and last cabinet. This option would be used if, for example, you wanted statistics on only selected locations scattered around the region; rather than run the program for all locations (thereby creating many large files that would not be used), you could instead run CDR Auto on only those locations of interest.

5. Enter last cabinet number: Enter a cabinet number

   If you want all cabinets (and entered "1" for the first cabinet number), enter 999 (or, if known, the highest cabinet number). If you prefer to select a subset range of cabinets (and entered the starting cabinet for the first cabinet number), enter the last cabinet in the desired range.

   After you have been prompted for the above information, the program will run without further input from you until all cabinet locations and their loops have been processed (for the CD currently in the drive).

6. Repeat this process for each CD with data from the year of interest. Data extracted from each subsequent CD are appended to the appropriate cabinet number output file (which is created during the processing of the first CD). The user is responsible for ensuring that each data CD, for a given year, is processed in this way.

   IMPORTANT: There is no error checking to protect against accidentally extracting data from the same CD more than once (and thus duplicating data in the output files). While CDR-Analyst will detect duplicate data, it will not detect missing data, so it is best to pay close attention when running CDR-Auto and process each CD for a given year exactly once.

Step 2. Data Quality Mapping

Because the analysis performed by CDR Analyst is highly dependent on the quality of the original sensor data that are being processed, it is important to evaluate the data that would be used in an analysis to determine whether enough valid data are available during the time periods of interest. Evaluating the level of quality before an analysis can save time and enhance the efficiency of the analytical process.

In some cases, data quality problems can be anticipated by referring to available information about construction projects or other events that were likely to disrupt data collection devices during the period of interest. For example, an HOV study should take into consideration a construction project that adds or disrupts an HOV lane (and possibly affects associated vehicle sensors in the pavement), or moves the HOV lane from an outside to inside lane. In other cases, however, there is not always an indication that enough valid data might not be available.

To better perform a data quality check, a stand-alone, spreadsheet-based prototype tool was developed to analyze the traffic data files (output files from the CDR Auto program) and compute the percentages of "good," "suspect," "bad," and "disabled" data at each measurement site, on a quarter by quarter basis throughout the year. Each 5-minute data value is tagged by data validity codes such as "good" (all 15 constituent values are considered valid), "bad" (all 15 values are considered invalid), "disabled" (all 15 values were collected when the data collection equipment at that sensor site was not operational), or "suspect" (all other combinations of 15 data point conditions). The estimated validity of each 5-minute data value is also recorded on the CD archive in the form of a code that summarizes the quality of the constituent 15 20-second values. This information is then summarized in graphical form by using an Excel macro. This summary is useful in determining which locations are likely to be problematic statistically, as well as determining which sites should be skipped altogether in developing contour maps or computing speed and travel times. It is important to study the input data to verify that there are enough "good" or valid data at each site used to produce output.

A number of cautions are relevant to good and usable data. You must determine the minimum number of "good" data that is acceptable for the type of analysis being performed (refer to the *CDR User's Guide*). There is no absolute guideline for the minimum number of good data that is required to develop a performance measure that you can feel confident about. This minimum threshold should take into account not only the overall number of valid data, but the temporal distribution of the data (refer to the *CDR User's Guide*). For example, a minimum data quality standard of at least 50 percent good data for the entire year does not take into account the fact that such a standard could be met by having 50 percent good data uniformly throughout the year, or having 100 percent good data in two quarters of the year and 0 percent good data in the other two quarters. In the latter situation, the resulting average yearly statistics might not fully reflect seasonal variations. In addition, it might be appropriate to consider data quality categories besides "good" data, since the standard for data tagged as "suspect" is conservative. Both CDR and CDR Analyst offer the option of accepting suspect values as valid data.

Data Quality Mapping Utility

Below is a description of the process for running the data quality mapping utility. An Excel macro processes a user-input command file that lists the data files to be processed. The macro accesses the traffic data files and tabulates the data quality on a cabinet by cabinet basis. This matrix of counts can then be analyzed to determine whether enough "good" data exist.

The macro allows individual data files (.dat extension) created by CDR Auto to be analyzed. To access the macro within Excel, go to the Tools menu, select "Macro," and open the "flag0123" macro. The macro asks for the name of a user-written command file (a text file) that lists the CDR Analyst output files to be processed into graphical form.

The command file should have a " .txt" extension in its filename. The files listed in the command file should include the extension.

The macro then processes each file, extracting and tabulating the number of data points for each cabinet that are in each of the four data quality categories: 0, 1, 2, and 3 (bad, good, suspect, and disabled, respectively). The result is a matrix of such values, which can be reviewed to determine whether sites (cabinets) of interest contain enough valid data. The naming protocol for the resulting output file uses the first eight characters of the last input file name in the command file, with an " .flg" extension. The data files should reside in the same folder as the mapping macro. This information is then summarized in graphical form (see Figure 2-1) to determine which locations are likely to be problematic statistically and which sites should be skipped altogether when input files are considered for contour maps or speed and travel times.

<u>Step 3. Running CDR Analyst</u>

CDR Analyst uses all the user-specified input files to produce statistics that reflect performance characteristics for all relevant lanes in a given location traveling in a particular direction (e.g., the total average daily northbound volume on all GP mainline lanes on I-5 at University Street). The instructions for producing output for these performance measures by running CDR Analyst are included in the following chapter.

A CDR Analyst preference file (CDR_pref.txt) is required to run the program and must be present in the same directory as CDR Analyst. Before using CDR Analyst, you should edit the preference file. It contains several constants used by the program:

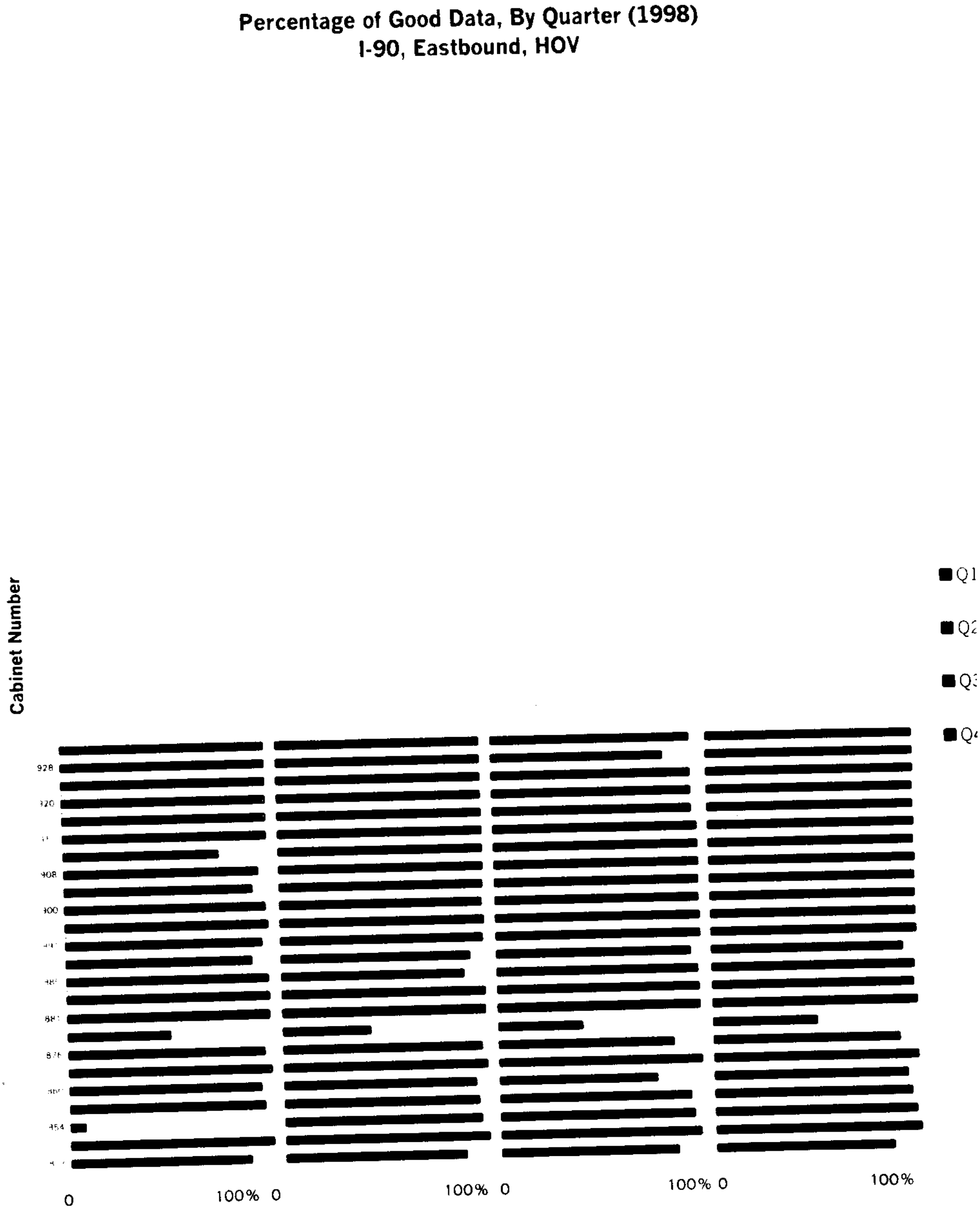

Figure 2-1 Sensor Data Quality by Location and Time of Year

50	Minimum required good lane rule (e.g., 50 means that at least 50% of lanes, at a given location, must have acceptable data).
15	Time (± minutes) window for bad/suspect data replacement
269	Minimum required good time periods per day (e.g., at least 269 out of 288 5-minute intervals must be good values)
1	Maximum allowable bad days (of a given day of week) per month
10	Minimum required months of a given day of week needed for calculating an annual profile
4	Minimum required annual average days needed for calculating AWDT (out of 5 weekdays)
6	Minimum required annual average days needed for calculating AADT (out of 7 days)
2.4	Constant (used in Normal Speed Formula)
19	Congestion Threshold (%) (e.g., if lane occupancy exceeds 19% it is considered congested; used for the histogram output option)
980101	Beginning Date Range (yymmdd)
981231	Ending Date Range (yymmdd)

You may opt to change these threshold settings with a text editor. The threshold values shown above are based on the central Puget Sound Freeway Usage and Performance report. There are no absolute guidelines for setting the threshold. However, it is important to use the same threshold values when doing a series of analyses whose results will be compared to one another.

Step 4. Producing Graphical Output.

CDR Analyst output can be post-processed with CDR Analyst utilities and templates to produce the following graphical outputs. The instructions for generating output for these performance measures are included in the following chapter.

Average Daily Site Profiles

CDR Analyst processes user-specified days of traffic data and produces site-specific traffic profiles as a function of time of day, which also includes peak hour and peak period volume and speed data. The first of these is an average 24-hour profile of volume per lane per hour at a selected location for a specified direction of travel (across all lanes), at 5-minute increments. You can specify that only weekdays will be used, or all days of the week. The second profile is of corresponding 24-hour estimated speed. The third is a 24-hour reliability profile, which estimates the percentage of time that the location is congested as a function of time of day. The definition of what constitutes congestion is based on the lane occupancy percentage threshold value; you can change this threshold in the preference file. This output is assembled to produce the following graphics:

- HOV Traffic Flow Profile
- Average Weekday GP and HOV Volume Profile
- Average Weekday Volume, Speed, and Reliability Conditions

Average Daily Corridor Profile

CDR Analyst also processes a series of user-specified locations along a corridor and produces an average 24-hour profile of lane occupancy percentages at each of those locations for a specified direction of travel, at 5-minute increments. The user can specify that only weekdays will be used, or all days of the week and have the output displayed as

- Weekday Average HOV Traffic Profile

Average Speed and Travel Time Profiles

CDR Analyst processes corridor information to produce three 24-hour profiles related to a specific trip. First, it estimates the average speed and travel time from one point to another on one corridor (e.g., a particular Interstate freeway or state highway that has vehicle sensor installations) as a function of the time that the trip starts (in 5-minute increments, throughout an average 24-hour day). Second, 90th percentile speed and travel time can be computed as a function of trip start time. The 90th percentile speed means that 90 percent of the time the vehicle will travel at or faster than this 90 th percentile speed value. Third, trip travel time reliability is estimated as a function of trip start time by computing the likelihood (as a percentage) that the overall trip speed will be less than 45 mph[1]. The output file can be displayed as

- Average Weekday HOV Speed and Reliability
- Average Weekday GP and HOV Travel Time

[1] The WSDOT HOV system policy states that "HOV lane vehicles should maintain or exceed an average speed of 45 mph or greater at least 90 percent of the time they use that lane during the peak hour (measured for a consecutive six-month period)."

CHAPTER THREE
CDR ANALYST OPERATING INSTRUCTIONS

This section provides instructions for producing performance measures with CDR Analyst from input data that correspond to the locations of interest for the traffic direction, lane type, and period of interest. These measures are grouped into (1) average daily site profiles, (2) average daily corridor profiles, and (3) average speed and travel time profiles. The graphical output is produced using the associated utility.

Average Daily Site Profiles

- **HOV Traffic Flow Profile (Utility A)**
  The resulting output describes HOV usage from location to location along a particular corridor for a specific direction during peak periods.

- **Average Weekday GP and HOV Volume Profile (Utility B)**
  The resulting output shows GP and HOV usage as a function of time of day for a specific location.

- **Average Weekday Volume, Speed, and Reliability Conditions (Utility C)**
  The resulting output is a 24-hour traffic performance profile of each site.

Average Daily Corridor Profile (Utility D)

- The resulting output includes a matrix of estimated congestion levels as a function of time of day and location along the corridor, which is converted into a topographic-style contour map

Average Speed and Travel Time Profiles

- **Average Weekday HOV Speed and Reliability (Utility E)**
  The resulting output describes HOV average 90th percentile speed, as well as speed reliability along a particular corridor as a function of trip start time

- **Average Weekday GP and HOV Travel Time (Utility F)**
  The resulting output shows GP and HOV travel time along a particular corridor as a function of trip start time.

PRODUCING DAILY SITE PROFILES

The types of site specific volume profiles produced include (1) HOV Volume Traffic Flow Profile, (2) Average Weekday GP and HOV Volume Profile, and (3)

Average Weekday Volume, Speed, and Reliability Conditions. Vehicle volumes can also be combined with information about per-vehicle person occupancy to estimate person throughput. The following are step-by-step instructions for using CDR Analyst to produce the profile types described above. These profiles require the same steps in running CDR Analyst to produce data output, but different templates to produce the final graphical output.

Running CDR Analyst

1. Double-click the program icon to start.

2. Accept preferences? Answer Y (yes) or N (no).

   The list of preferences includes preset parameters (e.g., time window for data replacement, allowable bad weekdays, congestion threshold, date range, etc.) for running the program. You may opt to change these values with a text editor.

3. Do you need to extract weekday data from seven day data files? Answer Y (yes) or N (no).

   All data files include both weekday and weekend data. If you want to produce statistics based only on weekdays, indicate your choice. Otherwise, all seven days of the week will be used to produce the desired statistic.

4. Do you wish to run a batch job? Answer Y (yes) or N (no).

   The batch job option is used to process multiple locations for corridor profiles and travel time profiles. It is not used for a single site profile, so answer N (no).

5. Do you want AWDT/AADT information? Answer Y (yes) or N (no).

   If AWDT/AADT statistics are desired, indicate that here.

6. Do you want peak hour information? Answer Y (yes) or N (no

   If peak hour and peak period statistics are desired, indicate that here.

7. Enter the file name.

   At this point, type the name of the file that contains the data for the site that you are interested in. The following is the (CDR Auto) file naming convention:

   CCCCLDYY.dat

   where

   CCCC = cabinet number (i.e., the measurement site); leading zeroes are used if < 4 digits

L = lane type (G = GP, H = HOV)

D = direction of travel (N=northbound, S=southbound, E=eastbound, W=westbound)

YY = year (e.g., 97 = 1997)

NOTE: CDR Analyst assumes that all files associated with the analysis (the CDR Analyst program, the input data files, batch files if any) are in the same directory.

8. Accept 'suspicious' data? Answer Y (yes) or N (no).

   Each 5-minute data point has a data quality indicator flag associated with it. This data flag indicates whether the data point is considered "good," "bad," "suspect," or "disabled" (i.e., the equipment is off-line). CDR Analyst uses all available good data, and attempts to replace bad, suspect, or disabled data points with nearby good data. However, you have the option to accept suspect data as good data. This option is available because the "suspect" label is based on a conservative threshold. In many cases, suspect data are very much consistent with the good data that surround them. However, if there is some question about this, you can specify that suspect data be considered the same as bad data and therefore subject to replacement by nearby good data.

9. Choose speed algorithm: Answer N (normal) or K (Kalman).

   Two methods are implemented in the program for estimating speeds. The so-called normal method uses the formula that WSDOT uses in its WebFlow web-based system to estimate speeds. The Kalman method was developed by D. Dailey at the University of Washington[2]. A preliminary version of the Kalman code has been implemented; however, associated constants have not yet been calibrated. Therefore, you are advised to use the normal method in the current version of CDR Analyst. In the "normal" algorithm, the average speed of vehicles at a site, across all lanes, for a given 5-miniute interval, is determined by using the core process described in Chapter 2, then using the resulting average per-lane volume and occupancy to estimate speed.

10. Enter OUTPUT file name:

    The resulting statistics are sent to an output file of your choice. The output file is assumed not to exist yet; if it does exist, you will be alerted and given the option to overwrite the existing file. The output file is placed in the same directory with the input data and CDR Analyst.

11. Use Utility A to create graphical output for the HOV Volume Traffic Flow Profile. Use Utility B to create graphical output for the Average Weekday GP and HOV Volume Profile.

Utility A – HOV Traffic Flow Profile

CDR Analyst creates a single site profile for each of the desired locations along the corridor. For each direction during a particular peak period (AM or PM), HOV volumes for these selected locations are combined in the same Excel spreadsheet to

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[2] D. J. Dailey, *A Statistical Algorithm for Estimating Speed from Single Loop Volume and Occupancy Measurements* Transportation research. Part B: Methodological, 1999.

create the HOV traffic flow profile graph. These values represent vehicle throughput during the peak period and are also instrumental for computing person throughput.

Figure 3-1 is an example of the HOV traffic flow profile graphic, in which HOV volumes along a given HOV corridor are depicted geographically during the peak periods for average weekdays.

Utility B –Average Weekday GP and HOV Volume Profile

The output CDR Analyst generates is used to create a single site volume profile for each of the desired locations An Excel template allows output from the CDR Analyst site-specific process to be displayed as a GP vs. HOV combination line graph. For a given location travelling in a particular direction. columns of GP volume and HOV volume are combined in the same Excel spreadsheet to create the graph. In some cases, the titles have to be modified manually. Figure 3-2 shows an example of the average weekday GP and HOV volume profile.

Utility C – Average Weekday Volume, Speed, and Reliability Conditions

An Excel macro allows individual output files (.out extension) from the CDR Analyst site profile process to be displayed as a volume line graph and reliability histogram. To access the file, open the macro file within Excel, then go to the Tools menu, select "Macro," and select and open the " histobat" macro.

The macro first asks for the name of a user-written command file (a text file) that lists the CDR Analyst output files to be processed into graphical form. The command file should have a ".bat" extension in its filename. The files listed in the command file should leave off the extension, which is assumed to be " .out."

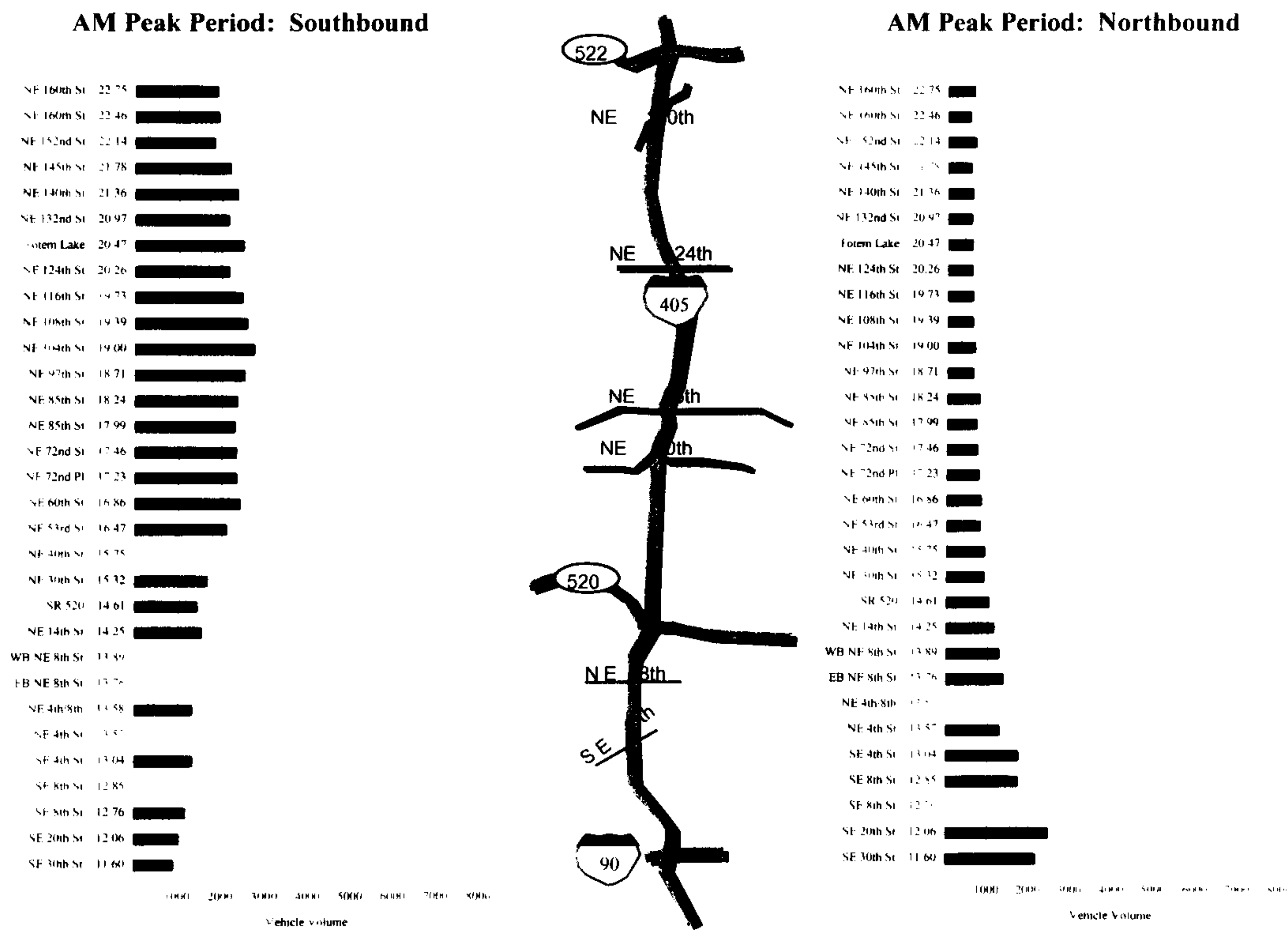
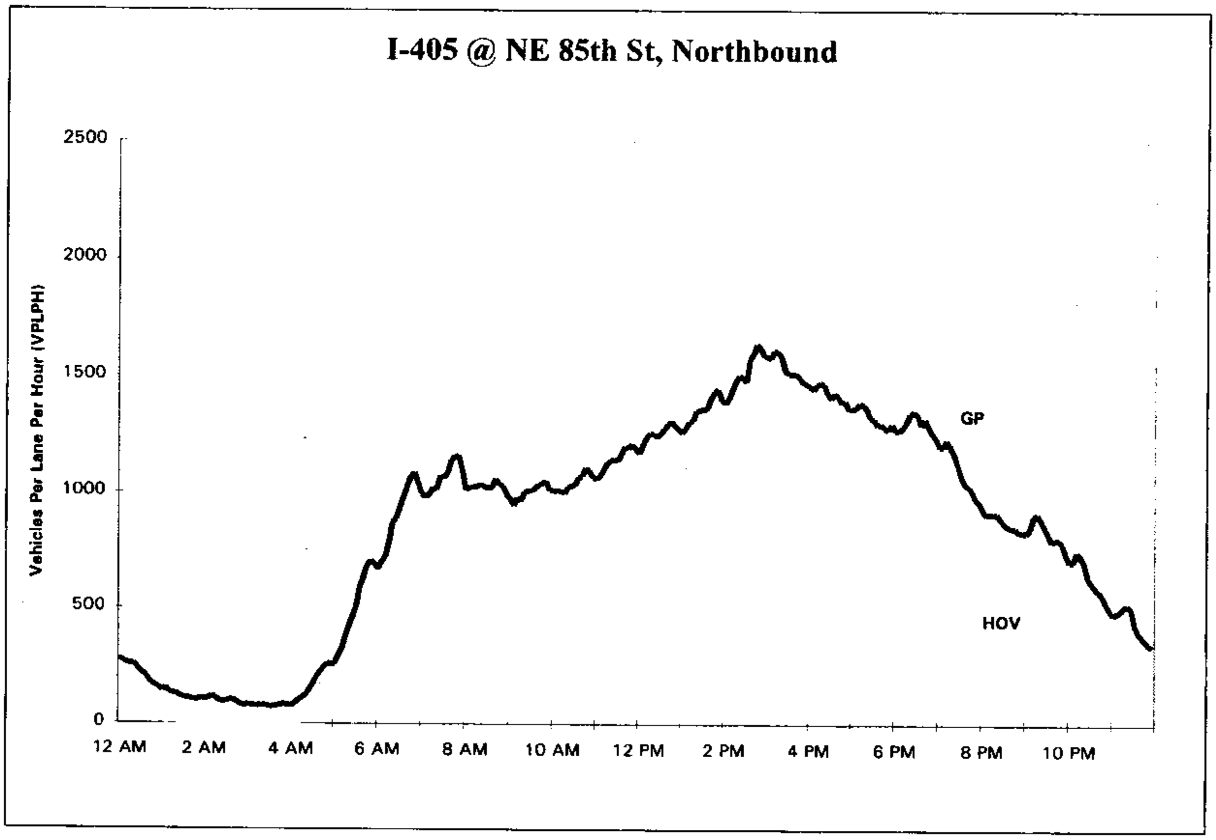


Figure 3-1. HOV Traffic Flow Profile (Nov-Dec, 1998): I-405 North of I-90 Interchange During the AM Peak Period



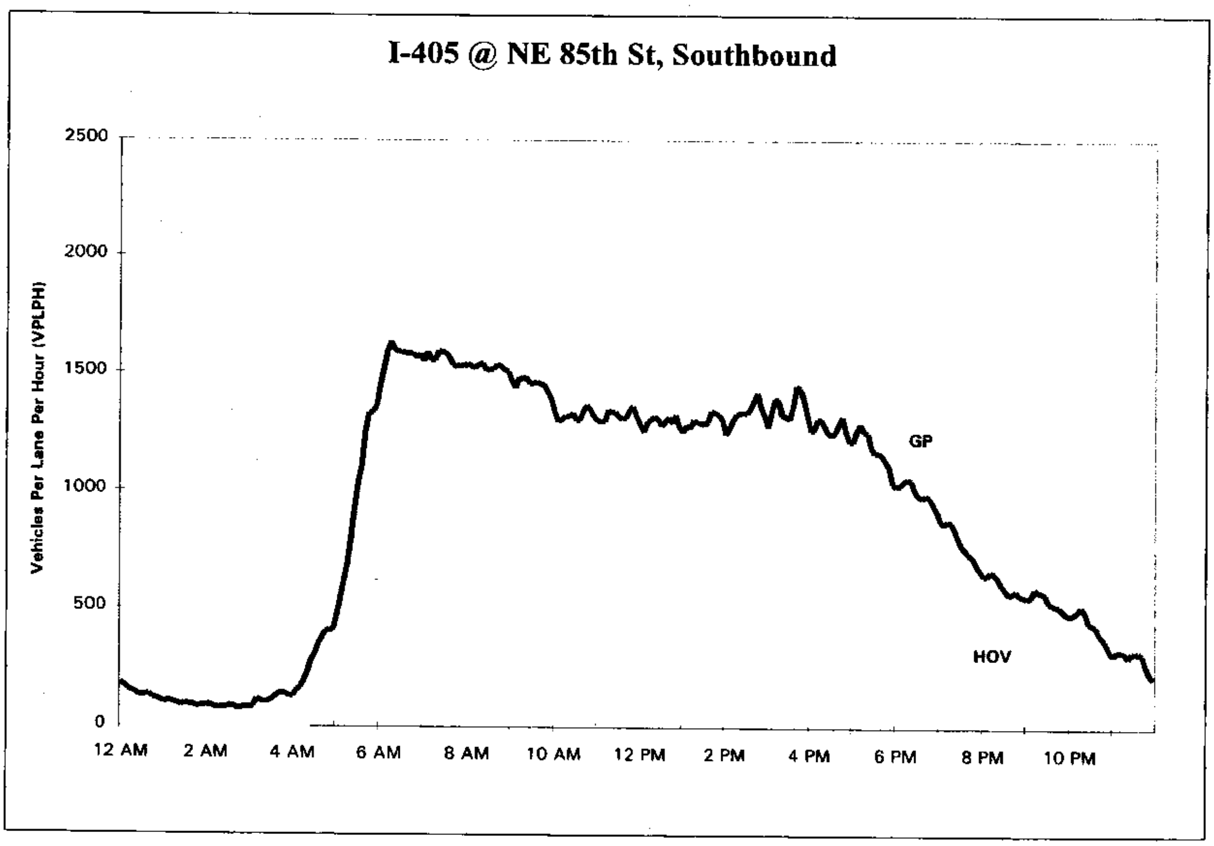
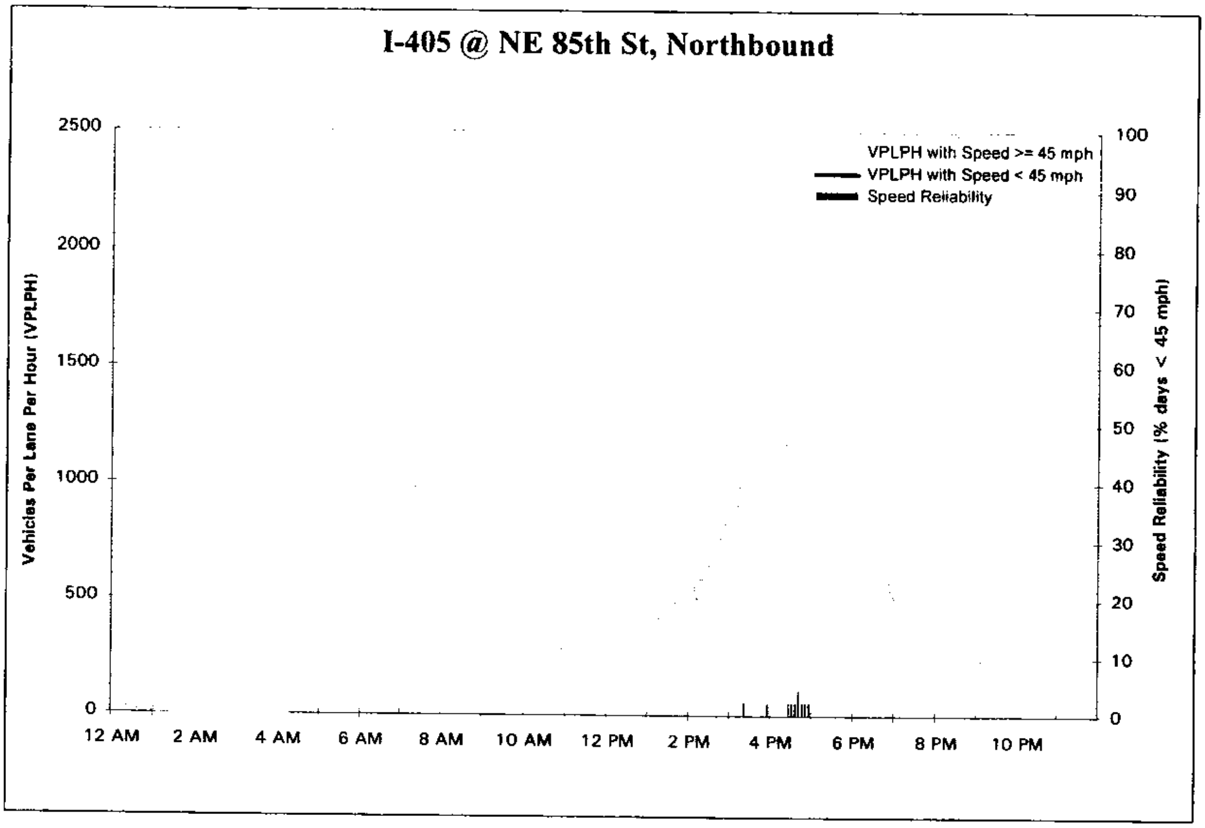


Figure 3-2. Average Weekday GP and HOV Volume Profile (1998): I-405 @ NE 85th St

The macro then asks if histograms will be produced. If the answer is yes, the graphs are produced. The macro color-codes the line graph on the basis of the speed profile using fixed color/speed ranges (red < 45 mph, yellow = 45 to 55 mph, green > 55 mph). The resulting output files have the same name as the input file, except with an ".hst" extension. Each file contains the original input file in one sheet and the resulting site performance graph in another sheet.

You can then specify whether to print graphs to the default printer. You can also specify whether the headers of the output data files (summary information) should be included with the print out. Note: If you answer "No" to the question about producing graphs but "Yes" to the question about printing, the " .hst" version of each file in the command file will be printed.

As can be seen in Figure 3-3, the resulting output shows a line graph of vehicle volume (measured per lane per hour) as a function of time of day, at a particular site for a given travel direction and lane type (GP or HOV). This graph is then supplemented with the speed estimate profile by adding a color to each data point on the volume curve; the color is based on the corresponding speed for that time interval. To determine the color for each data point, the speed information is mapped to several speed ranges; each range then corresponds to a different color. For example, if the calculated speed is estimated at or above 45 mph at 9:00 am, the corresponding volume line segment is gray at that time; if the speed is below 45 mph, the line is black. By combining the volume and speed profiles in this way, a single graph allows the viewer to distinguish between , for example, low traffic volumes associated with free-flow traffic and low volumes that are the result of congested conditions. This graph is then supplemented with an overlay of the



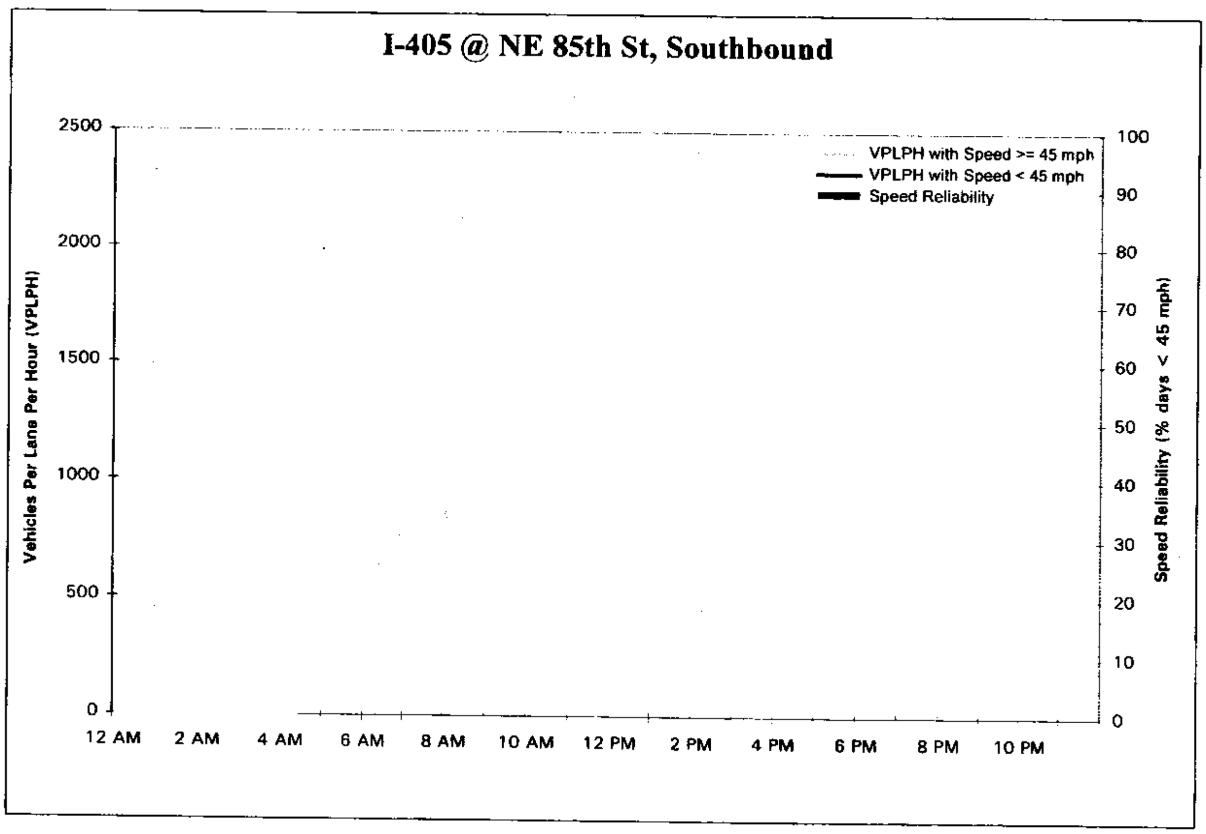


Figure 3-3. Average Weekday Volume, Speed, and Reliability Conditions: I-405 @ NE 85th St

reliability profile, in histogram or column graph form. When displayed in tandem with the color-coded volume line graph, the reliability histogram can help highlight the relationships between the averaged values of volume and speed, and the frequency of congestion. By measuring the frequency of congested conditions, the histogram indicates the extent to which there is significant day-to-day variability from the average values.

PRODUCING THE DAILY CORRIDOR PROFILE

The daily corridor profile is an average 24-hour profile of lane occupancy percentage at each of the selected locations for a specified direction of travel at 5-minute increments. The following are step-by-step instructions for using CDR Analyst to produce the profile.

Running CDR Analyst

1. Double-click the program icon to start.

2. Accept preferences? Answer Y (yes) or N (no).

   The list of preferences includes preset parameters (e.g., time window for data replacement, allowable bad weekdays, congestion threshold, date range, etc.) for running the program. You may opt to change these values with a text editor.

3. Do you need to extract weekday data from seven day data files? Answer Y (yes) or N (no).

   All data files include both weekday and weekend data. If you want to produce statistics based only on weekdays, indicate your choice. Otherwise, all seven days of the week will be used to produce the desired statistic.

4. Do you wish to run a batch job? Answer Y (yes) or N (no).

   The batch job option is used to process multiple locations for corridor profiles and travel time profiles. It is used for a travel time profile, so answer Y (yes).

5. Do you want travel time information? Answer Y (yes) or N (no).

   Answer N (no) to this question to avoid travel time profiles.

6. Do you want congestion frequency contours? Answer Y (yes) or N (no).

If you answer Y (yes) to this question, congestion frequency contour output will be computed. If you answer N (no), the output will be based on average occupancy. You should answer N to obtain output based on level of service.

7. Enter the batch file name.

   At this point, type the name of the batch file (a text file) that contains the data file names for the sites that you are interested in (file naming convention is shown below). There is no restriction on the batch file name; however, use the CDR Auto file naming convention for all files listed in the batch file. The list of files should be in ascending or descending order of milepost. The following is the file naming convention:

   CCCCLDYY.dat

   where

   CCCC = cabinet number (i.e., the measurement site); leading zeroes are used if < 4 digits

   L = lane type (G = GP, H = HOV)

   D = direction of travel (N=northbound, S=southbound, E=eastbound, W=westbound)

   YY = year (e.g., 97 = 1997)

   NOTE: CDR Analyst assumes that all files associated with the analysis (the CDR Analyst program, the input data files, batch files if any) are in the same directory.

8. Accept 'suspicious' data? Answer Y (yes) or N (no).

   Each 5-minute data point has a data quality indicator flag associated with it. This data flag indicates whether the data point is considered "good," "bad," "suspect," or "disabled" (i.e., the equipment is off-line). CDR Analyst uses all available good data, and attempts to replace bad, suspect, or disabled data points with nearby good data. However, you have the option to accept suspect data as good data. This option is available because the "suspect" label is based on a conservative threshold. In many cases, suspect data are very much consistent with the good data that surround them. However, if there is some question about this, you can specify that suspect data be considered the same as bad data and therefore subject to replacement by nearby good data.

9. Output file name.

   The resulting data are sent to an output file of your choice. The output file is assumed not to exist yet; if it does exist, you will be alerted and given the option to overwrite the existing file. The output file is placed in the same directory with the input data and the CDR Analyst program.

10. Use Utility D to create the graphical output for Weekday Average HOV Traffic Profile.

Utility D – Weekday Average HOV Traffic Profile

An Excel template converts output from the CDR Analyst contour process into a contour (topographic style) map. To use the template, copy the entire output data file from CDR Analyst into the "data" worksheet of the template; the "graph" sheet shows the result. In some cases, the milepost range will need to be modified. If significant changes are needed, it may be easier to use the Excel Wizard to create a new contour map. Note that the final version of the corridor graphic with both directions of travel and the corridor map must be created manually with a drawing program.

The resulting graph shows a contour map of the lane occupancy percentage information that is color-coded according to estimated congestion level (i.e., level of service). The range of values used for each color corresponds to different levels of traffic congestion, based on the level of service concept described in the *Highway Capacity Manual* for freeways with a free-flow speed of 65 mph. The following fixed ranges are used:

Color	Lane Occupancy %	LOS	General Traffic Description
green	0 to 10 percent	A, B, C	uninterrupted travel at the speed limit
yellow	10 to 13 percent	D	moderate traffic at or near the speed limit, with restricted movement (e.g., when changing lanes)
red	13 to 19 percent	E	traffic moving at or somewhat below the speed limit, with restricted movement
purple	above 19 percent	F	congested traffic with restricted movement

The result is a corridor overview of traffic conditions as a function of location along the corridor, as well as of time of day and direction of travel. The graphic is in a topographic map style in which elevation is replaced by average traffic conditions. Note: The template that is used to produce this graphic will produce one contour map for each direction of travel. To produce a two-direction graphic such as the one shown in Figure 3-4, each contour map and any descriptive map art must be produced separately, then brought together with a standard drawing program such as Corel Draw.

PRODUCING SPEED, RELIABILITY, AND TRAVEL TIME PROFILES

The following are step-by-step instructions on the use of CDR Analyst to produce the following corridor profiles: (1) Average Weekday HOV Speed and Reliability, (2) Average Weekday GP and HOV Travel Time. The speed and reliability profiles and travel time profiles require the same steps in running CDR-Analyst to produce data output, but different templates to produce the final graphical output.

Running CDR Analyst

1. Double-click the program icon to start.

2. Accept preferences? Answer Y (yes) or N (no).

   The list of preferences includes preset parameters (e.g., time window for data replacement, allowable bad weekdays, congestion threshold, date range, etc.) for running the program. You may opt to change these values with a text editor.

3. Do you need to extract weekday data from seven day data files? Answer Y (yes) or N (no)

   All data files include both weekday and weekend data. If you want to produce statistics based only on weekdays, indicate your choice. Otherwise, all seven days of the week will be used to produce the desired statistic.

4. Do you wish to run a batch job? Answer Y (yes) or N (no).

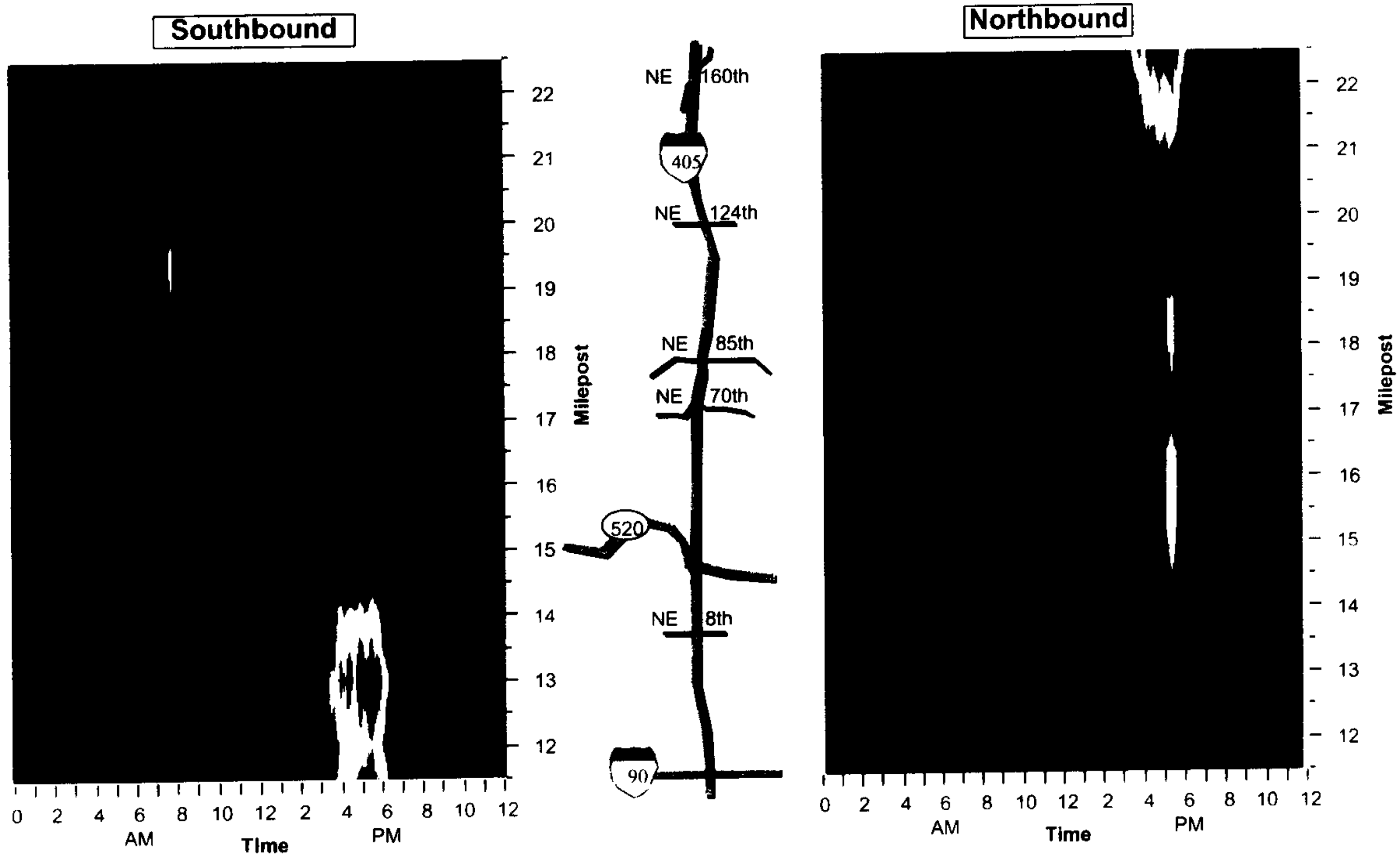
   The batch job option is used to process multiple locations for corridor profiles and travel time profiles. It is used for a travel time profile, so answer Y (yes).

5. Do you want travel time information? Answer Y (yes) or N (no).

   Answer Y (yes) to this question to get travel time profiles.

6. Do you want daily travel time information? Answer Y (yes) or N (no).

   This question refers to the option to either calculate travel times for each individual day and compute statistics based on this collection of times, or to compute an overall 24-hour profile of traffic data first, then compute travel time based on this aggregate profile. Answer Y (yes) to this question to get all three travel time profiles (average, 90th percentile, travel time



Uncongested, near speed limit | Restricted movement but near speed limit | More heavily congested, 45 - 55 mph | Extremely congested, unstable flow

Figure 3-4. 1998 Weekday Average HOV Traffic Profile: I-405 North of I-90 *(HOV Lane Placed Inside)*

reliability). If you answer N (no), you will only get an average travel time that is based on the aggregate 24-hour profile of all days processed. Usually, you should answer Y.

7. Enter the batch file name.

   At this point, type the name of the batch file (a text file) that contains the data file names for the sites that you are interested in (file naming convention is shown below). There is no restriction on the batch file name; however, use the CDR Auto file naming convention for all files listed in the batch file. The list of files should be in ascending or descending order of milepost. The following is the file naming convention:

   CCCCLDYY.dat

   where

   CCCC = cabinet number (i.e., the measurement site); leading zeroes are used if < 4 digits

   L = lane type (G = GP, H = HOV)

   D = direction of travel (N=northbound, S=southbound, E=eastbound, W=westbound)

   YY = year (e.g., 97 = 1997)

   NOTE: CDR Analyst assumes that all files associated with the analysis (the CDR Analyst program, the input data files, batch files if any) are in the same directory.

8. Accept suspect data? Answer Y (yes) or N (no).

   Each 5-minute data point has a data quality indicator flag associated with it. This data flag indicates whether the data point is considered "good," "bad," "suspect," or "disabled" (i.e., the equipment is off-line). CDR Analyst uses all available good data, and attempts to replace bad, suspect, or disabled data points with nearby good data. However, you have the option to accept suspect data as good data. This option is available because the "suspect" label is based on a conservative threshold. In many cases, suspect data are very much consistent with the good data that surround them. However, if there is some question about this, you can specify that suspect data be considered the same as bad data and therefore subject to replacement by nearby good data.

9. Choose speed algorithm? Answer N (normal) or K (Kalman).

   Two methods are implemented in the program for estimating speeds. The so-called normal method uses the formula that WSDOT uses in its WebFlow web-based system to estimate speeds. The Kalman method was developed by D. Dailey at the University of Washington[2]. A preliminary version of the Kalman code has been implemented; however, associated constants have not yet been calibrated. Therefore, you are advised to use the normal method in the current version of CDR Analyst. In the "normal" algorithm, the average speed of vehicles at a site, across all lanes, for a given 5-miniute interval, is determined by using the core process described in Chapter 2, then using the resulting average per-lane volume and occupancy to estimate speed.

10. Enter OUTPUT file name.

---

[2] D. J. Dailey, *A Statistical Algorithm for Estimating Speed from Single Loop Volume and Occupancy Measurements* Transportation research. Part B: Methodological, 1999.

The resulting data are sent to an output file of your choice. The output file is assumed not to exist yet; if it does exist, you will be alerted and given the option to overwrite the existing file. The output file is placed in the same directory with the input data and the CDR Analyst program.

11. Use Utility E to create graphical output for Estimated Weekday HOV Speed and Reliability. Use Utility F to create graphical output for Estimated Weekday Travel Time: GP vs. HOV Lanes.

Utility E – Average Weekday HOV Speed and Reliability

Output from the CDR Analyst speed and reliability process is manipulated by Utility E to produce the average weekday HOV speed and reliability graph. To use the template, copy the entire output data file from CDR Analyst into the "data" sheet of the template; the "graph" sheet shows the result. In some cases, the titles will need to be modified manually. As can be seen in Figure 3-5, the results are shown as a line graph of the 90th percentile speed and a superimposed speed and reliability measure histogram (column graph), displayed as a function of trip start time for a specific origin and destination.

Utility F – Average Weekday GP and HOV Travel Time

An Excel template allows output from the CDR Analyst travel time process to be displayed as a combination GP vs. HOV line graph figure. To use the template, copy the entire output data file from CDR Analyst into the "data" sheet of the template; the "graph" sheet shows the result. In some cases, the titles will need to be modified manually. As can be seen in Figure 3-6, the result is a line graph of the average travel time for GP and HOV lanes. The results are displayed as a function of trip start time for a specific origin and destination.

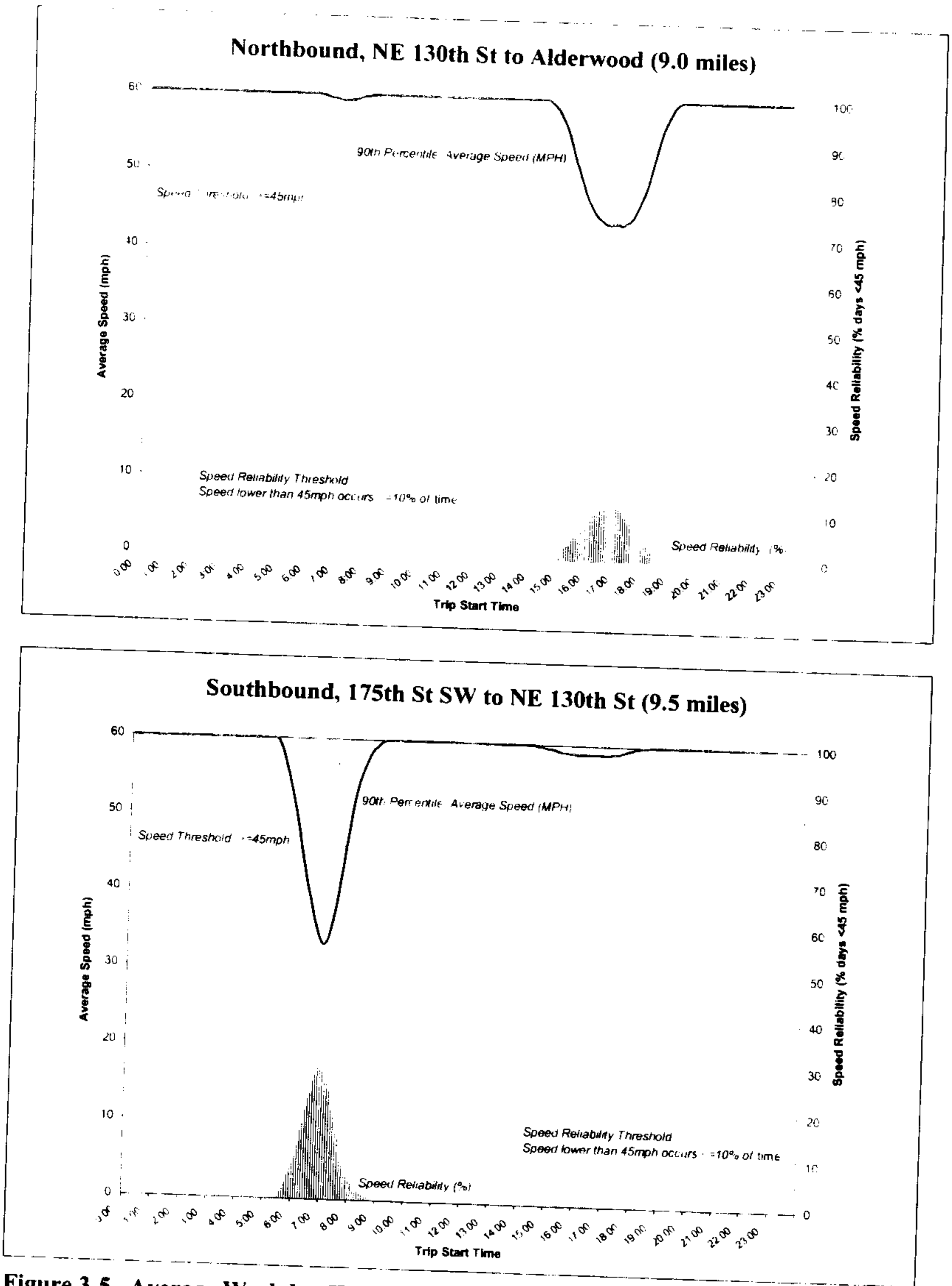


Figure 3-5. Average Weekday HOV Speed and Reliability (1998): I-5 North of the Seattle CBD

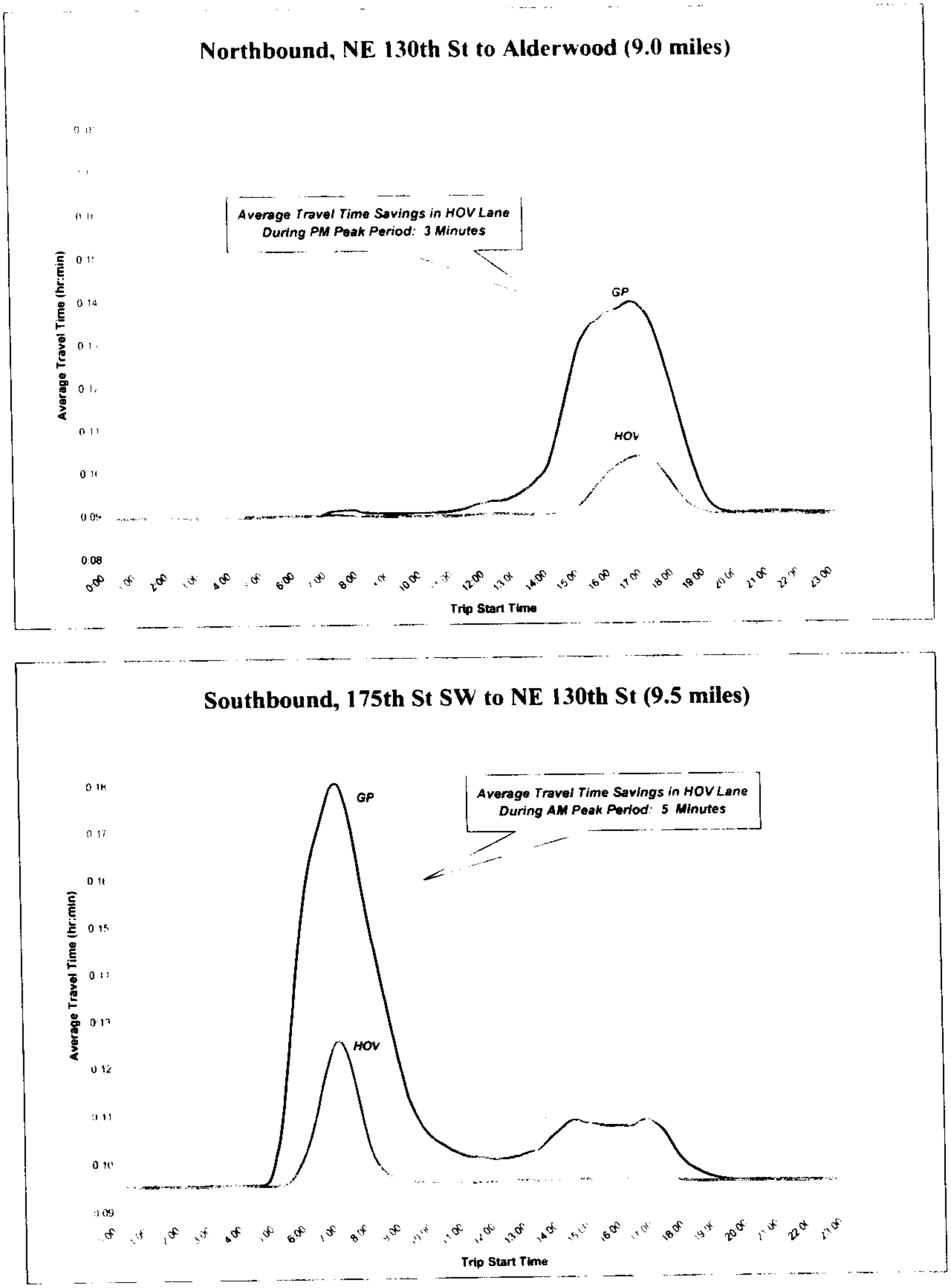


Figure 3-6. Average Weekday GP and HOV Travel Time (1998): I-5 North of the Seattle CBD

CHAPTER FOUR
THROUGHPUT ANALYSIS

DATA ELEMENT AND SOURCE

This section provides steps for computing person-carrying ability on HOV and GP facilities. The number of vehicles traveling on GP and HOV lanes at selected locations, computed by running CDR Analyst, is combined with available data about the average number of persons per vehicle (vehicle occupancy) to compare the number of people using GP and HOV lanes at selected sites on major corridors during the peak period. Three vehicle categories are analyzed: (1) passenger cars, (2) vans, and (3) transit buses. For cars and vans, the number of vehicles of each type at the site of interest is determined by multiplying vehicle volumes (from CDR Analyst) by the corresponding mode split data from the WSDOT HOV lane evaluation and monitoring project's field measurements (i.e., the percentage of all vehicles at a site that consists of cars, buses, vans, etc.). Person throughput at the site in cars or vans is then computed by multiplying the number of vehicles of each given type by the average number of passengers per vehicle, as determined from the research project or other transit agency sources. Average bus ridership is obtained from local transit agencies and does not need to be computed; however, the bus ridership is adjusted to reflect the actual percentage of buses traveling in each lane type, which is based on field measurement. The three resulting person volumes measured by vehicle type are then added together to produce an overall person volume estimate. The peak period person volume formula is as follows:

Total persons carried
= (# of persons in cars) + (# of transit riders) + (# of van riders)
= (Adj. Veh. Vol.) * (% Car)*(ACO) + (Adj. Veh. Vol.) * (% Van) * (VanOcc) + (Bus Ridership) * (HOV/GP Bus Dist.)

Table 4-1 defines each of the data elements used for this calculation and lists the source. All the estimates are prepared for AM peak (6:00-9:00) and PM peak (15:00-19:00) periods. Please refer to Chapter Three on CDR Analyst operating instructions for computing the vehicle volumes.

Table 4-1. Data Elements and Data Sources

Data Element	**Definition**	**Data Source**
Total Veh. Vol.	Total number of vehicles traveling at that site (for a given direction of travel and lane type)	CDR Data (1998 yearly peak period average)
Adj. Veh. Vol.	Total number of vehicles traveling at that site (for a given direction of travel and lane type), including cars, transit buses, and vans only	CDR Data (1998 yearly peak period average) and ACO Data included in *HOV Evaluation and Monitoring Phase IV* report (Q2 and Q3 1998 data)
ACO	Average car occupancy at that site (weighted average occupancy of 1, 2, 3 and 4+ person cars)	*HOV Evaluation and Monitoring Phase IV* report (Q2 and Q3 1998 data)
%Car, %Van	Percentage of vehicles that are cars (with 1 to 4+ passengers) or vans traveling at that site (for a given direction of travel and lane type)	ACO Data included in *HOV Evaluation and Monitoring Phase IV* report (Q2 and Q3 1998 data)
VanOcc	Average van occupancy at that site (including driver)	King County Metro Rideshare Operations Performance (9.27 for 1998)
Bus Ridership	Total number of peak period riders at a site traveling in a given direction on a given lane type.	Local transit agencies: KC Metro Transit, Community Transit, Pierce Transit (1998 peak period data)
HOV/GP Bus Dist.	Percentage of buses that travel in a given lane type at that site (GP or HOV)	ACO Data from *HOV Evaluation and Monitoring Phase IV* report (Q2 and Q3 1998 data)

ASSUMPTIONS AND CONSIDERATIONS

Locations along the HOV corridors are selected to demonstrate performance on the basis of the following considerations: (1) the number and availability of data collected electronically and manually, and (2) the appropriateness of the data collection locations to avoid examples that may not adequately represent performance in the corridor. Because the data are collected from different sources for different purposes and uses, a spatial and temporal match may not always be easily achieved among the types of data. For example, on I-405 at NE 12th St., the 1998 loop data and the 1997 bus data were obtainable. However, the ACO data were only available up to 1994 before the observation site was moved south to NE 4th St.

Table 4-2 is an example of potential data that were collected for selected locations to estimate person volumes during 1998. This entire list should be updated before future evaluations. Nevertheless, this table illustrates the importance of evaluating data availability, as well as the proximity of data collection locations associated with a particular site.

ACO Data

Observation sites where ACO field measurements are collected for both mainline GP and HOV facilities are limited. Because the available ACO data were collected on an averaged quarterly basis during AM and PM peak periods for weekdays only, the variability of the HOV system in carrying people over time, such as monthly, daily, and weekday versus weekend, was not assessed.

Table 4-2. Study Locations and Data Availability

Locations	ACO Data (Q2, Q3/1998)	Transit Data (Metro –Fall, CT – October, Pierce – Yearly 19 97)		Volume Data CDR- 1998 Average	
	Observation Location	*Agency*	*Observation Location*	*Cabinet Location*	*MP*
I-5 @ 112th SE – Everett	112th SE - Everett	CT	bt 128th St. SE/SR–526 (NB, SB)	112th St. SW – NB 112th St. SW – SB	187.98 187.88
I-5 @ NE 145th St.	NE 145th St.	Metro CT	bt NE 133th St./NE 130th St. (NB) bt NE 133th St./135th St. (SB) bt NE 130th St./NE 145th St.(NB, SB)	NE 137th St.	174.16
I-5 @ Albro Place	Albro Place	Metro Pierce	bt Alaska St./Edmunds St. (NB) bt S. Oregon St./Nevada St. (SB) I-5 @ S. 320th St.	S. Pearl St.	161.85
I-405 @ NE 85th St.	NE 85th St.	Metro CT	bt NE 124th St./NE 85th St. (NB, SB) bt SR-520 and NE 85th St. (NB, SB)	NE 85th St.-SB	17.99
I-405 @ SE 52nd st	112 Ave SE/Lk Wa Blvd.	Metro	bt SE 64th St./SE 69th Way (NB) bt SE 60th St./SE 64th St. (SB)	SE 59th St.	8.92
I-405 @ Tukwila Parkway	Tukwila Parkway	Metro	NA	Andover Park – E	.69
I-90 @ Midspan	*HOV* I-90 RL *GP* Island Crest Way	Metro	bt Rainier Ave/21st Ave S (EB) bt 21th Ave/22nd Ave (WB)	Mid Span WB Midspan EB	2.00 2.54
I-90 @ Newport Way	Newport Way	Metro	bt Front St N./270th Ave SE (EB, WB)	W LK Sam Pkwy - WB	13.49
SR 520 @ 84th Ave NE	Yarrow Point	Metro CT	bt Evergree Pt Rd./80th Ave NE (WB) SR-520	84th Ave. NE-WB	4.62
SR 167 @ S. 208th – Kent	S. 208th – Kent	Metro	bt S. 216th St/S. 222nd St. (NB) bt S. 216th St/S. 218th St. (SB)	4th Ave N 84th Ave. S	20.69 21.33

Transit Data

The notation of "peak period" may vary from transit agency to transit agency, depending on the area each serves, although the difference is generally less than a half hour. Metro Transit defines the AM peak period from 6:00 AM to 9:00 AM and the PM peak period from 3:30 PM to 6:30 PM. Community Transit defines 5:00 AM to 9:00 AM as the AM peak period and 3:00 PM to 6:00 PM as the PM peak period. For Pierce

Transit, the AM peak period is from 6:00 AM to 9:00 AM and the PM peak period is from 2:00 PM to 6:00 PM.

Volume Data

The analysis performed by CDR Analyst is highly dependent on the quality of the original sensor data. Loop data may be insufficient during the year because of road construction or loops in bad condition. Significant quantities of suspect or invalid data may affect the computation of measures of performance. Therefore, it is important to examine the data to verify that enough "good" or valid data are available at a given location. Chapter Two describes the data quality mapping option for reviewing the quality of available data at the sites of interest

PRODUCING GP VS. HOV THROUGHPUT COMPARISON

The vehicle and person throughput data for GP and HOV lanes are computed as both overall and per-lane statistics. This allows the determination of what proportion of total throughput is provided by the HOV facility, while also providing a fairer comparison of how much throughput the HOV lane is providing in comparison to a single GP lane. Figure 4-1 shows the results. The overall statistics show the percentage of vehicle and person volume carried by GP and HOV lanes. For each lane type, the total number of vehicles and persons carried is then divided by the number of lanes associated with each type of data, creating a per-lane statistic. It also shows the percentages of increase and decrease in the HOV lane's throughput ability in comparison to the GP lane on a per-lane basis.

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

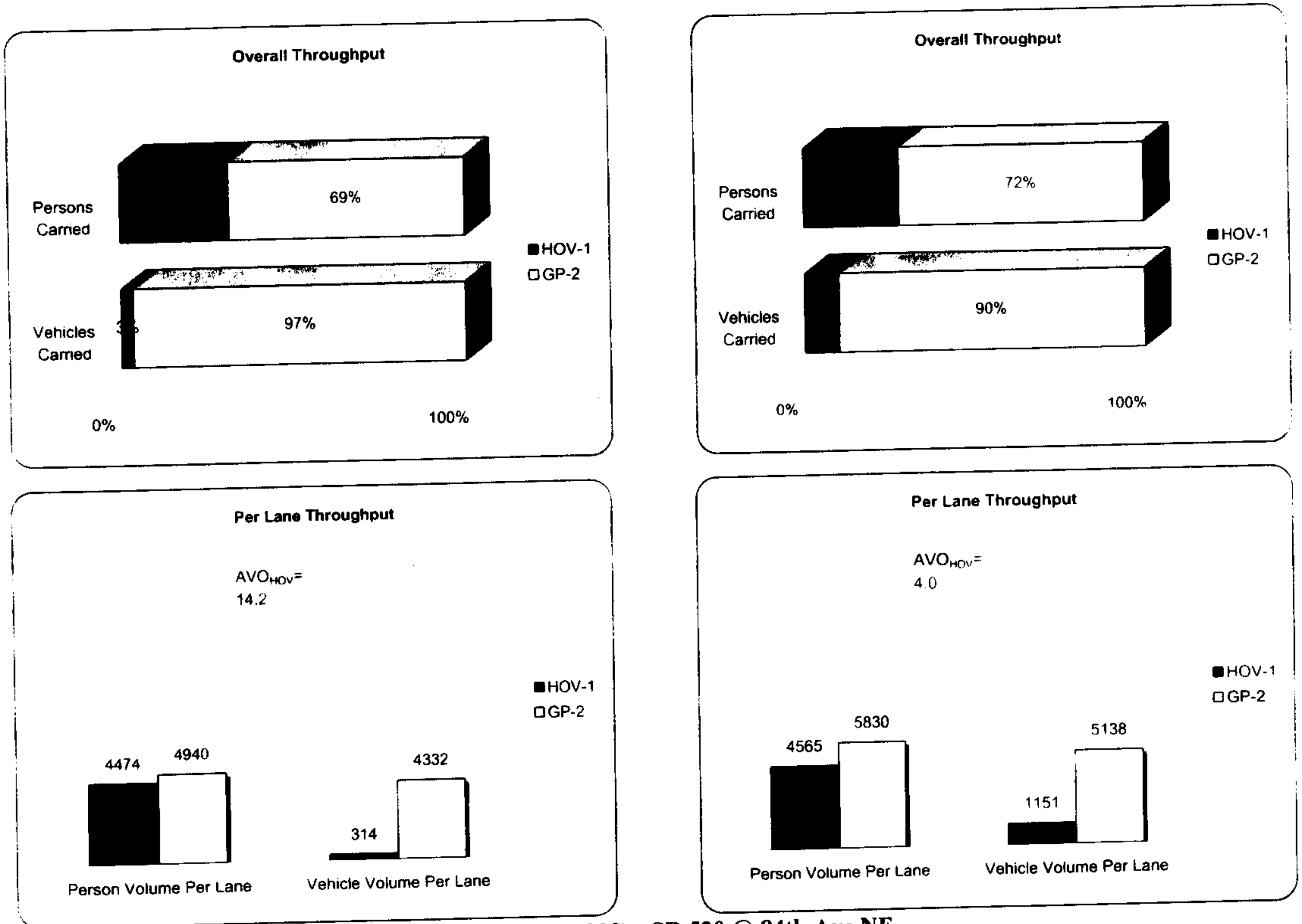


Figure 4-1. GP vs. HOV Throughput Comparison (1998): SR 520 @ 84th Ave NE