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A STUDY OF DRIVING AND STORAGE PATTERNS OF NONPRIMARY PRIVATE VEHICLES IN THE SOUTH COAST AIR BASIN

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ABSTRACT

Every post-1970 California vehicle is equipped with an evaporative emission control system (EECS). The main component of the EECS is a canister filled with activated charcoal which is designed to trap gasoline vapor from the carburetor after the engine is shutoff or from the fuel tank when the vehicle is not used for several days. It is suspected that current EECS may not be very effective for a nonprimary vehicle: vehicles which are used primarily for shorter trips than 7.5 miles each way or driven 3 days or less per week. The objectives of this study are to estimate the size of such nonprimary vehicle population and determine their typical driving and storage patterns through a telephone questionnaire survey. The survey was conducted for 800 households, which were randomly selected from white page listings of the 15 telephone directories covering the South Coast Air Basin (SCAB). Results of the survey indicate that the nonprimary vehicles constitute 52.6 percent of all vehicles or 2.95 million vehicles over the SCAB region. A cursory analysis of their driving and storage data and the recent laboratory test data on hot soak emission and purging has identified four distinct driving and storage patterns: low hot soak class of vehicles with long driving distance and small number of trips per week; moderate hot soak class of vehicles with moderate driving distance and large number of trips; high hot soak class of vehicles with short driving distance and large number of trips; and diurnals dominated class of vehicles with long driving distance and small number of days used per week.

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EXECUTIVE SUMMARY

for

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Every post-1970 California vehicle is equipped with an evaporative emission control system (EECS). The main component of the EECS is a canister filled with activated charcoal which is designed to trap gasoline vapor from the carburetor after the engine shut-off or from the fuel tank when the vehicle is not used for several days. It is suspected that current EECS may not be very effective for a nonprimary vehicle: vehicles which are used primarily for shorter trips than 7.5 miles each way or driven 3 days per or less week. The objectives of this study are to estimate the size of such nonprimary vehicle population in the South Coast Air Basin (SCAB) and identify their typical driving and storage patterns so that evaporative emissions from such vehicles can be simulated and tested at the ARB's Haagen-Smit Laboratory.

To achieve the above objectives, a telephone questionnaire survey was conducted for households, which were randomly selected from white page listings of the 15 telephone directories covering the SCAB region. A target number of 800 household interviews were first allocated to each of the four counties according to the estimated number of households in that county and, then, further broken down to each telephone directory service area according to the estimated number of residential listings in the directory. The actual number of interviews equaled or slightly exceeded the initially allocated number in every telephone directory service area.

Results of the survey indicate that the nonprimary vehicles constitute 52.6 percent of all vehicles or 2.95 million vehicles over the SCAB region. The survey also has revealed that there are fewer recent model year vehicles and more older vehicles in the present vehicle mix than the vehicle mix of 5 years ago and earlier years. Compared with the average vehicle mix of the total vehicle population the nonprimary vehicle population contains more older

vehicles, more recreational vehicles, and more American made vehicles. These nonprimary vehicles are stored predominantly outdoors and are used about evenly for work/school commuting, shopping, and other purposes. About 12 percent of nonprimary vehicles are driven less frequently than once a week, and the other 88 percent of vehicles are driven, on an average, 4 days a week, and used for five round trips a week.

An analysis of the driving and storage data obtained from the present analysis and the recent laboratory test data on hot soak emission and purging identified the following four distinct driving and storage patterns:

- Low hot soak class (27 percent of all nonprimary vehicles) characterized by long driving distance (7 miles on the average) and small numbers of trips (6) made and days (3) used per week,
- Moderate hot soak class (40 percent) characterized by moderate driving distance (4 miles), large numbers of trips (14) made and days (6) used per week,
- High hot soak class (16 percent) characterized by short driving distance (2 miles), large numbers of trips (12) made and days (6) used per week, and
- Diurnals dominated class (17 percent) characterized by long driving distance (7 miles) and extremely small numbers of trips (2) made and days (0) used per week.

The reliability of the present survey was examined by undertaking verification interviews of 83 households and by comparing the present survey estimates and other estimates on some socio-economic parameters. The verification interviews have revealed that the current survey estimates of driving and storage parameters are only moderately reliable while those of number and make of vehicles are quite reliable. The present survey estimates of type of house, ethnic heritage and household income are found to be in fair to good agreement with other estimates of such parameters.

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1.0 INTRODUCTION AND SUMMARY

The objective of this study is to identify the typical usage patterns for nonprimary private vehicles so that evaporative emissions from such vehicles can be simulated and tested at the ARB's Haagen-Smit Laboratory. Here, the nonprimary vehicles are all vehicles other than the primary vehicles that are driven regularly over 7.5 miles each way 4 days per week or more. For these nonprimary vehicles, current evaporative emission control systems (EECS) may not be very effective because the nonprimary vehicles tend to be used for short trips or remain unused for extended periods. Such operating conditions of nonprimary vehicles could make the EECS ineffective by overloading the charcoal canister due to insufficient purging, and thus by negating the adsorption effect of the activated charcoal.

To achieve the objective described above, a telephone questionnaire survey was designed and conducted in the South Coast Air Basin (SCAB). Specifically, the survey was made to estimate the nonprimary vehicle population in the SCAB and to obtain a profile of their driving and storage patterns. The telephone questionnaire survey was used for current information gathering efforts because it is far more cost effective than household visits by a questionnaire surveyor and yet is expected to attain considerably higher return rate than would a mail questionnaire survey.

The current evaporative emission tests conducted at the ARB's Haagen-Smit Laboratory are made according to the EPA recommended test procedure, which does not adequately reflect the typical driving conditions observed in real-world vehicle uses. As a result, evaporative emission factors derived from the test results may not be very representative for evaporative emissions of motor vehicles, in particular, those of nonprimary vehicles. The present survey would provide the needed information about nonprimary

vehicle's driving and storage patterns. By using the information gained from this survey, future evaporative emission procedures can be improved so as to yield basic emission data, from which a more accurate emission factor for evaporative emissions of motor vehicles can be determined.

1.1 SUMMARY OF FINDINGS

The following paragraphs summarize the findings of the telephone questionnaire survey and the conclusions reached in the subsequent analysis of the survey data. For convenient reference, the summary is organized according to the order of the chapters.

1.1.1 DESIGN OF THE SURVEY INSTRUMENT (CHAPTER 2.0)

- A questionnaire addressing vehicle ownership, socio-economic status, typical vehicle usage, and specific vehicle use during the past week was developed, refined and applied to an estimated 800 selected households in the SCAB region.

- The number of households to be interviewed in each of 15 telephone directory service areas was determined according to the estimated number of households in each area. The actual number of interviewed households in the present survey equaled or slightly exceeded the allocated number in each service area.

- The present survey has successfully interviewed 870 households throughout the SCAB region and has identified 770 nonprimary vehicles and 694 primary vehicles. The fraction of nonprimary vehicles to all vehicles is estimated to be 0.526, with the lower bound of 0.497 and the upper bound of 0.555 (Appendix D).

1.1.2 CHARACTERISTICS OF PRIMARY AND NONPRIMARY VEHICLE POPULATION (CHAPTER 3.0)

- The sample vehicle population obtained from the present survey exhibits that there are fewer recent model year vehicles and more older vehicles in the present vehicle mix than the vehicle mix of 5 years ago and earlier years.

- The mean age of all vehicles is estimated to be 6.5 years old, while those of the primary and nonprimary vehicles are, respectively, 5.5 and 7.5 year old, with the nonprimary vehicle population being comprised of more older vehicles than the other two vehicle populations.

- The population of nonprimary vehicles that are used for short trips (<7.5 miles each way) and/or are driven infrequently (≤3 days/week) consists of more recreational vehicles and more American made vehicles than does the total vehicle population.

- Nonprimary vehicles are stored predominantly outdoors (56 percent outdoor + 11 percent roofed carport) and driven evenly throughout the year (80 percent). Their usages are spread evenly over work/school commuting, shopping, and other uses.

- On an average, nonprimary vehicles are driven 4 days per week and are used for 10 one-way trips or five round trips per week. The typical driving distance and park duration of nonprimary vehicles are 5 miles and over 1 hour for work/school, 2 miles and 30 to 60 minues for shopping, and 5 miles and over 1 hour for other uses.

- About 12 percent of nonprimary vehicles are driven less frequently than once a week. These infrequent vehicles are used primarily for recreational (47 percent) or nonspecific (31 percent) purposes and their fuel tanks are kept at half full or less when not in use.

1.1.3 DRIVING AND STORAGE PATTERNS OF NONPRIMARY VEHICLES (CHAPTER 4.0)

- The key driving and storage parameters that affect the evaporative emission of a motor vehicle are considered to be the number of days used per week, the number of trips made per week, the average driving distance, and the average park duration. These four key parameters are used to estimate three emission related variables: multiple diurnal emission (= 7 - number of days used), hot soak emission (a function of number of trips and average park duration), and the amount of purging (a function of number of trips and average driving distance).

- The values of three emission related variables are computed for each nonprimary vehicle by using the interview results

and two functions for hot soak emission and amount of purging that were empirically determined from emission test data.

- The joint frequency distribution of number of diurnals, purge/hot soak ratio, and number of trips per week indicates that there are four distinct evaporative emission classes for nonprimary vehicles: low hot soak class (27 percent of all nonprimary vehicles), moderate hot soak class (40 percent), high hot soak class (16 percent), and diurnals dominated class (17 percent).

- The characteristics of vehicle usages in each class are: long driving distance (7 miles) and small numbers of trips (6) and days used (3) for low hot soak class; moderate driving distance (4 miles) and large numbers of trips (14) and days used (6) for moderate hot soak class; short driving distance (2 miles) and large numbers of trips (12) and days used (6) for high hot soak class; and long driving distance (7 miles) and extremely small numbers of trips (2) and days used (0) for diurnals dominated class.

1.1.4 COMPARISON BETWEEN PRESENT SURVEY ESTIMATES AND OTHER ESTIMATES (CHAPTER 5.0)

- In spite of the small sample size (800 households), the socio-ecomonic parameter values estimated from the present survey results are in fair to good agreement with other estimated values of house type from the 1980 California Department of Finance's statistics, of ethnic mix from the 1980 census statistics, and of household income from the LARTS urban/rural survey statistics.

1.2 RECOMMENDATIONS FOR FUTURE STUDIES

The present study has accomplished the initial objectives of estimating the size of the nonprimary vehicle population and identifying their typical usage patterns. However, the study also has unearthed several new problems which were not clearly recognized previously. Some of these problems are discussed in the following to bring to light the significance of how their impact might better quantify evaporative emissions from individual vehicles and those from the entire vehicle population.

1.2.1 DETERMINATION OF PURGE-TO-HOT SOAK RELATIONSHIP

Although the present study used the distance criterion of 7.5 miles for differentiating primary and nonprimary vehicles, it is not clear if the charcoal canister of a vehicle is sufficiently purged after each 7.5 mile continuous trip to completely trap subsequent hot soak emissions. To prove the above criterion, hot soak and purging tests must be made on a fleet of vehicles which well represent the real-world vehicle mix. It is necessary that a set of hot soak and purging tests be made for each vehicle in the test fleet to obtain datum points that can be used to determine an unknown function which relates parking duration to hot soak emission and a similar unknown function to relate driving distance to purging. By determining such two functions for every vehicle in the test fleet, one can deduce a generalized function of park duration for hot soak emissions and another generalized function of driving distance for purging.

Once the above two general functions are determined for the test fleet, the driving and storage information obtained from the present survey can be used to estimate the distribution of nonprimary vehicles over various canister conditions, from well purged dry condition to poorly purged wet (or saturated) condition. Should the 7.5 mile criterion be too lenient for determining if the canister is adequately purged, the list of households with primary vehicles developed in the present study can be used as a guide to obtain additional driving and storage pattern information.

1.2.2 DETERMINATION OF DIURNAL EMISSIONS FROM PARTIALLY SATURATED CANISTER

Current diurnal emission tests are made by using a vehicle with completely dry canisters. However, in the real-world use, every vehicle undergoes hot soak emissions before the vehicle is subject to diurnal emissions. That is, the canister is already partially

saturated before it is subject to gasoline vapor from the fuel tank due to diurnal temperature cycle. It is quite conceivable that although a dry canister is capable of trapping all gasoline vapors from multiple diurnals, a partially saturated canister is not.

Therefore, a determination of diurnal emissions from canisters with various degrees of saturation is important for correctly assessing the significnce of diurnal emissions from individual vehicles and the entire vehicle population. Here, again, the vehicle use information obtained from the present survey will be useful for estimating diurnal emissions from the vehicle population or for identifying the size and characteristics of a particular segment of the population that is prone to diurnal emissions.

1.2.3 MAIL SURVEY OF VEHICLE USE DIARY

The verification interviews conducted in the present study have revealed that the survey results of the vehicle use parameters are the least reliable. All the analyses that have some bearing on evaporative emission estimation are based on such driving and storage parameter data. The lower response reliability is not caused by the interviewer or the design of the present survey, but is a result of interviewees' attitude toward questions about their vehicle usage.

To remedy the unreliability of key driving and storage pattern information, a mail survey of vehicle usage consisting of a driving diary may be worthwhile to consider. On a voluntary basis, 300 to 500 households with motor vehicles (preferably nonprimary vehicles) will be asked to keep a diary of their vehicle usage for the period of one week. The diary is taken for each vehicle separately and includes such items as the destination of each trip, the distance, the length of park after reached the destination and so forth. Such diaries should provide data for more reliable vehicle usage parameter data, which we desperately need to know for evaporative emission estimation.

2.0 DESIGN OF THE SURVEY INSTRUMENT

The design of the questionnaire is important for any survey but it is particularly important for the present telephone survey because the quality and rate of respondent responses to the telephone interviewer's questions are largely dependent upon the communicative quality of the questionnaire. In order to design a questionnaire for the present survey, the data requirement for achieving the objective of the survey was first identified. Then, questions were prepared to derive from respondents the needed data, arranged in such a sequence to produce a smooth, natural, conversation between an interviewer and a respondent, and later refined many times until the quality of respondent response and the wide acceptance by interviewees were proven adequate for achieving the survey objective. Finally, the developed questionnaire was applied to the sample population, which had been selected randomly from the general population of households in the SCAB.

A more detailed discussion of individual steps taken in the survey and a survey outcome are described in the sections that follow.

2.1 IDENTIFICATION OF DATA REQUIREMENT

The objectives of the present survey are to estimate the nonprimary vehicle population in the SCAB and to identify their typical usage patterns. In order to achieve the above objectives, the following information must be gathered through a telephone questionnaire survey:

1. Vehicle ownership information,
2. General vehicle usage and storage information, and
3. Specific vehicle usage during the past week.
4. Socio-economic information.

The last item, socio-economic information about households interviewed is necessary to verify the present survey.

Table 2-1 lists specific questionnaire items that are necessary to cover each of the four information categories. For example, vehicle ownership information may include such questionnaire items as:

- Number of licensed drivers in the household
- Number of vehicles in the household
- Type, make and model year of each of those vehicles
- Period of ownership for each vehicle
- Odometer readings at the present and at the purchase of each vehicle.

Because the socio-economic information is necessary only as the background information of an interviewed household, the questionnaire items are limited to housing type, ethnic heritage and family income.

2.2 QUESTIONNAIRE DESIGN AND REFINEMENT

On the basis of the questionnaire items identified in the preceding section, an initial questionnaire was prepared and tested within the contractor's organization. The test results revealed several deficiencies of the initial questionnaire. The deficiencies were found mainly in those questions which involved a technical terminology unfamiliar to lay-persons, that required some thinking or arithmetic calculation to answer, or caused many interruptions in a conversation between an interviewer and a respondent. These deficiencies were corrected in a revised version of the initial questionnaire with the assistance of Eve Fielder, a questionnaire survey expert at UCLA's Institute of Social Science Research.

Table 2-1. LIST OF QUESTIONNAIRE ITEMS

VEHICLE OWNERSHIP ● number of licensed drivers ● number of vehicles ● type, make, and model year of each vehicle ● period of ownership for each vehicle ● odometer readings at the present and at the purchase of each vehicle
GENERAL VEHICLE USAGE AND STORAGE ● average number of days driven per week ● one-way distance of a typical longest daily trip ● amount of gasoline purchased per week ● where vehicle is stored ● seasonality of vehicle usage
SPECIFIC VEHICLE USAGE DURING PAST WEEK ● number of trips made on each day of week ● purpose of each trip ● one-way distance and parking duration of each trip
SOCIO-ECONOMIC INFORMATION ● housing type ● ethnic heritage ● family income

The revised questionnaire was then applied to interview the first 100 households randomly selected from telephone books covering the SCAB region. The questionnaire was workable but the interviewer experienced some difficulties in figuring out if the subject vehicle is primary or nonprimary and also in keeping track of the vehicle usage questions for each of the vehicles owned by the household.

The difficulties described above were alleviated by putting together those key questions to determine if the subject vehicle is primary or nonprimary on a separate sheet of the questionnaire. Furthermore, each question was provided answering space for up to four vehicles. The final questionnaire that was used for the present survey study is given in Appendix A.

2.3 SAMPLING PLAN AND INTERVIEW RESULTS

2.3.1 SAMPLING PLAN

The sampling plan used in the present survey is based on a stratified-random sampling of households from white page listings of the fifteen telephone books covering the SCAB region (Figure 2-1). First, a maximum possible number of interviews was targeted on the basis of the budgetary and time constraints; about 800 successful telephone interviews were expected to produce a reasonably adequate data base for achieving the objectives of the project. Second, this target of 800 interviews was allocated to each of the four counties, Los Angeles, Orange, San Bernardino and Riverside in the SCAB region, according to the number of households in that county (Table 2-2). Third, the allocated number of interviews for each county was further broken down to individual telephone book service areas in proportion to the number of white page residential listings in each telephone book (Table 2-3). Here, the number of residential listings was calculated by subtracting all commercial listings from the total number of white page listings. Because it is not possible to actually count all commercial and residential listings in each

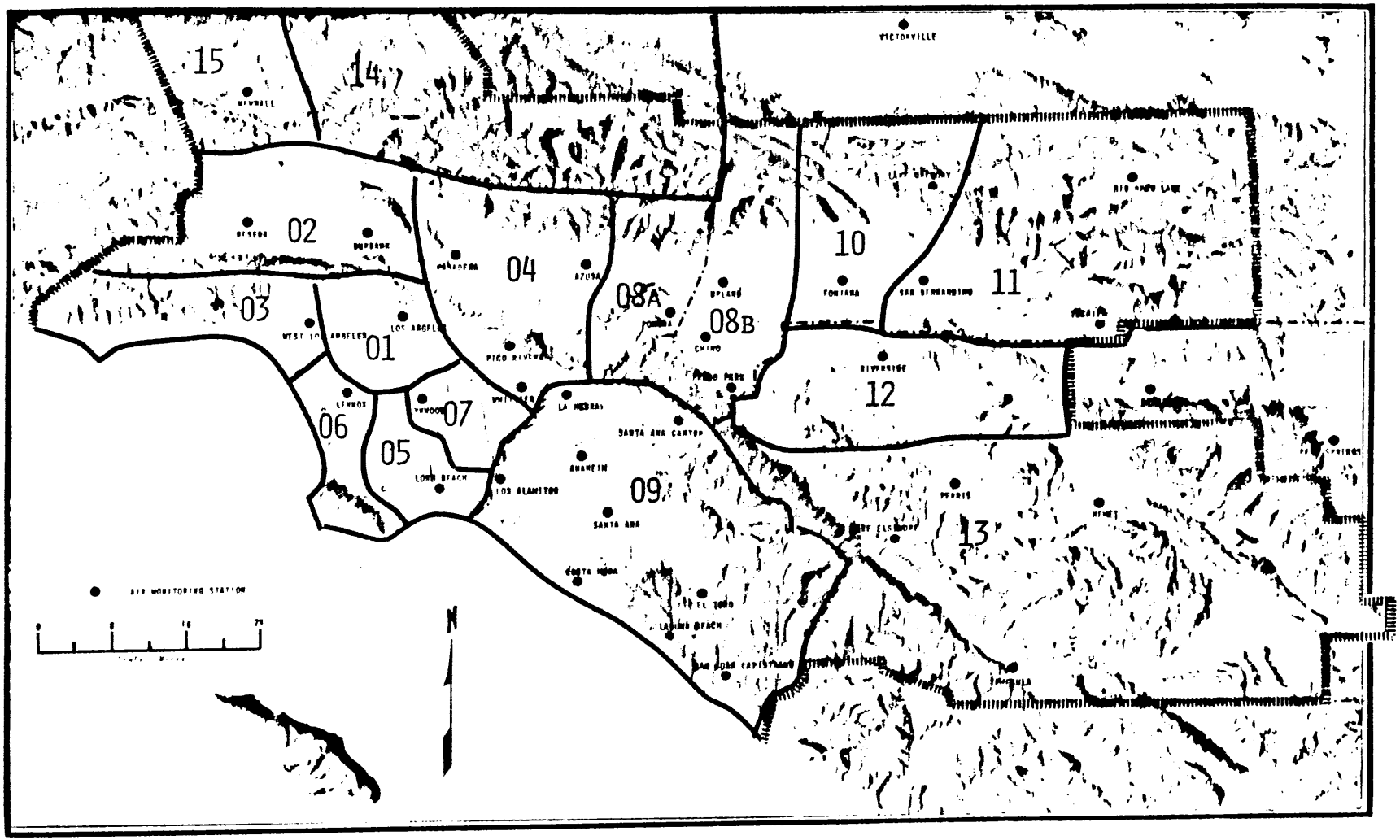

Figure 2-1. Service Area of Each of 15 Telephone Books Covering the South Coast Air Basin

Table 2-2. ALLOCATION OF SURVEY HOUSEHOLDS TO EACH OF FOUR COUNTIES IN SCAB REGION

County	1980 No. Households	Target No. Interviews
Los Angeles	2,702,050	549
Orange	685,631	139
San Bernardino	302,729	62
Riverside	243,779	50
TOTAL	3,934,189	800

Table 2-3. ALLOCATION OF SURVEY HOUSEHOLDS TO EACH TELEPHONE BOOK AREA

	Estimated White Page Listings	Estimated Percentage Residential	Estimated Residential Listings	Sample Allocation
Los Angeles County (549)				
01 Los Angeles	758,750	0.625	474,219	128
02 San Fernando	423,200	0.795	336,444	90
03 Western Section	263,200	0.870	228,984	62
04 Northeastern	388,400	0.770	299,068	80
05 Long Beach	244,200	0.837	204,395	55
06 South Bay	256,080	0.795	203,584	55
07 Downey-Norwalk	230,120	0.786	180,874	48
08 Pomona (L.A.)	91,249	0.892	81,394	22
14 Palmdale	14,960	0.714	10,681	3
15 Santa Clarita Valley	29,240	0.714	20,877	6
			2,040,520	549
Orange County (139)				
09 Orange County	615,120	0.782	481,024	139
San Bernardino County (62)				
08 Pomona (S.B.)	37,271	0.892	33,246	15
10 San Bernardino	97,580	0.765	74,649	33
11 Redlands	37,060	0.893	33,095	14
			140,990	62
Riverside County (50)				
12 Riverside	74,800	0.806	60,289	24
13 Hemet-Perris	70,720	0.904	63,931	26
			124,220	50

telephone book, the number of residential listings is estimated by multiplying the total number of white page listings by an estimated percentage of residential listings (refer to Table 2-3).

Telephone numbers for the allocated number of households to be interviewed in each telephone book area were then randomly selected from residential listings of that telephone book. In the actual selection process, random numbers were generated by a computer for the entire range of pages in the book, and those of columns and rows in each page. For example, six digit random numbers were generated for a telephone book with 867 white pages, 4 columns, and 87 rows per page. The first three digits of a random number is selected randomly from the range of 867 and designates a particular page number to look at. The next one digit is selected randomly from the numerals 1, 2, 3 and 4, and indicates what column of the page should be looked at. The last two digits tell us what row of the column of that page has a listing of the desired telephone number to be dialed for our questionnaire interviewing. If the telephone number is found to be a commercial listing, the number is omitted and the next telephone number located by another random number is used.

2.3.2 RESULTS OF TELEPHONE INTERVIEWING

The present survey required some special training for telephone interviewers, particularly because an interviewer had to make a decision on each vehicle in the course of his interview if the vehicle is primary, regular, or infrequent. If the vehicle is used 4 days or more per week and driven each way over 7.5 miles, then the vehicle is "primary" and fewer questions are asked about the vehicle's usage (see Appendix A). If the vehicle is used less than 1 day per week regardless of miles driven on each trip, then the vehicle is "infrequent" and special questions 15 through 18 addressing the vehicle usage are asked. All other vehicles are classified as a "regular" vehicle and a detailed usage profile

during the past week is solicited in addition to other questionnaire questions. Nonprimary vehicles include both "regular" and "infrequent" vehicles. If the household does not have any vehicle, then the household is asked only socio-economic questions (Q19 of Appendix A).

Because of the subtlety of the questionnaire application described above, each telephone interviewer was given special training of the correct use of the questionnaire before the interviewer started actual telephone interviewing. In spite of this special training, there were several occasions on which an interviewer misclassified the vehicle(s), excluding needed information on the vehicle's usage. On such occasions, the questionnaire was returned to the interviewer in order to obtain the missing information.

Results of telephone interviewing for the present questionnaire survey are summarized in Table 2-4. Of the 1,459 attempted interviews, 870 interviews resulted in a successful interview and the rest resulted in a failure. The majority of failed interviews happened mainly because the telephone number was either busy all the time, a commercial listing, or had been disconnected or changed to another number. Although we excluded commercial telephone numbers from our list of telephone numbers for interviewing, some apparently residential numbers turned out to be a law office or other professional or commercial service.

As seen from Table 2-4, the number of flat refusals for our interviewing is rather small, i.e., 176 as compared to the 870 successful interviews. The overall response rate of telephone interviewing is 0.596 or about 60 percent of all attempted interviews, and the refusal rate is 0.168 or about 17 percent of all actually contacted households. These results are pretty good for a telephone questionnaire service of this type. The good interview results are probably attributed to three things: the repeated

Table 2-4. SUMMARY RESULT OF TELEPHONE INTERVIEWING

Book No.	Service Area	Target No. Interviews	No. Attempted Interviews (1)	No. Successful Interviews (2)	Number of Refusals (3)	Response Rate (2)/(1)	Refusal Rate (3)/(2) + (3)
01	Los Angeles	128	211	128	14	.607	.099
02	San Fernando	90	207	125	38	.604	.233
03	Western Section	62	110	64	17	.582	.210
04	Northeastern Section	80	121	81	24	.669	.229
05	Long Beach	55	79	61	4	.772	.062
06	South Bay	55	122	60	16	.492	.211
07	Downey-Norwalk	48	84	55	8	.655	.127
08-a	Pomona (L.A.)	22	76	21	10	.487	.213
08-b	Pomona (S.B.)	15		16			
09	Orange County	139	273	140	28	.513	.167
10	San Bernardino	33	50	34	4	.680	.105
11	Redlands	14	24	21	2	.875	.087
12	Riverside	24	40	24	7	.600	.226
13	Hemet-Perris	26	38	26	3	.684	.103
14	Palmdale	3	10	5	1	.500	.167
15	Santa Clarita Valley	6	14	9	0	.643	.000
	SCAB TOTAL	800	1,459	870	176	.596	.168

refinement of the questionnaire with in-house and in-field tests, the use of trained interviewers at UCLA's Institute of Social Science Research, and the set policy that we try to contact a selected household many times and at different times of the day and week until we succeed in interviewing the right person in the household at the right time.

Table 2-5 summarizes the numbers of "primary" and "nonprimary" vehicles identified in the present survey. Among the 870 households surveyed, there were 1,464 motor vehicles (excluding motorcycles and off-road vehicles), of which 694 turned out to be "primary" vehicles and 770 to be "nonprimary" vehicles. The result indicates that about 53 percent of all vehicles are nonprimary vehicles and are used primarily for short distance (less than 7.5 miles each way) trips or for infrequent driving (less than 1 day per week).

The number of nonprimary vehicles in each county over the study area is estimated in Table 2-6. As of June 1981, there are 5,620,573 motor vehicles registered in the entire SCAB region. By multiplying this number by the percentage of nonprimary vehicles, 52.6 percent, we estimate the number of nonprimary vehicles over the SCAB to be around 2.95 million vehicles.

Table 2-5. NUMBERS OF PRIMARY AND NONPRIMARY VEHICLES IDENTIFIED IN EACH COUNTY AND TELEPHONE BOOK AREA

Book No.	Service Area	Target No. Interviews	No. Households Interviewed[a] (1)	No. Primary Vehicles (2)	No. Nonprimary Vehicles (3)	No. Cars per Household (3)+(2)/(1)	No. Nonprimary per Household (3)/(1)	Percent Nonprimary Vehicles (3)/(2)+(3)
01	Los Angeles	128	128	73	83	1.22	0.648	53.2%
02	San Fernando	90	125	98	116	1.71	0.928	54.2%
03	Western Section	62	64	44	54	1.53	0.843	55.1%
04	Northeastern Section	80	81	84	56	1.73	0.691	40.0%
05	Long Beach	55	61	41	49	1.48	0.803	54.4%
06	South Bay	55	60	49	49	1.63	0.817	50.0%
07	Downey-Norwalk	48	55	54	38	1.67	0.691	41.3%
08-a	Pomona (L.A.)	22	21	20	22	2.00	1.048	52.3%
14	Palmdale	3	5	4	5	1.80	1.000	55.6%
15	Santa Clarita Valley	6	9	9	10	2.11	1.111	52.6%
	Los Angeles County Total	549	609	476	482	1.57	0.791	50.3%
09	Orange County	139	140	136	147	2.02	1.050	51.9%
	Orange County Total	139	140	136	147	2.02	1.050	51.9%
08-b	Pomona (S.B.)	15	16	14	17	1.94	1.063	54.8%
10	San Bernardino	33	34	22	32	1.59	0.941	59.3%
11	Redlands	14	21	17	25	2.00	1.190	59.5%
	San Bernardino County Total	62	71	53	74	1.79	1.042	58.3%
12	Riverside	24	24	21	32	2.21	1.333	60.4%
13	Hemet-Perris	26	26	8	35	1.65	1.346	81.4%
	Riverside County Total	50	50	29	67	1.92	1.340	69.8%
	SCAB TOTAL	800	870	694	770	1.68	0.885	52.6%

[a]Includes households with no vehicle.

Table 2-6. ESTIMATED NUMBERS OF NONPRIMARY VEHICLES IN EACH COUNTY AND THE SCAB REGION

County	Total No. of[a] Registered Vehicles (1)	Percent Nonprimary Vehicles (2)	Estimated No. of Nonprimary Vehicles (1) x (2)/100
Los Angeles	3,761,774	50.3%	1,892,172
Orange	1,095,023	51.9%	568,317
San Bernardino	431,484	58.3%	251,555
Riverside	332,292	69.8%	231,940
SCAB TOTAL	5,620,573	52.6%	2,956,421 (2,943,984)[b]

[a]Total number of noncommercial automobiles registered as of June 1981.[6]

[b]The sum of individual county values.

3.0 CHARACTERISTICS OF PRIMARY AND NONPRIMARY VEHICLE POPULATION

In the present analysis, motor vehicles are classified into two categories: primary vehicles that are driven regularly on 4 days or more per week and over 7.5 miles in each typical one-way trip; and nonprimary vehicles that are driven either less frequently than 4 days per week or shorter distances than 7.5 miles in each typical one-way trip. Evaporative emissions of a nonprimary vehicles are suspected to be considerably greater than those of a primary vehicle because of insufficient purging of trapped gasoline vapor in the EECS due to the shorter driving distance and/or because of contraction-expansion cycles (hereafter called "multiple diurnals") of gasoline vapors in the fuel tank due to the extended period of nonuse.

A canister filled with activated charcoal (hereafter called "charcoal canister") is attached to every post-1970 California vehicle to trap gasoline vapor from the carburetor after the engine is turned off (i.e., "hot soaks") or from the fuel tank when the vehicle is not used for several days (i.e., "multiple diurnals"). When the vehicle is driven, the trapped gasoline vapor is circulated back to the intake manifold to be burned off in the cylinders.

The EECS, whose main component is the charcoal canister described above, is designed to hold approximately 50 grams of gasoline vapor, has been considered sufficient to trap most hot soak and multiple diurnal related emissions. Recently, however, the adequacy of the present EECS is questioned, particularly for nonprimary vehicles, which tend to have insufficient purging due to the shorter trips and/or large multiple diurnals due to the extended period of nonuse.

On the basis of the present survey results, the size and characteristics of the nonprimary vehicle population and their usage characteristics in the SCAB region are discussed in the two sections that follow.

3.1 POPULATION CHARACTERISTICS OF PRIMARY AND NONPRIMARY VEHICLES

In order to obtain accurate pictures of the primary and nonprimary vehicle populations from the survey results, the sample size for each telephone book service area is adjusted to match the target value to that area. Table 3-1 presents the adjusted sample size for each area that is used for calculating appropriate statistics to characterize the two vehicle populations. The sample sizes are the same as the target values for all telephone book areas except for the two sub-book areas, Pomona in Los Angeles County where the actual sample is one household less than the target value, and Pomona in San Bernardino County where the opposite occurred. As a result, Los Angeles county is under-represented by one household and San Bernardino is over-represented by one household. The above adjustment was made basically by deleting from the household database the first X-number of household data for the telephone book area where the survey had over-sampled households by X.

Table 3-2 presents the sample age distributions of primary and nonprimary vehicles as well as that of all vehicles. The total number of vehicles is 1,335, of which 635 are primary and 700 are nonprimary. In addition, there are five primary vehicles and four nonprimary vehicles, for which the model years are not known. Nonprimary vehicles constitute about 52.4 percent of the total vehicle population. The mean ages of the sample vehicle population and its two subpopulations are, respectively, 7 (=1981-1974), 6 (=1981-1975), and 8 (=1981-1973) years old, with the nonprimary vehicle population being the oldest. Because the present survey was made during the period from March 1981 to July 1981, the average birthday of 1981 model vehicles should be considered to be around 1980.5 rather than 1981. Then, the corrected mean age would be 6.5 for the total vehicle population, 5.5 for the primary vehicle population, and 7.5 for the nonprimary vehicle population.

Table 3-1. NUMBERS OF HOUSEHOLDS INTERVIEWED AND THOSE USED FOR ESTIMATING THE PRIMARY AND NONPRIMARY VEHICLE POPULATIONS

Book No.	Service Area	Target No. Interviews	No. Households Interviewed[a] (1)	No. Households Deleted From the Database	No. Households Used for Statistics
01	Los Angeles	128	128	0	128
02	San Fernando	90	125	35	90
03	Western Section	62	64	2	62
04	Northeastern Section	80	81	1	80
05	Long Beach	55	61	6	55
06	South Bay	55	60	5	55
07	Downey-Norwalk	48	55	7	48
08-a	Pomona (L.A.)	22	21	0	21
14	Palmdale	3	5	2	3
15	Santa Clarita Valley	6	9	3	6
	Los Angeles County Total	549	609	61	548
09	Orange County	139	140	1	139
	Orange County Total	139	140	1	139
08-b	Pomona (S.B.)	15	16	0	16
10	San Bernardino	33	34	1	33
11	Redlands	14	21	7	14
	San Bernardino County Total	62	71	8	63
12	Riverside	24	24	0	24
13	Hemet-Perris	26	26	0	26
	Riverside County Total	50	50	0	50
	SCAB TOTAL	800	870	70	800

[a]Includes households with no vehicle.

Table 3-2. AGE DISTRIBUTION OF PRIMARY AND NONPRIMARY VEHICLES

Model Year	All Vehicles (Number)	All Vehicles (Percent)	Primary Vehicles (Number)	Primary Vehicles (Percent)	Nonprimary Vehicles (Number)	Nonprimary Vehicles (Percent)
1981	56	4.2%	33	5.2%	23	3.3%
1980	106	7.9%	74	11.7%	32	4.6%
1979	131	9.8%	81	12.8%	50	7.1%
1978	144	10.8%	69	10.9%	75	10.7%
1977	104	7.8%	47	7.4%	57	8.1%
1976	86	6.4%	43	6.8%	43	6.1%
1975	55	4.1%	28	4.4%	27	3.9%
1974	101	7.6%	44	6.9%	57	8.1%
1973	87	6.5%	35	5.5%	52	7.4%
1972	97	7.3%	38	6.0%	59	8.4%
1971	55	4.1%	28	4.4%	27	3.9%
1970	66	4.9%	18	2.8%	48	6.9%
1969	72	5.4%	35	5.5%	37	5.3%
1968	48	3.6%	23	3.6%	25	3.6%
1967	23	1.7%	11	1.7%	12	1.7%
1966	20	1.5%	5	0.8%	15	2.1%
1965	21	1.6%	7	1.1%	14	2.0%
1960-65	36	2.7%	9	1.4%	27	3.9%
1959 and older	27	2.0%	7	1.1%	20	2.9%
TOTAL	1,335	100.0%	635	100.0%	700	100.0%
MEAN (Model yr/age)	1974(7)	-	1975(6)	-	1973(8)	-
MEDIAN (Model yr/age)	1975(6)	-	1977(4)	-	1974(7)	-
Unknown Model Year	9	-	5	-	4	-
GRAND TOTAL	1,344	-	640	-	704	-

The vehicle age distributions obtained from the present survey are different from those used in most mobile source emissions estimates, in which the percentage of each model year vehicle population to the total vehicle population is assumed to decrease exponentially with the vehicle age. The age distributions presented in Table 3-2 are a truncated bell-shape distribution, having their peak at 2 to 3 years after the most recent model year. This truncated bell-shape age distribution is probably a reflection of the slump of auto sales in recent years.

Table 3-3 provides a comparison between the vehicle age distribution of the present survey and that of the 1976 urban/rural survey that was conducted by the Los Angeles Regional Transporation Study[1,2] (LARTS) for six counties, including Ventura County and Imperial County as well as the four counties in the present study area. The vehicle age distribution of the present survey has a larger tail than that of the 1976 urban/rural survey, indicating that the present vehicle population has a greater fraction of older vehicles than does the vehicle population of 5 years ago. The smaller fraction (10.9 percent) of 1975-76 model year vehicles in the urban/rural survey than that (12.1 percent) of 1980-81 model year vehicles in the present survey is probably due to the fact that the urban/rural survey was conducted in the earlier part (January through June) of the year than the present survey period (March through July).

Differences between the primary and nonprimary vehicle populations are summarized in Tables 3-4 and 3-5. The nonprimary vehicle population tends to have relatively fewer passenger cars and more campers than does the primary vehicle population. The nonprimary vehicle population also tends to have more American made cars and fewer foreign made cars than does the primary vehicle.

In summary, the nonprimary vehicles that are used for short trips (less than 7.5 miles each way) or driven infrequently

Table 3-3. COMPARISON BETWEEN VEHICLE AGE DISTRIBUTION ESTIMATED BY 1976 URBAN/RURAL SURVEY AND THAT BY PRESENT SURVEY

Year	Urban/Rural Survey No. Vehicles	Percent	Year	Present Survey No. Vehicles	Percent
75-76	706,800	10.9%	80-81	162	12.1%
73-74	1,247,000	19.3%	78-79	275	20.6%
71-72	1,168,200	18.1%	76-77	190	14.2%
69-70	1,043,900	16.2%	74-75	156	11.7%
67-68	777,900	12.1%	72-73	184	13.8%
65-66	652,000	10.1%	70-71	121	9.1%
63-64	387,000	6.0%	68-69	120	9.0%
62-Older	468,500	7.3%	67-Older	127	9.5%
TOTAL	6,451,300	100.0%	TOTAL	1,335	100.0%

Table 3-4. MIX OF PRIMARY AND NONPRIMARY VEHICLES BY TYPE OF VEHICLE

Vehicle Type		Passenger Car	Vans	Trucks	Campers	TOTAL
Primary	Number	544	24	67	5	640
	Percent	85%	4%	10%	1%	100%
Nonprimary	Number	581	35	68	20	704
	Percent	82%	5%	10%	3%	100%

Table 3-5. MIX OF PRIMARY AND NONPRIMARY VEHICLES BY AMERICAN OR FOREIGN MAKE

Vehicle Type		American	Foreign	TOTAL
Primary	Number	414	224	638[a]
	Percent	65%	35%	100%
Nonprimary	Number	521	183	704
	Percent	74%	26%	100%

[a]Excludes the two vehicles whose make is unknown.

(3 days or less per week) make up over one-half of the total vehicle population and tend to consist of:

- more older vehicles than the average vehicle mix.
- more recreational vehicles than the average vehicle mix.
- more American made vehicles than the average vehicle mix.

3.2 USAGE AND STORAGE CHARACTERISTICS OF NONPRIMARY VEHICLES

This section discusses the usage and storage characteristics of nonprimary vehicles. It is convenient for subsequent discussions to further subdivide nonprimary vehicles into two classes: "regular" vehicles which are used primarily for short trips less than 7.5 miles each way, and "infrequent" vehicles which are used less frequently than once a week. The above classification of nonprimary vehicles was used in the present questionnaire survey and different questions were asked on "regular" and "infrequent" vehicles (see Appendix A).

3.2.1 PLACE OF STORAGE AND SEASONALITY IN USE

Storage of a vehicle affects the vehicle's evaporative emission because the diurnal temperature variation experienced at the storage area causes expansion and contraction of gasoline vapor in the fuel tank directly impacting the amount of gasoline vapor transmitted to the carburetor and EECD. Table 3-6 presents a summary of responses to the place of storage question. The summary indicates that over one-half (56 percent) of the nonprimary vehicle population are parked outdoor and subjected to a large outdoor temperature variation. Among the remaining 44 percent of nonprimary vehicles, 33 percent are parked in an enclosed garage and 11 percent are parked in a roofed carport.

Table 3-7 summarizes the seasonality in usage of nonprimary vehicles. Approximately 80 percent of the nonprimary vehicles are used evenly throughout a year. In the summer, 15 percent of the

Table 3-6. STORAGE PLACE OF NONPRIMARY VEHICLES

	Outdoor	Roofed Carport	Enclosed Garage	Total[a]
Number	424	79	249	752
Percent	56%	11%	33%	100%

[a]In addition, there are 18 unanswered cases.

Table 3-7. SEASONALITY IN VEHICLE USAGE

Seasonality in	Summer More	Winter More	Even Throughout Year	Total[a]
Driving Frequency	14.9%	4.1%	81.0%	100%
Driving Distance	16.9%	3.0%	80.1%	100%

[a]Valid responses are 736 for driving frequency and 729 for driving distance out of the total of 770 cases.

vehicles are driven more frequently and 17 percent of the vehicles are driven for longer distance trips than their annual averages. Only a small percentage (3 to 4 percent) of the vehicles are used more in the winter than in the summer.

3.2.2 USAGE CHARACTERISTICS OF NONPRIMARY VEHICLES

This subsection discusses usage characteristics of the 770 nonprimary vehicles identified in the present survey with respect to their use frequency, driving distance, parking duration, and trip purpose.

Figure 3-1 shows how many days each nonprimary vehicles was actually driven during the past week. The average frequency of use among all regular vehicles is 4 days per week but the largest number of regular vehicles are driven every day, i.e., 7 days per week. Figure 3-2 illustrates how many trips per week the nonprimary vehicle made during the past week and for what purposes those trips were made. Here, a trip is defined as a continuous driving from the start of engine to the shut-off of engine. Therefore, a usual round trip during which the engine is turned off for a while constitutes <u>two</u> trips while a special round trip without engine shut-off (e.g., a trip to pick up a child from school) is counted as <u>one</u> trip. The average value of total number of trips per week among all vehicles is 10.4, or roughly 5 round trips per week. The average number of commuting trips to work/school is 9.1, which is close to 10.4 for the total number of trips. It should be noted, however, that the total number of trips is averaged over all nonprimary vehicles while the number of commuting trips is averaged over commuter vehicles only, which are only 378 out of the 770 nonprimary vehicles. The rest of the vehicles are not used for commuting at all.

The average number of shopping trips per week is 3.6 or slightly less than two round trips per week. The number of vehicles used for shopping is 370, or 44 percent of the nonprimary vehicle population. The average number of trips made for other purposes is

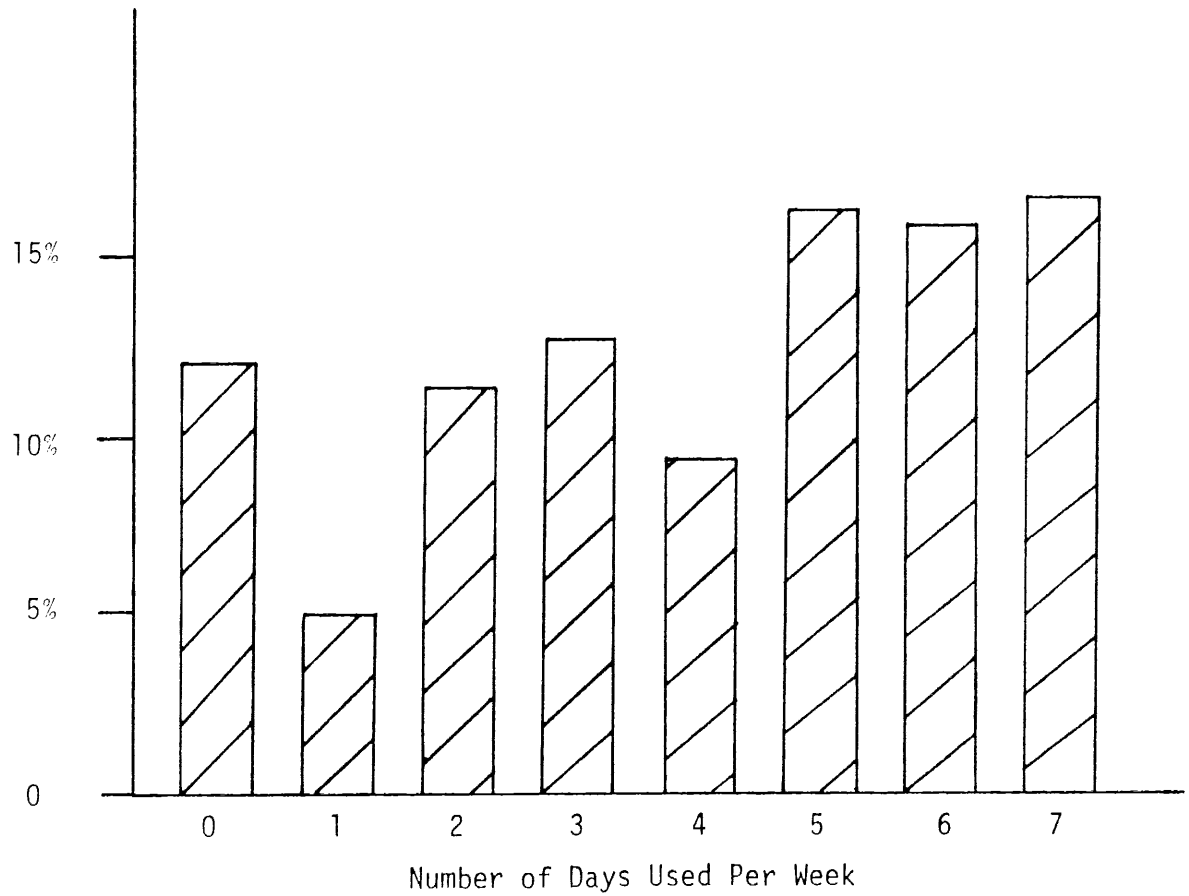

Figure 3-1. Frequency Distribution of Days Used During the Past Week

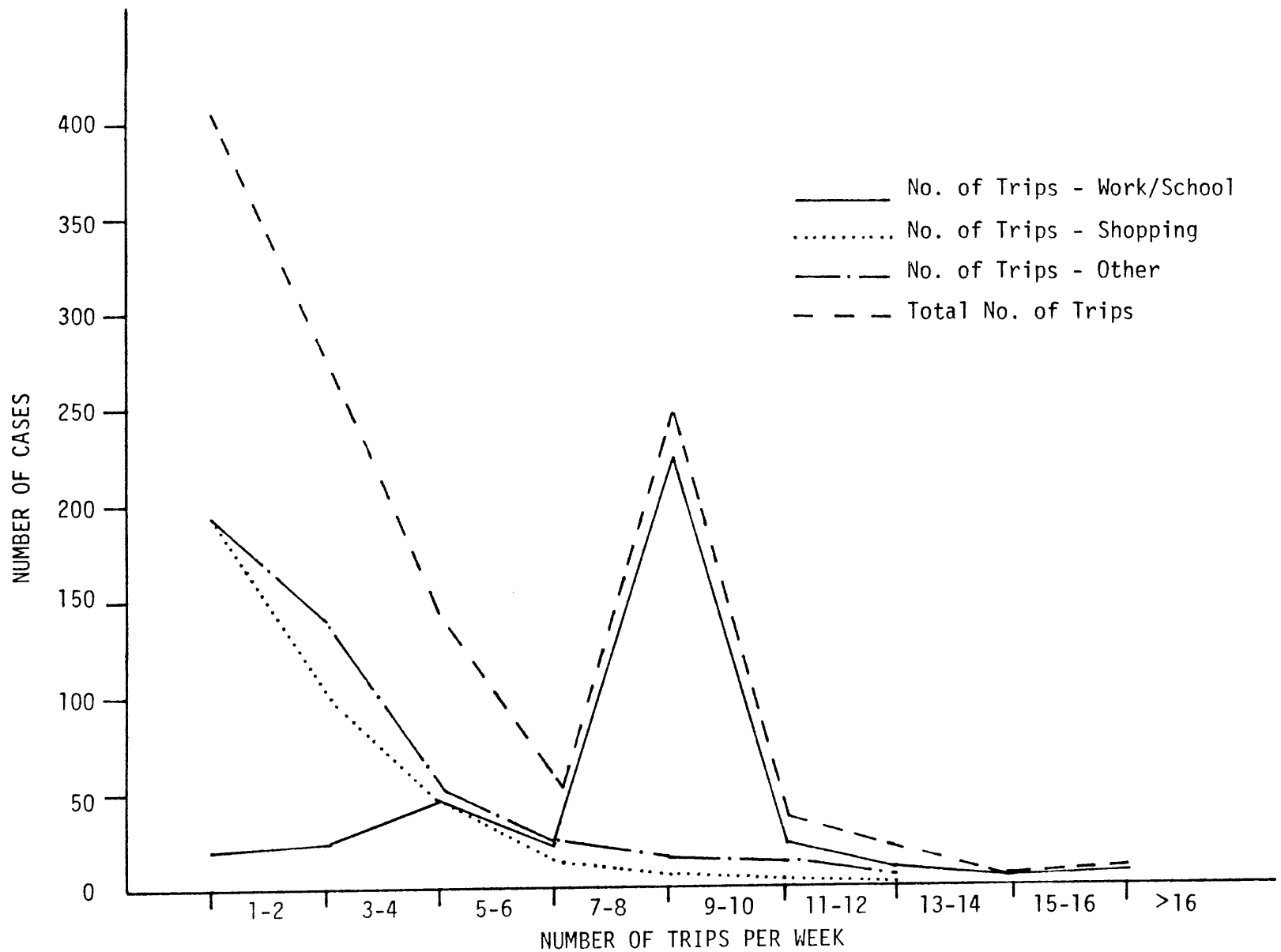

Figure 3-2. Number of Trips Made per Week for Work/School, Shopping and Others

4.3 or about two round trips per week. The number of vehicles used for other purposes is 449 out of the 770 nonprimary vehicles.

Table 3-8 summarizes driving distances to work/school, shopping and others. The median distance of the three trip types are, respectively, 5.0, 2.0, and 5.0 miles each way. The mean distances are 5.6, 3.4, and 9.8 miles, which are considerably greater than the median distances. The above statistics indicate that there are more shorter trips (than the mean distance) than longer trips.

Table 3-9 provides a sample distribution of park durations. In commuting trips, the vast majority park longer than 1 hour, while in shopping trips, more than one-half of the trips park less than 1 hour. Trips for other purposes also tend to park longer than 1 hour.

Among the 770 nonprimary vehicles, there are 89 infrequent vehicles which are used less frequently than once a week. For these infrequent vehicles, some special questions were asked about their primary use purpose and amount of gasoline kept in the tank when the vehicle is not used. Table 3-10 presents a summary of interview results on the above two questions. The primary usages of infrequent vehicles are for recreation (47 percent) and nonspecific purpose (31 percent). The amounts of gasoline left in the tank of an infrequent vehicle are generally one half full to near empty. Only 16 percent of the infrequent vehicles keep the fuel tank more than 3/4 full.

Table 3-8. SUMMARY STATISTICS OF DRIVING DISTANCE TO WORK/SCHOOL, SHOPPING AND OTHERS
(all values in miles)

Purpose	No. Cases	Minimum	25 Percent	Mean	Median 50 Percent	75 Percent	Maximum
Work/School	377	1.0	3.0	5.0	5.6	6.0	98.0[a]
Shopping	369	1.0	1.0	2.0	3.4	4.0	33.0
Other	445	1.0	2.0	5.0	9.8	10.0	98.0[a]

[a]Indicate a large distance over 100 miles.

Table 3-9. SUMMARY STATISTICS OF PARK DURATION IN TRIPS TO WORK/SCHOOL, SHOPPING AND OTHERS

Purpose	No. Cases	Frequency Distribution of Park Duration				
		Stopping Only	1 - 10 min.	10 - 30 min.	30 - 60 min.	Over 1 hour
Work/School	376	3.2%	1.3%	0.5%	2.4%	92.6%
Shopping	366	0.3%	2.2%	19.9%	34.7%	42.9%
Other	446	2.5%	2.2%	7.6%	10.1%	77.6%

Table 3-10. PRIMARY USAGE OF INFREQUENT VEHICLES AND AMOUNT GASOLINE LEFT IN TANK

Item	No. Cases	Frequency Distribution				
		Business	Recreation	Shopping & Chorus	Nonspecific	
Primary Usage	83	13.3%	47.0%	8.4%	31.3%	
		Full	3/4 Full	1/2 Full	1/4 Full	Near Empty
Gas in Tank	75	4.0%	12.0%	29.3%	21.3%	33.3%

4.0 DRIVING AND STORAGE PATTERNS OF NONPRIMARY VEHICLES

The primary objective of the present survey is to identify the typical usage patterns for nonprimary vehicles so that evaporative emissions from such vehicles can be simulated and tested at the ARB's Haagen-Smit Laboratory. This section first discusses some key variables that are important to specify driving and storage conditions and also to characterize a vehicle's evaporative emission. Then, by using the data obtained from the present survey and the emission test data obtained at the ARB's Haagen-Smit Laboratory, this section describes several distinct driving and storage patterns depicted from the survey data and their likely emission characteristics.

4.1 KEY VARIABLES TO CHARACTERIZE DRIVING AND STORAGE PATTERNS

Among many variables that are associated with driving and storage conditions, we selected the following variables for characterizing a vehicle's driving and storage pattern:

1. Number of days on which the vehicle was driven. N.
2. Number of trips made for work/school, shopping, and other during the past week. T_1, T_2, and T_3.
3. Average driving distance for work/school, shopping, and other. S_1, S_2, and S_3.
4. Average parking duration in work/school, shopping, and other. D_1, D_2, and D_3.

The above four variables are then used to calculate the three emission related variables:

- Multiple diurnal emissions, M.

$$M \propto 7 - N \qquad (1)$$

- Hot soak emissions, H.

$$H \propto \sum_{i=1}^{3} T_i \cdot f(D_i) \qquad (2)$$

where $f(D_i)$ is a monotone increasing function of D_i and the subscript i stands for a type of trip, i=1 for work/school, i=2 for shipping and i=3 for others.

- Adsorbed gas purging, P

$$P \propto \sum_{i=1}^{3} T_i \cdot g(S_i) \qquad (3)$$

where $g(S_i)$ is a monotone increasing function of S_i.

The two unknown functions $f(D_i)$ and $g(S_i)$ were empirically determined from some past emission test data and the special test data that was collected by the ARB for the present study. Many hot soak emission tests were conducted, but the great majority of them were done for hot soak periods lasting only 1 hour after the engine shut-off. One of ARB's project progress reports[3] contains the results of three 2 hour hot soak emission tests. In general, these hot soak tests were conducted using current model year vehicles; however, the tests periods were mostly conducted in the mid-1970's. Consequently the test data presents hot soak emission profiles for a somewhat older fleet of test vehicles. To update the emission test data, two additional tests were made for the present study by using two 1980 model year cars.[7]

Table 4-1 summarizes the results of the old and new hot soak tests. The hot soak emissions at 10, 30 and 120 minutes after engine shut-off are expressed as a percentage of the hot soak emission at 60 minutes. These percentage emissions for the five 2 hour hot soak emission tests are fairly similar, indicating that there exists a general hot soak function such as $f(D_i)$ in Equation 2.

Table 4-1. HOT SOAK EMISSIONS AS A PERCENTAGE OF 60 MINUTE HOT SOAK EMISSION

Time after engine turns off	Car No. 1 Chevrolet Impala 1970 E815414	Car No. 2 Ford Maverick 1976 New	Car No. 3 Plymouth Variant 1975 E836392	Car No. 4 Buick Regal 1980 545 ZFP	Car No. 5 Buick Regal 1980 1AOG628	Mean Percentage Emission Over Five Cars	Standard Deviation in Percentage Emission	Park Duration Category[a]
10 min	11%	12%	23%	19%	15%	16%	5%	33%
30 min	73%	76%	67%	58%	54%	66%	9%	67%
60 min	100%	100%	100%	100%	100%	100%	0	100%
120 min	114%	121%	143%	138%	158%	135%	18%	133%

[a]1 = 0-10 min, 2 = 11-30 min, 3 = 31-60 min, 4 = over 60 min parking. The percentage is computed as 1/3, 2/3, 3/3, and 4/3.

As to purging data, we could not find any past test data. Therefore, two purging tests were conducted for the present study by using a 1981 model year vehicle.[7] Results of the tests are shown in Figure 4-1. Although the purging tests were made using the same vehicle, the two tests results are quite different from each other, with the purging amount of the June 17 test being much greater than that of the June 24 test. In spite of this apparent difference in the two test results, their purging profiles relative to the purging amounts at 20 accumulated miles are quite similar to each other (see Table 4-2). Therefore, as the first approximation, the mean percentage purgings at 2, 5, 10, 15, 20, and 30 miles are used for the function values of 0-2, 3-5, 6-10, 11-15, 16-20, and over 20 mile drivings.

4.2 DETERMINATION OF TYPICAL USAGE PATTERNS

Because Equations 1, 2, and 3 indicate only the proportionality between the emission related variable on the left hand side and the vehicle usage variable(s) on the right hand side, it is not yet possible to estimate the total amount of evaporative emissions from the vehicle's usage variables. However, the three equations do indicate if the vehicle with a particular usage pattern is likely to produce a greater or lesser amount of each quantity than does the average fleet mix per vehicle.

Based on the above notion, nominal amounts of each quantity were computed for the 770 nonprimary vehicles from their usage variable values by equating the right and left hand sides of Equations 1, 2, and 3. By using the frequency distribution of calculated values of each variable, three similar sized classes were formed on each of the three variables: low, medium and high (Table 4-3).

In calculating the hot soak emissions by Equation 2, we encountered a difficulty in figuring out the park duration after

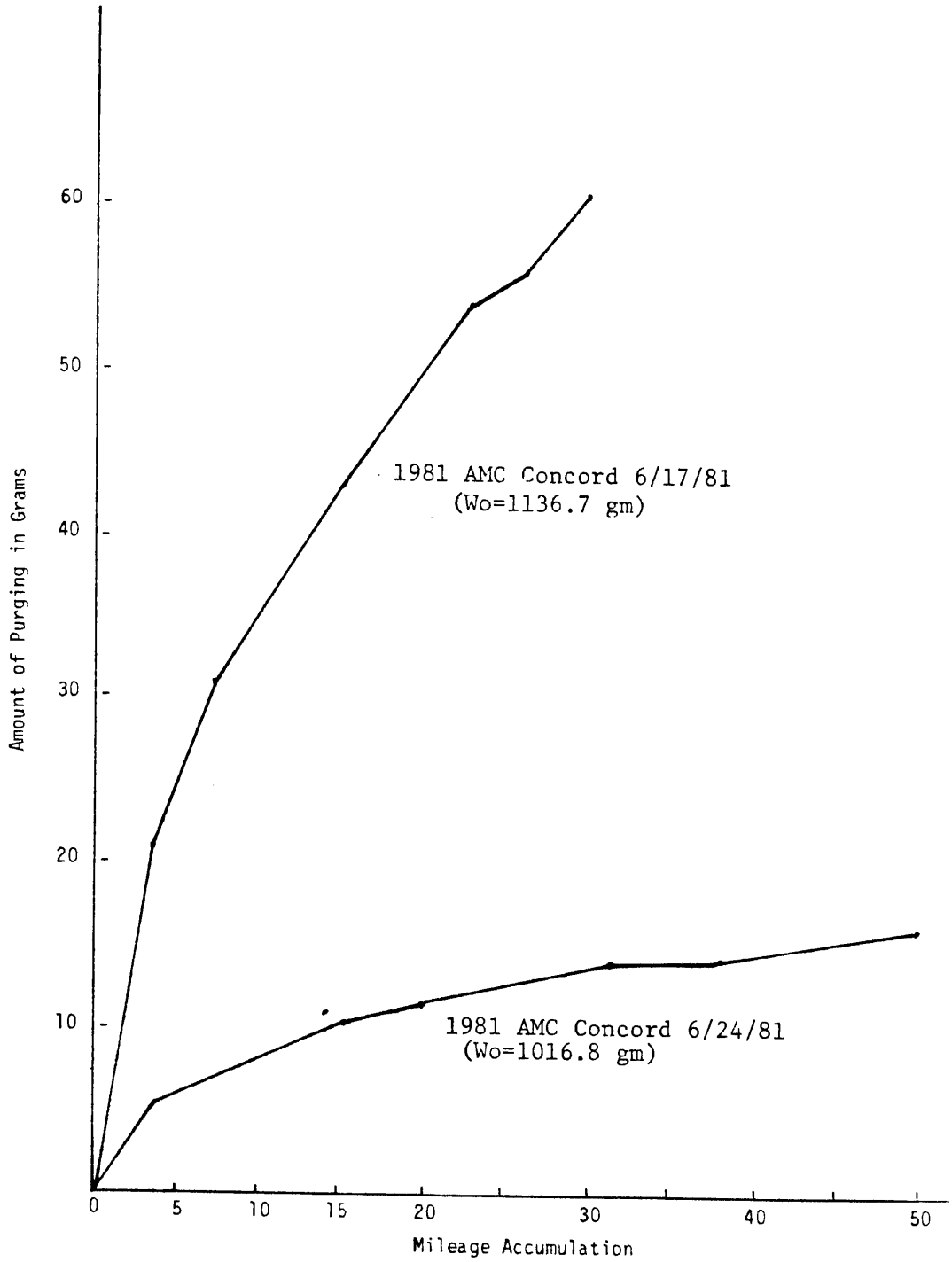

Figure 4-1. Results of Purging Tests Run on the 17th and 24th of June 1981

Table 4-2. ADSORPED GAS PURGING RATE AS PERCENTAGE OF 20 MILES PURGING VALUE

Mileage Accumulation	1981 AMC Concord 6/24/81	1981 AMC Concord 6/17/81	Mean Percentage Purging	Between Tests Variation	Driving Distance Category[a]
2 mi	39%	34%	35%	5%	20%
5 mi	52%	49%	51%	3%	40%
10 mi	69%	70%	70%	1%	60%
15 mi	89%	86%	88%	3%	80%
20 mi	100%	100%	100%	0%	100%
30 mi	118%	122%	120%	4%	120%

[a]1 = 0-2 mi, 2 = 3-5 mi, 3 = 6-10 mi, 4 = 11-15 mi, 5 = 16-20 mi, and 6 = over 20 mile driving. The percentage is computed as 1/5, 2/5, ..., 5/5, and 6/5.

Table 4-3. RANGES OF KEY EMISSION VARIABLE VALUES AND PERCENTAGE OF TOTAL VEHICLE POPULATION IN THE CLASS DEFINED BY THE RANGE

Variable		Low Class	Middle Class	High Class
Diurnals	Range	0 - 1	2 - 4	5 - 7
	Percent Total	33%	38%	29%
Purge	Range	0 - 2.6	2.7 - 4.8	4.9 - 21
	Percent Total	42%	30%	28%
Hot Soak[a]	Range	0 - 9.31	9.32 - 15.8	15.9 - 64
	Percent Total	41%	27%	32%

[a]Hot soak emissions are computed by assuming that every vehicle parks longer than 1 hour after completion of each round trip.

each round trip. In our telephone interviewing of households, we asked how long the car was parked during a round trip, say, for shopping. However, we did not ask how long the car was parked before the car was used for some other purpose. In the interview, it was not possible to ask the complete diary of their vehicle use without offending the respondents. With the missing information described above, we made an assumption about part duration after each round trip that every car parks longer than 1-hour after completion of each round trip.

The resulting frequency distribution over the 3 x 3 x 3 = 27 cell matrix is given in Table 4-4. An obvious feature of the distribution is that the largest number of cases in low, medium, and high diurnals occurs, respectively, in combinations of high purge - high hot soak, medium purge - medium hot soak, and low purge - low hot soak. The above trend is readily understandable from Equations 1 through 3. Because number of trips per week, T_i, is included in both hot soak and purge equations, Equations 2 and 3, the greater the number of trips, the higher both the hot soak emissions and the amount of purging tend to be. Also, the large number of trips tends to mean many days of vehicle use, i.e., low diurnals (see Equation 1).

The aggregated matrix over diurnals shows more clearly a positive association between hot soak and purge (Table 4-5). The other two aggregated matrices in Table 4-5 exhibit a negative association between hot soak and diurnals and between purge and diurnals.

From the above analysis, we guessed that a ratio of purge to hot soak would be nearly independent of number of trips and should indicate an emission characteristic of each driving pattern. For example, a low purge-to-hot soak ratio may mean near 100 percent hot soak emission after each engine shut-off. Then, a combination of a

Table 4-4. NUMBER OF VEHICLES WHOSE USAGE PATTERNS FALL INTO ONE OF 27 CELLS DEFINED BY VALUES OF DIURNALS, PURGE, AND HOT SOAK

Number of Diurnals: Low (<=1)	Low Hot Soak	Medium Hot Soak	High Hot Soak
Low Purge	0	14	8
Med. Purge	0	21	56
High Purge	0	9	134
Number of Diurnals: Med. (>1 <=4)	**Low Hot Soak**	**Medium Hot Soak**	**High Hot Soak**
Low Purge	64	34	0
Med. Purge	27	84	9
High Purge	6	36	24
Number of Diurnals: High (>=5)	**Low Hot Soak**	**Medium Hot Soak**	**High Hot Soak**
Low Purge	97	0	0
Med. Purge	20	1	0
High Purge	1	0	2

NOTE: In addition, there are 89 infrequent vehicles which should belong to high diurnal class.

Table 4-5. AGGREGATED MATRICES FOR HOT SOAK VERSUS PURGE, HOT SOAK VERSUS DIURNALS, AND PURGE VERSUS DIURNALS

A. Matrix Aggregated Over Diurnals	Low Hot Soak	Medium Hot Soak	High Hot Soak
Low Purge	(161 + 89)	48	8
Med. Purge	47	106	65
High Purge	7	45	160
B. Matrix Aggregated Over Purge	**Low Hot Soak**	**Medium Hot Soak**	**High Hot Soak**
Low Diurnals	0	44	198
Med. Diurnals	97	154	33
High Diurnals	(118 + 89)	1	2
C. Matrix Aggregated Over Hot Soak	**Low Purge**	**Medium Purge**	**High Purge**
Low Diurnals	22	77	143
Med. Diurnals	98	120	66
High Diurnals	(97 + 89)	21	3

NOTE: The 89 infrequent vehicles are added to the number of cases in the cell, to which they most likely belong.

large number of trips and a low ratio will result in high hot soak emissions.

Based on the above notion, we redefined the 27 cells by low, medium and high ranges of three variables: a purge-to-hot soak ratio, total number of trips per week, and number of diurnals per week. This time, the low, medium, and high range of each variable were determined such that the medium range contains approximately 50 percent of the total cases, and the low and high ranges contain approximately 25 percent each. The resulting frequency distribution over the 27 cell matrix is presented in Table 4-6.

In the table, each non-zero cell is indicated by a subjectively determined emission class. For example, any combination of low purge-to-hot soak ratio and medium or high number of trips in low and medium number of diurnals is considered to result in high hot soak emissions and thus designated by H. The reason is that the low purge-to-hot soak ratio means that the vehicle's charcoal canisters tend to be saturated most of the time. The medium-to-high number of trips, combined with the more frequently saturated canisters, will result in higher than average hot soak emissions. All vehicles experiencing six and seven diurnals per week are considered to be dominated by diurnal related emissions and thus designated by D. The other symbols include M, indicating moderate hot soak emissions; L, indicating low hot soak emissions; and CM, indicating the central cell defined by the middle range of each of the three variables.

Driving and storage characteristics of each of the five classes defined above are summarized in Table 4-7.

Low hot soak class (L), that constitutes 27 percent of the nonprimary vehicle population, is characterized by the large average distance (7.0 miles), the small number of trips (six trips per week), and the small number of days used (3 days per week). The moderate hot soak class (M), with 27 percent of the population, is characterized by the moderate average distance (4.3 miles), the

Table 4-6. FREQUENCY DISTRIBUTION OVER 27 CELLS DEFINED BY PURGE-HOT SOAK RATIO, NUMBER OF TRIPS AND DIURNALS

Diurnals/Trips	Purge-to-Hot Soak Ratio		
	Low (≤0.263)	Med. (0.263 - 0.451)	High (>0.451)
Low Diurnals (≤1)			
Low Trips (≤6)	0	0	0
Med. Trips (6-14)	47 (H)	86 (M)	23 (L)
High Trips (>14)	21 (H)	50 (M)	12 (M)
Med. Diurnals (1-5)			
Low Trips (≤6)	35 (M)	77 (L)	49 (L)
Med. Trips (6-14)	46 (H)	90 (CM)	52 (L)
High Trips (>14)	5 (H)	9 (M)	4 (M)
High Diurnals (>5)			
Low Trips (≤6)	7 (D)	7 (D)	21 (D)
Med. Trips (6-14)	0	0	0
High Trips (>14)	0	1 (D)	0
Total Infrequent Vehicles = 89 (D)			

H: Likely to result in high hot soak emission.

M: Likely to result in moderate hot soak emission.

L: Likely to result in low hot soak emission.

CM: Central cell defined by the middle range of each of the three variables and is likely to result in moderate hot soak emission.

D: Likely to result in high diurnal emission.

Table 4-7. FIVE EVAPORATIVE EMISSION CLASSES AND THEIR DRIVING AND STORAGE CHARACTERISTICS

Variable	Low Hot Soak Class	Moderate Hot Soak Class	Central Cell Class	High Hot Soak Class	Diurnals Dominated Class
Percent Total Population	27%	27%	13%	16%	17%
Median Range of Class Defining Variables					
Purge/Hot Soak Ratio	0.451 (0.251 - 0.902)	0.301 (0.100 - 1.200)	0.301 (0.248 - 0.408)	0.175 (0.063 - 0.246)	0.451 (0.150 - 0.902)
Total No. Trips/Week	6 (4 - 14)	14 (2 - 54)	10 (8 - 14)	12 (7 - 28)	2 (1 - 16)
No. Diurnals/Week	4 (0 - 5)	1 (0 - 6)	2 (2 - 4)	1 (0 - 5)	7 (6 - 7)
Median and First and Third Quatiles of Vehicle Usage Variables					
Average Distance in miles	7.0 (4.3 - 10.0)	4.3 (3.0 - 5.4)	4.0 (3.0 - 5.0)	2.0 (1.7 - 2.2)	7.0 (3.4 - 20.0)
Park Duration Category[a]	4.0 (3.5 - 4.0)	4.0 (3.7 - 4.0)	4.0 (3.6 - 4.0)	3.7 (3.2 - 4.0)	4.0 (3.0 - 4.0)
Storage Code[b]	1.0 (1.0 - 3.0)	1.0 (1.0 - 3.0)	2.0 (1.0 - 3.0)	1.0 (1.0 - 3.0)	1.0 (1.0 - 2.0)
Model Year 19xx	74 (70 - 78)	74 (71 - 78)	73 (70 - 77)	74 (70 - 78)	72 (67 - 76)
Total No. Trips/Week	6 (4 - 10)	14 (12 - 16)	10 (8 - 10)	12 (10 - 14)	2 (2 - 2)
Actual No. Days Used/Week	3 (2 - 4)	6 (5 - 7)	5 (4 - 5)	6 (5 - 7)	0 (0 - 1)

[a] 1: 1 - 10 min, 2: 11 - 30 min, 3: 31 - 60 min, 4: over 1 hour.

[b] 1: outdoor, 2: roofed carport, 3: enclosed garage.

large number of trips (14 trips per week), and the large number of days used (6 days per week). The high hot soak class (H), with 16 percent of the population, is characterized by the short average distance (2.0 miles), the large number of trips (12 trips per week), and the large number of days used (6 days per week).

The diurnals dominated class (D), with 17 percent of the population, is characterized by the large average distance (7.0 miles), the old model year (1972), the small number of trips (two trips per week), and the small number of days used (0 days per week). The central cell class (CM), with 13 percent of the population, has similar driving and storage characteristics to those of the moderate hot soak class (M). The two classes can be merged to form an enlarged moderate hot soak class that will constitute 40 percent of the total nonprimary vehicle population.

5.0 COMPARISON BETWEEN PRESENT SURVEY ESTIMATES AND OTHER ESTIMATES

This section discusses a comparison between present survey estimates and other estimates on some key parameters such as type of housing, income level, and vehicle ownership. Through such a comparison, the validity of, or the cause of sample biases in the present survey will also be discussed. First, comparisons of socio-economic parameters are made to check the soundness of, or the bias in the present survey design. Then, present estimates on vehicle ownership and the number of licensed drivers per household are compared with other survey estimates.

5.1 SOCIO-ECONOMIC PARAMETERS

Examined in this section are three socio-economic parameters: Distribution of housing unit by type, ethnic mix of interviewed household, and distribution of household income. In Table 5-1, the distribution of housing type estimated from the present survey is compared with that compiled by the California Department of Finance for 1980. Although the percentage of single family houses in the present survey is several percentage points greater than the percentage given in the Finance Department's statistic, its trend over the four counties follows that of the Finance Department's statistic.[4] The higher mix of single family houses in the survey households has resulted from the probable trend that households in single family housing tend to have a higher telephone listing rate than those in multiple unit housing. The percentage of mobile homes in the survey households is in close agreement with that of the Finance Department's statistic for each county and for the entire SCAB region.

Table 5-2a presents the ethnic mix in those households which were interviewed in the present survey, while given in Table 5-2b is the ethnic mix determined by the 1980 census.[5] Because the two

Table 5-1. DISTRIBUTION OF HOUSING UNIT BY TYPE: COMPARISON BY COUNTY AND YEAR

County		Present Survey				1980 California Department of Finance			
		House/ Single Family	Apartment/ Duplex (1)	Condominium/ Townhouse (2)	Mobile Home	Single	2 to 4 (3)	5 or More (4)	Mobile Home
Los Angeles	number	322	139	22	5	1,600,608	229,461	959,267	40,031
	percent	66%	28%	5%	1%	57%	8%	34%	1%
Orange	number	95	19	10	5	420,029	93,471	165,917	30,184
	percent	74%	15%	8%	4%	60%	13%	23%	4%
San Bernardino	number	47	8	0	3	264,615	24,581	38,468	27,053
	percent	81%	14%	0%	5%	75%	7%	11%	7%
Riverside	number	34	3	0	12	178,294	23,374	31,675	42,530
	percent	69%	6%	0%	24%	65%	8%	11%	16%
SCAB TOTAL	number	498	169	32	25	2,463,546	370,887	1,195,327	138,798
	percent	69%	23%	4%	3%	59%	9%	29%	3%

NOTE: The sum of (1) and (2) may correspond to that of (3) and (4).

Table 5-2a. ETHNIC MIX OF HOUSEHOLDS INTERVIEWED IN THE PRESENT SURVEY

County		No. Households Used for Statistics	No. Households Answering the Question	White	Black	Latino	Asian	Others
Los Angeles	number	548	491	364	60	38	26	3
	percent	-	100%	74%	12%	8%	5%	1%
Orange	number	139	129	113	7	1	7	1
	percent	-	100%	88%	5%	1%	5%	1%
San Bernardino	number	63	58	51	6	0	0	1
	percent	-	100%	88%	10%	0%	0%	2%
Riverside	number	50	49	45	3	1	0	0
	percent	-	100%	92%	6%	2%	0%	0%
SCAB TOTAL	number	800	727	573	76	40	33	5
	percent	-	100%	79%	10%	6%	5%	1%

Table 5-2b. TOTAL POPULATION COUNTS AND ETHNIC MIX BY COUNTY FROM 1980 CENSUS

County		Total Population	White	Black	Asian	American Indian	Others	Spanish[a]
Los Angeles	number	7,477,657	5,073,754	944,009	434,914	48,158	976,822	2,065,727
	percent	100%	68%	13%	6%	1%	13%	28%
Orange	number	1,931,570	1,668,170	25,285	86,876	12,842	138,297	286,331
	percent	100%	86%	1%	5%	1%	7%	15%
San Bernardino	number	893,157	736,043	47,740	14,918	10,063	84,393	165,295
	percent	100%	82%	5%	2%	1%	9%	19%
Riverside	number	663,923	545,547	30,857	9,208	7,202	71,109	124,496
	percent	100%	82%	5%	1%	1%	11%	19%
SCAB TOTAL	number	10,966,307	8,023,514	1,047,891	545,916	78,365	1,270,621	2,641,849
	percent	100%	73%	10%	5%	1%	11%	24%

[a]Spanish population is estimated independently of other ethnic groups, and can be a part of White population and/or Others population.

classification schemes are different, it is rather difficult to compare the survey ethnic mix and the census ethnic mix. White, Black and Asian groupings are the same between the two schemes. However, the census uses a different grouping scheme from the present survey for Latino (or Spanish) and Others. The White percentage of the survey result is higher than that of the census statistic by a few percentage points in every county. The Black percentages of the survey and the census disagree with each other for individual counties but agree for the SCAB total. The Asian percentages trace closely each other in individual counties and match precisely for the SCAB total. Others and Latino percentages are difficult to compare between the survey value and the census value because of the different classification schemes mentioned above.

Overall, it appears that the survey slightly oversampled White households and slightly undersampled Latino households. This bias in household sampling was probably caused by a lower-than-average response rate among Latino households rather than flaws in the original survey design.

Table 5-3 compares two distributions of household income: one obtained from the present survey and the other from the 1976 urban/rural survey conducted by the Los Angeles Regional Transportation Study.[1] Direct comparison of the two distributions is difficult because the ranges of household income are different between the two surveys and because the exact equivalence between a 1981 dollar and a 1976 dollar is not known for the study area. The underlying distribution of household income in the study area may also have altered from 1976 to 1981.

An apparent comparison between the two distributions indicates that the present survey contains more households from higher income groups than those indicated by the 1976 urban/rural survey. Again, this bias toward higher income households appears to be caused by a

Table 5-3. DISTRIBUTION OF HOUSEHOLD INCOME: COMPARISON BY COUNTY AND YEAR

Income (81$)	Los Angeles County Number	Los Angeles County Percent	Orange County Number	Orange County Percent	San Bernardino County Number	San Bernardino County Percent	Riverside County Number	Riverside County Percent	SCAB Total Number	SCAB Total Percent
Under 10,000	103	24%	11	11%	12	26%	11	26%	137	23%
10,000 - 20,000	125	30%	20	21%	17	36%	16	38%	178	29%
20,000 - 35,000	103	24%	26	27%	12	26%	11	26%	152	25%
35,000 - 50,000	59	14%	22	23%	5	11%	3	7%	89	15%
50,000 and over	31	7%	18	19%	1	2%	1	2%	51	8%

Income (76$)	Los Angeles County Number	Los Angeles County Percent	Orange County Number	Orange County Percent	San Bernardino and Riverside Counties Number	San Bernardino and Riverside Counties Percent	SCAB Total Number	SCAB Total Percent
Under 6,000	536,500	20%	89,900	15%	124,800	27%	751,200	20%
6,000 - 15,000	1,074,900	40%	208,700	34%	201,800	44%	1,485,400	40%
15,000 - 25,000	666,100	25%	212,600	34%	97,600	21%	976,300	26%
25,000 - 40,000	290,500	11%	86,400	14%	25,200	6%	402,100	11%
40,000 and over	114,500	4%	19,000	3%	8,400	2%	141,900	4%

NOTE: The 1981 household income distribution is obtained from the present survey, while the 1976 income distribution from the 1976 urban/rural survey.[1]

higher-than-average response rate among those households rather than flaws of the survey design itself.

In summary, the present survey has attained an even mix of housing types but has slightly biased the household mix by slightly undersampling Latino households and slightly oversampling higher income households.

5.2 VEHICLE OWNERSHIP AND LICENSED DRIVERS

Finally, vehicle ownership rate and number of drivers per household are estimated from results of the present survey, and the estimated values are compared with those arrived at by the 1976 urban/rural survey. Table 5-4 presents the estimated values by the present survey and those by the urban/rural survey. For Los Angeles County, both the number of licensed drivers per household and that of motor vehicles agree very closely between the present survey and the 1976 survey. The number of vehicles per household is 1.58 by the 1976 survey and 1.57 by the present survey. The 1.68 drivers per household of the urban/rural survey is just about midpoint between the upper and lower estimates (1.63 and 1.75) arrived at by the present survey.

For Orange County, the present survey values are about ten percent higher than those of the urban/rural survey. Although any exact comparison is not possible for San Bernardino and Riverside counties, the present survey estimates for the two counties also appear to be about ten percent higher than those of the urban/rural survey. The above three counties underwent rapid population and housing growths in the past 5 years; as a result these higher estimates may be a true reflection of the underlying changes in vehicle ownership rate and per household number of licensed drivers.

For the entire SCAB region, the present estimates of licensed drivers per household and number of vehicles per household are in close agreement with those of the 1976 urban/rural survey, but the

Table 5-4. NUMBER OF VEHICLES AND LICENSED DRIVERS PER HOUSEHOLD IN EACH COUNTY

County	Present Survey					Urban/Rural Survey	
	No. Households (1)	No. Motor Vehicles (2)	No. Licensed Drivers (3)	No. Drivers per Household (3)/(1)	No. Vehicles per Household (2)/(1)	No. Drivers per Household	No. Vehicles per Household
Los Angeles	548	860	959[a] 892[b]	1.75[a] 1.63[b]	1.57	1.68	1.58
Orange	139	282	291 281	2.09 2.02	2.03	1.86	1.82
San Bernardino	63	106	122 114	1.94 1.81	1.68	1.73	1.66
Riverside	50	96	98 96	1.96 1.92	1.92		
SCAB Total	800	1,344	1,470 1,383	1.84 1.73	1.68	1.71	1.64

[a]It is assumed that a household with no vehicle has, on an average, one licensed driver.

[b]It is assumed that a household with no vehicle does not have any licensed driver.

present values are about two to seven percent higher than the 1976 values.

6.0 REFERENCES

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5. "The 1980 Census Statistics for California," Personal Communication with Ms. Aurora Guzman, Bureau of the Census, West Los Angeles, CA, July 1981.

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APPENDIX A

QUESTIONNAIRE FOR PRIMARY VEHICLE USAGE IN SCAB

CALL RECORD SHEET

Telephone Book #_____ Service Area_____

Serial No. _____ PES USE ONLY ☐ ☐

Name* _____ Telephone No. ( ) _____

City* _____

*Write those of actual resident instead of those listed in computer print outs.

Call #	Date	Time	Outcome	Comments	Interviewer
1					
2					
3					
4					
5					
6					
7					
8					

Result: ☐ No Vehicle ☐ Primary ☐ Regular ☐ Infrequent

Questionnaire for Nonprimary Vehicle Usage in SCAB

Good (morning, afternoon, evening) I'm,_____ from Pacific Environmental Services. We are conducting a survey for the California State Air Resources Board. Specifically, we are studying the vehicle usage patterns of residents of the South Coast Air Basin. In order to get a better estimate of vehicle usage we are interviewing a representative sample of households in the area about their driving patterns. These data will be used by the State Air Resources Board for planning methods to combat air pollution. Your participation in this study is very important. Everything you tell us will be strictly confidential. Your name will not in any way be connected with the findings of this study.

INSTRUCTION: DETERMINE IF YOU ARE SPEAKING TO AN ADULT MEMBER OF HOUSEHOLD, IF NOT ASK TO SPEAK TO AN ADULT RESIDENT OR DETERMINE WHEN ONE WILL BE HOME. IF ADULT COMES TO PHONE RESTART INTRODUCTION. VERIFY TELEPHONE NUMBER, IF INCORRECT, APOLOGIZE, TERMINATE AND REDIAL.

Q1. First, I need to know how many vehicles does anyone in your household own passenger cars, vans, pick-ups, campers or any other type vehicles?

_____ No vehicles owned --Ask Q 19 only
_____ Passenger cars
_____ Vans
_____ Trucks
_____ Campers
_____ Others (specify)_____

(DO NOT INCLUDE MOTOR CYCLE, MOPED AND SO FORTH)

Q2. QUESTION HAS BEEN MOVED TO THE LAST PAGE OF THE QUESTIONNAIRE.

Q3. In total, how many persons in your household have a drivers license?

_____# Drivers

Q4. Approximately how many miles per year is each of these vehicles driven? (ASK IN SAME ORDER AS RECORDED IN Q2. IF DON'T KNOW # MILES PER YEAR ASK FOR MONTH, WEEK, OR DAY AND USE CONVERSION TABLE.)

V1: _____ Miles Per Year, Month, Week, Day

V2: _____ Miles Per Year, Month, Week, Day

V3: _____ Miles Per Year, Month, Week, Day

V4: _____ Miles Per Year, Month, Week, Day

Q's 5 and 6 HAVE BEEN MOVED TO THE LAST PAGE OF THE QUESTIONNIARE.

Q7. How many members of your household use the family vehicles to commute or go to school?

_____

IF NONE SKIP TO Q8

A. In which city does each one work or go to school.

V1_____

V2_____

V3_____

V4_____

Q8. On the average, how often is gasoline purchased for (Vehicle Name) and how many gallons?

	Time Period	Gallons (or Dollars)
V1:	_____	_____
V2:	_____	_____
V3:	_____	_____
V4:	_____	_____

Q9. How long have you owned each vehicle? (ASK IN ORDER OF Q2.)

V1: _____ Yrs._____Mos.

V2: _____ Yrs._____Mos.

V3: _____ Yrs._____Mos.

V4: _____ Yrs._____Mos.

Q10. Can you tell me, approximately, what the present odometer reading is for each vehicle? That is how many miles in total it has been driven? Can you remember how many miles each vehicle had on it when purchased? (ASK IN ORDER OF Q2.)

	PRESENT ODOMETER		AT PURCHASE	
V1:	_____	miles	_____	miles
V2:	_____	miles	_____	miles
V3:	_____	miles	_____	miles
V4:	_____	miles	_____	miles

Q11. Where is each vehicle typically parked or stored when not in use? Is it outdoors, in a roofed carport or in an enclosed garage? (ASK IN ORDER OF Q2.)

	OUTDOORS	ROOFED CARPORT	ENCLOSED GARAGE	OTHER (Specify)
V1:	1	2	3	4 _____
V2:	1	2	3	4 _____
V3:	1	2	3	4 _____
V4:	1	2	3	4 _____

Q12. Do you use the (Vehicle Name) more frequently in the summer, winter, or do you use it evenly throughout the year?

	Summer	Winter	Throughout Year
V1:	1	2	3
V2:	1	2	3
V3:	1	2	3
V4:	1	2	3

Q13. Do you tend to use the (Vehicle Name) for longer distance drive or shorter distance drive in the summer, compared to the average distances you drive in other seasons.

	More	Less	About Even
V1:	1	2	3
V2:	1	2	3
V3:	1	2	3
V4:	1	2	3

IF THE VEHICLE IS PRIMARY, SKIP TO THE FINAL QUESTION, Q19. IF THE VEHICLE IS REGULAR, ASK Q'S 14 and 19. IF THE VEHICLE IS INFREQUENT, ASK Q'S 15 THRU 19.

REGULAR VEHICLES: V _____ MAKE/MODEL _____

Q14. Now I would like to ask about vehicle usage of the (Vehicle Name) in the past week or some previous week if not used in the past week. Starting today, can you tell me the miles driven one way to work/school, shopping or other places and how long the car was parked after you reached each destination.

	WORK/SCHOOL	SHOPPING	OTHER (Specify)	OTHER (Specity)
SUNDAY Trip Distance Time Parked				
MONDAY Trip Distance Time Parked				
TUESDAY Trip Distance Time Parked				
WEDNESDAY Trip Distance Time Parked				
THURSDAY Trip Distance Time Parked				
FRIDAY Trip Distance Time Parked				
SATURDAY Trip Distance Time Parked				
PES USE ONLY				

REGULAR VEHICLES: V _____ MAKE/MODEL _____

Q14. Now I would like to ask about vehicle usage of the (Vehicle Name) in the past week or some previous week if not used in the past week. Starting today, can you tell me the miles driven one way to work/school, shopping or other places and how long the car was parked after you reached each destination.

	WORK/SCHOOL	SHOPPING	OTHER (Specify)	OTHER (Specity)
SUNDAY Trip Distance Time Parked				
MONDAY Trip Distance Time Parked				
TUESDAY Trip Distance Time Parked				
WEDNESDAY Trip Distance Time Parked				
THURSDAY Trip Distance Time Parked				
FRIDAY Trip Distance Time Parked				
SATURDAY Trip Distance Time Parked				
PES USE ONLY				

INFREQUENT VEHICLES RECORD #: V_____ _____

NAME: _____ _____

Q15. Now I have a few questions about the usage of the (Vehicle Name). Approximately how long ago did you last drive (Vehicle Name)?

	V _____	V _____
How long Ago	_____	_____

Q16. What do you primarily use the (Vehicle Name) for? Is it for?

	V_____	_____
Business	1	1
Recreational	2	2
Shopping and chores, or	3	3
Something else?	4	4

(Specify)_____

Q17. When you drive the (Vehicle Name), do you usually drive it more than 7.5 miles each way?

	V_____	V_____
YES	1	1
NO	2	2

Q18. When the (Vehicle Name) is not in use, how full do you usually keep the gas tank?

	V_____	_____	_____	_____
Full	1	1	1	1
3/4 Full	2	2	2	2
1/2 Full	3	3	3	3
1/4 Full	4	4	4	4
Nearly Empty/empty	5	5	5	5

Q.19. Finally, I need to know the type of house, your ethnic heritage and family income.

A. Do you live in a

House/single family unit	1
Apartment/Duplex	2
Condominium/Townhouse, or	3
Mobile home	4
Something else? _____	5

B. Which of the following best describes your ethnic or racial heritage:

White	1
Hispanic/Latino/Mexican-American	2
Black/Afro-American	3
Oriental/Asian	4
Other _____	5

C. Which of the following best describes the total income of your housefnold before taxes in 1980? Please stop me when your income falls into the category I read.

Less than $10,000	1
Between $10 and $20,000	2
Between $20 and $35,000	3
Between $35 and $50,000	4
Over $50,000	5
REFUSED	9

THANK AND TERMINATE.

Q2. Please tell me the make, model, and year of each of these vehicles and who is the primary driver of each.

	MAKE	MODEL	YEAR	PRIMARY DRIVER
V1:	_____	_____	19 _____	_____
V2:	_____	_____	19 _____	_____
V3:	_____	_____	19 _____	_____
V4:	_____	_____	19 _____	_____

Q5. How often does someone drive each of these vehicles? (ASK IN SAME ORDER AS Q2.)

V1: _____ Days Per: Week, Month, Year

V2: _____ Days Per: Week, Month, Year

V3: _____ Days Per: Week, Month, Year

V4: _____ Days Per: Week, Month, Year

Q6. For each vehicle, how many continuous miles is it driven one way on a typical longest daily trip? By trip we mean one driving distance from where you start to where you park such as a daily commute to work.

V1: _____ Miles Per Trip

V2: _____ Miles Per Trip

V3: _____ Miles Per Trip

V4: _____ Miles Per Trip

BASED ON Q's 5 and 6, DETERMINE FOR EACH VEHICLE IF IT IS:

Usage 4-Days or more per week and 1-way drive over 7.5 miles (IF YES THEN VEHICLE IS PRIMARY)

V_____ _____ _____

Used less than 1-day per week regardless of miles (IF YES THEN VEHICLE IS INFREQUENT)

V _____ _____ _____

ALL OTHER VEHICLES ARE REGULAR

V_____ _____ _____

APPENDIX B

HOUSEHOLD DATA SHEET AND COMPILED DATA

HOUSEHOLD AND VEHICLE OWNERSHIP DATA SHEET

	Item	Character(s)
Household Identification	1. Telephone Book No. (1-Los Angeles, ...15-Santa Clarita Valley)	1-2
	2. Serial No. for Random Selection (1~1,252)	3-6
	3. Household I.D. Number (1~1,000)	7-10
	4. County Code (1-Los Angeles, 2-Orange, 3-San Bernardino, 4-Riverside)	11
	5. Number of Licensed Drivers	12
Vehicle Ownership	6. Total Number of Vehicles	13
	7. Number of Primary Vehicles	14
	8. Vehicle Type of 1st Primary Vehicle (1-Passenger Car, 2-Van/Bus, 3-Truck, 4-Recreational Vehicle)	15
	9. Make of 1st Primary Vehicle (1-GM, 2-Ford, 3-Other U.S., 4-Toyota, 5-Datsun, 6-VW, 7-Other Foreign)	16
	10. Model Year (19__) of the 1st Primary Vehicle ('50 - '81)	17-18
	11. Vehicle Type of 2nd Primary Vehicle	19
	12. Make of 2nd Primary Vehicle	20
	13. Model Year of 2nd Primary Vehicle	21-22
	14. Vehicle Type of 3rd Primary Vehicle	23
	15. Make of 3rd Primary Vehicle	24
	16. Model Year of 3rd Primary Vehicle	25-26
	17. Vehicle Type of 4th Primary Vehicle	27

	Item	Character(s)
Vehicle Ownership	18. Make of 4th Primary Vehicle	28
	19. Model Year of 4th Primary Vehicle	29-30
	20. Number of Nonprimary Vehicles	31
	21. Vehicle Type of 1st Nonprimary Vehicle	32
	22. Make of 1st Nonprimary Vehicle	33
	23. Model Year of 1st Nonprimary Vehicle	34-35
	24. Vehicle Type of 2nd Nonprimary Vehicle	36
	25. Make of 2nd Nonprimary Vehicle	37
	26. Model Year of 2nd Nonprimary Vehicle	38-39
	27. Vehicle Type of 3rd Nonprimary Vehicle	40
	28. Make of 3rd Nonprimary Vehicle	41
	29. Model Year of 3rd Nonprimary Vehicle	42-43
	30. Vehicle Type of 4th Nonprimary Vehicle	44
	31. Make of 4th Nonprimary Vehicle	45
	32. Model Year of 4th Nonprimary Vehicle	46-47
Socio-Economic Info	33. Type of House (1-House, 2-Apartment/Duplex, 3-Condo/Townhouse, 4-Mobile Home)	48
	34. Ethnic Heritage (1-White, 2-Hispanic/Latino, 3-Black, 4-Oriental, 5-Other)	49
	35. Total Income of Household (1-<$10,000, 2-$10,000 and $20,000, 3-$20,000 and $35,000, 4-$35,000 and $50,000, 5-≥$50,000)	50

1 2	Book No.
3 4 5 6	Serial No.
7 8 9 10	Household I.D. No.
11	County Code
12	# Licensed Drivers
13	Total # Vehicles
14	# Primary Vehicles
15	Vehicle Type of 1st
16	Make of 1st
17 18	Model Year of 1st
19	Vehicle Type of 2nd
20	Make of 2nd
21 22	Model Year of 2nd
23	Vehicle Type of 3rd
24	Make of 3rd
25 26	Model Year of 3rd
27	Vehicle Type of 4th
28	Make of 4th
29 30	Model Year of 4th
31	# Nonprimary Vehicles
32	Vehicle Type of 1st
33	Make of 1st
34 35	Model Year of 1st
36	Vehicle Type of 2nd
37	Make of 2nd
38 39	Model Year of 2nd
40	Vehicle Type of 3rd
41	Make of 3rd
42 43	Model Year of 3rd
44	Vehicle Type of 4th
45	Make of 4th
46 47	Model Year of 4th
48	Type of House
49	Ethnic Heritage
50	Income Level

01000305341120	214702270	999
010005053311211279	11274	312
01001105321230	3126E22783163	213
01001200021900	0	231
01001300031900	0	211
010014056611111180	0	242
01001605311110	11370	999
010020053012212177	11273	221
010022052911111175	0	999
01002305281110	11372	112
01002505271110	11273	222
01002805261110	11173	213
010033052512211757	11666	113
0100380524133212681172	11172	122
01003905231110	11668	511
0100410522133214781476	11481	999
01004205971110	11171	139
01004300111900	0	242
01004405981110	11373	999
01004601181900	0	122
0100500599123311761279317 6	0	232
01005106001220	215741173	233
01005206011210	12379	129
01005302831110	11268	999
01005506021210	11180	999
01006000141900	0	431
010061011711111567	0	211
01006606031220	2127C1269	999
01006806041210	11180	112
01007000131900	0	131
010073060511111167	0	999
01007406061110	11172	131
01007600101900	0	139
0100770607143311781279127 2	0	114
01008406261120	211722374	124
01008500071900	0	211
01008800121900	0	121
01009306081320	211731773	132
01009400091900	0	999
01009506271110	11477	999
010096060912111379	0	212
01009800041900	0	999
010108011611111681	0	214
010109062813111767	0	213
01011506101110	1117C	999
01011600081900	0	239
010120062912111176	0	132
01012306111110	11175	142
010125061212311274	217781274	121
01013100051900	0	999
010132061312212275	11279	999
01013601151900	0	219
010139061413211675	11377	199
0101410615142215741778	0	139
01014300061900	0	999
010143061611111180	0	122
01014400221900	0	249
01014500231900	0	211
010147061713511172	4115616791364125 7	999
010148061811211170	11659	111

01015306301210	11165	132
010154063112211175	11178	999
01016106191110	11178	222
010162062012211777	11777	113
01016501141900	0	999
01016706211110	11778	999
01017201131110	11277	131
01017500241900	0	139
01018100151900	0	999
01018406221110	13165	999
01018506231110	11173	999
01018801891220	233741374	119
010193062411211668	11172	999
01019406321210	11674	999
010195063311111670	0	233
01019606341220	217693164	113
010198062512211179	12377	199
0101990635122216681373	0	122
01020006361111262	0	139
01020106371110	11368	211
01020206381220	212711575	121
01020300251900	0	122
01020601601110	11173	212
010210063912211171	11574	999
01021100261900	0	132
0102150640122214761378	0	999
010217011211211171	11372	221
010221064112213171	1117C	131
01022600271900	0	219
010227064211111271	0	139
010229064312211578	11372	999
010235064412211179	11674	999
01023800281900	0	132
01024106451220	212722371	999
010242064611111479	0	999
010243064712112278	0	213
01024606481110	11174	244
01024801111220	212681170	999
010251064911211365	11174	999
01025201101110	11269	121
01025701091110	11172	129
01025906501110	1117C	211
0102600108123213711373	14373	133
0102670422132212711167	0	122
01027004741900	0	211
0102750423122216781381	0	123
010284042413331176116812 78	0	134
01028504251110	11162	212
010286042612111364	0	123
010290042711111177	0	221
010292042812111273	0	133
01029303991900	0	121
01029404291110	11374	211
01029804301900	0	221
010300043111111159	0	231
01030204321110	11365	111
0103040433122211781578	0	244
0103080473122211701174	0	219
010312048611111265	0	233
01031404721221118 0	11169	124
01031804751221117 7	11172	219

01031904761900	0	121
01032004771111479	0	232
01032204831221177	11178	121
01032304801900	0	221
0103280478122216711178	0	132
01033104871111660	0	212
01033804791110	12699	221
02000805481221116 9	11168	999
0200090547133312761276 1276	0	212
02001005461111171	0	999
02001705411111274	0	999
02001905401110	11380	999
02002105451210	11164	119
02002305441220	217691769	999
02002905431321167 2	11179	999
02003105421221116 9	11175	999
0200320107124235741279	221711273	114
0200330106122211801178	0	315
02003506511220	217794378	412
02003606521111136 7	0	119
02003806531330	3177511761776	112
02003906541110	11272	112
02004101051220	211772368	119
02004206551211177 9	0	313
02004506561210	12179	219
02004706571211137 5	0	143
02004801041110	13279	122
02005006601220	215804380	213
02005206591110	11179	119
02005300291900	0	999
02005406581221137 0	11177	414
02005501591220	214771780	114
02005606611220	212731777	212
02005706621311127 3	0	212
02005801031221167 0	11374	414
02005906631110	11773	111
02006200301900	0	999
0200630664122211782174	0	412
02006406651110	11161	919
02006506661110	11277	313
0200670667122214781577	0	223
02006806681211126 9	0	219
02007106691320	217721664	119
0200720670122212691278	0	233
02007306711110	11175	313
02007401021241437 5	3167012694369	112
02007506721210	13272	222
02007906731921267 1	12676	112
02008106741231158 0	211781481	115
02008400311900	0	999
02008501011220	211701179	119
02008601001120	211744372	119
02009000991230	3117713694373	113
0200910098124315743271326 9	11171	114
02009200971211147 7	0	215
0200950095113217773479	11377	115
02009800961900	0	212
0200990191124217781173	222664379	115
02010000941220	211763463	111
02010100931221117 2	11280	113
02010200921321117 8	11276	114

02010501571320	213742375	112
02010600911120	212781366	114
020111009012211172	11275	114
020112008912713279	11279	113
02011300881110	11270	111
020116008711111479	0	319
02011800861900	0	999
02012300851220	211653166	119
02012400841110	11377	512
02012500831210	11177	112
02012700821110	11777	212
02013000811110	11279	212
02013104061510	11478	119
02013500801110	11256	211
020137007912321579127 0	11181	115
02013900781110	11179	314
02014100771230	3147514782279	115
020143007611111379	0	112
020144007511111168	0	313
02014700741220	217801178	119
020151015812311780	211741774	315
020155007311111769	0	194
02015800511110	11572	213
020159004713433274137913 80	11156	113
020161005011111174	0	211
02016200441900	0	211
02016400451900	0	315
020165004911111173	0	123
02016600481110	11176	311
020171005312221168316 8	0	113
02017400411320	214781576	212
02017800461210	11473	112
02018000431110	11281	312
020182004212211271	11371	112
020187004012211779	13476	144
020189005511111168	0	113
02019100391220	211801272	112
02019200381210	11373	111
020194003712221668148 1	0	219
020195003613111373	0	114
C2019600351222117717 78	0	119
02020000341320	211771769	115
020201005412221278327 3	0	112
020202019912221768167 2	0	112
020205003311111165	0	212
020206003211111672	0	222
020208006311111669	0	212
020212006214421176167 8	212811281	115
020216005216771773177711751781 0		119
020216005216771779177917 79	0	119
020217006112221169116 9	0	112
02021800601210	11778	212
02022200591220	212661273	212
02022601981110	11273	213
020228048212321781177 9	12672	143
020229005612212278	11171	115
020230005714331272127612 69	0	115
020232005811221276118 1	0	112
02023301971220	212731167	113
02023402031110	11170	122
020238019212222269156 7	0	129

02023901961222211771180	0	114
02024301951330	3317631721176	114
02024501941222212773373	0	113
02024602041110	11270	159
02024802021110	11178	121
02025301931431 1175	211703172	113
02025402001221 3378	11278	112
02025502011111179	0	212
02025701701900	0	111
02026001901121 1781	11267	115
02903108701220	216721178	114
03000105391221 1179	11681	122
03000305381221 1279	11778	999
03000905371210	11163	999
03001105361220	226701275	112
03001205351330	3127711781581	999
03001700701111 1175	0	411
03001806861221 1577	11778	243
03001900711900	0	412
03002203981110	11179	219
03002601871443138011811778	11772	115
03002806831211 3172	0	293
03003506821321 1181	11772	214
03003603961220	217681178	123
03003803951210	11177	212
03003906811110	11178	212
03004008261222 13771772	0	215
03004306801110	11368	211
03004401861221 1671	11772	315
03004500691111 1180	0	345
03004601881110	11177	212
03004700681211 3778	0	511
03004900671111 1774	0	112
03005000661333117712771779	0	119
03005503931111 1179	0	212
03005600651110	11168	919
03005706791110	11779	355
03005808281121 1780	11778	315
03006502781222 17801178	0	211
03006603971231 1158	212681261	213
03006706781220	212661669	212
03006906771111 1777	0	213
03007000641222 11751276	0	212
03007203941420	212731180	213
03007406761221 1776	11168	113
03007506751433147615742275	0	113
03007608241221 1173	11278	114
03007905001221 1174	11472	213
03008008251111 1166	0	112
03008104991900	0	211
03008204971220	211781476	143
03008304961120	212791272	119
03008404951122 11741669	0	112
03008704941900	0	119
03008904931111 1779	0	213
03009208271900	0	111
03009404921210	11169	212
03009504911110	11178	113
03009604901220	212794674	112
03009704891210	11379	131
03009904881221 1479	11669	213

03010004841210	11767	512
030101086411111773	0	219
030103086511111574	0	212
0301050863122212661180	0	215
03011208691110	11580	112
030115086212211180	11276	114
03011608681210	11177	112
030117086612211272	11164	119
03011908591110	11368	211
03012108581110	11166	119
03012408611440	411741272116231 72	119
030126086711211673	14478	214
03012708601110	11669	212
03032704851900	0	211
0400020521133326741664 1172	0	132
040003052012221175 1273	0	999
04000705091220	216701273	119
0400080513133212663275	11268	213
04003905081220	212731278	113
04001200011900	0	111
040015051911111177	0	213
040017051813111157	0	999
040018050511111168	0	999
040022027512211777	11179	113
040026027412213178	11177	113
040026050412211178	13177	112
040027051212211373	13563	119
040028051712111372	0	222
040030051112211173	11161	113
040031011913211779	11280	114
040034051012213177	11276	999
04003505031430	3166716692276	113
040036050219111273	0	121
04003805071110	11177	112
04004105141220	211771465	144
0400430282122212661280	0	113
040046051514531265317 63374	212661180	113
040049051612213264	11771	114
04005002761220	212763272	222
040051046612211776	11170	112
040052012011111177	0	139
040053018512211169	11177	111
04005504981900	0	211
040056046911111778	0	119
04005704671220	211793478	155
040058047111111771	0	319
040065047012111279	0	421
0400690468143311721375 1180	0	115
040072083012211278	11272	114
0400780834133212643180	11174	113
04008008311220	212673473	119
040083085612211775	13272	123
0400880829122217701157	0	114
0400890832123211651369	13153	112
040090083511111178	0	112
040091083614413278	3128017671270	119
0400920837122212721180	0	112
040094083812111177	0	119
0400960855133317721371 1469	0	114
040097083912211275	11668	119
0401010854122216732264	0	123

04010707021900	0	999
040108068911111371	0	412
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1500190435122234781576	0	114

APPENDIX C

NONPRIMARY VEHICLE DATA SHEET AND COMPILED DATA

DRIVING AND STORAGE PATTERN DATA SHEET

	Item	Characters(s)
Vehicle Identification	1. Telephone Book Number (1--Los Angeles.....15--Santa Clarita Valley)	1-2
	2. Serial Number for Random Selection (1 ~ 1,252)	3-6
	3. Vehicle I.D. Number for Non-primary Vehicles (1 ~ 1,500)	7-10
	4. Vehicle Use Category (1--Regular, 2--Infrequent)	11
	5. Vehicle Type (1--Passenger Car, 2--Van, 3--Truck, 4--Recreational Vehicle)	12
	6. Make of Vehicle (1--GM, 2--Ford, 3--Other U.S., 4--Toyota, 5--Datsun, 6--VW, 7--Other Foreign)	13
	7. Model Year (19__) ('50-'81)	14-15
General Usage Info.	8. Miles Driven Per Year in Thousands of Miles (0 ~ 50)	16-17
	9. Average Number of Days Driven Per Week (0 ~ 7)	18
	10. Longest Continuous Miles Driven on a Typical Day (0 ~ 99)	19-20
	11. Gallons of Gasoline Purchased (1 ~ 99)	21-22
	12. Fill-up Period in Days (1 ~ 365)	23-25
	13. Period of Ownership in Months (0 ~ 300)	26-28
	14. Present Odometer Reading in Thousands of Miles (1 ~ 200)	29-31
	15. Odometer Reading at Purchase in Thousands of Miles (0 ~ 200)	32-34

	Item	Character(s)
General Usage Info.	16. Storage Code (1--Outdoors, 2--Roofed Carport, 3--Enclosed Garage)	35
	17. Seasonality in Vehicle Usage (1--Summer more, 2--Winter more, 3--Throughout Year)	36
	18. Seasonality in Average Driving Distance (1--More in Summer, 2--Less in Summer, 3--About Even)	37
Regular Vehicle	19. Actual Number of Days the Vehicle Used Per Week (0 ~ 7)	38
	20. Number of Trips Made Per Week (0 ~ 99)	39-40
	21. Number of Trips Made for Work/School Per Week (0 ~ 14)	41-42
	22. Typical Distance Driven to Work/School in Miles (0 ~ 99)	43-44
	23. Typical Parking Duration After Reached Work/School (0--No Park, 1--0-10 min, 2--10-30 min, 3--30-1hr, 4--over 1 hr)	45
	24. Number of Trips Made for Shopping Per Week	46-47
	25. Typical Distance to Shopping	48-49
	26. Typical Parking Duration After Reached Shopping Place	50
	27. Number of Trips Made for Other Purposes	51-52
	28. Typical Distance Driven in Each Such Trip	53-54
	29. Typical Parking Duration in Each Such Trip	55
	30. Number of Trips Made on Sunday	56
	31. Number of Trips Made on Monday	57
	32. Number of Trips Made on Tuesday	58
	33. Number of Trips Made on Wednesday	59

	Item	Character(s)
Regular Vehicle	34. Number of Trips Made on Thursday	60
	35. Number of Trips Made on Friday	61
	36. Number of Trips Made on Saturday	62
Infrequent Vehicle	37. Number of Weeks Since Last Used (0 ~ 52)	63-64
	38. Primary Vehicle Usage (1--Business, 2--Recreational, 3--Shopping, 4--Other)	65
	39. Typical Driving Distance (1--More than 7.5 Miles, 2--Less than 7.5 Miles)	66
	40. Gas Left in Tank (1--Full, 2--Three Quarters Full, 3--Half Full, 4--Quarter Full, 5--Near Empty)	67

1 2	Book No.
3 4 5 6	Serial No.
7 8 9 10	Vehicle I.D. No.
11	Use Category
12	Vehicle Type
13	Make Type
14 15	Model Year
16 17	Annual Miles
18	No. Days Per Week
19 20	Longest Miles Driven
21 22	Gallons Purchased
23 24 25	Fillup Period
26 27 28	Period of Ownership
29 30 31	Miles at Present
32 33 34	Miles at Purchase
35	Storage Code
36	Seasonality in Veh. Us
37	Seasonality Driv. Dist.
38	Actual # Days per Week
39 40	# Trips per Week
41 42	# Trips for Work/Schl
43 44	Distance to Work/Schl
45	Park Duration
46 47	# Trips for Shopping
48 49	Distance for Shopping
50	Park Duration
51 52	# Trips for Others
53 54	Distance to Others
55	Park Duration
56	# Trips on Sunday
57	# Trips on Monday
58	# Trips on Tuesday
59	# Trips on Wednesday
60	# Trips on Thursday
61	# Trips on Friday
62	# Trips on Saturday
63 64	# Weeks Since Last Use
65	Primary Use
66	Distance Category
67	Gas in Tank
68 69 70	

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APPENDIX D

RELIABILITY OF KEY ELEMENTS

APPENDIX D
RELIABILITY OF KEY ELEMENTS

The present study is based on data obtained through telephone interviewing of households which are chosen randomly from white page listings of telephone directories. Therefore, before estimates made in this study can be used sensibly, errors associated with such estimates must be quantified. The errors to which survey data are subject can be classified into two types; sampling error -- errors associated with sample size and sampling technique, and non-sampling error - errors caused by factors not directly associated with sampling itself (e.g., transcription and keypunch errors, failure of interviewers to follow instructions, and failure of respondents to correctly answer interviewer's questions). This appendix addresses the two types of errors associated with the present survey.

SAMPLING ERRORS

Sample means were often used in the main text of this report as a point estimate of the underlying population. To indicate how precise such an estimate is, the confidence interval is often used. The confidence interval specifies a range within which the true mean of the population is expected to lie with a given level of probability. The confidence interval with 95 percent of confidence for the sample mean, $\bar{x}$, as an estimate of the true mean, μ, is written as

$$\bar{x} - 2\sqrt{\frac{Var(x)}{n}} < \mu < \bar{x} + 2\sqrt{\frac{Var(x)}{n}} \qquad (D1)$$

where Var(x) represents an estimate of the variance of the population and n stands for the sample size.

In estimating a ratio of nonprimary vehicles to all vehicles, R, the variance of such ratios was computed by using the following approximate formula:[8]

$$Var(R) \leq \sum_j (X_j - \bar{R}\ Y_j)/n\bar{y}^2 \qquad (D2)$$

where X_j and Y_j are, respectively, the numbers of nonprimary vehicles and all vehicles in the jth household and $\bar{y}$ is the mean number of vehicles per household.

Table D-1 summarizes the error band around each estimated mean of the key variables: number of drivers per household, number of all vehicles per household, number of nonprimary vehicles per household, and a ratio of nonprimary vehicles to all vehicles. According to the table, the average number of licensed drivers should lie between 1.62 and 1.76, and that of vehicles per household between 1.61 and 1.75. The ratio of nonprimary vehicles to all vehicles should be somewhere between 0.497 and 0.555.

Considering the relatively small sample size for the survey of this type, the above error bands are rather small, indicating that the sampling errors in the present survey do not pose any significant problem.

NONSAMPLING ERROR

Nonsampling errors or systematic errors could occur in data transcription, keypunching, erroneous answers of interview respondents and inaccurate interviews of telephone interviewers. First, we have made every possible effort to avoid errors in transcribing the interview results on a coding sheet and in keypunching the data onto a computer readable format, within the budgetary and time constraints. Then, in order to estimate errors or inaccuracies on the parts of respondents and interviewers, we made a second interview for about 130 households, which from the

Table D-1. RELIABILITY OF ESTIMATES OF DRIVERS/HOUSEHOLD (HH), ALL VEHICLES/HH, NONPRIMARY VEHICLES/HH, AND NONPRIMARY VEHICLES/VEHICLE
(The confidence intervals are given for 95 percent confidence level)

	Drivers/ HH	Vehicles/ HH	Nonprimary/ HH	Nonprimary/ Vehicle
Mean	1.69[a]	1.68	0.882	0.526
Variance	0.76	1.12	0.796	0.176[b]
Confidence Interval				
Lower Limit	1.62	1.61	0.819	0.497
Upper Limit	1.76	1.75	0.945	0.555
Sample Size	800	800	800	800

[a]An average of the upper and lower estimates given in Table 5-4 is used.

[b]The variance is computed by using the approximation, Eq. D2.

first interview results, were found to have at least one regular vehicle or two primary vehicles. Among them, 83 households answered some or all questions asked in the second interview.

Table D-2 presents results of the duplicate interview on vehicle related parameters. The consistency in responses to number of vehicles and number of drivers is fairly good (88 percent and 84 percent, respectively), but those for numbers of primary and nonprimary vehicles are somewhat poor, with 71 percent and 65 percent, respectively. It is interesting to note that people do remember the correct manufacturer of their vehicles (95 percent) but are not so good at remembering the correct model year (76 percent). The consistency rates described above are for all cases. The consistency rates for a subset, in which respondents in the first and second interviews have the same sex, is generally higher than those for all cases by a few percentage points (Table D-2).

Table D-2. CONSISTENCY OF FIRST AND SECOND INTERVIEW RESPONSES TO VEHICLE RELATED QUESTIONS

Vehicle	Difference Between the First and Second Interview 0	1	2	3 or More	Percent Same Response for All Cases	Percent Same Response Among Same Sex*
No. All Vehicles	73	8	2	0	88	89
No. Drivers	70	11	2	0	84	83
No. Primary Vehicles	53	15	7	0	71	76
No. Nonprimary Vehicles	49	19	7	0	65	72
Model Year	115	23	5	9	76	78
Make of Car	155	9			95	96

The reason for the low consistent rate for primary and nonprimary vehicles can be found in Table D-3. The consistency rates for vehicle usage parameters such as number of days used per week, number of miles driven on a typical trip, and number of gallons of gasoline purchased per week are all low, hovering around 60 percent. A determination of the primary or nonprimary vehicle must use the information about the vehicle's usage parameters, whose consistent rates are low. As a result, the consistent rates for primary and nonprimary vehicles also become low.

The first and second interviews were made, on an average, about two months apart. Therefore, the low consistency rates for the vehicle usage parameters may indeed reflect actual changes in their vehicle usages. If that is the case, their responses to the amount of gasoline purchased and the number of miles driven on a typical

Table D-3. CONSISTENCY OF FIRST AND SECOND INTERVIEW RESPONSES TO VEHICLE USAGE PARAMETERS

Variable	Range of Difference Between the First and Second Interview				Percent Consistent Response for All Cases	Percent Consistent Response Among Same Sex
	0	1	2	3 or more		
No. Days Used/Wk	79	35	19	14	54	58
	0~5	6~10	11~15	16 or more		
No. Miles Driven	90	17	11	17	67	66
	0~5	6~10	11~15	16 or more		
No. Gallons/ Week	66	28	6	11	59	66

trip may exhibit some logical relationship. Table D-4 was prepared to check such hypothesis. The results shown in the table do not support such hypothesis. Namely, the low consistency rates for the vehicle usage parameters appear to be characteristic of people's responses to such particular questions.

Table D-5 summarizes the responses to three socio-economic parameters in the first and second interviews. Although the response rate to the socio-economic questions is the lowest (25 percent to 30 percent of the households refused to answer the questions) among responses to other questions asked in the interview, the consistency rate is quite high, particularly for the type of house and the ethnic heritage questions (96 to 100 percent). These very high consistency rates appear to indicate that the interviewers were well trained for the present survey and were accurate in their interviewing. The consistency rate for the household income question is understandably low because the higest refusal rate on this question were observed throughout the interviewing.

Table D-4. INTER-RELATIONSHIP BETWEEN RESPONSES TO NUMBER OF MILES DRIVEN AND AMOUNT OF GASOLINE PURCHASE

No. Gallons Purchased in 1st Response vs 2nd Response	No. Miles Driven in 1st Response vs 2nd Response		
	Less	Same (±1 mile)	More
Less	13	8	8
Same (±2 gal)	13	20	9
More	6	17	11

Table D-5. CONSISTENCY OF FIRST AND SECOND INTERVIEW RESPONSES TO SOCIO-ECONOMIC PARAMETERS

Variable	First and Second Response Same	First and Second Response Different	Percent Consistent Response for all Cases	Percent Consistent Response Among Same Sex
Type of House	68	3	96	98
Ethnic Heritage	69	2	97	100
Income Level	41	17	71	80

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