Final Research Report

QUANTIFICATION METHODS FOR IDENTIFYING EMISSION REDUCTIONS RESULTING FROM SEASONAL AND EPISODIC PUBLIC EDUCATION PROGRAMS

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Abstract

Many air districts throughout the country conduct public education programs during the summer ozone season to encourage the public to reduce their driving on days forecast to violate ozone air quality standards. This research project developed a simple, low cost method for quantifying the travel and emission impacts of these programs, often called "Spare the Air" in California. The study developed survey methods and collected comprehensive travel data of a random sample of the general population and of individuals who said they responded to the Spare the Air message. The data, collected over two summer ozone seasons in Sacramento, allowed researchers to compare the travel behavior of the same individuals on both Spare the Air and regular (non-Spare the Air) summer days and of Spare the Air participants and non-participants. The study found a statistically significant difference between the self-reported vehicle trip reductions and measured vehicle trip changes due to Spare the Air programs among the Spare the Air participants. Applying the results of this study with simple and less costly surveys developed by the research team, air districts will be able to adjust future self-reported vehicle trip reductions and extrapolate them to the entire regional population of drivers within an acceptable margin of error.

Executive Summary

Background and Objectives

The purpose of this research was to develop a simple, low cost, accurate method for quantifying the travel and emission impacts of episodic public education campaigns, or so-called Spare the Air or ozone action programs. Air districts implementing such programs, such as the Spare the Air programs in Northern and Central California, have evaluated driver awareness and reactions to public education efforts aimed at reducing driving on predicted air pollution exceedence days. While these evaluations are getting more rigorous, they often lack the detailed information necessary to accurately estimate travel and emission impacts.

Method

The research design developed to measure travel and emission impacts of these programs, and develop a corresponding quantification method, involved the surveying of drivers in the Sacramento area in 1999 and 2000. The design involved telephone surveys on the evening after a Spare the Air alert and on regular summer days (non-Spare the Air days) for the same respondents. The research design included two important sample populations: (1) a group of drivers who said they purposely reduce trips because of Spare the Air (STA reducers) and (2) a control group of drivers who did not respond to the STA message (non-reducers) to gauge "typical" travel behavior. The survey over-sampled the reducers via a set of screening questions to obtain a sufficient number of respondents and ensure the required accuracy. Both surveys were conducted on Spare the Air days and again on non-Spare the Air among the same respondents, created a paired sampling design.

The survey documented travel activities and then asked about awareness of the program at the end of the survey, so as to not tip the respondent as to the purpose of the survey. The research design assumed that respondents might not be as accurate in their response to a summary question about travel reduction in comparison to detailed questions about trip-making over the past 24 hours or by comparing Spare the Air day behavior to "normal" days. As a result of these potential differences, one or more correction factors were envisioned to adjust simpler survey responses based on the observed relationship between STA and non-STA day behavior and differences between methods for getting at travel behavior changes.

Results

<u>Self-reported vehicle trip reductions vs. Measured Trip reductions</u>

The study found a statistically significant difference between self-reported vehicle trip reductions and measured vehicle trip changes due to Spare the Air campaign among the STA reducers.

The Correction Factor

The development of a correction factor was a central part of this research effort to create a less expensive, more accurate survey methodology for use by air districts. The need for a correction factor resulted from the fact that STA reducers tended to over-report trip reduction in response to summary questions about changes in travel behavior. Trip activities data were collected on a STA day and a subsequent non-STA day for 134 STA reducers and the control group of 177 non-reducers. The trip activity data indicated that the reducers on average drove 0.44 trips less on the STA day while the control group drove 0.65 trips more. By comparing the trip changes between the STA reducers and the control group (non-reducers), the net average trip reduction due to the Spare-the-Air is 1.1 trips. This trip reduction was found to be statistically significant.

The correction factor was calculated by dividing the net trip reduction figure, 1.1, by 2.2, the number of trips STA reducers reported reducing in response a direct question. The resulting correction factor is 0.50. In future evaluations of STA-type program, this factor can be applied to adjust an estimate of self-reported trip reduction from a simple survey to a more accurate estimate close to that derived from more detailed and comprehensive surveys.

The Percentage of Drivers in the Population Who Are STA Reducers

Of the total Sacramento drivers surveyed (N = 3,982), 4.8 percent were found to be Spare the Air reducers. These were drivers who reported having reduced their driving in response to the Spare the Air program, or who reported having reduced their driving because of air quality and who had also heard, read, or seen Spare the Air advertising in the preceding two days.

Driver Characteristics That Differentiate STA Reducers And Non-Reducers

The research effort included a logistic regression analysis to identify the characteristics of STA reducers that differentiate them from non-STA reducers. The findings were the following: (1) survey respondents who report that their employer notifies them about poor air quality days are about 1.6 times more likely to report being STA reducers than are employees whose employer does not notify them of poor air quality days; (2) survey respondents who are female are about 1.6 times more likely to report being STA reducers than are males, and (3) survey respondents with three or more children under 18 are about one-quarter as likely to report being STA reducers as are respondents with no children under 18.

Travel Behavior on Non-Spare the Air Days

To assess whether the travel behavior changes observed in reducers and non-reducers on Spare the Air days was unique to Spare the Air, it was important to analysis their non-Spare the Air day travel behavior. The number of trips made on non-Spare the Air days

by reducers and non-reducers appear to be not significantly different (at the p. ≤ .05 level).

Conclusions

The research findings derived from this study were used to develop a simple, affordable, yet reliable methodology for measuring the impact of episodic public education campaigns. The method involves: (1) modifying or creating a survey of drivers, (2) estimating the proportion of drivers who reduce trips for air quality reasons in response to the campaigns, (3) estimating the average number of self-reported driving trips reduced from the survey, (4) revising this trip reduction estimate with the correction factor, (5) applying regional average trip lengths for work and non-work trips to the adjusted number of trips reduced for each type of trip, and (6) using standard emission factors to estimate the reduction of ozone precursors and other pollutants resulting from this reduction in driving trips and miles. The method also allows for program cost effectiveness to be assessed by dividing annual program costs by annual emission reductions.

1.0 Introduction

Episodic ozone action / ozone alert programs are becoming more popular in many non-attainment areas of California and the U.S. Called "Spare the Air" programs in Sacramento, the San Francisco Bay Area, and San Joaquin Valley, these programs have been in place for up to 10 years. Spare the Air programs alert residents of an air basin as to likely exceedences of the federal or state air quality standards for ground-level ozone, or smog. Residents are asked to curtail, reduce, or postpone contributory activities, including driving motor vehicles. The U.S. Environmental Protection Agency (EPA) allows regions to take credit for up to three percent of emission reductions needed for attainment of the air quality standard through such "voluntary" programs, as long as they quantify the actual emission reductions.

In response to requests from several California air districts, and with the assistance of EPA's Office of Mobile Sources, ARB commissioned this research project to develop a quantification method. The method is intended to provide an affordable yet accurate methodology for measuring the actual trip reduction that results from ozone action public education programs and translating those travel impacts into emission reductions. The method was developed using survey data of drivers in Sacramento and is intended for use by any air district or evaluator wishing to quantify the impacts of an ozone action program.

In simplest terms, the method is designed to measure whether drivers, upon hearing a message about reducing travel to clean the air, actually change their travel behavior. Changes in travel behavior, if captured accurately in terms of vehicle trip and vehicle miles of travel reduced, can be transformed into emission reductions motor vehicle emission factors for the vehicle classes (e.g. passenger vehicles) affected by the program.

The research was designed to explore several issues:

Do some residents drive less on Spare the Air days?

Do they do so in response to specific messages about driving less on Spare the Air days?

If they do drive less, how many fewer driver trips do they purposely take?

How accurately can travelers recount their travel behavior changes?

What type of travel do they reduce…travel to work or discretionary trips?

How can changes be quantified in a manner appropriate for credit in the context of an air quality plan or other effort designed to assess the effects of the program?

How can air districts conduct a low cost survey to determine the effects of their program?

In order to answer these questions, residents of Sacramento County were surveyed via telephone the evening following a Spare the Air alert. The Sacramento area was selected as the location for the research due its past experience with evaluating its ozone action public education program, its partnership in the research, and willingness to cooperate in data collection activities. Two types of surveys were used – one to "screen" respondents to find residents who had "purposely reduced" travel that day. Another survey, the so-called "standard" survey, was given to randomly selected drivers. Each survey was fielded on a Spare the Air night and then again a week or two later to collect information from the same individuals on their travel behavior on "normal" (non-Spare the Air) days. This paired response research design allowed the research team to compare Spare the Air and non-Spare the Air travel behavior and compare travel "reducers" to a control group of non-reducers.

As mentioned above, the purpose of the research was to develop an affordable, yet accurate method for quantifying impacts of public education programs. Air districts would likely not be able to field the size and complexity of the surveys used in this research. Thus, this study used a more complex research design and from it a method was developed that adjusts findings from simpler, less expensive surveys. This adjustment, or correction factor, was based on the relationship observed in this research between the more detailed travel behavior responses and more simple summary responses.

More specifically, the method developed from this research adjusts for the over-reporting of trip reduction in response to ozone action programs. Travel behavior research has shown that traveler tend to under-report the number of trips they take due to recall. This research found that travelers tend to over-report the number of trips they reduce in response to air quality messages. The method is designed to correct for this over-reporting of trip reduction.

1.1 Need for Program Quantification

Agencies need to quantify the impacts and benefits of ozone action programs for many reasons. These diverse reasons, discussed below, are placed in three categories—air quality, travel / congestion, and program management / justification.

1.1.1 Air Quality

Areas must quantify the emission impacts of ozone action programs to satisfy several different federal / state clean air requirements and policies if emission reduction benefits are taken for the program.

State Implementation Plans (SIPs)

The emission reductions of control measures included in SIPs must be quantified. States therefore need to quantify the emission reductions from ozone action programs if

including those programs in SIPs as control measures and claiming emission reduction credit toward attainment or milestones. This includes tracking progress toward meeting claimed emission reductions, which is the principle aim of the recommended method.

EPA's 1997 VMEP policy allowed—for the first time—SIP emission reduction credits for voluntary mobile source programs, such as ozone action programs (VMEP = Voluntary Mobile Source Emission Reduction Program). In order to get up-front SIP credits, the VMEP policy requires states to: submit voluntary programs as a SIP revision, provide realistic / quantified estimates of emission reductions, commit to evaluate the programs, and remedy emission reduction shortfalls in a timely manner.

Transportation Conformity

The emission reductions from ozone action programs must be quantified in the same manner as for SIPs (e.g., same methodology and any updates to participation levels or emission factors) if those programs are used in conformity demonstrations for transportation plans, programs, and projects. Transportation conformity is demonstrated when the projected emissions from plans / programs / projects pass quantitative tests.

Transportation Plans / Programs - The Clean Air Act (CAA) conformity provision requires the projected emissions of planned transportation plans / programs to be consistent with SIP vehicle emission budgets needed to demonstrate attainment. The emission reductions from ozone action programs need to be quantified if those programs are included in transportation plans / programs and relied upon to help demonstrate that the plans / programs conform by staying within SIP emission budgets.

Spare the Air impact calculations in ozone areas do not need to be made for proposed transportation projects. Currently the only required emission calculations associated with transportation projects are for carbon monoxide non-attainment or maintenance areas. At some point in the future a "hotspot" assessment for particulate matter will also be required. It is unlikely, in any case, that a STA program would affect a transportation project in a quantifiable way.

Ozone Flex Programs

The emission reductions from ozone action programs must be quantified by areas wanting to participate in EPA's Ozone Flex Program, announced in June 2001. Ozone Flex areas must commit to update / develop emission inventories, conduct air quality modeling / monitoring, and evaluate control strategies that reduce ozone-forming pollutants. The evaluation must quantify projected emission reductions from the local measures.

The Ozone Flex program applies to areas currently attaining the 1-hour ozone standard and wanting credit for voluntarily adopting local programs that reduce emissions in advance of EPA's non-attainment designations for the 8-hour ozone standard. "Early action" areas could realize such significant benefits as avoiding: violations of the 8-hour

standard, subsequent non-attainment designations, and the mandated requirements / controls that will accompany such designations. Bottom line: EPA is offering major incentives to comply with Ozone Flex requirements, which include quantifying the impacts of local measures.

State / local governments and EPA must develop and sign a memorandum of agreement (MOA) to participate in the Ozone Flex Program. The MOA describes the local control measures that communities intend to develop, evaluate quantitatively, and implement to reduce emissions in advance of air quality violations.

1.1.2 Travel / Congestion

Areas need to quantify the travel—as well as emission reduction—impacts of voluntary programs because the travel benefits, such as decreased congestion, have grown in importance. The relative importance of quantifying travel versus emission impacts increased when Congress amended the Clean Air Act to make Employee Commute Option (ECO) programs optional. Mandated commuter programs became voluntary—and more broadly viewed beyond their original / primary purpose of reducing emissions.

As public frustration with congestion has grown—and congestion continues to rank as the #1 or #2 public concern in many regional opinion surveys, agencies have increasingly justified / advocated voluntary programs as one way to do something about congestion. The success of voluntary programs—the ability to increase participation rates will depend in part on how well agencies can quantify / communicate the benefits of reducing congestion.

1.1.3 Program Management / Justification

Quantification of program impacts—whether emission or motor vehicle travel reductions—provides key information essential for managing and increasing the effectiveness of voluntary programs. Such information helps shed light on what measures, or combination of measures, are achieving emission reduction or congestion relief targets and on what measures are falling short. Quantified results can help improve program performance by allowing more informed decisions on where to target limited resources to produce the greatest "bang for the buck."

Quantified program impacts, more than other types of information, can play a major role in justifying the program. When provided such information, participants can better understand how their participation is helping to clean the air or reduce congestion. This information is needed for both types of participants—citizens changing their behavior and making sacrifices, as well as companies changing corporate behavior and spending resources to achieve program goals. Quantified information is also key for getting / maintaining the political support of elected officials.

1.2 Overview of Research Report

The remainder of this research report describes the existing Spare the Air programs, the survey findings, analysis and development of a set of correction factors, and quantification methodology that can be used by air districts to quantify and document the results of their programs.

- Section 2.0 describes the three existing Spare the Air programs in California and their experience with evaluating travel and emission impacts.

- Section 3.0 describes the research design, as originally conceived and then modified, the surveys, and the data collection process. Copies of the survey instruments used in the research are included in Appendix B.

- Section 4.0 summarizes the analysis of the survey data to develop the key indicators of the proportion of reducers and the average net trip reduction. It also summarizes the results of a regression analysis performed to assess which factors contributed greatest to trip reduction. A detailed description of the regression methodology and findings is provided in Appendix C.

- Section 5.0 provides a discussion of the implications of the research by describing the basic steps of the recommended method, suggests why the method is transferable to other regions, and provides two examples of the application of the method to Sacramento and San Francisco.

- Section 6.0 summarizes the research findings and implications.

- Section 7.0 recommends further research and provides some insights into the future of ozone action public education program.

Appendix A includes a stand-alone quantification methodology for use by air districts or other evaluators in measuring the emission reduction impacts of episodic public education programs.

2.0 Review of Spare the Air Programs and Evaluations

Ozone action programs have been a prevalent response to air quality problems in many U.S. urban areas. Some of the longest standing programs are located in California. Programs in Sacramento and the San Francisco Bay Area, date to the early 1990's. The air districts in Sacramento, the Bay Area, and the San Joaquin Valley all coordinate their efforts within a consistent campaign called "Spare the Air." The experience of these air districts and their Spare the Air programs, and their past evaluation and measurement efforts, provides a good background to the development of the methodology described in this report.

2.1 Sacramento

History – The Sacramento region has had an air quality general awareness campaign since 1989, under the auspices of the Cleaner Air Partnership (a coalition of the Sacramento Metropolitan Chamber of Commerce and the American Lung Association). In 1995, the Spare the Air campaign was initiated using federal Congestion Mitigation and Air Quality Improvement Program (CMAQ) funds. The Cleaner Air Partnership has conducted public opinion polls of residents and business on the topic of air quality since 1986.

The Sacramento Metropolitan Air Quality Management District (SMAQMD) developed the Spare the Air programs to include general awareness campaigns, a system to advise the region of a Spare the Air day, and an Employer Network. The budget for the Spare the Air program has ranged between $110,000 - $400,000 annually, some of which is funded through the CMAQ program.

In 1996, an employer component, called the Spare the Air Bucks program was initiated to provide a financial incentive to employees that used alternative commute modes during the summer ozone season. Using Measure A (sales tax revenue) funds, the Spare the Air Bucks program is implemented through area Transportation Management Associations (TMAs).

The SMAQMD has developed a highly regarded web-site that includes ozone alert information and so-called "ozone movies" that show Air Quality Index readings both spatially and temporally. Research conducted in the fall of 1999 by the Cleaner Air Partnership revealed that nearly one-third of the region's residents had seen ozone maps on TV or the internet.

The 1998 Spare the Air campaign was quite busy (as in the Bay Area and the San Joaquin Valley) due to the El Nino weather pattern. A total of 24 Spare the Air advisory days were called. The SMAQMD now uses the new federal 8-hour standard of 8 pphm to call a Spare the Air day. In 1998, there were 29 exceedances of the new standard and 13 exceedences of the one hour standard. The 1998 STA campaign included TV and radio

spots to educate the public on clean air actions and notification of the media and employer coordinators of Spare the Air days (alerts).

1999 and 2000 STA Programs – the research conducted as part of this study involved the collection of survey data during the 1999 and 2000 ozone summer seasons in Sacramento. Cooler summer temperatures and stronger breezes resulted in fewer exceedences during these two summers. The SMAQMD issued 12 Spare the Air advisories in 1999 and only six in 2000. The Spare the Air campaigns included slightly fewer TV and radio spots than in 1998, but more employers participated as Spare the Air partners. The total budget in 2000 was $140,000 and this included advertising, employer network coordination and incentives, web site maintenance, general promotions, and the regional evaluation (see below).

Evaluation Experience – Sacramento has regularly evaluated its Spare the Air campaign, via independent evaluations conducted by the Cleaner Air Partnership in 1995, 1996, 1998, 1999, and 2000 (and more recently in 2001). The evaluation approach and specific methodology evolved during that period based on lessons learned from previous assessments and new thinking at the state and federal level. Additionally, instrumented vehicle data and travel diary surveys were available from Sacramento from 1996 and 1997. This data, and a comparison to Spare the Air surveys, was part of the original research design, but was not incorporated into the modified design as discussed in Section 3.0.

The evolution of the Sacramento evaluation is of great interest to this research for changes in their methodology track the changes in thinking among ozone action program evaluators. The primary survey questions about changes in travel behavior due to Spare the Air messages or air quality concerns provide a good background on this evolution:

1995 - A random sample of 600 "drivers" was surveyed after two ozone episodes. In response to the question*:*

"In the past week, do you recall being asked not to drive because our area was experiencing a period of unhealthy air,"

Fifty-six percent of those surveyed after the first episode (a 3-day weekend) and 80 % of those surveyed after the second episode (5 weekdays) were aware of the message to curtail driving. Of those recalling this request, 53% said they reduced driving for both episodes. Among those who said they reduced driving, the question was asked:

"Last (days of week) how many round trips did you not drive that you normally would have driven."

These questions were later viewed as leading the respondent by providing the desired response within the question (do you remember being asked not to drive?).

The mean per day reduction was calculated in 1995 to be 1.27 round trips (2.5 one-way daily trips) for the weekend episode. The equivalent daily reduction of weekday trips was estimated to be about one round trip per day (2.0 one-way daily trips). (Lamare, 1995)

1996 - A survey of 954 residents in the four-county region after an August episode was conducted along with a season-end survey of 659 residents in October. The questioning provided for a detailed assessment of awareness and trip-making changes.

"In the past week, have you seen or heard anything about air pollution in our metropolitan area?"

"Do you recall at any time this summer, being asked not to drive because our area was experiencing a period of unhealthy air?"

"In response to this request not to drive, did you consider reducing your driving?"

"Did you actually reduce driving?"

"The last time you were asked to reduce your driving, were you able to reduce by:

- *One round trip*
- *More than one round trip*
- *None (or less than one round trip)"*

The survey also asked questions about how the trips were reduced (delay trip, take transit, carpool, etc.) and what type of trip (work trip) was reduced. These survey questions were less leading by walking the respondent through their decision-making process *after* hearing about Spare the Air.

The results of the episode survey revealed that 70% of all drivers in the region were aware of the request not to drive. Over a third of all drivers (39%), and over half of those aware of the message, reported actually reducing trips. Thirty-one percent of drivers were able to enumerate the number of trips reduced. Participating drivers estimated a daily average of 1.6 round trips (3.2 one-way trips) reduced during the episode in 1996. Almost three-quarters of those who reduced trips said they did so to "improve air quality." (Lamare, 1996)

1998 - The 1998 evaluation included the inclusion of "control" days to get at "normal" travel behavior. A total of 1,870 surveys were conducted during the summer on 11 Spare the Air days and 13 "matched" non-Spare the Air days. Matching involved selecting non-Spare the Air days that were the same type of day in term of weekday vs. weekend and temperature. Unfortunately, it was impossible to find 100+ degree days that were not also Spare the Air days.

The 1998 survey was not as extensive as the 1996 instrument. Questions include:

"In the past (x) days, did you drive a car, truck or van less frequently than you usually do?

Instead of driving, did you (responses same as 1996)…?

And why did you make that change?

About how many round trips in your car did you avoid driving to reduce smog in the past (x) days?

In the past day or two, do you recall being asked to reduce the amount of driving you do because our area has been experiencing a period of unhealthy air?"

This survey represents a key change in the line of questioning by placing the inquiry of Spare the Air awareness at the end of the survey so as not to prompt an answer related to travel behavior changes.

Among respondents to the 11 post-episode surveys, 55% of respondents were aware that a Spare the Air day had been called. Twenty-two percent of drivers reported reducing driving on Spare the Air days. Some 7.6% of drivers reduced trips for air quality reasons. The average daily number of round trips reduced was estimated to be 1.55 (3.1 one-way trips) in 1998. (Lamare, 1998)

1999 – An evaluation was conducted by the Cleaner Air Partnership on behalf of the SMAQMD in 1999 and 2000, concurrent with the surveys conducted as part of this research. The survey questions were standardized in 1999 and have been consistent since to avoid instrumentation biases. The current survey asks the string of questions in the following manner:

"Thinking about yesterday, how many different TIMES did you get into a car?

Yesterday, did you drive your car, truck or van the same, more, or less frequently than you normally do on a (day of the week)?

What did you do instead of driving?

Why did you make that change or those changes?

About how many ROUND TRIPS in your car did you avoid driving yesterday to reduce air pollution?"

This questionnaire also ends with inquiries about recall of Spare the Air messages. Thus, the survey attempts to establish the proportion of reducers among the population of drivers, the trip reduction among those reducers, and the nature of and reasons for trip reduction. The survey also includes control days to gather information from a random sample of drivers to establish travel behavior (including reductions for air quality reasons) on non-Spare the Air days.

The 1999 evaluation revealed that the proportion of drivers who drove less for air quality reasons on Spare the Air days was about 4% and the average number of one-way trips reduced was 5 car trips. The evaluation then equated that 2 tons of ozone precursors (ROG and NOx together) per day were eliminated on Spare the Air days. If the trip reduction measured on control days (due to general air quality reasons as opposed to direct STA appeals) is subtracted from this result (estimated to be about 0.4 tons of ozone precursors per day), the net emission reduction was estimated to be 1.6 tons of ozone precursors. (Lamare, 1999)

2000 – In 2000, using the same questions, the proportion of reducers among drivers was estimated to be 2.2% and the average self-reported trip reduction among these reducers was 4 one-way trips. This resulted in an emission reduction of 1.04 tons of ozone precursors, or 0.74 tons after controlling for trip reduction on non-Spare the Air days. The evaluation postulated a less conservative approach which estimated that drivers, on average, took 0.45 more trips on non-STA days. So it could be said that Spare the Air resulted in 0.45 fewer trips when applied to the population of drivers in Sacramento or 4.68 tons of ozone precursors. The 2000 Sacramento evaluation also assessed cost effectiveness. It looked at the total program cost for the Spare the Air summer season ($140,000), the number of STA days (6), the estimated emission reduction (0.74 tons of NOx and ROG per day - and estimated the cost per ton reduced of $33,000 per ton reduced per day. (Holobow, 2000)

The key evaluation results, for the period 1998 –2000 are compared in Table 2.1:

Table 2.1

Results of Sacramento Spare the Air Annual Evaluations

Year	% Reducers	Average trip reduction	ROG Reduction
1998	7.6% of drivers	3.1 one-way trips	3.80 tons/day
1999	4.0% of drivers	5.0 one-way trips	1.60 tons/day
2000	2.2% of drivers	4.0 one-way trips	0.74 – 4.68 tons/day

2.2 Bay Area

History and Program Background - The Bay Area Air Quality Management District (BAAQMD), which serves the nine-county San Francisco Bay Area, began its summertime Spare the Air program in 1991. While wintertime seasonal pollution reduction programs existed in other regions, BAAQMD was one of the first air districts to target summertime ground-level ozone formation through a voluntary public education program.

At its inception, the goal of BAAQMD's Spare the Air campaign was to educate the public about actions they could take to personally improve air quality on days when air

quality was expected to be poor. The current objectives for the Spare the Air program include:

- Increase public awareness about how their behavior can improve air quality.
- Encourage Bay Area residents to change their behavior in order to reduce pollution levels.
- Forecast and alert the public of potentially unhealthy air quality events.
- In the long term, reduce the number of ozone action days in the Bay Area and improve overall air quality.

The campaign's origins trace back to a 1990 regional household survey, in which 66% of respondents said they had never heard of anything they could personally do to help improve air quality. At the same time, an episodic control program was included in the BAAQMD's 1991 Clean Air Plan as a voluntary program. The Spare the Air program was included in the 1991, 1994, and 1997 Bay Area Clean Air Plans as a Transportation Control Measure, but with no emission benefits attributed to the program.

The Bay Area Spare the Air program is similar to that implemented in Sacramento. An advertising campaign is conducted via radio and TV throughout the summer ozone season and Spare the Air days are called when the region forecasts conditions suggesting an exceedence of the federal air quality ozone standard. Employers are notified via a STA partner network and individuals can receive e-mail alerts. The Bay Area program also includes a Youth Outreach element to educate school age children and a winter Spare the Air campaign, focus mainly on wood smoke and particulate matter.

During the period of this research, 1999 – 2000, the Bay Area experienced similar climatic conditions as that in the Sacramento area, two cool summers. In fact, the BAAQMD called six Spare the Air alerts (the same number as in Sacramento) in 2000.

Evaluation Experience

The Bay Area has also conducted several evaluations of their Spare the Air program using independent contractors.

1996 – The BAAQMD contracted with RIDES for Bay Area Commuters to evaluate the public's awareness and understanding of the 1996 Spare the Air Campaign as well as behavior change resulting from air quality concerns. RIDES conducted two random telephone surveys of the general population on the evenings of two Spare the Air days. Both of these Spare the Air days occurred at the end of several-day episodes.

The survey asked the following questions to gauge behavior change:

"In the past 2 days, did you drive your car or truck less frequently than you normally do?

Did you know that today was a Spare the Air day?"

The BAAQMD survey did not attempt to estimate the number of trips reduced as a result of the campaign, but did ask the questions about knowledge of the public education program at the end of the survey. It estimated the number of people who drove less, used consumer products less, or used garden equipment less and knew it was a Spare the Air day (not equally comparable to the proportion of reducers for air quality reasons among drivers). Those who drove less, used consumer products less or used garden equipment less for air quality related reasons *and* who knew it was a Spare the Air day ranged from 2.7% to 6.6% of all respondents on the two episode days in which surveying was conducted.

Using the results found in the RIDES study, the BAAQMD estimated the emissions reductions associated with the Spare the Air campaign. The BAAQMD used the data to determine the range of emissions reductions associated with Spare the Air. To estimate the benefits of the Spare the Air program, the BAAQMD used the percent of the population that changed their behavior because of air quality related reasons and knew it was a Spare the Air day. All people who gave air quality related reasons for changing their behavior plus half the people who gave both air quality and other reasons for changing their behavior were included. The average number of trips reduced due to Spare the Air was assumed to be a round trip, or two one-way car trips.

In sum, the BAAQMD found a 0.35 to 1.25 tons per Spare the Air day reduction for ROG and a 0.07 to 0.99 ton per Spare the Air day reduction of NOx (including reductions from consumer products). (RIDES, 1997)

1998 - BAAQMD contracted with ICF Consulting to conduct the 1998 - 2001 evaluation studies. ICF conducted random telephone surveys of the general population to obtain an unbiased measure of Spare the Air recognition and participation. ICF also collected data from non-random, self-selected Spare the Air participants who were registered for Spare the Air information and alerts. This latter data collection effort was intended to better understand behavior change of those in the Employer Spare the Air program or who support Spare the Air. (ICF, 1998)

Four survey methods were used to assess participation in the 1998 Spare the Air (STA) Program:

- A telephone survey of 400 randomly selected residents on two STA evenings
- A survey posted on the District's website
- An e-mail survey sent to those receiving e-mail STA notices
- A hard copy survey for employees at partner employers without access to e-mail

To measure behavior change that occurred because it was a Spare the Air day, all four data collection methods included questions to set up a 3-level test. The respondent must have (1) known it was a Spare the Air day; (2) reduced emission-producing activity on that day; and (3) changed his/her behavior in response to the Spare the Air program.

The questions asked to set up the test were:

"Did you drive your automobile more frequently, less frequently, or the same as you usually do?

Did you use consumer products more frequently, less frequently, or the same as you usually do?

Did you use gas-powered garden tools more frequently, less frequently, or the same as you usually do?

Why did you make that change? (asked as follow-up questions to above questions)

Did you know that today was a Spare the Air day?"

Based on the results of the 1998 general public survey, the BAAQMD estimated the emissions reduced from Spare the Air. Using the survey findings that 38% of Bay Area residents were aware of the Spare the Air day and 6% of these respondents (or about 2% of all drivers) said they reduced trips, the BAAQMD assumed one trip reduced per day and used a trip length of 11.52 miles for commute trips and 5.37 miles for non-work trips for the purposes of estimating VMT reduction. From this, a reduction of 2.03 tons of ROG and 2.1 tons per day of NOx were estimated.

1999 and 2000 - ICF Consulting also conducted evaluations in 1999 and 2000, at the same time this research was ongoing. The same questionnaire was used in both years and represented an expanded instrument from that used in 1998. Regarding travel behavior changes, the survey defined "normal" or "usual" travel patterns as that occurring four or more days per week. The survey also asked for an estimate of the length and type of trip reduced.

Comparing 1998 – 2000 findings for one key indicator, the proportion of drivers who reduced trips did so for air quality reasons, and knew it was a Spare the Air day, the equivalent comparison is 2.1% in 1998, 1.4% in 1999 and 4.4% in 2000. (ICF, 2000)

2.3 San Joaquin Valley

The San Joaquin Valley first implemented its formal Spare the Air campaign in 1996. That year, employers were asked to participate in what heretofore had been a more general outreach campaign on consumer products and travel behavior. While the Spare the Air campaign is focused on ozone episodes, particulate matter is of concern in the valley as well. Another issue for the San Joaquin Valley is real and perceived inter-

regional air pollution transport issues. Further confusing the issue, commuters that work in the Bay Area and Sacramento may commute from the San Joaquin Valley. Residents of the Valley may also get Bay Area and Sacramento area TV and radio stations and, therefore, get information on Spare the Air alerts from those areas. All this underscores the need for close coordination between the three programs.

In 1997, 533 employers participated as Spare the Air partners. In 1998, this number exceeded 700 partners. Employers are provided with a toolkit of information, including instructions and materials for posting ozone alerts and recommended strategies for reducing emissions. These strategies include the provision of on-site services to reduce the need for travel, clean fleet vehicles, clean industrial practices, and other messages to get out to employees (such as postponing lawn care). Free program materials are made available to partner employers. Prior to 1999, the San Joaquin Valley had not conducted a general population survey to assess awareness and travel impacts.

2.4 Conclusion from Past Evaluations

For the past 5-7 years, evaluations of the Spare the Air programs have included special surveys or questions in broader surveys to ascertain whether people heard the message about reducing their driving on Spare the Air days, whether they in fact responded by driving less, and, if so, to measure the amount of travel reduced.

Improvements have been made over the years to reduce potential biases and increase the accuracy of the surveys. For example, earliest surveys asked about recognition of Spare the Air and the driving reduction message before asking if they reduced trips (in essence, telling the respondent the answer before asking the question). Later surveys opened with questions about trip making and ended with program recognition. As of 2000, Sacramento surveys asked if respondents traveled *less than usual*, while the Bay Area surveys asked whether they traveled *more frequently, less frequently, or about the same as usual.*

Trip reduction has been based on self-reported recall of changes in travel behavior. By asking what the change involved (new mode, linking trips, postponing travel) this enabled an estimate of vehicle trip reduction. The surveys also asked *why did they make the change* in an attempt to get at causality. The Sacramento survey asked the respondent directly for a self-estimate of trips reduced. The San Francisco evaluation process assumed the number of trips reduced.

Researchers (ICF and the Cleaner Air Partnership) have noted the limited budget for the annual evaluations, affecting both sample size and survey length. This is an important issue because the method developed by this project needs to be replicable under “normal” circumstances, which seems to be a limited budget for evaluation.

Overall, some lessons learned from the review of past evaluations in Sacramento and the Bay Area include:

- Early surveys did not include data on travel behavior change and were therefore insufficient to estimate emission reductions.

- These surveys did not include sufficient demographic questions.

- These questions designed to collect data on changes in behavior were still "leading" questions that could bias responses.

- The questions designed to collect data on behavior ask respondents to compare their behavior to what they "normally " or "usually do." Not only is it very difficult for respondents to know what they "usually do," in many cases, respondents do not have a "usual" routine, which creates a great deal of ambiguity to responses to this question.

- Along the same lines, survey experts have concluded that people do not accurately recall the number of trips they take in a given day.

- The questions that probe respondents on why they drove less (or used consumer products, etc. less) are asking about activities that were *not* undertaken. It is difficult for some people to accurately provide information on things they did not do.

- People were asked whether they drove, etc., less for air quality related reasons, other reasons, or a combination of the two. For those who chose "both air quality and other" reasons, there is no way to separate the impact of the two influences.

- Questions designed to capture a causality link between knowing it was a Spare the Air day and changing behavior were limited and were leading. Causality involves determining "cause" and "effect" to assess whether the measured behavior was due to the program or due to other factors. This was improved by asking travel questions first and program awareness questions last.

- The lack of accurate data on trip-making changes has forced the region to use simplifying assumptions that may lead to inaccurate estimates of emission benefits. In the Bay Area, the average number of trips reduced is assumed to average one daily vehicle round trip. In Sacramento, the average trip reduction per respondent was applied to all residents resulting in very large regional trip and emission reductions in 1996, although the 1998 - 2000 estimates were far more conservative.

- The random digit dial telephone survey in both regions was representative of the population "exposed" to Spare the Air and the results are generalizable.

- The employer/employee reporting processes in both regions is highly self-selected and biased in that only motivated participants (Bay Area) or those receiving incentives (Sacramento) report travel behavior changes. These results may be over-reported and were generally not included in regional emission reduction estimates.

- Baseline surveys or panel surveys were not conducted, thus requiring the use of retrospective questions gauged against "usual" behavior.

- The general public survey sample size in the Bay Area was based on the expected proportion of respondents who said they reduced trips, not on the expected magnitude of that change. In Sacramento, sample size was determined by the ability to get county-level results for awareness and for the proportion of respondents who said they reduced trips. More to the point, the sample sizes were budget-constrained in both regions, limiting the accuracy of the surveys for picking up very small changes in trip-making behavior.

These lessons, and the evolution of the survey instruments and evaluation methods in Sacramento and the Bay Area were very useful in crafting the ultimate research design developed for this research. The research design is discussed in detail in Section 3.0.

3.0 Methods

This chapter describes the methods used to (1) design the surveys; (2) collect the data; and (3) derive a correction factor for use in other air districts. The original research plan was altered due to unexpected issues associated with the data. Section 3.1 briefly described the method used; Section 3.2 describes the original research design; Section 3.3 reviews the alternative research approaches tested; and Section 3.4 describes the modifications to and adopted research design.

3.1 Summary of Method Applied

Telephone surveys were developed to collect travel data and other information necessary to help evaluate the impact of the Spare the Air program in Sacramento. One survey instrument was aimed at all drivers (called the "standard" survey') and a second survey instrument was developed to "screen" for drivers who purposely reduced driver trips to help air quality and in response to the Spare the Air ozone alerts. Both instruments were conducted using a random digit dialing sample from phone exchanges that service the Sacramento area. The screening survey was used to strategically over-sample for individuals likely to be Spare the Air reducers.

The sample employed a staggered panel design in which respondents were interviewed first on a Spare the Air day and again one or more weeks later on a day that was not a Spare the Air day. The screener, standard, and follow-up survey instruments are included in Appendix B.

The method yielded trip activity and demographic information of Spare the Air reducers and non- Reducers. The survey was conducted over the 1999-2000 summer ozone seasons.

3.2 Original Research Design

The original research design as requested by ARB for this study consisted of four main elements.

1. Review and Analyze Previous Diary and Instrumented Vehicle Studies
2. Replicate the ARB-Caltrans Trip Diary Study
3. Design and Implement a "Less Expensive" Survey of Drivers
4. Design and Implement a "Less Expensive" Survey of Employees

Although each element could stand alone as a research study, the original design sought to integrate the analyses and findings of each element to identify the limitations of

various methods of estimating the impacts of Spare the Air campaigns on trip behavior, develop correction factors to adjust for measurement error and biases associated with different data collection methods, and to devise a 'less expensive method' of quantifying the impacts that may be used by air quality management districts in the future. The following paragraphs briefly describe the purpose and tasks associated with each element.

3.2.1 Review and Analyze Previous Diary and Instrumented Vehicle Studies

The first research element involved reviewing two related studies conducted in the Sacramento area – one using instrumented vehicles to track actual trip behavior and a second trip diary/telephone survey of the drivers of the instrumented vehicles regarding their trip activity. The main purpose of the analysis was to identify how the trip activity reported in the diaries differed from the actual trip behavior as recorded by the data loggers in the instrumented vehicles. The data from both studies was to be used to develop a correction factor that would adjust for the reporting biases thought to be present in trip diary studies. A secondary purpose was to evaluate trip activity differences between Spare the Air days and non-Spare the Air days, using both the diary data and the instrumented vehicle data.

3.2.2 'Replicate' the ARB-Caltrans Trip Diary Study

One of the more common data collection methods for trip behavior studies are travel diaries. The advantage of using a diary is that researchers can often collect more detailed trip information than can be collected using traditional telephone survey methodologies. Because drivers are asked to fill-out trip diaries as they make trips, it has also been suggested that trip diaries may provide more accurate data on trip behavior than that recorded through telephone surveys that rely on recall of trip behavior. In this element, the team was to replicate a stream-lined version of the travel diaries previously employed by ARB and Caltrans and have participants record their trip behavior on a Spare the Air day as well as a non-Spare the Air day. This element served two purposes. First, because the panel of individuals participating in the diary study would be similar to those participating in the telephone surveys, and the studies would be conducted simultaneously, the travel diaries would provide data on trip behavior that could be meaningfully compared (in the aggregate) with the data collected through the telephone survey. This would enable the team to develop a correction factor to adjust for the difference in reported trip behavior between the telephone survey and the diary. Second, the diary would provide a link to the first research element, thereby allowing the team to link the correction factors developed in both elements. Together, the correction factors would enable the team to estimate how reported trip behavior varies from actual trip behavior for both types of data collection methodologies – travel diaries and telephone surveys.

3.2.3 Design and Implement a Survey of Drivers

As noted previously, the primary goal of the project was to develop a cost-effective way of collecting the data necessary to determine whether Spare the Air campaigns are having

an effect on travel behavior. Rather than continue to rely on travel diaries, the challenge was to design a survey instrument that could be used to measure trip behavior and estimate the impacts of Spare the Air campaigns on trip behavior. Having designed the survey instrument, the team was to use random digit dialing sampling methods to recruit a panel of 600 participants to be interviewed on a Spare the Air day as well as a non-Spare the Air day. The reported trip data would then be analyzed to determine if a systematic difference in trip behavior (be it number of trips, mode choice, etc.) existed between Spare the Air and non-Spare the Air Days.

3.2.4 Design and Implement a Survey of Employees

The fourth element of the original study plan involved recruiting a panel of employees who work for companies that participate in the partner Spare the Air program to participate in a survey similar to that described above for drivers. The intent of this element was to estimate whether the trip behavior of employees is influenced by the participation of the employer in the Spare the Air program. As with the driver study, the data for the employer study was to be analyzed to determine if a systematic difference in trip behavior (be it number of trips, mode choice, etc.) existed between Spare the Air and non-Spare the Air Days.

3.3 Modified Research Design Options

Prior to implementing the final three elements of the original research design, the team expected to make adjustments to the design based on the results of the first element – review and analysis of the previous travel diary/instrumented vehicle data. The impact of this analysis, combined with the results of several pre-tests of the driver and employer survey, prompted several important changes to the research design that are described in greater detail in the next section of this report. The purpose of the following paragraphs is to describe the various approaches that were tested, as well as the key findings that prompted the revisions to the original research design.

3.3.1 Review and Analyze Previous Diary and Instrumented Vehicle Studies

The analysis of the trip diary and instrumented vehicle data previously collected by other studies in the Sacramento area was unfortunately complicated by data quality and integrity issues. After much effort analyzing the data from the instrumented vehicle studies and the diaries, the team determined that the quality of the instrumented vehicle data was compromised to a point that a meaningful comparison of the instrumented vehicle data and travel diary data could not be conducted. Without a reliable measure of actual trip behavior for the travel diary participants that was to be gathered via the data loggers, the team was unable to determine if the trip behavior as reported in the travel diaries contained systematic measurement error and, if so, the magnitude and direction of the measurement error. Accordingly, the team was thus unable to estimate a correction factor to adjust for measurement error, assuming it existed.

The analysis of the trip diary and instrumented vehicle data, as well as prior studies regarding the impacts of Spare the Air campaigns on trip behavior, suggested that (A) individuals vary their trip behavior day-to-day, (B) Spare the Air campaigns may influence a relatively small percentage of drivers (i.e., 2-5%), and (C) the actual trip reduction behavior exhibited by those influenced by the campaign may be modest.

The possibility of having small 'effect sizes' due to Spare the Air campaigns, combined with substantial variability in trip behavior for the same individuals over time, prompted the team to revisit the overall research design. The primary concern was that small 'effect sizes' and substantial 'natural' variability in trip behavior meant that, *ceteris paribus*, the sample sizes needed to detect the possible effects of the Spare the Air campaign would have to be substantially larger than originally proposed. Because the budget for the project would not support the larger sample sizes for each of the three remaining elements of the original design (travel diary, driver telephone survey, and employer survey), the team considered several options for revising the original research design to still meeting the core objectives of the study while remaining within the allotted budget.

Another major issue involved separating the trip changes caused by other factors from those caused by Spare the Air programs. Many factors other than the Spare the Air public education program can affect variability of trip making on both Spare the Air days and non-Spare the Air days. Simply comparing the trip making between Spare the Air days and non-Spare the Air days among all drivers would not preclude the trip changes that were caused by other non-Spare-the Air factors. But comparing the trip changes between STA reducers and non-reducers would significantly increase the probability of detecting the Spare-the-Air impacts on trip making. This assumed that STA reducers' driving activities were similar to the non-reducers on the days that a Spare the Air ozone alert was not called. And indeed, the data indicated the mean trips of STA reducers on non-Spare-the-Air days were not statistically different from that of the non-reducers.

The first change was to remove the travel diary element from the design and devote the budget allotted to this task to expanding the sample sizes for the driver survey elements. Although this change precluded a direct comparison between the diary and simple telephone survey results – and thus precluded the development of a correction factor from this data – it was necessary because the sample size needed to measure relatively modest changes in Spare the Air travel behavior would have been cost-prohibitive to get a set of statistically significant changes. To compensate for this, the team decided to use a telephone survey instrument that is similar to a trip diary to gather detailed trip activities.

A second change was to include a question asking respondents directly about their trip reduction behavior. Individuals would be asked if they 'purposely reduced' their driving and, if so, why they did so. This direct trip reduction question is simple and can be easily incorporated into the recommended survey method for future air district use.

3.3.2 Pre-Tests

A final change to the original design was also entertained (and tested) at the pre-test stage – strategically over-sampling for people who indicated that they 'purposely reduced' the amount of driving they did. Because people who responded to the campaign (reducers) were thought to represent a small percentage of the driver population (2-5%), a proportional sampling method would produce very limited numbers of reducers even with large sample sizes. To be able to better estimate the trip behavior of reducers, it was decided that strategically over-sampling for 'reducers' should be tested to determine if it would be a more efficient and cost-effective method of obtaining interviews with reducers.

Four approaches were thus tested at the pre-test phase of the study:

1. A "standard" survey that included a direct measure of whether a respondent 'purposely reduced' their driving behavior.

2. A "screener" survey that asked the 'purposely reduced' question toward the beginning of the instrument to identify and filter for potential 'reducers'.

3. An employer/employee protocol for surveying through Spare the Air partner employers.

4. An employer screening protocol that would allow for the identification of Spare the Air partner employees via a general population telephone survey.

The following are the summaries from the pre-tests conducted.

<u>Pre-test of Standard Survey of Drivers</u>

Dates: July 19 & 21, 1999 (non Spare the Air days)

Protocol: To assess the standard survey instrument and interviewing protocol and determine if any substantive changes to the interviewer instructions, question language or instrument layout are needed.

Sample & Interviewing: A sample of respondents from the Sacramento area was drawn from a phone directory. The interviews were conducted between 6 PM and 9:30 PM.

Results: A total of 39 respondents were interviewed:

- Four reported no driver in the household
- Four broke off during the interview
- 31 completed the interview in full

- Of the seven that reported that they reduced their driving, two later reported no reduced trips (they were mistaken or confused)
- The average number of trips overall was 4.1
- Among those that reported actual trips reduced, the average number of trips taken was higher at 5.43
- Among those that reported actual trips reduced, the average number of trips reduced was 2.8
- Twenty-nine percent indicated that they had heard advertisements relating to poor air quality and driving in the past two days.
- The average number of motor vehicles, in working order, per household was 2.13
- One out of the 23 respondents who are actively employed indicated that their employer makes them aware of poor air quality days.
- One out of the 23 respondents who are actively employed indicated that their employer encourages them to drive less, car pool or use public transportation on poor air quality days.
- Of the 31 completes, 26 agreed to be interviewed a second time
- Of the five respondents that reported actual trips reduced, none indicated that they did so due to Spare the Air (note: the interviews took place on non-Spare the Air days)
- There were no problems with the language of the questions, interviewer instructions or layout of the instrument

Implications: Overall, the instrument worked well for interviewers as well as respondents. Respondents seemed to understand the point of the questions and were willing to provide meaningful answers. The average interview lasted 14 minutes and cost $23.42. Please refer to the screener survey pre-test description for a more detailed discussion.

<u>Pre-test of Screener Survey of Drivers</u>

Date: July 13, 1999 (Spare the Air day)

Protocol: To test the feasibility of screening for, identifying and over-sampling individuals who report that they purposely reduced their driving on a Spare the Air day. Also, to assess the questionnaire and determine if any substantive changes to the interviewer instructions, question language or instrument layout are needed.

Sample & Interviewing: A sample of respondents from the Sacramento area was drawn from a phone directory. The interviews were conducted between 6 PM and 9:30 PM.

Results: A total of 226 respondents were interviewed:

- 140 reported that they did not purposely decrease their driving.
- 23 reported that no driver was in the household at the time.
- 14 reported that they decreased their driving, but later indicated that they did not when asked about the trips they decreased.
- 9 'broke off' part way through the interview.
- 40 reported that they purposely decreased their driving.
- The average number of trips taken overall was 2.8.
- Of the 40 that reported a decrease in driving, six reported that they did so due to Spare the Air or that they did so due to 'poor air quality' and were aware of Spare the Air advertisements in the past two days.
- Average trip reduction for all individuals who reported reducing trips was 1.875 trips.
- Average trip reduction for those individuals who reported that they reduced trips due to Spare the Air was 2.17 trips.
- Sixty-eight percent of respondents indicated that they had heard advertisements relating to poor air quality and driving during the past two days.
- The average number of motor vehicles, in working order, per household was 2.25
- Five out of the 28 respondents who are actively employed reported that their employer makes them aware of poor air quality days.
- Nine out of the 28 respondents who are actively employed reported that their employer encourages them to drive less, car pool or use public transportation on poor air quality days.
- All six of the respondents who reported that they reduced their driving due to Spare the Air agreed to be interviewed a second time.

Implications: The results indicated that of those individuals who were contacted, were drivers, and agreed to participate in the study (203 individuals), approximately 20 percent reported that they purposely decreased their driving on the day of the interview and approximately three percent reported that they decreased their driving due to Spare the Air advertisements. Thus, approximately 15 percent of the individuals who reported reducing their driving also indicated that they did so due to Spare the Air advertisements.

The benefit of employing the 'purposely reduce' screener to identify and over-sample individuals who report that they reduced their driving was that the collective sample will have a higher concentration of individuals who reduce trips due to Spare the Air advertising than would occur if the screener is not employed. All other things being equal, by increasing the number of respondents in the sample who engage in trip reduction due to Spare the Air advertising, one would increase the probability that the

regression analysis will be able to detect statistically significant effects due to the Spare the Air campaign.

However, all other things were not equal in this case. One must also consider the substantial costs associated with screening out a large percentage (80%) of otherwise viable respondents who do not engage in trip reduction, as well as the costs associated with interviewing some respondents once and then not inviting them back for a second interview because they did not cite Spare the Air as a reason for reducing their driving. If one factors the cost per completed survey based on the number of respondents who are invited back for a second interview, there is a large difference between using the screener ($342.83) and not using the screener ($23.42). This cost differential meant that by using the screener to over-sample for individuals who report that they reduced their trips due to Spare the Air advertising, the number of total completed paired interviews supported by the budget would be reduced substantially. Although this is a rough estimate, for every one respondent interviewed using the screener version of the survey, 15 respondents could be interviewed using the standard survey.

In sum, although using the screener survey increased the number of respondents in the sample who engaged in trip reduction due to Spare the Air advertising – which, all other things being equal, would increase the probability that the regression analysis will be able to detect statistically significant effects due to the Spare the Air campaign assuming they exist – it would also substantially reduce the ultimate size of the sample – combined sample size of reducers and non-reducers. This may also have the effect of decreasing the probability of detecting statistically significant effects due to the Spare the Air campaign. The question, therefore, is which approach is ultimately the most cost-effective way of estimating trip reduction due to Spare the Air advertising – using the screener survey for a portion of the interviews or conducting all interviews using the survey without the screener?

Of course, this dilemma applied only to the first approach to estimating trip reduction by comparing trip behavior on Spare the Air and non-Spare the airs days in the aggregate. But the aggregate trip changes for all drivers not only reflected the changes due to the Spare the Air campaign but also many other factors. Furthermore, because the original design was to be modified to include a second method of measuring trip reduction by self-reported ‘purposely reduced trips’ – and this method would clearly benefit from strategically over-sampling for Spare the Air reducers. After calculating the sample requirement based on the pre-test result, it was estimated that about 120 STA reducers maybe required to detect statistically significant effects. It was obvious that survey without screening would not get a sufficient number of reducers within the budget.

Therefore the team recommended employing the strategic over-sample using the screener survey.

Pre-test of Employer/Employee Protocol

Dates: June 23 – 29, 1999 (initial phone calls)
July 1 – 9, 1999 (follow-up)

Protocol: To test the ability to randomly survey employees at randomly selected partner employers.

Results: A list of Spare the Air employer partners and worksite coordinators was obtained from the outreach contractor to the BAAQMD.

From 1,134 worksites, 101 were randomly selected to be contacted.

Of the 101 contacts, 9 were non-working phone numbers and 36 did not return the original inquiry phone call.

56 worksites were contacted and sent via fax a one-page summary of the survey requirements, endorsed by the BAAQMD.

All 56 worksites were re-contacted to inquire if they would consider participating in the survey and meet with a project representative to draw the employee sample and acquire phone numbers.

- 2 organizations (the Cities of Belmont and San Francisco) agreed to participate in the survey and meet with us to select employees.
- 4 organizations said they would seek approval from upper management and call back.
- 19 coordinators declined participation (including a ridesharing organization), mostly citing too much time and hassle required.
- 31 coordinators would not return our follow-up phone calls.

Implications: 101 inquiries resulted in only two public employers agreeing to participate. This cost approximately $4,000 to accomplish. Given the cost and inability to solicit participation among private employers and more worksites, this cannot be viewed as a cost effective means for determining employer effects.

Pre-test of Employer Screener

Date: July 7, 1999

Protocol: To test the willingness of respondents to state the name of their employer when asked in a screener question and assess the integrity of their responses.

Sample & Interviewing: A sample of respondents from San Francisco and Oakland was drawn from phone directories for each area. The interviews were conducted between 6 PM and 9:30 PM.

Results: A total of 100 respondents who are drivers were interviewed:

- 20 reported being unemployed
- 15 reported being retired
- 35 refused to provide the name of their employer
- 30 provided employer information

Implications: The results indicate that a high percentage of respondents were simply unwilling to provide their employers name. Although only 35 percent outright refused, the results suggest that a large number of respondents provided what is known as a 'soft refusal' by falsely stating that they are 'unemployed'. The Bay Area unemployment rate is approximately four percent, not 20 percent.

The results of this pre-test thus indicate that approximately 4.5 percent of respondents contacted using the screener will A) agree to provide a name AND B) work for a Spare the Air Employer. Based on the results of the pre-test, the cost of screening for and identifying these individuals is approximately $134.44 per individual, not including the costs associated with completing the remainder of the interview. Moreover, due to the length of the survey and respondent fatigue, only a portion of these individuals will be willing to complete two interviews. The pre-test results thus indicate that using the employer screener to identify and/or over-sample employees of Spare the Air Partner Employers is not a cost-effective course of action.

3.4 Modified Research Design (as adopted)

The results of the pre-tests, combined with the limited budget for the study, prompted the team to modify the original research design in the following ways:

1. The travel diary element was eliminated to provide a larger data collection budget for the screener and standard surveying elements.

2. The difficulty of completing employee surveys – via working through employers or using a general population survey and screening to find individuals who work for partner employers – suggested that attempting to isolate the effects of partner employer activities on trip behavior would be cost prohibitive. This element was also eliminated from the design.

3. A direct question regarding whether a respondent 'purposely reduced' their driving was added to the survey instruments. This question would be used to generate a *self-reported trip reduction* estimate.

4. The driver survey was conducted using both a standard version and a screening version, each drawing upon separate random digit dial (RDD) samples drawn from phone exchanges that service the Sacramento area. The screening version was used to strategically over-sample for individuals who were likely to be Spare the Air reducers.

The following sections describe in more detail the methods and protocols employed for the screener and standard surveys of drivers.

3.4.1 Sampling Design

The survey sample employed a staggered panel design in which respondents were interviewed first on a Spare the Air day, and again several weeks later on a day that was *not* a Spare the Air day. It was critical to have two interviews per respondent, as the goal was to identify the difference in trip behavior on a Spare the Air and non-Spare the Air day. Respondents were recruited for the first interview using a random digit dial (RDD) sampling method, then offered an incentive to agree to participate in the panel once they completed their first interview.

<u>Random Digit Dial Sample</u>

The sampling method for both the screener version and the non-screener version was a random digit dial method. The RDD sample was drawn by determining the active phone exchanges (the first three numbers of a seven digit phone number) and blocks with a given sampling area (in this case, by the zip codes that comprise the Sacramento area) and then producing a random list of all active residential phone numbers in the area. This method produced both listed and unlisted phone numbers and therefore eliminated the bias of not including unlisted phone number or new numbers. Because all telephone numbers in the area had an equal probability of being chosen for the survey, when combined with screening questions about residential location, age, gender and driving status, this sampling method was expected to produce a representative sample of drivers in the area of interest to this study. As data collection proceeded, the sample characteristics were monitored and adjustments made (if needed) to the sampling frame to ensure that the resulting sample reflected the desire universe.

Although the RDD sampling method is considered state-of-the-art for developing reliable surveys of residents, all sampling methods have their limitations. One of the known limitations of the RDD sample is its tendency to over-represent women and older individuals. The reason for this pattern is thought to be that women, particularly older women, are more likely to be at home AND more likely to answer the phone than men. To counterbalance this behavior disparity, the team employed a common screening question that asks to speak to the youngest male first. If the youngest male was not available, the youngest female was requested. The experience of the researchers and others has shown that this practice, along with monitoring the sample as data collection progresses, will produce a sample that is closer to the population profile than if the interviewer were to speak to the first person who answers the phone. This screening practice was employed in both the standard and screener versions of the survey. The final sample was evaluated to assess this issue. A cross-tab of age and gender was produced to see whether focusing first on the youngest male produced a disproportionate number of responses in this category. Indeed, the youngest category produced a proportionate number of respondents to older categories and was not disproportionately higher than young females. Therefore, the age and gender screening questions resulted in a well-balanced sample.

Timing of First and Second Interviews

The staggered nature of the panel design occurs because the first interviews were conducted throughout the 'smog season'. Some 'first interviews' were conducted on the first Spare the Air day of the season, some on the second, some on the third, etc. Because the first interviews were staggered throughout the season according to the distribution of Spare the Air days, so too were the second interviews.

3.4.2 Basic Interviewing Protocol

The protocol for when to conduct the first and second interview is described below using example dates drawn from the second season of interviewing.

- First and second interviews are to be conducted on Monday-Thursday, after 6PM.
- When a Spare the Air day is called on Monday June 12 for Tuesday, June 13, we notify the data collection facility and 'first interviews' will start at 6PM Tuesday June 13. All individuals interviewed on June 13 become Group A.
- If a Spare the Air day is called again on Tuesday June 13 for Wednesday June 14, we notify the data collection facility and 'first interviews' will again be conducted after 6PM on Wednesday, June 14. All individuals interviewed on June 14 become Group B. This process is repeated for each Spare the Air day in the smog season or until the interviewing budget is exhausted.

The second interviews are to be conducted on days that are not Spare the Air days. The protocol for second interviews is as follows:

- Exactly two weeks after the first interview was completed, attempt to complete a second interview with a respondent provided that a Spare that Air day did not occur within two days prior or is expected to occur on the next day. Using the example above, Group A is to receive their first attempt at a second interview on Tuesday, June 27, 2000 provided that a Spare the Air day did not occur on June 25, 26, 27 or is expected to occur on June 28.

- If a second interview was not completed at the first opportunity due either to a Spare the Air day occurring in the window or the respondent simply not being available, repeat the above process on the third week. Thus, for all members of Group A who did not complete their second interview on June 27, 2000, attempt to complete their second interview on Tuesday July 4, 2000 unless a Spare the Air day was called on July 2, 3, 4 or is expected on July 5.

- For all those respondents who do not have a completed second interview by the third week anniversary of their first interview, begin trying to complete their second interview on a daily basis Monday-Thursday for all days that are not within the window described above (within two days after a Spare the Air day or within one day of an expected Spare the Air day). Thus, second interviews for all members of Group A who did not complete their second interview on or before July 4 are to receive attempts on July 5, 6, 10, 11, 12 etc. until an interview is completed unless a day falls within the window described above.

- The above process is repeated for each Group, which will result in first and second interviews staggered across the smog season.

3.4.3 Survey Questionnaires

Both the standard and the screener instruments are included in Appendix B.

In the *standard* version, all adult residents who were drivers were eligible to take the survey. In order to over-sample for individuals who likely changed their behavior due to Spare the Air advertising, a *screener* version of the survey was also employed. With this version of the survey, individuals who stated that they purposely decreased their driving in the past day were interviewed, all others are terminated.

The questionnaires are essentially identical in question #'s and content, only the order in which the questions are presented is slightly different and the *screener* version terminates those individuals who do not report purposely reducing their driving, whereas the *standard* version does not. Both versions were administered to respondents selected using the RDD sampling method, although the samples for the standard and screener versions were drawn separately and were mutually exclusive.

The questionnaire for the second interview is essentially identical to the standard version of the first survey, only the background demographic questions are not asked in the second survey.

3.5 Data Collection

After surveying driving age residents in Sacramento during the summers of 1999 and 2000, the team completed 126 "Screener" surveys and 185 "Standard" surveys. In both cases, the surveys were conducted on a Spare the Air day and again on a non-Spare the Air day approximately two weeks later. To obtain these 311 completed surveys, the team contacted a total of 3,982 people in the Sacramento region. Among the 311 completed survey pairs, there were a total of 134 "reducers," 126 from the screener version and another eight from the standard survey.

The distribution of the interviews is summarized in the following table. The table shows the number of first interviews completed, the number of respondents who agreed to a second interview, and the number of completed second interviews by type of respondent (reducer, non-reducers, all respondents) and year of data collection (1999, 2000, combined 1999 and 2000).

Table 3.1

Summary of Data Collection 1999-2000

		Spare the Air Reducers			Non Spare the Air Reducers			All Survey Respondents		
		1st Survey	Agreed to 2nd Survey	Completed 2nd Survey	1st Survey	Agreed to 2nd Survey	Completed 2nd Survey	1st Survey	Agreed to 2nd Survey	Completed 2nd Survey
1999	Screener	31	29	22	315	0	0	136	29	22
	Standard	3	3	3	80	64	30	83	67	33
	Sub-total	*34*	*32*	*25*	*395*	*64*	*30*	*219*	*96*	*55*
2000	Screener	146	138	104	1595	0	0	935	138	104
	Standard	11	9	5	318	252	147	329	261	152
	Sub-total	*157*	*147*	*109*	*1913*	*252*	*147*	*1264*	*399*	*256*
1999-2000	**Total**	**191**	**179**	**134**	**2308**	**316**	**177**	**1483**	**495**	**311**

During the summer of 1999 and 2000, surveys were conducted the evening of the following Spare the Air days:

- Tuesday, **July 13, 1999** (pre-test; day 4 of 4-day episode)
- Wednesday, **August 25, 1999** (day 2 of a 4-day episode)
- Thursday, **August 26, 1999** (day 3 of a 4-day episode)
- Monday, **July 31, 2000** (day 2 of a 3-day episode; the first being a Sunday)
- Tuesday, **August 1, 2000** (day 3 of a 3-day episode)
- Wednesday, **September 20, 2000** (day 1 of a 1-day episode)

It should be noted that the Spare the Air days called in August 1999 coincided with a major forest fire that burned for several days north of the Sacramento Valley. Whether travel behavior was also affected by these conditions (smoke and ash) could not be determined from the survey method.

The resulting survey data sets were then cleaned and compiled for use in the analysis phase of the research. This analysis is discussed in the next section.

4.0 Results

The following section presents research results pertaining to the effects of Spare the Air (STA) on travelers and emissions associated with their travel behavior. In particular:

- Subsection 4.1 estimates the net effect of STA advertising on driver trip taking behavior.

- Since the research findings indicate that survey respondents over-report the number of trips reduced due to STA advertising, Subsection 4.2 develops a correction factor to take this phenomenon into account. . This correction factor is a key outcome of this study as it provides a way for other air districts to correct for over-reporting of trip reduction without their having to perform surveys as extensive as those performed in this study.

- Subsection 4.3 estimates the proportion of travelers reducing driving due to STA campaigns in which traveler surveys were used to gauge the effects of STA.

- Subsection 4.4 deals with an important parameter in the estimation of emission impacts of STA, namely VMT (Vehicle Miles Traveled). Because VMT is affected by the proportion of work and non-work related trips, this section estimates the proportion of these trips and the possibility of these trips varying in average length.

- Subsection 4.5 examines characteristics of drivers reporting trip reduction associated with STA. This section is important because it attempts to identify characteristics of drivers which might be important in the marketing and targeting strategies employed by STA campaigns.

- Subsection 4.6 explores travel behavior of survey respondents on non-Spare the Air days in order to assess whether Spare the Air day behavior changes are unique.

All the research results presented in this chapter of the report are based on analysis of the STA survey sample. The sample contains 3,982 individuals who responded to the "screener" version (N = 3,570) of the STA day survey or the "standard" version (N = 412) of the STA day survey. Of these 3,982 individuals, 311 responded to either the screener or standard versions of the STA day survey *and* also responded to the non-STA day (second) survey. The sample subsets analyzed and reported here are described in the relevant subsections of the research results on the following pages. The survey sample and its acquisition are described in greater detail in the previous section of this report. Copies of the survey questionnaires can be found in Appendix B.

4.1 Analysis of the Net Trip Reduction Due to STA Advertising

Analysis of the survey data was done to estimate the net effect of STA advertising on driver trip taking behavior. This analysis was executed through the following steps: (1) computation of trip reduction for the STA reducers defined as the difference in the average number of driver trips reported taken by STA reducers on the non-STA day survey minus the average number of trips these drivers reported taking on the STA day survey; (2) computation of trip reduction for the non-STA reducers defined as the difference in the average number of driver trips reported taken by non-STA reducers on the non-STA day survey minus the average number of trips these drivers reported taking on the STA day survey; (3) Subtraction of non-STA reducers trip reduction (from step 2) from STA reducer trip reduction (from step 1) to arrive at an estimate of net trip reduction and the net effect of STA advertising.

The calculations below include 311 survey respondents who completed both the STA day screener survey or standard survey and the subsequent non-STA day survey.

Results:

Table 4.1, below, reveals that 177 of 311 survey respondents identified as non-STA reducers reported taking an average of 0.6497 more trips on the STA day survey than they reported taking on the non-STA day survey (2.4463 - 3.0960 = -0.6497). A t-test of this decrease in trips from the STA day survey to the non-STA day survey was statistically significant (t = 3.11, df = 176, p. = 0.002).

Table 4.1

Non-STA Reducers Mean Trips Reported Taken on Non-STA Day Survey, Mean Trips Reported Taken on the STA Day Survey, and Mean Difference (Non-STA Day Mean Minus STA Day Mean), N = 177

	Non-STA Day Trips	STA Day Trips	Mean Difference
Mean	2.4463	3.0960	-.6497

Table 4.2, below, reveals that 134 of 311 survey respondents identified as STA reducers reported taking an average of 0.4478 fewer trips on the STA day survey than they reported taking on the non-STA day survey (2.9030 – 2.4552 = 0.4478). A t-test of this increase in trips from the STA day survey to the non-STA day survey was marginally statistically significant (t = -1.87, df = 133, p. =0.063).

Table 4.2

STA Reducers Mean Trips Reported Taken on Non-STA Day Survey, Mean Trips Reported Taken on the STA Day Survey, and Mean Difference (Non-STA Day Mean Minus STA Day Mean), N = 134

	Non-STA Day Trips	STA Day Trips	Mean Difference
Mean	2.9030	2.4552	.4478

The non-STA day minus STA day trip change difference between STA reducers and non-STA reducers is 0.4478 – (-0.6497) = 1.0975 (95% CI 0.4775 – 1.7175).

Table 4.3

Statistical Test of Difference in Mean Trip Change from the Non-STA Day Survey to the STA Day Survey. STA Reducers Versus Non-STA Reducers.

	t-test for Equality of Means				
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Equal variances assumed per results of test of homogeneity of variance	3.460	309	.001	1.0975	.31722

Thus as measured in this research, there was statistically significant net trip reduction due to STA advertising.

The finding that indicates non-reducers made more trips on Spare the Air days warrants some additional discussion. The research design was constructed to "control" for changes among drivers who did not identify themselves as purposeful reducers for air quality reasons. Thus, had the typical driver taken fewer trips on Spare the Air days, the research design would "discount" the finding among reducers to account for this broader phenomenon. At first glance, it is counterintuitive to think the typical driver would take *more* trips on days when the public education program is seeking a reduction in travel.

However, there may be an explanation that cannot be corroborated by the research – given that ozone alerts in the Sacramento area are called on summer days with hot, stagnant air, one natural response to these type of days might be for residents to drive more. This may include making auto trips, in air-conditioned automobiles, for trips that might be made by walking, bicycling or transit if the weather conditions were cooler and cleaner. Does this mean that Spare the Air public education announcements actually forewarn residents of the conditions that lead some to substitute non-motorized trips for auto trips? The research design did not seek to inquire or assess why respondents

increased trips. Therefore, the reasons for an overall increase in driving trips among the average resident cannot be fully analyzed. Since the research design was structured to 'control" for other changes in travel behavior, the additional trips made by non-reducers needs to be added to the reductions estimated for reducers to determine the net reduction among program participants.

Another possible explanation as to why non-reducers may have driven more on STA days has to do with a paired sample phenomenon of prior knowledge of the survey. Since respondents of the second survey had knowledge of the first survey, some could have used this knowledge to reduce their time on the phone by revealing less driving trips. Since the first survey was conducted on a Spare the Air day, all second surveys were conducted on non-Spare the Air days. If this phenomenon did occur, it could be a partial explanation as to why the survey showed more driving on STA days. However, an analysis showed that non-Spare the Air day driving trips between reducers and non-reducers is not statistically different (at the p. <.05 level). One would also presume that the prior knowledge phenomenon would be uniform with both reducers and non-reducers. Thus, there would be no significant impact on net trip reduction or the correction factor.

4.2 Correction Factor Rationale And Estimation

The affordable and accurate survey methodology that is the goal of this research will rely exclusively on direct survey questions to determine how many trips STA reducers have purposely reduced during an STA episode. The research results indicate that survey respondents over-report the number of trips reduced due to STA advertising in response to direct questions.

- To reduce this bias a correction factor was developed to adjust trip reduction findings from direct questions. The correction factor is based on the careful estimate of *net trip* reduction due to STA described in the preceding section.

- The correction factor divides the estimate of *trips reduced* (average net trip reduction) by *trips reported reduced* in response to direct survey questions.

- The resulting number is an adjusted estimate of trips *reduced* per trip *reported reduced* in response to direct questions.

Results:

The correction factor is estimated as the ratio of mean net trip reduction (1.0975, from the preceding section of the report) to the trip reduction reported in response to direct survey questions. Table 4.4 shows that the mean number of trips reported reduced due to STA advertising in response to direct survey questions was 2.2 for 134 survey respondents identified as STA reducers who completed both surveys.

Forming a ratio with the above numbers, the correction factor is:

$$1.0975 / 2.20 = 0.50$$

Thus, survey respondents are estimated to have reduced half the number of trips they report reducing in response to direct questions.

Table 4.4

Mean Number of Trips Reported Reduced in Direct Questions

	Mean	N
How many driving trips did you purposely decrease during this period?	2.20	134

4.3 Estimation of the Percentage of STA Reducers in the Population

An important calculation for purposes of all of the analysis presented in this section is an estimate of the percentage of STA reducers in the population of the region surveyed. "STA reducers" were defined to be survey respondents who met one of the following conditions: (1) the respondent reported reducing one or more trips because of STA advertising, OR (2) the respondent reported reducing one or more trips for air quality reasons, AND, the respondent reported having heard, read, or seen advertisements during the preceding two days talking about poor air quality and driving in the area. The combined surveys produced 191 STA reducers as identified in the first survey. They did not have to agree to or complete a second survey for purposes of determining the proportion of reducers among the driving population. For this part of the analysis, ARB chose to base the proportion of reducers on total driver surveys (screener and standard).

Results:

Some 191 respondents of the total of 3,982 surveyed met the definition of an STA reducer used in the surveys, resulting in 4.8% of the population of drivers.

4.4 Estimation of Work and Non-Work Trips Reduced by STA Reducers

Vehicle Miles Traveled (VMT) is an important parameter in estimating the emissions reduction due to the effects of STA. This subsection deals with VMT by estimating the proportions of work-related and non-work related trips because of the possibility that different kinds of trips are of different average lengths. To estimate the proportions of

work- and non-work related trips reported reduced by survey respondents, work-related trips were summed and divided by total trips reported reduced. The results appear below in Table 4.5.

Results:

Table 4.5 shows that 191 STA reducers reported reducing a total of 406 trips of which 60 were work-related. Thus about 14.8% of reduced trips were work-related (60 / 406 x 100% = 14.8%).

Table 4.5

Total All-Purpose Trips Reported Reduced and Total Work-Related Trips Reported Reduced By STA Reducers According To Diary-like Trip Reduction Questions On The STA Day Survey (N = 191 STA Reducers)

	Total All-purpose Trips Reoported Reduced	Total Work-Related Trips Reoported Reduced
Total Trips Reduced	406.00	60.00

4.5 Analysis of Driver Characteristics Associated With Reporting STA Trip Reduction

The Spare the Air survey offered an opportunity to explore the following question: What are the characteristics of individuals who report STA trip reduction compared to individuals who do not? This question is useful because the answer may help target STA campaigns more effectively. To explore this question, a number of covariates representing possible influences on the likelihood that an individual will report being an STA reducer were examined in a logistic regression analysis. Covariates considered included the following: 1) the number of motor vehicles in working order in the household, 2) age of respondent (calculated from question on year of birth), 3) the number of children under the age of 18 living in household, 4) the number of drivers in the household, 5) employment /retirement /student status, 6) employee payment for parking at work, 7) whether the respondent's employer notifies employees of poor air quality days, 8) whether the respondent's employer encourages employees to drive less, car pool, or use public transit on poor air quality days, 9) highest education level completed, 10) total pre-tax household income in 1999, and 11) respondent gender. These variables are widely known within the transportation community potentially to affect the volume of individual and household travel.

In analyzing these covariates in relation to STA reducer status, a four-step analytic process was used (Hosmer and Lemeshow, 1989). The steps in the analysis were the following:

(1) Careful univariate analyses of each covariate, and bivariate analyses of each covariate in relation to STA reducer status, retaining for further analysis all

covariates related to STA reducer status at probability values of p. < 0.25 in the bivariate analyses (Bendel and Afifi, 1977, Mickey and Greenland, 1989).

(2) The next step was multivariate analyses beginning with all covariates significantly related to STA reducer status at p. < 0.25 in earlier bivariate analysis. Variables continuing to show a significant relationship to STA reducer status were included in a "main effects" model of the characteristics of STA reducers. Covariates that were no longer significantly related to STA reducer status after initial multivariate runs were dropped from further analysis.

(3) The third analytic step included creation and testing of interaction terms to see whether any of these should be added to the "main effects" model created in the second step.

(4) The final analytic step considered the goodness of fit of the final model and examined the possibility of colinearity among the independent variables (covariates) included in the model.

Results:

A final model containing three covariates resulted from the analysis. The findings were the following:

- Survey respondents who report that their employer notifies them about poor air quality days are about 1.6 times more likely to report being STA reducers than are employees whose employer does not notify them of poor air quality days.

- Survey respondents who are female are about 1.6 times more likely to report being STA reducers than are males.

- Survey respondents with three or more children under 18 are about ¼ as likely to report being STA reducers as are respondents with no children under 18.

Interaction among these covariates was considered and found not to be significant. The model was checked for goodness of fit and colinearity. The model fits the data well and colinearity is not a problem.

Appendix C to the report contains a complete description of the above analysis and the results at the conclusion of each analytic step.

4.6 Analysis of Travel Behavior on Non- Spare the Air Days

A final important analytic question was whether reducers and non-reducers had comparable trip-making characteristics in the absence of Spare the Air. If Spare the Air days had a unique impact on reducers (who traveled less because of Spare the Air) and

non-reducers (who may have traveled more due to the conditions associated with Spare the Air days), then one would presume the trip-making patterns of each group would be comparable on the control (non-Spare the Air) days.

The average number of trips made by reducers on non-Spare the Air days was 2.9 trips (according to the paired survey sample) and the number of trips made by non-reducers was 2.45 trips on non-Spare the Air days. The difference in the mean number of trips made by these two groups on non-Spare the Air days was not statistically significant at the .05 level (although it was marginally statistically significant at the $.05 < p. < .10$ level). Thus, at the 95% confidence level, trip-making on non-Spare the Air days was not significantly different between reducers and non-reducers.

5.0 Discussion and Outline of Recommended Method

This chapter briefly describes the recommended method for evaluating an ozone action public education program, based on the results of this research study. Following the description of the method, a worked example for the Sacramento Spare the Air program is provided. Appendix A includes a Reference Manual for applying the recommended quantification method to an ozone action program.

5.1 Outline of Recommended Method

The method involves 10 steps, beginning with recommended questions to include in a survey. Steps also include how to tabulate organize and interpret the survey results; how to extrapolate the results to the total population in the target area; how to estimate the total number of vehicle trips and vehicle miles traveled that are reduced through the program; and how to estimate the emission reductions associated with a program.

The recommended evaluation method uses the Self-Reported Average Trip Reduction Correction Factor derived through this study as its core feature, along with a recommended set of survey questions. Also included in the recommended approach are a set of procedures to progress from the completed survey to estimated changes in vehicle travel and emissions for the region under study. Based on the findings cited above, we recommend the 10 steps described below be undertaken by air districts to evaluate the emission impacts from trip reduction due to their episodic public education campaigns.

The method would be used by air districts that have episodic summer ozone action programs that include a media campaign to advise the public to reduce driving on days that are anticipated to violate federal air quality ozone standards. Many air districts with existing programs already annually survey residents during and after the summer program, to assess awareness and resultant changes in behavior. If an air district decides to evaluate their episodic mobile source emission reduction program in order to quantify the travel and emission impacts, and/or to possibly seek State Implementation Plan (SIP) credit for a voluntary mobile source emission reduction program (VMEP), they would use the following 10-step method:

Step 1 – Create or Modify Survey and Sample Size

Most air districts field a follow-up survey during the smog season in order to capture driver awareness of and reaction to public education messages to avoid, delay or change mode of travel during air quality episodes. This telephone survey of driving age residents should be modified or expanded to include questions to:

1. Determine the proportion of “reducers” among all drivers
2. Calculate the average self-reported trips reduced among these reducers
3. Determine the type of trip (work vs. non-work) reduced

The specific questions to be included in the survey are described in Section 5.1.1.

Step 2 – Field Survey During Ozone Season

The survey should be fielded during episodes so that people are surveyed on the evening after an alert. In Sacramento, residents were called between 6:00 and 9:00 pm on each evening following an alert. So, if a Spare the Air alert was made on a Monday for the next day, residents were surveyed on Tuesday evening. Surveys should be distributed throughout the ozone season, if possible, so as to pick-up the cumulative effects of the public education campaign.

Step 3 – Tabulate Results

At the end of the ozone season, or when an adequate sample is collected, the results should be tabulated for use in the subsequent steps. From the questions, the proportion of reducers can be derived (expressed as a percent of total drivers that have reduced their trip making as a result of the program). The average number of self-reported trips reduced can also be derived. From the question on trip purpose, the proportion of work and non-work trips reduced can be derived. This proportion is used to determine the average trip length reduced, which is used to estimate the change in vehicle miles traveled.

Step 4 – Estimate the Total Number of Reducers

The proportion of reducers from Step 3 can be extrapolated to the total population of drivers in the region to estimate the total number of users by applying the proportion of reducers to the vehicle drivers in the region

Step 5 – Estimate the Average Trip Reduction

From the summary trip reduction question, the average number of self-reported trips can be derived for the sample of reducers.

Step 6 – Apply Self-Reported Trip Reduction Correction Factor

From the Sacramento research, a correction factor was developed to relate the actual trip reduction (1.0975 trips reduced -- derived by comparing Spare the Air and non-Spare the Air day travel behavior) to stated reduction (2.2 trips reduced)**. This correction factor is 0.5** (1.0975 /2.2). Thus, due to over-reporting of trips reduced, respondents claim to have reduced twice as many trips than they actually do based on the net average trip reduction.

Step 7 – Estimate Total Adjusted Trips Reduced

To estimate the total number of trips reduced, the adjusted trip reduction factor is applied to the total reducers.

Step 8 – Determine the Proportion of Work and Non-work Trips Reduced

The proportion of trips reduced that are work trips versus non-work trips is derived from the survey. These proportions are applied to the total adjusted trips reduced to determine the number of work and non-work trips reduced.

Step 9 – Estimate VMT Reduction

To estimate VMT reduction, the total estimated work and non-work trips reduced are multiplied by regional average trip lengths for each type of trip.

Step 10 – Estimate Emission Reduction

Using the California Air Resources Board's average auto emission factors for each year for affected vehicle classes (passenger cars and trucks - from the most current approved version of the EMFAC model), the emission reductions from the public education campaign can be estimated by applying the Trip End emission factors to total vehicle trip reduction and VMT emission factors to total VMT reduction. This analysis could be performed for reactive organic gases (ROG), nitrogen oxides (NOx), and particulate matter (PM_{10}). Carbon monoxide (CO) reductions could also be calculated if equivalent trip and VMT emission factors were available.

5.1.1 Recommended Survey Questions for Quantifying STA Program Effects

The following are a set of recommended survey questions that can form the basis of or be added to an ozone action program survey.

<u>To Determine Proportion of Reducers - ask of all respondents</u>

1A We're interested in the travel behavior of people in the region. Sometimes people will purposely **increase** the amount of driving they do in a day. An example of purposely **increasing** driving would be if a person decided to drive to the store when they **normally** would have walked, bicycled or taken a bus. Between 6PM yesterday and 6PM tonight *(or other 24-hour time period, based on survey)*, did you purposely **increase** the amount of your driving?
(If respondent asks to clarify what purposely increasing driving is, say "It means deciding to drive someplace when you usually travel there without driving')

Yes _____
No _____
DK/NA _____

1B Sometimes people will purposely **decrease** the amount of driving they do in a day. An example of purposely **decreasing** driving would be if a person decided to take a bus, walk, bike or ride with someone else to work when they **normally**

would have driven, or if someone decided to simply not take a trip they would have normally taken in a car. Between 6PM yesterday and 6PM tonight *(or other 24-hour time period, based on survey)*, did you purposely **decrease** the amount of your driving?
(If respondent asks to clarify what purposely increasing driving is, say "It means deciding to travel someplace without driving when you normally would have driven or deciding not to take a trip you would normally take in a car')

Yes	_____ (go to Question 2)
No	_____
DK/NA	_____

(Note: It is vital to ask both about increasing and decreasing trips in the screener so as not to bias the response)

<u>To Determine Self-Reported Trip Reduction – ask of respondents who **decreased** trips only</u>

2A You indicated that you purposely decreased the amount of driving you did between 6 PM yesterday and 6 PM tonight. I'd like to ask you about the driving trips you purposely decrease during this period? A 'trip' is defined as traveling from one place to another and then stopping. For example, leaving your house and going to the store is one trip. Leaving the store and going to work or coming back home is another trip. Another example of a trip is leaving your house and going to the bus or train station. Taking the bus or train to work would be a second trip. How many driving trips did you purposely decrease during this period?

1	_____
2	_____
3	_____
4	_____
5	_____
6	_____
7 or more	_____
None	_____
DK/NA	_____
Refused	_____

2B Thinking of the (first/second/third…) driving trip you DECREASED, how did you decrease the trip?

Didn't take trip	_____
Carpool passenger	_____
Public Transportation	_____
Bicycle	_____

Walk	_____
Worked at Home	_____
Other	_____
Refused	_____

2C (If Answered 'DIDN'T TAKE TRIP' to Question 2B for this trip, ask): What was the purpose of the trip going to be? (Any other answer to Question 2B for this trip, ask): What was the purpose of this trip?

Going to or from work	_____
Shopping	_____
Other (school, errands..)	_____
Don't know	_____
Refused	_____

2D Why did you purposely decrease this driving trip? (Don't prompt for specific answers):

Spare the Air or ads asking people to drive less	_____
Air quality reasons	_____
Other	_____

Ask Questions 2B-2D for each trip the respondent reports that they decreased.

3A In the past two days, have you heard, read or seen any advertisements or news broadcasts about Spare the Air, or poor air quality, or requests to drive less in this area?

Yes	_____
No	_____
DK/NA	_____

(Note: This question can be replaced by an air district-developed question to determine whether or not the respondent knew it was a Spare the Air day.)

Question 2B, how the trip was reduced, is optional, but important to capture how many trips were simply avoided versus due to mode change. These questions can be added to any awareness, attitude, and demographic questions needed for market research or other program evaluation efforts, as long as the trip-related questions are asked first to avoid inserting any bias from the other survey questions.

The sample size needed for the survey is determined based on the estimated percentage of reducers, the desired error band, and the self-reported trip sample variance. For example, assuming the proportion of reducers is 4% and the sample self-reported trip reduction variance is 1.8, a sample size of approximately 1,000 completed surveys is needed to get the desired accuracy of ± 1.2% on the proportion of reducers among the total respondents

and ± 0.5 trips on the self-reported average trips reduced. Instructions on how to estimate the actual sample size are provided in the reference manual (Appendix A0.

An air district should include these survey questions, sample size and protocol in the scope of work of the survey or market research organization that might be contracted to do the evaluation and/or collect the survey data. Once the surveying process has begun, the sample size should be adjusted if the reducer proportion or self-reported trip reduction variance is different than the above assumptions in the sample size determination.

5.2 Application to Sacramento Spare the Air Program 1999/2000

This section provides an example application of the calculation Steps 4 - 10 described in Section 5.1.

5.2.1 Calculation of Emission Impacts in Sacramento

Applying the recommended method (calculation Steps 4-10), including the correction factor, to the Sacramento Spare the Air campaign for 2000, the following impacts can be derived:

Step 4 – Estimate the Total Number of Reducers

The proportion of reducers from Step 3 can be extrapolated to the total population of drivers in the region to estimate the total number of users.

> In Sacramento, the proportion of reducers was approximately 4.8% of drivers. If there were 770,620 drivers within Sacramento County in 2000, the number of reducers (using the Sacramento finding) would be **36,990 reducers.** These reducers form the basis for trip, VMT and emission reduction estimates.
>
> 770,620 (drivers in region) x 0.048 (% reducers) = 36,990 reducers

Step 5 – Estimate the Average Trip Reduction

From Questions 2A, the average number of self-reported trips can be derived for the sample of reducers.

> In Sacramento, using the summary Question 2A (total trips reduced that day), the average reduction was **2.2** one-way driver trips**.**

Step 6 – Apply Self-Reported Trip Reduction Correction Factor

From the Sacramento research, a correction factor was developed to relate the measured trip reduction (1.0975 trips reduced -- derived by comparing Spare the Air and non-Spare the Air day travel behavior) to stated reduction (2.2 trips reduced among reducers

responding to both Spare the Air and non-Spare the Air day surveys). This correction factor is 0.50 (1.0975 / 2.2). Thus, due to over-reporting of trips reduced, respondents claim to have reduced a little over 40 percent more trips than they actually do based on the net average trip reduction.

> In Sacramento, the 2.2 average stated trips reduced, when adjusted with the trip reduction correction factor **(0.5)** would be 1.1 trips reduced per reducer (which, in Sacramento, is equal to the net average trip reduction estimated).
>
> 2.2 (self-reported trips reduced) x 0.5 (correction factor) = 1.1 adjusted trips reduced.

Step 7 – Estimate Total Adjusted Trips Reduced

To estimate the total number of trips reduced, the adjusted trip reduction factor is applied to the total reducers.

> In the case of Sacramento, the 36,990 reducers, each reducing an adjusted average of 1.1 trips, would realize an **overall regional Spare the Air day trip reduction of 40,689**.
>
> 36,990 (reducers) x 1.1 (average adjusted trips reduced) = 40,689 (total trips reduced)

Step 8 – Determine the Proportion of Work and Non-Work Trips Reduced

From Question 2C, the proportion of trips reduced that are work trips versus non-work trips is derived. These proportions can be applied to the total adjusted trips reduce to derive the total work trips and non-works trips reduced.

> The Sacramento survey found that work trips comprised 14.8% of trips reduced and 85.2% were from non-work trips (from Question 2C). Using these proportions, one can estimate the number of work and non-work trips reduced. If the total adjusted trips reduced was 40,689, **the number of work trips reduced would be 6,022 trips and the number of non-work trips reduced would be 34,667 trips**.
>
> 40,689 trips x 0.148 = 6,022 work trips reduced
>
> 40,689 x 0.852 = 34,667 non-work trips reduced

Step 9 – Estimate VMT Reduction

To estimate VMT reduction, the number of estimated work and non-work trips reduced are multiplied by regional average trip distances to determine VMT reduced for each type

of trip. The sum of these mileage reductions is used in the subsequent emissions analysis.

> Using average trip lengths from regional planning sources in Sacramento of 13.0 miles for work trips and 4.87 miles for other trips, the VMT reduction for each type of trip would be 78,286 miles and 168,828 respectively. **The total VMT reduction would be 247,114 miles.**
>
> 6,022 work trips reduced x 13.0 miles = 78,286 miles of travel reduced
>
> 34,667 non-work trips reduced x 4.87 miles = 168,828 miles of travel reduced
>
> 78,286 miles of work travel + 168,828 miles of other travel = 247,114 miles of total travel reduced.

Step 10 – Estimate Emission Reduction

Using the California Air Resources Board's (ARB's) average auto emission factors for the given analysis year (e.g. program evaluation year), the emission reductions from the public education campaign can be estimated by applying commute and average Trip End emission factors to total work and non-work vehicle trip reduction and VMT emission factors to total VMT reduction. This analysis could be performed for nitrogen oxides (NOx), reactive organic gases (ROG), particulate matter (PM10), and carbon monoxide (CO). This analysis focuses on NOx, which is the pollutant of greatest interest to Sacramento in terms of attainment.

> Using a Trip End NOx emission factor for 2000 of 1.063 grams for commute trips, 0.868 grams for all trips, and a VMT factor of 1.141 grams per mile (*from EMFAC 2000, v.2.02*), the **estimated emission reduction *on ozone action days* is 0.351 tons** as derived for Sacramento thusly:
>
> a) 6,022 work trips (starts) reduced x 1.063 grams/start = 6,401 grams = 14.1 lbs. or 0.007 tons per day
>
> b) 34,667 non-work trips reduced x 0.868 grams/start = 30,091 grams = 66.3 lbs. or 0.033 tons per day
>
> c) 247,114 miles reduced x 1.141 grams = 281,957 grams = 621 lbs. or 0.311 tons per day
>
> d) 14.1 lbs. + 66.3 lbs.+ 621 lbs. = 701.4 lbs. NOx per ozone action day
>
> e) 0.007 tons + 0.033 tons + 0.311 tons = 0.351 tons NOx per ozone action day

Thus, for the case of the Sacramento Spare the Air campaign in 2000, the ozone action public education campaign reduced 0.351 tons per day of NOx (on ozone action days) in

2000 by reducing over 40,000 daily trips and almost 250,000 miles of travel among 4.8% of the drivers in the region. Without showing the calculations, this example also would reduce 0.37 tons of ROG, and 0.06 tons of PM_{10}.

5.2.2 Program Cost Effectiveness

Air quality cost-effectiveness is often used by local agencies to help prioritize the use of air quality funds. Cost-effectiveness is expressed as dollars spent per pound (or ton) of emissions reduced. As air pollution control programs have been implemented, a generally accepted range of cost-effectiveness has emerged. The cost of ARB mobile source measures is typically less than $10,000 per ton of emissions reduced. Local air district stationary source measures have at times had higher costs (up to $20,000), and air pollution offset transactions have resulted in costs as high as $37,000 per ton. ARB has set a suggested threshold of $20,000 per ton for projects funded with Motor Vehicle Registration Fee Program funds. But ARB's cost-effectiveness guidelines also note that the California Clean Air Act requires that district include a public education element in their attainment plans and that it is difficult to quantify emission reductions for these programs and apply typical cost-effectiveness criteria. And while summer ozone season public education programs can result in behavioral changes that reduce motor vehicle travel, they also provide other benefits such as health advisories and general public awareness about air pollution.

Applying the ARB criteria to the public education program evaluated in this research, the air quality cost effectiveness of the program can be estimated in the following manner. The Spare the Air campaign program budget for 2000 was approximately $140,000. The program reduced 0.351 tons of NOx per Spare the Air day. There were six Spare the Air days in 2000 for a total of 2.106 tons reduced during Spare the Air days in 2000. If you add ROG and PM_{10}, the total reduction is 4.69 tons over the six days (2.106 + 2.22 + 0.36). This equates to a total of $29,850 per ton reduced, or $14.93 per pound.

5.3 Implications of Research Results for Future Program Evaluation

The principal implication of the results is that it is possible for air districts to conduct low cost surveys and adjust the findings using the correction factor developed through this more extensive study. The method is designed to derive three important inputs for the quantification of program impacts:

1. The *proportion of drivers* who purposely reduce trips for air quality reasons in response to ozone alerts (this represents the affected population).

2. The average self-reported trip reduction among these reducers.

3. The proportion of work trips and non-work trips.

Central to the method is the correction factor that adjusts a single summary indicator of trip reduction by the known net trip reduction based on detailed travel behavior research

among the same drivers. As described in Section 4.2, this correction factor is a ratio of net trip reduction to self-reported trip reduction, or 0.50 net trips reduced for every self-reported trip reduced. As a ratio of measured to self-reported travel behavior, the correction factor can be applied to other areas. In essence, the correction factor says: respondents to a less expensive survey will report twice as many trips being reduced as our research shows as being the more carefully estimated net trip reduction. It is this ratio that is transferable to other evaluation efforts, not the trip reduction results from the example study to which the survey was applied (Sacramento).

Therefore, how are local conditions handled within the recommended method? Here are some possible responses:

What if the area being evaluated has better public transportation or a better HOV system?

Differences in available alternative travel options should be reflected in self-reported trip reduction and the proportion of drivers who reduce trips (by using these options in higher proportions). The method would simply adjust the higher self-reported trips reduction to reflect over-reporting in a simple survey and apply that adjusted trip reduction finding to the higher proportion of reducers.

What if the public education program is more extensive or more effective?

Again, this will be reflected in the proportion of drivers who say they purposely reduce trips due to air quality and ozone alerts. A higher proportion of reducers will result in a higher number of vehicle trips reduced.

What if the program is more targeted to commuting? What if commuting distances are longer?

A greater focus on commuters could result in more and longer work trips being reduced. This would be reflected in the proportion of work trips reduced. The longer average trip length for work trips would result in greater VMT reduction.

Therefore, the recommended method was designed to provide a less expensive survey process, correction factor, and step-by-step calculations to enable any air district or other evaluator to quantify the impacts of their ozone public education programs on travel and emissions.

Is the method consistent with evaluation methods for other mobile source programs?

The recommended method is consistent with other ARB guidance on evaluating trip and emission reduction programs. For example, the ARB report "Methods to Find Cost-Effectiveness of Air Quality Projects" (ARB, 2002) includes default factors, such as the proportion of riders on new transit services that switched from driving alone, to adjust ridership numbers to reflect the fact that some riders will have simply switched from

another transit or high occupancy mode and therefore have not reduced a full trip in doing so.

6.0 Summary and Conclusions

6.1 Summary

Research Findings

The research conducted as part of this study contributes new knowledge about the impact of public education campaigns aimed at reducing travel and emissions during air pollution episodes. Key findings include:

- Drivers do respond to ozone action programs by changing their travel behavior. In Sacramento, some 4.8% of drivers surveyed *purposely* reduced vehicle trips for air quality reasons in response to Spare the Air (STA) alerts.

- The most common way to reduce trips, among these drivers, was to defer or eliminate a discretionary trip. This has been corroborated by parallel studies in Sacramento.

- Among a survey of all drivers, one somewhat surprising finding involved an increase in trips on Spare the Air days among all drivers of 7/10 of a trip (0.6497 more trips). Perhaps one explanation for this is the fact that ozone days are often the hottest, more stagnant days of the summer. Many residents of Sacramento may chose to drive more on these days because of climatic conditions.

- This complex research design involving STA day surveys and non-STA day surveys for reducers and all drivers enabled a net trip reduction number to be estimated that is presumably more accurate than summary recall of total trips reduced. If "reducers" make 0.4478 fewer trips on STA days and all drivers make 0.6497 more trips on STA days, the net average trip reduction among reducers is 1.0975 trips (0.4478 – (0.6497) = 1.0975)). This is because, as compared to other travelers, STA reducers make fewer trips *on top of not making more trips* like the average driver on STA days.

- Based on analysis of the data collected, a correction factor was developed to adjust the summary self-reported trip reduction response in a less expensive survey to account for what we know about net trip reduction. This correction factor was constructed as the ratio of self-reported trip reduction to net trip reduction (1.0975/2.2 = 0.50). This correction factor, or ratio, is then applied to self-reported trip reduction responses in future surveys to adjust for the over-reporting of trip reduction revealed through this research.

- In Sacramento, the application of the method to the data collected in 1999 and 2000 revealed that the Spare the Air program:

  - Reduced about 40,000 vehicle trips on each Spare the Air day

- Reduced about 247,000 miles of travel per Spare the Air day
- Reduced 0.351 ton of oxides of nitrogen (NOx) per Spare the Air day
- Reduced 0.37 of ROG and 0.06 tons of PM_{10} per Spare the Air day
- Reduced over five tons (4.69) of combined pollutants over six days. At an annual program cost in 2000 of $140,000, this equates to $29,850 per ton reduced or $14.93 per pound of pollutants reduced.

Recommended Method

The research results derived from this study were used to developed a less expensive, yet accurate method to quantify the emission reduction impacts of episodic public education programs such as the Spare the Air campaigns in Sacramento, the San Francisco Bay Area, and the San Joaquin Valley. The method involves the following 10 basic steps that could be followed by an air district as a modification to the follow-up ozone campaign surveys typically conducted:

1. Create or Modify General Population Telephone Survey and Sample Size
2. Field Survey Immediately After Ozone Alerts
3. Tabulate Survey Results and Key Factors
   - Proportion of reducers among all drivers
   - Average self-reported trip reduction among reducers
   - Proportion of work and non-work trips reduced
4. Estimate the Total Number of Reducers
5. Apply Average Self-Reported Trip Reduction to Reducers
6. Adjust for Over-reporting of Trip Reduction with Correction Factor
7. Estimate Total Adjusted Trip Reduction
8. Determine the Proportion of Work and Non-work Trips Reduced
9. Apply Trip Length to Trips to Estimate VMT Reduction
10. Apply Emission Factors to Estimate Emission Reductions

The method is relatively straightforward and is consistent with other ARB guidance on emission impact quantification of other transportation-related mobile source programs. These methods also use correction factors, such as those recommended by ARB for

adjusting new transit ridership by the proportion of riders who previously drove alone versus switching from another alternative mode or transit service.

6.2 Conclusions

This research has revealed several interesting findings for those managing or assessing the effectiveness of public education campaigns aimed at reducing travel, and therefore motor vehicle emissions. In so doing, a less expensive but still accurate method has been developed to allow air districts the ability to easily quantify the impacts of their ozone action programs.

This research corroborates local evaluations that have measured emission impacts in various ways. However, the research also shows that survey respondents over-report the number of trips they actually reduce, and thus the method adjusts self-reported behavior changes to off-set this potential over-estimation of benefits.

One of the goals of the research report was to improve the chances for Spare the Air programs to be approved by EPA as a control measure in State Implementation Plans. EPA staff on the Research Working Group are in general agreement that the recommended method advances the evaluation of episodic public education programs and that use of the method will enhance consideration for SIP credit. They recommend that any agency that intends to use this or a similar method for SIP or conformity credit consult with EPA and other appropriate agencies well in advance of applying for SIP credit.

Overall, the research findings and recommended method should assist air districts and others interested in evaluating the impacts of episodic ozone action programs by offering a consistent, affordable and accurate means for quantifying the travel and emission benefits of these programs.

7.0 Recommendations

The course of this research has suggested some areas for future dissemination, assistance, and research. The agency or group to provide this research or assistance might include: the ARB, EPA, or an organization or consortium of air pollution agencies, such as the somewhat informal consortium of air agency public information staff that manage ozone action programs that meet periodically around the U.S.

Dissemination

The results of this research should be disseminated to California air quality agencies, metropolitan planning organizations, and other local agencies in order to provide new information on the impacts of public education campaigns tied to episodic ozone action programs. Information might include:

- ✓ Findings on the proportion of drivers who respond to ozone alerts
- ✓ The "typical" response of these drivers in terms of trip reduction
- ✓ The need for a correction factor based on evidence of over-reporting of trip reduction
- ✓ Information on the types of trips reduced (e.g., discretionary trips)
- ✓ The resultant emission reduction findings from these travel behavior changes

This dissemination can take many forms, including:

- ✓ Presentations at conferences and seminars (e.g., AWMA, TRB, etc.)
- ✓ Papers submitted to air quality and transportation journals
- ✓ A brief summary prepared by ARB or EPA (i.e., from Executive Summary)
- ✓ Posting to websites, including ARB and EPA's TRAQ site

Future Assistance

The method developed from this research could be the subject for future training and assistance from ARB, EPA or others. The stand-alone reference manual prepared for this research effort (Appendix A) provides air districts and others with a "how-to" guide for using the recommended method to quantify the results of their episodic ozone action programs.

EPA's Transportation and Air Quality (TRAQ) program periodically organizes or assists with workshops around the U.S. to promulgate new guidance. Such workshops are good

opportunities to present the recommended method. A similar workshop might be considered for California.

Finally, the method could be automated in the form of a calculation spreadsheet or database, similar to ARB's current guidance on Air Quality Cost Effectiveness of Employer TDM Programs.

Future Research Recommendations

The design and execution of research is never perfect and there are always ways to advance our understanding through added research effort. The following are some possible avenues to improved understanding of Spare the Air programs suggested by the research reported here:

- A replication of the current analysis in another air district would advance our understanding of the development of correction factors and give us added confidence on our knowledge of how to do this. It would be particularly helpful if such a replication were to include trip-taking information from data loggers, or another unobtrusive mechanical means of tracking vehicle movements. Global positioning satellite systems might be a possibility. This would provide a powerful means of checking information from surveys and would help us understand their strengths and limitations better.

- Replication of the study of driver characteristics associated with being an STA reducer, with analysis of added factors believed to influence STA trip reduction, would be helpful in the design of STA trip reduction advertising campaigns.

- Research on the cumulative impact of STA advertising would also be desirable, both from the beginning to the end of a seasonal campaign or from year to year. Some air districts wonder if their program becomes more effect as the summer public education campaign gets more exposure or if, on the other hand, drivers become insensitive to Spare the Air pleas over time.

- Research into the behavior of non-reducers on Spare the Air days might help explain why this research found that non-reducers made more driver trips on Spare the Air days than on other days. This might also help focus the public education campaign if the message is having the unintended affect of warning drivers as to conditions that actually increase driving among the general public.

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List of Inventions Reported and Publications Produced

No inventions were reported as part of this research and no publications produced to date.

Glossary of Terms and Abbreviations

Acronym or Term	**Defintion**
ARB	California Air Resources Board
BAAQMD	Bay Area Air Quality Management District
BAYCAP	Bay Area Clean Air Partnership
CAA	Clean Air Act
CO	Carbon Monoxide
ECO	Employee Commute Options
EPA	U.S. Environmental Protection Agency
FHWA	Federal Highway Administration
LES	Less Expensive Survey
MOA	Memorandum of Agreement
NOx	Oxides of Nitrogen
OMS	Office of Mobile Sources
PM_{10}	Particulate Matter
ROG	Reactive Organic Gases
SACOG	Sacramento Area Council of Governments
SIP	State Implementation Plan
SJVUAPCD	San Joaquin Valley Unified Air Pollution Control District
SMAQMD	Sacramento Metropolitan Air Quality Management District
STA	Spare the Air

TRAQ	Transportation Air Quality (Center)
VMEP	Voluntary Mobile Source Emission Reduction Program
VMT	Vehicle Miles of Travel
TMA	Transportation Management Association
VOC	Volatile Organic Compounds

Appendix A

Quantification Method Reference Manual

A Method to Measure Travel and Emission Impacts of Ozone Action Public Education Programs

Appendix A of Research Report
ARB Contract No. 98-318

Quantification Method Reference Manual

A Method to Measure Travel and Emissions Impacts of Ozone Action Public Education Programs

Prepared for:

California Air Resources Board,
U.S. Environmental Protection Agency,
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April 30, 2003

Disclaimer

The statements and conclusions in the Report are those of the contractor and not necessarily those of the California Air Resources Board, the U.S. Environmental Protection Agency, or the Federal Highway Administration. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

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The original title of this research was: *Quantification Methods for Identifying Emission Reductions Resulting from Seasonal and Episodic Public Education Programs*

The consulting team included Eric N. Schreffler, ESTC, as principal investigator and prime contractor. Tim McLarney, PhD, Rick Sarles, and Bryan Godbe (Godbe Research and Analysis) conducted the survey research. Tom Higgins and Will Johnson, PhD (K.T. Analytics), conducted the analysis. ENVIRON assessed secondary data sources. Barbara Joy of Earth Matters provided input on the emissions analysis and edited the document. Kenneth Train, PhD provided key insights into the research design and recommended method. Gary Hawthorn provided input on environmental policy. Greg Stempson conducted research on employer data. Barb Laurenson researched the Spare the Air program in the Bay Area.

The research was funded by ARB and the Sacramento Metropolitan Air Quality Management District and through a grant provided by the U.S. Environmental Protection Agency and the Federal Highway Administration.

A Working Group provided direction and input to the research and consisted of:

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Table of Contents

One Background and Purpose

Episodic Emission Reduction Public Education Campaigns
(Ozone Action Programs)

Episodic emission reduction programs are public awareness campaigns designed to encourage individuals to reduce activities that contribute to air pollution on days when pollution levels are likely to be high. The campaigns provide information to the public through press, radio, television, billboard and similar media. This information is often supplemented by local area employers. Information about what activities contribute to pollution and what alternatives can be used to reduce pollution is provided. An example of an episodic program is an ozone action program.

Many cities in the U.S. have implemented ozone action programs to notify the public when air quality standards might be exceeded. These programs attempt to reduce harmful emissions on days when conditions are prime for high levels of ground level ozone. The alert programs are intended to educate the public and motivate individuals to curtail use of certain products or activities, such as consumer products (aerosols, some paints, etc.), outdoor barbequing, and use of the automobile on forecast exceedence days. Automobile emissions account for roughly a third to a half of ozone precursors (hydrocarbons and nitrogen oxides).

These "episodic" emission control programs are becoming increasing popular across the country as an innovative approach to reduce emissions. Specific benefits associated with these episodic controls programs often include:

- Education of the public on air quality issues
- Help in attaining and maintaining national ambient air quality standards
- Meeting specific emission reduction targets
- Managing/reducing congestion on episodic days
- Maintenance of economic benefits associated with air quality attainment status
- Protection of public health[1]

Episodic public education programs, often called ozone alert or ozone action programs (and all used interchangeably in this report), are becoming increasingly popular as new cities face designation as federal air quality non-attainment areas, as cities respond to the new 8-hour ozone standard, or as some cities seek new strategies to achieve or maintain attainment with air quality standards.

These episodic programs are appealing to areas which may have had limited success in achieving behavior changes on an ongoing basis. Ozone action programs seek reduction when air quality conditions are most critical and ask for responses on those days. They may also have the benefit of inducing long-term benefits by educating the public on air

[1] USEPA, " " Office of Mobile Sources, EPA420-F-97-022, December 1997.

quality hazards and the measures that individuals can take at any time to support cleaner air.

Purpose of Reference Manual

Areas that implement ozone alert or other episodic programs can benefit from quantifying the impacts of the program. Quantification of the benefits is required if an area is using the program for emission reduction credit in an air quality plan. Quantification is also highly useful for tracking and measuring the effectiveness of the program against its stated goals and for providing objective information to compare the program's effectiveness to other programs competing for public resources.

This reference manual provides a simple method for measuring the travel and emission impacts associated with these episodic public education campaigns. The method, as described here, would not readily apply to seasonal programs. The U.S. Environmental Protection Agency (EPA) allows up to 3 percent SIP credit (against needed emission reductions to achieve attainment), but few cities have adequately evaluated the quantifiable impacts of their programs. The method described in this report involves a simple survey that can be undertaken taken at a relatively low cost and in a short period of time (e.g. $15,000 – $75,000 with surveying conducted through the ozone season and then tabulated/reported over the following couple of months). The results of this simple and less costly survey are adjusted using a correction factor to accurately approximate the results that would have been achieved in a more extensive survey. Using surveys to measure travel behavior change and projecting the results to the entire population of drivers in a region should probably be more accurately called "estimation" of impacts. However, "measurement" is the more common term used by air districts and other practitioners, therefore, it is used in this reference. Other terms that have been used include evaluation and quantification.

In the study that led to the method described here, an extensive survey process was employed to collect detailed travel data. In addition, a set of simple "summary" survey questions was also included. A correction factor was then developed to adjust the results of the simple survey questions to replicate the results of the more extensive survey design. The simple survey, together with the correction factor, is the basis of the method recommended in this reference document. The method was developed with input and direction from the California Air Resources Board (ARB), EPA, the Federal Highway Administration (FHWA), the California Department of Transportation, three local air quality management districts in California, and other transportation and environmental organizations.

The remainder of this document includes:

> ***Section Two*** discusses why a city or air district would want to quantify the impact of their episodic public education program.

Section Three provides a basic overview of the recommended method for measuring impacts.

Section Four describes the planning process that should precede such an evaluation.

Section Five details, in step-by-step fashion, the data collection phase of the quantification method.

Section Six provides instruction on the measurement phase, including calculation of program impacts and a set of example calculations based on the 2002 Bay Area ozone action program (called "Spare the Air") evaluation that used the recommended methodology.

Section Seven discusses ways to summarize and report the findings of the evaluation.

Section Eight provides a case study of the 2002 San Francisco Bay Area "Spare the Air" program.

Section Nine provides sources of additional information and guidance from ARB and EPA.

Attachment 1 provides an example of the survey used in the Bay Area for collecting the necessary data and a summary of the responses.

Attachment 2 provides a detailed discussion of how to select the appropriate sample size for the survey.

Attachment 3 provides average auto emission factors for California.

Two Why Measure Program Impacts?

2.1 Why Evaluate Public Education Programs?

The genesis of this reference lies in the desire of several air districts in northern California to measure the travel and emission impacts of public education programs in a consistent manner, acceptable to state and federal air agencies. The California Air Resources Board (ARB) responded by commissioning the research that formed the foundation for this reference manual. The reference adds to ARB's growing set of evaluation methods related to trip reduction. EPA and FHWA were also partners in this research and reference to provide air districts a simple method for quantifying the emission impacts of these programs, allowing states to claim and maintain emission reduction credits for this aspect of their voluntary efforts (see below).

The primary purpose of this reference is to provide an acceptable approach for estimating the impacts of an episodic program such as an ozone action program for the purpose of crediting emission reductions in an air quality attainment plan. However, there are many other reasons why an agency might want to evaluate their public education program and measure travel and emission impacts:

- First, program managers, those responsible for developing, implementing, budgeting, and managing the public education campaigns should want to know how well the program is fairing against **stated goals** or implicit expectations. It is good management practice to annually or periodically evaluate how your program is doing.

- Second, the funding sources and decision makers that oversee the funds and programs want to know what **"bang for the buck"** they are receiving for the public expenditures. This "public accountability" issue is an important consideration, especially for programs that spend significant resources on paid advertising.

- Next, air quality and transportation specialists may want to know how successful and **cost effective** public education programs are in relation to other existing and potential means for reducing automobile emissions.

- Finally, environmental groups, the media, and the public are often interested in **learning the impact** of these ozone action programs given their visibility and potential importance to the region's air quality strategy.

Overall, the best advice might be summarized as "do it for yourself!" Program evaluation and assessment makes for good program management and allows you to address questions of air quality impacts and accountability to the public. The next two

sections discuss the need for measurement within the EPA voluntary measures credit process and within other air quality planning activities.

2.2 What is SIP Credit?

State Implementation Plans (SIPs) are formal plans showing how an area will meet federal air quality standards. SIPs must include control strategies for reducing emissions. Control strategies include a variety of emission control measures deemed appropriate for a given area. Each control measure includes estimates of how much it will reduce emissions. Reductions from each control measure count toward the total reductions needed in order to attain the air quality standard. These emission reductions are called "SIP credit" and must be developed in accordance with approved analysis methods conducted in coordination with local agencies.

In October 1997, EPA issued guidance that allows non-attainment areas to seek SIP credit for Voluntary Mobile Source Emission Reduction Programs (VMEP), including Seasonal and Episodic Ozone Action Day Programs. The policy allows regions and states to claim up to 3% of the total emission reductions needed for attainment to come from identified VMEPs. A few states have claimed credit in their SIP for voluntary activities, including ozone alert programs, among other activities. States may take this credit up-front if they base the anticipated emission reductions on realistic estimates (taking into account some uncertainties) and they *"commit to monitor, evaluate and report the resulting emissions effects of the voluntary measure."*[2] This guidance also requires that states describe, up front, how they plan to evaluate their programs and report results. So, areas need to carefully show how the anticipated emission results were forecasted and how the actual emission results will be measured based on the program as implemented.

As such, it is important that you work with your regional EPA office as you plan your measurement process if you are planning or contemplating seeking SIP credit. EPA anticipated this quantification methodology in their 1997 VMEP guidance. However, they also state that *"acceptable methodologies and procedures will not be limited to those developed by EPA…programs are encouraged to discuss technically sound alternative methods with EPA Regional Office staff."*[3] The bottom-line is, if you are seeking SIP credit, with or without using this quantification method, you should plan on early consultation with your EPA Regional Office.

[2] USEPA, "Guidance on Incorporating Voluntary Mobile Source Emission Reduction Programs in State Implementation Plans" Memorandum from Richard Wilson to EPA Regional Administrators, 10/24/97., p. 2..
[3] USEPA, op cit, p. 10

2.3 How Can Program Measurement Help with Other Air Quality Planning Activities?

While the primary uses for program measurement may include estimating progress toward SIP credit and general program evaluation, there are other air quality planning processes that can benefit from measuring the effects of episodic programs. These include:

- Quantifying impacts of federal Congestion Mitigation and Air Quality (CMAQ) projects, if CMAQ funds are used for the program, and comparing projected emission reduction to actual results;

- Quantifying emission reductions that could be used in conformity demonstrations if the program is not used for SIP credit, otherwise the conformity demonstration would presumably use the same emission reduction estimate as the SIP did, which is normal practice, or for conformity demonstrations covering years after the air quality attainment year;

- Quantifying emission reductions of other pollutants which are either maintenance or prevention of significant deterioration issues;

- Quantifying emission reductions of pollutants for which an area maybe at risk for nonattainment;

- Providing continued emission reductions;

- Quantification of program impacts for assessing congestion mitigation and other impacts;

- Assessing the effect of public information efforts on air pollution causing activities.

In short, there are many benefits available when applying a quantification method to estimate the effects of episodic programs.

2.4 Who Should Use this Measurement Method?

The above discussion about *why* someone might want to evaluate an episodic public education campaign suggests who might use this reference. Clearly, **program managers and public information officers**, who design, implement and shepherd ozone alert programs, should be interested in documenting the impacts of their programs. Other **air quality planners** and those responsible for SIP analysis, conformity, and other aspects of developing attainment or maintenance plans should find the method useful in both forecasting the potential impacts of these programs as well as quantifying the actual impacts. **Transportation** and air quality **planners** at Metropolitan Planning Organizations and other transportation agencies might also find the method useful to

assess the travel reduction impacts of public information programs. **State and federal air quality regulators**, who require measurement, should be interested in disseminating the reference and supporting its use. Finally, **marketing research** professionals and travel behavior specialists might find the method and its implications interesting to assess how people translate the public education message into action.

Three Overview of the Method

3.1 Basic Steps in Applying the Measurement Method

Most areas with existing ozone alert programs have undertaken surveys of area residents during or immediately after the "smog" season. These surveys are generally designed to gauge awareness of the program and specific messages within the public education campaign and its information channels (e.g., T.V., radio, print, etc.). These surveys are sometimes undertaken by advertising and marketing research firms that help design the campaigns for the purposes of improving the message and information channels. The method described in this document is designed to use a modified version of these awareness surveys to quantify the travel and emission impacts of public education programs. Areas that have not conducted surveys for their existing program, as well as areas that are just beginning a program, will find this method easy to implement.

The key feature of the survey method is the ability to collect information from area drivers on their self-reported changes in travel behavior and reasons for those changes on ozone action days. The survey should be fielded on the evening of an ozone alert so as to minimize any issues of diminished recall. As such, the method does not readily apply to seasonal programs. The method asks respondents for changes in their travel behavior on the day of the survey, not about changes over an entire summer or winter season. In contrast, seasonal program evaluations are more likely to involve a panel (multiple surveys of the same people) survey before, during and after the smog season.

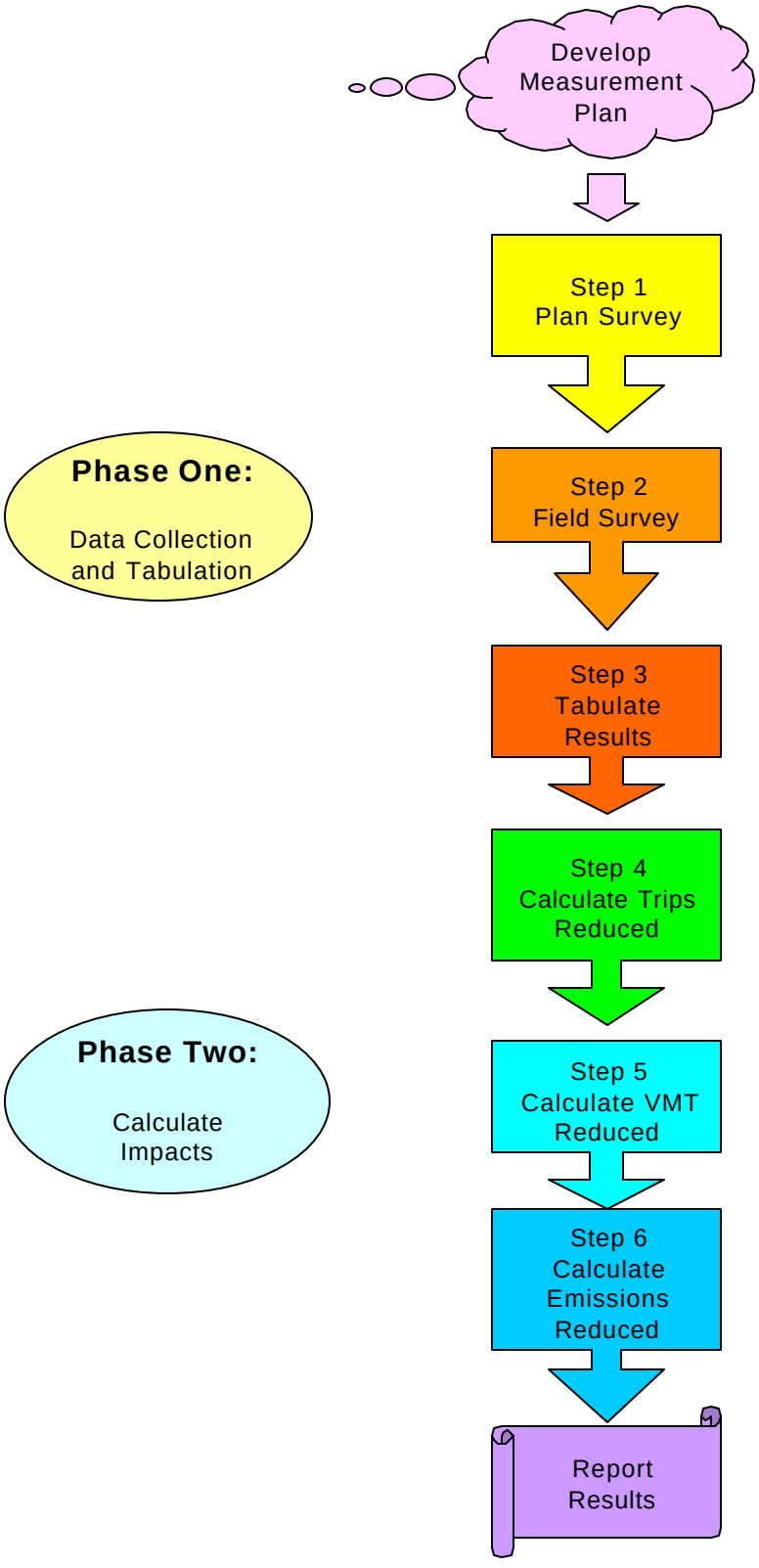
Figure 3.1 enumerates the key steps in the measurement method. The method begins, like any good planning process, with establishment of evaluation objectives in a measurement plan. Why are you measuring program impacts and what do you need to say when you have completed the evaluation?

The first phase of the quantification process involves the collection of survey data, including modification of the survey instrument, design of the survey protocol, and fielding of the survey on ozone alert days. The survey results are then tabulated and key responses are summarized to use in estimating impacts.

The second phase of the process calculates emission reduction from the program. Steps include the estimation of trip reduction (measuring the reduction of car use in response to the air quality message), translation of the number of trips reduced to the amount of vehicular travel (miles) reduced, and conversion of travel reduction to emission reduction (reduced tail pipe and evaporative emissions from reduced automobile use). These reductions can be reported as emissions reduced per day and per season. The cost per pound of emissions reduced can also be estimated so that the cost effectiveness of public education programs can be compared to other mobile and stationary source strategies.

Figure 3-1

Flow Chart of Measurement Method



3.2 Key Features of the Measurement Method

The recommended method has two key features that may differentiate it from other approaches. First, it relies on self-reported trip reduction among "qualified" drivers (those who reduced trips for air quality reasons in response to the program). . Second, and most importantly, it adjusts this self-reported trip reduction with a "correction" factor to account for the normal over-reporting of trip reduction among survey respondents. Each is discussed below.

Self-reported Trip Reduction

It seems fairly straightforward to ask residents or drivers whether they reduced travel as a result of the public education campaign and advertisements asking them to do so. However, when respondents sense what the socially acceptable answer might be, such as "I didn't drive as much today," they tend to provide this answer whether they did or didn't actually change their behavior. Early surveys asked respondents if they had heard the message asking them to drive less and if they indeed reduced driving. This was clearly a leading question. Other surveys asked if respondents increased, reduced, or traveled the same amount over their "normal" activity. This is problematic because in people's increasingly complicated lives, there is no longer such a thing as a "normal" or "usual" day or travel pattern.

Therefore, this method gets at trip reduction by asking two key questions at the beginning and end of the survey. Toward the beginning of the survey, area drivers are asked whether they "purposely" increased or decreased the amount of driving they did that day. People can purposely change their travel habits for a variety of reasons, including irregular activities, such as doctor's appointments or business meetings. They can also change their travel patterns in response to public pleas to reduce trips in response to poor air quality. Drivers are asked about increases and decreases in driving for that day so as to not bias their response or "tip" the survey's purpose. Then, late in the survey, respondents are asked ***why*** they reduced their driving and are not prompted with certain responses. If they respond that they reduced their driving because of the ozone action program and its message, they are deemed a "Reducer." As such, the survey has been carefully designed to elicit honest and accurate responses to the issue of trip reduction.

Two of the key survey responses used to calculate travel and emission impacts are:

- The proportion of drivers who reduce trips as a result of the program
- The self-reported number of trips they reduce

Correction Factor

Developing clear, non-leading questions that provide the necessary data to measure the impacts of the program is an essential part of the research that underpins the recommended method. However, the need to adjust self-reported trip reduction is the most crucial and unique aspect of the method. At the outset of the research it was acknowledged that people tend to *under-estimate* the number of trips they take in a day or a week. This is due to recall issues (hard to remember) or to the fact that people do not think of trips in the same way transportation analysts do. To transportation professionals, a trip is travel from point A to point B for a given purpose. So, if you drive from home to a convenience shop to get coffee and a donut and then on to work, this is two trips in the eyes of transportation planner – one shopping trip and one work trip. To most people, this is a typical commute trip.

Knowing this, the research was carefully designed to account for people's recall and the ability to describe trip-making activity in a simple survey. In the research, the questions mentioned above about trip reduction and reasons for that reduction, were included. However, the survey used in the underlying research also included detailed "diary" type survey questions about each trip made in the past 24 hours. This allows summary trip reduction responses to be compared to detailed trip making patterns.

The research design also evaluated two types of drivers during alert days and other days. "Reducers" (those saying they purposely reduced trip in response to ozone alerts or for air quality reasons) were surveyed on ozone alert days and also on non-alert days so that their actual behavior (actual change in trips made on alert and "normal" days) could be assessed. The same survey was also undertaken among all drivers on alert and non-alert days as a control to see if people traveled differently on ozone action days, for whatever reason.

The correction factor was developed as a ratio of "estimated" net trip reduction over "self-reported" trip reduction to come up with an adjustment factor for self-reporting. "Estimated" net trip reduction was derived from the careful research design that looked at alert day behavior and normal day behavior among reducers and all other drivers. The survey results yielded an estimate of average net trip reduction of about 1.1 driving trips per reducer.

The correction factor was then derived by dividing the estimated net trip reduction findings (1.1 trips) by the self-reported number of trips reduced among reducers, which was 2.2 trips reduced on ozone action days according to the summary reduction questions asked in the survey.

$$\text{Correction Factor} = \frac{\text{1.1 net trip reduction}}{\text{2.2 self-reported reduction}} = 0.5$$

Thus, the research conducted in association with this reference revealed that people who reduce trips in response to ozone action programs and air quality issues tend to

overestimate the number of trips reduced by an order of two to one. The method recommended here adjusts self-reported trip reduction survey results, using the correction factor, to bring it more in line with the findings of the more detailed research on travel behavior.

3.3 Why Can the Method be Used in My Region?

The research was conducted in Sacramento, so why can the method be used in any area with an episodic emission reduction public education program that includes a message of reducing car use? In a nutshell, the research developed a "relative" correction factor that is based on the relationship between summary responses and detailed responses of travel behavior on alert days and other days. And, since survey methodologists agree that survey respondents tend to answer questionnaires in a similar fashion, the correction factor should be applicable to any city.

However, what if your city has a different transportation system or more effective media campaign? Why discount trip reduction responses? Well, if there are more transportation alternatives in your city and people use them, then their number of self-reported trips reduced may be higher. If your media campaign is more aggressive, then the number of trips reduced may again be higher and the proportion of drivers who identify themselves as reducers will be higher. Therefore, unique aspects of your program that might result in increased program effectiveness will be reflected in the two primary survey responses: the proportion of reducers among drivers and the self-reported number of trips they reduce. The correction factor simply adjusts for people's tendency to over-report the number of trips they actually reduce.

Four Planning the Evaluation

4.1 Preparing a Measurement Plan

Program evaluation is often an afterthought to getting a new project off the ground or to annual ozone action program planning. This is because the impetus for measuring travel and emission impacts may have come from other parts of your agency or from other organizations.

However, having decided why evaluation is a good idea, based on the information in Section Two, you are ready to integrate evaluation into the overall program planning process. In fact, the results of yearly evaluations can become critical input for future program planning efforts.

The overall *evaluation* planning process should be well integrated into the annual *program* planning process, just as you plan for advertising, changes to the message, air quality forecasting, and media relations. As such, the overall annual program plans should include the resource and scheduling needs of the evaluation. The detailed plans for the evaluation and quantification efforts should be included in a ***measurement plan***.

The measurement plan will guide the evaluation, assist any contractors (such as survey contractors) in accomplishing their activities, and allow key individuals and agencies to review the measurement approach and intended results. For some air districts, this might mean having in-house air quality and transportation staff review the approach. For those who are contemplating SIP credit, the measurement plan should be reviewed by your regional EPA office to assure it meets the appropriate rigor for quantification.

The measurement plan might include the following items:

- Evaluation objectives
- Intended data to be collected
- Sample size and method
- Evaluation responsibilities
- Evaluation costs
- Evaluation schedule

Each is discussed below and further detail provided in Sections Five and Six. In addition to guiding the evaluation process, the measurement plan can be used as a guide for any evaluation contractor you might decide to retain to implement the evaluation, conduct the survey and/or prepare the measurement results. This will also help develop an evaluation scope of work for competitively soliciting bids from prospective contractors.

4.2 Elements of a Measurement Plan

Evaluation Objectives

Just as with any good plan, it is important to establish objectives for the evaluation itself. What are you trying to measure? How will you know if you measured results in a manner that will stand up to outside scrutiny? Some typical evaluation objectives might include:

- Measure travel and emission reduction impacts of the summer ozone alert program.
- Maintain objectivity and rigor throughout the quantification process.
- Report results and any needed explanations in a clear, straightforward manner.
- Finalize results within three months of the end of the ozone season.

Episodic public education programs may also have quantifiable targets or objectives set for them. In this case, the evaluation should attempt to measure fulfillment of or progress toward these awareness, travel or emission targets.

Data to be Collected

The measurement plan should carefully enumerate the data to be collected (Section Five) in order to estimate program impacts as described in Section Six. This will include:

- The proportion of self-identified "reducers" among all drivers in the non-attainment area
- The self-reported number of trips reduced
- The reason for reducing trips (awareness of ozone action message or air quality concerns)
- The type of trips reduced (work and non-work in order to assess trip distance)

The data elements might also include other areas of interest to the episodic public education campaign and its overall assessment. This might include the level of program awareness, recall of the specific message and call to action, awareness of employer support programs, and awareness of the air agency itself.

One good way for enumerating the data items is to outline the questions for the survey itself. This should begin with the recommended questions needed for impact quantification (see Section 5.1). An outline of the question topics and flow of the survey should be an integral part of the measurement plan and assist your evaluation contractor.

Sampling Plan

Another item that is needed, and which can help your evaluation contractor, is a specification of the intended survey type, sample source, sample size, and survey protocol. This reference manual makes recommendations in each of these areas, but you or your evaluation contractor could propose alternative approaches to accomplish the same level of quantification.

- **Survey type** refers to how the survey will be fielded (e.g., telephone interviews).
- **Sample source** is where you will get phone numbers from which to draw a random sample.
- **Sample size** refers to the number of useable surveys that you need to get in order to estimate the key data items needed to measure impacts. Specifically, you will need to decide how precise your estimates must be of the proportion of reducers and the average number of trips reduction in order to satisfy your evaluation objectives (see Attachment 2). You may need to adjust your survey plan in the middle of the ozone season if you are not getting enough surveys or if the variance around the key responses is higher or lower than expected.
- **Survey protocol** refers to how you will field the survey. In other words, will the survey be fielded the day of an ozone alert or the next day?

Evaluation Responsibilities

It is wise to also delineate who will be responsible for various elements of the evaluation. In other words, which elements will be contracted to a research or evaluation contractor? Which will be the responsibility of the public outreach staff and which handled by other agency staff? Will you use a ad hoc or standing committee of reviewers to review the results of the evaluation?

Evaluation Costs

Many program evaluation efforts suffer from under-budgeting, so it is important to estimate the needed financial resources for the evaluation. This might included needed staff time, contractor costs, separate survey costs, and reporting costs. This reference was designed to allow an air district or other agency to evaluate their ozone alert program for an annual cost of $15,000 to $75,000 in contractor costs. The lower bound of this estimate covers survey costs only and the upper bound includes surveying costs and contractor time to finalize the survey, tabulate results, and prepare an evaluation report. It is also important to note that survey length (in minutes) significantly affects surveying costs since the recommended method is a telephone interview.

Measurement costs can be minimized if you have a firm idea of the survey questions (including the specific questions provided here), the survey protocol, the sample size, and the data required for performing the measurement method and reporting results.

Contractor costs can be minimized if the telephone survey is out-sourced, but the survey preparation and report writing work is performed by agency staff.

Evaluation Schedule

Finally, it is important to develop an evaluation schedule that is well integrated into the overall annual ozone action program schedule. If, for example, the ozone season goes from May to October, a very generalized schedule might be:

January	Develop Measurement Plan and RFP
February	Solicit Bids for Evaluation Contractor
March	Select Evaluation Contractor
April	Draft Survey Instrument and Sampling Plan
May	Begin Surveying on Ozone Alert Days
August	Assess Sample to Date and Adjust
October	End Surveying
November	Tabulate Survey Results
December	Prepare Annual Evaluation Report

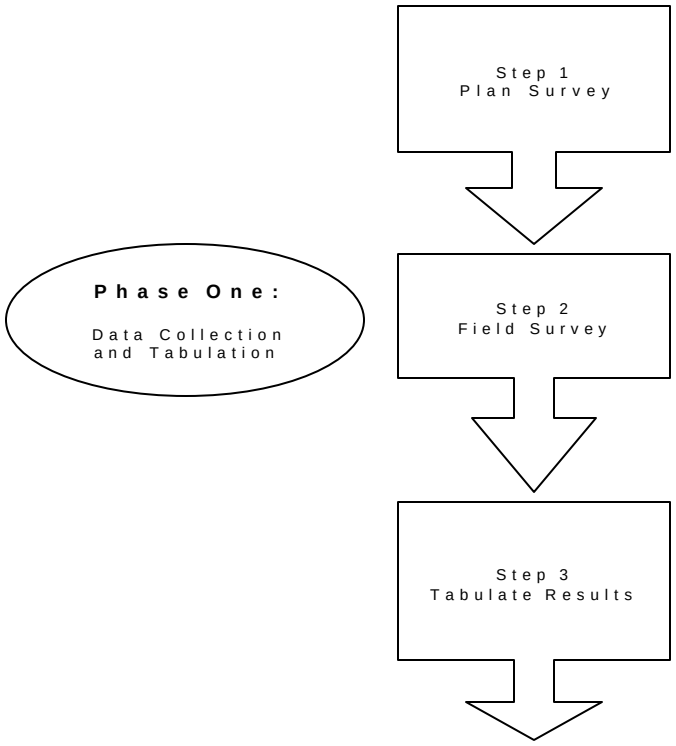
You may wish to perform an annual evaluation if you need to report results on an annual basis or to undertake annual adjustments to the program. If documenting the impact does not require annual reporting, then biennial or triennial evaluations may be more appropriate.

Overall, a sound and well thought out measurement plan can help you prepare for your first evaluation effort and each evaluation thereafter. The experience from each year should help to revise and strengthen the process and the effort in subsequent years.

The next two sections provide a detailed step-by-step guide for undertaking an evaluation of your episodic public education program. A quick reference for key recommendations is provided in a boxed format.

Five Phase One – Data Collection and Tabulation

This section enumerates the specific steps, with examples, of how to prepare a survey, field the survey, and tabulate results in order to gather the necessary data to calculate travel and emission impacts from you ozone alert program. The three steps in this phase, as shown in Figure 5-1, are:



Step 1 – Plan Survey

Step 2 – Field Survey

Step 3 – Tabulate Results

An example of a survey is included in Attachment 1.

Figure 5 –1

Phase One – Data Collection

5.1 Preparing to Survey - Step 1

Section Four described the need for and elements of a measurement plan. The measurement plan should outline the progression of steps necessary to evaluate your program and should be prepared by or with the ozone action program manager. However, you will probably need to contract with an outside vendor or consultant to perform the survey and tabulate the results. The measurement plan can become part of the solicitation for a vendor or consultant by helping interested bidders understand what you are intending to do.

However, the measurement plan will likely only outline the parameters of the evaluation and survey process. We recommend that you request of your contractor that they prepare a sampling plan and draft survey instrument based on the information in the measurement plan and the sample information provided in this reference. The sampling plan and certain survey parameters (length, method, etc.) can be included in the contractor's proposal, but the specific sample size, protocol, sampling frame and survey questionnaire should be developed as a collaborative exercise between the contractor and the ozone alert program.

> **Quick Reference:** *Use measurement plan as basis for retaining survey or evaluation contractor.*

The following is a recommended survey and sampling plan based on the research project's experience in Sacramento and San Francisco and includes information on the survey method, sampling frame, and sample size.

Survey Methodology

Since the objective of the evaluation is to assess the impact of the ozone alert message on all residents and drivers (as that is the target market), the recommended survey method is a Random Digit Dial (RDD) telephone survey of drivers within the non-attainment area or ozone alert targeted area. This involves calling households and asking to interview drivers. In Sacramento and San Francisco, we asked to first speak to the youngest male driver in the household. Why the youngest male? Experience has shown that women and older residents tend to answer the phone more than younger men, so this protocol assures that enough younger men are surveyed. You can monitor the survey results to make sure you are getting a good representation of ages and sexes.

> **Quick Reference:** *Use Random Digit Dial telephone survey of residents and drivers.*

Sampling Procedure

To determine which households to call, a directory of residential telephone numbers is needed. Telephone prefixes, that correspond to the zip codes within the target area, can be requested. These lists are often bought from special vendors for this specific purpose. A random sample needs to be drawn so that any resident and driver has an equal chance of being selected for the survey. This randomization maximizes the likelihood that the survey sample is representative of all drivers in the area.

> **Quick Reference:** *Obtain list of residential telephone prefixes within non-attainment area.*

Sample Size

The number of surveys that need to be collected depends on how accurate you would like the estimates of key survey findings. In order to measure impacts, the most important findings are a) the proportion of "reducers" among drivers and, b) the average self-reported trip reduction. For example, if the survey finds that 4% of drivers purposely reduce driving trips, and your desired accuracy is an error range of ± 1.2% was reasonable for the proportion of reducers, then the actual number may be between 2.8% and 5.2%. Likewise, if the survey finds that the average number of self-reported trips reduced is 2.0 with a sample variance of 2, and your desired accuracy is ± 0.5 trips, the actual average trip reduction could range from 1.5 to 2.5 trips reduced by reducers.

To meet this accuracy requirement for either proportion of reducers or self-reported trip reduction a sample size of 1,000 will be required. This conclusion depends on allowable error band. If you feel the above requirement is reasonable, i.e., ± 1.2% for proportion of reducers and ± 0.5 trips for mean trip reduction, then the sample size of 1,000 will be both necessary and sufficient to reach the requirement. Attachment 2 provides additional guidance on how to determine the sample size if you desire different accuracy levels.

> **Quick Reference:** *You should aim to collect at least 1,000 useable surveys.*

Remember, to achieve 1,000 completed surveys, you will have to contact many more residents due to refusals, lack of drivers at home, and surveys terminated while underway. Thus, a much larger sample is drawn (perhaps 3,000 – 5,000) to achieve 1,000 completed surveys.

Survey Instrument

You may already have a survey that you use during or at the end of the ozone season to assess awareness of and reactions to the public education campaign. This may be undertaken by or for the public relations or advertising contractors you use or conducted

by the air agency itself. On the other hand, you may have never conducted a survey as part of your program. In either case, in order to use the recommended measurement method, the questions you use for travel behavior and program awareness should be modeled after the recommended survey questions provided in this reference manual.

The research undertaken as part of this reference contemplated and tested various ways to ask about travel behavior changes and settled on an approach which asks drivers if they ***purposely*** increased or decreased their trip-making over the past 24 hours. Of course, there are many reasons why someone might decrease the number of trips they make by car, including personal circumstances such as having the car in the repair shop. However, one goal of the ozone action program is to induce people to purposely reduce their travel by car. Therefore, questions toward the end of the survey then asks why they decreased car use and if they heard any messages regarding clean air over the past few days. If they answer because they were aware of and responded to the public education message, or if they simply say they did it because of air quality concerns, and knew about the campaign, they are considered "reducers" in the measurement methodology.

The recommended survey questions to be added to your ozone season telephone survey are included on the next few pages. These questions can be added to other questions you might want to include, such as: general awareness of the campaign; knowledge of specific messages; changes in other behavior, such as use of consumer products or gardening equipment; knowledge of the air agency; and key demographics. Again, these should coincide with the evaluation objectives in your measurement plan. It is important to reduce survey bias by not mentioning air quality or the environment in the introduction to the survey and by asking questions about awareness of the campaign ***after*** asking about behavior changes. This will minimize the possibility that the respondent is answering questions based on perceived "green" responses instead of actual behavior. An example of the complete survey used to evaluate the Bay Area Spare the Air program, and a summary of responses for each question, is included in Attachment 1.

Recommended Survey Questions

To Determine Proportion of Reducers - ask of all respondents

1A We're interested in the travel behavior of people in the region. Sometimes people will purposely **increase** the amount of driving they do in a day. An example of purposely **increasing** driving would be if a person decided to drive to the store when they **normally** would have walked, bicycled or taken a bus. Between 6PM yesterday and 6PM tonight *(or other 24-hour time period, based on survey)*, did you purposely **increase** the amount of your driving?
(If respondent asks to clarify what purposely increasing driving is, say "It means deciding to drive someplace when you usually travel there without driving')

Yes _____
No _____
DK/NA _____

1B Sometimes people will purposely **decrease** the amount of driving they do in a day. An example of purposely **decreasing** driving would be if a person decided to take a bus, walk, bike or ride with someone else to work when they **normally** would have driven, or if someone decided to simply not take a trip they would have normally taken in a car. Between 6PM yesterday and 6PM tonight *(or other 24-hour time period, based on survey),* did you purposely **decrease** the amount of your driving?
(If respondent asks to clarify what purposely increasing driving is, say "It means deciding to travel someplace without driving when you normally would have driven or deciding not to take a trip you would normally take in a car')

Yes	_____ (go to Question 2)
No	_____
DK/NA	_____

(Note: It is vital to ask both about increasing and decreasing trips in the screener so as not to bias the response)

<u>To Determine Self-Reported Trip Reduction – ask of respondents who **decreased** trips only</u>

2A You indicated that you purposely decreased the amount of driving you did between 6 PM yesterday and 6 PM tonight. I'd like to ask you about the driving trips you purposely decrease during this period? A 'trip' is defined as traveling from one place to another and then stopping. For example, leaving your house and going to the store is one trip. Leaving the store and going to work or coming back home is another trip. Another example of a trip is leaving your house and going to the bus or train station. Taking the bus or train to work would be a second trip. How many driving trips did you purposely decrease during this period?

1	_____
2	_____
3	_____
4	_____
5	_____
6	_____
7 or more	_____
None	_____
DK/NA	_____
Refused	_____

2B Thinking of the (first/second/third…) driving trip you DECREASED, how did you decrease the trip?

Didn't take trip	_____
Carpool passenger	_____
Public Transportation	_____
Bicycle	_____
Walk	_____
Worked at Home	_____
Other	_____
Refused	_____

2C (If Answered 'DIDN'T TAKE TRIP' to Question 2B for this trip, ask): What was the purpose of the trip going to be? (Any other answer to Question 2B for this trip, ask): What was the purpose of this trip?

Going to or from work	_____
Shopping	_____
Other (school, errands..)	_____
Don't know	_____
Refused	_____

2D Why did you purposely decrease this driving trip? (Don't prompt for specific answers):

Ozone Alert Program (name) or ads asking people to drive less	_____
Air quality reasons	_____
Other	_____

Ask Questions 2B-2D for each trip the respondent reports that they decreased.

3A In the past two days, have you heard, read or seen any advertisements or news broadcasts about the Ozone Alert Program (name), or poor air quality, or requests to drive less in this area?

Yes	_____
No	_____
DK/NA	_____

(Note: This question can be replaced by an air district-developed question to determine whether or not the respondent knew it was an Ozone Alert day.)

Question 2B, how the trip was reduced, is optional, but important to capture how many trips were simply avoided versus due to mode change. These questions can be added to

any awareness, attitude, and demographic questions needed for market research or other program evaluation efforts, as long as the trip-related questions are asked first to avoid inserting any bias from the other survey questions.

> **Quick Reference:** *In order to use the recommended measurement method and correction factor, it is highly recommended you use the basic questions provided here.*

The information provided below and in Section Six provides specific instructions on how to use these questions to calculate travel and emission impacts.

Whether you modify an existing survey or create a new one from scratch and whether you develop it yourself or have your evaluation contractor develop the survey instrument, it is recommended that you have several people review it for clear language, logic, and specific attributes like the skip pattern and length. You may wish to have your contractor pre-test the survey instrument with around 10-20 individuals to check the length and to uncover any confusing language.

You may also wish to have the survey translated into other key languages, corresponding to your intended target market.

Remember, that the development and overall cost of the survey is more than drafting the questions. It will include survey development and the back and forth required to refine the questions, pre-testing, translation, and then the computer-programming necessary to have the survey available on a Computer Assisted Telephone Interview (CATI) system.

Survey Costs

In San Francisco, where the survey covered questions about trip reduction, consumer product use, and general awareness of the program and air district, the approximately 10 - 12 minute survey costs $10.00 - $20.00 per completed survey. As stated earlier, the entire measurement effort, including planning, surveying, calculating impacts, and reporting, should cost around $15,000 to $75,000, including survey costs (lower estimate) and consultant costs (higher costs). The cost estimates provided here are based on the research team's experience with the surveys used in this study as well as the total survey and contractor costs of current STA evaluations in California. The cost of the survey can be reduced by limiting the number of questions beyond those essential for evaluation purposes, as question duration (interviewing time) tends to drive surveying costs. If the survey only included those questions included above, the cost would be lower. Using the recommended survey questions provided here will also save contractor time and costs in survey development and pre-testing. After an evaluation scope of work is developed, the standard practice is usually to obtain bids from prospective contractors through an open "request for proposal" process. This allows an air district to compare different proposals and costs and to choose the contractor that best meets their needs.

Quick Reference: *The cost per completed survey will be around $10.00 - $20.00 for a 10-12 minute survey, including awareness and other questions in a standard follow-up survey.*

5.2 Conducting the Survey - Step 2

The actual conduct of the survey involves calling residents the evening of an ozone alert and then completing enough surveys over the course of the smog season to meet the sample size requirement without collecting all the surveys at one period.

Survey Protocol

The RDD survey should be conducted the evening of an ozone action day. So, for example, if an alert were called on a Tuesday afternoon for Wednesday, the surveying would commence Wednesday evening. In Sacramento and San Francisco, the survey was conducted from 6:00 to 9:00 p.m. If the episode lasted several days, surveys were conducted each night.

This presents somewhat of a dilemma for telephone survey vendors. The episodic nature of these public awareness campaigns means that surveyors will only have about 24 hours notice to prepare to survey. They must assure they have enough telephone interviewers on duty for the next night and may need to juggle other surveys being conducted at the same time. Most survey vendors will build this uncertainty into their surveying costs, but it is important to inform prospective vendors of this issue in advance.

Surveying also needs to be distributed over the entire ozone action season. This is important to capture the changes in program effectiveness over time and to avoid results being influenced by outside circumstances on a given day. For example, in the Sacramento research, one of the episodes for which surveys were collected coincided with a major wildfire north of Sacramento that brought smoke to the region. Had all the surveys for the season been conducted on during that one episode, the findings from the evaluation might have been significantly influenced by the presence of smoke. As it turned out, researchers found some variation in program effects from the beginning to the end of the season, but not from one year to the next. This might suggest that programs increase in effectiveness as residents are exposed to the public education message during the season.

Your survey or evaluation contractor will need to carefully decide how many surveys to collect during each episode. Again, this creates substantial uncertainty as the number of episodes and episode days varies from year to year and cannot be predicted. It is recommended that you collect at least 50% of the needed surveys early in the season, unless a large number of episode days occur in the first month or two.

Quick Reference: *The survey should be conducted the evening after an ozone alert is called.*

Readjust Sample Size

It is further recommended that you or your evaluation contractor monitor the survey process so that you can adjust the sample size or survey days if necessary.

It is important to check error range around each of the two key indicators (proportion of reducers among all drivers and self-reported average trip reduction) to see if your survey sample is meeting the requirements. If the range of error is significantly higher than the interval suggested here, you may need to increase your sample size by collecting more surveys.

You should also monitor the number of surveys being collected on a cumulative basis. If you have a lot of ozone alert days early in the season, you may wish to decrease the number of surveys per evening or even days you collect surveys. On the other hand, if you do not have any episode until the middle of the summer, you may need to increase the number of surveys you attempt to get each evening.

> **Quick Reference:** *Monitor survey progress throughout the season to determine whether the sample size or number of days surveyed needs to be adjusted.*

5.3 Tabulating Results - Step 3

At the end of the ozone season, or when an adequate sample is collected, the results should be tabulated for use in the subsequent calculation steps and for general use.

Generally, the results should first be tabulated as a set of "frequencies" for each question and possible response. This will be in the form, for example, of the number and percentage of respondents you say they have heard an ad or a news broadcast mentioning the ozone alert. These are sometimes called "top lines" because they can be tabulated and presented on the survey form itself. In other words, the number and percent of each response can simply be filled into a blank survey form for easy referral. This will also help to report survey results on other issues, such as awareness or knowledge of the air agency. Top lines are provided for the Bay Area sample survey in Attachment 1.

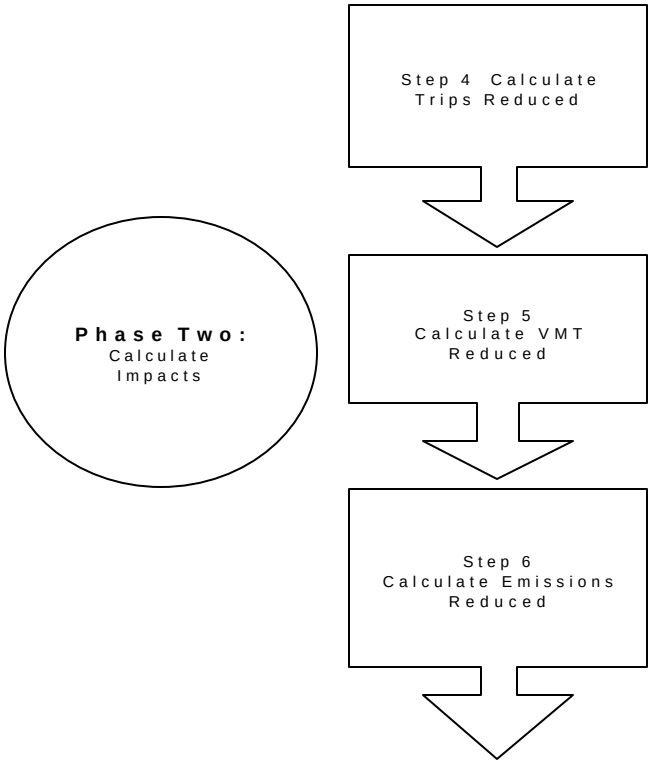
From the questions, the proportion of reducers can be derived (expressed as a percent of total drivers that have reduced their trip making as a result of the program). This will be derived from Questions 1B (reducer?), 2D (why reduce?) and 3A (aware of message). If the respondent said yes, they reduced trips in 1B *AND* they did so in response to the program or for air quality reasons in 2D *AND* they were aware of the ozone message, they are considered a reducer for the purposes of determining the proportion (%) of reducers among all drivers. This can be determined by running a conditional cross-tabulation of these questions.

The average number of self-reported trips reduced can be derived from Question 2A (how many trips reduced). From Question 2C on trip purpose (what would the purpose of the trip have been), the proportion of work and non-work trips reduced can be derived. This proportion is used to determine the average trip length reduced, which is used to estimate the change in vehicle miles traveled.

Quick Reference: *The survey results should be tabulated to allow for general results to be reported and key numbers generated for use in the method.*

Six Phase Two – Calculate Impacts

The ozone season is over -- you have collected the necessary survey data –now you can calculate the travel and emission impacts of your public education program. The measurement phase includes three steps, as shown in Figure 6-1. Travel and emission impacts include the calculation of vehicle trips reduced (number of cars taken off the road), the vehicle miles of travel reduced (the amount of car use reduced), and the reduction of automobile emissions (key pollutants removed from the air).



The next three steps include:

Step 4 – Calculate Trips Reduced

Step 5 – Calculate Miles Reduced

Step 6 – Calculate Emissions Reduced

Figure 6-1

Phase Two - Calculating Impacts

This section provides a simple method for calculating trip, VMT and emission reductions resulting from episodic public education campaigns. Armed with:

- survey results on the proportion of reducers,
- the average self-reported number of trips reduced,
- the trip reduction correction factor,
- the proportion of work and non-work trips reduced,

- information on the total number of drivers in the area, and
- their average travel distance for commute trips and other trips,

…you can calculate the travel and emission impacts of your program.

6.1 Calculating Trip Reduction - Step 4

Using data gathered via the telephone survey, the first part of the impact calculations will result in an estimate of the total number of vehicle trips reduced from the public education campaign.

The basic steps include:

Step 4a – Estimate Total Number of Reducers

Apply the proportion of reducers determined from the survey [Questions 1B (yes – decreased trips), 2D (in response to Spare the Air or air quality reasons), and 3A (yes, aware of Spare the Air message)] to the population of all drivers in the region to determine the total number of commuters who reduced trips on ozone action days.

Step 4b – Estimate Average Trip Reduction

From Questions 2A and 2D, determine the average number of trips reported by each reducer from the survey.

Step 4c – Apply Correction Factor to Self-reported Trip Reduction

Apply the recommended correction factor for adjusting self-reported trip reduction to derive adjusted average trip reduction. This corrects for the over-reporting of trips reduced by survey respondents in a summary question.

Step 4d – Estimate Total Adjusted Trips Reduced

Apply the adjusted number of trips reduced to the estimated total number of reducers in the population of drivers from Step 4a to derive total trips reduced.

Step 4e – Allocate Trips Reduced to Work and Non-work Trips

In order to correctly apply the emission factors in Step 6, the proportion of work trips (commute) and non-work trips (school, shopping, errands, entertainment, eating out, etc.) needs to be applied to total adjusted trips reduced. Using the proportion of

work and non-work trips reduced from Question 2C, the number of trips reduced for each of these two types of trip purposes can be estimated.

Quick Reference: *To determine the number of trips reduced as a result of the ozone action program, apply the proportion of reducers to the number of drivers in the region and then multiply the **corrected** average number of trips reduced to derive the adjusted total trip reduction for the region.*

To illustrate the application of the method, the following calculations are provided from the Bay Area case study (see Section Eight. The case study provides a background on the program and summarizes the results of the evaluation that used the recommended method.

Bay Area Example

Using results from the recommended survey Question 2 and applying the recommended method, including the correction factor to the Bay Area Spare the Air campaign for 2002, the following trip reduction impacts can be calculated:

Step 4a – Estimate the Total Number of Reducers

The proportion of reducers from the survey can be extrapolated to the total population of drivers in the region to estimate the total number of users.

In the Bay Area, the proportion of reducers was approximately 3.6% of drivers, based on the survey results. The number of licensed drivers in the Bay Area was approximately 4,750,000 in 2002 (according to regional planning sources). Therefore, there would be **171,000 reducers.** These reducers form the basis for trip, VMT and emission reduction estimates.

4,750,000 (drivers in region) x 0.036 (% reducers) = 171,000

Step 4b – Estimate the Average Trip Reduction

The average number of self-reported trips can be derived for the sample of reducers from the survey (that reduced for Spare the Air or air quality reasons).

In the Bay Area, the average self-reported trip reduction was **2.6** one-way driver trips**.**

Step 4c – Apply Self-Reported Trip Reduction Correction Factor

From the research, a correction factor was developed to relate the actual trip reduction to stated reduction (2.6 trips reduced). This correction factor is 0.50. Thus, due to over-reporting of trips reduced, respondents claim to have reduced twice as many trips than they actually do based on detailed analysis of behavior on Spare the Air and non-Spare the Air days and among reducers and non-reducers.

In the Bay Area, the 2.6 average stated trips reduced, when adjusted with the trip reduction correction factor (0.50) would be **1.3 trips** reduced per reducer.

2.6 (self-reported trips reduced) x 0.50 (correction factor) = 1.3 adjusted trips reduced.

Step 4d – Estimate Total Adjusted Trips Reduced

To estimate the total number of trips reduced, the adjusted trip reduction factor is applied to the total reducers.

In the Bay Area, the 171,000 reducers, each reducing an adjusted average of 1.3 trips, would realize an **overall regional Spare the Air day trip reduction of 222,300**.

171,000 (reducers) x 1.3 (average adjusted trips reduced) = 222,300 (total trips reduced)

Step 4e - Allocate Trips Reduced to Work and Non-work Trips

The total adjusted trips reduced need to be allocated to work and non-work trips in order to apply emission factors in Step 6 *(as noted below, if you do not have differential emission factors for commute trips versus all trips, you do not need to undertake this sub-step)*.

In the Bay Area, the survey found that work trips comprised 13% of trips reduced and 87% were from non-work trips. Thus, **28,899 work trips were reduced and 193,401 non-work trips reduced**.

222,300 x 0.13 = 28,899

222,300 x 0.87 = 193,401

6.2 Calculating VMT Reduction – Step 5

In order to estimate emission reductions, both the number of vehicle trips and the amount of travel, in terms of miles of travel, needs to be estimated. To estimate vehicle miles of travel (VMT) reduction, regional average trip lengths are used. Why not simply ask survey respondents how far they would have traveled? Research has shown that people have a hard time estimating mileage for all but the most routine of trips – such as commuting. Since the ARB research also showed that a majority of the trips reduced are not commute trips, the survey should not be used to estimate distance. Rather, a common practice in trip reduction evaluations is used, relying on regional average trip lengths from planning sources.

Step 5 – Applying Regional Trip Lengths to Trips Reduced

In this method, the number of work trips and non-work trips is used to estimated VMT reduction. Average trip distance for each type of trip (from regional planning sources --these distances are often used in regional transportation models and other analyses) are applied to the adjusted trip reduction results to derive VMT reduction.

Quick Reference: *Apply regional average trip lengths for work and non-work trips to total trips reduced for each type of trip to derive total VMT reduction.*

This process of converting trip reduction to VMT reduction is illustrated in the Bay Area example.

Bay Area Example

Step 5 – Applying Regional Trip Lengths to Trips Reduced

The Bay Area survey found that work trips comprised 13% of trips reduced and 87% were from non-work trips. Using these proportions, Step 4e estimated that 28,899 work trips and 193,401 non-work trips were reduced. The average trip length of a work trip is 13.69 miles and the average length of a non-work trip is 5.37 miles, according to regional planning sources. To estimate VMT reduction, the adjusted trips reduced are multiplied by the average trip length for each type of trip. Applying the average trip length for each type of trip to the adjusted number of trips reduced for each, **the program reduced 395,627 miles of work travel and 1,038,563 miles of non-work travel**. This equates to **a total of 1,434,190 miles of travel reduced**.

28,899 work trips x 13.69 miles = 395,627 work trip miles reduced

193,401 non-work trips x 5.37 miles = 1,038,563 non-work miles reduced

6.3 Calculating Emission Reduction – Step 6

The primary reason for evaluating the impact of your episodic public education campaign is, in one way or another, linked to its ability to reduce automobile emissions, clean the air, and contribute to your overall attainment strategy. Emission reduction calculations are really the easiest part of the method as they simply require application of standard emission factors to the trip and VMT reductions derived from the survey. Separate emission factors for work trips (commute trips) and for all trips are used, if available.

Emission Factors

Estimating emission reductions is a simple process if you have "per-start" and "per-mile" vehicle emission factors that can be applied to the results of trip and VMT reduction results. Then all you need to do is to multiply the VMT reductions by the appropriate emission factors expressed in grams per mile and the trip reductions by the appropriate emission factors expressed in grams per trip, and then convert the answer into pounds or tons. The only thing that may take time and effort in this step is obtaining these emission factors, which can be developed from the mobile source emissions model used in your region or by obtaining average emission factors developed by the air quality agency in your state.

If the analysis is being performed in California, you will use the EMFAC model or factors developed from it. If the analysis is being performed anywhere else in the United States you will use the MOBILE model. As of this writing, the most recent version of the MOBILE model is MOBILE6. The MOBILE model is developed by EPA. The most current version of the EMFAC model is EMFAC2002. The EMFAC model is developed by ARB.

If you are not familiar with the appropriate model, you can probably obtain the appropriate emission factors from your state air agency, your regional EPA office, or your local air district. In each case you would ask to speak with someone in charge of mobile source emission modeling. You would request emission factors for the year you want to analyze and specify that the factors be for averaged for light duty automobiles and trucks (passenger vehicles likely to be used as personal use vehicles). You will need to specify which pollutants you need (see next paragraph), and that you need gram per mile exhaust and evaporative emissions as well as trip end emission factors. If the agency cannot produce differential factors or commute trip-ends (per start) versus all trips, then the single per-start or per-mile factor can be applied to the total trips or VMT reduced (without having to established work versus non-work trips reduced). The example below uses the

EMFAC model, since the study and case examples leading to development of this reference manual were developed in California. By using the California emission factors, other regions would produce conservative estimates of emission impacts as the California vehicle fleet is cleaner than other states due to its more stringent emission standards.

The emission factors used in the examples presented here were provided by ARB, based on EMFAC2000, version 2.02. For program evaluations conducted in 2003 and beyond, newer EMFAC2002 factors should be used. They are provided in Attachment 3, along with an explanation for their use, implications of using the newer emission factors, and guidance for non-California applications.

Step 6 – Estimate Emission Reductions

Using the California Air Resources Board's (ARB's) or other locally-derived average auto emission factors for the given program year, the emission reductions from the public education campaign can be estimated by applying the Trip End emission factors to total vehicle trip reduction and VMT emission factors to total VMT reduction. This analysis is performed for nitrogen oxides (NOx), reactive organic gases (ROG), and particulate matter (PM_{10}). If you have different emission factors for your state (e.g., not California), or also want to include Carbon Monoxide (CO) estimates, these emission factors can easily be substituted in the method by using emission factors developed with the MOBILE emission model.

Quick Reference: *Apply trip end and VMT emission factors for each key pollutant to the work and non-work trip and VMT reduction estimates to derive total emissions reduced per day by pollutant.*

NOx, ROG and PM_{10} emission reduction calculations are provided for the Bay Area example.

Bay Area Example

This example uses emission factors from the EMFAC2000 model in order to maintain consistency with local air quality planning practice. It is recommended that any subsequent analyses use the most recent version of the EMFAC model (currently EMFAC2002). EMFAC2002 has additional data and refinements listed in the section after the example calculation.

The following emission factors were used for program year 2002 based on EMFAC 2000 Version 2.02:

Analysis Period	2002
ROG	
VMT (g/mile)	0.813
commute trip ends (g/trip end)	2.363
average trip ends (g/trip end)	1.413
NOx	
VMT (g/mile)	0.881
commute trip ends (g/trip end)	0.905
average trip ends (g/trip end)	0.757
PM_{10}	
VMT (g/mile)	0.224

Step 6a – Estimate NOx Reductions

Using a Trip End NOx emission factor for 2002 of 0.905 grams per trip end for commute (work) trips and 0.757 grams per average (non-work) trip end and a VMT factor of 0.881 grams per mile, the **estimated emission reduction for each Spare the Air** day **is 1.58 tons** as derived for the Bay Area thusly:

a) 28,899 work trips (starts) reduced x 0.905 grams/start = 26,154 grams per day

193,401 non-work trips reduced x 0.757 grams = 146,405 grams per day

26,154 grams + 146,405 grams = 172,559 grams = 380 lbs. or 0.19 tons per day NOx reduced

b) 1,434,190 miles reduced x 0.881 grams/mile = 1,263,521 grams = 2,783 lbs. or 1.39 tons per day

c) 308 lbs. + 2,783 lbs. = 3,091 lbs. NOx per Spare the Air day

d) 0.19 tons + 1.39 tons = 1.58 tons NOx per Spare the Air day

Step 6b – Estimate ROG Reductions

Using a Trip End ROG emission factor for 2002 of 2.363 grams per trip end for commute (work) trips and 1.413 grams per average (non-work) trip end and a VMT factor of 0.813 grams per mile, the **estimated emission reduction for each Spare the Air** day **is 1.66 tons** as derived for the Bay Area thusly:

a) 28,899 work trips (starts) reduced x 2.363 grams/start = 68,288 grams per day

193,401 non-work trips reduced x 1.413 grams = 273,276 grams per day

68,288 grams + 273,276 grams = 341,564 grams = 752 lbs. or 0.38 tons per day ROG reduced

b) 1,434,190 miles reduced x 0.813 grams/mile = 1,165,996 grams = 2,568.3 lbs. or 1.28 tons per day

c) 752 lbs. + 2,568.3 lbs. = 3,320.3 lbs. ROG per Spare the Air day

d) 0.38 tons + 1.28 tons = 1.66 tons ROG per Spare the Air day

Step 6c – Estimate PM_{10} Reductions

Using a VMT PM_{10} emission factor for 2002 of 0.224 grams (*from EMFAC 2000, v.2.02*), the **estimated emission reduction for each Spare the Air** day **is 0.354 tons** as derived for the Bay Area thusly:

a) 1,434,190 miles reduced x 0.224 grams = 321,259 grams = 707.6 lbs. or 0.354 tons per day

Note: EMFAC2002 has "trip end" emissions associated with PM_{10}. As shown in the examples for NOx and ROG, these emissions should be included in the total emission reduction calculation when using the method with the emission factors included in Attachment 3.

Step 6d – Estimate Average Daily Emission Reduction

The emission reduction calculations will be for a given Spare the Air Day. In a SIP, the reductions would likely be expressed in terms of tons per average ozone season day. If you are just evaluating the ozone program impacts for the purposes of an attainment demonstration, you can use the first technique to estimate emission reduction per ozone day and for the sum of all ozone days. To estimate total program emission reductions, you should:

a) multiply the Spare the Air Day daily emission reductions by the number of Spare the Air Days in the ozone season to estimate total emissions reduced over the season

If you want to estimate the impact for each day during the ozone season, to compare with any SIP estimates or to compare with other episodic measures, you should:

b) divide the total emissions over the season by the total number of days in the ozone season to arrive at a daily average emission reduction to report in the SIP.

Seven Reporting Results

The final, and equally important, step in measuring the impacts of your ozone alert program is the reporting of results. The form of this reporting depends on the primary audience for the information. However, a clear and well-written evaluation report and concise executive summary should be able to satisfy different needs, such as: agency management and board, internal air quality technicians, the media, other agencies (such as ARB and EPA), etc.

There are several key components of the report that should be included in any comprehensive evaluation report:

- An explanation of the purpose of the evaluation
- A description of the public education campaign and its objectives
- A listing of episode days and any other occurrences on those days
- A description of the survey process and levels of acceptable error
- A summary of all the survey findings
- A summary of the quantitative findings (trips, miles and emissions reduced)
- An interpretation of other findings (such as awareness and other issues)
- Conclusions and implications for future years
- An explanation of the quantification method and correction factor
- An appendix with the measurement calculations
- An appendix with the survey instrument

The summary of quantitative findings will need to show the results in terms of vehicle trips, VMT and emission reductions per episode day. The results of the evaluation cannot be applied to all days of the year or the ozone season, only to the number of alert days called for that year. This is because travel may only be reduced on those days.

When comparing across multiple years, it is important to show the trip and VMT reduction results for comparative purposes. Emission reduction findings will be affected by changes in emission factors. Emission factors change as the vehicle fleet changes and gets cleaner and as the science of emissions modeling improves. When comparing results across different years **and** regions, it may be better to compare the proportion of reducers and the average adjusted self-reported trip reduction as performance measures of program effectiveness.

Using the recommended method and standardized survey questions should allow air districts and others to confidently measure and interpret program impacts and begin to allow for more comparisons over time and across regions. This will serve to increase the confidence that policy makers have in episodic public education campaigns to deliver measurable emission reduction benefits.

Eight Case Study: Bay Area Spare the Air Program

This reference manual utilizes data from the Spare the Air program implemented by the Bay Area Air Quality Management District (BAAQMD) in the summer of 2002. The survey questions recommended in Section Five were incorporated into the BAAQMD's survey instrument to get at both program awareness and travel behavior change.

2002 Bay Area Spare the Air Program

The BAAQMD, serving the nine-county San Francisco Bay Area, initiated its summer ozone alert program, called Spare the Air, in 1991. This was the first of its kind in the U.S. The goal of the Spare the Air program is to educate the public about actions they can take to improve air quality on days when air quality is expected to be poor.

The Spare the Air program implemented in the summer of 2002 built upon the experience with past summer efforts. During the entire summer ozone season (June 3 – October 10, 2002), the Spare the Air campaign includes general outreach, promotion and advertising (billboards, TV and radio ads) that convey the general message of air quality awareness and actions residents can take to contribute to air quality improvement. The BAAQMD's Spare the Air program includes employer and youth outreach as part of its public education efforts.

At the heart of the Spare the Air program are ozone alert activities put into place in anticipation of an unhealthful air quality day. When the federal 8-hour standard for ozone precursors is forecast to be exceeded, the BAAQMD undertakes the following steps:

1. Approximately 14,500 residents and employees are notified by e-mail of Spare the Air being called for the next day.

2. Some 1,700 companies are notified as well, requesting they notify their employees of Spare the Air and actions they can take, including not driving to work the next day (using public transit, carpooling, bicycling, walking, etc.).

3. The print media, TV and radio stations are notified so they can pass the word on to the general public.

4. Notices are posted on the BAAQMD's web-site and toll-free telephone hot-line.

In the summer of 2002, seven Spare the Air days were called during the summer ozone season. As reported in Section Six, use of the recommended measurement method resulted in the estimation of 1.58 tons of NOx and 1.66 tons of ROG being reduced on each Spare the Air day.

Nine Additional Resources

Additional resources exist on the topic of measuring the benefits and impacts of voluntary trip reduction strategies.

California Air Resources Board

The California Air Resources Board offers evaluation tools to measure the impacts of trip reduction strategies, both public sector strategies such as carpool and vanpool programs and employer-based trip reduction programs. Two automated set of methods are available as part of ARB's Cost Effectiveness Analysis Tools:

> "Automated Methods to Find the Cost Effectiveness of Funding Air Quality Projects for FY 2000-2001" (Updated May 2002)
>
> "Determining the Cost Effectiveness of Employer TDM Programs" (Updated May 2002)

Both can be downloaded at http://www.arb.ca.gov/planning/tsaq/eval/eval.htm. For further information, contact Jeff Weir in ARB's Transportation Strategies Group (916-445-0098, jweir@arb.ca.gov).

U.S. Environmental Protection Agency

The U.S. Environmental Protection Agency is currently developing a toolkit to show the benefits of public outreach programs, tentatively entitled *"Outreach and Partnerships: Demonstrating the Benefits."* For more information, contact Susan Bullard, EPA Office of Transportation and Air Quality (bullard.susan@epa.gov).

Several reports exist on the topic of Episodic Control programs and other Voluntary Mobile Source Emission Reduction Programs, including:

> "Guidance on Incorporating Voluntary Mobile Source Emission Reduction Programs in State Implementation Plans (SIPs)," memorandum from Richard D. Wilson (Acting Assistant Administrator for Air and Radiation) to EPA Administrators, October 23, 1997. A copy can be found online at http://www.epa.gov/otaq/transp/vmweb/vmdesign.htm.
>
> "Voluntary Mobile Source Programs: Crediting Innovation and Experimentation," brochure (EPA-420-K-97-004). A copy can be found online at http://www.epa.gov/otaq/transp/vmweb/vmpoldoc.htm.

"Quantification of Episodic Control Programs: Technical Report (EPA-420-R-97-006, May 1998). This report examines methodologies used by five ozone action day program to quantify benefits and lessons learned.

"Community Action Programs: Blueprint for Program Design – Technical Report," (EPA-420-R-99-006, March 1999). This report provides an overview of design aspects of an ozone action day program, emphasizing best practices.

For information on including emission reductions from ozone alert programs in your SIP, contact your regional EPA office, or Mark Coryell at the EPA Office of Transportation and Air Quality (coryell.mark@epa.gov).

Attachment 1 Example of Survey

2002 Bay Area Spare the Air Survey and Top Line Responses

Godbe Research & Analysis
December 2002
Toplines (881 Interviews)

BAAQMD SPARE THE AIR STUDY

CONVENTIONAL ROUNDING RULES (.5 OR ABOVE IS ROUNDED UP TO THE NEXT WHOLE NUMBER, AND .4 OR BELOW IS ROUNDED DOWN TO THE PREVIOUS NUMBER) APPLY TO THE PERCENTAGES ON THE FOLLOWING PAGES. AS A RESULT, THE PERCENTAGES BELOW MAY NOT ADD UP TO 100 PERCENT.

Hello. My name is _____, and I'm calling on behalf of GRA, a public opinion research firm. We're conducting a survey concerning issues of importance to residents of the Bay Area region and we'd like to get the opinions of a driver in your household. It should just take a few minutes of their time.

(IF NEEDED) This is a survey only and I am not selling anything.

For statistical reasons, I would like to interview the youngest male driver who is at home right now.

(IF MALE DRIVER NOT AVAILABLE)

Then I would like to interview the youngest female driver who is at home right now.

(IF NO DRIVER EVER IN HOUSEHOLD, TERMINATE. IF DRIVER IN HOUSEHOLD BUT NOT CURRENTLY AVAILABLE, ATTEMPT TO SCHEDULE CALLBACK.)

(IF THE PERSON ASKS WHO THE SURVEY IS FOR, LET THEM KNOW THAT YOU CAN TELL THEM AT THE CONCLUSION OF THE INTERVIEW)

i. Do you regularly drive a vehicle four or more days per week?

Yes	84%	(SKIP TO Q1)
No	16%	

ii. What is your reason for not driving four or more days per week?

Don't have a car/driver's license	19%	(SKIP TO Q10)
Economic/convenience related	4%	(SKIP TO Q10)
Air quality related	2%	(SKIP TO Q10)
Other (SPECIFY:)	75%	(SKIP TO Q10)

1. We're interested in the travel behavior of people in the Bay Area -- specifically the number and types of trips that they make in a day. A 'trip' is defined as traveling from one place to another and then stopping. For example, if you left your house and went to the store, that is one trip. Leaving the store and going to work or coming back home is another trip. Another example would be if you left your house and went to the bus or train station, which is one trip. Taking the bus or train to your work would be a second trip. (MAKE SURE THEY UNDERSTAND WHAT A 'TRIP' IS).

   Please take a moment to think back over your day. Excluding any trips that were made 'on-the-job', such as driving a delivery truck, as well as any trips made on an airplane, how many trips did you make today?

   Mean Number of Trips Overall ---------- 3.03
   00 to 01---------- 25%
   02 to 03---------- 38%
   04 to 05---------- 25%
   06 to 07----------8%
   08 to 10----------4%
   11 to 20----------1%
   21 to 30----------0%

IF Q1 = 0 or 99 SKIP TO Q3

2. Sometimes people will purposely <u>increase</u> the amount of driving they do in a day. An example of purposely <u>increasing</u> driving would be if a person decided to drive to the store when they <u>normally</u> would have walked, bicycled, or taken a bus. Did you purposely <u>increase</u> the amount of your driving today?

   (IF RESPONDENT ASKS TO CLARIFY WHAT PURPOSELY INCREASING DRIVING IS, SAY "It means deciding to drive someplace when you would usually travel there without driving.")

   Yes----------7%
   No ---------- 93%

3. Sometimes people will purposely <u>decrease</u> the amount of driving they do in a day. An example of purposely <u>decreasing</u> driving would be if a person decided to take a bus, walk, bike or ride with someone else to work when they <u>normally</u> would have driven, or if someone decided to simply not take a trip they would have normally taken in a car. Did you purposely <u>decrease</u> the amount of your driving today?

(IF RESPONDENT ASKS TO CLARIFY WHAT PURPOSELY DECREASING DRIVING IS, SAY "It means deciding to go someplace without driving when you normally would have driven or deciding not to make a trip that you would normally would have made in a car.")

Yes	17%	
No	82%	(SKIP TO Q10)
(DON'T READ) DK/NA	1%	(SKIP TO Q10)

4. You indicated that you purposely decreased the amount of your driving today. How many driving trips did you purposely decrease today?

Average trips decreased	1.89
1 to 3	90%
4 to 6	8%
7 to 10	0%
Refused	2%

ASK Q5 THROUGH Q9 FOR EACH TRIP DECREASED (Q4)

Numbers presented in Q5 through Q9 represent the overall responses for all trips reduced.

5. Thinking of the (first/second/third…) driving trip you <u>decreased</u>, how did you decrease this trip?

Did not make the trip today	38%	(SKIP TO Q7)
Carpool/vanpool passenger	15%	
Public transportation	3%	
Combined trips	3%	(SKIP TO Q7)
Bicycled	6%	(SKIP TO Q7)
Walked	21%	(SKIP TO Q7)
Worked from home (telecommuted)	0%	(SKIP TO Q7)
Used the Internet to complete a task (other than telecommuting)	0%	(SKIP TO Q7)
Other (SPECIFY:)	10%	(SKIP TO Q7)
Refused	3%	(SKIP TO Q7)

6. Did you have to drive or be driven somewhere to catch your ride, such as to a transit stop or a Park and Ride lot?

Yes	34%
No	66%
(DON'T READ) DK/NA	0%

7. (IF Q5 = 1 THEN ASK:) What was the purpose of the trip going to be? (IF Q5 = ANYTHING OTHER THAN 1, ASK:) What was the purpose of this trip?

Going to or from work	13%
Going to or from school	3%
Shopping (mall, groceries)	34%
Recreation and entertainment (out for dinner, movies, beach, gym)	17%
Scheduled appointments, lessons, or practices (doctors, music, little league, soccer)	4%
Other (SPECIFY:)	21%
(DON'T READ) DK/NA	5%

8. How many miles would you say that this trip was, or would have been? (IF RESPONDENT SAYS THEY ARE UNSURE, ASK THEM TO GIVE THEIR BEST ESTIMATE)

Average miles of reduced trip	9.05
1 to 10	76%
11 to 20	16%
21 to 50	5%
51 to 100	2%

9. Why did you purposely decrease this driving trip? (DO NOT PROMPT FOR SPECIFIC ANSWERS)

32 of the 881 respondents (3.6%) indicated they decreased at least one trip because of Spare the Air ads or air quality reasons.

Spare the Air or ads asking people to drive less	25%
Air quality reasons	5%
Other	71%

10. OK, let me change subjects a bit. I'm going to read through a short list of activities, and as I read each, please tell me if you would normally do this activity. Would you normally use _____ today? (IF RESPONDENT INDICATES THEY WOULD NORMALLY PERFORM AN ACTIVITY, FOLLOW WITH:) Did you actually _____ today?

RANDOMIZE		NORMALLY USE?			ACTUALLY USE TODAY?		
		Yes	No	DK/NA	Yes	No	DK/NA
A.	Aerosol hairspray	14%	85%	1%	71%	29%	0%
B.	Insecticides	12%	88%	0%	39%	61%	0%
C.	Air fresheners	24%	76%	1%	61%	39%	0%
D.	Cologne or perfume	40%	59%	0%	76%	24%	0%
E.	Lighter fluid for barbeques	12%	87%	1%	19%	80%	1%
F.	Gas powered garden equipment	11%	89%	0%	29%	71%	0%
G.	Furniture polish	15%	84%	1%	28%	72%	0%
H.	Household cleaner sprays	41%	58%	0%	43%	57%	0%

FOR EACH ITEM IN Q10 IN WHICH THE RESPONDENT NORMALLY USES AN ITEM, BUT DID NOT TODAY, ASK Q11

11. Why did you choose not to use _____ (ITEM FROM Q10) today? (DO NOT READ ITEMS BELOW)

36 of the 881 respondents (4.1%) indicated they did *not* use at least one product listed in Q10 because of Spare the Air ads or air quality reasons. End of the season analyses will detail product usage.

		Percentage of those who said they normally use product that did not use product that day because of STA or air quality concerns	Percentage of total sample (881) that chose not to use product because of STA or air quality concerns
A.	Aerosol hairspray	4.000%	0.568%
B.	Insecticides	5.769%	0.681%
C.	Air fresheners	1.442%	0.341%
D.	Cologne or perfume	1.130%	0.454%
E.	Lighter fluid for barbeques	3.636%	0.454%
F.	Gas powered garden equipment	7.447%	0.795%
G.	Furniture polish	2.256%	0.341%
H.	Household cleaner sprays	3.836%	1.589%

12. In the past two days, have you heard, read, or seen any news stories or public service announcements about Spare the Air, poor air quality, or requests to drive less in this area, or to not use certain products that affect air quality?

Yes	63%	
No	36%	(Skip to Q15)
(DON'T READ) DK/NA	1%	(Skip to Q15)

13. Where did you see or hear the news story, advertisement, or public service announcement? (DON'T READ CHOICES: MULTIPLE RESPONSE PERMITTED)

Television	58%
Radio	37%
Magazine	0%
Newspaper	10%
On a website	2%
Mail piece	1%
Billboard	15%
Other	5%
Don't recall	1%

14. What do you remember about the story, advertisement or announcement?

Verbatim responses have been coded into the following categories. As multiple responses were allowed for this question, the numbers add to more than 100 and thus represent the percentage of individuals - among those who said 'Yes' to Question 12 - who mentioned a particular message.

STA Day	43%
Heat / High temperatures	23%
Poor air quality / smog	16%
Use public trans	6%
Carpool	11%
Ride bike	2%
Walk	1%
Don't BBQ	5%
Don't drive	31%
Don't use aerosol	3%
Don't use gas-powered tools	2%
Don't use lawn mowers	5%
Wait until PM for certain activities	4%
Conserve energy	4%
Other	28%
Can't remember	4%

15. Are you currently employed full time, employed part time, self-employed, a student, a homemaker, retired or are you not currently employed right now? (MULTIPLE RESPONSE PERMITTED)

Employed full-time	45%	
Employed part-time	10%	
Self-employed	13%	
Student	8%	
Homemaker	7%	(SKIP TO Q20)
Retired	16%	(SKIP TO Q20)
Not employed	9%	(SKIP TO Q20)
(DON'T READ) Refused	1%	(SKIP TO Q20)

ASK Q16 ONLY IF Q15 = 4

16. How do you normally commute to school? (MULTIPLE RESPONSE PERMITTED)

Drive vehicle alone	54%
Carpool	13%
Vanpool	2%
Public transit	15%
Bicycle	6%
Motorcycle	0%
Walk or jog	18%
Online schooling from home	2%
Other	2%
Refused	2%

ASK Q17 ONLY IF Q15 = 1, 2, OR 3 OTHERWISE SKIP TO Q20

17. How do you normally commute to work? (MULTIPLE RESPONSE PERMITTED)

Drive vehicle alone	80%
Carpool	8%
Vanpool	0%
Public transit	7%
Bicycle	3%
Motorcycle	1%
Walk or jog	3%
Online schooling from home	0%
Other	7%
Refused	1%

18. Does your employer notify you of poor air quality days?

Yes	12%
No	86%
(DON'T READ) DK/NA	2%

19. Does your employer encourage you to drive less, car pool, or use public transportation on poor air quality days?

Yes	24%
No	72%
(DON'T READ) DK/NA	4%

20. OK, let me change gears a bit. Have you ever heard of _____? (CODE DK/NA AS 'NO')

RANDOMIZE	**Yes**	**No**
A. Bay Area Air Quality Management District	56%	44%
B. Metropolitan Transportation Commission	56%	44%
C. The Spare the Air Campaign	75%	25%

QUESTIONS 21 AND 22 ARE TO BE ASKED FOR EACH Q20 ITEM THAT THE RESPONDENT HAS HEARD OF (=1)

21. Generally speaking, would you say you have a favorable or unfavorable opinion of _____ (ITEM FROM Q20), or do you have no opinion either way? (GET ANSWER THEN ASK:) Would that be very or somewhat (favorable/unfavorable)?

	Bay Area Quality Management District	Metropolitan Transportation Commission	The Spare the Air Campaign
Very favorable	18%	15%	47%
Somewhat favorable	23%	19%	30%
Neutral	41%	45%	18%
Somewhat unfavorable	5%	6%	2%
Very unfavorable	4%	5%	1%
DK/NA	9%	10%	2%

22. In the past six months, have you heard, read, or seen any news story, advertisements, or public service announcements about (ITEM FROM Q20)? (CODE NOT SURE AS 'NO')

	Bay Area Quality Management District	Metropolitan Transportation Commission	The Spare the Air Campaign
Yes	38%	37%	70%
No	60%	62%	30%
Refused	2%	1%	1%

To wrap things up, I have a few background questions for comparison purposes.

A. Including yourself, how many licensed drivers live in your household?

0 to 1	27%
2 to 3	63%
4 to 6	9%
7 to 10	0%
Refused	1%

B. In what year were you born?

18 to 24	11%
25 to 34	18%
35 to 44	20%
45 to 54	20%
55 to 64	14%
65+	15%
Refused	3%

C. What ethnic group do you consider yourself a part of or feel closest to? (IF RESPONDENT HESITATES, READ LIST)

Caucasian/White	64%
Latino/Hispanic	10%
African-American/Black	5%
Korean-American	0%
Japanese-American	0%
Chinese-American	2%
Vietnamese-American	0%
Other-Asian-American	7%
Pacific Islander	1%
Mixed	0%
Other	6%
DK/NA	4%

D. I have just one more question for you. I am going to read some income categories. Please stop me when I reach the category that best describes your total household income.

$49,999 or less	26%
$50,000 to $74,999	18%
$75,000 to $99,999	17%
$100,000 to $149,999	15%
$150,000 to $199,999	5%
$200,000 or more	5%
(DON'T READ) DK/NA/Refused	16%

Those are all the questions I have for you.
Thank you very much for participating. This survey was sponsored by the
Bay Area Air Quality Management District

E. Respondent's Gender:

Male	45%
Female	55%

Region:

Alameda ---------- 21%
Contra Costa ---------- 14%
Marin ---------- 4%
Napa ---------- 2%
San Francisco ---------- 13%
San Mateo ---------- 10%
Santa Clara ---------- 23%
Solano ---------- 5%
Sonoma ---------- 7%

Episode Date:

07/09/02 ---------- 23%
07/10/02 ---------- 22%
07/11/02 ---------- 8%
08/09/02 ---------- 11%
08/10/02 ---------- 13%
09/19/02 ---------- 23%

Attachment 2 Sample Size Determination

Several factors need to be considered in determining the sample size:

a) proportion of reducers, denoted as p;

b) desired accuracy of the proportion of reducers, or allowable error band, denoted as L_p;

c) variance of average self-reported trip reduction, denoted as σ^2

d) allowable error band for self-reported trip reduction, denoted as L_x

e) confidence level-- we recommend using 95%.

Two sample size requirements need to be determined:

1. Sample size requirement to meet allowable error band for proportion of reducers, L_p

Proportion of Reducers

The proportion of reducers follows the binomial distribution, with p being the proportion of reducers among the general population. The required sample size is:

$$n = 4pq/ L_p^{\,2}$$

where p is the proportion of reducers;
q=1-p;
L_p is allowable error band, e.g. 1.2%, or any number you desire.

2. Sample size requirement for reducers to meet allowable error band for self-reported trip reduction, L_x

Self-Reported Trip Reduction

We can reasonably assume that the average trip reduction $\overline{X}$ is approximately normally distributed when n is large enough (>=30). If you want to estimate the true mean of the self-reported trip reduction within L_x trips with 95% confidence, then the sample size required is

$$N_{reducer} = 4\sigma^2/ L_x^{\,2}$$

where σ^2 is variance of average self-reported trip reduction.
L_x is allowed error band, e.g.0.5 trips, or any number you desire.

Please note that n in the first formula, proportion of reducers, is the sample size from the general population, while $N_{reducer}$ is the sample size for reducers. You will need to meet both sample size requirements and the minimum number of reducers is 30.

Attachment 3 California Average Auto Emission Factors

EMFAC2002 Average Light Duty Passenger Vehicle Emission Factors for 2003 - 2005

(Fleet of Light-Duty Passenger Vehicles, Light-Duty Trucks, and Motorcycles)

Analysis Period	**2003**	**2004**	**2005**
ROG			
VMT (g/mile)	0.523	0.470	0.424
commute trip ends (g/trip end)	1.873	1.721	1.578
average trip ends (g/trip end)	1.364	1.250	1.144
NOx			
VMT (g/mile)	0.686	0.604	0.539
commute trip ends (g/trip end)	0.769	0.722	0.675
average trip ends (g/trip end)	0.695	0.650	0.613
PM10			
VMT (g/mile)	0.218	0.218	0.218
running exhaust only (g/mile)	*0.013*	0.013	0.013
tire and brake wear (g/mile)	*0.021*	*0.021*	*0.021*
road dust (g/mile)	*0.184*	*0.184*	*0.184*
commute trip ends (g/trip end)	0.014	*0.015*	*0.015*
average trip ends (g/trip end)	0.008	0.008	0.008
CO			
VMT (g/mile)	6.190	5.591	5.060
commute trip ends (g/trip end)	16.291	15.023	13.862
average trip ends (g/trip end)	11.834	10.888	10.031

Source: EMFAC2002, Version 2.2, statewide, average annual emissions, light-duty cars and trucks plus motorcycles. The rate summary model output report (rts) used for commute trip end calculations is based on temperature 75 degrees F and 50% humidity. The VMT factors equal running exhaust plus running losses divided by daily VMT. The average trip end factors equal statewide start emissions plus hot soak emissions divided by daily trips.

The commute trip end factors are based on an "off-model" calculation that equals statewide start emissions for a commute-type pre-start soak distribution plus hot soak emissions divided by daily trips. The commute trip end factors do not reflect the soak distribution used in EMFAC2002. Instead, the factors are calculated using a special commute-type pre-start soak distribution based on an analysis of the 1991 Statewide Travel Survey for all day home-work and work-home trips.

PM10 VMT factor includes motor vehicle exhaust, tire wear, brake wear, and entrained road dust. The road dust portion of the PM10 factor is based on U.S. EPA's Compilation of Air Pollutant Emission Factors (AP-42, January 1995). Silt loading and vehicle weight data used as inputs to EPA's equation are from Improvement of Specific Emission Factors (BACM Project No. 1), Final Report, Midwest Research Institute, March 1996. Vehicle trip reductions may have little, if any, effect on road dust emissions from high volume facilities thought to be in equilibrium, i.e., the dust is fully entrained due to the heavy traffic. The road dust PM10 factor, however,

may be multiplied times total VMT reductions as it has been scaled down to reflect emissions from lower-volume local and collector roads only.

NOTES: (1) The factors do not include medium-duty vehicles (5751 to 8500 GVW); however, emissions from medium-duty vehicles used as passenger vehicles have an insignificant effect on the average emission factor (1% or less) when added to the emission factors given for light-duty vehicles. (2) Light-duty vehicle emission standards require progressively cleaner fleet average emissions. This accounts for the gradual decrease in fleet average emission factors over time.

Source: California Air Resources Board (January 2003)

TO USE THE TABLE to find emissions related to Spare the Air Days: 1) select the year you want to analyze (years after 2005 will require a new EMFAC run; however it is expected that a newer version of EMFAC would be appropriate for use for 2004 and later analysis years in any case; 2) multiply daily miles reduced by the VMT factor, 3) multiply the number of trips reduced by the average trip end factor; 4) add VMT emission reductions to trip end emission reductions; 5) divide by 454 grams/lb to get lbs of emissions per Spare the Air Day; 6) repeat for each pollutant of interest. (Note: Use the commute trip end factor when analyzing work trips. Use the average trip end factor when analyzing a variety of trip types. The VMT factor is the same in both instances.)

Differences in Versions of EMFAC

The EMFAC model is maintained and updated regularly by the California Air Resources Board. EMFAC2000 was used in the example calculations in order to maintain consistency with the Bay Area SIP calculations. For reference, below we list the refinements included in the EMFAC model between EMFAC2000 and EMFAC2002. The gram per mile and the trip end emission factors are lower in the EMFAC2002 model than they were in the EMFAC2000 model, which will decrease the estimated effectiveness of the program.

EMFAC 2000 was updated to EMFAC2001 to include the following refinements, which cumulatively led to some changes in emission factors for affected vehicle classes.

- Elimination of Diesel Start Emissions
- Adjusted the fuel Correction Factors for Low Sulfur Diesel
- Corrected the Benefit Estimate for USEPA 2007+ Heavy-duty standards
- Modified the Benefit Estimate for LEVII/Tier II (Low Emitting Vehicles)
- Added Additional Chassis Dynamometer Data for Heavy-Duty
- Gasoline Powered Trucks
- Included LEVII and Tier II Programs
- Added Evaporative Emissions for ZEVs (Zero Emission Vehicles)
- Added New Standards for Urban Buses
- Modified the Air Conditioning Correction Factors based on Public Comment
- Updated Idle Emission Rates
- Updated School Bus Activity Estimates
- Updated Unregistered Vehicle Estimates

EMFAC2001 was updated to EMFAC2002 to include the following additional refinements:

- Revised Implementation Schedule for LEVII
- Correct Monthly Average Gasoline RVP (Reid Vapor Pressure)
- Correction to 2007+ HDD (Heavy Duty Diesel) PM Emission Rates
- Extended Idle for Heavy-Duty Trucks
- Modification of Passenger Car Mileage Accrual Rates
- Update Speed Distribution
- Update Vehicle Miles Traveled
- Update Population and Registration Distributions
- Revise Phase 3 Gasoline Fuel Correction Factor Start Date
  Standards-Ratio Factors for Tire Wear and Brake Wear PM
- Revising the Cutpoints for the Enhanced Inspection and Maintenance Program

Additional information for non-California users:

This methodology was developed in coordination, and with funding from EPA, FHWA, and agencies within California. The focus is on California examples and uses the California emission factor model EMFAC. However, many areas in the U.S. may find this methodology helpful in evaluating their Spare the Air programs.

The methodology would be applied exactly as described, except for the use of the MOBILE6 model in place of the EMFAC model. As noted above, the model can be run by the agency evaluating the program or output from the model for a specific area may be obtained from your local air district, state air agency, or regional EPA office. The model may be downloaded from http://www.epa.gov/otaq/m6.htm, Regional EPA offices can be contacted by going to www.epa.gov/region-of-your-choice (e.g. www.epa.gov/region01). There are ten regions in the U.S. If you are not sure what region you are in, you can type “regional offices” into the search box at the top of EPA’s main page and a list of regional office websites and states covered will appear.

Appendix B

Survey Instruments

Screener Version

Standard Version

Follow-up Survey

Godbe Research & Analysis **Time Began _____**
July 7, 2003 **Time Ended ____**
P3.5RS **Cluster # ______**

ARB SPARE THE AIR SURVEY
LES – PURPOSELY SCREENER
FIRST INTERVIEW

Hello. I'm calling on behalf of GRA, a public opinion research firm. We're conducting a survey concerning issues of importance to residents of the Sacramento and Bay Area regions and we'd like to get your opinions, it should just take a few minutes of your time.

(IF NEEDED) This is a survey only and I am <u>not</u> selling anything.

I would like to interview the youngest male driver who is at home right now.

(IF MALE DRIVER NOT AVAILABLE)

Then I would like to interview the youngest female driver who is at home right now.

(IF NO DRIVER EVER IN HOUSHOLD, TERMINATE. IF DRIVER IN HOUSEHOLD BUT NOT CURRENTLY AVAILABLE, CALL BACK)
^^

(NOTE: THE QUESTION NUMBERS ARE NOT SEQUENTIAL BECAUSE THEY ARE NUMBERED TO MATCH THE LES WITHOUT THE SCREENER)

3A. We're interested in the travel behavior of Californians. Sometimes people will purposely **increase** the amount of driving they do in a day. An example of purposely **increasing** driving would be if a person decided to drive to the store when they **normally** would have walked, bicycled or taken a bus. Between 6PM yesterday evening and 6PM tonight, did you purposely **increase** the amount of your driving?

(IF RESPONDENT ASKS TO CLARIFY WHAT PURPOSELY INCREASING DRIVING IS, SAY "IT MEANS DECIDING TO DRIVE SOMEPLACE WHEN YOU USUALLY TRAVEL THERE WITHOUT DRIVING")

Yes--- 1
No -- 2
DK/NA--- 3

(SCREENER)

4A. Sometimes people will purposely **decrease** the amount of driving they do in a day. An example of purposely **decreasing** driving would be if a person decided to take a bus, walk, bike or ride with someone else to work when they **normally** would have driven, or if someone decided to simply not take a trip they would have normally taken in a car. Between 6PM yesterday evening and 6PM tonight, did you purposely **decrease** the amount of your driving?

(IF RESPONDENT ASKS TO CLARIFY WHAT PURPOSELY DECREASING DRIVING IS, SAY "IT MEANS DECIDING TO TRAVEL SOMEPLACE WITHOUT DRIVING WHEN YOU NORMALLY WOULD HAVE DRIVEN, OR DECIDING NOT TO TAKE A TRIP YOU WOULD NORMALLY TAKE IN A CAR")

Yes----------	1	(Ask 1)
No ----------	2	(Terminate)
DK/NA----------	3	(Terminate)

++++++++++++++++++++++

1. We are also interested in the number and types of trips that people make in a day. A 'trip' is defined as traveling from one place to another and then stopping. For example, if you left your house and went to the store, that is one trip. Leaving the store and going to work or coming back home is another trip. Another example would be if you left your house and went to the bus or train station, that is one trip. Taking the bus or train to your work would be a second trip.

Thinking back over the 24 hour period from 6PM yesterday evening to 6PM tonight, excluding any trips that were made 'on-the-job' – such as driving a delivery truck – as well as trips made on an airplane, how many trips did you make during this time period? If you were traveling at 6PM please include this trip in the total.

Record Number of Trips:_____ (IF REFUSES, TERMINATE)
(IF RESPONDENT MADE NO TRIPS, SKIP TO 4B)

Next, I'd like to ask you some questions about each of these trips.
(ASK QUESTIONS 2A – 2F FOR THE FIRST TRIP, THEN REPEAT THE QUESTIONS IN SEQUENCE FOR EACH ADDITIONAL TRIP THE RESPONDENT MADE. CONTINUE TO PROMPT RESPONDENT FOR TRIP INFORMATION UNTIL THEY STATE THAT THEY MADE NO MORE TRIPS. THE NUMBER OF TRIPS REPORTED IN Q.2A-Q.2F MAY BE GREATER THAN THE NUMBER REPORTED IN Q.1 IF THE RESPONDENT REMEMBERS A STOP)

2A. Thinking of your (first/second/third…) trip, where were you coming from and what was the purpose of the trip? Remember, every time you stop it ends a trip. (RECORD RESPONSES BELOW ACCORDING TO APPROPRIATE CATEGORY)

Home to Work OR Work to Home	1	
Home to Shopping OR Shopping to Home	2	
Home to Other OR Other to Home	3	
Work to Other OR Other to Work	4	
Other to Other	5	
(Don't Read) DK	6	
(Don't Read) Refused	7	(Terminate)
No More Trips to Report	8	(Skip to 4B)

2B. Did you make any stops along the way? (IF YES, TELL RESPONDENT: "OK, I'D LIKE YOU TO ANSWER THE NEXT SERIES OF QUESTIONS FOR THE PART OF THE JOURNEY BEFORE THE STOP. THEN I WILL ASK YOU SOME QUESTIONS ABOUT THE PART OF THE JOURNEY AFTER THE STOP". FIRST ASK QUESTIONS 2C-2F FOR THE PART OF THE JOURNEY BEFORE THE STOP. THEN ASK 2A-2F FOR THE PORTION OF THE JOURNEY AFTER THE STOP)

Yes	1
No	2

2C. What type of transportation did you use for this trip?(ONLY READ CATEGORIES IF NECESSARY)

Auto Driver (car, truck or van)	1	(Ask 2D)
Auto Passenger (car, truck or van)	2	(Ask 2D)
Motorcycle	3	(Ask 2D)
Public Transportation (Bus,Train,BART,Ferry,etc)	4	(Skip to 2E)
Taxi	5	(Skip to 2E)
Bicycle/Skateboard/Roller Blades	6	(Skip to 2E)
Walk	7	(Skip to 2E)
Other	8	(Skip to 2E)
(Don't Read) Refused	9	(Terminate)

2D. Including yourself, how many individuals traveled with you?

1	1	
2	2	
3	3	
4	4	
5	5	
6	6	
7	7	
8 or more	8	
(Don't Read) DK	9	
(Don't Read) Refused	10	(Terminate)

2E. What time did the trip start? (RECORD TIME, WITH AM/PM) (IF SAY 'DON'T KNOW', BEST GUESS IS OK)

_____

_____

2F. What time did the trip end? (RECORD TIME, WITH AM/PM) (IF SAY 'DON'T KNOW, BEST GUESS IS OK)

_____

_____

(REPEAT QUESTIONS 2A – 2F IN SEQUENCE FOR EACH TRIP MADE BY RESPONDENT. CONTINUE TO ASK THESE QUESTIONS UNTIL THEY STATE THAT THEY MADE NO MORE TRIPS)

4B. You indicated earlier that you purposely **decreased** the amount of driving you did between 6PM yesterday and 6PM tonight. How many driving trips did you purposely **decrease** during this period?

1 ---------- 1
2 ---------- 2
3 ---------- 3
4 ---------- 4
5 ---------- 5
6 ---------- 6
7 or more---------- 7
None---------- 8 (Terminate)
DK/NA ---------- 9 (Terminate)
Refused ---------- 10 (Terminate)

4C. Thinking of the (first/second/third) driving trip you DECREASED, how did you decrease the trip?

Didn't take trip----------1
Carpool passenger ----------2
Public transportation (bus, train, BART, ferry, etc.) --3
Bicycle ----------4
Walk ----------5
Worked at Home ----------6
Other ----------7
(Don't read) Refused ----------8

4D. (IF ANSWERED 'DIDN'T TAKE TRIP' TO QUESTION 4C FOR THIS TRIP, ASK): What was the purpose of the trip going to be?
(ANY OTHER ANSWER TO QUESTION 4C FOR THIS TRIP, ASK):
What was the purpose of the trip?

Going to or from work ----------1
Shopping ---------- 2
Other (school, errands, recreation, etc.) ---------- 3
(Don't read) DK ---------- 4
(Don't read) Refused ---------- 5

4E. Why did you purposely decrease this driving trip? (DON'T PROMPT FOR SPECIFIC ANSWERS.)

(Don't read) Spare the Air or advertisements asking people to drive less---------- 1
(Don't read) Poor air quality ---------- 2
(Don't read) Other ---------- 3

(ASK QUESTIONS 4C-4E FOR EACH TRIP THE RESPONDENT REPORTS THAT THEY DECREASED)

(ASK QUESTIONS 5A AND 5B FOR ALL RESPONDENTS EXCEPT THOSE WHO ANSWER QUESTION 4E WITH RESPONSE CATEGORY '1' FOR ANY 'DECREASED' TRIP THAT THEY REPORT)

5A. Have you heard, read or seen any advertisements during the past two days that talk about poor air quality and driving in this area?

Yes---------- 1 (Ask 5B)
No ---------- 2 (Skip to 6)
DK/NA ---------- 3 (Skip to 6)

5B. What do you remember about the advertisements? (RECORD ANSWER BELOW)

_____

_____

_____

_____

_____

6. How many motor vehicles, in working order, are owned by the people in your household? (IF NEEDED: "A MOTOR VEHICLE IS A PASSENGER VEHICLE SUCH AS A CAR, VAN, SPORT-UTILITY VEHICLE, TRUCK OR MOTORCYCLE".)

1 ---------- 1
2 ---------- 2
3 ---------- 3
4 ---------- 4
5 ---------- 5
6 ---------- 6
7 ---------- 7
None ---------- 8
DK/NA ---------- 9
Refused ---------- 10

Thank you so much for your participation in this important research project. We have just a few more questions for comparison purposes.

(ONLY ASK QUESTIONS A & B FOR RESPONDENTS WHO ANSWERED QUESTION 4E WITH RESPONSE CATEGORY '1' FOR ANY 'DECREASED' TRIP THAT THEY REPORTED OR RESPONDENTS WHO ANSWERED 4E WITH RESPONSE CATEGORY '2' AND ANSWERED QUESTION 5A WITH RESPONSE CATEGORY '1'. EVERYONE ELSE SKIP TO QUESTION C)

A. With your permission we would like contact you just ONE more time during the next three months to do a shorter, follow-up survey. If you participate in this second survey your name will be entered into a random drawing to win a $1,000 cash prize. Can we have your permission to call you to do a shorter, follow-up survey?

(IF RESPONDENT SAYS NO):
We truly appreciate your cooperation and we assure you that if you agree we will only call ONE more time with your permission. Once again, if you participate in the second survey you will be eligible to win a $1,000 cash prize. Would you be willing to participate one more time with these assurances and knowing that your contribution is a valuable part of an important research project?

(IF ASKED WHAT THE PROJECT IS FOR, SAY "FOR ASSESSING TRANSPORTATION POLICY IN YOUR AREA")

Yes ---------- 1
No ---------- 2 (Skip to C)

B. So that we can ask for you by name next time we call, can we have your first name and the first initial of your last name? (IF NEEDED, STRESS THE FOLLOWING): This is only so that we can ask for you by name when we call – your name will not be used for any other purpose and will be held in strict confidence.

First Name & First Initial of Last Name: _____
(PROMPT IF THERE IS A JR. OR SR. WITH SAME NAME IN THE HOUSEHOLD – NOTE IF PERSON IS JOHN SR. OR JOHN JR.)

C. In what year were you born?

1975 to 1984---------- 1
1970 to 1974---------- 2
1965 to 1969---------- 3
1960 to 1964---------- 4
1955 to 1959---------- 5
1950 to 1954---------- 6
1945 to 1949---------- 7
1940 to 1944---------- 8
1935 to 1939---------- 9
1934 and before ---------- 10
(DON'T READ) Refused --------- 11

D. How many children under the age of 18 live in your home?

1 ---------- 1
2 ---------- 2
3 or more---------- 3
None---------- 4
Don't Know---------- 5
Refused ---------- 6

E. How many drivers live in your household?

Record Number:_____

F. Are you employed full time, part time, retired, a homemaker, a student or currently unemployed?

Full time	1	(Ask G)
Part time	2	(Ask G)
Retired	3	(Skip to J)
Homemaker	4	(Skip to J)
Unemployed	5	(Skip to J)
Student	6	(Skip to J)
Don't Know	7	(Skip to J)
Refused	8	(Skip to J)

G. Do you have to pay for part or all of the cost of parking at your place of employment?

Yes, pay part or all of cost	1
No, employer pays full cost	2
No parking fees at work	3
DK/NA	4

H. Does your employer notify you of poor air quality days?

Yes	1
No	2
DK/NA	3

I. Does your employer encourage you to drive less, car pool, or use public transportation on poor air quality days?

Yes	1
No	2
DK/NA	3

J. What is the highest level of education that you completed?

Did not graduate high school	1
High school graduate	2
Two year college	3
Four year college	4
Graduate school	5
DK/NA/Refused	6

K. What was the total income of your household before taxes in 1999?

$15,000 or under---------- 1
$15,001-$35,000---------- 2
$35,001-$50,000---------- 3
$50,001-$75,000---------- 4
$75,001-$100,000---------- 5
$100,001-$150,000---------- 6
$150,001or more---------- 7
(DON'T READ) Refused---------- 8

That is all I have. Thank you so much for participating!

L. Respondent's Sex: Male ---------- 1
Female ---------- 2

ALL INFORMATION BELOW IS REQUIRED

Respondent ID Number:_____ (Required to match for second survey)

PHONE _____

DAY OF THE WEEK _____

DATE OF INTERVIEW _____ VALIDATED BY _____

INTERVIEWER: _____

NUMBER: _____

_____

_____

Godbe Research & Analysis **Time Began _____**
July 7, 2003 **Time Ended ____**
3.4RS **Cluster # ______**

ARB SPARE THE AIR SURVEY
LES – NO SCREENER
FIRST INTERVIEW

Hello. I'm calling on behalf of GRA, a public opinion research firm. We're conducting a survey concerning issues of importance to residents of the Sacramento and Bay Area regions and we'd like to get your opinions, it should just take a few minutes of your time.

(IF NEEDED) This is a survey only and I am not selling anything.

I would like to interview the youngest male driver who is at home right now.

(IF MALE DRIVER NOT AVAILABLE)

Then I would like to interview the youngest female driver who is at home right now.

(IF NO DRIVER EVER IN HOUSHOLD, TERMINATE. IF DRIVER IN HOUSEHOLD BUT NOT CURRENTLY AVAILABLE, CALL BACK)
^^^

1. We're interested in the travel behavior of Californians, specifically the number and types of trips that they make in a day. A 'trip' is defined as traveling from one place to another and then stopping. For example, if you left your house and went to the store, that is one trip. Leaving the store and going to work or coming back home is another trip. Another example would be if you left your house and went to the bus or train station, that is one trip. Taking the bus or train to your work would be a second trip.

Please take a moment to think back over the 24 hour period from 6PM yesterday evening to 6PM tonight. Excluding any trips that were made 'on-the-job' – such as driving a delivery truck – as well as trips made on an airplane, how many trips did you make during this time period? If you were traveling at 6PM, please include this trip in the total.

Record Number of Trips:________________
(IF RESPONDENT MADE NO TRIPS, SKIP TO 4A)

Next, I'd like to ask you some questions about each of these trips.
(ASK QUESTIONS 2A – 2F FOR THE FIRST TRIP, THEN REPEAT THE QUESTIONS IN SEQUENCE FOR EACH ADDITIONAL TRIP THE RESPONDENT MADE. CONTINUE TO PROMPT RESPONDENT FOR TRIP INFORMATION UNTIL THEY STATE THAT THEY MADE NO MORE TRIPS. THE NUMBER OF TRIPS REPORTED IN Q.2A-Q.2F MAY BE GREATER THAN THE NUMBER REPORTED IN Q.1 IF THE RESPONDENT REMEMBERS A STOP)

2A. Thinking of your (first/second/third…) trip, where were you coming from and what was the purpose of the trip? Remember, every time you stop it ends a trip. (RECORD RESPONSES BELOW ACCORDING TO APPROPRIATE CATEGORY)

Home to Work OR Work to Home	1	
Home to Shopping OR Shopping to Home	2	
Home to Other OR Other to Home	3	
Work to Other OR Other to Work	4	
Other to Other	5	
(Don't Read) DK	6	
(Don't Read) Refused	7	(Terminate)
No More Trips to Report	8	(Skip to 3A)

2B. Did you make any stops along the way? (IF YES, TELL RESPONDENT: "OK, I'D LIKE YOU TO ANSWER THE NEXT SERIES OF QUESTIONS FOR THE PART OF THE JOURNEY BEFORE THE STOP. THEN I WILL ASK YOU SOME QUESTIONS ABOUT THE PART OF THE JOURNEY AFTER THE STOP". FIRST ASK QUESTIONS 2C-2F FOR THE PART OF THE JOURNEY BEFORE THE STOP. THEN ASK 2A-2F FOR THE PORTION OF THE JOURNEY AFTER THE STOP)

Yes	1
No	2

2C. What type of transportation did you use for this trip?(ONLY READ CATEGORIES IF NECESSARY)

Auto Driver (car, truck or van)	1	(Ask 2D)
Auto Passenger (car, truck or van)	2	(Ask 2D)
Motorcycle	3	(Ask 2D)
Public Transportation (Bus,Train,BART,Ferry,etc)	4	(Skip to 2E)
Taxi	5	(Skip to 2E)
Bicycle/Skateboard/Roller Blades	6	(Skip to 2E)
Walk	7	(Skip to 2E)
Other	8	(Skip to 2E)
(Don't Read) Refused	9	(Terminate)

2D. Including yourself, how many individuals traveled with you?

1	1	
2	2	
3	3	
4	4	
5	5	
6	6	
7	7	
8 or more	8	
(Don't Read) DK	9	
(Don't Read) Refused	10	(Terminate)

2E. What time did the trip start? (RECORD TIME, WITH AM/PM)

_____

_____

2F. What time did the trip end? (RECORD TIME, WITH AM/PM)

_____

_____

(REPEAT QUESTIONS 2A – 2F IN SEQUENCE FOR EACH TRIP MADE BY RESPONDENT. CONTINUE TO ASK THESE QUESTIONS UNTIL THEY STATE THAT THEY MADE NO MORE TRIPS)

3A. Sometimes people will purposely **increase** the amount of driving they do in a day. An example of purposely **increasing** driving would be if a person decided to drive to the store when they **normally** would have walked, bicycled or taken a bus. Between 6PM yesterday evening and 6PM tonight, did you purposely **increase** the amount of your driving?

(IF RESPONDENT ASKS TO CLARIFY WHAT PURPOSELY INCREASING DRIVING IS, SAY "IT MEANS DECIDING TO DRIVE SOMEPLACE WHEN YOU USUALLY TRAVEL THERE WITHOUT DRIVING")

Yes---------- 1
No ---------- 2
DK/NA---------- 3

4A. Sometimes people will purposely **decrease** the amount of driving they do in a day. An example of purposely **decreasing** driving would be if a person decided to take a bus, walk, bike or ride with someone else to work when they **normally** would have driven, or if someone decided to simply not take a trip they would have normally taken in a car. Between 6PM yesterday evening and 6PM tonight, did you purposely **decrease** the amount of your driving?

(IF RESPONDENT ASKS TO CLARIFY WHAT PURPOSELY DECREASING DRIVING IS, SAY "IT MEANS DECIDING TO TRAVEL SOMEPLACE WITHOUT DRIVING WHEN YOU NORMALLY WOULD HAVE DRIVEN, OR DECIDING NOT TO TAKE A TRIP YOU WOULD NORMALLY TAKE IN A CAR")

Yes---------- 1 (Ask 4B)
No ---------- 2 (Skip to 5A)
DK/NA---------- 3 (Skip to 5A)

4B. How many driving trips did you purposely decrease during this period?

1 ---------- 1
2 ---------- 2
3 ---------- 3
4 ---------- 4
5 ---------- 5
6 ---------- 6
7 or more---------- 7
None---------- 8
DK/NA ---------- 9
Refused ---------- 10

4C. Thinking of the (first/second/third) driving trip you DECREASED, how did you decrease the trip?

Didn't take trip----------1
Carpool passenger ----------2
Public transportation (bus, train, BART, ferry, etc.) --3
Bicycle ----------4
Walk ----------5
Worked at Home ----------6
Other ----------7
(Don't read) Refused ----------8

4D. (IF ANSWERED 'DIDN'T TAKE TRIP' TO QUESTION 4C, ASK): What was the purpose of the trip going to be?
(ANY OTHER ANSWER TO QUESTION 4C, ASK):
What was the purpose of the trip?

Going to or from work ----------1
Shopping ---------- 2
Other (school, errands, recreation, etc.) ----------3
(Don't read) DK ---------- 4
(Don't read) Refused ---------- 5

4E. Why did you purposely decrease this driving trip? (DON'T PROMPT FOR SPECIFIC ANSWERS.)

(Don't read) Spare the Air or advertisements asking people to drive less----------1
(Don't read) Poor air quality ---------- 2
(Don't read) Other ---------- 3

(ASK QUESTIONS 4C-4E FOR EACH TRIP THE RESPONDENT REPORTS THAT THEY DECREASED)

(ASK QUESTIONS 5A AND 5B FOR ALL RESPONDENTS EXCEPT THOSE WHO ANSWER QUESTION 4E WITH RESPONSE CATEGORY '1' FOR ANY 'DECREASED' TRIP THAT THEY REPORT)

5A. Have you heard, read or seen any advertisements during the past two days that talk about poor air quality and driving in this area?

Yes	1	(Ask 5B)
No	2	(Skip to 6)
DK/NA	3	(Skip to 6)

5B. What do you remember about the advertisements? (RECORD ANSWER BELOW)

_____

_____

_____

_____

_____

6. How many motor vehicles, in working order, are owned by the people in your household? (IF NEEDED: "A MOTOR VEHICLE IS A PASSENGER VEHICLE SUCH AS A CAR, VAN, SPORT-UTILITY VEHICLE, TRUCK OR MOTORCYCLE".)

1	1
2	2
3	3
4	4
5	5
6	6
7	7
None	8
DK/NA	9
Refused	10

Thank you so much for your participation in this important research project. We have just a few more questions for comparison purposes.

A. With your permission we would like contact you just ONE more time during the next three months to do a shorter, follow-up survey. If you participate in this second survey your name will be entered into a random drawing to win a $1,000 cash prize. Can we have your permission to call you to do a shorter, follow-up survey?

(IF RESPONDENT SAYS NO):
We truly appreciate your cooperation and we assure you that if you agree we will only call ONE more time with your permission. Once again, if you participate in the second survey you will be eligible to win a $1,000 cash prize. Would you be willing to participate one more time with these assurances and knowing that your contribution is a valuable part of an important research project?

(IF ASKED WHAT THE PROJECT IS FOR, SAY "FOR ASSESSING TRANSPORTATION POLICY IN YOUR AREA")

Yes ---------- 1
No ---------- 2 (Skip to C)

B. So that we can ask for you by name next time we call, can we have your first name and the first initial of your last name? (IF NEEDED, STRESS THE FOLLOWING): This is only so that we can ask for you by name when we call – your name will not be used for any other purpose and will be held in strict confidence.

First Name & First Initial of Last Name: _____
(PROMPT IF THERE IS A JR. OR SR. WITH SAME NAME IN THE HOUSEHOLD – NOTE IF PERSON IS JOHN SR. OR JOHN JR.)

C. In what year were you born?
1975 to 1984 ---------- 1
1970 to 1974 ---------- 2
1965 to 1969 ---------- 3
1960 to 1964 ---------- 4
1955 to 1959 ---------- 5
1950 to 1954 ---------- 6
1945 to 1949 ---------- 7
1940 to 1944 ---------- 8
1935 to 1939 ---------- 9
1934 and before ---------- 10
(DON'T READ) Refused --------- 11

D. How many children under the age of 18 live in your home?

1 ---------- 1
2 ---------- 2
3 or more---------- 3
None---------- 4
Don't Know---------- 5
Refused ---------- 6

E. How many drivers live in your household?

Record Number:_____

F. Are you employed full time, part time, retired, a homemaker, a student or currently unemployed?

Full time ---------- 1 (Ask G)
Part time---------- 2 (Ask G)
Retired---------- 3 (Skip to J)
Homemaker---------- 4 (Skip to J)
Unemployed ---------- 5 (Skip to J)
Student ---------- 6 (Skip to J)
Don't Know---------- 7 (Skip to J)
Refused ---------- 8 (Skip to J)

G. Do you have to pay for part or all of the cost of parking at your place of employment?

Yes, pay part or all of cost -------- 1
No, employer pays full cost------- 2
No parking fees at work---------- 3
DK/NA ---------- 4

H. Does your employer notify you of poor air quality days?

Yes---------- 1
No ---------- 2
DK/NA ---------- 3

I. Does your employer encourage you to drive less, car pool, or use public transportation on poor air quality days?

Yes ---------- 1
No ---------- 2
DK/NA ---------- 3

J. What is the highest level of education that you completed?

Did not graduate high school ---------- 1
High school graduate ---------- 2
Two year college ---------- 3
Four year college ---------- 4
Graduate school ---------- 5
DK/NA/Refused ---------- 6

K. What was the total income of your household before taxes in 1999?

$15,000 or under ---------- 1
$15,001-$35,000 ---------- 2
$35,001-$50,000 ---------- 3
$50,001-$75,000 ---------- 4
$75,001-$100,000 ---------- 5
$100,001-$150,000 ---------- 6
$150,001or more ---------- 7
(DON'T READ) Refused ---------- 8

That is all I have. Thank you so much for participating!

L. Respondent's Sex: Male ---------- 1
Female ---------- 2

ALL INFORMATION BELOW IS REQUIRED

Respondent ID Number: _____ (Required to match for second survey)

PHONE _____

DAY OF THE WEEK _____

DATE OF INTERVIEW _____ VALIDATED BY _____

INTERVIEWER: _____

NUMBER: _____

_____

_____

Godbe Research & Analysis **Time Began _____**
May 15, 2000 **Time Ended ____**
2.3T **Cluster # ______**

ARB SPARE THE AIR SURVEY

SECOND INTERVIEW

Hello, my I please speak to _________. Hi, my name is __________ and I'm calling on behalf of GRA, a public opinion research firm. Several weeks ago you participated in our survey on transportation and agreed to take a shorter follow-up survey. I'm calling because I'd like to get your opinions for the follow-up survey. Upon completion of this interview, your name will be entered into a drawing for $1,000.00.

(IF INDIVIDUAL SEEMS CONFUSED, CHECK TO MAKE SURE YOU ARE SPEAKING TO THE NAMED PERSON WHO TOOK THE ORIGINAL INTERVIEW ON TRANSPORTATION.)

(IF INDIVIDUAL STATES THAT THEY DID NOT COMPLETE AN INTERVIEW BEFORE, DOUBLE CHECK TO MAKE SURE YOU HAVE THE RIGHT NAME – IF YES, ASK IF THERE IS ANOTHER INDIVIDUAL AT THE NUMBER WHO HAS THE SAME NAME)

ONLY CONDUCT THE INTERVIEW IF YOU HAVE THE PERSON WHO TOOK THE FIRST INTERVIEW!!!
^^^

1. We're interested in the travel behavior of Californians, specifically the number and types of trips that they make in a day. A 'trip' is defined as traveling from one place to another and then stopping. For example, if you left your house and went to the store, that is one trip. Leaving the store and going to work or coming back home is another trip. Another example would be if you left your house and went to the bus or train station, that is one trip. Taking the bus or train to your work would be a second trip.

Please take a moment to think back over the 24 hour period from 6PM yesterday evening to 6PM tonight. Excluding any trips that were made 'on-the-job' – such as driving a delivery truck – as well as trips made on an airplane, how many trips did you make during this time period? If you were traveling at 6PM, please include this trip in the total.

Record Number of Trips:________________
(IF RESPONDENT MADE NO TRIPS, SKIP TO 4A)

Next, I'd like to ask you some questions about each of these trips.
(ASK QUESTIONS 2A – 2F FOR THE FIRST TRIP, THEN REPEAT THE QUESTIONS IN SEQUENCE FOR EACH ADDITIONAL TRIP THE RESPONDENT MADE. CONTINUE TO PROMPT RESPONDENT FOR TRIP INFORMATION UNTIL THEY STATE THAT THEY MADE NO MORE TRIPS. THE NUMBER OF TRIPS REPORTED IN Q.2A-Q.2F MAY BE GREATER THAN THE NUMBER REPORTED IN Q.1 IF THE RESPONDENT REMEMBERS A STOP)

2A. Thinking of your (first/next) trip, where were you coming from and what was the purpose of the trip? Remember, every time you stop it ends a trip. (RECORD RESPONSES BELOW ACCORDING TO APPROPRIATE CATEGORY)

Home to Work OR Work to Home	1	
Home to Shopping OR Shopping to Home	2	
Home to Other OR Other to Home	3	
Work to Other OR Other to Work	4	
Other to Other	5	
(Don't Read) DK	6	
(Don't Read) Refused	7	(Terminate)
No More Trips to Report	8	(Skip to 3A)

2B. Did you make any stops along the way? (IF YES, TELL RESPONDENT: "OK, I'D LIKE YOU TO ANSWER THE NEXT SERIES OF QUESTIONS FOR THE PART OF THE JOURNEY BEFORE THE STOP. THEN I WILL ASK YOU SOME QUESTIONS ABOUT THE PART OF THE JOURNEY AFTER THE STOP". FIRST ASK QUESTIONS 2C-2F FOR THE PART OF THE JOURNEY BEFORE THE STOP. THEN ASK 2A-2F FOR THE PORTION OF THE JOURNEY AFTER THE STOP)

Yes	1
No	2

2C. What type of transportation did you use for this trip?(ONLY READ CATEGORIES IF NECESSARY)

Auto Driver (car, truck or van)	1	(Ask 2D)
Auto Passenger (car, truck or van)	2	(Ask 2D)
Motorcycle	3	(Ask 2D)
Public Transportation (Bus,Train,BART,Ferry,etc)	4	(Skip to 2E)
Taxi	5	(Skip to 2E)
Bicycle/Skateboard/Roller Blades	6	(Skip to 2E)
Walk	7	(Skip to 2E)
Other	8	(Skip to 2E)
(Don't Read) Refused	9	(Terminate)

2D. Including yourself, how many individuals traveled with you?

1	1	
2	2	
3	3	
4	4	
5	5	
6	6	
7	7	
8 or more	8	
(Don't Read) DK	9	
(Don't Read) Refused	10	(Terminate)

2E. What time did the trip start? (RECORD TIME, WITH AM/PM) (IF SAYS 'DON'T KNOW', BEST GUESS IS OK)

_____

_____

2F. What time did the trip end? (RECORD TIME, WITH AM/PM) (IF SAYS 'DON'T KNOW', BEST GUESS IS OK)

_____

_____

(REPEAT QUESTIONS 2A – 2F IN SEQUENCE FOR EACH TRIP MADE BY RESPONDENT. CONTINUE TO ASK THESE QUESTIONS UNTIL THEY STATE THAT THEY MADE NO MORE TRIPS)

3A. Sometimes people will purposely **increase** the amount of driving they do in a day. An example of purposely **increasing** driving would be if a person decided to drive to the store when they **normally** would have walked, bicycled or taken a bus. Between 6PM yesterday evening and 6PM tonight, did you purposely **increase** the amount of your driving?

(IF RESPONDENT ASKS TO CLARIFY WHAT PURPOSELY INCREASING DRIVING IS, SAY "IT MEANS DECIDING TO DRIVE SOMEPLACE WHEN YOU USUALLY TRAVEL THERE WITHOUT DRIVING")

Yes---------- 1
No ---------- 2
DK/NA---------- 3

4A. Sometimes people will purposely **decrease** the amount of driving they do in a day. An example of purposely **decreasing** driving would be if a person decided to take a bus, walk, bike or ride with someone else to work when they **normally** would have driven, or if someone decided to simply not take a trip they would have normally taken in a car. Between 6PM yesterday evening and 6PM tonight, did you purposely **decrease** the amount of your driving?

(IF RESPONDENT ASKS TO CLARIFY WHAT PURPOSELY DECREASING DRIVING IS, SAY "IT MEANS DECIDING TO TRAVEL SOMEPLACE WITHOUT DRIVING WHEN YOU NORMALLY WOULD HAVE DRIVEN, OR DECIDING NOT TO TAKE A TRIP YOU WOULD NORMALLY TAKE IN A CAR")

Yes---------- 1 (Ask 4B)
No ---------- 2 (Skip to 5A)
DK/NA---------- 3 (Skip to 5A)

4B. How many driving trips did you purposely decrease during this period?

1 ---------- 1
2 ---------- 2
3 ---------- 3
4 ---------- 4
5 ---------- 5
6 ---------- 6
7 or more---------- 7
None---------- 8
DK/NA ---------- 9
Refused ---------- 10

4C. Thinking of the (first/second/third) driving trip you DECREASED, how did you decrease the trip?

Didn't take trip----------1
Carpool passenger ----------2
Public transportation (bus, train, BART, ferry, etc.) --3
Bicycle ----------4
Walk ----------5
Worked at Home ----------6
Other ----------7
(Don't read) Refused ----------8

4D. (IF ANSWERED 'DIDN'T TAKE TRIP' TO QUESTION 4C, ASK): What was the purpose of the trip going to be?
(ANY OTHER ANSWER TO QUESTION 4C, ASK):
What was the purpose of the trip?

Going to or from work ----------1
Shopping ---------- 2
Other (school, errands, recreation, etc.) ----------3
(Don't read) DK ---------- 4
(Don't read) Refused ---------- 5

4E. Why did you purposely decrease this driving trip? (DON'T PROMPT FOR SPECIFIC ANSWERS.)

(Don't read) Spare the Air or advertisements asking people to drive less----------1
(Don't read) Poor air quality ---------- 2
(Don't read) Other ---------- 3

(ASK QUESTIONS 4C-4E FOR EACH TRIP THE RESPONDENT REPORTS THAT THEY DECREASED)

(ASK QUESTIONS 5A AND 5B FOR ALL RESPONDENTS EXCEPT THOSE WHO ANSWER QUESTION 4E WITH RESPONSE CATEGORY '1' FOR ANY 'DECREASED' TRIP THAT THEY REPORT)

5A. Have you heard, read or seen any advertisements during the past two days that talk about poor air quality and driving in this area?

Yes	1	(Ask 5B)
No	2	(Skip to 6)
DK/NA	3	(Skip to 6)

5B. What do you remember about the advertisements? (RECORD ANSWER BELOW)

_____

_____

_____

_____

_____

6. How many motor vehicles, in working order, are owned by the people in your household? (IF NEEDED: "A MOTOR VEHICLE IS A PASSENGER VEHICLE SUCH AS A CAR, VAN, SPORT-UTILITY VEHICLE, TRUCK OR MOTORCYCLE".)

1	1
2	2
3	3
4	4
5	5
6	6
7	7
None	8
DK/NA	9
Refused	10

Thank you so much for your participation in this important research project. As promised, your name will be entered into a drawing with other survey participants to win a $1,000.00 cash prize. If your name is selected, we contact you at this number.

ALL INFORMATION BELOW IS REQUIRED

Respondent ID Number:_____ (Required to match first and second surveys)

PHONE _____

DAY OF WEEK:_____

DATE OF INTERVIEW _____ VALIDATED BY _____

INTERVIEWER: _____

NUMBER: _____

_____

_____

Appendix C

Regression Methodology

An Analysis of Factors Associated With Reported Reduction In Driver Trips In Response to Spare-the-Air Advertising

Abstract and Summary of Findings

A number of covariates representing possible influences on the likelihood that an individual will report reduction in driver trips in response to Spare-the-Air (STA) advertising have been examined in a logistic regression analysis. A final model containing three covariates resulted from the analysis. Interaction among these covariates was considered and found not to be significant. The model was checked for goodness of fit and colinearity. The model fits the data well. Colinearity is not a problem.

Survey respondents with three or more children under 18 are about ¼ as likely to report reducing driver trips in response to STA advertising, compared to respondents with no children under 18. Survey respondents who report that their employer notifies them about poor air quality days are about 1.6 times more likely to report reducing driver trips compared to employees whose employer does not notify them of poor air quality days. Survey respondents who are female are about 1.6 times more likely to report reducing driver trips in response to STA advertising compared to males.

Introduction

The Spare-the Air survey offers an opportunity to explore the following question: What are the characteristics of individuals who report having reduced driver trips in response to Spare-the-Air (STA) advertising compared to individuals who do not report reducing trips? To provide the basis for addressing this question the survey included a number of items found in previous transportation research to be related to driver behavior and other transportation outcomes. Questions included the following: 1.) the number of motor vehicles in working order in the household, 2.) age of respondent (calculated from question on year of birth), 3.) the number of children under the age of 18 living in household, 4.) the number of drivers in the household, 5.) employment/retirement/student status, 6.) employee payment for parking at work, 7.) employer notifies employees of poor air quality days, 8.) employer encourages employees to drive less, car pool, or use public transit on poor air quality days, 9.) highest education level completed, 10.) total pre-tax household income in 1999, and 11.) respondent gender.

Logistic Regression

To perform the desired analysis of the survey data, binary logistic regression was used. Binary logistic regression is a statistical technique that allows analysis of the associations between a set of independent variables (covariates) like the above listed survey items and a single dichotomous dependent (response) variable like the survey respondents' report/lack of report of trip reduction in response to STA advertising (SPSS, 2000). Logistic regression is similar to multiple linear regression in its production of a set of weights describing the influence on a response variable of each covariate, adjusting for the effects of other covariates evaluated simultaneously.

In logistic regression the weight produced for each covariate is called an odds ratio. The odds ratio approximates how much more likely (or unlikely) it is for a particular outcome (e.g. being an STA reducer) to occur among those with a particular characteristic (e.g. being female) (Hosmer and Lemeshow, 1989). An odds ratio of 2.0 for females, for example, would mean that women are twice as likely as men to be STA reducers. Conversely, an odds ratio of .5 for females, would indicate that

women are half as likely to be STA reducers as men. Odds ratios take on values from 0 to infinity, with an odds ratio of 1.0 indicating no influence of a covariate on the response variable.

In addition to the odds ratio, another quantity of interest in interpreting logistic regression results is the logistic regression coefficient. This coefficient indicates the rate of change in the probability that research subjects will manifest the response of interest for a unit change in a particular independent variable. The logistic regression coefficient and associated statistics are used to evaluate the statistical significance of the influence of individual covariates on the response variable.

Data Sample Used In The Analysis

Logistic regression requires that data values be present for the response variable and each covariate being considered in an analysis. The data values of the response variable (STA reducer or not) and the covariates (the above listed survey questions) were missing in some cases because survey respondents were either unwilling to answer certain questions, or didn't know the answers. The number of cases available for analysis varies depending on the number of covariates being analyzed. The more covariates are analyzed, the greater the likelihood that data values will be missing for some of them, and thus the greater the likelihood that particular cases will be eliminated from the analysis because of these missing data values. Thus, more cases are available for analyses in which fewer covariates are analyzed.

Because of the effects of missing information, the samples analyzed varied in size from one analysis to the next. More than 1400 cases were available in some bivariate analyses—those considering only the response variable and one covariate. By contrast, in one analysis that included the response variable and all the covariates, only 748 cases were available for analysis. The final fitted logistic regression model included three covariates with all data values available for 999 cases. In this analysis, there were 122 STA reducers and 877 non-STA reducers. In each analysis, all cases with complete data values on the covariate(s) of interest were used in order to maximize sample size. This insured maximum possible statistical power and resulted in the inclusion of as many STA reducers as possible.

Analytic Strategy

Hosmer and Lemeshow (1989) recommend the following steps in logistic regression analysis:

1. The initial step is careful univariate analyses of each covariate and bivariate analyses of each covariate in relation to the response variable. This allows the identification of covariates with zero cells. Zero (empty) cells produce aberrant results—zero or infinite odds ratio estimates and abnormally large standard errors for odds ratio estimates. Conceptually appropriate combination of adjacent covariate categories is recommended to eliminate zero cells. Bivariate analyses are used to examine the form of the relationship (e.g. binary, linear, curvilinear, etc.) of each covariate to the response variable. Bivariate analyses are also used to decide which covariates to include in initial multivariate model building runs. An accepted rule of thumb is to include in initial multivariate analyses all covariates related to the response variable at probability values < .25 in the initial bivariate analyses (Bendel and Afifi, 1977, Mickey and Greenland, 1989).
2. The second step is multivariate analyses beginning with all covariates significantly related to the response variable at p. < .25. This is followed by analyses in which those covariates found not to be related to the response variable at lower alpha levels (e.g. .10,

.05, etc.), are identified and eliminated. The result is a "main effects" model that considers only the effects of each covariate operating by itself and not in concert with any other covariates.

3. The third step includes creation and addition of interaction terms to the "main effects" model created in the second step. When the effects of a given covariate on the response variable are different at different levels (i.e. values) of a second covariate, the two covariates, acting in concert, are said to "interact". For example, the number of children present in a household might affect the likelihood of a survey respondent being an STA reducer. It may be that survey respondents who have lots of kids are less likely to be STA reducers. It might be the case, however, that having more children only reduces the tendency to report being an STA reducer among women, but not among men. If this were true, respondent sex and number of children in the household would be said to interact. The presence of interaction forces qualification of what can be said about the main effects of covariates acting by themselves. In this example, we can say that having more children reduces the likelihood that someone will be an STA reducer, but we must qualify our statement by noting that this effect of more children is only present among women. Thus, before unqualified statements about the effects of covariates acting individually can be made, the possibility of significant interaction must be actively analyzed. Any appropriate interaction terms must be included in the model.
4. The final step considers the goodness of fit of the final model containing all covariates and interaction terms added in previous steps.

Step 1: Univariate and Bivariate Analyses and Modifications in Variables.

Univariate Analysis

Using frequency distributions, all candidate covariates were examined and recoded as necessary to clearly capture the concepts they were intended to measure and to prevent the emergence of zero cells during later stages of the analysis. The final structure of each variable is listed below. Changes made to clarify concepts and avoid zero cells are noted.

1. Question 6, number of motor vehicles in working order owned by household members, was recoded as follows: First, category "8", "none" was set equal to 1 to make a category of "none or one" vehicle in the home. This was done because only 20 respondents reported no vehicles in the home and this small frequency was likely to have caused the emergence of zero cells in later analyses. A total of twelve households reported owning 6 or 7 vehicles. To avoid the emergence of zero cells in later analyses, these were combined with households reporting 5 vehicles. The final values of the covariate were 1=none or one vehicle, 2, 3, 4, and 5=five or more vehicles.

2. A categorical (ordinal) age variable was created to replace question C, the year of birth variable. This was done by first forming dates corresponding to the mid-points of each of the year-of-birth categories in question C. Next, for each survey respondent, this date was subtracted from the respondent's survey date in 1999 or 2000, the summers during which surveys were conducted. For each birth year category of the original survey question, new rounded upper and lower age category boundaries were then formed. The values of the resulting age variable were:

1.00 15.0 TO 25.0 years
2.00 > 25.0 TO 30.0 years
3.00 > 30.0 TO 35.0 years
4.00 > 35.0 TO 40.0 years
5.00 > 40.0 TO 45.0 years
6.00 > 45.0 TO 50.0 years
7.00 > 50.0 TO 55.0 years
8.00 > 55.0 TO 60.0 years
9.00 > 60.0 TO 65.0 years
10.00> 65.0 years

3. Question D, number of children under the age of 18 living in the household, was recoded to set the value "4" for "none" equal to 0. Final values were 0, 1, 2, and 3 or more.

4. Question E, the number of drivers in the household, was left as is. Final values were, 0 through any positive integer.

5. Question F, on employment/retirement/homemaker/student status was recoded. Category 5, "unemployed" was set to 0. Final values were as follows:

0 unemployed
1 full time
2 part time
3 retired
4 homemaker
6 student

6. Responses to question G were recoded to create a 0-1 dummy variable (dichotomy) as follows: Response categories 2 (employer pays parking cost) and 3 (no parking fees at work) were recoded as 0 (employee has no parking cost at work). Category 1 (pay part or all of cost) was left as is. Final values were 0 = no cost of parking at work, and 1 = employee pays part or all of parking cost at work.

7. Responses to question H were recoded to create a dummy variable (dichotomy) as follows: Category 2 (employer does not notify you of poor air quality days) was recoded as 0 and category 1 (employer notifies you of poor air quality days) was left as is. Final values were 0 (employer does not notify, etc.), and 1 (employer notifies, etc.).

8. Responses to question I were recoded to create a dummy variable (dichotomy) as follows: Category 2 (employer does not encourage you to drive less, etc.) was recoded as 0 and category 1 (employer encourages you to drive less, etc.) was left as is. Final values were 0 (employer does not encourage employees to drive less, etc.) on poor air quality days, and 1 (employer encourages employees to drive less, etc.) on poor air quality days.

9. Question J, highest level of education completed was left as is. Final values were the following:

1 did not graduate from high school
2 high school graduate

3 two years of college
4 four years of college
5 graduate school

10. Question K, income, was recoded to combine the highest two categories to prevent the emergence of zero cells in later analysis. Univariate analysis showed few respondents with incomes over $150,000. The resulting categories were:

1 $15,000 or under
2 $15,001 to $35,000
3 $35,001 to $50,000
4 $50,001 to $75,000
5 $75,001 to $100,000
6 $100,001 or more

11. Question L, gender, was recoded to create a dummy variable (dichotomy), with final values 0 = male, 1 = female.

12. The response variable, STA reducer status, was recoded as a dummy (dichotomy) and had final values of 0, not an STA reducer, and 1, STA reducer.

Bivariate Analyses

Table 1, page 6, summarizes the results of the bivariate analyses. In each of these separate analyses, a particular covariate was added as a single "block" to an initial model containing only a constant term. A block consists of one or more covariates all entered into an analysis in a single computational step. When a new block is added to a logistic regression model a "likelihood ratio test" (Hosmer and Lemeshow, 1989) is performed, indicating whether the newly included variable(s), considered as a block, add statistically significant predictive power to the model. All the covariates and their likelihood ratio tests are shown in Table 1. The likelihood ratio test follows a X^2 (chi square) distribution. Probabilities for the test for each covariate are shown in the right column of Table 1.

Results indicate that covariates 2, 3, 6-9, and 11 had relations with STA reducer status at significance levels < .25.

Table 1--Results of Bivariate Analysis

Covariate	Likelihood Ratio Test Statistic	Statistical Significance
1. Number of vehicles in working order in the household	2.90	.58
2. Respondent age on date of survey	25.10	.003*
3. Number of children in household under 18 years of age	8.40	.038*
4. Number of drivers in household	.65	.96
5. Employment/retirement/homemaker/student status	3.56	.61
6. Employee payment of part or all of parking cost at work	2.17	.14*
7. Employer notifies employees of poor air quality days	3.12	.077*
8. Employer encourages less driving on poor air days	2.82	.093*
9. Highest education level completed	5.83	.212*
10. Household pre-tax income in 1999	3.56	.62
11. Respondent gender (female)	13.60	.000*

* p. < .25

Analysis of covariate 2 (age on survey date) in relation to STA reducer status suggested the possibility of a sampling anomaly. Beginning with the lowest category of age (15.0 to 25.0), the percentages of respondents who report being STA reducers are as follows: 9.4%, 11.4%, 14.1%, 16.6%, 4.5%, 18.5%, 19.2%, 13.9%, 8.0%, and 13.7%. The precipitous drop in the percentage of STA reducers from 16.6% for 35 to 40 year olds, to 4.5% for those 40 to 45 years old, followed by an even more abrupt rise to 18.5% for 45 to 50 year olds, is difficult to understand as a normal behavioral progression in response to increasing age. A more natural progression would be a smoother one in which a drop to a much lower level would begin and end in categories adjacent to the one in which the drop reached its lowest point (4.5%). This did not occur. STA reducer status as a function of age has three, and perhaps four, clear reversals of trend (inflection points). There is no handy explanation for the shape of this function. It may well represent an anomalous sampling result. This sometimes occurs even when proper sampling techniques have been used, as in the present study. For this reason, age was dropped from further analysis.

Step 2: Multivariate Analyses

Because none of the candidate covariates had a large number of values, it was possible to treat each one as a categorical variable, thus insuring the discovery of relationships of any form (linear or non-linear) between covariates and the response variable. A categorical variable (covariate) is one with a relatively small number of discrete values, e.g. respondent sex (with values male or female) or income (captured using a few broad categories, e.g. with values “$0 to $15,000”, and “more than $15,000”). Categorical variables are distinguished from continuous ones, which have a theoretically infinite number of possible values. Examples of continuous variables could be weight, temperature, etc.

When treated as a categorical variable in a logistic regression, one value of a variable (usually the first or the one with the lowest numerical value) becomes a “reference category”, and each of the other categories becomes a “design variable”. For example, in treating respondent sex as a categorical

covariate in the present analysis, the value "male" (with the arbitrarily assigned numerical value zero) was treated as a reference category. The value "female" (with the arbitrarily assigned numerical value one) was treated as a "design variable".

In Table 2, below, reference categories and design variables are identified for each covariate. For example, covariate 3, Table 2, is number of children under 18 years of age. Its reference category value, as shown in the table, is "0"—no children under 18 years old in the household. The design variables for this covariate are 3(1), representing cases with one child under 18, 3(2), representing cases with two children under 18, and 3(3), representing cases with three or more children under 18. Results are shown only for the design variables.

In interpreting the results for a particular design variable, the reader should automatically incorporate in his/her thinking the phrase, "compared to cases in the reference category, cases represented by this design variable" are more (or less) likely to be STA reducers, etc.

At this stage of logistic regression analysis a number of methods are available for deciding which covariates to include in successive modeling steps. In the present case, the number of candidate covariates is small. Because of the small number of covariates available for inclusion in the model, we constructed a model containing every covariate remaining statistically significantly related to the response variable after adjustment for the effects of other covariates under consideration, avoiding approaches aimed at minimizing the number of covariates included in the model (Hosmer and Lemeshow, 1989). We are aware of no previous research on this topic and we therefore believe research on the topic is in its earliest stage. Under this circumstance it is reasonable to cast a little wider net in looking for covariates that might influence the response variable. We therefore used a statistical significance criterion (alpha level) of .10 in deciding which covariates to include in analyses subsequent to the initial multivariate analysis containing all covariates (Judd, Smith, and Kidder, 1991).

Consistent with the foregoing, covariates 3, 6-9, and 11, all related to STA reducer status at $p. < .25$ in the univariate/bivariate analyses were simultaneously analyzed in relation to STA reducer status. All covariates were added as a single block to an initial logistic regression model containing only a constant term. This resulted in identification of a subset of covariates that remained significantly related to the response variable at probability levels $< .10$ after adjustment for the effects of all the other covariates. The results of this analysis are shown in Table 2, below.

Table 2--Results of First Multivariate Analysis

Covariate	Logistic Regression Coefficient	Wald Statistic	Statistical Significance	Odds Ratio	Confidence Interval Lower Bound	Confidence Interval Upper Bound
3. # Children under 18. Reference value =0(none).	_____	_____	_____	_____	_____	_____
3(1) # Children under 18 = 1	-.113	.211	.646	.893	.551	1.45
3(2) # Children under 18 = 2	-.481	2.396	.122	.618	.336	1.14
3(3) # Children under 18 = 3 or more.	-1.332	6.328	.012*	.264	.094	.75
6. Employee payment of part or all of parking cost at work. Reference value = 0(no payment)	_____	_____	_____	_____	_____	_____
6(1) Employee payment of part or all of parking cost at work = 1(yes).	.146	.278	.598	1.158	.672	1.99
7. Employer notifies employees of poor air quality days. Reference value = 0 (no).	_____	_____	_____	_____	_____	_____
7(1) Employer notifies employees of poor air quality days = 1(yes).	.452	2.958	.085*	1.572	.939	2.63
8. Employer encourages less driving on poor air days. Reference value = 0(no).	_____	_____	_____	_____	_____	_____
8(1) Employer encourages less driving on poor air days = 1(yes).	.117	.239	.625	1.124	.703	1.80
9. Highest level of education completed. Reference value = 0(no H. S. grad.)	_____	_____	_____	_____	_____	_____
9(1) Education: H. S. grad.	.072	.012	.911	1.075	.302	3.82
9(2) Education: 2 yrs. college	.314	.238	.626	1.368	.388	4.82
9(3) Education: College grad.	-.036	.003	.956	.964	.269	3.46
9(4) Education: Graduate school	.446	.469	.494	1.562	.435	5.61
11. Respondent sex. Reference value = 0 (male).	_____	_____	_____	_____	_____	_____
11(1) Respondent sex = 1 (female).	.402	3.796	.051*	1.495	.998	2.24

* P. < .10.

Results for this multivariate run indicate that, adjusting for the effects of other covariates, three covariates influence the likelihood that a respondent will report being an STA reducer. The more children under 18, the greater the likelihood that the respondent is an STA reducer. Employees whose

employers notify them of poor air days are more likely to report being STA reducers. And women are more likely than men to report being STA reducers. These variables were retained for further analysis.

Step 3: Assessing Interaction Effects

It is always possible that the effects of a covariate on the response variable will be different at different levels of another covariate. As noted above, it could be that having several children under the age of 18 reduces the likelihood of being an STA reducer, but only among women. It is therefore necessary to form and examine the effects of interactions among the covariates (Hosmer and Lemeshow, 1989). To do this, the following interaction terms were formed:

- Children under 18 x employer notification of poor air quality days,
- Children under 18 x respondent sex,
- Employer notification of poor air quality days x respondent sex, and
- Children under 18 x employer notification x respondent sex.

To assess the effects of these interactions, each one was added in a separate logistic regression as a second covariate block to a model containing a constant term and an initial covariate block consisting of the (main effects) covariates (# Children under 18, Employer notification of poor air quality days, respondent sex) as an initial covariate block (Hosmer and Lemeshow, 1989). The effects of the interaction covariates are shown in Table 3. The results are interpreted using the likelihood ratio test explained above and used in Table 1.

Table 3—Assessment of Interaction Effects

Interaction Term	Likelihood Ratio Test Statistic	Statistical Significance
1. Number of children under 18 x employer notification of poor air quality days	.385	.943
2. Children under 18 x respondent sex	2.63	.452
3. Employer notification of poor air quality days x respondent sex	.13	.719
4. Children under 18 x employer notification x respondent sex	3.12	.374

The results in Table 3 show that none of the interaction terms added significantly to the model. The interactions were therefore not included in the final model.

The Final Model

The model emerging from the above analysis includes the main effects of the following covariates: number of children under 18 in the household, whether the employer notifies employees of poor air quality days, and respondent sex. Table 4 shows the model in its final form after being re-run including only these covariates. When the surviving covariates are entered in an analysis without other statistically insignificant covariates, each is statistically significant at p. < .05.

Table 4 indicates that survey respondents with three or more children under 18 are about ¼ as likely to report being STA reducers as respondents with no children under 18 (odds ratio = .248) . Survey respondents who are female are about 1.6 times as likely to report being STA reducers (odds ratio = 1.623). Finally, survey respondents who report that their employer notifies them about poor air quality days are about 1.6 times as likely to report being STA reducers (odds ratio = 1.636).

Table 4—Final Model

Covariate	Logistic Regression Coefficient	Wald Statistic	Statistical Significance	Odds Ratio	Confidence Interval	
					Lower Bound	Upper Bound
3. # Children under 18. Reference value =0(none).	_____	_____	_____	_____	_____	_____
3(1) # Children under 18 = 1	-.067	.079	.779	.935	.587	1.49
3(2) # Children under 18 = 2	-.474	2.50	.114	.622	.346	1.12
3(3) # Children under 18 = 3 or more.	-1.395	7.043	.008*	.248	.088	.694
7. Employer notifies employees of poor air quality days. Reference value = 0 (no).	_____	_____	_____	_____	_____	_____
7(1) Employer notifies employees of poor air quality days = 1(yes).	.492	4.517	.034*	1.636	1.039	2.58
11. Respondent sex. Reference value = 0 (male).	_____	_____	_____	_____	_____	_____
11(1) Respondent sex = 1 (female).	.484	5.684	.017*	1.623	1.09	2.42

P. < .05.

Step 4: Assessing Goodness of Fit and Colinearity

Hosmer and Lemeshow (1989) define goodness of fit as how well a model describes the outcome (response) variable of interest. Goodness of fit is typically measured using summary statistics that compare the observed frequency of occurrence of the response variable (being an STA reducer) with the frequency of occurrence predicted using the final model. Large differences between observed and expected occurrences of the response variable indicate lack of fit, and need to be addressed by modifying the covariates or by addition or deletion of covariates.

SPSS provides the Hosmer-Lemeshow test (Hosmer and Lemeshow, 1989), a summary measure of goodness of fit for the model. The Hosmer-Lemeshow test divides cases into groups according to likelihood that respondents are STA reducers. This produces a contingency table in which expected (based on the model) and observed frequency of occurrence of the response variable (STA reducers) are compared. The test statistic follows a X^2 distribution. If the resulting X^2 test is not statistically significantly different from zero, the model is said to fit. In the present case, the Hosmer-Lemeshow X^2 was 1.86, p. = .97, indicating quite reasonable fit of the model to the data.

The correlations among the covariates in the model were examined to identify any colinearity problems. Colinearity is present when there are substantial and statistically significant correlations among the covariates. When colinearity is present, it is not unusual to observe large changes in the influence of the covariates from one sample to another, indicating that a stable set of factors influencing the response variable has not been identified. The results of the colinearity analysis appear in Table 5. As can be seen, the correlations among the covariates are uniformly small and statistically insignificant, posing no problems of colinearity.

Table 5--Correlations Among Covariates

		# Children Under Age 18 in Household	Employes Notified of Poor Air Quality Days
Employes Notified of Poor Air Quality Days	Pearson Correlation	.010	
	Sig. (2-tailed)	.740	----------
	N	999	
Respondent Sex	Pearson Correlation	.029	-.040
	Sig. (2-tailed)	.267	.204
	N	1449	1010

Mathematical Expression Of The Logistic Regression Model

The purpose of logistic regression is to estimate the probability, P, that some event or condition, Y, will occur as a function of one or more independent variables (covariates), X. The mathematical expression the model is the following (Hosmer and Lemeshow, 1989):

$$P(Y = 1 \mid x) = \pi (x) = e^{g(x)} / 1 + e^{g(x)}$$

Where:

e = 2.7183 (the base of the natural logarithm)

$g(x) = S \beta_j X_j = \beta_0 X_0 + \beta_1 X_1 + \ldots + \beta_j X_j$, where the β_j, j = 1, 2, ..., p, are p logistic regression coefficients from a maximum likelihood estimation process (Hosmer and Lemeshow, 1989) and the X_j, j = 1, 2, ..., p, are p independent variables (covariates). The model includes a constant term $\beta_0(1) = \beta_0$.

One of the variables in the model (Number of children under 18 (in the household) is a discrete variable with 4 possible values (0, 1, 2, 3 or more). Values 1, 2, and 3 or more, are represented in the

model as design (dummy) variables, denoted as **# under age 18 (1)**, **# under age 18 (2)**, **and # under age 18 (= 3)**. Each of these is coded 1 if a case has the corresponding number of children under 18 (1, 2, or = 3) in the household, zero otherwise. The remaining variables in the model are Employer notifies employees of poor air quality days, denoted **Employer Notifies**, coded 1 if the employer notifies the employee of poor air quality days, zero otherwise; and survey respondent gender, denoted **Gender**, coded 1 if the respondent is female, zero otherwise.

For the final model estimated in this research, with the above definitions, we have:

$P(Y = 1 | X) = \pi (x) = e^{g(x)} / 1 + e^{g(x)}$, and

$g(x) = S ß_j X_j$ = -2.187 (**constant**) - .067 (**# under age 18 (1))**
- .474 (**# under age 18 (2))** - 1.395 (**# under age 18 (3))**
+ .492 (**Employer Notifies)** + .484 (**Gender).**

The odds ratios for each variable in the equation are found by exponentiating the respective logistic regression coefficients. They can be found in Table 4 of this (appendix) copy of the report.

Summary of Findings

A number of covariates representing possible influences on the likelihood that an individual will report being an STA reducer have been examined in a logistic regression analysis. A final model containing three covariates as main effects resulted from the analysis. Interaction among these covariates was considered and found not to be significant. The model was checked for goodness of fit and colinearity. The model fits the data well. Colinearity is not a problem.

Survey respondents with three or more children under 18 are about ¼ as likely to report being STA reducers compared to respondents with no children under 18. Survey respondents who report that their employer notifies them about poor aid quality days are about 1.6 times more likely to report being STA reducers compared to employees whose employer does not notify them of poor air quality days. Survey respondents who are female are about 1.6 times more likely to report being STA reducers compared to males.

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