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Epidemiologic Study of the Effects of Automobile Traffic on Blood Lead Levels

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EPIDEMIOLOGIC STUDY OF THE EFFECTS OF AUTOMOBILE TRAFFIC ON BLOOD LEAD LEVELS

by

D. E. Johnson, R. J. Prevost, J. B. Tillery,
K. T. Kimball and J. M. Hosenfeld
Southwest Research Institute
3600 Yoakum Blvd.
Houston, Texas 77006

Contract No. 68-02-2227

Project Officer

Warren A. Galke
Population Studies Division
Health Effects Research Laboratory
Research Triangle Park, N.C. 27711

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
HEALTH EFFECTS RESEARCH LABORATORY
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FOREWORD

The many benefits of our modern, developing, industrial society are accompanied by certain hazards. Careful assessment of the relative risk of existing and new man-made environmental hazards is necessary for the establishment of sound regulatory policy. These regulations serve to enhance the quality of our environment in order to promote the public health and welfare and the productive capacity of our Nation's population.

The Health Effects Research Laboratory, Research Triangle Park, conducts a coordinated environmental health research program in toxicology, epidemiology, and clinical studies using human volunteer subjects. These studies address problems in air pollution, non-ionizing radiation, environmental carcinogenesis and the toxicology of pesticides as well as other chemical pollutants. The Laboratory participates in the development and revision of air quality criteria documents on pollutants for which national ambient air quality standards exist or are proposed, provides the data for registration of new pesticides or proposed suspension of those already in use, conducts research on hazardous and toxic materials, and is preparing the health basis for non-ionizing radiation standards. Direct support to the regulatory function of the Agency is provided in the form of expert testimony and preparation of affidavits as well as expert advice to the Administrator to assure the adequacy of health care and surveillance of persons having suffered imminent and substantial endangerment of their health.

Lead, because of its variety of uses and its toxicity, has been a pollutant of much concern. The present study is an attempt to investigate the impact of automotive lead emissions on the amount of lead in the body of persons living along streets with typical urban traffic volume. The blood lead levels of persons of different ages have been investigated in relationship to traffic volumes of up to about 30,000 vehicles per day.

F. G. Hueter, Ph. D.
Acting Director,
Health Effects Research Laboratory

ABSTRACT

The objective of this research project was to characterize the absorption of lead by people of different age-sex groups exposed to automobile emissions of lead at traffic densities from less than 1000 cars per day to 25,000 cars per day. The relationships between traffic densities and lead content of various environmental and household samples were also examined. Participant selection was based upon a strict set of criteria which eliminated anyone whose blood-lead level was affected by exposure to sources of non-food lead other than automobile emissions.

The degree of absorption by the participants was determined by measuring blood-lead concentrations and blood-FEP levels. Blood CO levels were also measured. A micro-analytical technique was developed to accurately measure blood-lead at concentrations less than 30 μg/100 ml in 100 μl capillary blood samples from children. Also, hand-wipe samples from children were analyzed for lead.

The relationships between blood lead, handwipe lead and blood CO levels of participants of different age-sex groups and different traffic densities were examined. No significant relationships with traffic densities were found in the range of exposures studied.

Selected household samples were also measured for lead content to eliminate them as possible sources of lead for the participants and to examine the relationship of their lead concentration to traffic densities. Household samples investigated included water from resident's kitchen tap, paint from the interior and exterior surfaces of the residences, 28-day indoor dust samples, and window sill wipe samples.

Water was eliminated as a significant source of lead ingestion and there were no relationships between any household samples' lead content and traffic densities.

Outside environmental samples were also analyzed for lead. These included soil from participant residences, outdoor dust from selected sites in the study area, and air particulate matter from streets of different traffic densities where participants lived. Traffic counts were also made on these streets to determine traffic densities. Physical and chemical properties of the soil samples were also determined.

Increased soil lead concentrations were observed with increasing traffic density. Physical and chemical characteristics of the soil in the study area favor lead retention in the soil matrix. Lead in air was found to be related to increasing traffic density although the slope of the regression line was not steep.

A positive relationship between smoking and blood lead levels was found for both females and males in this study. Females who smoke had significantly higher blood lead levels than female exsmokers and nonsmokers. Male smokers and exsmokers had higher blood lead levels than nonsmokers, although this difference was not significant.

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I. INTRODUCTION

MOBILE EMISSIONS

Review of Related Lead Studies

Contributions of lead from various sources in the environment (air, water, soil, house dust, food) to accumulations in people have been the subject of many scientific investigations. These have been well summarized in the Environmental Protection Agency's air quality criteria document for lead, now in its third draft(1). The investigation reported herein is centered on the contribution of lead to populations from ambient air sources, primarily from automobile emissions; accordingly, discussion of the literature in this report will be restricted to these subjects.

Approximately 88 percent of the total atmospheric emissions of lead in 1975 were from automobile use with the remainder coming from lead-using industries primarily smelters. There has been concern regarding the contribution of lead from mobile sources to the levels of lead in people, especially those people living near heavily traveled roads. Lead originates from automotive sources via the burning of gasoline which contains tetraalkyl lead as an antiknock agent. The quantity of lead utilized in the United States has decreased somehwat during the last several years due to reduced gasoline lead content and to the introduction of the catalytic converter which requires nonleaded fuel.

In a previous program conducted by Southwest Research Institute[2], it was shown that traffic policemen and parking garage attendants had elevated blood leads levels as compared with control groups of participants. The blood lead levels were as follows: traffic policemen - 23.1 μg per 100 ml as compared to their controls - 18.4 μg; and parking garage attendants 28.3 μg per 100 ml as compared to their controls - 21.3 μg. The elevations in blood lead were attributed to exposure to lead primarily from mobile emissions. The control groups of participants were selected to match as closely as possible the positive group of participants for age, sex, smoking habits, and socioeconomic parameters. In general, the study participants did match closely regarding these parameters; however, the traffic policemen tended to have less eduation than their controls and the parking garage attendants were slightly younger than their controls. A second portion of the study involved adult females living near freeways and a control group of adult females living away from freeways. The results showed no significant differences in the blood lead of the two female populations, the values being 12.9 (near freeways) as compared with 11.9 μg per 100 ml. Blood lead values for males were consistently higher than for females and black participants tended to have higher blood leads than did white participants. Air lead measurements were not performed as a part of this study.

Galke, et al.[3] determined the blood levels of lead in 187 children, age one to five years living in Charleston, South Carolina. The relationship of lead in soil, paint and air was examined with regards to traffic densities and levels of lead in the blood of the children. It was found that the arithmetic mean blood lead level was related to both the lead in soil and automobile traffic.

Caprio, et al.[4] examined blood lead levels of children relative to how close they lived to a major traffic artery. The study, reported in 1974, included some 5,226 children living in Newark, New Jersey. Over 57 percent of the children living within 100 feet of a roadway had blood levels in excess of 40 µg per 100 ml. Lower levels of lead were seen for those children living further away from major roadways. The authors concluded that residential proximity to high traffic densities can contribute substantially to lead absorption in children. Their findings indicated that residential areas located immediately adjacent to an urban highway exhibited higher rates of excessive blood lead absorption in children than did households beyond 200 feet from the street. This study did not consider lead from other sources. Other studies of the contribution of mobile emissions to blood leads indicate that these higher blood lead values are not usually seen as a result of lead from automobile emissions alone. Contribution of lead from sources such as lead in paint might have been involved in this investigation.

Daines, et al.[5] studied black females living near a heavily trafficked highway in New Jersey. The study population in this investigation lived in houses on streets paralleling a major highway at three distances from it. Air lead levels were measured as were blood lead values. Mean annual air lead concentrations ranged from 4.6 μg per cubic meter to 2.24 μg per cubic meter from the closest to the furthermost distances. Mean blood lead levels of the three study groups of women in order of increasing distances from the freeway were 23.1, 17.4, and 17.6 μg per 100 ml. Measurement of lead was also performed in the air inside and outside of the homes, in those homes with and without air conditioning, and during times of winter and summer. The results showed levels of lead indoors were reduced approximately 50 percent in the wintertime when the windows were closed. Approximately the same percentage reduction in lead from outside to inside air was seen in homes with air conditioning units operated during the summertime. It was noted that the quality of the air conditioners utilized in these homes was poor.

Thomas, et al.[6] examined blood lead levels in 50 adults who lived at least three years within 250 feet of a major freeway in Los Angeles as compared with 50 other participants who had lived for similar periods near the

Pacific Ocean. The participants living close to the Pacific Ocean in this particular area were upwind (prevailing wind) of significant mobile emissions. Thomas et al. reported mean blood levels of 22.7 μg/100ml for males and 16.7 μg/100ml for females while their controls were 16.0 μg per 100 ml for men and 9.9 μg per 100ml for women. The results show significantly higher levels of lead in the population living near the freeway as compared with their control groups of participants. The authors concluded that the differences observed were consistent with coastal-inland atmospheric and blood lead gradients in the Los Angeles basin and that the effect of residential proximity to a freeway was not demonstrated. The results seen in this paper do not support the conclusion of the authors.

Waldron [7] reported on the mean blood lead levels of 41 males and 51 females living within 800 meters of a highway interchange. In this study, blood lead levels were measured in these participants prior to the opening of the highway interchange, and similar measurements were made following the opening of the freeway. The lead levels were 14.41 for males and 10.93 μg per 100ml for females during the baseline period, 18.95 and 14.93 approximately one year after interchange was open and two years after opening the values were 23.73 and 19.21 μg/100ml.

Jones, et al. [8] studied taxi drivers for blood lead value using a calculation of the driver's relative lead exposure as a result of the night versus day shift and the total mileage driven. The mean blood lead for the 50 London taxi drivers was 28 μg per 100 ml. These authors found no statistically significant differences in the blood lead levels related to their index of exposure.

A study performed in California by this laboratory examined the relationship of lead from mobile sources present in two communities, one in Los Angeles and the other in Lancaster (9,10,11). The study area in Los Angeles was located on the downwind side of the San Diego Freeway (traffic density of more than 200,000 cars per day) and the second was in the city of Lancaster, California located in a high desert area with a population of approximately 50,000. The two areas were selected to represent a relatively high and a relatively low area of exposure to mobile emissions. In each of the two areas, environmental measurements were made for lead in ambient air, soil and tap water. In addition, measurements of lead in paint of selected residences were made in the Los Angeles area. Participants from these two areas were examined for lead in blood, urine, hair and feces. Lead in ambient air in the Los Angeles site averaged 6.3 μg per cubic meter while in the control area (Lancaster), the average was 0.6 μg per cubic meter. Considerably higher levels of lead in soil were found in the Los Angeles site (1913.6 μg/g) than in Lancaster (66.9 μg/g). There was also a sharp dropoff of soil lead values at the

Los Angeles site when samples were examined with regard to distances downwind of the San Diego Freeway out to 300 feet. There were no differences in levels of lead in tap water for these sites. There were no painted surfaces with high levels of lead within residences in the Los Angeles study area.

Participants from each of the two areas of study included three primary age groups: children, young adults and elderly of both sexes. Lead levels of the Los Angeles participants were significantly higher than those of corresponding age and sex groups of the Lancaster participants for blood, hair and urine. Blood lead levels for all males and females were 19.3 and 14.2 μg/100ml, respectively, in Los Angeles and were 11.8 and 9.6 μg/100ml in Lancaster. The lead levels in feces of the Los Angeles participants were about the same or less than the average lead concentration of the Lancaster participants. Fecal lead measurements have been shown to be useful indicators of the consumption of lead in the diet. This study indicated that the levels of lead in the participants living near a significant source of mobile emissions of lead had substantially higher levels of lead in blood, urine and hair than did their control group of participants. It was also concluded that these differences were the result of exposure to lead present in air.

Snee [12] performed an analysis of nine epidemiology studies on male and female adult populations, four epidemiology studies of children, and four clinical studies of adult humans. He calculated the blood lead-air lead relationship for adults and found it to be approximately 1:1. He stated that this implies an exposure to an additional one microgram of lead per cubic meter of air can result in an increase of approximately 1 μg lead per 100 ml in blood. This calculated relationship of air lead values to blood lead is extremely important in the establishment of a standard for lead in ambient air. Using similar calculations of the blood lead to air lead relationship Bridbord [13] reported the ratio of air lead to blood lead was approximately 1:2 rather than the 1:1 calculated by Snee.

In the air quality criteria document for lead, a summary of the data on mobile emissions states that automobiles produce sufficient emissions of lead to increase air and nearby soil concentrations as well as to increase blood lead concentrations of both children and adults. The problem of accumulation of lead in these populations is of greater importance when the residences are located within 100 feet of the roadway.[1]

General Objective of this Research Project

This report describes the results of an epidemiologic study on the impact of automobile emissions on blood lead levels of persons of similar socioeconomic status, resident in an urbanized area. The residents to be studied were to live on streets with traffic densities that vary from less than 1,000 cars per day to approximately 25,000 cars per day. Previous studies have examined the impact on blood lead levels of lead emissions from mobile sources for traffic densities up to 250,000 cars per day. Unlike the above-mentioned studies, this one examined neighborhoods which probably represent a major portion of the population in the United States, that is, residents who live on streets with traffic densities between 1,000 cars per day and 25,000 cars per day. The general objective was to evaluate the contribution of airborne sources of lead, primarily from automobile emissions, to the environments near roadways and the contribution of this source of lead to residents living nearby. The data from this study should help to contribute to the body of knowledge necessary for the Environmental Protection Agency to assess the types of control measures needed, if any, on avoiding possible health effects of exposed populations in the United States.

Specific Objectives

The specific objectives of this study were to collect the necessary data such that the following relationship could be examined:

1. Traffic counts versus blood lead.
2. Traffic counts versus FEP levels.
3. Traffic counts versus ambient air lead levels.
4. Traffic counts versus soil lead.
5. Traffic counts versus house dust lead.
6. Traffic counts versus hand wipe lead.
7. Traffic counts versus windowsill wipe lead.

These relationships would be examined for traffic counts of 1,000 cars per day or less and up to approximately 25,000 cars per day with multiple points in between. In addition to these primary relationships, the following mini-studies were to be accomplished:

1. Determination of the effects of speed limits, intersections, and distances from roadway on correlation #3.
2. Determination of the quantities of lead present in different particle sizes as a function of distances from the roadway.

General Description of Project

This study was designed to minimize to the extent possible the confounding variables on the contribution of mobile emissions of lead to levels in the environment and exposed populations. A major metropolitan area was selected without significant sources of air emissions of lead other than from mobile sources. The site selected was Dallas, Texas which does not have any significant sources of lead other than two small stationary sources (smelter and battery manufacture) present on the south side of the city. Study areas were selected to avoid possible contribution of lead from these two secondary sources.

This investigation was composed of two primary components:

1. Examination of the relationship between traffic density and the level of lead in associated ambient air.

2. Examination of the relationship of blood lead and other household lead levels with traffic densities on adjacent streets.

The two parts of the study were performed in the same general area of north and northwest Dallas, Texas.

1. <u>Ambient Air Lead Study</u>

The air sampling program was to be performed in several locations within the same metropolitan area in which study participants lived. Air lead measurements were to be made using high volume samplers with sufficient numbers of 24 hour samples collected to provide for an accurate assessment of the air lead levels associated with different traffic densities. Mini-studies were conducted to examine the relationship of air lead values and traffic densities at varying distances from the roadway, and for in block as well as between block variation in air lead levels for the same traffic densities. Additional air samples were to be collected to provide an estimation of indoor/ outdoor differences of air lead levels at selected residences. The mini-studies were also to include examination of various sizes of lead containing particles as related to distances from roadways at selected traffic densities and evaluation of the effects of speed limits on the relationship of ambient air lead to traffic densities.

2. <u>Examination of the Relationship Between Traffic Density and Household Lead Levels</u>

This part of the study was designed to examine the relationship of traffic densities and the levels of lead present in the immediate environment of selected households, and blood lead and hand wipe lead level in household residents. The study was designed such that participants from residential units only at the ground level and within 100 feet of the center of the roadway would be selected. Additional restrictions included that the household would not be within 300 feet of any crossing roadway or within 500 feet of a major roadway. The study participants to be selected were pre-school age, 25 to 45 years, and over 60 years of age. For each age group, the intent was to examine those participants who spent a major portion of their time at home. Thus, for the middle age group, the objective was to recruit women that worked at home and in the elderly category, those individuals both male and female that were retired or had jobs within their home. The program included the development and design of a suitable questionnaire for collecting the necessary demographic characteristics of the study participants. The information was to include not only age, sex, length of time of residence, smoking habits, but also whether or not they made use of homemade or craft pottery for culinary purposes and any history of occupational exposure to lead.

For each of the households involved in this study, measurements were to be made of the lead in house dust and in the soil near the front stoop. In addition, measurements were to be made of the closest and most distant point of the living space to the center of the roadway. A traffic count would also be obtained near each residence. Paint surfaces of the residences were to be screened for lead content to preclude the involvement of leaded paint as a possible source of lead for young children.

All blood samples collected from the study participants were to be analyzed for lead, free erthrocyte protoporphyrin (FEP) and hematocrits. Hand wipes were also to be collected from each pre-school child for lead measurements. The measurements for both lead and FEP were to be made with a rigid quality control program to include some duplicate analysis with the Center of Disease Control. Additional environmental monitoring was to include measurement of lead in paint, in windowsill wipes and in the tap water of each residence.

II. METHODS

A. Site Selection

1. General Site Requirements

To accomplish the objectives of this study, a site was required at which populations are in residence on urban streets having traffic densities in the range of <1,000 to >25,000 cars per day. The population living on the urban streets must include a spectrum of ages of both sexes from preschool ages to over 60 years. In order to minimize interferences from extraneous parameters, the study was designed for middle economic class neighborhoods which are primarily white in ethnic makeup. Further, the areas selected should exhibit a low background in ambient air lead levels and in other identifiable lead sources (such as drinking water).

A most critical ingredient for site selection was the presence of sufficient members of populations living on streets with higher traffic densities: >15,000 cars per day. In many cases, perhaps the preponderance of cases, urban streets with greater than 15,000 cars per day become commercialized and have few or no residences directly on the street front. The following characteristics were considered in determining the appropriateness of each proposed study site: ambient lead levels; the numbers of persons living on streets with higher traffic densities; and the age, ethnic, and economic structure of these streets and areas.

2. Study Sites Considered

Two metropolitan areas were considered as possible site locations for the study: San Antonio and Dallas, Texas. Each of these cities has ambient air conditions which are conducive to studying air lead from automotive sources due to the lack of heavy, polluting industry. Traffic densities and populations of both of the cities lead the study team to estimate that both should be able to supply the necessary populations-at-risk in the appropriate age, race, sex, economic, and traffic-density mixes. The specific study design called for 480 white, middle economic class participants living in residences on streets selected for the study, with 120 participants at each of four separate traffic density levels:

Traffic Density (1000 cars/day)	Site Designation	Number of Participants
<1000	Site 1	120
8-14	Site 2	120
14-20	Site 3	120
>20	Site 4	120

To meet the requirements of the study for 120 participants at each traffic density level, it was estimated that a minimum of 200-300 candidate residences must be identified for each traffic density site. To qualify, candidate residences must be single-family dwellings or duplexes which lie within 100 feet of the center of the roadway but not within 100 yards of any traffic signal or stop sign on the roadway and must be located only on streets with 30-45 mph speed limits. In addition, a preference was indicated for houses which face the roadway and not on the corner of an intersection with a side street.

It should be noted that, in the original study design, inclusion of 5 traffic density levels was considered: <1,000; 7,500-12,500; 12,500-17,500; 17,500-22,500; >22,500 cars per day. These study design criteria were submitted to the Office of Management and Budget (OMB) with the standard information regarding requests for permission to use specific questionnaire forms. The OMB indicated that the design number of participants (480) would be more properly applied to four rather than five traffic density levels. Thus, the study design criteria were changed to the four site designations listed.

A preliminary siting study was performed at San Antonio to determine if that city could support the study with adequate numbers of residences qualified for the study. Census tract data from the 1970 census of population were used to determine areas of the city which met the basic ethnic and economic design, i.e., areas predominently white, middle class. From the census data, areas indicating 70% or greater white, non-Spanish residents were selected for on-site inspection. The areas selected were then inspected by driving through the potential neighborhoods and counting candidate residences. By direct inspection, the candidate areas were judged to be acceptable or not acceptable economically. Those exhibiting the run-down appearance of a poverty-level neighborhood or the extremely affluent appearance of a well-to-do neighborhood were omitted from further consideration.

Due to the problems encountered in San Antonio, a preliminary siting study was initiated in Dallas to determine the possibility of that city providing sufficient numbers of candidate residences, particularly at the higher traffic densities: >15,000 cars per day. Data from the 1970 census of the population in that city were obtained and reviewed and data regarding estimates of current traffic densities on main thoroughfares were obtained through the traffic department of that city. Candidate areas meeting ethnic and economic requirements (70% or greater white, non-Spanish) were selected and on-site inspections were conducted to determine the numbers of candidate residences available on the thoroughfares with higher traffic densities in these areas. Results of the preliminary siting study in Dallas indicated that more than adequate numbers of residences would be available in that city and its surrounding urbanized suburban areas.

Contacts were then made with the Institute of Urban Studies at Southern Methodist University in Dallas and preliminary arrangements were made for a field office and an on-site coordinator for the study based at that University. The City of Dallas was contacted and it was determined that the air pollution control group and the traffic department of that city were very interested in assisting SwRI to conduct a traffic lead study. Based on these findings, Dallas was selected as the study site. Pertinent data regarding justification for the change of site are presented in Appendix A.

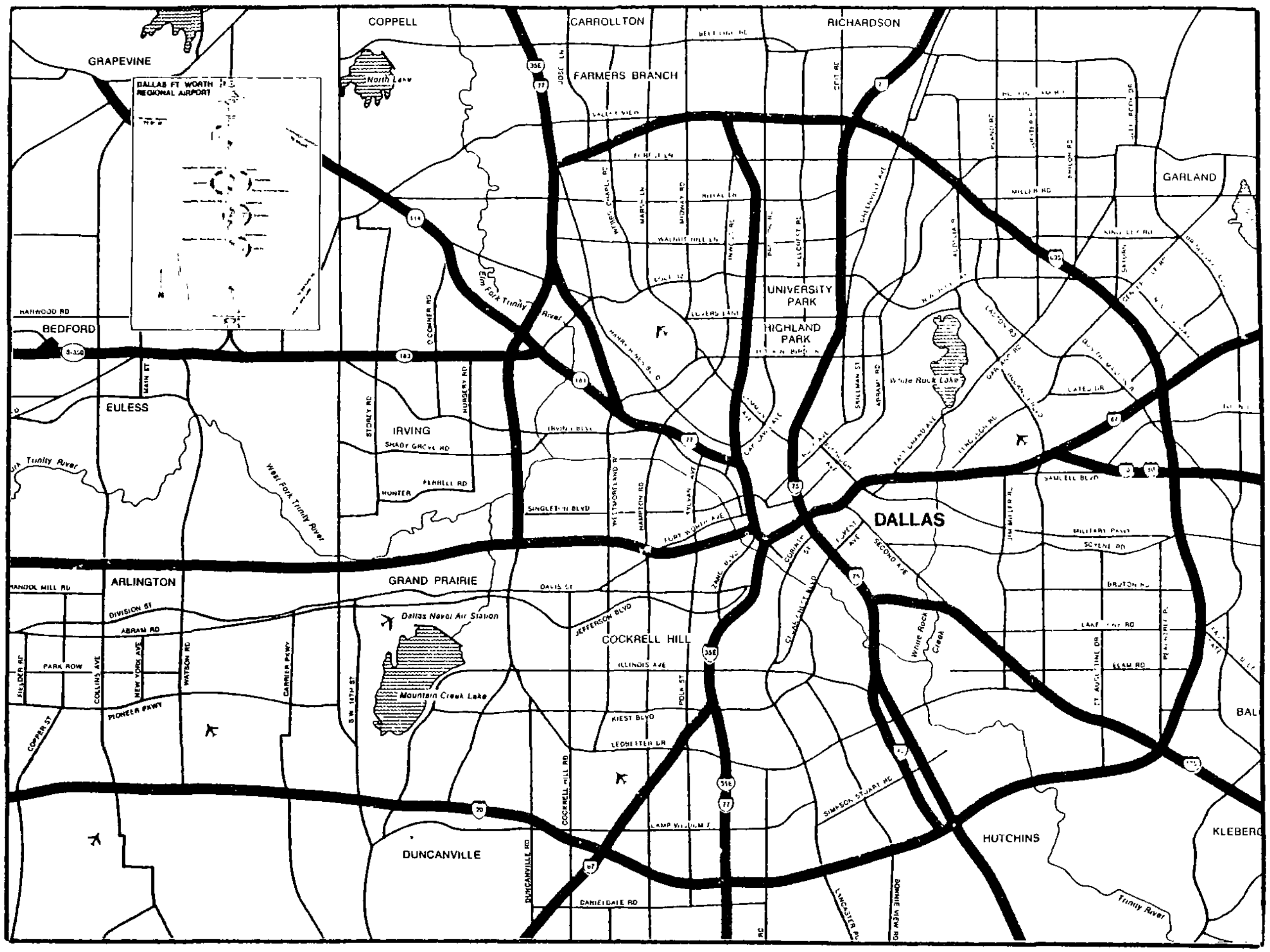
3. Description of the Study Site

The general site selected for this study is the Dallas Metropolitan Area, located in north central

Texas. The area has a mild, somewhat dry climate and has sufficient population to support the study; 1.5 million persons reported in the 1970 census of the population. It is a highly industrialized and commercialized area with little or no heavy polluting industries. The industrial-commercial makeup of the area is typified by light and sophisticated industries such as electronics, aircraft, merchandizing, and financial institutions. An abundance of heavily trafficked, multi-lane thoroughfares exists in the city, with residences located immediately along many thoroughfares. The traffic system in that city has historically been designed around these multi-lane thoroughfares and a network of such arteries exists across all of the metropolitan area. A map of the metropolitan area showing the traffic artery system is shown in Figure 1.

For use in this study, a set of thoroughfares was selected by use of data from the 1970 census of the population and data regarding current estimated traffic densities obtained from the traffic department of the city. At the outset, the study area was designed to include major portions of the north central

Figure 1. Traffic Artery Map of the Dallas Metro Area.



and northwest metropolitan areas, with some sections in the southwestern portion of the metro area. Included in the initial design area, in addition to the City of Dallas, were portions of the cities of Highland Park, University Park, Richardson, and Garland. These cities are either surrounded by the greater city of Dallas or are immediately adjacent to Dallas city limits. Review of the selected areas with City of Dallas and with EPA Region VI personnel revealed the location of a battery reclamation factory in the south central portion of the city. The plant was a known emitter of particulate lead and its location was such that a possible interference was established with the potential study areas selected in the southwest portion of the city. The southwest area was eliminated from use of the study because of potential contamination by the battery reclamation factory.

The loss of the southwest area of Dallas presented a handicap to the study efforts. One street in that area, Illinois Avenue, had been identified to contain more than 140 residences on portions of the thoroughfare with traffic densities greater than 20,000 cars per day. The loss of Illinois Avenue required the expansion of the study area to include the cities of Grand Prairie and Arlington and more areas in the city of Dallas in the east central and northeast. Detailed on-site inspection were performed for candidate streets in the added areas; a number of residences qualifying for the study were counted and a catalog was prepared showing numbers of residences versus traffic counts for all candidate streets. A map showing the principal areas of the metro area which served as study sites is shown in Figure 2.

4. Authorization of Study by Local Governments

Officials of the local governments in each municipality included in the siting analysis were then contacted regarding their selection as candidate study sites. Included were:

City of Dallas

Department of Health

Department of Consumer Affairs

Department of Environmental Health & Conservation

Town of Highland Park

City of University Park

Figure 2. Principal Study Areas within the Dallas Metro Area

City of Garland

City of Richardson

City of Grand Prairie

City of Arlington

For each municipality, a letter was prepared which provided general information regarding the traffic-lead study and requested permission for performing household surveys, recruiting volunteer participants, collecting biological samples, and performing traffic counts. Visits were made to each municipality requesting a briefing and more detailed information regarding specifics of the study were provided.

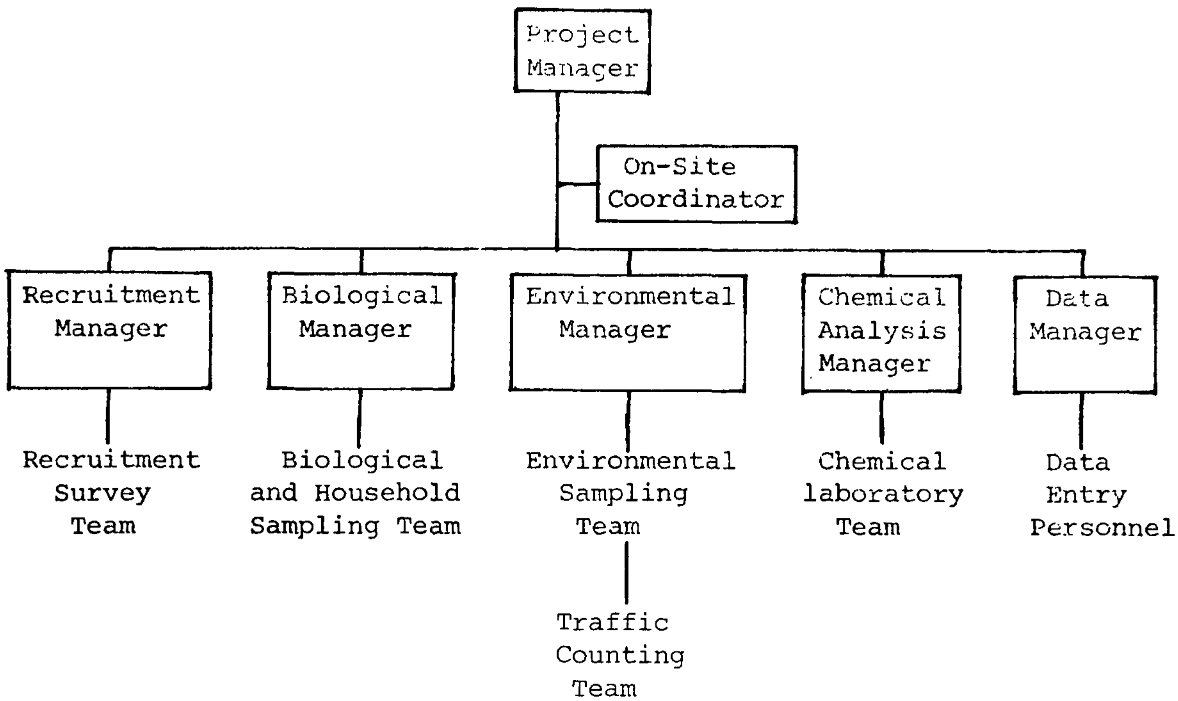
Letters of permission to proceed were received from each of the municipalities, including each of the three departments of the City of Dallas. A great deal of interest was indicated in the results of the study from a number of the communities and copies of our documentation upon completion of the study, were requested. Letters of permission from each of the communities are presented in Appendix B.

B. Project Staff

1. Overall Project

a. Roles

Staffing of the project called for a number of significant roles, headed by the Project Manager. Organization of these roles is shown in a project organization chart shown below.



Project Organization Chart

The Project Manager had total technical and administrative responsibility for the conduct of the study.

The Recruitment Manager was responsible for development of survey materials, establishment of the on-site-field office, and conduct of the household surveys. The on-site coordinator and the Household Survey Team reported directly to the Recruitment Manager during the survey activity period.

The On-site Coordinator was responsible for recruitment of the Survey Team, the Biological and Household Sampling Team, and the Environmental Monitoring Team, for management of the household survey activities, and for coordinating activities during the biological and environmental sampling period.

The Biological Manager had the overall responsibility for the field sample collection operations. His special duties were to direct the activities of the biological collection teams in the collection and processing of the biological and household samples.

The Environmental Manager had the responsibility for directing the personnel involved in the air sampling, traffic counting, paint analysis, and soil sampling operations. The principal duties of the environmental manager were to establish daily sites for the air samplers and to coordinate the traffic counting activities with the city traffic department involved. These duties also included the maintenance and repair of the air samplers and traffic counters. His activities in regard to the paint and soil sampling involved monitoring the daily activities of the personnel involved and to investigate any problems which occurred in these areas.

The Chemical Analysis Manager was responsible for the laboratory analysis of all samples collected and for the preparation of all data obtained from these analyses for submission to data analysis.

The Data Manager was responsible for entry of all data into computer processing format and for maintenance and analysis of the data obtained.

b. Personnel

With the exception of the On-site-coordinator, Ms. Linda Johnson, a graduate student at Southern Methodist University, all principal personnel involved in the study are staff of the Department of Environmental Sciences, Division of Chemistry and Chemical Engineering, Southwest Research Institute.

The Project Manager and principal investigator for the study reported herein was Dr. D. E. Johnson, Director, Department of Environmental Sciences.

The remaining principal personnel are listed as follows:

Role	Personnel
Recruitment Manager	R. J. Prevost Senior Research Analyst
Biological Manager and Chemical Analyses Manager	J. B. Tillery Senior Research Chemist
Environmental Manager	J. M. Hosenfeld Research Scientist
Data Manager	K. T. Kimball Research Statistician

2. Field Operations

a. Field Office

An on-site field office was established on the campus of Southern Methodist University at the Institute of Urban and Environmental Studies. An arrangement was made with the Director, Mr. Bennett Miller, for the use of office space, telephones, and a graduate student to serve as on-site-coordinator of study activities. For the purpose of recruitment of the on-site-coordinator and for definition of the support required for the coordinator, a qualifications list (Figure 3) was generated and provided to the Institute for Urban and Environmental Studies.

A qualified student was located and established as the on-site-coordinator for the study: Ms. Linda Johnson, a graduate student in public administration. Throughout the remainder of study activities in Dallas, Ms. Johnson served as the principal coordinator of all study activities in recruitment and field sampling and

Figure 3.

Qualifications for On-Site Coordinator and Sample Task Descriptions

1. Title: On-Site Coordinator
2. Availability: 20 Hours Per Week
3. Rate: $5.20 per hour (including SMU overhead rate)
4. Duration: 3 - 6 months
5. Office Space to store printed materials
6. Telephone: Available during normal work hours or receptionist/ secretary available to take messages for coordination in absence of coordinator.
7. Transportation for Coordinator: Must have car; reimbursed @ $.15/mile
8. Sample Tasks:
   a. Making appointments
   b. Meeting with officials to coordinate study activities and to collect information
   c. Picking up materials
   d. Delivery of materials
   e. Site surveying - counting residences in specific areas; streets with specific traffic densities
   f. Locating and interviewing survey team of 10 members
   g. Help set up traffic counting equipment
   h. Help set up air sampling equipment
   i. Coordination of household survey of 1000 households
   j. Record traffic counts
   k. Collect filters from air sampling equipment
   l. Help collect soil, dust, and blood samples from selected households.

served as the point of contact with municipal agencies and the general public.

A survey team was recruited through SMU and through manpower placement firms by the on-site coordinator. A set of recruitment and training materials was prepared by the project team with the help of the coordinator and a candidate team was assembled for training. A set of instructions (Figure 4) was distributed to the survey team members and details of the study were explained. The importance of recruitment of volunteers was stressed in the training sessions. Persons with previous experience in survey work were selected, where possible, and detailed instructions in the survey procedures to follow were provided in the training session.

Survey team members were hired through the offices of SMU or through local temporary manpower firms. No team members were hired directly by Southwest Research Institute. As an incentive, the survey workers were offered payment based on the number of forms completed and delivered to the coordinator. Two separate stages of survey activities were performed using these methods. In the first state, the workers were offered $2.50 per household form completed, and $2.00 per participant form completed. A minimum of $3.00 per hour worked up to 40 hours was established as a minimum payment. Most workers, however, were able to better this figure substantially. Because of difficulties in recruitment of volunteers, the amount paid per completed form was raised to $5.00 per participant form in the second stage of survey activities. Instruction materials used in training survey workers during the second stage are shown in Figure 4.

FIGURE 4.
DALLAS TRAFFIC LEAD STUDY INSTRUCTIONS
FOR PERFORMING HOUSEHOLD SURVEYS

Schedule of Activities

Friday, May 21	Training Session
Saturday, May 22	Survey Begins
Tuesday, May 25	Turn in Completed Forms and Review Progress
Thursday, May 27 -	Turn in Completed Forms and Review Progress
Saturday, May 29	Survey Complete
Tuesday, June 1	All Forms must be turned in by this Date

Rate of Pay

$5.00 per participant form completed
$2.50 per household form completed

If not enough forms are completed to yield $3.00 per hour worked, then $3.00 per hour will be paid. However, a good worker will be able to complete enough forms to always make more than this minimum rate.

Work Assignment

You will be assigned approximately 60 residences by address, along one or more busy streets. These residences have been carefully selected to meet certain requirements of the study. The work assignment is designed to take a normal 40 hour work week. You should have no trouble completing the assignment in one week of work. You may work any hours and days which you choose. Some workers have better success on weekends. You must complete the assignment and turn in all forms on or before Tuesday, June 1.

Early Completion

If you complete your assignment early, so much the better. You will be paid for the number of forms delivered. A goal should be to have all work completed by Friday, May 29. The sooner you complete your work, the sooner we can process the paper so you can be paid.

Each survey worker was provided with a specific assignment area for which he was responsible. Approximately 60 residences were located in each assignment, and the worker was asked to complete at least 50 household forms within one week.

b. Sample Collection

(1) Biological Collection Team

(a) Recruitment

The biological collection teams were composed of two individuals. One person was required to be a laboratory technician with recent experience in drawing blood from children. The other team member was not required to have any special technical skills but a friendly attitude and outgoing personality were qualities necessary for the job activities. These people were all hired through a temporary employment agency. Some of the laboratory technicians hired for this project were already working in a clinic or hospital (night shift or part time) specifically drawing blood from young children. The other technicians were not presently working at their profession but had recently been so. The longest time any laboratory technician had been away from this type of work was 6 weeks. All of the laboratory technicians were female and judged mature enough to perform the required tasks without direct supervision.

The second member of each biological collection team was a young woman between 18 and 22 years old. Most, if not all, were undergraduate students at local universities. These women were selected for this project based upon their demonstrated maturity and personality.

(b) Training

The week prior to the actual collection of samples, a training session for the biological collection teams was held on the SMU campus. The main purpose of the training session was to familiarize the laboratory technicians with the care necessary in taking blood samples for Pb analysis.[14] Since contamination (especially with the finger-prick technique) is a major concern in the collection of blood samples for Pb analysis, special emphasis was placed upon the modifications of the routine collection procedures to minimize this problem. Other points covered during the training session included: (1) what information was to be collected and how it was to be recorded, (2) how and where to collect the household samples, (3) procedure for taking handwipe samples from children, and, (4) procedures to follow during medical emergencies.

It was necessary that at least one team member have transportation available. Time was allotted during the training session for everyone to meet and to pair off as teams such that the transportation problem would be solved and there would not be any personality conflicts between team members.

(2) Environmental Sampling Team

(a) Recruitment

Collection of environmental samples required two individuals for the air sampling and traffic counting, one person for the paint analysis and one person for the soil sampling. No specific technical skill was required for these individuals but a steady job record along with demonstrated maturity were essential qualities necessary.

(b) Training

Team members were trained in the tasks they were to perform by the environmental manager. For the most part, this consisted of on-the-job training during the first week of field sampling. The individuals selected for these tasks were all male college students between 20 and 24 years old.

The most difficult job assignment, i.e., the task requiring some degree of technical know-how was the operation of the portable x-ray analyzer used to measure Pb content of paint in the participant's homes. The individual selected for this particular job received several hours of instruction and observation with the instrument before he was judged qualified to obtain accurate data with the instrument.

Instruction, demonstration, and observation by the environmental manager and soil chemist (subcontractor) were used to qualify the individual collecting the soil samples.

C. Determination of the Relationship Between Air Lead Levels and Traffic Flow Characteristics

1. Design

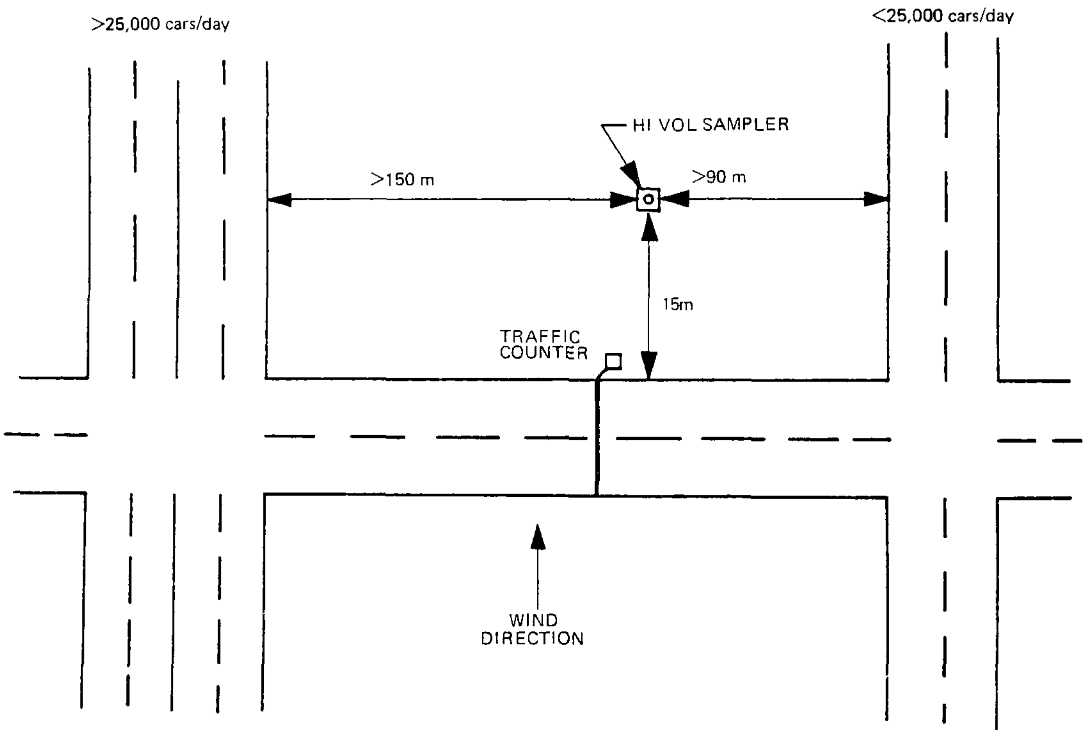
a. General Outline

The determination of air lead levels and traffic flow can be correlated using a variety of ministudies. While each ministudy as described below was complete in itself, their contribution to correlating the traffic and air lead values should not be underestimated.

The basic study involved a continuous twenty-five day sampling period during which traffic and air lead values were recorded. Streets with various traffic densities were monitored that included rates of less than 1,000 vehicles/day; 5,000; 10,000; 15,000; 20,000; and 25,000+ vehicles/day. Supplementing this basic study was the determination of the effects of speed limits, intersections and distances from the roadway. How the particle size varied as a function of distance from the roadway was also examined. Another ministudy determined the accuracy of collection times less than 24 hours. Studies were also performed to compare indoor and outdoor lead values of streets with 10,000 and 25,000 vehicles/day. In contrast to the above studies which used active collectors such as high volume samplers, one ministudy used a passive collector for settleable particulates.

In defining the lead particulate pattern from highways, it was important to eliminate or reduce as many confounding variables as was practical and so all of the air samples collected in this study had a number of common points between them. Figure 5 illustrates these common points. With the exception of those samples

Figure 5. General Criteria for Placement of High Volume Particulate Sampler.



taken for the distance and intersection studies, all samplers were placed in the middle of the block and 15 meters from the roadway. The samplers were approximately 1 meter above the ground on the same plane as the roadway; and unless the wind was parallel to the roadway, the samplers were placed on the downwind side. The selection of sites for air sampling was also based on the criteria of speed limit, i.e., between 30-45 mph, and distance from another major roadway, i.e., no closer than 150 meters. A major roadway for this study was defined as 25,000 cars/day or more. However, for those cross streets having less than 25,000 cars/day the minimum distance was 90 meters. During the period that the samplers were collecting particulates, meteorology data was also being collected. All sites chosen for air lead sampling were distant from any other known sources of lead. Sampling was performed only during periods of dry weather and with the exception of the 25-day study, only on weekdays.

b. Traffic Density Mini-study

During the time period that biochemical monitoring of the participants took place, an in-depth air sampling program was also performed. Begun approximately one week before the biochemical monitoring, air samples were collected at six different traffic densities for 25 days. Traffic counts were conducted at each site where air sampling occurred. Streets in each of the following traffic densities were monitored: 1,000; 5,000; 10,000; 15,000; 20,000; and 25,000 cars/day. Rather than sampling at just one site for each traffic density, three streets in each of the six densities were monitored. The streets were chosen in different sections of the city within the boundaries of the study area. The angle of the street in relation to the wind direction was also varied. Because of this wind direction variation, a set of three streets with the same traffic density was not monitored at the same time. While the monitoring of the streets for a specific traffic density was not purposefully randomized, the task of locating streets as other streets were being sampled created its own randomization. Each of the three streets studied for a given traffic density was monitored for 8 consecutive days plus an additional day at one site to meet the 25-day sampling requirement. Each street thus monitored had at least one weekend of sampling. Therefore, for the entire 25-day study at each of the six traffic densities having three streets each, a total of 150 air samples/ traffic counts were collected.

c. <u>Replicate High Volume Ministudy</u>

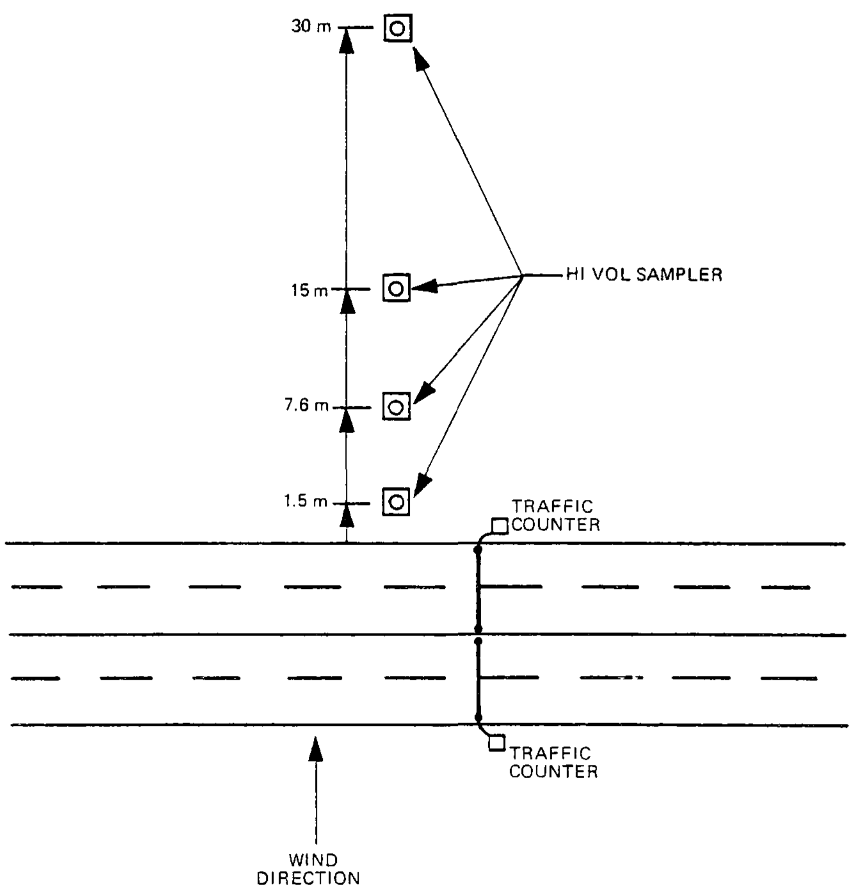
A large number of air samples were collected throughout the air monitoring studies of this project. These samples were collected using single high volume samplers deployed in the various sampling schemes described previously and also following this subsection. Since single samplers were used, it was important to determine the accuracy and precision that any one sampler might exhibit. A study was thus performed to determine these variables.

Two high volume samplers were placed about one meter apart from one another. These samplers were placed at one of the locations sampled during the twenty-five day study and followed the common point criteria mentioned above. Simultaneous air sampling using the same two samplers took place for 10 consecutive days. Traffic counting was also performed during these sampling runs.

d. Distance from Road Mini-study

Sites selected for this study required an area that was unobstructed for a minimum of 40m back from the roadway on the downwind side. (Figure 6). Four

Figure 6. Distance from Road Mini-Study.



samplers were set up at 1.5, 7.6, 15 and 30m from the roadway in the middle of the block. A traffic count was initiated and all samplers were turned on simultaneously. Two 24-hour sampling periods were recorded for each of the following traffic densities: 5,000, 15,000, and 25,000+ cars/day.

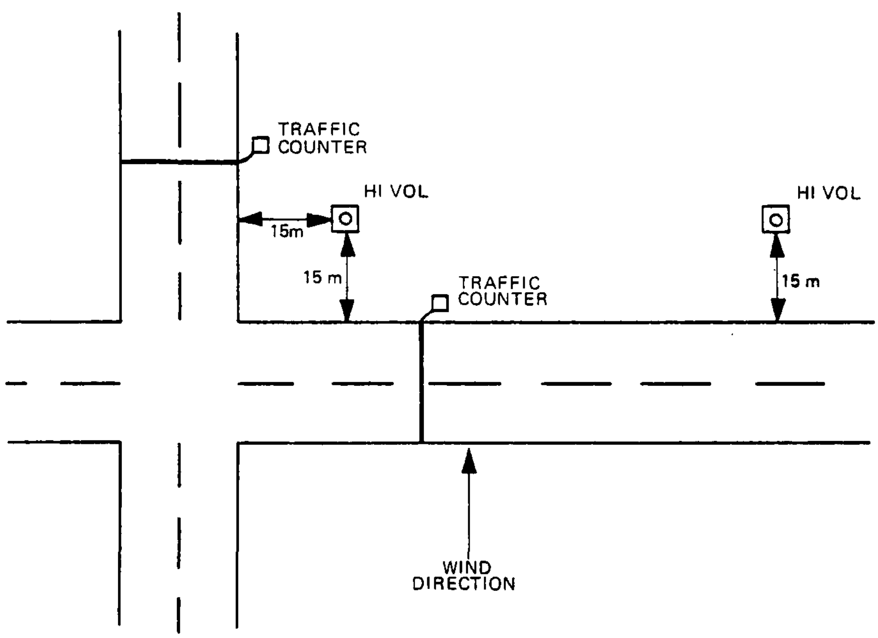
e. Particle Size as a Function of Distance from Road Mini-study

These samples were collected at the same site as the distance from the roadway study (25,000+cars/day only). An Andersen high-volume particle-sizing collection head was used to collect and separate the particles. This collection device separated the particulates into five aerodynamic size ranges, by particle diameter: 7 microns or larger; 3.3 to 7 microns; 2 to 3.3 microns; 1.1 to 2.0 microns and 0.01 to 1.1 microns. Samples were taken at each of the four distances as mentioned in the distance study using the Andersen sampling head.

f. Intersection Mini-study

Five different intersections with varying traffic densities were studied. These intersections were: 25,000 vs 10,000; 25,000 vs 5,000; 15,000 vs 1,000; 10,000 vs 5,000; and 10,000 vs 1,000 cars/day streets. Each of these combinations was studied for four weekdays. One sampler was set up on the downwind corner 15 meters from both roadways (Figure 7). The second sampler was set up at mid-block on the principal roadway and each roadway had its own traffic counter. With the aid of radio communications, the samplers were started simultaneously and the traffic count taken.

Figure 7. Intersection Ministudy



With the addition of corner homes to the study to increase the potential number of participants, an expanded intersection study was initiated. This dealt with the effect that side streets of less than 1,000 cars/day had on the lead levels of the principal street. Samples were set up on the corner and midblock of the principal street as described above and run for 24 hours. At the end of this time period the samplers were physically interchanged and the second sample collected. The samplers were switched to prevent any inherent bias in the collection. Traffic counts also were recorded on each street. Samples were taken at intersections of less than 1,000 cars/day vs 1,000; 8-14,000 vs 1,000; 14-20,000 vs 1,000; and 20,000+ vs 1,000 cars/day. Only four-corner intersections having stop signs on the side streets were selected.

g. Speed Limit Mini-study

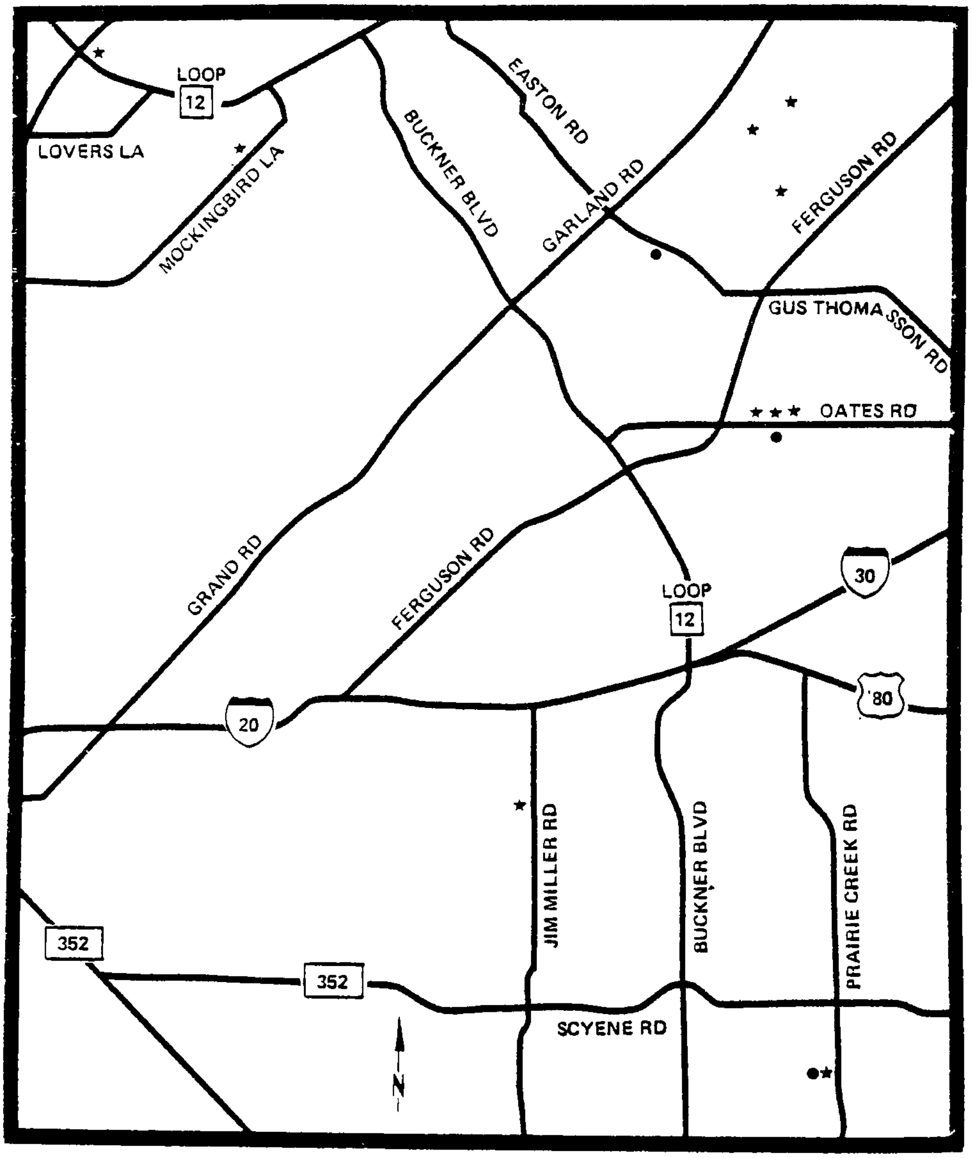
Two streets were chosen that had approximately the same number of cars per day. However, one street had a speed limit of 30 MPH while the other had a 45 MPH speed limit. Air samples and traffic counts were collected at each site for five days.

h. Indoor vs. Outdoor Mini-study

Ten residences of participants selected for biochemical monitoring were also selected for indoor air sampling. Five residences were chosen from a 25,000+ car/day street and five from 10,000 car/day street. The indoor sampler was usually placed in the living room. These samplers were of the same type as used outside, although the ones that were cleanest and with the best appearance were placed inside the home. If the homeowner objected to the living room placement, then another room such as a bedroom was chosen that was the same distance from the roadway as the living room. The second sampler was placed outside of the home. Each sampler was started simultaneously and a sample collected for 10-12 hours during the daytime (usually from 8-9 a.m. to 6-7 p.m.). Flow rates for both indoor and outdoor samplers were approximately 50 cubic feet per minute. Two days of sampling were conducted at each of the selected residences.

i. Dustfall Mini-study

Ten locations were selected throughout the study area to collect settleable particulates for 28 days. The number of locations assigned to specific sectors of the study area approximated the density of participants anticipated for that sector. Maps with the ten locations are illustrated in Figures 8, 9, and 10.



CITY OF DALLAS

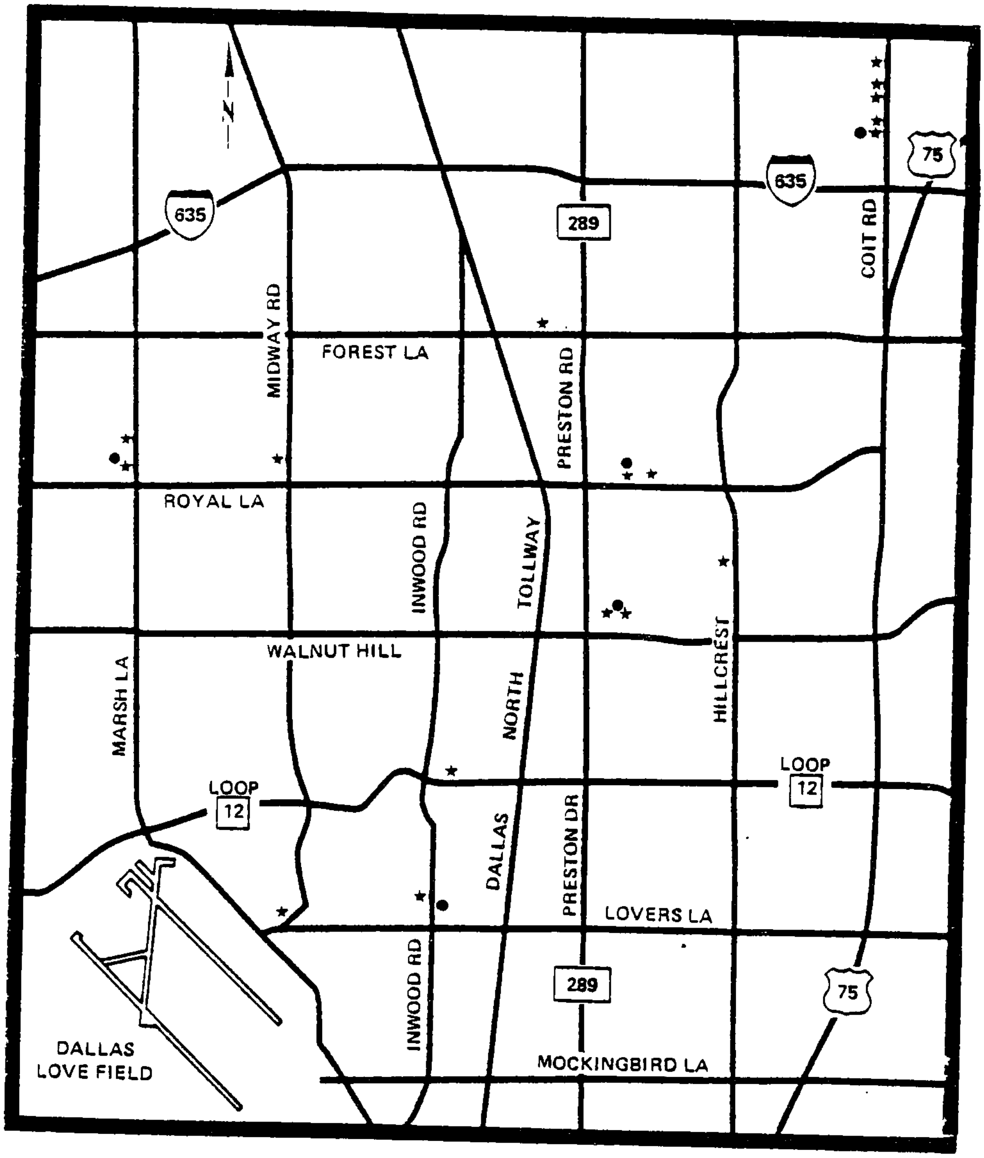
WESTERN SECTION

SCALE: 1" = 0.6 MILES

★ = HIVOL SAMPLERS

● = DUSTFALL COLLECTORS

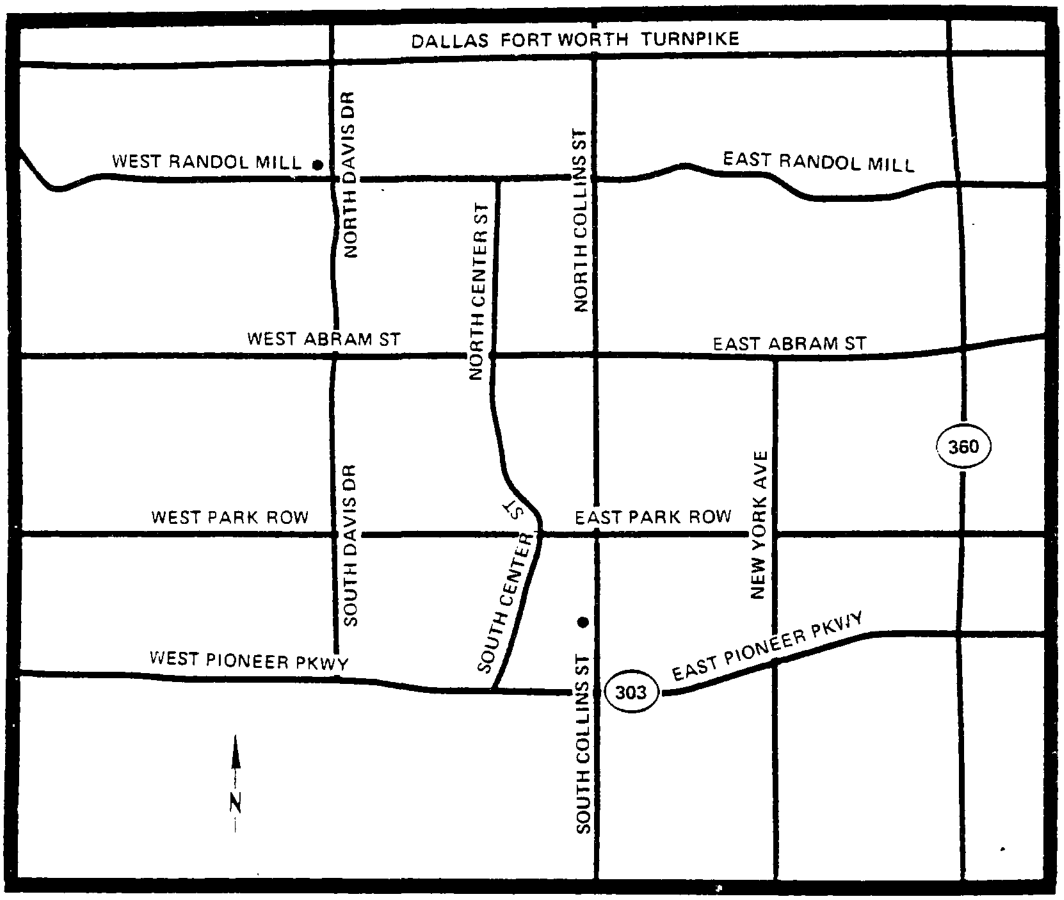
Figure 8



CITY OF DALLAS
NORTH CENTRAL SECTION

SCALE: 1" = 0.6 MILES
★ = HIVOL SAMPLERS
● = DUSTFALL COLLECTORS

Figure 9



CITY OF ARLINGTON

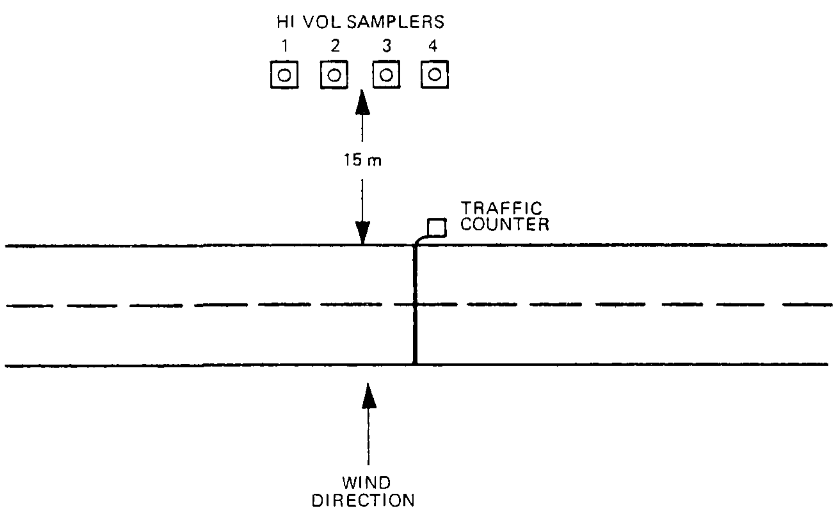
SCALE: 1" = 0.75 MILES
● = DUSTFALL COLLECTOR

Figure 1C

j. Collection Time Less Than 24 Hours Mini-study

Twenty-four samples were collected under the common point specifications described above except that they were collected for time intervals less than 24 hours. Time intervals of 1, 2, 4, 12 hours were used at traffic densities of 10,000, 15,000 and 25,000 cars/day. The collection scheme consisted of four samples placed side by side and equidistant from the roadway (Figure 11). All four samplers were started at the same time as was the

Figure 11. Collection Times Less than 24 Hours Ministudy.



traffic counter, usually between 8 and 9 A.M. When the one hour time interval came up the traffic count was noted and sampler 1 was turned off and the filter removed. At the next time interval of two hours, the cumulative traffic count was noted and sampler 2 was turned off. This sequence continued until the last collection was terminated 12 hours later. The following day, the sequence was repeated at the same location. Two sampling days were also performed at each of the remaining two traffic densities.

2. Sample Collection

a. Traffic Volume

A successful traffic counting operation was vital to the purpose of this contract. To insure that accurate and meaningful counts were obtained, coordination efforts were set up and maintained with the traffic and safety offices of the following governmental agencies located in the State of Texas:

City of Arlington
City of Dallas
City of Garland
City of Grand Prairie
City of Highland Park
City of Richardson
City of San Antonio
City of University Park
Texas Department of Highways

The purpose of the coordination efforts was twofold. The necessity of informing these different agencies of the anticipated traffic counting operations that would be conducted in their jurisdictional areas is obvious. Permission to conduct the surveys was then necessary before any type of activity cound be performed.

At this point, it should be mentioned that the data gathered under this contract would not have been possible without the excellent help and advice of the governmental agencies listed above. Instructions as to the proper placement of the traffic counting devices, loan of counting equipment, availability of previous traffic count data, donations of detailed city maps, all of these items contributed by the agencies listed above played an important role. Our gratitude to them is humbly offered.

Following contact with the various cities on whose streets the counting would be performed, a review of all published traffic count data was made to identify potential streets and areas for the counting survey. The streets were categorized based on their traffic count, i.e., less than 1,000 cars per day; 5,000; 10,000; 15,000; 20,000; and 25,000 cars/day and above. With the streets thus pigeon-holed, a culling of the unacceptable streets was based on availability of potential volunteer residences. A visual on-site survey of the tentatively selected streets was then made and the list of potential streets was further refined.

The apparatus used for traffic counting was mainly the Traficounter Junior (Streeter Amet, Grayslake, Illinois) although others such as Models RCH and MR from the same manufacturer were also used, but to a lesser extent. The Traficounter Junior is a digital counter which records axle count, while the MR and RCH counters print the axle count hourly on a paper tape. Other than this output difference, the operation and set-up of all counters was the same.

The streets for which traffic counting was required were inspected to determine proper placement of the counters. Instructions received from the Texas Highway Department, training by the City of San Antonio, and installation instructions from the equipment manufacturer provided the basis for traffic counter placement. Basically, a minimum distance of 50 meters was required from any cross street or intersection. Both ends of the road tube were attached to the pavement with concrete nails. One end of the tube was plugged and the other end was attached to the counter. A two-lane street was counted with one road tube and one counter since the counter was capable of an accurate count over both lanes even with the opposite traffic flow. On the streets included in the study, there were no three-lane streets. Four lanes of traffic required two counters, one for each direction of travel and where possible, the counters were placed on a center median and the road tube was extended to the outside lanes. The same set-up was used for 6 lanes of traffic with one counter for each direction of travel.

After the road tubes were in place and the counter turned on, a validation procedure was begun. For each counter, fifty cars were counted that passed over the road tube. This figure was compared with the value of the mechanical counter.

On a two lane street with one lane of traffic in each direction, occasionally two cars would activate the road tube simultaneously. The result was that three axles were counted instead of four as occurred when two cars crossed the road tube independently. Similar missed counts occurred when two or more lanes of traffic were flowing in the same direction. In this case when two cars were traveling side by side and crossed the road tube only two axles were counted instead of four. A correction factor was developed for each traffic count that would take into account these simultaneous crossings. This correction factor was based on the ratio of cars counted mechanically versus the visual count. The twenty-four hour count was then increased to reflect this ratio. A similar correction factor was also developed for multi-axled vehicles such as dump trucks or semi-trailer trucks. During the set up of the traffic counter(s) on a street, a visual count was made of multi-axled vehicles. This count, which usually lasted for an hour was then applied to the final traffic count in a manner similar to the simultaneous crossing factor. However, the truck factor decreased the total mechanical count because while the total axle count increases, only one vehicle passed over the road tube. With the exception of those streets over 15,000 vehicles/days, the truck correction factor decreased the twenty-four hour count on the average of 5 to 20 vehicles. On streets above 15,000 vehicles/day, the total count decreased an average of 15 to 35 vehicles.

At each location where traffic counting was performed, a data sheet was completed (Figure 12). The form had spaces for the counter machine number, set-up time and count, removal time and count, day, date, visual vs machine count, and a place for remarks. The set-up and removal time interval was maintained as close as possible to twenty-four hours with a one-hour difference being the exception. In the majority of cases, the equipment performed as it was designed. However, occasional problems included loose or broken road tubes, and tubes removed from the counter by vandals.

b. Air Particulates

The collection of air samples for the various studies described above was performed to define the lead particulate patterns near streets with varying

Figure 12.
AIR SAMPLING & TRAFFIC COUNTING
Dallas, Texas - 1976
Project 01-4294

Street ______________________________

Wind Direction ______________

Filter No. ______________

Hi-Vol Sampler No. ______________

	Rotameter (cfm)	Hour	Day	Date
Removal				
Set Up				
Average			Total X ______ Calibration Factor	

Total volume of air sampled ______________

Traffic Counter

Machine No. ________

	Counter Readings	Hour	Day	Date
Removal				
Set Up				
Total				

Visual/Machine Count:

Axle factor:
24 hour weekday total = ______________ vehicles

Remarks: ______________________________

traffic densities. For each air sample that was collected, a traffic count was recorded for that same collection interval.

The equipment used to collect the air samples were high-volume particulate samplers of standard design. Equipment from three different manufacturers (Staplex, BGI and General Metal Works) was used on this study. All high-volume samples used in this study used the same flow rate, 50-60 cfm. Basically, each consisted of a blower with an 8" x 10" holder for the filter. A weatherproof unit composed of wood or aluminum, depending on the manufacturer, protected the filter and the motor from the weather. Prior to sampling operations in the field, each hi-vol sampler was calibrated with a series of resistance plates. A secondary calibration curve was then developed for each sampler based on the primary calibration curve for the resistance plates. Each sampler was thus indirectly comparable to other samples used in the study since all were calibrated using a common source. Additional comparisons were made when duplicate simultaneous samples were taken using hi-vols placed next to one another.

Glass fiber filters, Type A (20.3 x 25.4 cm), without an organic binder (Gelman Instrument Co.) were used for the particulate collection media. A light table was used for visual inspection of each filter for thickness variation and pinholes. Filters passing this test were then sequentially numbered and separately placed in clean polyethylene bags and sealed. Those filters used for the particle size distribution study were conditioned at a constant temperature and humidity until a constant weight was achieved and then the filters placed in separate bags and sealed.

c. Dustfall

Ten locations were selected throughout the study area to collect settleable particulates. Locations and times when hi-vol samplers were operating nearby were avoided. The open-top collectors were set out for 28 days and were patterned after ASTM designation D 1739-70. Specifically the collection apparatus consisted of an acid-washed polyethylene bucket with a polyvinyl-chloride extension tube. The dimensions were such that the height of the bucket/extension tube was three times the diameter of the opening in the extension tube. The device was mounted atop a 2.5m pole and secured with guy wires. A maximum 30-degree angle was observed from the top of the collector to the nearest obstacles such as trees or houses. On top of the collection tube was a bird ring. It was placed so that if birds attempted to land on top of the tube, the ring prevented this from happening. Thus, any possible contamination from birds was prevented.

Following the 28-day collection period, the device was removed from its perch and covered. The sample was transferred to an acid-washed polyethylene bottle with multiple deionized water rinses. The sample was labelled and frozen.

3. Sample Analysis and Quality Control Procedures

a. Development of Analytical Methodology

Studies were performed to evaluate the analytical methods for determining the lead concentration in air particulate samples collected on 20.3 x 24.4 cm glass fiber filters.

A single 2.5 x 20.3 cm strip was used from each filter (9.8% of total surface area) for lead analysis. To determine the variability of lead concentration over the total filter, seven 2.5 x 20.3cm strips were cut from a single glass fiber filter sample and analyzed according to the procedure for air particulate samples. The results are given in Table 1 under precision of data.

Table 1. Analytical Parameters of Environmental Samples

Sample Matrix	Air Particulate (4)	Outdoor Dust (5)	Soil (6)
Sensitivity (1)	0.019 $\mu g/m^3$	0.0006 $\mu g/cm^2$	0.95 $\mu g/g$
Detection Limit (1)	0.021 $\mu g/m^3$	0.0058 $\mu g/cm^2$	1.02 $\mu g/g$
Linear Range (2)	3.38 $\mu g/m^3$	0.070 $\mu g/cm^2$	150 $\mu g/g$
Recovery (3)	96.3%	96.2%	90.0%
Precision:			
n	7	7	4
mean	1.44 $\mu g/m^3$	0.035 $\mu g/cm^2$	5.90 $\mu g/g$
std. dev.	0.19 $\mu g/m^3$	0.003 $\mu g/cm^2$	0.44 $\mu g/g$
RSD	13.2%	8.3%	7.4%

(1) see text for definition
(2) does not imply maximum linear range
(3) based upon average recovery of low Pb spike in sample matrix
(4) calculations based on 2000 m^3 sample
(5) surface area of 179.07 cm^2
(6) based on 5g sample

At a mean lead concentration of 1.44 μg/m^3, the relative standard deviation was 13.2%.

While performing the field studies, several air samplers were run simultaneously in pairs to obtain some indication of the variation due to the air samplers. Section IIIA2 summarizes the results of this study. There was no significant variation in the lead concentration of filters collected simultaneously.

The digestion time of air filters was investigated to determine if this would be a critical step in the procedure. Replicate samples were digested for 3 hours and for 24 hours according to the methodology. The 3-hour samples' average lead concentration was 6.6 μg/m^3 (RSD = 8.2%) and the 24-hour samples' average lead concentration was slightly higher at 7.2 μg/m^3 (RSD = 8.6%). This slight difference between the 3-hour and 24-hour digestions was not significant.

Table 1 summarizes the analytical parameters for air particulate samples.

The detection limit is defined as that quantity of lead which will give a signal 2X the standard deviation of a series of spiked samples whose lead signal is distinctly above the background signal. All values have been converted into the appropriate units for each sample matrix.

Sensitivity is defined as that quantity of lead in the digested sample matrix which will give 1% absorption.

In summary, these investigations show that low temperature ashing of the glass fiber filters prior to digestion was not necessary. The difference between the ashed and non-ashed filters was within the 13.2 variation recorded for different samples from the same filter.

Digestion of the air filters was complete within 3 hours and longer digestion times were not needed.

Since there could also be variation in the collection process, high-vol air samplers were run in pairs on several occasions to determine the range of variation due to the samplers themselves. There were no significant variations noted for any of these paired samplers.

The analytical methodology used for air particulate lead analysis was simple and required minimum sample handling. This allowed for less contamination of the samples and better data. The time involved in evaporating off the digestion acids was rather lengthy, but the addition of a flow of N^2 reduced this time considerably.

For samples with high lead concentrations, the method was easily adaptable to dilutions to maintain the lead concentration in the linear working range of the AAS.

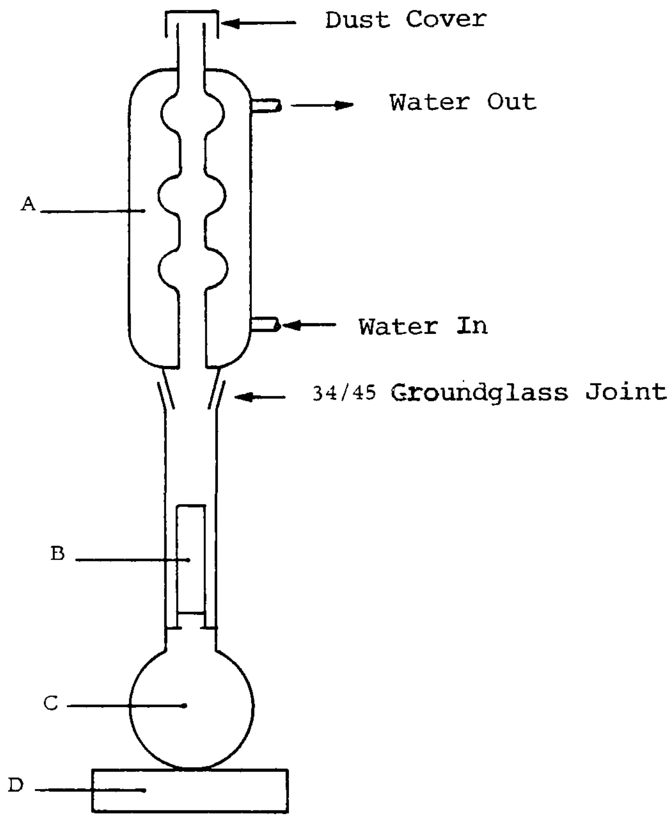
b. Air Particulate

The procedure of Thompson, Morgan and Purdue[15] was modified and used to analyze the air particulate samples for lead.

The 20.3 x 25.4 cm glass-fiber filter was removed from its polyethylene bag and placed on a polyethylene sheet. A plexiglas template and stainless steel surgical knife were used to cut a 2.5 x 20.3 cm strip from the filter. The remainder of the filter was returned to its polyethylene bag.

The strip of filter removed was carefully cut into 1-cm lengths and placed into a 2.5 x 8.5 cm Pyrex extraction thimble using Teflon-coated forceps. Eighty milliliters of digestion acid (16 ml of redistilled HCl and 64 ml of redistilled HNO_3) was added to the specially constructed boiling flask (Figure 13) and the extraction thimble carefully lowered into its neck. The flask was then connected to the condenser unit and heat was applied. Once the acids began to reflux and wash over the filter strips, the temperature was adjusted such that a continuous refluxing occurred. Refluxing was continued for 3 hours before the heat was removed and the digestion acids allowed to cool. Several milliliters of 0.1 $NHNO_3$ were poured through the top of the condenser and allowed to drain into the boiling flask.

Figure 13. Apparatus for the Acid Digestion of Air, Window Sill Wipe, and Hand Wipe Samples



A Ahlin-type condenser
B Extraction vessel with course glass disk
C Specially constructed boiling flask
D Hot plate

The boiling flask was removed from the condenser unit and the extraction thimble removed. The boiling flask was placed on a hot plate (300°C) and a flow of N_2 added to assist in evaporating the digestion acids. Once the volume was reduced to several milliliters (never to dryness) the flask was removed from the hot plate, cooled, and quantitatively transferred to a graduated centrifuge tube (15 ml). The sample volume was made to 5.0 ml with deionized water before the sample was centrifuged for 30 minutes at 2000 RPM.

A portion of the filtrate was decanted into a polyethylene vial (5-ml) taking care not to disturb the precipitate present. One ml of this solution was pipetted into a 10-ml volumetric flask and made to volume with deionized water. This diluted solution was then analyzed for Pb by aspiration into an air-acetylene flame AAS. Table 2 gives the analytical parameters use for the AAS determination of air and other sample matrices.

Table 2. Analytical Parameters for Atomic Absorption Spectrophotometric Lead Analysis

	ENVIRONMENTAL			HOUSEHOLD			BIOLOGICAL		
Instrument Parameter	Air	Soil	Outdoor Dust	Water	Indoor Dust	WindowSill Wipe	Veneous Blood	Capillary Blood	Hand-wipe
Wavelength					283.3 nm				
Slit					1.0 mm				
Source Current				8 mA					
Atomization[1]	Flame	Flame	Flame	Flameless	Flameless	Flame	Flameless	Flameless[2]	Flame
Dilution Factor	10	--	--	--	10	--	--	50	--

[1] Flame = air/acetylene
Flameless = graphite tube furnace (HGA-2000).
[2] Flameless = graphite tube furnace (IL-455).

Air particulate and outdoor dust samples (soil also) were quantitated for Pb content by analyzing a series of appropriately spiked sample matrices using the "method of additions" technique to establish an analytical curve (peak height vs Pb concentration). Analytical curves were calculated on a Hewlett-Packard Model 9810A programmable calculator using a least-square regression program to obtain the best fit to the data points. Figures 14 and 15 are typical analytical curves used to determine the Pb content of air and outdoor dust samples, respectively. Spiked sample standards were routinely analyzed with every 15 to 20 samples. This allowed a continuous upgrading of the analytical curve used to quantitate the samples.

Air samples were diluted 1:10 to keep their concentration within the linear range of the instrument.

Quality control samples consisted of spiked samples of the appropriate matrix analyzed routinely with the unknown samples. At least 4 quality controls were used to determine a daily recovery factor which was applied to the unknown samples.

c. Dustfall

Outdoor dust samples were thawed and transferred to a 250-ml Vycor beaker. The sample container was rinsed with several milliliters of concentrated HNO_3 and these rinsings added to the sample. Then, 20 ml of concentrated HNO_3 were added to the sample and it was placed on a hot plate (150°C). A raised watchglass was placed on the beaker to keep out contamination while the same was digested-evaporated. The sample was never allowed to boil

Figure 14. Analytical Curve for Lead in Air Particulate

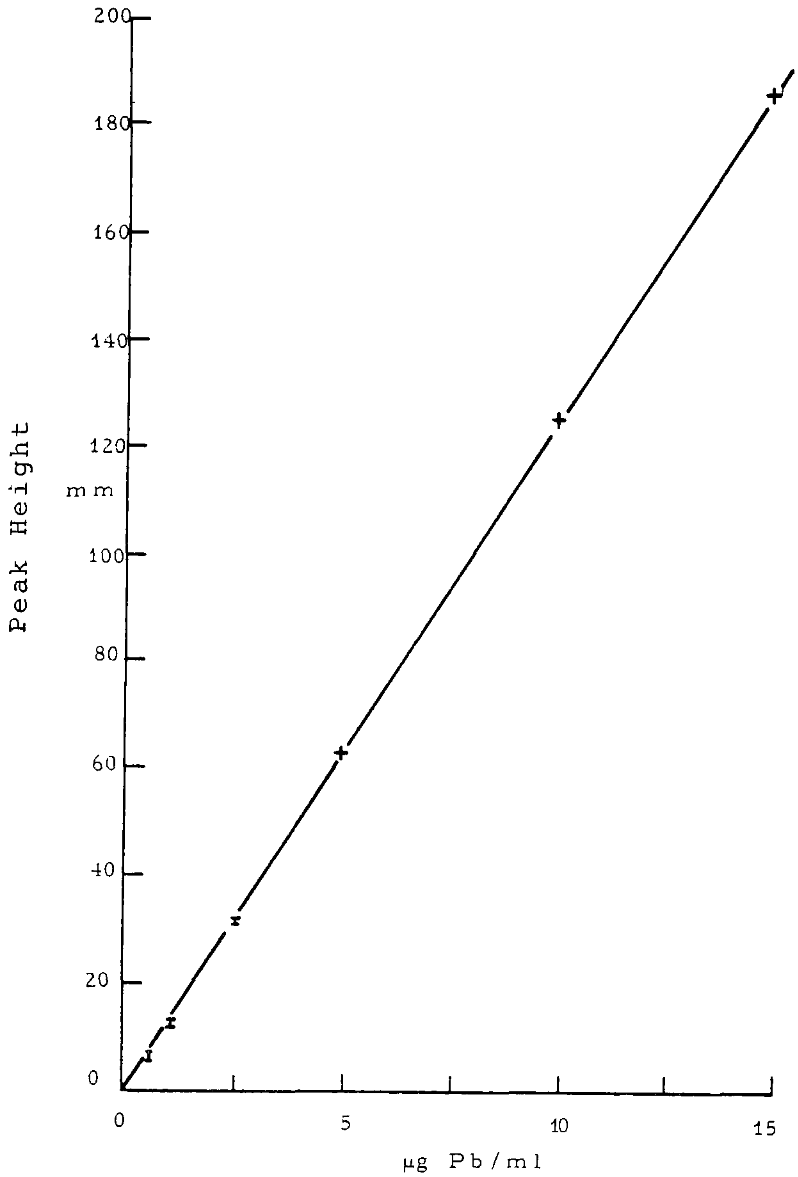
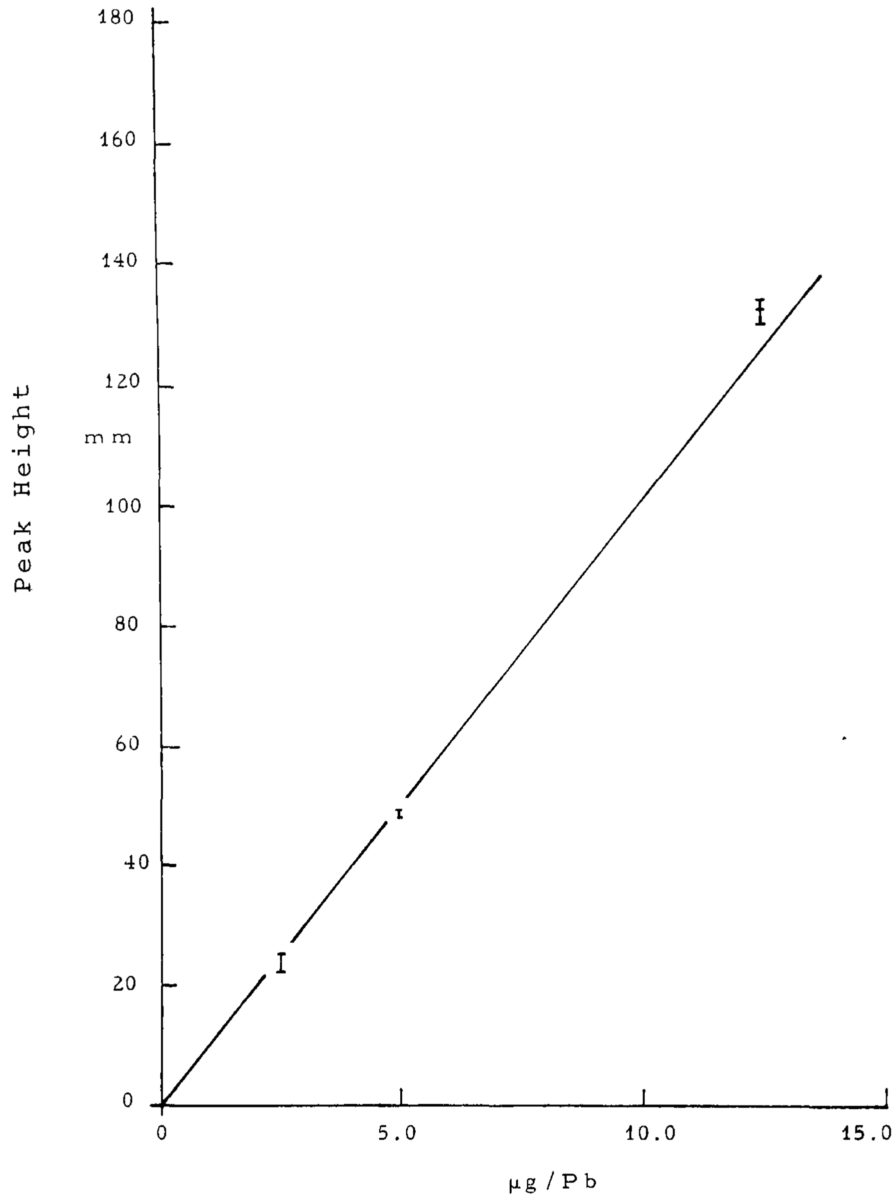


Figure 15. Analytical Curve for Lead in Outdoor Dust



and when 1 to 3 ml remained, it was removed from the hot plate and allowed to cool.

The sample was quantitatively transferred to a graduated centrifuge tube (12-ml) and made to 5 ml with deionized water. After centrifuging for 30 minutes at 3000 RPM, the supernatant was decanted into a small vial without disturbing the silica precipitate. This solution was then analyzed for Pb using flame AAS.

Quantitation and quality control of the outdoor dust samples has been described above.

D. Determine the Relationship of Blood Level and Traffic

1. Description of the Study

a. Study Design

The study described herein was designed to determine the relationship between blood lead and traffic density. To that purpose, a set of 442 volunteer participants were recruited who resided on streets with traffic densities varying from less than 1,000 cars per day to greater than 20,000 cars per day. Only persons who routinely were to be found at home and who did not have occupations which routinely took them away from their residence were selected to participate in the study. From each participant, blood samples were obtained as were other samples from the residence (dust, soil, water) and these samples were chemically analyzed regarding the amount of lead present. Traffic densities were measured for the street on which each participating residence was located. A detailed statistical analysis was then performed on the numerical results of chemical analysis and traffic counts to determine the relationship between these parameters.

b. Data to be Collected

(1) Demographic

The study was designed around a population of participants who can be generally characterized as white, middle class, who routinely spend their time at home most of the time and who do not have unusual exposure to lead. To obtain demographic information on selected households and on the residents of selected households, appropriate questionnaire forms were designed. The study design was to collect demographic information with questionnaire forms on 1000 households and on 480 individuals recruited and selected as voluntary paid participants.

(2) Environmental

On each street and residence selected for the study, study design included collection of a set of environmental data. This included obtaining traffic counts on each street selected and collection of a set of environmental samples at each residence: soil samples, tap water, house dust, and windowsill wipes. In addition a measurement of the amount of lead in surface paint and a handwipe(from pre-school children) was obtained from participating residences.

(3) Biological

From each study participant the study design included collection of a blood sample for analysis of lead content. For adults and larger preschool children, this was accomplished with a venipuncture. For smaller preschool children, the required blood sample was collected with a finger prick.

2. Data Collection Procedures

a. Demographic

For use in the household surveys, a household questionnaire form was developed in two parts, one directed to information on households, including all persons in the household collectively, and a second part directed to information on individuals who might serve as study participants. Appropriate questions were formulated to obtain the information sought on households and on individuals. This questionnaire as well as supporting material was then sent to OMB for approval (see Appendix C).

Clearance for development of a new form was obtained from OMB, and an OMB number was assigned (OMB-158-575022 with an expiration date of February 1977). A number of changes and improvements to the draft form shown in Appendix C were made by EPA and OMB in the process of obtaining OMB clearance. These are reflected in the final format of the form, shown in two parts: Traffic Lead Household Questionnaire (Figure 16) and Traffic Lead Individual Questionnaire (Figure 17).

OMB #158-S75022

INTERVIEWER USE ONLY
Interviewer ID #________
Household ID #________
Estimated Traffic Level [ ][ ] 6 7

OFFICE USE ONLY
Expiration Date February, 1977
ID # [ ][ ][ ][ ] [ ]
Cols. 1 2 3 4 5

TRAFFIC LEAD
HOUSEHOLD QUESTIONNAIRE

NAME: ________________________
Last Name First Name Middle Initial

ADDRESS: Street ________________ 9-28

City ________________ 29-43

Zip Code ________________ 44-48

Telephone ________________

1. How long have you and your household lived at this address? ________ years [ ][ ] 49-50

2. Does any member of your household routinely spend a portion of most days away from the home?
Yes ________ No ________ Total Number [ ] 51

If Yes, specify by name ________________

3. Then, are there any other members of your household who routinely spend most of their time at home?
Yes ________ No ________ Total Number [ ] 52

4. What are the ages, sexes, and family position of these members?

Name						
Age						
Sex						
Position						

Total Number Meeting Criteria [ ] 53

5. During the time in which your household has lived at this address, has any household member been employed as:

	Name of Member	No. Years Employed	Dates of Employment	Total No.	
(a) garage mechanic					54
(b) road maintenance worker					55
(c) solderer or welder					56
(d) shipyard worker					57
(e) battery reclamation plant worker					58
(f) electrical parts assembler					59
(g) plumber					60
(h) ore smelter worker					61

Yes ________ No ________
If Yes, complete the appropriate sections of the matrix.

6. Are any of the following articles used in storing, preparing, or serving food in your household?
(1) Unglazed Mexican type pottery
(2) Glazed Mexican type pottery
(3) Hand painted china flatware
(4) Any combination of the above
(5) None of the above [ ] 62

Figure 16. Traffic Lead Household Questionnaire.

7. Has any member of your household been screened for excess lead absorption?
(1) Yes ________ (2) No ________ — 63

8. Has any member of your household been diagnosed as having excess lead absorption?
(1) Yes ________ (2) No ________
If Yes, specify members by name ________ — 64

9. Is your home cooled with any of the following appliances?
(1) Central air conditioning
(2) Window air conditioning
(3) Evaporative cooler
(4) Window fan
(5) Ceiling exhaust fan
(6) Other ________ — 65

10. What type of structure is your house? (51% or more of exterior surface)
(1) Solid brick, concrete, or rock
(2) Brick or rock veneer
(3) Stucco
(4) Asbestos shingle
(5) Aluminum siding
(6) Composition siding
(7) Wood frame
(8) Other ________ — 66

11. What is the approximate age of your house? ________ years — 67-68

12. What is the highest educational level completed by your head of household?
(1) less than 8th grade
(2) 8th grade
(3) high school - incomplete
(4) high school - complete
(5) trade or vocational school beyond high school
(6) college (4 years) - incomplete
(7) college (4 years) - complete
(8) post graduate — 69

13. Would you or any of your family members participate in a health survey as a paid volunteer?
Yes ________ No ________
If yes, specify members by name ________
Total Number of Participant Forms Collected — 70

INTERVIEWER NOTE AND RECORD

14. Width of road by number of lanes. — 71

15. Is street a divided highway?
(1) Yes ________ (2) No ________ — 72

16. Estimated distance of residence from center of roadway in feet. — 73-75

17. Is residence at an intersection?
(1) Yes ________ (2) No ________ — 76

18. Is residence facing primary street?
(1) Yes ________ (2) No ________ — 77

19. On which side of street is house located?
(1) East (2) West (3) North (4) South — 78

Interviewer's Initials ________ H — 80

Figure 16. Traffic Lead Household Questionnaire (Cont'd.)

INTERVIEWER USE ONLY
Interviewer I.D # ________
Household I D # ________

OMB # 158-S75022

OFFICE USE ONLY
Expiration Date February, 1977
ID # [ ][ ][ ][ ][ ]
Cols. 1 2 3 4 5

TRAFFIC LEAD
INDIVIDUAL QUESTIONNAIRE

NAME: ____ 6-33

Last Name 6-20 | First Name 21-32 | Middle Initial 33

1 Sex: (1) Male ______ (2) Female ______ [ ] 34

2. Date of Birth: ______ Month ______ Day ______ Year DOB [ ][ ][ ][ ][ ][ ] 35-40

AGE IN YEARS [ ][ ] 41-42

3 How many years have you lived in this city? ________ years [ ][ ] 43-44

4. How many years have you lived at this address? ______ years [ ][ ] 45-46

5. In your hobbies do you either make or use any of the following items?
   (1) Homemade pottery
   (2) Lead soldiers
   (3) Hand painted china
   (4) Solder
   (5) Other known contacts with lead Specify ____________
   (6) Any combination of the above
   (7) None of the above
   [ ] 47

6. On the average how many hours a week do you spend away from home? __________ hours. [ ][ ][ ] 48-50

7 On the average how many hours do you spend riding in cars or buses around town? _______ hours. [ ][ ][ ] 51-53

8. Have you ever been diagnosed as being anemic?
   (1) Yes ______ (2) No ______ [ ] 54

9. Have you experienced in the last month any of the following?
   (1) Fever over 101 degrees
   (2) Hospitalization
   (3) Traumatic injury
   (4) Any combination of the above
   (5) None of the above
   [ ] 55

10. Have you ever smoked as many as five packs of cigarettes, that is, as many as 100 cigarettes during your entire life?
   (1) Yes ______ (2) No ______ [ ] 56

11 Do you now smoke cigarettes?
   (1) Yes ______ (2) No ______ [ ] 57

Figure 17. Traffic Lead Individual Questionnaire

12. If you are a current or an ex-cigarette smoker:
a. How many cigarettes do (did) you smoke per day?
(1) Less than 1/2 pack per day (1-5 cigarettes per day)
(2) About 1/2 pack per day (6-14 cigarettes per day)
(3) About 1 pack per day (15-25 cigarettes per day)
(4) About 1-1/2 packs per day (26-34 cigarettes per day)
(5) About 2 packs per day (35 or more cigarettes per day)
(9) N/A ☐ 58
b. How old were you when you first started smoking?______ years
(99) N/A ☐☐ 59-60
c. How old were you when you last gave up smoking, if you no longer smoke?________years
(99) N/A ☐☐ 61-62

13. If individual is a child: (Preschool Child)
a. Is the child involved in any of the following activities?
(1) Play or nursery school
(2) Day care away from its home
(3) Routinely stays away from home either at relatives or with friends
(4) Any combination of the above
(5) None of the above
(9) N/A ☐ 63
b. What is the child's usual play site?

At home indoors	Number of Hours Per Day	☐☐	64-65
At home outdoors near the house	Number of Hours Per Day	☐☐	66-67
At home outdoors near the street	Number of Hours Per Day	☐☐	68-69
Elsewhere	Number of Hours Per Day	☐☐	70-71

14. If individual is an adult. (20 years old or over)
a. Which of the following best describes your activity pattern?
(1) Employed outside the home (5) Full-time student
(2) Employed inside the home (6) Retired
(3) Unemployed (7) Other___________
(4) Housewife (9) N/A ☐ 72
b. For all jobs held in the last year please state for each:
(1) Nature of company, business or agency________________
(2) Specific job performed__________________________
(3) Number of years spent on job_________ years
(4) On the job were you ever exposed to lead?
(1) Yes_______ (2) No _______
If yes, specify details_______________________________ ☐ 73

YOU HAVE COMPLETED THE QUESTIONNAIRE.
THANK YOU

Interviewer's Initials_____________ IMNOWO123456 ☐ 74

P 80

Figure 17. Traffic Lead Individual Questionnaire (Cont.'d)

b. Household Data Recording and Scheduling

(1) Data Recording

This project required that a large amount of sample information be gathered from the participants and their homes. To minimize duplication and centralize this information, a "Participants and Household Checklist" was made for each household participating in this study. Figure 18 is an example of the form used.

Figure 18.
NEIGHBORHOOD LEAD STUDY
Participants & Household Checklist
01-4294

Appnt. Time: ______
Day: ______
Area: ______

	Prtcpnt ____		Prtcpnt ____		Prtcpnt ____		Prtcpnt ____	
	1st-sample-2nd		1st-sample-2nd		1st-sample-2nd		1st-sample-2nd	
I. Informed Consent								
Blood								
Handwipe (children only)								
Date Collected								

	Date Collected	Start Date
II. Window sill wipe	______	
Tap water	______	
Soil	______	
Indoor dust	______	______
Outdoor dust	______	______

	Indoor	Outdoor	Date
III. Lead in Paint			
Rhenium filter count	______	______	______
Lead filter count	______	______	
Results	______ mg/cm^2 (17-20)	______ mg/cm^2 (22-25)	

IV Distance from Roadway to: House front ______ ft; (28-30) House rear ______ ft. (33-35)

V. Cadmium Participants ?

Information collected by the biological collection teams, the paint analyzer, and on the soil collected were all recorded on this one sheet for each household.

Item I on this checklist provided space for up to four participants at each household to include 1st and 2nd blood samples, hand-wipe samples, and date collected.

Item II provided information on the household samples collected.

Item III was for recording x-ray analyses data on paint measurements.

Item IV provided space for measurement of house location in relationship to the street where traffic densities were measured.

Item V was included for informational purposes on another EPA project (EPA Contract 68-02-1725).

Also, a specific area on the checklist was used to indicate that the second set of validation forms had been completed.

Prior to each day of biological and environmental sample collection, these checklist sheets were organized in each team's notebook according to the households that team was scheduled to visit. Also included with each household checklist was the necessary sample labels for all samples to be collected at that location at that specific time.

Once the biological collection teams had collected the first samples from each household, the checklist sheets were placed into the paint analyzer's notebook. After the paint analysis had been completed at each residence, the checklist sheets were placed into the soil collector's notebook. The checklist sheets were stored in a master notebook following the entry of the soil data until the biological collection teams needed them for the collection of the second blood samples.

After all samples at each household had been completed, the checklist sheets were returned to the master notebook to prevent them from being lost during shipment to the San Antonio laboratories.

These checklist sheets provided a convenient means of accounting for which and what type of samples had been collected at each household.

Similar checklist sheets were maintained on the traffic counting and air sampling operations as described under the appropriate heading.

(2) Scheduling

Once the household surveys were complete (March 26, 1976), the SMU on-site coordinator began scheduling participants for collection of biological and household samples. This was accomplished using the following protocol:

(a) Participant information sheets were arranged according to general location within the city.

(b) Next, the sheets were grouped by street name, then by address.

(c) One to three schedulers would then begin telephoning the participant in a specific area to arrange a time for the biological collection teams to come by.

(d) As the appointments were made they were listed on worksheets giving the date, time, name, and address of the participant(s). These worksheets were made up daily for each biological collection team.

(e) At the end of each day the biological manager would pick up the worksheets and arrange the checklist sheets in each biological collection team's notebook according to the schedule. The appropriate computer printed labels were attached to each checklist and the notebooks were ready for the following day's sampling activities.

(f) The day before the scheduled appointment, a second telephone call was made to remind the participants about the appointment.

In the first week of scheduling, 30 minutes per household was alloted for sample collection.

This was later reduced to 20 minutes because of the efficiency and experience of the biological collection teams.

Because the study could not be confined to one area of the city as initially planned, scheduling of participants became a critical factor to the success of the project. The primary thought behind the scheduling protocol was to minimize the travel time of the collection teams between appointments. A self-contained "mobile laboratory" (16 ft. motor home) was used to further reduce travel time of the collection teams. Each day of sample collection, the mobile laboratory would be parked at some central location within the area being sampled. Usually this was a church or school parking lot. This allowed the biological collection teams to bring their samples in for processing and provided a convenient place to wait between appointment (if necessary). Also, the biological manager was located at the mobile laboratory and this gave him better control of the sample collection efforts. Frequent contact was made between the SMU on-site coordinator and the biological manager at the mobile laboratory to accommodate any last minute schedule changes.

After the second week of sampling, the biological collection teams were familiar with the different sampling areas and the scheduling was routine enough that a centralized location was used to coordinate the activities of the collection teams rather than the mobile laboratory.

Scheduling of paint analysis and soil collection was usually made one to two days before the actual collection. This was handled by the individual performing the collection or analysis.

c. Environmental

(1) Traffic Counts

Traffic was counted to categorize participant homes into sites. Each street on which a participant's residence was located had a traffic count taken. If a number of participants lived within a given block and there was no major cross street between residences then one count was taken to represent all those particular residences. For certain streets, then, multiple counts were required because of the intervention of major side streets or controlled intersections. Participant homes located on corners had both the principal street counted as well as the side street.

(2) Soil

At each residence of participants in this study, a soil sample was collected. The sample was collected at the front of the house near the front door. Surface soil was collected from flower beds or similar exposed areas. In selecting an area for sampling, an effort was made to stay away from those areas which appeared to have sand or top soil recently applied. If the area to be sampled was next to the house, a check of the area for paint chips was made. If no chips were seen, then a sample was taken at least 0.3m away from the house. This minimum distance was maintained to avoid any possible contamination that might have occurred if the house had been previously painted with lead-based paint. The soil sample was collected with a stainless steel trowel. The sample was then transferred to an acid-washed 250-ml polyethylene bottle for Pb analysis. A computer-printed label designating soil from that particular residence was attached to the bottle. A second sample was also collected for the determination of soil characteristics.

(3) Tap Water

Water samples were collected in 474-ml polyethylene containers by the biological collection team during the first visit to each household. The samples were collected from the cold water tap in the kitchen. The water was allowed to run for approximately 1 minute. Then the polyethylene container was rinsed 3 times before being filled. The appropriate label was attached and within 3 hours of collection the water samples were returned to the mobile laboratory. The samples were acidified (approximately 1%) with HNO_3 (reagent grade) and stored at room temperature until shipment. Water samples were frozen and packed in dry ice to minimize leakage during shipment to the San Antonio laboratories.

(4) Housedust

These samples were collected in a 23.0 x 31.2 cm plastic tray over a period of 28 days. The trays were placed by a member of the biological collection team during their first visit to the household. Location of where the tray was placed and the date was recorded on the checklist sheet. Ideally the trays were to be placed in an area where air current would not affect them or children have access to them. Usually the top of the refrigerator was the place where most dust trays were placed.

Instructions were given to the household participants about the dust trays. The trays were not to be disturbed for any reason and a staff member would call in about 28 days to make arrangements to pick up the tray.

Collection of the dust trays was carried out by one member of the biological collection team. Usually appointments were made by areas to reduce the travel time required to collect them. This caused some trays not to be collected exactly on the 28th day. The exact number of days for each dust sample is given in Appendix E.

The contents of the tray were quantitatively rinsed into a 474-ml polyethylene bottle with deionized water. The appropriate computer-generated label was attached and the sample stored at room temperature until shipment to the San Antonio laboratories. To minimize leakage during shipment, all samples were frozen and packed in dry ice.

(5) Windowsill Wipes

These samples were collected in a room nearest the street being counted. The biological collection team collected these samples from each household. Commercially available "Wash'n Dri Towelettes" were selected for this particular sampling after several brands were analyzed for Pb content prior to the field sampling. This particular brand had the lowest Pb content of any brand tested.

Initially, a plexiglas template 7.7 x 45.5 cm was used as a reference in collection of windowsill wipes. This proved unsuitable because many windowsills were too small to cover all of the template. Each collection team was supplied with a ruler and the actual area of the windowsill sampled was measured and recorded on the checklist sheet. The procedure used to wipe the windowsill was standardized so each team would collect the samples the same way. After wiping the windowsill by the prescribed method, the handy wipe was placed in a self-sealing polyethylene bag and the appropriate label attached.

These samples required no further processing in the field. They were packed and shipped at ambient temperature.

(6) Paint

A description of the x-ray analyzer used for paint analysis is given later (see sample analysis). During the first visit of the biological collection team to each household, the participants were told to expect a call from the paint analyzer to set up a time to survey their home (usually within 2 to 3 days).

Normally, the time required to complete the Pb paint survey for each household was approximately 20 to 25 minutes. At each household, two rooms were analyzed and at least two separate readings were performed on the exterior paint of the house. These readings were immediately recorded on the checklist sheet and converted into mg Pb/cm^2 with the appropriate calibration graphs.

Verification of the calibration of the x-ray analyzer was performed at least twice each day. Every night the instrument was connected to a charger unit so the batteries would be fully charged for each day's sampling.

(7) Hand-wipes

Each child participating in this study had one hand-wipe sample collected from him/her during the first or second visit of the biological collection team to the home. Collection of handwipe samples from children recently bathed were postponed until the second visit.

The hand-wipe sample was collected just prior to taking the blood sample from the child. If a capillary blood sample was to be collected, then the hand-wipe became an integral part of the blood collection procedure (see Biological Samples).

One "Wash 'n Dri Towelette" was used to thoroughly wipe both hands of the child. This "towelette" was then placed in a polyethylene bag and the proper label attached. Prior to taking this hand-wipe, the laboratory technician would use a "towelette" to clean her hand to reduce the possibility of contamination.

(8) Validation

A validation of information regarding each residence was performed during the collection of biological samples. A validation form (Figure 19) was used to collect pertinent data on each residence to be checked against the household questionnaire data. All households selected for the study met the established criteria.

A validation of information regarding each participant was performed during the collection of participant samples. A validation form (Figure 20) was used to collect pertinent data on each participant to be checked against the participant questionnaire data. All participants selected for collection of biological samples met the established criteria.

Figure19. Household Validation Form

Traffic Lead Validation

Informant's Name: ____________________
Address: ____________________
____
Phone #: ____________________
Family Position: ____________________

Household Questions-Circle Responses-Far right responses disqualify household.

1. Do you live in a corner residence?
   No Yes

2. Do you live in a single family dwelling or a duplex?
   Yes No

3. Is your residence 100 feet or less from the street?
   Yes No

4. Does your residence face the street?
   Yes No

5. Do you live on the ground floor?
   Yes No

6. Do you live within 300 feet of a traffic signal or a stop sign?
   No Yes

Household Eligible-Yes No

d. Biological

(1) General

The biological collection teams collected two blood samples from each participant approximately one week apart. These were venous blood samples collected from the antecubital vein using a 10 ml Vacutainer (minimal Pb). From previous experience, collecting venous blood from small children was not always possible and many times this would bias the data in the younger age groups. To assure sufficient

Figure 20. Traffic Lead Validation

Individual Questions--Circle Responses-Far right responses disqualify individual.

1. Name of Member: ______________________

2. How long have you lived at this address?
   3 months or more   Less than 3 months

3. Sex: Male
   Female

4. Age in years: ________

5. If individual is a child:

   Age: 1 thru 5 years   Less than 1 year & more than 5 years

   Does your child spend more than 30 hours a week away from home?
   No   Yes

   If yes:
   How many hours does your child spend away from home? ________
   Where does your child spend those hours? ______________

6. If individual is a female:

   Age: 20 thru 49 years   Less than 20 years & more than 49 years

   On the average, how many hours a week do you spend away from home?
   Less than 30 hours per week   30 hours or more per week

7. If the individual is 50 years old or more:

   On the average, how many hours a week do you spend away from home?
   Less than 30 hours per week   30 hours or more per week

   Are you retired from your work or work in your home?
   Yes   No

8. I M N O W O______Unk.

9. Date of Validation: ______________

10. Interviewer's Initials ________

Individual Eligible   Yes   No

data points in the younger age groups, an alternate type of blood sampling procedure would be used in those difficult cases. Capillary blood taken by the "finger-prick" method was the alternate procedure chosen because it was relatively easy to perform on a reluctant child and it was less traumatic than the venipuncture technique.

Because the "finger-prick" technique limits the volume (100μl) of blood taken for analysis and the procedure is more liable to contamination problems[14] every effort was made to convince the child and parent(s) to allow the venous blood be taken.

Fewer venous blood samples were taken from children on this project than we initially anticipated. The reason for this may be the fact that providing an alternate procedure, which in the mind of the parent is less traumatic to the child, may counteract any argument for the venous blood sample that the laboratory technician could make.

(2) Venous

Venous blood was taken from participants by the routine venipuncture technique commonly used in clinical laboratories. The procedure was modified in that dilute HNO_3 (3ml/liter) rinse of the puncture site was included to reduce the possibility of Pb contamination from the skin. The blood was collected in 10ml Vacutainer (Becton-Dickinson Co., Rutherford, N.J.) using the minimal Pb type (L3200XF313) containing 143 USP units of sodium heparin. Previous tests with this type of Vacutainer indicated the Pb content to be approximately 0.1 μg per tube[10].

Once the blood had been drawn, properly labeled, and thoroughly mixed, it was immediately placed in a small styrofoam cooler containing wet ice to maintain it at a chilled temperature. The blood samples remained in this cooler from 30 minutes up to 3 hours depending upon the sampling schedule of the biological collection teams. At the centralized location (mobile laboratory) one of the 10ml Vacutainers from each participant was opened and an aliquot taken for hematocrit determination. The unopened Vacutainers were properly marked to be used for the blood-Pb determination at the San Antonio laboratories. The Vacutainer which was opened was also sent along with the unopened one as a reserve.

(3) Fingerprick

Capillary blood samples were collected from children using the recommendations of Bratzel and Reed[14].

Usually, the child would sit in the parent's lap during the blood drawing to maintain control and to relieve the stress associated with the procedure. The child's arm would be fully extended and held at the elbow by the parent. The laboratory technician would grasp the child's hand and wash it very thoroughly using a "Wash' Dri towelette." Next, the 3rd or 4th finger would be held in such a way that the terminal digits were exposed and under complete control of the technician. A vigorous scrub was then made of the exposed finger using a gauze pad soaked in Phisohex soap. This would be followed by another gauze pad soaked in deionized water. Another gauze pad soaked in dilute HNO_3(3ml/liter) would be used to scrub the finger tip followed by another deionized water rinse and a final rinse with an isopropyl alcohol soaked pad. A sterile micro-lance was used to puncture the skin and the first few drops of blood were allowed to flow freely.

A 100 µl capillary blood-collection tube (ESA, Inc., Burlington, MA) was then used to collect the blood. Care was taken not to contaminate the puncture site or the capillary tube. Once the tube was filled to the mark, the laboratory technician would tilt the tube so the blood would not run out either end and hand it to the other team member to seal with polyethylene end caps. If possible, 3 or 4 such samples were collected from the same puncture site along with two hematocrit tubes.

These samples were placed into a polyethylene bag and the appropriate label attached. They were stored in the styrofoam ice chest until the collection team returned to the mobile laboratory.

Immediately upon receipt of the samples at the mobile laboratory, the hematocrits were determined and the samples stored in the refrigerator until shipment to the San Antonio laboratories.

Following each day of sample collection, all blood samples were packed in styrofoam mailers containing dry ice and shipped to the San Antonio laboratories by air express (counter to counter delivery). Usually the time from collection of the blood until it was analyzed for Pb averaged less than 24 hours.

3. Sample Analysis Procedures

a. General

(1) Instrumentation

All analyses were performed on either a Perkin-Elmer Model 503 Atomic Absorption Spectrophotometer (AAS) or a Perkin-Elmer Model 306 AAS. The Model 306 AAS is modified (Perkin-Elmer Modification Kit 040-0286) to reduce "stray light" from reaching the photomultiplier tube during operation of the flameless sampling devices.

Both AAS units are equipped with a Deuterium-Arc background corrector which corrects for non-specific absorption. The background corrector was routinely used on all analyses.

Absorption peaks were recorded on a Perkin-Elmer Model 056 Recorder with a 10mv range.

Flameless analyses were performed with the following graphite tube furnaces: (1) a Perkin-Elmer HGA-2100 with the Model 503 AAS, (2) a Perkin-Elmer HGA-2000 with the Model 306 AAS, and (3) an Instrumentation Laboratory IL-455 with the Model 306 AAS. Flame analyses on both AAS units were by air-acetylene flames using a single-slot, 10-cm Burner Head (Perkin-Elmer Model 303-0418).

(2) Reagents

All regents used for the preparation and analysis of the samples on this contract were of analytical grade or better.

b. General Quality Control

A major problem in trace metal analysis is contamination of glassware, reagents, and samples with the metal(s) being analyzed. Minimizing this problem requires an extensive control program involving glassware cleaning, protection, and quality control measures.

(1) Cleaning

All glassware and polyethylene containers that come in contact with samples or reagents are cleaned by the following procedure: Items are washed thoroughly with a laboratory detergent (Alconox, Inc., New York) in tap water. The clean glassware is rinsed with deionized water and placed in an acid vat containing HNO_3(1:1) and allowed to soak for 6 to 18 hours. Clean polyethylene containers are also placed in the acid vat but are removed after 4 to 6 hours. After acid soaking, the items are rinsed thoroughly with deionized water and placed in a drying oven until dry. The dry items are placed in a dust-free area and allowed to cool. Polyethylene containers are capped and sealed in polyethylene bags until ready for use. Glassware is returned to its proper container (see below) and stored in glassware cabinets until ready for use.

(2) Protection

All glassware items are kept in polyethylene containers to minimize exposure to dust in the laboratory. Each container is numbered and contains one type of glassware (i.e., watchglasses, 4-ml volumetric flask, etc.). When all the glassware in a container has been used, it is returned to that container and carried through the washing procedure (see above) as a unit. While the glassware is being washed, the container is also washed. Once the glassware has completed the wash cycle and dried, it is returned to the proper container. Several items (3 to 7) of glassware are removed from the container at this time for quality control checks.

(3) Quality Control

The number of each container of glassware going through the wash cycle is entered into a log book. Other information, such as name of technician performing washing procedure, type of glassware, length of acid-soaking, etc., are also recorded in this log book. This allows the glassware removed for quality control checks to be identified with a particular set of glassware being used in the laboratory. The glassware removed for quality control purposes is checked by rinsing with a known volume of 0.1N HNO_3 and comparing with the same acid that has not been used for rinsing. Normally one metal (Pb) is used for quality control checks but other metals may also be included if needed. The graphite furnace (AAS) is used for quality control analysis. Glassware which shows a significant difference between the used and unused rinsing acids metal content is referred back to the container number from which it came. That container is then returned to the washroom and the wash cycle repeated on all of its glassware.

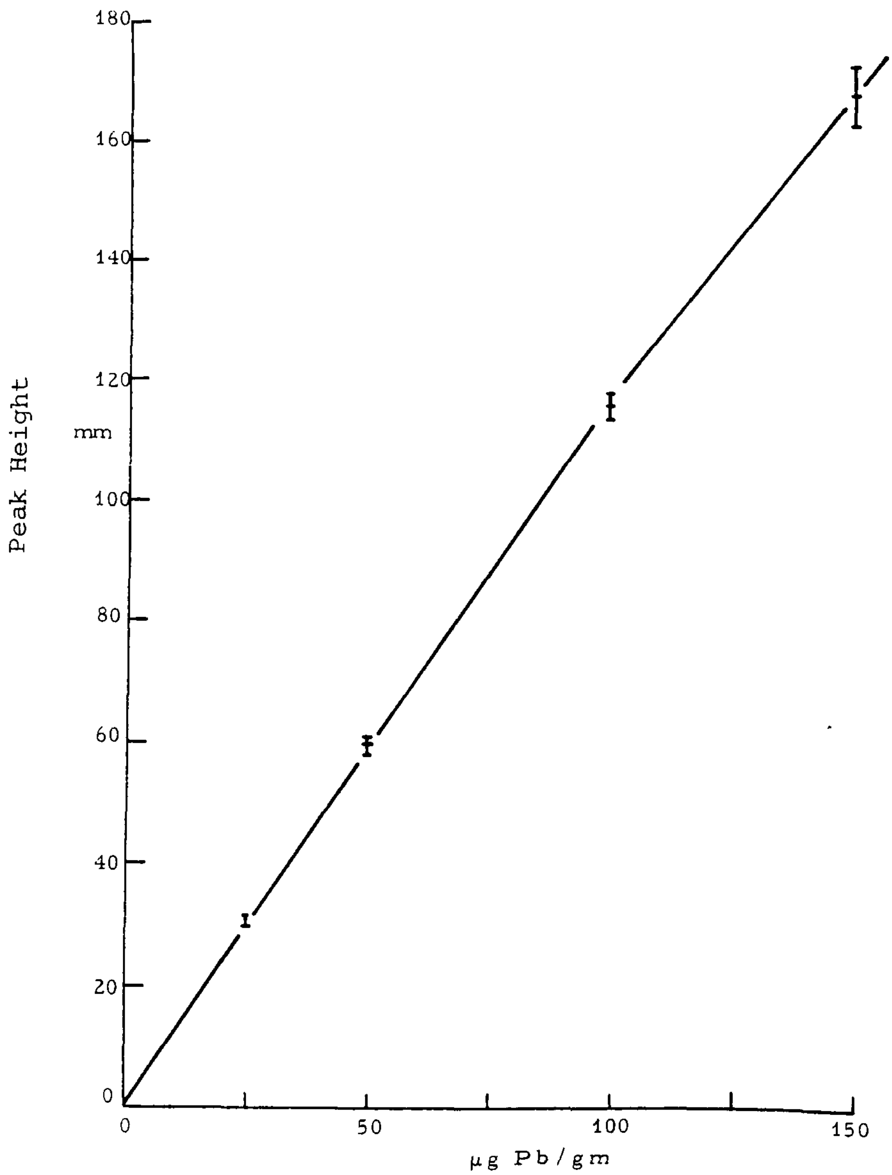
c. Soil

Soil samples were analyzed for Pb using a modification of the preferential leach procedure Smith and Window(16) used on dried sediment samples. Table 1 summarizes the analytical parameter for soil samples. The soil sample was dried at 65^{o}C overnight in an oven. The dried soil was ground to powder using a mortar and pestle and sieved through a 250 micron stainless steel screen. Then 5 g of the powdered sample was weighted into a 125-ml Erlenmeyer flask and 50 ml of the leach solution {acetic acid: hydroxylamine HCL (7:3)} was added. A polyethylene stopper was used to seal the flask. The sample was then placed on a mechanical shaker for 12 to 18 hours (overnight).

The leach solution was filtered through a glass-fiber filter (9cm) which had previously been rinsed with the leach solution. The filtrate was collected in a 50-ml polyethylene bottle and lead was determined on this solution using flameless AAS.

Soil samples were quantitated for Pb content by the procedure used for air particulate and outdoor dust. Figure 21 represents a typical analytical curve for soil-Pb. Quality control samples were spiked soil samples which were handled according to the procedures detailed for air particulate samples.

Figure 21. Analytical Curve for Lead in Soil



d. Water

Acidified water samples were analyzed directly by flameless AAS. No digestion or concentration was necessary on these samples. Table 3 summarizes the analytical parameters for water samples. Water samples

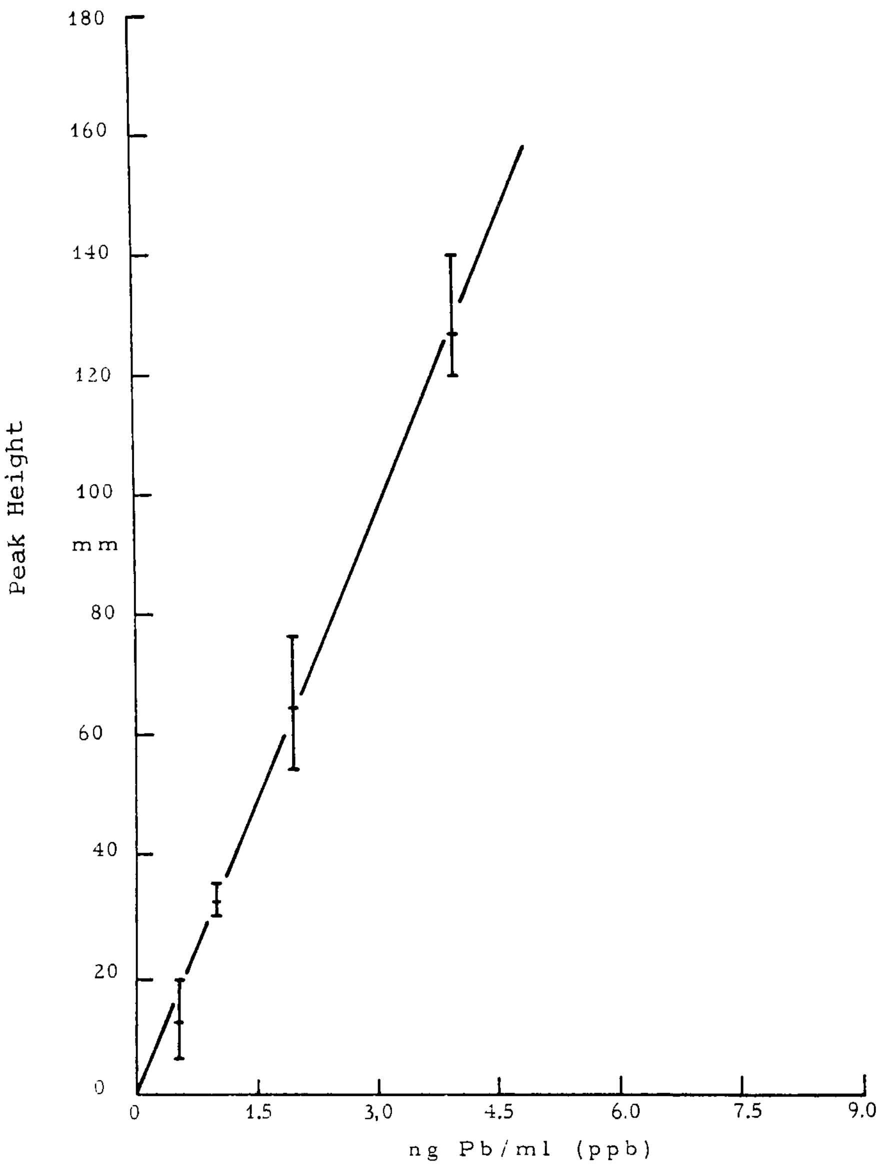
Table 3. Analytical Parameters of Environmental Samples

Sample Matrix	Window Sill Wipes (4)	Water	Indoor Dust (5)
Sensitivity (1)	0.6 ng/cm^2	0.04 ng/ml	0.075 ng/cm^2
Detection Limit (1)	5.0 ng/cm^2	0.2 ng/ml	1.0 ng/cm^2
Linear Range (2)	110 ng/cm^2	4.0 ng/ml	7.0 ng/cm^2
Recovery (3)	109.5%	94.4%	95.6%
Precision			
n	6	4	7
mean	26.0 ng/cm^2	0.4 ng/ml	8.7 ng/cm^2
std.dev.	2.0 ng/cm^2	0.1 ng/ml	0.7 ng/cm^2
RSD	8.7 %	25.0%	8.0%

(1) see text for definition
(2) does not imply maximum linear range
(3) based upon average recovery of low Pb spike in sample matrix
(4) surface area used to calculate = 350.4 cm^2
(5) surface area = 717.6 cm^2

were quantitated by the "method of additions" described earlier for air particulate samples. Figure 22 represents a typical analytical curve. Quality control consisted of Pb spiked water samples routinely analyzed with the unknown samples. A recovery factor was determined from these quality controls and applied to the water samples.

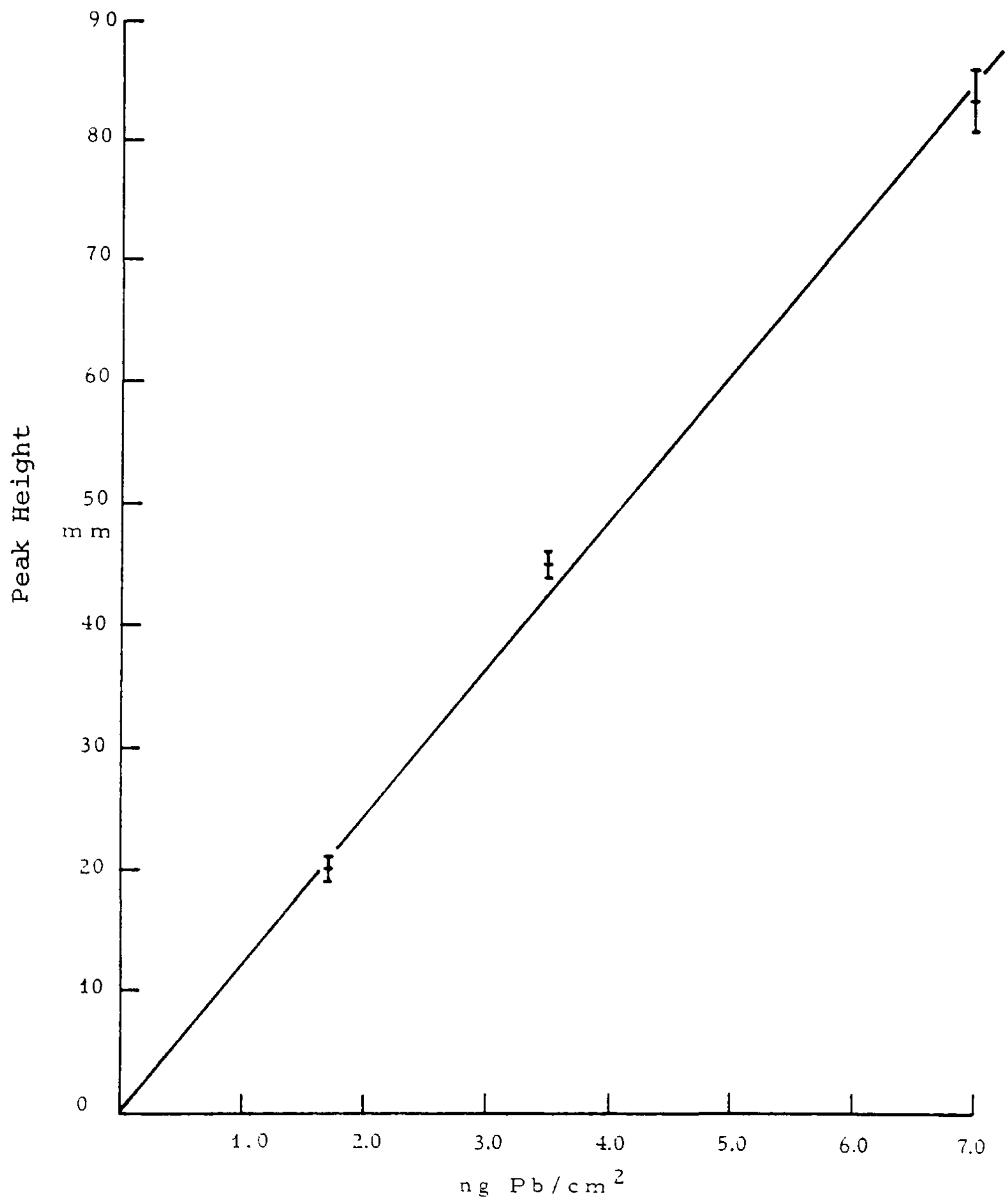
Figure 22. Analytical Curve for Lead in Water



e. House Dust

The same procedure used to analyze the outdoor dust samples was used to determine the Pb content of the indoor dust samples. Table 3 summarizes the analytical parameters for house dust samples. The Pb concentration was determined by flameless AAS. Indoor dust samples were measured by the same procedures used for water samples. Figure 23 is a typical analytical curve. Quality controls and recoveries were the same as described for water.

Figure 23. Analytical Curve for Lead in Indoor Dust



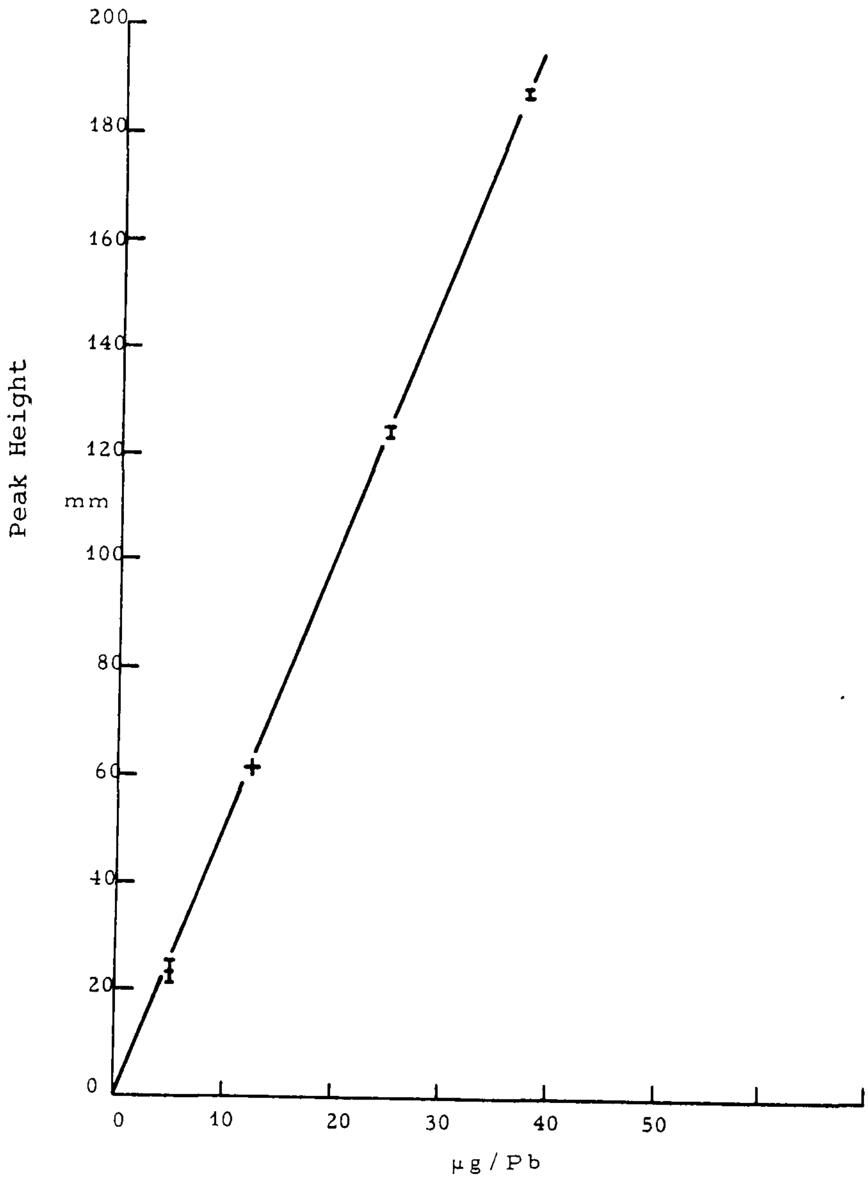
f. Windowsill Wipes

The windowsill wipe samples which were collected on "Wash 'N Dri" towelettes were analyzed by the procedure used for the particulate air samples. Table 3 summarizes the analytical parameters for windowsill wipes. The towelette was carefully removed from the polyethylene bag and placed into the 2.5 x 8.5 cm extraction thimble. Eighty milliliters of the digestion acid were added and the apparatus assembled as previously described (Figure 13). The final volume of the sample was brought to 5.0 ml with deionized water prior to centrifuging. An aliquot of this final volume was analyzed for Pb by flame AAS. Quantitation of these samples was by the procedure given for water samples above. Figure 24 is a typical example of an analytical curve. Quality controls and recoveries were the same as described above for water samples.

g. Paint X-Ray Fluorescence

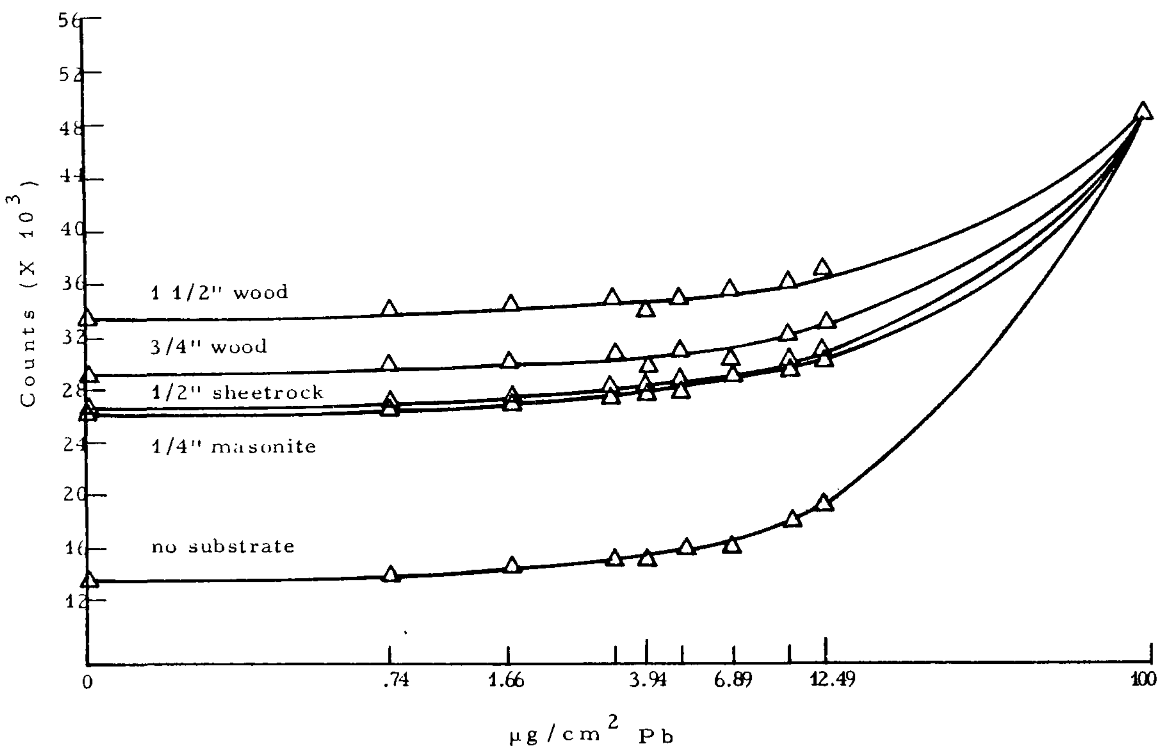
Each home where participants of this study resided was analyzed for lead in wall paint. An x-ray fluorescence analyzer, Model 700, manufactured by Columbia Scientific Industries, Austin, Texas, was used for this determination. This instrument employed a 3 mc Cd^{109} source with a lead and rhenium filter. Standardization of the instrument was obtained using lead standards borrowed from Columbia Scientific. These standards consisted of various concentrations of lead ranging from 0 to 6.89 mg/cm^2 in polyethylene

Figure 24. Analytical Curve for Lead in Window-Sill Wipes



wafers. By a combination of these standards with various substrates (1/4" masonite, 1/2" sheetrock, 3/4" and 1-1/2" wood, aggregate and brick), a calibration curve was obtained for any combination of substrate material and/or lead level encountered in participants' homes. Figures 25 and 26 illustrate these calibration curves.

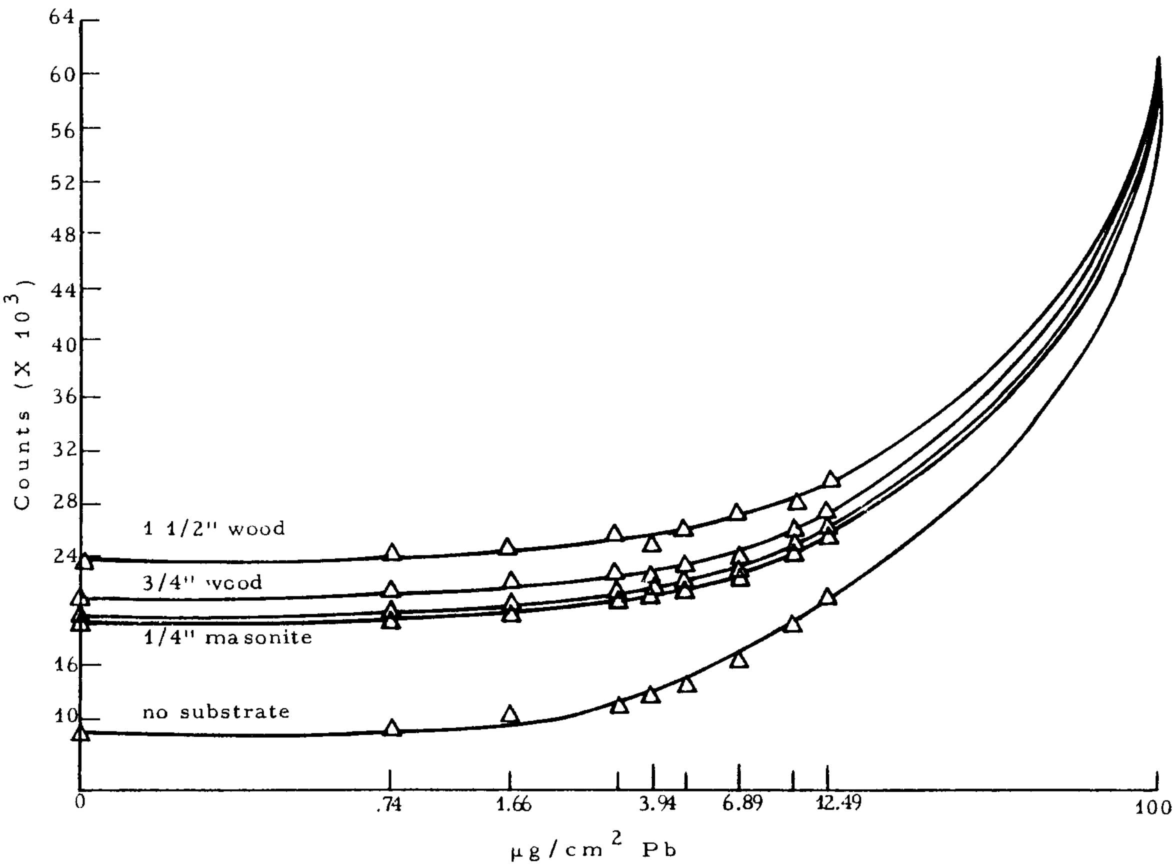
Figure 25.. X-Ray Fluorescence Analyzer Rhenium Filter Calibration Curve



The commonly accepted value for excessive lead in paint is difficult to measure in situ, as the corresponding paint thickness is undefined. For this study, the unit mg/cm²Pb was used which corresponds to the measuring geometry of the x-ray fluorescence detector. The relationship of paint thickness and mg/cm² Pb corresponding to 1% Pb is 1 to 4 mg/cm²Pb. The instrumentation used had a sensitivity of ± 0.1 to 0.3 mg/cm²Pb.

Two different painted surfaces, both inside and outside, of the participants' homes were analyzed.

Figure 26. X-Ray Fluorescence Analyzer Lead Filter Calibration Curve



On the inside of the home, measurements were taken in the room closest to the street such as a living room and, also, in the child's bedroom if applicable. The outside measurements were taken on either the front door or door jamb and the garage door. Condition of the painted surface analyzed was noted as was the general condition of all painted surfaces in the home. The exterior composition (brick, siding, etc.) was also noted. Twice a day, usually in the morning and afternoon, a 100% Pb standard was analyzed. This measurement gave a visual indication of the condition of the instrument and also provided a decay factor for the radioactive source. All readings were subsequently adjusted to reflect the condition of the source at the time of calibration.

h. Hand-Wipe Samples

Hand-wipe samples, which were collected on "Wash 'N Dri" towelettes, were analyzed by the procedure outlined above for windowsill wipe samples.

Hand-wipe samples from children were quantitated by the "method of additions" as described for the water samples. Figure 27 illustrates a typical analytical curve for hand-wipe samples. Quality controls for the hand-wipes were also similar to those of the water samples.

i. Blood

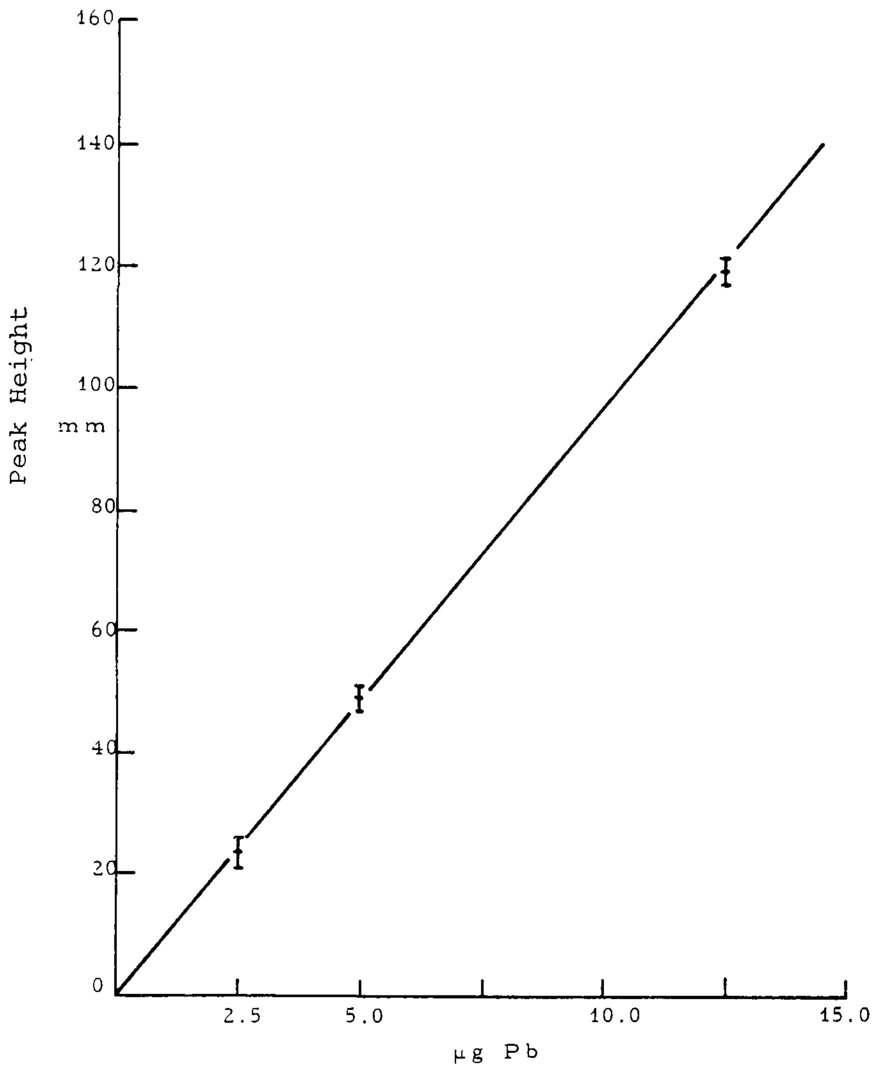
(1) Venous Blood

Development of Analytical Methodology

Several studies were performed to determine what parameters would affect the Pb content of blood samples collected in 10ml minimal Pb Vacutainers (sodium heparin anticoagulant).

One important question which needed addressing was whether the blood needed to be frozen, refrigerated or maintained at ambient temperatures between collection and analysis. Contact with several investigators running large-scale blood-Pb screening programs indicated

Figure 27. Analytical Curve for Lead in Hand Wipes



they either maintained the blood at ambient temperature or refrigerated it for shipment. Most investigators would refrigerate the blood once it arrived at the laboratory and analyze it within 3 to 5 days.

When the study site shifted to Dallas, plans were made such that blood samples collected would be refrigerated from the time of collection until Pb analyses were performed. Also these plans made provisions for the blood-Pb determinations to be done within 24 hours of collection.

A set (3 vacutainers) of bovine blood samples from the Center for Disease Control (CDC) Blood-Pb evaluation program were analyzed in duplicate for Pb on three different occasions over a period of 20 days. The blood was refrigerated during shipment (wet ice) from CDC and maintained in a cold room (40°C) during the 20-day period. Table 4 summarizes the data from this study. The average variation from the CDC Reference Lab value of the low Pb

Table 4. Effect of Refrigeration on Blood-Pb Values of Whole Blood (CDC Bovine Blood)

Sample ID	Day No. 1 μg/100 ml	Day No. 10 μg/100 ml	Day No. 20 μg/100 ml	Mean & Std. Dev.
1	38.9	41.0	38.3	39.4 ± 1.4
2	80.2	88.5	86.7	85.1 ± 4.4
3	60.3	67.3	63.9	63.8 ± 3.5

sample over 20 days was 14.7% while the high Pb sample varied only an average of 2.9%. Refrigeration (at 40°C) of whole blood samples is adequate protection to get accurate blood-Pb concentrations from venous blood samples up to 20 days.

Bovine blood samples from the CDC program were collected in Vacutainers containing EDTA as an anticoagulant whereas the Vacutainers used for this study contained sodium heparin. A comparison was made to determine if this would bias the blood-Pb data. Freshly drawn human blood was collected in both types of Vacutainers from the same individuals at the same time. Blood-Pb analysis of these bloods indicated the Vacutainers containing the EDTA gave results which were 21.9% lower than the blood from the Vacutainer containing the sodium heparin. Adding $CaCl^2$ to the blood with EDTA gave blood-Pb values the same as obtained from the sodium-heparin blood.

This effect of the anticoagulant would not affect the venous blood-Pb data from the Dallas study site since all samples were collected in Vacutainers containing sodium heparin and the spiked bloods used to quantitate these samples also contained sodium heparin.

Another study was performed to evaluate the effect different kinds of blood would have upon the blood-Pb values. The purpose here was to investigate bovine blood as a source for spiking to quantitate the human blood samples. This would be less expensive than having to purchase human blood for spiking standards. Both bovine and human blood samples were spiked with known amounts of Pb to establish calibration curves (concentration vs peak heights). The slope of the human blood calibration curve was 1.365 while the slope of the bovine blood calibration curve was 1.692. This represents an approximate 24% difference which favors the human blood. Therefore, it was necessary to match the kind of blood used for spiking standards with the kind of blood being analyzed for Pb. All venous blood samples collected in Dallas were quantitated using human blood purchased from a local blood bank. All CDC blood samples were quantitated using bovine blood (anticoagulant-EDTA) purchased from a local veterinarian.

Table 5 gives the analytical parameters for venous blood using this methodology.

Table 5. Analytical Parameters of Biological Samples

Sample Matrix	Venous Blood (3)	Capillary Blood (4)	Hand Wipes
Sensitivity (1)	0.5 μg/100 ml	1.2 μg/100 ml	0.11 μg
Detection Limit (1)	1.4 μg/100 ml	9.2 μg/100 ml	1.60 μg
Linear Range (2)	80 μg/100 ml	80 μg/100 ml	12.5 μg
Recovery (5)	101.0%	112.8% (6)	103.8%
Precision:			
n	7	7	6
mean	5.8 μg/100 ml	46.3 μg/100 ml	9.21 μg
std.dev.	0.3 μg/100 ml	4.6 μg/100 ml	0.80 μg
RSD	5.2%	9.9%	8.7%

(1) see text for definition
(2) does not imply maximum linear range
(3) 0.5 ml of whole blood
(4) 0.1 ml (100 μl) of whole blood
(5) based upon average recovery of low Pb spike in sample matrix
(6) recovery based upon CDC bovine blood analyzed over period of 11 days

Analysis Procedures

Venous blood taken from the antecubital vein of the participants was analyzed for Pb within 24 hours of collection. The samples were refrigerated (but not frozen) from collection until they were prepared for Pb analysis in the laboratory. Lead determinations were performed on the blood from the unopened vacutainer (see sample collection). The blood from the other vacutainer was transferred to a 30-cc polyethylene bottle and frozen ($0^{o}C$) for future analysis if needed.

The method of blood-Pb determinations used on the venous blood was patterned after that of Hwang, Ullucci, and Mokeler,(17) and Kubasik and Volosin.(18) A 500μl aliquot of whole blood was pipetted from the 10-ml vacutainer into a 5-ml screw-cap extraction tube. Then, 500μl of Trizma buffer solution (pH 7.0) (Sigma Chemical Co., St. Louis, Mo.) was added, followed by 500μl of a chelating-hemolyzing solution consisting of 2% ammonium pyrrolidine-dithiocarbamate (Aldrich Chemical Co., Milwaukee, Wisconsin) in a 2% solution of Triton X-100 surfactant (J. T. Baker Co., Phillipsburg, Pa.).

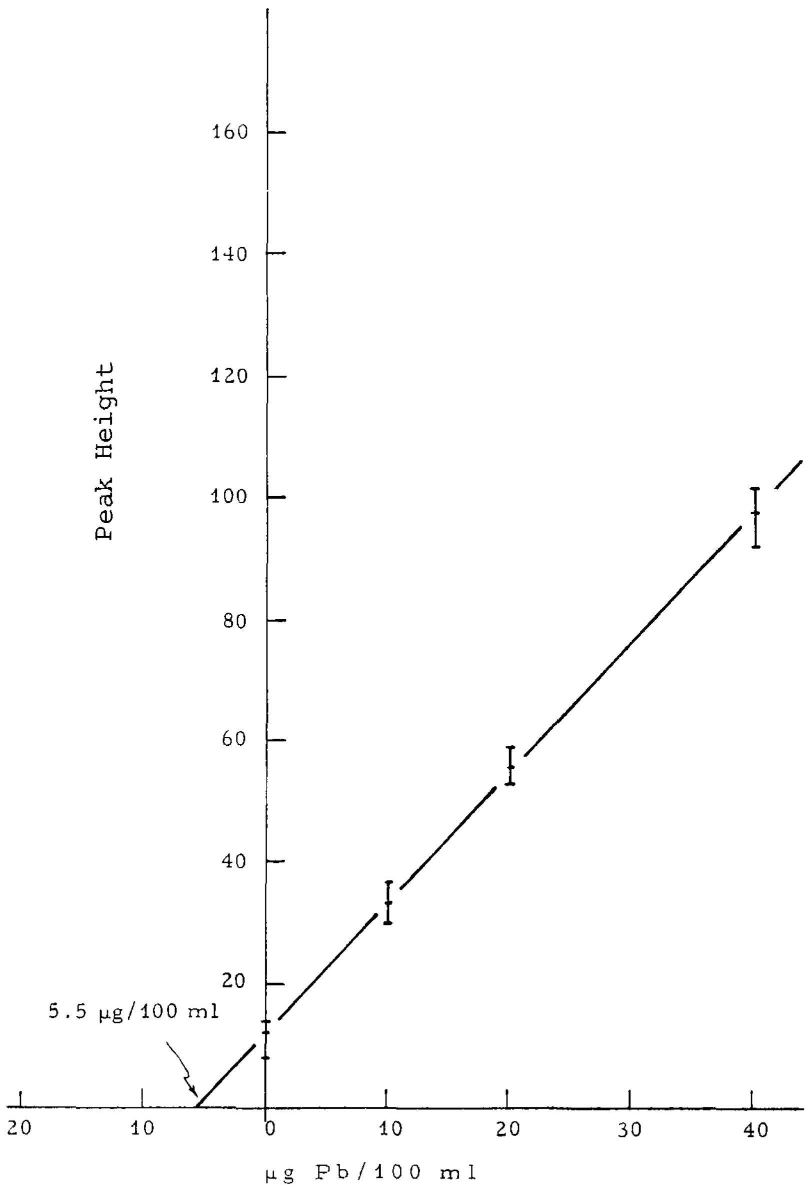
The sample was shaken to mix the reagents and then allowed to stand 10 to 15 minutes to ensure complete hemolysis of the blood. To extract the chelated Pb, 500μl of methyl isobutyl ketone (Eastman Kodak, Rochester, N.Y.) was added and the sample vigorously shaken for 5 minutes. The sample was centrifuged for 10 minutes at 2500 RPM and the organic layer removed for Pb determination by graphite furnace AAS.

Venous blood-Pb concentrations were determined by the "method of additions" using human blood (purchased from local blood bank) spiked at 3 or 4 different levels with Pb standards. From these spiked samples, an analytical curve was calculated on a Hewlett-Packard 9810A programmable calculator using a least-squares regression program to obtain the best fit to the data points. Figure 28 represents typical analytical curves for venous blood.

The unknown blood samples' Pb concentrations were determined using the slope of the analytical curve and the peak height of the sample less the peak height of the reagent blank. After every 15 to 20 samples were analyzed, a series of the spiked blood standards was analyzed to allow a continuous upgrading of the analytical curve.

Daily quality controls for the venous blood samples were the spiked human blood used to establish the analytical curve for Pb quantitation. The Pb concentration of this human blood used for quality controls was verified against CDC bovine blood samples of known Pb content.

Figure 28. Analytical Curve for Lead in Venous Blood



In summary, the extraction procedure used for Pb determinations in venous blood is relatively simple procedure that requires a minimum quantity of blood and because it is an extraction procedure avoids many of the matrix interferences commonly associated with blood-Pb analysis. The procedural steps are kept to a minimum thereby avoiding contamination and improving the accuracy and precision of the data.

It is important that the same anticongulant is used on both the blood spiking standards and the unknown blood samples. Blood samples which contain EDTA as the anticoagulant give lower blood-Pb values than blood samples preserved with sodium heparin. The reason for the lower results with EDTA could be the ability of the Pb to form complexes with the EDTA which would be more favored than the pyrollidinedithiocarbamate complex used to extract the Pb.

It is important to match the kind (species) of blood being analyzed for Pb with the spiked blood used to quantitate it. Extraction of bovine blood and human blood showed a matrix effect which was not compensated for by the extraction process.

The conditions which are used to preserve the whole blood samples until they are analyzed can affect the blood-Pb data. The studies performed to determine the best method of handling blood once it was collected until it was analyzed indicated that refrigeration (40^{o}C) will maintain the blood in a condition acceptable for blood-Pb analysis up to 20 days. The variation between duplicate blood samples collected from the same individual over a two-week period will also give information as to the effectiveness of the preservation technique and the analytical methodology used. A large variation between duplicates could be one indication that the preservation method is not adequate since the normal blood-Pb values would not be expected to vary over a very wide range within a short period of time. Microclotting of the whole blood caused by inadequate preservation techniques, would give highly variable results both on individual samples and on duplicates. There were no significant differences between the duplicate venous blood-Pb values for the subjects in this study.

The studies undertaken prior to collection and analyzing blood from the study participants helped to eliminate some variables which might have otherwise confounded the blood-Pb data and made it more difficult to interpret.

(2) Capillary Blood

Development of Analytical Methodology

Previous studies involving blood collection from young children indicated an alternate, less traumatic procedure should be available in those instances where child and/or parent object to venous blood being taken.

There are a number of screening methods based upon taking capillary blood by finger-prick and analyzing by a microanalytical technique using AAS.[19-22]

These methods have generally been for screening purposes where blood-Pb concentrations below 40 μg/100ml were not quantitated. Our purpose was to adapt one of these micro-techniques to analyze blood with Pb concentration less than 30 μg/100ml.

After considering the different techniques available for collecting the capillary blood for Pb analysis, we decided the 100 μl capillary tubes would provide the best method considering the field-sampling and shipping conditions they would be exposed to. Precalibrated capillary tubes are now made specifically for blood-Pb determinations, i.e., minimal Pb contamination.

The original methodology development involved diluting the blood to 2.5 ml rather than to 5.0ml. This dilution was not sufficient to reduce the matrix effect caused by the blood. At this dilution the background corrector (D_2arc) could not compensate for all the matrix interferences present when the sample was atomized in the graphite furnace. Increasing the ashing temperature to remove more of the matrix effect resulted in losses of Pb.

Increasing the dilution to 5ml improved the data but there were still some matrix effects not being corrected. At this point a chemical solution was tried since the instrument parameters (ashing temperature, time, etc.) had reached their maximum effect. A

"Keeper" element was introduced into the furnace with the sample to retain the Pb at the higher ashing temperatures of the furnace. A 10μl injection of a 50ppm Ni solution placed on top of the sample injection allowed ashing temperature of 600°C to 650°C without losses of Pb. This effectively removed all matrix effects.

Since the capillary blood samples would be taken by laboratory technicians without direct supervision and under conditions unfamiliar to the technician, the possibility of collecting more or less than the 100 μl was considered.

By using the diameter of the capillary tube and measuring the length of blood collected, the volume of blood in the capillary tube could be determined. To determine if this was a valid assumption, capillary tubes were fitted to various size Eppendorf pipets using a modified pipet tip. Known quantities of CDC blood were drawn into the capillaries. The length of the blood in the capillaries was measured and the blood was then analyzed by the capillary blood procedure. Table 6 gives the results of this study. The variation due to calculating the blood volume ranged from 1.2% to -14.3%. Most of the blood-Pb values determined by calculating the volume of blood were less than the CDC Reference Laboratories value for the blood. All were within the ±15% variation from the mean value 54.5 μg/100 ml).

Table 6. Determining Blood Volume in Capillary Tube by Indirect Measurement

Sample ID	Measured Volume µl	Length of Blood, mm	Calculated Volume, µl	Pb-Conc. in Blood µg/100 ml	% Difference from Extract Blood Value
80-1	80	47.0	78.6823	51.96	
80-2	80	47.5	79.5194	53.55	
80-S				52.75	-3.2%
90-1	90	53.5	89.5639	58.01	
90-2	90	53.5	89.5639	52.30	
90-S				55.15	+1.2%
95-1	95	57.0	95.4232	47.30	
95-2	95	57.0	95.4232	46.41	
95-S				46.86	-14.0%
100-1	100	59.0	98.7714	46.56	
100-2	100	58.5	97.9344	46.96	
100-S				46.70	-14.3%
110-1	110	65.5	109.653	50.49	
110-2	110	66.0	110.490	47.79	
110-S				49.14	-9.8%
120-1	120	71.5	119.698	49.10	
120-2	120	71.0	118.861	52.07	
120-S				50.88	-6.6%
	Total		Mean	50.25	-7.8%
			SD	3.35	
			CV %	6.7%	

As a precaution, all capillary blood samples were measured and the length of blood recorded prior to analysis. Calculation of the blood-Pb values using the measured volume and 100 µl did not change any of the data significantly.

Variations in the instrument parameters were determined to be a serious problem. The degrading of the graphite tube seemed to be a constantly changing parameter that would affect the blood-Pb data if not compensated for. Analyzing spiked blood standards and CDC bovine blood routinely with every 5 to 10 capillary blood samples eliminated this problem. Table 7 summarizes the results of the CDC bovine blood analyzed as quality control over a period of 8 consecutive days.

Table 7. CDC Bovine Blood as Quality Control for Capillary Blood-Pb Analysis

Number Days	Blood-Pb μg/100ml
0	43.5
1	44.5
2	47.0
3	45.8
4	39.9
5	54.4
6	49.1
7	44.8
mean	46.1
st.dev.	4.3
RSD	9.3%

Analysis Procedures

Capillary blood taken by the finger-prick technique was refrigerated from the time of collection until Pb analyses were performed in the laboratory. At least one and in some cases two of the extra blood capillary-tube samples were frozen for later Pb determination if the necessary information could not be obtained from the capillary tube analyzed immediately upon receipt at the laboratory.

Lead analysis of the capillary blood samples was performed by a procedure similar to that of Norral and Butler[23] using the graphite furnace technique (AAS) to improve sensitivity. The micro-capillary tube containing the blood sample was fitted to a modified pipet tip attached to a 200-µl Eppendorf pipet (Brinkman Instruments, Inc., Westbury, N. Y.). The blood was expelled from the microcapillary tube by slowly depressing the pipet plunger. This blood was expelled into a 5-ml volumetric flask containing 1.0 ml of 0.02% Triton X-100 solution. The tip of the microcapillary tube was placed below the surface of the X-100 solution while ejecting the blood sample. Then, approximately 100 to 150 µl of the X-100 was drawn into the capillary tube several times to rinse all the blood into the vial. Deionized water was used to make the volume to 5ml and the sample was thoroughly mixed.

Lead determination was made on this diluted blood sample by injecting 20 μl into a preprogrammed graphite tube furnace (IL 455 model) AAS, followed by 10μl of 50ppm Ni as described earlier.

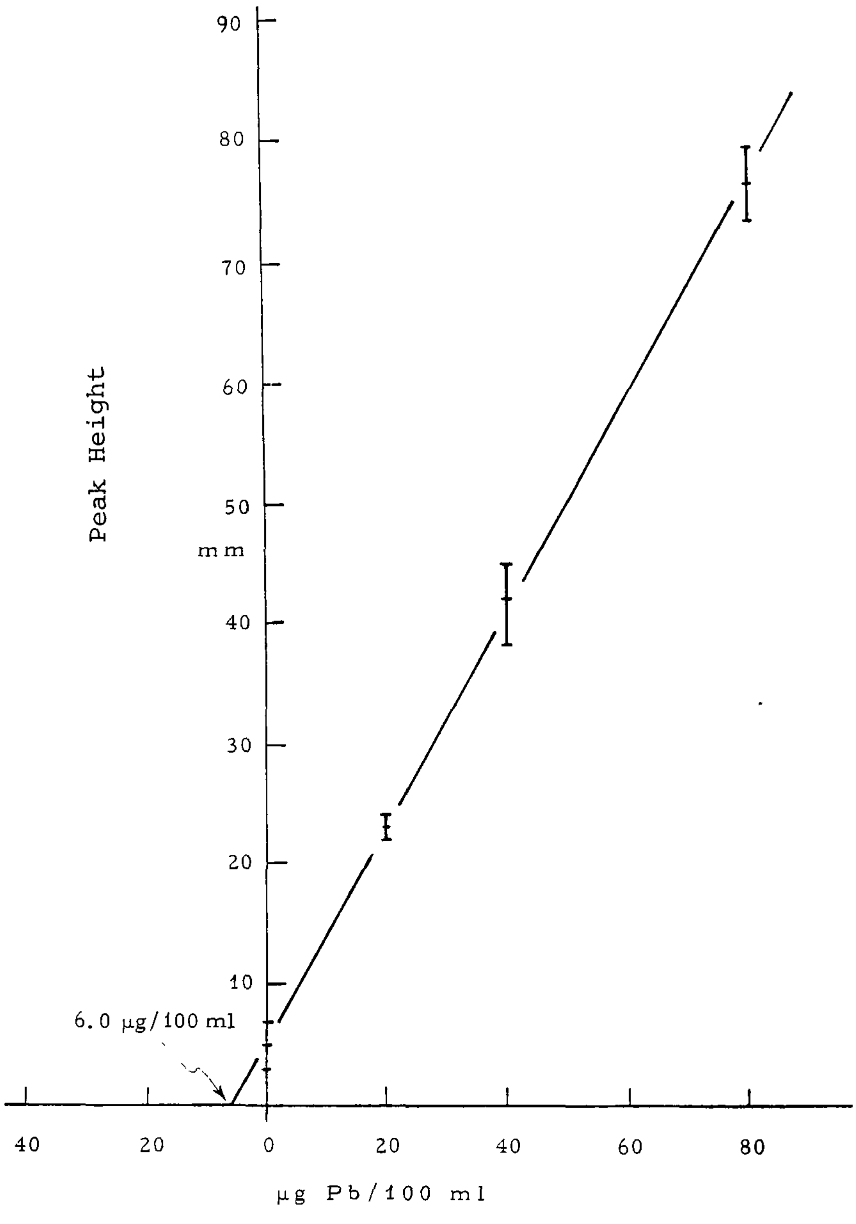
Quantitation of the capillary blood followed the same "method of additions" procedure outlined above for venous blood. Figure 29 represents a typical analytical curve plotted out.

For capillary blood, the daily quality controls were the spiked human blood used for quantitation of the samples. This human blood's Pb content was established by comparison with CDC bovine blood-Pb samples of known Pb concentration.

In summary, adapting a finger-prick blood sampling procedure to quantitate blood-Pb in a non-exposed population is subject to many hazards because of the quantity of blood available to work with. The extremely small volume (100 μl) of blood makes this methodology more susceptible to contamination since the Pb levels analyzed are in the ppb range. Due to the absolute Pb concentration analyzed and the increased possibility of contamination, the data will be more variable than the venous blood procedure.

Using the very sensitive graphite furnace AAS technique has allowed this micro method of blood-Pb analysis to succeed. Increases in the sophistication of the commercially available heated graphite furnace units

Figure 29. Analytical Curve for Lead in Capillary Blood



has moved the finger-prick method of blood-Pb analysis from a semiquantitative procedure to a fully quantitative one. This is important in that recent evidence indicates children may suffer from subacute Pb intoxication and not have a blood-Pb level high enough to measure accurately by the standard screening techniques. For these children it is critical to have a quantitative measure of their blood-Pb concentrations which can be used to evaluate their treatment programs. Since most clinical laboratories are now equipped with AAS, this makes the finger-prick technique a rapid and economical means of monitoring these children.

Also for epidemiological studies involving a blood-Pb monitoring the micromethod of analyzing capillary blood is both economical and provides better data with less trauma to the subjects being monitored.

Because commercial instrumentation has developed to where ppb and ppt levels of metals can be quantitated the general approach has been to dilute the sample to where matrix effects are not a problem. This requires very careful collection techniques in taking blood and also in preparing the sample to prevent excessive amounts of contamination. Recently, chemical methods have become popular in reducing these matrix effects to avoid the hazards associated with trying to analyze diluted samples in the ppt range.

Studies using 50 ppm Ni solution along with the sample aliquot in the graphite furnace have illustrated the feasibility of this technique to retain Pb while higher ashing temperature are used to remove matrix interferences.

Calculating the volume of blood by actually measuring the length of blood in the capillary tube provides a means of compensating for the collection problem which may be encountered under field conditions. Studies indicate this will provide accurate results even when the actual quantity of blood taken is more or less than 100µl.

(3) Hematocrits

Hematocrits were determined on all blood samples at the time of collection (see Sample Collection). Only one of the two 10ml vacutainers containing venous blood was opened so an aliquot of blood could be taken for hematocrit determination. This vacutainer was marked so it would not be used for the initial blood-Pb determination at the laboratory. It was retained (frozen) as a reserve sample.

A Clay-Adams hematocrit centrifuge was used to spin the collected capillary blood tubes and to measure their hematocrit value.

(4) Free Erythrocyte Protoporphyrin

Blood samples from each participant were analyzed for Free Erythrocyte Protoporphyrin (FEP). The method used was based on that described by Piomelli.[24][25]

Blood that was collected from the participants was analyzed for FEP the day after collection. The blood was allowed to come to room temperature before pipeting 20µl into an acid-washed test tube. While the tube was agitated on a Vortex mixer, 50µl of a 5% celite in 0.9% saline solution was added. Two milliliters of a 4:1 ethyl acetate:acetic acid mixture was added and the tube agitated for 10 seconds. Following centrifugation at 2500 RPM for 5 minutes, the supernatant was decanted into a clean cuvette. To the supernatant, 4 ml of 1.5N HCl was added, agitated, and then allowed to stand in a dark area for 30 minutes. This allowed the HCl/ethyl acetate interface to develop. The ethyl acetate layer was then aspirated with care so that none of the HCl layer was removed. The sample was then read in a filter fluorometer (Turner Model 430) with the excitation wave-length set at 405 mµ and the emission wavelength at 610 mµ.

Preparation of a standard curve for each run was based on the method of standard addition. One participant s sample from each day's run was selected and used for spiking. Triplicates of 20 µl of blood were pipetted into five sets of test tubes. These represented samples with no spike added (the blank) and samples to which 50, 100, 150 and 200 µl of a 1 µg/ml coproporphyrin I standard were added. The spiking solution was added to the blood already in the tube as it was agitated. The tubes were covered and set aside for 1 hour. After this setting time, 50 μl of the celite solution was added. The blank and standards were then extracted and analyzed along with the blood samples for that day. The amount of FEP in the samples was computed based on the factor obtained from the least squares method, then corrected for the hematocrit of the sample and reported as μg FEP/100 ml RBC.

The source for spiking the blood was coproporphyrin I obtained from Sigma Chemical (COP-I-5). To preweighed vials with 5 μg/vial, 5 ml of 1.5N HCl was added and then placed in a boiling water bath for 5 minutes. The vial was removed from the bath and then placed in a light-tight box to cool to room temperature. The light-sensitive contents were withdrawn as quickly as possible and the remaining portion returned to the darkened area.

In addition to the other reagents used, which had the highest purity obtainable, the ethyl acetate used in this procedure was cleaned prior to use. Approximately 500 ml of ethyl acetate was poured into a separatory funnel. To this approximately 200 ml of a 10 N NaOH solution was added and the two mixtures shaken for about 5 minutes. The NaOH was decanted and two deionized water washes followed. The cleaned ethyl acetate was then stored in an acid washed brown bottle until used.

(5) Carbon Monoxide in the Blood

The determination of carbon monoxide in the blood was performed based on a modification of the method reported by Collison, et al.[26] Carbon monoxide was released from the blood sample by the addition of sterox and potassium ferricyanide into a sample loop previously purged with helium carrier gas. The released gases were then swept onto a molecular sieve column and the separated CO was then detected by gas chromatography.

(6) CDC Blood-Lead Proficiency Testing Program

Our laboratory began participating in this evaluation program to verify the accuracy of the blood-lead extraction procedure (venous blood) used on this study.

Each month, 3 bovine blood samples were received in our laboratory from CDC in Atlanta, Georgia. The blood samples were to contain a low, high, and medium concentration of Pb obtained from cows fed various quantities of lead acetate with their feed. The medium Pb concentration of these samples was to be approximately 40 μg Pb/100 ml but this was actually closer to the average low concentration. The Pb concentrations of the blood were to be determined and reported by seven reference laboratories. Other laboratories participating in the program would try to come within ±15% of the reference laboratories' reported mean Pb concentrations of each sample. Monthly reports were issued summarizing the results of reference laboratories and participating laboratories.

All CDC bovine blood samples were analyzed for Pb using the procedure outlined earlier for venous blood and capillary blood samples.

These bovine blood samples were used to calibrate the spiked blood used daily to quantitate the venous blood samples (see venous blood analysis). Also the capillary blood samples (finger-pricks) were quantitated against these reference blood samples on a daily basis (see capillary blood analysis).

4. Statistical Procedures

The statistical procedure was to characterize the environment with respect to airborne lead in residential areas with traffic densities from less than 1000 to greater than 25,000 cars per day, and also to characterize and compare differences, if any, in blood lead levels among people who live on these streets. The environmental parameters that were measured for lead were air, soil, indoor and outdoor dust, windowsill wipes, and hand-wipes. Lead in tap water and house paint was also measured and used as a screening variable. The effects of traffic density, distance from street, intersections, particle size, speed limits and shorter collection times were also considered.

In general, the blood and environmental variables were tested either for differences among traffic sites using analysis of variance (ANOVA) or for a relationship with individual traffic counts using regression analysis or, in some cases, using both methods. When ANOVA was used, the variables were assigned to one of four traffic density sites: <1,000 (site 1); 1,000-13,500 (site 2); 13,500-19,500 (site 3); and >19,500 cars/day (site 4). These traffic classes were slightly modified from the more general classes discussed earlier to conform to natural grouping in the traffic counts. Histograms were made for each variable and transformations were applied if needed to meet the assumptions for the ANOVA. In all cases which were transformed, base 10 logarithms were used. When the assumptions could not be met, nonparametric tests were substituted. The same methods were applied in the smaller studies using t-tests, paired t-tests, and two-way ANOVA or their nonparametric analogues.

Regression analysis was used to define the relationship of some variables to actual traffic counts over the range <1,000 to >25,000 cars/day. Two procedures were used in interpretation of the regression analyses: scatter plots were examined and R^2 (the amount of variation in the dependent variable explained by the regression) was evaluated. Scatter plots of X and Y variables and residuals were generated in each analysis and were examined for non-linear relationships or possible transformations to improve the fit. When no transformations were suggested by the data, and R^2 was very small, further interpretation of the regression equation and the significance of the regression coefficient was not attempted.

The two blood lead measurements from each participant were handled in two ways. For the ANOVA, the duplicate measurements were arranged in a two-way mixed model design with Samples 1 and 2 as random effects and the four traffic densities as fixed effects. Variation between Samples 1 and 2 was then evaluated for bias in every sampling group and accurate estimates of the variances at each level could be obtained. The advantage of this method is that the alternative (averaging the two blood samples) significantly depressed the sample variance ($P < 0.001$). For the regression analyses, however, the intuitively correct approached is to pair a blood lead value for an individual with the traffic count at his residence; therefore, the average blood lead for each individual was used.

The raw data for all variables are listed in the appendices (D-I) or included in the text space (for the smaller studies). Zeros were used when no measurable lead could be detected. Blanks were used when no data was collected.

5. Participant Recruitment

a. General Approach

Volunteer participants who met a set of age, occupation, race, sex, and residence requirements were required for successful conduction of this study. The general approach to participant recruitment in this study was through use of a house-to-house survey in which volunteer participants were recruited. A household survey form was designed for use in the survey which solicited information regarding health and other characteristics of households along the selected streets. The household health questionnaire also served to determine if one or more members of a candidate household were eligible for inclusion in the study as volunteers.

To obtain background information on persons determined to be eligible for the study, a second portion of the household survey form was designed. With this individual questionnaire, information regarding pertinent characteristics of the individual was obtained for later use in selecting study participants from those individuals volunteering for the study and completing an individual questionnaire.

The household surveys, including administration of the individual questionnaires, were performed by survey workers going house-to-house along streets selected for study by the project team. The procedure incorporated at each doorway included the following:

- approach doorway of house, ring doorbell or knock
- survey worker introduces self and explains survey
- concept of a public health survey regarding traffic-produced lead is stressed
- permission to administer household survey is determined
- household questionnaire is administered
- eligibility of members of household is determined
- if no member is eligible, survey worker thanks resident for information
- if one or more member is eligible, survey worker determines if any would offer their services as paid volunteers and explains payment for biological samples
- individual questionnaire is administered to persons who volunteer
- volunteers are told they will be notified, if selected, and arrangements will be made for sample collection
- volunteer families are provided copy of information sheet on study (shown in Figure 30).
- survey worker thanks resident for information

Figure 30.

GENERAL INFORMATION FOR PARTICIPANTS OF
TRAFFIC LEAD PUBLIC HEALTH SURVEY

This public health survey is being conducted by Southwest Research Institute for the Environmental Protection Agency. The object of this survey is to determine if residents living near heavily trafficked streets are exposed to undue amounts of lead. The health survey will be conducted in three stages. The first is a house-to-house survey of selected residences, using a questionnaire form approved by the EPA and specifically designed for use on this study. The second stage involves collection of water, soil, and dust samples from residences and blood samples from individuals who volunteer to participate in the survey. All participants who provide samples to the study will be paid $25 for their services. In the third stage, air samples will be taken in the vicinity of residences and traffic will be counted.

As a volunteer paid participant, the following samples will be collected:

From Residence	From Participant
Soil sample(one cup)	Questionnaire form
Water sample(one cup)	Consent form
Dust sample (window sill wipe)	Handwipe from children
Dust sample(small tray)	Two blood samples
Examination of surface inside and outside of house for lead	-One week apart
	-Venipuncture for adults
	-Finger prick for small children

Each Participant will receive:

(1) Results of screening for lead in paint surfaces of their residence
(2) Summary of results of the overall survey
(3) Direct information if any abnormal blood lead levels are indicated in the participant
(4) $25 paid to each participant for their help

Schedule of Activities

(1) You will receive a letter to notify you of your selection as a participant

(2) You will be called to confirm your selection and to schedule a visit of the study team

(3) The study team will visit your home three times to collect samples and to pay you for your participation

(4) You will receive a letter indicating study results and thanking you for your help in this important study.

b. Eligibility Requirements

Participant eligibility requirements may be summarized as follows:

- persons who live in residences on streets selected for study

- residence at address for 6 months or more
- normal occupation does not take individual away from residence
- preschool children (males & females-toddler or older) females who work at home (ages 20-49) older persons (males & females-ages 50+)

In addition, only persons who are white, non-Spanish, were to be selected as participants in the study. To optimize the recruitment efforts required to solicit participants meeting all requirements, streets were selected for use in this study which census data indicate are 70% or more white, non-Spanish. In the recruitment activities, no effort was made at the survey worker level to bias the number of volunteers racially, i.e. all races were accepted as eligible volunteers. Only persons meeting all requirements, including race, were later selected as participants for collection of biological samples.

The distinction regarding persons eligible, volunteers, and participants should be noted at this time. Persons are regarded as eligible for the study if study criteria regarding age, occupation, sex, ethnic background, and residence are met. Eligible persons who volunteer are termed volunteers. From those who volunteered, a set of participants was selected and biological samples were collected from these participants. In the study recruitment activities, volunteers were sought without reference to the ethnic requirement (white, non-Spanish); i.e. persons of all races were recruited as volunteers. From those who volunteered, only persons who met all requirements, including ethnic, were selected as participants. Participants who delivered all required biological samples to the study team were each given $25 as compensation. The $25 is intended as partial compensation for the services these participants provided to the public health survey. This compensation provides an additional incentive for persons who would be interested in serving the study, but who otherwise might "let his neighbor" be bothered with giving blood samples and other samples.

c. First Stage of Household Surveys

In the first stage of survey activities, 20 survey workers were hired, trained, and released to perform surveys. The assignment for each worker consisted of a designated street (or streets) between two specified intersections. The worker was provided with an estimate of the number of qualified residences in his assignment and he was given strict criteria for the residences qualified for survey:

- single family dwellings or duplexes
- within 100 feet of roadway
- no houses within 100 yards of traffic signal or stop sign
- no corner houses
- only houses which face roadway.

The design criteria for this study was based on a compensation of $15 to participants selected for sample collection. As per the design criteria, the survey workers made this offer to eligible persons in their efforts to recruit them as volunteers.

After completion of nearly 1,000 household surveys, it became apparent that the design estimate of one participant for every two households was incorrect. The actual results were closer to one qualified participant for every four households. Examination of the possible alternatives indicated that a second stage of survey activities would be required, and that some changes in techniques would be necessary if the survey was to be a success insofar as recruitment of volunteers was concerned.

d. Second Stage of Household Surveys

A second stage of survey activities was designed to increase the success rate of volunteer recruitment. For the higher traffic density levels, an immediate problem was seen: most of the available residences in Sites 3 and 4 had been surveyed in the first stage of activities. In order to perform additional surveys, additional qualified residences would be required. To this purpose, it was proposed that the restrictions regarding usage of corner houses and only houses facing the main roadways be lifted. The Project Officer agreed to the lifting of these restrictions and thereby provided a significant new set of residences qualified for survey in Sites 3 and 4.

Because the percentage of volunteers per those eligible was viewed to be lower than expected in the first stage of recruitment activities, additional incentives were introduced for both the survey worker and the candidate volunteers. The amount paid to each survey worker in the stage two activities was raised to $5.00 for each complete participant form delivered to the coordinator. Additionally, the amount offered to the volunteer for compensation (if selected as a participant) was raised from the design value of $15 to the amount of $25 for each study participant providing a complete set of samples for the study.

The method of assignment of survey areas to each survey worker was also changed. A complete list of addresses of qualified residences was compiled by driving through all remaining candidate areas. Each survey worker was given a specific set of approximately 60 addresses of qualified residences. Fifteen survey workers were recruited and trained for the second set of survey activities and were each given the assignment of 60 addresses. The necessity for recruitment of preschool children was stressed to the workers since the first stage of survey activities had failed in this one group. When qualified preschoolers were determined to be present at a residence, the survey workers were asked to be particularly persuasive in recruiting that family as volunteers.

Two additional techniques were introduced in the second stage of survey activities to increase the success rate regarding recruitment of volunteers. A letter designed to introduce the survey worker was placed in the doorway of residences on a day preceding the actual surveying of the household. A copy of the letter, signed by the Project Director, is shown in Figure 31. Analysis of reactions to the household survey form revealed negative feelings regarding whether or not anyone was at home during daytime hours, as though they were worried about potential theft. Due to this noticed uneasiness regarding the form, the sequencing of questions was rearranged so that Questions 2 and 3 regarding routine of spending time at home or away from home were asked later in the interview. Also, a brief set of opinion questions were introduced in a sampling of cases to determine if these could soften the questionnaire and generate more response in those being interviewed. Questions on the sample opinion survey included the following:

1. Have you received a letter recently informing you about a public health survey?
2. Are you concerned about air pollution in your neighborhood?
3. Are you aware that automobile exhaust often contains lead?

Figure 31. LETTER OF INTRODUCTION

SOUTHWEST RESEARCH INSTITUTE

8500 CULEBRA ROAD • POST OFFICE DRAWER 28510 • SAN ANTONIO TEXAS 78284

May 17, 1976

As you may know, the Environmental Protection Agency is conducting a public health survey in the Dallas Metro Area. This survey is being performed by Southwest Research Institute with the help of the Center for Urban and Environmental Studies at SMU. The subject of the survey is air pollution resulting from automobile traffic. As you are probably aware, automobile exhaust often contains lead. The object of the study is to determine if undue amounts of lead are present in residents living near heavily trafficked streets.

We need your help to accomplish this survey. A member of our survey team will be contacting you in the next few days to ask you a few questions about air pollution in your neighborhood and to discuss our health study.

Interested persons can participate as paid volunteers to aid the study. Each participant will be paid $25 for providing blood samples and samples of water, soil, and dust from their homes. In addition, air in the vicinity of participating homes will be sampled and analyzed for the presence of pollutants.

Please remember that public health surveys can only be accomplished with the help of interested citizens such as yourself. You can help us determine the pollution level in your neighborhood. Our interviewer will be contacting you in a few days. If you would like to contact us, call Linda Johnson at SMU, 692-2532.

Sincerely,

Donald E Johnson

Dr. Donald E. Johnson

cr

SAN ANTONIO, HOUSTON, CORPUS CHRISTI, TEXAS, AND WASHINGTON, D.C

4. Which of the following places do you consider air pollution to be more of a problem for you and your family:

   a) In the vicinity of your home?
   b) Away from your home, i.e., work, while shopping, driving, etc.?

5. For which age group do you consider air pollution to be more of a problem:

   a) Children?
   b) Adults?
   c) Older?

The sample opinion surveys were introduced at the beginning of the survey for approximately 200 residences. The acceptance rate of the survey workers was viewed to be much higher by the survey workers involved with the sample opinion survey. Results of the sample survey are shown in Table 8.

Table 8. Sample Opinion Survey re Air Pollution Concern

			% Total
1.	Received Letter:	Yes	71
		No	29
2.	Concerned:	Yes	76
		No	24
3.	Aware of Lead:	Yes	93
		No	7
4.	More Problem:	Home	48
		Away	52
5.	Problem Group:	Children	44
		Adults	14
		Older	42

Survey activities were continued by repeatedly going into areas already surveyed to work the few residences not reached during earlier rounds. The survey activities were terminated when the resulting number of qualified participants was approximately equal to the redefined criteria of 40 participants per category.

e. Informed Consent

The use of individuals as participants in a public health study such as that described here requires the complete disclosure of information regarding the objective of the study, the use of individuals for provision of study samples, and any risks or potential of harm, if any, to the individuals as a result of their participation in the study. An Informed Consent form was specially designed for use in the study and is present in Figure 32.

During the initial visit to the residence of each participant, the details of the study and any risks to the participant were explained. The Informed Consent form was provided and a signature was obtained before initiation of sample collection.

Figure 32. Volunteer's Informal Consent

SOUTHWEST RESEARCH INSTITUTE

8500 CULEBRA ROAD SAN ANTONIO, TEXAS 78228

VOLUNTEER'S INFORMED CONSENT

I, ____
residing at ______________________________________
____
hereby acknowledge and certify to the following:

1. That I hereby volunteer and consent to participate as a human test subject in an experiment identified as 'Epidemiologic Study of the Effects of Exposure to Automobile Traffic on the Blood Lead Levels of Persons in Selected Age Groups' which is designed to determine the extent of exposure to environmental pollutants.

2. That I have been given, in my opinion, an adequate explanation of the nature, duration and purpose of the experiment, the means by which the experiment will be conducted and any possible inconveniences, hazards, discomforts, risks, and adverse effects on my health which could result from my participation therein;

3. That I have been informed of all appropriate alternative procedures, if any exist, that might be advantageous to me;

4. That I understand my questions concerning procedures which affect me will be answered fully and promptly;

5. That I understand that I have the right to withdraw my consent and to discontinue participation in this experiment at any time without prejudice regardless of the status of the experiment and regardless of the effect of such withdrawal on the objectives and results which the experiment is designed to achieve; and I also understand that my participation in the experiment may be terminated at any time by the investigator in charge of the project or the physician supervising the project regardless of my wishes to the matter;

6. That I hereby understand and agree that the samples collected from me will be analyzed for lead, FEP, hematocrit and carbon monoxide and that these are the only tests that will be made on these samples and that no medicinal compounds will be analyzed.

SRI

over...

Figure 32. Volunteer's Informed Consent (cont'd)

7. That I attained the age of ________ years on my last birthday which was ____, and that I am executing this Volunteer's Informed Consent as my free act and deed.

Executed ________________________________, 19_____.

____
Volunteer

____
Signature of Person Informing Volunteer and Obtaining Volunteer's Consent

Executed in the presence of:

____
Signature of Witness

(If volunteer is a minor, parent or guardian must complete the following.)

On behalf of ____, I hereby
(insert volunteer's name)
consent to and approve his/her executing the foregoing consent and participating in the above-identified experiment as a human test subject.

____
Signature of Parent/Guardian

Date: ____________________________

Executed in the presence of:

____
Signature of Witness

III. RESULTS

A. Determination of the Relationship Between Air Lead Levels and Traffic Flow Characteristics

1. Results of Traffic Density Mini-study

The objective of this study was to examine the relationship of air lead to traffic counts. Air lead was measured concurrently with traffic counts for several 24-hour periods at each of 17 locations. These locations were selected to cover the range of less than 1,000 to greater than 25,000 cars per day. The air lead concentrations and traffic counts obtained are presented in Table 9. For purposes of comparison and analysis, the data are also grouped into four traffic densities and the mean, standard error (SE), and number of days of observation (sample size) are shown.

Table 9. Mean Air Lead Concentrations and Traffic Counts at each Location and Traffic Density.

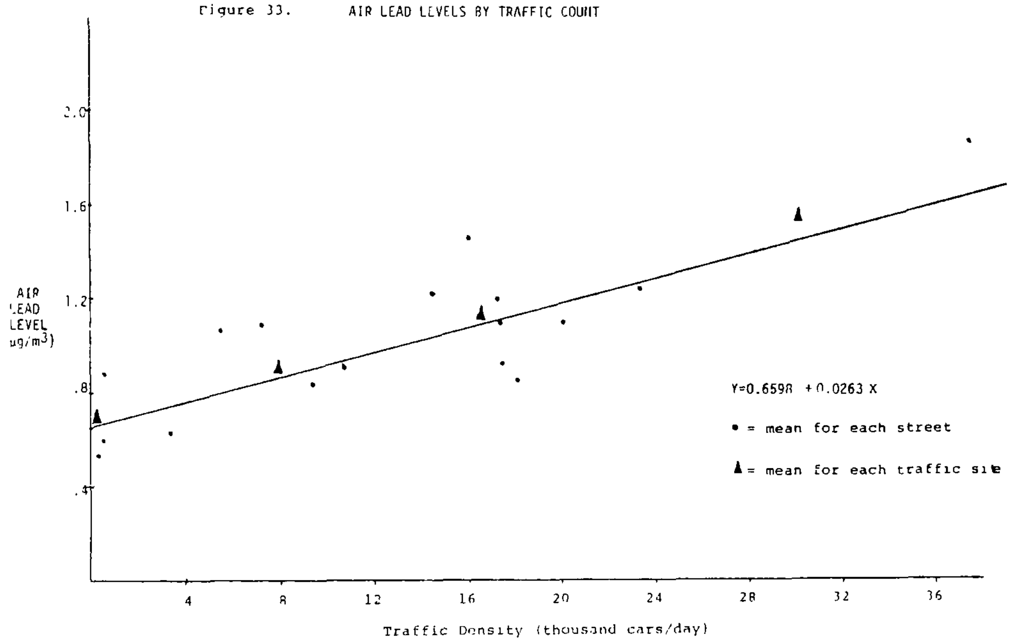
Location	Air Pb Mean ± SE**	Traffic Mean ± SE	Days N		Air Pb Mean ± SE	Mean Traffic Level
Myrtice	0.53 ± 0.073	117 ± 7	10			
Costa Mesa	0.60 ± 0.099	316 ± 4	7	Site 1*	0.67 ± 0.059	254
Mimosa	0.89 ± 0.103	371 ± 10	8			
Barnes Bridge	0.63 ± 0.097	3,578 ± 257	9			
Bluffview	1.07 0.131	5,246 ± 516	7			
Midway Hills	1.09 ± 0.109	7,129 ± 295	7	Site 2	0.89 ± 0.058	7,782
Prairie Creek	0.83 ± 0.145	9,340 ± 433	8			
Oates	0.91 ± 0.110	10,761 ± 509	16			
Inwood	1.21 ± 0.114	14,480 ± 1245	11			
Lovers Lane	1.48	16,128	1			
Mockingbird	1.20 ± 0.130	17,042 ± 1182	8			
Royal	1.10 ± 0.213	17,102 ± 1912	7	Site 3	1.07 ± 0.060	16,737
Forest	0.93 ± 0.104	17,740 ± 1014	9			
Jim Miller	0.85 ± 0.111	18,004 ± 343	9			
Marsh	1.10 ± 0.097	20,001 ± 841	10			
Coit	1.25 ± 0.313	23,311 ± 2175	6	Site 4	1.54 ± 0.148	30,085
N. W. Hwy.	1.86 ± 0.228	37,531 ± 1042	19			
				All Sites	1.06 ± 0.049	

Site 1 1,000 cars/day
Site 2 1,000 - 13,500 cars/day
Site 3 13,500 - 19,500 cars/day
Site 4 >19,500 cars/day

** Standard Error

The data for mean air lead vs mean traffic count for each location has been plotted and is shown in Figure 33. Over all sites, the mean air lead was 1.06 $\mu g/m^3$ and the mean traffic count was 17,330 cars per day. The mean air lead vs mean traffic density is also plotted for the four traffic density sites. An apparent relationship between traffic density and air lead is readily detected in Figure 33.

Figure 33. AIR LEAD LEVELS BY TRAFFIC COUNT



A total of 152 air lead measurements with corresponding traffic counts were taken and are listed in Appendix D. Using the method proposed by Mickey et al.,[27] outlier cases were tested with regression analysis. One outlier (4.93 µg/m³ - NW Hwy.) was rejected with the result that the variable air lead was normally distributed (with outlier included, skewness = 2.38, P = 0.02; without outlier, skewness = 1.20, P = 0.23). The frequency distribution of the variable air lead is given in Figure 34. Airlead

Figure 34. Frequency Distribution of the Variable Air Lead.

```
EXCLUDED
 VALUES
          ** (1)
            TABULATIONS AND COMPUTATIONS WHICH FOLLOW EXCLUDE VALUES LISTED ABOVE
MIDPOINTS
    2.850)
    2.700)
    2.550)
    2.400)**
    2.250)**
    2.100)**
    1.950)***
    1.800)***
    1.650)*********
    1.500)********
    1.350)**********
    1.200)**************
    1.050)M**************
    0.900)**************************
    0.750)****************
    0.600)******************
    0.450)************
    0.300)*******
    0.150)*
    0.000)*
   -0.150)
GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

 MEAN          1.014
S. DEV.        0.477
  N          150.000
MAXIMUM        2.430
MINIMUM        0.040
```

(1) The values 4.93 and 3.56 were excluded so that narrower class intervals could be used.

values were regressed on traffic counts with the result that 32.3% of the variation in air lead was explained. The regression equation given below was significant at $P = 1.2 \times 10^{-11}$.

$$Y = 0.6598 + 0.0263X$$

where

$$X = \text{24-hour traffic count}/1{,}000$$

and

$$Y = \text{air lead } (\mu g/m^3)$$

Examination of scatter plots of X and Y and residuals also indicated that the variable air lead was normally distributed and independent.

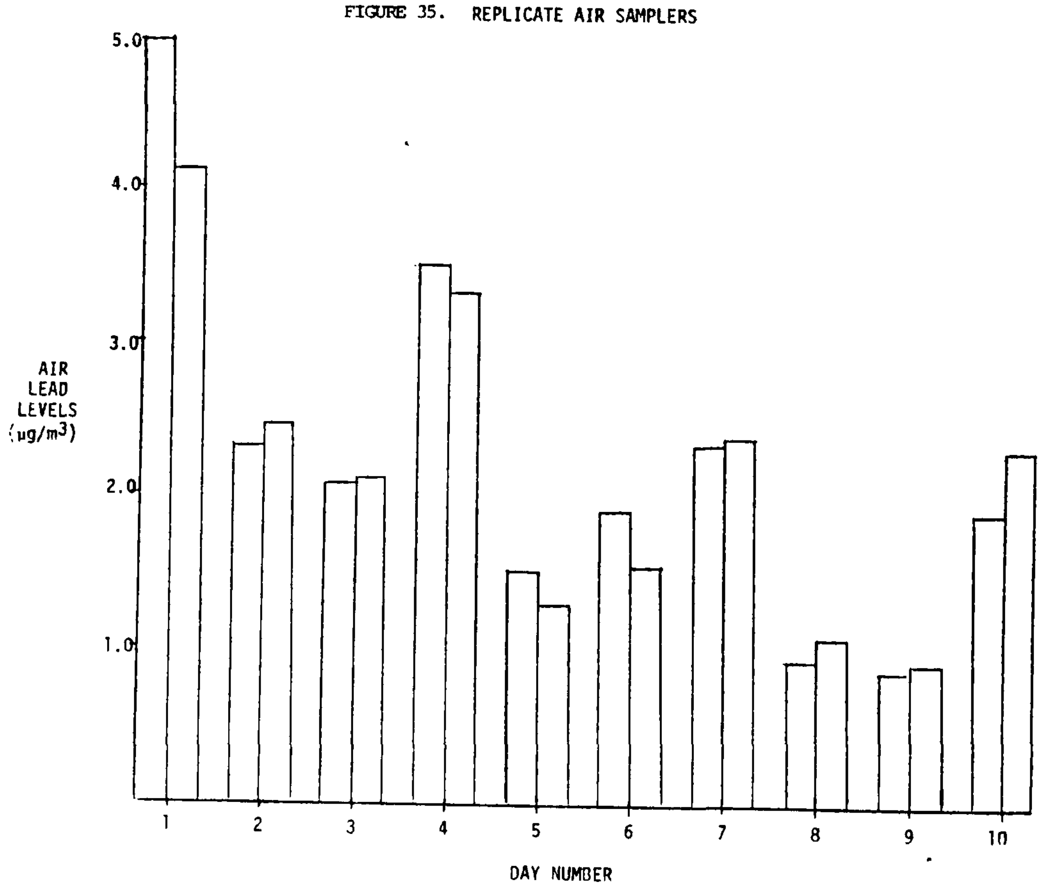
Further examination of the scatter diagrams indicated that most of the increase of Y(air lead) with X (traffic count) was in the 30,000 to 40,000 cars/day range. To verify this, air lead was regressed on traffic counts/1,000 with the highest location (NW Hwy.) omitted. This location included almost all of the traffic counts above 30,000 cars/day. The result was that only 15.1% of the variation in air lead was explained. The regression equation for air lead at these traffic densities was $Y = 0.7059 + 0.0214X$. There could be a nonlinear relationship, but the range of traffic counts prohibits its estimation (i.e., plots do not give any suggested transformation).

Conclusions: We conclude that on streets with traffic densities less than 25,000 cars/day, there is a small but significant relationship between air lead and traffic counts. Furthermore, as soon as traffic levels are increased to the range of 30,000 to 40,000 cars/day, the relationship improves markedly. The relationship is estimated by the equation $Y = 0.6598 + 0.263X$, where X is thousands of cars per day and Y is air lead, ($\mu g/m^3$).

2. Results of Replicate Hi-vol Mini-study

The objective of this study was to determine the reproducibility of air sampling data from replicate samples. For this purpose, replicate air samples were taken each day for 10 days at one location (NW Hwy) by placing two air samplers side by side for the 24-hour period. The lead concentrations of the 10 pairs of samples, their means, and standard errors are listed below. The air lead levels for the replicates on each day are shown in Figure 35.

FIGURE 35. REPLICATE AIR SAMPLERS



A paired comparisons t-test showed that there was no significant difference between lead concentrations in the two air samples taken each day ($t = 0.73$, $P = 0.48$); however, there was considerable variation over days for each air sampler. This can be explained by the fact that these samples include the outlier value (4.93 $\mu g/m^3$) discussed in the traffic density mini-study above. Means and standard errors were calculated omitting the outlier and its replicate with the result that the standard errors were similar to those in Table 13. The standard deviation divided by the mean or coefficient of variation (CV) which is a relative measure of variation was calculated for these two sets of samples as well as for the sixteen locations in Table 13 (one location had only one sample). The CV's ranged from 0.26 to 0.61 and these two samples had midrange CV values (0.41 and 0.43). Using a paired t-test the air samples from the remaining nine days were also not significantly different ($t = 0.13$, $P = 0.90$).

Air Lead ($\mu g/m^3$)

Air Sampler 1	Air Sampler 2
*4.93	4.11
2.33	2.42
2.06	2.09
3.56	3.35
1.51	1.26
1.91	1.55
2.32	2.38
0.93	1.09
0.82	0.92
1.89	2.30

Mean ± SE	2.23 ±0.388	2.15 ± 0.320
N	10	10
**Mean ±SE	1.93±0.262	1.93±0.274
	9	9

* = Outlier (P <<0.001)

** = Outlier excluded

3. Results of Particle Size Mini-study

The proportion of lead particles which are in the respirable range in suspended air lead at heights above the ground breathable by adults and children is important to the relationship between blood lead and an airborne lead source. It has been estimated that one-half to two-thirds of particulate lead emissions are in the respirable range (0.1 μ to 0.5 μ), [5] and that a density decline gradient in airborne lead concentration exists up to 200 feet from a highway.[4] Using <1.0 μ as the upper size limit for respirable particles, analyses were made to determine the proportion of suspended lead measured 1 meter above the ground in each of five particle size classes; whether these proportions changed over distances of 5 feet (1.5m), 25 feet (7.6m), 50 feet (15m), and 100 feet (30m) from the street; and the density decline gradient, if any, in respirable and non-respirable size ranges. This study was made in two cities (San Antonio, Texas and Dallas, Texas) on streets selected to have traffic densities of approximately 25,000 cars/day. Both sets of data are presented in Tables 10 and 11

Table 10 shows the air lead concentrations in each particle size class for one air sample taken at each of five distances from the street in San Antonio. The upper half of the table shows the lead concentrations (μg/m^3), and the lower half shows the lead concentration expressed as a proportion of the whole sample. The proportions in each size class remain approximately the same as the distance from the street increases. Approximately 50% of the lead in the sample is in the respirable range regardless of the distance from the street. The proportion of lead in each fraction vs. distance from the street is plotted in Figure 36.

Table 10. Lead Concentration (μg/m3) in Five Particle Size Ranges at Four Distances from the Street

San Antonio, Texas

Distance (Feet)	Particle Size (μ) >7.0	3.3-6.9	2.0-3.2	1.0-1.9	<1.0	Total
5	0.8175	0.5216	0.4664	0.3360	2.2775	4.4190
25	0.4417	0.6624	0.4093	0.3112	2.5472	4.3718
50	0.2882	0.1939	0.2830	0.1123	1.0003	1.8777
100	0.6129	0.2749	0.2142	0.2479	1.1593	2.5092
	Proportion of Lead in Each Size Range					
5	0.185	0.118	0.106	0.076	0.515	1.000
25	0.101	0.152	0.094	0.071	0.583	1.001
50	0.153	0.103	0.151	0.060	0.533	1.000
100	0.244	0.110	0.085	0.099	0.462	1.000
Mean	0.171	0.121	0.109	0.077	0.523	-----
SE	0.0299	0.0109	0.0146	0.0082	0.0250	-----

FIGURE 36
PROPORTION OF TOTAL LEAD FOUND IN EACH PARTICLE SIZE FRACTION
vs. DISTANCE FROM STREET

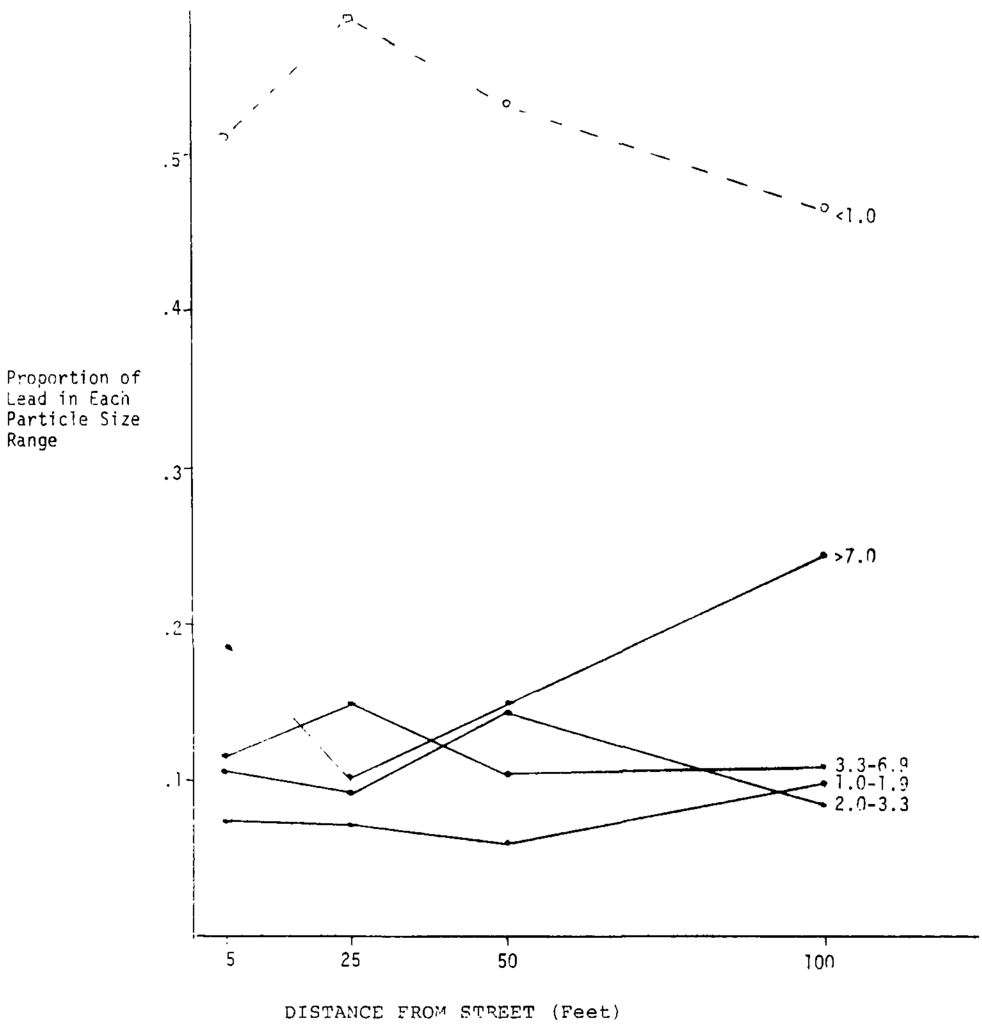


Table 11 shows the same information from the Dallas study. The two filters from the respirable range at 50 and 100 feet were lost and the results for the distances 5 feet and 25 feet are given. Again, more than half of the lead is in the respirable range with the remainder distributed

Table 11. Lead Concentration ($\mu g/m^3$) and Proportion in Five Particle Size Ranges at Four Distances from the Street.

Dallas, Texas

Distance (Feet)	Particle Sizes (μ)					
	>7.0	3.3-7.0	2.0-3.2	1.0-1.9	<1.0	Total
5	0.2224	0.2073	0.1295	0.1209	0.5461	1.2262
25	0.1290	0.0999	0.0707	0.0811	1.6987	2.0794
50	0.1163	0.1074	0.0667	0.0646	-----	-----
100	0.0871	0.1147	0.0382	0.0616	-----	-----
	Proportion of Lead in Each Size Range					
5	0.181	0.169	0.106	0.099	0.445	1.000
25	0.062	0.048	0.034	0.039	0.817	1.000
50	-----	-----	-----	-----	-----	-----
100	-----	-----	-----	-----	-----	-----
Mean	0.122	0.109	0.070	0.069	0.631	-----

among the other four size classes. The total air lead concentrations vs. distance from street for San Antonio and Dallas are plotted in Figure 37.

In Table 12, the lead concentrations at each distance are expressed as the percentage of the lead concentration at 5 feet from the street for the nonrespirable and respirable size ranges. There is no perceptible decline in the first 25 feet; in fact, the Dallas sample at 25 feet had a higher lead concentration. (This variation is not unexpected in a sample size of two.) At 50 feet and beyond, the lead concentration drops to approximately one-half the

FIGURE 37
AIR LEAD CONCENTRATION vs. DISTANCE FROM STREET

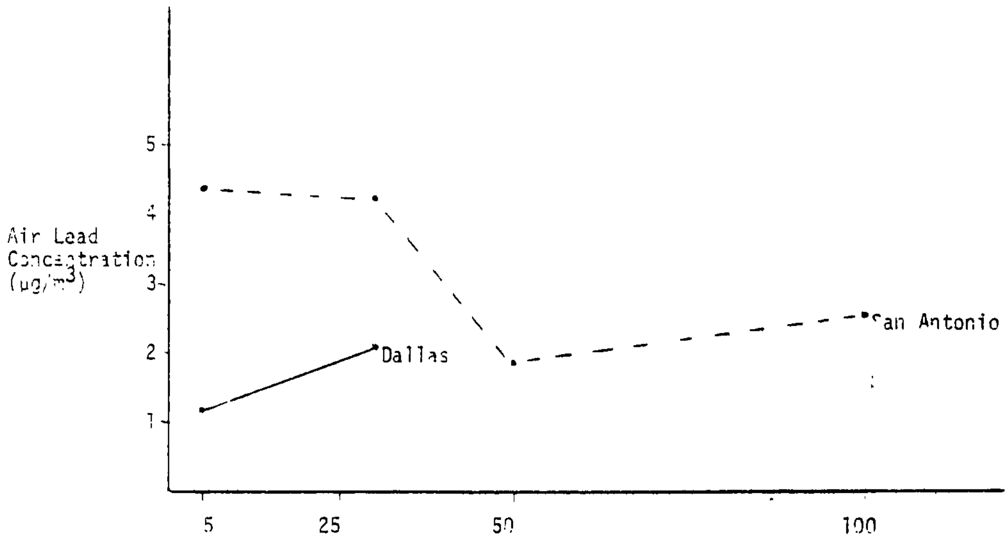


Table 12. Concentration of Lead Suspended in Air at Increasing Distances Expressed at % of Lead at 5 Ft. from Street.

Distance (Ft.)	≥ 1.0 u Nonrespirable Pb	< 1.0 u Respirable Pb	Total Pb
San Antonio			
5	100%	100%	100%
25	85.2	111.8	98.9
50	41.0	43.9	42.5
100	63.0	50.9	56.8
Dallas			
5	100%	100%	100%
25	56.0	311.1	169.6
50	52.2	---	---
100	44.3	---	---

concentration at 5 feet and is fairly consistent at this level in these three samples.

Conclusions: Approximately 50% of the airborne lead concentration is in the respirable range (< 1.0 μ) at distances from 5-100 feet from the street. In the non-respirable and respirable ranges, lead concentrations did not decline in the first 25 feet from the street but were approximately one-half the street level at 50 feet and at 100 feet.

4. Results of Distance from Road Mini-study

In the previous section, a density decline gradient in air lead concentrations at distances up to 200 feet from the street was discussed. Air samples and traffic counts were taken for two days at three traffic densities at four distances from the street: 5 feet (1.5m), 25 feet (7.6m), 50 feet (15m), and 100 feet (30m). The air lead concentrations in $\mu g/m^3$, and also expressed as a percentage of the air lead at 5 feet from the street, are given in Table 13. At every traffic locality there is a decline in air lead concentration with increasing distance from the street. Air lead levels vs distance from street for each locality are plotted in Figure 38. The decline seems to be more rapid at the higher traffic counts (32, 761 and 34, 645), but the sample size for this study is not large enough to make general statements regarding decline rate and air lead levels.

Table 13. Concentration of Lead Suspended in Air ($\mu g/m^3$ at Four Distances from the Street for Two Days at Three Traffic Densities.

Distance (Feet)	Actual Traffic Counts (Cars/Day)					
	9360	9588	16,886	18,123	32,761	34,645
5	2.15	1.04	1.38	1.82	3.24	3.14
25	1.35	0.86	1.65	1.37	1.48	1.85
50	1.17	0.59	1.22	1.02	1.22	1.46
100	0.74	---	0.47	0.99	1.09	1.02

Concentration of Lead Suspended in Air Expressed as the Percentage of Lead at 5 Ft. From Street

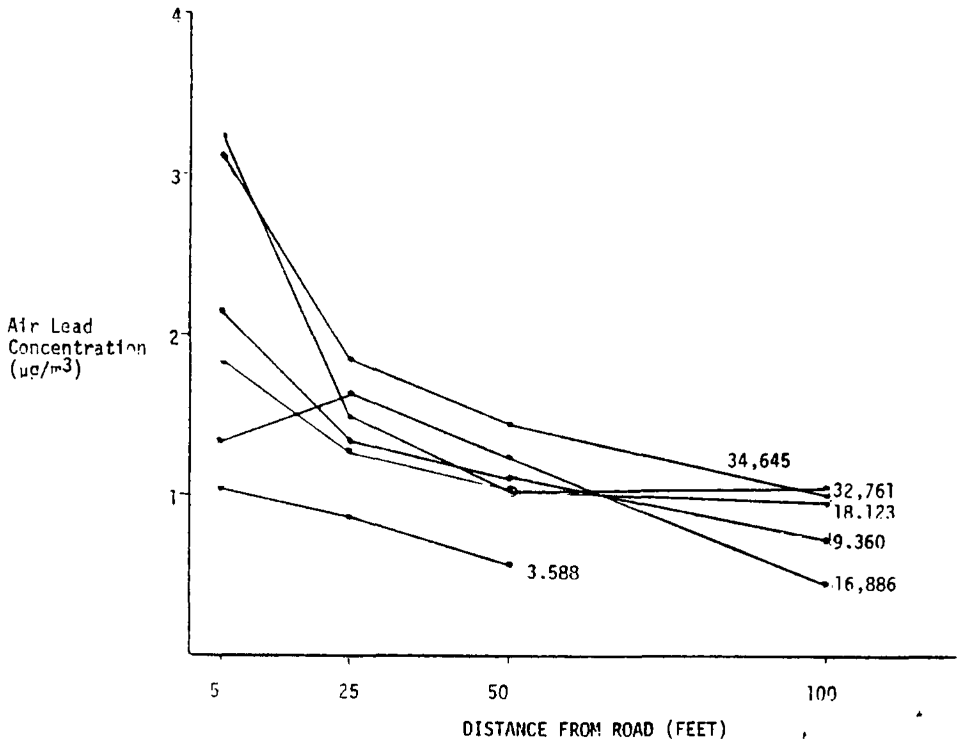
	Actual Traffic Counts (Cars/Day)						
	9360	9588	16,886	18,123	32,761	34645	Ave. %
5	100%	100%	100%	100%	100%	100%	100%
25	62.8	82.7	119.6	75.3	45.7	58.9	74.2%
50	54.4	56.7	88.4	56.0	37.7	.46.5	56.6%
100	34.4	---	34.1	54.4	33.6	32.5	37.8%

Conclusions: Air lead concentration declines rapidly in the first 50 feet from the street to levels of about 55% of the street concentration. At 100 feet from the street, the lead levels were less than 40% of the concentration at the street.

5. Results of Intersection Mini-Study

Two different intersection studies were done. The first study measured air lead for four days at each of five combinations of block and intersecting street traffic densities: 10,000/1,000; 10,000/5,000; 15,000/1,000;

FIGURE 38
AIR LEAD CONCENTRATIONS AS A FUNCTION OF DISTANCE
FROM ROAD AND TRAFFIC DENSITY



25,000/5,000; and 25,000/10,000 cars/day. The purpose of this study was to determine whether air lead levels were higher at intersections than at neighboring midblock locations. The intersecting streets were selected to add from 1,000 to 10,000 cars/day to the midblock traffic levels. At the time this study was designed, we did not expect to recruit participants for human studies from homes near intersections.

The second study was designed when it became necessary to recruit participants from corner homes (discussed in Section III B 1). The purpose of this study was to determine whether those participants who lived near 1,000 car/day intersecting streets were exposed to additional air lead. Four traffic density combinations were used: 1,000/1,000; 10,000/1,000; 15,000/1,000; and 25,000/1,000 cars/day. For clarity, we will refer to this study as the corner home study.

Air lead levels ($\mu g/m^3$) with actual traffic counts at the five traffic densities in the intersection study are given in Table 14. In Figure 39, mid-block vs intersection air lead levels were plotted to examine the correspondence between these locations within a block and to observe whether these air lead levels were related to increasing traffic density. Each point on the plot is a letter which defines its traffic density group:

A = 10,000/1,000

B = 10,000/5,000

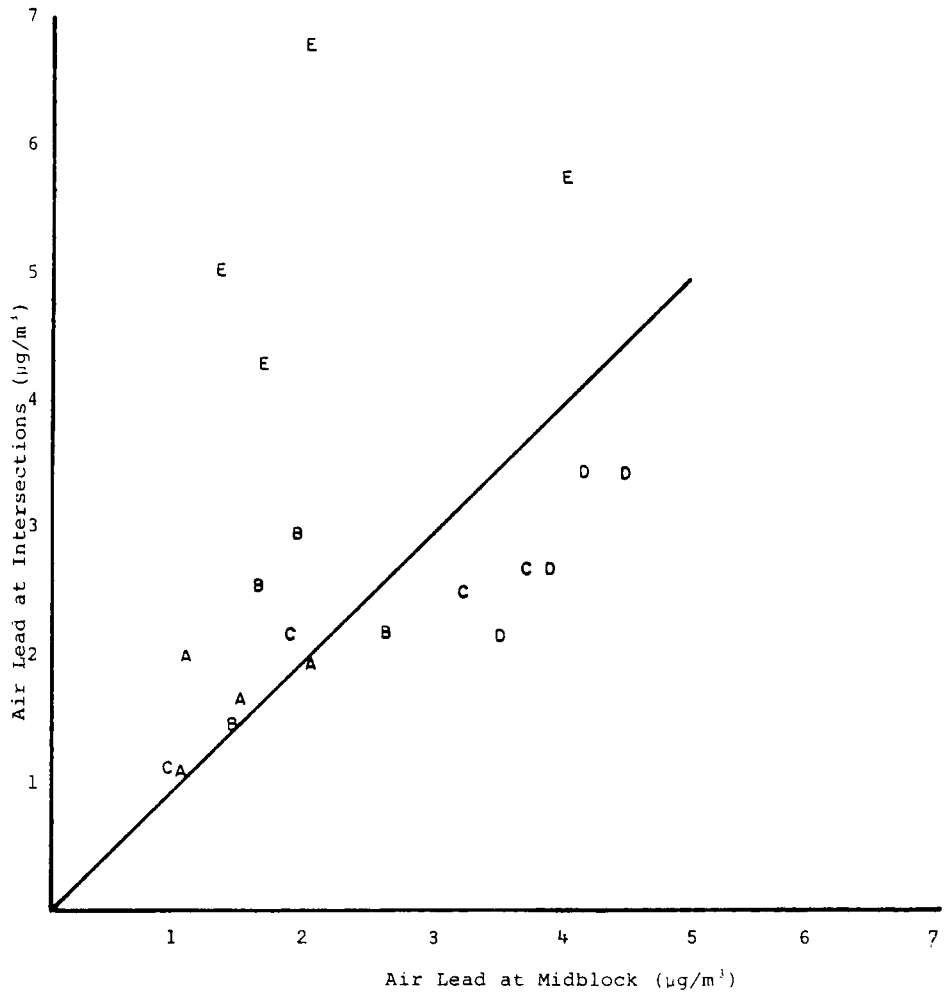
C = 15,000/1,000

D = 25,000/5,000

E = 25,000/10,000 cars/day.

The line drawn at 45^{o} merely indicates which of the two air leads determining a point is higher. Those points below the line have higher air lead at midblock than at intersections; and those above the line have higher air lead at intersections. The graph implies an approximate 1:1 correspondence between air lead at blocks and intersections

Figure 39. Intersection Study: Air Lead Levels at Intersection and Midblock Locations. Traffic Densities: A = 10,000; B = 10,000/5,000; C = 15,000/1,000; D = 25,000/5,000; E = 25,000/10,000 cars/day.



for traffic densities A-D(less than 30,000 cars/day). In addition, 50% of the points at these traffic densities fall below the 45° line indicating air lead is not higher at these intersections. There seems to be little differentiation between air lead levels at traffic densities less than 20,000 cars/day as indicated by the lack of clustering of groups A, B, and C. This agrees with our findings in traffic density mini-study (section III A 1) where the relationship between air lead and traffic density increased substantially only after traffic levels rose above 25,000 cars/day. Points labelled D and E on the graph are at traffic levels above 30,000 cars/day and indeed have higher air lead levels. The graph also implies that above 30,000 cars/day the relationship between midblock and intersection air lead changes; however, three of the midblock air lead levels at density E seem unusually low compared to other midblock air leads at similar traffic densities (see Table 14). As in the traffic density mini-study, the data are scarce at levels above 25,000 cars/day and few conclusions about trends can be drawn. The statistical significance of differences in air lead demonstrated in this graph was tested using a two level nested ANOVA with the result that significant differences were found among traffic densities ($P = 5.0 \times 10^{-6}$) and between midblock and intersection locations ($P = 1.1 \times 10^{-4}$). The variances of the ten groups were homogeneous.

Air lead and traffic density levels for the corner home study are listed in Table 15 and are plotted in Figure 40. Again a line is drawn at 45° to assist visual differentiation between air lead levels which were greater at midblock (below the line) and those greater at inter-ections (above the line). Air lead levels were greater

Table 14. Intersection Study: Air Lead Concentrations at Intersections and Midblock Locations.

Air Lead (μg/m³)		Traffic Counts (cars/day)		Estimated Traffic Density
Block	Intersection	Block	Intersecting Street	
1.44	1.65	7,794	261	A
1.05	2.02	9,971	1,652	
.98	1.09	9,970	1,803	10,000/1,000
1.96	1.91	9,804	1,697	
2.61	2.18	10,960	5,671	B
1.61	2.56	10,994	6,908	
1.88	2.98	11,446	6,184	10,000/5,000
1.39	1.44	12,259	6,781	
3.23	2.46	12,698	461	C
1.87	2.19	12,858	437	
.90	1.25	14,114	427	15,000/1,000
3.69	2.73	14,252	433	
4.15	3.48	22,818	7,646	D
3.47	2.19	23,189	7,819	
4.47	3.46	23,429	8,105	25,000/5,000
3.88	2.70	23,431	7,901	
4.02	5.77	23,607	7,918	E
1.63	4.30	27,740	10,337	
1.31	5.04	28,226	10,239	25,000/10,000
1.99	6.80	30,199	11,220	

Mean Air Lead (μg/m³)		
	Block	Intersection
A	1.36	1.67
B	1.87	2.29
C	2.42	2.15
D	3.99	2.96
E	2.24	5.48

at intersections at 8 of the 14 pairs of locations. There seems to be no clustering of traffic density levels A, B, C, or D. For this reason and the fact that two density D samples were lost, a paired comparison t-test was used to test for differences between air lead levels at intersections and midblock locations. Variances were tested

Table 15. Corner Home Study; Air Lead Levels ($\mu g/m^3$) at Intersections and Midblock Locations

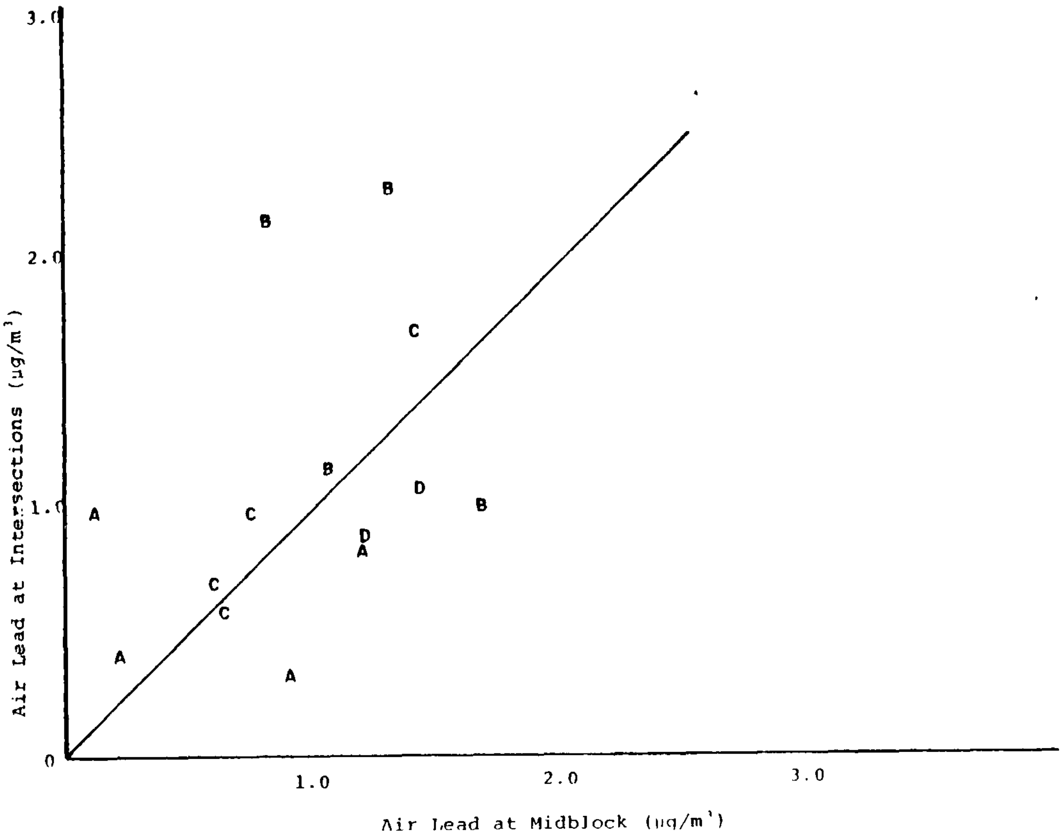
Air Lead ($\mu g/m^3$)		Traffic Counts (cars/day)		Estimated
Block	Intersection	Block	Intersecting Street	Traffic Density
.22	.41	121	120	A
.89	.33	146	140	
1.19	.86	390	292	1,000/1,000
.12	.98	393	245	
1.64	1.01	3,980	199	B
.81	2.15	8,651	728	
1.06	1.17	11,266	1,229	10,000/1,000
1.30	2.29	12,712	996	
.73	.99	11,467	200	C
1.42	1.72	12,411	146	
.58	.71	16,567	831	15,000/1,000
.63	.58	16,629	952	
1.19	.90	21,324	249	D
1.42	1.07	23,883	246	25,000/1,000

Mean Air Lead ($\mu g/m^3$)	Block	Intersection
A	0.61	0.65
B	1.20	1.66
C	0.84	1.00
D	1.31	0.99
Overall Mean	0.94	1.08
Standard Error of Mean	0.122	0.158

and were homogeneous. No significant difference was found between air lead levels at these locations at the 0.05 level (t = 0.90, P = 0.39).

Conclusions: Two intersections studies were done. In the first, significant increases in air lead levels were found among traffic densities which ranged from 8,000 to 40,000 cars/day. In the same study air lead levels were significantly higher at intersections than at in midblock locations primarily due to differences at the

Figure 40. Corner Home Study: Air Lead Levels at Midblock and Intersections Locations. Traffic Densities: A = 1,000/1,000; B 10,000/1,000; C = 15,0000/1,000; D = 25,000/1,000 cars/day.



highest traffic density. The second study tested for an increase in air lead levels for participants in this study who lived near 1,000 car/day intersecting streets. No significant differences in these midblock and 1,000 car/day intersections locations were found.

6. Results of Speed Limit Mini-study

The objective of this study was to determine the effect of traffic speed on the amount of air lead for a given traffic leve. Air lead concentrations ($\mu g/m^3$) were measured in two speed zones: 30 MPH and 45 MPH. Air samples and traffic counts were taken for five days each on a 30 MPH and on a 45 MPH street which had similar traffic densities. Although an attempt was made to locate two streets with the same traffic density, the mean traffic count on the 45 MPH street (9369 cars/day) was 19% higher than the mean for the 30 MPH street (7879 cars/day). We would expect lower air lead levels at the faster traffic speed due to the shorter time that the vehicle is present to emit lead. Higher traffic counts at the faster speed could cause elevation of air lead levels thereby reducing the difference in air lead between the two speed zones. This effect, if it exists, will make the difference in air lead over speed zones more difficult to detect. The air lead levels and associated traffic counts and means are given in Table 16.

Table 16. Air Lead Concentrations ($\mu g/m^3$) at Two Speed Limits (30 and 45 MPH).

	30 MPH		45 MPH	
	Air Lead ($\mu g/m^3$)	Traffic Count	Air Lead ($\mu g/m^3$)	Traffic Count
	0.898	7433	0.827	9853
	0.650	7665	0.424	9624
	0.844	8570	0.623	8994
	0.947	8054	0.598	9198
	1.860	7672	0.219	9176
Mean	1.040	7879	0.538	9369

Air Lead ($\mu g/m^3$)

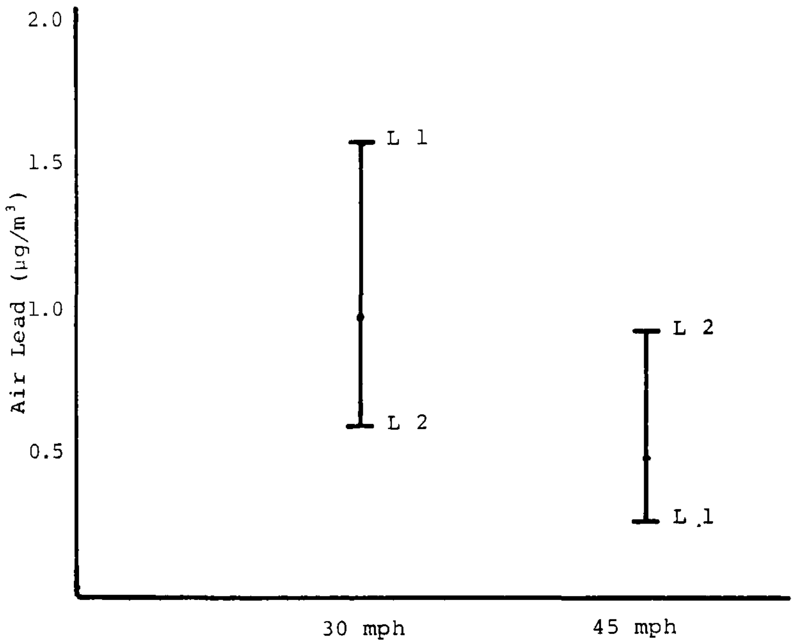
	Geometric Mean	L_1	L_2
30 MPH	0.97	0.60	1.58
45 MPH	0.49	0.26	0.93

A two fold difference can be seen between the mean values for air lead, with the higher level being associated to the 30 MPH site. It will be noticed that one value at the 30 MPH site is significantly higher than the others. Even without this data point (1.860), the mean value for the 30 MPH site is still 0.835 $\mu g/m^3$ vs 0.538 for the 45 MPH site. Comparison of geometric means also shows a factor of two between the two sites.

To examine the statistical significance of these results, a paired t-test was used with log transformation to achieve homogeneity of variance. No significant difference was found between the air lead levels at the two speed zones ($t = 1.31$, $P = 0.07$), although a two fold difference can be seen between the geometric means (0.97 and 0.49). The large variation in these samples is reflected in the size of the confidence limits plotted in Figure 41.

Conclusions: A large apparent difference was noticed between air lead levels on 30 MPH and 45 MPH streets with the lower speed having nearly twice the air lead of the higher speed. However, the statistical confidence was not established in this result, perhaps due to the limited sample size.

Figure 41
Air Lead Concentrations vs Two Speed Limits



7. <u>Results of Indoor vs outdoor Air Lead Mini-study</u>

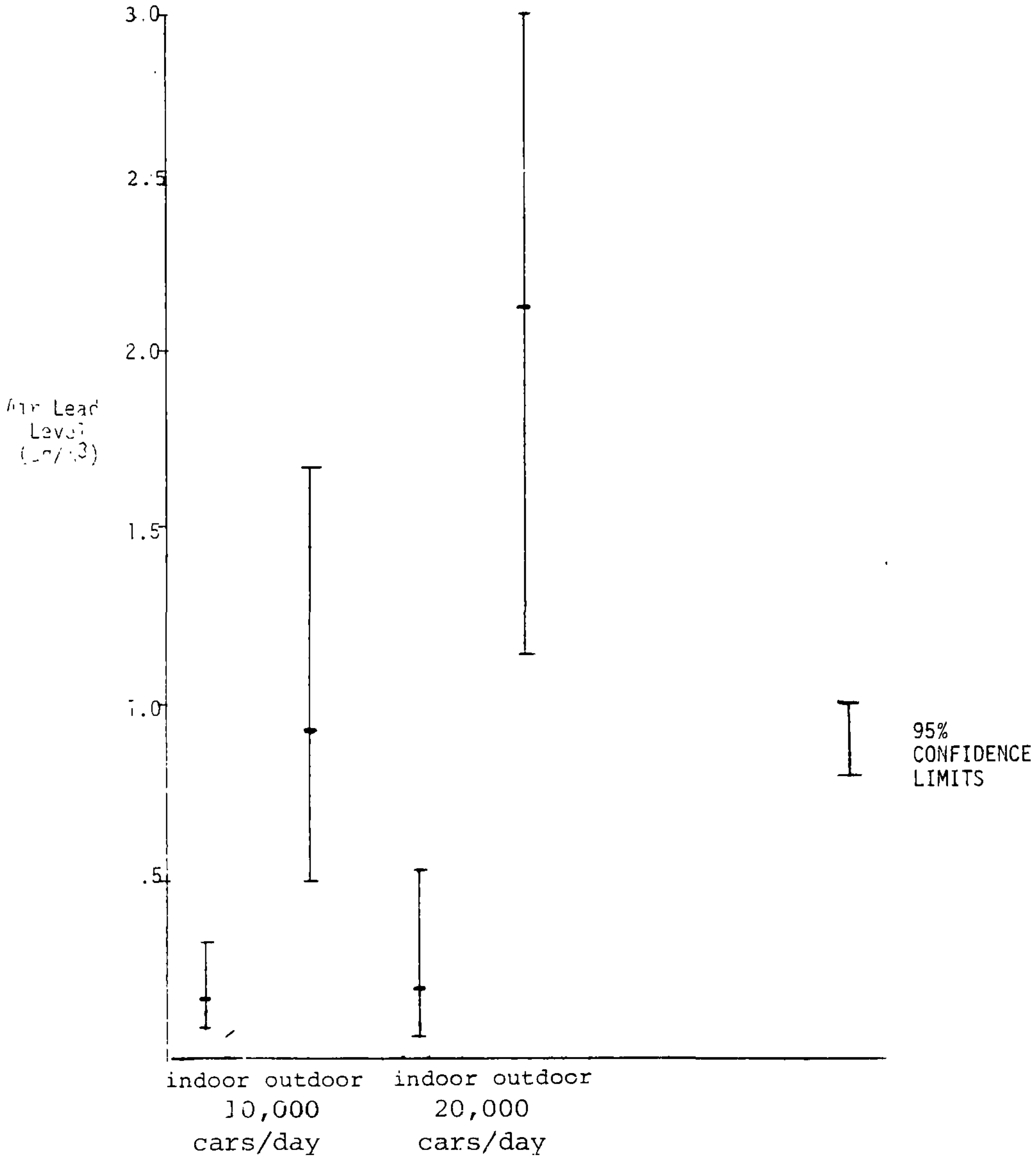
It was of interest to know whether a significant portion of the lead in outside air near the street was present inside homes. Air lead measurements were made both inside and outside the same house simultaneously for a 10-12 hour period. As these measurements were made using standard Hi vol samples run between 50 and 60 cfm the distinct possibility exists for the sampler to have acted as a vacuum and therefore produced artifically low air lead levels. Sixteen of these pairs of measurements were made at two different traffic densities (9 at 10,000 cars/day, and 7 at 20,000 cars/day). These data with means and confidence limits are given below and are plotted in Figure 42.

Indoor vs Outdoor Air Lead ($\mu g/m^3$)

	10,000 cars/day		20,000 cars/day	
	Indoor	Outdoor	Indoor	Outdoor
	*0.34	0.87	0.12	1.70
	0.65	.17	0.23	2.17
	0.30	3.01	0.27	0.98
	0.07	0.69	0.07	1.92
	0.09	1.70	0.12	2.31
	0.10	1.12	0.25	2.46
	0.08	0.81	0.55	3.87
	0.34	1.32		
	0.19	0.74		
Arithmetic Mean	0.24	1.16	0.23	2.20
Geometric Mean	0.18	0.92	0.19	2.05
L_1	0.10	0.50	0.10	1.40
L_2	0.34	1.68	0.36	3.01
N	9	9	7	7

* Evaporative Cooler

FIGURE 42
INDOOR vs. OUTDOOR AIR LEAD CONCENTRATIONS
AT TWO TRAFFIC DENSITIES



All of these houses had central or window air conditioning units with one exception (marked with an asterick) which had an evaporative cooler. A two-way ANOVA (fixed effects) was used to test the effects of indoor vs outdoor air lead and 10,000 vs 20,000 cars/day.

Prior to a $\log_{10}$ transformation, the variances of the four groups were heterogeneous; therefore, log transformed data were used for the ANOVA. There was no significant difference in the traffic densities (P = 0.10) nor was the interaction term significant (P = 0.14). The difference between indoor and outdoor air lead levels was highly significant ($F = 61.70$, $P = 1.5 \times 10^{-8}$.

The sampling variation is often large in small samples such as these. For example, the standard deviation for these data is 1.11, roughly twice 0.61, the standard deviation of the 152 air lead measurements used in the traffic density study. For this reason, differences among means which seem large may not be significant, i.e., the difference between outdoor air lead means, 1.16 and 2.20. Referring to Table 9, we see that air lead means at traffic densities similar to 20,000 cars/day vary from 0.85 to 1.25 $\mu g/m^3$ with 6-10 replicates per mean. Mean air lead for these 25 samples was 1.05 $\mu g/m^3$ with mean traffic count 20,076 cars/day. Interpretation of a 2X difference in outdoor air lead in this mini-study would be invalid in view of the large variation here and the findings of the larger air lead/traffic density mini-study (IIIA1).

Conclusions: There were highly significant differences between outdoor and indoor air lead with outdoor air lead 5 to 10 times higher. There were no differences between indoor samples taken on a 10,000 cars/day street and those taken on a 20,000 cars/day street. Outdoor lead samples at the 10,000 vs 20,000 cars/day were very close to but not significantly different at the 0.05 level.

8. Results of Indoor vs. Outdoor Dustfall Mini-study

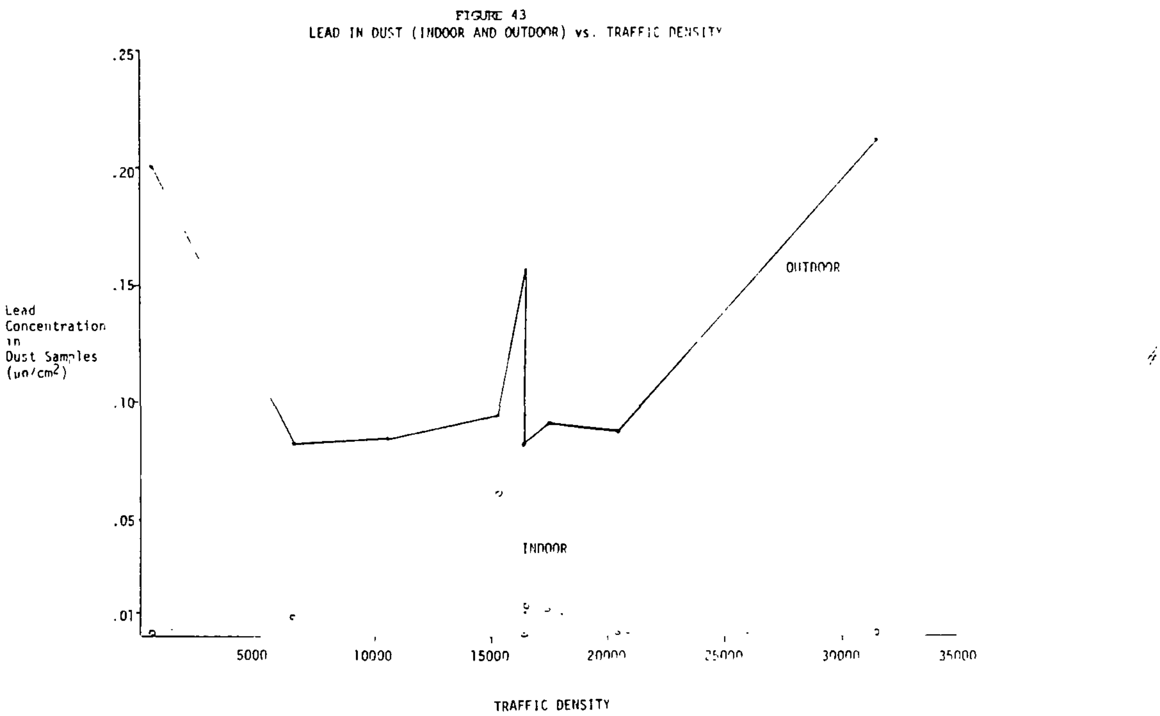
Outdoor dust samples (28-day dustfall) were taken at 10 locations and each sample was paired with an indoor dust sample either from the same residence or within the same area. The lead concentrations of these pairs of samples and actual traffic counts and their means and standard errors are given in Table 17 and are plotted in Figure 43. One outdoor dust lead (0.7252) was tested as an outlier using Dixon's r_{10}

Table 17. Outdoor Dustfall Lead Concentrations (ug/cm2) from Ten Locations with Corresponding Indoor Dustfall Lead Concentrations (ug/cm2) and Traffic Counts.

Outdoor Dust Pb (ug/cm2)	Indoor Dust Pb (ug/cm2)	Traffic Count
0.2000	0.0026	474
0.0827	0.0092	6654
0.0865	0.0025	10637
0.0945	0.0604	15156
0.0811	0.0016	16219
0.1586	0.0128	16381
0.0913	0.0104	17452
0.0892	0.0034	20483
0.7252*	0.0047	20928
0.2121	0.0071	31542
Mean ± SE 0.1218 ± 0.01779 N=9	Mean ± SE 0.0122 ± 0.0062 N=9	

* Rejected as outlier (P<< 0.005)

test,[28] found to be significantly higher than the other samples (r_{10} = 0.80, P << 0.005), and rejected. If this outlier had not been rejected, the results of this analysis would have been the same but with a lower level of significance, because retaining it makes the variance considerably higher. The lead concentrations of the 9 remaining pairs of samples

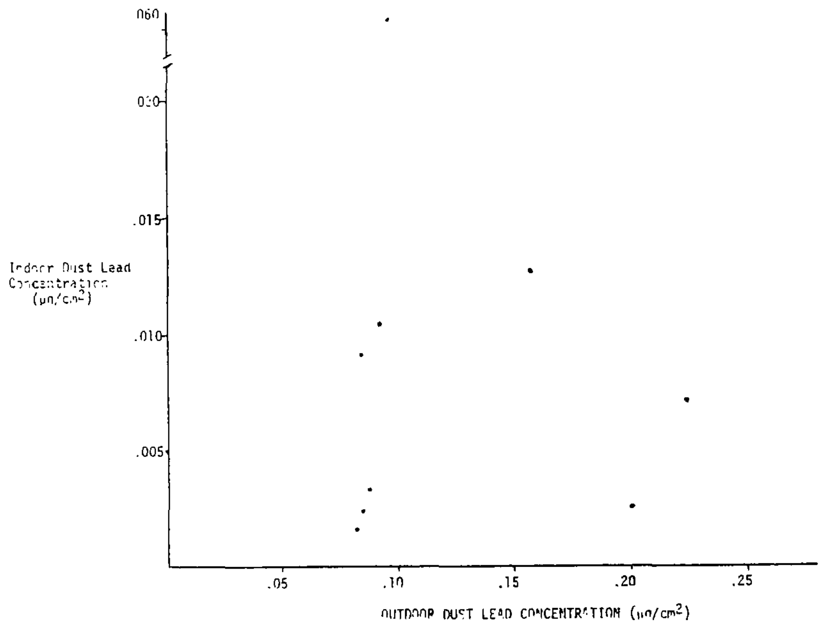


were compared using Wilcoxon's signed ranks test and were found to be significantly different ($P<0.005$). Indoor vs. outdoor dust lead is plotted in Figure 44. The mean outdoor dust lead (0.1218 $\mu g/cm^2$) was approximately 10 times the mean for indoor dust lead (0.0122 $\mu g/cm^2$). When outdoor dust lead was compared with the mean of all 268 indoor dust lead samples discussed in section III B 3 (0.0082 $\mu g/cm^2$), the ratio was approximately 15:1.

Different collection methods were used: indoor dust samples with a tray and outdoor samples with a bucket. Both are described in the Methods section. The reason for this difference was to avoid possible effects of wind outside. Rain had no effect on outdoor samples since rainwater was simply held in the bucket (see Section III C 2).

Conclusions: Outdoor dust lead concentrations from 9 locations were found to be significantly higher (at least 10X) than indoor dust lead concentrations in adjacent or nearby residences.

FIGURE 44. INDOOR vs. OUTDOOR DUST LEAD CONCENTRATIONS AT 9 MATCHED LOCATIONS



9. Results of Collection Times Less 24 Hours Mini-study

Twenty-four hour collection times for air lead and traffic density have been used for most of the studies described in this report. This mini-study was designed to determine whether shorter sampling times could be used to measure air lead as efficiently as 24 hour sampling periods. Air samples and traffic counts were taken for two days each at three traffic densities for following shorter time periods: 1 hour, 2 hours, 4 hours, and 12 hours. One location was used for each traffic density (10,000, 15,000 and 25,000 cars/day). Twenty-four hour samples from the same street which were begun either on the same day, the same day of the week, or a similar day of the week were used. (Midweek days were not considered similar to Mondays, Fridays, or weekends.) The number of hours sampled, date sampling began, traffic counts, and air lead levels are listed in Table 18.

Table 18. Collection Times Less Than 24 Hours: Air Lead and Traffic Counts for Five Collection Times at Three Traffic Levels.

# Hours Sampled	Date Began	Traffic Count	Traffic Count Projected to 24 Hr.	Air Lead (ug/m^3)	Range of Air Lead for each time	Estimated Traffic Level
1	9/24	483	11,592	2.23	0.62	10,000 cars/day
* 1	9/25	189	4,536	1.61		
2	9/24	1,110	13,320	0.74	0.27	
* 2	9/25	658	7,896	0.01		
4	9/24	2,244	13,464	0.91	0.26	
* 4	9/25	1,908	11,448	0.65		
12	9/24	7,624	15,248	1.31	0.04	
*12	9/25	7,458	14,916	1.35		
24	9/24	9,970	9,970	0.98	0.07	
*24	9/25	9,971	9,971	1.05		
1	9/29	584	14,016	3.19	0.89	15,000 cars/day
1	9/30	671	16,104	2.30		
2	9/29	1,158	13,896	1.40	0.16	
2	9/30	1,338	16,056	1.24		
4	9/29	2,941	17,646	1.40	0.64	
4	9/30	3,086	18,516	0.76		
12	9/29	9,004	18,008	1.77	0.58	
12	9/30	9,422	18,884	1.19		
24	10/1	12,698	12,698	3.23	0.46	
24	9/23	14,252	14,252	3.69		
1	10/17	1,374	32,976	2.00	4.91	25,000 cars/day
1	10/24	1,282	30,768	6.91		
2	10/17	2,671	32,052	2.33	4.95	
2	10/24	2,718	32,616	7.28		
4	10/17	5,896	35,376	1.88	5.35	
4	10/24	5,949	35,694	7.23		
12	10/17	17,314	34,628	1.29	5.63	
12	10/24	16,903	33,806	6.92		
24	10/21	22,818	22,818	4.15	0.32	
24	10/22	23,429	23,429	4.47		

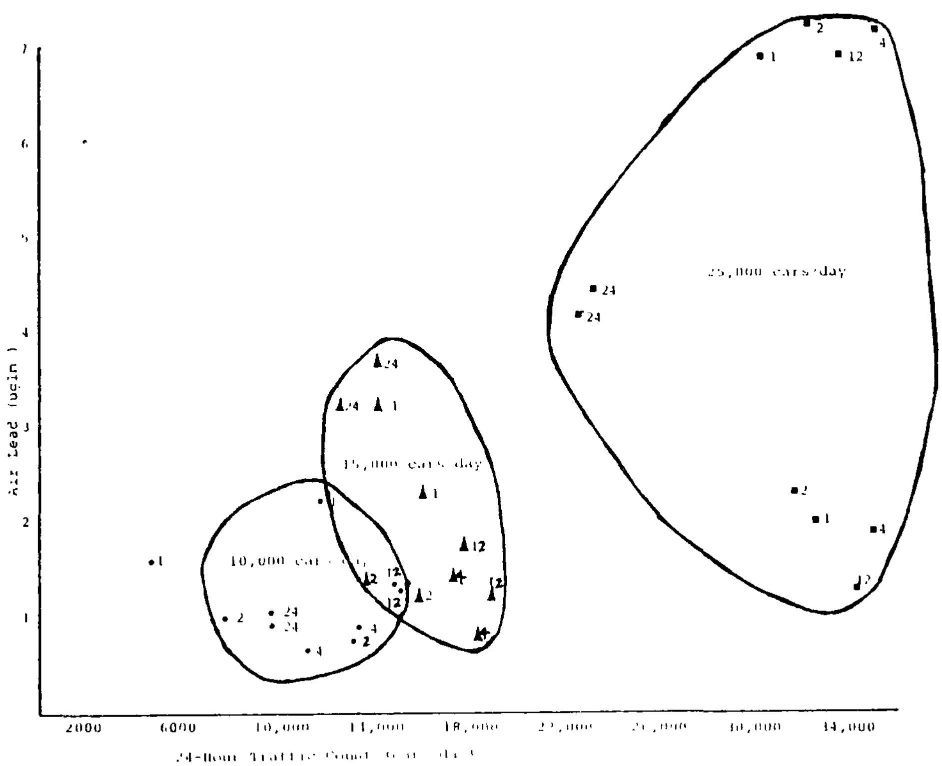
* Shows effect of sampling began at 10 A.M.
Others began at 8-9 A.M.

Also listed are all of the traffic counts adjusted to a 24 hour time period and the range (or difference in this case) between the two air lead samples for each time period. On a given day the 1, 2, 4, and 12 hour samplers were begun at the same time (8-9 A.M.). On the following day or the same day one week later, the samplers were begun again at the same time. There is an exception at the 10,000 car/day location where samplers were begun on 9/25 at 10 A.M. instead of 8-9 A.M. As a result the 1, 2, and 4 hour traffic counts are depressed by 60%, 41%, and 15%, respectively, when compared to the corresponding traffic counts on 9/24. Comparison of the two 12 hour counts shows that the difference has diminished to 2% after this length of sampling time, and there is no difference after the 24 hour sampling period. Thus longer sampling minimizes the effects of the exact time when sampling began. Air lead levels did not seem to be affected by the late starting time; however, the results of the other mini-studies show that air lead is not especially sensitive to differences in low traffic counts. The difference in starting time would probably have caused a difference in air lead at a 30,000 car/day location.

Traffic counts were overestimated when sampled for less than 24 hours as indicated by the lower 24 hour counts in the column for traffic counts adjusted to 24 hour time periods. This is expected since the shorter time periods were during the daytime.

The range in air lead decreases as sampling time increases at all three traffic locations (see Table 18). This implies that longer sampling periods have lower variances although two samples are not adequate for drawing conclusions about variances. At the 25,000 car/day location, the range or difference between duplicate times is unusually large. Comparison of air lead levels and sampling dates shows that for times 1, 2, 4, and 12 hours, air lead levels on 10/17 are 2.00, 2.33, 1.88, and 1.29 and on 10/24 are 6.91, 7.28, 7.23, and 6.92 $\mu g/m^3$. Traffic counts for duplicate samples are similar. The consistently lower air lead levels on 10/17 are probably the result of some meteorological condition, i.e., a change in wind direction, rain, or air stagnation. It is not possible to determine the exact cause at this time. The air lead levels vs. traffic counts (adjusted to 24 hour level) are plotted in Figure 45 with each of the three locations encircled. The differences in dates 10/17 and 10/24 at the 25,000 car/day

Figure 45. Air Lead Levels vs Traffic Density for Four Collection Times at Three Traffic Levels (• = 10,000, ▲ = 15,000; ■ = 25,000 cars/day).



location are prominent. The smaller ranges of the 24 hour samples as opposed to the 1, 2, 4, and 12 hour samples are seen in the 10,000 and 15,000 car/day locations. The low outlying point at 2280 cars/day reflects the 10 A.M. start-up time. No relationships such as higher or lower estimates of air lead associated with length of sampling times can be seen.

Conclusions: Shorter collection times tend to overestimate traffic volume and introduce more variability in air lead measurements. The range in air lead measurements increased with shorter sampling times at all traffic densities. No relationship between air lead levels and length of collection times was seen.

B. Determination of the Relationship Between Blood Lead Levels and Traffic Density

1. Results of Recruitment Activities

a. Number of Subjects

(1) Original Design

The original design criteria for participants included the following numbers of qualified volunteers in each age, sex, and traffic density category:

	Traffic Density				
	Site 1	Site 2	Site 3	Site 4	Total
Preschoolers					
Male	30	30	30	30	120
Female	30	30	30	30	120
Females that work at home (20-49 yrs)	30	30	30	30	120
Older persons (50+ yrs.) Male & Female	30	30	30	30	120

(2) Modified Design

Even with additional incentives and techniques, the results of recruitment of volunteers was less than completely successful in the second stage of survey activities. This is particularly true regarding the recruitment of preschoolers.

Because of the severe problems of meeting the required numbers of preschoolers, it was proposed to the Project Officer that the number be revised to the following specifications:

	Traffic Density				
	Site 1	Site 2	Site 3	Site 4	Total
Preschoolers Male & Female	40	40	40	40	160
Females that work at home (20-49 yrs.)	40	40	40	40	160
Older Persons (50+ yrs.) Male & Female	40	40	40	40	160
					480

The Project Officer agreed to this change as being acceptable and within reasonable probability of attainment, seeing the results at that time.

(3) Volunteers Obtained

Results of the survey recruitment activities are presented in Table 19. A total of 1850

TABLE 19.

RECRUITMENT RESULTS

Parameter	Traffic Density				Total
	Site 1	Site 2	Site 3	Site 4	
No. HHQ Forms	545	485	409	411	1850
Total No. Residents	1452	1283	1026	1130	4891
Ave. No. Residents/HH	2.66	2.64	2.51	2.75	2.64
Total No. Eligible*	523	533	242	301	1599
Total No. Volunteers	201	213	119	184	717
Ave. % of Volunteers (of those eligible)	38.4	40.0	49.2	61.1	44.8

* Number eligible obtained from Household Questionnaire form; no reference to race on HHQ form.

household surveys were performed for households with 4891 residents. A total of 1599 residents were encountered who were eligible regarding age, occupation, sex, and residence of which 717 volunteers were recruited. Of the 1850 residences, 986 or 53% of the total reported one or more persons eligible for the study (without regard to race). From the 986 residences reporting one or more eligible person, 476 or 48% of the total provided one or more volunteers for the study. The total of 717 volunteers from the 986 residences reporting one or more eligible persons yields a rate of .72 volunteers per residence with one or more eligible persons. This response rate is considered to be very good for a residential study involving free living (rather than institutional or isolated) populations.

The Household Questionnaire Form used in this study makes no reference to race or ethnic background. In the recruitment of volunteers, no reference was made to any requirement for race or ethnic background. The neighborhoods selected for the study were selected so as to maximize the potential for finding white, non-Spanish volunteers. The number of volunteers obtained, shown in Table 19, include some who were later ineligible due to the requirements for participants to be white, non-Spanish. From these numbers, the average percent of volunteers of those listed as eligible is 44.8%. It is expected that this number would be higher if the statistics accounted for only white, non-Spanish. Because no reference is made to race in the HHQ form, and the number of eligible persons is determined with use of that form, it is not possible to calculate the precise number.

A second factor is also reflected in the statistics presented in Table 19 regarding the percent of volunteers. The volunteer rate was significantly higher in the second stage of recruitment due to the increased efforts directed at recruitment and additional recruitment techniques applied. The second stage of recruitment was concentrated on the higher traffic densities (Sites 3 and 4) and the percent volunteering reached greater than 60% as opposed to 40% for Sites 1 and 2.

An analysis has been performed to compare household characteristics for volunteers versus persons eligible who did not volunteer for this study. Results are presented below. Five pertinent characteristics of the households were used in the comparison: (1) Median education level of the household head, (2) Occurrence of

Comparison of Household Characteristics:
Volunteers vs. Eligible Non-Volunteers

Household Characteristics	Households of Eligible Persons Who Volunteered (Col 53>0,Col 70>0)	Households of Eligible Persons Who Refused Col 53>0,Col 70=0)
Median Education Level of Household Head	Level 6 - Partial College	Level 6 - Partial College
Occurrence of Lead Screening	1.9%	1.8%
Presence of Air Conditioning	94.7%	95.5%
Median Age of Structure	21 years	22 years
Median Length of Residence	7 years	11 years

lead screening for one or more members of the family previous to this study, (3) Presence of air conditioning (central or window unit) in the home, (4) Median Age of the structure, and (5) Median length of residence at the address. For four of the five characteristics, the volunteers are remarkably similar to those refusing to volunteer. On the fifth characteristic, length of the residence at the address, a sizeable difference is noticed in the median values: 7 years for volunteers, 11 years for eligible non-volunteers. This difference may be interpreted to mean that those who were the more established residents (having lived in the neighborhood longer) may be more reluctant to volunteer than those with less length of residence in the neighborhood who are more mobile by definition and perhaps more open to change or approach by a study such as this. The conclusion of this comparison is that little or no bias is indicated due to any differences in characteristics of volunteers versus those eligible who did not volunteer.

In summary, the average number of eligible persons per household encountered was 0.86 and the average number of persons volunteering per household was 0.39, or approximately one for every 2.5 residences. The average number of volunteers per residence with one or more eligible persons is 0.72, and is considered high. The average number of eligible preschoolers per household was 0.10 and the average number of preschool volunteers per household was 0.067, or approximately one for every 15 residences. The low number of preschoolers is considered to be at least in part due to the high traffic densities involved in the study. A strong bias exists for families with small children not to locate on busy thoroughfares. Characteristics of the eligible population who volunteered are very similar to characteristics of eligible non-volunteers

b. Participant Selection

(1) Number of Participants Accomplished

The number of participants for which samples have been obtained is presented in Table 20 by age, sex, and traffic level. Of the persons volunteering for the study, only those meeting all criteria, including the ethnic criterion of white, non-Spanish were included as participants. The numbers presented in Table 20 accounts for dropout of volunteers who were selected but who subsequently were unable to participate (refused, moved, etc.).

Table 20. Number of Participants by Age, Sex, and Traffic Level

Traffic Level	Total	M	F	1-8 yrs		19-49 yrs		50 yrs.	
				M	F	M	F	M	F
1	130	35	95	20	24	0	50	15	21
2	113	35	78	17	15	0	41	18	22
3	117	28	89	6	19	0	48	22	22
4	82	22	60	11	9	0	39	11	12
Total	442	120	322	54	67	0	178	66	77

Of the total 442 participants selected for the study, the number of preschool participants totaled 121, females 18-49 years totaled 178, and older persons totaled 143. These numbers compare to the design criterion of 160 persons in each category. It is apparent that recruitment of the younger and older participants was less successful than the middle group. The worst statistics were obtained for the highest traffic density level, Site 4, where a total of 20 preschoolers and 23 older persons were recruited. The design criterion was 40 persons in each of these categories.

(3) Selection Criteria

From the volunteers recruited, a set of participants was selected which best met all the study criteria for age, sex, race, economic level, occupation, length of residence, and traffic density. For each of these parameters a set of guidelines was established for minimum restrictions and for selection of bias where more than sufficient candidate volunteers were available for a given category of participants.

(a) Age

The age groupings for participants were adjusted to mixinize usage of the volunteers available for selection. The minimum age for older persons was shifted from 60 years to 50 years due to insufficient members of volunteers in the 60 and over group. A small number of females who work at home were selected with ages less than 20 years due to multiple members of family being selected.

(b) Sex

For the preschool children, the design criteria included separate categories for males and for females. Because of the difficulties encountered in recruitment, the separate categories for males and females were combined to a single category and volunteers were selected on the basis of age rather than age and sex. For Site 1, sufficient volunteers were available to select equal numbers of males and females.

(c) Race

Of those persons volunteering for the study, only white, non-Spanish persons were selected to participate in the study.

(d) Economic Level

Study volunteers were obtained from areas of the city designated as middle class by use of census records and by direct observation of the apparent economic level of study neighborhoods.

(e) Occupation

The occupation of volunteers was restricted to those who were routinely occupied at home. For persons partially occupied away from home, a guideline cut off level of 20 hours per week was established and applied to candidate volunteers. If the candidate volunteers spent more than 20 hours a week (half-time of a normal 40 hour week) at an occupation (work, school, nursery, etc.) away from home, the volunteer was not accepted as a participant.

(f) Length of Residence

A minimum of 6 months residence was required of volunteers selected as participants.

(g) Traffic Density

Candidate volunteers were selected for each traffic density site on the basis of estimated traffic densities determined from maps and existing traffic records. Traffic on each of the streets from which volunteers were selected was counted during the study activities. The traffic counting activities and results are documented in Section IV. D. These actual traffic counts were used to replace the estimated counts used to initially assign candidate volunteers to specific traffic density sites. Thus, the final assignment of study participants to specific traffic density levels is based on measured rather than estimated traffic counts.

(h) Excess Volunteers

Where an excess of volunteers was available, selection of participants was based on two premises. First, for preschoolers and persons over 50 years, an equal number of males and females was desired. Secondly, in all age classes, an even distribution of ages was desired; i.e., equal representation of all ages within the category. Participants were selected to meet these goals as much as possible from the volunteers available.

For preschoolers, no surplus was available from the volunteers. All qualified volunteers were selected. For females in the middle group, all with preschool children enrolled as participants were selected first. Selection of the remainder was based on an even distribution of ages. In the older group, no excess of males was available. No excess of older group females was available in Site 4; all qualified volunteers were selected. In Sites 1,2, and 3, older females were selected on the basis of the best distribution of ages.

(3) Participating Households at Intersections

An analysis of the number of participating households at intersections is presented in Table 21. Of the total of 280 participating households, 55 were at intersections or a total of 19.6% of all residences.

Table 21. Number of Participating Households at Intersections

Parameter	Traffic Density				
	Site 1	Site 2	Site 3	Site 4	Total
Total Number of Households Contacted	545	485	409	411	1850
Total Number of Participating Households	76	70	79	55	280
Total Number of Participating Households at Intersections	5	7	29	14	55
% Participating Households at Intersections	6.6	10.0	36.6	25.4	19.6

The number at intersections varied considerably from lowest 6.6%, Site 1) to highest (36.6%, Site 3). A significant difference is also noted between the lower two traffic density sites (average of 8.2%) and the higher two traffic density sites (average 32.0%). This difference is explained in that more recruiting occurred in the higher two sites during stage 2 of the study. It was also taken into account that location on an intersection with very low traffic density is less important for thoroughfares with very high traffic densities (Sites 3 and 4) than for streets with less traffic density (Sites 1 and 2).

2. Description of the Study Participants

a. General Description

In the study reported herein, the participants who were selected and who actually provided the study with biological and other environmental samples can be generally characterized as white, middle class residents of a very urbanized community. Participating families have heads of household who are educated to the level of partial college education, as a median value. Of the adult participants, 32% are classified as smokers.

b. Paint Lead Restriction

Participants were selected without regard to paint lead at the outset. Biological and other samples were collected from all participants. The measurement for paint lead was analyzed after sample collection activities were complete. Participants with paint lead measurements in excess of 1% lead (1-4 mg/cm^2) were excluded from statistical analysis if the lead levels for these individuals were found to be elevated. Following this criterion, data were eliminated for four female participants and no male participants.

c. Demographic Characteristics

The demographic characteristics of selected participants is shown in Table 22. These characteristic patterns are representative of the volunteers excluded from the study as well as those selected as participants. The excluded volunteers were of essentially the same demographic structure as the participating volunteers. From Table 22 it may be seen that for the characteristics of number of persons routinely at home, median education, median length of residence, and median hours per week away from home, the participant characteristics are remarkably con-

Table 22. Participant Demographic Characteristics

Traffic Level	Number of Smokers	% Smokers (Adults)	Persons Routinely at home		Median Education*	Median Length of Residence	Median hrs/week away form home
			median	avg.			
1	23	26.4	2	1.9	6	6 yrs.	10
2	33	39.3	2	1.8	5	6 yrs.	10
3	32	34.8	2	1.8	6	6 yrs.	10
4	13	28.1	2	1.6	6	5 yrs.	10
Total	106	32.5	2	1.8	6	6 yrs.	10

*What is the highest educational level completed by your head of household?
(1) less than 8th grade
(2) 8th grade
(3) high school-incomplete
(4) high school-complete
(5) trade or vocational school beyond high school
(6) college-incomplete
(7) college (4 years)-complete
(8) post graduate

sistent for the four traffic density sites. The percentage of smokers does vary significantly between the highest 39.3%, Site 2) and the lowest (26.4%, Site 1). Sites 1-4 are sufficiently similar in demographic characteristics to serve as comparison groups for use in the study.

3. Environmental Data

a. Soil

Soil lead concentrations (μg/g) from outside 277 residences were examined to determine their relationship to traffic density. The frequency distributions of soil lead over all sites and within the four traffic densities (sites) are shown in Figures 46 and 47. Soil lead concentrations were significantly skewed to the right both in the overall distribution (skewness = 39.6) and in the four sites (skewness = 9.5, 20.4, 5.2, and 6.8 for sites 1-4, respectively). The critical value for skewness at $P = 0.05$ is 1.96. After a base 10 logarithmic transformation, the data were not significantly skewed (overall skewness = -0.85, skewness at sites = 0.13, -0.45, -0.33, 0.92). A single classification ANOVA was used to test for differences among the four sites using a log transformation to meet the assumptions for this test. There were significant differences in soil lead among the four sites at $P = 0.008$, $F = 4.0$. Multiple comparisons tests (Student-Newman-Keuls or SNK procedure) were done to determine at

Figure 46. Frequency Distribution of Soil Lead.

```
MIDPOINTS
 840.000)
 800.000)
 760.000)
 720.000)*
 680.000)
 640.000)*
 600.000)
 560.000)*
 520.000)
 480.000)*****
 440.000)**
 400.000)****
 360.000)***
 320.000)****
 280.000)********
 240.000)***********
 200.000)**************
 160.000)********************************
 120.000)M***********************************************
  80.000)************************************************************/[illegible]
  40.000)************************************************************/[illegible]
   0.0  )******
 -40.000)
 -80.000)
GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE
```

MEAN	127.568
S. DEV.	110.424
N	277.
MAXIMUM	730.090
MINIMUM	3.870

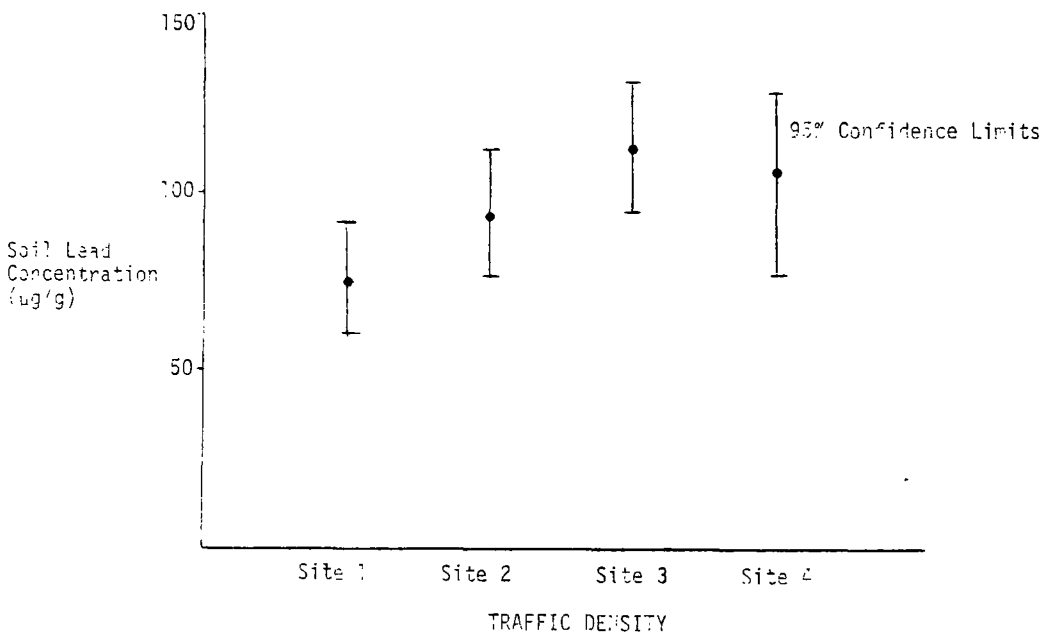
Figure 47. Frequency Distibution of Soil Lead at each Traffic Density.

```
          SITE 1                 SITE 2                  SITE 3                  SITE 4
          .......................*.......................*.......................*................

MIDPOINTS
 840.400)
 800.000)
 760.400)
 720.800)*
 680.000)
 640.000)                                                                        *
 600.000)
 560.000)                        *
 520.000)
 480.000)**                      *                       *                       *
 440.000)*                                               *
 400.000)*                                               ***
 360.400)                                                **                      *
 320.800)                        **                      *                       *
 280.000)***                     *                       **                      **
 240.000)*                       **                      *****                   ***
 200.400)**                      ****                    *****                   ***
 160.000)*****                   ***********             M*******                *******
 120.400)M********               M*************          ***************         M*******
  80.000)******************      ************            **********************21 ***************
  40.000)**********************28 *******************    ***********             *************
   0.0  )****                    *                       *
 -40.800)
 -84.400)
GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE
```

	SITE 1	SITE 2	SITE 3	SITE 4
MEAN	111.974	121.549	142.058	135.464
S. DEV.	125.244	97.654	105.338	110.514
N	75.000	69.000	79.000	55.000
MAXIMUM	730.090	540.840	492.970	620.190
MINIMUM	6.100	3.870	13.910	26.620

which sites soil concentrations were different. The SNK procedure is a posteriori test which delimits sets of means which are not significantly different but are within a larger set of means which are significantly different.[29] The four sites are listed below in increasing size of the mean (column 5), and nonsignificant sets of sites are underlined. The back-transformed means, their confidence limits (L_1 and L_2), and sample sizes (N) are also given. The relationship between these means is shown graphically in Figure 48.

Figure 48. Soil Lead vs. Traffic Density.



	Geometric Mean	L_1	L_2	N	Nonsignificant Sets of Means
Site 1	73.62	59.74	90.73	75	1 2 3 4
Site 2	92.26	76.21	111.69	68	
Site 3	110.92	94.44	130.27	79	
Site 4	105.93	87.92	127.62	55	

The means for soil lead in Sites 3 and 4 (>13,500 cars/day are significantly higher than in Sites 1 and 2 (<13,500 cars/day); and Sites 2, 3 and 4 (>8,000 cars/day) are significantly higher than Site 1 <600 cars/day). Although the mean for Site 3 is higher than the mean for Site 4, the difference is not significant. When the means are ranked in increasing order (as shown above), they are also in order of increasing traffic density (with the exception of Sites 3 and 4 in which soil lead concentrations are approximately the same).

The relationship between soil lead and actual traffic counts for the residences can be further described by the regression equation: $y = 117.60 + 0.80 X$, where y = soil lead (µg/g) and X = traffic count/1000. This regression equation must be interpreted with caution; however, since only 0.5% of the variation soil lead has been explained ($R^2 = 0.0049$). When R^2 is small (<0.04), the variance around the regression is almost as large as the original variance of y (soil lead) and interpretation of the regression is inadvisable.[30] Examination of scatter plots and residuals did not suggest any transformations for this range of traffic counts. The soil lead concentrations and corresponding traffic counts are listed in Appendix E.

A study was performed to determine how selected soil characteristics would effect the availability of lead deposited on soil from auto emissions in the study areas. This study was conducted by an independent soil chemist and the detailed report is given in Appendix J.

The soil characteristics examined were texture, clay minerology, organic content, and pH. The texture of the soils varied but a majority contained a clay content which would favor retention of divalent Pb deposited from auto emissions. This clay texture makes the soils less permeable to rain water and would minimize the amount of downward transportation of Pb from the top soils. This would also favor runoff from the top soil layers during heavy thunderstorms.

A majority (80%) of the soils had moderately high to high organic contents. Due to the complexing and chelating agents normally present in organic matter, it is reasonable to believe these soils would favor retention of Pb.

Most of the soil was within a pH range of 7.0 to 8.0. This along with the high carbonate and sulfate ion content of the soils in this area favor the formation of insoluble Pb carbonates, phosphates and sulfates. These compounds are not likely to be leached from the soils thereby favoring retention of the Pb. About 20% of the soils examined showed signs of alteration of the natural texture of the soils. This is thought to be the mixing of fluvial sands to improve the plant growth characteristics of the soils. The addition of this sand does not favor Pb retention on these particular soils.

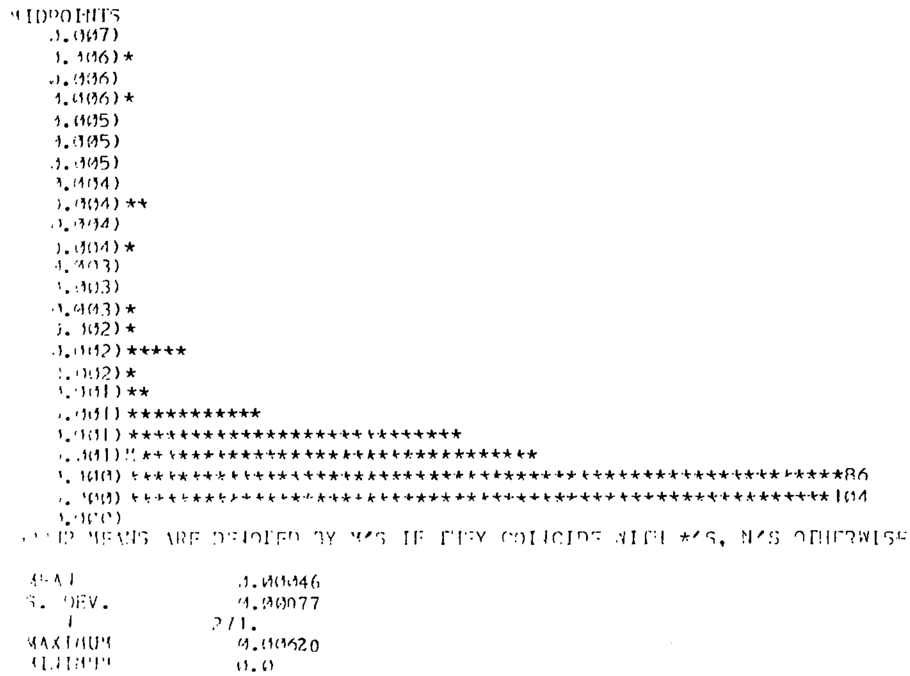
The soil samples studied in the Dallas county-Arlington area indicated retention of Pb deposited on them would be favored and leaching by environmental factors (i.e., rainfall) would be minimal.

Conclusions: There were significant differences in soil lead concentrations among the four sites with Sites 1 and 2 (lower traffic density) significantly lower than Sites 3 and 4 (higher traffic density). No linear (or nonlinear) relationship could be described for these data. In the study of soil characteristics, the majority of the soils were high in clay content and in organic matter. These types of soils have a high potential for adsorption and storage of lead and formation of relatively insoluble precipitates of lead. The clay soils retain lead deposited on and adsorbed by them; however, low permeability of the clay may reduce initial infiltration during heavy rainfall.

b. Tap Water

Tap water samples were taken from 271 residences for determination of lead content (μg/ml.). Because drinking water is a source of lead, it was necessary to determine the exact levels to which the participants of this study were exposed and whether these lead levels varied over the four traffic density sites. The frequency distributions for the variable water lead over all sites and for each site are shown in Figures 49 and 50. The data are very skewed to the right because of the large number

Figure 49. Frequency Distribution of Tap Water Lead.



of very low values (103 of the total 271 were below the detection limit of 0.0002 μg/ml and are recorded as zeroes). Transformations of the data did not correct the skewness; therefore, a nonparametric test (Kruskal-Wallis one way ANOVA) was used to determine whether there were differences in water lead among traffic sites. The results (Table 23) indicate that lead content is similar in Sites 1, 2, and 4; and the significant difference is caused by low lead content in Site 3. Therefore, no adjustments were made for additional sources of lead in water. Means and 95%

Figure 50. Frequency Distribution of Tap Water Lead at each Traffic Density.

```
          SITE 1                       SITE 2                   SITE 3                      SITE 4
MIDPOINTS
   0.007)
   0.006)                                                                                   *
   0.006)
   0.006)                     *
   0.005)
   0.005)
   0.005)
   0.004)
   0.004)*                    *
   0.004)
   0.004)                     *
   0.003)
   0.003)
   0.003)                                              *
   0.002)                                                                                   *
   0.002)**                   **                                                            *
   0.002)*
   0.001)**
   0.001)****                 **                       *                                    ****
   0.001)*********            *****                    *******                              *****
   0.001)M*************       M***                     ********                             M******
   0.000)********************* **********************  M**********************28            ******************
  -0.000)**********************24 **********************31 ***********************32         *****************
  -0.000)
GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

 MEAN         0.00052          0.00049          0.00030          0.00057
S. DEV.       0.00067          0.00100          0.00042          0.00097
  N          75.000           67.000           77.000           52.000
MAXIMUM       0.00430          0.00580          0.00280          0.00620
MINIMUM       0.0              0.0              0.0              0.0
```

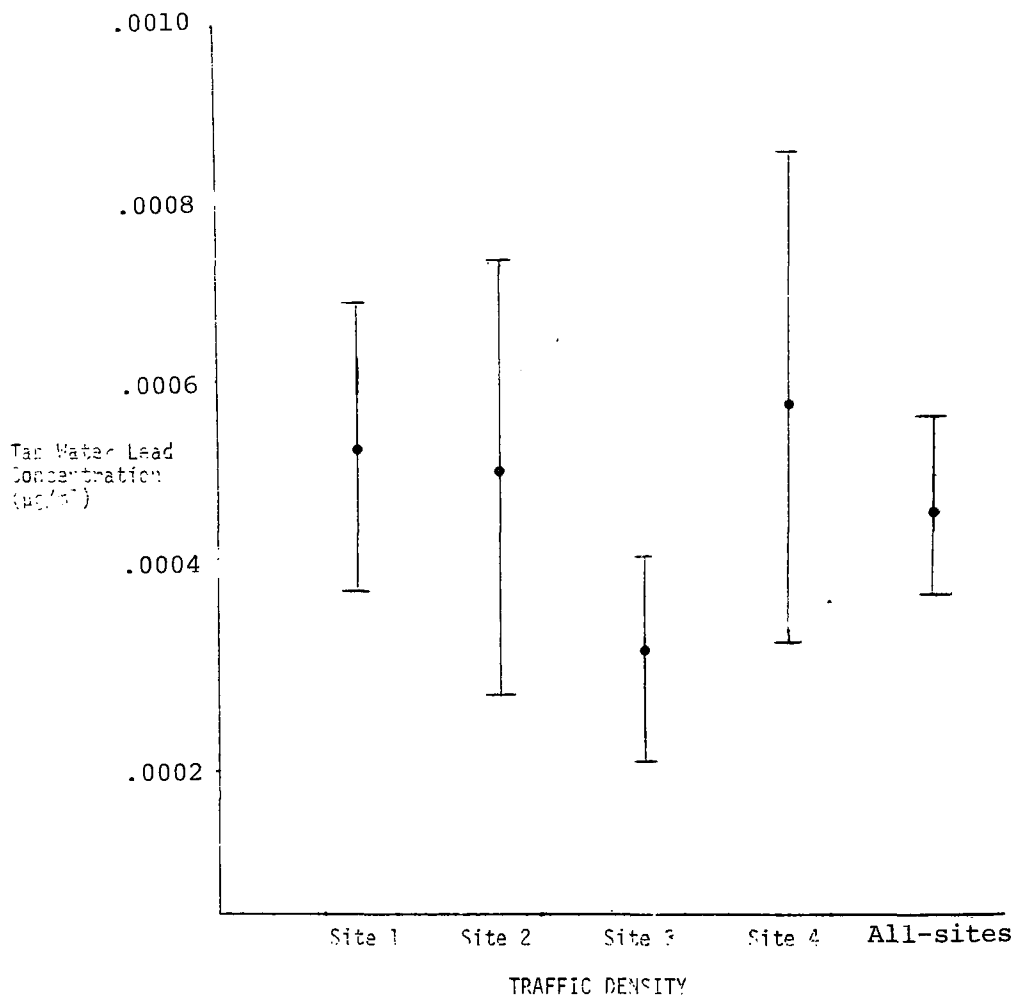
confidence limits at each site and over all sites are shown in Figure 51. The mean lead concentration in tap water from all sites was 0.00046 ± 0.000047 μg/ml.

Table 23. Test for Differences Among Sites in H_2O Lead Concentration (μg/ml) Using Kruskal-Wallis Test

	N	Rank Sum	Mean	SE of Mean
Site 1	75	11280.5	0.00052	0.0000778
Site 2	67	8249.0	0.00049	0.0001224
Site 3	77	9571.0	0.00030	0.0000474
Site 4	52	7755.5	0.00057	0.0001349

Kruskal-Wallis test statistic = 7.99*, Prob. = 0.045
All Sites: Mean ± SE = 0.00046 ± 0.000047 μg/ml

Figure 51. Tap Water Lead Concentration vs. Traffic Density.



<u>Conclusions:</u> Lead content in drinking water was similar in Sites 1, 2, and 4 and lower in Site 3. No adjustments were made for an additional source of lead via drinking water.

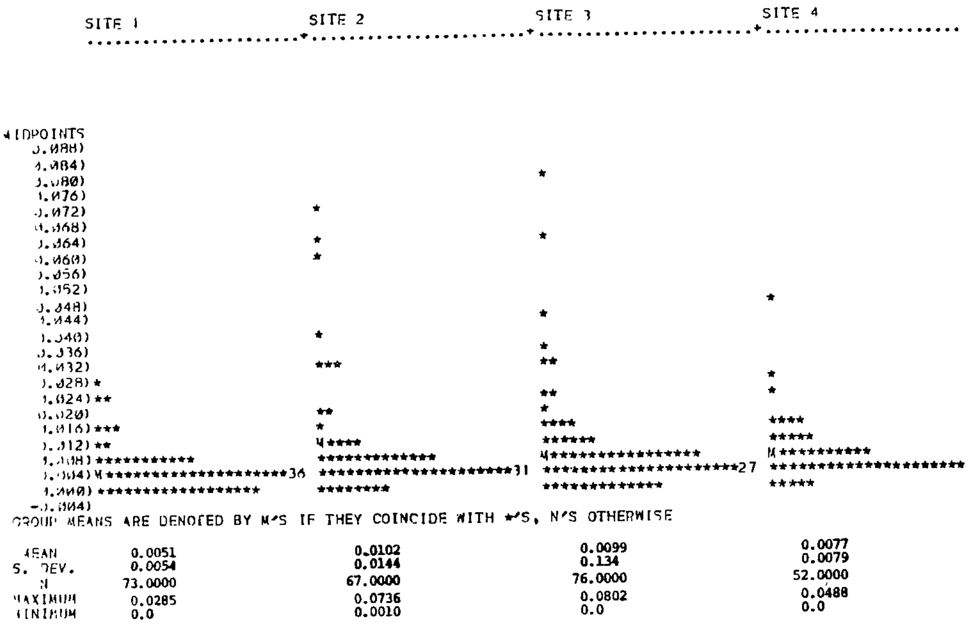
c. Indoor Dust

Indoor dust samples (28-day dustfall) were taken at 268 residences. In some cases, the dust tray could not be collected on the 28th day; therefore, all dust lead values were adjusted to a 28-day base. The adjusted dust lead concentrations (μg/cm^2) and the number of collection days are given in Appendix E. Frequency distributions of the variable indoor dust lead over all traffic densities (Figure 52) and for each site (Figure 53) were examined. The mean indoor dust was highest in Site 2 and a relationship with increasing traffic density is not apparent. Regression analysis explained only 0.7% of the variation in indoor dust lead (R^2 = 0.0065); y = 0.0070 + 0.0001 X, where y = indoor dust lead (μg/cm^2)

Figure 52. Frequency Distribution of Indoor Dust Lead.

```
MIDPOINTS
  0.088)
  0.084)
  0.080)*
  0.076)
  0.072)*
  0.068)
  0.064)**
  0.060)*
  0.056)
  0.052)
  0.048)*
  0.044)*
  0.040)*
  0.036)*
  0.032)*****
  0.028)**
  0.024)*****
  0.020)***
  0.016)*************
  0.012)********************
  0.008)M*********************************************************
  0.004)***************************************************************118
  0.000)*************************************************
 -0.004)
GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

MEAN          0.0082
S. DEV.       0.0112
N           268.0000
MAXIMUM       0.0802
MINIMUM       0.0
```

Figure 53. Frequency Distribution of Indoor Dust Lead at each Traffic Density.



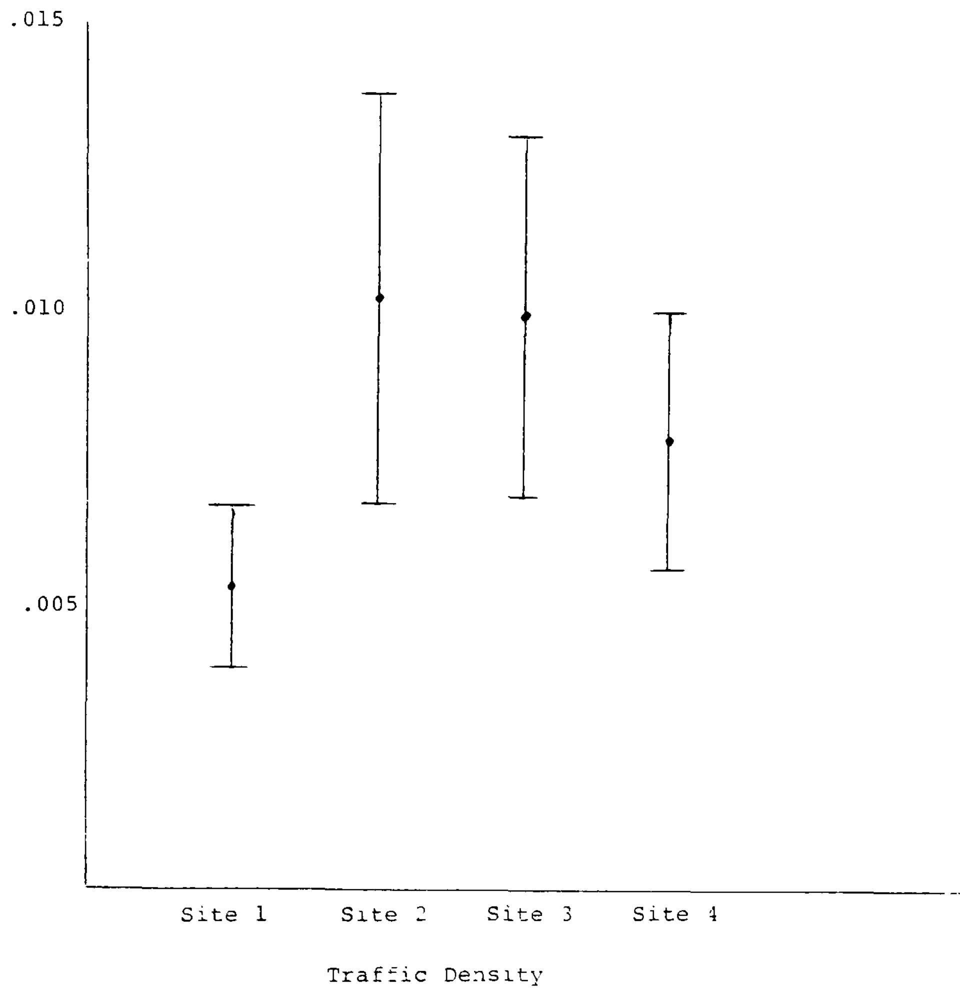
and X = traffic count/1000. Scatter plots did not suggest any transformations. The means and 95% confidence limits for each site and all sites are shown in Figure 54.

Conclusions: No detectable relationship between traffic density and lead concentration in indoor dust samples was found.

d. Windowsill Wipes

Windowsill wipes were taken at 258 residences and the lead content of each was measured. Frequency distributions of the variable windowsill wipe lead over all sites and at each site are shown in Figures 55 and 56. Two outliers were rejected: 1.9540 in Site 2 and 4.6857

Figure 54. Indoor Dust Lead vs Traffic Density



in Site 3 which were 5.5 and 13.3 standard deviations above the overall mean (P<< .001). Means and confidence limits of each site and over all sites are shown in Figure 57.

Figure 55. Frequency Distribution of Windowsill Wipe Lead

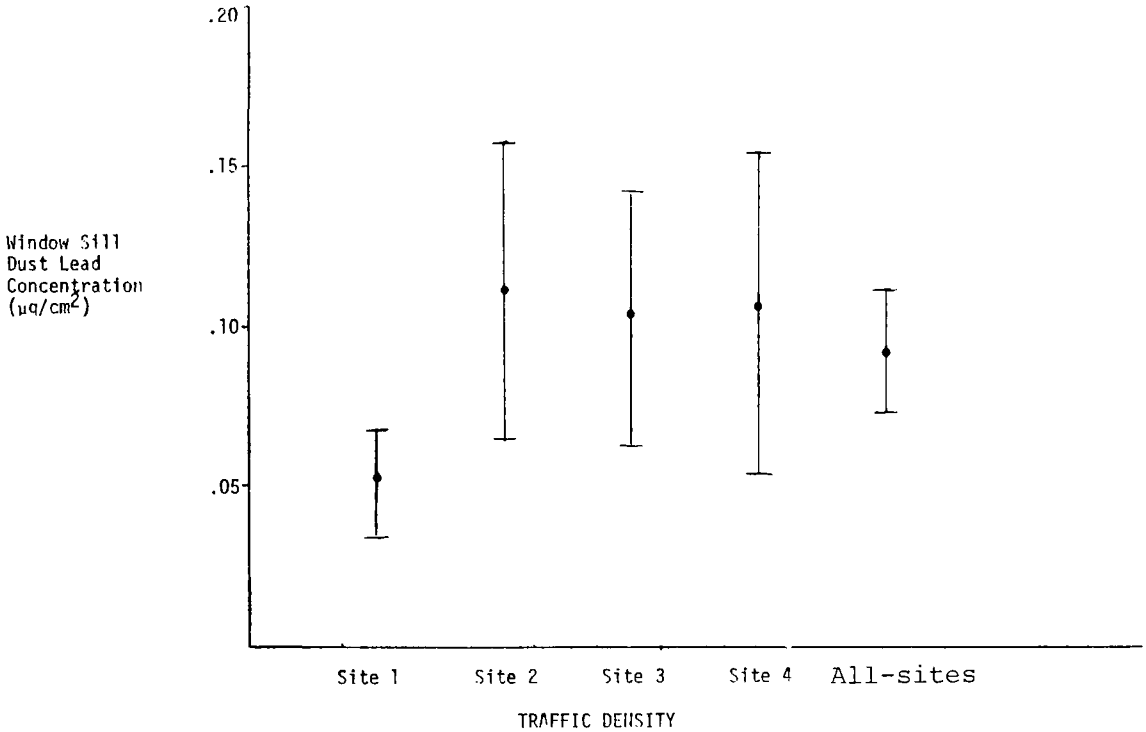
```
EXCLUDED
 VALUES(1)
          **
           TABULATIONS AND COMPUTATIONS WHICH FOLLOW EXCLUDE VALUES LISTED ABOVE
MIDPOINTS
   1.050)
   1.000)
   0.950)
   0.900)**
   0.850)*
   0.800)**
   0.750)
   0.700)*
   0.650)
   0.600)*
   0.550)**
   0.500)*
   0.450)**
   0.400)**
   0.350)****
   0.300)****
   0.250)****
   0.200)*********
   0.150)***************
   0.100)M**********************
   0.050)***********************************************************79
  -0.000)***********************************************************104
  -0.050)
  -0.100)
GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

 MEAN          0.092
S. DEV.        0.155
  N          256.000
MAXIMUM        0.911
MINIMUM        0.0
```

(1) Excluded values are 1.9540 (Site 2) and 4.6857 (Site 3).

Figure 56. Frequency Distribution of Windowsill Wipe Lead at each Traffic Density.

```
           SITE 1                  SITE 2                   SITE 3                  SITE 4
           ......................+......................+......................+....................

EXCLUDED
 VALUES
                                  *(1)                     * (2)

            TABULATIONS AND COMPUTATIONS WHICH FOLLOW EXCLUDE VALUES LISTED ABOVE
MIDPOINTS
    1.050)
    1.000)
    0.950)
    0.900)                        *                                                 *
    0.850)                                                 *
    0.800)                        *                                                 *
    0.750)
    0.700)                                                 *
    0.650)
    0.600)                                                 *
    0.550)                                                 *                        *
    0.500)                        *
    0.450)                        *                        *
    0.400)*                       *
    0.350)                        **                       *                        *
    0.300)*                                                ***
    0.250)*                       *                        **
    0.200)*                       ****                     **                       **
    0.150)***                     ****                     ***                      *****
    0.100)*******                 M***                     N****                    N******
    0.050)M*******************    *********************    ***********************24 **************
   -0.000)*********************35 ********************     ***********************29 ********************
   -0.050)
   -0.100)
GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

 MEAN       0.052                 0.112                    0.103                    0.105
S. DEV.     0.072                 0.179                    0.168                    0.179
   N       69.000                61.000                   74.000                   52.000
MAXIMUM     0.414                 0.898                    0.871                    0.911
MINIMUM     0.0                   0.001                    0.0                      0.0
(1) 1.9540,  (2) 4.6857
```

Figure 57. Windowsill Wipe Lead vs.Traffic Density.



Examination of the means reveals no relationship between windowsill lead and traffic density. Scatter plots did not indicate any appropriate transformations, and only 1% of the variation was explained by regression of windowsill lead on traffic counts (Y = 0.0718 + 0.0016 X, where Y = windowsill lead and X = traffic count/1000). Mean lead content in windowsill wipe lead concentrations with corresponding traffic counts are given in Appendix E.

Conclusions: No significant relationship could be found between lead in windowsill wipes and traffic density.

e. Hand-wipes

The lead measured in hand-wipes from 122 children was examined with respect to traffic counts and blood lead (see Appendix F). The rationale for hand-wipe analysis is that small children playing outside will come in more direct contact with lead in soil and outside dust and can transfer this lead into their bodies by putting their hands into their mouths. The frequency distribution of the variable hand-wipe lead over all sites and for each site are shown in Figures 58 and 59. Hand-wipe lead values were regressed on traffic counts with the results that only a small amount of variation (6.2%) in hand-wipe lead was explained ($y = 7.35 + 0.20\ X$, where y - hand-wipe lead and X = traffic count/1000). The relationship between blood lead and hand-wipe lead was also examined but only 0.3% of the variation in blood lead was explained by lead on children's hands. The means and confidence limits for hand-wipe lead ($\mu g/cm^2$) over all sites and at each traffic density site are given in Figure 60; the mean hand-wipe lead concentration over all sites was $9.3 \pm 0.65\ \mu g/cm^2$.

Conclusions: No substantial relationships were found between lead in hand-wipe samples and traffic counts or between blood lead and hand-wipe lead.

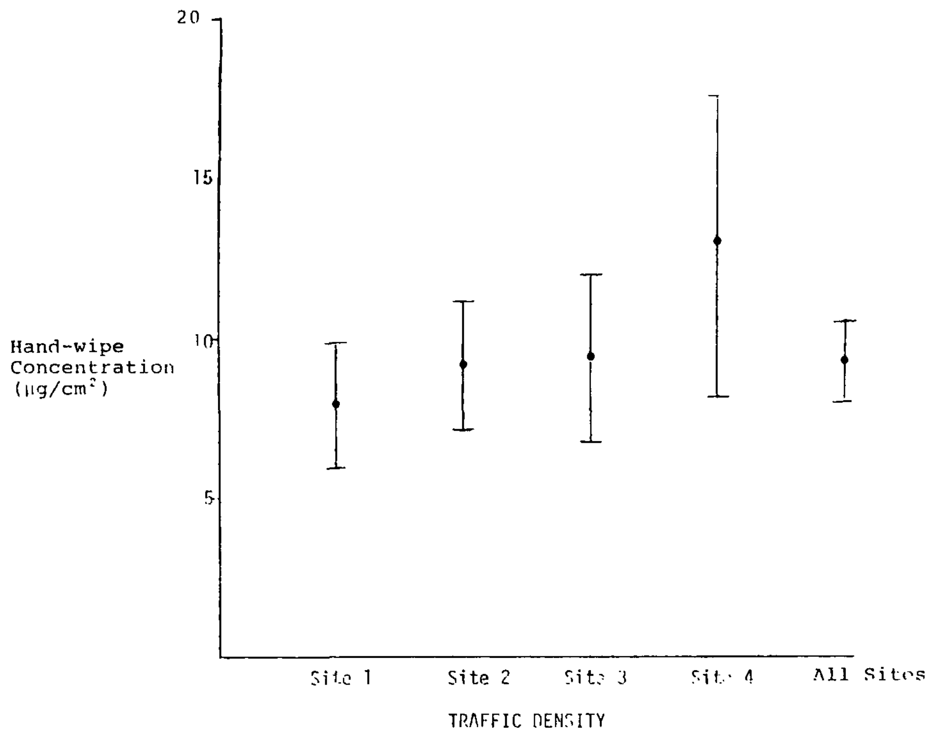
Figure 58. Frequency Distribution of Hand-wipe Lead.

```
          ..................................................................+......
MIDPOINTS
 51.000)
 48.000)
 45.000)
 42.000)*
 39.000)*
 36.000)
 33.000)
 30.000)**
 27.000)*
 24.000)**
 21.000)***
 18.000)********
 15.000)***
 12.000)****************
  9.000)M****************
  6.000)**************************************
  3.000)*******************************
   .   )
 -3.000)
 -6.000)
 MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

MEAN              9.378
S. DEV.           7.173
  N             121.
MAXIMUM          41.410
MINIMUM           1.600
```

Figure 59. Frequency Distribution of Hand-wipe Lead at each Traffic Density.

```
          SITE 1                    SITE 2                      SITE 3                     SITE 4
        ....................+.......................:+......................+.............
MIDPOINTS
  51.000)
  48.000)
  45.000)
  42.000)                                                                        *
  39.000)*
  36.000)
  33.000)
  30.000)                                                                        **
  27.000)*
  24.000)                   *                        *
  21.000)                   **                       *
  18.000)*                  **                       ***                         **
  15.000)*                  *                                                    *
  12.000)******             ****                     **                          M***
   9.000)M******            M****                    M*                          **
   6.000)**************     **********               **********                  ****
   3.000)**************     *******                  *****                       ****
   0.0  )
  -3.000)
  -6.000)
GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

MEAN        7.898                9.177                    9.405                    12.998
S. DEV.     6.789                5.646                    6.091                    10.114
N          45.000               32.000                   24.000                    20.000
MAXIMUM    39.730               23.240                   23.800                    41.410
MINIMUM     1.600                2.770                    3.030                     3.380
```

Figure 60. Hand-Wipe Lead vs Traffic Density



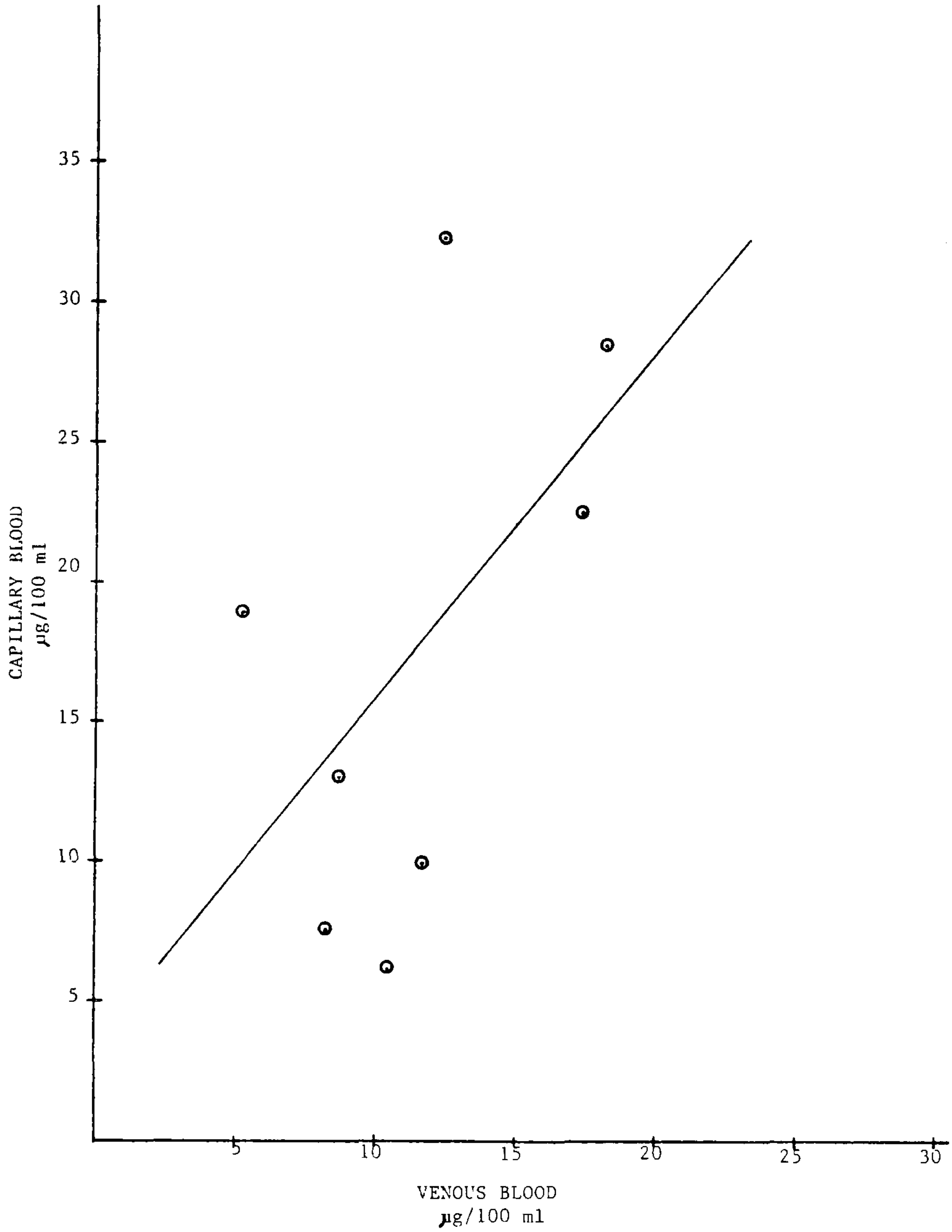
4. Biological Data

a. Blood

(1) Distribution of Variable Blood Lead

Venipuncture was the preferred method for blood collection and was used for all adults and children when possible. When the child or the parent of the child would not agree to venipuncture, a fingerprick sample was taken. Of 235 blood samples from children, 66% (154) were fingerprick and the remaining 81 were venipuncture samples. For comparison of the two methods, both types were collected from some participants. Eight participants allowed both fingerprick and venipuncture samples to be taken on the same day, and the blood lead levels were determined. Venous blood lead vs fingerprick blood lead levels for each of these participants is plotted in Figure 61. The slope of the fitted line is 1.24. Using these 8 matched pairs, the difference between the methods was examined using a paired comparisons t-test and was not significant (t=1.80, P=0.11). With log transformed data, the variances from these two groups of 8 were homogeneous. This means that the blood lead levels from fingerprick samples were not significantly higher or lower than matched venipuncture samples. However, the fingerprick method was significantly more variable as indicated by a F test comparing the variances of fingerprick samples (n = 154) and venipuncture samples (n = 81) from all children (F = 2.09, P <.001). This relationship is approximately the same in the smaller sex-age-site groups of children. Exclusion of the more variable fingerprick samples would cause sample size in most sex-site groups for children to be inadequate for interpretation of the analysis; therefore, the alternatives were to either combine the methods or omit the venipuncture samples for children using only fingerprick samples. The second alternative would also result in small samples in

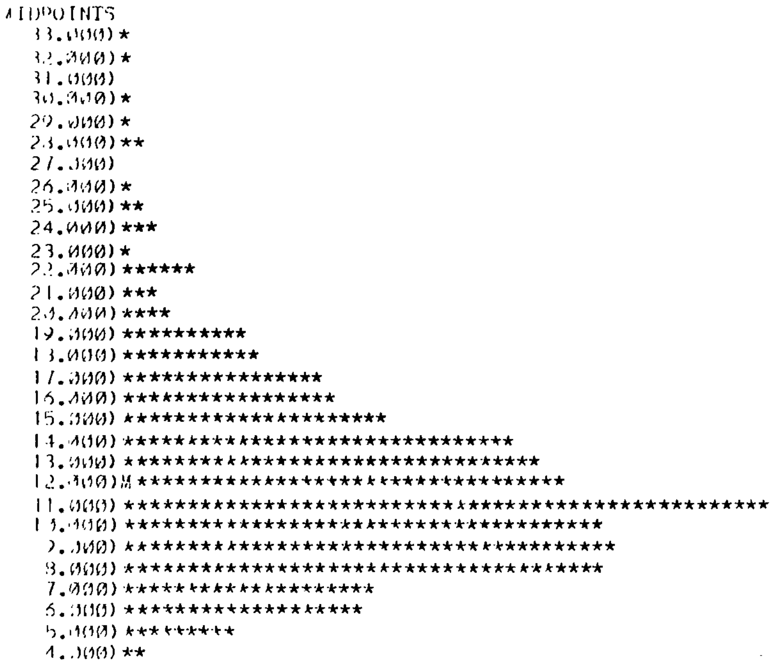
Figure 61. Venous Blood Lead vs Capillary Blood Lead Samples from the Same Participant.



some groups; i.e., Site 4. Since both methods were used in every sex and site group (for children) in approximately the proportions mentioned above (2 fingerprick: 1 venous), it was decided to use the combined methods for analysis.

The site, sex, age, and blood analyses for each participant are given in Appendix G. Finger prick blood lead concentrations are listed in Appendix H. Two blood samples were taken one week apart from each participant. Evaluation of the paired venous blood samples using a paired t-test on log transformed data indicated there was no significant difference between the two samples (mean difference = 0.14 μg/100 ml, $t = 0.85$, $P = 0.39$); the same analysis performed on finger-prick blood lead samples showed no significant difference in samples 1 and 2 (mean difference = 0.56, $t = 0.21$, $P = 0.84$). The two samples from each participant were therefore averaged for most of the statistical analyses. The frequency distribution of mean blood lead over all participants excluding those eliminated from analysis due to other lead exposures (see page 208) is shown in Figure 62. The frequency distribution of the mean blood lead for each age-sex group and for each traffic density are shown in Figures 63 and 64, with the same exclusions as above. The overall frequency distribution was significantly skewed to the right ($P = 5 \times 10^{-7}$) as were most of the smaller age-sex and site groups. A log transformation caused the data to be normally distributed. Blood samples 1 and 2 were not averaged for the ANOVA as in the other analyses. In the ANOVA, differences between samples 1 and 2 were examined in each analysis. For this reason, the frequency distribution for all blood samples ($n = 708$) was

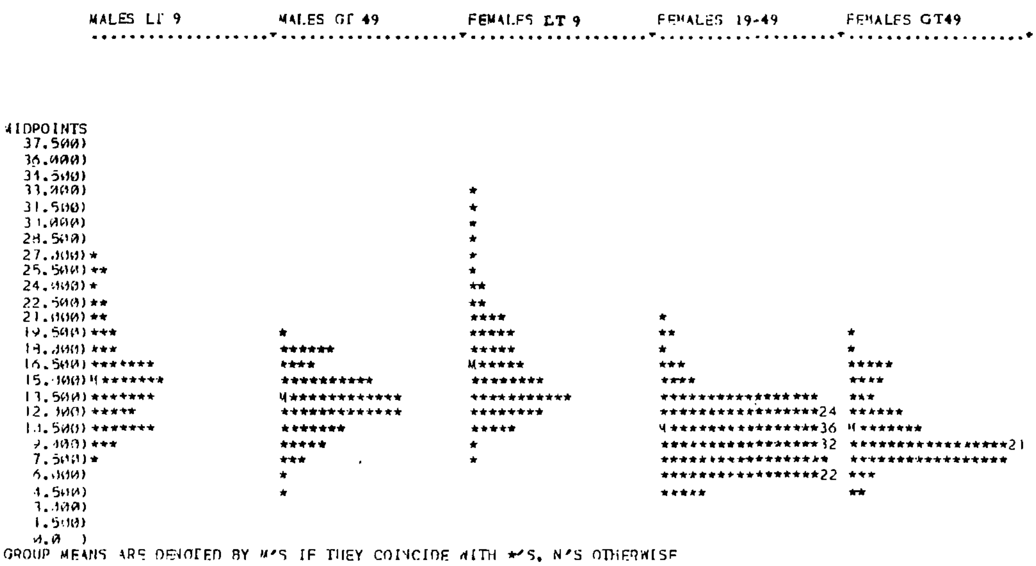
Figure 62. Frequency Distribution of Mean Blood Lead.



GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

MEAN	12.193
S. DEV.	4.624
N	416.000
MAXIMUM	33.000
MINIMUM	4.290

Figure 63. Frequency Distribution of Mean Blood Lead for each Age and Sex Group.

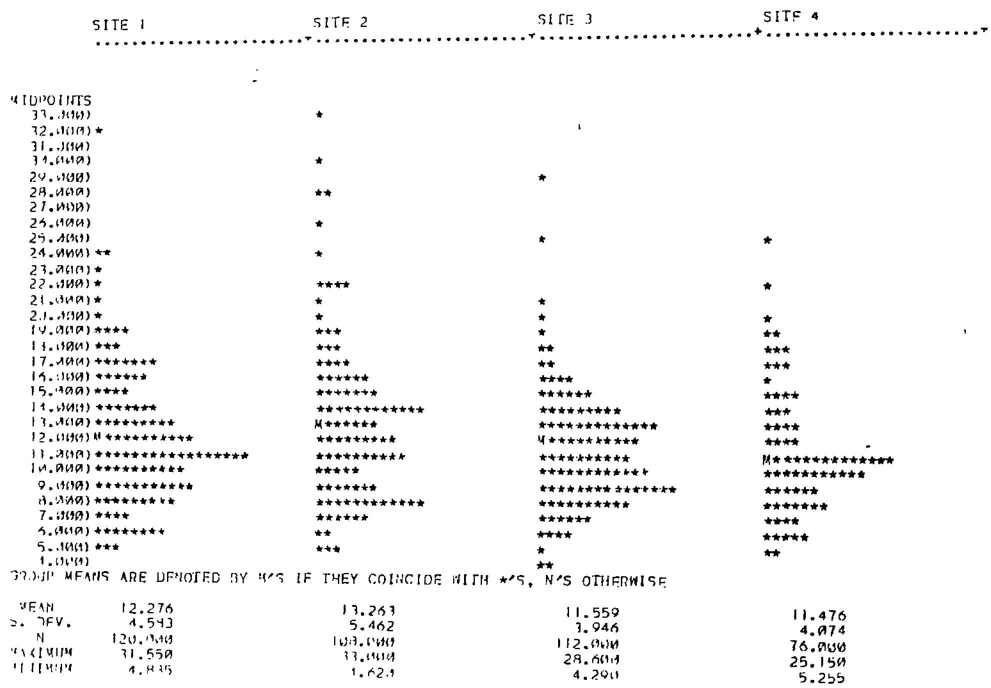


GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

	MALES LT 9	MALES GT 49	FEMALES LT 9	FEMALES 19-49	FEMALES GT49
MEAN	15.424	12.929	16.714	10.065	10.034
S. DEV.	4.626	3.146	5.515	3.064	3.247
N	52.000	64.000	64.000	165.000	71.000
MAXIMUM	27.520	19.075	33.000	21.585	19.085
MINIMUM	7.650	4.410	7.250	4.620	4.290

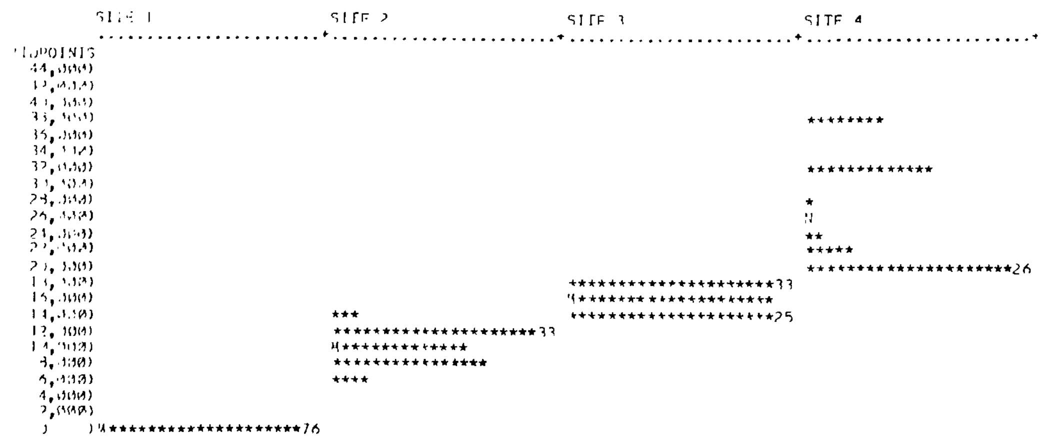
examined and found to be normally distributed after log transformation. The distribution of all fingerprick blood lead was also normal after log transformation.

Figure 64. Frequency distribution of mean blood lead at each traffic density.



The distribution of traffic counts for the 280 households of the participants is shown below: There is no overlap among the sites because these traffic counts were used to assign households to sites. The mean traffic count, number of residences in a site (N), and minimum and maximum traffic counts are given for each site and over all sites.

Frequency Distribution of Traffic Counts for Households for Participants by Sites



GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

	Site 1	Site 2	Site 3	Site 4
MEAN	382	10,251	16,301	25,964
S. DEV.	141	2,152	1,967	6,714
N	76	70	79	55
MAXIMUM	599	13,072	19,000	37,850
MINIMUM	155	5,918	13,684	19,578

MEAN	12,366
S. DEV.	9,593
N	280
MAXIMUM	37,850
MINIMUM	155

<u>Conclusions</u>: The venipuncture and finger-prick blood samples for children were combined for statistical analysis. Normal distribution of the variable blood lead can be achieved using a logarithmic transformation.

(2) <u>Screening Variables</u>

Tap water and house paint were samples at each residence and measured for lead content so that these potential sources of lead would not confound the results of the blood lead analyses. Lead in tap water was discussed in

Section III B 3 b and no adjustments will be made for additional sources of lead in water.

Lead measurements were made on 985 painted surfaces in the 280 households (two indoor and two outdoor at each house) and are listed in Appendix I. The means, their standard errors, and sample sizes for indoor paint lead and outdoor paint lead for each of the four traffic density sites are given in Table 24; means and confidence limits are plotted in Figure 65. A measurement of 1.0 to 4.0 mg Pb/cm^2 paint (depending on the thickness of the paint) corresponds to 1% lead content in paint. Using the highest paint lead value obtained, forty-four percent (124/280) of the residences had a paint lead value over 1.0 mg/cm^2. Eight percent (23/280) had a paint lead value over 4.0 mg/cm^2 therefore, this level was used as a screening level for excessive lead in paint. The blood lead levels of participant residing in a house with any paint value 4.0 mg/cm^2 was examined (39 participants, 12 of these 39 were children). Figure 66 shows the frequency distribution of blood lead of participants residing in houses with paint lead above and below 4.0 mg/cm^2. Blood lead of participants who had used pottery for food containe

Table 24. Paint Lead Concentration (mg/cm^2): Means, their Standard Errors and Sample Sizes for Indoor and Outdoor Paint Lead at each Traffic Site.

		Indoor Paint Lead	Outdoor Paint Lead
Site 1	Mean ±SE	0.21 ± 0.041	1.10 ± 0.167
	N	152	125
Site 2	Mean ±SE	0.22 ± 0.070	1.04 ± 0.148
	N	138	108
Site 3	Mean ±SE	0.44 ± 0.137	1.22 ± 0.209
	N	153	121
Site 4	Mean ±SE	0.10 ± 0.026	0.84 ± 0.167
	N	108	80

Figure 65. Paint Lead vs Traffic Density

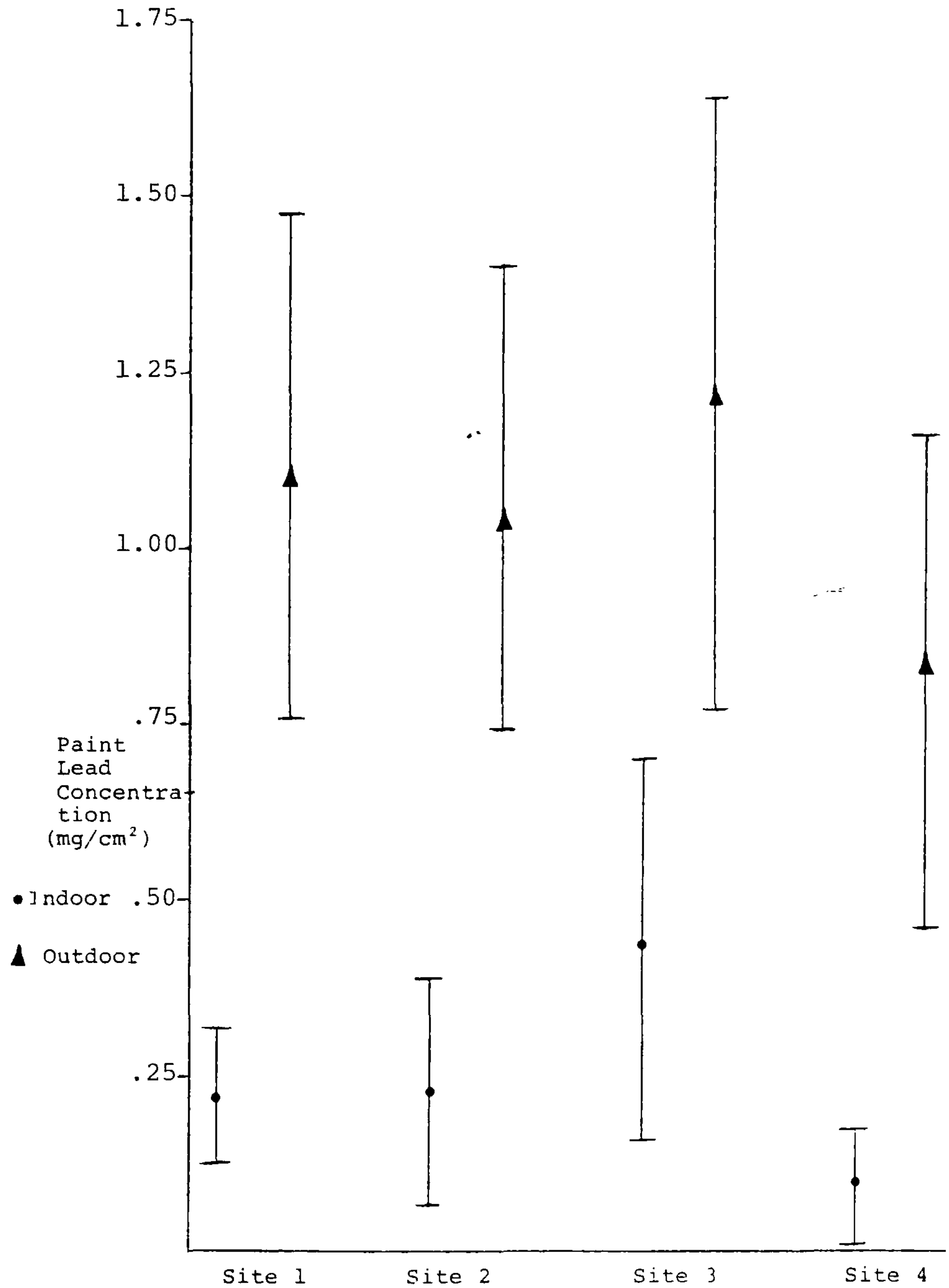
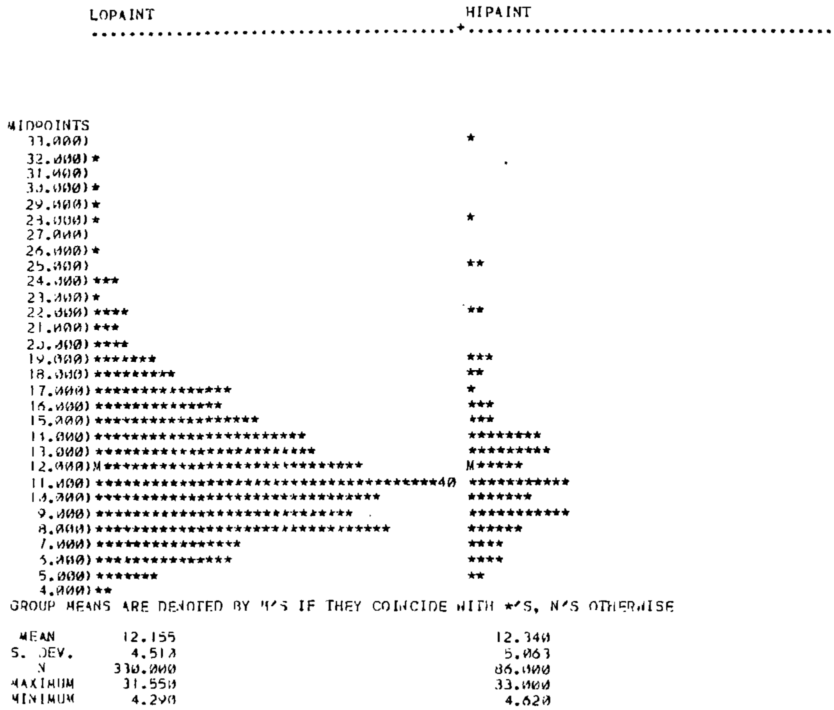


Figure 66. Frequency Distribibition of Mean Blood Lead Levels of Participants exposed to Paint Lead below and above 4.0 mg/cm² in their homes.



(47), had hobbies or occupations involving lead (44 and 9), and children who often played near the street (13) were also examined. Because there was some overlap, the total number of participants examined was 127. Each log (blood lead) for each of these participants was compared to the mean for that age-sex-site group. Only those which were higher than the mean were tested using Dixon's test for extreme values: $B_1 = (x_n - \bar{x})/\sigma$ (28), where x_n = the blood lead measurement, $\bar{x}$ = the mean for that age-sex-site group, and s = an independent estimate of the standard deviation. The standard deviation of all venous blood samples (n = 708) was used as the independent estimate of σ. The analogous fingerprick standard deviation (n = 160) was used for the fingerprick blood samples. Because these are screening variables, a very conservative level of a (0.10) was set which rejected cases greater than 1.3 standard deviations above the mean. This is a one-tailed test, because the alternative hypothesis is that the mean of these blood lead values is higher due to this additional exposure to lead.

Twenty-nine blood samples from 20 of the 127 participants were found to be outliers ($P<0.10$). This means that 29 blood lead measurements were greater than 1.3 standard deviations (one-tailed test) above the mean for their respective age-sex-site group. From a table of areas of a normal curve, we see that 9.68% or 84 of the 868 blood samples are expected to be this deviant in a normally distributed variable and we have examined approximately 30% of the total participants (127 of 441). Therefore, more stringent requirements for rejection were sought. Ten of these participants were found to have significantly high blood lead in both samples. These 10 were rejected. Their blood lead measurements and probabilities are shown in Table 25.

Conclusions: Six screening variables (tap water, house paint, pottery, hobbies, occupations, and playsites near street) were examined as additional sources of lead exposure. The blood lead levels of 127 participants who could have been exposed to lead from

Table 25. Results of Test for Extreme Values (Dixon's B_1 Test) on Blood Samples of Participants Potentially Exposed to Other Lead Sources

ID #	Site	Sex	Age	Exposure[b]	Mean[a]	Bl 1[c]	P	Bl 2	P	df
2412	1	M	55	2, 3	14.55	25.38	.067	25.21	.070	28
0076	1	F	31	1, 2, 5	8.98	18.73	.022	27.50	.001	95
0276	1	F	38	2	8.98	17.00	.040	15.69	.063	95
0067	1	F	42	5	8.98	16.42	.049	16.07	.055	95
5397	2	F	54	2	9.97	15.74	.106	19.95	.031	41
9326	2	F	66	2	9.97	19.47	.036	17.58	.062	41
5498	3	F	1	5	15.93	28.50	.093	40.60	.019	30
5626	3	F	31	1, 2, 3	10.15	17.01	.078	16.23	.099	93
3311	3	F	54	1	8.96	16.25	.053	18.73	.024	42
7821	4	F	36	1	9.30	15.16	.090	19.27	.024	74

a antilog of mean of log y

[b]Exposure Code

1 Paint
2 Hobby
3 Job
4 Plays near street
5 Pottery

c Bl 1 blood sample 1, Bl 2 blood sample 2

one or more of these sources were examined, and 10 participants were rejected as outliers.

(3) Blood Lead vs Traffic Density

Two way ANOVA was used to test for differences in blood lead among sites and among samples (1 and 2) for each age-sex group. The ANOVA was mixed-model with sites fixed and samples as random effects. Interaction and error mean squares were pooled for testing the fixed effects according to the rules proposed by Bancroft[31]. The results are shown in Table 26. There are significant differences among sites at P<0.05 in all sex-age groups except males >49. No significant differences between samples 1 and 2 are seen in any groups nor are there any significant interactions (sites x samples).

Table 26. Two-Way ANOVA of the Effects of Sites and Samples on Log(Blood Lead) for Each Age-Sex Group

Males < 9

Source	DF	MS	F Ratio	Prob.	Nonsignificant Sites
Sites	3	0.1034	4.2033	0.0076	3 < 1 < 4 < 2
Samples	1	0.0017	0.0670	0.7963	
Sites*Samp	3	0.0027	0.1080	0.9553	
Error	98	0.0252			

Males > 49

Source	DF	MS	F Ratio	Prob.	Nonsignificant Sites
Sites	3	0.0377	2.2575	0.0850	3 < 2 < 4 < 1
Samples	1	0.0002	0.0139	0.9064	
Sites*Samp	3	0.0114	0.6736	0.5698	
Error	121	0.0169			

Females < 9

Source	DF	MS	F Ratio	Prob.	Nonsignificant Sites
Sites	3	0.0868	3.3806	0.0205	4 < 3 < 1 < 2
Samples	1	0.0601	2.2891	0.1329	
Sites*Samp	3	0.0015	0.0580	0.9816	
Error	121	0.0263			

Females 19-49

Source	DF	MS	F Ratio	Prob.	Nonsignificant Sites
Sites	3	0.0807	4.4039	0.0076	1 < 4 < 2 < 3
Samples	1	0.0126	0.6270	0.4290	
Sites*Samp	3	0.0065	0.3251	0.8072	
Error	328	0.0201			

Females > 49

Source	DF	MS	F Ratio	Prob.	Nonsignificant Sites
Sites	3	0.0685	3.3438	0.0211	3 < 4 < 2 < 1
Samples	1	0.0044	0.2111	0.6467	
Sites*Samp	3	0.0068	0.3293	0.8042	
Error	136	0.0208			

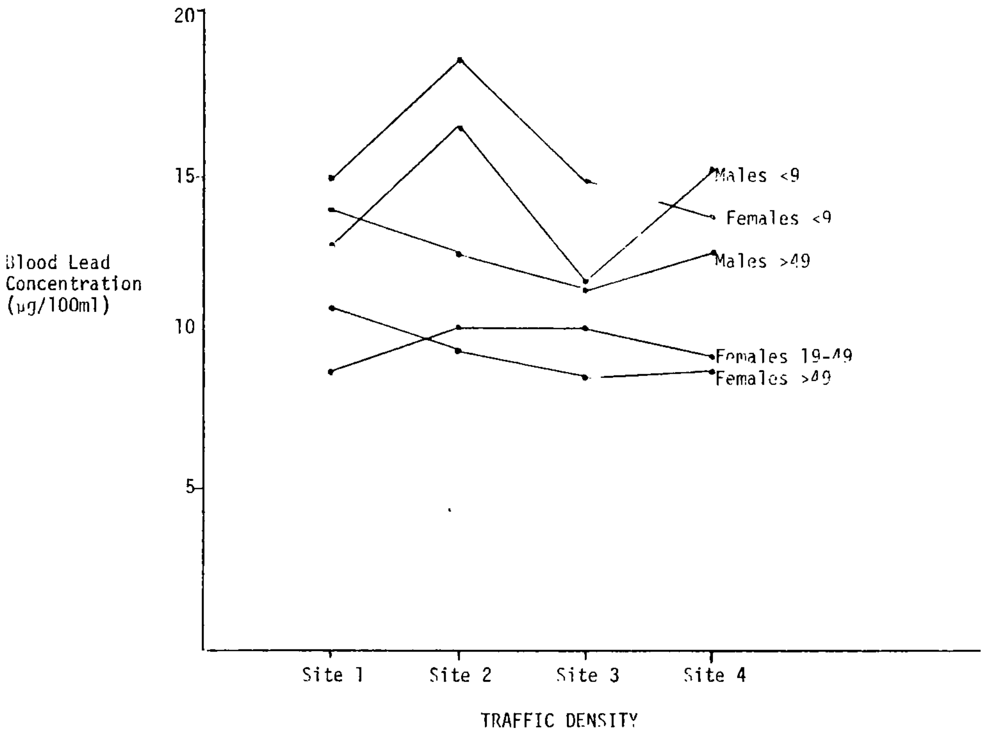
The mean of each site (with samples 1 and 2 pooled) were ranked from smallest to largest, and multiple comparisons (SNK procedure) were used to determine groups of site means which were not significantly different at $P<0.05$. These nonsignificant sets of sites are underlined in Table 26. There appears to be no pattern of increasing blood lead with increasing traffic density (site number) at these traffic levels. The back-transformed means (antilog of mean of log x), their confidence limits (L_1 and L_2), and sample sizes (N) are given in Table 27. Mean blood lead vs. traffic density is plotted for each age and sex group in Figure 67.

The relationship of individual blood lead values to corresponding actual traffic counts was examined using regression analysis. The blood lead concen-

Table 27. Blood Lead Concentrations (ug/100ml): Means, Confidence Limits (L_1 and L_2), and Sample Sizes (N) for each Age-Sex Group at each Site (Computed from Log (Blood Lead) and Back-Transformed).

		Site 1	Site 2	Site 3	Site 4
Males	Mean	12.58	16.48	11.67	15.07
	L_1	11.20	14.90	9.38	12.94
	L_2	14.82	18.23	14.51	17.54
	N	33	34	12	22
Males [illegible]	Mean	13.[illegible]	12.42	11.56	12.53
	L_1	12.35	11.08	10.52	11.08
	L_2	15.17	13.91	12.71	14.17
	N	27	36	44	22
Females [illegible]	Mean	14.91	13.58	14.89	13.60
	L_1	13.37	16.26	13.22	10.77
	L_2	16.53	21.23	16.78	17.19
	N	48	30	36	15
Females [illegible]	Mean	8.77	10.07	10.05	9.14
	L_1	8.20	9.30	9.44	8.47
	L_2	9.38	10.90	10.69	9.87
	N	92	79	92	73
Females > [illegible]	Mean	10.76	9.35	8.67	8.91
	L_1	9.75	8.37	7.69	8.03
	L_2	11.67	10.45	9.76	9.89
	N	41	38	41	24

Figure 67. Blood Lead Concentration vs Traffic Density for each Age and Sex Group.



trations were regressed on traffic counts (n = 843) with the result that only 0.3% of the total variance was explained by the regression (R_2 = 0.003). The regression equation is as follows: $Y = 12.52 - 0.03 X$, where Y = blood lead (µg/100 ml) and X = traffic count/1000. Scatter plots of X and Y variables and of residuals were also examined and these did not indicate that further transformations would improve the fit.

Conclusions: There was no detectable relationship between blood lead levels and traffic density at these traffic levels.

to be significantly higher than either adult female group ($P<0.001$) and female children to be significantly higher than male children at a probability approximately equal to 0.05 ($t_s = 1.71$ as opposed to critical value = 1.65). These were one-tailed tests.

Conclusions: Blood lead was significantly higher in children than in adults for both males and females. With regard to sex differences in blood lead, female children were slightly higher than male children, and male adults were significantly higher than female adults. There were no differences between middle-age and older female groups.

b. FEP and Hematocrit

FEP determinations have been shown to be related to lead exposure and have been proposed as a simple and reliable prescreening test for undue lead absorption especially at levels above 39 μg/100ml.[25] Hematocrits have also been suggested as a less expensive and more efficient method of detecting lead exposure.

The frequency distributions of the FEP and HCT are shown over all sites, for each site (ages and sexes combined), and for each age and sex group (traffic sites combined) in Figures 68-73. Each FEP and HCT value represents the average of two samples from one participant. Regression analysis was used to examine the relationship

Table 28. Two-Way ANOVA of the Effects of Sex and Age on Log(Blood Lead) at Sites 1, 2, 3, 4, and All-Sites

Site 1

Source	SS	DF	MS	F Ratio	Prob.
Sex	0.0240	1	0.0240	1.0327	0.3112
Age	0.1047	1	0.1047	4.5074	0.0354
Sex*Age	0.2874	1	0.2874	12.3767	0.0006
Error	3.4837	150	0.0232		

Site 2

Source	SS	DF	MS	F Ratio	Prob.
Sex	0.0427	1	0.0427	2.1048	0.1492
Age	1.5161	1	1.5161	74.7177	0.0000
Sex*Age	0.2595	1	0.2595	12.7911	0.0005
Error	2.7189	134	0.0203		

Site 3

Source	SS	DF	MS	F Ratio	Prob.
Sex	0.0022	1	0.0022	0.0945	0.7590
Age	0.3624	1	0.3624	15.5735	0.0001
Sex*Age	0.3354	1	0.3354	14.4137	0.0002
Error	3.0016	129	0.0233		

Site 4

Source	SS	DF	MS	F Ratio	Prob.
Sex	0.1854	1	0.1854	9.9484	0.0023
Age	0.3494	1	0.3494	18.7444	0.0000
Sex*Age	0.0541	1	0.0541	2.9043	0.0923
Error	1.4726	79	0.0186		

All-Sites

Source	SS	DF	MS	F Ratio	Prob.
Sex	0.2115	1	0.2115	9.2171	0.0025
Age	2.3628	1	2.3628	102.9859	0.0000
Sex*Age	0.7658	1	0.7658	33.3784	0.0000
Error	11.5633	504	0.0229		

Neither sex had consistently higher blood lead levels over all age groups. Using t-tests, the age groups were examined individually. Adult males were shown

(4) <u>Sex and Age Difference in Blood Lead</u>

Previous studies have shown that males as a group maintained higher blood lead levels than females living in the same area with much the same external lead exposures and that children had higher levels than adults [9] [32]. Two-way ANOVA (fixed effects) were used at each site and for all sites with sexes (male, female) as rows and ages(<9, >49) as columns to determine whether the same relationships were true for these data (Table 28). Because the design must be balanced for this analysis, the females 19-49 group was not included. The interaction term (sex X age) was a highly significant ($P<0.001$) at sites 1, 2, 3, and all-sites. In Figure 67, we see the explanation for the significant interaction: the lead values for male adults were higher than for female adults; but for children, the females were higher than the males. In Site 4, the males were higher than females in both age groups; therefore, the interaction term in the ANOVA was not significant. In all five ANOVA, the terms for differences among ages were significant at $P<0.05$ (in spite of the slight overlap at Site 1) or at $P<0.01$ (sites 2, 3, 4, and all-sites). Because the interaction involved the sexes and not the ages, we can safely generalize that age groups were significantly different; i.e., blood lead for children was significantly higher than for adults in both male and female groups.

Figure 68. Frequency Distribution FEP

```
MIDPOINTS
 196.000)
 189.000)
 182.000)*
 175.000)
 168.000)*
 161.000)
 154.000)
 147.000)*
 140.000)*
 133.000)***
 126.000)*
 119.000)*****
 112.000)******
 105.000)***************
  98.000)**********************
  91.000)*****************************
  84.000)***********************************
  77.000)*********************************
  70.000)M*******************************************
  63.000)***********************************
  56.000)******************************
  49.000)***************************
  42.000)********************
  35.000)************
  28.000)**
  21.000)*****
  14.000)*
   7.000)
   0.0  )*
  -7.000)
GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

 MEAN          72.944
S. DEV.        24.462
   N          330.000
MAXIMUM       179.540
MINIMUM         0.0
```

between FEP and blood lead resulting in the equation, Y = 71.96 + 0.07 X, where Y = FEP concentration (μg/100 ml RBC) and X = blood lead (μg/100 ml). Only 0.01% of the variation in FEP was explained (R^2 = 0.0001) by this regression. This is consistent with the findings of Piomelli [25] who reported no significant relationship between FEP and blood lead levels when only the samples with lead levels up to 39 μg/100 ml were considered (R = 0.02). Although we did not find any blood lead levels above 40 μg/100 ml (see Appendix G), the blood lead in children was higher than in adults. Therefore, FEP concentration was regressed on blood lead from children only with the same result: only 0.3% was explained (Y = 61.07 + 0.42 X, where Y = FEP concentration in μg/100 ml RBC, and X = blood lead in μg/100 ml). Examination of scatter plots of X and Y and

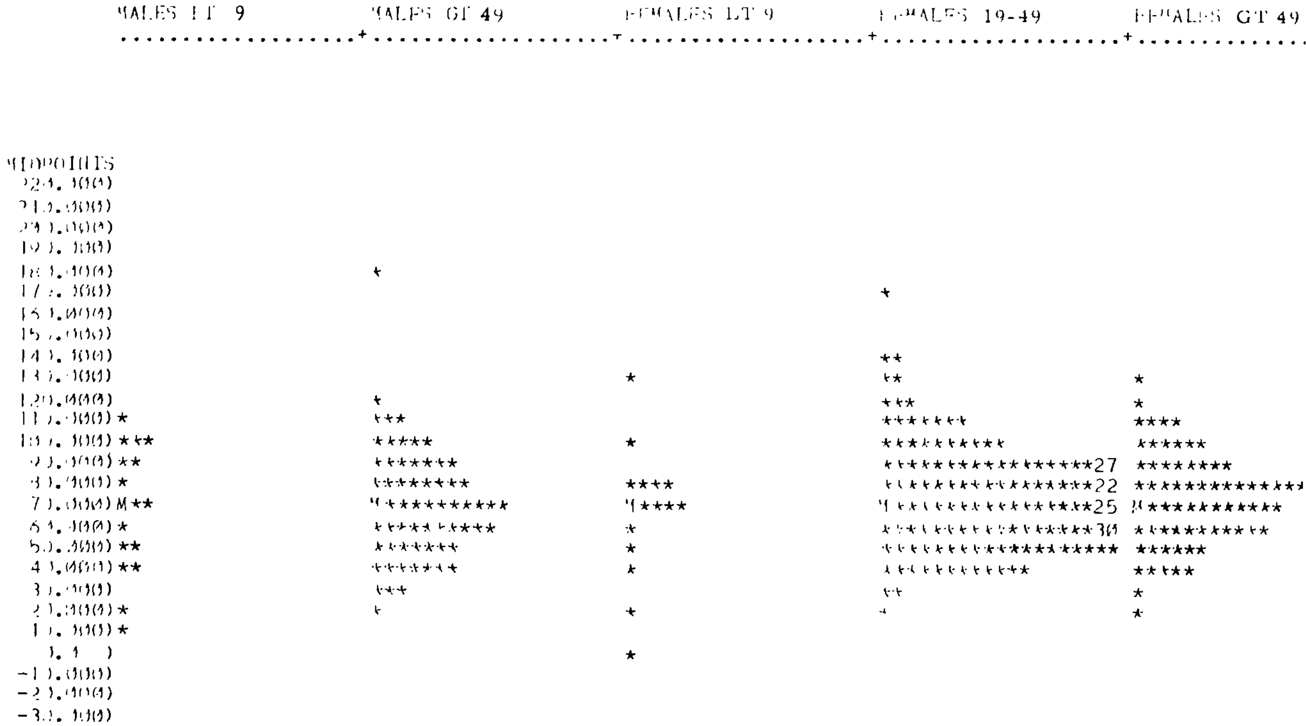
Figure 69. Frequency Distribution of FEP at each Traffic Density.

```
          SITE 1               SITE 2               SITE 3               SITE 4
          .....................+....................+....................+...................

MIDPOINTS
 196.000)
 189.000)
 182.000)                                                                 *
 175.000)
 163.000)*
 161.000)
 154.000)
 147.000)                                          *
 140.000)*
 133.000)*                     **
 126.000)*
 119.000)**                    *                    **
 112.000)**                    *                    *                     **
 105.000)******                ******               **                    *
  98.000)********              *******              ***                   ****
  91.000)***********           **********           *****                 ***
  84.000)*************         **********           *******               *****
  77.000)M*********            M****                ************          ******
  70.000)*********             *************        ***********           M**********
  63.000)********              ************         M*******              ********
  56.000)*******               *******              ***********           *****
  49.000)****                  ******               **************        ****
  42.000)*****                 ***                  *******               *****
  35.000)*                     **                   ********              *
  28.000)                      *                    *
  21.000)                      **                   **                    *
  14.000)                                                                 *
   7.000)
   0.0   )*
  -7.000)
GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

 MEAN         80.088               75.110               65.643               70.407
 S. DEV.      24.948               22.793               23.089               25.149
 N            91.000               86.000               94.000               59.000
 MAXIMUM     167.500              133.500              144.500              179.500
 MINIMUM       0.0                 21.000               21.500               12.000
```

residuals did not indicate that transformations would improve the fit.

The relationship of hematocrits and blood lead was examined. Only 3.7% of the variation in hematocrits was explained by the regression on blood lead ($Y = 38.64 + 0.22\ X$, where Y = HCT and X = blood lead in μg/100 ml). Scatter plots and plots of residuals were examined, and further transformations and analyses were

Figure 70. Frequency Distribution of FEP for each Age-Sex Group.



GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

MEAN	67.735	70.929	67.844	71.269	74.135
S. DEV.	28.938	26.174	30.305	23.643	22.347
N	17.000	64.000	16.000	153.000	70.000
MAXIMUM	147.000	179.500	127.000	167.500	133.500
MINIMUM	12.500	23.000	[illegible]	21.500	22.000

not indicated. FEP and hematocrit concentrations are listed in Appendix G, and means, their standard errors, and sample sizes for each age-sex group are given in Table 29 (FEP) and Table 30 (Hematccrit).

Conclusions: No significant relationships between FEP and blood lead or between hematocrits and blood lead were found at these blood lead levels (<40 μg/100 ml).

Figure 71. Frequency Distribution of HCT.

```
MIDPOINTS
   56.000)
   55.000)
   54.000)
   53.000)*
   52.000)*
   51.000)
   50.000)*
   49.000)***
   48.000)****
   47.000)*********
   46.000)**************
   45.000)***********
   44.000)******************
   43.000)***************************
   42.000)**************************************************
   41.000)**************************************************
   40.000)M*************************************
   39.000)**************************************
   38.000)******************************************
   37.000)*********************************************
   36.000)************************
   35.000)************
   34.000)**************
   33.000)*****
   32.000)*
   31.000)*
   30.000)*
   29.000)
   28.000)
   27.000)
GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

 MEAN          40.373
S. DEV.         3.567
   N          379.000
MAXIMUM        53.500
MINIMUM        30.500
```

Figure 72. Frequency Distribution of HCT at each Traffic Density.

```
SITE 1                   SITE 2                   SITE 3                   SITE 4
........................+........................+........................+........................+

MIDPOINTS
  56.000)
  55.000)
  54.000)
  53.000)                         *
  52.000)                                                                           *
  51.000)
  50.000)                         *
  49.000)                         *                        **
  48.000)                         ***                      *
  47.000)                         **                       ****                     **
  46.000)****                     ****                     ****                     *
  45.000)**                       ****                     *                        ***
  44.000)**                       ***********              ***                      *
  43.000)******                   ******                   ***********              **
  42.000)***************          **********               ***************          ********
  41.000)*****************        M********                M*******                 ***********
  40.000)M*************           ********                 ******                   M******
  39.000)************             *******                  *******                  *********
  38.000)*******                  *********                *************            **********
  37.000)*******                  **********               *************            ***********
  36.000)*****                    ********                 *****                    ****
  35.000)***                      ****                     ***                      *
  34.000)**                       ***                      ***                      *****
  33.000)                         **                       **                       *
  32.000)                                                                           *
  31.000)                                                                           *
  30.000)                         *
  29.000)
  28.000)
  27.000)
GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

MEAN        40.303             40.785             40.530             39.645
S. DEV.      2.638              4.151              3.635              3.526
N           65.000            135.000            100.000             79.000
MAXIMUM     46.500             53.500             49.000             52.000
MINIMUM     34.000             30.500             33.500             31.000
```

Figure 73. Frequency Distribution of HCT for each Age-Sex Group.

```
         MALES LT 9         MALES GT 49        FEMALES LT 9       FEMALES 19-49      FEMALES GT 49
         ..................+..................+..................+..................+.................

MIDPOINTS
  54.000)
  53.000)                   *
  52.000)                   *
  51.000)
  50.000)                                                                            *
  49.000)                   **                                    *
  48.000)                   ***                                                      *
  47.000)                   ******                                *                  *
  46.000)                   ********                              ****               *
  45.000)                   *****                                 ****               *
  44.000)                   M***                                  *******            ******
  43.000)                   *********                             *********          *******
  42.000)                   *********                             *****************26 ***********
  41.000)                   *****              *                  *****************28 M***********
  40.000)**                 **                                    M****************26 *****
  39.000)******             ***                *****              ************       *********
  38.000)*****              *                  **********         **************     *********
  37.000)M*************     *                  M*******           ****************   *
  36.000)***                                   **********         ********           *
  35.000)***                                   ***                ***                **
  34.000)*                                     *******            *****
  33.000)***                                   **
  32.000)                   *
  31.000)                                                         *
  30.000)                                                                            *
  29.000)
GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE
```

	MALES LT 9	MALES GT 49	FEMALES LT 9	FEMALES 19-49	FEMALES GT 49
MEAN	37.257	44.057	36.859	40.373	41.137
S. DEV.	1.754	3.501	1.809	2.879	3.140
N	37.000	61.000	46.000	165.000	69.000
MAXIMUM	40.500	53.500	41.000	49.000	50.000
MINIMUM	33.500	32.500	33.000	31.000	30.500

Table 29. FEP (ug/100 ml RBC's) Means, their Standard Errors, and Sample Sizes (N) for each Age - Sex Group at each Site.

		Site 1	Site 2	Site 3	Site 4
Males < 9	Mean ± SE	84.7 ± 12.90	69.5 ± 7.05	50.8 ± 19.69	38.5 ± 9.27
	N	11	21	4	6
Males > 49	Mean ± SE	76.6 ± 7.16	70.5 ± 4.78	66.8 ± 4.90	76.5 ± 9.14
	N	27	36	44	22
Females < 9	Mean ± SE	66.4 ± 8.90	69.1 ± 11.24	65.6 ± 14.5	68.5 ± 26.63
	N	13	10	9	4
Females 19-49	Mean ± SE	84.9 ± 3.87	80.3 ± 3.64	63.7 ± 3.56	68.5 ± 2.80
	N	32	77	92	73
Females > 49	Mean ± SE	78.3 ± 5.44	73.7 ± 4.36	68.8 ± 6.04	72.3 ± 7.40
	N	41	38	41	23

Table 30. Hematocrit (%): Means and Their Standard Errors and Sample Sizes (N) for Each Age - Sex Group at each Site.

		Site 1	Site 2	Site 3	Site 4
Males < 19	Mean ± SE	36.6 ± 0.51	37.3 ± 0.34	37.0 ± 0.65	36.9 ± 0.34
	N	25	33	11	21
Males > 19	Mean ± SE	42.5 ± 0.56	45.3 ± 0.52	44.5 ± 0.51	43.4 ± 1.08
	N	28	36	40	22
Females < 19	Mean ± SE	37.5 ± 0.38	37.0 ± 0.43	36.9 ± 0.37	36.4 ± 0.47
	N	31	28	34	18
Females 19-49	Mean ± SE	40.4 ± 0.34	40.8 ± 0.41	40.5 ± 0.35	39.7 ± 0.32
	N	94	79	90	76
Females > 49	Mean ± SE	40.3 ± 0.41	41.9 ± 0.68	40.8 ± 0.59	41.0 ± 0.51
	N	41	40	39	23

c. Carbon Monoxide (CO)

Carbon monoxide levels in the blood were determined on a subsample of the study population. From the venipuncture blood specimens collected an attempt was made to select an approximately equal number of specimens for males and females, smokers and nonsmokers for each of the four traffic density sites. This resulted in CO determinations being made on 201 blood specimens from 163 persons. Thirty-eight of these samples were second samples from the same person. The frequency distribution of the 201 samples is shown in Figure 74. Two peaks can be seen in the histogram: one at 0.1% which represents the nonsmokers and one at 0.8% for the smokers. Before a relationship between traffic levels and %CO could be determined, the smokers were separated from the nonsmokers. CO content in blood samples from 141 participants who do not smoke was analyzed for differences among the four traffic density sites using a Kruskal-Wallis analysis of variance and found to be not significant ($H = 2.237$, $X^2_{.05(3)} = 7.815$). The nonparametric test was used after transformations did not correct skewness of the data. The means and their standard errors and sample sizes are given below:

	Mean ± SE	N
Site 1	0.136 ± 0.0107	42
Site 2	0.138 ± 0.0125	32
Site 3	0.122 ± 0.0088	37
Site 4	0.139 ± 0.0114	30

All concentrations (for nonsmokers and smokers are given in Appendix G.

Conclusions: There was no significant difference in CO content in the blood of persons who do not smoke and who live at four different traffic densities.

Figure 74. Frequency Distribution of Carbon Monoxide in Blood.

```
0.0 ) *****
0.10) ************************************************************************************92
0.20) **********************************************
0.30) ***********
0.40) **
0.50) **
0.60) ***
0.70) ******
0.80) ********
0.90) *****
1.00) ***
1.10) ***
1.20) ****
1.30) **
1.40) ****
1.50) *
1.60) **
1.70) **
1.80)
1.90) *
2.00)
2.10) *
2.20)
```

d. Blood Lead Levels and Cigarette Smoking

Smokers, exsmokers, and nonsmokers were examined for differences in blood lead levels. Participants from all traffic densities were pooled for this analysis, since increasing traffic density had no detectable effect on blood lead at the traffic levels in this study. Data for adult males and adult females were examined separately, however, because their blood lead levels were shown to be different. Single classification ANOVA was used to test for differences among mean blood lead levels for the three groups: smokers, exsmokers, and nonsmokers. The blood lead value for each participant was the average of two blood lead measurements. A log transformation was used on the variable blood lead to meet the assumptions for this test; therefore, the means discussed below are geometric means.

For the adult females, blood lead levels were 11.2, 9.2, and 8.7 μg/100ml for smoker, exsmokers, and nonsmokers, respectively. The differences were highly significant ($P = 1.1 \times 10^{-8}$). Multiple comparisons tests (SNK procedure) showed no significant difference between exsmokers and nonsmokers; however, blood lead levels in smokers were significantly higher than in either exsmokers or nonsmokers. The log (base 10) transformed frequency distribution, means, standard deviations and sample sizes are presented in Figure 75. The backtransformed (geometric) mean for each group is given in parentheses.

Figure 75 Frequency Distribution of the Variable Blood Lead in Three Smoking Groups of Adult Females and the Results of ANOVA among these Groups.

```
SMOKERS                      EXSMOKE                       NONSMOKE
............................*..............................*..............................

MIDPOINTS
   1.400)
   1.350)*
   1.300)***
   1.250)**                 *                              **
   1.200)**                 *                              ****
   1.150)**********         *                              *****
   1.100)**********         *                              ******
   1.050)M*****************  ***********                   *************
   1.000)**************     ****                           ***************
   0.950)*********          M***                           M*******************
   0.900)*****              ******                         ******************
   0.850)***                ***                            **********
   0.800)*                  **                             *********
   0.750)                   **                             ********
   0.700)                   *                              ****
   0.650)                                                  ***
   0.600)
   0.550)
GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

MEAN        1.051 (11.2)              0.9[illegible] (9.2)           0.939 (8.7)
S. DEV.     0.109                     0.1[illegible]                 0.133
N           80.000                    37.[illegible]                 118.000
MAXIMUM     1.331                     1.[illegible]                  1.235
MINIMUM     0.762                     0.[illegible]                  0.632

ALL GROUPS COMBINED

                                      [illegible] OF [illegible]     MEAN SQUARE  F RATIO   PROB. F EXCEEDED

MEAN        0.98[illegible] (9.6)     BETWEEN  [illegible]  [illegible]   0.304[illegible]  19.8367   0.000000011
S. DEV.     0.131                     WITHIN   [illegible]  232           0.0154
N           235.                      TOTAL    [illegible]  234
MAXIMUM     1.334
MINIMUM     0.632
```

For the adult males, mean blood lead levels for smokers, exsmokers, and nonsmokers were 12.9, 13.1 and 11.5 μg/100 ml, respectively. Although these means were not significantly different (P = 0.20), a positive relationship can be seen between blood lead levels in males and cigarette smoking. Blood lead levels for smokers and exsmokers are greater than for nonsmokers. Figure 76 shows the log transformed frequency distribution for these three groups.

<u>Conclusions:</u> A highly significant association between smoking and blood lead levels was seen in adult females Blood lead levels among female smokers was significantly greater than for exsmokers and nonsmokers. The relationship

Figure 76. Frequency Distribution of the Variable Blood Lead in Three Smoking Groups of Adult Males and the Results of ANOVA among these Groups.

```
SMOKERS                       EXSMOKER                      NONSMOKE
............................*.............................*..............................

MIDPOINTS
 1.320)
 1.280)                       *                             *
 1.240)*                      ****                          *
 1.200)*                      ****                          **
 1.160)****                   *****                         *
 1.120)M*                     M***                          ***
 1.080)**                     ***                           *****
 1.040)*                      *                             M**
 1.000)***                    **                            *
 0.960)                                                     ***
 0.920)                       ***
 0.880)
 0.840)                       *
 0.800)                                                     *
 0.760)
 0.720)
 0.680)
 0.640)                                                     *
GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

MEAN        1.112 (12.9)           1.118 (13.1)            1.0[illegible] (11.5)
S. DEV.     0.080                  0.115                   0.142
N          14.000                 28.000                  22.000
MAXIMUM     1.252                  1.280                   1.264
MINIMUM     0.992                  0.850                   0.644

ALL GROUPS COMBINED

                                        SUM OF SQUARES   DF   MEAN SQUARE  F RATIO   PROB. F EXCEEDED

MEAN          1.097 (12.5)    BETWEEN      0.0462         2     0.0231     1.6335       0.[illegible]37
S. DEV.       0.120           WITHIN       0.8617        61     0.0141
N            64.              TOTAL        0.9078        63
MAXIMUM       1.280
MINIMUM       0.644
```

between blood lead levels for the three groups was as follows: smokers>exsmokers>nonsmokers. In adult males, differences among groups were not statistically significant; however, smokers and exsmokers had similar blood lead levels which were higher than those for nonsmokers.

5. Multivariate Analysis

In earlier sections of this report, each variable was examined either singly or for a relationship with one other variable. The variation in blood lead is here examined for a relationship to the combination of all environmental variables and other characteristics of the participants and their homes obtained through the questionnaire information. Twenty-five independent variables were used in a least squares regression analysis with blood lead as the dependent variable. Separate analyses were made for children and for adults using the same variables with the exception of number 22 (smoking for adults and hand-wipe lead for children). The 25 variables and regression coefficients for each least squares regression analysis are listed in Table 31. The analyses estimated the amounts of variation in blood lead that is accounted for by the simultaneous effect of the environmental and other variables. Simple correlation coefficients among all of the 26 variables for adults and for children are presented in Table 32.

For children, 21.7% of the variation about the mean blood lead can be attributed to the linear effects of the variables listed in Table 31. This result is obtained using ordinary least squares regression. The regression coefficient associated with traffic count is negative but not

Table 31. Variables and Regression Coefficients for Least Squares Regression Analysis

Number	Name	Regression Coefficients Children	Adults
0		17.33	11.55
1	Traffic Count	- 0.37	- 0.17
2	Occupational Lead Exposure	3.95	- 0.91
3	Glazed Pottery	- 0.46	0.62
4	Screened for Lead Absorption	1.92	1.98
5	Diagnosed as Lead Poisoned	3.36	- 4.25
6	Cooking Appliances	- 3.68	- 0.86
7	Age of House	0.09	- 0.01
8	Education of Head of Household	0.91	0.13
9	Paint Lead - Indoor	- 0.14	- 0.13
10	Paint Lead - Indoor	0.31	0.18
11	Paint Lead - Outdoor	- 0.16	- 0.07
12	Paint Lead - Outdoor	0.05	- 0.06
13	Distance from Road	- 0.01	- 0.00
14	Sex	- 1.90	2.76
15	Age	- 0.34	0.03
16	Length of Residence	0.11	- 0.02
17	Exposure to Lead Through Hobby	- 3.72	- 0.33
18	Hours Away from Home	- 0.07	0.02
19	Hours in Car/Bus	0.21	0.02
20	Anemia	- 2.86	- 0.68
21	Sick	1.74	1.22
22	Smoke (Adult) Handwipe (children)	- 0.02	- 1.15
23	Tapwater	- 6.51	- 0.42
24	Soil	- 0.00	0.00
25	Indoor Dust	42.00	- 4.77
26	Blood Lead		

significantly different from zero at the 5% level. A negative coefficient here indicates that when the other 24 variables are held constant that blood lead tends to decrease as traffic count increases. Since the coefficient is not significant this means that if we exclude the variable traffic count from the regression we can expect that the resulting R^2 will not decrease significantly from 21.7%.

Table 32. Simple Correlation Coefficients Among All Variables for Children and Adults.

Children

1.000																									
.067	1.000																								
-.187	.122	1.000																							
.082	.385	-.084	1.000																						
.105	-.045	-.052	.623	1.000																					
-.045	.073	.984	.050	.331	1.000																				
.177	-.163	.077	.147	.028	-.005	1.000																			
.138	-.000	.211	.126	.378	.503	.009	1.000																		
-.011	-.033	.118	-.012	-.329	.047	.064	.085	1.000																	
.002	-.086	.086	-.052	-.325	-.090	.123	-.371	-.048	1.000																
-.096	-.167	-.013	.130	-.381	.004	.259	-.033	-.067	-.061	1.000															
-.080	-.020	.003	-.123	-.077	-.068	.301	-.002	-.039	-.076	.491	1.000														
-.025	-.166	.073	-.079	-.351	.049	.408	.187	-.085	-.037	.193	.080	1.000													
.015	-.025	-.041	.073	.317	-.073	.040	-.016	-.065	.044	.058	-.072	.061	1.000												
-.120	-.005	-.039	-.045	-.364	-.366	-.022	-.195	.018	-.061	.064	.105	.048	-.135	1.000											
-.097	-.031	.115	-.173	-.014	.035	.200	.063	-.066	-.145	.079	.142	.188	-.109	.325	1.000										
.019	.302	.037	-.022	-.314	.022	-.159	.055	-.021	-.026	-.057	-.023	-.013	-.087	.045	.021	1.000									
.064	-.095	.072	-.069	-.126	.091	-.246	-.033	-.065	.067	-.062	-.158	-.082	-.060	.249	.300	.093	1.000								
-.006	-.092	-.078	-.092	.339	.005	-.011	-.027	-.001	-.012	.117	.118	-.011	.035	-.070	-.056	.194	.150	1.000							
.052	-.080	-.093	-.055	-.134	-.138	-.073	-.208	-.052	.013	-.002	-.028	-.123	.196	-.052	-.075	-.024	-.058	-.056	1.000						
.213	-.127	-.147	-.088	-.355	-.439	-.261	-.331	-.073	.218	.007	-.011	-.109	-.120	.140	-.176	-.038	-.007	.079	.145	1.000					
.272	.181	-.194	.050	.368	-.250	.107	-.044	-.033	-.004	.010	.148	-.169	.068	-.050	.091	-.004	-.215	-.059	.007	.127	1.000				
-.014	.071	.125	.201	.395	.041	.025	.190	.090	-.093	-.073	.057	.065	-.011	-.000	.128	.133	.116	.070	-.082	-.027	-.044	1.000			
-.020	.388	.007	-.053	-.346	-.121	.045	-.230	-.053	-.055	-.021	.060	-.071	-.045	-.062	-.054	-.075	-.188	-.004	.024	.102	.079	-.133	1.000		
.130	-.114	-.127	-.074	-.363	-.205	.124	-.234	-.077	.233	.010	.157	-.125	.011	.048	-.044	-.063	-.059	.051	.016	.117	.199	-.190	.029	1.000	
-.020	.158	-.053	.191	.147	-.039	.110	.044	-.024	.081	-.059	.059	-.030	-.167	-.128	-.058	.002	-.163	.088	-.177	.058	.169	.077	.029	.103	1.000

(continued)

Table 32. (continued)

Adults

1.000																									
-.057	1.000																								
-.200	.075	1.000																							
-.007	.178	-.065	1.000																						
.045	.063	-.048	.740	1.000																					
.028	.056	.069	.036	.027	1.000																				
-.201	.030	.070	-.042	.038	-.147	1.000																			
.046	-.132	.074	-.008	-.052	.181	.050	1.000																		
.009	-.047	-.001	-.027	-.030	.004	.121	.073	1.000																	
-.029	-.057	-.037	.091	.158	-.067	.236	-.068	.051	1.000																
-.097	.098	-.023	.067	.107	-.055	.248	-.082	-.004	.070	1.000															
.059	-.013	-.076	-.049	-.055	.050	.267	.062	.044	.060	.359	1.000														
.077	.052	.002	.007	.017	.018	.329	.069	-.092	.023	.072	.152	1.000													
.057	.116	-.042	.053	.061	.007	.110	-.112	-.015	.000	.041	.041	.161	1.000												
.058	.117	-.028	.014	.019	.050	.112	-.198	-.043	.005	-.013	.028	.191	.606	1.000											
-.022	.129	.033	-.061	-.008	-.003	.298	-.090	-.034	.079	.025	.060	.313	.346	.594	1.000										
-.042	.079	.107	-.063	-.047	-.060	.048	.083	-.001	.010	-.185	-.043	.021	.137	-.012	.116	1.000									
.058	-.046	.132	-.103	-.089	.040	-.150	.082	-.032	.018	-.133	-.042	-.067	-.043	-.052	-.020	.008	1.000								
-.002	-.058	.003	-.106	-.137	.061	-.099	.053	-.058	-.030	-.053	-.004	.004	-.040	-.042	-.120	-.002	.408	1.000							
-.044	-.031	.122	-.044	-.039	-.026	-.050	.042	-.014	-.013	.028	-.061	-.163	-.316	-.263	-.178	.007	.013	-.029	1.000						
-.085	-.081	.036	-.052	-.038	.055	.011	-.126	-.030	-.002	-.027	.035	-.058	-.113	-.152	-.064	-.005	.029	.073	.008	1.000					
-.061	-.097	.059	-.137	-.030	-.048	.025	.095	.027	.020	-.015	-.060	-.017	.008	.129	.089	-.077	.053	.024	-.004	-.178	1.000				
.113	-.019	-.003	-.006	.004	.023	-.117	.041	-.002	-.023	-.051	-.033	-.057	-.029	-.038	-.061	-.011	.039	-.022	.082	-.018	-.012	1.000			
.015	.045	.034	-.003	.054	-.133	.207	.025	.003	.062	.108	.057	.004	-.016	-.073	.012	-.032	-.101	-.062	.038	-.040	-.074	-.028	1.000		
-.005	-.010	.121	.011	.036	-.027	.089	-.024	-.030	-.009	.060	.011	-.022	-.002	-.051	-.025	-.044	.017	-.057	-.054	-.046	.081	-.005	.061	1.000	
-.006	.005	.018	.021	-.066	-.018	.021	-.065	-.045	.021	-.043	.000	.060	.388	.268	.121	.040	.037	.047	-.199	.092	-.275	.048	.068	-.063	1.000

Ridge regression is a biased estimation technique which in theory can provide regression coefficients that are closer to their true value on the average than those coefficients resulting from least squares regression. This method of analysis yielded the fact that the sign of the traffic count coefficient did not change to a positive value for the set of possible ridge coefficients (ridge trace) computed by Hocking's program. Evidently, the reason that the sign of this coefficient is negative is not due to the independent variables being highly correlated.

Variable selection methods developed by Hocking selected the variable traffic count only after many other variables had been included in the regression equation. In no case was traffic count selected before 14 of the other 25 variables had been selected. In this sense the traffic count is an important determinant of blood lead only when many other more important variables are held constant.

Apparently, when traffic count is measured as in this study its linear effect on children's blood lead is weak. However, it seems plausible to assume from this analysis that the suggestion that blood leads decrease as traffic count increase is a general conclusion that can be expected to be found in other studies similar to this one. There may be underlying factors that are specific to this study situation that are responsible for this coefficient having the wrong sign.

Factor analysis is a multivariate technique used to probe the variables for underlying factors of central importance. Principal component extraction of factors was applied to the 25 independent variables. Each factor explains a portion of the variance in the correlation matrix of the 25 independent variables. Normally, only the factors explaining the highest portions are considered worthy of further analysis. However, our goal in using factor analysis is to attempt to determine if the reason that the regression coefficient of traffic count is negative is due to spurious error sources.

We do this in three steps.

First, it should be noted that the regression coefficient of traffic count and blood lead can be written as a linear combination of the ith factor loading with the jth variable (say a_{ij}) and the regression coefficient (say b_i) of the ith factor on blood lead. That is, the regression coefficient of traffic count on blood lead (including as independent variables all 25 variables) is equal to

$$\sum_{i=1}^{25} a_{ij} \, b_i$$

So our first step is to regress these 25 underlying factors on blood lead to obtain the a_i.

Now some of these terms are positive and some are negative. (If the 25 variables had all been uncorrelated then only one term would be nonzero). Also some of these factors primarily represent true underlying mechanisms of central interest in this study. That is, mechanisms that can be expected to influence the data whether this study was conducted in Dallas or San Francisco. Other factors represent mechanisms that are unique to this study. We call these common factors error factors.

Secondly, we proceed on the assumption that factors whose terms are positive in the above sum are the true factors. If we add only these terms we can expect to obtain an adjusted positive regression coefficient. When the last assumption is completely false this correlation should be 'too big'.

Thirdly, we concentrate our analysis on the 'positive factors'. If we can identify these factors then we will obtain assurance that the last assumption holds (at least for those factors so identified).

Instead of concentrating our efforts on identifying the positive factors we could have considered the negative factors. However, we did not do this because it was thought that identifying negative factors correctly would be a much more difficult process.

Lastly, even though this process may seem subjective, it is not difficult to consider relationships between variables that could pass undetected by this analysis. For example, the requirement of orthogonality which simplifies the analysis usually makes the factor identification process more difficult. Thus, we consider this method to be a quick and dirty look at the multivariate aspect of this problem. Considering only the first six factors (listed in Table 33)

Table 33. Correlations with the 25 independent variables of the six principal component factors that contribute most to R^2 (Data from children only)

Variable No.	I	II	III	IV	V	VI
1	.0298	.0523	.1697	-.1521	.2027	.0173
2	.0679	.1399	-.2458	-.1452	.2890	-.2559
3	-.1711	-.1145	-.1503	.0722	-.1461	.0676
4	.0299	.2411	-.3407	-.1389	.3904	-.2163
5	-.0662	.2589	.2344	.1530	.2629	-.2441
6	-.0390	-.0074	-.0514	.2393	.0166	.2591
7	.1232	.3555	-.0887	-.4509	-.3858	-.0135
8	.0159	.0719	-.2639	-.1507	.0115	.0768
9	-.4392	-.0234	.0143	.0543	.0062	.0655
10	-.2759	-.0417	-.1592	.0911	.0043	.1540
11	.1086	.1950	.2367	-.0425	-.3594	-.0767
12	.0860	.2750	-.0971	-.0905	-.3278	-.2371
13	.1473	.1077	-.1783	.4074	-.3126	-.0070
14	.5012	.1676	.1563	-.0722	.0300	.1970
15	.0931	-.2542	-.0938	.2140	-.1516	-.4575
16	.2082	-.1358	-.0428	-.2838	-.2698	-.3860
17	-.0232	-.1538	.2868	-.0499	.1102	-.2252
18	.1108	-.5144	-.0146	.0730	-.0199	-.1547
19	-.1616	-.0931	-.3619	.0299	-.0628	-.0326
20	.4570	.0038	-.3172	.0968	.0603	.1558
21	-.1308	-.1226	-.2442	-.2668	.0941	-.0786
22	.0256	.3277	-.1717	.4381	.0849	-.2058
23	-.1247	.0143	.1666	.0611	.0907	-.3335
24	-.0320	.1896	.2165	.1390	.0595	-.0548
25	-.2187	.1166	.0381	.0403	-.0659	.0115
Percentage Variation Explained	6.62	4.25	2.15	1.81	1.14	1.12

that are most highly correlated with blood lead we find that these factors account for an R^2 of 17.1 whereas before an R^2 of 21.7 was achieved using all the variables. Thus, we see that most (79% = 17.1/21.7) of the variation explained using the 25 variables is explained using only these six factors. Factors II, IV and V are the positive factors of the six factors. Combined they account for 1.81 + 4.25 + 1.14 = 7.20 of the R^2 of 17.8% or 40% of 17.8.

Factor II is correlated with the age of the house, hours away from home and handwipes. The blood lead is higher due to this factor when the child spends less time away from home, lives in an older house and has higher handwipe lead values.

Factor IV is correlated with age of house, distance from the road and handwipes. The blood lead is higher on this factor for a child who lives in a newer house farther from the road and has higher handwipe lead levels.

Factor V is correlated with screened for lead absorption, age of house, and both indoor and outdoor paint. The blood lead is higher on this factor for a child who lives in a newer house which has low lead in the indoor and outdoor paint. Neither he nor members of the family in the house have been screened for excess lead absorption.

Factor II seems to be indicating that the subgroup of this population of children that have the characteristics that are correlated with factor II are in a slightly higher exposure category to automobile generated lead. Factor IV, the most important of the three factors, indicates that distance from the road to the house is an additional important variable.

Factor V is difficult to interpret as reflecting exposure from environmental lead. For this reason this factor is regarded as an error factor.

In conclusion, there are 3 positive factors that suggest that blood lead increases when traffic counts increase. Two of these factors suggest that more careful screening is required to insure that the children live in houses of a similar age and a similar distance from the road and spend only a short amount of time away from home. However, even with such increased control there is no suggestion that a dramatic improvement in the R^2 will result. This analysis only considered the effect on the relationship between blood lead and traffic count caused by these 24 other variables. The inclusion of additional variables may improve the relationship. For example, traffic speed limits would be a good variable to include. More confident conclusions would require a more in depth analysis.

For adults, 28.6% of the total variation in blood lead was explained by regression on the 25 environmental variables. Using only the first six factors we achieve an R^2 of 21.0, which is 73% (21.0/28.6) of the variation

Table 34. Correlations with the 25 independent variables of the six principal component factors that contribute most to R^2 (data from adults only).

Variable No.	I	II	III	IV	V	VI
1	.0076	-.1876	.2276	-.1453	-.3840	.1015
2	-.1587	.2371	.3788	-.2511	-.1922	.1172
3	.0405	.0341	-.2032	-.0311	-.0081	.1075
4	-.1033	.0183	-.0045	.0008	.1148	-.0164
5	-.1289	-.0574	.0929	.1412	.0913	-.0412
6	.0373	.0953	.0118	.2382	-.2541	.0449
7	-.3030	-.0198	-.0003	-.1343	.0907	-.0278
8	.1211	-.3481	.0611	-.4398	.1652	-.0560
9	.0130	-.2379	-.0054	.0837	.0418	.5955
10	-.1077	-.0376	-.0780	-.1805	-.4358	-.0319
11	-.1555	.1315	-.0277	-.0301	.0684	.0229
12	-.1460	.1346	.0824	.1775	-.0665	.1092
13	-.2944	.0310	-.0999	.0730	.0096	-.3751
14	-.4072	.0229	-.1661	-.4620	.1636	.2371
15	-.4481	-.0275	-.0759	-.0653	.0259	-.0051
16	-.4346	-.0033	.1277	.2806	-.0817	-.1403
17	-.0497	.0781	.2114	.2726	-.0911	.1488
18	.1556	.1343	-.0086	.1147	-.0597	.1277
19	.1444	.2720	-.0228	-.0241	.1971	.0214
20	.2538	-.0614	-.0802	-.2089	-.2477	-.3209
21	.1145	.5298	.4945	-.2719	.1567	.0466
22	-.0311	-.4834	.5968	.0363	.0756	-.2037
23	.0941	-.1611	.0015	.0669	.4648	.0454
24	-.0574	-.0761	.1573	.1982	.2089	.1525
25	-.0173	-.1718	-.0207	-.0474	-.2387	.4011
Percent Variation Explained	5.2%	4.58%	4.30%	2.32%	2.30%	2.29%

explained by using all 25 factors. These six factors are shown in Table 34. Only factors IV and VI which are the positive factors will be interpreted. Factor IV is correlated with sex and education of head of household. Blood lead is higher on this factor for adult males living in households of lower educational levels. Factor VI is correlated with indoor paint lead, distance from road, and indoor dust lead. Blood lead levels were higher on this factor for those persons exposed to higher indoor dust lead, indoor paint lead, and living closer to the roadway. The meaning of an association between paint lead and blood lead in adults is not clear. Perhaps these paint lead levels are related to higher dust lead levels inside the home.

In summary, for adults from 2% to 5% of the variaation in blood lead can be explained by factors concerned with sex, education, indoor dust lead, and distance from road. The exact nature of these relationships is not clear. At this low level of correlation, the effect of a variable on blood lead may be positive when combined with one variable and negative when combined with another. None of the relationships shown here seem to have a strong effect on blood lead or clarify the effect of traffic density on blood lead.

Conclusions: No strong relationships between blood lead and environmental variables were seen in the regression analyses for children and for adults. A small portion of the variation in blood lead was explained by factors concerned with those who spent more time away from home, sex, education levels, indoor dust lead, and distance from the road. No effects of traffic density on blood lead were clarified for adults or children.

IV. DISCUSSION

A. Air Monitoring Study

The principal objective of this air monitoring effort was to examine the relationship of ambient air lead levels with concurrent traffic count measurements. Previous studies have demonstrated that there is a general relationship between traffic counts and air lead values obtained immediately adjacent to the roadway. This study was designed to calibrate the relationship in the general vicinity of the epidemiologic study as well as to investigate the importance of other parameters of traffic exposures from combustion of leaded basoline. Furthermore, these data may be useful in estimating the air lead exposures of a number of urban residents in the United States, since traffic count data are often available for urban areas. These data are relevant to the total problem of air lead exposures from automobiles because, as stated in the Introduction of this report, a very large proportion of the total population of the United States resides on streets with traffic densities ranging from less than 1,000 cars per day up to 25,000 cars per day, the traffic densities covered in this study.

The results of this study indicate that there was a small but significant relationship between ambient air lead levels and traffic counts. This relationship was much stronger when the traffic densities reached 30,000 to 40,000 vehicles per day. The ambient air lead levels ranged from 0.5 at less than 1,000 vehicles per day to 1.9 $\mu g/m^3$ for the higher traffic density levels. This study shows that a relationship exists between traffic counts and air lead over this range but that the relationship is not a strong one and that other variables such as the presence of obstructions near the site where the air samplers were located, meteorological factors and sampler variability may have obscured the primary relationship. During the study, placement of the high volume air samplers was conducted very carefully to avoid the problems of interference from high shrubs and buildings; however, their influence could not be completely avoided. The samplers were always located at a specified distance from the roadway and were always located downwind from it relative to the wind direction for that 24 hour period of monitoring. Air data collected during the early stages of the project indicated that placement of a high volume air sampler near a residence with a large shrub in between the sampler and the roadway provided a much lower level of lead than for corresponding residences in which no shrub was present. In the primary study samplers were placed to avoid this type of problem

The high volume air samplers were also located at approximately 3 feet above ground level which is near the breathing zone for small children. Most ambient air samplers operating in the United States for regulatory purposes are located between 10 and 20 feet above ground level. Data from this study may not be directly comparable to data collected at other sites with samplers located between 10 and 15 feet above ground level due to the possibility that a vertical gradient in air lead levels may be present.

Outdoor air lead was measured at four distances from the street to determine whether air lead levels decline in the first 100 feet from the roadway. For all distances measured, 5 to 100 feet from the road, air lead concentrations declined rapidly with distance from the street. At 50 feet, concentrations were about 55 percent of the street concentrations. For air lead collections from 5 to 100 feet from the street, approximately 50 percent of the airborne lead was in the respirable range, that is, less than 1 μ and the proportions in each size class remained approximately the same as the distance from the street increased.

Two intersection studies were done to determine whether residents at intersections are exposed to higher air lead levels than their neighbors at midblock locations on the same street. One study used only intersections with small side streets (less than 1,000 cars per day). The objective of this study was to determine additional lead exposure, if any, of corner home residents who were participants in the epidemiology portion of this study. No additional lead exposure was measured for these participants. However, in the second study where larger intersections were used, significantly higher lead levels were found at intersections. This occurred mainly at intersections where primary streets had greater than 25,000 and secondary streets had at least 10,000 cars per day. Further studies will have to be made to clarify this, because of the small amount of data collected at the higher traffic densities.

Air lead levels were measured at two speed limits (30 MPH and 45 MPH) on streets with approximately the same traffic density to determine whether air lead levels are influenced by vehicular speed The air lead levels at 30 MPH were twice those at 45 MPH, although a statistical difference in the two samples could not be shown, possibly due to large variation and small sample sizes.

Most of the air lead samples in this study were taken for a 24 hour period. A study was made of air lead measurements taken for shorter collection times: one, two, four and twelve hours. Shorter collection times overestimated traffic volume and introduced more variability in air lead measurements. The range in air lead measurements increased with shorter sampling times at all traffic densities. No relationship between air lead levels and length of collection times was seen.

Two of the ministudies conducted under the air sampling program dealt with the influence of indoor versus outdoor exposures. These studies were the simultaneous hi-vol monitoring inside and outside of homes and the dustfall study. Although the use of hi-vol samplers in the indoor environment may be somewhat questionable because of the possible "cleansing" effect of the high sampling rate the results obtained in this study are not greatly different from those obtained in studies which used lower sampling rates.

In this study, indoor/ourdoor air lead samples were taken at two traffic densities, nine samples at 10,000 cars daily and seven at 20,000 cars daily. The results showed a highly significant difference in the levels of lead indoors versus outdoors at both the sites. Thus at 10,000 cars per day, the indoor air lead levels were 0.18 μg per cubic meter while the mean value for the outside air was 0.92 μg per cubic meter. The levels of lead in air indoors at the 20,000 cars per day was 0.20 μg per cubic meter. Therefore, our results indicate an approximate ten-fold reduction in air lead levels from outdoor to indoor air. These monitoring studies were conducted during the summer months in Dallas, Texas where the temperatures are usually in the 90's. Questionnaire data indicated that virtually all the houses in both the epidemiology study as well as the monitoring study had air conditioning of some type.

Daines et al. using a low volume sampler in New Jersey during the summer discovered a 65% reduction in air lead levels when air conditioners were used.[5] Benson _et al._ have summarized the indoor/outdoor literature as indicating particulate lead may be significantly reduced by efficiently operating air conditioners with filters in place, but that operation of evaporative coolers produce an almost one to one ratio of air lead to indoor lead.

That there might be a problem with the "cleansing" effect may be seen from the following calculations. The hi-vol sampler was operated at a flow rate of approximately 50 cubic feet per minute usually in the living room of the selected residences. Both indoor and outdoor monitoring were performed over the same 12 hour period during the daytime. A typical room in which the sampler was placed would contain 350 cubic feet of air, and in this study the doors into the other rooms were left open, thus allowing free movement of air within the home. Allowing for no infiltration of air into the room there would be a complete passage of air through the filter every 7 minutes or 100 times during the monitoring period. If the living room was 1/4 of the cubic footage of the home there would be 25 passages within the monitoring day.

Outdoor dust samples were taken at ten locations and each sample was paired with an indoor dust sample covering the same time period (28 days). These comparisons of indoor versus outdoor dust levels were made at traffic densities from less than 500 cars per day to more than 30,000 cars per day. The mean for the ten outdoor samples was 0.12 μg per square meter while the mean for indoors was 0.012 μg per square meter. These results are consistent with the approximate ten-fold reduction of lead outdoors versus indoors in the air lead measurements. This ten-fold relationship occurred at each traffic density.

In a study conducted in Southern California there were two study areas, one near a freeway in Los Angeles with traffic densities of more than 200,000 cars per day and the other in a city of 50,000 (Lancaster) in a high desert area. The mean air lead values were 6.3 $\mu g/m^3$ for Los Angeles and 0.6 $\mu g/m^3$ for Lancaster. The range of air lead means for this study were from 0.5 to 1.9 $\mu g/m^3$. The residences studied in Los Angeles were within 100 feet of the edge of the freeway and they did not have air conditioning. During the sampling effort (September 1974), the windows of these residences were open much of the time. The majority of the residences in Lancaster utilized evaporative coolers which provide a large exchange of outside air with inside air. It has been concluded[33] that air lead levels present indoors in homes with evaporative coolers are equal to levels present in outside air. The outside air lead measurements were therefore good representations of air lead exposure for the Southern California studies. As stated earlier, this probably is not true for the Dallas study; soil lead levels in the Los Angeles study area ranged from 673 to 3633 $\mu g/m^3$ and from 43 to 98 $\mu g/m^3$ in the Lancaster area. For this study the soil lead values ranged from 4 to 730 $\mu g/m^3$. Yankel *et al.*[34] reports an extensive study of the relationship of air and soil lead levels to levels of lead in blood of children living in these environments. He stated that soil levels in excess of 1000 μg/m³ (30 day average) will result in excessive percentages of children exceeding 40 μg lead/100 ml blood. These conditions were present for the Los Angeles site for our southern California study but not for this study.

Topsoil characteristics were determined for the study area near participants' residences. These characteristics were determined on the same soil samples in which soil lead measurements were made. The objective of this effort was to examine the potential of the type of soil with regards to lead adsorption, retention and release of these top soils. The majority of the soils were high in clay content and in organic matter. These types of soils have a high potential for adsorption and storage of lead. The chemistry of the soil favors the formation of relatively insoluble precipitates of lead. The clay soils should retain lead deposited on and absorbed by them; however, low permeability of the clay may reduce initial infiltration during heavy rainfalls.

B. Epidemiology Study of Traffic Density Relative to Levels of Lead in the Environment and Blood of Residents

It has been suggested that the distribution of blood lead levels for any relatively homogeneous population closely follows a log normal distribution(34,35,36). In the southern California study performed in this laboratory (9,10,11) blood leads were log normal for the adult population. Results from this study show that the blood lead values for adults and children had log normal distributions. The measurement variance was considerably smaller for this study than for the one in southern California and was consistent with the variance in other lead studies. This was true for venous blood lead measurements but not for the micromethods used on blood collected from the finger prick method. The micromethod of blood lead measurement results in more variability than for the usual macro method of analysis. Also the procedure for collecting capillary blood using the fingerprick technique is subject to more contamination effects at the time of collection and analysis than the venipuncture procedure.

Examination of the relationship of traffic counts to levels of lead in the blood of participants revealed no detectable relationship for traffic counts ranging from less than 1,000 cars per day to more than 25,000 cars per day. No significant statistical relationship between traffic density and blood lead levels for any age group or sex was found. Blood lead levels were significantly higher in children, ranging from 7 to 33 μg per 100 ml, than in adults, which ranged from 4 to 21 μg per 100 ml. No relationships were found between traffic counts and measurements of FEP, hematocrits, carbon monoxide levels in blood, and lead in hand-wipe samples.

A positive relationship between smoking and blood lead levels was found for both females and males in this study. Females who smoke had significantly higher blood lead levels than female exsmokers and nonsmokers. Male smokers and exsmokers had higher blood lead levels than nonsmokers, although this difference was not significant.

This study was designed to examine participants at four basic traffic densities: less than 1,000; 8,000-14,000; 14,000-20,000; and 20,000-30,000 cars per day. The epidemiology study was designed such that there would be some expected differences in exposure of these residents to levels of lead in the air as a result of their living on streets of these traffic densities. The results of the air monitoring study discussed above indicated that mean air lead levels ranged from 0.5 μg per cubic meter to a high of 1.9 μg per cubic meter. This differential in levels of lead in the air is quite small. Previous studies examining the relationship of air lead with blood lead levels have been successful for air lead at 2 μg and above. If there are significant differences in blood lead over the range investigated in this study, it is obvious that it could have been seen only with much larger numbers of participants than were included in this study.

Another factor which may have contributed to the failure to demonstrate a relationship between blood lead and traffic count in this study was the difference in exposure between the indoor and outdoor environments. Since this study was performed during the hottest time of the year it may be reasonable to suppose that participants may have spent a significant proportion of their day in the cool environment of their home produced by their air conditioners. If the air lead levels measured within the home are accurate then the observed result would be entirely predictable.

V. CONCLUSIONS

1. Examination of the relationship of traffic counts from >1,000 to <25,000 cars per day with the concentrations of lead in the blood of residents on these streets revealed no detectable relationship.
2. No significant relationships were found between traffic counts and FEP, hematocrits, carbon monoxide levels in blood, and lead in hand-wipes.
3. There was a small but significant relationship between levels of lead in the air and traffic densities. Mean air lead values for each street ranged from 0.5 to 1.9 $\mu g/m^3$ from Site 1 to Site 4.
4. There were significantly higher levels of lead in soil near residences in Sites 3 and 4 than in Sites 1 and 2. Soil characteristics in the study site areas favor retention of lead.
5. No significant relationships were found between traffic counts and the level of lead in indoor dustfall and window-sill wipes.
6. Comparison of lead levels in air and dustfall inside selected residences with similar measurements taken outside revealed tenfold higher levels of lead indoors.
7. The lack of an association between traffic counts and blood lead levels can be understood in terms of the

lead exposures generated by the studied traffic volumes. The air lead levels observed at the maximum traffic densities (<2 μg/m^3) have not been previously shown to result in increased blood leads and neither have the soil lead levels observed. Furthermore, the use of air conditioning may have contributed to the lack of an association by further reducing the effective air lead exposure.

8. The levels of lead in the populations studied are similar to values seen in other middle class sub-burban populations without occupational lead exposures and not living near an expressway.

9. Higher levels of lead in blood were found in children than in adults and higher blood leads were seen in adult males than in adult females. In children, females had slightly higher levels of lead in blood than did males.

10. Approximately 50% of the airborne lead was in the respirable range at distances from 5-100 feet from the street. The ratio of particle sizes of lead did not change with distances from the street (5-100 feet). Air lead concentrations decline rapidly in the first 50 feet from the street.

11. There were no increases in lead levels at intersections.

12. Air lead levels in 30 MPH speed zones were approximately twice air lead levels in 45 MPH zones; however, this difference was not statistically significant.

13. No significant relationship was found between lead levels at peak traffic hours and traffic counts.

14. A significant association between blood lead and smoking was seen. Female smokers had significantly higher blood lead levels than exsmokers and nonsmokers. In males, smokers and exsmokers had higher blood lead levels than nonsmokers, although this difference was not significant.

15. Lead contamination of blood samples is more critical with the capillary blood (finger-prick) collection than with the venous blood collection.

16. The accuracy and precision of the capillary blood methodology is more variable than the venous blood methodology.

VI. RECOMMENDATIONS

1. To provide the data needed to accurately evaluate the effects of automotive emissions of lead on the population and the environment, more studies of this type are needed. This type of data is essential in making regulatory decisions regarding lead in gasoline.
2. Efforts should be made to evaluate the levels of lead present indoors in air and dust. Indoor lead levels of residential homes, particularly those using air conditioning units appear to be much lower than in outdoor areas. More information is needed regarding how and where people spend their time at home. Factors such as the amount of time spent indoors vs the amount spent outdoors need to be addressed. Sampling should be done to better quantitate the indoor vs outdoor environments in various types of residential areas.
3. Evaluation of alternate dispersion mechanisms for lead emissions from automobiles should be done to better identify what happens to it in the environment.
4. Analytical methods used to quantitate the amount of lead in people and the environment need to be standardized so that improved comparisons and

evaluations can be made.

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APPENDIX A

JUSTIFICATION FOR CHANGE OF STUDY SITE TO DALLAS

JUSTIFICATION FOR CHANGE OF STUDY SITE TO DALLAS

San Antonio, Texas, was selected at the outset of this study as the study site after preliminary studies of traffic densities and general population characteristics. Thoroughfares with adequate traffic densities were identified for each of the five major categories of traffic density for which the study is designed: 1) 1,000 or less cars per day, 2) 7,500-12,500 cars per day, 3) 12,500-17,500 cars per day, 4) 17,500-22,500 cars per day, and 5) 22,500 and more cars per day. Demographic information from census records were used to identify expected population characteristics. From the limited pre-analysis, it was concluded that San Antonio could meet the study requirement for adequate number of participant populations residing on thoroughfares with appropriate traffic densities.

An in-depth site analysis was performed in San Antonio as the first step in Contract 68-02-2227. Table 1 presents a summary of the results of that site analysis. The residences indicated in Table 1 are located on thoroughfares or residential streets in areas of the city appropriate for study due to economic and ethnic requirements: areas which are primarily white and middle class.

Residences which are not at an intersection are desired for the study. This restriction would eliminate all corner houses. To meet the minimum study requirement of 200 or more residences in each traffic density level, corner houses would have to be considered in San Antonio for four of the five traffic density classes, as seen from Table 1. For 1000 or less cars/day, there are more than adequate numbers. The 300 shown are

Table 1.
Summary of Site Analysis for Selected Areas of San Antonio

Traffic Density (thousands of cars/day)	Number of Residences Within 100 ft. of Roadway		
	Not on Corner	On Corner	Total
1 or less	300	--	300
7.5-12.5	120	159	279
12.5-17.5	64	156	220
17.5-22.5	61	122	183
22.5 or more	77	35	112

but a sampling of those available. For all other traffic density levels, corner houses would have to be considered. For the highest two levels, even consideration of corner houses would not provide the 200 residences required.

Review of the results of the in-depth site analysis has indicated that San Antonio will not provide the study with the desired numbers of residences for the purposes of recruitment of study participants. Three principal factors are seen as the cause of this. First, much of the traffic in San Antonio is carried by the freeway network, which is quite extensive, rather than by non-freeway, multi-lane traffic arteries. This limits the area of the city which can provide potential for study. A major freeway is presently under construction in the central northside area of the city. Until it is completed, the existing multi-lane thoroughfares are carrying the traffic load. Sufficient traffic densities were found to exist in that area of the city to much greater extent than any other area. This, coupled with economic and ethnic restrictions regarding the candidate populations, provided the basis for limiting the study to the central northside area. Second, much of the portions of thoroughfares with the highest two levels of traffic density has been developed commercially such that few residences are present in many of the best areas considering the traffic densities. Third, large numbers of the residences found on the thoroughfares are corner houses which face the side street rather than the primary thoroughfare. Use of these residences in the study is not desired due to possible error introduced by traffic from the side street.

A preliminary siting study in Dallas, Texas, has indicated that the potential exists for finding adequate numbers of residences appropriate for study in that city. The city has sufficient population to support a study of this type, with 1.5 million people reported in the metropolitan area in the 1970 census. The current estimate of population in the combined Dallas/Fort Worth metropolitan area is approximately 2.5 million persons. Though highly industrialized and commercialized with light and sophisticated industries such as electronics, aircraft, and merchandizing, little or no heavy or polluting industry exists in the area. Data on air quality indicate there are no point sources of lead (telephone contact with Mr. Fred Barnes, Chief, Air Pollution Control, City of Dallas, Texas).

An abundance of heavily trafficked, multi-lane thoroughfares exist in all parts of the city; some in excess of 30,000 cars per day. The traffic system in Dallas has historically been designed around such multi-lane thoroughfares, and a network of such arteries spreads across the city. Figure 1 shows a map of the metropolitan area of Dallas, Texas.

Results of preliminary counting of residences on a sampling of thoroughfares in Dallas are presented in Table 2. Only single family residences which face the roadway were counted. Thus, corner houses facing side streets are not included in the count. Corner houses facing the primary thoroughfare were not excluded from the count. It is estimated that no more than 20% of the residences counted were corner houses and, thus, 80% or more would be appropriate for this study. The streets shown are but a sampling of those available throughout the city and were selected from areas estimated to have acceptable economic and ethnic characteristics. From Table 2, it is apparent that the minimum study requirement of 200 or more residences in each traffic density class should be easily obtained in that city.

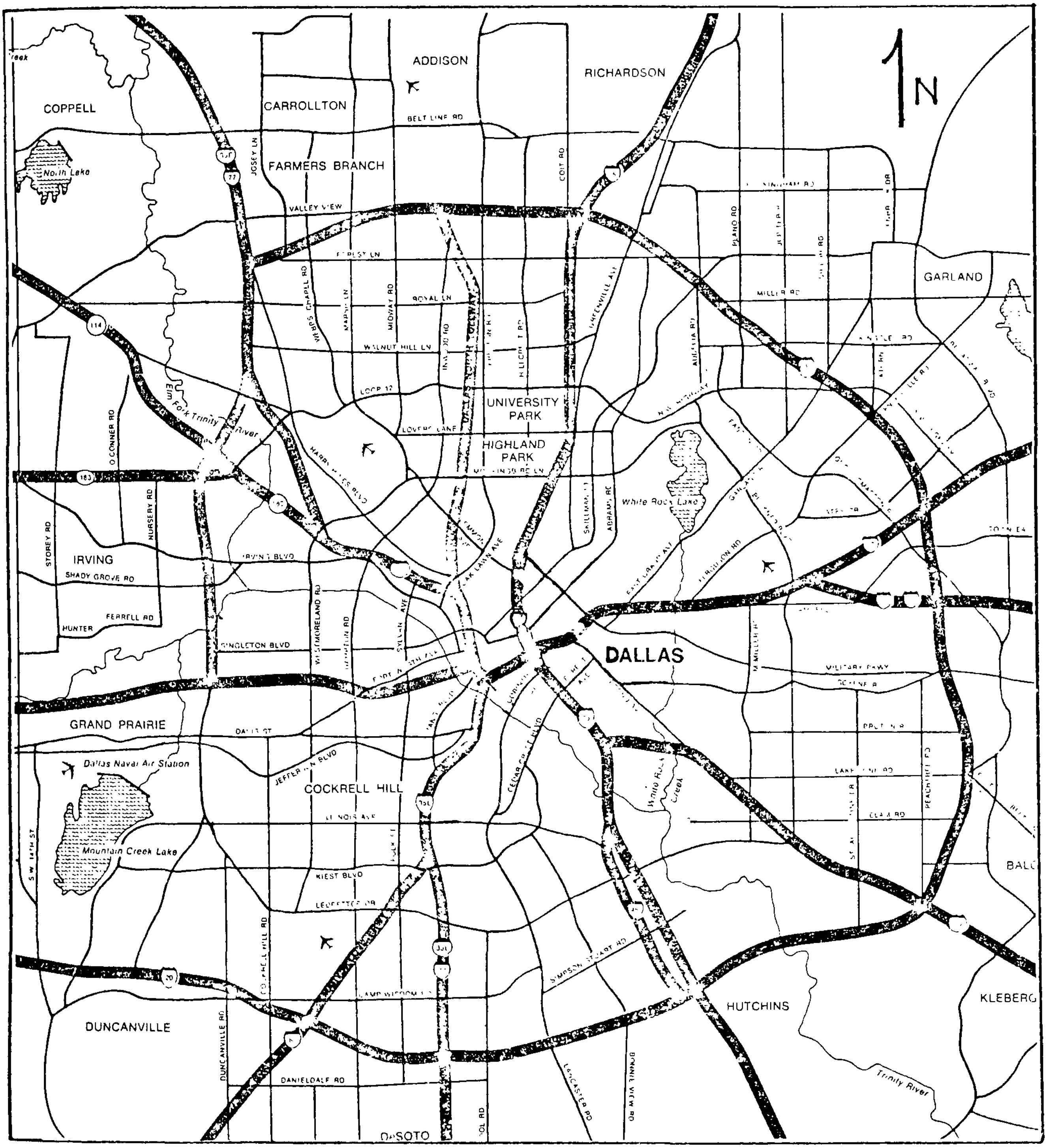
Because working in Dallas, rather than San Antonio, will require significant efforts away from the facilities of Southwest Research Institute, there will be need for establishing a base for activities in that city. Preliminary contacts have been made with personnel of the Center for Urban and Environmental Studies at Southern Methodist University. Preliminary arrangements have been made to devote a graduate student part-time to this project to serve as on-site coordinator for study activities in Dallas. Through the office of the graduate student, the University will provide office space and telephone facilities for utilization by the study team while on location in Dallas.

Contacts have also been made with the air pollution control group of the City of Dallas, and they are very interested in assisting in the study proposed for their city. The traffic department of Dallas has also indicated that they will assist in the study.

TABLE 2. SINGLE FAMILY RESIDENCES: DALLAS

Street	Number of Residences Within 100 Feet of Roadway Which Face the Roadway		
	12.5-17.5 Thous. cars/day	17.5-22.5 thous. cars/day	22.5 - thous. cars/day
Mockingbird Lane	184	127	68
Jupiter Road	--	29	--
Garland Road	--	--	10
Forest Lane	60	--	--
Marsh Avenue	--	10	29
Lemon Avenue	--	27	--
Inwood Road	--	78	32
Gaston Avenue	120	--	--
Illinois Avenue	--	32	146
Buckner Blvd.	16	69	--
East Grand Avenue	23	--	--
Hampton Road	50	--	--
TOTAL	453	372	285
80% of Total	362	297	228

Figure 1.
Expressways and Major Thoroughfares
Dallas, Texas



APPENDIX B

LETTERS OF PERMISSION TO PROCEED FROM LOCAL GOVERNMENTS

CITY OF DALLAS

March 17, 1976

R. John Prevost
Senior Research Analyst
Department of Social Sciences
Southwest Research Institute
Post Office Drawer 28510
San Antonio, Texas 78284

Dear Mr. Prevost:

In response to your letter of March 4, we certainly have no objection to your conducting the proposed study of blood lead levels in people exposed to particularly high levels of air pollution by automobiles in Dallas. We would appreciate receiving a copy of whatever information you develop.

Sincerely,

E. Lowell Berry, M.D., M.P.H.
Director of Public Health

ELB:tg

CITY OF DALLAS

March 10, 1976

Mr. R. John Prevost
Senior Research Analyst
Department of Social Sciences
Southwest Research Institute
Post Office Drawer 28510
San Antonio, Texas 78284

Dear Mr. Prevost:

This is to acknowledge our telephone conversation this date dealing with your plan to conduct a public health survey in Dallas under contract with the U. S. Environmental Protection Agency.

I do appreciate your informing me that you will have representatives conducting a door-to-door survey using an EPA questionnaire. Since your proposed survey as described will involve neither charitable solicitation nor home solicitation as defined in existing City ordinances, no permit of any type from this department will be required.

Please contact me if you need further information.

Sincerely,

Charles H Vincent

Charles H. Vincent, Director
Department of Consumer Affairs

CHV/jec

DEPARTMENT OF CONSUMER AFFAIRS CITY HALL DALLAS TEXAS 75201 TELEPHONE 214/748-9711

CITY OF DALLAS

March 10, 1976

Mr. R. John Prevost
Senior Research Analyst
Department of Social Sciences
Southwest Research Institute
8500 Culebra Road
P. O. Drawer 28510
San Antonio, Texas 78284

Dear Mr. Prevost:

We thank you for sending us your plans March 3 on lead surveys in Dallas. Our department has no objections to these plans.

Please let us know if we can be of assistance, and keep us informed of the results of this survey.

Very truly yours,

George W. Hintgen, P.E.
Environmental Research Coordinator
Environmental Health and Conservation

GWH:wg

THE TOWN OF
Highland Park
TEXAS

4700 DREXEL DRIVE, DALLAS 75205
Telephone 521-4161

March 23, 1976

Mr. R. John Prevost
Southwest Research Institute
8500 Culebra Road
P. O. Drawer 28510
San Antonio, Texas 78284

Dear Mr. Prevost:

This will acknowledge your letter of March 19 in which you indicate the selection of Mockingbird Lane in Highland Park for a portion of your surveys.

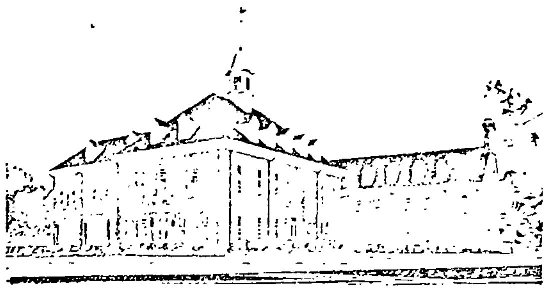
The Town attempts to control the activities of solicitors of all types through the Police Department. For this reason, and because of the possibility of traffic surveys, you are asked to contact the Police Department prior to beginning any activity of the type described.

Sincerely yours,

J. D. Hancock, Jr.
Town Administrator

JDH:mm

CC: Chief W. H. Gardner



CITY OF
UNIVERSITY PARK
3800 UNIVERSITY BOULEVARD
P.O. BOX 8005
DALLAS, TEXAS
75205

E. WILSON GERMANY
Mayor
FRED N. PEEK
Commissioner
PETER S. CHANTILIS
Commissioner
LELAND D. NELSON
City Manager - Clerk

March 9, 1976

Mr. R. John Prevost
Senior Research Analyst, Department of Social Sciences
Southwest Research Institute
8500 Culebra Road
P. O. Drawer 28510
San Antonio, Texas 78284

Dear Mr. Prevost:

I have your letter of March 4, 1976, in which you indicate that you are going to conduct a study in the Dallas metropolitan area under an EPA contract. More definitely, you are going to study and examine the relationship between traffic density and lead in the air and blood of exposed populations. Included in that sample study will be a portion of University Park.

In response to your request to use a portion of the City of University Park for your study, I would say that we would have no objection whatsoever. In fact, if we can help you in any way in your study, please let us know. We would be interested in the results of your study.

Sincerely yours,

Leland Nelson

Leland Nelson
City Manager

LN:dh
cc: Mr. Jim Murphy, City Engineer
Mr. J. D. Brown, Chief of Police

City of Garland

Post Office Box 189 / Garland, Texas 75040

March 30, 1976

Mr. R. John Prevost
Senior Research Analyst
Southwest Research Institute
P. O. Drawer 28510
San Antonio, Texas 78284

Dear Mr. Prevost:

The purpose of this letter is to confirm the results of our visit Monday, March 29. The Southwest Research Institute is authorized to conduct the study to examine the relationship between traffic densities and lead in the ambiant air and blood in the exposed populations on Walnut Street in Garland. As we discussed, you agreed to supply the City of Garland with the names of all project researchers assigned to Garland, the locations to which they will be assigned, and the location of traffic densities and air quality measuring devices. This information should be supplied to Mr. Bill Cox, City Sanitarian.

Should further information be required, please advise.

Sincerely,

Donald E. Paschal, Jr.
Donald E. Paschal, Jr.
Community Services Administrator

DEP/hc

cc: Linda Johnson

A GROWING CITY WITH A PLANNED FUTURE

THE CITY OF RICHARDSON

RICHARDSON, TEXAS

May 26, 1976

Mr. R. John Prevost
Senior Research Analyst
Department of Social Sciences
Southwest Research Institute
Post Office Drawer 28510
San Antonio, Texas 78284

Subject: EPA Contract 68-02-2227

Dear Mr. Prevost:

This letter is to advise that Richardson will participate in the above cited EPA study at the following locations.

1. Belt Line Road from Central Expressway west to Coit Road.

2. Coit Road from Spring Valley Road north to Arapaho Road.

If further locations are considered in your survey, please advise this office prior to commencement of survey work.

Yours very truly,

Bob Hughey

BH:br

cc: Mr. Ted C. Willis
Assistant City Manager

cc: Mr. Kenneth R. Yarbrough
Chief of Police

"THE ELECTRONICS CITY OF THE WORLD" A CITY OF FINE CHURCHES, SCHOOLS, HOMES AND INDUSTRY
P. O. BOX 309 RICHARDSON, TEXAS 75080 AREA CODE 214 235-8331

May 27, 1976

Mr. R. John Prevost
Senior Research Analyst
Department of Social Sciences
Southwest Research Institute
Post Office Drawer 28510

Subject: EPA Contract 68-02-2227

Dear Mr. Prevost:

This letter is confirming our telephone conversation today whereby Mr. Hughey is granting permission to extend the boundaries of your EPA study from Coit Road at Spring Valley Road north to Campbell Road to include the nine residences between Arapaho Road and Melrose Drive.

Yours very truly,

(Mrs.) Barbara A. Rusch
Secretary to Mr. Hughey

/BR

cc: Mr. Ted C. Willis
Assistant City Manager

GRAND PRAIRIE
ALL AMERICA CITY

March 22, 1976

R. John Prevost
Dept. of Social Sciences
Southwest Research Institute
P. O. Box 28510
San Antonio, TX 78284

Dear Mr. Prevost:

I have been asked to answer your letter dated March 17, 1976. We will be happy to cooperate in any way possible in your public health survey. Please feel free to call on me.

Yours truly,

Burl Cockrell, R. S.
Director of Environmental Health

BC/jm

cc: Kenneth Burr, Chief of Police

CITY OF GRAND PRAIRIE, P.O. BOX 11, GRAND PRAIRIE, TEXAS 75050 TEL. (AC 214) 263-5221

File [illegible]

City of Arlington Texas

Box 231
Zip Code 76010
Arlington Phone
(817) 275-3271
Dallas Phone
(214) 262-4660

March 29, 1976

Mr. R. John Prevost
Senior Research Analyst
Department of Social Sciences
Southwest Research Institute
P.O. Drawer 28510
San Antonio, TX 78284

Dear Mr. Prevost:

In regard to your correspondence of March 17, 1976, the City of Arlington has no objections to the lead study work to be conducted in the City by the Southwest Research Institute.

In this connection, please inform me of the proposed locations for automatic traffic counting, and particulate air sampling devices within the City at least one week prior to their planned installation. City Public Safety, and Traffic and Transportation personnel will review the locations to determine their adequacy from a safety standpoint. You will be notified only if the locations proposed are not satisfactory.

Enclosed for your information is correspondence sent to your Project Coordinator at SMU.

Sincerely,

Ross B. Calhoun
City Manager

cc: Linda Johnson, Project Coordinator
SMU

enclosure

City of Arlington Texas

Box 231
Zip Code 76010
Arlington Phone
(817) 275-3271
Dallas Phone
(214) 262-4660

March 29, 1976

TO WHOM IT MAY CONCERN:

This letter is to certify that the Southwest Research Institute has the permission of the City of Arlington to conduct a house-to-house public health survey.

This survey is part of a study by the Institute to examine relationships between traffic densities, and lead in the ambient air and lead in the blood of exposed populations.

The study is being conducted by the Institute for the U.S. Environmental Protection Agency.

Thank you for cooperating with the survey team.

Sincerely,

Ross B. Calhoun
City Manager

/ss

APPENDIX C

JUSTIFICATION FOR HOUSEHOLD HEALTH SURVEY FOR LEAD

JUSTIFICATION OF HOUSEHOLD HEALTH SURVEY FOR LEAD

A. Supporting Statement Justification

1. This new questionnaire is required to obtain information on a population on human volunteers living in a major metropolitan area (San Antonio, Texas). The primary objective of this program is to determine body burden levels of lead in populations of a major metropolitan area without occupational exposure to lead. The amount of lead found in blood of the human participants, lead in soil, lead in house dust, lead in hand wipes, lead in tap water, and lead in ambient air will be correlated with traffic densities. No suitable questionnaire forms of this type are currently available within the Environmental Protection Agency or known from other agencies which meet the design requirements of this study. This questionnaire is to be utilized on EPA contract number 68-02-2227 entitled "Epidemiologic Study of the Effect of Exposure to Automobile Traffic on the Blood Levels of Persons in Selected Age Groups". A copy of the Work Plan for this program is attached.

It has been shown that the levels of lead in body burdens of populations are related to factors such as age, sex, race, cigarette smoking, and use of certain types of lead-containing articles to prepare or serve food. This questionnaire form would provide the necessary information to assist in the final statistical evaluation of collected data that would guide the EPA in its assessment of potential health effects associated with body burdens of lead. This questionnaire will solicit personal information from some 1250 individuals living within the study area with regard to age, sex, smoking habits, and occupation. From a maximum of 1250 subjects completing the questionnaire, 440 will be selected to provide the study with the following three age groups: preschool, 1-6 years; adult, 20-59 years; retired, 60 years and over. Each of these individuals would then be sampled twice for blood. These samples would be analyzed for concentrations of lead. The mean concentrations of each of the three age groups will be calculated along with standard deviations and confidence limits for the means. These data will then be correlated with traffic density levels to determine the relationship. Additional statistical correlations will be made to determine the possible relationship between concentrations of lead and the covariate information collected on the questionnaire.

This project will be conducted as a contract with SwRI under the technical direction of Dr. Dnnald E. Johnson. The attached Work Plan from Southwest Research Institute provides more details on the plans for this survey.

2. The data collected using this survey instrument and the follow-up statistical analysis will be utilized by the Environmental Protection Agency to assess the potential health effects associated with body burdens of lead as related to automobile traffic.

3. There are some preliminary data in the literature which indicate that certain parameters such as age, sex, ethnic origin, smoking history, etc., are associated with the body burdens of lead. This in-depth survey of human subjects and comparisons to traffic density will provide more definitive information about these relationships.

B. <u>Description of Survey Plan</u>

1. The survey design will be aimed at determining the body burdens of lead of populations living within 100 feet of streets carrying traffic densities which vary from less than 1000 cars per day to greater than 25,000 cars per day. It is estimated that the total population living within 100 feet of such streets within the United States is significantly over one million.

2. The survey is designed to initially contact and survey 1,000 households, 200 at streets carrying each of the following approximate traffic densities: less than 1000 cars per day, 10,000 cars per day, 15,000 cars per day, 20,000 cars per day, and 25,000 or more cars per day. Each household will be contacted by a personal interviewer. A set of general information will be obtained from the person interviewed. If appropriate age and occupational status are determined, the person will be asked questions 12 and 13 of the Household Health Survey for Lead: "Would you participate in a health survey as a paid volunteer ? Other members of household?" It is anticipated that approximately 440 subjects who respond to this questionnaire will be chosen, on the basis of age,

occupation, and location categories, to participate as paid volunteers. Each subject will be sent a letter announcing that he or she has been selected for the survey; a time and place will be specified as to when a team will visit the subject's house to accomplish the blood and soil samples.

A pre-test of the questionnaire has been conducted. This pre-test was conducted with five representative individuals from the staff of Southwest Research Institute, and no difficulties were encountered. The question of non-responders for this particular survey does not appear to represent a problem, since the burden for the individuals at households to respond to this is minimal and number of non-responders is expected to be very low.

3. The statistical design of the project will come primarily from Mr. David Camann with Southwest Research Institute. The Environmental Protection Agency's statistician, ______________________________ ______________________________, has reviewed this protocol.

4. Name of the Contractor: Southwest Research Institute. Contractor's role: the primary role is to collect information and provide a final report to include statistical evaluation of data and conclusions regarding the body burdens of lead found and the correlation to traffic density.

Southwest Research Institute guarantees confidentiality of the collected data to the subjects surveyed. No direct reference to the collected data using the subject's name or address will be made. The compilation of subject's name and address will be maintained in a confidential file and will not be directly related to any of the collected data. Each subject surveyed will be assigned a code number, and the coded number with the individual's name will be maintained only in the files of Dr. Donald E. Johnson, principal investigator, at Southwest Research Institute.

C. Time Schedule for Data Collection and Publication

The contract term is for twelve months with an additional 60 days for review of the draft final report. The final report should be completed September, 1976. Monthly progress reports will also be submitted. It is estimated that the elapsed time between the completion of data collection and the issuance of the first published report will be six months.

D. Consultations Outside the Agency

Southwest Research Institute has consulted with the City of San Antonio for assistance and coordination in the conduct of the survey.

E. Estimation of Respondent Reporting Burden

The estimation of respondent reporting burden for the Household Health Survey is ten minutes, with a maximum of 20 minutes. This estimate is based on a preliminary pre-test survey of randomly selected Southwest Research Institute employees and should be the amount of time necessary for even a large household to complete.

F. Sensitive Questions

Questions 7 and 8 of the General Information Questions ask questions regarding diagnosed incidence of lead poisoning and approximate age of the home. This information is essential in order to provide an assessment of the background of lead poisoning and potential for lead poisoning due to pica. Questions 10 and 11 of the General Information and 5, 6, and 7 of the Individual Information Questions provide data regarding the occupation of the individual. These questions are essential to establish that the individual is not occupationally exposed to lead and that he generally spends his day in the vicinity of his home. Questions 8 and 9 of the Individual Information establish the individual's smoking history. This is essential because this study is concerned with air-borne pollutants, and cigarette smoking affects the absorption rate of such chemicals. Other questions refer to some of the socio-economic background necessary to make valid statistical comparisons with other areas.

QUESTIONNAIRE 4294-1
HOUSEHOLD HEALTH SURVEY FOR LEAD

Name ______________________________
Last Name, First Name M. I.

Address: Street ______________________
City ______________________
Zip Code ______________________
Telephone ______________________

General Information Questions

1. How many persons reside in your household? ________

2. For each person in your household, including yourself, please indicate the age and sex, beginning with the oldest and proceeding to the youngest:

Age ____ ____ ____ ____ ____ ____ ____ ____
Sex ____ ____ ____ ____ ____ ____ ____ ____

3. Households with minor children present:
Do both parents reside in household? ________

4. What educational level has been completed by the head of your household?

1 - Less than 8th grade
2 - 8th grade
3 - High School - Incomplete
4 - High School Completed
5 - College - Incomplete
6 - College - Complete
7 - Graduate School

5. Do you cool your home with any of the following appliances?

1 - Central air conditioning
2 - Window air conditioner
3 - Evaporative cooler
4 - Window fan
5 - Ceiling exhaust fan
6 Other ________

6. Are any of the following articles used in preparing or serving meals in your household:

1 - Unglazed pottery made in Mexico
2 - Glazed pottery made in Mexico
3 - Hand painted flatware
4 - None of these

7. Has any member of your household been diagnosed for lead poisoning? ________
If so, which member or members? ______________________

8. What is the approximate age of your home? ________ years

9. Are you ever aware of a smell or odor from automobile traffic?
Inside house ________
Outside house ________

10. Do any members of your household have occupations which normally take them away from home during their work hours? ________
If so, which members? ______________________

11. Do any members of your household have occupations which normally do not take them away from home? ________
If so, which members? ______________________

12. Would you participate in a health survey as a paid volunteer? (Paid $15 for blood, dust, and soil samples) ________

13. Other members of household? ______________________

Individual Information Questions

1. Date of Birth ____________ Month ______ Day ______ Year

2. Sex: 1 - Male 2 - Female

3. What is your marital status?
   - 1 Single
   - 2 - Married
   - 3 - Separated
   - 4 - Divorced
   - 5 - Widowed
   - 6 - Other

4. How many years have you lived in San Antonio? ______ years
   At your present address? ______ years

5. What is your usual occupation? (Please specify) ____________
   Are you presently occupied in this manner? ______

6. Does your occupation usually take you away from home? ______

7. Which of these best describes your present occupational status?
   - 1 - Employed fulltime (including self employed)outside home
   - 2 Employed part-time outside home
   - 3 - Employed inside home
   - 4 Unemployed
   - 5 Housewife
   - 6 - Student
   - 7 Play/Nursery School
   - 8 - Pre-school
   - 9 - Retired

8. Have you ever smoked as many as five packs of cigarettes, that is, as many as 100 cigarettes during your entire life? ______
   Do you now smoke cigarettes? ______

9. If you are a current or an ex-cigarette smoker:

   a. How many cigarettes do (did) you smoke per day

      1--Less than 1/2 pack per day (1-5 cigarettes per day)
      2--About 1/2 pack per day (6-14 cigarettes per day)
      3--About 1 pack per day (15-25 cigarettes per day)
      4--About 1-1/2 packs per day (26-34) cigarettes per day)
      5--About 2 packs per day (35 or more cigarettes per day)

   b. How old were you when you first started smoking? ______ Years

   c. How old were you when you last gave up smoking, if you no longer smoke? ______ Yea

YOU HAVE COMPLETED THE QUESTIONNAIRE-THANK YOU

Interviewer Note and Record

1. Site Number ______
2. Distance to center of primary roadway ______
3. Distance to other nearest roadway ______
4. IMNOWO 123456 ______

8/7/75

STANDARD FORM NO. 83
OFFICE OF MANAGEMENT AND BUDGET

FOR O.M.B. USE

CLEARANCE REQUEST AND NOTICE OF ACTION

(Under Federal Reports Act and Bureau of the Budget Circular No. A-40, as amended)

IMPORTANT — Submit the required number of copies of SF-83, together with the material for which approval is requested to:

CLEARANCE OFFICER
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

READ INSTRUCTIONS BEFORE COMPLETING FORM

PART A – REQUEST BY FEDERAL AGENCY FOR CLEARANCE

*Items marked with asterisk may be omitted for preliminary plans or recordkeeping requirements

1. SEND "NOTICE OF ACTION" TO: Name and mailing address

2. Bureau and division or office originating request

3. Name(s), title(s), and telephone numbers of person(s) who can best answer questions regarding request.

FORM OR DOCUMENT IDENTIFICATION

4. Title of form or document submitted
HOUSEHOLD HEALTH SURVEY FOR LEAD

*5. Agency Form Number(s)

6. Type of form or document
1 ☐ Application
2 ☐ Program evaluation
3 ☐ Other management report
4 ☒ Statistical survey or report
5 ☐ Preliminary plan or contract
6 ☐ Recordkeeping requirement
7 ☐ Other – *Specify*

7. Current (or former) O.M.B. clearance – Number
Expiration date

8. Requested expiration date
June 1976

9. Type of request
1 ☒ New
2 ☐ Revision
3 ☐ Extension (No change)
4 ☐ Reinstatement

*10. Frequency of use
1 ☐ Single time
2 ☒ On occasion
3 ☐ Weekly
4 ☐ Monthly
5 ☐ Quarterly
6 ☐ Semi-annually
7 ☐ Annually
8 ☐ Other *(See instructions)*

11. Related forms or documents *(Give O.M.B. number. Enclose in parentheses any to be replaced.)*

12. Catalog of Federal Domestic Assistance program number (if applicable)

COLLECTION AND RESPONDENTS

*13a. Collection method *(Check as many as apply)*
1 ☐ Mail
2 ☒ Personal interview
3 ☐ Other – *Describe*

*13b. Collected by –
4 ☐ Agency
5 ☒ Contractor
6 ☐ Other – *Describe*

14a. Type of respondents involved *(Check predominant one)*
1 ☒ Individuals or households
2 ☐ Business firms (non-farm)
3 ☐ Farms
4 ☐ Government agencies
5 ☐ Other – *Describe*

14b. Brief description of respondents (i.e., "households in 50 largest SMSA's; "retail grocery stores")

*15. Summary of estimated respondent burden	Number
a. Estimated number of respondents	1250
b. If sample, approximate number in universe	over one million
c. Reports filed annually by each respondent (item 10)	onee
d. Total annual responses (a X c)	1250
e. Estimated average number of man-hours required per response	1/3
f. Estimated TOTAL MAN-HOURS of respondent burden (d X e)	416

AUTHORITY AND CONFIDENTIALITY

*16a. Is report form –
1 ☐ Voluntary?
2 ☒ Required to obtain benefit?
3 ☐ Mandatory? *Cite statute*

*16b. Does your agency pledge confidentiality?
1 ☒ Yes 2 ☐ No

CONSULTATIONS OUTSIDE AGENCY

17. In developing the report form or other documents, were consultations held with individuals or organizations outside your agency?
1 ☒ Yes – If "yes," identify persons and describe outcome in SUPPORTING STATEMENT. *(See instructions)*
2 ☐ No

CERTIFICATION BY AUTHORIZED OFFICIALS SUBMITTING REQUEST – We certify that the form or other document submitted for approval is necessary for the proper performance of this agency's functions, that the information requested is not available from any other source, to the best of our knowledge, and that the request is consistent with applicable O.M.B. and agency policy directives. Signature and title of:

Approving official for agency	Date	Agency clearance officer or other agency official	Date

APPENDIX D

Appendix D contains the air lead concentrations and corresponding traffic counts. The abbreviated variables and their units are explained below.

Traffic Class	Estimated traffic class
Street	Name of street
Date	Date on which 24-hour count was started
Traffic Count	Actual traffic count
Air Pb	Air lead concentration ($\mu g/m^3$)

APPENDIX D

Traffic Class	Street	Date	Traffic Count	Air Pb
Ø1ØØØ	MIMOSA	Ø5/26/76	336	.65
Ø1ØØØ	MIMOSA	Ø5/27/76	364	1.22
Ø1ØØØ	MIMOSA	Ø5/28/76	375	1.Ø3
Ø1ØØØ	MIMOSA	Ø5/29/76	358	.35
Ø1ØØØ	MIMOSA	Ø6/Ø2/76	365	.74
Ø1ØØØ	MIMOSA	Ø6/Ø3/76	437	.89
Ø1ØØØ	MIMOSA	Ø6/Ø4/76	343	1.Ø5
Ø1ØØØ	MIMOSA	Ø6/Ø5/76	421	1.16
Ø1ØØØ	COSTA MESA	Ø6/Ø5/76	32Ø	.46
Ø1ØØØ	COSTA MESA	Ø6/Ø6/76	311	.32
Ø1ØØØ	COSTA MESA	Ø6/Ø7/76	315	.33
Ø1ØØØ	COSTA MESA	Ø6/Ø8/76	325	.65
Ø1ØØØ	COSTA MESA	Ø6/Ø9/76	327	.56
Ø1ØØØ	COSTA MESA	Ø6/1Ø/76	321	1.Ø5
Ø1ØØØ	COSTA MESA	Ø6/11/76	314	.36
Ø1ØØØ	MYRTICE	Ø6/15/76	69	.61
Ø1ØØØ	MYRTICE	Ø6/16/76	141	.46
Ø1ØØØ	MYRTICE	Ø6/17/76	138	.43
Ø1ØØØ	MYRTICE	Ø6/18/76	126	.41
Ø1ØØØ	MYRTICE	Ø6/19/76	1Ø6	.71
Ø1ØØØ	MYRTICE	Ø6/2Ø/76	1Ø6	.89
Ø1ØØØ	MYRTICE	Ø6/21/76	112	.43
Ø1ØØØ	MYRTICE	Ø6/22/76	13Ø	.33
Ø1ØØØ	MYRTICE	Ø6/23/76	121	.22
Ø1ØØØ	MYRTICE	Ø6/24/76	146	.89
Ø5ØØØ	BLUFFVIEW	Ø5/28/76	4947	1.5Ø
Ø5ØØØ	BLUFFVIEW	Ø5/29/76	3647	.61
Ø5ØØØ	BLUFFVIEW	Ø5/3Ø/76	3193	.6Ø
Ø5ØØØ	BLUFFVIEW	Ø5/31/76	5977	1.Ø2
Ø5ØØØ	BLUFFVIEW	Ø6/Ø1/76	6568	1.21
Ø5ØØØ	BLUFFVIEW	Ø6/Ø2/76	6146	1.24
Ø5ØØØ	BLUFFVIEW	Ø6/Ø3/76	629Ø	1.33
Ø5ØØØ	MIDWAY HILLS	Ø6/Ø3/76	6577	1.32
Ø5ØØØ	MIDWAY HILLS	Ø6/Ø5/76	7344	.82
Ø5ØØØ	MIDWAY HILLS	Ø6/Ø6/76	6634	.74
Ø5ØØØ	MIDWAY HILLS	Ø6/Ø7/76	3169	1.53
Ø5ØØØ	MIDWAY HILLS	Ø6/Ø8/76	7555	1.25
Ø5ØØØ	MIDWAY HILLS	Ø6/Ø9/76	7741	.92
Ø5ØØØ	MIDWAY HILLS	Ø6/1Ø/76	5338	1.Ø8
Ø5ØØØ	MIDWAY HILLS	Ø6/11/76		.62

APPENDIX D (CONTINUED)

Traffic Class	Street	Date	Traffic Count	Air Pb
05000	BARNES BRIDGE	06/17/76	4417	.54
05000	BARNES BRIDGE	06/18/76	1346	.43
05000	BARNES BRIDGE	06/19/76	2754	.46
05000	BARNES BRIDGE	06/20/76	4443	1.13
05000	BARNES BRIDGE	06/21/76	2722	.48
05000	BARNES BRIDGE	06/22/76	2807	.41
05000	BARNES BRIDGE	06/23/76	2917	.34
05000	BARNES BRIDGE	06/24/76	3938	.93
05000	BARNES BRIDGE	06/25/76	4659	.87
10000	PRAIRIE CREEK	06/04/76	9630	.48
10000	PRAIRIE CREEK	06/05/76	8254	.91
10000	PRAIRIE CREEK	06/06/76	7845	.73
10000	PRAIRIE CREEK	06/07/76	8902	1.73
10000	PRAIRIE CREEK	06/08/76	8659	.86
10000	PRAIRIE CREEK	06/09/76	9224	.89
10000	PRAIRIE CREEK	06/10/76	11055	.45
10000	PRAIRIE CREEK	06/11/76	11186	.54
10000	OATES	06/11/76	10735	.64
10000	OATES	06/12/76	9795	.55
10000	OATES	06/13/76	9376	.73
10000	OATES	06/14/76	11242	.71
10000	OATES	06/15/76	11569	.86
10000	OATES	06/16/76	11019	1.25
10000	OATES	06/17/76	11451	1.86
10000	OATES	06/18/76	10575	.61
10000	OATES	06/29/76	11266	1.06
10000	OATES	06/30/76	12712	1.30
10000	OATES	07/01/76	11857	.86
10000	OATES	07/03/76	10757	.04
10000	OATES	07/04/76	4463	.71
10000	OATES	07/05/76	9262	1.17
10000	OATES	07/06/76	12660	.68
10000	OATES	07/07/76	13400	1.58
15000	INWOOD	05/26/76	11355	1.63
15000	INWOOD	05/28/76	17452	1.60
15000	INWOOD	05/29/76	7737	1.01
15000	INWOOD	05/30/76	7604	.74
15000	INWOOD	05/31/76	14957	1.21
15000	INWOOD	06/02/76	13630	1.05
15000	INWOOD	06/03/76	13092	1.36

APPENDIX D (CONTINUED)

Traffic Class	Street	Date	Traffic Count	Air Pb
15000	INWOOD	06/04/76	19193	1.51
15000	INWOOD	06/05/76	12318	.85
15000	INWOOD	06/06/76	14945	.62
15000	INWOOD	06/07/76	16404	1.63
15000	JIM MILLER	06/10/76	18662	.74
15000	JIM MILLER	06/11/76	13573	.53
15000	JIM MILLER	06/14/76	17904	.37
15000	JIM MILLER	06/15/76	19152	.97
15000	JIM MILLER	06/16/76	18475	.94
15000	JIM MILLER	06/17/76	16122	.54
15000	JIM MILLER	06/18/76	13916	1.03
15000	JIM MILLER	06/19/76	17221	1.42
15000	JIM MILLER	06/20/76	16913	1.12
15000	FOREST LANE	06/12/76	16555	.67
15000	FOREST LANE	06/13/76	15669	.55
15000	FOREST LANE	06/14/76	21252	.69
15000	FOREST LANE	06/15/76	20431	.76
15000	FOREST LANE	06/16/76	18563	1.13
15000	FOREST LANE	06/17/76	18924	.94
15000	FOREST LANE	06/18/76	21391	.83
15000	FOREST LANE	06/19/76	14829	1.08
15000	FOREST LANE	06/20/76	12473	1.62
15000	LOVERS LANE	06/18/76	16128	1.43
20000	MARSH	05/27/76	21077	.62
20000	MARSH	05/28/76	22348	1.64
20000	MARSH	05/29/76	15314	.83
20000	MARSH	05/30/76	14578	.88
20000	MARSH	05/31/76	19625	1.06
20000	MARSH	06/01/76	20489	.97
20000	MARSH	06/02/76	23648	1.06
20000	MARSH	06/03/76	19559	1.42
20000	MARSH	06/23/76	21334	1.19
20000	MARSH	06/22/76	23353	1.42
20000	ROYAL	05/27/76	24178	1.16
20000	ROYAL	05/31/76	15218	1.02
20000	ROYAL	06/02/76	17133	.25
20000	ROYAL	06/04/76	15120	2.03
20000	ROYAL	06/05/76	12554	.77
20000	ROYAL	06/06/76	11101	.93
20000	ROYAL	06/07/76	26253	1.51

APPENDIX D (CONTINUED)

Traffic Class	Street	Date	Traffic Count	Air Pb
20000	MOCKINGBIRD	06/24/76	13790	1.37
20000	MOCKINGBIRD	06/25/76	21197	1.37
20000	MOCKINGBIRD	06/26/76	10877	.78
20000	MOCKINGBIRD	06/27/76	13878	.93
20000	MOCKINGBIRD	06/28/76	17902	1.20
20000	MOCKINGBIRD	06/29/76	18495	1.94
20000	MOCKINGBIRD	06/30/76	16857	1.01
20000	MOCKINGBIRD	07/01/76	13345	.97
25000	N. W. HWY	05/27/76	42529	1.34
25000	N. W. HWY	05/28/76	45805	4.93*
25000	N. W. HWY	05/29/76	33762	2.33
25000	N. W. HWY	05/30/76	33700	2.06
25000	N. W. HWY	05/31/76	42800	3.56
25000	N. W. HWY	06/02/76	41079	1.51
25000	N. W. HWY	06/03/76	42899	1.91
25000	N. W. HWY	06/04/76	41602	2.32
25000	N. W. HWY	06/05/76	33846	.93
25000	N. W. HWY	06/06/76	33716	.82
25000	N. W. HWY	06/07/76	38950	1.89
25000	N. W. HWY	06/04/76	44381	2.22
25000	N. W. HWY	06/05/76	38018	.95
25000	N. W. HWY	06/06/76	31477	.88
25000	N. W. HWY	06/07/76	32835	1.51
25000	N. W. HWY	06/08/76	31217	1.69
25000	N. W. HWY	06/09/76	35137	1.74
25000	N. W. HWY	06/10/76	36345	1.53
25000	N. W. HWY	06/11/76	31998	1.22
25000	COIT	06/22/76	31542	1.67
25000	COIT	07/02/76	26355	.38
25000	COIT	07/04/76	20483	.63
25000	COIT	07/05/76	20481	1.61
25000	COIT	07/06/76	24572	.84
25000	COIT	07/07/76	16430	2.40

* Rejected as outlier (P << .001)

APPENDIX E

The variables tap water lead, soil lead, indoor dust lead, windowsill wipe lead, and traffic for each household are given in Appendix E. The abbreviated captions and units are given below.

Hsld. ID	Household ID
Site	Traffic density site
H_2O	Lead concentration in tap water (μg/ml)
Soil	Lead concentration in soil (μg/g)
# Days	Actual number of sampling days for indoor dust
Idust	Lead concentration in indoor dust ($\mu g/cm^2$) adjusted to to a 28 day base
Wsill	Lead concentration in windowsill wipe dust ($\mu g/cm^2$)
Traffic	Actual traffic count

APPENDIX E

Hsld. ID	Site	H2O	Soil	#Days	Idust	Wsill	Traffic
1500		0.0009					
2435		0.0000					
5115			69.78				
5880		0.0005					
7240		0.0002					
0005	1	0.0004	6.10	27	0.0035	0.0838	320
0010	1	0.0003	38.61	27	0.0055	0.3143	320
0015	1	0.0002	36.58	28	0.0080	0.1162	194
0025	1	0.0000	40.64	27	0.0011	0.0104	599
0050	1	0.0000	39.62	27	0.0024	0.0000	558
0055	1	0.0004	54.87	27	0.0059	0.0093	558
0060	1	0.0017	45.72	27	0.0027	0.0000	186
0065	1	0.0003	75.19	27	0.0046	0.0461	596
0070	1	0.0009	118.88	27	0.0015		596
0075	1	0.0021	127.01	31	0.0033		596
0080	1	0.0003	49.79	27	0.0000	0.0246	599
0090	1	0.0005	49.79	27	0.0048	0.0050	599
0100	1	0.0002	424.47	27	0.0062	0.0116	529
0105	1	0.0000	481.07	27	0.0030	0.0061	529
0120	1	0.0000	86.37	27	0.0038	0.0183	537
0130	1	0.0008	184.92	29	0.0027	0.0049	346
0135	1	0.0003	81.29	28	0.0031	0.0954	346
0140	1	0.0012	95.51	47	0.0032	0.0115	336
0145	1	0.0007	168.67	27	0.0146	0.0126	336
0150	1	0.0005	29.47	27	0.0029	0.0400	336
0155	1	0.0012	28.43			0.0545	336
0160	1	0.0009	22.34	27	0.0062	0.0127	336
0165	1	0.0000	44.69	27	0.0022	0.0403	336
0170	1	0.0003	47.73	27	0.0011	0.0926	346
0180	1	0.0000	133.03	27	0.0054	0.1349	336
0250	1	0.0016	63.98	28	0.0013	0.0411	472
0255	1	0.0006	140.14			0.1282	596
0260	1	0.0000	76.17	27	0.0122	0.0332	474
0265	1	0.0013	82.26	28	0.0113	0.0384	155
0270	1	0.0003	157.41	28	0.0235	0.0421	346
0275	1	0.0010	60.93	28	0.0164	0.0300	471
1395	1	0.0003	481.07	27	0.0024	0.0152	155
1400	1	0.0000	61.94	28	0.0065	0.0000	202
1405	1	0.0020	110.69	27	0.0016	0.1172	155
1410	1	0.0000	77.18	27	0.0012	0.0563	155

APPENDIX E (CONTINUED)

Hsld. ID	Site	H20	Soil	#Days	Idust	Wsill	Traffic
1415	1	0.0006	37.33	27	0.0030	0.0143	343
1420	1	0.0000	47.73	27	0.0010	0.0248	255
1425	1	0.0002	117.80	27	0.0041		343
1515	1	0.0004	118.82	28	0.0018		571
1520	1	0.0002		29	0.0061	0.0470	571
1530	1	0.0000	730.09	27	0.0027	0.0574	571
1535	1	0.0000	8.13	27		0.0356	571
1540	1	0.0005	33.56	28	0.0000	0.0742	571
1550	1	0.0000	96.61	27	0.0089	0.0156	571
1560	1	0.0000	108.82	38	0.0091	0.2126	571
1565	1	0.0002	203.40	27	0.0027		571
1840	1	0.0043	73.22	28	0.0037	0.0218	320
1845	1	0.0000	65.09	27	0.0080	0.1035	194
1850	1	0.0014	95.60	27	0.0071	0.0242	194
1855	1	0.0005	115.93	27	0.0155	0.0082	194
1860	1	0.0008	43.81	27	0.0029	0.4138	335
1870	1	0.0000	27.46	27	0.0000	0.0148	335
1875	1	0.0006	44.74	27	0.0022	0.0441	335
1890	1	0.0008	29.49	27	0.0026	0.0064	320
1895	1	0.0000	10.17	27	0.0026	0.0070	320
1900	1	0.0010	29.49	27	0.0024	0.0157	320
1905	1	0.0000	17.29	28	0.0012	0.1375	320
1915	1	0.0004	43.81	27	0.0022	0.0539	335
1925	1	0.0000	45.77	27	0.0285	0.0869	320
2145	1	0.0013	243.83	27	0.0018	0.0304	336
2160	1	0.0009	291.21	27	0.0012	0.0000	178
2165	1	0.0007	46.49	27	0.0018	0.0503	173
2170	1	0.0000	63.68	27	0.0029	0.0165	178
2175	1	0.0007	65.70	27	0.0050	0.0206	471
2200	1	0.0006	101.03	28	0.0000	0.0097	471
2205	1	0.0002	176.83	27	0.0038	0.0087	471
2410	1	0.0005	51.54	27	0.0024	0.0227	479
2440	1		264.34	27	0.0056		259
2460	1	0.0000	26.28	27	0.0088		259
2465	1	0.0002	394.51	27	0.0013	0.0451	259
2470	1	0.0000	271.67	30	0.0225	0.2278	300
2480	1	0.0000	147.57	27	0.0020	0.0071	300
2485	1	0.0007	52.56	28	0.0063	0.0219	474
2490	1	0.0009	37.93	27	0.0027	0.0059	474
2500	1	0.0002	37.40	27	0.0059	0.0692	364

Hsld. ID	Site	H20	Soil	#Days	Idust	Wsill	Traffic
2505	1	0.0000	56.60	27	0.0041	0.0149	364
3105	2	0.0035	97.22	27	0.0043	0.0231	9538
3115	2	0.0022		27			6577
3210	2	0.0005	73.69	27	0.0187	0.0312	11765
3220	2	0.0058	47.07	27	0.0057	0.0139	11765
3225	2	0.0002	143.27	27	0.0367	0.1728	11765
3230	2	0.0000	74.71	27	0.0066	0.3309	11765
3425	2	0.0010	104.38	27	0.0055	0.0087	8651
3435	2	0.0003	110.52	27	0.0095	0.0102	6654
3665	2	0.0041	61.43	27	0.0027	0.0390	12514
3670	2	0.0003	148.38	27	0.0030	0.0264	12514
3675	2	0.0002	108.48	27	0.0111	0.4468	12514
3695	2	0.0000	111.55	28	0.0030	0.0506	12514
3870	2	0.0000	135.08	27	0.0036	0.0155	11467
3875	2	0.0000	56.23	29	0.0321	0.0093	11467
3940	2	0.0000	190.67	29	0.0092	0.0667	10200
3905	2	0.0000	25.00	27	0.0011	0.0124	10200
5380	2	0.0010	111.65	28	0.0391	0.1749	13000
5390	2	0.0000	53.03	28	0.0025	0.2145	13000
5395	2	0.0000	214.14	28	0.0316	0.2357	13000
5575	2	0.0000	28.77	29	0.0024	0.0031	10637
5590	2		95.57	27	0.0039	0.0193	12411
5645	2	0.0005	55.68	29	0.0020	0.0126	9362
5660	2	0.0002	31.55	27	0.0032	0.0296	9362
5665	2	0.0012	32.48	27	0.0010	0.0242	11765
5670	2	0.0020	26.91	27	0.0102	1.9540	12411
5675	2	0.0000	34.33	27	0.0026	0.0303	10637
5685	2	0.0000	105.57	29	0.0080	0.2196	12514
5700	2	0.0013	173.24	27	0.0043	0.0337	11765
5725	2	0.0000	51.44	27	0.0020	0.0012	12411
7185	2	0.0002	39.31			0.0102	9098
7265	2	0.0004	37.39	27	0.0059		12331
7290	2		230.34	28	0.0068	0.1906	12331
9010	2	0.0009	312.67	27	0.0030	0.0159	7154
9015	2	0.0000		27	0.0073	0.2072	7154
9020	2	0.0006	167.56	27	0.4712	0.0819	6776
9070	2	0.0000	156.97	27	0.0041	0.0261	7154
9075	2	0.0008	59.71	26	0.0028	0.0479	7154
9090	2	0.0004	145.42	29	0.0032	0.0298	7154
9095	2	0.0000	91.49	29	0.0010		7154

APPENDIX E (CONTINUED)

Hsld. ID	Site	H20	Soil	# Days	Idust	Wsill	Traffic
9100	2	0.0003	235.30	27	0.0178		7154
9105	2	0.0000	494.17	27	0.0090		7154
9115	2	0.0000	124.71	27	0.0041		7154
9125	2	0.0000	58.74	27	0.0123	0.0291	7154
9130	2	0.0002	110.74	27	0.0472	0.0286	7154
9195	2	0.0003	73.78	28	0.0011	0.0249	8209
9205	2	0.0000	102.56	27	0.0408	0.1390	11708
9210	2	0.0000	540.84	34	0.0038	0.4858	11708
9215	2	0.0000	72.57	28	0.0314	0.3855	11708
9220	2	0.0000	122.83	28	0.0012	0.0350	11338
9225	2	0.0000	307.49	28	0.0043	0.0330	11338
9230	2	0.0002	145.14	28	0.0083	0.8182	11338
9235	2	0.0002	84.19	28	0.0024	0.3286	11338
9280	2	0.0000	200.30	27	0.0736	0.3980	11817
9285	2	0.0000	196.43	27	0.0100	0.0217	11494
9290	2	0.0003	163.05	27	0.0037	0.0318	8197
9295	2	0.0004	57.09	27	0.0054	0.0125	13072
9300	2	0.0000	83.22	27	0.0204	0.0279	13072
9305	2	0.0000	64.83	27	0.0138	0.0130	8464
9310	2	0.0002	109.34	27	0.0304	0.1128	9708
9315	2	0.0000	106.44	29	0.0031	0.0196	8464
9325	2	0.0000	49.84	29	0.0029	0.0247	9456
9340	2	0.0000	144.17	27	0.0598	0.0529	9456
9345	2	0.0002	3.87	37	0.0025	0.0986	9456
9360	2	0.0007	77.44	27	0.0022	0.0716	9456
9365	2	0.0002	31.77	27	0.0135		11708
9370	2	0.0004	109.21	27	0.0624	0.0439	11708
9380	2	0.0003	140.93	29	0.0056	0.0466	13072
9390	2	0.0000	169.78	27	0.0048	0.0282	9456
9485	2		41.70	27	0.0038		11494
9490	2	0.0010	298.84	28	0.0050	0.1563	5918
3080	3	0.0004	137.13	27	0.0012	0.0340	16219
3090	3	0.0004	63.44	27	0.0017	0.0174	16219
3100	3	0.0008	91.08	27	0.0362	0.0227	16219
3310	3	0.0000	384.35	27	0.0802	0.0528	13800
3335	3	0.0004	345.92	28	0.0000	0.0342	13800
3650	3	0.0007	226.36	27	0.0624	0.0147	16128
3660	3	0.0000	119.73	31	0.0153	0.0509	16128
4020	3	0.0003	104.97	28	0.0036	0.0653	17931
4025	3	0.0004	81.86	28	0.0052	0.0092	17931

APPENDIX E (CONTINUED)

Hsld. ID	Site	H20	Soil	# Days	Idust	Wsill	Traffic
5080	3		33.15	27	0.0079	0.0974	18790
5085	3	0.0000	30.70	27	0.0015	0.0338	18790
5090	3	0.0003	112.59	28	0.0100	0.0080	18790
5095	3	0.0005	73.50	27	0.0030	0.1608	18790
5100	3	0.0002	31.64	27	0.0037	0.0097	18790
5105	3	0.0004	91.18	28	0.0027	0.0189	18790
5130	3	0.0004	236.95	27	0.0097	0.0142	14000
5135	3	0.0000	197.21	27	0.0080	0.2062	14000
5165	3	0.0003	137.70	26	0.0073	0.2792	18245
5240	3	0.0000	78.16	27	0.0055		13800
5365	3	0.0005	153.52	29	0.0024	0.1411	15257
5370	3		141.43				15257
5400	3	0.0000	124.68	28	0.0127	0.0065	15570
5405	3	0.0000	45.39	27	0.0150		15570
5440	3	0.0000	39.16	28	0.0012	0.0203	16882
5445	3	0.0003	78.32	28	0.0026	0.0563	16882
5455	3	0.0013	253.01	27	0.0046	0.0385	15442
5460	3	0.0002	187.89	30	0.0047	0.0177	15442
5465	3	0.0003	58.74	28	0.0000	0.0336	18245
5470	3	0.0002	114.82	28	0.0037	0.0171	18245
5480	3	0.0000	130.84	28	0.0104	0.0331	17452
5490	3	0.0009	70.31	28	0.0018	0.0256	17452
5495	3	0.0009	69.43	28	0.0031	0.1234	18548
5505	3	0.0000	110.36	28	0.0337	0.4252	17000
5510	3	0.0000	84.55	27	0.0019	0.1405	15000
5520	3	0.0004	62.68	28	0.0023	0.8714	13800
5525	3	0.0000	236.98	27	0.0063	0.2477	14000
5540	3	0.0004	236.07	28	0.0097	0.0364	19000
5545	3	0.0007	46.79	28	0.0052	0.1041	18245
5550	3	0.0009	61.33	27	0.0032	0.0404	17000
5555	3	0.0004	222.03	39		4.6857	13800
5565	3	0.0005	67.74	28	0.0035	0.0746	16500
5585	3	0.0000	239.61	28	0.0053	0.0739	18245
5595	3	0.0000	77.95	28	0.0233	0.0407	16381
5605	3	0.0003	337.87	28	0.0038	0.0105	17119
5625	3	0.0000	146.56	27	0.0330	0.3451	18354
5635	3	0.0002	13.91	27	0.0041	0.0391	18354
5680	3	0.0002	62.17	31	0.0082	0.0071	18354
5690	3	0.0008	73.38	27	0.0063	0.0471	18548
5695	3	0.0009	105.57	27	0.0020	0.0003	17119

APPENDIX E (CONTINUED)

Hsld. ID	Site	H20	Soil	#Days	Idust	Hsill	Traffic
5705	3	0.0000	65.87	28	0.0137	0.0337	17119
5715	3	0.0005	93.84	33	0.0445	0.2857	15156
5730	3	0.0000	160.62	28	0.0080	0.0132	13700
5735	3	0.0000	81.21	28	0.0160	0.5396	13700
5740	3	0.0002	27.97	28	0.0063	0.0113	13700
5745	3	0.0000	199.18	28	0.0123	0.0483	13700
5755	3	0.0000	114.39	30	0.0047	0.0248	13700
5760	3	0.0000	434.41	27	0.0022	0.0469	13700
5765	3	0.0000	76.70	28	0.0319	0.0193	13700
5770	3	0.0003	89.33	27	0.0199	0.0289	13700
5775	3	0.0000	79.40	27	0.0160	0.2812	13700
5780	3	0.0000	133.54	29	0.0080	0.0205	13700
5785	3	0.0000	347.53	28	0.0108	0.0105	13700
5850	3	0.0002	170.54	28	0.0079	0.0157	16536
7075	3	0.0002	141.89	27	0.0017	0.0091	18790
7100	3	0.0005	387.13	28	0.0153	0.0175	18790
7340	3	0.0002	38.20	28	0.0128	0.2517	16331
7385	3	0.0000	178.32	28	0.0249	0.0875	16331
7580	3	0.0003	492.97	27	0.0036	0.0230	18790
7605	3	0.0005	203.40	27	0.0018	0.2228	18790
7620	3	0.0003	203.40	27	0.0071	0.0322	13684
7630	3	0.0000	146.22	27		0.5377	13684
7655	3	0.0000	132.16	27	0.0044		13684
7705	3	0.0000	136.84	29	0.0057	0.0000	13424
7720	3	0.0003	63.69	28	0.0061	0.0108	14500
7745	3	0.0000	401.34	27	0.0045	0.0302	13634
7775	3	0.0028	33.27	27	0.0017	0.0048	18790
7850	3	0.0000	55.13	27	0.0094	0.0053	18216
9470	3	0.0009	54.10	27	0.0080	0.7163	17047
9475	3	0.0000	186.65	35	0.0038	0.1126	18354
3700	4	0.0005	191.36	28	0.0157	0.0042	37350
5225	4	0.0003	160.96			0.5268	20890
5230	4	0.0000	47.45	27	0.0034	0.2164	20362
5360	4	0.0000	76.30	28	0.0067	0.1580	20928
5410	4	0.0000	58.71	23	0.0017	0.0043	20928
5415	4	0.0006	56.07	28	0.0031	0.1255	20928
5485	4	0.0013	40.05	27	0.0017	0.0411	20890
7170	4	0.0004	117.92	27	0.0035	0.7964	20483
7180	4	0.0025	95.87	28	0.0310	0.0583	21300
7220	4	0.0003	260.22	31	0.0065	0.0941	20432

APPENDIX E (CONTINUED)

Hsld. ID	Site	H20	Soil	#Days	Idust	Wsill	Traffic
7225	4	0.0062	86.28	27	0.0118	0.0949	20432
7270	4	0.0004	214.37	27	0.0035	0.0643	20432
7275	4	0.0003	160.10	27	0.0138		20432
7390	4	0.0000	127.51	32	0.0117	0.0246	23885
7395	4	0.0003	175.44			0.0057	23885
7415	4	0.0000	78.61	25	0.0074	0.0641	22670
7515	4	0.0000	71.90	27	0.0000	0.0044	37850
7520	4	0.0002	117.92	32	0.0032	0.1065	37850
7525	4	0.0004	222.63	27	0.0078	0.0161	37850
7545	4	0.0009	58.48	28	0.0142	0.0238	37850
7550	4	0.0004	221.67	27	0.0027	0.0147	37850
7585	4	0.0002	157.47	32	0.0488	0.2118	20432
7610	4	0.0003	100.29	27	0.0045	0.0315	37850
7640	4	0.0009	620.19			0.0837	27537
7645	4	0.0006	238.06	27	0.0033	0.1169	37850
7650	4	0.0002	76.86	32	0.0016	0.0513	20000
7660	4	0.0000	136.84	27	0.0130	0.9109	31542
7665	4	0.0009	76.86	29	0.0025	0.0132	31542
7670	4	0.0000	79.67	27	0.0150	0.3727	31542
7675	4	0.0021	30.93	27	0.0099	0.0185	19578
7680	4	0.0000	79.67	31	0.0070	0.0036	19578
7685	4	0.0004	29.06	27	0.0030	0.1710	31542
7690	4	0.0007	92.79	28	0.0017	0.1531	20141
7700	4	0.0003	312.74	28	0.0027	0.1206	20572
7715	4	0.0002	60.84	27	0.0074	0.0063	20483
7725	4	0.0002	64.64	27	0.0056	0.0094	21300
7735	4		169.21	27	0.0032	0.0269	20432
7750	4	0.0006	471.77	27	0.0262		21300
7760	4	0.0000	262.14	27	0.0057	0.0358	21300
7765	4	0.0013	65.59	27	0.0144	0.0602	20432
7780	4	0.0945	101.72	29	0.0082	0.0189	31542
7785	4	0.0011	52.29	27	0.0057	0.0180	31542
7790	4	0.0000	153.06	27	0.0028	0.0090	31542
7795	4	0.0000	59.89	27	0.0041	0.0592	20928
7800	4	0.0007	173.01	28	0.0224	0.1392	20432
7805	4	0.0000	112.18	29	0.0036	0.0426	20928
7810	4	0.0000	212.03	28	0.0022	0.0601	20141
7815	4	0.0007	26.62	27	0.0049	0.0174	31542
7820	4	0.0002	54.19	27	0.0117	0.0662	31542
7825	4	0.0009	82.70	27	0.0057	0.0149	31542
7830	4	0.0008	349.84	27	0.0093	0.0245	31542
7835	4	0.0000	106.47	27	0.0075		31542
7840	4	0.0000	55.13	27	0.0074	0.0000	31542
7845	4		56.09	27	0.0030	0.0175	20432
9465	4	0.0013	39.85	28	0.0038	0.0365	20362

APPENDIX F

Appendix F contains the variables handwipe lead, blood lead, and traffic counts for each participant (children only). The units are given below.

Site	Traffic density site
Traffic Count	Actual traffic count
Part. ID	Participant ID
Handwipe Pb	Lead concentration in handwipe sample ($\mu g/cm^2$)
Blood Pb 1	Lead concentration in blood sample 1 ($\mu g/100$ ml)

APPENDIX F

Site	Traffic Count	Part. ID	Handwipe Pb	Blood Pb 1
1	320	0007	10.82	6.40
1	194	0017	9.22	17.47
1	599	0026	2.22	30.90
1	558	0052	7.87	36.00
1	558	0058	3.84	17.81
1	558	0059	8.42	13.70
1	186	0061	9.27	19.60
1	596	0066	3.85	31.30
1	596	0072	11.37	10.40
1	596	0077	7.73	15.12
1	599	0091	1.83	19.70
1	599	0092	7.11	5.40
1	529	0103	6.12	28.20
1	529	0107	5.60	5.40
1	346	0132	4.25	14.10
1	336	0152	13.35	9.10
1	336	0156	1.64	19.60
1	336	0161	3.19	8.30
1	336	0167	2.29	13.90
1	336	0168	9.79	15.10
1	346	0172	6.54	15.98
1	346	0173	1.60	11.96
1	335	0182	5.19	12.00
1	336	0183	7.50	8.10
1	472	0252	5.38	17.90
1	596	0257	11.53	16.08
1	596	0258	10.71	15.80
1	346	0271	8.45	16.30
1	346	0272	3.36	7.25
1	202	1402	6.57	13.29
1	571	1531	3.84	7.50
1	571	1532	14.31	11.98
1	571	1561	4.62	11.98
1	571	1562	39.73	9.36
1	194	1852	5.89	14.86
1	335	1862	17.30	14.80
1	320	1892	3.84	
1	320	1893	1.92	10.41
1	178	2172	26.84	18.40
1	178	2173	5.21	29.80
1	471	2201	3.34	17.60

APPENDIX F (CONTINUED)

Site	Traffic Count	Part. ID	Handwipe Pb	Blood Pb
1	471	2206	5.72	31.00
1	474	2487	12.04	10.08
1	364	2501	6.32	11.10
1	364	2502	5.54	14.40
2	11765	3226	11.01	17.06
2	11765	3227	12.46	24.35
3	16128	3662	12.00	12.90
2	12514	3667	5.57	14.40
2	12514	3672	10.57	17.06
2	12514	3673	11.69	12.88
2	12514	3697	10.14	13.48
2	11467	3876	6.54	16.88
4	20390	5227	9.23	15.80
4	20928	5362	4.13	15.95
4	20928	5412	4.42	20.80
4	20928	5413	6.72	9.50
4	20928	5417	6.65	21.60
3	17452	5493	7.30	8.20
3	18548	5497	3.88	17.10
3	17000	5507	10.08	16.10
3	17000	5508	19.03	24.20
3	15040	5512	17.96	13.64
3	18245	5547	23.30	15.61
3	13800	5557	13.29	5.40
3	16500	5567	9.70	12.70
3	18245	5586	19.78	19.60
3	16381	5597	6.28	19.70
3	17119	5606	4.23	6.10
2	9362	5662	4.13	15.90
2	11765	5667	8.68	23.40
3	18354	5681	4.25	10.52
2	12514	5686	6.86	12.44
2	11765	5701	2.99	18.35
3	13700	5732	4.31	13.70
3	13700	5757	4.90	14.40
3	13700	5771	3.03	39.50
3	13700	5776	7.40	17.00
3	13700	5781	18.63	13.70
3	16586	5352	7.34	14.46
4	20433	7171	12.79	17.10
4	20432	7272	8.45	11.60

APPENDIX F (CONTINUED)

Site	Traffic Count	Part. ID	Handwipe Pb	Blood Pb 1
2	12331	7291	18.25	28.40
4	23885	7392	29.17	17.32
4	27537	7642	41.41	14.60
4	37850	7647	6.31	14.90
4	20572	7702	12.37	29.10
3	14500	7722	4.80	17.40
4	21300	7752	6.66	
4	21300	7753	16.62	15.16
4	31542	7787	3.38	11.40
4	31542	7788	13.11	7.00
4	20928	7797	14.79	11.80
4	20928	7807	18.25	30.90
4	20141	7812	4.32	10.10
4	31542	7817	30.36	9.50
3	13216	7851	6.32	14.90
2	7154	9071	3.48	10.61
2	7154	9131	6.46	13.50
2	11338	9221	3.57	16.47
2	11338	9237	8.74	14.09
2	11817	9282	16.66	19.60
2	8197	9292	7.24	14.40
2	8197	9293	6.05	13.18
2	13072	9297	21.32	35.84
2	13072	9302	4.06	13.03
2	13072	9303	2.77	15.30
2	9708	9312	4.80	13.03
2	9708	9313	6.66	16.25
2	11708	9372	23.24	17.40
2	13072	9382	5.73	27.30
2	9456	9392	6.09	33.10
4	20362	9465	10.62	11.27
3	17047	9471	5.72	19.27
3	17047	9472	4.86	27.90
2	11494	9487	3.69	18.15
2	5918	9492	14.31	36.60
2	5918	9493	10.16	23.30
2	5918	9494	20.30	18.90
2	5918	9496	8.98	12.10
3	17452	5492	6.24	14.60

APPENDIX G

The variables listed in Appendix G pertain to identification of the participant and the blood analyses. Abbreviated captions are explained below and units are given for each variable.

Hsld. ID	- Household ID
Site	- Traffic density site
Traffic Count	- Cars/day
DOW	- Day of week on which the traffic count was made
Part. ID	- Participant ID
Sex	- Sex of the participant (1 = Male; 2 = Female)
Age	- Age of the participant
Blood Pb 1	- Blood lead measurement (μg lead/100 ml blood) from blood sample 1
Blood Pb 2	- Blood lead measurement (μg lead/100 ml blood) from blood sample 2
HCT 1	- Hematocrit value from blood sample 1
HCT 2	- Hematocrit value from blood sample 2
FEP 1	- FEP value from blood sample 1 (μg/100 ml RBC's)
FEP 2	- FEP value from blood sample 2 (μg/100 ml RBC's)
CO 1	- % carbon monoxide in blood sample 1 (ml/100 ml)
CO2	- % carbon monoxide in blood sample 2 (ml/100 ml)
Smok. code	- Smoking Code / # packs/day

Smoking Code	# packs/day
0	0 (does not smoke)
1	≤1/2
2	1
3	1 1/2
4	2

Paint	- Highest of the four paint values for the household (mg/cm^2)

APPENDIX G

Hsld. ID	Site	Traffic Count	DOW	Part. ID	Sex	Age	Blood Pb 1	Blood Pb 2	HCT 1	HCT 2	FEP 1	FEP 2	CO 1	CO 2	Smok. Code	Paint
1530	1	571	3	1531	1	01	7.50	14.40		37						.2
1890	1	320	3	1892	1	01		9.50		36						2.5
2500	1	364	5	2501	1	01	11.10	10.60		30						.0
0075	1	596	5	0077	1	02	15.12	22.90	36		48					4.3
0105	1	529	5	0107	1	02	5.40									.0
0155	1	336	2	0156	1	02	19.60	22.50		32						1.6
0025	1	599	4	0026	1	03	30.90	8.80		33						1.1
0150	1	336	2	0152	1	03	9.10	12.90		35						1.6
0160	1	336	2	0161	1	03	8.30	17.30		35						2.7
0165	1	336	2	0167	1	03	13.90	11.00		35						.9
0255	1	596	5	0258	1	03	15.80	14.30	35	36						10.1
1860	1	335	4	1862	1	03	14.80	10.20		33						.2
1890	1	320	3	1893	1	03	10.41	11.12	38	40	80	121		.1	0	2.5
2205	1	471	5	2206	1	03	31.00	13.50		38						6.5
0055	1	558	4	0058	1	05	17.81	17.12	42	39	18	177	.1	.1	0	.0
0090	1	599	4	0092	1	05	5.40	29.00		37						.0
2485	1	474	5	2487	1	05	10.08	10.39	38	37	73	47	.1	.1	0	.4
2500	1	364	5	2502	1	05	14.40	7.90		37						.0
0170	1	346	2	0172	1	06	15.98	18.17	39	39	70	11L		.2	0	1.1
1560	1	571	3	1562	1	06	9.36	8.76	37	37	98	89				.9
0120	1	537	5	0122	1	60	12.95	12.94	45	43	107	108	.1	.3	0	1.4
2480	1	300	3	2481	1	60	24.52	11.25	41	38	89	114	.3	.8	1	.3
1425	1	343	3	1426	1	61	12.24	12.42	46	44	43	44				.2
2470	1	300	3	2471	1	61	13.88	14.47	44	41	20	67	.1	.2	0	.6
1410	1	155	2	1411	1	65	12.51	15.00	48	45	87	81	.2		0	1.5
1550	1	571	3	1551	1	65	14.07	16.00	43	41	21	51	.8		1	.5
1515	1	571	3	1517	1	66	14.64	12.17	39	39	56	71				3.2
2160	1	178	2	2162	1	67	11.22	10.13	43	40	58	82	.2	.2	0	.7
1540	1	571	3	1541	1	68	18.73	16.47	45	48	146	47	.1	.2	0	.7
2165	1	178	2	2167	1	72	15.73	16.75	37	40	83	43	.1	.3	0	.4

APPENDIX G (CONTINUED)

Hsld. ID	Site	Traffic Count	DOW	Part. ID	Sex	Age	Blood Pb 1	Blood Pb 2	HCT 1	HCT 2	FEP 1	FEP 2	CO 1	CO 2	Smok. Code	Paint
0030	1	599	4	0081	1	75	13.18	11.38	43	43	99	125	.4	.8	0	.9
2465	1	259	2	2467	1	77	18.50	17.21	48	40	64	121	.1	.2	0	.0
0140	1	336	2	0142	1	80	16.95		43	43	148					.9
2440	1	259	2	2441	1	80	10.87	9.75	43	43	4	88	.1	.2	0	.0
0050	1	558	4	0052	2	01	36.00	27.10		39						1.4
0100	1	529	5	0103	2	01	28.20	20.50		36						.5
0090	1	599	4	0091	2	02	19.70	17.90		36						.0
0130	1	346	2	0132	2	02	14.10	9.60	38	35						.7
0180	1	336	2	0182	2	02	12.00	14.90		37						2.7
0055	1	558	4	0059	2	03	13.70	14.40		39						.0
0250	1	472	3	0252	2	03	17.90	14.65	35	34	49	33				.1
1400	1	202	3	1402	2	03	13.29	13.73			0	0	.1		0	1.7
0270	1	346	2	0271	2	04	16.30	8.94	35	42	94	50				1.1
1850	1	194	4	1852	2	04	14.86	17.12	37	35	175	79				.5
2170	1	178	2	2172	2	04	18.40	19.30		38						.0
0095	1	320	3	0097	2	05	6.40	8.10		34						1.5
0015	1	194	4	0017	2	05	17.47	13.99	37	36	39	77				.9
0060	1	186	4	0061	2	05	19.60	9.21		39		84				.0
0065	1	596	5	0066	2	05	31.30	13.80		40						.5
0165	1	336	2	0168	2	05	15.10	32.10		36						.9
0170	1	346	2	0173	2	05	11.96	13.20	37	33	44	100				1.1
0180	1	336	2	0183	2	05	8.10	13.80		36						2.7
0255	1	596	5	0257	2	05	16.08	12.06	37	40	75	64				10.1
1530	1	571	3	1532	2	05	11.98	14.50	40		64		.1		0	.2
2200	1	471	5	2201	2	05	17.60	15.40	38							3.0
0070	1	596	5	0072	2	06	10.40	12.40		42						12.5
2170	1	178	2	2173	2	06	29.80	8.30		39		97				.0
1560	1	571	3	1561	2	08	11.98	11.64	39	38	65	73				.8
0155	1	336	2	0157	2	22	8.84	10.13	42	43	60	112				1.6
1520	1	571	3	1521	2	22	10.15	9.03	42	39	47	111	.1		0	.9

APPENDIX G (CONTINUED)

Hsld. ID	Site	Traffic Count	DOW	Part. ID	Sex	Age	Blood Pb 1	Blood Pb 2	HCT 1	HCT 2	FEP 1	FEP 2	CO 1	CO 2	Smok. Code	Paint
0265	1	155	2	0267	2	23	17.00	15.69	35	43	199	76				.2
1850	1	194	4	1851	2	23	5.18	4.59	35	33	103	68				.5
0015	1	194	4	0016	2	25	13.55	10.36	42	41	93	105				.9
0250	1	472	3	0251	2	25	10.59	12.06	34	33	97	68				.0
0150	1	336	2	0151	2	26	9.28	8.12	41	39	62	94				1.6
1400	1	202	3	1401	2	26	5.18	6.94	39	37	107	131	.0		0	1.7
1530	1	571	3	1533	2	26	9.10	9.29	46	38	55	128	1.1		3	.2
1890	1	320	3	1891	2	26	5.18	5.00	40	40	119	95				2.5
0270	1	346	2	0272	2	27	7.25	16.99	34	37	128	96				2.1
0050	1	558	4	0051	2	28	10.18	10.03	43	38	4	100				1.4
0180	1	336	2	0181	2	28	10.41	10.13	42	42	127	87	.9		1	2.7
0255	1	596	5	0256	2	28	14.25	12.57	35	43	79	48				10.1
1860	1	335	4	1861	2	28	5.71	7.26	43	43	151	85				.2
0160	1	336	2	0162	2	29	8.06	7.54	44	43	58	72	.1		0	2.7
2205	1	471	5	2207	2	29		8.99	44	34		66				6.5
0025	1	599	4	0027	2	30	10.87	11.38	40	42	19	66				1.1
0130	1	346	2	0131	2	30	8.75	8.11	37	38	89	70				.7
0170	1	346	2	0171	2	30	11.69	10.34	43	43	51	64				1.1
2170	1	178	2	2171	2	30	8.09	6.24	41	41	49	105	.1		0	.0
0005	1	320	3	0006	2	31	16.01	10.85	45	37	119	61				4.5
0055	1	558	4	0056	2	31	6.94	7.75	44	39	30	124				.0
0165	1	336	2	0166	2	31	6.48	5.25	43	42	85	101	.2		0	.9
1875	1	335	4	1876	2	31	15.91	13.73	47	33	138	197				.2
2485	1	474	5	2486	2	31	12.00	10.64	47	45	103	75		.2	0	.0
0100	1	529	5	0101	2	33	11.10	12.95	41	41	47	118				.5
0105	1	529	5	0106	2	33	9.94	9.90	43	41	18	67				.0
0145	1	336	2	0146	2	33	6.22	5.83	38	39	96	58				1.1
0060	1	186	4	0062	2	34	6.01	5.11	40	38	43	128				.0
2240	1	471	5	2202	2	34	11.10	10.58	46	35	55	93	.0		0	3.0
1845	1	194	4	1846	2	35	8.44		41	40	200					1.4

APPENDIX G (CONTINUED)

Hsld. ID	Site	Traffic Count	DOW	Part. ID	Sex	Age	Blood Pb 1	Blood Pb 2	HCT 1	HCT 2	FEP 1	FEP 2	CO 1	CO 2	Smok. Code	Paint
1915	1	335	4	1916	2	35	9.10	7.73	44	39	134	71				.7
2500	1	364	5	2503	2	36	5.32	4.50	37	38	54	73	.1		0	.3
0070	1	596	5	0071	2	37	8.56	9.73	43	48	18	79				12.5
2175	1	471	5	2176	2	40	10.18	11.64	45	37	20	89	.0		0	4.4
0260	1	474	5	0261	2	42	7.20	7.90	34	36	50	57				1.1
1565	1	571	3	1566	2	42	8.06	8.50	40	43	50	121				.0
1895	1	320	3	1896	2	42	5.06	6.42	43	39	63	97				3.0
1395	1	155	2	1396	2	43	11.96	11.57	42	33	78	112				2.7
0010	1	320	3	0011	2	44	7.54	7.50	41	33	62	52				1.4
1535	1	571	3	1536	2	44	11.53	10.90	42	38	77	34		.2	0	2.1
2490	1	474	5	2491	2	44	6.01	5.50	39	37	65	103	.1		0	.3
1870	1	335	4	1871	2	47	11.72	12.68	47	45	77	96				1.4
0135	1	346	2	0136	2	49	9.89	8.44	42	43	74	92				.7
1405	1	155	2	1406	2	49	6.12	6.27	40	40	106	95				2.3
1425	1	343	3	1427	2	49	6.75	10.13	41	42	129	73	.1		0	.2
2505	1	364	5	2506	2	50	14.18	10.08	43	40	59	108	1.2		2	.3
0140	1	336	2	0141	2	52	16.69	13.68	43	42	97	59				.9
1420	1	255	3	1421	2	53	9.89	9.84	42	41	47	75				1.6
2460	1	259	2	2461	2	53	14.57	13.99	40	33	50	86	.7		1	.3
1415	1	343	3	1416	2	54	11.98	10.99	44	45	108	54				.3
1905	1	320	3	1906	2	55	9.31	7.05	40	33	119	85	.2		0	.2
2480	1	300	3	2482	2	55	15.96	17.75	37	13	54	43	.1		0	.3
0120	1	537	5	0121	2	56	17.11	17.00	41	33	18	100				1.4
1410	1	155	2	1412	2	56	6.48			41	0		.1		0	1.5
1900	1	320	3	1901	2	56	8.84	7.96	44	43	82	89		1.0	2	.9
1925	1	320	3	1927	2	58	9.89	10.25	46	37	78	103				1.1
2410	1	479	5	2411	2	59	15.19	18.69	38	42	24	103	.9		4	.9
1840	1	320	3	1841	2	61	10.37	10.99	43	38	58	81				.7
2160	1	178	2	2161	2	66	8.79	24.52	42	35	18	120				.7
1855	1	194	4	1856	2	67	14.41	9.55	42	43	168	99				1.4

APPENDIX G (CONTINUED)

Hsld. ID	Site	Traffic Count	DOW	Part. ID	Sex	Age	Blood Pb 1	Blood Pb 2	HCT 1	HCT 2	FEP 1	FEP 2	CO 1	CO 2	Smok. Code	Paint
2165	1	178	2	2166	2	67	9.02	9.00	41	41	75	67				.3
1515	1	571	3	1516	2	69	7.01	7.20	42	42	60	116	.2		0	3.2
2465	1	259	2	2466	2	69	9.02	9.75	38	44	52	108	.1		0	.3
2440	1	259	2	2442	2	77	7.63	9.82	33	35	38	124	.1		0	.3
2145	1	336	3	2146	2	79	9.94	8.33	45	39	81	97				.0
1925	1	320	3	1926	2	84	9.83	7.48	43	42	77	134		.2	0	1.1
5660	2	9362	2	5662	1	01	15.90	13.50	35	35						.0
9280	2	11817	2	9282	1	01	19.60	14.60	34	35						3.3
9470	2	7154	3	9471	1	02	10.61	13.57	37	37	14	33				1.3
9290	2	8197		9292	1	02	14.40	16.00	33	34						1.4
3665	2	12514		3667	1	03	14.40	34.50	33	39						.2
3670	2	12514		3673	1	03	12.38	13.20	37	37	98					1.4
3875	2	11467	5	3876	1	03	16.88	15.61	39	43	67	70				2.7
9300	2	13072	3	9302	1	03	13.03	14.14	41	39	53	81				.0
3225	2	11765	3	3227	1	04	24.85	27.23	39	39	28	51				.5
3670	2	12514		3672	1	04	17.06	17.01	33	33	95	112				1.4
9290	2	8197		9293	1	04	13.18	16.30	39		84					1.4
9295	2	13072	3	9297	1	04	35.84	19.20	38	37	86					2.6
9310	2	9708	2	9312	1	04	13.03	15.00	38	35	43	38	.1	.1	0	8.3
5685	2	12514		5686	1	05	12.44	16.65	40	37	44	118	.1		0	1.1
7290	2	12331	3	7291	1	05	23.40	16.10	33	36						.0
9485	2	11494	2	9487	1	05	18.15	15.98	36	38	102	29				.2
3695	2	12514		3697	1	06	13.48	13.57	41	38	102	112				4.7
3220	2	11765	3	3221	1	51	14.64	16.43	45	45	85	85				.2
3425	2	8651	4	3427	1	57	12.50	15.28	43	43	89	72	.1		0	.2
9230	2	11338	4	9231	1	59	10.50	7.58	44	44	75	69				3.5
9345	2	9456	3	9346	1	59	8.58	14.14	40	42	119	73		.1	0	2.3
3105	2	9588	3	3106	1	62	17.36.	14.04	48	46	99	95		.1	0	.0
9325	2	9456	3	9327	1	63	13.84	13.37	46	45	59	95	.7		1	1.6
5380	2	13000		5381	1	68	7.05	7.12	42	42	63	26	.1	.2	0	.4

APPENDIX G (CONTINUED)

Hsld. ID	Site	Traffic Count	DOW	Part. ID	Sex	Age	Blood Pb 1	Blood Pb 2	HCT 1	HCT 2	FEP 1	FEP 2	CO 1	CO 2	Smok. Code	Paint
9010	2	7154	3	9011	1	68	14.64	14.72	54	53	40	80	1.3		3	.5
9075	2	7154	3	9076	1	70	10.06	12.68	43	45	3	56				.0
3675	2	12514		3676	1	71	13.48	12.42	48	48	87	40				2.1
7265	2	12331	3	7266	1	71	13.39	15.55	48	48	93	50	.8	.6	2	2.5
9360	2	9456	3	9361	1	71	20.28	17.87	43	44	45	83	.2	.1	0	.5
3230	2	11765	3	3232	1	75	18.67	15.38	47	45	70	120	.1		0	.2
9285	2	11494	2	9287	1	75	6.58	5.54	44	41	25	118				.5
3870	2	11467	5	3871	1	75	21.23	15.46	49	53	109	37	[illegible]	1.7	0	.7
9305	2	8464	2	9307	1	76	10.89	9.55	43	42	76	191	.3	.2	0	.2
9315	2	8464	2	9317	1	78	10.35	8.12	44	43	37	72		.1	0	1.6
9125	2	7154	3	9126	1	84	14.10	15.86	44	44	37	63				.7
9495	2	5918	3	9496	2	01	12.10	11.60	33	37						2.1
9130	2	7154	3	9131	2	02	13.50	18.70	37	34						1.6
9220	2	11338	4	9221	2	02	16.47	11.30	38	37	110					3.9
9310	2	9708	2	9313	2	02	16.25	19.87	39		42	0				6.3
9490	2	5918	3	9494	2	02	18.90	25.90	35	38						2.1
9390	2	9456	3	9392	2	03	33.10	32.90	37	35						3.0
5700	2	11765	3	5701	2	04	18.35	22.70	39	37	48		.1		0	.2
9235	2	11338	4	9237	2	04	14.09	12.17	38	34	114	96				5.7
9370	2	11708	2	9372	2	04	17.40	20.90	38	36						6.9
9490	2	5918	3	9493	2	04	23.30	20.00	38	41						2.1
5665	2	11765	3	5667	2	05	23.40	8.67	35	37		58		.1	4	.5
9300	2	13072	3	9303	2	05	15.30	13.50	41	41						.0
9380	2	13072	3	9382	2	05	27.30	33.20	38		57					.2
9490	2	5918	3	9492	2	05	36.60	18.60	33	33						2.1
3225	2	11765	3	3226	2	05	17.06	19.01	39	33	70	96				.5
9280	2	11817	2	9281	2	21	10.35	9.05	38	35	57	88				3.3
3435	2	6654	6	3436	2	22	6.53	5.54	37	34	89	91	.5		2	1.3
9105	2	7154	3	9106	2	23	13.57	11.27	46	45	35	95				.7
9490	2	5918	3	9491	2	23	8.37	7.90	37	38	102	17				2.1

APPENDIX G (CONTINUED)

Hsld. ID	Site	Traffic Count	DOW	Part. ID	Sex	Age	Blood Pb 1	Blood Pb 2	HCT 1	HCT 2	FEP 1	FEP 2	CO 1	CO 2	Smok. Code	Paint
5700	2	11765	3	5702	2	24	3.90	9.89	34	34	132	105	.3		2	.2
3665	2	12514		3666	2	26	12.29	9.88	39	40	122	74	.2		0	.2
3900	2	10200		3901	2	26	4.66	4.78	34	34	119	47				1.3
9435	2	11494	2	9488	2	26	12.99	10.15	37	35	36	64				.2
5675	2	10637	2	5676	2	27	7.97	7.96	43	42	92	107				.9
9295	2	13072	3	9296	2	27	8.74	8.12	40	41	68	75				2.6
9300	2	13072	3	9301	2	27	10.61	15.86	41	40	93	92				.0
5665	2	11765	3	5666	2	28		5.15		41		68				.5
9290	2	8197		9291	2	28	10.50	8.41	45	46	61	117				1.4
3225	2	11765	3	3223	2	29	13.30	12.42	37	37	59	99				.5
9070	2	7154	3	9072	2	29	13.84	13.86	48	43	68	193				1.3
9130	2	7154	3	9132	2	29	11.15	11.27	41	41	80	132				1.6
9380	2	13072	3	9381	2	29	21.62	17.58	50	42	44	49				.2
9365	2	11708	2	9366	2	30	7.40	7.54	42	44	65	106				.3
9020	2	6776	3	9021	2	31	6.32	6.98	38	36	72	102				.2
3670	2	12514		3671	2	32	9.01	7.54		37	0	68				1.4
5685	2	12514		5687	2	32	9.32	12.66	40	42	44	88				1.1
9115	2	7154	3	9116	2	32	13.61	12.71	41	41	80	132				1.1
3695	2	12514		3696	2	33	8.71	7.26	39	41	93	89				4.7
9390	2	9456	3	9391	2	33	19.29	23.88	46	43	67					3.3
9370	2	11708	2	9371	2	34	15.18	11.27	44	42	62	54				6.9
9205	2	11708	2	9206	2	37	14.64	13.57	44	44	62	83				2.5
5670	2	12411	6	5671	2	38	17.73	10.17	38	35	103	84	.1		0	.0
9100	2	7154	3	9101	2	38	11.99	9.42	43	45	71	46				2.5
9210	2	11708	2	9211	2	38	14.92	14.72	43	39	89	71				1.1
9310	2	9708	2	9311	2	38	12.76	10.70	47	42	46	87		.1	1	8.3
5590	2	12411	6	5591	2	39	9.13	10.14	43	43	77	43				.0
9235	2	11338	4	9236	2	39	11.99	11.04	42	38	41	72				5.7
3905	2	10200		3906	2	40			36	41						.5
5575	2	10637	2	5576	2	41	8.67	9.66	42	41	107	69				3.9

APPENDIX G (CONTINUED)

Hsld. ID	Site	Traffic Count	DOW	Part. ID	Sex	Age	Blood Pb 1	Blood Pb 2	HCT 1	HCT 2	FEP 1	FEP 2	CO 1	CO 2	Smok. Code	Paint
5660	2	9362	2	5661	2	41	9.38	10.88	41	43	46	28				.0
5725	2	12411	6	5726	2	42	7.32	6.32	39	40	97	128	.1		0	.0
3210	2	11765	3	3211	2	43	11.69	13.28	47	43	93	88				1.4
9015	2	7154	3	9016	2	46	13.30	13.86	46	43	71	99				.9
9195	2	8209		9196	2	47	5.13	4.11	43	41	164	103				2.5
9485	2	11494	2	9486	2	47	13.57	8.45	39		77					.2
9340	2	9456	3	9341	2	48	5.25	11.57	42	39	39	109		.2	0	5.6
3425	2	8651	4	3426	2	50	6.75	9.84	39	43	42	77	.1		0	.2
9285	2	11494	2	9286	2	50	6.86	6.68	43	40	63	122				.6
5645	2	9362	2	5646	2	52	20.48	12.34	40	43	99	65				.0
9095	2	7154	3	9096	2	55	9.63	5.66	51	46	153	37				1.1
9215	2	11708	2	9216	2	56			39	37						.4
9090	2	7154	3	9091	2	57	11.15	11.85	40	40	55	83				.0
9345	2	9456	3	9347	2	57	10.15	9.27	42	42	113	87		.1	0	2.3
9010	2	7154	3	9012	2	60	11.15	12.13	51	49	53	75	2.1		4	.5
5390	2	13000		5391	2	61	6.79	9.20	43	45	75	57		.2	0	.3
7185	2	9098		7186	2	61	8.20	9.38	39	37	58	81	.1		0	3.0
3105	2	9588	3	3107	2	62	14.33	12.34	44	41	82	81		.1	0	.0
5380	2	13000		5382	2	63	11.90	11.28	44	45	86	14		.3	0	.0
3675	2	12514		3677	2	68	19.74	18.43	44	43	95	31				2.1
9230	2	11338	4	9232	2	69	10.20	7.58	43	42	101	63				3.5
9360	2	9456	3	9362	2	69	5.78	4.97	44	42	25	87				.5
9225	2	11338	4	9226	2	70	12.59	10.13	48	37	36	61				6.2
3230	2	11765	3	3231	2	75	9.01	6.69	41	39	40	64	.1		0	.2
9305	2	8464	2	9306	2	75	7.12	6.68	44	41	87	89		.1	0	.2
9315	2	8464	2	9316	2	75	8.74	6.98	45	43	61	85		.1	1	1.6
9125	2	7154	3	9127	2	89	7.12	8.41	31	33	70	146				.7
5775	3	13700	3	5776	1	02	17.00	9.50	38	37						.2
5555	3	13800	3	5557	1	03	5.40	9.03	36	33						2.4
5545	3	18245	5	5547	1	04	15.61	11.39	37	37	75	32	.1	.1	0	1.1

APPENDIX G (CONTINUED)

Hsld. ID	Site	Traffic Count	DOW	Part. ID	Sex	Age	Blood Pb 1	Blood Pb 2	HCT 1	HCT 2	FEP 1	FEP 2	CO 1	CO 2	Smok. Code	Paint
5490	3	17452	6	5492	1	05	14.60	16.10	.40	44						3.0
5680	3	18354		5681	1	06	10.52	8.29	34	33	[illegible]	91	.1	.1	0	1.0
5780	3	13700	3	5781	1	05	13.70	14.93	37							2.3
5240	3	13800	3	5242	1	53	10.09	10.39	47	47	62	88	1.6	1.9	2	.7
5165	3	18245	5	5166	1	54	12.38	12.43	43	42	53	111	.1	.1	0	.3
7630	3	13684	4	7631	1	56	8.67	9.91	43	44	44	77	.2	.3	0	12.5
3310	3	13300	3	3312	1	59	9.01	10.61	41	41	53	103	.8		1	9.5
5480	3	17452	6	5481	1	59	9.13	13.55	49	49	89	46	.1		0	12.5
3100	3	16219	3	3101	1	60	15.87	15.86	47	43	126	88	.2		0	.2
5080	3	18790	5	5081	1	63	12.93	13.79	50		69	0				.2
5400	3	15570	4	5401	1	64	12.32	12.57	45	42	60	73	.2	.2		4.6
5440	3	16882	4	5441	1	65	5.48	3.34	44	43	60	69	.1	.1	0	1.1
4025	3	17931	4	4026	1	66	15.57	12.64	48	45	99	73				1.1
5445	3	16882	4	5446	1	67	7.84	8.42	48	43	67	13	1.1	1.0	0	1.1
5715	3	15156		5717	1	67	10.50	15.57	45	42	46	56	.1	.1	0	.7
5105	3	18790	5	5106	1	68	11.27	13.61	44		67	0	.1	.1	0	.2
5465	3	18245	5	5466	1	68	11.45	13.70	43	42	65	85	.1	.1	0	1.1
7620	3	13684	4	7622	1	68	17.88	17.44	47	45	84	73	.2		0	4.4
3650	3	16128	6	3651	1	70	9.90	21.02	48	43	75	85	.2		0	2.5
5095	3	18790	5	5096	1	70	11.50	13.31	48	45	126	110	.2		0	.0
5100	3	18790	5	5102	1	77	11.50	12.58	43		92	0	.2		0	.0
7075	3	18790	5	7076	1	77	12.68	15.25	41		46	0				.0
5405	3	15570	4	5406	1	78	10.45	18.06	35	43	34	107	.1	.1	0	1.6
3080	3	16219	3	3081	1	80	11.99	9.27	45	47	106	65	.2		1	3.1
7385	3	16381	4	7387	1	81	10.74	8.42	40	44	66	28	.1		0	1.1
5585	3	18245	5	5586	2	01	19.60	17.10	36							2.3
5770	3	13700	3	5771	2	01	39.50	17.70	35	31						.0
5595	3	16381	4	5597	2	02	19.73	11.60	34	33						.2
9470	3	17047		9471	2	02	19.27	15.69	37	37	117	17		.2	0	.0
5490	3	17452	6	5493	2	03	8.20	12.80	39	39						3.0

APPENDIX G (CONTINUED)

Hsld. ID	Site	Traffic Count	DOW	Part. ID	Sex	Age	Blood Pb 1	Blood Pb 2	HCT 1	HCT 2	FEP 1	FEP 2	CO 1	CO 2	Smok. Code	Paint
5505	3	17000	3	5507	2	03	16.10	33.90	38	43						3.2
5605	3	17119		5605	2	03	5.10	12.00	38	32	46	124				3.0
5755	3	13700	3	5757	2	03	14.40	11.90		35						1.6
3660	3	16128	6	3662	2	04	12.90	10.80	33	37						2.4
7720	3	14500		7722	2	01	17.40	13.00	40	39						.7
7850	3	18216		7851	2	04	11.93	15.20	36	41						1.3
9470	3	17047		9472	2	04	27.90	13.36	37	41		16				.0
5505	3	17000	3	5508	2	05	24.20	14.10	36	38						3.2
5510	3	15400	2	5512	2	05	13.64	9.08	37	37	72	30				.0
5565	3	16500		5567	2	05	12.70	15.40	36	36						12.5
5730	3	13700	3	5732	2	05	13.70	14.90	34	33						1.1
5850	3	16586		5852	2	05	14.46	13.11	35	34	53	115				.0
5495	3	18548	5	5497	2	06	17.10	9.00	33	33						.2
5370	3	15257	3	5371	2	19	11.74	11.85	45	43	53	92				6.3
5770	3	13700	3	5772	2	22	11.27	10.75	40	43	66	26	.9		2	.0
5540	3	19000		5541	2	23	10.52	10.94	37	36	118	83				.7
7100	3	18790	5	7101	2	23	10.56	12.09	42	42	45	67	.2		1	.2
5510	3	15400	2	5511	2	26	14.43	11.79	41	44	37	25				.0
5525	3	14000	5	5525	2	26	10.80	9.66	41	44	97	64				.2
5550	3	17000		5551	2	26	6.24	6.09	36	37	34	50				5.3
5565	3	16500		5566	2	26	8.67	8.37	39	41	18	73				12.5
5760	3	13700	3	5761	2	26	11.66	14.27	41		104	0				12.5
3660	3	16128	6	3661	2	27	14.68	7.97	37	33	98	87	.1	.1	0	2.4
5470	3	18245	5	5471	2	28	12.44	13.13	43	42	55	62				.2
5595	3	16381	4	5595	2	28	11.53	15.69	39	38	39	42				.2
7530	3	18790	5	7581	2	28	7.02	7.72	44	43	55	105				2.[illegible]
5455	3	15442		5456	2	29	8.83	9.13	40	37	29	122				.5
5555	3	13800	3	5556	2	30	14.77	7.12	39	33	43	55				2.1
5705	3	17119		5705	2	30	10.48	9.60	40	43	66	68		.2	1	1.6
5755	3	13700	3	5756	2	31	7.05	8.16	35	33	59	48				1.6

APPENDIX G (CONTINUED)

Hsld. ID	Site	Traffic Count	DOW	Part. ID	Sex	Age	Blood Pb 1	Blood Pb 2	HCT 1	HCT 2	FEP 1	FEP 2	CO 1	CO 2	Smok. Code	Paint
5460	3	15442		5461	2	32	11.50	10.64	43	41	53	69				1.0
4420	3	17931	4	4421	2	33	10.50	8.08	38	37	84	102				.5
5490	3	17452	6	5491	2	33	10.98	9.63	44	41	51	87		.7	1	3.0
5545	3	18245	5	5546	2	33	11.91	6.76	40	35	43	0				1.1
5775	3	13700	3	5777	2	33			40	43						.2
3335	3	13300	3	3336	2	34	9.27	9.18	48	50	22	67	1.6	1.4	2	.0
5585	3	18245	5	5587	2	34	7.28	4.51	41	36	29	67				2.3
5680	3	18354		5682	2	34	8.67	7.36	39	41	31	47	.1		0	1.0
5690	3	18548	5	5691	2	34	7.74	9.13	36	37	78	111	.1		0	1.6
5745	3	13700	3	5746	2	35	7.73	8.95	37	40	100	99				.4
5505	3	17400	3	5506	2	36	10.38	8.17	43	43	78	69				3.2
9470	3	17047		9473	2	36	9.50	9.46	42	40	79	28		.0	0	.0
9475	3	18354		9476	2	36	17.24	15.46	42	43	71	36				.0
5780	3	13700	3	5782	2	37	11.27	12.57	43	45	62	14	1.2		2	2.3
5135	3	14400	5	5136	2	38	15.74	13.10	41	46	92	45		.6	2	2.5
5495	3	18548	5	5496	2	38	10.52	9.82	42	41	54	45		.9	1	.2
7775	3	18790	5	7776	2	38	11.27	11.91	38	33	144	185				.0
5520	3	13300	2	5521	2	39	9.66	16.99	43	44	118	25				1.4
5740	3	13700	3	5741	2	39	19.95	14.40	38	32	71	16				.0
5695	3	17119		5696	2	40	10.29	8.37	41	32	81	48	.1		0	2.3
5730	3	13700	3	5731	2	40	7.58	9.93	41	43	78	26				1.4
5635	3	18354		5636	2	41	9.37	10.39	42	41	41	73	.1		0	.2
5765	3	13700	3	5766	2	41	11.27	11.61	39	45	95	74				.0
7705	3	18424	4	7706	2	42	7.97	5.53	40	42	73	40				.0
5365	3	15257	3	5366	2	44	7.02	7.72	39	42	62	121				.2
5850	3	16586		5851	2	44	10.14	10.54	41	43	45	50				.0
5785	3	13700	3	5786	2	45	16.37	12.67	46		129	0				.0
3090	3	16219	3	3091	2	47	25.41	14.77	45		144	0		1.4	4	1.4
7745	3	13684	4	7746	2	47	5.84	6.02	37	37	79	45				4.5
5735	3	13700	3	5736	2	49	6.53	6.86		29	0	71				.0

APPENDIX G (CONTINUED)

Hsld. ID	Site	Traffic Count	DOW	Part. ID	Sex	Age	Blood Pb 1	Blood Pb 2	HCT 1	HCT 2	FEP 1	FEP 2	CO 1	CO 2	Smok. Code	Paint
5130	3	14000	5	5131	2	52	7.97	7.48	39	37	75	132				.9
5240	3	13300	3	5241	2	52	7.97		45	41	53					.7
7720	3	14500		7721	2	53	5.21	4.52	35	35	43	31				.7
7340	3	16381	4	7341	2	54	7.32	7.38	38	41	70	3	.2		1	1.6
7385	3	16381	4	7386	2	58	7.53	7.12	41	42	92	26	.0		0	1.1
4025	3	17931	4	4027	2	60	15.28	10.53	43	41	81	118				1.1
5480	3	17452	6	5482	2	60	12.38	11.35	43.	42	40	107				12.5
7655	3	13684	4	7656	2	60	10.32	10.83	40	39	43	58		.7	2	.9
7620	3	13684	4	7621	2	62	6.31	5.53	44	45	78	75				4.4
5090	3	18790	5	5091	2	63	8.37	7.84	36	35	105	65		.2	1	.3
5105	3	18790	5	5107	2	63	8.93	10.50	45		64	0		.1	0	.2
5715	3	15156		5716	2	63	6.37	2.21	43	35	48	102				.7
3080	3	16219	3	3082	2	64	9.01	6.68	49	45	179	55	.1		0	3.1
5095	3	18790	5	5097	2	64	7.49	7.96	43	43	58	43				.3
5445	3	16882	4	5447	2	64	7.84	9.46	38	38	100	81				1.1
7605	3	18790	5	7606	2	64	14.57	15.54	41	45	59	100				.7
5465	3	18245	5	5467	2	65	19.79	11.94	38	35	87	67	.1	.1	0	1.1
5085	3	18790	5	5086	2	66	8.90	8.45	47	45	62	98				.7
5405	3	15570	4	5407	2	66	7.61	11.27	37	39	48	24				1.6
5100	3	18790	5	5101	2	71	11.93	14.28	41		122	0				.9
7075	3	18790	5	7477	2	75	8.20	8.93	39		115	0				.3
5410	4	20928	4	5412	1	01	20.80	17.40	33	35						.2
7815	4	31542	3	7817	1	01	9.50	15.10	34	33						.5
7390	4	23885	4	7392	1	02	17.32	17.20	35	35	59		.1		0	1.4
7700	4	20572	4	7702	1	02	29.10	21.20		37						3.1
5360	4	20928	4	5362	1	03	15.95	19.90	39	38	39		.1		0	.9
5415	4	20928	4	5417	1	04	21.50	21.60	37	33						.1
7750	4	21300	5	7753	1	04	15.16	13.86	37	35	4	20	.1	.1	0	1.6
7735	4	31542	3	7738	1	04	7.00	11.20	37	33						.3
7640	4	27537		7642	1	05	14.60	17.50	37	37						3.2

APPENDIX G (CONTINUED)

Hsld. ID	Site	Traffic Count	DOW	Part. ID	Sex	Age	Blood Pb 1	Blood Pb 2	HCT 1	HCT 2	FEP 1	FEP 2	CO 1	CO 2	Smok. Code	Paint
7795	4	20928	4	7797	1	05	11.80	9.21	36	37		47				2.5
7310	4	20141		7812	1	05	10.10	12.43	39	39		62		.1	0	.2
3700	4	37850	5	3701	1	65	11.79	12.88	46	48	132	45		.7	0	1.4
7545	4	37850	5	7546	1	65	17.17	13.55	45	45	52	73	.1		0	2.1
7415	4	22670		7417	1	66	8.63	8.68	49	40	38	59	.1	.2	0	2.7
7650	4	20490		7652	1	67	13.90	13.10	53	51	61	22	.1	.2	0	.0
7520	4	37850	5	7522	1	69	8.67	7.23	48	47	93	84	.3		0	.3
7184	4	21300	5	7182	1	70	12.38	23.67	42	41	29	42	.2	.1	0	.5
7395	4	23885	4	7397	1	72	10.21	9.98	32	33	186	173	.2		2	1.4
7550	4	37850	5	7551	1	74	11.74	15.01	41	42	59	54	.1		0	8.7
7275	4	20432	3	7276	1	75	12.45	11.66	47	44	84	42	.3	.4	1	.2
7610	4	37850	5	7611	1	77	14.11	15.74	42	43	82	65	.1		0	.9
7525	4	37850	5	7527	1	93	16.22	16.97	39	43	102	107	.1		0	.5
7750	4	21300	5	7752	2	01			34	35						1.6
7645	4	37850	5	7647	2	02	14.90	18.30	37	38						.9
7785	4	31542	3	7787	2	02	11.40	10.50	34	35						.0
7805	4	20928	4	7807	2	02	30.90	5.56	34	35		18				.0
5225	4	20390	5	5227	2	03	15.80		37	43						1.6
5410	4	20928	4	5413	2	03	9.50	11.50	40	38						.2
7270	4	20432	3	7272	2	03	11.60	17.70	34	35						.0
9465	4	20362	5	9466	2	05	11.27	11.02	37	35	131	31				.0
7170	4	20483	5	7171	2	06	17.10	23.84	38	33	94					1.3
7750	4	21300	5	7751	2	19	9.83	11.32	43	41	53	59				1.6
7825	4	31542	3	7826	2	19	10.52	8.63	39	41	18	61		.3	1	3.9
7700	4	20572	4	7701	2	24	9.13	8.93	37	37	61	122		.7	2	3.0
7805	4	20928	4	7806	2	24	4.95		34	35	43					.4
7640	4	27537		7641	2	25	10.98	11.66	37	38	47	73	1.3		2	3.2
5410	4	20928	4	5411	2	26	4.95	5.56	39	39	83	41		.1	0	.2
5360	4	20928	4	5361	2	28	11.53	12.06	43	42	62	50		.8	2	.9
7270	4	20432	3	7271	2	29	9.62	10.14	40	41	73	45	.1		0	.4

APPENDIX G (CONTINUED)

Hsld. ID	Site	Traffic Count	DOW	Part. ID	Sex	Age	Blood Pb 1	Blood Pb 2	HCT 1	HCT 2	FEP 1	FEP 2	CO 1	CO 2	Smok. Code	Paint
7645	4	37850	5	7646	2	29	7.26	6.50	43	40	68	70				.9
7795	4	20928	4	7796	2	29	8.55	4.67	39	37	66	107				2.5
5415	4	20928	4	5416	2	30	9.42	10.50	40	39	109	66				.0
5485	4	20890	5	5485	2	31	6.59	6.34	40	41	57	70		.1	0	1.4
7715	4	20483	5	7716	2	31		4.22	40	42		79				.0
7785	4	31542	3	7786	2	31	7.74	8.94	41	43	55	48				.0
7810	4	20141		7811	2	31	9.60	16.99	41	38	81	79		.6	2	.2
7815	4	31542	3	7816	2	32	11.45	10.90	38	37	60	81		.2	0	.5
5225	4	20890	5	5226	2	33	12.15	10.65	44	41	63	87	.8	1.1	4	1.6
7585	4	20432	3	7586	2	33	6.27	5.83	41	44	65	47				.5
7830	4	31542	3	7831	2	33	18.39	19.02	40	37	57	66		.2	1	.2
7515	4	37850	5	7516	2	34	10.32	10.83	42	39	70	72	1.0		1	.7
7685	4	31542	3	7686	2	34	7.97	8.37	38	36	73	52				.0
7735	4	20432	3	7736	2	34	7.97	6.32	40	43	86	64	.2		4	.0
9465	4	20362	5	9467	2	34	10.85	11.53	42	41	115	39				.0
7665	4	31542	3	7666	2	35	5.19	7.10	41	43	55	83				.5
7675	4	19578		7676	2	37	11.03	11.66	38	35	77	69				.0
7780	4	31542	3	7781	2	37	11.91	13.19	39	43	18	109		.2	0	.2
7670	4	31542	3	7671	2	39	6.35	5.86	41	40	58	24				.0
7835	4	31542	3	7836	2	40	11.45	8.90	41	33	0	88				.0
7390	4	23885	4	7391	2	41	15.22	12.06	43	42	75	61	.1		0	1.4
7760	4	21300	5	7761	2	42	9.13	12.17	38	37	59	76		.5	0	.5
7800	4	20432	3	7801	2	42	5.13	6.10	41	38	34	112				.0
7660	4	31542	3	7661	2	46	10.29	9.89	45	45	74	79				.2
7680	4	19578		7681	2	46	9.84	11.34	44	40	62	74				.5
7690	4	20141		7691	2	48	8.44	7.10	32	30	137	58				.3
7790	4	31542	3	7791	2	48	10.98	9.32	40	36	57	115				.3
7840	4	31542	3	7841	2	48	8.67		40	42	43					.0
7725	4	21300	5	7726	2	49	8.67	11.66	40	41	57	87				.2
7765	4	20432	3	7766	2	49	12.21	15.21	37	33	93	64		.3	1	.0

APPENDIX G (CONTINUED)

Hsld. ID	Site	Traffic Count	DOW	Part. ID	Sex	Age	Blood Pb 1	Blood Pb 2	HCT 1	HCT 2	FEP 1	FEP 2	CO 1	CO 2	Smok. Code	Paint
5230	4	20362	5	5231	2	52	12.38	10.33	41	41	81	31	.1	.1	0	.0
7220	4	20432	3	7221	2	54	9.60	9.88	42	43	107	89	1.4		2	1.6
7650	4	20000		7651	2	55	5.21	5.56	38	39	85	16				.0
7845	4	20432	3	7846	2	57	6.54	8.37		42	0	44				.5
7225	4	20432	3	7226	2	59	10.09	10.65	43	43	56	30	.2		0	.0
7415	4	22670		7416	2	63	8.11	7.94	38	39	55	29	.2		0	2.7
7520	4	37850	5	7521	2	67	8.44	8.69	46	45	61		.9		1	.0
7395	4	23885	4	7396	2	68	9.16	7.64	41	42	65	136	.3		0	1.4
7550	4	37850	5	7552	2	68	8.67	8.93	39	38	75	59				8.7
7610	4	37850	5	7612	2	69	13.86	15.01	44	44	90	134				.9
7180	4	21300	5	7181	2	70	7.97	8.63	43	43	126	103	.1		0	.2
7275	4	20432	3	7277	2	76	9.85	8.37	38	38	77	64				.2

APPENDIX H

Fingerprick samples 1 and 2 for each participant are given in Appendix H. The units are explained below.

Participant ID

Fingerprick 1	Lead concentration in fingerprick sample 1 (µg/100 ml)
Fingerprick 2	Lead concentration in fingerprick sample 2 (µg/100 ml)

APPENDIX M

Participant ID	Fingerprick 1	Fingerprick 2
0007	6.40	8.10
0126	30.90	[illegible].80
0152	36.00	27.10
0159	13.70	14.40
0161	19.60	
0166	31.30	13.80
0172	10.40	12.40
0177		22.90
0191	19.70	17.90
0192	5.40	20.00
0103	28.20	24.50
0107	5.40	
0132	14.10	9.60
0152	9.10	12.90
0156	19.60	22.50
0161	8.30	17.30
0167	13.90	11.00
0168	15.10	32.10
0182	12.00	14.90
0183	8.10	13.80
0258	15.80	14.30
1531	7.50	14.40
1532		14.50
1362	14.80	14.20
1392		9.50
2172	18.40	19.30
2173	29.80	
2201	17.60	15.40
2206	31.00	13.50
2501	11.10	10.60
2502	14.40	7.90
3662	12.90	10.80
3667	14.40	34.50
3673		13.20
5227	15.80	
5362		10.90
5412	20.80	17.40
541[illegible]	9.50	11.50
5417	21.60	21.60
5492	14.60	15.10
5493	8.20	12.80
5497	17.10	9.00
5507	16.10	33.90

APPENDIX H (CONTINUED)

Participant ID	Fingerprick 1	Fingerprick 2
5557	5.40	9.90
5567	12.70	15.40
5586	19.60	17.10
5597	19.70	11.60
5506	6.10	12.00
5562	15.90	13.50
5667	23.40	
5701		22.70
5732	13.70	14.90
5757	14.40	11.90
5771	39.50	17.70
5776	17.00	9.50
5781	13.70	14.90
7171	17.10	
7272	11.60	17.70
7291	28.40	16.10
7392		17.20
7642	14.60	17.50
7647	14.90	18.30
7702	29.10	21.20
7722	17.40	13.00
7737	11.40	14.50
7788	7.00	11.20
7797	11.30	
7807	30.90	
7812	10.10	
7817	9.50	15.10
7851	14.90	15.20
9131	13.50	18.70
9221		11.30
9282	19.60	14.60
9292	14.40	16.00
9293		16.30
9297		19.20
9303	15.30	13.50
9372	17.40	20.90
9382	27.30	33.20
9392	33.10	32.90
9472	27.90	
9492	36.60	13.60
9493	23.30	2[illegible].00
9494	18.90	25.90
9496	12.10	11.60

APPENDIX I

The paint lead concentrations, distance from street, and composition of each household are given in Appendix I. The abbreviated captions and units are explained below.

Hsld. ID	Household ID
Site	Traffic density site
Inside 1st & 2nd	Lead concentrations in paint from two places inside the house (mg/cm^2)
Outside 1st & 2nd	Lead concentrations in paint from two places outside the house (mg/cm^2)
Dist 1	Distance from the street to the front of the house (ft)
Dist 2	Distance from the street to back of the house (ft)
Composition	Composition of the house, cross street, speed limit

BK	Brick
WD	Wood
ST	Stucco
ASB. SHGL.	Asbestos shingle
AL. SHGL.	Aluminum shingle
AL. SIDING	Aluminum siding
METAL SHGL.	Metal shingle
WD. SHGL.	Wood shingle

APPENDIX I

Hsld. ID	Site	Inside 1 st	Inside 2 nd	Outside 1 st	Outside 2 nd	Dist 1	Dist 2	Composition
0005	1	.2	.0	.7	4.5	40	66	WD&BK.
0010	1	.2	.0	1.4		42	74	BK.
0015	1	.0	.0	.9	.0	38	69	BK.&WD.
0025	1	.0	1.1	.0		79	119	BK.
0050	1	.0	.0	1.4	1.1	50	86	BK.
0055	1	.0	.0	.0		51	85	BK.
0060	1	.0	.0	.0		43	119	BK.
0065	1	.5	.0	.0	.0	116	178	BK.
0070	1	.0	.0	12.5	8.6	82	115	ST.
0075	1	4.3	.0	.0	2.1	80	130	ST.
0080	1	.0	.9	.0		68	94	BK
0090	1	.0	.0	.0	.0	73	88	BK
0100	1	.0	.0	.5		70	98	BK
0105	1	.0	.0	.0		69	98	BK
0120	1	.0	.0	1.4	.7	90	193	BK.
0130	1	.2	.0	.7		44	66	BK&WD.
0135	1	.0	.2	.7	.0	44	82	BK&WD.
0140	1	.7	.5	.7	.9	44	74	BK&WD
0145	1	.7	.0	.0	1.1	48	77	WD&BK
0150	1	.2	.2	1.6	.0	42	86	BK
0155	1	.0	.7	.0	1.6	47	80	BK&WD
0160	1	.0	.7	2.7	2.3	42	70	BK&WD.
0165	1	.7	.2	.9	.5	62	85	BK&WD
0170	1	.0	.2	1.1	.5	64	90	BK
0180	1	.2	.5	2.7		42	70	BK&WD
0250	1	.0	.0	.0	.0	77	108	BK
0255	1	.0	.0	10.1	1.4	85	128	BK
0260	1	1.1	.2	.9		60	100	WD.
0265	1	.0	.2	.2		52	73	BK.
0270	1	.0	.0	1.1	2.1	54	86	BK
0275	1	.0	.0	3.0		64	103	BK
1395	1	.0	2.5	1.3	2.7	46	69	WD.&BK.
1400	1	1.7	.0	.9	.0	63	86	BK&WD
1405	1	.0	.5	2.3	1.6	48	74	BK&WD.
1410	1	.7	.0	.0	1.5	46	69	BK&WD
1415	1	.0	.0	.0	.0	49	79	BK&WD
1420	1	.0	.0	1.6		46	71	BK.
1425	1	.0	.0	.2		47	75	BK&WD.
1515	1	.0	.9	3.2	1.6	47	81	WD&BK
1520	1	.0	.9	.7		51	81	BK&WD.

APPENDIX I (CONTINUED)

Hsld. ID	Site	Inside 1 st	Inside 2 nd	Outside 1 st	Outside 2 nd	Dist 1	Dist 2	Composition
1530	1	.2	.0	.0	.0	38	71	BK&WD.
1535	1	.0	.0	2.1		47	72	WD
1540	1	.0	.0	.5	.7	45	73	BK&WD
1550	1	.2	.0	.0	.5	43	68	BK&WD.
1560	1	.5	.0	.9	.0	44	68	WD&BK
1565	1	.0	.0			43	71	BK&WD
1840	1	.0	.0	.7	.0	40	75	BK&WD
1845	1	.5	.2	1.4		45	75	WD&BK
1850	1	.5	.0	.0	.5	45	76	WD&BK
1855	1	.0	.0	1.4		47	76	BK&WD
1860	1	.2	.2	.2	.2	50	76	WD&BK.
1870	1	.5	.2	1.4	1.1	48	72	BK&WD
1875	1	.0	.2	.0	.2	45	67	WD&BK
1890	1	.9	.2	2.5	2.5	44	76	BK&WD
1895	1	.2	.7	2.7	3.0	44	67	BK&WD
1900	1	.2	.0	.9		58	73	BK
1905	1	.0	.0	.0	.2	64	87	BK&WD
1915	1	.0	.7	.0	.0	44	69	BK&WD.
1925	1	.5	.2	1.1		40	68	BK
2145	1	.0	.0	.0		80	117	BK&WD
2160	1	.0	.0	.5	.7	60	96	BK
2165	1	.0	.0	.0	.0	69	114	BK.
2170	1	.0	.0	.0	.0	65	85	BK&WD.
2175	1	.0	2.1	2.5	4.4	57	89	BK
2200	1	.5	.0	3.0	.0	52	73	BK
2205	1	.0	.5	3.0	6.5	78	117	BK&WD.
2410	1	.0	.0	.9	.5	75	148	BK
2440	1	.0	.0	.0	.0	88	126	BK
2460	1	.0	.0	.0		62	95	WD&BK.
2465	1	.0	.0	.0	.0	48	119	BK&WD.
2470	1	.0	.0	.0	.0	57	87	WD
2480	1	.0	.0	.0		71	107	BK
2485	1	.0	.0	.0		59	92	BK&WD
2490	1	.0	.0	.0		53	89	WD.
2500	1	.0	.0	.0	.0	75	114	ST.
2505	1	.0	.0	.0	.0	60	100	BK.
3105	2	.0	.0			87	114	BK.
3115	2	.9	.0			45	84	BK
3210	2	.0	.1	.5	1.4	43	63	BK&WD-35MPH.
3220	2	.0	.2	.0	.0	48	83	BK-35MPH

APPENDIX I (CONTINUED)

Hsld. ID	Site	Inside 1 st	Inside 2 nd	Outside 1 st	Outside 2 nd	Dist 1	Dist 2	Composition
3225	2	.5	.0	.0		43	66	BK&WD.-35MPH
3230	2	.2	.2	.2		53	70	WD&BK.-35MPH.
3425	2	.2	.0	.0	.0	39	62	WD&BK.
3435	2	.0	.0	.7	1.8	51	82	BK
3665	2	.0	.2			60	91	BK.
3670	2	.0	.0	1.4		62	100	BK.
3675	2	.0	.0	2.1		60	89	BK&WD
3695	2	.0	.0	4.7	.0	59	89	ST.
3870	2	.5	.0	.0	.7	85	120	BK&WD
3875	2	.0	.5	2.7		120	175	BK.
3900	2	.0	.0	1.3		41	96	BK.
3905	2	.0	.0	.0	.5	42	97	BK.
5380	2	.0	.0	.0		103	130	BK.
5390	2	.0	.0	.0	.0	64	95	BK&WD.
5395	2	.0	.0	1.1	.5	93	119	BK
5575	2	.0	.0	3.9		42	76	BK&WD.-35MPH.
5590	2	.0	.0	.0		23	83	BK-HILLCREST
5645	2	.0	.0	.0		42	80	BK&WD.-35MPH
5660	2	.0	.0	.0	.0	45	81	BK&WD-35MPH
5665	2	.0	.0	.0	.5	52	92	BK.&ST.&WD.
5670	2	.0	.0	.0		38	125	BK-HILLCREST
5675	2	.0	.0	.9	.0	55	91	BK&WD.-35MPH.
5685	2	.2	.0	1.1		53	91	BK
5700	2	.2	.0	.0		23	67	BK-FERGUSON
5725	2	.0	.0	.0	.0	15	97	BK-PRESTON
7100	3	.0	.0	.2		83	128	BK
7185	2	.0	.0	1.4	3.0	84	122	BK&WD.
7265	2	.2	.2	2.5	.0	43	65	BK
7290	2	.0	.0	.0	.0	63	96	BK.
7580	3	.0	.7	2.5		55	112	BK
7605	3	.0	.7			46	74	BK
9010	2	.0	.2	.5		59	87	BK
9015	2	.9	.0	.7	.0	58	97	BK
9020	2	.0	.0	.2		63	98	BK&WD
9070	2	.0	.3	1.8		39	54	BK
9075	2	.0	.0			38	69	BK.
9090	2	.0	.0	.0		40	79	BK.
9095	2	.0	.0	.0	1.1	39	62	BK.
9100	2	.0	.0	2.3	2.5	42	65	BK&WD.
9105	2	.0	.7	.0	.0	32	65	BK&WD.

APPENDIX I (CONTINUED)

Hsld. ID	Site	Inside 1 st	Inside 2 nd	Outside 1 st	Outside 2 nd	Dist 1	Dist 2	Composition
9115	2	.0	.0	.2	1.1	42	77	BK&WD
9125	2	.3	.5	.7		39	73	BK.
9130	2	.0	1.6	.0		31	65	BK&WD.
9195	2	.0	.0	.0	2.5	43	74	BK.
9205	2	.0	.9	2.5	.0	41	70	WD.-35MPH.
9210	2	.9	1.1	.0	.4	44	73	WD-35MPH
9215	2	.0	.0	.0		73	111	WOOD&AL.SIDING-35MPH.
9220	2			.0	3.9	57	85	BK&WD
9225	2	.0	.0	2.7	6.2	57	91	WD.
9230	2	.0	3.0	3.5		60	103	BK
9235	2	.0	.0	5.7	.0	60	104	BK&WD.
9280	2	.0	.0	3.8	.0	54	85	WD.-35MPH
9285	2	.5	.0	.6	.0	32	70	WD.-35MPH
9290	2	.0	.0	1.4	1.1	60	90	BK&WD.
9295	2	.0	2.6	.2	.9	60	84	WD.-35MPH
9300	2	.0	.0	.0	.0	60	86	WD.-35MPH
9305	2	.0	.2	.0	.0	50	88	BK.-35MPH
9310	2	.0	8.3	.0	.0	50	91	WD&AL.SHGL-35MPH.
9315	2	.0	.2	1.6	.0	50	88	BK-35MPH
9325	2	.0	.0	1.4	1.6	45	78	WD-35MPH.
9340	2	.2	.9	3.9	5.6	44	65	WD.-35MPH
9345	2	.2	.0	2.3	1.1	57	87	WD.-35MPH
9360	2	.5	.0	.0		37	57	WD.-35MPH
9365	2	.0	.0	.0		83	124	WD&METAL SHNGL
9370	2	.0	.0	.0	6.9	42	94	WD.
9380	2	.0	.2	.0	.2	60	84	WD.-35MPH.
9390	2	.2	1.8	3.8	2.7	33	66	WD.-35MPH.
9485	2	.0	.2	.0	.0	53	95	WD.-JIM MILLER@35MPH
9490	2	.0	.0		2.1	40	69	WD&METAL SHGL
3080	3	.0	3.1			70	100	BK.
3090	3	.0	.0	1.4		66	93	BK
3100	3	.0	.0	.0	.2	67	103	BK
3310	3	.0	.0	9.5	.0	46	67	WD.
3335	3	.0	.0	.0	.0	46	74	WD&BK
3650	3	.0	.0	2.5		58	84	BK.
3660	3	.0	2.4	.0		62	91	BK.
4020	3	.2	.0	.5		36	64	BK&WD
4025	3	.0	.0	1.1	.5	36	64	BK&WD.
5080	3	.2	.0	.0	.0	40	100	BK.
5085	3	.5	.2	.7		45	108	BK

APPENDIX I (CONTINUED)

Hsld. ID	Site	Inside 1 st	Inside 2 nd	Outside 1 st	Outside 2 nd	Dist 1	Dist 2	Composition
5090	3	.0	.0	.0	.0	46	96	BK
5095	3	.0	.0	.0	.0	43	89	BK
5100	3	.0	.0	.0	.0	46	87	BK
5105	3			.2		47	79	BK
5130	3	.0	.0	.9	.9	35	70	BK
5135	3	.0	.0	2.5	.0	44	77	BK
5165	3	.0	.0	.0		40	65	BK 35MPH
5240	3	.0	.0	.7		45	72	BK.-35MPH.
5365	3	.0	.2	.0	.0	49	78	BK&WD.
5370	3	.0	.0	6.3	1.5	49	79	WD.
5400	3	.0	.0	3.6	4.6	50	83	BK&WD
5405	3	.0	.0	1.1	1.6	62	93	BK&WD
5440	3	.0	.0	.7	1.1	93	132	BK.
5445	3	.0		1.1	.0	84	130	WD.
5455	3	.5	.0	.0		58	116	BK.
5460	3	.2	.5	1.8	.0	44	84	BK.
5465	3	1.1	.0	.0		39	84	BK. 35MPH
5470	3	.2	.0	.0		34	64	BK-35MPH
5480	3	.5	.0	.0	12.5	82	105	BK&SHGL
5490	3	.0	.0	2.7	3.0	150	200	BK&SHGL
5495	3	.0	.2	.0	.0	35	94	BK-WALNUT HILL LN.-35MPH
5505	3	.0	.0	1.1	3.2	25	70	WD&BK-FERGUSON
5510	3	.0	.0	.0		30	57	ASB.SHGL-35MPH.
5520	3	.0	.0	1.4	.0	25	73	BK&WD.30MPH.GUS THOM
5525	3	.2	.0			45	78	BK.
5540	3	.0	.7	.0		16	56	BK&ST-PRESTON
5545	3	.0	.0	1.1	.9	50	100	WD&BK.-35MPH-WALNUT HILL
5550	3	.0	5.3	.0	.9	47	83	BK-PRESTON
5555	3	.9	.0	2.4		25	71	BK
5565	3	12.5	.0	.0		21	71	BK. HILLCREST
5585	3	.0	.0	2.1	2.3	38	113	WD.-WALNUT HILL
5595	3	.2	.0	.0		41	68	ASB.SHGL
5605	3	.0	.0	.5	3.8	58	138	BK-PRESTON
5625	3	8.0	2.5	.0	3.0	12	57	BK&WD.-WEBBS CHAPEL
5635	3	.2	.0	.0	.0	56	94	BK&WD.-WEBBS CHAPEL
5680	3	.0	.0	1.8	1.1	23	89	BK-WEBBS CHAPEL
5690	3	.0	.0	1.6		61	93	BK-35MPH
5695	3	.0	2.3			65	185	BK&WD-PRESTON
5705	3	.0	.0	1.6	1.6			BK&WD.-PRESTON
5715	3	.0	.0	.7	.7	26	62	BK-EASTON

APPENDIX I (CONTINUED)

Hsld. ID	Site	Inside 1 st	Inside 2 nd	Outside 1 st	Outside 2 nd	Dist 1	Dist 2	Composition
5730	3	1.4	.0	.2		66	101	BK
5735	3	.0	.0	.0		71	100	BK
5740	3	.0	.0	.0	.0	49	103	BK
5745	3	.0	.0	.0	.0	72	102	BK
5755	3	.0	.2	1.6	.0	50	81	BK&WD-BELT LINE
5760	3	12.5	.0	4.1		91	135	ST.
5765	3	.0	.0			22	84	BK.
5770	3	.0	.0	.0		15	74	BK BELT LINE
5775	3	.0	.2	.0	.0	33	76	BK.-BELT LINE
5780	3	.0	.2	.7	2.3	63	92	BK&WD.
5785	3	.0	.0	.0	.0	70	104	BK&ASB.SHGL
5850	3	.0	.0	.0	.0	68	103	BK.
7075	3	.0	.0	.0	.0	50	101	BK
7340	3	.5	.0	1.6	.2	47	88	WD.
7385	3	.0	.0	.9	1.1	40	66	BK&WD.
7620	3	2.1	4.4	1.6	2.3	70	134	BK
7630	3	.0	.0	12.5	12.5	45	72	WD.
7655	3	.0	.0	.0	.9	70	115	BK
7705	3	.0	.0	.0		115	167	BK
7720	3			.0	.7	45	92	WD.
7745	3	1.6	.0	4.6	.0	49	95	BK-CEDAR CREST
7775	3	.0	.0	.0		54	123	BK&WD. E.MOCKINGBIRD
7850	3	.2	.0	1.3	.9	83	125	WD&ASB.SHGL
9470	3	.0	.0			48	108	BK. PRESTON
9475	3	.0	.0	.0	.0	61	132	BK.-WEBBS CHAPEL
3700	4	.0	.0	1.4	.5	82	138	BK.
5225	4	1.6	.0	.0	.0	56	90	WD-40MPH
5230	4	.0	.0	.0	.0	69	118	BK&WD-40MPH
5360	4	.0	.0	.9	.0	47	84	WD.
5410	4	.0	.0	.2	.0	49	76	BK&WD.
5415	4	.0	.0	.0		53	79	BK&ASB.SHGL
5485	4	.0	.5	.9	1.4	80	118	BK&WD. 40MPH
7170	4	.0	.2	1.8	.0	110	158	ASB.SHGL-35MPH.
7180	4	.2	.5	.5	.5	47	73	BK&WD.-35MPH
7220	4	.0	.0	.7	1.6	57	90	BK
7225	4	.0	.0	.0	.0	57	104	BK
7270	4	.0	.0	.0		63	93	BK
7275	4	.0	.2	.0		53	85	BK
7390	4	.0	1.4	1.1		47	69	ASB.SHGL
7395	4	.0	.0	1.4	.0	44	67	WD.

APPENDIX I (CONTINUED)

Hsld. ID	Site	Inside 1 st	Inside 2 nd	Outside 1 st	Outside 2 nd	Dist 1	Dist 2	Composition
7415	4	.0	.0	2.7	2.3	77	115	BK&WD.
7515	4	.2	.0	.0	.7	57	141	BK&WD.
7520	4	.0	.0	.0	.0	67	98	BK&WD.
7525	4	.5	.2	.0	.2	60	113	BK&WD.
7545	4	.0	.9	1.4	2.1	81	136	BK
7550	4	.9	.5	3.2	8.7	63	114	BK
7585	4	.0	.0	.5	.2	55	86	BK
7610	4	.0	.0	.2	.9	122	162	WD&BK
7640	4	.0	.0	3.2	.2	45	87	ASB.WD SHGL
7645	4	.5	.0	.9	.5	152	175	WD&BK
7650	4	.0	.0	.0	.0	107	132	WD.
7660	4	.0	.0	.0	.2	32	75	BK-COIT RD
7665	4	.5	.0	.0		35	76	BK.
7670	4	.0	.0	.0		35	67	BK.
7675	4	.0	.0			25	90	BK.-ABRAMS
7680	4	.5	.0	.2	.5	24	95	BK.-ABRAMS
7685	4	.0	.0	.0		33	95	BK-COIT RD
7690	4	.0	.0			35	114	BK PRESTON RD
7700	4	.0	.0	3.0	2.3	45	80	BK.
7715	4	.0	.0	.0		33	115	BK-MARSH
7725	4	.0	.2	.0		31	111	BK.-MARSH
7735	4	.0	.0	.0		51	75	BK-WALNUT
7750	4	.0	.0	1.1	1.6	35	74	BK&WD.-MARSH 35MPH
7760	4	.0	.5	.5	.0	34	87	WD&BK-MARSH-35MPH
7765	4	.0	.0	.0		44	93	BK WALNUT
7780	4	.2	.0			33	74	BK.-COIT RD
7785	4			.0		34	93	BK.-COIT RD
7790	4	.0	.0			34	87	BK CORNER HOUSE-COIT
7795	4	.0	.0	1.4	2.5	41	85	ST&WD
7800	4	.0	.0	.0	.0	43	87	WD&BK-WALNUT
7805	4	.0	.0	.0		33	69	ASB.SHGL
7810	4	.0	.0	.2		59	88	BK.-PRESTON
7815	4	.0	.5	.0		30	84	BK-COIT
7820	4	.0	.0	7.5		31	82	BK-COIT
7825	4	.0	.0	.9	3.9	35	85	BK&WD.
7830	4	.0	.2			47	74	BK-COIT
7835	4	.0	.0			34	90	BK.-HILLCREST
7840	4	.0	.0	.0		30	79	BK.
7845	4	.0	.2	.5		41	85	BK-WALNUT
9465	4	.0	.0	.0	.0	55	125	BK.40MPH-FOREST LN.

APPENDIX J

Report to Southwest Research Institute by
Geoderma Consultants - Dallas, Texas

STUDY OF SELECTED SOIL CHARACTERISTICS IN DALLAS COUNTY/ARLINGTON AREA IN RELATION TO THE RETENTION, RELEASE AND TRANSMISSION OF AUTOMOBILE EXHAUST LEAD

REPORT TO SOUTHWESTERN RESEARCH INSTITUTE

by

Geoderma Consultants
4810 Cole Avenue
Dallas, Texas 75205

October 26, 1976

Abstract

A study was performed to examine soil characteristics which have the potential to affect lead adsorption, retention and release from top-soils in the Dallas/Arlington metroplex area.

In particular, texture, clay mineralogy, organic content, and soil pH were studied. The majority of soils were high in clay content and organic matter and had high potential for adsorption and storage of automobile exhaust if it were deposited on the soil surface and allowed to infil trate into the top soil. Soil chemistry is such that relatively insoluble precipitates are likely to be favored.

The slowly permeable native of the clay soils might reduce the amount of lead infiltrating into the soil and allow it to be removed by runoff.

Introduction of exotic sand has modified the texture of 10 to 20% of the soils checked by laboratory procedures and would reduce lead retention in such soils.

Table of Contents

I. *Introduction*

A study to examine levels of lead in the blood of Dallas/Arlington metroplex residents was conducted under the auspices of the Southwest Research Institute and funded by the Environmental Protection Agency. It was hypothesized that top-soils in yards might be a source of lead absorbed into the blood of the local residents. The origin of the lead was thought to be automobile exhaust.

A supplementary study was conducted contemporaneously with the examination of lead levels in residents' blood and in yard top-soils. The study examined the soil components which would affect the retention and release of lead from the soil and soil characteristics which might determine potential routes for lead ingestion into the human bloodstream.

Soil components known to interact with atmospherically derived lead are clay minerals and a variety of chelating and complexing compounds. Soil chemistry, in particular pH and the availability of anion groups such as $CO_3^=$, $SO_4^=$ and phosphates, is important in the formation of lead compounds of varying solubility and in affecting the fixation of lead in soil.

Other characteristics such as texture, amount of humus material and permeability are important in determining the leaching environment, and the susceptibility of topsoil to erosive forces which remove and transport lead contaminated particles.

The supplementary study, designed to provide background information to aid in the interpretation of the lead analyses, was confined to top-soil environments, 0-6 inches, in residential yards. Samples were collected by staff of the Southwest Research Institute.

Each sample was classified according to grain-size distribution (texture) and a large sub-sample was randomly chosen for more detailed laboratory analyses of texture, pH, clay mineralogy and total organic matter.

II. *Method*

Soil Conservation Service (S.C.S.) mapping of soils in Dallas County and Arlington is available on 1:20,000 scale aerial photographs. The location of each sample site was examined and the soil texture described in the S.C.S. soil series descriptions, noted for the upper six inches.

A randomly chosen sample of 50 soils were examined by laboratory procedures to ascertain the reliability of the S.C.S. classification and mapping.

The same 50 samples were later analyzed for pH and total organic content. The three major soil textural classifications found in the Dallas/Arlington area were analyzed for clay mineral species using x-ray diffraction methodology; a total of ten soils were thus examined.

Additional information on soil chemistry was taken from the S.C.S. soil series descriptions and available chemical data and used as an aid to interpret the soils as potential sources and sinks of environmental lead.

III. *Results*

a) S.C.S. classification of soil textures (Table 1)

More than 50% of the soil samples had a clayey (C) texture (see tables 1 and 2). For these soils clay size particles constitute greater than 40% of the inorganic content. Clay size particles are the principle adsorbers of divalent lead ($Pb^{=}$) and retain lead longer than other inorganics. The clay textured soils have the greatest potential for lead storage.

Greater than 33% of the samples have a silty clay (Sic) texture. These soils also have greater than 40% clay size particles and a similar high potential to retain lead as the clayey soils.

Clay loam (CL) and sandy clay loams (SCL), greater 27% and 20% clay respectively, have sufficient clay to make them significant storers of lead but constitute such a small part of the total sample as to be insignificant.

Sandy loams (SL) have less than 20% clay and are capable of adsorbing far less lead on the mineral surfaces than the clayier counterparts.

The majority of the soils have textures and mineralogy which make them slowly permeable to rain-water or artificial sprinkling. Lead deposited in the upper horizons would, after initial wetting of the soil, be subjected to a slow downward flow of water through miniscule capil lary spaces and along adsorbed layers coating the clay mineral surface. Downward transportation of lead would be minimized compared to the coarser textured loamy sands or sandy loams. Indeed ca^{2+} ions which are usually more soluble and transportable than Pb^{2+} ions are often incompletely removed from the top-soils of the clays and silty clays.

However, the surface water runoff from the soils is greater than for the coarser textured soils and if automobile lead were confined by fall-out to the very upper part of the topsoil surface it might be largely washed away across the soil surface during heavy thunderstorms on even gentle (>1%) slopes.

The clayey and silty clay soils have a certain degree of cohesiveness when dry and are less susceptible to wind erosion than the loamier or fine sandy soils. However, transportation into houses by wet clay adhering to boots and shoes is obvious.

b) *Laboratory analysis check on grain size*

Fifty of the samples were checked for grain size by laboratory procedures. Twenty percent had coarser, sandier textures than allowed by the S.C.S. mapping units and classification (Table 3).

Two possible reasons exist for this discrepancy. Soils of limited areal extent can either be overlooked during field mapping or be too small to include as separate map units. Alternatively, the soil texture could have been altered by the addition of exotic sands for purposes of improving soil drainage or yard fertility, or during construction.

The practice of adding fluvial sands to clayey or silty clay soils is common on the Blackland Prairie areas of Dallas County and other parts of North Central Texas. That it occurred for 20% of the subsample serves as a warning that a considerable part of the total sample probably has been modified by sands brought into the garden. This may be significant when interpreting the importance of on-site adsorption of lead by soil minerals.

c) *Clay mineralogy of selected soil samples*

Ten subsamples representing the 3 major soil texture classes were analyzed for clay mineralogy (Table 3). The clay fraction was divided into coarse (2μ to 0.2μ) and medium to fine (<0.2μ) sizes.

The clay textured soils showed no significant difference between coarse and medium size fractions. Montmorillonite (>40%) was dominant, kaolinite present in smaller quantities (10-20%). Montmorillonite has a high cation exchange capacity (CEC 80 to 120 me.) and a great potential to adsorb and retain lead. Kaolinite (CEC 10 to 20 me.) has a lesser potential to retain lead. Thus the clayey montmorillonite soils that formed over the Austin Chalk and Eagle Ford Shales could be significant sinks for atmospheric derived lead. Especially if acting in conjunction with high amounts of soil organics.

The clay mineralogy of the silty clay textured soils changes from coarse to medium clays. In the coarser clays, degraded mica (illite?) predominates (>40%) with kaolinite and montmorillonite in lesser quantities (10-20%). The degraded mica has a high cation exchange capacity and could be a good potential storer of lead. In the finer clay fraction montmorillonite is the dominant clay (>40%) and consequently the potential for storing lead on the many small clay surfaces is high.

The sandy loam textured soils are predominantly kaolinite (>40%) in the coarser fractions, with degraded mica and mixed mica/montmorillonite interlayered clays subordinate. Kaolinite, as previously noted has a lesser potential for adsorbing lead. In the finer textured clays kaolinite gives way to mixed layered clays and these mica/montmorillonite interlayered minerals have a high cation exchange capacity and potential to adsorb lead. However, the smaller total clay amount in sandy loam must be considered.

The predominant adsorbed cation is ca^{2+} in most of the soils derived from the Cretacious formations. Bittel and Miller (1974) measured the exchange of Pb^{2+} against Ca^{2+} on montmorillonite, illite and kaolinite. In these experiments Pb^{2+} was preferentially adsorbed, resulting in selectivity coefficients of about 2-3.

d) *Organic content of soils*

The great majority of soils (80%) had organic contents between 6 and 15% dry weight (Table 4). Sixty percent of soils had organic contents greater than 9%. These soils have moderately high to high organic amounts. Various organically derived compounds and organo-clay complexes are the major retainers of lead along with clay in the soil. Although the analyses was not designed to analyze for chelates and complexing agents, it is a reasonable assumption that soils with high percentages of organics anc clays have a good probability of forming such derivatives. Certainly clay soils with organic matter >9%

have much greater potential to adsorb and retain environmental lead than the sandier or loamier textured soil with low organic contents such as samples #9100 and #9345.

e) *The pH of soil samples*

The great majority of the laboratory analyzed subsamples had pHs between 7.0 and 8.0. This is within the neutral to moderately alkali range that is expected of topsoils derived from calcium carbonate rich parent material. Apparently yard practices, including addition of fertilizers and organic matter (?) have not substantially changed surface soil pHs.

Relatively little is presently known about lead chemistry in soils. Gasoline combustion being the main source of lead most of the lead will be deposited as soluble halides, lead Chlorobromide, Pb CLBr. Singer and Hanson (1969) described how excess lead is probably decreased after deposition on the soil due to the formation of relatively insoluble compounds with carbonates, phosphates and sulfates. The clayey and silty clay soils derived from the Austin Chalk and Eagle Ford Shales are high in both carbonate and sulfate ions. At neutral to moderately alkaline pHs the formation of the lead carbonate and lead sulfates would be favored At very high pHs the lead would be partially released from these compounds. At very low pHs lead would be desorbed from the clay-mineral surfaces. However, the large reservoirs of ca^{2+} ions in the soils, especially on the clay surfaces acts as a buffer against extremes of pH and favors stabilization and retention of the lead against leaching and root absorption. The low hydraulic conductivity (K factor) of the clay and silty-clay soils would further reduce the leaching of the lead compound precipitates.

IV. *Conclusions*

Soil characteristics in the study area appear to be favorable for the retention of lead and lead compounds within the soil system. In particular high quantities of negatively charged clay mineral surfaces for adsorption of Pb^{2+}, high organic contents to form complexing and chelating agents,and an ample supply of sulfates and carbonates at favorable pHs so that insoluble lead compounds can form. In addition soil permeability is low due to the swelling clays in the profile,and the climatic characteristics of heavy rainfalls with associated high water losses in surface runoff do not favor leaching. The latter factor might be important in reducing the initial infiltration of automobile lead into the soil due to losses in surface runoff, or preferential movement of water through dessication cracks to depth within the profile.

As high as 20% of the sub-sampled soils had coarser textures than would be expected from S.C.S. mapping and classification. This is thought to be due to the practice of mixing fluvial sands with clayey soils to produce more favorable textures for plant growth. The sand would have lesser capability to retain lead within the soil system. The problem of the exotic sands being contaminated with lead from non-automobile exhaust sources has not been studied and is unknown at this time.

Table 1. Master List of Soil Samples with Soil Conservation Service Texture Classification

Sample #	Traffic Density	Texture
2485	474	C
2490	474	Sic
0005	320	C
0010	320	C
1840	320	Sic
1880	320	Sic
1890	320	Sic
1895	320	Sic
1900	320	C
1905	320	C
1925	320	Sic
0050	558	Sic
0120	537	C
1505	571	C
1515	571	C
1520	571	C
1530	571	C
1535	571	C
1540	571	Sic
1550	571	C
1560	571	C
1565	571	C
2160	178	Sic
2165	178	Sic
2170	178	Sic
2175	178	Sic
2180	471	Sic
2200	471	Sic
2205	471	Sic

Sample	Traffic Density	Texture
0130	346	Sic
0135	346	C
0170	346	C
0270	346	C
2440	259	C
2460	259	Sic
2465	259	Sic
2470	300	Sic
2475	300	C
2480	300	C
2410	479	Sic
2500	364	C
2505	364	C
2145	336	Sic
0025	599	Sic
0090	599	C
1860	335	Sic
1870	335	Sic
1875	335	Sic
1915	335	Sic
0015	194	C
1845	194	C
1850	194	C
1855	194	C
1395	155	C
1405	155	C
1410	155	C
0250	472	C
1400	202	C
0140	336	C
0145	336	C

Sample	Traffic Density	Texture
0150	336	C
0155	336	C
0160	336	C
0165	336	C
0180	336	C
1415	343	C
1425	343	C
1420	255	C
0060	186	C
0065	596	C
0070	596	C
0275	471	C
0255	596	C
9220	11338	SL
9225	11338	SL
9295	13072	SL
9300	13072	SL
9380	13072	SL
4020	17931	SL
4025	17931	SCL
3210	11765	Sic
3220	11765	Sic
3225	11765	Sic
3230	11765	C
3900	10200	Sic
3905	10200	Sic
3310	13800	Sic
3335	13800	Sic
3870	11467	CL
3875	11467	Sic
3285	12944	Sic

Sample	Traffic Density	Texture
9305	8464	C
9315	8464	C
9485	11494	Sic
9310	9708	SL
9325	9456	C
9340	9456	C
9345	9456	C
9360	9456	C
9390	9456	C
5620	12514	Sic
5685	12514	Sic
3650	16128	C
3660	16128	C
3665	12514	C
3670	12514	C
3675	12514	C
3695	12514	C
9480	12514	C
3105	9588	Sic
3425	8651	C
9490	5918	C
9495	5918	C
3435	6654	C
9010	7154	Sic
9015	7154	Sic
9020	6776	Sic
9070	7154	Sic
9075	7154	Sic
9090	7154	C
9095	7154	Sic

Sample	Traffic Density	Texture
9100	7154	Sic
9105	7154	Sic
9115	7154	C
9125	7154	Sic
9130	7154	Sic
5575	10637	C
5615	9362	C
5645	9362	C
5660	9362	C
5675	10637	C
3080	16219	C
3090	16219	C
3100	16219	C
9195	8209	C
9290	8197	C
9205	11708	C
9210	11708	C
9280	11817	C
9365	11708	C
9370	11708	C
5440	16882	SL
5445	16882	SCL
5555	13800	C
5730	13700	C
5780	13700	C
5545	18245	C
5635	18354	C
5365	15257	C
5370	15257	SL
5625	18354	C
5695	17119	C

Sample	Traffic Density	Texture
5670	1244	C
5520	13800	C
5665	11765	C
5225	20890	C
5230	20362	C
5485	20890	C
5240	13800	C
5480	17452	Sic
5490	17452	Sic
5550	17000	C
5510	15000	SL
5585	18245	Sic
5080	18790	Sic
5085	18790	Sic
5090	18790	Sic
5095	18790	Sic
5100	18790	Sic
5105	18790	Sic
5110	18790	Sic
5115	18790	Sic
5455	15442	Sic
5460	15442	Sic
5725	12411	Sic
5410	20928	SCL
5415	20928	SCL
5360	20928	SL
5400	15570	SL
5405	15570	SL
9465	20362	C
5605	17119	C

Sample	Traffic Density	Texture
5560	17119	Sic
5380	13000	SL
5390	13000	SL
5595	13000	SL
5680	18354	C
5700	11765	C
5505	17000	C
9475	18354	C
5130	14000	Sic
5135	14000	Sic
5525	14000	Sic
5540	19000	C
9470	17047	C
5715	15156	C
5495	18548	C
5500	14769	Sic
5590	12411	Sic
5470	18245	C
5690	18548	C
5710	18245	C
5165	18245	C
5465	18245	C
5770	13700	C
5565	16500	C
7815	31542	Sic
7840	31542	Sic
7690	20141	C
7750	21300	C
7835	31542	C

Sample	Traffic Density	Texture
7700	20572	Sic
7705	18424	C
7720	14500	SL
7775	18790	Sic
7675	19578	Sic
7390	23885	C
7395	23885	C
7415	22670	SL
7790	31542	C
7660	31542	Sic
7680	19578	Sic
7845	20432	C
7760	21300	C
7640	27537	C
7780	31542	C
7805	20928	Sic
7170	20483	C
7180	21300	C
7850	18216	C
7810	20141	C
7075	18790	Sic
7100	18790	Sic
7580	18790	Sic
7605	18790	Sic
7620	13684	Sic
7630	13684	Sic
7655	13684	Sic
7745	13684	Sic
7800	20432	C
3700	37850	CL

Sample	Traffic Density	Texture
7515	37850	CL
7520	37850	C
7525	37850	CL
7545	37850	CL
7550	37850	CL
7610	37850	CL
7645	37850	CL
7710	21336	C
7765	20432	C
7340	16381	LS
7385	16381	SL
7785	31542	Sic
7185	9098	Sic
7665	31542	Sic
7670	31542	Sic
7825	31542	Sic
7685	31542	Sic
7755	20928	SL
7220	20432	C
7225	20432	C
7265	12331	C
7270	20432	C
7275	20432	C
7290	12331	C
7585	20432	Sic
7725	21300	C
7820	31542	C
7830	31542	C
7650	20000	CL

Table 2. Classification of Top-Soils According to S.C.S. Soil Texture Classes

CLAY(C)	SILTY CLAY (Sic)	SANDY LOAM (SL)	CLAY LOAM (CL)	SANDY CLAY LOAM (SCL)	LOAMY SAND (LS)
142	93	17	9	3	1

Table 3. Laboratory Analysis of Subsample of 50 Soils for Grain Size, pH, Organic Content and Clay Mineralogy (10 Samples)

#	CLASS	GRAIN SIZE	CHECK	pH	ORG %	CLAY MINS <.02μ	CLAY MINS >.02μ
5130	16	Sic	√	7.3	0.7	M_1 K_3	M_1 K_2 M_2 Q_3
7675	16	Sic	√	7.8	8.8	M_1 K_3	M_1 K_2 M_2 Q_3
1395	90	C	√	7.2	15.9	M_1 K_3	M_1 K_2 Q_3
7705	90	C	√	7.8	11.8	M_1 K_3	M_1 K_2 Q_3
7170	9	C	√	7.8	11.3	M_1 K_3	M_1 K_3 Q_3
7800		C	√	7.6	11.4		
3695	9	C	√	7.6	8.2	M_1 K_3	M_1 K_2 Q_3
9090	12	C	SL	7.3	8.1		
5590	16	Sic	√	7.4	11.0	M_1 K_3 Mi_3	M_i K_2 M_2 O_{13}
9115	12	C	SL	7.2	12.0		
3210	16	Sic	√	7.7	7.3		
5550	9	C	√	7.9	11.5	M_1 K_3 O_{13}	M_1 K_2 O_{13}
7700	18	Sic	√	7.1	11.7		
9205	9	C	√	7.8	8.3		
5460	16	Sic	√	7.1	9.0		
9315	41	SL	√	7.6	5.2	Mc_1 K_3	K_1 Mi_3 Mc_1
5115	16	Sic	√	7.8	12.3		
9100	16	Sic	LS	6.8	2.7		
5605	9	C	√	7.4	11.3		

#	CLASS	GRAIN SIZE	CHECK	pH	ORG %	CLAY MINS <.02μ	CLAY MINS >.02μ
3650	9	C	√	7.9	13.1		
9345	9	C	S	7.8	1.3		
9390	9	C	√	7.7	8.2		
5455	90	C	√	7.9	9.6	M_1 K_3 Q_3	M_1 K_2 Q_{13}
7790	9	C	√	7.6	13.4		
7835	9	C	√	7.6	11.1		
2440	9	C	√	7.8	12.3		
7630	16	Sic	√	7.4	8.0		
2460	16	Sic	√	7.2	9.6		
3675	9	C	√	7.8	12.7		
5495	9	C	√	7.4	7.8		
7075	18	Sic	SCL	5.5	12.9		
2480	9	C	√	7.3	11.7		
5585	85	Sic	√	7.0	5.5		
7850	9	C	SC	7.5	6.2		
7185	16	Sic	√	7.6	8.8		
9325	9	C	SCL	7.4	4.8		
7745	18	Sic	√	7.6	9.6		
5480	85	Sic	√	7.2	5.3		
5660	9	C	SC	7.8	5.5		
5665	9	C	√	7.4	11.5		
7100	16	Sic	SL	7.5	12.4		

#	CLASS	GRAIN SIZE	CHECK	pH	ORG %	CLAY MINS <.02μ	CLAY MINS >.02μ
5505	9	C	√	7.6	10.6		
7725	85	Sic	√	7.6	9.6		
5080	16	Sic	SL	7.4	4.8		
5485	9	C	√	7.7	11.2		
7680	16	Sic	√	7.4	10.5		
3335	16	Sic	√	7.2	12.1		
9305	41	SL	√	7.3	4.3		
5670	9	C	√	7.7	13.0		
5715	9	C	√	7.8	12.8		

M = Montmorillonite

K = Kaolinite

Mi = Mica (Illitie)

Mc = Mixed layered clays; montmorillonite/mica.

Q = Quartz

1 =	> 40%	Estimation from
2 =	> 20%	areas under x-ray diffractogram
3 =	< 10%	curve.

Note: % will not necessarily sum to 100% due to non-crystalline allophanic substances within clay fraction.

Table 4. Summary of the Percentage of Organic Matter in Soils of the Laboratory Analyzed Sub-Sample

Percent Organic Matter	>1%	>3%	>6%	>9%	>12%	>15%
# Samples	2	7	10	19	10	1

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Singer, M.J., and Hanson, L., 1969. Lead accumulations in soils near highways in the Twin Cities metropolitan area. Soil Science Society of America Proceedings, 33, pp. 152-153.

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

This study investigated the absorption of lead by persons of different age-sex groups exposed to automobile emissions of lead at traffic densities from less than 1,000 cars per day to 25,000 cars per day. The relationships between traffic density and lead in various environmental samples were also examined. A house-to-house survey based on a strict set of selection criteria was used to recruit study participants. At each house a series of environmental measurements were taken: traffic volume, tap water, paint-interior and exterior, housedust and window sill wipes. Two blood samples were taken a week apart. In the range of traffic exposures studied no relationship with blood lead levels was observed (maximum mean air lead $< 2.0\ \mu g/m^3$). A positive relationship between smoking and blood lead levels was found for both males and females. This relationship was statistically significant for females but not for males.

17. KEY WORDS AND DOCUMENT ANALYSIS

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