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Urban Soil Lead Abatement Demonstration Project

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Baltimore Report

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1. EXECUTIVE SUMMARY

Over the last 20 years, it has become increasingly clear that the health effects of elevated blood lead levels in children are long term, if not permanent. Public health programs have focused on lead paint as the most significant source of exposure. However, other sources of lead exposure (air, water, and soil) continue to be of concern.

The importance of soil contamination, although recognized by the preventive community, has never been quantitatively studied in terms of its impact. The 1986 Superfund Amendments and Reauthorization Act (SARA) provided funds for a national multi-city study of the impact of abating residential lead contaminated soil on the blood lead levels of children. Baltimore was one of three cities selected as a study site.

1.1 STUDY DESIGN

This study was designed to investigate the effect of soil abatement on children's blood lead levels as a preventive strategy. The hypothesis to be tested was that a reduction in soil lead levels would result in a statistically significant decrease in children's blood lead levels.

Neighborhoods to be used as study sites were selected based upon their having areas of exposed soil around the house, a moderate risk for lead poisoning, a sufficient number of participants to test the hypothesis, pre-1950 central city housing, comparable demographic indicators, and primarily residential housing.

Although census tract data was an important factor, neighborhoods were selected to permit the inclusion and exclusion of portions of census tracts that did not meet the study site criteria. The communities of Lower Park Heights and Walbrook Junction were selected for the project sites. Following the collection of baseline environmental and biological data, Lower Park Heights was selected as the study area and Walbrook Junction as the control area by randomization.

Subjects were enrolled by door to door recruitment based upon the following criteria: (1) living in one of selected areas, (2) living in same house for at least 3 continuous months and with no plans to move in the immediate future; and (3) between 6 mo and 6 years of

age. Sample size calculations indicated that at least 88 children were needed in the control area and 44 in the study area. To allow for attrition it was decided to enroll 400 children.

All environmental and biological sampling occurred after the child was enrolled in the project. All laboratory analyses were conducted by the Maryland Department of Health and Mental Hygiene Laboratories Administration.

1.2 ENVIRONMENTAL MEASURES

Soil sampling was done to characterize the potential exposure of participant children to lead from soil and to document the effectiveness of abatement in reducing soil lead levels. The soil sampling and analysis protocols were developed in conjunction with the EPA and the demonstration project teams from Boston and Cincinnati. Using detailed property diagrams and 15 cm soil coring apparatus, an average of nine composite surface (top 2 cm) and nine deep (bottom 2 cm) core samples were taken at specified sites on the property.

Interior vacuum dust sampling was conducted to characterize the potential exposure of children to lead from dust and to document whether there was any increase in interior dust levels following paint stabilization and soil abatement. The dust sampling protocol was developed by Dr. Thomas Spittler of EPA Region I. An average of 3 dust samples were collected from the floors of the entry area(s) and two of the child's primary play areas. Because of the small size of the dust samples, it was decided to analyze each sample both by laboratory x-ray fluorescence (XRF) and by wet digestion atomic absorption spectrophotometry (AAS).

Household first draw water samples from all faucets in the household were collected to characterize the potential exposure of children from drinking water. Standard EPA water sampling and analysis protocols were used.

Exterior paint samples were collected at the time of the first environmental visit to examine the contribution of exterior paint to soil lead. Paint chip samples were collected from painted surfaces and analyzed by XRF (Kevex). After the last biological testing session, interior paint was analyzed for lead using portable XRF analyzers (Princeton Gamma Tech XK3). Measurements were taken in the child's bedroom, kitchen, and living room on

a painted wall surface and a painted wood surface (window, door). The sites of measurement were indicated on a diagram of the room.

1.3 DEMOGRAPHIC AND BEHAVIORAL QUESTIONNAIRE

Within 1 week of enrollment, each child was scheduled for baseline biological testing and interview data collection. The Biological Coordinator and staff administered a questionnaire to the parent/guardian or primary caretaker to collect demographic data and assess behaviors and other factors which influence the child's contact with various sources of lead. Follow-up interviews were conducted with each round of biological testing.

1.4 BIOLOGIC MEASURES

Blood samples for blood lead level (whole blood), free erythrocyte protoporphyrin (FEP), ferritin, and total iron binding capacity (TIBC) were collected 6 times throughout the study. Blood lead levels were determined using graphite furnace atomic absorption and FEP levels were determined by Chisolm's double extraction method. Quality control was maintained by a strict internal quality control program and participation in the CDC quality control system. The soil abatement intervention was conducted between rounds 3 and 4.

Hand wipes were obtained to determine lead dust levels on the child's hands at the time of each blood collection. The protocols for sampling and analysis were developed by the University of Cincinnati. Damage to the laboratory exhaust system, required a change from the nitric acid/perchloric acid method of analysis to the hot nitric acid methodology after round 2.

1.5 INTERVENTIONS

Houses with exterior leaded paint in both the study and control areas received exterior paint stabilization the summer and fall of 1990. Paint stabilization consisted of wet scraping the chipping, peeling paint followed by HEPA vacuuming the area. A primer and two coats of latex paint were applied to all painted surfaces. The purpose of paint stabilization was to

remove or encapsulate any chipping, peeling paint to prevent re-contamination of the abated soil.

Soil was abated only in the study area during the summer/fall of 1990, within 1 week of paint stabilization. Areas located within the property boundaries with a soil lead level greater than 500 ppm lead were abated. Abatement consisted of removal of the top 6 in. of soil and replacement with clean soil (less than 50 ppm lead), the area was then sodded or seeded depending upon characteristics of the site.

During the exterior paint stabilization and soil abatement, household members were not allowed on the property. Space was provided at a local community center for the families during the work.

1.6 ANALYSIS

The purpose of the statistical analysis was to investigate the relationship between children's blood lead levels and the measurable sources of lead to which they was exposed. Several models were selected to determine whether or not the intervention of removing lead contaminated soil had any impact on the child's blood lead level.

A correlation analysis was performed on the four environmental variables (soil, dust, exterior paint, and interior paint). This analysis demonstrated a strong relationship between exterior paint and lead in soil, and between interior paint interior dust lead level. The remaining correlation coefficients were not significant. The data analysis was conducted using both SAS and GLIM statistical software.

The natural log transformation was applied to the response variable (blood lead and hand lead) to meet the assumption of normality necessary for linear regression. The following models were performed on two different populations within the study: (1) children who participated in all 6 rounds and (2) all children sampled.

The first model measures the direct effect of group assignment on the log of blood lead in each round:

$$LPbB_{ij} = b_{oj}\, T_i + b_{ij}\, C_i + e_{ij}$$

where for the ith child in round j,
$LPbB_{ij}$ = Log of blood lead
T_i = 1 if in treatment group, otherwise 0
C_i = 1 if in control group, else 0
e_{ij} = error term

This model computes a geometric mean and a standard error for each group. These can be transformed back to the original scale of blood lead and the groups compared through use of a two sample t-test.

The second multiple linear regression model uses the log of blood lead as the response variable with group assignment, age, season, socio-economic status, and the interaction between mouthing behavior and log of hand lead as covariates:

$$LPbB_{ij} = b_{oj}T_i + b_{ij}C_i + b_{2j}Age_{ij}\ b_{3j}SES_i + b_{4j}Season_{ij} + b_{6j}LPbH!_{ij} + b_{7j}LPbH2_{ij} + e_{ij}$$

where for the ith child in round j,
$LPbB_{ij}$ = Log of blood lead
T_i = 1 if in treatment group, else 0
C_i = 1 if in control group, else 0
Age_{ij} = Age
SES_i = Socio-economic status of family
$Season_{ij}$ = 1 if sampled in summer, else 0
$LPBH1_{ij}$ = log hand lead if he/she exhibits weak mouthing behavior, else 0
$LPbH2_{ij}$ = log hand lead if he/she exhibits strong mouthing behavior, else 0
e_{ij} = error term

Similar to the first model, a geometric mean and associated standard error for blood lead are produced that are comparable through use of t=tests.

The third model evaluates the effects of group assignment on the log of hand lead:

$$LPbH_{ij} = b_{oj}\ T_i + b_{ij}\ C_i + e_{ij}$$

where for the ith child in round j,
$LPbH_{ij}$ = Log of hand lead
T_i = 1 if in treatment group, otherwise 0
C_i = 1 if in control group, else 0
e_{ij} = error term

The fourth model has log of hand lead as the response variable with group assignment, age, season, gender, and interior dust as the covariates:

$$LPbH_{ij} = b_{oj}T_i + b_{ij}C_i + b_{2j}Age_{ij}\ \ b_{3j}Sex_i + b_{4j}Season_{ij} + b_{6j}Dust_i + e_{ij}$$

where for the ith child in round j,

$LPbH_{ij}$ = Log of hand lead
T_i = 1 if in treatment group, else 0
C_i = 1 if in control group, else 0
Age_{ij} = Age
Sex_i = Socio-economic status of family
$Season_{ij}$ = 1 if sampled in summer, else 0
$Dust_{ij}$ = log hand lead if he/she exhibits weak mouthing behavior, else 0
e_{ij} = error term

The final model describes the association between the lead found on the hands of a child and the sources of lead exposure measured within the child's home environment:

$$LPbH_{ij} = b_{oj}Male_i + b_{ij}Female_i + b_{2j}Age_{ij}\ \ b_{3j}Season_i + b_{4j}Dust_{ij} + b_{6j}Soil_i + e_{ij}$$

where for the ith child in round j,

$LPbH_{ij}$ = Log of hand lead
$Male_i$ = 1 if male, else 0
$Female_i$ = 1 if female, else 0
Age_{ij} = Age
$Season_i$ = 1 if sampled in summer, else 0
$Dust_{ij}$ = Measure of dust lead in home
$Soil_{ij}$ = Measure of soil lead in home
e_{ij} = error term

1.6.1 Results

The statistical models were applied to the two populations to evaluate the potential bias introduced by participant dropout. The regression coefficients were virtually identical between the two populations for demographic, biological and environmental parameters, indicating that the effect of participant dropout on the statistical models was negligible.

Although soil abatement in Baltimore did not result in the expected decrease of 1,000 ppm lead in soil, the average decrease in soil lead levels was 550 ppm (using the tri mean measure). Based on the literature, the expected decrease in blood lead levels related to

this magnitude of soil decrease would be 1 to 3 μg/dl. In round 4, 3 mo following intervention, the blood lead levels of children in the study area decreased 1.5 μg/dl and in the control group decreased 1 μg/dl. This round of testing was in the winter months of January through March, 1990. In round 5, May 22 through July 17, 1990, the blood lead in the study group returned to the pre-abatement level and remained at that level in round 6. However, the control group remained below the pre-abatement level throughout rounds 5 and 6. Due to the longitudinal aspect of this study, it is difficult to interpret these results, however there does not seem to be any clinically significant reduction in children's blood lead levels resulting from the soil abatement.

The effect of soil abatement on hand lead was also hard to interpret due to the longitudinal aspect of the study. In the pre-intervention sampling rounds there was no significant difference in hand lead levels between the treatment and control groups. In the sampling round immediately following intervention, hand lead levels of children in the control group were slightly less than those in the group which received soil abatement. This round of sampling occurred during the winter months, when children are not outdoors much, making it difficult to conclude if soil abatement had anything to do with this observation. In the final two sampling rounds, which occurred during the spring and summer months, the hand lead levels sharply increased in both groups. The hand lead concentration of children in the abated group was lower than those of children in the control group for both of these rounds. Although not statistically significant, this temporal trend may indicate a slight effect of soil abatement on children's hand lead levels.

The regression coefficients of mouthing behavior as an effect modifier for hand lead in the blood lead models indicated that children who exhibit stronger mouthing behavior will have higher blood lead levels. This trend was apparent in all six sampling rounds. The use of age as a continuous variable is questionable because the effect of age on blood lead may not be linear. There seemed to be a negative effect of socio-economic status (as determined by the Hollingshead Four Factor Index) on blood lead levels throughout the study.

1.7 CONCLUSIONS

Statistical analysis of the data from the Baltimore Lead in Soil Project provides no evidence that the soil abatement has a direct impact on the blood lead level of children in the study. The statistical analyses to date have consisted of adjusted and unadjusted analysis for selected covariates. It should be pointed out that the Baltimore study areas, both abated and control, had lead based paint. Thus the conclusion might be more precisely stated as "in the presence of lead based paint in the children's homes, abatement of soil lead alone provides no direct impact on the blood lead levels of children".

1.8 IMPLICATIONS

The findings of this study might help avoid costly abatements of soil in cities, like Baltimore, where the principal sources of lead exposure for children is lead in paint and lead in household dust. Soil abatement for cities like Baltimore does not appear to be a cost effective preventive strategy used alone, but it may well be an adjunct, in selected cases, to the overall environmental management of children who become lead poisoned.

2.0 INTRODUCTION

2.1 HEALTH EFFECTS

There has been a tremendous explosion in knowledge of the health effects of lead over the past 20 years which has led to a progressive lowering of the blood lead levels considered to be of concern. The Surgeon General Statement established an action level 40 μg/dl in 1970. The Centers for Disease Control (CDC) lowered it to 30 μg/dl in 1975, to 25 μg/dl in 1985 and to 10 μg/dl in 1991. The basis for these changes was findings of adverse effects at lower and lower blood lead levels. It is now apparent that the blood lead threshold for adverse neuro-developmental effect on the fetus and young children is 10 μg/dl. Furthermore, experimental evidence indicates that these effects are long lasting, if not permanent (Air Criteria, ATSDR).

National Health and Nutrition Education Survey II (NHANES II) from 1976 to 1980 measured the distribution of blood lead concentrations in the United States population. The mean blood lead level across the U.S. population in 1976, just prior to the decrease in leaded gasoline, was found to be 15.9 μg/dl. By 1980, with the continued decrease in the use of leaded gasoline, the mean blood lead concentration had dropped to 9.6 μg/dl (Annest, 1983). Although urban poor minority children were found to have the highest risk of lead poisoning, elevated blood lead levels were found across all social, geographic and racial groups.

2.2 BIOLOGICAL FATE AND METABOLISM OF LEAD

Absorption of ingested lead in children is more efficient than in adults. Absorption rates are influenced by particle size (Barltrop and Meek, 1979) and nutritional factors (Barltrop, 1974, 1975; Rosen, 1980).

Rabinowitz (1980) studied adults fed solutions of lead with and without food to investigate the influence of food on lead absorption. He demonstrated that lead absorption was reduced from 15 to 50% without food to 8 to 13 % with food. Bio-availability appears to differ according to source and form of lead and is poorly understood.

Dietary lead intake in excess of 5 μg/ Kg of body weight/day in infants from birth to 2 years of age results in positive lead balance (Ziegler, et al., 1978). They also found an inverse relationship between the amount of calcium in the diet and the absorption of lead.

Once absorbed, lead is distributed throughout the soft tissue and bone. There is a continuous active process of absorption, tissue deposition and excretion. Deficiencies in iron, calcium, and phosphorus are directly correlated with increased blood lead levels in humans and experimental animals (Mahaffey, 1981; Mahaffey et al., 1980).

Under normal circumstances, the excretion of lead occurs 50-50 between the kidneys and bowel (Rabinowitz, 1976).

2.3 SOIL AND DUST LEAD AND THEIR RELATIONSHIP TO BLOOD LEAD

Whereas, air and food were significant sources of lead through the 1970's, these major sources have been substantially reduced by reductions in lead gasoline and food. This led the ADSTR to conclude in 1988, that as "persistent sources for childhood lead poisoning in the U.S., lead in paint and lead in dust and soil will continue as major problems into the foreseeable future".

Lead poisoning in children was first reported in Australia by Gibson, et al. (1892). Through experimentation and observation, Gibson concluded in 1904, "I believe and advance a very strong plea for painted walls and railings as the source of the lead, and for the biting of fingernails or sucking of fingers, as in a majority of cases, the means of conveyance of the lead to the patient". Gibson's observation lay fallow for 70 years until Sayre, et al. (1974) demonstrated an association between house dust and hand dust and blood lead in a study of inner city and suburban homes.

Most studies in children during the last past 20 years have been around smelters and mines. Roels, et al. (1980), in a study of school children who live near a smelter, reported partial correlations between blood lead, hand lead, and air lead indicated that in the smelter area the quantitative contribution of air lead to the children's blood lead levels is negligible compared to hand lead. This relationship was found after air emissions from the smelter had

been substantially decreased. These and other studies are extensively reviewed in the EPA Air Quality Criteria for Lead (1986).

Ter Haar (1974) demonstrated a gradient in lead contamination between houses and the nearest roadway suggesting that the house itself is also a source of lead in the soil. It is generally believed that the major contributors to soil lead in cities are automobile exhaust and exterior paint. Rabinowitz (1980) and Yaffe (1979) investigated sources of lead in blood by use of stable isotope ratios distinguishing lead sources from paint and gasoline in a variety of media, such as dust, soil, and blood. Whereas adult's blood lead resembled the isotope ratio in airborne lead, the stable isotope ratios in children resembled interior household dust, in some cases, and, in other cases, exterior paint and soil.

The EPA published a biokinetic model for lead (U.S. Environmental Protection Agency, 1990). In this approach, amounts of lead in food, water, air and soil are calculated from available data together with absorption factors for each. From this, total intake of lead can be estimated and lead concentrations associated with various levels of intake can be projected and modeled. Data from Binder, et al. (1986), in a study carried out in E. Helena, Montana, appeared to validate this model. In these studies, the data suggested that children might ingest 50 to 500 mg of soil per day.

Duggan and Inskip (1985) reviewed studies related to blood lead-soil lead ratio, or the amount of increase in blood lead that can be attributed to a soil lead increase of 1,000 ppm. They reported that this ratio is very variable between studies (range 1 to 9 μg pb/dl/blood per 1,000 μg pb/g soil). The ratio tended to be higher for younger children and lower for older children. These data strongly suggest there may also be differences in the bioavailability of lead from different environmental sources. Most of the studies they reviewed were related to exposure to lead oxide dust among children living in the vicinity of lead smelters. By contrast, there have been few studies of residential lead soils, away from smelters (Stark, et al., 1982, Shellshear, 1975).

2.4 BALTIMORE AS A STUDY SITE

Baltimore was one of the cities selected by an extensive review in 1987 to carry out one of three linked studies on the issue of lead in soil and its impact on children's health.

Baltimore City has a serious lead poisoning problem, which was first recognized in the 1930's as a result of an epidemic of lead poisoning related to burning battery casings for heat during the depression (Williams, 1933). Following removal of wooden lead acid battery casings from the market, lead poisoning cases continued to occur and it became apparent, that among children, lead poisoning due to the ingestion of leaded paint was a serious problem. The Baltimore City Health Department established a laboratory in 1935 to provide free diagnostic blood lead testing. This policy has continued through the years with a formal screening program under CDC sponsorship being established in 1975.

Nearly all these children receive their excessive exposure through contact with lead paint, contaminated indoor dust and possibly contaminated outdoor soil (Mielke, 1983). Other sources of exposure in Baltimore are uncommon. The water supply is non-corrosive and there are no uncontrolled emissions of the magnitude of some mining and smelting towns. Few occupations involve lead exposure, principally auto body and radiator repair and the construction industry. As in other cities, occasional poisonings occur due to lead glazed ceramics, fishing weights, and other unusual sources. But the most serious threat is the continuing legacy of lead paint on older housing that becomes increasingly more available to children as it ages, deteriorates, or during renovations.

Public health programs have focused on lead paint as the most significant source of exposure and will continue to do so. The impracticality of widespread safe and permanent abatements of the inside and outside of houses make it incumbent on us to consider what are appropriate components of community based or individual approaches to reducing exposure to lead.

The importance of soil contamination is of concern to preventive programs but has never been quantitatively studied in terms of its impact. Before launching into major spending to abate lead in soil it is appropriate that we have an accurate picture of its impact on prevention.

It is important to recognize that the impact of lead in soil may be quite different for high risk children than it is for the general population of children. This study is designed to examine only the impact of soil abatement as a preventive strategy. The study design does not answer the next obvious question, which is whether soil abatement combined with paint

abatement might be more effective than paint abatement alone in the management of poisoned children.

3. METHODOLOGY

3.1 PROTOCOL FOR STUDIES INVOLVING HUMAN SUBJECTS

The Human Volunteers Committee Institutional Review Board (IRB) of the Department of Health and Mental Hygiene reviewed the proposal submitted to the Environmental Protection Agency along with all study protocols, the questionnaires and the consent forms. Full approval was granted by the IRB in September, 1988. In addition, since Dr. J. Julian Chisolm is a co-investigator and is on faculty at Johns Hopkins University, the proposal and related materials were submitted for IRB review at Johns Hopkins. Full approval of this group was granted in March, 1988, along with annual approval in 1989, 1990, and 1991.

3.1.1 Confidentiality

Particular attention was paid to the collection and handling of all personal, health related or medical information. All such information was treated as confidential. Personal identifiers were removed prior to processing the data and replaced with codes utilizing a simple three digit sequential numbering system. Only coded information was entered into the data base. Code keys were considered confidential. All confidential material was retained under direct control of the investigation team.

Confidential medical information was accessible only to the members of the investigation team and the subjects themselves or their physicians on receipt of a release of information form signed by the subject specifying to whom the information should be released.

Unless otherwise indicated (e.g., need for long term follow-up) confidential material will be disposed of by shredding hard copies and deleting electronic data after a period of 5 years.

3.1.2 Informed Consent

Informed consent was obtained prior to any procedure and participation was voluntary throughout the project. No minor (under 18 years) was included in the project unless informed consent was obtained from the parent or guardian.

Information provided to study subjects was in language likely to be understood by the subject and was explained orally as well as in a written statement. There was an opportunity to ask information of individuals familiar with the study and competent to address any related issues and questions. No coercion was used by the investigation team when enrolling subjects into the study.

3.1.3 Ethical Considerations

All procedures and interventions were reviewed for determination of safety to the participant and community. No procedures were allowed which exposed human subjects to risks. Because of the medical and developmental ramifications of elevated blood lead levels, the parent or guardian of all children who had blood lead levels $\geq$ 25 μg/dl (1985 CDC action level) were notified. Information concerning the health and development effects of lead poisoning was given to the parent/guardian and they were encouraged to seek medical care. Upon informing the parents/guardians, the project informed the Baltimore City Health Department Lead Poisoning Prevention Program of all elevated blood lead levels per Maryland Regulations.

The children with elevated blood lead levels were not dropped from the study but were retained to monitor their lead levels.

3.2 STUDY DESIGN

The purpose of this project was to investigate the effects of removal and/or abatement of lead contaminated soil with respect to childhood lead exposure. The hypothesis as stated in the null was:

1. A significant reduction of lead ($\geq$1,000 ppm) in residential soil accessible to children will not result in a significant decrease (3 to 6 μg/dl) in their blood lead levels.

Garden soil samples collected in Baltimore prior to the study and previous research (Mielke, Chaney, 1982) suggested that soil lead levels could be decreased by 1,000 ppm following abatement. However, soil samples collected during the study indicated lead contamination was less than previous expected. Of the 204 properties tested for the study, only 110 (54%) had soil lead levels above 1,000 ppm. For the remaining houses, abatement would not achieve 1,000 ppm decrease in soil lead levels. In order to make use of the voluminous amount of data collected in this project, the null hypothesis has been restated as follows:

1a A significant reduction of lead in residential soil accessible to children will not result in a statistically significant decrease in their blood lead levels.

The final study design is illustrated in Figure 3-1. If soil abatement was found to be associated with significant reduction in blood lead, similar treatment was planned for the control area.

3.2.1 Site Selection

The sites for the project were selected based on the following criteria:

1. Identification as a moderate risk area for lead poisoning as determined by number of hospitalizations for lead toxicity, lead screening results and/or predictions based on the existence of risk factors.

2. Sufficient number of potential participants to test the hypothesis, based on birth rates, power analysis and predicted recruitment and attrition rates.

3. Areas of exposed soil thought to be contaminated with lead at high concentrations and accessible to children.

4. Pre-1950 central city houses in comparable condition as determined by drive-by exterior inspections and housing census data.

5. Low likelihood of concurrent lead paint abatement projects performed with other funding mechanisms.

6. Comparable socioeconomic class and other demographic indicators, as determined by census data.

7. Areas should be non-contiguous.

8. Areas should be residential, single family housing and not near highways.

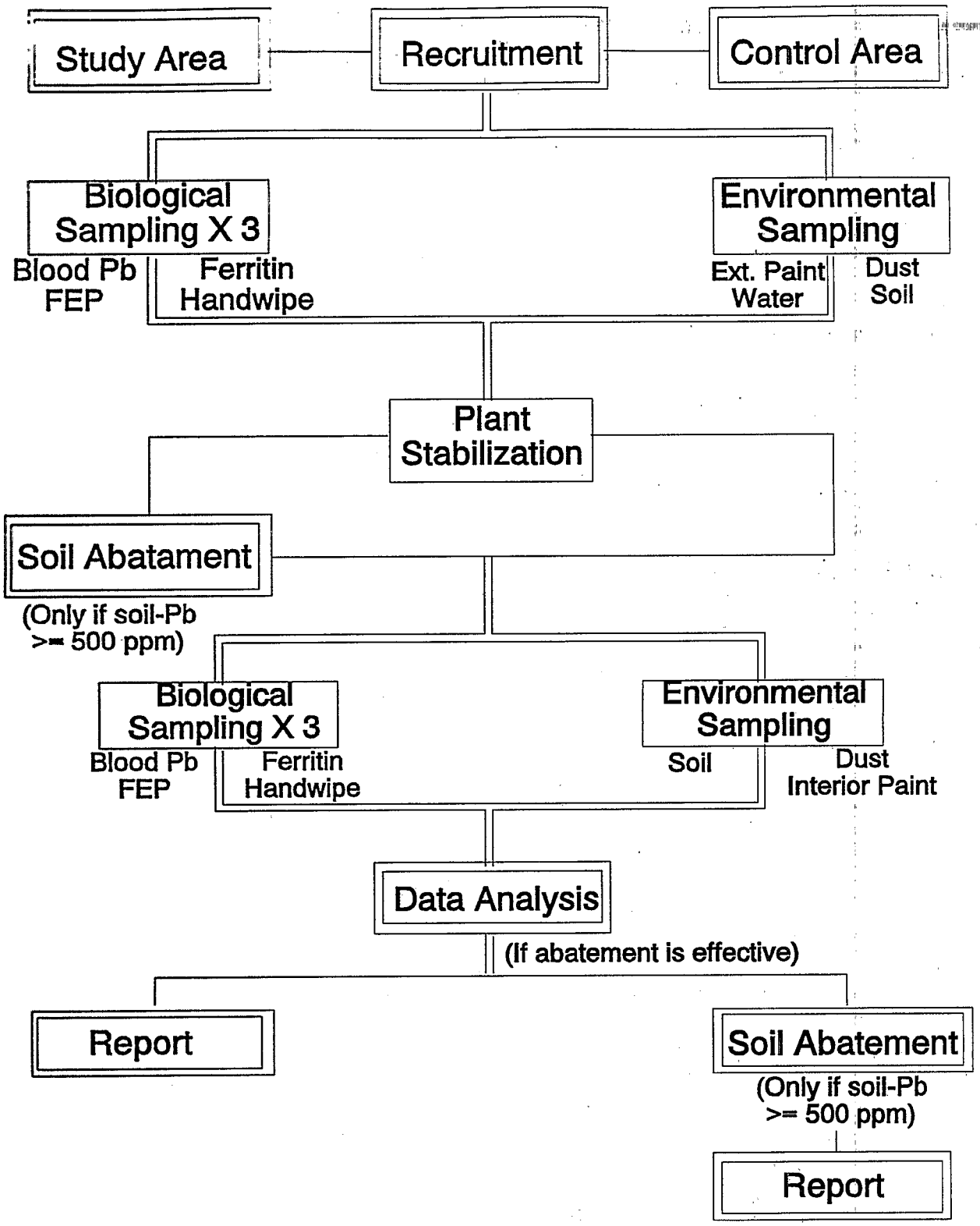


Figure 3-1. Baltimore study design.

Selection criteria applied to both the study and control areas.

During the initial phase of development of this project an intensive effort went into the development of area profiles for site selection. Census tract data and information on lead poisoning cases (also by census tract) formed the basis for initial site identification. Field data based on drive through evaluations of the candidate areas helped narrow the field based on accessibility of soil, confounding lead sources and similarities between study sites in terms of layout and housing type.

Once the study sites had been identified, the boundaries of census tracts seemed arbitrary and a decision was made to redraw the study neighborhoods based on homogeneity and numbers of potential participants rather than the census tract borders. This permitted the inclusion and exclusion of portions of census tracts based on their actual identification with a neighborhood. The use of neighborhoods avoided having to exclude families simply because they lived on one side of the street outside the census tract. It similarly avoided having to include large areas with few children or little exposed soil.

3.2.2 Rationale for Study Site Criteria

Areas which were known to have no more than a moderate incidence of childhood lead poisoning were desired to avoid the chance that other interventions would influence the child's blood lead level during the period of the study. State of Maryland regulations require an environmental evaluation and case management by the community health nurse, in concert with the primary care provider, for blood lead levels ≥ 25 μg/dl, the 1985 Centers for Disease Control (CDC) action level for lead poisoning. In addition, the primary care provider is required to perform a thorough medical and nutritional evaluation. Thus, medical and environmental interventions act as confounding variables. For the same reason, areas that were expected to have lead paint abatement performed by other funding sources were excluded from site consideration.

Communities in which the residences had accessible yards with at least some exposed soil were considered because the children would have an opportunity for exposure to contaminated soil. Single family housing with front and back enclosed yards were desired because of increased likelihood of children playing in the immediate vicinity of their home. Although most housing of this type in Baltimore is row or town houses, some communities

have a mixture of row housing and semi- or detached housing. Houses built prior to 1950 tend to have the highest risk because of deterioration of lead paint over the years. Such properties are likely to be surrounded by soil contaminated with lead paint chips and dust from deterioration of existing paint and from previous removal or renovation efforts.

A further consideration in selecting study and control areas is that they should be non-contiguous communities. This avoids confounding results from crossover with children moving from one area to another. Baltimore neighborhoods tend to be close knit communities with extended families frequently residing within a few blocks of each other. Care of children is often shared with grandparents or other relatives living close by. Although families of low income rental units move frequently, they seldom move more than a few blocks away.

Socioeconomic status and other demographics have been associated with blood lead levels. Residential areas were selected to avoid the influence of heavy vehicular traffic and heavy industry.

3.2.3 Prestudy Data Gathering

In order to select suitable study and control areas, the project drew upon previous studies and data sources and performed soil sampling from candidate sites in Baltimore City. Since Baltimore had been the site of an extensive soil study in the past, (Chaney and Mielke, 1982) the results of this study were used in the initial identification of possible sites.

Baltimore City, like many older urban centers, has a large number of housing units painted with lead paint. A large body of information on patterns of lead poisoning in the city from screening results, number of hospitalizations and previous studies were available in the site selection process. In addition, data sources on risk factors such as socioeconomic status, race, age, and housing were utilized.

3.2.4 Comparison of Study Communities

Based on the above information, the communities of Lower Park Heights and Walbrook Junction were selected for the project sites.

The comparability of these two neighborhoods was borne out by baseline environmental and biological data gathered in the course of the study. Mean soil lead levels were slightly

higher for Walbrook Junction than for Lower Park Heights, but the difference was not statistically significant ($p = 0.08$, two sample t test). All houses in both areas had lead-based paint on the exterior. The remaining variables of interior dust and water were comparable for the two areas. A comparison of community characteristics is found in Table 3-1.

TABLE 3-1. CHARACTERISTICS OF STUDY AND CONTROL SITES AT TIME OF ENROLLMENT INTO STUDY

		Lower Park Heights (study area)	Walbrook Junction (control area)	Total
Soil Lead Level (Tri mean PPM, XRF Analysis)	Mean =	546	660	598
	S.D. =	326	384	357
	N* =	112	92	204
Dust Lead Level Floors** (XRF Analysis)	Mean =	778	775	777
	S.D. =	1287	985	1156
	N =	115	97	212
Exterior Paint (Mean mg/cm^2)	Mean =	4.71	5.01	4.95
	S.D. =	3.95	6.15	5.08
	N =	109	94	203
Water - First Draw (Mean μg/l)	Mean =	7.83	5.66	6.84
	S.D. =	15.85	9.89	13.5
	N =	133	112	245
% Owner Occupied Premises ***		33.5	45.9	38.7

*N = Number of housing units
** = Total dust per area sampled (4 feet^2)
*** = At time of intervention

Random allocation of the areas to study or control status was made, by the toss of a coin, after the collection of baseline environmental and biological data to avoid selection bias. Lower Park Heights was selected, in January 1990, as the study site where soil abatement was to be carried out.

3.2.5 Study Population

Door to door recruitment in the areas was done to enroll study subjects. Criteria for participation in the project was based upon the following child characteristics:

1. Child must live in one of the selected sites.

2. Child must have lived in the same house for at least 3 continuous months and the family had no plans to move in the next year.

3. Child must have been between 6 mo and 6 years of age at the time of enrollment in the study. Special emphasis was placed on recruiting children under 3 years of age.

3.2.6 Rationale for Study Subject Criteria

Three month residency at the current address was required to ensure that the child's baseline blood lead levels reflect the current residence's environment. Intention to remain in current residence was selected to minimize attrition following enrollment in the study. Children were not excluded if they attended day care or were enrolled in pre-kindergarten programs.

Because of their increased vulnerability to the effects of lead, children between 6 mo and 6 years were recruited. There was a special interest to identify and recruit children under the age of 3 years, because these children will be in the population at risk throughout the study and still have a high degree of hand-to-mouth activity. Children in this age group also spend more time in the home environment.

During the enrollment phase of the study, no attempt was made to limit the number of children recruited per housing unit. Some of the housing units contain 2 to 3 single mothers with 1 to 2 children each. There were also some parents with several children and some multi-generational families in which grand-mother and mother would each have a child in the study. Throughout the study (rounds 1 through 6), the percent of housing units with more than one child remained consistent around 60% and the number of housing units with up to 3 children averaged 93%.

3.2.7 Sample Size Calculation

Sample size calculations were based upon the following assumptions:

- the lead abatement intervention is the only change in the two populations
- at least one-half of the properties would have soil concentrations high enough to warrant abatement, so that the effect of abatement would be felt by at least half of the study area population (Ns)
- $\alpha = 0.05$ (one tail test)
- $1\text{-}\beta = 0.80$ (power of test)
- $\sigma \approx 42$ (variance) S.D. $= 6.5\ \mu g/dl$
- $(\mu c - \mu s) = 3\mu g/dl$ (protocol)

The sample size formula for control population is:

$$Nc = \frac{(Z\alpha+Z\beta)^2 \ \sigma^2 \ (K+1)/K}{(\mu c-\mu s)^2}$$

Thus, in the control group Nc = 88 and in the study group Ns = 44. It was hoped that the study would have at least 200 participants in the study, 100 from each area. To allow for 20% attrition each year over the three years of the study, it was decided to enroll 400 participants at the beginning of the study. (See actual attrition rates in section on final study population.)

3.2.8 Comparison of Final Study Population

At the time of enrollment into the study, children in Walbrook Junction were slightly older than those in Lower Park Heights. However, at the time of round 3 blood screening, immediately prior to the intervention, and for children who remained in the study for its duration, the two groups were similar in age. There was no significant difference in the ages between those that stayed in the study versus those that dropped before round 3 testing.

The mean blood lead levels and ferritin levels were similar for the two populations both at time of enrollment and at the time of round 3 testing.

Socioeconomic level according to the Hollingshead Four Factor Index varied from the time of enrollment into the study and round 3 of testing. At the time of enrollment into the study there was no statistical difference in the two groups socioeconomic level. However by round 3, the socioeconomic level for Walbrook Junction was higher than that for Lower Park Heights. Those who dropped from the study in Lower Park Heights had a higher level of

maternal education than those who remained in the study. This education difference in the drop out group did not occur in Walbrook Junction.

The characteristics of the final study population are presented in Table 3-2.

TABLE 3-2. CHARACTERISTICS OF FINAL STUDY POPULATION BASED ON ROUND 3 STUDY DATA

	Lower Park Heights (study group)	Walbrook Junction (control group)	Total
Age in Months	Mean = 47.2	50.1	48.4
	S.D. = 22.3	18.8	20.9
	N* = 154	116	270
Blood Lead Level (μg/dl)	Mean = 11.1	10.2	10.7
	S.D. = 6.5	5.4	6.1
	N = 154	116	270
Ferritin Level	Mean = 23.5	22.9	23.3
	S.D. = 18.7	14.7	17.1
	N = 148	107	255
% Male**	52.6	40.4	47.4
	N = 152	114	255
% Black	100	100	100
% Class 5, SES***	49.8	51.9	50.8

* N = Number of children enrolled in round 3.
** p = 0.047.
*** According to Hollingshead Four Factor Index of Socio-economic Status.

3.2.9 Attrition and Retention

In the first round of biological sampling held between August 22, 1999 and December 2, 1988, 408 children were recruited into the study (212 in Park Heights or the study area and 196 in Walbrook Junction or the control area). By round 2 held February 2, 1989 and August 15, 1989, 100 (24.5%) children were lost to the project because of lack of interest/refusal to participate or moving out of the study area. During round 2, 14 additional children were enrolled in the study.

Because of the time lag in implementing the paint stabilization and soil abatement, an additional round of biological testing was conducted from January 22, 1990 to August 13, 1990, and prior to the interventions occurring. At this time, 270 children were tested, a loss of an additional 102 (31.6%) children. Once more, this loss was due primarily to moving out of the area and refusal to participate or be tested. An additional 50 children were enrolled in the study during this time. No new recruitment or enrollment occurred after this round.

At the beginning of round 3 and continuing throughout the study, an intensive program to retain study participants was conducted by the Outreach Coordinator and her assistant. The focus of their campaign was to increase the participant's interest and commitment to the project. This was achieved by increased personal contact with the participants and their landlords (see section on Community Outreach).

Interventions, paint stabilization in study and control areas and soil abatement in study area, took place from April 27, 1990 through December 10, 1990. Round 4 biological testing took place three months after the interventions between January 2, 1991 and March 26, 1991. Despite the above intensive efforts, 73 children (27%) were lost to the study primarily because of refusal of the landlord to participate in the study. An added benefit to the increased contact and outreach activities was the shorter time period necessary for each biological clinic because of less missed appointments.

Round 5 biological testing occurred between May 22, 1991 and July 19, 1991. One-hundred-ninety-three children were seen, an attrition rate of only 4% (8 children). Four children who were tested in round 3 but were unable to come to round 4 were also seen.

The final round of testing occurred from August 19, 1991 to September 30, 1991. For this round 185 children were tested, with an attrition rate of 5.7% (11 children). Once more, 3 children who had been seen in rounds 3 and 4 but not round 5 were tested.

The overall attrition rate for the project with an initial enrollment of 408 children, a loss of 294 children and an addition of 71 children was 54.6% (see Table 3-3 and Figure 3-2).

TABLE 3-3. ATTRITION AND RECRUITMENT ROUNDS 1 THROUGH 6

ROUND	TOTAL SEEN	ATTRITION	% LOSS	GAIN
1	408	0	0	
2	322	100	24.5	14
3	270	102	31.6	50
INTERVENTION				
4	197	73	27.0	0
5	193	8	4.0	4
6	185	11	5.7	3

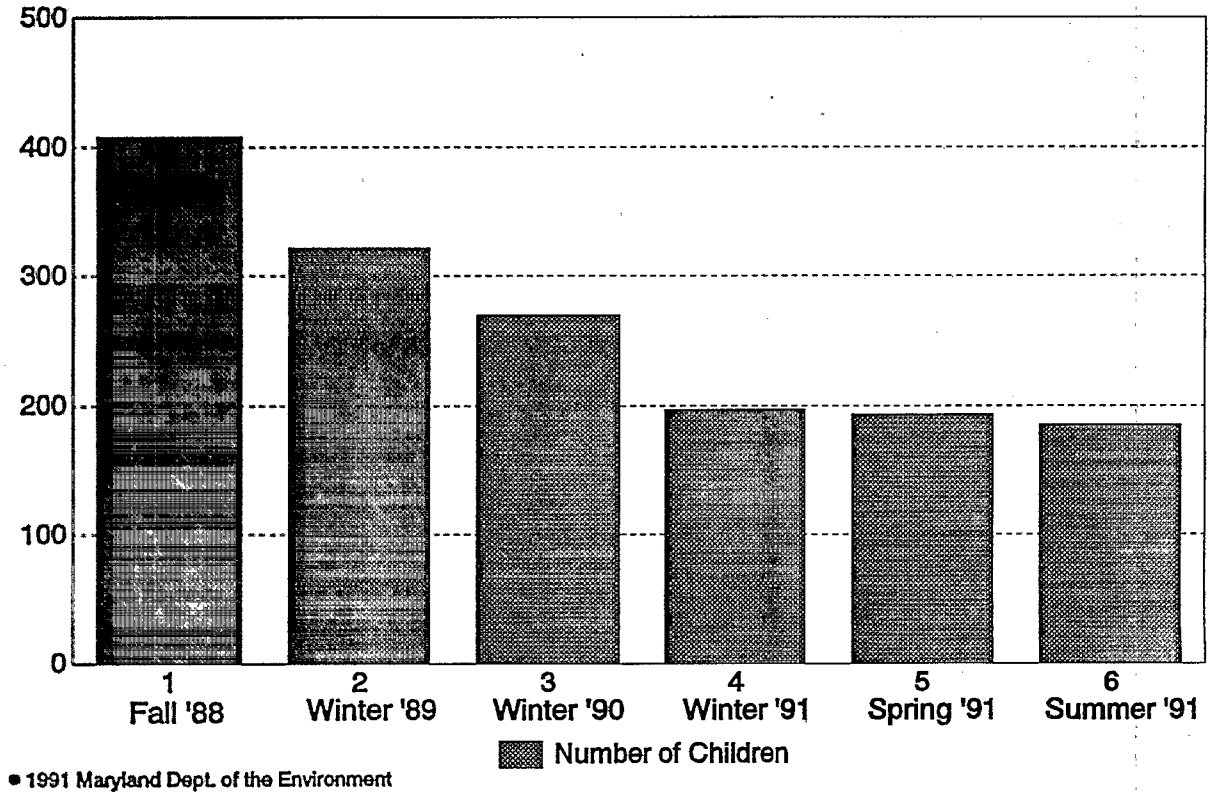


Figure 3-2. Recruitment and retention of participants.

3.2.10 Community Outreach/Public Relations

The success of this project depended upon good relationships between the project and the participants, as well as the maintenance of a positive image for the project in the eyes of the communities directly impacted by the project. This image depended not only on what was done, but on how it was presented. Public Relations and Community Outreach positions were developed to create an awareness of lead hazards and the measures that reduce lead exposure in general and the specific activities being undertaken as part of the project in particular.

3.2.11 Public Relations Officer

The Public Relations Officer was responsible for marketing the project to the public, especially the populations that directly contributed to the success of the project.

Prior to the start of the project, The Maryland Department of the Environment began to increase efforts in the public relations and awareness areas in order to lay the groundwork for the project itself. These activities included an opening ceremony press conference to announce the award of the grant; the declaration by the Governor of Maryland designating May 15 through 22, 1988, as Lead Poisoning Prevention Week, creating a forum for a variety of publicity/education efforts; and the creation of a logo and slogan to increase name recognition of the project.

Once the study neighborhoods were selected, interaction with the neighborhood groups escalated. Meetings were held with community organizations, political leaders and church groups to enroll participants and with community and coalition groups to enlist support for the project.

Staff training in community relations was done to assure that the project maintained a positive image in the community. Tee shirts, jackets and caps with the project logo were worn by all staff in the field to increase project visibility.

The Public Relations Officer also made arrangements for media coverage of the project. Television stations were contacted and arrangements made for visits to the environmental and biological testing sites. Continuing stories on the project were done by two television stations in the area. A series of newspaper articles on lead hazards included a section on the project.

Television and radio public service spot announcements were produced with the cooperation of a local community college's tele-communication students. They were aired by the television and radio stations during the initial recruitment and enrollment period of the study.

Some Baltimore landlords were hesitant to allow their rental properties to be in the study out of concern that participation in the study would leave them vulnerable to law suits related to the possibility of lead poisoning. The project solicited the cooperation of the Baltimore Property Owners Association (POA) to support the project among its members. Meetings were held with reluctant landlords both in groups and individually to explain the project and to decrease concerns related to liability. The Project Manager spoke at POA training sessions concerning lead abatement of properties. Letters were also sent to all property owners with property in the study explaining the project and answering legal questions that had been raised.

3.2.12 Community Outreach Coordinator

The Community Outreach Coordinator worked with the Public Relations Officer and the Environmental Health Aides in the recruitment and retention of participants in the study. The coordinator acted as a liaison between the communities in the study and the project. The Outreach Coordinator conducted training sessions with all project staff in outreach techniques and worked with them on how to handle difficult situations. The Outreach Coordinator, Environmental Health Aides and other staff were then assigned to door-to-door recruitment at alternate hours (evenings and weekends) in addition to normal business hours. Every house in each community was contacted by someone in the study. If the mother of an eligible child was not at home on the first visit, literature on the project was left and a return visit was scheduled. Within 3 mo, 408 children were enrolled into the study.

The Outreach Coordinator also met individually with landlords who were reluctant to participate in the study to explain the project and the benefits to the property owner. Photos of before and after paint stabilization were used to help convince rental property owners of the benefits of participation. Of the properties enrolled in the study, 75% were as a direct result of this intensive person to person campaign.

Once the subjects were enrolled, emphasis was placed upon keeping clinic appointments and retention in the study. The Outreach Coordinator placed emphasis on the positive aspects of the mother's concern for her child's present and future health.

Additional recruitment took place prior to abatement in the study area because attrition had been a problem, mainly due to families moving away. Pre-abatement data (biological and environmental) was collected on the new participants.

In order to encourage the attendance by the participants at scheduled clinics, an incentive plan was developed. Children who had blood tests performed received a tee-shirt and sticker with the project's logo. A variety of incentives were offered to the parents/guardians for bringing their children to the clinic and included the following:

- One month passes on the Metro Transportation System for all mothers who brought their children in during a particular month.
- Food coupons to local grocery stores for mothers who brought their children in during a particular clinic.
- Coupons to be redeemed for turkeys at a local super market for all participants for Thanksgiving, 1989.
- Shoe coupons for children's shoes for children who attended a particular clinic session.
- Educational toys and books for all children who attended a particular clinic session.
- Social events (parties and skating events with refreshments and entertainment) for all participants and their family members who remained in the study.
- Drawings for prizes to family if child attended clinic on first scheduled visit.

The Outreach Coordinator also worked with families to prevent eviction from houses in which paint stabilization and soil abatement had been performed but biological monitoring had not yet been completed. She worked with landlords, social agencies and church/community support groups to obtain assistance for the families in meeting their rent and electricity obligations. It was necessary to offer rent assistance to ten families in the study area who were notified of eviction intent by their landlords. This was a one time

payment and required attendance at a budget planning session conducted by the Outreach Coordinator.

At the completion of the study, vacuum cleaners were given to all households that participated in the entire study.

4. INTERVENTIONS

Project Timeline presented in Figure 4-1.

4.1 ENVIRONMENTAL MEASUREMENTS AND ANALYSIS

4.1.1 Soil

Soil sampling was conducted to characterize the potential exposure of participant children to lead from the soil and to document the reduction in soil lead levels following soil abatement. Initial soil sampling was started August, 1988. However, because of a drought that year in the Baltimore area, the soil sampling was postponed until after the initial enrollment and blood testing of participant children. Soil sampling resumed November, 1988, and continued through February, 1989, because of the unusually mild winter. Follow-up sampling was conducted within 1 week of soil abatement to document the decrease in soil lead levels.

The soil sampling and analysis protocol was developed in conjunction with the EPA and the demonstration project teams from Boston and Cincinnati (see Appendix A). A decision was made to use X-Ray Fluorescence (XRF) for soil analysis following participation in the Round Robin Study to evaluate the effectiveness of XRF analysis versus wet digestion Atomic Absorption Spectrometry (AAS).

The soil sampling process is summarized below. The protocols for soil sampling and soil analysis by XRF are in Appendix A. After a child was enrolled into the study, a detailed drawing was made of the property that showed the boundary of the lot, the buildings on the lot, the position of sidewalks and other paved areas, and the position of play areas, if known.

Using the diagrams, composited soil samples were taken throughout the property. The large area pattern of soil testing was utilized on most of the properties in the study. A line 20 in. from the base of the foundation into the soil area and running the length of the foundation was measured and marked with stakes. One composite sample was collected along this foundation line and one was collected along the boundary if the yard was less than 10 ft. wide. If the property was more than 16 ft. wide, an additional composite sample was

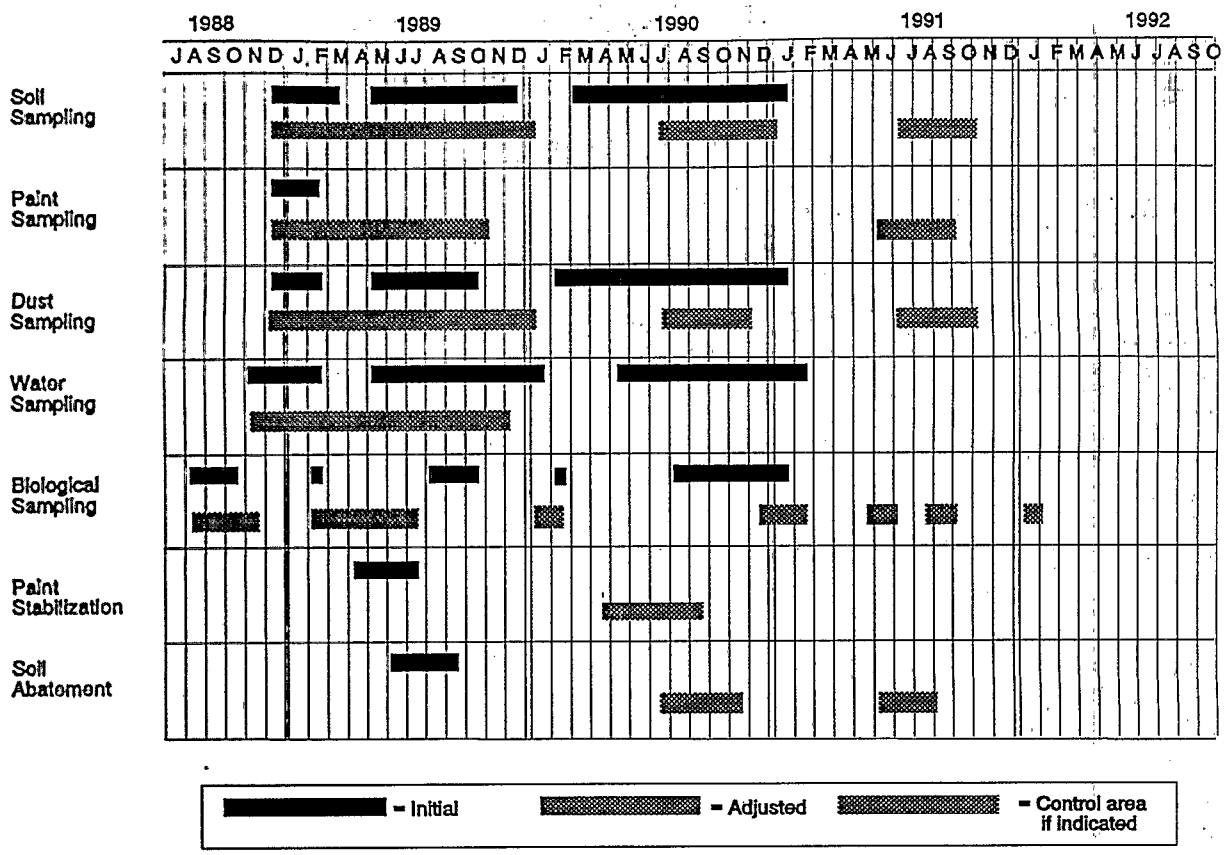


Figure 4-1. Schedule of project activites.

collected midway between the foundation line and the boundary. Ten randomly selected 15 cm. (6 in.) long core samples were collected on each line.

From each core sample, the top 2 cm. and the bottom 2 cm. were put into separate bags labeled "top" and "bottom". The tops/bottoms from each line were composited and identified as a single sample. All soil samples were transported to the State Of Maryland Department of Health and Mental Hygiene (DHMH) Laboratories Administration and analyzed by XRF.

Following soil abatement, composite soil samples were taken from at least three sites (foundation, mid-yard and boundary) in the abated areas of each property using the above method.

4.1.2 Dust

Household dust sampling was conducted to characterize the potential exposure of children to lead from dust and to document whether there was any increase in interior dust lead levels following paint stabilization and soil abatement. The dust sampling was carried out at the time of the initial environmental visit and within 1 week following soil abatement in the study area. In the control area, second dust samples were collected after stabilization but with no time limit.

The dust sampling protocol was developed by Dr. Thomas Spittler of Region I of the Environmental Protection Agency. Based on the recommendation of Dr. Spittler and the results of the Round Robin Study, the study initially planned on analyzing all dust samples by XRF. Because of difficulty with analysis of the small sample size ($\leq$50 mg.), it was decided to analyze each sample first by XRF and then by wet digestion AAS. The dust sampling protocol and each method of dust analysis is in Appendix A .

For this study, the household dust samples were defined as the samples that represent dust most likely to impact on a child's hands during indoor activity. During the environmental visit, a sketch of the approximate layout of the residence was made and sampling sites were selected and indicated on the diagram. The areas targeted for dust sampling were the main entrance to the household and the two areas most frequently used for play activities of the child or children. Additional areas for sampling that could be selected include secondary entrances to the household, additional areas of activity frequented by the children, and sources of accumulation of dust within the household (rugs and upholstered furniture).

The Sirchee-Spittler Hand Held Dust Vacuum unit, which is a dust buster that had been modified to catch the dust sample in a fine mesh stainless steel screen, was used to obtain the samples. At each sample site, a 4 $\times$ 4 foot sample area was measured and marked with masking tape. The dust sample was taken from the marked area. The sample was transported in an upright sealed paper envelope to the DHMH Laboratory Administration for analysis.

4.1.3 Water

Household water samples were collected to characterize the potential exposure of children to lead in drinking water. First draw water samples were collected from all drinking water faucets in the household by Environmental Health Aides. Health Aides visually inspected the sink area for indications of prior water use. If water had been used that morning, another appointment was made for water sample collection. If unable to obtain a first draw water sample after two tries, a non-first draw sample was collected. This was indicated on the sample sheet and in the data file. The samples were transported to DHMH Laboratories Administration for analysis. The water collection and analysis protocols are in Appendix A.

4.1.4 Exterior Paint

Exterior paint samples were collected to determine the contribution of exterior paint to the soil lead level at the time of the first environmental visit. Sample locations of painted surfaces that were peeling, chipped or cracked were identified. A sample approximately 2.0 in. in diameter of all paint down to the substrate was obtained from each exterior surface that was chipping or peeling. This sample was taken to DHMH Laboratories Administration for analysis by XRF. The exterior paint sampling and analysis protocols are in Appendix A.

4.1.5 Interior Paint

At the end of the biological sampling, portable XRF analyzers were used to identify interior lead paint to characterize the exposure to interior leaded paint. Measurements were taken in the child's bedroom, kitchen and living room or other area identified by the parent as a primary child play area. One measurement was taken in each room on a painted wall surface and one on a painted wood surface (window, door frame). The sites of measurement were indicated on a sketch of the room. The interior paint sampling protocol is in Appendix A. Information on interior lead paint was shared with the Baltimore City Health Department LPPP.

4.1.6 Quality Assurance for Soil and Dust Sampling and Analysis

A quality assurance plan for the sampling and analysis of environmental samples was developed by the Baltimore Soil Lead Abatement Demonstration Project and the State of Maryland Department of Health and Mental Hygiene Laboratories Administration. (See Appendix A) It includes a description of the proper procedures for sampling, sample custody, equipment calibration and analysis, internal quality control checks and corrective actions.

The laboratory also participated in an external quality control plan for soil and dust analysis that was supervised by Dr. Harold Vincent of EPA/EMSL Las Vegas. Audit samples for soil and dust were developed by EMSL and inserted in the analysis stream by the Environmental Coordinator (Appendix B). The project is awaiting final biweight distributions for the soil and dust audit samples from EMSL to determine fraction of results outside of the analytical acceptance windows at the 95% prediction interval. The windows are to be derived by EMSL using a modification of the EPA's biweight program. These windows will apply to the XRF and AAS determination of lead. Lead values outside the given ranges for the audit sample will affect assignment of a flag for data obtained for the related sample group.

4.2 DEMOGRAPHIC AND BEHAVIORAL QUESTIONNAIRE

Within 1 week of enrollment, each child was scheduled for baseline blood testing and data collection. These were performed at space donated by The Liberty Medical Center for the Lead in Soil Clinic. The Biological Coordinator and staff (all Registered Nurses with public health experience) administered a questionnaire to the child's parent/guardian or primary care giver. The questionnaire was designed to (1) collect demographic information to characterize the study population and (2) assess behaviors and other factors that influenced the child's contact with various sources of lead. Drs. Katherine Farrell and Julian Chisolm initiated the development of the questionnaire. Dr. Edmund Maes of the Centers for Disease Control reviewed the questionnaire and his comments were incorporated into the final copy. Copies of the questionnaire are included in Appendix E.

Two questionnaires were utilized in the course of the study. The first questionnaire obtained data on the child's previous health status. It was felt that this information would

not change over time and the data was not gathered on subsequent visits to the clinic. The follow-up questionnaire was administered at all remaining blood collecting sessions to verify demographic data and to identify behavioral changes over time.

The interviewing staff was supervised by the Biological Coordinator. Each interviewer was observed during the first few interviews and at regular intervals throughout each screening session. Immediate feedback was given. The Biological Coordinator was available for guidance and interpretation of questions/responses throughout each screening session. The original Biological Coordinator remained with the study for its duration.

4.3 BIOLOGICAL SAMPLING AND MEASURES

Blood samples for blood lead level (whole blood), free erythrocyte protoporphyrin (FEP), ferritin and total iron binding capacity (TIBC) and hand wipes for lead were collected 6 times throughout the study. The FEP, ferritin, and TIBC were collected as nutritional status indicators. All biological sampling took place at the clinic site donated by Liberty Medical Center. The sampling schedule for blood and handwipes was the same for the study and control groups and was as follows:

ROUND	DATES OF SAMPLING SESSIONS/INTERVENTIONS
Pre-abatement	
1	August 22, 1988 to December 2, 1988
2	February 2, 1989 to August 15, 1989
3	January 22, 1990 to August 13, 1990
Interventions	
Paint stabilization in study and control areas	April 27, 1990 to November 10, 1990
Soil abatement in study area	September 4, 1990 to December 10, 1990
Post-abatement	
4	January 3, 1991 to March 26, 1991
5	May 22, 1991 to July 19, 1991
6	August 19, 1991 to September 30, 1991

4.3.1 Blood

During the blood sampling, approximately 5 ml of blood was drawn from the antecubital vein by a trained pediatric phlebotomist. Two ml of blood were utilized for blood lead level and FEP analysis. The remaining blood was centrifuged in the clinic and the plasma extracted for ferritin and TIBC analysis. All blood samples were cooled at collection and were transported to the State of Maryland Department of Health and Mental Hygiene Laboratories Administration (DHMH) Laboratories Administration within 24 h of collection.

All laboratory results were reviewed within one day of receipt from the laboratory and health care providers were notified of the results. If the blood lead level was 25 μg/dl or higher, the child was referred to the Baltimore City Health Department Lead Poisoning Prevention Program and followed according to Maryland state law. During the course of the study, no environmental or medical interventions were reported by the parent/guardian.

All blood analysis was performed by the DHMH Laboratories Administration personnel. The laboratory meets stringent performance criteria including experience in performing biologic analysis for health studies, participation in proficiency testing programs, continuous OSHA certification and a detection limit of 1 μg/dl for blood lead.

DHMH Laboratories determine blood lead levels using graphite furnace atomic absorption (Pruszkowski, Cornick, and Slavin, 1983) and FEP using double extraction method (Chisolm and Brown, 1975). Ferritin was determined by Abbott's Ferricyme Enzyme Immunoassay (Forman and Parker, 1980) and TIBC by Radioactive Energy Attenuation (REA) using Abbott TDX analyzer (Shaffar and Stroupe, 1983).

4.3.2 Hand Lead Determinations

Hand wipe samples were obtained each time blood samples were collected. Health Aides were trained and supervised by the Biological Coordinator in the proper hand wipe collection protocol (see Appendix A). To assess the extent of any contamination during sampling, six wipes from each container opened were handled to simulate wiping the child's hands. These were analyzed to determine background wet wipe lead levels.

Each set of hand wipes was transported to DHMH Laboratories Administration for analysis. The Cincinnati perchloric acid analysis of hand wipes protocol was utilized for

rounds 1 and 2 of screening. However, damage to the laboratory exhaust system by the acid, precluded further analysis using this methodology, therefore, starting with round 3 and continuing for subsequent rounds, 1M hot HNO_3 was used in analysis (see Appendix A). The total quantity of lead was reported in μg per pair of hands.

In order to address concerns that some parents might wash children's hands before bringing them to the clinic, elbow wipes were collected for comparison in round 1. This decision was based on the premise that mothers might wash the child's hands but not wash the whole arm up to the elbow. The resulting analysis found no indication that children's hands had been recently washed. Elbow wipes were not used in subsequent rounds.

4.3.3 Quality Assurance and Control for Blood Lead Measurements

The State of Maryland DHMH Laboratories Administration maintained strict internal quality control for their blood lead analysis. Calibration curves are composed of a minimum of a blank and three standards. A calibration curve is made every hour of continuous sample analysis. A minimum of one blank per sample batch was analyzed to determine if contamination or any memory effects were occurring. Check standards were analyzed after every 15 samples. One duplicate sample was run for every 10 samples. A duplicate sample is a sample brought through the whole sample preparation process. Spiked samples or standard reference materials were periodically employed to ensure the correct procedures were followed and that all equipment was operating correctly.

The laboratory also participated in the external quality control system for blood analysis developed and overseen by Dr. Daniel Paschal of the Centers for Disease Control. The project followed the guidelines of the CDC quality assurance standards (Appendix B). Analysis of Baltimore's bench and blind data by Dr. Paschal indicated that there were no statistically significant trends with time and that the laboratory detection limits were appropriate and precise (see Appendix B).

The protocol also includes the results of the initial characterization of the four whole blood pools used in this project. Each laboratory was individually compared as to within-run precision, among runs precision and total precision. The laboratory detection limits, using the definition of the limit of detection as 3 SD (wr) developed by Winefordner, were also compared. The conclusions stated by CDC were that: (1) comparable values were obtained

in all laboratories, (2) laboratory data for blood lead were produced from analytical systems in statistical control (as defined by Shewhart); and (3) no statistically significant time trends were observed in the data (i.e., the difference in pre- and post-abatement blood lead values are real and not the product of unstable analytical systems) (Centers for Disease Control, 1991).

4.4 DETAILED DESCRIPTION OF THE INTERVENTIONS

4.4.1 Exterior Paint Stabilization

Houses with exterior leaded paint in both the study and control area received exterior paint stabilization during the summer and fall of 1990. Paint stabilization consisted of wet scraping the chipping, peeling lead paint followed by HEPA (High Efficiency Particle Accumulator)-vacuuming the area to capture the leaded paint chips and dust. Paint scrapings and debris were sealed in plastic bags at least 6 mils thick and disposed of in a municipal landfill according to the regulations in COMAR 26.02.07.07. A primer and 2 coats of latex paint were applied to all painted surfaces within 48 hours of the scraping and vacuuming. The purpose of the paint stabilization was to safely remove or encapsulate any chipping, peeling paint to prevent re-contamination of the abated soil.

Precautions were taken to avoid contamination of surrounding areas by covering the immediate ground and neighboring porches and yards with protective plastic; taping all windows and doors of the house, and strict worker safety guidelines. Occupants of neighboring properties were contacted, given an explanation of the activities and requested to stay out of the work area and to keep their doors and windows closed. These activities were monitored by project staff to ensure the safety of the participating family, neighborhood residents, and workers.

Residents were encouraged not to be on site during this process. To provide the families with somewhere to go during the paint stabilization process, space was obtained at a local community center for the duration of the interventions. Families were transported to and from the center in project vans, were provided age appropriate activities throughout the day and were fed a snack or lunch, depending upon the time frame, while there.

4.4.2 Soil Abatement

Soil was abated in the study group during the summer/fall of 1990, within 1 week after the paint stabilization of the house. Detailed diagrams were made of each property (see Figure 4-2) with fixed boundaries such as fences, hedges, sidewalks and house foundation indicated. These boundaries defined areas which were identified as area A, B, C, etc. Each area was treated as a unit in the soil abatement process. If the area/unit had soil sample results of greater than 500 ppm lead, the entire area was abated. Separate areas of the property which had sample results less than 500 ppm were not abated. Thus, if area A as defined by the house, 2 sidewalks, and side fence was the front yard and had one or more soil lead levels greater than 500 ppm, the entire area was abated.

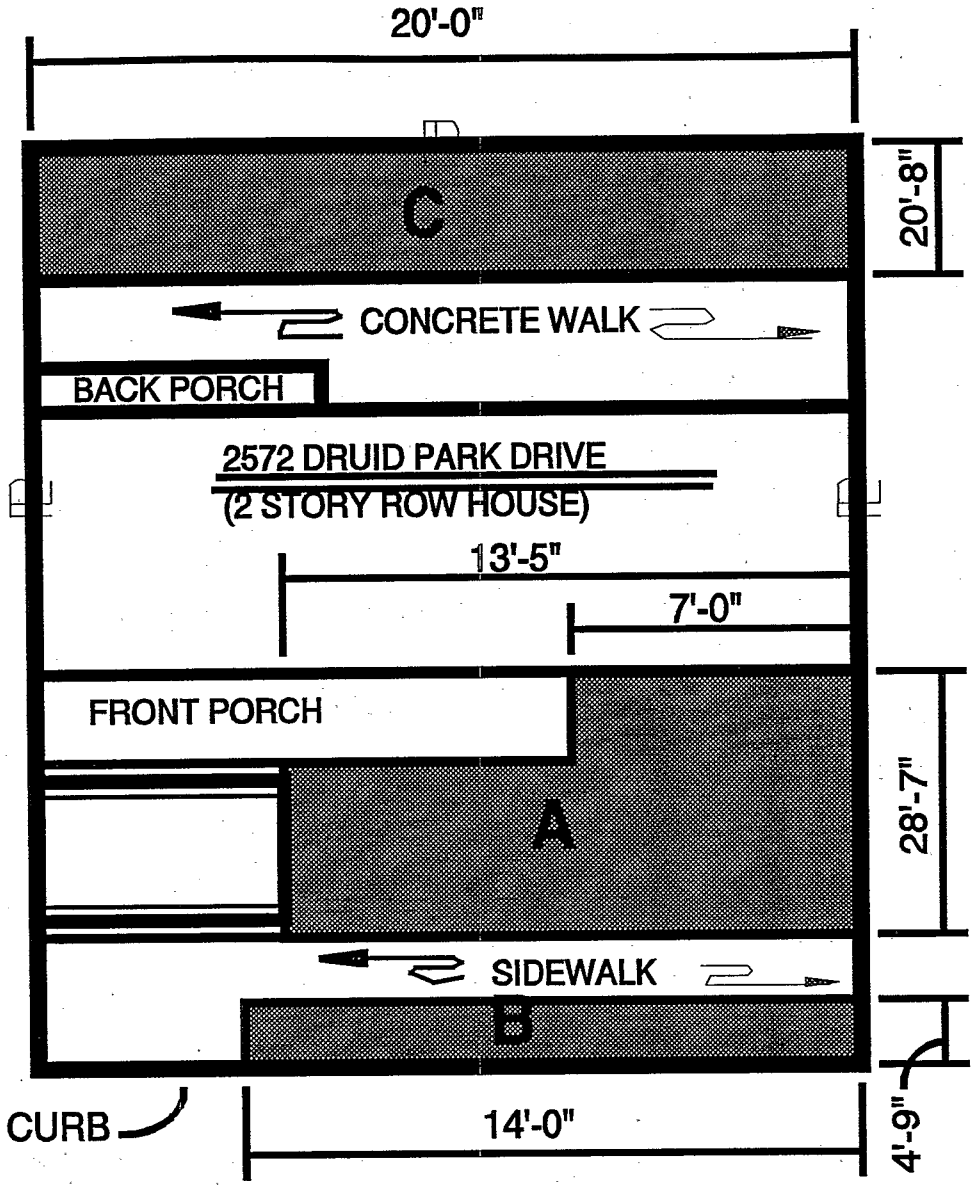
The purpose of the soil abatement was to remove lead contaminated soil on the study properties and to provide a barrier between lead contaminated soil and the child. Abatement was performed by removal of the top 6 in. of ground coverings and soil. This soil was replaced with previously tested soil containing less than 50 ppm lead. The replacement soil was analyzed for the contractor for lead and other metals by an independent laboratory (Business Industrial Safety Supplies [BISS] in Baltimore, Maryland) using wet digestion AAS.

The area was then sodded or seeded depending upon characteristics of the site. Families were given printed material on how to care for their newly abated lawns. Areas of bare soil with lead levels less than 500 ppm were prepped and seeded to provide ground cover. If the property did not have exterior water access, the sites were watered weekly by a private contractor during the summer dry spells.

Residents were discouraged from being on site during the soil abatement process. The temporary relocation to a community center described above was utilized.

4.4.3 Abatement Costs

The costs of paint stabilization and soil abatement activities are included primarily as an indication of feasibility for other investigators and for public health interventions. It should be stressed, however, that costs are likely to vary greatly between areas and from project to project based on local factors, constraints on purchasing and procurement, and the size of the proposed abatement.



DESCRIPTION

ABATEMENT METHOD : REMOVE AND DISPOSE OF TOP 6 INCHES OF SOIL, REFILL WITH "CLEAN" MATERIAL AS SPECIFIED.

AREA : "A" = 336 SF
"B" = 67 SF
"C" = 414 SF

COVER : COVER AREAS "A" THRU "C" WITH SOD

STATE OF MARYLAND

DEPARTMENT OF THE ENVIRONMENT
LEAD PAINT STABILIZATION PROJECT

IN BALTIMORE CITY

Figure 4-2. Typical property diagram.

Costs can be broken down into those for exterior paint stabilization and those for soil abatement. Further breakdown indicates costs related to sampling, analysis, stabilization/abatement and replacement of soil with landscaping. These costs reflect the unique conditions under which the abatements were conducted for the study.

The study incurred a variety of costs that may or may not be applicable to other projects. These included costs related to mowing grass and removing debris before work could start ($10,010.00), watering newly sodded or seeded yards during 1990 summer drought ($6,000.00), alternate housing during the paint stabilization and soil abatement phase ($2,388.33) and food for participants and families while in alternate housing ($205.00). Many of these expenses would not be applicable to the activities taken as part of the environmental management of a child with elevated blood lead levels.

Four contracts were ultimately developed for the purpose of the exterior paint stabilization in both areas and soil abatement in the study area. Because of the lack of experience within the project with contract development related to these activities, contracts 1, 2, and 3 were developed by the Beavin Company Architectural/Engineering (A/E) firm for $39,715.38. The firm reviewed contract 4 for the project for $411.33. The total cost for the development of the four contracts was $40,126.71. Based upon experience in this area, this cost may not be applicable in future soil abatements in this or other communities.

For the exterior paint stabilization of 125 houses in the study and control houses the average cost per house was $3166.41 with a range of $366.00 to $5178.00. The total cost for exterior paint stabilization was $248,087.29. Table 4-1 presents a detailed cost breakdown for paint stabilization. (See Appendix H for bid schedule of units covered in contract.) Force account work for repair, removal or replacement of painted surfaces such as porches or steps cost an additional $6,858.43.

The average cost per house of soil abatement in the study areas was $2163.39 with a range of $600.00 to $4891.33. For the 63 houses in the study area, the total cost of soil abatement was $136,293.62. Table 4-2 presents a detailed cost breakdown for soil abatement. Additional costs of $2516.74 covered force account work such as removal and replacement of fences.

TABLE 4-1. BALTIMORE PAINT STABILIZATION

1.	Paint Sampling and Analysis	
	Labor, Sampling 125 properties	$ 2,820.00
	Sample Collection Knives	160.03
	Sample Collection Envelopes	72.98
	Miscellaneous Supplies	200.00
	Analysis of approximately 858 exterior samples	8580.00
	Total Paint Sampling and Analysis	11,833.01
2.	Contract Development and Supervision	
	Engineering Design and Supervision	$20,063.36
	Salaries	
	Administrative Contract Specialist (6 mo)	12,000.00
	4 Enviornmental Health Aides (6 mo)	29,800.00
	Total Contract Development and Supervision	61,863.36
3.	Stabilization Contracts	
	Mobilization	65,018.00
	125 Properties @ $1,984.70 Each	248,087.29
	Total Stabilization Contracts	313,105.29
4.	Miscellaneous Extra Costs	
	Pre-Stabilization Yard Cleaning	
	Total Miscellaneous Extra Costs	9,000.00
	BALTIMORE PAINT STABILIZATION GRAND TOTAL	$395,801.66
	Total Stabilization Contract Work 125 Properties	$248,087.29
	Average Cost Per Property	$3,166.41
	Average Cost for Windows Per Property	$511.00
	Average Cost for Doors Per Property	$ 89.00
	Average Cost for Other Exterior Work	$1,055.86

TABLE 4-2. BALTIMORE SOIL ABATEMENT

1.	Soil Sampling and Analysis		
	Labor, Sampling 70 properties		$ 1,656.00
	4 Core Sampling Tubes @ $507.08 each		2,028.30
	4 Core Sampling Tubes @ $57.87 each		231.48
	1200 Polyethylene Bags @ $646.80 per 1000		776.16
	Miscellaneous Supplies		211.71
	Analysis of 4330 samples		43,300.00
	EPTOX Analysis 70 properties		9,520.00
	Total Soil Sampling and Analysis		57,723.65
2.	Contract Development and Supervision		
	Engineering Design and Specification		20,063.36
	Salaries		
	Environmental Coordinator (6 mo)		16,000.00
	2 Environmental Health Aids (6 mo)		16,000.00
	Total Contract Development and Supervision		52,126.71
3.	Abatement Contract		
	Delineation 70 @ $600.00 each		42,000.00
	63 Properties @ $1,478.43 each		93,141.09
	70 Properties (<500 ppm) Landscape Work		14,394.29
	Total Abatement Contract		149,535.38
4.	Miscellaneous Extra Costs		
	Pre-Abatement Yard Cleaning		1,010.00
	Vehicle Storage During Abatement		490.00
	Hoses and Sprinklers		50.00
	Post-Abatement Yard Maintenance		6,000.00
	Total Miscellaneous Extra Costs		7,550.00
	BALTIMORE SOIL ABATEMENT GRAND TOTAL		$245,222.41
	Total Abatement Contract Cost for 63 Properties		$136,293.62
	Average Abatement Contract Cost for 63 Properties		$2,163.39
	Average Total Cost Per Property (63)		$ 3,892.42
	Total Cubic Yards Soil Abated	902.04 CY	
	Cost Per Cubic Yard of Soil Abated		$ 341.93
	Total Cubic Yard Soil Replaced	964.78 CY	

5. ANALYSIS

5.1 DATA COLLECTION AND MANAGEMENT

Within the project, data were generated and maintained in distinct groups: environmental (pre-abatement soil, dust, exterior paint, and water analysis and post-abatement soil and interior paint analysis), biological (blood and hand lead analysis), and questionnaire data. Two of the three data groups, biological and questionnaire, were repeated every time blood was drawn. Each blood sampling is referred to as a round. There were six rounds in the study. Within the environmental data set, soil and dust samples were obtained before and after abatement. Interior and exterior paint, and water samples were obtained once through-out the study prior to abatement.

Data from the laboratories and the questionnaire were coded onto data entry forms. The original report sheets and questionnaires were stored in separate files.

Quality control and assurance measures included checking all completed questionnaires and forms manually for accuracy and completeness. Standard data entry validation tools (double entry, range checks, etc.) were used for all data sets created through data entry. Any problems were resolved on an ongoing basis. Data was backed up daily and archived weekly in an off-site location.

The study data base consists of data files that were created by data entry using the dBase III database management system. All dBase III files were converted into Statistical Analysis System (SAS) data sets for data management and analysis.

Information can be combined from various files by the use of the key fields of PROPID and ID. PROPID is the unique seven digit identifier for a property in the study and ID is the unique three digit identifier for each child. All the Environmental databases contain the PROPID and all Biological databases contain the ID fields. The Questionnaire database contains both the PROPID and the ID fields and is, therefore, the link between the Biological and Environmental data files. All files can be merged through the Questionnaire files.

A more detailed description of the data management plan is included in Appendix C.

5.2 RESULTS

5.2.1 Effect of Soil Abatement

Soil abatement in Baltimore, while effective in reducing surface lead levels to 0 to 50 ppm, did not achieve the desired decrease in soil lead levels of 1,000 ppm. This is because of the lower soil lead levels encountered prior to abatement. The average decrease in soil lead levels was 550 ppm (using tri mean measure). Based on the literature, the expected decrease in blood lead levels related to this magnitude of soil lead decrease might have been in the 1 to 3 μg/dl range. However, even prior to abatement, a relationship between soil lead levels and blood lead levels for the children in the study was not found. This may be because the soil contamination in Baltimore was clearly related to proximity to lead painted surfaces of houses and was not uniform as it would be in cities where the source of lead was air deposition from a stationary point source, such as, a smelter.

The soil lead concentrations decreased with distance from the house. These areas might have been preferred as play areas for some children. Although the study included data on time spent outdoors and/or at other properties, insufficient information was available to distinguish between time spent playing within 2 ft. of the house or farther away.

The abatements were carried out on the immediate property included in the project. Most abatements were of single properties in an area with few abatements carried out on several contiguous properties. Very few (1 or 2) children used public playgrounds for play. These tended to be older children and the play areas were surfaced with concrete rather than soil.

The properties in the project generally had enclosed yards. This allowed for little crossover to "next-door" yards for play. The front yards were more likely to be open, but children usually played in enclosed areas. Even the open yards tended to have clearly demarcated property markers (i.e., hedges and small fences between properties).

5.2.2 Relationship to Blood Lead Level

Statistical analysis of the data from the Baltimore Lead in Soil Project provides no evidence that the soil abatement has a direct impact on the blood lead level of the children in the study. The analysis to date has consisted of an unadjusted analysis and analysis adjusting for selected covariates. Both analyses indicate no significant difference between the abated

area and the control area insofar as blood lead levels are concerned. The principal reason for this finding appears to be the low levels of soil lead found in the area under study.

6. DATA ANALYSIS

6.1 VARIABLE SELECTION

The purpose of the statistical analysis was to investigate the relationship between a child's blood lead concentration, and the measurable sources of lead that the child was exposed to during each round of sampling. These models were then used to determine whether or not the experimental treatment of removing contaminated soil had any impact on the blood lead concentration of the children involved in the study. The models that were selected for presentation in this paper excluded many of the variables that were measured throughout the experiment. A list of all the variables measured during the experiment can be found in the Data Management Plan in Appendix C. Following is a rationale and brief description for the variables that were used in the analysis.

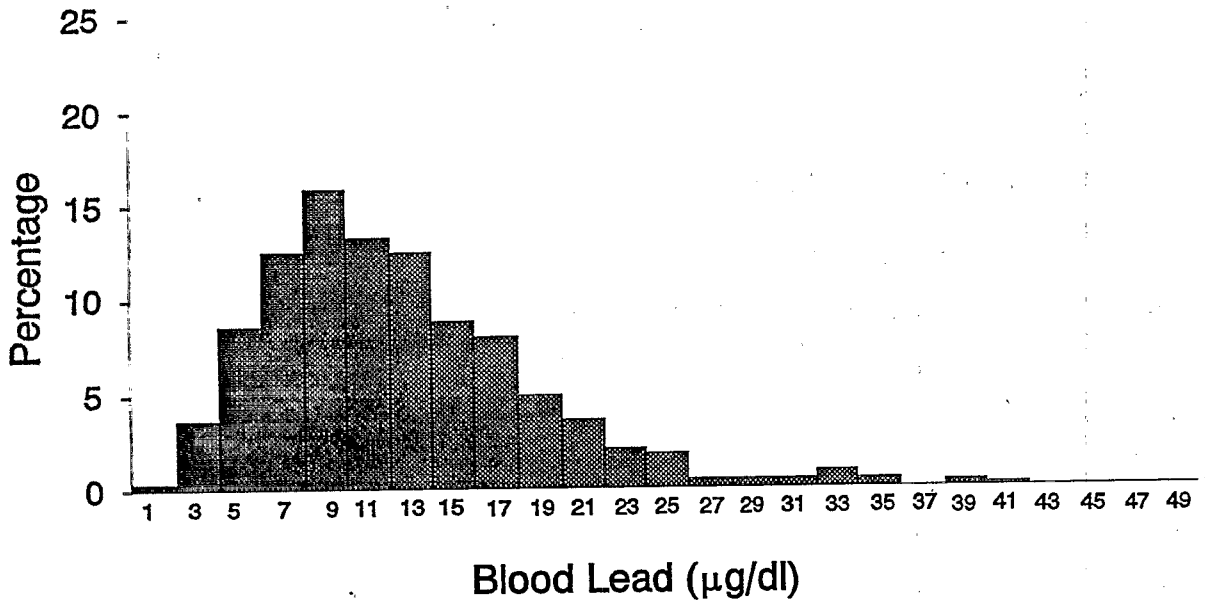
6.2 BIOLOGIC VARIABLES AND VARIABLES FROM THE QUESTIONNAIRE

6.2.1 Blood Lead

Blood lead concentration, as measured in micrograms of lead per deciliter, was designated as the response variable in the multiple linear regression models. The distribution of blood lead concentration was skewed to high values in each of the sampling rounds throughout the experiment. This made it necessary to pursue an appropriate transformation of the blood lead data to make its distribution appear more normal. The natural log transformation was selected, thus inferences from the regression models can be interpreted in terms of the geometric mean of the blood lead. The distribution of the original and log transformed blood lead concentration for each round is presented in Figures 6-1 to 6-6.

6.2.2 Hand Lead

Similar to the distribution of blood lead, hand lead measured in micrograms of lead per hand wipe sample had a distribution that was skewed to high values in each sampling round.



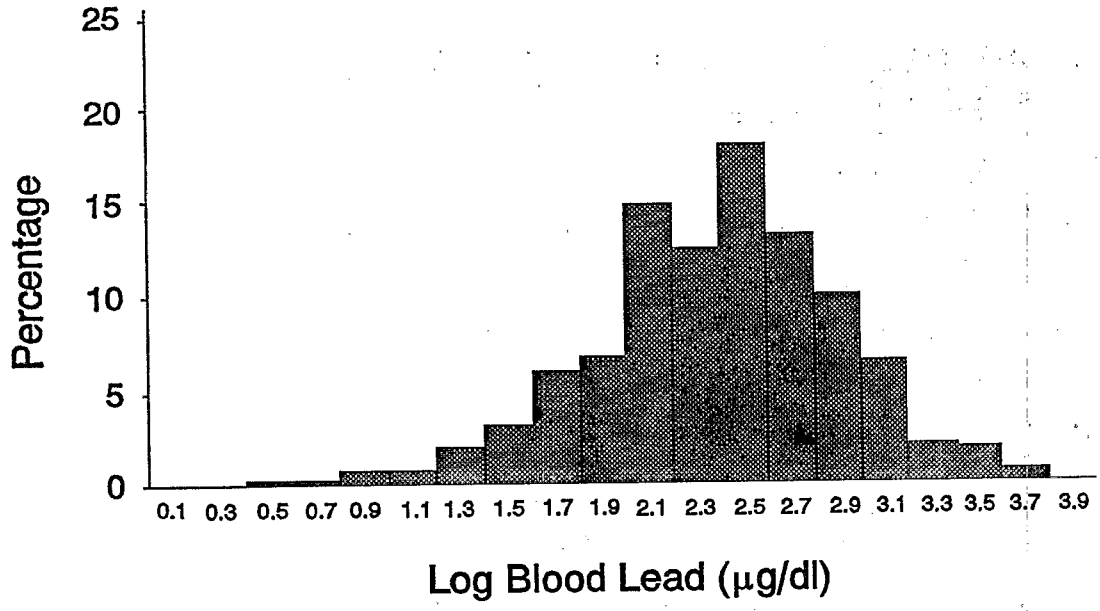
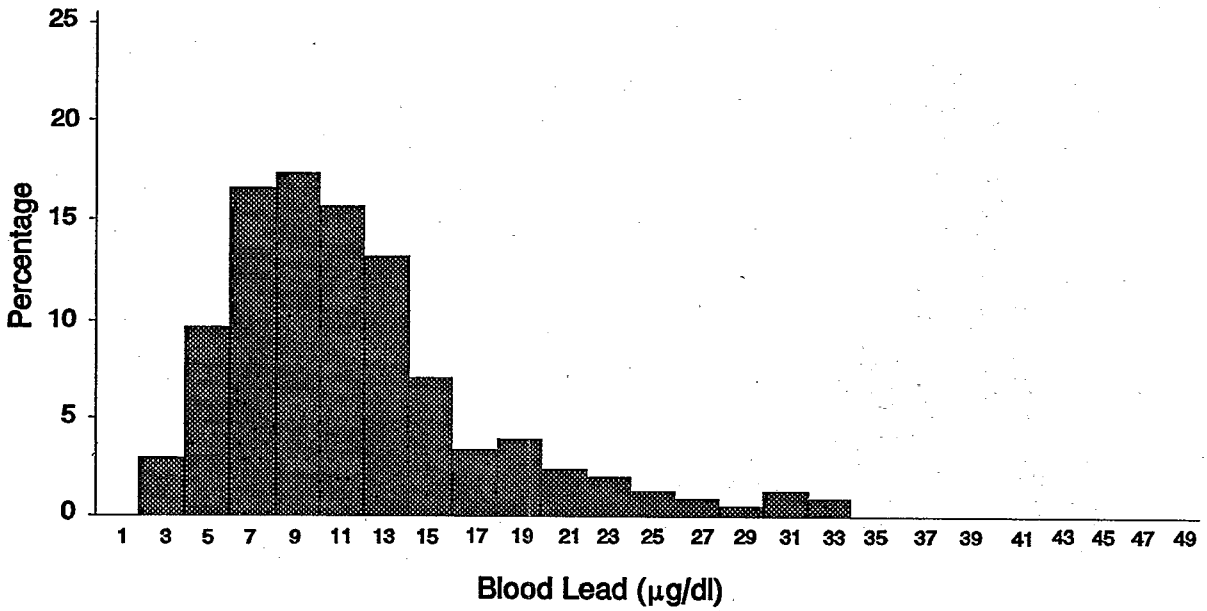


Figure 6-1. Normal and log-transformed distributions for blood lead, Round 1.



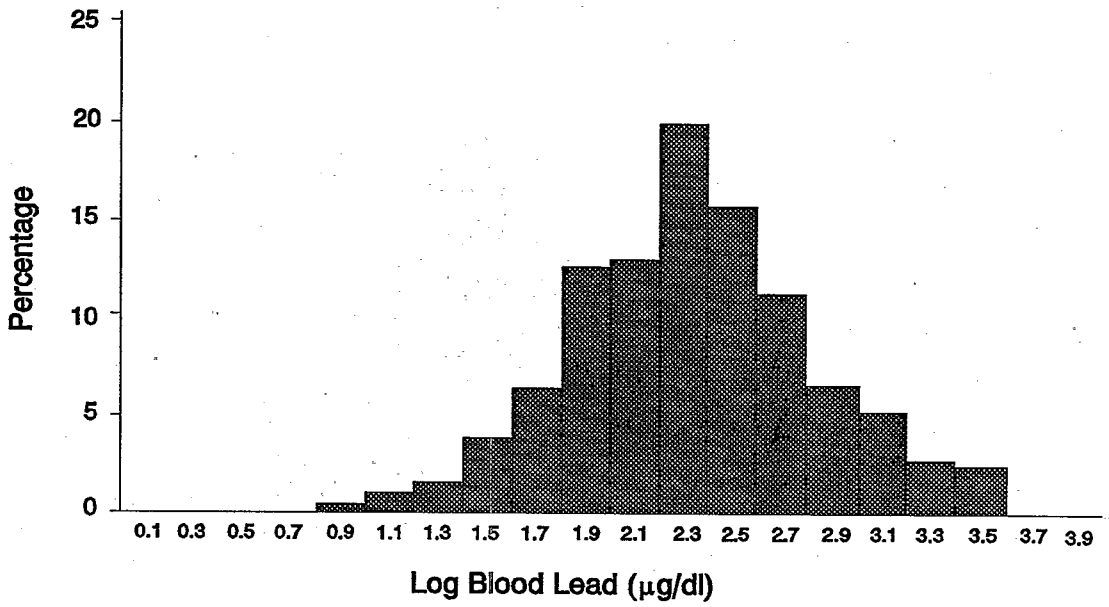
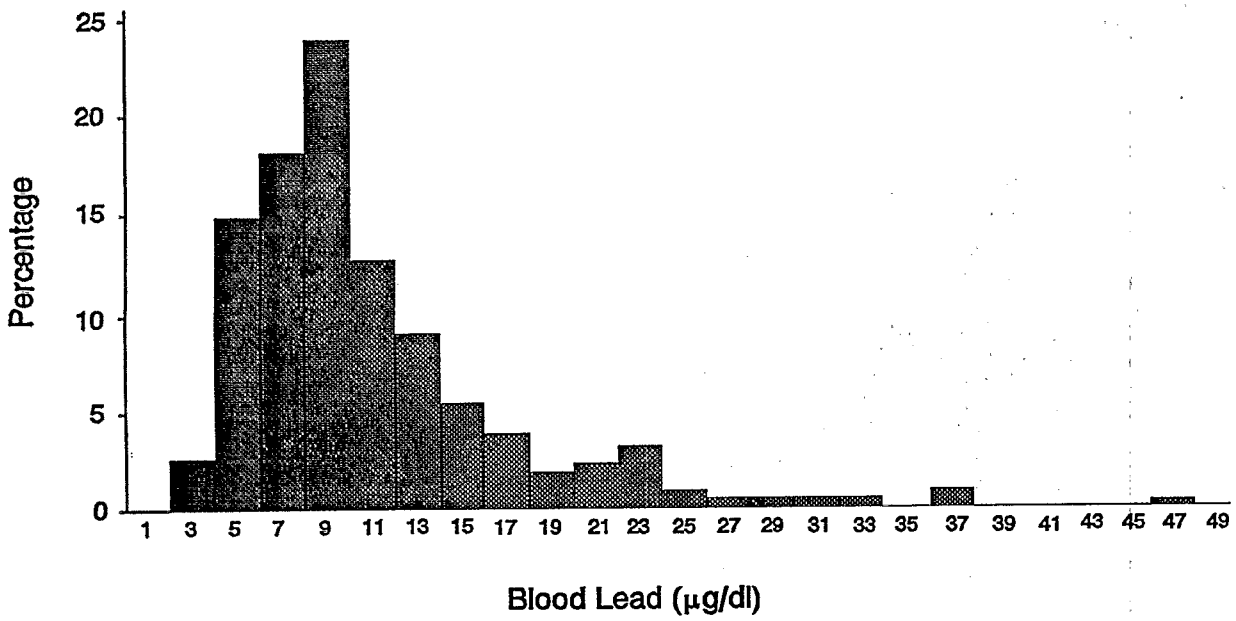


Figure 6-2. Normal and log-transformed distributions for blood lead, Round 2.



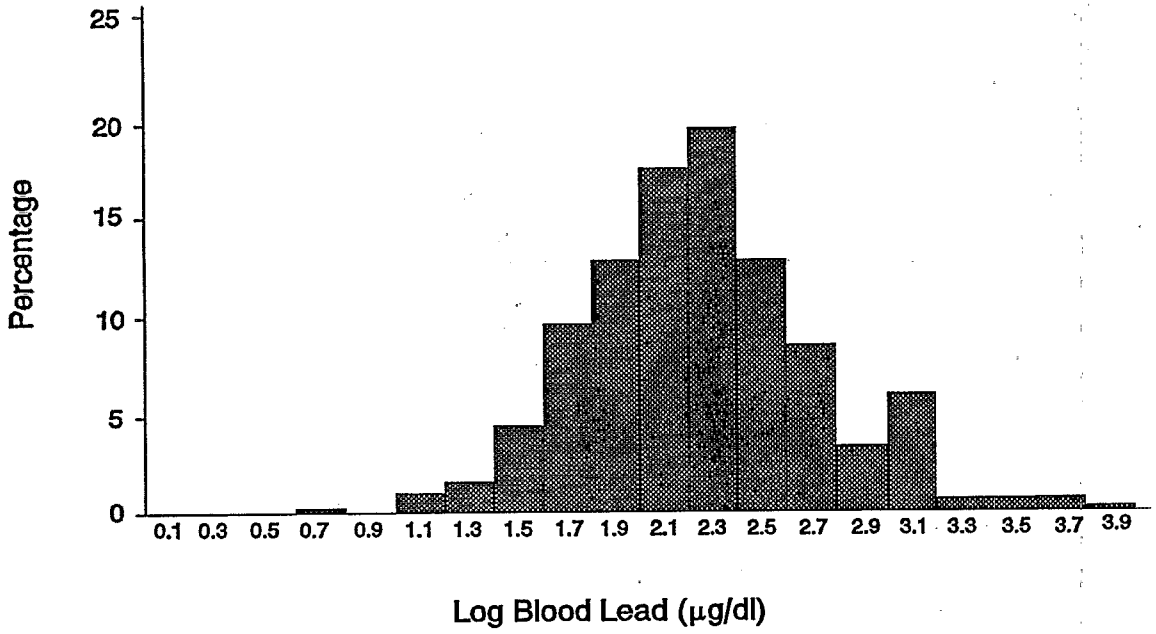
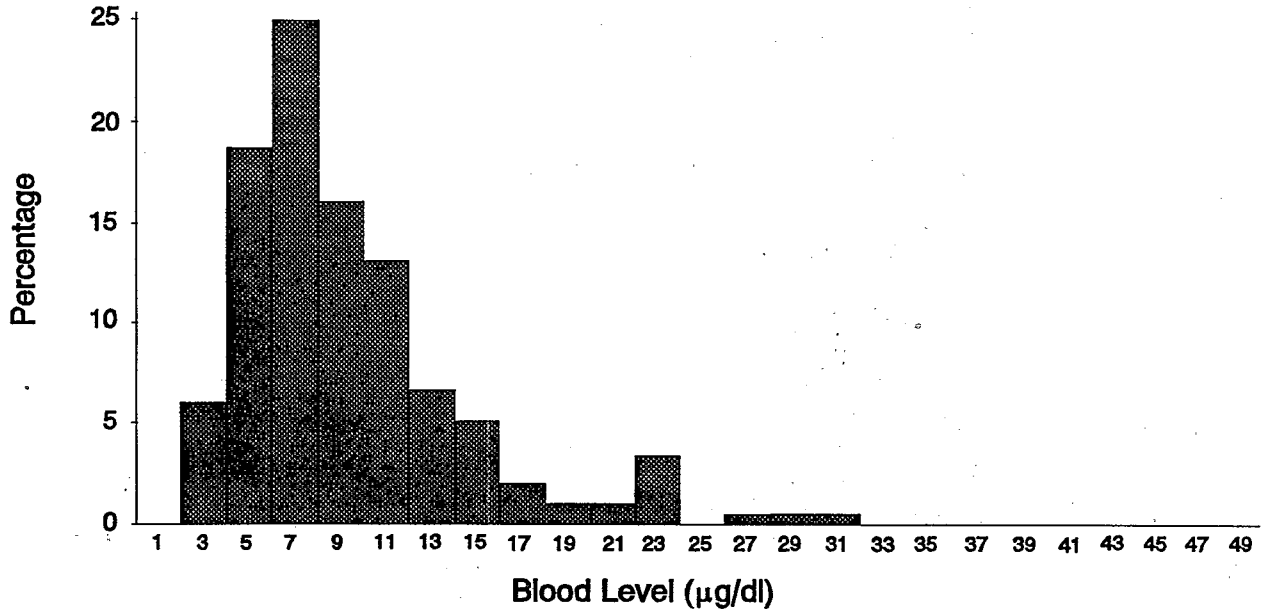


Figure 6-3. Normal and log-transformed distributions for blood lead, Round 3.



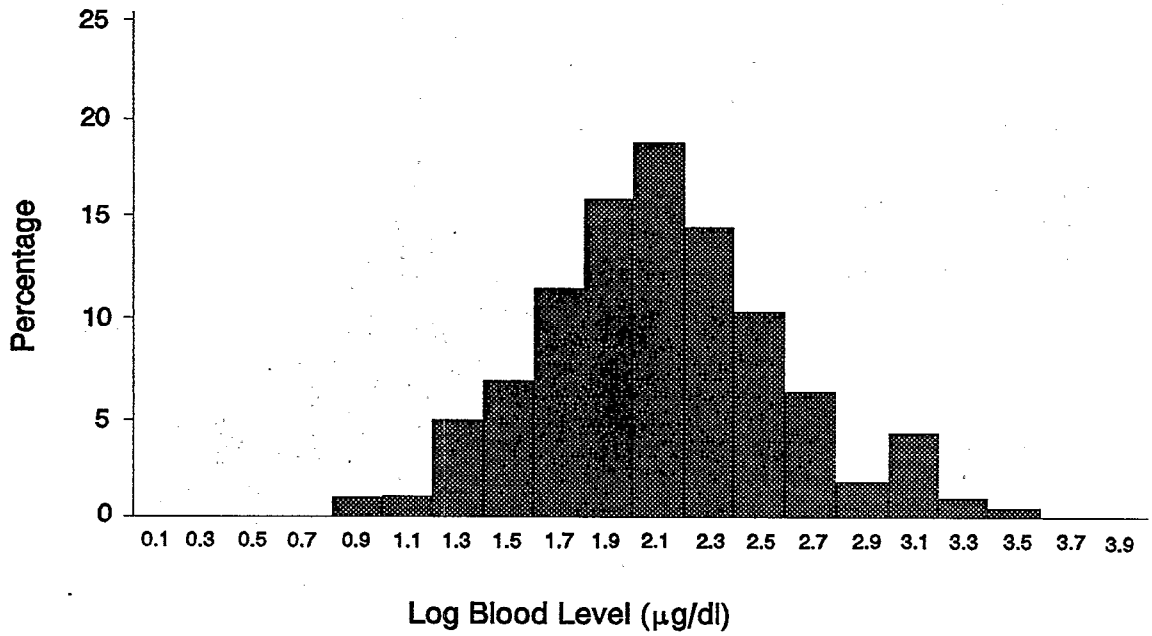
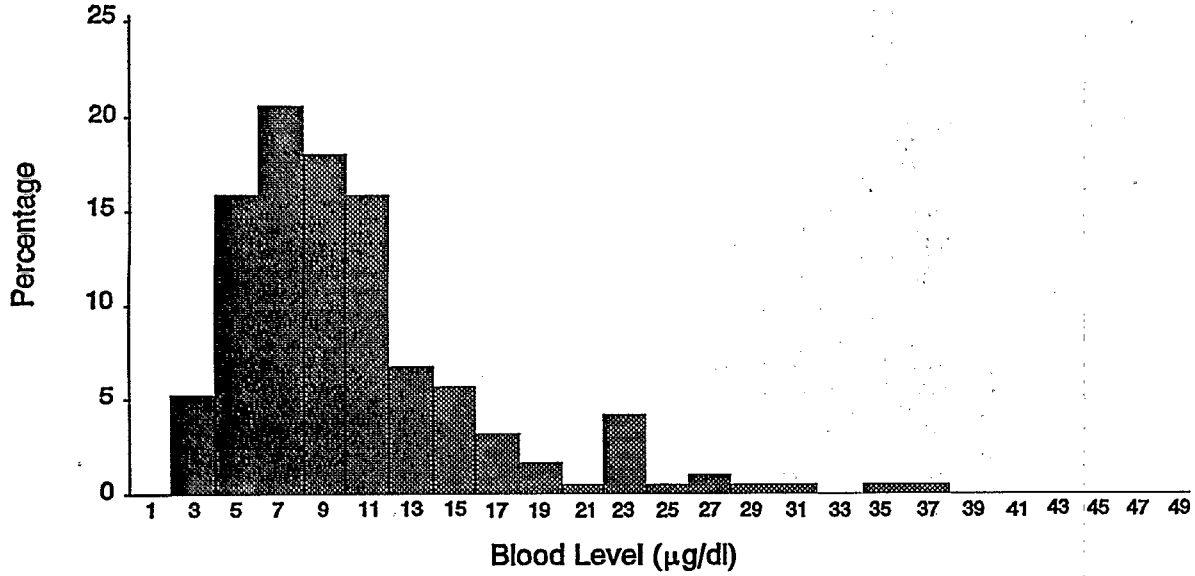


Figure 6-4. Normal and log-transformed distributions for blood lead, Round 4.



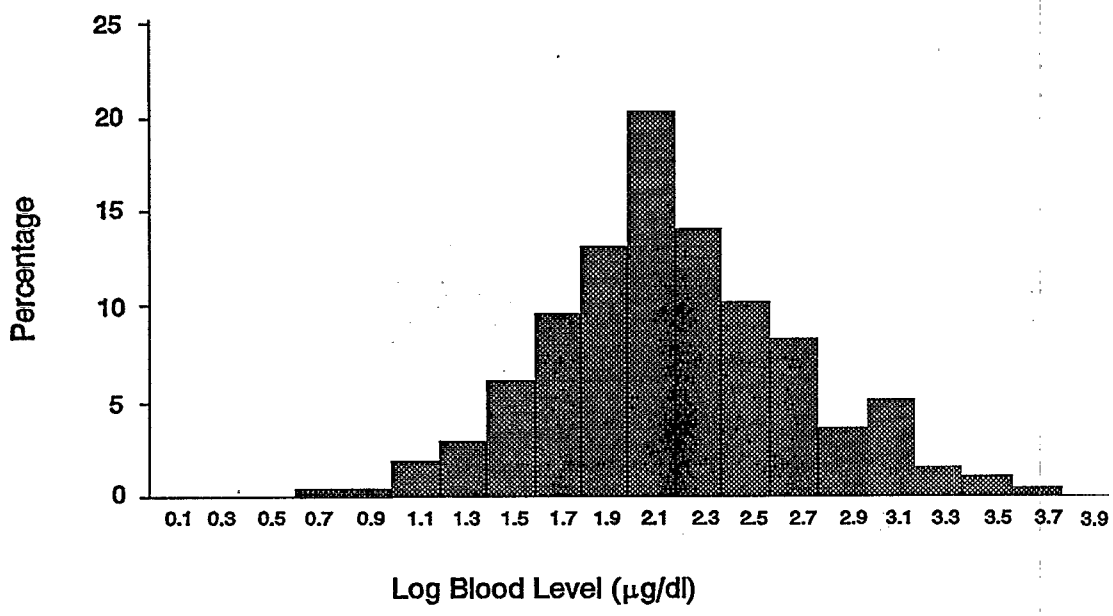
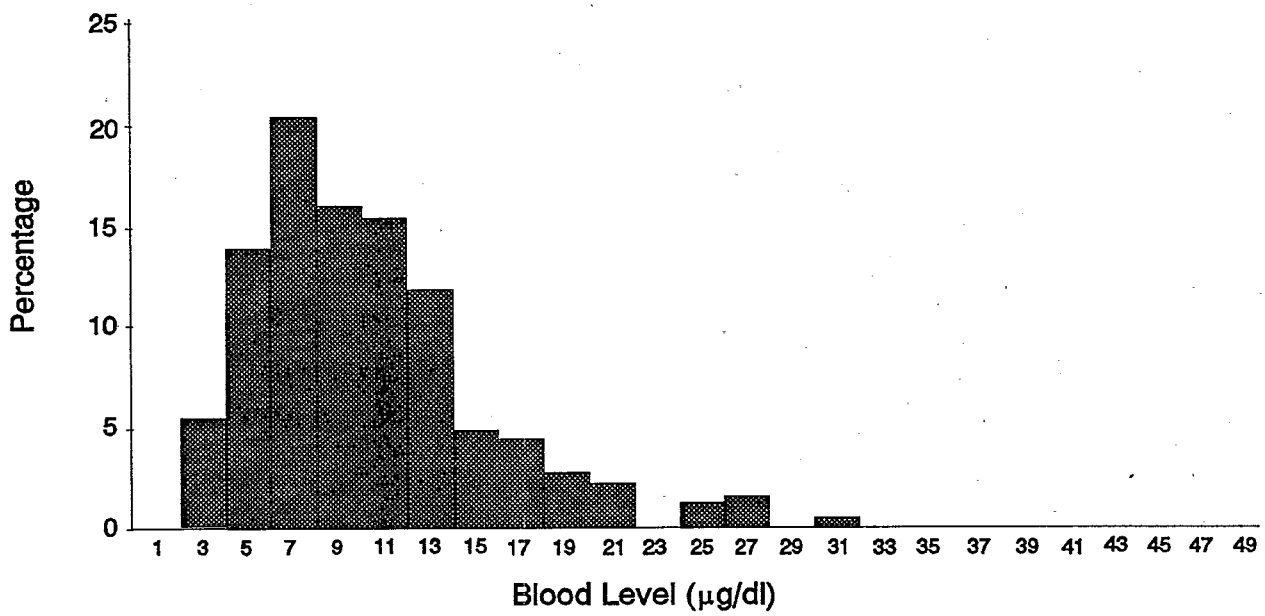


Figure 6-5. Normal and log-transformed distributions for blood lead, Round 5.



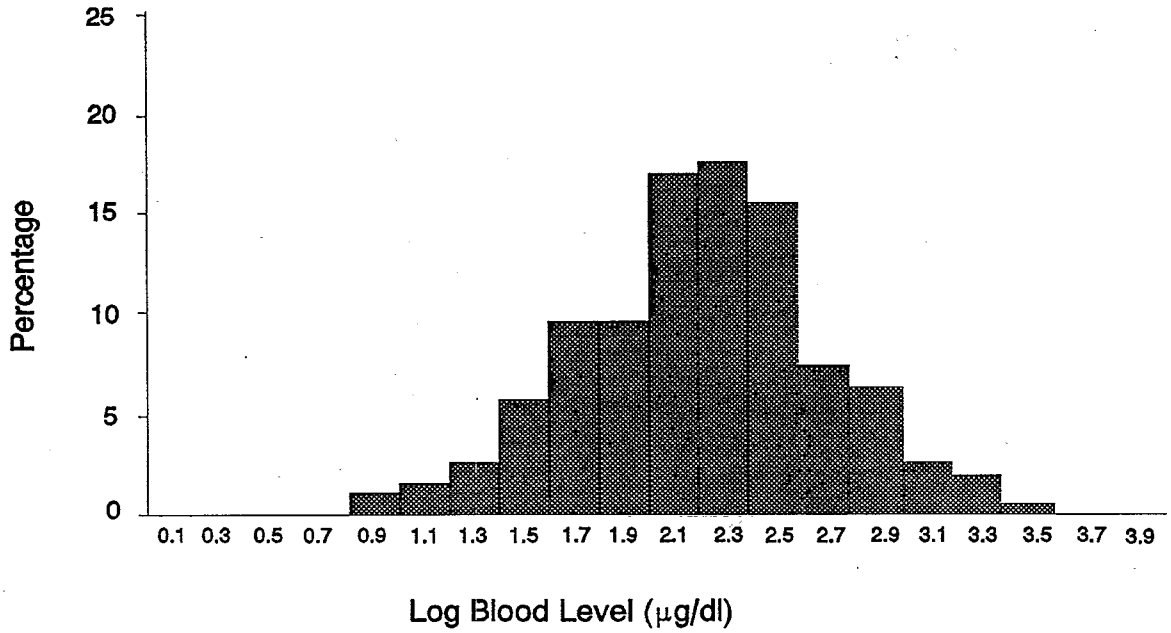


Figure 6-6. Normal and log-transformed distributions for blood lead, Round 6.

The natural log transformation was once again selected for this variable. The distribution of the original and log transformed hand lead is presented in Figures 6-7 to 6-12.

6.2.3 Age

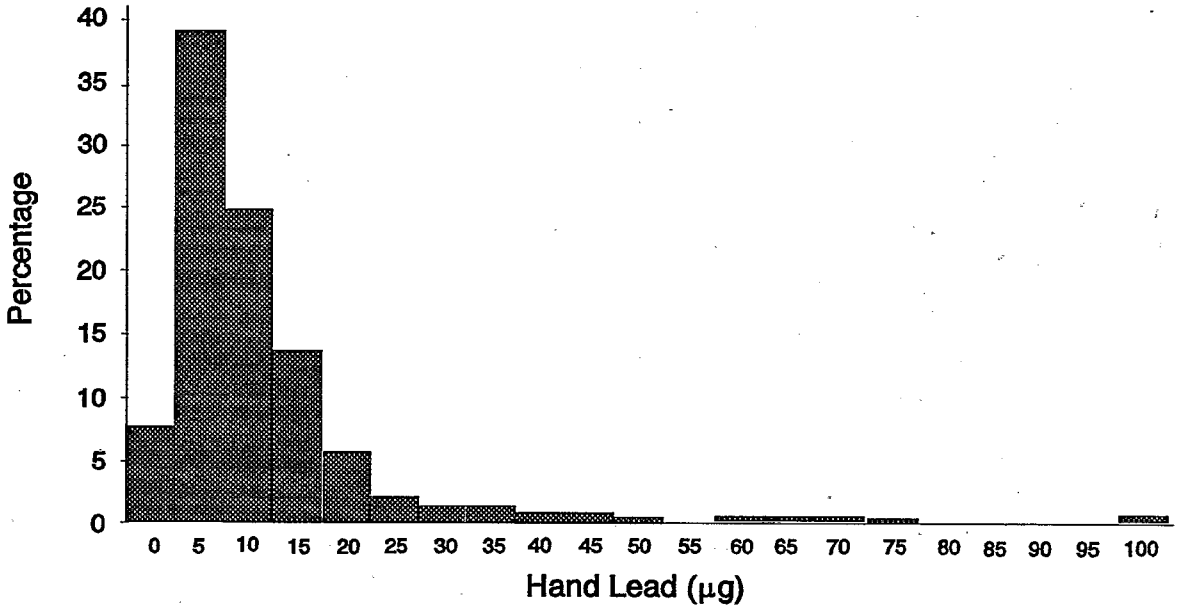
The age of each child was measured in years to the nearest decile for use as a covariate in the multiple regression models. The distribution of age seemed approximately uniform throughout the experiment. Age is known to have an effect on both blood lead and hand lead, although this effect may not be functionally linear. Age was therefore broken into four groups [(0-1), (1-2), (2-3), and (3+)] for use as covariates in the regression models. Dichotomous indicator variables were fit in the regression models for the first three age groups, and a linear term for age was included in the models for those children who were older than three years.

6.2.4 Socioeconomic Status

SES as measured by the Hollingshead Four Factor Index (Appendix F) was computed for the family of each child in each round of sampling based on questions from the parental interview. The measure of SES was then averaged for use as a covariate. The distribution of SES is presented in Figure 6-13.

6.2.5 Season

Season is a dichotomous variable indicating whether or not the blood sample was drawn between the months of November and March. This variable was included in the regression models because children in Baltimore do not typically spend much time outside during the winter months, thus the lead exposure sources may change with season. It has also been documented that the blood lead concentration of children is usually higher in the summer months. Another approach to adjusting for seasonal variation within regression models is to include a fourier transformation of the sample date. This approach would be useful in a longitudinal analysis of the data set, but there is not enough seasonal variation within each round of sampling to justify this approach in the cross sectional models.



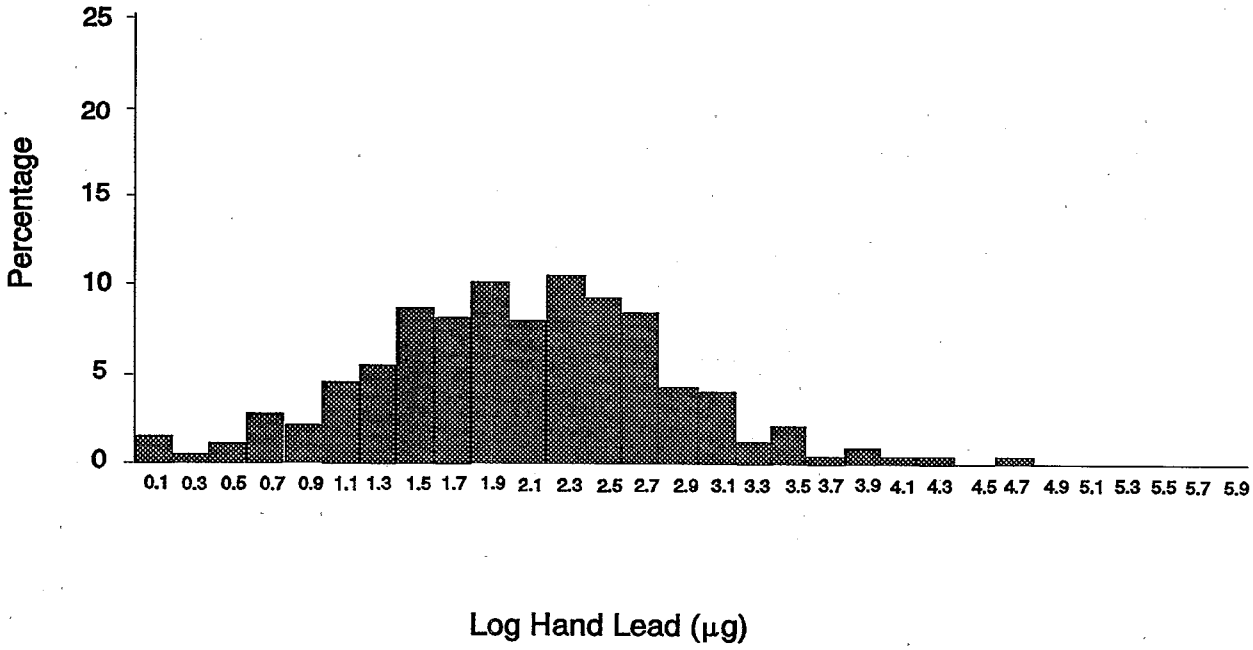


Figure 6-7. Normal and log-transformed distributions for hand lead, Round 1.

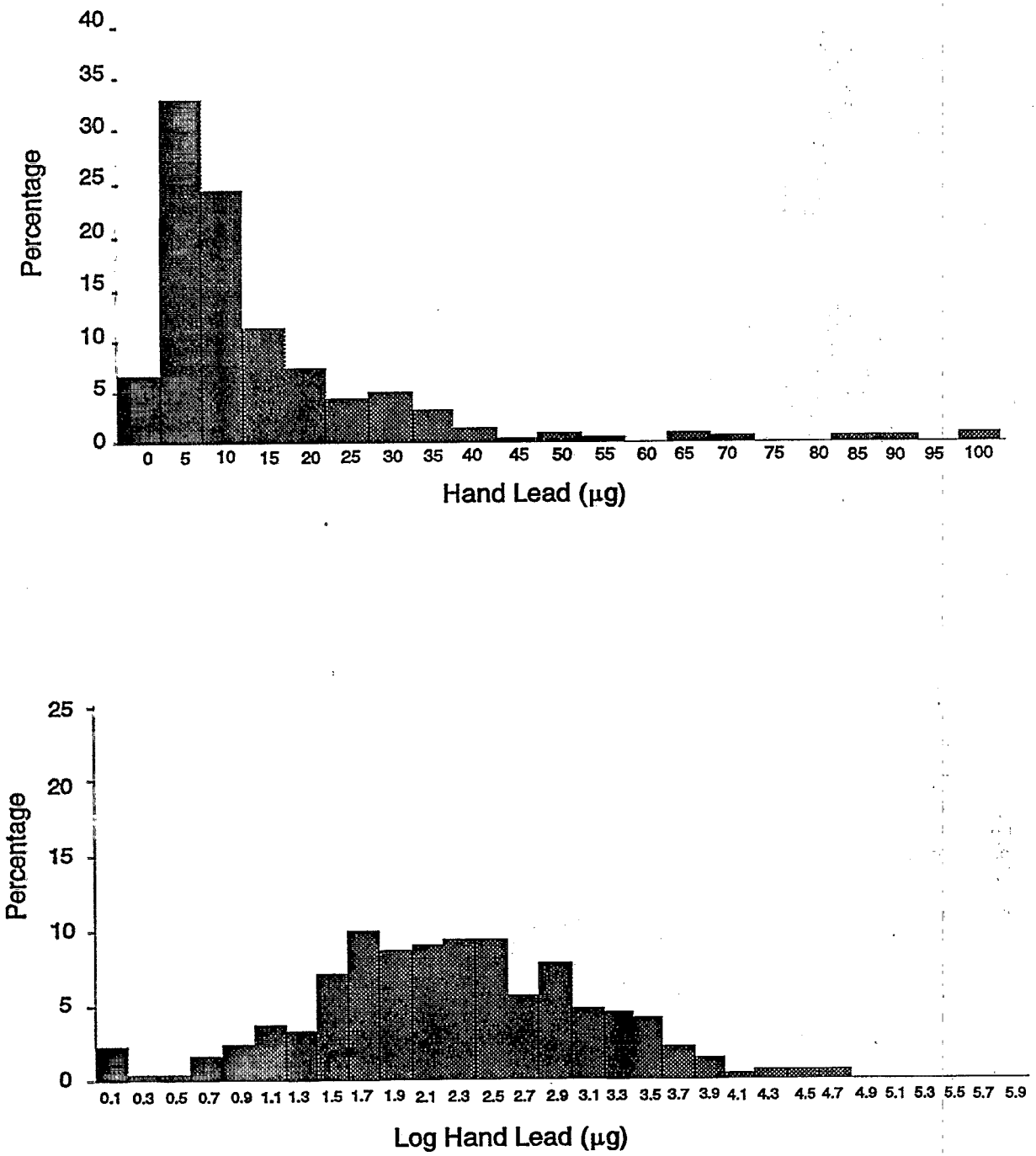
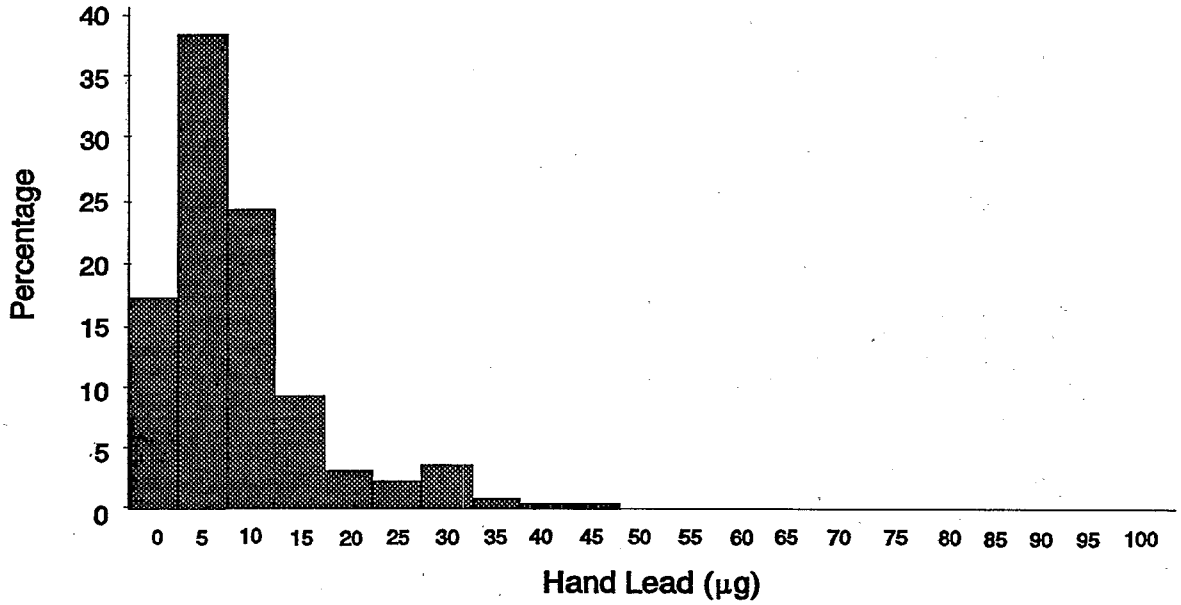


Figure 6-8. Normal and log-transformed distributions for hand lead, Round 2.



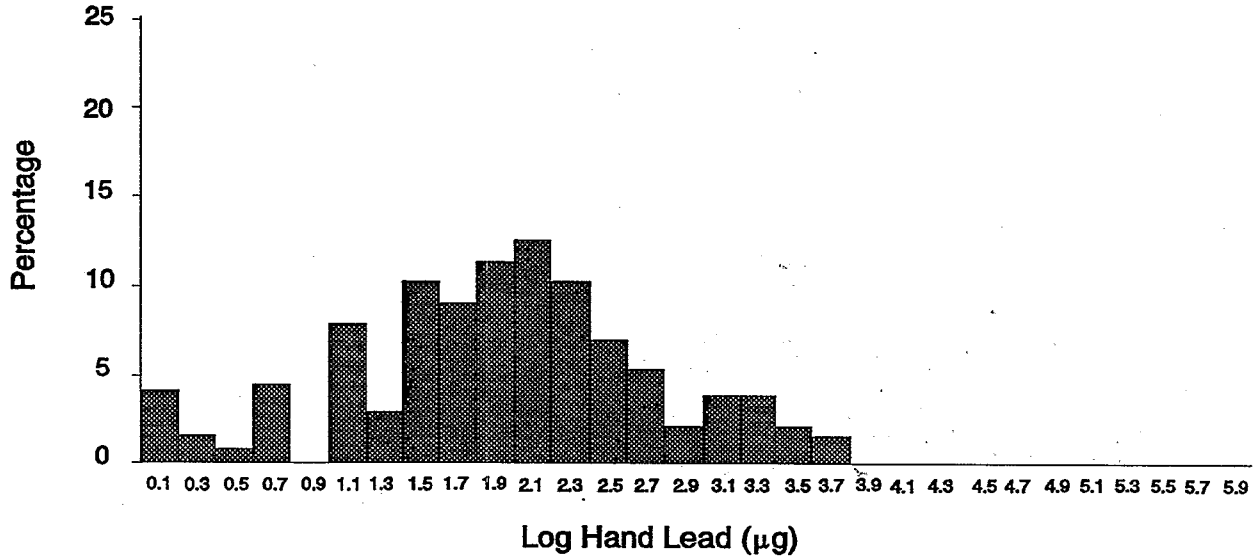


Figure 6-9. Normal and log-transformed distributions for hand lead, Round 3.

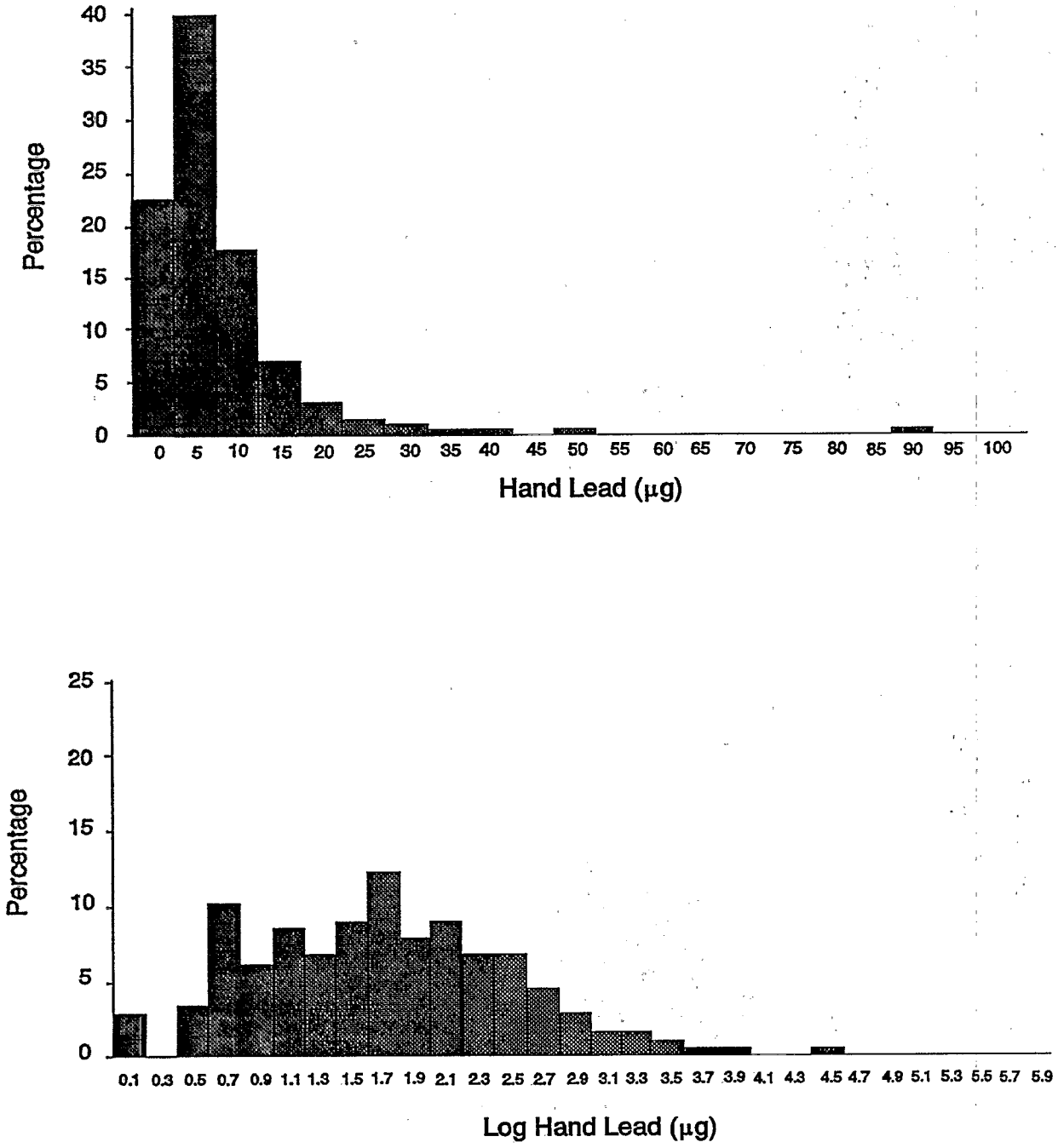
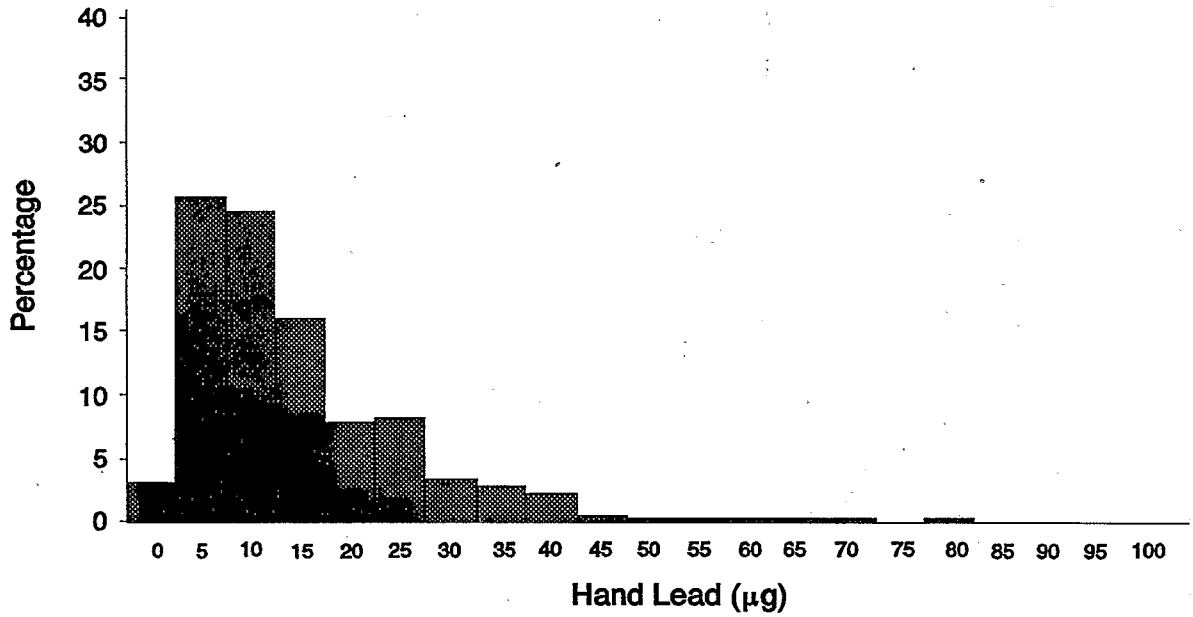


Figure 6-10. Normal and log-transformed distributions for hand lead, Round 4.



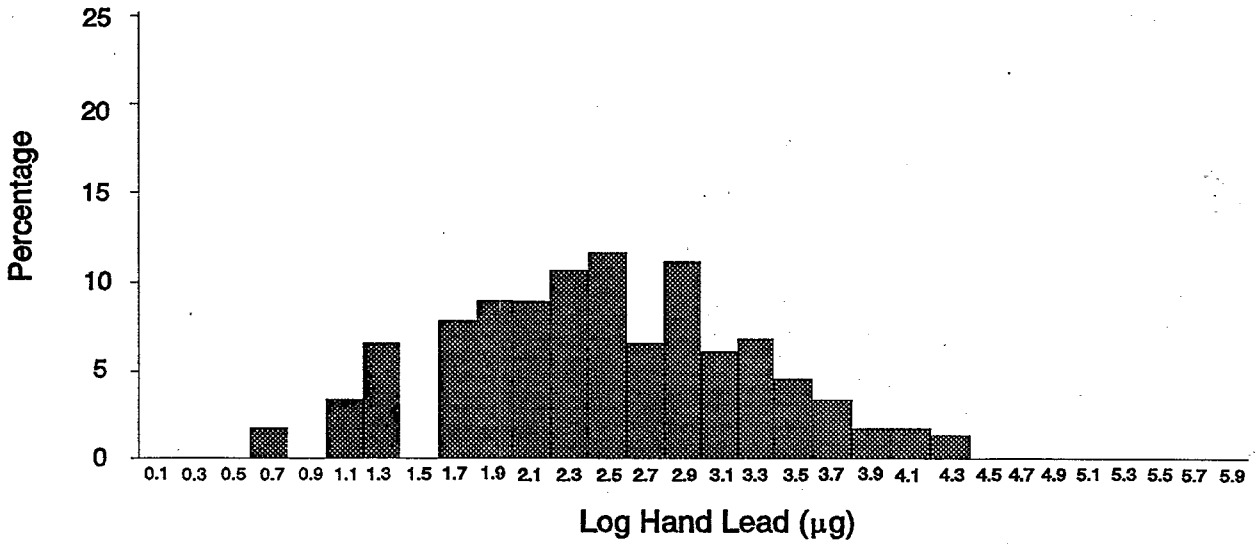


Figure 6-11. Normal and log-transformed distributions for hand lead, Round 5.

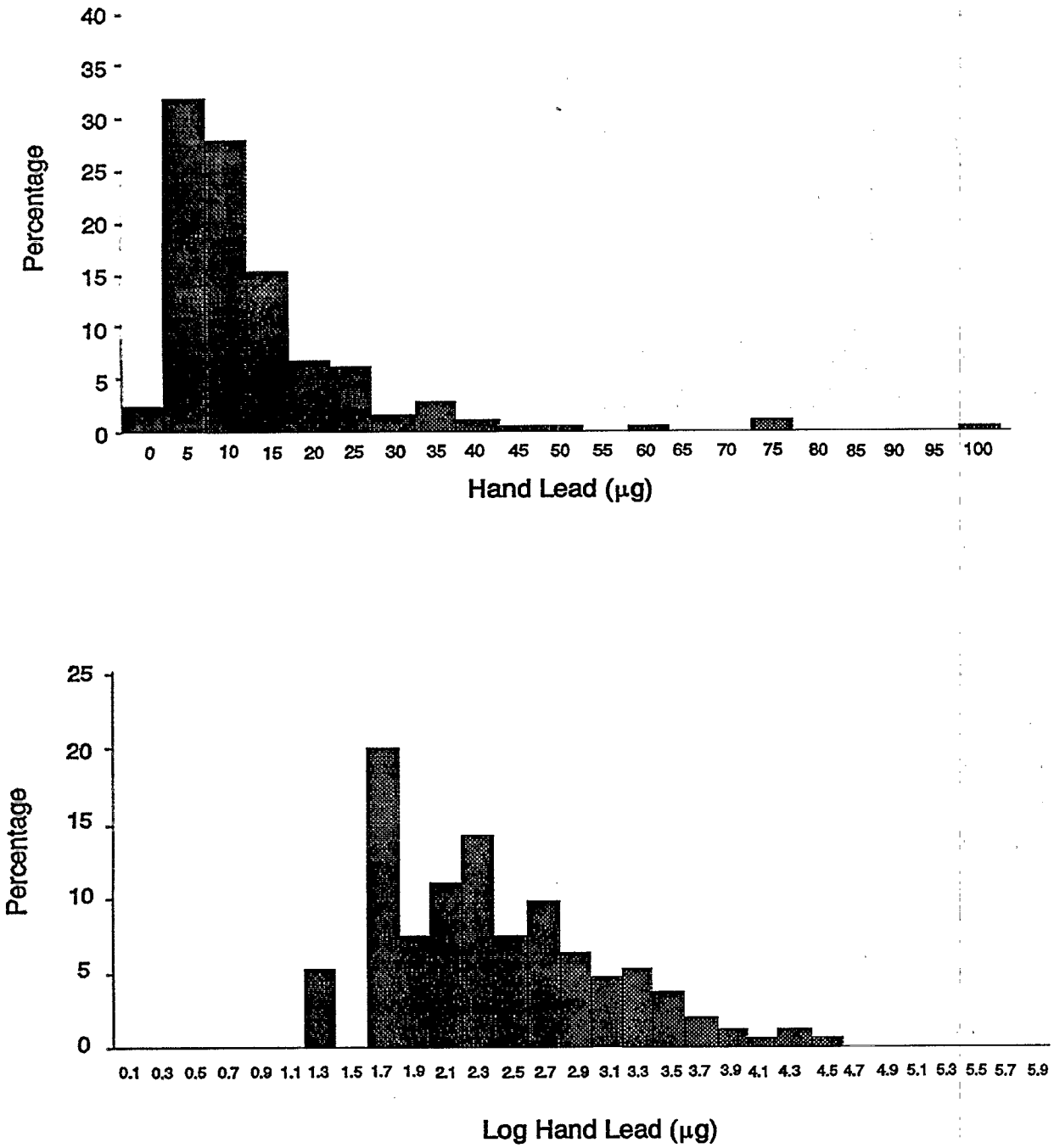


Figure 6-12. Normal and log-transformed distributions for hand lead, Round 6.

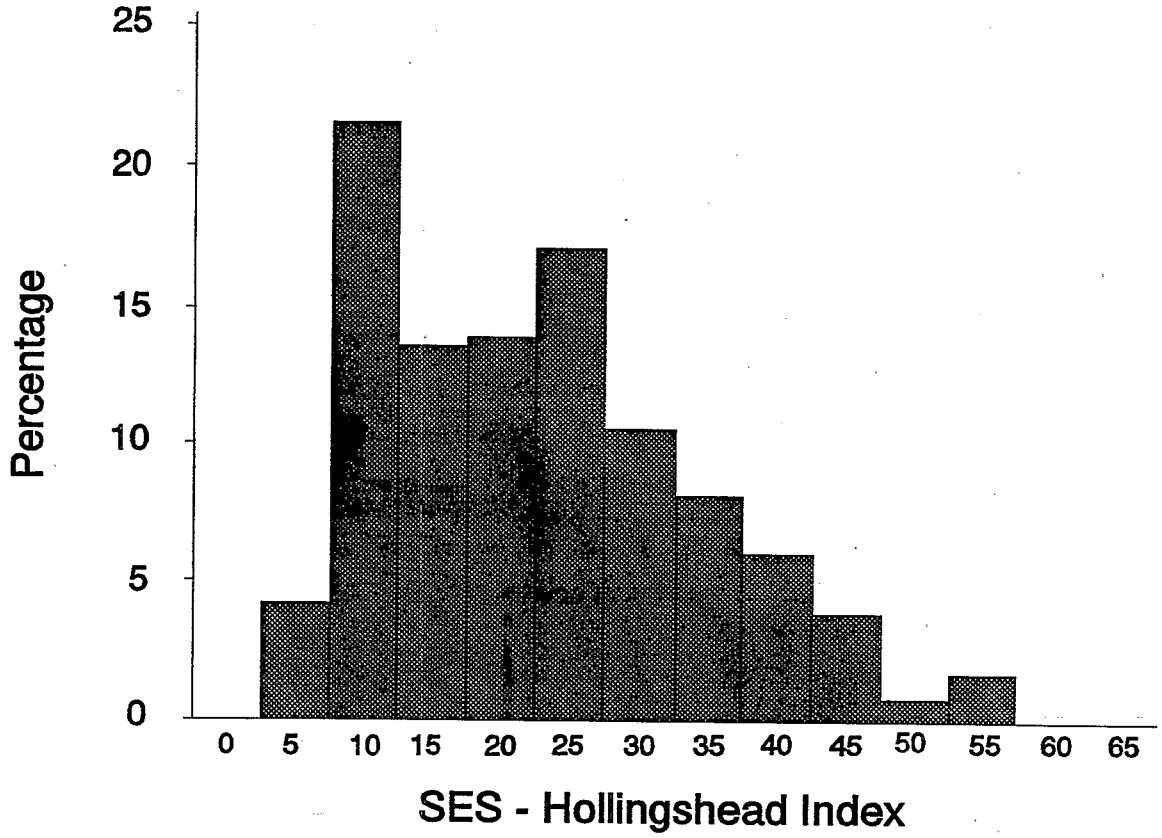


Figure 6-13. Distribution of SES scores using Hollingshead Index.

6.2.6 Mouthing Behavior

Mouthing behavior is a dichotomous variable created by combining the parental response from the following two questions in the questionnaire:

401. How often does the child put her/his fingers in her/his mouth?

1 = a lot } SOME
2 = just once in a while}
3 = almost never } NEVER

402. How often does the child put toys and things that are not food into her/his mouth?

1 = a lot } SOME
2 = just once in a while}
3 = almost never } NEVER

			FINGER 401	
	TOYS	SOME	STRONG	WEAK
Mouthing Behavior =	402	NEVER	WEAK	WEAK

This variable was designed to be used as an effect modifier in the regression model. It allows the differences in the effect of hand wipes on blood lead according to mouthing behavior to be seen.

6.3 ENVIRONMENTAL VARIABLES

6.3.1 Abatement

This is a dichotomous variable which indicates whether or not the property received the experimental treatment of soil abatement following the third round of biological sampling.

6.3.2 Soil Lead

Many top-soil samples were taken from each property and analyzed for lead content by the method of X-ray fluorescence in units of micrograms of lead per gram of soil. The XRF analysis result was multiplied by the constant derived for Baltimore from the Intercalibration Study conducted by the EPA and cities involved in the study (Appendix G).

Combining the measurements of these samples into a single soil exposure variable for each property was necessary for use as a covariate in the statistical models. The number of soil samples collected differed from property to property, based both on the size of each yard, and the number of defined areas in the yard available for sampling.

Summary statistics of the lead concentration measurements of surface soil were produced for each property. They are as follows:

1) Mean
2) Median
3) Maximum
4) Upper Quartile
5) Lower Quartile
6) Foundation Mean
7) Foundation Median
8) Foundation Maximum

These summary statistics were used as variables in a principal components analysis, to find which ones characterize most of the variability of soil within a property. This analysis led to the selection of the tri-mean of soil lead concentration as a covariate for the regression models where,

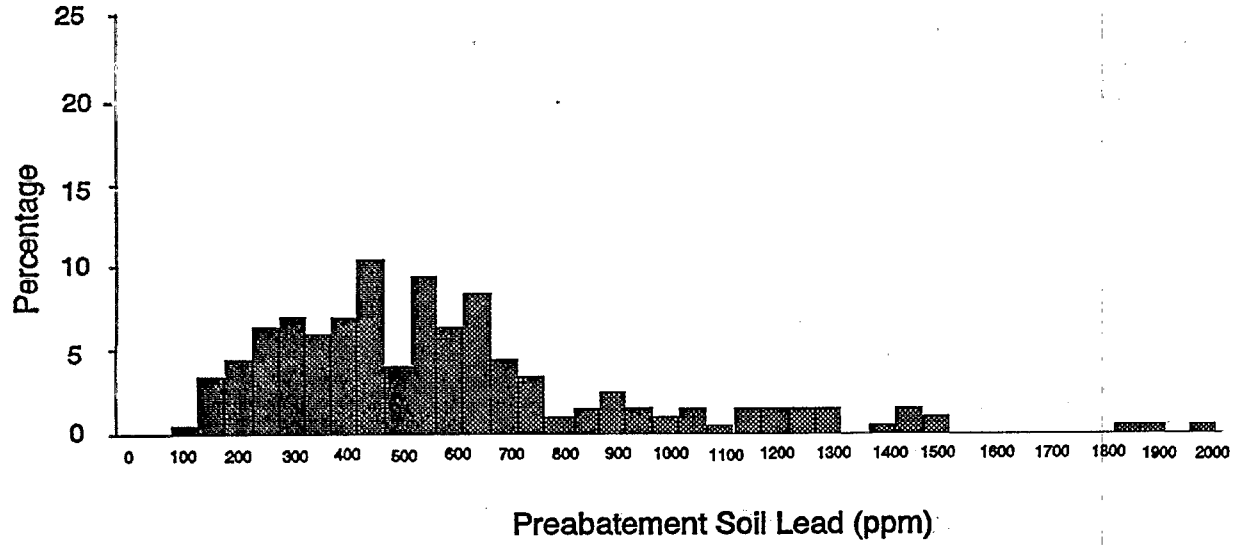
Tri-Mean = (Lower Quartile + 2*Median + Upper Quartile) / 4

The distribution of soil lead concentration for both treatment and control groups is displayed in Figures 6-14 and 6-15.

6.3.3 Dust Lead

Interior dust samples were collected from several different rooms in each child's home. Each dust sample was weighed in units of milligrams per surface area sample (16 ft^2), then analyzed for lead concentration by method of X-ray Fluorescence (ppm) and then later measured by Atomic Absorption Spectrometry (ppm). The dust results were also multiplied by the appropriate constant for Baltimore derived from the Intercalibration Study (Appendix G).

Once again, the problem of combining these samples into one variable which indexes lead content in interior dust of a given property arose. The mass of dust collected in each sample was highly variable, making it difficult to directly compare measurements in units of parts per million. It was decided to select a measurement for dust lead that represented the average amount of lead in dust per surface area sampled in each property. The dust variable was computed as a weighted average of the dust lead concentration measurements, each measurement weighted by the mass of sample collected. The XRF measurements, were selected because they correlated slightly better with blood lead than did the AAS measurements.



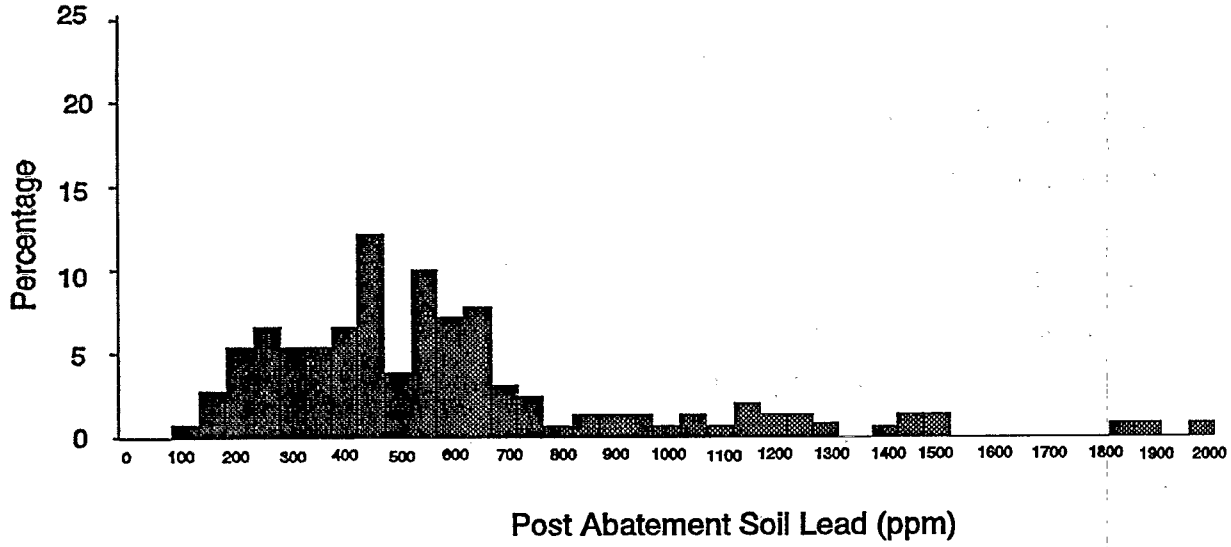
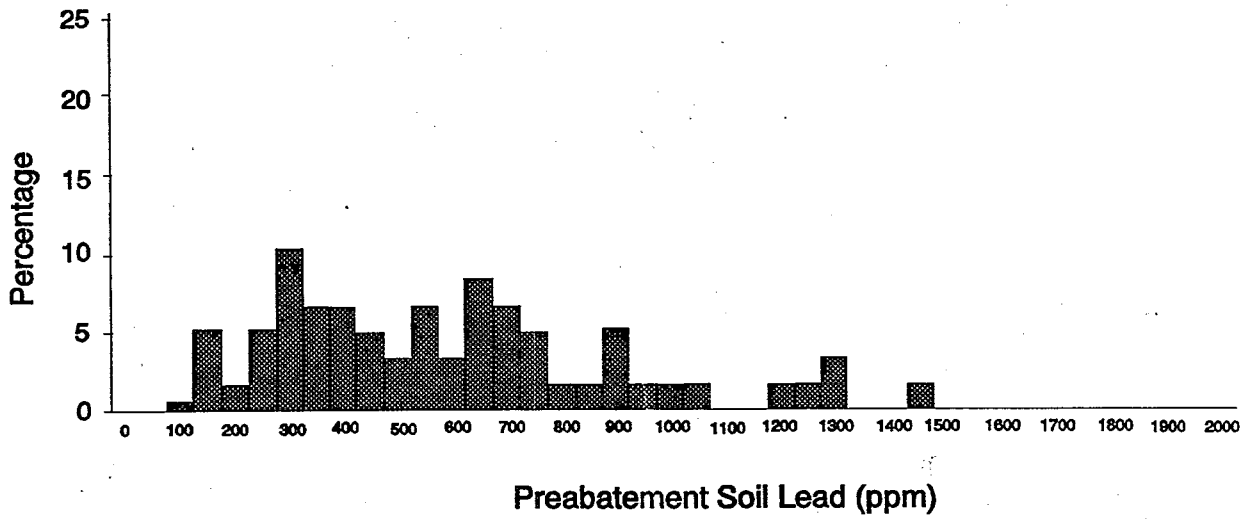


Figure 6-14. Tri-mean of pre- and postabatement soil lead concentrations for control group.



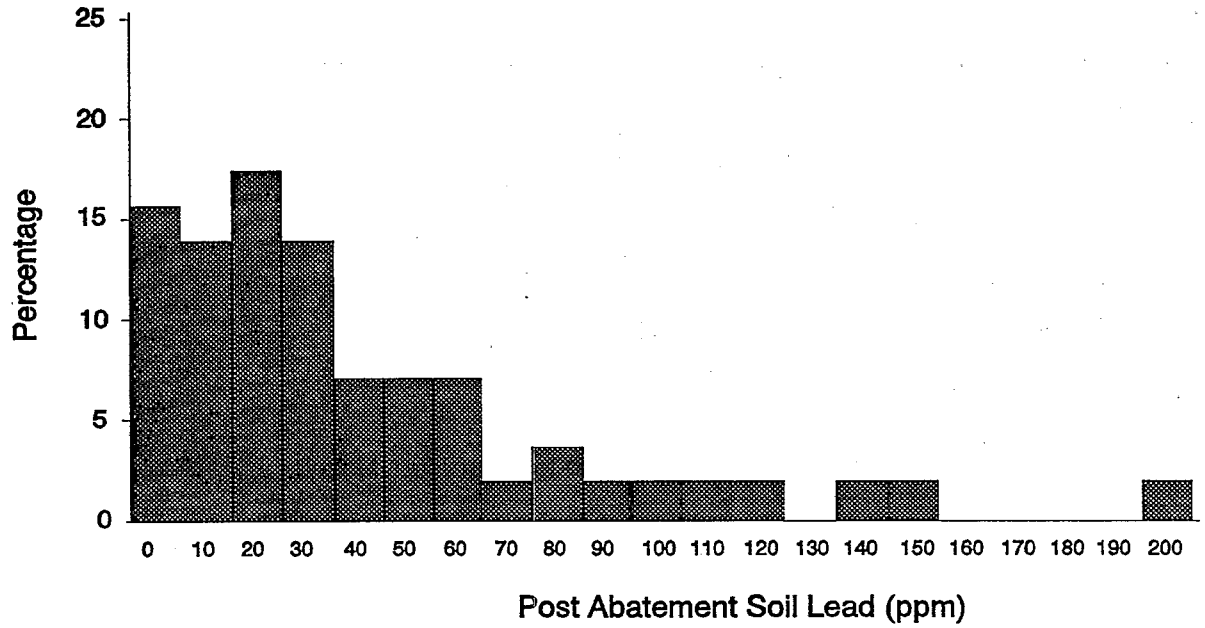


Figure 6-15. Tri-mean of pre- and postabatement soil lead concentrations for treatment group.

$$DUST = \frac{{}^{Ni}\Sigma_{j=1} (XRF_j)\ (WEIGHT_j)}{{}^{Ni}\Sigma_{j=1}\ (WEIGHT_j)}$$

i = 1,..,# OF PROPERTIES

j = 1,..,N

N =# OF DUST SAMPLES COLLECTED FROM PROPERTY

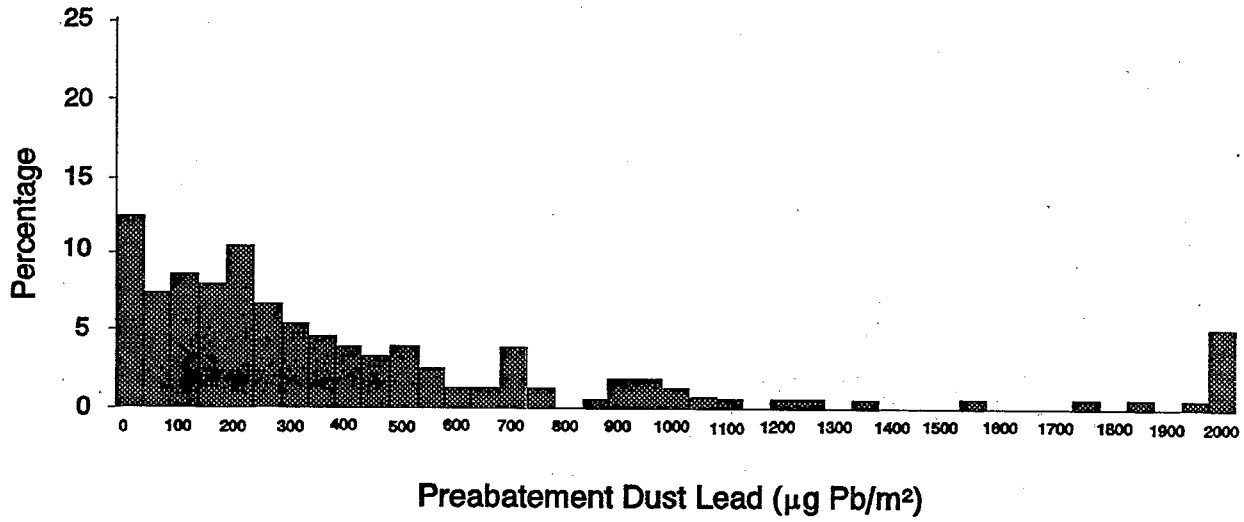
The distribution of dust lead concentrations per unit area sampled is displayed in Figures 6-16 to 6-19.

6.3.4 Exterior Paint

Paint Chips were collected from the exterior of each home prior to paint stabilization, and were analyzed by XRF in units of ppm. The tri-mean of the exterior paint measurements was selected as a covariate through use of principal components analysis.

6.3.5 Interior Paint

Measurements of micrograms of lead per centimeter squared were taken from painted surfaces inside each home using a portable X-ray fluorometer. The maximum reading was used to indicate whether or not a property contained interior lead based paint. A maximum measurement of 1.5 milligrams per centimeter square or greater thus indicates that there is some lead based interior paint within the property. The cut-off point of 1.5 mg/cm^2 was used to dichotomize interior paint for some of the statistical analyses. Interior paint measurements were not taken from every property involved in the study because of an inability to access the house during the interior paint lead analysis time period.



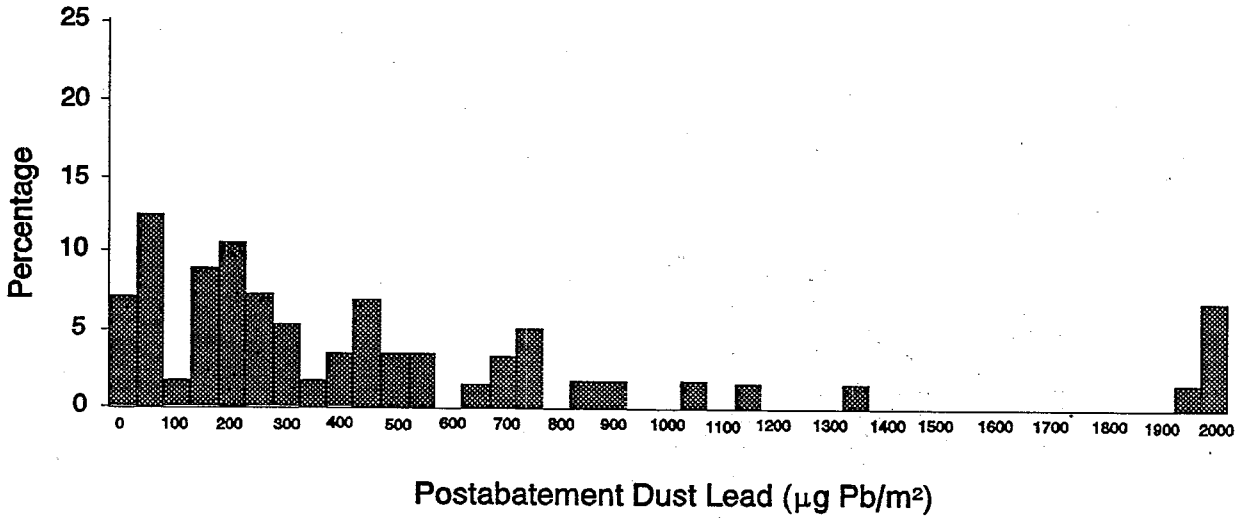
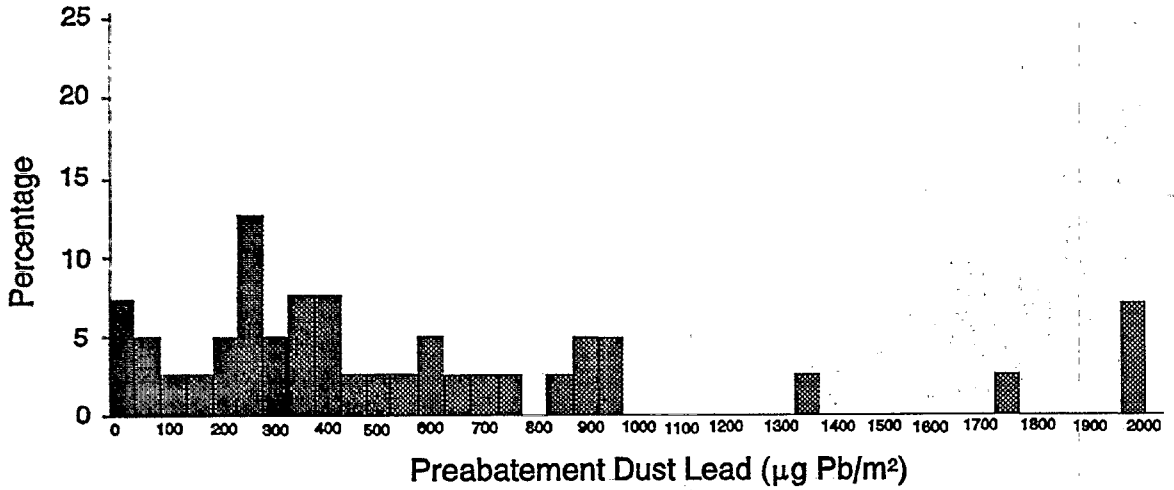


Figure 6-16. Pre- and postabatement dust lead load for control group, all properties.



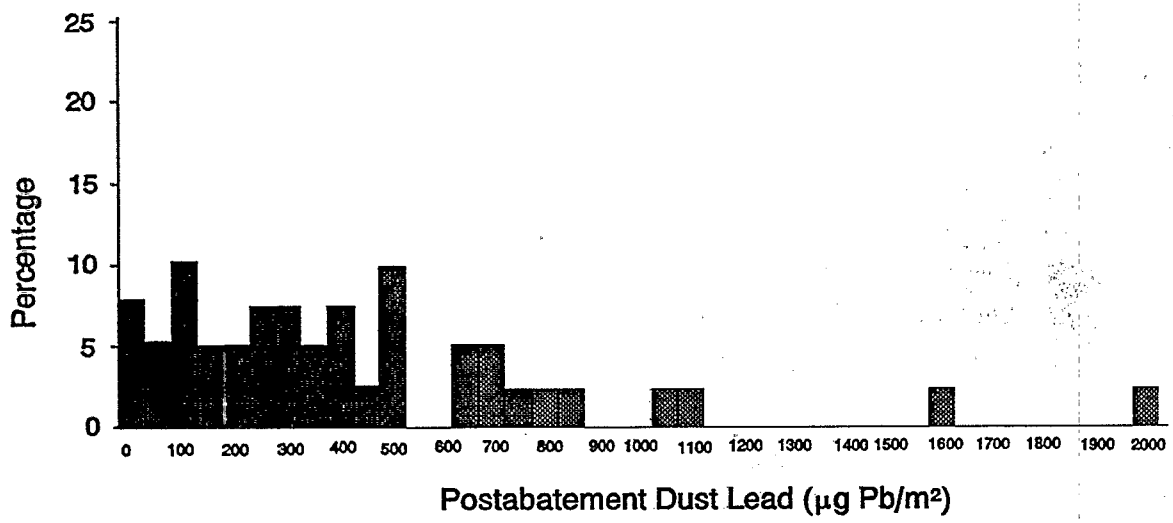
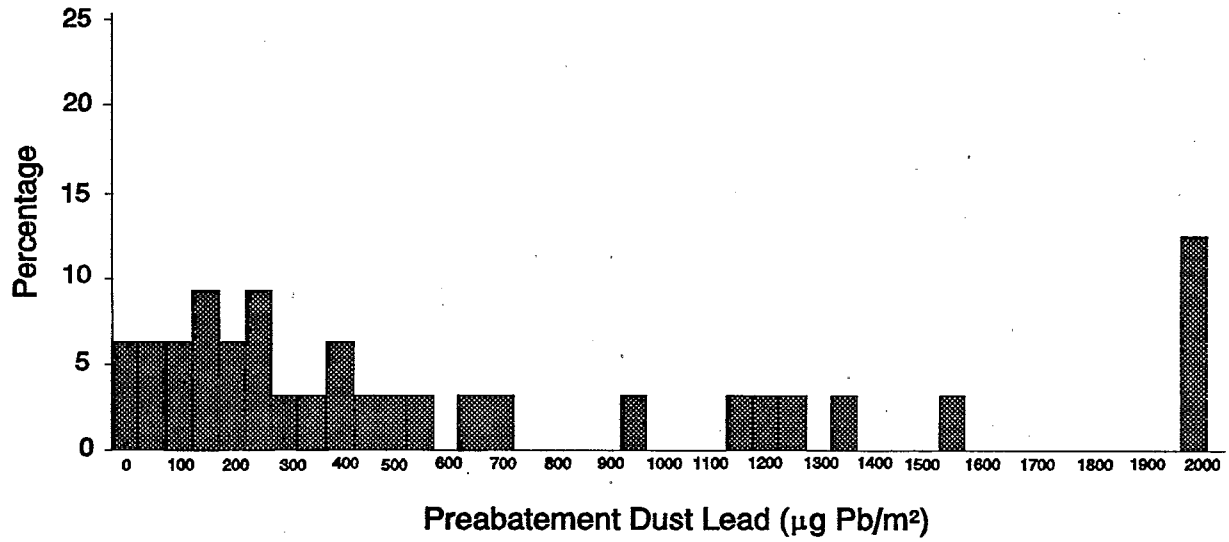


Figure 6-17. Pre- and postabatement dust lead load for treatment group, all properties.



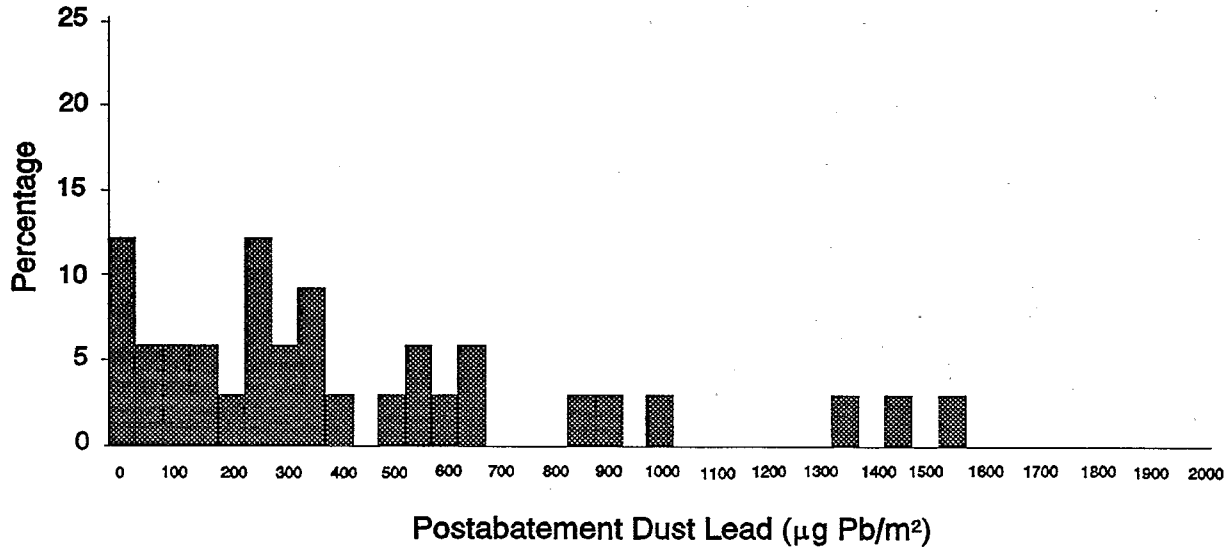
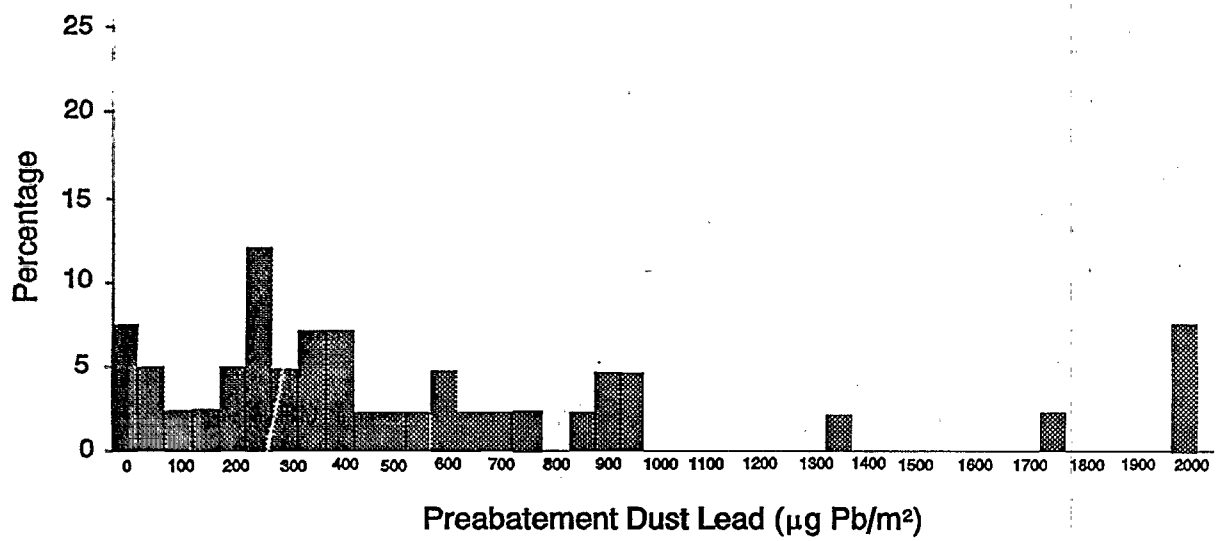


Figure 6-18. Pre- and postabatement dust lead load for control group. Data are for those properties that were sampled both before and after intervention.



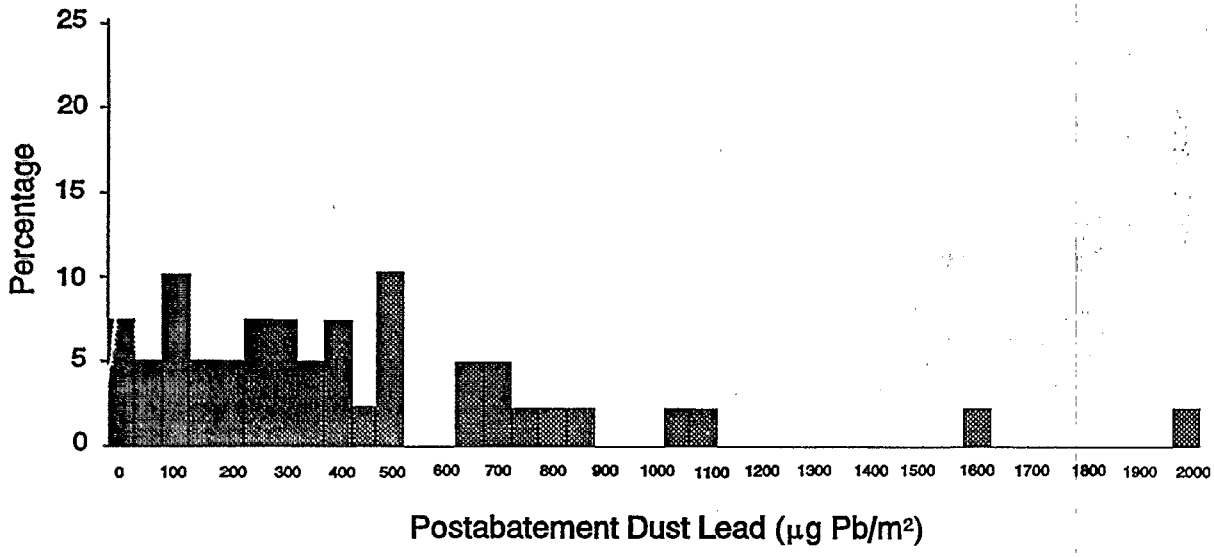


Figure 6-19. Pre- and postabatement dust lead load for treatment group. Data are for those properties that were sampled both before and after intervention.

7. STATISTICAL ANALYSIS

The intention of the statistical models was to evaluate the effects of soil abatement on blood lead while still taking into consideration the pathway through which a child is likely to develop lead poisoning:

```
                DETERIORATION
                      ↓
Interior Paint ===> Dust                    AGE AND SEASON
                                      Hand Lead =====> Blood Lead
                                          ↑          ↑          ↑
Exterior Paint ===> Soil                GENDER   MOUTHING     SES
                      ↑                          BEHAVIOR
                  EROSION
```

This pathway suggests that environmental lead exposure sources influence blood lead through the hand to mouth activity of the child. The lead found on the hands of a child results from contact with lead contaminated dust and/or soil. The pathway also indicates that the erosion of interior and exterior paint contribute to the lead contained in dust and soil.

7.1 STATISTICAL ANALYSIS OF ENVIRONMENTAL VARIABLES

The proposed pathway for lead poisoning in children indicates that dust lead and soil lead are the primary exposure sources in a child's environment. It is therefore important to show that the dust lead and soil lead levels were comparable between the treatment and control groups prior to intervention.

<u>Question 1</u> - Were the soil lead levels comparable in the treatment and control groups prior to intervention?

A two sample t-test yields a t-statistic of 0.049 with 202 degrees of freedom, indicating that there is no difference in soil lead between the treatment and control groups (Table 7-1) prior to intervention.

TABLE 7-1. SOIL STATISTICS BEFORE INTERVENTION

Group	N	Mean	se
Treatment	57	503.6	268.2
Control	147	501.3	312.1

Question 2 - Were the dust lead levels comparable in the treatment and control groups prior to intervention?

A two sample t-test yields a t-statistic of 0.851 with 210 degrees of freedom, indicating that there is no difference in dust lead between the treatment and control groups (Table 7-2) prior to intervention. The distributions of pre intervention soil and dust lead for treatment and control groups are presented in Figures 6-14 to 6-19.

TABLE 7-2. DUST STATISTICS BEFORE INTERVENTION

Group	N	Mean	se
Treatment	57	2,869.4	380.1
Control	155	1,902.8	152.8

Following intervention, properties which received the experimental treatment of soil abatement were re-sampled for quality control reasons. These measurements of post intervention soil lead can be used to demonstrate whether or not the project achieved a significant reduction in soil lead in the treatment properties.

Question 3 - Was there a significant reduction in soil lead in the properties that received the experimental treatment of soil removal?

A one sample t-test on the difference yields a t-statistic of 13.15 with 56 degrees of freedom, indicating that there is a statistically significant difference in pre-intervention and post intervention soil lead levels (Table 7-3) in the treatment group.

TABLE 7-3. PRE- AND POST-INTERVENTION SOIL STATISTICS

Group	N	Mean	se
Pre Intervention	57	503.6	268.2
Post Intervention	57	33.6	34.9
Difference	57	470.1	269.8

The distribution of post intervention soil lead for the treatment groups is presented in Figure 6-15.

Data for evaluating whether soil recontamination has occurred in the abated properties has not been collected. Post intervention soil samples were not taken from control properties under the assumption that the soil lead concentration in these areas would remain stable.

The experimental treatment of soil abatement may have an impact on the interior dust lead levels. Interior dust samples were collected following intervention in several properties in both the treatment and control groups in an effort to address this issue.

Question 4 - Was there a significant reduction in interior dust lead in properties that received soil abatement?

A one sample t-test on the difference yields a t-statistic of 1.32 with 39 degrees of freedom, indicating that there is no significant difference in pre intervention and post intervention dust lead levels (Table 7-4) in the treatment properties.

TABLE 7-4. DUST STATISTICS FOR CONTROL GROUP BEFORE AND AFTER SOIL ABATEMENT

Group	N	Mean	se
Pre Intervention	40	1,751.4	3,169.1
Post Intervention	40	1,108.7	1,480.7
Difference	40	642.7	3,089.2

Question 5 - Was there a significant reduction in interior dust lead in the control properties?

A one sample t-test on the difference yields a t-statistic of 2.25 with 32 degrees of freedom, indicating that there is a statistically significant difference in pre intervention and post intervention dust lead levels (Table 7-5) in the control properties.

TABLE 7-5. DUST STATISTICS FOR TREATMENT GROUP BEFORE AND AFTER SOIL ABATEMENT

Group	N	Mean	se
Pre Intervention	33	1,784.9	2,340.9
Post Intervention	33	976.0	928.9
Difference	33	808.8	2,068.8

The Distributions of pre and post intervention dust lead for both treatment and control properties that were sampled following abatement is presented in Figures 6-16 and 6-19.

A correlation analysis was performed on the four environmental variables (soil, dust, exterior paint and interior paint) to evaluate the first part of the proposed pathway. The correlation coefficient between soil and exterior paint was +0.18 (p-value 0.0134), and the correlation coefficient between dust and interior paint was +0.22 (p-value 0.0240). The remaining correlation coefficients were not significant at the alpha=0.05 level. This analysis confirmed the belief that erosion of exterior paint contributes to lead in soil, while

deteriorating interior paint is positively associated with lead in interior dust. The correlation matrix is presented in Figure 7-1.

The measurement for interior paint was easily dichotomized into an indicator of whether or not the property had lead based paint on interior surfaces (a measurement of interior paint greater than 1.5 mg/cm^2 was taken as a positive result). If the proposed pathway is to be upheld, one would expect higher interior dust lead levels in the houses that tested positive for interior lead paint.

Question 6 - Is the interior dust lead concentration higher in those properties that tested positive for interior lead based paint?

A one sample t-test on the difference yields a t-statistic of 2.76 with 103 degrees of freedom, indicating that there is a statistically significant difference in dust lead concentration between properties that test positive and properties that test negative for interior lead based paint (Table 7-6).

7.2 STATISTICAL MODELS FOR BLOOD LEAD AND HAND LEAD

The experimental treatment in the Baltimore Study was designed to eliminate the bottom half of the pathway through exterior paint stabilization and soil abatement. The following statistical models evaluate the effect that this treatment had on both hand lead and blood lead of children participating in the study. Both response variables for these models, blood lead and hand lead, appear to be distributed log-normal as mentioned earlier. This leaves two logical statistical approaches for modeling these data:

1) Apply a natural log transformation to the response variable and model the data through multiple linear regression with additive errors.

2) Use the untransformed response variable in a multivariate normal generalized linear model with a log link function.

The errors associated with this model are multiplicative. The main difference between these two statistical approaches is in the interpretation of the regression coefficients. The

CORRELATION ANALYSIS

Four Variables: Soil Dust
Exterior Paint Interior Paint

Simple Statistics

Variable	N	Mean	Std. Dev.	Sum
SOIL	204	597.80991	357.11916	121953
DUST	212	776.90932	1156	164705
INTERIOR PAINT	106	5.37013	4.02194	569.23333
EXTERIOR PAINT	203	4.85391	5.07530	985.34388

Pearson Correlation Coefficients
Prob. > |R| under Ho: Rho=0
Number of Observations

	SOIL	DUST	INTERIOR PAINT	EXTERIOR PAINT
SOIL	1.00000 0.0 204	0.08666 0.2236 199	0.17189 0.0856 101	0.17724 0.0134 194
DUST	0.08666 0.2236 199	1.00000 0.0 212	0.22203 0.0228 105	0.05334 0.4566 197
INTERIOR PAINT	0.17189 0.0856 101	0.22203 0.0228 105	1.00000 0.0 106	-0.02332 0.8152 103
EXTERIOR PAINT	0.17724 0.0134 194	0.05334 0.4566 197	-0.02332 0.8152 103	1.00000 0.0 203

Figure 7-1. Correlation matrix of environmental variables.

TABLE 7-6. DUST STATISTICS FOR PROPERTIES WITH AND WITHOUT LEAD-BASED PAINT

Group	N	Mean	se
Positive	65	1,432.0	2,136.7
Negative	40	627.7	754.9

first approach was selected for presentation in this report, although the statistical results for both approaches is presented in Appendix I.

The following cross sectional models were performed on two different populations from within the study; the first consisting only of children who consistently participated in all six rounds of the study, and the second consisting of all children sampled throughout the experiment. This helped to evaluate the sensitivity of the statistical models to participant dropout.

The first model measures the direct effect of group assignment (treatment or control) on the log of the blood lead in each round: $LPbB_{ij} = b_{0j}T_i + b_{1j}C_i + e_{ij}$ where for the ith child, in round j,

$LPbB_{ij}$ = Log of blood lead of child(i) in round j
T_i = 1 if child(i) is in treatment group, else 0
C_i = 1 if child(i) is in control group, else 0
e_{ij} = error term for child(i) in round j.

Essentially, this model computes a geometric mean and standard error for each group. These can be transformed back to the original scale of blood lead, and the two experimental groups can be compared through use of a two sample t-test.

Next is a multiple linear regression model which uses the log of blood lead as the response variable with group assignment, age, season, socio economic status, and the interaction between mouthing behavior and log of hand lead as covariates. $LPbB_{ij} = b_{0j}T_i + b_{1j}C_i + b_{2j}Age0_{ij} + b_{3j}\,Age1_{ij} + b_{4j}\,Age2_{ij} + b_{5j}\,Age3_{ij} + b_{6j}\,SES_i + b_{7j}\,Season_{ij} + b_{8j}\,LPbH1_{ij} + b_{9j}\,LPbH2_{ij} + e_{ij}$ where for the ith child in round j,

$LPbB_{ij}$ = Log of blood lead of child(i) in round j
T_i = 1 if child(i) is in treatment group, 0 else
C_i = 1 if child(i) is in control group, 0 else
$Age0_{ij}$ = 1 if child(i) is age(0-1) in round j, 0 else
$Age1_{ij}$ = 1 if child(i) is age(1-2) in round j, 0 else
$Age2_{ij}$ = 1 if child(i) is age(2-3) in round j, 0 else
$Age3_{ij}$ = (Age-3) if child(i) is age(3+) in round j, 0 else
SES_i = Socio economic status of child(i)'s family
$Season_{ij}$ = 1 if child(i) was sampled in the summer of round j, 0 else
$LPbH1_{ij}$ = Log hand lead for child(i) in Round j, if he/she exhibits weak mouthing behavior, 0 else
$LPbH2_{ij}$ = Log hand lead for child(i) in Round j, if he/she exhibits strong mouthing behavior, 0 else
e_{ij} = error term for child(i) in round j

** Note - Season was only included as a covariate in the first two rounds.

This model allows the assessment of the effects of soil abatement after adjusting for covariates described in the pathway that may influence a child's blood lead concentration. Similar to the first model, a geometric mean and associated standard error for blood lead are produced which are comparable through the use of t-tests.

The third model evaluates the effects of group assignment on the log of hand lead. This model is identical to the first model except for the change in response variable:

$LPbH_{ij}$ = $b_{0j}\, T_i + b_{1j}\, C_i + e_{ij}$ where for the ith child, in round j,
$LPbH_{ij}$ = Log of hand lead of child(i) in round j
T_i = 1 if child(i) is in treatment group, else 0
C_i = 1 if child(i) is in control group, else 0
e_{ij} = error term for child(i) in round j.

The fourth model has log of hand lead as the response variable with group assignment, age, season, gender, and interior dust as covariates: $LPbH_{ij} = b_{0j}T_i + b_{1j}C_i + b_{2j}\, Age0_{ij} + b_{3j}\, Age1_{ij} + b_{4j}\, Age2_{ij} + b_{5j}\, Age3_{ij} + b_{6j}\, Sex_i + b_{7j}\, Season_{ij} + b_{8j}\, Dust_i + e_{ij}$ where for the ith child in round j,

$LPbH_{ij}$ = Log of hand lead of child(i) in round j
T_i = 1 if child(i) is in treatment group, 0 else
C_i = 1 if child(i) is in control group, 0 else
$Age0_{ij}$ = 1 if child(i) is age(0-1) in round j, 0 else

$Age1_{ij}$ = 1 if child(i) is age(1-2) in round j, 0 else
$Age2_{ij}$ = 1 if child(i) is age(2-3) in round j, 0 else
$Age3_{ij}$ = (Age-3) if child(i) is age(3+) in round j, 0 else
Sex_i = 1 if child(i) is female, 0 else
$Season_{ij}$ = 1 if child(i) was sampled in the summer of round j, 0 else
$Dust_i$ = Measure of dust lead in child(i)'s home
e_{ij} = error term for child(i) in round j

** Note - Season was only included as a covariate in the first 2 rounds. Rounds 3 through 6 had no seasonal variation among the participants.

This model allows us to evaluate the effects of soil abatement after adjusting for the covariates described in the pathway that are thought to influence a child's hand lead concentration.

The final model presented has log of hand lead as the response variable with gender, age, season, interior dust lead, and soil lead as covariates. $LPbH_{ij} = b_{0j}\ Male_i + b_{1j}\ Female_i + b_{2j}\ Age0_{ij} + b_{3j}\ Age1_{ij} + b_{4j}\ Age2_{ij} + b_{5j}\ Age3_{ij} + b_{6j}\ Season_{ij} + b_{7j}\ Dust_i + b_{8j}\ Soil_i + e_{ij}$ where for the ith child in round j,

$LPbH_{ij}$ = Log of hand lead of child(i) in round j
$Male_i$ = 1 if child(i) is male, 0 else
$Female_i$ = 1 if child(i) is female, 0 else
$Age0_{ij}$ = 1 if child(i) is age(0-1) in round j, 0 else
$Age1_{ij}$ = 1 if child(i) is age(1-2) in round j, 0 else
$Age2_{ij}$ = 1 if child(i) is age(2-3) in round j, 0 else
$Age3_{ij}$ = (Age-3) if child(i) is age(3+) in round j, 0 else
$Season_{ij}$ = 1 if child(i) was sampled in the summer of round j, 0 else
$Dust_i$ = Measure of dust lead in child(i)'s home
$Soil_{ij}$ = Measure of soil lead in child(i)'s home in round j
e_{ij} = error term for Child(i) in Round j

** Note - Season was only included as a covariate in the first two rounds, Rounds 3 through 6 had no seasonal variation among the participants.

The measure of soil lead changes in round 4 for properties which received soil abatement.

This model describes the association between the lead found on the hands of a child, and the sources of lead exposure measured within that child's home environment.

Regression coefficients and their corresponding confidence intervals from these models are presented and discussed in the Results section. These models contain only those covariates which were consistently statistically significant in each of the rounds. Models that included other potential confounders which were measured throughout the study were explored at great length. The data analysis was conducted using both SAS and GLIM statistical software. The methods used (correlation analysis, multiple linear regression, two sample t-tests, and confidence intervals) are described in standard statistical text books.

7.3 INTERPRETATION OF REGRESSION COEFFICIENTS

The above cross sectional statistical models used the log transform of either blood or head lead measurements as the response variable in a multiple linear regression model. The regression coefficients derived from these models have additive effects on the log transformed response variable. When the estimates are converted back to the original unit of measure, these parameter estimates are interpreted as having multiplicative effects: $\log(Y_i) = \Sigma\, \beta_j' X_i + e_i$, where i = 1 to n (sample size) and j = 0 to p (number of parameters)

$$\begin{aligned} Y_i &= \exp(\Sigma\, \beta^*_j{}' X_i) * \exp(e_i) \\ &= \exp(\beta^*_0 X_{i0}) * \exp(\beta^*_1 X_{i1}) * \ldots * \exp(\beta^*_p X_{ip}) * \exp(e_i) \end{aligned}$$

The regression coefficients (β^*) for this multiplicative model are computed by exponentiating the regression coefficients from the additive model on the log scale.

$$\beta^*_j = \exp(\beta_j)$$

The associated standard errors for regression coefficients from the multiplicative model are calculated by using the delta method:

$$se(\beta^*_j) = \exp(\beta_j) * \sigma * \{X'X_{jj}\}^{-1/2}$$

Models for Comparison with Boston and Cincinnati Projects

A second set of statistical models were explored and evaluated for the purpose of comparing and contrasting the findings of the Baltimore study with the results of the Boston and Cincinnati projects. These models use post intervention log blood lead as a response variable, and a summary of the pre intervention log blood lead along with group assignment as covariates. These models were fit cross sectionally for each post intervention round of sampling, and similar models were also fit for log hand lead.

7.4 RESULTS OF STATISTICAL ANALYSIS

Regression coefficients and their associated standard errors for both the additive and multiplicative interpretations of the statistical models are presented in Tables 7-7 through 7-23. The regression coefficients computed in each round for each covariate were also graphically displayed in the form of 95% Confidence Intervals across the time line of the experiment. The vertical line in the center of these graphs represents the time at which soil abatement occurred during the experiment. When appropriate, a zero line is drawn to help ascertain whether or not the corresponding regression coefficients are statistically different from zero at the $\alpha = 0.05$ significance level.

The statistical models were applied to two different populations within the experiment to evaluate the potential bias introduced from participant dropout. The graphs of the regression coefficients were virtually identical between these two populations, indicating that the effect of participant dropout on the statistical models was negligible. These graphs are presented in Figures 7-2 through 7-22.

7.4.1 Model 1

Geometric means of blood lead and their associated standard errors were calculated in each round for children for both the treatment and control groups in this model. This measures the direct effect of group assignment on blood lead. The geometric means of the two groups seem almost identical to each other in the first three rounds, thus there is no statistical difference between the treatment and control groups prior to intervention. This is evidence that the two groups were comparable from the start of the study. Following the

intervention procedure of soil abatement, there is no significant difference between the abated group and the control group as measured by this model. Contrary to the hypothesis of interest, it seems as if children in the control group have slightly lower blood lead concentration in the rounds following intervention, although this pattern is not statistically significant. The regression coefficients, associated standard errors and confidence intervals from model 1 are presented in Table 7-7 and Figures 7-2 and 7-3.

7.4.2 Model 2

This model calculates the geometric means and associated standard errors for group assignment after adjusting for variables that are thought to influence a child's blood lead concentration. The regression coefficients for the effect of group assignment in this model are similar to those found in the first model. There is no detectable difference in group assignment in the rounds prior to and following intervention (Table 7-8 and Figures 7-4 and 7-5).

The effect of age on blood lead was determined by creating 3 indicator variables for the age groups (0-1), (1-2) and (2-3), and including a linear term for children over the age of 3. The intercept for the (0-1) age group was significantly negative through the rounds of sampling that included these very young children. This can be explained by the fact that infants demand constant supervision from their caretakers. The (1-2) and (2-3) age groups were positive in some rounds and negative in others. The linear term attached to children over the age of 3 was consistently negative and significant in the latter part of the experiment, indicating that blood lead decreases with age after a child is 3 years old (Table 7-9 and Figure 7-6).

Socioeconomic status consistently has a statistically significant negative effect on the blood lead of children participating in our study. Thus the blood lead of a child is inversely related to the level of education and profession of the parent(s) (Table 7-10 and Figure 7-7).

Season was added as a covariate in the first 2 rounds, as these sampling rounds took place over a change of season. The literature suggests that blood lead concentration is typically higher in the months when children actively play outdoors. The effect of season on blood lead is statistically significant only in the first round of the study (Table 7-11 and Figure 7-8).

TABLE 7-7. REGRESSION COEFFICIENT FOR DIRECT EFFECT OF ABATEMENT ON BLOOD LEAD MODEL 1

Children Present In All Six Rounds of Sampling

		Log (Blood Lead)		Blood Lead	
Round	Group	EST	SE	EST	SE
1	Treatment	2.473	0.06491	11.8580	0.76970
	Control	2.428	0.05300	11.3362	0.60082
2	Treatment	2.383	0.06220	10.8374	0.67408
	Control	2.327	0.04971	10.2472	0.50939
3	Treatment	2.245	0.06584	9.4404	0.62156
	Control	2.228	0.05638	9.2813	0.52328
	INTERVENTION				
4	Treatment	2.117	0.06830	8.3062	0.56731
	Control	2.028	0.05825	7.5989	0.44263
5	Treatment	2.179	0.06743	8.8375	0.59591
	Control	2.088	0.05903	8.0688	0.47630
6	Treatment	2.234	0.06549	9.3371	0.61149
	Control	2.123	0.06120	8.3562	0.51140

All Children Sampled Throughout Experiment

		Log (Blood Lead)		Blood Lead	
Round	Group	EST	SE	EST	SE
1	Treatment	2.405	0.06001	11.0784	0.66482
	Control	2.361	0.03592	10.6015	0.38081
2	Treatment	2.338	0.05857	10.3605	0.60681
	Control	2.313	0.03355	10.1047	0.33901
3	Treatment	2.257	0.05313	9.5544	0.50762
	Control	2.254	0.04314	9.5258	0.41094
	INTERVENTION				
4	Treatment	2.169	0.05309	8.7495	0.46451
	Control	2.036	0.05339	7.6599	0.40896
5	Treatment	2.259	0.05682	9.5735	0.54397
	Control	2.106	0.05584	8.2153	0.45874
6	Treatment	2.305	0.05360	10.0242	0.53730
	Control	2.134	0.05423	8.4486	0.45817

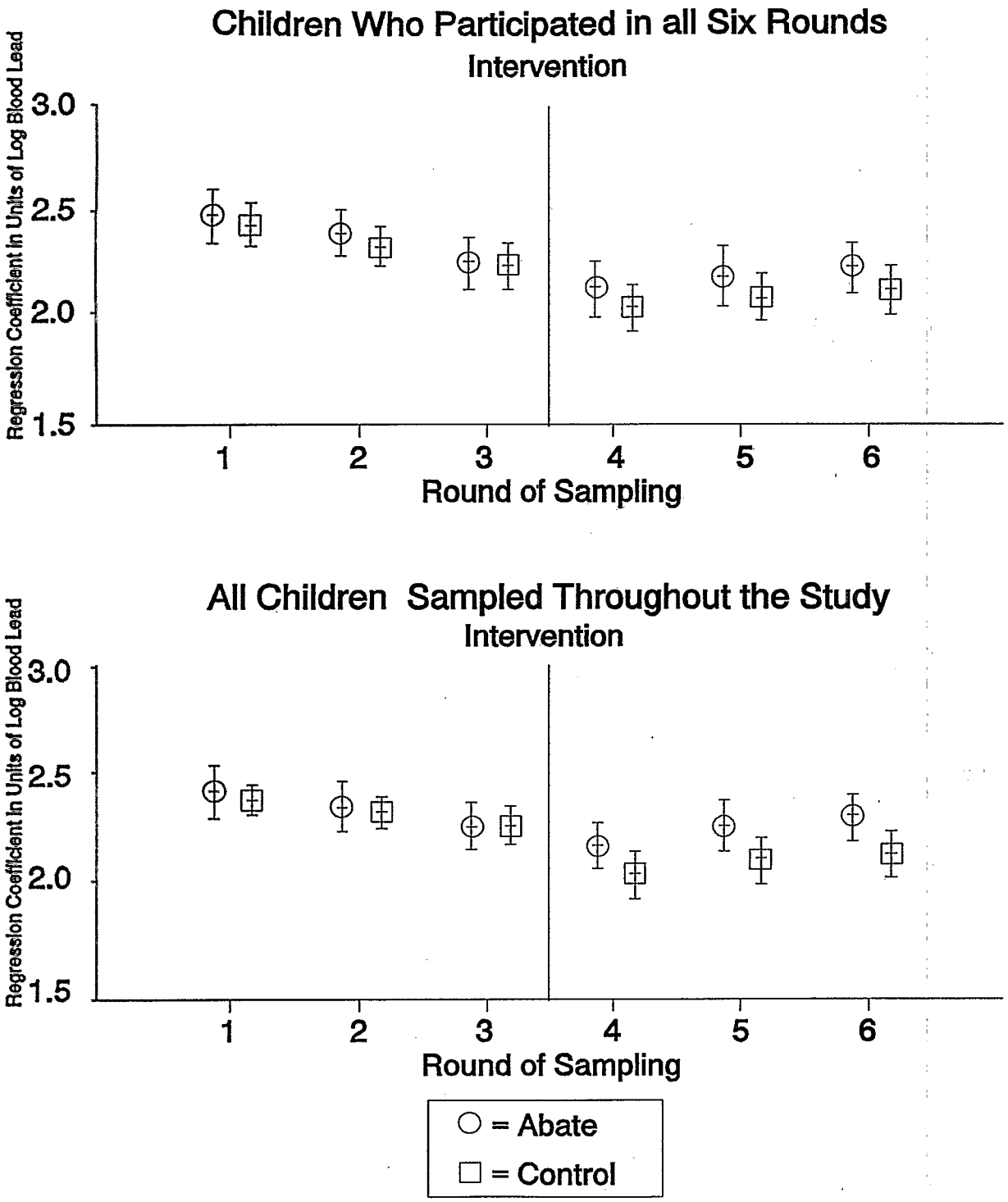


Figure 7-2. Model 1 results of effect of soil abatement on blood lead, log transformed. Bars show 95% confidence interval on regression coefficient.

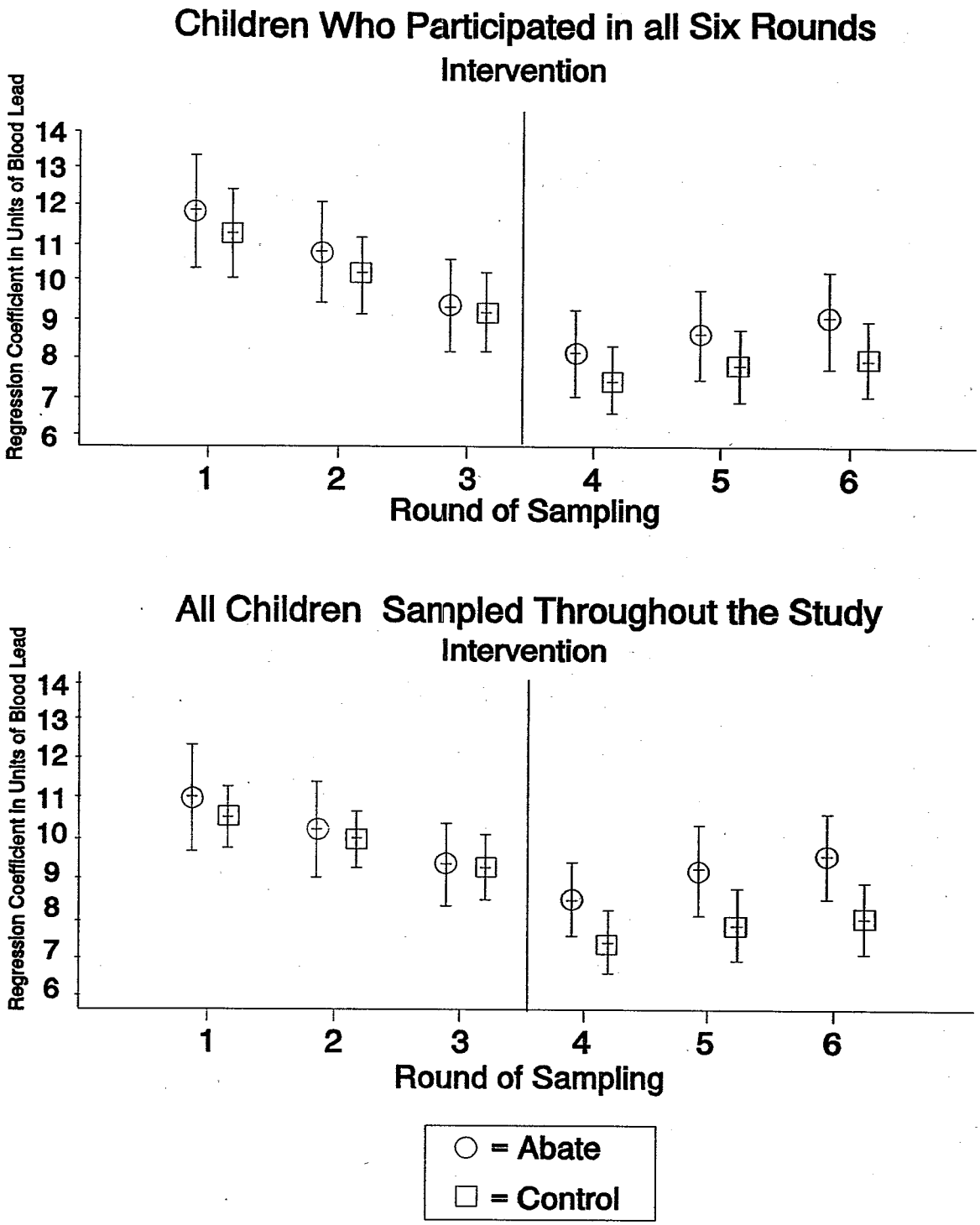


Figure 7-3. Model 1 results of effect of soil abatement on blood lead. Bars show 95% confidence interval on regression coefficient.

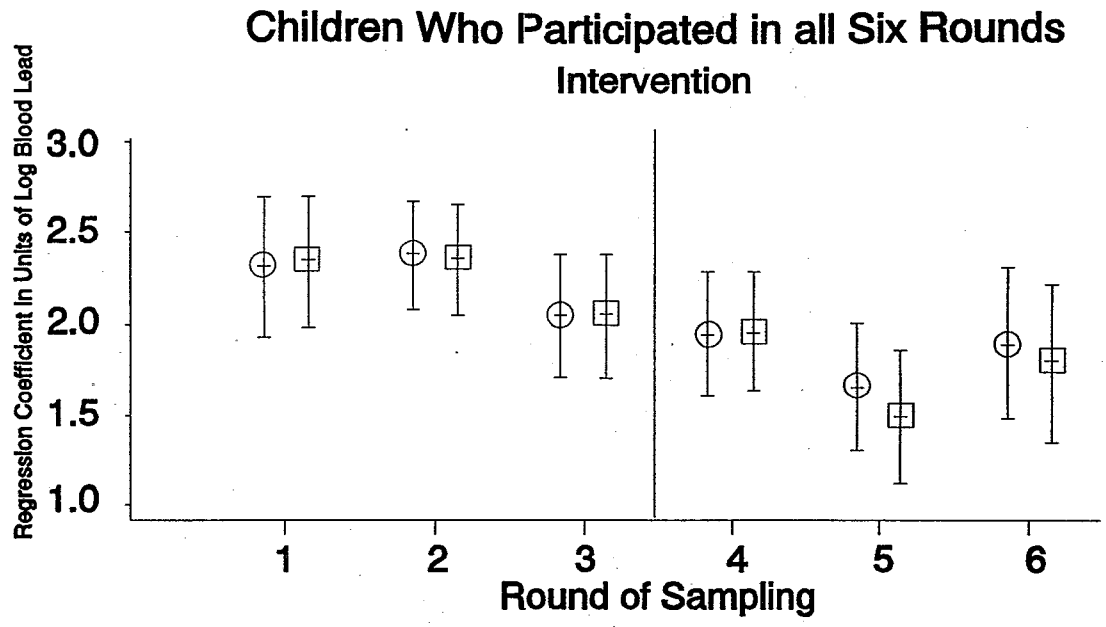
TABLE 7-8. REGRESSION COEFFICIENT FOR ADJUSTED EFFECT OF ABATEMENT ON BLOOD LEAD MODEL 2

Children Present In All Six Rounds of Sampling

		Log (Blood Lead)		Blood Lead	
Round	Group	EST	SE	EST	SE
1	Treatment	2.319	0.1947	10.1655	1.97922
	Control	2.341	0.1832	10.3916	1.90375
2	Treatment	2.388	0.1562	10.8917	1.70128
	Control	2.361	0.1590	10.6015	1.68565
3	Treatment	2.069	0.1728	7.9169	1.36804
	Control	2.073	0.1712	7.9486	1.36081
	INTERVENTION				
4	Treatment	1.977	0.1669	7.2210	1.20519
	Control	1.998	0.1623	7.3743	1.19685
5	Treatment	1.710	0.1743	5.5290	0.96370
	Control	1.549	0.1879	4.7068	0.88440
6	Treatment	1.956	0.2066	7.0710	1.46087
	Control	1.854	0.2186	6.3853	1.39583

All Children Sampled Throughout Experiment

		Log (Blood Lead)		Blood Lead	
Round	Group	EST	SE	EST	SE
1	Treatment	2.333	0.1306	10.3088	1.34633
	Control	2.327	0.1265	10.2472	1.29626
2	Treatment	2.441	0.1209	11.4845	1.38848
	Control	2.431	0.1197	11.3702	1.36102
3	Treatment	2.202	0.1378	9.0431	1.24614
	Control	2.213	0.1349	9.1431	1.23340
	INTERVENTION				
4	Treatment	2.094	0.1304	8.1173	1.05850
	Control	2.094	0.1283	8.1173	1.04145
5	Treatment	1.874	0.1512	6.5143	0.98496
	Control	1.665	0.1662	5.2857	0.87848
6	Treatment	2.095	0.1631	8.1254	1.32526
	Control	1.954	0.1736	7.0569	1.22507



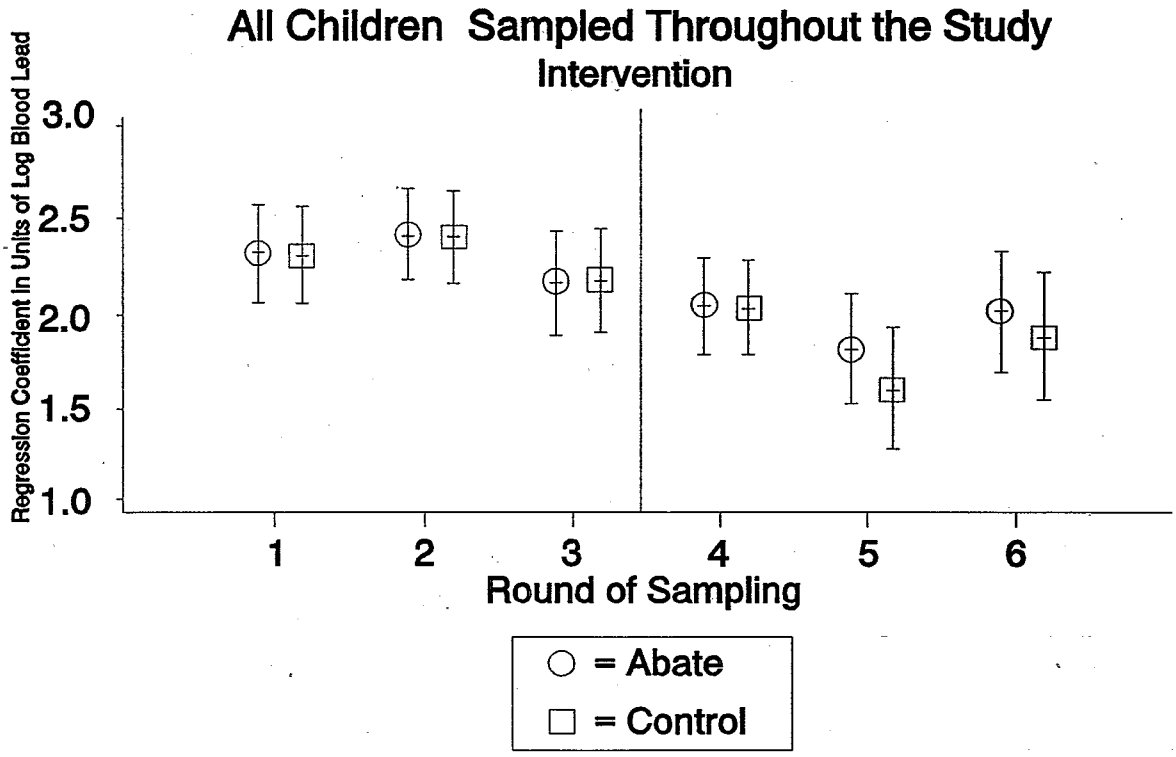


Figure 7-4. Model 2 results of effect of soil abatement on blood lead, log transformed. Bars show 95% confidence interval on regression coefficient.

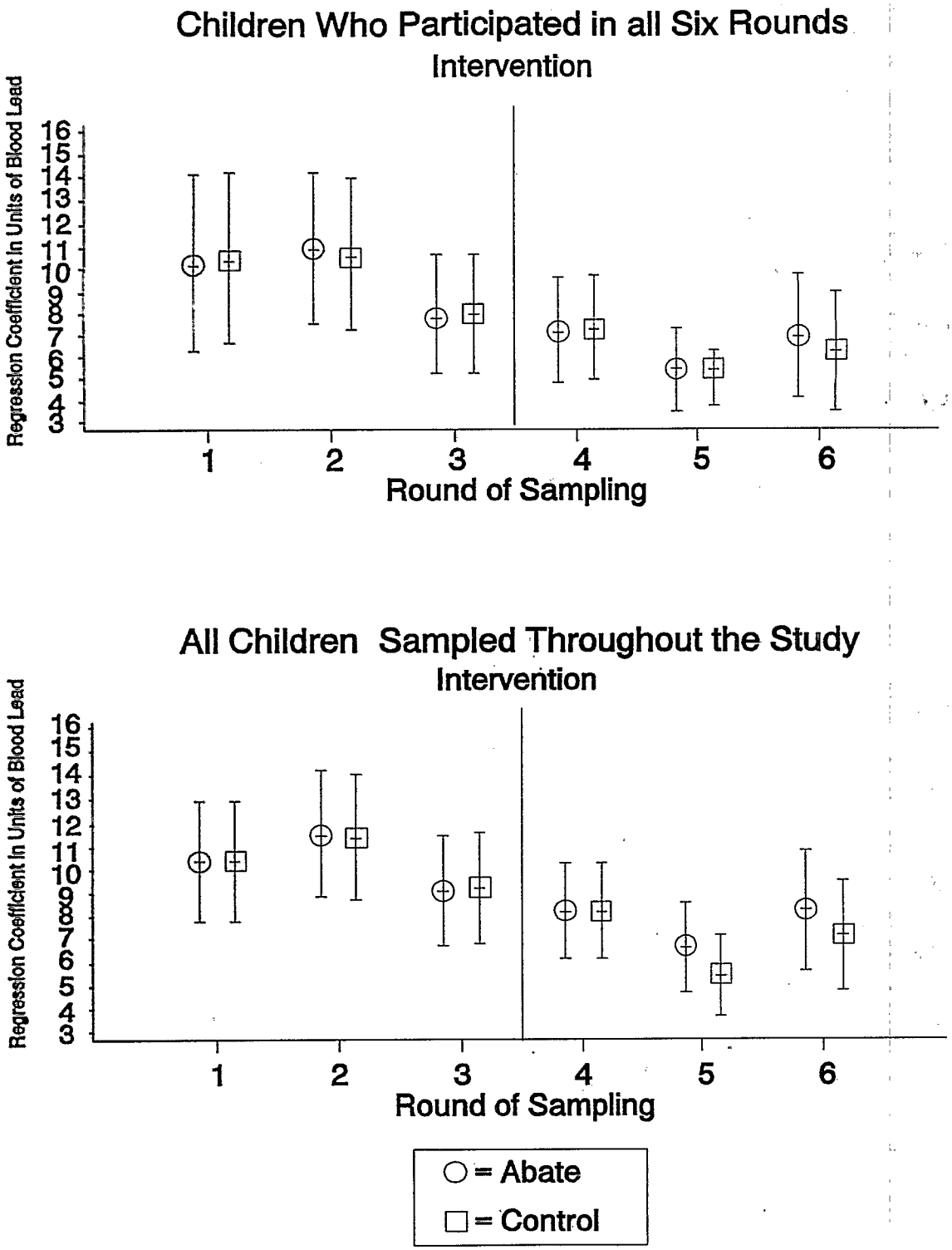
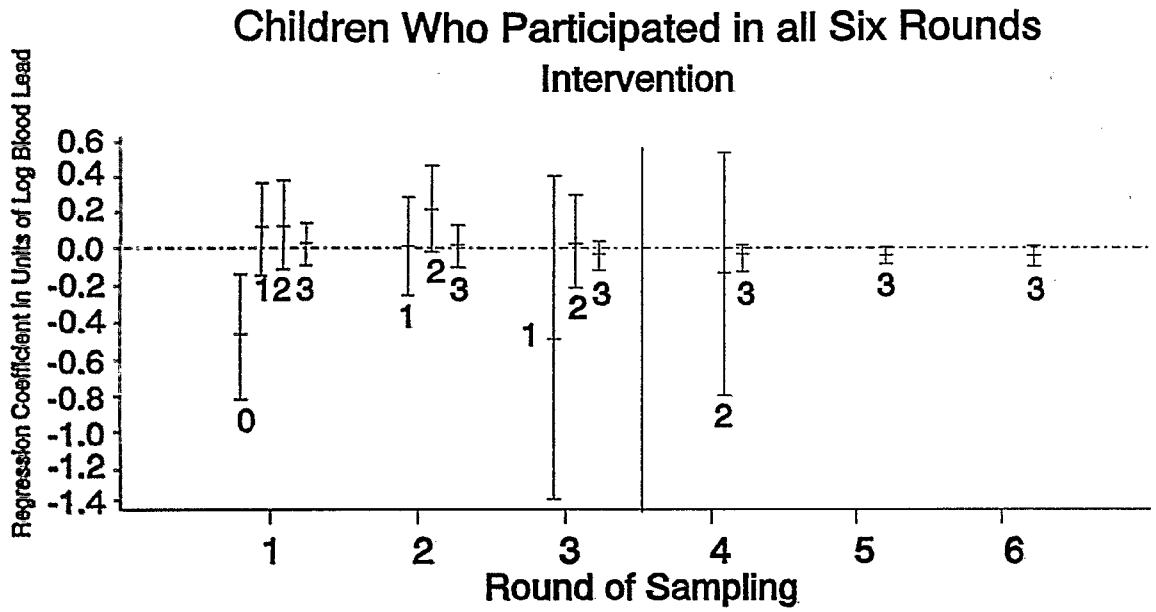


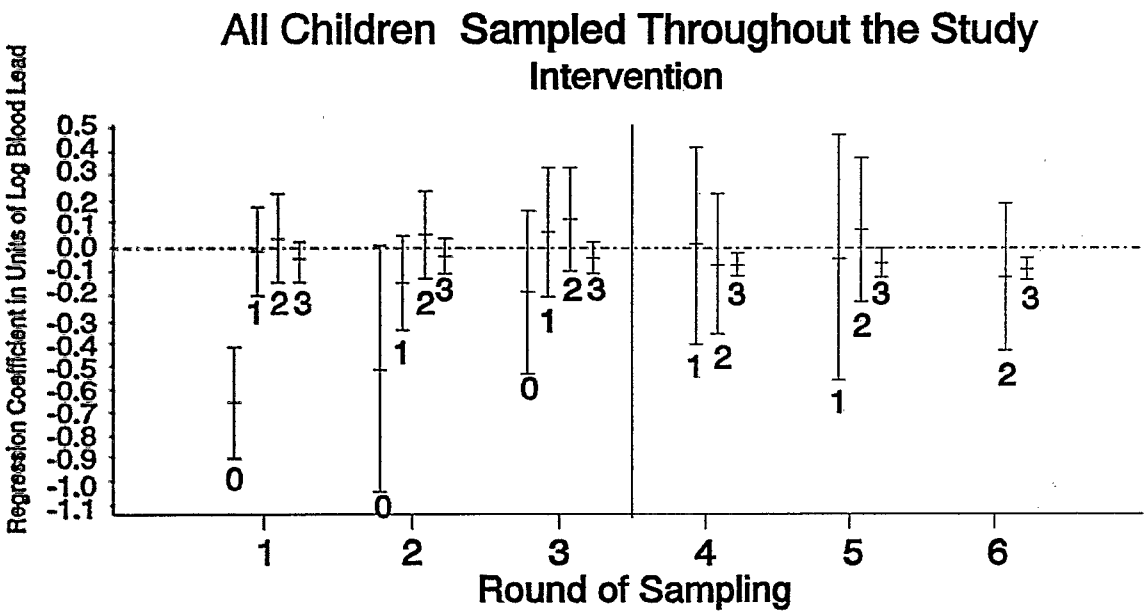
Figure 7-5. Model 2 results of effect of soil abatement on blood lead. Bars show 95% confidence interval on regression coefficient.

TABLE 7-9. REGRESSION COEFFICIENT FOR EFFECT OF AGE ON BLOOD LEAD MODEL 2

Children Present In All Six Rounds of Sampling					
		Log (Blood Lead)		Blood Lead	
Round	Group	EST	SE	EST	SE
1	Age 0	-0.46810	0.17720	0.62619	0.11096
	Age 1	0.11890	0.13280	1.12626	0.14957
	Age 2	0.13090	0.12460	1.13985	0.14203
	Age 3	0.02635	0.05892	1.02670	0.06049
2	Age 1	0.00754	0.13890	1.00757	0.13995
	Age 2	0.21740	0.12720	1.24284	0.15809
	Age 3	0.02353	0.05385	1.02381	0.05513
3	Age 1	-0.49180	0.46130	0.61152	0.28210
	Age 2	0.03714	0.13620	1.03784	0.14135
	Age 3	-0.04629	0.04060	0.95477	0.03876
	INTERVENTION				
4	Age 2	-0.13210	0.34310	0.87625	0.30064
	Age 3	-0.05259	0.02992	0.94877	0.02839
5	Age 3	-0.04856	0.02675	0.95260	0.02548
6	Age 3	-0.04667	0.02956	0.95440	0.02821

All Children Sampled Throughout Experiment					
		Log (Blood Lead)		Blood Lead	
Round	Group	EST	SE	EST	SE
1	Age 0	-0.65580	0.12450	0.51903	0.06462
	Age 1	-0.01758	0.09485	0.98257	0.09320
	Age 2	0.03895	0.09171	1.03972	0.09535
	Age 3	-0.04762	0.03830	0.95350	0.03652
2	Age 0	-0.51210	0.26700	0.59924	0.16000
	Age 1	-0.14680	0.10140	0.86347	0.08756
	Age 2	0.05951	0.09507	1.06132	0.10090
	Age 3	-0.03420	0.03748	0.96638	0.03622
3	Age 0	-0.18430	0.17720	0.83169	0.14737
	Age 1	0.07009	0.13960	1.07260	0.14974
	Age 2	0.12180	0.10790	1.12953	0.12188
	Age 3	-0.04249	0.03370	0.95840	0.03230
	INTERVENTION				
4	Age 1	0.02029	0.21100	1.02050	0.21532
	Age 2	-0.06191	0.15040	0.93997	0.14137
	Age 3	-0.07006	0.02446	0.93234	0.02280
5	Age 1	-0.02518	0.26480	0.97513	0.25822
	Age 2	0.08798	0.15340	1.09197	0.16751
	Age 3	-0.06385	0.02378	0.93815	0.02231
6	Age 2	-0.10740	0.15940	0.89817	0.14317
	Age 3	-0.06745	0.02294	0.93477	0.02144





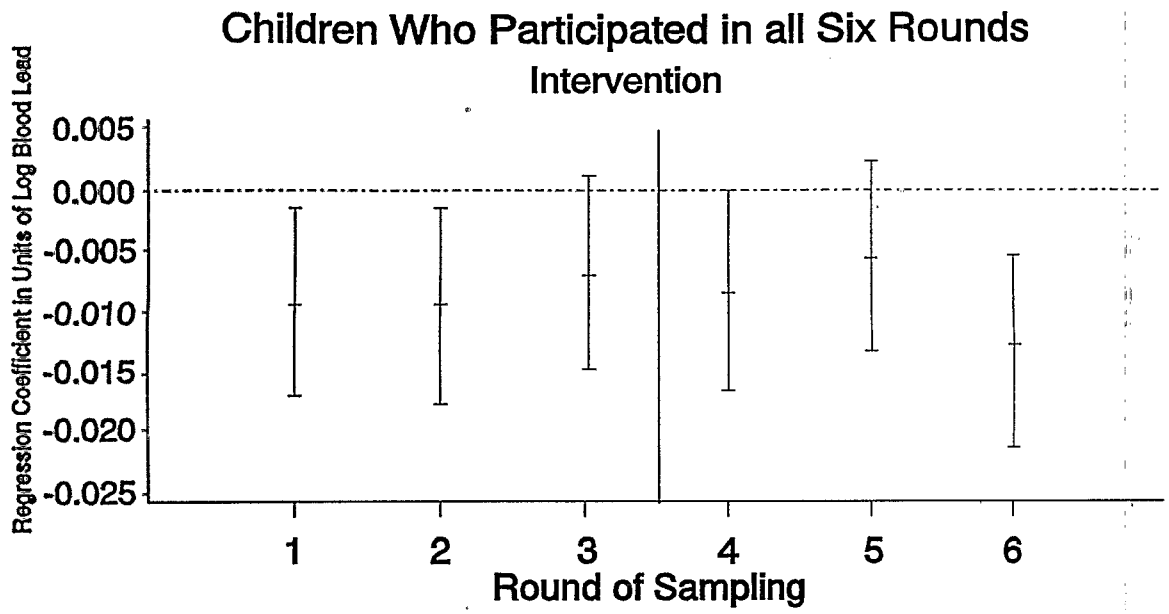
0 = Age0	2 = Age2
1 = Age1	3 = Age3

Figure 7-6. Model 2 results of effect of age on blood lead, log transformed. Bars show 95% confidence interval on regression coefficient.

TABLE 7-10. REGRESSION COEFFICIENT FOR EFFECT OF SES ON BLOOD LEAD MODEL 2

Children Present In All Six Rounds of Sampling				
	Log (Blood Lead)		Blood Lead	
Round	EST	SE	EST	SE
1	-0.009112	.003973	0.99093	.0039370
2	-0.009250	.004070	0.99079	.0040325
3	-0.006410	.004198	0.99361	.0041712
INTERVENTION				
4	-0.007688	0.004291	0.99234	.0042581
5	-0.004526	0.003968	0.99548	.0039501
6	-0.012690	0.004315	0.98739	.0042606
All Children Sampled Throughout Experiment				
	Log (Blood Lead)		Blood Lead	
Round	EST	SE	EST	SE
1	-0.009923	.002417	0.99013	.0023931
2	-0.010820	.002662	0.98924	.0026334
3	-0.007053	.003221	0.99297	.0031984
INTERVENTION				
4	-0.008668	.003405	0.99137	.0033756
5	-0.007217	.003319	0.99281	.0032951
6	-0.012290	.003347	0.98779	.0033061

Hand lead is positively associated with blood lead, as indicated by this model. Mouthing behavior acts as an effect modifier for hand lead in this model, so that the effect of hand lead is calculated separately for the two types of mouthing behavior. Although there is no significant difference between these types of behavior, it is comforting to observe that the effect of hand lead on blood lead is consistently higher for those children who exhibit strong mouthing behavior (Table 7-12 and Figure 7-9).



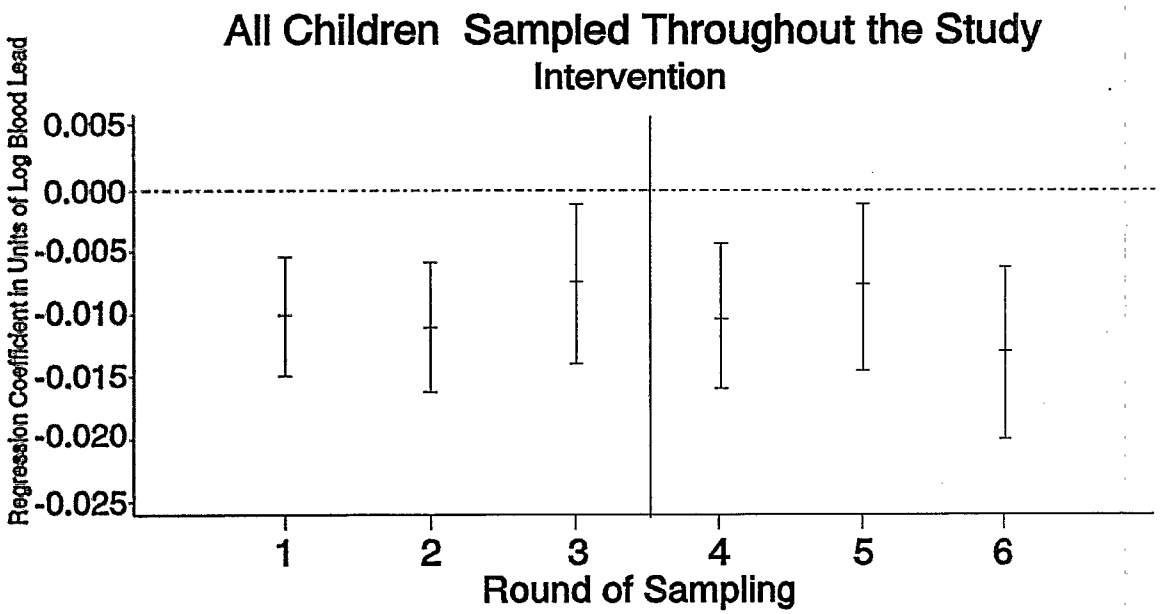


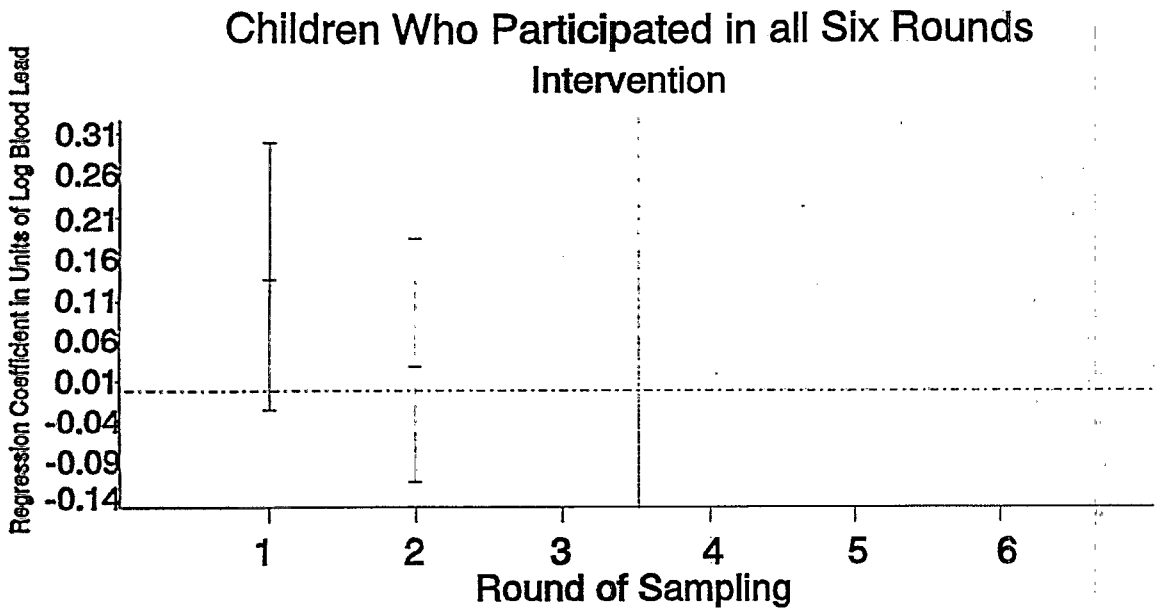
Figure 7-7. Model 2 results of effect of socioeconomic status on blood lead, log transformed. Bars show 95% confidence intervals on regression coefficient.

TABLE 7-11. REGRESSION COEFFICIENT FOR EFFECT OF SEASON ON BLOOD LEAD MODEL 2

Children Present In All Six Rounds of Sampling				
	Log (Blood Lead)		Blood Lead	
Round	EST	SE	EST	SE
1	0.13700	0.08284	1.14683	0.095003
2	0.03492	0.07738	1.03554	0.080130
All Children Sampled Throughout Experiment				
	Log (Blood Lead)		Blood Lead	
Round	EST	SE	EST	SE
1	0.13910	0.05343	1.14924	0.061404
2	0.00414	0.05630	1.00415	0.056534

7.4.3 Model 3

As in the first model, Geometric means of hand lead and their associated standard errors are calculated in each round for both the treatment and control groups in this model. This measures the direct effect of group assignment on hand lead. The geometric means of the two groups seemed to be almost identical to each other in the first 3 rounds, indicating that there is no detectable difference between the two groups in hand lead measure prior to intervention. In round four, the children in the control group on average had slightly lower hand lead concentration than children in the treatment group. This difference is not statistically valid, and the hand lead measurements in round four were taken between the months of January and February, when children have little exposure to soil in the city of Baltimore. Rounds five and six took place during the summer. Although the difference is not statistically valid, the hand lead measurements of children in the abated group are lower on average in the last two rounds of sampling (Table 7-13 and Figures 7-10 and 7-11).



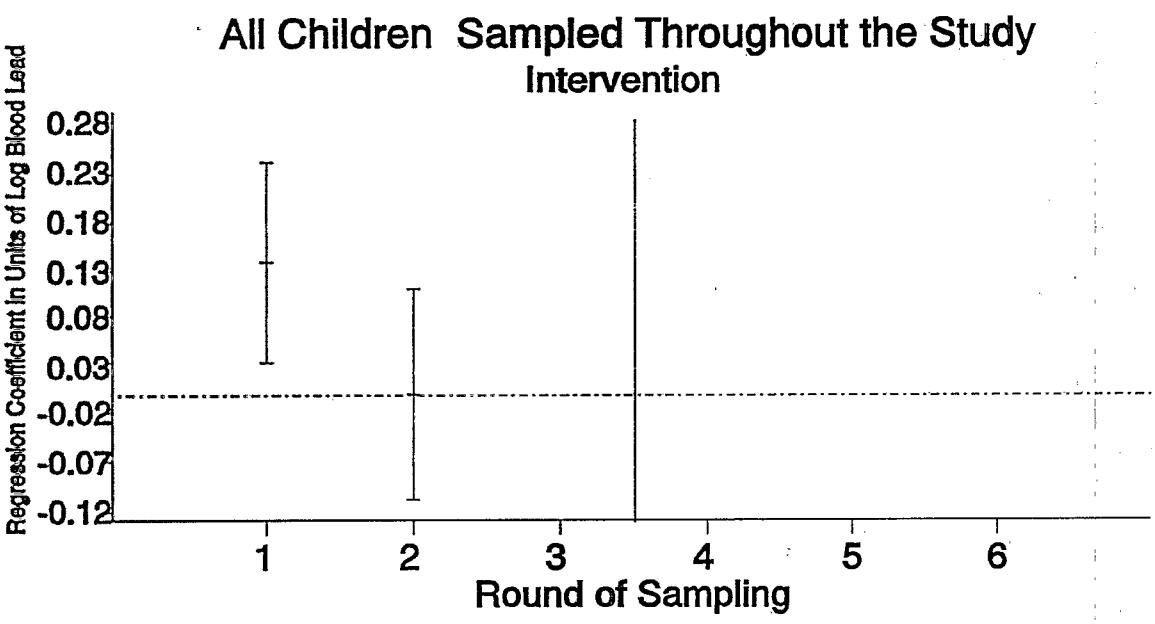


Figure 7-8. Model 2 results of effect of season on blood lead, log transformed. Bars show 95% confidence interval on regression coefficient.

TABLE 7-12. REGRESSION COEFFICIENT FOR EFFECT OF LOG HAND LEAD ON BLOOD LEAD MODEL 2

Children Present In All Six Rounds of Sampling

		Log (Blood Lead)		Blood Lead	
Round	Group	EST	SE	EST	SE
1	Weak	0.06375	0.06111	1.06583	0.06513
	Strong	0.14500	0.05798	1.15604	0.06703
2	Weak	0.02039	0.04701	1.02060	0.04798
	Strong	0.07505	0.04542	1.07794	0.04896
3	Weak	0.15650	0.05300	1.16941	0.06198
	Strong	0.23520	0.05273	1.26516	0.06671
	INTERVENTION				
4	Weak	0.19030	0.05733	1.20961	0.06935
	Strong	0.28240	0.05888	1.32631	0.07809
5	Weak	0.25380	0.04902	1.28891	0.06318
	Strong	0.38870	0.05584	1.47506	0.08237
6	Weak	0.26090	0.06144	1.29810	0.07976
	Strong	0.35800	0.07089	1.43047	0.10141

All Children Sampled Throughout Experiment

		Log (Blood Lead)		Blood Lead	
Round	Group	EST	SE	EST	SE
1	Weak	0.11390	0.04152	1.12064	0.04653
	Strong	0.16500	0.03896	1.17939	0.04595
2	Weak	0.06129	0.03494	1.06321	0.03715
	Strong	0.10270	0.03445	1.10816	0.03818
3	Weak	0.08384	0.04169	1.08745	0.04534
	Strong	0.18150	0.04068	1.19901	0.04878
	INTERVENTION				
4	Weak	0.16470	0.04659	1.17904	0.05493
	Strong	0.27190	0.04401	1.31246	0.05776
5	Weak	0.24530	0.04527	1.27800	0.05786
	Strong	0.37150	0.05017	1.44991	0.07274
6	Weak	0.24120	0.04998	1.27278	0.06361
	Strong	0.33010	0.05402	1.39111	0.07515

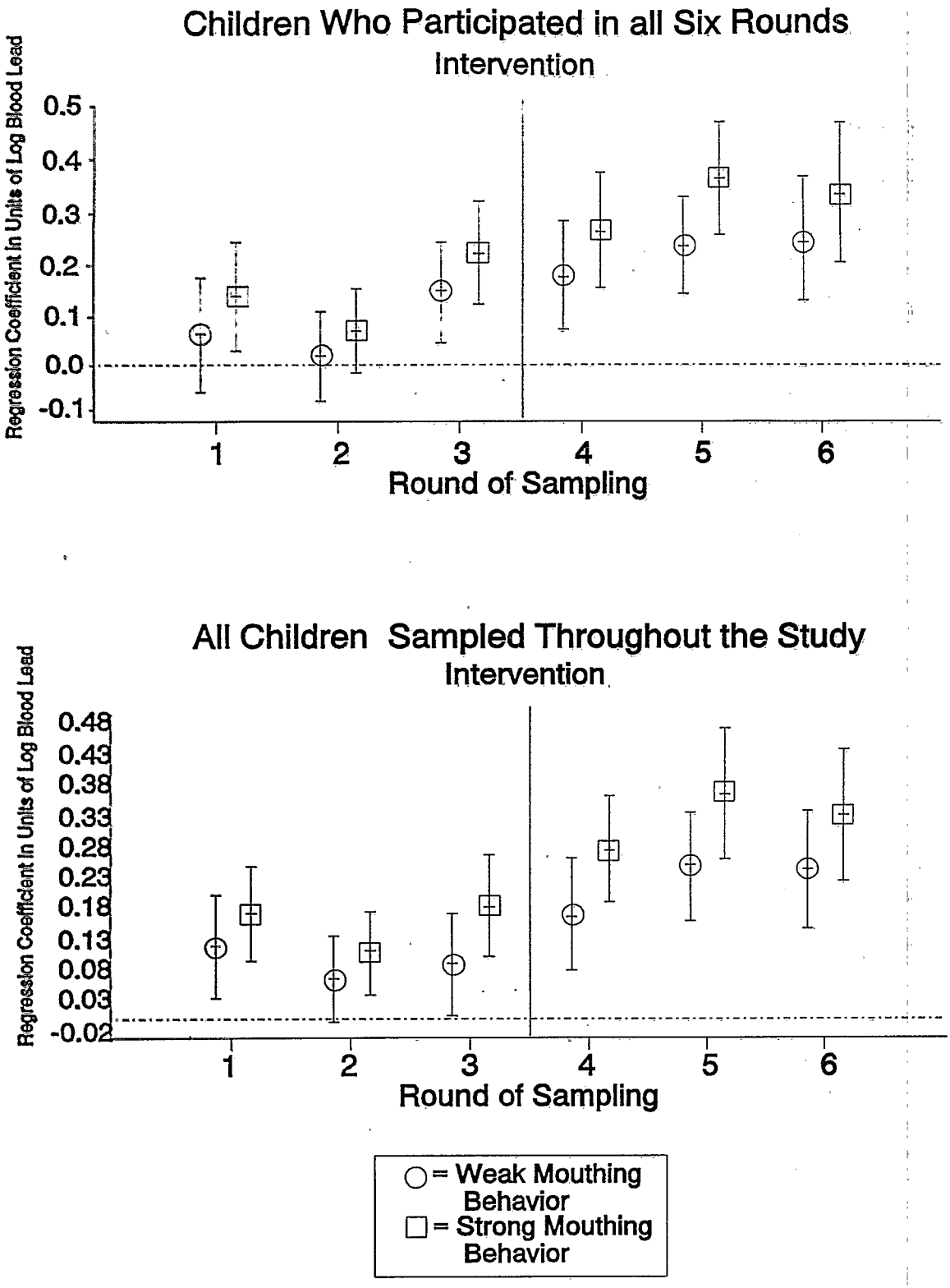


Figure 7-9. Model 2 results of effect of hand lead on blood lead, log transformed. Bars show 95% confidence interval on regression coefficient.

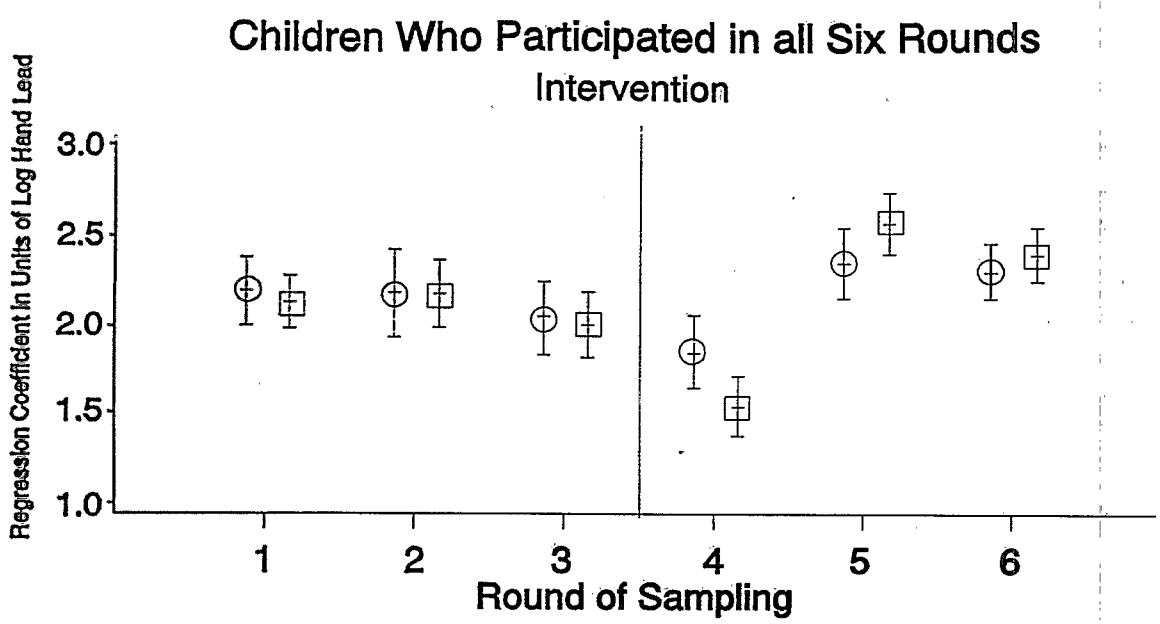
TABLE 7-13. REGRESSION COEFFICIENTS FOR EFFECT OF ABATEMENT ON HAND LEAD MODEL 3

Children Present In All Six Rounds of Sampling

		Log (Hand Lead)		Hand Lead	
Round	Group	EST	SE	EST	SE
1	Treatment	2.198	0.09658	9.0070	0.86989
	Control	2.136	0.07886	8.4655	0.66759
2	Treatment	2.187	0.12480	8.9084	1.11177
	Control	2.191	0.09972	8.9442	0.89191
3	Treatment	2.053	0.10970	7.7912	0.85470
	Control	2.021	0.09397	7.5459	0.70909
	INTERVENTION				
4	Treatment	1.878	0.10300	6.5404	0.67366
	Control	1.565	0.08781	4.7827	0.41997
5	Treatment	2.387	0.10210	10.8808	1.11093
	Control	2.616	0.08934	13.6809	1.22225
6	Treatment	2.352	0.08260	10.5066	0.86784
	Control	2.451	0.07719	11.5999	0.89540

All Children Sampled Throughout Experiment

		Log (Hand Lead)		Hand Lead	
Round	Group	EST	SE	EST	SE
1	Treatment	2.095	0.09132	8.1254	0.74202
	Control	2.090	0.05466	8.0849	0.44192
2	Treatment	2.157	0.11280	8.6452	0.97517
	Control	2.278	0.06462	9.7571	0.63051
3	Treatment	1.899	0.08919	6.6792	0.59572
	Control	1.958	0.07243	7.0851	0.51318
	INTERVENTION				
4	Treatment	1.859	0.08674	6.4173	0.55664
	Control	1.544	0.08724	4.6833	0.40857
5	Treatment	2.347	0.08131	10.4542	0.85003
	Control	2.627	0.07992	13.8322	1.10547
6	Treatment	2.374	0.07138	10.7403	0.76664
	Control	2.448	0.07222	11.5652	0.83524



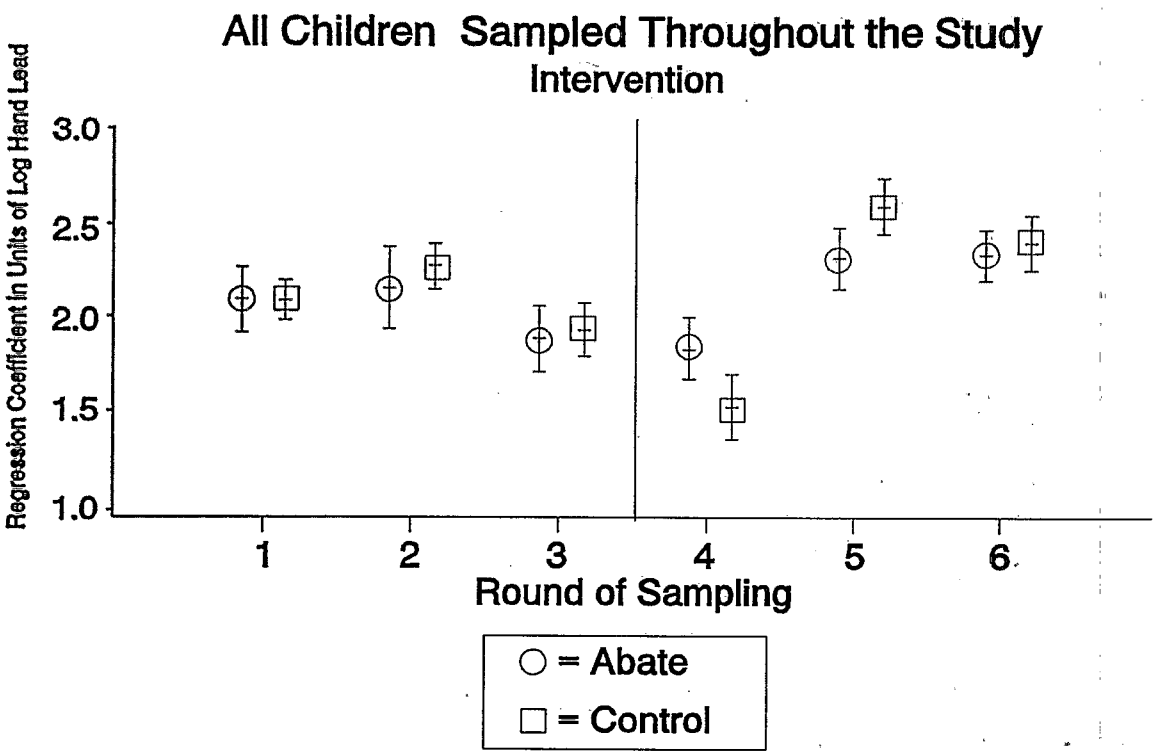
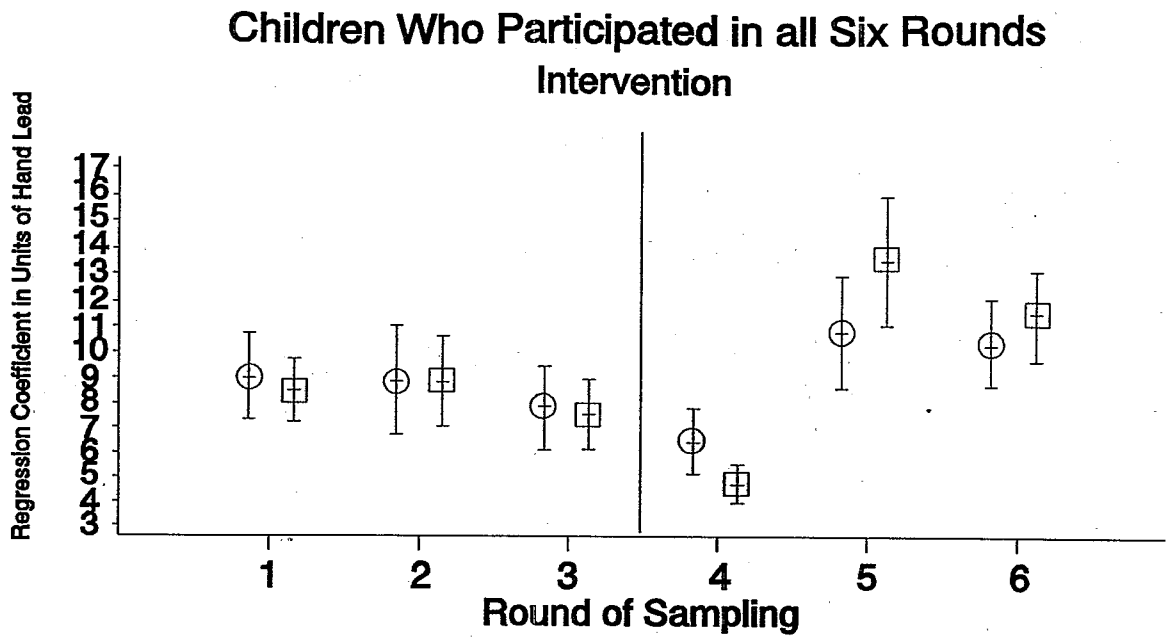


Figure 7-10. Model 3 results of effect of soil abatement on hand lead, log transformed. Bars show 95% confidence interval on regression coefficient.



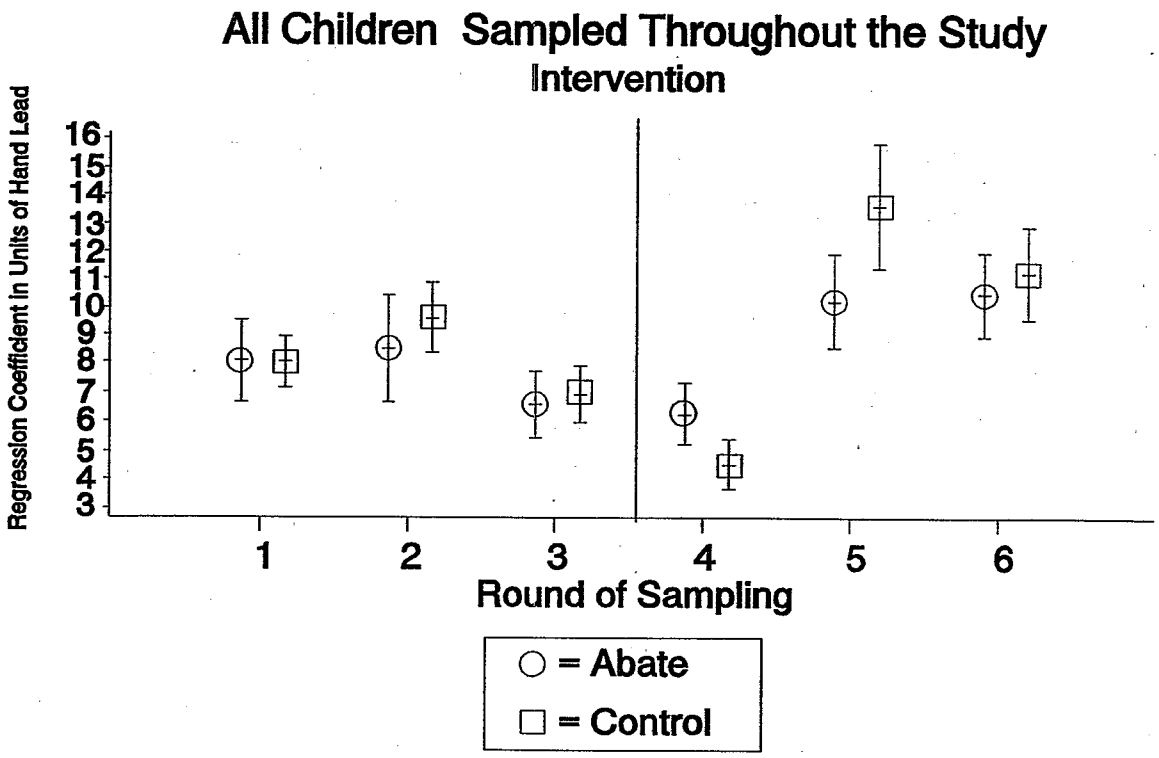


Figure 7-11. Model 3 results of effect of soil abatement on hand lead. Bars show 95% confidence interval on regression coefficient.

7.4.4 Model 4

This model is similar to the second model, in that it computed geometric means and associated standard errors for group assignment after adjusting for variables that are thought to be influence a child's hand lead concentration. The regression coefficients for the effect of group assignment in this model are similar to those found in the third model, although the associated standard errors are somewhat larger. There is no detectable difference between the two groups in the rounds prior to intervention. The differences observed in the effect of group assignment on hand lead following soil abatement were not statistically significant (Table 7-14 and Figures 7-12 and 7-13).

There was a positive association between age and hand lead measurements in the sampling rounds of the experiment prior to intervention. Although this effect was not statistically valid, one interpretation of this result is that as children are more active and are supervised less as they grow older (Table 7-15 and Figure 7-14).

Gender was added as a covariate for hand lead, because it was observed that the female participants seemed to have better personal hygiene. The regression coefficient for female gender in this model was consistently negative as expected (Table 7-16 and Figure 7-15).

Hand lead was measured over a change in season for the first 2 rounds, therefore a covariate which indicates this seasonal change was included in the model. This covariate was not significant in either round for this model (Table 7-17 and Figure 7-16).

A measure of interior dust lead concentration was added as a covariate in this model. The effect of dust lead on hand lead is consistently positive throughout the experiment. This effect seems weaker in those rounds that took place over the summer, indicating that the children probably spend less time inside their houses in these rounds (Table 7-18 and Figure 7-17).

7.4.5 Model 5

The final model attempts to measure the effect of both soil and dust lead concentration on hand lead measures independent of the effect of group assignment. Soil concentrations measured before intervention were used as covariates in rounds 1 through 3 in the abated properties. Following intervention, soil samples from the abated properties were collected and analyzed for use as the soil covariate in the abated properties for the remaining 3 rounds.

TABLE 7-14. REGRESSION COEFFICIENTS FOR ADJUSTED EFFECT OF ABATEMENT ON BLOOD LEAD MODEL 2

Children Present In All Six Rounds of Sampling

		Log (Hand Lead)		Hand Lead	
Round	Group	EST	SE	EST	SE
1	Treatment	2.498	0.1937	12.1582	2.35503
	Control	2.394	0.1739	10.9572	1.90546
2	Treatment	1.933	0.2311	6.9102	1.59695
	Control	1.979	0.2214	7.2355	1.60194
3	Treatment	2.239	0.1974	9.3839	1.85239
	Control	2.267	0.1870	9.6504	1.80463
	INTERVENTION				
4	Treatment	1.789	0.1752	5.9835	1.04830
	Control	1.531	0.1692	4.6228	0.78218
5	Treatment	2.192	0.1764	8.9531	1.57933
	Control	2.456	0.1704	11.6581	1.98654
6	Treatment	2.422	0.1567	11.2684	1.76575
	Control	2.556	0.1557	12.8842	2.00607

All Children Sampled Throughout Experiment

		Log (Hand Lead)		Hand Lead	
Round	Group	EST	SE	EST	SE
1	Treatment	2.298	0.1451	9.9543	1.44436
	Control	2.259	0.1313	9.5753	1.25700
2	Treatment	1.794	0.1794	6.0135	1.07881
	Control	1.902	0.1611	6.6993	1.07925
3	Treatment	2.141	0.1643	8.5079	1.39785
	Control	2.187	0.1516	8.9084	1.35052
	INTERVENTION				
4	Treatment	1.691	0.1560	5.4249	0.84628
	Control	1.444	0.1574	4.2376	0.66700
5	Treatment	2.232	0.1428	9.3185	1.33068
	Control	2.521	0.1464	12.4410	1.82137
6	Treatment	2.402	0.1313	11.0452	1.45024
	Control	2.505	0.1362	12.2436	1.66757

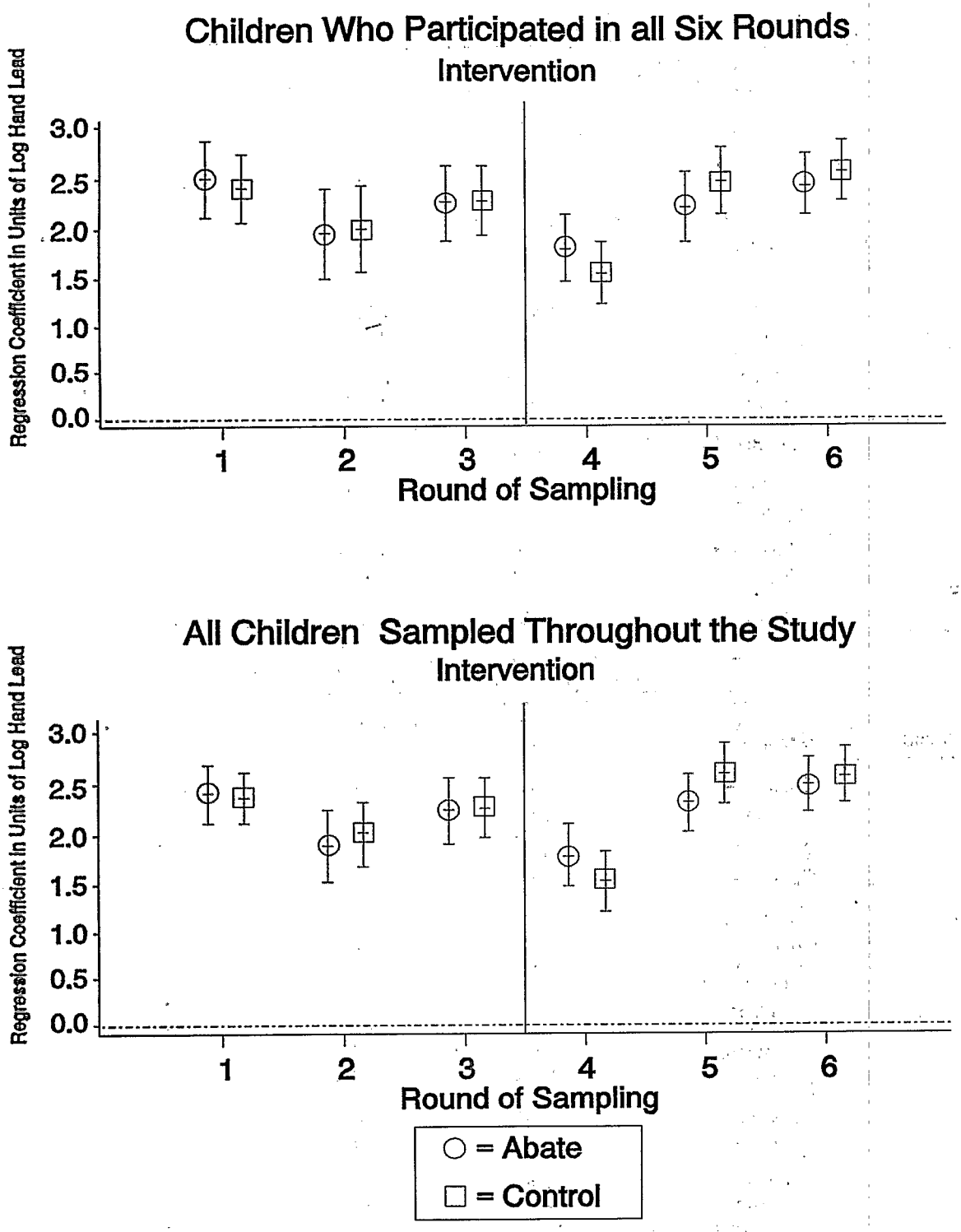


Figure 7-12. Model 4 results of effect of soil abatement on hand lead, log transformed. Bars show 95% confidence interval on regression coefficient.

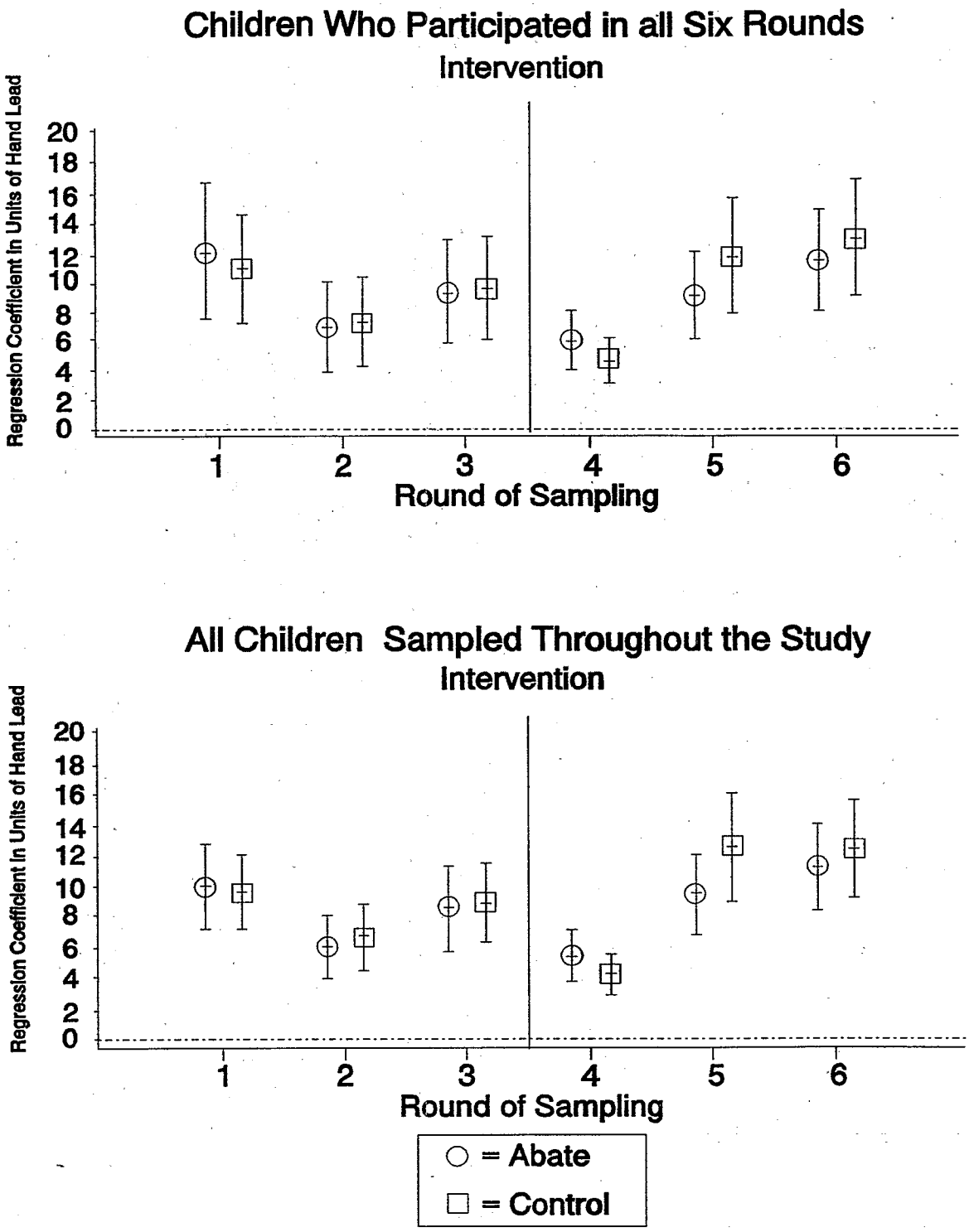
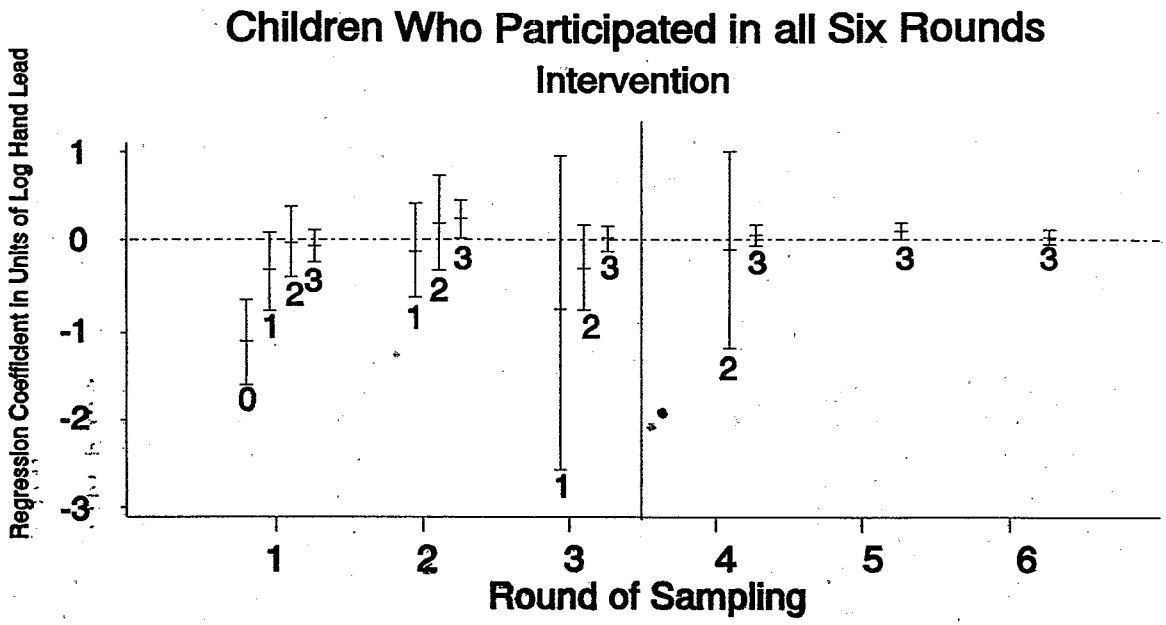


Figure 7-13. Model 4 results of effect of soil abatement on hand lead. Bars show 95% confidence interval on regression coefficient.

TABLE 7-15. REGRESSION COEFFICIENTS FOR EFFECT OF AGE ON HAND LEAD MODEL 4

Children Present In All Six Rounds of Sampling					
		Log (Hand Lead)		Hand Lead	
Round	Group	EST	SE	EST	SE
1	Age 0	-1.10200	0.25130	0.33221	0.08348
	Age 1	-0.33540	0.19940	0.71505	0.14258
	Age 2	0.00674	0.19320	1.00676	0.19451
	Age 3	-0.03076	0.09023	0.96971	0.08750
2	Age 1	-0.15050	0.26730	0.86028	0.22995
	Age 2	0.16700	0.24980	1.18175	0.29520
	Age 3	0.20380	0.10150	1.22605	0.12444
3	Age 1	-0.79020	0.79460	0.45375	0.36055
	Age 2	-0.31750	0.23140	0.72797	0.16845
	Age 3	-0.00479	0.06893	0.99522	0.06860
	INTERVENTION				
4	Age 2	-0.13830	0.55240	0.87084	0.48105
	Age 3	0.04095	0.04757	1.04180	0.04956
5	Age 3	0.08735	0.04513	1.09128	0.04925
6	Age 3	0.03363	0.03881	1.03420	0.04014

All Children Sampled Throughout Experiment					
		Log (Hand Lead)		Hand Lead	
Round	Group	EST	SE	EST	SE
1	Age 0	-1.21400	0.18400	0.29701	0.05465
	Age 1	-0.41660	0.14850	0.65928	0.09790
	Age 2	-0.07236	0.14810	0.93020	0.13776
	Age 3	0.01890	0.06098	1.01908	0.06214
2	Age 0	-0.72620	0.50740	0.48374	0.24545
	Age 1	-0.11540	0.19240	0.89101	0.17143
	Age 2	0.06398	0.18190	1.06607	0.19392
	Age 3	0.21540	0.06869	1.24036	0.08520
3	Age 0	-0.68540	0.29330	0.50389	0.14779
	Age 1	-0.45940	0.22920	0.63166	0.14478
	Age 2	-0.21580	0.17980	0.80590	0.14490
	Age 3	0.01716	0.05653	1.01731	0.05751
	INTERVENTION				
4	Age 1	0.83000	0.37990	2.29332	0.87123
	Age 2	0.35360	0.27510	1.42419	0.39179
	Age 3	0.04633	0.04440	1.04742	0.04651
5	Age 1	0.87800	0.43680	2.40608	1.05098
	Age 2	0.01320	0.25880	1.01329	0.26224
	Age 3	0.06734	0.03758	1.06966	0.04020
6	Age 2	0.39450	0.24260	1.48364	0.35993
	Age 3	0.03421	0.00335	1.03480	0.03451



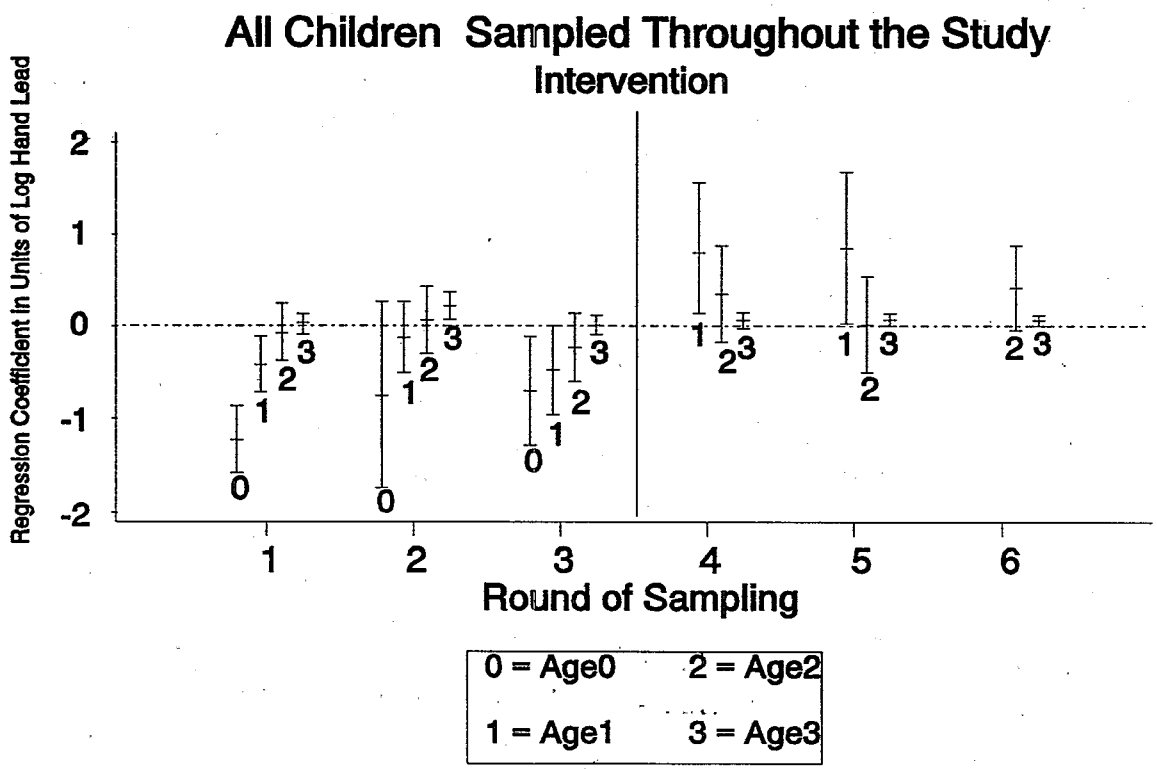


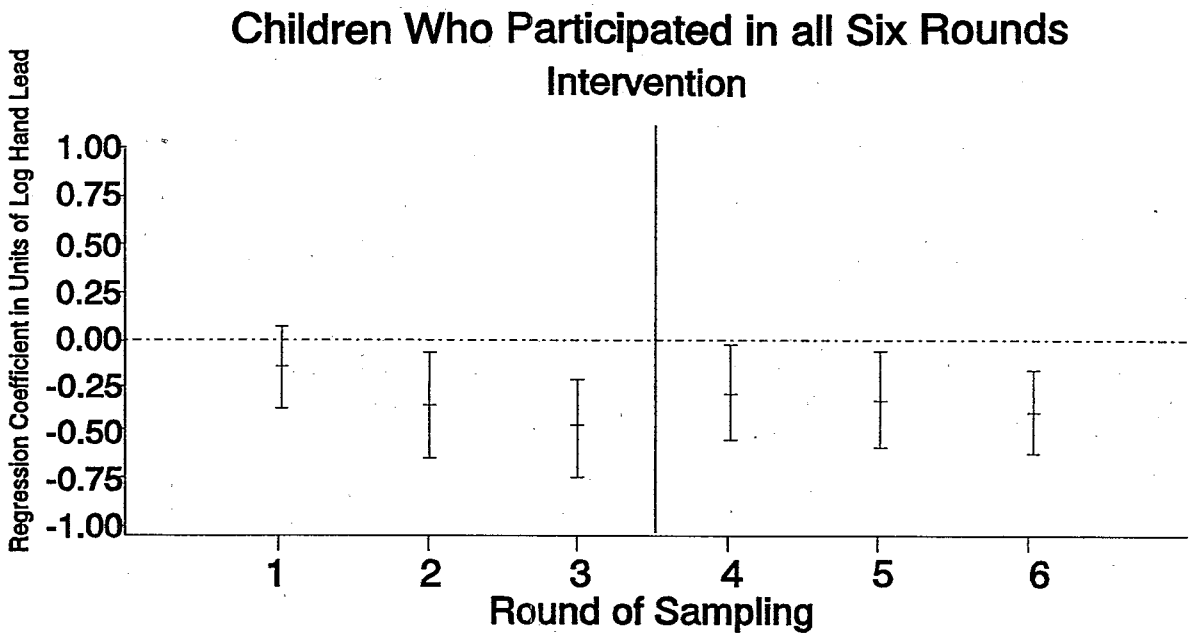
Figure 7-14. Model 4 results of effect of age on hand lead, log transformed. Bars show 95% confidence interval on regression coefficient.

TABLE 7-16. REGRESSION COEFFICIENTS FOR EFFECT OF FEMALE GENDER ON HAND LEAD MODEL 4

Children Present In All Six Rounds of Sampling				
	Log (Hand Lead)		Hand Lead	
Round	EST	SE	EST	SE
1	-0.1454	0.11490	0.86468	0.09935
2	-0.3607	0.14870	0.69719	0.10367
3	-0.4888	0.13740	0.61336	0.08428
INTERVENTION				
4	-0.2887	0.13180	0.74924	0.09875
5	-0.3327	0.13110	0.71699	0.09400
6	-0.4055	0.10930	0.66664	0.07286
All Children Sampled Throughout Experiment				
	Log (Hand Lead)		Hand Lead	
Round	EST	SE	EST	SE
1	-0.1462	0.08502	0.86398	0.07346
2	-0.1378	0.10600	0.87127	0.09235
3	-0.4666	0.10530	0.62713	0.06604
INTERVENTION				
4	-0.1999	0.12200	0.81881	0.09990
5	-0.2834	0.11110	0.75322	0.08368
6	-0.3392	0.09927	0.71234	0.07071

The measure of soil lead concentration for properties in the control group remained the same for all six rounds of the experiment. This model also adjusts for covariates that are thought to influence hand lead.

The effect of gender on hand lead in this model is similar to that found in the previous model; hand lead is higher on average for the male participants (Table 7-19 and Figure 7-18).



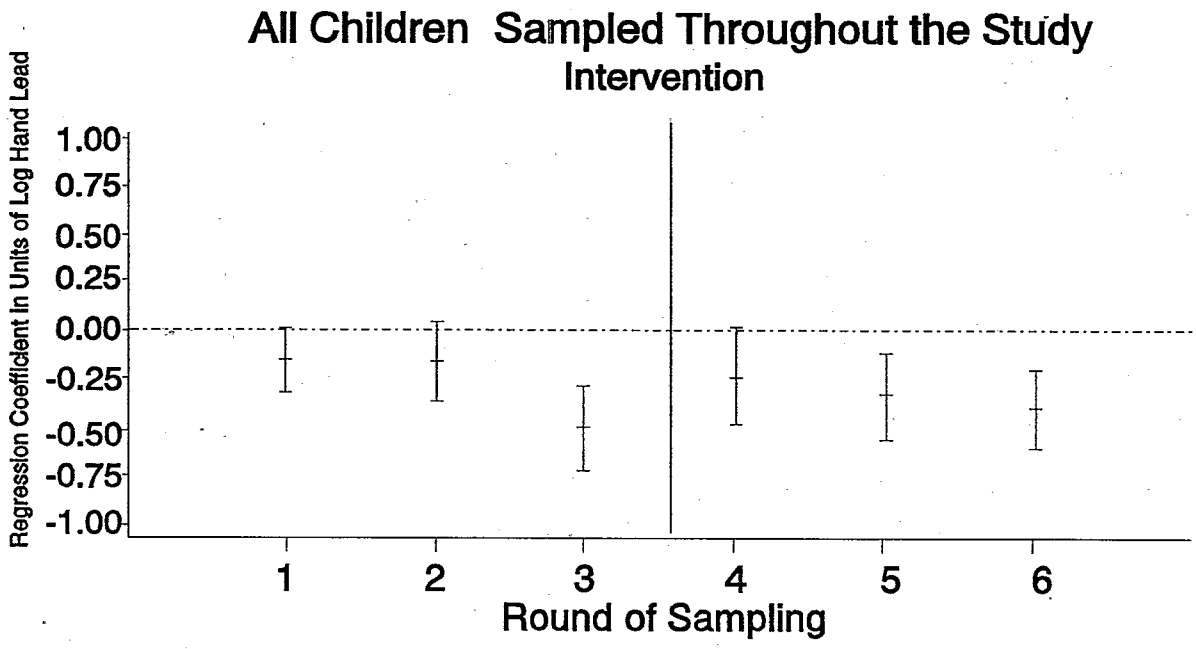


Figure 7-15. Model 4 results of femal gender effect on hand lead, log transformed. Bars show 95% confidence interval on regression coefficient.

TABLE 7-17. REGRESSION COEFFICIENTS FOR EFFECT OF SEASON ON HAND LEAD MODEL 4

Children Present In All Six Rounds of Sampling				
	Log (Hand Lead)		Hand Lead	
Round	EST	SE	EST	SE
1	-0.11910	0.12610	0.88772	0.11194
2	0.05406	0.14940	1.05555	0.15770
All Children Sampled Throughout Experiment				
	Log (Hand Lead)		Hand Lead	
Round	EST	SE	EST	SE
1	0.02264	0.08617	1.02290	0.08814
2	0.12090	0.10570	1.12851	0.11928

Age is positively associated with hand lead (Table 7-20 and Figure 7-19). Change in season has no an effect on the hand lead concentration of children in the study (Table 7-21 and Figure 7-20).

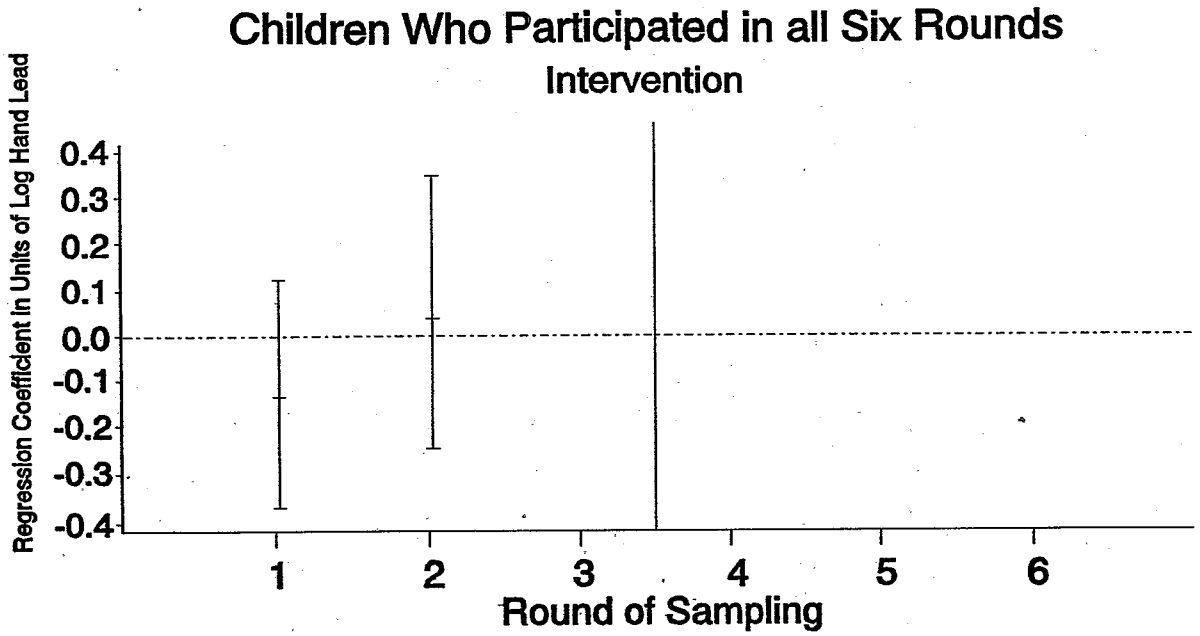
The effect of dust lead concentration on hand lead was consistently positive throughout the experiment. This effect is markedly higher in the sampling rounds that took place during the winter months (Table 7-22 and Figure 7-21).

The effect of soil lead concentration on hand lead was inconsistent throughout the experiment. The inconsistency could not be attributed to season in the same way that the effect of dust lead was explained (Table 7-23 and Figure 7-22).

The R-squared coefficient and estimated mean square error from these 5 models are presented in Table 7-24.

The results of the models applied to the Baltimore data for the purpose of comparison to the Boston and Cincinnati results revealed no statistical difference between treatment and control groups in any of the rounds following intervention. The statistical output from these models are in Appendix I.

The reader will notice that there are different numbers of children included in each of the cross sectional models, even in the population which consisted of children who were



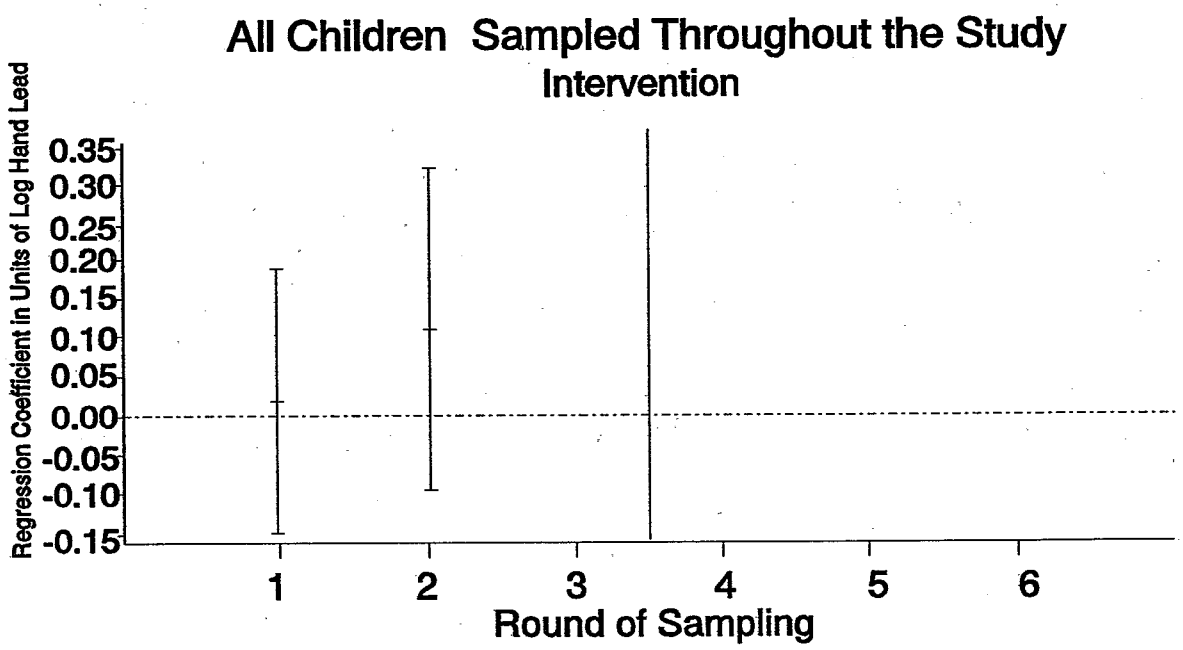
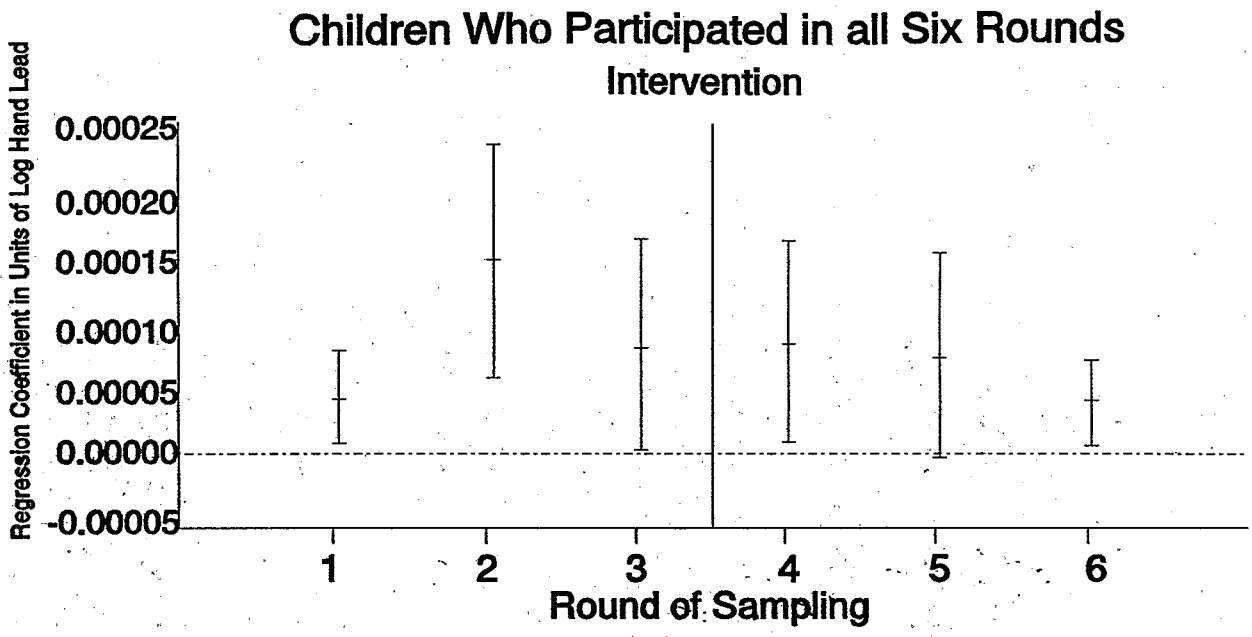


Figure 7-16. Model 4 results of effect of season on hand lead, log transformed. Bars show 95% confidence interval on regression coefficient.

TABLE 7-18. REGRESSION COEFFICIENTS FOR EFFECT OF DUST ON HAND LEAD MODEL 4

Children Present In All Six Rounds of Sampling				
	Log (Hand Lead)		Hand Lead	
Round	EST	SE	EST	SE
1	.00000710	.00003667	1.00000710	.000036670
2	.00014850	.00004625	1.00014851	.000046257
3	.00008436	.00004288	1.00008436	.000042884
INTERVENTION				
4	.00008650	.00004040	1.00008650	.000040403
5	.00007582	.00004064	1.00007582	.000040643
6	.00000500	.00003345	1.00000500	.000033450
All Children Sampled Throughout Experiment				
	Log (Hand Lead)		Hand Lead	
Round	EST	SE	EST	SE
1	.00003876	.00003166	1.00003876	.000031661
2	.00015090	.00003866	1.00015091	.000038666
3	.00008175	.00003749	1.00008175	.000037493
INTERVENTION				
4	.00008103	.00003922	1.00008103	.000039223
5	.00006544	.00003703	1.00006544	.000037032
6	.00001513	.00003226	1.00001513	.000032260



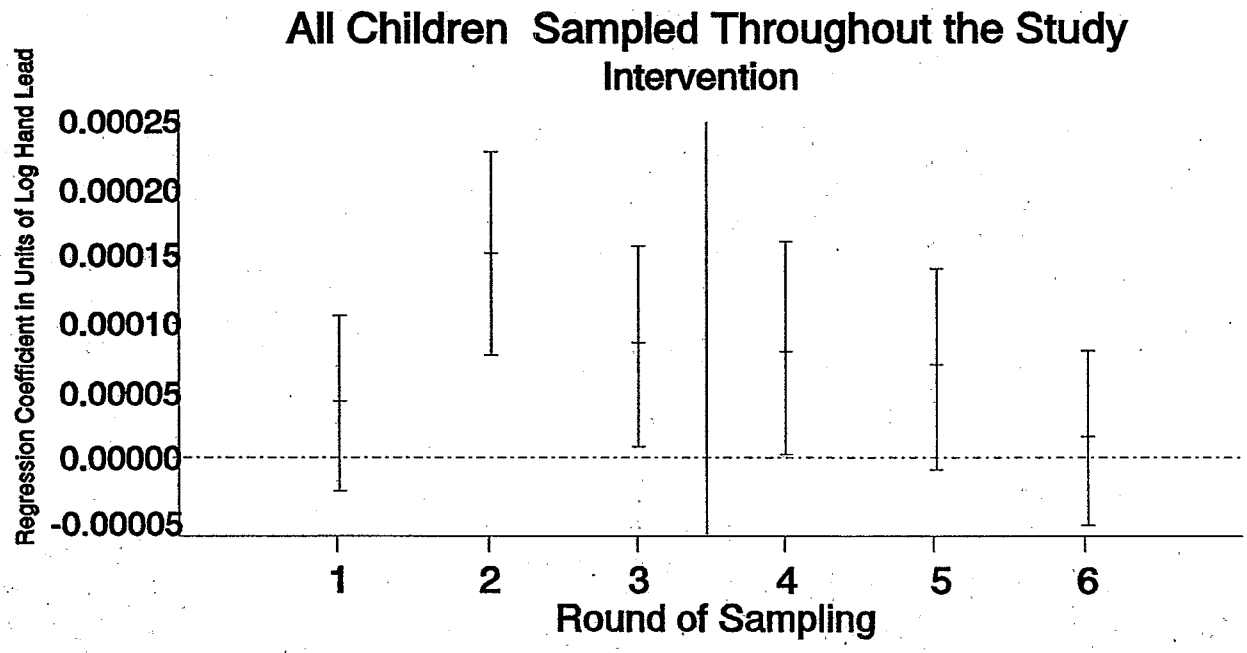


Figure 7-17. Model 4 results of effect of dust lead on hand lead, log transformed. Bars show 95% confidence interval on regression coefficient.

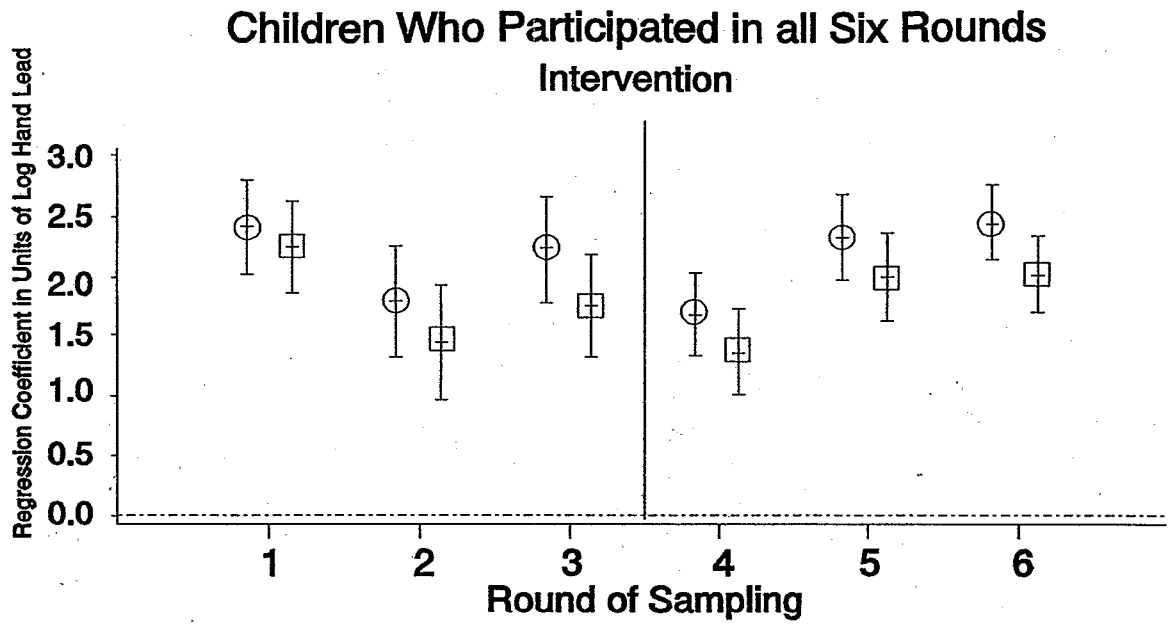
TABLE 7-19. REGRESSION COEFFICIENTS FOR EFFECT OF GENDER ON HAND LEAD MODEL 5

Children Present In All Six Rounds of Sampling

		Log (Hand Lead)		Hand Lead	
Round	Group	EST	SE	EST	SE
1	Male	2.424	0.1928	11.2909	2.17689
	Female	2.277	0.1889	9.7474	1.84128
2	Male	1.792	0.2417	6.0014	1.45055
	Female	1.441	0.2434	4.2249	1.02835
3	Male	2.224	0.2230	9.2442	2.06146
	Female	1.741	0.2160	5.7030	1.23186
	INTERVENTION				
4	Male	1.672	0.1716	5.3228	0.91339
	Female	1.360	0.1835	3.8962	0.71495
5	Male	2.293	0.1729	9.9046	1.71251
	Female	1.969	0.1903	7.1635	1.36322
6	Treatment	2.414	0.1527	11.1786	1.70697
	Control	1.997	0.1657	7.3669	1.22070

All Children Sampled Throughout Experiment

		Log (Hand Lead)		Hand Lead	
Round	Group	EST	SE	EST	SE
1	Male	2.281	0.1372	9.7865	1.34270
	Female	2.135	0.1370	8.4570	1.15862
2	Male	1.762	0.1717	5.8241	0.99999
	Female	1.626	0.1750	5.0835	0.88961
3	Male	2.199	0.1782	9.0160	1.60665
	Female	1.730	0.1648	5.6407	0.92958
	INTERVENTION				
4	Male	1.609	0.1539	4.9978	0.76916
	Female	1.399	0.1595	4.0511	0.64616
5	Male	2.316	0.1425	10.1351	1.44425
	Female	2.037	0.1489	7.6676	1.14170
6	Male	2.400	0.1283	11.0232	1.41427
	Female	2.053	0.1344	7.7912	1.04714



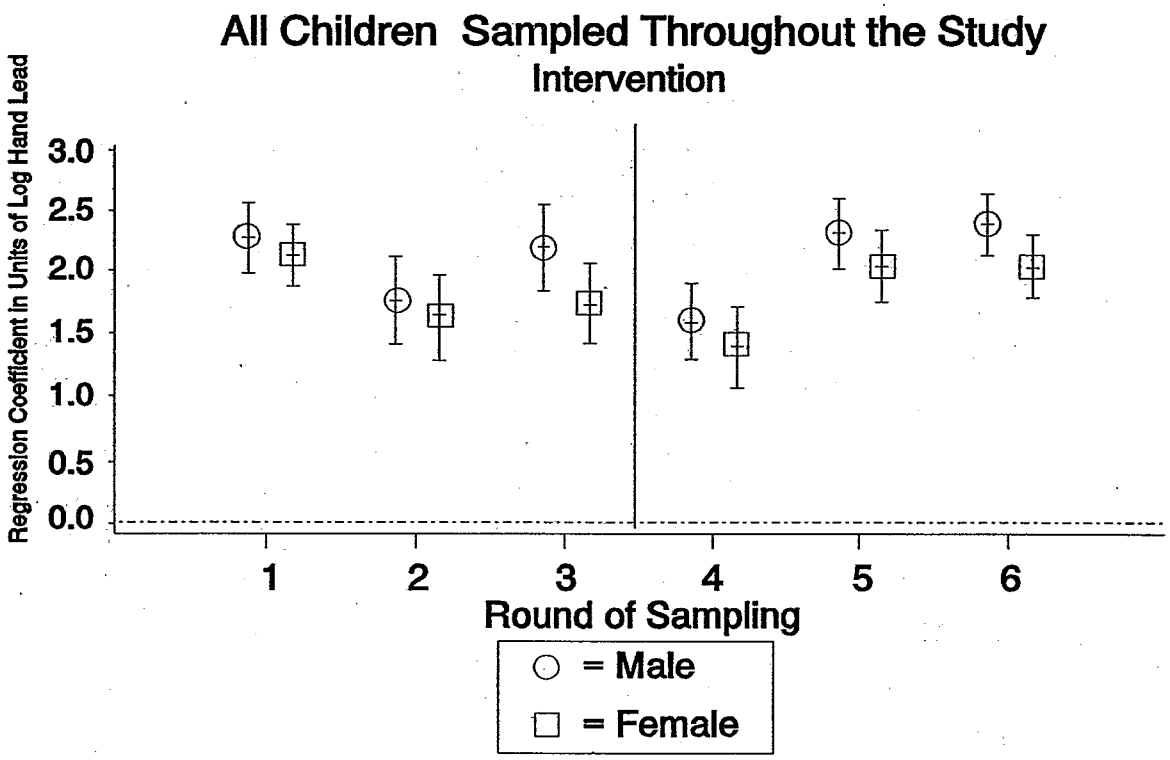


Figure 7-18. Model 5 results of effect of gender on hand lead, log transformed. Bars show 95% confidence interval on regression coefficient.

TABLE 7-20. REGRESSION COEFFICIENTS FOR EFFECT OF AGE ON HAND LEAD MODEL 5

Children Present In All Six Rounds of Sampling					
		Log (Hand Lead)		Hand Lead	
Round	Group	EST	SE	EST	SE
1	Age 0	-1.10600	0.25210	0.33088	0.08341
	Age 1	-0.33970	0.20150	0.71198	0.14346
	Age 2	-0.01190	0.19250	0.98817	0.19022
	Age 3	-0.03152	0.09115	0.96897	0.08832
2	Age 1	-0.19250	0.26700	0.82489	0.22025
	Age 2	0.14940	0.24820	1.16114	0.28819
	Age 3	0.18480	0.10160	1.20298	0.12222
3	Age 1	-0.77470	0.79260	0.46084	0.36526
	Age 2	-0.31930	0.23090	0.72666	0.16779
	Age 3	-0.00567	0.06877	0.99434	0.06838
	INTERVENTION				
4	Age 2	-0.22040	0.55860	0.80220	0.44811
	Age 3	0.04482	0.4817	1.04584	0.05038
5	Age 3	0.08537	0.04570	1.08912	0.04977
6	Age 3	0.03344	0.03862	1.03401	0.03993

All Children Sampled Throughout Experiment					
		Log (Hand Lead)		Hand Lead	
Round	Group	EST	SE	EST	SE
1	Age 0	-1.21200	0.18500	0.29760	0.05506
	Age 1	-0.41590	0.14950	0.65975	0.09863
	Age 2	-0.07558	0.14800	0.92721	0.13723
	Age 3	0.01779	0.06142	1.01795	0.06252
2	Age 0	-0.72440	0.50570	0.48462	0.24507
	Age 1	-0.12660	0.19190	0.88109	0.16908
	Age 2	0.06258	0.18100	1.06458	0.19269
	Age 3	0.20830	0.06867	1.23158	0.08457
3	Age 0	-0.69160	0.29410	0.50077	0.14728
	Age 1	-0.47870	0.22670	0.61959	0.14046
	Age 2	-0.21700	0.17990	0.80493	0.14481
	Age 3	0.01706	0.05657	1.01721	0.05754
	INTERVENTION				
4	Age 1	0.87800	0.38380	2.40608	0.92345
	Age 2	0.41440	0.27630	1.51346	0.41817
	Age 3	0.04575	0.04488	1.04681	0.04698
5	Age 1	0.86730	0.44460	2.38047	1.05836
	Age 2	-0.01182	0.26340	0.98825	0.26030
	Age 3	0.07011	0.03820	1.07263	0.04097
6	Age 2	0.39450	0.24150	1.48364	0.35830
	Age 3	0.03247	0.03332	1.03300	0.03442

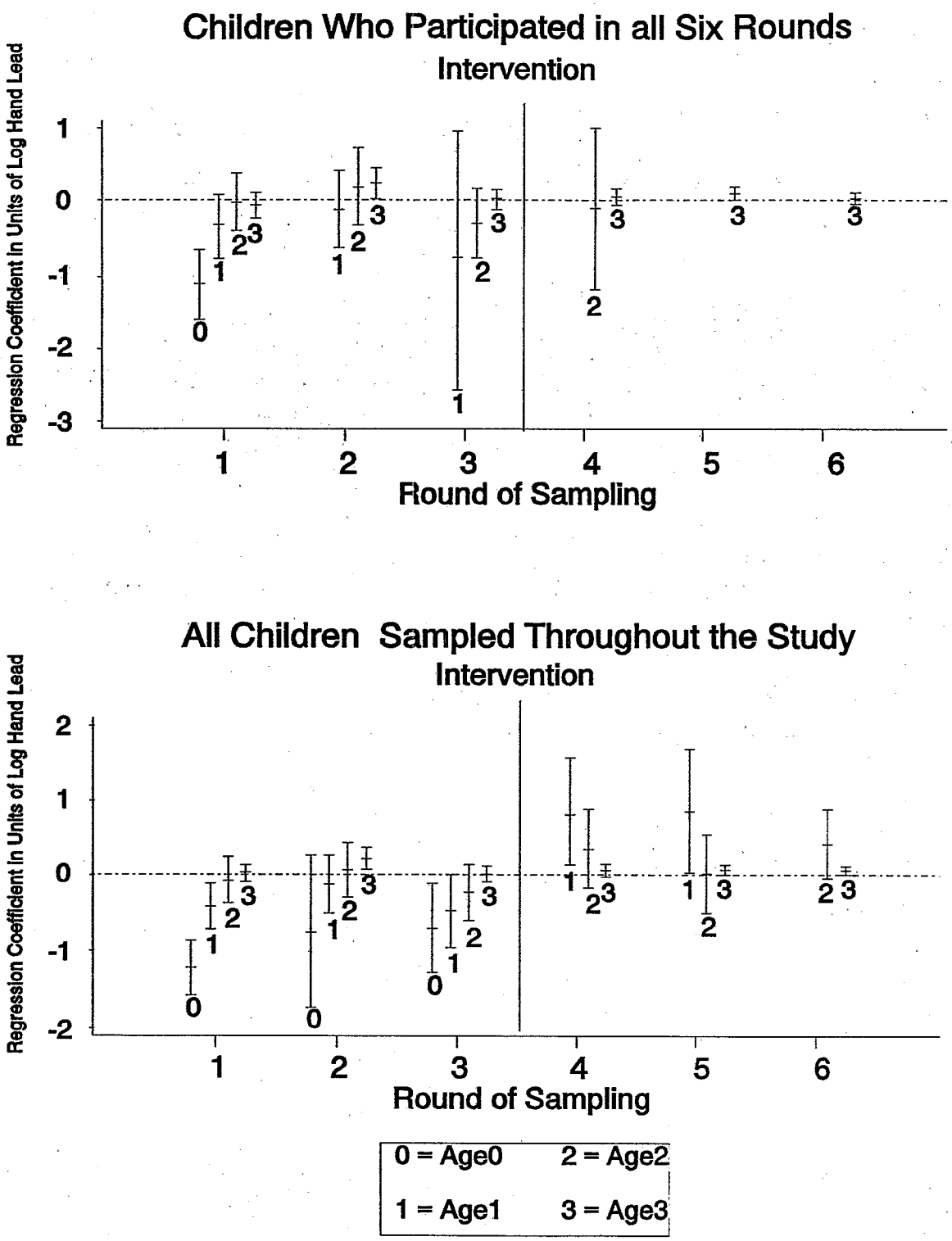


Figure 7-19. Model 5 results of effect of age on hand lead, log transformed. Bars show 95% confidence interval on regression coefficient.

TABLE 7-21. REGRESSION COEFFICIENTS FOR EFFECT OF SEASON ON HAND LEAD MODEL 5

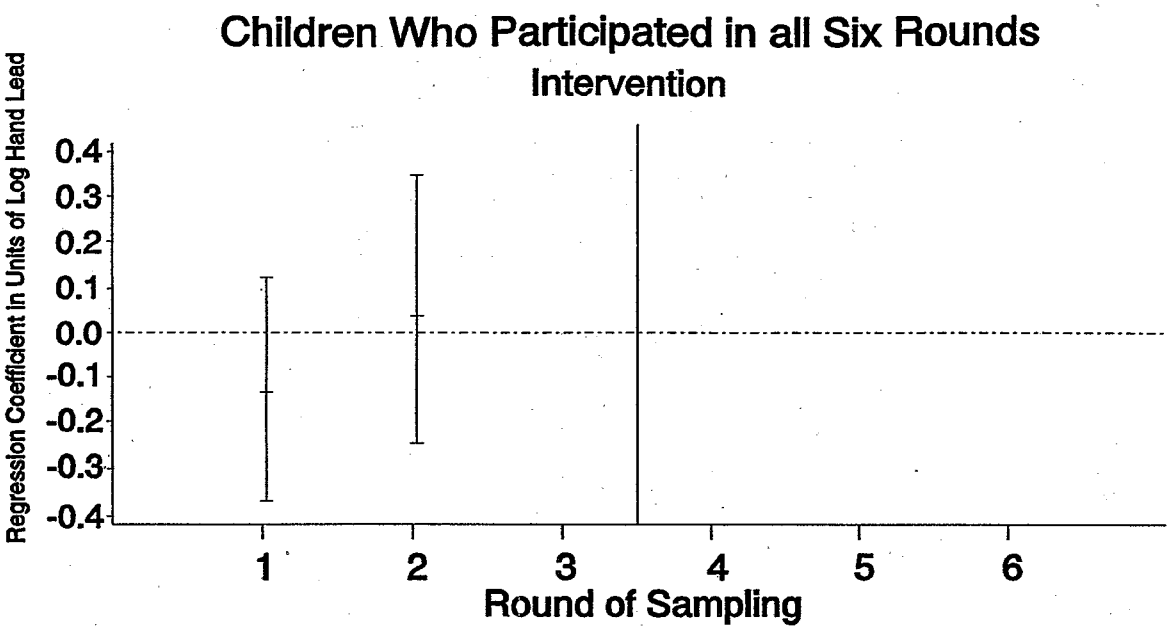
Children Present In All Six Rounds of Sampling				
	Log (Hand Lead)		Hand Lead	
Round	EST	SE	EST	SE
1	-0.08192	0.11830	0.92135	0.10900
2	0.08260	0.14960	1.08611	0.16248
All Children Sampled Throughout Experiment				
	Log (Hand Lead)		Hand Lead	
Round	EST	SE	EST	SE
1	0.02684	0.08542	1.02720	0.08774
2	0.13030	0.10560	1.13917	0.12030

present in all six rounds of sampling. This is largely a result of missing or unavailable data for the models (mostly destroyed or inadequate samples).

7.5 IMPLICATIONS OF FINDINGS

If it can be assumed that the dose response relationship between soil lead and blood lead is sigmoidal in shape, it would be expected that the reductions achieved at the low levels in this study would not result in statistically significant reductions in blood lead levels.

The findings of this project may help avoid costly abatements of soil in cities where, like Baltimore, the principal source of lead exposure for children is paint in and around their houses along with the resulting house dust. There may be individual children, however, who are more likely to benefit from soil abatement; i.e., those who have unusually strong mouthing behavior or pica. For these children, however, environmental controls, while important, must be supplemented with attention to hygiene, nutrition, and any underlying behavioral or medical problems. Abatement of lead paint problems and of lead dust levels in



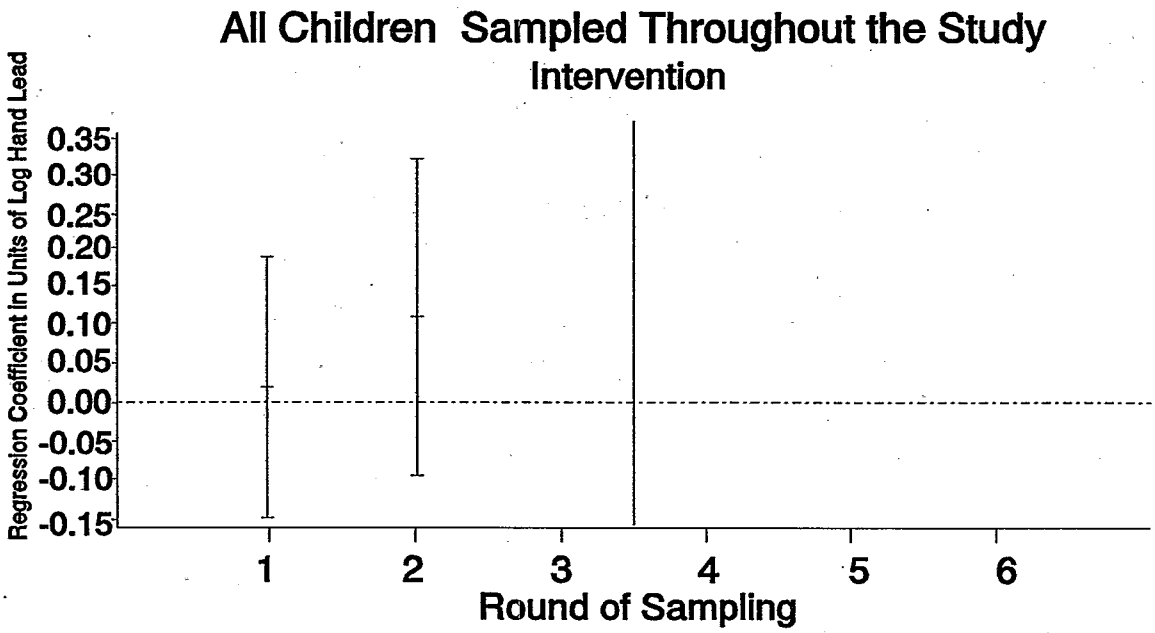


Figure 7-20. Model 5 results of effect of season on hand lead, log transformed. Bars show 95% confidence interval on regression coefficient.

TABLE 7-22. REGRESSION COEFFICIENTS FOR EFFECT OF DUST ON HAND LEAD MODEL 5

Children Present In All Six Rounds of Sampling				
	Log (Hand Lead)		Hand Lead	
Round	EST	SE	EST	SE
1	.00000730	.00003677	1.00000730	.000036770
2	.00014840	.00004587	1.00014841	.000045877
3	.00008422	.00004286	1.00008422	.000042864
INTERVENTION				
4	.00008800	.00004094	1.00008800	.000040944
5	.00007411	.00004116	1.00007411	.000041163
6	.00000390	.00003329	1.00000390	.000033290
All Children Sampled Throughout Experiment				
	Log (Hand Lead)		Hand Lead	
Round	EST	SE	EST	SE
1	.00004023	.00003176	1.00004023	.000031761
2	.00014350	.00003862	1.00014351	.000038626
3	.00008190	.00003760	1.00008190	.000037603
INTERVENTION				
4	.00008444	.00003958	1.00008444	.000039583
5	.00006301	.00003762	1.00006301	.000037622
6	.00001454	.00003216	1.00001454	.000032160

their houses would probably take priority over soil abatement, which might be limited to areas of obvious contamination where the child is known to spend time.

Soil abatement for cities like Baltimore does not appear to be a cost effective preventive strategy used alone, but it may well be an adjunct, in selected cases, to the overall environmental management of children who become lead poisoned.

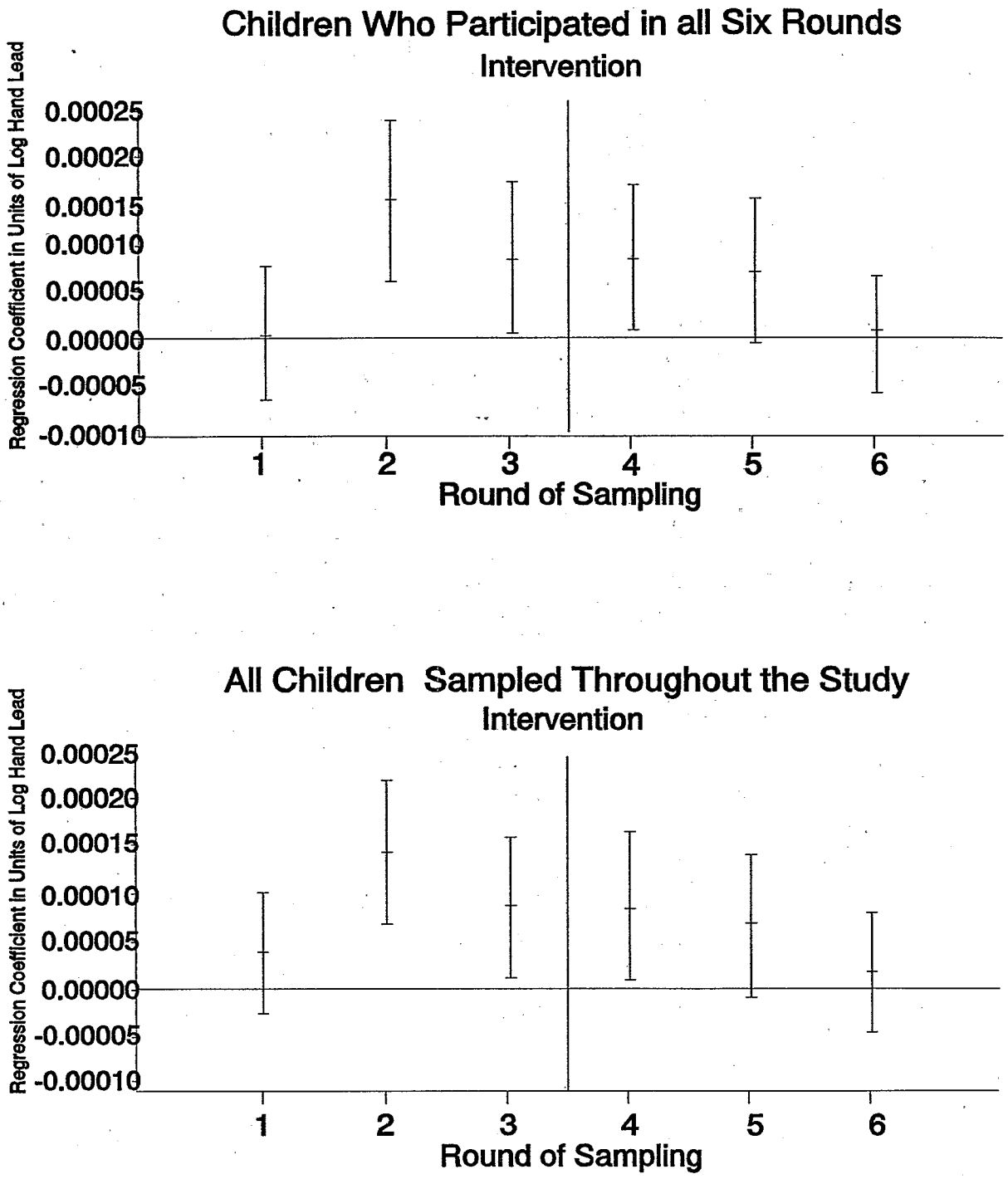


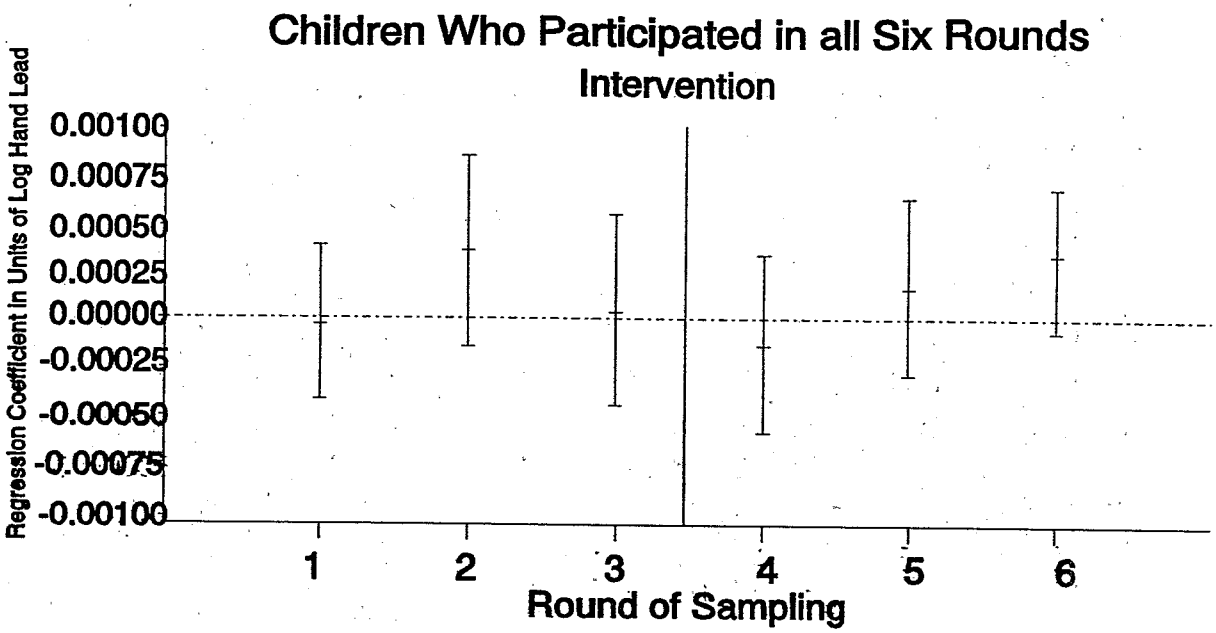
Figure 7-21. Model 5 results of effect of dust lead on hand lead, log transformed. Bars show 95% confidence interval on regression coefficient.

TABLE 7-23. REGRESSION COEFFICIENTS FOR EFFECT OF SOIL LEAD ON HAND LEAD MODEL 5

Children Present In All Six Rounds of Sampling				
	Log (Hand Lead)		Hand Lead	
Round	EST	SE	EST	SE
1	-0.00000500	.00002036	0.99999500	.00020360
2	0.00036780	.00002507	1.00036787	.00025709
3	0.00006254	.00002586	1.00006254	.00025862
INTERVENTION				
4	-0.00010790	.00002379	0.99989211	.00013070
5	0.00019070	.00002413	1.00019072	.00015734
6	0.00033070	.00001967	1.00033075	.00020959
All Children Sampled Throughout Experiment				
	Log (Hand Lead)		Hand Lead	
Round	EST	SE	EST	SE
1	-0.00002800	.00001307	0.99997200	.00023787
2	0.00024190	.00001573	1.00024193	.00024135
3	0.00005640	.00002096	0.99994360	.00019677
INTERVENTION				
4	-0.00017300	.00002306	0.99982701	.00023056
5	0.00024000	.00002168	1.00024003	.00021685
6	0.00025980	.00001899	1.00025983	.00018995

7.6 CALL FOR FURTHER RESEARCH

The models that were applied to the Baltimore data were cross sectional by sampling round, and do not combine all the data from the study into one model. One of the assumptions of linear regression models is that each response is independent and identically distributed from a known distribution. The multiple measurements taken on each child throughout the experiment violates the assumption of independence. Some of the children in



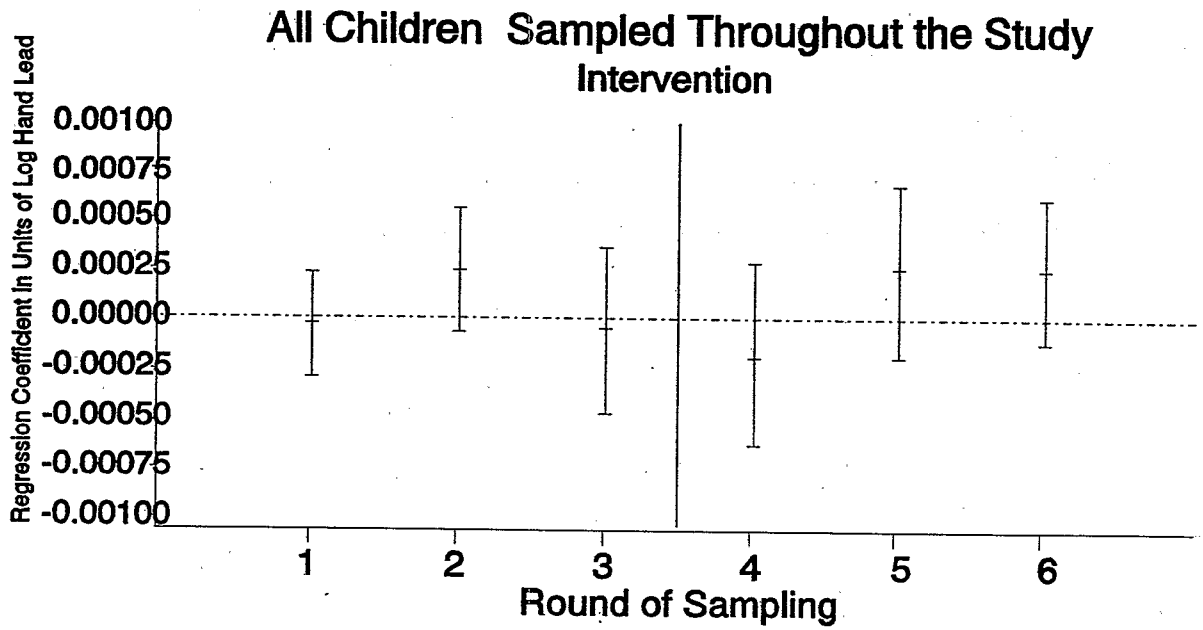


Figure 7-22. Model 5 results of effect of soil lead on hand lead, log transformed. Bars show 95% confidence interval on regression coefficient.

TABLE 7-24. R-SQUARED COEFFICIENT AND MEAN SQUARE ERROR FOR MODELS WITH LOG (BLOOD LEAD) AS THE RESPONSE VARIABLE

Model 1 - Population 1				
Round	N	DF	R-Square	Variance
1	140	138	0.002	0.2359
2	136	134	0.003	0.2051
3	130	128	0.000	0.2384
4	133	131	0.008	0.2612
5	136	134	0.008	0.2683
6	133	131	0.012	0.2659
Model 1 - Population 2				
Round	N	DF	R-Square	Variance
1	273	271	0.001	0.2593
2	255	253	0.000	0.2162
3	229	227	0.000	0.2569
4	175	173	0.018	0.2480
5	173	171	0.021	0.2744
6	170	168	0.029	0.2471
Model 2 - Population 1				
Round	N	DF	R-Square	Variance
1	140	130	0.230	0.1931
2	136	127	0.105	0.1943
3	130	122	0.193	0.2020
4	133	126	0.204	0.2179
5	136	130	0.324	0.1885
6	133	127	0.251	0.2080

TABLE 7-24 (cont'd). R-SQUARED COEFFICIENT AND MEAN SQUARE ERROR FOR MODELS WITH LOG (BLOOD LEAD) AS THE RESPONSE VARIABLE

Model 2 - Population 2				
Round	N	DF	R-Square	Variance
1	273	263	0.296	0.1883
2	255	245	0.133	0.1936
3	229	220	0.162	0.2222
4	175	167	0.279	0.1886
5	173	165	0.359	0.1863
6	170	163	0.325	0.1771
Model 3 - Population 1				
Round	N	DF	R-Square	Variance
1	140	138	0.002	0.5224
2	136	134	0.000	0.8253
3	130	128	0.000	0.6623
4	133	131	0.039	0.5937
5	136	134	0.021	0.6146
6	133	131	0.006	0.4230
Model 3 - Population 2				
Round	N	DF	R-Square	Variance
1	273	271	0.000	0.6005
2	255	253	0.003	0.8017
3	229	227	0.001	0.7239
4	175	173	0.036	0.6621
5	173	171	0.034	0.5620
6	170	168	0.003	0.4381

TABLE 7-24 (cont'd). R-SQUARED COEFFICIENT AND MEAN SQUARE ERROR FOR MODELS WITH LOG (BLOOD LEAD) AS THE RESPONSE VARIABLE

Model 4 - Population 1				
Round	N	DF	R-Square	Variance
1	140	131	0.176	0.4544
2	136	128	0.153	0.7319
3	130	123	0.132	0.5983
4	133	127	0.111	0.5668
5	136	131	0.107	0.5732
6	133	128	0.104	0.3902
Model 4 - Population 2				
Round	N	DF	R-Square	Variance
1	273	264	0.211	0.4862
2	255	246	0.157	0.6978
3	229	221	0.160	0.6256
4	175	168	0.100	0.6368
5	173	166	0.117	0.5294
6	170	164	0.080	0.4141
Model 5 - Population 1				
Round	N	DF	R-Square	Variance
1	140	131	0.171	0.4568
2	136	128	0.166	0.7209
3	130	123	0.132	0.5983
4	133	127	0.087	0.5822
5	136	131	0.084	0.5881
6	133	128	0.113	0.3863
Model 5 - Population 2				
Round	N	DF	R-Square	Variance
1	273	264	0.211	0.4864
2	255	246	0.162	0.6934
3	229	221	0.159	0.6260
4	175	168	0.082	0.6496
5	173	166	0.088	0.5467
6	170	164	0.085	0.4121

the Baltimore study also reside in the same household, and are likely to be correlated as well (Figure 6). While combining the data from all six rounds of sampling, these correlation structures must be taken into consideration. Another statistical issue is that the time of sampling was not consistent throughout the experiment. There were also children who were present in most of the rounds of sampling but may have missed 1 or 2 rounds (Figure 6). The data from measurements on these children may provide additional information for explaining the effects of soil abatement. Research is now being conducted in an effort to combine the data longitudinally while addressing these issues.

8. REFERENCES

Agency for Toxic Substances and Disease Registry: The Nature and Extent of Lead Poisoning in Children. *U.S. Public Health Service, U.S. Department of Health and Human Services 1988*

Annest JL, Pirkle JL, Makuc D, Neese JW, Bayse DD, Kovar MG: Chronological Trend in Blood Lead Levels between 1976-1980. *New England Journal of Medicine 1983;308:1373-1377*

Barltrop D, Khoo HE: The influence of Nutritional Factors on Lead Absorption. *Postgraduate Medical Journal 1975;51:795-800*

Barltrop D, Meek F: Effect of Particle Size on Lead Absorption from the Gut. *Archives of Environmental Health 1979;34:280-285*

Barltrop D, Strehlow CD, Thorton I, Webb JS: Significance of High Soil Lead Concentrations for Childhood Lead Burdens. *Environmental Health Perspectives 1974;7:75-82*

Binder S, Sokal D, Maughan D: Estimating Soil Ingestion: The use of tracer elements in estimating the amount of soil ingestion by young children. *Archives of Environmental Health 1986;41:341-345*

Centers of Disease Control: External Quality Assurance/Quality Control. May, 1991.

Chisolm JJ, Jr, Brown DH: Micro-scale photofluorometric determination of "free erythrocyte porphyrin" (protoporphyrin IX). *Clinical Chemistry 1975; 21:1669-1682*

Duggan MJ, Inskip MJ: Childhood Exposure to Lead in Surface Dust and Soil: A Community Health Problem. *Public Health Review 1985;13:1-54*

Environmental Protection Agency: Air Quality Criteria for Lead. Pub. No. 600/8-83/028bf. *Research Triangle NC: EPA 1986:1-4*

Forman DT, Parker SL: The measurement and interpretation of Serum Ferritin. *Annals of Clinical and Laboratory Science 1980;10: 345-350*

Gibson JL, Love W, Hardine D, Bancroft P, Turner AJ: Notes on Lead Poisoning as observed among children in Brisbane. *1892; Transcription of the 3rd Intercolonial Medical Congress:76-83*

Mahaffey KR: Nutritional Factors in Lead Poisoning. *Nutrition Reviews 1981;39:353-362*

Mahaffey KR, Rader JI: Metabolic Interactions: Lead, Calcium, and Iron. *Annals of the N.Y. Academy of Science 1980;355:285-297*

Mielke HW, Anderson JC, Berry KJ, Mielke PW, Chaney RL, Leech M: Lead Concentrations in Inner-City Soils as a Factor in the Child Lead Problem. *American Journal of Public Health 1983;73,12:1366-1369*

Pruszkowski E, Cornick GR, Slavin W: Blood lead determination with the platform furnace technique. *Atomic Spectroscopy 1983;4:59-61*

Rabinowitz MB, Kopple JD, Wetherill GW: Effects of Food intake and fasting on Gastrointestinal lead absorption in humans. *American Journal of Clinical Nutrition, 1980;33:1784-1788*

Rabinowitz MB, Wetherill GW, Kopple JD: Kinetic Analysis of Lead Metabolism in Healthy Humans. *The Journal of Clinical Investigation 1976;58:260-270*

Roels HA, Buchet J-P, Lauwerys R, Bruaux P, Claeys-Thoreau F Lafontaine A, Verduyn G: Exposure to Lead by the Oral and the Pulmonary Routes of Children Living in the Vicinity of a Primary Lead Smelter. *Environmental Research 1980;22:81-94*

Rosen JF, Chesney RW, Hamstra A, DeLuca HF, Mahaffey KR: Reduction in 1,25-Dihydroxyvitamin D in Children with Increased Lead Absorption. *New England Journal of Medicine 1980;302:1128-1131*

Sayre JW, Charney E, Jaroslav V, Pless IB: House and Hand Dust as a Potential Source of Childhood Lead Exposure. *American Journal of Disease in Children 1974;127:167-170*

Shaffar M, Stroupe SD: A general method for routine clinical chemistry on the Abbott TDx analyzer. *Clinical Chemistry 1983;129:1251 (abstract)*

Shellshear ID, Jordan LD, Hogan DJ, Shannon FT: Environmental Lead Exposure in Christchurch Children: Soil Lead a Potential Hazard. *New Zealand Medical Journal 1975;81:382-386*

Stark AD, Quah RF, Meigs JW, DeLouise ER: The Relationship of Environmental Lead to Blood-Lead Levels in Children. *Environmental Research 1982;27:372-383*

Ter Haar, G. and Aronow, R: New information on Lead in Dirt and Dust as related to the Childhood Lead Problem. *Environmental Health Perspective 1974;7:83-89*

USEPA: Uptake/Biokinetic Model. ECAO/CIN/September 1, 1990.

Williams H, Schulze WH, Rothchild HB, Brown AS, Smith FR, Jr.: Lead Poisoning from the Burning of Battery Casings. *Journal of the American Medical Association 1933;100:1485-1489*

Ziegler EE, Edwards BB, Jensen RL, Mahaffey KR, Fomon SJ: Absorption and Retention of Lead by Infants. *Pediatric Research 1978;12:29-34*

APPENDICES

Baltimore Soil Lead Abatement

Demonstation Project

Final Report

Submitted April 20, 1992

to

The Environmental Protection Agency

by

Katherine P. Farrell, M.D., M.P.H.

J. Julian Chisolm, M.D.

Charles A. Rohde, Ph.D.

Boon P. Lim, M.D., M.P.H.

Merrill C. Brophy, M.S.N., R.N.

and

Warren J. Strauss, B.S.

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Protocols

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BLOOD LEAD, TIBC, AND FERRITIN

BLOOD COLLECTION AND PROCESSING PROTOCOL

A. COLLECTION PROCEDURE

1. Materials needed per participant

   - Gauze sponges, sterile, individually wrapped 2X2" (2)
   - Alcohol wipe (2)
   - Bandaid
   - 3 mL lavender top vacutainer
   - 5 mL red top vacutainer
   - 21 or 23 gauge butterfly (used for children in place of needle)
   - 5 cc syringe
   - Tourniquet
   - 3 cc plastic screw top tube
   - Pipette
   - Pre-printed labels
   - Refrigerator or cooler for holding blood
   - Latex gloves

2. Venipuncture procedure

   - Locate a suitable table for blood drawing and lay out blood collection supplies. Put on gloves.

   - Locate the puncture site. Hold with 2 fingers on one side of the "alcohol wipe" so that only one side touches the puncture site. Wipe the area in a circular motion beginning with a narrow radius and moving outward so as to not cross over the area already cleaned. Repeat with a second alcohol wipe.

   - Locate vein and cleanse in manner previously described, then apply the tourniquet. If it is necessary to feel the vein again, do so; but after you feel it, cleanse with alcohol wipe again.

   - Fix the vein by pressing down on the vein about 1/2 inch below the proposed point of entry into the skin.

   - Approach the vein in the same direction the vein is running, holding the needle so that it makes a 45 degree angle with the examinee's arm.

   - Push the needle, with bevel facing up, firmly and deliberately into the vein. If the needle is in the vein, blood will flow freely into the butterfly tubing. If no blood enters the tubing, probe for the vein until entry is indicated by blood flowing freely into the tubing.

- For collection, loosen the tourniquet immediately after blood flow is established and release entirely when the syringe is filled.

- Completely fill the syringe and then withdraw the needle with a slow but firm motion. When the needle is out of the arm, press gauze firmly on the puncture. Heavy pressure as the needle is being withdrawn should be avoided because it may cause the sharp point of the needle to cut the vein.

- Have the examinee raise his arm (not bend it) and continue to hold the gauze in place for three (3) minutes. This will help prevent hematomas.

- Insert butterfly needle into purple top tube and allow to fill. To ensure accurate results, a minimum of 1.75 mL of blood must be drawn into the 3 mL lavender top tube to provide the proper ratio of anticoagulant to blood. Invert the lavender top tube several times to ensure proper mixing.

- Insert needle into red top tube with examinee's ID number written on it and allow rest of blood to flow in. Allow red top tube to "cool" at room temperature 10 minutes. Spin red top tube 15 minutes in centrifuge. Pipette sera to plastic screw top tube. Discard red top tube, butterfly needle, and syringe in safety container.

- Label lavender top tubes with pre-printed labels provided, and use a ballpoint pen to add the date collected and your initials to the label. The lavender top tube should be affixed with the label showing the participant's ID number (e.g. 88002B1) identified "Lead in Soil Blood Lead". The red top tube should be labeled with the participants ID number. The plastic screw top tube should have participant's ID number written in indelible ink.

- Place a bandaid on the participant's arm.

B. PROCESSING

- Place the lavender top tubes and the plastic screw top tube upright in a rack in the cooler or refrigerator within 30 minutes after being drawn. Log in the specimens and keep cool until transported to lab. For the lavender top tube, note on the log sheet if a full draw is not obtained (minimum blood volume is 1.75 mL) or if the blood was not refrigerated within 30 minutes.

ANALYTICAL METHOD FOR BLOOD LEAD

GRAPHITE FURNACE AAS

A. GLASSWARE, SUPPLIES AND EQUIPMENT:

1. Pipettes, 5 mL Mohr, graduated in 1/10 mL

2. Pipettes, Class A, Volumetric: 5.0 mL, 10.0 mL, 15.0 mL, and 25.0 mL

3. Flasks, Class A, Volumetric: 100 mL, 200 mL, 500 mL,

4. Eppendorf Pipettes: 20 µL and 500 µL

5. Eppendorf Pipette Tips: 20 µL clear tips and 500 µL blue tips

6. Falcon Tubes (Falcon 2063): 12 x 75 mm, polypropylene, round - bottom tube with cap

7. Disposable Sampling Cups: 1.5 mL polystyrene or polyethylene

8. Analytical Balance

9. Pyrolytically Coated Graphite Tube (Perkin-Elmer, part number B010-9322)

10. Pyrolytic Graphite L'vov Platform (Perkin-Elmer, part number B010-9324)

11. Lead Hollow Cathode Lamp (Perkin-Elmer, part number 0303-6039)

12. Micromedic Automatic Pipette with 1 mL and 50 µL Sampling Pumps and 1 mL and 200 µL Dispensing Pumps

13. Rotator-Labindustries Labquake Shaker

14. Vortex-Genie Mixer

15. Sonifier Cell Disruptor

16. Hydro-Ultrapure Water System

17. Perkin-Elmer Zeeman/5000 System (Model 5000 Atomic Absorption Spectrometer, Zeeman Graphite Furnace, HGA-400 Furnace Programmer, AS-40 Autosampler). System is interfaced to a PC with printer (IMS 286 Computer, CM 4531 EGA Monitor, Epson LX 810 Printer).

18. Argon Gas, 99.996% Purity (as per Perkin-Elmer recommendation)

B. MATRIX MODIFIER

(0.2% $NH_4H_2PO_4$ and 0.05% $Mg(NO_3)_2.4H_2O$ or 0.05% $Mg(NO_3)_2.6H_2O$ in 1% HNO_3 ULTREX:

1. Reagents Required:

   a. Ammonium Phosphate, Monobasic ($NH_4H_2PO_4$) ULTREX Ultrapure Reagent, J.T.Baker Chemical Co.

   b. Magnesium Nitrate $Mg(NO_3)_2.4H_2O$, or $Mg(NO_3)_2.6H_2O$, Johnson Mathey Chemicals Limited (distributed by Alfa Products)

   c. Nitric Acid (HNO_3), ULTREX, J.T. Baker Chemical Co.

2. Preparation of Matrix Modifier:

   a. 0.05% $Mg(NO_3)_2$: weigh 0.3716 grams if using $Mg(NO_3)_2.4H_2O$ or 0.4331 grams if using $Mg(NO_3)_2.6H_2O$ on an analytical balance. Transfer to 500 mL volumetric flask.

   b. 0.2% $NH_4H_2PO_4$: weigh 1.000 gram $NH_4H_2PO_4$ on an analytical balance. Transfer to same 500 mL volumetric flask.

   c. Add approx. 250 mL 1% HNO_3 ULTREX to flask; stopper; swirl contents to dissolve salts.

   d. After salts are in solution, qs to 500 mL with 1% HNO_3 ULTREX.

   e. Stopper and mix thoroughly.

C. PREPARATION OF LEAD STANDARDS:

CAUTION: All glassware must be "lead-free." Clean all pipettes by soaking at least 24 hours in 30-50% HNO_3, then rinsing thoroughly with deionized water; oven dry. Fill volumetric flasks with 30-50% HNO_3. Let stand at least 24 hours. Rinse thoroughly with deionized water; air dry.

1. Aqueous Stock Standard (10 ppm Lead): prepare from 1000 ppm Lead Standard (Alfa Products, Ventron Division, or Varian, Sunnyvale CA). Into a Class A volumetric flask, pipette 5 mL of 1000 ppm Lead Standard, using a 5 mL Mohr

TD pipette or a 5 mL Class A volumetric pipette. QS to 500 mL with 1% HNO_3 ULTREX; stopper; mix.

2. Aqueous Working Standards (prepare weekly):

Working µg/L	Standard ppm or µg/mL	Stock (mL of 10 ppm)	Total Volume (mL) (qs with deionized water)
250	0.25	5	200
500	0.50	5	100
1000	1.0	10	100
1250	1.25	25	200
1500	1.5	15	100

Label, date, and initial all solutions.

3. Blood Lead Standards:

a. Preparation of Base Blood (1/10 Dilution of a "Low Lead" Blood): Using a Micromedic Automatic Pipette, dispense 300 µL of a child's non-hemolyzed, EDTA-preserved blood, with a lead concentration of 4-6 µg Pb/dL) into a labeled Falcon tube. Add 2700 µL Triton X-100 in three 900 µL portions. Mix by swirling gently; cap tube; vortex (lowsetting). Prepare a week's supply of base bloods. Dilute each patient's blood separately (DO NOT POOL BLOOD); refrigerate. 3 mL base blood is needed for a six point calibration curve. All standards in one run must be prepared from the SAME base blood.

b. Preparation of Blood Lead Standards (method of Standard Additions). Prepare fresh daily:

1) With an Eppendorf pipette transfer 20 µL of each aqueous standard (250, 500, 1000, 1250, and 1500 µg/L) into one of five Falcon tubes, labeled Stds 1,2,3,4,5.

2) With an Eppendorf pipette add 500 µL of base blood (from Step 3a), to each tube. Mix by swirling; cap tube. The remaining base blood in the tube is the Zero Calibrator unspiked blood).

The actual concentration of Pb (µg/L) in each Blood Standard is: Std #1 = 9.615; Std #2 = 19.231; Std #3 = 38.462; Std #4 = 48.077; Std #5 = 57.692.

D. QUALITY CONTROL

1. Source of Controls:

   a. CDC and CAP Proficiency Test Bloods. These specimens are used as controls, after the test values have been established by CDC or CAP.

   b. Ciba-Corning BLD Tox I, II (Bi-Level Whole Blood Assayed Toxicology Controls), Product Code 9660. The DHMH Laboratory establishes a mean and follows CDC guidelines to determine the acceptable range (± 4 µg/dL, or 10%, whichever is greater) for these controls.

2. Three Controls (low 10 µg/dL, middle 30 µg/dL and high 40-60 µg/dL) are analyzed in a run.

3. Maintaining QC Records: All QC results must be plotted daily by the analyst on charts specifically reserved for the instrument used in the analyses.

E. OPERATION OF ZEEMAN/5000 SYSTEM:

1. TURN ON ARGON TANK (tank pressure 350 kPa, 41 psi).

2. TURN ON H_2O (faucet at sink - water flow not too fast; optimum Flow Rate 2.5 L/min).

3. TURN ON AUTOSAMPLER (AS-40). Power Sequence takes 60 seconds; it then goes into STANDBY (sampling arm is above overflow vessel). ALWAYS TURN AS-40 AUTOSAMPLER ON BEFORE THE HGA-400 PROGRAMMER AND AA 5000.

4. TURN FURNACE GAS CONTROL ON (there are three positions: ON, OFF, OPEN). TURN POWER ON. E-45 error message appears on digital display and a warning alarm sounds, if the power is turned on before the gas. Use CE (CLEAR ENTRY) to turn off alarm. Make sure GAS CONTROL FLOW is ON.

5. TURN AA 5000 POWER ON.
   TURN RUN SWITCH ON.
   Turn optical interface (located top, right in lamp compartment) to ZAA position.

6. TURN COMPUTER, MONITOR AND PRINTER ON (see Analytical Instrument Software Operator's Manual).

7. SET AA 5000 PARAMETERS:

   a. Install lamp with lamp window facing the Zeeman Furnace Module (active lamp position is in the front).

   b. Note the ZAA lamp position number and plug the lamp into the receptacle in the turret hub, corresponding to that number.

   c. Turn Accessory Switch ON (on Zeeman Furnace Module).

   d. Select ZAA above Accessory Switch).

   e. Press Lamp # (1-6), corresponding to position of lamp location.

   f. Select the proper current (Pb Lamp 10 ma). Never use higher than the specified current. Press 10 and LAMP MA.

   g. Select proper SLIT-LOW for the element (Pb 0.7 ma).

   h. Press correct wavelength number (Pb 283.3) on keyboard. Press \ PEAK.

8. ADJUST LAMP after at least 5 minutes warm-up time.

   a. Press SET UP. The main display will show a value of approximately 50. If upper limit of SET UP (99) is displayed, press GAIN to bring display down to 50.

   b. Adjust lamp with two adjustment screws (located front-bottom of lead lamp on lamp mount) and slide lamp forward or backward in the mount, until a maximum reading is achieved. If an overrange (99) is obtained, press GAIN and continue adjusting lamp.

   c. Press SET UP again to cancel SET UP Mode.

   d. To check PM (photomultiplier) VOLTAGE press CHECK and GAIN; record PM Voltage and Lamp Energy on Lab Chart.

9. SET ADDITIONAL AA PARAMETERS AFTER LAMP ADJUSTMENT (FOLLOW THIS ORDER):

   a. PRESS 5.0 t (time must match Atomization Time).

b. CHOOSE PEAK AREA on AA 5000.

c. PRESS NUMBER AVG (omit this step if not averaging 2 or more readings).

d. PRESS PRINT.

e. PRESS 1 STO (to store AA Parameters).

10. PROGRAM THE HGA-400 PROGRAMMER:

Furnace Conditions for Pb Determination

STEP	1	2	3	4	5	6	7
TEMP(°C)	100	130	650	20	1800	2600	20
RAMP TIME *(s)	5	5	5	1	0	1	1
HOLD TIME (s)	10	10	45	4	5	5	10
RECORDER				48	REC	REC	
READ						READ	
BASELINE					0		
INT GAS (MINI FLOW) mL/min							
EXT.ALT (STOP FLOW)**						STOP FLOW	

* When RAMP TIME is zero (Max. Power Heating), Temperature Control requires calibration.

** If STOP FLOW does not work, press 0 MINI FLOW.

Note: Adjustment of Furnace Conditions must be made as needed. Graphics and physical observations must also yield favorable results.

11. CALIBRATE OPTICAL TEMPERATURE SENSOR (the optimal temperature sensor is only used when operating in the Maximum Power Heating Mode):

a. First purge line of air by entering 120 TEMP on Furnace Programmer. Press MANUAL TEMP key and hold for 5 seconds.

b. Set Range Selector on the Furnace Assembly to the correct range for the required atomization temperature for lead (1800°C); Range Selector

>1500°C. If unable to achievecalibration of the optical sensor at this setting, use < 1500°C.

c. Press RECORDER MANUAL (to turn the electromagnet on).

d. Enter the Atomization Temperature (1800°C) for lead and press and hold MANUAL TEMP key. Hold entire time while adjusting calibration control (for 15-20 seconds when atomization temperature is ≤ 2000°C; for 5 seconds when atomization temperature is > 2000°C). Wait briefly and then adjust the CAL control fairly rapidly to obtain balance of the indicator lights (red/green).

e. Release MANUAL TEMP key.

f. Press REC MAN (to turn electromagnet off).
It is important NOT TO OVERHEAT THE MAGNET.
Repeat Steps 11c-11g several times to get correct balance.

12. PRELIMINARIES FOR AS-40 AUTOSAMPLER:

a. The AS-40 has been in STANDBY (the arm is up in the air). Keep the flushing liquid reservoir filled with 0.05% Triton X-100. Empty Waste Bottle regularly.

b. While in STANDBY:

NOTE: The sampling arm can only be moved manually when the Autosampler is in STANDBY Mode.

1) Check that the pipette tip is positioned correctly, by checking the tip as it enters the entry hole in the graphite tube (use flashlight or lamp to look into the entry hole of the graphite tube).

2) Check the tip in relation to the L'vov Platform (with a dental mirror, positioned to the right of the right window assembly, of the furnace assembly).

3) Adjustments can be made to improve positioning:

a) The whole sample carriage can be realigned to center the tip as it enters furnace. Release Table LOCK Control (on right front of table; turn counterclockwise).

(1) To adjust left-right movement: turn LATERAL Control Knob on left side of the table.

(2) To adjust forward-backward movement: turn HORIZONTAL Control Knob on front of table, to left of the LOCK/RELEASE Control Knob. After adjustment, tighten table LOCK/RELEASE Control Knob.

b) Knob to right of sampling arm (closest to Furnace) adjusts immersion depth of tip into the solution in sample cup. Directly in front of this knob is the knob to adjust penetration depth of tip into graphite tube.

13. PROGRAM AS-40 AUTOSAMPLER:

a. Press STANDBY to take it out of STANDBY.

b. If there are less than 35 cups being used, enter the LAST SAMPLE location number.

c. Press 10 (µL), SAMPLE VOLUME.

d. Press 5 (µL), ALT VOLUME.

e. Press 1, INST PROG (if 1 STO already programmed on AA 5000 (Step 9e).

f. Press 1 HGA PROG (HGA 400 Programmer cannot store program).

14. PROGRAM COMPUTER: see Analytical Instrument Software Operator Manual, pp. 3-16; also, DHMH Lead Laboratory Computer Guide for Zeeman 5000 AA, pp. 1-17.

15. PRELIMINARIES TO BLOOD LEAD ANALYSIS:

a. Blank Furnace

1) Enter 120 TEMP on Furnace Programmer.

2) Press MANUAL TEMP key and hold for 5 seconds to purge line of air.

3) Press START on Furnace Programmer. When operation is complete, the absorbance value appears on the AA 5000 display.

4) Press AZ (Automatic Zero) on Model 5000 to make Furnace read 0.

5) Repeat Steps 15a(3) and 15a(4) to ensure Furnace is blanked (0.001 or better).

b. Check the deionized water to determine quality of H_2O, the Triton X-100 with matrix modifier (referred to as Sample Blank) and the highest Blood Pb Standard (to check that the absorbance of this standard will give an acceptable Characteristic Mass of 12 ± 20%.

A good technique for checking the proper set-up of the instrument is by running the highest Blood Pb Standard, the calculation of its Characteristic

Mass, and the comparison of this value with the accepted value (12 ± 20%).

1) Place cup containing 1% HNO_3, in position #1 of AS-40 Method Tray.

2) Place deionized H_2O in cup #2.

3) Place Triton X-100 in cup #3.

4) Place highest Blood Pb Standard in cup #4.

5) Press 1, MANUAL, START on the Autosampler.

6) Note Absorbance of each sample on the Digital Display. Record Absorbance of H_2O on Lab Chart.

7) If Absorbance reading of deionized H_2O or Triton X-100 is not acceptable (must be ± 0.002 or better), re-run using a fresh aliquot in another cup.

   a) Press STANDBY at Step 6 of Furnace Program (to stop Autosampler), otherwise the sample tray will rotate to the next position in the Autosampler.

   b) Press STANDBY to take the Autosampler out of STANDBY.

   c) Press the Cup Position # desired.

   d) Press MANUAL, START.

   e) Note Absorbance on Digital Display.

c. Calculate the CHARACTERISTIC MASS (CM) pg/0.0044 A-s:

$$CM = \frac{\text{Sample Volume X Std Conc X 0.0044 (1\% Absorption)}}{\text{Abs Blood Std - Abs Base Blood}}$$

Example:

$$CM = \frac{10\ \mu L \times 57.692\ \mu g/L \times 0.0044}{.215\ (.235 - .020)} = 11.81\ pg/0.0044\ A\text{-}s$$

Enter CM value on Lab Chart. Ideal CM value for Pb is 12 ± 20%.

G. SPECIMEN PREPARATION:

1. Write up worksheets with patients' names, allowing two cups for each patient. Computer generated worksheets may be used. Specimen position # on worksheet corresponds to cup position # on Autosampler. Cups # 1-7 are for the Blank (0.5% Triton X-100) and six Blood Lead Standards, including Base Blood Blank. Three Blood Lead Standards (run as check standards) and 3 Controls are included in each run: one of each at the beginning, in the middle, and at the end.

2. Mix specimen by rotating. If specimen is clotted, sonification is necessary.

3. Micromedic Automatic Pipette Parameters:

   a. Set 50 µL Sampling Pump at 0600.

   b. Set 200 µL Dispensing Pump (for 0.5% Triton X-100) at 0450.

4. With the Micromedic Pipette, aspirate 30 µL specimen into the delivery tip. Dispense the sample, with 90 µL 0.5% Triton X-100 diluent, into the bottom of a properly labeled Falcon tube.

5. Aspirate air into the delivery tip and dispense 90 µL of 0.5% Triton X-100 into the same tube, as in Step 4.

6. Repeat Step 5.

7. Cap tube; mix contents of tube by swirling, or, Vortex (low setting).

8. Before pipetting next specimen, wipe tip with tissue and rinse tip, by aspirating air and dispensing 0.5% Triton X-100 into the waste beaker. Wipe off tip with tissue and proceed to next specimen, repeating Steps G(4-7).

Pipette each patient's specimen in duplicate.

H. SPECIMEN ANALYSIS:

1. Zeeman/5000 System:

a. Screen on Computer Monitor displays "Data Collection - Tray Position Pointer". Note: Refer to Step E14 for Programming Computer.

THE CURSOR MUST BE ON "AUTO ZERO".

b. Place cup containing Matrix Modifier into position ZERO (to the left of the sampling tray).

c. Place 0.5% Triton X-100 in sampling cup in positions AZ (Auto Zero) and 1.

d. Place standards in sampling cups, positions 2-7. Replace cover.

e. Press STANDBY to take Autosampler out of STANDBY.

f. Press RESET and START.

g. While the Triton X-100, in the AZ position, is being delivered into the graphite tube, check tip position for proper delivery, using a dental mirror placed to the right of the window assembly. If it is delivering properly, press F1 on the computer keyboard. If it is not, press STANDBY on the Autosampler to stop it. Manually adjust the tip, according to "Preliminaries for AS-40 Autosampler" (Step E12). Wait until all steps in the Furnace Program have been completed. Press STANDBY. Repeat Steps G5-6.

h. While standards are running, start to load specimens and controls onto sampling tray.

i. After all standards have been run, check slope, intercept and correlation coefficient, to determine acceptability of curve. R (correlation coefficient) must be 0.999.

j. Continue to load samples onto sampling tray. The last specimen should always be a freshly pipetted control. Cover sampling tray to minimize evaporation.

k. When the analysis of the last specimen is complete, a buzzer in the AS-40 Autosampler Programmer sounds

briefly. This completes the first tray. At this point, additional specimens may be run. One standard curve is used for approximately 20-25 specimens, in duplicate.

l. Results are calculated by the computer.

m. Repeat the analysis, if the following occurs:

1) The Absorbance Reading of a specimen is higher than the Absorbance Reading of the highest standard: With an Eppendorf pipette, make a 1:2 dilution of patient's blood with 0.5% Triton X-100 prior to repeat analysis.

2) The initial Pb result is >35 µg/dL.

3) The initial Pb result is <2 µg/dL.

I. INSTRUMENT SHUT DOWN:

1. Zeeman/5000 AA:

a. Temporary Shut Down:

1) Gas Switch OFF on HGA-400.

2) E45 displays on HGA-400 and alarm sounds. Press CLEAR ENTRY to turn alarm off.

b. Complete Shut Down:

1) Computer, Monitor, Printer: TURN OFF, as per computer instructions in DHMH Lead Laboratory Computer Guide, pp.19-20.

2) Turn Argon gas tank OFF. Dials on tank regulator must be at ZERO.

3) Turn H_2O OFF (faucet at sink).

4) HGA-400 Programmer:

c) Turn Gas Switch OFF.

d) E45 displays and buzzer alarm sounds; press CLEAR ENTRY to turn alarm off.

e) Press OFF on Furnace Programmer.

5) Zeeman 5000: Turn ACCESSORY Switch OFF.

6) AA 5000:

a) Press POWER OFF.

b) Press STANDBY.

c) Close lamp compartment cover, if open.

7) AS-40 Autosampler: Press POWER OFF. This module must ALWAYS BE TURNED OFF LAST.

J. REFERENCES:

Pruszkowska, E., Carnrick, G.R., Slavin, W.: "Blood Lead Determination with the Platform Furnace Technique." Atomic Spectroscopy 1983; Vol. 4, No. 2: 59-61.

Pascal, D.: "Calibration Procedure for Graphite Furnace Blood Lead". Centers for Disease Control, Atlanta, GA 30333: Feb, 1986. Perkin-Elmer Model 5000 Atomic Absorption Spectrometer; Zeeman/5000 System; AS-40 Autosampler Sequencer Version; HGA-400 Graphite Furnace Instruction Manuals. Norwalk, Connecticut, 1984.

Perkin-Elmer Zeeman/3030 Atomic Absorption Spectrometer Operator's Manual (Publications B385). Norwalk, Connecticut.

Analytical Instrument Software, Inc.: "Auto-AA on Line QC Software" Operator's Manual, 1989.
Micromedic Systems Automatic Pipette Operating Manual. Horsham, Pennsylvania.

DHMH Lead Laboratory Computer Guide for Zeeman/5000 AA, Sept. 1991.
DHMH Lead Laboratory Computer Guide for Zeeman/3030 AA, Sept. 1991.

BALTIMORE SOIL LEAD ABATEMENT DEMONSTRATION PROJECT

HAND WIPE PROTOCOL FOR LEAD DETECTION

Purpose

The purpose of the testing is to detect lead levels on children's hands. Sampling occurs during the clinic visit. During the summer sampling period, samples are obtained from the hand area. During the winter sampling, samples are obtained only from the hand area. Elbow wipes were also obtained during the initial summer sampling to eliminate false negatives due to hand washing.

Materials

- wipes
- disposable gloves
- plastic bags
- labels

Procedure

At the opening of each box of gloves or Wash-a-bye baby Wipes, a blank control is obtained. The investigator wears disposable gloves. The investigators wipe all surfaces of their own gloved hands using three wipes per hand. These six wipes are placed in a plastic bag with the sample surface folded inward and labeled as blank with the test date.

For each child to be sampled, the investigator identifies the child and obtains the ID number that the child has been assigned and dons a new pair of gloves.

For hand levels, the investigator wipes the child's hand on all surfaces using three wipes per hand. Each wipe is applied to all hand surfaces, up to and including the wrist. A total of six wipes are used per child per sampling. The six wipes are then be placed in a single plastic bag with the subject's ID number as follows:

88 _ _ _ _ C _

Sampling of the elbow area also requires three wipes per elbow. Each wipe is be applied to the entire posterior elbow and two inches up and down the arm. All six wipes are placed in a single plastic bag and labeled as follows using the subject's ID number:

88 _ _ _ _ E _

At the end of the sampling period, all bags of samples are collected and transported to the state laboratory administration for analysis.

LEAD ANALYSIS OF HANDWIPES

Nitric Acid/Perchloric Acid Digestion

(Used in Cleaning Children's Hands and Elbows)

A. **GLASSWARE, SUPPLIES AND EQUIPMENT:**

1. Beakers: Griffin, Pyrex brand, graduated, 800 mL
2. Flasks, volumetric, Class A: 100 mL, 200 mL and 1 Liter
3. Test tubes: polypropylene, round bottom with caps, 17 x 100 mm (Falcon #2059)
4. Watch glasses, Pyrex brand, 75 mm diameter
5. Pipettes, volumetric, Class A: 2.0 mL, 5.0 mL, 10.0 mL, 15.0 mL and 20.0 mL
6. Pipette, graduated: 10 mL
7. Cylinders, Pyrex brand, graduated: 10 mL with stopper; 100 mL and 250 mL without stopper
8. Baby Wipes: commercial, alcohol free baby wipes (ex: Wash a-Bye Baby)
9. Hotplates
10. Atomic Absorption Flame Spectrophotometer, Varian Model AA5 with Background corrector and IM 6 Indicating Module
11. Atomic Absorption Flame Spectrometer, Perkin Elmer 3030B
12. Deionized water: Hydro Service Ultrapure Water System
13. Perchloric Acid Fume Hood

B. **REAGENTS:**

1. Nitric Acid, 10.0% (prepared from 'Baker Analyzed' Reagent)
2. Nitric Acid/Perchloric Acid (Ratio 5:4)

   Nitric Acid: 'Baker Analyzed' Reagent

   Perchloric Acid, 60%: G. Frederick Smith

C. **STANDARDS:**

1. "Stock" Standard (100 ppm Lead):

   20 mL of Varian Techtron Lead Standard (1000 ppm) diluted to 200 mL with 10.0% HNO_3

2. "Working Standards":

Working Standard ppm	mL of Stock (100 ppm)	Total Volume (mL) qs with 10.0% HNO_3
2.0	2.0	100
5.0	5.0	100
10.0	10.0	100
15.0	15.0	100
20.0	20.0	100

   A 0.6 "working" standard is prepared with 6 mL of 10.0 ppm standard, diluted to 100 m: with 10.0% HNO_3.

3. Label, date and initial all solutions.

D. **SAMPLES:**

Samples are received from the "Lead in Soil Project" for AAS analyses. Twelve wipes per child are received; 3 wipes per hand in one baggie and 3 wipes per elbow in a second baggie.

E. **CONTROLS and BLANKS:**

Four Controls (2.0, 5.0, 10.0 and 20.0 ppm working standards added to wipes) and two Total Reagent Blanks are included in every group of 40 samples.

F. **PROCEDURE:**

1. Preparation of Samples for Acid Digestion:

   a. Acid washing of glassware: All glassware must be acid washed prior to use. Soak for 24 hours in 30% v/v nitric acid/deionized water; rinse with deionized water. Glassware must be oven-dried and cooled to room temperature prior to use.

   b. Label each beaker with the sample number.

   c. Transfer, with a minimum of contact, all handwipes from the child's hands to a labeled, acid washed 800 mL beaker. To a second 800 mL beaker transfer all wipes from the child's elbows. Partially cover each beaker with a watch glass.

d. Air dry overnight prior to addition of acid.

2. Hot Nitric Acid/Perchloric Acid Digestion:

a. To each beaker, add 100 mL of the acid mixture (5:4 ratio nitric acid/perchloric acid).

b. Cover the beakers with watch glasses and place the beakers on hot plate in a perchloric acid fumehood.

Adjust the setting to the hotplate to achieve low boil or simmer. The handwipe material will dissolve in the acid at this temperature. Swirl the beakers frequently to prevent material from sticking to the sides of the beakers.

c. After the material is dissolved, continue heating until the sample is evaporated just to dryness. DO NOT BAKE.

d. Add 5 mL of 10.0% nitric acid to each beaker. Heat the sample at a low boil or simmer on a hot plate to redissolve lead; swirl beaker.

e. Transfer the solution into a labeled, acid washed 10 mL graduated cylinder with stopper or to a new labeled graduated Falcon tube. Rinse beaker and watch glass with a very small amount (±1.5 mL) of 10.0% nitric acid and transfer to the same graduated cylinder or Falcon tube.

f. Repeat rinse procedure three times.

g. Allow solution to come to room temperature.

h. Dilute to 10 mL volume with 10.0% nitric acid. Stopper cylinder or cap tube and mix well. Allow contents to settle to avoid necessity of filtering. The samples are ready for AA analyses.

VARIAN AA5 FLAME PARAMETERS:
AA settings used:
Resonance line 2833 A°
Slit Width 100+ microns
Lead Lamp: Source Current 4-5 mamps
Fuel acetylene 3.0
Oxidant air 7.0
Support Pressure 21-22
Recorder Varian Model 9176, Span 2 mv/FS, Speed 2mm/min

PERKIN ELMER 3030B FLAME PARAMETERS:

ELEMENT: Pb WAVELENGTH (NM): 283.3 SLIT (NM): 0.7

FLAME: AIR-ACETYLENE, OXIDIZING (LEAN, BLUE)

CHAR CONC: 0.45 SENS CHECK (MG/L): 20.0 LINEAR TO (MG/L): 20.0

1. TECHNIQUE: AA
2. LAMP CURRENT (MA): 10
3. SIGNAL PROCESSING: HOLD
4. CALIBRATION: LINEAR
5. NOMINAL WEIGHT: 1.0
6. STATISTICS: SINGLE READING
7. TIME (SECOND): 5.0
8. READ DELAY (SECONDS): 0.0
9. SCREEN FORMAT: BASIC DATA
10. PRINTER: OFF
11. RECORDER SIGNAL: 0.2 CONT ABS
12. RECORDER EXP: 1000

13. S1: 20.0
14. S2: 15.0
15. S3: 10.0
16. S4: 5.0
17. S5: 2.0
18. S6: 0.6
19. S7:
20. S8:
21. RSLP:

Computer IMS 286 used in conjunction with the Perkin Elmer 3030B. Results are obtained in ug Pb.

REFERENCES

University of Cincinnati Medical Center, Lead Program Project, Institute of Environmental Health. "7.4.2. Digestion of Handwipes Samples, " p. 100 (received August, 1988).

Perkin Elmer Model 303B Atomic Absorption Spectrometer Instruction Manual. Norwalk, Connecticut, 1987.

Varian Techtron Model AA-5 Atomic Absorption Spectrophotometer Instruction Manual. Melbourne, Victoria, Australia, January, 1971.
Analytical Instrument Software, Inc.: "Auto-AA on Line QC Software" Operators Manual, 1989.

LEAD ANALYSIS OF HANDWIPES

Nitric Acid (1M) Extraction

(Used in Cleaning Children's Hands)

A. **GLASSWARE, SUPPLIES AND EQUIPMENT:**

1. Beakers: Griffin, Pyrex brand, graduated, 50 mL, 250 mL, and 800 mL
2. Flasks, volumetric, Class A: 100 mL, 200 mL, and 2 liter
3. Watch glasses, Pyrex brand, 75 mm diameter
4. Test tubes: polypropylene, round bottom with caps, 17 x 100 mm (Falcon #2059)
5. Filter paper: Whatman #40, 9.0 cm diameter
6. Pipettes, volumetric, Class A: 2.0 mL, 5.0 mL, 10.0 mL, 15.0 mL, and 20.0 mL
7. Pipette, graduated: 10 mL
8. Cylinders, Pyrex brand, graduated: 50 mL, 100 mL and 250 mL
9. Hotplates
10. Atomic Absorption Flame Spectrometer, Perkin Elmer 3030B
11. Deionized water: Hydro Service Ultrapure Water System
12. Fume Hood

B. **REAGENT:**

1. Nitric Acid, 1M (prepared from Baker Analyzed Reagent)

C. **STANDARDS:**

1. "Stock" Standard (100 ppm Lead):

   20 mL of Varian Techtron Lead Standard (1000 ppm) diluted to 200 mL with 1.0 M HNO_3

2. "Working Standards":

Working Standard ppm	mL of Stock (100 ppm)	Total Volume (mL) qs with 1.0 M HNO_3
2.0	2.0	100
5.0	5.0	100
10.0	10.0	100
15.0	15.0	100
20.0	20.0	100

A 0.6 "working" standard is prepared with 6 mL of 10.0 ppm standard, diluted to 100 mL with 1.0 M HNO_3.

3. Label, date and initial all solutions.

D. **SAMPLES**

Samples are received from the "Lead in Soil Project" for AAs analyses. Six wipes per child are received; three wipes per hand in one baggie.

E. **CONTROLS AND BLANKS:**

Four Controls (2.0, 5.0, 10.0 and 20.0 ppm working standards added to wipes and two Total Reagent Blanks are included in every group of 42 samples.

F. **PROCEDURES:**

1. Preparation of Samples for Acid Digestion:

   a. Acid washing of glassware: All glassware must be acid washed prior to use. soak for 24 hours in 30% v/v nitric acid/deionized water; rinse with deionized water. Glassware must be oven-dried and cooled to room temperature prior to use.

   b. Label each beaker with the sample number.

   c. Transfer, with a minimum of contact, all handwipes from the child's hands to a labeled, acid washed 800 mL beaker. Partially cover the beaker with a watch glass.

   d. Air dry overnight prior to addition of acid.

2. Nitric Acid Digestion:

a. Add 100 mL 1 M HNO_3 to each beaker.

b. Swirl beaker for 10 seconds.

c. Cover beaker with a watch glass and allow acid to extract at room temperature for 2 hours.

d. Decant the acid solution from the beaker containing handwipes into a labeled, acid washed 250 mL beaker.

e. Add 50 mL 1 M HNO_3 to the handwipes in the 800 mL beaker.

f. Swirl the beaker for 10 seconds.

g. Decant the acid solution into the same 250 mL beaker to composite the acid rinses.

h. Repeat Steps e, f and g to achieve a total acid solution of approximately 200 mL.

i. Cover each 250 mL beaker with a watch glass and place beakers on a hotplate. Adjust setting so that contents of beakers simmer (low boil) for two hours.

j. Evaporate the samples to dryness. DO NOT BAKE.

k. Add approximately 3-5 mL 1 M HNO_3, rinsing the watch glass and the sides of the beaker.

l. Heat beakers on a hotplate to redissolve the lead. Adjust the setting to achieve a low boil or simmer.

m. Filter to remove undissolved material into a 50 mL labeled, acid washed beaker. Make several rinsings of the 250 mL beaker and the filter paper with $\pm$1.5 mL 1 M HNO_3.

n. Place the 50 mL beakers on a hotplate. Heat at a low boil or simmer to reduce volume to approximately 5.0 mL.

o. Transfer the solution into a new labeled, graduated Falcon tube.

p. Rinse the beaker with a very small amount ($\pm$1.5 mL) of 1 M HNO_3 and transfer to the same Falcon tube.

q. Repeat rinse procedure three times.

r. Allow solution to come to room temperature.

s. Dilute to 10 mL volume with 1.0 M HNO_3. Cap tube and mix well. Allow contents to settle to avoid necessity of filtering. The samples are ready for AA analyses.

PERKIN ELMER 3030B FLAME PARAMETER:

ELEMENT: Pb WAVELENGTH (NM): 283.3 SLIT (NM): 0.7

FLAME: AIR-ACETYLENE, OXIDIZING (LEAN, BLUE)

CHAR CONC: 0.45 SENS CHECK (MG/L): 20.0 LINEAR TO (MG/L): 20.0

1.	TECHNIQUE: AA	2.	LAMP CURRENT (MA): 10
3.	SIGNAL PROCESSING: HOLD	4.	CALIBRATION: LINEAR
5.	NOMINAL WEIGHT: 1.0	6.	STATISTICS: SINGLE READING
7.	TIME (SECOND): 5.0	8.	READ DELAY (SECONDS): 0.0
9.	SCREEN FORMAT: BASIC DATA	10.	PRINTER: OFF
11.	RECORDER SIGNAL: 0.2 CONT ABS	12.	RECORDER EXP: 1000

13.	S1:	20.0	14.	S2:	15.0	15.	S3:	10.0
16.	S4:	5.0	17.	S5:	2.0	18.	S6:	0.6
19.	S7:		20.	S8:		21.	RSLP:	

Computer IMS 286 used in conjunction with the Perkin Elmer 3030B. Results obtained are in ug Pb.

<u>REFERENCES:</u>

University of Cincinnati Medical Center, Lead Program Project, Institute of Environmental Health "Acid Digestion of Handwipe Samples, Method B: 1 M Nitric Acid Extraction" pp 41 & 42 (received May, 1990).

Perkin Elmer Model 3030B Atomic Absorption Spectrometer Instruction Manual. Norwalk, Connecticut, 1987.

Analytical Instrument Software, Inc.: "Auto-AA on Line QC Software" Operators Manual, 1989.

BALTIMORE SOIL LEAD ABATEMENT DEMONSTRATION PROJECT

SOIL SAMPLING PROTOCOL

I. Site Description

For each location, a detailed drawing should be made that shows the boundary of the lot, the position of the main building and any other buildings such as storage sheds or garages, the position of the sidewalks, driveways, and other paved areas, the position of the play areas if obvious, and the position of the areas with exposed soil (grassy or bare), also, showing roof rain spouts and general drainage patterns.

In addition to the diagram, briefly describe the location, including the following information:

- Type of building construction
- Condition of main building
- Condition of property (debris, standing water, vegetation cover)
- Nature of adjacent property
- Presence and type of fence
- Animals on property
- Apparent use of yard (toys, sandbox, children present)
- Underground utilities

II. Soil Area Description

For each soil area (i.e. front patch, front yard, back yard, side yards) identified on the general diagram, draw a full page diagram showing the approximate dimensions and position relative to the building foundation. Indicate vegetation and bare soil areas, as well as obvious traffic patterns. Identify the category of land use, such as roadside, property boundary, adjacent to foundation, play area. Mark the sample location on the diagram.

III. Sampling Schemes

Measure the soil area to determine the sampling scheme. Select the sample scheme for each soil area which adequately characterize the potential exposure of children to lead in the dust from this soil. Identify the suspected areas of high lead concentrations and the assumed general distribution pattern of lead concentrations at the soil surface.

Small Area Pattern. Measure and mark off an area 20 inches from the base of the foundation into the soil area. Repeat measuring and marking at the boundaries. The area inside the marked pattern indicates the sampling collection area. If the sampling collection area is less than two meters in each dimension, a single composite sample may be taken if it appears that such a sample would adequately represent the soil area. (Collect two sample bags, mark one bag top and the other bag bottom.)

Large Area Pattern. Measure and mark off an area 20 inches from the base of the foundation into the soil area. Repeat measuring and marking at the boundaries. The area inside the marked pattern indicates the sampling collection area. Collect one composite sample at the foundation and one composite sample at the boundary of the yard if the area is less than 10 feet wide. (Collect four sample bags, two bags marked top and two bags marked bottom.) Collect an additional composite sample at an imaginary sample line between the foundation and boundary sample areas if the yard is larger than 16 feet wide. (Collect six sample bags, three bags marked top and three bags marked bottom.)

Very Large Area Pattern. Measure and mark off an area 20 inches from the base of the foundation into the soil area. Repeat measuring and marking at the boundaries. If a yard is wider than 16 feet and more than 20 feet long then divide the yard into a vertical half and a horizontal half. Collect one composite sample at the from each section of the yard. (Collect twelve sample bags, six bags marked top and six bags marked bottom.)

IV. Sample Collection

Clean and decontaminate the corer after each sample collection. Remove vegetation and debris from the corer at the point of insertion into the soil, but do not remove any soil or decayed litter. Drive the corer in to the ground to a depth of 15 cm (6 in.). If this depth cannot be reached, the corer should be extracted and cleaned, and another attempt made nearby. If repeated attempts do not permit a 15 cm core, take the sample as deep as possible, and record the maximum penetration depth on the sample record sheet.

Collect ten randomly selected core samples from within the sampling area. The cores make a composite sample identified as a single sample. Record composite information on the sample sheet.

Combine the top two inch segment of each core into one composite sample and combine the bottom two inch segment of each core into second composite sample. Assemble composite soil core segments in clean previously unused plastic bags suitable for prevention of contamination and loss of the sample. Remove debris and leafy vegetation from the top sample material. Do not remove soil or decomposed litter from the sample material. This is the most critical part of the soil sample and is likely to be the highest in lead concentration.

Record the sample identification number on the bag and the sample record sheet. Store the composite soil sample at ambient temperature until submitted to the laboratory for analysis.

Clean the corer after collecting each sample composite by reinsertion of the corer into the soil of the next sampling area. Draw field blanks for each soil area by inserting the core borer into randomly selected locations within the sample area. These blanks are drawn prior to sample collection and at the conclusion of sampling.

V. Sample Handling and Storage

Seal the sample bags to prevent loss or contamination of the sample and storage samples in a cool, dry location.

Record-keeping and Sample Custody

Initiate soil sample records for each location which consists of a location diagram and description, a plot diagram for each distinct soil plot, and sample record sheet for each sample in a plot.

Sequentially number samples bags. Record sample numbers on location diagram, soil area description, and sample record sheet.

Deliver the sample to the laboratory and release the sample to the laboratory personnel for analysis.

BALTIMORE SOIL LEAD ABATEMENT DEMONSTRATION PROJECT

SOIL ANALYSIS (XRF) PROTOCOL

A. SAMPLE PREPARATION

1. Identify sample information to be logged in on the Lead in Soil Processing Sheets. Record the contract number, sample information, date, time and total sample number on the processing sheet.

   Example:

   Date received: 03/30/89
   Time: 12:30 p.m.
   Total Number of Samples Received from: 41 from Ms. Merrill Brophy
   Sample Identification Number: #590312565
   Site address: 2092 W. Preston Street
   Area: Front yard

2. Record the soil sample information on the XRF Run Sheets. Assign sequential analysis identification number to the sample.

   Example:

   The last Fine Soil Fraction sample number was 0436, then the next sample would be a Total Soil Fraction sample numbered 0437.

3. Specimen containers and XRF sample cups are to be prepared before soil samples can be processed.

   a. Label specimen containers. Include the date, the analysis number, the sample's identification number, and the particular soil fraction - Fine or Total.

   b. Label XRF sample cups. Include only the analysis (cup) number.

4. Air dry samples overnight at room temperature. Use disposable weigh boat or Kraft paper to air dry sample. Wear gloves during this process.

   a. Label weigh boat. Include the sample's identification number, and the sample's analysis number (cup number).

   b. Place weigh paper (glassine) on disposable weigh boat.

   c. Transfer sample onto weigh boat to air dry.

   d. Return samples to corresponding bags after air drying.

5. Sieving process must be done under the hood. Gloves and dust mist respirators <u>must be worn</u> throughout this process.

a. Sift pulverized sample in a 2 mm 9.0 mesh sieve by using the back of a gloved hand to crush larger particles.

b. Place the sample that passed through the sieve into a specimen container labeled "Total Soil Fraction".

6. Run samples through an Open Pan Riffle Sampler to obtain a homogenous sample.

7. Place the homogenized Total Soil Fraction sample into the open pan and riffle once. This will divide the sample into two parts.

8. Then take one part of the sample and put into the open pan and riffle to yield a quarter sample. The remaining three-fourths of the sample should be placed into a specimen container labeled Total Soil Fraction.

9. Pass the quartered sample in a 250 um 60.0 mesh sieve. This represents the Fine Soil Fraction. Discard particles that cannot pass through the 250 um sieve.

10. If the quartered sample does not seem to be at least two grams, then take the Total Soil Fraction from its specimen container and repeat steps 5 -8. After enough Fine Soil Fraction has been collected, remember to take the soil that did not pass through the 250 um and replace it back into the specimen container labeled Total Soil Fraction.

11. Clean sieves by tapping on a hard surface to remove residual particles. This must be done between sample processing.

12. After steps 4-10 are completed, the Total Soil and Fine Soil Fraction of a sample should be placed in XRF sample cups respectively. Use a spoon or spatula to place the sample into a labeled XRF sample cup.

13. Seal XRF sample cup with mylar film and a ring.

Samples are now ready to be analyzed by Kevex X-ray Fluorescence Spectroscopy (XRF). List samples according to their analysis number that corresponds with the sample's identification number.

B. <u>XRF ANALYSIS</u>

1. Approximately 2 g of Total Soil Fraction or Fine Soil Fraction sample are poured into sample cups (Somar Labs, Inc., Cat. No. 340), fitted with windows of 1/4 mil thick X-ray polypropylene film (Chemplex Industries, Inc., Cat. No. 425). The sample cup should be at least half full.

2. The sample cup is sealed with a sheet of micropourous film (Spex Industries, Inc., Cat. No. 352A) held in place by the snap-on sample cup cap. The exact weight of the sample is not important, but should be in the range of 2-6 g.

3. The instrument configuration for the Kevex Delta Analyst Energy Dispersive X-ray spectrometer is:

a. Kevex Analyst 770/8000 Excitation/Detection Subsystem:

1) X-ray tube: Kevex high output rhodium anode

2) Power supply: Kevex 60 KV, 3.3 mA.

3) Detector/cryostat: Kevex Quantum - UTW lithium, drifted silicon.

b. Kevex Delta Analyzer:

1) Computer mainframe: Digital Equipment Corp, PDP 11/73

2) Computer software: Kevex XRF Toolbox II, Version 4.14

3) Disk drives: Iomega Bernoulli box, dual drives, 10 MB

4) Pulse processor: Kevex 4460

5) Energy to digital converter: Kevex 5230

c. Operating conditions:

1) Excitation mode: Mo secondary target with 4 mil thick Mo filter

2) Excitation conditions: 30 kV, 0.4 MA

3) Acquisition time: 100 livetime seconds

4) Shaping time constant: 7.5 microseconds

5) Sample chamber atmosphere: air

6) Detector collimator: TA

d. Analytical conditions:

1) Escape peaks, and background should be removed from all spectra.

2) The intensity ratio, defined as the integral of counts in the Pb (LA) window divided by the integral of the counts in the Mo (KA) Compton scatter window, should be determined for each spectrum.

3) The intensity ratios for the standards should be used to determine a linear least squares calibration curve.

At the time of the analysis, there was no established detection limit for this type of analytical method. However, the laboratory employed a standard calibration range from 78 to 4,000 ppm lead. The lab worked within this linear range for all analysis. SRM 1645 (714 ± 28 ppm Pb) was used as part of quality control.

QUALITY ASSURANCE PLAN
SOIL

MARYLAND STATE LABORATORIES ADMINISTRATION

I. INTRODUCTION

This quality assurance document sets forth the Division of Environmental Chemistry Multi-Element Analysis Laboratory (MEAL) policies and procedures that maximize the quality of laboratory performance. The goal of the laboratory is to provide a quality service of elemental analysis.

It is the policy of MEAL to maintain an active quality assurance/quality control (QA/QC) program to provide analytical data of known and supportable quality and ensure a high professional standard in analytical data generated in support of projects undertaken for the public by state and federal agencies.

II. SAMPLE COLLECTION

Soil samples are collected by the Maryland Department of the Environment (MDE) personnel for a variety of programs and projects. All collectors are trained in sampling procedures.

Soil samples that are to be analyzed for metals are collected and stored in clean previously unused polystyrene bags.

III. SAMPLE ACCEPTANCE, PRESERVATION, AND STORAGE

All incoming samples are delivered to the Soil Laboratory. As the samples are accepted, they are assigned a laboratory sample number and the submission form is dated with the current date.

The quantity of sample submitted must be adequate for all analyses requested.

IV. METHODOLOGY

Lead is quantified via the Kevex XRF analyzer.

Ten percent of the samples are replicated. Certified SRM are included throughout each tray run.

V. A. Requirements

1. Perform routine preventive maintenance on the Kevex unit.

2. A NBS standard should be analyzed once per tray of samples for lead. The measured value should be within the control limits established by NBS.

3. At least one replicate sample should be run every 10 samples, or with each set of samples to verify precision of the method.

VI. DATA REDUCTION, VALIDATION, AND REPORTING

An important element in the quality control program is the validation of data by the use of accuracy and precision determinations. Precision describes the degree to which data generated from replicate measurements differ from one another. Accuracy refers to the correctness of the data. Replicate samples are analyzed periodically. Analysis and replicated data is also graphically illustrated by plotting the numerical difference between replicates versus sample number. The mean and standard deviation are calculated for sample data.

Blind samples of known values are inserted into the sample stream for analysis by the sample collectors.

VII. INSTRUMENT RECORDS AND LOGBOOKS

Maintain instrument records and logbooks for each instrument including the following:

1. Operations manuals with updates as provided by the manufacturers

2. Service manuals and schedules of recommended preventive maintenance

3. Maintenance logbooks containing entries describing all maintenance performed on the instrument both by the multi-element laboratory personnel, as well as qualified service engineers

4. Sample logbooks containing a record of all samples analyzed listed by date of analysis. These logbooks contain pertinent information, such as sample identification, instrument conditions, and analyst. Any special modifications made to either the instrument or to the analytical protocol are also noted.

VIII. GENERAL LABORATORY PRACTICES

The purchase of standard (or reference) material must be accompanied by a certification or assay of composition.

BALTIMORE SOIL LEAD ABATEMENT DEMONSTRATION PROJECT

HOUSEHOLD DUST PROTOCOL

Household dust sampling should be carried out at the time of the environmental visit to the home of the study participant.

For this study, the household dust samples are defined as the samples that represent dust most likely to impact on a child's hands during indoor activity. This would include dust on window sills, and furniture, as well as dust on toys and other objects likely to be handled by children. A minimum of three areas should be sampled: at the main entrance to the household, and two areas most frequently used for play activities by the child or children. Additional areas may be selected that represent: 1) secondary entrances to the household (back or side doors); 2) sources or accumulation of dust within the household (paint, rugs, upholstered furniture); 3) additional play areas or other areas of activity frequented by the children.

The sample has two components that are important to interpreting lead exposure, the concentration of lead in the dust and the amount of dust, or loading, on the surface. The concentration of lead in dust appears to be closely related to the amount of lead on children's hands, whereas the amount of dust on surfaces is an indicator of the importance of this route of human exposure. At least 10% of the samples should be over a defined area to determine the household loading factor.

Sketch the approximate layout of the residence and select to sampling. Bear in mind that some areas, such as foyer, may reflect outdoor dust to a greater degree than others.

The sampling apparatus is the Sirchee-Spittler Hand Held Dust Vacuum unit which is attached to a 'Dustbuster' hand held type vacuum. Prior to the sample collection the sample collection screen must be clean.

For some samples, both the weight of the dust and the lead concentration of the dust will be measured. In this case, it is necessary to sample a defined area, so that the results may be expressed in µg Pb/m . Mark the 4' x 4' sample area with tape. The surface of the sample area is vacuumed with back and forth strokes about 1-2 inches in width. The vacuum is most efficient if the head is held parallel to the ground at a 45 degree angle. A single pass across the surface of the sample area is sufficient to collect adequate sample amounts. After dust sampling, the vacuum unit is kept in an upright position until the sample screen is ready to be removed. Turn the vacuum off and remove the sample screen. Empty the contents of the sample screen into a labeled-reinforced paper envelope. Seal the envelope with scotch tape. The sample amount required for analysis is equal to 2 grams of dust. If the sample amount from the area is not sufficient additional sample material may be collected from another 4'x 4' sample area and added to the initial sample. Record sample data on the appropriate chain of custody form. Transport the sample to the laboratory in a manner to ensure upright envelope delivery.

BALTIMORE SOIL LEAD ABATEMENT DEMONSTRATION PROJECT

DUST ANALYSIS (XRF) PROTOCOL

1. Identify sample information to be logged in on the Lead in Dust Processing Sheets. Record the contract number, sample information, date, time and total sample number on the processing sheet.

   Example:
   Date received: 06/30/90
   Time: 12:30 p.m.
   Total Number of Samples Received from: 41 from Ms. Merrill Brophy
   Sample Identification Number: #590312565
   Site address: 2092 W. Preston Street
   Area: Front door area
   Area Collected (square feet): 4

   Record the dust sample information on the XRF Run Sheets. Assign analysis identification number to the sample.
   Example:

   The last dust sample number was 0436, then the next sample would be numbered 0437.

2. XRF sample cups (Somar Labs, Inc., Cat. No. 340) are to be prepared before dust samples can be processed.

   A. Assemble XRF cup for weighing.

      1) Place the 26 mm ring, with rounded surface down, on a flat surface

      2) Cover with a 3 X 3 inch piece of mylar film (Spex Industries, Inc., Cat. No.352A)

      3) Snap/fit the 24 mm ring over the mylar film and inner ring

   B. Label XRF sample cups. Include only the analysis (cup) number.

3. Transfer dust from envelope, as quantitatively as possible, onto a 60.0 mesh, 250 um, 3 inch wide stainless steel sieve with a pan and cover.

   A. Discard particles that cannot pass through the 60 mesh sieve.

   B. Clean sieves by tapping on a hard surface to remove residual particles. This must be done between sample processing.

4. Balance scale to nearest mg. and weigh empty XRF sample cup. Record the weight (e.g. 28 mg).

5. Using a pyrex funnel tripod, transfer dust into center of sample cup.

   A. Weigh and record weight of dust samples. The minimum acceptable sample is 20 mg.

   B. Seal XRF cup, containing dust sample, with another piece of mylar file. Snap/fit 21 mm ring over this assembly.

   C. Record lab accession number on outer ring of cup and on side rim at finger grip cover.

   D. Clean glass funnel with compressed air.

6. Remove cover of cup containing dust sample and place cup in the Kevex XRF 7700/8000 for analysis.

   A. The instrument reading in ppm is obtained.

   B. Calculation:

$$\frac{\text{sample weight}}{\text{no. sq. ft.}} = \text{mg/sq. ft.; ppm}$$

   Example: if sample weight = 28 mg; XRF reading = 200 ppm; area sampled = 4 sq. ft.

$$\frac{28\ \text{mg}}{4\ \text{sq. ft.}} = 7\ \text{mg./sq. ft.; 200 ppm}$$

XRF ANALYSIS

The instrument configuration for the Kevex Delta Analyst Energy Dispersive X-ray spectrometer is:

A. Kevex Analyst 770/8000 Excitation/Detection Subsystem:

   1) X-ray tube: Kevex high output rhodium anode

   2) Power supply: Kevex 60 xC, 3.3 mA.

   3) Detector/cryostat: Kevex Quantum - UTW lithium, drifted silicon.

B. Kevex Delta Analyzer:

   1) Computer mainframe: Digital Equipment Corp, PDP 11/73

   2) Computer software: Kevex XRF Toolbox II, Version 4.14

   3) Disk drives: Iomega Bernoulli box, dual drives, 10 MB

   4) Pulse processor: Kevex 4460

5) Energy to digital converter: Kevex 5230

C. Operating conditions:

1) Excitation mode: Mo secondary target with 4 mil thick Mo filter.

2) Excitation conditions: 30 keV, 0.40 - 0.60 mA

3) Acquisition time: 100 livetime seconds

4) Shaping time constant: 7.5 microseconds

5) Sample chamber atmosphere: air

6) Detector collimator: TA

D. Analytical conditions:

1) Escape peaks, and background should be removed from all spectra.

2) The intensity ratio, defined as the integral of counts in the Pb (LA) window divided by the integral of the counts in the Mo (KA) Compton scatter window, should be determined for each spectrum.

3) The intensity ratios for the standards should be used to determine a linear least squares calibration curve.

LEAD ANALYSIS OF SURFACE DUST

A. GLASSWARE, SUPPLIES AND EQUIPMENT:

1. Beakers: Griffin, Pyrex brand, graduated, 100 mL
2. Flasks, volumetric, Class A: 25 mL, 50 mL, 100 mL, 200 mL, 1 liter and 2 liter
3. Funnels, micro, polypropylene, 24 mm top I.D., 4.5 mm stem diameter (Bel-Art #14685-0024)
4. Test tubes: polypropylene, round bottom with caps, 17 x 100 mm (Falcon #2059)
5. Watch glasses, Pyrex brand, 75 mm diameter
6. Filter paper, Whatman #42, 5.5 cm diameter
7. Pipettes, volumetric, Class A: 2.0 mL, 5.0 mL, 6.0 mL, 10,0 mL, 15.0 mL and 20.0 mL
8. Pipettes, graduated: 2mL and 5 mL
9. Cylinders, Pyrex brand, graduated: 25 mL, 100 mL and 500 mL
10. Analytical Balance, 4-place, Mettler AE240
11. Hotplates
12. Atomic Absorption Flame Spectrophotometer, Perkin Elmer 3030B
13. Deionized water: Hydro Service Ultrapure Water System
14. Fume Hood

B. REAGENTS:

1. Nitric Acid, 7 M (prepared from 'Baker Analyzed' Reagent)
2. Nitric Acid, 1 M (prepared from 'Baker Analyzed' Reagent)

C. STANDARDS:

1. "Stock" Standard (100 ppm Lead):
   20 mL of Varian Techtron Lead Standard (1000 ppm) diluted to 200 mL with 1M HNO_3

2. "Working" Standards:

Working Standard ppm	mL of Stock (100 ppm)	Total Volume (mL) qs with 1M HNO_3
2.0	2.0	100
5.0	5.0	100
10.0	10.0	100
15.0	15.0	100
20.0	20.0	100

A 0.6 ppm "working" standard is prepared with 6 mL of 10.0 ppm standard, diluted to 100 mL with 1 M HNO_3.

3. Label, date and initial all solutions.

D. **SAMPLES:**

Dust samples received from the "Lead in Soil Project" for AAS analysis are in XRF Cups (Somar), covered with mylar film. They were previously analyzed by XRF 700/8000. For the most part, sample weight is well below 100 mg.

E. **CONTROLS AND BLANKS:**

Duplicate NBS #1579 (11.87% Pb) Controls and two Total Reagent Blanks are included in every group of 25 samples.

F. **PROCEDURE:**

1. Preparation of Samples for Acid Digestion:

   a. Acid washing of glassware: All glassware must be acid washed prior to use. Soak for 24 hours in 30% v/v nitric acid/deionized water; rinse with deionized water. Glassware must be oven-dried and cooled to room temperature prior to use.

   b. Label a 100 mL beaker with sample number. Tare beaker on a calibrated 4-place analytical balance.

   c. Transfer dust sample from XRF cup into tared beaker.

      1) Small quantity dust sample (25 mg or less): Transfer dust as completely as possible. Some dust adhers to the mylar film and cannot be transferred.

2) Large quantity dust sample (50 mg or more): Transfer a minimum of 50 mg dust. If quantity is 100 mg or more, analyze in duplicate for precision check.

d. Weigh sample and record weight on form provided by Environmental Chemistry Division.
One run constitutes approximately 25 samples.

2. Hot Nitric Acid Digestion:

a. To each sample in the beaker, add 25 mL 7 M nitric acid, washing down the dust from the sides of the beaker.

b. Cover each beaker with a watch glass and place beakers on a hotplate. Adjust setting so that contents of beakers simmer (low boil) for two hours.

c. Remove beakers from hotplate and allow to cool.

d. For samples weighing 25 mg or less:

1) Transfer digested sample to a 25 mL Class A volumetric flask.

2) Rinse beaker and watch glass with 5 mL of 1M nitric acid and transfer to same flask.
Repeat rinse procedure at least three times.

3) Dilute to volume with 1M nitric acid.

4) Stopper flask and mix well.

5) Filter through Whatman #42 filter paper, using a polypropylene micro funnel, into a <u>new</u> labeled Falcon tube. Cap the tube. The sample is ready for AA analysis.

e. For samples weighing 50 mg or greater:

1) Filter the digested sample into a 50 mL Class A volumetric flask, rinsing the 100mL beaker, watch glass and filter paper with 5 mL of 1M nitric acid.

2) Repeat rinse procedure at least three times.

3) Dilute to volume with 1M nitric acid.

4) Stopper flask and mix well.

5) Pour contents of volumetric flask into a <u>new</u> labeled Falcon tube. Cap the tube. The sample is ready for AA analysis.

PERKIN ELMER 3030B FLAME PARAMETERS:

ELEMENT: PB WAVELENGTH (NM): 283.3 SLIT (NM): 0.7

FLAME: AIR-ACETYLENE, OXIDIZING (LEAN, BLUE)

CHAR CONC: 0.45 SENS CHECK (MG/L): 20.0 LINEAR TO (MG/L): 20.0

1.	TECHNIQUE: AA	2.	LAMP CURRENT (MA): 10
3.	SIGNAL PROCESSING: HOLD	4.	CALIBRATION: LINEAR
5.	NOMINAL WEIGHT 1.0	6.	STATISTICS: SINGLE READING
7.	TIME (SECOND): 5.0	8.	READ DELAY (SECONDS): 0.0
9.	SCREEN FORMAT: BASIC DATA	10.	PRINTER: OFF
11.	RECORDER SIGNAL: 0.2 CONT ABS	12.	RECORDER EXP: 1000

13. S1: 20.0	14. S2: 15.0	15. S3: 10.0
16. S4: 5.0	17. S5: 2.0	18. S6: 0.6
19. S7:	20. S8:	21. RSLP:

Computer IMS 286 used in conjunction with the Perkin Elmer 3030B. Results obtained in percent; then converted to ppm. Results are reported in both units.

REFERENCES:

University of Cincinnati Medical Center, Lead Program Project, Institute of Environmental Health. "Surface Dust Analysis Protcol", pp 11-13 (received 12/90).

Perkin Elmer Model 3030B Atomic Absorption Spectrophotometer Instruction Manual. Norwalk, Connecticut, 1987.

Analytical Instrument Software, Inc.: "Auto-AA on Line QC Software"Operators Manual,1989.

National Bureau of Standards Report 10674, "Experimental Evaluation of Analytical Methods for Determining Lead in Paint and Building Materials". U.S. Department of Commerce National Bureau of Standards, Jan. 6, 1972.

QUALITY ASSURANCE PLAN

DUST

MARYLAND STATE LABORATORIES ADMINISTRATION

I. INTRODUCTION

This quality assurance document sets forth the Division of Environmental Chemistry Multi-Element Analysis Laboratory (MEAL) policies and procedures that maximize the quality of laboratory performance. The goal of the laboratory is to provide a quality service of elemental analysis.

It is the policy of MEAL to maintain an active quality assurance/quality control (QA/QC) program to provide analytical data of known and supportable quality and ensure a high professional standard in analytical data generated in support of projects undertaken for the public by state and federal agencies.

II. SAMPLE COLLECTION

Dust samples are collected by the Maryland Department of the Environment (MDE) personnel for a variety of programs and projects. All collectors are trained in sampling procedures.

Dust samples that are to be analyzed for metals are collected and stored in clean previously unused paper envelopes.

III. SAMPLE ACCEPTANCE, PRESERVATION, AND STORAGE

All incoming samples are delivered to the Multi-Elements Analysis Laboratory. As the samples are accepted, they are assigned a laboratory sample number and the submission form is dated with the current date.

The quantity of sample submitted must be adequate for all analyses requested.

IV. METHODOLOGY

Lead is quantified via the Kevex XRF analyzer. Ten percent of the samples are replicated. Certified SRM is included each tray run.

V. QUALITY CONTROL

A. Requirements

1. Perform routine preventive maintenance on the Kevex unit.

2. A NBS standard should be analyzed once per tray of samples for lead. The measured value should be within the control limits established by NBS.

samples Kofverify of the method.

VI. DATA REDUCTION, VALIDATION, AND REPORTING

An important element in the quality control program is the validation of data by the use of accuracy and precision determinations. Precision describes the degree to which data generated from replicate measurements differ from one another. Accuracy refers to the correctness of the data. Replicate samples are analyzed periodically. Analysis and replicated data is also graphically illustrated by plotting the numerical difference between replicates versus sample number. The mean and standard deviation are calculated for sample data.

VII. INSTRUMENT RECORDS AND LOGBOOKS

Maintain instrument records and logbooks for each instrument including the following:

1. Operations manuals with updates as provided by the manufacturers

2. Service manuals and schedules of recommended preventive maintenance

3. Maintenance logbooks containing entries describing all maintenance performed on the instrument both by the multi-element laboratory personnel, as well as qualified service engineers

4. Sample logbooks containing a record of all samples analyzed listed by date of analysis. These logbooks contain pertinent information, such as sample identification, instrument conditions, and analyst. Any special modifications made to either the instrument or to the analytical protocol are also noted.

VIII. GENERAL LABORATORY PRACTICES

The purchase of standard (or reference) material must be accompanied by a certification or assay of composition.

BALTIMORE SOIL LEAD ABATEMENT DEMONSTRATION PROJECT

PAINT CHIP SAMPLING PROTOCOL

1. Visually evaluate the residence for evidence of peeled, chipped, cracked paint on all surfaces.

2. Identify sample locations of painted surfaces that are peeling, chipped or cracked.

3. Collect paint samples using the sharp edge of a small knife blade to scrape all layers of the suspect material down to the substrate. The area sampled will equal a diameter of 2.0 inches.

4. Place the sampled material in a previously unused sampling paper envelope and seal all edges of the envelope.

5. Mark the sample envelope with the property identification number, sample code and sample number.

6. Return samples to the office.

7. Record sample information on index card file.

8. Deliver samples to lab for analysis.

9. Report sample results to Lead In Soil personnel using the modem.

10. Samples which contain 0.06% lead will be positive for lead in this study.

11. Lead In Soil personnel record sample results on main property file.

12. Residences which do not reflect sample results of 0.06% lead in the paint chips sampled will not be scheduled for paint stabilization.

BALTIMORE SOIL LEAD ABATEMENT DEMONSTRATION PROJECT

PAINT CHIP ANALYSIS PROTOCOL

A. **Using the Mortar & Pestle Method:**

1. Paint chips delivered to the Lab.

2. Samples must be logged in on the Lead in Soil Processing Sheets. The date, the time, the total number of samples brought by the collector, and all the information listed on the sample bag should be written on this sheet. The information listed on the sample bag will include the sample identification number, the address and particular area from which the sample was taken needs to be written on the Lead in Soil Processing Sheet. Example:

   Date received: 3/22/89

   Time: 12:30 p.m.

   Total Number of Samples Received From: 135 from Ms. Merrill Brophy

   Sample Identification Number: #590316535

   Address: 2092 W. Preston Street

   Area: Side of Front Door

3. The paint samples then need to be written up on the XRF Run Sheets. Identification number is assigned. The sample is then given an analysis number by the analyst. The number given to the sample is used only as a means to identify a particular sample for analysis. The samples should be written in consecutive sequence. Example:

   The last sample analyzed was number 0439, then the next paint chips sample should be numbered 0440.

4. Specimen Containers and XRF Sample Cups are to be prepared before samples can be processed.

   a. Label Specimen Containers - Include the date, the analysis number, and the Samples's Identification Number.

   b. Label XRF Sample Cups - Include only the analysis (i.e. cup) number only.

5. Mortar & Pestle should always be clean.

6. Place paint chips into mortar and use the pestle to crush the sample. Continue to crush the sample until a homogeneous mixture is attained. Gloves and respirators <u>must be worn</u>.

7. Use a spoon or spatula to place the sample into a corresponding XRF sample cup, then seal the cup with mylar film and a ring.

8. Before next sample is crushed, the mortar and pestle should be wiped clean. Wipe the mortar and pestle with a clean paper towel, then wash them with distilled water and dry them with a clean paper towel. This process should be done after each sample.

9. Once all samples have completed steps 1 - 7, the samples are now ready for analysis.

10. Analyzed sample results are recorded onto XRF Run Sheets in ppm's..

B. <u>Using Electric Mill Method</u>

1. Paint chips delivered to the lab.

2. Samples must be logged in on the Lead in Soil Processing Sheets. The date, the time, the total number of samples brought by the collector, and all the information listed on the sample bag should be written on this sheet. The information listed on the sample bag will include the sample's identification number, the site address and particular are from which the sample was taken needs to be written on the Lead in Soil Processing Sheet. Example:

   Date received: 3/30/89

   Time: 12:30 p.m.

   Total number of Samples Received From: 135 from Ms. Merrill Brophy

   Sample Identification Number: #590316521

   Address: 2092 W. Preston Street

   Area: Side of Front Door

3. The paint chip samples identification numbers are recorded on the XRF Run Sheets. The sample is then assigned an analysis number by the analyst. The number given to the sample by the analyst is used only as a means to identify a particular sample for analysis. The samples should be written in consecutive sequence.

Example:
The last sample analyzed was number 0439, then the paint chip sample should be numbered 0440.

4. Specimen containers and XRF sample cups are to be prepared before sample can be processed.

   a. Label Specimen containers - Include the date, the analysis number, and the sample's identification number.

   b. Label XRF Sample Cups - Include analysis number only.

5. Electric Mill should always be clean.

6. Electrical grinding <u>must always be done under the hood. Gloves and respirators must be worn.</u>

   a. Place paint chip samples into the Electric Mill.

   b. Turn Electric Mill on for approximately 3 minutes.

   c. Turn grinder off after 3 minutes, wait for the dust to settle, remove lid and check to see if a homogeneous mixture was attained.

7. Use a spoon or spatula to place the sample into a corresponding XRF sample cup, then seal the cup with mylar film and a ring.

8. Before the next sample can be processed, the Electric Mill should be cleaned. Wipe the Electric Mill with a clean paper towel inside and out, dampen another paper towel and clean the mill very well, and then dry the Electric Mill with another clean, dry paper towel. This process should be done between each sample.

9. Once all samples have completed steps 1 - 7, the samples are now ready for analysis.

10. Analyzed sample results are recorded onto XRF Run Sheets in ppm's.

QUALITY ASSURANCE PLAN

PAINT CHIPS

MARYLAND STATE LABORATORIES ADMINISTRATION

I. INTRODUCTION

This quality assurance document sets forth the Division of Environmental Chemistry Multi-Element Analysis Laboratory (MEAL) policies and procedures that maximize the quality of laboratory performance. The goal of the laboratory is to provide a quality service of elemental analysis.

It is the policy of MEAL to maintain an active quality assurance/quality control (QA/QC) program to provide analytical data of known and supportable quality and ensure a high professional standard in analytical data generated in support of projects undertaken for the public by state and federal agencies.

II. SAMPLE COLLECTION

Paint chip samples are collected by the Maryland Department of the Environment (MDE) personnel for a variety of programs and projects. All collectors are trained in sampling procedures.

Paint chip samples that are to be analyzed for metals are collected and stored in clean previously unused paper envelopes.

III. SAMPLE ACCEPTANCE, PRESERVATION, AND STORAGE

All incoming samples are delivered to the Multi-Elements Analysis Laboratory. As the samples are accepted, they are assigned a laboratory sample number and the submission form is dated with the current date.

The quantity of sample submitted must be adequate for all analyses requested.

IV. METHODOLOGY

Lead is quantified via the Kevex XRF analyzer.

V. QUALITY CONTROL

A. Requirements

1. Perform routine preventive maintenance on the Kevex unit.

2. By NBS standard should be analyzed once per tray for the lead measured. The measured value should be within the control limits established by NBS.

3. At least one replicate sample should be run every 10 samples, or with each set of samples to verify precision of the method.

VI. DATA REDUCTION, VALIDATION, AND REPORTING

An important element in the quality control program is the validation of data by the use of accuracy and precision determinations. Precision describes the degree to which data generated from replicate measurements differ from one another. Accuracy refers to the correctness of the data. Replicate samples are analyzed periodically. Analysis and replicated data is also graphically illustrated by plotting the numerical difference between replicates versus sample number. The mean and standard deviation are calculated for sample data.

VII. INSTRUMENT RECORDS AND LOGBOOKS

Maintain instrument records and logbooks for each instrument including the following:

1. Operations manuals with updates as provided by the manufacturers

2. Service manuals and schedules of recommended preventive maintenance

3. Maintenance logbooks containing entries describing all maintenance performed on the instrument both by the multi-element laboratory personnel, as well as qualified service engineers

4. Sample logbooks containing a record of all samples analyzed listed by date of analysis. These logbooks contain pertinent information, such as sample identification, instrument conditions, and analyst. Any special modifications made to either the instrument or to the analytical protocol are also noted.

VIII. GENERAL LABORATORY PRACTICES

The purchase of standard (or reference) material must be accompanied by a certification or assay of composition.

BALTIMORE SOIL LEAD ABATEMENT DEMONSTRATION PROJECT

DRINKING WATER SAMPLING PROTOCOL

1. Residents are notified that water must not be turned on prior to the Environmental Health Aide sampling the system on the sampling day.

2. Do not shut off water flow valve to the sink fixture (which would prevent use of the system prior to first draw) as this may introduce lead corrosion products into the sample.

3. Morning first draw is collected from a cold water tap which had not been used for 8-18 hours. Determine if water was used prior to sample collection. If water was used, state the use in the remarks on the sample collection form.

4. Water samples are collected from each household faucet in 250 ml cubitainers.

5. Water samples are preserved on site with 5 ml of nitric acid per liter.

6. Water tap is closed after filling each sample container to prevent loss of product and to ensure representative collections.

7. Keep samples cool (4 degrees C) after collection prior to analysis.

BALTIMORE LEAD IN SOIL

WATER ANALYSIS PROTOCOL

LEAD

Reference: Method 239.2 (Atomic Absorption, furnace technique) EPA - 600/4-79-020

Optimum Concentration Range: 5-100 µg/L

Detection Limit: 1 µg/L

Application:

Tests for lead are carried out using the graphite furnace atomic absorption technique as described herein. Samples, blanks, quality control, replicate, and spike test solutions are prepared as described and placed in trays for automatic sampling (see Quality Assurance Plan). This instrument setup and analysis steps are performed using the parameters defined.

Preparation of Standard Solution

1. Stock lead solution: Commercially available containing 1000 mg/L (1000 ppm) of lead.

2. Matrix modifier - Ammonium monobasic Phosphate + Magnesium Nitrate Solution: Transfer 4 grams of $NH^4H^2PO^4$ monobasic Ultrex reagent and 0.2 grams of Mg $(NO^3)^2$, Suprapure, to a 100-mL volumetric flask and makeup to mark with deionized distilled water (DW) containing 0.5% (v.v) HNO^3.

3. Working lead solution: Dilute the stock solution to the ratios needed as calibration standards at the time of analysis. The calibration standards and reagent blank must be prepared with the same acid, i.e., 0.5% (v/v) HNO^3. The reagent blank (RB) used in all subsequent dilutions is prepared by diluting 5 mL conc. HNO^3 to 1 L with DW. A 1-ppm solution is prepared by dilution of the 1000-ppm stock solution with RB. This 1-ppm solution is used to obtain calibration standards of 0, 5, 10, 25, 50, and 100 ppb lead. To obtain the calibration standards, withdraw appropriate aliquots of the 1-ppm solution and dilute to 100 mL with RB.

Sample Preparation

All samples solutions for analysis are acidified in the field or in the laboratory and contain 0.5% (v/v) conc. HNO^3.

Instrument Parameters for Lead Analysis

1. Drying Time and Temp: 40 sec. - 120 degrees C

2. Charring Time and Temp: 40 sec - 1000 degrees C

3. Atomizing Time and Temp: 5 sec - 1800 degrees C

4. Cleaning Time and Temp: 5 sec - 2600 degrees C

5. Cooling Time and Temp: 20 sec - 25 degrees C

6. Purge Gas Atmosphere: Argon

7. Wavelength: 283.3 nm

8. Slit: 0.7 nm

9. Tub/site: Pyro coated tube with L'vov platform

10. Matrix Modifier Setting: 5 µl

11. Sample and Standard Quantity Setting: 20 µL

12. Max power: 30

13. Background correction mode: on

14. Lamp: electrodeless discharge lamp (EDL)

Note: Parameters 1, 2, 4, and 5 use 1 sec. ramp time. Parameter 3 uses 0 sec. ramp time and gas stop flow.

<u>Instruments Used</u>

1. Perkin-Elmer model 3030 Atomic Absorption Spectrophotometer with D^2 Arc Background Corrector

2. Perkin-Elmer PR-100 printer

3. HGA-300 graphite furnace

4. AS-40 Auto Sampler

QUALITY ASSURANCE PLAN

WATER

MARYLAND STATE LABORATORIES ADMINISTRATION

I. INTRODUCTION

This quality assurance document sets forth the Division of Environmental Chemistry Multi-Element Analysis Laboratory (MEAL) policies and procedures that maximize the quality of laboratory performance. The goal of the laboratory is to provide a quality service of elemental analysis.

It is the policy of MEAL to maintain an active quality assurance/quality control (QA/QC) program to provide analytical data of known and supportable quality and ensure a high professional standard in analytical data generated in support of projects undertaken for the public by state and federal agencies.

II. SAMPLE COLLECTION

Water samples are collected by the Maryland Department of the Environment (MDE) personnel for a variety of programs and projects. All collectors are trained in sampling procedures and approved by the Division of Water Supply of the MDE.

Water samples that are to be analyzed for metals are collected and stored in clean polyethylene or polypropylene containers with teflon-lined lids.

III. SAMPLE ACCEPTANCE, PRESERVATION, AND STORAGE

All incoming samples are delivered to the Water Laboratory. As the samples are accepted, they are assigned a laboratory sample number and the submission form is dated with the current date.

To ensure that samples are not degraded and that their integrity is maintained, all samples for metal analysis must be kept at 4 degrees C until receipt, and must be received by the laboratory no later than one day after collection. Water samples for total metals analysis should be preserved with analytical grade nitric acid at a pH of 2 or less (typically 0.5% v/v). The quantity of sample submitted must be adequate for all analyses requested.

IV. METHODOLOGY

The following elements (arsenic, cadmium, chromium, lead, silver and selenium) are quantified via graphite furnace atomic absorption spectrophotometer.

Samples are analyzed after a blank and three different standard calibration concentrations are completed. The characteristic mass or sensitivity of the analyte is calculated for any of three standards using the following equation:

$$\frac{(\text{mL sample}) \times (\text{conc. of standard in ppb}) \times (0.0044)}{\text{peak area (abs.)}}$$

The first sample in each tray of 35 positions is always an EPA water supply quality control sample and is followed by a standard equivalent to one half of the maximum contaminant level (MCL). Ten percent of the samples are replicated. One hundred percent are spiked. Blanks and different concentrations of standards are included throughout each tray run.

V. QUALITY CONTROL

A. Minimum Requirements

1. All quality control data should be maintained and available for easy reference or inspection.

2. An unknown performance evaluation sample must be analyzed once per year for the metals measured. Results must be within the control limit established by EPA. If problems arise, they should be corrected, and a follow-up performance sample should be analyzed.

3. Minimum Daily Control

   a. After a calibration curve composed of a minimum of a reagent blank and three standards has been prepared, subsequent calibration curves must be verified by use of at least a reagent blank and one standard at or near the MCL. Daily checks must be within ± 10 percent of original curve.

   b. If 20 or more samples per day are analyzed, the working standard curve must be verified by running an additional standard at or near the MCL every 20 samples. Checks must be within ± 10 percent of the original curve.

B. Optional Requirements

1. Routine preventive maintenance on balances and the atomic absorption spectrophotometer.

2. Class S weights should be available to make periodic checks on balances.

3. Chemicals should be dated upon receipt of shipment and replaced as needed or before shelf life has been exceed.

4. A known reference sample (NBS) should be analyzed once per quarter for the metals measured. The measured value should be within the control limits established by NBS.

5. At least one duplicate sample should be run every 10 samples, or with each set of samples to verify precision of the method. Checks should be within the control limit established by EPA.

6. Standard deviation should be obtained and documented for all measurements being conducted.

7. Quality control charts or a tabulation of mean and standard deviation should be used to document validity of data on a daily basis. See Attachments 2 and 3 for accuracy Quality Control chart sheets and precision Quality Control chart sheets, respectively.

VI. DATA REDUCTION, VALIDATION, AND REPORTING

An important element in the quality control program is the validation of data by the use of accuracy and precision determinations. Precision describes the degree to which data generated from replicate measurements differ from one another. Accuracy refers to the correctness of the data. In an analysis run, a replicate and spike are run periodically. Percent recoveries are calculated on spike sample data and accepted when recoveries are between 85% and 115%. If recoveries are outside this range, samples are re-poured and re-spiked for additional determinations. Percent recovery data is transferred onto graphs. Replicated data is also graphically illustrated by plotting the numerical difference between replicates versus sample number. An upper warning limit and upper control limit is calculated by multiplying the mean by 2.51 and 3.27 respectively. These quality control charts are very useful in determining if a system is in a state of statistical control. These charts are also used to visualize and monitor the relative variability of repetitive data. (See Attachment 2). the formula to calculate the mean of the precision data is as follows:

$$R = (\quad d_i \ )/N$$

d_i = the difference btween replicate results
N = number of samples

The mean and standard deviation are calculated for the spiked sample data.

The percent recovery is calculated using the following formula:

$$\% \ R = \frac{(SSR - SR)}{SA} \times 100$$

SSR = spiked sample result
SR = sample result
SA = spike added

In addition to replicates and spikes, the analytical sample runs include numerous calibration checks. A reagent blank and standard are run periodically. EPA water supply quality control samples and NBS trace elements standards, and various other commercially prepared standards are also analyzed during each run.

VII. INSTRUMENT RECORDS AND LOGBOOKS

Instrument records and logbooks are maintained for each instrument. These records include the following:

1. Operations manuals with updates as provided by the manufacturers.

2. Service manuals and schedules of recommended preventive maintenance.

3. Maintenance logbooks containing entries describing all maintenance performed on the instrument both by the multi-element laboratory, as well as by qualified service engineers.

4. Sample logbooks containing a record of all samples analyzed listed by date of analysis. These logbooks contain pertinent information, such as sample identification, instrument conditions, and analyst. Any special modifications made to either the instrument or to the analytical protocol are also noted.

VIII. GENERAL LABORATORY PRACTICES

A. Laboratory Water

Laboratory pure water is supplied by a reverse osmosis, mixed bed ion exchange system. Effluent water passes through a 0.5 um filter and the resistance of the outlet water is monitored with an in-line conductivity probe (18 megohms).

B. Analytical Reagent

Analytical reagent grade chemicals are purchased for all analyses and the following requirements are maintained:

1. All chemicals and standards are dated upon receipt and the expiration date is also posted on the container.

2. Stock and working standards are labeled with concentration, date prepared and expiration date and with the initials of the preparer.

C. Analytical Glassware

All volumetric glassware used in chemical analysis is certified to be Class A Grade.

Disposable plastic tubes are used to minimize contamination.

D. Preparation of Standard Solutions

1. All standard solutions are made by one of the following techniques:

(a) Dilution of a primary standard grade reagent to volume using Class A volumetric glassware.

(b) Dilution of a known standard solution to volume using Class A volumetric glassware (serial standard method).

2. Shelf life of standard solution is dependent upon the stability of reagent used and the frequency of use. Standard solutions are labeled with date of preparation and expiration, and the initials of the person who made them.

3. The purchase of any standard (or reference) solution must be accompanied by a certification or assay of composition. Without such certification, said standard will not be used.

E. Standardization Procedures

Any solution that will be used as a standard is checked against a primary standard unless otherwise certified.

F. Hollow Cathode Lamp (HCL) and Electrodeless Discharge Lamp (EDL) Documentation

1. All HCL and EDL lamps are dated upon arrival.

2. The intensity of each lamp is check upon arrival and recorded with each use. The lamp is replaced if the intensity goes below 75% of its original value.

BALTIMORE SOIL IN LEAD ABATEMENT DEMONSTRATION PROJECT

LEAD PAINT STABILIZATION PROTOCOL

The work included in this portion of the contract includes:

A. Before-preparation practices

1. Prior to preparation, occupants shall be notified of starting date and expected date of completion. They shall be instructed to remove all movable objects from the work area and be informed about the proper method of entrance to and egress from the property. Signs of heavy cardboard shall be posted at each property, in a location clearly visible to passersby, at least seven days prior to the start of work.

2. Windows and doors in the work area shall be taped using duct tape or equivalent water proof tape to seal out dust for the duration of the work. Six mil thick plastic should be installed on vertical surfaces where wet scraping occurs.

3. All workers will be required to change into appropriate work clothes, including shoes, upon arrival at the work site. Remove work clothing before leaving work site. Each worker will be required to wear a half-mask air purifying respirator equipped with high efficiency filters while in the work area. Smoking, eating, and drinking will not be permitted in the work area. The contractor will provide water, a dressing room, washroom and toilet facilities for use of his employees.

4. Blood will be taken from the workers and tested prior to starting the project, at two months and at the conclusion of the project.

B. Complete preparation of exterior surfaces containing cracking, chipping, peeling or chalking lead based paint includes removal of deteriorated paint, High Efficiency Particulate Air (HEPA) vacuum cleaning, washing and rinsing.

1. Methods of removal are limited to wet scraping in which the surface being worked on is kept constantly wet using a water spray.

2. Removal includes complete collection and disposal of all resulting debris and dust.

3. Cleanup shall include HEPA vacuuming of all surfaces to remove dust; if this is not feasible, wet methods may be used, including wet sweeping, or shovelling.

4. Debris, including used sealing tape, used drop cloths, filters, and disposable clothing shall be disposed of according to hazardous waste regulations. Waste shall be recorded by type, quantity, and disposal site.

C. Minimum preparation, washing and rinsing to remove dust and dirt, of surfaces adjacent to those treated above shall be done as necessary, to match those surfaces.

D. Repainting can begin after the site has been inspected and approved and shall begin within 48 hours of completion of surface preparation. The contractor shall provide all labor, materials, equipment, and services necessary for satisfactory application of field painting.

1. All caulking shall be done as directed by the Project Manager. Caulk shall be a one part 100% liquid polymer, acrylic base compound, non-sagging, non-staining, and of gum consistency.

2. All paint shall be applied using a brush or roller. All surfaces being repainted shall receive one coat of primer and two finish coats. Paint shall be unscarred and completely integral. Sufficient drying time must be allowed between coats to satisfy the manufacturer's requirements. Paint shall be a high quality latex based system composed of a primer and an exterior finish, and shall have a lead content of not more than 0.06%.

3. Upon completion of the work, all paint spots shall be removed from walls, glass and other surfaces. All rubbish and accumulated materials shall be removed and area must be left in a clean, orderly and acceptable condition.

E. The contractor may, with approval of the project manager, choose to cover such items as window frames, porch eaves and door frames with 0.032 inch thick, alloy 3004 - H 134 aluminum sheets as an alternate to scraping and repainting them.

1. Prior to starting work, all windows and doors of the affected structure shall be taped to seal out any dust.

2. Covering shall be formed on site to produce a close fitting cover with smooth bends, close joints, and a generally neat appearance.

3. Fasteners shall be spaced in accordance with good practice, hidden where possible.

4. Joints at corners and at edges where aluminum abuts masonry shall be neatly made and neatly and fully caulked. Caulk shall be one part 100% liquid polymer, acrylic base compound, non-sagging, non-staining, gum consistency.

5. After completion of work and at the end of the day, all resulting debris and dust shall be removed using a HEPA vacuum cleaner and disposed of according to regulations.

BALTIMORE SOIL IN LEAD ABATEMENT DEMOSTRATION PROJECT

SOIL ABATEMENT PROTOCOL

Background: Removal of soil to a depth of 6 inches and replacement of the soil with topsoil and sod is based on the results of analysis for lead levels in the soil. If the lead levels in the soil were equal to or greater than 500 ppm; the study property will be scheduled for removal of the soil. If the lead levels in the soil are less than 500 ppm; bare spots of the study property were reseeded to reduce dust levels.

Work included in this part of the contract includes:

A. Before preparation practices

1. Prior to preparation residents shall be notified of starting date and estimated date of completion. They shall be instructed to remove all movable objects from the work area and the contractor will control access to the work area. Signs of heavy cardboard shall be posted at each property in a location clearly visible to passersby at least seven days before work begins.

2. Blood will be taken from the workers and tested prior to starting the project, at two months, and at the conclusion of the project.

3. Windows and doors adjacent to the work area shall be taped with duct tape or equivalent waterproof tape. The contractor shall use a light water spray to eliminate or capture any dust produced by the abatement procedures.

4. Workers will be required to change into work clothes, including shoes, upon arrival at the site. Remove work clothes before leaving the work site. Each worker will be required to wear a half-mask air purifying respirator equipped with high efficiency filters while working. Eating, drinking, and smoking will not be permitted in the work area. The contractor will provide water, a dressing room, washroom and toilet facilities for the use of his employees.

B. Preparation of the designated area includes physically locating and marking the limits of the area using stakes and tape or some other approved method, removing and disposing of any trash within the work area limits, and carefully removing any existing shrubs, plants, or ground cover other than grass to an adequate storage place. Fencing shall also be removed and stored.

C. Excavation of the soil to a depth of six inches. Mist the area to be excavated with water to control dust levels. Dispose of the excavated soil in an appropriate manner depending on the toxicity or lack thereof.

D. Placing and compaction of "clean" soil (earth material obtained off site, which shall have been previously tested (at least 5 days prior) for lead and found to have less than 50 ppm).

E. After the refill has been acceptably compacted, the area shall be covered with two inches of clean topsoil and sodded. Shrubs, plants, and/or ground cover shall be replanted. In an area close to a work area where there is an established stand of grass, the contractor may be required to seed existing bare areas. Seeding shall consist of loosening the existing soil to a depth of two inches ; removal of all clods, stone and other foreign materials larger than three inches in any dimension, application of a 5-10-10 fertilizer at a rate of 5 pounds per 100 square feet and seed mix No. 2 at a rate of 0.25 pounds per 100 square feet, raking fertilizer and seed into the prepared bed to a depth of not more than 1/4 inch, compaction using an approved lawn roller, and application of an approved mulch. All existing fencing removed during the course of soil lead abatement work shall be re-erected.

F. At the end of each workday cleanup shall include vacuuming, with a High Efficiency Particulate Air (HEPA) vacuum cleaner, all surfaces adjacent to the work area to remove all dust. After complete removal and cleanup, the site is ready for inspection.

G. All lead contaminated debris including soil, filters and disposable clothing shall be disposed of in accordance with hazardous or solid waste regulations.

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QUALITY ASSURANCE PLAN

PROJECT TITLE: BALTIMORE SOIL LEAD ABATEMENT DEMONSTRATION PROJECT (LIS)

EPA PROJECT MANAGER: RICHARD BRUNKER, Ph.D.

LIS PROJECT MANAGER: MERRILL BROPHY, R.N., M.S.N.

PERFORMING ORGANIZATION: MARYLAND DEPARTMENT OF THE ENVIRONMENT, TOXICS, ENVIRONMENTAL SCIENCE & HEALTH

APPROVALS:

PROJECT MANAGER:_____
(MERRILL BROPHY, R.N., M.S.N.)

QA MONITOR:_____
(ELI REINHARZ)

PROGRAM ADMINISTRATOR:_____
(BARBARA CONRAD, R.N., M.P.H.)

PRIMARY INVESTIGATOR:_____
(KATHERINE FARRELL, M.D., M.P.H)

EPA PROJECT MANAGER:_____
(RICHARD BRUNKER, Ph. D.)

QUALITY ASSURANCE PLAN

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2.0 General Project Overview

2.1 Project Details

Project Title: Baltimore Lead In Soil Demonstration Project

EPA Project Manager: Richard Brunker, Ph.D.

LIS Investigators: Dr. Katherine Farrell, M.P.H.
Dr. J. Julian Chisolm, Jr.
Dr. Boon Lim, M.P.H.
Charles Rodhe, Ph.D.

MDE Project Manager: Merrill Brophy, R.N., M.S.N.

Project QA Monitor: Alice Zeiger, Toxicologist 89-90
Eli Reinharz, Ecological Assessment 90-92

Project Category: Type II

Project Duration: 3 years

Type of Project: Superfund Urban Soil Abatement Demonstration Project

Project Address: Maryland Department of the Environment
TESH/LIS
2500 Broening Hwy
Baltimore, MD 21224

Project Phone No: 410-631-3820

2.2. Statement of Decision

Study the correlation between removal of soil lead hazards from child's environment at home and blood lead levels.

2.3 Purpose of the Study

Observe effects of soil abatement on children's blood lead levels.

2.4 Description of the Project

Project will study two areas in Baltimore City which are of pre-1978 construction and typical of lead containing type houses in the urban area. A control group will be established and will receive all testing and treatment as study group except the soil abatement. Blood lead levels will be studied over the course of the project beginning with baseline levels and at regularly scheduled times. Soil, dust, water and paint samples will be collected at all project houses. Paint stabilization will be conducted at all project houses to reduce likelihood of recontamination of house soils. Soil abatement for areas of the houses with lead results of >500 ppm will be conducted on study area houses.

2.5 Anticipated Results

Hypothesis stated a reduction of 1000 ppm of soil lead would result in a reduction of 3 - 6 μg/dl blood lead level.

2.6 Consequences of Incorrect Decisions

The consequences of incorrect decisions would be the wrongful assumption of soil lead levels influencing children's blood lead levels.

2.7 List of Project Measurements

Table 2.7.1

2.8 Application of Environmental Findings

These findings will be used by EPA in determining future actions/protocols for management of soil lead.

2.9 Sampling Summary Table
Table 2.9.1

2.10 Project Time Line
Figure 2.10.1

2.11 Project Flow Chart
Figure 2.11.1

2.12 Organizational Chart
Figure 2.11.1

2.13 Contractor and Subcontractor Geographical Locations
Contractor:
Maryland Department of the Environment
Toxics, Environmental Science and Health
2500 Broening Hwy
Baltimore, MD 21224

Subcontractor:
State of Maryland Department of Health and Mental Hygiene
Laboratories Administration
301 W. Preston St.
Baltimore, MD 21204

2.14 Procedure for Monitoring Contractors and Subcontractors

The procedure for EPA monitoring of MDE will be through quarterly reports and site visits.

The procedure for MDE monitoring of subcontractors of the project will include blind audits and site visits.

2.15 Description of Contractor and Subcontractor Communications with EPA or MDE

Quarterly reports to be submitted to Region III EPA by MDE. Interim report will be submitted to EPA. Financial Status Reports will be submitted annually to EPA. Regularly scheduled meetings to be conducted by EPA Region III Oversite Coordinator.

Laboratories Administration communicates with MDE through laboratory analysis results. Regularly scheduled meetings to be conducted by MDE with Laboratory Administration personnel. A Memorandum of Understanding is to be developed between MDE and the Laboratories Administration.

3.0 Quality Assurance Plan Description

3.1 Introduction

The purpose of the Quality Assurance Plan (QAP) for the Baltimore Lead-in-Soil Demonstration Project is to indicate prime responsibilities and prescribe requirements for assuring that the project is planned and executed in a manner consistent with defined quality assurance objectives. This QAP provides guidance and specifications to assure that:

1. All field sampling, methodologies and documentation, sample preparation, handling and transportation are conducted consistently according to established procedures;

2. All laboratory determinations and analytical results are valid through preventative maintenance, instrument calibration, and analytical protocols;

3. Samples are identified and controlled through sample tracking systems and chain-of-custody protocols;

4. Records are retained as documentary evidence of the sample integrity, applied processes, equipment used, and analytical results; and

5. Generated data is validated and its use in calculations documented.

3.2 Quality Assurance Plan Summary

Information provided within this document summarizes the specific tasks required for the project as well as other pertinent information.

3.2.1 Quality Assurance Plan Background

Data collected from Baltimore's Childhood Lead Poisoning Prevention Program, coupled with the CDC report, led to the following conclusion:

a. Children playing in the area of exposed, lead contaminated soil may ingest lead in the course of their normal hand-to-mouth activities.

b. Direct contact with lead contaminated soil may result in increased body burden of lead.

c. Exposure of humans to lead through ingestion or inhalation can result in toxic effects in the brain, central and peripheral nervous system, kidney, and hematopoietic system. Anemia is an early manifestation of lead poisoning. Peripheral neuropathy also results from lead poisoning. Young children under the age of six are especially prone to the most profound and deleterious effects of lead exposure. Chronic exposure to low levels of lead can cause permanent learning disabilities in children.

3.2.2 Demonstration Project

The Baltimore Soil Lead Abatement Demonstration Project shall involve sampling approximately 400 selected children from two urban neighborhoods (Park Heights - study area, Walbrook Junction - control area) for blood lead levels to determine base line data, sampling their yards to establish soil lead levels, and their residences to determine dust lead levels, removing contaminated soil in the study area, re-sampling the children during the following year to observe the effects of the soil removal. Property owner consent is required for the houses to be enrolled in the project. This QAP addresses the soil, dust, water and paint collection and analysis.

The environmental staff will consist of one industrial hygienist, as the Environmental Coordinator, and six Environmental Health Aides. The Environmental Health Aides will conduct environmental sampling at project properties according to the attached protocols. The Environmental Coordinator schedules the sampling and supervises the sampling and documentation of samples

Detailed environmental sampling will be conducted during 1988 and 1989, as necessary, at the selected children's properties. Environmental sampling includes: soil, interior dust, water, and exterior paint. Common environmental characteristics of the study and control area properties include:

a. exterior paint positive for lead
b. soil areas included in the property

4.0 Quality Assurance Objectives

4.1 General

The quality of environmental sampling made during this study will be determined by the following characteristics: accuracy, precision, representativeness, completeness, and comparability.

4.2 Represenativeness

Sampling procedures will be used to assure that samples collected are representative of the media. Sample handling protocols protect the representativeness of the collected sample. Proper documentation will ensure that protocols have been followed and that sample identification and integrity are assured.

5.0 Responsibility for Quality Assurance

5.1 Lead-in-Soil Project Manager

The project manager is responsible for:

-approving, maintaining and implementing the Quality Assurance Plan for this project,

-indicating the types of quality assurance records to be maintained for this project and,

-approving sampling procedures and operating systems.

5.2 Lead-in-Soil Environmental Coordinator

The environmental coordinator is responsible for:

-developing sampling protocols for soil, dust, water and paint,

-training other LIS personnel in the implementation of environmental protocols,

-scheduling environmental sample collection,

-reviewing sample collection information, results and data,

-periodically checking the sampling equipment for cleanliness and condition

-informing the project manager of sampling issues and,

-randomly checking the data entry forms of sample analysis results for accuracy against the original sample results form submitted by the laboratory.

5.3 Lead-in-Soil Environmental Health Aides

The environmental health aides are responsible for:

-collecting environmental samples from project properties as scheduled.

-collecting environmental samples according to project protocols.

-submitting samples and appropriate paperwork to the lab for sample analysis.

-transcribing sample analysis results to the data entry forms.

-checking data entry forms for accuracy before submitting them to the environmental coordinator.

6.0 Sampling Procedures

6.1 General

Sampling protocols will be followed as closely as possible allowing however in the inherent differences between each project property. Deviation from sampling protocols will be clearly documented on diagrams or forms.

6.2 Equipment List

Standard sampling equipment is provided for the project. A complete listing of equipment is located in Appendix M.

6.3 Record Keeping

All environmental materials, forms, equipment and supplies which have been used for this project are maintained by the Environmental Coordinator.

7.0 Soil Sampling

7.1 Detailed Soil Sampling

7.1.1 Sampling Schemes

After properties are selected and enrolled in the project, they undergo detailed soil sampling. Top soil samples will be collected by soil corer at the surface to a depth of 2 inches. Bottom soil samples will be collected from the soil corer at a depth of 4-6 inches by the project staff according to the attached protocols. The soil sample will be collected using one of the defined pattern: line source, targeted area, small area, or grid pattern. Pattern selection will be based upon the layout of the subject property at the discretion of the Environmental Coordinator. Sketches indicating property details and sample locations will be made by Environmental Health Aides.

7.1.2 Handling of Samples

Soil samples are collected in polyproplyene plastic bags and labeled at the time of collection. Samples are recorded on a chain-of-custody form and submitted to the laboratory by the Environmental Coordinator. Laboratory personnel receive samples and issue a sample receipt for the project file. Analysis results are recorded on Soil Processing Sheets and returned to the Environmental Coordinator.

7.2 Toxicity Soil Testing

7.2.1 EP Toxicity Soil Testing Sampling Scheme (EPTOX)

Soil samples from study area properties will be analyzed by EPTOX prior to the soil stabilization phase of the project to determine disposal requirements of the soil removed during stabilization. Top soil samples will be collected by soil corer at the surface to a depth of 2 inches from locations within each area to be stabilized. Randomly selected sites within the area to be stabilized will be sampled in the following manner:

One sample from an area 20 inches from foundation, one sample from the middle of the area and one sample from 20 inches inside the area will be composited for EPTOX testing.

Soil samples are collected in polyproplyene plastic bags and labeled at the time of collection. Samples are recorded on a chain-of-custody form and submitted to the laboratory by the Environmental Coordinator. Laboratory personnel receive

samples and issue a sample receipt for the project file. Analysis results are recorded on Sample Processing Sheets and submitted to the Environmental Coordinator.

7.2.2 Toxicity Characteristics Leaching Procedure (TCLP)

Soil samples from control area properties will be analyzed by TCLP to determine disposal requirements of the soil. Top soil samples will be collected by soil corer at the surface to a depth of 2 inches from locations within each area to be stabilized. Randomly selected sites within the area to be stabilized will be sampled in the following manner:

One sample from an area 20 inches from foundation, one sample from the middle of the area and one sample from 20 inches inside the area will be composited for EP Toxicity testing.

Soil samples are collected in polyproplyene plastic bags and labeled at the time of collection. Samples are recorded on a chain-of-custody form and submitted to the laboratory by the Environmental Coordinator. Laboratory personnel receive samples and issue a sample receipt for the project file. Analysis results are recorded on Sample Processing Sheets and returned to the Environmental Coordinator.

7.3 Handling of Samples

7.3 Post Stabilization Soil Sampling

7.3.1 Sampling Schemes

Post stabilization soil sampling is conducted after paint stabilization and soil abatement. The primary purpose of this sampling is to document the effectiveness of stabilization activities. Soil abatement contracts require replacement soil to contain less than 50ppm lead. Top soil samples will be collected by soil corer at the surface to a depth of 2 inches. Bottom soil samples will be collected from the soil corer at a depth of 4-6 inches by the project staff according to the attached protocols. The soil sample will be collected using one of the defined pattern: line source, targeted area, small area, or grid pattern. Pattern selection will be based upon the layout of the subject property at the discretion of the environmental coordinator. Sketches indicating property details and sample locations will be made by environmental health aides.

7.3.2 Handling of Samples

Soil samples are collected in polyproplyene plastic bags and labeled at the time of collection. Samples are recorded on a chain-of-custody form and submitted to the laboratory by the Environmental Coordinator. Laboratory personnel receive samples and issue a sample receipt for the project file. Analysis results are recorded on Sample Processing Sheets and submitted to the Environmental Coordinator.

8.0 Paint Sampling

8.1 Exterior Paint Sampling

8.1.1 Sampling Schemes

Properties selected for the project will be sampled for lead content of exterior painted surfaces of all structures. Representative samples of chipped, cracked, flaking or peeling paint chips will be collected for analysis.

8.1.2 Handling of Samples

Paint chip samples collected will be stored in reinforced paper envelopes and labeled at the time of collection. Samples will be recorded on a chain-of-custody form and submitted to the laboratory by the Environmental Coordinator. Laboratory personnel receive samples and issue a sample receipt for the project file. Analysis results will be recorded on Paint Processing Sheets and submitted to the Environmental Coordinator.

8.2 Interior Paint Sampling

8.2.1 Sampling Schemes

Properties selected for the project will be sampled for lead content of two interior surfaces of three rooms within the house. Record sample identification numbers, codes, condition of surface tested and results on Lead-in-Soil LBP Inspection Forms. A sample copy of the LBP Inspection Form is located in Appendix F.

PGT XRF Calibration
Calibration of the PGT XRF Lead Based Paint Analyzer is required at the beginning and end of each interior survey. Calibration checks against three paint standards is required. Each check is recorded in the calibration record and the page where it is recorded is indicated on the LBP Inspection Form. Each calibration check must fall within the acceptable range as indicated on the standards.

9.0 Dust Sampling

9.1 Pre-Stabilization

9.1.1 Sampling Schemes

Properties selected for the project will be sampled for lead content of dust on interior surfaces within the house.

9.1.2 Handling of Samples

Dust samples collected will be stored in reinforced paper envelopes and labeled at the time of collection. Samples will be recorded on a chain-of-custody form and submitted to the laboratory by the Environmental Coordinator. Laboratory personnel receive samples and issue a sample receipt for the project file. Analysis results will be recorded on Paint Processing Sheets and submitted to the Environmental Coordinator.

9.2 Post-Stabilization

9.2.1 Sampling Schemes

Properties selected for the project will be sampled for lead content of dust on interior surfaces within the house.

9.2.2 Handling of Samples

Dust samples collected will be stored in reinforced paper envelopes and labeled at the time of collection. Samples will be recorded on a chain-of-custody form and submitted to the laboratory by the Environmental Coordinator. Laboratory personnel receive samples and issue a sample receipt for the project file. Analysis results will be recorded on Paint Processing Sheets and submitted to the Environmental Coordinator.

10.0 Water Sampling

10.1 Sampling Schemes

Properties selected for the project will be sampled for lead content of drinking water sources within the house. Annotate on the Water Analysis Form those samples collected that will not be first draw (from pipes not used for 8-18 hours previously).

10.2 Handling of Samples

A vial of 1M nitric acid was added to labeled sample collection containers prior to collection of the water sample. Record water samples on a Water Analysis Form, store on ice and submit to the laboratory at the end of the day.

11.0 Chain-of-Custody

11.1 General

EPA has established a program of sample chain-of-custody that is followed during sample handling activities in both field and laboratory operations.

Chain-of-custody procedures document the sample history and constitute a crucial part of sampling and analysis programs. Chain-of-custody documentation verifies the identification and history of a sample from collection through the time of analysis.

The objective of sample custody identification and control is to ensure that:

-all samples scheduled for collection, as appropriate for the data required, will be uniquely identified;

-the collection samples will be analyzed and traceable to specific analysis records,

-important sample characteristics will be preserved;

-samples will be protected from loss or damage;

-an alteration of samples (e.g., filtration, preservation) is documented;

-a record of sample integrity is established for legal and technical purposes; and

The chain-of-custody record is used to:

-document sample handling procedures, including sample location, and sample number; and

-describe the chain-of-custody process.

The chain-of-custody description section requires:

-the sample number;

-the name(s) of the sampler(s) and the person shipping the samples;

-the date and time that the samples were delivered for shipping; and

-the names of those responsible for receiving the samples at the laboratory.

Samples of a chain-of-custody record for soil, paint, and dust samples are shown in Appendix F. A sample of the water sample analysis form is shown in Appendix F.

As samples are collected, entries will be made on the chain-of-custody form. Data to be noted includes:

-date and time,
-sampler(s) name,
-type of sample,
-sample identification number,
-project name,
-name of person to receive results,
-property identification number and street address.

Soil, dust, water and paint chip sample containers will be labelled by an indelible marker with the appropriate information necessary to match the sample container to the chain-of-custody record.

When samples are received at the laboratory, the laboratory technician will verify each and every sample against the chain-of-custody, note any discrepancies or losses of samples, and then sign for receipt of the samples. The laboratory technician may also contact filed personnel to resolve deficiencies, irregularities, discrepancies, etc., prior to accepting the samples. Samples will remain under the control of the laboratory technician until samples are ultimately disposed.

A sample is considered to be in custody if it:

-is in the physical possession of the responsible party;

-is in view of the responsible party;

-is secured by the responsible party to prevent tampering; or

-is secured by the responsible party in a restricted area.

Chain-of-Custody is initiated at the time of sample collection and follows the sample through to the laboratory where it is replaced by a Laboratory Processing Sheet. Sample information and results will be recorded on the Laboratory Processing Sheet and returned to the Environmental Coordinator.

11.2 Sample Receipt

All samples will be delivered to the laboratory by a member of the LIS field sampling team. Upon receipt chain-of-custody and sample integrity will be checked and any problems recorded. Samples will then be logged in by laboratory personnel who will accept and sign the chain-of-custody record.

Each sample received by the laboratory is assigned a unique sequential Laboratory Identification number which will identify the sample in the laboratory's internal tracking system.

11.3 Sample Storage

Samples not destroyed by the analysis process will be returned to the Environmental Coordinator for inventory and storage at the secured facility for the duration of the project.

12.0 Quality Assurance Plan Soil Analysis

12.1. Introduction

This quality assurance document sets forth laboratory policies and procedures that maximize the quality of laboratory performance. The laboratory goal is to provide a quality service of elemental analysis.

Soil samples submitted for analysis for metals will be collected and stored in clean previously unused polystyrene bags.

12.2 Sample Acceptance, Preservation, and Storage

All incoming samples will be delivered to the Soil Laboratory. As the samples are accepted, they will be assigned a laboratory sample number and the submission form is dated with the current date.

The quantity of sample submitted must be adequate for all analyses requested.

12.3 Methodology

Lead will be quantified via the Kevex XRF analyzer. Ten percent of the samples will be replicated. Certified NBS Standards will be included each tray run.

12.4 Quality Assurance

All quality assurance data will be maintained and available for easy reference or inspection. An unknown performance evaluation sample must be analyzed once per year for the metals measured. If problems arise, they should be corrected, and a follow-up performance sample should be analyzed.

Perform routine preventive maintenance on the Kevex unit.

A NBS standard should be analyzed once every tray run for lead measured. The measured value should be within the control limits established by NBS.

At least one replicate sample should be run every 10 samples, or with each set of samples to verify precision of the method.

12.5 Data Reduction, Validation, and Reporting

An important element in the quality control program is the validation of data by the use of accuracy and precision determinations. Precision describes the degree to which data generated from replicate measurements differ from one another. Accuracy refers to the correctness of the data. Replicate samples will be analyzed periodically. Analysis and replicated data is also graphically illustrated by plotting the numerical difference between replicates versus sample number. The mean and standard deviation will be calculated for sample data. Blind samples of known values will be inserted into the sample stream for analysis by the sample collectors.

12.6 Instrument Records and Logbooks

Maintain instrument records and logbooks for each instrument including the following:

Operations manuals with updates as provided by the manufacturers, Service manuals and schedules of recommended preventive maintenance, maintenance logbooks containing entries describing all maintenance performed on the instrument both by the multi-element laboratory personnel, as well as qualified service engineers, and Sample logbooks containing a record of all samples analyzed listed by date of analysis. These logbooks contain pertinent information, such as sample identification, instrument conditions, and analyst. Any special modifications made to either the instrument or to the analytical protocol will also noted.

12.7 General Laboratory Practices

The purchase of standard (or reference) material must be accompanied by a certification or assay of composition.

13.0 Quality Assurance Plan Water Analysis

13.1. Introduction

This quality assurance document sets forth laboratory policies and procedures that maximize the quality of laboratory performance. The laboratory goal is to provide a quality service of elemental analysis for the project.

It is the laboratories policy to maintain an active quality assurance program to provide analytical data of known and supportable quality and ensure a high professional standard in analytical data generated in support of the project undertaken for the public by state and federal agencies.

13.2 Sample Collection

Water samples for this project will be collected by trained sampling collectors who are approved by the Division of Water Supply of the MDE.

Water samples to be analyzed for metals will be collected and stored in clean polyethylene or polypropylene containers with teflon-lined lids.

13.3 Sample Acceptance, Preservation and Storage

All incoming samples will be delivered to the Water Laboratory. As the samples are accepted, they are assigned a laboratory sample number and the submission form is dated with the current date.

To avoid sample degradation, all samples for metal analysis must be kept at 4 degrees C until receipt, and must be received by the laboratory no later than one day after collection. Water samples for total metals analysis should be preserved with analytical grade nitric acid at a pH of 2 or less (typically 0.5% v/v). The quantity of sample submitted must be adequate for all analyses requested.

13.4 Methodology

Arsenic, cadmium, chromium, lead, silver and selenium will be quantified via graphite furnace atomic absorption spectrophotometer. Samples will be analyzed after a blank and three different standard calibration concentrations will be completed. The first sample in each tray of 35 positions is always an EPA water supply quality control sample and is followed by a standard equivalent to one half of the maximum

contaminant level (MCL). Ten percent of the samples are replicated. One hundred percent will be spiked. Blanks and different concentrations of standards will be included throughout each tray run.

13.5 Quality Control Minimum Requirements

All quality control data will be maintained and available for easy reference or inspection. An unknown performance evaluation sample must be analyzed once per year for the metals measured. Results must be within the control limit established by EPA. If problems arise, they should be corrected, and a follow-up performance sample should be analyzed.

Prepare a calibration curve composed of a minimum of a reagent blank and three standards, verify subsequent calibration curves by use of at least a reagent blank and one standard at or near the MCL. Daily checks must be within ± 10 percent of original curve. If 20 or more samples per day are analyzed, the working standard curve must be verified by running an additional standard at or near the MCL every 20 samples. Checks must be within ± 10 percent of the original curve.

Routine preventive maintenance on balances and the atomic absorption spectrophotometer. Class S weights should be available to make periodic checks on balances.

Chemicals should be dated upon receipt of shipment and replaced as needed or before shelf life has been exceed. A known reference sample (NBS) should be analyzed once per quarter for the metals measured. The measured value should be within the control limits established by NBS. At least one duplicate sample should be run every 10 samples, or with each set of samples to verify precision of the method. Checks should be within the control limit established by EPA.

Standard deviation should be obtained and documented for all measurements being conducted. Quality control charts or a tabulation of mean and standard deviation should be used to document validity of data on a daily basis.

13.6 Data Reduction, Validation and Reporting

An important element in the quality control program is the validation of data by the use of accuracy and precision determinations. Precision describes the degree to which data generated from replicate measurements differ from one another.

Accuracy refers to the correctness of the data. In an analysis run, a replicate and spike will be run periodically. Percent recoveries will be calculated on spike sample data and accepted when recoveries are between 85% and 115%. If recoveries are outside this range, samples will be re-poured and re-spiked for additional determinations. Percent recovery data is transferred onto graphs. Replicated data is also graphically illustrated by plotting the numerical difference between replicates versus sample number. An upper warning limit and upper control limit is calculated by multiplying the mean by 2.51 and 3.27 respectively. Quality control charts will be very useful in determining if a system is in a state of statistical control and will be used to visually monitor the relative variability of repetitive data.

13.7 Instrument Records and Logbooks

Instrument records and logbooks will be maintained for each instrument. These records include the following:

1. Operations manuals with updates as provided by the manufacturers. Service manuals and schedules of recommended preventive maintenance.

2. Maintenance logbooks containing entries describing all maintenance performed on the instrument both by the multi-element laboratory, as well as by qualified service engineers.

3. Sample logbooks containing a record of all samples analyzed listed by date of analysis. These logbooks contain pertinent information, such as sample identification, instrument conditions, and analyst. Any special modifications made to either the instrument or to the analytical protocol will be also noted.

13.8 General Laboratory Practices

13.8.1 Laboratory Water

Laboratory pure water is supplied by a reverse osmosis, mixed bed ion exchange system. Effluent water passes through filter and the resistance of the outlet water is monitored with an in-line conductivity probe (18 megohms).

13.8.2 Analytical Reagent

Analytical reagent grade chemicals will be purchased for all analyses and the following requirements will be maintained. All chemicals and standards will be dated upon receipt and the expiration date is also posted on the container. Stock and working standards will be labeled with concentration, date prepared and expiration date and with the initials of the preparer.

13.8.3 Analytical Glassware

All volumetric glassware used in chemical analysis is certified to be Class A Grade. Disposable plastic tubes will be used to minimize contamination.

13.8.4 Preparation of Standard Solutions

All standard solutions will be made by diluting primary standard grade reagent to volume using Class A volumetric glassware, or diluting a known standard solution to volume using Class A volumetric glassware (serial standard method).

Shelf life of standard solution is dependent upon the stability of reagent used and the frequency of use. Standard solutions will be labeled with date of preparation and expiration, and the initials of the person who made them.

The purchase of any standard (or reference) solution must be accompanied by a certification or assay of composition. Without such certification, said standard will not be used.

13.8.5 Standardization Procedures

Any solution that will be used as a standard is checked against a primary standard unless otherwise certified.

13.9 Hollow Cathode Lamp (HCL) and Electrodeless Discharge Lamp (EDL) Documentation

1. All HCL and EDL lamps will be dated upon arrival.

2. The intensity of each lamp is check upon arrival and recorded with each use. The lamp is replaced if the intensity goes below 75% of its original value.

14.0 Quality Assurance Plan Dust Analysis

14.1 Introduction

This quality assurance document sets forth laboratory policies and procedures that maximize the quality of laboratory performance. The goal of the laboratory is to provide a quality service of elemental analysis for the project.

The quality assurance program uses analytical data of known and supportable quality to ensure a high professional standard in analytical data generated in support of projects undertaken for the public by state and federal agencies.

14.2 Sample Collection

Dust samples will be collected by trained sampling collectors for this project. All collectors will be trained in sampling procedures. Dust samples to be analyzed for metals will be collected and stored in clean previously unused paper envelopes and recorded on the chain-of-custody.

14.3 Sample Acceptance, Preservation and Storage

All incoming samples will be delivered to the laboratory. As the samples are accepted, they will be assigned a laboratory sample number and the submission form is dated with the current date. The quantity of sample submitted must be adequate for all analyses requested.

14.4 Methodology

Lead will be quantified via the Kevex XRF analyzer. Ten percent of the samples will be replicated. Certified NBS standards will be included each tray run.

14.5 Quality Control

Perform routine preventive maintenance on the Kevex unit.

A NBS standard should be analyzed once per tray for lead. The measured value should be within the control limits established by NBS. At least one replicate sample should be run every 10 samples, or with each set of samples to verify precision of the method.

14.6 Data Reduction, Validation and Reporting

An important element in the quality control program is the validation of data by the use of accuracy and precision determinations. Precision describes the degree to which data generated from replicate measurements differ from one another. Accuracy refers to the correctness of the data. Replicate samples will be analyzed periodically. Analysis and replicated data is also graphically illustrated by plotting the numerical difference between replicates versus sample number. The mean and standard deviation will be calculated for sample data.

14.7 Instrument Records and Logbooks

Maintain instrument records and logbooks for each instrument including the following:

1. Operations manuals with updates as provided by the manufacturers. Service manuals and schedules of recommended preventive maintenance

2. Maintenance logbooks containing entries describing all maintenance performed on the instrument both by the multi-element laboratory personnel, as well as qualified service engineers

3. Sample logbooks containing a record of all samples analyzed listed by date of analysis. These logbooks contain pertinent information, such as sample identification, instrument conditions, and analyst. Any special modifications made to either the instrument or to the analytical protocol will be also noted.

14.8 General Laboratory Practices

The purchase of standard (or reference) material must be accompanied by a certification or assay of composition.

15.0 Quality Assurance Plan - Paint Chips

15.1 Introduction

This quality assurance document sets forth the laboratory policies and procedures which maximize the quality of laboratory performance. The goal of the laboratory is to provide a quality service of elemental analysis.

It is the policy of the laboratory to maintain an active quality assurance program to provide analytical data of known and supportable quality and ensure a high professional standard in analytical data generated in support of the project.

15.2 Sample Collection

Paint chip samples will be collected by trained sampling collectors and stored in clean previously unused paper envelopes.

15.3 Sample Acceptance, Preservation and Storage

All incoming samples will be delivered to the laboratory, assigned a laboratory sample number and the submission form is dated with the current date.

The quantity of sample submitted must be adequate for all analyses requested.

15.4 Methodology

Lead will be quantified via the Kevex XRF analyzer. Ten percent of the samples will be replicated. Blanks will be included each tray run.

15.5 Quality Control

Perform routine preventive maintenance on the Kevex unit.

A NBS standard should be analyzed once per tray for lead. The measured value should be within the control limits established by NBS. At least one replicate sample should be run every 10 samples, or with each set of samples to verify precision of the method.

15.6 Data Reduction, Validation and Reporting

An important element in the quality control program is the validation of data by the use of accuracy and precision determinations. Precision describes the degree to which data generated from replicate measurements differ from one another. Accuracy refers to the correctness of the data. Replicate samples will be analyzed periodically. Analysis and replicated data is also graphically illustrated by plotting the numerical difference between replicates versus sample number. The mean and standard deviation will be calculated for sample data.

15.7 Instrument Records and Logbooks

Maintain instrument records and logbooks for each instrument including the following:

Operations manuals with updates as provided by the manufacturers

Service manuals and schedules of recommended preventive maintenance

Maintenance logbooks containing entries describing all maintenance performed on the instrument both by the multi-element laboratory personnel, as well as qualified service engineers

Sample logbooks containing a record of all samples analyzed listed by date of analysis. These logbooks contain pertinent information, such as sample identification, instrument conditions, and analyst. Any special modifications made to either the instrument or to the analytical protocol will be also noted.

15.8 General Laboratory Practices

The purchase of standard (or reference) material must be accompanied by a certification or assay of composition.

16.0 Data Assessment

16.1 General

The purpose of data quality assessment is to assure that data generated under the program will be accurate and consistent with project objectives. The quality of data will be assessed based on the precision, accuracy, consistency, and completeness of the data that area measured or generated.

Data quality assessment will be conducted in three phases:

Phase I
Prior to data collection, sampling, and analysis, procedures will be evaluated in regard to their ability to generate the appropriate, technically acceptable information required to achieve project objectives. This QA plan meets this requirement by establishing project objectives defined in the terms of required sampling analysis protocols.

Phase 2
During data collection, results will be assessed to assure that the selected procedures are efficient and effective and the data generated provided sufficient information to achieve project objectives. Precision and accuracy of measurement systems will also be evaluated. In general, evaluation of data will be based on performance audits, results of duplicate and reference sample analyses, and review of completeness objectives.

Phase 3
Throughout the data collection activities, an assessment of the adequacy of the data base generated in regard to completing project objectives will be undertaken. Recommendations for improved quality control will be developed, if appropriate. In the event that data gaps are identified, the Project Manager may recommend the collection of additional raw data to fully support the project's findings and recommendations.

Documentation may include:

-number of duplicate and reference samples analyzed;

-identification of statistical techniques, if used, to measure central tendency, dispersion, or testing for outlier;

-use of historical data and its reference; and

-identification of analytical method.

16.2 Precision and Accuracy

Assessment of precision and accuracy of analytical data is accomplished via review of duplicate analyses (precision) and reference standard (accuracy) in soil. Precision is generally expressed as the relative percent difference (RPD). Accuracy is expressed as percent recovery. Precision must be assessed for each matrix, since distribution of contaminants may be non-homogeneous, especially in soil. Precision in samples must be reviews with knowledge of the matrix and level of analyte present. Corrective action or documentation of substandard precision is the laboratory's responsibility. Accuracy is also impacted by matrix interferences. Each method which provides quality control requirements and acceptance criteria also specifies the method of generating the data to be reviewed. It is the laboratory's responsibility to attempt to identify the source of substandard recoveries and either take corrective action or document the cause.

Precision control requirements and acceptance criteria also specify the method of generating the data to be reviewed. It is the laboratory's responsibility to attempt to identify the source of substandard recoveries and either take corrective action or document the cause.

16.3 Completeness

Completeness is generally assessed as a percentage of data intended to be generated, and is most often utilized in Phase 3 of the data assessment process. Assessment of completeness will be undertaken by the Project Manager in cooperation with the LIS staff.

16.4 Corrective Action

Corrective or preventative action is required when potential or existing conditions are identified that may have an adverse impact on data quantity or quality. Corrective action could be immediate or long-term. In general, any member of the program staff who identifies a condition adversely affecting quality can initiate corrective action by notifying in writing his or her supervisor and the Project Manager. The written communication will identify the condition and explain how it may affect data quality or quantity.

An analysis or analytical system is considered to be out-of-control when it does not conform to the conditions specified by the method or standard operating procedures which apply. To confirm that an analysis or analytical system is in control, the laboratory routinely performs instrument calibration checks, analysis of method blanks and method blank spikes. These results will be compared to the results of quality control samples to laboratory control charts or analytical protocol criteria (e.g.,U.S. EPA-CLP).

A Corrective Action Documentation Form, Appendix F is to be completed for each out-of-control situation. The analyst, working with his or her supervisor or task leader, will attempt to determine the cause of the problem and take appropriate corrective action. Analysis may not resume until the problem has been corrected and it is determined that the analysis is back in control. Demonstration of the restoration of analytical control will normally be accomplished by generating satisfactory calibration and or quality assurance sample data. This documentation will be attached to the corrective action documentation form to be placed in the project files.

16.5 Immediate Corrective Action

Immediate corrective action is applied to spontaneous, non-recurring problems, such as an instrument malfunction. The individual who detects or suspects non-conformace will immediately notify his or her supervisor. The supervisor and the appropriate task leader will then investigate the extent of the problem and take the necessary corrective steps. If a large quantity of data is affected, the task leader must prepare a memorandum to the Project Manager. The individual will collectively decide how to proceed. If the problem is limited in scope, the task leader will decide on the corrective action measure, document the solution in the appropriate workbook, and notify the Project Manager.

16.5 Long-Term Corrective Action

Long term corrective action procedures will be devised and implemented to prevent the recurrence of a potentially serious problem. The Project Manager will be notified of the problem and will conduct an investigation to determine the severity and extent of the problem. The Project Manager will then file a corrective action request with the appropriate supervisory personnel.

List of Appendices

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Appendix A

XRF Analyzer Calibration Procedure

Baltimore Lead In Soil Demonstration Project
GUIDANCE DOCUMENT FOR X-RF

Definition: The field X-Ray fluorescence (XRF) analyzer is a direct reading insturment which determines lead concentration on painted surfaces. The advantages of the XRF analyzer are the integrity of the surface is not disturbed and results are available immediately. XRF reading represents the concentration of lead in mg/cm2.

Analysis of paint chips is also used to identify lead in painted surfaces. Obtaining paint chips samples breaks the integrity of the surface and the chips must be submitted to a laboratory for wet chemistry analysis. Readings represent the percentage of lead in the paint by volume, or percentage.

Although both XRF and paint chip analysis should be fairly consistent with each other, the results of one testing method cannot be converted to the other.

Standard Procedures: Follow standard procedures to obtain reliable results when using these analyzers. Factors that may interfer with the XRF analyzers, include:

* Substrate material
* Temperature extremes (eg. below 35F or above 95F)
* Zero drift
* Zinc
* Radio waves
* Vibration

Three XRF readings within a 1.7 range are recorded and the mean is reported as the lead concentration of a surface. If the readings are not within a 1.7 range repeat the process of collecting readings within the acceptable range. If the readings remain greater than the 1.7 range, do not use this analyzer on this substrate. Possible solution: Recalibrate the analyzer and resample.

The basic technique for reducing the variability of XRF readings is to take repeated measurements at the same point. Statistical theory shows the variablity of the average of a set of repeated measurements is less than the variabiltiy of individual measurements. The greater the number of repeated measurements, the greater the reduction in variability. Use paint chip samples analysis to back up XRF readings as explained further in this document.

Analyst Qualifications: The operator must have adequate training and experience using the equipment. All XRF operators in TESH's Lead Programs have the following qualifications:

* Trained in radiation health and safety, including knowledge of Federal, state and local laws and regulations governing the licensing and use of radioactive devices.

* Listed by name on the license for the XRF equipment used, issued by MDE Center for Radiological Health.

* Assigned ring badge for monitoring exposure.

* Attended classroom training in use of XRF analyzer, principles of operation and calibration. Content considered to be essential includes:

    1. Required number of readings per surface tested.

    2. Factors that affect XRF analysis.

    3. Need for back up paint scrapings (when, where).

    4. Knowledge of how to take paint scrapings.

    5. On-the-Job training with other experienced inspector/tester.

    6. Knowledge of building construction.

Field work Guidelines: Inspectors using XRF analyzer should use a logbook assigned fo the analyzer. All reading taken must be recorded as well as operation, maintenance and repair information.

* Charge the batteries continually when the insturment is not in use and 12 hours before use in the field.

* Calibrate the insturment on site before a survey is done. Follow the manufactures instructions for calibration as summarized below:

  Turn on the analyzer, allow the analyzer to warmed up for at least ten minutes then take seven to eight calibration readings using both the lead and non-lead standards. Record the calibrations in the notebook and indicate the calibration page on the survey form.

* Compare warm up reading to post-warm up readings. The differences between these readings may indicated low battery problems, etc.

* Take a minimum of three readings per surface tested. If the first two readings are very high, e.g., over 6.0 mg/cm2 it is not required to take the third reading.

* At levels where the XRF readings are questionable, (0.5 - 2.5 mg/cm2) results must be verified by paint scrapings. A representative sample of the surface in question should be taken. For example, if all wood trim in the living room appears similar and all readings are 1.5 mg/cm2, one paint sample would be adequate to verify these readings.

* Check for zero standard after a reading of 10.0mg/cm2 or after a series of 5.0 mg/cm2 or higher and record all these readings on the test form.

* Use the analyzers only on surfaces that are flat and as wide as the face of the analyzer. Paint scrapings should be taken if surface is narrow or irregular.

* Use back-up paint scrapings on metal, concrete or brick surfaces and components that contain air spaces, such as hollow core doors.

* If the analyzer moves while taking a reading start over with that reading.

Collection of Paint Scrapings: Collect samples in an uniform and consistent manner. Samples should contain all paint layers but not the substrate material.

Surfaces that should be tested: All painted interior and exterior surfaces should be tested, including:

*all walls within each room,

*all parts of windows including sash, frames, wells, and sills,

*all parts of stairs including risers, treads, balusters, baseboards, and newel posts.

*all parts of porches including railings, balusters, columns, ceilings, and floors.

Make a sketch of the dwelling and indicate the north direction. Identify all rooms by a code number. Identify each sample by using the sample identification number and appropriate code number. Sample diagram attached.

Interpretation of results: XRF readings in excess of 2.5 mg/cm2 can be considered positive without additional testing. XRF readings of 0.5 - 2.5 mg/cm2 should be confirmed with paint chip analysis. Results of paint scrapings at 0.5 or higher are considered to be positive. Some results fall into "grey areas" that require additional professional assessment to make a determination. In cases such as this, contact the Environmental Coordinator for assistance.

Appendix B

Demonstration Project Flow Chart

Figure 2.11.1
Demonstration Project Flow Chart

Preliminary surface soil sampling

↓

Analyze soil with XRF

↓

Data to LIS

[Pb] > 500 ppm in soil areas
where children reside and LBP on exterior of residence

NO

1. Property scheduled for paint stabilization.

2. Property not scheduled for soil stabilization.

3. Analyze soil, dust, paint, and water for lead.

4. Data to LIS

YES

1. Property scheduled for paint stabilization.

2. Property scheduled for soil stabilization.

3. Excavate soil to a depth of 6 inches and remove soil. Fill excavated area with clean fill; re-sample abated areas to determine post abatement soil lead levels.

4. Data to LIS

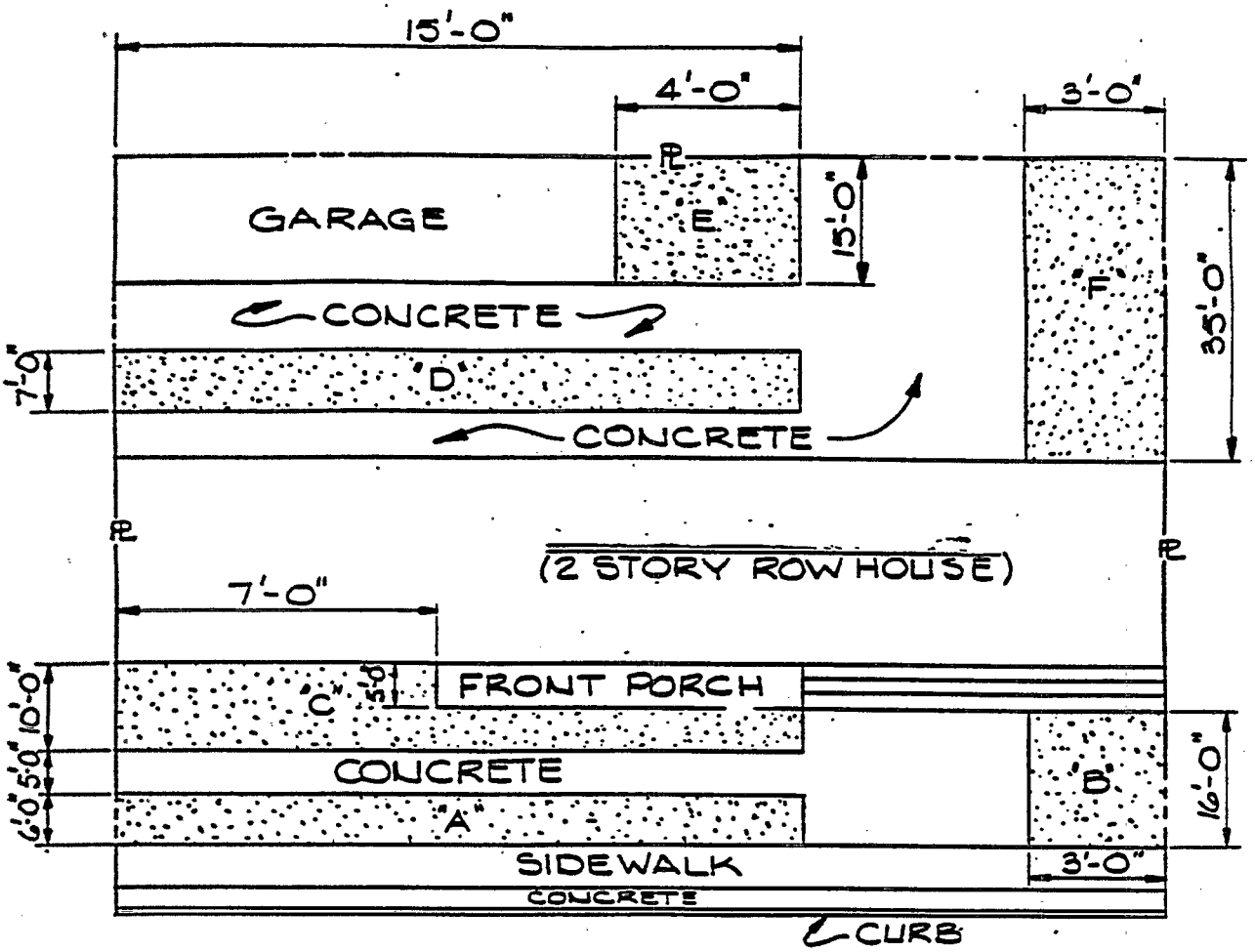
Appendix C

Management Plans

PAGE
Data Management Plan.....C-1
Safety Guidelines.....C-39
Public Relations Plan.....C-42

Appendix C

Baltimore Contract Abatement Diagram Example



DESCRIPTION

ABATEMENT METHOD: REMOVE AND DISPOSE OF TOP 6 INCHES OF SOIL, REFILL WITH "CLEAN" MATERIAL AS SPECIFIED.

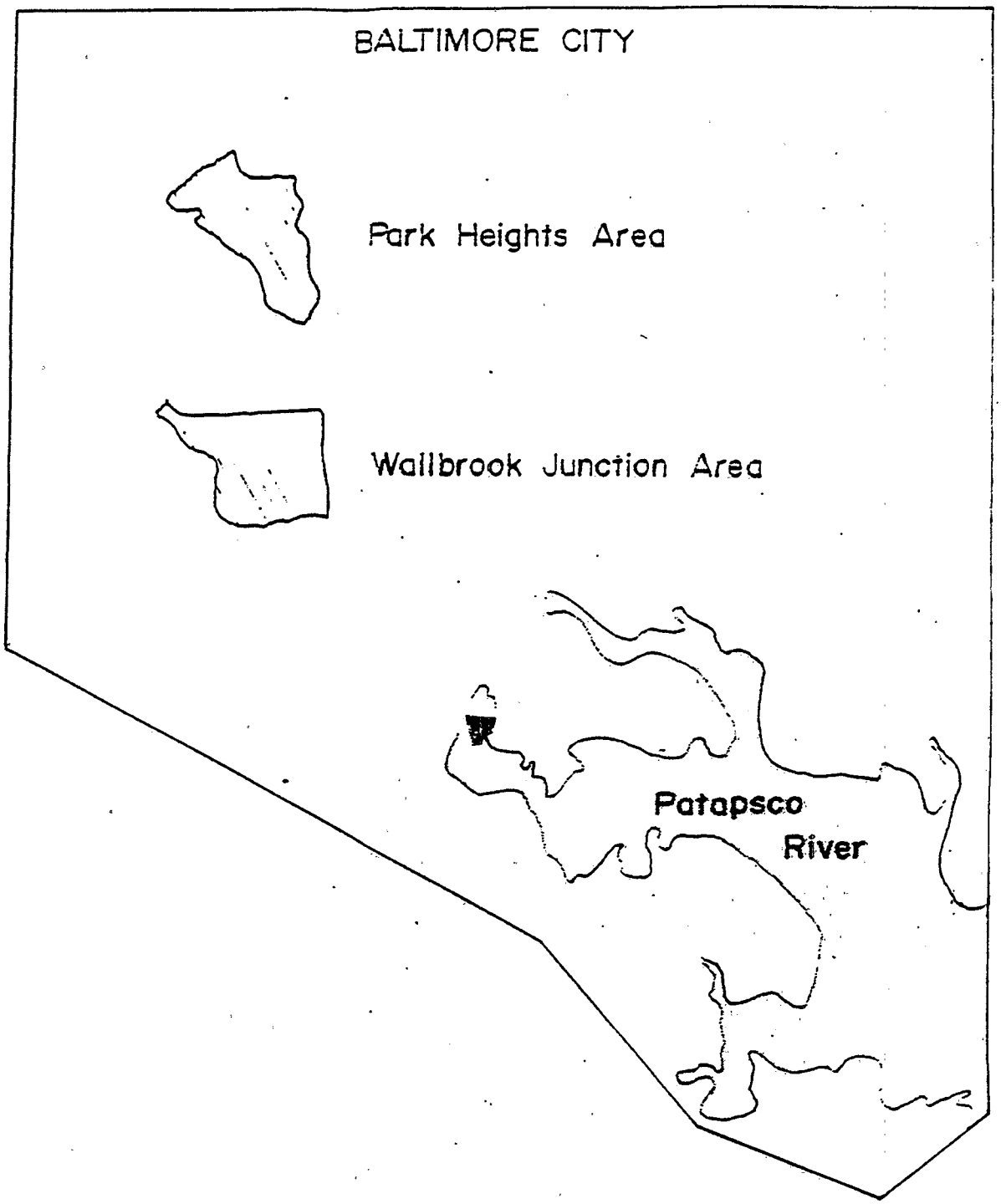
AREA: "A" = 90 SF } NO ABATEMENT REQ'D, SEED AS SPECIFIED.
"B" = 48 SF }
"C" = 110 SF
"D" = 105 SF
"E" = 60 SF
"F" = 105 SF

COVER: COVER AREAS "C" THRU "F" WITH SOD AS DIRECTED BY THE ARCHITECT.

	STATE OF MARYLAND DEPARTMENT OF THE ENVIRONMENT LEAD PAINT STABILIZATION PROJECT IN BALTIMORE CITY
	LEAD IN SOIL ABATEMENT
BEAVIN COMPANY	CONTRACT NO. MDE-88-001-TESH-1 CONTRACT # 4

Appendix D

Baltimore Project Vicinity Map



VICINITY MAP

No Scale

Appendix E

Protocols

Sampling Collection
Sample Analysis QA

BALTIMORE SOIL LEAD ABATEMENT DEMONSTRATION PROJECT

SOIL SAMPLING PROTOCOL

I. Site Description

For each location, a detailed drawing should be made that shows the boundary of the lot, the position of the main building and any other buildings such as storage sheds or garages, the position of the sidewalks, driveways, and other paved areas, the position of the play areas if obvious, and the position of the areas with exposed soil (grassy or bare), also, showing roof rain spouts and general drainage patterns.

In addition to the diagram, briefly describe the location, including the following information:

- Type of building construction
- Condition of main building
- Condition of property (debris, standing water, vegetation cover)
- Nature of adjacent property
- Presence and type of fence
- Animals on property
- Apparent use of yard (toys, sandbox, children present)
- Underground utilities

II. Soil Area Description

For each soil area (i.e. front patch, front yard, back yard, side yards) identified on the general diagram, draw a full page diagram showing the approximate dimensions and position relative to the building foundation. Indicate vegetation and bare soil areas, as well as obvious traffic patterns. Identify the category of land use, such as roadside, property boundary, adjacent to foundation, play area. Mark the sample location on the diagram.

III. Sampling Schemes

Measure the soil area to determine the sampling scheme. Select the sample scheme for each soil area which adequately characterize the potential exposure of children to lead in the dust from this soil. Identify the suspected areas of high lead concentrations and the assumed general distribution pattern of lead concentrations at the soil surface.

Small Area Pattern. Measure and mark off an area 20 inches from the base of the foundation into the soil area. Repeat measuring and marking at the boundaries. The area inside the marked pattern indicates the sampling collection area. If the sampling collection area is less than two meters in each dimension, a single composite sample may be taken if it appears that such a sample would adequately represent the soil

area. (Collect two sample bags, one bag marked top and the other bag marked bottom.)

Large Area Pattern. Measure and mark off an area 20 inches from the base of the foundation into the soil area. Repeat measuring and marking at the boundaries. The area inside the marked pattern indicates the sampling collection area. Collect one composite sample at the foundation and one composite sample at the boundary of the yard if the area is less than 10 feet wide. (Collect four sample bags, two bags marked top and two bags marked bottom.) Collect an additional composite sample at an imaginary sample line between the foundation and boundary sample areas if the yard is larger than 16 feet wide. (Collect six sample bags, three bags marked top and three bags marked bottom.)

Very Large Area Pattern. Measure and mark off an area 20 inches from the base of the foundation into the soil area. Repeat measuring and marking at the boundaries. If a yard is wider than 16 feet and more than 20 feet long then divide the yard into a vertical half and a horizontal half. Collect one composite sample at the from each section of the yard. (Collect twelve sample bags, six bags marked top and six bags marked bottom.)

IV. Sample Collection

Collect ten randomly selected core samples from within the sampling area. The cores make a composite sample identified as a single sample. Record composite information on the sample sheet.

Clean and decontaminate the corer after each sample collection. Remove vegetation and debris from the corer at the point of insertion into the soil, but do not remove any soil or decayed litter. Drive the corer in to the ground to a depth of 15 cm (6 in.). If this depth cannot be reached, the corer should be extracted and cleaned, and another attempt made nearby. If repeated attempts do not permit a 15 cm core, take the sample as deep as possible, and record the maximum penetration depth on the sample record sheet.

Combine the top two inch segment of each core into one composite sample and combine the bottom two inch segment of each core into second composite sample. Remove debris and leafy vegetation from the top sample material. Do not remove soil or decomposed litter from the sample material. This is the most critical part of the soil sample and is likely to be the highest in lead concentration.

Assemble composite soil core segments in clean previously unused plastic bags suitable for prevention of contamination of the sample. Record the sample identification number on the

bag and the sample record sheet. Store the composite soil sample at ambient temperature until submitted to the laboratory for analysis.

Clean the corer after collecting each sample composite by reinsertion of the corer into the soil of the next sampling area.

Draw field blanks for each soil area by inserting the core borer into randomly selected locations within the sample area. These blanks are drawn prior to sample collection and at the conclusion of sampling.

V. Sample Handling and Storage

Seal the sample bags to prevent loss or contamination of the sample and storage samples in a cool, dry location.

Record-keeping and Sample Custody

Initiate soil sample records for each location which consists of a location diagram and description, a plot diagram for each distinct soil plot, and sample record sheet for each sample in a plot.

Sequentially number samples bags. Record sample numbers on location diagram, soil area description, and sample record sheet.

Deliver the sample to the laboratory and release the sample to the laboratory personnel for analysis.

QUALITY ASSURANCE PLAN
FOR SOIL (CORER SAMPLE)

I. INTRODUCTION

This quality assurance document sets forth the Baltimore Lead-in-Soil Project's (LIS) policies and procedures that maximize the quality of sample collection and laboratory performance. The goal of the sample collector is to provide a representative sample of the surface to be tested according to the appropriate protocol. The goal of the laboratory is to provide a quality service of elemental analysis.

It is the policy of LIS to maintain an active quality assurance (QA) program to provide analytical data of known and supportable quality and ensure a high professional standard in analytical data generated in support of projects undertaken for the public by state and federal agencies.

II. SAMPLE COLLECTION

Soil samples are collected by LIS personnel for this project. All collectors are trained in sampling procedures.

Soil samples for metals analysis are collected and stored in clean previously unused polystyrene bags. Sample bags are labeled with a unique sample identification number and sample code which reflects the location of the sample site. A corresponding chain-of-custody form is completed at the time of sample collection.

III. SAMPLE ACCEPTANCE, PRESERVATION, AND STORAGE

All incoming samples are delivered to Maryland's Department of Health and Mental Hygiene (DHMH) for analysis. As the samples are accepted, they are assigned a laboratory number and the chain-of-custody is dated with the current date.

The quantity of sample submitted must be adequate for all analyses requested.

IV. SAMPLE RESULTS

Following DHMH analysis, the results are reported to the LIS Environmental Coordinator (EC). Excess sample material and DHMH sample cups are returned to the LIS project for storage at a secured facility. The LIS EC reviews the data results and assigns preliminary data processing tasks to the Environmental Health Aides I (EHA), who transfers the sample number and results to data entry forms. Each set of data entry forms are double checked by level II EHA personnel.

Upon completion of the data information transfer the data entry sheets are surrendered to data entry personnel for double entry into the data base.

V. DATA REVIEW

A review of all raw data and data base soil files is to be conducted prior to the end of the study.

BALTIMORE SOIL LEAD ABATEMENT DEMONSTRATION PROJECT

PAINT CHIP ANALYSIS PROTOCOL

A. **Using the Mortar & Pestle Method:**

1. Paint chips delivered to the Lab.

2. Samples must be logged in on the Lead in Soil Processing Sheets. The date, the time, the total number of samples brought by the collector, and all the information listed on the sample bag should be written on this sheet. The information listed on the sample bag will include the sample identification number, the address and particular area from which the sample was taken needs to be written on the Lead in Soil Processing Sheet. Example:

   Date received: 3/22/89

   Time: 12:30 p.m.

   Total Number of Samples Received From: 135 from Ms. Merrill Brophy

   Sample Identification Number: #590316535

   Address: 2092 W. Preston Street

   Area: Side of Front Door

3. The paint samples then need to be written up on the XRF Run Sheets. Identification number is assigned. The sample is then given an analysis number by the analyst. The number given to the sample is used only as a means to identify a particular sample for analysis. The samples should be written in consecutive sequence. Example:

   The last sample analyzed was number 0439, then the next paint chips sample should be numbered 0440.

4. Specimen Containers and XRF Sample Cups are to be prepared before samples can be processed.

   a. Label Specimen Containers - Include the date, the analysis number, and the Samples's Identification Number.

   b. Label XRF Sample Cups - Include only the analysis (i.e. cup) number only.

5. Mortar & Pestle should always be clean.

6. Place paint chips into mortar and use the pestle to crush the sample. Continue to crush the sample until a homogeneous mixture is attained. Gloves and respirators must be worn.

7. Use a spoon or spatula to place the sample into a corresponding XRF sample cup, then seal the cup with mylar film and a ring.

8. Before next sample is crushed, the mortar and pestle should be wiped clean. Wipe the mortar and pestle with a clean paper towel, then wash them with distilled water and dry them with a clean paper towel. This process should be done after each sample.

9. Once all samples have completed steps 1 - 7, the samples are now ready for analysis.

10. Analyzed sample results are recorded onto XRF Run Sheets in ppm's..

B. Using Electric Mill Method

1. Paint chips delivered to the lab.

2. Samples must be logged in on the Lead in Soil Processing Sheets. The date, the time, the total number of samples brought by the collector, and all the information listed on the sample bag should be written on this sheet. The information listed on the sample bag will include the sample's identification number, the site address and particular are from which the sample was taken needs to be written on the Lead in Soil Processing Sheet. Example:

Date received: 3/30/89

Time: 12:30 p.m.

Total number of Samples Received From: 135 from Ms. Merrill Brophy

Sample Identification Number: #590316521

Address: 2092 W. Preston Street

Area: Side of Front Door

3. The paint chip samples identification numbers are recorded on the XRF Run Sheets. The sample is then assigned an analysis number by the analyst. The number given to the sample by the analyst is used only as a means to identify a particular sample for analysis. The samples should be written in consecutive sequence. Example:

   The last sample analyzed was number 0439, then the paint chip sample should be numbered 0440.

4. Specimen containers and XRF sample cups are to be prepared before sample can be processed.

   a. Label Specimen containers - Include the date, the analysis number, and the sample's identification number.

   b. Label XRF Sample Cups - Include analysis number only.

5. Electric Mill should always be clean.

6. Electrical grinding <u>must always be done under the hood. Gloves and respirators must be worn.</u>

   a. Place paint chip samples into the Electric Mill.

   b. Turn Electric Mill on for approximately 3 minutes.

   c. Turn grinder off after 3 minutes, wait for the dust to settle, remove lid and check to see if a homogeneous mixture was attained.

7. Use a spoon or spatula to place the sample into a corresponding XRF sample cup, then seal the cup with mylar film and a ring.

8. Before the next sample can be processed, the Electric Mill should be cleaned. Wipe the Electric Mill with a clean paper towel inside and out, dampen another paper towel and clean the mill very well, and then dry the Electric Mill with another clean, dry paper towel. This process should be done between each sample.

9. Once all samples have completed steps 1 - 7, the samples are now ready for analysis.

10. Analyzed sample results are recorded onto XRF Run Sheets in ppm's.

QUALITY ASSURANCE PLAN FOR PAINT CHIP SAMPLES

I. INTRODUCTION

This quality assurance document sets forth the Baltimore Lead-in-Soil Demonstration Project's (LIS) policies and procedures that maximize the quality of sample collection and laboratory performance. The goal of the sample collector is to provide a representative sample of the surface to be tested according to the appropriate protocol. The goal of the laboratory is to provide a quality service of elemental analysis.

It is the policy of LIS to maintain an active quality assurance (QA) program to provide analytical data of known and supportable quality and ensure a high professional standard in analytical data generated in support of projects undertaken for the public by state and federal agencies.

II. SAMPLE COLLECTION

Paint chip samples are collected by LIS personnel for this project. All collectors are trained in sampling procedures.

Paint chip samples for metals analysis are collected and stored in clean previously unused paper envelopes. Sample envelopes are labeled with a unique sample identification number and sample code which reflects the location of the sample site. A corresponding chain-of-custody form is completed at the time of sample collection.

III. SAMPLE ACCEPTANCE, PRESERVATION, AND STORAGE

All incoming samples are delivered to Maryland's Department of Health and Mental Hygiene (DHMH) for analysis. As the samples are accepted, they are assigned a laboratory sample number and the chain-of-custody form is dated with the current date.

The quantity of sample submitted must be adequate for all analyses requested.

IV. SAMPLE RESULTS

Following DHMH analysis, the results are reported to the LIS Environmental Coordinator (EC). Excess sample material and DHMH sample cups are returned to the LIS project for storage at a secured facility. The LIS EC reviews the data results and assigns preliminary data processing work to the environmental health aides I (EHA), who transfer the sample number and results to data entry forms. Each set of data entry forms are double checked by level II EHA personnel.

Upon completion of the data information transfer the data entry sheets are surrendered to data entry personnel for double entry into the data base.

V. DATA REVIEW

A review of all raw data and data base paint chip files is to be conducted at the prior to the end of the study.

BALTIMORE SOIL LEAD ABATEMENT DEMONSTRATION PROJECT

DRINKING WATER SAMPLING PROTOCOL

1. Residents are notified that water must not be turned on prior to the Environmental Health Aide sampling the system on the sampling day.

2. Do not shut off water flow valve to the sink fixture (which would prevent use of the system prior to first draw) as this may introduce lead corrosion products into the sample.

3. Morning first draw is collected from a cold water tap which had not been used for 8-18 hours. Determine if water was used prior to sample collection. If water was used, state the use in the remarks on the sample collection form.

4. Water samples are collected from each household faucet in 250 ml cubitainers.

5. Water samples are preserved on site with 5 ml of nitric acid per liter.

6. Water tap is closed after filling each sample container to prevent loss of product and to ensure representative collections.

7. Keep samples cool (4 degrees C) after collection prior to analysis.

QUALITY ASSURANCE PLAN
FOR DRINKING WATER SAMPLE

I. INTRODUCTION

This quality assurance document sets forth the Baltimore Lead-in-Soil Demonstration Project's (LIS) policies and procedures that maximize the quality of sample collection and laboratory performance. The goal of the sample collector is to provide a represenative sample of the surface to be tested according to the appropriate protocol. The goal of the laboratory is to provide quality service of elemental analysis.

It is the policy of LIS to maintain an active quality assurance (QA) program to provide analytical data of known and supportable quality and ensure a high professional standard in analytical data generated in support of projects undertaken for the public by state and federal agencies.

II. SAMPLE COLLECTION

Water samples are collected by LIS for this project. All collectors are trained in sampling procedures and approved by the Maryland Department of the Environment's Division of Water Supply.

Water samples analyzed for metals are collected and stored in clean polyethylene or polypropylene cubitainers with teflon-lined lids. A premeasured vial of nitric acid is added to the container prior to the water sample collection. The cubitainers are labeled with a unique sample identification number and sample code which reflects the location of the sample site. A corresposnding chain-of-custody form is completed at the time of sample collection. Cubitainers are stored in a small cooler partially filled with ice. Sample containing cubitainers should not be allowed to freeze.

III. SAMPLE ACCEPTANCE, PRESERVATION, AND STORAGE

All incoming samples are delivered to Maryland's Department of Health and Mental Hygiene (DHMH) Water Laboratory. As the samples are accepted, they are assigned a laboratory sample number and the chain-of-custody form is dated with the current date.

To ensure that samples are not degraded and that their integrity is maintained, all samples for metal analysis must be received by the laboratory no later than one day after collection.

The quantity of sample submitted must be adequate for all analyses requested.

VI. SAMPLE RESULTS

Following DHMH analysis, the results are reported to the LIS Environmental Coordinator (EC) who reviews trhe data results and assigns preliminary data processing work to the Environmental Health Aides I (EHA) who transfers the sample number and results to data entry forms. Each set of data entry forms are double checked by level II EHA personnel.

Upon completion of the data information transfer the data entry sheets are surrendered to data processing personnel for double entry into the data base.

V. DATA REVIEW

A review of all raw data and data base water files is to be conducted prior to the end of the study.

BALTIMORE SOIL LEAD ABATEMENT DEMONSTRATION PROJECT

HOUSEHOLD DUST PROTOCOL

Household dust sampling should be carried out at the time of the environmental visit to the home of the study participant.

For this study, the household dust samples are defined as the samples that represent dust most likely to impact on a child's hands during indoor activity. This would include dust on window sills, and furniture, as well as dust on toys and other objects likely to be handled by children. A minimum of three areas should be sampled: at the main entrance to the household, and two areas most frequently used for play activities by the child or children. Additional areas may be selected that represent: 1) secondary entrances to the household (back or side doors); 2) sources or accumulation of dust within the household (paint, rugs, upholstered furniture); 3) additional play areas or other areas of activity frequented by the children.

The sample has two components that are important to interpreting lead exposure, the concentration of lead in the dust and the amount of dust, or loading, on the surface. The concentration of lead in dust appears to be closely related to the amount of lead on children's hands, whereas the amount of dust on surfaces is an indicator of the importance of this route of human exposure. At least 10% of the samples should be over a defined area to determine the household loading factor.

Sketch the approximate layout of the residence and select to sampling. Bear in mind that some areas, such as entryway, may reflect outdoor dust to a greater degree than others.

The sampling apparatus is the Sirchee-Spittler Hand Held Dust Vacuum unit which is attached to a 'Dustbuster' hand held type vacuum. Prior to the sample collection the sample collection screen must be clean.

For some samples, both the weight of the dust and the lead concentration of the dust will be measured. In this case, it is necessary to sample a defined area, so that the results may be expressed in ug Pb/m . Mark the 4' x 4' sample area with tape. The surface of the sample area is vacuumed with back and forth strokes about 1-2 inches in width. The vacuum is most efficient if the head is held parallel to the ground at a 45 degree angle. A single pass across the surface of the sample area is sufficient to collect adequate sample amounts. After dust sampling, the vacuum unit is kept in an upright position until the sample screen is ready to be removed. Turn the vacuum off and remove the sample screen. Empty the contents of the sample screen into a labeled-reinforced paper envelope. Seal the envelope with scotch tape.

The sample amount required for analysis is equal to 2 grams of dust. If the sample amount from the area is not sufficient additional sample material may be collected from another 4'x 4' sample area and added to the initial sample.

Record sample data on the appropriate chain of custody form.

Transport the sample to the laboratory in a manner to ensure upright envelope delivery.

QUALITY ASSURANCE PLAN
FOR DUST (VACUUM SAMPLED)

I. INTRODUCTION

This quality assurance document sets forth the Baltimore Lead-in-Soil Demonstration Project's (LIS) policies and procedures that maximize the quality of sample collection and laboratory performance. The goal of the sample collector is to provide a representative sample of the surface to be tested according to the appropriate protocol. The goal of the laboratory is to provide a quality service of elemental analysis.

It is the policy of LIS to maintain an active quality assurance (QA) program to provide analytical data of known and supportable quality and ensure a high professional standard in analytical data generated in support of projects undertaken for the public by state and federal agencies.

II. SAMPLE COLLECTION

Dust samples are collected by LIS personnel for this project. All collectors are trained in sampling procedures.

Dust samples for metal analysis are collected and stored in clean previously unused paper envelopes. Sample envelopes are labeled with a unique sample identification number and sample code which reflects the location of the sample site. A corresponding chain-of-custody form is completed at the time of sample collection.

III. SAMPLE ACCEPTANCE, PRESERVATION, AND STORAGE

All incoming samples are delivered to Maryland's Department of Health and Mental Hygiene (DHMH) for analysis. As the samples are accepted, they are assigned a laboratory sample number and the chain-of-custody form is dated with the current date.

The quantity of sample submitted must be adequate for all analyses requested.

IV. SAMPLE RESULTS

Following DHMH analysis, the results are reported to the LIS Environmental Coordinator (EC) who reviews the data results and assigns preliminary data processing tasks to the Environmental Health Aides I (EHA), who transfer to sample number and results to data entry forms. Each set of data entry forms are double checked by level II EHA personnel.

Upon completion of the data information transfer the data entry sheets are surrendered to the data entry personnel for double entry into the data base.

V. DATA REVIEW

A review of all raw data and data base dust files is to be conducted prior to the end of the study.

Appendix F

Sample Forms

STATE OF MARYLAND
DEPARTMENT OF HEALTH AND MENTAL HYGIENE
Laboratories Administration
201 W. Preston St.
P.O. Box 2355, Baltimore, Maryland 21203
J. Mehsen Joseph, Ph.D., Director

LAB NO. _____

HAZARDOUS WASTE LABORATORY
Metals Analysis Report Form

PRIORITY _____

Collector _____ (Name/Time/Date) Sample Source _____

Sample ID No. _____ Preservative Used _____

Sample Alert _____

Specify Program: RCRA: _____ NPDES: _____ OTHER: _____

Chain of Custody Sample Possession:

From: _____ (Name/Time/Date) To: _____ (Name/Time/Date)

From: _____ (Name/Time/Date) To: _____ (Name/Time/Date)

Circle Type of Analysis:

1. EP Toxicity 2. Priority Pollutant 3. Total Metals 4. Dissolved Metals

Indicate Type of Sample:

Liquid _____ Solid _____ Percent Solids _____%

Metals in ppm

	Element	EP	Total		Element	EP	Total
	Antimony				Aluminum		
	Arsenic				Calcium		
	Barium				Cobalt		
	Beryllium				Magnesium		
	Cadmium				Manganese		
	Chromium				Potassium		
	Copper				Sodium		
	Iron				Vanadium		
	Lead						
	Mercury						
	Nickel						
	Selenium						
	Silver						
	Thallium						
	Zinc						
	Chromium Cr+6						

SELECT OTHER ELEMENTS FROM REVERSE SIDE OF THIS FORM

Section Chief: _____ Date: _____ Verified By: _____ Authorized By: _____

DHMH-3209 ‹6

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97494

PRESS HARD—BALL POINT PEN ONLY

STATE OF MARYLAND
DEPARTMENT OF HEALTH AND MENTAL HYGIENE
Laboratories Administration
201 W. Preston St.
P.O. Box 2355, Baltimore, Maryland 21203
J. Mehsen Joseph, Ph.D., Director

WATER ANALYSIS

Lab No. Date Received

Do not write above this line.

Data Category Code

Bottle Number: _____ Name: _____ County: _____

Source of Sample: _____ Collector: _____
Street Town or City (include telephone Number

Sample Types (Circle):				
Drinking Water	Community (Public Treated)	Source (Raw Water)	Emergency
Landfill	Non-Community (Pub. Untreated)	Distribution (Treated)	Routine
Stream	Private	MCL	Recheck
Other	Other		

Remarks: _____

County | Plant No. | Sampling Station | Date Collected | Date & Time are Required for Valid Samples | Time | Iced | Acid | Type of Acid: _____

Field Data: pH* | Chlorine Residual: Free | Total | Specific Conductance

✓	ANALYSIS	CODE	RESULTS	✓	ANALYSIS	CODE	RESULTS
	pH*	00403			Arsenic	01002	
	Alkalinity (Total)	00410			Barium	01007	
	pH*, Ca CO_3 SAT.	70311			Cadmium	01027	
	Alkalinity, Ca CO_3 SAT.	74023			Chromium	01034	
	Hardness	00900			Lead	01051	
	Ammonia-N	00608			Mercury	71900	
	Nitrate-Nitrate N	00630			Selenium	01147	
	Nitrite N	00615			Silver	01077	
	MBAS	38260					
	Chloride	00940			Aluminum	01105	
	Fluoride	00951			Calcium	00916	
	Color*	00081			Copper	01042	
	Turbidity*	00076			Iron	01045	
	Conductance*, SPEC	00095			Magnesium	00927	
	Sulfate	00945			Manganese	01055	
	Total Solids	00500			Nickel	01067	
	Dissolved Solids	70300			Potassium	00937	
					Sodium	00929	
					Zinc	01092	

*Results reported in units, all others in milligrams per liter (ppm)

LEAD IN SOIL SAMPLE PROCESSING/XMET RUN SHEET

RECEIVED BY:_____ ANALYSIS DATE:_____

SHEET #_____

RECEIVED FROM:_____ ANALYSIST:_____

PROPERTY ADDRESS	SAMP ID NUMBER	PPM -1	PPM -2

STATE OF MARYLAND
DEPARTMENT OF HEALTH AND MENTAL HYGIENE
LABORATORIES ADMINISTRATION
201 W. Preston Street
Baltimore, MD 21203

DUST EXAMINATION FOR LEAD

COUNTY CODE _____ DATE SUBMITTED_____

SAMPLES COLLECTED BY:_____

SCHOOL/DAY CARE IDENTIFICATION NUMBER:_____

SAMPLE TYPE: DAYCARE DUST WIPE SURVEY SCHOOL DUST WIPE SURVEY

PROGRAM: MULTI MEDIA LEAD STUDY MDE STATE CODE:_____(DC ONLY)

REPORT RESULTS TO:_____
(NAME) (PHONE NUMBER)
MDE/TESH 2500 BROENING HWY. BALTIMORE, MD 21224

NO.	Sample Code	Location (sill, well, floor)	Area in Inches (lxw)	Laboratory Results
1.				
2.				
3.				
4.				
5.				

DO NOT COMPLETE - FOR LAB USE ONLY

SAMPLE RECEIVED BY:_____

DATE RECEIVED:_____REPORTED_____ANALYST_____

REMARKS:_____

_____

INTERPRETATION OF RESULTS
(Results reported in Micrograms Lead per Square Foot (ug/ft2)
Threshold Limit: Floor 200 Window Sill 500 Window Well 800

ENVIRONMENTAL DATA ENTRY FORM

PROP ID	SAMPLE NUMBER	SAMPLE CODE	RESULTS				
			WGT MGM	XRF PPM	WGT	AAS PPM	FLAG

DEPARTMENT OF THE ENVIRONMENT
TESH LEAD LAB
MULTI-MEDIA LEAD STUDY

XRF SAMPLE RECORD

FIELD STAFF SUBMITTING: _____

SAMPLE DATE: _____

PRIORITY: _____

SAMPLE LOCATION: _____

SAMPLE TYPE: _____

SAMPLE ID NUMBER	WET WT	DRY WT	SAMP WT	RESULTS

SAMPLE RECEIVED BY: _____

DATE RECEIVED: _____

ANALYST ASSIGNED: _____

ANALYSIS DATE: _____

REVIEWED BY: _____

RESULTS REPORTED: _____

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TESH/LIS
2500 BROENING HWY
BALTIMORE, MD 21224

CHAIN OF CUSTODY

SAMPLE TYPE	SAMPLE LOCATION	SAMPLE NUMBER

PERSON RELEASING SAMPLES: _____ DATE: _____

PERSON RECEIVING SAMPLES: _____ DATE: _____

PERSON RELEASING SAMPLES: _____ DATE: _____

PERSON RECEIVING SAMPLES: _____ DATE: _____

MARYLAND DEPARTMENT OF THE ENVIRONMENT

LEAD IN SOIL DEMONSTRATION PROJECT

LEAD BASED PAINT INSPECTION FORM
COVER PAGE

Project _____ Project ID _____ Number of Rooms _____ Number of Pages Attached _____

Street Address _____ XRF Manufacturer _____ Serial # _____

City, State, Zip _____ County _____ Calibration Log Page _____

Inspector _____ CCA Regional Contact _____

Inspector's Notes:

_____

_____

_____

Diagram of Unit:

Label rooms by number clockwise from entry. Note unusual features of unit. Include Street Name

MARYLAND DEPARTMENT OF THE ENVIRONMENT

LEAD IN SOIL DEMONSTRATION PROJECT

LBP INSPECTION FORM
FRONT PAGE

Project _____

Room Name and Number _____ Page _____ of _____ Date _____

Street Address _____ Time _____ am____ pm____ Inspector _____

City, State, Zip _____ County _____ XRF Serial # _____

EBL Case _____ ID _____ Sampling Temp _____ XRF Calibration Log Page _____

Sample Codes		Readings mg/cm			Extra Space	Sample mean	ALC-SEL CLC	Maintenance	Abate	Sent to Lab( )	Laboratory Results
		1	2	3							
#	ALC										
	SEL										
#	ALC										
	SEL										

Approximate sampling time: _____

Inspector Comments: _____

Room Diagram and Sample Location

Label N from Entry:

Notes (Key for Codes)

Repeat: No Yes LOG Page_____

MARYLAND DEPARTMENT OF THE ENVIRONMENT

LEAD IN SOIL DEMONSTRATION PROJECT

LBP INSPECTION FORM
DATA PAGE

Project _____

Room Name and Number _____ Page _____ of _____ Date _____

Street _____ Time _____ am___ pm___ Inspector _____

Sampling Temp _____ XRF Calibration Log Page _____

Sample Codes		Readings mg/cm			Extra Space	Sample mean	ALC-SEL CLC	Maintenance	Abate	Sent to Lab( )	Laboratory Results
		1	2	3							
#	ALC										
	SEL										
#	ALC										
	SEL										
#	ALC										
	SEL										
#	ALC										
	SEL										
#	ALC										
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#	ALC										
	SEL										
#	ALC										
	SEL										
#	ALC										
	SEL										
#	ALC										
	SEL										

CORRECTIVE ACTION DOCUMENTATION FORM

DESCRIPTION OF PROBLEM and when identified: _____

_____

_____

_____

_____

State cause of problem if known or suspected: _____

_____

_____

_____

SEQUENCE OF CORRECTIVE ACTION: (If no responsible person is identified, bring this form directly to the QA Coordinator)

State date, person, and action planned: _____

_____

_____

_____

_____

_____

_____

_____

_____

CA Initially Approved By: _____

Date: _____

Follow-up dates: _____

Description of follow-up: _____

_____

_____

_____

_____

Final CA Approved By: _____

Date: _____

Appendix G

Glossaries
Units of Measure and Abbreviations

GLOSSARY OF UNITS OF MEASURE

C - Celsius

M - Mole, a chemical unit of measure

megaohms - Ten^6 ohms

mg/l - milligrams per liter

ml - milliliter

ppm - Parts Per Million

GLOSSARY OF ABBREVIATIONS

AA - Atomic Adsorption

CDC - Centers for Disease Control

EC - Environmental Coordinator

EDL - Electrodeless Discharge Lamp

EHA - Environmental Health Aid

EPA - Environmental Protection Agency

EPTOX - EP Toxicity Testing

HCL - Hollow Cathode Lamp

LBP - Lead Based Paint

LIS - Lead-in-Soil Program

MCL - Maximum Contaminant Level

MDE - Maryland Department of the Environment

MEAL - Multi-Element Analysis Laboratory

NBS - National Bureau of Standards

Pb - Lead

QA - Quality Assurance

QAP - Quality Assurance Plan

QC - Quality Control

RPD - Relative Percent Differance

S - Classification of Weights

TCLP - Toxicity Characteristics Leaching Procedure

XRF - X-Ray Fluorescence

Appendix H

Method Detection Limits

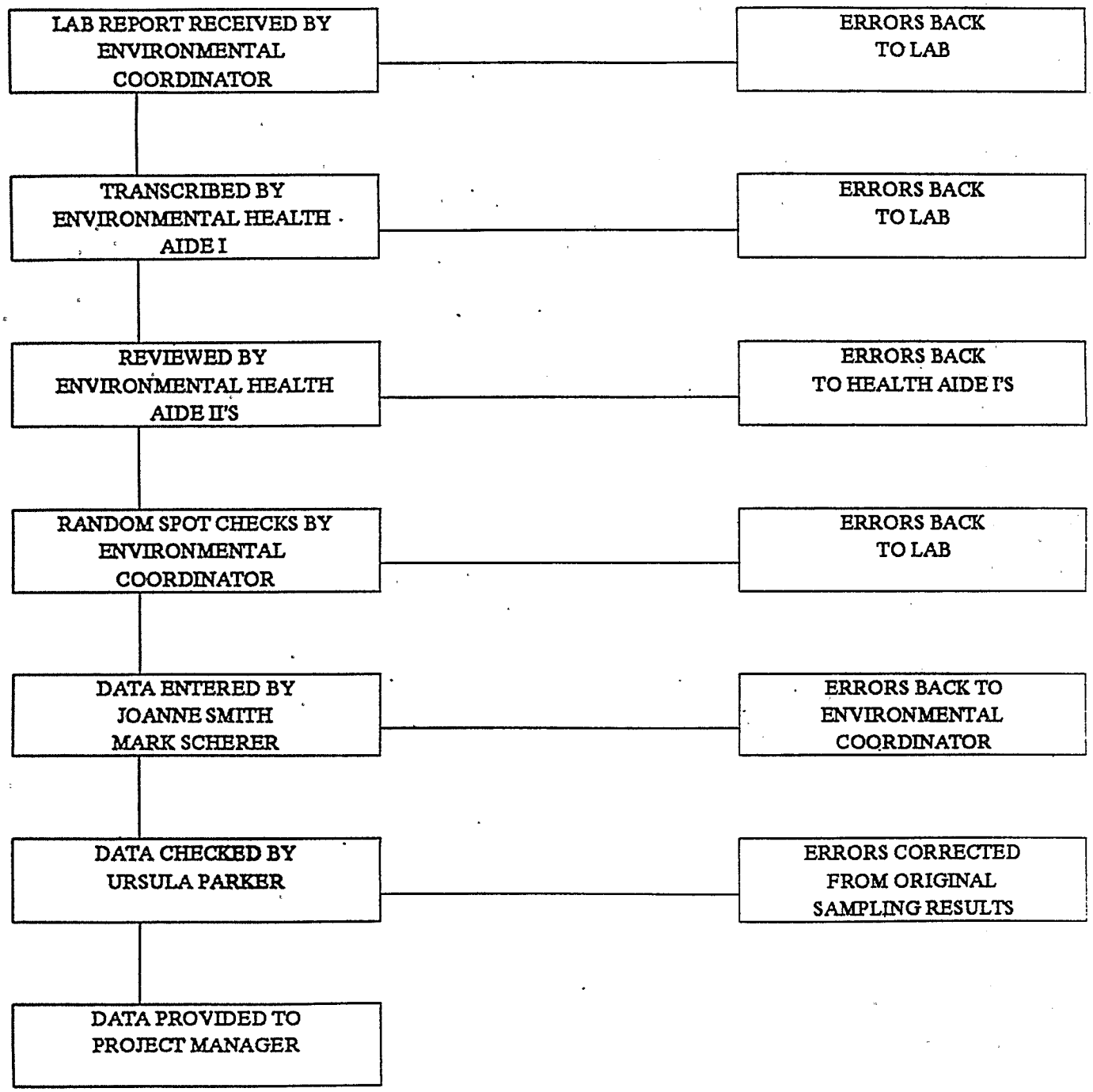
DETECTION LIMITS

Blood Lead	1.6 µg/dl
FEP	6 µg/dl
Ferritin	1.2 ng/dl
Soil - XRF	Calibrated for 78 to 4,000 ppm
Dust - XRF	Calibrated for 78 to 12,000 ppm
Dust - AAS	1,600 ppm (if sample quantity is adequate)
Dust - Handwipes	1.8 µg
Paint - XRF	Calibrated for 1,000 to 18,000 ppm

Appendix I

Flow Chart of Data Handling

FLOW CHART OF DATA HANDLING



Appendix J

Environmental Sampling Statistics

Table 2.9.1
Sampling Summary Table

ENVIRONMENTAL STATISTICS

LOCATION: AREA 1

	SOIL	WATER	PAINT	DUST	POST SOIL	POST DUST
Number of Observations	1339	294	485	333	153	118
Sample Mean	550	9.9	4.9	1068	60	754
Maximum Value	6800	420	37.1	22600	619	7300
Minimum Value	22	0	0	2	1	13
Sample Median	348	2.2	3.0	418	22	430
Upper Quartile	607	6.1	6.88	935	54	929
Lower Quartile	206	.9	.91	180	13	235
Sample Unit of Measure	ppm	ppb	ppm	ppm	ppm	ppm

ENVIRONMENTAL STATISTICS

LOCATION: AREA 2

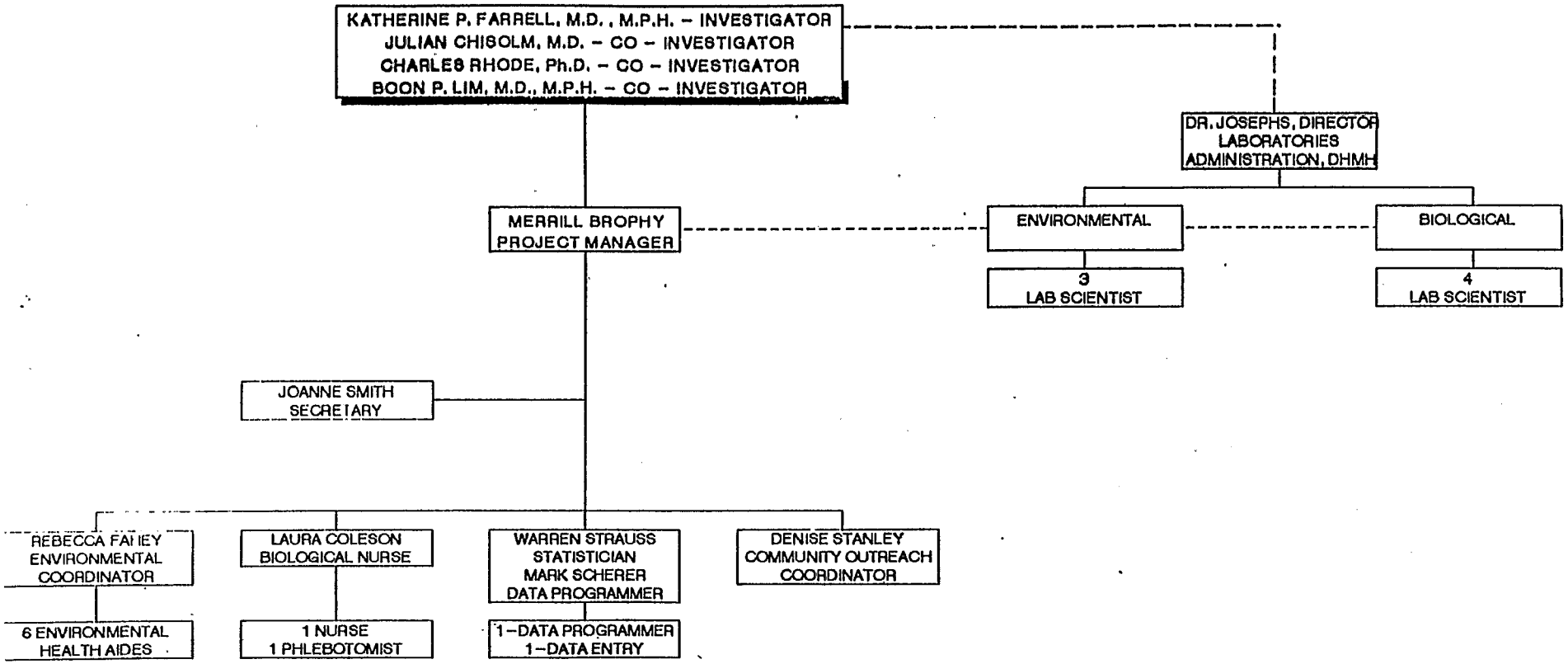
	SOIL	WATER	PAINT	DUST	POST SOIL	POST DUST
Number of Observations	826	252	373	297	N/A	59
Sample Mean	596	6.6	5.4	1077	N/A	954
Maximum Value	7500	103	70	21200	N/A	7000
Minimum Value	39	0	.02	1	N/A	5
Sample Median	409	1.9	2.4	436	N/A	438
Upper Quartile	693	4.9	7.11	1100	N/A	926
Lower Quartile	243	.4	.76	187	N/A	159
Sample Unit of Measure	ppm	ppb	ppm	ppm	ppm	ppm

Appendix K

LIS Demonstration Project Personnel Flow Chart

MARYLAND DEPARTMENT OF THE ENVIRONMENT

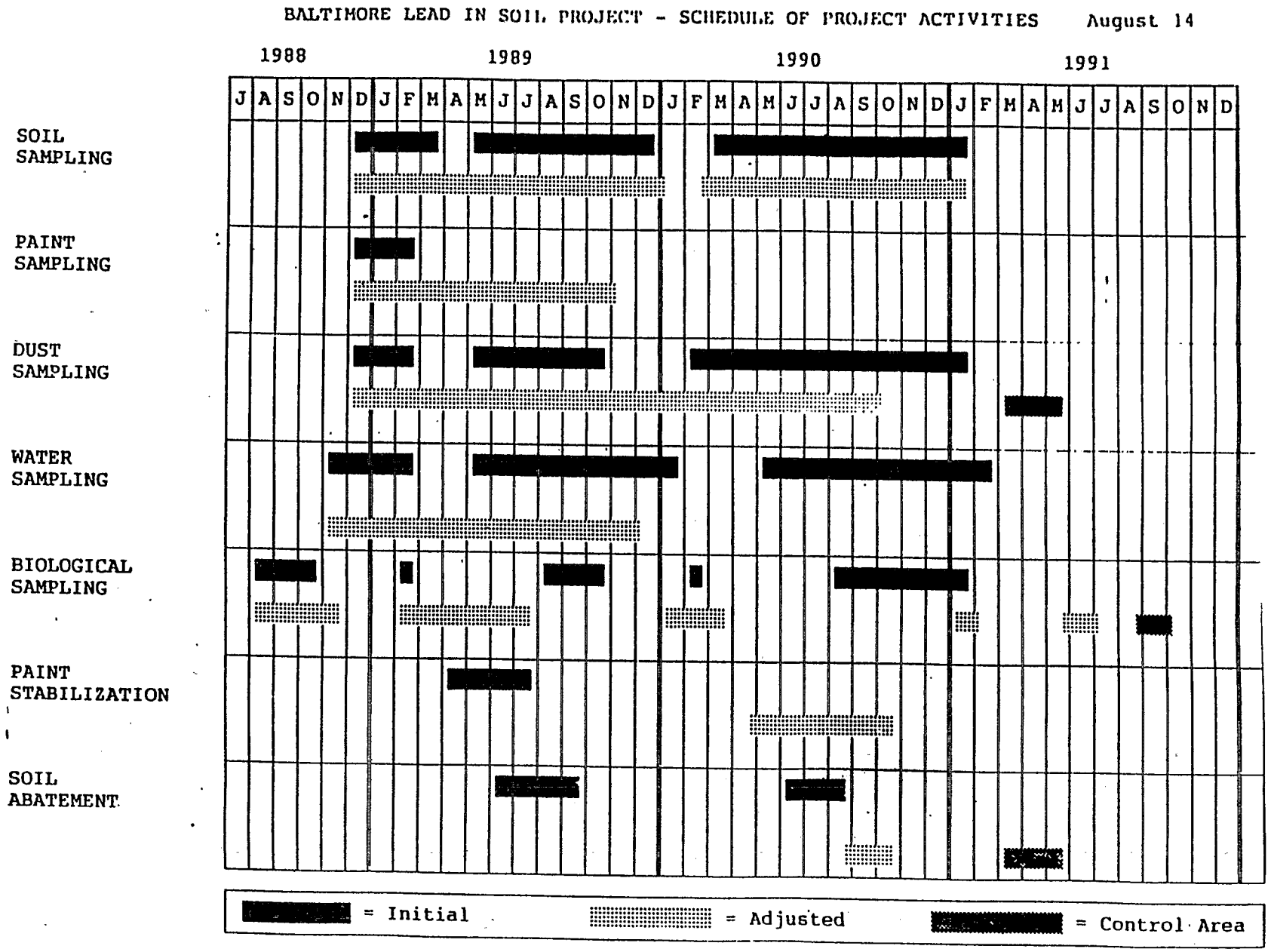
LEAD IN SOIL PROJECT



Appendix L

LIS Demonstration Project Time Line

Figure 2.10.1
Project Time Line



Appendix M

Equipment List

ENVIRONMENTAL SURVEY CHECKLLIST

EQUIPMENT REQUIRED	Y/N	COMMENTS/CONDITION
CODE MANUAL		
747-XRF ANALYZER		
RING BADGE		
TAPE MEASURE		
ARCHITECT'S TEMPLATE		
CLIP BOARD		
LBP-FORMS		
PERMANENT LAB MARKER		
VACUUM		
SIRCHEE ATTACHMENT		
FILTERS		
SAMPLE COLLECTION TUBES		
LAB POLICEMAN		
4'X 4' TEMPLATE		
PAINT SCRAPPER		
SAMPLE COLLECTION ENVELOPES		

EQUIPMENT REQUIRED	Y/N	COMMENTS/CONDITION
SOIL PROBE		
PROBE CLEANING TOOL		
SAMPLE COLLECTION BAGS		

LEAD IN SOIL PROJECT

EXTERNAL QUALITY ASSURANCE/QUALITY CONTROL

QUALITY ASSURANCE FOR BLOOD LEAD ANALYSIS (CENTERS FOR DISEASE CONTROL)

A. INTRODUCTION

The lead in soil demonstration project of its nature requires blood lead data of the highest quality. Expected differences in blood lead levels from successful abatement are of the order of 2-4 µg/dL, thus placing unusually stringent requirements on long term laboratory precision. The quality control issues including establishment and maintenance of a high degree of precision over the entire duration of the project. The key function of the quality assurance system is to ensure the absence of any "drift" (downward or upward) with analytical values with time, such that any difference in blood lead values over time cannot be attributed to with time, such that any difference in blood lead values over time cannot be attributed to changes in the analytical system. Simply stated, this will help insure that statistically speaking, observed changes in blood lead are real- that is, due to intervention and not attributable to changes in the laboratory method over time. Since the CDC has extensive experience in such activities from the National Health and Nutrition Examination Survey (NHANES) and other long term studies, we were asked by the USEPA to provide assistance. The material following is a summary of laboratory related issues that were included in the overall QC program.

B. ELEMENTS OF A QUALITY CONTROL SYSTEM

In order for any analytical measurements to be valid and interpretable, the sources of error for each unique measurement system must be identified and minimized. This, then, is the major function of quality control. In the specific example of blood lead measurements, the following have been shown from experience to be the major sources of error:

1) contamination of the specimen during collection, storage, or analysis

2) deterioration of the specimen by clotting, denaturation, or other processes

3) instability of the measurement system, either over a short (within run/day) or long time span

4) improper calibration for the measurement system

5) errors in data handling, storage, or reporting

Quality control therefore must include a number of components, both within and external to the laboratory: 1) collection of an uncontaminated specimen; 2) preservation and shipping (if needed) of the specimen under conditions that assure integrity; 3) monitoring of analytical method performance, to include instrumental stability, maintenance, and performance of the analyst(s); and 4) accuracy and completeness of all data, to include specimen identification, data reduction, and data interpretation. Some critical components of each of these areas include:

1. Specimen Collection

Proper screening of all specimen collection equipment to define any detectable levels of the analyte, and estimate variability of this contamination.

Written protocols for specimen collection which describe in detail all sampling equipment and its use, precautions to avoid contamination, and other requirements (time of day, fasting/non-fasting state of subject) which might affect specimen integrity.

2. Specimen Preservation and Shipping

Proper packing, storage and shipping temperatures, suggested means of conveyance for timely receipt of specimens.

Detailed shipping and specimen log forms to allow description of each specimen to record any variances from collection or shipping protocols.

3. Analytical method Performance

Method selected must demonstrate precision and accuracy in the appropriate analytical range and should be simple, rugged, rapid and cost-effective. Ideally, the detection limit should be ca. 2 μg/dL with precision about 5 % at the 10 mg/dL level for the proposed study.

Instrumental stability, and by inference "method" stability, should be documented by analysis of control materials, both "bench" and "blind". It is desirable that materials with certified values of the analyte of interest be an analyzed regularly to demonstrate method accuracy. It is suggested that at least t 10% of the specimens be quality control pools.

4. Bench and Bwnd Quality Control Materials

Blind quality control pools should be inserted at a rate of 5% by a source external to the laboratory. These specimens should be in the same container type and labelled with pseudopatient numbers such that they are indistinguishable from patient samples. It is suggested that the blind (and bench) pools have two concentrations- one in the "expected" range of values for the majority of patient samples and one at or near the "decision level" for undue exposure. It is important that the blind materials be truly blind to the analyst for maximum effectiveness in the detection of analytical system error. The "pseudopatient" numbers used in labelling of the blinds will be decoded by the supervisor only, and that analytical run evaluated on the basis of pre-established control limits.

Use of quality control charts for means (X bar) and ranges (R) is essential; it is suggested that 20 runs be made for characterization of all quality control materials, and that these data be analyzed by two-way analysis of variance (ANOVA) to produce these charts. These charts should be in use by the analyst for each run for the evaluation of "bench" or known blood controls (and by the supervisor for blinds) by use of mean and range control limits, such that corrective actions needed may be made in a timely way.

Criteria for repeat analytical runs (due to "out of control" condition as indicated by results from quality control samples) are dependent on the number of pools in the quality control system.

Inclusion of blind splits (duplicate samples within run, with different identification number such that identification by the analyst is prevented) is suggested at a 5% rate; some split specimens may be submitted to an external laboratory for verification of accuracy or comparability. If specimen collection

constraints allow, it is recommended that at least 10% of the specimens be split with an external laboratory.

Criteria should be established as to "acceptable" agreement with the external laboratory.

5. Accuracy and Blanks

Blanks, consisting of samples in which ultrapure water is processed through the entire analytical procedure, are a useful part of quality assurance. The data from these determinations can be used to evaluate potential contamination in the laboratory environment as well as estimate the limit of detection to the analytical method.

Establishment of accuracy through the regular analysis of reference materials or proficiency testing pools is an essential part of good laboratory practice, and will help establish the accuracy of the method. The pools used for this accuracy assessment should be as close to identical to the survey samples as possible.

6. Data Integrity

Data logging should be performed for each run in approved notebooks or other data forms as soon as possible following each run. Electronic data entry may be desirable either as an adjunct to or replacement for "hard copy". It is recommended, however, that instrumental data be collected on hard copy in such a way that all data can be independently verified or reconstructed.

Data reduction should be standardized; all records of calculations should be secured and available for review.

C. DESCRIPTION OF QUALITY CONTROL SYSTEM USED

From previous experience in "long-term" quality control, a system was established that is similar to that used in the NHANES surveys. The cardinal features of such a system include written protocols for specimen collection, shipping, and analysis, a systematic screening of all specimen collection equipment and containers, establishment of statistical control limits by each individual laboratory, and supervision of all QC activities by a local laboratory supervisor. Since the three laboratories already had QC systems in place, there was a need to establish a common set of protocols and procedures for the entire project.

1. Initial Activities

Each laboratory was provided with a description of the sample collection and shipping protocols developed at CDC (1), as well as a reprint of our analytical method for blood lead (Appendix A). Summary descriptions of the QC system used in NHANES, as well as general descriptions of the NHANES quality control system were distributed (Appendix B,C).

Four whole bovine blood pools were collected at CDC, evaluated for lead content, and aliquoted into 2 mL Vacutainer brand whole blood collection containers (blind pools) or plastic screw-capped vials (bench pools). The Vacutainer specimen containers (as well as the plastic vials for the bench controls) were screened by established protocol (1), and had been purchased in sufficient quantity to allow all thee projects to use them as standard specimen containers. Pools such as these (whole bovine blood, stabilized with 1.5 mg/mL disodium EDTA) have been shown to be stable at least two years at 4 C, the recommended storage temperature. Data from this screening are presented in Table 1. Aliquots of these four pools were distributed to the laboratories, and duplicate analysis of the four pools was

performed over a series of twenty analytical runs. The data generated from these analyses were used to calculate the QC limits for both means (X bar) and ranges of duplicate measurements of these pools. The method of calculation is presented in Appendix D, using POOL "A" from Standard Reference Materials (SRM) 955 from the National Institutes of Standards and Technology (NIST). The calculations are based on two-way analysis of variance (ANOVA) as described by Shewhart (2,3).

Results of the calculated limits for these four pools were sent to the three laboratories to be used as part of the laboratory quality control program. Results of the calculation for the three laboratories, as well as CDC, are presented in Table 2. The quality control limits could then be used in two ways:

1) the limits for the "blind" pools were used to evaluate the blind quality control pools, which were inserted into each analytical run by the supervisor; and

2) the limits for the "bench" pools could be used by the analyst (along with those for any additional pools) to evaluate the degree of statistical control for the analysis.

Insertion of the "blind" pools was random, using a random numbering table numbering scheme presented by Taylor (4), with identical labels as study subject specimens and identical Vacutainers (2 mL liquid EDTA, lot # 8E014 EXP 5/90). An example of the labelling system is given in Table 3. If names were provided on the sample labels, then fictitious names were provided for the "blinds" by the supervisor. The source if banes could be random names from a metro phone book, or any other appropriate source.

2. Calibration

Since three different analytical methods were used in the study, the issue of calibration of the analytical systems was very important. The CDC recommendation to all three laboratories was that either SRM 3128 (from NIST) or equivalent aqueous standards for lead be used. In the case of the graphite furnace AAS methods (Boston and Baltimore), a version of the CDC published method was used for analysis, which includes "matrix matched" standards and lead nitrate aqueous standards. The DPASV method used by Cincinnati (5) includes standards analyzed by isotope dilution mass-spectroscopy (IDMS). In all three laboratories, the ultimate test of the accuracy of calibrations generation of accurate values for reference materials. As can be seen from Table 2, all three laboratories agreed well (within 5%) with each other, and generated comparable results on the four pools provided by CDC (Figure 1).

3. Interpretation of Data

The quality control system outlined here has multiple uses:

1) evaluation of "day-today" statistical control of the analytical system;

2) verification of analytical performance on "blinds" - known samples inserted in each analytical run to verify precision

3) evaluation of any "trends" in the analytical performance of the method over time- either short term (days/week) or long term (months/years)

With the use of common rules for the verification of statistical control (4), all the laboratories would follow a statistically valid and proven method for data evaluation. Any problems not resolved at the local level were presented to CDC for resolution.

D. RESULTS OF QUALITY CONTROL SYSTEMS

Data from the initial characterization for the four whole blood pools used in this project are presented in Table 2. Each laboratory can be individually compared as to within-run precision, among runs precision, and total precision. Using the definition of the limit of detection as 3 SD(wr) developed by Winefordner (6), the laboratory detection limits may also be compared.

Of equal importance are the long-term quality control data, especially in terms of time trends. The Shewhart plots for the three laboratories are presented in Figure 2. As can can be readily seen, no long-term trends in analytical values with time are evident. Statistical tests of the null hypothesis (that is, a "0" slope of X bar versus time) reveled no statistically significant trends with time.

The conclusions that can be drawn from these three systems are as follows:

1) comparable values were obtained on common quality control materials, which covered the analytical concentration range of interest;

2) laboratory data for blood lead were produced from analytical systems in statistical control (as defined by Shewhart); and

3) no statistically significant time trends were observed in the data- that is , the difference in pre- and post abatement blood lead values are real and not the product of unstable analytical systems.

Table 1 Data from Lead Screening

2 mL Vacutainers (B D lot #8E016 Exp. 5/90) Catalog # 6384

Analytical result N = 42 tubes;
soaked overnight (12 hr in 1% v/v nitric acid)

X = 0.0964 ug/dL lead (SD = 0596 ug/dL CV = 62%)

3 mL plastic vials (linear polyethylene) Falcon Catalog #

Analytical result N = 42 tubes;
soaked overnight (12 hr in 1% v/v nitric acid)

X = 0.51 ng/mL Equivalent to 0.025 mg/dL (SD = 0.36 ng/mL CV = 71%)

Capillary Collection Butterflies BD Catalog # 7251; 7253)

Analytical results; One mL 1% v/v nitric acid passed through each collector)
N = 5 results collectors each size

X = <0.1 ng/mL (cat 7251)
X = <0.1 ng/mL (cat 7253)

Table 2 quality Contol Limits- Means and Ranges

LAB	POOL	MEAN	95% Conf Limits MEAN	RANGE	99% Conf Limits MEAN	RANGE
CDC	BLIND1	4.6	3.0-6.2	1.6	2.5-6.7	2.1
	BENCH2	43.5	38.2-48.8	2.2	36.5-50.5	2.9
	BENCH1	1.8	1.0-2.5	1.4	0.8-2.7	1.9
	BLIND2	10.7	8.5-12.9	1.4	7.8-13.6	1.8
MD	BLIND1	5.1	4.2-5.9	0.9	4.0-6.2	1.1
	BENCH2	45.7	43.9-47.6	1.1	43.3-48.2	1.5
	BENCH1	2.0	1.45-2.63	0.6	1.27-2.8	0.8
	BLIND2	11.1	9.6-12.6	1.0	9.2-13.1	1.4
CN	BLIND1	3.5	1.9-5.1	3.2	1.4-5.6	4.2
	BENCH2	43.3	40.5-46.1	2.2	39.6-46.9	2.9
	BENCH1	2.4	0.9-4.0	2.0	0.4-4.5	2.6
	BLIND2	8.9	7.1-10.7	3.1	6.5-11.2	4.1
BOS	BLIND1	4.0	2.4-5.6	0.8	1.9-6.1	1.0
	BENCH2	47.0	42.9-51.2	2.9	41.6-52.6	3.8
	BENCH1	0.2	-1.2-1.5	0.8	-1.6-1.9	1.1
	BLIND2	10.6	8.6-12.5	1.3	8.0-13.1	1.7

Table 3 Labelling System for Blinds

RUN NUMBER	SPECIMEN NUMBERS	BLIND SPECIMENS (L) OR (H)
1	1-25	10 (L) 15(H)
2	26-50	26(L) 50(L)
3	51-75	51(H) 52(L)
4	76-100	84(L) 96(H)
5	101-125	107(H) 118(L)
6	126-150	136(L) 137(H)
7	151-175	158(L) 159(H)
8	176-200	185(H) 195(H)
9	201-225	204(L) 214(L)
10	226-250	232(L) 239(H)
11	251-275	264(L) 266(L)
12	276-300	286(L) 298(L)
13	301-325	301(H) 317(H)
14	326-350	328(L) 348(L)
15	351-375	374(L) 359(H)
16	376-400	394(L) 399(H)
17	401-425	404(L) 417(H)
18	426-450	427(H) 431(H)

E. REFERENCES:

1) "Lake Couer d' Alene Idaho Cadmium and Lead Study-Specimen Collection and Shipping Protocol" Division of Environmental Health Laboratory Sciences, Center for Environmental Health, Centers for Disease Control, Atlanta, GA 30333 8/6/86.

2) "Determination of Lead in Blood Using Electrothermal Atomization Atomic Absorption Spectrophotometry with a L'vov Platform and Matrix Modifier", D.T. Miller, D.C. Paschal, E.W. Gunter, P.E. Stroud, and J. D' Angelo, Analyst, 112, pp 1701-4 (1987).

3) "A Multi-Rule Shewhart Chart for Quality Control in Clinical Chemistry", J.O Westgaard, P.L. Barry, and M. R. Hunt, Clinical Chemistry,, 27, pp. 493-501 (1981).

4) "A Quality Assurance Program for Health and Environmental Chemistry", M.A. Gaultier and E.S. Gladney, American Laboratory, pp. 17-22, July 1987.

5) "Elements of Sequential Analysis" Chapter in Biostatistics, A.E. Lewis, ed. Reinhold Publishing Corp., New York, 1966.

6) "Quality Assurance of Chemical Measurements", John Taylor, Lewis Publishers, Cheslea, MI 1987.

7) "Anodic Stripping Voltammetry Procedure Modified for Improved Accuracy of Blood Lead Analysis", S.M. Roda, R.D. Greenland, R.L. Bornschein, and P.B. Hammond, Clinical Chemistry, 34, pp. 563-7 (1988).

8) "Limit of Detection- A Closer Look at the IUPAC Definition", G.L. Long and J.D. Winefordner, Analytical Chemistry, 55, pp 712A-724A, (1983)

LEAD IN SOIL PROJECT

QA/QC for Soil, Dust, and Handwipes (US EPA/EMSL/LV)

Section 1

Preparation Laboratory Operations

1.1 Sample Receipt

Three cities are involved in the superfund Lead Abatement Program; Baltimore, Boston, and Cincinnati. EMSL-LV supplies the field samplers in each city with 30-gallon plastic barrels for soil samples and 1-gallon metal containers for interior dust samples. A minimum of two soil and two dust samples are collected in each city and shipped to EMSL-LV. The preparation laboratory manager records the arrival date of all samples received.

1.2 Sample Labeling

1.2.1 Soil and Dust

Each soil sample is labeled and identified by a unique sample code as described below.

A BOS H 01 001 (example)
digits 1 234 5 67 8-10

Digits	Representation
1	Sample type - "A" = audit "C" = calibration
2-4	City code - "BOS", "BAL", "CIN"
5	Concentration - "H" = high, "M" = medium, "L" = low
6-7	2 kg sample - represents number of the 2 kg container in which soil was subsampled. If sample is dust the number would represent the 100g container.
8-10	20 g aliquot - numbered aliquot from soil 2 kg container or 2g aliquot from dust 100 g container.

Analytical laboratories at each city provide sample labels and containers to be used for that city. Prior to shipping, the EMSL labels are removed and the city labels are affixed to the sample containers. Also, the EMSL-LV codes and corresponding city codes are recorded in a log book for each sample.

1.2.2 Handwipes

Each handwipe sample is labeled and identified by a unique sample code as described below.

A BOS H 001 (example)
digits 1 234 5 6-8

Digits	Representation
1	Sample type - "A" = audit "C" = calibration
2-4	City code - "BOS", "BAL", "CIN"
5	Concentration - "H" = high, "M" = medium, "L" = low
6-8	Internal ID - the last three numbers of the internal LESC ID.

Analytical laboratories at each city provide sample labels and containers to be used for that city. Prior to shipping, the EMSL labels are removed and the city labels are affixed to the sample containers. Also, the EMSL-LV codes and corresponding city codes are recorded in a log book for each sample.

1.3 Sample Tracking

1.3.1 Soil and Dust

The preparation laboratory manager tracks each sample as it progresses through the preparation procedures and records progress in a logbook.

The following information is recorded on a daily basis.

Sample Type - soil, interior dust

City - Boston, Baltimore, Cincinnati

Concentration - high, medium, low

Dried - whether sample has been dried (yes/no)

Crushed - whether sample has been crushed (yes/no)

Bulk homogenization - Whether bulk sample has been homogenized (yes/no)

Pulverized - whether sample has been pulverized (yes/no)

2 kg split - Whether bulk sample has been split into 2 Kg samples. If this step is partially complete, the number of aliquots prepared will be recorded.

100 g split - Whether 2 kg soil aliquots have been split into 100 g aliquots or whether the bulk dust sample have been split into 100 g aliquots. If this step is partially complete, the number of aliquots prepared will be recorded.

20 g split - Whether 100 g soil aliquots have been split into 20 g aliquots or 100 g dust aliquots have been split into 2 g aliquots. If this step is partially complete, the number of aliquots prepared will be recorded.

The appropriate types of information will be made available for dust and handwipe samples. As aliquots are sent to analytical laboratories, this information will also be recorded (see sample shipment).

1.3.2 Handwipes

The appropriate types of information will be made available for dust and handwipe samples. As aliquots are sent to analytical laboratories, this information will also be recorded (see sample shipment).

. Sample Type - handwipe

. City - Boston, Baltimore, Cincinnati

. Concentration - high, medium, low

. Spiked - whether sample has been spiked (yes/no)

The appropriate types of information will be made available for dust and handwipe samples. As aliquots are sent to analytical laboratories, this information will also be recorded (see sample shipment).

1.4 Sample Custody

Custody is transferred from the field samplers to the preparation laboratory manager when the samples are received. The sample remain in the custody of the preparation laboratory manager until they are shipped to the analytical laboratories.

1.5 Sample Storage

All samples are placed in cold storage upon receipt until there is room for them in the drying room. After air drying, the samples are returned to cold storage until processing.

1.6 Sample Shipment

As samples are shipped a shipping form (Figure 1.1) is sent to both the laboratory manager and QA manager. The form sent to the laboratory manager contains only the types and numbers of samples sent and the city sample code information for each sample. The form sent to the QA manager contains information as well as the EMSL sample code, which identifies the concentrations of each sample.

LEAD ABATEMENT QA SAMPLE SHIPMENT FORM

LAB_____ SAMPLE TYPE_____
BATCH _____
DATE SHIPPED_____
NO OF SAMPLES_____

Sample Number	City Sample Code	EMSL Sample Code
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		

FIGURE 1.1 LEAD ABATEMENT SAMPLE SHIPMENT FORM

Section 2

Soil Audit Sample Preparation Procedures

2.1 Overview

Specific areas of the preparation laboratory are designated for sample processing. Sample integrity during processing is ensured by: (1) the use of detailed sample labels, (2) documenting the status of each sample during the processing, (3) following the preparation documenting the status of each sample during each processing step.

Bulk soil samples are processed as outlined in Figure 2.1 Each step is detailed in sections 2.2 -2.8.

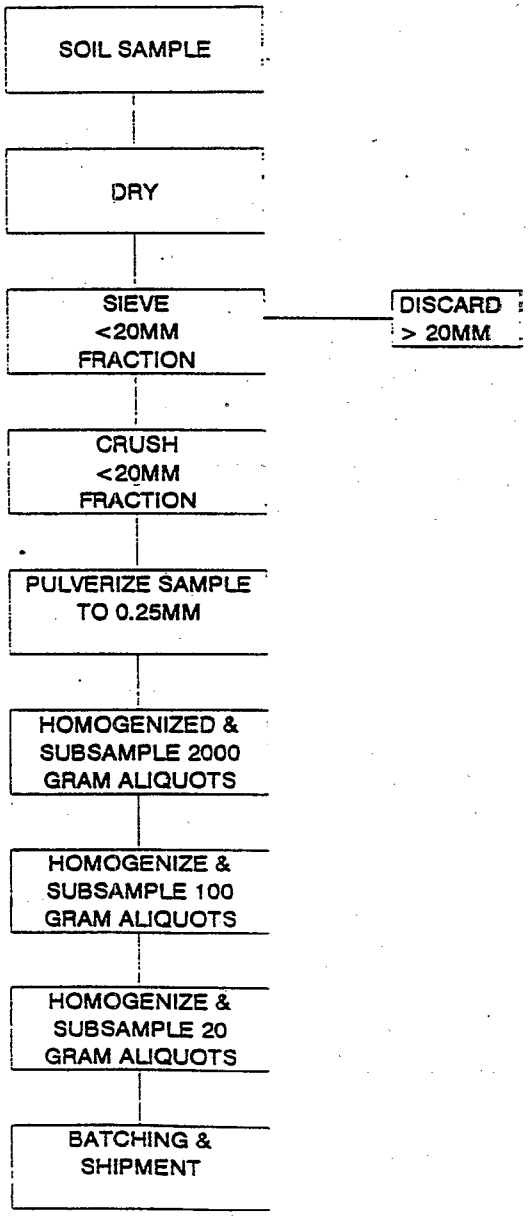


FIGURE 2.1 SOIL AUDIT SAMPLE PREPARATION FLOW

2.2 Sample drying

2.2.1 Summary

Samples tables constructed of PVC and heavy nylon mesh are used to air dry the samples. Use of the mesh enhances air circulation and increases the rate of sample drying. These tables are located in a dust free drying room.

Chemicals as well as food, drinks and smoking are prohibited in the drying area. A separate pair of gloves is worn when handling each sample. Care is exercised during the cleaning operation to avoid contamination of samples. Only one sample at a time is dried to avoid cross contamination. Weekly vacuuming or sweeping is performed to clean the floors of the drying room. Sweep EZ, a sweeping compound) is used at least once a week to control dust accumulation in the drying area.,

2.2.2 Equipment:

Drying tables with nylon mesh surface
Kraft paper, 36 inch wide rolls
Rubber gloves, unpowdered

2.2.3 Procedure

Label a bulk sample processing data form for each sample to be air dried. Place two fresh sheets of kraft paper, approximately 1 square meter in area, on the drying table. Wearing gloves, slowly spread the sample on top of the paper, taking care not to lose any soil off the paper or contaminate any adjacent samples. Disaggregate any large peds. Soils high in clay may harden nearly irreversibly if allowed to dry without a preliminary disaggregation of medium and coarse peds. Place an additional sheet of kraft paper loosely over the sample. Daily stir the soil sample to facilitate drying. During the first few days replace the bottom sheet of paper in order to alleviate excessive moisture accumulation. Note any observations of fungal or algal growth on the data form.

Allow the sample to air dry for a minimum of four days. Prior experience indicates that samples dry to a constant moisture content (1-2.5%) within three days at the EMSL-LV preparation laboratory.

2.2.4 Quality Control

When samples are received, labels are checked and recorded. Wearing gloves, the samples are spread out on kraft paper, which is an effective barrier separating the samples from the PVC mesh tables. A cover sheet of kraft paper is used to reduce potential contamination. When handling the samples, gloves are always worn.

2.3 Initial Disaggregation and Sieving

2.3.1 Summary

When a bulk soil sample is air dry, it is disaggregated and sieved in order to remove large rock fragments and to prepare the sample for crushing, pulverization, homogenization and subsampling. This procedure is accomplished in two steps: (1) disaggregation and sieving through a 20-mm sieve and, (2) crushing, pulverizing, and sieving through a 2-mm sieve.

2.3.2 Equipment:

Fumehood
Kraft paper
Plastic bags
Respirator
rolling pin
Rubber stopper
Tyvek suit

2mm sieve
20mm sieve

2.3.3 Procedure

Place a 1 m^2 sheet of kraft paper on the sieving table under a vented fumehood. Place a 60 cm^2 sheet of kraft papers on the larger piece of paper and spread a portion of one bulk sample within the confines of the 60 cm^2 sheet. Carefully examine the nature of the rock fragments within the sample and determine the amount of pressure necessary in order to disaggregate the soil peds without fracturing or crushing the fragments. Place another 60 cm^2 sheet of kraft paper over the sample and gently roll the rolling pin across the sample. Enough force should be applied to break up the peds, but not so much that weathered rock fragments are crushed. Place this crushed sample in the 20-mm mesh sieve and push the soil through the sieve with a rubber stopper onto the kraft paper. Attempt to include any soil adhering to rock fragments. Place the sieved material in a clean container and repeat the process until all of the soil of from one bulk sample is sieved. All rock fragments and other material larger than 20-mm is placed in a plastic bag and properly discarded.

Crush the minus 20-mm fraction (The Crushing procedure is described in section 2.4) then passed through a 2-mm sieve using the procedure described above.

The sieves are cleaned after each sample by tapping the sieve on a hard surface and brushing out the sieve to expunge any remaining soil particles.

2.3.4 Quality Control

The disaggregation and sieving areas should be covered with kraft paper and cleaned after each sample has been sieved. When sieving, gloves must be worn, as well as an appropriate mask and protective clothing. The laboratory manager will frequently check the sieving operation for proper equipment and for adherence to protocol. A member of the EMSL-LV QA staff will visit the preparation laboratory to ensure adherence to protocol.

2.4 Crushing

2.4.1 Summary

After soils are sieved through the 20-mm sieve, the < 20-mm material is passed through a rock crusher. The intent of crushing is to further reduce the particle size to 2mm.

2.4.2 Equipment

Brush
Compressed air
Crusher
Gloves
Mask
Protective Clothing
Plastic bags
Scoop
2-mm sieve

2.4.3 Procedure

With a scoop, place a portion of the minusm soil fraction to the crusher opening. Turn the crusher on. The crusher deposits the resulting crushed material into a collection bin at the bottom of the machine. After the first scoop is crushed, shut the machine off and sieve the crushed material through the 2-mm sieve (described in Section 2.4). If all the material passes through this sieve, the crushing plates are sufficiently close enough to continue processing. If not, adjust the plates and repeat the procedure on the same sample until all the material passes through the 2-mm sieve. Once the collection bin is full, turn the machine off and deposit the material into a clean labeled plastic bag. Repeat the operation

until all soil from one bulk sample is crushed. Thoroughly clean the machine with compressed air and a brush between samples.

2.4.4 Quality Control

When crushing, gloves must be worn, as well as a mask and protective clothing. The machine opening should be tightly fastened to minimize dust. The laboratory manager will frequently check processing equipment for proper operations, for adherence to protocol including proper maintenance. A member of the EMSL QA staff will visit the preparation laboratory to ensure adherence to protocol

2.5 Pulverizing

2.5.1 Summary

The routine soil samples that are analyzed by the cities are ground to a particle size of less than 0.25mm. Therefore, it is necessary to provide audit materials with the same particle size fraction. The preparation laboratory pulverizes the minus 2-mm soil fraction to a particle size of less than 0.25mm.

2.5.2 Equipment

Brush
Compressed air
Gloves
Mask
Plastic bags
Protective Clothing
Pulvenizer
Scoop
0.25mm sieve

2.5.3 Procedure

With a scoop, place a portion of the minus 2-mm soil fraction material into the pulverizer opening. Turn the power on. The pulverizer grinds the soil and deposits it into a collection bin at the bottom of the machine. After the first scoop is pulverized, shut the machine off and sieve the material through the 0.25-mm sieve. If all the material passes through this sieve, the grinding plates are sufficiently close enough to continue pulverization. If not, adjust the plates and repeat the procedure on the same sample until all the material passes through the 0.25-mm sieve (described in Section 3.6). Once the collection bin is full, turn the machine off and deposit the pulverized material into a clean labeled container. Repeat the operation until all soil is pulverized. Thoroughly clean the machine with compressed air and a brush.

2.5.4 Quality Control

When pulverizing, gloves must be worn, as well as a mask and protective clothing. The machine opening should be tightly fastened to minimize dust. the laboratory manager will frequently check the processing equipment for proper operation, for adherence to protocol including proper maintenance. A member of the EMSL QA staff will visit the preparation laboratory to ensure adherence to protocol.

2.6 Final Sieving

2.6.1 Summary

To ensure that the pulverized audit sample has a particle size < 0.25mm it is resieved through 0.25mm sieve.

2.6.2 Equipment

Fumehood

Kraft paper
Paint Brush
Plastic bags
0.25-mm sieve
3x5 card

2.6.3 Procedure

Place a 1 m^2 sheet of kraft paper on the sieving table under a vented fumehood. Place a 60 cm^2 sheet of kraft paper on the larger piece of paper. Place a portion of the soil material in the 0.25-mm sieve and screen the material using a rocking motion. Use a paint brush or 3 x 5 card to gently push the material through. Place any material > 0.25mm into a separate pile. Continue this procedure until the complete sample is sieved. Save the material not passing through the .25mm sieve for further pulverization.

2.6.4 Quality Control

When sieving, gloves must be worn, as well as a mask and protective clothing. The laboratory manager will frequently check the sieving processing equipment for proper operation and for adherence to protocol. A member of the EMSL-LV QA staff will visit the preparation laboratory to ensure adherence to protocol.

2.7 Homogenization and Subsampling to 2-kg Aliquots

2.7.1 Summary

Prior to splitting the 2 kg aliquots into 20 g aliquots, the bulk soil (minus 0.25mm fraction) is homogenized using a combination of three techniques; drum-rolling. cone and quartering, and riffle-splitting. After homogenizing, the bulk sample is split into 2 kg aliquots using a riffle splitter.

2.7.2 Equipment

Drum homogenizer
Gloves
Kraft paper
Labels
Large riffle splitter
Mask
Protective clothing
Shovel
Top loading balance
2-L sample bottles

2.7.3 Procedure

2.7.3.1 Drum homogenization/Cone and Quartering

Place all of the < 0.25mm fraction from one soil sample into the drum homogenizer. Slowly rotate the drum for five minutes. Pour the entire sample onto a large piece of kraft paper so that the sample takes on the shape of a cone. Homogenize the cone by dividing the cone into four equal quarters by lines going clockwise from 1 to 4. Using a shovel, remove the first quarter to form anew cone. The third, second and fourth quarters are piled sequentially over the first quarter. The procedure is performed seven times in succession. Figure 2.2 illustrates the technique.

Figure 2.2 Top and side views of the soil cone

2.7.3.2 Riffle splitting

Position the two collecting bins under the large riffle splitter (Figure 2.3). Pour the entire sample evenly across the baffles of the riffle splitter. Transfer the soil from each collecting bin into the distribution pan and replace the receiving pans under the riffle splitter. Repeat this procedure five times in succession.

2.7.3.3 Subsampling

After the homogenization, 2 kg aliquots are obtained. If the cone and quartering technique is used, place a clean 2-L sample bottle at the bottom of the cone and, with an upward movement, collect a sample weighing approximately 2000 grams (+/-20 grams). If the riffle splitting technique is used, place a clean 2-L sample bottle at one end of the collecting bin and moved to the other end to fill the bottle. The sample is labeled using the procedure described in Section 2.2. The first 2 kg aliquots for each audit concentration's identified with "01" and subsequent aliquots numbered consecutively. The other information within the sample code will ensure a unique sample identity. Repeat this procedure for the entire amount of homogenized audit sample. Store the audit samples in cold storage until further processing.

Figure 2.3 Large Riffle Splitter

2.7.4 Quality Control

When homogenizing, gloves must be worn, as well as a mask and protective clothing. Prepare labels for the 2 kg samples prior to the processing step in order to avoid mislabeling. the laboratory manager will frequently check the homogenization operation for proper processing equipment and for adherence to protocol A member of the EMSL-LV QA staff will visit the preparation laboratory to ensure adherence to protocol.

2.8 Homogenization and Subsampling to 100 g and 20g Aliquots

2.8.1 Summary

Each 2 kg aliquot prepared in section 2.7 is further homogenized in a medium sized riffle splitter and split into 100 g aliquot. the 100 g aliquots are then homogenized in a small riffle splitter and split into 20 g aliquots. These two procedures are done simultaneously in order to avoid the use of intermediate sample containers and the possibility of mislabeling.

2.8.2 Equipment

Gloves
Fumehood
Laboratory containers (20 g samples)
Open pan balance
Plastic bags
Riffle splitters, medium (24 chute 13-1/2" x 15-3/8") and small (32 chutes 6-5/8" x 9")
Scoop

2.8.3 Procedure

2.8.3.1 Homogenization and Subsampling to 100 grams

2.8.3.1.1 Initial Homogenization-- Position the two receiving pans under the medium riffle splitter. Pour the entire 2 kg sample evenly across the baffles of the riffle splitter. Transfer the soil from each receiving pan into the distribution pans and replace the receiving pans under the riffle splitter. Repeat this procedure five times in succession.

2.8.3.1.2 Splitting to 500 g Aliquots-- Pour the sample evenly across the baffles and place the soil from one receiving pan aside. Transfer the soil in the other receiving pan to the distribution pan and split once more. This should produce approximately a 500 g samples in each receiving pan. Place these samples on separate sheets of kraft paper. Split the soil from the other receiving pan similarly. This produces a total of four 500 g aliquots from each 2kg aliquot.

2.8.3.1.3 Splitting to 100 g aliquots-- Pour the 500 g sample evenly across the baffles and place the soil from one receiving pan into a plastic bag. Transfer the soil in the other receiving pan to the distribution pan and continue splitting as necessary until approximately 100-g of soil occupies one of the receiving pans. Place the entire contents of this pan into the distribution pan of the small riffle splitter (see section below). Repeat the procedure until all of the 2 kg aliquot is split into 100 g aliquots.

2.8.3.2 Homogenization and Subsampling to 20 grams

2.8.3.2.1 Initial Homogenization--Position the two receiving pans under the small riffle splitter. Pour the entire 100 g aliquot from the distribution pan evenly across the baffles of the riffle splitter. Transfer the soil from each receiving pan into the distribution pan and replace the receiving pans under the riffle splitter. Repeat this step five times in succession.

2.8.3.2.2 Splitting into 20 g Aliquots--Pour a 100 g aliquots evenly across the baffles of the small riffle splitter. Place the soil from one receiving pan into a plastic bag. Transfer the soil from other receiving pans under the riffle splitter. Repeat this step five times in succession.

2.8.3.2.2 Splitting into 20 g Aliquots-- Pour a 100 g aliquots evenly across the baffles of the small riffle splitter. Place the soil from one receiving pan into a plastic bag. Transfer the soil from other receiving pan to the distribution pan and continue splitting as necessary until approximately 20 g of soil occupies one of the receiving pans. Place the entire contents of the pan into the pre-labeled sample container provided by the analytical laboratories. Repeat the procedure until the entire 100 g sample is split into five 20 g aliquots.

2.8.4 Quality Control

When homogenizing and subsampling, gloves must be worn, as well as a mask and protective clothing. The laboratory manager will frequently check the operation for proper use of equipment and for adherence to protocol. A member of the EMSL QA staff will visit the preparation laboratory to ensure adherence to protocol As samples are characterized, precision estimates for each audit sample type will be developed. If the pooled relative precision estimate (RSD) for an audit sample whose concentration is above 10 times the detection limit (~100ppm) is greater than ten percent, the preparation laboratory will combine all 20 g aliquots, rehomogenize, then resplit the sample.

Section 3

Dust Audit Sample Preparation Procedures

3.1 Overview

Dust samples of different concentration will be supplied to EMSL-LV from each city. From these samples, EMSL-LV will provide three audit samples with Pb at low, mid, and high concentration ranges and three calibration standards at similar concentrations. The bulk samples are air dried, sieved, homogenized and split into 2-gram aliquots as outlined in Figure 4.1. Participating laboratories supply EMSL-LV with sample containers, labels, and the appropriate labeling techniques for the samples

A random subsample of the audit samples will be characterized by EMSL-LV. Fifty samples at each concentration range will be analyzed for Pb by XRF. A subset of these samples will be analyzed by ICPES after nitric acid extraction. Characterization data will be supplied to the Lead Abatement QA manager.

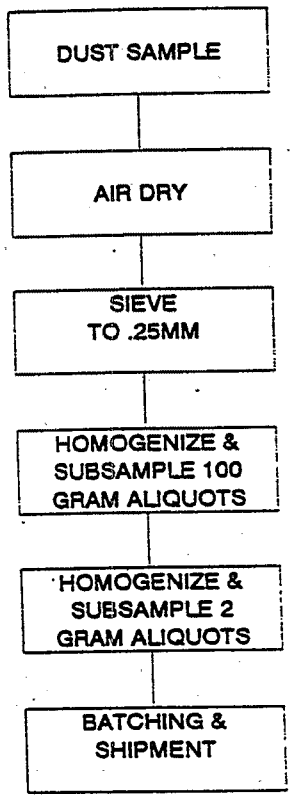


FIGURE 3.1 DUST AUDIT SAMPLE PREPARATION FLOW

3.2 Sample drying

Interior dust audit samples will be sent from the participating cities of Boston, Baltimore and Cincinnati in one gallon containers. Upon arrival, remove the lid of each container and allowed it to air dry before further preparation. The samples are kept in the shipping container during air-drying to prevent loss of sample.

3.3 Sieving to 0.25mm

3.3.1 Equipment

Fumehood
Kraft paper
Paint brush
0.25mm Sieve
3 x 5 index cards

3.3.2 Procedure

Place a 1 m^2 sheet of kraft paper onto the preparation table. On top of this sheet place a 60 cm^2 sheet of kraft paper. Set a 0.25mm mesh sieve on top of the smaller sheet of kraft paper. Portions of the dust sample are placed into the sieve and gently pushed through with either a paint brush or a 3 x 5 card. Material greater than 0.25m is placed in a plastic bag for proper disposal.

3.4 Homogenization and Subsampling to 2 Gram Aliquots

3.4.1 Equipment

Fumehood
Gloves
Laboratory containers (2 gram samples)
Open pan balance
Plastic bags
Riffle splitter, medium (24 chute 13-1/2" X125-3/8"
Riffle splitter, mini (14 chutes, 2-1/16" X 3-3/4")
Scoop

3.4.2 Procedure

4.4.2.1 Homogenization and Subsampling to 100 grams

Position the two receiving pans under the small riffle splitter. Pour the entire contents of the minus 0.25mm dust fraction evenly across the baffles of the riffle splitter. Transfer the dust from each receiving pan into the distribution pan and replace the receiving pans under the riffle splitter. Repeat this step five times in succession with the material in each receiving pan.

Pour the sample evenly across the baffles and place the dust from one receiving pan into a plastic bag. Transfer the soil in the other receiving pan to the distribution pan and continue splitting as necessary until approximately 100 g of dust occupies one of the receiving pans. Place the entire contents of this pan into the distribution pan of the mini riffle splitter (see section below). Repeat the procedure until all of the dust sample is split into 100 g aliquots.

3.4.2.2 Homogenization and Subsampling to 2 Grams

Position the two receiving pans under the mini riffle splitter. Pour the 100 g aliquot evenly across the baffles of the riffle splitter. Transfer the dust from each receiving pan into the distribution pan and replace the receiving pans under the riffle splitter. Repeat this step five times in succession with the material in each receiving pan.

Splitting to 25 g Aliquots--

Pour the 100 g aliquot evenly across the baffles and place the dust from one receiving pan aside. Transfer the dust in the other receiving pan to the distribution pan and split once more. This produces a 25 g aliquot in each receiving pan. Place the 25 g aliquots on separate sheets of kraft paper. Similarly split the remaining dust to produce an additional a total of two 5 g aliquots.

Splitting to 2 g Subsamples--

Pour the 25 g aliquot evenly across the baffles of the mini riffle splitter and place the soil from one receiving pan into a plastic bag. Transfer the soil in the other receiving pan to the distribution pan and continue splitting as necessary until approximately 2 g of soil occupies one of the receiving pans. Place the entire contents of the this pan into the pre-labeled sample container provided by the analytical laboratories. Similarly split the dust set aside in the plastic bag. Repeat the procedure until all of the 25g aliquots are split into 2 g samples.

3.4.3 Quality Control

When homogenizing and subsampling, gloves must be worn, as well as a mask and protective clothing. The laboratory manager will frequently check the sieving operation for proper equipment and for adherence to protocol. A member of the EMSL QA staff will visit the preparation laboratory to ensure adherence to protocol. As samples are characterized, precision estimates at each concentration will be developed. If the pooled precision estimate for an audit sample whose concentration is above 10 times the detection limit (~100ppm) is greater then ten percent relative standard deviation, the preparation laboratory will and resplit rehomogenize the sample.

3.4.2 Procedure

4.4.2.1 Homogenization and Subsampling to 100 grams

Position the two receiving pans under the small riffle splitter. Pour the entire contents of the minus 0.25mm dust fraction evenly across the baffles of the riffle splitter. Transfer the dust from each receiving pan into the distribution pan and replace the receiving pans under the riffle splitter. Repeat this step five times in succession with the material in each receiving pan.

Pour the sample evenly across the baffles and place the dust from one receiving pan into a plastic bag. Transfer the soil int the other receiving pan to the distribution p[an and continue splitting as necessary until approximately 100 g of dust occupies one of the receiving pans. Place the entire contents of this pan into the distribution pan of the mini riffle splitter (see section below). Repeat the procedure until all of the dust sample is split into 100 g aliquots.

3.4.2.2 Homogenization and Subsampling to 2 Grams

Position the two receiving pans under the mini riffle splitter. Pour the 100 g dust aliquot evenly across the baffles of the riffle splitter. Transfer the dust from each receiving pan into the distribution pan and replace the receiving pans under the riffle splitter. Repeat this step five times in succession with the material in each receiving pan.

Splitting to 25 g Aliquots--

Pour the 100 g aliquot evenly across the baffles and place the dust from one receiving pan aside. Transfer the dust in the other receiving pan to the distribution pan and split once more. This produces a 25 g aliquot in each receiving pan. Place the 25 g aliquots on separate sheets of kraft paper. Similarly split the remaining dust to produce an additional a total of two 25 g aliquots.

Splitting to 2 g Subsamples--

Pour the 25 g aliquot evenly across the baffles of the mini riffle splitter and place the soil from one receiving pan into a plastic bag. Transfer the soil in the other receiving pan to the distribution pan and continue splitting as necessary until approximately 2 g of soil occupies one of the receiving pans. Place the entire contents of the this pan into the pre-labeled sample container provided by the analytical laboratories. Similarly split the dust set aside in the plastic bag. Repeat the procedure until all of the 25g aliquots are split into 2 g samples.

3.4.3 Quality Control

When homogenizing and subsampling, gloves must be worn, as well as a mask and protective clothing. The laboratory manager will frequently check the sieving operation for proper equipment and for adherence to protocol. A member of the EMSL QA staff will visit the preparation laboratory to ensure adherence to protocol As samples are characterized, precision estimates at each concentration will be developed. If the pooled precision estimate for an audit sample whose concentration is above 10 times the detection limit (~100ppm) is greater than ten percent relative standard deviation, the preparation laboratory will and resplit rehomogenize the sample.

Section 4

Handwipe Audit Sample Preparation

4.1 Summary

As part of the Superfund Lead Abatement program, children's hands are swabbed with handwipes which are then analyzed for lead. As part of the quality control, handwipes audit samples are included with the unknown handwipe samples for analysis. Handwipe audit samples are spiked with lead at three different levels; 5ug, 20ug, and 40ug lead.

4.2 Equipment

Box of wet handwipes
200 mg/L and 1000 mg/L solutions
ml pipette
Ziploc type plastic bags
Plastic gloves

4.3 Procedure

4.3.1 Regents

. 1000 mg/L Pb - Certified standard obtained commercially.
. 200 mg/L Pb - Dilute 1000 mg/L Pb solution 1:5 with reagent water.

4.3.2 Spiking Procedure

. Unopened containers of wet-wipes are provided by the participating cities,
. Working in laminar flow clean hood, wearing clean gloves, Pull out 6 wet wipes from the same container and place into a stack (i.e., one on top of the other). Using a micropipet, add the spike to the center of the wet wipe stack between the third and forth wipe). The spike volumes are given below;

- 5 ug spike - 25 uL of 200 mg/L Pb standard
- 20 ug spike - 20 uL of 1000 mg/Pb standard
- 40 ug spike - 40 uL of 1000 mg/L Pb standard

. Fold and crumple the wet wipe stack and place into a zip-lock bag. Seal and label the bag with lab ID number. Record the lab ID and spike level into a lab notebook.

Section 5

Urban Soil, Urban Dust, And Wet-Wipe

Audit Sample Characterization

5.1 Sample Preparation

5.1.1 Reagents

Concentrated nitric acid (ACS Reagent grade)
Concentrated nitric acid (Double deionized)
Hydrofluoric acid (48% high purity)
Reagent water (ASTM type II)

5.1.2 Hot nitric Acid (HNO_3) Extraction

Place 1 g sample (weighed to nearest 0.1 mg) or packet of wet wipes into a clean 100 mL beaker. Add 50 mL 7N HNO_3 to soil or dust samples. Add 50 mL 1N HNO_3 to wet wipe samples. Push wet wipes down with glass stirring rod to ensure complete coverage. Cover with a watch glass and heat gently at 95°C for 2 hours. Maintain at least 25 mL volume in the beaker by adding 7N HNO^3 (1N for wet wipe samples) as necessary. After digesting, cool and add 10 mL of water. Filter through Whatman No. 1 filter paper into a 100 mL volumetric flask. Rinse beaker and filter with additional water. Dilute to volume with water.

5.1.3 Total Digestion of Urban Soil and Dust Samples

. Add 0.5g (weighed to nearest 0.1 mg) sample into a clean teflon microwave digestion vessel. Add 9 mL of concentrated HNO^3, and 4 mL of 48% HF. Cap and seal the vessels. Weigh capped vessel to the nearest .01g and place in microwave oven. A total of 12 vessels must be placed in oven. Use blanks if extra spaces must be filled. Heat at 520 Watts for 30 minutes. Let the samples cool and irradiate again at the same setting.

. Cool. Weigh capped vessels. Rinse condensate from cap and vessel walls into vessel. Transfer quantitatively to a 100 mL polypropylene volumetric flask. Dilute with reagent water to the mark.

. If not determined previously, determine percent solids as in Section 6.2.

5.1.4 Preparation of Loose Powder Samples for XRF Analysis

. Pour a 5g soil sample or 2 g dust sample into a powder cup and seal with 3.6 um mylar film.

5.2 Percent Solid Determination

Determine the percent solids in the soil or dust samples by drying a 5g aliquot at 105°C for 24 hours. Place a 5g sample (weighed to the nearest mg) in a tared aluminum weighing dish. Dry at 105°C for 24 hours. Cool in a desiccator. Reweigh to the nearest mg.

Percent solids = [100 (wet wt. - dry wt.) /wet wt.].

5.3 Sample Analysis

5.3.1 Summary

Samples were analyzed by XRF to determine Pb concentrations and homogeneity. The XRF soil audit concentrations were verified by ICP or GFFAAS. From the fifty aliquots of each soil analyzed by XRF, a subset of 7 aliquots were analyzed by ICP or GFFAAS.

5.3.2 ICPAES and GFAAS Analysis

The acid digests are analyzed by either ICPAES or GFFAAS depending on the lead concentration in the digestate. Solutions containing Pb concentrations greater than 10 times the ICPAES IDL are analyzed by ICPAES (IDL is about 50 ppb). Lower concentrations are measured by GFAAS. The instruments are calibrated and the digestates analyzed. HF resistant components are used for the total digest solutions. Quality control is described in Section 5.5.

5.3.3 XRF Analysis

Loose powder samples are analyzed by XRF. The analysis conditions for lead are; Ag secondary target, X-ray tube voltage = 35 Kev, X-ray tube current = 3 mA, atmosphere = air, counting time = 200 sec. live time. The lead L-beta peak/ Ag compton peak ratio is calculated. The lead concentration is determined from the ratio and the calibration curve (Ratio vs. Concentration). Quality control is described in Section 6.5.

5.4 Instrument Calibration

5.4.1 ICPAES and GFFAAS Analysis

The instruments are calibrated following the manufacturer's guidelines. A series of calibration standards are analyzed and a calibration line calculated using linear regression of intensity vs. standard concentration.

5.4.2 XRF Analysis

The XRF is calibrated by acquiring spectra from a series of urban soil standards with known lead concentrations. Acquisition conditions are given in Section 5.3.3. The Pb L-beta peak and Ag compton peak are measured from the spectra and the Pb LB peak/Ag Compton peak ratios are calculated. A calibration line is calculated using linear regression of ratio vs. standard concentration.

5.5 Quality Control

5.5.1 Sample Related Quality Control

The following QC are prepared for ICPEAS and GFAAS analysis

. Matrix Spike Sample - one sample per 20 will be spiked with lead prior to digestion.

. Reagent Blank Sample - One reagent blank will be prepared per group of 20 samples.

group of 20 samples. Control Sample (LCS) - One LCS sample will be prepared and analyzed per

5.5.2 Analysis Related Quality Control

The following QC samples are analyzed along with routine samples:

5.5.2.1 ICPAES and GFAAS Analyses

Initial Calibration Verification (ICV) Standard - After calibration, the ICV is analyzed. The percent recovery must be 90-110%. The ICV solution is a standard from a different source than the calibration standards.

Initial Calibration Blank (ICB) - After = analysis of the ICV, the ICB is analyzed. The measured concentration must be less than 2 times the IDL.

Interference Check Solution (ICS) - An ICS solution is analyzed after the ICV and ICB are analyzed. The ICS contains 500 ppm of major interferents (Mg, Ca, Fe, Al) and a known Pb concentration. The % recovery of Pb must be 75-125%.

Detection Limit Sample (DL) - A DL sample is analyzed after the ICS solution. The concentration of the DL solution is twice the IDL.

Continuing Calibration Verification Standard (CCV) - A CCV is analyzed every 10 sample and after the last sample. The CCV concentration is in the mid-calibration range. The % recovery must be 90-110%. If not, the instrument must be recalibrates and all samples up to the last acceptable CCV must be reanalyzed.

Continuing Calibration Blank Sample (CCB) - A CCB is analyzed after every CCV. The concentration must be less than twice the IDL.

5.5.2.2 XRF Analyses

Reference Monitor (RM) - Prior to analysis, a reference monitor sample is measured. The reference monitor intensity provides a standard measure of the x-ray flux that irradiates the samples being analyzed. The reference monitor provides a method of standardizing and/or compensating for changes in the x-ray tube flux.

High Initial Calibration Verification Standard (ICVH) - An ICVH sample is analyzed after the RM and after the last sample in a run. The concentration of Pb is at the high end of the range of interest.

Low Initial Calibration Verification Sample (ICVL) - an ICVL is analyzed after the ICVH. The concentration of Pb is at low end of the range of interest.

Section 6

Audit Sample Window Generation

6.1 Soil, Dust, and Handwipe Audit Samples

At least 50 aliquots from each soil and dust are analyzed by XRF, wet wipes are analyzed by ICPES. A biweight statistical procedure is used to calculate audit windows. The biweight approach has an advantage over the classical approach in that it identifies outliers and weights them in a manner that gives them less influence on the accuracy window.

After analysis, enter the data into the program, which then generates three estimates of prediction intervals for single future observation from a univariate normal population (Figure 7.1).

(1) Classical - Based on all data Reference: Whitmore, G.A. "Prediction Limits for a Univariate Normal Observation", The American Statistician, VOL. 40, NO. 2, may 1986, PP 141-143.

(2) W/O Outliers - Outliers Removed by Grubbs' Test Reference: Barnett, V. and Lewis, T. "Outliers in Statistical Data", 2ND ED., John Wiley and Sons, New York, 1984, P. 167.

(3) Biweight - Robust Estimation Using Biweight Procedure Reference: Kafadar, K. "A Biweight Approach to the One Sample Problem", Journal of the American Statistical Association, VOL. 77, NO. 378, PP. 416-424.

PREDICTION INTERVAL SUMMARY REPORT

DATA FILE:

TYPE OF ESTIMATOR	# OF DATA	SAMPLE MEAN	SAMPLE STD DEV	95% INTERVAL LOWER	95% INTERVAL UPPER	99% INTERVAL LOWER	99% INTERVAL UPPER
CLASSICAL	50	927.1480	41.4193	843.0907	1011.2050	814.9757	1039.3200
W/O OUTLIERS	50	927.1480	41.4193	843.0907	1011.2050	814.9757	1039.3200
BIWEIGHT	50	923.4212	43.1311	835.8742	1010.9680	806.5920	1040.2500

FIGURE 7.1 Example of Audit Sample Prediction Interval Summary Report

The program also performs the following;

1) Tests for normality using the Kolmogorov-Smirnov and the Anderson-Darling statistic
2) Presents a histogram of the data
3) Lists the data and the biweight weighting factors

The information is sent to the project QA manger for review before audit samples are sent to laboratories for inclusion in sample batches.

Section 7

Safety

7.1 Laboratory Safety

Environmental samples invariably involve undesirable if not hazardous materials and must be handled with respect. Special equipment and facilities are provided to prevent cross contamination of space and other samples. Special training in the use of the above may be needed (Section 1.3.3).

Personnel engaged in handling hazardous samples undergo initial and periodic medical examinations to insure that they have not contracted medical problems related to the materials with which they are involved.

7.1.1 Equipment and Supplies

Dust mask
Full face respirator
Laboratory coat
PVC gloves
Tyvek suits

7.1.2 Preparation Laboratory

Dedicated equipment and special facilities are used during sample preparation. The LESC warehouse has two rooms dedicated to sample drying, sieving, homogenization, riffle splitting, and sample aliquoting. During each of the above procedures the following equipment is required: full face respirator, tyvek suit, and PVC gloves.

7.1.3 Characterization Laboratory

The analytical laboratory requires personnel to: 1) work in a laminar hood and wear a dust mask while splitting samples, 2) wear PVC gloves while handling samples.

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