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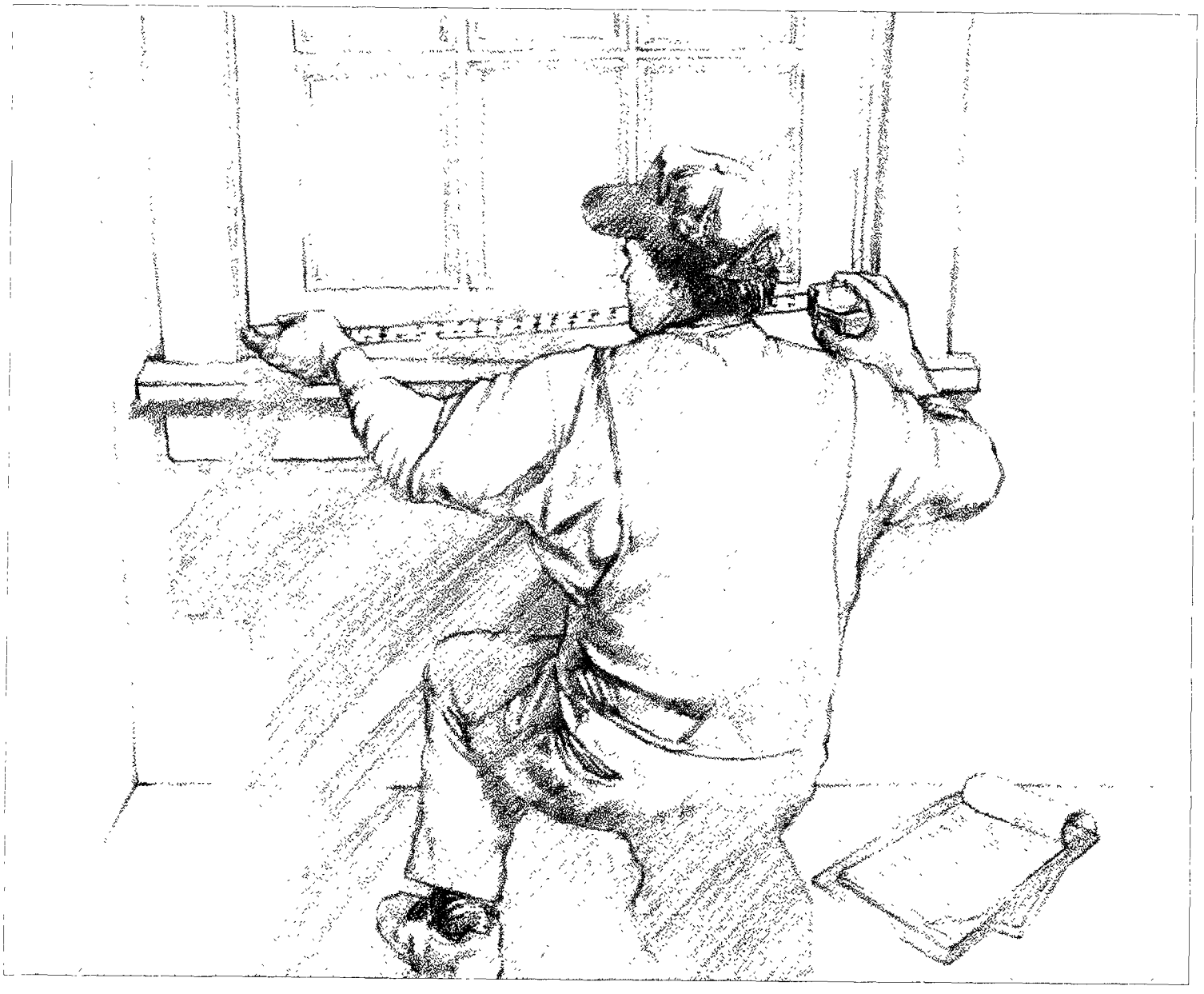
COMPREHENSIVE ABATEMENT PERFORMANCE PILOT STUDY

VOLUME I: RESULTS OF LEAD DATA ANALYSIS



February 1995

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FINAL REPORT

for the

COMPREHENSIVE ABATEMENT PERFORMANCE PILOT STUDY

VOLUME I: RESULTS OF LEAD DATA ANALYSES

Technical Programs Branch
Chemical Management Division
Office of Pollution Prevention and Toxics
Office of Prevention, Pesticides, and Toxic Substances
U.S. Environmental Protection Agency
Washington, D.C. 20460

DISCLAIMER

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This study was funded and managed by the U.S. Environmental Protection Agency. The study was conducted collaboratively by two organizations under contract to the Environmental Protection Agency, Battelle Memorial Institute and Midwest Research Institute. Each organization's responsibilities are listed below.

Battelle Memorial Institute (Battelle)

Battelle was responsible for the design of the study, for producing the design documentation and the Quality Assurance Project Plan, for developing training for the field teams, for recruiting cooperators for the study, for providing the team leader for the field team, for data management of combined study data, for auditing the study data, for conducting the statistical analysis of the data, and for writing the final report.

Midwest Research Institute (MRI)

Midwest Research Institute was responsible for participating in the planning for the study, for writing certain chapters and appendices in the Quality Assurance Project Plan, for developing training for and training the field teams, for providing the technicians who collected the field samples, for auditing the field teams, for conducting the laboratory analysis of the field samples, for managing the data associated with the field samples, for auditing the laboratory results, and for contributing sections of the final report.

U.S. Environmental Protection Agency (EPA)

The Environmental Protection Agency was responsible for managing the study, for reviewing the design and the Quality Assurance Project Plan, for assessing the performance of the recruiters and the field teams, for reviewing the final report, and for arranging the peer review of the design and the final report. The EPA Work Assignment Managers were Benjamin Lim and John Schwemberger. The EPA Project Officers were Gary Grindstaff, Phil Robinson, Joseph Breen, and Janet Remmers.

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EXECUTIVE SUMMARY

This report presents the results from the pilot study that preceded the Comprehensive Abatement Performance Study. The goal of the Comprehensive Performance Study was to assess the long-term impact of lead-based paint abatement. The pilot study was conducted to test the sampling and analysis protocols that were intended for the full study. These protocols called for determining the levels of lead in dust and soil samples collected at residential units. The pilot study was conducted at six houses, and all steps that were planned for the full study were included in the pilot.

The major finding of the pilot was the difference between wipe and vacuum methods for collecting dust. The choice of method had a noticeable impact on the level of lead associated with the collected sample.

All other sampling and analysis aspects of the pilot study were completed successfully. In particular, an inter-laboratory comparison of dust and soil samples indicated no systematic difference in lead levels between the two laboratories. In addition, intra-laboratory comparisons of sample results by inductively coupled plasma-atomic absorption spectrometry (ICP) and the more sensitive graphite furnace atomic absorption spectrometry (GFAA) indicated good agreement within the common domain of instrument detection limits. The pilot study suggested that GFAA analysis would not be necessary for the full study, if sufficient amount of sample was collected for ICP analysis.

Other important findings from the pilot study were results related to variance components. Estimates of random house-to-house, room-to-room, and side-by-side sample variability were obtained for most of the sample types in the study. These estimates were used for determining the number of houses and number of samples per house for the full study.

1.0 INTRODUCTION AND SUMMARY

This report presents final results from the Comprehensive Abatement Performance Pilot Study, conducted in 1991 by Battelle Memorial Institute and Midwest Research Institute (MRI) for the U.S. Environmental Protection Agency's Office of Pollution Prevention and Toxics (OPPT). The objectives, approach, and design of this study, although briefly summarized here, are completely described in the "Quality Assurance Project Plan for the Abatement Performance Pilot Study" (Battelle and MRI, 1991).

1.1 STUDY DESIGN

Under an interagency Memorandum of Understanding, the Environmental Protection Agency (EPA) is provided technical support to the Department of Housing and Urban Development (HUD) with respect to the abatement of lead-based paint hazards in public and private housing. As part of its lead-based paint research activities, HUD carried out a Demonstration Program in ten cities to assess the costs and short-term efficacy of alternative methods of lead-based paint abatement. A variety of abatement methods were tested in approximately 120 multi-family public housing units in three cities -- Omaha, Cambridge, and Albany -- and in 172 single-family housing units in the FHA inventory in seven metropolitan areas -- Baltimore, Birmingham, Denver, Indianapolis, Seattle, Tacoma, and Washington. The FHA portion of the Demonstration has now been completed, and OPPT is planning to conduct a follow-up study (referred to as the Comprehensive Abatement Performance (CAP) Study) of these housing units with the following objectives:

1. Compare abatement methods or combination of methods relative to performance over time. Assess whether there are differences in performance.

2. Characterize levels of lead in household dust and exterior soil over time for HUD Demonstration and control homes.

3. Investigate the relationship between lead in household dust and lead from other sources, in particular,

exterior soil, rugs, upholstered furniture, and air ducts.

The CAP Study is one of two major field studies currently being conducted by OPPT. While the CAP Study will examine relatively high-cost lead-based paint abatement alternatives tested by HUD in their Demonstration Program, OPPT will also examine lower-cost repair and maintenance methods for dealing with lead-based paint and associated lead contaminated dust (Battelle and Kennedy Krieger Institute, 1992). Like the CAP Study, the first step in the Repair and Maintenance Study was to conduct a pilot program to test the sampling and analysis protocols planned (Battelle and Kennedy Krieger Institute, 1992). This document describes the results from the CAP Pilot Study.

The Pilot Study was intended to investigate the field, laboratory, and statistical analysis procedures planned for the full CAP Study. In particular, the objectives of the Pilot Study were as follows:

- Test the sampling and analysis protocols;
- Evaluate the questionnaires and other field data forms;
- Provide variance estimates to help determine the final design of the full CAP Study;
- Assess the performance (i.e., sensitivity, accuracy, and precision) of the sampling and analysis methods;
- Compare analytical results for the MRI (primary) and Kennedy Krieger Institute (secondary) laboratories; and
- Compare the vacuum/total digestion protocol planned for the full CAP Study with the wipe/ashing protocol previously used in the HUD Demonstration Study.

The first five objectives are all necessary precursors that will help to refine the study design and methods for the full CAP Study. The final objective is intended to further enhance our ability to assess the HUD abatement methods by providing a bridge

between earlier dust measurements from the HUD Demonstration obtained with a wipe sampling method, and our current dust measurements obtained with vacuum sampling.

Our data analysis approach for the Pilot Study focused on three statistical study objectives: variance component estimation, comparison of vacuum and wipe protocols, and assessment of the performance of the sampling and analysis methods. Because this study was a pilot, we did not state our Data Quality Objective (DQO) in terms of a specific statistical hypothesis to be tested for the full CAP Study. Instead, our objective for the Pilot was to collect sufficient information to allow us to estimate variance components that are key to the subsequent design of the full study. Specifically, our DQO was to collect a minimally sufficient amount of data to allow estimation of the following important sources of variation that may be found in measurements of lead in interior dust:

- Variations between houses abated with different methods;
- Variations between houses abated with the same method;
- Variations between rooms abated with the same method within a house;
- Variations between sampling locations and abated components within a room; and
- Variations from non-paint sources.

In order to assess these sources of variation, our DQO was to successfully collect and measure lead levels in a nearly complete set (i.e., 95% data completeness) of 258 dust and soil samples.

The field sampling design for the Pilot Study included samples to address the variance component estimation and comparison of vacuum and wipe sampling. All of these samples are shown in Table 1-1 and Figure 1-1. A summary of the most

important design considerations for the Pilot Study is contained in the following points:

- To assess variability associated with different housing units and different abatement methods, six housing units in Denver were sampled. Two units were selected from those predominantly abated by encapsulation/enclosure methods, two units were selected from those predominantly abated by removal methods, and two units were selected from those control houses already tested by HUD and found relatively free of lead-based paint.
- To assess variability from different sources within a house, a total of 18 regular vacuum dust samples was collected in each house (Table 1-1). Sampling was performed in two different rooms of each house. When selecting two abated rooms, rooms were chosen that were both predominantly abated by the same method used for the house in general.
- Soil samples were collected in the Pilot Study to help assess potential non-paint sources of lead contamination in interior dust. For two sides of each house, soil samples were collected both at the foundation of the house and at the property boundary. In addition, soil samples were collected immediately outside the front and rear entryways.
- For each of the six housing units included in the Pilot Study, one room was selected for comparative vacuum and wipe sampling. This room was a third room added to the two sampled rooms discussed above. Within each room selected for comparative sampling, a randomized side-by-side arrangement of paired vacuum samples and paired wipe samples was collected from the floor. In addition, paired samples were collected on both the stool and channel of the two windows in the room. The window stool was defined as the horizontal board inside the window -- often called the window sill. The window channel was defined as the surface below the window sash and inside the screen and/or storm window. One window was typically designated for either paired vacuum or paired wipe samples; while to other window was designated for paired vacuum-wipe sampling (see KIT in Figure 1-1).

Table 1-1. Summary of Environmental Sampling Planned for the CAP Study

Sample Type	Number of Samples Planned	
	Samples Per Unit	Total (6 Units)
Regular Samples		
1. Vacuum Dust		
a. Floor (2 per room)	4	24
b. Window Stool (2 per room)	4	24
c. Window Channel (2 per room)	4	24
d. Rug/Upholstery (1 per room)	2	12
e. Air Ducts (1 per room)	2	12
f. Entryway (Front & Back)	2	12
2. Soil Cores		
a. Near Foundation	2	12
b. Property Boundary	2	12
c. Entryway (Front & Back)	2	12
Vacuum vs. Wipe Samples		
3. Vacuum Dust		
a. Floor	2	12
b. Window Stool	2	12
c. Window Channel	2	12
4. Wipe Dust		
a. Floor	2	12
b. Window Stool	2	12
c. Window Channel	2	12
Quality Control Samples		
5. Interlaboratory Comparison		
a. Vacuum Floor Dust	1	6
b. Soil Cores	1	6
	1	6
6. Field Blanks		
a. Vacuum Dust	1	6
b. Wipe Dust	1	6
c. Soil Core Liners	1	6
7. Side-by-Side Samples		
a. Vacuum Floor Dust	1	6
b. Soil Cores	1	6
Total	43	258

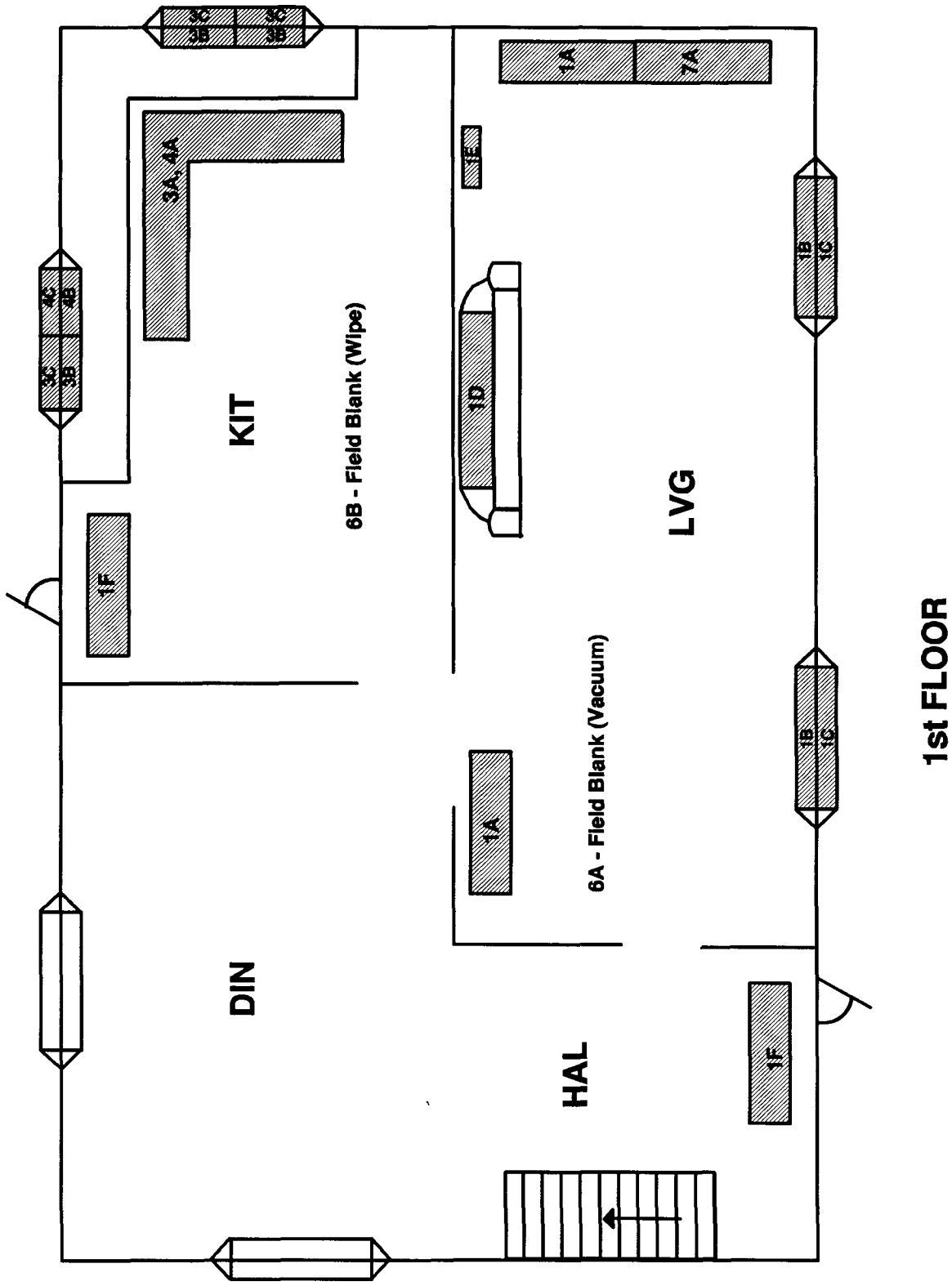

Figure 1-1. Example of Sampling Locations Within a Unit, with Sample Type Identified for Each Location as Reflected in Table 1-1.

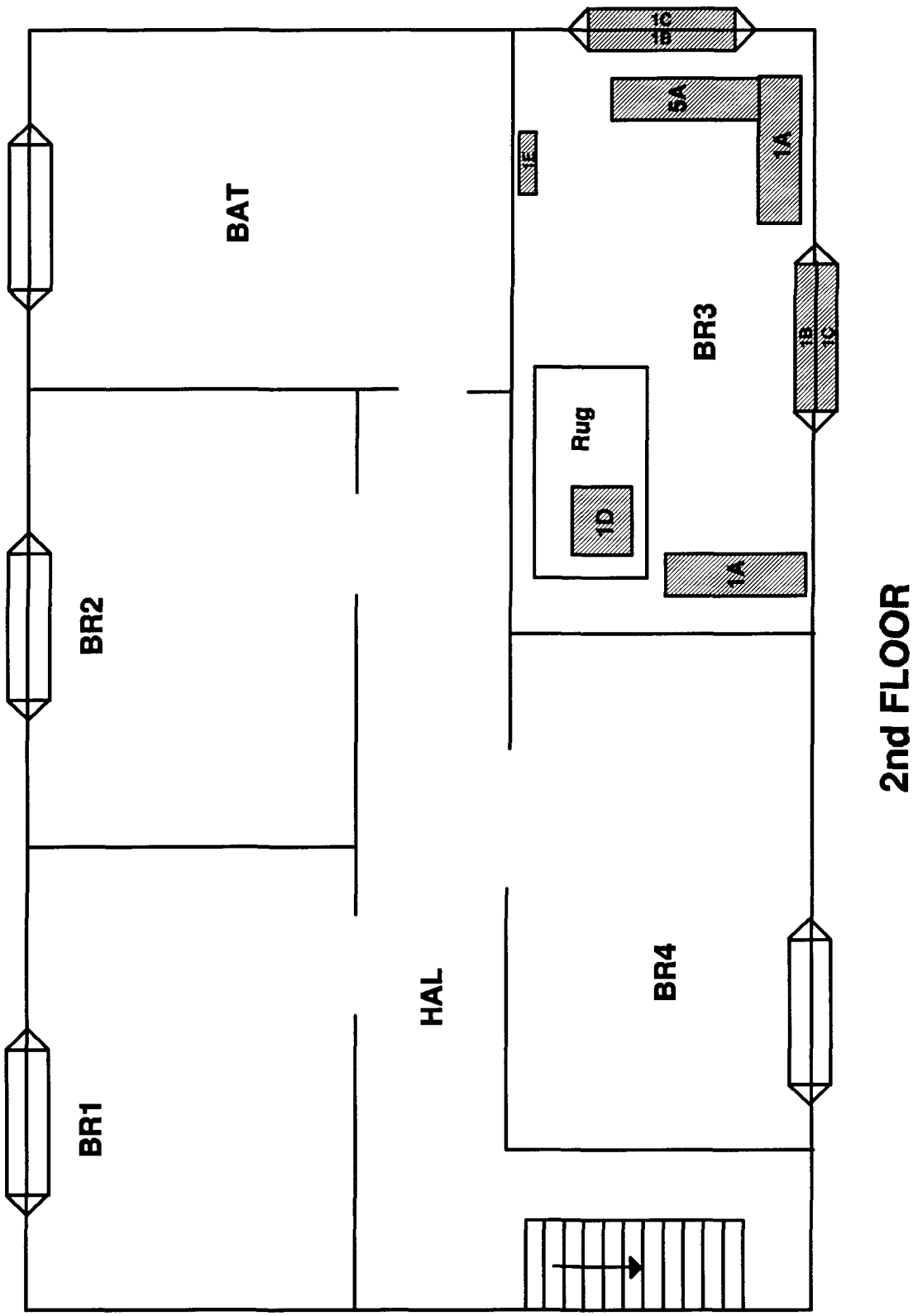

Figure 1-1. (Continued)

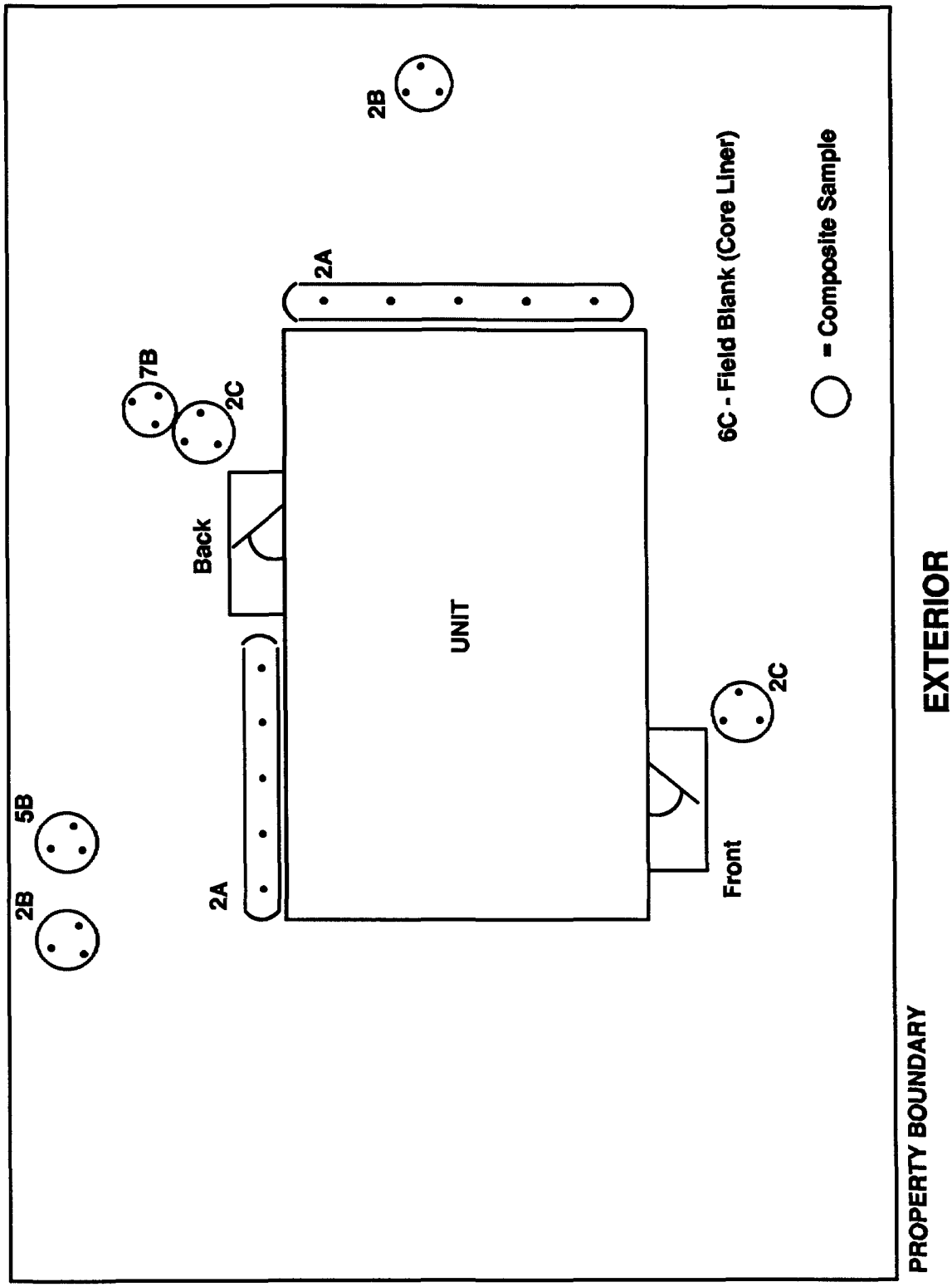

Figure 1-1. (Continued)

- Seven quality control samples (i.e., field side-by-sides, field blanks, and interlaboratory comparison samples) were collected to assess variability introduced by the sampling method, sample handling, and laboratory effects.

It should be emphasized here that control houses are houses which were classified as not needing abatement because they were found by HUD as being relatively free of lead-based paint. Thus, this study does not assess lead levels before and after abatement. Instead, this report provides a comparison of lead levels in abated houses to those in houses not needing abatement.

In addition, during sampling it was discovered that one control house (Unit 19) was undergoing partial renovation, and one encapsulation/enclosure house (Unit 51) was undergoing full renovation. In order to evaluate the impact of renovation and also control for its effect when estimating the abatement effect, a renovation measure was included in the statistical models as a covariate (see Section 4.2).

1.2 SUMMARY OF RESULTS

This report, which is organized into two volumes, provides a complete description of the CAP Pilot Study results. Volume I summarizes the findings from a thorough statistical analysis of the lead measurements collected for interior dust and exterior soil samples. Volume II describes the results of a multivariate statistical analysis of lead, cadmium, chromium, titanium, and zinc measurements made on those same samples.

Section 2.0 of this Volume I presents findings concerning recruitment, risk communication, and experiences in the field. Next, in Section 3.0, results of the data management activities are provided. This section completely describes all of the data collected in the Pilot Study, and summarizes our suggestions for enhancements to the data management system for the full CAP Study. Section 4.0 presents the findings from the statistical analysis of the Pilot Study data. In keeping with the Pilot

Study design, the analysis considered a wide variety of topics, including estimation of renovation and abatement effects, estimation of variance components, comparison between lead levels in different sampling media (e.g., soil and dust) and at different sampling locations (e.g., floors and window stools), comparison of lead levels measured by the vacuum and wipe sampling protocols, and comparison of CAP Pilot sampling results with earlier results from the HUD Demonstration study. Finally, Section 5.0 presents results of the statistical evaluation of various field and laboratory quality control data collected in the study.

The results of the CAP Pilot Study can be organized into three categories: findings pertaining to the three CAP Study objectives listed in Section 1.1, those pertaining to other important topics, including comparisons between vacuum and wipe dust sampling protocols, and conclusions concerning operational aspects of the study, such as recruitment, risk communication, field data collection, and data management. The major findings of the Pilot Study which pertain to the three primary objectives of the CAP Study are as follows:

1. Levels of Lead in Dust and Soil -- Environmental samples for six houses in Denver were analyzed for lead levels in two media (dust and soil) and at several different sampling locations (e.g., floors, windows, foundation soil, boundary soil). For dust samples, geometric average lead concentrations ranged from a high of 1440 $\mu g/g$ for window channel samples, to a low of 174 $\mu g/g$ for bed, rug, and upholstery samples. For soil samples, geometric average lead concentrations ranged from 217 $\mu g/g$ for foundation samples, to 121 $\mu g/g$ for boundary samples.

2. Compare Abatement Methods -- Two of six houses sampled were unabated, uncontaminated control houses; two houses were abated by encapsulation/enclosure methods; and two houses were abated by removal methods. In addition, two of the six houses were undergoing full or partial renovation at the time of sampling.

a. Units under renovation had average dust lead loadings ($\mu g/ft^2$) on floors and window stools many times higher than those in unrenovated control units.

b. Floor lead loadings ($\mu g/ft^2$) in abated rooms were comparable to those in control units; however, floor lead loadings in unabated rooms of abated units were many times higher than those in abated rooms of the same units.

3. Relationships Between Lead in Different Media and Locations -- Lead levels were compared for six different interior locations (i.e., floors, entryways, window channels, window stools, air ducts, and bed/rug/upholstery) and three different exterior locations (i.e., entryways, foundation, and property boundary).

   a. Soil lead concentrations ($\mu g/g$) were generally well correlated among the three exterior sampling locations. The soil lead concentrations were also often correlated with interior dust lead concentrations.

   b. Average lead concentrations in boundary soil samples (121 $\mu g/g$) were significantly lower than those in entryway soil samples (196 $\mu g/g$) and foundation soil samples (217 $\mu g/g$) suggesting that the housing unit may contain additional sources of lead (e.g., lead-based paint) which contaminate nearby soil beyond the contamination introduced by other area sources, such as fallout from automotive or other combustion processes.

Other major findings from the Pilot Study which are not necessarily directly related to the three primary objectives of the CAP Study are:

4. Vacuum Versus Wipe Sampling -- A total of 64 vacuum and wipe samples were collected in the Pilot Study for comparative analysis. The wipe sampling procedure produced lead loadings ($\mu g/ft^2$) for floor samples that were approximately 5 times higher, with a 95% confidence interval of 2 to 15, and lead loadings for window stool samples that were approximately 5 times higher, with a 95% confidence interval of 3 to 8, than those by the vacuum sampling procedure.

5. CAP Pilot Data Versus HUD Demonstration Data -- CAP Pilot soil concentration data were highly correlated with HUD Demonstration soil concentration data, although the HUD Demonstration data were moderately higher (approximately 25%) than the CAP Pilot data. Both the CAP Pilot and HUD Demonstration dust and soil lead data appear to be only weakly correlated with the HUD Demonstration XRF/AAS measurements of lead in paint.

6. Interlaboratory Comparison -- A total of 68 vacuum dust and soil samples were collected and randomly assigned to the primary and secondary laboratories for comparative analysis. No systematic differences were found in the lead concentrations reported by the two laboratories for matching pairs of samples.

Major findings from the Pilot Study concerning operational aspects are as follows:

7. Recruitment -- Most occupants who were contacted about the Pilot Study were enthusiastic about participating. Telephone calls in combination with next-day delivery mailings provided an effective means of contacting these individuals. Also, due to the observed magnitude of the renovation effects on lead levels, future studies should make an effort to control this factor in the selection of homes. At the very minimum, renovation should be controlled for in any data analysis.

8. Risk Communication -- Recruitment mailings and written reports of the Pilot Study results provided effective means of communicating to residents the potential health risks of lead exposure.

9 Field Data Collection -- The sampling protocols for dust and soil performed well in the field, although the Pilot Study results indicated the need for a more efficient vacuum sampling device. Sampling required 5 to 7 hours of work at each pilot house; but with the reduced number of samples and modified dust sampling device planned for the full study, this time is expected to be reduced to about 1½ to 3 hours.

10. Data Management -- Use of separate field and laboratory sample IDs proved very helpful for effectively tracking samples. Detailed instructions for completing field data collection forms, formally capturing laboratory

analysis comments, and frequent meetings between field, laboratory, data management, and statistical analysis personnel are recommended for the full CAP Study to more effectively communicate important information to the entire project team.

2.0 RECRUITMENT, RISK COMMUNICATION, AND FIELD EXPERIENCES

This section presents a summary of recruitment, risk communication, and field sampling experiences from the Pilot Study.

2.1 RECRUITMENT EXPERIENCES

In order to meet the goals of recruiting a minimum of six occupied units for participation in the Pilot Study, 20 houses were targeted for recruitment. Owners or occupants were contacted by telephone or next-day delivery letter to explain the purpose of the study, why their home was selected for this study, and to solicit their cooperation in allowing a team of investigators visit their home to collect dust and soil samples. A script was used for recruitment. Recruitment letters and a brochure were also mailed to residents.

A high level of interest and a willingness to participate in the study was displayed by occupants reached by telephone. However, reaching people by telephone required late-night efforts because of the time difference between the East Coast and Denver.

Next-day delivery letters were found to be appropriate for recruiting residents of investor-owned units. Because the names of these occupants were not known, use of next-day delivery conveyed an importance that would not have been conveyed had regular mail been used. Next-day delivery service also proved to be an inexpensive method for determining if the unit was unoccupied. Thirteen of the original 20 houses were unoccupied or unreachable. In addition, one resident (removal house) refused delivery of the recruitment package claiming they did not know Battelle. However, because they did not accept delivery, they did not know what they were refusing, and therefore this refusal probably had no biasing effect on the study results.

Pilot testing of the telephone interview identified questions that needed modification or elimination. Pilot testing of the recruitment script indicated the appropriateness of the script.

2.2 RISK COMMUNICATION

Risk communication efforts employed in the Pilot Study consisted of two components: (1) risk communication associated with recruitment into the study, and (2) risk communication resulting from conduct of the study. During the recruitment phase of the project, all subjects were solicited by telephone for participation in the study. This telephone solicitation was the first information received by owner-occupants, while residents of investor-owned property were solicited by telephone after they responded to the next-day delivery letter addressed to "resident". The telephone solicitation was done according to a pre-designed script, one of whose purposes was to describe potential hazards associated with lead exposure.

All participating residents also received mailings which described the potential hazards associated with lead exposure. The mailings comprised the second risk communication effort for owner-occupants and the first risk communication effort for residents of investor-owner units. Two separate letters were sent in these mailings. Each letter described the health hazards associated with lead exposure. Along with these letters a brochure was enclosed describing the study and the hazards associated with lead exposure.

Letters and reports of the visual inspection and laboratory analysis were sent to the Pilot Study participants informing them of the results of the data collection effort. By highlighting results that indicate potential "hot spots" of lead, areas in need of better housekeeping were brought to their attention. Study participants were referred to their local health department for more information.

2.3 SAMPLE COLLECTION, PREPARATION AND ANALYSIS PROCEDURES

This section summarizes the collection and analysis methods used for the vacuum dust, wipe dust, and soil samples.

2.3.1 Sample Collection Procedures

Vacuum samples of surface dust were collected from floors, window stools and channels, upholstered furniture, rugs and air ducts. The vacuum sampling device consisted of a Teflon pick-up nozzle mounted on a pre-weighed 37-mm, mixed-cellulose ester filter cassette (0.8-μm pore size). This device was coupled to a rotary-vane vacuum with Tygon tubing. The area vacuumed was nominally 4-ft^2 for floor samples, 1-ft^2 for upholstery and rug samples, and the entire accessible surface for window stools, channels, and air ducts. Vacuuming time for each square foot was nominally two minutes.

Wipe samples of surface dust were collected from uncarpeted floors, window stools and window channels. The surfaces were wiped with standard, name-brand wipes, using a sampling method used in the HUD Demonstration. The area wiped was 1-ft^2 for floor samples and the entire accessible surface for window stool and channel samples.

Soil samples were collected with a 1-inch internal diameter soil recovery probe and a 12-inch stainless steel core sampler with cross-bar handle and hammer attachments. Each sample was a composite consisting of three to five soil cores, each 0.5 inches in depth as measured from the top of the soil surface.

2.3.2 Sample Preparation and Chemical Analysis

Dust vacuum samples were analyzed using a modified version of EPA SW-846 Method 3050, followed by EPA SW-846 Method 6010, Inductively Coupled Plasma (ICP). Lead levels in sample digests which fell below ten times the ICP instrumental detection limit were reanalyzed by EPA SW-846 Method 7421, Graphic Furnace Atomic Absorption Spectrometry (GFAA). Gravimetric analysis of the sampling cassettes was performed in a humidity-temperature stabilized environment prior to field collection and prior to digestion in order to measure the amount of dust collected and calculate results on a concentration basis.

Dust wipe samples were first prepared using an ashing procedure followed by digestion using a modified version of NIOSH 7082, and then analyzed by Flame AA (SW-846 Method 7000 Series).

Soil samples were first prepared using a drying and homogenization step followed by digestion using a modified version of EPA SW-846 Method 3050, and then analyzed using a modified version of EPA SW-846 Method 6010, ICP.

2.4 FIELD EXPERIENCES

In general, the field sampling protocols for dust and soil performed well in the field. Two issues that warrant special mention are the time required to sample at each house, and the efficiency of the vacuum nozzle for collecting interior dust samples.

Initially, it was estimated that sampling at each house would take from two to three hours. However, the time actually required in the Pilot Study was from five to seven hours for a single house. This was with a field crew of three people collecting between 33 and 38 samples per house. Factors contributing to the time required included cleaning of the sampling equipment between each sample, the time required to collect vacuum dust samples, and the initial learning curve for field sample collection.

The time required to sample interior dust is inversely proportional to the efficiency of the sampling protocol. During the training period for the Pilot Study, it appeared that the vacuum protocol selected, and in particular the sampling device used, was inefficient at collecting all of the dust from several common surfaces (e.g., floors, window channels). Specifically, the sampler appeared to be incapable of collecting all the dust that was visibly present in a number of cases. Subsequent to the pilot field work, a new vacuum sampler was developed for the full study.

3.0 DATA MANAGEMENT AND PRELIMINARY ANALYSES

This section presents a summary of the data management and data verification activities, as well as preliminary data analysis leading up to the full statistical analysis.

3.1 DATA MANAGEMENT

There were several sources of data in the Pilot Study, including the recruitment, field data collection, and laboratory analysis activities. The individual data sources are described below:

- Cover Sheet - Contains unit information such as city, address, categorized abatement method, name of unit occupant, owner, and members of the sampling team. Each record corresponds to a different housing unit.

- Interview - Contains interview questionnaire information regarding demographics, habits, pets, hobbies, etc. of the occupants. Each record corresponds to a different housing unit.

- Visual Observation Form - Contains information on the physical surface condition of abated components. Three interior rooms as well as the exterior of each house were observed in the Pilot Study. Each record corresponds to a different abated component, and the current condition of these observed components is designated.

- Field Sample Log - Contains information used to identify the planned sampling location, sample medium, sample type, etc. and the link between field and laboratory sample IDs. Each record corresponds to a planned and/or collected field sample.

- Field Analytical Results - Contains laboratory analysis results for dust and soil samples. Each record corresponds to a collected and analyzed field sample.

- Quality Control Analytical Results - Contains quality control results for each laboratory batch. Each record corresponds to a reported calibration or quality control sample.

Data from the Cover Sheet, Interview, Visual Observation Form, Field Sample Log, and Analytical Results were processed using the procedures stated in Section 5.0 of the Quality Assurance Project Plan (QAPjP) for the Pilot Study (Battelle and MRI, 1991). These data are organized into SAS datasets.

3.1.1 Sample Collection

A summary of the field samples planned, field samples collected, analytical data received, and analytical data used in the statistical analysis for each unit is provided in Table 3-1. For completeness, Table 3-1 also summarizes all of the laboratory QC, trip blank and laboratory comparison data received from the primary and secondary laboratories. A further breakdown of this information by sample type and medium is provided in Table 3-2.

There were a total of seven housing units recruited for the Pilot Study, six participating and one alternate. There were 258 samples planned; 228 were actually collected, and 225 analytical results were reported by the primary and secondary laboratories.

A total of 19 extra (i.e., unplanned) field samples was collected:

- three small nozzle field blanks,
- one small nozzle air duct,
- two replacement samples for samples mistakenly collected with the wrong name-brand baby wipes,
- one sample taken to replace a sample with an excessive amount of saw dust, and
- twelve soil samples split to create 12 extra samples for interlaboratory comparison.

Among the planned samples, 72 (36 pairs) were to be collected for the vacuum versus wipe comparison. All twelve of

Table 3-1. Unit Summary of Sample Collection

Housing Unit ID	Abatement Method	Renovation Performed	Planned Samples	Planned Samples Collected	Extra Samples Collected	Analytical Results Received	Analytical Results Used in Analysis
33	Control	None	43	34	3	37	37
43	Removal	None	43	38	2	40	40
17	Removal	None	43	34	2	36	36
19	Control	Partial	43	33	5	35(a)	33(b)
80	Encaps/Enclose	None	43	36	4	40	40
51	Encaps/Enclose	Full	43	34	3	37	36(b)
Sub-Total			258	209	19	225	222(b)
ICPS(c) for Reported GFAA						33	33
Lab QC Samples						383	383
Baltimore Lab comparison						38	38
Trip Blanks						53	53
Total			258	209	19(b)	732	729(b)

(a) Three collected samples do not have data reported: two collected with wrong name-brand baby wipes, one sample spilled in laboratory. Two samples were mistakenly collected into the same cassette (03 and 09). Therefore, only one analytical result was received but is counted as two results.

(b) Three samples were deleted from the analysis. Unit 19, sample #03 and #09 as described above and unit 51, sample #12 because cassette was filled with sawdust after only one square foot had been sampled.

(c) Inductively coupled plasma atomic emission spectroscopy.

Table 3-2. Summary of Planned Samples, Collected Samples and analytical results used in analysis

Sample Type and Medium	Planned Samples to be Collected	Planned Samples Collected	Extra Samples Collected	Analytical Results Reported	Analytical Results Used in Data Analysis
Regular					
1. Vacuum Dust					
a. Floor	24	24		24[b]	22[c]
b. Window Stool	24	15		15	15
c. Window Channel	24	8		8	8
d. Upholstery/Carpet	12	8		8	8
e. Air Duct	12	10	1	11[b]	10[c]
f. Entry Way	12	12		12	12
2. Soil Core					
a. Foundation	12	12	4[a]	16	16
b. Boundary	12	12	2[a]	14	14
c. Entry Way	12	12		12	12
Vacuum vs. Wipe					
3. Vacuum Dust					
a. Floor	12	12		12	12
b. Window Stool	12	10		10	10
c. Window Channel	12	3		3	3
4. Wipe Dust					
a. Floor	12	12	1	12	12
b. Window Stool	12	12		12	12
c. Window Channel	12	6		6	6
Quality Control					
5. Interlab Comparison					
a. Vacuum Dust (Flr)	6	6		6	6
b. Soil Core	6	6	6[a]	12	12
6. Field Blanks					
a. Vacuum Dust	6	6	3	9	9
b. Wipe Dust	6	6	1	6	6
c. Soil Core Liners	6	6		6	6
7. Side-by-side					
a. Vacuum Floor Dust	6	5	1	5	5
b. Soil Core	6	6		6	6
Total	258	209	19	225	222[c]

(a) A total of 12 soil samples were split, and half of each sample was sent to the primary laboratory and the secondary laboratory for chemical analysis.

(b) Two samples were collected into the same cassette (19-03 floor and 19-09 air duct) and only one analytical result was received but counted as two results.

(c) Samples 51-12, 19-03, and 19-09 were excluded from the analysis.

the planned vacuum-wipe floor sample pairs were collected. Among the window stool samples, all 3 of the planned wipe-wipe pairs were collected, 2 of the 3 planned vacuum-vacuum pairs were collected, and all 6 of the vacuum-wipe pairs were collected. Among the window channel samples, 2 of the 3 planned wipe-wipe pairs were collected, 1 of the 3 planned vacuum-vacuum pairs was collected, and 1 of the 6 planned vacuum-wipe pairs was collected. In addition, 1 window channel wipe sample was collected, but the corresponding vacuum sample was not.

3.1.2 Analytical Data Transfer

Ten batches of data were received from the primary laboratory: four batches of vacuum cassette dust data, four batches of wipe dust data, and two batches of soil data. The secondary laboratory provided one batch of laboratory comparison data.

The primary laboratory also reported data for a total of 53 trip blanks: one regular batch of 52 trip blank data, and one trip blank that was reported with a batch of vacuum cassette data. There were two batches of ICP results reported, including 29 data for regular samples and 4 quality control results. These ICP data were used to compare with GFAA results generated for the same samples.

The secondary laboratory provided 18 laboratory comparison data for samples collected in Denver that are part of the subtotal in Table 3-1.

3.1.3 Sampling and Analysis Deviations

A sampling and analysis deviation was considered to have occurred if any of the following criteria was met:

- a sample was not collected in the field
- more than 43 planned samples were collected at any one house

- a collected sample's analytical results were not reported, or
- a sample was collected with the wrong protocol.

The last two criteria are pertinent to the analysis and are further discussed below.

There were three samples collected in unit 19 for which analytical results were not reported: two samples collected with the wrong brand of baby wipes[1], and one sample spilled in the laboratory. There were also three sampling protocol violations. In unit 19, two planned samples were collected into the same cassette; thus, only one analytical result could be reported for two different planned samples. In unit 51, the analytical results were invalidated for a regular cassette that was filled with sawdust after sampling only one square foot. These three samples were excluded from all of the statistical analyses discussed in Section 4.0 of this report.

3.1.4 Experiences From The Pilot Study

The field preparation, forms processing, data transfer, and data tracking went well for the Pilot Study. However, the following observations will be addressed to make improvements to the data management system:

- Use of a separate field ID and laboratory ID proved to very helpful, for example it helped determine that a trip blank was reported as a regular sample.
- Development of a more detailed set of instructions for completing field data forms is needed since more than one sampling team is usually collecting samples.
- Scheduling a meeting of the field and data management personnel after returning from the field was useful to alert everyone of unusual occurrences in the field.

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[1] It was discovered that baseline measures of lead vary across brands. For comparability, it was decided to use the same brand of wipes as was used in the HUD Demonstration.

- Development of a system to formally capture laboratory comments about individual sample results was useful in the subsequent statistical analysis.

3.2 OUTLIER ANALYSIS

This section begins the presentation of results from statistical analysis of the CAP Pilot study data. A complete listing of these data is provided in the Appendix. The data are sorted by unit ID, the room or yard in which the sample was collected, and the component sampled. The sample location variable is a general location measure (e.g., within a room) which facilitates the pairing of side-by-side samples for later analysis. Only two field samples, other than field blanks, had levels of lead below the detection limit. These samples, floor wipe measures in unit 33, were set at the detection limit of 13.77 $\mu g/ft^2$.

In this section are presented the outlier analysis statistical approach, the outliers identified, and the findings of the laboratory review of the outlier data.

3.2.1 Outlier Analysis Approach

Formal statistical outlier tests were performed on the natural logarithms of the lead concentration data and lead loading data. Data were placed into groups of comparable values, and a maximum absolute studentized residual procedure was used to identify potential outliers. When a potential outlier was identified, that value was excluded from the group, and the outlier test was performed again. This procedure was repeated until no additional outliers were detected. After all potential outliers were identified, a list of these samples was sent to the laboratory for rechecking. The following sections further explain this procedure.

3.2.2 Data Groups

The following homogeneous groups of data were identified for each indicated sample type:

- Vacuum cassette dust samples (7 groups): air duct, upholstery (including bed coverings and throw rugs), interior entryway, floor (excluding entryway), window stool, window channel, and floor (including entryway);
- Wipe dust samples (3 groups): floor, window stool, and window channel;
- Soil Samples (4 groups): boundary, foundation, exterior entryway, and all exterior samples combined.

Initially, data for all six units in the Pilot Study were combined for the outlier tests in these groups. Subsequent outlier tests were also performed by segregating the data in each group by abatement method and by housing unit, but only if there were at least three samples in the resulting subgroups.

3.2.3. The Outlier Test

The SAS procedure GLM (SAS PC, ver. 6.04) was used to compute the studentized residual for each data value in a group by fitting a "constant" model (i.e., mean value plus error term) to the log-transformed data in each group. The absolute values of the studentized residuals were then compared to the upper .05/n quantile of a t distribution with n-2 degrees of freedom, where n is the number of data values in the group. If the maximum absolute studentized residual was greater than or equal to the .05/n quantile, the corresponding data value was flagged as a potential outlier. The outlier test was then repeated, excluding additional potential outliers, until no more outliers were detected. Table 3-3 lists the outliers found as a result this test.

Of the 135 lead loading values reported, four (or 3%) were identified as potential outliers. This includes 3 out of

Table 3-3. CAPS Pilot Study Outliers

LOADING OUTLIERS

Sample Processing Batch #	Laboratory ID	Medium	Study ID/Sample ID	Loading (ug/ft^2)
CRS	900383	Cassette	80/06	13087.15
CLS	900337	Cassette	19/08	187.30
CSS	900041	Cassette	51/08	59.42
WSS	900849	Wipe	51/34	1628.77

CONCENTRATION OUTLIERS

Sample Processing Batch #	Laboratory ID	Medium	Study ID/Sample ID	Concentration (ug/g)
CLS	900357	Cassette	19/09	69.53
CLS	900009	Cassette	51/21	4026.20
CRS	900383	Cassette	80/06	61573.85
SSS	901067	Soil	43/26	289.61
SSS	901057	Soil	17/23	363.88
SSS	901095	Soil	80/24	941.59
SSS	901074	Soil	33/27	167.51
CKC	901119	Cassette	17/01	50.00
CSS	900105	Cassette	17/32	63.69

105 cassette samples and 1 out of 30 wipe samples. Of the 153 lead concentrations reported, 9 (or 6%) were identified as potential outliers. This includes 5 out of 105 cassette samples and 4 out of 48 soil samples.

3.2.4 Resolution of Outlier Questions

Potential outliers were screened by a statistician to eliminate those which were merely numerical anomalies due to sample sizes of only 3 or 4. A list of the remaining outliers was sent to the laboratory for review. After rechecking, the laboratory verified that no transcription errors had occurred in reporting the results for these samples.

3.3 DUST COLLECTED AND AREA SAMPLED

When planning a field study to collect dust samples in a residential setting, information about the amount of dust collected and the square footage sampled is invaluable for interpreting the resulting lead loadings and concentrations. Detection limits for dust lead concentrations are a direct function of the amount of dust collected. The area sampled information for window stools and channels is quite useful for design purposes since it provides information on the size of these components. In Table 3-4, descriptive statistics are reported by sample type for the amount of dust collected (mg) by the vacuum sampling method, and the area sampled (ft^2) by both the vacuum and wipe sampling methods. The descriptive statistics presented are the geometric mean, logarithmic standard deviation, minimum, and maximum for the amount of dust collected and the arithmetic mean, standard deviation, minimum, and maximum for the area sampled. The symbols (abbreviations) used in Table 3-4 to represent the different sample types are described in Table 3-5. These symbols will be used repeatedly in the text, tables, and figures in this report.

It is important to understand what is meant by "abatement effect" in this study. The control houses were houses

Table 3-4. Descriptive Statistics for Amount of Dust Collected (mg) and Area Sampled (ft^2) by Sample Type

	ARD	BRU	EWY-I	FLR-V	FLR-W	WST	WST (1/2)	WCH	WCH (1/2)
Amount of Dust (mg)									
N	10	8	12	39	0	15	10	8	3
Geometric Mean	154.26	48.62	287.35	204.70	.	49.38	26.78	221.96	279.64
LN Standard Deviation	1.13	1.24	1.37	1.36	.	1.20	1.39	0.80	1.48
Minimum	25.4	8.7	13.3	21.3	.	6.2	4.8	78.0	103.6
Maximum	561.3	388.6	1819.0	1902.5	.	283.6	385.5	1001.4	1522.9
Area Sampled (ft^2)									
N	10	8	12	46	13	15	22	8	9
Arithmetic Mean	0.54	1.00	4.00	3.98	1.00	1.23	0.65	0.42	0.20
Standard Deviation	0.59	0.00	0.00	0.15	0.00	0.70	0.44	0.26	0.10
Minimum	0.22	1.00	4.00	3.00	1.00	0.35	0.23	0.09	0.06
Maximum	1.67	1.00	4.00	4.00	1.00	2.60	1.56	0.88	0.34

Table 3-5. Symbols Used to Denote Sample Types in Tables and Figures

Sample Type	Symbol	Description
Air Duct Dust	ARD	Dust samples from an air duct
Bed Cover-Rug-Upholstery Dust	BRU	Dust samples from a bed cover, rug, or upholstered furniture
Entryway Dust (Interior)	EWY (-I)	Dust samples from inside an entryway
Floor Dust	FLR	Dust samples from the floor
	FLR-V	Vacuum dust samples from the floor
	FLR-W	Wipe dust samples from the floor
Window Stool Dust	WST	Dust samples from a window stool
	WST(1/2)	Dust samples from a split window stool
	WST-V	Vacuum dust samples from a window stool
	WST-W	Wipe dust samples from a window stool
Window Channel Dust	WCH	Dust samples from a window channel
	WCH(1/2)	Dust samples from a split window channel
	WCH-V	Vacuum dust samples from a window channel
	WCH-W	Wipe dust samples from a window channel
Soil	BDY	Soil samples from the boundary of the property
	EWY-O	Soil samples from outside an entryway
	FDN	Soil samples near the foundation of the unit

tested by HUD and found to be relatively free of lead-based paint. Therefore these houses were not abated. The abated houses were houses tested by HUD and found to contain sufficient lead-based paint to warrant abatement. Therefore these houses were abated. The data analyzed in this report were obtained by dust and soil sampling conducted subsequently at both types of homes. Thus the "abatement effect" is really a measure of the difference in lead levels between abated houses (which were abated due to presence of lead) and unabated houses which were previously identified by XRF as being relatively free of lead-based paint. In some sense, it is a measure of how well abatement brings dust and soil lead levels in line with corresponding levels in houses determined to be relatively free of lead-based paint.

The amount of dust collected is illustrated graphically in Figure 3-1. The area sampled is similarly illustrated in Figure 3-2. In these figures, box and whisker plots are displayed for each sample type. The boxplot is a useful scheme for portraying the center, scatter, and skewness of a dataset. The lower and upper quartiles of the data are represented by the bottom and top of the box, respectively. At least 50% of the data lies within the box. The bar within the box represents the median of the data. The lower and upper tails of the distribution of the sample data are represented by the whiskers extending from the bottom and top of the box. Extreme data points are classified as either minor (pluses) or extreme outliers (stars) based on the distance of the data value from the quartiles relative to the distance between the upper and lower quartiles (interquartile range). The arithmetic mean of the data is portrayed with a diamond. Split window stools and channels in the bridge rooms are separated from full window stools and channels in the regular rooms since the split stools and channels provide only about half the sampling area of a full window stool or channel, as shown in Table 3-4 and Figure 3-2.

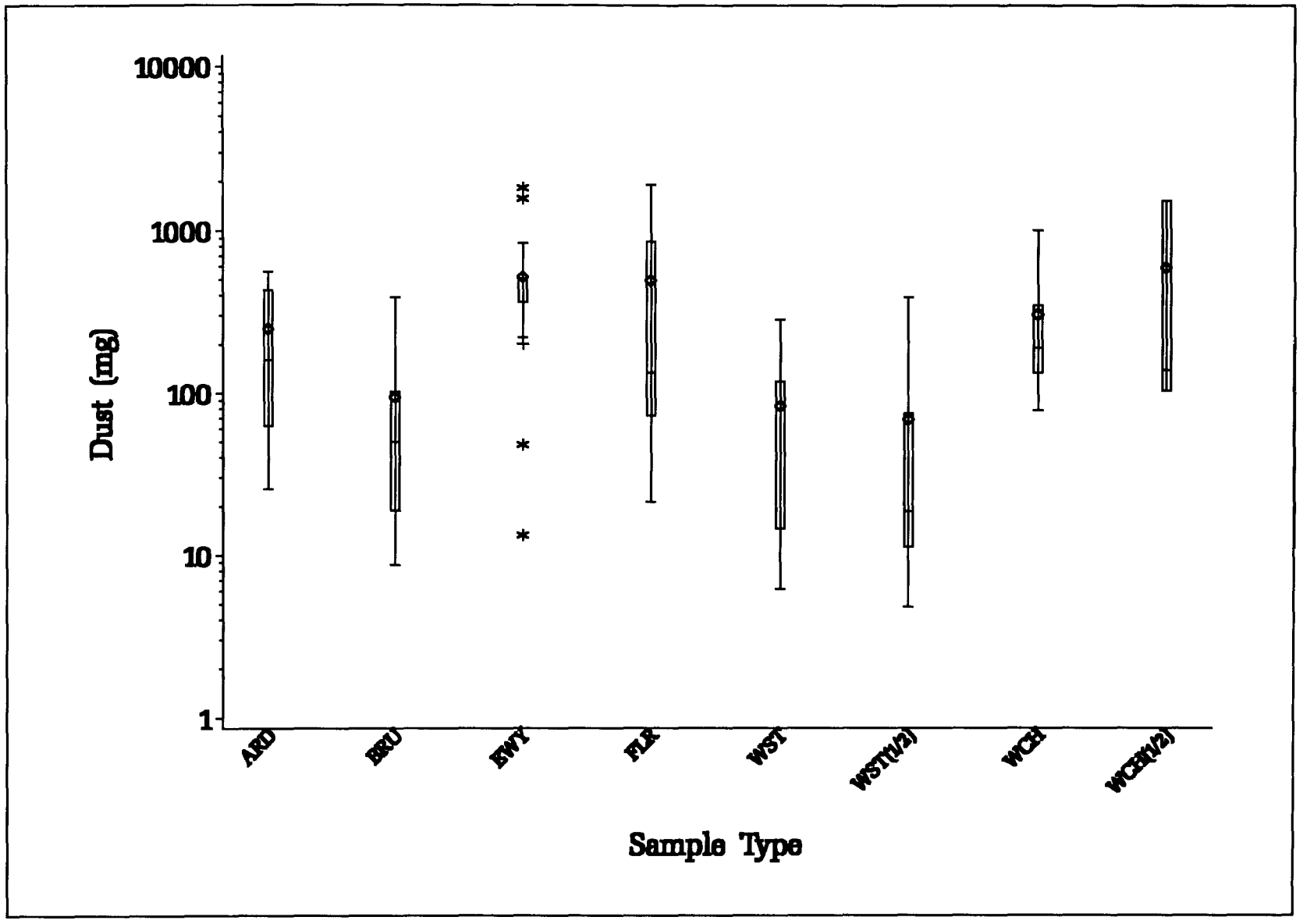

Figure 3-1. Amount of dust collected (mg) by sample type.

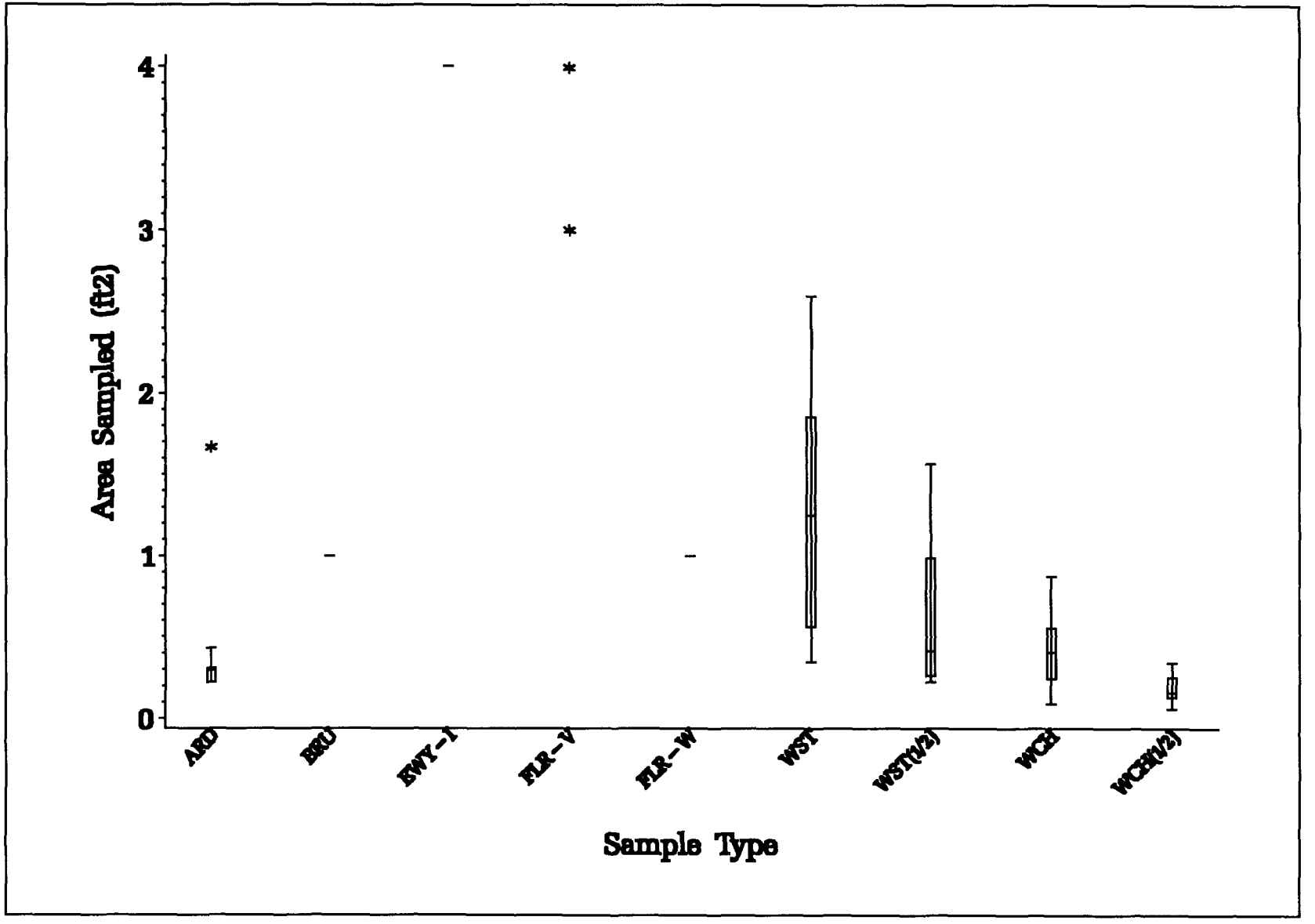

Figure 3-2. Area sampled (ft^2) by sample type.

As illustrated in Figure 3-1, the amount of dust collected by the vacuum sampler was seldom less than 10 mg (the amount targeted by the laboratory chemists in the study plans),and never exceeded 2 grams (2000 mg). Bedcover, rug, and upholstery samples, and window stool samples, provided the smallest amounts of dust primarily due to the area sampled. The large amount of dust collected from window channel samples is due to a very high dust loading which compensates for the very small area available for sampling (less than for window stool samples).

As illustrated in Figure 3-2, the area sampled for bedcover, rug, and upholstery (1 ft^2), interior entryway (4 ft^2), and floor wipe (1 ft^2) samples was always the same. The area sampled for floor vacuum samples was 4 ft^2, with a single exception. The average area sampled for air duct samples was slightly over 1/2 ft^2, for full window stool samples was slightly over 1 ft^2, and for full window channel samples was slightly under 1/2 ft^2.

3.4 COMPARISON OF ICP AND GFAA RESULTS

The protocol for analysis of the vacuum cassette dust samples called for an initial analysis by ICP. This analysis method was denoted by ICP-V in the previous section. If the ICP result was less than 10 times the ICP detection limit, the sample was reanalyzed by GFAA. The ICP and GFAA results for the samples reanalyzed by GFAA are reported in Table 3-6. The table presents the location, type and amount of lead collected (μg lead per sample) for each sample. The samples are listed in increasing amounts of lead as measured by ICP. These results are illustrated graphically in Figure 3-3. Separate plotting symbols are utilized in the figure to distinguish between the various sample types. The three samples reported by ICP as having a negative concentration (i.e., well below the detection limit) are plotted against 0.1 μg/sample on the ICP axis. As shown in the figure, agreement between the two methods was very good, indicating that the supplementary analysis by GFAA was probably unnecessary.

Table 3-6. ICP and GFAA Measurements (Lead Loading and Lead Concentration) for Samples Analyzed by GFAA

Unit	Room	Component	MRIID	Sample Type	ICP Amount (μg/sample)	GFAA Amount (μg/sample)
544	KIT	N/A	900098	Field Blank	0*	0.061
564	LVG	N/A	900284	Field Blank	0*	0.22
N/A	N/A	N/A	900458	Trip Blank	0*	0.16
571	KIT	N/A	900436	Field Blank	0.47	0.44
506	BD2	N/A	900273	Field Blank	0.51	0.16
506	BD2	N/A	900271	Field Blank	0.53	0.21
564	LVG	N/A	900353	Field Blank	0.62	0.20
507	DIN	N/A	900239	Field Blank	0.72	0.17
571	BAT	N/A	900435	Field Blank	0.82	0.24
544	BD1	BRU	900114	Regular	0.87	1.02
564	LVG	WSL	900373	Regular	1.544	2.090
571	BD3	BRU	900456	Regular	1.74	1.56
571	EWY	FLR	900446	Regular	2.176	2.947
588	BAT	N/A	900033	Field Blank	2.638	3.131
564	BD1	BRU	900360	Regular	3.644	4.216
506	LVG	BRU	900261	Regular	3.942	3.777
506	BD2	FLR	900249	Regular	3.952	3.896
507	DIN	FLR	900241	Regular	4.120	3.920
506	BD2	FLR	900255	Regular	4.23	4.19
506	LVG	WSL	900250	Regular	4.501	4.660
507	LVG	FLR	900197	Regular	4.78	4.74
506	BD2	WSL	900247	Regular	5.215	4.254
544	LVG	WSL	900103	Regular	5.863	5.824
544	KIT	FLR	900119	Regular	6.059	6.400
507	LVG	WSL	900205	Regular	6.077	5.979
506	LDY	WSL	900274	Regular	6.372	6.504
507	KIT	WSL	900229	Regular	6.769	6.626
N/A	N/A	N/A	900484	Reference Material	12.3038	12.134
N/A	N/A	N/A	900485	Reference Material	13.11	13.0814
N/A	N/A	N/A	900481	Reference Material	13.43	10.74
N/A	N/A	N/A	900468	Reference Material	39.84	40.1520
564	KIT	WSL	900351	Regular	62.240	68.15
564	EWY	FLR	900347	Regular	78.878	91.606
564	LVG	FLR	900365	Regular	285.538	326.298

* The calculated final concentration was negative.

Note: Some of the ICP amounts are estimates. They were calculated using the weight and concentration of the sample.

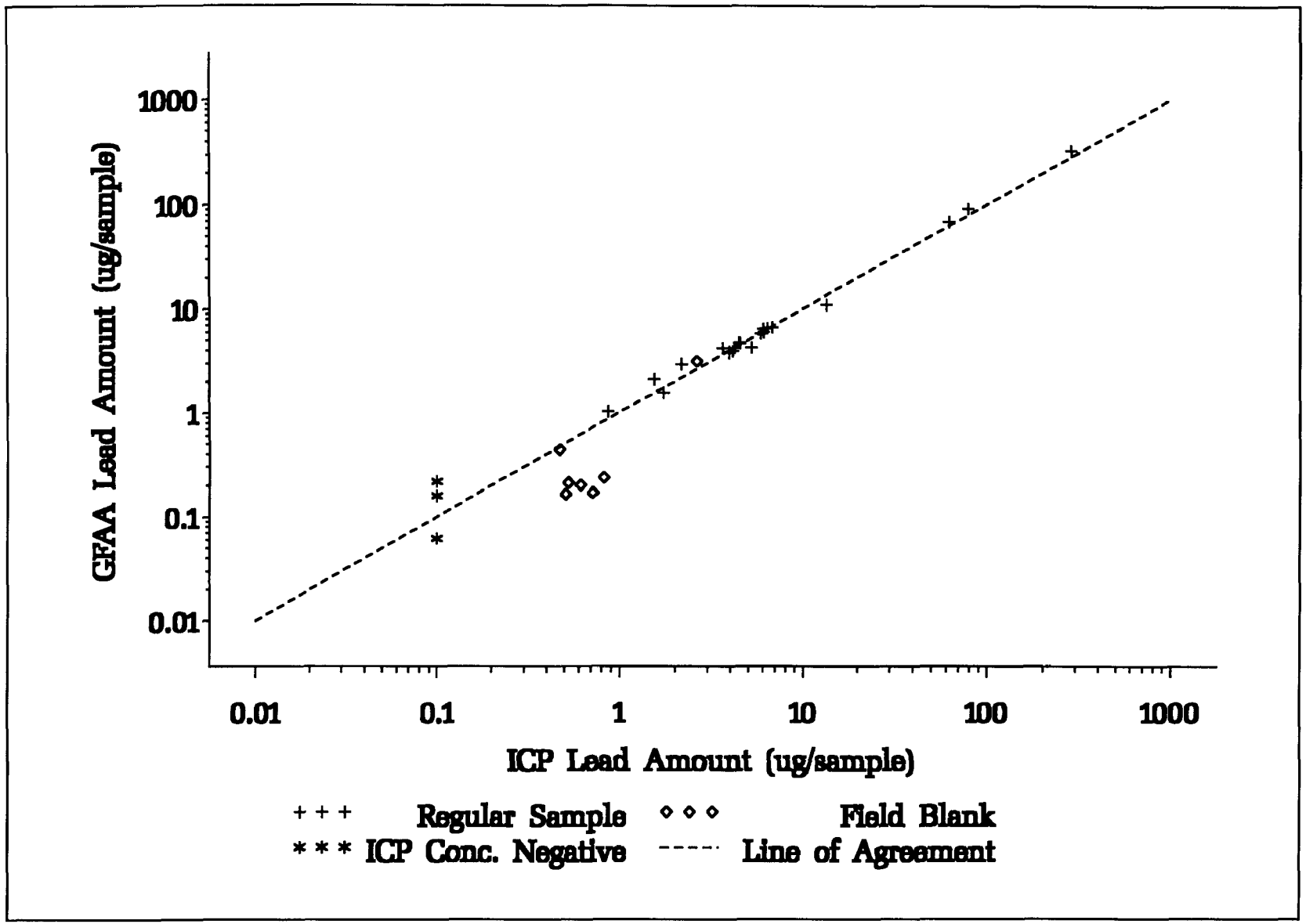

Figure 3-3. Plot of ICP lead amounts vs. GFAA lead amounts for cassette samples analyzed by GFAA.

4.0 DATA INTERPRETATION

Interpretation of the study data began with the production of descriptive statistics in both tabular and graphical form. These descriptive statistics are presented in Section 4.1. Next, statistical models were fitted to the measurement data to estimate various variance components (unit-to-unit, room-to-room, exterior side-to-side, sampling location-to-sampling location, and duplicate-to-duplicate) and to estimate the effects of renovation and abatement. The statistical models employed are defined in Section 4.2.

It is important to understand what is meant by "abatement effect" in this study. The control houses were houses tested by HUD and found to be relatively free of lead-based paint. Therefore these houses did not warrant abatement. The abated houses were houses tested by HUD and found to contain lead-based paint. These houses were abated. The data analyzed in this report were obtained by dust and soil sampling conducted subsequently at both types of homes. Thus the "abatement effect" is really a measure of the difference in lead levels between abated houses and unabated houses. In some sense, it is a measure of how well abatement brings dust and soil lead levels in line with corresponding levels in houses determined to be relatively free of lead-based paint.

Modeling results are presented in Section 4.3. Two different models were fitted to the data. The first model contains only an overall geometric mean and random effects; no fixed effects are included. The purpose of this model is to assess general variability without attributing the variability to any particular cause. Results from the first model are reported in Section 4.3.1. The second model fitted includes fixed-effect terms to represent renovation and abatement effects which attempt to explain portions of the unit-to-unit and room-to-room variability. Results from the second model may be found in Section 4.3.2.

In Section 4.3, results for dust samples are reported separately for two different statistical models, three different measured values (lead loading, lead concentration, and dust loading), and in some cases two different sampling methods (vacuum and wipe). In Section 4.4, the modeling results are summarized for each of the six dust sample types (air dust, bed/rug/upholstery, entryway, floor, window stool, and window channel). These summaries span the results from the two different statistical models and the different measurement types for each sample type. Section 4.5 provides similar summaries for the three soil sample types (boundary, entryway, and foundation).

Having summarized the data by sample type, relationships between the sample types were then examined. These relationships are characterized in terms of correlation matrices and scatterplot matrices in Section 4.6.

As stated earlier, one of the objectives of the Pilot Study was to compare the vacuum sampling protocol with the wipe sampling protocol. Paired measurements for these two sampling protocols are compared statistically in Section 4.7. Finally, in Section 4.8, the data collected in this study were compared to data previously recorded for the housing units as part of the HUD Demonstration.

All sampling was done in six houses, and the results should be interpreted with this in mind. As a result of the analyses and comparisons performed, the following broad conclusions may be drawn:

1. Units under renovation had relatively high interior lead loadings on readily available surfaces such as entryways, floors and window stools; floor lead loadings in the units undergoing full renovation were estimated to be 70 times higher than those in control units; both higher lead concentrations in the dust (5 times higher) and higher dust loadings (14 times higher) appeared to contribute to the higher lead loadings.

2. There is some evidence that abated units had higher interior lead loadings on readily available surfaces; it

appears that this is due primarily to higher lead concentrations.

3. For floor lead loadings, abated rooms had lead levels which were comparable to those in control units; however, lead loadings in unabated rooms in abated units were 10 times higher than abated rooms in the same unit; higher dust loading appeared to be the primary cause.

4. With window stools as the exception, differences in dust lead loadings among different sample types can be attributed to differences in both dust lead concentration and dust loading on the surface being sampled; dust lead concentration and dust lead loading were positively correlated from sample type to sample type.

5. The higher lead loadings for window stools relative to floors can be attributed primarily to higher lead concentrations in the dust, and not to higher dust loadings.

6. Soil lead concentrations for the three types of samples collected (boundary, entryway, and foundation) were highly correlated from unit to unit, both before and after correcting for renovation and abatement effects. Also, the lead concentration in boundary soil samples was significantly lower than that in entryway and foundation soil samples.

7. Interior dust lead concentrations for the six types of samples collected (air duct, bed/rug/upholstery, entryway, floor, window stool, and window channel) generally were not highly correlated even after correction for renovation and abatement effects; exceptions were:

   - entryway samples with floor samples before correction for renovation and abatement effects, and

   - air duct samples with bed/rug/upholstery samples and floor samples, window stool samples, and window channel samples as a group after correction for renovation and abatement effects.

8. Interior dust lead concentrations were generally correlated with soil lead concentrations:

- before correction for renovation and abatement effects, entryway, floor and window stool dust lead concentrations were all positively correlated with soil lead concentrations for all three soil sample types;

- after correction for renovation and abatement effects, dust lead concentrations for all interior dust sample types, except entryway samples, were positively correlated with soil lead concentrations for all three soil sample types.

9. Based on paired data for the two sampling procedures, the wipe sampling procedure appeared to produce lead loadings on the order of 5 times higher than the vacuum method; this would be consistent with a sampling efficiency of approximately 10-20% for the vacuum sampler.

10. The CAP Pilot Study soil concentration data were highly correlated with HUD Demonstration soil concentration data with the HUD Demonstration data being 25% higher on average; floor lead loadings for the two studies did not appear correlated.

11. For floor and window stool lead loadings and soil lead concentrations, results from both the CAP Pilot Study and the HUD Demonstration appeared to be somewhat positively correlated with XRF/AAS measurements of paint lead loading from the HUD Demonstration. However, if anything, window channel lead loadings appeared to be negatively correlated with the XRF/AAS measurements. This negative correlation cannot be explained simply by window replacement as none of the windows were replaced during abatement of the units examined in the Pilot Study.

4.1 DESCRIPTIVE STATISTICS

Three basic types of measurements were examined for the dust and soil samples. They are:

- Lead Loading: Amount of lead (μg) in household dust per square foot (ft^2) of surface area sampled

- Lead Concentration: Amount of lead (μg) per gram (g) of household dust sampled <u>or</u> amount of lead (μg) per gram (g) of soil sampled

- Dust Loading: Amount of household dust (mg) per square foot (ft^2) of surface area sampled.

Vacuum dust samples produce all three measurements. Wipe dust samples produce only lead loading measurements since the amount of dust collected cannot be determined. For soil samples, lead concentration was determined because a volume, not a surface, was sampled.

Descriptive statistics for all units combined are presented by sample type in Table 4-1 for all three measurement types. The abbreviations used to denote the different sample types have been defined previously in Table 3-5. The descriptive statistics reported include the number of samples, geometric mean, median, arithmetic mean, logarithmic standard deviation, minimum, and maximum.

Log-transformed responses (lead loadings, lead concentrations, and dust loadings) were used in all of the statistical analyses. Using log-transformed environmental lead measures is common and supported in the literature. Reeves et al. (1982) found that the normal distribution was statistically rejected for each of the environmental measures they studied (lead in paint, soil, and house dust), and that the data tend to be closer in form to the log-normal distribution. Based on the data obtained in this study, one obvious reason for using log-transformed data is the fact that in many cases, the responses range over two to three orders of magnitude (see Figures 4-1a, b), especially for lead loadings. Another justification for using this transformation is that the geometric means are often much closer to the median than the arithmetic mean (see Table 4-1). This is evidence that the distributions are more symmetric on a log scale than on a linear scale. Also, examining residuals from a partial model fit to the log-transformed data (the full model leaves only 2 to 4 degrees of freedom for error) including the fixed effects and a random unit effect, only one of the eighteen lead sample types (floor vacuum lead loading) was

Table 4-1. Descriptive Statistics for Lead Loading ($\mu g/ft^2$), Lead Concentration ($\mu g/g$), and Dust Loading (mg/ft^2) by Sample Type for All Units Considered

	ARD	BRU	EWY-I	FLR-V	WST-V	WCH-V	BDY	EWY-O	FDN	FLR-W	WST-W	WCH-W
N	10	8	12	39	25	11	15	16	17	12	12	6
Lead Loading ($\mu g/ft^2$)												
G Mean	307.77	8.46	22.59	13.16	34.06	1249.73				50.98	144.05	800.66
Median	486	9	24	9	17	977				27	142	833
A Mean	859	32	161	65	622	2502				476	564	898
LN SD	5.26	5.41	7.07	6.24	7.26	3.65				6.42	5.24	1.73
Min	26.99	1.02	0.74	0.97	0.80	197.09				13.77	18.39	335.38
Max	3909.60	187.30	1578.88	561.64	13087.15	9246.81				3832.53	4216.85	1529.67
Lead Concentration ($\mu g/g$)												
G Mean	748.68	173.81	314.27	255.21	723.85	1448.30	121.37	196.00	216.95			
Median	671	156	261	223	562	1141	98	254	238			
A Mean	859	232	602	416	3728	2370	170	291	313			
LN SD	1.73	2.30	2.66	2.52	4.35	2.88	2.42	2.70	2.49			
Min	363.44	66.32	88.42	50.00	70.83	367.88	43.29	40.35	49.18			
Max	1699.36	484.57	4026.20	2446.16	61573.85	7238.25	345.81	899.20	941.59			
Dust Loading (mg/ft^2)												
G Mean	411.08	48.65	71.87	51.57	47.05	862.89						
Median	389	55	72	33	44	829						
A Mean	831	94	134	119	83	1504						
LN SD	4.09	3.45	3.93	3.93	2.83	2.86						
Min	37.62	8.71	3.34	5.30	11.30	254.55						
Max	2435.86	388.60	454.75	634.17	545.58	6449.93						

rejected as non-normal. However, when the untransformed data was fit to this model, eight sample types were rejected, includingall three floor dust lead responses, all window stool dust lead responses, and both entryway dust lead responses.

The geometric mean and logarithmic standard deviation are natural summary parameters for lognormally distributed data. The geometric mean is calculated by first taking the natural logarithm of the data values, calculating the arithmetic mean of the logarithms, and then exponentiating (taking the antilog of) the resulting arithmetic mean. The logarithmic standard deviation is calculated by first taking the natural logarithm of the data values, then calculating the usual standard deviation.

Figures 4-1a through 4-1c contain box-and-whisker plots of lead loadings, concentration and sample loadings for various sample types. The symbols used in these plots have been defined in Section 3.3.

Lead loading measurements along with the geometric mean lead loading for all units are plotted versus sample type in Figure 4-1a. Similar plots for lead concentration and dust loading measurements are presented as Figures 4-1b and 4-1c, respectively. Figure 4-2 is a bar graph illustrating the geometric means for all three measurement types by sample type; and Table 4-2 presents geometric means for each individual housing unit.

The geometric means from Table 4-2 are plotted versus unit number in Figures 4-3 through 4-5. Figure 4-3 illustrates geometric means for the floor and upholstery sample types: BRU, FLR-V, FLR-W, and EWY-I. Lead loadings, lead concentrations, and dust loadings are presented in Figures 4-3a, 4-3b, and 4-3c, respectively. Figure 4-4 illustrates geometric means for the window and air duct sample types: WCH-V, WCH-W, WST-V, WST-W, and ARD. Lead loadings, lead concentrations, and dust loadings are presented in Figures 4-4a, 4-4b, and 4-4c, respectively. Finally, geometric mean lead concentrations in soil samples are presented in Figure 4-5.

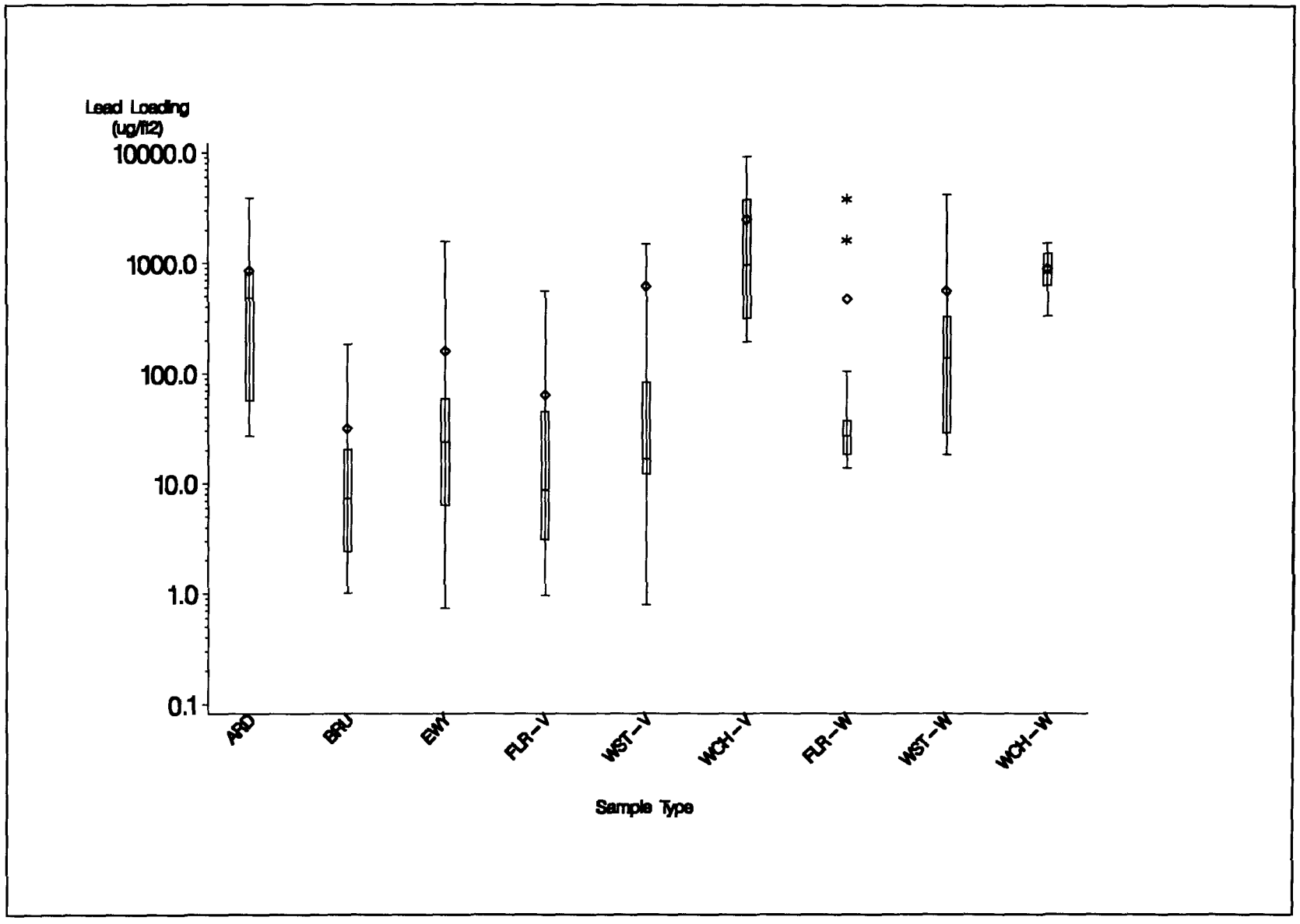

Figure 4-1a. Lead loading measurements ($\mu g/ft^2$) and geometric mean lead loading for all units by sample type.

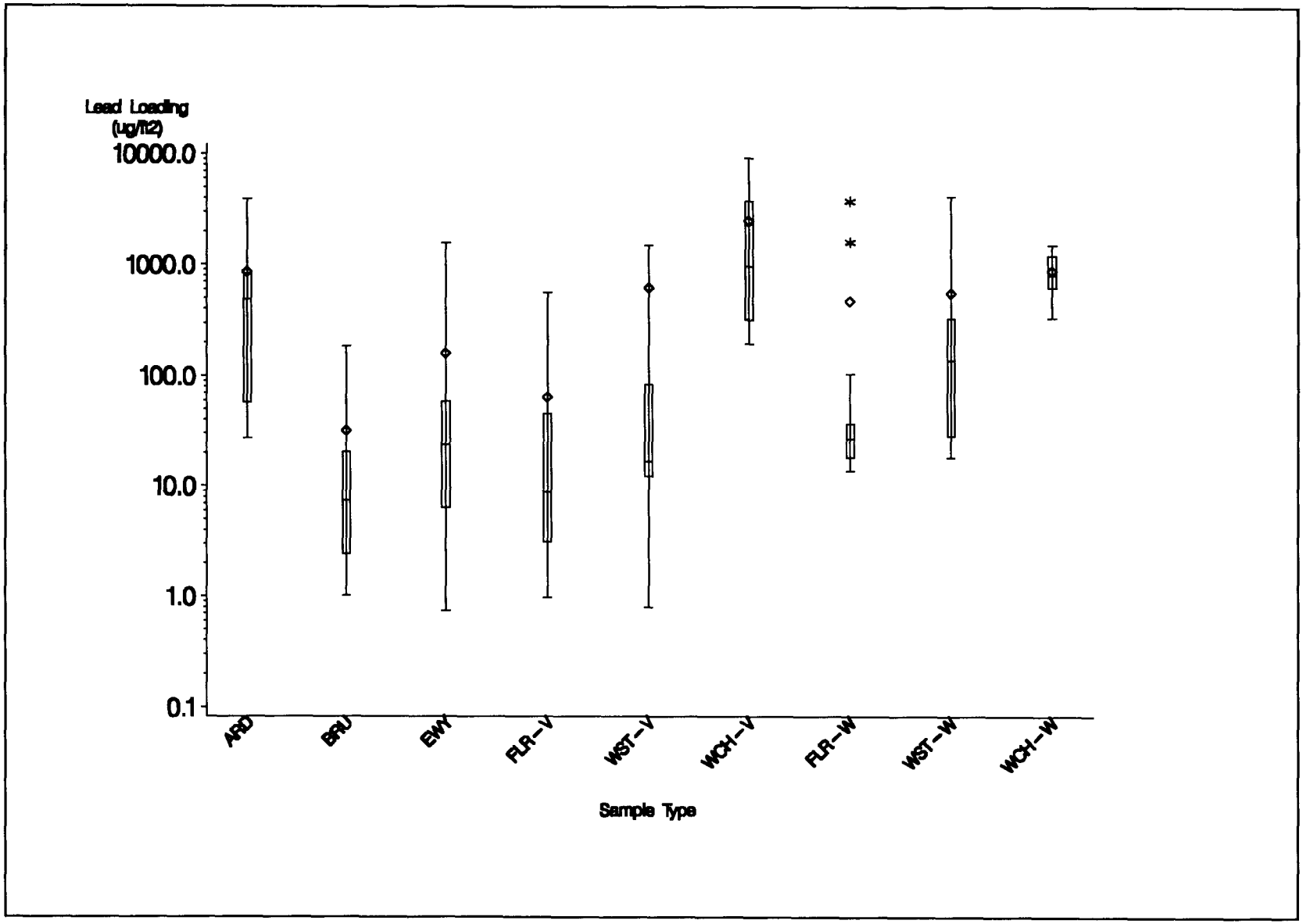

Figure 4-1b. Lead concentration measurements ($\mu g/g$) and geometric mean lead concentration for all units by sample type.

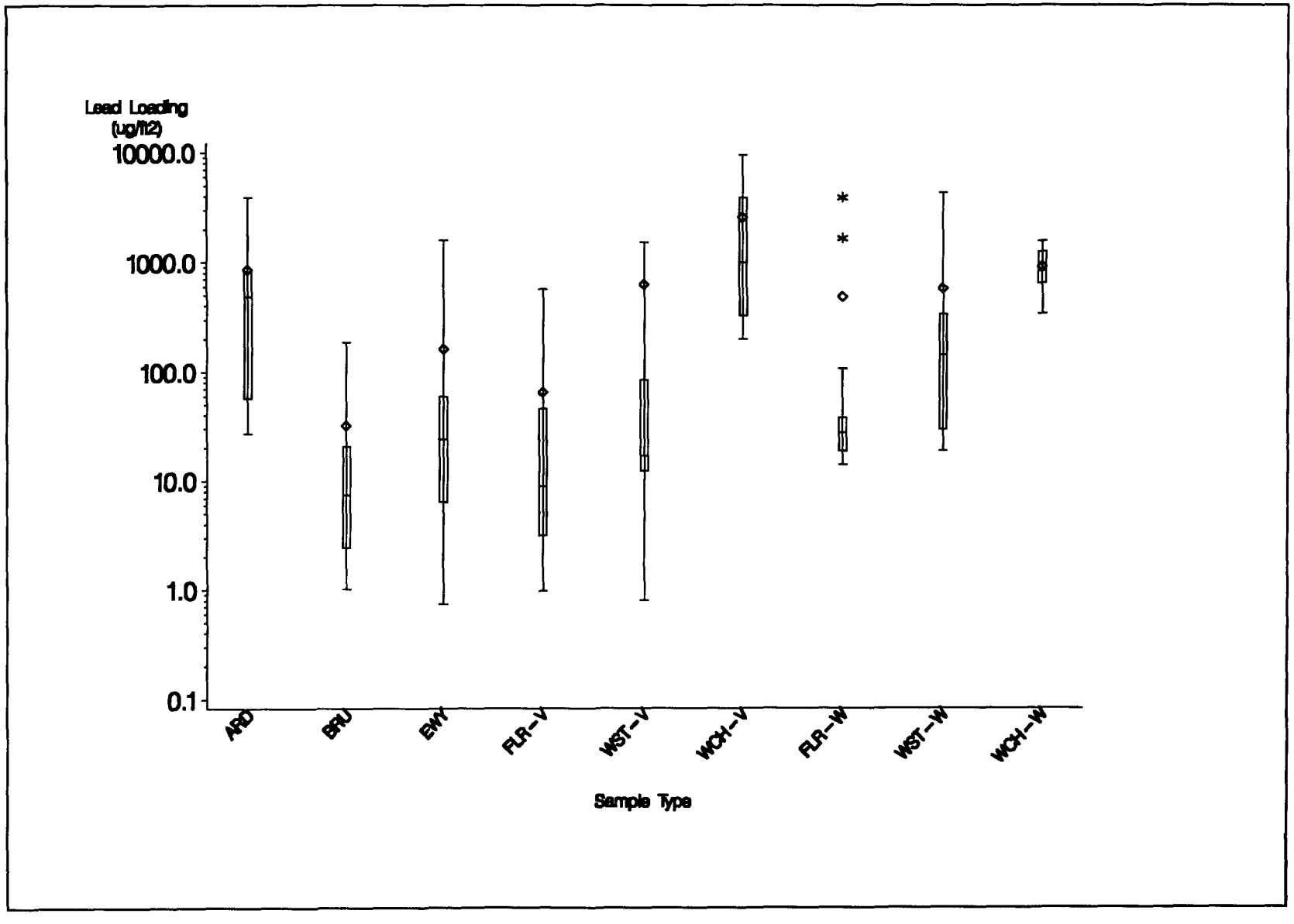

Figure 4-1c. Dust loading measurements (mg/ft^2) and geometric mean dust loading for all units by sample type.

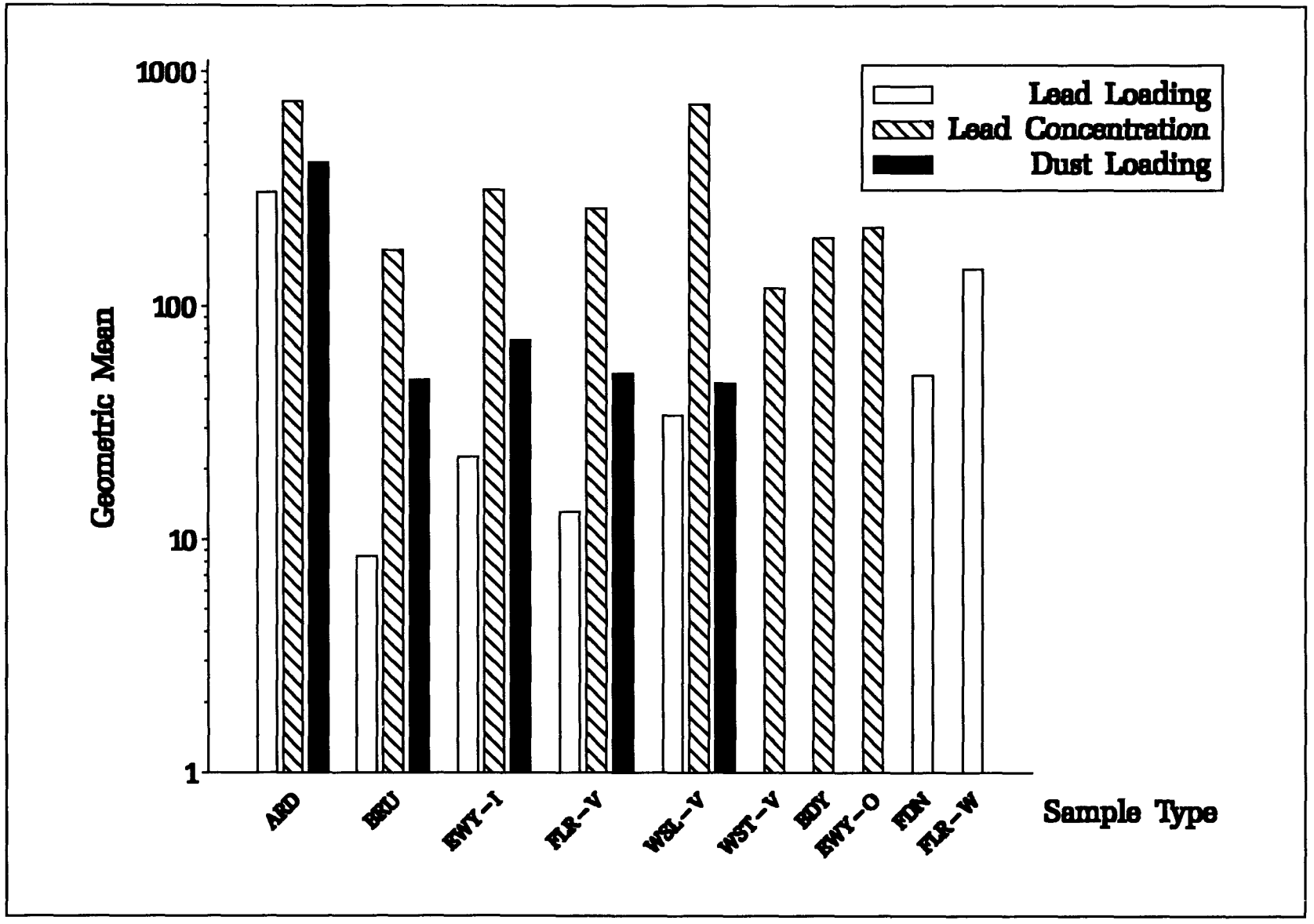

Figure 4-2. Geometric means over all units for lead loading (L) in $\mu g/ft^2$, lead concentration (C) in $\mu g/g$, and dust loading (D) in mg/ft^2 by sample

Table 4-2. Geometric Mean for Lead Loading ($\mu g/ft^2$), Lead Concentration ($\mu g/g$), and Dust Loading (mg/ft^2) by Sample Type and Unit

Unit		ARD	BRU	EWY-I	FLR-V	WST-V	WCH-V	BDY	EWY-O	FDN	FLR-W	WST-W	WCH-W
33	N	2	1	2	7	4	1	2	3	3	2	3	0
	Lead Loading	649	4	6	2	10	3697	.	.	.	14	141	
	Lead Concent.	875	117	106	131	425	7238	86	79	147	.	.	
	Dust Loading	742	32	60	19	23	511	.	.	.	.	.	
43	N	2	2	2	7	3	2	2	3	3	2	3	3
	Lead Loading	1313	14	12	3	12	1658	.	.	.	21	25	518
	Lead Concent.	834	141	394	221	525	1175	133	338	246	.	.	.
	Dust Loading	1574	102	29	14	23	1411	.	.	.	.	.	.
17	N	2	1	2	7	6	1	3	2	3	2	1	0
	Lead Loading	38	1	23	12	17	977	.	.	.	24	24	
	Lead Concent.	511	67	270	166	368	1141	59	160	68	.	.	
	Dust Loading	74	15	86	74	47	856	.	.	.	.	.	
19	N	1	2	2	5	3	1	3	3	2	2	1	1
	Lead Loading	57	28	44	57	10	1201	.	.	.	35	191	1530
	Lead Concent.	624	483	193	173	139	368	57	73	108	.	.	.
	Dust Loading	91	58	228	330	72	3263	.		.		.	.
80	N	3	2	2	7	5	3	2	3	3	2	1	0
	Lead Loading	505	6	4	9	152	1954	.	.	.	29	163	
	Lead Concent.	861	151	275	305	3828	2914	325	380	515	.	.	
	Dust Loading	587	43	16	29	40	671	.	.	.	.	.	
51	N	0	0	2	6	4	3	3	2	3	2	3	2
	Lead Loading			415	262	273	507	.	.	.	2498	1345	1112
	Lead Concent.			1605	1227	1854	828	325	674	599	.	.	.
	Dust Loading			259	213	147	613	.	.	.	.	.	.

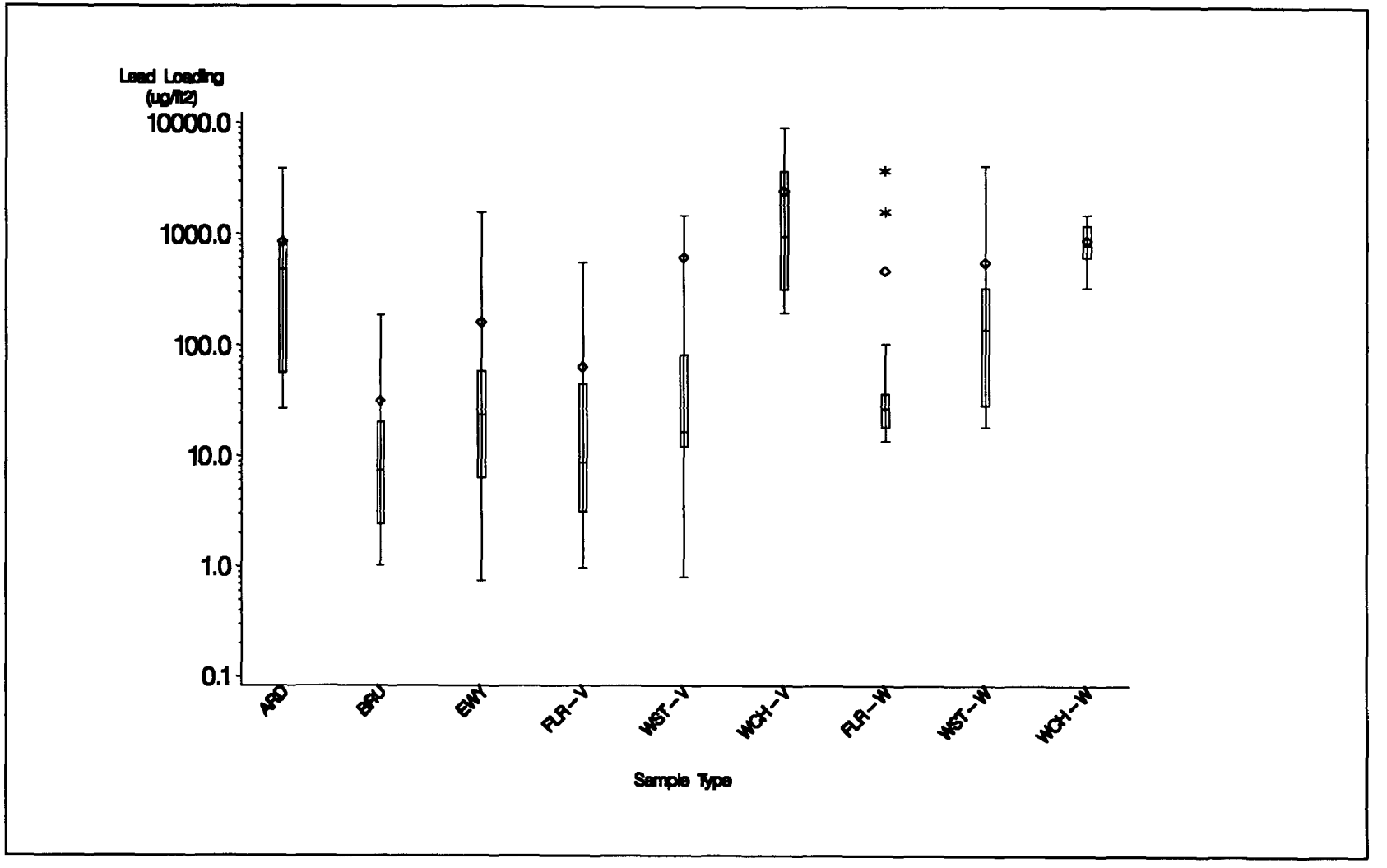

Figure 4-3a. Geometric means by unit for floor and upholstery samples: lead loading ($\mu g/ft^2$).

Unit 51 was undergoing full renovation and Unit 19 was undergoing partial renovation at the time of sampling.

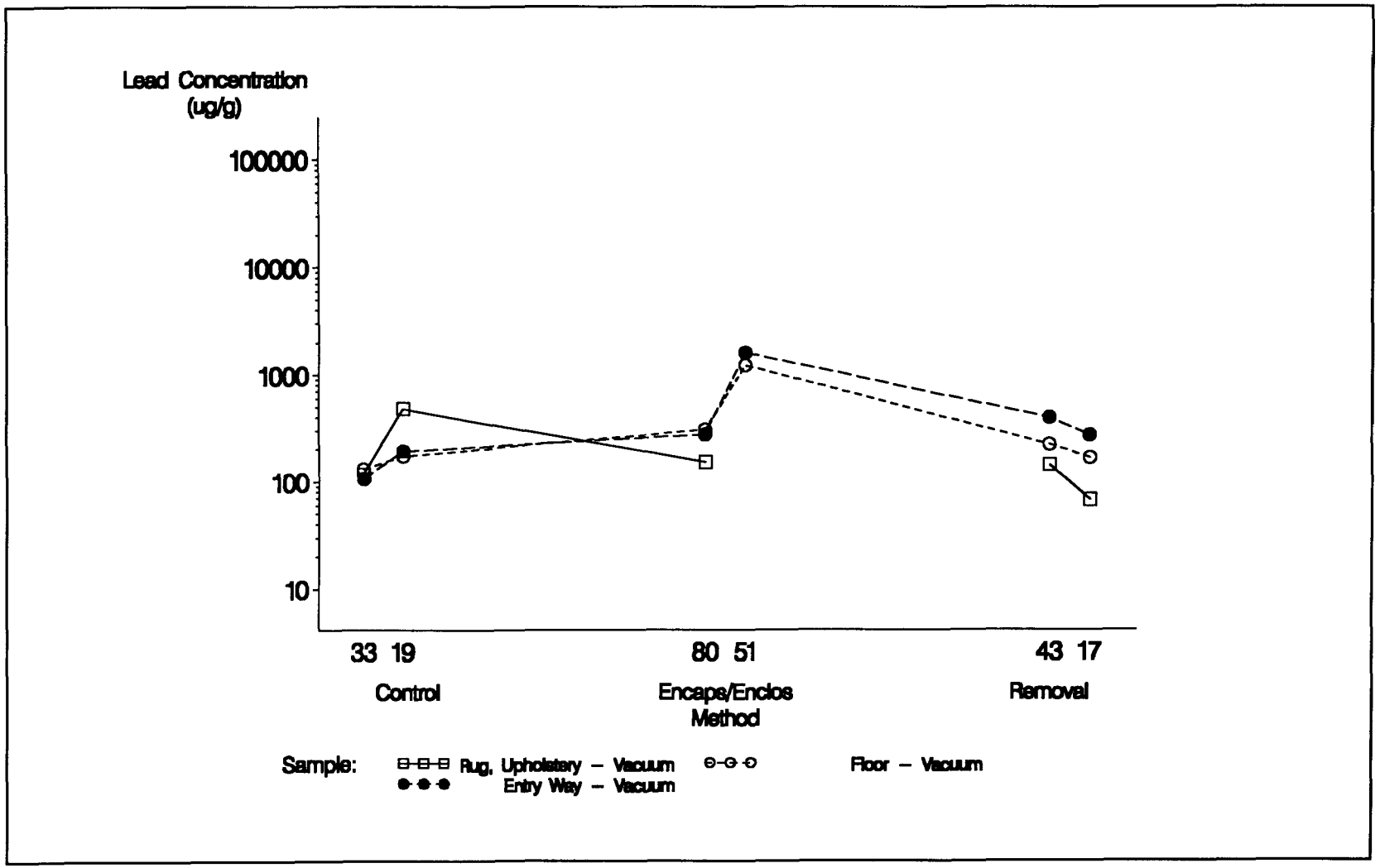

Figure 4-3b. Geometric means by unit for floor and upholstery samples: lead concentration ($\mu g/g$).

Unit 51 was undergoing full renovation and Unit 19 was undergoing partial renovation at the time of sampling.

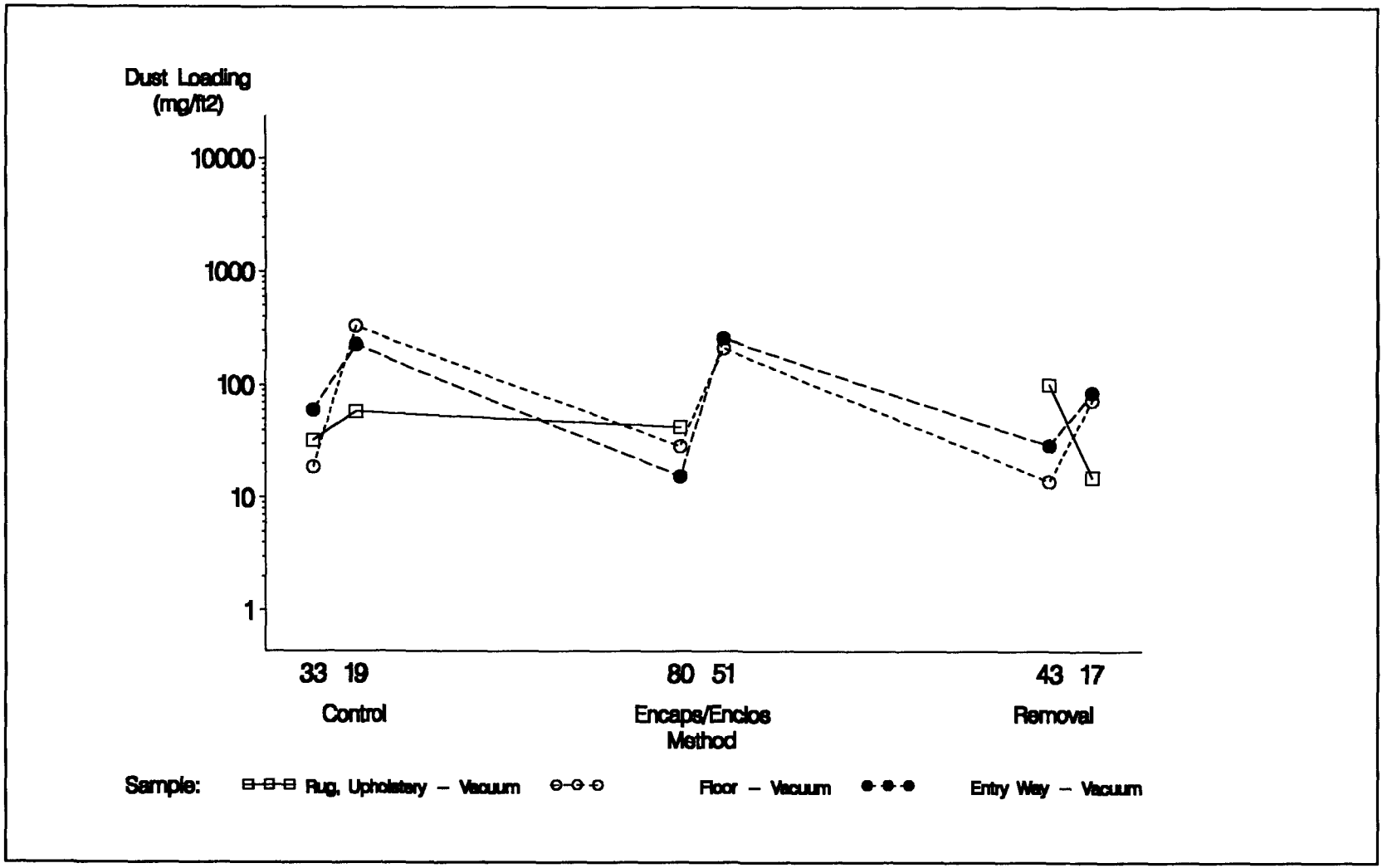

Figure 4-3c. Geometric means by unit for floor and upholstery samples: dust loading (mg/ft^2).

Unit 51 was undergoing full renovation and Unit 19 was undergoing partial renovation at the time of sampling.

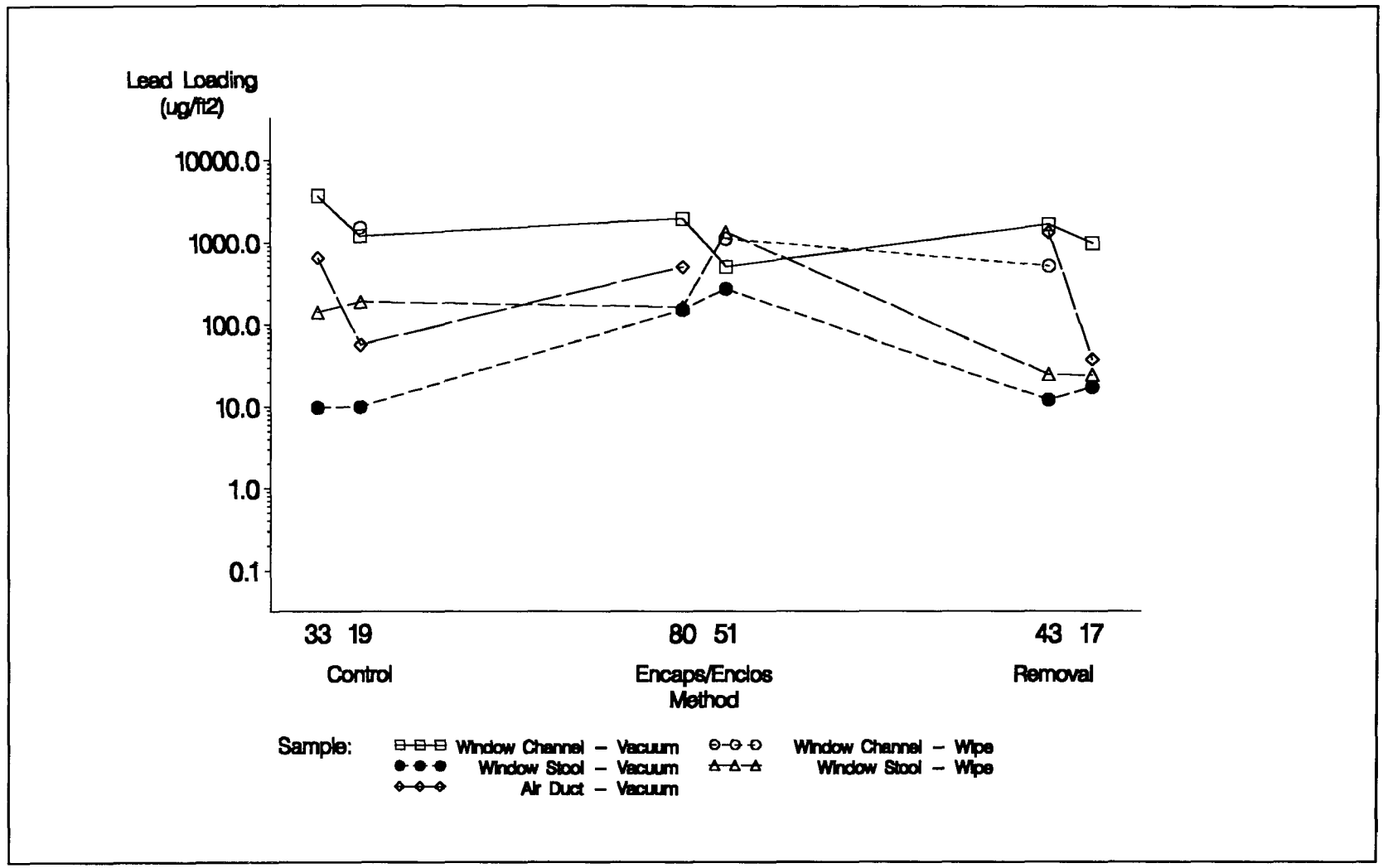

Figure 4-4a. Geometric means by unit for window and air duct samples: lead loading ($\mu g/ft^2$).

Unit 51 was undergoing full renovation and Unit 19 was undergoing partial renovation at the time of sampling.

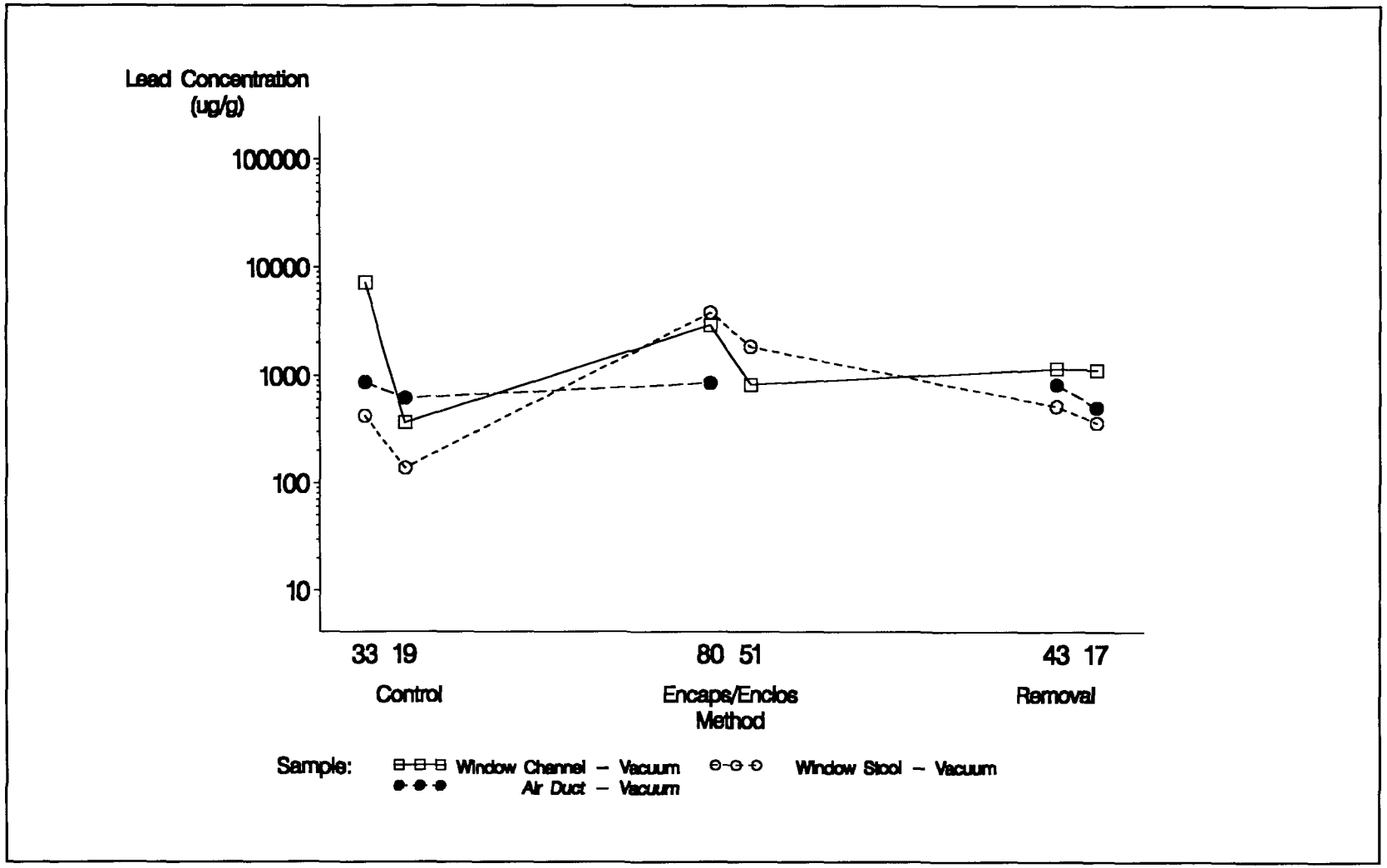

Figure 4-4b. Geometric means by unit for window and air duct samples: lead concentration ($\mu g/g$).

Unit 51 was undergoing full renovation and Unit 19 was undergoing partial renovation at the time of sampling.

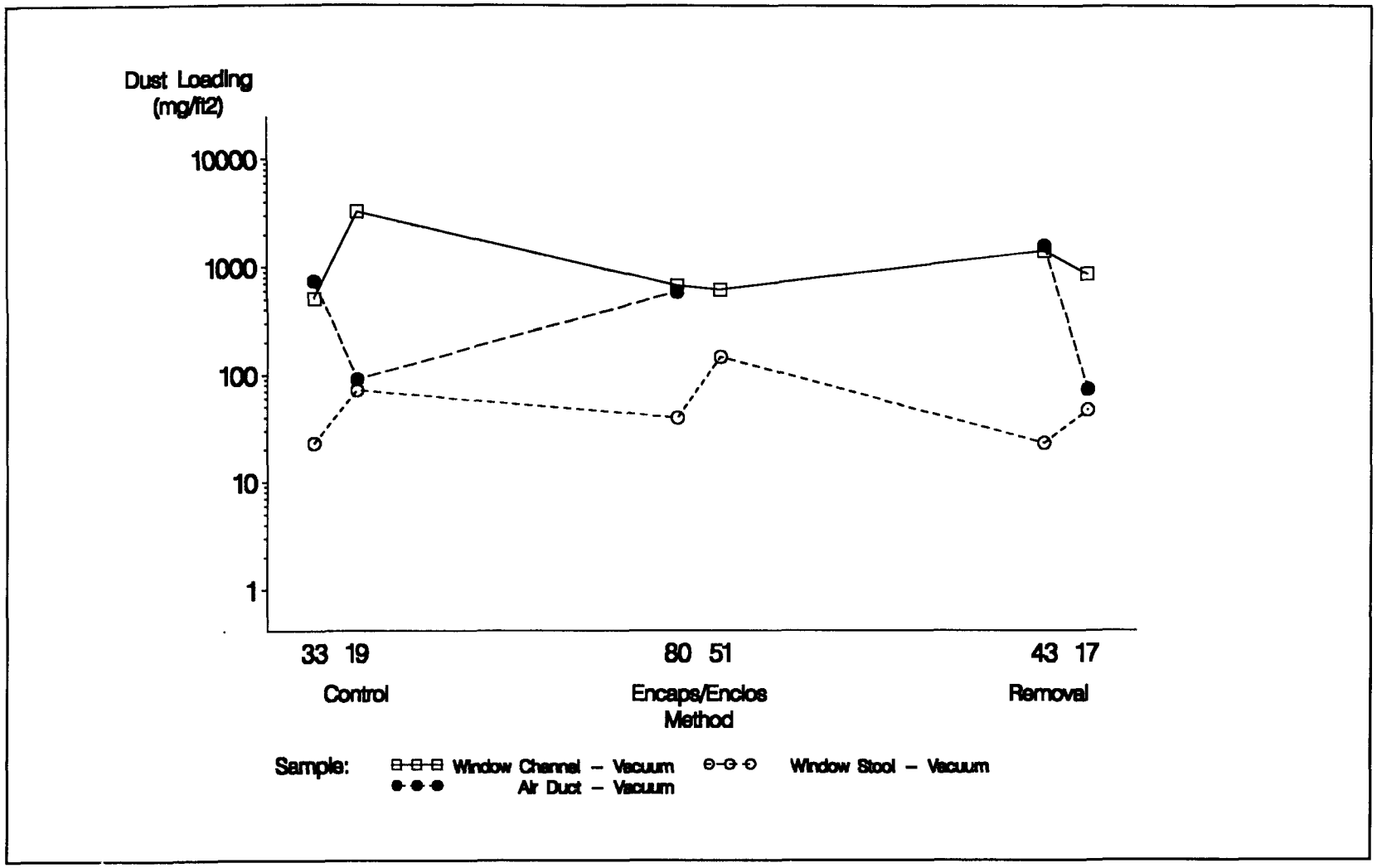

Figure 4-4c. Geometric means by unit for window and air duct samples: dust loading (mg/ft^2).

Unit 51 was undergoing full renovation and Unit 19 was undergoing partial renovation at the time of sampling.

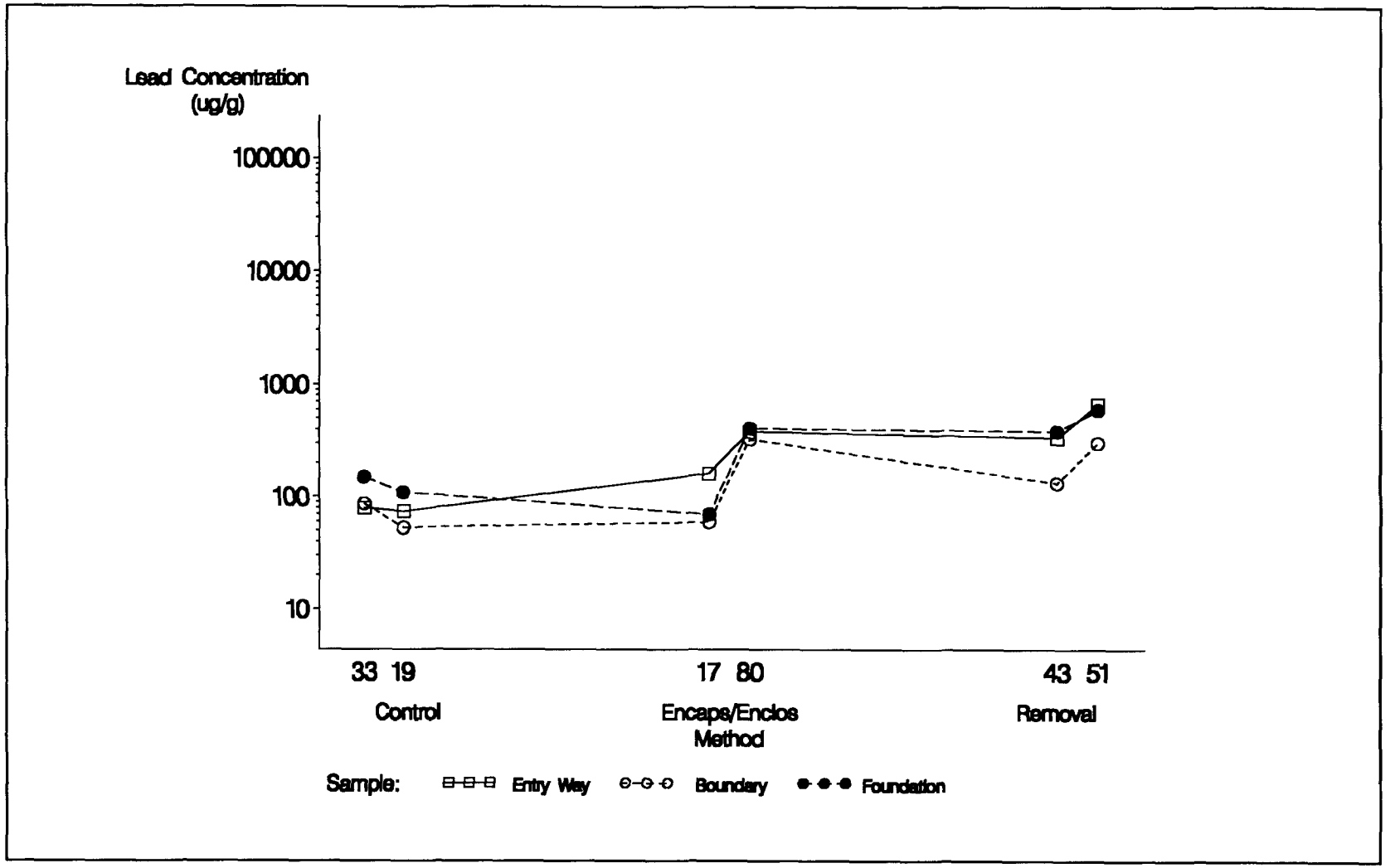

Figure 4-5. Geometric means by unit for soil samples: lead concentration (μg/g).

Unit 51 was undergoing full renovation and Unit 19 was undergoing partial renovation at the time of sampling.

The correlation between loadings and concentrations was assessed for the six types of vacuum samples. Table 4-3 displaysthe estimated correlations for each of these along with the significance level of each estimate. These estimates are based on the log-transformed data.

For five of the six sample types the estimated correlation was significantly different from zero. Pooling across sample types, the average correlation was 0.77, and this was highly significant.

Table 4-3. Loading versus Concentration Correlations for Dust Samples

Sample Type	Number of Samples	Estimated Correlation	Significance Level
Air Ducts	10	.59	.0738
Bed/Rug/Upholstery	8	.72	.0461
Entryway	12	.76	.0041
Floor	39	.69	.0001
Window Stool	25	.86	.0001
Window Channel	11	.62	.0433
Across Sample Types	105	.77	.0001

The effect of renovation on dust lead loadings for floor and bed/rug/upholstery samples is evident in Figure 4-3a. Control Unit 19 was undergoing partial renovation and encapsulation/enclosure Unit 51 was undergoing full renovation. The remaining four units show similar lead loadings. Examination of Figures 4-3b and 4-3c lead to the conclusion that renovation produces both higher lead concentrations and higher dust loadings for these sample types, which both contribute to higher lead loadings. In contrast, no effect for abatement or abatement method is evident in Figure 4-3.

There is no clear renovation effect or abatement effect for the sample types plotted in Figure 4-4, window and air duct samples. One possible exception is that the renovation of Unit 19 has produced higher dust loadings where the dust has a lower lead concentration. In Figure 4-5, three of the four abated units show consistently higher soil lead concentrations across all three sampling locations.

4.2 STATISTICAL MODELS

In this section, the statistical models that were fitted to the lead loading, lead concentration, and dust loading data are described. These models are the basis for the statistical analyses described in Sections 4.3, 4.4 and 4.5. All statistical models for dust samples contained an overall geometric mean. The models contained random effects for unit-to-unit, room-to-room, sampling location-to-sampling location, and duplicate-to-duplicate variability. At the unit level, there were fixed effects for renovation and abatement. At the room level, there was a fixed effect for abatement. The mathematical form of the fullest model for dust samples was

$$\ln(X_{ijkm}) = \ln(CGA) + \ln(B_{RENO})RENO_i + \ln(B_{HP})HP_i + H_i + \ln(B_{RP})RP_{ij} + R_{ij} + S_{ijk} + D_{ijkm} \quad (1)$$

for

$i = 1, \ldots, 6$ (# units)
$j = 1, \ldots,$ # rooms/unit
$k = 1, \ldots,$ # sampling locations/room
$m = 1, \ldots,$ # duplicates/sampling location

where

X_{ijkm} = measured lead loading (L_{ijkm}), lead concentration (C_{ijkm}), or dust loading (D_{ijkm}) for the mth (replicate) sample at the kth sampling location in the jth room in the ith unit,

CGA = overall geometric average of the dependent variable for unrenovated control units,

B_{RENO} = fixed multiplicative increase in the dependent variable due to an ongoing full renovation of the unit,

$RENO_i$ = 1 if ith unit is being fully renovated (Unit 51); 1/2 if the unit is being partially renovated (Unit 19); zero if the unit is not being renovated (other 4 units),

B_{HP} = fixed multiplicative increase in the dependent variable due to abatement having been performed somewhere in the unit,

HP_i = 1 if the ith unit was abated; zero otherwise,

H_i = random effect for the ith unit; assumed to follow a normal distribution with mean zero and standard deviation σ_H,

B_{RP} = fixed multiplicative increase in the dependent variable due to abatement having been performed somewhere in the room,

RP_{ij} = 1 if the jth room in the ith unit was abated; zero otherwise,

R_{ij} = random effect for the jth room in the ith unit; assumed to follow a normal distribution with mean zero and standard deviation σ_R,

S_{ijk} = random effect for the kth sampling location in the jth room in the ith unit; assumed to follow a normal distribution with mean zero and standard deviation σ_S,

D_{ijkm} = random effect for the mth sample at the kth sampling location in the jth room in the ith unit; assumed to follow a normal distribution with mean zero and standard deviation σ_D (includes variability due to the sample collection process and variability due to the laboratory analysis process).

Two versions of the model were fitted to the data. The first model contained no fixed effects. That is, the terms in the model involving $RENO_i$, HP_i, and RP_i were excluded. The second version of the model included the fixed effects. The model was tailored to each of the sample types as follows:

- For air duct, bed/rug/upholstery, and entryway samples, it was not possible to estimate sampling location-to-sampling location and duplicate-to-duplicate variability.
- For floor wipe samples, it was not possible to estimate room-to-room and sampling location-to-sampling location variability.
- For window channel wipe samples, it was not possible to estimate room-to-room variability.
- The room level abatement term, RP_i, was estimated only for lead loadings from vacuum floor samples; it was not statistically significant for any other measurement type.
- Because of an insufficient number of samples, it was not possible to estimate abatement or renovation effects on wipe loadings for window channels or bed/rug/upholstery measurements.

The statistical model for soil samples was similar to the model for dust samples. However, side-to-side replaced room-to-room as the within-unit variability source. Since samples were taken at only a single sampling location on each side of the unit, the sampling location-to-sampling location random effect was confounded with the side-to-side random effect. Also, since exterior abatement information was not available by side of unit, a fixed effect for abatement was included only at the unit level. The mathematical form of the fullest model for soil concentrations was

$$\ln(C_{ijm}) = \ln(CGA) + \ln(B_{RENO})RENO_i + \ln(B_{HP})HP_i + H_i + S_{ij} + D_{ijm} \quad (2)$$

for

$i = 1, \ldots, 6$ (# units)

$j = 1, 2$ (# sides/unit)

$m = 1, \ldots,$ # duplicates/side

where

C_{ijm} = measured lead concentration for the mth (replicate) sample on the jth side of the unit in the ith unit;

CGA = overall geometric average of the lead concentration for unrenovated control units,

B_{RENO} = fixed multiplicative increase in the lead concentration due to an ongoing full renovation of the unit;

$RENO_i$ = 1 if ith unit is being fully renovated (Unit 51); 1/2 if the unit is being partially renovated (Unit 19); zero if the unit is not being renovated (other 4 units),

B_{HP} = fixed multiplicative increase in the lead concentration due to abatement having been performed somewhere in the unit;

HP_i = 1 if the ith unit was abated; zero otherwise,

H_i = random effect for the ith unit; assumed to follow a normal distribution with mean zero and standard deviation σ_H,

S_{ij} = random effect for the jth side of the unit at the ith unit; assumed to follow a normal distribution with mean zero and standard deviation σ_S,

D_{ijm} = random effect for the mth (replicate) sample on the jth side of the unit at the ith unit; assumed to follow a normal distribution with mean zero and standard deviation σ_D (includes variability due to the sample collection process and variability due to the laboratory analysis process).

Just as for dust measurements, two versions of the model were fitted to the soil concentrations, the first containing no fixed effects. No tailoring of the soil concentration model was necessary for the individual sample types.

The following random effects were allowed to be correlated, so that different samples and sample types within a unit, within a room, on the same side of a unit, or from the same window could be correlated:

- unit-to-unit random effects for all dust measurements and all soil concentrations within a unit
- room-to-room random effects for all dust measurements within a room
- side-to-side random effects for soil concentrations on the same side of a unit
- sampling location-to-sampling location (window-to-window) random effects for dust measurements within a window.

As is standard with mixed models of this type, all other random effect terms in the models were assumed to be independently distributed.

All statistical analyses were performed with the Statistical Analysis System (SAS) software. For each component sampled, sample medium and response (lead loading, lead concentration, or dust loading), the modeling results could be obtained from several runs of the SAS PROC GLM procedure. The random effects are specified in a RANDOM statement employing the test option, in the order appearing in the tables. For both fixed effects and random effects, all tests are based on Type I sums of squares using the proper denominator based on expected mean squares approximations. The fixed effect tests and estimates are those obtained by including each fixed effect last among the fixed effects, but before all random effects. Thus, each fixed effect is tested for significance controlling for all other fixed effects in the model, and comparing it to the proper linear combination of random effects for an error term. A separate GLM run would be required for each fixed effect in the model.

For the estimates and confidence bounds of the random effects, linear combinations of the observed mean squares were used. Therefore, a generalization of Satterthwaite's approximation (for the 2-sample t-test) is used to estimate degrees of freedom.

In fact, the above procedure was implemented in SAS/IML to avoid the need for multiple GLM runs and the resulting voluminous output, including many pages listing all Type I estimable functions.

4.3 MODELING RESULTS BY MEASUREMENT TYPE

Twenty-four (24) different types of measured values were fitted to the statistical models described in Section 4.2. These measured values fall into three main categories:

- **Lead Loading:** Air duct, bed/rug/upholstery, interior entryway, floor vacuum, window stool vacuum, window channel vacuum, floor wipe, window stool wipe, and window channel wipe samples
- **Lead Concentration:** Air duct, bed/rug/upholstery, interior entryway, floor vacuum, window stool vacuum, window channel vacuum, boundary soil, exterior entryway soil, and foundation soil samples
- **Dust Loading:** Air duct, bed/rug/upholstery, interior entryway, floor vacuum, window stool vacuum, and window channel vacuum samples.

Results from fitting each type of measured value to two different models are provided. Results from the first model, which included no fixed effects, are reported in Section 4.3.1. Results are reported in Section 4.3.2 for the second version of the model, which included fixed-effect terms. The p-values reported are the observed significance levels for the given test. A reported p-value of 0.00 indicates that the actual p-value was less than .005.

4.3.1 Estimates of Variance Components With No Fixed Effects

The first model fitted to the 24 measured values contained no fixed effects. The purpose of this model was to assess general variability without attributing the variability to any particular cause. Note that for all models, the dependent variable was the logarithm of the measurement of interest.

The statistical models for dust samples always contain an overall geometric mean and can contain random effects for unit-to-unit, room-to-room, sampling location-to-sampling location, and duplicate-to-duplicate variability. The statistical models for soil samples always contain an overall geometric mean and can contain random effects for unit-to-unit, side-to-side, and duplicate-to-duplicate variability. As indicated in Section 4.2, the model was tailored to the individual sample types. Thus, some models contain only a subset of the four random effect terms. Generally, if the variance component associated with a random effect term can be estimated it is included in the model.

The results of fitting the random effect models to the 24 measured values are reported in Table 4-4. Results for lead loading measurements, lead concentration measurements, and dust loading measurements are reported in Tables 4-4a, 4-4b, and 4-4c, respectively. The rows of the table are defined by the sample type which can be vacuum, wipe, or soil, and the component type which can take on the following values:

- **Vacuum:** Air duct, bed/rug/upholstery, entryway, floor, window stool, and window channel
- **Wipe:** Floor, window stool, and window channel
- **Soil:** Boundary, entryway, and foundation.

Each row of the table represents a separate fit of the model to a particular set of measurements.

An estimate of the overall geometric mean is provided as the top value in each box in the fourth column. The bottom value is

Table 4-4a. Geometric Mean and Variance Component Estimates from Model with No Fixed Effects: Lead Loading ($\mu g/ft^2$)

Sample Type	Component	Sample Size	Geometric Mean*	Standard Deviation**				
				Total	Unit	Room	Sampling Location	Replicate Sample
Vacuum	Air Duct	10	**308** 0.69	**1.72** (6.34)	**1.24** (1.70) 0.12	**1.19** (5)		
Vacuum	Bed/Rug/Uph	8	**8** 0.50	**1.66** (6.89)	**0** (0.42) 0.70	**1.93** (3)		
Vacuum	Entryway	12	**23** 0.68	**1.99** (8.95)	**1.24** (1.33) 0.18	**1.56** (6)		
Vacuum	Floor	39	**13** 0.72	**1.95** (7.42)	**1.67** (4.09) 0.00	**0.78** (5.95) 0.04	**0.39** (1.48) 0.18	**0.47** (11)
Vacuum	Window Stool	25	**34** 0.62	**2.04** (13.89)	**1.08** (1.31) 0.13	**1.66** (13) 0.01	**0.35** (4) 0.33	**0.32** (2)
Vacuum	Window Channel	11	**1250** 0.21	**1.25** (6.83)	**0** (1.65) 0.92	**1.37** (0.82) 0.92	**1.06** (0.81) 0.19	**0.35** (1)
Wipe	Floor	12	**51** 0.79	**1.95** (5.14)	**1.92** (4.86) 0.00			**0.33** (6)
Wipe	Window Stool	12	**144** 0.77	**1.76** (5.73)	**1.69** (4.74) 0.88	**0** (1) 0.65	**0.79** (2) 0.08	**0.40** (3)

* Logarithmic standard error is listed below the mean.

** Top value is estimated logarithmic standard deviation, middle value is estimated degrees of freedom for estimating the random effect standard deviation, and bottom value (when present) is observed significance level.

Table 4-4b. Geometric Mean and Variance Component Estimates from Model with No Fixed Effects: Lead Concentration (μg/g)

Sample Type	Component	Sample Size	Geometric Mean*	Standard Deviation**				
				Total	Unit	Room or Side	Sampling Location	Replicate Sample
Vacuum	Air Duct	10	**749** 0.08	**0.53** (7.35)	**0.00** (2.59) 0.90	**0.67** (5)		
Vacuum	Bed/Rug/Uph	8	**174** 0.33	**0.84** (6.30)	**0.43** (0.34) 0.37	**0.72** (3)		
Vacuum	Entryway	12	**314** 0.37	**1.01** (7.14)	**0.81** (2.94) 0.05	**0.60** (6)		
Vacuum	Floor	39	**255** 0.33	**0.97** (10.43)	**0.71** (3.13) 0.01	**0.49** (4.63) 0.06	**0.36** (4.64) 0.03	**0.25** (11)
Vacuum	Window Stool	25	**724** 0.51	**1.53** (11.51)	**1.00** (2.34) 0.04	**1.02** (7.89) 0.06	**0.44** (1.8) 0.23	**0.29** (2)
Vacuum	Window Channel	11	**1448** 0.38	**1.08** (7.90)	**0.17** (0) 0.52	**1.06** (2.95) 0.19	**0** (0.28) 0.63	**0.17** (1)
Soil	Boundary	15	**121** 0.34	**0.92** (7.51)	**0.69** (2.32) 0.08	**0.61** (5.93) 0.00		**0.05** (3)
Soil	Entryway	16	**196** 0.37	**1.03** (8.21)	**0.78** (2.59) 0.08	**0.45** (1.02) 0.27		**0.51** (4)
Soil	Entryway (2 outliers deleted)	14	**216** 0.40	**1.04** (7.01)	**0.81** (2.49) 0.09	**0.63** (4.35) 0.02		**0.18** (3)
Soil	Foundation	17	**217** 0.36	**0.96** (6.94)	**0.77** (2.93) 0.05	**0.54** (5.09) 0.01		**0.17** (5)

* Logarithmic standard error is listed below the mean.

** Top value is estimated logarithmic standard deviation, middle value is estimated degrees of freedom for estimating the random effect standard deviation, and bottom value (when present) is observed significance level.

Table 4-4c. Geometric Mean and Variance Component Estimates from Model with No Fixed Effects: Dust Loading (mg/ft^2)

Sample Type	Component	Sample Size	Geometric Mean*	Standard Deviation**				
				Total	Unit	Room	Sampling Location	Replicate Sample
Vacuum	Air Duct	10	**411** 0.59	**1.46** (6.30)	**1.06** (1.74) 0.11	**1.00** (5)		
Vacuum	Bed/Rug/Uph	8	**49** 0.23	**1.18** (5.47)	**0.00** (1.60) 0.89	**1.64** (3)		
Vacuum	Entryway	12	**72** 0.45	**1.39** (9.60)	**0.75** (0.80) 0.24	**1.17** (6)		
Vacuum	Floor	39	**52** 0.52	**1.45** (8.43)	**1.18** (3.79) 0.00	**0.70** (7.99) 0.03	**0.00** (0.30) 0.64	**0.51** (11)
Vacuum	Window Stool	25	**47** 0.28	**1.06** (17.95)	**0.39** (0.48) 0.26	**0.75** (3.52) 0.18	**0.57** (2.67) 0.14	**0.26** (2)
Vacuum	Window Channel	11	**863** 0.18	**1.02** (7.47)	**0.00** (1.46) 0.89	**0.63** (0.06) 0.56	**1.21** (0.96) 0.09	**0.18** (1)

* Logarithmic standard error is listed below the mean.

** Top value is estimated logarithmic standard deviation, middle value is estimated degrees of freedom for estimating the random effect standard deviation, and bottom value (when present) is observed significance level.

the logarithmic standard error of this estimate. The logarithmic standard error is the standard error of the logarithm of the estimate.

In the last four columns, the top value in each box is an estimate of the corresponding variance component in standard deviation form. As indicated previously, it was not possible to include all random effects in every model. When it was not possible to include a random effect in the model, the box associated with the random affect is left blank and the line separating it from one or more of the other boxes is eliminated. In these cases, the random effects associated with these long boxes are confounded and the standard deviation estimate reported corresponds to the combined variability from all corresponding random sources. That is, if a standard deviation estimate is not reported for a particular source of variability, then the estimate reported to the left of the blank area includes the variability contributed by the source for which no estimate was reported.

For example, for wipe floor samples, the estimate reported in the unit standard deviation column is actually an estimate of the combined unit-to-unit, room-to-room within unit, and sampling location-to-sampling location within room variation. However, the replicate sample standard deviation is indeed an estimate of the side-by-side standard deviation of wipe floor samples.

The top value in each box in the fifth column of Table 4-4 is an estimate of the total standard deviation. Note that this value and all other standard deviation estimates in Table 4-4 are <u>logarithmic</u> standard deviations. For dust samples, the total standard deviation is the standard deviation of a measured value from a randomly selected duplicate sample from a randomly selected sampling location in a randomly selected room in a randomly selected unit. For soil samples, the total standard deviation is the standard deviation of a soil lead concentration from a randomly selected duplicate sample from a randomly

selected sampling location on a randomly selected side of a randomly selected unit.

In most cases, the total variance (the total standard deviation squared) is simply the sum of the individual variances (the individual standard deviations squared). This will not be the case, however, if any of the individual standard deviation estimates is reported as zero. Due to the small number of degrees of freedom available for estimating certain variance components, some of the individual variance estimates were initially negative. Since all variances are by definition nonnegative, when this occurred the estimate presented in Table 4-4 is zero. When calculating the total variance, however, it is appropriate to use the negative estimate of an individual variance component in the sum.

The value in parentheses below each standard deviation estimate is the approximate number of degrees of freedom associated with the estimate. The larger the number of degrees of freedom, the more precise the estimate. In the unit, room or side, and sampling location standard deviation columns, a value is sometimes reported below the approximate degrees of freedom. This value is the observed significance level (OSL) of the test of the hypothesis that the corresponding standard deviation is equal to zero. A small value of the OSL is an indication that the standard deviation is significantly larger than zero. This test can be performed for all but the lowest order variance component (farthest to the right).

The variance component estimates are illustrated graphically in Figure 4-6a for lead loading, in Figure 4-6b for lead concentration, and in Figure 4-6c for dust loading. These figures provide a pictorial view of the estimates in Tables 4-4a, 4-4b, and 4-4c, respectively. (In Figure 4-6b, EWY2-O refers to the analysis reported in Table 4-4b in which 2 outliers were deleted.) For each sample type, the estimated standard deviations have been squared to convert them to estimated variances. In order to see how each variance component

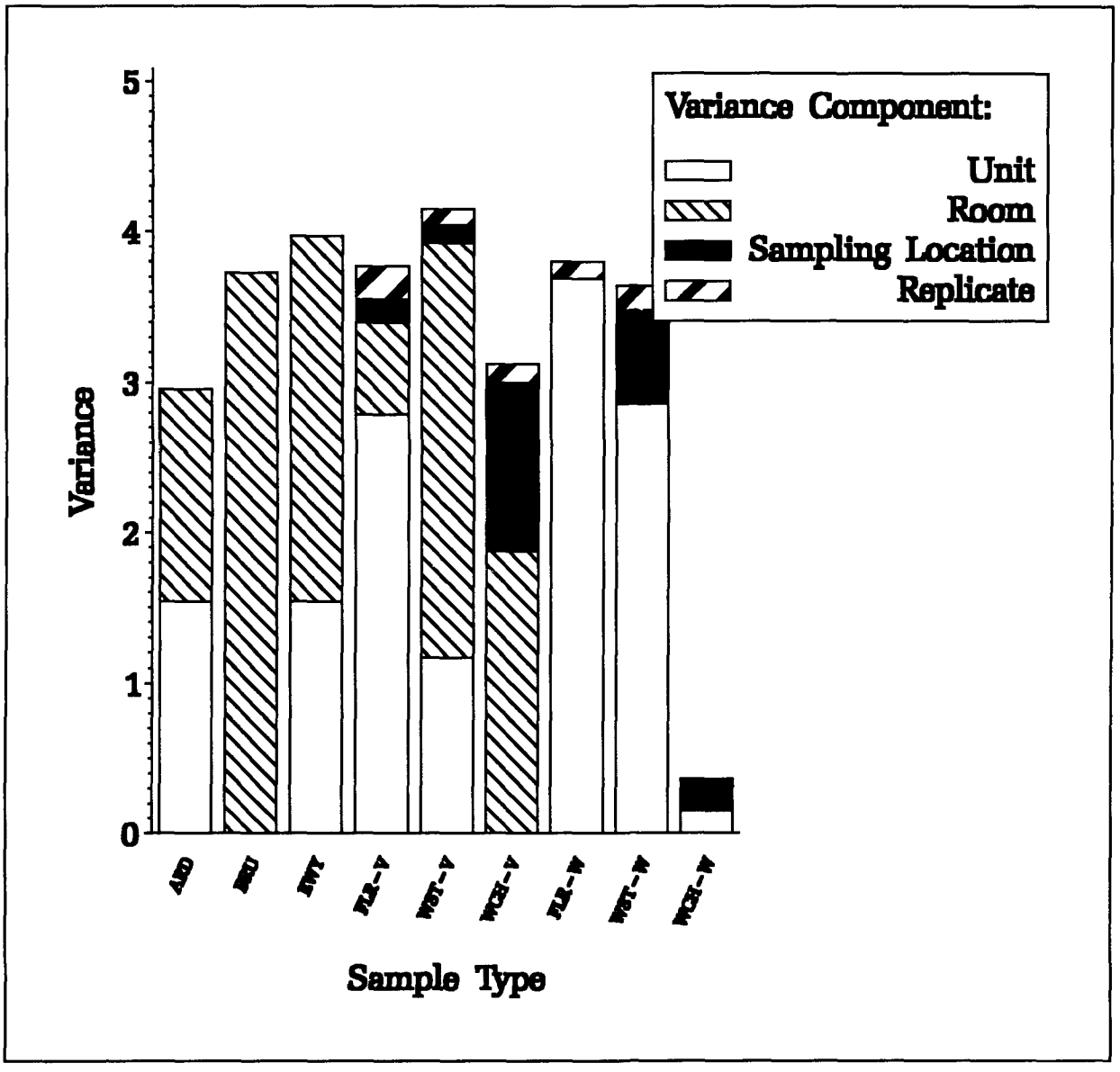

Figure 4-6a. Variance component estimates from model with no fixed effects: lead loading ($\mu g/ft^2$).

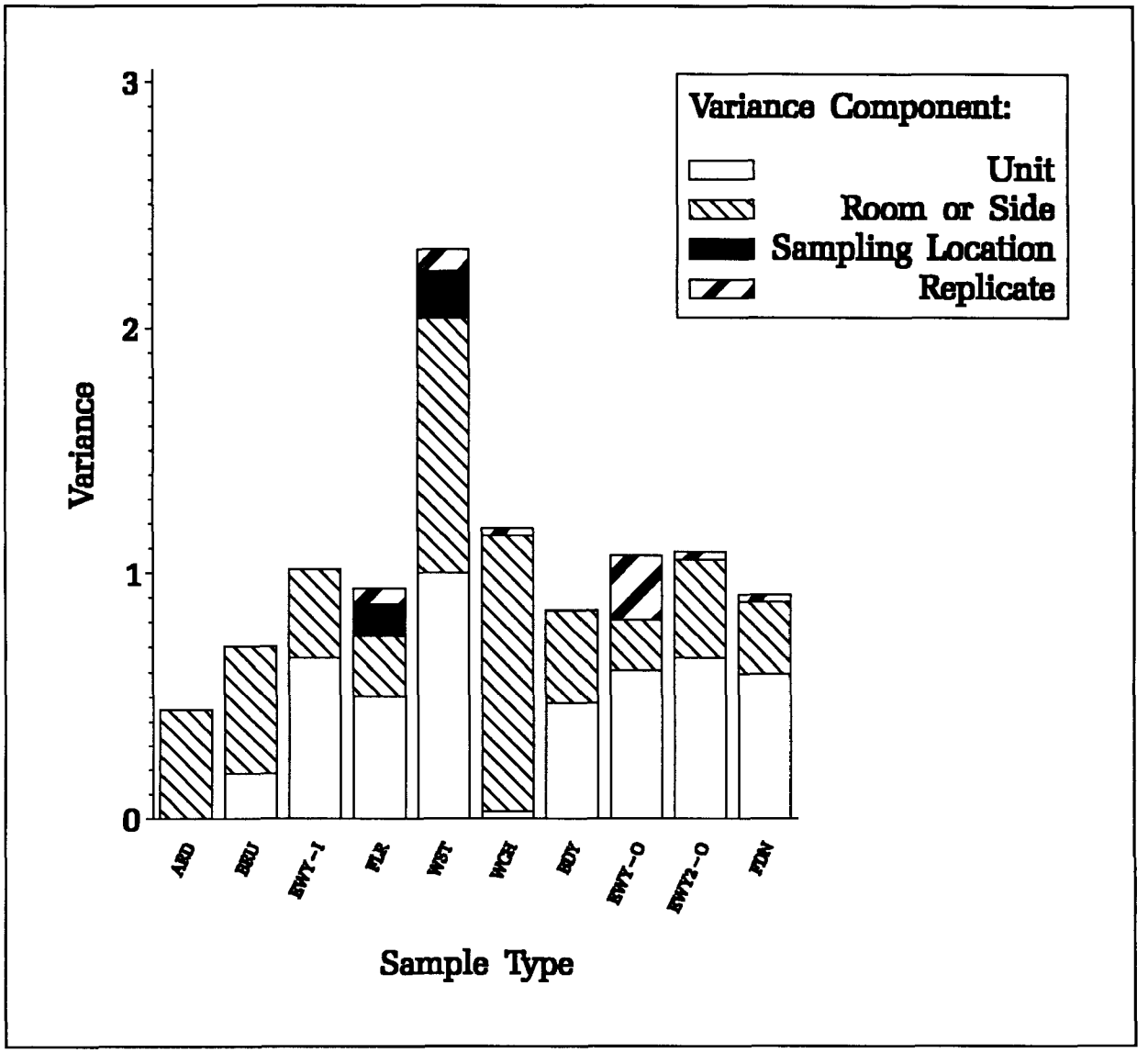

Figure 4-6b. Variance component estimates from model with no fixed effects: lead concentration ($\mu g/g$).

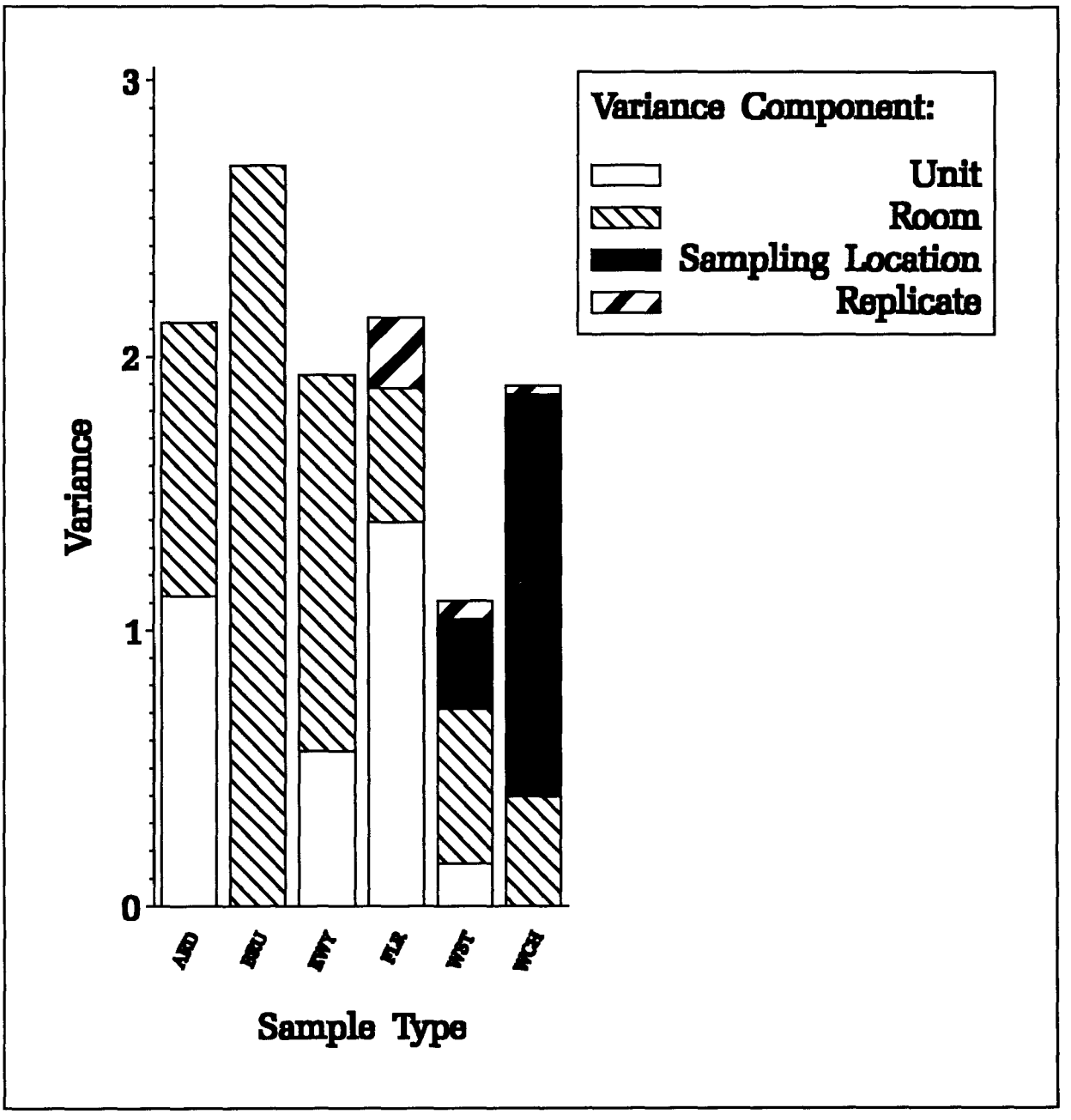

Figure 4-6c. Variance component estimates from model with no fixed effects: dust loading (mg/ft^2).

contributes to total variability, the estimates are stacked. In most cases, the total height of the bar is the total variance (square of the total standard deviation). This will not be the case if any of the individual standard deviation estimates is reported as zero, as discussed above.

The following subsection contains a discussion of which variance components are estimable for which sample types. This discussion is followed by individual summaries of the modeling results for lead loading, lead concentration, and dust loading. Later, in Section 4.4, global summaries of the modeling results are presented by sample type (e.g., floor samples, window channel samples).

Estimable Variance Components

For air duct, bed/rug/upholstery, and entryway vacuum samples, the unit-to-unit variance component was estimable as well as the combined room-to-room, sampling location-to-sampling location, and replicate-to-replicate variance component. The last three variance components are confounded here because only a single sample was taken in each room.

For floor, window stool, and window channel vacuum samples, all variance components could be estimated. There were more vacuum samples for floors (39) and window stools (25) than for any other sample type in the study.

For floor wipe samples, the replicate-to-replicate variance component can be estimated as well as a combined unit-to-unit, room-to-room, and sampling location-to-sampling location variance component. The first three variance components are confounded here because floor wipe sampling was conducted at a single sampling location in a single room in each house.

For window stool wipe samples, all variance components were estimated, but there was very little data available for these estimates. By design, the unit-to-unit and room-to-room variance components should be confounded, since window stool wipe samples were to be taken in only one room per house. However, sometimes

a secondary bridge room was selected, allowing the possibility of assessing room-to-room variability when window stool wipe samples were taken in both rooms.

For window channel wipe samples, it was possible to estimate the combined unit-to-unit and room-to-room variance component, the sampling location-to-sampling location variance component and the replicate-to-replicate variance component. However, since there were only six samples, few degrees of freedom are available to estimate the variance components. The first two variance components are confounded since window channel wipe samples were taken in only one room per house.

The soil data followed a simple structure for all three sample types (boundary, entryway, foundation). This structure permitted estimates of the unit-to-unit variance component, the combined side-to-side and sampling location-to-sampling location variance component, and the replicate-to-replicate variance component. For soil samples, the sampling location-to-sampling location random effect is confounded with the side-to-side random effect since samples were taken at only a single sampling location on each side of the unit.

Lead Loadings

The following is a summary of the modeling results for lead loading for the model with no fixed effects. These results are reported in Table 4-4a and the variance component estimates illustrated in Figure 4-6a.

The geometric average lead loadings for the different sample types in decreasing order are:

- Window channel (vacuum 1250 $\mu g/ft^2$, wipe 801 $\mu g/ft^2$)
- Air duct (308 $\mu g/ft^2$)
- Window stool (vacuum 34 $\mu g/ft^2$, wipe 144 $\mu g/ft^2$)
- Entryway (23 $\mu g/ft^2$)

- Floor (vacuum 13 $\mu g/ft^2$, wipe 51 $\mu g/ft^2$)
- Bed/rug/upholstery (8 $\mu g/ft^2$).

Interestingly, the window channel samples had the lowest two total standard deviations (1.25 for vacuum, 0.61 for wipe). For the remaining sample types, the total standard deviation was fairly consistent ranging from a low of 1.66 (bed/rug/upholstery) to a high of 2.04 (vacuum window stool).

The unit-to-unit variance component is statistically significant (at the 0.05 level) for only two sample types: floor vacuum samples and floor wipe samples. This variance component is marginally significant for air duct, entryway, and vacuum window stool samples. The estimated variance component is negative for bed/rug/upholstery and vacuum window channel samples. With the exception of these last two sample types, the unit-to-unit variance component is a substantial contributor to total variability. Of those sample types for which the room-to-room variance component could be tested for significance, it is significant for only vacuum floor and vacuum window stool samples.

Lead Concentrations

The following is a summary of the modeling results for lead concentration for the model with no fixed effects. These results are reported in Table 4-4b and variance component estimates illustrated in Figure 4-6b. As reported in Section 5.3, one pair of side-by-side soil samples differed significantly (unit 19). Because of the effect of this pair of data values on the replicate standard deviation, modeling results for entryway soil samples are also reported with this pair of values (outliers) eliminated.

The geometric average lead concentrations for the different sample types in decreasing order are:

- Window channel dust (1448 μg/g)
- Air duct dust (749 μg/g)
- Window stool dust (724 μg/g)
- Entryway dust (314 μg/g)
- Floor dust (255 μg/g)
- Foundation soil (217 μg/g)
- Entryway soil (196 μg/g)
- Bed/rug/upholstery dust (174 μg/g)
- Boundary soil (121 μg/g).

The six dust sample types are in the same exact order as for lead loadings. Note also that the soil lead concentrations are lower than all the dust lead concentrations except for the bed/rug/upholstery sample type.

The smallest total standard deviation was observed for air ducts (0.53) and the largest was for window stools (1.53). The remainder of the total standard deviations were fairly consistent from a low value of 0.84 (bed/rug/upholstery) to a high of 1.08 (vacuum window channel). Note that the variability in lead concentrations is substantially lower than the variability in lead loadings. This is logical since the variability in lead loadings includes variability due to both lead concentrations and dust loadings.

For the vacuum dust sample types, the unit-to-unit variance component is statistically significant for entryways, floors, and window stools. The room-to-room variance component is also marginally significant for floors and window stools. For all three soil sample types, both the unit-to-unit variance component and the side-to-side variance component were at least marginally significant. With the exception of air duct and vacuum window channel samples, the unit-to-unit variance component was a

substantial contributor to total variability for both dust and soil samples.

Dust Loading

The following is a summary of the modeling results for dust loading for the model with no fixed effects. These results are reported in Table 4-4c and variance component estimates illustrated in Figure 4-6c.

The geometric average dust loadings for the different vacuum sample types in decreasing order are:

- Window channel (863 mg/ft^2)
- Air duct (411 mg/ft^2)
- Entryway (72 mg/ft^2)
- Floor (52 mg/ft^2)
- Bed/rug/upholstery (49 mg/ft^2)
- Window stool (47 mg/ft^2).

The average dust loading values fall in exactly the same order as for lead loadings and concentrations, with one major exception. Window stools have dropped from third to last place in the list. These results lead to two conclusions concerning lead loadings:

- The higher lead loadings for window stools relative to floors can be attributed primarily to higher lead concentrations in the stool dust and not to higher dust loadings.
- With window stools as the exception, differences in dust lead loadings among different sample types can be attributed to differences in both dust lead concentration and dust loading on the surface being sampled; dust lead concentration and dust lead loading are positively correlated from sample type to sample type (see Table 4-3).

The smallest total standard deviation was observed for window channels (1.02) and the largest was for air ducts (1.46). The four other total standard deviations varied throughout this range. Note again that the variability in dust loadings is substantially lower than the variability in lead loadings. Again, this is logical since the variability in lead loadings includes variability due to both lead concentrations and dust loadings.

Floor samples had the only statistically significant variance components. Both the unit-to-unit and room-to-room variance components were observed to be significant. For air duct, entryway, and floor samples, the unit-to-unit variance component is a substantial contributor to total variability. For bed/rug/upholstery, window stool, and window channel samples, the unit-to-unit variance component is only a minor contributor to total variability.

4.3.2 Estimates of Renovation Effects, Abatement Effects, and Variance Components

A second statistical model was fitted to the data for each of the sample types. The second model is exactly like the model fitted in Section 4.3.1, except that fixed-effect terms representing renovation and abatement effects have been added to the model. These terms attempt to explain portions of the unit-to-unit and room-to-room variability. Due to the limited number of units and the importance of the renovation effect, it is not possible to include fixed-effect terms for type of abatement or amount of abatement without reducing the degrees of freedom for unit-to-unit variability to an unreasonably low value. Estimates of the geometric mean, estimated fixed effects for abatement and renovation, and variance component estimates are reported in Table 4-5a for lead loading, in Table 4-5b for lead concentration, and in Table 4-5c for dust loading.

Rather than representing an overall mean for all units, the geometric mean now represents the expected value of the dependent

Table 4-5a. Estimated Renovation Effects, Estimated Abatement Effects, and Variance Component Estimates from Mixed Model ANOVA: Lead Loading ($\mu g/ft^2$)

Sample Type	Component	Sample Size	Fixed Effects*				Random Effects Standard Deviation**				
			Geometric Mean for Unrenovated Control Houses	Renovation	House Abatement	Room Abatement	Total	Unit	Room	Sampling Location	Replicate Sample
Vacuum	Air Duct	10	**649** (1.76)	**0.01** (5.26) 0.43	**0.49** (2.03) 0.76		**1.95** (3.12)	**1.54** (1.24) 0.07	**1.19** (5)		
Vacuum	Entryway	12	**6.62** (0.52)	**40.9** (0.74) 0.02	**1.57** (0.60) 0.51		**1.30** (8.90)	**0.00** (1.66) 0.76	**1.56** (6)		
Vacuum	Floor	39	**3.76** (0.49)	**70.0** (0.70) 0.01	**9.93** (0.99) 0.06	**0.13** (0.90) 0.05	**0.99** (12.79)	**0.43** (0.55) 0.21	**0.64** (4) 0.08	**0.39** (1.48) 0.18	**0.47** (11)
Vacuum	Window Stool	25	**6.70** (0.95)	**6.11** (1.34) 0.26	**5.47** (1.09) 0.21		**1.86** (11.77)	**0.69** (0.28) 0.27	**1.66** (11.27) 0.01	**0.35** (0.89) 0.33	**0.32** (2)
Vacuum	Window Channel	11	**2873** (0.69)	**0.29** ***	**0.59** (0.64) 0.45		**1.02** (4.07)	**0.00** (2.89) 0.98	**1.37** (0.82) 0.42	**1.06** (0.81) 0.19	**0.35** (1)
Wipe	Floor	12	**7.63** (0.41)	**69.4** (0.57) 0.01	**3.53** (0.47) 0.07		**0.59** (4.15)	**0.48** (1.96) 0.04			**0.33** (6)
Wipe	Window Stool	12	**100** (0.82)	**28.2** (1.00) 0.09	**0.40** (0.94) 0.41		**1.07** (3.88)	**0.94** (2.11) 0.59	**0.00** (0.87) 0.65	**0.79** (1.39) 0.08	**0.40** (3)

* Top value is geometric means or multiplicative estimate, middle value is logarithmic standard error of estimate, and bottom value (when present) is observed significance level.

** Top value is estimated logarithmic standard deviation, middle value is estimated degrees of freedom for estimating the random effect standard deviation, and bottom value (when present) is observed significance level; the last standard deviation estimate (on the right) cannot be tested for significance and, therefore, has no observed significance level.

*** The denominator in the F-statistic to test the significance of this effect was negative and therefore a significance level based on this test cannot be calculated.

Table 4-5b. Estimated Renovation Effects, Estimated Abatement Effects, and Variance Component Estimates from Mixed Model ANOVA: Lead Concentration ($\mu g/g$)

Sample Type	Component	Sample Size	Fixed Effects*				Random Effects Standard Deviation**				
			Geometric Mean for Unrenovated Control Houses	Renovation	House Abatement	Room Abatement	Total	Unit	Room or Side	Sampling Location	Replicate Sample
Vacuum	Air Duct	10	**875** (0.33)	**0.51** (1.34) 0.63	**0.84** (0.37) 0.67		**0.58** (6.94)	**0.00** (1.22) 0.68	**0.67** (5)		
Vacuum	Entryway	12	**96.3** (0.15)	**4.85** (0.21) 0.00	**3.25** (0.17) 0.01		**0.47** (8.06)	**0.00** (3.46) 0.89	**0.60** (6)		
Vacuum	Floor	39	**106** (0.35)	**4.89** (0.50) 0.05	**2.86** (0.71) 0.18	**0.73** (0.65) 0.64	**0.70** (12.14)	**0.31** (0.55) 0.21	**0.45** (3.54) 0.08	**0.36** (4.64) 0.03	**0.25** (11)
Vacuum	Window Stool	25	**245** (0.95)	**1.42** (1.35) 0.81	**4.06** (1.10) 0.29		**1.56** (6.98)	**1.06** (1.53) 0.04	**1.02** (7.89) 0.06	**0.44** (1.80) 0.23	**0.29** (2)
Vacuum	Window Channel	11	**2150** (0.83)	**0.33** (0.98) 0.38	**0.95** (0.92) 0.96		**1.12** (4.94)	**0.35** (0.03) 0.45	**1.06** (2.95) 0.19	**0.00** (0.28) 0.63	**0.17** (1)
Soil	Boundary	15	**53.6** (0.61)	**2.14** (0.85) 0.44	**2.41** (0.70) 0.29		**0.89** (4.77)	**0.65** (1.34) 0.11	**0.61** (5.93) 0.00		**0.05** (3)
Soil	Entryway	16	**65** (0.30)	**1.92** (0.45) 0.23	**4.71** (0.34) 0.02		**0.64** (11.11)	**0.00** (0.14) 0.56	**0.45** (1.02) 0.27		**0.51** (4)
Soil	Foundation	17	**109** (0.70)	**2.39** (0.98) 0.44	**1.97** (0.80) 0.46		**0.99** (4.11)	**0.81** (1.87) 0.04	**0.54** (5.09) 0.01		**0.17** (5)

* Top value is geometric mean or multiplicative estimate, middle value is logarithmic standard error of estimate, and bottom value (when present) is observed significance level.

** Top value is estimated logarithmic standard deviation, middle value is estimated degrees of freedom for estimating the random effect standard deviation, and bottom value (when present) is observed significance level; same as Table 4-4a.

Table 4-5c. Estimated Renovation Effects, Estimated Abatement Effects, and Variance Component Estimates from Mixed Model ANOVA: Dust Loading (mg/ft^2)

Sample Type	Component	Sample Size	Fixed Effects*				Random Effects Standard Deviation**				
			Geometric Mean for Unrenovated Control Houses	Renovation	House Abatement	Room Abatement	Total	Unit	Room	Sampling Location	Replicate Sample
Vacuum	Air Duct	10	**742** (1.49)	**0.02** (4.45) 0.43	**0.58** (1.72) 0.78		**1.65** (3.11)	**1.31** (1.24) 0.07	**1.00** (5)		
Vacuum	Entryway	12	**69** (0.54)	**8.33** (0.77) 0.07	**0.48** (0.62) 0.32		**1.09** (8.64)	**0.00** (0.17) 0.56	**1.17** (6)		
Vacuum	Floor	39	**36** (0.64)	**14.31** (0.90) 0.06	**3.47** (1.19) 0.34	**0.18** (1.03) 0.13	**1.09** (7.94)	**0.70** (1.41) 0.06	**0.70** (7.31) 0.03	**0.00** (0.30) 0.64	**0.51** (11)
Vacuum	Window Stool	25	**27** (0.27)	**4.32** (0.37) 0.02	**1.35** (0.30) 0.38		**0.88** (18.54)	**0.00** (3.28) 0.78	**0.75** (3.52) 0.18	**0.57** (2.67) 0.14	**0.26** (2)
Vacuum	Window Channel	11	**1336** (0.75)	**0.87** (0.29) 0.95	**0.62** (0.79) 0.57		**1.06** (6.50)	**0.00** (0.97) 0.75	**0.63** (0.06) 0.56	**1.21** (0.96) 0.09	**0.18** (1)

* Top value is geometric mean or multiplicative estimate, middle value is logarithmic standard error of estimate, and bottom value (when present) is observed significance level.

** Top value is estimated logarithmic standard deviation, middle value is estimated degrees of freedom for estimating the random effect standard deviation, and bottom value (when present) is observed significance level; same as Table 4-4a.

variable for unrenovated control units. As in Table 4-4, the estimated geometric mean is reported as the top value in the fourth column with the logarithmic standard error reported in parentheses below.

For renovation, house abatement, and room abatement effects, estimated effects are reported as the top value in the fifth through seventh columns of Table 4-5. The estimate is an estimate of the multiplicative effect of the presence of that condition. For example, to determine an estimate of the geometric average lead concentration (Table 4-5a) for vacuum window stool samples in abated, unrenovated houses, multiply the geometric mean for unrenovated control houses by the estimate for house abatement:

$$6.70 * 5.47 = 36.56\ \mu g/ft^2$$

Below each of these estimates, the logarithmic standard error of the estimate is reported in parentheses. The bottom value reported in these columns is the observed significance level of the test that the true multiplicative effect is equal to one (i.e., no multiplicative effect) versus the alternative that the multiplicative factor is not equal to one. The estimated geometric means from the mixed model analysis are presented in Figure 4-7a for lead loading, lead concentration, and dust loading. The estimated multiplicative effects are illustrated graphically in Figure 4-7b for lead loading, in Figure 4-7d for lead concentration, and in Figure 4-7f for dust loading. Effects with an observed significance level of 0.05 or less are marked with an asterisk (*).

The last four columns of Table 4-5 provide estimates of the various variance components after controlling for the fixed effects listed previously for that sample type. The structure is the same for these as it was in Table 4-4. Notice that the degrees of freedom for the unit standard deviation are smaller than in Table 4-4. The variance component estimates are

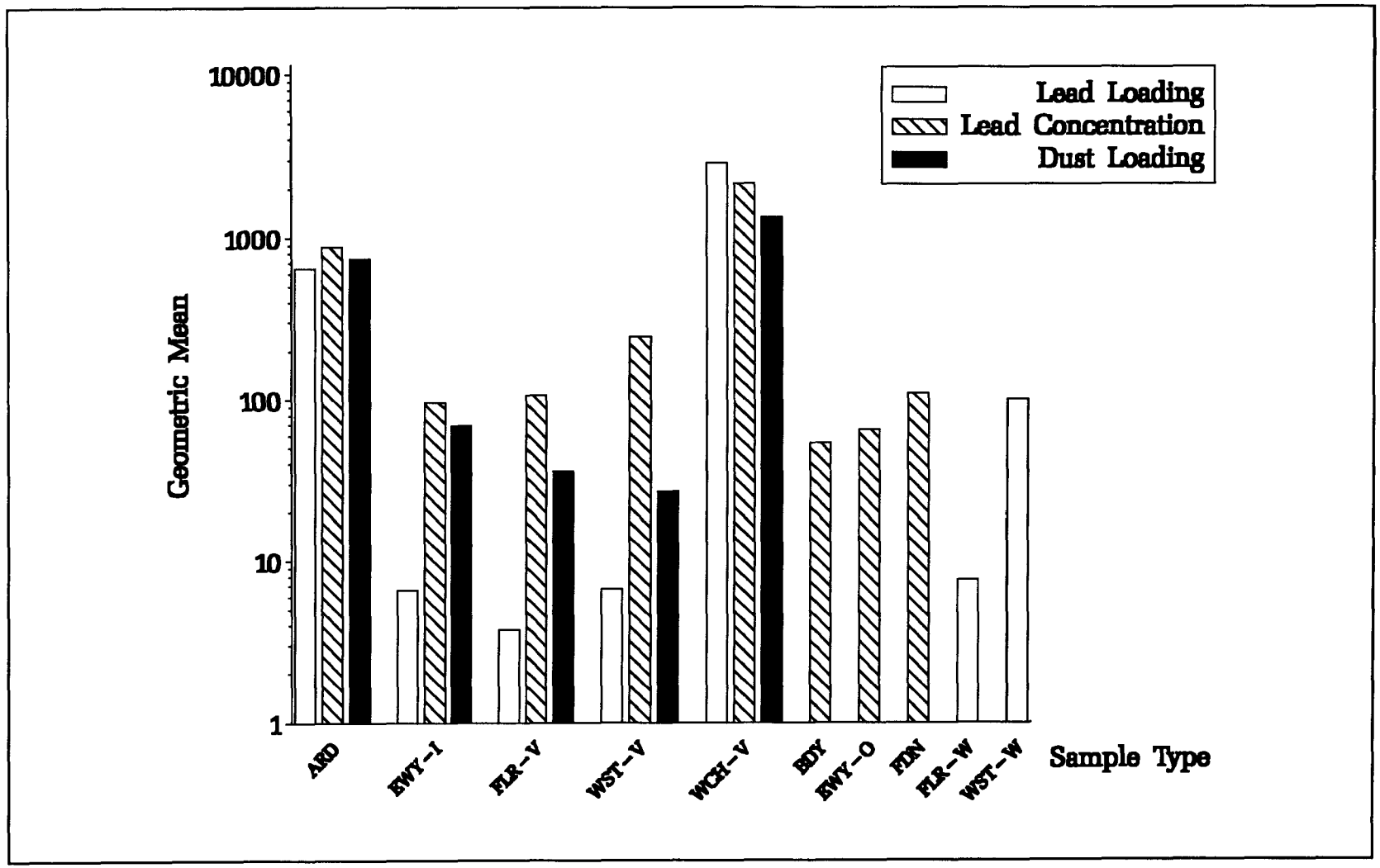

Figure 4-7a. Estimated geometric mean in unrenovated control units for lead loading in $\mu g/ft^2$, lead concentration in $\mu g/g$, and dust loading in mg/ft^2 by sample type.

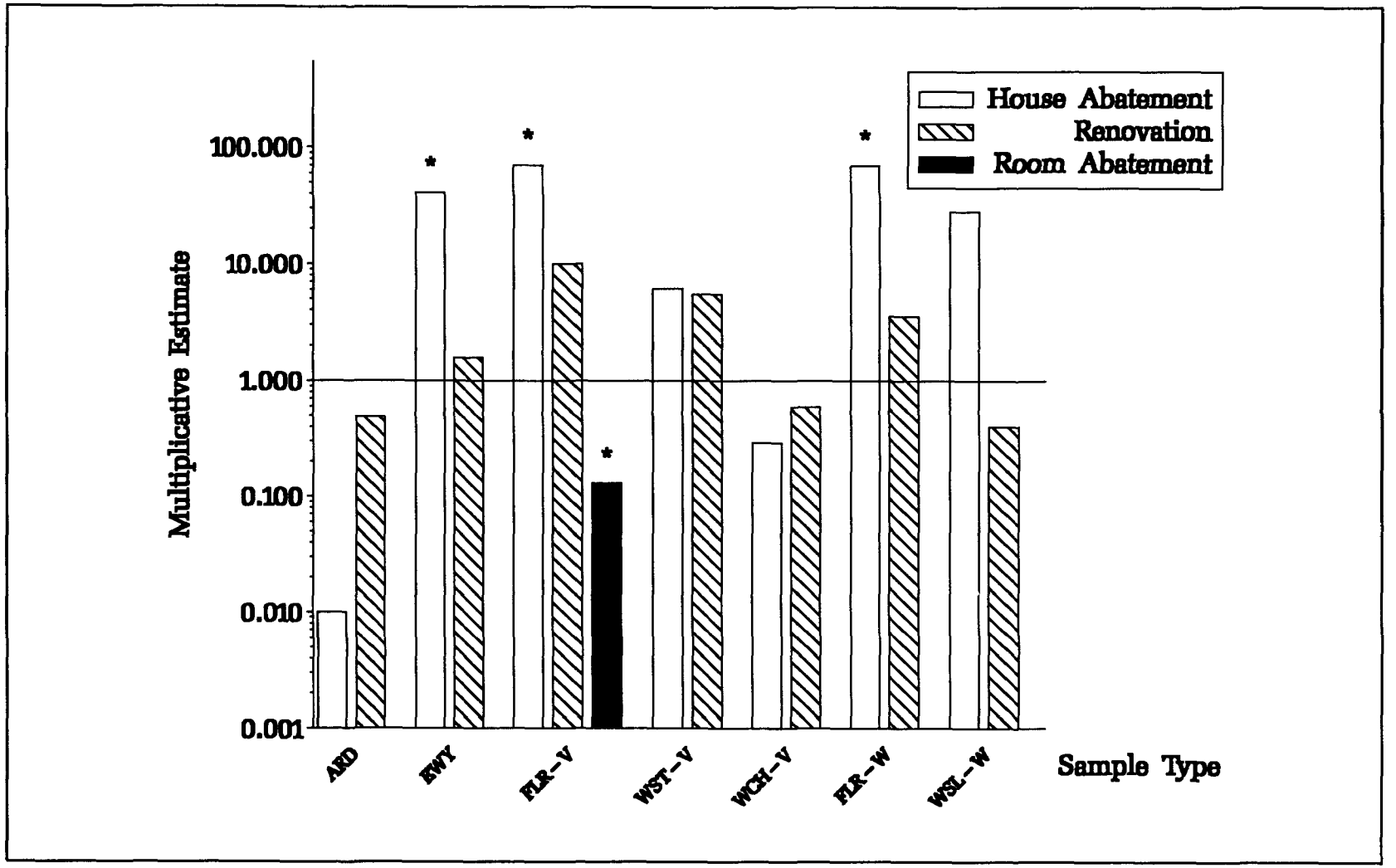

Figure 4-7b. Estimated multiplicative effects of renovation and abatement from mixed model ANOVA: lead loading ($\mu g/ft^2$).

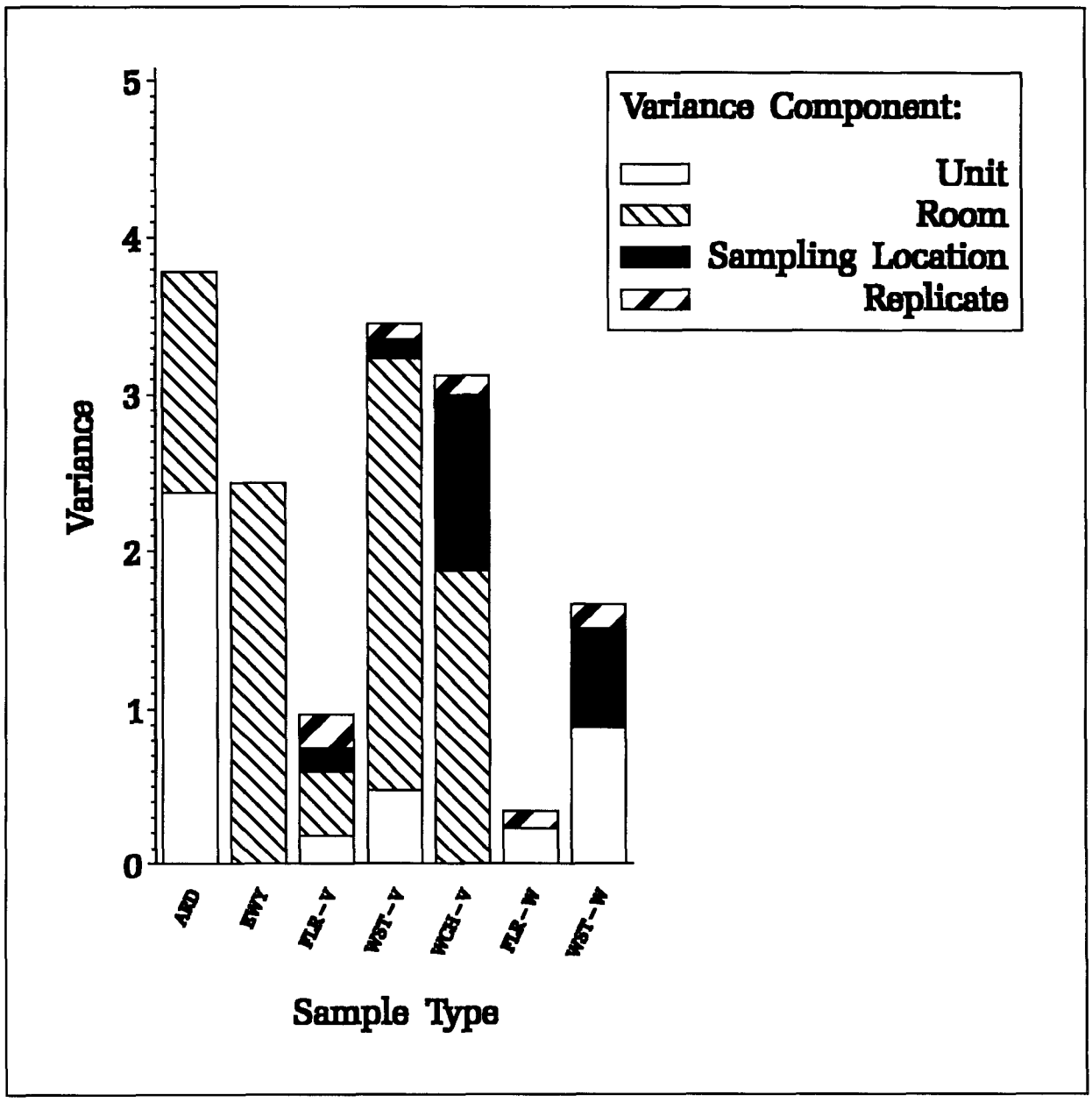

Figure 4-7c. Variance component estimates from mixed model ANOVA: lead loading ($\mu g/ft^2$).

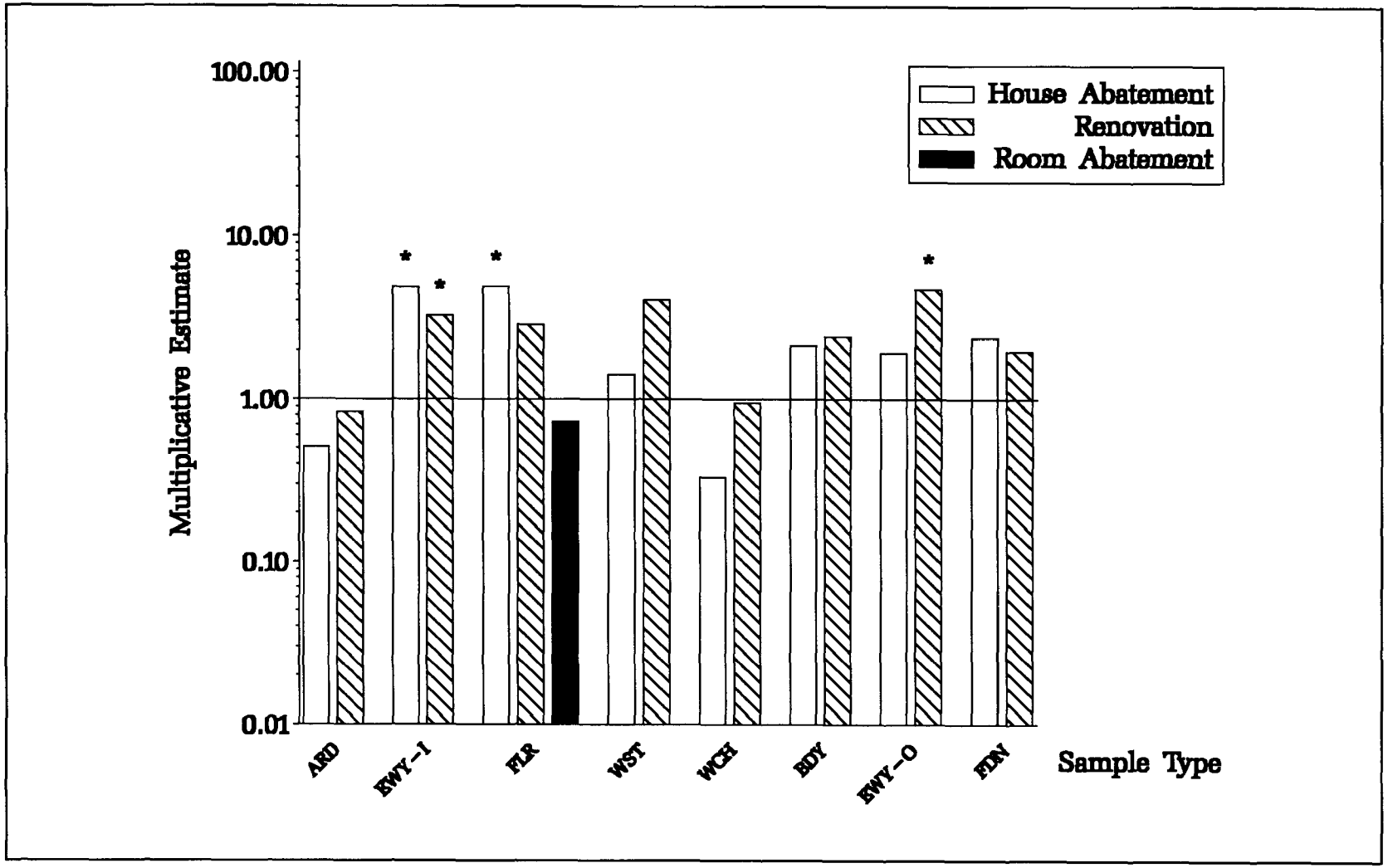

Figure 4-7d. Estimated multiplicative effects of renovation and abatement from mixed model ANOVA: lead concentration ($\mu g/g$).

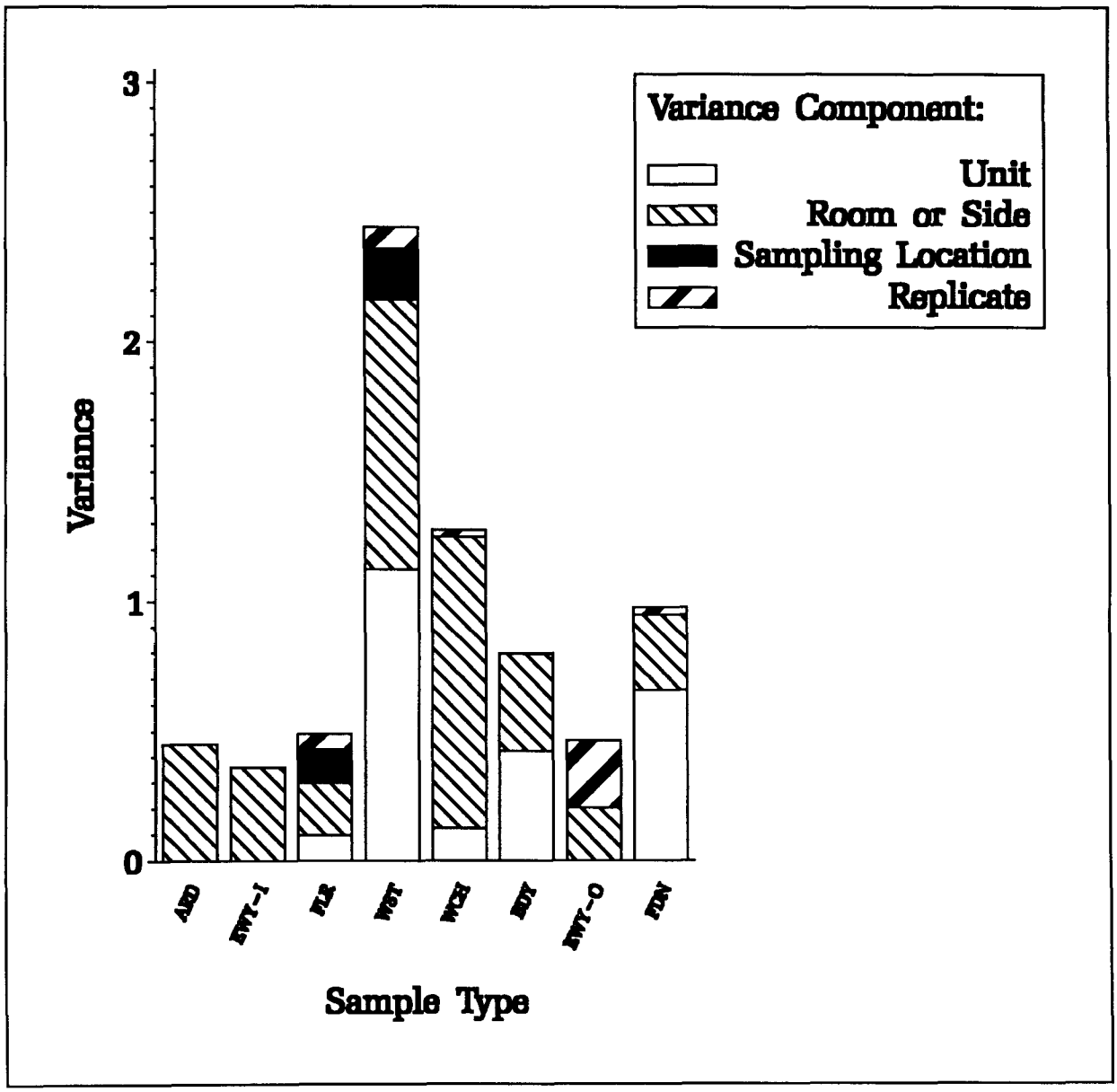

Figure 4-7e. Variance component estimates from mixed model ANOVA: lead concentration ($\mu g/g$).

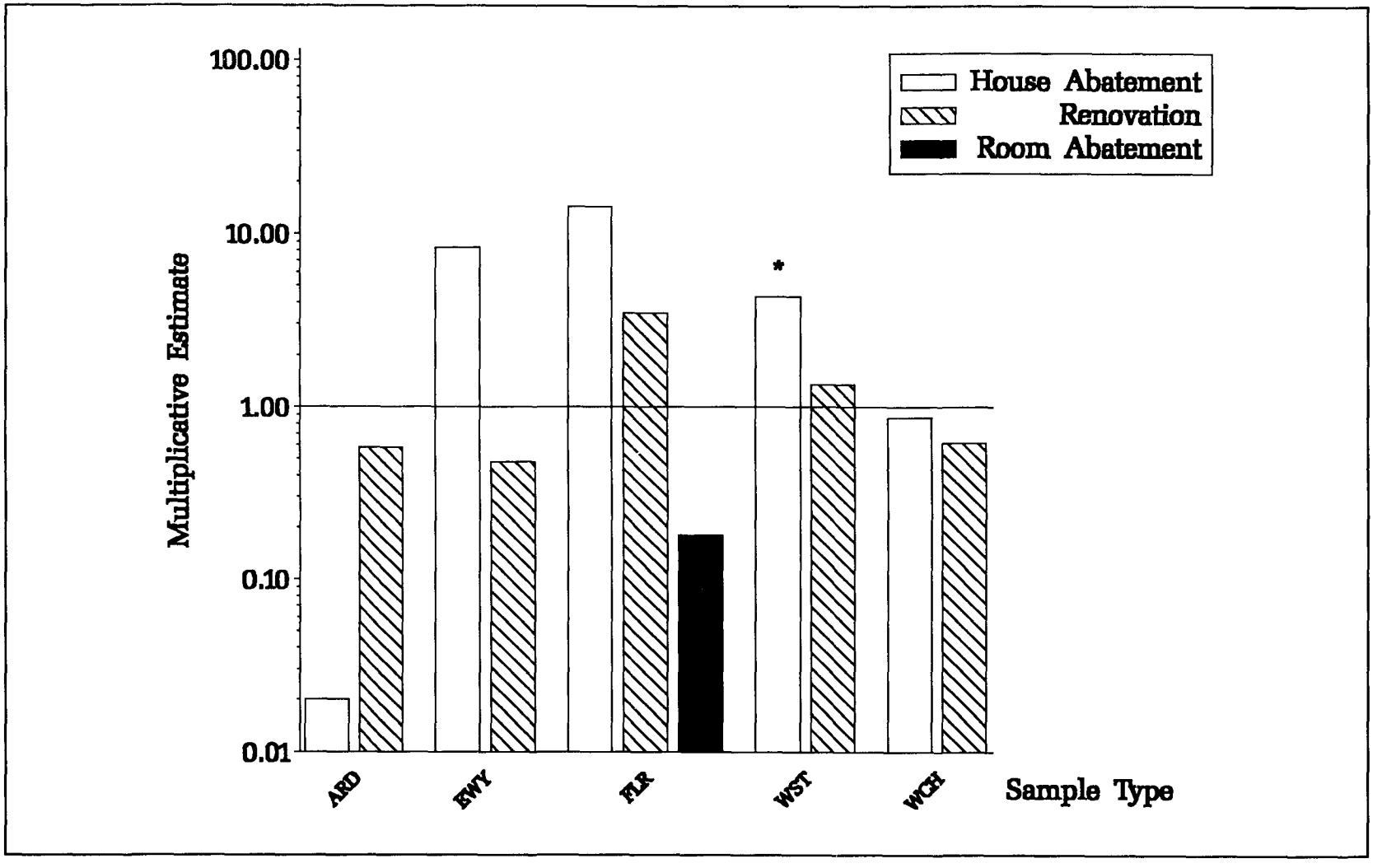

Figure 4-7f. Estimated multiplicative effects of renovation and abatement from mixed model ANOVA: dust loading (mg/ft^2).

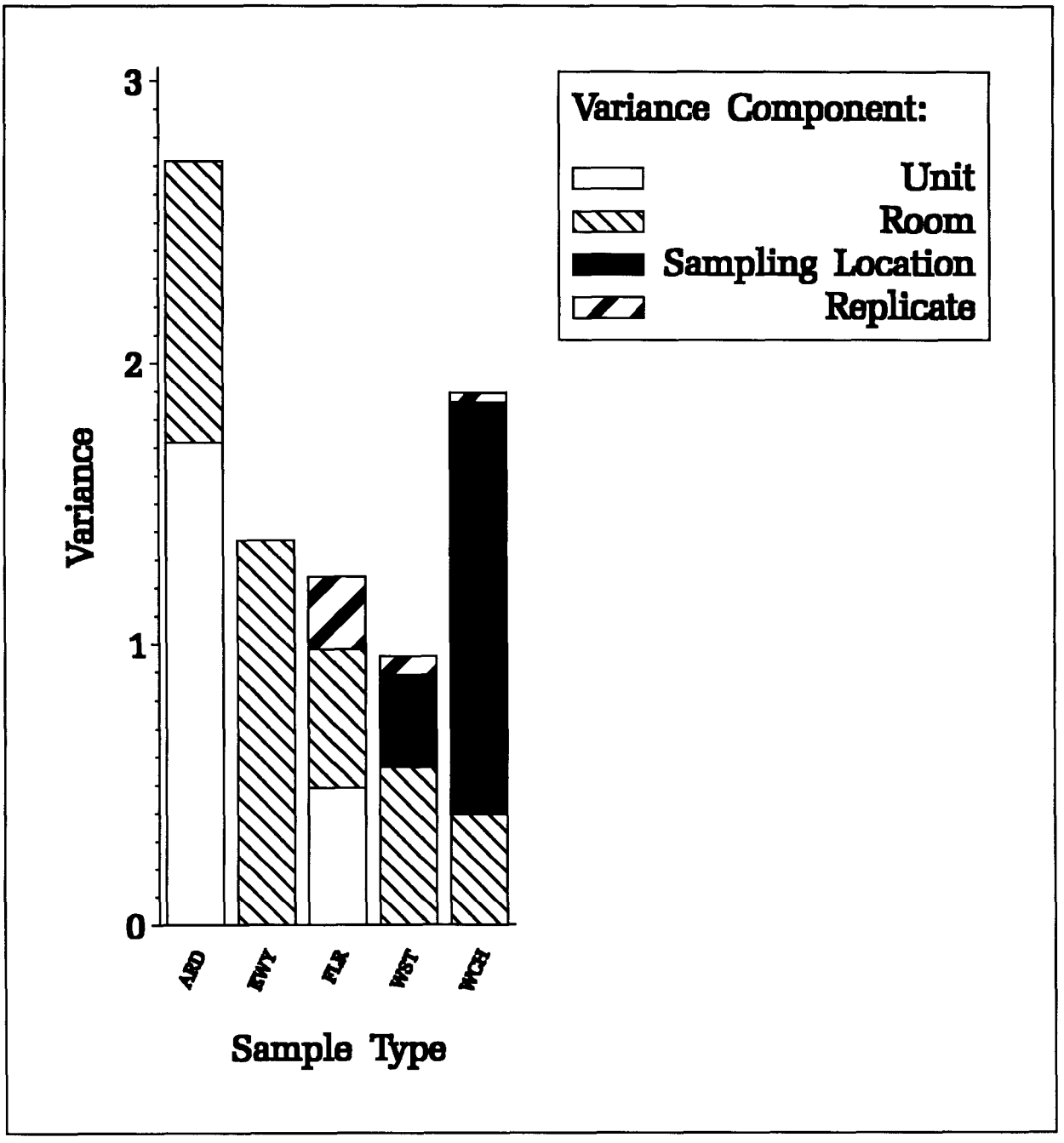

Figure 4-7g. Variance component estimates from mixed model ANOVA: dust loading (mg/ft^2).

illustrated graphically in Figure 4-7c for lead loading, in Figure 4-7e for lead concentration, and in Figure 4-7g for dust loading. Comparing the estimates of variance in Figure 4-7 to the estimates in Figure 4-6 gives an indication of the amount of variability explained by the fixed effects. Due to the small amount of data, the degrees of freedom for estimating the random effects are small. Therefore, conclusions about the significance of these effects should be made with caution. Also, in general, variance components are expected to decrease when fixed-effect terms are added to the model. However, because of the small number of degrees of freedom, some variance components (e.g., lead loading variance for air duct samples) may increase when fixed effects are added.

The room abatement effect was significant only for floor lead loading. In fitting lead loading and lead concentration to various models for components other than floors, the room abatement effect was never even marginally significant (the significance level was never below 0.20). Therefore, room abatement is only included in models for the floor samples.

Each fixed effect was tested for significance when added last among the fixed effects in the model, but before all the random effects in the model. The denominator mean square used in each test was the proper linear combination of the estimated variance components as determined by expected mean square equations.

Lead Loadings

The following is a summary of the modeling results for lead loading for the model with fixed effects included. These results are reported in Table 4-5a. The geometric means are illustrated in Figure 4-7a, estimates of the fixed effects of renovation and abatement are illustrated in Figure 4-7b, and the variance component estimates are illustrated in Figure 4-7c.

The geometric average lead loadings expected in unrenovated control houses for the different sample types in decreasing order are:

- Window channel (vacuum 2873 $\mu g/ft^2$)
- Air duct (649 $\mu g/ft^2$)
- Window stool (vacuum 6.70 $\mu g/ft^2$, wipe 100 $\mu g/ft^2$)
- Floor (vacuum 3.76 $\mu g/ft^2$, wipe 7.63 $\mu g/ft^2$)
- Entryway (6.62 $\mu g/ft^2$).

The floor samples had the lowest two total standard deviations (0.99 for vacuum, 0.59 for wipe). Air ducts (1.95) and vacuum window stool (1.86) samples were the highest.

The unit-to-unit variance component is statistically significant (at the 0.05 level) only for floor wipe samples. This variance component is marginally significant for air duct samples. The estimated variance component is negative for entryway and window stool samples. With the exception of these two sample types, the unit-to-unit variance component is a substantial contributor to total variability even after controlling for the fixed effects. Of those sample types for which the room-to-room variance component could be tested for significance, it is significant only for vacuum window stool samples.

The renovation effect was only statistically significant in explaining the responses for entryway samples, and both vacuum and wipe floor samples. For all sample types except air ducts and vacuum window channels, the estimated effect of renovation was to increase lead loadings. The effect was strongest for both vacuum and wipe floor samples.

In general, abatement history of a house was found to be less significant than renovation for lead loading. For no component was this effect strongly significant. In the cases of

vacuum and wipe floor samples, a marginal significance was observed. For all sample types except air ducts, vacuum window channels, and wipe window stools, houses which have been abated in the past have higher lead loadings.

The effect of room abatement was found to be significant only for floor vacuum samples. In abated houses, abated rooms were observed to have lower floor lead loadings than unabated rooms.

Lead Concentrations

The following is a summary of the modeling results for lead concentration for the model with fixed effects included. These results are reported in Table 4-5b. The estimates of the fixed effects and variance components are illustrated in Figures 4-7d,e respectively.

The geometric average lead concentrations estimated for unrenovated control houses for the different sample types in decreasing order are:

- Window channel dust (2150 μg/g)
- Air duct dust (875 μg/g)
- Window stool dust (245 μg/g)
- Foundation soil (109 μg/g)
- Floor dust (106 μg/g)
- Entryway dust (96.3 μg/g)
- Entryway soil (65 μg/g)
- Boundary soil (54 μg/g).

The three dust sample types with the highest concentrations are in the same exact order as for lead loadings. Note that none of the soil lead concentrations are very high, but foundation soil levels are close to the floor and entryway dust levels.

The smallest total standard deviation was observed for entryways (0.47) and the largest was for window stools (1.56).

The unit-to-unit variance component is statistically significant for window stool dust samples and foundation soil samples. The room-to-room (side-to-side) variance component is significant for boundary and foundation soil samples. The unit-to-unit variance component is a substantial contributor to total variability for floor, window stool, boundary, and foundation sample types.

For concentrations, the renovation effect was only statistically significant in explaining the data for entryway samples and floor samples. As was the case for lead loadings, for all sample types except air ducts and vacuum window channels, the estimated effect of renovation was to increase lead concentrations. Also consistent with the results for lead loadings, the effect was seen to be strongest in floor samples.

House abatement was only found to be significant in both types of entryway samples (vacuum and soil). As for renovation, for all sample types except air ducts and vacuum window channels, houses which have been abated in the past have higher lead concentrations. The component with the strongest estimated abatement effect was soil entryway samples.

Again, a room abatement effect was only included in the model for lead concentrations on floors. However, it was not observed as significant. The estimated room abatement effect of 0.73 indicates that in abated houses, abated rooms were observed to have slightly lower floor lead concentrations than unabated rooms.

Dust Loading

The following is a summary of the modeling results for dust loading for the model with fixed effects included. These results are reported in Table 4-5c. The estimates of fixed effects and variance components are illustrated in Figures 4-7f,g respectively.

The geometric average dust loadings expected in unrenovated control houses for the different vacuum sample types in decreasing order are:

- Window channel (1336 mg/ft^2)
- Air duct (742 mg/ft^2)
- Entryway (69 mg/ft^2)
- Floor (36 mg/ft^2)
- Window stool (27 mg/ft^2).

The average dust loading values fall in exactly the same order as for the uncorrected geometric means.

The smallest total standard deviation for dust loadings was found for window stools (0.88) and the highest for air ducts (1.65). The remaining four sample types had very consistent total variation (1.09, 1.09, 1.06).

Floor samples had the only statistically significant variance components. The unit-to-unit variance component was marginally significant ($p=0.06$), and the room-to-room variance was significant ($p=0.03$). For air duct and floor samples, the unit-to-unit variance component is a substantial contributor to total variability. For entryway, window stool, and window channel samples, the unit-to-unit variance component is only a minor contributor to total variability.

The renovation effect was only statistically significant in explaining the variability in dust loadings for vacuum window stool samples. For all sample types except air ducts and vacuum window channels, the estimated effect of renovation was to increase dust loadings. The effect was strongest for vacuum floor samples.

Abatement was not found to be significant for any of the components. The strongest estimated effect was for floors. For

all sample types except air ducts and vacuum window channels, houses with an abatement history have higher dust loadings.

The effect of room abatement was not found to be statistically significant for floor samples. However, in abated houses, unabated rooms were observed to have approximately five times higher floor dust loadings than abated rooms.

4.4 MODELING RESULTS FOR DUST SAMPLES BY SAMPLE TYPE

In Section 4.3, results for dust samples were reported separately for two different statistical models, three different measured values (lead loading, lead concentration, and dust loading), and in some cases two different sampling methods (vacuum and wipe). In this section, results are reported by the following sample types:

- Air duct samples
- Bed/Rug/Upholstery samples
- Interior entryway samples
- Floor samples
- Window stool samples
- Window channel samples.

An attempt is made to draw global conclusions that span the two different statistical models and the different measurement types for each sample type.

4.4.1 Air Duct Samples

There were only 10 air duct samples collected in the Pilot Study and used in the statistical analyses; their geometric mean lead loading was 308 $\mu g/ft^2$. An estimate of the corresponding mean in unrenovated control houses was 649 $\mu g/ft^2$. The geometric mean lead concentration was 749 $\mu g/g$. For unrenovated control houses, the estimate was 875 $\mu g/g$.

The variation in lead loadings (standard deviation 1.72) was equally due to unit-to-unit and room-to-room differences.

However, for lead concentrations, the differences were virtually all due to room-to-room differences.

Air duct and window channel (vacuum) samples were the only sample types in the Pilot Study for which renovation and abatement were estimated to reduce both lead loadings and concentrations. For air duct lead loading, the estimated multiplicative effect of renovation was 0.01; the multiplicative effect of abatement was 0.49. For concentrations, the effect was 0.51 for renovation, and 0.84 for abatement. Neither of these effects was observed as statistically significant, and neither reduced the substantial unit-to-unit variation in lead loading.

4.4.2 Bed/Rug/Upholstery Samples

Only eight bed/rug/upholstery samples were collected in the Pilot Study, allowing only a limited statistical analysis. Unit 51, which was under full renovation, had none of these items present to sample. The geometric mean lead loading was the lowest of all sample types (8 $\mu g/ft^2$), and the geometric mean concentration was second lowest (174 $\mu g/g$) only larger than boundary soil samples).

The variation seen in the lead loadings and concentrations of these samples was not due to differences between units; it was primarily due to within-unit differences. Due to the small amount of data, tests for renovation and abatement effects were not attempted.

4.4.3 Interior Entryway Samples

There were 12 entryway vacuum samples collected in the Pilot Study, front and back entryway samples from each of the six units. The geometric mean lead loading for these samples (23 $\mu g/ft^2$) was almost twice as high as the mean for other floor lead loadings (13 $\mu g/ft^2$). This is primarily due to the presence of more dust, but also partially due to a higher concentration of lead in the dust (314 $\mu g/g$) as compared to the corresponding results for other floor samples (255 $\mu g/g$).

Both abatement (p=0.01) and renovation (p=0.00) were statistically significant in explaining the variation for concentrations. As compared with unrenovated control houses, lead concentrations were about 3 times higher in abated houses, and about 5 times higher in renovated houses. For lead loadings, only renovation was observed as significant here, but the loadings for renovated control houses were more than 40 times greater than those for unrenovated control houses.

4.4.4 Floor Samples

For floors, both vacuum and wipe samples were collected in the Pilot Study. Vacuum sample modeling results are presented first for lead loading, lead concentration, and dust loading. Wipe sample modeling results are then presented for lead loading, and compared to the vacuum sample modeling results.

Floor Vacuum Samples

The 39 floor vacuum samples collected in the Pilot Study were by far the largest number collected for any sample type. The overall geometric mean lead loading of these samples was 13 $\mu g/ft^2$. After controlling for renovation and abatement effects, the estimate of this mean for unrenovated control houses was 3.8 $\mu g/ft^2$. The overall geometric mean for lead concentrations was 255 $\mu g/g$. After controlling for renovation and abatement effects, this figure was 106 $\mu g/g$.

Most of the variability in lead loadings and lead concentrations on vacuum samples from floors was due to unit-to-unit differences (Table 4-4). Replicate-to-replicate variation was observed near the same magnitude as sampling location-to-sampling location variation. For both lead loadings and lead concentrations, most of the unit level differences were explained by the renovation and abatement factors. For lead loadings, houses under renovation had lead loadings 70 times higher than unrenovated control houses. This large lead loading is due both to an increased concentration of lead in the dust (4.89 times

higher), and a larger amount of dust on the floors in houses under renovation (14.31 times larger).

Lead loadings were also found 10 times higher in abated homes than in unrenovated control houses. The lead concentrations were about 2.9 times higher, and the dust loadings about 3.5 times higher.

Floor lead loadings taken by the vacuum method were the only measurements in the Pilot Study for which room abatement history was found to be statistically significant. Unabated rooms in abated houses have about 8 times higher lead loadings than abated rooms in abated houses, (i.e., the lead loadings in abated rooms are about 13% of those in unabated rooms in abated houses). This would suggest either these unabated rooms were contaminated by dust prior to or during abatement and never completely cleaned, or that there may be residual lead-based paint in these unabated rooms.

The same phenomenon was evident in the lead concentrations and dust loadings for vacuum samples, but it was not as pronounced, and therefore the room abatement effect was not observed as statistically significant.

Floor Wipe Samples

There were a total of 12 floor wipe samples collected in the Pilot Study, two side-by-side samples from each unit. The geometric mean of these samples was 51 $\mu g/ft^2$. After controlling for renovation and abatement effects, the mean for unrenovated control houses was 7.6 $\mu g/ft^2$.

The estimate of unit-to-unit standard deviation is actually an estimate of the combined variation of unit-to-unit, room-to-room, and sampling location-to-sampling location standard deviation. As expected, this combined variation far exceeded the replicate-to-replicate (side-by-side) variation. This variation was mostly explained by renovation and abatement effects, but even after controlling for these factors, the unit-to-unit differences were still statistically significant. The results

for floor wipe samples are similar to the results for floor vacuum samples. The effect of renovation on lead loadings was estimated as virtually the same under both methods (i.e., a 70-fold difference). The multiplicative effect of house abatement was higher for vacuum samples, but both were positive (9.9 compared to 3.5).

The variance component estimates for lead loadings from the vacuum and wipe methods are also similar. The combined unit-to-unit, room-to-room, and sampling location-to-sampling location standard deviation was estimated (by pooling the three individual standard deviations in Table 4-4) at 1.89 $\mu g/ft^2$ for vacuum samples, compared to 1.92 for wipe samples. The replicate-to-replicate standard deviation was 0.47 $\mu g/ft^2$ for vacuum samples, and 0.33 $\mu g/ft^2$ for wipe samples.

Although this section provides some comparison of the vacuum and wipe sampling results, a further detailed comparison of the wipe and vacuum methods based on paired data collected in the "bridge" rooms is given in Section 4.7.

4.4.5 Window Stool Samples

For window stools, there were also both vacuum and wipe samples collected in the Pilot Study. As for floor samples in the previous section, vacuum sample modeling results are presented first for lead loading, lead concentration, and dust loading. Wipe sample modeling results are then presented for lead loading, and compared to the vacuum sample modeling results.

Window Stool Vacuum Samples

There were 25 window stool vacuum samples collected in the Pilot Study. The geometric mean lead loading for these samples (34 $\mu g/ft^2$) was relatively low, but the geometric mean lead concentration (724 $\mu g/g$) was among the highest observed, exceeded only by window channels and air ducts. In addition the largest loading observed in the entire study was found by vacuuming a window stool (13087 $\mu g/ft^2$ found in unit 80).

Window stool vacuum samples were observed to have the largest total variation of any of the sample types observed, for both lead loadings and lead concentrations. This variation was mainly due to room-to-room differences, and unit-to-unit variation. Window-to-window within room differences and replicate-to-replicate differences were small by comparison. These variations could not be explained by renovation or abatement effects (i.e., neither of these effects was found to be statistically significant). However, on average, in houses under renovation, lead loadings were 6.1 times higher, and dust loadings were 4.3 times higher, than in unrenovated control houses. In abated houses, lead loadings were 5.5 times higher and lead concentrations were 4.1 times higher than in unrenovated control houses. Thus, one might conjecture that higher lead loadings in renovated houses were mainly due to larger amounts of dust, while higher lead loadings in abated houses are possibly due to higher concentrations of lead in the dust.

Window Stool Wipe Samples

There were a total of 12 window stool wipe samples collected in the Pilot Study. The overall geometric mean of these samples was 144 $\mu g/ft^2$; while the mean in unrenovated control houses was estimated at 100 $\mu g/ft^2$. The unit-to-unit differences were seen to be the primary source of variation in these samples. However, there was a marginally significant window-to-window within room variation ($p=0.08$) observed. For the wipe method, the estimated effect of renovation on window stool samples was to increase lead loadings by a factor of 28. On average, abated houses had window stool wipe lead loadings of less than half (0.40) of those in unabated houses. However, neither of these effects was found to be statistically significant. The lead loading window stool results for wipe samples differ in several major ways from the window stool results for vacuum samples. The main difference between the two methods was in the observed effect of abatement. By the wipe method, abated houses had a lower than average lead

loading, while by the vacuum method, abated houses had 5.5 times higher lead loadings than unabated homes.

A second qualitative difference seen in the results by the two sampling methods was in the room-to-room variation estimates (Table 4-4). By the wipe method, the room-to-room differences were negligible, but by the vacuum method, room-to-room differences were determined to be the primary source of variation in the lead loadings. This difference may be due in part to the low number of degrees of freedom available for estimating the room-to-room variation for wipe samples.

Another difference observed between the two methods was in the average lead loading observed. Comparing the results discussed above and before controlling for the fixed effects, the wipe method had a geometric mean 4.23 times larger than the vacuum method. This difference is mostly due to a general multiplicative bias factor of approximately 5 to 10 between the two methods (see Section 4.7). After controlling for the fixed effects, the results are even less comparable; the estimated loading in unrenovated control houses is 15 times higher by the wipe method (100 $\mu g/ft^2$) than by the vacuum method (6.7 $\mu g/ft^2$).

4.4.6 Window Channel Samples

Similar to the case of floors and window stools, both vacuum and wipe samples were collected from window channels in the Pilot Study. As in these previous cases, vacuum sample modeling results are presented first for lead loading, lead concentration, and dust loading. Wipe sample modeling results are then presented for lead loading, and compared to the vacuum sample modeling results.

Window Channel Vacuum Samples

There were only 11 window channel vacuum samples collected in the Pilot Study. The geometric mean lead loading (1250 $\mu g/ft^2$) and lead concentration (1448 $\mu g/g$) were highest for these samples among all sample types taken. Oddly, the largest average

loadings and concentrations were found in the unrenovated control house. This sample type and air ducts were the only ones for which renovation and abatement were estimated to reduce lead loading and concentration. The average dust loadings on window channels were also lower in abated homes and in renovated homes.

There was little unit-to-unit variation observed for window channel vacuum samples (Table 4-4); this was consistent across all three measurements (lead loading, lead concentration, and dust loading). Variation was primarily attributed to room-to-room differences, however, there was also a substantial difference in lead loadings seen between windows within rooms. Neither abatement nor renovation were observed to be significant factors for these samples. This is not surprising, since these factors are unit-level explanatory variables, and there were only small differences observed between units.

Window Channel Wipe Samples

There were only six window channel wipe samples collected from a total of three units. The geometric mean lead loading of these samples was 801 $\mu g/ft^2$, exceeded only by the mean lead loading on window channels taken by the vacuum method. This sample type had the smallest estimated total variability of all lead loading measurements. There were not enough data available for wipe window channel samples to fit a mixed model analysis of variance. Thus, no results for renovation and abatement effects are presented.

The estimate of sampling location-to-sampling location (window-to-window) variation was observed as statistically significant compared with the replicate-to-replicate variability, which was estimated as the smallest among lead loadings for all sample types. Both the vacuum and wipe sampling methods on window channels produced the highest estimates of geometric mean lead loading, and the lowest estimates of total variation among lead loadings. Aside from the fact that the lead loadings were

larger for the vacuum method than for the wipe method, qualitatively, the results by the two methods were similar.

4.5 MODELING RESULTS FOR SOIL SAMPLES BY SAMPLE TYPE

In Section 4.3, results for soil samples were reported separately for two different statistical models. In this section, results are reported by the following sample types:

- Boundary samples
- Exterior entryway samples
- Foundation samples.

An attempt is made to draw global conclusions that span the two different statistical models for each sample type.

4.5.1 Boundary Soil Samples

There were a total of 15 boundary soil samples collected in the Pilot Study. The geometric mean lead concentration was 121 μg/g. For unrenovated control houses, the mean was about half as large (54 μg/g).

The results of fitting the statistical model equation (2) to these 15 samples is shown in Table 4-4b. The unit-to-unit standard deviation (0.69) was about as large as the side-to-side standard deviation (0.61). Both were statistically significant (unit-to-unit was marginal). On average, houses under renovation were estimated to have lead concentrations about twice as high as others, and houses where abatement was performed had average concentrations about 2.4 times higher. Neither of these factors was seen as statistically significant.

4.5.2 Exterior Entryway Soil Samples

There were a total of 16 entryway soil samples collected in the Pilot Study. The replicate-to-replicate variance in lead concentrations was large in comparison with the other two soil sample types (100 times larger than for boundary samples and 9

times larger than for foundation samples). Therefore, the data were examined to look for any gross inconsistencies.

For Unit 19, in the front yard, there were two side-by-side soil samples taken near the entryway. The measured concentrations here were 196.53 μg/g and 49.69 μg/g. This was by far the largest observed difference (on a log scale) between side-by-side samples found for any of the soil sample types. Computing the variance components for entryways without these two samples gave an estimated replicate-to-replicate standard deviation consistent with that for foundation soil samples (0.18 μg/g compared with 0.17 μg/g). These samples are referred to as outliers for lack of a better term, although because of the small sample size, there is no proof that they will not be found typical of soil lead concentrations in the full CAP Study.

The analysis of variance for entryway soil samples was performed with and without these samples removed. The main difference observed was that with the outliers removed, the side-to-side variation was statistically significant, while with all the data included, it was not. Since there was little difference in the estimates from the mixed model, the results using all the data are presented.

Using all the data, the geometric mean lead concentration for entryway soil samples was 196 μg/g. The corresponding estimate for unrenovated control homes was 65 μg/g. After controlling for renovation, abatement was observed to have a statistically significant (p=.02) effect on these lead levels; the multiplicative effect of renovation was estimated at 1.9, while abated houses had 4.7 times higher lead concentrations than unrenovated control houses.

4.5.3 Foundation Soil Samples

There were 17 foundation soil samples collected in the Pilot Study. The geometric mean lead concentration in these samples was 217 μg/g. For unrenovated control houses, this mean was estimated to be 109 μg/g.

The total variation in these samples was similar to that observed in the other soil samples. Most of this variation was due to unit-to-unit and side-of-house differences. The variation was not explained by renovation or abatement effects (i.e., neither of these factors was statistically significant. Nonetheless, foundation soil lead concentrations were 2.4 times higher in houses under renovation, and 2 times higher in abated houses, as compared to unrenovated control houses.

4.5.4 Comparison of the Soil Sample Types

An analysis of variance was performed on the soil sample types to determine whether there was a statistical difference in the lead concentrations between boundary, entryway, and foundation samples. Using all the soil data, there was significant ($p=.02$) statistical evidence of a difference in the results. Applying a multiple comparison test, there was a significant difference between the boundary samples and each of the other two soil sample types; however, the difference between entryway and foundation soil sample results was not statistically significant.

4.6 RELATIONSHIPS BETWEEN SAMPLE TYPES

In Sections 4.4 and 4.5, the pilot data have been summarized by dust sample type and soil sample type, respectively. Attention is now turned to relationships between the various sample types. The primary methods employed to examine these relationships are correlation matrices and scatterplot matrices.

The primary data employed to examine the relationships between sample types are the geometric means by unit presented in Table 4-2. Both the lead loading and lead concentration means are examined.

Lead Loading

The correlation matrix for lead loading unit means is presented as Table 4-6a. To locate a correlation of interest, locate the row corresponding to the first sample type and the column corresponding to the second sample type. Correlation information for the two sample types is presented in the corresponding box. Within each box, the three values presented are:

- **Top value:** Correlation coefficient between the logarithms of the geometric unit means
- **Middle value:** Observed significance level of the test of the hypothesis of no correlation (correlation coefficient equal to zero)
- **Bottom value:** Degrees of freedom associated with the variance estimates used in calculating the correlation coefficient.

Only the upper right-hand half of the matrix, above the shaded diagonal, is filled in since the lower left-hand half of the matrix would contain redundant information.

The lead loading unit means are presented graphically in Figure 4-8a. This figure is a scatterplot matrix, or a collection of bivariate plots organized into matrix form. As with the correlation matrix, to locate a plot of interest, identify the row associated with one sample type and the column associated with the other sample type. The plot is presented in the corresponding box. Within each box, the horizontal axis represents increasing values of the column variable on a logarithmic scale. Similarly, the vertical axis represents increasing values of the row variable on a logarithmic scale. The abbreviations employed on the diagonal to identify the different sample types are defined in Table 3-5.

Table 4-6a. Unit-to-Unit Correlations Among Sample Types: Lead Loading

		Vacuum						Wipe		
		Air Duct	Bed/Rug Uph	Entryway	Floor	Window Stool	Window Channel	Floor	Window Stool	Window Channel
Vacuum	Air Duct		**0.27*** .67* (4)*	**-0.77** .13 (4)	**-0.80** .10 (4)	**0.16** .79 (4)	**0.73** .16 (4)	**-0.51** .38 (4)	**0.01** .99 (4)	
	Bed/Rug/Uph			**0.20** .74 (4)	**0.31** .61 (4)	**-0.13** .83 (4)	**0.03** .96 (4)	**0.44** .46 (4)	**0.42** .48 (4)	
	Entryway				**0.91** .01 (5)	**0.41** .42 (5)	**-0.89** .02 (5)	**0.89** .02 (5)	**0.62** .19 (5)	**0.57** .61 (2)
	Floor					**0.57** .24 (5)	**-0.87** .03 (5)	**0.86** .03 (5)	**0.74** .09 (5)	**0.81** .40 (2)
	Window Stool						**-0.51** .30 (5)	**0.75** .09 (5)	**0.67** .15 (5)	**0.18** .88 (2)
	Window Channel							**-0.80** .05 (5)	**-0.39** .45 (5)	**-0.48** .68 (2)
Wipe	Floor								**0.79** .06 (5)	**0.32** .79 (2)
	Window Stool									**0.69** .51 (2)
	Window Channel									

* Top value is estimated correlation coefficient, middle value is observed significance level, and bottom value is degrees of freedom.

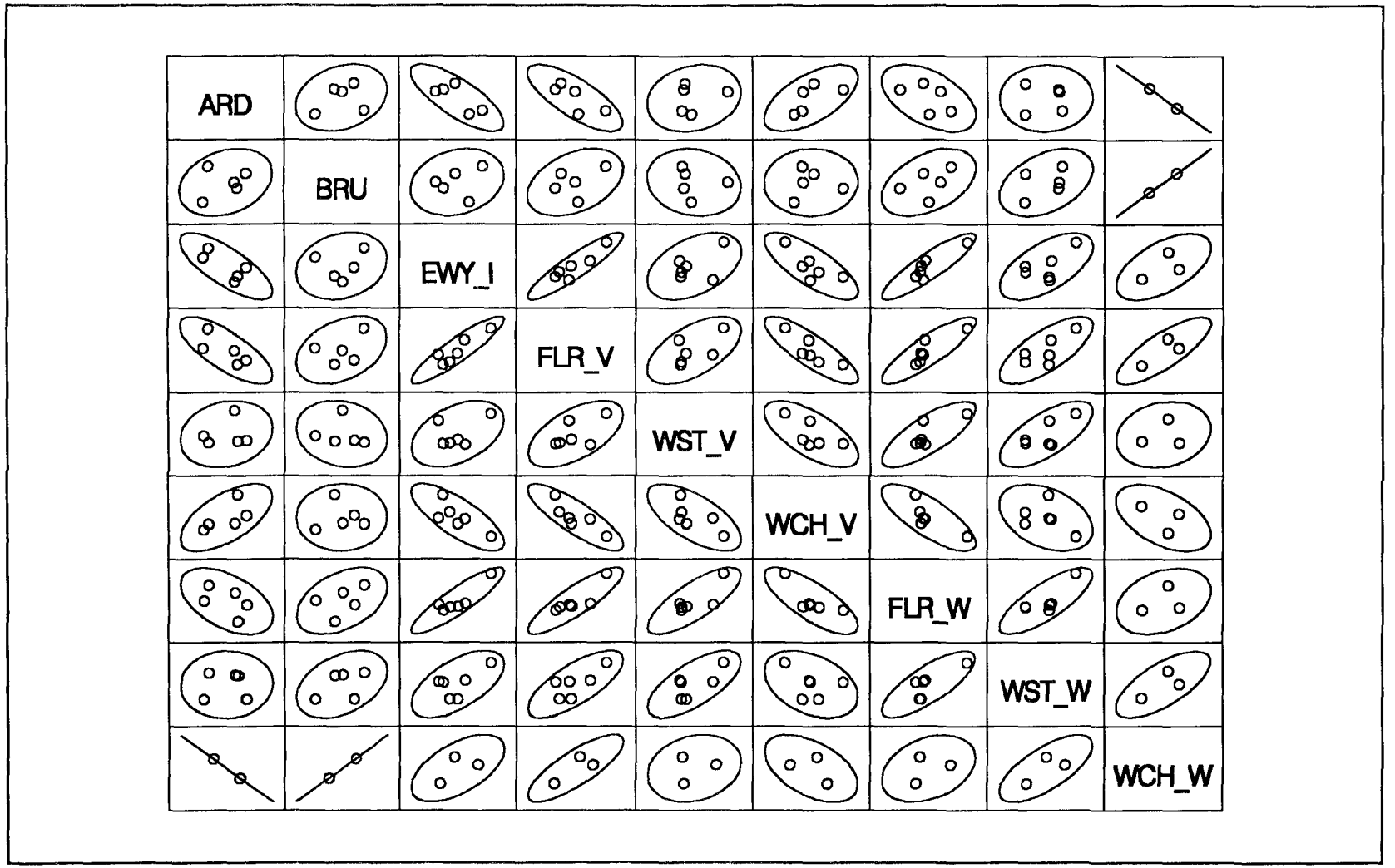

Figure 4-8a. Scatterplot matrix of geometric unit means for different sample types: lead loading ($\mu g/ft^2$).

The ellipse plotted in each box of Figure 4-8a is the ellipse that contains 95% of the probability associated with the estimated bivariate normal distribution for the plotted data. The narrower the ellipse, the stronger the correlation between the two sample types. If the ellipse is oriented from the lower left-hand corner of the box to the upper right-hand corner of the box, the sample types are positively correlated. If, on the other hand, the ellipse is oriented from the upper left-hand corner of the box to the lower right-hand corner of the box, the sample types are negatively correlated.

Lead loadings for entryway dust were found to be statistically significantly positively correlated with those for both floor vacuum and floor wipe samples. Lead loadings for window channel vacuum samples were found to be significantly negatively correlated with each of these three sample types. There was also a strong positive relationship observed between the lead loadings of floor vacuum and wipe samples.

It may be possible that correlation present in the lead loading data, or conversely the lack of correlation, is due to nonrandom factors such as renovation or abatement. For example, if all units which were abated have high lead loadings on both floors and window stools, and unabated units have low levels for both of these sample types, then floor loadings and window stool loadings will be highly correlated, when there may be no correlation at all beyond the effect of abatement history. To examine this relationship, a correlation matrix and scatterplot matrix were created for lead loadings after controlling for fixed effects.

Specifically for each sample type, the residuals from the mixed model analysis of variance performed in Section 4.3.2 were averaged to produce average residuals for each unit. These average unit residuals were used (in place of the logarithms of the geometric unit means) in calculating the correlation coefficients that are presented in Table 4-6b. The average unit residuals were also plotted in scatterplot matrix form in Figure 4-8b.

When controlling for the fixed effects, one must realize that some degrees of freedom for estimation of correlation are sacrificed to estimate the fixed effects. This was accounted for in the significance levels and degrees of freedom provided in Table 4-6b. Since only six houses were sampled in the Pilot Study, and two house-level fixed effects were found to be important, the reduction to 2 or 3 degrees of freedom has a serious negative impact on the statistical power to detect non-zero correlations in Table 4-6b. In particular, there were insufficient data to test unit-to-unit correlations between dust lead loadings collected on window channels and any other sample type, after controlling for abatement and renovation effects. This factor should not be a problem in the full CAP Study.

After correcting for renovation and abatement affects, none of the correlation estimates was observed to be significant. However, there are several relationships worth noting. Whereas lead loadings for entryway, floor vacuum, and floor wipe samples were all found to be significantly <u>positively</u> correlated before controlling for the fixed effects, they were all found to be <u>negatively</u> correlated after correcting for the fixed effects. This may suggest that the effects of renovation and abatement override any house-to-house relationship between these sample types.

Table 4-6b. Unit-to-Unit Correlations Among Sample Types After Correction for Renovation and Abatement Effects: Lead Loading

		Vacuum						Wipe		
		Air Duct	Bed/Rug Uph	Entryway	Floor	Window Stool	Window Channel	Floor	Window Stool	Window Channel
Vacuum	Air Duct		**0.99*** 09* (2)*	**-0.63** .57 (2)	**-0.16** .90 (2)	**0.12** .92 (2)	**0.71** .50 (2)	**-0.02** .99 (2)	**0.21** .87 (2)	
	Bed/Rug/Uph			**-0.60** .59 (2)	**-0.19** .88 (2)	**0.09** .94 (2)	**0.72** .49 (2)	**-0.01** .99 (2)	**0.14** .91 (2)	
	Entryway				**-0.38** .62 (3)	**-0.81** .19 (3)	**-0.75** .25 (3)	**-0.22** 78 (3)	**-0.76** .24 (3)	
	Floor					**0.36** .64 (3)	**-0.27** .73 (3)	**-0.53** .47 (3)	**0.11** .89 (3)	
	Window Stool						**0.63** .37 (3)	**0.55** .45 (3)	**0.91** .09 (3)	
	Window Channel							**0.66** .34 (3)	**0.67** .33 (3)	
Wipe	Floor								**0.65** .35 (3)	
	Window Stool									
	Window Channel									

* Top value is estimated correlation coefficient, middle value is observed significance level, and bottom value is degrees of freedom.

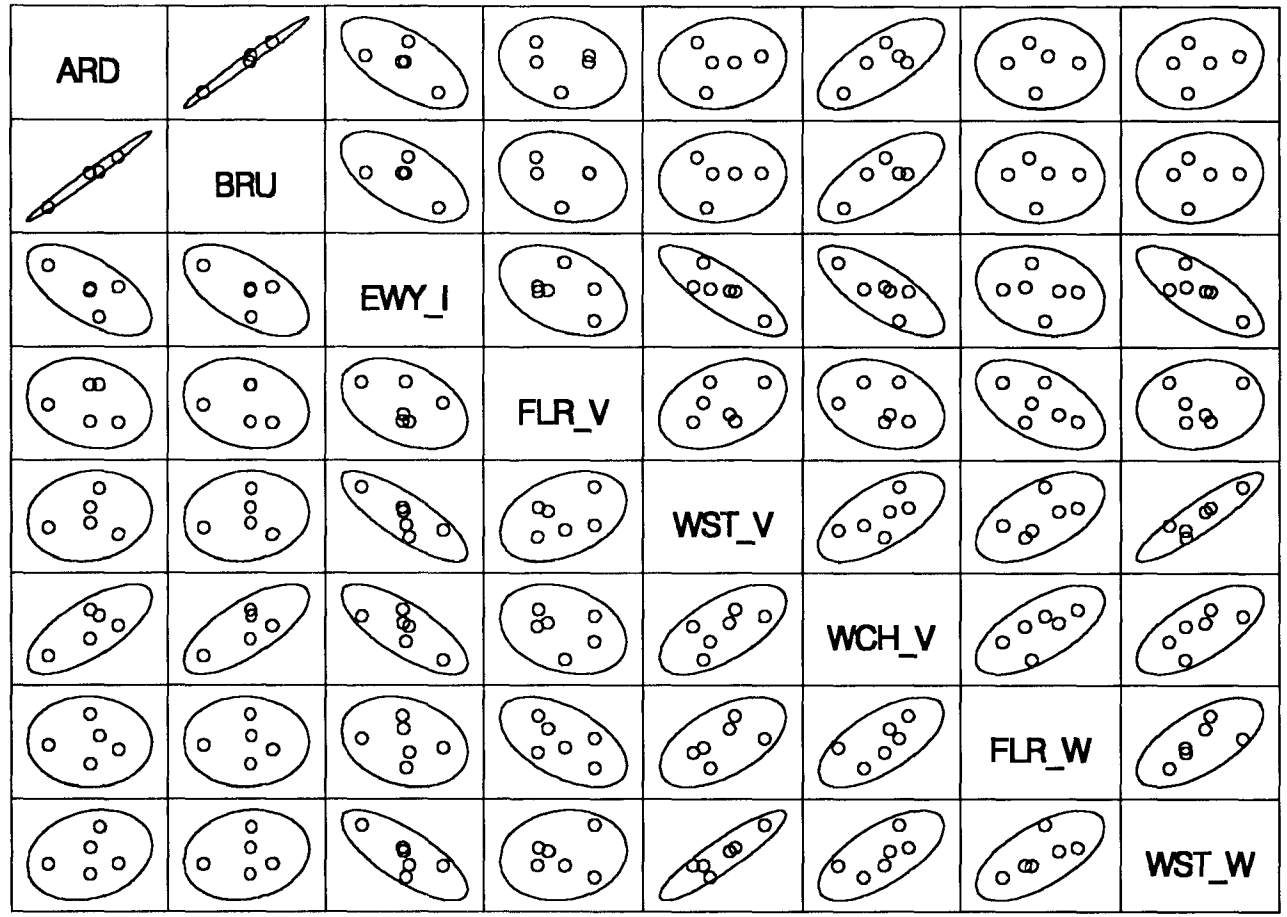

Figure 4-8b. Scatterplot matrix of geometric unit means for different sample types after correction for renovation and abatement effects: lead loading ($\mu g/ft^2$). (Note: Wipe window channel lead loadings excluded because of insufficient degrees of freedom to estimate correlations.)

Lead loadings for air ducts and bed/rug/upholstery samples had the highest correlation coefficient after correction. Lead loadings for window stool vacuum and wipe samples were also found to be positively correlated. In addition, lead loadings for entryway samples were found to be negatively correlated with those for every other sample type after correction for the fixed effects.

Lead Concentration

Table 4-7a contains unit-to-unit correlation coefficients for the geometric mean lead concentration data. This table is analogous to Table 4-6a, but is for lead concentrations rather than lead loadings. The geometric mean lead concentration data are plotted in scatterplot matrix form in Figure 4-9a. This figure is analogous to Figure 4-8a.

There were several positive correlations found for lead concentrations. Entryway and floor vacuum results were highly correlated (0.94). Lead concentrations for floor and window stool samples were also significantly correlated with those for each of the soil sample types. In addition, lead concentrations for all soil sample types had a statistically significant positive correlation. The strongest of these correlations was seen between boundary and foundation soil samples (0.98). It is also interesting to note that there were no strong negative correlations observed.

In Table 4-7b and Figure 4-9b, the relationship between lead concentrations is examined after correcting for renovation and abatement effects. This table and figure are directly analogous to Table 4-6b and Figure 4-8b for lead loadings.

Table 4-7a. Unit-to-Unit Correlations Among Sample Types: Lead Concentration

		Vacuum						Soil		
		Air Duct	Bed/Rug Uph	Entryway	Floor	Window Stool	Window Channel	Boundary	Entryway	Foundation
Vacuum	Air Duct		**0.08***	**-0.14**	**0.31**	**0.54**	**0.64**	**0.70**	**0.32**	**0.81**
			.90*	.82	.35	.35	.25	.19	.60	.10
			(4)*	(4)	(4)	(4)	(4)	(4)	(4)	(4)
	Bed/Rug/Uph			**-0.12**	**0.10**	**-0.34**	**-0.56**	**-0.10**	**-0.35**	**0.10**
				.84	.88	.57	.33	.88	.57	.87
				(4)	(4)	(4)	(4)	(4)	(4)	(4)
	Entryway				**0.94**	**0.50**	**-0.44**	**0.65**	**0.86**	**0.63**
					.00	.31	.38	.16	.03	.18
					(5)	(5)	(5)	(5)	(5)	(5)
	Floor					**0.64**	**-0.28**	**0.79**	**0.83**	**0.79**
						.17	.60	.06	.04	.06
						(5)	(5)	(5)	(5)	(5)
	Window Stool						**0.36**	**0.94**	**0.81**	**0.86**
							.48	.00	.05	.03
							(5)	(5)	(5)	(5)
	Window Channel							**0.19**	**-0.09**	**0.14**
								.72	.87	.80
								(5)	(5)	(5)
Soil	Boundary								**0.87**	**0.98**
									.03	.00
									(5)	(5)
	Entryway									**0.81**
										.05
										(5)
	Foundation									

* Top value is estimated correlation coefficient, middle value is observed significance level, and bottom value is degrees of freedom.

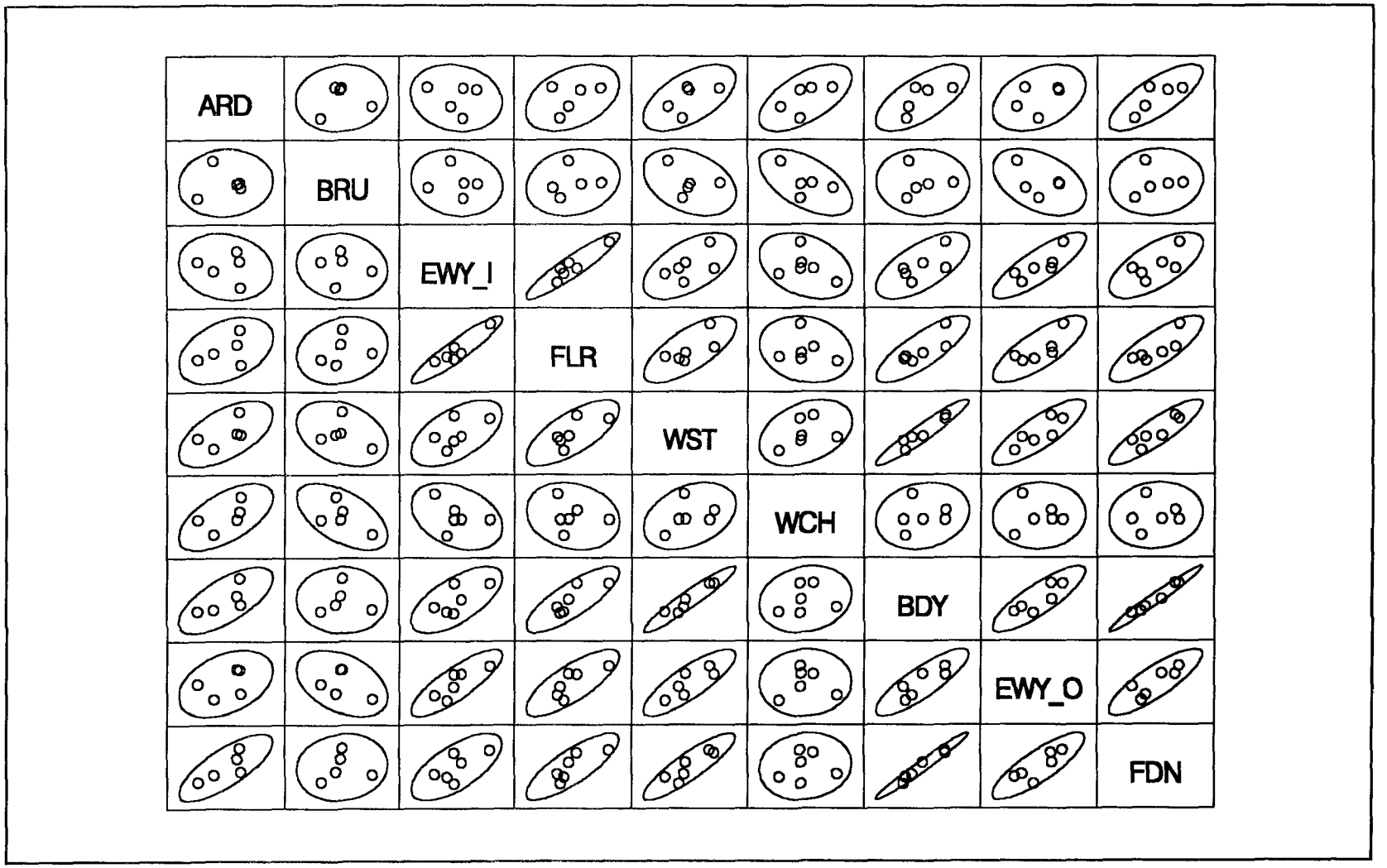

Figure 4-9a. Scatterplot matrix of geometric unit means for different sample types: lead concentration (μg/g).

Table 4-7b. Unit-to-Unit Correlations Among Sample Types After Correction for Renovation and Abatement Effects: Lead Concentration

		Vacuum						Soil		
		Air Duct	Bed/Rug Uph	Entryway	Floor	Window Stool	Window Channel	Boundary	Entryway	Foundation
Vacuum	Air Duct		**0.99*** .09* (2)*	**0.45** .70 (2)	**0.76** .45 (2)	**0.59** .60 (2)	**0.24** .85 (2)	**0.80** .41 (2)	**0.92** .26 (2)	**0.89** .30 (2)
	Bed/Rug/Uph			**0.43** .72 (2)	**0.75** .46 (2)	**0.59** .60 (2)	**0.26** .83 (2)	**0.80** .41 (2)	**0.92** .26 (2)	**0.88** .32 (2)
	Entryway				**0.35** .65 (3)	**-0.04** .96 (3)	**0.26** .74 (3)	**0.20** .80 (3)	**0.54** .46 (3)	**0.33** .67 (3)
	Floor					**0.92** .08 (3)	**0.79** .21 (3)	**0.97** 01 (4)	**0.93** .07 (3)	**0.96** .04 (3)
	Window Stool						**0.77** .23 (3)	**0.94** .06 (3)	**0.76** .24 (3)	**0.88** .12 (3)
	Window Channel							**0.70** .23 (3)	**0.61** .39 (3)	**0.61** .39 (3)
Soil	Boundary								**0.90** .10 (3)	**0.98** .02 (3)
	Entryway									**0.95** .05 (3)
	Foundation									

* Top value is estimated correlation coefficient, middle value is observed significance level, and bottom value is degrees of freedom.

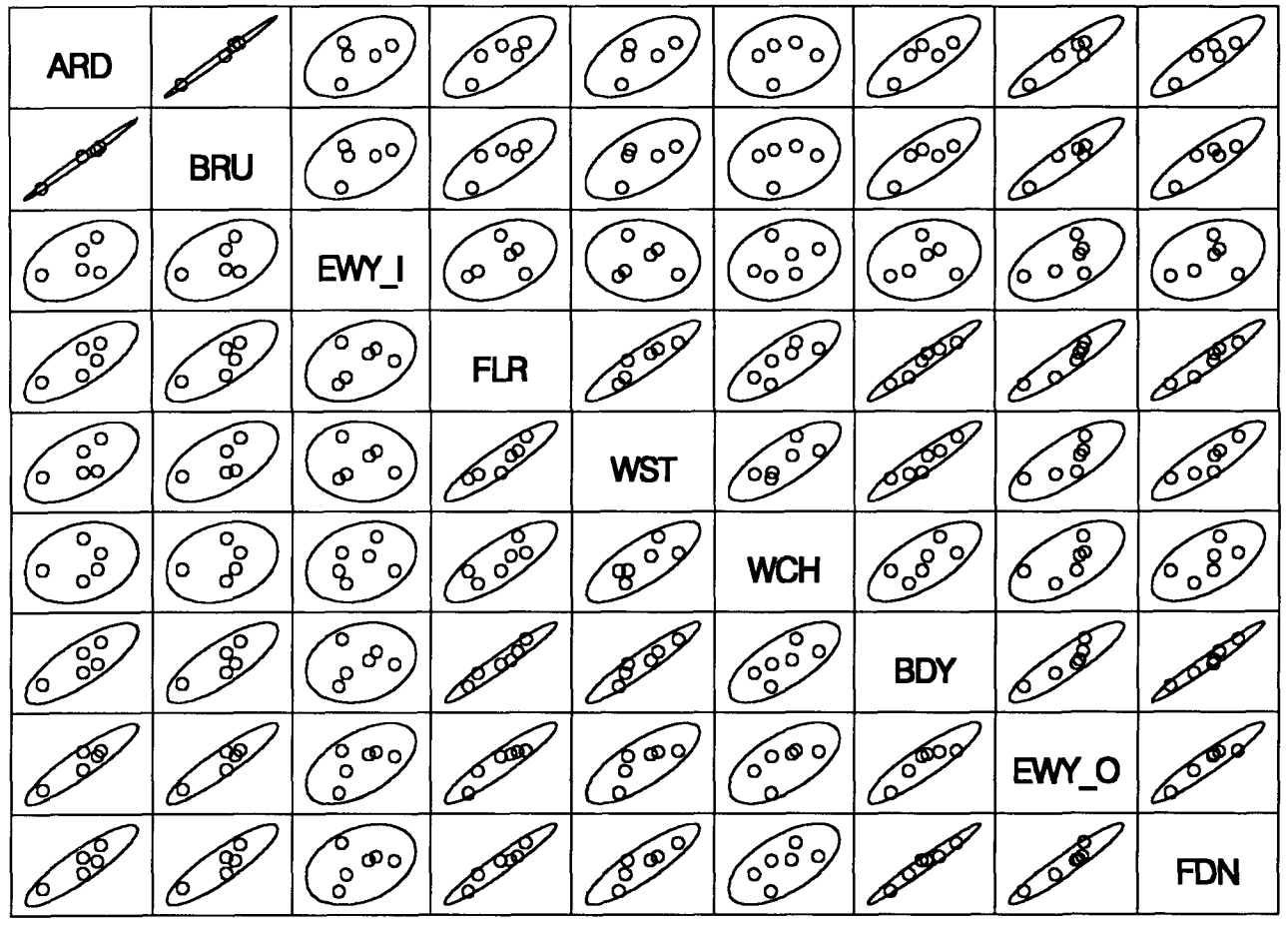

Figure 4-9b. Scatterplot matrix of geometric unit means for different sample types after correction for renovation and abatement effects: lead concentration (μg/g).

After correction for renovation and abatement effects, the relationships among the lead concentrations appear stronger than before controlling for them. The reduction in degrees of freedom increases the threshold at which correlation estimates are considered statistically significant, but there are many positive relationships exhibited in the data, and some were statistically significant.

Lead concentrations for floor samples are significantly correlated with soil samples taken at the boundary (0.97), entryway (0.93, marginal), and foundation (0.96). The lead concentrations for soil samples are still strongly correlated after controlling for the fixed effects. This may indicate that it is not the fixed effect of renovation or abatement which causes the data for these soil sample types to be correlated.

4.7 COMPARISON OF VACUUM AND WIPE SAMPLING PROCEDURES

One of the objectives of the Pilot Study was to compare the vacuum and wipe sampling protocols. In each of the units a "bridge room" was selected and side-by-side vacuum and wipe samples were taken. The purpose of collecting these data was to build a "bridge" between the sampling method for the full CAP Study, the vacuum method, and the wipe sampling method employed in the HUD Demonstration.

The vacuum versus wipe comparison data for floor lead loadings, window stool lead loadings, and window channel lead loadings are listed in Tables 4-8a, 4-8b, and 4-8c, respectively. In Table 4-8a, all side-by-side duplicate floor lead loadings are included even when they are not from the "bridge" room. These measurements contain information on the expected variation between side-by-side samples when they are taken using the same sampling protocol.

Table 4-8a. Vacuum versus Wipe Comparison Data: Floor Lead Loadings ($\mu g/ft^2$)

Unit	Room	Sampling Location[1]	Vacuum #1	Vacuum #2	Vacuum Geo. Mean	Wipe #1	Wipe #2	Wipe Geo. Mean
33	Kitchen	3	3.13	2.08	2.552	13.77[2]	13.77[2]	13.77
	Living Room	1	5.57	4.21	4.842	.	.	.
43	Dining Room	1	2.56	4.64	3.447	.	.	.
	Kitchen	3	8 76	4.57	6.327	18.42	24.27	21.14
17	Front Bedroom (BD1)	1	45.18	36.03	40.346	.	.	.
	Living Room	3	9.84	8.68	9.242	18.42	30.12	23.55
19	Kitchen	3	39.42	31.82	35.417	33.45	36.95	35.16
80	Back Bedroom (BD3)	1	10 69	8.31	9.428	.	.	.
	Kitchen	3	2.50	1.45	1.904	36.95	22.96	29.13
51	Front Bedroom (BD1)	3	59.42	374.03	149.080	3832.53	1628.77	2498.46
	Back Bedroom (BD3)	1	312 43	409.98	357.897	.	.	.

1 Sampling location identifies a general location sampled in each room.
2 The lead levels in these two samples were below the level of detection for the wipe analytical method; value reported is the detection limit.

Table 4-8b. Vacuum versus Wipe Comparison Data: Window Stool Lead Loadings ($\mu g/ft^2$)

Unit	Room	Sampling Location[1]	Vacuum #1	Vacuum #2	Vacuum Geo. Mean	Wipe #1	Wipe #2	Wipe Geo. Mean
33	Kitchen	4	.	.	.	105.80	121.73	113.486
	Utility Room	1	25.84	.	.	217.91	.	.
43	Kitchen	1	6.72	.	.	27.43	.	.
	Kitchen	4	.	.	.	18.39	30.53	23.695
17	Living Room	1	6.33	.	.	24.42	.	.
	Living Room	4	16.48	12.20	14.179	.	.	.
19	Kitchen	1	96.47	.	.	190.75	.	.
80	Kitchen	4	147.85	83.62	111.190	.	.	.
	Pantry	1	33.91	.	.	163.11	.	.
51	Front Bedroom (BD1)	1	600.26	.	.	4216 85	.	.
	Front Bedroom (BD1)	4	.	.	.	1142.59	504.54	759.264

1 Sampling location identifies a general location sampled in each room.

Table 4-8c. Vacuum versus Wipe Comparison Data: Window Channel Lead Loadings ($\mu g/ft^2$)

Unit	Room	Sampling Location[1]	Vacuum #1	Vacuum #2	Vacuum Geo. Mean	Wipe #1	Wipe #2	Wipe Geo. Mean
43	Kitchen	1	9246.81	.	.	335.38	.	.
	Kitchen	4	.	.	.	658.39	631.05	644.58
80	Kitchen	4	3771.04	6167.62	4822.69	.	.	.
51	Front Bedroom (BD1)	4	.	.	.	1008.29	1225.76	1111.72

[1] Sampling location identifies a general location sampled in each room.

With regard to window channel samples, the Pilot Study design called for sampling from two split windows in the "bridge" room in each unit. One window was to have both vacuum and wipe samples taken and the other was to have either two vacuum samples or two wipe samples taken. As is evident in Table 4-8c, sampling window channels turned out to be a difficult task (e.g., windows painted shut). Only four split window channels were actually sampled, and only one window was sampled with both the vacuum and wipe sampling methods.

The paired floor lead loadings from Table 4-8a are plotted in Figure 4-10a. In the figure, lead loadings from wipe samples are plotted versus lead loadings from vacuum samples. A reference line which represents complete agreement between the two sampling methods is also included. With one exception, the lead loadings from wipe samples exceed the lead loadings from vacuum samples. A statistical analysis was performed to quantify this relationship.

Both the vacuum lead loadings and wipe lead loadings are assumed to follow a lognormal distribution. For this reason a log-linear model was employed to characterize the relationship between wipe and vacuum lead loadings. The model fitted to the data was

$$\log(W) = \log(\alpha) + \beta \log(V) + \log(E) \qquad (3)$$

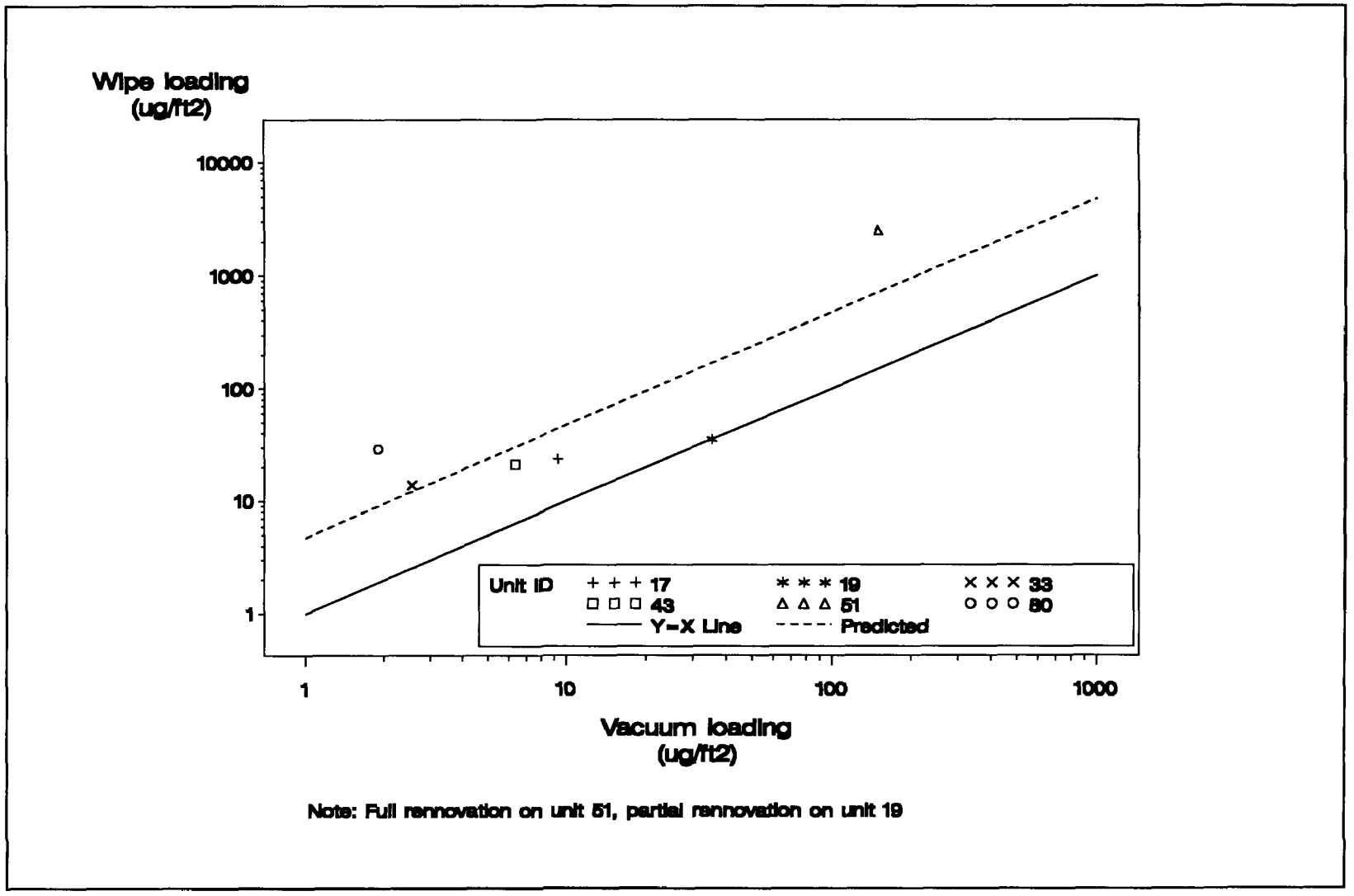

Figure 4-10a. Vacuum vs. wipe comparison: geometric means by sample location for floor lead loadings ($\mu g/ft^2$).

where W and V are the geometric means for vacuum and wipe samples, respectively, from Table 4-8a; E represents a random error term which is assumed to follow a lognormal distribution. Restating the model in terms of the wipe lead loading results

$$W = \alpha V^{\beta} E. \tag{4}$$

If β is not equal to one, the multiplicative bias between the two sampling methods changes with the magnitude of the measurements. However, if β=1, there is a fixed multiplicative bias (α) between the sampling methods which does not change with the magnitude of the measurements. Also, for β=1, the model of Equations (3) and (4) simplifies to the assumption that the ratio W/V follows a lognormal distribution with geometric mean α.

This model of Equations (3) and (4) was fitted to the six pairs of floor lead loading measurements plotted in Figure 4-10a, and the hypothesis H_0: β=1, the hypothesis of a fixed multiplicative bias, was tested. The estimate of β is 1.05 and the observed significance level of the test is 0.90. Since the hypothesis could not be rejected, the model was then refitted with the β parameter set to one (1). The estimate of the multiplicative bias (α) of wipe over vacuum measurements is 4.76 with a 95% confidence interval of (1.52, 14.95). This result implies that, on average, the wipe lead loadings are 4.76 times larger than matching vacuum lead loadings on floors. The reader should note that the slope of the estimated regression line (dashed) in Figure 4-10a is strongly influenced by the observation from the house with the highest loadings by both methods.

The paired window stool lead loadings from Table 4-8b are plotted in Figure 4-10b. The statistical analysis performed for floor lead loadings was repeated for the window stool lead loading data. For window stool lead loadings, the estimate of β is 1.07 and the observed significance level of the test of a

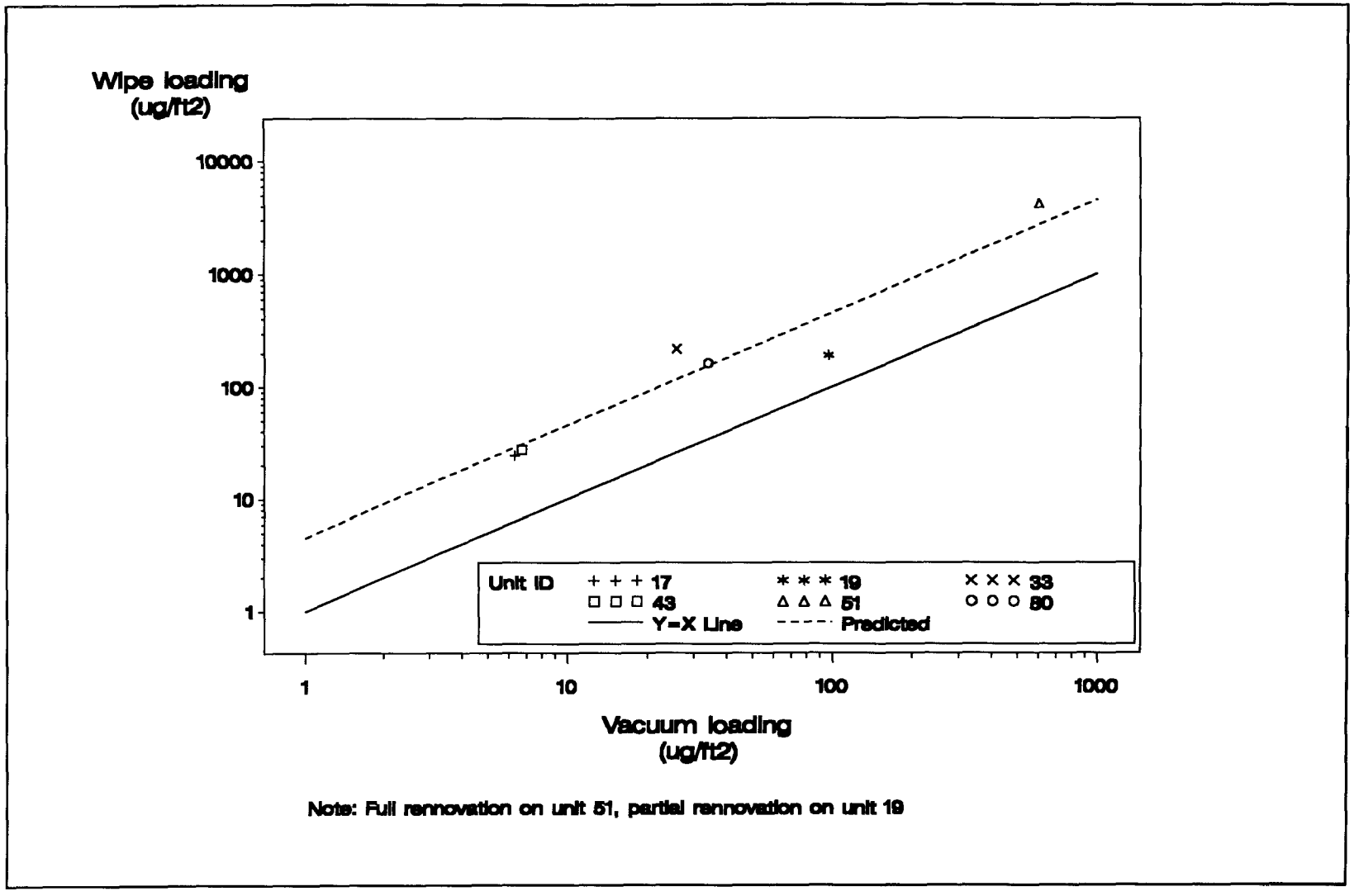

Figure 4-10b. Vacuum vs. wipe comparison: geometric means by sample location for window stool loadings ($\mu g/ft^2$).

fixed multiplicative bias (H_0: β=1) is 0.66. Since, again, the hypothesis could not be rejected, the model was refitted with the β parameter set to one (1). The estimate of the multiplicative bias (α) of wipe over vacuum measurements is 4.55 with a much tighter 95% confidence interval of (2.66, 7.78). This resultimplies that, on the average, the window stool wipe lead loadings are 4.55 times larger than matching vacuum lead loadings.

As evidenced in Table 4-8c, only one pair of window channel lead loadings is available. Therefore, no statistical analysis of the window channel data was performed.

The precision of the vacuum and wipe measurement techniques can also be compared by examining the replicate sample log standard deviation results in Tables 4-4a and 4-5a. The replicate sample standard deviation (reported in the last column) provides an estimate of the standard deviation of duplicate samples taken side-by-side for each sample type. Examining these values for floors, window stools, and window channels sampled by both vacuum and wipe techniques, neither sampling technique can be judged to be significantly more precise. Most data for this type of comparison were available for floor samples. Here the standard deviation for duplicate vacuum samples (0.47) was observed to be larger than that for wipe samples (0.33), but their confidence intervals overlap considerably. The 95% confidence interval for vacuum precision was (0.24, 1.35). The corresponding interval for wipe precision was (0.14, 1.60)

4.8 COMPARISON OF CAP PILOT DATA AND HUD DEMONSTRATION DATA

While conducting the HUD Demonstration project, detailed environmental data were collected by HUD on all units. Interior XRF/AAS results and lead loadings from the HUD Demonstration are presented in Table 4-9 by sample type and room. The tabled values are geometric mean values over all data collected in a room.

Table 4-9. Geometric Means for CAP Pilot and HUD Demonstration Data by Room: Interior XRF/AAS Results (mg/cm^2) and Dust Lead Loadings (μg/ft^2)

			Floor Samples			Window Stool Samples			Window Channel Samples		
Unit	Room	HUD Demo XRF (mg/cm^2)	HUD Demo Wipe (μg/ft^2)	CAP Pilot Wipe (μg/ft^2)	CAP Pilot Vacuum (μg/ft^2)	HUD Demo Wipe (μg/ft^2)	CAP Pilot Wipe (μg/ft^2)	CAP Pilot Vacuum (μg/ft^2)	HUD Demo Wipe (μg/ft^2)	CAP Pilot Wipe (μg/ft^2)	CAP Pilot Vacuum (μg/ft^2)
33	Bathroom	0.1732	.	.	.	.	.	.	.	.	.
	Bedroom #1	0.1682	.	.	.	.	.	.	.	.	.
	Bedroom #2	0.1414	.	.	1.009	.	.	8.75	.	.	.
	Bedroom #3	0.2449	.	.	.	.	.	.	.	.	.
	Entry Way	.	.	.	6.389	.	.	.	.	.	.
	Kitchen	0.2696	.	13.77	2.552	.	113.49	.	.	.	.
	Laundry	0.2783	.	.	.	.	217.91	25.84	.	.	.
	Living Room	0.1000	.	.	4.325	.	.	6.36	.	.	3696.72
43	Bathroom *	0.3686	67.00	.	.	.	.	.	331	.	.
	Bedroom #1 *	0.2213	122.00	.	.	158	.	.	.	.	.
	Bedroom #2 *	0.3021	153.00	.	.	35	.	.	906	.	.
	Dining Room *	0.4479	135.00	.	2.266	77	.	16.67	.	.	.
	Entry Way	.	.	.	11.501	.	.	.	.	.	.
	Game Room *	8.3247	9.00	.	.	.	.	.	.	.	.
	Kitchen *	0.3093	50.00	21.14	6.327	16	24.88	6.72	161	518.44	9246.81
	Living Room *	0.9076	86 00	.	2.395	143	.	15.94	584	.	297.37
17	Bathroom	0.2510	4.00	.	.	11	.	.	.	.	.
	Bedroom #1	0.3947	.	.	37.351	18	.	40.61	.	.	.
	Bedroom #2	0.3053	.	.	.	2	.	.	.	.	.
	Dining Room	.	.	.	.	4	.	.	.	.	.
	Entry Way	.	.	.	23.215	.	.	.	.	.	.
	Game Room	0.5000	.	.	.	13	.	.	.	.	.
	Hall	0.1565	11.00	.	.	.	.	.	.	.	.
	Kitchen *	0.5360	3.00	.	3.001	5	.	13.12	.	.	976.70
	Laundry	0.3107	.	.	.	.	.	.	.	.	.
	Living Room *	0.4919	9.00	23.55	9.242	1	24.42	10.84	.	.	.

Note: An * is used to indicate the specified room was abated.

Table 4-9. Geometric Means for CAP Pilot and HUD Demonstration Data by Room: Interior XRF/AAS Results (mg/cm^2) and Dust Lead Loadings (μg/ft^2) (Continued)

			Floor Samples			Window Stool Samples			Window Channel Samples		
Unit	Room	HUD Demo XRF (mg/cm^2)	HUD Demo Wipe (μg/ft^2)	CAP Pilot Wipe (μg/ft^2)	CAP Pilot Vacuum (μg/ft^2)	HUD Demo Wipe (μg/ft^2)	CAP Pilot Wipe (μg/ft^2)	CAP Pilot Vacuum (μg/ft^2)	HUD Demo Wipe (μg/ft^2)	CAP Pilot Wipe (μg/ft^2)	CAP Pilot Vacuum (μg/ft^2)
19	Bathroom	0.3064	.	.	.	.	.	.	.	.	.
	Bedroom #1	0.1000	.	.	77.284	.	.	13.06	.	.	1200.56
	Bedroom #2	0.4000	.	.	.	.	.	.	.	.	.
	Entry Way	.	.	.	43.822	.	.	.	.	.	.
	Hall	.	.	.	.	.	.	.	.	.	.
	Kitchen	0.2621	.	35.16	35.417	.	190.75	96.47	.	1529.67	.
	Living Room	0.3000	.	.	65.359	.	.	0.80	.	.	.
80	Bathroom *	2.6561	95.00	.	23.009	3859	.	13087.15	.	.	.
	Bedroom #1	0.5000	.	.	.	16	.	.	.	.	.
	Bedroom #2 *	1.9003	551.00	.	.	68	.	.	396	.	.
	Bedroom #3 *	1.1793	119.00	.	12.735	48	.	14.75	100	.	320.80
	Basement	0.6915	.	.	.	.	.	.	.	.	.
	Dining Room	0.3869	26693.00	.	.	31	.	.	.	.	.
	Entry Way	.	.	.	4.278	.	.	.	.	.	.
	Kitchen *	1.1919	257.00	29.13	1.904	115	.	111.19	201	.	4822.69
	Living Room	0.3000	388.00	.	.	32	.	.	.	.	.
	Pantry *	0.5625	112.00	.	.	23	163 11	33.91	115	.	.
51	Bathroom #2 *	3.5156	.	.	.	.	.	.	.	.	.
	Bathroom *	2.1193	149.33	.	561.640	262	.	1053.17	112	.	695.81
	Bedroom #1 *	4.6480	186.00	2498.46	149.080	279	1344.59	600.26	260	1111.72	.
	Bedroom #2 *	3.2728	145.00	.	.	361	.	.	.	.	.
	Bedroom #3 *	1.7660	32.50	.	353.417	22	.	93.44	.	.	433.22
	Entry Way	.	.	.	415.132	.	.	.	.	.	.
	Hall *	20.1501	396.84	.	.	.	.	.	.	.	.
	Hall #2 *	.	8.00	.	.	.	.	.	.	.	.
	Kitchen *	4.0964	45.00	.	.	140	.	.	194	.	.
	Laundry *	1.0000	310.00	.	.	47	.	.	70	.	.
	Living Room *	4.0309	119.00	.	.	70	.	.	382	.	.

Note: An * is used to indicate the specified room was abated.

Along with the HUD Demonstration data in Table 4-9, lead loadings for vacuum and wipe samples from the CAP Pilot are also reported. These tabled values are also geometric mean values over all data in a room. As evidenced by the sparseness of Table 4-9, there are very few rooms in which there are both HUD Demonstration wipe data and CAP Pilot data. The best such comparative data are found for floor samples where there are 11 rooms that have both HUD Demonstration wipe samples and CAP Pilot vacuum samples. Data for these rooms are plotted in Figure 4-11 where the CAP Pilot vacuum lead loadings are plotted versus the HUD Demonstration wipe lead loadings. There appears to be little agreement between the two sets of measurements.

In the case of HUD Demonstration XRF/AAS measurements, there are several rooms in the CAP Pilot units where comparisons are possible. In Figure 4-12, the CAP Pilot and HUD Demonstration lead loadings are plotted versus the HUD Demonstration XRF/AAS measurements. Separate plots for floor lead loadings, window stool lead loadings, and window channel lead loadings are presented as Figures 4-12a, 4-12b, and 4-12c, respectively. HUD Demonstration and CAP Pilot floor lead loadings appear to increase slightly with increasing XRF/AAS readings. For example, the highest geometric mean lead loading for CAP Pilot wipe samples (around 2498 $\mu g/ft^2$) was in a room with a relatively high XRF/AAS reading (4.648 mg/cm^2).

Window stool lead loadings (Figure 4-12b) show a somewhat stronger increasing trend with increasing XRF/AAS readings. This pattern is evident for all three types of lead loading measurements. If anything, window channel lead loadings (Figure 4-12c) may show a slightly decreasing trend with increasing XRF/AAS readings.

Table 4-10 is similar to Table 4-9 but contains exterior XRF/AAS measurements from the HUD Demonstration, and soil lead concentration measurements from both the HUD Demonstration (post-abatement) and the CAP Pilot. Data for the sides of the units where both HUD Demonstration and CAP Pilot soil lead measurements

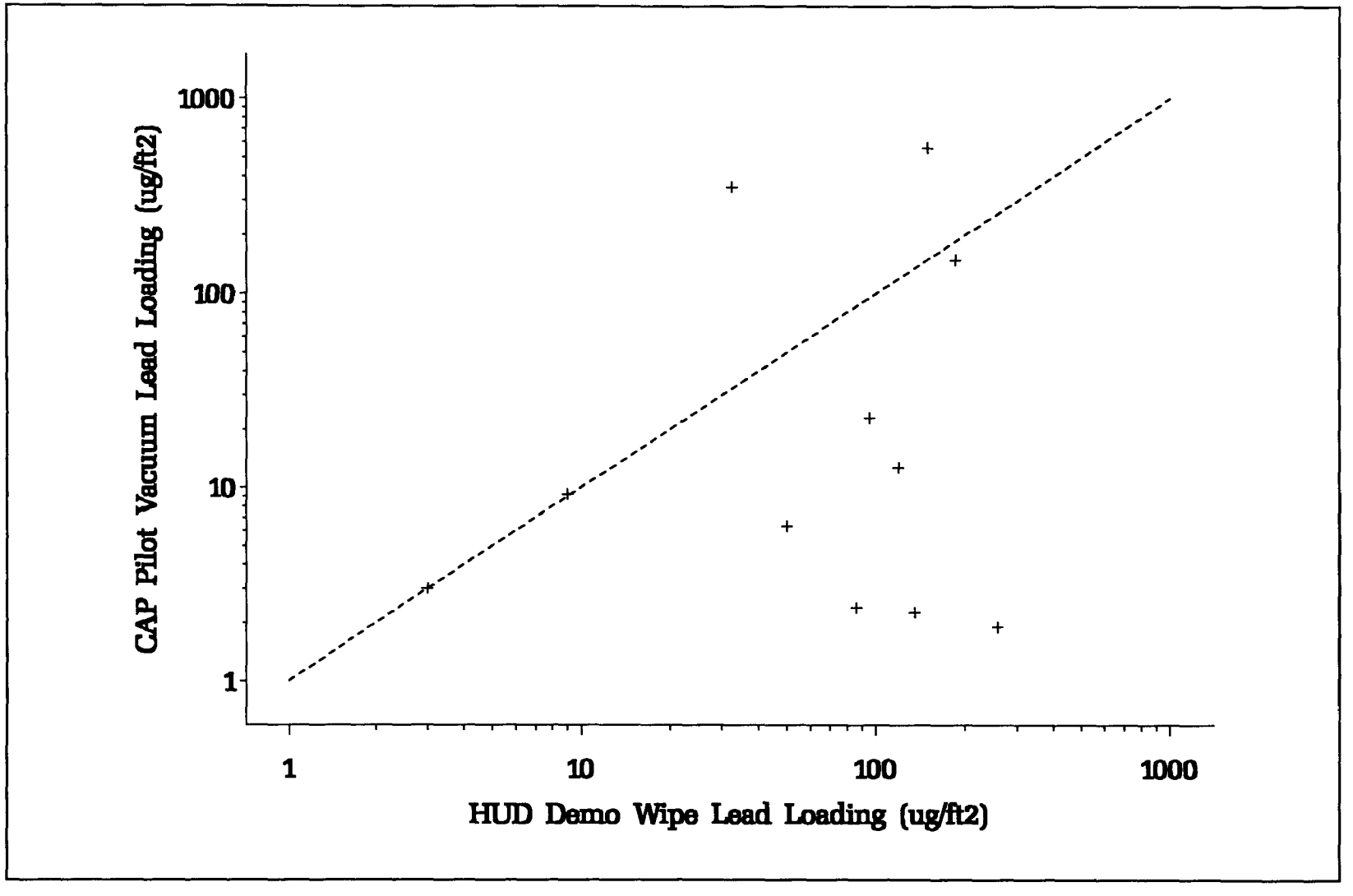

Figure 4-11. CAP pilot vacuum versus HUD Demonstration wipe data: geometric mean floor lead loading ($\mu g/ft^2$) by room.

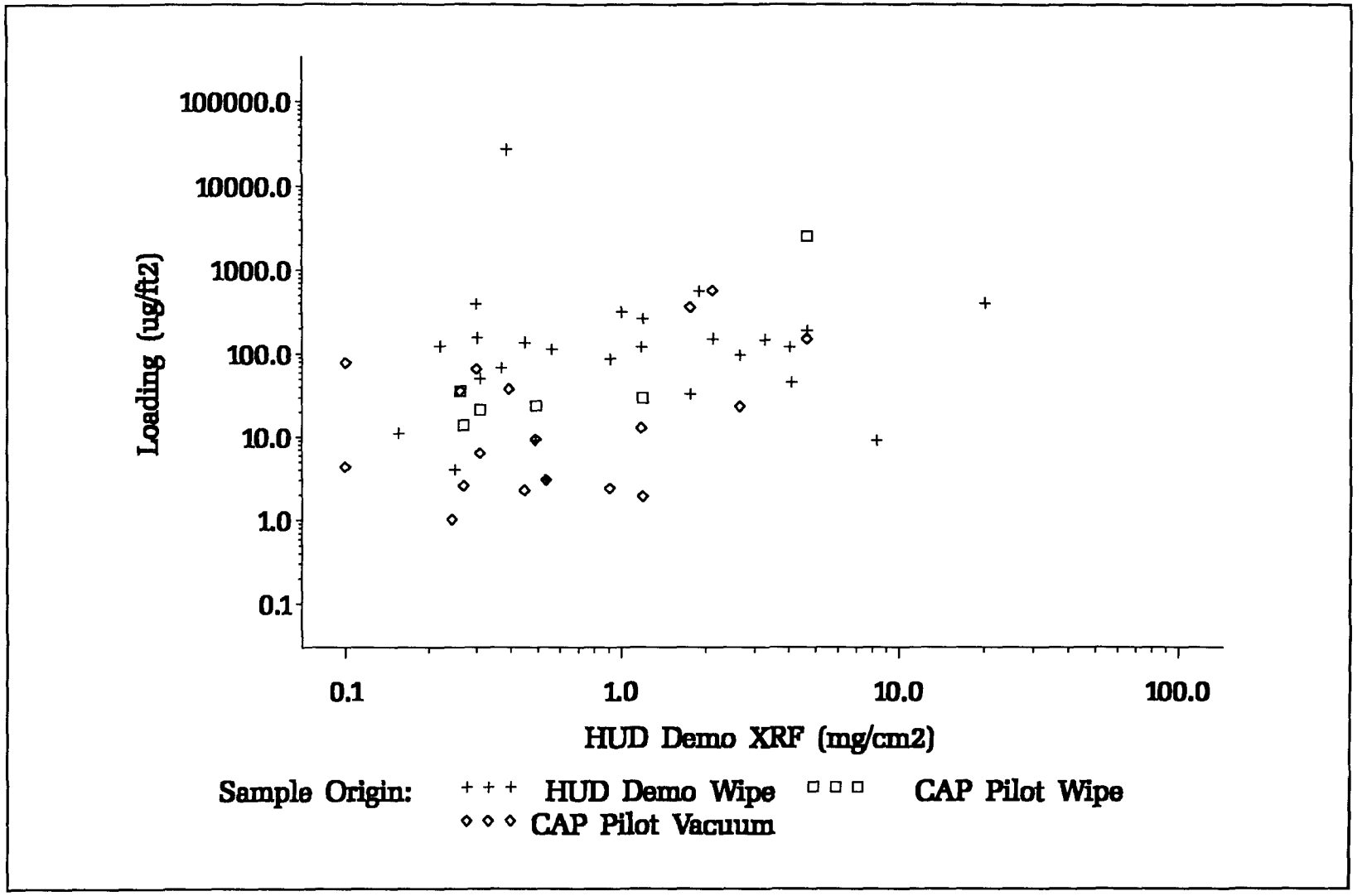

Figure 4-12a. CAP pilot and HUD Demonstration floor lead loadings ($\mu g/ft^2$) versus HUD Demonstration XRF/AAS results: geometric means by room.

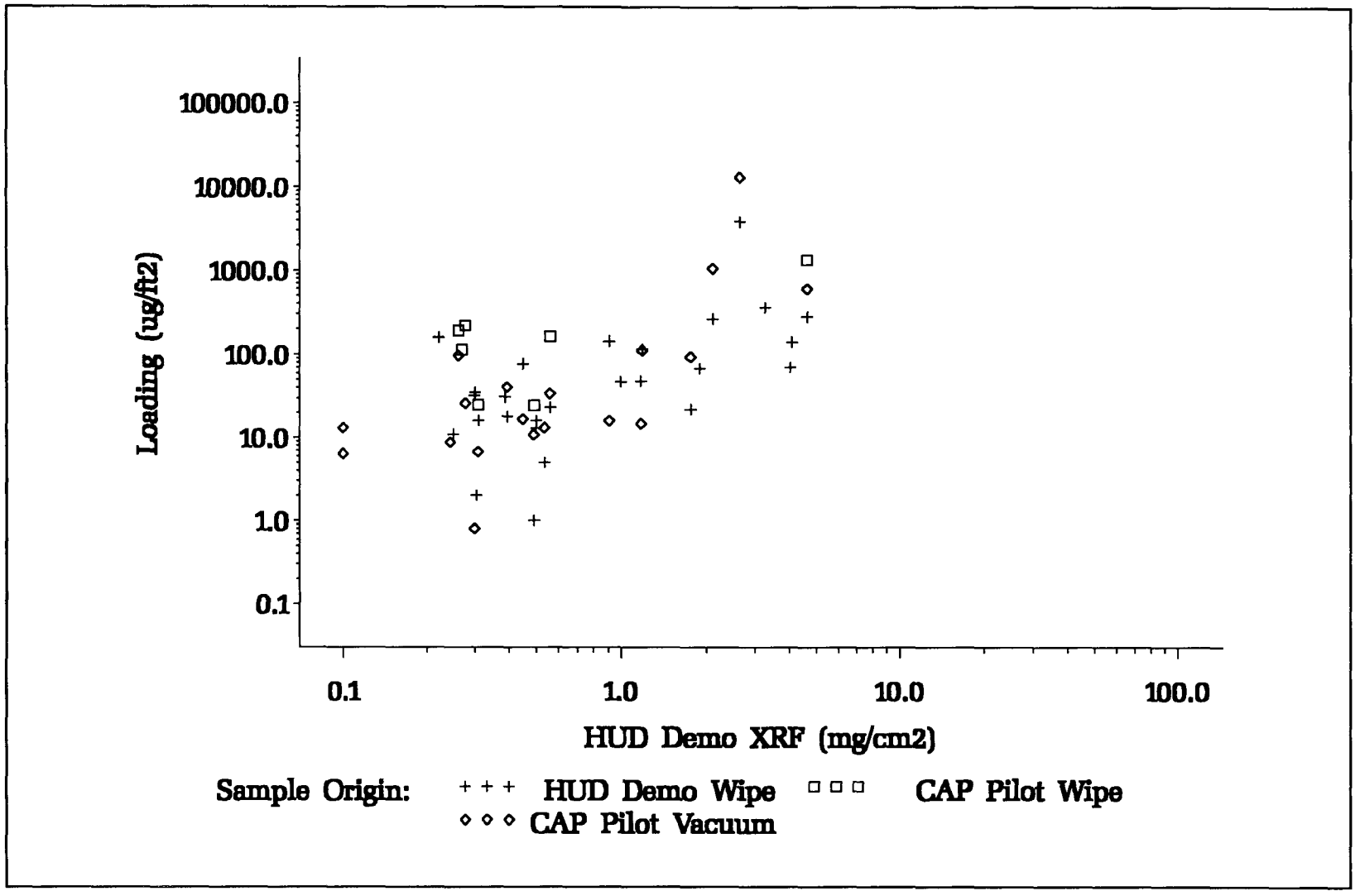

Figure 4-12b. CAP pilot and HUD Demonstration window stool lead loadings ($\mu g/ft^2$) versus HUD Demonstration XRF/AAS results: geometric means by room.

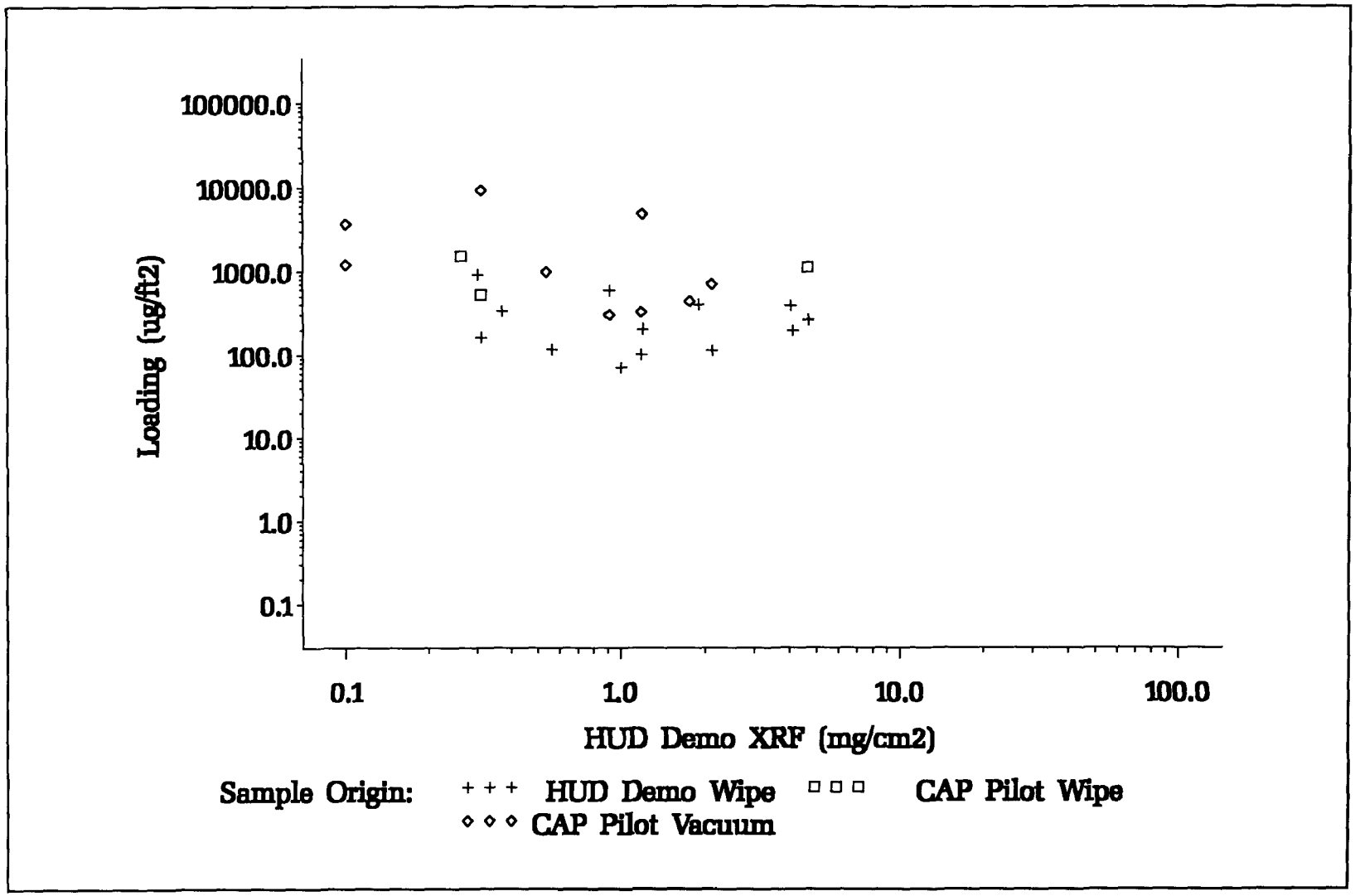

Figure 4-12c. CAP Pilot and HUD Demonstration window channel lead loadings ($\mu g/ft^2$) versus HUD demonstration XRF/AAS results: geometric means by room.

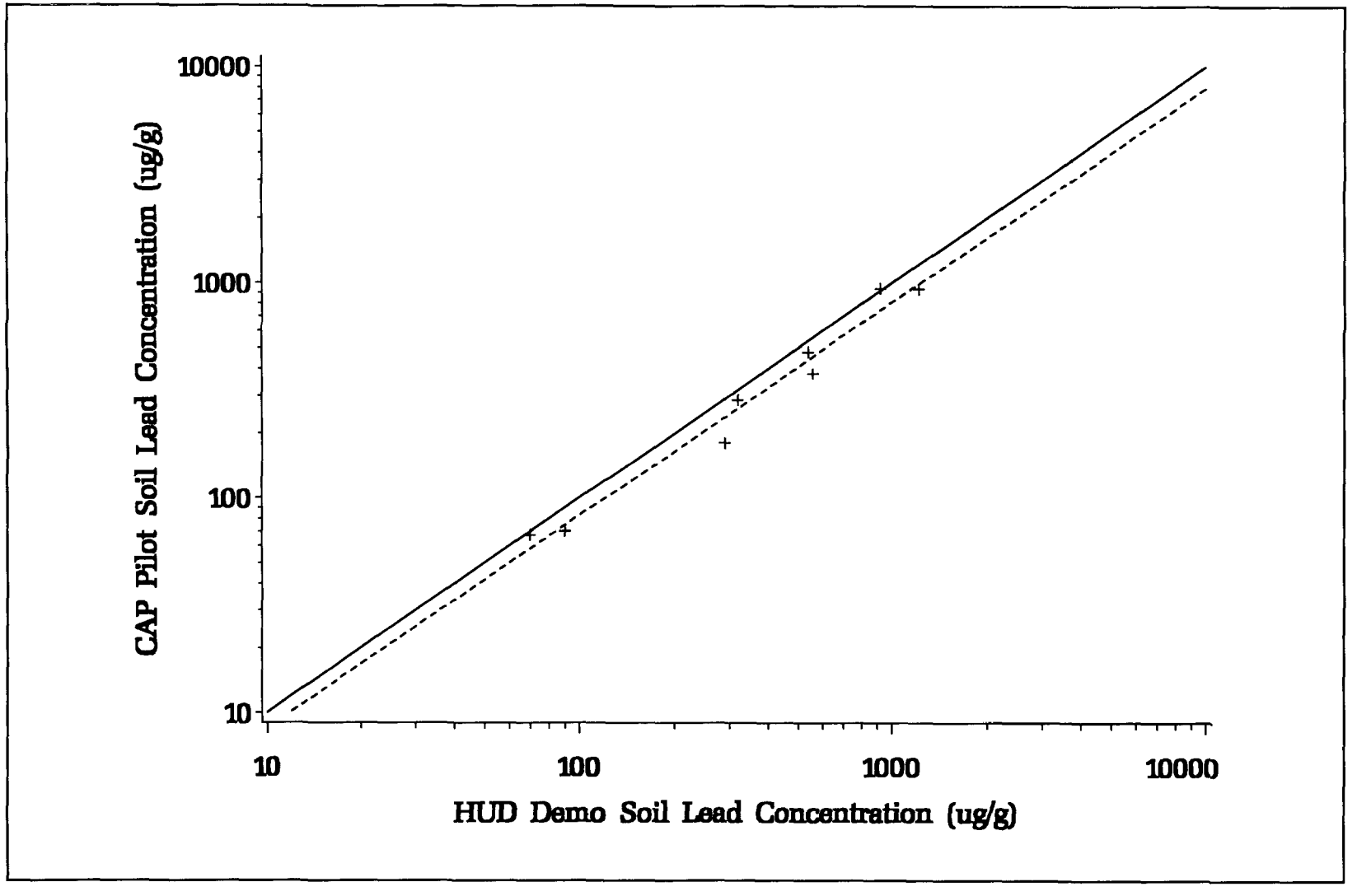

Figure 4-13. CAP Pilot soil versus HUD Demonstration soil data: geometric mean foundation soil lead concentration (μg/g) by side of unit.

Table 4-10. Geometric Means for CAP Pilot and HUD Demonstration Data by Side of Unit: Exterior XRF/AAS Results (mg/cm^2) and Soil Lead Concentrations ($\mu g/g$)

Unit	Location	HUD Demo XRF of Adjacent Wall (mg/cm^2)	HUD Demo Soil ($\mu g/g$)	CAP Pilot Soil ($\mu g/g$)
33	Back Yard	0.1	.	.
	Front Yard	0.2	.	108.210
	Left Side Yard	.	.	171.237
	Right Side Yard	.	.	.
43	Back Yard	.	288.7	180.720
	Front Yard	6.6	318.9	287.027
	Left Side Yard	.	443.0	.
	Right Side Yard	10.8	1112.8	.
17	Back Yard	.	70.0	67.514
	Front Yard	6.9	120.0	.
	Left Side Yard	.	90.0	70.240
	Right Side Yard	.	90.0	.
19	Back Yard	.	.	.
	Front Yard	.	.	49.180
	Left Side Yard	.	.	238.390
	Right Side Yard	.	.	.
80	Back Yard	.	558.0	381.288
	Front Yard	.	500.0	.
	Left Side Yard	.	920.0	941.590
	Right Side Yard	.	.	.
51	Back Yard	5.3	539.2	479.202
	Front Yard	13.5	1218.0	937.650
	Left Side Yard	9.3	1026.4	.

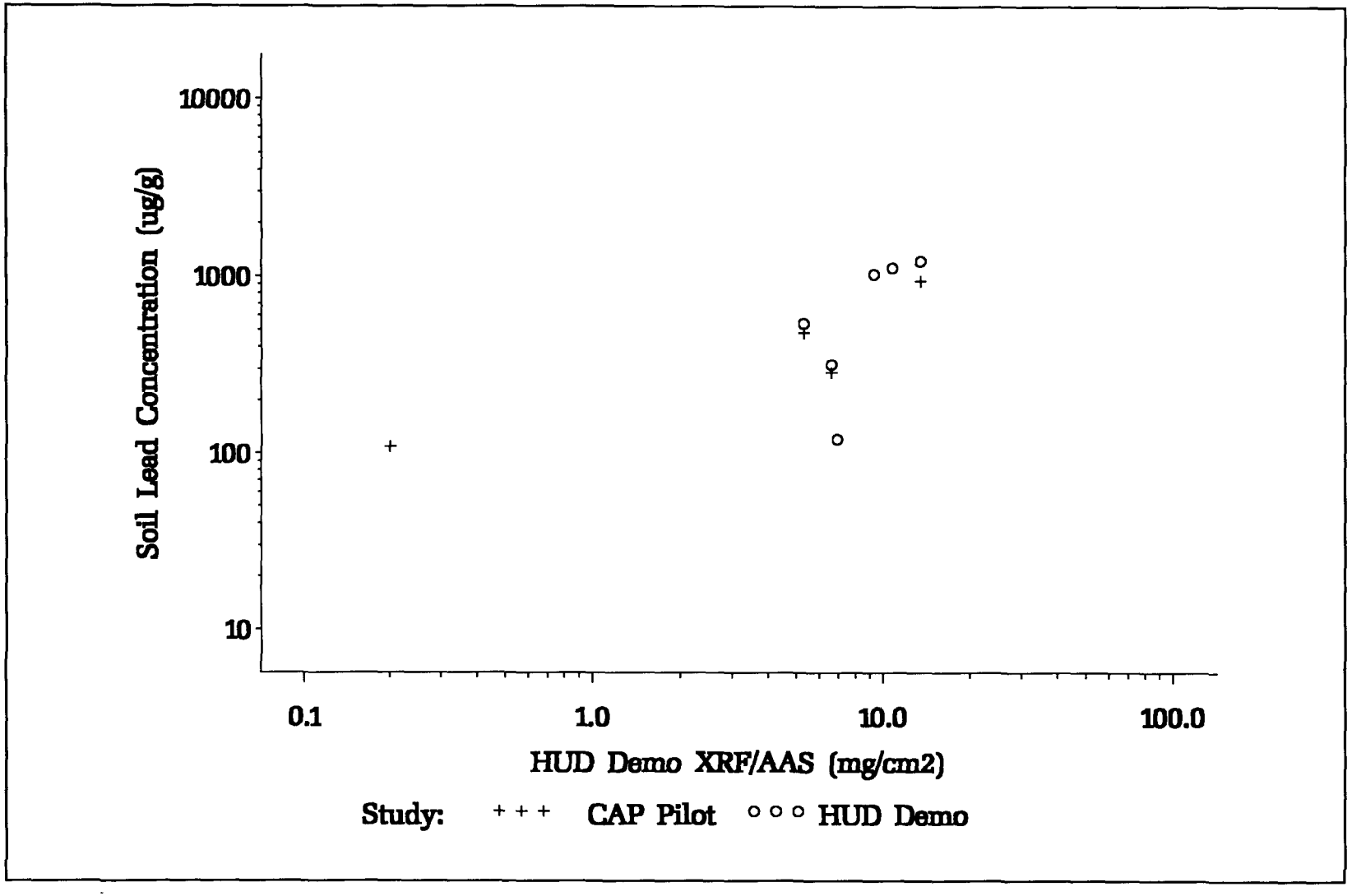

Figure 4-14. CAP Pilot and HUD Demonstration soil lead concentrations ($\mu g/g$) versus HUD Demonstration XRF/AAS results: geometric means by side

were taken are plotted against each other in Figure 4-13. This plot shows good correlation between the two sets of soil lead concentrations, with the HUD Demonstration concentrations being about 25% higher on average. The fitted regression (dashed line) has a nonsignificant intercept -0.15 and a significant slope coefficient of 0.99.

In Figure 4-14, the CAP Pilot and HUD Demonstration soil lead concentration values are plotted versus the exterior HUD Demonstration XRF/AAS readings. In this figure there is apossible increasing trend evident in soil lead concentrations with increasing XRF/AAS readings. This pattern appears for both the CAP Pilot and HUD Demonstration soil lead concentration measurements.

5.0 STATISTICAL ANALYSIS OF QUALITY CONTROL DATA

In order to assure that the sampling and analytical protocols employed in the Pilot Study were producing data of sufficient quality, a number of different quality control (QC) samples were included in the study design. These QC samples are designed to control and assess quality in the: (1) collection of samples in the field, (2) preparation of field samples for laboratory analysis, and (3) quantitative analysis of samples in the laboratory. The quality control samples included in the study may be organized under four major categories:

- Blank Samples: Trip blanks, field blanks, method blanks, and calibration blanks
- Recovery Samples: Reference material samples, spiked samples, calibration verification samples, and interferant check standards (ICP only)
- Duplicate Samples: Side-by-side field samples and spiked duplicate samples
- Interlaboratory Comparison Samples: Side-by-side field samples to be analyzed by two different laboratories.

In general, analysis of the QC data led to the following conclusions:

1. Overall, analysis of the blank samples suggests little if any procedural contamination. Blank contamination was, noted in the dust wipe blank samples used for sampling, but not in the dust wipe blank samples used for field cleaning.
2. With the exception of one very low percent recovery for a flame atomic absorption (FAA-W) reference material sample, the results for all recovery samples indicate very good method performance.
3. Spiked duplicate samples created in the laboratory exhibited very good agreement. With the exception of one pair of soil samples, side-by-side field samples exhibited good agreement, but also exhibited some inherent variability as would be expected in field duplicates.

4. Though the estimated ratio of results from the secondary laboratory to results from the primary laboratory suggest the primary laboratory lead concentrations are slightly lower, this difference is not statistically significant. There appears to be no laboratory bias.

Detailed results of statistical analyses performed on the data from each of the four categories of QC samples are reported in the following sections. The quality control samples were assumed to follow a lognormal distribution and were, therefore, log transformed prior to analysis. The small number of samples for each type of quality control procedure precluded an effective evaluation of their distribution. For the majority of quality control samples, statistical analysis of the untransformed and transformed data suggested both could be normally distributed. In Section 4.1, evidence is cited supporting the log transformation of the field samples. The log transformation was, therefore, employed also on the quality control samples.

5.1 BLANK SAMPLES

Blank samples are samples which are expected to contain no lead or only a very small amount of lead. In the CAP Pilot Study four types of blank samples were analyzed: trip blanks, field blanks, method blanks, and calibration blanks. Each type of blank sample served a specific purpose. Trip blanks were analyzed to identify any problems with the gravimetric procedures used to determine the amount of dust collected by the vacuum sampling method. Field blanks were analyzed to identify sample contamination anywhere in the normal process of sample collection, transport, preparation and analysis. Method blanks were analyzed to examine sample contamination in the normal process of sample preparation and analysis. Calibration blanks were analyzed to examine any changes in instrument performance that may effect estimated lead concentrations reported for regular study samples.

Only gravimetric analysis was performed for trip blanks. The trip blank data consists of pre-field and post-field weights (mg) of 52 cassettes sent to the field. The difference between the post-field and pre-field weights was assumed to be normally distributed. Unlike other quality control samples, trip blanks did not involve the measurement of lead content. As a result, the simple assumption of a normal distribution was utilized. The arithmetic mean difference was 1.8 mg, with a standard deviation of 0.2 mg. An estimated 95% tolerance interval for the difference is (1.2 mg, 2.3 mg). The cassettes, therefore, return from the field weighing marginally more than they did before leaving. However, since the estimated bias of 1.8 mg is small in comparison with the geometric mean dust amounts in Table 3-4, no adjustment was made to sample weights or concentrations.

The three other types of blank samples (field, method, and calibration) were all analyzed for lead content. Just as with the regular study data, the measured amount of lead per sample was assumed to follow a lognormal distribution.

Data for the three types of blanks were generated for each of the following four combinations of sample medium, sampling method, and analytical method:

- Dust by Vacuum by GFAA (GFAA-V)
- Dust by Vacuum by ICP (ICP-V)
- Dust by Wipe by FAA (FAA-W)
- Soil by Core by ICP (ICP-S)

Descriptive statistics are reported for the data from blank samples in Table 5-1.

The descriptive statistics reported include the number of samples, number of results above the detection limit, minimum, and maximum. When possible, the geometric mean and logarithmic standard deviation for the amount of lead per sample are reported. In addition, a 95% upper confidence bound on the .95 quantile for the amount of lead per sample is also provided. For

Table 5-1. Descriptive Statistics Tolerance Bound for μg Lead/Sample in Blank Samples

Type of Blank	Type of Analysis	Sample Size	# Above Detection Limit	Minimum	Maximum	Geometric Mean	LN Standard Deviation	Upper 95% Tolerance Bound
Field	GFAA-V	9	9	0.06	3.13	0.26	1.07	6.56
	FAA-W	6	6	6.15	18.02	10.63	0.39	44.83
	ICP-S	6	2	0.30	3.33	0.12	2.79	[2]
Method	GFAA-V	12	12	0.04	0.30	0.12	0.66	0.76
	ICP-V[1]	15	10	0.14	0.98	0.35	0.91	3.57
	ICP-V	16	11	0.14	8.29	0.40	1.29	9.81
	FAA-W	7	2	2.65	16.96	2.26	1.57	[2]
	ICP-S	4	3	0.30	3.12	1.04	1.11	37.56
Calibration	GFAA-V[3]	11	0	0.68	1.38	.	.	.
	ICP-V	30	23	0.01	0.05	0.02	0.57	0.06
	FAA-W	12	2	0.07	0.34	0.05	0.59	0.46
	ICP-S	15	3	0.01	0.05	0.00	2.59	38.29

Censored Analysis

[1] - Without the 8.29 μg/sample method blank measure from batch, CSS.

[2] - Insufficient number of noncensored samples available to calculate a reasonable tolerance bound.

[3] - Insufficient data available to perform analysis. All data were censored.

the sake of simplicity, this bound will be referred to as the estimated 95% tolerance bound. These calculations were possible only when a sufficient number of results above the detection limit were obtained in a category.

If all results were above detection, calculation of the geometric mean and logarithmic standard deviation was routine, and the estimated upper 95% tolerance bound was calculated using an exact procedure for lognormal distributions. In instances where a portion of the quality control data was censored on the left (e.g., field blank samples), a lognormal model was fitted to the data and its parameters estimated. The SAS procedure LIFEREG was utilized in obtaining these estimates. LIFEREG maximized the log-likelihood function via a ridge stabilized Newton-Raphson algorithm, thereby providing maximum likelihood estimates of the log mean and log standard deviation. In these cases, an approximate procedure was used to calculate the estimated 95% upper tolerance bound using the detection limit for each sample as the censoring value. The approximate nature is due to employing the maximum likelihood estimates in determining traditional 95% tolerance bounds. Since the traditional approach does not include an adjustment to the bounds reflecting censored data, the estimated tolerance bounds are approximate. When a high percentage of the results were below detection, it was not possible to calculate a geometric mean, logarithmic standard deviation or estimated 95% upper tolerance bound, and these fields are left blank.

When spiked and spiked duplicate cassette and wipe samples were analyzed, an unspiked cassette or wipe was also analyzed. These unspiked samples have been included in Table 5-1 as method blanks.

The data for blank samples are illustrated in Figure 5-1. The amount of lead (μg) found in each blank sample is plotted by category. Different plotting symbols are used to indicate

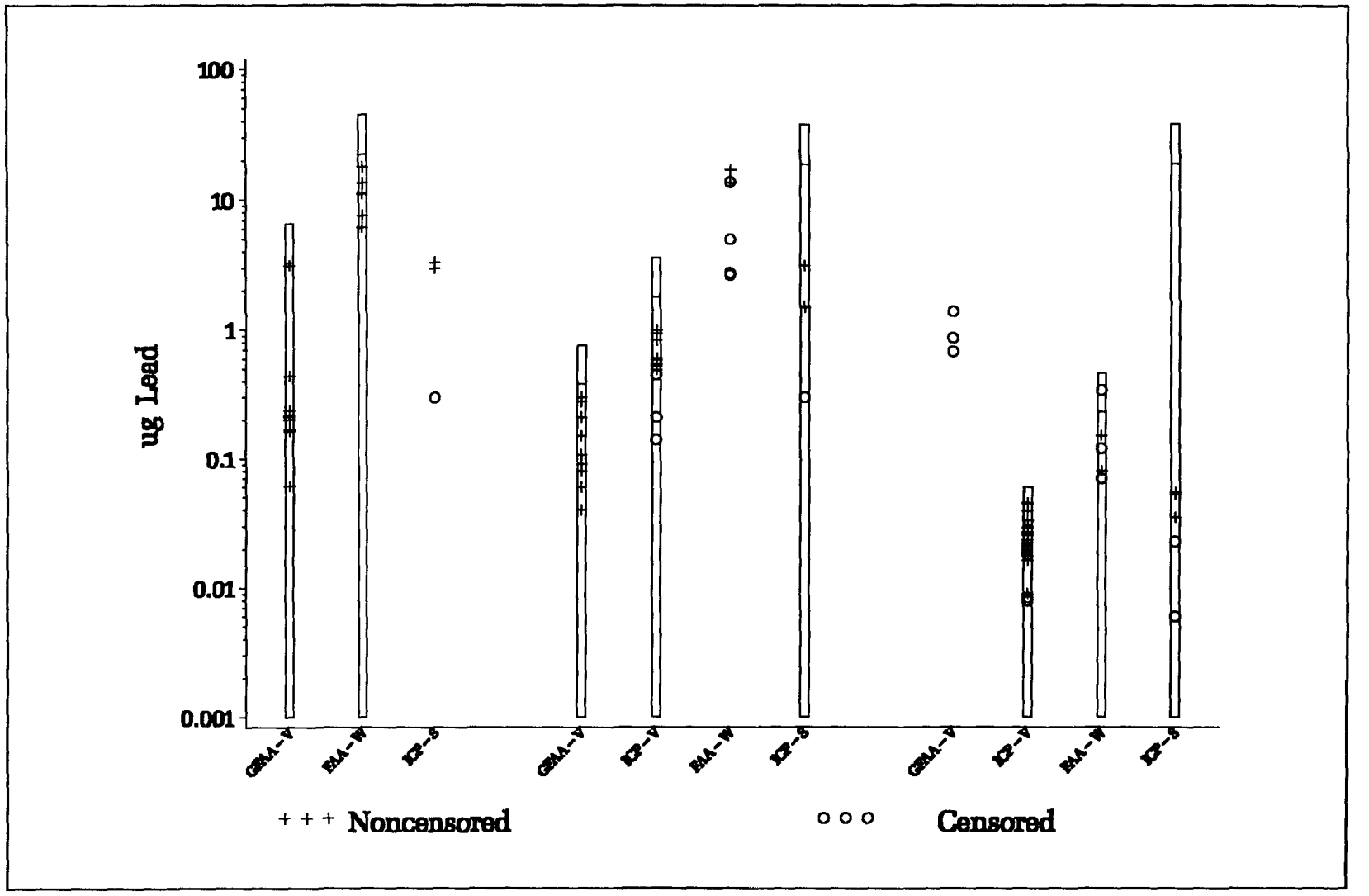

Figure 5-1. Individual measurements and tolerance bounds for μg lead/sample in blank samples.

whether the result was above detection or below detection, in which case the detection limit is plotted. In those cases where an estimated tolerance bound could be calculated, the estimated 95% upper tolerance bound is illustrated in the figure by a bar which has the tolerance bound as its upper value.

Dust wipes appear to contain more background lead, or to become contaminated by routine handling, to a larger extent than do the other sampling media. This is evidenced by geometric means of 10.63 μg lead per sample for field blank wipes, and 2.26 μg lead per sample for method blank wipes. Analysis of the vacuum dust and soil field blanks suggests them to be only marginally contaminated by sample handling. With the exception of wipes, results from the method blanks suggest that the laboratory procedures correctly report a negligible amount of lead when the sample contains none. Similarly, the calibration blank results provide evidence that the calibration regression equations remained valid. The GFAA calculated vacuum dust calibration blanks could not be examined since all were below the detection limit.

Because it was suspected that the brand of wipes used in the HUD Demonstration are contaminated with measurable amounts of lead, pre-field testing of wipes was conducted revealing lead levels similar to those found in the CAP Pilot blank samples. Despite this, the same brand of wipe was used in the CAP Pilot to maintain comparability with HUD Demonstration results, and because the contamination level was small relative to the expected amounts of lead in regular samples.

5.2 RECOVERY SAMPLES

Recovery samples are samples which contain a known amount of lead or have been spiked with a known amount of lead. Four types of recovery samples were incorporated in the CAP Pilot Study: reference material samples, spiked samples, calibration verification samples, and interferant check standards (ICP only). The reference material samples verify the ability of the

laboratory procedure to correctly determine the amount of lead in samples similar to the regular samples. Spiked samples verify the ability of the laboratory procedure to correctly determine a known amount of lead in regular study samples. The calibration verification samples evaluate the continued viability of the calibration regression equations. The interferant check standard samples are a check on the effect of interferences to the ICP analysis procedure. Again there are four combinations of sample medium, sampling method, and analysis method of interest.

All spiked samples, including both members of each spiked duplicate pair, are included in the calculations in this section. For GFAA, the first continuing calibration verification (CCV) sample in each batch of samples processed was excluded from the calculations since this result is simply a repeated recording of the results for the midpoint calibration standard, relabelled as a continuing calibration verification sample.

For all but spiked soil samples, the analytical result for each recovery sample was taken to be the ratio of the measured amount of lead in a sample to the known amount of lead in the sample. When multiplied by 100, this value is commonly referred to as the percent recovery. The percent recovery value is assumed to follow a lognormal distribution. If the geometric mean of the lognormal distribution is 100%, this is an indication that lead is over-recovered half the time and under-recovered half the time. Percent recovery values over 100% indicate a measured value exceeding the known amount of lead, and values under 100% indicate a measured value below the known amount.

The analysis of spiked soil samples required slightly different procedures. Spiked cassette and wipe samples were created by spiking a known amount of lead into a new cassette or onto a new wipe. Therefore, the amount of lead contained in these samples was known. However, spiked soil samples were created by spiking a regular soil sample with a known amount of lead. Since the sample already contained some lead, a different

calculation of percent recovery was required. For spiked soil samples, percent recovery was calculated as

$$\frac{\left[\begin{array}{c}\text{measured } \mu g \text{ lead} \\ \text{in spiked sample}\end{array}\right] - \left[\begin{array}{c}\text{measured } \mu g \text{ lead in} \\ \text{unspiked sample}\end{array}\right]}{\mu g \text{ lead in spike}} * 100$$

As before, the percent recovery value was assumed to follow a lognormal distribution.

Descriptive statistics for recovery samples are reported in Table 5-2. The descriptive statistics reported include the number of samples, minimum, maximum, geometric mean, and logarithmic standard deviation. Also, an estimated 95% tolerance interval (upper and lower 97.5% tolerance bounds) was calculated using an exact procedure for lognormal distributions.

The data for recovery samples are illustrated in Figure 5-2. The percent recovery for each recovery sample is plotted by recovery sample category. The estimated 95% tolerance interval is illustrated in the figure by a bar extending from the lower tolerance bound to the upper tolerance bound.

The analysis of the recovery samples indicates good recovery of the lead. The only estimated tolerance interval that does not contain 100% is that for FAA-W calibration samples. However, all values in the estimated tolerance interval, (101%, 112%), are very close to 100%. The estimated tolerance intervals for spiked samples, calibration verification samples, and interferant check standards are all narrow, indicating good method performance. The estimated tolerance intervals for GFAA-V, ICP-V, and ICP-S reference material samples are wider; however, this is due primarily to the small number (4) of samples analyzed. Though more FAA-W reference material samples (10) were analyzed, one very low value results in a wide tolerance interval. With this very low value removed, the estimated tolerance interval for

Table 5-2. Descriptive Statistics and Tolerance Bounds for Percent Recovery in Recovery Samples

Type of Recovery	Type of Analysis	Sample Size	Minimum	Maximum	Geometric Mean	LN Standard Deviation	Lower 95% Tolerance Bound	Upper 95% Tolerance Bound
Reference Material	GFAA-V	4	73.7	101.5	84	0.14	36	194
	ICP-V	4	88.9	98.7	93	0.05	68	127
	FAA-W	10	54.5	133.2	106	0.25	46	245
	ICP-S	4	80.1	127.3	101	0.19	32	320
Spiked	GFAA-V	12	103.7	112.9	108	0.03	98	119
	ICP-V	16	90.7	105.7	100	0.04	88	114
	FAA-W	8	105.3	130.1	117	0.07	91	150
	ICP-S	8	100.6	108.4	103	0.03	94	114
Calibration (Initial & Continuing)	GFAA-V	11	102.4	109.4	106	0.02	99	113
	ICP-V	30	96.9	106.1	102	0.02	96	108
	FAA-W	17	103.2	108.9	106	0.02	101	112
	ICP-S	15	100.0	109.4	104	0.03	96	113
Interferant Check Standard	ICP-V	15	91.0	106.4	99	0.05	87	114
	ICP-S	7	96.2	119.4	105	0.07	78	140

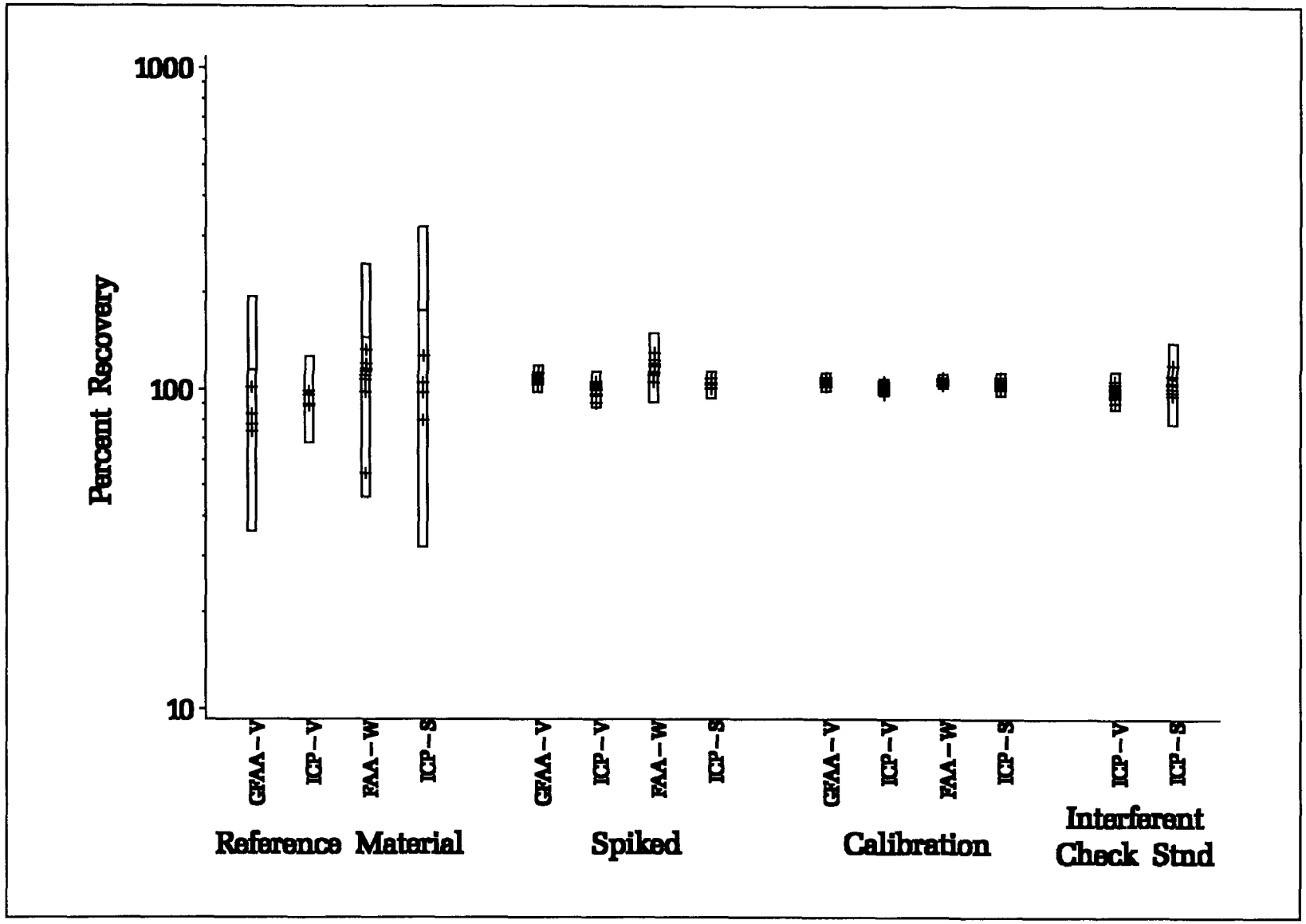

Figure 5-2. Individual measurements and tolerance bounds for percent recovery in recovery samples.

FAA-W reference material samples (85,153) is also quite satisfactory.

5.3 DUPLICATE SAMPLES

Duplicate samples are samples which are expected to be similar either because they were collected side-by-side in the field (side-by-side samples) or they are created to be similar in the laboratory (spiked duplicates). In both cases the samples are analyzed one after the other in the same analytical batch. Note that the side-by-side soil samples collected for the purpose of interlaboratory comparison are also included in these batches.

The analytical result for each pair of duplicate samples was the ratio of the larger measured lead result to the smaller measured lead result. This ratio has a minimum value of one. The log of this ratio was assumed to follow the absolute value of a normal distribution with mean zero and standard deviation σ.

Descriptive statistics for duplicate samples are reported in Table 5-3. The descriptive statistics reported include the number of samples, maximum ratio, and logarithmic standard deviation. Also, an estimated 95% upper tolerance bound was calculated using an exact procedure for lognormal distributions with known geometric mean.

The data for duplicate samples are illustrated in Figure 5-3. The ratio for each duplicate pair is plotted by duplicate sample category. The estimated 95% upper tolerance bound is illustrated in the figure by a bar extending from a value of one to the upper tolerance bound.

The duplicate sample results suggest good agreement between spiked duplicate samples. With the exception of one pair of side-by-side soil samples, good agreement is also exhibited for side-by-side samples; however, the inherent variability between field samples, even when they are collected side-by-side, is evidenced by the higher ratios and tolerance bounds for these sample types.

Table 5-3. Descriptive Statistics and Tolerance Bounds for the Ratio of Duplicate Samples

Type of Duplicate	Type of Analysis	Units	Maximum Ratio	LN Standard Deviation	Sample Size	Upper 95% Tolerance Bound
Field Side-by-Side	ICP-V	µg/g	1.49	0.26	5	1.68
	ICP-V	µg/ft^2	1.81	0.35	5	2 03
	ICP-S	µg/g	3.96	0.60	12	2.22
	ICP-S[1]	µg/g	1.49	0.23	11	1.47
Spiked Duplicate	GFAA-V	µg/sample	1.07	0.04	6	1.08
	ICP-V	µg/sample	1.11	0.05	8	1.10
	FAA-W	µg/sample	1.17	0.11	4	1.25
	ICP-S	µg/sample	1.02	0.01	4	1.03

[1] Excluding one pair of soil samples from batch SSS whose ratio is 3.96.

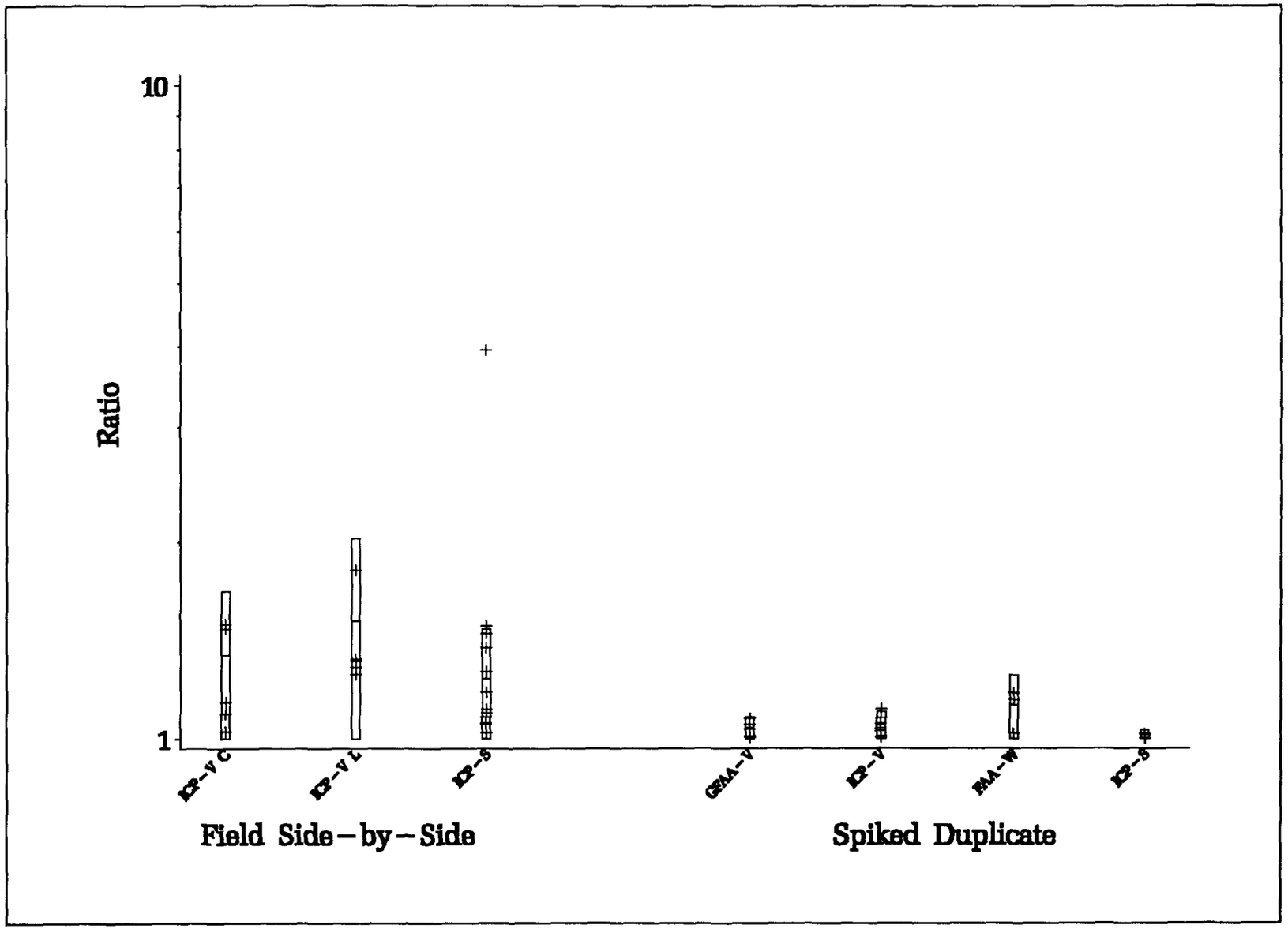

Figure 5-3. Individual measurements and tolerance bounds for the ratio of duplicate samples.

5.4 INTERLABORATORY COMPARISON SAMPLES

Interlaboratory comparison samples were utilized to examine possible laboratory bias in the analysis of regular field samples. Side-by-side vacuum cassette samples and soil samples from each pilot unit in Denver, as well as six units in Baltimore (Battelle and Kennedy Krieger Institute, 1992), were randomly sent to the primary and secondary laboratories. In the case of soil, the samples were homogenized and split before being sent to the two laboratories. The analysis results from these samples were compared to identify any systematic differences between results reported by the two laboratories.

The data used in the interlaboratory comparison were the ratios of the secondary laboratory result to the primary laboratory result. These data are plotted in Figure 5-4. In the statistical analysis, the ratio data were assumed to follow a lognormal distribution with a geometric mean of one (1). The interlaboratory comparison data were analyzed with a general linear model which included effects for laboratory, city, side-by-side variation, and unit-to-unit variation.

The geometric mean ratio for the vacuum cassette samples was 1.07 for Denver units and 0.95 for Baltimore units. Since the hypothesis tests of equal variance and equal geometric mean ratios were both accepted, the data were pooled. The pooled cassette data had a geometric mean ratio of 1.01 with an estimated 95% tolerance interval of (0.24, 4.26).

For the side-by-side soil samples, the hypothesis test of no laboratory bias was accepted for both the Denver and Baltimore units. The data had equal variances and no significant laboratory-by-city interaction effect, so the soil data from both cities were pooled. The pooled soil data had an estimated geometric mean of 1.09 and an estimated 95% tolerance interval of (0.82, 1.50).

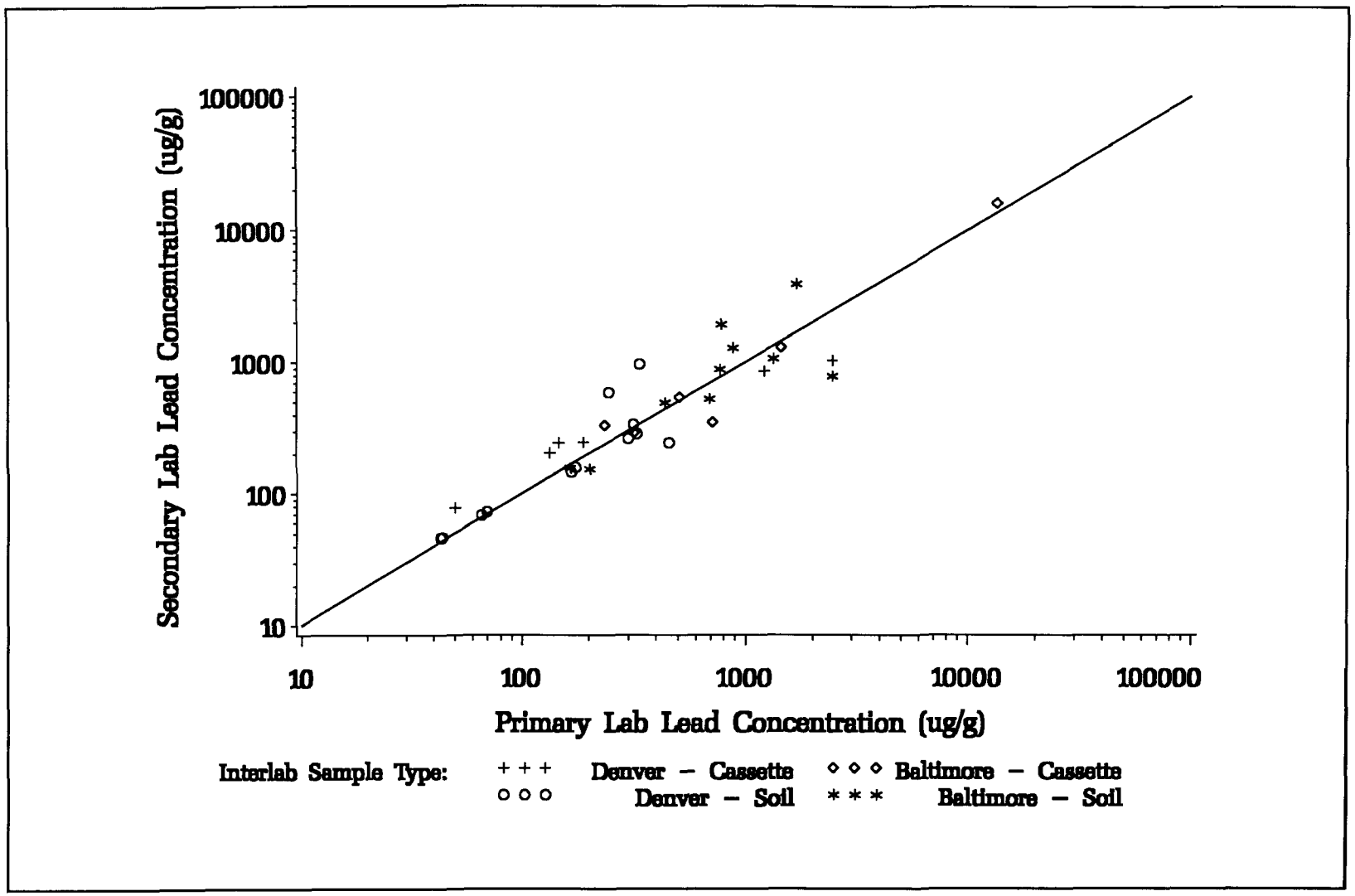

Figure 5-4. Secondary laboratory lead concentrations ($\mu g/g$) versus primary laboratory lead concentrations for interlaboratory comparison soil and cassette samples.

The geometric mean ratios are similar for both cassette and soil samples, although the soil data suggest that the primary laboratory results are slightly lower than those of the secondary laboratory. This difference, however, is not statistically significant.

6.0 REFERENCES

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15. Supplementary Notes

16. Abstract (Limit 200 words)

This report presents the results from the pilot study that preceded the Comprehensive Abatement Performance Study. The goal of the Comprehensive Performance Study was to assess the long-term impact of lead-based paint abatement. The pilot study was conducted to test the sampling and analysis protocols that were intended for the full study. These protocols called for determining the levels of lead in dust and soil samples collected at residential units. The pilot study was conducted at six houses, and all steps that were planned for the full study were included in the pilot.

The major finding of the pilot was the difference between wipe and vacuum methods for collecting dust. The choice of method had a noticeable impact on the level of lead associated with the collected sample In addition, an inter-laboratory comparison of dust and soil samples indicated no systematic difference in lead levels between the two laboratories. Also, intra-laboratory comparisons of sample results by inductively coupled plasma-atomic absorption spectrometry (ICP) and the more sensitive graphite furnace atomic absorption spectrometry (GFAA) indicated good agreement within the common domain of instrument detection limits.

Estimates of random house-to-house, room-to-room, and side-by-side sample variability were obtained for most of the sample types in the study. These estimates were used for determining the number of houses and number of samples per house for the full study.

17 Document Analysis

a. Descriptors

Lead, Lead-Based Paint Abatement, Statistical Analysis

b. Identifiers/Open-Ended Terms

HUD Abatement Demonstration, Encapsulation, Enclosure, Removal

c. COSATI Field/Group

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APPENDIX A

CAP Pilot Study Data

CAP Pilot Study Data

House ID	Sample ID	Room or Yard Location	General Sample Location	Component	Sample Medium	Sample Type	Analysis Method	Date Collected	Lead Concentration (ug/g)	Below Detection	Lead Loading (ug/ft2)	Laboratory
17	27	BAC	6	BDY	Soil	Regular	ICP	05/14/91	70.46		.	Primary
	23	BAC	2	EWY	Soil	Regular	ICP	05/14/91	363.88		.	Primary
	25	BAC	4	FDN	Soil	Regular	GFAA	05/14/91	72.70		.	Secondary
	25	BAC	4	FDN	Soil	Regular	ICP	05/14/91	69.40		.	Primary
	29	BAC	4	FDN	Soil	Lab Comparison	GFAA	05/13/91	68.40		.	Secondary
	29	BAC	4	FDN	Soil	Lab Comparison	ICP	05/13/91	65.68		.	Primary
	30	BAC	.	N/A	Soil	Field Blank	ICP	05/14/91	.	<	.	Primary
	19	BD1	6	ARD	Dust - Vacuum	Regular	ICP	05/13/91	717.46		26.99	Primary
	18	BD1	5	BDC	Dust - Vacuum	Regular	GFAA	05/13/91	66.92		1.02	Primary
	18	BD1	5	BDC	Dust - Vacuum	Regular	ICP	05/13/91	57.06		0.87	Primary
	11	BD1	1	FLR	Dust - Vacuum	Regular	ICP	05/13/91	373.18		45.18	Primary
	12	BD1	1	FLR	Dust - Vacuum	Field Side-by-Side	ICP	05/13/91	328.03		36.03	Primary
	13	BD1	2	FLR	Dust - Vacuum	Regular	ICP	05/13/91	224.71		32.01	Primary
	15	BD1	3	WCH	Dust - Vacuum	Regular		.	.		.	
	17	BD1	4	WCH	Dust - Vacuum	Regular		.	.		.	
	14	BD1	3	WST	Dust - Vacuum	Regular	ICP	05/13/91	726.85		45.59	Primary
	16	BD1	4	WST	Dust - Vacuum	Regular	ICP	05/13/91	337.99		36.18	Primary
	20	EWY	5	FLR	Dust - Vacuum	Regular	ICP	05/13/91	281.60		41.36	Primary
	21	EWY	7	FLR	Dust - Vacuum	Regular	ICP	05/13/91	258.73		13.03	Primary
	22	FRO	1	EWY	Soil	Regular	ICP	05/13/91	70.40		.	Primary
	09	KIT	6	ARD	Dust - Vacuum	Regular	ICP	05/13/91	363.44		52.77	Primary
	01	KIT	1	FLR	Dust - Vacuum	Regular	GFAA	05/13/91	50.00		1.60	Primary
	01	KIT	1	FLR	Dust - Vacuum	Regular	ICP	05/13/91	47.45		1.51	Primary
	02	KIT	.	FLR	Dust - Vacuum	Lab Comparison	GFAA	05/13/91	77.90		.	Secondary
	03	KIT	2	FLR	Dust - Vacuum	Regular	ICP	05/13/91	253.91		5.63	Primary
	10	KIT	.	N/A	Dust - Vacuum	Field Blank	GFAA	05/13/91	22.65		.	Primary
	10	KIT	.	N/A	Dust - Vacuum	Field Blank	ICP	05/13/91	0.00	<	.	Primary
	08	KIT	5	UPH	Dust - Vacuum	Regular		.	.		.	
	05	KIT	3	WCH	Dust - Vacuum	Regular		.	.		.	
	07	KIT	4	WCH	Dust - Vacuum	Regular	ICP	05/13/91	1141.31		976.70	Primary
	04	KIT	3	WST	Dust - Vacuum	Regular		.	.		.	
	06	KIT	4	WST	Dust - Vacuum	Regular	ICP	05/13/91	220.83		13.12	Primary
	26	LFT	5	BDY	Soil	Regular	ICP	05/13/91	52.22		.	Primary
	28	LFT	5	BDY	Soil	Field Side-by-Side	ICP	05/13/91	56.36		.	Primary
	24	LFT	3	FDN	Soil	Regular	ICP	05/13/91	70.24		.	Primary
	31	LVG	3	FLR	Dust - Vacuum	Regular	ICP	05/13/91	153.00		9.84	Primary
	32	LVG	3	FLR	Dust - Vacuum	Regular	ICP	05/13/91	63.69		8.68	Primary
	33	LVG	3	FLR	Dust - Wipe	Regular	FAA	05/13/91	.		18.42	Primary
	34	LVG	3	FLR	Dust - Wipe	Regular	FAA	05/13/91	.		30.12	Primary
	43	LVG	.	N/A	Dust - Wipe	Field Blank	FAA	05/13/91	.		.	Primary
	37	LVG	1	WCH	Dust - Wipe	Regular		.	.		.	
	38	LVG	1	WCH	Dust - Vacuum	Regular		.	.		.	
	41	LVG	4	WCH	Dust - Vacuum	Regular		.	.		.	
	42	LVG	4	WCH	Dust - Vacuum	Regular		.	.		.	
	35	LVG	1	WST	Dust - Wipe	Regular	FAA	05/13/91	.		24.42	Primary
	36	LVG	1	WST	Dust - Vacuum	Regular	GFAA	05/13/91	506.43		6.33	Primary

CAP Pilot Study Data (Continued)

House ID	Sample ID	Room or Yard Location	General Sample Location	Component	Sample Medium	Sample Type	Analysis Method	Date Collected	Lead Concentration (ug/g)	Below Detection	Lead Loading (ug/ft2)	Laboratory
17	36	LVG	1	WST	Dust - Vacuum	Regular	ICP	05/13/91	509.83		6.37	Primary
	39	LVG	4	WST	Dust - Vacuum	Regular	ICP	05/13/91	269.55		16.48	Primary
	40	LVG	4	WST	Dust - Vacuum	Regular	ICP	05/13/91	336.78		12.20	Primary
19	23	BAC	2	EWY	Soil	Regular	ICP	05/16/91	40.35		.	Primary
	19	BD1	6	ARD	Dust - Vacuum	Regular	ICP	05/16/91	624.41		57.10	Primary
	18	BD1	5	BDC	Dust - Vacuum	Regular	GFAA	05/16/91	484.57		4.22	Primary
	18	BD1	5	BDC	Dust - Vacuum	Regular	ICP	05/16/91	418.85		3.64	Primary
	11	BD1	1	FLR	Dust - Vacuum	Regular	ICP	05/16/91	301.15		55.10	Primary
	12	BD1	1	FLR	Dust - Vacuum	Field Side-by-Side		05/16/91	.		.	
	13	BD1	2	FLR	Dust - Vacuum	Regular	ICP	05/16/91	402.30		108.40	Primary
	15	BD1	3	WCH	Dust - Vacuum	Regular		.	.		.	
	17	BD1	4	WCH	Dust - Vacuum	Regular	GFAA	05/16/91	367.88		1200.56	Primary
	14	BD1	3	WST	Dust - Vacuum	Regular		.	.		.	
	16	BD1	4	WST	Dust - Vacuum	Regular	ICP	05/16/91	215.27		13.06	Primary
	20	EWY	7	FLR	Dust - Vacuum	Regular	GFAA	05/16/91	201.07		22.90	Primary
	20	EWY	7	FLR	Dust - Vacuum	Regular	ICP	05/16/91	173.13		19.72	Primary
	21	EWY	5	FLR	Dust - Vacuum	Regular	ICP	05/16/91	184.41		83.86	Primary
	26	FRO	5	BDY	Soil	Regular	ICP	05/16/91	98.17		.	Primary
	22	FRO	1	EWY	Soil	Regular	ICP	05/16/91	49.69		.	Primary
	28	FRO	1	EWY	Soil	Field Side-by-Side	ICP	05/16/91	196.53		.	Primary
	24	FRO	3	FDN	Soil	Regular	ICP	05/16/91	49.18		.	Primary
	31	KIT	3	FLR	Dust - Vacuum	Regular	ICP	05/16/91	99.50		39.42	Primary
	32	KIT	3	FLR	Dust - Vacuum	Regular	ICP	05/16/91	67.94		31.82	Primary
	33	KIT	3	FLR	Dust - Wipe	Regular	FAA	05/16/91	.		33.45	Primary
	34	KIT	3	FLR	Dust - Wipe	Regular		05/16/91	.		.	
	44	KIT	3	FLR	Dust - Wipe	Regular	FAA	05/16/91	.		36.95	Primary
	43	KIT	.	N/A	Dust - Wipe	Field Blank	FAA	05/16/91	.		.	Primary
	46	KIT	.	N/A	Dust - Wipe	Field Blank		05/16/91	.		.	
	37	KIT	1	WCH	Dust - Wipe	Regular	FAA	05/16/91	.		1529.67	Primary
	38	KIT	1	WCH	Dust - Vacuum	Regular		.	.		.	
	41	KIT	4	WCH	Dust - Vacuum	Regular		.	.		.	
	42	KIT	4	WCH	Dust - Vacuum	Regular		.	.		.	
	35	KIT	1	WST	Dust - Wipe	Regular	FAA	05/16/91	.		190.75	Primary
	36	KIT	1	WST	Dust - Vacuum	Regular	GFAA	05/16/91	176.82		96.47	Primary
	36	KIT	1	WST	Dust - Vacuum	Regular	ICP	05/16/91	161.45		88.08	Primary
	39	KIT	4	WST	Dust - Vacuum	Regular		.	.		.	
	40	KIT	4	WST	Dust - Vacuum	Regular		.	.		.	
	27	LFT	6	BDY	Soil	Regular	GFAA	05/16/91	46.20		.	Secondary
	27	LFT	6	BDY	Soil	Regular	ICP	05/16/91	43.29		.	Primary
	29	LFT	6	BDY	Soil	Lab Comparison	GFAA	05/16/91	46.70		.	Secondary
	29	LFT	6	BDY	Soil	Lab Comparison	ICP	05/16/91	44.16		.	Primary
	25	LFT	4	FDN	Soil	Regular	ICP	05/16/91	238.39		.	Primary
	30	LFT	.	N/A	Soil	Field Blank	ICP	05/16/91	.		.	Primary
	09	LVG	6	ARD	Dust - Vacuum	Regular	GFAA	05/16/91	69.53		942.66	Primary

CAP Pilot Study Data (Continued)

House ID	Sample ID	Room or Yard Location	General Sample Location	Component	Sample Medium	Sample Type	Analysis Method	Date Collected	Lead Concentration (ug/g)	Below Detection	Lead Loading (ug/ft2)	Laboratory
19	01	LVG	1	FLR	Dust - Vacuum	Regular	GFAA	05/16/91	189.93		81.57	Primary
	01	LVG	1	FLR	Dust - Vacuum	Regular	ICP	05/16/91	166.20		71.38	Primary
	02	LVG	.	FLR	Dust - Vacuum	Lab Comparison	FAA	05/16/91	246.10		.	Secondary
	03	LVG	2	FLR	Dust - Vacuum	Regular	GFAA	05/16/91	69.53		52.37	Primary
	10	LVG	.	N/A	Dust - Vacuum	Field Blank	GFAA	05/16/91	67.29		.	Primary
	10	LVG	.	N/A	Dust - Vacuum	Field Blank	ICP	05/16/91	204.67		.	Primary
	45	LVG	.	N/A	Dust - Vacuum	Field Blank	GFAA	05/16/91	90.60		.	Primary
	45	LVG	.	N/A	Dust - Vacuum	Field Blank	ICP	05/16/91	0.00	<	.	Primary
	08	LVG	5	UPH	Dust - Vacuum	Regular	ICP	05/16/91	481.99		187.30	Primary
	05	LVG	3	WCH	Dust - Vacuum	Regular		.	.		.	
	07	LVG	4	WCH	Dust - Vacuum	Regular		.	.		.	
	04	LVG	3	WST	Dust - Vacuum	Regular	GFAA	05/16/91	70.83		0.80	Primary
	04	LVG	3	WST	Dust - Vacuum	Regular	ICP	05/16/91	52.36		0.59	Primary
	06	LVG	4	WST	Dust - Vacuum	Regular		.	.		.	
33	23	BAC	2	EWY	Soil	Regular	ICP	05/15/91	135.78		.	Primary
	08	BD3	5		Dust - Vacuum	Regular		.	.		.	
	09	BD3	6	ARD	Dust - Vacuum	Regular	ICP	05/15/91	476.55		107.72	Primary
	01	BD3	1	FLR	Dust - Vacuum	Regular	GFAA	05/15/91	134.75		1.05	Primary
	01	BD3	1	FLR	Dust - Vacuum	Regular	ICP	05/15/91	136.37		1.06	Primary
	02	BD3	.	FLR	Dust - Vacuum	Lab Comparison	GFAA	05/15/91	203.50		.	Secondary
	03	BD3	2	FLR	Dust - Vacuum	Regular	GFAA	05/15/91	182.92		0.97	Primary
	03	BD3	2	FLR	Dust - Vacuum	Regular	ICP	05/15/91	185.53		0.99	Primary
	10	BD3	.	N/A	Dust - Vacuum	Field Blank	GFAA	05/15/91	91.92		.	Primary
	10	BD3	.	N/A	Dust - Vacuum	Field Blank	ICP	05/15/91	229.57		.	Primary
	44	BD3	.	N/A	Dust - Vacuum	Field Blank	GFAA	05/15/91	60.63		.	Primary
	44	BD3	.	N/A	Dust - Vacuum	Field Blank	ICP	05/15/91	189.44		.	Primary
	05	BD3	3	WCH	Dust - Vacuum	Regular		.	.		.	
	07	BD3	4	WCH	Dust - Vacuum	Regular		.	.		.	
	04	BD3	3	WST	Dust - Vacuum	Regular	GFAA	05/15/91	574.88		8.75	Primary
	04	BD3	3	WST	Dust - Vacuum	Regular	ICP	05/15/91	704.70		10.73	Primary
	06	BD3	4	WST	Dust - Vacuum	Regular		.	.		.	
	20	EWY	7	FLR	Dust - Vacuum	Regular	ICP	05/15/91	128.02		7.20	Primary
	21	EWY	5	FLR	Dust - Vacuum	Regular	ICP	05/15/91	88.42		5.67	Primary
	27	FRO	6	BDY	Soil	Regular	ICP	05/15/91	167.51		.	Primary
	22	FRO	1	EWY	Soil	Regular	ICP	05/15/91	63.20		.	Primary
	28	FRO	1	EWY	Soil	Field Side-by-Side	ICP	05/15/91	56.96		.	Primary
	25	FRO	4	FDN	Soil	Regular	ICP	05/15/91	108.21		.	Primary
	31	KIT	3	FLR	Dust - Vacuum	Regular	ICP	05/15/91	116.07		3.13	Primary
	32	KIT	3	FLR	Dust - Vacuum	Regular	ICP	05/15/91	88.19		2.08	Primary
	33	KIT	3	FLR	Dust - Wipe	Regular	FAA	05/15/91	.	<	13.77	Primary
	34	KIT	3	FLR	Dust - Wipe	Regular	FAA	05/15/91	.	<	13.77	Primary
	43	KIT	.	N/A	Dust - Wipe	Field Blank	FAA	05/15/91	.		.	Primary
	41	KIT	4	WCH	Dust - Wipe	Regular		.	.		.	
	42	KIT	4	WCH	Dust - Wipe	Regular		.	.		.	

CAP Pilot Study Data (Continued)

House ID	Sample ID	Room or Yard Location	General Sample Location	Component	Sample Medium	Sample Type	Analysis Method	Date Collected	Lead Concentration (ug/g)	Below Detection	Lead Loading (ug/ft2)	Laboratory
33	39	KIT	4	WST	Dust - Wipe	Regular	FAA	05/15/91	.		105.80	Primary
	40	KIT	4	WST	Dust - Wipe	Regular	FAA	05/15/91	.		121.73	Primary
	37	LDY	1	WCH	Dust - Wipe	Regular		.	.		.	
	38	LDY	1	WCH	Dust - Vacuum	Regular		.	.		.	
	35	LDY	1	WST	Dust - Wipe	Regular	FAA	05/15/91	.		217.91	Primary
	36	LDY	1	WST	Dust - Vacuum	Regular	GFAA	05/15/91	580.72		25.84	Primary
	36	LDY	1	WST	Dust - Vacuum	Regular	ICP	05/15/91	568.97		25.31	Primary
	26	LFT	5	BDY	Soil	Regular	ICP	05/15/91	44.12		.	Primary
	24	LFT	3	FDN	Soil	Regular	FAA	05/15/91	145.90		.	Secondary
	24	LFT	3	FDN	Soil	Regular	ICP	05/15/91	166.85		.	Primary
	29	LFT	3	FDN	Soil	Lab Comparison	FAA	05/15/91	158.80		.	Secondary
	29	LFT	3	FDN	Soil	Lab Comparison	ICP	05/15/91	175.74		.	Primary
	30	LFT	.	N/A	Soil	Field Blank	ICP	05/15/91	.	<	.	Primary
	19	LVG	6	ARD	Dust - Vacuum	Regular	ICP	05/15/91	1605.02		3909.60	Primary
	11	LVG	1	FLR	Dust - Vacuum	Regular	ICP	05/15/91	188.67		5.57	Primary
	12	LVG	1	FLR	Dust - Vacuum	Field Side-by-Side	ICP	05/15/91	128.35		4.21	Primary
	13	LVG	2	FLR	Dust - Vacuum	Regular	ICP	05/15/91	106.82		3.45	Primary
	18	LVG	5	UPH	Dust - Vacuum	Regular	GFAA	05/15/91	116.93		3.78	Primary
	18	LVG	5	UPH	Dust - Vacuum	Regular	ICP	05/15/91	122.04		3.94	Primary
	15	LVG	3	WCH	Dust - Vacuum	Regular		.	.		.	
	17	LVG	4	WCH	Dust - Vacuum	Regular	ICP	05/15/91	7238.25		3696.72	Primary
	14	LVG	3	WST	Dust - Vacuum	Regular	GFAA	05/15/91	174.52		4.79	Primary
	14	LVG	3	WST	Dust - Vacuum	Regular	ICP	05/15/91	168.59		4.63	Primary
	16	LVG	4	WST	Dust - Vacuum	Regular	ICP	05/15/91	561.92		8.44	Primary
43	27	BAC	6	BDY	Soil	Regular	ICP	05/14/91	60.75		.	Primary
	23	BAC	2	EWY	Soil	Regular	ICP	05/14/91	204.61		.	Primary
	28	BAC	2	EWY	Soil	Field Side-by-Side	ICP	05/14/91	304.05		.	Primary
	25	BAC	4	FDN	Soil	Regular	ICP	05/14/91	180.72		.	Primary
	19	DIN	6	ARD	Dust - Vacuum	Regular	GFAA	05/14/91	611.38		824.96	Primary
	11	DIN	1	FLR	Dust - Vacuum	Regular	ICP	05/14/91	234.42		2.56	Primary
	12	DIN	1	FLR	Dust - Vacuum	Field Side-by-Side	ICP	05/14/91	255.76		4.64	Primary
	13	DIN	2	FLR	Dust - Vacuum	Regular	GFAA	05/14/91	149.05		0.98	Primary
	13	DIN	2	FLR	Dust - Vacuum	Regular	ICP	05/14/91	156.67		1.03	Primary
	10	DIN	.	N/A	Dust - Vacuum	Field Blank	GFAA	05/14/91	64.80		.	Primary
	10	DIN	.	N/A	Dust - Vacuum	Field Blank	ICP	05/14/91	275.67		.	Primary
	18	DIN	5	UPH	Dust - Vacuum	Regular	ICP	05/14/91	195.48		15.79	Primary
	15	DIN	3	WCH	Dust - Vacuum	Regular		.	.		.	
	17	DIN	4	WCH	Dust - Vacuum	Regular		.	.		.	
	14	DIN	3	WST	Dust - Vacuum	Regular		.	.		.	
	16	DIN	4	WST	Dust - Vacuum	Regular	ICP	05/14/91	378.35		16.67	Primary
	20	EWY	7	FLR	Dust - Vacuum	Regular	ICP	05/14/91	263.47		3.16	Primary
	21	EWY	5	FLR	Dust - Vacuum	Regular	ICP	05/14/91	589.33		41.86	Primary
	26	FRO	5	BDY	Soil	Regular	ICP	05/15/91	289.61		.	Primary
	22	FRO	1	EWY	Soil	Regular	ICP	05/14/91	622.77		.	Primary

CAP Pilot Study Data (Continued)

House ID	Sample ID	Room or Yard Location	General Sample Location	Component	Sample Medium	Sample Type	Analysis Method	Date Collected	Lead Concentration (ug/g)	Below Detection	Lead Loading (ug/ft2)	Laboratory
43	24	FRO	3	FDN	Soil	Regular	FAA	05/14/91	970.60		.	Secondary
	24	FRO	3	FDN	Soil	Regular	ICP	05/14/91	336.58		.	Primary
	29	FRO	3	FDN	Soil	Lab Comparison	FAA	05/15/91	589.80		.	Secondary
	29	FRO	3	FDN	Soil	Lab Comparison	ICP	05/15/91	244.77		.	Primary
	30	FRO	.	N/A	Soil	Field Blank	ICP	05/15/91	.	<	.	Primary
	31	KIT	3	FLR	Dust - Vacuum	Regular	ICP	05/14/91	307.91		8.76	Primary
	32	KIT	3	FLR	Dust - Vacuum	Regular	ICP	05/14/91	309.13		4.57	Primary
	33	KIT	3	FLR	Dust - Wipe	Regular	FAA	05/14/91	.		18.42	Primary
	34	KIT	3	FLR	Dust - Wipe	Regular	FAA	05/14/91	.		24.27	Primary
	43	KIT	.	N/A	Dust - Wipe	Field Blank	FAA	05/14/91	.		.	Primary
	37	KIT	1	WCH	Dust - Wipe	Regular	FAA	05/14/91	.		335.38	Primary
	38	KIT	1	WCH	Dust - Vacuum	Regular	ICP	05/14/91	1433.63		9246.81	Primary
	41	KIT	4	WCH	Dust - Wipe	Regular	FAA	05/14/91	.		658.39	Primary
	42	KIT	4	WCH	Dust - Wipe	Regular	FAA	05/14/91	.		631.05	Primary
	35	KIT	1	WST	Dust - Wipe	Regular	FAA	05/14/91	.		27.43	Primary
	36	KIT	1	WST	Dust - Vacuum	Regular	GFAA	05/14/91	396.78		6.72	Primary
	36	KIT	1	WST	Dust - Vacuum	Regular	ICP	05/14/91	405.34		6.86	Primary
	39	KIT	4	WST	Dust - Wipe	Regular	FAA	05/14/91	.		18.39	Primary
	40	KIT	4	WST	Dust - Wipe	Regular	FAA	05/14/91	.		30.53	Primary
	09	LVG	6	ARD	Dust - Vacuum	Regular	ICP	05/14/91	1137.67		2089.88	Primary
	01	LVG	1	FLR	Dust - Vacuum	Regular	GFAA	05/14/91	147.28		1.19	Primary
	01	LVG	1	FLR	Dust - Vacuum	Regular	ICP	05/14/91	138.81		1.12	Primary
	02	LVG	.	FLR	Dust - Vacuum	Lab Comparison	GFAA	05/14/91	243.60		.	Secondary
	03	LVG	2	FLR	Dust - Vacuum	Regular	ICP	05/14/91	204.80		4.82	Primary
	08	LVG	5	UPH	Dust - Vacuum	Regular	ICP	05/14/91	102.12		13.11	Primary
	05	LVG	3	WCH	Dust - Vacuum	Regular	ICP	05/14/91	962.83		297.37	Primary
	07	LVG	4	WCH	Dust - Vacuum	Regular		.	.		.	
	04	LVG	3	WST	Dust - Vacuum	Regular	GFAA	05/14/91	964.39		15.94	Primary
	04	LVG	3	WST	Dust - Vacuum	Regular	ICP	05/14/91	980.24		16.21	Primary
	06	LVG	4	WST	Dust - Vacuum	Regular		.	.		.	
51	27	BAC	6	BDY	Soil	Regular	FAA	05/17/91	286.20		.	Secondary
	27	BAC	6	BDY	Soil	Regular	ICP	05/17/91	329.34		.	Primary
	29	BAC	6	BDY	Soil	Lab Comparison	FAA	05/17/91	262.70		.	Secondary
	29	BAC	6	BDY	Soil	Lab Comparison	ICP	05/17/91	300.49		.	Primary
	23	BAC	2	EWY	Soil	Regular	ICP	05/17/91	504.71		.	Primary
	25	BAC	4	FDN	Soil	Regular	ICP	05/17/91	538.96		.	Primary
	28	BAC	4	FDN	Soil	Field Side-by-Side	ICP	05/17/91	426.07		.	Primary
	30	BAC	.	N/A	Soil	Field Blank	ICP	05/17/91	.	<	.	Primary
	09	BAT	6	ARD	Dust - Vacuum	Regular		.	.		.	
	01	BAT	1	FLR	Dust - Vacuum	Regular	ICP	05/13/91	2446.16		561.64	Primary
	02	BAT	.	FLR	Dust - Vacuum	Lab Comparison	FAA	05/13/91	1032.80		.	Secondary
	03	BAT	2	FLR	Dust - Vacuum	Regular		.	.		.	
	10	BAT	.	N/A	Dust - Vacuum	Field Blank	GFAA	05/13/91	2236.47		.	Primary
	10	BAT	.	N/A	Dust - Vacuum	Field Blank	ICP	05/13/91	1884.11		.	Primary

CAP Pilot Study Data (Continued)

House ID	Sample ID	Room or Yard Location	General Sample Location	Component	Sample Medium	Sample Type	Analysis Method	Date Collected	Lead Concentration (ug/g)	Below Detection	Lead Loading (ug/ft2)	Laboratory
51	08	BAT	5	UPH	Dust - Vacuum	Regular		.	.		.	
	05	BAT	3	WCH	Dust - Vacuum	Regular		.	.		.	
	07	BAT	4	WCH	Dust - Vacuum	Regular	ICP	05/13/91	2733.50		695.81	Primary
	04	BAT	3	WST	Dust - Vacuum	Regular		.	.		.	
	06	BAT	4	WST	Dust - Vacuum	Regular	ICP	05/13/91	6367.01		1053.17	Primary
	31	BD1	3	FLR	Dust - Vacuum	Regular	ICP	05/13/91	1784.38		59.42	Primary
	32	BD1	3	FLR	Dust - Vacuum	Regular	ICP	05/13/91	1760.35		374.03	Primary
	33	BD1	3	FLR	Dust - Wipe	Regular	FAA	05/13/91	.		3832.53	Primary
	34	BD1	3	FLR	Dust - Wipe	Regular	FAA	05/13/91	.		1628.77	Primary
	43	BD1	.	N/A	Dust - Wipe	Field Blank	FAA	05/13/91	.		.	Primary
	37	BD1	4	WCH	Dust - Wipe	Regular	FAA	05/13/91	.		1008.29	Primary
	38	BD1	4	WCH	Dust - Wipe	Regular	FAA	05/13/91	.		1225.76	Primary
	41	BD1	1	WCH	Dust - Wipe	Regular		.	.		.	
	42	BD1	1	WCH	Dust - Vacuum	Regular		.	.		.	
	35	BD1	4	WST	Dust - Wipe	Regular	FAA	05/13/91	.		1142.59	Primary
	36	BD1	4	WST	Dust - Wipe	Regular	FAA	05/13/91	.		504.54	Primary
	39	BD1	1	WST	Dust - Wipe	Regular	FAA	05/13/91	.		4216.85	Primary
	40	BD1	1	WST	Dust - Vacuum	Regular	ICP	05/13/91	3580.94		600.26	Primary
	19	BD3	6	ARD	Dust - Vacuum	Regular		.	.		.	
	11	BD3	1	FLR	Dust - Vacuum	Regular	ICP	05/13/91	966.16		312.43	Primary
	12	BD3	7	FLR	Dust - Vacuum	Regular	ICP	05/13/91	466.55		602.92	Primary
	13	BD3	2	FLR	Dust - Vacuum	Regular	ICP	05/13/91	711.55		202.01	Primary
	44	BD3	1	FLR	Dust - Vacuum	Field Side-by-Side	ICP	05/13/91	646.48		409.98	Primary
	18	BD3	5	UPH	Dust - Vacuum	Regular		.	.		.	
	15	BD3	3	WCH	Dust - Vacuum	Regular	ICP	05/13/91	420.97		952.24	Primary
	17	BD3	4	WCH	Dust - Vacuum	Regular	ICP	05/13/91	492.56		197.09	Primary
	14	BD3	3	WST	Dust - Vacuum	Regular	ICP	05/13/91	773.93		138.93	Primary
	16	BD3	4	WST	Dust - Vacuum	Regular	ICP	05/13/91	670.18		62.84	Primary
	20	EWY	1	FLR	Dust - Vacuum	Regular	ICP	05/13/91	640.15		109.15	Primary
	21	EWY	1	FLR	Dust - Vacuum	Regular	ICP	05/13/91	4026.20		1578.88	Primary
	26	FRO	5	BDY	Soil	Regular	ICP	05/17/91	345.81		.	Primary
	22	FRO	1	EWY	Soil	Regular	ICP	05/17/91	899.20		.	Primary
	24	FRO	3	FDN	Soil	Regular	ICP	05/17/91	937.65		.	Primary
80	27	BAC	6	BDY	Soil	Regular	ICP	05/18/91	342.53		.	Primary
	23	BAC	2	EWY	Soil	Regular	ICP	05/18/91	349.75		.	Primary
	28	BAC	2	EWY	Soil	Field Side-by-Side	ICP	05/18/91	411.94		.	Primary
	25	BAC	4	FDN	Soil	Regular	FAA	05/18/91	243.00		.	Secondary
	25	BAC	4	FDN	Soil	Regular	ICP	05/18/91	458.86		.	Primary
	29	BAC	4	FDN	Soil	Lab Comparison	FAA	05/18/91	337.10		.	Secondary
	29	BAC	4	FDN	Soil	Lab Comparison	ICP	05/18/91	316.83		.	Primary
	30	BAC	.	N/A	Soil	Field Blank	ICP	05/18/91	.		.	Primary
	09	BAT	6	ARD	Dust - Vacuum	Regular	ICP	05/18/91	1699.36		507.77	Primary
	01	BAT	1	FLR	Dust - Vacuum	Regular	ICP	05/18/91	1211.33		19.05	Primary
	02	BAT	.	FLR	Dust - Vacuum	Lab Comparison	FAA	05/18/91	856.20		.	Secondary

CAP Pilot Study Data (Continued)

House ID	Sample ID	Room or Yard Location	General Sample Location	Component	Sample Medium	Sample Type	Analysis Method	Date Collected	Lead Concentration (ug/g)	Below Detection	Lead Loading (ug/ft2)	Laboratory
80	03	BAT	2	FLR	Dust - Vacuum	Regular	ICP	05/18/91	649.18		27.79	Primary
	10	BAT	.	N/A	Dust - Vacuum	Field Blank	GFAA	05/18/91	124.41		.	Primary
	10	BAT	.	N/A	Dust - Vacuum	Field Blank	ICP	05/18/91	433.29		.	Primary
	08	BAT	5	RUG	Dust - Vacuum	Regular	ICP	05/18/91	344.30		26.58	Primary
	05	BAT	3	WCH	Dust - Vacuum	Regular		.	.		.	
	07	BAT	4	WCH	Dust - Vacuum	Regular		.	.		.	
	04	BAT	3	WST	Dust - Vacuum	Regular		.	.		.	
	06	BAT	4	WST	Dust - Vacuum	Regular	ICP	05/18/91	61573.85		13087.15	Primary
	19	BD3	6	ARD	Dust - Vacuum	Regular	ICP	05/18/91	965.14		463.41	Primary
	18	BD3	5	BDC	Dust - Vacuum	Regular	GFAA	05/18/91	66.32		1.56	Primary
	18	BD3	5	BDC	Dust - Vacuum	Regular	ICP	05/18/91	73.83		1.74	Primary
	11	BD3	1	FLR	Dust - Vacuum	Regular	ICP	05/18/91	179.77		10.69	Primary
	12	BD3	1	FLR	Dust - Vacuum	Field Side-by-Side	ICP	05/18/91	175.40		8.31	Primary
	13	BD3	2	FLR	Dust - Vacuum	Regular	ICP	05/18/91	242.78		23.25	Primary
	15	BD3	3	WCH	Dust - Vacuum	Regular	GFAA	05/18/91	938.17		320.80	Primary
	17	BD3	4	WCH	Dust - Vacuum	Regular		.	.		.	
	14	BD3	3	WST	Dust - Vacuum	Regular	ICP	05/18/91	680.12		14.75	Primary
	16	BD3	4	WST	Dust - Vacuum	Regular		.	.		.	
	20	EWY	1	FLR	Dust - Vacuum	Regular	GFAA	05/18/91	342.28		24.73	Primary
	21	EWY	5	FLR	Dust - Vacuum	Regular	GFAA	05/18/91	221.60		0.74	Primary
	21	EWY	5	FLR	Dust - Vacuum	Regular	ICP	05/18/91	163.61		0.54	Primary
	26	FRO	5	BDY	Soil	Regular	ICP	05/18/91	307.97		.	Primary
	22	FRO	1	EWY	Soil	Regular	ICP	05/18/91	379.56		.	Primary
	45	KIT	6	ARD	Dust - Vacuum	Regular	ICP	05/18/91	389.48		548.74	Primary
	31	KIT	3	FLR	Dust - Vacuum	Regular	ICP	05/18/91	181.70		2.50	Primary
	32	KIT	3	FLR	Dust - Vacuum	Regular	ICP	05/18/91	223.33		1.45	Primary
	33	KIT	3	FLR	Dust - Wipe	Regular	FAA	05/18/91	.		36.95	Primary
	34	KIT	3	FLR	Dust - Wipe	Regular	FAA	05/18/91	.		22.96	Primary
	43	KIT	.	N/A	Dust - Wipe	Field Blank	FAA	05/18/91	.		.	Primary
	44	KIT	.	N/A	Dust - Vacuum	Field Blank	GFAA	05/18/91	176.18		.	Primary
	44	KIT	.	N/A	Dust - Vacuum	Field Blank	ICP	05/18/91	188.70		.	Primary
	41	KIT	4	WCH	Dust - Vacuum	Regular	ICP	05/18/91	4550.00		3771.04	Primary
	42	KIT	4	WCH	Dust - Vacuum	Regular	ICP	05/18/91	5794.19		6167.62	Primary
	39	KIT	4	WST	Dust - Vacuum	Regular	ICP	05/18/91	7880.70		147.85	Primary
	40	KIT	4	WST	Dust - Vacuum	Regular	ICP	05/18/91	4657.60		83.62	Primary
	24	LFT	3	FDN	Soil	Regular	ICP	05/18/91	941.59		.	Primary
	37	PAN	1	WCH	Dust - Wipe	Regular		.	.		.	
	38	PAN	1	WCH	Dust - Vacuum	Regular		.	.		.	
	35	PAN	1	WST	Dust - Wipe	Regular	FAA	05/18/91	.		163.11	Primary
	36	PAN	1	WST	Dust - Vacuum	Regular	ICP	05/18/91	534.94		33.91	Primary

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15. Supplementary Notes

16. Abstract (Limit 200 words)

This report presents the results from the pilot study that preceded the Comprehensive Abatement Performance Study. The goal of the Comprehensive Performance Study was to assess the long-term impact of lead-based paint abatement. The pilot study was conducted to test the sampling and analysis protocols that were intended for the full study. These protocols called for determining the levels of lead in dust and soil samples collected at residential units. The pilot study was conducted at six houses, and all steps that were planned for the full study were included in the pilot.

The major finding of the pilot was the difference between wipe and vacuum methods for collecting dust. The choice of method had a noticeable impact on the level of lead associated with the collected sample. In addition, an inter-laboratory comparison of dust and soil samples indicated no systematic difference in lead levels between the two laboratories. Also, intra-laboratory comparisons of sample results by inductively coupled plasma-atomic absorption spectrometry (ICP) and the more sensitive graphite furnace atomic absorption spectrometry (GFAA) indicated good agreement within the common domain of instrument detection limits

Estimates of random house-to-house, room-to-room, and side-by-side sample variability were obtained for most of the sample types in the study. These estimates were used for determining the number of houses and number of samples per house for the full study.

17. Document Analysis

a. Descriptors

Lead, Lead-Based Paint Abatement, Statistical Analysis

b. Identifiers/Open-Ended Terms

HUD Abatement Demonstration, Encapsulation, Enclosure, Removal

c. COSATI Field/Group

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Department of Commerce